9 Amp 5V/3.3V Input Adjustable

Integrated Switching Regulator

Power Trends Products from Texas Instruments

SLTS035A

(Revised 6/30/2000)

- Single Device 9A Output
- Input Voltage Range: 3.1V to 6.0V
- Adjustable Output Voltage
- 90% Efficiency
- Remote Sense Capability
- Standby Function
- Over-Temperature Protection

The PT6600 series is a high performance family of 14-Pin SIP (Single In-line Package) Integrated Switching Regulators (ISRs), designed for standalone operation in applications requiring as much as 9A of output current.

The PT6600 series will operate off either a 3.3V or 5V input bus and requires only two external capacitors for proper operation. Please note that this product does not include short circuit protection.

PT Series Suffix (PT1234X)

Heat

Spreade

Р

D

Heat Spreader

with Side Tabs

R

G

В

Case/Pin

Configuration

Vertical Through-Hole

Horizontal Through-Hole

Horizontal Surface Mount E

Pin-Out Information C

V_{out} Adjust

Pin Function Remote Sense Do not connect STBY*-Standby 4 Vin $\overline{V_{in}}$ $\overline{\overline{V_{in}}}$ 6 7 GND 8 GND 9 GND 10 GND 11 Vout Vout 12 Vout 13

14

 Ordering
 Information

 PT6601!
 = +3.3 Volts

 † PT6602!
 = +1.5 Volts

 PT6603!
 = +2.5 Volts

 PT6604!
 = +3.6 Volts

 † PT6605!
 = +1.2 Volts

 † PT6606!
 = +1.8 Volts

+3.3V Input Bus Capable



Note: Back surface of product is conducting metal.

Standard Application	
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21 =	Required	330µF	electrolytic (1)
22 =	Required	330µF	electrolytic (1)
$2_{1} =$	NFET-or	Open	Collector Gate

Specifications

(

Characteristics			Р	T6600 SERIE	S	
$(T_a = 25^{\circ}C \text{ unless noted})$	Symbols	Conditions	Min	Тур	Max	Units
Output Current	Io	$T_a = 60^{\circ}$ C, 200 LFM, pkg P $T_a = 25^{\circ}$ C, natural convection	0.1 (2) 0.1 (2)	_	9.0 (4) 7.0 (4)	А
Input Voltage Range	V_{in}	$\begin{array}{ll} 0.1A \leq I_{o} \leq 8.0A & V_{o}\text{=} +2.5/3.3V \\ V_{o} \leq 1.8V \\ V_{o}\text{=} +3.6V \end{array}$	4.5 3.1 4.8	_	6.0 6.0 6.0	V
Output Voltage Tolerance	ΔV_{o}		Vo-0.1	-	Vo+0.1	V
Output Voltage Adjust Range	$\mathrm{V}_{\mathrm{oadj}}$	$\begin{array}{ll} \mbox{Pin 14 to } V_o \mbox{ or ground } & V_o \mbox{ +3.3V } \\ V_{i\mu}\mbox{min=+3.1V } \mbox{ or } V_o \mbox{+1.2V } \\ \mbox{ (whichever is greater) } & V_o \mbox{=+3.5V } \\ V_o \mbox{=+3.6V } \end{array}$	2.25 1.27 1.80 2.50		4.20 2.65 3.50 4.30	V
Line Regulation	Reg _{line}	$\begin{array}{llllllllllllllllllllllllllllllllllll$		±7 ±3 ±7	±17 ±8 ±13	mV
Load Regulation	Reg _{load}	$ \begin{array}{ll} V_{in} = +5V, 0.1 \leq I_o \leq 8.0A & V_o = +3.3V \\ V_o = +1.5V \\ V_o = +2.5V \end{array} $	=	±17 ±12 ±13	±33 ±23 ±25	mV
V _o Ripple/Noise	V_n	V_{in} = 5V, I_o = 8.0A	—	50	—	mVpp
Transient Response with $C_2 = 330 \mu F$	$\overset{t_{tr}}{V_{os}}$	$I_{\rm o}$ step between 4.0A and 8.0A $V_{\rm o}$ over/undershoot	_	100 150	_	μSec mV
Efficiency	η			90 76 85		%
			_	83 68 76		%
Switching Frequency	$f_{ m o}$	$\begin{array}{l} 3.1\mathrm{V} \leq \mathrm{V_{in}} \leq 6.0\mathrm{V} \\ 0.1\mathrm{A} \leq \mathrm{I_o} \leq 8.0\mathrm{A} \end{array}$	475	600	725	kHz
Absolute Maximum Operating Temperature Range	Та	Over V _{in} range	-40 (3)	_	+85 (4)	°C
Thermal Resistance	θ_{ja}	Free Air Convection (40-60 LFM)		25	_	°C/W

Continued



9 Amp 5V/3.3V Input Adjustable Integrated Switching Regulator

Specifications (continued)

Characteristics	I	PT6600 SERIE				
(T _a = 25°C unless noted)	Symbols	Conditions	Min	Тур	Max	Units
Storage Temperature	Ts	—	-40	—	+125	°C
Mechanical Shock	_	Per Mil-STD-883D, Method 2002.3	_	500	_	G's
Mechanical Vibration	—	Per Mil-STD-883D, Method 2007.2, 20-2000 Hz, soldered in a PC board	_	7.5	_	G's
Weight	_	_	_	14	_	grams

Notes: (1) The PT6600 series requires two 330µF electrolytic capacitors (input and output) for proper operation in all applications. The input capacitance must be rated for a minimum of 1.1Arms of ripple current. See the application note, PT6500/6600 Series Capacitor Recommendations.
(2) ISR will operate down to no load with reduced specifications.
(3) For operation below 0°C, use tantalum capacitors for C_{DN} and C_{OUT}. For more information, contact an Application Specialist.
(4) See Safe Operating Curves, or contact the factory for the appropriate derating.

TYPICAL CHARACTERISTICS

Safe Operating Area Curves (@ Vin=+5.0V) (See Note B)



PT6601D (Horizontal)



Output Current (Amps)

PT6601R (Vertical with Side Tab)



PT6601, 3.3 VDC (See Note A)

Efficiency vs Output Current







Power Dissipation vs Output Current



Note A: All data listed in the above graphs bas been developed from actual products tested at 25°C. This data is considered typical data for the ISR. Note B: SOA curves represent operating conditions at which internal components are at or below manufacturer's maximum rated operating temperatures.





Adjusting the Output Voltage of the PT6600 5V Bus Converters

The output voltage of the Power Trends PT6600 Series ISRs may be adjusted higher or lower than the factory trimmed pre-set voltage with the addition of a single external resistor. Table 1 accordingly 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 R2, between pin 14 (V adjust) and pins 7-10 (GND).

Add a resistor (R1), between pin 14 (V Adjust Down: adjust) and pins 11-13 (V_{out}).

Refer to Figure 1 and Table 2 for both the placement and value of the required resistor, either (R1) or R2 as appropriate.

Notes:

Table 1

- 1. Use only a single 1% resistor in either the (R1) or R2 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 (R1) between pin 14 (V adjust) and pin 1 (Remote Sense) can benefit load regulation.
- 4. The minimum input voltage required by the part is V_{out} + 1.2 or 3.1V, whichever is higher.

Figure 1



The values of (R1) [adjust down], and R2 [adjust up], can also be calculated using the following formulae.

(R1) =
$$\frac{R_o (V_a - 1.0)}{(V_o - V_a)} - R_s k\Omega$$

$$R2 = \frac{R_o}{V_a - V_o} - R_s \qquad k\Omega$$

Where: $V_{a} = Original output voltage$ $V_{a}^{o} = Adjusted output voltage$

 R_{o} = The resistance value in Table 1

R = The series resistance from Table 1

PT6600 ADJUSTMENT AND FORMULA PARAMETERS									
PT6605	PT6607	PT6602	PT6608	PT6606	PT6603	PT6601	PT6604		
1.2	1.3	1.5	1.7	1.8	2.5	3.3	3.6		
1.14	1.19	1.27	1.36	1.4	1.8	2.25	2.5		
2.35	2.45	2.65	2.85	2.95	3.5	4.2	4.3		
2.49	2.49	2.49	2.49	2.49	4.99	12.1	10.0		
2.0	2.0	2.0	2.0	2.0	4.22	12.1	12.1		
	TMENT AND FO PT6605 1.2 1.14 2.35 2.49 2.0	TMENT AND FORMULA PARAMETE PT6605 PT6607 1.2 1.3 1.14 1.19 2.35 2.45 2.49 2.49 2.0 2.0	TMENT AND FORMULA PARAMETERS PT6605 PT6607 PT6602 1.2 1.3 1.5 1.14 1.19 1.27 2.35 2.45 2.65 2.49 2.49 2.49 2.0 2.0 2.0	TIMENT AND FORMULA PARAMETERS PT6605 PT6607 PT6602 PT6608 1.2 1.3 1.5 1.7 1.14 1.19 1.27 1.36 2.35 2.45 2.65 2.85 2.49 2.49 2.49 2.49 2.0 2.0 2.0 2.0	TMENT AND FORMULA PARAMETERS PT6605 PT6607 PT6602 PT6608 PT6606 1.2 1.3 1.5 1.7 1.8 1.14 1.19 1.27 1.36 1.4 2.35 2.45 2.65 2.85 2.95 2.49 2.49 2.49 2.49 2.49 2.0 2.0 2.0 2.0 2.0	TIMENT AND FORMULA PARAMETERS PT6605 PT6607 PT6602 PT6608 PT6606 PT6603 1.2 1.3 1.5 1.7 1.8 2.5 1.14 1.19 1.27 1.36 1.4 1.8 2.35 2.45 2.65 2.85 2.95 3.5 2.49 2.49 2.49 2.49 4.99 2.0 2.0 2.0 2.0 4.22	TIMENT AND FORMULA PARAMETERS PT6605 PT6607 PT6602 PT6608 PT6606 PT6603 PT6601 1.2 1.3 1.5 1.7 1.8 2.5 3.3 1.14 1.19 1.27 1.36 1.4 1.8 2.25 2.35 2.45 2.65 2.85 2.95 3.5 4.2 2.49 2.49 2.49 2.49 4.99 12.1 2.0 2.0 2.0 2.0 4.22 12.1		

Table 2								
PT6600 ADJU	STMENT RESISTO	R VALUES						
Series Pt #	PT6605	PT6607	PT6602	PT6608	PT6606	PT6603	PT6601	PT6604
V _o (nom)	1.2	1.3	1.5	1.7	1.8	2.5	3.3	3.6
V _a (req'd)								
1.15	(5.5)kΩ							
1.2		(3.0)kΩ						
1.25	47.8kΩ	(10.5)kΩ						
1.3	22.9kΩ		(1.7)kΩ					
1.35	14.6kΩ	47.8kΩ	(3.8)kΩ					
1.4	10.5kΩ	22.9kΩ	(8.0)kΩ	(1.3)kΩ	(0.5)kΩ			
1.45	8.0kΩ	14.6kΩ	(20.4)kΩ	(2.5)kΩ	(1.2)kΩ			
1.5	6.3kΩ	10.5kΩ		(4.2)kΩ	(2.2)kΩ			
1.55	5.1kΩ	8.0kΩ	47.8kΩ	(7.1)kΩ	(3.5)kΩ			
1.6	4.2kΩ	6.3kΩ	22.9kΩ	(12.9)kΩ	(5.5)kΩ			
1.65	3.5kΩ	4.1kΩ	14.6kΩ	(30.4)kΩ	(8.8)kΩ			
1.7	3.0kΩ	4.2kΩ	10.5kΩ		(15.4)kΩ			
1.75	2.5kΩ	3.5kΩ	8.0kΩ	47.8kΩ	(35.4)kΩ			
1.8	2.2kΩ	3.0kΩ	6.3kΩ	22.9kΩ		(1.5)kΩ		
1.85	$1.8 \text{k}\Omega$	2.5kΩ	5.1kΩ	14.6kΩ	47.8kΩ	(2.3)kΩ		
1.9	1.6kΩ	2.2kΩ	4.2kΩ	10.5kΩ	22.9kΩ	(3.3)kΩ		
1.95	1.3kΩ	1.8kΩ	3.5kΩ	8.0kΩ	14.6kΩ	(4.4)kΩ		
2.0	1.1kΩ	1.6kΩ	3.0kΩ	6.3kΩ	10.5kΩ	(5.8)kΩ		
2.05	0.9kΩ	1.3kΩ	2.5kΩ	5.1kΩ	8.0kΩ	(7.4)kΩ		
2.1	$0.8 \mathrm{k}\Omega$	1.1kΩ	2.2kΩ	4.2kΩ	6.3kΩ	(9.5)kΩ		
2.15	0.6kΩ	0.9kΩ	1.8kΩ	3.5kΩ	5.1kΩ	(12.2)kΩ		
2.2	$0.5 \mathrm{k}\Omega$	0.8 k Ω	1.6kΩ	3.0kΩ	4.2kΩ	(15.7)kΩ		
2.25	$0.4k\Omega$	0.6kΩ	1.3kΩ	2.5kΩ	3.5kΩ	(20.7)kΩ	(2.3)kΩ	
2.3	0.3kΩ	0.5kΩ	1.1kΩ	2.2kΩ	3.0kΩ	(28.2)kΩ	(3.6)kΩ	
2.35	$0.2k\Omega$	0.4kΩ	0.9kΩ	1.8kΩ	2.5kΩ	(40.7)kΩ	(5.1)kΩ	
2.4		0.3kΩ	0.8kΩ	1.6kΩ	2.2kΩ	(65.6)kΩ	(6.7)kΩ	
2.45		0.2kΩ	0.6kΩ	1.3kΩ	1.8kΩ	(140.0)kΩ	(8.5)kΩ	
2.5			0.5kΩ	1.1kΩ	1.6kΩ		(10.6)kΩ	(1.5)kΩ
2.55			0.4kΩ	0.9kΩ	1.3kΩ	95.6kΩ	(12.9)kΩ	(2.7)kΩ
2.6			0.3kΩ	$0.8 \text{k}\Omega$	1.1kΩ	45.7kΩ	(15.6)kΩ	(3.9)kΩ
2.65			0.2kΩ	0.6kΩ	6.9kΩ	29.0kΩ	(18.6)kΩ	(5.3)kΩ
2.7				0.5kΩ	0.8kΩ	20.7kΩ	(22.2)kΩ	(6.8)kΩ
2.75				0.4kΩ	0.6kΩ	15.7kΩ	(26.4)kΩ	(8.5)kΩ
2.8				0.3kΩ	0.5kΩ	12.4kΩ	(31.5)kΩ	(10.4)kΩ
2.85				0.2kΩ	0.4kΩ	10.0kΩ	(37.6)kΩ	(12.6)kΩ
2.9					0.3kΩ	8.3kΩ	(45.4)kΩ	(15.0)kΩ
2.95					0.2kΩ	0.9kΩ	(55.3)kΩ	(17.9)kΩ
3.0						5.8kΩ	(68.6)kΩ	(21.2)kΩ
3.1						4.1kΩ	(115.0)kΩ	(29.9)kΩ
3.2						2.9kΩ	(254.0)kΩ	(42.9)kΩ
3.3						2.0kΩ		(64.6)kΩ
3.4						1.3kΩ	109.0kΩ	(108.0)kΩ
3.5						0.8kΩ	48.4kΩ	(238.0)kΩ
3.6							28.2kΩ	
3.7							18.2kΩ	87.9kΩ
3.8							12.1kΩ	37.9kΩ
3.9	4/. V _{out} >3.8V	dc requires Vin >	-5.0Vdc !				8.1kΩ	21.2kΩ
4.0							5.2kΩ	12.9kΩ
4.1							3.0kΩ	7.9kΩ
4.2							1.3kΩ	4.6kΩ
4.3								2.2kΩ

R1 = (Blue) R2 = Black



Using the Standby Function on the PT6600 5V Bus Converters

For applications requiring output voltage On/Off control, the 14-pin PT6600 ISR series incorporates a standby function. This function may be used in applications that require 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, and provides a regulated output when a valid supply voltage is applied to V_{in} (pins 4, 5, & 6) with respect to GND (pins 7-10). If a low voltage² is then applied to pin-3 the regulator output will be disabled and the input current drawn by the ISR will drop to less than 50mA⁴. The standby control may also be used to hold-off the regulator output during the period that input power is applied.

The standby control pin is ideally controlled using an open-collector (or open-drain) discrete transistor (See Figure 1). It may also be driven directly from a dedicated TTL³ compatible gate. Table 1 provides details of the threshold requirements.

Table 1	Inhibit	Control	Thresholds	(2,3)
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Parameter	Min	Max	
Enable (VIH)	1V	5V	
Disable (VIL)	-0.1V	0.35V	

Notes:

- The Standby/Inhibit control logic is similar for all Power Trends' modules, but the flexibility and threshold tolerances will be different. For specific information on this function for other regulator models, consult the applicable application note.
- 2. The Standby control pin is ideally controlled using an open-collector (or open-drain) discrete transistor and requires no external pull-up resistor. The control input has an open-circuit voltage of about 1Vdc. To disable the regulator output, the control pin must be pulled to less than 0.35Vdc with a low-level 0.5mA sink to ground.
- 3. The Standby input on the PT6600 series may be driven by a differential output device, making it compatible with TTL logic. A standard TTL logic gate will meet the $0.35 V V_{IL}$ (max) requirement (Table 1) at $0.5 mA I_{OL}$. <u>Do not</u> use devices that can drive the Standby control input above 5Vdc.
- When the regulator output is disabled the current drawn from the input source is reduced to approximately 30– 40mA (50mA maximum).





Turn-On Time: In the circuit of Figure 1, turning Q_1 on applies a low voltage to the Standby control (pin 3) and disables the regulator ouput. Correspondingly, turning Q_1 off releases the low-voltage signal and enables the output. The PT6600 ISR series regulators have a fast response and will provide a fully regulated output voltage within 250 µsec. The actual turn-on time will vary with load and the total amount of output capacitance. The waveform of Figure 2 shows the typical output voltage response of a PT6601 (3.3V) following the turn-off of Q_1 at time t = 0.0 secs. The waveform was measured with a 5Vdc input voltage, and 0.6 Ω load.

Figure 2





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