

Off-Line Quasi-Resonant Switching Regulators

Features and Benefits

- Quasi-resonant topology IC \Rightarrow Low EMI noise and soft switching
- Bottom-skip mode \Rightarrow Improved system efficiency over the entire output load by avoiding increase of switching frequency
- Auto-Standby mode \Rightarrow Lowers input power at very light output load condition
- Avalanche-guaranteed MOSFET \Rightarrow Improves system-level reliability and does not require V_{DSS} derating
- $800 V_{DSS} / 0.66 \Omega R_{DS(on)}$
- Various protections \Rightarrow Improved system-level reliability
 - Pulse-by-pulse drain overcurrent limiting
 - Overvoltage Protection (bias winding voltage sensing), with latch
 - Overload Protection with latch
 - Maximum on-time limit

Package: 7-Pin TO-3P



Not to scale

Description

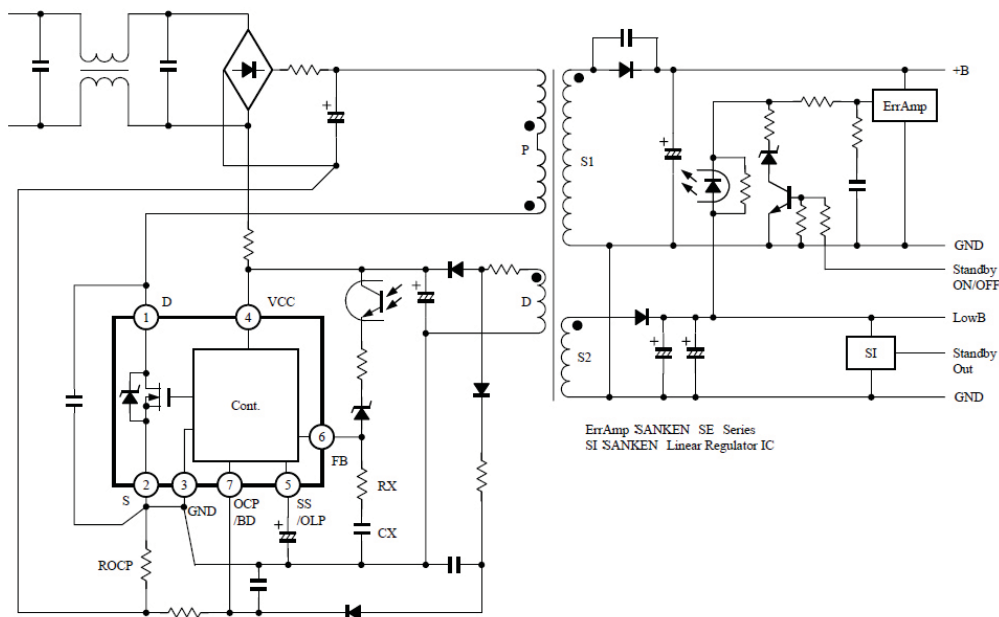
The STR-X6769 is a quasi-resonant topology IC designed for SMPS applications. It shows lower EMI noise characteristics than conventional PWM solutions, especially at greater than 2 MHz. It also provides a soft-switching mode to turn on the internal MOSFET at close to zero voltage (V_{DS} bottom point) by use of the resonant characteristic of primary inductance and a resonant capacitor.

The package is a fully molded TO-3P, which contains the controller chip (MIC) and MOSFET, enabling output power up to 310 W at 230 VAC and 210 W at universal input. The bottom-skip mode skips the first bottom of V_{DS} and turns on the MOSFET at the second bottom point, to minimize an increase of operating frequency at light output load, improving system-level efficiency over the entire load range.

There are two standby functions available to reduce the input power under very light load conditions. The first is Auto-Standby mode, which is internally triggered by periodic sensing, and the other is a manual standby mode, which is executed by clamping the secondary output. In general applications, the manual standby mode reduces the input power further compared to Auto-Standby mode.

Continued on the next page...

Typical Application



Description (continued)

The soft-start mode minimizes surge voltage and reduces power stress to the MOSFET and to the secondary rectifying diodes during the start-up sequence. Various protections such as overvoltage, overload, overcurrent, maximum on-time protections and avalanche-energy-guaranteed MOSFET secure good system-level reliability.

Applications include the following:

- Set Top Box
- LCD PC monitor, LCD TV
- Printer, Scanner
- SMPS power supplies

Selection Guide

| Part Number | Package |
|-------------|---------|
| STR-X6769 | TO-3P |

Absolute Maximum Ratings at $T_A = 25^\circ\text{C}$

| Parameter | Symbol | Conditions | Rating | Unit |
|--|--------------------|---|-------------|------------------|
| Drain Current ¹ | $I_{D\text{peak}}$ | Single pulse | 22 | A |
| Maximum Switching Current ² | $I_{D\text{max}}$ | $T_A = -20^\circ\text{C}$ to 125°C | 22 | A |
| Single Pulse Avalanche Energy ³ | E_{AS} | Single pulse, $V_{DD} = 30\text{ V}$, $L = 50\text{ mH}$, $I_{L\text{peak}} = 3.9\text{ A}$ | 395 | mJ |
| Input Voltage for Controller (MIC) | V_{CC} | | 35 | V |
| SS/OLP Terminal Voltage | $V_{SS\text{OLP}}$ | | -0.5 to 6.0 | V |
| FB Terminal Inflow Current | I_{FB} | | 10 | mA |
| FB Terminal Voltage | V_{FB} | I_{FB} within the limits of I_{FB} | -0.5 to 9.0 | V |
| OCP/BD Terminal Voltage | $V_{OCP\text{BD}}$ | | -1.5 to 5.0 | V |
| MOSFET Power Dissipation ⁴ | P_{D1} | With infinite heatsink Without heatsink | 46 2.8 | W W |
| Controller (MIC) Power Dissipation | P_{D2} | $V_{CC} \times I_{CC}$ | 0.8 | W |
| Operating Internal Leadframe Temperature | T_F | Recommended operation temperature, see cautions | -20 to 125 | $^\circ\text{C}$ |
| Operating Ambient Temperature | T_{OP} | | -20 to 125 | $^\circ\text{C}$ |
| Storage Temperature | T_{stg} | | -40 to 125 | $^\circ\text{C}$ |
| Channel Temperature | T_{ch} | | 150 | $^\circ\text{C}$ |

¹Refer to MOSFET ASO curve

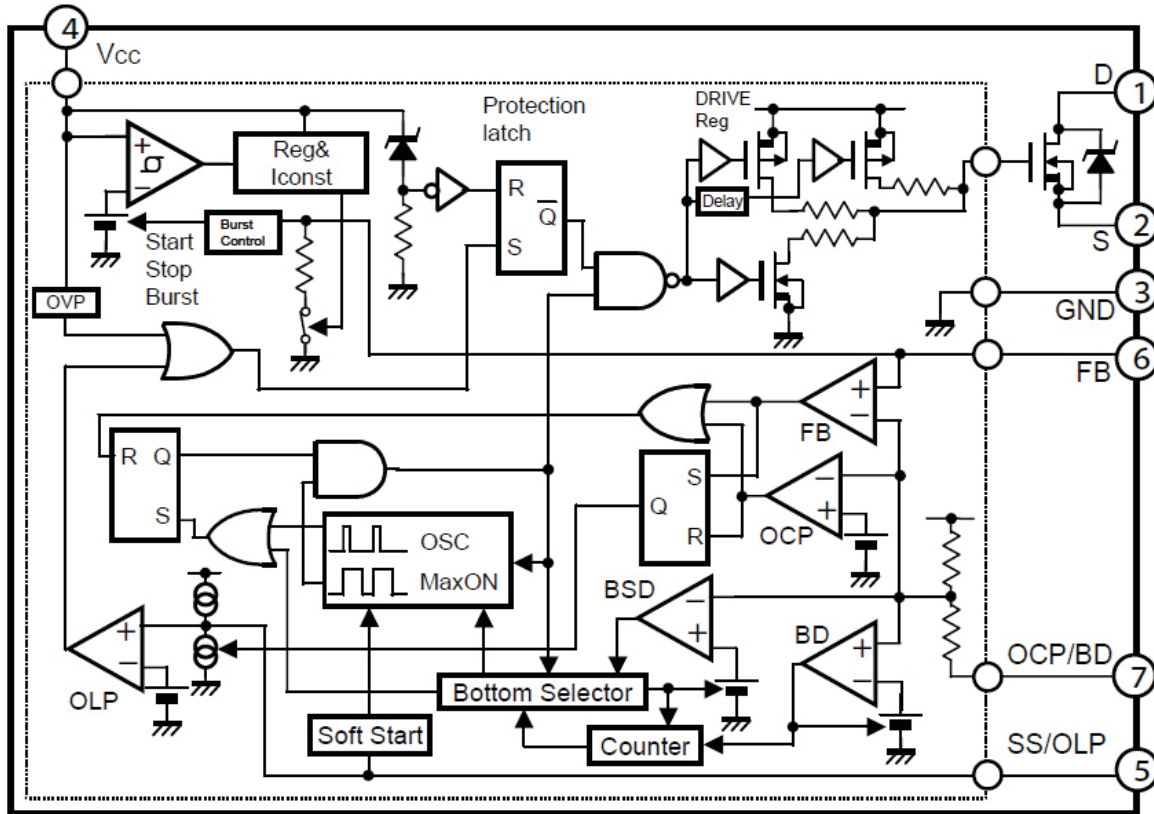
² $I_{D\text{MAX}}$ is the drain current determined by the drive voltage of the IC and the threshold voltage, V_{th} , of the MOSFET

³Refer to Avalanche Energy Derating curve

⁴Refer to MOSFET T_a - P_{D1} curve

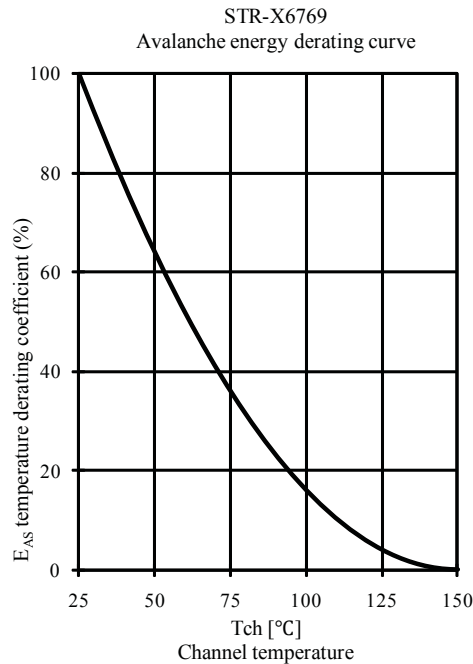
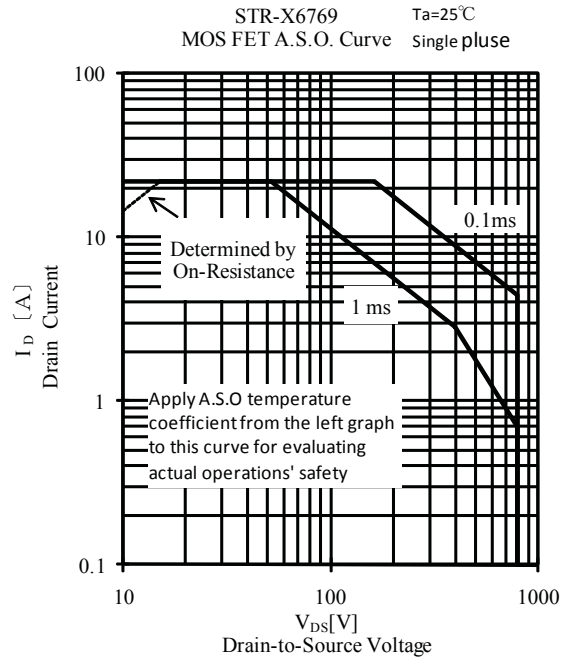
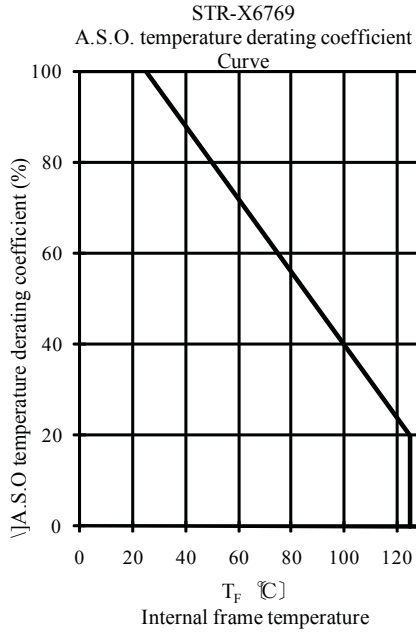
All performance characteristics given are typical values for circuit or system baseline design only and are at the nominal operating voltage and an ambient temperature, T_A , of 25°C , unless otherwise stated.

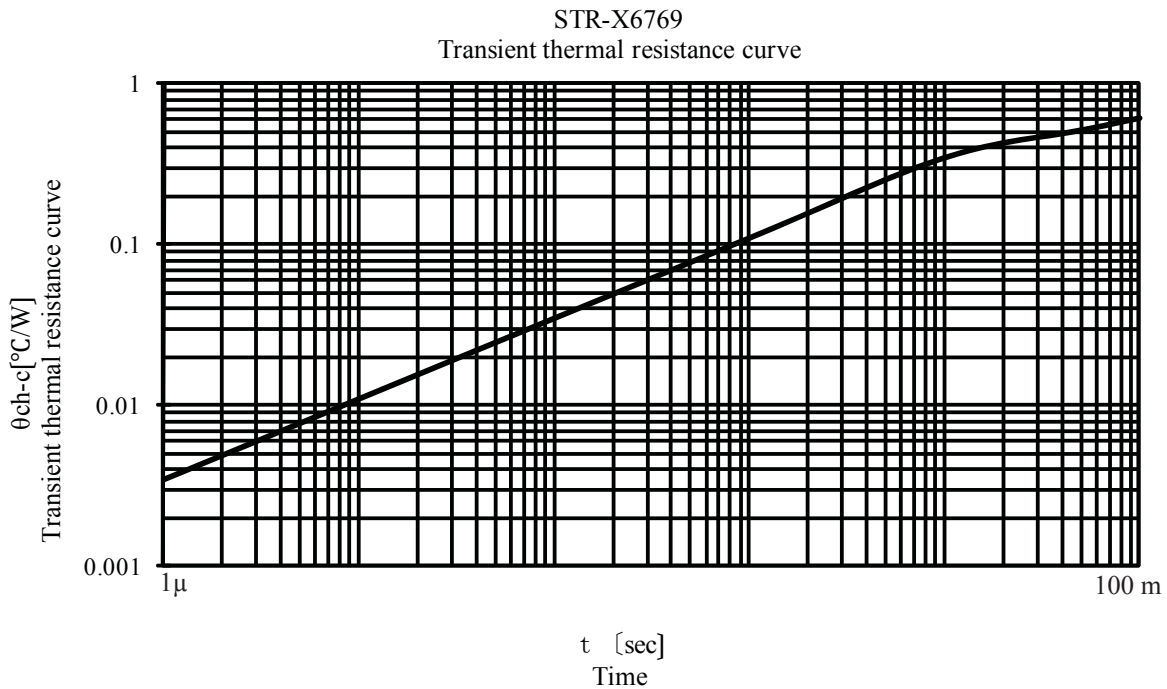
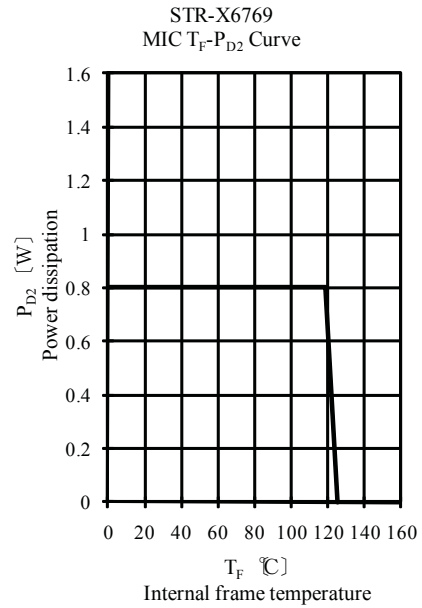
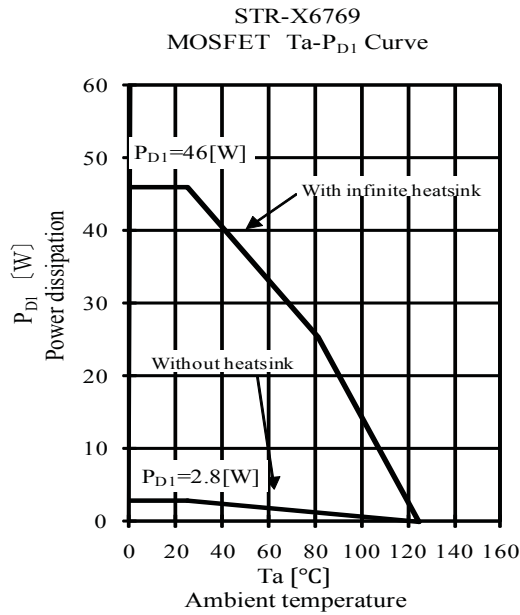
Functional Block Diagram



Terminal List Table

| Number | Name | Description | Functions |
|--------|--------|---|--|
| 1 | D | Drain | MOSFET drain |
| 2 | S | Source | MOSFET source |
| 3 | GND | Ground terminal | Ground |
| 4 | VCC | Power supply terminal | Input of power supply for control circuit |
| 5 | SS/OLP | Soft Start/Overload Protection terminal | Input to set delay for Overload Protection and Soft Start operation |
| 6 | FB | Feedback terminal | Input for Constant Voltage Control and Burst (intermittent) Mode oscillation control signals |
| 7 | OCP/BD | Overcurrent Protection/Bottom Detection | Input for Overcurrent Detection and Bottom Detection signals |





ELECTRICAL CHARACTERISTICS

| Characteristic | Symbol | Test Conditions | Min. | Typ. | Max. | Units |
|--|-------------------|--|--------|--------|--------|--------------------|
| ELECTRICAL CHARACTERISTICS for Controller (MIC)¹ , valid at $T_A = 25^\circ\text{C}$, $V_{CC} = 20\text{ V}$, unless otherwise specified | | | | | | |
| Power Supply Start-up Operation | | | | | | |
| Operation Start Voltage | $V_{CC(ON)}$ | $V_{CC} = 0 \rightarrow 20\text{ V}$ | 16.3 | 18.2 | 19.9 | V |
| Operation Stop Voltage | $V_{CC(OFF)}$ | $V_{CC} = 20 \rightarrow 8.8\text{ V}$ | 8.8 | 9.7 | 10.6 | V |
| Circuit Current In Operation | $I_{CC(ON)}$ | | – | – | 6 | mA |
| Circuit Current In Non-Operation | $I_{CC(OFF)}$ | $V_{CC} = 15\text{ V}$ | – | – | 100 | μA |
| Oscillation Frequency | f_{osc} | | 19 | 22 | 25 | kHz |
| Soft Start Operation Stop Voltage | $V_{SSOLP(SS)}$ | $V_{SS/OLP}$ increasing | 1.1 | 1.2 | 1.4 | V |
| Soft Start Operation Charging Current | $I_{SSOLP(SS)}$ | $V_{SS/OLP} = 0\text{ V}$ | –710 | –550 | –390 | μA |
| Normal Operation | | | | | | |
| Bottom-Skip Operation Threshold Voltage 1 | $V_{OCPBD(BS1)}$ | | –0.720 | –0.665 | –0.605 | V |
| Bottom-Skip Operation Threshold Voltage 2 | $V_{OCPBD(BS2)}$ | | –0.485 | –0.435 | –0.385 | V |
| Overcurrent Detection Threshold Voltage | $V_{OCPBD(LIM)}$ | $V_{OCP/BD}$ falling | –0.995 | –0.940 | –0.895 | V |
| OCP/BD Terminal Outflow Current | I_{OCPBD} | $V_{OCP/BD} = -0.95\text{ V}$ | –250 | –100 | –40 | μA |
| Quasi-Resonant Operation Threshold Voltage 1 | $V_{OCPBD(TH1)}$ | $V_{OCP/BD}$ falling | 0.28 | 0.40 | 0.52 | V |
| Quasi-Resonant Operation Threshold Voltage 2 | $V_{OCPBD(TH2)}$ | $V_{OCP/BD}$ rising | 0.67 | 0.80 | 0.93 | V |
| FB Terminal Threshold Voltage | $V_{FB(OFF)}$ | V_{FB} rising | 1.32 | 1.45 | 1.58 | V |
| FB Terminal Inflow Current (Normal Operation) | $I_{FB(ON)}$ | $V_{FB} = 1.6\text{ V}$ | 600 | 1000 | 1400 | μA |
| Standby Operation | | | | | | |
| Standby Operation Start Voltage | $V_{CC(S)}$ | $V_{CC} = 0 \rightarrow 15\text{ V}$, $V_{FB} = 1.6\text{ V}$ | 10.3 | 11.2 | 12.1 | V |
| Standby Operation Start Voltage Interval | $V_{CC(SK)}$ | $V_{CC(SK)} = V_{CC(S)} - V_{CC(OFF)}$ | 1.10 | 1.35 | 1.65 | V |
| Standby Non-Operation Circuit Current | $I_{CC(S)}$ | $V_{CC} = 10.2\text{ V}$, $V_{FB} = 1.6\text{ V}$ | – | 20 | 56 | μA |
| FB Terminal Inflow Current, Standby Operation | $I_{FB(S)}$ | $V_{CC} = 10.2\text{ V}$, $V_{FB} = 1.6\text{ V}$ | – | 4 | 14 | μA |
| FB Terminal Threshold Voltage, Standby Operation | $V_{FB(S)}$ | $V_{CC} = 15\text{ V}$, V_{FB} rising | 0.55 | 1.10 | 1.50 | V |
| Minimum On Time | $t_{ON(MIN)}$ | | 0.35 | 1.00 | 1.50 | μs |
| Protection Operation | | | | | | |
| Maximum On Time | $t_{ON(MAX)}$ | | 27.5 | 32.5 | 39.0 | μs |
| Overload Protection Operation Threshold Voltage | $V_{SSOLP(OLP)}$ | | 4.0 | 4.9 | 5.8 | V |
| Overload Protection Operation Charging Current | $I_{SSOLP(OLP)}$ | $V_{SS/OLP} = 2.5\text{ V}$ | –16 | –11 | –6 | μA |
| Overvoltage Protection Operation Voltage | $V_{CC(OVP)}$ | $V_{CC} = 0 \rightarrow 30\text{ V}$ | 25.5 | 27.7 | 29.9 | V |
| Latch Circuit Holding Current ² | $I_{CC(H)}$ | $V_{CC(OFF)} - 0.3\text{ V}$ | – | 45 | 140 | μA |
| Latch Circuit Release Voltage ² | $V_{CC(La.OFF)}$ | $V_{CC} = 30 \rightarrow 6\text{ V}$, OVP operating | 6.0 | 7.2 | 8.5 | V |
| ELECTRICAL CHARACTERISTICS for MOSFET , valid at $T_A = 25^\circ\text{C}$, unless otherwise specified | | | | | | |
| Drain-to-Source Breakdown Voltage | V_{DSS} | $I_{DSS} = 300\text{ }\mu\text{A}$ | 800 | – | – | V |
| Drain Leakage Current | I_{DSS} | $V_{DSS} = 800\text{ V}$ | – | – | 300 | μA |
| On Resistance | $R_{DS(on)}$ | $I_{DS} = 3.0\text{ A}$ | – | – | 0.66 | Ω |
| Switching Time | t_f | | – | – | 700 | ns |
| Thermal Resistance | $R_{\theta ch-F}$ | Channel to internal frame | – | – | 0.99 | $^\circ\text{C/W}$ |

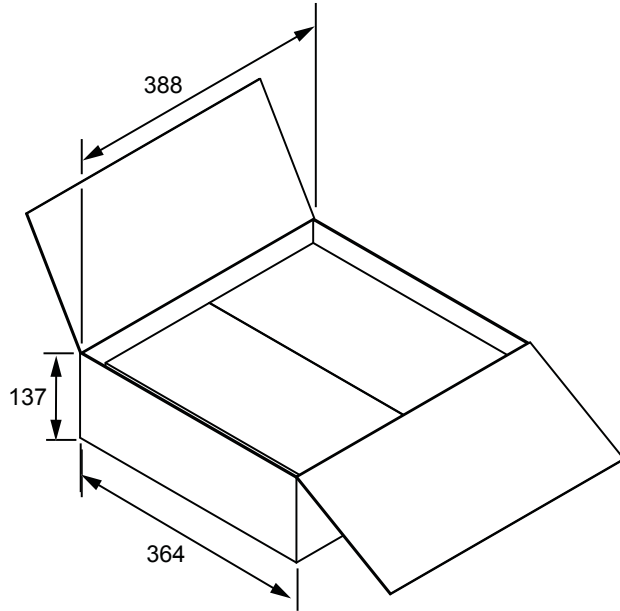
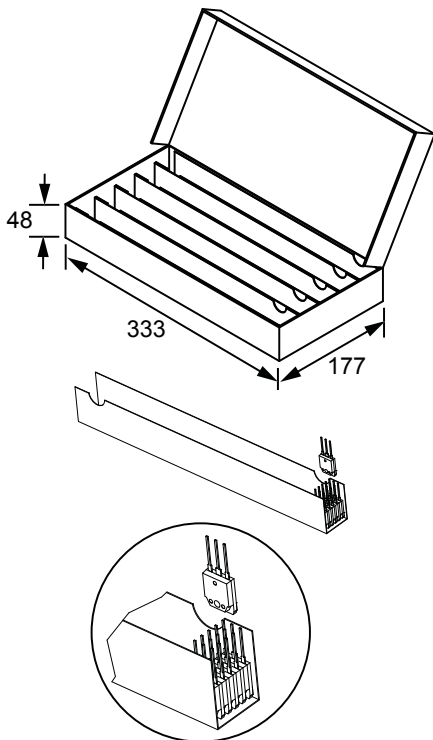
¹Current polarity with respect to the IC: positive current indicates current sink at the terminal named, negative current indicates source at the terminal named.

²The latch circuit means a circuit operated OVP and OLP.

Packing Specifications

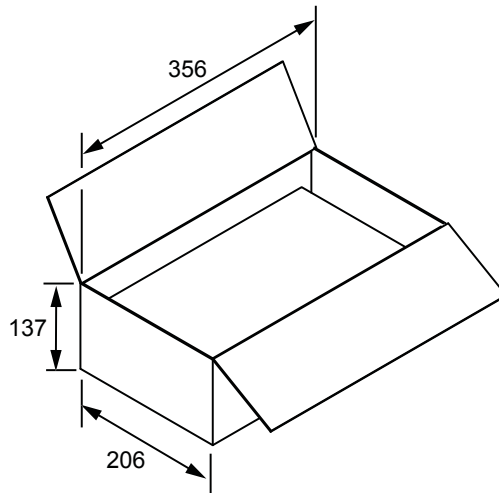
100 pieces per tray
5 trays per inner carton
(Outer packing dependent on quantity)

Dimensions in millimeters



4 inner cartons per outer carton
500 pieces maximum per inner carton
2000 pieces maximum per outer carton

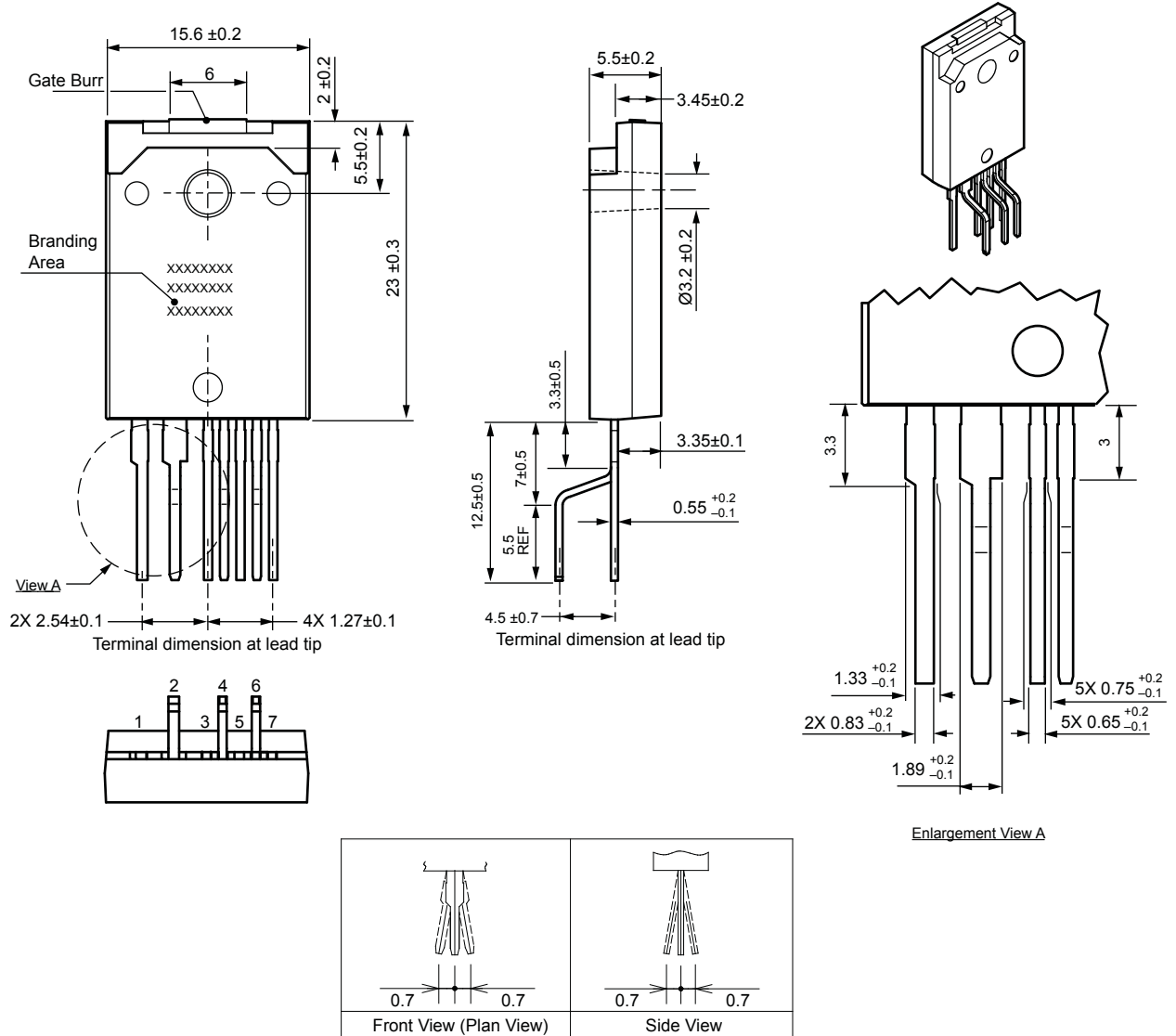
Dimensions in millimeters



2 inner cartons per outer carton
500 pieces maximum per inner carton
1000 pieces maximum per outer carton

Dimensions in millimeters

Package Outline Drawing, TO-3P



Gate burr: 0.3 mm (max.)
 Terminal core material: Cu
 Terminal treatment: Ni plating and Pb-free solder dip
 Leadform: 1901

Approximate weight: 6 g

Dimensions in millimeters

Drawing for reference only

Branding codes (exact appearance at manufacturer discretion):

1st line, type: STR

2nd line, subtype: X6769

3rd line, lot: YM DD

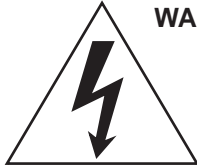
Where: Y is the last digit of the year of manufacture

M is the month (1 to 9, O, N, D)

DD is the 2-digit date



Leadframe plating Pb-free. Device composition includes high-temperature solder (Pb >85%), which is exempted from the RoHS directive.



WARNING — These devices are designed to be operated at lethal voltages and energy levels. Circuit designs that embody these components must conform with applicable safety requirements. Precautions must be taken to prevent accidental contact with power-line potentials.

The use of an isolation transformer is recommended during circuit development and breadboarding.

Because reliability can be affected adversely by improper storage environments and handling methods, please observe the following cautions.

Cautions for Storage

- Ensure that storage conditions comply with the standard temperature (5°C to 35°C) and the standard relative humidity (around 40 to 75%); avoid storage locations that experience extreme changes in temperature or humidity.
- Avoid locations where dust or harmful gases are present and avoid direct sunlight.
- Reinspect for rust on leads and solderability of products that have been stored for a long time.

Cautions for Testing and Handling

When tests are carried out during inspection testing and other standard test periods, protect the products from power surges from the testing device, shorts between adjacent products, and shorts to the heatsink.

Remarks About Using Silicone Grease with a Heatsink

- When silicone grease is used in mounting this product on a heatsink, it shall be applied evenly and thinly. If more silicone grease than required is applied, it may produce stress.
- Coat the back surface of the product and both surfaces of the insulating plate to improve heat transfer between the product and the heatsink.
- Volatile-type silicone greases may permeate the product and produce cracks after long periods of time, resulting in reduced heat radiation effect, and possibly shortening the lifetime of the product.
- Our recommended silicone greases for heat radiation purposes, which will not cause any adverse effect on the product life, are indicated below:

| Type | Suppliers |
|--------|--------------------------------------|
| G746 | Shin-Etsu Chemical Co., Ltd. |
| YG6260 | Momentive Performance Materials |
| SC102 | Dow Corning Toray Silicone Co., Ltd. |

Heatsink Mounting Method

- Torque When Tightening Mounting Screws. Thermal resistance

Recommended operation temperature

- Inner frame temperature in operation $T_F = 115^\circ\text{C}$

increases when tightening torque is low, and radiation effects are decreased. When the torque is too high, the screw can strip, the heatsink can be deformed, and distortion can arise in the product frame. To avoid these problems, observe the recommended tightening torques for this product package type, TO-3P: 0.588 to 0.785 N•m (6 to 8 kgf•cm).

- For effective heat transfer, the contact area between the product and the heatsink should be free from burrs and metal fragments, and the heatsink should be flat and large enough to contact over the entire side of the product, including mounting flange and exposed thermal pad, and have a minimal mounting hole to prevent possible deflection and cracking of the product case when fastened to the heatsink.

Soldering

- When soldering the products, please be sure to minimize the working time, within the following limits:

260±5°C 10 s

350±5°C 3 s

- Soldering iron should be at a distance of at least 1.5 mm from the body of the products

Electrostatic Discharge

- When handling the products, operator must be grounded. Grounded wrist straps worn should have at least 1 MΩ of resistance to ground to prevent shock hazard.
- Workbenches where the products are handled should be grounded and be provided with conductive table and floor mats.
- When using measuring equipment such as a curve tracer, the equipment should be grounded.
- When soldering the products, the head of soldering irons or the solder bath must be grounded in order to prevent leak voltages generated by them from being applied to the products.
- The products should always be stored and transported in our shipping containers or conductive containers, or be wrapped in aluminum foil.

The products described herein are manufactured in Japan by Sanken Electric Co., Ltd. for sale by Allegro MicroSystems, Inc.

Sanken and Allegro reserve the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the performance, reliability, or manufacturability of its products. Therefore, the user is cautioned to verify that the information in this publication is current before placing any order.

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