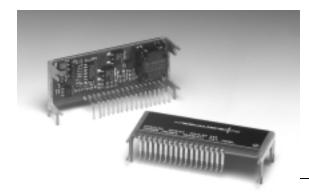
(Revised 1/14/2002)



Features

- Up to 14A Output Current
- +12V Input

EXCALIBUR

- 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, μ Ps, 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	Α	(EMA)
SMD	C	(EMC)

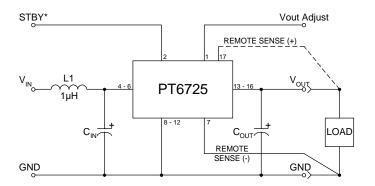
^{*} Previously known as package styles 1340/50. (Reference the applicable package code drawing for the dimensions and PC board layout)

Pin-Out Information

Pin	Function
1	Vo Adjust
2	STBY*
3	Do Not Connect
4	Vin
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



 $\begin{array}{l} C_{in} = Required \ 1000 \mu F \ electrolytic \\ C_{out} = Required \ 330 \mu F \ electrolytic \\ L1 = Optional \ 1 \mu H \ input \ choke \end{array}$



14-A 12V-Input Adjustable **Integrated Switching Regulator**

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

Characteristic	Symbol	Conditions	Min	Тур	Max	Units
Output Current	I_{o}	T_a =+60°C, 200LFM V_o \le 2.5V T_a =+25°C, natural convection V_o >2.5V	0.1 (1) 0.1 (1)	=	14 13	A
Input Voltage Range	$ m V_{in}$	Over I _o Range	10.8	_	13.2	VDC
Set Point Voltage Tolerance	Votol		_	±1	±1.5 (2)	$%V_{o}$
Temperature Variation	Reg_{temp}	$-40^{\circ} \le T_a \le +85^{\circ}C, I_o = I_o min$	_	±0.5	_	$%V_{o}$
Line Regulation	Regline	Over V _{in} range	_	±5	±10	mV
Load Regulation	Regload	Over Io range	_	±5	±10	mV
Total Output Voltage Variation	ΔV_{o} tot	Includes set-point, line, load, $-40^{\circ} \le \Gamma_a \le +85^{\circ}C$	_	±2	±3	$%V_{o}$
Efficiency	η	$\begin{array}{c} I_{o} = 9.0A & V_{o} = 5.0V \\ V_{o} = 3.3V \\ V_{o} = 2.5V \\ V_{o} = 1.5V \\ V_{o} = 1.5V \\ V_{o} = 1.2V \end{array}$		93 90 87 84 81 78		%
Vo Ripple (pk-pk)	$V_{\rm r}$	20MHz bandwidth	_	35	_	mV_{pp}
Transient Response	t _{tr}	5A/µs load step, 50% to 100% I _o max	_	70	_	μs
	$\Delta m V_{tr}$	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 Input Low Current	V _{IH} V _{IL} I _{IL}	Referenced to $-V_{in}$ (pin 8)	 _0.1		Open (3) +0.4	V mA
Standby Input Current	I _{in} standby	pins 2 & 8 connected	_	0.5	1.0	mA
External Output Capacitance	Cout	See application schematic	330	_	15,000	μF
External Input Capacitance	Cin	See application schematic	1,000	_	_	μF
Operating Temperature Range	Ta	Over V _{in} range	-40 (4)	_	+85 (5)	°C
Storage Temperature	Ts	_	-40	_	+125	°C
Reliability	MTBF	Per Bellcore TR-332 50% stress, T _a =40°C, ground benign	7.8	_	_	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	_	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.

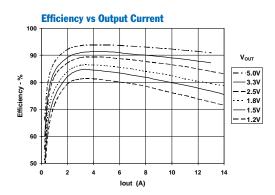
- (5) See Safe Operating Area curves or contact the factory for the appropriate derating.
 (6) The case pins on through-hole package types (suffixes N & A) must be soldered. For more information see the applicable package outline drawing.

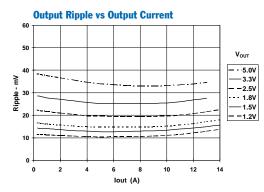
Input/Output Capacitors: For proper operation in all applications, the PT6725 series requires a 1,000µF input capacitor (C_{in}) with a minimum 1.6Arms ripple current rating. And a 330µF output capacitor (C_{out}) with a maximum ESR of $50m\Omega$ at 100kHz. For transient or dynamic load applications, 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.

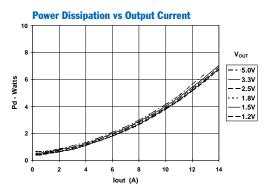
Input Inductor: An input filter inductor is optioinal for most applications. The inductor must be sized to bandle 6.5ADC with a typical value of 1µH.

14-A 12V-Input Adjustable Integrated Switching Regulator

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







Safe Operating Area; $V_{in} = 12V$ (See Note B) $PT6724, V_0 = 5.0V$ ပ္ပ - 2001 FM - 120LFM -60LFM - Nat Conv 12 PT6725, V_o =3.3V - 200LFM 120LFM -60LFM - Nat Conv 30 12 PT6726, V_o =2.5V Airflow - 200LFM - 120LFM - Nat Conv 30 12 $PT6729, V_0 = 1.2V$ - 200LFM - 120LFM -60LFM - Nat Conv 2 10 12

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



PT6721/22 & PT6725 Series

Capacitor Recommendations for the 12V-Input PT6721/22 and PT6725 Series of ISRs

Input Capacitors

The recommended input capacitor(s) is determined by 1.6 Arms minimum ripple current rating and $1,000 \mu F$ 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 <u>not</u> 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					ntity	
	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 25V 25V	680 1000 1000	0.043Ω 0.038Ω 0.038Ω	1655mA 1655mA 1690mA	12.5×20 12.5×20 16×15	2 1 1	1 2 1	EEUFC1V681 EEUFC1E102 EEUFC1E102S
FC/FK (Surface Mount)	50V 25V 35V	1000 1000 470	0073Ω 0.038Ω 0.043Ω	1610mA 2000mA 1690mA	16×16.5 18×16.5 16×16.5	1 1 2	1 1 1	EEVFK1H102M EEVFC1E102N EEVFC1V471N
United Chemi-con LXV Series	35V 35V 16V	680 1000 470	0.034Ω 0.038Ω 0.084Ω÷2 =0.042Ω	1690mA 1630mA 825mA (×2)	12.5×25 16×20 10×16	2 1 2	1 1 1	LXV35VB680M12X25LL LXV35VB102M16X20LL LXV16VB471M10X16LL
Nichicon PL Series	35V 25V	680 1200	0.036Ω 0.039Ω	1660mA 1600mA	12.5×25 18×15	2 1	1 1	UPL1V681MHH UPL1E122MHH6
PM Series	35V	1000	0.034Ω	1770mA	16×20	1	1	UPM1V102MHH6
Os-con: SS SV (surface Mount)	10V 10V	330 330	0.025Ω 0.020Ω	3500mA 3800mA	10×10.5 10.3×10.3	N/R(1) N/R(1)	1 1	10SS330M (V _o <5V) 10SV330 (V _o <5V)
AVX Tantalum TPS (Surface Mount)	10V 10V	330 330	0.1Ω÷2 =0.05Ω 0.06Ω÷2 =0.03Ω	>2500mA >3000mA	7.3L ×5.7W ×4.1H	N/R(1) N/R(1)	2 2	TPSE337M010R0100 TPSV337M010R0060
Kemet Tantalum T510/T495 Series (Surface Mount)	10V 10V	330 220	0.033Ω $0.07\Omega \div 2 = 0.035\Omega$	1400mA >2000mA	4.3W ×7.3L ×4.0H	N/R(1) N/R(1)	1 2	510X337M010AS 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.



PT6725 Series

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 $V_{\rm in}$ (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 $0.5 \, {\rm mA} \, ^1$. 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 typically the input voltage $V_{\rm in}$. Table 1 gives the circuit parameters for this control input.

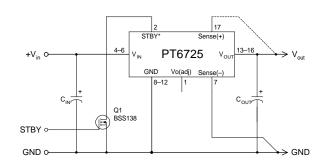
Table 1 Standby Control Requirements (2, 3)

Parameter	Min	Тур	Max	
Input Low (V _{IL})	-0.1V		+0.4V	
I _{stby} (pin 2 =ground)	_	-0.5mA	_	
V _{stby} (open circuit)	_	V _{in}	_	

Notes:

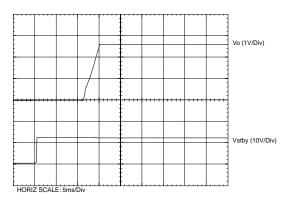
- 1. When the regulator output is disabled the current drawn from the + $V_{\rm in}$ input source is typically reduced to 0.5 mA.
- 2 The standby control input requires no external pull-up resistor. The open-circuit voltage of the STBY* pin is approximately th input voltage V_{in} (+12V).
- 3. The standby 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 Q₁ 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_0 , of a PT6726 (2.5V) following the turn-off of Q_1 . The turn-off of Q_1 corresponds to the rise in $V_{\rm stby}$. The waveform was measured with a 12Vdc input voltage, and 9.3ADC resistive load.

Figure 2



PT6725 Series

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 $^{\text{TM}}$ 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 $V_a \, (\text{min})$ and $V_a \, (\text{max})$.

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.

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

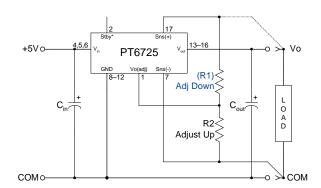
$$R_2 = \frac{R_0 \cdot V_r}{V_a - V_o} - R_s \qquad k\Omega$$

Where: Vo = 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.

PT6705/PT6715 Series

Table 1

ADJUSTMEN	ADJUSTMENT AND FORMULA PARAMETERS										
Series Pt #	PT6729	PT6728	PT6727	PT6726	PT6725	PT6724					
Vo (nom)	1.2	1.5	1.8	2.5	3.3	5.0					
Va (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

Series Pt #	PT6729	PT6728	PT6727	PT6726	Series Pt #	PT6725	PT6724
V _o (nom)	1.2V	1.5V	1.8V	2.5V	V _o (nom)	3.3V	5.0
V _o (non) V _a (req'd)	1.2 V	1.5 V	1.0 V	2.3 V	V _a (req'd)	3.3 V	5.0
	(7.4)1.0					(2.0)1.0	
1.1	(5.1)kΩ				2.75	(2.0)kΩ	
1.15	(45.1)kΩ				2.8	(5.7)kΩ	
1.2	425010				2.85	(10.2)kΩ	
1.25	135.0kΩ					(15.9)kΩ	
1.3	55.1kΩ				2.95	(23.1)kΩ	
1.35	28.4kΩ				3.0	(32.8)kΩ	
1.4	15.1kΩ				3.05	(46.3)kΩ	
1.45	7.1kΩ				3.1	(66.6)kΩ	
1.47	4.7kΩ	(18.1)kΩ			3.15	(100.0) k Ω	
1.5	1.8kΩ				3.2	(168.0) k Ω	
1.55		209.0kΩ			3.25	(371.0)kΩ	
1.6		79.6kΩ			3.3		
1.65		36.5kΩ			3.35	229.0kΩ	
1.7		14.9kΩ			3.4	102.0kΩ	
1.75			(46.1) k Ω		3.45	59.8kΩ	
1.8					3.5	38.6kΩ	
1.85			204.0kΩ		3.55	25.9kΩ	
1.9			77.1kΩ		3.6	17.4kΩ	
1.95			$34.8 \mathrm{k}\Omega$		3.65	11.4kΩ	
2.0			13.6kΩ		3.7	$6.9 \mathrm{k}\Omega$	
2.05					3.75	$3.3 \mathrm{k}\Omega$	
2.1					<u> </u>		
2.15					4.1		(3.7)k
2.2					4.2		(8.4)k
2.25				(6.0) k Ω	4.3		(14.4)k
2.3				(18.3)kΩ	4.4		(22.5)k
2.35				(38.8)kΩ	4.5		(33.8)k
2.4				(79.8)kΩ	4.6		(50.8)k
2.45				(203.0)kΩ	4.7		(79.0)k
2.5					4.8		(136.0)k
2.55				221.0kΩ	4.9		(305.0)k
2.6				93.8kΩ	5.0		, , ,
2.65				51.5kΩ	5.1		90.5k c
2.7				30.3kΩ	5.2		32.8kg
2.75				17.6kΩ	5.3		13.6kg
2.8				9.1kΩ	5.4		4.0kΩ
2.85				3.1k			

R1 = (Blue) R2 = Black





11-Jan-2013

PACKAGING INFORMATION

Orderable Device	Status	Package Type	_	Pins	Package Qty	Eco Plan	Lead/Ball Finish	MSL Peak Temp	Samples
	(1)		Drawing			(2)		(3)	(Requires Login)
PT6724N	LIFEBUY	SIP MODULE	EMD	17	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type	
PT6725C	LIFEBUY	SIP MODULE	EMC	17	10	Pb-Free (RoHS)	Call TI	Level-3-215C-168HRS	

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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