

## 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
- 500  $V_{DSS}$  / 0.36  $\Omega$   $R_{DS(on)}$
- 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

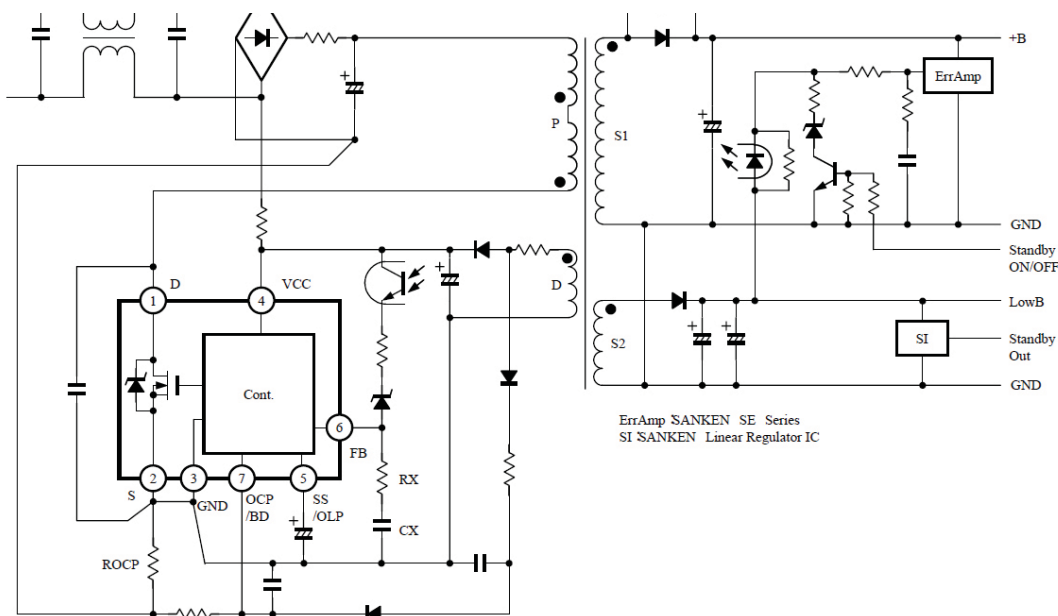
The STR-X6737 is a quasi-resonant topology IC designed for SMPS applications. It shows lower EMI noise characteristics than conventional PWM solutions, especially at greater than 2 MHz. It also provides a soft-switching mode to turn on the internal MOSFET at close to zero voltage ( $V_{DS}$  bottom point) 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 280 W at 120 VAC 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 modes 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-X6737	TO-3P

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

Parameter	Symbol	Conditions	Rating	Unit
Drain Current <sup>1</sup>	$I_{Dpeak}$	Single pulse	22	A
Maximum Switching Current <sup>2</sup>	$I_{Dmax}$	$T_A = -20^\circ\text{C}$ to $125^\circ\text{C}$	22	A
Single Pulse Avalanche Energy <sup>3</sup>	$E_{AS}$	Single pulse, $V_{DD} = 30\text{ V}$ , $L = 50\text{ mH}$ , $I_{Lpeak} = 3.0\text{ A}$	239	mJ
Input Voltage for Controller (MIC)	$V_{CC}$		35	V
SS/OLP Terminal Voltage	$V_{SSOLP}$		-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	$V_{OCPBD}$		-1.5 to 5.0	V
MOSFET Power Dissipation <sup>4</sup>	$P_{D1}$	With infinite heatsink	44	W
		Without heatsink	2.8	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	$^\circ\text{C}$

<sup>1</sup>Refer to MOSFET ASO curve

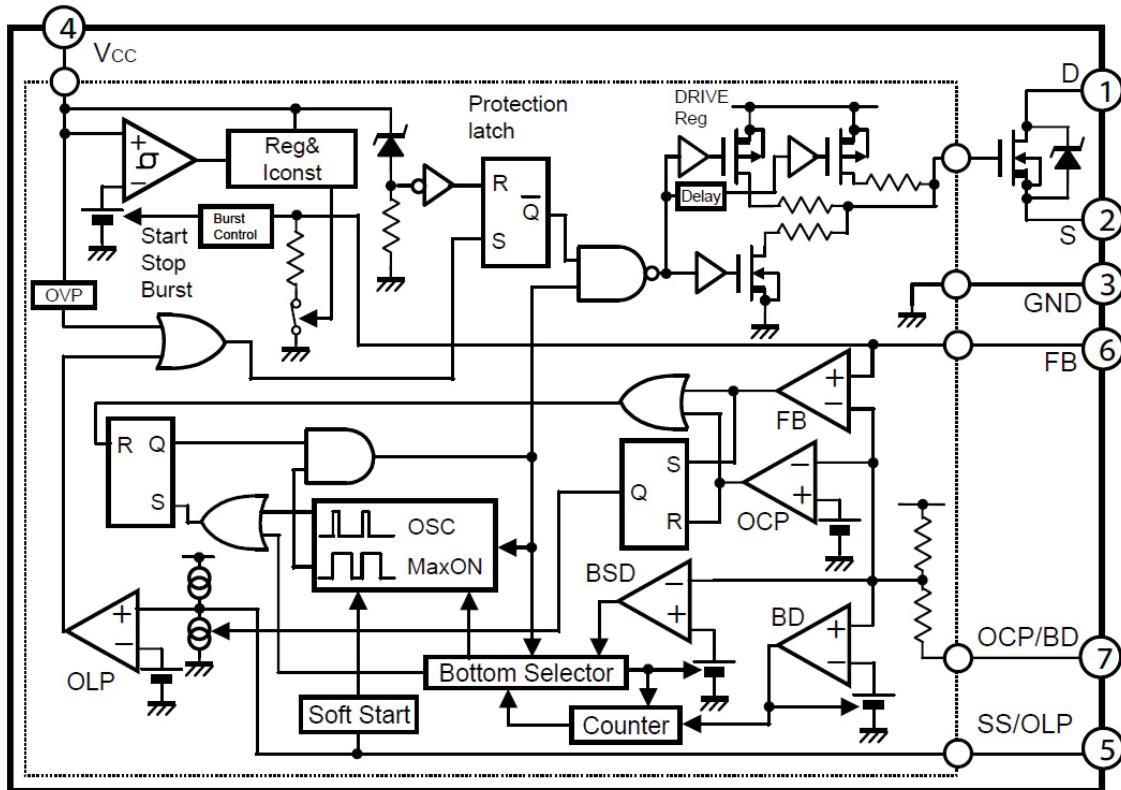
<sup>2</sup> $I_{DMAX}$  is the drain current determined by the drive voltage of the IC and the threshold voltage,  $V_{th}$ , of the MOSFET

<sup>3</sup>Refer to Avalanche Energy Derating curve

<sup>4</sup>Refer to MOSFET Ta-PD1 curve

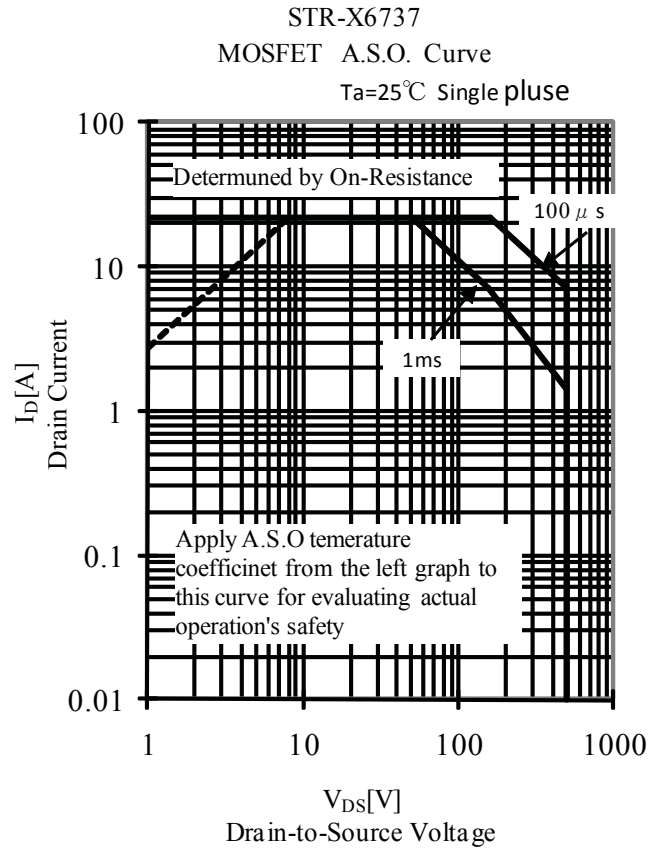
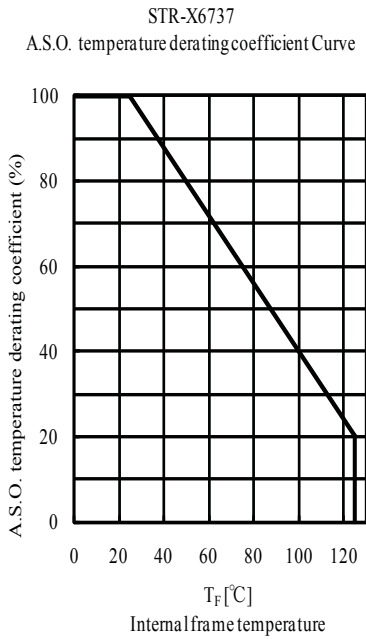
All performance characteristics given are typical values for circuit or system baseline design only and are at the nominal operating voltage and an ambient temperature,  $T_A$ , of  $25^\circ\text{C}$ , unless otherwise stated.

Functional Block Diagram

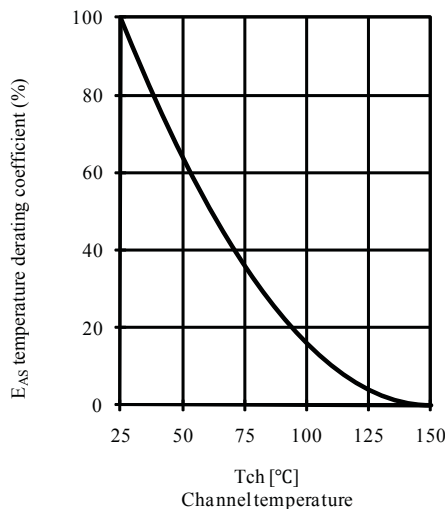


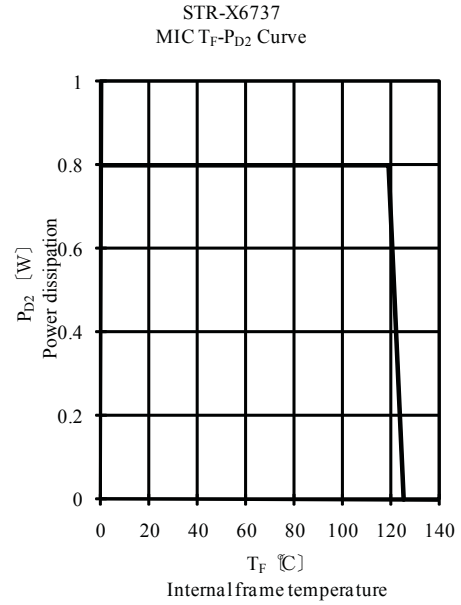
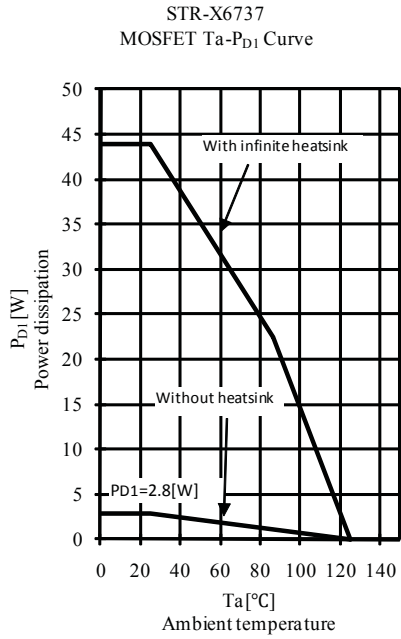
Terminal List Table

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

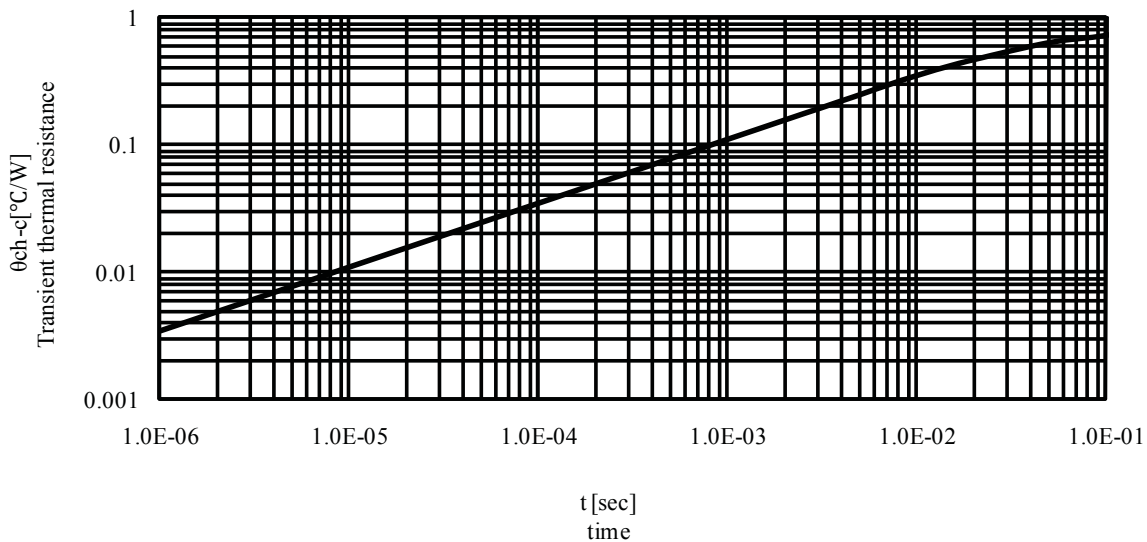


STR-X6737  
Avalanche energy derating curve





STR-X6737  
Transient thermal resistance curve



## ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
<b>ELECTRICAL CHARACTERISTICS for Controller (MIC)<sup>1</sup>, valid at T<sub>A</sub> = 25°C, V<sub>CC</sub> = 20 V, unless otherwise specified</b>						
<b>Power Supply Start-up Operation</b>						
Operation Start Voltage	V <sub>CC(ON)</sub>	V <sub>CC</sub> = 0→20 V	16.3	18.2	19.9	V
Operation Stop Voltage	V <sub>CC(OFF)</sub>	V <sub>CC</sub> = 20→8.8 V	8.8	9.7	10.6	V
Circuit Current In Operation	I <sub>CC(ON)</sub>		–	–	6	mA
Circuit Current In Non-Operation	I <sub>CC(OFF)</sub>	V <sub>CC</sub> = 15 V	–	–	100	μA
Oscillation Frequency	f <sub>osc</sub>		19	22	25	kHz
Soft Start Operation Stop Voltage	V <sub>SSOLP(SS)</sub>	V <sub>SS/OLP</sub> increasing	1.1	1.2	1.4	V
Soft Start Operation Charging Current	I <sub>SSOLP(SS)</sub>	V <sub>SS/OLP</sub> = 0 V	–710	–550	–390	μA
<b>Normal Operation</b>						
Bottom-Skip Operation Threshold Voltage 1	V <sub>OCPBD(BS1)</sub>		–0.720	–0.665	–0.605	V
Bottom-Skip Operation Threshold Voltage 2	V <sub>OCPBD(BS2)</sub>		–0.485	–0.435	–0.385	V
Overcurrent Detection Threshold Voltage	V <sub>OCPBD(LIM)</sub>	V <sub>OCP/BD</sub> falling	–0.995	–0.940	–0.895	V
OCP/BD Terminal Outflow Current	I <sub>OCPBD</sub>	V <sub>OCP/BD</sub> = –0.95 V	–250	–100	–40	μA
Quasi-Resonant Operation Threshold Voltage 1	V <sub>OCPBD(TH1)</sub>	V <sub>OCP/BD</sub> falling	0.28	0.40	0.52	V
Quasi-Resonant Operation Threshold Voltage 2	V <sub>OCPBD(TH2)</sub>	V <sub>OCP/BD</sub> rising	0.67	0.80	0.93	V
FB Terminal Threshold Voltage	V <sub>FB(OFF)</sub>	V <sub>FB</sub> rising	1.32	1.45	1.58	V
FB Terminal Inflow Current (Normal Operation)	I <sub>FB(ON)</sub>	V <sub>FB</sub> = 1.6 V	600	1000	1400	μA
<b>Standby Operation</b>						
Standby Operation Start Voltage	V <sub>CC(S)</sub>	V <sub>CC</sub> = 0→15 V, V <sub>FB</sub> = 1.6 V	10.3	11.2	12.1	V
Standby Operation Start Voltage Interval	V <sub>CC(SK)</sub>	V <sub>CC(SK)</sub> = V <sub>CC(S)</sub> – V <sub>CC(OFF)</sub>	1.10	1.35	1.65	V
Standby Non-Operation Circuit Current	I <sub>CC(S)</sub>	V <sub>CC</sub> = 10.2 V, V <sub>FB</sub> = 1.6 V	–	20	56	μA
FB Terminal Inflow Current, Standby Operation	I <sub>FB(S)</sub>	V <sub>CC</sub> = 10.2 V, V <sub>FB</sub> = 1.6 V	–	4	14	μA
FB Terminal Threshold Voltage, Standby Operation	V <sub>FB(S)</sub>	V <sub>CC</sub> = 15 V, V <sub>FB</sub> rising	0.55	1.10	1.50	V
Minimum On Time	t <sub>ON(MIN)</sub>		0.75	1.10	1.50	μs
<b>Protection Operation</b>						
Maximum On Time	t <sub>ON(MAX)</sub>		27.5	32.5	39.0	μs
Overload Protection Operation Threshold Voltage	V <sub>SSOLP(OLP)</sub>		4.0	4.9	5.8	V
Overload Protection Operation Charging Current	I <sub>SSOLP(OLP)</sub>	V <sub>SS/OLP</sub> = 2.5 V	–16	–11	–6	μA
Overvoltage Protection Operation Voltage	V <sub>CC(OVP)</sub>	V <sub>CC</sub> = 0→30 V	25.5	27.7	29.9	V
Latch Circuit Holding Current <sup>2</sup>	I <sub>CC(H)</sub>	V <sub>CC(OFF)</sub> – 0.3 V	–	45	140	μA
Latch Circuit Release Voltage <sup>2</sup>	V <sub>CC(La.OFF)</sub>	V <sub>CC</sub> = 30→6 V, OVP operating	6.0	7.2	8.5	V
<b>ELECTRICAL CHARACTERISTICS for MOSFET, valid at T<sub>A</sub> = 25°C, unless otherwise specified</b>						
Drain-to-Source Breakdown Voltage	V <sub>DSS</sub>	I <sub>DSS</sub> = 300 μA	500	–	–	V
Drain Leakage Current	I <sub>DSS</sub>	V <sub>DSSS</sub> = 500 V	–	–	300	μA
On Resistance	R <sub>DS(on)</sub>	I <sub>DS</sub> = 4.0 A	–	–	0.36	Ω
Switching Time	t <sub>f</sub>		–	–	500	ns
Thermal Resistance	R <sub>θch-F</sub>	Channel to internal frame	–	–	1.09	°C/W

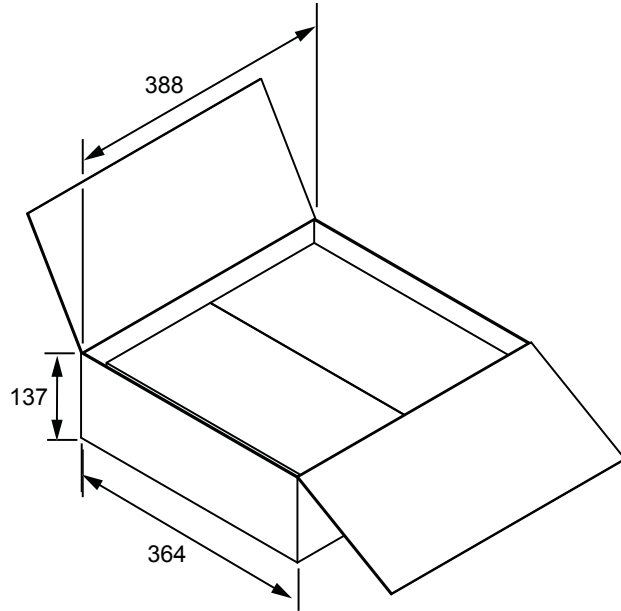
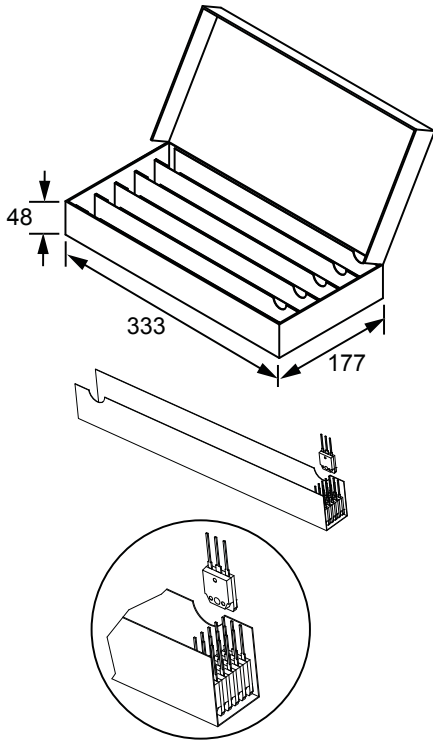
<sup>1</sup>Current polarity with respect to the IC: positive current indicates current sink at the terminal named, negative current indicates source at the terminal named.

<sup>2</sup>The latch circuit means a circuit operated OVP and OLP.

**Packing Specifications**

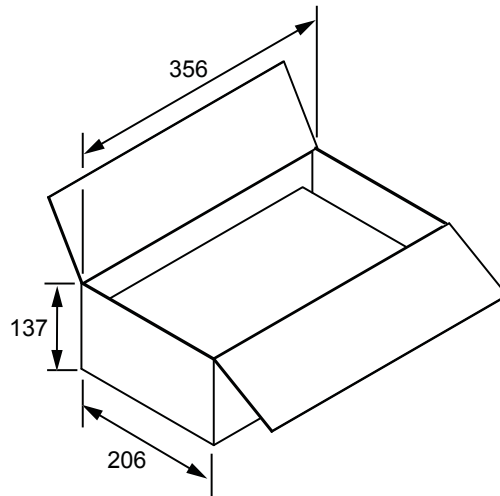
100 pieces per tray  
5 trays per inner carton  
(Outer packing dependent on quantity)

Dimensions in millimeters



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

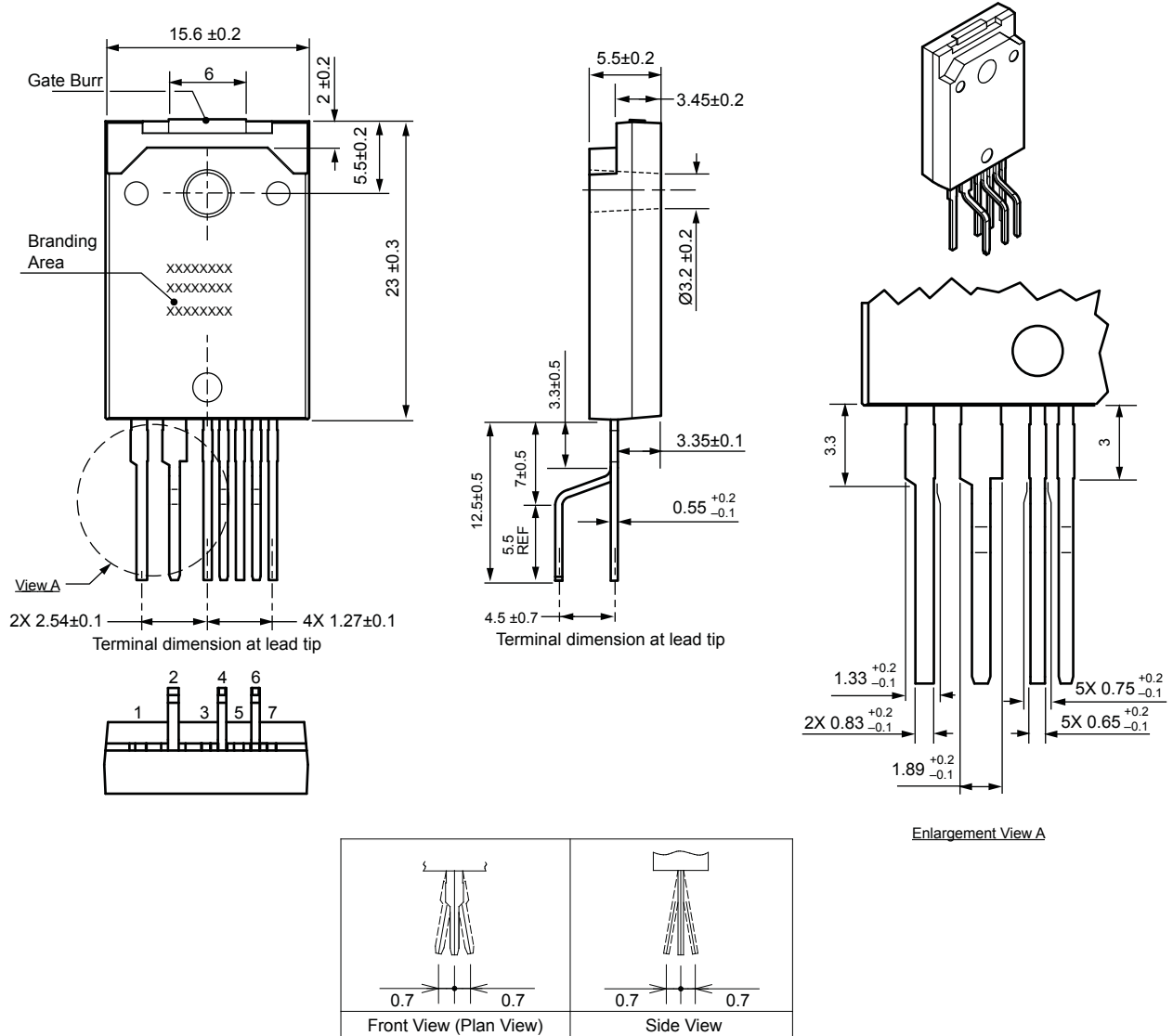
Dimensions in millimeters



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

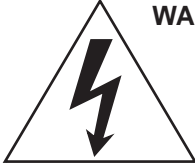
Approximate weight: 6 g  
 Dimensions in millimeters

Drawing for reference only  
 Branding codes (exact appearance at manufacturer discretion):  
 1st line, type: STR  
 2nd line, subtype: X6737  
 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.

#### Recommended operation temperature

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

#### Heatsink Mounting Method

- **Torque When Tightening Mounting Screws.** Thermal resistance 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.

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