

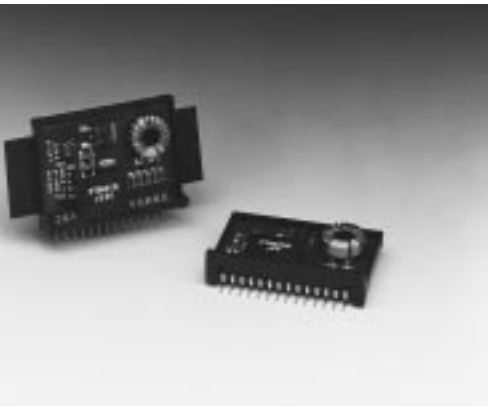
## PT6600 Series

9 Amp 5V/3.3V Input Adjustable  
Integrated Switching Regulator

**Power Trends Products**  
from Texas Instruments

SLTS035A

(Revised 6/30/2000)



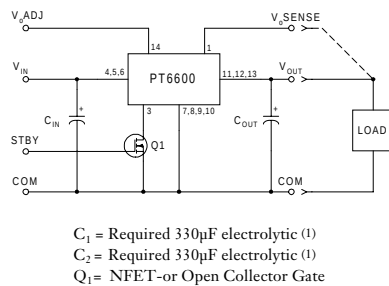
- Single Device 9A Output
- Input Voltage Range: 3.1V to 6.0V
- Adjustable Output Voltage
- 90% Efficiency
- Remote Sense Capability
- Standby Function
- Over-Temperature Protection

The PT6600 series is a high performance family of 14-Pin SIP (Single

In-line Package) Integrated Switching Regulators (ISRs), designed for stand-alone operation in applications requiring as much as 9A of output current.

The PT6600 series will operate off either a 3.3V or 5V input bus and requires only two external capacitors for proper operation. Please note that this product does not include short circuit protection.

### Standard Application



### Pin-Out Information

| Pin | Function         |
|-----|------------------|
| 1   | Remote Sense     |
| 2   | Do not connect   |
| 3   | STBY*-Standby    |
| 4   | $V_{in}$         |
| 5   | $V_{in}$         |
| 6   | $V_{in}$         |
| 7   | GND              |
| 8   | GND              |
| 9   | GND              |
| 10  | GND              |
| 11  | $V_{out}$        |
| 12  | $V_{out}$        |
| 13  | $V_{out}$        |
| 14  | $V_{out}$ Adjust |

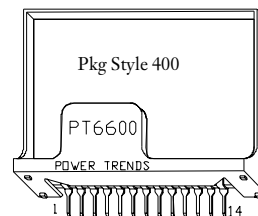
### Ordering Information

|           |              |
|-----------|--------------|
| PT6601!   | = +3.3 Volts |
| † PT6602! | = +1.5 Volts |
| PT6603!   | = +2.5 Volts |
| PT6604!   | = +3.6 Volts |
| † PT6605! | = +1.2 Volts |
| † PT6606! | = +1.8 Volts |

†3.3V Input Bus Capable

### PT Series Suffix (PT1234X)

| Case/Pin Configuration   | Heat Spreader | Heat Spreader with Side Tabs |
|--------------------------|---------------|------------------------------|
| Vertical Through-Hole    | P             | R                            |
| Horizontal Through-Hole  | D             | G                            |
| Horizontal Surface Mount | E             | B                            |



Note: Back surface of product is conducting metal.

### Specifications

| Characteristics<br>( $T_a = 25^\circ\text{C}$ unless noted) | Symbols              | Conditions                                                                                                                                | PT6600 SERIES                                                    |                                       |                                  | Units                 |
|-------------------------------------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|---------------------------------------|----------------------------------|-----------------------|
|                                                             |                      |                                                                                                                                           | Min                                                              | Typ                                   | Max                              |                       |
| Output Current                                              | $I_o$                | $T_a = 60^\circ\text{C}$ , 200 LFM, pkg P<br>$T_a = 25^\circ\text{C}$ , natural convection                                                | 0.1 (2)<br>0.1 (2)                                               | —                                     | 9.0 (4)<br>7.0 (4)               | A                     |
| Input Voltage Range                                         | $V_{in}$             | $0.1A \leq I_o \leq 8.0A$<br>$V_o = +2.5/3.3V$<br>$V_o \leq 1.8V$<br>$V_o = +3.6V$                                                        | 4.5<br>3.1<br>4.8                                                | —                                     | 6.0<br>6.0<br>6.0                | V                     |
| Output Voltage Tolerance                                    | $\Delta V_o$         | $V_{in} = +5V$ , $I_o = 8.0A$<br>$T_a = 0^\circ\text{C}$ to $65^\circ\text{C}$                                                            | $V_o - 0.1$                                                      | —                                     | $V_o + 0.1$                      | V                     |
| Output Voltage Adjust Range                                 | $V_{oadj}$           | Pin 14 to $V_o$ or ground<br>$V_{in} \text{ min} = +3.1V$ or $V_o + 1.2V$<br>(whichever is greater)                                       | $V_o = +3.3V$<br>$V_o = +1.5V$<br>$V_o = +2.5V$<br>$V_o = +3.6V$ | 2.25<br>1.27<br>1.80<br>2.50          | 4.20<br>2.65<br>3.50<br>4.30     | V                     |
| Line Regulation                                             | $\text{Reg}_{line}$  | $4.5V \leq V_{in} \leq 6.0V$ , $I_o = 8.0A$<br>$3.1V \leq V_{in} \leq 6.0V$ , $I_o = 8.0A$<br>$4.5V \leq V_{in} \leq 6.0V$ , $I_o = 8.0A$ | $V_o = +3.3V$<br>$V_o = +1.5V$<br>$V_o = +2.5V$                  | —<br>$\pm 7$<br>$\pm 3$<br>$\pm 7$    | $\pm 17$<br>$\pm 8$<br>$\pm 13$  | mV                    |
| Load Regulation                                             | $\text{Reg}_{load}$  | $V_{in} = +5V$ , $0.1 \leq I_o \leq 8.0A$                                                                                                 | $V_o = +3.3V$<br>$V_o = +1.5V$<br>$V_o = +2.5V$                  | —<br>$\pm 17$<br>$\pm 12$<br>$\pm 13$ | $\pm 33$<br>$\pm 23$<br>$\pm 25$ | mV                    |
| $V_o$ Ripple/Noise                                          | $V_n$                | $V_{in} = 5V$ , $I_o = 8.0A$                                                                                                              | —                                                                | 50                                    | —                                | mVpp                  |
| Transient Response<br>with $C_2 = 330\mu\text{F}$           | $t_{tr}$<br>$V_{os}$ | $I_o$ step between 4.0A and 8.0A<br>$V_o$ over/undershoot                                                                                 | —<br>—                                                           | 100<br>150                            | —                                | $\mu\text{Sec}$<br>mV |
| Efficiency                                                  | $\eta$               | $V_{in} = +5V$ , $I_o = 3.0A$<br>$V_o = +3.3/3.6V$<br>$V_o = +1.5V$<br>$V_o = +2.5V$                                                      | —<br>—<br>—<br>—                                                 | 90<br>76<br>85                        | —                                | %                     |
|                                                             |                      | $V_{in} = +5V$ , $I_o = 8.0A$<br>$V_o = +3.3/3.6V$<br>$V_o = +1.5V$<br>$V_o = +2.5V$                                                      | —<br>—<br>—<br>—                                                 | 83<br>68<br>76                        | —                                | %                     |
| Switching Frequency                                         | $f_o$                | $3.1V \leq V_{in} \leq 6.0V$<br>$0.1A \leq I_o \leq 8.0A$                                                                                 | 475                                                              | 600                                   | 725                              | kHz                   |
| Absolute Maximum<br>Operating Temperature Range             | $T_a$                | Over $V_{in}$ range                                                                                                                       | -40 (3)                                                          | —                                     | +85 (4)                          | $^\circ\text{C}$      |
| Thermal Resistance                                          | $\theta_{ja}$        | Free Air Convection (40-60 LFM)                                                                                                           | —                                                                | 25                                    | —                                | $^\circ\text{C/W}$    |

Continued

# PT6600 Series

## 9 Amp 5V/3.3V Input Adjustable Integrated Switching Regulator

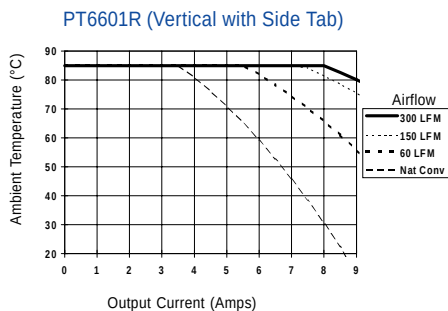
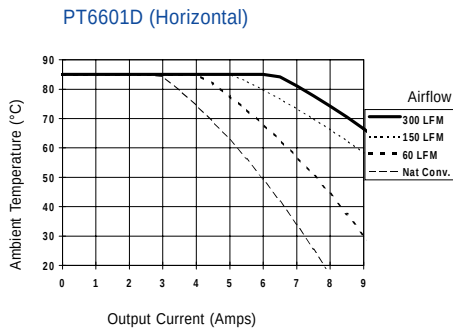
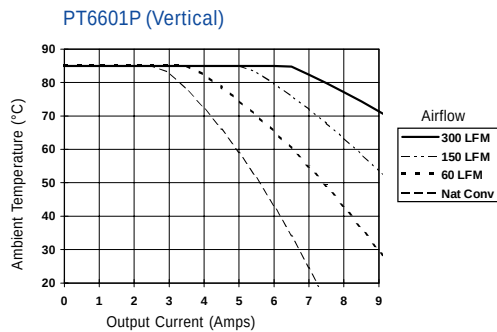
### Specifications (continued)

| Characteristics<br>(T <sub>a</sub> = 25°C unless noted) | Symbols        | Conditions                                                          | PT6600 SERIES |     |      | Units |
|---------------------------------------------------------|----------------|---------------------------------------------------------------------|---------------|-----|------|-------|
|                                                         |                |                                                                     | Min           | Typ | Max  |       |
| Storage Temperature                                     | T <sub>s</sub> | —                                                                   | -40           | —   | +125 | °C    |
| Mechanical Shock                                        | —              | Per Mil-STD-883D, Method 2002.3                                     | —             | 500 | —    | G's   |
| Mechanical Vibration                                    | —              | Per Mil-STD-883D, Method 2007.2, 20-2000 Hz, soldered in a PC board | —             | 7.5 | —    | G's   |
| Weight                                                  | —              | —                                                                   | —             | 14  | —    | grams |

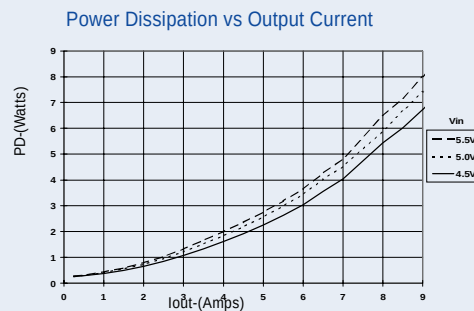
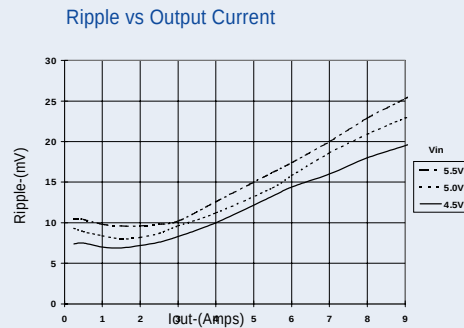
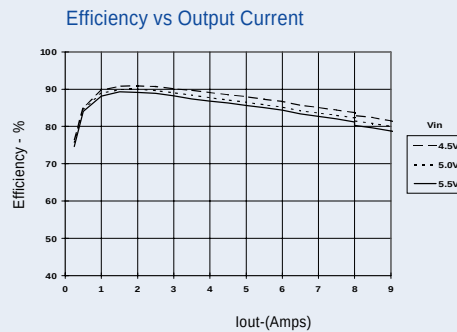
Notes: (1) The PT6600 series requires two 330µF electrolytic capacitors (input and output) for proper operation in all applications. The input capacitance must be rated for a minimum of 1.1 Arms of ripple current. See the application note, PT6500/6600 Series Capacitor Recommendations.  
 (2) ISR will operate down to no load with reduced specifications.  
 (3) For operation below 0°C, use tantalum capacitors for C<sub>IN</sub> and C<sub>OUT</sub>. For more information, contact an Application Specialist.  
 (4) See Safe Operating Curves, or contact the factory for the appropriate derating.

## TYPICAL CHARACTERISTICS

### Safe Operating Area Curves (@ V<sub>in</sub>=+5.0V) (See Note B)



### PT6601, 3.3 VDC (See Note A)



Note A: All 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 temperatures.

## PT6600 Series

### Adjusting the Output Voltage of the PT6600 5V Bus Converters

The output voltage of the Power Trends PT6600 Series ISRs may be adjusted higher or lower than the factory trimmed pre-set voltage with the addition of a single external resistor. Table 1 accordingly gives the allowable adjustment range for each model in the series as  $V_a$  (min) and  $V_a$  (max).

**Adjust Up:** An increase in the output voltage is obtained by adding a resistor R2, between pin 14 ( $V_o$  adjust) and pins 7-10 (GND).

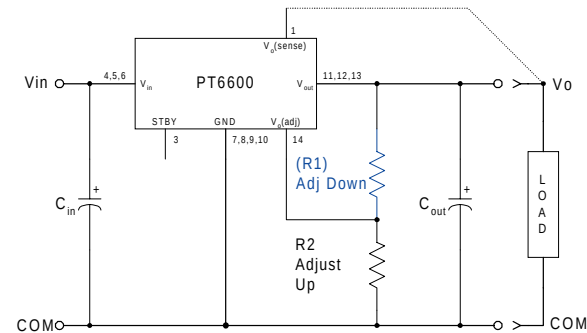
**Adjust Down:** Add a resistor (R1), between pin 14 ( $V_o$  adjust) and pins 11-13 ( $V_o$  adjust).

Refer to Figure 1 and Table 2 for both the placement and value of the required resistor, either (R1) or R2 as appropriate.

#### Notes:

1. Use only a single 1% resistor in either the (R1) or R2 location. Place the resistor as close to the ISR as possible.
2. Never connect capacitors from  $V_o$  adjust to either GND,  $V_{out}$ , or the Remote Sense pin. Any capacitance added to the  $V_o$  adjust pin will affect the stability of the ISR.
3. If the Remote Sense feature is being used, connecting the resistor (R1) between pin 14 ( $V_o$  adjust) and pin 1 (Remote Sense) can benefit load regulation.
4. The minimum input voltage required by the part is  $V_{out} + 1.2$  or 3.1V, whichever is higher.

Figure 1



The values of (R1) [adjust down], and R2 [adjust up], can also be calculated using the following formulae.

$$(R1) = \frac{R_o (V_a - 1.0)}{(V_o - V_a)} - R_s \text{ k}\Omega$$

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

Where:  $V_o$  = Original output voltage  
 $V_a$  = Adjusted output voltage  
 $R_o$  = The resistance value in Table 1  
 $R_s$  = The series resistance from Table 1

Table 1

PT6600 ADJUSTMENT AND FORMULA PARAMETERS

| Series Pt #         | PT6605 | PT6607 | PT6602 | PT6608 | PT6606 | PT6603 | PT6601 | PT6604 |
|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| $V_o$ (nom)         | 1.2    | 1.3    | 1.5    | 1.7    | 1.8    | 2.5    | 3.3    | 3.6    |
| $V_a$ (min)         | 1.14   | 1.19   | 1.27   | 1.36   | 1.4    | 1.8    | 2.25   | 2.5    |
| $V_a$ (max)         | 2.35   | 2.45   | 2.65   | 2.85   | 2.95   | 3.5    | 4.2    | 4.3    |
| $R_o$ (k $\Omega$ ) | 2.49   | 2.49   | 2.49   | 2.49   | 2.49   | 4.99   | 12.1   | 10.0   |
| $R_s$ (k $\Omega$ ) | 2.0    | 2.0    | 2.0    | 2.0    | 2.0    | 4.22   | 12.1   | 12.1   |

## PT6600 Series

Table 2

PT6600 ADJUSTMENT RESISTOR VALUES

| Series Pt #            | PT6605                                                          | PT6607   | PT6602   | PT6608   | PT6606   | PT6603    | PT6601    | PT6604    |
|------------------------|-----------------------------------------------------------------|----------|----------|----------|----------|-----------|-----------|-----------|
| V <sub>0</sub> (nom)   | 1.2                                                             | 1.3      | 1.5      | 1.7      | 1.8      | 2.5       | 3.3       | 3.6       |
| V <sub>a</sub> (req'd) |                                                                 |          |          |          |          |           |           |           |
| 1.15                   | (5.5)kΩ                                                         |          |          |          |          |           |           |           |
| 1.2                    |                                                                 | (3.0)kΩ  |          |          |          |           |           |           |
| 1.25                   | 47.8kΩ                                                          | (10.5)kΩ |          |          |          |           |           |           |
| 1.3                    | 22.9kΩ                                                          |          | (1.7)kΩ  |          |          |           |           |           |
| 1.35                   | 14.6kΩ                                                          | 47.8kΩ   | (3.8)kΩ  |          |          |           |           |           |
| 1.4                    | 10.5kΩ                                                          | 22.9kΩ   | (8.0)kΩ  | (1.3)kΩ  | (0.5)kΩ  |           |           |           |
| 1.45                   | 8.0kΩ                                                           | 14.6kΩ   | (20.4)kΩ | (2.5)kΩ  | (1.2)kΩ  |           |           |           |
| 1.5                    | 6.3kΩ                                                           | 10.5kΩ   |          | (4.2)kΩ  | (2.2)kΩ  |           |           |           |
| 1.55                   | 5.1kΩ                                                           | 8.0kΩ    | 47.8kΩ   | (7.1)kΩ  | (3.5)kΩ  |           |           |           |
| 1.6                    | 4.2kΩ                                                           | 6.3kΩ    | 22.9kΩ   | (12.9)kΩ | (5.5)kΩ  |           |           |           |
| 1.65                   | 3.5kΩ                                                           | 4.1kΩ    | 14.6kΩ   | (30.4)kΩ | (8.8)kΩ  |           |           |           |
| 1.7                    | 3.0kΩ                                                           | 4.2kΩ    | 10.5kΩ   |          | (15.4)kΩ |           |           |           |
| 1.75                   | 2.5kΩ                                                           | 3.5kΩ    | 8.0kΩ    | 47.8kΩ   | (35.4)kΩ |           |           |           |
| 1.8                    | 2.2kΩ                                                           | 3.0kΩ    | 6.3kΩ    | 22.9kΩ   |          | (1.5)kΩ   |           |           |
| 1.85                   | 1.8kΩ                                                           | 2.5kΩ    | 5.1kΩ    | 14.6kΩ   | 47.8kΩ   | (2.3)kΩ   |           |           |
| 1.9                    | 1.6kΩ                                                           | 2.2kΩ    | 4.2kΩ    | 10.5kΩ   | 22.9kΩ   | (3.3)kΩ   |           |           |
| 1.95                   | 1.3kΩ                                                           | 1.8kΩ    | 3.5kΩ    | 8.0kΩ    | 14.6kΩ   | (4.4)kΩ   |           |           |
| 2.0                    | 1.1kΩ                                                           | 1.6kΩ    | 3.0kΩ    | 6.3kΩ    | 10.5kΩ   | (5.8)kΩ   |           |           |
| 2.05                   | 0.9kΩ                                                           | 1.3kΩ    | 2.5kΩ    | 5.1kΩ    | 8.0kΩ    | (7.4)kΩ   |           |           |
| 2.1                    | 0.8kΩ                                                           | 1.1kΩ    | 2.2kΩ    | 4.2kΩ    | 6.3kΩ    | (9.5)kΩ   |           |           |
| 2.15                   | 0.6kΩ                                                           | 0.9kΩ    | 1.8kΩ    | 3.5kΩ    | 5.1kΩ    | (12.2)kΩ  |           |           |
| 2.2                    | 0.5kΩ                                                           | 0.8kΩ    | 1.6kΩ    | 3.0kΩ    | 4.2kΩ    | (15.7)kΩ  |           |           |
| 2.25                   | 0.4kΩ                                                           | 0.6kΩ    | 1.3kΩ    | 2.5kΩ    | 3.5kΩ    | (20.7)kΩ  | (2.3)kΩ   |           |
| 2.3                    | 0.3kΩ                                                           | 0.5kΩ    | 1.1kΩ    | 2.2kΩ    | 3.0kΩ    | (28.2)kΩ  | (3.6)kΩ   |           |
| 2.35                   | 0.2kΩ                                                           | 0.4kΩ    | 0.9kΩ    | 1.8kΩ    | 2.5kΩ    | (40.7)kΩ  | (5.1)kΩ   |           |
| 2.4                    |                                                                 | 0.3kΩ    | 0.8kΩ    | 1.6kΩ    | 2.2kΩ    | (65.6)kΩ  | (6.7)kΩ   |           |
| 2.45                   |                                                                 | 0.2kΩ    | 0.6kΩ    | 1.3kΩ    | 1.8kΩ    | (140.0)kΩ | (8.5)kΩ   |           |
| 2.5                    |                                                                 |          | 0.5kΩ    | 1.1kΩ    | 1.6kΩ    |           | (10.6)kΩ  | (1.5)kΩ   |
| 2.55                   |                                                                 |          | 0.4kΩ    | 0.9kΩ    | 1.3kΩ    | 95.6kΩ    | (12.9)kΩ  | (2.7)kΩ   |
| 2.6                    |                                                                 |          | 0.3kΩ    | 0.8kΩ    | 1.1kΩ    | 45.7kΩ    | (15.6)kΩ  | (3.9)kΩ   |
| 2.65                   |                                                                 |          | 0.2kΩ    | 0.6kΩ    | 6.9kΩ    | 29.0kΩ    | (18.6)kΩ  | (5.3)kΩ   |
| 2.7                    |                                                                 |          |          | 0.5kΩ    | 0.8kΩ    | 20.7kΩ    | (22.2)kΩ  | (6.8)kΩ   |
| 2.75                   |                                                                 |          |          | 0.4kΩ    | 0.6kΩ    | 15.7kΩ    | (26.4)kΩ  | (8.5)kΩ   |
| 2.8                    |                                                                 |          |          | 0.3kΩ    | 0.5kΩ    | 12.4kΩ    | (31.5)kΩ  | (10.4)kΩ  |
| 2.85                   |                                                                 |          |          | 0.2kΩ    | 0.4kΩ    | 10.0kΩ    | (37.6)kΩ  | (12.6)kΩ  |
| 2.9                    |                                                                 |          |          |          | 0.3kΩ    | 8.3kΩ     | (45.4)kΩ  | (15.0)kΩ  |
| 2.95                   |                                                                 |          |          |          | 0.2kΩ    | 0.9kΩ     | (55.3)kΩ  | (17.9)kΩ  |
| 3.0                    |                                                                 |          |          |          |          | 5.8kΩ     | (68.6)kΩ  | (21.2)kΩ  |
| 3.1                    |                                                                 |          |          |          |          | 4.1kΩ     | (115.0)kΩ | (29.9)kΩ  |
| 3.2                    |                                                                 |          |          |          |          | 2.9kΩ     | (254.0)kΩ | (42.9)kΩ  |
| 3.3                    |                                                                 |          |          |          |          | 2.0kΩ     |           | (64.6)kΩ  |
| 3.4                    |                                                                 |          |          |          |          | 1.3kΩ     | 109.0kΩ   | (108.0)kΩ |
| 3.5                    |                                                                 |          |          |          |          | 0.8kΩ     | 48.4kΩ    | (238.0)kΩ |
| 3.6                    |                                                                 |          |          |          |          |           | 28.2kΩ    |           |
| 3.7                    |                                                                 |          |          |          |          |           | 18.2kΩ    | 87.9kΩ    |
| 3.8                    |                                                                 |          |          |          |          |           | 12.1kΩ    | 37.9kΩ    |
| 3.9                    | 4/. V <sub>OUT</sub> >3.8Vdc requires V <sub>IN</sub> >5.0Vdc ! |          |          |          |          |           | 8.1kΩ     | 21.2kΩ    |
| 4.0                    |                                                                 |          |          |          |          |           | 5.2kΩ     | 12.9kΩ    |
| 4.1                    |                                                                 |          |          |          |          |           | 3.0kΩ     | 7.9kΩ     |
| 4.2                    |                                                                 |          |          |          |          |           | 1.3kΩ     | 4.6kΩ     |
| 4.3                    |                                                                 |          |          |          |          |           |           | 2.2kΩ     |

R1 = (Blue) R2 = Black

## PT6600 Series

### Using the Standby Function on the PT6600 5V Bus Converters

For applications requiring output voltage On/Off control, the 14-pin PT6600 ISR series incorporates a standby function. This function may be used in applications that require power-up/shutdown sequencing, and wherever there is a requirement for the output status of the module to be controlled by 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 when a valid supply voltage is applied to  $V_{in}$  (pins 4, 5, & 6) with respect to GND (pins 7-10). If a low voltage<sup>2</sup> is then applied to pin-3 the regulator output will be disabled and the input current drawn by the ISR will drop to less than 50mA<sup>4</sup>. The standby control may also be used to hold-off the regulator output during the period that input power is applied.

The standby control 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<sup>3</sup> compatible gate. Table 1 provides details of the threshold requirements.

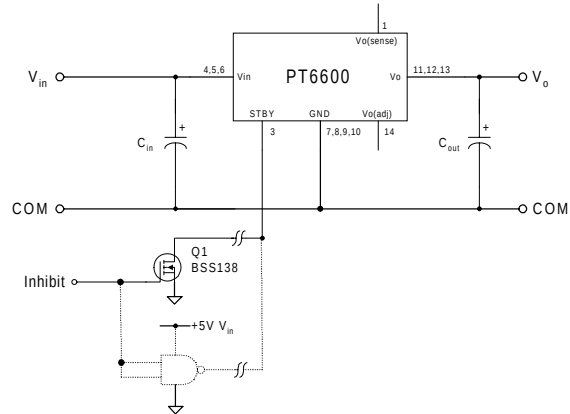
Table 1 Inhibit Control Thresholds <sup>(2,3)</sup>

| Parameter            | Min   | Max   |
|----------------------|-------|-------|
| Enable ( $V_{IH}$ )  | 1V    | 5V    |
| Disable ( $V_{IL}$ ) | -0.1V | 0.35V |

#### Notes:

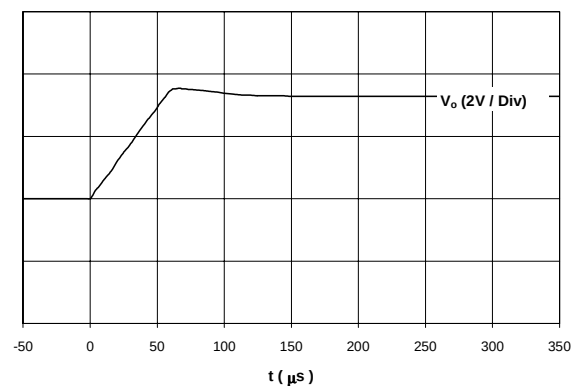
1. The Standby/Inhibit control logic is similar for all Power Trends' modules, but the flexibility and threshold tolerances will be different. For specific information on this function for other regulator models, consult the applicable application note.
2. The Standby control pin is ideally controlled using an open-collector (or open-drain) discrete transistor and requires no external pull-up resistor. The control input has an open-circuit voltage of about 1Vdc. To disable the regulator output, the control pin must be pulled to less than 0.35Vdc with a low-level 0.5mA sink to ground.
3. The Standby input on the PT6600 series may be driven by a differential output device, making it compatible with TTL logic. A standard TTL logic gate will meet the 0.35V  $V_{IL}(\text{max})$  requirement (Table 1) at 0.5mA  $I_{OL}$ . Do not use devices that can drive the Standby control input above 5Vdc.
4. When the regulator output is disabled the current drawn from the input source is reduced to approximately 30–40mA (50mA maximum).

Figure 1



**Turn-On Time:** In the circuit of Figure 1, turning  $Q_1$  on applies a low voltage to the Standby control (pin 3) and disables the regulator output. Correspondingly, turning  $Q_1$  off releases the low-voltage signal and enables the output. The PT6600 ISR series regulators have a fast response and will provide a fully regulated output voltage within 250  $\mu\text{sec}$ . The actual turn-on time will vary with load and the total amount of output capacitance. The waveform of Figure 2 shows the typical output voltage response of a PT6601 (3.3V) following the turn-off of  $Q_1$  at time  $t = 0.0$  secs. The waveform was measured with a 5Vdc input voltage, and 0.6 $\Omega$  load.

Figure 2



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