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**PT6650 Series**

**5-A 12 /24-V Input Adjustable Integrated Switching Regulator**

SLTS038B -FEBRUARY 1999 - REVISED MARCH 2004



**Features**

- Single Device: 5-A Output
- Input Voltage Range: 9 V to 28 V
- 12 V / 24 V Input Compatible
- Adjustable Output Voltage
- 80 % Efficiency
- Output Remote Sense
- On/Off Standby Function

**Description**

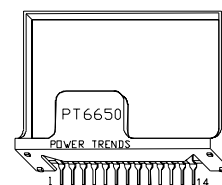
The PT6650 power modules are a series of high efficiency, non-isolated step-down integrated switching regulators (ISRs). These regulators are designed to operate over a 9 V to 28 V input voltage range to produce a tightly regulated output voltage at load currents of up to 5 A. The wide input voltage range allows them to operate off either a 12 V or 24 V DC input bus system, making them ideal for general purpose and industrial applications. The series includes standard output voltage options ranging from 15 V down to 2.5 V, and down to 1.8 V with adjustment. Only two external capacitors are required for proper operation.

The PT6650 series is housed in a low-cost 14-pin SIP (Single In-line Package) and is available in both vertical and horizontal configurations, including surface-mount.

**Ordering Information**

- PT6651□ = 3.3 Volts
- PT6652□ = 2.5 Volts
- PT6653□ = 5 Volts
- PT6654□ = 9 Volts
- PT6655□ = 15 Volts
- PT6656□ = 12 Volts

Note: Back surface of product is conducting metal



**PT Series Suffix (PT1234x)**

Case/Pin Configuration	Order Suffix	Package Code *
Vertical	<b>P</b>	(EED)
Horizontal	<b>D</b>	(EEA)
SMD	<b>E</b>	(EEC)
Horizontal, 2-Pin Tab	<b>M</b>	(EEM)
SMD, 2-Pin Tab	<b>L</b>	(EEL)
Horizontal, 2-Pin Ext Tab	<b>Q</b>	(EEQ)
SMD, 2-Pin Ext Tab	<b>F</b>	(EEF)
Vertical, Side Tab	<b>R</b>	(EEE)
Horizontal, Side Tab	<b>G</b>	(EEG)
SMD, Side Tab	<b>B</b>	(EEK)

\* Previously known as package styles 400/410.

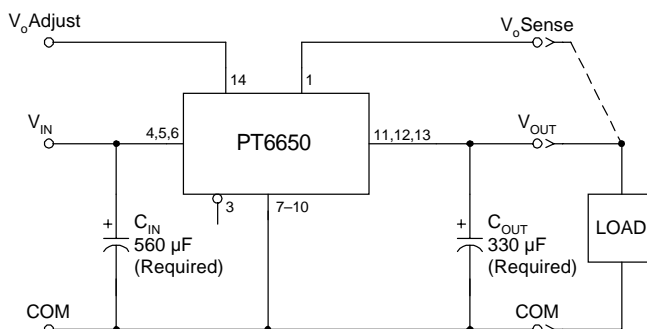
(Reference the applicable package code drawing for the dimensions and PC board layout)

**Pin-Out Information**

Pin	Function
1	Remote Sense
2	Do Not Connect
3	STBY*
4	V <sub>in</sub>
5	V <sub>in</sub>
6	V <sub>in</sub>
7	GND
8	GND
9	GND
10	GND
11	V <sub>out</sub>
12	V <sub>out</sub>
13	V <sub>out</sub>
14	V <sub>o</sub> Adjust *

\* For further information, see application notes.

**Standard Application**



C<sub>in</sub> = Required 560 µF electrolytic  
C<sub>out</sub> = Required 330 µF electrolytic

**PT6650 Series**
**5-A 12 /24-V Input Adjustable Integrated Switching Regulator**

SLTS038B -FEBRUARY 1999 - REVISED MARCH 2004

**Specifications** (Unless otherwise stated,  $T_a = 25^\circ\text{C}$ ,  $V_{in} = 24\text{ V}$ ,  $C_{in} = 560\ \mu\text{F}$ ,  $C_{out} = 330\ \mu\text{F}$ , and  $I_o = I_o(\text{max})$ )

Characteristic	Symbol	Conditions	PT6650 SERIES			Units	
			Min	Typ	Max		
Output Current	$I_o$	Over $V_{in}$ range	$V_o \leq 12\text{ V}$ $V_o = 15\text{ V}$	0.1 (1) 0.1 (1)	— —	5 (2) 4 (2)	A
Input Voltage Range	$V_{in}$	$I_o(\text{min}) \leq I_o \leq I_o(\text{max})$	$V_o < 6\text{ V}$ $V_o > 6\text{ V}$	9 $V_o + 3$	— —	28 28	V
Output Voltage Tolerance	$\Delta V_o$	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	$V_o \text{ adj}$	Pin 14 to $V_o$ or ground	$V_o = 3.3\text{ V}$ $V_o = 2.5\text{ V}$ $V_o = 5\text{ V}$ $V_o = 9\text{ V}$ $V_o = 12\text{ V}$ $V_o = 15\text{ V}$	2.2 1.8 3 6 9 10	— — — — — —	4.7 4.3 6.5 10.2 13.6 17	V
Line Regulation	$\text{Reg}_{\text{line}}$	$9\text{ V} \leq V_{in} \leq 28\text{ V}$		—	$\pm 0.5$	$\pm 1$	$\%V_o$
Load Regulation	$\text{Reg}_{\text{load}}$	$0.1 \leq I_o \leq 5\text{ A}$		—	$\pm 0.5$	$\pm 1$	$\%V_o$
$V_o$ Ripple (pk-pk)	$V_r$	20 MHz bandwidth	$V_o < 6\text{ V}$ $V_o > 6\text{ V}$	— —	50 1	— —	$\text{mV}_{\text{pp}}$ $\%V_o$
Transient Response with $C_2 = 330\ \mu\text{F}$	$t_{tr}$	0.15 A/ $\mu\text{s}$ load step, 50% to 100% $I_o(\text{max})$		—	100	—	$\mu\text{Sec}$
	$V_{tr}$	$V_o$ over/undershoot		—	100	—	mV
Efficiency	$\eta$	$I_o = 50\% I_o \text{ max}$	$V_o = 3.3\text{ V}$	—	81	—	%
			$V_o = 2.5\text{ V}$	—	76	—	
			$V_o = 5\text{ V}$	—	85	—	
		$I_o = I_o \text{ max}$	$V_o = 3.3\text{ V}$	—	80	—	%
$V_o = 2.5\text{ V}$	—		75	—			
$V_o = 5\text{ V}$	—		84	—			
Switching Frequency	$f_s$	$9\text{ V} \leq V_{in} \leq 28\text{ V}$		500	550	600	kHz
On/Off Standby (Pin 3) Input High Voltage Input Low Voltage Input Low Current	$V_{IH}$ $V_{IL}$ $I_{IL}$	Referenced to GND		1 -0.1	— —	Open (3) 0.3	V
				—	-0.25	—	mA
				—	15	30	mA
External Output Capacitance	$C_{out}$			330	—	3,000	$\mu\text{F}$
External Input Capacitance	$C_{in}$			560 (4)	—	—	$\mu\text{F}$
Operating Temperature Range	$T_a$	Over $V_{in}$ range		-40	—	85 (2)	$^\circ\text{C}$
Solder Reflow Temperature	$T_{\text{reflow}}$	Surface temperature of module pins or case		—	—	215 (5)	$^\circ\text{C}$
Storage Temperature	$T_s$	—		-40	—	125	$^\circ\text{C}$
Reliability	MTBF	Per Bellcore TR-332 50% stress, $T_a = 40^\circ\text{C}$ , ground benign		7.2	—	—	$10^6$ Hrs
Mechanical Shock	—	Per Mil-Std-883D, method 2002.3, 1ms, half-sine, mounted to a fixture		—	500	—	G's
Mechanical Vibration	—	Mil-Std-883D, Method 2007.2, 20-2000Hz, soldered in PCB		—	7.5	—	G's
Weight	—		Case styles P, D, & E	—	12.5	—	grams
			Case styles R, G, & B	—	16.5	—	
			Case styles L & M	—	15.5	—	
			Case styles F & Q	—	22	—	
Flammability	—	Materials meet UL 94V-0					

**Notes:** (1) The ISR will operate at no load with reduced specifications.

(2) See Safe Operating Area curves or contact the factory for the appropriate derating.

(3) The STBY\* control (pin 3) has an internal pull-up and if it is left open circuit the module will operate when input power is applied. The open-circuit voltage is typically 1.5 V. Consult the related application note for other interface considerations.

 (4) The module requires a 560 $\mu\text{F}$  electrolytic capacitor at the input and 330 $\mu\text{F}$  at the output for proper operation in all applications. In addition, the input capacitance,  $C_{in}$ , must be rated for a minimum of 1.2 Arms of ripple current. For transient or dynamic load applications additional capacitance may be necessary. For more information consult the related application note on capacitor recommendations.

 (5) During solder reflow of SMD package version do not elevate the module case, pins, or internal component temperatures above a peak of 215 $^\circ\text{C}$ . For further guidance refer to the application note, "Reflow Soldering Requirements for Plug-in Power Surface Mount Products," (SLTA051).

**PT6650 Series**

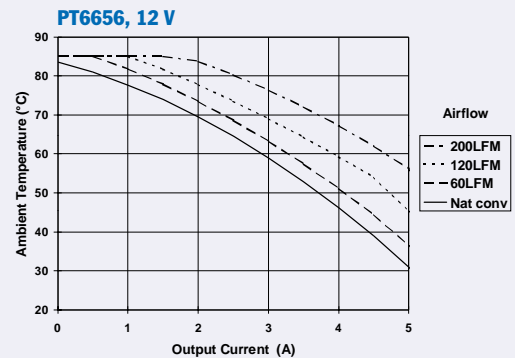
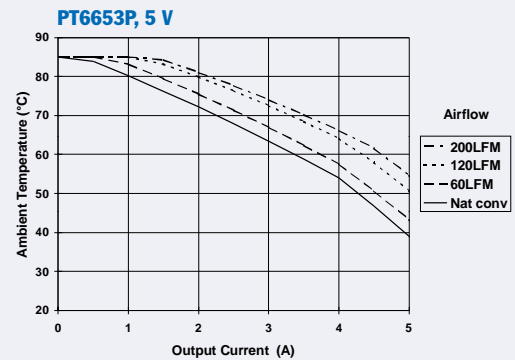
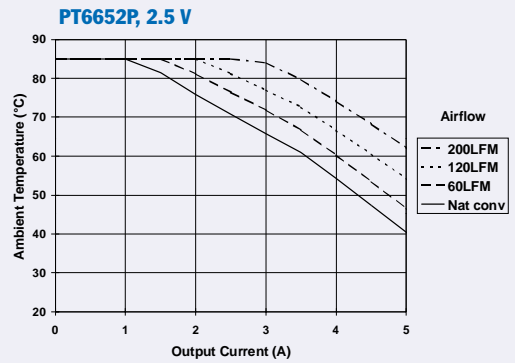
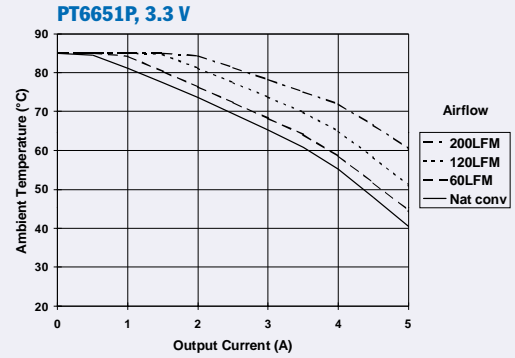
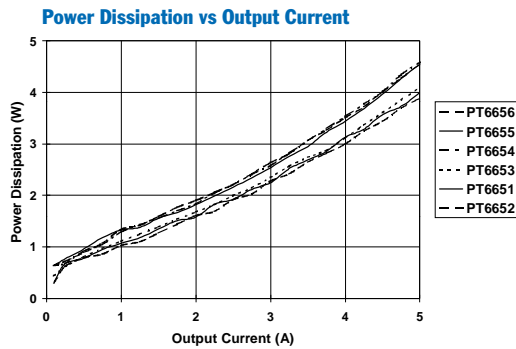
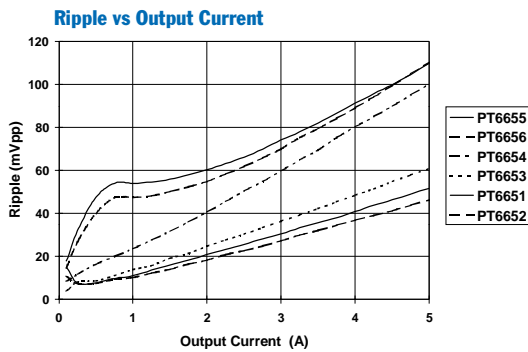
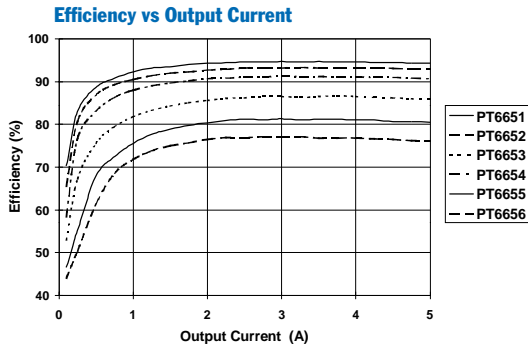
**Typical Characteristics**

5-A 12 /24-V Input Adjustable Integrated Switching Regulator

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**PT6650 Series @V<sub>IN</sub>= 24 V** (See Note A)

**Safe Operating Area @V<sub>IN</sub>= 24 V** (See Note B)



**Note A:** Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the regulator.

**Note B:** SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures

## Application Notes

### PT6650 Series

### Capacitor Recommendations for the PT6650 Regulator Series

#### Input Capacitor:

The required input capacitor is determined by 560  $\mu\text{F}$  capacitance value, and a minimum ripple current rating of 1.2 Arms. The ripple current rating and less than 120 m $\Omega$  equivalent series resistance (ESR) are the major considerations, along with operating temperature, when selecting input capacitors.

Tantalum/Os-Con capacitors are not recommended due to a minimum voltage rating of 2 $\times$  (the max. DC voltage + AC ripple). This is standard practice to ensure reliability.

#### Output Capacitors:

The ESR specification of the output capacitor should be a minimum of 50 m $\Omega$  \*. Electrolytic capacitors have marginal ripple performance at frequencies greater than 400 kHz but excellent low frequency transient response. Above the ripple frequency ceramic capacitors are necessary to improve the transient response and reduce any high-frequency noise components apparent during higher current excursions. Electrolytic capacitors with appropriate ESR values are identified in Table 1-1. In low-temperature applications (<0  $^{\circ}\text{C}$ ), a higher capacitance with lower ESR will improve performance.

\* Os-Con and ultra low ESR type capacitors are not recommended on the output bus as they degrade regulator stability.

#### Tantalum Capacitors (For $V_o < 5.1\text{ V}$ )

Tantalum type capacitors can be used on the output bus for output voltages less than 5.1 V. Voltages higher than this will exceed the capacitor's published surge voltage limits.

If tantalum capacitors are located on the output bus, an appropriate fuse with  $I^2t$  current derating is recommended along with an external clamp component. An Output Over-voltage Clamp (OOVC) will fault the output fuse to protect the capacitors in event of an over-voltage condition. The OOVC can be a simple zener high power diode, 3 W to 5 W, located on the load side of the output bus. The zener diode should be rated to 1.3 times the normal output voltage.

#### Capacitor Table

Table 1-1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The number of capacitors required at both the input and output buses is identified for each capacitor type.

*This is not an extensive capacitor list. Capacitors from other vendors are available with comparable specifications. Those listed are for guidance. The RMS ripple current rating and ESR (Equivalent Series Resistance at 100 kHz) are critical parameters necessary to insure both optimum regulator performance and long capacitor life.*

**Table 1-1: Input/Output Capacitors**

Capacitor Vendor/ Series	Capacitor Characteristics					Quantity		Vendor Part Number
	Working Voltage	Value ( $\mu\text{F}$ )	(ESR) Equivalent Series Resistance	Max. Ripple Current @85 $^{\circ}\text{C}$ (Irms)	Physical Size (mm)	Input Bus	Output Bus	
Panasonic FC (Radial)	50 V	560	0.068 $\Omega$	1900 mA	18 $\times$ 15	1	1	EEUFC1H561
	50 V	390	0.080 $\Omega$	1610 mA	16 $\times$ 15	2	1	EEUFC1H391S
	50 V	390	0.080 $\Omega$	1610 mA	16 $\times$ 15	2	1	EEUFC1H391S
FC/FK (SMT)	63 V	680	0.080 $\Omega$	1690 mA	18 $\times$ 16.5	1	1	EEVFK1J681M
	35 V	330	0.080 $\Omega$	850 mA	10 $\times$ 10.2	N/R [1]	1	EEVFK1V331P
	50 V	1000	0.073 $\Omega$	1610 mA	16 $\times$ 16.5	1	1	EEVFK1H102M
United Chemi-con LXZ/LXV Series	50 V	680	0.048 $\Omega$	1840 mA	16 $\times$ 20	1	1	LXZ50VB681M16X20LL
	35 V	330	0.068 $\Omega$	1050 mA	10 $\times$ 16	N/R [1]	1	LXV35VB331M10X16LL
MVY (SMT)	35 V	220	0.150 $\Omega$	670 mA	10 $\times$ 10.3	N/R [1]	2	MVY35VC2211M10X10TP
Nichicon PM Series	50 V	560	0.044 $\Omega$	1550 mA	16 $\times$ 20	1	1	UPM1H561MHH6
	63 V	560	0.039 $\Omega$	1400 mA	18 $\times$ 20	1	1	UPM1J561MHH6
	50 V	330	0.060 $\Omega$	1210 mA	16 $\times$ 15	2	1	UPM1H331MHH6
AVX Tantalum TPS (SMT)	10 V	330	0.10 $\Omega$	>2500 mA	7.3L	N/R [1]	1 [2]	TPSE337M010R0100 ( $V_o < 5.1\text{V}$ )
	10 V	330	0.06 $\Omega$	>3000 mA	$\times 5.7\text{W}$ $\times 4.1\text{H}$	N/R [1]	1 [2]	TPSV337M010R0060 ( $V_o < 5.1\text{V}$ )
Kemet Tantalum T496/T495 Series (SMT)	10 V	220	0.500 $\Omega$	500 mA	4.3W	N/R [1]	2 [2]	T496X227M010AS ( $V_o < 5.1\text{V}$ )
	10 V	220	0.070 $\Omega$	>2000 mA	$\times 7.3\text{L}$ $\times 4.0\text{H}$	N/R [1]	2 [2]	T495X227M0100AS ( $V_o < 5.1\text{V}$ )
Sprague Tantalum 594D Series (SMT)	10 V	330	0.130 $\Omega$	1393 mA	7.2L $\times 6\text{W}$ $\times 4.1\text{H}$	N/R [1]	1 [2]	595D337X0010R2T ( $V_o < 5.1\text{V}$ )

**Notes:** [1] N/R –Not recommended. The voltage rating does not meet the minimum operating limits.  
[2] A fused input bus is recommended when tantalum capacitors are used on the output bus.

## Application Notes

### PT6650 Series

#### Using the Standby Function on the PT6650 Series of 12/24-V Input Bus Converters

For applications requiring output voltage On/Off control, the 14-pin PT6650 ISR series incorporates a standby function. This feature may be used for power-up/shut-down 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, providing a regulated output whenever a valid supply voltage is applied to  $V_{in}$  (pins 4, 5, & 6) with respect to GND (pins 7-10). Connecting pin 3 to ground<sup>1</sup> will disable the regulator output and reduce the input current to less than 30 mA<sup>3</sup>. Grounding the standby control will also hold-off the regulator output during the period that input power is applied.

The standby input is ideally controlled with an open-drain discrete transistor (See Figure 2-1). It can also be driven directly from a dedicated TTL<sup>2</sup> compatible gate. Table 2-1 provides details of the threshold requirements.

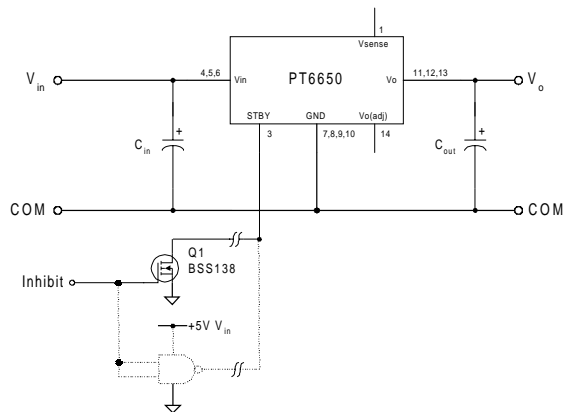
**Table 2-1 Inhibit Control Thresholds<sup>(1, 2)</sup>**

Parameter	Min	Max
Enable ( $V_{IH}$ )	1 V	5 V
Disable ( $V_{IL}$ )	-0.1 V	0.3 V

#### Notes:

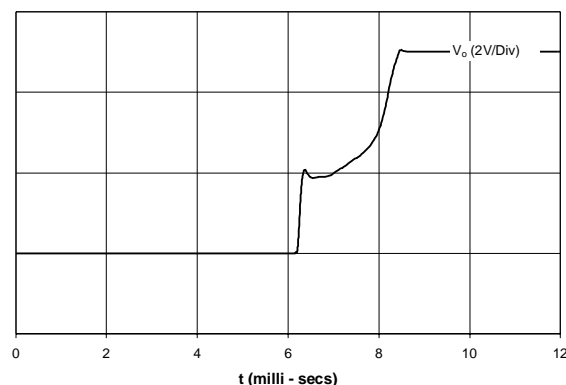
1. The Standby input on the PT6650 regulator series may be controlled using either an open-collector (or open-drain) discrete transistor, or a device with a totem-pole output. A pull-up resistor is not necessary. The control input has an open-circuit voltage of about 1.5 Vdc. To disable the regulator output, the control pin must be "pulled" to less than 0.3 Vdc with a low-level 0.25 mA maximum sink to ground.
2. The Standby input on the PT6650 series is also compatible with TTL logic. A standard TTL logic gate will meet the 0.3 V  $V_{IH(max)}$  requirement (Table 2-1) at 0.25 mA sink current. *Do not* drive the Standby control input above 5 Vdc.
3. When the regulator output is disabled the current drawn from the input source is reduced to approximately 15 mA (30 mA maximum).
4. The turn-off time of  $Q_1$ , or rise time of the standby input is not critical on the PT6650 series. Turning  $Q_1$  off over periods up to 100 ms will not damage the regulator. However, a slow turn-off time will increase both the initial delay and rate-of-rise of the output voltage.

**Figure 2-1**



**Turn-On Time:** Turning  $Q_1$  off in Figure 2-1, removes the low-voltage signal at pin 3 and enables the output. The PT6650 series of regulators will provide a fully regulated output within 12 ms. The actual turn-on time may vary with load and the total amount of output capacitance. Figure 2-2 shows the typical output voltage waveform of a PT6653 (5 V) following the prompt turn-off of  $Q_1$  at time  $t=0$  secs. The waveform was measured with a 24 V input voltage, and 5 A resistive load.

**Figure 2-2**



## Application Notes

### PT6650 Series

#### Adjusting the Output Voltage of the PT6650 5-A 24-V Bus Converter Series

The output voltage of the 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 3-1 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 ( $V_o$  adj) and pins 7-10 (GND).

**Adjust Down:** To decrease the output voltage, add a resistor ( $R_1$ ), between pin 14 ( $V_o$  adj) and pins 11-13 ( $V_{out}$ ).

Refer to Figure 3-1 and Table 3-2 for both the placement and value of the required resistor, either ( $R_1$ ) or  $R_2$  as appropriate.

#### Notes:

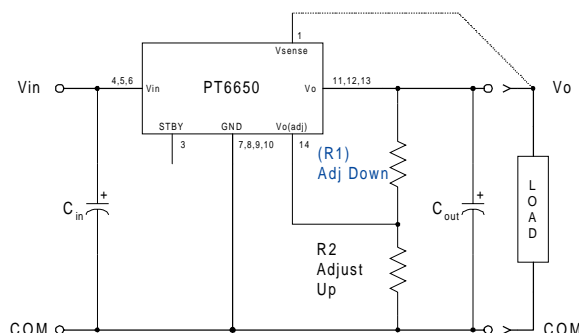
1. Use only a single 1 % resistor in either the ( $R_1$ ) or  $R_2$  location. Place the resistor as close to the ISR as possible.
2. Never connect capacitors from  $V_o$  adjust to either GND,  $V_{out}$ , or the Remote Sense pin. Any capacitance added to the  $V_o$  adjust pin will affect the stability of the ISR.
3. If the remote sense feature is being used, connecting the resistor ( $R_1$ ) between pin 14 ( $V_o$  adj) and pin 1 (Remote Sense) can benefit load regulation.
4. Adjustments to the output voltage may place additional limits on the input voltage for the part. The revised limits must comply with the following requirements.

$$V_{in} (\text{min}) = (V_{out} + 3) \text{ V or } 9 \text{ V, whichever is higher.}$$

$$V_{in} (\text{max}) = (10 \times V_{out}) \text{ V or } 28 \text{ V, whichever is less.}$$

5. For output voltages above 12.5 Vdc, the maximum output current must be limited to 4 Adc.

Figure 3-1



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

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

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

Where:  $V_o$  = Original output voltage  
 $V_a$  = Adjusted output voltage  
 $R_o$  = The resistance value in Table 3-1  
 $R_s$  = The series resistance from Table 3-1

Table 3-1

#### PT6650 ADJUSTMENT AND FORMULA PARAMETERS

Series Pt #	PT6652	PT6651	PT6653	PT6654	PT6656	PT6655
$V_o$ (nom)	2.5 V	3.3 V	5 V	9 V	12 V	15 V
$V_a$ (min)	1.8 V	2.2 V	3 V	6 V	9 V	10 V
$V_a$ (max)	4.3 V	4.7 V	6.5 V	10.2 V	13.6 V	17 V
$R_o$ (k $\Omega$ )	4.99	4.22	2.49	2	2	2
$R_s$ (k $\Omega$ )	2.49	4.99	4.99	12.7	12.7	12.7

Application Notes *continued*

PT6650 Series

Table 3-2

PT6650 ADJUSTMENT RESISTOR VALUES

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

R<sub>1</sub> = (Blue) R<sub>2</sub> = Black

Series Pt #	PT6654	PT6656	PT6655
Current	5 Adc	5 Adc	4 Adc
V <sub>o</sub> (nom)	9 Vdc	12 Vdc	15 Vdc
V <sub>a</sub> (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	64.8 kΩ	(36.1) kΩ	
9.4	26.1 kΩ	(41.2) kΩ	
9.6	13.1 kΩ	(47.1) kΩ	
9.8	6.7 kΩ	(54.1) kΩ	
10.0	2.8 kΩ	(62.6) kΩ	(25.8) kΩ
10.2	0.2 kΩ	(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		94.8 kΩ	(73.3) kΩ
12.4		41.1 kΩ	(81.6) kΩ
12.6		23.1 kΩ	(91.3) kΩ
12.8		14.2 kΩ	(103.0) kΩ
13.0		8.8 kΩ	(117.0) kΩ
13.2		5.2 kΩ	(133.0) kΩ
13.4		2.7 kΩ	(154.0) kΩ
13.6		0.7 kΩ	(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			42.3 kΩ
16.0			14.8 kΩ
16.5			5.6 kΩ
17.0			1.1 kΩ



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