

### Features

- 5A Non-Isolated Output
- >90% Efficiency
- Low-cost Alternative to Isolated Converters
- 15 to 36V Input Voltage Range
- Adjustable Output Voltage
- Output Remote Sense
- Standby Function
- Solderable Copper Case
- Surface Mountable
- IPC Lead Free 2

### Description

The PT6880 product family is a series of highly efficient, non-isolated integrated switching regulator (ISR) modules. Designed to operate off a wide-input bus, these regulators produce a tightly regulated output voltage at load currents of up to 5A. The series includes standard output voltage options ranging from 2.5V to 15V.

The series is an ideal choice for general purpose and industrial applications that operate off a 24/28V battery providing a low-cost alternative to a fully isolated converter.

The PT6880 series is packaged in a thermally efficient, 18-pin, space-saving copper case. Both vertical and horizontal configurations are available, including surface-mount.

### Ordering Information

<b>PT6881</b> □	=	3.3 Volts
<b>PT6882</b> □	=	2.5 Volts
<b>PT6883</b> □	=	5.0 Volts
<b>PT6884</b> □	=	9.0 Volts
<b>PT6885</b> □	=	15.0 Volts
<b>PT6886</b> □	=	12.0 Volts

### PT Series Suffix (PT1234 x)

Case/Pin Configuration	Order Suffix	Package Code *
Vertical	<b>N</b>	(EPD)
Horizontal	<b>A</b>	(EPA)
SMD	<b>C</b>	(EPC)

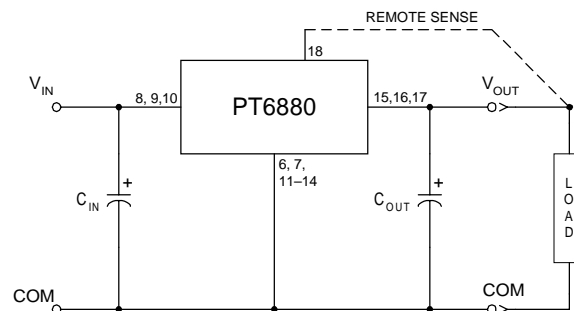
\* Previously known as package styles 1500/10. (Reference the applicable package code drawing for the dimensions and PC board layout).

### Pin-Out Information

Pin	Function
1	Vo Adjust
2	No Connect
3	No Connect
4	STBY *
5	No Connect
6	GND
7	GND
8	Vin
9	Vin
10	Vin
11	GND
12	GND
13	GND
14	GND
15	Vout
16	Vout
17	Vout
18	Remote Sense

\* For further information, see application notes.

### Standard Application



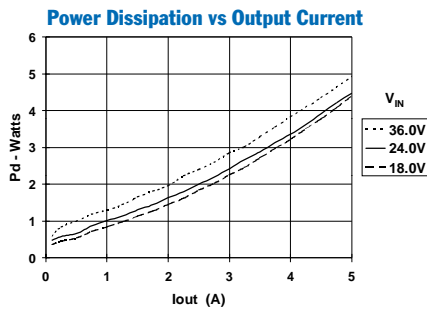
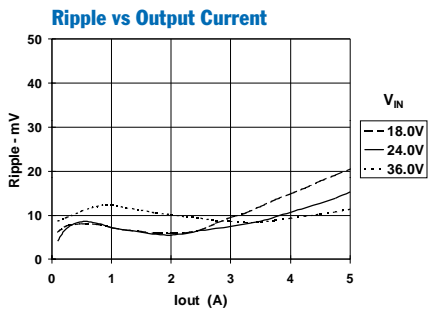
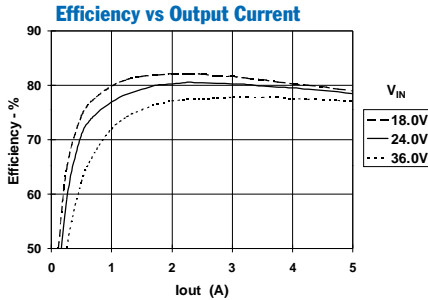
C<sub>in</sub> = Required 560µF electrolytic  
C<sub>out</sub> = Required 330µF electrolytic

**Specifications** (Unless otherwise stated,  $T_a = 25^\circ\text{C}$ ,  $V_{in} = 28\text{V}$ ,  $C_{in} = 560\mu\text{F}$ ,  $C_{out} = 330\mu\text{F}$ , and  $I_o = I_{o,max}$ )

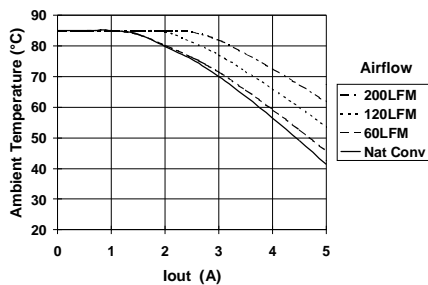
Characteristic	Symbol	Conditions	PT6880 SERIES			Units
			Min	Typ	Max	
Output Current	$I_o$	$T_a = 60^\circ\text{C}$ , 200LFM	$V_o \leq 12\text{V}$ 0.1 (1) $V_o > 12\text{V}$ 0.1 (1)	—	5 4	A
Input Voltage Range	$V_{in}$	Over $I_o$ range	$V_o = 2.5\text{V}$ 15 $V_o = 3.3\text{V}$ 15 $V_o = 5.0\text{V}$ 15 $V_o \geq 6.5\text{V}$ 18	—	25 (2) 33 (2) 36 36	Vdc
Set Point Voltage Tolerance	$V_o\text{tol}$		—	$\pm 0.5$	$\pm 1$	$\%V_o$
Temperature Variation	$\text{Reg}_{\text{temp}}$	$-40^\circ \leq T_a \leq +85^\circ\text{C}$ , $I_o = I_{o,min}$	—	$\pm 0.5$	—	$\%V_o$
Line Regulation	$\text{Reg}_{\text{line}}$	Over $V_{in}$ range	—	$\pm 0.5$	$\pm 1$	$\%V_o$
Load Regulation	$\text{Reg}_{\text{load}}$	Over $I_o$ range	—	$\pm 0.5$	$\pm 1$	$\%V_o$
Total Output Voltage Variation	$\Delta V_{o,tot}$	Includes set-point, line, load, $-40^\circ \leq T_a \leq +85^\circ\text{C}$	—	$\pm 1.5$	$\pm 2$	$\%V_o$
Efficiency	$\eta$		$V_o = 15\text{V}$ — $V_o = 12\text{V}$ — $V_o = 9.0\text{V}$ — $V_o = 5.0\text{V}$ — $V_o = 3.3\text{V}$ — $V_o = 2.5\text{V}$ —	90 88 87 82 73 78	— — — — — —	%
$V_o$ Ripple (pk-pk)	$V_r$	20MHz bandwidth	$V_o \leq 5\text{V}$ — $V_o > 5\text{V}$ —	50 1	— —	mV <sub>pp</sub> $\%V_o$
Transient Response	$t_{tr}$ $\Delta V_{tr}$	$5\text{A}/\mu\text{s}$ load step, 50% to 100% $I_{o,max}$ $V_o$ over/undershoot	—	100 $\pm 100$	— —	$\mu\text{s}$ mV
Switching Frequency	$f_s$	Over $V_{in}$ and $I_o$ range	500	550	600	kHz
On/Off Standby (Pin 4)		Referenced to GND (pin 6)				
Input High Voltage	$V_{IH}$		2.0	—	Open (3)	V
Input Low Voltage	$V_{IL}$		-0.1	—	+0.4	
Input Low Current	$I_{IL}$		—	-0.5	—	mA
Standby Input Current	$I_{in, standby}$	pins 4 & 6 connected	—	16	35	mA
External Input Capacitance	$C_{in}$	See application schematic	560 (4)	—	—	$\mu\text{F}$
External Output Capacitance	$C_{out}$	See application schematic	330 (4)	—	1,000	$\mu\text{F}$
Operating Temperature Range	$T_a$	Over $V_{in}$ range	-40	—	85 (5)	$^\circ\text{C}$
Solder Reflow Temperature	$T_{\text{reflow}}$	Surface temperature of module pins or case	—	—	215 (6)	$^\circ\text{C}$
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	7.7	—	—	$10^6$ 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	Suffix N, A — Suffix C	20 (7) 15 (7)	— —	G's
Weight	—		—	23	—	grams
Flammability	—	Materials meet UL 94V-0				

- Notes:**
- (1) The ISR will operate at no load with reduced specifications.
  - (2) The stated maximum input voltage assumes the nominal output voltage. If the output voltage is adjusted (trimmed) to some other value, consult the related application note on output voltage adjustment for the revised input voltage limitations.
  - (3) The STBY\* control (pin 4) 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 low (less than 5V). Consult the related application note for interface considerations.
  - (4) For guidance on suitable input and output capacitors consult the accompanying application note, "Capacitor Recommendations for the PT6880 Series."
  - (5) See Safe Operating Area curves or contact the factory for the appropriate derating.
  - (6) 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).
  - (7) The case pins on through-hole package types (suffixes N & A) must be soldered. For more information consult the applicable package outline drawing.

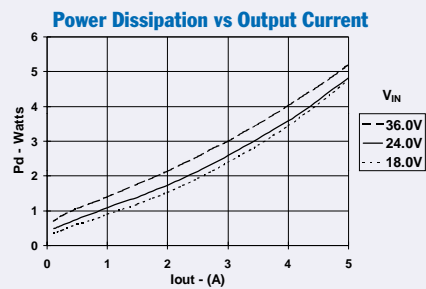
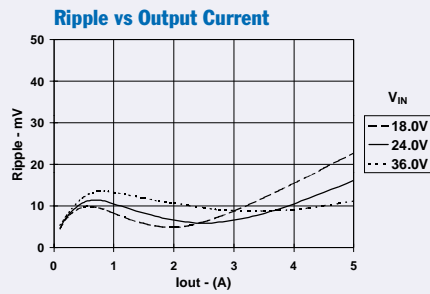
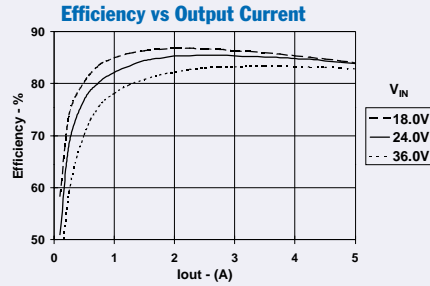
PT6881,  $V_{out} = 3.3V$  (Note A)



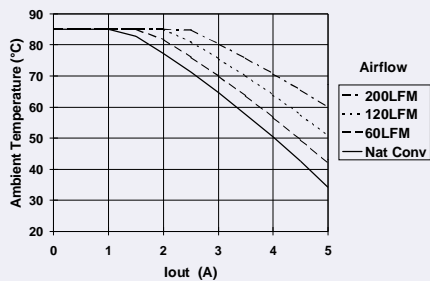
SOA Curves @  $V_{in} = +24V$  (Note B)



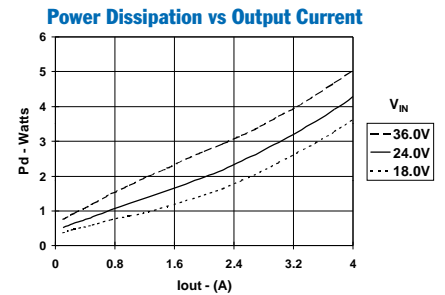
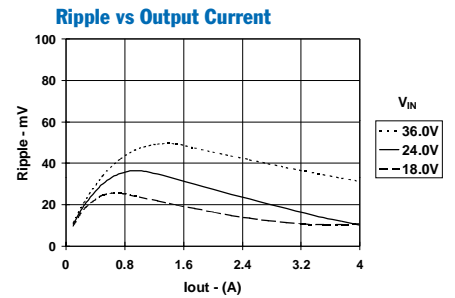
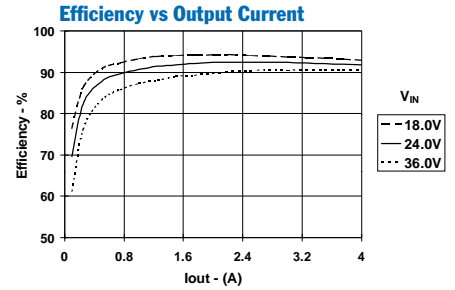
PT6883  $V_{out} = 5V$  (Note A)



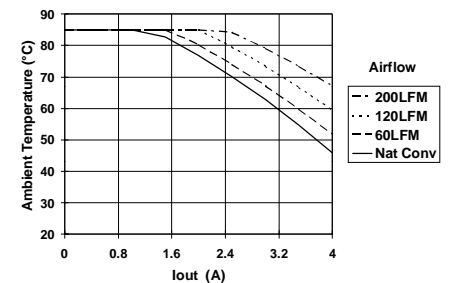
SOA Curves @  $V_{in} = +24V$  (Note B)



PT6886,  $V_{out} = 12V$  (Note A)



SOA Curves @  $V_{in} = +24V$  (Note B)



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

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

### Capacitor Recommendations for the PT6880 Regulator Series

#### Input Capacitor:

The required input capacitor is determined by a 1.2Arms minimum ripple current rating and 560µF capacitance value. The ripple current rating and <120mΩ equivalent series resistance (ESR) are the major considerations, along with temperature, when designing with different types of capacitors.

Tantalum/Os-Con® capacitors are not recommended due to a minimum voltage rating of 2× (the maximum DC voltage + AC ripple). This is necessary to improve the reliability of these capacitors in high bus applications.

#### Output Capacitors:

The ESR specification of the output capacitor should be at least 50mΩ. Electrolytic capacitors have marginal ripple performance at frequencies greater than 400kHz 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°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 $V_{out} < 5.1V$ )

Tantalum type capacitors can be used on the output bus for output voltages less than 5.1V. 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<sup>2</sup>t current derating is recommended along with an external clamp component. An Output Over-voltage Clamp (OOVC) will fault the output fuse protecting the capacitors in event of an over-voltage condition. The OOVC can be a simple zener high power diode, 3-5W, 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 100kHz) 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(µF)	(ESR) Equivalent Series Resistance	105°C Maximum Ripple Current(Irms)	Physical Size(mm)	Input Bus	Output Bus	
Panasonic FC (Radial)	50V	560	0.068Ω	1900mA	18×15	1	1	EEUFC1H561
	50V	390	0.080Ω	1610mA	16×15	2	1	EEUFC1H391S
	50V	390	0.080Ω	1610mA	16×15	2	1	EEUFC1H391S
FC/FK (Surface Mtg)	63V	680	0.080Ω	1690mA	18×16.5	1	1	EEVFK1J681M
	35V	330	0.080Ω	850mA	10×10.2	N/R (1)	1	EEVFK1V331P
	50V	1000	0.073Ω	1610mA	16×16.5	1	1	EEVFK1H102M
United Chemi-con LXZ/LXV Series	50V	680	0.048Ω	1840mA	16×20	1	1	LXZ50VB681M16X20LL
	35V	330	0.068Ω	1050mA	10×16	N/R (1)	1	LXV35VB331M10X16LL
MVY (Surface Mtg)	35V	220	0.150Ω	670mA	10×10.3	N/R (1)	2	MVY35VC2211M10X10TP
Nichicon PM Series	50V	560	0.044Ω	1550mA	16×20	1	1	UPM1H561MHH6
	63V	560	0.039Ω	1400mA	18×20	1	1	UPM1J561MHH6
	50V	330	0.060Ω	1210mA	16×15	2	1	UPM1H331MHH6
AVX Tantalum TPS (Surface Mtg)	10V	330	0.10Ω	>2500mA	7.3L	N/R (1)	1	TPSE337M010R0100 ( $V_o < 5.1V$ )
	10V	330	0.06Ω	>3000mA	×5.7W ×4.1H	N/R (1)	1	TPSV337M010R0060 ( $V_o < 5.1V$ )
Kemet Tantalum (2) T496 /T495 Series (Surface Mount)	10V	220	0.500Ω	500mA	4.3W ×7.3L ×4.0H	N/R (1)	2	T496X227M010AS ( $V_o < 5.1V$ )
	10V	220	0.070Ω	>2000mA		N/R (1)	2	T495X227M0100AS ( $V_o < 5.1V$ )
Sprague Tantalum (2) 594D Series (Surface Mount)	10V	330	0.130Ω	1393mA	7.2L ×6W ×4.1H	N/R (1)	1	595D337X0010R2T ( $V_o < 5.1V$ )

- 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.

## Using the On/Off Standby Function on the PT6880 Excalibur™ Series of ISRs

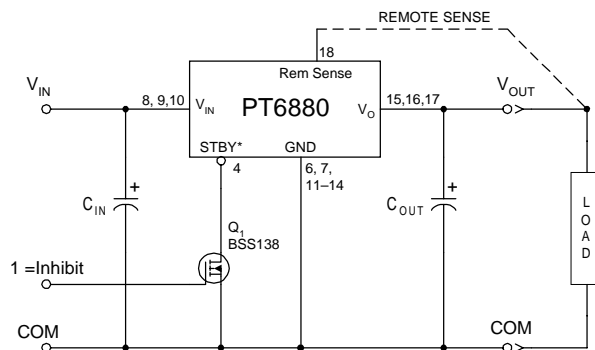
The PT6880 series of integrated switching regulators (ISRs) incorporate an on/off standby function, which may be used to disable the regulator output. This function is provided by the *STBY\** control (pin 4). If pin 4 is left open-circuit the regulator operates normally, providing a regulated output whenever a valid supply voltage is applied to  $V_{in}$  (pins 8–10) with respect to *GND* (pins 6, 7, & 11–14). If the *STBY\** control is driven low to ground <sup>1</sup>, the regulator output is disabled and the input current drawn by the ISR drops to its idle value <sup>2</sup>.

The *STBY\** pin must be controlled with a low-leakage open-collector (or open-drain) discrete transistor <sup>3</sup>. See Figure 2-1 for the application schematic, and Table 2-1 for the input parameters.

**Table 2-1 Standby Control Requirements**

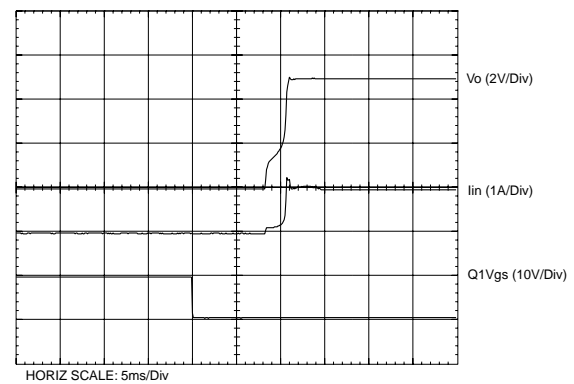
Parameter	Min	Typ	Max
Enable ( $V_{IH}$ )	—		Open Circuit
Disable ( $V_{IL}$ )	-0.2V		0.3V
$I_{stby}$ (pin 4 =ground)		-50 $\mu$ A	
$V_{stby}$ (open circuit)		1.4V	2V

**Figure 2-1**



**Turn-On Time:** In the circuit of Figure 2-1, turning  $Q_1$  on applies a low voltage to pin 4 and disables the regulator output. Correspondingly, turning  $Q_1$  off removes the low-voltage signal and enables the output. Once enabled the output will typically experience a 5–10ms delay followed by a quick ramp-up of voltage. The regulator should provide a fully regulated output within 20ms. The waveforms of Figure 1-2 show the rise of both the output voltage and input current for a PT6883 (5V). The turn off of  $Q_1$  corresponds to the drop of  $Q_1 V_{gs}$ . The waveform was measured with a 24Vdc input voltage and 4-ADC load.

**Figure 2-2**



**Notes:**

1. To ensure that the regulator output is disabled, the control pin must be pulled to less than 0.3Vdc with a low-level 0.1mA sink to ground.
2. When the regulator output is disabled the current drawn from the  $V_{in}$  input source is typically reduced to less than 20mA.
3. The standby control input is *NOT* compatible with TTL devices that incorporate a totem-pole output drive. Use only a true open-collector device, preferably a low-leakage discrete bipolar transistor (or MOSFET). *Do Not* use a pull-up resistor, or drive the *STBY\** pin with an external voltage.

## Adjusting the Output Voltage of the PT6880 5-A Excalibur™ Converter Series

The output voltage of the Power Trends PT6880 Excalibur series of ISRs may be adjusted higher or lower than the factory trimmed pre-set voltage with the addition of a single external resistor <sup>1</sup>. Table 3-1 gives the respective 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 1 ( $V_o$  Adjust) and pins 6, 7 /11-14 (GND).

**Adjust Down:** Add a resistor ( $R_1$ ), between pin 1 ( $V_o$  Adjust) and pins 15-17 ( $V_{out}$ ).

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.

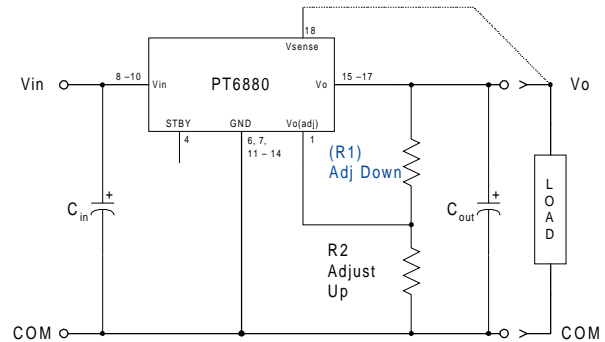
### Notes:

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,  $V_{outb}$  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 1 ( $V_o$  Adjust) and pin 18 (Remote Sense) can benefit load regulation.
4. For output voltages above 10Vdc, the maximum output current must be limited to 4Adc.
5. 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.

$$V_{in} (\text{min}) = (V_{out} + 3)V \text{ or } 15V, \text{ whichever is higher.}$$

$$V_{in} (\text{max}) = (10 \times V_{out})V \text{ or } 36V, \text{ whichever is less.}$$

Figure 3-1



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

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

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

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

Table 3-1

### PT6880 ADJUSTMENT AND FORMULA PARAMETERS

Series Pt #	PT6882	PT6881	PT6883	PT6884	PT6886	PT6885
$V_o$ (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
$R_o$ (k $\Omega$ )	4.99	4.22	2.49	2.0	2.0	2.0
$R_s$ (k $\Omega$ )	2.49	4.99	4.99	12.7	12.7	12.7

PT6880 Series

Table 3-2

PT6880 ADJUSTMENT RESISTOR VALUES

Series Pt #	PT6882	PT6881	PT6883	Series Pt #	PT6884	PT6886	PT6885
Current	5Adc	5Adc	5Adc	Current	5Adc	4Adc	4Adc
V <sub>o</sub> (nom)	2.5Vdc	3.3Vdc	5Vdc	V <sub>o</sub> (nom)	9Vdc	12Vdc	15Vdc
V <sub>a</sub> (req'd)				V <sub>a</sub> (req'd)			
1.8	(1.4)kΩ			6.0	(6.9)kΩ		
1.9	(2.9)kΩ			6.2	(9.2)kΩ		
2.0	(5.0)kΩ			6.4	(11.9)kΩ		
2.1	(8.1)kΩ			6.6	(14.0)kΩ		
2.2	(13.3)kΩ	(1.0)kΩ		6.8	(18.6)kΩ		
2.3	(23.7)kΩ	(2.3)kΩ		7.0	(23.0)kΩ		
2.4	(54.9)kΩ	(3.9)kΩ		7.2	(28.3)kΩ		
2.5		(5.8)kΩ		7.4	(35.0)kΩ		
2.6	59.9kΩ	(8.4)kΩ		7.6	(43.5)kΩ		
2.7	28.7kΩ	(11.7)kΩ		7.8	(55.0)kΩ		
2.8	18.3kΩ	(16.5)kΩ		8.0	(71.0)kΩ		
2.9	13.1kΩ	(23.6)kΩ		8.2	(95.0)kΩ		
3.0	10.0kΩ	(35.4)kΩ	(1.6)kΩ	8.4	(135.0)kΩ		
3.1	7.9kΩ	(59.0)kΩ	(2.3)kΩ	8.6	(215.0)kΩ		
3.2	6.4kΩ	(130.0)kΩ	(3.1)kΩ	8.8	(455.0)kΩ		
3.3	5.3kΩ		(4.0)kΩ	9.0		(31.7)kΩ	
3.4	4.4kΩ	81.5kΩ	(5.1)kΩ	9.2	64.8kΩ	(36.1)kΩ	
3.5	3.8kΩ	38.3kΩ	(6.2)kΩ	9.4	26.1kΩ	(41.2)kΩ	
3.6	3.2kΩ	23.8kΩ	(7.6)kΩ	9.6	13.1kΩ	(47.1)kΩ	
3.7	2.7kΩ	16.6kΩ	(9.1)kΩ	9.8	6.7kΩ	(54.1)kΩ	
3.8	2.3kΩ	12.3kΩ	(10.9)kΩ	10.0	2.8kΩ	(62.6)kΩ	(25.8)kΩ
3.9	2.0kΩ	9.4kΩ	(13.0)kΩ	10.2	0.2kΩ	(72.8)kΩ	(28.3)kΩ
4.0	1.7kΩ	7.4kΩ	(15.6)kΩ	10.4		(85.7)kΩ	(31.1)kΩ
4.1	1.4kΩ	5.8kΩ	(18.7)kΩ	10.6		(102.0)kΩ	(34.1)kΩ
4.2	1.2kΩ	4.6kΩ	(22.6)kΩ	10.8		(124.0)kΩ	(37.3)kΩ
4.3	1.0kΩ	3.7kΩ	(27.6)kΩ	11.0		(155.0)kΩ	(40.9)kΩ
4.4		2.9kΩ	(34.2)kΩ	11.2		(201.0)kΩ	(44.9)kΩ
4.5		2.2kΩ	(43.6)kΩ	11.4		(278.0)kΩ	(49.3)kΩ
4.6		1.7kΩ	(57.6)kΩ	11.6		(432.0)kΩ	(54.3)kΩ
4.7		1.2kΩ	(80.9)kΩ	11.8		(895.0)kΩ	(59.8)kΩ
4.8			(128.0)kΩ	12.0			(66.1)kΩ
4.9			(268.0)kΩ	12.2		94.8kΩ	(73.3)kΩ
5.0				12.4		41.1kΩ	(81.6)kΩ
5.1			88.4kΩ	12.6		23.1kΩ	(91.3)kΩ
5.2			41.7kΩ	12.8		14.2kΩ	(103.0)kΩ
5.3			26.1kΩ	13.0		8.8kΩ	(117.0)kΩ
5.4			18.4kΩ	13.2		5.2kΩ	(133.0)kΩ
5.5			13.7kΩ	13.4		2.7kΩ	(154.0)kΩ
5.6			10.6kΩ	13.6		0.7kΩ	(181.0)kΩ
5.7			8.4kΩ	13.8			(217.0)kΩ
5.8			6.7kΩ	14.0			(268.0)kΩ
5.9			5.4kΩ	14.2			(343.0)kΩ
6.0			4.4kΩ	14.5			(570.0)kΩ
6.1			3.5kΩ	15.0			
6.2			2.8kΩ	15.5			42.3kΩ
6.3			2.2kΩ	16.0			14.8kΩ
6.4			1.7kΩ	16.5			5.6kΩ
6.5			1.2kΩ	17.0			1.1kΩ

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

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