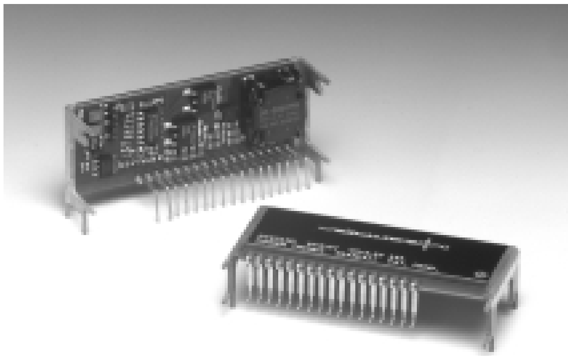
14-A 12V-Input Adjustable Integrated Switching Regulator

EXCALIBUR

SLTS102A

(Revised 1/14/2002)



Features

- Up to 14A Output Current
- +12V Input
- 93% Efficiency (PT6724)
- On/Off Standby Function
- Differential Remote Sense
- Adjustable Output Voltage
- Short Circuit Protection
- 17-pin Space-Saving Package
- Solderable Copper Case

Description

The PT6725 series of power modules are integrated switching regulators (ISRs), housed in a 17-pin space saving solderable copper package. These modules operate off a 12V input power bus to provide up to 14A of low-voltage power for the industry's latest high-speed, DSPs, µPs, and bus drivers. The series includes the standard output bus voltage options, ranging from 1.2V to 5.0V. The factory preset voltage can also be adjusted over a limited range with a single external resistor.

Features include a *Standby* function, output short circuit protection, and a differential *Remote Sense* to compensate for voltage drop between the ISR and load. The modules are available in both through-hole and surface mount configurations.

Ordering Information

PT6724❐ = 5.0 Volts
PT6725❐ = 3.3 Volts
PT6726❐ = 2.5 Volts
PT6727❐ = 1.8 Volts
PT6728❐ = 1.5 Volts
PT6729❐ = 1.2 Volts

PT Series Suffix (PT1234x)

Case/Pin Configuration	Order Suffix	Package Code *
Vertical	N	(EMD)
Horizontal	A	(EMA)
SMD	C	(EMC)

** Previously known as package styles 1340/50.*

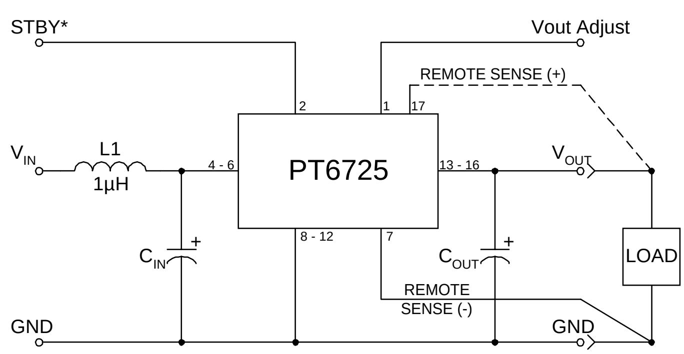
(Reference the applicable package code drawing for the dimensions and PC board layout)

Pin-Out Information

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

* *For further information, see application notes.*

Standard Application



C_{in} = Required 1000µF electrolytic
C_{out} = Required 330µF electrolytic
L1 = Optional 1µH input choke

TEXAS INSTRUMENTS

Specifications (Unless otherwise stated, T_a =25°C, V_{in} =12V, C_{in} =1,000µF, C_{out} =330µF, and I_o =$I_o$max)

			PT6725 SERIES			
Characteristic	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Output Current	I_o	T_a =+60°C, 200LFM V_o≤2.5V T_a =+25°C, natural convection V_o >2.5V	0.1 (1) 0.1 (1)	— —	14 13	A
Input Voltage Range	V_{in}	Over I_o Range	10.8	—	13.2	VDC
Set Point Voltage Tolerance	V_o tol		—	±1	±1.5 (2)	%V_o
Temperature Variation	Reg_{temp}	–40° ≤T_a ≤ +85°C, I_o =$I_o$min	—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range	—	±5	±10	mV
Load Regulation	Reg_{load}	Over I_o range	—	±5	±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° ≤T_a ≤ +85°C	—	±2	±3	%V_o
Efficiency	η	I_o =9.0A V_o =5.0V V_o =3.3V V_o =2.5V V_o =1.8V V_o =1.5V V_o =1.2V	— — — — — —	93 90 87 84 81 78	— — — — — —	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth	—	35	—	mV_{pp}
Transient Response	t_{tr}	5A/µs load step, 50% to 100% $I_o$max	—	70	—	µs
	ΔV_{tr}	V_o over/undershoot	—	±100	—	mV
Short Circuit Threshold	I_{sc} threshold		—	20	32	A
Switching Frequency	f_s	Over V_{in} and I_o range	300	350	400	kHz
Remote On/Off (Pin 2) Input High Voltage Input Low Voltage	 V_{IH} V_{IL}	Referenced to –V_{in} (pin 8)	 — –0.1	 — —	 Open (3) +0.4	V
Input Low Current	I_{IL}		—	–0.5	–	mA
Standby Input Current	I_{in} standby	pins 2 & 8 connected	—	0.5	1.0	mA
External Output Capacitance	C_{out}	See application schematic	330	—	15,000	µF
External Input Capacitance	Cin	See application schematic	1,000	—	—	µF
Operating Temperature Range	T_a	Over V_{in} range	-40 (4)	—	+85 (5)	°C
Storage Temperature	T_s	—	-40	—	+125	°C
Reliability	MTBF	Per Bellcore TR-332 50% stress, T_a =40°C, ground benign	7.8	—	—	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	—	15 (6)	—	G's
Weight	—		—	23	—	grams
Flammability	—	Materials meet UL 94V-0				

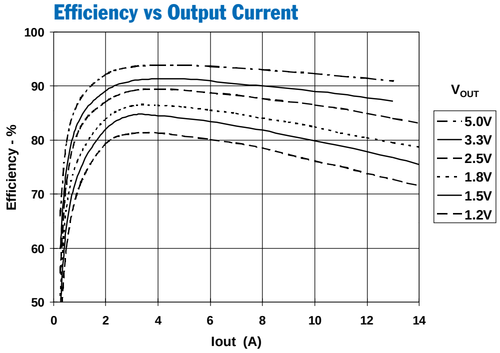
Notes: *(1) The ISR will operate at no load with reduced specifications.*
(2) If the remote sense feature is not being used, connect the Remote Sense Gnd (pin 7) to GND (pin 8) for optimum output voltage accuracy.
(3) The STBY control (pin 2) has an internal pull-up and if it is left open circuit the module will operate when input power is applied. The open-circuit voltage is typically the input voltage, Vin. Refer to the application notes for other interface considerations.*
(4) For operation below 0°C, Cin and Cout must have stable characteristics. Use either low ESR tantalum or Oscon® capacitors. See application notes.
(5) See Safe Operating Area curves or contact the factory for the appropriate derating.
(6) The case pins on through-hole package types (suffixes N & A) must be soldered. For more information see the applicable package outline drawing.

Input/Output Capacitors: *For proper operation in all applications, the PT6725 series requires a 1,000µF input capacitor (C_{in}) with a minimum 1.6Arms ripple current rating. And a 330µF output capacitor (C_{out}) with a maximum ESR of 50mΩ at 100kHz. For transient or dynamic load applications, additional output capacitance may be necessary. The maximum allowable output capacitance is 15,000µF. For more information consult the related application note on capacitor recommendations.*

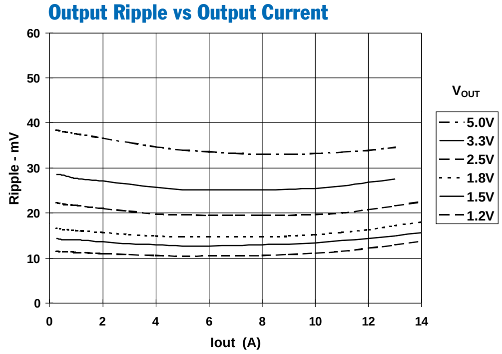
Input Inductor: *An input filter inductor is optioinal for most applications. The inductor must be sized to handle 6.5ADC with a typical value of 1µH.*

Characteristic Data; V_{in} =12V *(See Note A)*

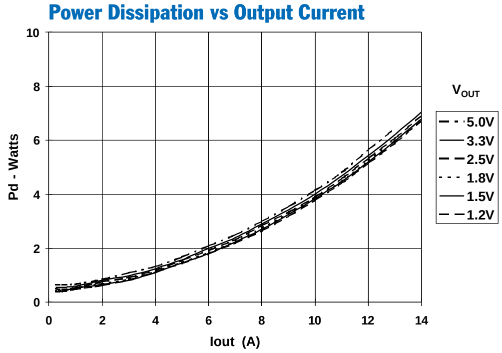
Efficiency vs Output Current



Output Ripple vs Output Current

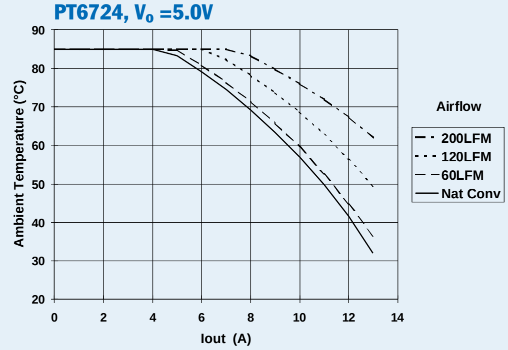


Power Dissipation vs Output Current

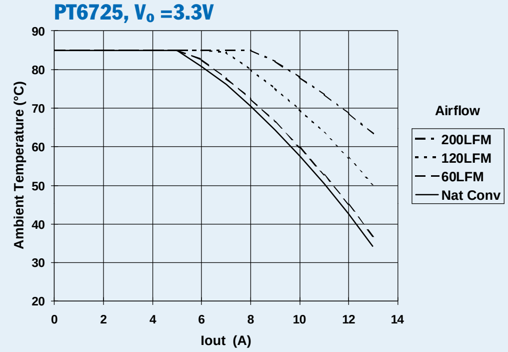


Safe Operating Area; V_{in} =12V *(See Note B)*

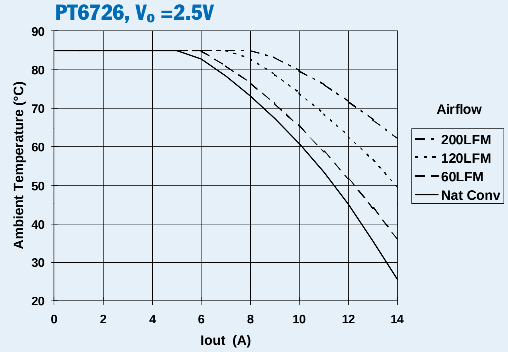
PT6724, V_o =5.0V



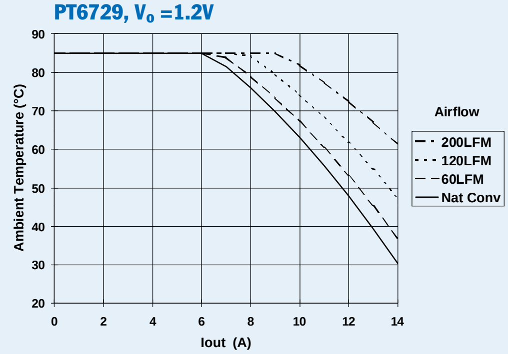
PT6725, V_o =3.3V



PT6726, V_o =2.5V



PT6729, V_o =1.2V



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 12V-Input PT6721/22 and PT6725 Series of ISRs

Input Capacitors

The recommended input capacitor(s) is determined by 1.6Arms minimum ripple current rating and 1,000µF minimum capacitance. Ripple current and Equivalent Series Resistance (ESR) values are the major considerations along with temperature when selecting the proper capacitor. The tantalum capacitors listed below cannot be used on the input bus since they are not rated for 12V operation.

Output Capacitors

The minimum required output capacitance is 330µF with a maximum ESR less than or equal to 50mΩ. Failure to observe this requirement may lead to regulator instability or oscillation. Electrolytic capacitors have poor ripple performance at frequencies greater than 400kHz, but excellent low frequency transient response. Above the ripple frequency ceramic decoupling capacitors are necessary to improve the transient response and reduce any microprocessor high frequency noise components apparent during higher current excursions. Preferred low ESR type capacitor part numbers are identified in the Table 1 below.

Tantalum Characteristics

Tantalum capacitors are recommended on the output bus but only AVX TPS Series, Sprague 593D/594/595 Series, or Kemet T495/T510 Series. These capacitors are recommended over other types due to their higher surge current, excellent power dissipation and ripple current ratings. As a caution, the TAJ Series by AVX is not recommended. This series exhibits considerably higher ESR, reduced power dissipation and lower ripple current capability. The TAJ Series is also less reliable compared to the TPS series when determining power dissipation capability.

Capacitor Table

Table 1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The suggested minimum quantities per regulator for both the input and output buses are identified.

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 the critical parameters are necessary to insure both optimum regulator performance and long capacitor life.

Table 1 Capacitors Characteristic Data

Capacitor Vendor/ Series	Capacitor Characteristics					Quantity		
	Working Voltage	Value(µF)	(ESR) Equivalent Series Resistance	105°C Maximum Ripple Current(Irms)	Physical Size(mm)	Input Bus	Output Bus	Vendor Part Number
Panasonic FC (Radial)	35V	680	0.043Ω	1655mA	12.5×20	2	1	EEUFC1V681
	25V	1000	0.038Ω	1655mA	12.5×20	1	2	EEUFC1E102
	25V	1000	0.038Ω	1690mA	16×15	1	1	EEUFC1E102S
FC/FK (Surface Mount)	50V	1000	0073Ω	1610mA	16×16.5	1	1	EEVFK1H102M
	25V	1000	0.038Ω	2000mA	18×16.5	1	1	EEVFC1E102N
	35V	470	0.043Ω	1690mA	16×16.5	2	1	EEVFC1V471N
United Chemi-con LXV Series	35V	680	0.034Ω	1690mA	12.5×25	2	1	LXV35VB680M12X25LL
	35V	1000	0.038Ω	1630mA	16×20	1	1	LXV35VB102M16X20LL
	16V	470	0.084Ω÷2 =0.042Ω	825mA (×2)	10×16	2	1	LXV16VB471M10X16LL
Nichicon PL Series	35V	680	0.036Ω	1660mA	12.5×25	2	1	UPL1V681MHH
	25V	1200	0.039Ω	1600mA	18×15	1	1	UPL1E122MHH6
PM Series	35V	1000	0.034Ω	1770mA	16×20	1	1	UPM1V102MHH6
Os-con: SS	10V	330	0.025Ω	3500mA	10×10.5	N/R(1)	1	10SS330M (V_o <5V)
SV (surface Mount)	10V	330	0.020Ω	3800mA	10.3×10.3	N/R(1)	1	10SV330 (V_o <5V)
AVX Tantalum TPS (Surface Mount)	10V	330	0.1Ω÷2 =0.05Ω	>2500mA	7.3L ×5.7W ×4.1H	N/R(1)	2	TPSE337M010R0100
	10V	330	0.06Ω÷2 =0.03Ω	>3000mA		N/R(1)	2	TPSV337M010R0060
Kemet Tantalum T510/T495 Series (Surface Mount)	10V	330	0.033Ω	1400mA	4.3W ×7.3L ×4.0H	N/R(1)	1	510X337M010AS
	10V	220	0.07Ω÷2 =0.035Ω	>2000mA		N/R(1)	2	T495X227M0100AS
Sprague Tantalum 594D Series (Surface Mount)	10V	330	0.045Ω	2360mA	7.2L ×6W ×4.1H	N/R(1)	1	594D337X0010R2T

Note: *(N/R -Not recommended) The 10V-rated tantalum capacitors cannot be used on the input bus.*

Using the Standby Function of the PT6725 Series of Integrated Switching Regulators

The PT6725 series of power modules are high efficiency regulators that operate off a +12V input bus voltage. These regulators incorporate an on/off '*Standby*' function, which may be used to disable the regulator output.

The standby function is provided by the *STBY** control, pin 2. If pin 2 is left open-circuit the regulator operates normally, and provides a regulated output when a valid supply voltage is applied to V_{in} (pins 4–6) with respect to GND (pins 8–12). If a low voltage [3] is then applied to pin 2 the regulator output will be disabled and the input current drawn by the ISR will be reduced to 0.5mA [1]. The standby control may also be used to hold-off the regulator output during the period that input power is applied.

Pin 2 is ideally controlled with an open-collector (or open-drain) discrete transistor (See Figure 1). The open-circuit voltage is typcially the input voltage V_{in}. Table 1 gives the circuit parameters for this control input.

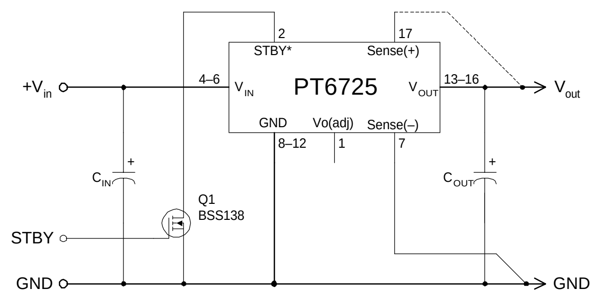
Table 1 Standby Control Requirements [2, 3]

Parameter	Min	Typ	Max
Input Low (V_{IL})	–0.1V		+0.4V
I_{stby} (pin 2 =ground)	—	–0.5mA	—
V_{stby} (open circuit)	—	V_{in}	—

Notes:

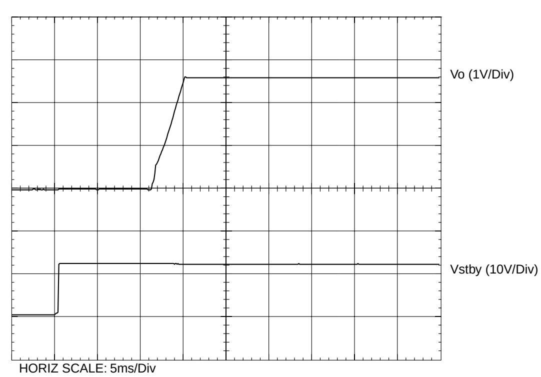
1. When the regulator output is disabled the current drawn from the +V_{in} input source is typically reduced to 0.5mA.
2 The standby control input <u>requires no external pull-up resistor</u>. The open-circuit voltage of the STBY* pin is approximately th input voltage V_{in} (+12V).
3. The standby control input is <u>*Not*</u> compatible with TTL devices that incorporate a totem-pole output drive. Use only a true open-collector device, preferably a discrete bipolar transistor (or MOSFET). To ensure the regulator output is disabled, the control pin must be pulled to less than 0.4Vdc with a low-level 0.5mA sink to ground.
4. After Q_1 in Figure 1 is turned off and before the output begins to rise, the regulator output will assert a low impedance to ground. If an external voltage is applied to the output it will sink current and possibly over-stress the part.

Figure 1



Turn-On Time: In the circuit of Figure 1, turning Q_1 on applies a low voltage to the STBY control (pin 2) and disables the regulator ouput. Correspondingly, turning Q_1 off removes the low-voltage signal and enables the output. Once enabled, the output will typically experience a 10–15ms delay followed by a predictable ramp-up of voltage. The regulator should provide a fully regulated output voltage within 30ms. Figure 2 shows the output voltage response, V_o, of a PT6726 (2.5V) following the turn-off of Q_1. The turn-off of Q_1 corresponds to the rise in V_{stby}. The waveform was measured with a 12Vdc input voltage, and 9.3ADC resistive load.

Figure 2



Adjusting the Output Voltage of the PT6725 Series of Integrated Switching Regulators

The PT6725 series of ISRs are non-programmable versions of the PT6721/2 Excalibur™ regulators. The regulators have a fixed output voltage, which may be adjusted higher or lower than the factory pre-set voltage using a single external resistor. Table 1 gives the 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 pin 7 (Remote Sense GND).

Adjust Down: Add a resistor (R_1), between pin 1 (V_o Adjust) and pin 17 (Remote Sense 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.

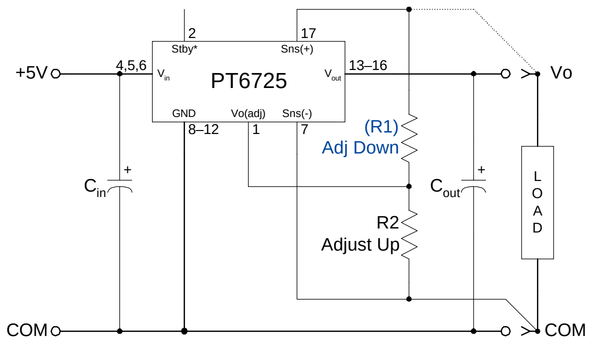
The values of (R_1) [adjust down], and R_2 [adjust up], can also be calculated using the following formulas.

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

$$R_2 = \frac{R_o \cdot V_r}{V_a - V_o} - R_s \quad k\Omega$$

Where: V_o = Original output voltage
V_a = Adjusted output voltage
V_r = The reference voltage (Table 1)
R_o = The multiplier resistance (Table 1)
R_s = The internal series resistance (Table 1)

Figure 1



Notes:

1. Use only a single 1% resistor in either the (R_1) or R_2 location. Place the resistor as close to the regulator as possible.
2. Never connect capacitors from V_o Adjust to either GND, V_{out}, or the Remote Sense pins. Adding capacitance to the V_o Adjust pin will affect the stability of the ISR.
3. If the Remote Sense feature is not being used, pin 7 must be connected to pin 8 for optimum output voltage accuracy. The resistors (R_1) and R_2 may then be connected from 'V_o Adjust' to either V_{out} or GND respectively.

Table 1

ADJUSTMENT AND FORMULA PARAMETERS

Series Pt #	PT6729	PT6728	PT6727	PT6726	PT6725	PT6724
V_o (nom)	1.2	1.5	1.8	2.5	3.3	5.0
V_a (min)	1.09	1.47	1.75	2.25	2.75	4.01
V_a (max)	1.52	1.73	2.0	2.85	3.75	5.47
V_r (V)	0.8	1.27	1.27	1.27	1.27	1.27
R_o (kΩ)	10.0	10.2	10.0	10.0	10.0	9.09
R_s (kΩ)	24.9	49.9	49.9	33.2	24.9	24.9

Table 2

ADJUSTMENT RESISTOR VALUES

Series Pt #	PT6729	PT6728	PT6727	PT6726
V_o (nom)	1.2V	1.5V	1.8V	2.5V
V_a (req'd)				
1.1	(5.1)kΩ			
1.15	(45.1)kΩ			
1.2				
1.25	135.0kΩ			
1.3	55.1kΩ			
1.35	28.4kΩ			
1.4	15.1kΩ			
1.45	7.1kΩ			
1.47	4.7kΩ	(18.1)kΩ		
1.5	1.8kΩ			
1.55		209.0kΩ		
1.6		79.6kΩ		
1.65		36.5kΩ		
1.7		14.9kΩ		
1.75			(46.1)kΩ	
1.8				
1.85			204.0kΩ	
1.9			77.1kΩ	
1.95			34.8kΩ	
2.0			13.6kΩ	
2.05				
2.1				
2.15				
2.2				
2.25				(6.0)kΩ
2.3				(18.3)kΩ
2.35				(38.8)kΩ
2.4				(79.8)kΩ
2.45				(203.0)kΩ
2.5				
2.55				221.0kΩ
2.6				93.8kΩ
2.65				51.5kΩ
2.7				30.3kΩ
2.75				17.6kΩ
2.8				9.1kΩ
2.85				3.1k

Series Pt #	PT6725	PT6724
V_o (nom)	3.3V	5.0
V_a (req'd)		
2.75	(2.0)kΩ	
2.8	(5.7)kΩ	
2.85	(10.2)kΩ	
2.9	(15.9)kΩ	
2.95	(23.1)kΩ	
3.0	(32.8)kΩ	
3.05	(46.3)kΩ	
3.1	(66.6)kΩ	
3.15	(100.0)kΩ	
3.2	(168.0)kΩ	
3.25	(371.0)kΩ	
3.3		
3.35	229.0kΩ	
3.4	102.0kΩ	
3.45	59.8kΩ	
3.5	38.6kΩ	
3.55	25.9kΩ	
3.6	17.4kΩ	
3.65	11.4kΩ	
3.7	6.9kΩ	
3.75	3.3kΩ	
.		
4.1		(3.7)kΩ
4.2		(8.4)kΩ
4.3		(14.4)kΩ
4.4		(22.5)kΩ
4.5		(33.8)kΩ
4.6		(50.8)kΩ
4.7		(79.0)kΩ
4.8		(136.0)kΩ
4.9		(305.0)kΩ
5.0		
5.1		90.5kΩ
5.2		32.8kΩ
5.3		13.6kΩ
5.4		4.0kΩ

R1 = (Blue) R2 = Black

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265