

# PT6702—3.3V

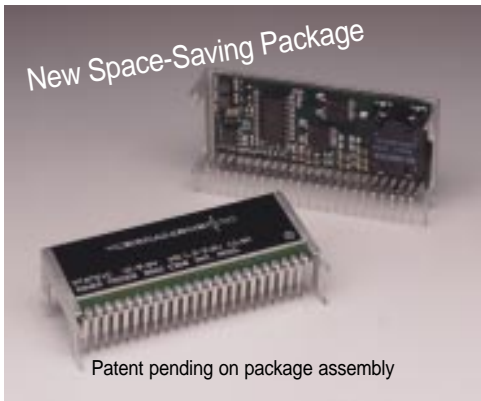
13 Amp Programmable  
Integrated Switching Regulator

**Power Trends Products**  
from Texas Instruments



SLTS070A

(Revised 10/31/2000)



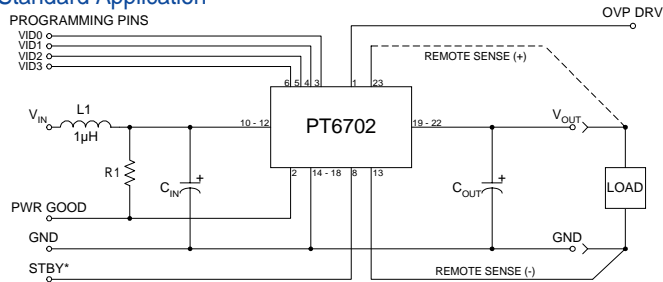
- +3.3V Input
- 4-bit Programmable:  
1.3V to 2.05V
- High Efficiency
- Differential Remote Sense
- Short Circuit Protection
- Over-Voltage Drive
- Power Good Signal
- Space Saving SIP Package
- Solderable Copper Case

The PT6702 is 13Amp fully integrated switching regulator housed in a unique, space-saving package. The PT6702 operates from +3.3V input to provide a high-performance, low-voltage power source for the industry's latest  $\mu$ Ps, DSPs, and bus drivers.

The output is programmable from 1.3V to 2.05V with a 4-bit input, compatible with Intel's Pentium® II Processor.

The PT6702 has short circuit protection, a "Power Good" output, and an over-voltage protection (OVP) drive output.

## Standard Application



$C_{in}$  = Required 1000 $\mu$ F electrolytic  
 $C_{out}$  = Required 330 $\mu$ F electrolytic  
 L1 = Optional 1 $\mu$ H input choke  
 R1 = Required 10k $\Omega$  pull-up when using Pwr Good signal. Pwr good output is high when the output voltage is within specification.

## PT6700 Product Family

	Input Voltage	Vout Adjust	OVP/ Pwr Good	Requires +12V Bias
PT6701	5V	VID	✓	
PT6702	3.3V	VID	✓	
PT6705	5V	Resistor		✓
PT6715	5V	Resistor		
PT6721	12V	VID	✓	
PT6725	12V	Resistor		

## Specifications

Characteristics ( $T_a = 25^\circ\text{C}$ unless noted)	Symbols	Conditions	PT6702 SERIES			Units
			Min	Typ	Max	
Output Current	$I_o$	$T_a = +60^\circ\text{C}$ , 200 LFM, pkg N $T_a = +25^\circ\text{C}$ , natural convection	0.1 (1) 0.1 (1)	—	13.0 13.0	A
Input Voltage Range	$V_{in}$	$0.1A \leq I_o \leq 13.0A$	3.1 (2)	—	3.6	V
Output Voltage Tolerance	$\Delta V_o$	$V_{in} = +3.3V$ , $I_o = 13.0A$ $-40^\circ\text{C} \leq T_a \leq +85^\circ\text{C}$	$V_o - 0.03$	—	$V_o + 0.03$	V
Line Regulation	$Reg_{line}$	$3.1V \leq V_{in} \leq 3.6V$ , $I_o = 13.0A$	—	$\pm 10$	—	mV
Load Regulation	$Reg_{load}$	$V_{in} = +3.3V$ , $0.1 \leq I_o \leq 13.0A$	—	$\pm 20$	—	mV
$V_o$ Ripple/Noise	$V_n$	$V_{in} = +3.3V$ , $I_o = 13.0A$	—	50	—	mV
Transient Response with $C_{out} = 330\mu\text{F}$	$t_{rr}$ $V_{os}$	$I_o$ step between 6A and 12A $V_o$ over/undershoot	—	50 100	—	$\mu\text{Sec}$ mV
Efficiency	$\eta$	$V_{in} = +3.3V$ , $I_o = 8A$	$V_o = 1.8V$ $V_o = 1.5V$	86 84	—	% %
Switching Frequency	$f_o$	$3.1V \leq V_{in} \leq 3.6V$ $0.1A \leq I_o \leq 13.0A$	300	350	400	kHz
Absolute Maximum Operating Temperature Range	$T_a$	Over $V_{in}$ and $I_o$ Ranges	-40 (3)	—	+85 (4)	$^\circ\text{C}$
Storage Temperature	$T_s$	—	-40	—	+125	$^\circ\text{C}$
Mechanical Shock	—	Per Mil-STD-883D, Method 2002.3 1 msec, Half Sine, mounted to a fixture	—	500	—	G's
Mechanical Vibration	—	Per Mil-STD-883D, Method 2007.2, 20-2000 Hz, Soldered in a PC board	—	15	—	G's
Weight	—	—	—	26	—	grams

- Notes: (1) ISR—will operate down to no load with reduced specifications.  
 (2) The minimum input voltage is 3.1V or  $V_{out} + 1.1V$ , whichever is greater.  
 (3) For operation below  $0^\circ\text{C}$ ,  $C_{in}$  and  $C_{out}$  must have stable characteristics. Use either low ESR tantalum or Oscon® capacitors.  
 (4) See Safe Operating Area curves.  
 (5) If the remote sense ground is not used, pin 7 must be connected to pin 8 for optimal output voltage accuracy.

Output Capacitors: The PT6702 requires a minimum output capacitance of 330 $\mu$ F for proper operation. The maximum allowable output capacitance is 15,000 $\mu$ F.  
 Input Filter: An input filter is optional for most applications. The input inductor must be sized to handle 10.0ADC with a typical value of 1 $\mu$ H. The input capacitance must be rated for a minimum of 2.0Arms of ripple current. For transient or dynamic load applications, additional capacitance may be required.

# PT6702—3.3V

## 13 Amp Programmable Integrated Switching Regulator

### Pin-Out Information

Pin	Function	Pin	Function
1	OVP Drive	13	Remote Sense Gnd <sup>(5)</sup>
2	Pwr Good	14	GND
3	VID0	15	GND
4	VID1	16	GND
5	VID2	17	GND
6	VID3	18	GND
7	Connect to Pin 13	19	V <sub>out</sub>
8	STBY*	20	V <sub>out</sub>
9	Do not connect	21	V <sub>out</sub>
10	V <sub>in</sub>	22	V <sub>out</sub>
11	V <sub>in</sub>	23	Remote Sense V <sub>out</sub>
12	V <sub>in</sub>		

For STBY\* pin  
open = output enabled  
ground = output disabled.

### Programming Information

VID3	VID2	VID1	VID0	V <sub>out</sub>
1	1	1	1	1.30V
1	1	1	0	1.35V
1	1	0	1	1.40V
1	1	0	0	1.45V
1	0	1	1	1.50V
1	0	1	0	1.55V
1	0	0	1	1.60V
1	0	0	0	1.65V
0	1	1	1	1.70V
0	1	1	0	1.75V
0	1	0	1	1.80V
0	1	0	0	1.85V
0	0	1	1	1.90V
0	0	1	0	1.95V
0	0	0	1	2.00V
0	0	0	0	2.05V

Logic 0 = Pin 13 potential (remote sense gnd)  
Logic 1 = Open circuit (no pull-up resistors)  
VID3 may not be changed while the unit is operating.

### Ordering Information

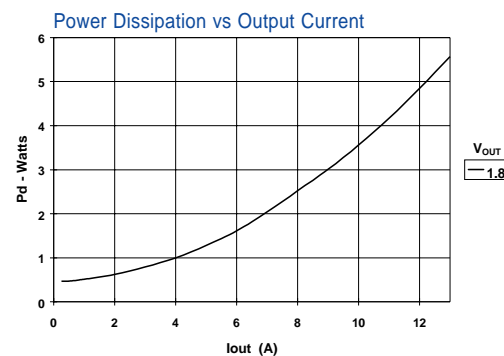
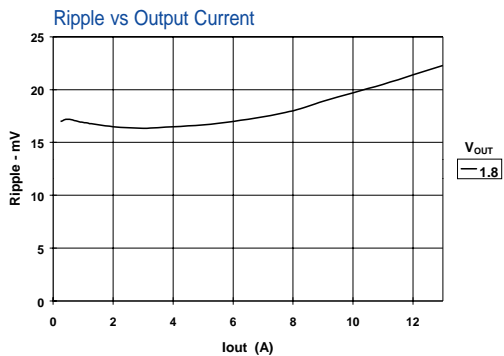
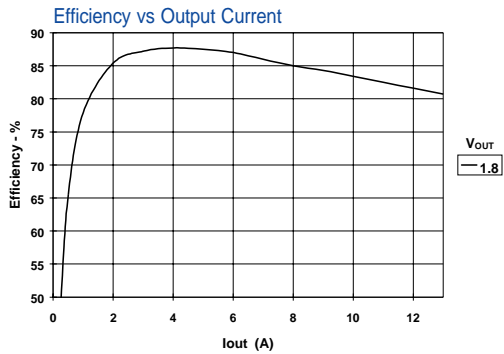
PT6702□ = 1.3 to 2.05 Volts  
(For dimensions and PC board layout, see Package Styles 1300 and 1310.)

### PT Series Suffix (PT1234X)

Case/Pin Configuration	
Vertical Through-Hole	N
Horizontal Through-Hole	A
Horizontal Surface Mount	C

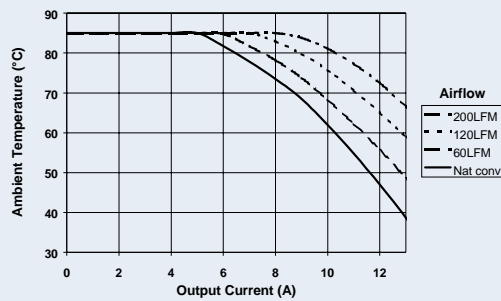
## TYPICAL CHARACTERISTICS

PT6702, V<sub>IN</sub> = 3.3V (See Note A)



Safe Operating Area Curves (See Note B)

PT6702, @V<sub>in</sub> = 3.3V & V<sub>o</sub> = 1.8V



Note A: Characteristic data has been developed from actual products tested at 25°C. This data is considered typical for the ISR

Note B: SOA curves represent the conditions at which internal components are at or below manufacturer's maximum operating temperatures.

## PT6701/PT6702/PT6721

### Operating Features of the Programmable PT6700 "Excalibur™" Series ISRs

#### Power Good

Programmable versions of the PT6700 Series regulators incorporate a *PWR Good* output (pin 2). This output is open-drain and generates an active-high signal when the sensed output from the ISR is within a nominal  $\pm 10\%$  of the programmed set point. When the regulated output is outside this range, pin 2 asserts a logic low (typically  $< 0.1V$ ). A  $10K\Omega$  pull-up resistor to a valid bus voltage is required. If the power good feature is not used, the pull-up resistor can be omitted. The maximum voltage that may be applied to the pull-up resistor is 15V.

#### Over-Voltage Protection (OVP)

The PT6700 programmable regulators also incorporate an OVP function. The *OVP DRV* (pin 1) normally has a logic low output (typically  $< 0.1V$ ). When the ISR's sensed output exceeds the programmed output setting by 15%, pin 1 produces a 60mA, +12V drive signal. This drive signal can trigger an SCR, which can be used to disable the input voltage, or alternatively interface to another external monitoring device. When the ISR output voltage returns to within 15% of its programmed setting, pin 1 reverts back to its low state. If the OVP function is not used, pin 1 may be left open circuit.

#### Stand-By Function

The PT6700 series ISRs incorporate a standby function. This feature may be used for power-up sequencing, or whenever there is a requirement for the output voltage to be controlled by external circuitry.

If the *STBY\** input (pin 8) is left open-circuit the regulator operates normally, providing a regulated output when a valid supply voltage is applied to  $V_{in}$  (pins 10-12) with respect to GND (pins 14-18). Connecting pin 8 to ground places the regulator in standby mode, and reduces the input current to typically 20mA (30mA max). Applying a ground signal to pin 8 prior to power-up, will disable the output during the period that input power is applied. To ensure that the regulator output is fully enabled, pin 8 must be allowed to rise to a minimum of 3.0V.

#### Notes:

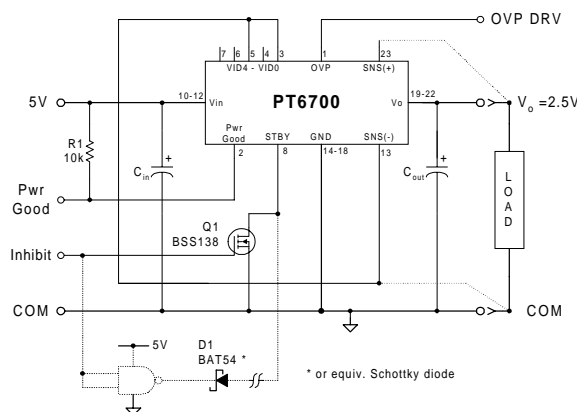
1. The standby on the PT6700 series is ideally controlled with an open-collector (or open-drain) discrete transistor (See fig. 1). Table 1 gives the threshold requirements. *Do Not* use a pull-up resistor. The control input has an open-circuit voltage of about 4.0Vdc. To set the regulator output to zero, the control pin must be "pulled" to less than 1.0Vdc with a sink to ground.

2. The Standby input can also be interfaced to TTL or other bi-directional output device using a schottky diode. See Figure 1.
3. When placed in the standby mode, the regulator output may assert a low impedance to ground. If an external voltage is applied to the output, it will sink current and possibly over-stress the part.

Table 1 Inhibit Control Threshold <sup>2,3</sup>

Parameter	Min	Typ	Max
Enable ( $V_{IH}$ )	3.0V		
Disable ( $V_{IL}$ )	-0.1V	0.4V	1.0V
Istby		0.01mA	

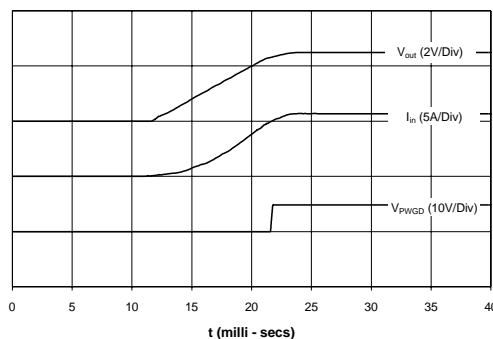
Figure 1



#### Turn-On Time

Turning  $Q_1$  in Figure 1 off, removes the low-voltage signal at pin 8 and enables the output. Following a brief delay of 10-15ms, the output voltage of the PT6700 regulator rises to full regulation within 30ms. Figure 2 shows the typical output voltage waveform of a PT6701 following the prompt turn-off of  $Q_1$  at time  $t = 0$  secs. The output voltage was set to 2.5V. The waveforms were measured with a 5V input source voltage, and 10A resistive load.

Figure 2



### Pin-Coded Output Voltage Adjustment on Non-Isolated “Excalibur™” Series ISRs

The PT6701/6702/6721 Excalibur™ ISRs incorporate a pin-coded voltage control to adjust the output voltage. The control pins are identified VID0 - VID4 (pins 3-7) respectively. When these control pins are left open-circuit the ISR output will regulate at its factory trimmed output voltage. Each pin is internally connected to a precision resistor, which when grounded changes the output voltage by a set amount. By selectively grounding VID0-VID4, the output voltage these ISRs can be programmed in incremental steps over the specified output voltage range. The program code and output voltage range of these ISRs is compatible with the voltage ID specification defined by Intel Corporation. The code is used in conjunction with voltage regulator modules (VRMs) that are used to power Intel's Pentium® microprocessors. Refer to Figure 1 below for the connection schematic, and the respective device Data Sheet for the appropriate programming code information.

#### Notes:

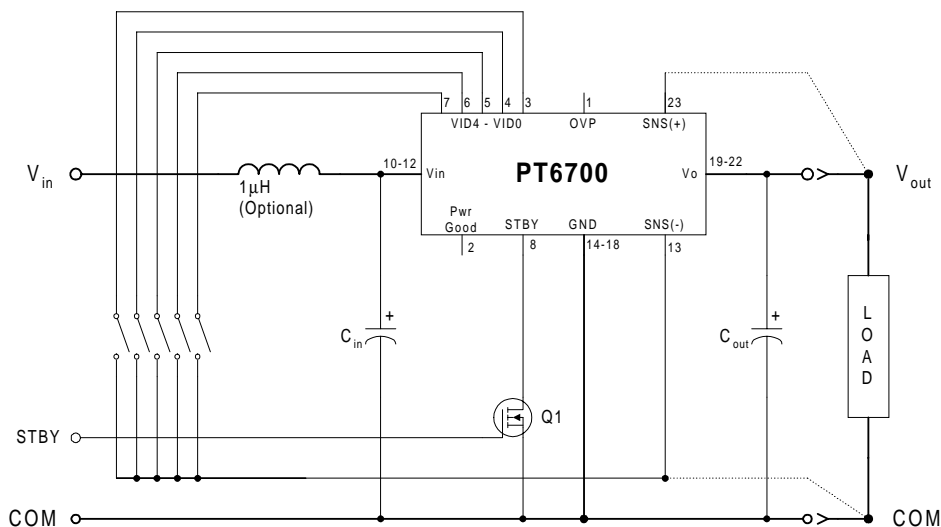
- The programming convention is as follows:-
  - Logic 0: Connect to pin13 (Remote Sense Ground).
  - Logic 1: Open circuit/open drain (See notes 2, & 4)
- Do not connect pull-up resistors to the voltage programming pins.
- To minimize output voltage error, always use pin 13 (Remote Sense Ground) as the logic “0” reference. While the regular ground (pins 14-18) can also be used for programming, doing so will degrade the load regulation of the product.

- If active devices are used to ground the voltage control pins, low-level open drain MOSFET devices should be used over bipolar transistors. The inherent  $V_{ce(sat)}$  in bipolar devices introduces errors in the device's internal voltage control circuit. Discrete transistors such as the BSS138, 2N7002, IRLML2402, or the 74C906 hex open-drain buffer are examples of appropriate devices.

#### Active Voltage Programming:

Special precautions should be taken when making changes to the voltage control program code while the unit is powered. It is highly recommended that the ISR be either powered down or held in standby. Changes made to the program code while  $V_{out}$  is enabled induces high current transients through the device. This is the result of the electrolytic output capacitors being either charged or discharged to the new output voltage set-point. The transient current can be minimized by making only incremental changes to the binary code, i.e. one LSB at a time. A minimum of 100 $\mu$ s settling time between each program state is also recommended. Making non-incremental changes to VID3 and VID4 with the output enabled is discouraged. If they are changed, the transients induced can overstress the device resulting in a permanent drop in efficiency. If the use of active devices prevents the program code being asserted prior to power-up, pull pin 8 (STBY) to the device GND during the period that the input voltage is applied to  $V_{in}$ . Releasing pin 8 will then allow the device output to initiate a soft-start power-up to the programmed voltage.

Figure 1



PT6701, PT6702, PT6705 Series,  
& PT6715 Series

Capacitor Recommendations for the Non-Isolated  
13A Excalibur™ Series of Regulators

Input Capacitors

The recommended input capacitance is determined by the 2.0 ampere minimum ripple current rating and 1000µF minimum capacitance. Capacitors listed below must be rated for a minimum of 2x the input voltage with +5V operation. Ripple current and ≤100mΩ Equivalent Series Resistance (ESR) values are the major considerations along with temperature when selecting the proper capacitor.

Output Capacitors

The minimum required output capacitance is 330µF with a maximum ESR less than or equal to 100mΩ. Failure to observe this requirement may lead to regulator instability or oscillation. Electrolytic capacitors have poor ripple performance at frequencies greater than 400kHz, but excellent low frequency transient response. Above the ripple frequency ceramic decoupling capacitors are necessary to improve the transient response and reduce any high frequency noise components apparent during higher current excursions. Preferred low ESR type capacitor part numbers are identified in Table 1 below.

Tantalum Characteristics

Tantalum capacitors with a minimum 10V rating are recommended on the output bus, but only the AVX TPS Series, Sprague 594/595 Series, or Kemet T495/T510 Series. The AVX TPS Series, Sprague Series or Kemet Series capacitors are specified over other types due to their higher surge current, excellent power dissipation and ripple current ratings. As an example, the TAJ Series by AVX is not recommended. This series exhibits considerably higher ESR, reduced power dissipation and lower ripple current capability. The TAJ Series is a less reliable compared to the TPS series when determining power dissipation capability.

Capacitor Table

Table 1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The suggested minimum quantities per regulator for both the input and output buses are identified.

*This is not an extensive capacitor list. The table below is a suggested selection guide for input and output capacitors. Other capacitor vendors are available with comparable RMS ripple current rating and ESR (Equivalent Series Resistance at 100kHz). These critical parameters are necessary to insure both optimum regulator performance and long capacitor life.*

Table 1 Capacitors Characteristic Data

Capacitor Vendor Series	Capacitor Characteristics					Quantity		Vendor Number
	Working Voltage	Value(µF)	(ESR) Equivalent Series Resistance	85°C Maximum Ripple Current(Irms)	Physical Size(mm)	Input Bus	Output Bus	
Panasonic FC Surface Mtg	25V	1000	0.038Ω	2000mA	18x16.5	1	1	EEVFC1E102N EEVFC1V331LQ
	35V	330	0.065Ω	1205mA	12.5x16.5		1	
FA Radial	25V	330	0.090Ω	765mA	10x12.5	1	1	EEUFA1E331 EEUFA1E122S
	25V	1200	0.032Ω	2000mA	18x15		1	
United Chemi -Con LFX Radial FX Surface Mtg	25V	330	0.084Ω	825mA	10x16	1	1	LXV25VB331M10X16LL LXV35VB122M16X25LL LXV16VB272M16X25LL 10FX680M(Os-con)
	35V	1200	0.028Ω	2070mA	16x25		1	
	16V	2700	0.028Ω	2070mA	16x25		1	
	10V	680	0.015Ω/2=0.007Ω	>7000mA	10X10.5		2	
Nichicon PL Series PM Series	25V	330	0.095Ω	750mA	10x15	1	1	UPL1E331MPH6 UPL1E222MHH6 UPM1E331MPH6
	25V	2200	0.028Ω	2050mA	18x20		1	
	25V	330	0.095Ω	750mA	10x15		1	
Oscon SS SV	10V	330	0.025Ω/3=0.008Ω	>7000mA	10x10.5	3	1	10SS330M 10SV330M(Surface Mtg)
	10V	330	0.020Ω/3=0.007Ω	>7000mA	10.3x12.6	3	1	
AVX Tantalum TPS- Series	10V	330	0.100Ω/3=0.034Ω	>3500mA	7.0Lx	3	1	TPSV337M010R0100 TPSV337M010R0060
	10V	330	0.060Ω/3=0.02Ω	>3500mA	5.97Wx 3.45H	3	1	
Vishay/Sprague Tantalum 595D/594D	10V	330	0.045Ω/3=0.015Ω	>4600mA	7.2L x 6.0W x 3.5H	3	1	594D337X0010R2T Surface Mount 595D687X0010R2T
	10V	680	0.090Ω/4=0.023Ω	>2500mA		2	1	
Kemet Tantalum T510/T495 Series	10V	330	0.035Ω/3=0.012Ω	>5000mA	4.3Wx7.3L x4.0H	3	1	T510X337M010AS T495X227M010AS Surface Mount
	10V	220	0.070Ω/5=0.035Ω	>3000mA		5	2	
Sanyo Poscap TPB	10V	220	0.040Ω/5=0.008Ω	>3000mA	7.2L x 4.3W x 3.1H	5	2	10TPB220M Surface Mount

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
PT6702C	ACTIVE	SIP MOD ULE	ELC	23	10	TBD	Call TI	Level-3-215C-168HRS
PT6702N	ACTIVE	SIP MOD ULE	ELD	23	10	TBD	Call TI	Level-1-215C-UNLIM

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
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