PWM Off-Line Switching Regulator ICs

Features and Benefits

- TO-220 fully-molded package with 6 pins
- Current mode PWM control
- PWM and frequency modulation functions: reduces EMI noise, simplifies EMI filters, and cuts cost by external part reduction
- Built-in Slope Compensation circuit: avoids subharmonic oscillation
- Automatic Standby Mode function (Input Power < 40 mW at no load)
  - Normal operation: PWM mode
  - Light load operation: Standby mode (burst oscillation)
- Built-in Audible Noise Suppression function during Standby mode

Continued on the next page…

Package: TO-220F-6L

Not to scale

Description

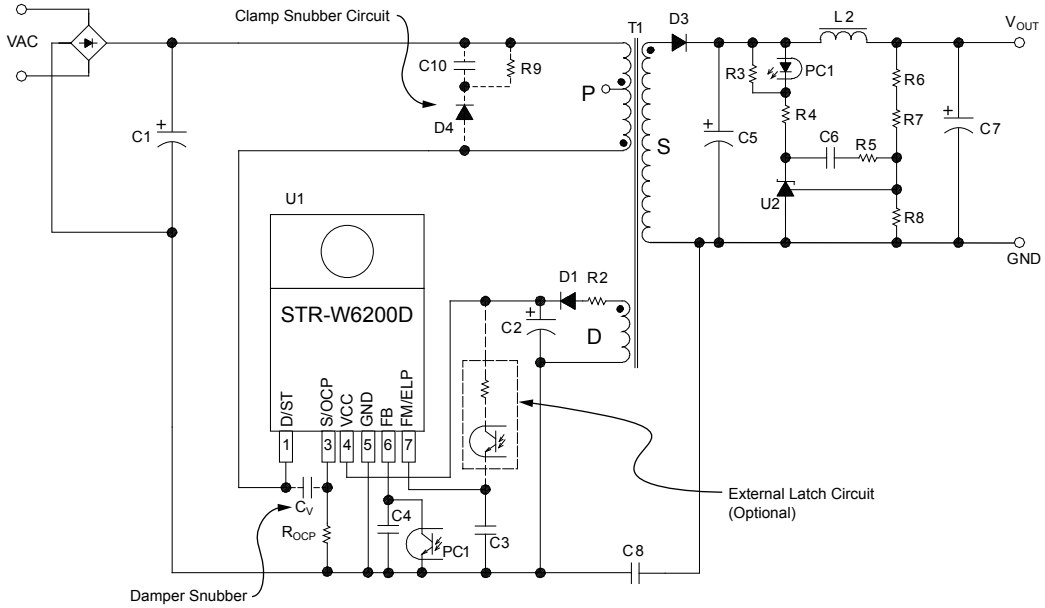
STR-W6200D series are power ICs for switching power supplies, incorporating a power MOSFET and a current mode PWM controller IC in one package.

Including a startup circuit and a standby function in the controller, the product achieves low power consumption, low standby power, and high cost-effectiveness in power supply systems, while reducing external components.

Applications:

Switching power supplies for electronic devices such as:
- White goods
- Consumer electronics
- Office automation
- Industrial equipment
- Communication equipment

Typical Application



Features and Benefits (continued)

- Built-in startup circuit: reduces power consumption in standby operation, and eliminates external components
- Bias-Assist function: improves startup operation, suppresses VCC pin voltage drop in operation, and allows use of smaller V_{CC} capacitor
- Built-in Leading Edge Blanking function
- Protection Functions:
  - Overcurrent Protection function (OCP); pulse-by-pulse, built-in compensation circuit to minimize OCP point variation on AC input voltage
  - Overload Protection function (OLP); auto restart, built-in timer, reduces heat during overload condition, and few external components required
  - External Latch Protection function (ELP): latched shutdown by external signal
  - Overvoltage Protection function (OVP): latched shutdown
  - Thermal Shutdown function (TSD); latched shutdown

Selection Guide

Part Number	f_{OSC} (kHz)	MOSFET V_{DSS}(min) (V)	$R_{DS(on)}$ (max) (Ω)	P_{OUT}* (W)	
				230 VAC	85 to 265 VAC
STR-W6251D	67	650	3.95	45	30
STR-W6252D			2.8	60	40
STR-W6253D			1.9	90	60

*The listed output power is based on the thermal ratings, and the peak output power can be 120% to 140% of the value stated here. At low output voltage and short duty cycle, the output power may be less than the value stated here.

The polarity value for current specifies a sink as "+," and a source as "−," referencing the IC.

Absolute Maximum Ratings Unless specifically noted, valid at T_A = 25°C

Characteristic	Symbol	Note			Pin	Rating	Unit
Drain Peak Current[1]	I_{DPEAK}	STR-W6251D	Single Pulse		1-3	2.6	A
		STR-W6252D				3.2	A
		STR-W6253D				10	A
Maximum Switching Current[2]	I_{DMAX}	STR-W6251D	T_A = –20°C to 125°C		1-3	2.6	A
		STR-W6252D				3.2	A
		STR-W6253D				10	A
Avalanche Energy[3]	E_{AS}	STR-W6251D	I_{LPEAK} = 2 A	Single Pulse, V_{DD} = 99 V, L = 20 mH	1-3	47	mJ
		STR-W6252D	I_{LPEAK} = 2.3 A			62	mJ
		STR-W6253D	I_{LPEAK} = 2.7 A			86	mJ
S/OCP Pin Voltage	V_{OCP}				3-5	–6 to 6	V
FM/ELP Pin Voltage	V_{FM}				7-5	–0.3 to 12	V
FM/ELP Pin Sink Current	I_{FM}				7-5	3	mA
FB Pin Voltage	V_{FB}	FB pin is open			6-5	–0.3 to 9	V
Controller Part Input Voltage	V_{CC}				4-5	0 to 32	V
MOSFET Power Dissipation[4]	P_{D1}	STR-W6251D	With infinite heatsink		1-3	25	W
		STR-W6252D				26	W
		STR-W6253D				27.5	W
		Without heatsink				1.3	W
Controller Part Power Dissipation	P_{D2}				4-5	0.8	W
Internal Frame Temperature in Operation	T_F	Recommended operating temperature is T_F = 105°C (max)			–	–20 to 115	°C
Operating Ambient Temperature	T_{op}				–	–20 to 115	°C
Storage Temperature	T_{stg}				–	–40 to 125	°C
Channel Temperature	T_{ch}				–	150	°C

[1]Refer to MOSFET Safe Operating Area Curve.
[2]The Maximum Switching Current is the drain current determined by the drive voltage of the IC and threshold voltage (V_{th}) of the MOSFET.
[3]Refer to MOSFET Avalanche Energy Derating Coefficient Curve.
[4]Refer to MOSFET Temperature versus Power Dissipation Curve.

Electrical Characteristics of Control Part Unless specifically noted, T_A is 25°C, V_{CC} = 18 V

Characteristic	Symbol	Pin	Min.	Typ.	Max	Unit
Power Supply Startup Operation						
Operation Start Voltage	$V_{CC(ON)}$	4-5	13.9	15.5	17.1	V
Operation Stop Voltage	$V_{CC(OFF)}$	4-5	8.0	8.9	9.8	V
Circuit Current in Operation	$I_{CC(ON)}$	4-5	–	1.4	2.8	mA
Circuit Current in Non-Oscillation	$I_{CC(STOP)}$	4-5	–	0.8	1.3	mA
Circuit Current in Non-Operation	$I_{CC(OFF)}$	4-5	–	5	20	µA
Startup Current	$I_{STARTUP}$	4-5	–0.9	–1.6	–2.3	mA
Bias Assist Voltage	$V_{CC(BIAS)}$	4-5	13.6	15.2	16.8	V
Normal Operation						
FM/ELP Pin High Threshold Voltage	$V_{FM(H)}$	7-5	4.0	4.5	5.0	V
FM/ELP Pin Low Threshold Voltage	$V_{FM(L)}$	7-5	2.4	2.8	3.2	V
FM/ELP Pin Voltage Difference	ΔV_{FM}	7-5	1.4	1.7	1.8	V
FM/ELP Pin Source Current	$I_{FM(SRC)}$	7-5	–17.4	–13	–8.6	µA
FM/ELP Pin Sink Current	$I_{FM(SNK)}$	7-5	8.6	13	17.4	µA
Average Switching Frequency	$f_{OSC(AVG)}$	1-5	60	67	74	kHz
Frequency Modulation Deviation	Δf	1-5	4.8	6.9	9	kHz
Maximum Duty Cycle (On-duty)	D_{MAX}	1-5	71	75	79	%
FB Pin Maximum Feedback Current	$I_{FB(MAX)}$	6-5	–220	–160	–100	µA
Standby Operation Startup Voltage	V_{STBY}	6-5	0.99	1.10	1.21	V
Slope Compensation Startup Duty Cycle	D_{SLP}	6-5	–	27	–	%
Slope Compensation Rate	SLP	6-5	–22	–17	–12	mV/µs
Protection Operation						
OCP Threshold Voltage at Zero Duty Cycle (0% On-duty)	V_{OCP1}	3-5	0.71	0.78	0.86	V
Drain Peak Current Compensation Coefficient	D_{PC}	–	1.5	1.9	2.3	mV/D%
OCP Threshold Voltage After Compensation	V_{OCP2}	3-5	0.82	0.93	1.04	V
LEB Time	t_{BW}	1-5	280	400	520	ns
OLP Delay Time*	t_{DLY}	1-5	–	200	–	ms
Circuit Current in OLP-Operation	$I_{CC(OLP)}$	4-5	–	410	700	µA
OVP Threshold Voltage	$V_{CC(OVP)}$	4-5	27	28.5	30	V
Latch Circuit Holding Current	$I_{CC(La.H)}$	4-5	–	140	220	µA
Latch Circuit Release Voltage	$V_{CC(La.OFF)}$	4-5	6.4	7.1	7.8	V
ELP Threshold Voltage	V_{ELP}	7-5	6.4	7.1	7.8	V
Sink Current in ELP Operation	I_{ELP}	7-5	–	55	100	µA
Thermal Shutdown Activating Temperature	$T_{J(TSD)}$	–	135	–	–	°C

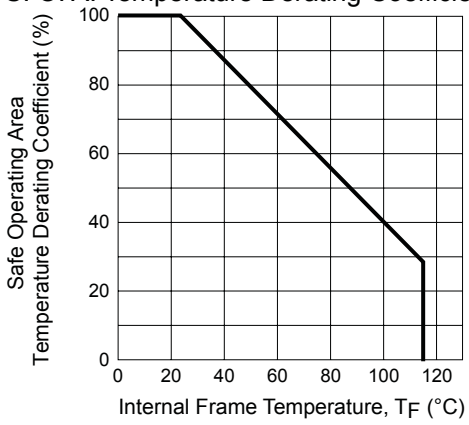
*Reference value of 47 nF capacitor between FM/ELP and GND Pins.

Electrical Characteristics of MOSFET Unless specifically noted, T_A is 25°C

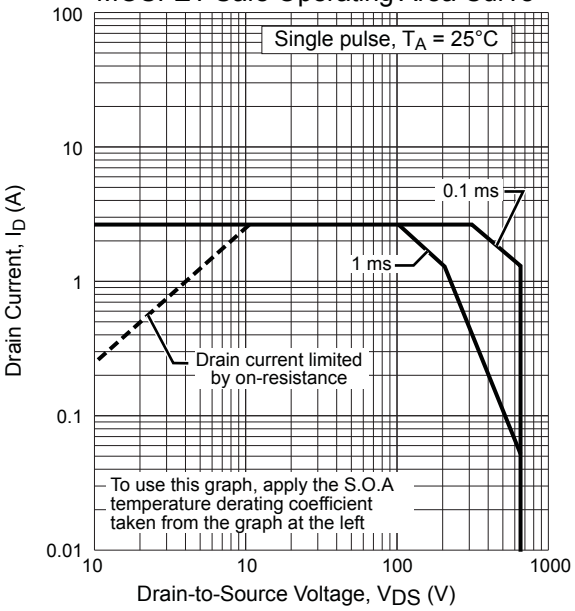
Characteristic	Symbol	Note		Pin	Min.	Typ.	Max.	Unit
Drain-to-Source Breakdown Voltage	V_{DSS}			1-3	650	–	–	V
Drain Leakage Current	I_{DSS}			1-3	–	–	300	μA
On-Resistance	$R_{DS(ON)}$	STR-W6251D		1-3	–	–	3.95	Ω
		STR-W6252D			–	–	2.8	Ω
		STR-W6253D			–	–	1.9	Ω
Switching Time	t_r			1-3	–	–	400	ns
Thermal Resistance	$R_{\theta ch-F}$	STR-W6251D	Between channel and internal frame	–	–	–	2.23	°C/W
		STR-W6252D			–	–	2.04	°C/W
		STR-W6253D			–	–	1.75	°C/W

Typical Characteristic Performance
STR-W6251D

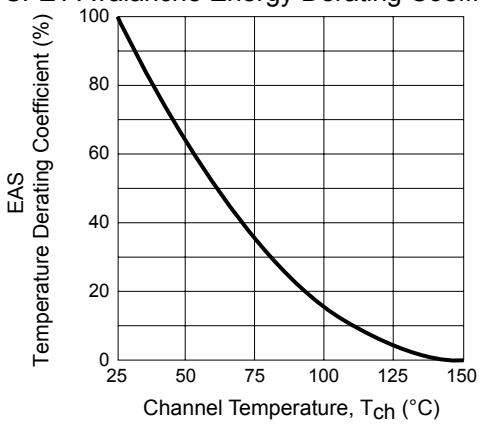
S. O. A. Temperature Derating Coefficient Curve



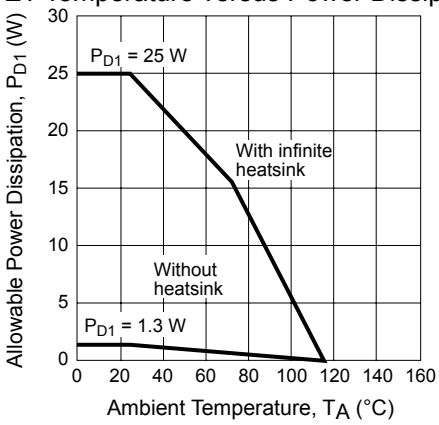
MOSFET Safe Operating Area Curve



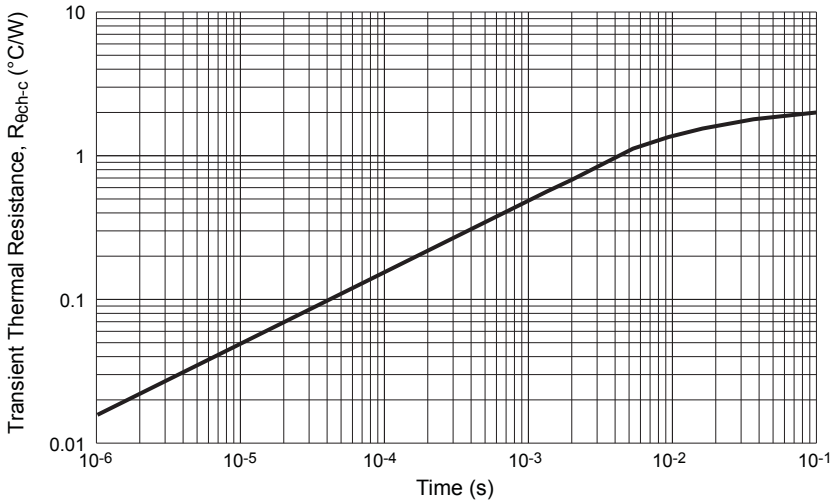
MOSFET Avalanche Energy Derating Coefficient Curve



MOSFET Temperature versus Power Dissipation Curve

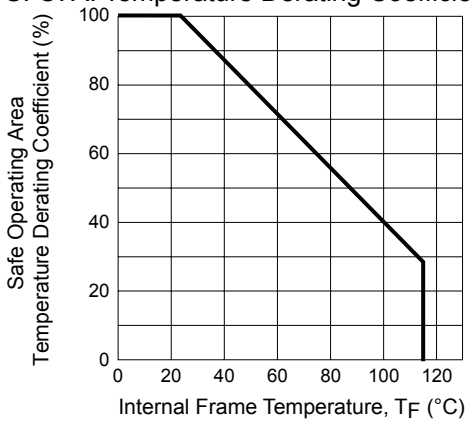


Transient Thermal Resistance Curve

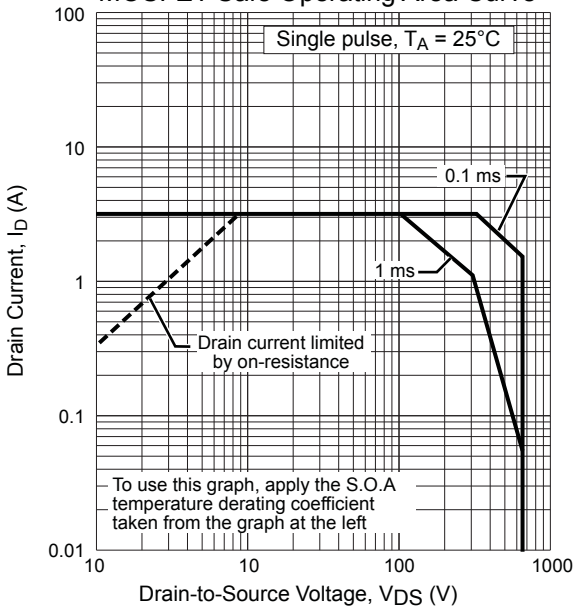


Typical Characteristic Performance
STR-W6252D

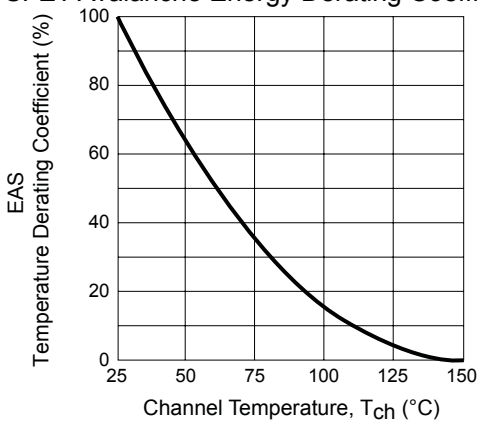
S. O. A. Temperature Derating Coefficient Curve



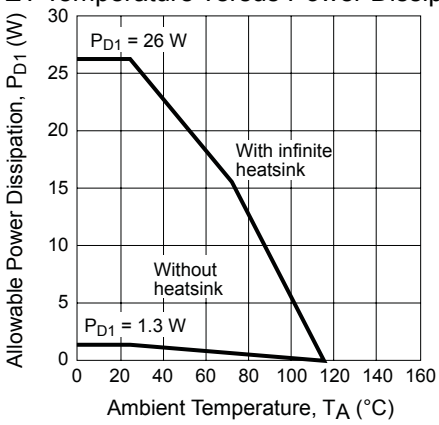
MOSFET Safe Operating Area Curve



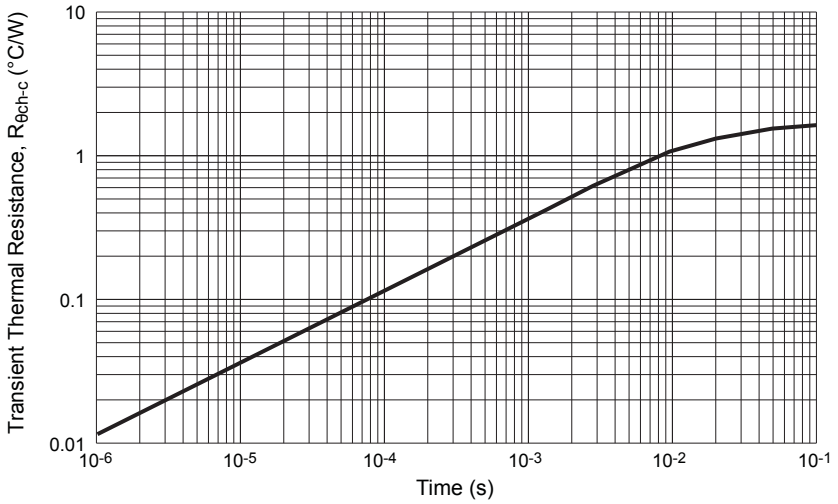
MOSFET Avalanche Energy Derating Coefficient Curve



MOSFET Temperature versus Power Dissipation Curve

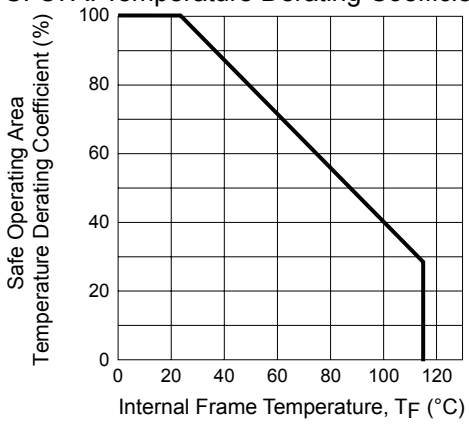


Transient Thermal Resistance Curve

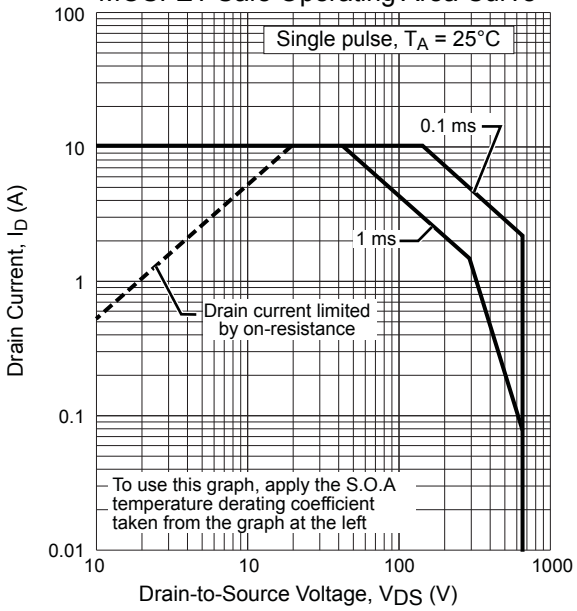


Typical Characteristic Performance
STR-W6253D

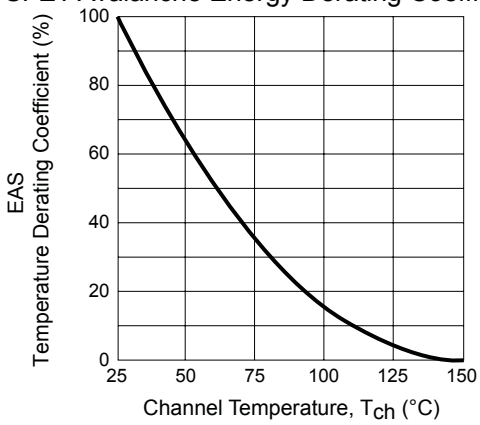
S. O. A. Temperature Derating Coefficient Curve



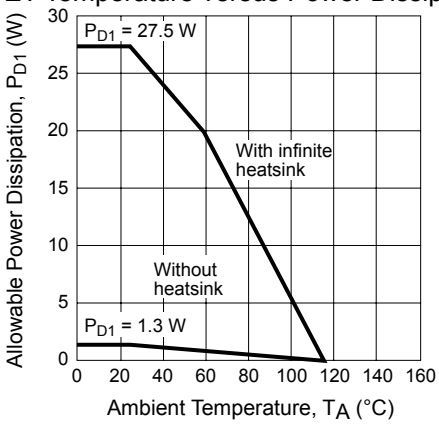
MOSFET Safe Operating Area Curve



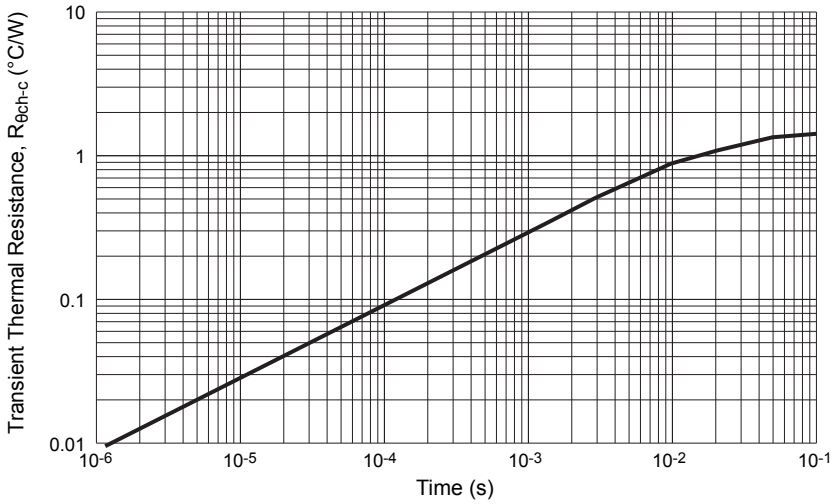
MOSFET Avalanche Energy Derating Coefficient Curve



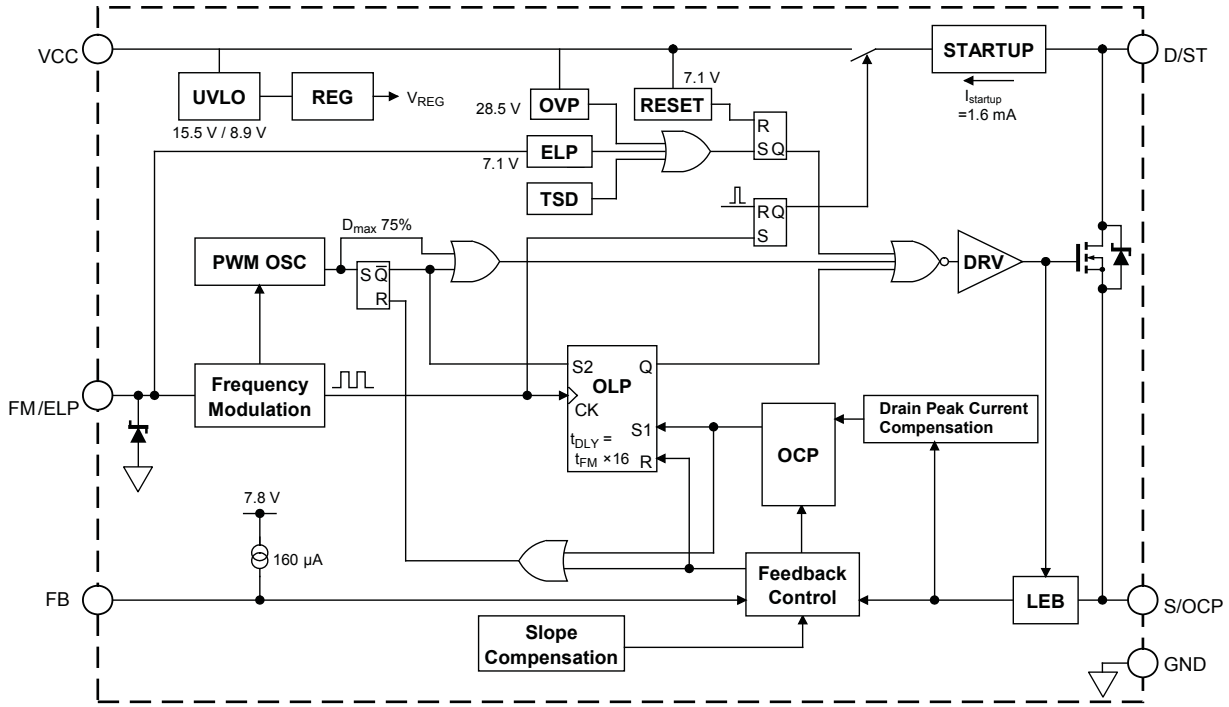
MOSFET Temperature versus Power Dissipation Curve



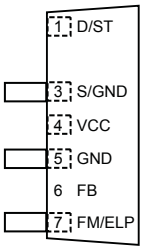
Transient Thermal Resistance Curve



Functional Block Diagram



Pin-out Diagram

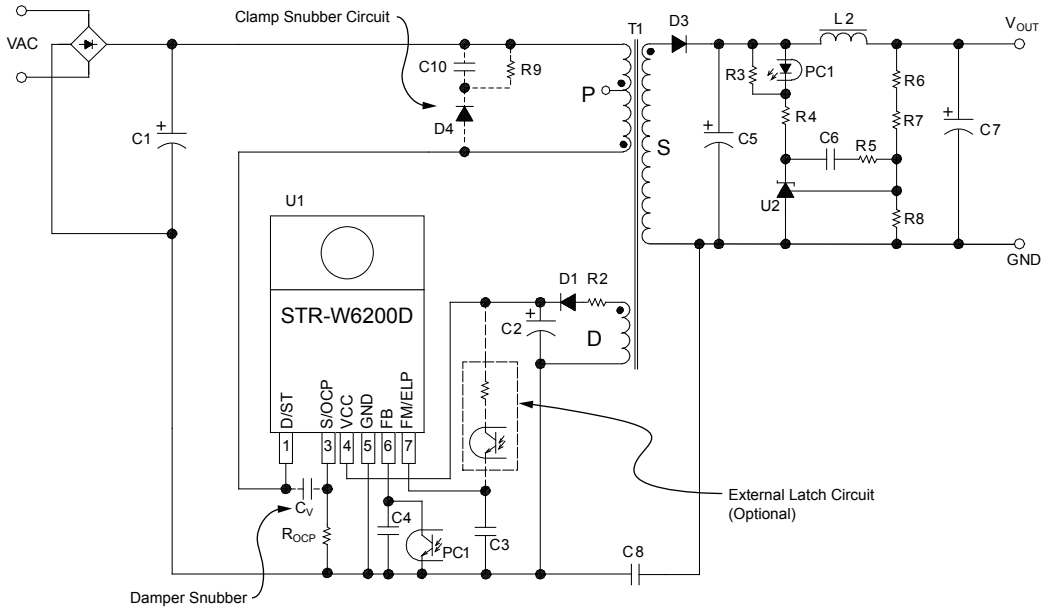


(LF2003)

Pin List Table

Number	Name	Function
1	D/ST	MOSFET drain and input of the startup current
2	–	(Pin removed)
3	S/OCP	MOSFET source and input of Overcurrent Protection (OCP) signal
4	VCC	Power supply voltage input for Control Part and input of Overvoltage Protection (OVP) signal
5	GND	Ground
6	FB	Input for constant voltage control signal
7	FM/ELP	Capacitor connection pin for frequency modulation and input of External Latch Protection

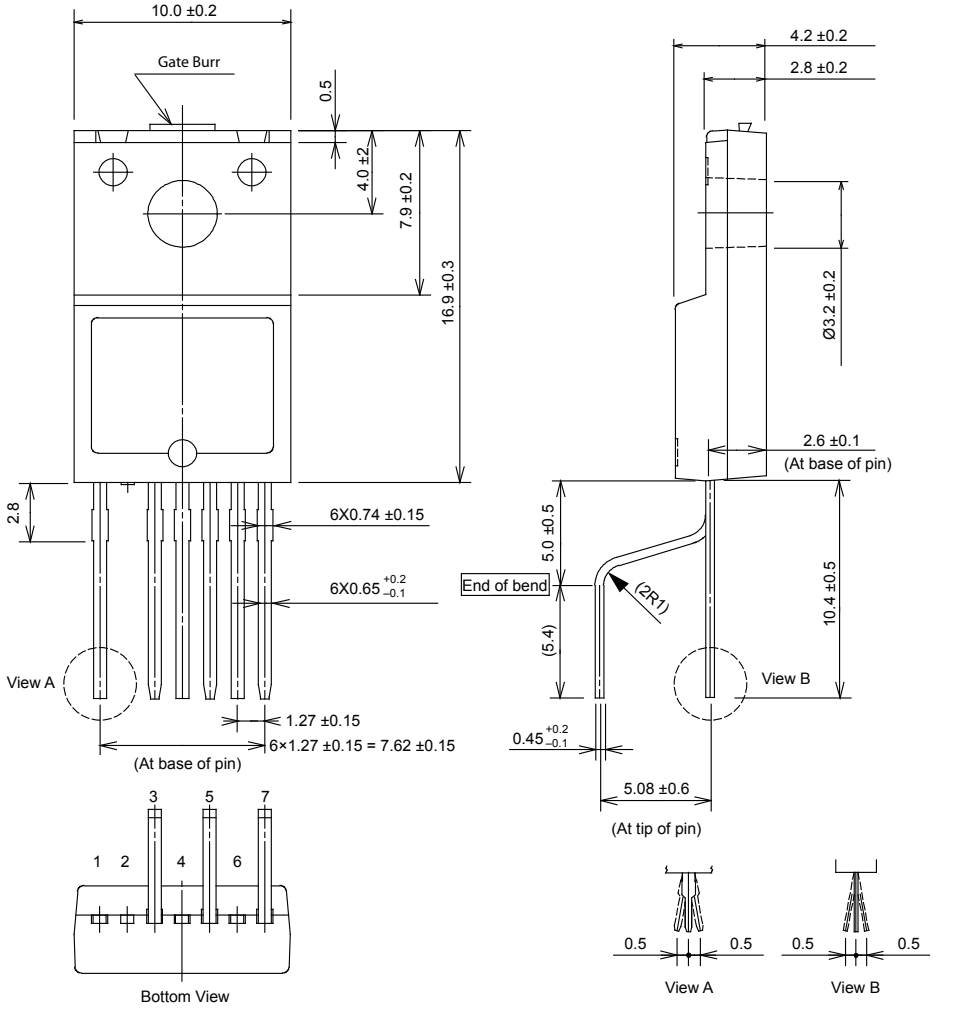
Typical Application Circuit



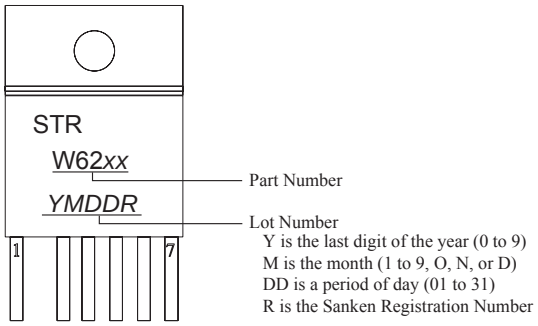
The following design feature should be observed: In applications having a power supply specified such that V_{DS} has large transient surge voltages, a clamp snubber circuit of a capacitor-resistor-diode (CRD) combination should be added on the primary winding, P, or a damper snubber circuit of a capacitor (C) or a resistor-capacitor (CR) combination should be added between the D/ST pins and the S/OCP pin.

Package Diagram

TO-220F-6L package
Leadform: 2003



Unit: mm
Dashed line at Gate Burr indicates protrusion of 0.3 mm (max)



Y is the last digit of the year (0 to 9)
M is the month (1 to 9, O, N, or D)
DD is a period of day (01 to 31)
R is the Sanken Registration Number

Pin treatment Pb-free. Device composition compliant with 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 1.5 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.

- The contents in this document are subject to changes, for improvement and other purposes, without notice. Make sure that this is the latest revision of the document before use.
- Application and operation examples described in this document are quoted for the sole purpose of reference for the use of the products herein and Sanken can assume no responsibility for any infringement of industrial property rights, intellectual property rights or any other rights of Sanken or any third party which may result from its use.
- Although Sanken undertakes to enhance the quality and reliability of its products, the occurrence of failure and defect of semiconductor products at a certain rate is inevitable. 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 the society due to device failure or malfunction.
- Sanken products listed in this document are designed and intended for the use as components in general purpose electronic equipment or apparatus (home appliances, office equipment, telecommunication equipment, measuring equipment, etc.).

  When considering the use of Sanken products in the applications where higher reliability is required (transportation equipment and its control systems, traffic signal control systems or equipment, fire/crime alarm systems, various safety devices, etc.), and whenever long life expectancy is required even in general purpose electronic equipment or apparatus, please contact your nearest Sanken sales representative to discuss, prior to the use of the products herein.

  The use of Sanken products without the written consent of Sanken in the applications where extremely high reliability is required (aerospace equipment, nuclear power control systems, life support systems, etc.) is strictly prohibited.
- In the case that you use Sanken products or design your products by using Sanken products, the reliability largely depends on the degree of derating to be made to the rated values. Derating may be interpreted as a case that an operation range is set by derating the load from each rated value or surge voltage or noise is considered for derating in order to assure or improve the reliability. In general, derating factors include electric stresses such as electric voltage, electric current, electric power etc., environmental stresses such as ambient temperature, humidity etc. and thermal stress caused due to self-heating of semiconductor products. For these stresses, instantaneous values, maximum values and minimum values must be taken into consideration.

  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.
- When using the products specified herein by either (i) combining other products or materials therewith or (ii) physically, chemically or otherwise processing or treating the products, please duly consider all possible risks that may result from all such uses in advance and proceed therewith at your own responsibility.
- Anti radioactive ray design is not considered for the products listed herein.
- Sanken assumes no responsibility for any troubles, such as dropping products caused during transportation out of Sanken's distribution network.
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