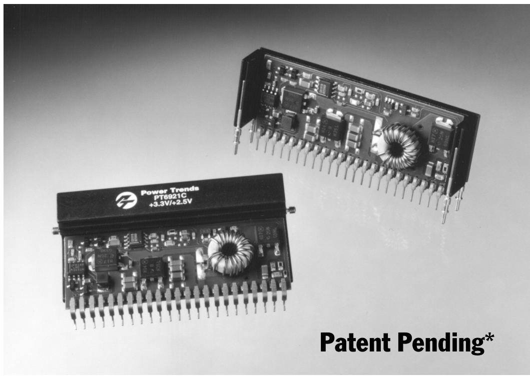
## 25 Watt 5V Input Dual Output Integrated Switching Regulator

**SLTS042A**

*(Revised 6/30/2000)*



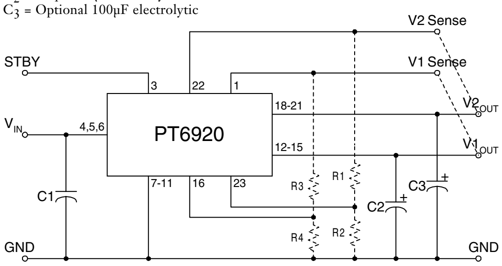
**Patent Pending***

- Dual Outputs:
  +3.3V/6A
  +2.5V/2.2A or +1.8V/1.5A
- Adjustable Output Voltage
- Remote Sense (both outputs)
- Standby Function
- Over-Temperature Protection
- Soft-Start
- Internal Sequencing
- 23-pin SIPPackage

The PT6920 is a series of 25W dual output ISRs that were purposely designed to power the latest generation DSP chips. Both output voltages are independently adjustable, allowing either output voltages to be changed to accomodate a DSP upgrade. The internal power sequencing of both outputs meet the requirements of TI's 'C6000 series DSPs.

## Standard Application

$C_1$ = Req'd 560µF electrolytic (1)
$C_2$ = Req'd 330µF electrolytic (1)
$C_3$ = Optional 100µF electrolytic




Note: for PT6921 only:
with pin 23 open, V2out=2.5V
with pin 23 shorted to pin 22, V2out=1.8V

## Pin-Out Information

| Pin | Function | Pin | Function |
|---|---|---|---|
| 1 | $V_1$ Remote Sense | 13 | $V_{1out}$ |
| 2 | Do Not Connect | 14 | $V_{1out}$ |
| 3 | STBY | 15 | $V_{1out}$ |
| 4 | $V_{in}$ | 16 | $V_1$ Adjust |
| 5 | $V_{in}$ | 17 | Do Not Connect |
| 6 | $V_{in}$ | 18 | $V_{2out}$ |
| 7 | GND | 19 | $V_{2out}$ |
| 8 | GND | 20 | $V_{2out}$ |
| 9 | GND | 21 | $V_{2out}$ |
| 10 | GND | 22 | $V_2$ Remote Sense |
| 11 | GND | 23 | $V_2$ Adjust* |
| 12 | $V_{1out}$ | | |

## Ordering Information

**PT6921❑** = +3.3 Volts
+2.5/+1.8 Volts
**PT6922❑** = +3.3 Volts
+1.5 Volts

## PT Series Suffix (PT1234X)

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

*(For dimensions and PC board layout, see Package Styles 1100 and 1110.)*

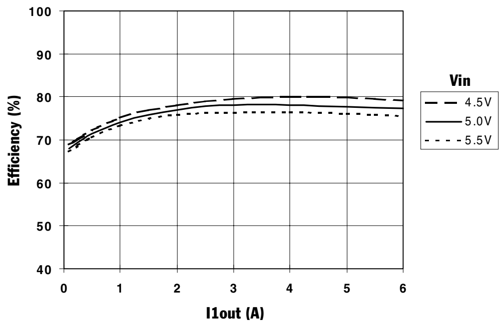
## Specifications

| Characteristics ($T_a$= 25°C unless noted) | Symbols | Conditions | | PT6920 SERIES Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| Output Current | $I_o$ | $T_a$ = +60°C, 200 LFM, pkg N | $V_1$ = 3.3V | 0.1 (2) | — | 5.5 (3) | A |
| | | | $V_2$ = 2.5V | 0 | — | 2.2 (3) | |
| | | | $V_2$ = 1.8V | 0 | — | 1.75 (3) | |
| | | | $V_2$ = 1.2V | 0 | — | 1.2 (3) | |
| | | $T_a$ = +25°C, natural convection | $V_1$ = 3.3V | 0.1 | — | 6.0 | A |
| | | | $V_2$ = 2.5V | 0 | — | 2.2 | |
| | | | $V_2$ = 1.8V | 0 | — | 1.75 | |
| | | | $V_2$ = 1.2V | 0 | — | 1.2 | |
| Input Voltage Range | $V_{in}$ | $0.1A \leq I_o \leq I_{max}$ | | 4.5 | — | 5.5 | V |
| Output Voltage Tolerance | $\Delta V_o$ | $V_{in}$ = +5V, $I_o = I_{max}$, both outputs 0°C ≤ $T_a$ ≤ +65°C | | Vo-0.1 | — | Vo+0.1 | V |
| Line Regulation | $Reg_{line}$ | $4.5V \leq V_{in} \leq 5.5V$, $I_o = I_{max}$ | $V_1$ = 3.3V | — | ±7 | ±17 | mV |
| | | | $V_2$ = 2.5V | — | ±7 | ±13 | |
| Load Regulation | $Reg_{load}$ | $V_{in}$ = +5V, $0.1 \leq I_o \leq I_{max}$ | $V_1$ = 3.3V | — | ±17 | ±33 | mV |
| | | | $V_2$ = 2.5V | — | ±4 | ±10 | |
| $V_o$ Ripple/Noise | $V_n$ | $V_{in}$ = +5V, $I_o = I_{max}$ | $V_1$ = 3.3V | — | 50 | — | mV |
| | | | $V_2$ = 2.5V | — | 25 | — | |
| Transient Response with $C_2$ = 330µF | $t_{tr}$ | $I_o$ step between $0.5xI_{max}$ and $I_{max}$ | | — | 25 | — | µSec |
| | $V_{os}$ | $V_o$ over/undershoot | $V_1$ = 3.3V | — | 60 | — | mV |
| | | | $V_2$ = 2.5V | — | 60 | — | |
| Efficiency | η | $V_{in}$ = +5V, $I_o$ = 4A total | | — | 75 | — | % |
| Switching Frequency | $f_o$ | $4.5V \leq V_{in} \leq 5.5V$ $0.1A \leq I_o \leq I_{max}$ | | 475 | 600 | 725 | kHz |
| Absolute Maximum Operating Temperature Range | $T_a$ | Over $V_{in}$ Range | | –40 (4) | — | +85 (5) | °C |
| Storage Temperature | $T_s$ | — | | -40 | — | +125 | °C |
| Weight | — | Vertical/Horizontal | | — | 29 | — | grams |

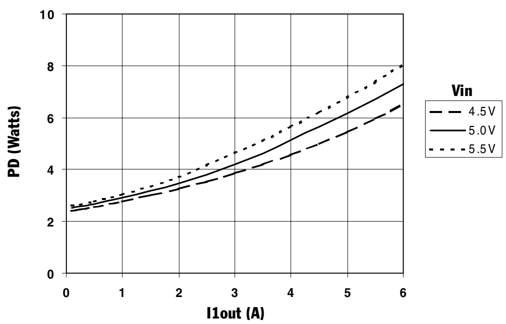
***Notes:*** (1) *The PT6920 series requires a 560µF electrolytic capacitor on the input and a 330µF electrolytic capacitor on the output for proper operation in all applications.*
(2) *$I_o$min current of 0.1A can be divided btween both outputs; $V_1$, or $V_2$. The ISR will operate down to no-load with reduced specifications.*
(3) *$I_o$max listed for each output assumes the maximum current drawn simultaneously on both outputs. Consult the factory for the absolute maximum.*
(4) *For operating temperatures below 0°C, use tantalum type capacitors on both the input and output.*
(5) *See Safe Operating Area curves for appropriate derating.*

**PT6921, $V_2out = 2.5V$, $I_2out = 2.2A$** (See Note A)

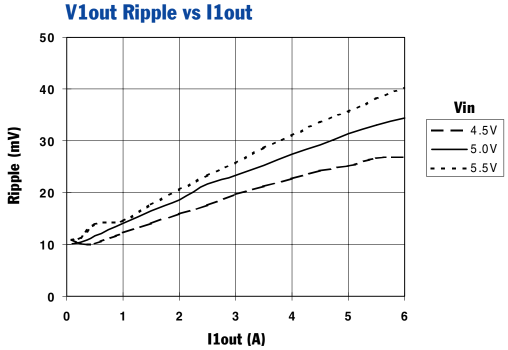
**Total Efficiency vs I1out**



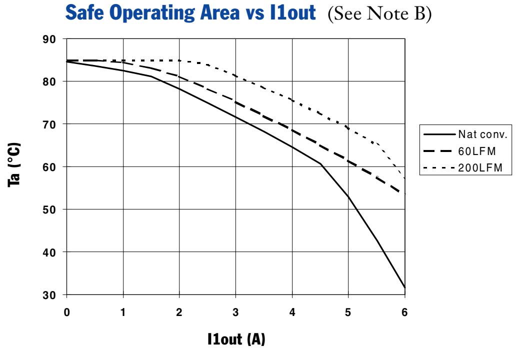

**Total Power Dissipation vs I1out**




**V1out Ripple vs I1out**




**Safe Operating Area vs I1out** (See Note B)




**Note A:** *All characteristic data listed in the above graphs has been developed from actual products tested at 25°C. This data is considered typical data for the ISR.*
**Note B:** *SOA curves represent operating conditions at which internal components are at or below manufacturer's maximum rated operating conditions.*

## Adjusting the Output Voltage of the PT6920 and PT6930 Dual Output Voltage ISRs

Each output voltage from the PT6920 and PT6930 series of ISRs can be independantly adjusted higher or lower than the factory trimmed pre-set voltage. $V_1$ (the voltage at $V_1$out), or $V_2$ (the voltage at $V_2$out) may each be adjusted either up or down using a single external resistor [2]. Table 1 gives the adjustment range for both $V_1$ and $V_2$ for each model in the series as $V_a$(min) and $V_a$(max). Note that $V_2$ must always be lower than $V_1$ [3].

**$V_1$ Adjust Up:** To increase the output, add a resistor R4 between pin 16 ($V_1$ Adjust) and pins 7-11 (GND) [2].

**$V_1$ Adjust Down:** Add a resistor (R3), between pin 16 ($V_1$ Adjust) and pin 1 ($V_1$ Remote Sense) [2].

**$V_2$ Adjust Up:** Add a resistor R2 between pin 23 ($V_2$ Adjust) and pins 7-11 (GND) [2].

**$V_2$ Adjust Down:** Add a resistor (R1) between pin 23 ($V_2$ Adjust) and pin 22 ($V_2$ Remote Sense) [2].

Refer to Figure 1 and Table 2 for both the placement and value of the required resistor.

**Notes:**

1. The output voltages, $V_1$out and $V_2$out, may be adjusted independantly.
2. Use only a single 1% resistor in either the (R3) or R4 location to adjust $V_1$, and in the (R1) or R2 location to adjust $V_2$. Place the resistor as close to the ISR as possible.
3. $V_2$ must always be at least 0.2V lower than $V_1$.
4. $V_2$ on both the PT6921 and PT6931 models may be adjusted from 2.5V to 1.8V by simply connecting pin 22 ($V_2$ Remote Sense) to pin 23 ($V_2$ Adjust). For more details, consult the data sheet.
5. If $V_1$ is increased above 3.3V, the minimum input voltage to the ISR must also be increased. The minimum required input voltage must be $(V_1 + 1.2)$V or 4.5V, whichever is greater. Do not exceed 5.5V
6. Never connect capacitors to either the $V_1$ Adjust or $V_2$ Adjust pins. Any capacitance added to these control pins will affect the stability of the respective regulated output.
7. Adjusting either voltage ($V_1$ or $V_2$) may increase the power dissipation in the regulator, and correspondingly change the maximum current available at either output. Consult the factory for application assistance.

The adjust up and adjust down resistor values can also be calculated using the following formulas. Be sure to select the correct formula parameter from Table 1 for the output and model being adjusted.

$$\text{(R1) or (R3)} = \frac{R_o (V_a - 1)}{V_o - V_a} - R_s \quad k\Omega$$

$$\text{R2 or R4} = \frac{R_o}{V_a - V_o} - R_s \quad k\Omega$$

Where:
$V_o$ = Original output voltage, ($V_1$ or $V_2$)
$V_a$ = Adjusted output voltage
$R_o$ = The resistance value from Table 1
$R_s$ = The series resistance from Table 1

*Table 1*

**PT6920 ADJUSTMENT RANGE AND FORMULA PARAMETERS**

| Output Bus | $V_1$ out | $V_2$ out | |
|---|---|---|---|
| Series Pt # | | | |
| Standard Case | PT6921/22 | PT6921 | PT6922 |
| Excalibur Case | PT6931/32 | PT6931 | PT6932 |
| Adj. Resistor | (R3)/R4 | (R1)/R2 | (R1)/R2 |
| $V_o$(nom) | 3.3V | 2.5V | 1.5 |
| Va(min) | 2.3V | 1.8V | 1.2 |
| Va(max) | 3.6V | 3.0V | 3.0 |
| $R_o$ (kΩ) | 12.1 | 10.0 | 9.76 |
| $R_s$ (kΩ) | 12.1 | 11.5 | 6.49 |

*Figure 1*

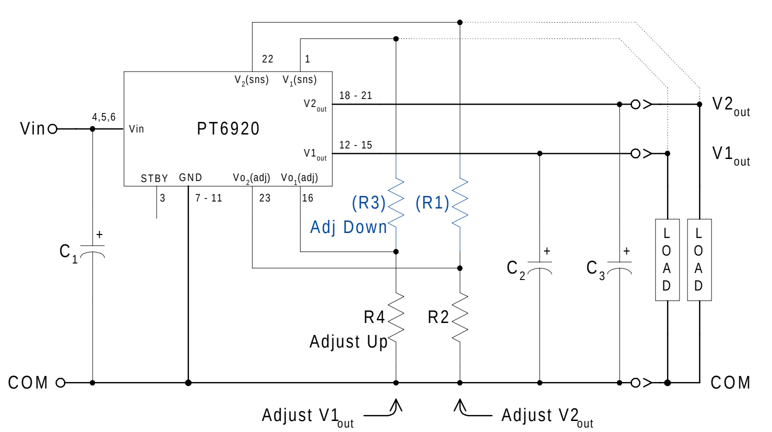


***Table 2***

**PT6920/PT6930 ADJUSTMENT RESISTOR VALUES**

| Output Bus | $V_1$out | $V_2$out | |
|---|---|---|---|
| Series Pt# | | | |
| Standard Case | PT6921/6922 | PT6921 | PT6922 |
| Excalibur Case | PT6931/6932 | PT6931 | PT6932 |
| Adj Resistor | (R3)/R4 | (R1)/R2 | (R1)/R2 |
| $V_o$(nom) | 3.3Vdc | 2.5Vdc | 1.5Vdc |
| $V_a$(req'd) | | | |
| 1.2 | | | (0.0)kΩ |
| 1.25 | | | (3.3)kΩ |
| 1.3 | | | (8.2)kΩ |
| 1.35 | | | (16.3)kΩ |
| 1.4 | | | (32.6)kΩ |
| 1.45 | | | (81.4)kΩ |
| 1.5 | | | |
| 1.55 | | | 189.0kΩ |
| 1.6 | | | 91.1kΩ |
| 1.65 | | | 58.6kΩ |
| 1.7 | | | 42.3kΩ |
| 1.75 | | | 32.6kΩ |
| 1.8 | | (0.0)kΩ | 26.0kΩ |
| 1.85 | | (1.6)kΩ | 21.4kΩ |
| 1.9 | | (3.5)kΩ | 17.9kΩ |
| 1.95 | | (5.8)kΩ | 15.2kΩ |
| 2.0 | | (8.5)kΩ | 13.0kΩ |
| 2.05 | | (11.8)kΩ | 11.3kΩ |
| 2.1 | | (16.0)kΩ | 9.8kΩ |
| 2.15 | | (21.4)kΩ | 8.5kΩ |
| 2.2 | | (28.5)kΩ | 7.5kΩ |
| 2.25 | | (38.5)kΩ | 6.5kΩ |
| 2.3 | (3.6)kΩ | (53.5)kΩ | 5.7kΩ |
| 2.35 | (5.1)kΩ | (78.5)kΩ | 5.0kΩ |
| 2.4 | (6.7)kΩ | (129.0)kΩ | 4.4kΩ |
| 2.45 | (8.5)kΩ | (279.0)kΩ | 3.8kΩ |
| 2.5 | (10.6)kΩ | | 3.3kΩ |
| 2.55 | (12.9)kΩ | 189.0kΩ | 2.8kΩ |
| 2.6 | (15.6)kΩ | 88.5kΩ | 2.4kΩ |
| 2.65 | (18.6)kΩ | 55.2kΩ | 2.0kΩ |
| 2.7 | (22.2)kΩ See Note 3 | 38.5kΩ | 1.6kΩ |
| 2.75 | (26.4)kΩ | 28.5kΩ | 1.3kΩ |
| 2.8 | (31.5)kΩ | 21.8kΩ | 1.0kΩ |
| 2.85 | (37.6)kΩ | 17.1kΩ | 0.7kΩ |
| 2.9 | (45.4)kΩ | 13.5kΩ | 0.5kΩ |
| 2.95 | (55.3)kΩ | 10.7kΩ | 0.2kΩ |
| 3.0 | (68.6)kΩ | 8.5kΩ | 0.0kΩ |
| 3.05 | (87.1)kΩ | | |
| 3.1 | (115.0)kΩ | | |
| 3.15 | (161.0)kΩ | | |
| 3.2 | (254.0)kΩ | | |
| 3.25 | (532.0)kΩ | | |
| 3.3 | | | |
| 3.4 | 109.0kΩ See Note 5 | | |
| 3.5 | 48.4kΩ | | |
| 3.6 | 28.2kΩ | | |

R1/R3 = (Blue) R2/R4 = Black

## Using the Standby Function on the PT6920 and PT6930 Dual Output Voltage Converters

Both output voltages of the 23-pin PT6920/6930 dual output converter may be disabled using the regulator's standby function. This function may be used in applications that require power-up/shutdown sequencing, or wherever there is a requirement to control the output voltage On/Off status with external circuitry.

The standby function is provided by the *STBY** control, pin 3. If pin 3 is left open-circuit the regulator operates normally, and provides a regulated output at both $V_1$out (pins 12–15) and $V_2$out (pins 18–21) whenever a valid supply voltage is applied to $V_{in}$ (pins 4, 5, & 6) with respect to GND (pins 7-11). If a low voltage[2] is then applied to pin-3 both regulator outputs will be simultaneously disabled and the input current drawn by the ISR will typcially drop to less than 30mA (50mA max). The standby control may also be used to hold-off both regulator outputs during the period that input power is applied.

The standby pin is ideally controlled using an open-collector (or open-drain) discrete transistor (See Figure 1). It may also be driven directly from a dedicated TTL[3] compatible gate. Table 1 provides details of the threshold requirements.

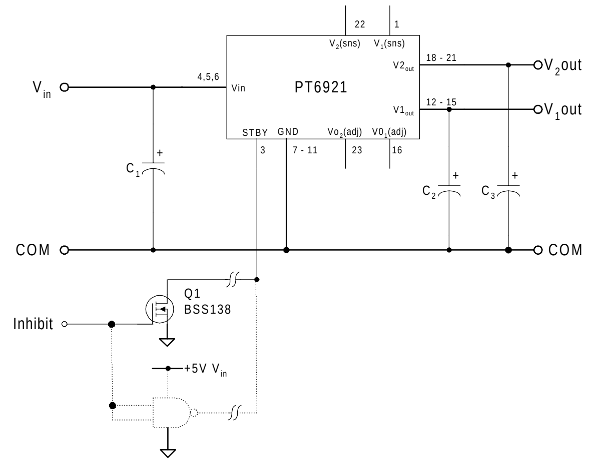
***Table 1 Inhibit Control Thresholds*** [2,3]

| Parameter | Min | Max |
|---|---|---|
| Enable ($V_{IH}$) | 1.8V | Vin |
| Disable ($V_{IL}$) | –0.1V | 0.8V |

**Notes:**

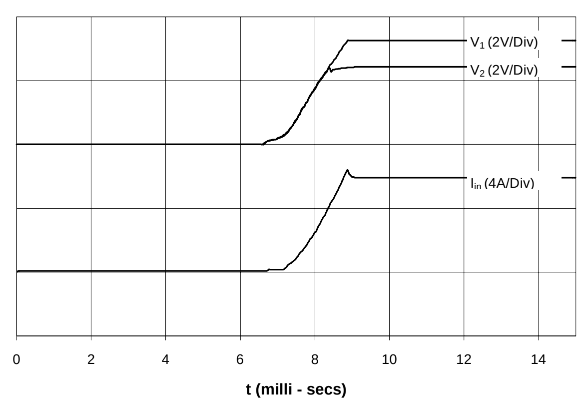
1. The Standby/Inhibit control logic is similar for all Power Trends' modules, but the flexibility and threshold tolerances will be different. For specific information on this function for other regulator models, consult the applicable application note.
2. The Standby control pin is ideally controlled using an open-collector (or open-drain) discrete transistor and requires no external pull-up resistor. To disable the regulator output, the control pin must be pulled to less than 0.8Vdc with a low-level 0.5mA sink to ground.
3. The Standby input on the PT6920/6930 series may be driven by a differential output device, making it directly compatible with TTL logic. The control input has an internal pull-up to the input voltage $V_{in}$. A voltage of 1.8V or greater ensures that the regulator is enabled. <u>*Do not*</u> use devices that can drive the Standby control input above 5.5V or $V_{in}$.

***Figure 1***




**Turn-On Time:** Turning $Q_1$ in Figure 1 off removes the low-voltage signal at pin 3 and enables both outputs from the PT6920/6930 regulator. Following a delay of about 5–10ms, $V_1$out and $V_2$out rise together until the lower voltage, $V_2$out, reaches its set output. $V_1$out then continues to rise until both outputs reach full regulation voltage. The total power-up time is less than 15ms, and is relatively independant of load, temperature, and output capacitance. Figure 2 shows waveforms of the input current $I_{in}$, and output voltages $V_1$out and $V_2$out, for a PT6921 (3.3V/2.5V). The turn-off of $Q_1$ corresponds to t =0 secs. The waveforms were measured with a 5Vdc input voltage, and with resistive loads of 5.5A and 2.2A at the $V_1$out and $V_2$out outputs respectively.

***Figure 2***



## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Samples (Requires Login) |
|---|---|---|---|---|---|---|---|---|---|
| PT6921A | LIFEBUY | SIP MODULE | EJJ | 23 | 8 | Pb-Free (RoHS) | Call TI | N / A for Pkg Type | |
| PT6921C | LIFEBUY | SIP MODULE | EJK | 23 | 8 | Pb-Free (RoHS) | Call TI | Level-1-215C-UNLIM | |
| PT6921N | LIFEBUY | SIP MODULE | EJH | 23 | 10 | Pb-Free (RoHS) | Call TI | N / A for Pkg Type | |

(1) 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.

(2) 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)

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

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| **Products** | | **Applications** | |
|---|---|---|---|
| Audio | www.ti.com/audio | Automotive and Transportation | www.ti.com/automotive |
| Amplifiers | amplifier.ti.com | Communications and Telecom | www.ti.com/communications |
| Data Converters | dataconverter.ti.com | Computers and Peripherals | www.ti.com/computers |
| DLP® Products | www.dlp.com | Consumer Electronics | www.ti.com/consumer-apps |
| DSP | dsp.ti.com | Energy and Lighting | www.ti.com/energy |
| Clocks and Timers | www.ti.com/clocks | Industrial | www.ti.com/industrial |
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