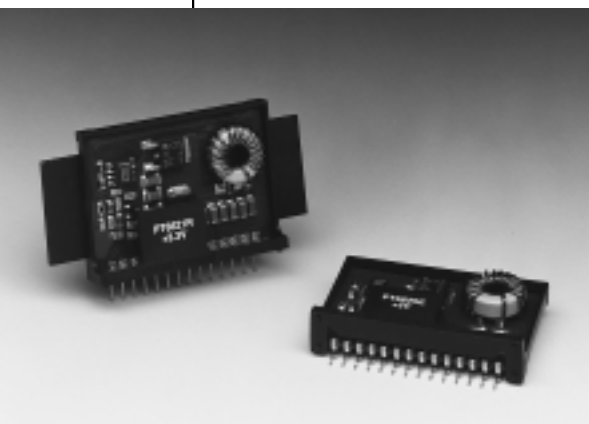


PT6650 Series**5 AMP 24V INPUT
INTEGRATED SWITCHING REGULATOR**

[Application Notes](#)
[Mechanical Outline](#)
[Product Selector Guide](#)

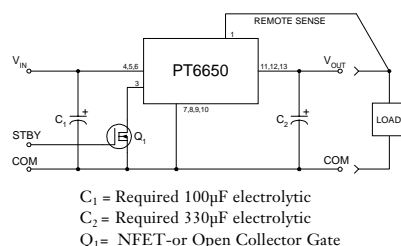


- Single Device: 5A Output
- Input Voltage Range: 9V to 28V
- Adjustable Output Voltage
- 80% Efficiency
- Remote Sense Capability
- Standby Function

The PT6650 series is a new addition to Power Trends' line of 24V bus Integrated Switching Regulators

(ISRs). Designed for general purpose industrial applications requiring as much as 5A of output current, the PT6650 is packaged in a 14-Pin SIP (Single In-line Package) and is available in a surface-mount configuration.

Only two external capacitors are required for proper operation. Please note that this product does not include short circuit protection.

Standard Application**Pin-Out Information**

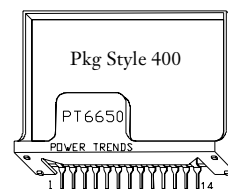
| | |
|----|------------------|
| 1 | Remote Sense |
| 2 | Do Not Connect |
| 3 | STBY* - Standby |
| 4 | V_{in} |
| 5 | V_{in} |
| 6 | V_{in} |
| 7 | GND |
| 8 | GND |
| 9 | GND |
| 10 | GND |
| 11 | V_{out} |
| 12 | V_{out} |
| 13 | V_{out} |
| 14 | V_{out} Adjust |

Ordering Information

| | |
|---------|---------------|
| PT6651□ | = +3.3 Volts |
| PT6652□ | = +2.5 Volts |
| PT6653□ | = +5.0 Volts |
| PT6654□ | = +9.0 Volts |
| PT6655□ | = +15.0 Volts |
| PT6656□ | = +12.0 Volts |

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 ($T_a = 25^\circ\text{C}$ unless noted) | Symbols | Conditions | PT6650 SERIES | | | |
|---|----------------------|--|--|---|----------------------------|--|
| | | | Min | Typ | Max | Units |
| Output Current | I_o | $T_a = 60^\circ\text{C}$, 200 LFM, pkg P $T_a = 25^\circ\text{C}$, natural convection | 0.1* 0.1* | — | 5.0** 5.0** | A A |
| Input Voltage Range | V_{in} | $0.1\text{A} \leq I_o \leq 5.0\text{A}$ | $V_o \leq +6\text{V}$ $V_o > +6\text{V}$ | +9V V_o+3 | — — | +28V +28V V V |
| Output Voltage Tolerance | ΔV_o | Over V_{in} range $T_a = -40^\circ\text{C}$ 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 | $V_o = +3.3\text{V}$ $V_o = +2.5\text{V}$ $V_o = +5.0\text{V}$ $V_o = +9.0\text{V}$ $V_o = +12\text{V}$ $V_o = +15\text{V}$ | 2.2 1.8 3.0 6.0 9.0 10.0 | — — — — — — | 4.7 4.3 6.5 10.2 13.6 17.0 V |
| Line Regulation | Reg_{line} | $+9\text{V} \leq V_{in} \leq +28\text{V}$, $I_o = 5.0\text{A}$ | — | ± 0.5 | ± 1.0 | % V_o |
| Load Regulation | Reg_{load} | $V_{in} = +24\text{V}$, $0.1 \leq I_o \leq 5.0\text{A}$ | — | ± 0.5 | ± 1.0 | % V_o |
| V_o Ripple/Noise | V_n | $V_{in} = +24\text{V}$, $I_o = 5.0\text{A}$ | $V_o \leq +6\text{V}$ $V_o > +6\text{V}$ | 50 1.0 | — | mVpp % V_o |
| Transient Response with $C_2 = 330\mu\text{F}$ | t_{tr} V_{os} | I_o step between 2.5A and 5.0A V_o over/undershoot | — | 100 100 | — | µSec mV |
| Efficiency | η | $V_{in} = +24\text{V}$, $I_o = 0.5 \times I_{o\max}$ | $V_o = +3.3\text{V}$ $V_o = +2.5\text{V}$ $V_o = +5.0\text{V}$ | 81 76 85 | — — — | % % % |
| | | $V_{in} = +24\text{V}$, $I_o = I_{o\max}$ | $V_o = +3.3\text{V}$ $V_o = +2.5\text{V}$ $V_o = +5.0\text{V}$ | 80 75 84 | — — — | % % % |
| | | | | | | |
| | | | | | | |
| Switching Frequency | f_o | $9\text{V} \leq V_{in} \leq 28\text{V}$ Over I_o range | 500 | 550 | 600 | kHz |
| Recommended Operating Temperature Range | T_a | Free Air Convection (40-60 LFM) Over V_{in} and I_o ranges with heat tab | -40 | — | +65 | $^\circ\text{C}$ |
| Storage Temperature | T_s | — | -40 | — | +125 | $^\circ\text{C}$ |
| 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 |

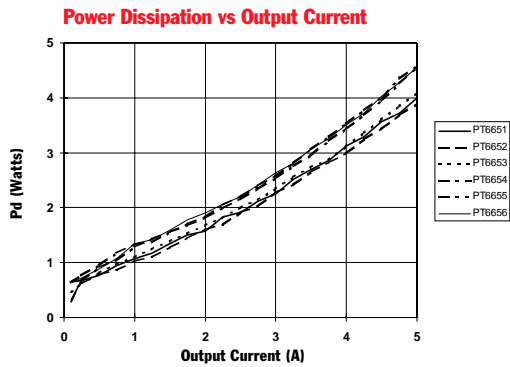
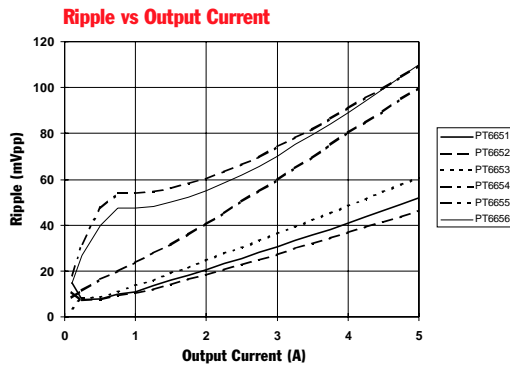
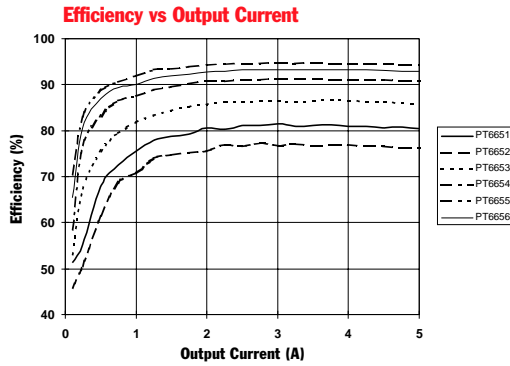
* ISR will operate down to no load with reduced specifications. ** See SOA curves.

Note: The PT6650 Series requires a 330µF(output) and 100µF(input) electrolytic capacitors for proper operation in all applications.

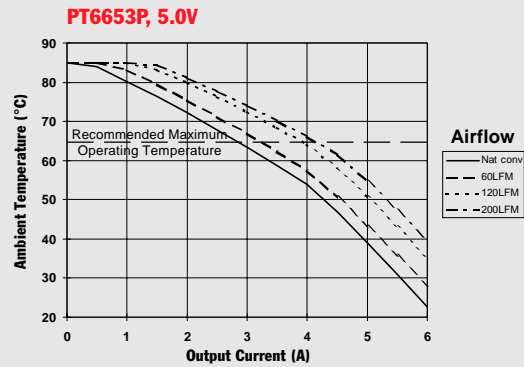
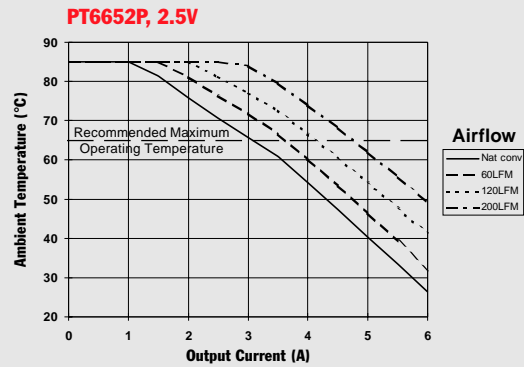
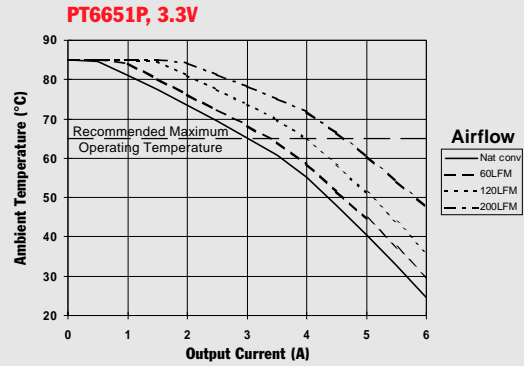
CHARACTERISTIC DATA

PT6650 Series

PT6650 Series @Vin=+24V



Safe Operating Area Curves @Vin=+24V



[More Application Notes](#)**Adjusting the Output Voltage of the PT6650 5Amp 24V Bus Converter Series**

The output voltage of the Power Trends PT6650 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).

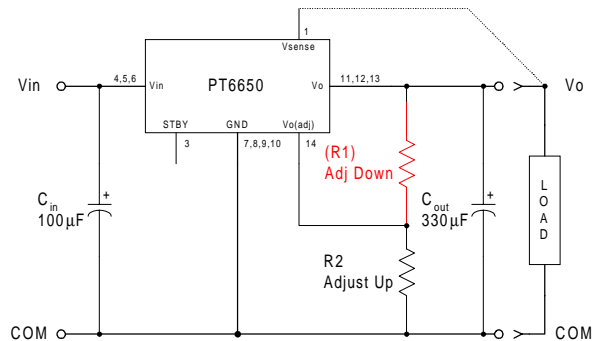
Adjust Up: An increase in the output voltage is obtained by adding a resistor R_2 , between pin 14 (V_o adjust) and pins 7-10 (GND).

Adjust Down: Add a resistor (R_1), between pin 14 (V_o adjust) and pins 11-13 (V_{out}).

Refer to Figure 1 and Table 2 for both the placement and value of the required resistor, either (R_1) or R_2 as appropriate.

Notes:

1. Use only a single 1% resistor in either the (R_1) or R_2 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 (R_1) 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 $V_{out} + 3$, or 9V, whichever is higher.
5. For output voltages above 12.5Vdc, the maximum output current must be limited to 4Adc.

Figure 1

The values of (R_1) [adjust down], and R_2 [adjust up], can also be calculated using the following formulae.

$$(R_1) = \frac{R_o (V_o - 1.25)(V_a - 1.25)}{1.25 (V_o - V_a)} - R_s \quad k\Omega$$

$$R_2 = \frac{R_o (V_o - 1.25)}{V_a - V_o} - R_s \quad k\Omega$$

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**PT6650 ADJUSTMENT AND FORMULA PARAMETERS**

| Series Pt # | PT6652 | PT6651 | PT6653 | PT6654 | PT6656 | PT6655 |
|--|--------|--------|--------|--------|--------|--------|
| V_o (nom) | 2.5V | 3.3V | 5.0V | 9.0V | 12.0V | 15.0V |
| V_a (min) | 1.8V | 2.2V | 3.0V | 6.0V | 9.0V | 10.0V |
| V_a (max) | 4.3V | 4.7V | 6.5V | 10.2V | 13.6V | 17.0V |
| R_o (kΩ) | 4.99 | 4.22 | 2.49 | 2.0 | 2.0 | 2.0 |
| R_s (kΩ) | 2.49 | 4.99 | 4.99 | 12.7 | 12.7 | 12.7 |

PT6650 Series**Application****Notes****Table 2****PT6650 ADJUSTMENT RESISTOR VALUES**

| Series Pt # | PT6652 | PT6651 | PT6653 |
|------------------------|----------|-----------|-----------|
| Current | 5Adc | 5Adc | 5Adc |
| V _o (nom) | 2.5Vdc | 3.3Vdc | 5.0Vdc |
| V _a (req'd) | | | |
| 1.8 | (1.4)kΩ | | |
| 1.9 | (2.9)kΩ | | |
| 2.0 | (5.0)kΩ | | |
| 2.1 | (8.1)kΩ | | |
| 2.2 | (13.3)kΩ | (1.0)kΩ | |
| 2.3 | (23.7)kΩ | (2.3)kΩ | |
| 2.4 | (54.9)kΩ | (3.9)kΩ | |
| 2.5 | | (5.8)kΩ | |
| 2.6 | 59.9kΩ | (8.4)kΩ | |
| 2.7 | 28.7kΩ | (11.7)kΩ | |
| 2.8 | 18.3kΩ | (16.5)kΩ | |
| 2.9 | 13.1kΩ | (23.6)kΩ | |
| 3.0 | 10.0kΩ | (35.4)kΩ | (1.6)kΩ |
| 3.1 | 7.9kΩ | (59.0)kΩ | (2.3)kΩ |
| 3.2 | 6.4kΩ | (130.0)kΩ | (3.1)kΩ |
| 3.3 | 5.3kΩ | | (4.0)kΩ |
| 3.4 | 4.4kΩ | 81.5kΩ | (5.1)kΩ |
| 3.5 | 3.8kΩ | 38.3kΩ | (6.2)kΩ |
| 3.6 | 3.2kΩ | 23.8kΩ | (7.6)kΩ |
| 3.7 | 2.7kΩ | 16.6kΩ | (9.1)kΩ |
| 3.8 | 2.3kΩ | 12.3kΩ | (10.9)kΩ |
| 3.9 | 2.0kΩ | 9.4kΩ | (13.0)kΩ |
| 4.0 | 1.7kΩ | 7.4kΩ | (15.6)kΩ |
| 4.1 | 1.4kΩ | 5.8kΩ | (18.7)kΩ |
| 4.2 | 1.2kΩ | 4.6kΩ | (22.6)kΩ |
| 4.3 | 1.0kΩ | 3.7kΩ | (27.6)kΩ |
| 4.4 | | 2.9kΩ | (34.2)kΩ |
| 4.5 | | 2.2kΩ | (43.6)kΩ |
| 4.6 | | 1.7kΩ | (57.6)kΩ |
| 4.7 | | 1.2kΩ | (80.9)kΩ |
| 4.8 | | | (128.0)kΩ |
| 4.9 | | | (268.0)kΩ |
| 5.0 | | | |
| 5.1 | | | 88.4kΩ |
| 5.2 | | | 41.7kΩ |
| 5.3 | | | 26.1kΩ |
| 5.4 | | | 18.4kΩ |
| 5.5 | | | 13.7kΩ |
| 5.6 | | | 10.6kΩ |
| 5.7 | | | 8.4kΩ |
| 5.8 | | | 6.7kΩ |
| 5.9 | | | 5.4kΩ |
| 6.0 | | | 4.4kΩ |
| 6.1 | | | 3.5kΩ |
| 6.2 | | | 2.8kΩ |
| 6.3 | | | 2.2kΩ |
| 6.4 | | | 1.7kΩ |
| 6.5 | | | 1.2kΩ |

| Series Pt # | PT6654 | PT6656 | PT6655 |
|------------------------|-----------|-----------|-----------|
| Current | 5Adc | 5Adc | 4Adc |
| V _o (nom) | 9.0Vdc | 12.0Vdc | 15.0Vdc |
| V _a (req'd) | | | |
| 6.0 | (6.9)kΩ | | |
| 6.2 | (9.2)kΩ | | |
| 6.4 | (11.9)kΩ | | |
| 6.6 | (14.0)kΩ | | |
| 6.8 | (18.6)kΩ | | |
| 7.0 | (23.0)kΩ | | |
| 7.2 | (28.3)kΩ | | |
| 7.4 | (35.0)kΩ | | |
| 7.6 | (43.5)kΩ | | |
| 7.8 | (55.0)kΩ | | |
| 8.0 | (71.0)kΩ | | |
| 8.2 | (95.0)kΩ | | |
| 8.4 | (135.0)kΩ | | |
| 8.6 | (215.0)kΩ | | |
| 8.8 | (455.0)kΩ | | |
| 9.0 | | (31.7)kΩ | |
| 9.2 | 64.8kΩ | (36.1)kΩ | |
| 9.4 | 26.1kΩ | (41.2)kΩ | |
| 9.6 | 13.1kΩ | (47.1)kΩ | |
| 9.8 | 6.7kΩ | (54.1)kΩ | |
| 10.0 | 2.8kΩ | (62.6)kΩ | (25.8)kΩ |
| 10.2 | 0.2kΩ | (72.8)kΩ | (28.3)kΩ |
| 10.4 | | (85.7)kΩ | (31.1)kΩ |
| 10.6 | | (102.0)kΩ | (34.1)kΩ |
| 10.8 | | (124.0)kΩ | (37.3)kΩ |
| 11.0 | | (155.0)kΩ | (40.9)kΩ |
| 11.2 | | (201.0)kΩ | (44.9)kΩ |
| 11.4 | | (278.0)kΩ | (49.3)kΩ |
| 11.6 | | (432.0)kΩ | (54.3)kΩ |
| 11.8 | | (895.0)kΩ | (59.8)kΩ |
| 12.0 | | | (66.1)kΩ |
| 12.2 | | 94.8kΩ | (73.3)kΩ |
| 12.4 | | 41.1kΩ | (81.6)kΩ |
| 12.6 | | 23.1kΩ | (91.3)kΩ |
| 12.8 | | 14.2kΩ | (103.0)kΩ |
| 13.0 | | 8.8kΩ | (117.0)kΩ |
| 13.2 | | 5.2kΩ | (133.0)kΩ |
| 13.4 | | 2.7kΩ | (154.0)kΩ |
| 13.6 | | 0.7kΩ | (181.0)kΩ |
| 13.8 | | | (217.0)kΩ |
| 14.0 | | | (268.0)kΩ |
| 14.2 | | | (343.0)kΩ |
| 14.5 | | | (570.0)kΩ |
| 15.0 | | | |
| 15.5 | | | 42.3kΩ |
| 16.0 | | | 14.8kΩ |
| 16.5 | | | 5.6kΩ |
| 17.0 | | | 1.1kΩ |

R1 = (Red) R2 = Black

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