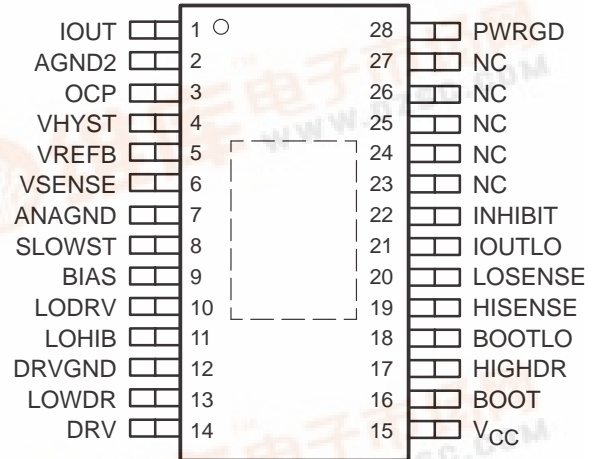


SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

- **$\pm 1\%$ Reference Over Full Operating Temperature Range**
- **Synchronous Rectifier Driver for $>90\%$ Efficiency**
- **Fixed Output Voltage Options of 1.5 V, 1.8 V, 2.5 V, and 3.3 V**
- **User-Selectable Hysteretic-Type Control**
- **Low Supply Current . . . 3 mA Typ**
- **11.4-V to 13-V Input Voltage Range, V_{CC}**
- **Power Good Output**
- **Programmable Soft-Start**
- **Overvoltage/Overcurrent Protection**
- **Active Deadtime Control**

**PWP PACKAGE
(TOP VIEW)**



NC – No internal connection

description

The TPS5615 family of synchronous-buck regulator controllers provides an accurate supply voltage to DSPs. The output voltage is internally set by a resistive divider with an accuracy of 1% over the full operating temperature range. A hysteretic controller with user-selectable hysteresis is used to dramatically reduce overshoot and undershoot caused by load transients. Propagation delay from the comparator inputs to the output drivers is less than 250 ns. Overcurrent shutdown and crossover protection for the output drivers combine to eliminate destructive faults in the output FETs. PWRGD monitors the output voltage and pulls the open-collector output low when the output drops below 93% of the nominal output voltage. An overvoltage circuit disables the output drivers if the output voltage rises 15% above the nominal value. The inhibit pin can be used to control power sequencing. Inhibit and undervoltage lockout assures that the 12-V supply voltage and system supply voltage (5 V or 3.3 V) are within proper operating limits before the controller starts. The output driver circuits include 2-A drivers with internal 8-V gate-voltage regulators that can easily provide sufficient power for today's high-powered DSPs. The high-side driver can be configured either as a ground-referenced driver or as a floating bootstrap driver. The TPS5615 family is available in a 28-pin TSSOP PowerPad™ package. It operates over a junction temperature range of 0°C to 125°C.

AVAILABLE OPTIONS

T _J	OUTPUT VOLTAGE	PACKAGE
		TSSOP† (PWP)
0°C to 125°C	1.5 V	TPS5615PWP
	1.8 V	TPS5618PWP
	2.5 V	TPS5625PWP
	3.3 V	TPS5633PWP

† The PWP package is available taped and reeled. Add R suffix to device type (e.g., TPS5615PWPR).

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PowerPAD is a trademark of Texas Instruments Incorporated.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

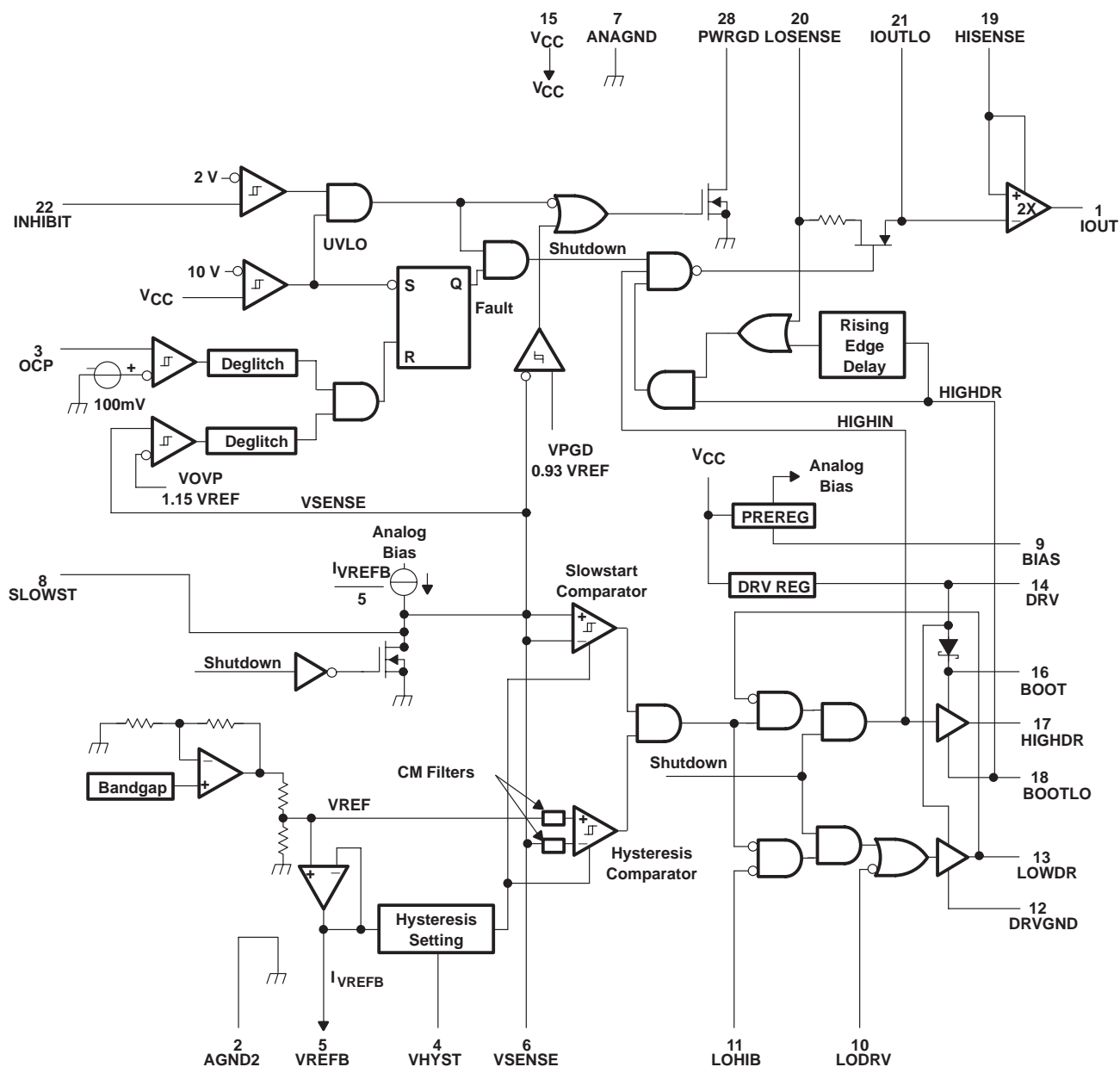
Copyright © 2000, Texas Instruments Incorporated



TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

functional block diagram



TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
AGND2	2		Analog ground (must be connected).
ANAGND	7		Analog ground
BIAS	9		Analog bias pin. A 1- μ F capacitor should be connected from BIAS to ANAGND.
BOOT	16		Bootstrap. A 1- μ F capacitor should be connected from BOOT to BOOTLO.
BOOTLO	18		Bootstrap low. Connect to the junction of the high-side and low-side FETs for floating drive configuration. Connect to PGND for ground-reference drive configuration.
DRV	14		Drive regulator for the FET drivers. A 1- μ F capacitor should be connected from DRV to DRVGND.
DRVGND	12		Drive ground. Ground for FET drivers. Connect to FET PWRGND.
HIGHDR	17		High drive. Output drive to high-side power switching FETs.
HISENSE	19		High current sense. For current sensing across high-side FETs, connect to the drain of the high-side FETs; for optional current sensing scheme, connect to power supply side of current-sense resistor placed in series with high-side FET drain.
INHIBIT	22		Disables the drive signals to the MOSFET drivers. Also serves as UVLO for system logic supply (3.3 V or 5 V). An external pullup resistor should be connected to system-logic supply.
IOUT	1		Current out. Output voltage on this terminal is proportional to the load current as measured across the $R_{ds(on)}$ of the high side FET. The voltage on this terminal equals $2 \times R_{DS(ON)} \times I_{OUT}$. In applications where very accurate current-sensing is required, a sense resistor should be connected between the input supply and the drain of the high-side FETs.
IOUTLO	21		Current sense low output. This is the voltage on the LOSENSE terminal when the high-side FETs are on. A ceramic capacitor (between 0.033 μ F and 0.1 μ F) should be connected from IOUTLO to HISENSE to hold the sensed voltage.
LODRV	10		Low drive enable. Normally tied to 5 V. To configure the low-side FET as a crowbar, pull LODRV low.
LOHIB	11		Low side inhibit. Connect to the junction of the high- and low-side FETs to control the anti-cross-conduction and eliminate shoot-through current. Disabled when configured in crowbar mode.
LOSENSE	20		Low current sense. For current sensing across high-side FETs, connect to the source of the high-side FETs; for optional current sensing scheme, connect to high-side FET drain side of current-sense resistor placed in series with high-side FET drain.
LOWDR	13		Low drive. Output drive to synchronous rectifier FETs.
NC	23–27		No connect
OCP	3		Over current protection. Current limit trip point is set with a resistor divider between IOUT and ANAGND.
PWRGD	28		Power good. PWRGD signal goes high when output voltage is within 7% of voltage setpoint. Open-drain output.
SLOWST	8		Slow Start (soft start). A capacitor from SLOWST to ANAGND sets the slowstart time. Slowstart current = $I_{VREFB}/5$
VHYST	4		Hysteresis set input. The hysteresis is set with a resistor divider from VREFB to ANAGND. Hysteresis = $2 \times (V_{REFB} - V_{HYST})$
V _{CC}	15		12-V supply. A 1- μ F capacitor should be connected from V _{CC} to DRVGND.
VREFB	5		Buffered reference voltage
VSENSE	6		Voltage sense Input. To be connected from converter output voltage bus to sense and control output voltage. It is recommended that a RC low-pass filter be connected at this pin to filter noise.

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

detailed description

Vref

The reference voltage section consists of a temperature-compensated bandgap reference and a resistive divider that sets the output voltage option. The output voltage, VREF, is within 1% of the nominal setting over the full junction temperature range of 0°C to 125°C, and a V_{CC} supply voltage range of 11.4 V to 12.6 V. The output of the reference network is indirectly brought out through a buffer to the VREFB pin. The voltage on this pin will be within 2% of VREF. It is not recommended to drive loads with VREFB, other than setting the hysteresis of the hysteretic comparator, because the current drawn from VREFB sets the charging current for the slowstart capacitor. Refer to the *slowstart* section for additional information.

hysteretic comparator

The hysteretic comparator regulates the output voltage of the synchronous-buck converter. The hysteresis is set by 2 external resistors and is centered on VREF. The 2 external resistors form a resistor divider from VREFB to ANAGND, with the output voltage connecting to the VHYST pin. The hysteresis of the propagation delay from the comparator inputs to the driver outputs is 250 ns (maximum). The maximum hysteresis setting is 60 mV.

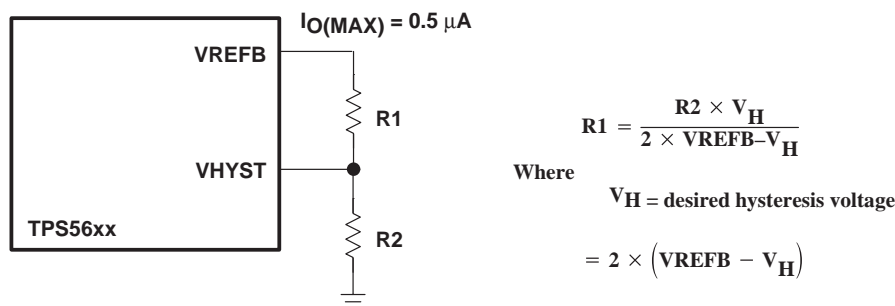


Figure 1. Setting the Hysteresis Voltage

low-side driver

The low-side driver is designed to drive low-R_{ds(on)} n-channel MOSFETs. The current rating of the driver is 2 A, source or sink. The bias to the low-side driver is internally connected to the DRV regulator.

high-side driver

The high-side driver is designed to drive low-R_{ds(on)} n-channel MOSFETs. The current rating of the driver is 2 A, source or sink. The high-side driver can be configured either as a ground-referenced driver or as a floating bootstrap driver. When configured as a floating driver, the bias voltage to the driver is developed from the DRV regulator. The internal bootstrap diode, connected between the DRV and BOOT pins, is a Schottky for improved drive efficiency. The maximum voltage that can be applied between BOOT and DRV_{GND} is 30 V. The driver can be referenced to ground by connecting BOOT_{LO} to DRV_{GND}, and connecting BOOT to either DRV or V_{CC}.

deadtime control

Deadtime control prevents shoot-through current from flowing through the main power FETs during switching transitions by actively controlling the turn-on times of the MOSFET drivers. The high-side driver is not allowed to turn on until the gate-drive voltage to the low-side FET is below 2 V; the low-side driver is not allowed to turn on until the voltage at the junction of the 2 FETs (V_{phase}) is below 2 V.

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

detailed description (continued)

current sensing

Current sensing is achieved by sampling and holding the voltage across the high-side power FET while the high-side FET is on. The sampling network consists of an internal 60-Ω switch and an external ceramic hold capacitor. Recommended value of the hold capacitor is between 0.033 μF and 0.1 μF. The actual value should give a time constant ($60\ \Omega \times C_H$) greater than the FET on time. Internal logic controls the turn-on and turn-off of the sample/hold switch such that the switch does not turn on until the Vphase voltage transitions high, and the switch turns off when the input to the high-side driver goes low. Thus sampling will occur only when the high side FET is conducting current. The voltage on the IOUT pin equals 2 times the sensed high-side voltage. In applications where a higher accuracy in current-sensing is required, a sense resistor can be placed in series with the high-side FET and the voltage across the sense resistor can be sampled by the current sensing circuit. See Figures 2 and 3.

overcurrent protection

The overcurrent protection (OCP) circuit monitors the current through the high-side FET. The overcurrent threshold is adjustable with an external resistor divider between IOUT and ANAGND, with the divider voltage connected to OCP. If the voltage on OCP (V_S) exceeds 100 mV, then a fault latch is set and the output drivers are turned off. The latch will remain set until V_{CC} goes below the undervoltage lockout value. A 3-μs deglitch timer is included for noise immunity. The OCP circuit is also designed to protect the high-side power FET against a short-to-ground fault on the terminal common to both power FETs (Vphase).

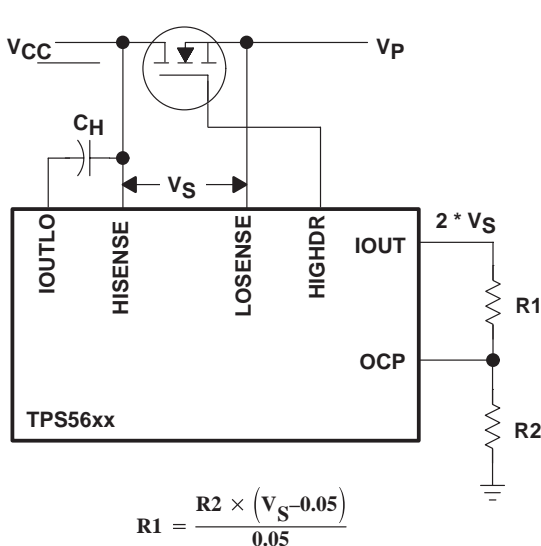


Figure 2. OCP Using FET ON-Resistance

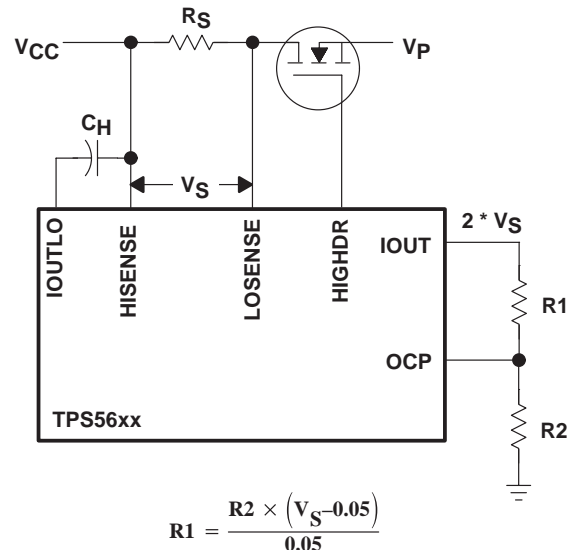


Figure 3. Precision OCP Using External Resistor

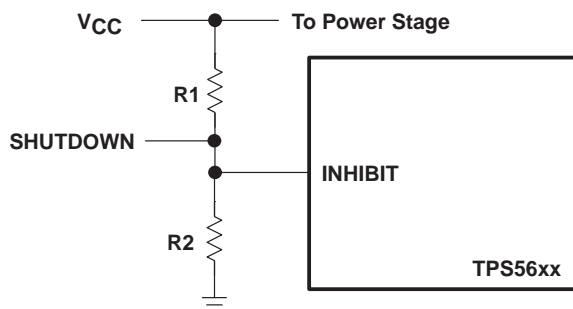
inhibit

INHIBIT is a TTL-compatible digital input used to enable the controller. When INHIBIT is low, the output drivers are low and the slowstart capacitor is discharged. When INHIBIT goes high, the short across the slowstart capacitor is released and normal converter operation begins. When the system-logic supply is connected to INHIBIT, it also controls power sequencing by locking out controller operation until the system-logic supply exceeds the input threshold voltage of the inhibit circuit. Thus the 12-V supply and the system-logic supply (either 5 V or 3.3 V) must be above UVLO thresholds before the controller is allowed to start up. The INHIBIT comparator start threshold is 2.1 V and the hysteresis is 100 mV.

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

detailed description (continued)



$$R2 = \frac{2.1 \times R1}{V_{TRIP} - 2.1}$$

Where

V_{TRIP} = desired V_{SUPPLY} trip voltage

Figure 4. Input Undervoltage Lockout Circuit Using INHIBIT

V_{CC} undervoltage lockout (UVLO)

The undervoltage lockout circuit disables the controller while the V_{CC} supply is below the 10-V start threshold during power up. While the controller is disabled, the output drivers will be low and the slowstart capacitor will be shorted. When V_{CC} exceeds the start threshold, the short across the slowstart capacitor is released and normal converter operation begins. There is a 2-V hysteresis in the undervoltage lockout circuit for noise immunity.

slowstart

The slowstart circuit controls the rate at which V_O powers up. A capacitor is connected between SLOWST and ANAGND and is charged by an internal current source. The slowstart charging current is determined by the following equation:

$$I_{SLOWSTART} = \frac{I(VREFB)}{5}$$

where $I(VREFB)$ is the current flowing out of VREFB. It is recommended that no additional loads be connected to VREFB, other than the resistor divider for setting the hysteresis voltage. The maximum current that can be sourced by the VREFB circuit is 500 μ A. The slowstart time is set by:

$$t_{SLOWSTART} = 5 \times C_{SLOWST} \times R_{VREFB}$$

where R_{VREFB} is the total external resistance from VREFB to ANAGND.

power good

The power good circuit monitors for an undervoltage condition on V_O . If V_O is 7% below V_{REF} , then PWRGD is pulled low. PWRGD is an open-drain output.

overvoltage protection

The overvoltage protection (OVP) circuit monitors V_O for an overvoltage condition. If V_O is 15% above V_{REF} , then a fault latch is set and both output drivers are turned off. The latch will remain set until V_{CC} goes below the undervoltage lockout value. A 3- μ s deglitch timer is included for noise immunity. Refer to the LODRV section for information on how to protect the load against overvoltages due to a shorted fault across the high-side power FET.

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

detailed description (continued)

drive regulator

The drive regulator provides drive voltage to the output drivers. The minimum drive voltage is 7 V. The minimum short circuit current is 100 mA. Connect a 1- μ F ceramic capacitor from DRV to DRVND.

LODRV

The LODRV circuit is designed to protect the load against overvoltages that occur if the high-side FETs become shorted. External components to sense an overvoltage condition are required to use this feature. When an overvoltage fault occurs, LODRV is pulled low and the low-side FET will be turned on, overriding all control signals inside the TPS56xx controller. The crowbar action will short the system-logic supply to ground through the faulted high-side FETs and the low-side FETs. A fuse, in series with V_{IN} , should be added to disconnect the short circuit.

absolute maximum ratings over operating free-air temperature (unless otherwise noted)[†]

Supply voltage range, V_{CC} (see Note 1)	–0.3 to 14 V
Input voltage range: BOOT to DRVND (high-side driver ON)	–0.3 to 30 V
BOOT to HIGHDRV	–0.3 to 15 V
BOOT to BOOTLO	–0.3 to 15 V
INHIBIT, LODRV	–0.3 to 7.3 V
PWRGD, OCP	–0.3 to 7 V
LOHIB, LOSENSE, IOUTLO, HISENSE	–0.3 to 14 V
VSENSE	–0.3 to 5 V
Voltage difference between ANAGND and DRVND	± 0.5 V
Output current, VREFB	0.5 mA
Short circuit duration, DRV	Continuous
Continuous total power dissipation	See Dissipation Rating Table
Operating junction temperature range, T_J	0°C to 125°C
Storage temperature range, T_{stg}	–65°C to 150°C
Lead temperature soldering 1,6 mm (1/16 inch) from case for 10 seconds	260°C

[†] Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: Unless otherwise specified, all voltages are with respect to ANAGND.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
PWP	1150 mW	11.5 mW/°C	630 mW	460 mW

TPS5615, TPS5618, TPS5625, TPS5633

SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, V_{CC}		11.4	13	V
Input voltage	BOOT to DRVND	0	28	V
	BOOT to BOOTLO	0	13	
	INHIBIT, LODRV, PWRGD, OCP	0	6	
	LOHIB, LOSENSE, IOUTLO, HISENSE	0	13	
	VSENSE	0	4.5	
Voltage difference between ANAGND and DRVND		0	± 0.2	V
Output current, V_{REFB}^{\dagger}		0	0.4	mA

\dagger Not recommended to load V_{REFB} other than to set hysteresis since $I_{V_{REFB}}$ sets slowstart time.

electrical characteristics over recommended operating virtual junction temperature range, $V_{CC} = 12$ V, $I_{DRV} = 0$ A (unless otherwise noted)

reference

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VREF	Reference voltage	$V_{CC} = 11.4$ V to 12.6 V	1.485		1.515	V
	TPS5615					
	TPS5618		1.782		1.818	
	TPS5625		2.475		2.525	
	TPS5633		3.267		3.333	
VREFB	Output voltage	$I_{REFB} = 50$ μ A	$V_{REF} - 2\%$	V_{REF}	$V_{REF} + 2\%$	V
VREFB	Output regulation	10 μ A $\leq I_O \leq 500$ μ A		2		mV

power good

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Undervoltage trip threshold		90	93	95	%VREF
Low-level output voltage, PWRGD	$I_O = 5$ mA		0.5	0.75	V
High-level input current, PWRGD	$V_{PWRGD} = 6$ V		1		μ A
Hysteresis			10		mV

overvoltage protection

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Overvoltage trip threshold		112	115	120	%VREF
Hysteresis	See Note 2		10		mV

NOTE 2: Ensured by design, not tested.

slowstart

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Charge current	$V_{SLOWST} = 0.5$ V, $I_{V_{REFB}} = 65$ μ A	10.4	13	15.6	μ A
Discharge current	$V_{SOFTST} = 1$ V		3		mA
Comparator input offset voltage				10	mV
Comparator input bias current	See Note 2		10	100	nA
Hysteresis		-7.5		7.5	mV

NOTE 2: Ensured by design, not tested.

TPS5615, TPS5618, TPS5625, TPS5633

SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

electrical characteristics over recommended operating virtual junction temperature range,
 $V_{CC} = 12\text{ V}$, $I_{DRV} = 0\text{ A}$ (unless otherwise noted) (continued)

inhibit

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Startup threshold		1.9	2.1	2.35	V
Hysteresis		0.08	0.1	0.12	V
Stop threshold		1.85			V

input undervoltage lockout

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Startup threshold		9.25	10	10.75	V
Hysteresis		1.9	2	2.2	V
Stop threshold		7.5			V

hysteretic comparator

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input offset voltage		-2.5		2.5	mV
Input bias current	See Note 2			500	nA
Hysteresis accuracy	$V_{REFB} - V_{HYST} = 15\text{ mV}$, (hysteresis window = 30 mV)	-3.5		3.5	mV
Maximum hysteresis setting	$V_{REFB} - V_{HYST} = 30\text{ mV}$		60		mV

NOTE 2: Ensured by design, not tested.

overcurrent protection

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
OCP trip threshold		90	100	110	mV
Input bias current				100	nA

TPS5615, TPS5618, TPS5625, TPS5633

SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

**electrical characteristics over recommended operating virtual junction temperature range,
V_{CC} = 12 V, I_{DRV} = 0 A (unless otherwise noted) (continued)**

high-side VDS sensing

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Gain			2		V/V
Initial accuracy	V _{HISENSE} = 12 V, V _{LOSENSE} = 11.9 V Differential input to Vds sensing amp = 100 mV	194		206	mV
IOUTLO sink current	5 V ≤ V _{IOUTLO} ≤ 13 V			250	nA
IOUT source current	V _{IOUT} = 0.5 V, V _{HISENSE} = 12 V, V _{IOUTLO} = 11.5 V	500			μA
IOUT sink current	V _{IOUT} = 0.05 V, V _{HISENSE} = 12 V, V _{IOUTLO} = 12 V	50			μA
Output voltage swing	V _{HISENSE} = 11 V	0		2	V
	V _{HISENSE} = 4.5 V	0		1.5	
	V _{HISENSE} = 3 V	0		0.75	
	R _{IOUT} = 10 kΩ				
LOSENSE high-level input voltage	V _{HISENSE} = 4.5 V, See Note 2	2.85			V
LOSENSE low-level input voltage	V _{HISENSE} = 4.5 V, See Note 2			2.4	V
Sample/hold resistance	11.4 V ≤ V _{HISENSE} ≤ 12.6 V, LOSENSE connected to HISENSE, V _{HISENSE} - V _{IOUTLO} = 0.15 V	50	60	80	Ω
	4.5 V ≤ V _{HISENSE} ≤ 5.5 V, LOSENSE connected to HISENSE, V _{HISENSE} - V _{IOUTLO} = 0.15 V	62	85	123	
	3 V ≤ V _{HISENSE} ≤ 3.6 V, LOSENSE connected to HISENSE, V _{HISENSE} - V _{IOUTLO} = 0.15 V	67	95	144	
CMRR	V _{HISENSE} = 12.6 V to 3 V, V _{HISENSE} - V _{IOUTLO} = 100 mV	69	75		dB

NOTE 2: Ensured by design, not tested.

deadtime

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
LOHIB	High-level input voltage	See Note 2	2.4		V
LODR		See Note 2	3		
LOHIB	Low-level input voltage	See Note 2		1.4	V
LODR		See Note 2		1.7	

NOTE 2: Ensured by design, not tested.

LODRV

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
LODRV	High-level input voltage	1.85			V
	Low-level input voltage			0.95	V

drive regulator

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	11.4 V ≤ V _{CC} ≤ 12.6 V, I _{DRV} = 50 mA	7		9	V
Output regulation	1 mA ≤ I _{DRV} ≤ 500 mA		100		mV
Short-circuit current		100			mA

TPS5615, TPS5618, TPS5625, TPS5633

SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

**electrical characteristics over recommended operating virtual junction temperature range,
V_{CC} = 12 V, I_{DRV} = 0 A (unless otherwise noted) (continued)**

bias regulator

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	11.4 V ≤ V _{CC} ≤ 12.6 V, See Note 3	6			V

NOTE 3: The bias regulator is designed to provide a quiet bias supply for the TPS56xx controller. External loads should not be driven by the bias regulator.

output drivers

PARAMETER (see Note 4)		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Peak output current	High-side sink	Duty cycle < 2%, t _{pw} < 100 μs, T _J = 125°C, V _{BOOT} – V _{BOOTLO} = 6.5 V, V _{HIGHDR} = 1.5 V (SRC) or 5 V (sink), See Note 2	2			A
	High-side source		2			
	Low-side sink	Duty cycle < 2%, t _{pw} < 100 μs, T _J = 125°C, V _{DRV} = 6.5 V, V _{LOWDR} = 1.5 V (SRC) or 5 V (sink), See Note 2	2			
	Low-side source		2			
Output resistance	High-side sink	T _J = 125°C, V _{BOOT} – V _{BOOTLO} = 6.5 V, V _{HIGHDR} = 1.5 V (SRC) or 5 V (sink)			3	Ω
	High-side source				45	
	Low-side sink	T _J = 125°C, V _{DRV} = 6.5 V, V _{LOWDR} = 1.5 V (SRC) or 5 V (sink)			5.7	
	Low-side source				45	

NOTES: 2. Ensured by design, not tested.

4. The pull up/down circuits of the drivers are bipolar and MOSFET transistors in parallel. The peak output current rating is the combined current from the bipolar and MOSFET transistors. The output resistance is the R_{DS(ON)} of the MOSFET transistor when the voltage on the driver output is less than the saturation voltage of the bipolar transistor.

supply current

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{CC} supply voltage range		11.4	12	13	V
V _{CC} quiescent current	V _{INHIBIT} = 5 V, V _{BOOTLO} = 0 V, V _{CC} > 10.75 V at startup, See Note 2		3	10	mA
	V _{INHIBIT} = 5 V, V _{BOOTLO} = 0 V, V _{CC} > 10.75 V at startup, C _{HIGHDR} = 50 pF, f _{swx} = 200 kHz		5		
High-side drive regulator quiescent current	V _{INHIBIT} = 0 V or V _{CC} < 9.25 V at startup, V _{BOOT} = 13 V, V _{BOOTLO} = 0 V			80	μA
	V _{INHIBIT} = 5 V, V _{BOOT} = 13 V, V _{CC} > 10.75 V at startup, V _{BOOTLO} = 0 V, C _{HIGHDR} = 50 pF, f _{swx} = 200 kHz		2		mA

NOTE 2: Ensured by design, not tested.

TPS5615, TPS5618, TPS5625, TPS5633

SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

**switching characteristics over recommended operating virtual junction temperature range,
 $V_{CC} = 12\text{ V}$, $I_{DRV} = 0\text{ V}$ (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Propagation delay	VSENSE to HIGHDR or LOWDR (excluding deadtime)	Overdrive = 10 mV (see Note 2)		150	250	ns
	OCP comparator	See Note 2		1		μs
	OVP comparator	See Note 2		1		
	PWRGD comparator	See Note 2		1		
	SLOWST comparator	Overdrive = 10 mV (see Note 2)		560	900	ns
Rise time	HIGHDR output	$C_L = 9\text{ nF}$, $V_{BOOT} = 6.5\text{ V}$, $V_{BOOTLO} = 0\text{ V}$, $T_J = 125^\circ\text{C}$			60	ns
	LOWDR output	$C_L = 9\text{ nF}$, $V_{DRV} = 6.5\text{ V}$, $T_J = 125^\circ\text{C}$			60	
Fall time	HIGHDR output	$C_L = 9\text{ nF}$, $V_{BOOT} = 6.5\text{ V}$, $V_{BOOTLO} = 0\text{ V}$, $T_J = 125^\circ\text{C}$			60	ns
	LOWDR output	$C_L = 9\text{ nF}$, $V_{DRV} = 6.5\text{ V}$, $T_J = 125^\circ\text{C}$			60	
Deglitch time (includes comparator propagation delay)	OCP	See Note 2	2		5	μs
	OVP	See Note 2	2		5	
Response time	High-side VDS sensing	$V_{HISENSE} = 12\text{ V}$, V_{IOUTLO} pulsed from 12 V to 11.9 V, 100 ns rise/fall times, See Note 2			2	μs
		$V_{HISENSE} = 4.5\text{ V}$, V_{IOUTLO} pulsed from 4.5 V to 4.4 V, 100 ns rise/fall times, See Note 2			3	
		$V_{HISENSE} = 3\text{ V}$, V_{IOUTLO} pulsed from 3 V to 2.9 V, 100 ns rise/fall times, See Note 2			3	
Short-circuit protection rising-edge delay	SCP	$LOSENSE = 0\text{ V}$, (see Note 2)	300		500	ns
Turn-on/turn-off delay	V_{DS} sensing sample/hold switch	$3\text{ V} \leq V_{HISENSE} \leq 11\text{ V}$, $V_{LOSENSE} = V_{HISENSE}$ (see Note 2)	30		100	ns
Crossover delay time	LOWDR to HIGHDRV, and LOHIB to LOWDR	See Note 2	30		100	ns
Prefilter pole frequency	Hysteretic comparator	See Note 2		5		MHz
Propagation delay	LODRV	See Note 2			400	ns

NOTE 2: Ensured by design, not tested.

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

TYPICAL CHARACTERISTICS

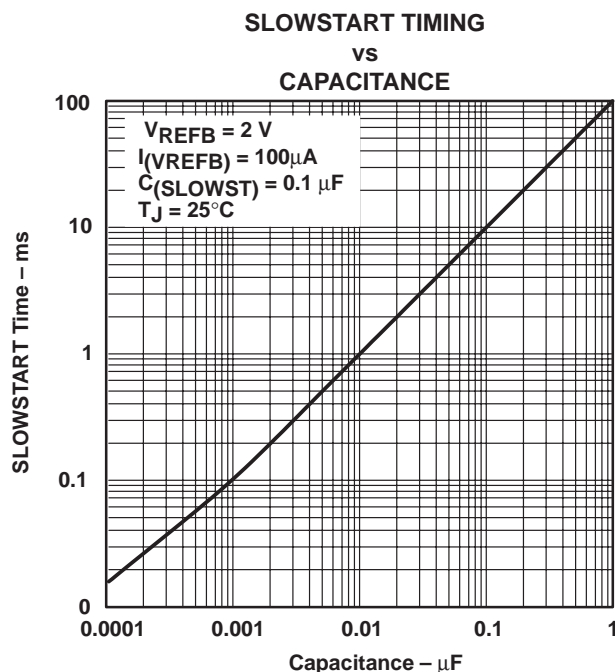


Figure 5

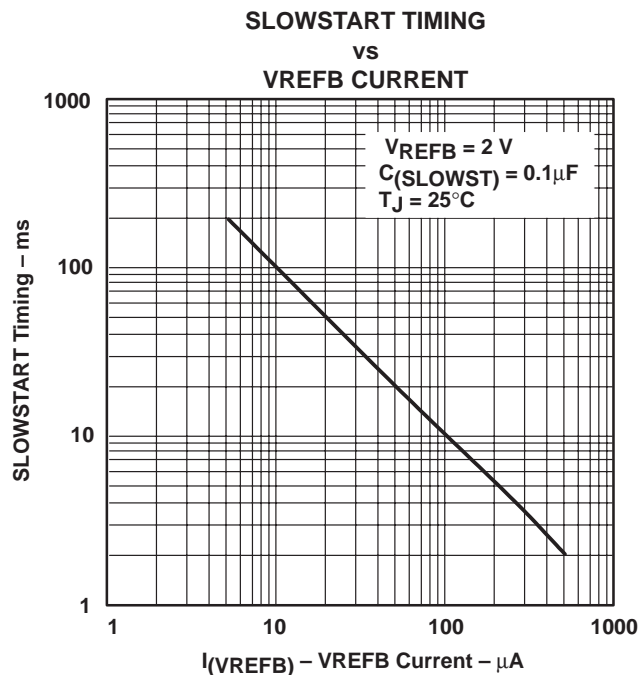


Figure 6

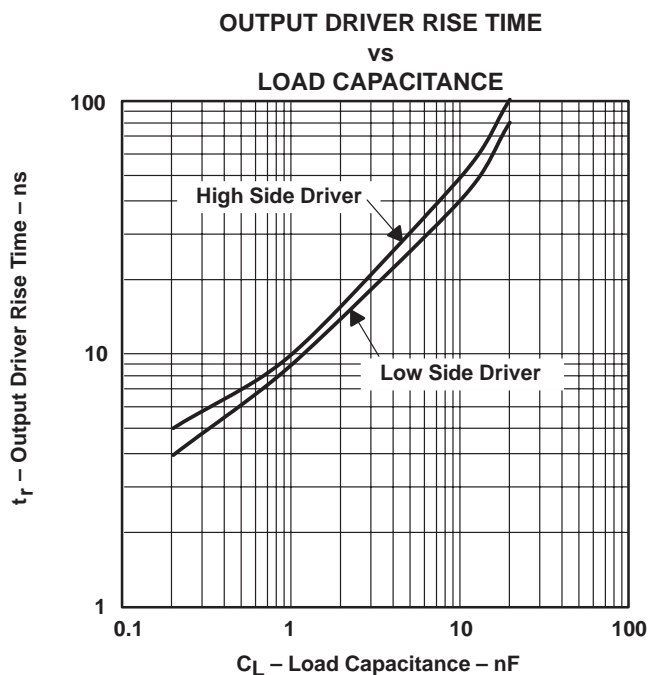


Figure 7

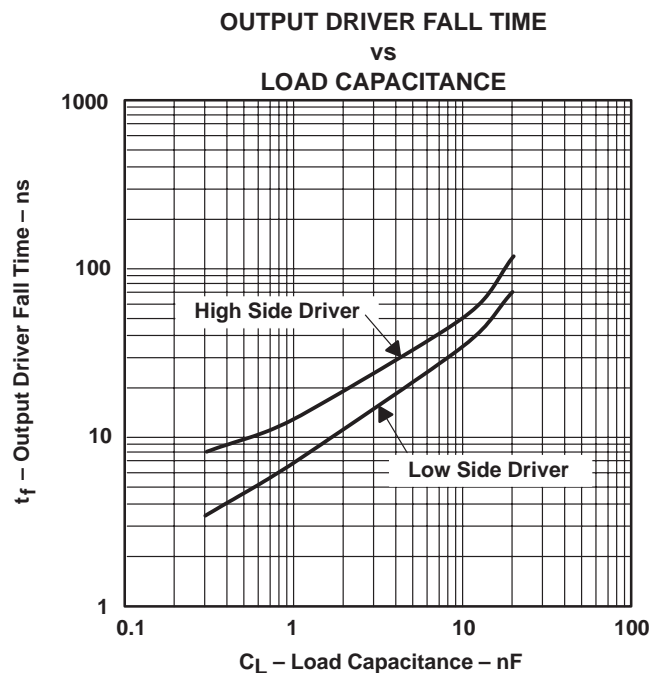
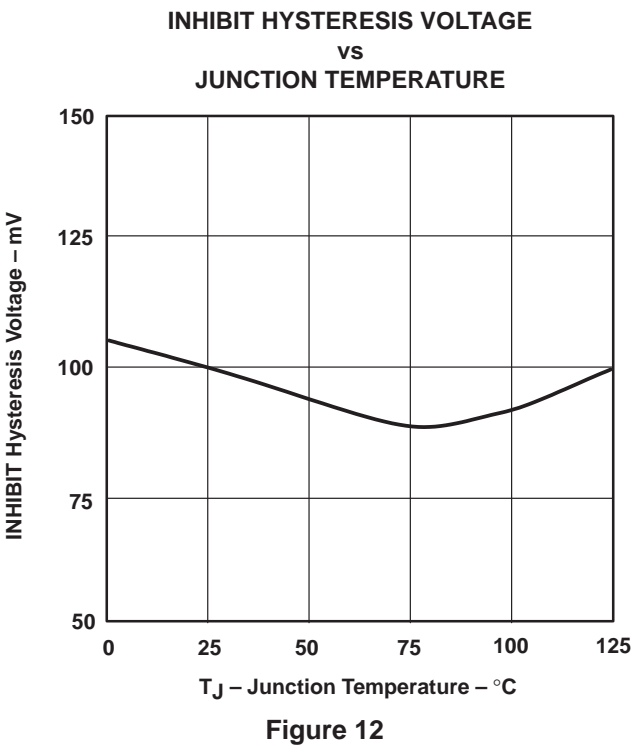
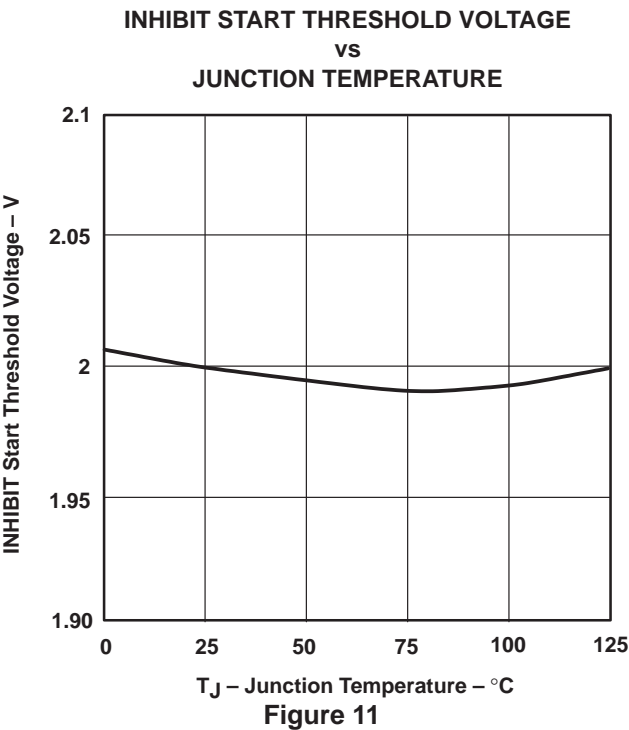
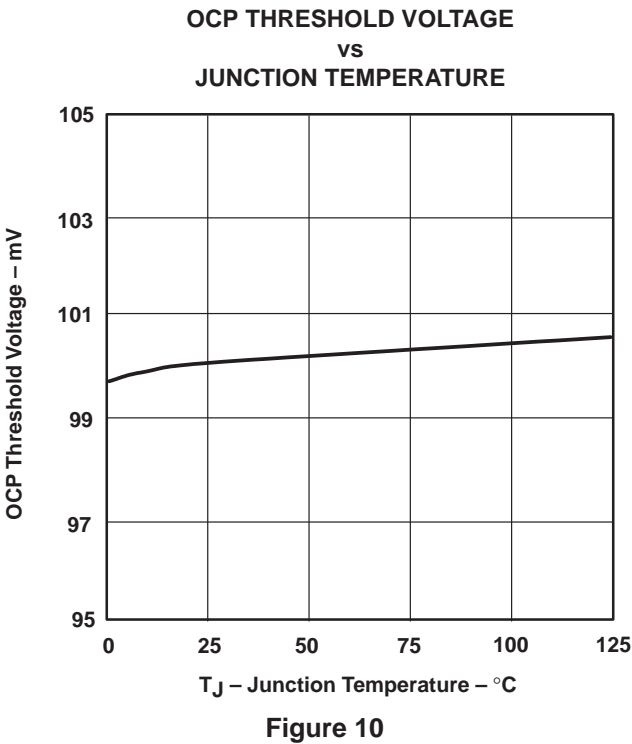
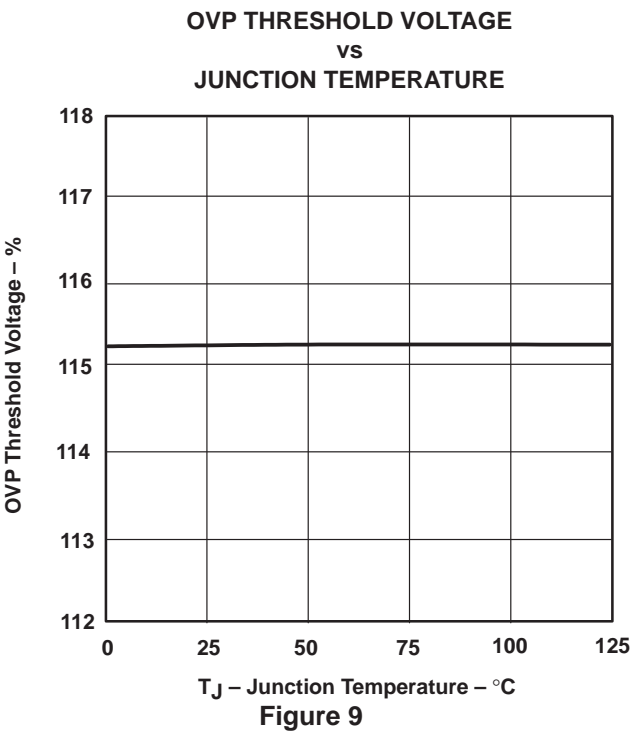


Figure 8

TPS5615, TPS5618, TPS5625, TPS5633
SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

TYPICAL CHARACTERISTICS



TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

TYPICAL CHARACTERISTICS

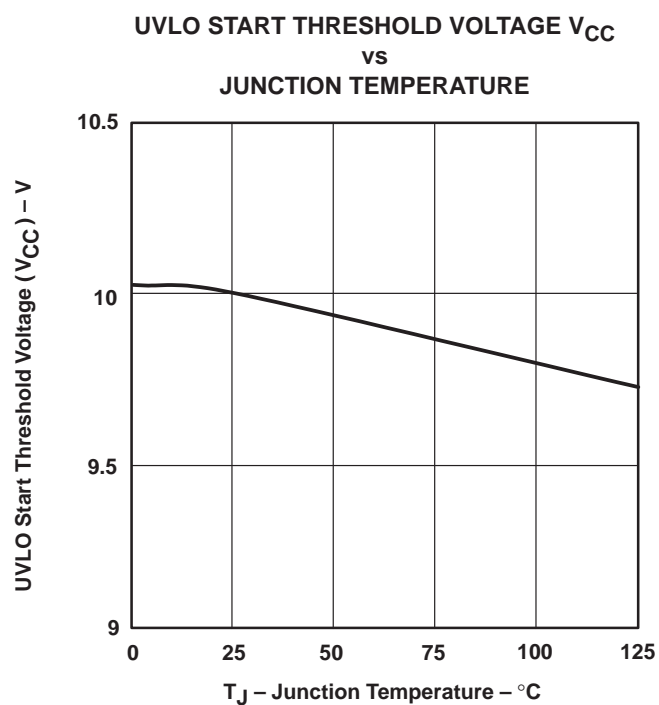


Figure 13

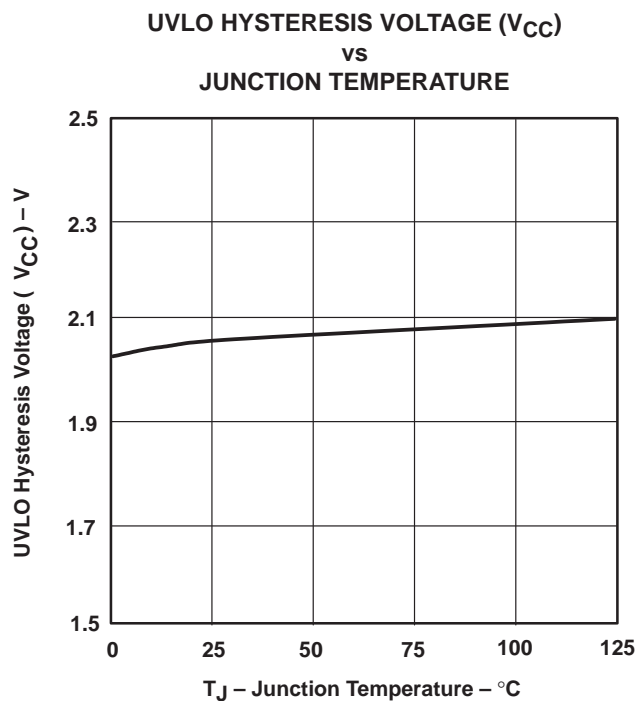


Figure 14

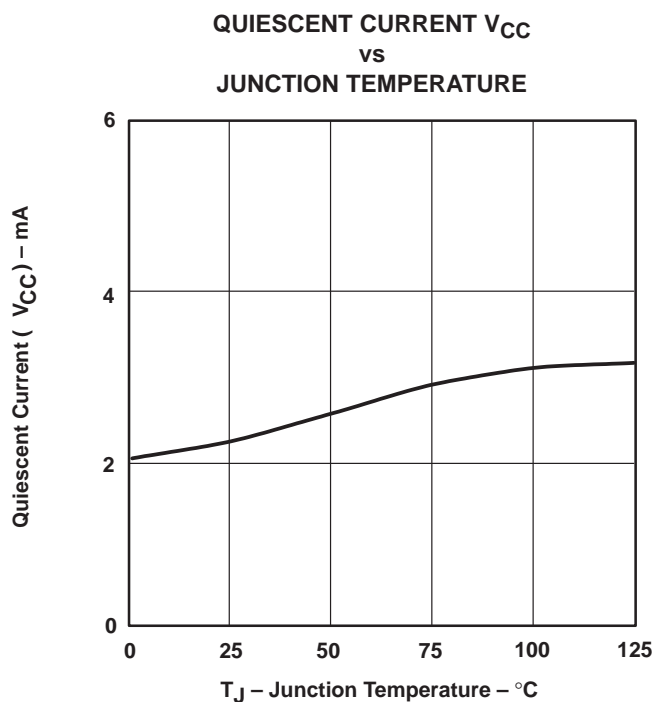


Figure 15

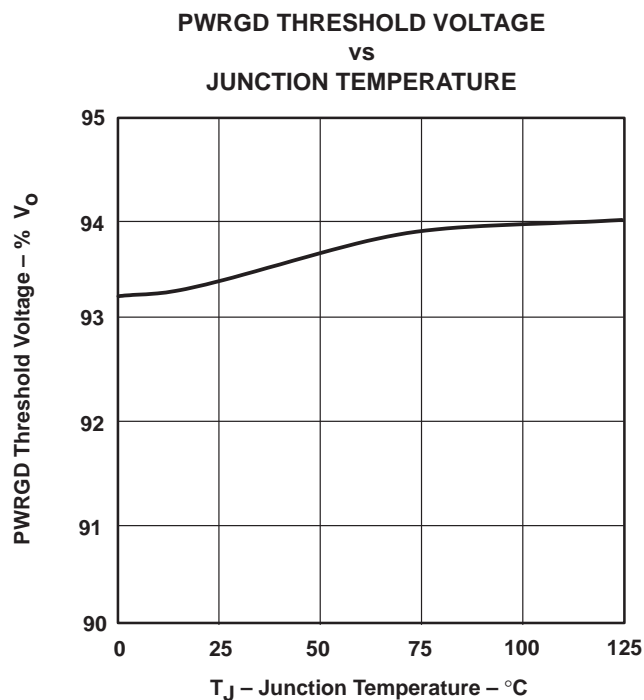
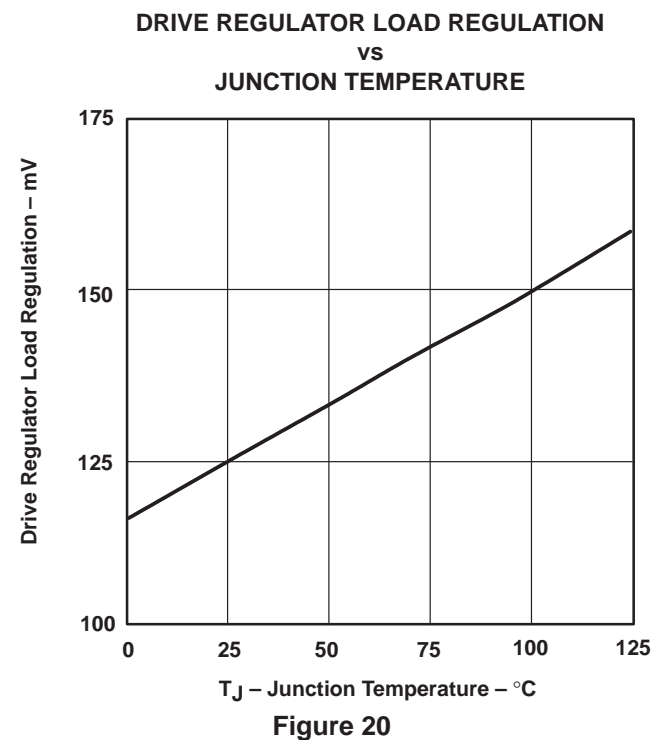
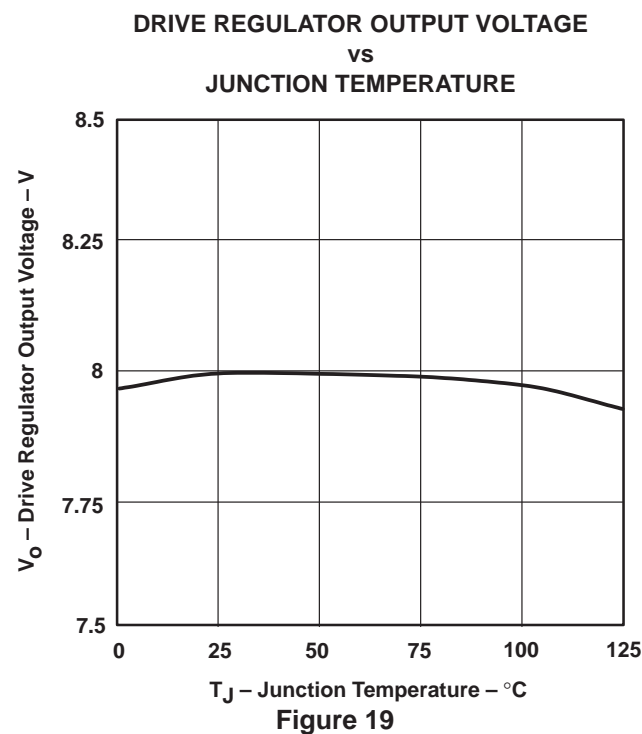
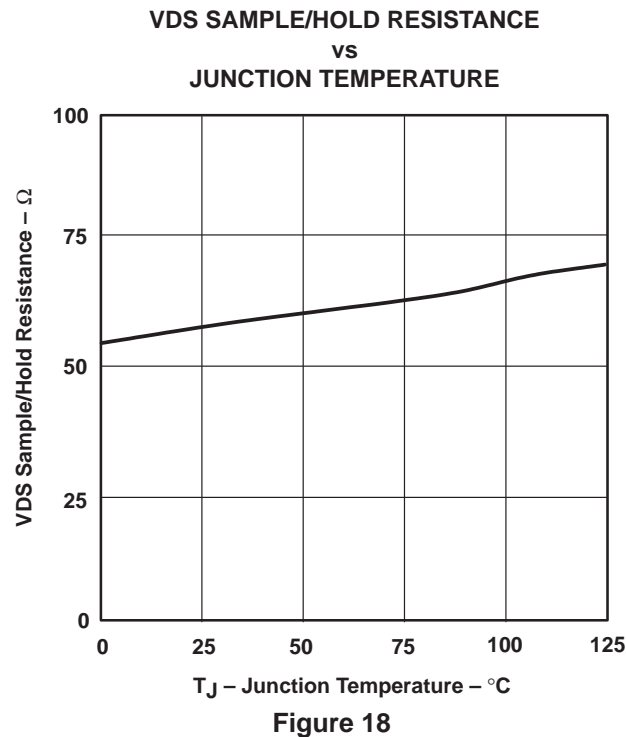
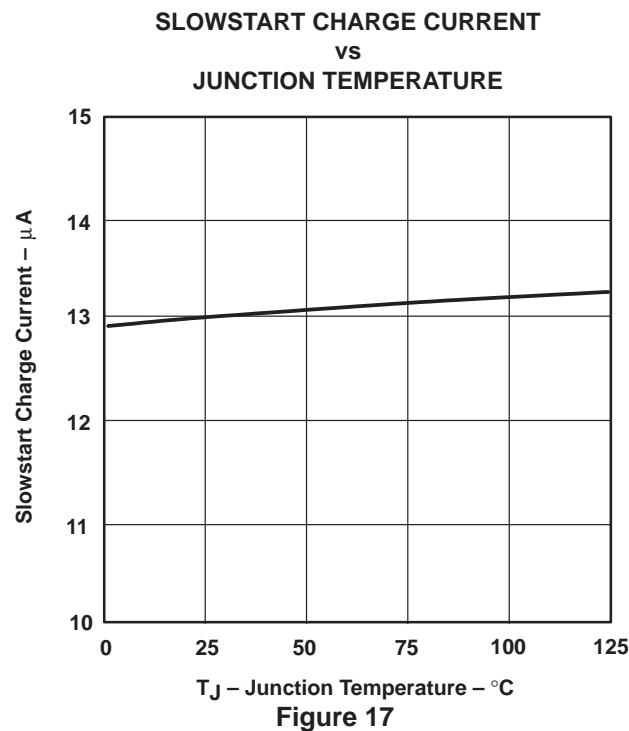


Figure 16

TPS5615, TPS5618, TPS5625, TPS5633
SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

TYPICAL CHARACTERISTICS



TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

TYPICAL CHARACTERISTICS

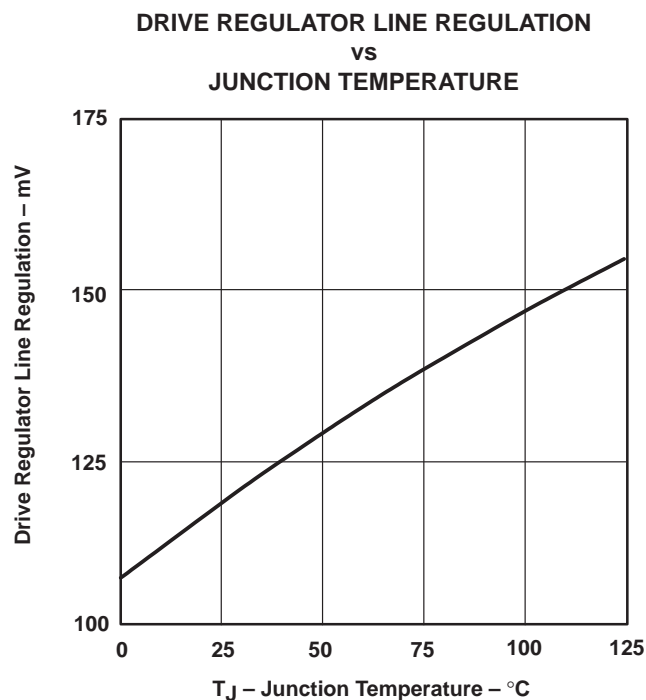


Figure 21

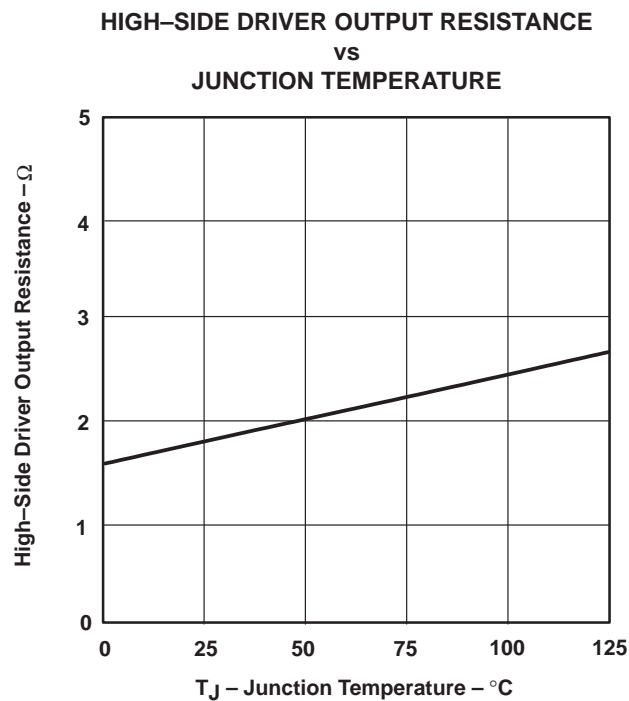


Figure 22

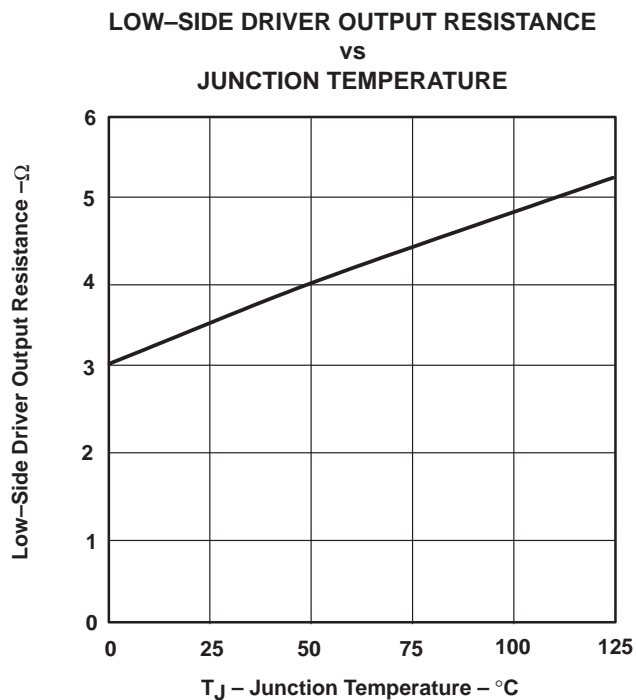


Figure 23

TPS5615, TPS5618, TPS5625, TPS5633

SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

APPLICATION INFORMATION

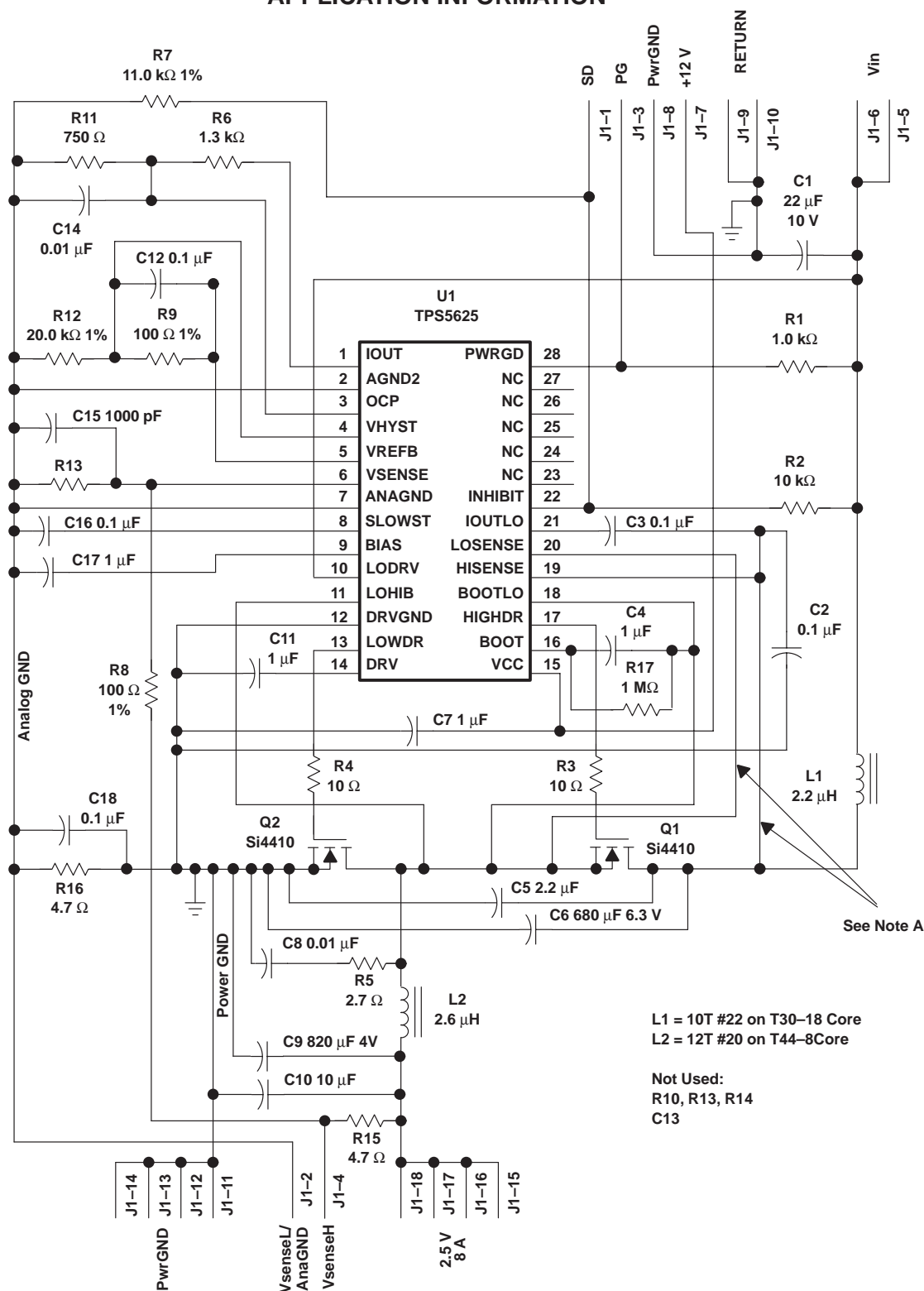
Synchronous rectifier buck regulator circuits are used where high efficiency and low dropout voltages are required. The TPS56xx controller is useful in applications with very high transient loads and wide dc load ranges, such as multiple-DSP applications.

The circuit below will meet a wide variety of applications with maximum continuous-rated output currents of up to 8 A. Design tradeoffs, such as cost, size, or efficiency may need to be addressed for specific applications. Care should be taken in the proper layout (see last section of this data sheet for specific layout guidelines), especially in the higher-current configurations, to ensure that noise and ripple are kept to a minimum. Basic layout considerations are discussed in the *1996 Power Supply Circuits Databook* (Literature no. SLVD002). Design guidelines and equations are discussed in *Synchronous Buck Converter Design Using TPS56xx Controllers in SLVP10x EVMs User's Guide* (Literature no. SLVU007).

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

APPLICATION INFORMATION



NOTE A: These two traces should be physically close to each other for good noise immunity.

Figure 24. Typical Design Schematic

TPS5615, TPS5618, TPS5625, TPS5633

SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

Table 1. Test Results for 2.5-V, 8-A Converter

TEST	CONDITIONS	QTY	UNITS
Output voltage	$V_{IN} = 5.25\text{ V}$, $I_O = 8\text{ A}$	2.50	V
Load regulation	$V_{IN} = 5.25\text{ V}$, $I_O = 0.8\text{ to }8\text{ A}$	0.4	%
Line regulation	$I_O = 6\text{ A}$, $V_{CC} = 4.5\text{ V to }6\text{ V}$	0.2	%
Ripple	$V_{IN} = 5.25\text{ V}$, $I_O = 8\text{ A}$	50	mVpp
Efficiency	$V_{IN} = 5.25\text{ V}$, $I_O = 8\text{ A}$	89	%

Table 2. 2.5-V, 8-A Converter Bill of Materials

REF DES	QTY	PART NUMBER	DESCRIPTION	MFG
C1	1	10SS22M	Capacitor, Os-Con, 22 μF , 10 V, 20%	Sanyo
C2	4	GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μF , 16 V, 10%, X7R	muRata
C3		GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μF , 16 V, 10%, X7R	muRata
C4	4	GRM42-6Y5V105Z016A	Capacitor, Ceramic, 1 μF , 16 V, +80%–20%	muRata
C5	1	GRM42-6Y5V225Z016A	Capacitor, Os-Con, 2.2 μF , 16 V, Y5U	muRata
C6	1	6SP680M	Capacitor, Os-Con, 680 μF , 6.3 V, 20%	Sanyo
C7		GRM42-6Y5V105Z016A	Capacitor, Ceramic, 1 μF , 16 V, +80%–20%	muRata
C8	2	GRM39X7R103K025A	Capacitor, Ceramic, 0.01 μF , 25 V, 10%, X7R	muRata
C9	1	4SP820M	Capacitor, Os-Con, 820 μF , 4 V, 20%	Sanyo
C10	1	GRM235Y5V106Z016A	Capacitor, Ceramic, 10 μF , 16 V, Y5V	muRata
C11		GRM42-6Y5V105Z016A	Capacitor, Ceramic, 1 μF , 16 V, +80%–20%	muRata
C12		GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μF , 16 V, 10%, X7R	muRata
C14		GRM39X7R103K025A	Capacitor, Ceramic, 0.01 μF , 25 V, 10%, X7R	muRata
C15	1	GRM39X7R102K050A	Capacitor, Ceramic, 1000 pF, 50 V, 10%, X7R	muRata
C16		GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μF , 16 V, 10%, X7R	muRata
C17		GRM42-6Y5V105Z016A	Capacitor, Ceramic, 1 μF , 16 V, +80%–20%	muRata
C18		GRM39X7R104K016A	Capacitor, Ceramic, 0.1 μF , 16 V, 10%, X7R	muRata
J1	1	S1122-18-ND	Header, RA, 18-pin, 0.23 Posts \times 0.20 Tails	Sullins
L1	1		Inductor, Filter, 2.2 μH , 8.5 A (10T #22 on T30-18 Core)	
L2	1		Inductor, Filter, 2.6 μH , 8.5 A (12T #20 on T44-8 Core)	
Q1	2	Si4410DY	FET, N-ch, 30-V, 10-A, 13-m Ω	Siliconix
Q2		Si4410DY	FET, N-ch, 30-V, 10-A, 13-m Ω	Siliconix
R1	3	Std	Resistor, Chip, 1.0 k Ω , 1/16W, 5%	
R2	1	Std	Resistor, Chip, 10 k Ω , 1/16W, 5%	
R3	2	Std	Resistor, Chip, 10 Ω , 1/10W, 5%	
R4		Std	Resistor, Chip, 10 Ω , 1/10W, 5%	
R5	1	Std	Resistor, Chip, 2.7 Ω , 1/4W, 5%	
R6		Std	Resistor, Chip, 1.3 k Ω , 1/16W, 5%	
R7	1	Std	Resistor, Chip, 11.0 k Ω , 1/16W, 1%	
R8	2	Std	Resistor, Chip, 100 Ω , 1/16W, 1%	
R9		Std	Resistor, Chip, 100 Ω , 1/16W, 1%	
R11		Std	Resistor, Chip, 750 Ω , 1/16W, 5%	
R12	1	Std	Resistor, Chip, 20.0 k Ω , 1/16W, 1%	
R15	2	Std	Resistor, Chip, 4.7 Ω , 1/16W, 5%	
R16		Std	Resistor, Chip, 4.7 Ω , 1/16W, 5%	
R17	1	Std	Resistor, Chip, 1 M Ω , 1/16W, 5%	
U1	1	TPS5625PWP	IC, PWM Ripple Controller, Fixed 2.5 V	TI

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

APPLICATION INFORMATION

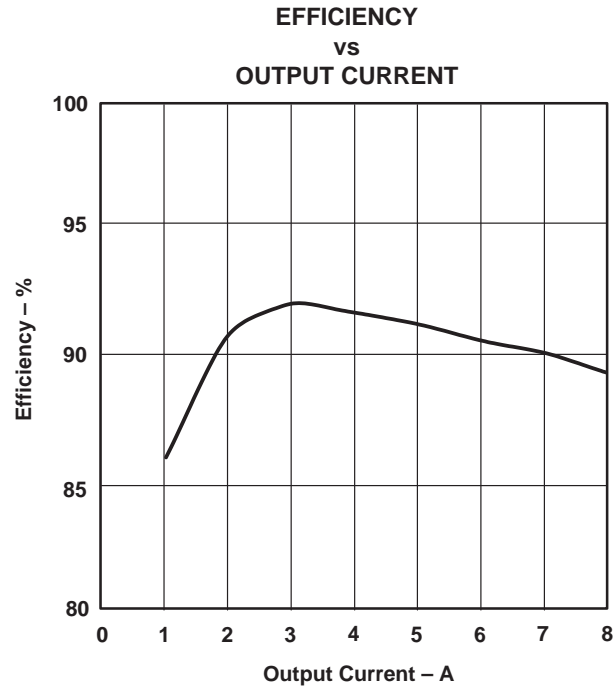


Figure 25

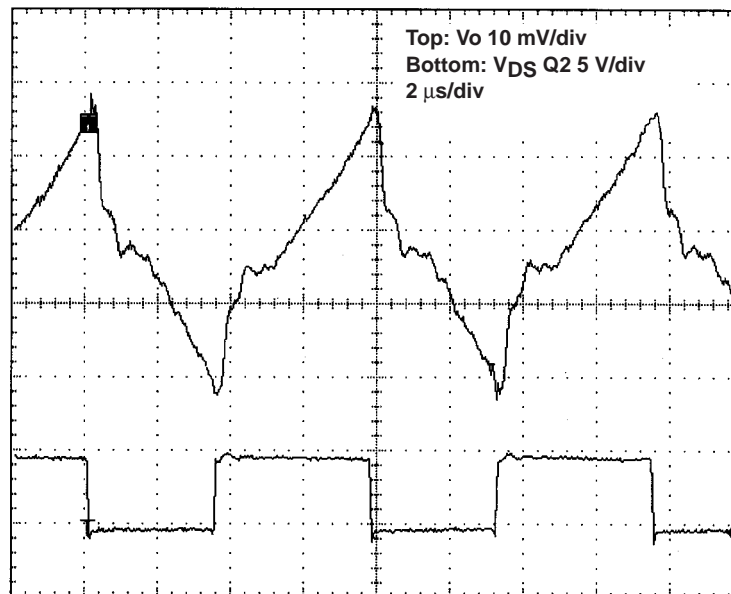


Figure 26. Output Voltage Ripple at 8 A

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

APPLICATION INFORMATION

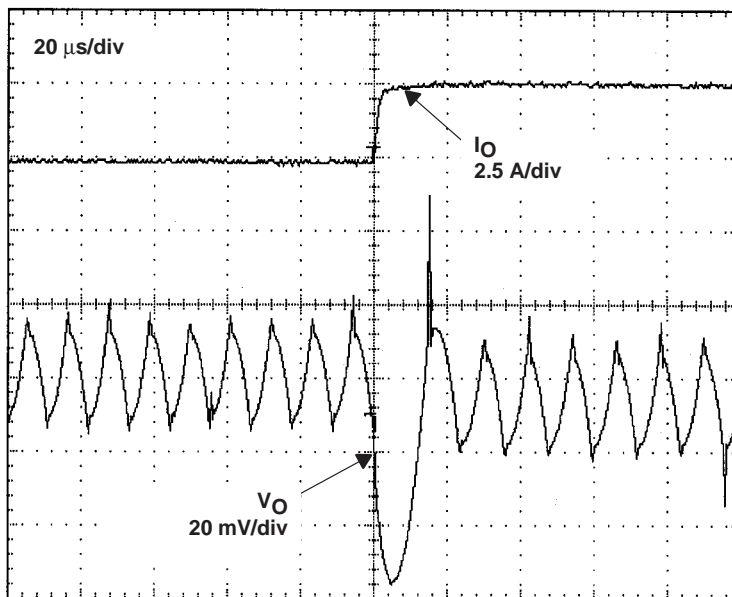


Figure 27. Rising Load Transient Response

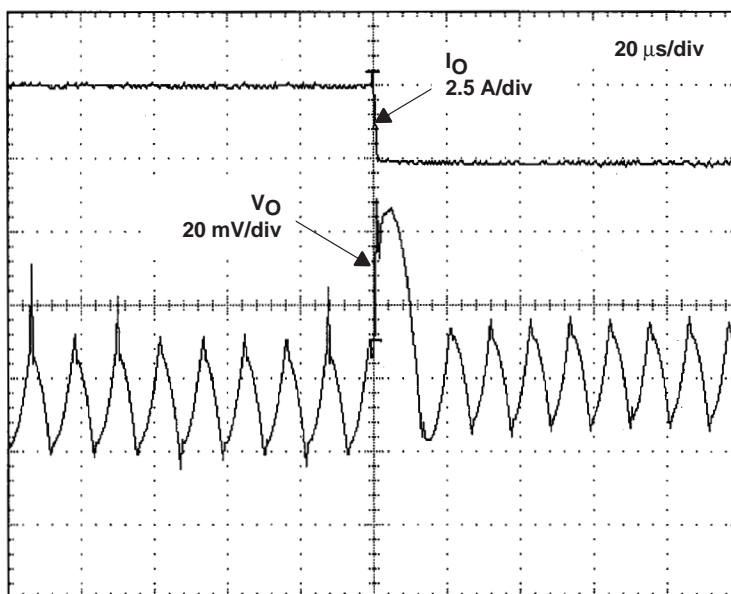


Figure 28. Falling Load Transient Response

TPS5615, TPS5618, TPS5625, TPS5633 SYNCHRONOUS-BUCK HYSTERETIC REGULATOR CONTROLLER

SLVS177B – SEPTEMBER 1998 – REVISED JULY 2000

APPLICATION INFORMATION

layout guidelines

Good power supply results will only occur when care is given to proper design and layout. Layout will affect noise pickup and generation and can cause a good design to perform with less than expected results. With a range of currents from milliamps to tens or even hundreds of amps, good power supply layout is much more difficult than most general PCB design. The general design should proceed from the switching node to the output, then back to the driver section and, finally, place the low-level components. Below are several specific points to consider before layout of a TPS56xx design begins.

1. All sensitive analog components should be referenced to ANAGND. These include components connected to SLOWST, IOUT, OCP, VSENSE, VREFB, VHYST, BIAS, and LOHIB.
2. Analog ground and drive ground should be isolated as much as possible. Ideally, analog ground will connect to the ground side of the bulk storage capacitors, on V_O , and drive ground will connect to the main ground plane close to the source of the low-side FET.
3. Connections from the drivers to the gate of the power FETs should be as short and wide as possible to reduce stray inductance. This becomes more critical if external gate resistors are not being used.
4. The bypass capacitor for the DRV regulator should be placed close to the TPS56xx and be connected to DRVGND.
5. The bypass capacitor for V_{CC} should be placed close to the TPS56xx and be connected to DRVGND.
6. When configuring the high-side driver as a floating driver, the connection from BOOTLO to the power FETs should be as short and as wide as possible. The other pins that also connect to the power FETs, LOHIB and LOSENSE, should have a separate connection to the FETs, since BOOTLO will have large peak currents flowing through it.
7. When configuring the high-side driver as a floating driver, the bootstrap capacitor (connected from BOOT to BOOTLO) should be placed close to the TPS56xx.
8. When configuring the high-side driver as a ground referenced driver, BOOTLO should be connected to DRVGND.
9. The bulk storage capacitors across V_I should be placed close to the power FETs. High-frequency bypass capacitors should be placed in parallel with the bulk capacitors and connected close to the drain of the high-side FET and close to the source of the low-side FET.
10. High-frequency bypass capacitors should be placed across the bulk storage capacitors on V_O .
11. HISENSE and LOSENSE should be connected very close to the drain and source, respectively, of the high-side FET. HISENSE and LOSENSE should be routed very close to each other to minimize differential-mode noise coupling to these traces.

MECHANICAL DATA

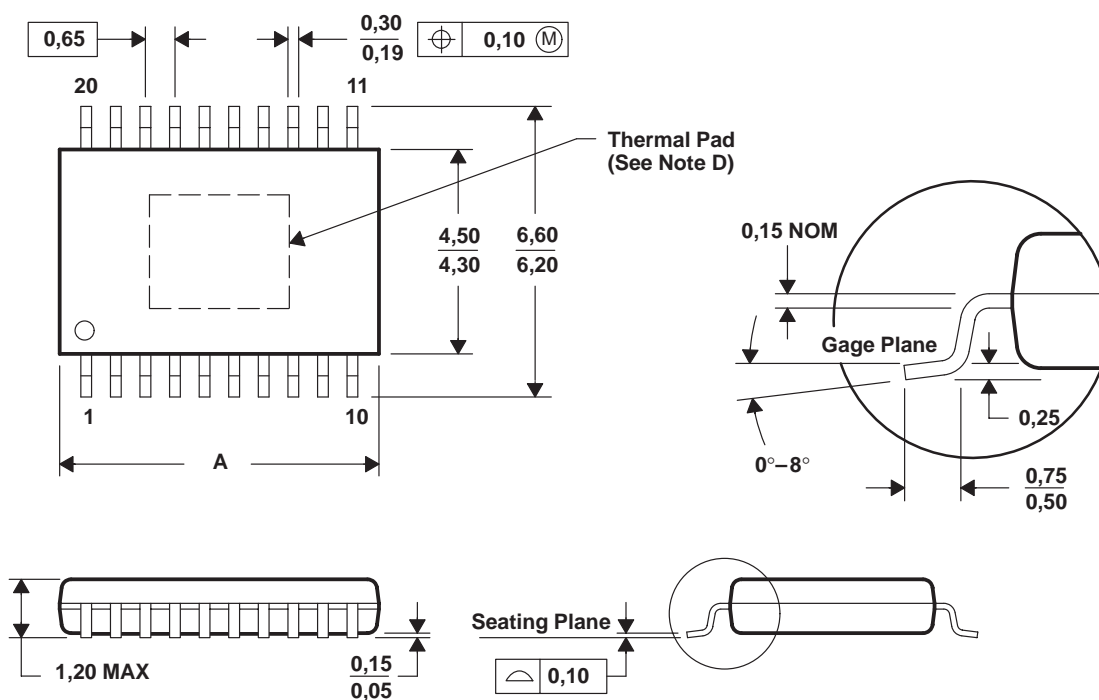
MHTS001D – JANUARY 1995 – REVISED MAY 1999

MECHANICAL DATA

PWP (R-PDSO-G^{})**

PowerPAD™ PLASTIC SMALL-OUTLINE

20 PINS SHOWN



PINS ** DIM	14	16	20	24	28
A MAX	5,10	5,10	6,60	7,90	9,80
A MIN	4,90	4,90	6,40	7,70	9,60

4073225/F 10/98

- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusions.
 - D. The package thermal performance may be enhanced by bonding the thermal pad to an external thermal plane. This pad is electrically and thermally connected to the backside of the die and possibly selected leads.
 - E. Falls within JEDEC MO-153

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Customers are responsible for their applications using TI components.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.