

# Quasi-Resonant Topology Primary 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  $V_{DS}$  derating
- 650 V / 0.73  $\Omega$
- Various protections  $\Rightarrow$  Improved system-level reliability

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## Package: 6-pin TO-220



*Not to scale*

## Description

The STR-W6756 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.

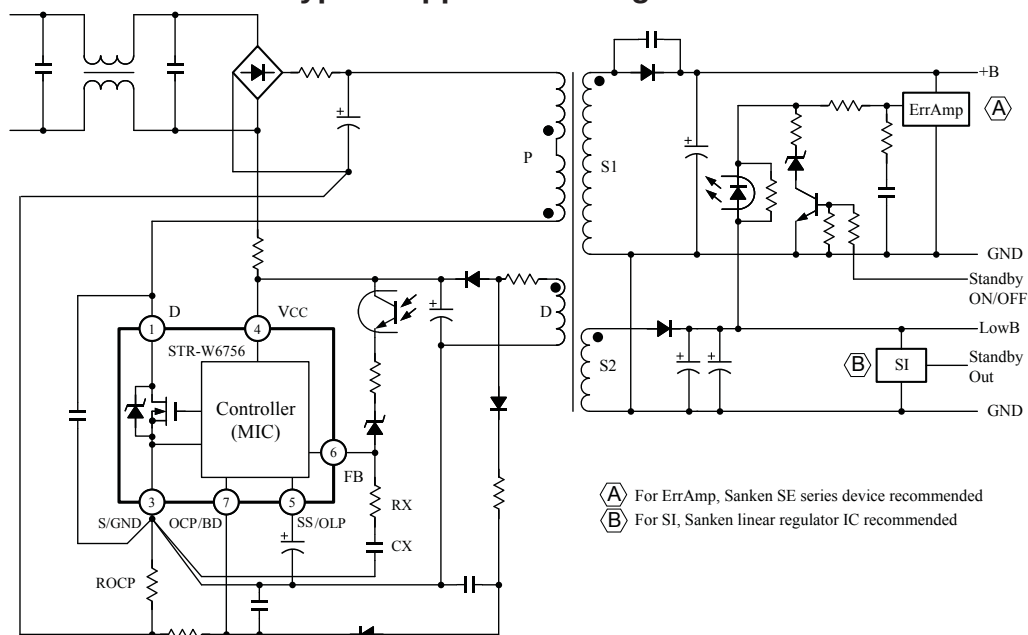
The package is a fully molded TO-220, which contains the controller chip (MIC) and MOSFET, enabling output power up to 140 W with universal input or 240 W with a 230 VAC input. The bottom-skip mode skips the first bottom of  $V_{DS}$  and turns on the MOSFET at the second bottom point, to minimize an 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.

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

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## Typical Application Diagram



## Features and Benefits (continued)

- 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 |
|-------------|---------|
| STR-W6756   | TO-220  |

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

| Parameter                                  | Symbol             | Conditions                                                                                     | Rating      | Unit             |
|--------------------------------------------|--------------------|------------------------------------------------------------------------------------------------|-------------|------------------|
| Drain Current <sup>1</sup>                 | $I_{D\text{peak}}$ | Single pulse                                                                                   | 15          | A                |
| Maximum Switching Current <sup>2</sup>     | $I_{D\text{max}}$  | $T_A = -20^\circ\text{C}$ to $125^\circ\text{C}$                                               | 15          | A                |
| Single Pulse Avalanche Energy <sup>3</sup> | $E_{AS}$           | Single pulse, $V_{DD} = 99\text{ V}$ , $L = 20\text{ mH}$ , $I_{L\text{peak}} = 6.05\text{ A}$ | 400         | 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                                                                         | 29          | W                |
|                                            |                    | Without heatsink                                                                               | 1.3         | 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 115  | $^\circ\text{C}$ |
| Operating Ambient Temperature              | $T_{OP}$           |                                                                                                | -20 to 115  | $^\circ\text{C}$ |
| Storage Temperature                        | $T_{stg}$          |                                                                                                | -40 to 125  | $^\circ\text{C}$ |
| Channel Temperature                        | $T_{ch}$           |                                                                                                | 150         | $^\circ\text{C}$ |

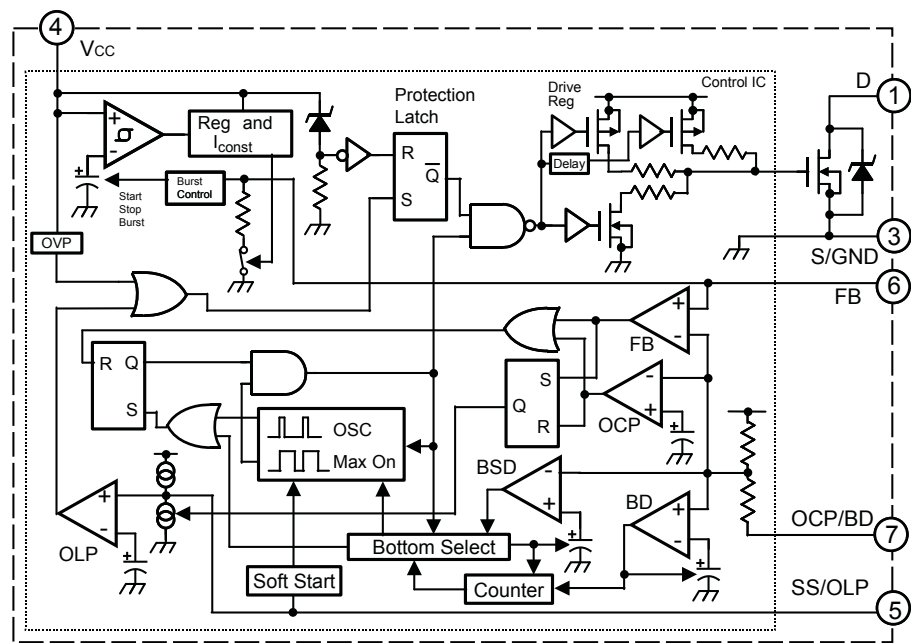
<sup>1</sup>Refer to figure 2

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



Terminal List Table

| Number | Name   | Description                             | Functions                                                                                    |
|--------|--------|-----------------------------------------|----------------------------------------------------------------------------------------------|
| 1      | D      | Drain                                   | MOSFET drain                                                                                 |
| 2      | NC     | Clipped                                 | No connection                                                                                |
| 3      | S/GND  | Source/ground terminal                  | MOSFET source and 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                                 |

Figure 1 – MOSFET Safe Operating Area  
Derating Curve

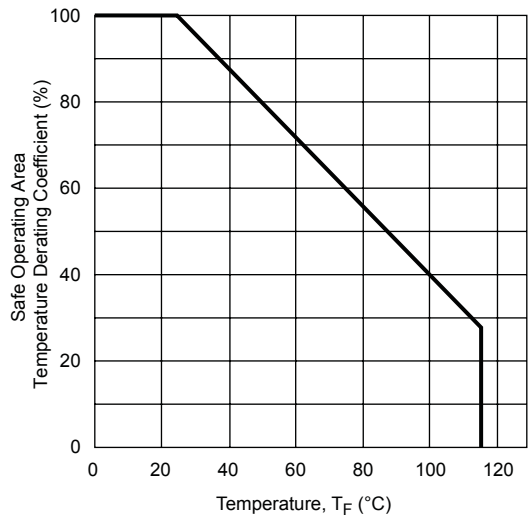


Figure 2 – MOSFET Safe Operating Area  
Drain Current versus Voltage  
at T<sub>A</sub> = 25°C, Single Pulse

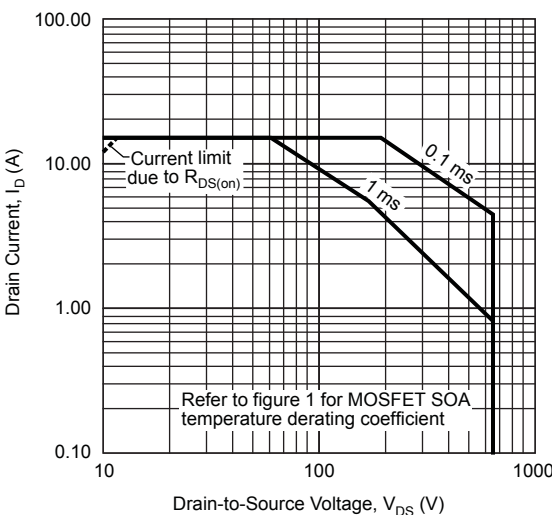


Figure 3 – MOSFET Avalanche Energy Derating Curve

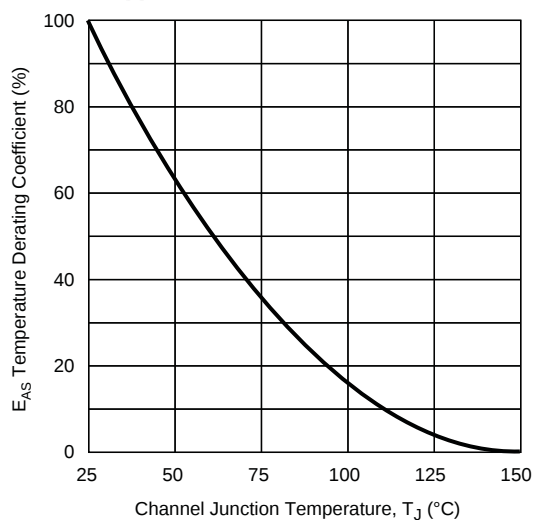
 $V_{DD} = 99\text{ V}$ ,  $L = 20\text{ mH}$ ,  $I_L = 3.6\text{ A}$ 


Figure 4 – Transient Thermal Resistance

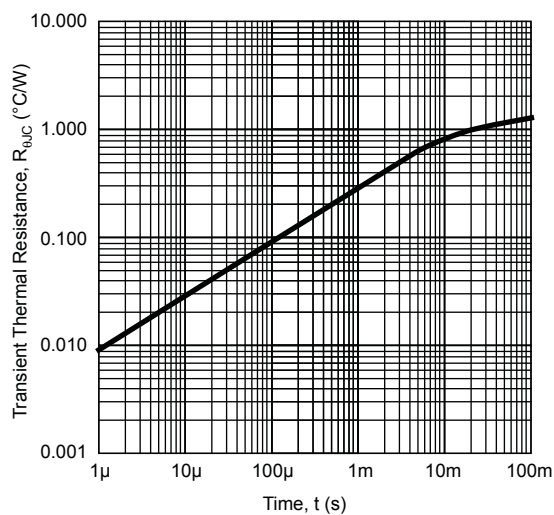
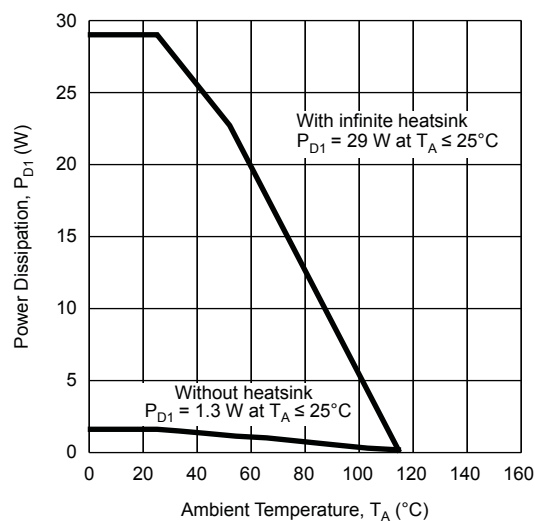


Figure 5 – MOSFET Power Dissipation versus Temperature



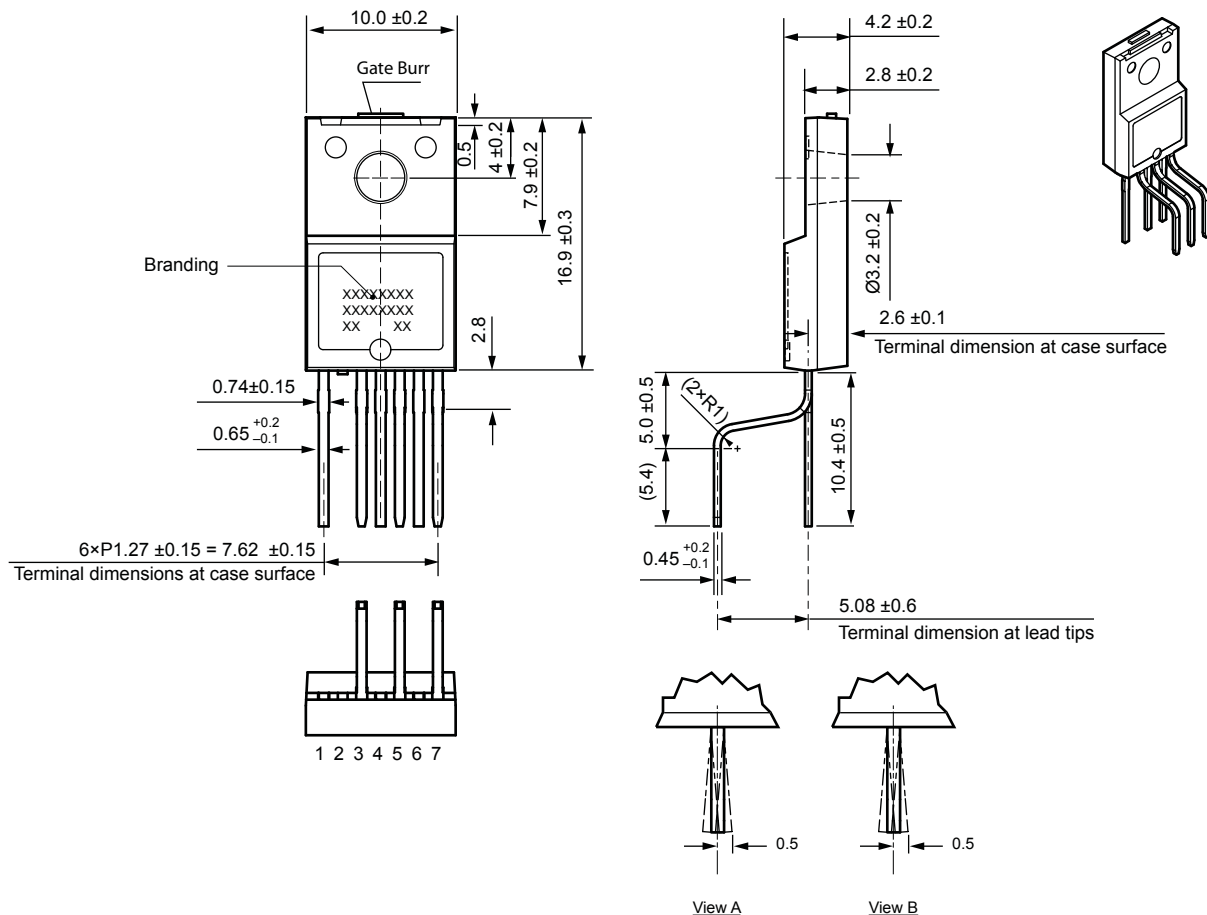
## ELECTRICAL CHARACTERISTICS

| Characteristic                                                                                                                                               | Symbol            | Test Conditions                                                | Min.   | Typ.   | Max.   | Units              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------------------------------|--------|--------|--------|--------------------|
| <b>ELECTRICAL CHARACTERISTICS for Controller (MIC)<sup>1</sup></b> , valid at $T_A = 25^\circ\text{C}$ , $V_{CC} = 20\text{ V}$ , unless otherwise specified |                   |                                                                |        |        |        |                    |
| <b>Power Supply Start-up Operation</b>                                                                                                                       |                   |                                                                |        |        |        |                    |
| 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    | $\mu\text{A}$      |
| 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   | $\mu\text{A}$      |
| <b>Normal Operation</b>                                                                                                                                      |                   |                                                                |        |        |        |                    |
| 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    | $\mu\text{A}$      |
| 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   | $\mu\text{A}$      |
| <b>Standby Operation</b>                                                                                                                                     |                   |                                                                |        |        |        |                    |
| Standby Operation Start Voltage                                                                                                                              | $V_{CC(S)}$       | $V_{CC} = 0 \rightarrow 15\text{ V}$ , $V_{FB} = 1.6\text{ V}$ | 10.3   | 11.1   | 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     | $\mu\text{A}$      |
| FB Terminal Inflow Current, Standby Operation                                                                                                                | $I_{FB(S)}$       | $V_{CC} = 10.2\text{ V}$ , $V_{FB} = 1.6\text{ V}$             | –      | 4      | 14     | $\mu\text{A}$      |
| 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                                                                                                                                              | $t_{ON(MIN)}$     |                                                                | 0.65   | 1.00   | 1.35   | $\mu\text{s}$      |
| <b>Protection Operation</b>                                                                                                                                  |                   |                                                                |        |        |        |                    |
| Maximum On Time                                                                                                                                              | $t_{ON(MAX)}$     |                                                                | 27.5   | 32.5   | 39.0   | $\mu\text{s}$      |
| 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     | $\mu\text{A}$      |
| 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 <sup>2</sup>                                                                                                                   | $I_{CC(H)}$       | $V_{CC(OFF)} - 0.3\text{ V}$                                   | –      | 45     | 140    | $\mu\text{A}$      |
| Latch Circuit Release Voltage <sup>2</sup>                                                                                                                   | $V_{CC(La.OFF)}$  | $V_{CC} = 30 \rightarrow 6\text{ V}$ , OVP operating           | 6.0    | 7.2    | 8.5    | V                  |
| <b>ELECTRICAL CHARACTERISTICS for MOSFET</b> , valid at $T_A = 25^\circ\text{C}$ , unless otherwise specified                                                |                   |                                                                |        |        |        |                    |
| Drain-to-Source Breakdown Voltage                                                                                                                            | $V_{DSS}$         | $I_D = 300\text{ }\mu\text{A}$                                 | 650    | –      | –      | V                  |
| Drain Leakage Current                                                                                                                                        | $I_{DSS}$         | $V_{DS} = 650\text{ V}$                                        | –      | –      | 300    | $\mu\text{A}$      |
| On Resistance                                                                                                                                                | $R_{DS(on)}$      | $I_D = 2.2\text{ A}$                                           | –      | –      | 0.73   | $\Omega$           |
| Switching Time                                                                                                                                               | $t_f$             |                                                                | –      | –      | 400    | ns                 |
| Thermal Resistance                                                                                                                                           | $R_{\theta ch-F}$ | Channel to internal frame                                      | –      | –      | 1.5    | $^\circ\text{C/W}$ |

<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.

## PACKAGE DIMENSIONS, TO-220



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

Dimensions in millimeters

Drawing for reference only  
Branding codes (exact appearance at manufacturer discretion):  
1st line, type: STR  
2nd line, subtype: W6756  
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.

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 the 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 the product pins, and wrong connections. Ensure all test parameters are within the ratings specified by Sanken for the products.

## Remarks About Using Silicone Grease with a Heatsink

- When silicone grease is used in mounting the products on a heatsink, it shall be applied evenly and thinly. If more silicone grease than required is applied, it may produce excess stress.
- Volatile-type silicone greases may crack after long periods of time, resulting in reduced heat radiation effect. Silicone greases with low consistency (hard grease) may cause cracks in the mold resin when screwing the products 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 | Momentive Performance Materials Inc. |
| SC102  | Dow Corning Toray Co., Ltd.          |

## Cautions for Mounting to a Heatsink

- When the flatness around the screw hole is insufficient, such as when mounting the products to a heatsink that has an extruded (burred) screw hole, the products can be damaged, even with a lower than recommended screw torque. For mounting the products, the mounting surface flatness should be 0.05 mm or less.

- Please select suitable screws for the product shape. Do not use a flat-head machine screw because of the stress to the products. Self-tapping screws are not recommended. When using self-tapping screws, the screw may enter the hole diagonally, not vertically, depending on the conditions of hole before threading or the work situation. That may stress the products and may cause failures.
  - Recommended screw torque: 0.588 to 0.785 N•m (6 to 8 kgf•cm).
  - For tightening screws, if a tightening tool (such as a driver) hits the products, the package may crack, and internal stress fractures may occur, which shorten the lifetime of the electrical elements and can cause catastrophic failure. Tightening with an air driver makes a substantial impact. In addition, a screw torque higher than the set torque can be applied and the package may be damaged. Therefore, an electric driver is recommended.
- When the package is tightened at two or more places, first pre-tighten with a lower torque at all places, then tighten with the specified torque. When using a power driver, torque control is mandatory.

## Soldering

- When soldering the products, please be sure to minimize the working time, within the following limits:  
260±5°C 10±1 s (Flow, 2 times)  
380±10°C 3.5±0.5 s (Soldering iron, 1 time)
- Soldering should be at a distance of at least 2.0 mm from the body of the products.

## Electrostatic Discharge

- When handling the products, the operator must be grounded. Grounded wrist straps worn should have at least 1 MΩ of resistance from the operator to ground to prevent shock hazard, and it should be placed near the operator.
- 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 Sanken shipping containers or conductive containers, or be wrapped in aluminum foil.

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In addition, it should be noted that since power devices or IC's including power devices have large self-heating value, the degree of derating of junction temperature affects the reliability significantly.

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