

## Quasi-Resonant Topology Primary Switching Regulators

### Features and Benefits

- Quasi-resonant topology IC  $\Rightarrow$  Low EMI noise and soft switching
- Bottom-skip operation  $\Rightarrow$  Improved system efficiency over the entire output load by avoiding increase of switching frequency
- Standby burst mode operation  $\Rightarrow$  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 / 0.57  $\Omega$ , 160 W (120 Vac input)

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### Package: 6-pin TO-220



### Description

The STR-W6735 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 operation 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.

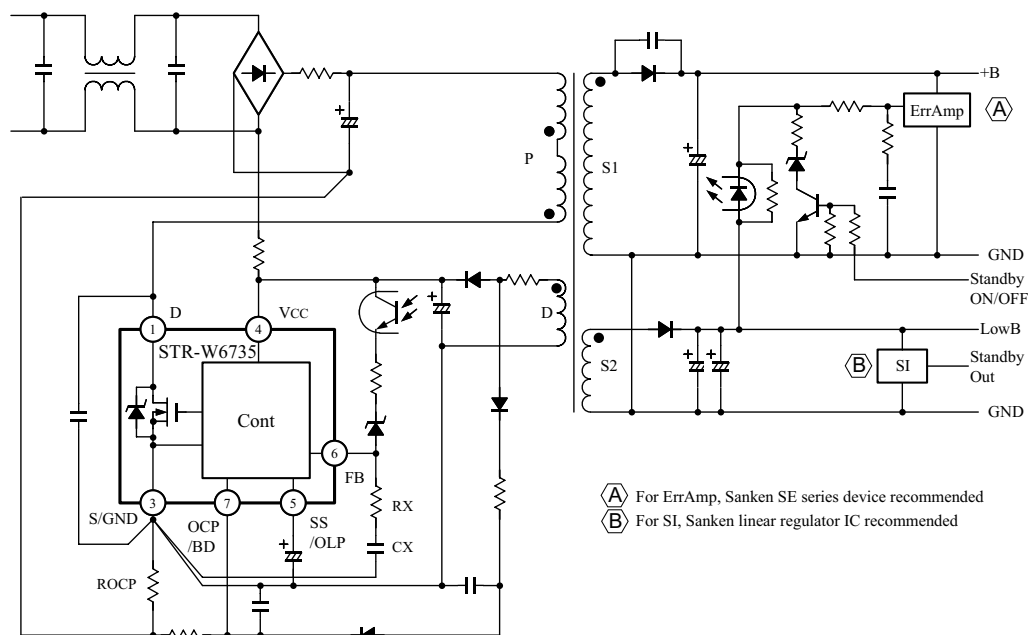
The package is a fully molded TO-220, which contains the controller chip (MIC) and MOSFET, enabling output power up to 160 W with a 120 Vac input. The bottom-skip function skips the first bottom of  $V_{DS}$  and turns on the MOSFET at the second bottom point, to minimize an increase of operational frequency 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 an auto-burst mode operation that 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 the auto-burst mode.

The soft-start function minimizes surge voltage and reduces power stress to the MOSFET and to the secondary rectifying

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### Typical Application



**Features and Benefits (continued)**

- 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

**Description (continued)**

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 | Packing          |
|-------------|---------|------------------|
| STR-W6735   | TO-220  | Bulk, 100 pieces |

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

| Parameter                                  | Symbol             | Terminal | Conditions  | Rating      | Unit             |
|--|--------------------|----------|---|-------------|------------------|
| Drain Current <sup>1</sup>                 | $I_{D\text{peak}}$ | 1 - 3    | Single pulse  | 20          | A                |
| Maximum Switching Current <sup>2</sup>     | $I_{D\text{max}}$  | 1 - 3    | $T_A = -20^\circ\text{C}$ to $125^\circ\text{C}$  | 20          | A                |
| Single Pulse Avalanche Energy <sup>3</sup> | $E_{AS}$           | 1 - 3    | Single pulse, $V_{DD} = 99\text{ V}$ , $L = 20\text{ mH}$ , $I_{L\text{peak}} = 5.8\text{ A}$ | 380         | mJ               |
| Input Voltage for Controller (MIC)         | $V_{CC}$           | 4 - 3    |   | 35          | V                |
| SS/OLP Terminal Voltage                    | $V_{SS\text{OLP}}$ | 5 - 3    |   | -0.5 to 6.0 | V                |
| FB Terminal Inflow Current                 | $I_{FB}$           | 6 - 3    |   | 10          | mA               |
| FB Terminal Voltage                        | $V_{FB}$           | 6 - 3    | $I_{FB}$ within the limits of $I_{FB}$  | -0.5 to 9.0 | V                |
| OCP/BD Terminal Voltage                    | $V_{OCP\text{BD}}$ | 7 - 3    |   | -1.5 to 5.0 | V                |
| MOSFET Power Dissipation <sup>4</sup>      | $P_{D1}$           | 1 - 3    | With infinite heatsink  | 28.7        | W                |
|  |                    |          | Without heatsink  | 1.3         | W                |
| Controller (MIC) Power Dissipation         | $P_{D2}$           | 4 - 3    | $V_{CC} \times I_{CC}$  | 0.8         | W                |
| Operating Internal Leadframe Temperature   | $T_F$              | —        | Refer to $T_{OP}$   | -20 to 115  | $^\circ\text{C}$ |
| Operating Ambient Temperature              | $T_{OP}$           | —        |   | -20 to 115  | $^\circ\text{C}$ |
| Storage Temperature                        | $T_{stg}$          | —        |   | -40 to 125  | $^\circ\text{C}$ |
| Junction Temperature                       | $T_J$              | —        |   | 150         | $^\circ\text{C}$ |

<sup>1</sup>Refer to figure 2

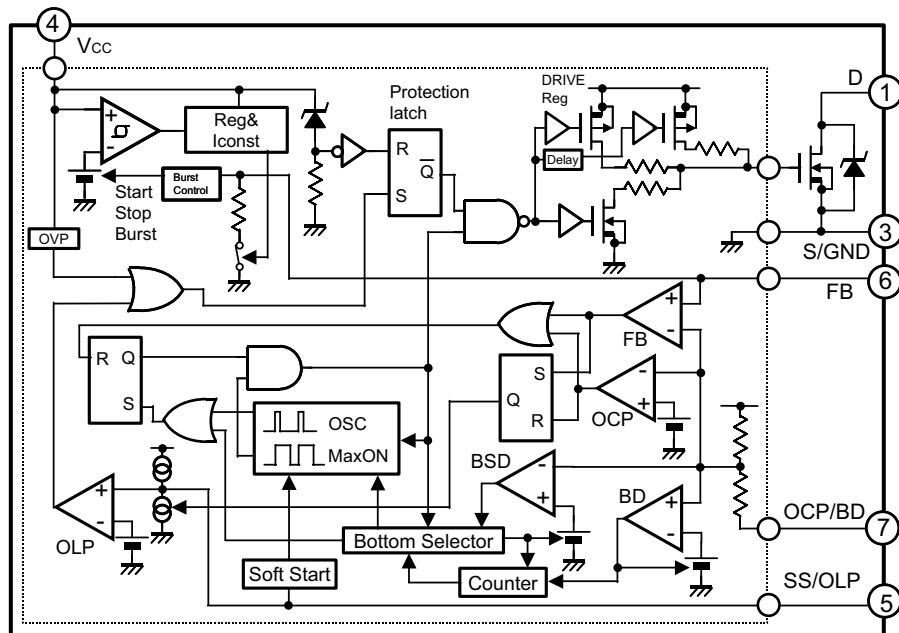
<sup>2</sup> $I_{D\text{MAX}}$  is the drain current determined by the drive voltage of the IC and the threshold voltage,  $V_{th}$ , of the MOSFET

<sup>3</sup>Refer to figure 3

<sup>4</sup>Refer to figure 5

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 of  $+25^\circ\text{C}$ , unless otherwise stated.

## *Quasi-Resonant Topology Primary Switching Regulators*



### Figure 1 – MOSFET Safe Operating Area Derating Curve

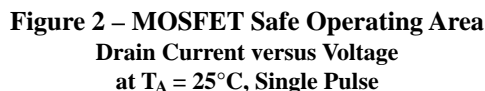


Figure 3 – MOSFET Avalanche Energy Derating Curve

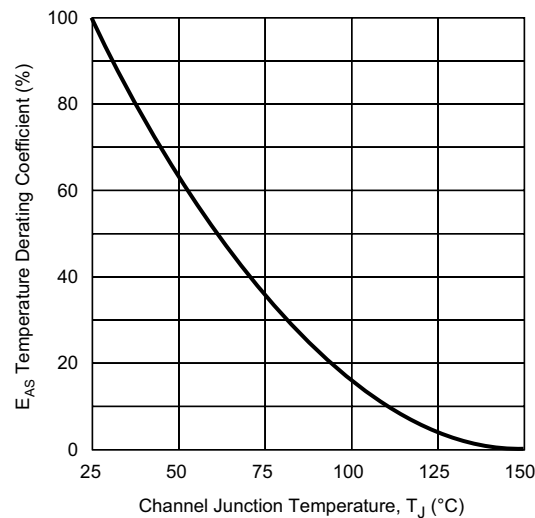


Figure 4 – Transient Thermal Resistance

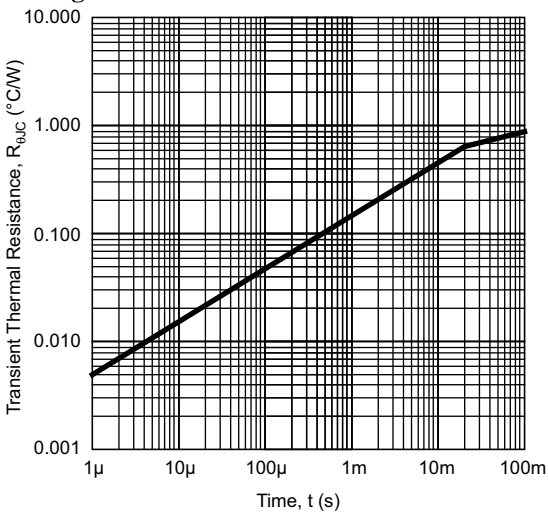
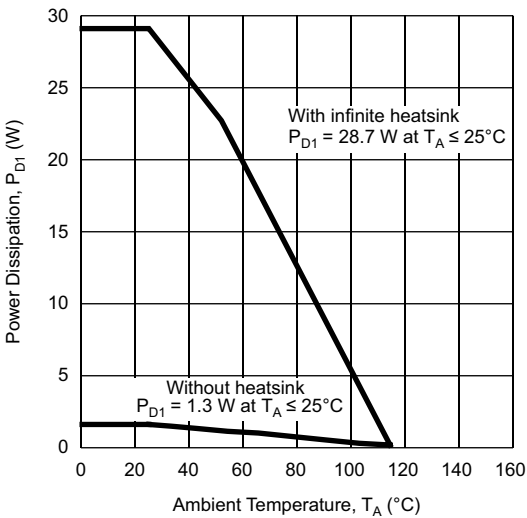


Figure 5 – MOSFET Power Dissipation versus Temperature



**ELECTRICAL CHARACTERISTICS**

| Characteristic   | Symbol                  | Terminals                  | 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>     | 4 - 3                      | 16.3   | 18.2   | 19.9   | V     |
| Operation Stop Voltage   | V <sub>CC(OFF)</sub>    | 4 - 3                      | 8.8    | 9.7    | 10.6   | V     |
| Circuit Current In Operation   | I <sub>CC(ON)</sub>     | 4 - 3                      | –      | –      | 6      | mA    |
| Circuit Current In Non-Operation   | I <sub>CC(OFF)</sub>    | 4 - 3                      | –      | –      | 100    | μA    |
| Oscillation Frequency  | f <sub>osc</sub>        | 1 - 3                      | 19     | 22     | 25     | kHz   |
| Soft Start Operation Stop Voltage  | V <sub>SSOLP(SS)</sub>  | 5 - 3                      | 1.1    | 1.2    | 1.4    | V     |
| Soft Start Operation Charging Current  | I <sub>SSOLP(SS)</sub>  | 5 - 3                      | –710   | –550   | –390   | μA    |
| <b>Normal Operation</b>  |                         |                            |        |        |        |       |
| Bottom-Skip Operation Threshold Voltage 1  | V <sub>OCPBD(BS1)</sub> | 7 - 3                      | –0.720 | –0.665 | –0.605 | V     |
| Bottom-Skip Operation Threshold Voltage 2  | V <sub>OCPBD(BS2)</sub> | 7 - 3                      | –0.485 | –0.435 | –0.385 | V     |
| Overcurrent Detection Threshold Voltage  | V <sub>OCPBD(LIM)</sub> | 7 - 3                      | –0.995 | –0.940 | –0.895 | V     |
| OCP/BDOCP/BD Terminal Outflow Current  | I <sub>OCPBD</sub>      | 7 - 3                      | –250   | –100   | –40    | μA    |
| Quasi-Resonant Operation Threshold Voltage 1   | V <sub>OCPBD(TH1)</sub> | 7 - 3                      | 0.28   | 0.40   | 0.52   | V     |
| Quasi-Resonant Operation Threshold Voltage 2   | V <sub>OCPBD(TH2)</sub> | 7 - 3                      | 0.67   | 0.80   | 0.93   | V     |
| FB Terminal Threshold Voltage  | V <sub>FB(OFF)</sub>    | 6 - 3                      | 1.32   | 1.45   | 1.58   | V     |
| FB Terminal Inflow Current (Normal Operation)  | I <sub>FB(ON)</sub>     | 6 - 3                      | 600    | 1000   | 1400   | μA    |
| <b>Standby Operation</b>   |                         |                            |        |        |        |       |
| Standby Operation Start Voltage  | V <sub>CC(S)</sub>      | 4 - 3                      | 10.3   | 11.1   | 12.7   | V     |
| Standby Operation Start Voltage Interval   | V <sub>CC(SK)</sub>     | 4 - 3                      | 1.10   | 1.35   | 1.75   | V     |
| Standby Non-Operation Circuit Current  | I <sub>CC(S)</sub>      | 4 - 3                      | –      | 20     | 56     | μA    |
| FB Terminal Inflow Current, Standby Operation  | I <sub>FB(S)</sub>      | 6 - 3                      | –      | 4      | 14     | μA    |
| FB Terminal Threshold Voltage, Standby Operation   | V <sub>FB(S)</sub>      | 6 - 3                      | 0.55   | 1.10   | 1.50   | V     |
| Minimum On Time  | t <sub>ON(MIN)</sub>    | 1 - 3                      | –      | 0.75   | 1.20   | μs    |
| Maximum On Time  | t <sub>ON(MAX)</sub>    | 1 - 3                      | 27.5   | 32.5   | 39.0   | μs    |
| <b>Protection Operation</b>  |                         |                            |        |        |        |       |
| Overload Protection Operation Threshold Voltage  | V <sub>SSOLP(OLP)</sub> | 5 - 3                      | 4.0    | 4.9    | 5.8    | V     |
| Overload Protection Operation Charging Current   | I <sub>SSOLP(OLP)</sub> | 5 - 3                      | –16    | –11    | –6     | μA    |
| Overvoltage Protection Operation Voltage   | V <sub>CC(OVP)</sub>    | 4 - 3                      | 25.5   | 27.7   | 29.9   | V     |
| Latch Circuit Holding Current <sup>2</sup>   | I <sub>CC(H)</sub>      | 4 - 3                      | –      | 45     | 140    | μA    |
| Latch Circuit Release Voltage <sup>2</sup>   | V <sub>CC(La.OFF)</sub> | 4 - 3                      | 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>        | 1 - 3                      | 500    | –      | –      | V     |
| Drain Leakage Current  | I <sub>DSS</sub>        | 1 - 3                      | –      | –      | 300    | μA    |
| On Resistance  | R <sub>DS(on)</sub>     | 1 - 3                      | –      | –      | 0.57   | Ω     |
| Switching Time   | t <sub>f</sub>          | 1 - 3                      | –      | –      | 400    | ns    |
| Thermal Resistance   | R <sub>θJA</sub>        | Junction to Internal Frame | –      | –      | 1.55   | °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.

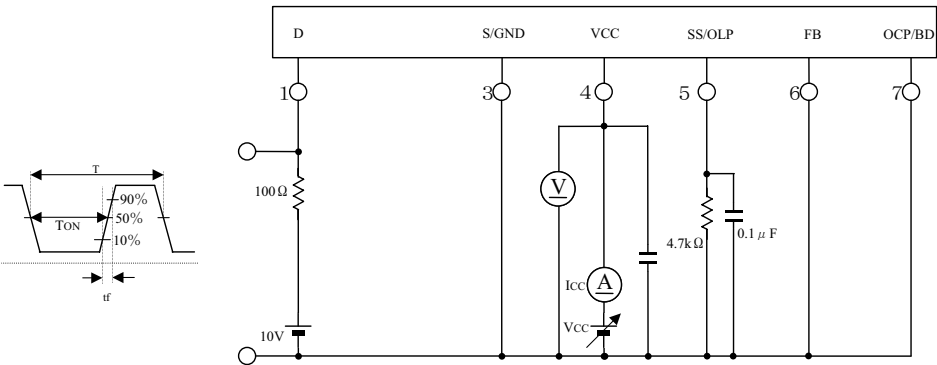
<sup>2</sup>Latch circuit refers to operation during Overload Protection or Overvoltage Protection.

## ELECTRICAL CHARACTERISTICS Test Conditions\*

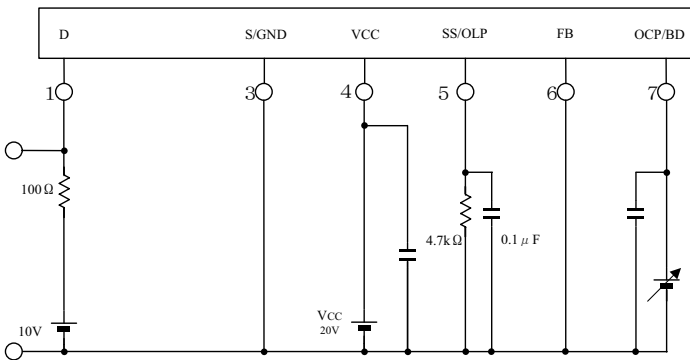
| Parameter                                       | Test Conditions  | V <sub>CC</sub><br>(V)     | Measurement<br>Circuit |
|---|--|----------------------------|------------------------|
| Operation Start Voltage                         | V <sub>CC</sub> voltage at which oscillation starts.   | 0→20                       | 1                      |
| Operation Stop Voltage                          | V <sub>CC</sub> voltage at which oscillation stops.  | 20→8.8                     |                        |
| Circuit Current In Operation                    | Inflow current flowing into power supply terminal in oscillation.  | 20                         |                        |
| Circuit Current In Non-operation                | Inflow current flowing into power supply terminal prior to oscillation.  | 15                         |                        |
| Oscillation Frequency                           | Oscillating frequency ( $f_{osc} = 1 / T$ ).   | 20                         |                        |
| Soft Start Operation Stop Voltage               | SS/OLP terminal voltage at which ISS/OLP reach $\geq -100 \mu A$ by raising the SS/OLP terminal voltage from 0 V gradually.  | 20                         | 5                      |
| Soft Start Operation Charging Current           | SS/OLP terminal charging current (SS/OLP terminal voltage = 0 V).  |                            |                        |
| Bottom-Skip Operation Threshold Voltage 1       | Input 1 $\mu s$ pulse width, as shown in waveform 1, to OCP/BD terminal twice after V <sub>1-3</sub> rises. After that, offset the input waveform gradually from 0 V in the minus direction. Measurement of the offset voltage V <sub>OCPBD(BS1)</sub> is taken when the V <sub>1-3</sub> start-to-fall point switches from two-pulses-after to one-pulse-after. | 20                         | 3                      |
| Bottom-Skip Operation Threshold Voltage 2       | After measuring V <sub>OCPBD(BS1)</sub> , as shown in waveform 2, offset the input waveform gradually. Measurement of the offset voltage V <sub>OCPBD(BS2)</sub> is taken when the V <sub>1-3</sub> start-to-fall point switches from two-pulses-after to one-pulse-after.   |                            |                        |
| Overcurrent Detection Threshold Voltage         | OCP/BD terminal voltage at which oscillation stops by lowering the OCP/BD terminal voltage from 0 V gradually.   | 20                         | 2                      |
| OCP/BDOCP/BD Terminal Outflow Current           | OCP/BD terminal outflow current (OCP/BD terminal voltage = -0.95 V).   |                            |                        |
| Quasi-Resonant Operation Threshold Voltage 1    | OCP/BD terminal voltage at which oscillation starts with setting the OCP/BD terminal voltage at 1 V, and then lowering the voltage gradually.  |                            |                        |
| Quasi-Resonant Operation Threshold Voltage 2    | OCP/BD terminal voltage at which oscillation stops by raising the OCP/BD terminal voltage from 0 V gradually.  | 20                         | 4                      |
| FB Terminal Threshold Voltage                   | FB terminal voltage at which oscillation stops by raising the FB terminal voltage from 0 V gradually.  |                            |                        |
| FB Terminal Inflow Current (Normal Operation)   | FB terminal inflow current (FB terminal voltage = 1.6 V).  | 20                         |                        |
| Standby Operation Start Voltage                 | V <sub>CC</sub> voltage at which I <sub>CC</sub> reaches $\geq 1$ mA (FB terminal voltage = 1.6 V).  | 0→15                       |                        |
| Standby Operation Start Voltage Interval        | Specified by $V_{CC(SK)} = V_{CC(S)} - V_{CC(OFF)}$ .  | —                          |                        |
| Standby Non-Operation Circuit Current           | Inflow current flowing into power supply terminals prior to oscillation (FB terminal voltage = 1.6 V).   | 10.2                       |                        |
| FB Terminal Inflow Current, Standby Operation   | FB terminal inflow current (FB terminal voltage = 1.6 V).  | 10.2                       |                        |
| FB Terminal Threshold Voltage Standby Operation | FB terminal voltage at which oscillation starts by raising the FB terminal voltage from 0 V gradually.   | 15                         | 6                      |
| Minimum On Time                                 | Waveform between terminals 1 and 3 at low.   | 20                         |                        |
| Maximum On Time                                 | Waveform between terminals 1 and 3 at low.   | 20                         | 1                      |
| Overload Protection Operation Threshold Voltage | SS/OLP terminal voltage at which oscillation stops.  | 20                         | 5                      |
| Overload Protection Operation Charging Current  | SS/OLP terminal charging current (SS/OLP terminal voltage = 2.5 V).  | —                          |                        |
| Overvoltage Protection Operation Voltage        | V <sub>CC</sub> voltage at which oscillation stops.  | 0→30                       | 1                      |
| Latch Circuit Holding Current                   | Inflow current at V <sub>CC(OFF)</sub> - 0.3; after OVP operation.   | V <sub>CC(OFF)</sub> - 0.3 |                        |
| Latch Circuit Release Voltage                   | V <sub>CC</sub> voltage at which I <sub>CC</sub> reaches 20 $\mu A$ or lower by decreasing V <sub>CC</sub> after OVP operation.  | 30→6                       |                        |

\*Oscillating operation is specified with a rectangular waveform between terminals 1 and 3.

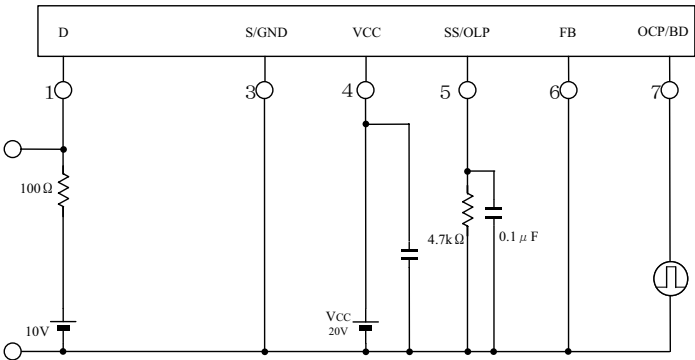
Measurement Circuit 1



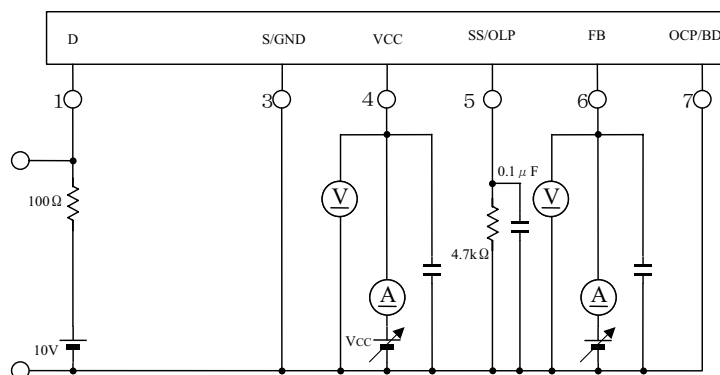
Measurement Circuit 2



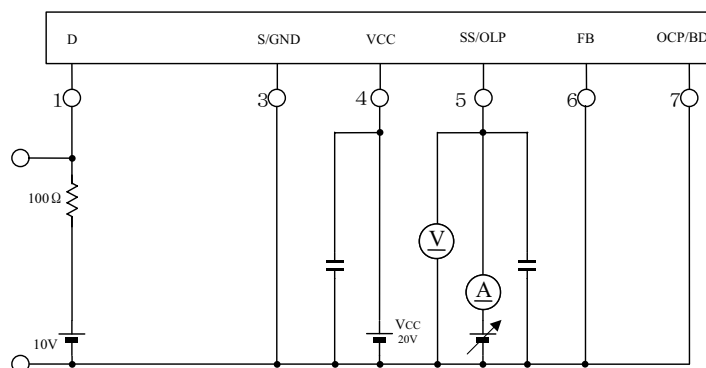
Measurement Circuit 3



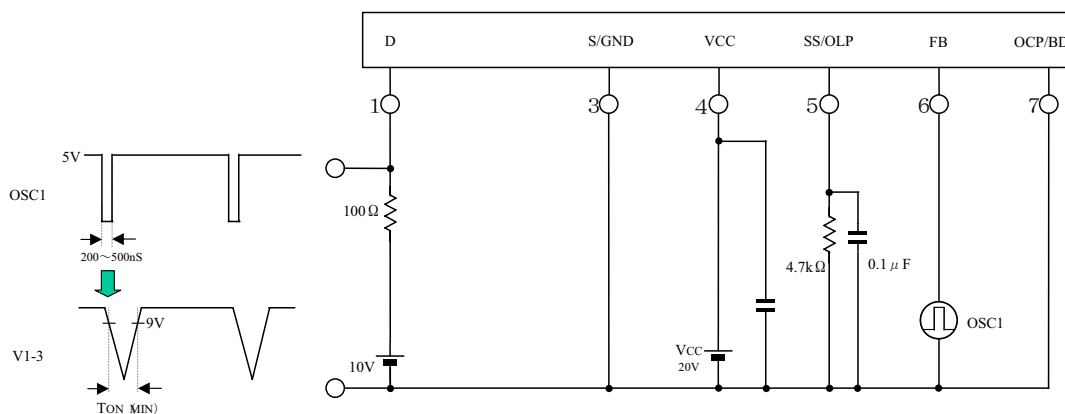
### Measurement Circuit 4



### Measurement Circuit 5

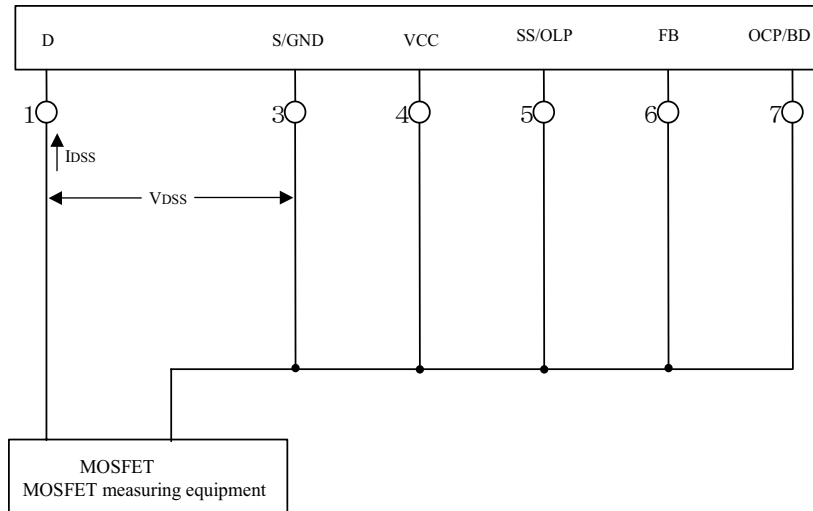


### Measurement Circuit 6

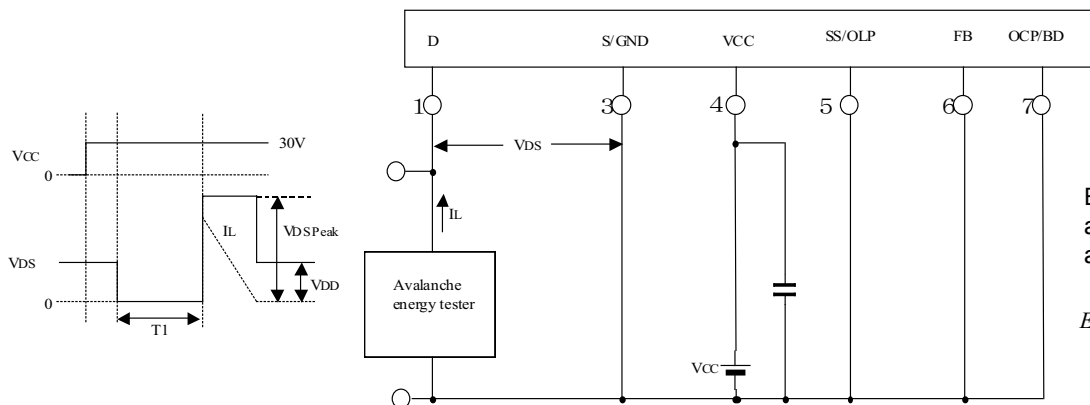




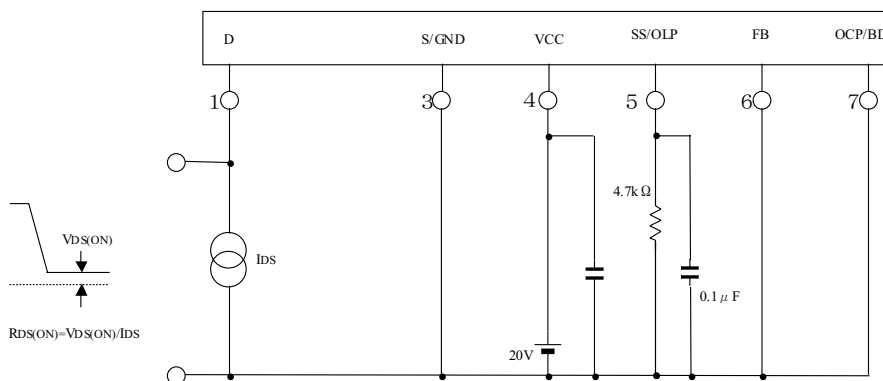
Measurement Circuit 7

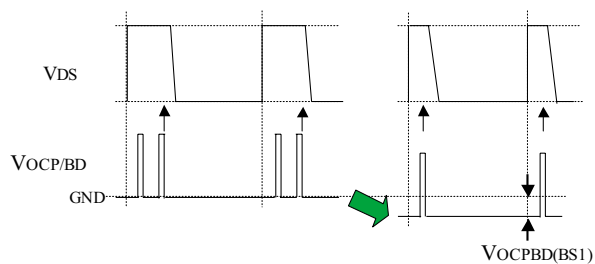
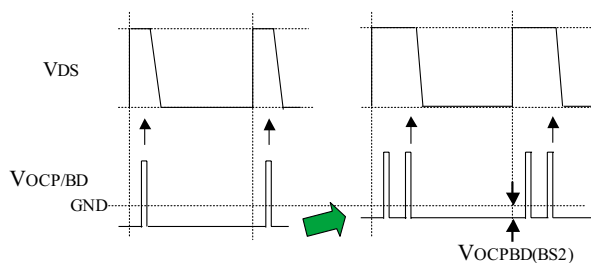


Measurement Circuit 8

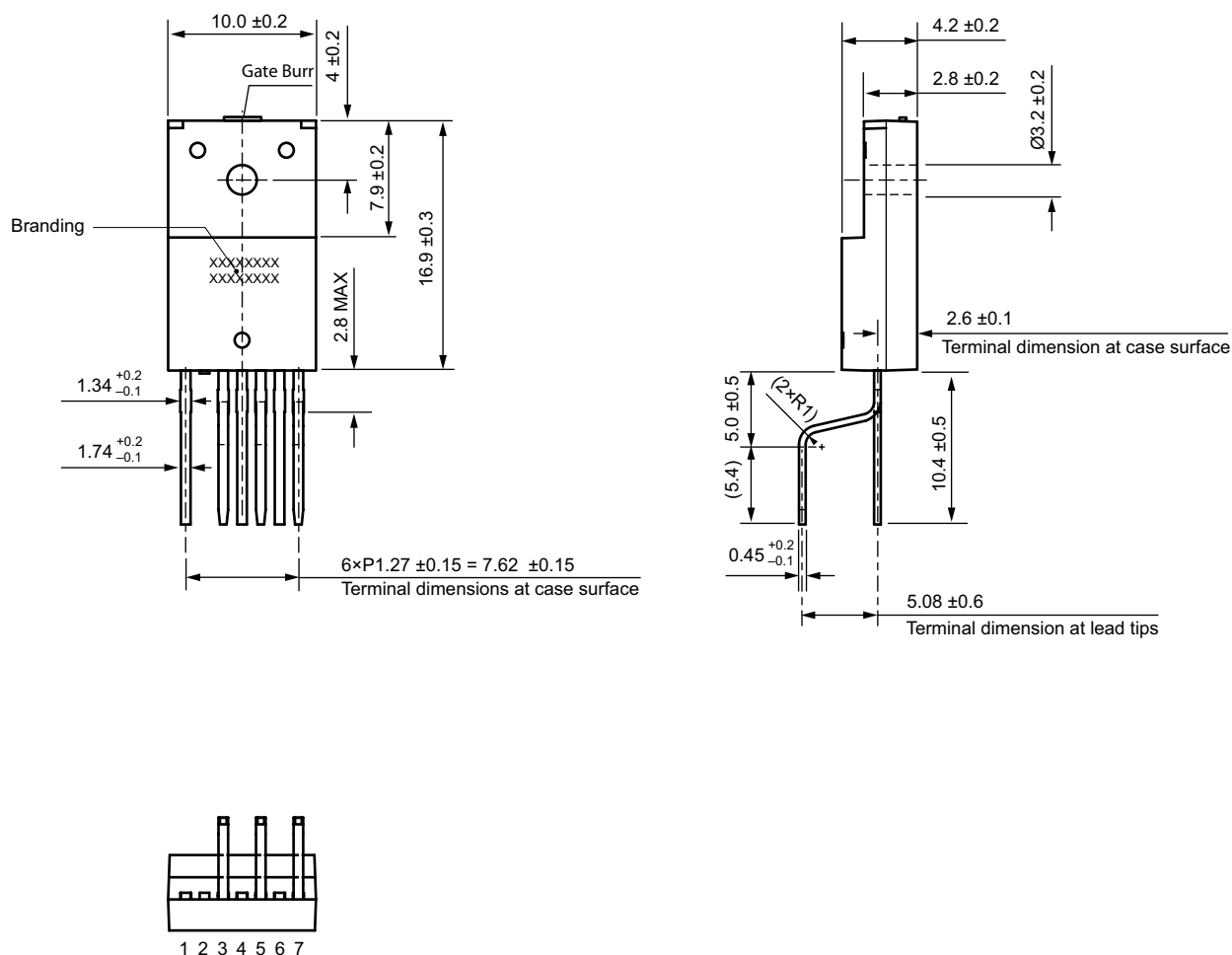


Measurement Circuit 9



**Waveform 1****Waveform 2**

## PACKAGE DIMENSIONS, TO-220



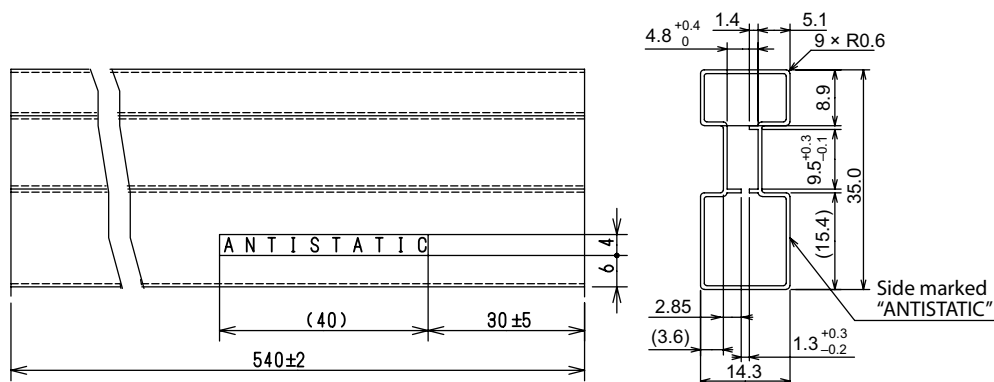
Gate burr: 0.3 mm (max.)  
Terminal core material: Cu  
Terminal treatment: Ni plating and solder dip  
Heat sink material: Cu  
Heat sink treatment: Ni plating  
Leadform: 2003  
Weight (approximate): 2.3 g

Dimensions in millimeters

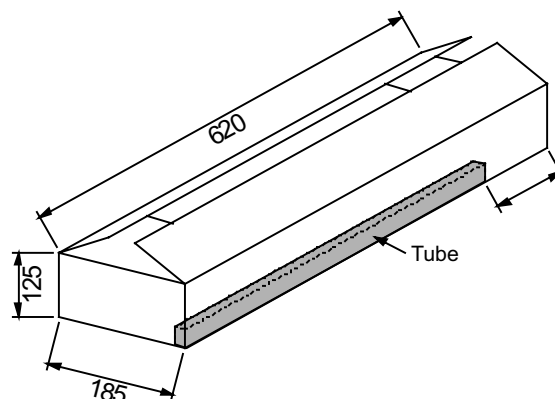
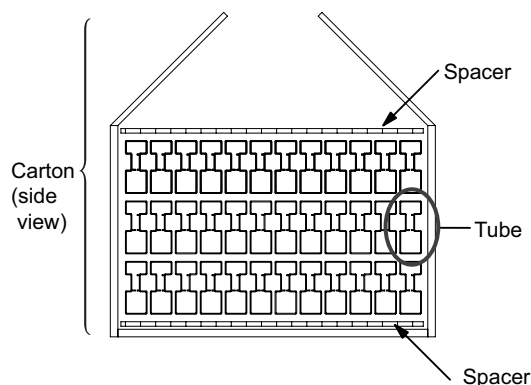
Drawing for reference only  
Branding codes (exact appearance at manufacturer discretion):  
1st line, type: W6735  
2nd line, lot: YMDD R  
Where: Y is the last digit of the year of manufacture  
M is the month (1 to 9, O, N, D)  
DD is the 2-digit date  
R is the manufacturer registration symbol

### PACKING SPECIFICATIONS Minimum packing option: Tube FM-205 E

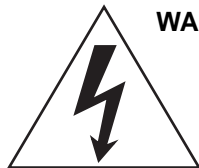
**Shipping Tube Dimensions:**  
 Wall thickness:  $0.6 \pm 0.3$  mm  
 Wall warp:  $< 2$  mm  
 Material: Hardened polyvinyl  
 Coating: antistatic  
 Tolerance  $\pm 0.4$  mm,  
 unless otherwise specified



**Shipping Carton Dimensions:**  
 Capacity: 1800 pieces maximum per carton  
 36 tubes per carton  
 3 rows, 12 tubes per row



All dimensions: mm



**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. Do not connect grounded test equipment.

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 in 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.
- Volatile-type silicone greases may produce cracks after long periods of time, resulting in reduced heat radiation effect. Silicone grease with low consistency (hard grease) may cause cracks in the mold resin when screwing the product to a heatsink.
- 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 | GE Toshiba Silicone Co., Ltd.        |
| SC102  | Dow Corning Toray Silicone Co., Ltd. |

#### 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.

#### Assembly

- During soldering or other operations, the interior frame temperature of the device should never exceed 105°C.
- Recommended screw torque through the mounting tab is 0.588 to 0.785 N • m (6 to 8 kgf • cm)

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