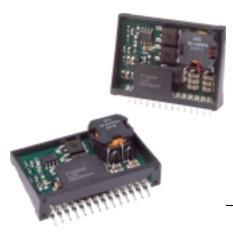
# 5-A 12 /24-V Input Adjustable Integrated Switching Regulator



#### **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**

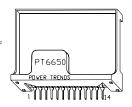
The PT6650 power modules are a series of high efficiency, non-isolated step-down integrated switching regulators (ISRs). These regulators are designed to operate over a 9 V to 28 V input voltage range to produce a tightly regulated output voltage at load currents of up to 5 A. The wide input voltage 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	P	(EED)
Horizontal	D	(EEA)
SMD	E	(EEC)
Horizontal, 2-Pin Tab	M	(EEM)
SMD, 2-Pin Tab	L	(EEL)
Horizontal, 2-Pin Ext Tab	Q	(EEQ)
SMD, 2-Pin Ext Tab	F	(EEF)
Vertical, Side Tab	R	(EEE)
Horizontal, Side Tab	G	(EEG)
SMD, Side Tab	В	(EEK)

<sup>\*</sup> Previously known as package styles 400/410.

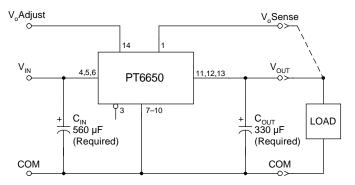
(Reference the applicable package code drawing for the dimensions and PC board layout)

#### **Pin-Out Information**

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

<sup>\*</sup> For further information, see application notes.

### **Standard Application**



 $C_{in}$  = Required 560  $\mu F$  electrolytic  $C_{out}$  = Required 330  $\mu F$  electrolytic

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

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

Characteristic         Symbol         Conditions         Win Vocal St Vocal S					PT6650 SERIES			
Input Voltage Range	Characteristic	Symbol	Conditions		Min	Тур	Max	Units
Output Voltage Tolerance	Output Current	$I_{o}$	Over V <sub>in</sub> range					A
Output Voltage Adjust Range         V <sub>o</sub> adj V <sub>o</sub> adj V <sub>o</sub> adj         Pin 14 to V <sub>o</sub> or ground V <sub>o</sub> adj V <sub>o</sub> = 3 V V <sub>o</sub> = 5 V V <sub>o</sub> = 5 V V <sub>o</sub> = 12 V V <sub>o</sub> = 10 V V <sub>o</sub> = 12 V V <sub>o</sub> = 12 V V <sub>o</sub> = 10 V V <sub>o</sub> =	Input Voltage Range	V <sub>in</sub>	$I_o(min) \le I_o \le I_o(max)$					V
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Output Voltage Tolerance	$\Delta V_{\rm o}$			V <sub>o</sub> -0.1	_	V <sub>o</sub> +0.1	V
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Output Voltage Adjust Range	$ m V_o$ adj	Pin 14 to $V_{\rm o}$ or ground	$V_o = 2.5 \text{ V}$ $V_o = 5 \text{ V}$ $V_o = 9 \text{ V}$ $V_o = 12 \text{ V}$	1.8 3 6 9	_	4.3 6.5 10.2 13.6	V
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Line Regulation	Reg <sub>line</sub>	$9 \text{ V} \le \text{V}_{\text{in}} \le 28 \text{ V}$		_	±0.5	±1	$%V_{o}$
Transient Response   t <sub>tr</sub>	Load Regulation	Regload	0.1 ≤ I <sub>o</sub> ≤5 A		_	±0.5	±1	%V <sub>o</sub>
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	V <sub>o</sub> Ripple (pk-pk)	$V_{\rm r}$	20 MHz bandwidth					${}^{ m mV_{pp}}_{ m V_o}$
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Transient Response	t <sub>tr</sub>	0.15 A/µs load step, 50% to 10	0% I <sub>o</sub> max	_	100	_	μSec
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	with C2 = 330μF	$ m V_{tr}$	Vo over/undershoot		_	100	_	mV
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Efficiency	η	$I_o = 50 \% I_o max$	$V_0 = 2.5 \text{ V}$		76		%
Non/Off Standby (Pin 3)			$I_o = I_o \text{ max}$	$V_o = 3.3 \text{ V}$ $V_o = 2.5 \text{ V}$ $V_o = 5 \text{ V}$	_	75		%
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Switching Frequency	$f_{s}$	$9 \text{ V} \leq \text{V}_{\text{in}} \leq 28 \text{ V}$		500	550	600	kHz
Standby Input Current   Iin standby   pin 3 to GND   —   15   30   mA	Input High Voltage Input Low Voltage	$ m V_{IL}$	Referenced to GND		-0.1		0.3	
External Output Capacitance   Cout   330   — 3,000   µF	Standby Input Current	In standby	pin 3 to GND		_			
External Input Capacitance   Cin   560 (4)		/	F		330	_	3,000	
Operating Temperature Range         Ta         Over V <sub>in</sub> range         -40         —         85 (2)         °C           Solder Reflow Temperature         T <sub>reflow</sub> Surface temperature of module pins or case         —         —         215 (5)         °C           Storage Temperature         T <sub>s</sub> —         —         40         —         125 °C           Reliability         MTBF         Per Bellcore TR-332 50% stress, T <sub>a</sub> =40 °C, ground benign         7.2         —         —         106 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 R, G, & B — 16.5 —	External Input Capacitance				560 (4)	_	_	μF
Storage Temperature         Ts         —         -40         —         125         °C           Reliability         MTBF         Per Bellcore TR-332 50% stress, Ta =40 °C, ground benign         7.2         —         —         106 Hrs           Mechanical Shock         —         Per Mil-Std-883D, method 2002.3, Ims, half-sine, mounted to a fixture         —         500         —         Gs           Mechanical Vibration         —         Mil-Std-883D, Method 2007.2, 20-2000Hz, soldered in PCB         —         7.5         —         Gs           Weight         —         Case styles P, D, & E Case style	Operating Temperature Range		Over V <sub>in</sub> range		-40	_	85 (2)	°C
Storage Temperature         Ts         —         -40         —         125         °C           Reliability         MTBF         Per Bellcore TR-332 50% stress, Ta =40 °C, ground benign         7.2         —         —         106 Hrs           Mechanical Shock         —         Per Mil-Std-883D, method 2002.3, Ims, half-sine, mounted to a fixture         —         500         —         Gs           Mechanical Vibration         —         Mil-Std-883D, Method 2007.2, 20-2000Hz, soldered in PCB         —         7.5         —         Gs           Weight         —         Case styles P, D, & E Case style	Solder Reflow Temperature	$T_{reflow}$	Surface temperature of module	e pins or case	_	_	215 (5)	°C
Mechanical Shock   —   Per Mil-Std-883D, method 2002.3,   ms, half-sine, mounted to a fixture   —   500   —   G's	Storage Temperature		_	•	<del>-4</del> 0	_	125	°C
Ims, half-sine, mounted to a fixture		MTBF		l benign	7.2	_	_	106 Hrs
Veight   Case styles P, D, & E   12.5	Mechanical Shock	_			_	500	_	G's
Weight — Case styles P, D, & E — 12.5 — Case styles R, G, & B — 16.5 — Gase styles L & M — 15.5 — Gase styles F & Q — 22 —	Mechanical Vibration	_	Mil-Std-883D, Method 2007.2 20-2000Hz, soldered in PCB	2,	_	7.5	_	G's
Flammability — Materials meet UL 94V-0	Weight	_	Ca Ca:	se styles R, G, & B Case styles L & M		16.5 15.5		grams
	Flammability	_	Materials meet UL 94V-0					

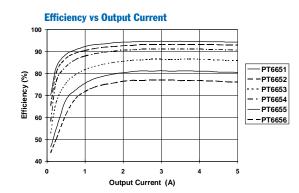
Notes: (1) The ISR will operate at no load with reduced specifications.
(2) See Safe Operating Area curves or contact the factory for the appropriate derating.
(3) The STBY\* control (pin 3) has an internal pull-up and if it is left open circuit the module will operate when input power is applied. The open-circuit voltage is typicially 1.5 V. Consult the related application note for other interface considerations.
(4) The module requires a 560µF electrolytic capacitor at the input and 330µF at the output for proper operation in all applications. In addition, the input capacitance, Cin, 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.

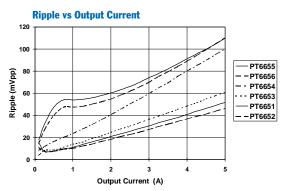
<sup>(5)</sup> During solder reflow of SMD package version do not elevate the module case, pins, or internal component temperatures above a peak of 215°C. For further guidance refer to the application note, "Reflow Soldering Requirements for Plug-in Power Surface Mount Products," (SLTA051).

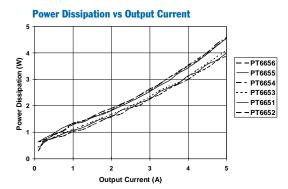
5-A 12 /24-V Input Adjustable Integrated Switching Regulator

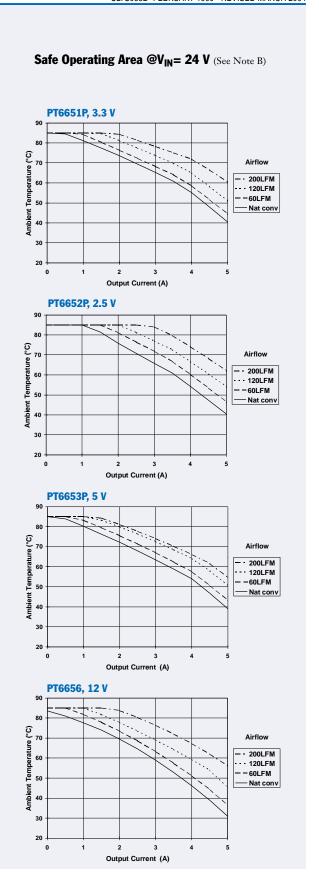
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## **PT6650 Series @V<sub>IN</sub>= 24 V** (See Note A)









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



PT6650 Series

# Capacitor Recommendations for the PT6650 Regulator Series

### **Input Capacitor:**

The required input capacitor is determined by 560  $\mu F$  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× (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 °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 $V_0 < 5.1 V$ )

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 I²t 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				ntity		
	Working Voltage	Value (µF)	(ESR) Equivalent Series Resistance	Max. Ripple Current @85°C (Irms)	Physical Size (mm)	Input Bus	Output Bus	Vendor Part Number
Panasonic FC (Radial)	50 V 50 V 50 V	560 390 390	0.068 Ω 0.080 Ω 0.080 Ω	1900 mA 1610 mA 1610 mA	18×15 16×15 16×15	1 2 2	1 1 1	EEUFC1H561 EEUFC1H391S EEUFC1H391S
FC/FK (SMT)	63 V 35 V 50 V	680 330 1000	$0080 \Omega$ $0.080 \Omega$ $0.073 \Omega$	1690 mA 850 mA 1610 mA	18×16.5 10×10.2 16×16.5	1 N/R [1] 1	1 1 1	EEVFK1J681M EEVFK1V331P EEVFK1H102M
United Chemi-con LXZ/LXV Series	50 V 35 V	680 330	0.048 Ω 0.068 Ω	1840 mA 1050 mA	16×20 10×16	1 N/R [1]	1 1	LXZ50VB681M16X20LL LXV35VB331M10X16LL
MVY (SMT)	35 V	220	0.150 Ω	670 mA	10×10.3	N/R [1]	2	MVY35VC2211M10X10TP
Nichicon PM Series	50 V 63 V 50 V	560 560 330	0.044 Ω 0.039 Ω 0.060 Ω	1550 mA 1400 mA 1210 mA	16×20 18×20 16×15	1 1 2	1 1 1	UPM1H561MHH6 UPM1J561MHH6 UPM1H331MHH6
AVX Tantalum TPS (SMT)	10 V 10 V	330 330	0.10 Ω 0.06 Ω	>2500 mA >3000 mA	7.3L ×5.7W ×4.1H	N/R [1] N/R [1]	1 [2] 1 [2]	TPSE337M010R0100 (V <sub>o</sub> <5.1V) TPSV337M010R0060 (V <sub>o</sub> <5.1V)
Kemet Tantalum T496 /T495 Series (SMT)	10 V 10 V	220 220	0.500 Ω 0.070 Ω	500 mA >2000 mA	4.3W ×7.3L ×4.0H	N/R [1] N/R [1]	2 [2] 2 [2]	T496X227M010AS (V <sub>o</sub> <5.1V) T495X227M0100AS (V <sub>o</sub> <5.1V)
Sprague Tantalum 594D Series (SMT)	10 V	330	0.130 Ω	1393 mA	7.2L ×6W ×4.1H	N/R [1]	1 [2]	595D337X0010R2T (V <sub>o</sub> <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 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/shutdown 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  $^1$  will disable the regulator output and reduce the input current to less than 30 mA  $^3$ . 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.

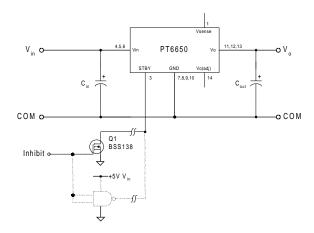
Table 2-1 Inhibit Control Thresholds (1, 2)

Parameter	Min	Max	
Enable (VIH)	1 V	5 V	
Disable (V <sub>IL</sub> )	-0.1 V	0.3 V	

### **Notes:**

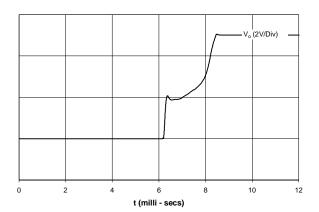
- 1. The Standby input on the PT6650 regulator series may be controlled using either an open-collector (or open-drain) discrete transistor, or a device with a totem-pole output. A pull-up resistor is not necessary. The control input has an open-circuit voltage of about 1.5 Vdc. To disable the regulator output, the control pin must be "pulled" to less than 0.3 Vdc with a low-level 0.25 mA maximum sink to ground.
- 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<sub>IL</sub>(max) requirement (Table 2-1) at 0.25 mA sink
  current. <u>Do not</u> 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 voltage 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



#### 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 preset 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 ( $V_0$  adj) and pins 7-10 (GND).

**Adjust Down:** To decrease the output voltage, add a resistor  $(R_1)$ , between pin 14  $(V_o \text{ adj})$  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.

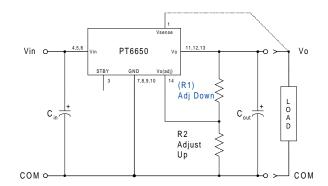
#### Notes:

- 1. Use only a single 1 % resistor in either the (R<sub>1</sub>) or R<sub>2</sub> location. Place the resistor as close to the ISR as possible.
- Never connect capacitors from V<sub>0</sub> adjust to either GND, V<sub>out</sub>, or the Remote Sense pin. Any capacitance added to the V<sub>0</sub> 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  $(V_o \text{ adj})$  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.

$$V_{in}$$
 (min) =  $(V_{out} + 3) V$  or 9 V, whichever is higher.  
 $V_{in}$  (max) =  $(10 \times V_{out}) V$  or 28 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.

$$\begin{array}{ccc} (R_1) & = & \frac{R_o \left( V_o - 1.25 \right) \left( V_a - 1.25 \right)}{1.25 \left( V_o - V_a \right)} & -R_s & k\Omega \end{array}$$

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

Where: V<sub>o</sub> = Original output voltage

V<sub>a</sub> = Adjusted output voltage

 $R_0$  = The resistance value in Table 3-1

 $R_s$  = The series resistance from Table 3-1

Table 3-1

PTG650 ADJUSTMENT AND FORMULA PARAMETERS							
Series Pt #	PT6652	PT6651	PT6653	PT6654	PT6656	PT6655	
Vo (nom)	2.5 V	3.3 V	5 V	9 V	12 V	15 V	
V <sub>a</sub> (min)	1.8 V	2.2 V	3 V	6 V	9 V	$10\mathrm{V}$	
V <sub>a</sub> (max)	4.3 V	4.7 V	6.5 V	10.2 V	13.6 V	17 V	
R <sub>o</sub> (kΩ)	4.99	4.22	2.49	2	2	2	
R <sub>s</sub> (kΩ)	2.49	4.99	4.99	12.7	12.7	12.7	

# PT6650 Series

Table 3-2

PT6650 ADJU	STMENT RESISTO	R 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	$(1.4) \mathrm{k}\Omega$			
1.9	(2.9) kΩ			
2.0	(5.0) kΩ			
2.1	(8.1) kΩ			
2.2	(13.3) kΩ	$(1.0) k\Omega$		
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	$(1.6) k\Omega$	
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	$(9.1) \mathrm{k}\Omega$	
3.8	2.3 kΩ	12.3 kΩ	(10.9) kΩ	
3.9	$2.0~\mathrm{k}\Omega$	$9.4  \mathrm{k}\Omega$	$(13.0) \mathrm{k}\Omega$	
4.0	$1.7~\mathrm{k}\Omega$	$7.4~\mathrm{k}\Omega$	$(15.6) \mathrm{k}\Omega$	
4.1	$1.4 \mathrm{k}\Omega$	5.8 kΩ	$(18.7) \mathrm{k}\Omega$	
4.2	1.2 kΩ	$4.6 \text{ k}\Omega$	$(22.6) \mathrm{k}\Omega$	
4.3	1.0 kΩ	3.7 kΩ	$(27.6) \mathrm{k}\Omega$	
4.4		2.9 kΩ	$(34.2) \mathrm{k}\Omega$	
4.5		2.2 kΩ	$(43.6) \mathrm{k}\Omega$	
4.6		1.7 kΩ	$(57.6) \mathrm{k}\Omega$	
4.7		1.2 kΩ	(80.9)kΩ	
4.8			(128.0) kΩ	
4.9			$(268.0) \mathrm{k}\Omega$	
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 5.4 kΩ	
6.0			4.4 kΩ 3.5 kΩ	
6.1			2.8 kΩ	
6.3			2.6 kΩ 2.2 kΩ	
6.4			1.7 kΩ	
6.5			1.7 kΩ	
$R_1 = (Blue)$	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	$(6.9) \mathrm{k}\Omega$		
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	$(135.0) \mathrm{k}\Omega$		
8.6	$(215.0) \mathrm{k}\Omega$		
8.8	(455.0) kΩ		
9.0		$(31.7) \mathrm{k}\Omega$	
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		$(102.0) \mathrm{k}\Omega$	(34.1) kΩ
10.8		$(124.0) \mathrm{k}\Omega$	(37.3) kΩ
11.0		$(155.0) \mathrm{k}\Omega$	(40.9) kΩ
11.2		(201.0) kΩ	(44.9) kΩ
11.4		$(278.0)  k\Omega$	(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	$(117.0) \mathrm{k}\Omega$
13.2		5.2 kΩ	(133.0) kΩ
13.4		2.7 kΩ	$(154.0) \mathrm{k}\Omega$
13.6		0.7 kΩ	(181.0) kΩ
13.8			(217.0) kΩ
14.0			$(268.0) \mathrm{k}\Omega$
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

 $R_1 = (Blue)$   $R_2 = Black$ 

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