










































































































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























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



















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




















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




















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# LM101A/LH2101A

## General Purpose Operational Amplifier

### Features

- Input offset voltage 0.7 mV
- Input bias current 30 nA
- Input offset current 1.5 nA
- Full frequency compensation 30pF
- Supply voltage  $\pm 5.0\text{V}$  to  $\pm 20\text{V}$

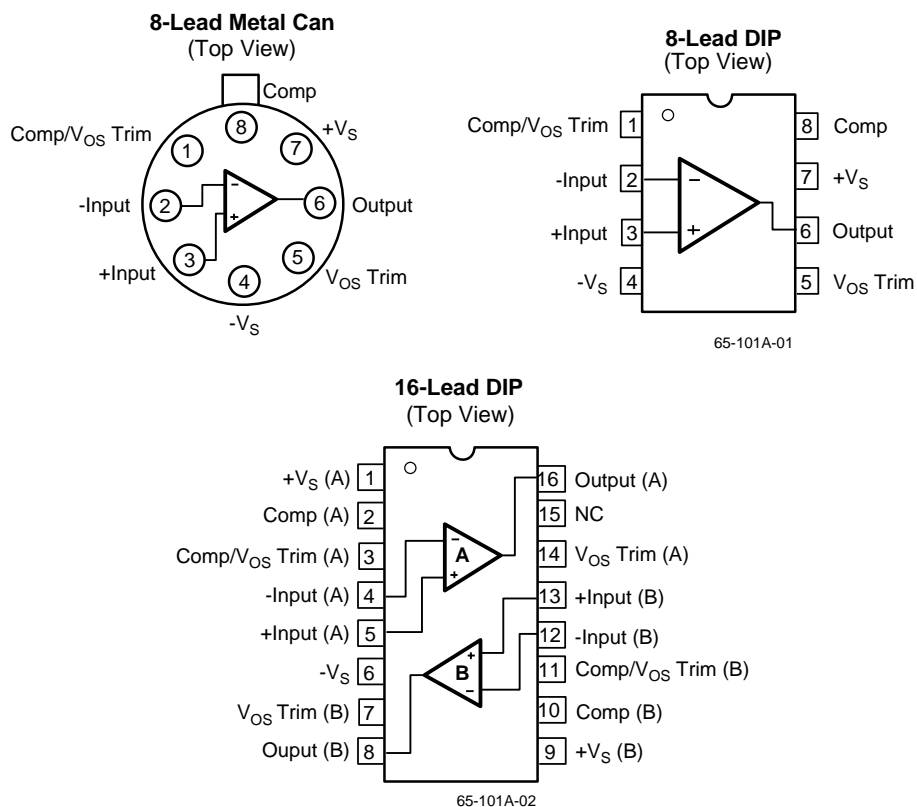
### Description

The LM101A/LH2101A is a general purpose high performance operational amplifier fabricated monolithically on a silicon chip by an advanced epitaxial process. The LH2101A consists of two LM101A ICs in one 16-lead DIP. The units may be fully compensated with the addition of a 30 pF capacitor stabilizing the circuit for all feedback configurations including capacitive loads.

The device may be operated as a comparator with a differential input as high as 30V. Used as a comparator the output can be clamped at any desired level to make it compatible with logic circuits.

The LM101A and LH2101A operate over the full military temperature range from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

## Pin Assignments



## Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply Voltage		$\pm 22$	V
Differential Input Voltage		30	V
Input Voltage <sup>1</sup>		$\pm 15$	V
Output Short-Circuit Duration <sup>2</sup>	Indefinite		
Storage Temperature Range	-65	+150	°C
Operating Temperature Range	-55	+125	°C
Lead Soldering Temperature (60 sec)		+300	°C

### Notes:

- For supply voltages less than  $\pm 15$ V, the absolute maximum input voltage is equal to the supply voltage.
- Observe package thermal characteristics.

## Thermal Characteristics

Parameter	8-Lead Ceramic DIP	8-Lead TO-99 Metal Can	16-Lead Ceramic DIP
Maximum Junction Temperature	+175°C	+175°C	+175°C
Maximum $P_D$ $T_A < 50^\circ\text{C}$	833 mW	658 mW	1042 mW
Thermal Resistance, $\theta_{JC}$	45°C/W	50°C/W	60°C/W
Thermal Resistance, $\theta_{JA}$	150°C/W	190°C/W	120°C/W
For $T_A > 50^\circ\text{C}$ Derate at	8.33 mW/°C	5.26 mW/°C	8.33 mW/°C

## Electrical Characteristics

$C = 30\text{pF}$ ;  $\pm 5.0\text{V} \leq V_S \leq \pm 20\text{V}$ ;  $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$  unless otherwise specified

Parameters	Test Conditions	LM101A/LH2101 A			Units
		Min.	Typ.	Max.	
Input Offset Voltage	$T_A = +25^\circ\text{C}$ , $R_S \leq 50\text{ k}\Omega$		0.7	2.0	mV
Input Offset Current	$T_A = +25^\circ\text{C}$		1.5	10	nA
Input Bias Current	$T_A = +25^\circ\text{C}$		30	75	nA
Input Resistance	$T_A = +25^\circ\text{C}$	1.5	4.0		M $\Omega$
Supply Current	$T_A = +25^\circ\text{C}$ $V_S = \pm 20\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = +25^\circ\text{C}$ , $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$ , $R_L \geq 2\text{ k}\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 50\text{ k}\Omega$			3.0	mV
Average Input Offset Voltage Drift	$R_S \leq 50\text{ k}\Omega$		3.0	15	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				20	nA
Average Input Offset Current Drift	$+25^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.01	0.1	nA/°C
	$-55^\circ\text{C} \leq T_A \leq +25^\circ\text{C}$		0.02	0.2	
Input Bias Current				100	nA
Supply Current	$T_A = +125^\circ\text{C}$ , $V_S = \pm 20\text{V}$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$ , $R_L \geq 2\text{ k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$ , $R_L = 10\text{ k}\Omega$	$\pm 12$	$\pm 14$		V
	$R_L = 2\text{ k}\Omega$	$\pm 10$	$\pm 13$		
Input Voltage Range	$V_S = \pm 20\text{V}$	$\pm 15$			V
Common Mode Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	96		dB
Power Supply Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	96		dB



## Typical Performance Characteristics

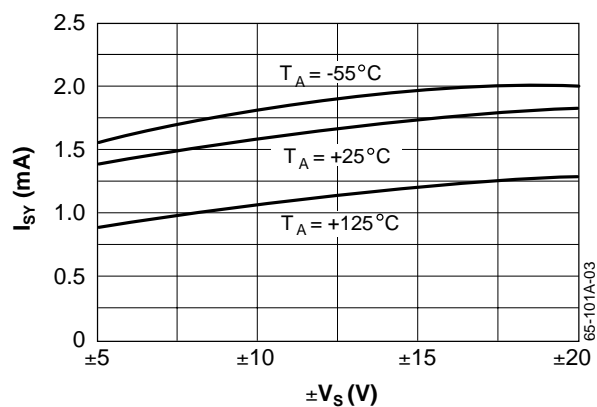


Figure 1. Supply Current vs. Supply Voltage

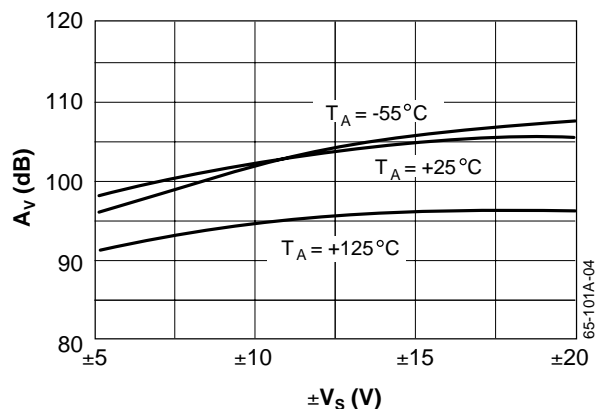


Figure 2. Voltage Gain vs. Supply Voltage

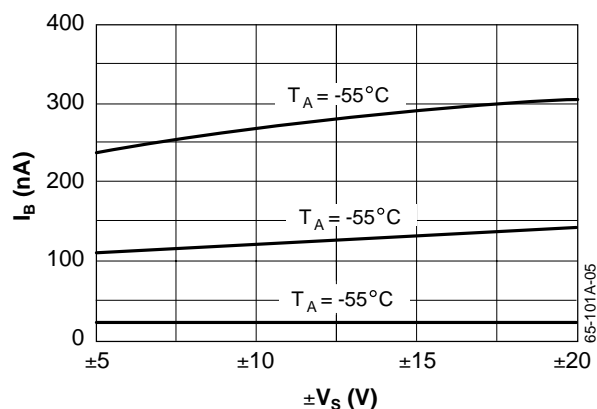


Figure 3. Input Bias Current vs. Supply Voltage

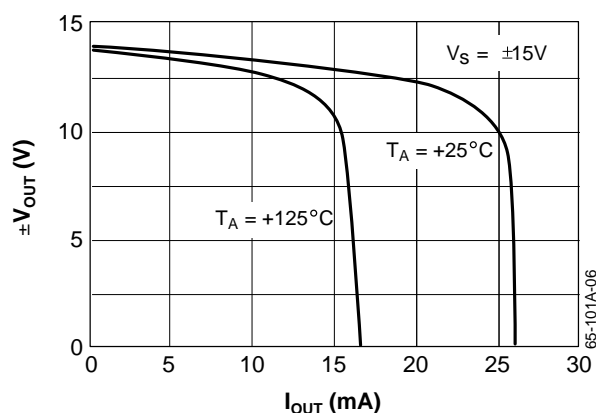


Figure 4. Current Limiting Output Voltage vs. Output Current

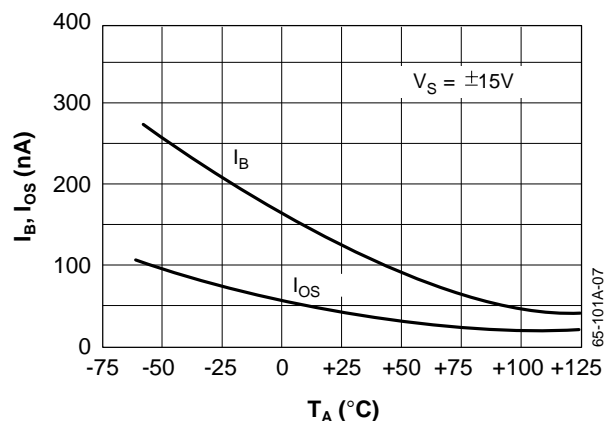


Figure 5. Input Bias, Offset Current vs. Temperature

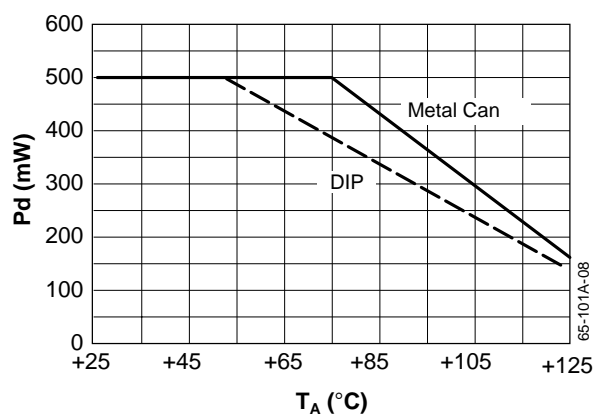


Figure 6. Maximum Power Dissipation vs. Temperature

## Typical Performance Characteristics (continued)

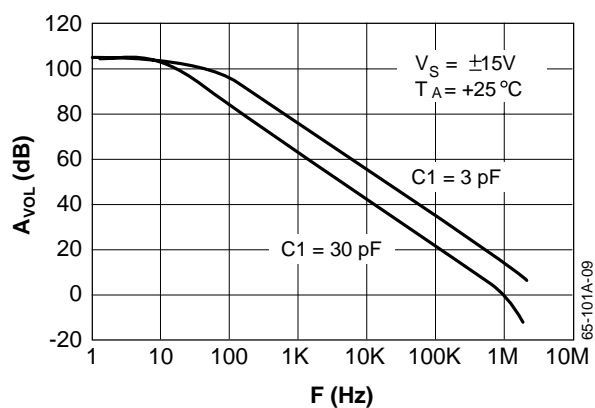


Figure 7. Open Loop Gain vs. Frequency

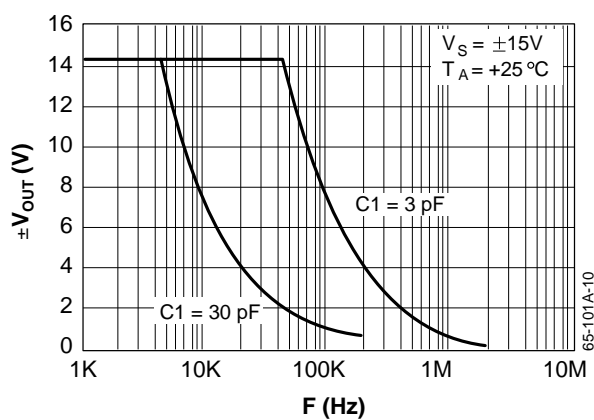


Figure 8. Output Voltage Swing vs. Frequency

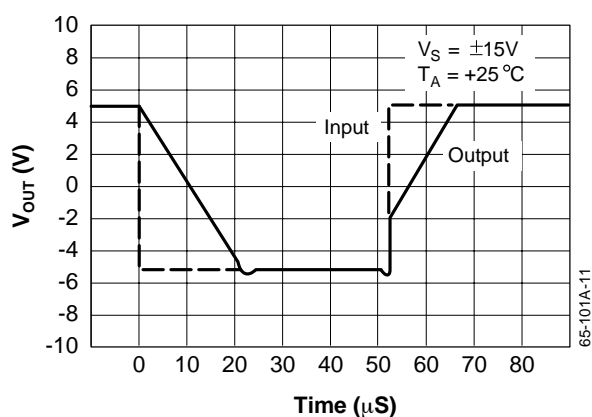
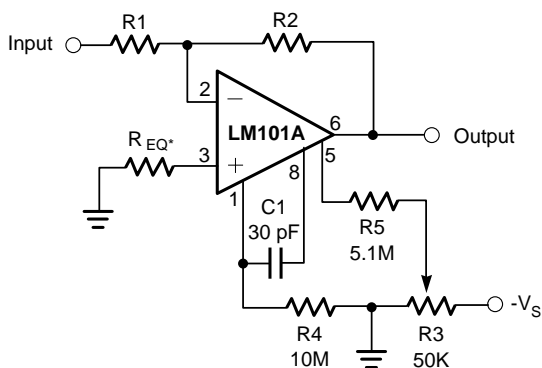


Figure 9. Follower Large Signal Pulse Response Output Voltage vs. Time

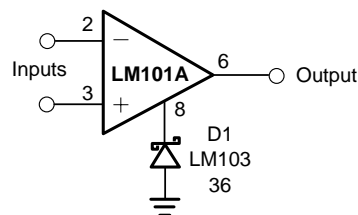
## Typical Applications



\*May be zero or equal to parallel combination of R1 and R2 for minimum offset.

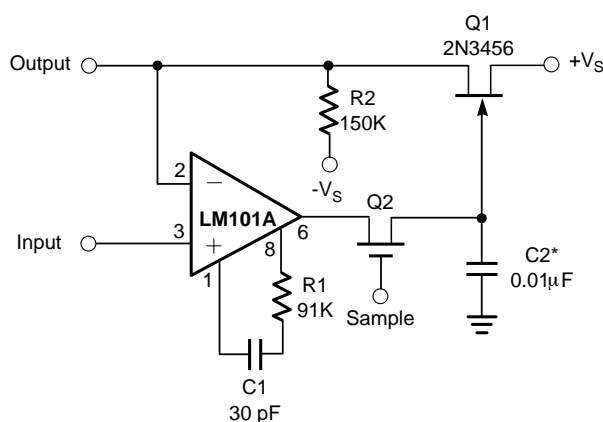
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**Figure 10. Inverting Amplifier with Balancing Circuit**



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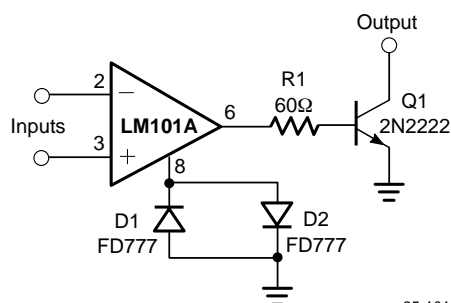
**Figure 11. Voltage Comparator for Driving DTL or TTL ICs**



\*Polycarbonate dielectric capacitor

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**Figure 12. Low Drift Sample and Hold**



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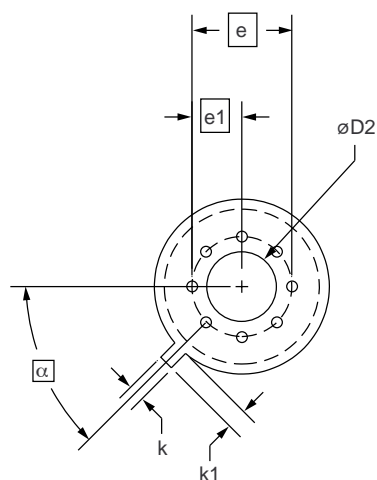
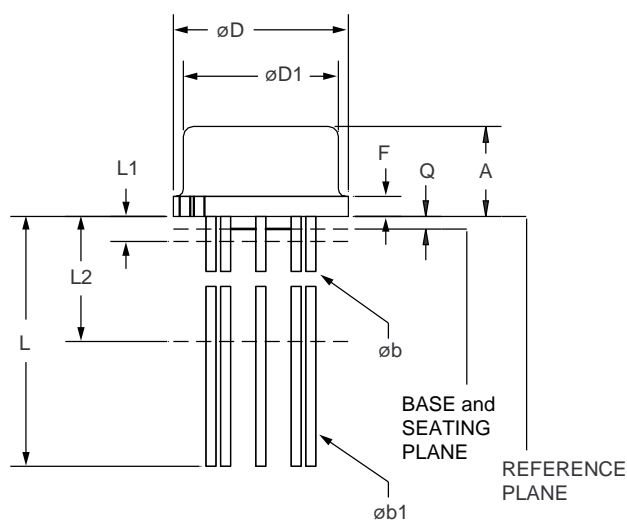
**Figure 13. Voltage Comparator for Driving RTL Logic or High Current Driver**

**Notes:**

**Notes:**

## Mechanical Dimensions

### 8-Lead TO-99 Metal Can



Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.165	.185	4.19	4.70	
øb	.016	.019	.41	.48	1, 5
øb1	.016	.021	.41	.53	1, 5
øD	.335	.375	8.51	9.52	
øD1	.305	.335	7.75	8.51	
øD2	.110	.160	2.79	4.06	
e	.200 BSC		5.08 BSC		
e1	.100 BSC		2.54 BSC		
F	—	.040	—	1.02	
k	.027	.034	.69	.86	
k1	.027	.045	.69	1.14	2
L	.500	.750	12.70	19.05	1
L1	—	.050	—	1.27	1
L2	.250	—	6.35	—	1
Q	.010	.045	.25	1.14	
α	45° BSC		45° BSC		

#### Notes:

- (All leads) øb applies between L1 & L2. øb1 applies between L2 & .500 (12.70mm) from the reference plane. Diameter is uncontrolled in L1 & beyond .500 (12.70mm) from the reference plane.
- Measured from the maximum diameter of the product.
- Leads having a maximum diameter .019 (.48mm) measured in gauging plane, .054 (1.37mm) +.001 (.03mm) –.000 (.00mm) below the reference plane of the product shall be within .007 (.18mm) of their true position relative to a maximum width tab.
- The product may be measured by direct methods or by gauge.
- All leads – increase maximum limit by .003 (.08mm) when lead finish is applied.

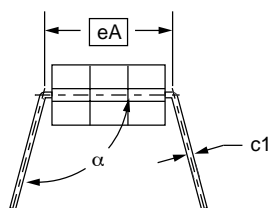
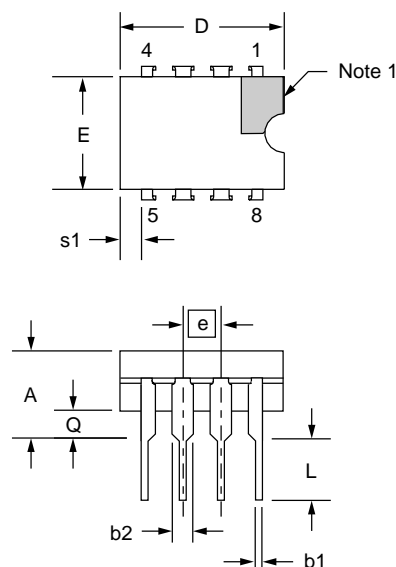
## Mechanical Dimensions (continued)

### 8-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.045	.065	1.14	1.65	2, 8
c1	.008	.015	.20	.38	8
D	—	.405	—	10.29	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.125	.200	3.18	5.08	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 4, 5 and 8 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm 0.010$  (.25mm) of its exact longitudinal position relative to pins 1 and 8.
6. Applies to all four corners (leads number 1, 4, 5, and 8).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Six spaces.



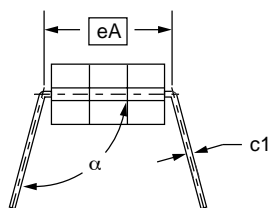
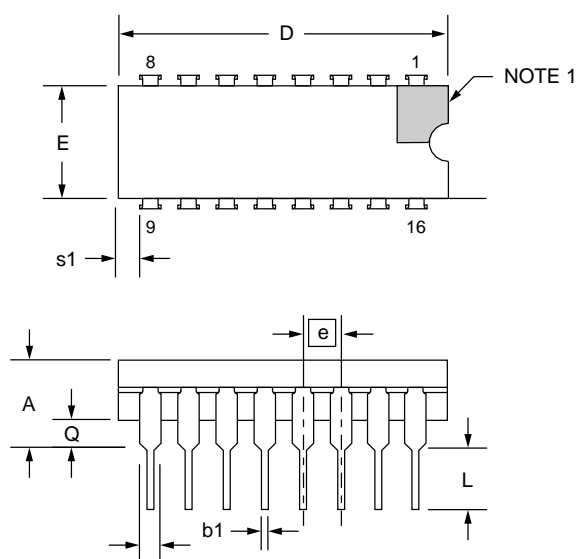
## Mechanical Dimensions (continued)

### 16-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.050	.065	1.27	1.65	2
c1	.008	.015	.20	.38	8
D	.745	.840	18.92	21.33	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.115	.160	2.92	4.06	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 8, 9 and 16 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm .010$  (.25mm) of its exact longitudinal position relative to pins 1 and 16.
6. Applies to all four corners (leads number 1, 8, 9, and 16).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Fourteen spaces.





## Ordering Information

Part Number	Package	Operating Temperature Range
LM101AD	8-Lead Ceramic DIP	-55°C to +125°C
LM101AD/883B	8-Lead Ceramic DIP	-55°C to +125°C
LM101AT	8-Lead Metal Can	-55°C to +125°C
LM101AT/883B	8-Lead Metal Can	-55°C to +125°C
LH2101AD	16-Lead Ceramic DIP	-55°C to +125°C
LH2101AD/883B	16-Lead Ceramic DIP	-55°C to +125°C

**Notes:**

1. /883B suffix denotes Mil-Std-883. Level B processing.
2. Contact a Fairchild Semiconductor sales office or representative for ordering information on special package/ temperature range combinations.

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1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

# LM108A/LH2108A

## Precision Operational Amplifiers

### Features

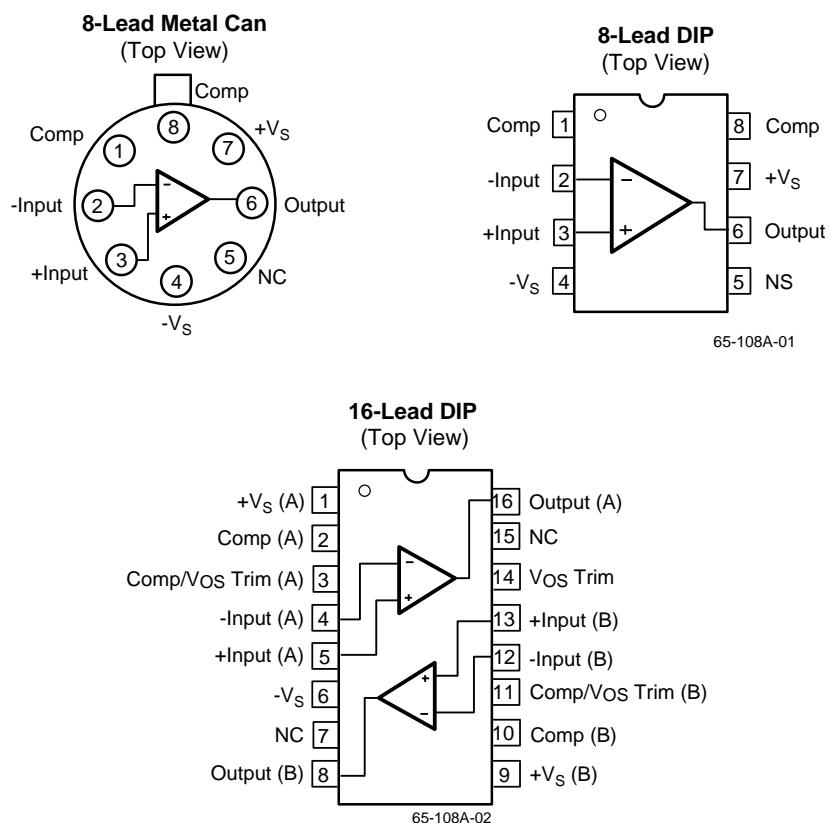
- Low input bias current — 2 nA
- Low input offset current — 200 pA
- Low input offset voltage — 500 $\mu$ V
- Low input offset drift — 5  $\mu$ V/°C
- Wide supply range —  $\pm$ 3V to  $\pm$ 20V
- Low supply current — 0.6 mA
- High PSRR — 96 dB
- High CMRR — 96 dB
- MIL-STD-883B available

### Description

The LM108A operational amplifiers features low input bias current combined with the advantages of bipolar transistor construction; input offset voltages and currents are kept low over a wide range of temperature and supply voltage. Fairchild Semiconductor's superbeta bipolar manufacturing process includes extra treatment at epitaxial growth to ensure low input voltage noise.

The LH2108 consists of two LM108 ICs in one 16-lead DIP. The "A" versions meet tighter electrical specifications than the plain versions. All types are available with 883B military screening.

## Pin Assignments



## Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply Voltage		$\pm 20$	V
Differential Input Current <sup>1</sup>		$\pm 10$	mA
Input Voltage <sup>2</sup>		$\pm 15$	V
Output Short-Circuit Duration <sup>2</sup>	Continuous		
Operating Temperature Range	-55	+125	°C
Storage Temperature Range	-65	+150	°C
Lead Soldering Temperature (60 seconds)		+300	°C

### Notes:

1. The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, if a differential input voltage in excess of 1V is applied between the inputs, excessive current will flow, unless some limiting resistance is provided.
2. For supply voltages less than  $\pm 15$ V, the absolute maximum input voltage is equal to the supply voltage.

## Thermal Characteristics

Parameter	8-Lead Metal Can	8-Lead Ceramic DIP	16-Lead Ceramic DIP
Maximum Junction Temperature	+175°C	+175°C	+175°C
Max. $P_{DTA} < 50^{\circ}\text{C}$	658 mW	833 mW	1042 mW
Thermal Resistance, $\theta_{JC}$	50°C/W	45°C/W	60°C/W
Thermal Resistance, $\theta_{JA}$	190°C/W	150°C/W	120°C/W
For $T_A > 50^{\circ}\text{C}$ Derate at	5.26 mW/°C	8.33 mW/°C	8.38 mW/°C

## Electrical Characteristics

$\pm 5\text{V}$ ,  $\leq V_S \leq \pm 20\text{V}$  and  $T_A \leq +25^{\circ}\text{C}$  unless otherwise noted

Parameters	Test Conditions	LM108A/LH2108A			LM108/LH2108			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Offset Voltage			0.3	0.5		0.7	2.0	mV
Input Offset Current			0.05	0.2		0.05	0.2	nA
Input Bias Current			0.8	2.0		0.8	2.0	nA
Input Resistance <sup>1</sup>		30	70		30	70		MΩ
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$ , $V_{OUT} \pm 10\text{V}$ , $R_L \geq 10\text{K}\Omega$	80	300		50	300		V/mV
Supply Current	Each Amplifier		0.3	0.6		0.3	0.6	mA
$\pm 5\text{V}$ , $\leq V_S \leq \pm 20\text{V}$ ; $-55^{\circ}\text{C} \leq T_A \leq +25^{\circ}\text{C}$ unless otherwise noted								
Input Offset Voltage			0.4	1.0		1.0	3.0	mV
Avg. Input Offset Voltage Drift <sup>2</sup>			1.0	5.0		3.0	15	μV/°C
Input Offset Current			0.1	0.4		0.1	0.4	nA
Avg. Input Offset Current Drift <sup>2</sup>			0.5	2.5		0.5	2.5	pA/°C
Input Bias Current			1.0	3.0		1.0	3.0	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$ , $V_{OUT} = \pm 10\text{V}$ , $R_L \geq 10\text{K}\Omega$	40	200		25	200		V/mV
Output Voltage Swing	$R_L \geq 10\text{K}\Omega$ , $V_S = \pm 20\text{V}$	±16	±18		±16	±18		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±13.5			±13.5			V
Common Mode Rejection Ratio	$V_{CM} = \pm 13.5\text{V}$ , $V_S = \pm 15\text{V}$	96	110		85	100		dB
Power Supply Rejection Ratio	$V_S = \pm 15\text{V}$	96	110		80	96		dB
Supply Current	Each Amplifier			0.6			0.6	mA

### Notes:

1. Guaranteed by input bias current specification.
2. Sample tested.

## Typical Applications

The LM108 series has very low input offset and bias currents; the user is cautioned that printed circuit board leakages can produce significant errors especially at high board temperatures. Careful attention to board layout and

cleaning procedure is required to achieve the LM108A's rated performance. It is suggested that board leakage be minimized by encircling the input pins with a guard ring maintained at a potential close to that of the inputs. The guard ring should be driven by a low impedance source such as an amplifier's output or ground.

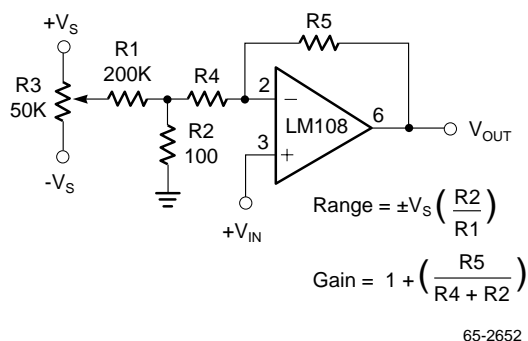


Figure 1. Offset Adjustment for Non-Inverting Amplifiers

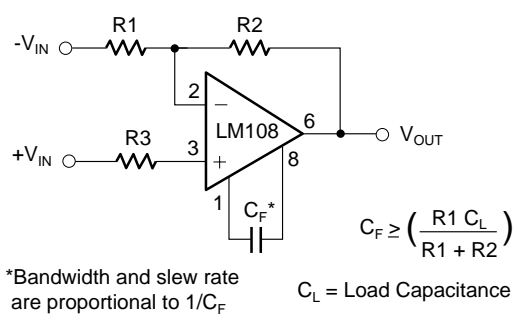


Figure 2. Standard Compensation Circuit

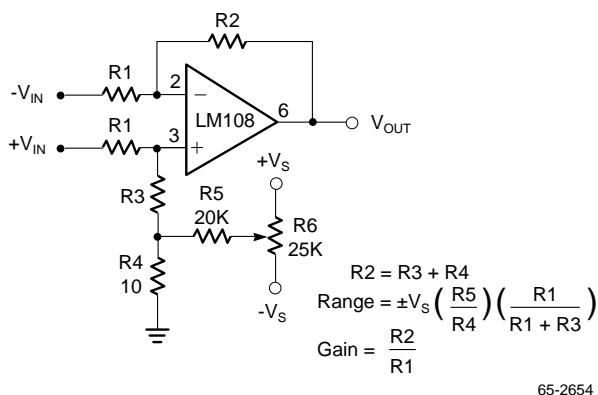


Figure 3. Offset Adjustment for Differential Amplifiers

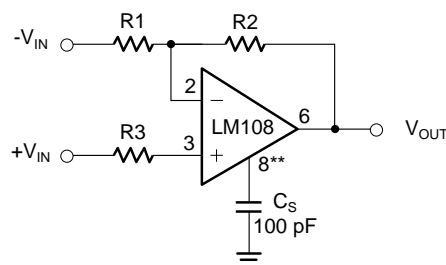


Figure 4. Alternate Frequency Compensation

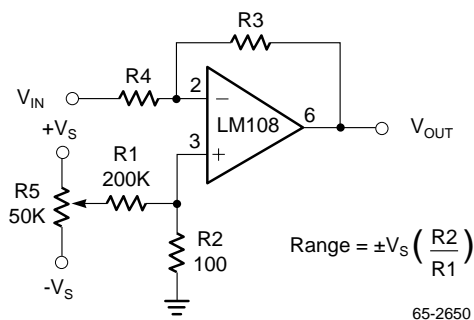


Figure 5. Offset Adjustment for Inverting Amplifiers

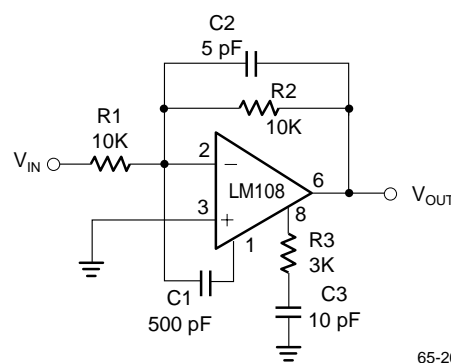
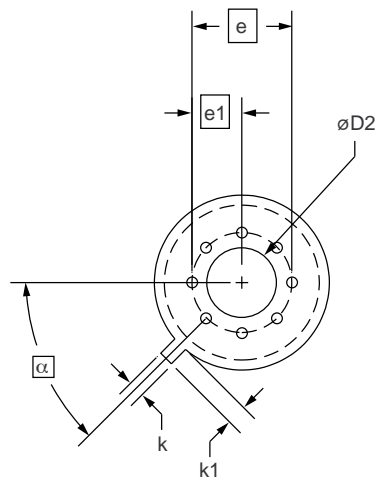
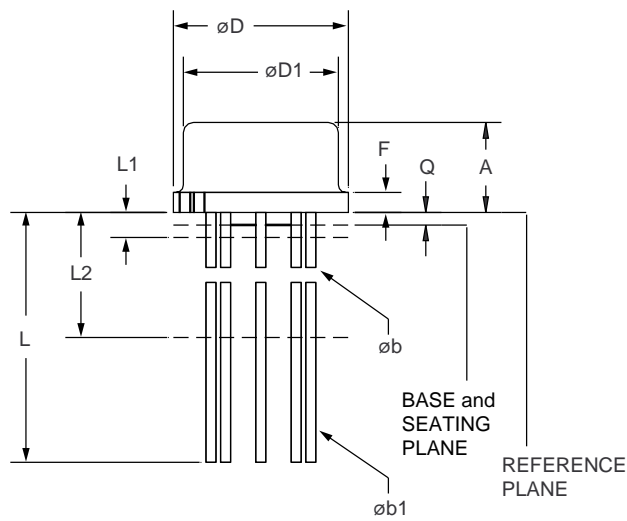


Figure 6. Feedforward Compensation

## Mechanical Dimensions

### 8-Lead TO-99 Metal Can



Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.165	.185	4.19	4.70	
$\phi b$	.016	.019	.41	.48	1, 5
$\phi b1$	.016	.021	.41	.53	1, 5
$\phi D$	.335	.375	8.51	9.52	
$\phi D1$	.305	.335	7.75	8.51	
$\phi D2$	.110	.160	2.79	4.06	
e	.200 BSC		5.08 BSC		
e1	.100 BSC		2.54 BSC		
F	—	.040	—	1.02	
k	.027	.034	.69	.86	
k1	.027	.045	.69	1.14	2
L	.500	.750	12.70	19.05	1
L1	—	.050	—	1.27	1
L2	.250	—	6.35	—	1
Q	.010	.045	.25	1.14	
$\alpha$	45° BSC		45° BSC		

#### Notes:

- (All leads)  $\phi b$  applies between L1 & L2.  $\phi b1$  applies between L2 & .500 (12.70mm) from the reference plane. Diameter is uncontrolled in L1 & beyond .500 (12.70mm) from the reference plane.
- Measured from the maximum diameter of the product.
- Leads having a maximum diameter .019 (.48mm) measured in gauging plane, .054 (1.37mm) +.001 (.03mm) –.000 (.00mm) below the reference plane of the product shall be within .007 (.18mm) of their true position relative to a maximum width tab.
- The product may be measured by direct methods or by gauge.
- All leads – increase maximum limit by .003 (.08mm) when lead finish is applied.

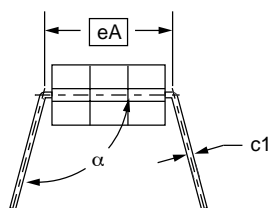
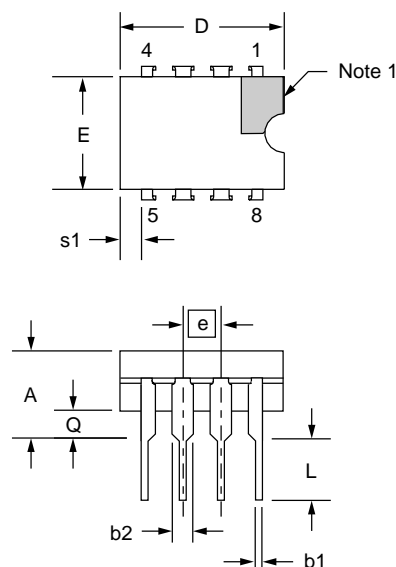
## Mechanical Dimensions (continued)

### 8-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.045	.065	1.14	1.65	2, 8
c1	.008	.015	.20	.38	8
D	—	.405	—	10.29	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.125	.200	3.18	5.08	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 4, 5 and 8 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm 0.010$  (.25mm) of its exact longitudinal position relative to pins 1 and 8.
6. Applies to all four corners (leads number 1, 4, 5, and 8).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Six spaces.



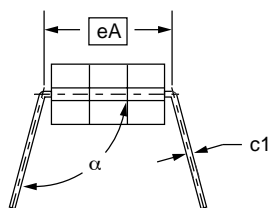
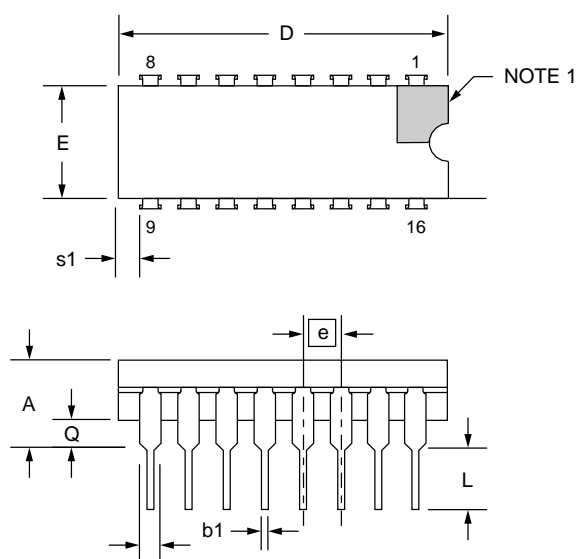
## Mechanical Dimensions (continued)

### 16-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.050	.065	1.27	1.65	2
c1	.008	.015	.20	.38	8
D	.745	.840	18.92	21.33	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.115	.160	2.92	4.06	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 8, 9 and 16 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm .010$  (.25mm) of its exact longitudinal position relative to pins 1 and 16.
6. Applies to all four corners (leads number 1, 8, 9, and 16).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Fourteen spaces.





## Ordering Information

Part Number	Package	Operation Temperature Range
LM108D	8-Lead Ceramic DIP	-55°C to +125°C
LM108D/883B	8-Lead Ceramic DIP	-55°C to +125°C
LM108AD	8-Lead Ceramic DIP	-55°C to +125°C
LM108AD/883B	8-Lead Ceramic DIP	-55°C to +125°C
LM108T	8-Lead Metal Can TO-99	-55°C to +125°C
LM108T/883B	8-Lead Metal Can TO-99	-55°C to +125°C
LM108AT	8-Lead Metal Can TO-99	-55°C to +125°C
LM108AT/883B	8-Lead Metal Can TO-99	-55°C to +125°C
LH2108D	16-Lead Ceramic DIP	-55°C to +125°C
LH2108D/883B	16-Lead Ceramic DIP	-55°C to +125°C
LH2108AD	16-Lead Ceramic DIP	-55°C to +125°C
LH2108AD/883B	16-Lead Ceramic DIP	-55°C to +125°C

**Note:**

1. /883B suffix denotes Mil-Std-883, Level B processing

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# LM111/LH2111

## Voltage Comparators

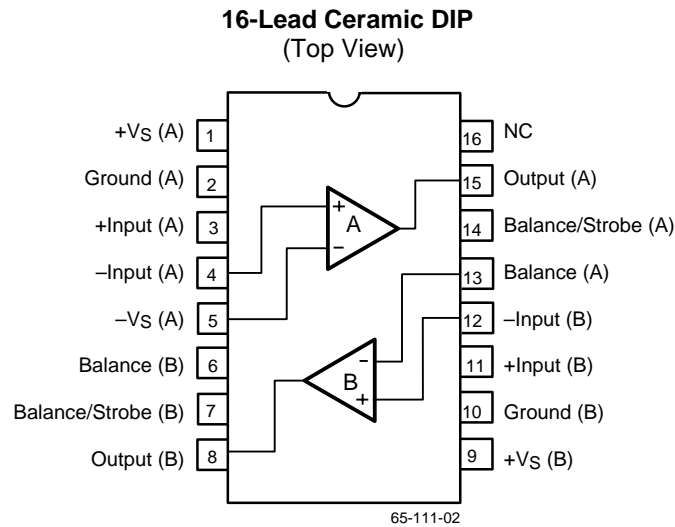
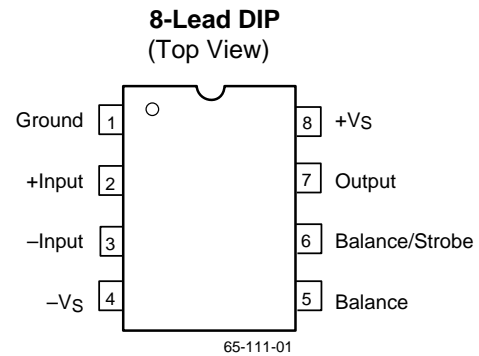
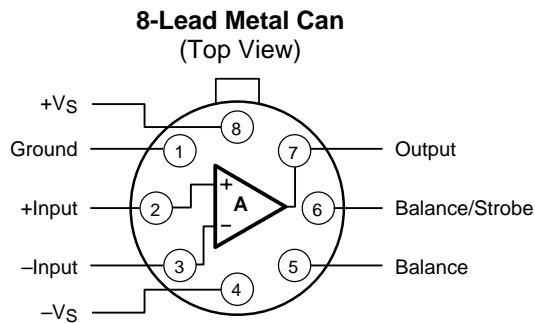
### Features

- Low input offset current — 4 nA
- Low input bias current — 60 nA
- Operates from a single +5V supply
- Response Time — 200 ns

### Description

These low input current voltage comparators are designed to operate over a wide range of supply voltages, including +15V and single +5V supplies. Their outputs are compatible with DTL, RTL, TTL and MOS devices, and can be connected in “wire-OR” configuration. The LH2111 consists of two LM111 ICs packaged in a 16-lead DIP. The LH2111 is available with MIL-STD 883B screening.

## Pin Assignments



## Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Supply Voltage	-18	+18	V
Output to -Vs		50	V
Ground to -Vs		30	V
Differential Input Voltage		30	V
Input Voltage <sup>1</sup>	-15	+15	V
Power Dissipation <sup>2</sup>		500	mW
Output Short Circuit Duration		10	seconds
Storage Temperature Range	-65	+150	°C
Operating Temperature Range	-55	+125	°C
Voltage at Strobe Pin		+Vs-5	V
Lead Soldering Temperature (60 seconds)		+300	°C

### Notes:

- For supply voltages other than  $\pm 15\text{V}$ , the maximum input is equal to the supply voltage.
- Observe package thermal characteristics.

## Thermal Characteristics

Parameter	8-Lead Metal Can	8-Lead Ceramic DIP	16-Lead Ceramic DIP
Maximum Junction Temperature	+175°C	+175°C	+175°C
Maximum P <sub>D</sub> T <sub>A</sub> < 50°C	658 mW	833 mW	1042 mW
Thermal Resistance, $\theta_{JC}$	50°C/W	45°C/W	60°C/W
Thermal Resistance, $\theta_{JA}$	190°C/W	150°C/W	120°C/W
For T <sub>A</sub> > 50°C Derate at	5.26 mW/°C	8.33 mW/°C	8.38 mW/°C

## Electrical Characteristics

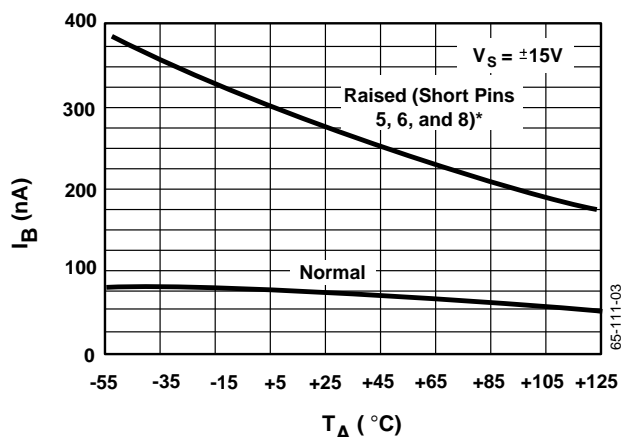
V<sub>S</sub> = ±15V<sup>1</sup> and -55°C ≤ T<sub>A</sub> ≤ +125°C unless otherwise noted.

Parameters	Test Conditions	Min.	Typ.	Max.	Units
Input Offset Voltage <sup>2</sup>	T <sub>A</sub> = +25°C, R <sub>S</sub> 50 kΩ		0.7	3.0	mV
Input Offset Current <sup>2</sup>	T <sub>A</sub> = +25°C		4.0	10	nA
Input Bias Current	T <sub>A</sub> = +25°C		60	100	nA
Large Signal Voltage Gain	T <sub>A</sub> = +25°C	40	200		V/mV
Response Time	T <sub>A</sub> = +25°C, 100 mV step, 5 mV overdrive		200		ns
Output Voltage Low (VOL)	V <sub>IN</sub> ≤ 5 mV, I <sub>L</sub> = 50 mA, T <sub>A</sub> = +25°C		3.0		mA
Output Leakage current	V <sub>IN</sub> 25 mV, V <sub>OUT</sub> = 35V, T <sub>A</sub> = +25°C, I <sub>STROBE</sub> = 3 mA		0.2	10	nA
Input Offset Voltage <sup>2</sup>	R <sub>S</sub> ≤ 50 KΩ		1.5	4.0	mV
Input Offset Current <sup>2</sup>			5.0	20	nA
Input Bias Current			100	150	nA
Input Voltage Range	Pin 7 pull up may go to +5V	-14.5		13.0	V
Output Voltage Low (VOL)	+V <sub>S</sub> = 4.5V, -V <sub>S</sub> = 0V, V <sub>IN</sub> ≤ -6 mV, I <sub>OUT</sub> = 8.0 mA		0.23	0.4	V
Output Leakage Current	V <sub>IN</sub> ≥ 5 mV, V <sub>OUT</sub> = 35V		100	500	nA
Positive Supply Current	T <sub>A</sub> = +25°C, each amplifier		5.1	6.0	mA
Negative Supply Current	T <sub>A</sub> = +25°C, each amplifier		4.1	5.0	mA

### Notes:

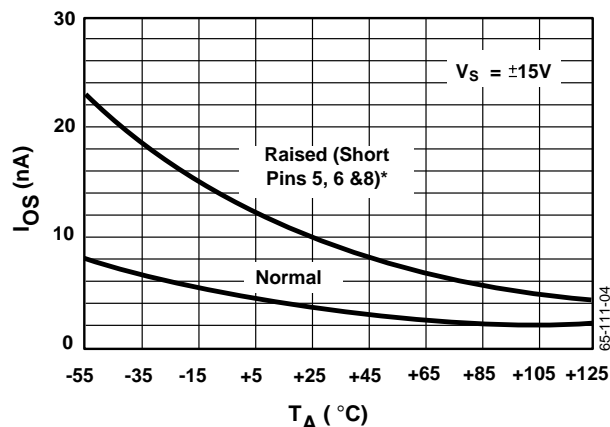
1. V<sub>OS</sub>, I<sub>OS</sub> and I<sub>B</sub> specifications apply for V<sub>S</sub> = +5V to V<sub>S</sub> = ±15V.
2. V<sub>OS</sub> and I<sub>OS</sub> are maximum values required to drive the output to within 1V of either supply with a 1 mA load.
3. Do not short circuit the strobe pin to ground—drive it with a 3 to 5 mA current. Instead.
4. If the strobe and balance pins are unused, short them together for maximum AC stability.

## Typical Performance Characteristics



\* Pin numbers are for 8-lead packages

Figure 1. Input Bias Current vs. Temperature



\* Pin numbers are for 8-lead packages

Figure 2. Input Offset Current vs. Temperature

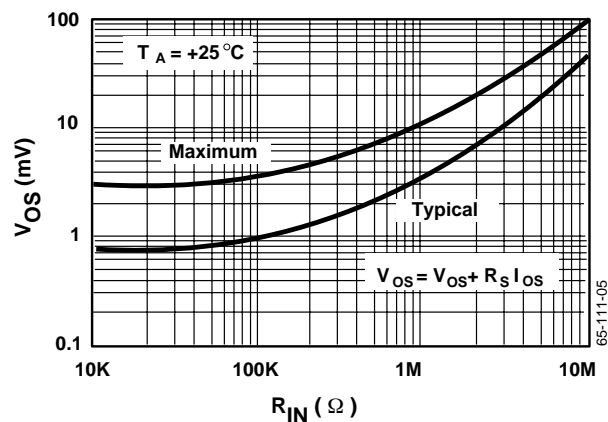


Figure 3. Equivalent Input Offset Voltage vs. Input Resistance

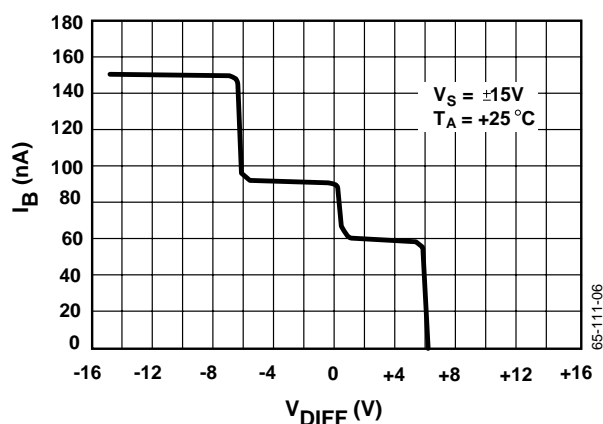


Figure 4. Input Bias Current vs. Differential Input Voltage

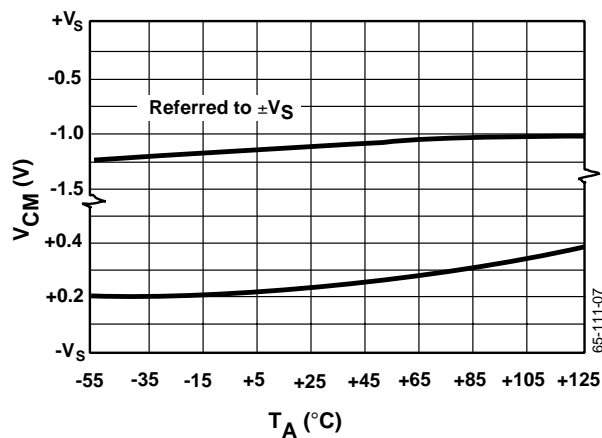


Figure 5. Common Mode Limits vs. Temperature

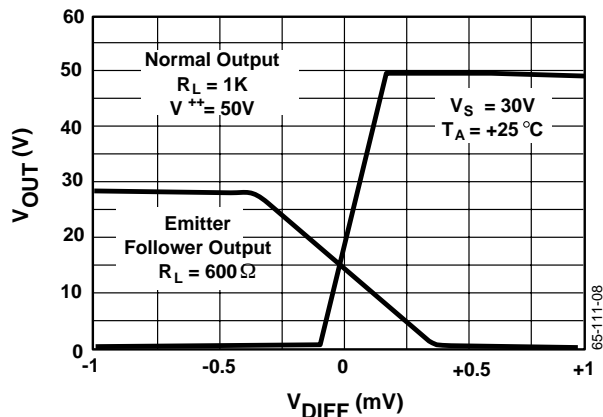


Figure 6. Output Voltage vs. Differential Input Voltage

## Typical Performance Characteristics (continued)

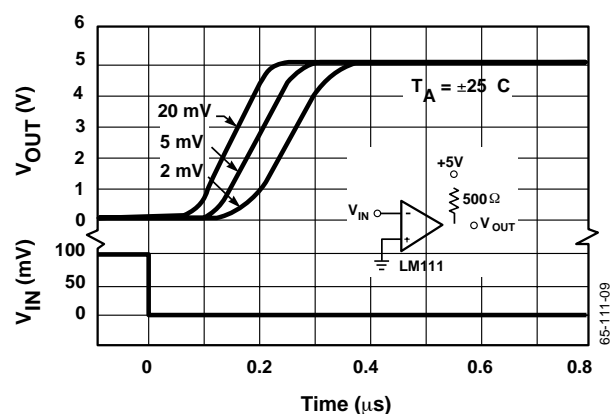


Figure 7. Input Overdrive vs. Response Times

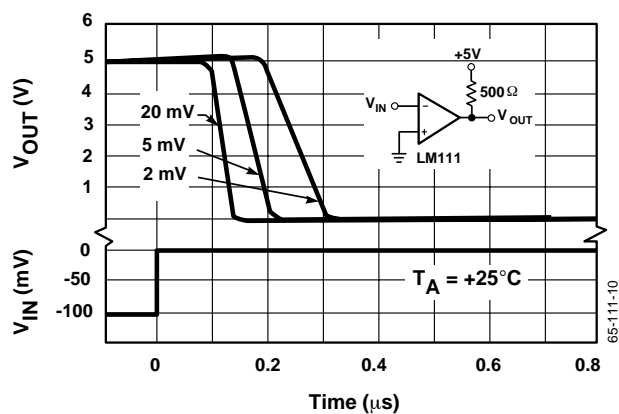


Figure 8. Input Overdrive vs. Response Times

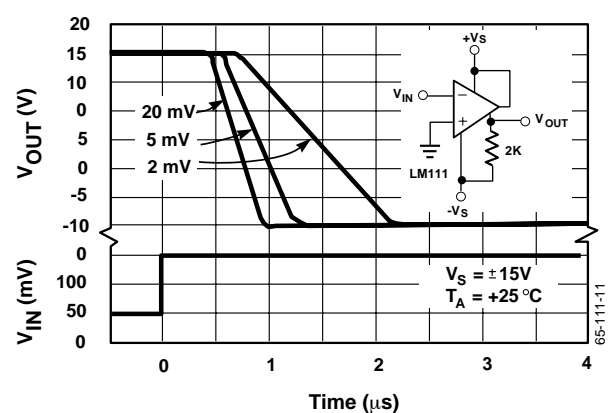


Figure 9. Input Overdrive vs. Response Times

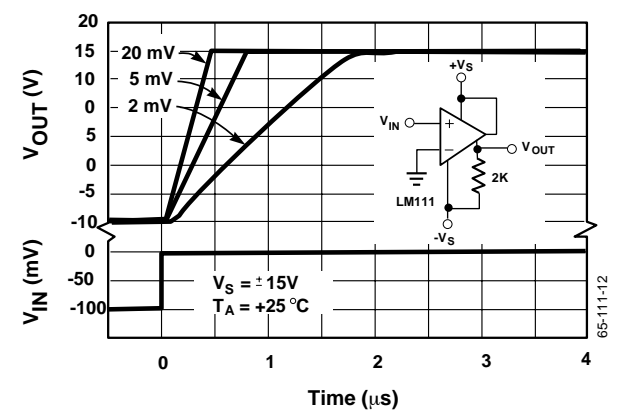


Figure 10. Input Overdrive vs. Response Times

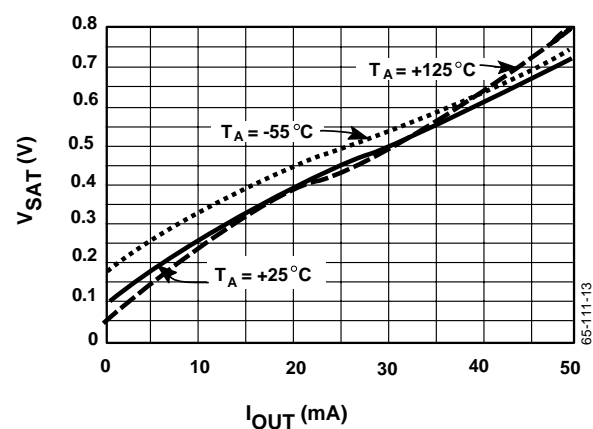


Figure 11. OpenSaturation Voltage vs. Output Current

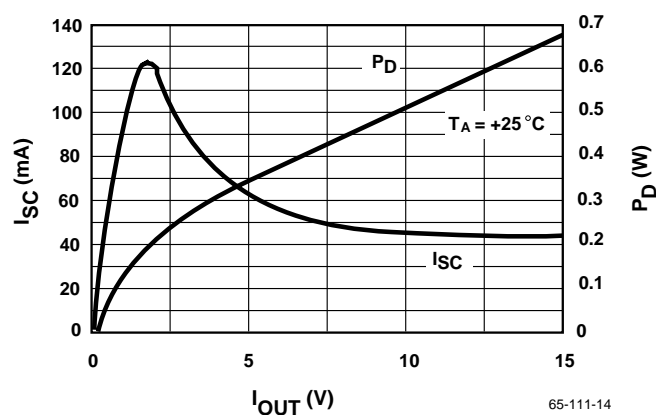


Figure 12. Short Circuit Current, Power Dissipation vs. Output Voltage

Typical Performance Characteristics (continued)

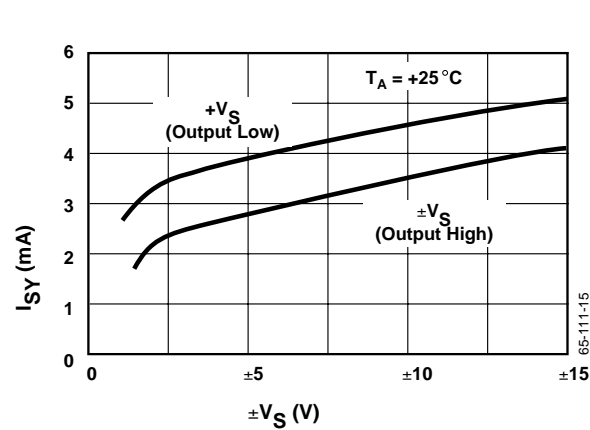


Figure 13. Supply Current vs. Supply Voltage

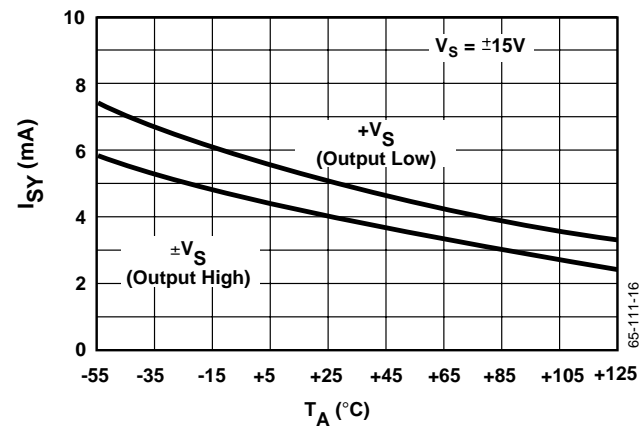


Figure 14. Supply Current vs. Temperature

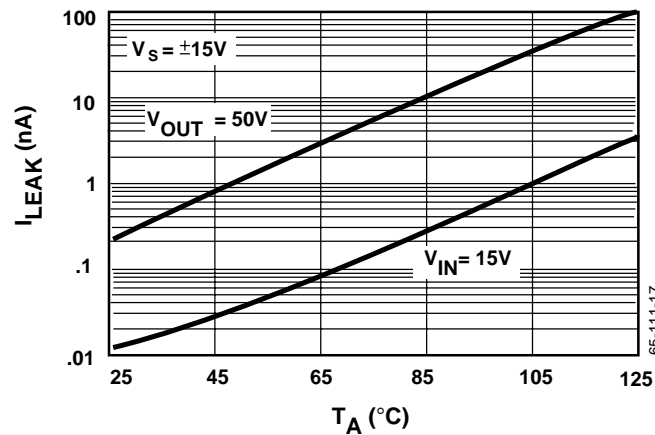


Figure 15. Leakage Current vs. Temperature

**Notes:**



**Notes:**

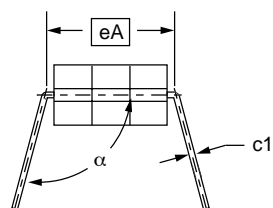
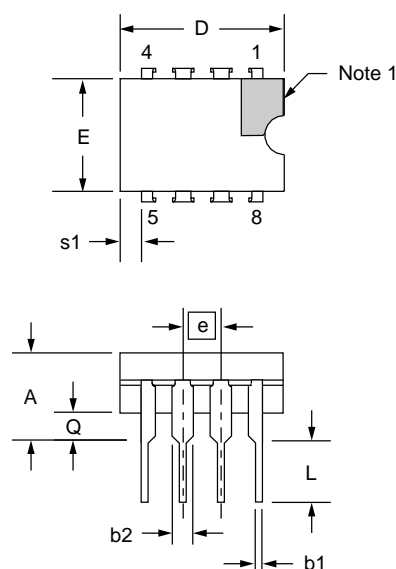
## Mechanical Dimensions

### 8-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.045	.065	1.14	1.65	2, 8
c1	.008	.015	.20	.38	8
D	—	.405	—	10.29	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.125	.200	3.18	5.08	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 4, 5 and 8 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm .010$  (.25mm) of its exact longitudinal position relative to pins 1 and 8.
6. Applies to all four corners (leads number 1, 4, 5, and 8).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Six spaces.



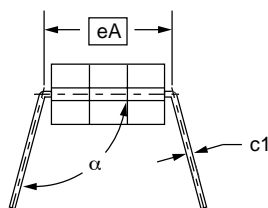
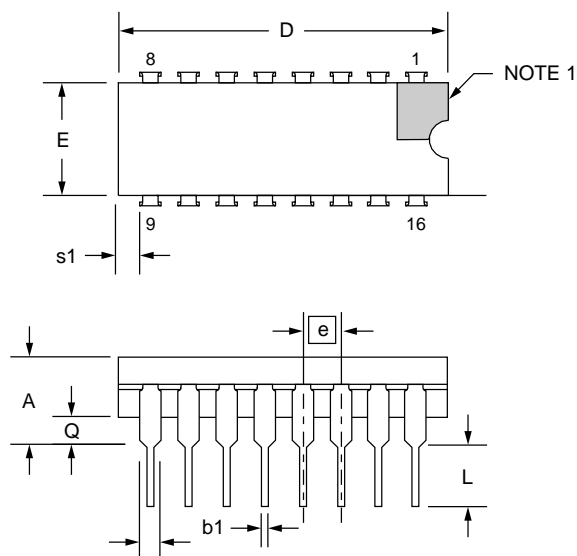
## Mechanical Dimensions (continued)

### 16-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.050	.065	1.27	1.65	2
c1	.008	.015	.20	.38	8
D	.745	.840	18.92	21.33	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.115	.160	2.92	4.06	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

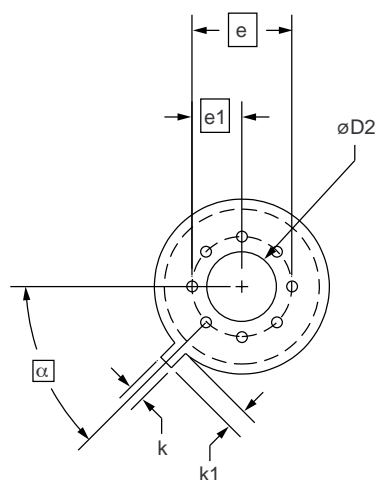
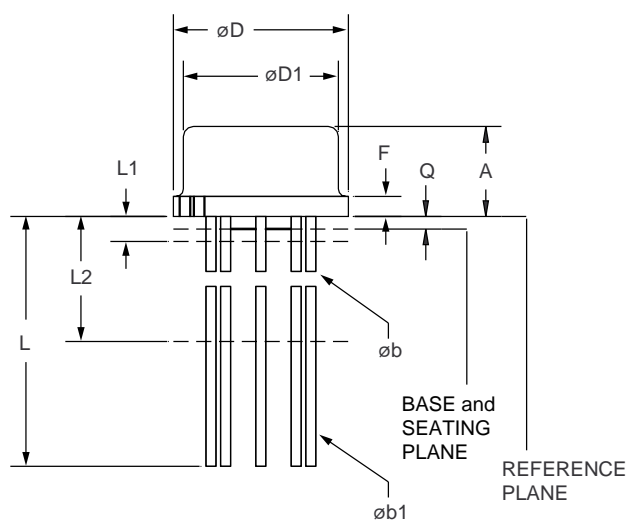
#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 8, 9 and 16 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm .010$  (.25mm) of its exact longitudinal position relative to pins 1 and 16.
6. Applies to all four corners (leads number 1, 8, 9, and 16).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Fourteen spaces.



## Mechanical Dimensions (continued)

### 8-Lead Metal Can (TO-99)



Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.165	.185	4.19	4.70	
$\phi b$	.016	.019	.41	.48	1, 5
$\phi b1$	.016	.021	.41	.53	1, 5
$\phi D$	.335	.375	8.51	9.52	
$\phi D1$	.305	.335	7.75	8.51	
$\phi D2$	.110	.160	2.79	4.06	
e	.200 BSC		5.08 BSC		
e1	.100 BSC		2.54 BSC		
F	—	.040	—	1.02	
k	.027	.034	.69	.86	
k1	.027	.045	.69	1.14	2
L	.500	.750	12.70	19.05	1
L1	—	.050	—	1.27	1
L2	.250	—	6.35	—	1
Q	.010	.045	.25	1.14	
$\alpha$	45° BSC		45° BSC		

#### Notes:

- (All leads)  $\phi b$  applies between L1 & L2.  $\phi b1$  applies between L2 & .500 (12.70mm) from the reference plane. Diameter is uncontrolled in L1 & beyond .500 (12.70mm) from the reference plane.
- Measured from the maximum diameter of the product.
- Leads having a maximum diameter .019 (.48mm) measured in gauging plane, .054 (1.37mm) +.001 (.03mm) –.000 (.00mm) below the reference plane of the product shall be within .007 (.18mm) of their true position relative to a maximum width tab.
- The product may be measured by direct methods or by gauge.
- All leads – increase maximum limit by .003 (.08mm) when lead finish is applied.

## Ordering Information

Part Number	Package	Operating Temperature Range
LM111T/883B	8-Lead Metal Can (TO-99)	-55°C to +125°C
LM111D/883B	8-Lead Ceramic DIP	-55°C to +125°C
LH2111D	16-Lead Ceramic DIP	-55°C to +125°C
LH2111D/883B	16-Lead Ceramic DIP	-55°C to +125°C

**Note:**

1. /883 B suffix denotes MIL-STD-883, Level B processing

### LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

# LM124/LM324

## Single-Supply Quad Operational Amplifier

### Features

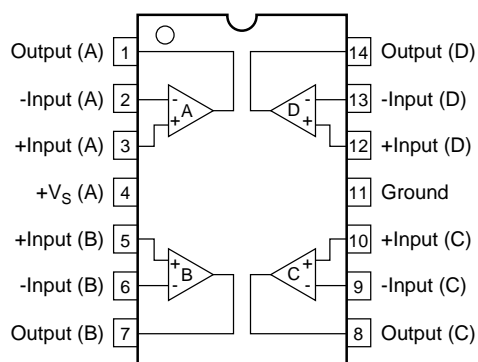
- Large DC voltage gain—100 dB
- Compatible with all forms of logic
- Temperature compensated
- Unity Gain Bandwidth—1 MHz
- Large output voltage swing—0V to (+VS -1.5V)
- Input common mode voltage range includes ground

### Description

Each of the devices in this series consists of four independent high-gain operational amplifiers that are designed for single-supply operation. Operation from split power supplies is also possible and the low power supply drain is independent of the magnitude of the power supply voltage.

Used with a dual supply, the circuit will operate over a wide range of supply voltages. However, a large amount of crossover distortion may occur with loads to ground. An external current-sinking resistor to -VS will reduce crossover distortion. There is no crossover distortion problem in single-supply operation if the load is direct-coupled to ground.

## Pin Assignments



## Absolute Maximum Ratings

Parameter	Conditions	Min.	Max.	Units
Supply Voltage			+32 or $\pm 16$	V
Differential Input Voltage			32	V
Input Voltage		-0.3	+32	V
Output Short Circuit to Ground <sup>1</sup>	One Amplifier $+V_S \leq 15V$ and $T_A = +25^\circ C$	Continuous		
Input Current <sup>2</sup>	$V_{IN} < -0.3V$		50	mA
<b>Operating Temperature Range</b>				
LM124		-55	+125	$^\circ C$
LM324		0	+70	$^\circ C$

### Notes:

- Short circuits from the output to  $+V_S$  can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of  $+V_S$ . At values of supply voltage in excess of  $+V_S$ , continuous short circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.
- This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the op amps to go to the  $+V_S$  voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage again returns to a value greater than 0.3V.

## Thermal Characteristics

Parameter	SOIC	Plastic DIP	Ceramic DIP
Maximum Junction Temperature	+125 $^\circ C$	+125 $^\circ C$	+175 $^\circ C$
Max. PD $T_A < 50^\circ C$	300 mW	468 mW	1042 mW
Thermal Resistance, $\theta_{JC}$	—	—	60 $^\circ C/W$
Thermal Resistance, $\theta_{JA}$	200 $^\circ C/W$	160 $^\circ C/W$	120 $^\circ C/W$
For $T_A > 50^\circ C$ Derate at	5.0 mW/ $^\circ C$	6.25 mW/ $^\circ C$	8.38 mW/ $^\circ C$

## Electrical Characteristics

+V<sub>S</sub> = +5.0V (see Note 1) and T<sub>A</sub> = +25°C, unless otherwise noted.

Parameters		Test Conditions	LM124			LM324			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Offset Voltage <sup>1</sup>				±2.0	±5.0		±2.0	±7.0	mV
Input Bias Current <sup>2</sup>				45	150		45	250	nA
Input Offset Current				±3.0	±30		±5.0	±50	nA
Input Voltage Range <sup>3</sup>		+V <sub>S</sub> = +30V	0		+V <sub>S</sub> -1.5	0		+V <sub>S</sub> -1.5	V
Supply Current (Over Temperature)		R <sub>L</sub> = ∞, +V <sub>S</sub> = 30V		1.5	3.0		1.5	3.0	mA
		R <sub>L</sub> = ∞ on all op amps		0.7	1.2		0.7	1.2	mA
Large Signal Voltage Gain		+V <sub>S</sub> = 15V (for large V <sub>OUT</sub> swing) R <sub>L</sub> ≥ 2 KΩ	50	100		25	100		V/mV
Output Voltage Swing	V <sub>OH</sub>	+V <sub>S</sub> = +30V, R <sub>L</sub> = 2KΩ	26			26			V
	V <sub>OH</sub>	R <sub>L</sub> ≥ 10 KΩ	27	28		27	28		V
	V <sub>OL</sub>	+V <sub>S</sub> = +5.0V, R <sub>L</sub> = 10KΩ		5.0	20		5.0	20	mV
Common Mode Rejection Ratio			70	85		65	70		dB
Power Supply Rejection Ratio			65	100		65	100		dB
Channel Separation <sup>4</sup>		F = 1 KHz to 20 KHz (Input referred)		-120			-120		dB
Output Current	Source	V <sub>IN+</sub> = 1V, V <sub>IN-</sub> = 0V, +V <sub>S</sub> = 15V	20	40		20	40		mA
	Sink	V <sub>IN-</sub> = 1V, V <sub>IN+</sub> = 0V, +V <sub>S</sub> = 15V	10	20		10	20		mA
		V <sub>IN+</sub> = 1V, V <sub>IN-</sub> = 0V, +V <sub>OUT</sub> = 200 mV	12	50		12	50		μA

### Notes:

- V<sub>OUT</sub> = 1.4V, R<sub>S</sub> = 0Ω with +V<sub>S</sub> from 5V to 30V; and over the full common mode range (0V to +V<sub>S</sub>-1.5V).
- The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
- The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common mode voltage range is +V<sub>S</sub>-1.5V, but either or both inputs can go to +32V without damage.
- Due to proximity of external components, ensure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.



## Electrical Characteristics

+V<sub>S</sub> = +5.0V, LM124 = -55° ≤ T<sub>A</sub> ≤ 125°C, LM324 = 0°C ≤ T<sub>A</sub> ≤ 70°C unless other wise noted.

Parameters		Test Conditions	LM124			LM324			Unit
			Min.	Typ .	Max .	Min.	Typ.	Max .	
Short Circuit Current <sup>1</sup>		T <sub>A</sub> = +25°C		40	60		40	60	mA
Input Offset Voltage <sup>2</sup>					±7.0			±9.0	mV
Input Offset Voltage Drift		R <sub>S</sub> = 0Ω		7.0			7.0		μV/°C
Input Offset Current					±100			±150	nA
Input Offset Current Drift				10			10		pA/°C
Input Bias Current <sup>3</sup>				40	300		40	500	nA
Input Voltage Range <sup>4</sup>		+V <sub>S</sub> = +30V	0		+V <sub>S</sub> -2.0	0		+V <sub>S</sub> -2.0	V
Large Signal Voltage Gain		+V <sub>S</sub> = +15V (For Large V <sub>OUT</sub> Swing) R <sub>L</sub> ≥ 2.0 KΩ	25			15			V/mV
Output Voltage Swing	V <sub>OH</sub>	+V <sub>S</sub> = +30V, R <sub>L</sub> = 2 KΩ	26			26			V
	V <sub>OH</sub>	R <sub>L</sub> ≥ 10 KΩ	27	28		27	28		V
	V <sub>OL</sub>	+V <sub>S</sub> = +5.0V, R <sub>L</sub> = 10 KΩ		5.0	20		5.0	20	mV
Output Current	Source	V <sub>IN+</sub> = +1.0V, V <sub>IN-</sub> = 0V, +V <sub>S</sub> = +15V	10	20		10	20		mA
	Sink	V <sub>IN-</sub> = +1.0V, V <sub>IN+</sub> = 0V, +V <sub>S</sub> = +15V	5.0	8.0		5.0	8.0		mA
Differential Input Voltage <sup>4</sup>					+V <sub>S</sub>			+V <sub>S</sub>	V

### Notes:

1. Short circuits from the output to +V<sub>S</sub> can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of +V<sub>S</sub>. At values of supply voltage in excess of +V<sub>S</sub>, continuous short circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on an amplifiers.
2. V<sub>OUT</sub> = 1.4V, R<sub>S</sub> = 0Ω with +V<sub>S</sub> from 5V to 30V and over the full common mode range (0V to +V<sub>S</sub> -1.5V).
3. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
4. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common mode voltage range is +V<sub>S</sub> -1.5V, but either or both inputs can go to +32V without damage.

Typical Performance Characteristics

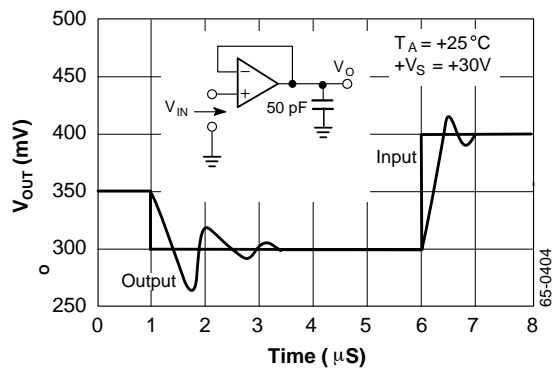


Figure 1. Follower Small Signal Pulse Response

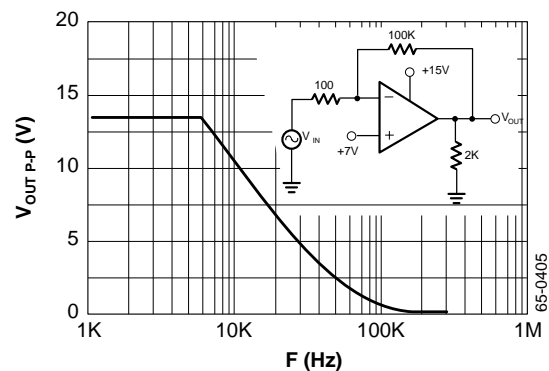


Figure 2. Output Voltage Swing vs. Frequency

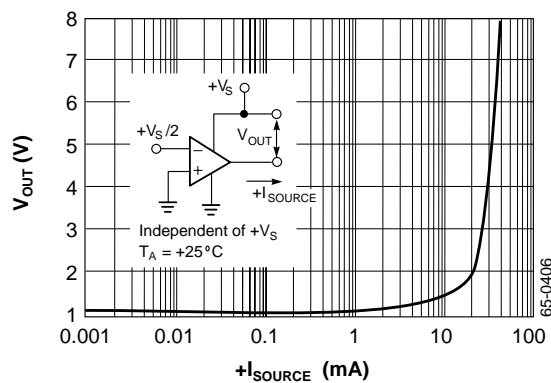


Figure 3. Output Voltage vs. Output Source Current

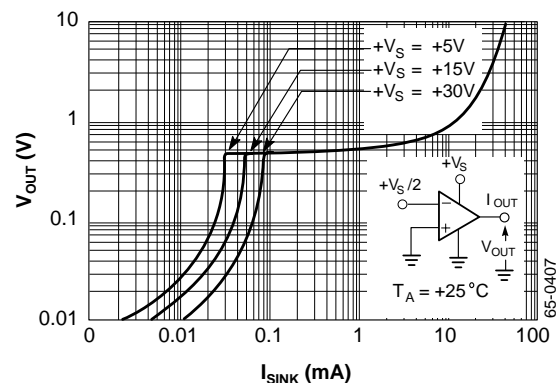


Figure 4. Output Voltage vs. Output Sink Current

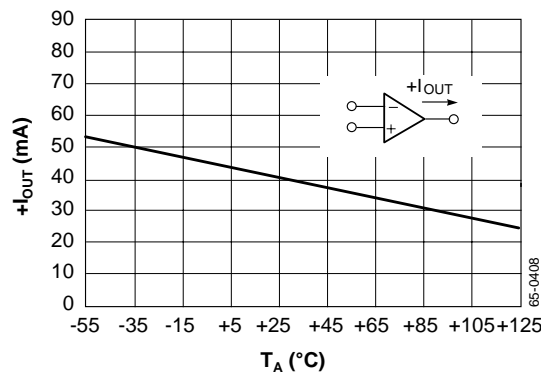


Figure 5. Current Limiting Output Current vs. Temperature

## Typical Performance Characteristics (continued)

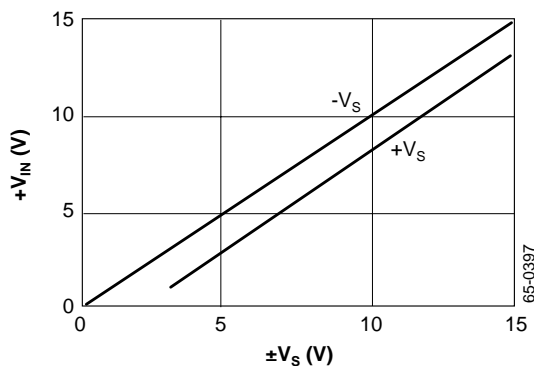


Figure 6. Input Voltage vs. Supply Voltage

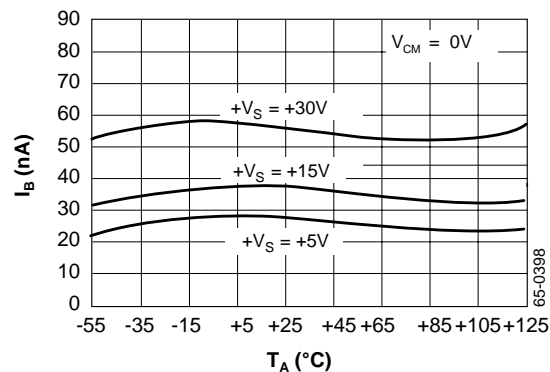


Figure 7. Input Bias Current vs. Temperature

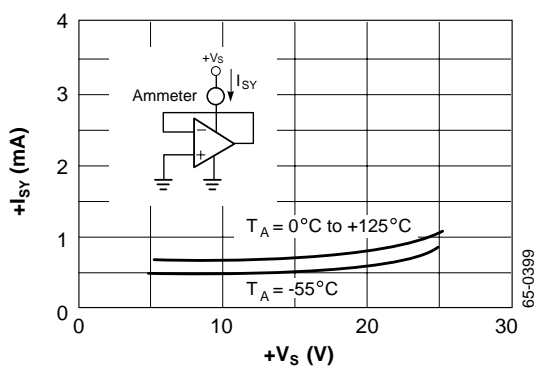


Figure 8. Supply Current vs. Supply Voltage

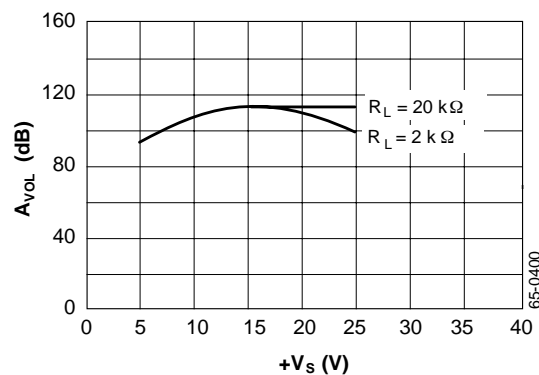


Figure 9. Open Loop Voltage Gain vs. Supply Voltage

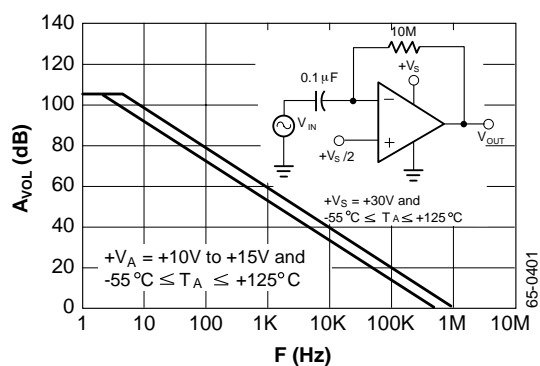


Figure 10. Open Loop Voltage Gain vs. Frequency

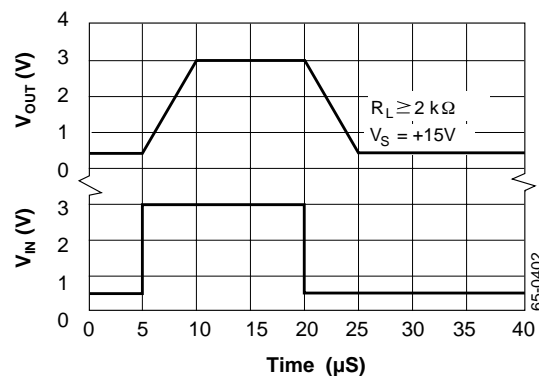


Figure 11. Follower Large Pulse Response Signal vs. Time

**Notes:**

**Notes:**

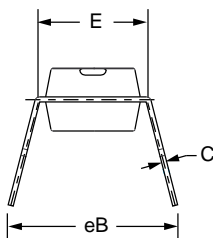
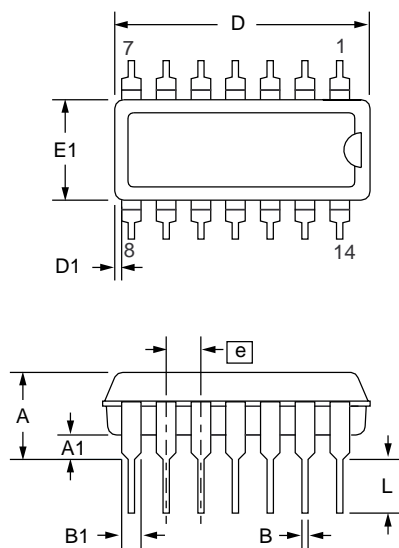
## Mechanical Dimensions

### 14-Lead Plastic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.210	—	5.33	
A1	.015	—	.38	—	
A2	.115	.195	2.93	4.95	
B	.014	.022	.36	.56	
B1	.045	.070	1.14	1.78	
C	.008	.015	.20	.38	4
D	.725	.795	18.42	20.19	2
D1	.005	—	.13	—	
E	.300	.325	7.62	8.26	
E1	.240	.280	6.10	7.11	2
e	.100 BSC		2.54 BSC		
eB	—	.430	—	10.92	
L	.115	.200	2.92	5.08	
N	14		14		5

**Notes:**

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E1" do not include mold flashing. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. Terminal numbers are shown for reference only.
4. "C" dimension does not include solder finish thickness.
5. Symbol "N" is the maximum number of terminals.



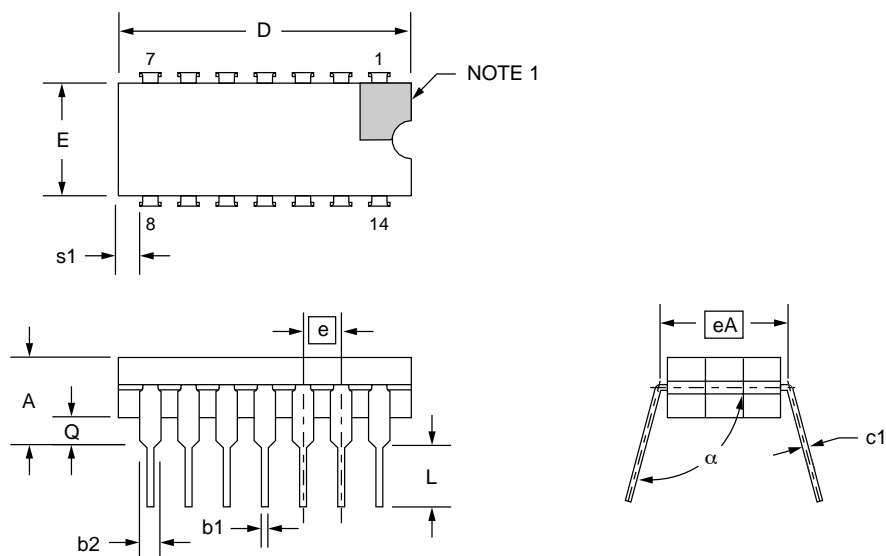
## Mechanical Dimensions (continued)

### 14-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.045	.065	1.14	1.65	2
c1	.008	.015	.20	.38	8
D	—	.785	—	19.94	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.125	.200	3.18	5.08	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 7, 8 and 14 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm .010$  (.25mm) of its exact longitudinal position relative to pins 1 and 14.
6. Applies to all four corners (leads number 1, 7, 8, and 14).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Twelve spaces.



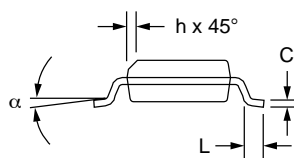
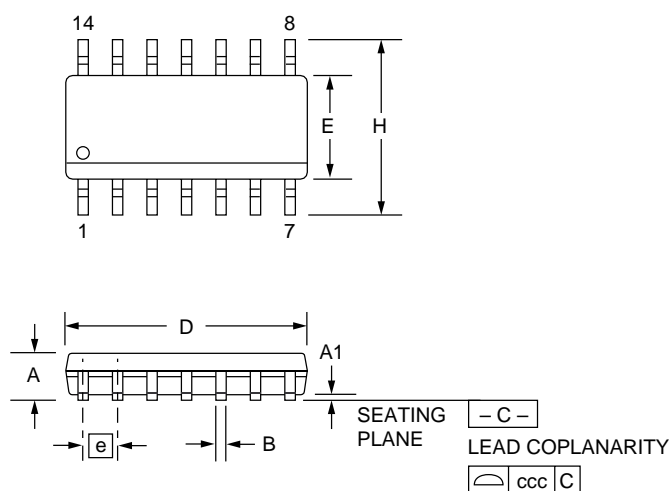
## Mechanical Dimensions (continued)

### 14-Lead SOIC

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.053	.069	1.35	1.75	
A1	.004	.010	0.10	0.25	
B	.013	.020	0.33	0.51	
C	.008	.010	0.19	0.25	5
D	.336	.345	8.54	8.76	2
E	.150	.158	3.81	4.01	2
e	.050 BSC		1.27 BSC		
H	.228	.244	5.79	6.20	
h	.010	.020	0.25	0.50	
L	.016	.050	0.40	1.27	3
N	14		14		6
$\alpha$	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

#### Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.





## Ordering Information

Part Number	Package	Operating Temperature Range
LM324M	14-Lead Plastic SOIC	0°C to +70°C
LM324N	14-Lead Plastic DIP	0°C to +70°C
LM124D	14-Lead Ceramic DIP	-55°C to +125°C
LM124D/883B	14-Lead Ceramic DIP	-55°C to +125°C

**Note:**

1. 883B suffix denotes Mil-Std-883, Level B processing.

### LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

# LM139/LM139A, LM339

## Single Supply Quad Comparators

### Features

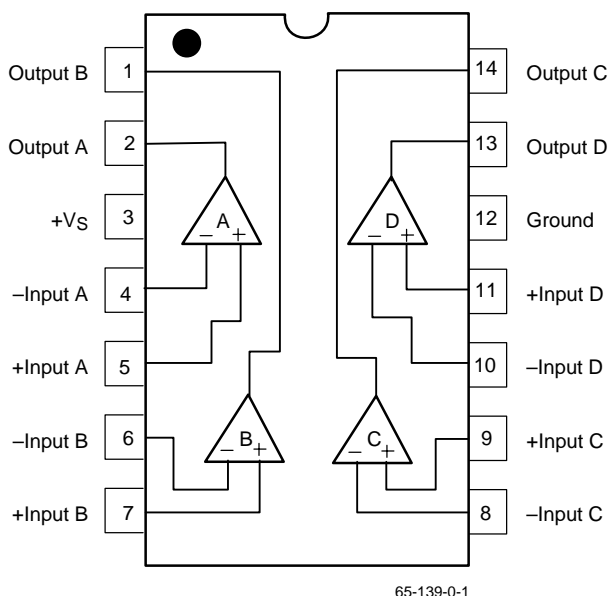
- Input common mode voltage range includes ground
- Wide single supply voltage range—2V to 36V
- Output compatible with TTL, DTL, ECL, MOS and CMOS logic systems
- Very low supply current drain (0.8 mA) independent of supply voltage

### Description

These devices offer higher frequency operation and faster switching than can be had from internally compensated quad op amps. Intended for single supply applications, the Darlington PNP input stage allows them to compare voltages that include ground. The two stage common-emitter output circuit provides gain and output sink capacity of 3.2 mA at an output level of 400 mV. The output collector is left open, permitting the designer to drive devices in the range of 2V to 36V.

They are intended for applications not needing response time less than 1  $\mu$ s, but demanding excellent op amp input parameters to offset voltage, current and bias current, to ensure accurate comparison with a reference voltage.

## Pin Assignments



## Absolute Maximum Ratings

Parameter	Min.	Max.	Unit.
Supply Voltage	-8	+36 or +8	V
Differential Input Voltage		36	V
Input Voltage Range <sup>2</sup>	-0.3	+36	V
Output Short Circuit to Ground <sup>1</sup>	Continuous		
Input Current ( $V_{IN} < -0.3V$ ) <sup>(2)</sup>		50	mA
Operating Temperature Range			
LM139	-55	+125	°C
LM339	0	+70	°C
Storage Temperature Range	-65	150	°C
Lead Soldering Temperature			
SOIC, 10 seconds		+260	°C
DIP, 60 seconds		+300	°C

### Notes:

- Short circuits from the output to +V<sub>S</sub> can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA independent of the magnitude of +V<sub>S</sub>.
- This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltage of the comparators to go to the +V<sub>S</sub> voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and nominal output states will re-establish when the input voltage, which was negative, again returns to a value greater than -0.3V.

## Thermal Characteristics

Parameter	SOIC	Plastic DIP	Ceramic DIP
Maximum Junction Temperature	+125°C	+125°C	+175°C
Maximum P <sub>D</sub> T <sub>A</sub> < 50°C	300 mW	468 mW	1042mW
Thermal Resistance, $\theta_{JC}$	—	—	60°C/W
Thermal Resistance, $\theta_{JA}$	200°C/W	160°C/W	120°C/W
For T <sub>A</sub> > 50°C Derate at	5.0 mW/°C	6.25 mW/°C	8.33 mW/°C

## Electrical Characteristics

V<sub>S</sub> = +5V, see Note 1.

Parameters	Test Conditions	LM139A			Unit
		Min.	Typ.	Max.	
Input Offset Voltage	T <sub>A</sub> = +25°C <sup>2</sup>		±1.0	±2.0	mV
Input Bias Current	Output In Linear Range T <sub>A</sub> = +25°C <sup>3</sup> , V <sub>CM</sub> = 0V		25	100	nA
Input Offset Current	T <sub>A</sub> = +25°C, V <sub>CM</sub> = 0V		±3.0	±25	nA
Input Voltage Range	T <sub>A</sub> = +25°C <sup>4</sup> , V <sub>S</sub> = 30V			+V <sub>S</sub> –1.5	V
Supply Current	R <sub>L</sub> = ∞ on all comparators, T <sub>A</sub> = +25°C		0.8	2.5	mA
Large Signal Voltage Gain	R <sub>L</sub> = ∞, +V <sub>S</sub> = 30V, R <sub>L</sub> ≥ 15 KΩ, +V <sub>S</sub> = +5V (to support large V <sub>OUT</sub> swing) T <sub>A</sub> = +25°C	50	200		V/mV
Large Signal Response Time	V <sub>IN</sub> = TTL Logic Swing, V <sub>REF</sub> = 1.4V, V <sub>RL</sub> = 5V, R <sub>L</sub> = 5.1 KΩ, T <sub>A</sub> = +25°C		300		ns
Response Time	V <sub>RL</sub> = 5V, R <sub>L</sub> = 5.1 KΩ, T <sub>A</sub> = +25°C <sup>5</sup>		1.3		μs
Output Sink Current	V <sub>IN–</sub> ≥ 1V, V <sub>IN+</sub> = 0, V <sub>OUT</sub> ≤ 1.5V, T <sub>A</sub> = +25°C	6.0	16		mA
Saturation Voltage	V <sub>IN–</sub> ≥ 1V, V <sub>IN+</sub> = 0, I <sub>SINK</sub> ≤ 4 mA, T <sub>A</sub> = 25°C		250	400	mV
Output Leakage Current	V <sub>IN+</sub> ≥ 1V, V <sub>IN–</sub> = 0, V <sub>OUT</sub> = 5V, T <sub>A</sub> = +25°C		0.1		μA
Input Offset Voltage <sup>2</sup>				±4.0	mV
Input Offset Current	V <sub>CM</sub> = 0V			±100	nA
Input Bias Current	V <sub>CM</sub> = 0V			300	nA
Input Voltage Range	+V <sub>S</sub> = 30V	0		+V <sub>S</sub> –2.0	V
Saturation Voltage	V <sub>IN–</sub> ≥ 1V, V <sub>IN+</sub> = 0, I <sub>SINK</sub> ≤ 4 mA			700	mV
Output Leakage Current	V <sub>IN+</sub> ≥ 1V, V <sub>IN–</sub> = 0, V <sub>OUT</sub> = 30V			1.0	μA
Differential Input Voltage <sup>7</sup>	V <sub>IN+</sub> ≥ 0V, (or -V <sub>S</sub> , if used) <sup>6</sup>			36	V

### Notes:

- These specifications apply for +V<sub>S</sub> = 5V and -55°C ≤ T<sub>A</sub> ≤ +125°C, unless otherwise stated. The LM339 temperature specifications are limited to 0°C ≤ T<sub>A</sub> ≤ +70°C.
- At output switch points V<sub>OUT</sub> = 1.4V, R<sub>S</sub> = 0Ω with +V<sub>S</sub> from 5V to 30V; and over the full input common mode range (V<sub>OUT</sub> to +V<sub>S</sub>–1.5V).
- The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.
- The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common mode voltage range is +V<sub>S</sub>–1.5V, but either or both inputs can go to +30V without damage.
- The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained. See Typical Performance Characteristics section.
- Positive excursions of input voltage may exceed the power supply level. As long as the other voltage remains within the common mode range, the comparator will provide a proper output state. The low input voltage stage must not be less than -0.3V (or 0.3V below the magnitude of the negative power supply, if used).
- Guaranteed by design.

## Electrical Characteristics

$V_S = +5V$ , see Note 1.

Parameters	Test Conditions	LM139			LM339			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = +25^\circ C^2$		$\pm 2.0$	$\pm 5.0$		$\pm 2.0$	$\pm 5.0$	mV
Input Bias Current	Output in Linear Range $T_A = +25^\circ C^3$ , $V_{CM} = 0V$		25	100		25	250	nA
Input Offset Current	$T_A = +25^\circ C$ , $V_{CM} = 0V$		$\pm 3.0$	$\pm 25$		$\pm 5.0$	$\pm 50$	nA
Input Voltage Range	$T_A = +25^\circ C^4$ , $+V_S = 30V$	0		$+V_S$ $-1.5$	0		$+V_S$ $-1.5$	V
Supply Current	$R_L = \infty$ on all comparators, $T_A = +25^\circ C$		0.8	2.5		0.8	2.5	mA
Large Signal Voltage Gain	$R_L = \infty$ , $+V_S = 30V$ , $R_L \geq 15 K\Omega$ , $+V_S = +5V$ (to support large $V_{OUT}$ swing), $T_A = +25^\circ C$	25	200			200		V/mV
Large Signal Response Time	$V_{IN} = \text{TTL Logic Swing}$ , $V_{REF} = 1.4V$ , $V_{RL} = 5V$ , $R_L = 5.1 K\Omega$ , $T_A = +25^\circ C$		300			300		ns
Response Time	$V_{RL} = 5V$ , $R_L = 5.1 K\Omega$ $T_A = +25^\circ C^5$		1.3			1.3		$\mu s$
Output Sink Current	$V_{IN-} \geq 1V$ , $V_{IN+} = 0$ , $V_{OUT} \leq 1.5V$ , $T_A = +25^\circ C$	6.0	16		6.0	16		mA
Output Voltage, $V_{OL}$	$V_{IN} \geq 1V$ , $V_{IN+} = 0$ , $I_{SINK} \leq 4 \text{ mA}$ , $T_A = +25^\circ C$		250	400		250	400	mV
Output Leakage Current	$V_{IN+} \geq 1V$ , $V_{IN-} = 0$ , $V_{OUT} = 5V$ , $T_A = +25^\circ C$		0.1			0.1		$\mu A$
Input Offset Voltage <sup>2</sup>				$\pm 9.0$			$\pm 9.0$	mV
Input Offset Current				$\pm 100$			$\pm 150$	nA
Input Bias Current	$V_{CM} = 0V$			300			400	nA
Input Voltage Range	$V_{CM} = 30V$	0		$+V_S$ $-2.0$	0		$+V_S$ $-2.0$	V
Output Voltage $V_{OL}$	$V_{IN-} \geq 1V$ , $V_{IN+} = 0$ $I_{SINK} \leq 4 \text{ mA}$			700			700	mV
Output Leakage Current	$V_{IN+} \geq 1V$ , $V_{IN-} = 0$ $V_{OUT} = 30V$			1.0			1.0	$\mu A$
Differential Input Voltage <sup>7</sup>	$V_{IN+} \geq 0V$ (or $-V_S$ , if used) <sup>6</sup>			36			36	V

### Notes:

- These specifications apply for  $+V_S = 5V$  and  $-55^\circ C \leq T_A \leq +125^\circ C$ , unless otherwise stated. The LM339 temperature specifications are limited to  $0^\circ C \leq T_A \leq +70^\circ C$ .
- At output switch points  $V_{OUT} = 1.4V$ ,  $R_S = 0\Omega$  with  $+V_S$  from 5V to 30V; and over the full input common mode range ( $V_{OUT}$  to  $+V_S - 1.5V$ ).
- The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.
- The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common mode voltage range is  $+V_S - 1.5V$ , but either or both inputs can go to  $+30V$  without damage.
- The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained. See Typical Performance Characteristics section.
- Positive excursions of input voltage may exceed the power supply level. As long as the other voltage remains within the common mode range, the comparator will provide a proper output state. The low input voltage stage must not be less than -0.3V (or 0.3V below the magnitude of the negative power supply, if used).
- Guaranteed by design.

Typical Performance Characteristics

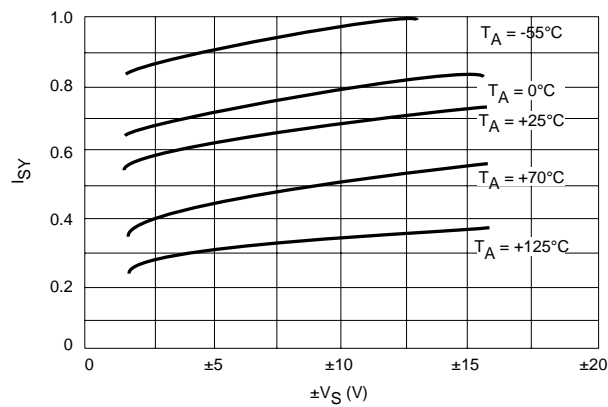


Figure 1. Supply Current vs. Supply Voltage

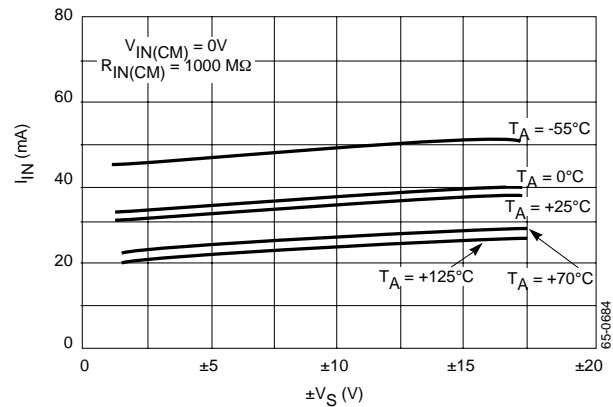


Figure 2. Input Current vs. Supply Voltage

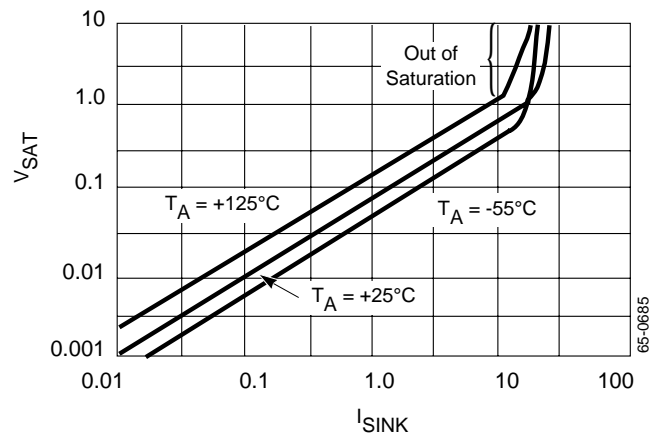


Figure 3. Output Saturation Voltage vs. Sink Current

## Typical Performance Characteristics (continued)

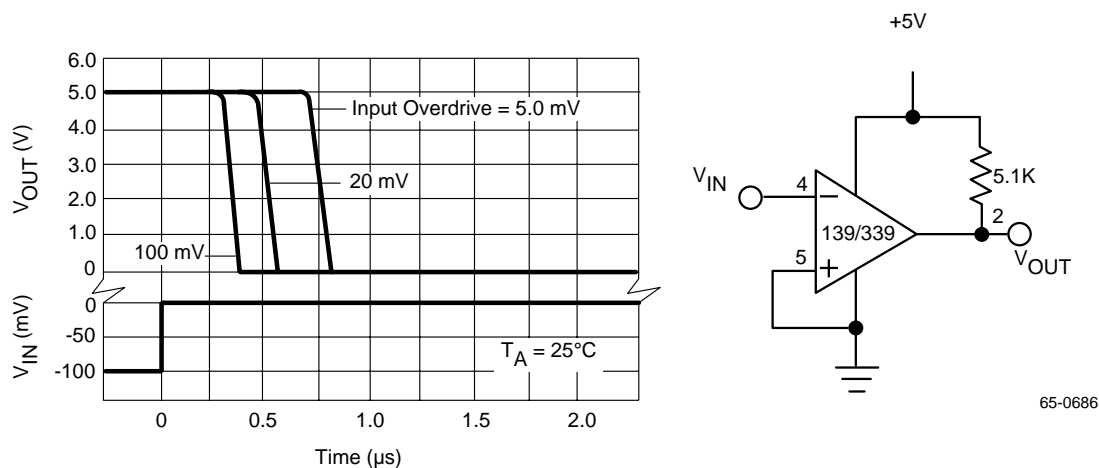


Figure 4. Input Overdrive Response Time

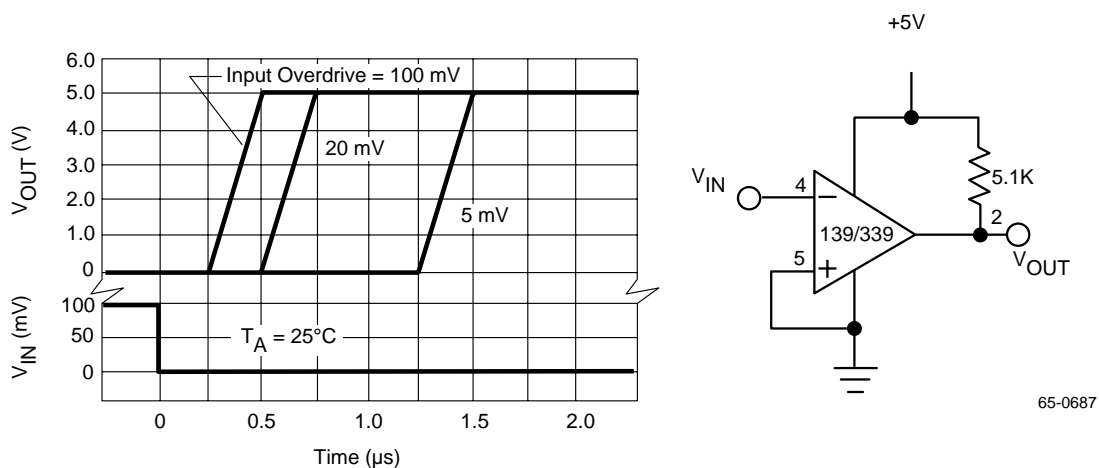
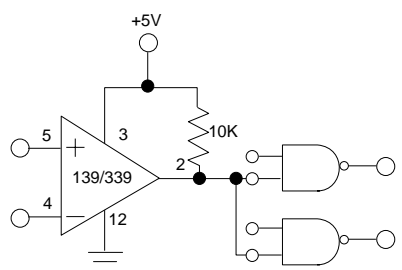


Figure 5. Input Overdrive Response Time

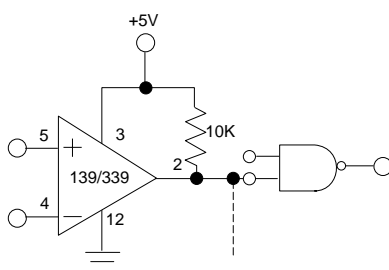
## Applications

Single Supply ( $+V_S = +15V$ ).



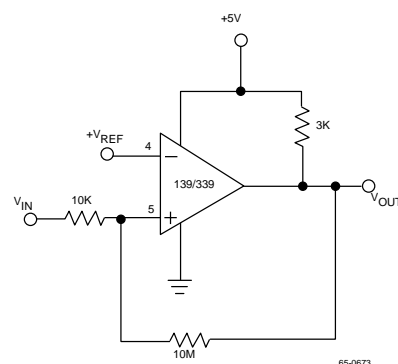
65-0671

Figure 6. Driving TTL



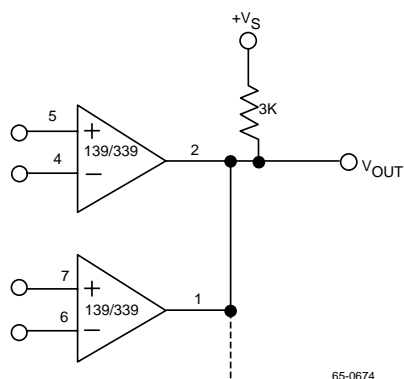
65-0672

Figure 7. Driving CMOS



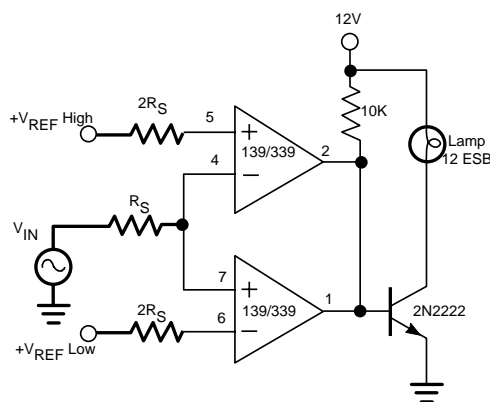
65-0673

Figure 8. Comparator with Hysteresis



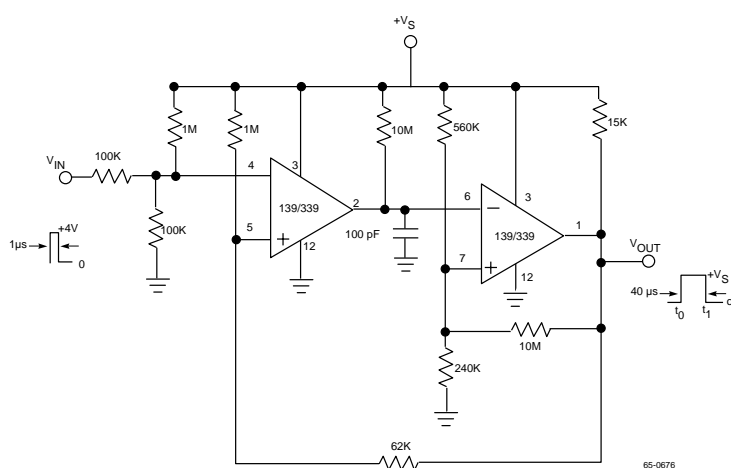
65-0674

Figure 9. ORing the Output



65-0675

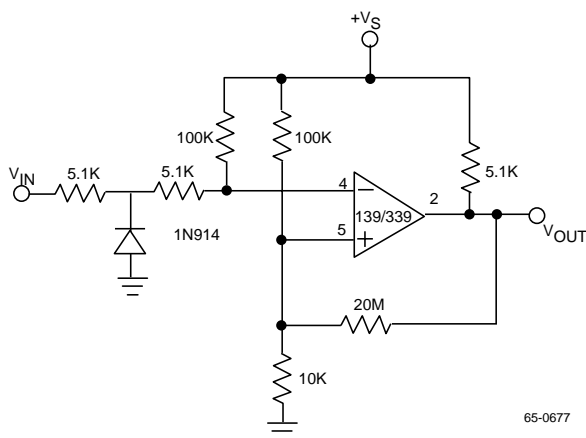
Figure 10. Limit Comparator



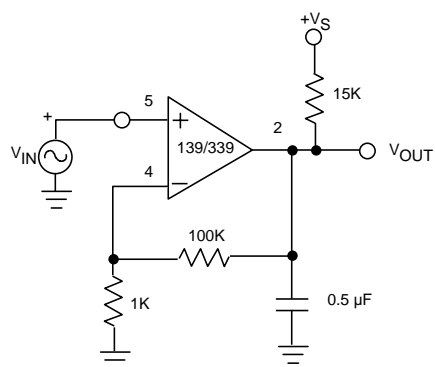
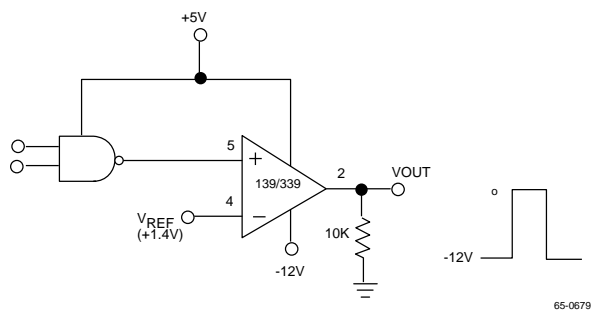
65-0676

Figure 11. One-Shot Multivibrator with Input Lock Out

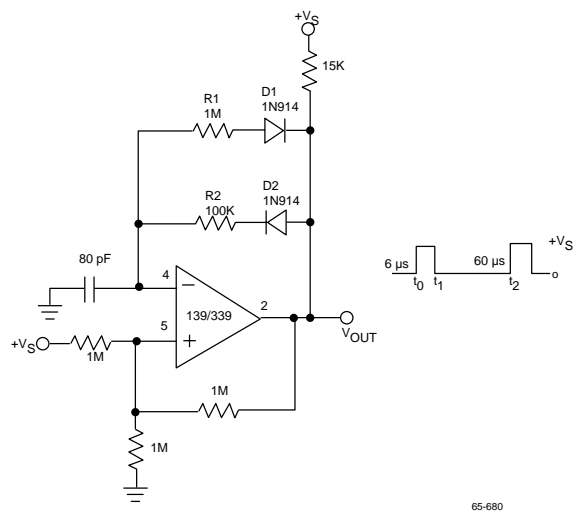


**Applications** (continued)Single Supply ( $+V_S = +15V$ ).

65-0677

**Figure 12. Zero Crossing Detector (Single Power Supply)****Figure 13. Low Frequency Op Amp**

65-0679

**Figure 14. TTL to MOS Logic Converter**

65-680

**Figure 15. Pulse Generator**

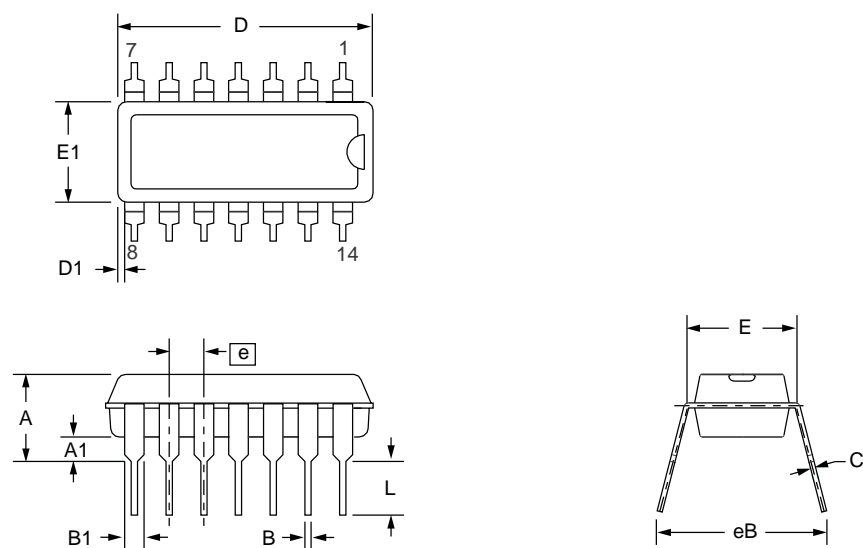
## Mechanical Dimensions

### 14-Lead Plastic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.210	—	5.33	
A1	.015	—	.38	—	
A2	.115	.195	2.93	4.95	
B	.014	.022	.36	.56	
B1	.045	.070	1.14	1.78	
C	.008	.015	.20	.38	4
D	.725	.795	18.42	20.19	2
D1	.005	—	.13	—	
E	.300	.325	7.62	8.26	
E1	.240	.280	6.10	7.11	2
e	.100 BSC		2.54 BSC		
eB	—	.430	—	10.92	
L	.115	.200	2.92	5.08	
N	14		14		5

**Notes:**

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E1" do not include mold flashing. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. Terminal numbers are shown for reference only.
4. "C" dimension does not include solder finish thickness.
5. Symbol "N" is the maximum number of terminals.



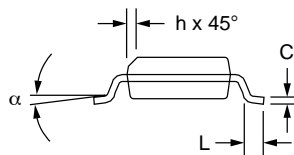
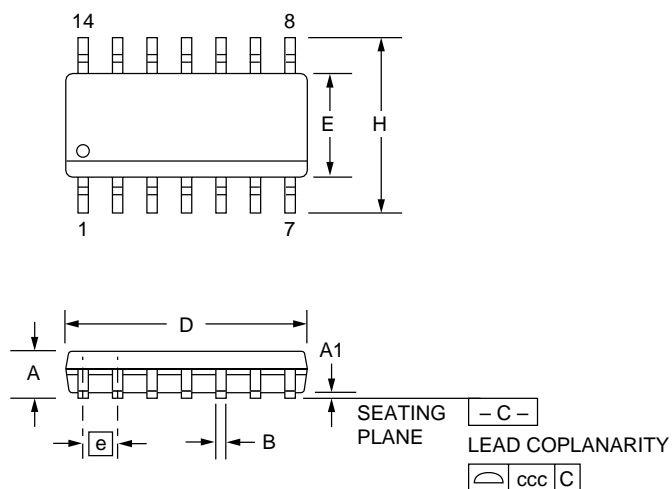
## Mechanical Dimensions (continued)

### 14-Lead Plastic SOIC

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.053	.069	1.35	1.75	
A1	.004	.010	0.10	0.25	
B	.013	.020	0.33	0.51	
C	.008	.010	0.19	0.25	5
D	.336	.345	8.54	8.76	2
E	.150	.158	3.81	4.01	2
e	.050 BSC		1.27 BSC		
H	.228	.244	5.79	6.20	
h	.010	.020	0.25	0.50	
L	.016	.050	0.40	1.27	3
N	14		14		6
$\alpha$	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

#### Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.



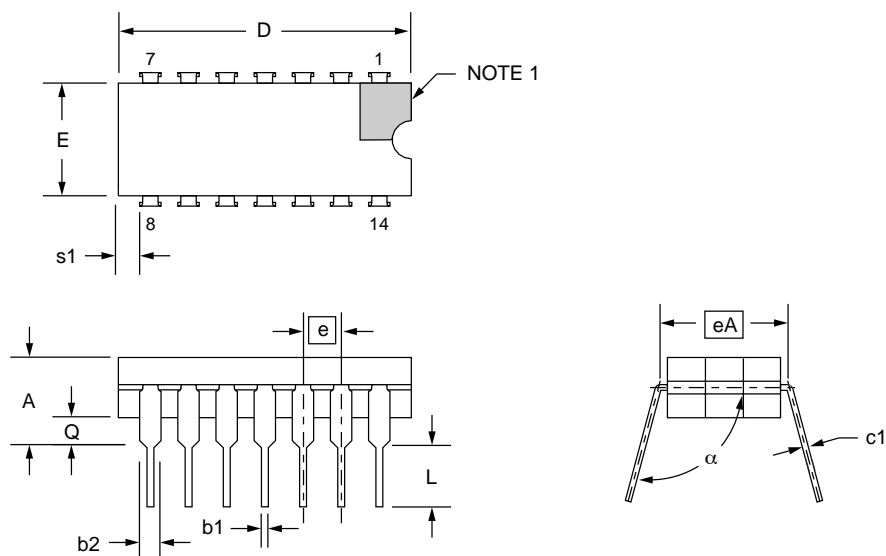
## Mechanical Dimensions (continued)

### 14-Lead Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.045	.065	1.14	1.65	2
c1	.008	.015	.20	.38	8
D	—	.785	—	19.94	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.125	.200	3.18	5.08	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 7, 8 and 14 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm .010$  (.25mm) of its exact longitudinal position relative to pins 1 and 14.
6. Applies to all four corners (leads number 1, 7, 8, and 14).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Twelve spaces.



## Ordering Information

Part Number	Package	Operating Temperature Range
LM339M	14-Lead Plastic SOIC	0°C to +70°C
LM339N	14-Lead Plastic DIP	0°C to +70°C
LM139D	14-Lead Ceramic DIP	-55°C to +125°C
LM139D/883B	14-Lead Ceramic DIP	-55°C to +125°C
LM139AD	14-Lead Ceramic DIP	-55°C to +125°C
LM139AD/883B	14-Lead Ceramic DIP	-55°C to +125°C

**Notes:**

1. /883B suffix denotes MIL-STD-883, Level B processing

### LIFE SUPPORT POLICY

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1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## DUAL OPERATIONAL AMPLIFIERS

The LM1458 series are dual general purpose operational amplifiers, having short circuits protected and require no external components for frequency compensation.

High common mode voltage range and absence of "latch up" make the LM1458 ideal for use as voltage followers.

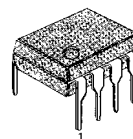
The high gain and wide range of operating voltage provides superior performance in integrator, summing amplifier and general feedback applications.

## FEATURES

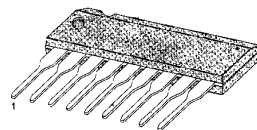
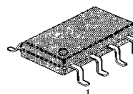
- Internal frequency compensation
- Short circuit protection
- Large common mode and differential voltage range
- No latch up
- Low power consumption

9 SIP

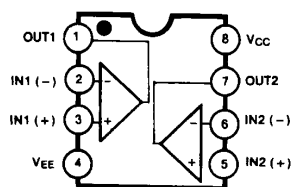
8 DIP



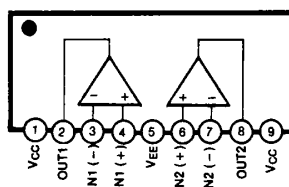
8 SOP



## BLOCK DIAGRAM

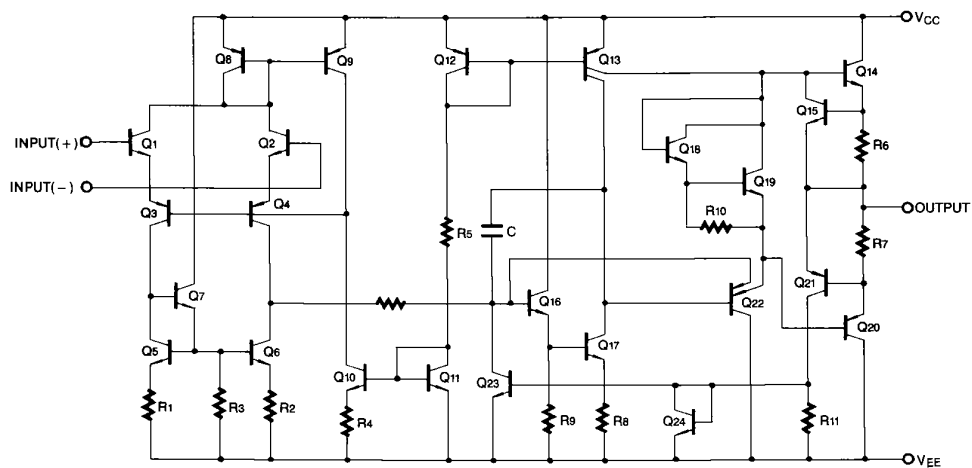


## ORDERING INFORMATION



Device	Package	Operating Temperature
LM1458N LM1458AN	8 DIP	0 ~ + 70°C
LM1458S LM1458AS	9 SIP	
LM1458M LM1458AM	8 SOP	
LM1458IN LM1458AIN	8 DIP	
LM1458IS LM1458AIS	9 SIP	-25 ~ + 85°C
LM1458IM LM1458AIM	8 SOP	

## SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Power Supply Voltage	$V_{CC}$	$\pm 18$	V
Input Differential Voltage	$V_{I(DIFF)}$	30	V
Input Voltage	$V_I$	$\pm 15$	V
Operating Temperature Range LM1458/AI	$T_{OPR}$	$-25 \sim +85$	$^{\circ}\text{C}$
LM1458/A		$0 \sim +70$	$^{\circ}\text{C}$
Storage Temperature Range	$T_{STG}$	$-65 \sim +150$	$^{\circ}\text{C}$

**ELECTRICAL CHARACTERISTICS**(V<sub>CC</sub> = +15V, V<sub>EE</sub> = -15V, T<sub>A</sub> = 25 °C unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM1458A/AI			LM1458/I			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V <sub>IO</sub>	R <sub>S</sub> ≤ 10KΩ		2.0	6.0		2.0	10	mV
Input Offset Current	I <sub>IO</sub>			20	200		20	300	nA
Input Bias Current	I <sub>BIAS</sub>			80	500		80	700	nA
Large Signal Voltage Gain	G <sub>V</sub>	V <sub>O(P-P)</sub> = ±10V, R <sub>L</sub> ≥ 2.0KΩ	20	200		20	200		V/mV
Input Voltage Range	V <sub>I(R)</sub>		±12	±13		±11	±13		V
Input Resistance	R <sub>I</sub>		0.3	1.0		0.3	1.0		MΩ
Common Mode Rejection Ratio	CMRR		70	90		60	90		dB
Power Supply Rejection Ratio	PSRR		77	90		77	90		dB
Supply Current (Both Amplifier)	I <sub>CC</sub>			2.3		2.3	8.0		mA
Output Voltage Swing	V <sub>O(P-P)</sub>	R <sub>S</sub> ≤ 10KΩ	±12	±14	5.6	±11	±14		V
		R <sub>S</sub> ≤ 10KΩ	±10	±13		±9	±13		
Output Short Circuit Current	I <sub>SC</sub>			20		20			mA
Power Consumption	P <sub>C</sub>	V <sub>O</sub> = 0V		70	170		70	240	mW
Transient Response (Unity Gain)									
Rise Time	t <sub>RES</sub>	V <sub>I</sub> = 20mV, R <sub>L</sub> ≥ 2KΩ, C <sub>L</sub> ≤ 100pF		0.3			0.3		μs
Overshoot	OS	V <sub>I</sub> = 20mV, R <sub>L</sub> ≥ 2KΩ, C <sub>L</sub> ≤ 100pF		15			15		%
Slew Rate	SR	V <sub>I</sub> = 10V, R <sub>L</sub> ≥ 2KΩ, C <sub>L</sub> ≤ 100pF		0.5			0.5		V/μs

**ELECTRICAL CHARACTERISTICS**(V<sub>CC</sub> = +15V, V<sub>EE</sub> = -15V, NOTE 1, unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM1458A/AI			LM1458/I			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V <sub>IO</sub>	R <sub>S</sub> ≤ 10KΩ			7.5			12	mV
Input Offset Current	I <sub>IO</sub>				300			400	nA
Input Bias Current	I <sub>BIAS</sub>				800			1000	nA
Large Signal Voltage Gain	G <sub>V</sub>	V <sub>O(P-P)</sub> = ±10V, R <sub>L</sub> ≤ 2.0KΩ	15			15			V/mV
Common Mode Rejection Ratio	CMRR	R <sub>S</sub> ≥ 10KΩ	70	90		70	90		dB
Power Supply Rejection Ratio	PSRR	R <sub>S</sub> ≥ 10KΩ	77	90		77	90		dB
Output Voltage Swing	V <sub>O(P-P)</sub>	R <sub>L</sub> = 10KΩ	±12	±14		±11	±14		V
		R <sub>L</sub> = 2KΩ	±10	±13		±9	±13		
Input Voltage Range	V <sub>I(R)</sub>		±12			±12			V

## NOTE 1

LM1458/A: 0 °C ≤ T<sub>A</sub> ≤ 70 °CLM1458I/AI: -25 °C ≤ T<sub>A</sub> ≤ +85 °C



## TYPICAL PERFORMANCE CHARACTERISTICS

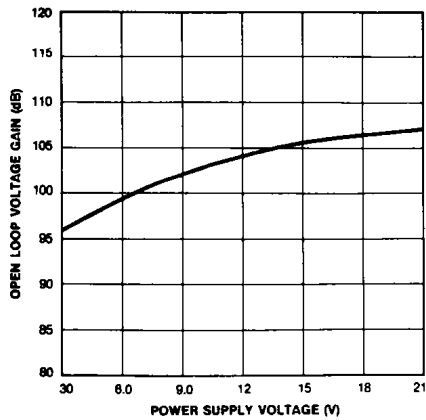
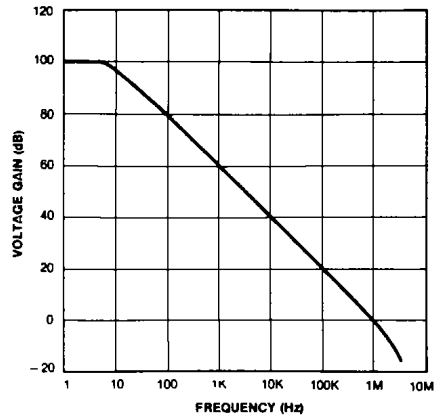
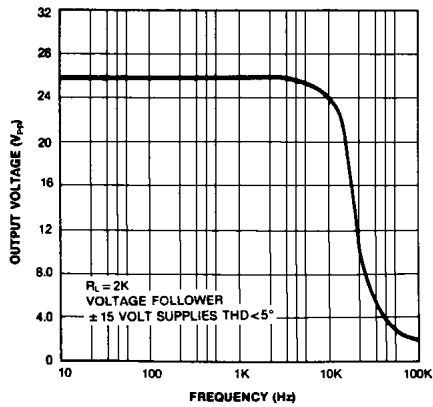
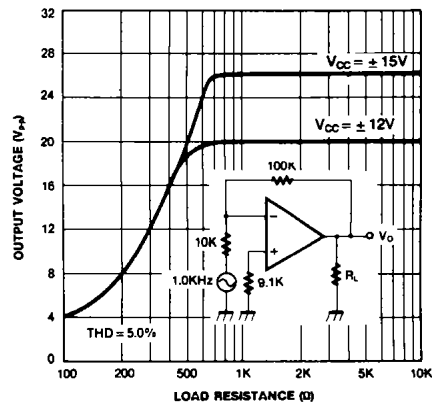
Fig. 1 OPEN-LOOP VOLTAGE GAIN  
vs POWER SUPPLY VOLTAGES

Fig. 2 OPEN-LOOP FREQUENCY RESPONSE

Fig. 3 POWER BANDWIDTH  
(LARGE SIGNAL SWING vs FREQUENCY)Fig. 4 OUTPUT VOLTAGE SWING  
vs LOAD RESISTANCE

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

# LM148

## Low Power Quad 741 Operational Amplifier

### Features

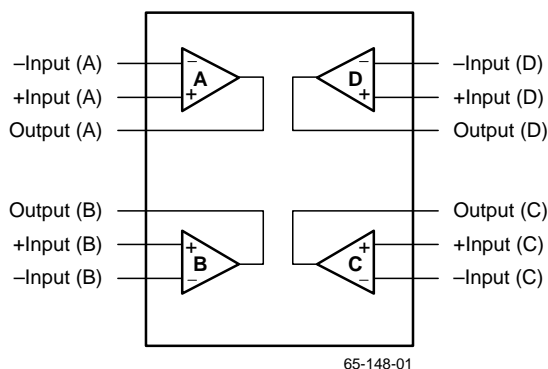
- 741 op amp operating characteristics
- Low supply current drain—0.6 mA/amplifier
- Class AB output stage—no crossover distortion
- Pin compatible with the LM124
- Low input offset voltage—1.0 mV
- Low input offset current—4.0 nA
- Low input bias current—30 nA
- Unity gain bandwidth—1.0 MHz
- Channel Separation—120 dB
- Input and output overload protection

### Description

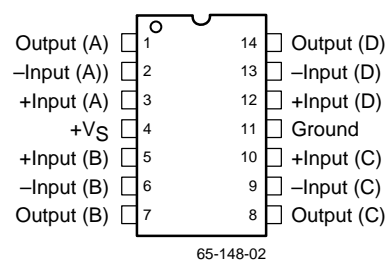
The LM148 is a true quad 741. It consists of four independent high-gain, internally compensated, low-power operational amplifiers which have been designed to provide functional characteristics identical to those of the familiar 741 operational amplifier. In addition, the total supply current for all four amplifiers is comparable to the supply current of a single 741 type op amp. Other features include input offset currents and input bias currents which are much less than those of a standard 741. Also, excellent isolation between amplifiers has been achieved by independently biasing each amplifier and using layout techniques which minimize thermal coupling.

The LM148 can be used anywhere multiple 741 type amplifiers are being used and in applications where amplifier matching or high packing density is required.

### Block Diagram



## Pin Assignments



## Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Supply Voltage	-22	+22	V
Differential Input Voltage		44	V
Input Voltage <sup>1</sup>	-22	+22	V
Output Short Circuit Duration <sup>2</sup>	Indefinite		
Storage Temperature Range	-65	+150	°C
Operating Temperature Range	-55	+125	°C
Lead Soldering Temperature (60 sec.)	+300°C		

### Notes:

1. For supply voltages less than  $\pm 15\text{V}$ , the absolute maximum input voltage is equal to the supply voltage.
2. Short circuit to ground on one amplifier only.

## Thermal Characteristics

Parameter	14-Lead Ceramic DIP
Maximum Junction Temperature	+175°C
Maximum $P_D$ $T_A < 50^\circ\text{C}$	1042 mW
Thermal Resistance, $\theta_{JC}$	60°C/W
Thermal Resistance, $\theta_{JA}$	120°C/W
For $T_A > 50^\circ\text{C}$ derate at	8.33 mW/°C

## Electrical Characteristics

( $V_S = \pm 15V$  and  $T_A = 25^\circ C$ , unless otherwise noted)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Input Offset Voltage	$R_S \leq 10K\Omega$		1.0	5.0	mV
Input Offset Current			4.0	25	nA
Input Bias Current			30	100	nA
Input Resistance (Differential Mode) <sup>1</sup>		0.8	2.5		M $\Omega$
Supply Current, All Amplifiers	$V_S = \pm 15V$		2.4	3.6	mA
Large Signal Voltage Gain	$V_S = \pm 15V$ , $V_{OUT} = \pm 10V$ , $R_L \geq 2K\Omega$	50	160		V/mV
Channel Separation	$F = 1\text{ Hz } 20\text{ KHz}$		120		dB
Unity Gain Bandwidth			1.0		MHz
Phase Margin				60	Degrees
Slew Rate				0.5	V/ $\mu S$
Short Circuit Current			25		mA
<b>The following specifications apply for <math>V_S = \pm 15V</math>, <math>-55^\circ C \leq T_A \leq +125^\circ C</math>.</b>					
Input Offset Voltage	$R_S \leq 10K\Omega$			6.0	mV
Input Offset Current				75	nA
Input Bias Current				325	nA
Large Signal Voltage Gain	$V_S = \pm 15V$ , $V_{OUT} = 10V$ , $R_L < 2K\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15V$	$R_L = 10K\Omega$	$\pm 12$	$\pm 13$	V
		$R_L = 2K\Omega$	$\pm 10$	$\pm 12$	
Input Voltage Range	$V_S = \pm 15V$	$\pm 12$			V
Common Mode Rejection Ratio	$R_S \leq 10K\Omega$	70	90		dB
Power Supply Rejection Ratio	$R_S \leq 10K\Omega$	77	96		dB

**Note:**

1. Guaranteed by design but not tested.

## Typical Performance Characteristics

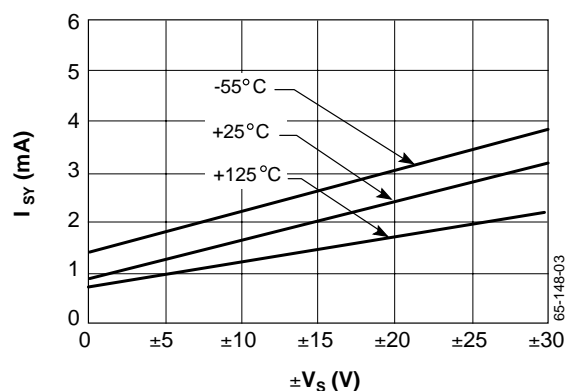


Figure 1. Supply Current vs. Supply Voltage

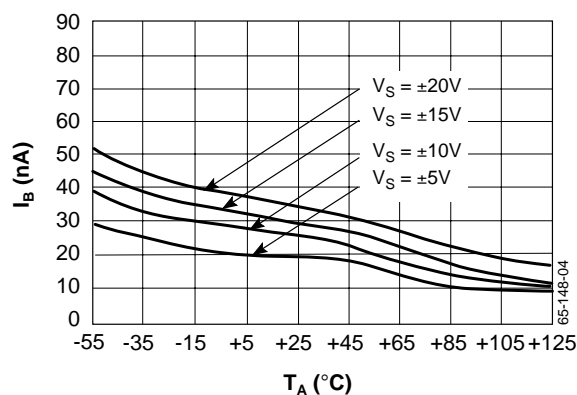


Figure 2. Input Bias Current vs. Temperature

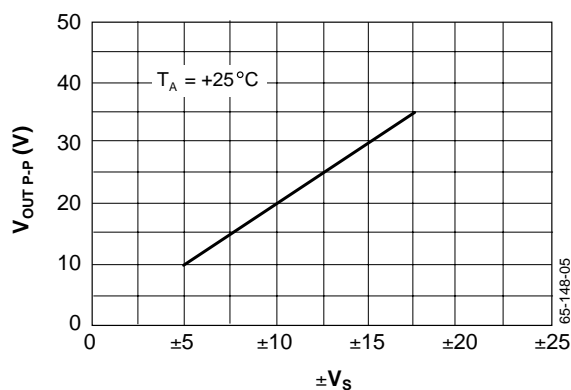


Figure 3. Output Voltage Swing vs. Supply Voltage

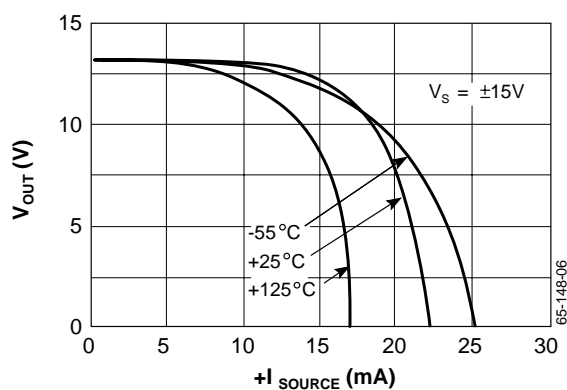


Figure 4. Positive Current Limit Output Voltage vs. Output Source Current

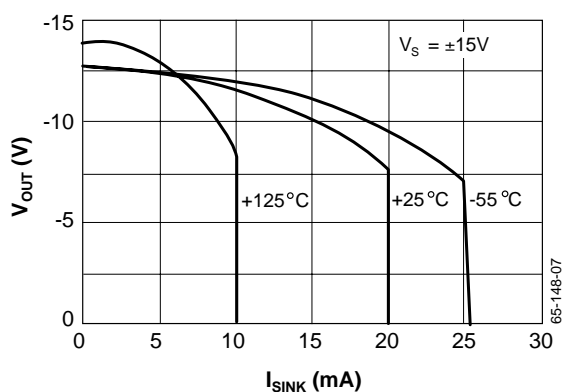


Figure 5. Negative Current Limit Output Voltage vs. Output Sink Current

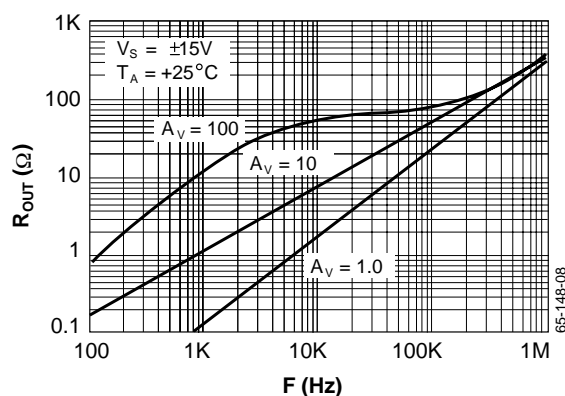


Figure 6. Output Impedance vs. Frequency

## Typical Performance Characteristics (continued)

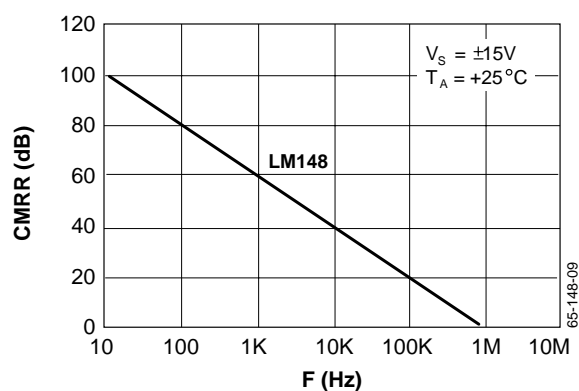


Figure 7. CMRR vs. Frequency

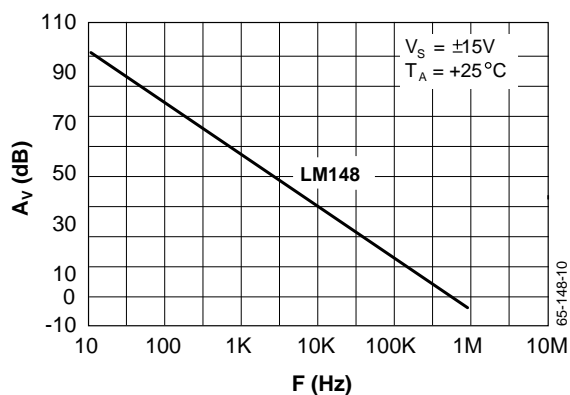


Figure 8. Open Loop Gain vs. Frequency

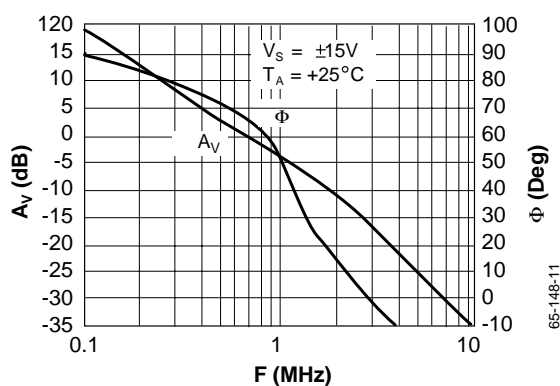


Figure 9. Gain, Phase vs. Frequency

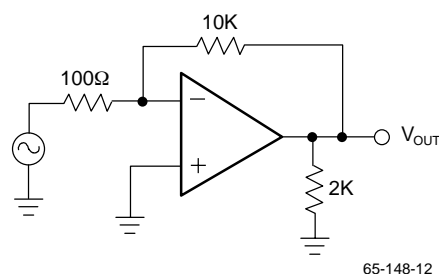
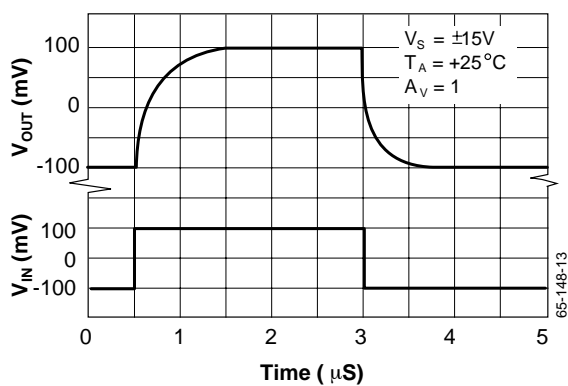
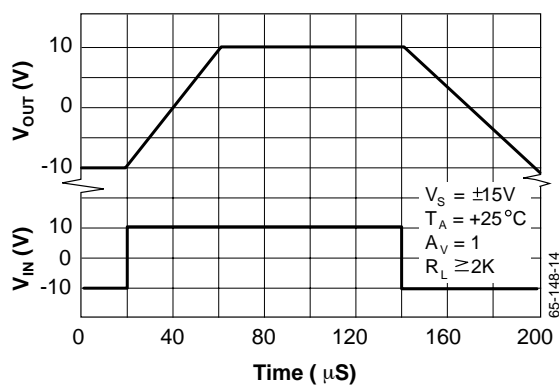


Figure 10. Gain, Phase Test Circuit

Figure 11. Small Signal Pulse Response  
Input, Output Voltage vs. TimeFigure 12. Large Signal Pulse Response  
Output Voltage vs. Time

## Typical Performance Characteristics (continued)

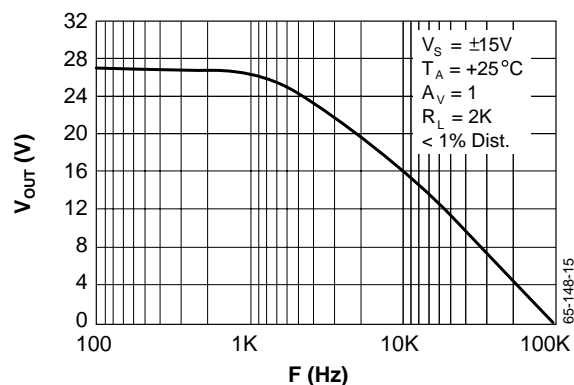


Figure 13. Undistorted Output Voltage Swing vs. Frequency

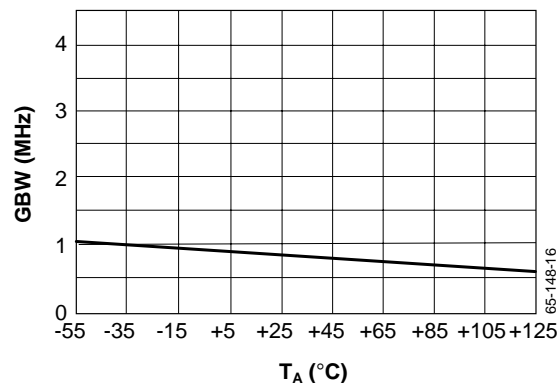


Figure 14. Gain Bandwidth Product vs. Temperature

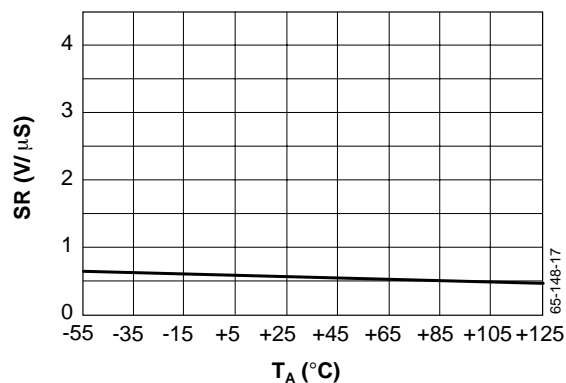


Figure 15. Slew Rate vs. Temperature

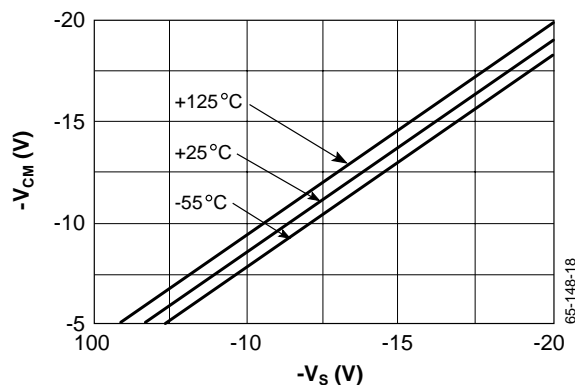


Figure 16. Negative Common Mode Input Voltage vs. Supply Voltage

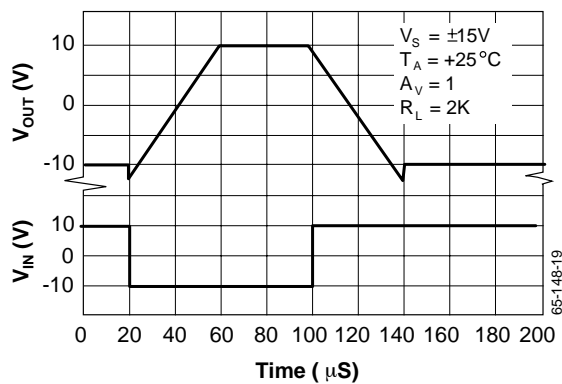


Figure 17. Inverting Large Signal Pulse Response Input, Output Voltage vs. Time

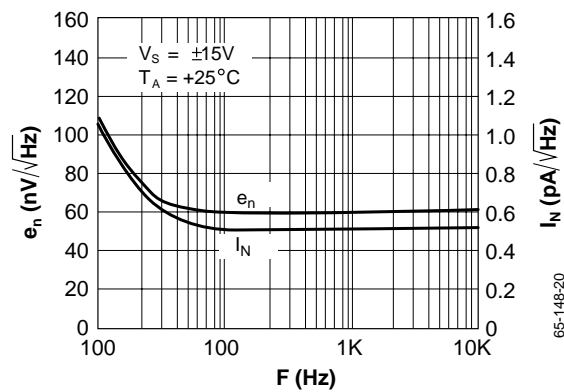


Figure 18. Input Noise Voltage, Current Densities vs. Frequency



## Typical Performance Characteristics (continued)

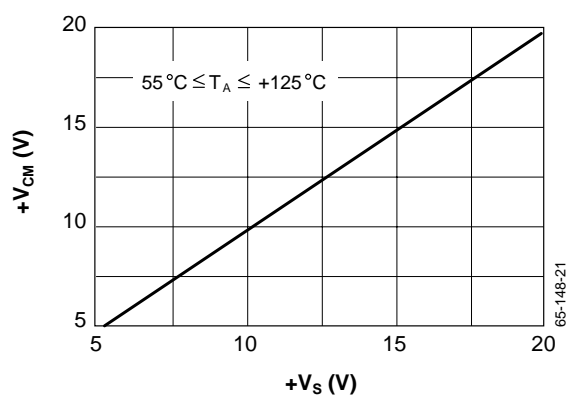


Figure 19. Positive Common Mode, Input Voltage vs. Supply Voltage

## Typical Simulation

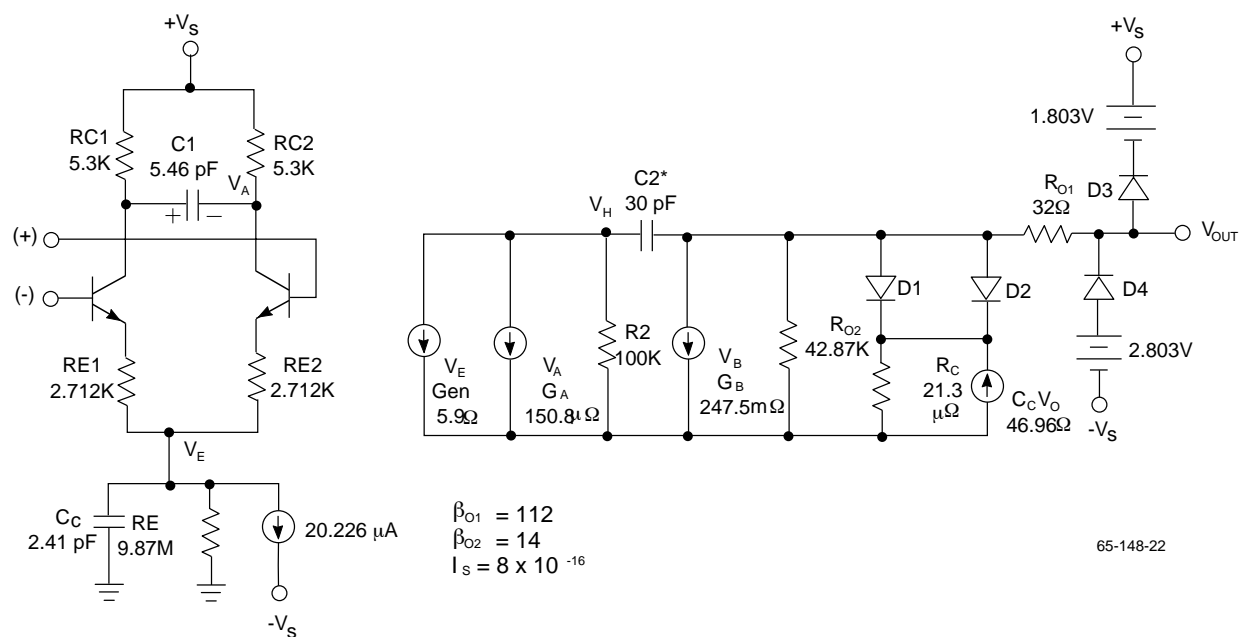


Figure 20. LM148 Macromodel for Computer Simulation

## Applications Discussion

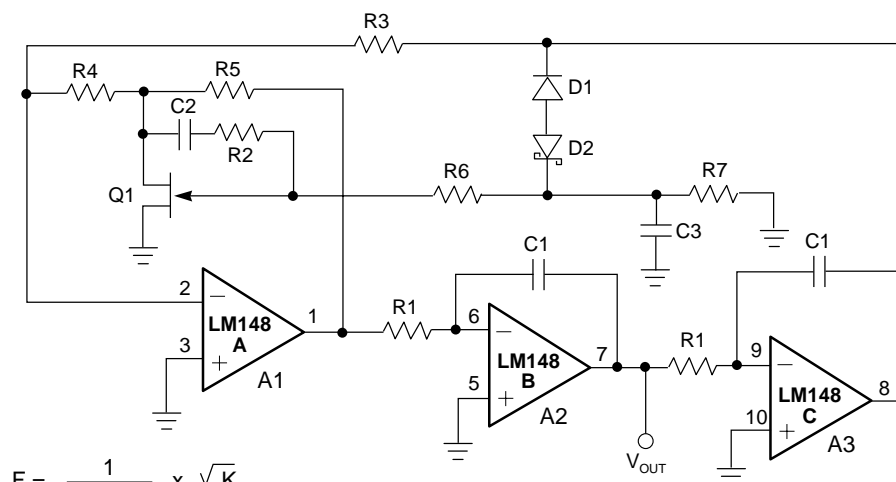
The LM148 low power quad operational amplifier exhibits performance comparable to the popular 741. Substitution can therefore be made with no change in circuit behavior.

The input characteristics of these devices allow differential voltages which exceed the supplies. Output phase will be correct as long as one of the inputs is within the operating common mode range. If both exceed the negative limit, the output will latch positive. Current limiting resistors should be used on the inputs in case voltages become excessive.

When capacitive loading becomes much greater than 100pF, a resistor should be placed between the output and feedback connection in order to reduce phase shift.

The LM148 is short circuit protected to ground and supplies continuously when only one of the four amplifiers is shorted. If multiple shorts occur simultaneously, the unit can be destroyed due to excessive power dissipation.

To assure stability and to minimize pickup, feedback resistors should be placed close to the input to maximize the feedback pole frequency (a function of input to ground capacitance). A good rule of thumb is that the feedback pole frequency should be 6 times the operating -3.0B frequency. If less, a lead capacitor should be placed between the output and input.



$$F = \frac{1}{2\pi R_1 C_1} \times \sqrt{K}$$

$$K = \frac{R_4 R_5}{R_3} \left( \frac{1}{R_{DS}} + \frac{1}{R_4} + \frac{1}{R_5} \right)$$

$$R_{DS} \cong \left( \frac{R_{ON}}{1 - \frac{V_{GS}}{V_P}} \right)^{1/2}$$

$$F_{MAX} = 5.0 \text{ KHz}, \text{ THD} \leq 0.03\%$$

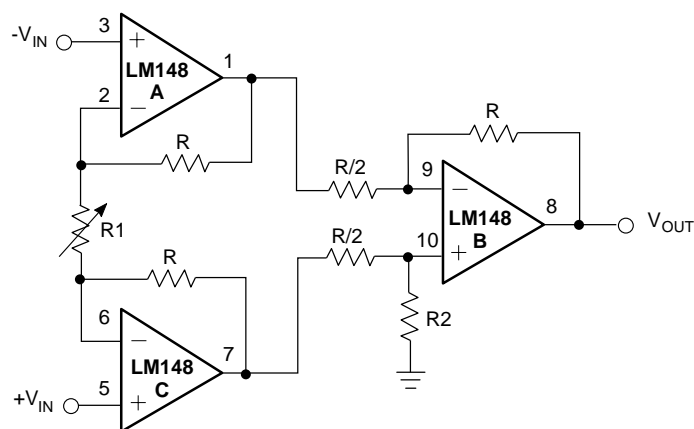
R1 = 100K pot., C1 = 0.0047 μF, C2 = 0.01 μF, C3 = 0.1 μF, R2 = R6 = R7 = 1M, R3 = 5.1K, R4 = 12Ω.  
R5 = 240Ω, Q1 = NS5102, D1 = 1N914, D2 = 3.6V avalanche diode (ex. LM103), V<sub>S</sub> = ±15V

A simpler version with some distortion degradation at high frequencies can be made by using A1 as a simple inverting amplifier, and by putting back to back zeners in feedback loop of A3.

65-148-23

Figure 21. One Decade Low Distortion Sinewave Generator

## Applications Discussion (continued)



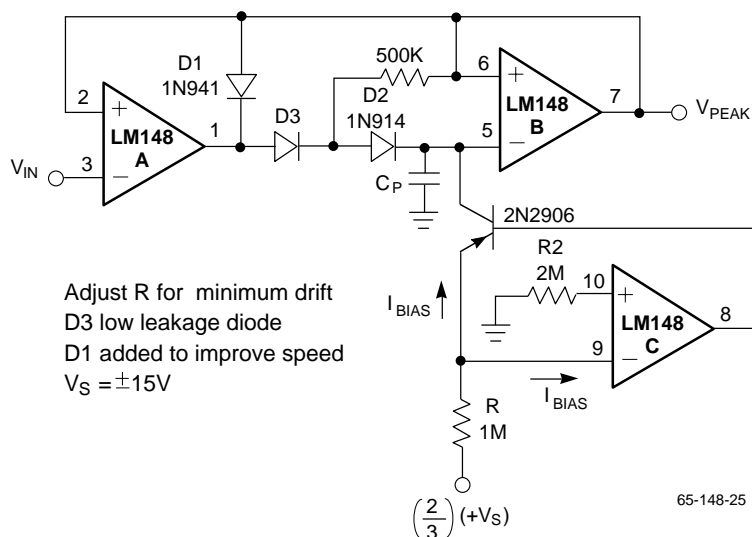
$$V_{OUT} = 2 \left( \frac{2R}{R1} + 1 \right) \cdot (-V_S - 3V) \leq V_{IN\ CM} \leq (+V_S - 3V)$$

$$V_S = \pm 15V$$

$R = R2$ , trim  $R2$  to boost CMRR

65-148-24

**Figure 22. Low Cost Instrumentation Amplifier**

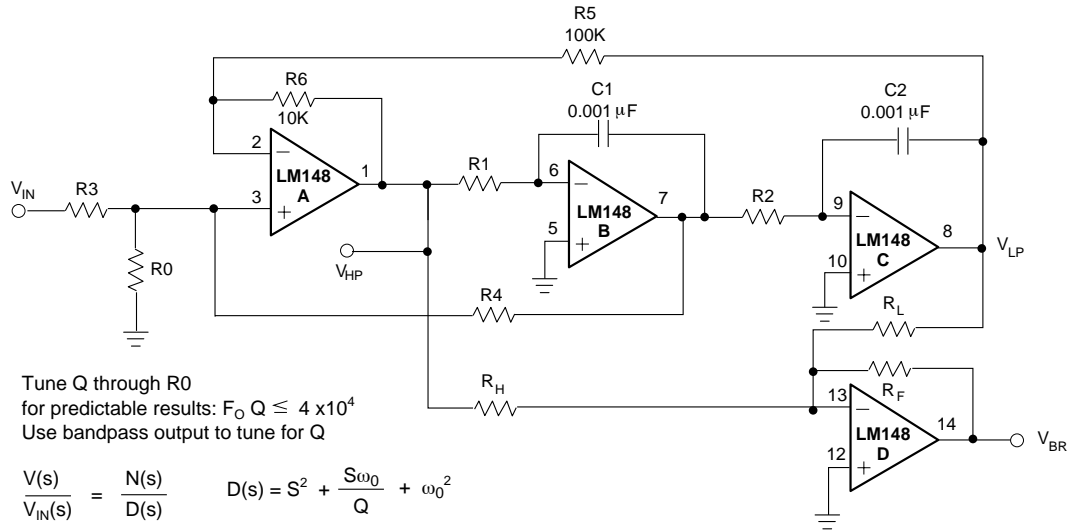


Adjust  $R$  for minimum drift  
 $D3$  low leakage diode  
 $D1$  added to improve speed  
 $V_S = \pm 15V$

65-148-25

**Figure 23. Low Voltage Peak Detector with Bias Current Compensation**

## Applications Discussion (continued)



$$\frac{V(s)}{V_{IN}(s)} = \frac{N(s)}{D(s)} \quad D(s) = S^2 + \frac{S\omega_0}{Q} + \omega_0^2$$

$$N_{HP}(s) = S^2 H_{OHP}, \quad N_{BP}(s) = \frac{-S\omega_0 H_{OBP}}{Q}, \quad N_{LP} = \omega_0^2 H_{OLP}$$

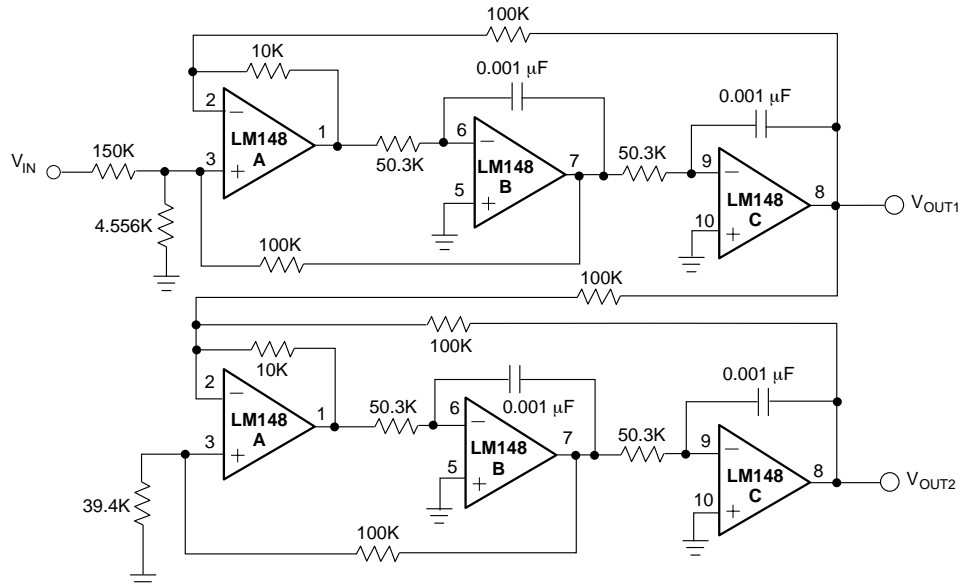
$$F_O = \frac{1}{2\pi} \sqrt{\frac{R_6}{R_5}} \sqrt{\frac{1}{t_1 t_2}}, \quad t_1 = R_1 C_1, \quad Q = \left( \frac{1 + R_4 | R_3 + R_4 | R_0}{1 + R_6 | R_5} \right) \left( \frac{R_6}{R_5} \frac{t_1}{t_2} \right)^{1/2}$$

$$F_{NOTCH} = \frac{1}{2\pi} \left( \frac{R_H}{R_L t_1 t_2} \right)^{1/2}, \quad H_{OHP} = \frac{1 + R_6 | R_5}{1 + R_3 | R_0 + R_3 | R_4}, \quad H_{OBP} = \frac{1 + R_4 | R_3 + R_4 | R_0}{1 + R_3 | R_0 + R_3 | R_4}$$

$$H_{OLP} = \frac{1 + R_5 | R_6}{1 + R_3 | R_0 + R_3 | R_4}$$

65-148-26

Figure 24. Universal State-Space Filter

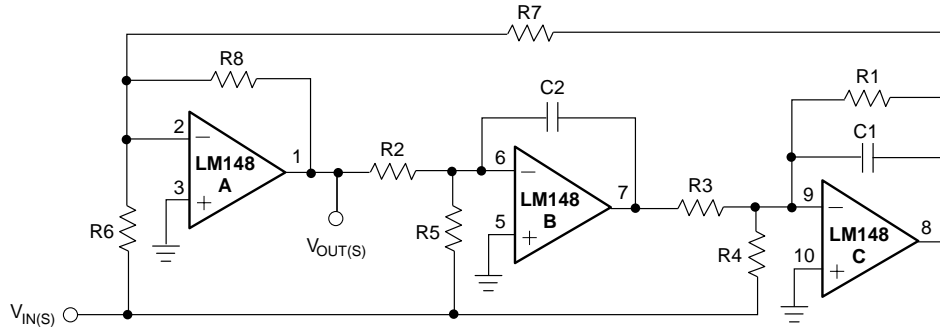


65-148-27

Use general equations, and tune each section separately.  
 $Q_{1st} \text{ Section} = 0.541$ ,  $Q_{2nd} \text{ Section} = 1.306$ .  
 The response should have 0 dB peaking.

Figure 25. 1 KHz 4-Pole Butterworth Filter

## Applications Discussion (continued)



$$Q = \sqrt{\frac{R8}{R7}} \left( \frac{R1C1}{\sqrt{R3C2R2C1}} \right), F_0 = \frac{1}{2\pi} \sqrt{\frac{R8}{R7}} \left( \frac{1}{\sqrt{R2R3C1C2}} \right), F_{\text{NOTCH}} = \frac{1}{2\pi} \sqrt{\frac{R6}{R3R5R7C1C2}}$$

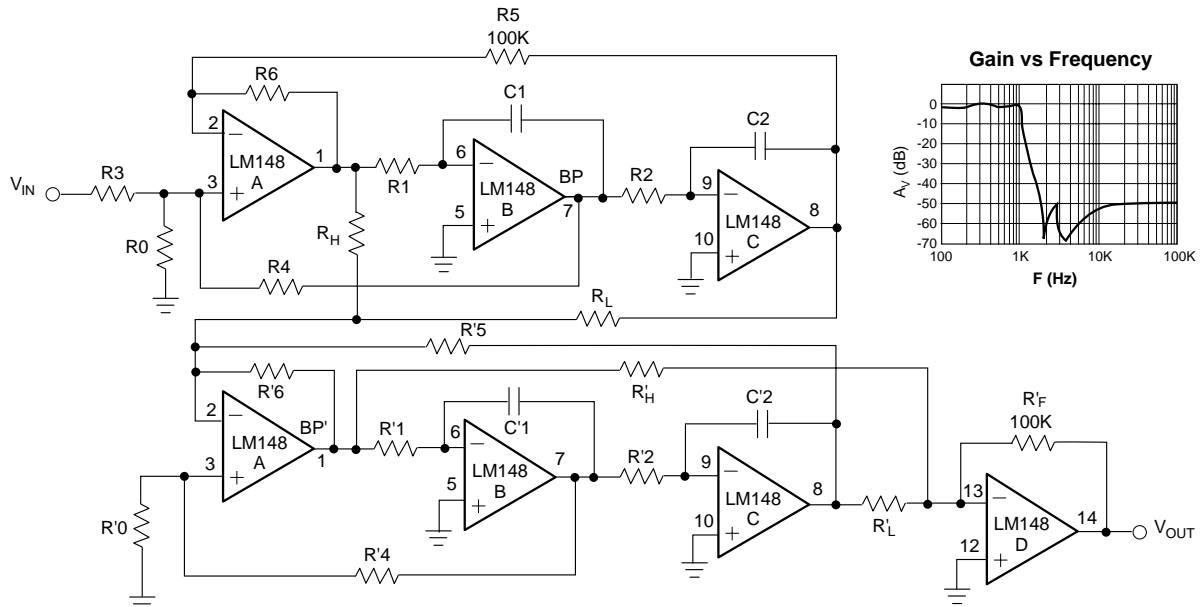
$$\text{Necessary condition for notch: } \frac{1}{R6} = \frac{R1}{R4R7}$$

Examples:  $F_{\text{NOTCH}} = 3 \text{ kHz}$ ,  $Q = 5$ ,  $R1 = 270\text{K}$ ,  $R2 = R3 = 20\text{K}$ ,  $R4 = 27\text{K}$ ,  $R5 = 20\text{K}$ ,  $R6 = R8 = 10\text{K}$ ,  $R7 = 100\text{K}$ .  
 $C1 = C2 = 0.001 \mu\text{F}$ .

Better noise performance than the state-space approach.

65-148-28

Figure 26. 3 Amplifier Bi-Quad Notch Filter



$F_C = 1 \text{ kHz}$ ,  $F_S = 2 \text{ kHz}$ ,  $F_P = 0.543$ ,  $F_Z = 2.14$ ,  $Q = 0.841$ ,  $F'_P = 0.987$ ,  $F'_Z = 4.92$ .  
 $Q' = 4.403$  normalized to ripple BW.

$$F_P = \frac{1}{2\pi} \sqrt{\frac{R6}{R5}} \left( \frac{1}{t} \right), F_Z = \frac{1}{2\pi} \sqrt{\frac{R_H}{R_L}} \left( \frac{1}{t} \right), Q = \frac{1 + R4/R3 + R4/R0}{1 + R6/R5} \times \sqrt{\frac{R6}{R5}}, Q' = \sqrt{\frac{R'6}{R'5}} \times \frac{1 + R'4/R'0}{1 + R'6/R'5 + R'6/R'_P}$$

$$R_P = \frac{R_H R_L}{R_H + R_L}$$

Use the B/P outputs to tune  $Q$ ,  $Q'$ , tune the 2 sections separately.

$R1 = R2 = 92.6\text{K}$ ,  $R3 = R4 = R5 = 100\text{K}$ ,  $R6 = 10\text{K}$ ,  $R0 = 107.8\text{K}$ ,  $R_L = 100\text{K}$ ,  $R_H = 155.1\text{K}$ ,  
 $R'1 = R'2 = 50.9\text{K}$ ,  $R'4 = R'5 = 100\text{K}$ ,  $R'6 = 10\text{K}$ ,  $R'0 = 5.78\text{K}$ ,  $R'_L = 100\text{K}$ ,  $R'_H = 248.12\text{K}$ ,  $R'_F = 100\text{K}$ .

65-148-29

All capacitors are  $0.001 \mu\text{F}$ .

Figure 27. 4th Order 1 KHz Elliptic Filter (4 Poles, 4 Zeros)

**Notes:**

**Notes:**

**Notes:**



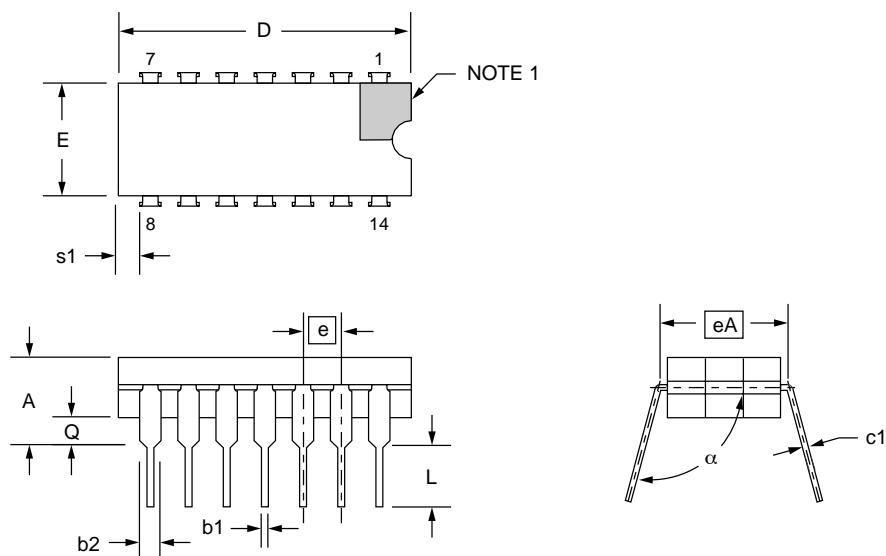
## Mechanical Dimensions

### 14-Pin Ceramic DIP

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.200	—	5.08	
b1	.014	.023	.36	.58	8
b2	.045	.065	1.14	1.65	2
c1	.008	.015	.20	.38	8
D	—	.785	—	19.94	4
E	.220	.310	5.59	7.87	4
e	.100 BSC		2.54 BSC		5, 9
eA	.300 BSC		7.62 BSC		7
L	.125	.200	3.18	5.08	
Q	.015	.060	.38	1.52	3
s1	.005	—	.13	—	6
$\alpha$	90°	105°	90°	105°	

#### Notes:

1. Index area: a notch or a pin one identification mark shall be located adjacent to pin one. The manufacturer's identification shall not be used as pin one identification mark.
2. The minimum limit for dimension "b2" may be .023 (.58mm) for leads number 1, 7, 8 and 14 only.
3. Dimension "Q" shall be measured from the seating plane to the base plane.
4. This dimension allows for off-center lid, meniscus and glass overrun.
5. The basic pin spacing is .100 (2.54mm) between centerlines. Each pin centerline shall be located within  $\pm .010$  (.25mm) of its exact longitudinal position relative to pins 1 and 14.
6. Applies to all four corners (leads number 1, 7, 8, and 14).
7. "eA" shall be measured at the center of the lead bends or at the centerline of the leads when " $\alpha$ " is 90°.
8. All leads – Increase maximum limit by .003 (.08mm) measured at the center of the flat, when lead finish applied.
9. Twelve spaces.



## Ordering Information

Part Number	Package	Operating Temperature Range
LM148D	14-Lead Ceramic DIP	-55°C to +125°C
LM148D/883B	14-Lead Ceramic DIP	-55°C to +125°C

**Note:**

1. 883B suffix denotes Mil-Std-883, Level B processing

### LIFE SUPPORT POLICY

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1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

# LM1851

## Ground Fault Interrupter

### Features

- No potentiometer required
- Direct interface to SCR
- Supply voltage derived from AC line—26V shunt
- Adjustable sensitivity
- Grounded neutral fault detection
- Meets UL943 standards
- 450  $\mu$ A quiescent current
- Ideal for 120V or 220V systems

### Description

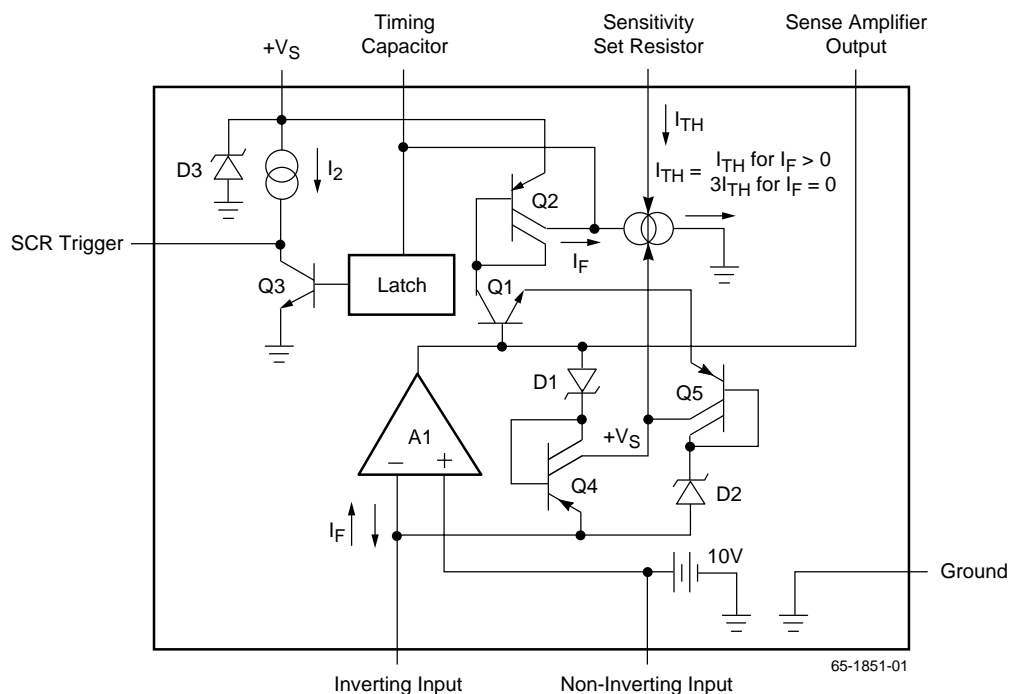
The LM1851 is a controller for AC outlet ground fault interrupters. These devices detect hazardous grounding conditions (example: a pool of water and electrical equipment connected to opposite phases of the AC line) in consumer and industrial environments. The output of the IC triggers an external SCR, which in turn opens a relay circuit breaker to prevent a harmful or lethal shock.

Full advantage of the U.S. UL943 timing specification is taken to ensure maximum immunity to false triggering due

to line noise. A special feature is found in circuitry that rapidly resets the integrating timing capacitor in the event that noise pulses introduce unwanted charging currents. Also, flip-flop is included that ensures firing of even a slow circuit breaker relay on either half-cycle of the line voltage when external full wave rectification is used.

The application circuit can be configured to detect both normal faults (hot wire to ground) and grounded neutral faults.

### Block Diagram



## Functional Description

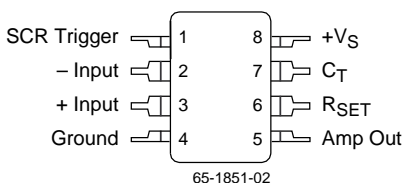
The voltage at the supply pin is clamped to +26V by the internal shunt regulator D3. This shunt regulator also generates an artificial ground voltage for the noninverting input of A1 (shown as a +10V source). A1, Q1, and Q2 act as a current mirror for fault current signals (which are derived from an external transformer). When a fault signal is present, the mirrored current charges the external timing capacitor until its voltage exceeds the latch trigger threshold (typically 17.5V). When then this threshold is exceeded, the latch engages and Q3 turns off, allowing I2 to drive the SCR connected to pin 1.

Extra Circuitry in the feedback path of A1 works with the switched current source I1 to remove any charge on C<sub>T</sub> induced by noise in the transformer. If no fault current is

present, then I1 discharges C<sub>T</sub> with a current equal to 3 I<sub>TH</sub>, where I<sub>TH</sub> is the value of current set by the external R<sub>SET</sub> resistor. If fault signals are present at the input of A1 (which is held at virtual ground, +10V), one of the two current mirrors in the feedback path of A1 (Q4 and Q5) will become active, depending on which half-cycle the fault occurs. This action will raise the voltage at V<sub>S</sub>, switching I1 to a value equal to I<sub>TH</sub>, and reducing the discharge rate of C<sub>T</sub> to better allow fault currents to charge it.

Notice that I<sub>TH</sub> discharges C<sub>T</sub> during both half-cycles of the line, while I<sub>F</sub> only charges C<sub>T</sub> during the half-cycle in which I<sub>F</sub> exits pin 2 (since Q1 will only carry fault current in one direction). Thus, during one half-cycle, I<sub>F</sub>-I<sub>TH</sub> charges C<sub>T</sub>, while during the other half-cycle I<sub>TH</sub> discharges it.

## Pin Assignments



## Definition of Terms

### Normal Fault

An unintentional electrical path, R<sub>B</sub>, between the load terminal of the hot line and the ground, as shown by the dashed lines in Figure 1.

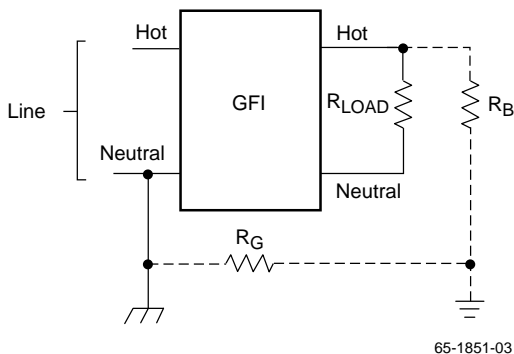


Figure 1. Normal Fault

### Grounded Neutral Fault

An unintentional electrical path between the load terminal of the neutral line and the ground, as shown by the dashed lines in Figure 2.

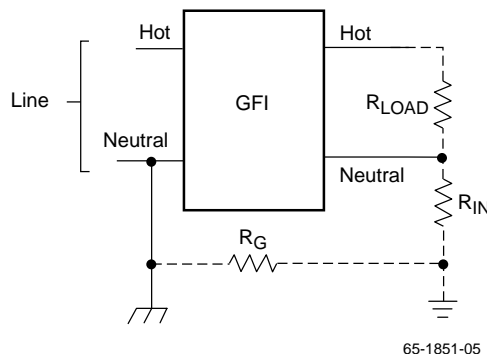


Figure 2. Grounded Neutral Fault

## Normal Fault Plus Grounded Neutral Fault

The combination of the normal fault and the grounded neutral fault, as shown by the dashed lines in Figure 3.

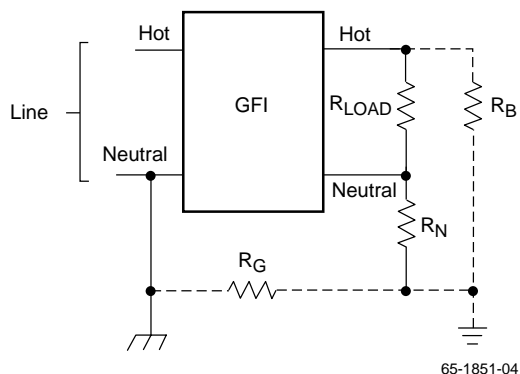


Figure 3. Normal Fault Plus Grounded Neutral Fault

## Absolute Maximum Ratings

Parameter	Conditions	Min	Max	Units
Supply Current			19	mA
Power Dissipation			570	mW
Operating Temperature		-40	70	°C
Lead Soldering Temperature	SOIC, 10 seconds		260	°C
	DIP, 60 seconds		300	°C

## Thermal Characteristics

Parameter	Conditions	Min	Max	Units
Maximum Junction Temperature			125	°C
Maximum $P_{DTA} < 50^{\circ}\text{C}$	DIP		468	mW
	SOIC		300	
Thermal Resistance, $\theta_{JA}$	DIP		160	°C/W
	SOIC		240	
For $T_A > 50^{\circ}\text{C}$ , derate at	DIP		6.25	mW/°C
	SOIC		4.17	

## DC Electrical Characteristics

(TA = +25°C, ISHUNT = 5 mA)

Parameters	Test Conditions	Min	Typ	Max	Units
Power Supply Shunt Regulator Voltage	Pin 8, Average Value	22	26	30	V
Latch Trigger Voltage	Pin 7	15	17.5	20	V
Sensitivity Set Voltage	Pin 8 to Pin 6	6	7	8.2	V
Output Drive Current	Pin 1 With Fault	0.5	1	2.4	mA
Output Saturation Voltage	Pin 1 Without Fault		100	240	mV
Output Saturation Resistance	Pin 1 Without Fault		100		Ω
Output External Current Sinking Capability <sup>1</sup>	Pin 1 Without Fault, V <sub>PIN1</sub> Held to 0.3V	2	5		mA
Noise Integration Sink Current Ratio	Pin 7, Ratio of Discharge Currents Between No Fault Fault and Fault Conditions	2.0	2.8	3.6	μA/μA

### Notes:

1. This external applied current is in addition to the internal "output drive current" source.

## AC Electrical Characteristics

(TA = +25°C, ISHUNT = 5 mA)

Parameters	Conditions	Min	Typ	Max	Units
Normal Fault Current Sensitivity <sup>2</sup>	See Figure 9	3	5	7	mA
Normal Fault Trip Time <sup>1</sup>	500Ω Fault, see Figure 10		18		mS
Normal Fault With Grounded	500Ω Normal Fault		18		mS
Neutral Fault Trip Time <sup>1</sup>	2Ω Neutral, see Figure 10				

### Notes:

1. Average of 10 trials.
2. Required UL sensitivity tolerance is such that external trimming of LM1851 sensitivity is necessary.

## Typical Performance Characteristics ( $T_A = +25^\circ\text{C}$ )

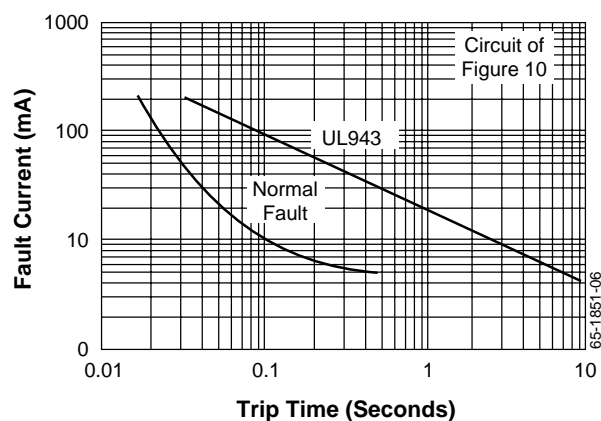


Figure 4. Average Trip Time vs. Fault Current

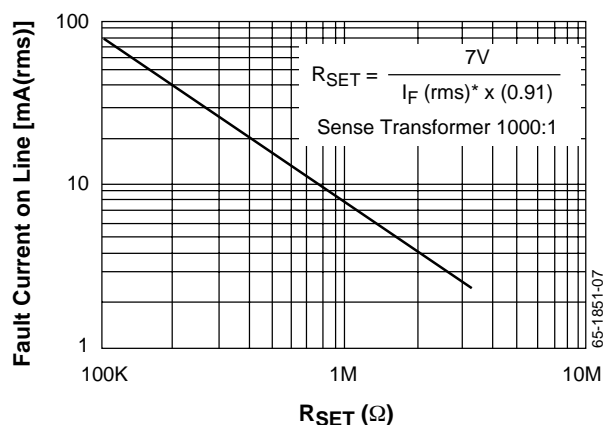
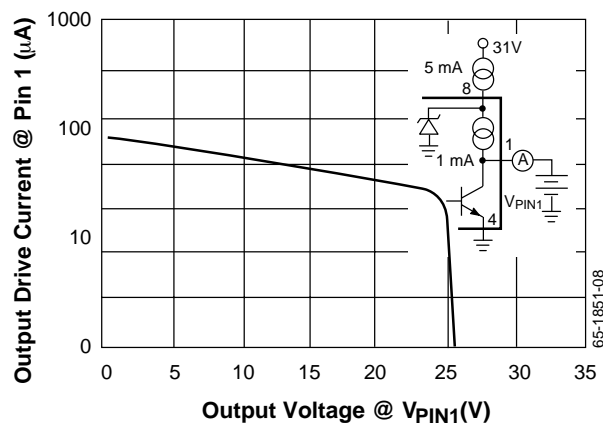
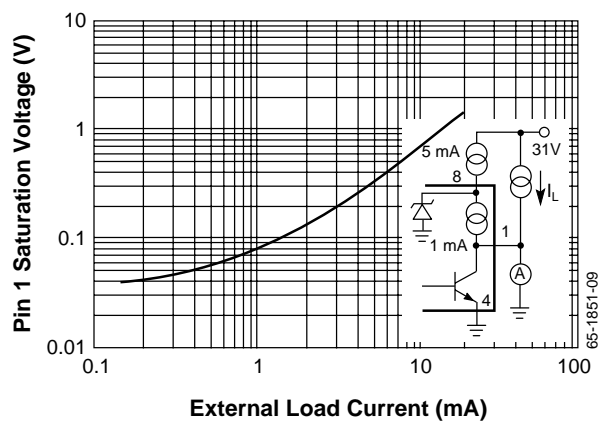
Figure 5. Normal Fault Current Threshold vs.  $R_{SET}$ 

Figure 6. Output Drive Current vs. Output Voltage

Figure 7. Pin 1 Saturation Voltage vs. External Load Current,  $I_L$

## Applications Discussion

A typical ground fault interrupter circuit is shown in Figure 10. It is designed to operate on 120 VAC line voltage with 5 mA normal fault sensitivity.

A full-wave rectifier bridge and a 15k/2W resistor are used to supply the dc power required by the IC. A 1  $\mu$ F capacitor at pin 8 is used to filter the ripple of the supply voltage and is also connected across the SCR to allow firing of the SCR on either half-cycle. When a fault causes the SCR to trigger, the circuit breaker is energized and line voltage is removed from the load.

At this time no fault current flows and the CT discharge current increases from  $I_{TH}$  to  $3I_{TH}$  (see Block Diagram). This quickly resets both the timing capacitor and the output latch. The circuit breaker can be reset and the line voltage again supplied to the load, assuming the fault has been removed. A 1000:1 sense transformer is used to detect the normal fault. The fault current, which is basically the difference current between the got and neutral lines, is stepped down by 1000 and fed into the input pin of the operational amplifier through a  $10\text{ }\mu\text{F}$  capacitor. The  $0.0033\text{ }\mu\text{F}$  capacitor between pin 2 and pin 3 and the  $200\text{ pF}$  between pins 3 and 4 are added to obtain better noise immunity. The normal fault sensitivity is determined by the timing capacitor discharging current,  $I_{TH}$ .  $I_{TH}$  can be calculated by:

$$I_{TH} = \frac{7V}{R_{SET}} \div 2 \quad (1)$$

At the decision point, the average fault current just equals the threshold current,  $I_{TH}$ .

$$I_{TH} = \frac{I_F(rms)}{\gamma} \times 0.91 \quad (2)$$

Where  $I_F(\text{rms})$  is the rms input fault current to the operational amplifier and the factor of 2 is due to the fact that  $I_F$  charges the timing capacitor only during one half-cycle, while  $I_{TH}$  discharges the capacitor continuously. The factor 0.91 converts the rms value to an average value. Combining equations (1) and (2) we have:

$$R_{\text{SET}} = \frac{7\text{V}}{I_{\text{F}}(\text{rms}) \times 0.91} \quad (3)$$

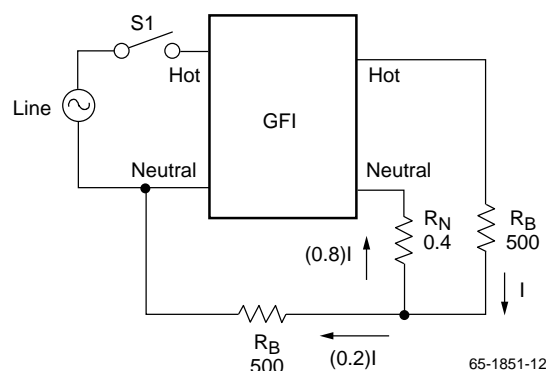
For example, to obtain 5 mA(rms) sensitivity for the circuit in Figure 7 we have:

$$R_{\text{SET}} = \frac{7\text{V}}{\frac{5\text{ mA} \times 0.91}{1000}} = 1.5\text{M}\Omega \quad (4)$$

The correct value for  $R_{SET}$  can also be determined from the characteristic curve that plots equation (3). Note that this is an approximate calculation; the exact value of  $R_{SET}$  depends on the specific sense transformer used and LM1851 tolerances. Inasmuch as UL943 specifies a sensitivity “window” of 4 mA to 6mA, provision should be made to adjust  $R_{SET}$  with a potentiometer.

Independent of setting sensitivity, the desired integration time can be obtained through proper selection of the timing capacitor,  $C_T$ . Due to the large number of variables involved, proper selection of  $C_T$  is best done empirically. The following design example should only be used as a guideline.

Assume the goal is to meet UL943 timing requirements. Also assume that worst case timing occurs during GFI start-up (S1 closure) with both a heavy normal fault and a  $2\Omega$  grounded neutral fault present. This situation is shown diagrammatically in Figure 8.



**Figure 8.**

UL943 specifies  $\leq 25$  ms average trip time under these conditions. Calculation of  $C_T$  based upon charging currents due to normal fault only is as follows:

1. Start with a  $\leq 25$  ms specification. Subtract 3 ms GFI turn-on time (15k and 1  $\mu$ F). Subtract 8 ms potential loss of one half-cycle due to fault current sense of half-cycles only.
2. Subtract 4 ms time required to open a sluggish circuit breaker.
3. This gives a total  $\leq 10$  ms maximum integration time that could be allowed.
4. To generate 8 ms value of integration time that accommodates component tolerances and other variables:

$$C_T = \frac{1 \times T}{V} \quad (5)$$



where:

T = integration time

V = threshold voltage

I = average fault current into CT

$$I = \underbrace{\left( \frac{120 V_{AC(rms)}}{R_B} \right)}_{\text{heavy fault current generated (swamps ITH)}} \underbrace{\left( \frac{R_N}{R_G + R_N} \right)}_{\text{portion of fault current shunted around GFI}} \times \underbrace{\left( \frac{1 \text{ turn}}{1000 \text{ turns}} \right)}_{\text{current division of input sense transformer}} \times \underbrace{\left( \frac{1}{2} \right)}_{\text{CT charging on half-cycles only}} \times \underbrace{(0.91)}_{\text{rms to average conversion}} \quad (6)$$

therefore:

$$C_T = \frac{\left[ \left( \frac{120}{500} \right) \times \left( \frac{0.4}{1.6 + 0.4} \right) \times \left( \frac{1}{1000} \right) \times \left( \frac{1}{2} \right) \times (0.91) \right]}{17.5} \times 0.008$$

$$C_T = 0.01 \mu F \quad (7)$$

In practice, the actual value of CT will have to be modified to include the effects of the neutral loop upon the net charging current. The effect of neutral loop induced currents is difficult to quantize, but typically they sum with normal fault currents, thus allowing a larger value of CT.

For UL943 requirements, 0.015  $\mu F$  has been found to be the best compromise between timing and noise.

For those GFI standards not requiring grounded neutral detection, a still larger value capacity can be used and better noise immunity obtained.

The larger capacitor can be accommodated because  $R_N$  and  $R_G$  are not present, allowing the full fault current, I, to enter the GFI.

In Figure 10, grounded neutral detection is accomplished by feeding the neutral coil with 120 Hz energy continuously and allowing some of the energy to couple into the sense transformer during conditions of neutral fault.

Transformers may be obtained from Magnetic Metals, Inc., 21st Street and Hayes Street, Camden, NJ 08101—(609) 964-7842.

## Application Circuits

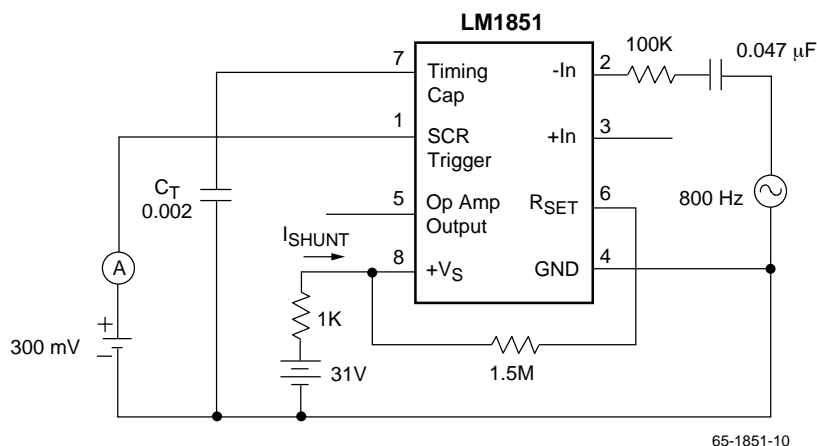
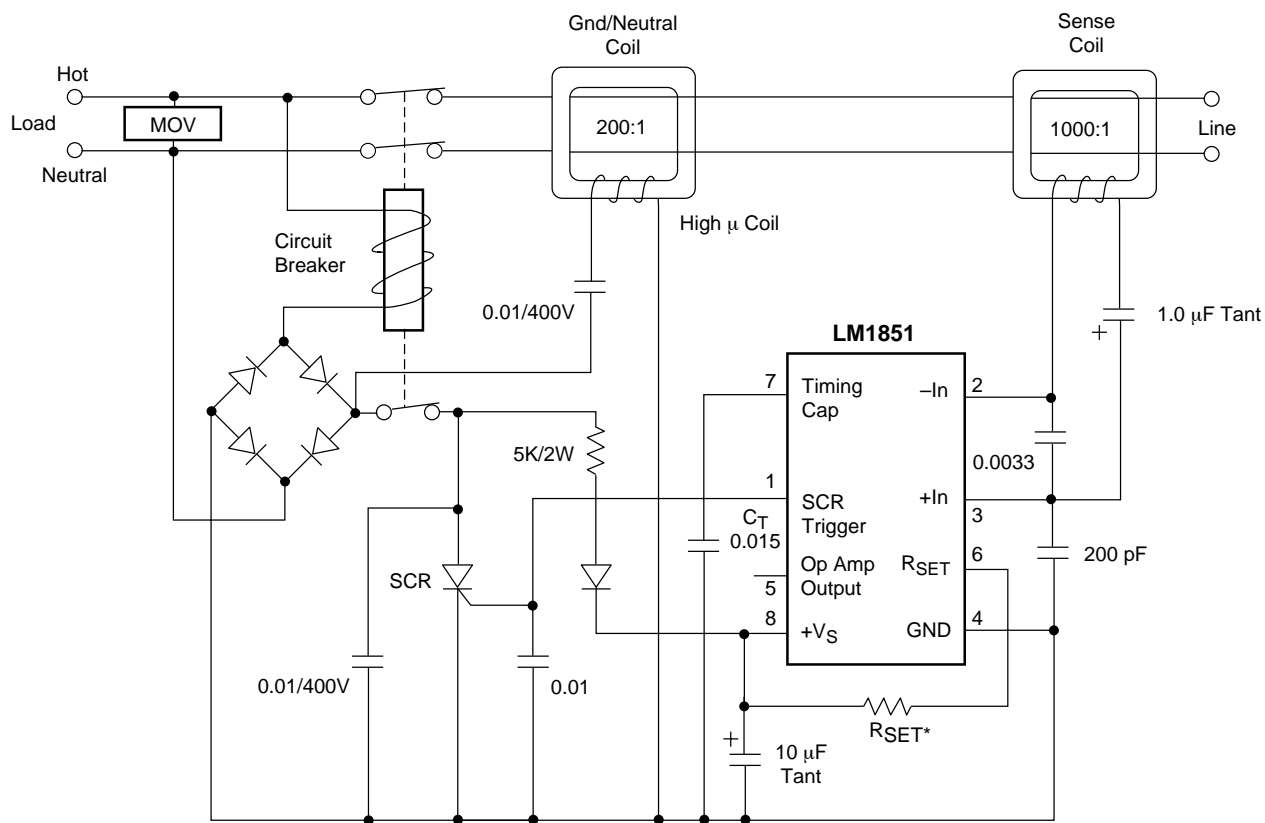


Figure 9. Normal Fault Sensitivity Test Circuit

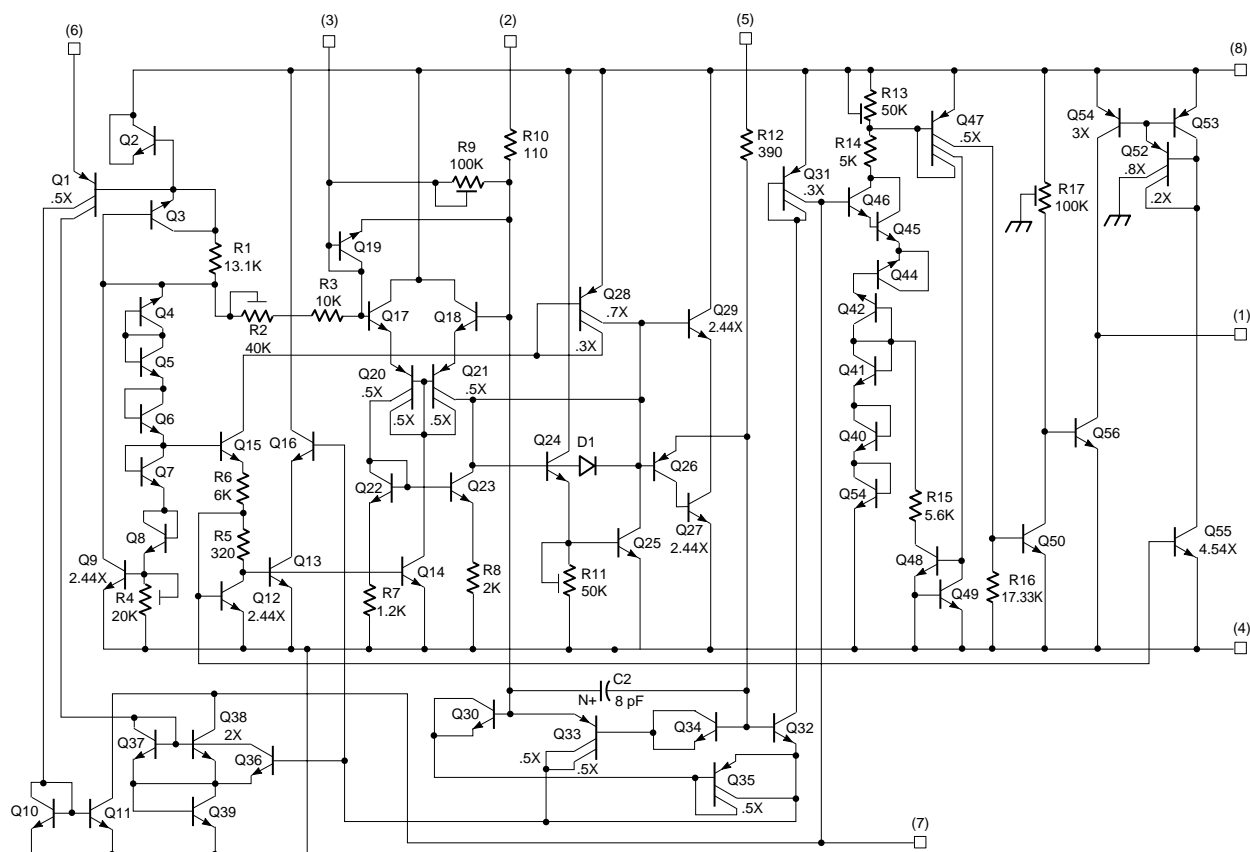


\*Adjust  $R_{SET}$  for desired sensitivity.

65-1851-11

Figure 10. 120 Hz Neutral Transformer Application

## Schematic Diagram



65-1851-13

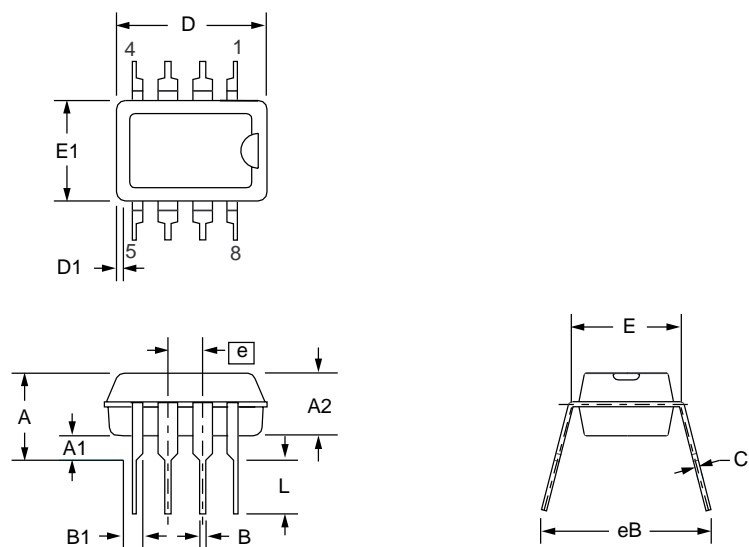
## Mechanical Dimensions

### 8-Lead Plastic DIP Package

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.210	—	5.33	
A1	.015	—	.38	—	
A2	.115	.195	2.93	4.95	
B	.014	.022	.36	.56	
B1	.045	.070	1.14	1.78	
C	.008	.015	.20	.38	4
D	.348	.430	8.84	10.92	2
D1	.005	—	.13	—	
E	.300	.325	7.62	8.26	
E1	.240	.280	6.10	7.11	2
e	.100 BSC		2.54 BSC		
eB	—	.430	—	10.92	
L	.115	.160	2.92	4.06	
N	8°		8°		5

#### Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E1" do not include mold flashing. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. Terminal numbers are for reference only.
4. "C" dimension does not include solder finish thickness.
5. Symbol "N" is the maximum number of terminals.



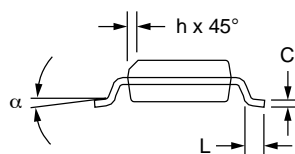
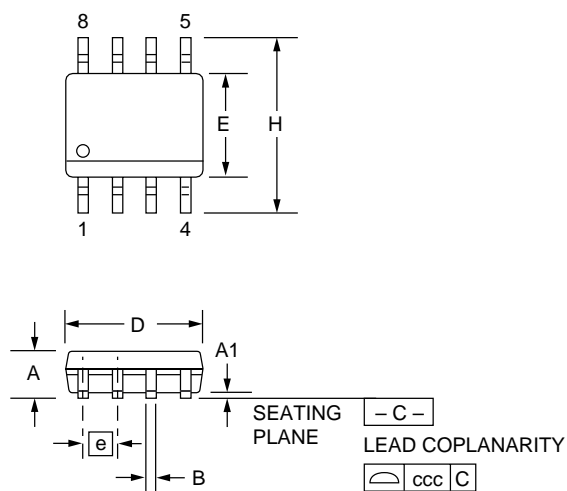
## Mechanical Dimensions (continued)

### 8-Lead Plastic SOIC Package

Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.053	.069	1.35	1.75	
A1	.004	.010	0.10	0.25	
B	.013	.020	0.33	0.51	
C	.008	.010	0.20	0.25	5
D	.189	.197	4.80	5.00	2
E	.150	.158	3.81	4.01	2
e	.050 BSC		1.27 BSC		
H	.228	.244	5.79	6.20	
h	.010	.020	0.25	0.50	
L	.016	.050	0.40	1.27	3
N	8		8		6
$\alpha$	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

#### Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.



## Ordering Information

Part Number	Package	Operating Temperature Range
LM1851AN	8-lead Plastic DIP	-40°C to +70°C
RV4145M	8-lead Plastic SOIC	-40°C to +70°C

### LIFE SUPPORT POLICY

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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

# LM1882•54ACT/74ACT715 LM1882-R•54ACT/74ACT715-R Programmable Video Sync Generator

## General Description

The 'ACT715/LM1882 and 'ACT715-R/LM1882-R are 20-pin TTL-input compatible devices capable of generating Horizontal, Vertical and Composite Sync and Blank signals for televisions and monitors. All pulse widths are completely definable by the user. The devices are capable of generating signals for both interlaced and noninterlaced modes of operation. Equalization and serration pulses can be introduced into the Composite Sync signal when needed.

Four additional signals can also be made available when Composite Sync or Blank are used. These signals can be used to generate horizontal or vertical gating pulses, cursor position or vertical Interrupt signal.

These devices make no assumptions concerning the system architecture. Line rate and field/frame rate are all a function of the values programmed into the data registers, the status register, and the input clock frequency.

The 'ACT715/LM1882 is mask programmed to default to a Clock Disable state. Bit 10 of the Status Register, Register 0, defaults to a logic "0". This facilitates (re)programming before operation.

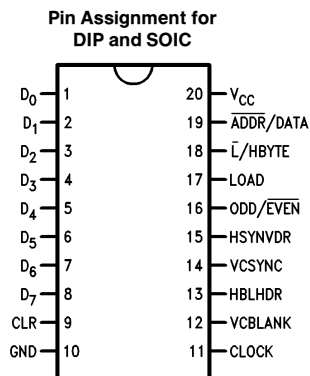
The 'ACT715-R/LM1882-R is the same as the 'ACT715/LM1882 in all respects except that the

'ACT715-R/LM1882-R is mask programmed to default to a Clock Enabled state. Bit 10 of the Status Register defaults to a logic "1". Although completely (re)programmable, the 'ACT715-R/LM1882-R version is better suited for applications using the default 14.31818 MHz RS-170 register values. This feature allows power-up directly into operation, following a single CLEAR pulse.

## Features

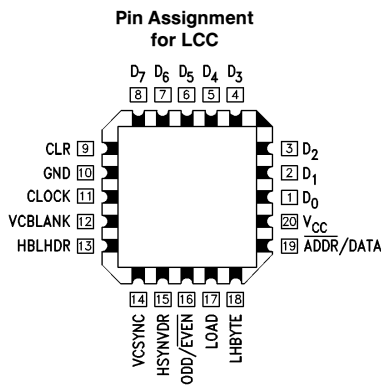
- Maximum Input Clock Frequency > 130 MHz
- Interlaced and non-interlaced formats available
- Separate or composite horizontal and vertical Sync and Blank signals available
- Complete control of pulse width via register programming
- All inputs are TTL compatible
- 8 mA drive on all outputs
- Default RS170/NTSC values mask programmed into registers
- 4 KV minimum ESD immunity
- 'ACT715-R/LM1882-R is mask programmed to default to a Clock Enable state for easier start-up into 14.31818 MHz RS170 timing

## Connection Diagrams



TL/F/10137-1

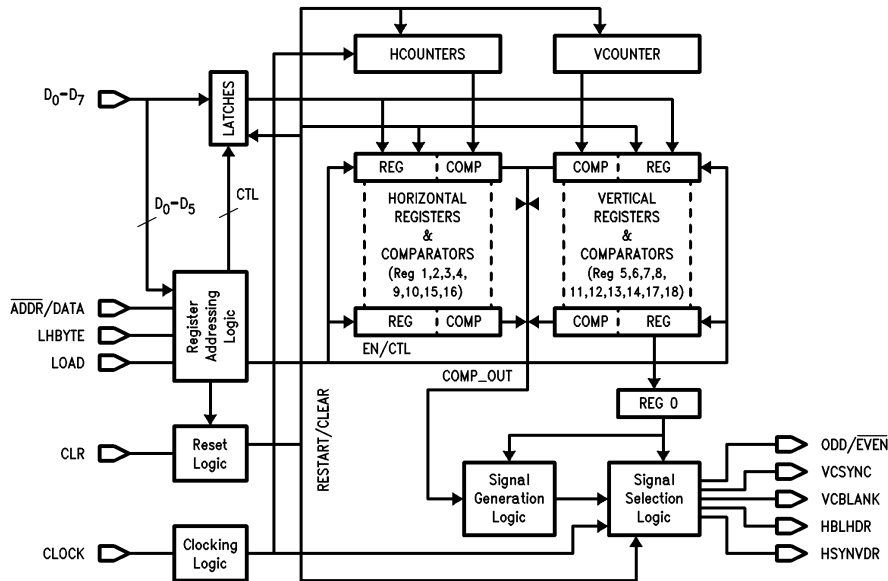
**Order Number LM1882CN or LM1882CM**  
**For Default RS-170, Order Number LM1882-RCN or LM1882-RCM**



TL/F/10137-2

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## Logic Block Diagram



TL/F/10137-3

## Pin Description

There are a Total of 13 inputs and 5 outputs on the 'ACT715/LM1882.

**Data Inputs D0-D7:** The Data Input pins connect to the Address Register and the Data Input Register.

**ADDR/DATA:** The ADDR/DATA signal is latched into the device on the falling edge of the LOAD signal. The signal determines if an address (0) or data (1) is present on the data bus.

**L/HBYTE:** The L/HBYTE signal is latched into the device on the falling edge of the LOAD signal. The signal determines if data will be read into the 8 LSB's (0) or the 4 MSB's (1) of the Data Registers. A 1 on this pin when an ADDR/DATA is a 0 enables Auto-Load Mode.

**LOAD:** The LOAD control pin loads data into the Address or Data Registers on the rising edge. ADDR/DATA and L/HBYTE data is loaded into the device on the falling edge of the LOAD. The LOAD pin has been implemented as a Schmitt trigger input for better noise immunity.

**CLOCK:** System CLOCK input from which all timing is derived. The clock pin has been implemented as a Schmitt trigger for better noise immunity. The CLOCK and the LOAD signal are asynchronous and independent. Output state changes occur on the falling edge of CLOCK.

**CLR:** The CLEAR pin is an asynchronous input that initializes the device when it is HIGH. Initialization consists of setting all registers to their mask programmed values, and initializing all counters, comparators and registers. The CLEAR pin has been implemented as a Schmitt trigger for better noise immunity. A CLEAR pulse should be asserted by the user immediately after power-up to ensure proper initialization of the registers—even if the user plans to (re)program the device.

**Note:** A CLEAR pulse will disable the CLOCK on the 'ACT715/LM1882 and will enable the CLOCK on the 'ACT715-R/LM1882-R.

**ODD/EVEN:** Output that identifies if display is in odd (HIGH) or even (LOW) field of interlace when device is in interlaced mode of operation. In noninterlaced mode of operation this output is always HIGH. Data can be serially scanned out on this pin during Scan Mode.

**VCSYNC:** Outputs Vertical or Composite Sync signal based on value of the Status Register. Equalization and Serration pulses will (if enabled) be output on the VCSYNC signal in composite mode only.

**VCBLANK:** Outputs Vertical or Composite Blanking signal based on value of the Status Register.

**HBLHDR:** Outputs Horizontal Blanking signal, Horizontal Gating signal or Cursor Position based on value of the Status Register.

**HSYNVDR:** Outputs Horizontal Sync signal, Vertical Gating signal or Vertical Interrupt signal based on value of Status Register.

## Register Description

All of the data registers are 12 bits wide. Width's of all pulses are defined by specifying the start count and end count of all pulses. Horizontal pulses are specified with-respect-to the number of clock pulses per line and vertical pulses are specified with-respect-to the number of lines per frame.

### REG0—STATUS REGISTER

The Status Register controls the mode of operation, the signals that are output and the polarity of these outputs. The default value for the Status Register is 0 (000 Hex) for the 'ACT715/LM1882 and is "512" (200 Hex) for the 'ACT715-R/LM1882-R.



## Register Description (Continued)

**Bits 0–2**

B <sub>2</sub>	B <sub>1</sub>	B <sub>0</sub>	VCBLANK	VCSYNC	HBLHDR	HSYNVDR
0	0	0	CBLANK	CSYNC	HGATE	VGATE
(DEFAULT)						
0	0	1	VBLANK	CSYNC	HBLANK	VGATE
0	1	0	CBLANK	VSYN	HGATE	HSYN
0	1	1	VBLANK	VSYN	HBLANK	HSYN
1	0	0	CBLANK	CSYN	CURSOR	VINT
1	0	1	VBLANK	CSYN	HBLANK	VINT
1	1	0	CBLANK	VSYN	CURSOR	HSYN
1	1	1	VBLANK	VSYN	HBLANK	HSYN

**Bits 3–4**

B <sub>4</sub>	B <sub>3</sub>	Mode of Operation
0	0	Interlaced Double Serration and Equalization
(DEFAULT)		
0	1	Non Interlaced Double Serration
1	0	Illegal State
1	1	Non Interlaced Single Serration and Equalization

Double Equalization and Serration mode will output equalization and serration pulses at twice the HSYNC frequency (i.e., 2 equalization or serration pulses for every HSYNC pulse). Single Equalization and Serration mode will output an equalization or serration pulse for every HSYNC pulse. In Interlaced mode equalization and serration pulses will be output during the VBLANK period of every odd and even field. Interlaced Single Equalization and Serration mode is not possible with this part.

### Bits 5–8

Bits 5 through 8 control the polarity of the outputs. A value of zero in these bit locations indicates an output pulse active LOW. A value of 1 indicates an active HIGH pulse.

B5— VCBLANK Polarity

B6— VCSYN Polarity

B7— HBLHDR Polarity

B8— HSYNVDR Polarity

### Bits 9–11

Bits 9 through 11 enable several different features of the device.

B9— Enable Equalization/Serration Pulses (0)  
Disable Equalization/Serration Pulses (1)

B10— Disable System Clock (0)  
Enable System Clock (1)

Default values for B10 are “0” in the ‘ACT715/LM1882 and “1” in the ‘ACT715-R/LM1882-R.

B11— Disable Counter Test Mode (0)  
Enable Counter Test Mode (1)

This bit is not intended for the user but is for internal testing only.

## HORIZONTAL INTERVAL REGISTERS

The Horizontal Interval Registers determine the number of clock cycles per line and the characteristics of the Horizontal Sync and Blank pulses.

REG1— Horizontal Front Porch

REG2— Horizontal Sync Pulse End Time

REG3— Horizontal Blanking Width

REG4— Horizontal Interval Width # of Clocks per Line

## VERTICAL INTERVAL REGISTERS

The Vertical Interval Registers determine the number of lines per frame, and the characteristics of the Vertical Blank and Sync Pulses.

REG5— Vertical Front Porch

REG6— Vertical Sync Pulse End Time

REG7— Vertical Blanking Width

REG8— Vertical Interval Width # of Lines per Frame

## EQUALIZATION AND SERRATION PULSE SPECIFICATION REGISTERS

These registers determine the width of equalization and serration pulses and the vertical interval over which they occur.

REG 9— Equalization Pulse Width End Time

REG10— Serration Pulse Width End Time

REG11— Equalization/Serration Pulse Vertical Interval Start Time

REG12— Equalization/Serration Pulse Vertical Interval End Time

## VERTICAL INTERRUPT SPECIFICATION REGISTERS

These Registers determine the width of the Vertical Interrupt signal if used.

REG13— Vertical Interrupt Activate Time

REG14— Vertical Interrupt Deactivate Time

## CURSOR LOCATION REGISTERS

These 4 registers determine the cursor position location, or they generate separate Horizontal and Vertical Gating signals.

REG15— Horizontal Cursor Position Start Time

REG16— Horizontal Cursor Position End Time

REG17— Vertical Cursor Position Start Time

REG18— Vertical Cursor Position End Time

## Signal Specification

### HORIZONTAL SYNC AND BLANK SPECIFICATIONS

All horizontal signals are defined by a start and end time. The start and end times are specified in number of clock cycles per line. The start of the horizontal line is considered pulse 1 not 0. All values of the horizontal timing registers are referenced to the falling edge of the Horizontal Blank signal (see *Figure 1*). Since the first CLOCK edge, CLOCK #1, causes the first falling edge of the Horizontal Blank reference pulse, edges referenced to this first Horizontal edge are  $n + 1$  CLOCKS away, where “n” is the width of the timing in question. Registers 1, 2, and 3 are programmed in this manner. The horizontal counters start at 1 and count until HMAX. The value of HMAX must be divisible by 2. This

## Signal Specification (Continued)

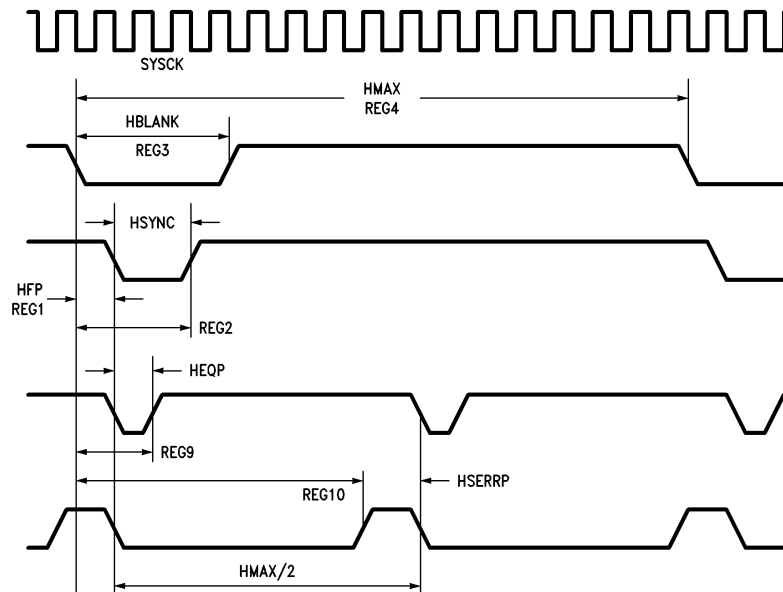


FIGURE 1. Horizontal Waveform Specification

TL/F/10137-4

limitation is imposed because during interface operation this value is internally divided by 2 in order to generate serration and equalization pulses at  $2 \times$  the horizontal frequency. Horizontal signals will change on the falling edge of the CLOCK signal. Signal specifications are shown below.

$$\begin{aligned}\text{Horizontal Period (HPER)} &= \text{REG}(4) \times \text{ckper} \\ \text{Horizontal Blanking Width} &= [\text{REG}(3) - 1] \times \text{ckper} \\ \text{Horizontal Sync Width} &= [\text{REG}(2) - \text{REG}(1)] \times \text{ckper} \\ \text{Horizontal Front Porch} &= [\text{REG}(1) - 1] \times \text{ckper}\end{aligned}$$

### VERTICAL SYNC AND BLANK SPECIFICATION

All vertical signals are defined in terms of number of lines per frame. This is true in both interlaced and noninterlaced modes of operation. Care must be taken to not specify the Vertical Registers in terms of lines per field. Since the first CLOCK edge, CLOCK #1, causes the first falling edge of the Vertical Blank (first Horizontal Blank) reference pulse, edges referenced to this first edge are  $n + 1$  lines away, where "n" is the width of the timing in question. Registers 5, 6, and 7 are programmed in this manner. Also, in the interlaced mode, vertical timing is based on half-lines. Therefore registers 5, 6, and 7 must contain a value twice the total horizontal (odd and even) plus 1 (as described above). In non-interlaced mode, all vertical timing is based on whole-lines. Register 8 is always based on whole-lines and does not add 1 for the first clock. The vertical counter starts at the value of 1 and counts until the value of VMAX. No restrictions exist on the values placed in the vertical registers. Vertical Blank will change on the leading edge of HBLANK. Vertical Sync will change on the leading edge of HSYNC. (See Figure 2A.)

$$\begin{aligned}\text{Vertical Frame Period (VPER)} &= \text{REG}(8) \times \text{hper} \\ \text{Vertical Field Period (VPER/n)} &= \text{REG}(8) \times \text{hper/n} \\ \text{Vertical Blanking Width} &= [\text{REG}(7) - 1] \times \text{hper/n} \\ \text{Vertical Syncing Width} &= [\text{REG}(6) - \text{REG}(5)] \times \text{hper/n} \\ \text{Vertical Front Porch} &= [\text{REG}(5) - 1] \times \text{hper/n} \\ \text{where } n &= 1 \text{ for noninterlaced} \\ &= 2 \text{ for interlaced}\end{aligned}$$

### COMPOSITE SYNC AND BLANK SPECIFICATION

Composite Sync and Blank signals are created by logically ANDing (ORing) the active LOW (HIGH) signals of the corresponding vertical and horizontal components of these signals. The Composite Sync signal may also include serration and/or equalization pulses. The Serration pulse interval occurs in place of the Vertical Sync interval. Equalization pulses occur preceding and/or following the Serration pulses. The width and location of these pulses can be programmed through the registers shown below. (See Figure 2B.)

$$\begin{aligned}\text{Horizontal Equalization PW} &= [\text{REG}(9) - \text{REG}(1)] \times \text{ckper} \\ \text{REG } 9 &= (\text{HFP}) + (\text{HEQP}) + 1 \\ \text{Horizontal Serration PW} &= [\text{REG}(4)/n + \text{REG}(1) - \text{REG}(10)] \times \text{ckper} \\ \text{REG } 10 &= (\text{HFP}) + (\text{HPER}/2) - (\text{HSERR}) + 1\end{aligned}$$

Where  $n = 1$  for noninterlaced single serration/equalization  
 $n = 2$  for noninterlaced double serration/equalization  
 $n = 2$  for interlaced operation

## Signal Specification (Continued)

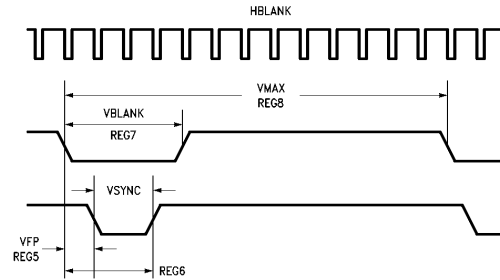


FIGURE 2A. Vertical Waveform Specification

TL/F/10137-5

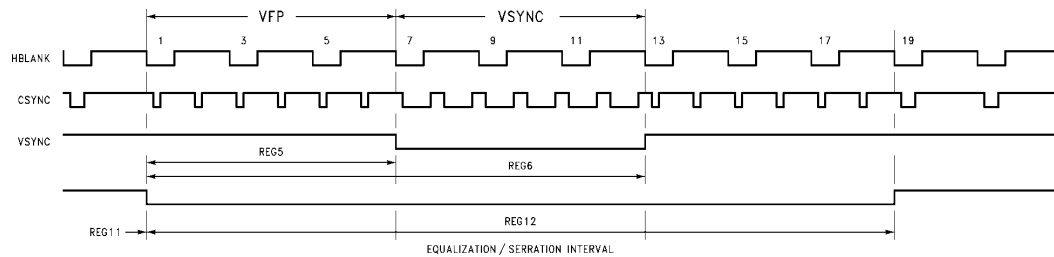


FIGURE 2B. Equalization/Serration Interval Programming

TL/F/10137-12

### HORIZONTAL AND VERTICAL GATING SIGNALS

Horizontal Drive and Vertical Drive outputs can be utilized as general purpose Gating Signals. Horizontal and Vertical Gating Signals are available for use when Composite Sync and Blank signals are selected and the value of Bit 2 of the Status Register is 0. The Vertical Gating signal will change in the same manner as that specified for the Vertical Blank.

$$\text{Horizontal Gating Signal Width} = [\text{REG}(16) - \text{REG}(15)] \times \text{ckper}$$

$$\text{Vertical Gating Signal Width} = [\text{REG}(18) - \text{REG}(17)] \times \text{hper}$$

### CURSOR POSITION AND VERTICAL INTERRUPT

The Cursor Position and Vertical Interrupt signal are available when Composite Sync and Blank signals are selected

and Bit 2 of the Status Register is set to the value of 1. The Cursor Position generates a single pulse of n clocks wide during every line that the cursor is specified. The signals are generated by logically ORing (ANDing) the active LOW (HIGH) signals specified by the registers used for generating Horizontal and Vertical Gating signals. The Vertical Interrupt signal generates a pulse during the vertical interval specified. The Vertical Interrupt signal will change in the same manner as that specified for the Vertical Blanking signal.

$$\text{Horizontal Cursor Width} = [\text{REG}(16) - \text{REG}(15)] \times \text{ckper}$$

$$\text{Vertical Cursor Width} = [\text{REG}(18) - \text{REG}(17)] \times \text{hper}$$

$$\text{Vertical Interrupt Width} = [\text{REG}(14) - \text{REG}(13)] \times \text{hper}$$

## Addressing Logic

The register addressing logic is composed of two blocks of logic. The first is the address register and counter (ADDRCNTR), and the second is the address decode (ADDRDEC).

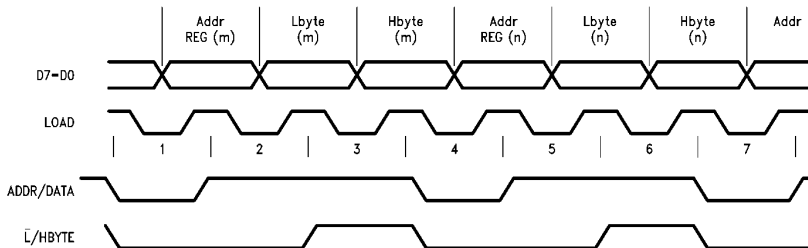
### ADDRCNTR LOGIC

Addresses for the data registers can be generated by one of two methods. Manual addressing requires that each byte of each register that needs to be loaded needs to be addressed. To load both bytes of all 19 registers would require a total of 57 load cycles (19 address and 38 data cycles). Auto Addressing requires that only the initial register value be specified. The Auto Load sequence would require only 39 load cycles to completely program all registers (1 address and 38 data cycles). In the auto load sequence the low order byte of the data register will be written first followed by the high order byte on the next load cycle. At the

time the High Byte is written the address counter is incremented by 1. The counter has been implemented to loop on the initial value loaded into the address register. For example: If a value of 0 was written into the address register then the counter would count from 0 to 18 before resetting back to 0. If a value of 15 was written into the address register then the counter would count from 15 to 18 before looping back to 15. If a value greater than or equal to 18 is placed into the address register the counter will continuously loop on this value. Auto addressing is initiated on the falling edge of LOAD when ADDRDATA is 0 and LHBYTE is 1. Incrementing and loading of data registers will not commence until the falling edge of LOAD after ADDRDATA goes to 1. The next rising edge of LOAD will load the first byte of data. Auto Incrementing is disabled on the falling edge of LOAD after ADDRDATA and LHBYTE goes low.

#### Manual Addressing Mode

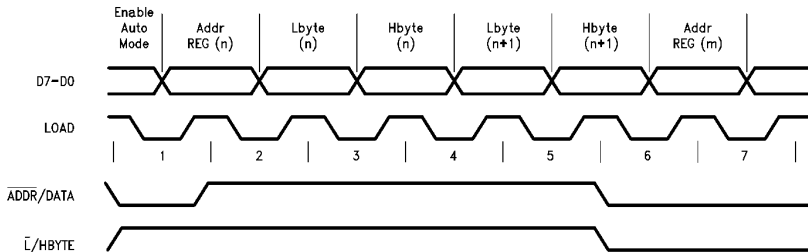
Cycle #	Load Falling Edge	Load Rising Edge
1	Enable Manual Addressing	Load Address m
2	Enable Lbyte Data Load	Load Lbyte m
3	Enable Hbyte Data Load	Load Hbyte m
4	Enable Manual Addressing	Load Address n
5	Enable Lbyte Data Load	Load Lbyte n
6	Enable Hbyte Data Load	Load Hbyte n



TL/F/10137-7

#### Auto Addressing Mode

Cycle #	Load Falling Edge	Load Rising Edge
1	Enable Auto Addressing	Load Start Address n
2	Enable Lbyte Data Load	Load Lbyte (n)
3	Enable Hbyte Data Load	Load Hbyte (n); Inc Counter
4	Enable Lbyte Data Load	Load Lbyte (n + 1)
5	Enable Hbyte Data Load	Load Hbyte (n + 1); Inc Counter
6	Enable Manual Addressing	Load Address



TL/F/10137-8

## Addressing Logic (Continued)

### ADDRDEC LOGIC

The ADDRDEC logic decodes the current address and generates the enable signal for the appropriate register. The enable values for the registers and counters change on the falling edge of LOAD. Two types of ADDRDEC logic is enabled by 2 pair of addresses, Addresses 22 or 54 (Vectored Restart logic) and Addresses 23 or 55 (Vectored Clear logic). Loading these addresses will enable the appropriate logic and put the part into either a Restart (all counter registers are reinitialized with preprogrammed data) or Clear (all registers are cleared to zero) state. Reloading the same ADDRDEC address will not cause any change in the state of the part. The outputs during these states are frozen and the internal CLOCK is disabled. Clocking the part during a Vectored Restart or Vectored Clear state will have no effect on the part. To resume operation in the new state, or disable the Vectored Restart or Vectored Clear state, another non-ADDRDEC address must be loaded. Operation will begin in the new state on the rising edge of the non-ADDRDEC load pulse. It is recommended that an unused address be loaded following an ADDRDEC operation to prevent data registers from accidentally being corrupted. The following Addresses are used by the device.

Address 0	Status Register REG0
Address 1–18	Data Registers REG1–REG18
Address 19–21	Unused
Address 22/54	Restart Vector (Restarts Device)
Address 23/55	Clear Vector (Zeros All Registers)
Address 24–31	Unused
Address 32–50	Register Scan Addresses
Address 51–53	Counter Scan Addresses
Address 56–63	Unused

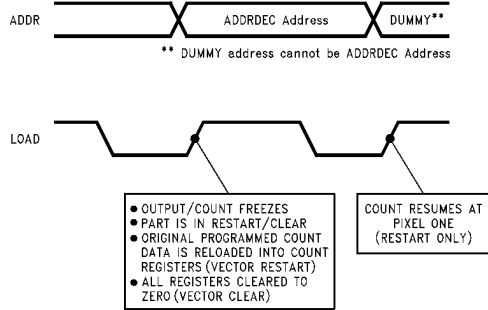
At any given time only one register at most is selected. It is possible to have no registers selected.

### VECTORED RESTART ADDRESS

The function of addresses 22 (16H) or 54 (36H) are similar to that of the CLR pin except that the preprogramming of the registers is not affected. It is recommended but not required that this address is read after the initial device configuration load sequence. A 1 on the ADDRDATA pin (Auto Addressing Mode) will not cause this address to automatically increment. The address will loop back onto itself regardless of the state of ADDRDATA unless the address on the Data inputs has been changed with ADDRDATA at 0.

### VECTORED CLEAR ADDRESS

Addresses 23 (17H) or 55 (37H) is used to clear all registers to zero simultaneously. This function may be desirable to use prior to loading new data into the Data or Status Registers. This address is read into the device in a similar fashion as all of the other registers. A 1 on the ADDRDATA pin (Auto Addressing Mode) will not cause this address to automatically increment. The address will loop back onto itself regardless of the state of ADDRDATA unless the address on the Data inputs has been changed with ADDRDATA at 0.



TL/F/10137-9

FIGURE 3. ADDRDEC Timing

### GEN LOCKING

The 'ACT715/LM1882 and 'ACT715-R/LM1882-R is designed for master SYNC and BLANK signal generation. However, the devices can be synchronized (slaved) to an external timing signal in a limited sense. Using Vectored Restart, the user can reset the counting sequence to a given location, the beginning, at a given time, the rising edge of the LOAD that removes Vector Restart. At this time the next CLOCK pulse will be CLOCK 1 and the count will restart at the beginning of the first odd line.

Preconditioning the part during normal operation, before the desired synchronizing pulse, is necessary. However, since LOAD and CLOCK are asynchronous and independent, this is possible without interruption or data and performance corruption. If the defaulted 14.31818 MHz RS-170 values are being used, preconditioning and restarting can be minimized by using the CLEAR pulse instead of the Vectored Restart operation. The 'ACT715-R/LM1882-R is better suited for this application because it eliminates the need to program a 1 into Bit 10 of the Status Register to enable the CLOCK. Gen Locking to another count location other than the very beginning or separate horizontal/vertical resetting is not possible with the 'ACT715/LM1882 nor the 'ACT715-R/LM1882-R.

### SCAN MODE LOGIC

A scan mode is available in the ACT715/LM1882 that allows the user to non-destructively verify the contents of the registers. Scan mode is invoked through reading a scan address into the address register. The scan address of a given register is defined by the Data register address + 32. The internal Clocking signal is disabled when a scan address is read. Disabling the clock freezes the device in its present state. Data can then be serially scanned out of the data registers through the ODD/EVEN Pin. The LSB will be scanned out first. Since each register is 12 bits wide, completely scanning out data of the addressed register will require 12 CLOCK pulses. More than 12 CLOCK pulses on the same register will only cause the MSB to repeat on the output. Re-scanning the same register will require that register to be reloaded. The value of the two horizontal counters and 1 vertical counter can also be scanned out by using address numbers 51–53. Note that before the part will scan out the data, the LOAD signal must be brought back HIGH.

## Addressing Logic (Continued)

Normal device operation can be resumed by loading in a non-scan address. As the scanning of the registers is a non-destructive scan, the device will resume correct operation from the point at which it was halted.

## RS170 Default Register Values

The tables below show the values programmed for the RS170 Format (using a 14.31818 MHz clock signal) and how they compare against the actual EIA RS170 Specifications. The default signals that will be output are CSYNC, CBLANK, HDRIVE and VDRIVE. The device initially starts at the beginning of the odd field of interlace. All signals have active low pulses and the clock is disabled at power up. Registers 13 and 14 are not involved in the actual signal information. If the Vertical Interrupt was selected so that a pulse indicating the active lines would be output.

Reg	D Value H		Register Description
REG0	0	000	Status Register (715/LM1882)
REG0	1024	400	Status Register (715-R/LM1882-R)
REG1	23	017	HFP End Time
REG2	91	05B	HSYNC Pulse End Time
REG3	157	09D	HBLANK Pulse End Time
REG4	910	38E	Total Horizontal Clocks
REG5	7	007	VFP End Time
REG6	13	00D	VSYSNC Pulse End Time
REG7	41	029	VLANK Pulse End Time
REG8	525	20D	Total Vertical Lines
REG9	57	039	Equalization Pulse End Time
REG10	410	19A	Serration Pulse Start Time
REG11	1	001	Pulse Interval Start Time
REG12	19	013	Pulse Interval End Time
REG13	41	029	Vertical Interrupt Activate Time
REG14	526	20E	Vertical Interrupt Deactivate Time
REG15	911	38F	Horizontal Drive Start Time
REG16	92	05C	Horizontal Drive End Time
REG17	1	001	Vertical Drive Start Time
REG18	21	015	Vertical Drive End Time

	Rate	Period
Input Clock	14.31818 MHz	69.841 ns
Line Rate	15.73426 kHz	63.556 $\mu$ s
Field Rate	59.94 Hz	16.683 ms
Frame Rate	29.97 Hz	33.367 ms

### RS170 Horizontal Data

Signal	Width	$\mu$ s	%H	Specification ( $\mu$ s)
HFP	22 Clocks	1.536		1.5 $\pm$ 0.1
HSYNC Width	68 Clocks	4.749	7.47	4.7 $\pm$ 0.1
HBLANK Width	156 Clocks	10.895	17.15	10.9 $\pm$ 0.2
HDRIVE Width	91 Clocks	6.356	10.00	0.1H $\pm$ 0.005H
HEQP Width	34 Clocks	2.375	3.74	2.3 $\pm$ 0.1
HSERR Width	68 Clocks	4.749	7.47	4.7 $\pm$ 0.1
HPER iod	910 Clocks	63.556	100	

### RS170 Vertical Data

VFP	3 Lines	190.67		6 EQP Pulses
VSYSNC Width	3 Lines	190.67		6 Serration Pulses
VLANK Width	20 Lines	1271.12	7.62	0.075V $\pm$ 0.005V
VDRIVE Width	11.0 Lines	699.12	4.20	0.04V $\pm$ 0.006V
VEQP Intrvl	9 Lines		3.63	9 Lines/Field
VPERiod (field)	262.5 Lines	16.683 ms		16.683 ms/Field
VPERiod (frame)	525 Lines	33.367 ms		33.367 ms/Frame

## Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage ( $V_{CC}$ )	−0.5V to +7.0V
DC Input Diode Current ( $I_{IK}$ )	
$V_I = -0.5V$	−20 mA
$V_I = V_{CC} + 0.5V$	+20 mA
DC Input Voltage ( $V_I$ )	−0.5V to $V_{CC} + 0.5V$
DC Output Diode Current ( $I_{OK}$ )	
$V_O = -0.5V$	−20 mA
$V_O = V_{CC} + 0.5V$	+20 mA
DC Output Voltage ( $V_O$ )	−0.5V to $V_{CC} + 0.5V$
DC Output Source or Sink Current ( $I_O$ )	±15 mA
DC $V_{CC}$ or Ground Current per Output Pin ( $I_{CC}$ or $I_{GND}$ )	±20 mA
Storage Temperature ( $T_{STG}$ )	−65°C to +150°C

Junction Temperature ( $T_J$ )

Ceramic	175°C
Plastic	140°C

**Note 1:** Absolute maximum ratings are those values beyond which damage to the device may occur. The databook specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature and output/input loading variables. National does not recommend operation of FACT™ circuits outside databook specifications.

## Recommended Operating Conditions

Supply Voltage ( $V_{CC}$ )	4.5V to 5.5V
Input Voltage ( $V_I$ )	0V to $V_{CC}$
Output Voltage ( $V_O$ )	0V to $V_{CC}$
Operating Temperature ( $T_A$ )	
74ACT	−40°C to +85°C
54ACT	−55°C to +125°C
Minimum Input Edge Rate ( $\Delta V/\Delta t$ )	
$V_{IN}$ from 0.8V to 2.0V	
$V_{CC}$ @ 4.5V, 5.5V	125 mV/ns

## DC Characteristics For 'ACT Family Devices over Operating Temperature Range (unless otherwise specified)

Symbol	Parameter	V <sub>CC</sub> (V)	ACT/LM1882		54ACT/LM1882		74ACT/LM1882		Units	Conditions
			T <sub>A</sub> = +25°C C <sub>L</sub> = 50 pF		T <sub>A</sub> = −55°C to +125°C C <sub>L</sub> = 50 pF		T <sub>A</sub> = −40°C to +85°C			
			Typ	Guaranteed Limits						
V <sub>OH</sub>	Minimum High Level Output Voltage	4.5	4.49	4.4	4.4	4.4	V	I <sub>OUT</sub> = −50 μA		
		5.5	5.49	5.4	5.4	5.4	V			
		4.5		3.86	3.7	3.76	V	*V <sub>IN</sub> = V <sub>IL</sub> /V <sub>IH</sub>		
V <sub>OL</sub>	Maximum Low Level Output Voltage	5.5		4.86	4.7	4.76	V	I <sub>OH</sub> = −8 mA		
		4.5	0.001	0.1	0.1	0.1	V	I <sub>OUT</sub> = 50 μA		
		5.5	0.001	0.1	0.1	0.1	V			
I <sub>OLD</sub>	Minimum Dynamic Output Current	4.5		0.36	0.5	0.44	V	*V <sub>IN</sub> = V <sub>IL</sub> /V <sub>IH</sub>		
		5.5		0.36	0.5	0.44	V	I <sub>OH</sub> = +8 mA		
		5.5			32.0	32.0	mA	V <sub>OLD</sub> = 1.65V		
I <sub>OHD</sub>	Minimum Dynamic Output Current	5.5			−32.0	−32.0	mA	V <sub>OHD</sub> = 3.85V		
I <sub>IN</sub>	Maximum Input Leakage Current	5.5		±0.1	±1.0	±1.0	μA	V <sub>I</sub> = V <sub>CC</sub> , GND		
I <sub>CC</sub>	Supply Current Quiescent	5.5		8.0	160	80	μA	V <sub>IN</sub> = V <sub>CC</sub> , GND		
I <sub>CCT</sub>	Maximum I <sub>CC</sub> /Input	5.5	0.6		1.6	1.5	mA	V <sub>IN</sub> = V <sub>CC</sub> − 2.1V		

\*All outputs loaded; thresholds on input associated with input under test.

**Note 1:** Test Load 50 pF, 500Ω to Ground.

## AC Electrical Characteristics

Symbol	Parameter	V <sub>CC</sub> (V)	ACT/LM1882			54ACT/LM1882		74ACT/LM1882		Units
			T <sub>A</sub> = +25°C C <sub>L</sub> = 50 pF			T <sub>A</sub> = −55°C to +125°C C <sub>L</sub> = 50 pF		T <sub>A</sub> = −40°C to +85°C C <sub>L</sub> = 50 pF		
			Min	Typ	Max	Min	Max	Min	Max	
f <sub>MAXI</sub>	Interlaced f <sub>MAX</sub> (HMAX/2 is ODD)	5.0	170	190		130		150		MHz
f <sub>MAX</sub>	Non-Interlaced f <sub>MAX</sub> (HMAX/2 is EVEN)	5.0	190	220		145		175		MHz
t <sub>PLH1</sub> t <sub>PHL1</sub>	Clock to Any Output	5.0	4.0	13.0	15.5	3.5	19.5	3.5	18.5	ns
t <sub>PLH2</sub> t <sub>PHL2</sub>	Clock to ODDEVEN (Scan Mode)	5.0	4.5	15.0	17.0	3.5	22.0	3.5	20.5	ns
t <sub>PLH3</sub>	Load to Outputs	5.0	4.0	11.5	16.0	3.0	20.0	3.0	19.5	ns

## AC Operating Requirements

Symbol	Parameter	V <sub>CC</sub> (V)	ACT/LM1882		54ACT/LM1882	74ACT/LM1882	Units
			T <sub>A</sub> = +25°C		T <sub>A</sub> = −55°C to +125°C	T <sub>A</sub> = −40°C to +85°C	
			Typ	Guaranteed Minimums			
t <sub>sc</sub> t <sub>sc</sub>	Control Setup Time ADDR/DATA to LOAD− L/HBYTE to LOAD−	5.0	3.0 3.0	4.0 4.0	4.5 4.5	4.5 4.5	ns ns
t <sub>sd</sub>	Data Setup Time D7−D0 to LOAD+	5.0	2.0	4.0	4.5	4.5	ns
t <sub>hc</sub>	Control Hold Time LOAD− to ADDR/DATA LOAD− to L/HBYTE	5.0	0 0	1.0 1.0	1.0 1.0	1.0 1.0	ns ns
t <sub>hd</sub>	Data Hold Time LOAD+ to D7−D0	5.0	1.0	2.0	2.0	2.0	ns
t <sub>rec</sub>	LOAD+ to CLK (Note 1)	5.0	5.5	7.0	8.0	8.0	ns
t <sub>wld</sub> − t <sub>wld</sub> +	Load Pulse Width LOW HIGH	5.0 5.0	3.0 3.0	5.5 5.0	5.5 7.5	5.5 7.5	ns ns
t <sub>wclr</sub>	CLR Pulse Width HIGH	5.0	5.5	6.5	9.5	9.5	ns
t <sub>wck</sub>	CLOCK Pulse Width (HIGH or LOW)	5.0	2.5	3.0	4.0	3.5	ns

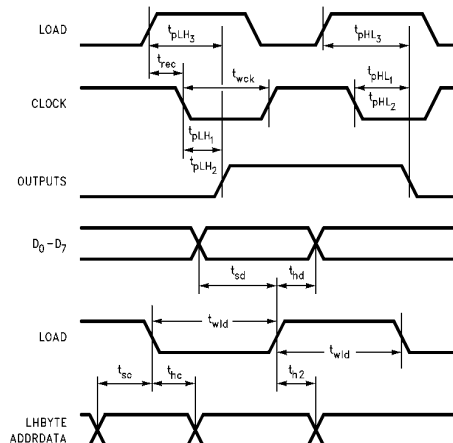
**Note 1:** Removal of Vectored Reset or Restart to Clock.

## Capacitance

Symbol	Parameter	Typ	Units	Conditions
C <sub>IN</sub>	Input Capacitance	7.0	pF	V <sub>CC</sub> = 5.0V
C <sub>PD</sub>	Power Dissipation Capacitance	17.0	pF	V <sub>CC</sub> = 5.0V



## AC Operating Requirements (Continued)



TL/F/10137-6

FIGURE 4. AC Specifications

## Additional Applications Information

### POWERING UP

The 'ACT715/LM1882 default value for Bit 10 of the Status Register is 0. This means that when the CLEAR pulse is applied and the registers are initialized by loading the default values the CLOCK is disabled. Before operation can begin, Bit 10 must be changed to a 1 to enable CLOCK. If the default values are needed (no other programming is required) then Figure 5 illustrates a hardwired solution to facilitate the enabling of the CLOCK after power-up. Should control signals be difficult to obtain, Figure 6 illustrates a possible solution to automatically enable the CLOCK upon power-up. Use of the 'ACT715-R/LM1882-R eliminates the need for most of this circuitry. Modifications of the Figure 6 circuit can be made to obtain the lone CLEAR pulse still needed upon power-up.

Note that, although during a Vectored Restart none of the preprogrammed registers are affected, some signals are affected for the duration of one frame only. These signals are the Horizontal and Vertical Drive signals. After a Vectored Restart the beginning of these signals will occur at the first CLK. The end of the signals will occur as programmed. At the completion of the first frame, the signals will resume to their programmed start and end time.

### PREPROGRAMMING "ON-THE-FLY"

Although the 'ACT715/LM1882 and 'ACT715-R/LM1882-R are completely programmable, certain limitations must be set as to when and how the parts can be reprogrammed. Care must be taken when reprogramming any End Time registers to a new value that is lower than the current value. Should the reprogramming occur when the counters are at a count after the new value but before the old value, then the counters will continue to count up to 4096 before rolling over.

For this reason one of the following two precautions are recommended when reprogramming "on-the-fly". The first recommendation is to reprogram horizontal values during the horizontal blank interval only and/or vertical values during the vertical blank interval only. Since this would require delicate timing requirements the second recommendation may be more appropriate.

The second recommendation is to program a Vectored Restart as the final step of reprogramming. This will ensure that all registers are set to the newly programmed values and that all counters restart at the first CLK position. This will avoid overrunning the counter end times and will maintain the video integrity.

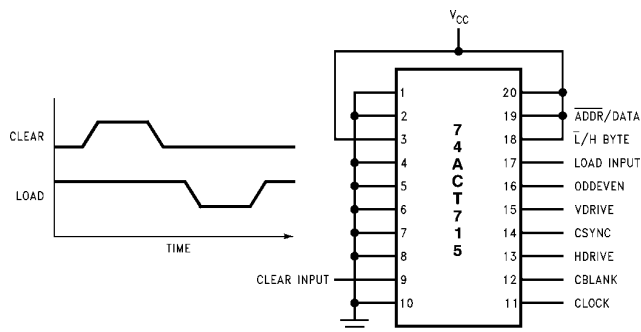
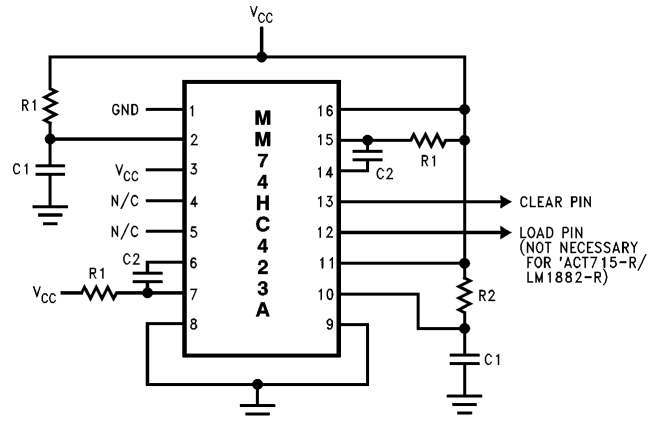


FIGURE 5. Default RS170 Hardwire Configuration

TL/F/10137-10

## Additional Applications Information (Continued)



TL/F/10137-11

**Note:** A 74HC221A may be substituted for the 74HC423A Pin 6 and Pin 14 must be hardwired to GND

### Components

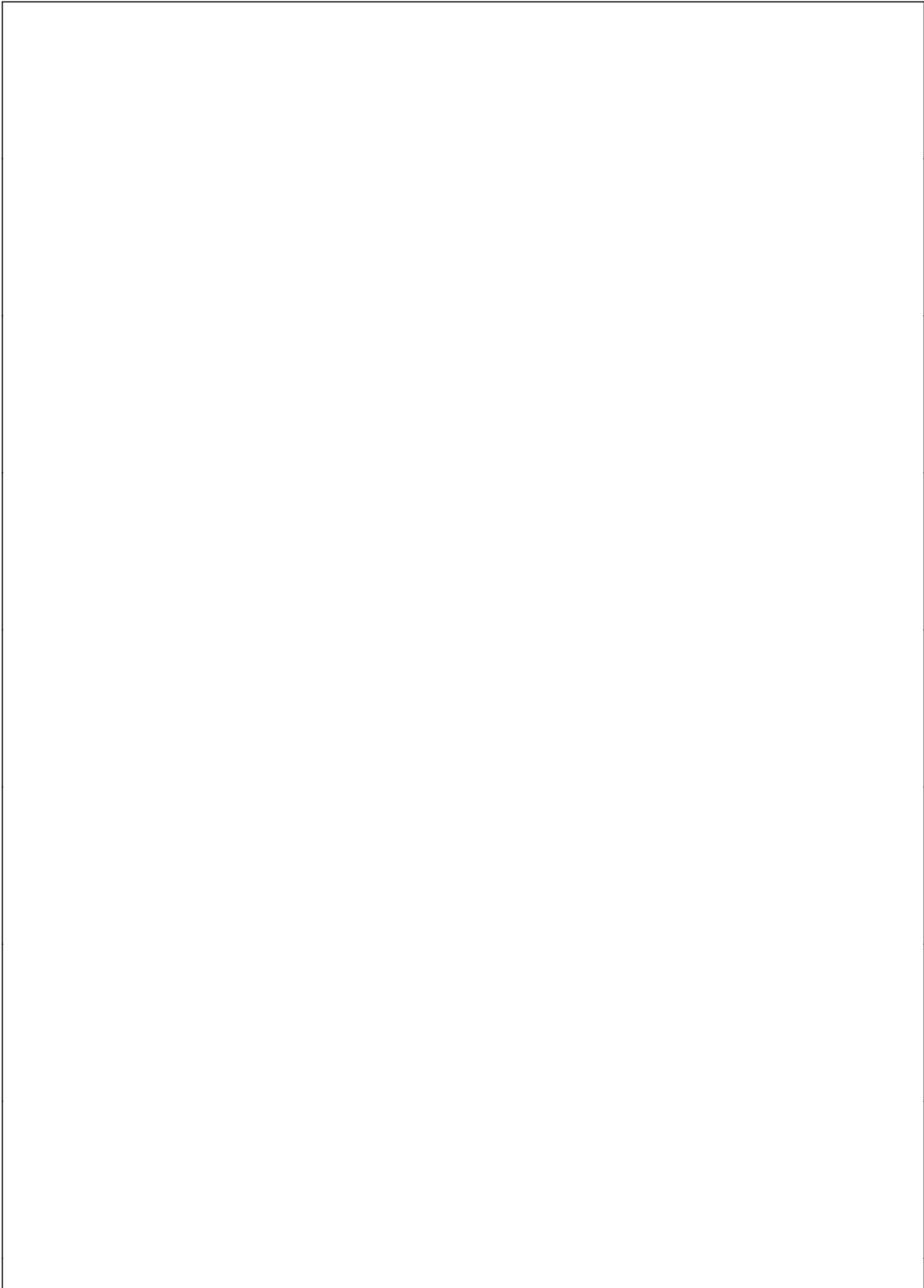
R1: 4.7k C1: 10  $\mu$ F  
R2: 10k C2: 50 pF

**FIGURE 6. Circuit for Clear and Load Pulse Generation**

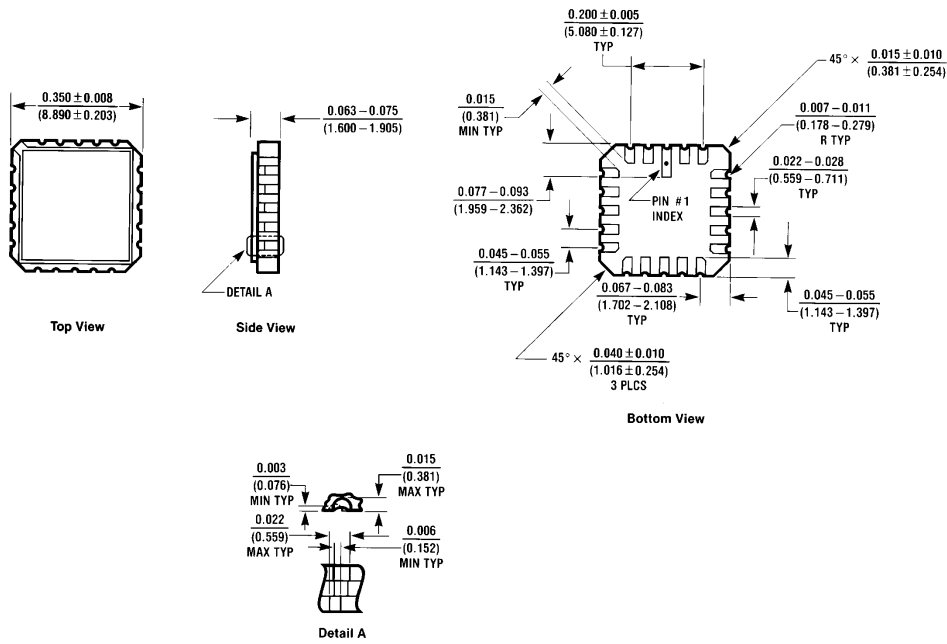
## Ordering Information

The device number is used to form part of a simplified purchasing code where a package type and temperature range are defined as follows:

Temperature Range Family	74ACT	715	P	C	QR	Special Variations
74ACT = Commercial TTL-Compatible						X = Devices shipped in 13" reels
54ACT = Military TTL-Compatible						QR = Commercial grade device with burn-in
Device Type						QB = Military grade device with environmental and burn-in processing shipped in tubes.
715 = Default: CLOCK Disabled						
715-R = Default: CLOCK Enabled						
Package Code						Temperature Range
P = Plastic DIP						C = Commercial ( $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ )
D = Ceramic DIP						M = Military ( $-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ )
L = Leadless Chip Carrier (LCC)						
S = Small Outline (SOIC)						
OR						
Default: CLOCK Disabled	LM1882CM = Commercial Small Outline (SOIC)					
	LM1882CN = Commercial Plastic DIP					
	LM1882J/883 = Military Ceramic Dip					
	LM1882E/883 = Military Leadless Chip Carrier					
Default: CLOCK Enabled	LM1882-RCM = Commercial Small Outline (SOIC)					
	LM1882-RCN = Commercial Plastic DIP					
	LM1882-RJ/883 = Military Ceramic Dip					
	LM1882-RE/883 = Military Leadless Chip Carrier					

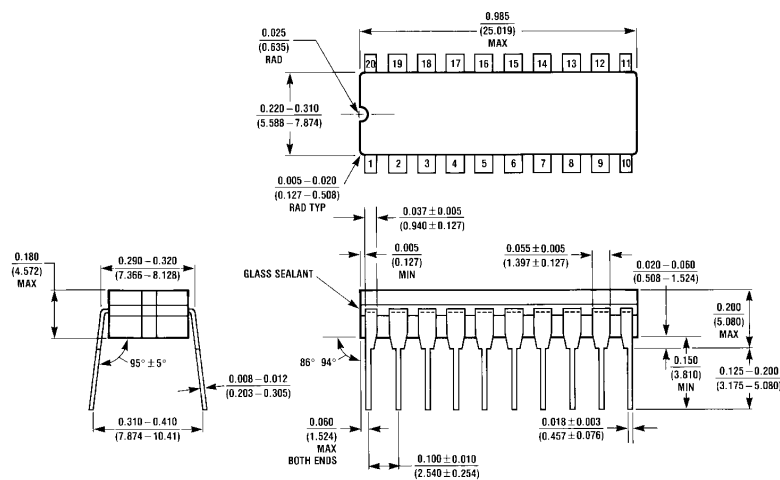


# Physical Dimensions inches (millimeters)

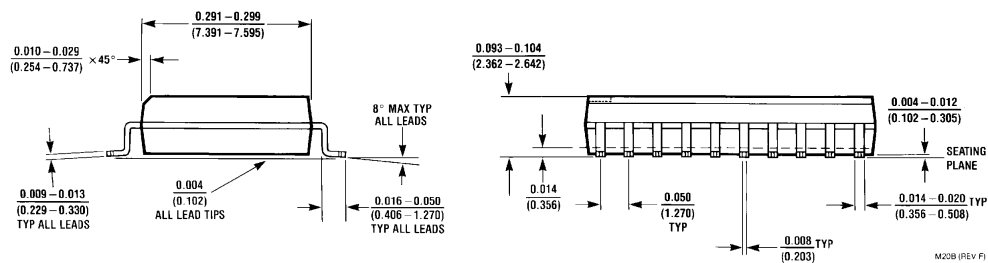
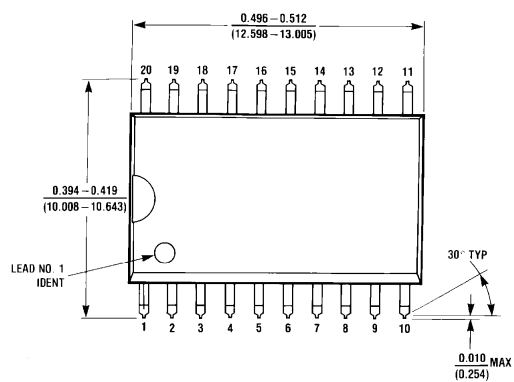


**20-Terminal Ceramic Leadless Chip Carrier (L)**  
**NS Package Number E20A**

E20A (REV D)

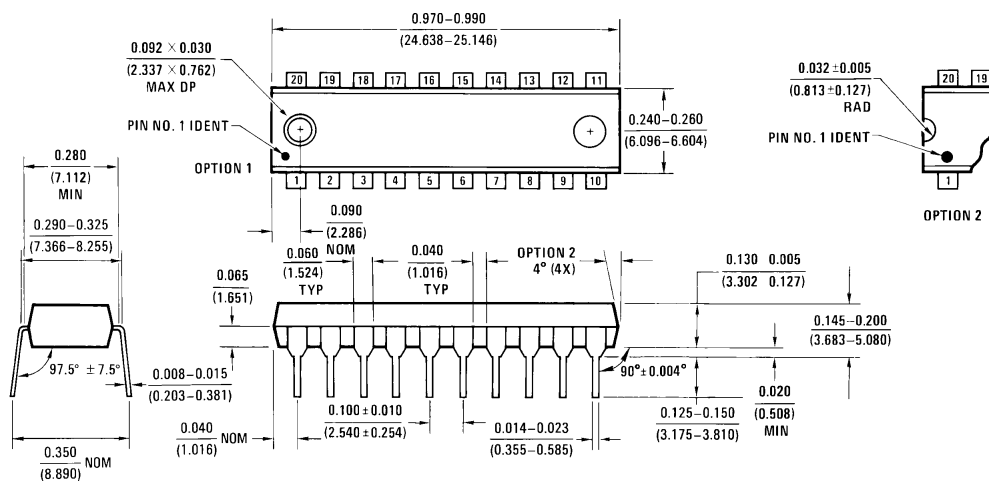
**Physical Dimensions** inches (millimeters) (Continued)

**20-Lead Ceramic Dual-In-Line Package (D)**  
**NS Package Number J20A**



**20-Lead Small Outline Integrated Circuit (S)  
NS Package Number M20B**

## Physical Dimensions inches (millimeters) (Continued)



20-Lead Plastic Dual-In-Line Package (P)  
NS Package Number N20B

N20B (REV A)

## LIFE SUPPORT POLICY

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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# LM224/A, LM324/A, LM2902 QUAD OPERATIONAL AMPLIFIER

## QUAD OPERATIONAL AMPLIFIERS

14 DIP

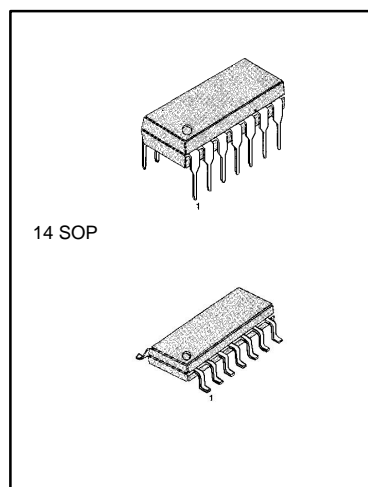
The LM224 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide voltage range.

Operation from split power supplies is also possible so long as the difference between the two supplies is 3 volts to 32 volts.

Application areas include transducer amplifier, DC gain blocks and all the conventional OP amp circuits which now can be easily implemented in single power supply systems.

## FEATURES

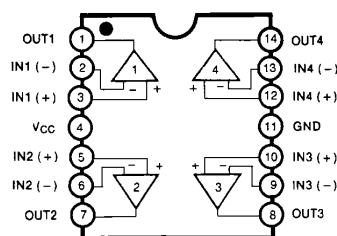
- Internally frequency compensated for unity gain
- Large DC voltage gain: 100dB
- Wide power supply range: LM224/A, LM324/A: 3V ~32V (or  $\pm 1.5 \sim 15V$ )  
LM2902: 3V~26V (or  $\pm 1.5V \sim 13V$ )
- Input common-mode voltage range includes ground
- Large output voltage swing: 0V DC to  $V_{CC} - 1.5V$  DC
- Power drain suitable for battery operation.



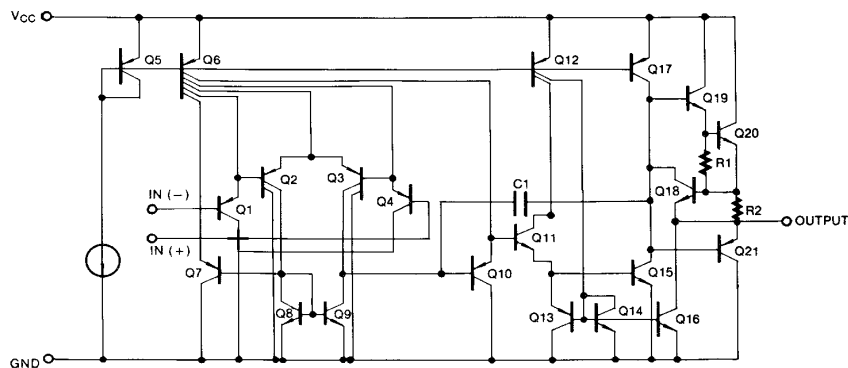
## ORDERING INFORMATION

Device	Package	Operating Temperature
LM324N LM324AN	14 DIP	0 ~ +70°C
LM324M LM324AM	14 SOP	
LM224N LM224AN	14 DIP	-25 ~ +85°C
LM224M LM224AM	14 SOP	
LM2902N	14 DIP	-40 ~ +85°C
LM2902M	14 SOP	

## BLOCK DIAGRAM



## SCHEMATIC DIAGRAM (One Section Only)



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Rev. B

# LM224/A, LM324/A, LM2902 QUAD OPERATIONAL AMPLIFIER

## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	LM224/LM224A	LM324/LM324A	LM2902	Unit
Power Supply Voltage	$V_{CC}$	$\pm 18$ or 32	$\pm 18$ or 32	$\pm 13$ or 26	V
Differential Input Voltage	$V_{I(DIFF)}$	32	32	26	V
Input Voltage	$V_I$	-0.3 to + 32	-0.3 to +32	-0.3 to +26	V
Output Short Circuit to GND $V_{CC} \leq 15V$ $T_A = 25^\circ C$ (One Amp)		Continuous	Continuous	Continuous	
Power Dissipation	$P_D$	570	570	570	mW
Operating Temperature Range	$T_{OPR}$	-25 ~ +85	0 ~ + 70	-40 ~ + 85	$^\circ C$
Storage Temperature Range	$T_{STG}$	-65 ~ + 150	-65 ~ + 150	-65 ~ + 150	$^\circ C$

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = 5.0V$ ,  $V_{EE} = GND$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM224			LM324			LM2902			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0V$ to $V_{CC} = 1.5V$ $V_{O(P)} = 1.4V$ , $R_S = 0\Omega$		1.5	5.0		1.5	7.0		1.5	7.0	mV
Input Offset Current	$I_{IO}$			2.0	30		3.0	50		3.0	50	nA
Input Bias Current	$I_{BIAS}$			40	150		40	250		40	250	nA
Input Common-Mode Voltage Range	$V_{I(R)}$	$V_{CC} = 30V$ ( $V_{CC} = 26V$ for KA2902)	0		$V_{CC} - 1.5$	0	$V_{CC} - 1.5$		0		$V_{CC} - 1.5$	V
Supply Current	$I_{CC}$	$R_L = \infty$ , $V_{CC} = 30V$ (all Amps)		1.0	3		1.0	3		1.0	3	mA
		$R_L = \infty$ , $V_{CC} = 5V$ (all Amps) ( $V_{CC} = 26V$ for KA2902)		0.7	1.2		0.7	1.2		0.7	1.2	mA
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15V$ , $R_L \geq 2K\Omega$ $V_{O(P)} = 1V$ to 11V	50	100		25	100			100		V/mV
Output Voltage Swing	$V_{O(H)}$	$V_{CC} = 30V$ $V_{CC} = 26V$ for 2902		26		26				22		V
		$R_L = 2K\Omega$ $R_L = 10K\Omega$	27	28		27	28		23	24		V
	$V_{O(L)}$	$V_{CC} = 5V$ , $R_L \geq 10K\Omega$		5	20		5	20		5	100	mV
Common-Mode Rejection Ratio	CMRR		70	85		65	75		50	75		dB
Power Supply Rejection Ratio	PSRR		65	100		65	100		50	100		dB
Channel Separation	CS	$f = 1KHz$ to 20KHz		120			120			120		dB
Short Circuit to GND	$I_{SC}$			40	60		40	60		40	60	mA
Output Current	$I_{SOURCE}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	20	40		20	40		20	40		mA
		$V_{I(+)} = 0V$ , $V_{I(-)} = 1V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	10	13		10	13		10	13		mA
	$I_{SINK}$	$V_{I(+)} = 0V$ , $V_{I(-)} = 1V$ $V_{CC} = 15V$ , $V_{O(R)} = 200mV$	12	45		12	45					$\mu A$
Differential Input Voltage	$V_{I(DIFF)}$				$V_{CC}$			$V_{CC}$			$V_{CC}$	V



# LM224/A, LM324/A, LM2902      QUAD OPERATIONAL AMPLIFIER

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = 5.0V$ ,  $V_{EE} = GND$ , unless otherwise specified)

The following specification apply over the range of  $-25^{\circ}C \leq T_A \leq +85^{\circ}C$  for the LM224; and the  $0^{\circ}C \leq T_A \leq +70^{\circ}C$  for the LM324 ; and the  $-40^{\circ}C \leq T_A \leq +85^{\circ}C$  for the LM2902

Characteristic	Symbol	Test Conditions	LM224			LM324			LM2902			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{ICM} = 0V$ to $V_{CC} = 1.5V$ $V_{O(P)} = 1.4V$ , $R_S = 0\Omega$			7.0			9.0			10.0	mV
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$			7.0			7.0			7.0		$\mu V/^{\circ}C$
Input Offset Current	$I_{IO}$				100			150			200	nA
Input Offset Current Drift	$\Delta I_{IO}/\Delta T$			10			10			10		$pA/^{\circ}C$
Input Bias Current	$I_{BIAS}$				300			500			500	nA
Input Common-Mode Voltage Range	$V_{IC(R)}$	$V_{CC} = 30V$ ( $V_{CC} = 26V$ for KA2902)	0		$V_{CC} - 2.0$	0		$V_{CC} - 2.0$	0		$V_{CC} - 2.0$	V
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15V$ , $R_L \geq 2.0K\Omega$ $V_{O(P)} = 1V$ to $11V$	25			15			15			V/mV
Output Voltage Swing	$V_{O(H)}$	$V_{CC} = 30V$ $V_{CC} = 26V$ for 2902	26			26			22			V
	$V_{O(L)}$	$R_L = 2K\Omega$ $R_L = 10K\Omega$	27	28		27	28		23	24		V
		$V_{CC} = 5V$ , $R_L \geq 10K\Omega$		5	20		5	20		5	100	mV
Output Current	$I_{SOURCE}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	10	20		10	20		10	20		mA
	$I_{SINK}$	$V_{I(+)} = 0V$ , $V_{I(-)} = 1V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	10	13		5	8		5	8		mA
Differential Input Voltage	$V_{I(DIFS)}$				$V_{CC}$			$V_{CC}$			$V_{CC}$	V

# LM224/A, LM324/A, LM2902      QUAD OPERATIONAL AMPLIFIER

## ELECTRICAL CHARACTERISTICS

( $V_{CC}=50V$ ,  $V_{EE} = GND$ ,  $T_A=25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM224A			LM324A			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0V$ to $V_{CC} = 1.5V$ $V_{O(P)} = 1.4V$ , $R_S = 0 \Omega$		1.0	3.0		1.5	3.0	mV
Input Offset Current	$I_{IO}$			2	15		3.0	30	nA
Input Bias Current	$I_{BIAS}$			40	80		40	100	nA
Input Common-Mode Voltage Range	$V_{I(R)}$	$V_{CC} = 30V$	0		$V_{CC} - 1.5$	0		$V_{CC} - 1.5$	V
Supply Current (All Amps)	$I_{CC}$	$V_{CC} = 30V$		1.5	3		1.5	3	mA
		$V_{CC} = 5V$		0.7	1.2		0.7	1.2	mA
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15V$ , $R_L \geq 2 K\Omega$ $V_{O(P)} = 1V$ to $11V$	50	100		25	100		V/mV
Output Voltage Swing	$V_{O(H)}$	$V_{CC} = 30V$ , $R_L = 2 K\Omega$	26			26			V
	$V_{O(H)}$	$V_{CC} = 26V$ for 2902, $R_L = 10 K\Omega$	27	28		27	28		V
	$V_{O(L)}$	$V_{CC} = 5V$ , $R_L \geq 10 K\Omega$		5	20		5	20	mV
Common-Mode Rejection Ratio	CMRR		70	85		65	85		dB
Power Supply Rejection Ratio	PSRR		65	100		65	100		dB
Channel Separation	CS	$f = 1KHz$ to $20KHz$		120			120		dB
Short Circuit to GND	$I_{SC}$			40	60		40	60	mA
Output Current	$I_{SOURCE}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$	20	40		20	40		mA
	$I_{SINK}$	$V_{I(+)} = 0V$ , $V_{I(-)} = 1V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	10	20		10	20		mA
	$I_{SINK}$	$V_{I(+)} = 0V$ , $V_{I(-)} = 1V$ $V_{CC} = 15V$ , $V_{O(P)} = 200mV$	12	50		12	50		$\mu A$
Differential Input Voltage	$V_{I(DIFF)}$				$V_{CC}$			$V_{CC}$	V

# LM224/A, LM324/A, LM2902      QUAD OPERATIONAL AMPLIFIER

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = 5.0V$ ,  $V_{EE} = GND$ , unless otherwise specified)

The following specification apply over the range of  $-25^{\circ}C \leq T_A \leq +85^{\circ}C$  for the LM224A; and the  $0^{\circ}C \leq T_A \leq +70^{\circ}C$  for the LM324A

Characteristic	Symbol	Test Conditions	LM224A			LM324A			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0V$ to $V_{CC} = 1.5V$ $V_{O(P)} = 1.4V$ , $R_S = 0\Omega$			4.0			5.0	mV
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$			7.0	20		7.0	30	$\mu V/^{\circ}C$
Input Offset Current	$I_{IO}$				30			75	nA
Input Offset Current Drift	$\Delta I_{IO}/\Delta T$			10	200		10	300	$pA/^{\circ}C$
Input Bias Current	$I_{BIAS}$			40	100		40	200	nA
Input Common-Mode Voltage Range	$V_{I(R)}$	$V_{CC} = 30V$	0		$V_{CC} - 2.0$	0		$V_{CC} - 2.0$	V
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15V$ , $R_L \geq 2.0K\Omega$	25			15			V/mV
Output Voltage Swing	$V_{O(P-P)}$	$V_{CC} = 30V$ , $R_L = 2K\Omega$	26			26			V
		$R_L = 10K\Omega$	27	28		27	28		
		$V_{CC} = 5V$ , $R_L \geq 10K\Omega$		5	20		5	20	mA
Output Current	$I_{SOURCE}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$	10	20		10	20		mA
	$I_{SINK}$	$V_{I(+)} = 0V$ , $V_{I(-)} = 1V$ $V_{CC} = 15V$	5	8		5	8		mA
Differential Input Voltage	$V_{I(DIFF)}$				$V_{CC}$			$V_{CC}$	V

# LM224/A, LM324/A, LM2902 QUAD OPERATIONAL AMPLIFIER

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 INPUT VOLTAGE RANGE

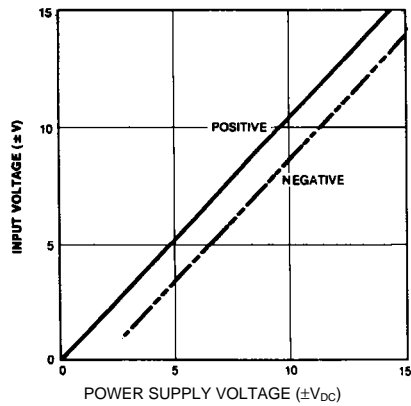


Fig. 2 INPUT CURRENT

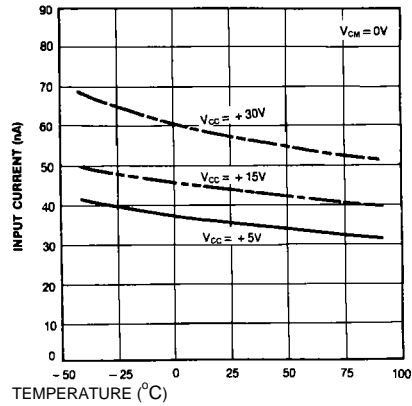


Fig. 3 SUPPLY CURRENT

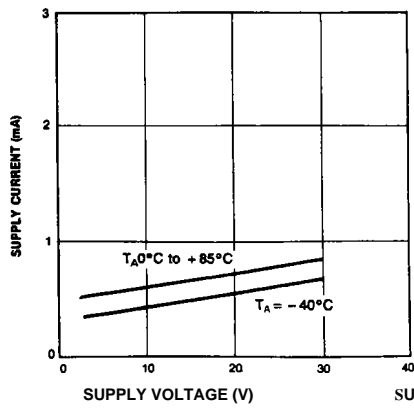


Fig. 4 VOLTAGE GAIN

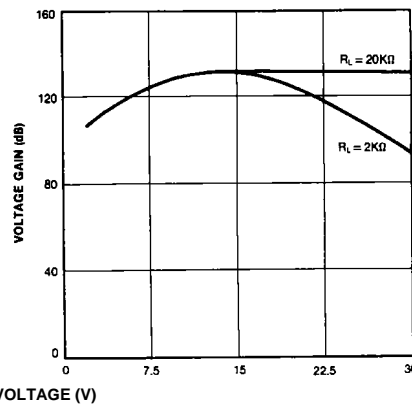


Fig. 5 OPEN LOOP FREQUENCY RESPONSE

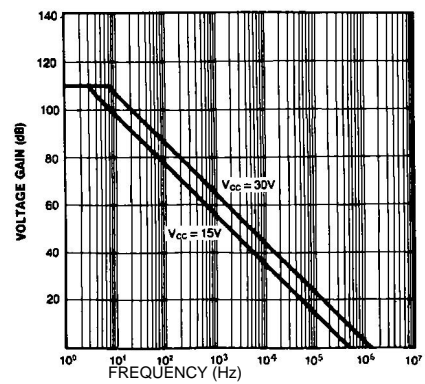
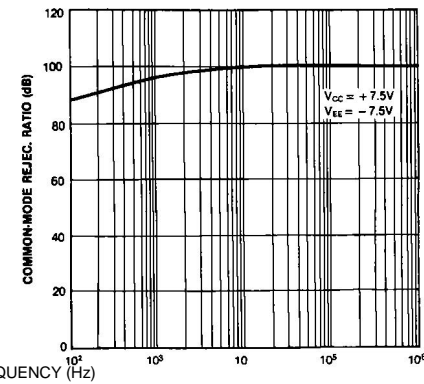


Fig. 6 COMMON-MODE REJECTION RATIO



# LM224/A, LM324/A, LM2902 QUAD OPERATIONAL AMPLIFIER

Fig. 7 SLEW RATE

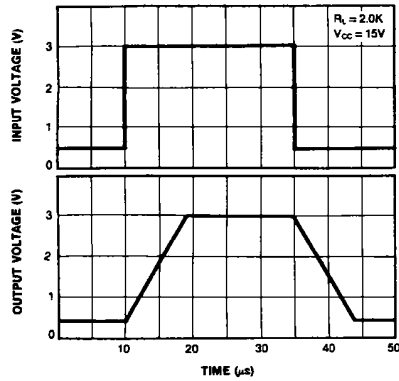


Fig. 8 VOLTAGE FOLLOWER PULSE

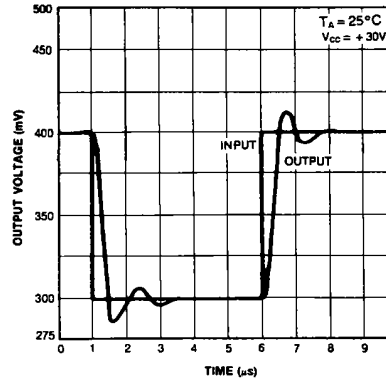
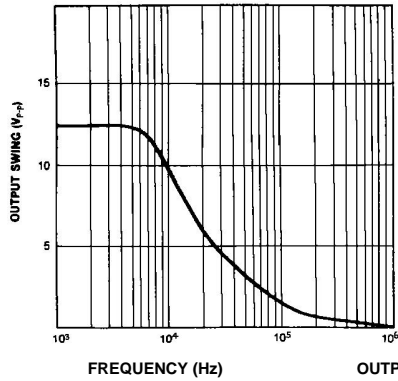


Fig. 10 OUTPUT CHARACTERISTICS

Fig. 9 LARGE SIGNAL FREQUENCY RESPONSE



CURRENT SOURCING

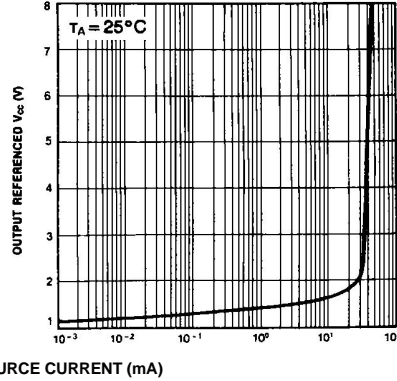


Fig. 11 OUTPUT CHARACTERISTICS  
CURRENT SINKING

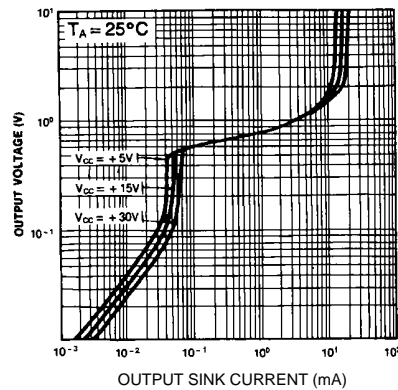
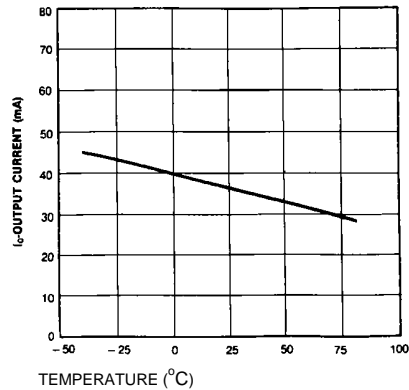


Fig. 12 CURRENT LIMITING



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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

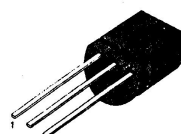
Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

## LM336-2.5/B/LM236-2.5 (KA336-2.5, KA236-2.5) PROGRAMMABLE SHUNT REGULATOR

### PROGRAMMABLE SHUNT REGULATOR

The LM336-2.5/B integrated Circuits are precision 2.5V shunt regulators. The monolithic IC voltage references operates as a low temperature coefficient 2.5V zener with 0.2 $\Omega$  dynamic impedance. A third terminal on the KA336-2.5/B allow the reference voltage and temperature coefficient to be trimmed easily. LM3362.5/B are useful as a precision 2.5V low voltage reference for digital voltmeters, power supplies or op amp circuitry. The 2.5V make it convenient to obtain a stable reference from low voltage supplies. Further, since the LM336-2.5/B operate as shunt regulators, they can be used as either a positive or negative voltage reference.

TO-92



1: Adj. 2: + 3: -

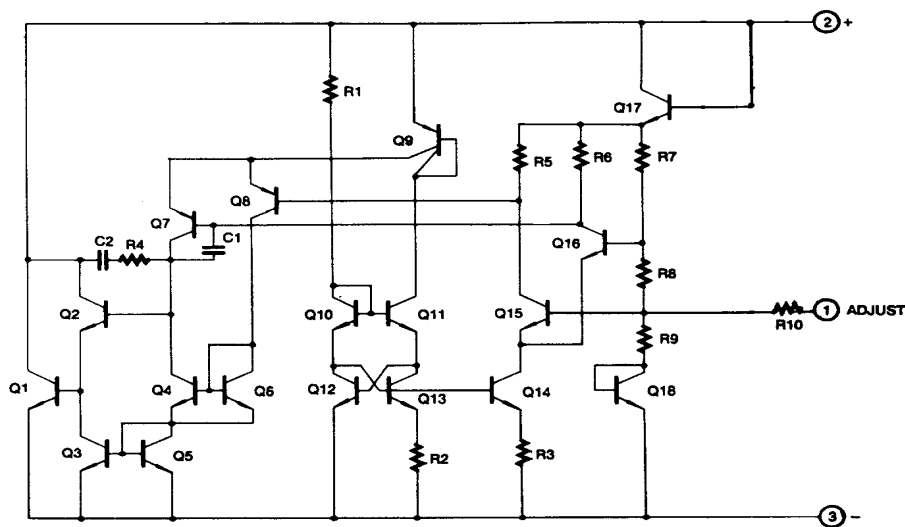
### FEATURES

- Low temperature coefficient
- Guaranteed temperature stability 4mV typical
- 0.2  $\Omega$  dynamic impedance
- $\pm 1.0\%$  initial tolerance available.
- Easily trimmed for minimum temperature drift

### ORDERING INFORMATION

Device	Package	Operating Temperature
LM336Z-2.5	TO-92	0 ~ +70°C
LM336Z-2.5B		
LM236Z-2.5		-25 ~ +85°C

### SCHEMATIC DIAGRAM



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Rev. B

## LM336-2.5/B/LM236-2.5 (KA336-2.5, KA236-2.5) PROGRAMMABLE SHUNT REGULATOR

### ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Reverse Current	$I_R$	15	mA
Forward Current	$I_F$	10	mA
Operating Temperature Range LM336-2.5/B LM236-2.5	$T_{OPR}$	0 ~ + 70 - 25 ~ +85	°C °C
Storage Temperature Range	$T_{STG}$	- 60 ~ + 150	°C

### ELECTRICAL CHARACTERISTICS ( $T_{MIN} < T_A < T_{MAX}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM336/236			LM336B			
			Min	Typ	Max	Min	Typ	Max	
Reverse Breakdown Voltage	$V_R$	$T_A = +25^{\circ}\text{C}$ $I_R = 1\text{mA}$	2.44	2.49	2.54	2.465	2.49	2.515	V
Reverse Breakdown Change with Current	$\Delta V_R / \Delta I_R$	$T_A = +25^{\circ}\text{C}$ $400\mu\text{A} \leq I_R \leq 10\text{mA}$		2.6	6		2.6	10	mV
Reverse Dynamic Impedance	$Z_D$	$T_A = +25^{\circ}\text{C}$ $I_R = 1\text{mA}$		0.2	0.6		0.2	1	$\Omega$
Temperature Stability	$ST_T$	$I_R = 1\text{mA}$ $T_{MIN} \leq T_A \leq T_{MAX}$		1.8	6		1.8	6	mV
Reverse Breakdown Change with Current	$\Delta V_R / \Delta I_R$	$T_{MIN} \leq T_A \leq T_{MAX}$ $400\mu\text{A} \leq I_R \leq 10\text{mA}$		3	10		3	12	mV
Reverse Dynamic Impedance	$Z_D$	$I_R = 1\text{mA}$ $T_{MIN} \leq T_A \leq T_{MAX}$		0.4	1		0.4	1.4	$\Omega$
Long Term Stability	ST	$I_R = 1\text{mA}$ $T_{MIN} \leq T_A \leq T_{MAX}$		20			20		ppm

LM236:  $T_{MIN} = -25^{\circ}\text{C}$ ,  $T_{MAX} = +85^{\circ}\text{C}$

LM336:  $T_{MIN} = 0^{\circ}\text{C}$ ,  $T_{MAX} = +70^{\circ}\text{C}$



TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1. Reverse Voltage Change

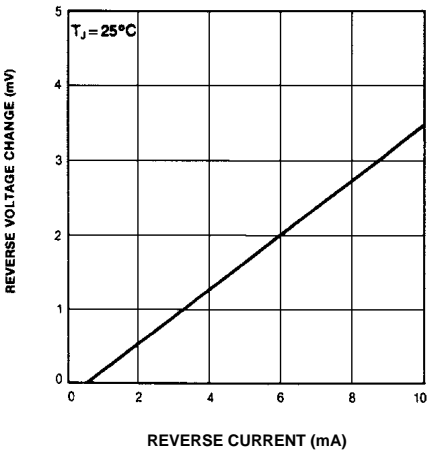


Fig. 2 Reverse Characteristics

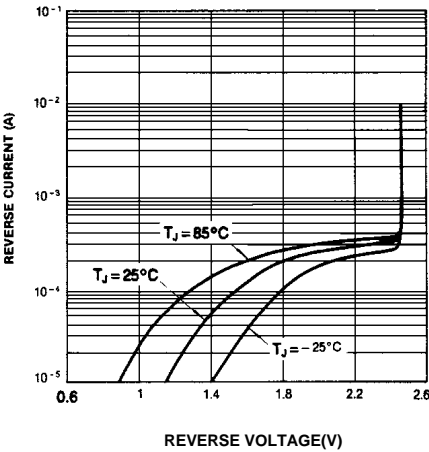


Fig. 3 Temperature Drift

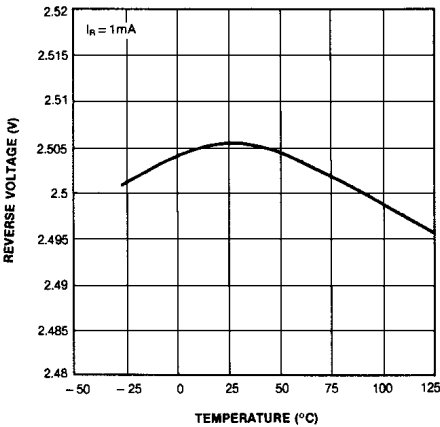
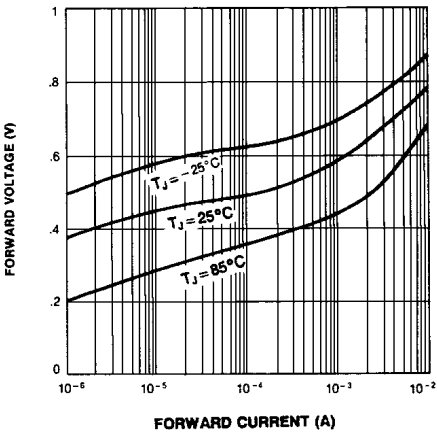


Fig. 4 Forward Characteristics



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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

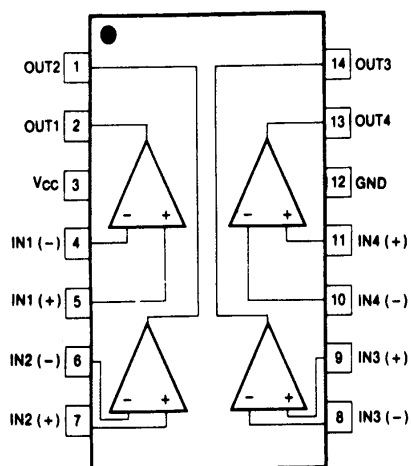
### QUAD DIFFERENTIAL COMPARATOR

The LM239 series consists of four independent voltage comparators designed to operate from single power supply over a wide voltage range.

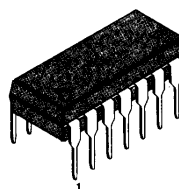
### FEATURES

- Single or dual supply operation
- Wide range of supply voltage  
LM239/A, LM339/A, LM2901: 2 ~ 36V (or  $\pm 1 \sim \pm 18V$ )  
LM3302: 2 ~ 28V (or  $\pm 1 \sim \pm 14V$ )
- Low supply current drain 800 $\mu A$  Typ
- Open collector outputs for wired and connectors
- Low input bias current 25nA Typ
- Low Input offset current  $\pm 2.3nA$  Typ.
- Low input offset voltage  $\pm 1.4mV$  Typ.
- Common mode input voltage range includes ground.
- Low output saturation voltage
- Output compatible with TTL, DTL and MOS logic system

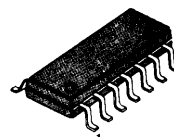
### BLOCK DIAGRAM



14 DIP



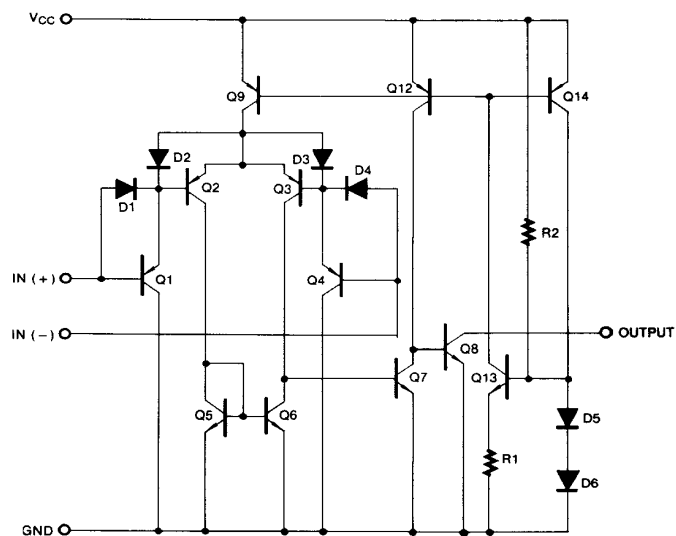
14 SOP



### ORDERING INFORMATION

Device	Package	Operating Temperature
LM339N LM339AN	14 DIP	0 ~ +70°C
LM339M LM339AM	14 SOP	
LM239N LM239AN	14 DIP	-25 ~ +85°C
LM239M LM239AM	14 SOP	
LM2901N LM2901M	14 DIP 14 SOP	-40 ~ +85°C
LM3302N LM3302M	14 DIP 14 SOP	

## SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Supply Voltage	$V_{CC}$	$\pm 18$ or 36	V
Supply Voltage Only LM3302	$V_{CC}$	$\pm 14$ or 28	V
Differential Input Voltage	$V_{I(DIFF)}$	36	V
Differential Input Voltage Only LM3302	$V_{I(DIFF)}$	28	V
Input Voltage	$V_I$	- 0.3 to +36	V
Input Voltage Only LM3302	$V_I$	- 0.3 to +28	V
Output Short Circuit to GND		Continuous	
Power Dissipation	$P_D$	570	mW
Operating Temperature LM339/LM339A	$T_{OPR}$	0 ~ + 70	°C
LM239/LM239A		- 25 ~ + 85	°C
LM2901/LM3302		- 40 ~ + 85	°C
Storage Temperature	$T_{STG}$	- 65 ~ + 150	°C

**ELECTRICAL CHARACTERISTICS**(V<sub>CC</sub> = 5V, T<sub>A</sub> = 25°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM239A/LM339A			LM239/LM339			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V <sub>IO</sub>	V <sub>CM</sub> = 0V to V <sub>CC</sub> = 1.5V		±1	±2		±1.4	±5	mV
		V <sub>O(P)</sub> = 1.4V, R <sub>S</sub> = 0Ω			±4.0			±9.0	
Input Offset Current	I <sub>IO</sub>			±2.3	±50		±2.3	±50	nA
					±150			±150	
Input Bias Current	I <sub>BIAS</sub>			57	250		57	250	nA
					400			400	
Input Common Mode Voltage Range	V <sub>I(R)</sub>		0		V <sub>CC</sub> -1.5	0		V <sub>CC</sub> -1.5	V
			0		V <sub>CC</sub> -2	0		V <sub>CC</sub> -2	
Supply Current	I <sub>CC</sub>	R <sub>L</sub> = ∞		1.1	2.0		1.1	2.0	mA
Voltage Gain	G <sub>V</sub>	V <sub>CC</sub> = 15V, R <sub>L</sub> ≥ 15KΩ (for large swing)	50	200		50	200		V/mV
Large Signal Response Time	t <sub>RES</sub>	V <sub>I</sub> = TTL Logic Swing V <sub>REF</sub> = 1.4V, V <sub>RL</sub> = 5V, R <sub>L</sub> = 5.1KΩ		350			350		ns
Response Time	t <sub>RES</sub>	V <sub>RL</sub> = 5V, R <sub>L</sub> = 5.1KΩ		1.4			1.4		μs
Output Sink Current	I <sub>SINK</sub>	V <sub>I(-)</sub> ≥ 1V, V <sub>I(+)</sub> = 0V, V <sub>O(P)</sub> ≤ 1.5V	6	18		6	18		mA
Output Saturation Voltage	V <sub>SAT</sub>	V <sub>I(-)</sub> ≥ 1V, V <sub>I(+)</sub> = 0V		140	400		140	400	mV
		I <sub>SINK</sub> = 4mA			700			700	
Output Leakage Current	I <sub>O(LKG)</sub>	V <sub>I(-)</sub> = 0V		0.1			0.1		nA
		V <sub>I(+)</sub> = 1V			1.0			1.0	
Differential Voltage	V <sub>I(DIFF)</sub>				36			36	V

Note 1.

LM339/A: 0 ≤ T<sub>A</sub> ≤ +70°CLM239/A: -25 ≤ T<sub>A</sub> ≤ +85°CLM2901/3302: -40 ≤ T<sub>A</sub> ≤ +85°C

**ELECTRICAL CHARACTERISTICS**(V<sub>CC</sub> = 5V, T<sub>A</sub> = 25°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM2901			LM3302			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V <sub>IO</sub>	V <sub>CM</sub> = 0V to V <sub>CC</sub> = 1.5V		2	7		2	20	mV
		V <sub>O(P)</sub> = 1.4V, R <sub>S</sub> = 0Ω		9	15			40	
Input Offset Current	I <sub>IO</sub>			2.3	50		3	100	nA
		NOTE 1		50	200			300	
Input Bias Current	I <sub>BIAS</sub>			57	250		57	250	nA
		NOTE 1		200	500			1000	
Input Common Mode Voltage Range	V <sub>I(R)</sub>		0		V <sub>CC</sub> -1.5	0		V <sub>CC</sub> -1.5	V
		NOTE 1	0		V <sub>CC</sub> -2	0		V <sub>CC</sub> -2	
Supply Current	I <sub>CC</sub>	R <sub>L</sub> = ∞		1.1	2.0		1.1	2.0	mA
		R <sub>L</sub> = ∞, V <sub>CC</sub> = 30V		1.6	2.5				
Voltage Gain	G <sub>V</sub>	V <sub>CC</sub> = 15V, R <sub>L</sub> ≥ 15KΩ (for large swing)	25	100		2	30		V/mV
Large Signal Response Time	t <sub>RES</sub>	V <sub>I</sub> = TTL Logic Swing V <sub>REF</sub> = 1.4V, V <sub>RL</sub> = 5V, R <sub>L</sub> = 5.1KΩ		350			350		ns
Response Time	t <sub>RES</sub>	V <sub>RL</sub> = 5V, R <sub>L</sub> = 5.1KΩ		1.4			1.4		μs
Output Sink Current	I <sub>SINK</sub>	V <sub>I(-)</sub> ≥ 1V, V <sub>I(+)</sub> = 0V, V <sub>O(P)</sub> ≤ 1.5V	6	18		6	18		mA
Output Saturation Voltage	V <sub>SAT</sub>	V <sub>I(-)</sub> ≥ 1V, V <sub>I(+)</sub> = 0V		140	400		140	400	mV
		I <sub>SINK</sub> = 4mA			700			700	
Output Leakage Current	I <sub>O(LKG)</sub>	V <sub>I(-)</sub> = 0V		0.1			0.1		nA
		V <sub>I(+)</sub> = 1V			1.0			1.0	
Differential Voltage	V <sub>I(DIFF)</sub>	NOTE 1			36			36	V

Note 1.

LM339/A: 0 ≤ T<sub>A</sub> ≤ +70°CLM239/A: -25 ≤ T<sub>A</sub> ≤ +85°CLM2901/3302: -40 ≤ T<sub>A</sub> ≤ +85°C

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 SUPPLY CURRENT

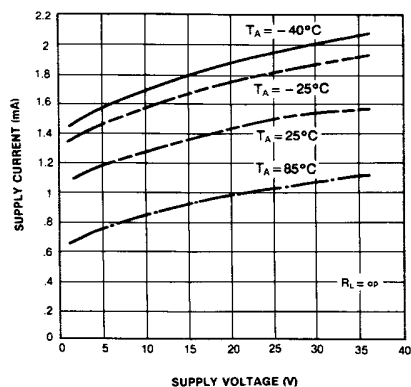


Fig. 2 INPUT CURRENT

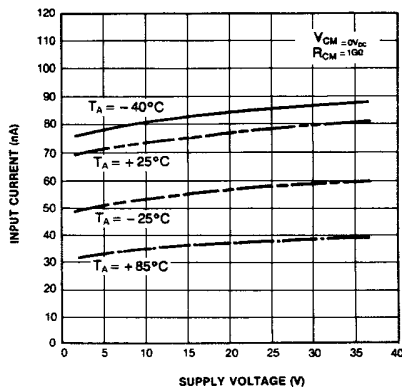


Fig. 3 OUTPUT SATURATION VOLTAGE

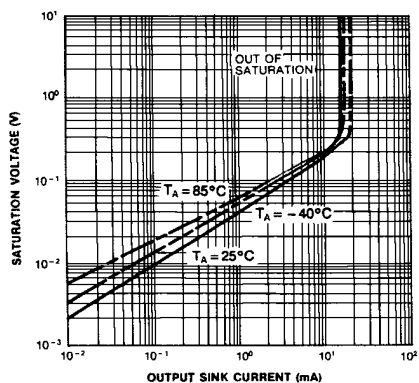


Fig. 4 RESPONSE TIME FOR VARIOUS INPUT OVERDRIVE-NEGATIVE TRANSITION

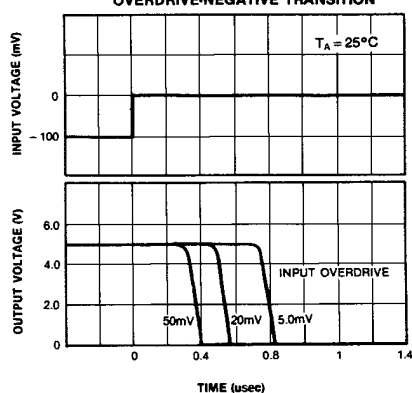
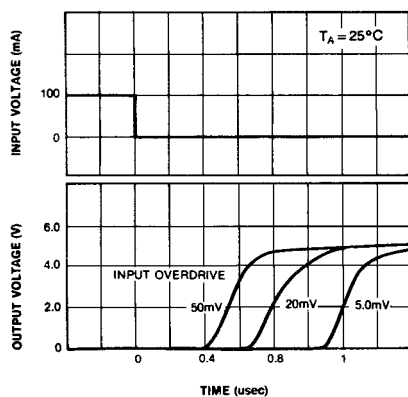


Fig. 5 RESPONSE TIME FOR VARIOUS INPUT OVERDRIVE-POSITIVE TRANSITION



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FACT™	QS™
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1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

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Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.



## QUAD OPERATIONAL AMPLIFIERS

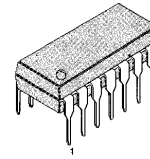
The LM248/LM348 is a true quad LM741. It consists of four independent, high-gain, internally compensated, low-power operational amplifiers which have been designed to provide functional characteristics identical to those of the familiar LM741 operational amplifier. In addition the total supply current for all four amplifiers is comparable to the Supply current of a single LM741 type OP Amp.

Other features include input offset currents and input bias current which are much less than those of a standard LM741. Also, excellent isolation between amplifiers has been achieved by independently biasing each amplifier and using layout techniques which minimize thermal coupling.

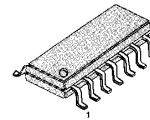
## FEATURES

- LM741 OP Amp operating characteristics
- Low supply current drain
- Class AB output stage-no crossover distortion
- Pin compatible with the LM324 & LM3403
- Low input offset voltage: 1mV Typ.
- Low input offset current: 4nA Typ.
- Low input bias current: 30nA Typ.
- Gain bandwidth product for LM348 (unity gain): 1.0MHz Typ.
- High degree of isolation between amplifiers: 120dB
- Overload protection for inputs and outputs

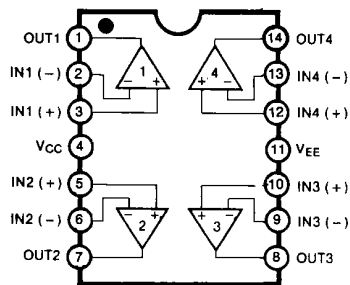
14 DIP



14 SOP



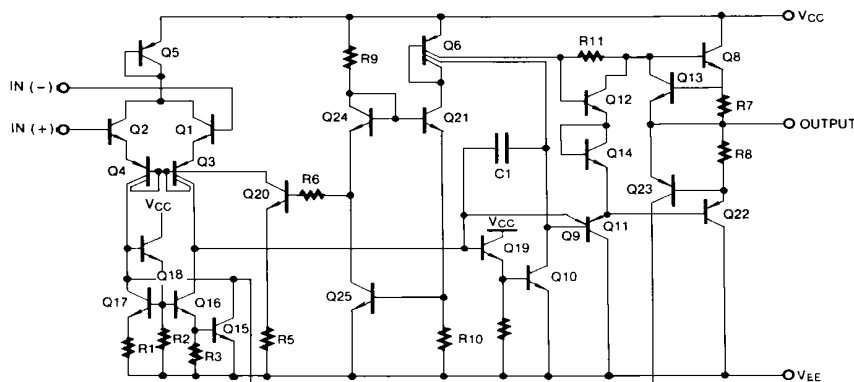
## BLOCK DIAGRAM



## ORDERING INFORMATION

Device	Package	Operating Temperature
LM348N	14 DIP	0 ~ +70°C
LM348M	14 SOP	
LM248N	14 DIP	-25 ~ +85°C
LM248M	14 SOP	

## SCHEMATIC DIAGRAM (One Section Only)



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Rev. B

ABSOLUTE MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	Value	Unit
Supply Voltage	$V_{CC}$	$\pm 18$	V
Differential Input Voltage	$V_{I(DIFF)}$	36	V
Input Voltage	$V_I$	$\pm 18$	V
Output Short Circuit Duration		Continuous	
Operating Temperature KA248	$T_{OPR}$	- 25 ~ +85	$^\circ\text{C}$
KA348		0 ~ +70	$^\circ\text{C}$
Storage Temperature	$T_{STG}$	- 65 ~ +150	$^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 15V, V<sub>EE</sub> = -15V, T<sub>A</sub> = 25 $^\circ\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM248			LM348			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$R_S \leq 10\text{K}\Omega$ NOTE 1		1	6.0		1	6.0	mV
					7.5			7.5	
Input Offset Current	$I_{IO}$	NOTE 1		4	50		4	50	nA
					125			100	
Input Bias Current	$I_{BIAS}$	NOTE 1		30	200		30	200	nA
					500			400	
Input Resistance	$R_I$		0.8	2.5		0.8	2.5		M $\Omega$
Supply Current (all Amplifiers)	$I_{CC}$			2.4	4.5		2.4	4.5	mA
Large Signal Voltage Gain	$G_V$	$R_L \geq 2\text{K}\Omega$ NOTE 1	25	160		25	160		V/mV
			15			15			
Channel Separation	CS	f = 1KHz to 20KHz		120			120		dB
Common Mode Input Voltage Range	$V_{I(R)}$	NOTE 1	$\pm 12$			$\pm 12$			V
Small Signal Bandwidth	BW	$G_V = 1$		1.0			1.0		MHz
Phase Margin	MPH	$G_V = 1$		60			60		Degree
Slew Rate	SR	$G_V = 1$		0.5			0.5		V/ $\mu\text{s}$
Output Short Circuit Current	$I_{SC}$			25			25		mA
Output Voltage Swing	$V_{O(P,P)}$	$R_L \geq 10\text{K}\Omega$	$\pm 12$	$\pm 13$		$\pm 12$	$\pm 13$		V
		$R_L \geq 2\text{K}\Omega$	$\pm 10$	$\pm 12$		+0	$\pm 12$		
Common Mode Rejection Ratio	CMRR	$R_S \geq 10\text{K}\Omega$	70	90		70	90		dB
Power Supply Rejection Ratio	PSRR	$R_S \geq 10\text{K}\Omega$	77	96		77	96		dB

## NOTE 1

LM348:  $0 \leq T_A \leq +70^\circ\text{C}$ LM248:  $-25 \leq T_A \leq +85^\circ\text{C}$

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 SUPPLY CURRENT

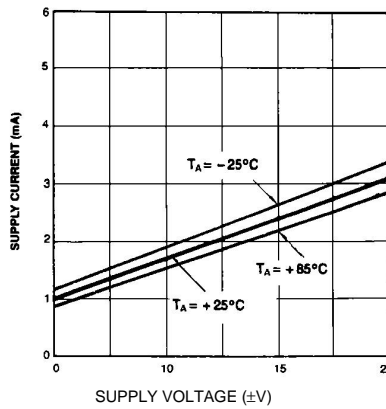


Fig. 2 VOLTAGE SWING

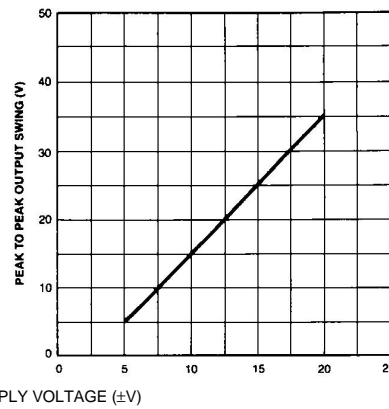


Fig. 3 SOURCE CURRENT LIMIT

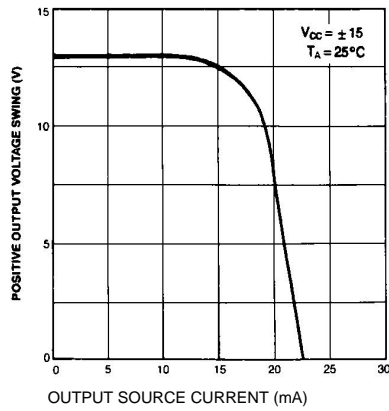


Fig. 4 SINK CURRENT LIMIT

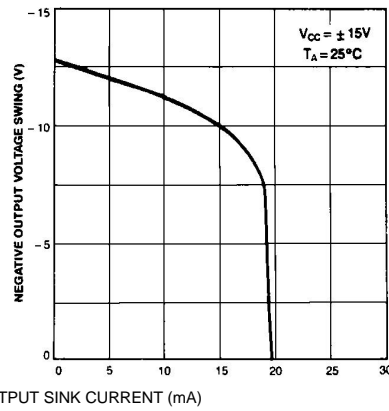


Fig. 5 OUTPUT IMPEDANCE

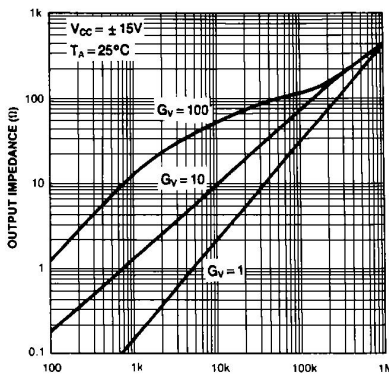


Fig. 6 COMMON-MODE REJECTION RATIO

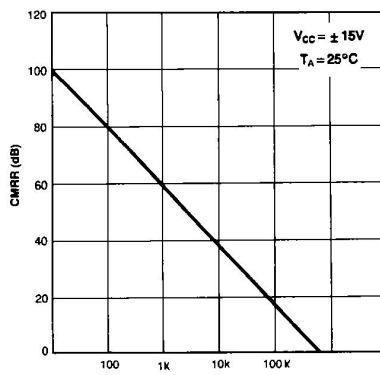


Fig. 7 OPEN LOOP FREQUENCY RESPONSE

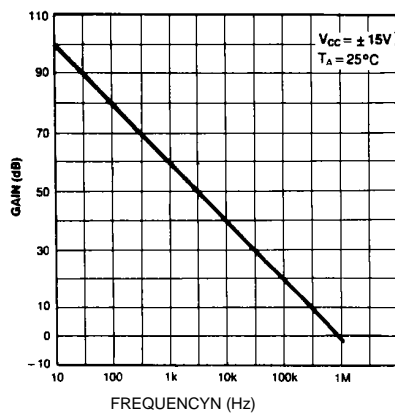


Fig. 8 BODE PLOT

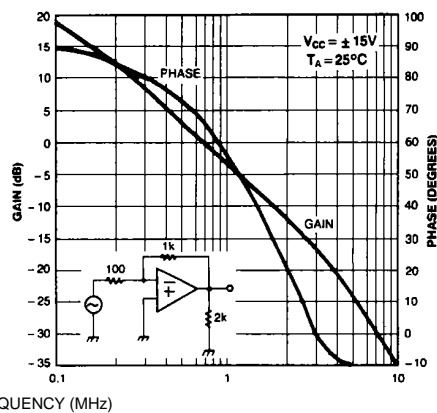


Fig. 9 LARGE SIGNAL PULSE RESPONSE

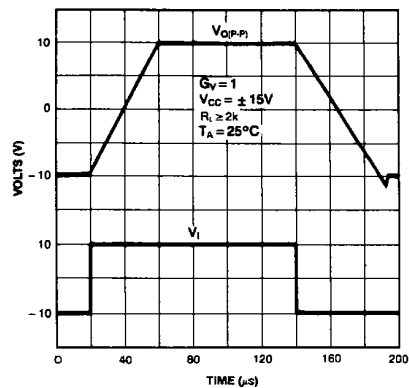


Fig. 10 SMALL SIGNAL PULSE RESPONSE

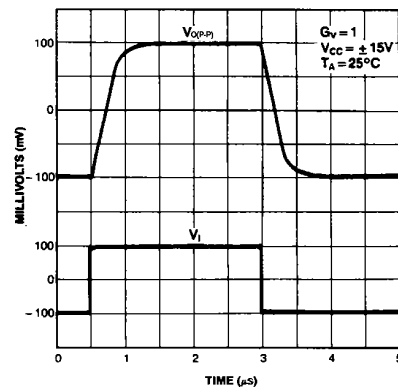


Fig. 11 UNDISTORTED OUTPUT VOLTAGE SWING

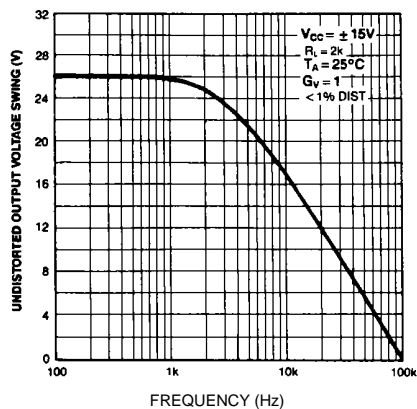


Fig. 12 INVERTING LARGE SIGNAL PULSE RESPONSE

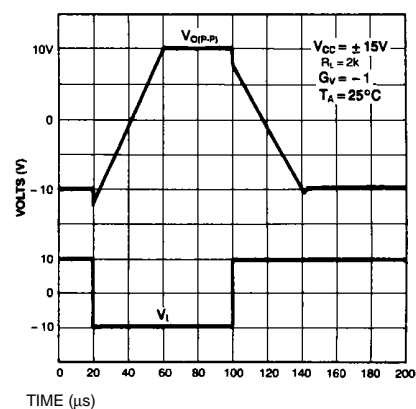


Fig. 13 INPUT NOISE VOLTAGE AND NOISE CURRENT

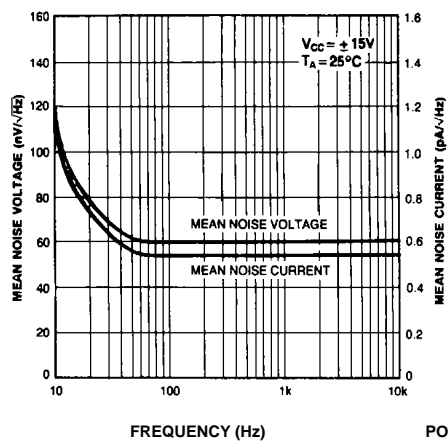


Fig. 14 POSITIVE COMMON MODE INPUT VOLTAGE LIMIT

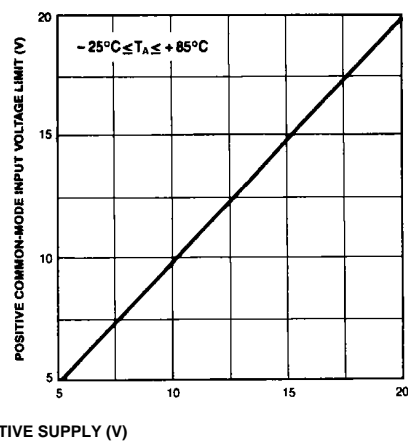
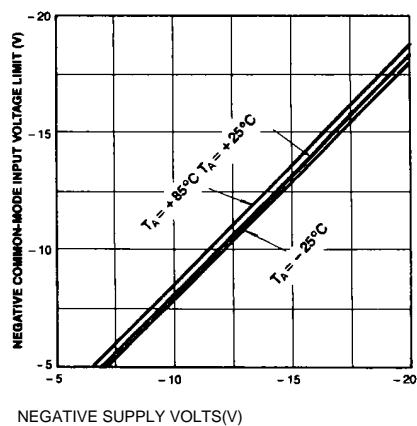


Fig. 15 NEGATIVE COMMON-MODE INPUT VOLTAGE LIMIT



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FACT Quiet Series™	Quiet Series™
FAST®	SuperSOT™-3
FASTr™	SuperSOT™-6
GTO™	SuperSOT™-8
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# LM258/A, LM358/A, LM2904 DUAL OPERATIONAL AMPLIFIER

## DUAL OPERATIONAL AMPLIFIERS

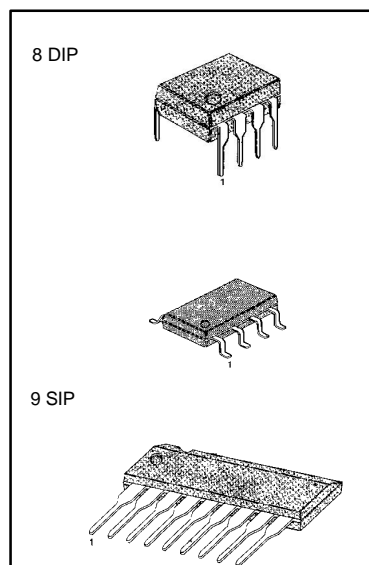
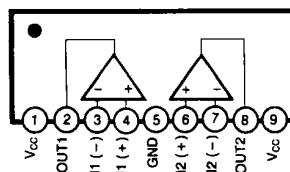
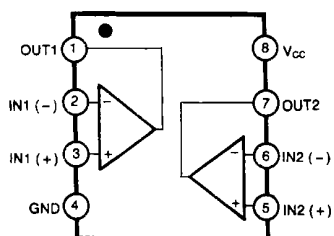
The LM258 series consists of four independent, high gain, internally Frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltage.

Operation from split power supplies is also possible and the low power Supply current drain is independent of the magnitude of the power Supply voltage. Application areas include transducer amplifier, DC gain blocks and all the conventional OP amp circuits which now can be easily implemented in single 8 SOP power supply system.

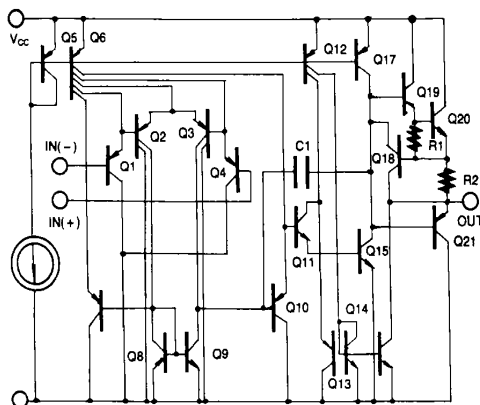
## FEATURES

- Internally frequency compensated for unity gain
- Large DC voltage gain: 100dB
- Wide power supply range: LM258/A, LM358/A: 3V~32V (or  $\pm 1.5V \sim 16V$ )  
LM2904: 3V~26V (or  $\pm 1.5V \sim 13V$ )
- Input common-mode voltage range Includes ground
- Large output voltage swing: 0V DC to  $V_{CC} - 1.5V$  DC
- Power drain suitable for battery operation.

## BLOCK DIAGRAM



## SCHEMATIC DIAGRAM (One section only)



## ORDERING INFORMATION

Device	Package	Operating Temperature
LM358N	8 DIP	0 ~ + 70°C
LM358AN		
LM358S	9 SIP	
LM358AS		
LM358M	8 SOP	-25 ~ + 85°C
LM358AM		
LM258N	8 DIP	
LM258AN		
LM258S	9 SIP	-40 ~ + 85°C
LM258AS		
LM258M	8 SOP	
LM258AM		
LM2904N	8 DIP	-40 ~ + 85°C
LM2904S	9 SIP	
LM2904M	8 SOP	

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Rev. B

# LM258/A, LM358/A, LM2904 DUAL OPERATIONAL AMPLIFIER

## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	LM258/LM258A	LM358/LM358A	LM2904	Unit
Supply Voltage	$V_{CC}$	$\pm 16$ or 32	$\pm 16$ or 32	$\pm 13$ or 26	V
Differential Input Voltage	$V_{I(DIFF)}$	32	32	26	V
Input Voltage	$V_I$	-0.3 to +32	-0.3 to +32	-0.3 to +26	V
Output Short Circuit to GND $V_{CC} \leq V$ , $T_A = 25^\circ\text{C}$ (One Amp)		Continuous	Continuous	Continuous	
Operating Temperature Range	$T_{OPR}$	-25 ~ + 85	0 ~ + 70	-40 ~ + 85	$^\circ\text{C}$
Storage Temperature Range	$T_{STG}$	-65 ~ + 150	-65 ~ + 150	-65 ~ + 150	$^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = 5.0\text{V}$ ,  $V_{EE} = \text{GND}$ ,  $T = 25^\circ\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM258			LM358			LM2904			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0\text{V}$ to $V_{CC} - 1.5\text{V}$ $V_{O(P)} = 1.4\text{V}$ , $R_S = 0\Omega$		2.9	5.0		2.9	7.0		2.9	7.0	mV
Input Offset Current	$I_{IO}$			3	30		5	50		5	50	nA
Input Bias Current	$I_{BIAS}$			45	150		45	250		45	250	nA
Input Common-Mode Voltage Range	$V_{I(R)}$	$V_{CC} = 30\text{V}$ (KA2904, $V_{CC} = 26\text{V}$ )	0		$V_{CC} - 1.5$	0		$V_{CC} - 1.5$	0		$V_{CC} - 1.5$	V
Supply Current	$I_{CC}$	$R_L = \infty$ , $V_{CC} = 30\text{V}$ (KA2902, $V_{CC} = 26\text{V}$ )		0.8	2.0		0.8	2.0		0.8	2.0	mA
		$R_L = \infty$ , over full temperature range		0.5	1.2		0.5	1.2		0.5	1.2	mA
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15\text{V}$ , $R_L \geq 2\text{K}\Omega$ $V_{O(P)} = 1\text{V}$ to $11\text{V}$	50	100		25	100		25	100		V/mV
Output Voltage Swing	$V_{O(H)}$ $V_{O(L)}$	$V_{CC} = 30\text{V}$ , $R_L = 2\text{K}\Omega$	26			26			22			V
		$V_{CC} = 26\text{V}$ for 2904, $R_L = 10\text{K}\Omega$	27	28		27	28		23	24		V
		$V_{CC} = 5\text{V}$ , $R_L \geq 10\text{K}\Omega$		5	20		5	20		5	100	mV
Common-Mode Rejection Ratio	CMRR		70	85		65	80		50	80		dB
Power Supply Rejection Ratio	PSRR		65	100		65	100		50	100		dB
Channel Separation	CS	$f = 1\text{KHz}$ to $20\text{KHz}$		120			120			120		dB
Short Circuit to GND	$I_{SC}$			40	60		40	60		40	60	mA
Output Current	$I_{SOURCE}$ $I_{SINK}$	$V_{I(+)} = 1\text{V}$ , $V_{I(-)} = 0\text{V}$ $V_{CC} = 15\text{V}$ , $V_{O(P)} = 2\text{V}$	10	30		10	30		10	30		mA
		$V_{I(+)} = 0\text{V}$ , $V_{I(-)} = 1\text{V}$ $V_{CC} = 15\text{V}$ , $V_{O(P)} = 2\text{V}$	10	15		10	15		10	15		mA
		$V_{I(+)} = 0\text{V}$ , $V_{I(-)} = 1\text{V}$ $V_{CC} = 15\text{V}$ , $V_{O(P)} = 200\text{mA}$	12	100		12	100					$\mu\text{A}$
Differential Input Voltage	$V_{I(DIFF)}$				$V_{CC}$			$V_{CC}$			$V_{CC}$	V



# LM258/A, LM358/A, LM2904 DUAL OPERATIONAL AMPLIFIER

## ELECTRICAL CHARACTERISTICS

( $V_{CC}=5.0V$ ,  $V_{EE}=GND$ , unless otherwise specified)

The following specification apply over the range of  $-25^{\circ}C \leq T_A \leq +85^{\circ}C$  for the KA258; and the  $0^{\circ}C \leq T_A \leq +70^{\circ}C$  for the LM358; and the  $-40^{\circ}C \leq T_A \leq +85^{\circ}C$  for the LM2904

Characteristic	Symbol	Test Conditions	LM258			LM358			LM2904			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0V$ to $V_{CC} = 1.5V$ $V_{O(P)} = 1.4V$ , $R_S = 0\Omega$			7.0			9.0			10.0	mV
Input Offset Voltage Drift	$V_{IO}$	$R_S = 0\Omega$		7.0			7.0			7.0		$\mu V/^{\circ}C$
Input Offset Current	$I_{IO}$				100			150		45	200	nA
Input Offset Current Drift	$\Delta I_{IO}/\Delta T$			10			10			10		$pA/^{\circ}C$
Input Bias Current	$I_{BIAS}$			40	300		40	500		40	500	nA
Input Common-Mode Voltage Range	$V_{I(R)}$	$V_{CC} = 30V$ (KA2904, $V_{CC} = 26V$ )	0		$V_{CC} = 2.0$	0		$V_{CC} = 2.0$	0		$V_{CC} = 2.0$	V
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15V$ , $R_L \geq 2.0K\Omega$ $V_{O(P)} = 1V$ to $11V$	25			15			15			V/mV
Output Voltage Swing	$V_{O(H)}$	$V_{CC} = 30V$	26			26			26			V
		$V_{CC} = 26V$ for 2904	27	28		27	28		27	28		V
	$V_{O(L)}$	$V_{CC} = 5V$ , $R_L \geq 10K\Omega$		5	20		5	20		5	20	mV
Output Current	$I_{SOURCE}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	10	30		10	30		10	30		mA
	$I_{SINK}$	$V_{I(+)} = 0V$ , $V_{I(-)} = 1V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	5	8		5	9		5	9		mA
Differential Input Voltage	$V_{I(DIFF)}$				$V_{CC}$			$V_{CC}$			$V_{CC}$	V

# LM258/A, LM358/A, LM2904 DUAL OPERATIONAL AMPLIFIER

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = 5.0V$ ,  $V_{EE} = GND$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM258A			LM358A			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0V$ to $V_{CC} = 1.5V$ $V_{O(P)} = 1.4V$ , $R_S = 0\Omega$		1.0	3.0		2.0	3.0	mV
Input Offset Current	$I_{IO}$			2	15		5	30	nA
Input Bias Current	$I_{BIAS}$			40	80		45	100	nA
Input Common-Mode Voltage Range	$V_{I(R)}$	$V_{CC} = 30V$	0		$V_{CC} = 1.5$	0		$V_{CC} = 1.5$	V
Supply Current	$I_{CC}$	$R_L = \infty$ , $V_{CC} = 30V$		0.8	2.0		0.8	2.0	mA
		$R_L = \infty$ , over full temperature range		0.5	1.2		0.5	1.2	mA
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15V$ , $R_L \geq 2K\Omega$ $V_O = 1V$ to $11V$	50	100		25	100		V/mV
Output Voltage Swing	$V_{OH}$	$V_{CC} = 30V$ , $R_L = 2K\Omega$	26			26			V
		$V_{CC} = 26V$ for 2904, $R_L = 10K\Omega$	27	28		27	28		V
	$V_{OL}$	$V_{CC} = 5V$ , $R_L \geq 10K\Omega$		5	20		5	20	mV
Common-Mode Rejection Ratio	CMRR		70	85		65	85		dB
Power Supply Rejection Ratio	PSRR		65	100		65	100		dB
Channel Separation	CS	$f = 1KHz$ to $20KHz$		120			120		dB
Short Circuit to GND	$I_{SC}$			40	60		40	60	mA
Output Current	$I_{SOURCE}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	20	30		20	30		mA
	$I_{SINK}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	10	15		10	15		mA
		$V_{in+} = 0V$ , $V_{in-} = 1V$ $V_{O(P)} = 200mV$	12	100		12	100		$\mu A$
Differential Input Voltage	$V_{I(DIFF)}$				$V_{CC}$			$V_{CC}$	V

# LM258/A, LM358/A, LM2904 DUAL OPERATIONAL AMPLIFIER

## ELECTRICAL CHARACTERISTICS ( $V_{CC} = 5.0V$ , $V_{EE} = GND$ . unless otherwise specified)

The following specification apply over the range of  $-25^{\circ}C \leq T_A \leq +85^{\circ}C$  for the LM258A; and the  $0^{\circ}C \leq T_A \leq +70^{\circ}C$  for the LM358A

Characteristic	Symbol	Test Conditions	LM258A			LM358A			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0V$ to $V_{CC} = 1.5V$ $V_{O(P)} = 1.4V$ , $R_S = 0\Omega$			4.0			5.0	mV
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$			7.0	15		7.0	20	$\mu V/^{\circ}C$
Input Offset Current	$I_{IO}$				30			75	nA
Input Offset Current Drift	$\Delta I_{IO}/\Delta T$			10	200		10	300	$pA/^{\circ}C$
Input Bias Current	$I_{BIAS}$			40	100		40	200	nA
Input Common-Mode Voltage Range	$V_{I(R)}$	$V_{CC} = 30V$	0		$V_{CC} = 2.0$	0		$V_{CC} = 2.0$	V
Output Voltage Swing	$V_{O(H)}$	$V_{CC} = 30V$ , $R_L = 2K\Omega$	26			26			V
	$V_{O(H)}$	$V_{CC} = 30V$ , $R_L = 10K\Omega$	27	28		27	28		V
	$V_{O(L)}$	$V_{CC} = 5V$ , $R_L \geq 10K\Omega$		5	20		5	20	mV
Large Signal Voltage Gain	$G_V$	$V_{CC} = 15V$ , $R_L \geq 2.0K\Omega$ $V_{O(P)} = 1V$ to $11V$	25			15			V/mV
Output Current	$I_{SOURCE}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	10	30		10	30		mA
	$I_{SINK}$	$V_{I(+)} = 1V$ , $V_{I(-)} = 0V$ $V_{CC} = 15V$ , $V_{O(P)} = 2V$	5	9		5	9		mA
Differential Input Voltage	$V_{I(DIFF)}$				$V_{CC}$			$V_{CC}$	V

TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 SUPPLY CURRENT

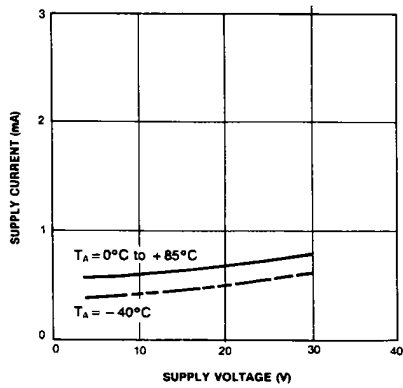


Fig. 2 VOLTAGE GAIN

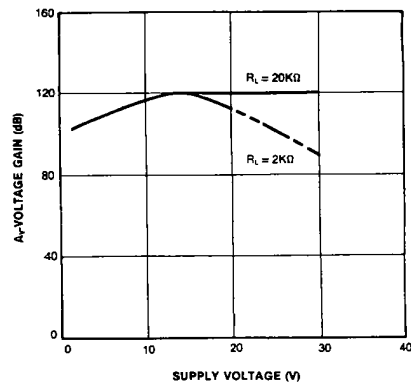


Fig. 3 OPEN LOOP FREQUENCY RESPONSE

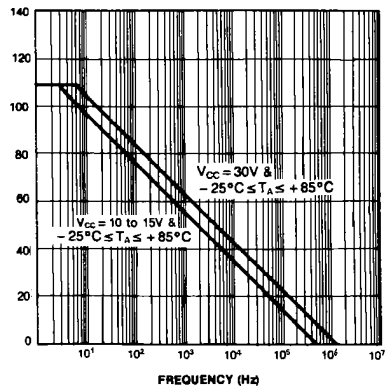


Fig. 4 LARGE SIGNAL FREQUENCY

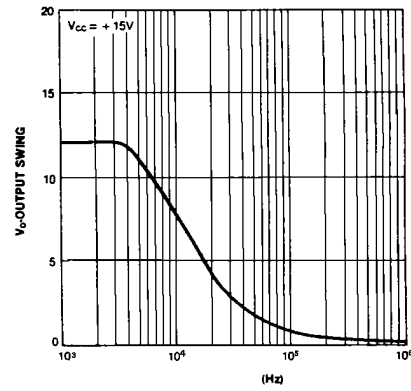


Fig. 5 OUTPUT CHARACTERISTICS  
CURRENT SOURCING

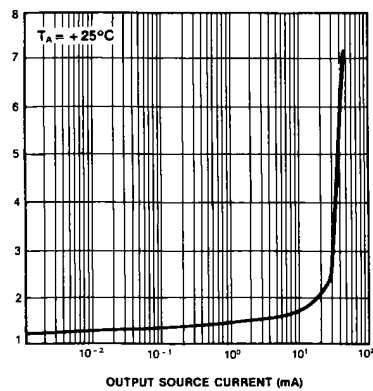
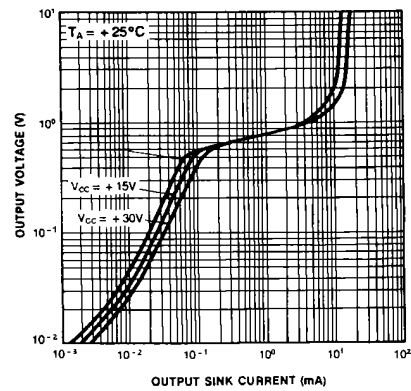


Fig. 6 OUTPUT CHARACTERISTICS  
CURRENT SINKING



# LM258/A, LM358/A, LM2904 DUAL OPERATIONAL AMPLIFIER

Fig. 7 INPUT VOLTAGE RANGE

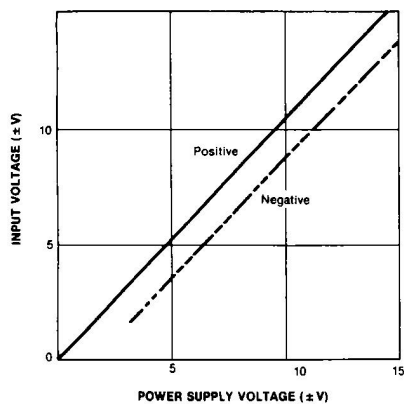


Fig. 8 COMMON-MODE REJECTION RATIO

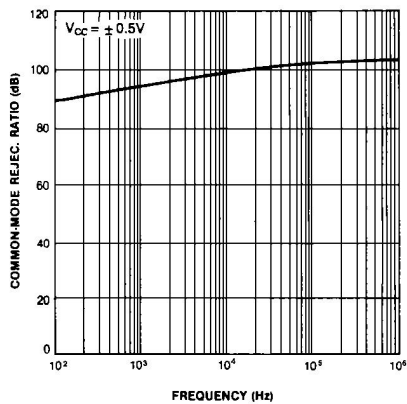


Fig. 9 CURRENT LIMITING

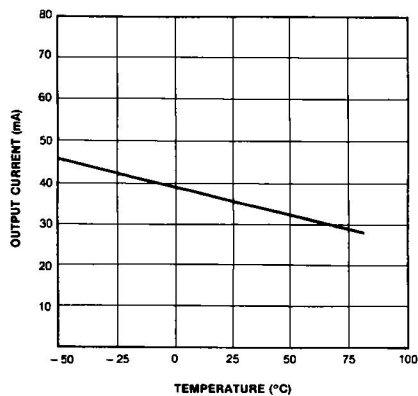


Fig. 10 INPUT CURRENT

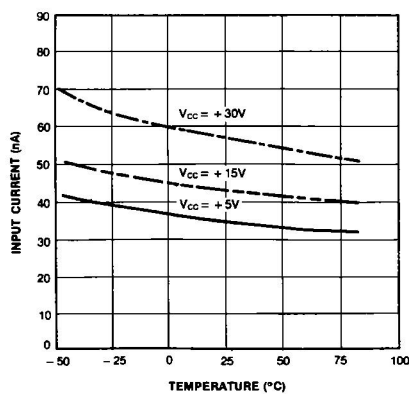


Fig. 11 VOLTAGE FOLLOWER PULSE RESPONSE

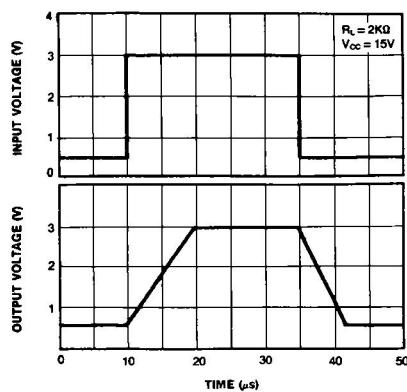
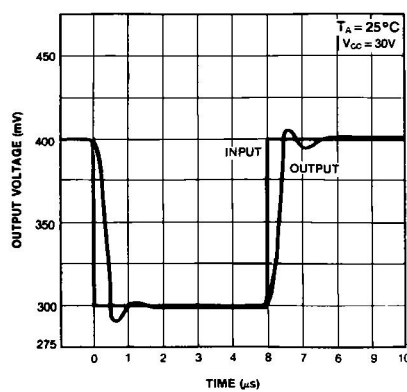


Fig. 12 VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)



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FAST®  
FASTr™  
GTO™  
HiSeC™

ISOPLANAR™  
MICROWIRE™  
POP™  
PowerTrench™  
QS™  
Quiet Series™  
SuperSOT™-3  
SuperSOT™-6  
SuperSOT™-8  
TinyLogic™

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1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

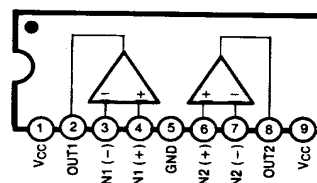
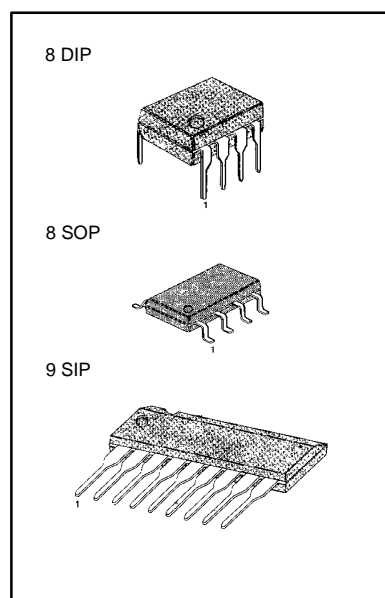
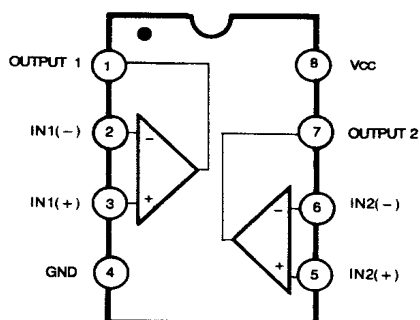
## DUAL DIFFERENTIAL COMPARATOR

The LM/KA293 series consists of two independent voltage comparators designed to operate from a single power supply over a wide voltage range.

## FEATURES

- Single Supply Operation: 2V to 36V
- Dual Supply Operation:  $\pm 1V$  to  $\pm 18V$
- Allow Comparison of Voltages Near Ground Potential
- Low Current Drain 800 $\mu A$  Typ
- Compatible with all Forms of Logic
- Low Input Bias Current 25nA Typ
- Low Input Offset Current  $\pm 5nA$  WP
- Low Offset Voltage  $\pm 1mV$  Typ

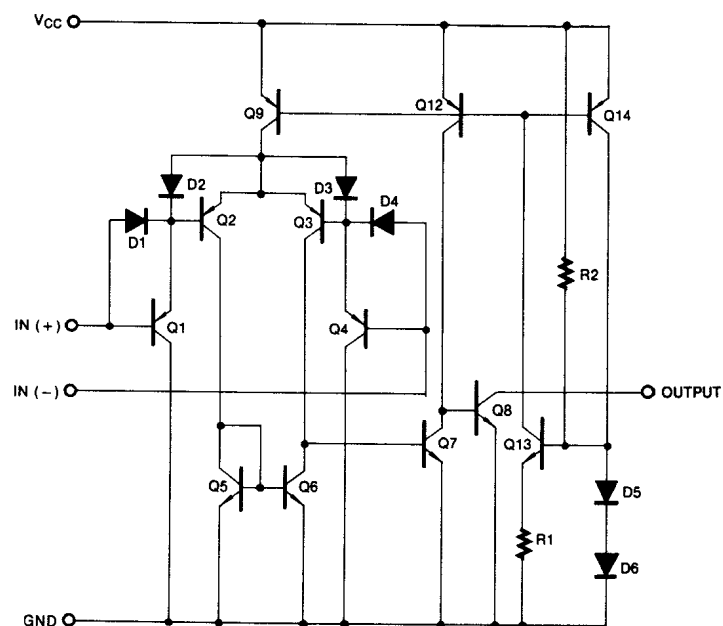
## BLOCK DIAGRAM



## ORDERING INFORMATION

Device	Package	Operating Temperature
LM393N (KA393)	8 DIP	0 ~ + 75°C
LM393AN (KA393A)		
KA393S	9 SIP	
KA393AS		
LM393M (KA393D)	8 SOP	-25 ~ + 85°C
KA393AD		
KA293	8 DIP	
KA293A		
KA293S	9 DIP	-40 ~ + 85°C
KA293AS		
KA293D	8 SOP	
KA293AD		
KA2903	8 DIP	-40 ~ + 85°C
KA2903D	8 SOP	
KA2903S	9 SIP	

## SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Power Supply Voltage	$V_{CC}$	$\pm 18$ or 36	V
Differential Input Voltage	$V_{I(DIFF)}$	36	V
Input Voltage	$V_I$	- 0.3 to +36	V
Output Short Circuit to GND		Continuous	
Power Dissipation	$P_D$	570	mW
Operating Temperature	$T_{OPR}$	0 ~ + 70	°C
LM393/LM393A		- 25 ~ + 85	
LM293/LM293A		- 40 ~ + 85	
LM2903			
Storage Temperature	$T_{STG}$	- 65 ~ + 150	°C



**ELECTRICAL CHARACTERISTICS** ( $V_{CC}=5V$ ,  $T_A=25^{\circ}C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM293A/LM393A			LM293/LM393			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM}=0V$ to $V_{CC}=1.5V$ $V_{O(P)}=1.4V$ , $R_S=0\Omega$ NOTE 1		$\pm 1$	$\pm 2$		$\pm 1$	$\pm 5$	mV
Input Offset Current	$I_{IO}$	NOTE 1		$\pm 5$	$\pm 50$		$\pm 5$	$\pm 50$	nA
Input Bias Current	$I_{BIAS}$	NOTE 1		65	250		65	250	nA
Input Common Mode Voltage Range	$V_{I(R)}$	NOTE 1	0		$V_{CC}-1.5$	0		$V_{CC}-1.5$	V
			0		$V_{CC}-2$	0		$V_{CC}-2$	
Supply Current	$I_{CC}$	$R_L = \infty$ $R_L = \infty$ , $V_{CC} = 30V$		0.6	1		0.6	1	mA
				0.8	2.5		0.8	2.5	
Voltage Gain	$G_V$	$V_{CC}=15V$ , $R_L \geq 15K\Omega$ (for large $V_{O(P)swing}$ )	50	200		50	200		V/mV
Large Signal Response Time	$t_{RES}$	$V_I = \text{TTL Logic Swing}$ $V_{REF}=1.4V$ , $V_{RL}=5V$ , $R_L=5.1K\Omega$		350			350		ns
Response Time	$t_{RES}$	$V_{RL}=5V$ , $R_L=5.1K\Omega$		1.4			1.4		$\mu s$
Output Sink Current	$I_{SINK}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$ , $V_{O(P)} \leq 1.5V$	6	18		6	18		mA
Output Saturation Voltage	$V_{SAT}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$ $I_{SINK} = 4mA$ NOTE 1		160	400		160	400	mV
					700			700	
Output Leakage Current	$I_{O(LKG)}$	$V_{I(-)} = 0V$ , $V_{I(+)} = 1V$		0.1			0.1		nA
		$V_{O(P)} = 30V$			1.0			1.0	$\mu A$

## NOTE 1

LM393/A:  $0 \leq T_A \leq +70^{\circ}C$ LM293/A:  $-25 \leq T_A \leq +85^{\circ}C$ LM2903:  $-40 \leq T_A \leq +85^{\circ}C$

**ELECTRICAL CHARACTERISTICS** ( $V_{CC}=5V$ ,  $T_A=25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM2903			Unit
			Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM}=0V$ to $V_{CC}=1.5V$		$\pm 1$	$\pm 7$	mV
		$V_{O(P)}=1.4V$ , $R_S=0\Omega$ NOTE 1		$\pm 9$	$\pm 15$	
Input Offset Current	$I_{IO}$			$\pm 5$	$\pm 50$	nA
		NOTE 1		$\pm 50$	$\pm 200$	
Input Bias Current	$I_{BIAS}$			65	250	nA
		NOTE 1			500	
Input Common Mode Voltage Range	$V_{I(R)}$		0		$V_{CC}-1.5$	V
		NOTE 1	0		$V_{CC}-2$	
Supply Current	$I_{CC}$	$R_L = \infty$		0.6	1	mA
		$R_L = \infty$ , $V_{CC} = 30V$		1	2.5	
Voltage Gain	$G_V$	$V_{CC}=15V$ , $R_L \geq 15K\Omega$ (for large $V_{O(P-P)swing}$ )	25	100		V/mV
Large Signal Response Time	$t_{RES}$	$V_I = \text{TTL Logic Swing}$ $V_{REF}=1.4V$ , $V_{RL}=5V$ , $R_L=5.1K\Omega$		350		ns
Response Time	$t_{RES}$	$V_{RL}=5V$ , $R_L=5.1K\Omega$		1.5		$\mu s$
Output Sink Current	$I_{SINK}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$ , $V_{O(P)} \leq 1.5V$	6	16		mA
Output Saturation Voltage	$V_{SAT}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$		160	400	mV
		$I_{SINK} = 4mA$ NOTE 1			700	
Output Leakage Current	$I_{O(LKG)}$	$V_{I(-)} = 0V$ , $V_{I(+)} = 1V$		0.1		nA
		$V_{O(P)} = 5V$ $V_{O(P)} = 30V$			1.0	

NOTE 1

LM393/A:  $0 \leq T_A \leq +70^\circ C$ LM293/A:  $-25 \leq T_A \leq +85^\circ C$ LM2903:  $-40 \leq T_A \leq +85^\circ C$

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 SUPPLY CURRENT

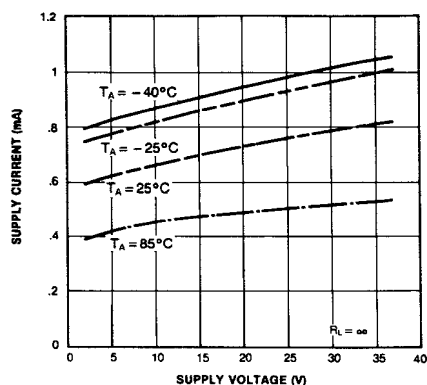


Fig. 2 INPUT CURRENT

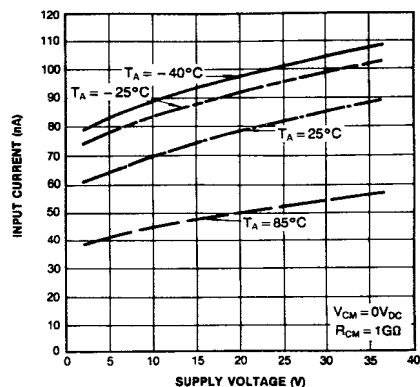


Fig. 3 OUTPUT SATURATION VOLTAGE

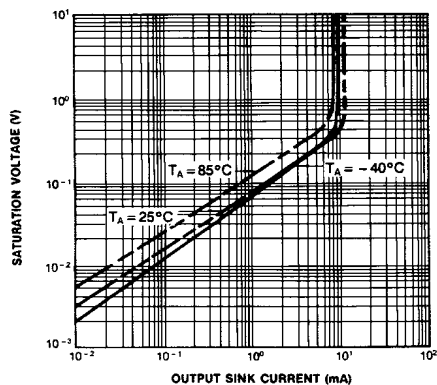


Fig. 4 RESPONSE TIME FOR VARIOUS INPUT OVERDRIVE-NEGATIVE TRANSITION

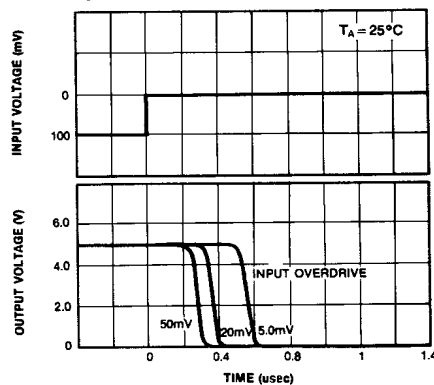
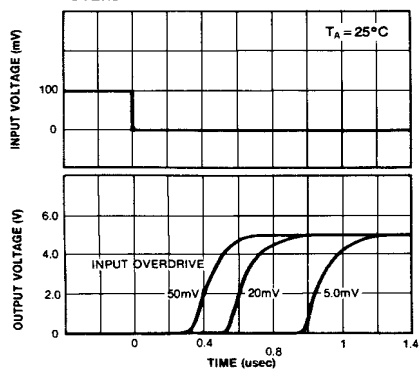


Fig. 5 RESPONSE TIME FOR VARIOUS INPUT OVERDRIVE-POSITIVE TRANSITION



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E <sup>2</sup> C MOS™	PowerTrench®	
FACT™	QFET™	
FACT Quiet Series™	QS™	
FAST®	Quiet Series™	
FASTr™	SuperSOT™-3	
GTO™	SuperSOT™-6	
HiSeC™	SuperSOT™-8	

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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### Definition of Terms

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No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

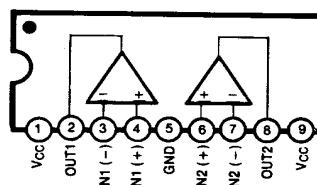
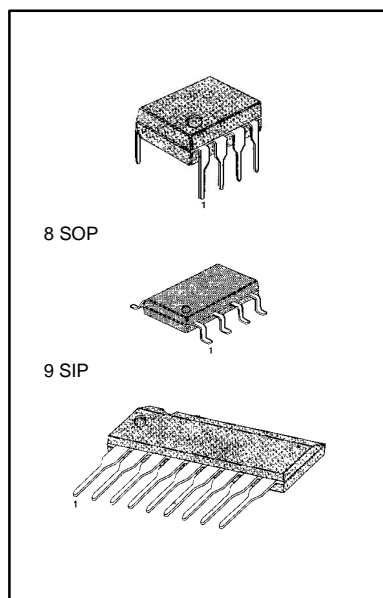
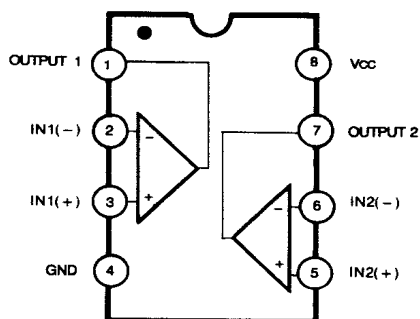
**DUAL DIFFERENTIAL COMPARATOR**

8 DIP

The LM293 series consists of two independent voltage comparators designed to operate from a single power supply over a wide voltage range.

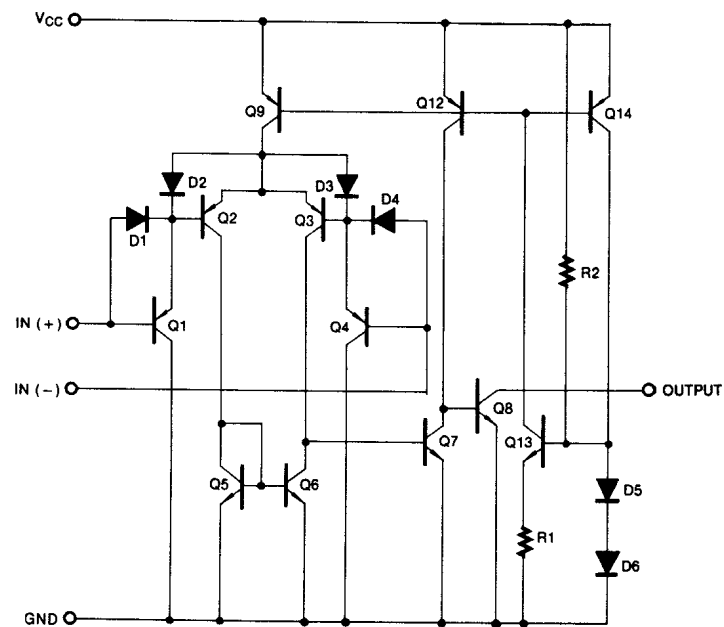
**FEATURES**

- Single Supply Operation: 2V to 36V
- Dual Supply Operation:  $\pm 1V$  to  $\pm 18V$
- Allow Comparison of Voltages Near Ground Potential
- Low Current Drain 800 $\mu A$  Typ
- Compatible with all Forms of Logic
- Low Input Bias Current 25nA Typ
- Low Input Offset Current  $\pm 5nA$  WP
- Low Offset Voltage  $\pm 1mV$  Typ

**BLOCK DIAGRAM****ORDERING INFORMATION**

Device	Package	Operating Temperature
LM393N LM393AN	8 DIP	0 ~ + 75°C
LM393S LM393AS	9 SIP	
LM393M LM393AM	8 SOP	
LM293N LM293AN	8 DIP	-25 ~ + 85°C
LM293S LM293AS	9 DIP	
LM293M LM293AM	8 SOP	
LM2903N	8 DIP	-40 ~ + 85°C
LM2903M	8 SOP	
LM2903S	9 SIP	

## SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Power Supply Voltage	$V_{CC}$	$\pm 18$ or 36	V
Differential Input Voltage	$V_{I(DIFF)}$	36	V
Input Voltage	$V_I$	- 0.3 to +36	V
Output Short Circuit to GND		Continuous	
Power Dissipation	$P_D$	570	mW
Operating Temperature	$T_{OPR}$	0 ~ + 70	°C
LM393/LM393A		- 25 ~ + 85	
LM293/LM293A		- 40 ~ + 85	
LM2903			
Storage Temperature	$T_{STG}$	- 65 ~ + 150	°C

**ELECTRICAL CHARACTERISTICS** ( $V_{CC}=5V$ ,  $T_A=25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM293A/LM393A			LM293/LM393			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM}=0V$ to $V_{CC}=1.5V$		$\pm 1$	$\pm 2$		$\pm 1$	$\pm 5$	mV
		$V_{O(P)}=1.4V$ , $R_S=0\Omega$ NOTE 1			$\pm 4.0$			$\pm 9.0$	
Input Offset Current	$I_{IO}$	NOTE 1		$\pm 5$	$\pm 50$		$\pm 5$	$\pm 50$	nA
					$\pm 150$			$\pm 150$	
Input Bias Current	$I_{BIAS}$	NOTE 1		65	250		65	250	nA
					400			400	
Input Common Mode Voltage Range	$V_{I(R)}$		0		$V_{CC}-1.5$	0		$V_{CC}-1.5$	V
		NOTE 1	0		$V_{CC}-2$	0		$V_{CC}-2$	
Supply Current	$I_{CC}$	$R_L = \infty$		0.6	1		0.6	1	mA
		$R_L = \infty$ , $V_{CC} = 30V$		0.8	2.5		0.8	2.5	
Voltage Gain	$G_V$	$V_{CC}=15V$ , $R_L \geq 15K\Omega$ (for large $V_{O(P)swing}$ )	50	200		50	200		V/mV
Large Signal Response Time	$t_{RES}$	$V_I = \text{TTL Logic Swing}$ $V_{REF}=1.4V$ , $V_{RL}=5V$ , $R_L=5.1K\Omega$		350			350		ns
Response Time	$t_{RES}$	$V_{RL}=5V$ , $R_L=5.1K\Omega$		1.4			1.4		$\mu s$
Output Sink Current	$I_{SINK}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$ , $V_{O(P)} \leq 1.5V$	6	18		6	18		mA
Output Saturation Voltage	$V_{SAT}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$		160	400		160	400	mV
		$I_{SINK} = 4mA$ NOTE 1			700			700	
Output Leakage Current	$I_{O(LKG)}$	$V_{I(-)} = 0V$ , $V_{I(+)} = 1V$		0.1			0.1		nA
		$V_{O(P)} = 30V$			1.0			1.0	

## NOTE 1

LM393/A:  $0 \leq T_A \leq +70^\circ C$ LM293/A:  $-25 \leq T_A \leq +85^\circ C$ LM2903:  $-40 \leq T_A \leq +85^\circ C$

**ELECTRICAL CHARACTERISTICS** ( $V_{CC}=5V$ ,  $T_A=25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM2903			Unit
			Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$V_{CM}=0V$ to $V_{CC}=1.5V$		$\pm 1$	$\pm 7$	mV
		$V_{O(P)}=1.4V$ , $R_S=0\Omega$ NOTE 1		$\pm 9$	$\pm 15$	
Input Offset Current	$I_{IO}$	NOTE 1		$\pm 5$	$\pm 50$	nA
				$\pm 50$	$\pm 200$	
Input Bias Current	$I_{BIAS}$	NOTE 1		65	250	nA
					500	
Input Common Mode Voltage Range	$V_{I(R)}$	NOTE 1	0		$V_{CC}-1.5$	V
			0		$V_{CC}-2$	
Supply Current	$I_{CC}$	$R_L = \infty$		0.6	1	mA
		$R_L = \infty$ , $V_{CC} = 30V$		1	2.5	
Voltage Gain	$G_V$	$V_{CC}=15V$ , $R_L \geq 15K\Omega$ (for large $V_{O(P-P)swing}$ )	25	100		V/mV
Large Signal Response Time	$t_{RES}$	$V_I = \text{TTL Logic Swing}$ $V_{REF}=1.4V$ , $V_{RL}=5V$ , $R_L=5.1K\Omega$		350		ns
Response Time	$t_{RES}$	$V_{RL}=5V$ , $R_L=5.1K\Omega$		1.5		$\mu s$
Output Sink Current	$I_{SINK}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$ , $V_{O(P)} \leq 1.5V$	6	16		mA
Output Saturation Voltage	$V_{SAT}$	$V_{I(-)} \geq 1V$ , $V_{I(+)} = 0V$		160	400	mV
		$I_{SINK} = 4mA$ NOTE 1			700	
Output Leakage Current	$I_{O(LKG)}$	$V_{I(-)} = 0V$ , $V_{O(P)} = 5V$		0.1		nA
		$V_{I(+)} = 1V$ , $V_{O(P)} = 30V$			1.0	$\mu A$

NOTE 1

LM393/A:  $0 \leq T_A \leq +70^\circ C$ LM293/A:  $-25 \leq T_A \leq +85^\circ C$ LM2903:  $-40 \leq T_A \leq +85^\circ C$



## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 SUPPLY CURRENT

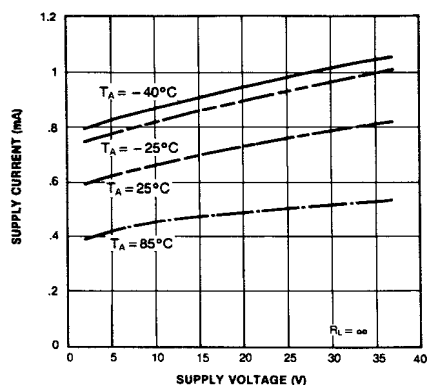


Fig. 2 INPUT CURRENT

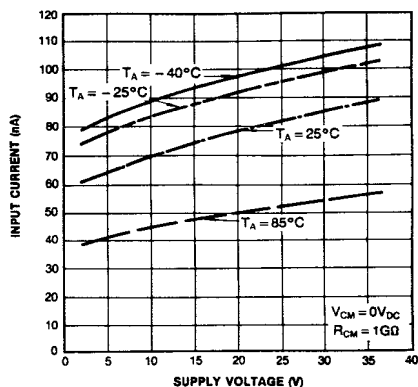


Fig. 3 OUTPUT SATURATION VOLTAGE

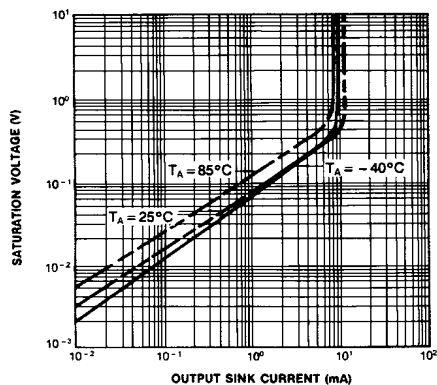


Fig. 4 RESPONSE TIME FOR VARIOUS INPUT OVERDRIVE-NEGATIVE TRANSITION

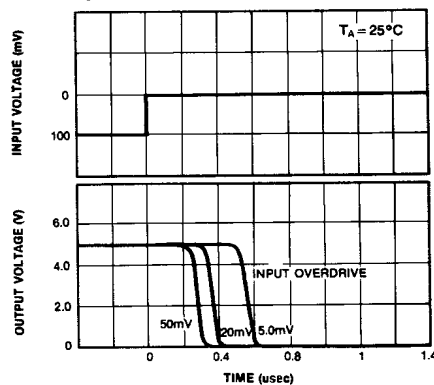
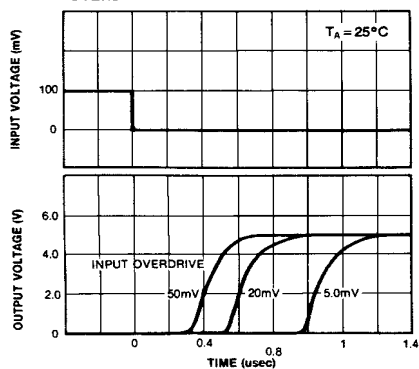


Fig. 5 RESPONSE TIME FOR VARIOUS INPUT OVERDRIVE-POSITIVE TRANSITION



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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

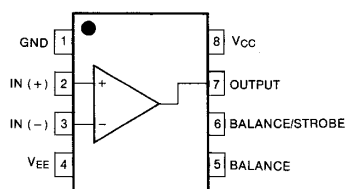
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**VOLTAGE COMPARATOR**

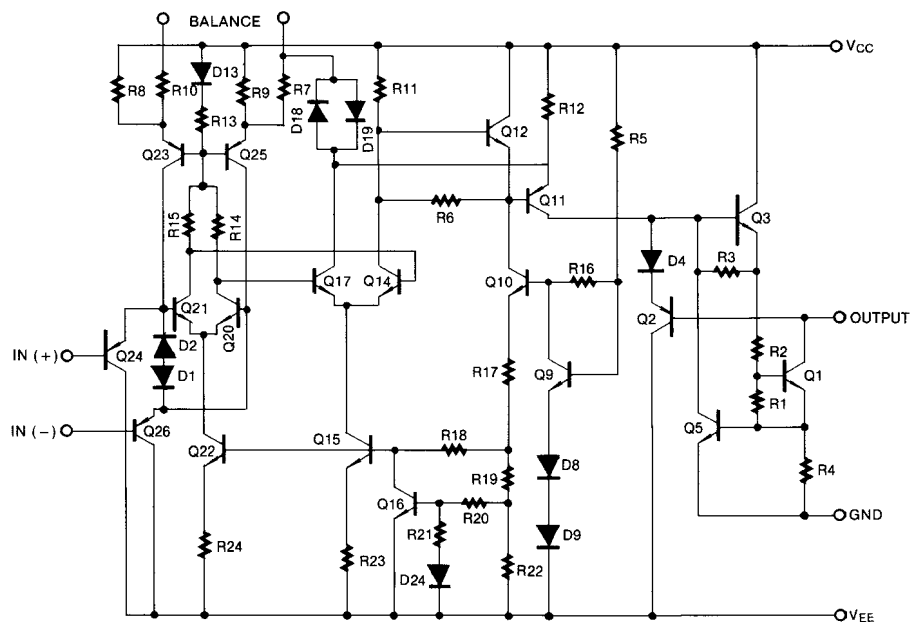
The LM311 series is a monolithic, low input current voltage comparator.  
The device is also designed to operate from dual or single supplies voltage

**FEATURE**

- Low input bias current : 250nA (Max)
- Low input offset current : 50nA (Max)
- Differential Input Voltage :  $\pm 30V$ .
- Power supply voltage : single 5.0V supply to  $\pm 15V$ .
- Offset voltage null capability.
- Strobe capability.

**BLOCK DIAGRAM****ORDERING INFORMATION**

Device	Package	Operating Temperature
LM311N	8 DIP	0 ~ +70°C
LM311M	8 SOP	

**SCHEMATIC DIAGRAM**

## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Total Supply Voltage	$V_{CC}$	36	V
Output to Negative Supply Voltage KA311	$V_O - V_{EE}$	40	V
Ground to Negative voltage	$V_{EE}$	-30	V
Differential Input Voltage	$V_{I(DIFF)}$	30	V
Input Voltage	$V_I$	$\pm 15$	V
Output Short Circuit Duration		10	sec
Power Dissipation	$P_D$	500	mW
Operating Temperature Range	$T_{OPR}$	0 ~ +70	°C
Storage Temperature Range	$T_{STG}$	- 65 ~ +150	°C

ELECTRICAL CHARACTERISTICS ( $V_{CC} = 15V$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Offset Voltage	$V_{IO}$	$R_S \leq 50K\Omega$		1.0	7.5	mV
		NOTE 1			10	
Input Offset Current	$I_{IO}$			6	50	nA
		NOTE 1			70	
Input Bias Current	$I_{BIAS}$			100	250	nA
		NOTE 1			300	
Voltage Gain	$G_V$		40	200		V/mV
Response Time	$t_{RES}$	NOTE 2		200		ns
Saturation Voltage	$V_{SAT}$	$I_O = 50mA$ , $V_I \leq -10mV$		0.75	1.5	V
		$V_{CC} \geq 4.5V$ , $V_{EE} = 0V$		0.23	0.4	
		$I_{SINK} = 8mA$ , $V_I \geq -10mV$ , NOTE 1				
Strobe "NO" Current	$I_{STR(ON)}$			3		mA
Output Leakage Current	$I_{SINK}$	$I_{STR} = 3mA$ , $V_I \geq 10mV$ $V_{O(P)} = 35V$ , $V_{EE} = V_{GND} = -5V$		0.2	50	nA
Input Voltage Range	$V_{I(R)}$	NOTE 1	-14.5 to 13.0	-14.7 to 13.8		V
Positive Supply Current	$I_{CC}$			3.0	7.5	mA
Negative Supply Current	$I_{EE}$			-2.2	-5.0	mA
Strobe Current	$I_{STR}$			3		mA

NOTE 1.  $0 \leq T_A \leq +70^\circ C$ 

2. The response time specified is for a 100mV input step with 5mV over drive.

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 INPUT BIAS CURRENT

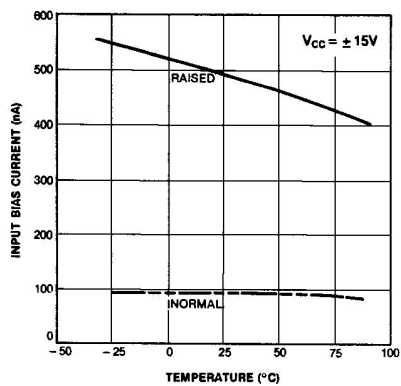


Fig. 2 INPUT OFFSET CURRENT

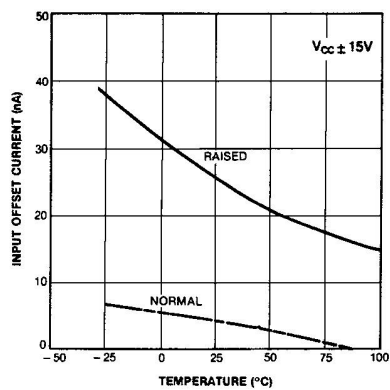


Fig. 3 OFFSET VOLTAGE VS INPUT RESISTANCE

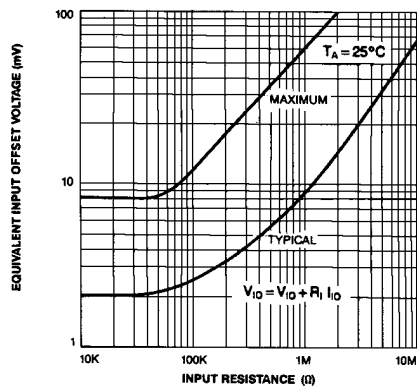


Fig. 4 INPUT BIAS CURRENT VS DIFFERENTIAL

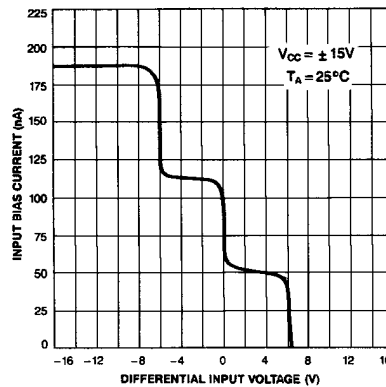


Fig. 5 COMMON MODE LIMITS VS TEMPERATURE

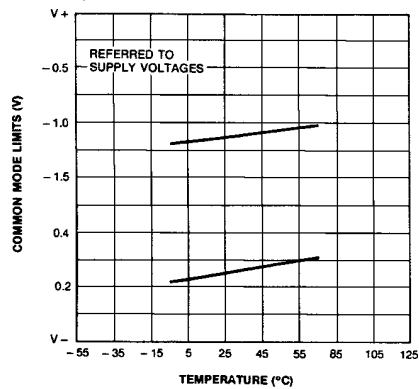


Fig. 6 OUTPUT VOLTAGE VS DIFFERENTIAL

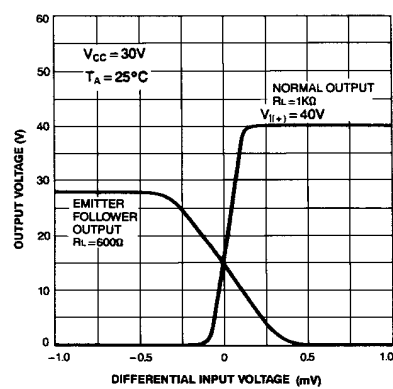


Fig. 7 SATURATION VOLTAGE VS CURRENT

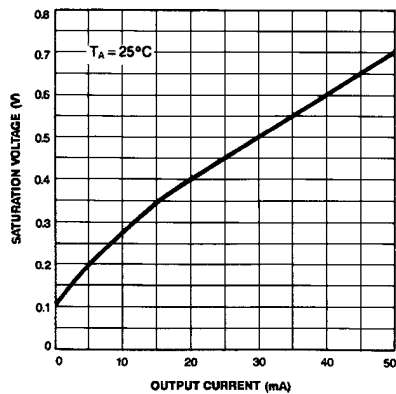


Fig. 8 SUPPLY CURRENT VS TEMPERATURE

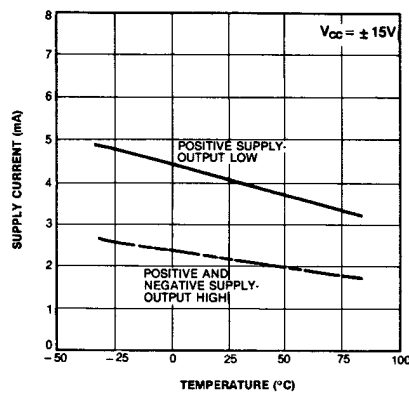


Fig. 9 LEAKAGE CURRENTS VS TEMPERATURE

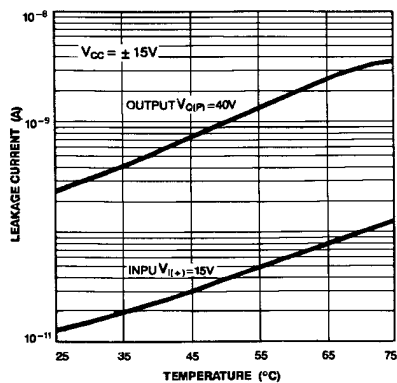


Fig. 10 SUPPLY CURRENT VS SUPPLY VOLTAGE

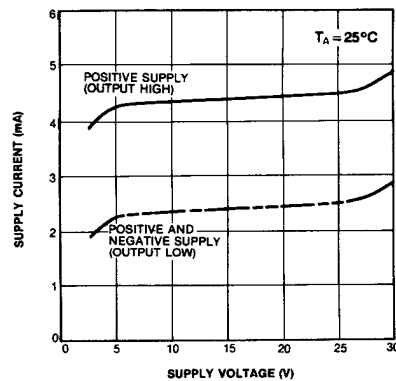


Fig. 11 OUTPUT SATURATION VOLTAGE

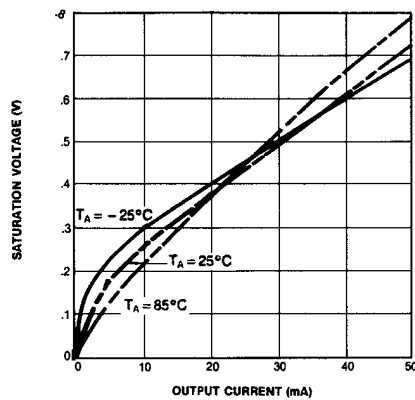
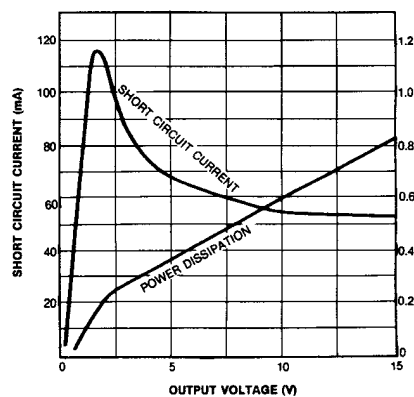


Fig. 12 OUTPUT LIMITING CHARACTERISTICS



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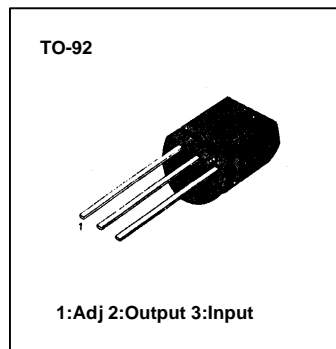
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**3-TERMINAL 0.1A POSITIVE ADJUSTABLE REGULATOR**

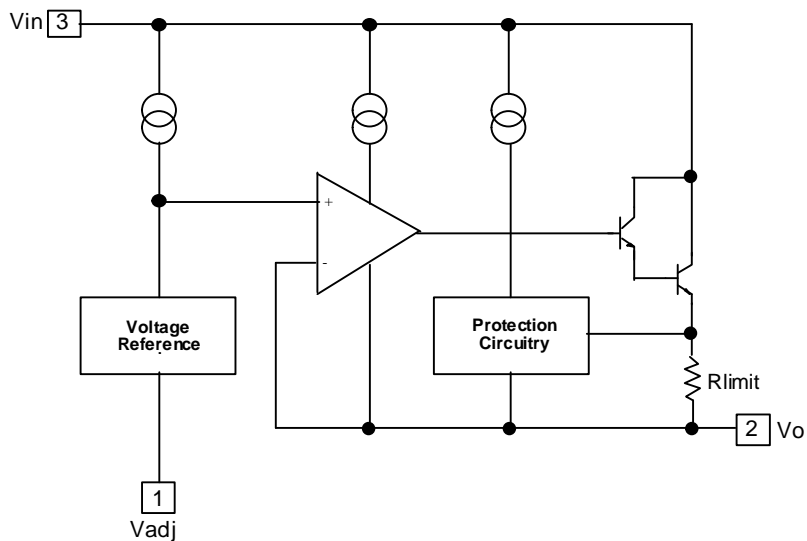
The LM317L is a 3-terminal adjustable positive voltage regulator capable of supplying in excess of 100mA over an output voltage range of 1.2V to 37V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage.

**FEATURES**

- Output current in excess of 100mA
- Output adjustable between 1.2V and 37V
- Internal thermal-overload protection
- Internal short-circuit current-limiting
- Output transistor safe-area compensation
- Floating operation for high-voltage applications

**ORDERING INFORMATION**

Device	Package	Operating Temperature
LM317LZ	TO-92	0 ~ 125°C

**BLOCK DIAGRAM**



# LM317L (KA317)      ADJUSTABLE VOLTAGE REGULATOR (POSITIVE)

## ABLOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Input-Output Voltage Differential	$V_I - V_O$	40	V
Power Dissipation	$P_D$	Internally limited	W
Operating Temperature Range	$T_{OPR}$	0 ~ +125	°C
Storage Temperature Range	$T_{STG}$	-65 ~ +125	°C

## ELECTRICAL CHARACTERISTICS

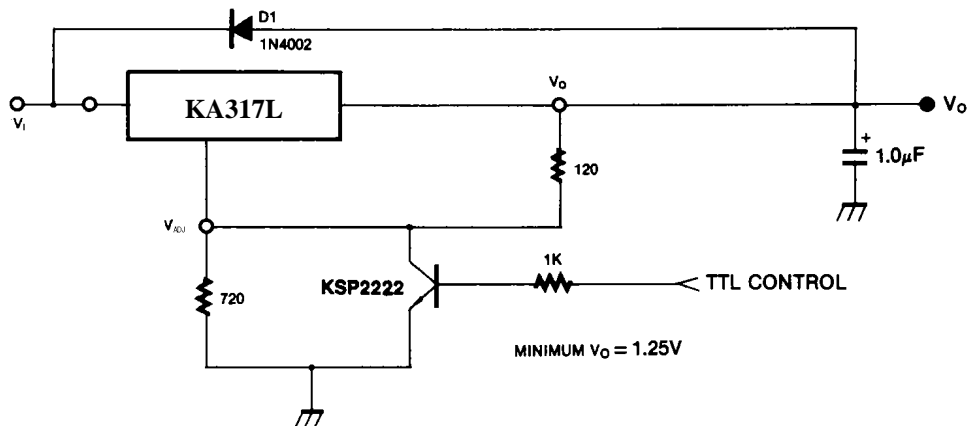
( $V_I - V_O = 5V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $P_{DMAX} = 625mW$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
*Line Regulation	$\Delta V_O$	$T_A = +25^\circ C$ $3V \leq V_I \leq V_O \leq 40V$		0.01	0.04	% / V
		$3V \leq V_I \leq V_O \leq 40V$		0.02	0.07	
*Load Regulation	$\Delta V_O$	$T_A = +25^\circ C$ $10mA \leq I_O \leq 100mA$ $V_O \leq 5V$ $V_O \geq 5V$		5 0.1	25 0.5	mV % / $V_O$
		$10mA \leq I_O \leq 100mA$ $V_O \leq 5V$ $V_O \geq 5V$		20 0.3	70 1.5	mV % / $V_O$
Adjustment Pin Current	$I_{ADJ}$			50	100	$\mu A$
Adjustment Pin Current Change	$\Delta I_{ADJ}$	$3V \leq V_I - V_O \leq 40V$ $10mA \leq I_O \leq 100mA$ $P_D < P_{DMAX}$		0.2	5	$\mu A$
Reference Voltage	$V_{REF}$	$3V < V_I - V_O < 40V$ $10mA \leq I_O \leq 100mA$ $P_D \leq P_{DMAX}$	1.20	1.25	1.30	V
Temperature Stability	$ST_T$			0.7		%
Minimum Load Current to Maintain Regulation	$I_{L(MIN)}$	$V_I - V_O = 40V$		3.5	10	mA
		$V_I - V_O = 5V$ $P_D < P_{DMAX}$	100	200		
		$V_I - V_O = 40V$ $P_D < P_{DMAX}$ , $T_A = +25^\circ C$	25	50		
RMS Noise, % of $V_{OUT}$	$e_N$	$T_A = +25^\circ C$ $10Hz < f < 10KHz$		0.003		% / $V_O$
Ripple Rejection	RR	$V_O = 10V$ , $f = 120Hz$ without $C_{ADJ}$ $C_{ADJ} = 10\mu F$	66	65 80		dB
Long-Term Stability	ST	$T_J = +125^\circ C$ , 1000 Hours		0.3		%

\* Load and Line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## TYPICAL APPLICATIONS

Fig. 1 5V Electronic Shutdown Regulator



D1 protects the device during an input short circuit.

Fig. 2 Slow Turn-On Regulator

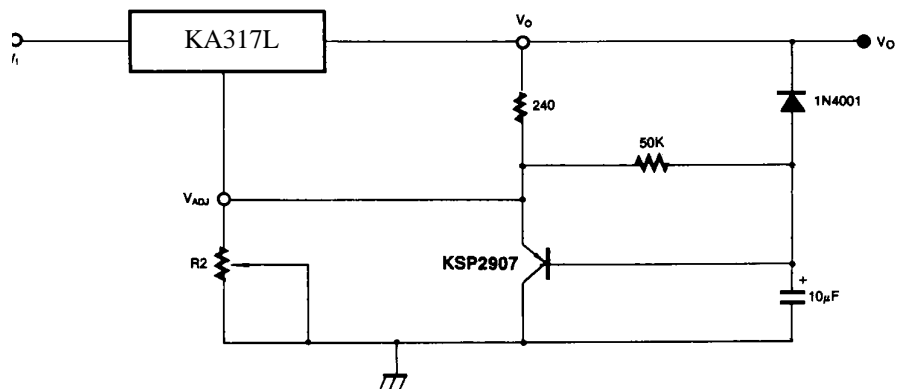
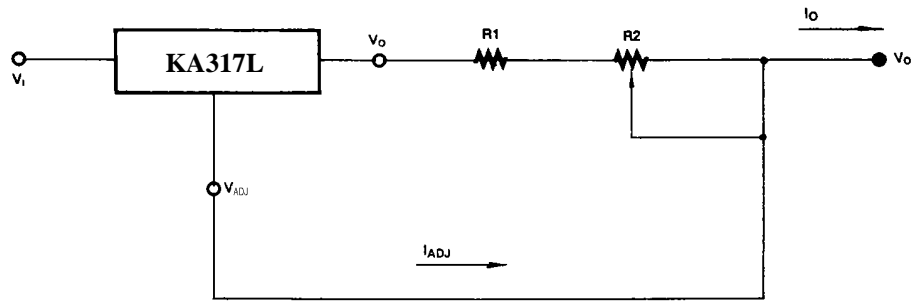


Fig. 3 Current Regulator

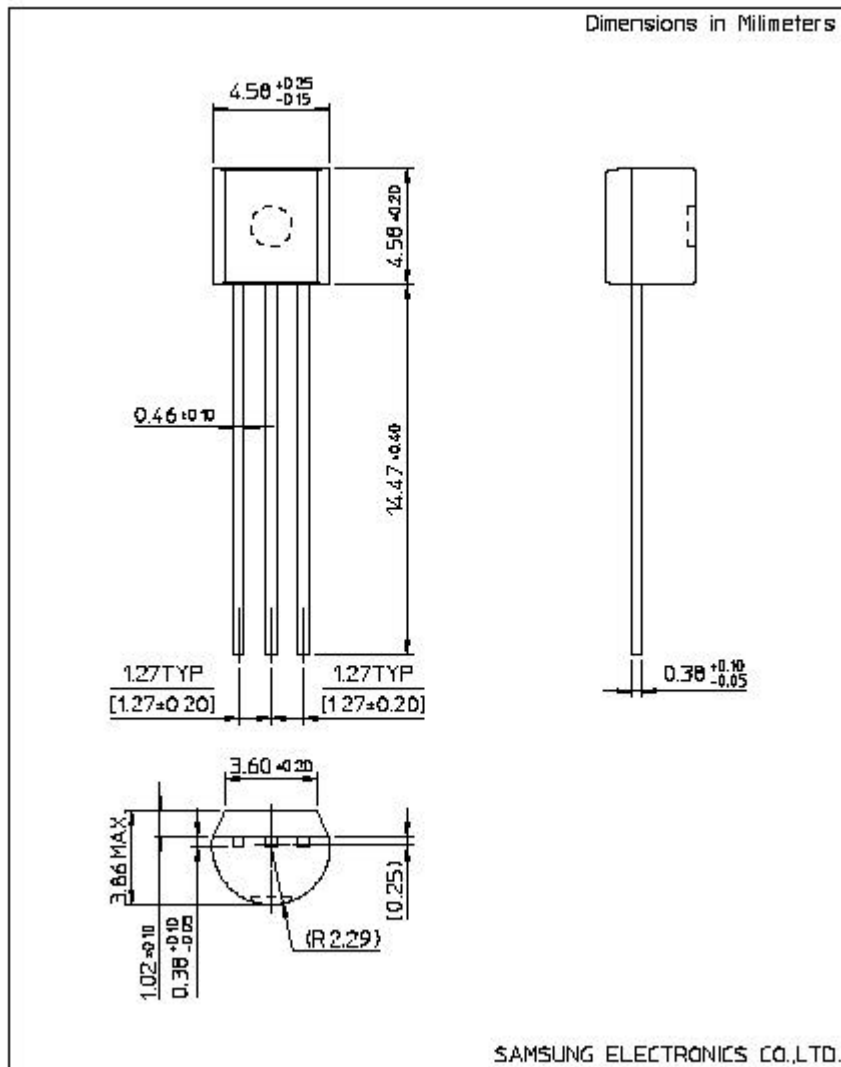


$$I_{O\text{MAX}} = \left( \frac{V_{\text{REF}}}{R_1} \right) + I_{\text{ADJ}} \approx \frac{1.25\text{V}}{R_1}$$

$$I_{O\text{MIN}} = \left( \frac{V_{\text{REF}}}{R_1 + R_2} \right) + I_{\text{ADJ}} \approx \frac{1.25\text{V}}{R_1 + R_2}$$

$$5\text{mA} < I_o < 500\text{mA}$$

TO-92



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# LM337 (KA337) ADJUSTABLE VOLTAGE REGULATOR (NEGATIVE)

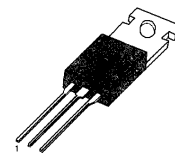
## 3-TERMINAL 1.5A NEGATIVE ADJUSTABLE REGULATOR

The LM337 is a 3-terminal negative adjustable regulator. It supply in excess of 1.5A over an output voltage range of -1.2V to -37V. This regulator requires only two external resistor to set the output voltage. Included on the chip are current limiting, thermal overload protection and safe area compensation.

### FEATURES

- Output current in excess of 1.5A
- Output voltage adjustable between -1.2V and -37V
- Internal thermal-overload protection
- Internal short-circuit current limiting
- Output transistor safe-area compensation
- Floating operation for high-voltage applications
- Standard 3-pin TO-220 package

TO-220

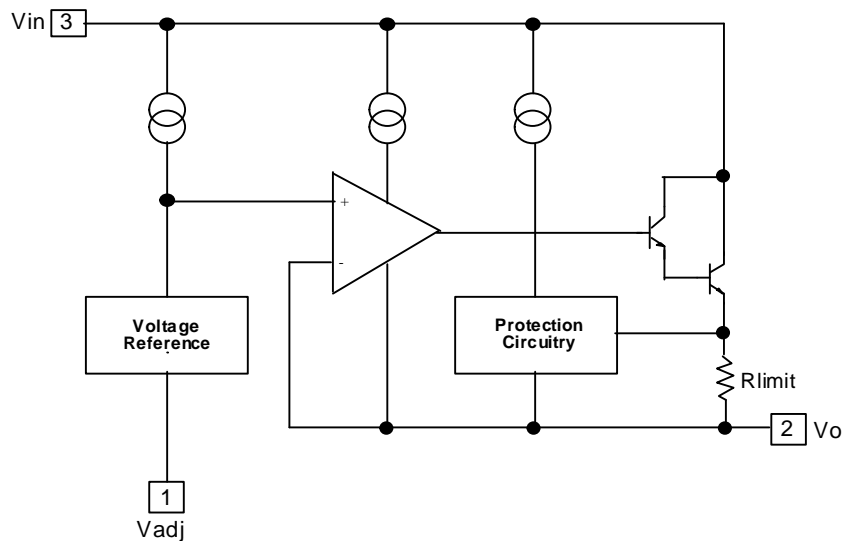


1:Adj 2:Input 3:Output

### ORDERING INFORMATION

Device	Package	Operating Temperature
LM337T	TO-220	0 ~ + 125°C

### BLOCK DIAGRAM



# LM337 (KA337) ADJUSTABLE VOLTAGE REGULATOR (NEGATIVE)

## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Input-Output Voltage Differential	$V_I - V_O$	40	V
Power Dissipation	$P_D$	Internally limited	W
Operating Temperature Range	$T_{OPR}$	0 ~ +125	°C
Storage Temperature Range	$T_{STG}$	-65 ~ +125	°C

## ELECTRICAL CHARACTERISTICS

( $V_I - V_O = 5V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $P_{DMAX} = 20W$ , unless otherwise specified)

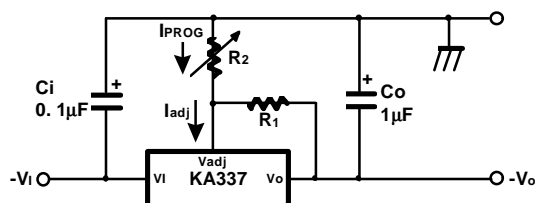
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Line Regulation	$V_O$	$T_A = +25^\circ C$ $-40V \leq V_O - V_I \leq -3V$		0.01	0.04	% / V
		$-40V \leq V_O - V_I \leq -3V$		0.02	0.07	
Load Regulation	$V_O$	$T_A = +25^\circ C$ $10mA \leq I_O \leq 0.5A$		15	50	mV
		$10mA \leq I_O \leq 1.5A$		15	150	
Adjustable Pin Current	$I_{ADJ}$			50	100	$\mu A$
Adjustable Pin Current	$\Delta I_{ADJ}$	$T_A = +25^\circ C$ $10mA \leq I_O \leq 1.5A$ $-40V \leq V_O - V_I \leq -3V$		2	5	$\mu A$
Reference Voltage	$V_{REF}$	$T_A = +25^\circ C$	-1.213	-1.250	-1.287	V
		$-40V \leq V_O - V_I \leq -3V$ $10mA \leq I_O \leq 1.5A$	-1.200	-1.250	-1.300	
Temperature Stability	$ST_T$			0.6		%
Minimum Load Current to Maintain Rejection		$-40V \leq V_O - V_I \leq -3V$		2.5	10	mA
		$-10V \leq V_O - V_I \leq -3V$		1.5	6	
Output Noise	$e_n$	$T_A = +25^\circ C$ $10Hz \leq f \leq 10KHz$		$3 \times V_{OUT}$		V/10 <sup>6</sup>
Ripple Rejection Ratio		$V_O = -10V$ , $f = 120Hz$		60		dB
		$C_{ADJ} = 10\mu F$	66	77		
Long Term Stability	ST	$T_J = 125^\circ C$ , 1000Hours		0.3	1	%
Thermal Resistance Junction to Case	$R_{EJC}$			4		°C / W

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used

## LM337 (KA337) ADJUSTABLE VOLTAGE REGULATOR (NEGATIVE)

### TYPICAL APPLICATIONS

Fig. 1 Programmable Regulator



\* Ci is required if regulator is located more than 4

inches from power supply filter.

A 1.0µF solid tantalum or 10µF aluminum electrolytic is recommended.

Co is necessary for stability. A 1.0µF solid tantalum or 10µF aluminum electrolytic is recommended.

$$V_o = -1.25V (1 + R_2 / R_1)$$



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FACT™	QS™
FACT Quiet Series™	Quiet Series™
FAST®	SuperSOT™-3
FASTr™	SuperSOT™-6
GTO™	SuperSOT™-8
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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

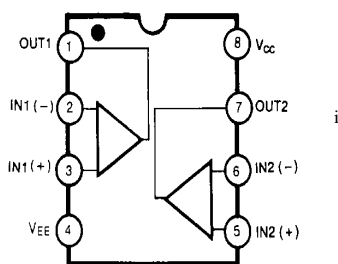
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**DUAL OPERATIONAL AMPLIFIER**

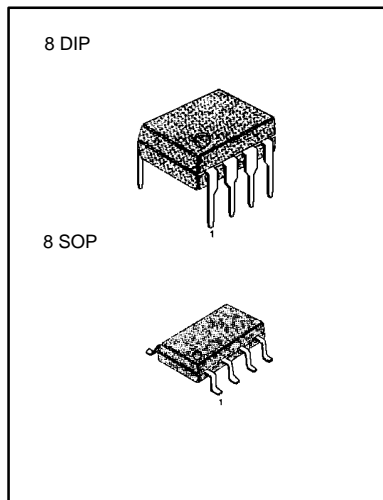
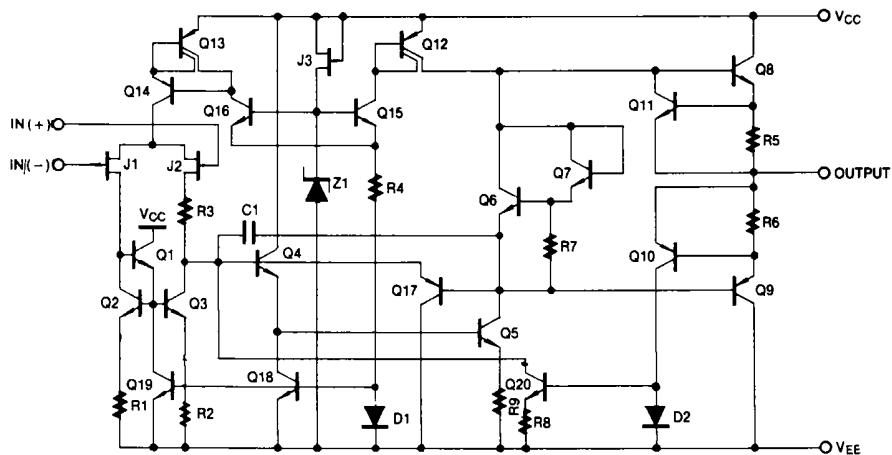
The LF353 is a JFET input operational amplifier with an internally compensated input offset voltage. The JFET input device provides with bandwidth, low input bias currents and offset currents.

**FEATURES**

- Internally trimmed offset voltage: 10mV
- Low input bias current: 50pA
- Wide gain bandwidth: 4MHz
- High slew rate: 13V/μs
- High Input impedance:  $10^{12}\Omega$

**BLOCK DIAGRAM**

**ORDERING INFORMATION**

Device	Package	Operating Temperature
LF353N	8 DIP	0 ~ + 70°C
LF353M	8 SOP	
LF353S	9 SIP	


**SCHEMATIC DIAGRAM (One Section Only)**


**ABSOLUTE MAXIMUM RATINGS**

Characteristics	Symbol	Value	Unit
Power Supply Voltage	$V_{CC}$	$\pm 18$	V
Differential Input Voltage	$V_{I(DIFF)}$	30	V
Input Voltage Range	$V_I$	$\pm 15$	V
Output Short Circuit Duration		Continuous	
Power Dissipation	$P_D$	500	mW
Operating Temperature Range	$T_{OPR}$	0 ~ +70	°C
Storage Temperature Range	$T_{STG}$	-65 ~ +150	°C

**ELECTRICAL CHARACTERISTICS**

( $V_{CC}=+15V$ ,  $V_{EE}=-15V$ ,  $T_A=25^\circ C$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Offset Voltage	$V_{IO}$	$R_S=10K\Omega$ $0^\circ C \leq T_A \leq +70^\circ C$		5.0	10	mV
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	$R_S=10K\Omega$ $0^\circ C \leq T_A \leq +70^\circ C$		10		$\mu V/^\circ C$
Input Offset Current	$I_{IO}$	$0^\circ C \leq T_A \leq +70^\circ C$		25	100	pA
Input Bias Current	$I_{BIAS}$	$0^\circ C \leq T_A \leq +70^\circ C$		50	200	pA
Input Resistance	$R_I$			$10^{12}$		$\Omega$
Large Signal Voltage Gain	$G_V$	$V_{O(P-P)} = \pm 0V$ $R_L = 2K\Omega$ $0^\circ C \leq T_A \leq +70^\circ C$	25	100		V/mV
Output Voltage Swing	$V_{O(P-P)}$	$R_L = 10K\Omega$	$\pm 12$	$\pm 13.5$		V
Input Voltage Range	$V_{I(R)}$		$\pm 11$	$\pm 15/-12$		V
Common Mode Rejection Ratio	CMRR	$R_S \geq 10K\Omega$	70	100		dB
Power Supply Rejection Ratio	PSRR	$R_S \geq 10K\Omega$	70	100		dB
Power Supply Current	$I_{CC}$			3.6	6.5	mA
Slew Rate	SR	$G_V = 1$		13		V/ $\mu s$
Gain-Bandwidth Product	GBM			4		MHz
Channel Separation	CS	$f = 1Hz \sim 20KHz$ (Input referenced)	120	120		dB
Equivalent Input Noise Voltage	$V_{NI}$	$R_S = 100\Omega$ $f = 1KHz$	16	16		nV/ $\sqrt{Hz}$
Equivalent Input Noise Current	$I_{NI}$	$f = 1KHz$	0.01	0.01		pA/ $\sqrt{Hz}$

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FACT<sup>TM</sup>  
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FAST<sup>®</sup>  
FAST<sup>r</sup><sup>TM</sup>  
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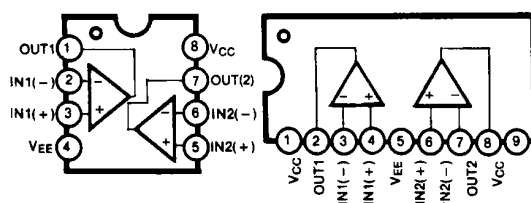
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## DUAL JFET INPUT OPERATIONAL

## FEATURES

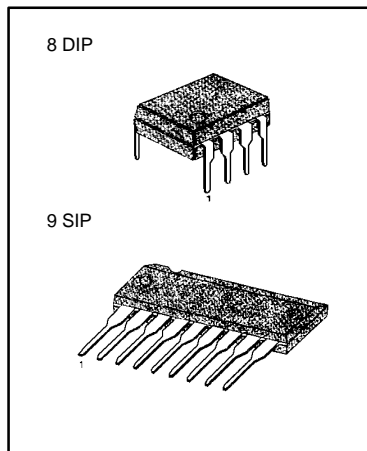
- Low supply current: 400pA MAX
- Low input bias Current: 50pA MAX
- Low input offset voltage: 1mV MAX
- High slew rate: 1V/ $\mu$ s
- High gain bandwidth: 1MHz

## BLOCK DIAGRAM

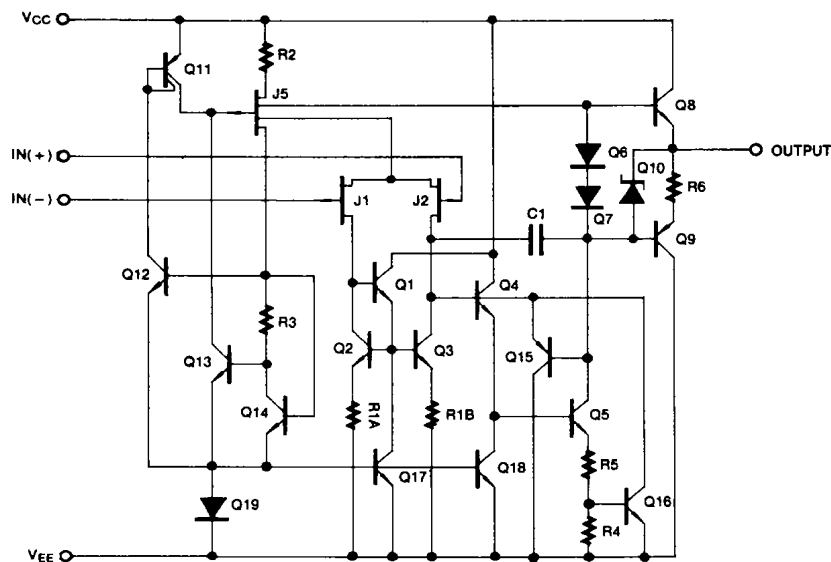


## ORDERING INFORMATION

Device	Package	Operating Temperature
LM442N LM442AN	8 DIP	0 ~ +70°C
LM442S LM442AS	9 SIP	



## SCHEMATIC DIAGRAM (One Section Only)



## ABSOLUTE MAXIMUM RATINGS

Characteristics	Symbol	Value	Unit
Power Supply Voltage LM442 LM442A	$V_{CC}$	$\pm 18$ $\pm 20$	V
Differential Input Voltage	$V_{I(DIFF)}$	30	V
Input Voltage range	$V_I$	$\pm 15$	V
Output Short Circuit Duration		Continuous	
Power Dissipation	$P_D$	670	mW
Operating Temperature Range LM442/A	$T_{OPR}$	0 ~ + 70	°C
Storage Temperature Range	$T_{STG}$	-65 ~ + 150	°C

## ELECTRICAL CHARACTERISTICS

(T<sub>A</sub>=25°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM442A			LM442			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$R_S = 10K\Omega$		0.5	1.0		1.0	5.0	mV
		Note 1						7.5	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	$R_S = 10K\Omega$		7	10		7		$\mu V/^\circ C$
Input Offset Current	$I_{IO}$			5	25		5	50	pA
		Note 1			15			15	
Large Signal Voltage Gain	$I_{BIAS}$			10	50		10	100	pA
		Note 1			30			30	
Large Signal Voltage Gain	$G_V$	$R_L = 10K\Omega$	50	200		25	200		V/mV
		$V_{O(P,P)} = \pm 0V$ Note 1	25	200		15	200		
Output Voltage Swing	$V_{O(P-P)}$	$R_S = 10K\Omega$	$\pm 17$	$\pm 18$		$\pm 12$	$\pm 13$		V
Input Voltage Range	$V_{I(R)}$		$\pm 16$	+18 -17		$\pm 11$	+15 -12		V
Common-Mode Rejection Ratio	CMRR	$R_S \leq 10K\Omega$	80	100		70	95		dB
Power Supply Rejection Ratio	PSRR	$R_S \leq 10K\Omega$	80	100		70	90		dB
Input Resistance	$R_I$			$10^{12}$		$10^{12}$			$\Omega$
Supply Current	$I_{CC}$			300	400		400	500	$\mu A$
Slew Rate	SR		0.8	1		0.6	1		V/ $\mu S$
Gain Bandwidth Product			0.8	1		0.6	1		MHz
Channel Separation	CS	f = 1Hz-20KHz (input referenced)		120			120		dB
Equivalent Input Noise Voltage	$V_{NI}$	$R_S = 100\Omega$ f = 1KHz		35			35		$nV/\sqrt{Hz}$
Equivalent Input Noise Current	$I_{NI}$	f = 1KHz		0.01			0.01		$pA/\sqrt{Hz}$

NOTE 1. LM442/A : 0 ≤ T<sub>A</sub> ≤ +70 °C

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## SINGLE TIMER

The LM555/I is a highly stable controller capable of producing accurate timing pulses. With monostable operation, the time delay is controlled by one external and one capacitor. With astable operation, the frequency and duty cycle are accurately controlled with two external resistors and one capacitor.

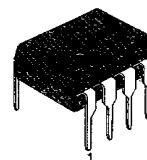
## FEATURES

- High Current Drive Capability (= 200mA)
- Adjustable Duty Cycle
- Temperature Stability of 0.005%/°C
- Timing From  $\mu$ Sec To Hours
- Turn Off Time Less Than 2 $\mu$ Sec

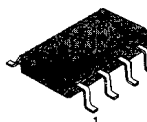
## APPLICATIONS

- Precision Timing
- Pulse Generation
- Time Delay Generation
- Sequential Timing

8 DIP



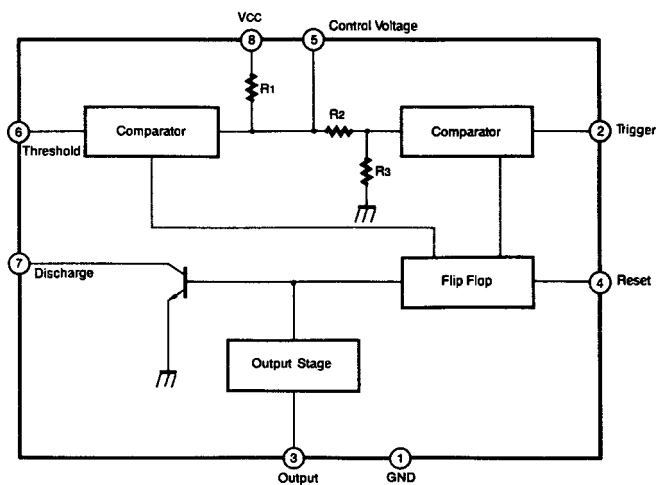
8 SOP



## ORDERING INFORMATION

Device	Package	Operating Temperature
LM555CN	8 DIP	0 ~ +70°C
LM555CM	8 SOP	
LM555CIN	8 DIP	-40 ~ +85°C
LM555CIM	8 SOP	

## BLOCK DIAGRAM





**ABSOLUTE MAXIMUM RATINGS** ( $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	Value	Unit
Supply Voltage	$V_{CC}$	16	V
Lead Temperature (soldering 10sec)	$T_{LEAD}$	300	$^\circ\text{C}$
Power Dissipation	$P_D$	600	mW
Operating Temperature Range LM555C LM555CI	$T_{OPR}$	0 ~ + 70 - 40 ~ + 85	$^\circ\text{C}$
Storage Temperature Range	$T_{STG}$	- 65 ~ + 150	$^\circ\text{C}$

**ELECTRICAL CHARACTERISTICS**( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5 \sim 15\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Voltage	$V_{CC}$		4.5		16	V
Supply Current	$I_{CC}$	$V_{CC} = 5\text{V}$ , $R_L = \infty$		3	6	mA
* <sup>1</sup> (low stable)		$V_{CC} = 15\text{V}$ , $R_L = \infty$		7.5	15	mA
*Timing Error (Monostable)	ACCUR	$R_A = 1\text{K}\Omega$ to 100K $\Omega$ $C = 0.1\mu\text{F}$				% ppm/ $^\circ\text{C}$ %/V
<sup>2</sup> Initial Accuracy				1.0	3.0	
Drift with Temperature				50		
Drift with Supply Voltage				0.1	0.5	
*Timing Error (astable)	ACCUR	$R_A = 1\text{K}\Omega$ to 100K $\Omega$ $C = 0.1\mu\text{F}$				% ppm/ $^\circ\text{C}$ %/V
<sup>2</sup> Initial Accuracy				2.25		
Drift with Temperature				150		
Drift with Supply Voltage				0.3		
Control Voltage	$V_C$	$V_{CC} = 15\text{V}$	9.0	10.0	11.0	V
		$V_{CC} = 5\text{V}$	2.6	3.33	4.0	V
Threshold Voltage	$V_{TH}$	$V_{CC} = 15\text{V}$		10.0		V
		$V_{CC} = 5\text{V}$		3.33		V
* <sup>3</sup> Threshold Current	$I_{TH}$			0.1	0.25	$\mu\text{A}$
Trigger Voltage	$V_{TR}$	$V_{CC} = 5\text{V}$	1.1	1.67	2.2	V
Trigger Voltage	$V_{TR}$	$V_{CC} = 15\text{V}$	4.5	5	5.6	V
Trigger Current	$I_{TR}$	$V_{TR} = 0\text{V}$		0.01	2.0	$\mu\text{A}$
Reset Voltage	$V_{RST}$		0.4	0.7	1.0	V
Reset Current	$I_{RST}$			0.1	0.4	mA

## SINGLE TIMER

## ELECTRICAL CHARACTERISTICS

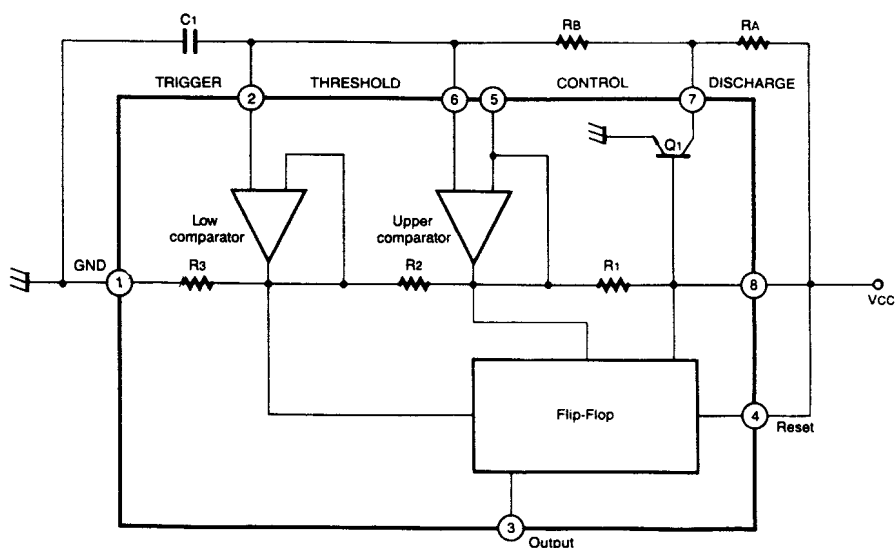
(T<sub>A</sub> = 25°C, V<sub>CC</sub> = 5 ~ 15V, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Low Output Voltage	$V_{OL}$	$V_{CC} = 15V$ $I_{SINK} = 10mA$ $I_{SINK} = 50mA$		0.06 0.3	0.25 0.75	V V
		$V_{CC} = 5V$ $I_{SINK} = 5mA$		0.05	0.35	V
High Output Voltage	$V_{OH}$	$V_{CC} = 15V$ $I_{SOURCE} = 200mA$ $I_{SOURCE} = 100mA$		12.5 13.3		V V
		$V_{CC} = 5V$ $I_{SOURCE} = 100mA$	2.75	3.3		V
Rise Time of Output	$t_R$			100		ns
Fall Time of Output	$t_F$			100		ns
Discharge Leakage Current	$I_{LKG}$			20	100	nA

Notes:

1. Supply current when output is high is typically 1mA less at  $V_{CC} = 5V$
2. Tested at  $V_{CC} = 5.0V$  and  $V_{CC} = 15V$
3. This will determine maximum value of  $R_A + R_B$  for 15V operation, the max. total  $R = 20M\Omega$ , and for 5V operation the max. total  $R = 6.7M\Omega$

## APPLICATION CIRCUIT



## APPLICATION NOTE

The application circuit shows astable mode.

Pin 6 (threshold) is tied to Pin 2 (trigger) and Pin 4 (reset) is tied to  $V_{CC}$  (Pin 8).

The external capacitor  $C_1$  of Pin 6 and Pin 2 charges through  $R_A$ ,  $R_B$  and discharges through  $R_B$  only.

In the internal circuit of the LM555 one input of the upper comparator is the  $2/3 V_{CC}$  ( $*R_1 = R_2 = R_3$ , another input if it is connected Pin 6).

As soon as charging  $C_1$  is higher than  $2/3 V_{CC}$ , discharge transistor  $Q_1$  turns on and  $C_1$  discharges to collector of transistor  $Q_1$ .

Therefore, the flip-flop circuit is reset and output is low.

One input of lower comparator is the  $1/3 V_{CC}$ , discharge transistor  $Q_1$  turn off and  $C_1$  charges through  $R_A$  and  $R_B$ .

Therefore, the flip-flop circuit is set and output is high.

So to say, when  $C_1$  charges through  $R_A$  and  $R_1$  output is high and when  $C_1$  discharges through  $R_B$  output is low.

The charge time (output is high)  $T_1$  is  $0.693 (R_A + R_B) C_1$  and the discharge time (output is low)  $T_2$  is  $0.693 (R_B C_1)$ .

$$(I_n \frac{V_{CC}-1/3V_{CC}}{V_{CC}-2/3V_{CC}}) (0.693)$$

Thus the total period time  $T$  is given by

$$T = T_1 + T_2 = 0.693 (R_A + 2R_B) C_1.$$

Then the frequency of astable mode is given by

$$f = \frac{1}{T} = \frac{1.44}{(R_A + 2R_B)C_1}$$

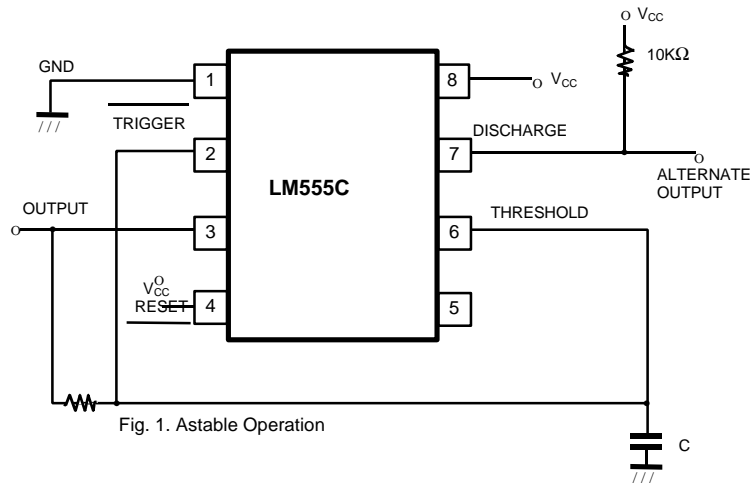
The duty cycle is given by

$$D.C = \frac{T_H}{T} = \frac{R_B}{R_A + 2R_B}$$

If you make use of the LM556 you can make two astable modes.

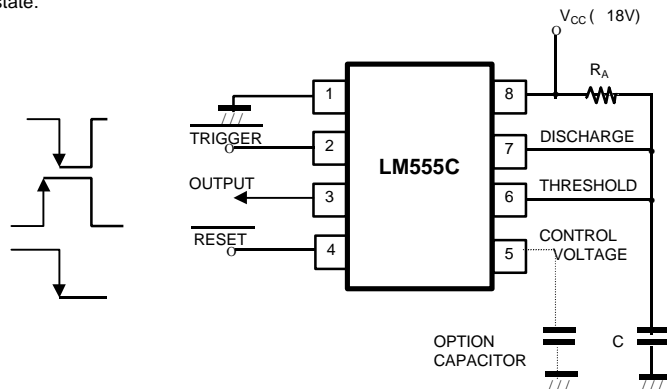
### Astable Operation

The LM555 can free run as a multivibrator by triggering itself; refer to Fig.2. The output can swing from  $V_{DD}$  to GND and have 50% duty cycle square wave. Less than 1% frequency deviation can be observed, over a voltage range of 2 to 5V.  $f = 1/1.4RC$



### Monostable Operation

The LM555 can be used as a one-shot, i.e. monostable multivibrator. Initially, because the inside discharge transistor is on state, external timing capacitor is held to GND potential. Upon application of a negative TRIGGER pulse pin 2, the internal discharge transistor is off state and the voltage across the capacitor increases with time constant  $T = R_A C$  and OUTPUT goes to high state. When the voltage across the capacitor equals  $2/3 V_{CC}$  the inner comparator is reset by THRESHOLD input and the discharge transistor goes to on state, which in turn discharges the capacitor rapidly and drives the OUTPUT to its low state.



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## DUAL TIMER

The LM556/I series dual monolithic timing circuits are a highly stable controller capable of producing accurate time delays or oscillation. The LM556 is a dual LM555. Timing is provided an external resistor and capacitor for each timing function.

The two timers operate independently of each other, sharing only  $V_{CC}$  and ground.

The circuits may be triggered and reset on falling wave forms. The output structures may sink or source 200mA.

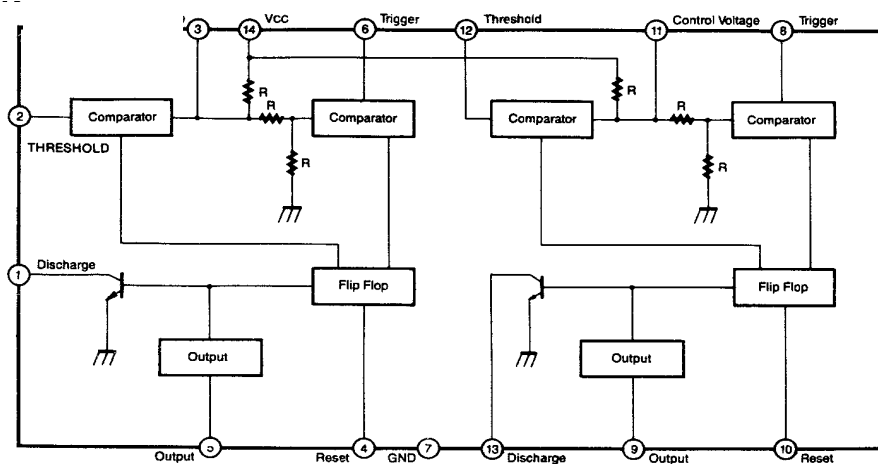
## FEATURES

- Replaces Two LM555C Timers
- Operates in Both Astable and Monostable Modes
- High Output Current
- TTL Compatible
- Timing From Microsecond to Hours
- Adjustable Duty Cycle
- Temperature Stability Of 0.005% Per °C

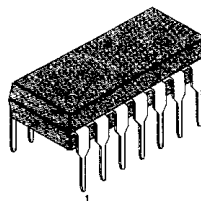
## APPLICATIONS

- Precision Timing
- Pulse Shaping
- Pulse Width Modulation
- Frequency Division
- Traffic Light Control
- Sequential Timing
- Pulse Generator
- Time Delay Generator
- Touch Tone Encoder
- Tone Burst Generator

## BLOCK DIAGRAM



14 DIP



## ORDERING INFORMATION

Device	Package	Operating Temperature
LM556CN	14 DIP	0 ~ + 70°C
LM556ICN	14 DIP	-40 ~ + 85°C

ABSOLUTE MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	Value	Unit
Supply Voltage	$V_{CC}$	16	V
Lead Temperature (soldering 10sec)	$T_{LEAD}$	300	$^\circ\text{C}$
Power Dissipation	$P_D$	600	mW
Operating Temperature Range LM556 LM556I	$T_{OPR}$	0 ~ + 70 - 40 ~ + 85	$^\circ\text{C}$
Storage Temperature Range	$T_{STG}$	- 65 ~ + 150	$^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS

( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5 \sim 15\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Voltage	$V_{CC}$		4.5		16	V
*1 Supply Current (two timers) (low state)	$I_{CC}$	$V_{CC} = 5\text{V}$ , $R_L = \infty$ $V_{CC} = 15\text{V}$ , $R_L = \infty$		5 16	12 30	mA mA
*2 Timing Error (monostable) Initial Accuracy Drift with Temperature Drift with Supply Voltage	ACCUR $\Delta t/\Delta T$ $\Delta t/\Delta V_{CC}$	$R_A = 2\text{k}\Omega$ to $100\text{k}\Omega$ $C = 0.1\mu\text{F}$ $T = 1.1\text{RC}$		0.75 50 0.1		% ppm/ $^\circ\text{C}$ %/V
Control Voltage	$V_C$	$V_{CC} = 15\text{V}$ $V_{CC} = 5\text{V}$	9.0 2.6	10.0 3.33	11.0 4.0	V V
Threshold Voltage	$V_{TH}$	$V_{CC} = 15\text{V}$ $V_{CC} = 5\text{V}$	8.8 2.4	10.0 3.33	11.2 4.2	V V
*3 Threshold Voltage	$I_{TH}$			30	250	nA
Trigger Voltage	$V_{TR}$	$V_{CC} = 15\text{V}$ $V_{CC} = 5\text{V}$	4.5 1.1	5.0 1.6	5.6 2.2	V V
Trigger Current	$I_{TR}$	$V_{TH} = 0\text{V}$		0.01	2.0	$\mu\text{A}$
*5 Reset Voltage	$V_{RST}$		0.4	0.6	1.0	V
Reset Current	$I_{RST}$			0.03	0.6	mA
Low Output Voltage	$V_{OL}$	$V_{CC} = 15\text{V}$ $I_{SINK} = 10\text{mA}$ $I_{SINK} = 50\text{mA}$ $I_{SINK} = 100\text{mA}$ $I_{SINK} = 200\text{mA}$ $V_{CC} = 5\text{V}$ $I_{SINK} = 8\text{mA}$ $I_{SINK} = 5\text{mA}$		0.1 0.4 2.0 2.5  0.25 0.15	0.25 0.75 3.2   0.35 0.25	V V V V  V V

**ELECTRICAL CHARACTERISTICS**(T<sub>A</sub> = 25°C, V<sub>CC</sub> = 5 ~ 15V, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
High Output Voltage	V <sub>OH</sub>	V <sub>CC</sub> = 15V I <sub>SOURCE</sub> = 200mA		12.5		V
		I <sub>SOURCE</sub> = 100mA	12.75	13.3		V
		V <sub>CC</sub> = 5V I <sub>SOURCE</sub> = 100mA	2.75	3.3		V
Rise Time of Output	t <sub>R</sub>			100	300	ns
Fall Time of Output	t <sub>F</sub>			100	300	ns
Discharge Leakage Current	I <sub>LKG</sub>			10	100	nA
*4 Matching Characteristics						
Initial Accuracy	ACCUR			1.0	2.0	%
Drift with Temperature	Δt/ΔT			10		ppm/°C
Drift with Supply Voltage	Δt/ΔV <sub>CC</sub>			0.2	0.5	%/V
*2 Timing Error (astable)						
Initial Accuracy	ACCUR	R <sub>A</sub> , R <sub>B</sub> = 1kΩ to 100kΩ C = 0.1μF V <sub>CC</sub> = 15V		2.25		%
Drift with Temperature	Δt/ΔT			150		ppm/°C
Drift with Supply Voltage				0.3		%/V

## Notes:

- \*1. Supply current when output is high is typically 1.0mA less at V<sub>CC</sub> = 5V
- \*2. Tested at V<sub>CC</sub> = 5V and V<sub>CC</sub> = 15V
- \*3. This will determine the maximum value of R<sub>A</sub> + R<sub>B</sub> for 15V operation.  
The maximum total R = 20MΩ, and for 5V operation the maximum total R = 6.6MΩ.
- \*4. Matching characteristics refer to the difference between performance characteristics of each timer section in the monostable mode.
- \*5. As reset voltage lowers, timing is inhibited and then the output goes low.



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## HIGH SPEED VOLTAGE COMPARATOR

The LM710/I is a high speed voltage comparator intended for use as an accurate, low-level digital level sensor or as a replacement for operational amplifiers in comparator applications where speed is of prime importance.

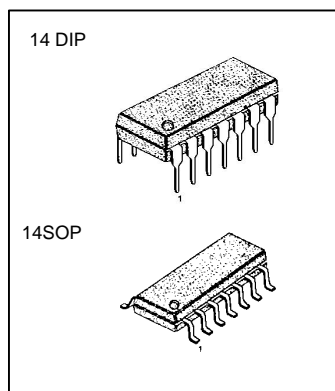
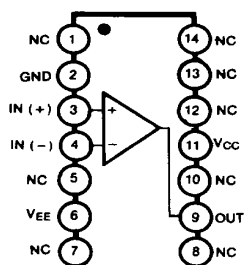
The output of the comparator is compatible with all integrated logic forms.

The LM710/I is useful as pulse height discriminators, a variable threshold Schmitt trigger, voltage comparator in high-speed A/D converters, a memory sense amplifier or a high noise immunity line receiver.

## FEATURES

- Low offset voltage: 5mV
- High gain: 1000 V/V
- High speed: 40ns Typ

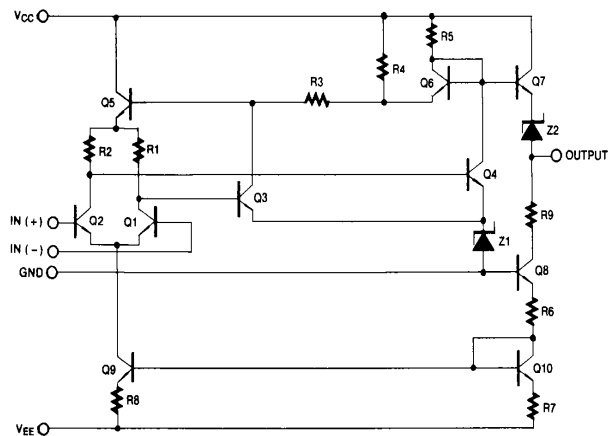
## BLOCK DIAGRAM



## ORDERING INFORMATION

Device	Package	Operating Temperature
LM710N	14 DIP	0 ~ 70°C
LM710M	14 SOP	
LM710IN	14 DIP	-25 ~ 85°C
LM710IM	14 SOP	

## SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Characteristic	Symbol	Value	Unit
Positive Supply Voltage	$V_{CC}$	+14	V
Negative Supply Voltage	$V_{EE}$	-7	V
Peak Output Current	$I_{PK}$	10	mA
Output Short Circuit Duration		10	Sec
Differential Input Voltage	$V_{I(DIFF)}$	5	V
Input Voltage	$V_I$	$\pm 7$	V
Power Dissipation	$P_D$	500	mW
Operating Temperature Range LM710	$T_{STG}$	0 ~ +70	°C
LM710I		-25 ~ +85	°C
Storage Temperature Range	$T_{STG}$	-65 ~ +150	°C

ELECTRICAL CHARACTERISTICS ( $V_{CC} = +12V$ ,  $V_{EE} = -6V$ ,  $T = 25^\circ C$ , unless otherwise specified)

Characteristics	Symbol	Test Conditions	LM710I			LM710			UNIT
			Min	Typ	Max	Min	Typ	Max	
Input Offset voltage	$V_{IO}$	$R_S \leq 200\Omega$ , Note1		0.6	2.0		1.6	5.0	mV
		Note 2			3.0			6.5	
Input Offset Current (Note 1)	$I_{IO}$	NOTE 1		0.75	3.0		1.8	5.0	nA
		Note 2		1.8	7.0			7.5	
Input Bias Current	$I_{BIAS}$			5.0	20		7.0	25	nA
		Note 2		27	45		25	40	
Large Signal Voltage Gain	$G_V$		1250	1800		1000	1700		V/V
		Note 2							
Input Voltage Range	$V_{I(R)}$	$V_{CC} = -7V$	$\pm 5.0$			$\pm 5.0$			V
Common Mode Rejection Ratio	CMRR	$R_S \leq 200\Omega$ , NOTE 2	80	95		70	94		dB
Differential Input Voltage Range	$V_{ID(R)}$		$\pm 5.0$			$\pm 5.0$			V
Positive Output Level	$V_{O(H)}$	$0 \leq I_O \leq 5mA$ , $V_I \geq 5mV$	2.5	2.9	4.0	2.5	2.9	4.0	V
Negative Output Level	$V_{O(L)}$	$V_I \geq 5mV$	-1.0	-0.5	0	-1.0	-0.5	0	V
Output Sink Current	$I_{SINK}$	$V_{O(P)} = 0V$ , $V_I \geq 5mV$	2.0	2.2		1.6	2.2		mA
Positive Supply Current	$I_{CC}$	$V_{O(P)} \leq 0V$		4.7	9.0		4.7	9.0	mA
Negative Supply Current	$I_{EE}$	$V_{O(P)} = 0V$ , $V_I = 5mV$		4.0	7.0		4.0	7.0	mA
Power Consumption	$P_D$	$V_{O(P)} = 0V$ , $V_I = 10mV$		80	150			150	mW
Response Time	$t_{RES}$	(Note 3)		40			40		ns

Note 1. The input offset voltage and input offset current are specified for a logic threshold voltage as follows:

For 710I, 1.65V at  $-25^\circ C$ , 1.4V at  $+25^\circ C$ , 1.15V at  $+85^\circ C$ . For 710, 1.5V at  $0^\circ C$ , 1.4V at  $+25^\circ C$ , 1.2V at  $+70^\circ C$ .

Note 2. LM710:  $0 \leq T_A \leq +70^\circ C$

LM710I:  $-25 \leq T_A \leq +85^\circ C$

Note 3. The response time specified is a 100mV input step with 5mV overdrive (LM710).

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 SUPPLY CURRENT

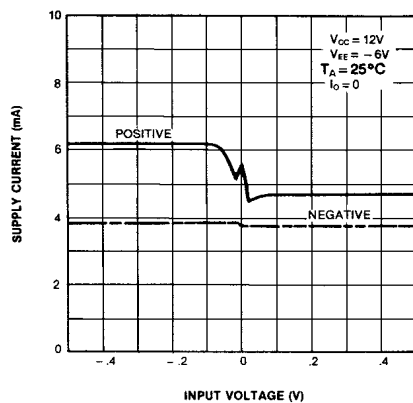


Fig. 2 VOLTAGE GAIN

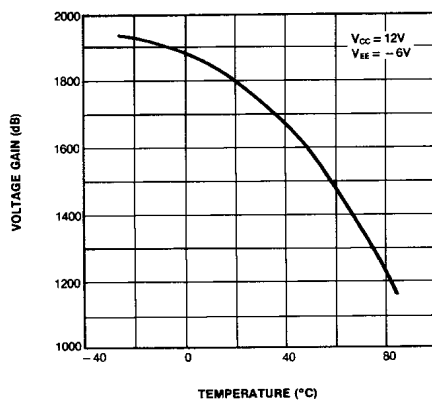


Fig. 3 INPUT OFFSET CURRENT

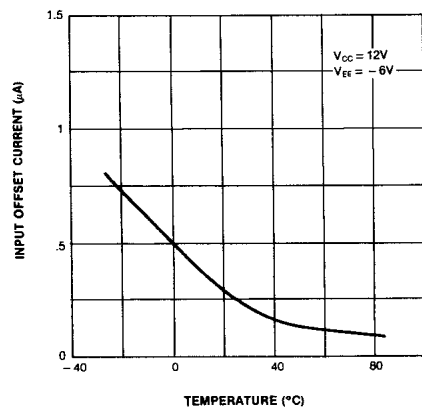


Fig. 4 INPUT BIAS CURRENT

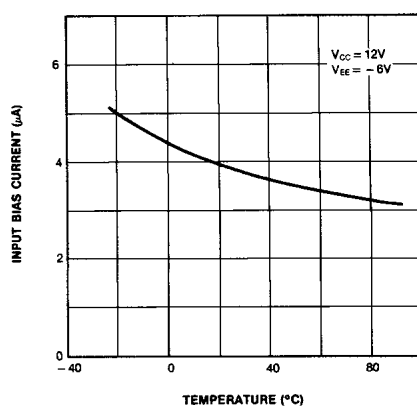


Fig. 5 OUTPUT VOLTAGE LEVEL

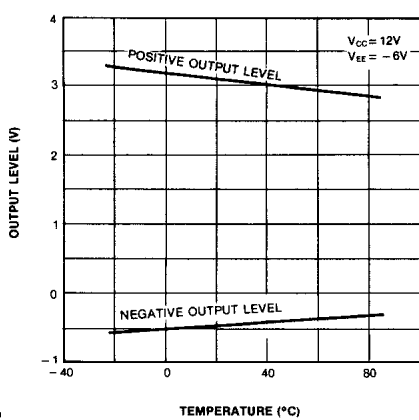
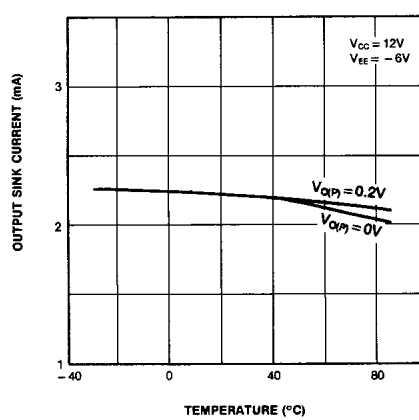


Fig. 6 OUTPUT SINK CURRENT



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## DUAL HIGH-SPEED DIFFERENT COMPARATOR

The LM711/I consists of two voltage comparators with the separate differential inputs, a common output and provision for strobing each side independently. The device features high accuracy, fast response, low offset voltage, a large input voltage range, low power consumption and compatibility with practically all integrated logic forms.

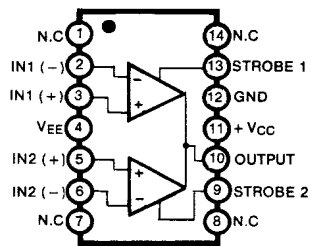
The LM711/I can be used as a sense amplifier for memories, and a dual comparator with OR'ed outputs is required, such as a double-ended limit detector.

## FEATURES

- Fast response time: 40ns (Typ)
- Output compatible with most TTL circuits
- Independent strobing of each comparator
- Low offset voltage

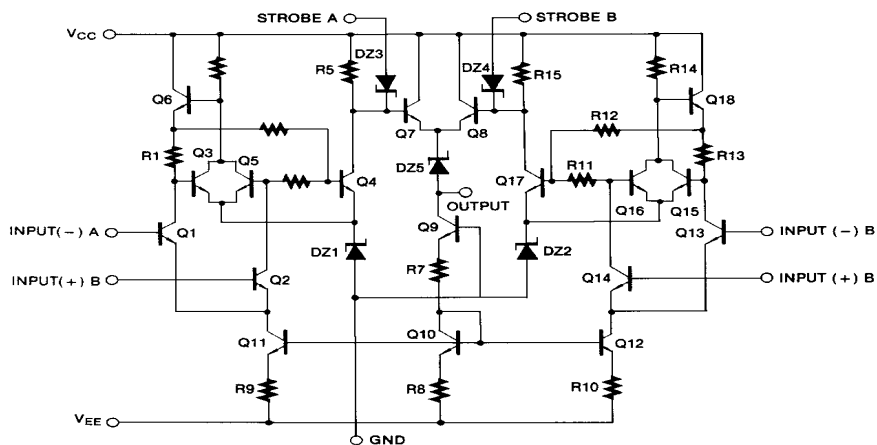
## ORDERING INFORMATION

## BLOCK DIAGRAM



Device	Package	Operating Temperature
LM711N	14 DIP	0 ~ + 70°C
LM711M	14 SOP	
LM711IN	14 DIP	-25 ~ + 85°C
LM711IM	14 SOP	

## SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub>=25°C)

Characteristic	Symbol	Value	Unit
Positive Supply Voltage	V <sub>CC</sub>	+14	V
Negative Supply Voltage	V <sub>EE</sub>	-7	V
Differential Input Voltage	V <sub>I(DIFF)</sub>	5	V
Input Voltage	V <sub>I</sub>	±7	V
Strobe Voltage	V <sub>STR</sub>	0 ~ 6	V
Peak Output Current	I <sub>O(P)</sub>	50	mA
Continuous Total Power Dissipation	P <sub>D</sub>	500	mW
Operating Temperature Range LM711	T <sub>OPR</sub>	0 ~ + 70	°C
LM711I	T <sub>OPR</sub>	-65 ~ + 150	°C
Storage Temperature Range	T <sub>STG</sub>	-25 ~ + 85	°C

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +12V, V<sub>EE</sub> = -6V, T<sub>A</sub>=25°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM711I			LM711			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V <sub>IO</sub>	R <sub>S</sub> ≤ 200Ω, V <sub>CH</sub> = 0V		1.0	3.5		1.0	5.0	mV
		V <sub>O(P)</sub> = 1.4V <b>Note 2</b>			4.5			6.0	
Input Offset Current (Note 1)	I <sub>IO</sub>	V <sub>O(P)</sub> = 1.4V		0.5	10.0		0.5	15	μA
		<b>Note 2</b>			20			25	
Input Bias Current	I <sub>BIAS</sub>			25	75		25	100	μA
		<b>Note 2</b>			150			150	
Large Signal Voltage Gain	G <sub>V</sub>		750	1500		700	1500		V/V
		<b>Note 2</b>	500			500			
Input Voltage Range	V <sub>I(R)</sub>	V <sub>EE</sub> = -7.0V	±5.0			±5.0			V
Differential Input Voltage Range	V <sub>ID(R)</sub>		±5.0			±5.0			V
Output Resistance	R <sub>O</sub>			200			200		Ω
Output Voltage (High)	V <sub>O(H)</sub>	V <sub>I</sub> ≥ 10mV		4.5	5.0		4.5	5.0	V
Output Voltage (Low)	V <sub>O(L)</sub>	V <sub>I</sub> ≤ 10mV	-1.0		0	-1.0	-0.5	0	V
Loaded Output High Level	V <sub>OH</sub>	V <sub>I</sub> ≥ 5mV, I <sub>O</sub> = 5mA	2.5	3.5		2.5	3.5		mA
Strobed Output Level	V <sub>STR</sub>	V <sub>STROBE</sub> ≥ 3V	-1.0		0	-1.0		0	V
Output Sink Current	I <sub>SINK</sub>	V <sub>I</sub> ≥ 10mV, V <sub>O(P)</sub> ≥ 0V	0.5	0.8		0.5	0.8		mA
Positive Supply Current	I <sub>CC</sub>	V <sub>O(P)</sub> = 0V, V <sub>I</sub> = 10mV		8.6			8.6		mA
Negative Supply Current	I <sub>EE</sub>	V <sub>O(P)</sub> = 0V, V <sub>I</sub> = 5mV		3.9			3.9		mA
Strobe Current	I <sub>STR</sub>	V <sub>STROBE</sub> = 100mV		1.2	2.5		1.2	2.5	mA
Power Consumption	P <sub>D</sub>	V <sub>O(P)</sub> = 0V, V <sub>I</sub> ≥ 10mV		130	200		130	230	mW
Response Time	t <sub>RES</sub>	(NOTE 1)		40			40		ns
Strobe Release Time	T <sub>RE</sub>			12			12		ns

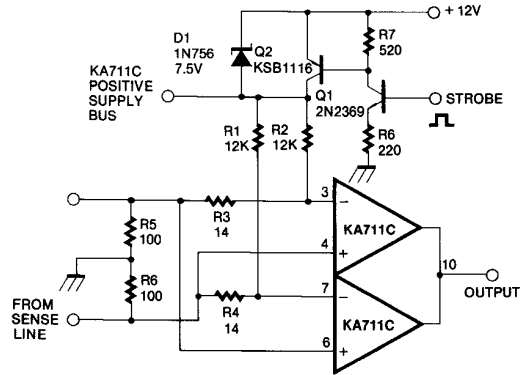
Note: 1. The response time specified is for a 100mV input step with 10mV overdrive

2. LM711: 0 ≤ T<sub>A</sub> ≤ +70°CLM711I: -25 ≤ T<sub>A</sub> ≤ +85°C

3. The input offset voltage and input offset current are specified for a logic threshold voltage of 711I, 1.65V at -25°C, 1.4V at +25°C, 1.15V at +85°C, for 711, 1.5V at 0°C, 1.4V at +25°C, 1.2V at +70°C.

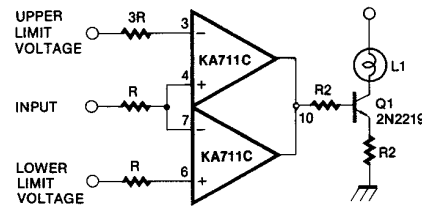
## TYPICAL APPLICATIONS

\* Fig. 1 Sense Amplifier With Supply Strobing  
for Reduced Power Consumption\*



\* Standby dissipation is about 40mW

Fig. 2 Double-Ended Limit Detector  
With Lamp Driver





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FACT™	QS™
FACT Quiet Series™	Quiet Series™
FAST®	SuperSOT™-3
FASTr™	SuperSOT™-6
GTO™	SuperSOT™-8
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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

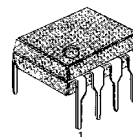
## SINGLE OPERATIONAL AMPLIFIERS

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. It is intended for a wide range of analog applications. The high gain and wide range of operating voltage provide superior performance in integrator, summing amplifier, and general feedback applications.

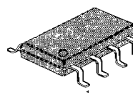
## FEATURES

- Short circuit protection
- Excellent temperature stability
- Internal frequency compensation
- High Input voltage range
- Null of offset

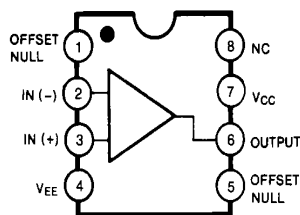
8 DIP



8 SOP



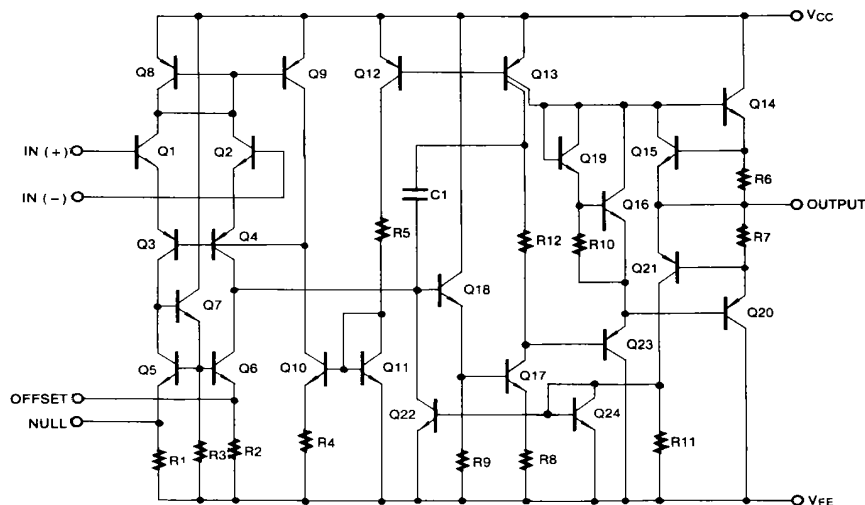
## BLOCK DIAGRAM



## ORDERING INFORMATION

Device	Package	Operating Temperature
LM741N LM741EN	8 DIP	0 ~ +70°C
LM741M LM741EM	8 SOP	
LM741IN LM741EIN	8 DIP	-40 ~ +85 °C
LM741IM LM741EIM	8 SOP	

## SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	LM741	LM741E	LM741I	Unit
Supply Voltage	$V_{CC}$	$\pm 18$	$\pm 22$	$\pm 18$	V
Differential Input Voltage	$V_{I(DIFF)}$	30	30	30	V
Input Voltage	$V_I$	$\pm 15$	$\pm 15$	$\pm 15$	V
Output Short Circuit Duration		Indefinite	Indefinite	Indefinite	
Power Dissipation	$P_D$	500	500	500	mW
Operating Temperature Range	$T_{OPR}$	$0 \sim +70$	$0 \sim +70$	$-40 \sim +85$	$^\circ\text{C}$
Storage Temperature Range	$T_{STG}$	$-65 \sim +150$	$-65 \sim +150$	$-65 \sim +150$	$^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = 15\text{V}$ ,  $V_{EE} = -15\text{V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM741E			LM741/LM741I			Unit
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$	$R_S \leq 10\text{K}\Omega$					2.0	6.0	mV
		$R_S \leq 50\Omega$		0.8	3.0				
Input Offset Voltage Adjustment Range	$V_{IO(R)}$	$V_{CC} = \pm 20\text{V}$	$\pm 10$				$\pm 15$		mV
Input Offset Current	$I_{IO}$			3.0	30		20	200	nA
Input Bias Current	$I_{BIAS}$			30	80		80	500	nA
Input Resistance	$R_I$	$V_{CC} = \pm 20\text{V}$	1.0	6.0		0.3	2.0		$\text{M}\Omega$
Input Voltage Range	$V_{I(R)}$		$\pm 12$	$\pm 13$		$\pm 12$	$\pm 13$		V
Large Signal Voltage Gain	$G_V$	$R_L \geq 2\text{K}\Omega$							V/mV
		$V_{CC} = \pm 20\text{V}$ , $V_{O(P,P)} = \pm 15\text{V}$	50						
		$V_{CC} = \pm 15\text{V}$ , $V_{O(P,P)} = \pm 10\text{V}$				20	200		
Output Short Circuit Current	$I_{SC}$		10	25	35		25		mA
Output Voltage Swing	$V_{O(P,P)}$	$V_{CC} = \pm 20\text{V}$							V
		$R_L \geq 10\text{K}\Omega$	$\pm 16$						
		$R_L \geq 10\text{K}\Omega$	$\pm 15$						
		$V_{CC} = \pm 15\text{V}$				$\pm 12$	$\pm 14$		
Common Mode Rejection Ratio	CMRR	$R_S \leq 10\text{K}\Omega$ , $V_{CM} = \pm 12\text{V}$				70	90		dB
		$R_S \leq 50\text{K}\Omega$ , $V_{CM} = \pm 12\text{V}$	80	95					
Power Supply Rejection Ratio	PSRR	$V_{CC} = \pm 15\text{V}$ to $V_{CC} = \pm 15\text{V}$ $R_S \leq 50\Omega$	86	96					dB
		$V_{CC} = \pm 15\text{V}$ to $V_{CC} = \pm 15\text{V}$ $R_S \leq 10\text{K}\Omega$				77	96		

## ELECTRICAL CHARACTERISTICS (Continued)

Characteristic		Symbol	Test Conditions	LM741E			LM741/LM741I			Unit
				Min	Typ	Max	Min	Typ	Max	
Transient Response	Rise Time	$t_R$	Unity Gain		0.25	0.8		0.3		$\mu s$
	Overshoot	OS			6.0	20		10		%
Bandwidth		BW		0.43	1.5					MHz
Slew Rate		SR	Unity Gain	0.3	0.7			0.5		V/ $\mu s$
Supply Current		$I_{CC}$	$R_L = \infty \Omega$					1.5	2.8	mA
Power Consumption	$P_C$		$V_{CC} = \pm 20V$		80	150				mW
			$V_{CC} = \pm 15V$					50	85	

## ELECTRICAL CHARACTERISTICS

( $-40^\circ C \leq T_A \leq 85^\circ C$  for the KA741I  $^\circ C \leq T_A \leq 70^\circ C$  for the LM741 and LM741E.  $V_{CC} = \pm 15V$ , unless otherwise specified)

Characteristic		Symbol	Test Conditions	LM741E			LM741/LM741I			Unit
				Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$V_{IO}$		$R_S \leq 50\Omega$			4.0				mV
			$R_S \leq 10K\Omega$						7.5	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$				15					$\mu V/^\circ C$
Input Offset Current	$I_{IO}$					70			300	nA
Input Offset Current Drift	$\Delta I_{IO}/\Delta T$					0.5				nA/ $^\circ C$
Input Bias Current	$I_{BIAS}$					0.21			0.8	$\mu A$
Input Resistance	$R_I$	$V_{CC} = \pm 20V$		0.5						M $\Omega$
Input Voltage Range	$V_{I(R)}$			$\pm 12$	$\pm 13$		$\pm 12$	$\pm 13$		V
Output Voltage Swing	$V_{O(P-P)}$	$V_{CC} = \pm 20V$	$R_S \geq 10K\Omega$	$\pm 16$						V
			$R_S \geq 2K\Omega$	$\pm 15$						
		$V_{CC} = \pm 15V$	$R_S \geq 10K\Omega$				$\pm 12$	$\pm 14$		
			$R_S \geq 2K\Omega$				$\pm 10$	$\pm 13$		
Output Short Circuit Current	$I_{SC}$			10		40	10		40	mA
Common Mode Rejection Ratio	CMRR		$R_S \leq 10K\Omega$ , $V_{CM} = \pm 12V$				70	90		dB
			$R_S \leq 50K\Omega$ , $V_{CM} = \pm 12V$	80	95					
Power Supply Rejection Ratio	PSRR	$V_{CC} = \pm 20V$ to $\pm 5V$	$R_S \leq 50\Omega$	86	96					dB
			$R_S \leq 10K\Omega$				77	96		
Large Signal Voltage Gain	$G_V$	$R_S \geq 2K\Omega$	$V_{CC} = \pm 20V$ , $V_{O(P-P)} = \pm 15V$	32						V/mV
			$V_{CC} = \pm 15V$ , $V_{O(P-P)} = \pm 10V$				15			
			$V_{CC} = \pm 15V$ , $V_{O(P-P)} = \pm 2V$	10						

## TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 7 OUTPUT RESISTANCE vs FREQUENCY

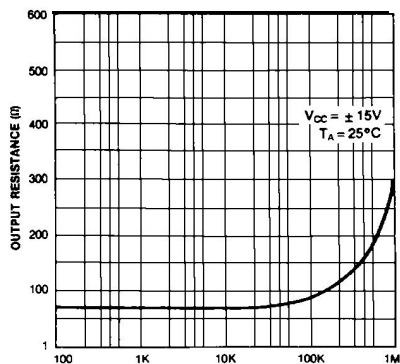


Fig. 8 INPUT RESISTANCE AND INPUT CAPACITANCE vs FREQUENCY

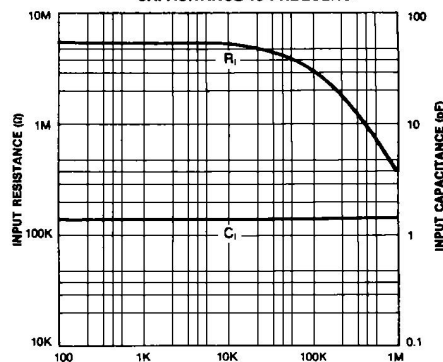


Fig. 9 INPUT BIAS CURRENT vs AMBIENT TEMPERATURE

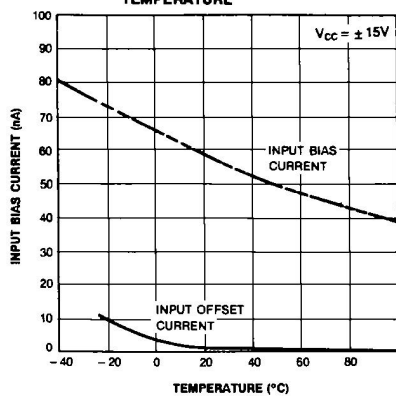


Fig. 10 POWER CONSUMPTION vs AMBIENT TEMPERATURE

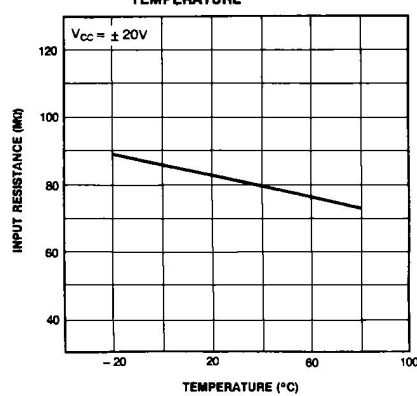


Fig. 11 INPUT OFFSET CURRENT vs AMBIENT TEMPERATURE

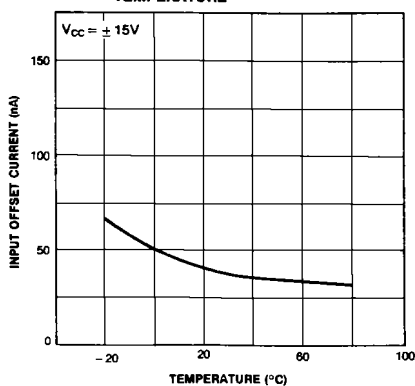


Fig. 12 INPUT RESISTANCE vs AMBIENT TEMPERATURE

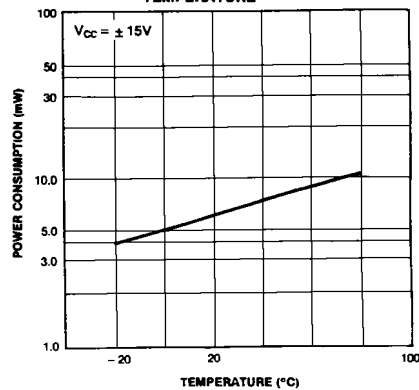


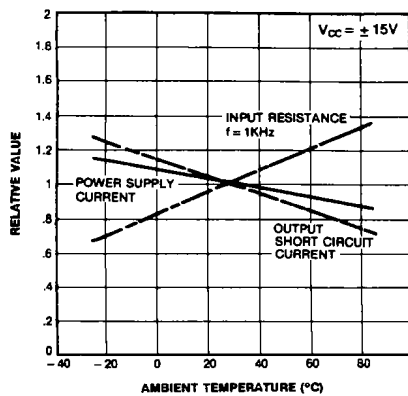
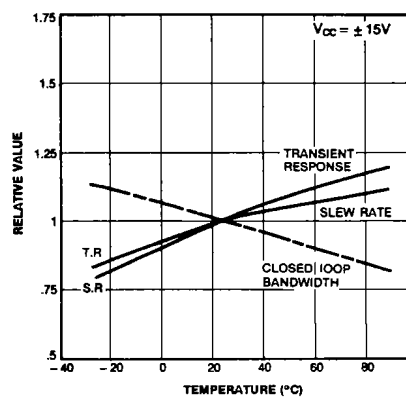
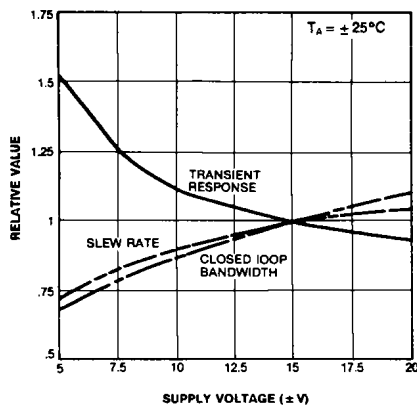
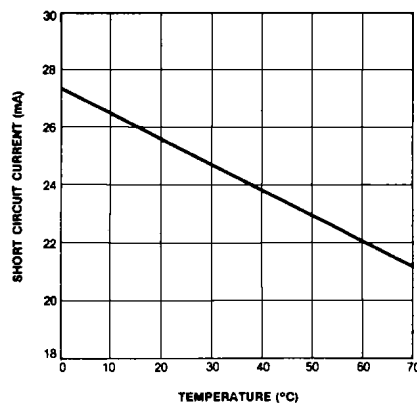
Fig. 13 NORMALIZED DC PARAMETERS  
vs AMBIENT TEMPERATUREFig. 14 FREQUENCY CHARACTERISTICS  
vs AMBIENT TEMPERATUREFig. 15 FREQUENCY CHARACTERISTICS  
vs SUPPLY VOLTAGEFig. 16 OUTPUT SHORT CIRCUIT CURRENT  
vs AMBIENT TEMPERATURE

Fig. 17 TRANSIENT RESPONSE

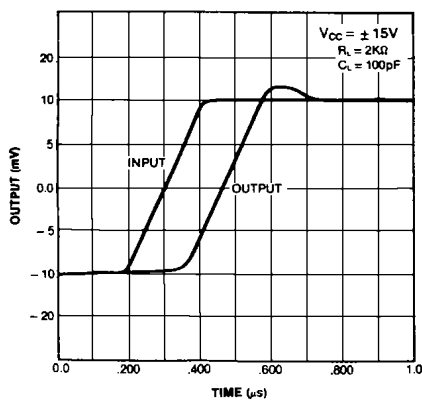
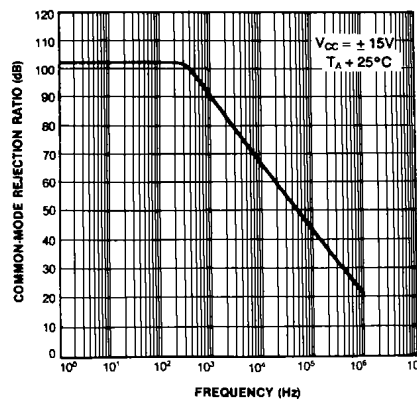
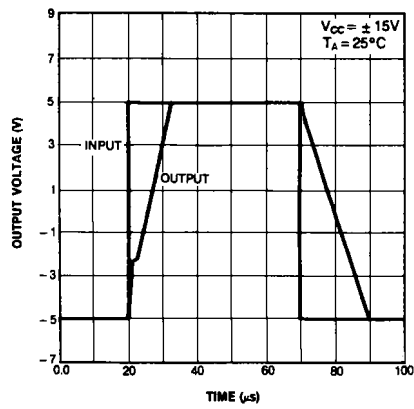
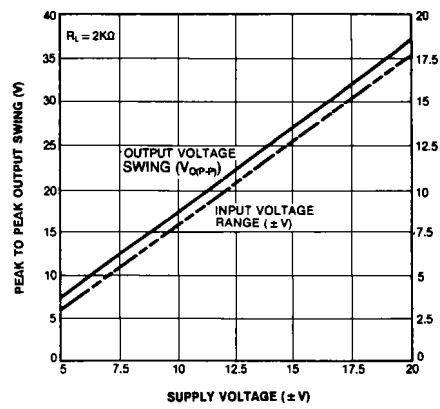
Fig. 18 COMMON-MODE REJECTION RATIO  
vs FREQUENCY

Fig. 18 VOLTAGE FOLLOWER LARGE  
SIGNAL PULSE RESPONSEFig. 19 OUTPUT SWING AND INPUT RANGE  
vs SUPPLY VOLTAGE

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SuperSOT™-6  
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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
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Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.



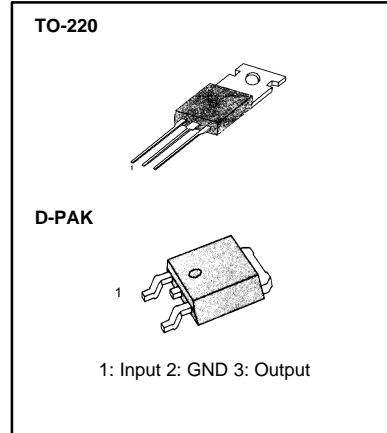
# LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

## 3-TERMINAL 1A POSITIVE VOLTAGE REGULATORS

The LM78XX series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

## FEATURES

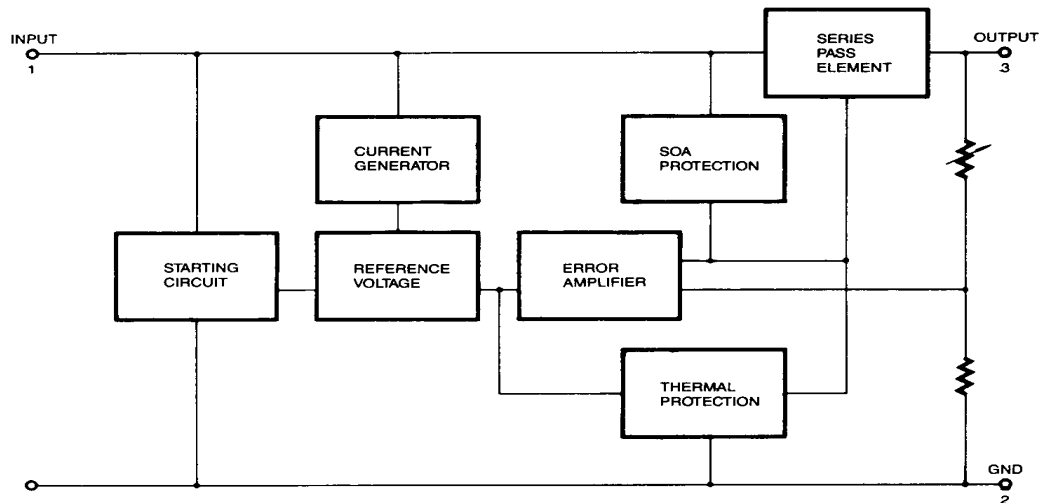
- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 11, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor SOA Protection



## ORDERING INFORMATION

Device	Output Voltage Tolerance	Packag	Operating Temperature
KA78XXCT	± 4%	TO-220	0 ~ +125 °C
KA78XXAT	± 2%		-40 ~ +125 °C
KA78XXIT	± 4%		
KA78XXR	± 2%	D-PAK	0 ~ +125 °C
KA78XXAR	± 2%		-40 ~ +125 °C
KA78XXIR	± 4%		

## BLOCK DIAGRAM



## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub> = +25°C, unless otherwise specified)

Characteristic	Symbol	Value	Unit
Input Voltage (for V <sub>O</sub> = 5V to 18V) (for V <sub>O</sub> = 24V)	V <sub>I</sub>	35	V
	V <sub>I</sub>	40	V
Thermal Resistance Junction-Cases	R <sub>θJC</sub>	5	°C/W
Thermal Resistance Junction-Air	R <sub>θJA</sub>	65	°C/W
Operating Temperature Range KA78XX/A/R/RA KA78XXI/RI	T <sub>OPR</sub>	0 ~ +125	°C
		-40 ~ +125	°C
Storage Temperature Range	T <sub>STG</sub>	-65 ~ +150	°C

### LM7805/I/R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit, T<sub>MIN</sub> < T<sub>J</sub> < T<sub>MAX</sub>, I<sub>O</sub> = 500mA, V<sub>I</sub> = 10V, C<sub>I</sub> = 0.33μF, C<sub>O</sub> = 0.1μF, unless otherwise specified)

Characteristic	Symbol	Test Conditions		LM7805I			LM7805			Unit
				Min	Typ	Max	Min	Typ	Max	
Output Voltage	V <sub>O</sub>	T <sub>J</sub> =+25 °C		4.8	5.0	5.2	4.8	5.0	5.2	V
		5.0mA ≤ I <sub>O</sub> ≤1.0A, P <sub>O</sub> ≤ 15W								
		V <sub>I</sub> = 7V to 20V V <sub>I</sub> = 8V to 20V		4.75	5.0	5.25	4.75	5.0	5.25	
Line Regulation	ΔV <sub>O</sub>	T <sub>J</sub> =+25°C	V <sub>O</sub> = 7V to 25V		4.0	100		4.0	100	mV
			V <sub>I</sub> = 8V to 12V		1.6	50		1.6	50	
Load Regulation	ΔV <sub>O</sub>	T <sub>J</sub> =+25°C	I <sub>O</sub> = 5.0mA to1.5A		9	100		9	100	mV
			I <sub>O</sub> =250mA to 750mA		4	50		4	50	
Quiescent Current	I <sub>Q</sub>	T <sub>J</sub> =+25 °C			5.0	8		5.0	8	mA
Quiescent Current Change	ΔI <sub>Q</sub>	I <sub>O</sub> = 5mA to 1.0A			0.03	0.5		0.03	0.5	mA
		V <sub>I</sub> = 7V to 25V						0.3	1.3	
		V <sub>I</sub> = 8V to 25V			0.3	1.3				
Output Voltage Drift	ΔV <sub>O</sub> /ΔT	I <sub>O</sub> = 5mA			-0.8			-0.8		mV/°C
Output Noise Voltage	V <sub>N</sub>	f = 10Hz to 100Khz, T <sub>A</sub> =+25 °C			42			42		μV/V <sub>O</sub>
Ripple Rejection	RR	f = 120Hz V <sub>O</sub> = 8 to 18V		62	73		62	73		dB
Dropout Voltage	V <sub>O</sub>	I <sub>O</sub> = 1A, T <sub>J</sub> =+25 °C			2			2		V
Output Resistance	R <sub>O</sub>	f = 1KHz			15			15		mΩ
Short Circuit Current	I <sub>SC</sub>	V <sub>I</sub> = 35V, T <sub>A</sub> =+25 °C			230			230		mA
Peak Current	I <sub>PK</sub>	T <sub>J</sub> =+25 °C			2.2			2.2		A

\* T<sub>MIN</sub> < T<sub>J</sub> < T<sub>MAX</sub>

LM78XXI/RI: T<sub>MIN</sub> = -40°C, T<sub>MAX</sub> = +125°C

LM78XX/R: T<sub>MIN</sub> = 0°C, T<sub>MAX</sub> = +125°C

\* Load and line regulation are specified at constant junction temperature. Changes in V<sub>O</sub> due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7806//R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 11V$   $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7806I			LM7806			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ C$	5.75	6.0	6.25	5.75	6.0	6.25	V
		$5.0mA \leq I_O \leq 1.0A$ , $P_D \leq 15W$							
		$V_I = 8.0V$ to $21V$ $V_I = 9.0V$ to $21V$	5.7	6.0	6.3	5.7	6.0	6.3	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$V_I = 8V$ to $25V$ $V_I = 9V$ to $13V$		5 1.5	120 60		5 1.5	120 60	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$I_O = 5mA$ to $1.5A$ $I_O = 250mA$ to $750A$		9 3	120 60		9 3	120 60	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		5.0	8		5.0	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$			0.5			0.5	mA
		$V_I = 8V$ to $25V$						1.3	
		$V_I = 9V$ to $25V$			1.3				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.8			-0.8		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ , $T_A = +25^\circ C$		45			45		$\mu V/V_O$
Ripple Rejection	RR	$f = 120Hz$ $V_I = 9V$ to $19V$	59	75		59	75		dB
Dropout Voltage	$V_D$	$I_O = 1A$ , $T_J = +25^\circ C$		2			2		V
Output Resistance	$R_D$	$f = 1KHz$		19			19		$m\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35V$ , $T_A = +25^\circ C$		250			250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XX/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7808I/R/RI ELECTRICAL CHARACTERISTICS

(Refer to test Circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 14V$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7808I			LM7808			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ C$	7.7	8.0	8.3	7.7	8.0	8.3	V
		$5.0mA \leq I_O \leq 1.0A$ , $P_O \leq 15W$							
		$V_I = 10.5V$ to $23V$ $V_I = 11.5V$ to $23V$	7.6	8.0	8.4	7.6	8.0	8.4	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$V_I = 10.5V$ to $25V$ $V_I = 11.5V$ to $17V$		5.0	160		5.0	160	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$I_O = 5.0mA$ to $1.5A$ $I_O = 250mA$ to $750mA$		10	160		10	160	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		5.0	8		5.0	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1.0A$		0.05	0.5		0.05	0.5	mA
		$V_I = 10.5V$ to $25V$					0.5	1.0	
		$V_I = 11.5V$ to $25V$		0.5	1.0				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.8			-0.8		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ , $T_A = +25^\circ C$		52			52		$\mu V/V_O$
Ripple Rejection	RR	$f = 120Hz$ , $V_I = 11.5V$ to $21.5$	56	73		56	73		dB
Dropout Voltage	$V_D$	$I_O = 1A$ , $T_J = +25^\circ C$		2			2		V
Output Resistance	$R_O$	$f = 1KHz$		17			17		m $\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35V$ , $T_A = +25^\circ C$		230			230		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XX/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7809I/R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit.  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 15V$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7809I			LM7809			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ C$	8.65	9	9.35	8.65	9	9.35	V
		$5.0mA \leq I_O \leq 1.0A$ , $P_D \leq 15W$ $V_I = 11.5V$ to $24V$ $V_I = 12.5V$ to $24V$				8.6	9	9.4	
			8.6	9	9.4				
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$V_I = 11.5V$ to $25V$ $V_I = 12V$ to $25V$		6	180		6	180	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$		2	90		2	90	mV
		$I_O = 5mA$ to $1.5A$ $I_O = 250mA$ to $750mA$		12	180		12	180	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		5.0	8		5.0	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1.0A$			0.5			0.5	mA
		$V_I = 11.5V$ to $26V$						1.3	
		$V_I = 12.5V$ to $26V$			1.3				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5mA$		-1			-1		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ , $T_A = +25^\circ C$		58			58		$\mu V / V_O$
Ripple Rejection	RR	$f = 120Hz$ $V_I = 13V$ to $23V$	56	71		56	71		dB
Dropout Voltage	$V_D$	$I_O = 1A$ , $T_J = +25^\circ C$		2			2		V
Output Resistance	$R_O$	$f = 1KHz$		17			17		$m\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35V$ , $T_A = +25^\circ C$		250			250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XX/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7810I/R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500\text{mA}$ ,  $V_I = 16\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7810I			LM7810			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	9.6	10	10.4	9.6	10	10.4	V
		$5.0\text{mA} \leq I_O \leq 1.0\text{A}$ , $P_D \leq 15\text{W}$							
		$V_I = 12.5\text{V to } 25\text{V}$ $V_I = 13.5\text{V to } 25\text{V}$	9.5	10	10.5	9.5	10	10.5	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$							mV
		$V_I = 12.5\text{V to } 25\text{V}$ $V_I = 13\text{V to } 25\text{V}$		10 3	200 100		10 3	200 100	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$							mV
		$I_O = 5\text{mA to } 1.5\text{A}$ $I_O = 250\text{mA to } 750\text{mA}$		12 4	200 400		12 4	200 400	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.1	8		5.1	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA to } 1.0\text{A}$			0.5			0.5	mA
		$V_I = 12.5\text{V to } 29\text{V}$						1.0	
		$V_I = 13.5\text{V to } 29\text{V}$			1.0				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		-1			-1		mV/°C
Output Noise Voltage	$V_N$	$f = 10\text{Hz to } 100\text{KHz}$ , $T_A = +25^\circ\text{C}$		58			58		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ $V_I = 13\text{V to } 23\text{V}$	56	71		56	71		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2			2		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		17			17		m $\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250			250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ\text{C}$ ,  $T_{MAX} = +125^\circ\text{C}$

LM78XX/R:  $T_{MIN} = 0^\circ\text{C}$ ,  $T_{MAX} = +125^\circ\text{C}$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7811//R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 18V$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7811I			LM7811			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ C$	10.6	11	11.4	10.6	11	11.4	V
		$5.0mA \leq I_O \leq 1.0A$ , $P_D \leq 15W$							
		$V_I = 13.5V$ to $26V$ $V_I = 14.5V$ to $26V$	10.5	11	11.5	10.5	11	11.5	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$V_I = 13.5V$ to $25V$ $V_I = 14V$ to $21V$		10 3.0	220 110		10 3	220 110	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$I_O = 5.0mA$ to $1.5A$ $I_O = 250mA$ to $750mA$		12 4	220 110		12 4	220 110	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		5.1	8		5.1	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1.0A$			0.5			0.5	mA
		$V_I = 13.5V$ to $29V$						1.0	
		$V_I = 14.5V$ to $29V$			1.0				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5mA$		-1			-1		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ , $T_A = +25^\circ C$		70			70		$\mu V / V_O$
Ripple Rejection	RR	$f = 120Hz$ $V_I = 14V$ to $24V$	55	71		55	71		dB
Dropout Voltage	$V_D$	$I_O = 1A$ , $T_J = +25^\circ C$		2			2		V
Output Resistance	$R_O$	$f = 1KHz$		18			18		m $\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35V$ , $T_A = +25^\circ C$		250			250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XX/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7812I/R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 19V$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7812I			LM7812			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ C$	11.5	12	12.5	11.5	12	12.5	V
		$5.0mA \leq I_O \leq 1.0A$ , $P_D \leq 15W$							
		$V_I = 14.5V$ to $27V$ $V_I = 15.5V$ to $27V$	11.4	12	12.6	11.4	12	12.6	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$V_I = 14.5V$ to $30V$ $V_I = 16V$ to $22V$		10	240		10	240	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$I_O = 5mA$ to $1.5A$ $I_O = 250mA$ to $750mA$		11	240		11	240	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		5.1	8		5.1	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1.0A$		0.1	0.5		0.1	0.5	mA
		$V_I = 14.5V$ to $30V$					0.5	1.0	
		$V_I = 15V$ to $30V$			1.0				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5mA$	0.5	-1			-1		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ , $T_A = +25^\circ C$		76			76		mV/ $V_O$
Ripple Rejection	RR	$f = 120Hz$ $V_I = 15V$ to $25V$	55	71		55	71		dB
Dropout Voltage	$V_D$	$I_O = 1A$ , $T_J = +25^\circ C$		2			2		V
Output Resistance	$R_O$	$f = 1KHz$		18			18		mΩ
Short Circuit Current	$I_{SC}$	$V_I = 35V$ , $T_A = +25^\circ C$		230			230		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2			2.2		A

$T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XX/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.



## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7815//R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 23V$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7815I			LM7815			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	V <sub>O</sub>	T <sub>J</sub> =+25 °C	14.4	15	15.6	14.4	15	15.6	V
		5.0mA ≤ I <sub>O</sub> ≤1.0A, P <sub>D</sub> ≤15W	14.2 5	15	15.75	14.25	15	15.75	
		V <sub>I</sub> = 17.5V to 30V V <sub>I</sub> = 18.5V to 30V							
Line Regulation	ΔV <sub>O</sub>	T <sub>J</sub> =+25 °C		11	300		11	300	mV
				3	150		3	150	
Load Regulation	ΔV <sub>O</sub>	I <sub>O</sub> = 5mA to 1.5A		12	300		12	300	mV
		T <sub>J</sub> =+25 °C I <sub>O</sub> = 250mA to 750mA		4	150		4	150	
Quiescent Current	I <sub>O</sub>	T <sub>J</sub> =+25 °C		5.2	8		5.2	8	mA
Quiescent Current Change	ΔI <sub>O</sub>	I <sub>O</sub> = 5mA to 1.0A			0.5			0.5	mA
		V <sub>I</sub> = 17.5V to 30V						1.0	
		V <sub>I</sub> = 18.5V to 30V			1.0				
Output Voltage Drift	ΔV <sub>O</sub> /ΔT	I <sub>O</sub> = 5mA		-1			-1		mV/ °C
Output Noise Voltage	V <sub>N</sub>	f = 10Hz to 100Khz, T <sub>A</sub> =+25 °C		90			90		μV/V <sub>O</sub>
Ripple Rejection	RR	f = 120Hz V <sub>I</sub> = 18.5V to 28.5V	54	70		54	70		dB
Dropout Voltage	V <sub>D</sub>	I <sub>O</sub> = 1A, T <sub>J</sub> =+25 °C		2			2		V
Output Resistance	R <sub>O</sub>	f = 1KHz		19			19		mΩ
Short Circuit Current	I <sub>SC</sub>	V <sub>I</sub> = 35V, T <sub>A</sub> =+25 °C		250			250		mA
Peak Current	I <sub>PK</sub>	T <sub>J</sub> =+25 °C		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XXR/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7818I/R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 27V$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7818I			LM7818			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ C$	17.3	18	18.7	17.3	18	18.7	V
		$5.0mA \leq I_O \leq 1.0A$ , $P_D \leq 15W$ $V_I = 21V$ to $33V$ $V_I = 22V$ to $33V$	17.1	18	18.9	17.1	18	18.9	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$		15	360		15	360	mV
		$V_I = 21V$ to $33V$ $V_I = 24V$ to $30V$		5	180		5	180	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$		15	360		15	360	mV
		$I_O = 5mA$ to $1.5A$ $I_O = 250mA$ to $750mA$		5.0	180		5.0	180	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		5.2	8		5.2	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1.0A$			0.5			0.5	mA
		$V_I = 21V$ to $33V$						1	
		$V_I = 22V$ to $33V$			1.0				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5mA$		-1			-1		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ , $T_A = +25^\circ C$		110			110		$\mu V/V_O$
Ripple Rejection	RR	$f = 120Hz$ $V_I = 22V$ to $32V$	53	69		53	69		dB
Dropout Voltage	$V_D$	$I_O = 1A$ , $T_J = +25^\circ C$		2			2		V
Output Resistance	$R_O$	$f = 1KHz$		22			22		$m\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35V$ , $T_A = +25^\circ C$		250			250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XXR/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7824I/R/RI ELECTRICAL CHARACTERISTICS

(Refer to test circuit,  $T_{MIN} < T_J < T_{MAX}$ ,  $I_O = 500mA$ ,  $V_I = 33V$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	LM7824I			LM7824			Unit
			Min	Typ	Max	Min	Typ	Max	
Output Voltage	$V_O$	$T_J = +25^\circ C$	23	24	25	23	24	25	V
		$5.0mA \leq I_O \leq 1.0A$ , $P_D \leq 15W$ $V_I = 27V$ to $38V$ $V_I = 28V$ to $38V$	22.8	24	25.2	22.8	24	25.25	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$V_I = 27V$ to $38V$ $V_I = 30V$ to $36V$		17 6	480 240		17 6	480 240	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$							mV
		$I_O = 5mA$ to $1.5A$ $I_O = 250mA$ to $750mA$		15 5.0	480 240		15 5.0	480 240	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		5.2	8		5.2	8	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1.0A$		0.1	0.5		0.1	0.5	mA
		$V_I = 27V$ to $38V$					0.5	1	
		$V_I = 28V$ to $38V$		0.5	1				
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5mA$		-1.5			-1.5		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ , $T_A = +25^\circ C$		160			60		$\mu V/V_O$
Ripple Rejection	RR	$f = 120Hz$ $V_I = 28V$ to $38V$	50	67		50	67		dB
Dropout Voltage	$V_D$	$I_O = 1A$ , $T_J = +25^\circ C$		2			2		V
Output Resistance	$R_O$	$f = 1KHz$		28			28		m $\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35V$ , $T_A = +25^\circ C$		230			230		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2			2.2		A

\*  $T_{MIN} < T_J < T_{MAX}$

LM78XXI/RI:  $T_{MIN} = -40^\circ C$ ,  $T_{MAX} = +125^\circ C$

LM78XX/R:  $T_{MIN} = 0^\circ C$ ,  $T_{MAX} = +125^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7805A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+125^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 10\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	4.9	5	5.1	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 5\text{W}$ $V_I = 7.5$ to $20\text{V}$	4.8	5	5.2	
Line Regulation	$\Delta V_O$	$V_I = 7.5$ to $25\text{V}$ $I_O = 500\text{mA}$		5	50	V
		$V_I = 8\text{V}$ to $12\text{V}$		3	50	
		$T_J = +25^\circ\text{C}$ $V_I = 7.3\text{V}$ to $25\text{V}$		5	50	
		$T_J = +25^\circ\text{C}$ $V_I = 8\text{V}$ to $12\text{V}$		1.5	25	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		9	100	V
		$I_O = 5\text{mA}$ to $1\text{A}$		9	100	
		$I_O = 250$ to $750\text{mA}$		4	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.0	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA}$ to $1\text{A}$			0.5	mA
		$V_I = 8\text{V}$ to $25\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$V_I = 7.5\text{V}$ to $20\text{V}$ , $T_J = +25^\circ\text{C}$			0.8	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$		-0.8		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 8\text{V}$ to $18\text{V}$		68		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		17		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\*Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7806A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+150^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 11\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	5.58	6	6.12	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 8.6$ to $21\text{V}$	5.76	6	6.24	
Line Regulation	$\Delta V_O$	$V_I = 8.6$ to $25\text{V}$ $I_O = 500\text{mA}$		5	60	mV
		$V_I = 9\text{V}$ to $13\text{V}$		3	60	
		$T_J = +25^\circ\text{C}$		$V_I = 8.3\text{V}$ to $21\text{V}$	5	60
				$V_I = 9\text{V}$ to $13\text{V}$	1.5	30
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		9	100	mV
		$I_O = 5\text{mA}$ to $1\text{A}$		4	100	
		$I_O = 250$ to $750\text{mA}$		5.0	50	
		$T_J = +25^\circ\text{C}$		4.3	6	
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA}$ to $1\text{A}$			0.5	mA
		$V_I = 9\text{V}$ to $25\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$V_I = 8.5\text{V}$ to $21\text{V}$ , $T_J = +25^\circ\text{C}$			0.8	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$		-0.8		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 9\text{V}$ to $19\text{V}$		65		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		17		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7808A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+150^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 14\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	7.84	8	8.16	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 8.6$ to $21\text{V}$	7.7	8	8.3	
Line Regulation	$\Delta V_O$	$V_I = 10.6$ to $25\text{V}$ $I_O = 500\text{mA}$		6	80	mV
		$V_I = 11$ to $17\text{V}$		3	80	
		$T_J = +25^\circ\text{C}$ $V_I = 10.4\text{V}$ to $23\text{V}$		6	80	
		$V_I = 11\text{V}$ to $17\text{V}$		2	40	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		12	100	mV
		$I_O = 5\text{mA}$ to $1\text{A}$		12	100	
		$I_O = 250$ to $750\text{mA}$		5	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.0	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA}$ to $1\text{A}$			0.5	mA
		$V_I = 11\text{V}$ to $25\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$V_I = 10.6\text{V}$ to $23\text{V}$ , $T_J = +25^\circ\text{C}$			0.8	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$		-0.8		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 11.5\text{V}$ to $21.5\text{V}$		62		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		18		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7809A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+125^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 15\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	8.82	9.0	9.18	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 11.2$ to $24\text{V}$	8.65	9.0	9.35	
Line Regulation	$\Delta V_O$	$V_I = 11.7$ to $25\text{V}$ $I_O = 500\text{mA}$		6	90	mV
		$V_I = 12.5$ to $19\text{V}$		4	45	
		$T_J = +25^\circ\text{C}$	$V_I = 11.5\text{V}$ to $24\text{V}$	6	90	
			$V_I = 12.5\text{V}$ to $19\text{V}$	2	45	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.0\text{A}$		12	100	mV
		$I_O = 5\text{mA}$ to $1.0\text{A}$		12	100	
		$I_O = 250$ to $750\text{mA}$		5	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.0	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$V_I = 11.7\text{V}$ to $25\text{V}$ , $T_J = +25^\circ\text{C}$			0.8	mA
		$V_I = 12\text{V}$ to $25\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$I_O = 5\text{mA}$ to $1.0\text{A}$			0.5	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 12\text{V}$ to $22\text{V}$		62		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2.0		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		17		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7810A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+125^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 16\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	9.8	10	10.2	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 12.8$ to $25\text{V}$	9.6	10	10.4	
Line Regulation	$\Delta V_O$	$V_I = 12.8$ to $26\text{V}$ $I_O = 500\text{mA}$		8	100	mV
		$V_I = 13$ to $20\text{V}$		4	50	
		$T_J = +25^\circ\text{C}$ $V_I = 12.5\text{V}$ to $25\text{V}$		8	100	
		$V_I = 13\text{V}$ to $20\text{V}$		3	50	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		12	100	mV
		$I_O = 5\text{mA}$ to $1.0\text{A}$		12	100	
		$I_O = 250$ to $750\text{mA}$		5	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.0	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$V_I = 13\text{V}$ to $26\text{V}$ , $T_J = +25^\circ\text{C}$			0.5	mA
		$V_I = 12.8\text{V}$ to $25\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$I_O = 5\text{mA}$ to $1.0\text{A}$			0.5	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/°C
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 14\text{V}$ to $24\text{V}$		62		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2.0		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		17		m $\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.



## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7811A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+125^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 18\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	10.8	11.0	11.2	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 13.8$ to $26\text{V}$	10.6	11.0	11.4	
Line Regulation	$\Delta V_O$	$V_I = 12.8$ to $26\text{V}$ $I_O = 500\text{mA}$		10	110	mV
		$V_I = 15$ to $21\text{V}$		4	55	
		$T_J = +25^\circ\text{C}$ $V_I = 13.5\text{V}$ to $26\text{V}$		10	110	
		$V_I = 15\text{V}$ to $21\text{V}$		3	55	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		12	100	mV
		$I_O = 5\text{mA}$ to $1.0\text{A}$		12	100	
		$I_O = 250$ to $750\text{mA}$		5	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.1	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$V_I = 13.8\text{V}$ to $26\text{V}$ , $T_J = +25^\circ\text{C}$			0.8	mA
		$V_I = 14\text{V}$ to $27\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$I_O = 5\text{mA}$ to $1.0\text{A}$			0.5	
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 14\text{V}$ to $24\text{V}$		61		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2.0		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		18		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7812A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+125^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 19\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	11.75	12	12.25	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 14.8$ to $27\text{V}$	11.5	12	12.5	
Line Regulation	$\Delta V_O$	$V_I = 14.8$ to $30\text{V}$ $I_O = 500\text{mA}$		10	120	mV
		$V_I = 16$ to $22\text{V}$		4	120	
		$T_J = +25^\circ\text{C}$		10	120	
				3	60	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		12	100	mV
		$I_O = 5\text{mA}$ to $1.0\text{A}$		12	100	
		$I_O = 250$ to $750\text{mA}$		5	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.1	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$V_I = 15\text{V}$ to $30\text{V}$ , $T_J = +25^\circ\text{C}$			0.5	mA
		$V_I = 14\text{V}$ to $27\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$I_O = 5\text{mA}$ to $1.0\text{A}$			0.8	
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 14\text{V}$ to $24\text{V}$		60		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2.0		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		18		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7815A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+150^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 23\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	14.7	15	15.3	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 17.7$ to $30\text{V}$	14.4	15	15.6	
Line Regulation	$\Delta V_O$	$V_I = 17.9$ to $30\text{V}$ $I_O = 500\text{mA}$		10	150	mV
		$V_I = 20$ to $26\text{V}$		5	150	
		$T_J = +25^\circ\text{C}$ $V_I = 17.5\text{V}$ to $30\text{V}$ $V_I = 20\text{V}$ to $26\text{V}$		11	150	
				3	75	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		12	100	mV
		$I_O = 5\text{mA}$ to $1.0\text{A}$		12	100	
		$I_O = 250$ to $750\text{mA}$		5	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.2	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$V_I = 17.5\text{V}$ to $30\text{V}$ , $T_J = +25^\circ\text{C}$			0.5	mA
		$V_I = 17.5\text{V}$ to $30\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$I_O = 5\text{mA}$ to $1.0\text{A}$			0.8	
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 18.5\text{V}$ to $28.5\text{V}$		58		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2.0		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		19		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7818A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+150^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 27\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	17.64	18	18.36	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 21$ to $33\text{V}$	17.3	18	18.7	
Line Regulation	$\Delta V_O$	$V_I = 21$ to $33\text{V}$ $I_O = 500\text{mA}$		15	180	mV
		$V_I = 21$ to $33\text{V}$		5	180	
		$T_J = +25^\circ\text{C}$ $V_I = 20.6\text{V}$ to $33\text{V}$		15	180	
		$T_J = +25^\circ\text{C}$ $V_I = 24\text{V}$ to $30\text{V}$		5	90	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		15	100	mV
		$I_O = 5\text{mA}$ to $1.0\text{A}$		15	100	
		$I_O = 250$ to $750\text{mA}$		7	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.2	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$V_I = 21\text{V}$ to $33\text{V}$ , $T_J = +25^\circ\text{C}$			0.5	mA
		$V_I = 21\text{V}$ to $33\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$I_O = 5\text{mA}$ to $1.0\text{A}$			0.8	
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = +25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 18.5\text{V}$ to $28.5\text{V}$		57		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2.0		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		19		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM7824A/RA ELECTRICAL CHARACTERISTICS

(Refer to the test circuits.  $T_J = 0$  to  $+150^\circ\text{C}$ ,  $I_O = 1\text{A}$ ,  $V_I = 33\text{V}$ ,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	23.5	24	24.5	V
		$I_O = 5\text{mA}$ to $1\text{A}$ , $P_D \leq 15\text{W}$ $V_I = 27.3$ to $38\text{V}$	23	24	25	
Line Regulation	$\Delta V_O$	$V_I = 27$ to $38\text{V}$ $I_O = 500\text{mA}$		18	240	mV
		$V_I = 21$ to $33\text{V}$		6	240	
		$T_J = +25^\circ\text{C}$ $V_I = 26.7\text{V}$ to $38\text{V}$		18	240	
		$V_I = 30\text{V}$ to $36\text{V}$		6	120	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ\text{C}$ $I_O = 5\text{mA}$ to $1.5\text{A}$		15	100	mV
		$I_O = 5\text{mA}$ to $1.0\text{A}$		15	100	
		$I_O = 250$ to $750\text{mA}$		7	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$		5.2	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$V_I = 27.3\text{V}$ to $38\text{V}$ , $T_J = +25^\circ\text{C}$			0.5	mA
		$V_I = 27.3\text{V}$ to $38\text{V}$ , $I_O = 500\text{mA}$			0.8	
		$I_O = 5\text{mA}$ to $1.0\text{A}$			0.8	
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		-1.5		mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ $T_A = 25^\circ\text{C}$		10		$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 500\text{mA}$ $V_I = 18.5\text{V}$ to $28.5\text{V}$		54		dB
Dropout Voltage	$V_D$	$I_O = 1\text{A}$ , $T_J = +25^\circ\text{C}$		2.0		V
Output Resistance	$R_O$	$f = 1\text{KHz}$		20		$\text{m}\Omega$
Short Circuit Current	$I_{SC}$	$V_I = 35\text{V}$ , $T_A = +25^\circ\text{C}$		250		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$		2.2		A

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### TYPICAL PERFORMANCE CHARACTERISTICS

Fig. 1 Quiescent Current

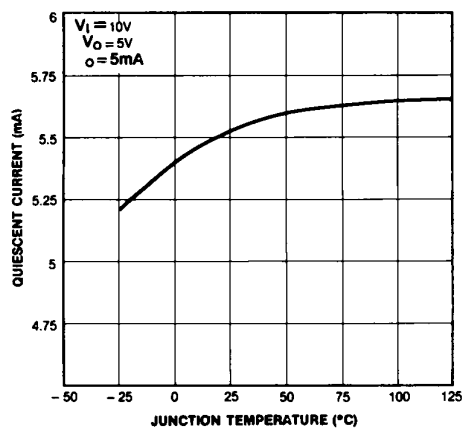


Fig. 2 Peak Output Current

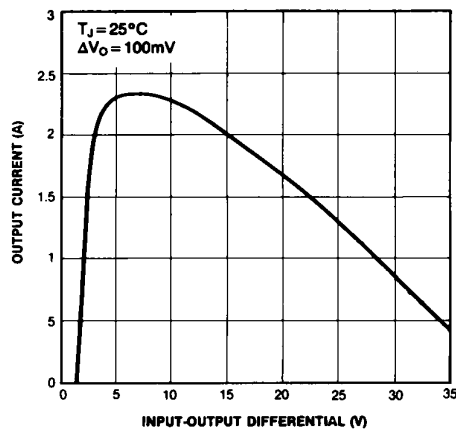


Fig. 3 Output Voltage

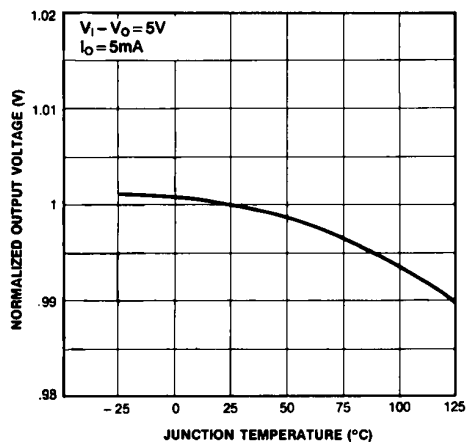
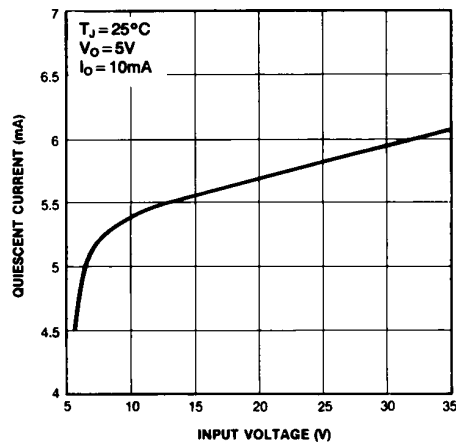


Fig. 4 Quiescent Current



## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

### TYPICAL APPLICATIONS

Fig. 5 DC Parameters

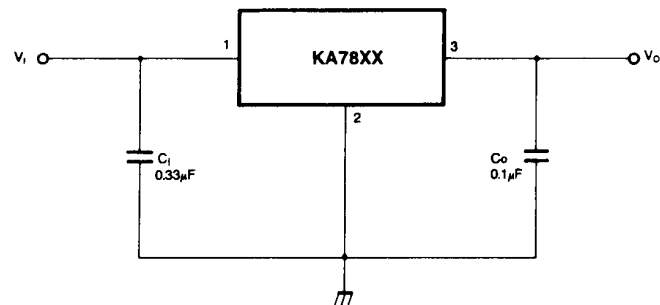


Fig. 6 Load Regulation

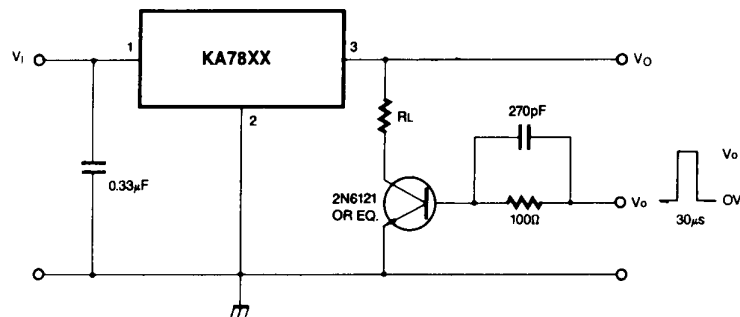
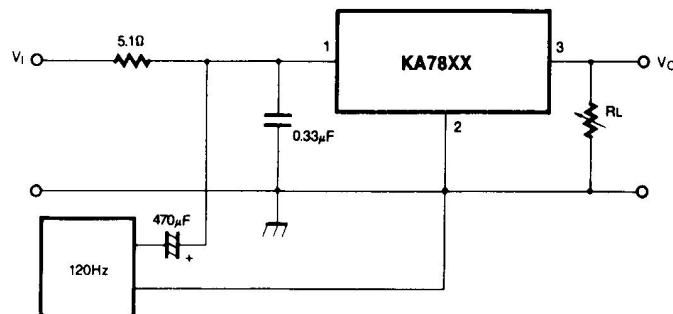


Fig. 7 Ripple Rejection



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## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

Fig. 8 Fixed Output Regulator

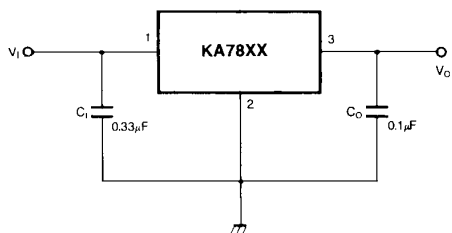
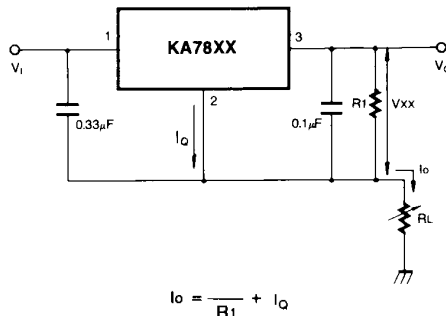


Fig. 9 Constant Current Regulator



### Notes:

- (1) To specify an output voltage, substitute voltage value for "XX."  
A common ground is required between the input and the Output voltage. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.
- (2)  $C_I$  is required if regulator is located an appreciable distance from power supply filter.
- (3)  $C_O$  improves stability and transient response.

Fig. 10 Circuit for Increasing Output Voltage

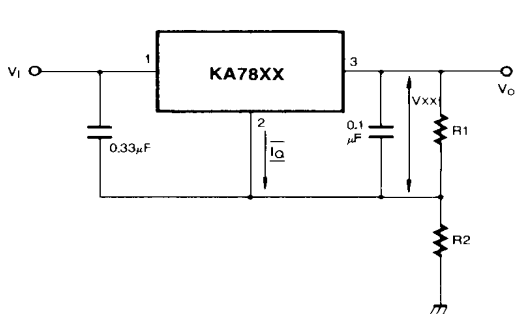
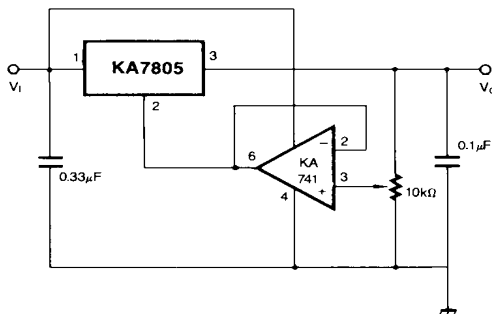


Fig. 11 Adjustable Output Regulator (7 to 30V)



$$I_{R1} \geq 5 I_Q$$

$$V_O = V_{XX} (1 + R_2/R_1) + I_Q R_2$$



# LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

## TYPICAL APPLICATIONS (Continued)

Fig. 12 High Current Voltage Regulator

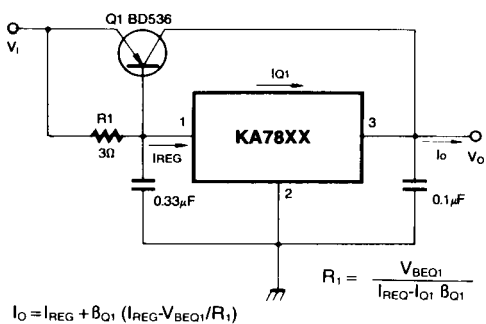


Fig. 13 High Output Current with Short Circuit Protection

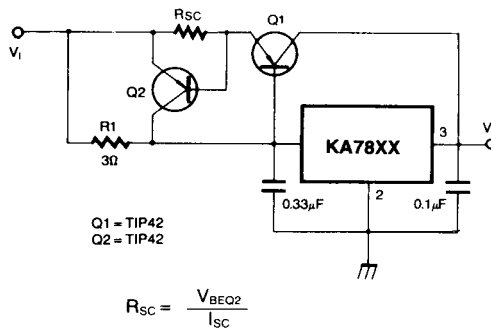


Fig. 14 Tracking Voltage Regulator

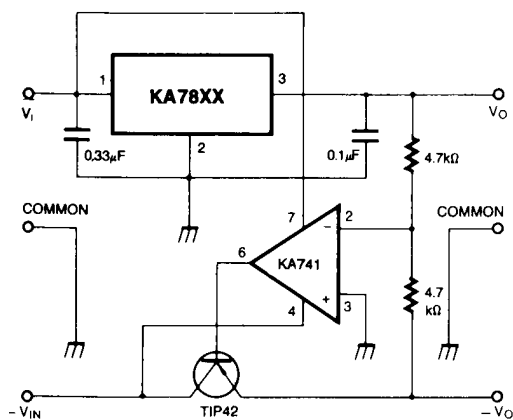
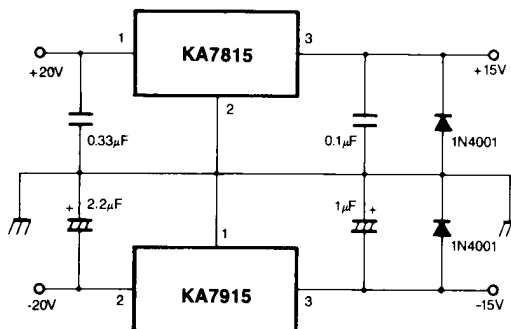


Fig. 15 Split Power Supply (±15V-1A)



## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

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### TYPICAL APPLICATIONS (Continued)

Fig. 16 Negative Output Voltage Circuit

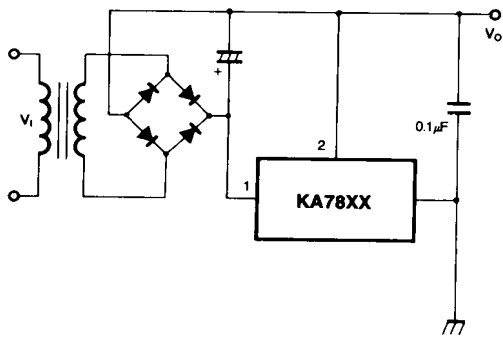
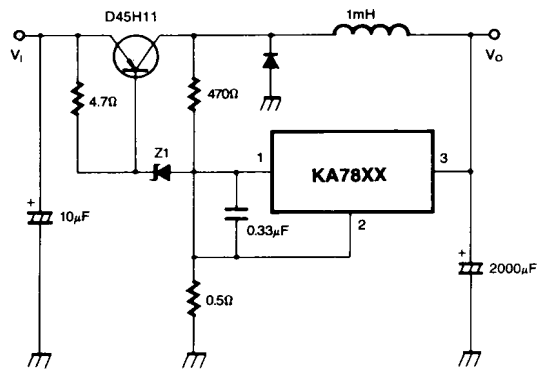


Fig. 17 switching Regulator



## LM78XX (KA78XX, MC78XX) FIXED VOLTAGE REGULATOR (POSITIVE)

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### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
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# LM78LXX (KA78LXX, MC78LXX) FIXED VOLTAGE REGULATOR (POSITIVE)

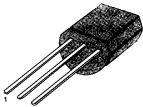
## 3-TERMINAL 0.1A POSITIVE VOLTAGE REGULATORS

The LM78LXX series of fixed voltage monolithic integrated circuit voltage regulators are suitable for application that required supply up to 100mA.

## FEATURES

- Maximum Output Current of 100mA
- Output Voltage of 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V and 24V
- Thermal Overload Protection
- Short Circuit Current Limiting
- Output Voltage Offered in  $\pm 5\%$  Tolerance

### TO-92



1: Output 2: GND 3: Input

### 8 SOP

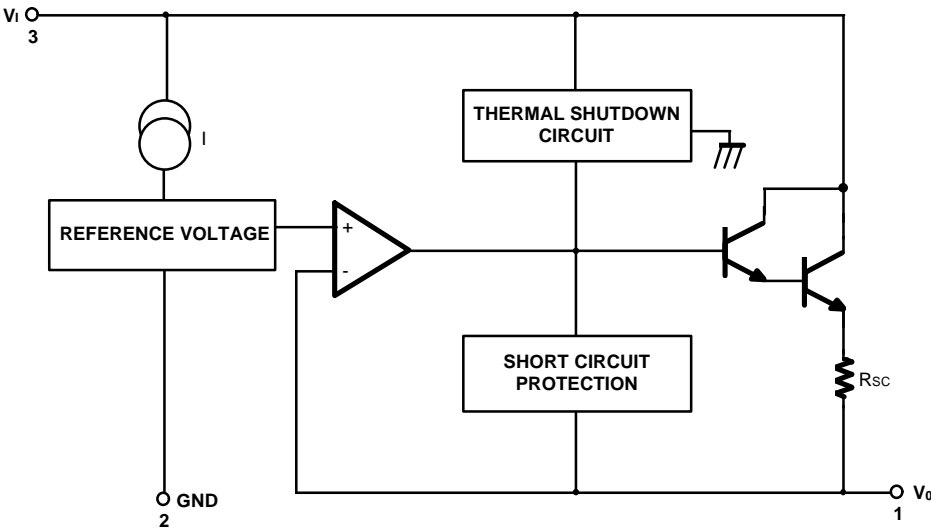


1: Output 2: GND 3: GND 4: NC  
5: NC 6: GND 7: GND 8: Input

## ORDERING INFORMATION

Device	Package	Operating Temperature
LM78LXXACZ	TO-92	- 45 ~ + 125°C
LM78LXXM	8 SOP	0 ~ + 125°C

## BLOCK DIAGRAM



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Rev. B

## LM78LXX (KA78LXX, MC78LXX) FIXED VOLTAGE REGULATOR (POSITIVE)

### ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub> = 25 °C, unless otherwise specified)

Characteristic	Symbol	Value	Unit
Input Voltage (for V <sub>O</sub> = 5V, 8V) (for V <sub>O</sub> = 12V, 15V)	V <sub>I</sub>	30	V
		35	V
Operating Junction Temperature Range	T <sub>J</sub>	0 ~ +150	°C
Storage Temperature Range	T <sub>STG</sub>	-65 ~ +150	°C

### LM78L05 ELECTRICAL CHARACTERISTICS

(V<sub>I</sub> = 10V, I<sub>O</sub> = 40mA, 0 °C ≤ T<sub>J</sub> ≤ 125 °C, C<sub>I</sub> = 0.33 μF, C<sub>O</sub> = 0.1 μF, unless otherwise specified. (Note 1)

Characteristic		Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage		V <sub>O</sub>	T <sub>J</sub> = 25 °C		4.8	5.0	5.2	V
Line Regulation		ΔV <sub>O</sub>	T <sub>J</sub> = 25 °C	7V ≤ V <sub>I</sub> ≤ 20V		8	150	mV
				8V ≤ V <sub>I</sub> ≤ 20V		6	100	mV
Load Regulation		ΔV <sub>O</sub>	T <sub>J</sub> = 25 °C	1mA ≤ I <sub>O</sub> ≤ 100mA		11	60	mV
				1mA ≤ I <sub>O</sub> ≤ 40mA		5.0	30	mV
Output Voltage		V <sub>O</sub>	7V ≤ V <sub>I</sub> ≤ 0V 7V ≤ V <sub>I</sub> ≤ V <sub>MAX</sub> (Note 2)	1mA ≤ I <sub>O</sub> ≤ 40mA			5.25	V
				1mA ≤ I <sub>O</sub> ≤ 70mA	4.75		5.25	V
Quiescent Current		I <sub>Q</sub>	T <sub>J</sub> = 25 °C			2.0	5.5	mA
Quiescent Current Change	with line	ΔI <sub>Q</sub>	8V ≤ V <sub>I</sub> ≤ 20V				1.5	mA
	with load	ΔI <sub>Q</sub>	1mA ≤ I <sub>O</sub> ≤ 40mA				0.1	mA
Output Noise Voltage		V <sub>N</sub>	T <sub>A</sub> = 25 °C, 10Hz ≤ f ≤ 100KHz			40		μV/V <sub>O</sub>
Temperature Coefficient of V <sub>O</sub>		ΔV <sub>O</sub> /ΔT	I <sub>O</sub> = 5mA			-0.65		mV/°C
Ripple Rejection		RR	f = 120Hz, 8V ≤ V <sub>I</sub> ≤ 18V, T <sub>J</sub> = 25 °C		41	80		dB
Dropout Voltage		V <sub>D</sub>	T <sub>J</sub> = 25 °C			1.7		V

## LM78LXX (KA78LXX, MC78LXX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM78L06 ELECTRICAL CHARACTERISTICS

( $V_I = 12V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq 125^\circ C$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified. (Note 1))

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	5.75	6.0	6.25	V
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$	8.5V < $V_I$ < 20V	64	175	mV
			$9V \geq V_I \geq 20V$	54	125	mV
Load Regulation	$\Delta V_O$	$T_J = 25^\circ C$	$1mA < I_O < 100mA$	12.8	80	mV
			$1mA < I_O < 70mA$	5.8	40	mV
Output Voltage	$V_O$	$8.5 < V_I < 20V$ , $1mA < I_O < 40mA$	5.7		6.3	V
		$8.5 < V_I < V_{MAX}(\text{Note})$ , $1mA < I_O < 70mA$	5.7		6.3	V
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		3.9	6.0	mA
		$T_J = 125^\circ C$			5.5	mA
Quiescent Current Change	with line with load	$\Delta I_Q$	$9 < V_I < 20V$		1.5	mA
		$\Delta I_Q$	$1mA < I_O < 40mA$		0.1	mA
Output Noise Voltage	$V_N$	$T_A = 25^\circ C$ , $10Hz < f < 100KHz$		40		$\mu V/V_O$
Temperature Coefficient of $V_O$	$\Delta V_O/\Delta T$	$I_O = 5mA$		0.75		mV/ $^\circ C$
Ripple Rejection	RR	$f = 120Hz$ , $10V < V_I < 20V$ , $T_J = 25^\circ C$	40	46		dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$		1.7		V

### LM78L08 ELECTRICAL CHARACTERISTICS

( $V_I = 14V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq 125^\circ C$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ , unless otherwise specified. (Note 1))

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	7.7	8.0	8.3	V
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$	$10.5V \leq V_I \leq 23V$	10	175	mV
			$11V \leq V_I \leq 23V$	8	125	mV
Load Regulation	$\Delta V_O$	$T_J = 25^\circ C$	$1mA \leq I_O \leq 100mA$	15	80	mV
			$1mA \leq I_O \leq 40mA$	8.0	40	mV
Output Voltage	$V_O$	$10.5V \leq V_I \leq 23V$	7.6		8.4	V
		$10.5V \leq V_I \leq V_{MAX}(\text{Note 2})$	7.6		8.4	V
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		2.0	5.5	mA
Quiescent Current Change	with line with load	$\Delta I_Q$	$11V \leq V_I \leq 23V$		1.5	mA
		$\Delta I_Q$	$1mA \leq I_O \leq 40mA$		0.1	mA
Output Noise Voltage	$V_N$	$T_A = 25^\circ C$ , $10Hz \leq f \leq 100KHz$		60		$\mu V/V_O$
Temperature Coefficient of $V_O$	$\Delta V_O/\Delta T$	$I_O = 5mA$		-0.8		mV/ $^\circ C$
Ripple Rejection	RR	$f = 120Hz$ , $11V \leq V_I \leq 21V$ , $T_J = 25^\circ C$	39	70		dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$		1.7		V

## LM78LXX (KA78LXX, MC78LXX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM78L09 ELECTRICAL CHARACTERISTICS

( $V_I = 15V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq 125^\circ C$ ,  $C_I = 0.33 \mu F$ ,  $C_O = 0.1 \mu F$ , unless otherwise specified. (Note 1))

Characteristic		Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage		$V_O$	$T_J = 25^\circ C$	8.64	9.0	9.36	V
Line Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$11.5V \leq V_I \leq 24V$	90	200	mV
				$13V \leq V_I \leq 24V$	100	150	mV
Load Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$1mA \leq I_O \leq 100mA$	20	90	mV
				$1mA \leq I_O \leq 40mA$	10	45	mV
Output Voltage		$V_O$	$11.5V \leq V_I \leq 24V$	$1mA \leq I_O \leq 40mA$	8.55	9.45	V
			$11.5V \leq V_I \leq V_{MAX}$ (Note 2)	$1mA \leq I_O \leq 70mA$	8.55	9.45	V
Quiescent Current		$I_Q$	$T_J = 25^\circ C$		2.1	6.0	mA
Quiescent Current Change	with line	$\Delta I_Q$	$13V \leq V_I \leq 24V$			1.5	mA
	with load	$\Delta I_Q$	$1mA \leq I_O \leq 40mA$			0.1	mA
Output Noise Voltage		$V_N$	$T_A = 25^\circ C$ , $10Hz \leq f \leq 100KHz$		70		$\mu V/V_O$
Temperature Coefficient of $V_O$		$\Delta V_O/\Delta T$	$I_O = 5mA$		-0.9		mV/ $^\circ C$
Ripple Rejection		RR	$f = 120Hz$ , $12V \leq V_I \leq 22V$ , $T_J = 25^\circ C$	38	44		dB
Dropout Voltage		$V_D$	$T_J = 25^\circ C$		1.7		V

### LM78L10 ELECTRICAL CHARACTERISTICS

( $V_I = 16V$ ,  $I_O = 40mA$ ,  $0^\circ C < T_J < 125^\circ C$ ,  $C_I = 0.33 \mu F$ ,  $C_O = 0.1 \mu F$ , unless otherwise specified. (Note 1))

Characteristic		Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage		$V_O$	$T_J = 25^\circ C$	9.6	10.0	10.4	V
Line Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$12.5 < V_I < 25V$	100	220	mV
				$14V \geq V_I \geq 25V$	100	170	mV
Load Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$1mA < I_O < 100mA$	20	94	mV
				$1mA < I_O < 70mA$	10	47	mV
Output Voltage		$V_O$	$12.5 < V_I < 25V$ , $1mA < I_O < 40mA$	9.5		10.5	V
			$12.5 < V_I < V_{MAX}(\text{Note})$ , $1mA < I_O < 70mA$	9.5		10.5	
Quiescent Current		$I_Q$	$T_J = 25^\circ C$		4.2	6.5	mA
			$T_J = 125^\circ C$			6.0	
Quiescent Current Change	with line	$\Delta I_Q$	$12.5 < V_I < 25V$			1.5	mA
	with load	$\Delta I_Q$	$1mA < I_O < 40mA$			0.1	
Output Noise Voltage		$V_N$	$T_A = 25^\circ C$ , $10Hz < f < 100KHz$		74		$\mu V/V_O$
Temperature Coefficient of $V_O$		$\Delta V_O/\Delta T$	$I_O = 5mA$		0.95		mV/ $^\circ C$
Ripple Rejection		RR	$f = 120Hz$ , $15V < V_I < 25V$ , $T_J = 25^\circ C$	38	43		dB
Dropout Voltage		$V_D$	$T_J = 25^\circ C$		1.7		V



## LM78LXX (KA78LXX, MC78LXX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM78L12 ELECTRICAL CHARACTERISTICS

( $V_I = 19V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq 125^\circ C$ ,  $C_I = 0.33 \mu F$ ,  $C_O = 0.1 \mu F$ , unless otherwise specified. (Note 1))

Characteristic		Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage		$V_O$	$T_J = 25^\circ C$	11.5	12	12.5	V
Line Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$14.5V \leq V_I \leq 27V$	20	250	mV
				$16V \leq V_I \leq 27V$	15	200	mV
Load Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$1mA \leq I_O \leq 100mA$	20	100	mV
				$1mA \leq I_O \leq 40mA$	10	50	mV
Output Voltage		$V_O$	$14.5V \leq V_I \leq 27V$	11.4		12.6	V
			$14.5V \leq V_I \leq V_{MAX}$ (Note 2)	$1mA \leq I_O \leq 70mA$	11.4	12.6	V
Quiescent Current		$I_Q$	$T_J = 25^\circ C$		2.1	6.0	mA
Quiescent Current Change	with line	$\Delta I_Q$	$16V \leq V_I \leq 27V$			1.5	mA
	with load	$\Delta I_Q$	$1mA \leq I_O \leq 40mA$			0.1	mA
Output Noise Voltage		$V_N$	$T_A = 25^\circ C$ , $10Hz \leq f \leq 100KHz$		80		$\mu V/V_O$
Temperature Coefficient of $V_O$		$\Delta V_O/\Delta T$	$I_O = 5mA$		-1.0		mV/ $^\circ C$
Ripple Rejection		RR	$f = 120Hz$ , $15V \leq V_I \leq 25V$ , $T_J = 25^\circ C$	37	65		dB
Dropout Voltage		$V_D$	$T_J = 25^\circ C$		1.7		V

### LM78L15 ELECTRICAL CHARACTERISTICS

( $V_I = 23V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq 125^\circ C$ ,  $C_I = 0.33 \mu F$ ,  $C_O = 0.1 \mu F$ , unless otherwise specified. (Note 1))

Characteristic		Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage		$V_O$	$T_J = 25^\circ C$	14.4	15	15.6	V
Line Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$17.5V \leq V_I \leq 30V$	25	300	mV
				$20V \leq V_I \leq 30V$	20	250	mV
Load Regulation		$\Delta V_O$	$T_J = 25^\circ C$	$1mA \leq I_O \leq 100mA$	25	150	mV
				$1mA \leq I_O \leq 40mA$	12	75	mV
Output Voltage		$V_O$	$17.5V \leq V_I \leq 30V$	14.25		15.75	V
			$17.5V \leq V_I \leq V_{MAX}$ (Note 2)	$1mA \leq I_O \leq 70mA$	14.25	15.75	V
Quiescent Current		$I_Q$	$T_J = 25^\circ C$		2.1	6.0	mA
Quiescent Current Change	with line	$\Delta I_Q$	$20V \leq V_I \leq 30V$			1.5	mA
	with load	$\Delta I_Q$	$1mA \leq I_O \leq 40mA$			0.1	mA
Output Noise Voltage		$V_N$	$T_A = 25^\circ C$ , $10Hz \leq f \leq 100KHz$		90		$\mu V/V_O$
Temperature Coefficient of $V_O$		$\Delta V_O/\Delta T$	$I_O = 5mA$		-1.3		mV/ $^\circ C$
Ripple Rejection		RR	$f = 120Hz$ , $18.5V \leq V_I \leq 28.5V$ , $T_J = 25^\circ C$	34	60		dB
Dropout Voltage		$V_D$	$T_J = 25^\circ C$		1.7		V

## LM78LXX (KA78LXX, MC78LXX) FIXED VOLTAGE REGULATOR (POSITIVE)

### LM78L18 ELECTRICAL CHARACTERISTICS

( $V_I = 27V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq 125^\circ C$ ,  $C_I = 0.33 \mu F$ ,  $C_O = 0.1 \mu F$ , unless otherwise specified. (Note 1))

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	17.3	18	18.7	V
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		145	300	mV
		$21V \leq V_I \leq 33V$		135	250	mV
Load Regulation	$\Delta V_O$	$T_J = 25^\circ C$		30	170	mV
		$1mA \leq I_O \leq 100mA$		15	85	mV
		$1mA \leq I_O \leq 40mA$				
Output Voltage	$V_O$	$21V \leq V_I \leq 33V$	17.1		18.9	V
		$21V \leq V_I \leq V_{MAX}$ (Note 2)	17.1		18.9	V
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		2.2	6.0	mA
Quiescent Current	with line	$\Delta I_Q$			1.5	mA
Change	with load	$\Delta I_Q$			0.1	mA
Output Noise Voltage	$V_N$	$T_A = 25^\circ C$ , $10Hz \leq f \leq 100KHz$		150		$\mu V/V_O$
Temperature Coefficient of $V_O$	$\Delta V_O/\Delta T$	$I_O = 5mA$		-1.8		mV/ $^\circ C$
Ripple Rejection	RR	$f = 120Hz$ , $23V \leq V_I \leq 33V$ , $T_J = 25^\circ C$	34	48		dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$		1.7		V

### LM78L24 ELECTRICAL CHARACTERISTICS

( $V_I = 33V$ ,  $I_O = 40mA$ ,  $0^\circ C \leq T_J \leq 125^\circ C$ ,  $C_I = 0.33 \mu F$ ,  $C_O = 0.1 \mu F$ , unless otherwise specified. (Note 1))

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	23	24	25	V
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		160	300	mV
		$27V \leq V_I \leq 38V$		150	250	mV
		$28V \leq V_I \leq 38V$				
Load Regulation	$\Delta V_O$	$T_J = 25^\circ C$		40	200	mV
		$1mA \leq I_O \leq 100mA$		20	100	mV
		$1mA \leq I_O \leq 40mA$				
Output Voltage	$V_O$	$27V \leq V_I \leq 38V$	22.8		25.2	V
		$27V \leq V_I \leq V_{MAX}$ (Note 2)	22.8		25.2	V
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		2.2	6.0	mA
Quiescent Current	with line	$\Delta I_Q$			1.5	mA
Change	with load	$\Delta I_Q$			0.1	mA
Output Noise Voltage	$V_N$	$T_A = 25^\circ C$ , $10Hz \leq f \leq 100KHz$		200		$\mu V/V_O$
Temperature Coefficient of $V_O$	$\Delta V_O/\Delta T$	$I_O = 5mA$		-2.0		mV/ $^\circ C$
Ripple Rejection	RR	$f = 120Hz$ , $28V \leq V_I \leq 38V$ , $T_J = 25^\circ C$	34	45		dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$		1.7		V

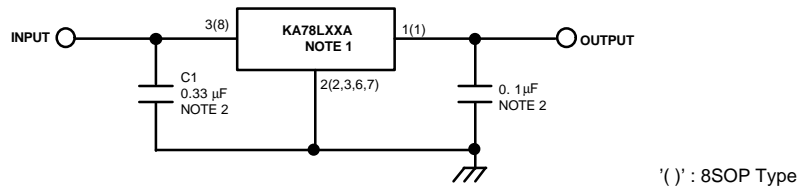
#### Notes

1. The maximum steady state usable output current and input voltage are very dependent on the heat sinking and/or lead length of the package. The data above represent pulse test conditions with junction temperature as indicated at the initiation of tests.
2. Power dissipation  $\leq 0.75W$ .

## LM78LXX (KA78LXX, MC78LXX) FIXED VOLTAGE REGULATOR (POSITIVE)

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### TYPICAL APPLICATION



#### Notes

1. To specify an output voltage, substitute voltage value for "XX".
2. Bypass Capacitors are recommend for optimum stability and transient response and should be located as close as possible to the regulator

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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
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# MC78MXX (LM78MXX) (KA78MXX)

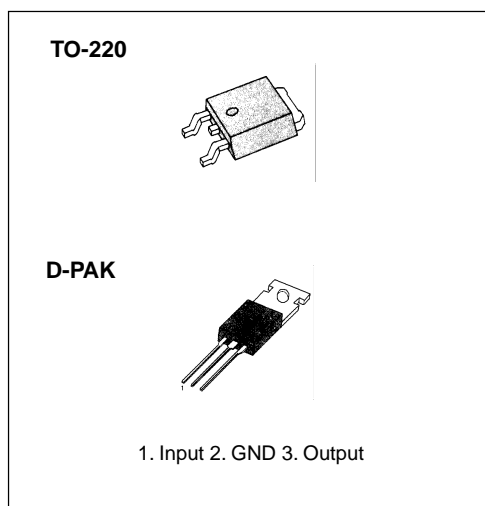
## 3-Terminal 0.5A Positive Voltage Regulators

### Features

- Output Current up to 0.5A
- Output Voltages of 5, 6, 8, 10, 12, 15, 18, 20, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor SOA Protection
- Industrial and commercial temperature range

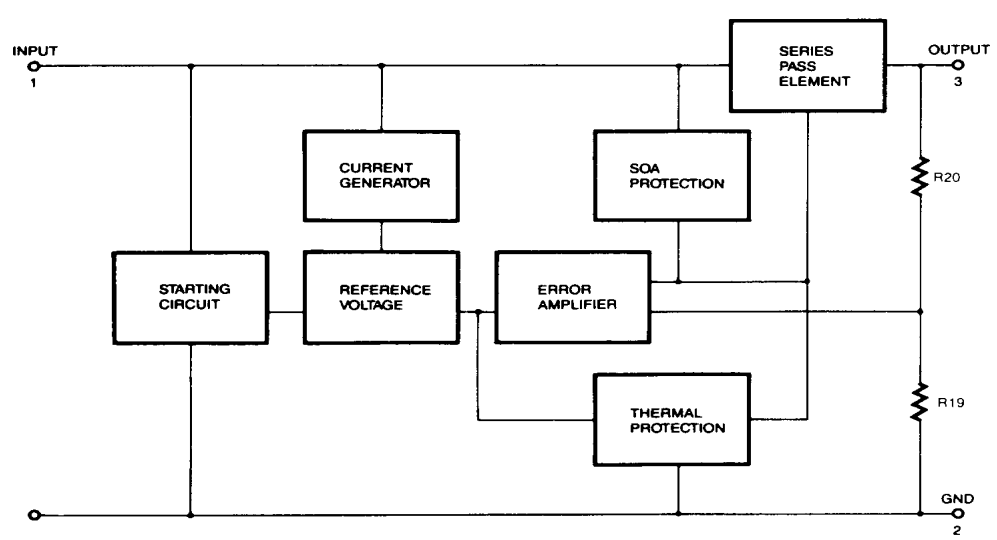
### Description

The MC78MXX (LM78MXX) (KA78MXX) series of three-terminal positive regulators are available in the TO-220/D-PAK package with several fixed output voltages making it useful in a wide range of applications.



**Fixed Voltage Regulator (Positive)**

Internal Block Diagram



Fixed Voltage Regulator (Positive)

**Absolute Maximum Ratings** ( $T_a=+25^{\circ}\text{C}$ , Unless otherwise specified)

Parameter	Symbol	Value	Unit
Input Voltage (for $V_O = 5\text{V}$ to $18\text{V}$ ) (for $V_O = 24\text{V}$ )	$V_I$	35	V
	$V_I$	40	V
Thermal Resistance Junction-Cases	$R_{\theta JC}$	5	$^{\circ}\text{C/W}$
Thermal Resistance Junction-Air	$R_{\theta JA}$	65	$^{\circ}\text{C/W}$
Operating Temperature Range KA78MXXI/RI KA78MXX/R	$T_{OPR}$	-40~ + 125	$^{\circ}\text{C}$
		0~ + 125	$^{\circ}\text{C}$
Storage Temperature Range	$T_{STG}$	-65~ + 150	$^{\circ}\text{C}$

**KA78M05/I/R/RI Electrical Characteristics**

(Refer to the test circuits,  $T_{MIN} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O=350\text{mA}$ ,  $V_I=10\text{V}$ , unless otherwise specified,  $C_I = 0.33\text{mF}$ ,  $C_O=0.1\text{mF}$ )

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Units
Output Voltage	$V_O$	$T_J=+25^{\circ}\text{C}$		4.8	5	5.2	V
		$I_O = 5$ to $350\text{mA}$ $V_I = 7$ to $20\text{V}$		4.75	5	5.25	
Line Regulation	$\Delta V_O$	$I_O = 200\text{mA}$ $T_J = +25^{\circ}\text{C}$	$V_I = 7$ to $25\text{V}$	-	-	100	mV
			$V_I = 8$ to $25\text{V}$	-	-	50	
Load Regulation	$\Delta V_O$	$I_O = 5\text{mA}$ to $0.5\text{A}$ , $T_J = +25^{\circ}\text{C}$		-	-	100	mV
		$I_O = 5\text{mA}$ to $200\text{mA}$ , $T_J = +25^{\circ}\text{C}$		-	-	50	
Quiescent Current	$I_Q$	$T_J=+25^{\circ}\text{C}$		-	4.0	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA}$ to $350\text{mA}$		-	-	0.5	mA
		$I_O = 200\text{mA}$ $V_I = 8$ to $25\text{V}$		-	-	0.8	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$ $T_J = 0$ to $+125^{\circ}\text{C}$		-	- 0.5	-	mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$		-	40	-	mV/ $V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 300\text{mA}$ $V_I = 8$ to $18\text{V}$		62	-	-	dB
Dropout Voltage	$V_D$	$T_J = +25^{\circ}\text{C}$ , $I_O = 500\text{mA}$		-	2	-	V
Short Circuit Current	$I_{SC}$	$T_J = +25^{\circ}\text{C}$ , $V_I = 35\text{V}$		-	300	-	mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		-	700	-	mA

**NOTE:**

- $T_{MIN} < T_J < T_{MAX}$   
KA78MXX/RI:  $T_{MIN} = -40^{\circ}\text{C}$ ,  $T_{MAX} = +125^{\circ}\text{C}$   
KA78MXX/R:  $T_{MIN} = 0^{\circ}\text{C}$ ,  $T_{MAX} = +125^{\circ}\text{C}$
- Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**Fixed Voltage Regulator (Positive)**

KA78M06/I/R/RI Electrical Characteristics

(Refer to the test circuits, TMIN ≤TJ ≤ +125°C, IO=350mA, VI=11V, unless otherwise specified, CI = 0.33mF, CO=0.1mF)(

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	VO	TJ=+25°C	5.75	6	6.25	V
		IO = 5 to 350mA VI= 8 to 21V	5.7	6	6.3	
Line Regulation	ΔVO	IO = 200mA TJ =+25°C	-	-	100	mV
		VI= 8 to 25V VI = 9 to 25V			50	
Load Regulation	ΔVO	IO = 5mA to 0.5A, TJ =+25°C	-	-	120	mV
		IO = 5mA to 200mA, TJ =+25°C	-	-	60	
Quiescent Current	IQ	TJ=+25°C	-	4.0	6	mA
Quiescent Current Change	ΔIQ	IO = 5mA to 350mA	-	-	0.5	mA
		IO = 200mA VI = 9 to 25V	-	-	0.8	
Output Voltage Drift	ΔV/ΔT	IO = 5mA TJ = 0 to +125°C	-	- 0.5	-	mV/°C
Output Noise Voltage	VN	f = 10Hz to 100KHz	-	45	-	mV/VO
Ripple Rejection	RR	f = 120Hz, IO = 300mA VI = 9 to 19V	59	-	-	dB
Dropout Voltage	VD	TJ =+25°C, IO = 500mA	-	2	-	V
Short Circuit Current	ISC	TJ= +25°C, VI= 35V	-	300	-	mA
Peak Current	IPK	TJ =+25°C	-	700	-	mA

NOTE:

1. TMIN:  
KA78MXX/RI: TMIN = -40°C  
KA78MXX/R: TMIN = 0°C
2. Load and line regulation are specified at constant, junction temperature. Change in VO due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Fixed Voltage Regulator (Positive)



**KA78M08//R/RI ELECTRICAL CHARACTERISTICS**(Refer to the test circuits,  $T_{MIN} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = 14\text{V}$ , unless otherwise specified,  $C_I = 0.33\text{mF}$ ,  $C_O = 0.1\text{mF}$ )

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	7.7	8	8.3	V
		$I_O = 5 \text{ to } 350\text{mA}$ $V_I = 10.5 \text{ to } 23\text{V}$	7.6	8	8.4	
Line Regulation	$\Delta V_O$	$I_O = 200\text{mA}$ $T_J = +25^{\circ}\text{C}$	-	-	100	mV
		$V_I = 11 \text{ to } 25\text{V}$	-	-	50	
Load Regulation	$\Delta V_O$	$I_O = 5\text{mA} \text{ to } 0.5\text{A}$ , $T_J = +25^{\circ}\text{C}$	-	-	160	mV
		$I_O = 5\text{mA} \text{ to } 200\text{mA}$ , $T_J = +25^{\circ}\text{C}$	-	-	80	
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$	-	4.0	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA} \text{ to } 350\text{mA}$	-	-	0.5	mA
		$I_O = 200\text{mA}$ $V_I = 10.5 \text{ to } 25\text{V}$	-	-	0.8	
Output Voltage Drift	$RR$	$I_O = 5\text{mA}$ $T_J = 0 \text{ to } +125^{\circ}\text{C}$	-	- 0.5	-	mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{KHz}$	-	52	-	mV/ $V_O$
Ripple Rejection	$RR$	$f = 120\text{Hz}$ , $I_O = 300\text{mA}$ $V_I = 9 \text{ to } 19\text{V}$	56	-	-	dB
Dropout Voltage	$V_D$	$T_J = +25^{\circ}\text{C}$ , $I_O = 500\text{mA}$	-	2	-	V
Short Circuit Current	$I_{SC}$	$T_J = +25^{\circ}\text{C}$ , $V_I = 35\text{V}$	-	300	-	mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$	-	700	-	mA

**NOTE:**

- $T_{MIN}$ :  
KA78MXX/RI:  $T_{MIN} = -40^{\circ}\text{C}$   
KA78MXX/R:  $T_{MIN} = 0^{\circ}\text{C}$
- Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**Fixed Voltage Regulator (Positive)**

KA78M10//R/RI Electrical Characteristics

(Refer to the test circuits, TMIN ≤TJ ≤ +125°C, IO=350mA, VI=17V, unless otherwise specified, CI = 0.33mF, CO=0.1mF)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	VO	TJ= +25°C	9.6	10	10.4	V
		IO = 5 to 350mA VI= 12.5 to 25V	9.5	10	10.5	
Line Regulation	ΔVO	IO = 200mA TJ =+25°C	-	-	100	mV
		VI= 12.5 to 25V VI = 13 to 25V	-	-	50	
Load Regulation	ΔVO	IO = 5mA to 0.5A, TJ =+25°C	-	-	200	mV
		IO = 5mA to 200mA, TJ =+25°C	-	-	100	
Quiescent Current	IQ	TJ=+25°C	-	4.1	6	mA
Quiescent Current Change	ΔIQ	IO = 5mA to 350mA	-	-	0.5	mA
		IO = 200mA VI = 12.5 to 25V	-	-	0.8	
Output Voltage Drift	ΔV/ΔT	IO = 5mA TJ = 0 to +125°C	-	- 0.5	-	mV/°C
Output Noise Voltage	VN	f = 10Hz to 100KHz	-	65	-	mV/VO
Ripple Rejection	RR	f = 120Hz, IO = 300mA VI = 13 to 23V	55	-	-	dB
Dropout Voltage	VD	TJ =+25°C, IO = 500mA	-	2	-	V
Short Circuit Current	ISC	TJ= +25°C, VI= 35V	-	300	-	mA
Peak Current	IPK	TJ =+25°C	-	700	-	mA

NOTE:

- 1. TMIN:  
KA78MXX/RI: TMIN = -40°C  
KA78MXX/R: TMIN = 0°C
- 2. Load and line regulation are specified at constant, junction temperature. Change in VO due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Fixed Voltage Regulator (Positive)

**KA78M12//R/RI Electrical Characteristics**(Refer to the test circuits,  $T_{MIN} \leq T_J \leq 125^\circ\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = 19\text{V}$ , unless otherwise specified,  $C_I = 0.33\text{mF}$ ,  $C_O = 0.1\text{mF}$ )

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	$V_O$	$T_J = +25^\circ\text{C}$	11.5	12	12.5	V
		$I_O = 5 \text{ to } 350\text{mA}$ $V_I = 14.5 \text{ to } 27\text{V}$	11.5	12	12.6	
Line Regulation	$\Delta V_O$	$I_O = 200\text{mA}$ $T_J = +25^\circ\text{C}$	-	-	100	mV
		$V_I = 14.5 \text{ to } 30\text{V}$ $V_I = 16 \text{ to } 30\text{V}$	-	-	50	
Load Regulation	$\Delta V_O$	$I_O = 5\text{mA} \text{ to } 0.5\text{A}$ , $T_J = +25^\circ\text{C}$	-	-	240	mV
		$I_O = 5\text{mA} \text{ to } 200\text{mA}$ , $T_J = +25^\circ\text{C}$	-	-	120	
Quiescent Current	$I_Q$	$T_J = +25^\circ\text{C}$	-	4.1	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA} \text{ to } 350\text{mA}$	-	-	0.5	mA
		$I_O = 200\text{mA}$ $V_I = 14.5 \text{ to } 30\text{V}$	-	-	0.8	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$ $T_J = 0 \text{ to } +125^\circ\text{C}$	-	- 0.5	-	mV/ $^\circ\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{kHz}$	-	75	-	mV/ $V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 300\text{mA}$ $V_I = 15 \text{ to } 25\text{V}$	55	-	-	dB
Dropout Voltage	$V_D$	$T_J = +25^\circ\text{C}$ , $I_O = 500\text{mA}$	-	2	-	V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ\text{C}$ , $V_I = 35\text{V}$	-	300	-	mA
Peak Current	$I_{PK}$	$T_J = +25^\circ\text{C}$	-	700	-	mA

**NOTE:**

- $T_{MIN}$ :  
KA78MXX/RI:  $T_{MIN} = -40^\circ\text{C}$   
KA78MXX/R:  $T_{MIN} = 0^\circ\text{C}$
- Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**Fixed Voltage Regulator (Positive)**

KA78M15//R/RI ELECTRICAL CHARACTERISTICS

(Refer to the test circuits, TMIN ≤TJ ≤ +125°C, IO=350mA, VI =23V, unless otherwise specified, CI = 0.33mF, CO=0.1mF)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	VO	TJ=+25°C	14.4	15	15.6	V
		IO = 5 to 350mA VI= 17.5 to 30V	14.25	15	15.75	
Line Regulation	ΔVO	IO = 200mA TJ =+25°C	-	-	100	mV
		VI= 17.5 to 30V VI = 20 to 30V	-	-	50	
Load Regulation	ΔVO	IO = 5mA to 0.5A, TJ =+25°C	-	-	300	mV
		IO = 5mA to 200mA, TJ =+25°C	-	-	150	
Quiescent Current	IQ	TJ=+25°C	-	4.1	6	mA
Quiescent Current Change	ΔIQ	IO = 5mA to 350mA	-	-	0.5	mA
		IO = 200mA VI = 17.5 to 30V	-	-	0.8	
Output Voltage Drift	ΔV/ΔT	IO = 5mA TJ = 0 to +125°C	-	- 1	-	mV/°C
Output Noise Voltage	VN	f = 10Hz to 100KHz	-	100	-	mV/VO
Ripple Rejection	RR	f = 120Hz, IO = 300mA VI = 18.5 to 28.5V	54			dB
Dropout Voltage	VD	TJ =+25°C, IO = 500mA	-	2	-	V
Short Circuit Current	ISC	TJ= +25°C, VI= 35V	-	300	-	mA
Peak Current	IPK	TJ = + 25°C	-	700	-	mA

NOTE:

1. TMIN:  
KA78MXX/RI: TMIN = -40°C  
KA78MXX/R: TMIN = 0°C
2. Load and line regulation are specified at constant, junction temperature. Change in VO due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Fixed Voltage Regulator (Positive)

## KA78M18/I/R/RI Electrical Characteristics

(Refer to the test circuits,  $T_{MIN} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = 26\text{V}$ , unless otherwise specified,  $C_I = 0.33\text{mF}$ ,  $C_O = 0.1\text{mF}$ )

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	17.3	18	18.7	V
		$I_O = 5 \text{ to } 350\text{mA}$ $V_I = 20.5 \text{ to } 33\text{V}$	17.1	18	18.9	
Line Regulation	$\Delta V_O$	$I_O = 200\text{mA}$ $V_I = 21 \text{ to } 33\text{V}$	-	-	100	mV
		$T_J = +25^{\circ}\text{C}$ $V_I = 24 \text{ to } 33\text{V}$	-	-	50	
Load Regulation	$\Delta V_O$	$I_O = 5\text{mA} \text{ to } 0.5\text{A}$ , $T_J = +25^{\circ}\text{C}$	-	-	360	mV
		$I_O = 5\text{mA} \text{ to } 200\text{mA}$ , $T_J = +25^{\circ}\text{C}$	-	-	180	
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$	-	4.2	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA} \text{ to } 350\text{mA}$	-	-	0.5	mA
		$I_O = 200\text{mA}$ $V_I = 21 \text{ to } 33\text{V}$	-	-	0.8	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$ $T_J = 0 \text{ to } 125^{\circ}\text{C}$	-	-1.1	-	mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{kHz}$		100	-	$\mu\text{V}/V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 300\text{mA}$	53		-	dB
Dropout Voltage	$V_D$	$T_J = +25^{\circ}\text{C}$ , $I_O = 500\text{mA}$	-	2	-	V
Short Circuit Current	$I_{SC}$	$T_J = +25^{\circ}\text{C}$ , $V_I = 35\text{V}$	-	300	-	mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$	-	700	-	mA

### NOTE:

- $T_{MIN}$ :  
KA78MXX/R:  $T_{MIN} = -40^{\circ}\text{C}$   
KA78MXX/R:  $T_{MIN} = 0^{\circ}\text{C}$
- Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Fixed Voltage Regulator (Positive)

KA78M20/I/R/RI Electrical Characteristics

(Refer to the test circuits, TMIN ≤ TJ ≤ +125°C, IO = 350mA, VI = 29V, unless otherwise specified, CI = 0.33mF, CO = 0.1mF)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	VO	TJ = +25°C	19.2	20	20.8	V
		IO = 5 to 350mA VI = 23 to 35V	19	20	21	
Line Regulation	ΔVO	IO = 200mA TJ = +25°C	-	-	100	mV
		VI = 23 to 35V VI = 24 to 35V	-	-	50	
Load Regulation	ΔVO	IO = 5mA to 0.5A, TJ = +25°C	-	-	400	mV
		IO = 5mA to 200mA, TJ = +25°C	-	-	200	
Quiescent Current	IQ	TJ = +25°C	-	4.2	6	mA
Quiescent Current Change	ΔIQ	IO = 5mA to 350mA	-	-	0.5	mA
		IO = 200mA VI = 23 to 35V	-	-	0.8	
Output Voltage Drift	ΔV/ΔT	IO = 5mA TJ = 0 to +125°C	-	-1.1	-	mV/°C
Output Noise Voltage	VN	f = 10Hz to 100KHz	-	110	-	mV/VO
Ripple Rejection	RR	f = 120Hz, IO = 300mA VI = 24 to 34V	53	-	-	dB
Dropout Voltage	VD	TJ = +25°C, IO = 500mA	-	2	-	V
Short Circuit Current	ISC	TJ = +25°C, VI = 35V	-	300	-	mA
Peak Current	IPK	TJ = +25°C	-	700	-	mA

- NOTE:
- TMIN:  
KA78MXX/RI: TMIN = -40°C  
KA78MXX/R: TMIN = 0°C
  - Load and line regulation are specified at constant, junction temperature. Change in VO due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Fixed Voltage Regulator (Positive)

## KA78M24/I/R/RI Electrical Characteristics

(Refer to the test circuits,  $T_{MIN} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = 33\text{V}$ , unless otherwise specified,  $C_I = 0.33\text{mF}$ ,  $C_O = 0.1\text{mF}$ )

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	23	24	25	V
		$I_O = 5 \text{ to } 350\text{mA}$ $V_I = 27 \text{ to } 38\text{V}$	22.8	24	25.2	
Line Regulation	$\Delta V_O$	$I_O = 200\text{mA}$ $T_J = +25^{\circ}\text{C}$	-	-	100	mV
		$V_I = 28 \text{ to } 38\text{V}$	-	-	50	
Load Regulation	$\Delta V_O$	$I_O = 5\text{mA} \text{ to } 0.5\text{A}$ , $T_J = +25^{\circ}\text{C}$	-	-	480	mV
		$I_O = 5\text{mA} \text{ to } 200\text{mA}$ , $T_J = +25^{\circ}\text{C}$	-	-	240	
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$	-	4.2	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5\text{mA} \text{ to } 350\text{mA}$	-	-	0.5	mA
		$I_O = 200\text{mA}$ $V_I = 27 \text{ to } 38\text{V}$	-	-	0.8	
Output Voltage Drift	$\Delta V/\Delta T$	$I_O = 5\text{mA}$ $T_J = 0 \text{ to } +125^{\circ}\text{C}$	-	- 1.2	-	mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{kHz}$	-	170	-	mV/ $V_O$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $I_O = 300\text{mA}$ $V_I = 28 \text{ to } 38\text{V}$	50	-	-	dB
Dropout Voltage	$V_D$	$T_J = +25^{\circ}\text{C}$ , $I_O = 500\text{mA}$	-	2	-	V
Short Circuit Current	$I_{SC}$	$T_J = +25^{\circ}\text{C}$ , $V_I = 35\text{V}$	-	300	-	mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$	-	700	-	mA

### NOTE:

- $T_{MIN}$ :  
KA78MXX/RI:  $T_{MIN} = -40^{\circ}\text{C}$   
KA78MXX/R:  $T_{MIN} = 0^{\circ}\text{C}$
- Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Fixed Voltage Regulator (Positive)

Typical Applications

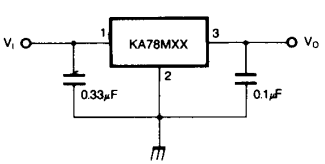


Figure 1. Fixed Output Regulator

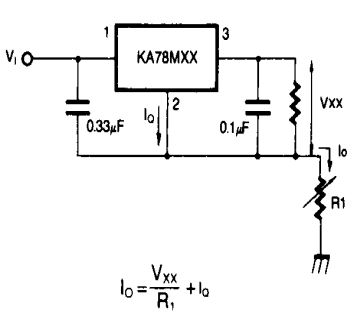


Figure 2. Constant Current Regulator

- Notes:
- 1. To specify an output voltage, substitute voltage value for "XX"
  - 2. Although no output capacitor is needed for stability, it does improve transient response.
  - 3. Required if regulator is located an appreciable distance from power Supply filter

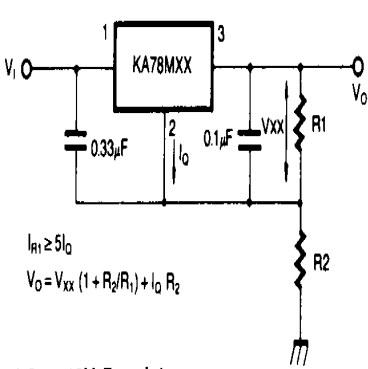
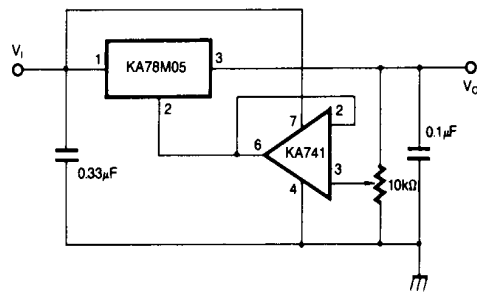
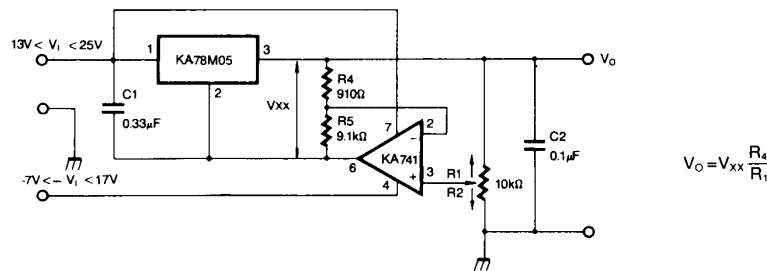


Figure 3. Circuit for Increasing Output Voltage





#### Figure 4. Adjustable Output Regulator (7 to 30V)



### Figure 5. 0.5 to 10V Regulator

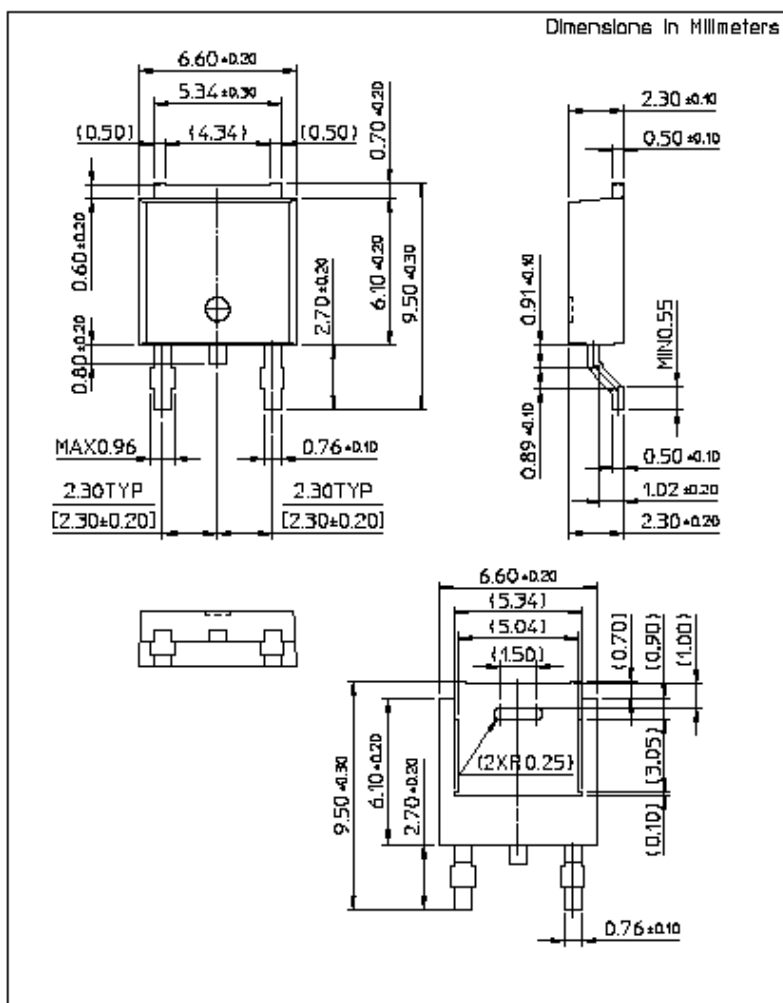
Ordering Information

Device	Package	Operating Temperature
MC78MXXCT (LM78XXCT) (KA78MXX)	TO-220	0 ~ + 125°C
KA78MXXI		-40 ~ +125°C
MC78MXXCDT (KA78MXXR)	D-PAK	0 ~ + 125°C
KA78MXXRI		-40 ~ + 125°C

Fixed Voltage Regulator (Positive)



**D-PAK**



## Fixed Voltage Regulator (Positive)

# Fixed Voltage Regulator (Positive)

## LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

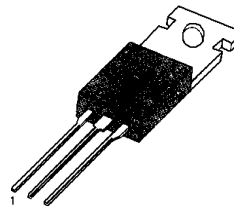
### 3-TERMINAL 0.5A POSITIVE VOLTAGE REGULATORS

The LM78MXXC/I series of three-terminal positive regulators are available in the TO-220 package with several fixed output voltages making it useful in a wide range of applications.

#### FEATURES

- Output Current up to 0.5A
- Output Voltages of 5; 6; 8; 10; 12; 15; 18; 20; 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor SOA Protection
- Industrial and commercial temperature range

TO-220

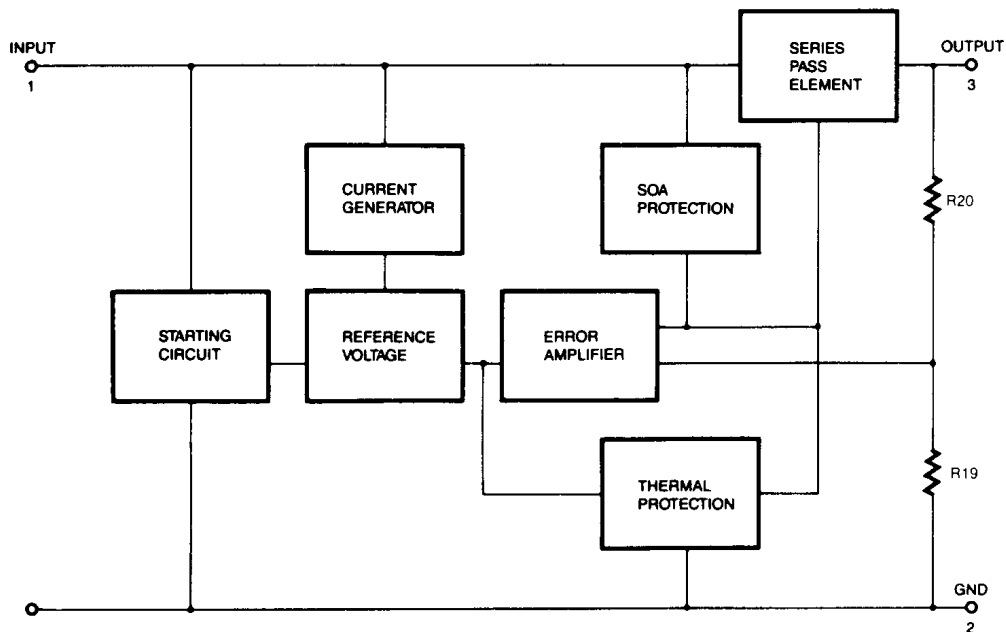


1:Input 2: GND 3: Output

#### ORDERING INFORMATION

Device	Package	Operating Temperature
LM78MXXT	TO-220	0 ~ + 125°C
LM78MXXIT	TO-220	- 40 ~ +125°C

#### BLOCK DIAGRAM



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Rev. B

**ABSOLUTE MAXIMUM RATINGS** ( $T_A=25^\circ\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Value	Unit
Input Voltage (for $V_O = 5V$ to $18V$ )	$V_I$	35	V
(for $V_O = 24V$ )	$V_I$	40	V
Thermal Resistance Junction-Cases	$R_{EJC}$	5	$^{\circ}C/W$
Thermal Resistance Junction-Air	$R_{EJA}$	65	$^{\circ}C/W$
Operating Temperature Range KA78XXI	$T_{OPR}$	-40~ + 125	$^{\circ}C$
KA78XX		0~ + 125	$^{\circ}C$
Storage Temperature Range	$T_{STG}$	-65~ + 150	$^{\circ}C$

**LM78M05/I ELECTRICAL CHARACTERISTICS**

(Refer to the test circuits,  $T_{MIN}$   $T_J$   $125^{\circ}C$ ,  $I_O=350mA$ ,  $V_I=10V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^{\circ}C$	4.8	5	5.2	V
		$I_O = 5$ to $350mA$ $V_I = 7$ to $20V$	4.75	5	5.25	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^{\circ}C$			100	mV
		$V_I = 7$ to $25V$ $V_I = 8$ to $25V$			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to $0.5A$ , $T_J = 25^{\circ}C$			100	mV
		$I_O = 5mA$ to $200mA$ , $T_J = 25^{\circ}C$			50	
Quiescent Current	$I_Q$	$T_J = 25^{\circ}C$		4.0	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $350mA$			0.5	mA
		$I_O = 200mA$ $V_I = 8$ to $25V$			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to $125^{\circ}C$		- 0.5		mV/ $^{\circ}C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$		40		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 8$ to $18V$	62			dB
Dropout Voltage	$V_D$	$T_J = 25^{\circ}C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^{\circ}C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^{\circ}C$		700		mA

\*  $T_{MIN}$   $T_J$   $T_{MAX}$

LM78MXXI:  $T_{MIN} = -40^{\circ}C$ ,  $T_{MAX} = +125^{\circ}C$

LM78MXX:  $T_{MIN} = 0^{\circ}C$ ,  $T_{MAX} = +125^{\circ}C$

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.



**LM78M06/I ELECTRICAL CHARACTERISTICS**(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=11V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	5.75	6	6.25	V
		$I_O = 5$ to $350mA$ $V_I = 8$ to $21V$	5.7	6	6.3	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 8$ to $25V$ $V_I = 9$ to $25V$			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to $0.5A$ , $T_J = 25^\circ C$			120	mV
		$I_O = 5mA$ to $200mA$ , $T_J = 25^\circ C$			60	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.0	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $350mA$			0.5	mA
		$I_O = 200mA$ $V_I = 9$ to $25V$			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to $125^\circ C$		- 0.5		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$		45		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 9$ to $19V$	59			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$ LM78MXXI:  $T_{MIN} = -40^\circ C$ LM78MXX:  $T_{MIN} = 0^\circ C$ \* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM78M08/I ELECTRICAL CHARACTERISTICS**(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=14V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	7.7	8	8.3	V
		$I_O = 5$ to $350mA$ $V_I = 10.5$ to $23V$	7.6	8	8.4	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 10.5$ to $25V$ $V_I = 11$ to $25V$			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to $0.5A$ , $T_J = 25^\circ C$			160	mV
		$I_O = 5mA$ to $200mA$ , $T_J = 25^\circ C$			80	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.0	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $350mA$			0.5	mA
		$I_O = 200mA$ $V_I = 10.5$ to $25V$			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to $125^\circ C$		- 0.5		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$		52		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 9$ to $19V$	56			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$ LM78MXXI:  $T_{MIN} = -40^\circ C$ LM78MXX:  $T_{MIN} = 0^\circ C$ \* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM78M10/I ELECTRICAL CHARACTERISTICS**(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=17V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	9.6	10	10.4	V
		$I_O = 5$ to $350mA$ $V_I = 12.5$ to $25V$	9.5	10	10.5	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 12.5$ to $25V$ $V_I = 13$ to $25V$			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to $0.5A$ , $T_J = 25^\circ C$			200	mV
		$I_O = 5mA$ to $200mA$ , $T_J = 25^\circ C$			100	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.1	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $350mA$			0.5	mA
		$I_O = 200mA$ $V_I = 12.5$ to $25V$			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to $125^\circ C$		- 0.5		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$		65		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 13$ to $23V$	55			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$ LM78MXXI:  $T_{MIN} = -40^\circ C$ LM78MXX:  $T_{MIN} = 0^\circ C$ \* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM78M12/I ELECTRICAL CHARACTERISTICS**

(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=19V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	11.5	12	12.5	V
		$I_O = 5$ to 350mA $V_I = 14.5$ to 27V	11.5	12	12.6	
Lines Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 14.5$ to 30V $V_I = 16$ to 30V			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to 0.5A, $T_J = 25^\circ C$			240	mV
		$I_O = 5mA$ to 200mA, $T_J = 25^\circ C$			120	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.1	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to 350mA			0.5	mA
		$I_O = 200mA$ $V_I = 14.5$ to 30V			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to 125°C		- 0.5		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to 100KHz		75		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 15$ to 25V	55			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$

LM78MXXI:  $T_{MIN} = -40^\circ C$

LM78MXX:  $T_{MIN} = 0^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM78M15/I ELECTRICAL CHARACTERISTICS**(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=23V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	14.4	15	15.6	V
		$I_O = 5$ to $350mA$ $V_I = 17.5$ to $30V$	14.25	15	15.75	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 17.5$ to $30V$ $V_I = 20$ to $30V$			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to $0.5A$ , $T_J = 25^\circ C$			300	mV
		$I_O = 5mA$ to $200mA$ , $T_J = 25^\circ C$			150	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.1	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $350mA$			0.5	mA
		$I_O = 200mA$ $V_I = 17.5$ to $30V$			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to $125^\circ C$		- 1		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$		100		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 18.5$ to $28.5V$	54			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$ LM78MXXI:  $T_{MIN} = -40^\circ C$ LM78MXX:  $T_{MIN} = 0^\circ C$ \* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM78M18/I ELECTRICAL CHARACTERISTICS**(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=26V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	17.3	18	18.7	V
		$I_O = 5$ to 350mA $V_I = 20.5$ to 33V	17.1	18	18.9	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 21$ to 33V $V_I = 24$ to 33V			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to 0.5A, $T_J = 25^\circ C$			360	mV
		$I_O = 5mA$ to 200mA, $T_J = 25^\circ C$			180	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.2	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to 350mA			0.5	mA
		$I_O = 200mA$ $V_I = 21$ to 33V			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to 125°C		- 1.1		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to 100KHz		100		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 22$ to 32V	53			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$ LM78MXXI:  $T_{MIN} = -40^\circ C$ LM78MXX:  $T_{MIN} = 0^\circ C$ \* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM78M20/I ELECTRICAL CHARACTERISTICS**

(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=29V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	19.2	20	20.8	V
		$I_O = 5$ to 350mA $V_I = 23$ to 35V	19	20	21	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 23$ to 35V $V_I = 24$ to 35V			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to 0.5A, $T_J = 25^\circ C$			400	mV
		$I_O = 5mA$ to 200mA, $T_J = 25^\circ C$			200	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.2	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to 350mA			0.5	mA
		$I_O = 200mA$ $V_I = 23$ to 35V			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to 125°C		- 1.1		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to 100KHz		110		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 24$ to 34V	53			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$

LM78MXXI:  $T_{MIN} = -40^\circ C$

LM78MXX:  $T_{MIN} = 0^\circ C$

\* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM78M24/I ELECTRICAL CHARACTERISTICS**(Refer to the test circuits,  $T_{MIN}$   $T_J$  125°C,  $I_O=350mA$ ,  $V_I=33V$ , unless otherwise specified,  $C_I = 0.33\mu F$ ,  $C_O=0.1\mu F$ )

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = 25^\circ C$	23	24	25	V
		$I_O = 5$ to $350mA$ $V_I = 27$ to $38V$	22.8	24	25.2	
Line Regulation	$\Delta V_O$	$I_O = 200mA$ $T_J = 25^\circ C$			100	mV
		$V_I = 27$ to $38V$ $V_I = 28$ to $38V$			50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to $0.5A$ , $T_J = 25^\circ C$			480	mV
		$I_O = 5mA$ to $200mA$ , $T_J = 25^\circ C$			240	
Quiescent Current	$I_Q$	$T_J = 25^\circ C$		4.2	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $350mA$			0.5	mA
		$I_O = 200mA$ $V_I = 27$ to $38V$			0.8	
Output Voltage Drift	$\frac{\Delta V_O}{\Delta T}$	$I_O = 5mA$ $T_J = 0$ to $125^\circ C$		- 1.2		mV/°C
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$		170		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = 300mA$ $V_I = 28$ to $38V$	50			dB
Dropout Voltage	$V_D$	$T_J = 25^\circ C$ , $I_O = 500mA$		2		V
Short Circuit Current	$I_{SC}$	$T_J = 25^\circ C$ , $V_I = 35V$		300		mA
Peak Current	$I_{PK}$	$T_J = 25^\circ C$		700		mA

\* $T_{MIN}$ LM78MXXI:  $T_{MIN} = -40^\circ C$ LM78MXX:  $T_{MIN} = 0^\circ C$ \* Load and line regulation are specified at constant, junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.



## APPLICATION CIRCUIT

Fig. 1 Fixed output regulator

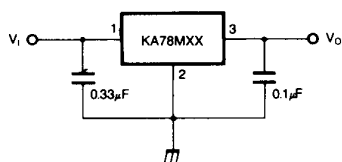
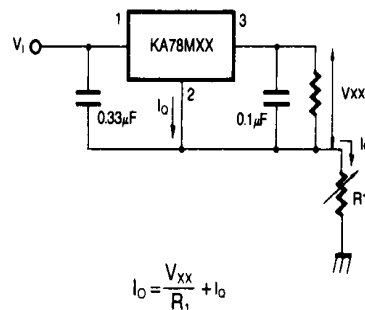


Fig. 2 Constant current regulator



## Notes:

- (1) To specify an output voltage, substitute voltage value for "XX".
- (2) Although no output capacitor is needed for stability, it does improve transient response.
- (3) Required if regulator is located an appreciable distance from power supply filter.

Fig. 3 Circuit for Increasing output voltage

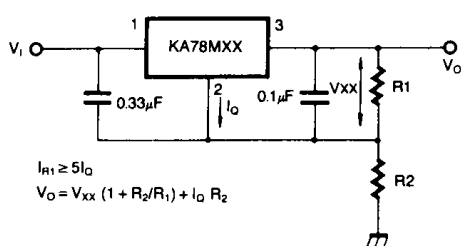


Fig. 4 Adjustable output regulator (7 to 30V)

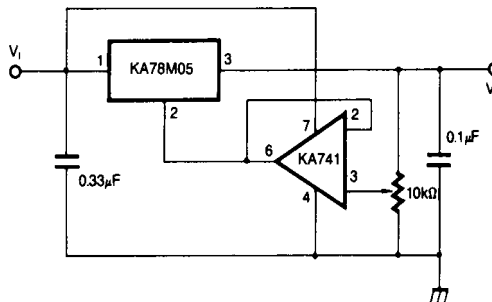
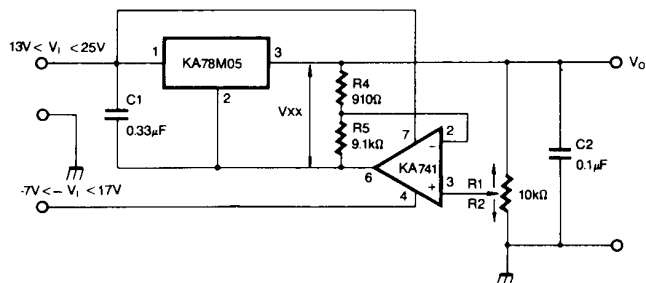


Fig. 5 0.5 to 10V Regulator



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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
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# LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

## ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub>=+25°C, unless otherwise specified)

Characteristic	Symbol	Value	Unit
Input Voltage	V <sub>I</sub>	-35	V
Thermal Resistance Junction-Cases	R <sub>θJC</sub>	5	°C / W
Junction-Air	R <sub>θJA</sub>	65	°C / W
Operating Temperature Range	T <sub>OPR</sub>	0 ~ +125	°C
Storage Temperature Range	T <sub>STG</sub>	- 65 ~ +150	°C

## LM7905 ELECTRICAL CHARACTERISTICS

(V<sub>I</sub> = 10V, I<sub>O</sub> = 500mA, 0°C ≤ T<sub>J</sub> ≤ +125°C, C<sub>I</sub> = 2.2μF, C<sub>O</sub> = 1μF, unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	V <sub>O</sub>	T <sub>J</sub> = +25°C	- 4.8	- 5.0	- 5.2	V
		I <sub>O</sub> = 5mA to 1A, P <sub>O</sub> 15W V <sub>I</sub> = -7 to -20V	- 4.75	- 5.0	- 5.25	
Line Regulation	ΔV <sub>O</sub>	T <sub>J</sub> = 25°C		5	50	mV
		V <sub>I</sub> = -7 to -20V I <sub>O</sub> = 1A		2	25	
		V <sub>I</sub> = -8 to -12V I <sub>O</sub> = 1A		7	50	
		V <sub>I</sub> = -7.5 to -25V		7	50	
Load Regulation	ΔV <sub>O</sub>	I <sub>O</sub> = 5mA to 1.5A		10	100	mV
		T <sub>J</sub> = +25°C I <sub>O</sub> = 250 to 750mA		3	50	
Quiescent Current	I <sub>Q</sub>	T <sub>J</sub> = +25°C		3	6	mA
Quiescent Current Change	ΔI <sub>Q</sub>	I <sub>O</sub> = 5mA to 1A		0.05	0.5	mA
		V <sub>I</sub> = -8 to -25V		0.1	0.8	
Temperature Coefficient of V <sub>O</sub>	ΔV <sub>O</sub> /ΔT	I <sub>O</sub> = 5mA		- 0.4		mV/°C
Output Noise Voltage	V <sub>N</sub>	f = 10Hz to 100KHz T <sub>A</sub> = +25°C		40		μV
Ripple Rejection	RR	f = 120Hz, I <sub>O</sub> = -35V ΔV <sub>I</sub> = 10V	54	60		dB
Dropout Voltage	V <sub>D</sub>	T <sub>J</sub> = +25°C I <sub>O</sub> = 1A		2		V
Short Circuit Current	I <sub>SC</sub>	T <sub>J</sub> = +25°C, V <sub>I</sub> = -35V		300		mA
Peak Current	I <sub>PK</sub>	T <sub>J</sub> = +25°C		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in V<sub>O</sub> due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7906 ELECTRICAL CHARACTERISTICS

( $V_I = 11V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	- 5.75	- 6	- 6.25	V
		$I_O = 5mA$ to 1A, $P_O = 15W$ $V_I = -9$ to - 21V	- 5.7	- 6	- 6.3	
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		10	120	mV
		$V_I = -8$ to - 25V $V_I = -9$ to -12V		5	60	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $I_O = 5mA$ to 1.5A		10	120	mV
		$T_J = +25^\circ C$ $I_O = 250$ to 750mA		3	60	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to 1A			0.5	mA
		$V_I = -9$ to -25V			1.3	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.5		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to 100KHz $T_A = +25^\circ C$		130		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7908 ELECTRICAL CHARACTERISTICS

( $V_I = 14V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	- 7.7	- 8	- 8.3	V
		$I_O = 5mA$ to 1A, $P_O = 15W$ $V_I = -1.5$ to -23V	- 7.6	- 8	- 8.4	
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		10	100	mV
		$V_I = -10.5$ to -25V $V_I = -11$ to -17V		5	80	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $I_O = 5mA$ to 1.5A		12	160	mV
		$T_J = +25^\circ C$ $I_O = 250$ to 750mA		4	80	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to 1A		0.05	0.5	mA
		$V_I = -11.5$ to -25V		0.1	1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.6		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to 100KHz $T_A = +25^\circ C$		175		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7909 ELECTRICAL CHARACTERISTICS

( $V_I = 14V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	- 8.7	- 9.0	- 9.3	V
		$I_O = 5mA$ to $1A$ , $P_O = 15W$ $V_I = -1.5$ to $-23V$	- 8.6	- 9.0	- 9.4	
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		10	180	mV
		$V_I = -10.5$ to $-25V$ $V_I = -11$ to $-17V$		5	90	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $I_O = 5mA$ to $1.5A$		12	180	mV
		$T_J = +25^\circ C$ $I_O = 250$ to $750mA$		4	90	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$		0.05	0.5	mA
		$V_I = -11.5$ to $-25V$		0.1	1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.6		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ $T_A = +25^\circ C$		175		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7912 ELECTRICAL CHARACTERISTICS

( $V_I = 18V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	-11.5	-12	-12.5	V
		$I_O = 5mA$ to $1A$ , $P_O = 15W$ $V_I = -15.5$ to $-27V$	-11.4	-12	-12.6	
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		12	240	mV
		$V_I = -14.5$ to $-30V$ $V_I = -16$ to $-22V$		6	120	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $I_O = 5mA$ to $1.5A$		12	240	mV
		$T_J = +25^\circ C$ $I_O = 250$ to $750mA$		4	120	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$		0.05	0.5	mA
		$V_I = -15$ to $-30V$		0.1	1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.8		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ $T_A = +25^\circ C$		200		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.



## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7915 ELECTRICAL CHARACTERISTICS

( $V_I = 23V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	-14.4	-15	-15.6	V
		$I_O = 5mA$ to $1A$ , $P_O = 15W$	-14.25	-15	-15.75	
		$V_I = -18$ to $-30V$				
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		12	300	mV
		$V_I = -17.5$ to $-30V$		6	150	
		$V_I = -20$ to $-26V$				
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$		12	300	mV
		$I_O = 5mA$ to $1.5A$				
		$T_J = +25^\circ C$ $I_O = 250$ to $750mA$		4	150	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$		0.05	0.5	mA
		$V_I = -18.5$ to $-30V$		0.1	1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.9		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ $T_A = +25^\circ C$		250		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7918 ELECTRICAL CHARACTERISTICS

( $V_I = 27V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	-17.3	-18	-18.7	V
		$I_O = 5mA$ to $1A$ , $P_O = 15W$ $V_I = -22.5$ to $-33V$	-17.1	-18	-18.9	
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		15	360	mV
		$V_I = -21$ to $-33V$ $V_I = -24$ to $-30V$		8	180	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $I_O = 5mA$ to $1.5A$		15	360	mV
		$T_J = +25^\circ C$ $I_O = 250$ to $750mA$		5	180	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$			0.5	mA
		$V_I = -22$ to $-33V$			1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-1		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ $T_A = +25^\circ C$		300		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7924 ELECTRICAL CHARACTERISTICS

( $V_I = 33V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	- 23	- 24	- 25	V
		$I_O = 5mA$ to $1A$ , $P_O \leq 15W$ $V_I = -27$ to $-38V$	- 22.8	- 24	- 25.2	
Line Regulation	$\Delta V_O$	$T_J = 25^\circ C$		15	480	mV
		$V_I = -27$ to $-38V$ $V_I = -30$ to $-36V$		8	180	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $I_O = 5mA$ to $1.5A$		15	480	mV
		$T_J = +25^\circ C$ $I_O = 250$ to $750mA$		5	240	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$			0.5	mA
		$V_I = -27$ to $-38V$			1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-1		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ $T_A = +25^\circ C$		400		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

### LM7905A ELECTRICAL CHARACTERISTICS

( $V_I = 10V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	- 4.9	- 5.0	- 5.1	V
		$I_O = 5mA$ to 1A, $P_O = 15W$ $V_I = -7$ to -20V	- 4.8	-5.0	- 5.2	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $V_I = -7$ to -20V $I_O = 1A$		5	50	mV
		$V_I = -8$ to -12V $I_O = 1A$		2	25	
		$V_I = -7.5$ to -25V		7	50	
		$V_I = -8$ to -12V $I_O = 1A$		7	50	
Load Regulation	$\Delta V_O$	$I_O = 5mA$ to 1.5A		10	100	mV
		$T_J = +25^\circ C$ $I_O = 250$ to 750mA		3	50	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to 1A		0.05	0.5	mA
		$V_I = -8$ to -25V		0.1	0.8	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		- 0.4		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to 100KHz $T_A = +25^\circ C$		40		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ , $I_O = -35V$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

( $V_I = 18V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	-11.75	-12	-12.25	V
		$I_O = 5mA$ to $1A$ , $P_O = 15W$ $V_I = -15.5$ to $-27V$	-11.5	-12	-12.5	
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$		12	240	mV
		$V_I = -14.5$ to $-30V$ $V_I = -16$ to $-22V$		6	120	
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$ $I_O = 5mA$ to $1.5A$		12	240	mV
		$T_J = +25^\circ C$ $I_O = 250$ to $750mA$		4	120	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$		0.05	0.5	mA
		$V_I = -15$ to $-30V$		0.1	1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.8		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ $T_A = +25^\circ C$		200		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

( $V_I = 23V$ ,  $I_O = 500mA$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ ,  $C_I = 2.2\mu F$ ,  $C_O = 1\mu F$ , unless otherwise specified.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^\circ C$	-14.7	-15	-15.3	V
		$I_O = 5mA$ to $1A$ , $P_O = 15W$	-14.4	-15	-15.6	
		$V_I = -18$ to $-30V$				
Line Regulation	$\Delta V_O$	$T_J = +25^\circ C$		12	300	mV
		$V_I = -17.5$ to $-30V$		6	150	
		$V_I = -20$ to $-26V$				
Load Regulation	$\Delta V_O$	$T_J = +25^\circ C$		12	300	mV
		$I_O = 5mA$ to $1.5A$				
		$T_J = +25^\circ C$ $I_O = 250$ to $750mA$		4	150	
Quiescent Current	$I_Q$	$T_J = +25^\circ C$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5mA$ to $1A$		0.05	0.5	mA
		$V_I = -18.5$ to $-30V$		0.1	1	
Temperature Coefficient of $V_O$	$\Delta V_O / \Delta T$	$I_O = 5mA$		-0.9		mV/ $^\circ C$
Output Noise Voltage	$V_N$	$f = 10Hz$ to $100KHz$ $T_A = +25^\circ C$		250		$\mu V$
Ripple Rejection	RR	$f = 120Hz$ $\Delta V_I = 10V$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25^\circ C$ $I_O = 1A$		2		V
Short Circuit Current	$I_{SC}$	$T_J = +25^\circ C$ , $V_I = -35V$		300		mA
Peak Current	$I_{PK}$	$T_J = +25^\circ C$		2.2		A

\* Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

Fig.1 Output Voltage

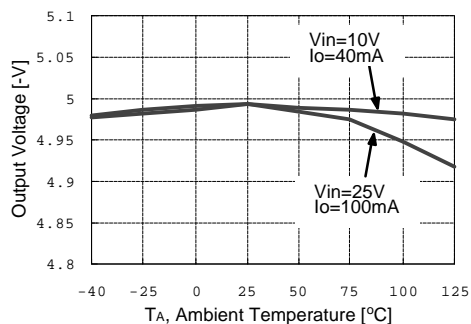


Fig. 2 Load Regulation

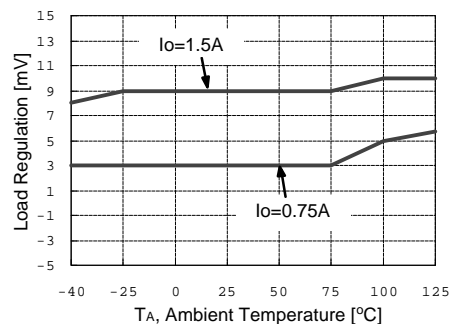


Fig.3 Quiescent Current

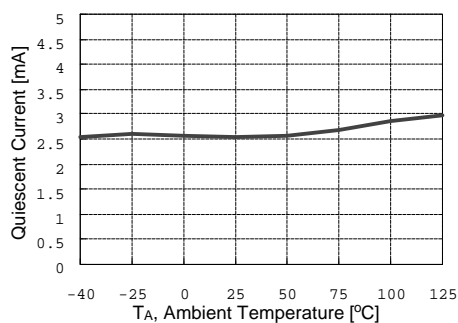


Fig. 4 Dropout Voltage

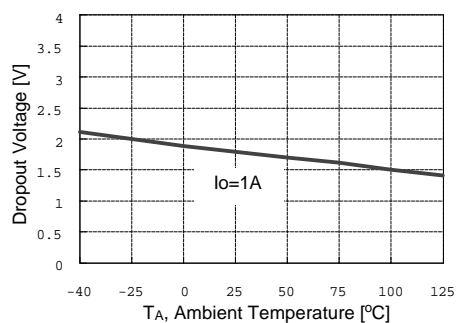
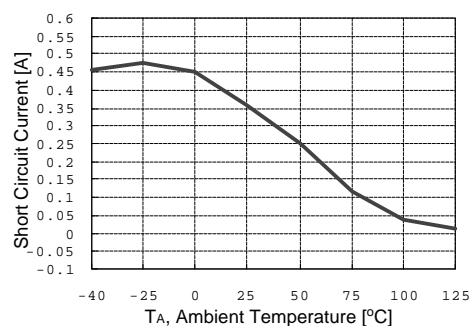


Fig.5 Short Circuit Current

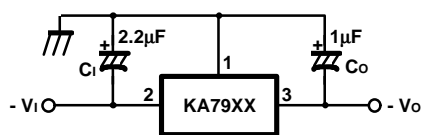


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TYPICAL APPLICATIONS

## LM79XX/A (KA79XX, MC79XX) FIXED VOLTAGE REGULATOR (NEGATIVE)

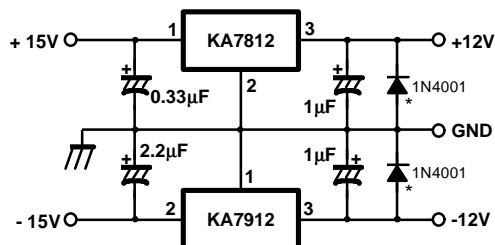
Fig. 6 Negative Fixed output regulator



**Notes:**

- (1) To specify an output voltage, substitute voltage value for "XX".
- (2) Required for stability. For value given, capacitor must be solid tantalum. If aluminum electrolytics are used, at least ten times value shown should be selected.  $C_i$  is required if regulator is located an appreciable distance from power supply filter.
- (3) To improve transient response. If large capacitors are used, a high current diode from input to output (1N4001 or similar) should be introduced to protect the device from momentary input short circuit.

Fig. 7 Split power supply ( $\pm 12V/1A$ )



\*: Against potential latch-up problems.



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PowerTrench™  
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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

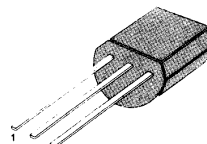
**3-TERMINAL 0.1A NEGATIVE VOLTAGE REGULATORS**

These regulators employ internal current limiting and thermal shutdown, making them essentially indestructible.

**FEATURES**

- Output current up to 100mA
- No external components
- Internal thermal over load protection
- Internal short circuit current limiting
- Output Voltage Offered in  $\pm 5\%$  Tolerance
- Output Voltage of -5V, -12V, -15V, -18V and -24V

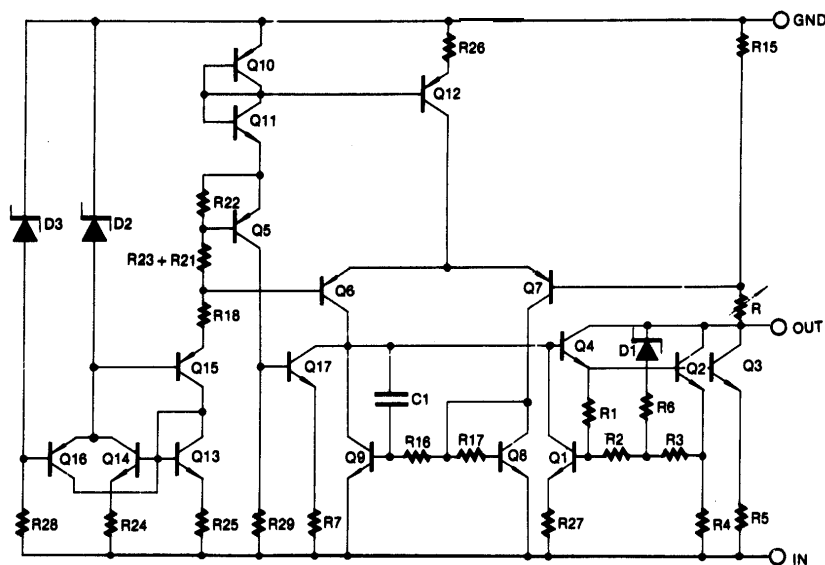
TO-92



1: GND 2: Input 3: Output

**ORDERING INFORMATION**

Device	Package	Operating Temperature
MC79LXXACP (LM79LXXACZ) KA79LXXAZ	TO - 92	0 ~ + 125°C

**SCHEMATIC DIAGRAM**

## MC79LXXA (LM79LXXA) (KA79LXXA)      FIXED VOLTAGE REGULATOR (NEGATIVE)

### ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub> = +25°C, unless otherwise specified)

Characteristic	Symbol	Value	Unit
Input Voltage (-5V) (-12V to -18V) (-24V)	V <sub>I</sub>	-30 -35 -40	V <sub>DC</sub>
Operating Temperature Range	T <sub>OPR</sub>	0 ~ +125	°C
Storage Temperature Range	T <sub>STG</sub>	-65 ~ +150	°C

### MC79L05A ELECTRICAL CHARACTERISTICS

(V<sub>I</sub> = -10V, I<sub>O</sub> = 40mA, C<sub>I</sub> = 0.33μF, C<sub>O</sub> = 0.1μF, 0°C ≤ T<sub>J</sub> ≤ +125°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	V <sub>O</sub>	T <sub>J</sub> = +25°C	- 4.8	- 5.0	- 5.2	V
Line Regulation	ΔV <sub>O</sub>	T <sub>J</sub> = +25°C -7.0V ≥ V <sub>I</sub> ≥ -20V -8V ≥ V <sub>I</sub> ≥ -20V		15 150	100	mV
Load Regulation	ΔV <sub>O</sub>	T <sub>J</sub> = +25°C 1.0mA ≤ I <sub>O</sub> ≤ 100mA 1.0mA ≤ I <sub>O</sub> ≤ 40mA		20 10	60 30	mV
Output Voltage	V <sub>O</sub>	-7.0V > V <sub>I</sub> > -20V, 1.0mA ≤ I <sub>O</sub> ≤ 40mA V <sub>I</sub> = -10V, 1.0mA ≤ I <sub>O</sub> ≤ 70mA	- 4.75 - 4.75		- 5.25 - 5.25	V
Quiescent Current	I <sub>Q</sub>	T <sub>J</sub> = +25°C T <sub>J</sub> = +125°C		2.0	6.0 5.5	mA
Quiescent Current Change	ΔI <sub>Q</sub>	With Line With Load -8V ≥ V <sub>I</sub> ≥ -20V 1.0mA ≤ I <sub>O</sub> ≤ 40mA			1.5 0.1	mA
Output Noise Voltage	V <sub>N</sub>	T <sub>A</sub> = +25°C, 10Hz ≤ f ≤ 100KHz		30		μV
Ripple Rejection	RR	f = 120Hz, -8V ≥ V <sub>I</sub> ≥ -18V T <sub>J</sub> = +25°C	41	60		dB
Dropout Voltage	V <sub>D</sub>	T <sub>J</sub> = +25°C		1.7		V

\* Load and line regulation are specified at constant junction temperature. Change in V<sub>O</sub> due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**MC79L12A ELECTRICAL CHARACTERISTICS**(V<sub>I</sub> = -19V, I<sub>O</sub> = 40mA, C<sub>I</sub> = 0.33μF, C<sub>O</sub> = 0.1μF, 0°C ≤ T<sub>J</sub> ≤ +125°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	V <sub>O</sub>	T <sub>J</sub> = +25°C	-11.5	-12.0	-12.5	V
Line Regulation	ΔV <sub>O</sub>	T <sub>J</sub> = +25°C	-14.5V ≥ V <sub>I</sub> ≥ -27V		250	mV
			-16V ≥ V <sub>I</sub> ≥ -27V		200	
Load Regulation	ΔV <sub>O</sub>	T <sub>J</sub> = +25°C	1.0mA ≤ I <sub>O</sub> ≤ 100mA		100	mV
			1.0mA ≤ I <sub>O</sub> ≤ 40mA		50	
Output Voltage	V <sub>O</sub>	-14.5V > V <sub>I</sub> > -27V, 1.0mA ≤ I <sub>O</sub> ≤ 40mA	-11.4		-12.6	V
		V <sub>I</sub> = -19V, 1.0mA ≤ I <sub>O</sub> ≤ 70mA	-11.4		-12.6	
Quiescent Current	I <sub>Q</sub>	T <sub>J</sub> = +25°C			6.5	mA
		T <sub>J</sub> = +125°C			6.0	
Quiescent Current Change	With Line	ΔI <sub>Q</sub>	-16V ≥ V <sub>I</sub> ≥ -27V		1.5	mA
	With Load				0.1	
Output Noise Voltage	V <sub>N</sub>	T <sub>A</sub> = +25°C, 10Hz f 100KHz		80		μV
Ripple Rejection	RR	f = 120Hz, -150V ≥ V <sub>I</sub> ≥ -25V T <sub>J</sub> = +25°C	37	42		dB
Dropout Voltage	V <sub>D</sub>	T <sub>J</sub> = +25°C		1.7		V

\* Load and line regulation are specified at constant junction temperature. Change in V<sub>O</sub> due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**MC79L15A ELECTRICAL CHARACTERISTICS**(V<sub>I</sub> = -23V, I<sub>O</sub> = 40mA, C<sub>I</sub> = 0.33μF, C<sub>O</sub> = 0.1μF, 0°C ≤ T<sub>J</sub> ≤ +125°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	V <sub>O</sub>	T <sub>J</sub> = +25°C	-14.4	-15.0	-15.6	V
Line Regulation	ΔV <sub>O</sub>	T <sub>J</sub> = +25°C	-17.5V ≥ V <sub>I</sub> ≥ -30V		300	mV
			-27V ≥ V <sub>I</sub> ≥ -30V		250	
Load Regulation	ΔV <sub>O</sub>	T <sub>J</sub> = +25°C	1.0mA ≤ I <sub>O</sub> ≤ 100mA		150	mV
			1.0mA ≤ I <sub>O</sub> ≤ 40mA		75	
Output Voltage	V <sub>O</sub>	-17.5V > V <sub>I</sub> > -30V, 1.0mA ≤ I <sub>O</sub> ≤ 40mA	-14.25		-15.75	V
		V <sub>I</sub> = -23V, 1.0mA ≤ I <sub>O</sub> ≤ 70mA	-14.25		-15.75	
Quiescent Current	I <sub>Q</sub>	T <sub>J</sub> = +25°C			6.5	mA
		T <sub>J</sub> = +125°C			6.0	
Quiescent Current Change	With Line	ΔI <sub>Q</sub>	-20V ≥ V <sub>I</sub> ≥ -30V		1.5	mA
	With Load				0.1	
Output Noise Voltage	V <sub>N</sub>	T <sub>A</sub> = 25°C, 10Hz ≤ f ≤ 100KHz		90		μV
Ripple Rejection	RR	f = 120Hz, -18.5V ≥ V <sub>I</sub> ≥ -28.5V T <sub>J</sub> = +25°C	34	39		dB
Dropout Voltage	V <sub>D</sub>	T <sub>J</sub> = +25°C		1.7		V

\* Load and line regulation are specified at constant junction temperature. Change in V<sub>O</sub> due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## MC79LXXA (LM79LXXA) (KA79LXXA) FIXED VOLTAGE REGULATOR (NEGATIVE)

### MC79L18A ELECTRICAL CHARACTERISTICS

( $V_I = -27V$ ,  $I_O = 40mA$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ , unless otherwise specified)

Characteristic		Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage		$V_O$	$T_J = +25^\circ C$	-17.3	-18.0	-18.7	V
Line Regulation		$\Delta V_O$	$T_J = +25^\circ C$	-20.7V $\geq V_I \geq -33V$		325	mV
				-21V $\geq V_I \geq -33V$		275	
Load Regulation		$\Delta V_O$	$T_J = +25^\circ C$	$1.0mA \leq I_O \leq 100mA$		170	mV
				$1.0mA \leq I_O \leq 40mA$		85	
Output Voltage		$V_O$	$-20.7V > V_I > -33V$ , $1.0mA \leq I_O \leq 40mA$		-17.1	-18.9	V
			$V_I = -1.0V$ , $1.0mA \leq I_O \leq 70mA$		-17.1	-18.9	
Quiescent Current		$I_Q$	$T_J = +25^\circ C$			6.5	mA
			$T_J = +125^\circ C$			6.0	
Quiescent Current Change	With Line	$\Delta I_Q$	$-21V \geq V_I \geq -33V$			1.5	mA
	With Load		$1.0mA \leq I_O \leq 40mA$			0.1	
Output Noise Voltage		$V_N$	$T_A = +25^\circ C$ , $10Hz \leq f \leq 100KHz$		150		$\mu V$
Ripple Rejection		RR	$f = 120Hz$ , $-23V \geq V_I \geq -33V$ $T_J = +25^\circ C$		33	48	dB
Dropout Voltage		$V_D$	$T_J = +25^\circ C$		1.7		V

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

### MC79L24A ELECTRICAL CHARACTERISTICS

( $V_I = -33V$ ,  $I_O = 40mA$ ,  $C_I = 0.33\mu F$ ,  $C_O = 0.1\mu F$ ,  $0^\circ C \leq T_J \leq +125^\circ C$ , unless otherwise specified)

Characteristic		Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage		$V_O$	$T_J = +25^\circ C$	-23	-24	-25	V
Line Regulation		$\Delta V_O$	$T_J = +25^\circ C$	-27V $\geq V_I \geq -38V$		350	mV
				-28V $\geq V_I \geq -38V$		300	
Load Regulation		$\Delta V_O$	$T_J = +25^\circ C$	$1.0mA \leq I_O \leq 100mA$		200	mV
				$1.0mA \leq I_O \leq 40mA$		100	
Output Voltage		$V_O$	$-27V > V_I > -38V$ , $1.0mA \leq I_O \leq 40mA$		-22.8	-25.2	V
			$V_I = -33V$ , $1.0mA \leq I_O \leq 70mA$		-22.8	-25.2	
Quiescent Current		$I_Q$	$T_J = +25^\circ C$			6.5	mA
			$T_J = +125^\circ C$			6.0	
Quiescent Current Change	With Line	$\Delta I_Q$	$-28V \geq V_I \geq -38V$			1.5	mA
	With Load		$1.0mA \leq I_O \leq 40mA$			0.1	
Output Noise Voltage		$V_N$	$T_A = +25^\circ C$ , $10Hz \leq f \leq 100KHz$		200		$\mu V$
Ripple Rejection		RR	$f = 120Hz$ , $-29V \geq V_I \geq -35V$ $T_J = +25^\circ C$		31	47	dB
Dropout Voltage		$V_D$	$T_J = +25^\circ C$		1.7		V

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## TYPICAL APPLICATIONS

## Design Considerations

The MC79LXXA Series of fixed voltage regulators are designed with Thermal Overload Protection that shuts down the circuit when subjected to an excessive power overload condition. Internal Short-Circuit Protection that limits the maximum current the circuit will pass.

In many low current applications, compensation capacitors are not required. However, it is recommended that the regulator input be bypassed with a capacitor if the regulator is connected to the power supply filter with long wire lengths, or if the output load capacitance is large. An input bypass

capacitor should be selected to provide good high - frequency characteristics to insure stable operation under all load conditions. A  $0.33\mu\text{F}$  or larger tantalum, mylar, or other capacitor having low internal impedance at high frequencies should be chosen. The bypass capacitor should be mounted with the shortest possible leads directly across the regulator's input terminals. Normally good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead. Bypassing the output is also recommended.

Fig. 1 Positive And Negative Regulator

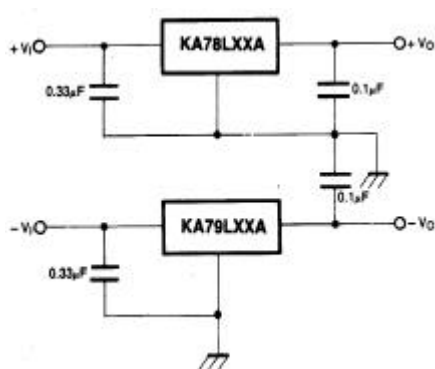
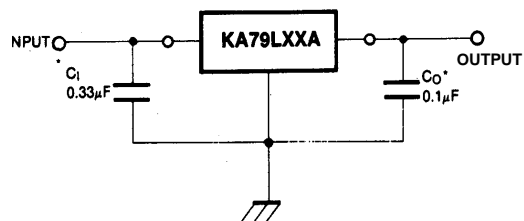


Fig. 2 Typical Application

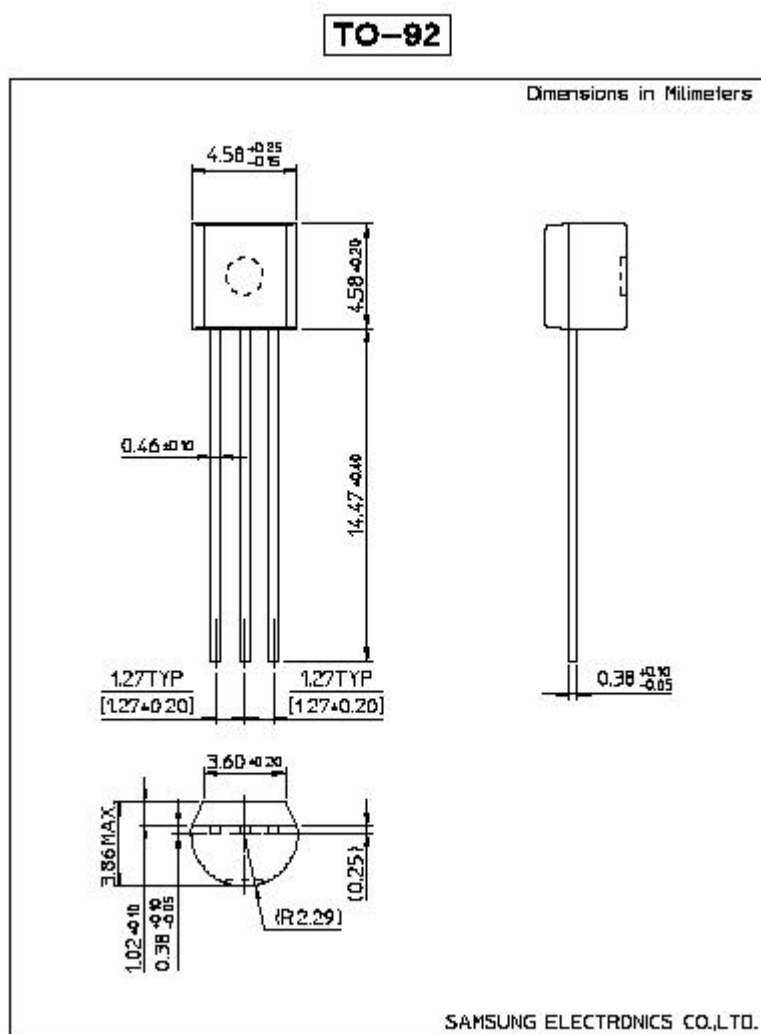


A common ground is required between the Input and the output voltages. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.

=  $C_1$  is required if regulator is located an appreciable distance from power supply filter.

\*\* =  $C_0$  improves stability and transient response.

## PACKAGE DIMENSION



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CROSSVOLT <sup>TM</sup>	POP <sup>TM</sup>	VCX <sup>TM</sup>
E <sup>2</sup> C <sub>MOS</sub> <sup>TM</sup>	PowerTrench <sup>®</sup>	
FACT <sup>TM</sup>	QFET <sup>TM</sup>	
FACT Quiet Series <sup>TM</sup>	QS <sup>TM</sup>	
FAST <sup>®</sup>	Quiet Series <sup>TM</sup>	
FAST <sub>r</sub> <sup>TM</sup>	SuperSOT <sup>TM</sup> -3	
GTO <sup>TM</sup>	SuperSOT <sup>TM</sup> -6	
HiSeC <sup>TM</sup>	SuperSOT <sup>TM</sup> -8	

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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

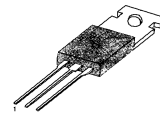
Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.



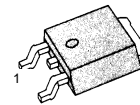
## 3-TERMINAL 0.5A NEGATIVE VOLTAGE REGULATORS

The LM79MXX series of 3-Terminal medium current negative voltage regulators are monolithic integrated circuits designed as fixed voltage regulators. These regulators employ internal current limiting, thermal shutdown and safe-area compensation making them essentially indestructible.

TO-220



D-PAK



1: GND 2: Input 3: Output

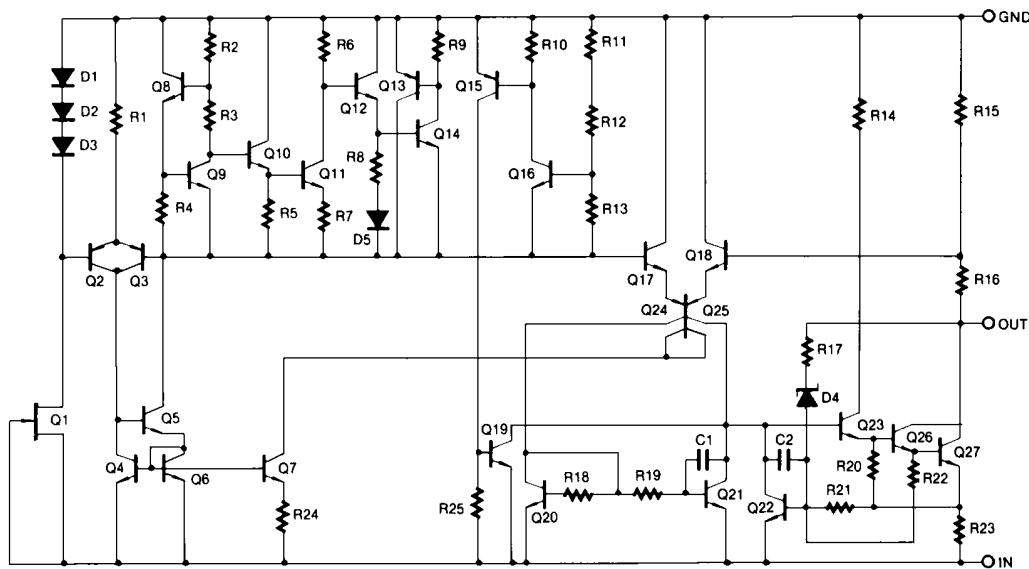
## FEATURES

- No external components required
- Output current in excess of 0.5A
- Internal thermal-overload
- Internal short circuit current limiting
- Output transistor safe-area compensation
- Output Voltages of -5V, -6V, -8V, -12V, -15V, -18V and -24V

## ORDERING INFORMATION

Device	Package	Operating Temperature
LM79MXX	TO-220	0 ~ +125 °C
LM79MXXR	D-PAK	0 ~ +125 °C

## SCHEMATIC DIAGRAM



**ABSOLUTE MAXIMUM RATINGS** ( $T_A = +25\text{ }^{\circ}\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Value	Unit
Input Voltage(for $V_O = -5\text{V}$ to $-18\text{V}$ ) (for $V_O = -24\text{V}$ )	$V_I$	-35	V
	$V_I$	-40	V
Thermal Resistance Junction-Cases	$R_{\theta JC}$	5	$^{\circ}\text{C}/\text{W}$
Thermal Resistance Junction-Air	$R_{\theta JA}$	65	$^{\circ}\text{C}/\text{W}$
Operating Temperature Range	$T_{OPR}$	0 ~ +125	$^{\circ}\text{C}$
Storage Temperature Range	$T_{STG}$	65 ~ +125	$^{\circ}\text{C}$

**LM79MO5/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0\text{ }^{\circ}\text{C} \leq T_J \leq +125\text{ }^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = 10\text{V}$ , unless otherwise specified,  $C_I = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ )

Characteristic	Symbol	Test condition	MIN	TYP	MAX	Unit
Output Voltage	$V_O$	$T_J = +25\text{ }^{\circ}\text{C}$	-4.8	-5	-5.2	V
		$I_O = 5$ to $350\text{mA}$	-4.75	-5	-5.25	
		$V_I = -7$ to $-25\text{V}$				
Line Regulation	$\Delta V_O$	$T_J = +25\text{ }^{\circ}\text{C}$		7.0	50	mV
		$V_I = -7$ to $-25\text{V}$ $V_I = -8$ to $-25\text{V}$		2.0	30	
Load Regulation	$\Delta V_O$	$I_O = 5\text{mA}$ to $500\text{mA}$ $T_J = 25\text{ }^{\circ}\text{C}$		30	100	mV
Quiescent Current	$I_Q$	$T_J = 25\text{ }^{\circ}\text{C}$		3.0	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
		$I_O = 200\text{mA}$			0.4	
		$V_I = -8\text{V}$ to $-25\text{V}$				
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-0.2		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ , $100\text{KHz}$ $T_J = +25\text{ }^{\circ}\text{C}$		40		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ $V_I = -8$ to $-18\text{V}$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25\text{ }^{\circ}\text{C}$ , $I_O = 500\text{mA}$		1.1		V
Short Circuit Current	$I_{SC}$	$T_J = +25\text{ }^{\circ}\text{C}$ , $V_I = -35\text{V}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25\text{ }^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M06/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -11\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 5.75	- 6.0	- 6.25	V
		$I_O = 5 \text{ to } 350\text{mA}$				
		$V_I = -8.0 \text{ to } -25\text{V}$	- 5.7	- 6.0	- 6.3	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		7.0	60	mV
		$V_I = -8 \text{ to } -25\text{V}$		2.0	40	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$ $I_O = 5.0\text{mA} \text{ to } 500\text{mA}$		30	120	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5 \text{ to } 350\text{mA}$			0.4	mA
		$V_I = -8\text{V} \text{ to } -25\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		0.4		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{KHz}, T_A = +25^{\circ}\text{C}$		50		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}, V_I = -9 \text{ to } -19\text{V}$	54	60		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}, T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}, T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M08/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -14\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 7.7	- 8.0	- 8.3	V
		$I_O = 5 \text{ to } 350\text{mA}$				
		$V_I = -10.5 \text{ to } -25\text{V}$	- 7.6	- 8.0	- 8.4	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		7.0	80	mV
		$V_I = -10.5 \text{ to } -25\text{V}$ $V_I = -11 \text{ to } -21\text{V}$		2.0	50	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$ $I_O = 5.0\text{mA} \text{ to } 500\text{mA}$		30	160	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5 \text{ to } 350\text{mA}$			0.4	mA
		$V_I = -8\text{V} \text{ to } -25\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O / \Delta T$	$I_O = 5\text{mA}$		-0.6		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{KHz}, T_A = +25^{\circ}\text{C}$		60		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}, V_I = -9 \text{ to } -19\text{V}$	54	59		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}, T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}, T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M12/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -19\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	-11.5	-12	-12.5	V
		$I_O = 5$ to $350\text{mA}$ $V_I = -14.5$ to $-30\text{V}$	-11.4	-1.2	-12.6	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		8.0	80	mV
		$V_I = -14.5$ to $-30\text{V}$ $V_I = -15$ to $-25\text{V}$		3.0	50	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		30	240	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
		$V_I = -14.5\text{V}$ to $-30\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-0.8		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ , $T_A = +25^{\circ}\text{C}$		75		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $V_I = -15$ to $-25\text{V}$	54	60		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}$ , $T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}$ , $T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M15/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -23\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	-14.4	-15	-15.6	V
		$I_O = 5$ to $350\text{mA}$ $V_I = -17.5$ to $-30\text{V}$	-14.25	-15	-15.75	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		9.0	80	mV
		$V_I = -17.5$ to $-30\text{V}$ $V_I = -18$ to $-28\text{V}$		5.0	50	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		30	240	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
		$V_I = -17.5\text{V}$ to $-28\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ , $T_A = +25^{\circ}\text{C}$		90		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $V_I = -18.5$ to $-28.5\text{V}$	54	59		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}$ , $T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}$ , $T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M18/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -27\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 17.3	- 18	- 18.7	V
		$I_O = 5$ to $350\text{mA}$ $V_I = -21$ to $-33\text{V}$	- 17.1	- 18	- 18.9	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		9.0	80	mV
		$V_I = -21$ to $-33\text{V}$ $V_I = -24$ to $-30\text{V}$		5.0	80	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$ $I_O = 5.0\text{mA}$ to $500\text{mA}$		30	360	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
		$V_I = -21\text{V}$ to $-33\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ , $T_A = +25^{\circ}\text{C}$		110		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $V_I = -22$ to $-32\text{V}$	54	59		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}$ , $T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}$ , $T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M24/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -33\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 23	- 24	- 25	V
		$I_O = 5$ to $350\text{mA}$ $V_I = -27$ to $-38\text{V}$	- 22.8	- 24	- 25.2	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		9.0	80	mV
		$V_I = -27$ to $-38\text{V}$ $V_I = -30$ to $-36\text{V}$		5.0	70	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$ $I_O = 5.0\text{mA}$ to $500\text{mA}$		30	300	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
		$V_I = -27\text{V}$ to $-38\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ , $T_A = +25^{\circ}\text{C}$		180		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $V_I = -28$ to $-38\text{V}$	54	58		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}$ , $T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}$ , $T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## TYPICAL APPLICATIONS

Bypass capacitors are recommended for stable operation of the KA79MXX series of regulators over the input voltage and output current ranges. Output bypass capacitors will improve the transient response of the regulator.

The bypass capacitors, (2μF on the input, 1μF on the output) should be ceramic or solid tantalum which have good high frequency characteristics. If aluminum electrolytics are used, their values should be 10μF or larger. The bypass capacitors should be mounted with the shortest leads, and if possible, directly across the regulator terminals.

Fig. 1 Fixed Output Regulator

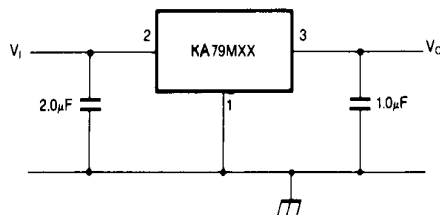
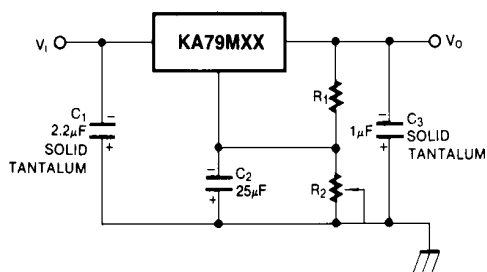


Fig. 2 Variable Output

**Note**

1. Required for stability. For value given, capacitor must be solid tantalum. 25μF aluminum electrolytic may be substituted.
2. C<sub>2</sub> improves transient response and ripple rejection. Do not increase beyond 50μF.

$$V_{OUT} = V_{SET} \left( \frac{R_1 + R_2}{R_1} \right)$$

Select R<sub>2</sub> as follows

KA79M 05: 300Ω, KA79M12: 750Ω, KA79M15: 11Ω

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

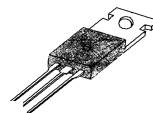
## 3-TERMINAL 0.5A NEGATIVE VOLTAGE REGULATORS

The KA79MXX series of 3-Terminal medium current negative voltage regulators are monolithic integrated circuits designed as fixed voltage regulators. These regulators employ internal current limiting, thermal shutdown and safe-area compensation making them essentially indestructible.

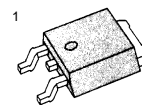
## FEATURES

- No external components required
- Output current in excess of 0.5A
- Internal thermal-overload
- Internal short circuit current limiting
- Output transistor safe-area compensation
- Output Voltages of -5V, -6V, -8V, -12V, -15V, -18V and -24V

TO-220



D-PAK

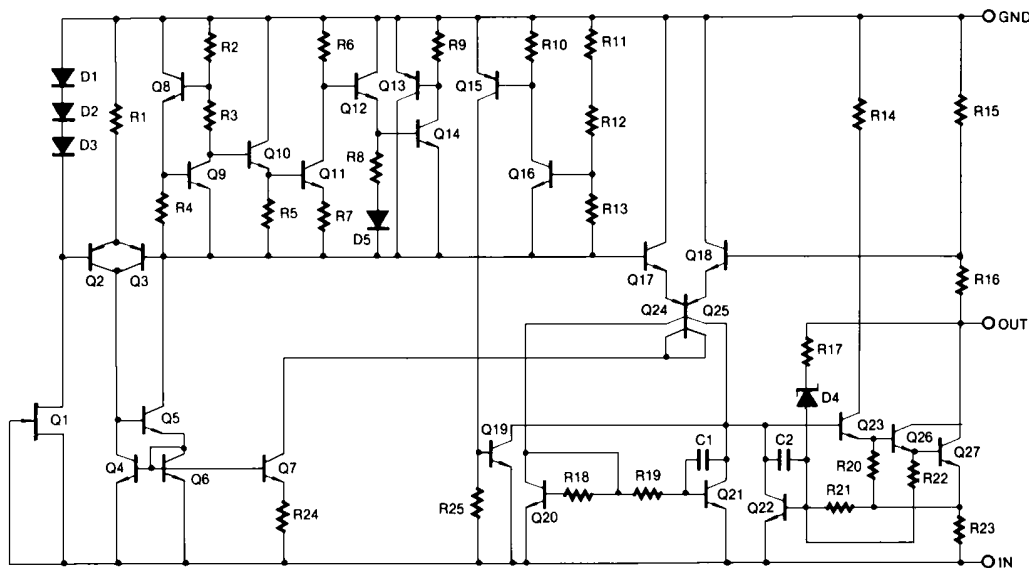


1: GND 2: Input 3: Output

## ORDERING INFORMATION

Device	Package	Operating Temperature
KA79MXX	TO-220	0 ~ +125 °C
KA79MXXR	D-PAK	0 ~ +125 °C

## SCHEMATIC DIAGRAM





**ABSOLUTE MAXIMUM RATINGS** ( $T_A = +25\text{ }^{\circ}\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Value	Unit
Input Voltage(for $V_O = -5\text{V}$ to $-18\text{V}$ ) (for $V_O = -24\text{V}$ )	$V_I$	-35	V
	$V_I$	-40	V
Thermal Resistance Junction-Cases	$R_{\theta JC}$	5	$^{\circ}\text{C}/\text{W}$
Thermal Resistance Junction-Air	$R_{\theta JA}$	65	$^{\circ}\text{C}/\text{W}$
Operating Temperature Range	$T_{OPR}$	0 ~ +125	$^{\circ}\text{C}$
Storage Temperature Range	$T_{STG}$	65 ~ +125	$^{\circ}\text{C}$

**LM79MO5/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0\text{ }^{\circ}\text{C} \leq T_J \leq +125\text{ }^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = 10\text{V}$ , unless otherwise specified,  $C_1 = 0.33\mu\text{F}$ ,  $C_O = 0.1\mu\text{F}$ )

Characteristic	Symbol	Test condition	MIN	TYP	MAX	Unit
Output Voltage	$V_O$	$T_J = +25\text{ }^{\circ}\text{C}$	-4.8	-5	-5.2	V
		$I_O = 5$ to $350\text{mA}$	-4.75	-5	-5.25	
		$V_I = -7$ to $-25\text{V}$				
Line Regulation	$\Delta V_O$	$T_J = +25\text{ }^{\circ}\text{C}$		7.0	50	mV
		$V_I = -7$ to $-25\text{V}$ $V_I = -8$ to $-25\text{V}$		2.0	30	
Load Regulation	$\Delta V_O$	$I_O = 5\text{mA}$ to $500\text{mA}$ $T_J = 25\text{ }^{\circ}\text{C}$		30	100	mV
Quiescent Current	$I_Q$	$T_J = 25\text{ }^{\circ}\text{C}$		3.0	6.0	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
		$I_O = 200\text{mA}$			0.4	
		$V_I = -8\text{V}$ to $-25\text{V}$				
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-0.2		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ , $100\text{KHz}$ $T_J = +25\text{ }^{\circ}\text{C}$		40		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ $V_I = -8$ to $-18\text{V}$	54	60		dB
Dropout Voltage	$V_D$	$T_J = +25\text{ }^{\circ}\text{C}$ , $I_O = 500\text{mA}$		1.1		V
Short Circuit Current	$I_{SC}$	$T_J = +25\text{ }^{\circ}\text{C}$ , $V_I = -35\text{V}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25\text{ }^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M06/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -11\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 5.75	- 6.0	- 6.25	V
		$I_O = 5$ to $350\text{mA}$				
		$V_I = -8.0$ to $-25\text{V}$	- 5.7	- 6.0	- 6.3	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$	$V_I = -8$ to $-25\text{V}$	7.0	60	mV
			$V_I = -9$ to $-19\text{V}$	2.0	40	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$	$I_O = 5.0\text{mA}$ to $500\text{mA}$	30	120	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
			$V_I = -8\text{V}$ to $-25\text{V}$		0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		0.4		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ , $T_A = +25^{\circ}\text{C}$		50		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $V_I = -9$ to $-19\text{V}$	54	60		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}$ , $T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}$ , $T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M08/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -14\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 7.7	- 8.0	- 8.3	V
		$I_O = 5$ to $350\text{mA}$				
		$V_I = -10.5$ to $-25\text{V}$	- 7.6	- 8.0	- 8.4	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$	$V_I = -10.5$ to $-25\text{V}$	7.0	80	mV
			$V_I = -11$ to $-21\text{V}$	2.0	50	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$	$I_O = 5.0\text{mA}$ to $500\text{mA}$	30	160	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5$ to $350\text{mA}$			0.4	mA
			$V_I = -8\text{V}$ to $-25\text{V}$		0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-0.6		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz}$ to $100\text{KHz}$ , $T_A = +25^{\circ}\text{C}$		60		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}$ , $V_I = -9$ to $-19\text{V}$	54	59		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}$ , $T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}$ , $T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M12/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -19\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	-11.5	-12	-12.5	V
		$I_O = 5 \text{ to } 350\text{mA}$				
		$V_I = -14.5 \text{ to } -30\text{V}$	-11.4	-1.2	-12.6	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		8.0	80	mV
		$V_I = -15 \text{ to } -25\text{V}$		3.0	50	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		30	240	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5 \text{ to } 350\text{mA}$			0.4	mA
		$V_I = -14.5\text{V} \text{ to } -30\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-0.8		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{KHz}, T_A = +25^{\circ}\text{C}$		75		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}, V_I = -15 \text{ to } -25\text{V}$	54	60		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}, T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}, T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M15/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -23\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	-14.4	-15	-15.6	V
		$I_O = 5 \text{ to } 350\text{mA}$				
		$V_I = -17.5 \text{ to } -30\text{V}$	-14.25	-15	-15.75	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		9.0	80	mV
		$V_I = -18 \text{ to } -28\text{V}$		5.0	50	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		30	240	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5 \text{ to } 350\text{mA}$			0.4	mA
		$V_I = -17.5\text{V} \text{ to } -28\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{KHz}, T_A = +25^{\circ}\text{C}$		90		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}, V_I = -18.5 \text{ to } -28.5\text{V}$	54	59		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}, T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}, T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M18/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -27\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 17.3	- 18	- 18.7	V
		$I_O = 5 \text{ to } 350\text{mA}$ $V_I = -21 \text{ to } -33\text{V}$	- 17.1	- 18	- 18.9	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		9.0	80	mV
		$V_I = -21 \text{ to } -33\text{V}$ $V_I = -24 \text{ to } -30\text{V}$		5.0	80	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$ $I_O = 5.0\text{mA} \text{ to } 500\text{mA}$		30	360	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5 \text{ to } 350\text{mA}$			0.4	mA
		$V_I = -21\text{V} \text{ to } -33\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{KHz}, T_A = +25^{\circ}\text{C}$		110		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}, V_I = -22 \text{ to } -32\text{V}$	54	59		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}, T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}, T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

**LM79M24/R ELECTRICAL CHARACTERISTICS**(Refer to test circuit,  $0^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ ,  $I_O = 350\text{mA}$ ,  $V_I = -33\text{V}$ , unless otherwise specified)

Characteristic	Symbol	Test condition	Min	Typ	Max	Unit
Output Voltage	$V_O$	$T_J = +25^{\circ}\text{C}$	- 23	- 24	- 25	V
		$I_O = 5 \text{ to } 350\text{mA}$ $V_I = -27 \text{ to } -38\text{V}$	- 22.8	- 24	- 25.2	
Line Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$		9.0	80	mV
		$V_I = -27 \text{ to } -38\text{V}$ $V_I = -30 \text{ to } -36\text{V}$		5.0	70	
Load Regulation	$\Delta V_O$	$T_J = +25^{\circ}\text{C}$ $I_O = 5.0\text{mA} \text{ to } 500\text{mA}$		30	300	mV
Quiescent Current	$I_Q$	$T_J = +25^{\circ}\text{C}$		3	6	mA
Quiescent Current Change	$\Delta I_Q$	$I_O = 5 \text{ to } 350\text{mA}$			0.4	mA
		$V_I = -27\text{V} \text{ to } -38\text{V}$			0.4	
Output Voltage Drift	$\Delta V_O/\Delta T$	$I_O = 5\text{mA}$		-1.0		mV/ $^{\circ}\text{C}$
Output Noise Voltage	$V_N$	$f = 10\text{Hz} \text{ to } 100\text{KHz}, T_A = +25^{\circ}\text{C}$		180		$\mu\text{V}$
Ripple Rejection	RR	$f = 120\text{Hz}, V_I = -28 \text{ to } -38\text{V}$	54	58		dB
Dropout Voltage	$V_D$	$I_O = 500\text{mA}, T_J = +25^{\circ}\text{C}$		1.1		V
Short Circuit Current	$I_{SC}$	$V_I = -35\text{V}, T_J = +25^{\circ}\text{C}$		140		mA
Peak Current	$I_{PK}$	$T_J = +25^{\circ}\text{C}$		650		mA

\* Load and line regulation are specified at constant junction temperature. Change in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty is used.

## TYPICAL APPLICATIONS

Bypass capacitors are recommended for stable operation of the KA79MXX series of regulators over the input voltage and output current ranges. Output bypass capacitors will improve the transient response of the regulator. The bypass capacitors, (2μF on the input, 1μF on the output) should be ceramic or solid tantalum which have good high frequency characteristics. If aluminum electrolytics are used, their values should be 10μF or larger. The bypass capacitors should be mounted with the shortest leads, and if possible, directly across the regulator terminals.

Fig. 1 Fixed Output Regulator

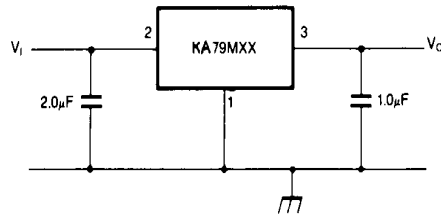
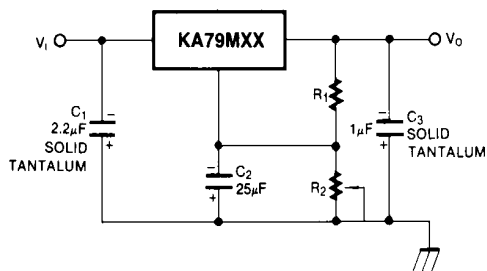


Fig. 2 Variable Output

**Note**

1. Required for stability. For value given, capacitor must be solid tantalum. 25μF aluminum electrolytic may be substituted.
2. C<sub>2</sub> improves transient response and ripple rejection. Do not increase beyond 50μF.

$$V_{OUT} = V_{SET} \left( \frac{R_1 + R_2}{R_1} \right)$$

Select R<sub>2</sub> as follows

KA79M 05: 300Ω, KA79M12: 750Ω, KA79M15: 11Ω

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