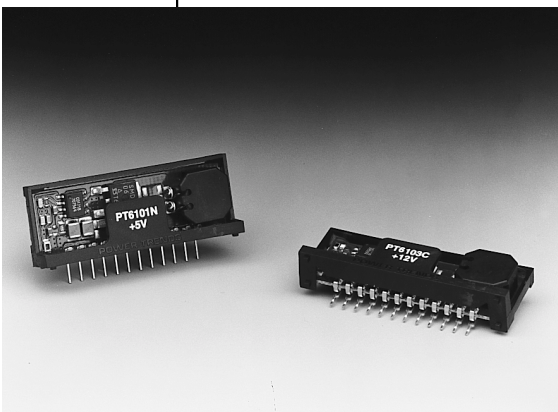
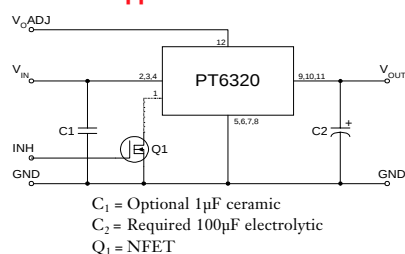


**PT6320 Series****3 AMP ADJUSTABLE LOW VOLTAGE INPUT  
INTEGRATED SWITCHING REGULATORS****SLTS065**  
(Revised 6/4/98)

- Low Voltage Input (7V)
- 90% Efficiency
- Adjustable Output Voltage
- Internal Short Circuit Protection
- Over-Temperature Protection
- On/Off Control (Ground Off)

The PT6320 series is a low voltage input (typically 7V) version of Power Trends' high-performance 3A, 12 pin SIP Integrated Switching

Regulators (ISRs). These ISRs are designed with premium low threshold FETs for those applications requiring very low input/output voltage differentials such as battery powered equipment. This high-performance ISR family offers a unique combination of features combining 90% typical efficiency with open-collector on/off control and adjustable output voltage. Quiescent current in the shutdown mode is less than 100µA.

**Standard Application****Specifications****Pin-Out Information**

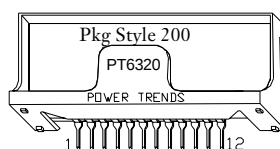
| Pin | Function             |
|-----|----------------------|
| 1   | Inhibit (30V max)    |
| 2   | V <sub>in</sub>      |
| 3   | V <sub>in</sub>      |
| 4   | V <sub>in</sub>      |
| 5   | GND                  |
| 6   | GND                  |
| 7   | GND                  |
| 8   | GND                  |
| 9   | V <sub>out</sub>     |
| 10  | V <sub>out</sub>     |
| 11  | V <sub>out</sub>     |
| 12  | V <sub>out</sub> Adj |

**Ordering Information**

PT6322□ = +5 Volts  
PT6323□ = +3.3 Volts

**PT Series Suffix (PT1234X)**

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



| Characteristics<br>(T <sub>a</sub> =25°C unless noted)                   | Symbols                            | Conditions                                                                                                                               | PT6320 SERIES          |            |               |                          |
|--------------------------------------------------------------------------|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------|---------------|--------------------------|
|                                                                          |                                    |                                                                                                                                          | Min                    | Typ        | Max           | Units                    |
| Output Current                                                           | I <sub>O</sub>                     | Over V <sub>in</sub> range                                                                                                               | 0.1*                   | —          | 3.0           | A                        |
| Short Circuit Current                                                    | I <sub>sc</sub>                    | V <sub>in</sub> = V <sub>o</sub> + 5V                                                                                                    | —                      | 5.0        | —             | A <sub>pk</sub>          |
| Input Voltage Range<br>(Note: inhibit function cannot be used above 30V) | V <sub>in</sub>                    | 0.1 ≤ I <sub>O</sub> ≤ 3.0 A<br>V <sub>o</sub> = 3.3V<br>V <sub>o</sub> = 5V                                                             | 7<br>7                 | —          | 26<br>30/38** | V<br>V                   |
| Output Voltage Tolerance                                                 | ΔV <sub>o</sub>                    | Over V <sub>in</sub> Range, I <sub>O</sub> = 3.0 A<br>T <sub>a</sub> = 0°C to +60°C                                                      | —                      | ±1.0       | ±2.0          | % V <sub>o</sub>         |
| Line Regulation                                                          | Reg <sub>line</sub>                | Over V <sub>in</sub> range                                                                                                               | —                      | ±0.25      | ±0.5          | % V <sub>o</sub>         |
| Load Regulation                                                          | Reg <sub>load</sub>                | 0.1 ≤ I <sub>O</sub> ≤ 3.0 A                                                                                                             | —                      | ±0.25      | ±0.5          | % V <sub>o</sub>         |
| V <sub>o</sub> Ripple/Noise                                              | V <sub>n</sub>                     | V <sub>in</sub> = V <sub>in</sub> min, I <sub>O</sub> = 3.0A                                                                             | —                      | ±2         | —             | % V <sub>o</sub>         |
| Transient Response<br>with C <sub>o</sub> = 100µF                        | t <sub>tr</sub><br>V <sub>os</sub> | 50% load change<br>V <sub>o</sub> over/undershoot                                                                                        | —                      | 100<br>5.0 | 200<br>—      | µSec<br>% V <sub>o</sub> |
| Efficiency                                                               | η                                  | V <sub>in</sub> = 9V, I <sub>O</sub> = 0.5 A, V <sub>o</sub> = 3.3V<br>V <sub>in</sub> = 9V, I <sub>O</sub> = 0.5 A, V <sub>o</sub> = 5V | —                      | 84<br>89   | —             | %                        |
| Switching Frequency                                                      | f <sub>o</sub>                     | Over V <sub>in</sub> and I <sub>O</sub> ranges                                                                                           | 400                    | 500        | 600           | kHz                      |
| Shutdown Current                                                         | I <sub>sc</sub>                    | V <sub>in</sub> = 15V                                                                                                                    | —                      | 100        | —             | µA                       |
| Quiescent Current                                                        | I <sub>nl</sub>                    | I <sub>O</sub> = 0A, V <sub>in</sub> = 10V                                                                                               | —                      | 10         | —             | mA                       |
| Output Voltage Adjustment Range                                          | V <sub>o</sub>                     | Below V <sub>o</sub><br>Above V <sub>o</sub>                                                                                             | See Application Notes. |            |               |                          |
| Absolute Maximum Operating Temperature Range                             | T <sub>a</sub>                     |                                                                                                                                          | -40                    | —          | +85           | °C                       |
| Recommended Operating Temperature Range                                  | T <sub>a</sub>                     | Free Air Convection, (40-60LFM)<br>At V <sub>in</sub> = 24V, I <sub>O</sub> = 2.5A                                                       | -40                    | —          | +80***        | °C                       |
| Thermal Resistance                                                       | θ <sub>ja</sub>                    | Free Air Convection (40-60LFM)                                                                                                           | —                      | 30         | —             | °C/W                     |
| Storage Temperature                                                      | T <sub>s</sub>                     |                                                                                                                                          | -40                    | —          | +125          | °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                                                                      | —                      | 10         | —             | G's                      |
| Weight                                                                   | —                                  |                                                                                                                                          | —                      | 6.5        | —             | grams                    |

\* ISR will operate to no load with reduced specifications.

\*\* Input voltage cannot exceed 30V when the inhibit function is used. \*\*\* See Thermal Derating chart.

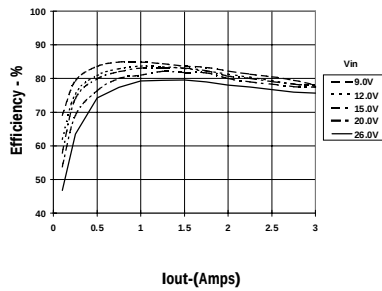
Note: The PT6320 Series requires a 100µF electrolytic or tantalum output capacitor for proper operation in all applications.

# CHARACTERISTIC DATA

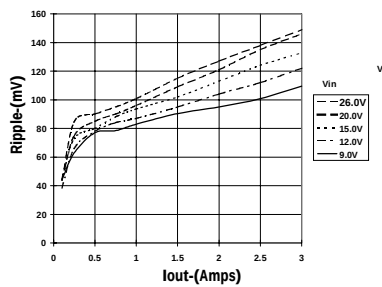
## PT6320 Series

### PT6323, 3.3 VDC (See Note 1)

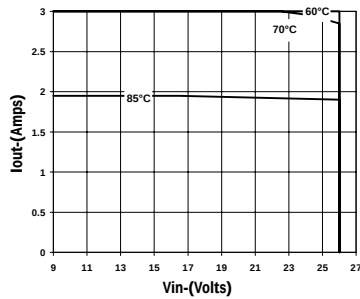
#### Efficiency vs Output Current



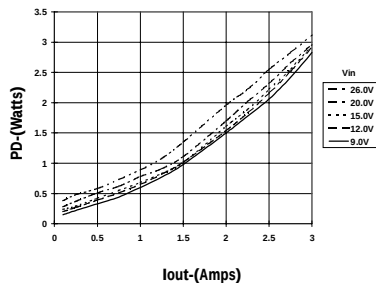
#### Ripple vs Output Current



#### Thermal Derating ( $T_a$ ) (See Note 2)

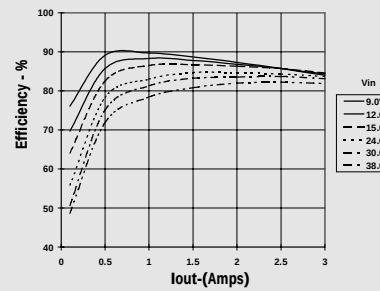


#### Power Dissipation vs Output Current

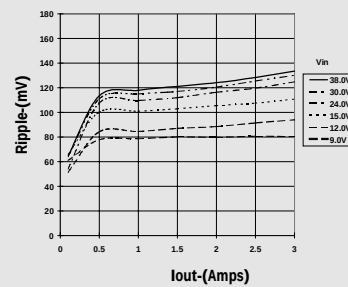


### PT6322, 5.0 VDC (See Note 1)

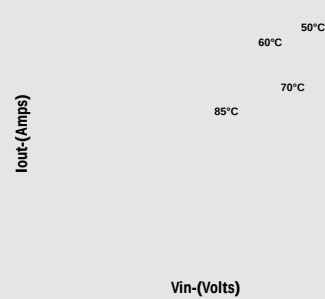
#### Efficiency vs Output Current



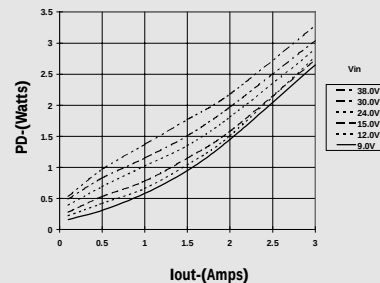
#### Ripple vs Output Current



#### Thermal Derating ( $T_a$ ) (See Note 2)



#### Power Dissipation vs Output Current



**Note 1:** All data listed in the above graphs except for derating data has been developed from actual products tested at 25°C. This data is considered typical data for the ISR  
**Note 2:** Thermal derating graphs are developed in free air convection cooling of 40-60 LFM. (See Thermal Application note.)

[More Application Notes](#)**Adjusting the Output Voltage of Power Trends' Wide Input Range Bus ISRs**

The output voltage of the Power Trends' Wide Input Range 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 for either 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 12 ( $V_o$  adjust) and pins 5-8 (GND).

**Adjust Down:** Add a resistor (R1), between pin 12 ( $V_o$  adjust) and pins 9-11 ( $V_{out}$ ).

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 or  $V_{out}$ . Any capacitance added to the  $V_o$  adjust pin will affect the stability of the ISR.
4. Adjustments to the output voltage may place additional limits on the maximum and minimum input voltage for the part. The revised maximum and minimum input voltage limits must comply with the following requirements. Note that the minimum input voltage limits are also model dependent.

$$V_{in}(\max) = (8 \times V_a)V \text{ or } *30/38V, \text{ whichever is less.}$$

*\*Limit is 30V when inhibit function is active.*

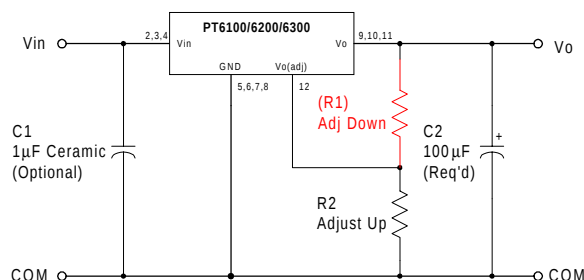
**PT6x0x/PT6x1x series:**

$$V_{in}(\min) = (V_a + 4)V \text{ or } 9V, \text{ whichever is greater.}$$

**PT6x2x series:**

$$V_o < 10V; \quad V_{in}(\min) = (V_a + 2.0)V \text{ or } 7.0V, \text{ whichever is greater.}$$

$$V_o \geq 10V; \quad V_{in}(\min) = (V_a + 2.5)V$$

**Figure 1**

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

$$(R1) = \frac{R_o (V_a - 1.25)}{V_o - V_a} \quad k\Omega$$

$$R2 = \frac{1.25 R_o}{V_a - V_o} \quad k\Omega$$

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

**Table 1**

| ISR ADJUSTMENT RANGE AND FORMULA PARAMETERS |        |        |        |        |
|---------------------------------------------|--------|--------|--------|--------|
| 1Adc Rated                                  | PT6102 | PT6101 |        | PT6103 |
|                                             | PT6122 | PT6121 |        |        |
| 2Adc Rated                                  | PT6213 |        | PT6212 | PT6214 |
|                                             | PT6223 |        | PT6222 |        |
| 3Adc Rated                                  | PT6303 |        | PT6302 | PT6304 |
|                                             | PT6323 |        | PT6322 |        |
| $V_o$ (nom)                                 | 3.3    | 5.0    | 5.0    | 12.0   |
| $V_a$ (min)                                 | 1.89   | 1.88   | 2.18   | 2.43   |
| $V_a$ (max)                                 | 6.07   | 11.25  | 8.5    | 22.12  |
| $R_o$ (k $\Omega$ )                         | 66.5   | 150.0  | 90.9   | 243.0  |

**Table 2****ISR ADJUSTMENT RESISTOR VALUES**

| 1Adc Rated                   | PT6102     | PT6101     |            | PT6103      |
|------------------------------|------------|------------|------------|-------------|
|                              | PT6122     | PT6121     |            |             |
| 2Adc Rated                   | PT6213     |            | PT6212     | PT6214      |
|                              | PT6223     |            | PT6222     |             |
| 3Adc Rated                   | PT6303     |            | PT6302     | PT6304      |
|                              | PT6323     |            | PT6322     |             |
| <b>V<sub>O</sub> (nom)</b>   | <b>3.3</b> | <b>5.0</b> | <b>5.0</b> | <b>12.0</b> |
| <b>V<sub>A</sub> (req.d)</b> |            |            |            |             |
| 1.9                          | (30.9)kΩ   | (31.5)kΩ   |            |             |
| 2.0                          | (38.4)kΩ   | (37.5)kΩ   |            |             |
| 2.1                          | (47.1)kΩ   | (44.0)kΩ   |            |             |
| 2.2                          | (57.4)kΩ   | (50.9)kΩ   | (30.8)kΩ   |             |
| 2.3                          | (69.8)kΩ   | (58.3)kΩ   | (35.4)kΩ   |             |
| 2.4                          | (85.0)kΩ   | (66.3)kΩ   | (40.2)kΩ   |             |
| 2.5                          | (104.0)kΩ  | (75.0)kΩ   | (45.5)kΩ   | (32.0)kΩ    |
| 2.6                          | (128.0)kΩ  | (84.4)kΩ   | (51.1)kΩ   | (34.9)kΩ    |
| 2.7                          | (161.0)kΩ  | (94.6)kΩ   | (57.3)kΩ   | (37.9)kΩ    |
| 2.8                          | (206.0)kΩ  | (106.0)kΩ  | (64.0)kΩ   | (40.9)kΩ    |
| 2.9                          | (274.0)kΩ  | (118.0)kΩ  | (71.4)kΩ   | (44.1)kΩ    |
| 3.0                          | (388.0)kΩ  | (131.0)kΩ  | (79.5)kΩ   | (47.3)kΩ    |
| 3.1                          | (615.0)kΩ  | (146.0)kΩ  | (88.5)kΩ   | (50.5)kΩ    |
| 3.2                          | (1300.0)kΩ | (163.0)kΩ  | (98.5)kΩ   | (53.8)kΩ    |
| 3.3                          |            | (181.0)kΩ  | (110.0)kΩ  | (57.3)kΩ    |
| 3.4                          | 831.0kΩ    | (202.0)kΩ  | (122.0)kΩ  | (60.8)kΩ    |
| 3.5                          | 416.0kΩ    | (225.0)kΩ  | (136.0)kΩ  | (64.3)kΩ    |
| 3.6                          | 227.0kΩ    | (252.0)kΩ  | (153.0)kΩ  | (68.0)kΩ    |
| 3.7                          | 208.0kΩ    | (283.0)kΩ  | (171.0)kΩ  | (71.7)kΩ    |
| 3.8                          | 166.0kΩ    | (319.0)kΩ  | (193.0)kΩ  | (75.6)kΩ    |
| 3.9                          | 139.0kΩ    | (361.0)kΩ  | (219.0)kΩ  | (79.5)kΩ    |
| 4.0                          | 119.0kΩ    | (413.0)kΩ  | (250.0)kΩ  | (83.5)kΩ    |
| 4.1                          | 104.0kΩ    | (475.0)kΩ  | (288.0)kΩ  | (87.7)kΩ    |
| 4.2                          | 92.4kΩ     | (533.0)kΩ  | (335.0)kΩ  | (91.9)kΩ    |
| 4.3                          | 83.1kΩ     | (654.0)kΩ  | (396.0)kΩ  | (96.3)kΩ    |
| 4.4                          | 75.6kΩ     | (788.0)kΩ  | (477.0)kΩ  | (101.0)kΩ   |
| 4.5                          | 69.3kΩ     | (975.0)kΩ  | (591.0)kΩ  | (105.0)kΩ   |
| 4.6                          | 63.9kΩ     | (1260.0)kΩ | (761.0)kΩ  | (110.0)kΩ   |
| 4.7                          | 59.4kΩ     | (1730.0)kΩ | (1050.0)kΩ | (115.0)kΩ   |
| 4.8                          | 55.4kΩ     |            | (1610.0)kΩ | (120.0)kΩ   |
| 4.9                          | 52.0kΩ     |            |            | (125.0)kΩ   |
| 5.0                          | 48.9kΩ     |            |            | (130.0)kΩ   |
| 5.1                          | 46.2kΩ     | 1880.0kΩ   | 1140.0kΩ   | (136.0)kΩ   |
| 5.2                          | 43.8kΩ     | 937.0kΩ    | 568.0kΩ    | (141.0)kΩ   |
| 5.3                          | 41.6kΩ     | 625.0kΩ    | 379.0kΩ    | (147.0)kΩ   |
| 5.4                          | 39.6kΩ     | 469.0kΩ    | 284.0kΩ    | (153.0)kΩ   |
| 5.5                          | 37.8kΩ     | 375.0kΩ    | 227.0kΩ    | (159.0)kΩ   |
| 5.6                          | 36.1kΩ     | 313.0kΩ    | 189.0kΩ    | (165.0)kΩ   |
| 5.7                          | 34.6kΩ     | 268.0kΩ    | 162.0kΩ    | (172.0)kΩ   |
| 5.8                          | 33.3kΩ     | 234.0kΩ    | 142.0kΩ    | (178.0)kΩ   |
| 5.9                          | 32.0kΩ     | 208.0kΩ    | 126.0kΩ    | (185.0)kΩ   |
| 6.0                          | 30.8kΩ     | 188.0kΩ    | 114.0kΩ    | (192.0)kΩ   |

R1 = (Red) R2 = Black

**ISR ADJUSTMENT RESISTOR VALUES (Cont)**

| 1Adc Rated                   | PT6101     |            | PT6103      |
|------------------------------|------------|------------|-------------|
|                              | PT6121     |            |             |
| 2Adc Rated                   |            | PT6212     | PT6214      |
|                              |            | PT6222     |             |
| 3Adc Rated                   |            | PT6302     | PT6304      |
|                              |            | PT6322     |             |
| <b>V<sub>O</sub> (nom)</b>   | <b>5.0</b> | <b>5.0</b> | <b>12.0</b> |
| <b>V<sub>A</sub> (req.d)</b> |            |            |             |
| 6.2                          | 156.0kΩ    | 94.7kΩ     | (207.0)kΩ   |
| 6.4                          | 134.0kΩ    | 81.2kΩ     | (223.0)kΩ   |
| 6.6                          | 117.0kΩ    | 71.0kΩ     | (241.0)kΩ   |
| 6.8                          | 104.0kΩ    | 63.1kΩ     | (259.0)kΩ   |
| 7.0                          | 93.8kΩ     | 56.8kΩ     | (279.0)kΩ   |
| 7.2                          | 85.2kΩ     | 51.6kΩ     | (301.0)kΩ   |
| 7.4                          | 78.1kΩ     | 47.3kΩ     | (325.0)kΩ   |
| 7.6                          | 72.1kΩ     | 43.7kΩ     | (351.0)kΩ   |
| 7.8                          | 67.0kΩ     | 40.6kΩ     | (379.0)kΩ   |
| 8.0                          | 62.5kΩ     | 37.9kΩ     | (410.0)kΩ   |
| 8.2                          | 58.6kΩ     | 35.5kΩ     | (444.0)kΩ   |
| 8.4                          | 55.1kΩ     | 33.4kΩ     | (483.0)kΩ   |
| 8.6                          | 52.1kΩ     |            | (525.0)kΩ   |
| 8.8                          | 49.3kΩ     |            | (573.0)kΩ   |
| 9.0                          | 46.9kΩ     |            | (628.0)kΩ   |
| 9.5                          | 41.7kΩ     |            | (802.0)kΩ   |
| 10.0                         | 37.5kΩ     |            | (1060.0)kΩ  |
| 10.5                         | 34.1kΩ     |            | (1500.0)kΩ  |
| 11.0                         | 31.3kΩ     |            |             |
| 11.5                         |            |            |             |
| 12.0                         |            |            |             |
| 12.5                         |            |            | 608.0kΩ     |
| 13.0                         |            |            | 304.0kΩ     |
| 13.5                         |            |            | 203.0kΩ     |
| 14.0                         |            |            | 152.0kΩ     |
| 14.5                         |            |            | 122.0kΩ     |
| 15.0                         |            |            | 101.0kΩ     |
| 15.5                         |            |            | 86.8kΩ      |
| 16.0                         |            |            | 75.9kΩ      |
| 16.5                         |            |            | 67.5kΩ      |
| 17.0                         |            |            | 60.8kΩ      |
| 17.5                         |            |            | 55.2kΩ      |
| 18.0                         |            |            | 50.6kΩ      |
| 18.5                         |            |            | 46.7kΩ      |
| 19.0                         |            |            | 43.4kΩ      |
| 19.5                         |            |            | 40.5kΩ      |
| 20.0                         |            |            | 38.0kΩ      |
| 20.5                         |            |            | 35.7kΩ      |
| 21.5                         |            |            | 33.8kΩ      |
| 21.5                         |            |            | 32.0kΩ      |
| 22.0                         |            |            | 30.4kΩ      |

## Using the Inhibit Function on Power Trends' Wide Input Range Bus ISRs

For applications requiring output voltage On/Off control, the 12pin ISR products incorporate an inhibit function. The function has uses in areas such as battery conservation, power-up sequencing, or any other application where the regulated output from the module is required to be switched off. The On/Off function is provided by the *Inhibit* control, pin 1.

The ISR functions normally with pin 1 open-circuit, providing a regulated output whenever a valid source voltage is applied to  $V_{in}$ , (pins 2, 3, & 4). When a low-level<sup>2</sup> ground signal is applied to pin 1 the regulator output is disabled, and the input current to the ISR is reduced to about 100 $\mu$ A<sup>3/</sup>.

Figure 1 shows an application schematic, which details the typical use of the inhibit function. Note the discrete transistor, Q1. The inhibit control has its own internal pull-up with a maximum open-circuit voltage of 8.3VDC. Only devices with a true open-collector or open-drain output can be used to control this pin. A discrete bipolar transistor or MOSFET is recommended.

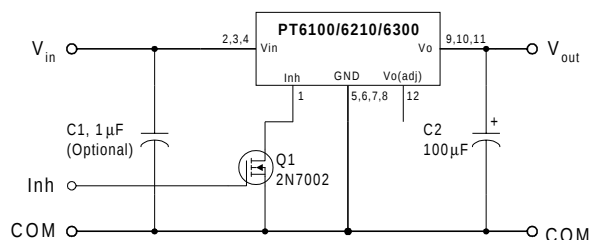
### Notes:

1. The inhibit control logic is similar for all Power Trends' modules, but the flexibility and threshold tolerances will be different. For specific information on the inhibit function of other ISR models, consult the applicable application note.
2. Use only a true open-collector device (preferably a discrete transistor) for the inhibit input. Do Not use a pull-up resistor, or drive the input directly from the output of a TTL or other logic gate. To disable the output voltage, the control pin should be pulled low to less than +1.5VDC.
3. The following equation may be used to determine the approximate current drawn from the input supply at  $V_{in}$ , and through Q1 when the inhibit is active.

$$I_{stby} = V_{in} \div 155k\Omega \pm 20\%$$

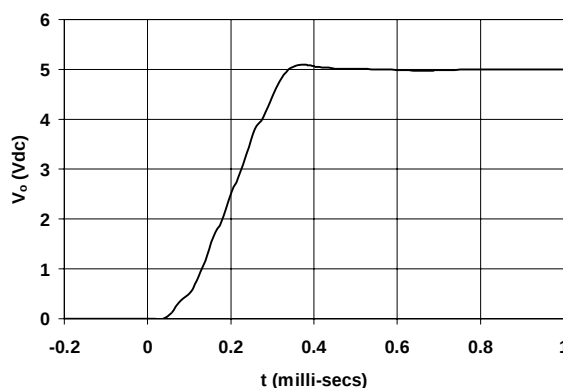
4. When the inhibit control pin is active, i.e. pulled low, the maximum input voltage is limited to +30Vdc.
5. Do not control the inhibit input with an external DC voltage. This will lead to erratic operation of the ISR and may over-stress the regulator.
6. Avoid capacitance greater than 500pF at the Inhibit control pin. Excessive capacitance at this pin will cause the ISR to produce a pulse on the output voltage bus at turn-on.
7. Keep the On/Off transition to less than 10 $\mu$ s. This prevents erratic operation of the ISR, which can cause a momentary high output voltage.

**Figure 1**



**Turn-On Time:** The output of the ISR is enabled automatically when external power is applied to the input. The *Inhibit* control pin is pulled high by its internal pull-up resistor. The ISR produces a fully regulated output voltage within 1-msec of either the release of the Inhibit control pin, or the application of power. The actual turn-on time will vary with the input voltage, output load, and the total amount of capacitance connected to the output. Using the circuit of Figure 1, Figure 2 shows the typical rise in output voltage for the PT6101 following the turn-off of Q1 at time  $t=0$ . The waveform was measured with a 9Vdc input voltage, and 5-Ohm resistive load.

**Figure 2**



## **IMPORTANT NOTICE**

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Customers are responsible for their applications using TI components.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.