

60 W-Universal Input/40 W-230 Vac Input PWM Switching Regulators

Features and Benefits

- Overcurrent protection (OCP) with ac input voltage compensation function; no additional peripheral circuits required—minimizes dependency of OCP on ac input
- Overload protection (OLP) with integrated timer reduces power stress (temperature rise) at overload condition, requires no peripheral components
- Avalanche-guaranteed MOSFET improves device capability of withstanding excess surge voltage, providing a simple surge absorber circuit without breakdown voltage derating
- Start-up circuit eliminates the need for a start-up resistor, and helps to reduce input power consumption

Continued on the next page...

Package: TO-220



Not to scale

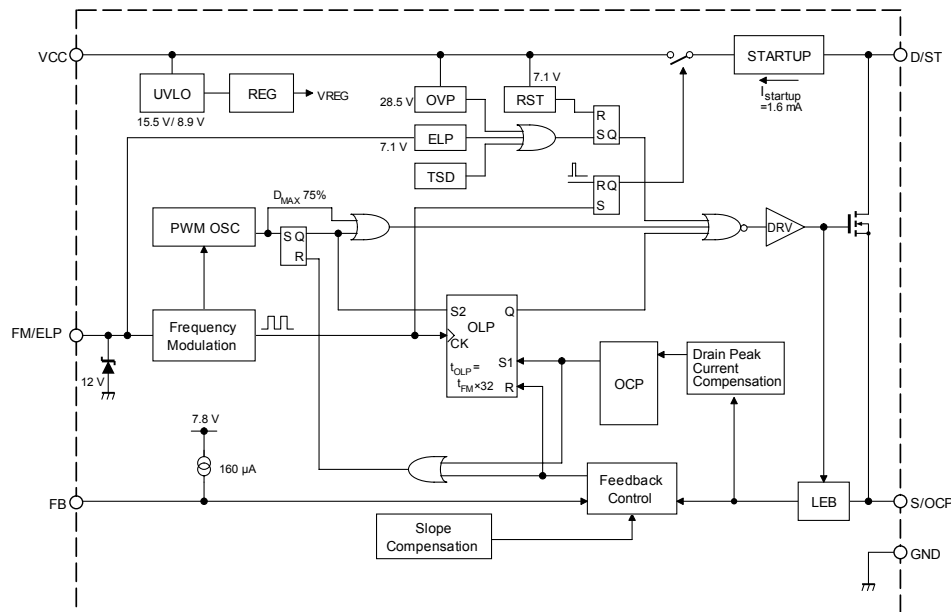
Description

The STR-W6200D series are current-mode PWM ICs that incorporate controller chips. These devices are manufactured using a proprietary high-voltage BCD process, and avalanche-guaranteed MOSFETs. These elements allow power supply systems designs that are highly reliable and simple, with fewer peripheral components. These ICs also provide Auto-Burst mode operation, which lowers input power requirements at light loads, and improves efficiency over the entire load range and universal-input range.

Applications include:

- TV set top box
- LCD PC monitor, LCD TV
- Printer, scanner
- General consumer, PC, and industrial applications requiring SMPS power supply with standby mode

Functional Block Diagram



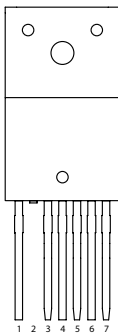
Features and Benefits (continued)

- Bias Assist function improves start-up performance by self-biasing the VCC pin, and allows a use of a small value VCC capacitor, resulting in improved response to overvoltage conditions
- Very low current consumption in nonoperating (UVLO) state: $I_{CC(off)} = 5 \mu A$ (typical) at $V_{CC} = 13.8 V$
- Slope compensation circuit stabilizes operation, preventing interference from subharmonics
- Leading Edge Blanking
- Various protections:
 - Overcurrent Protection (OCP), pulse-by-pulse sensing
 - Overload Protection (OLP), auto restart after certain duration
 - External Latch Protection (ELP), latched
 - Overvoltage Protection (OVP), latched
 - Thermal Shut Down (TSD), latched
- Externally-activated shut down protection (ELP) for emergency system shut down
- Auto-Burst Standby function (pin < 0.1 W at zero output load condition)
- Audible noise reducing function in Standby mode
- TO-220 full-molded package with 6 pins

Selection Guide

| Part Number | Packing |
|-------------|--------------------|
| STRW6252D | 50 pieces per tube |

Pin-out Diagram



Terminal List Table

| Number | Name | Description | Functions |
|--------|--------|--|--|
| 1 | D/ST | Drain/startup terminal | MOSFET drain and input of start-up signal |
| 2 | NC | Clipped | No connection |
| 3 | S/OCP | Source/Overcurrent Protection terminal | MOSFET source and input of overcurrent detection signal |
| 4 | VCC | Power supply terminal | Input of power supply for control circuit |
| 5 | GND | Ground terminal | Ground |
| 6 | FB | Feedback terminal | Input of constant voltage control signal |
| 7 | FM/ELP | Frequency jittering and External Latch Protection terminal | Control input for frequency jittering control, and External Latch Protection |

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.

ABSOLUTE MAXIMUM RATINGS at $T_A = 25^\circ\text{C}$

| Characteristic | Symbol | Terminal | Note | Rating | Unit |
|--|-------------|----------|---|------------|------------------|
| Drain Current ¹ | I_{Dpeak} | 1-3 | Single Pulse | 3.2 | A |
| Maximum Switching Current ² | I_{DMAX} | 1-3 | $T_A = -20$ to 125°C | 3.2 | A |
| Single Pulse Avalanche Energy ³ | E_{AS} | 1-3 | Single Pulse | 62 | mJ |
| | I_{Dpeak} | 1-3 | $V_{DD} = 99\text{ V}$, $L = 20\text{ mH}$ | 2.3 | A |
| S/OCP Terminal Voltage | V_{OCP} | 3-5 | | -6 to 6 | V |
| FM/ELP Terminal Voltage | V_{FM} | 7-5 | | -0.3 to 12 | V |
| FM/ELP Terminal Inflow Current | I_{FM} | 7-5 | | 3 | mA |
| FB Terminal Voltage | V_{FB} | 6-5 | | -0.3 to 9 | V |
| Controller (MIC) Input Voltage | V_{CC} | 4-5 | | 0 to 32 | V |
| MOSFET Power Dissipation ⁴ | P_{D1} | 8-1 | With infinite heatsink | 26 | W |
| | | | Without heatsink | 1.3 | W |
| Controller (MIC) Power Dissipation | P_{D2} | 5-3 | For $V_{CC} \times I_{CC}$ | 0.8 | W |
| Operating Internal Frame 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 | $^\circ\text{C}$ |
| Channel Junction Temperature | T_J | - | | 150 | $^\circ\text{C}$ |

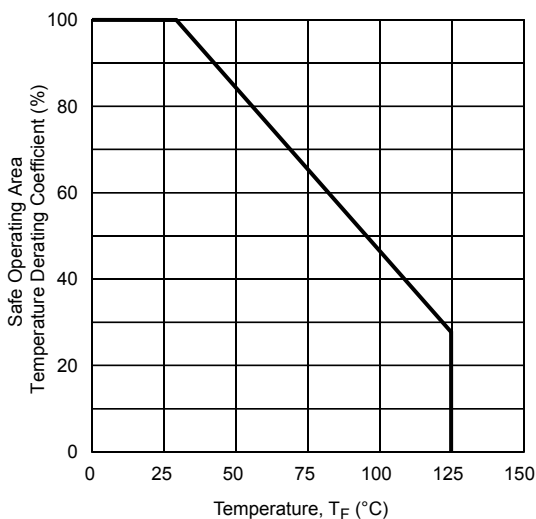
¹Refer to figure 1

² I_{DMAX} is the drain current on the D/ST pin determined by the drive voltage of the IC and the threshold voltage, V_{th} , of the MOSFET

³Refer to figure 3

⁴Refer to figure 4

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



**Figure 2 – MOSFET Safe Operating Area
Drain Current versus Voltage
at $T_A = 25^\circ\text{C}$, Single Pulse**

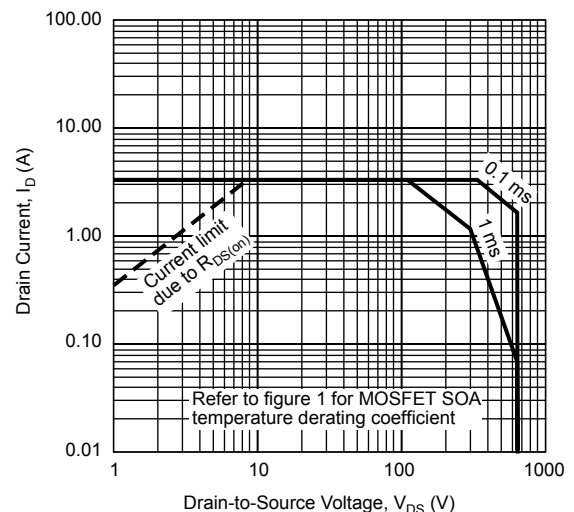


Figure 3 – MOSFET Avalanche Energy Derating Curve

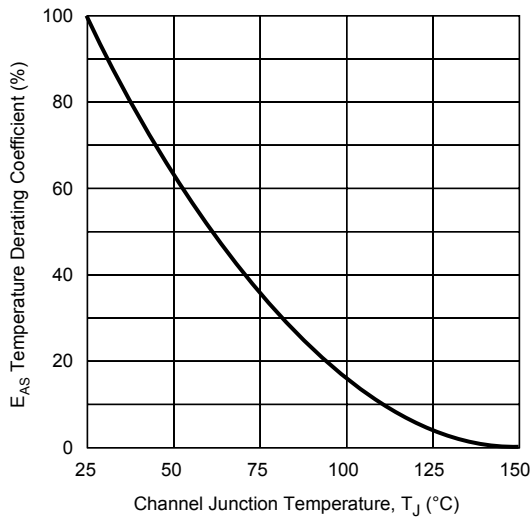


Figure 4 – Transient Thermal Resistance

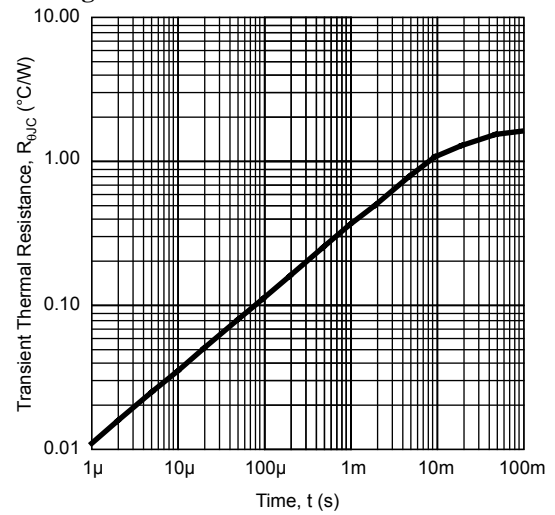
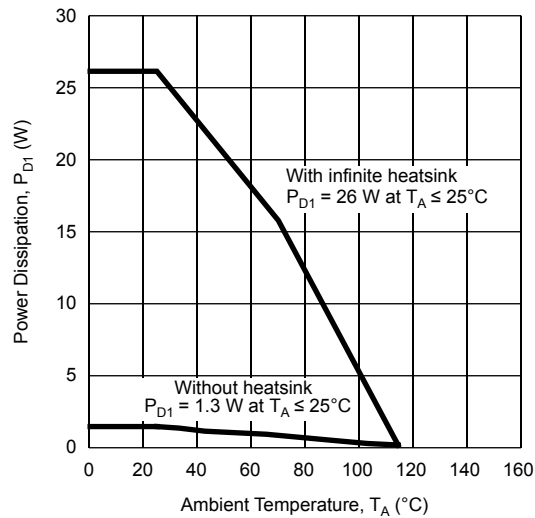


Figure 5 – MOSFET Power Dissipation versus Temperature



ELECTRICAL CHARACTERISTICS valid at $V_{CC} = 18\text{ V}$, $T_A = 25^\circ\text{C}$, unless otherwise specified

| Characteristic | Symbol | Terminal | Test Conditions | Min. | Typ. | Max | Units |
|--|-----------------|----------|--|-------|------|------|-------------------|
| Power Supply Start-up Operation | | | | | | | |
| Operation Start Voltage | $V_{CC(ON)}$ | 4-5 | (VCC voltage at which operation starts) Measurement circuit 1, $V_{CC} = 0$ through 13.9 through 17.1 V | 13.9 | 15.5 | 17.1 | V |
| Operation Stop Voltage | $V_{CC(OFF)}$ | 4-5 | (VCC voltage at which operation stops) Measurement circuit 1, $V_{CC} = 17.1$ through 9.8 to 8.0 V | 8.0 | 8.9 | 9.8 | V |
| Circuit Current in Operation | $I_{CC(ON)}$ | 4-5 | (Inflow current into VCC terminal in oscillation) Measurement circuit 1 | – | 1.4 | 2.8 | mA |
| Circuit Current in Non-Oscillation | $I_{CC(STOP)}$ | 4-5 | (Inflow current into VCC terminal at $V_{FB} = 0\text{ V}$) Measurement circuit 1 | – | 0.8 | 1.3 | mA |
| Circuit Current in Non-Operation | $I_{CC(OFF)}$ | 4-5 | (Inflow current into VCC terminal prior to oscillation) Measurement circuit 1, $V_{CC} = 13.8$ | – | 5 | 20 | μA |
| Start-up Current | $I_{startup}$ | 4-5 | (Inflow current into D/ST terminal) Measurement circuit 7, $V_{CC} = 0$, D/ST = 450 V | –0.9 | –1.6 | –2.3 | mA |
| Bias Assist Voltage | V_{BIAS} | 4-5 | (VCC voltage at which $I_{startup}$ starts, and $I_{startupBias}$ begins) Measurement circuit 7, $V_{CC} = 17.1$ through 13.6 to 16.8 V | 13.6 | 15.2 | 16.8 | V |
| Operating Characteristics | | | | | | | |
| FM/ELP High Threshold Voltage | $V_{FM(H)}$ | 7-5 | (FM/ELP terminal voltage at which I_{FM} changes from $-13\ \mu\text{A}$ to $13\ \mu\text{A}$) Measurement circuit 2 | 4.0 | 4.5 | 5.0 | V |
| FM/ELP Low Threshold Voltage | $V_{FM(L)}$ | 7-5 | (FM/ELP terminal voltage at which I_{FM} changes from $13\ \mu\text{A}$ to $-13\ \mu\text{A}$) Measurement circuit 2 | 2.4 | 2.8 | 3.2 | V |
| FM/ELP Voltage Hysteresis | V_{FMhys} | 7-5 | $(V_{FM(H)} - V_{FM(L)})$ Measurement circuit 2 | 1.4 | 1.7 | 1.8 | V |
| FM/ELP Outflow Current ¹ | I_{FMsrc} | 7-5 | (FM/ELP terminal outflow current at $V_{FM} = V_{FM(L)}$) Measurement circuit 2 | –17.4 | –13 | –8.6 | μA |
| FM/ELP Inflow Current ¹ | I_{FMsink} | 7-5 | (FM/ELP terminal inflow current at $V_{FM} = V_{FM(H)}$) Measurement circuit 2 | 8.6 | 13 | 17.4 | μA |
| Average Switching Frequency | $f_{OSC(av)}$ | 1-5 | (D/ST terminal average oscillation frequency) Measurement circuit 2 | 60 | 67 | 74 | kHz |
| Frequency Jitter Deviation | Δf | 1-5 | f_{OSC} (peak-to-peak) Measurement circuit 2 | 4.8 | 6.9 | 9 | kHz |
| Maximum Duty Cycle | D_{MAX} | 1-5 | (Maximum width of the low portion of the D/ST terminal waveform) Measurement circuit 2 | 71 | 75 | 79 | % |
| FB Maximum Feedback Current ¹ | $I_{FB(MAX)}$ | 6-5 | (FB terminal outflow current at $V_{FB} = 0\text{ V}$) Measurement circuit 3 | –220 | –160 | –100 | μA |
| Burst Threshold Voltage | $V_{burst(th)}$ | 6-5 | Set $V_{FM} = 0\text{ V}$ and decrease V_{FB} ($V_{burst(th)}$ is the FB terminal voltage level at which D/ST changes from low to high) Measurement circuit 3 | 0.99 | 1.10 | 1.21 | V |
| Slope Compensation Start-up Duty Cycle | D_{SLP} | 6-5 | $D_{SLP} = (\beta / t_4) \times 100$ (see figure for measurement circuit 4 for values of t) Measurement circuit 4 | – | 27 | – | % |
| Slope Compensation Rate | SLP | 6-5 | $SLP = 0.02 / (t_2 - t_1)$ (see figure for measurement circuit 4 for values of t) Measurement circuit 4 | –22 | –17 | –12 | mV/ μs |

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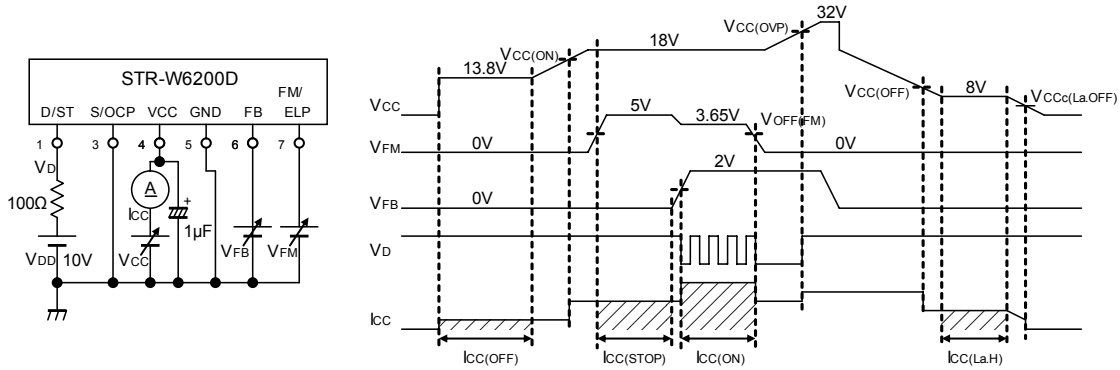
ELECTRICAL CHARACTERISTICS, continued, valid at $V_{CC} = 18\text{ V}$, $T_A = 25^\circ\text{C}$, unless otherwise specified

| Characteristic | Symbol | Terminal | Test Conditions | Min. | Typ. | Max | Units |
|---|------------------|----------|--|------|------|------|--------------------|
| Protection Operation | | | | | | | |
| OCP Threshold Voltage at Zero Duty Cycle (0% On-Duty) | V_{OCP1} | 3-5 | Set $V_{FM} = 0\text{ V}$ and increase V_{OCP} . (V_{OCP1} is the S/OCP terminal voltage level at which D/ST changes from low to high) Measurement circuit 5 | 0.71 | 0.78 | 0.86 | V |
| Drain Peak Current Compensation Coefficient | D_{PC} | – | $D_{PC} = -0.75 \times SLP / f_{OSC(av)}$ | 1.5 | 1.9 | 2.3 | mV/DC% |
| OCP Threshold Voltage After Compensation | V_{OCP2} | 3-5 | $V_{OCP2} = D_{PC} \times D_{MAX} + V_{OCP1}$ | 0.82 | 0.93 | 1.04 | V |
| Leading Edge Blanking Time | t_{blank} | 1-5 | (The low portion of the D/ST terminal waveform at $V_{OCP} = 2\text{ V}$) Measurement circuit 5 | 280 | 400 | 520 | ns |
| OLP Delay Time | t_{OLP} | 1-5 | (Time between setting FB terminal open and when oscillation stops) Measurement circuit 6 | – | 200 | – | ms |
| Circuit Current in OLP-Operation | $I_{CC(OLP)}$ | 4-5 | (Inflow current into VCC terminal after OLP operation) Measurement circuit 6 | – | 410 | 700 | μA |
| OVP Protection Voltage | $V_{CC(OVP)}$ | 4-5 | (VCC terminal voltage at which the voltage of D/ST terminal is switched from low to high by decreasing V_{FB} after setting $V_{FM} = 0\text{ V}$) Measurement circuit 1, $V_{CC} = 18.0\text{ V}$ through 27 to 30 V | 27 | 28.5 | 30 | V |
| Latch Circuit Sustaining Current ² | $I_{CC(La,H)}$ | 4-5 | (Inflow current into VCC terminal after OVP operation) Measurement circuit 1, $V_{CC} = 7.8\text{ V}$ | – | 140 | 220 | μA |
| Latch Circuit Release Voltage ² | $V_{CC(La,OFF)}$ | 4-5 | (VCC voltage at which I_{CC} is dropped below 20 μA by decreasing V_{CC} after OVP operation) $V_{CC} = 31.0\text{ V}$ through 7.8 to 6.4 V | 6.4 | 7.1 | 7.8 | V |
| ELP Threshold Voltage | V_{ELP} | 7-5 | (FM/ELP terminal voltage at which the oscillation of the D/ST terminal waveform is stopped by increasing V_{FM}) Measurement circuit 2 | 6.4 | 7.1 | 7.8 | V |
| Inflow Current at External Latch Protection | I_{ELP} | 7-5 | (Inflow current at $V_{FM} = V_{ELP}$) Measurement circuit 2 | – | 55 | 100 | μA |
| Thermal Shut Down Operating Temperature | T_{JTSD} | – | | 135 | – | – | $^\circ\text{C}$ |
| Power MOSFET Characteristics | | | | | | | |
| Drain-to-Source Breakdown Voltage | V_{DSS} | 1-3 | $I_D = 300\ \mu\text{A}$, Measurement circuit 8 | 650 | – | – | V |
| Drain Leakage Current | I_{DSS} | 1-3 | $V_D = 650\text{ V}$, Measurement circuit 7 | – | – | 300 | μA |
| ON-Resistance | $R_{DS(ON)}$ | 1-3 | $I_D = 1.0\text{ A}$, $V_{FM} = 0\text{ V}$ Measurement circuit 10 | – | – | 2.8 | Ω |
| Switching Time | t_r | 1-3 | Measurement circuit 9 | – | – | 400 | ns |
| Thermal Resistance | $R_{\theta J-F}$ | – | Measured between junction and internal frame | – | – | 2.04 | $^\circ\text{C/W}$ |
| Single Pulse Avalanche Energy | E_{AS} | – | Measurement circuit 11 | – | – | – | – |

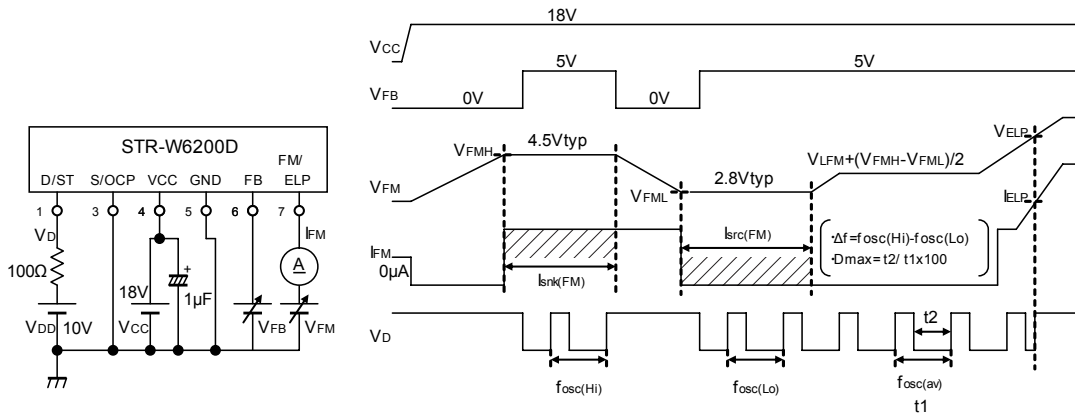
¹Input and output current polarity at the device pin; plus(+) represents sink and minus(–) represents source.

²The latch circuit means a circuit operated ELP, OVP, and TSD.

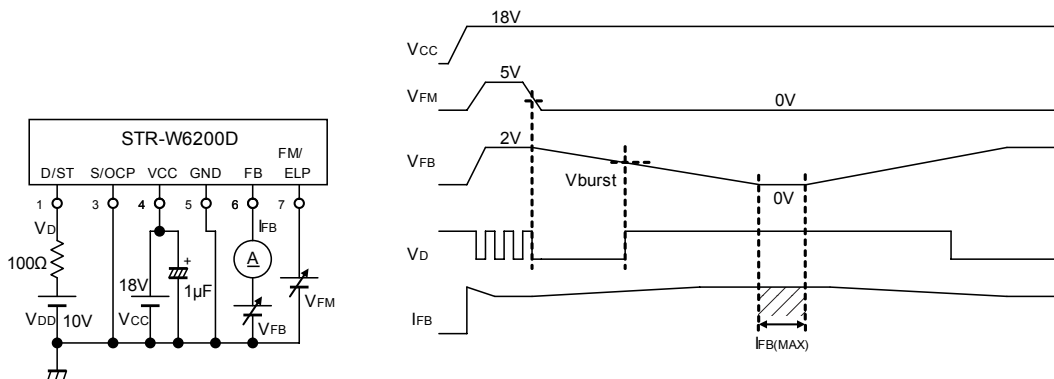
Measurement Circuit 1



Measurement Circuit 2



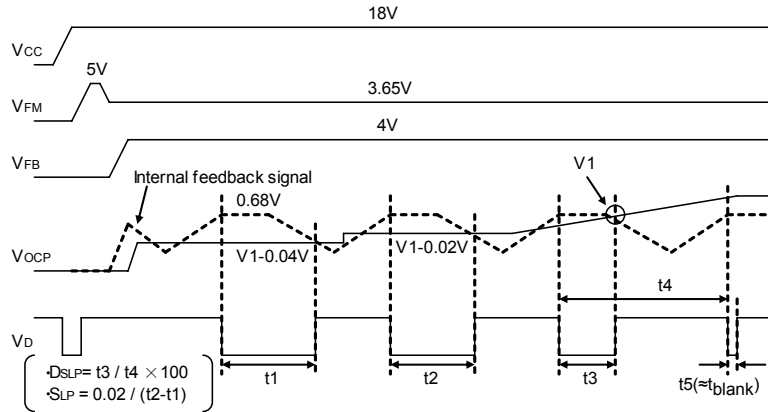
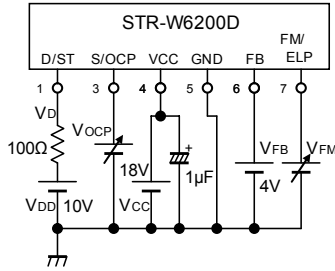
Measurement Circuit 3



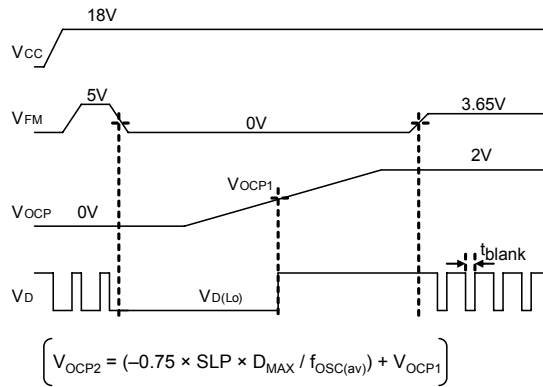
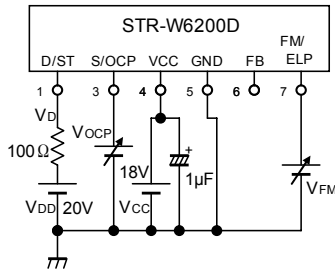
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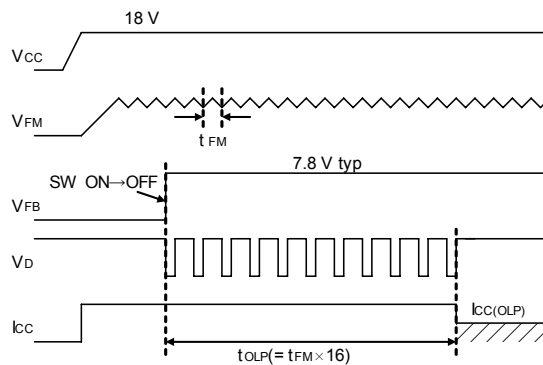
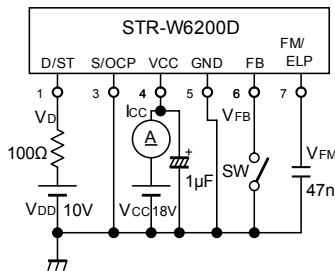
Measurement Circuit 4



Measurement Circuit 5



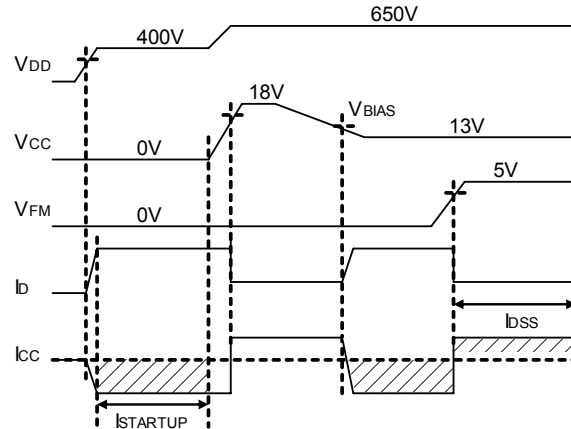
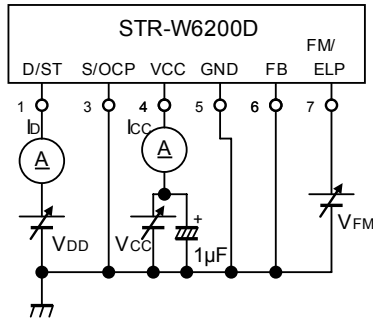
Measurement Circuit 6



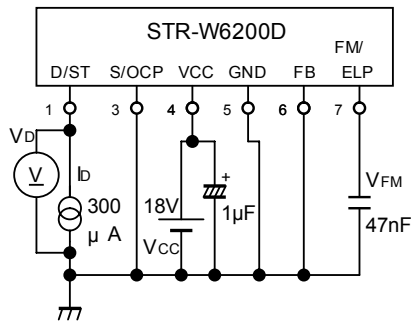
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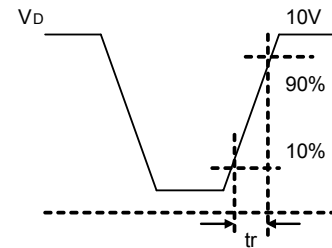
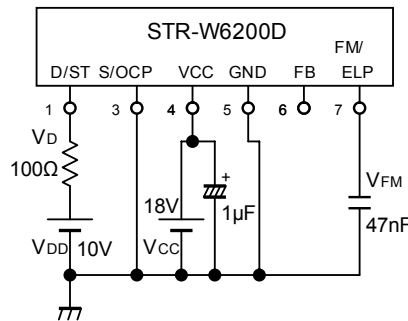
Measurement Circuit 7



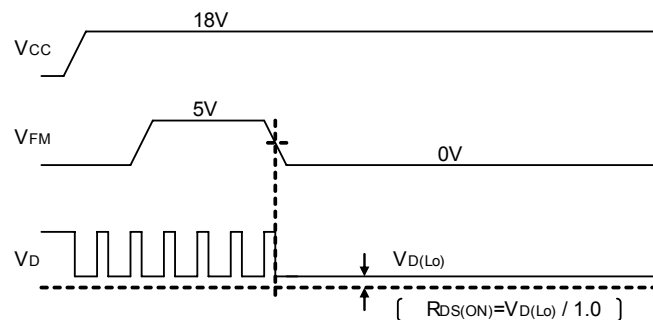
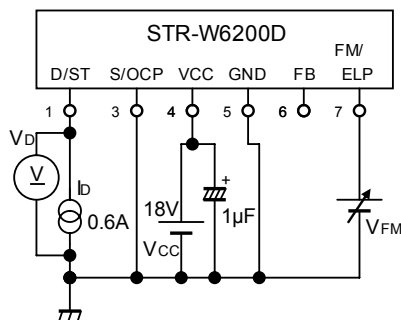
Measurement Circuit 8



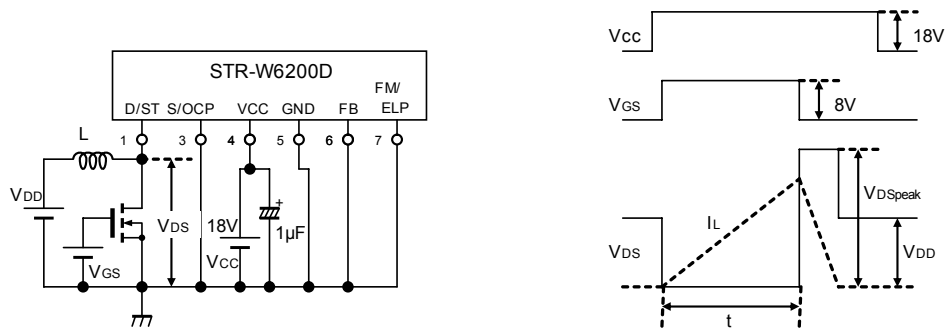
Measurement Circuit 9



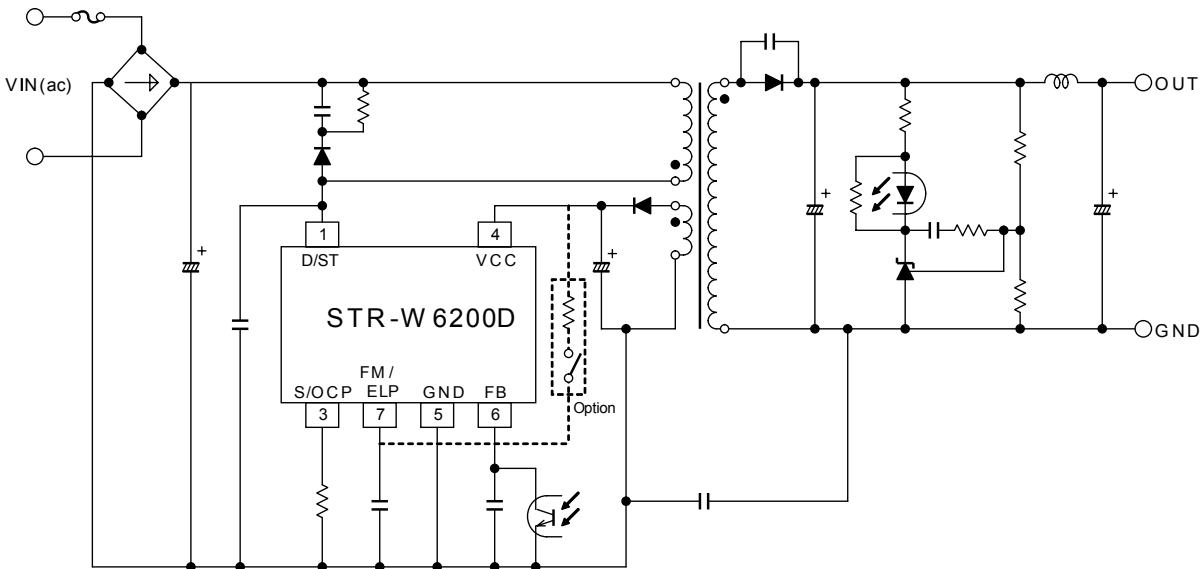
Measurement Circuit 10



Measurement Circuit 11



TYPICAL APPLICATION CIRCUIT

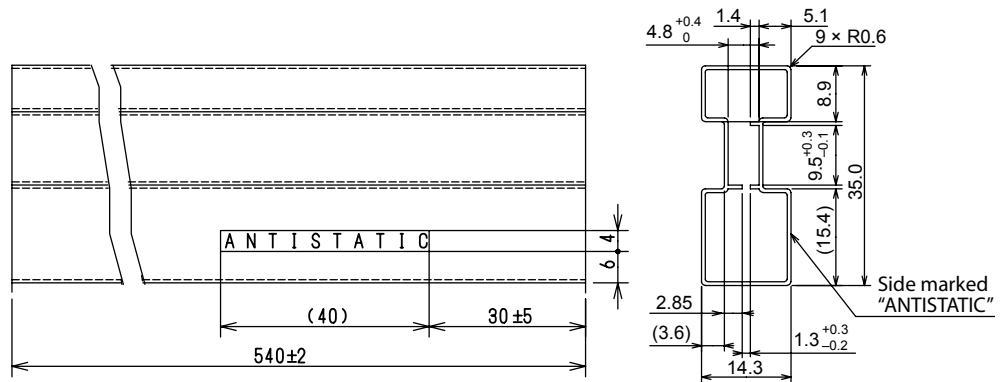


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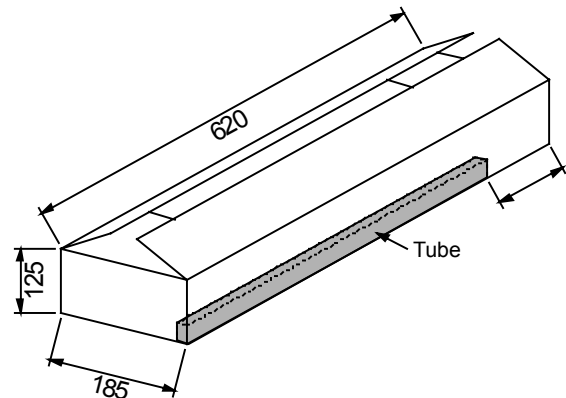
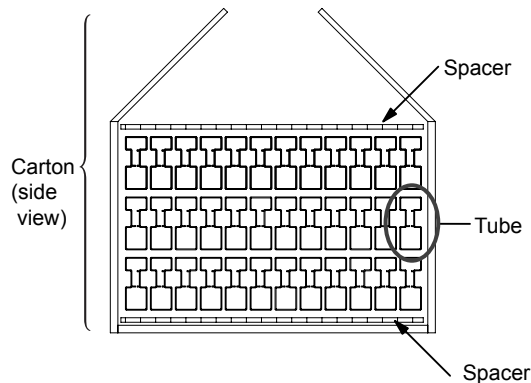
60 W-Universal Input/40 W-230 Vac Input PWM Switching Regulators

PACKING SPECIFICATIONS Minimum packing option: Tube FM-205 E

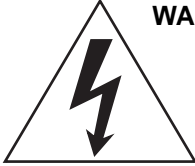
Shipping Tube Dimensions:
 Wall thickness: 0.6 ± 0.3 mm
 Wall warp: < 2 mm
 Material: Hardened polyvinyl
 Coating: antistatic
 Tolerance ± 0.4 mm,
 unless otherwise specified



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 | 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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Users of Sanken products are requested to take, at their own risk, preventative measures including safety design of the equipment or systems against any possible injury, death, fires or damages to society due to device failure or malfunction.

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When considering the use of Sanken products in applications where higher reliability is required (transportation equipment and its control systems or equipment, fire- or burglar-alarm systems, various safety devices, etc.), contact a company sales representative to discuss and obtain written confirmation of your specifications.

The use of Sanken products without the written consent of Sanken in applications where extremely high reliability is required (aerospace equipment, nuclear power-control stations, life-support systems, etc.) is strictly prohibited.

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Allegro MicroSystems, Inc.
115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000
www.allegromicro.com



Worldwide ContactsAsia-Pacific**China****Sanken Electric Hong Kong Co., Ltd.**

Suite 1026, Ocean Centre
Canton Road, Tsimshatsui
Kowloon, Hong Kong
Tel: 852-2735-5262, Fax: 852-2735-5494

Sanken Electric (Shanghai) Co., Ltd.

Room 3202, Maxdo Centre
Xingyi Road 8, Changning District
Shanghai, China
Tel: 86-21-5208-1177, Fax: 86-21-5208-1757

Taiwan Sanken Electric Co., Ltd.

Room 1801, 18th Floor
88 Jung Shiau East Road, Sec. 2
Taipei 100, Taiwan R.O.C.
Tel: 886-2-2356-8161, Fax: 886-2-2356-8261

Japan**Sanken Electric Co., Ltd.
Overseas Sales Headquarters**

Metropolitan Plaza Building
1-11-1 Nishi-Ikebukuro, Toshima-ku
Tokyo 171-0021, Japan
Tel: 81-3-3986-6164, Fax: 81-3-3986-8637

Korea**Sanken Electric Korea Co., Ltd.**

Samsung Life Yeouido Building 16F
23-10, Yeouido-Dong, Yeongdeungpo-gu
Seoul 150-734, Korea
Tel: 82-2-714-3700, Fax: 82-2-3272-2145

Singapore**Sanken Electric Singapore Pte. Ltd.**

150 Beach Road, #14-03 The Gateway West
Singapore 189720
Tel: 65-6291-4755, Fax: 65-6297-1744

Europe**Sanken Power Systems (UK) Limited**

Pencoed Technology Park
Pencoed, Bridgend CF35 5HY, United Kingdom
Tel: 44-1656-869-100, Fax: 44-1656-869-162

North America**United States****Allegro MicroSystems, Inc.**

115 Northeast Cutoff
Worcester, Massachusetts 01606, U.S.A.
Tel: 1-508-853-5000, Fax: 1-508-853-7895

Allegro MicroSystems, Inc.

14 Hughes Street, Suite B105
Irvine, California 92618, U.S.A.
Tel: 1-949-460-2003, Fax: 1-949-460-7837