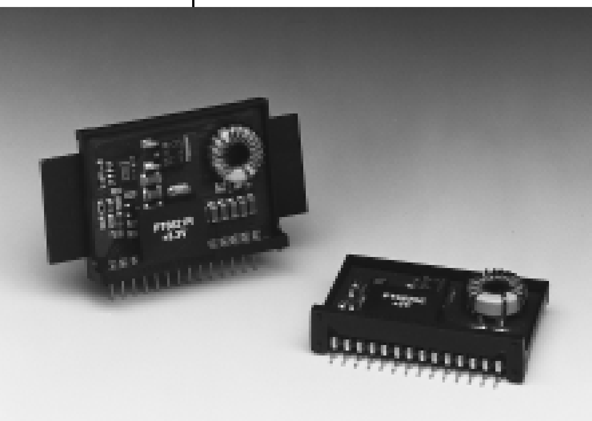
PT6650 Series

5 AMP 24V INPUT INTEGRATED SWITCHING REGULATOR

Application Notes
Mechanical Outline
Product Selector Guide

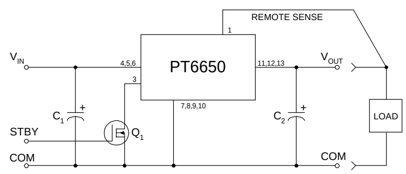


- Single Device: 5A Output
- Input Voltage Range: 9V to 28V
- Adjustable Output Voltage
- 80% Efficiency
- Remote Sense Capability
- Standby Function

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



C_1 = Required 100µF electrolytic
C_2 = Required 330µF electrolytic
Q_1 = NFET-or Open Collector Gate

Pin-Out Information

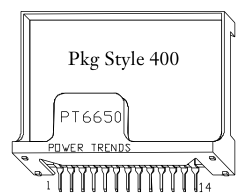
Pin	Function
1	Remote Sense
2	Do Not Connect
3	STBY*- Standby
4	V_{in}
5	V_{in}
6	V_{in}
7	GND
8	GND
9	GND
10	GND
11	V_{out}
12	V_{out}
13	V_{out}
14	V_{out} Adjust

Ordering Information

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°C unless noted)	Symbols	Conditions		PT6650 SERIES Min	Typ	Max	Units
Output Current	I_o	T_a = 60°C, 200 LFM, pkg P T_a = 25°C, natural convection		0.1* 0.1*	— —	5.0** 5.0**	A A
Input Voltage Range	V_{in}	$0.1A \le I_o \le 5.0A$	$V_o \le +6V$ $V_o > +6V$	+9V Vo+3	— —	+28V +28V	V V
Output Voltage Tolerance	ΔV_o	Over V_{in} range T_a = -40°C to +65°C		Vo-0.1	—	Vo+0.1	V
Output Voltage Adjust Range	V_{oadj}	Pin 14 to V_o or ground	V_o = +3.3V V_o = +2.5V V_o = +5.0V V_o = +9.0V V_o = +12V V_o = +15V	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}	$+9V \le V_{in} \le +28V$, I_o = 5.0A		—	±0.5	±1.0	%V_o
Load Regulation	Reg_{load}	V_{in} = +24V, $0.1 \le I_o \le 5.0A$		—	±0.5	±1.0	%V_o
V_o Ripple/Noise	V_n	V_{in} = +24V, I_o = 5.0A	$V_o \le +6V$ $V_o > +6V$	—	50 1.0	—	mVpp %V_o
Transient Response with C_2 = 330µF	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} = +24V, I_o = 0.5x $I_{o\,max}$	V_o = +3.3V V_o = +2.5V V_o = +5.0V	— — —	81 76 85	— — —	% % %
		V_{in} = +24V, I_o = $I_{o\,max}$	V_o = +3.3V V_o = +2.5V V_o = +5.0V	— — —	80 75 84	— — —	% % %
Switching Frequency	f_o	$9V \le V_{in} \le 28V$ 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	°C
Storage Temperature	T_s	—		-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

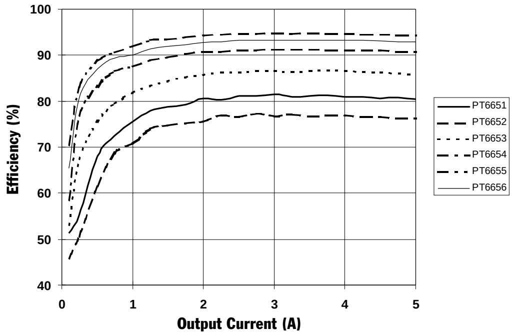
* ISR will operate down to no load with reduced specifications. ** See SOA curves.

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

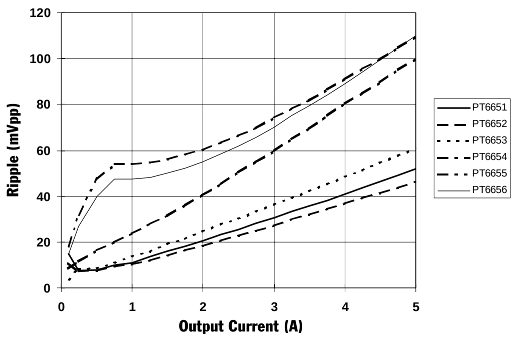
Power Trends, Inc. 27715 Diehl Road, Warrenville, IL 60555 **(800) 531-5782** Fax: (630) 393-6902 **http://www.powertrends.com**

PT6650 Series @Vin=+24V

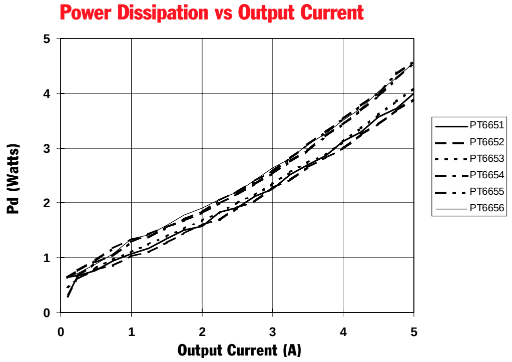
Efficiency vs Output Current



Ripple vs Output Current

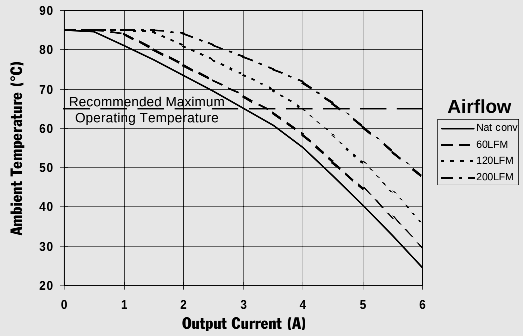


Power Dissipation vs Output Current

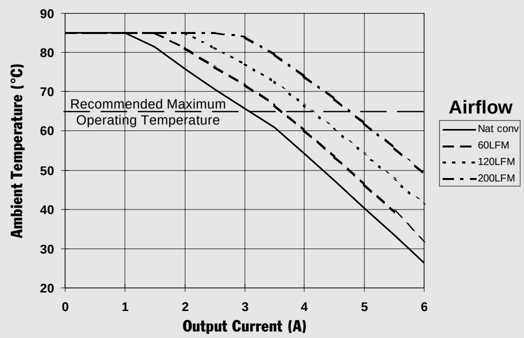


Safe Operating Area Curves @Vin=+24V

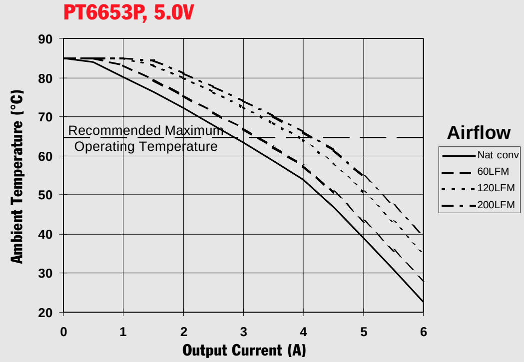
PT6651P, 3.3V



PT6652P, 2.5V



PT6653P, 5.0V



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 R2, between pin 14 (V_o adjust) and pins 7-10 (GND).

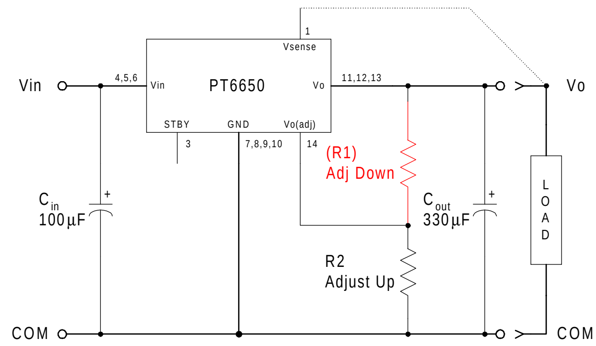
Adjust Down: Add a resistor (R1), between pin 14 (V_o adjust) and pins 11-13 (V_{out}).

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% resistorin 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} + 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 (R1) [adjust down], and R2 [adjust up], can also be calculated using the following formulae.

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

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

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

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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