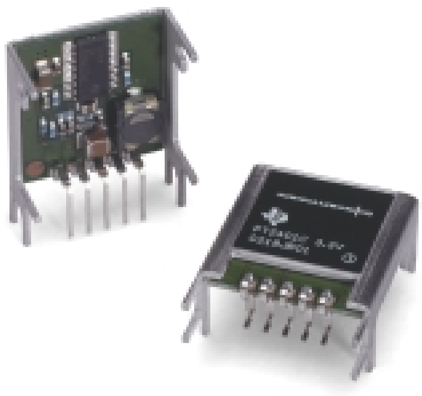
6-A 5-V/3.3-V Input Adjustable *SWIFT*™ Power Module

SLTS169C - MAY 2002 - REVISED OCTOBER 2003



Features

- Fully Functional SWIFT Module
- Single-Device: 5 V/3.3 V Input
- DSP Compatible
- No Output Capacitors Required
- High Efficiency (93 % at 4 A)
- Small Footprint (0.355 in², Suffix 'N')
- Adjustable Output Voltage
- On/Off Inhibit Function
- Short Circuit Protection
- Thermal Shutdown
- Space-Saving package
- Solderable Copper Case

Description

The PT5400 Excalibur™ power modules are a series of high-performance integrated switching regulators (ISRs) based on TI's SWIFT (Switcher With Integrated FET Technology) regulator ICs. These ready-to-use modules are rated for up to 6 A of output current from input voltages as low as 3.1 V, providing a convenient step-down power source for the industry's latest high-performance DSPs and microprocessors. The series includes output voltage options as low as 1.0 VDC.

The PT5400 modules are packaged in a 5-pin thermally efficient copper case, which offers the advantage of solderability along with a small footprint (0.355 in², suffix 'N'). Both through-hole and surface mount pin configurations are available.

The product features external output voltage adjustment, an on/off inhibit function, short circuit protection, and thermal shutdown. A 100-µF input capacitor is required for proper operation.

Ordering Information

Input Bus 5 V	Input Bus 3.3 V	Pt No.	Vout
✓		PT5401□	3.3 Volts
✓		PT5402□	2.5 Volts
	✓	PT5408□	2.5 Volts
✓	✓	PT5403□	2.0 Volts
✓	✓	PT5404□	1.8 Volts
✓	✓	PT5405□	1.5 Volts
✓	✓	PT5406□	1.2 Volts
✓	✓	PT5407□	1.0 Volts

PT Series Suffix (PT1234x)

Case/Pin Configuration	Order Suffix	Package Code
Vertical	N	(EFK)
Horizontal	A	(EFL)
SMD	C	(EFM)

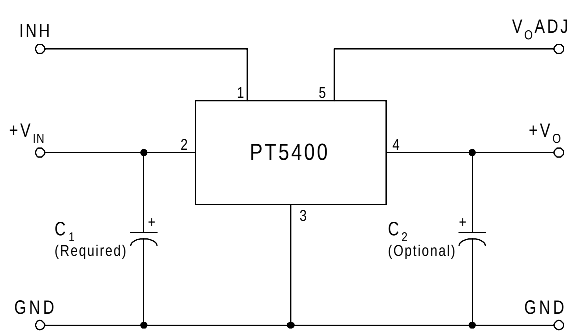
(Reference the applicable package code drawing for the dimensions and PC board layout)

Pin-Out Information

Pin	Function
1	Inhibit *
2	Vin
3	GND
4	V_o
5	V_o Adjust

** For Inhibit pin:*
Open = output enabled
Ground = output disabled

Standard Application



C_1 = Required 100 µF
C_2 = Optional 100 µF

Environmental Specifications

Characteristics	Symbols	Conditions		PT5400 Series Min	Typ	Max	Units
Operating Temperature Range	T_a	Over V_{in} range		–40 (i)	—	85	°C
Over-Temperature Shutdown	OTP	internal junction temp, auto-reset		—	150	—	°C
Storage Temperature	T_s	—		–40	—	125	°C
Solder Reflow Temperature	T_{reflow}	Measured on any part of module		—	—	215 (ii)	°C
Mechanical Shock		Mil-STD-883D, Method 2002.3 Half Sine, mounted to a fixture		—	500	—	G's
Mechanical Vibration		Mil-STD-883D, Method 2007.2, 20-2000 Hz, PCB mounted	Vertical Horizontal	—	20 (iii)	—	G's
Weight	—	—		—	6.5	—	grams
Flammability	—	Materials meet UL 94V-0					

Notes: (i) *For operation below 0 °C the external capacitors must have stable characteristics. Use either a low ESR tantalum or Oscon® capacitor.*
(ii) *During solder reflow of SMD package version, do not elevate the case, pin, or internal component temperatures above the stated maximum. For further guidance refer to the application note, "Reflow Soldering Requirements for Plug-in Power Surface Mount Products," (SLTA051).*
(iii) *The case pins on the through-hole package types (suffixes N & A) must be soldered. For more information see the applicable package outline drawing.*

Electrical Specifications (Except PT5408)

Unless otherwise stated, T_a =25 °C, V_{in} =5 V, C_1 =100 µF, C_2 =0 µF, and I_o =$I_o$max

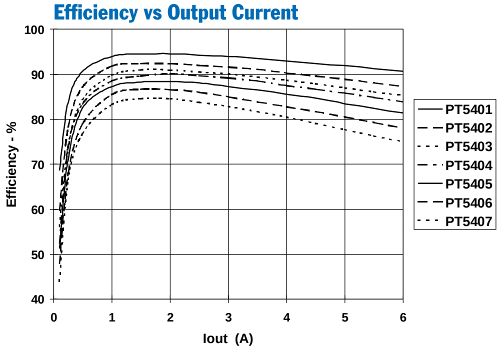
Characteristics	Symbols	Conditions		PT5400 Series (Except PT5408) Min	Typ	Max	Units
Output Current	I_o	V_{in} =5 V V_{in} =3.3 V		0 0	— —	6 (1) 5.5 (1)	A
Input Voltage Range	V_{in}	Over I_o range	$V_o \geq 2.5$ V $V_o \leq 2.0$ V	4.5 3.1	—	5.5 5.5	V
Set-Point Voltage Tolerance	V_o tol			—	—	±2	%V_o
Temperature Variation	ΔReg_{temp}	–40 °C <T_a < +85 °C		—	±0.5	—	%V_o
Line Regulation	ΔReg_{line}	Over V_{in} range		—	±5	—	mV
Load Regulation	ΔReg_{load}	Over I_o range		—	±10	—	mV
Total Output Variation	ΔReg_{tot}	Includes set-point, line, load, –40 °C ≤ T_a ≤ +85 °C		—	—	±3	%V_o
Efficiency	η	V_{in} =5 V, I_o =4 A	PT5401 (3.3 V) PT5402 (2.5 V) PT5403 (2.0 V) PT5404 (1.8 V) PT5405 (1.5 V) PT5406 (1.2 V) PT5407 (1.0 V)	— — — — — — —	93 91 88 87 85 82 80	— — — — — — —	%
		V_{in} =3.3 V, I_o =4 A	PT5403 (2.0 V) PT5404 (1.8 V) PT5405 (1.5 V) PT5406 (1.2 V) PT5407 (1.0 V)	— — — — —	88 86 84 81 78	— — — —	%
V_o Ripple (pk-pk)	V_r	20 MHz bandwidth		—	15	—	mVpp
Transient Response	 t_{tr} ΔV_{tr}	1 A/µs load step, 50 to 100 % $I_o$max, C_2 =100 µF Recovery time V_o over/undershoot		 — —	 50 50	 — —	 µSec mV
Current Limit Threshold	I_{lim}	ΔV_o = –50 mV		—	12	—	A
Output Voltage Adjust	V_o adj			—	±10	—	%
Switching Frequency	f_s	Over V_{in} and I_o ranges		—	700	—	kHz
Under-Voltage Lockout	UVLO	V_{in} increasing V_{in} decreasing		— —	2.95 2.8	— —	V
Inhibit Control (pin1) Input High Voltage Input Low Voltage	 V_{IH} V_{IL}	Referenced to GND (pin3)		 V_{in} –0.5 –0.2	 — —	 Open (2) 0.8	V
Input Low Current	I_{IL}	Pin 1 to GND		—	–10	—	µA
Standby Input Current	I_{in} standby	pins 1 & 3 connected		—	1	—	mA
External Input Capacitance	C_1			100 (3)	—	—	µF
External Output Capacitance	C_2			0	100 (4)	1,000	µF
Reliability	MTBF	Per Bellcore TR-332 50 % stress, T_a =40 °C, ground benign		48	—	—	10^6 Hrs

Notes: (1) *See SOA curves or consult factory for the appropriate derating.*
(2) *The Inhibit control (pin 1) has an internal pull-up, and if left open-circuit the module will operate when input power is applied. A small low-leakage (<100 nA) MOSFET is recommended to control this input. See application notes for more information.*
(3) *The regulator requires a minimum of 100 µF input capacitor with a minimum 300 mArms ripple current rating. For further information, consult the related application note on Capacitor Recommendations.*
(4) *An external output capacitor is not required for basic operation. Adding 100 µF of distributed capacitance at the load will improve the transient response.*

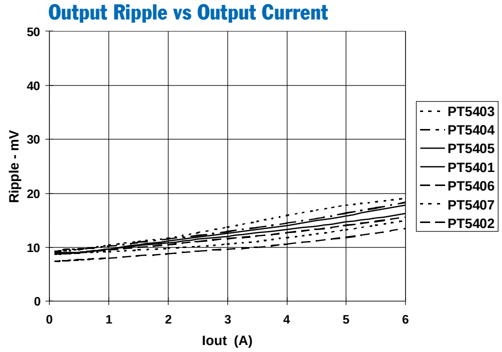
Typical Characteristics (Except PT5408)

Performance Data; V_{in} =5 V (See Note A)

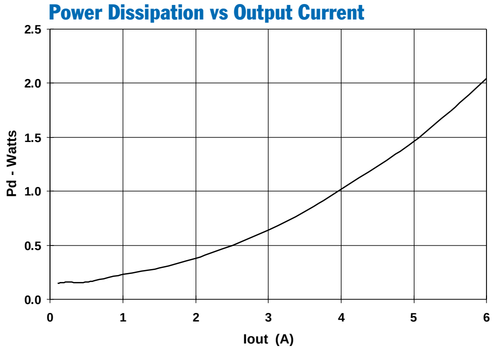
Efficiency vs Output Current



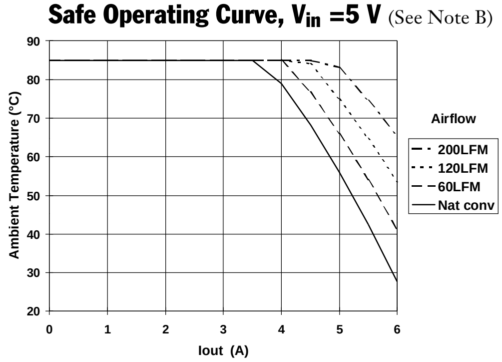
Output Ripple vs Output Current



Power Dissipation vs Output Current

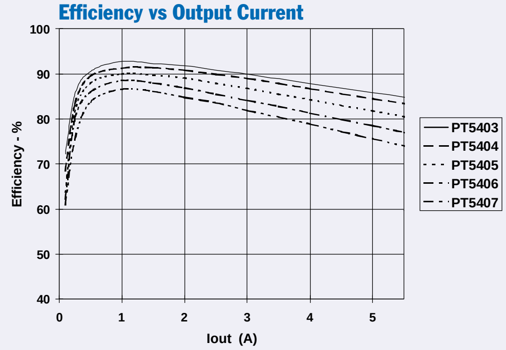


Safe Operating Curve, V_{in} =5 V (See Note B)

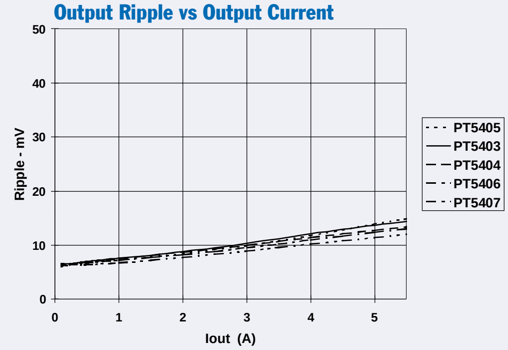


Performance Data; V_{in} =3.3 V (See Note A)

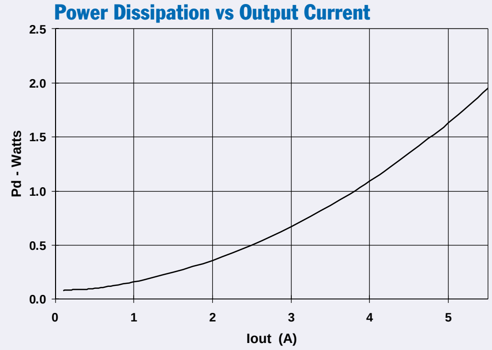
Efficiency vs Output Current



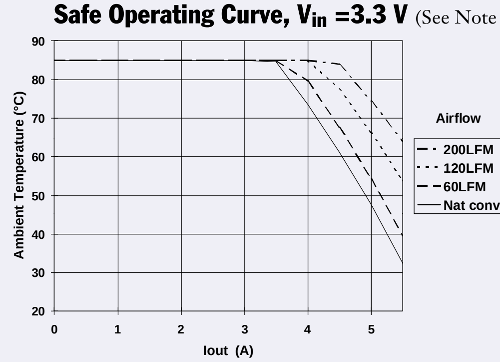
Output Ripple vs Output Current



Power Dissipation vs Output Current



Safe Operating Curve, V_{in} =3.3 V (See Note B)



Note A: *Characteristic data has 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.*

Electrical Specifications (PT5408 only)

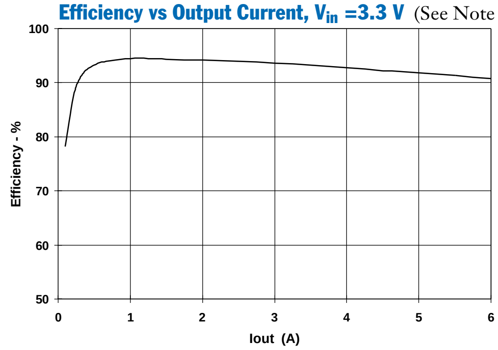
Unless otherwise stated, T_a =25 °C, V_{in} =3.3 V, C_1 =100 µF, C_2 =0 µF, and I_o =$I_o$max

Characteristics	Symbols	Conditions	PT5408 Min	Typ	Max	Units
Output Current	I_o	V_{in} =3.3 V	0	—	6 (1)	
Input Voltage Range	V_{in}	Over I_o range	3.1		3.6	
Set-Point Voltage Tolerance	V_o tol		—	—	±2	%V_o
Temperature Variation	ΔReg_{temp}	–40 °C <T_a < +85 °C	—	±0.5	—	%V_o
Line Regulation	ΔReg_{line}	Over V_{in} range	—	±5	—	mV
Load Regulation	ΔReg_{load}	Over I_o range	—	±10	—	mV
Total Output Variation	ΔReg_{tot}	Includes set-point, line, load, –40 °C ≤ T_a ≤ +85 °C	—	—	±3	%V_o
Efficiency	η	I_o =4 A	—	92		
V_o Ripple (pk-pk)	V_r	20 MHz bandwidth	—	15	—	mVpp
Transient Response		1 A/µs load step, 50 to 100 % $I_o$max, C_2 =100 µF				
	t_{tr}	Recovery time	—	50	—	µSec
	ΔV_{tr}	V_o over/undershoot	—	50	—	mV
Current Limit Threshold	I_{lim}	ΔV_o = –50 mV	—	13	—	A
Output Voltage Adjust	V_o adj		—	±10	—	%
Switching Frequency	f_s	Over V_{in} and I_o ranges	—	700	—	kHz
Under-Voltage Lockout	UVLO	V_{in} increasing	—	2.95	—	V
		V_{in} decreasing	—	2.8	—	V
Inhibit Control (pin1)		Referenced to GND (pin3)				
Input High Voltage	V_{IH}		V_{in} –0.5	—	Open (2)	V
Input Low Voltage	V_{IL}		–0.2	—	0.8	V
Input Low Current	I_{IL}	Pin 1 to GND	—	–10	—	µA
Standby Input Current	I_{in} standby	pins 1 & 3 connected	—	1	—	mA
External Input Capacitance	C_1		100 (3)	—	—	µF
External Output Capacitance	C_2		0	100 (4)	1,000	µF
Reliability	MTBF	Per Bellcore TR-332 50 % stress, T_a =40 °C, ground benign	48	—	—	10^6 Hrs

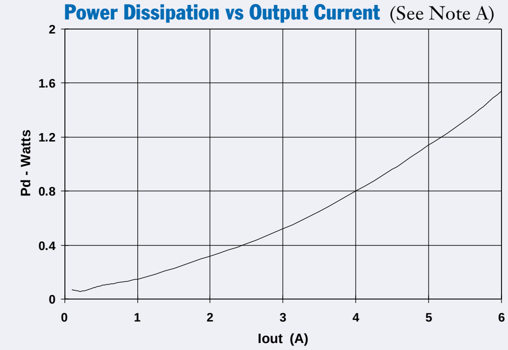
Notes: (1) *See SOA curves or consult factory for the appropriate derating.*
(2) *The Inhibit control (pin 1) has an internal pull-up, and if left open-circuit the module will operate when input power is applied. A small low-leakage (<100 nA) MOSFET is recommended to control this input. See application notes for more information.*
(3) *The regulator requires a minimum of 100 µF input capacitor with a minimum 300 mArms ripple current rating. For further information, consult the related application note on Capacitor Recommendations.*
(4) *An external output capacitor is not required for basic operation. Adding 100 µF of distributed capacitance at the load will improve the transient response.*

Typical Characteristics (PT5408 only)

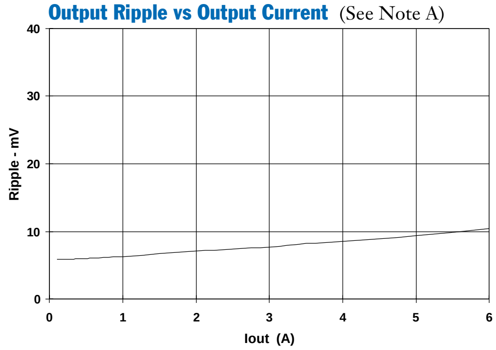
Efficiency vs Output Current, V_{in} =3.3 V (See Note A)



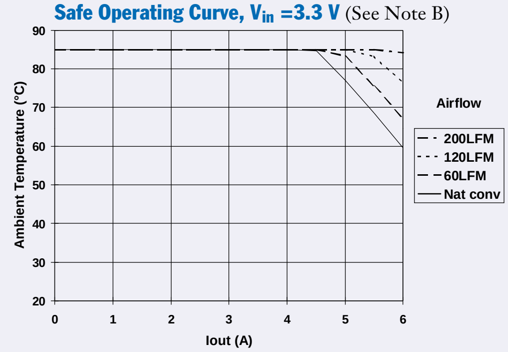
Power Dissipation vs Output Current (See Note A)



Output Ripple vs Output Current (See Note A)



Safe Operating Curve, V_{in} =3.3 V (See Note B)



Note A: *Characteristic data has 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.*

Operating Features of the PT5400 *SWIFT*™ Series of Power Modules

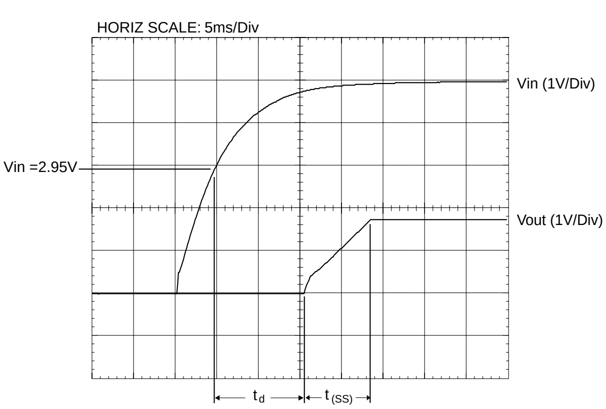
Under-Voltage Lockout (UVLO)

The PT5400 SWIFT series of power modules incorporate an under-voltage lockout (UVLO) function. The UVLO function provides a clean transition during power-up and power-down, allowing the regulator to tolerate a slowly rising input voltage. The UVLO prevents operation of the module until the input voltage has risen above 2.95 V. Below this threshold the status of the inhibit control pin is overriden, and the module will not produce an output. When the input voltage rises above this threshold, the output status of the module is determined by the inhibit control pin. If the inhibit control is open-circuit (not grounded), the module will automatically power up. The UVLO circuit has approximately 0.16 V of hysteresis, and will completely turn off the module when a falling input voltage drops below about 2.8 V. *(Note: Even though the applied input voltage may be above the UVLO threshold, operation to the published specifications requires that the input voltage be at or above the minimum specified for each model in the series. This ensures that the output voltage of the module is in regulation.)*

Soft-Start Power Up

Following either the application of a valid input source voltage, or the removal of a ground signal to the inhibit control pin (with input power applied), the module will initiate a soft-start power up. The soft start has two effects on the start-up characteristic. It introduces a short time delay prior to the start-up of the output voltage, and also slows the rate at which the output voltage rises. Figure 1-1 shows the power-up characteristic of a PT5404 (1.8 V). In this example the delay time, t_d, is measured from the point at which the input voltage rises above 2.95 V (the UVLO threshold), to the point that the output voltage starts to rise. The time period $t_{(SS)}$ is the rise time of the output voltage ramp. The value of t_d and $t_{(SS)}$ are are approximately 10 ms and 7.5 ms respectively.

Figure 1-1; Soft-Start Characteristic and Timing



If desired, both time periods can be lengthened with the addition of a low value capacitor between the Inhibit control (pin 1) and the COM (pin 3). For a given value of external capacitance, C_{inh}, the formulas for calculating the approximate effect on t_d and $t_{(SS)}$ are given below.

$$t_d \approx (C_{inh} + 0.047\ \mu F) \times \frac{1.2\ V}{5\ \mu A}$$

$$t_{(SS)} \approx (C_{inh} + 0.047\ \mu F) \times \frac{0.7\ V}{5\ \mu A}$$

Note: The capacitor should be placed as close to the regulator as possible. Adding 0.047 µF of external capacitance to the Inhibit pin approximately doubles the value of t_d and $t_{(SS)}$.

Current Limit Protection

The output current limit feature is one of two fault protection mechanisms built into the PT5400 modules. Its purpose is to protect both the module and input source against the occurance of a load fault, thereby isolating the fault and preventing it from propagating to other parts of the power system. The PT5400 regulators sense the current switched by the series (high-side) power MOSFET. The circuit implements a continuous current limit characteristic. Upon the removal of the fault the output voltage will promptly recover, and the module will return to normal operation.

A current limit condition will also increase the module's power dissipation, which may cause the temperature of the internal components to significantly rise. If the condition persists, the module may begin to cycle in and out of thermal shutdown.

Thermal Shutdown

Thermal shutdown is the second fault protection mechanism and protects the module's internal circuitry against excessively high temperatures. A rise in the temperature of the internal circuitry may be the result of a drop in airflow, a high ambient temperature, or a sustained over-current load fault. If the junction temperature of the internal components exceed 150 °C, the module will shutdown. Once in thermal shutdown, the regulator is disabled and the output voltage is reduced to zero. The recovery is automatic and begins with a soft-start power up. Recovery occurs when the the sensed temperature decreases 10 °C below the trip point.

Capacitor Recommendations for the PT5400 *SWIFT*™ Series of Power Modules

Input Capacitors

The recommended input capacitance is determined by 100 µF minimum capacitance, 300 mA (rms) minimum ripple current rating, and less than 300 mΩ equivalent series resistance (ESR). The ripple current rating, ESR, and operating temperature are the major considerations when selecting the input capacitor.

It is recommended that tantalum capacitors have a minimum voltage rating of at least twice the working voltage, including the ac ripple. This is necessary to insure reliability with 3.3-V input voltage bus applications.

Output Capacitors (optional)

The ESR of the output bulk (non-ceramic) capacitance must be between 10 mΩ ≤ESR ≤200 mΩ. Electrolytic capacitors have poor ripple performance at frequencies greater than 400 kHz but excellent low frequency transient response. Above the ripple frequency, ceramic decoupling capacitors are recommended to improve the transient response and reduce any high frequency noise components apparent during higher current excursions. A maximum of 100 µF ceramic capacitance may be added to the output bus.

Tantalum/ Ceramic Capacitors

Tantalum capacitors are acceptable on the output bus. Tantalum, Os-con®, or ceramic capacitor types are recommended for applications where ambient temperatures fall below 0 °C. Ceramic capacitors may be used instead of electrolytic types on both the input and output bus. The input bus must have at least the minimum amount of capacitance. For the output bus the total amount of ceramic capacitance should be limited to 100 µF.

Capacitor Tables

Table 2-1 identifies vendors with acceptable ESR and maximum allowable ripple current (rms) ratings. Capacitors recommended for the output are identified under the Output Bus column with the required quantity.

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 (at 100 kHz) are critical parameters necessary to insure both optimum regulator performance and long capacitor life.

Table 2-1; Recommended Input/Output Capacitors

Capacitor Vendor/ Component Series	Capacitor Characteristics					Quantity		
	Working Voltage	Value (µF)	(ESR) Equivalent Series Resistance	Max Ripple at 85 °C Current (Irms)	Physical Size (mm)	Input Bus	Output Bus	Vendor Number
Panasonic WA (SMT)	10V	120 µF	0.035 Ω	2800 mA	8.3×6.9	1	1	EEFWA1A121P
Panasonic FC FK (SMT)	16 V 16 V	220 µF 330 µF	0.150 Ω 0.160 Ω	555 mA 600 mA	10×10.2 8×10.2	1 1	1 1	EEUFC1C221 EEVFK1C331P
United Chemi–Con FS PXA (SMT) MVZ (SMT) PS	 10 V 10 V 16 V 10 V	 100 µF 120 µF 220 µF 270 µF	 0.040 Ω 0.027 Ω 0.170 Ω 0.014 Ω	 2100 mA 2430 mA 450 mA 4420 mA	 6.3×9.8 8×6.7 8×10 8×11.5	 1 1 1 1	 1 1 1 1	 10FS100M PXA10VC121MH80TP MVZ25VC221MH10TP 10PS270MH11
Nichicon(F55)SMT- WG (SMT) PM	10V 35 V 25 V	100 µF 100µF 150 µF	0.055 Ω 0.150 Ω 0.160 Ω	2000 mA 670 mA 460 mA	7,3x4,3 10×10 10×11.5	1 1 1	1 1 1	F551A101MN UWG1V101MNR1GS UPM1E151MPH
Sanyo Os-con® SVP (SMT) SP TPA	 10 V 16 V 10 V	 120 µF 100 µF 100 µF	 0.040 Ω 0.025 Ω 0.080 Ω	 >2500 mA >2800 mA >1200 mA	 7×8 6.3×9.8 7.3×4.8	 1 1 1	 1 1 1	 10SVP120M 16SPS100M 10TPA100M
AVX Tantalum TPS	10 V 10 V	100 µF 220 µF	0.100 Ω 0.100 Ω	>1090 mA >1414 mA	7.3L ×4.3W ×4.1H	1 1	1 1	TPSD107M010R0100 TPSV227M010R0100
Kemet T520 T495	10 V 10 V	100 µF 100 µF	0.080 Ω 0.100 Ω	1200 mA >1100 mA	7.3L ×5.7W ×4.0H	1 1	1 1	T520D107M010AS T495X107M010AS
Sprague 594D/595D	10 V 10 V	150 µF 120 µF	0.090 Ω 0.140 Ω	1100 mA >1000 mA	7.3L ×6.0W ×4.1H	1 1	1 1	594D157X0010C2T 595D127X0010D2T
TDK- Ceramic X5R Murata Ceramic X5R 1210 Case	6.3 V 6.3 V	47 µF 47 µF	0.002 Ω 0.002 Ω	>1400 mA >1000 mA	3.6L ×2.8W ×2.8H	2 2	2 (max) 2 (max)	C3225X5R0J476KT/MT GRM32ER60J476M/6.3

Using the Inhibit Control of the PT5400 *SWIFT*™ Series of Power Modules

For applications requiring output voltage On/Off control, the PT5400 series of SWIFT power modules incorporate an inhibit function. This function can be used wherever there is a requirement for the module to be switched off. The On/Off function is provided by the *Inhibit* (pin 1) control.

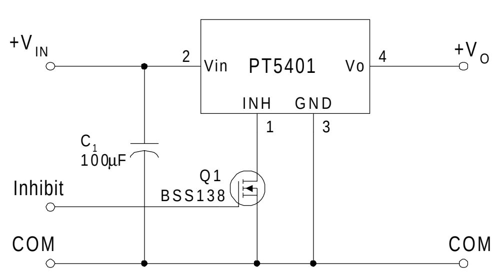
The ISR functions normally with Pin 1 open-circuit, providing a regulated output whenever a valid source voltage is applied to V_{in}, (pin 2). When a low-level[2] ground signal is applied to pin 1, the regulator output will be disabled.

Figure 3-1 shows an application schematic, which details the typical use of the Inhibit function. Note the discrete transistor (Q1). The Inhibit control has its own internal pull-up to $+V_{in}$ potential. An open-collector or open-drain device is required to control this input [1]. The Inhibit pin control thresholds are given in Table 3-1.

Table 3-1; Inhibit Control Requirements

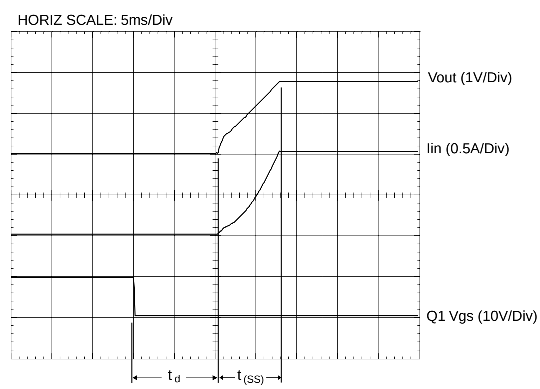
Parameter	Min	Max
Enable (V_{IH})	V_{in} – 0.5	Open
Disable (V_{IL})	–0.2V	+0.5V

Figure 3-1



Turn-On Time: In the circuit of Figure 3-1, turning Q_1 on applies a low-voltage to the *Inhibit* control (pin 1) and disables the regulator output. Correspondingly, turning Q_1 off allows the ISR to execute a soft-start power up. The soft-start power up consists of a short delay, t_d, followed by a period, $t_{(SS)}$, in which the output voltage rises from zero to its full regulation voltage. (See the section on Soft-Start Power Up). The module produces a fully regulated output voltage within 25msec. Figure 3-2 shows the typical rise in both output voltage and input current for a PT5404 (1.8V), following the turn-off of Q_1. The turn off of Q_1 corresponds to the drop in the Q_1 Vgs waveform. The time periods, t_d and $t_{(SS)}$, are indicated. The waveforms were measured with a 5Vdc input voltage, and 0.7-Ω resistive load.

Figure 3-2



Notes:

1. Use an open-collector device (preferably a discrete transistor) for the Inhibit input. A pull-up resistor is not necessary. To disable the output voltage, the control pin should be pulled low to less than +0.5VDC.

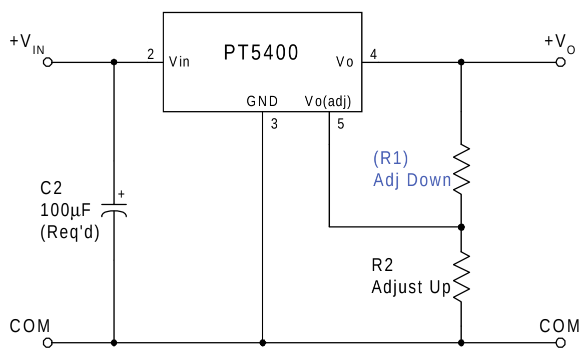
Adjusting the Output Voltage of the PT5400 Series of 6-A *SWIFT*™ Power Modules

The output voltage of the PT5400 series of SWIFT power modules may be adjusted higher or lower than the factory trimmed pre-set voltage with the addition of a single external resistor. Table 4-1 gives the allowable adjustment range for each model of 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 5 (V_o adj) and pin 3 (GND).

Adjust Down: Add a resistor (R_1), between pin 5 (V_o adj) and pin 4 (V_{out}).

Figure 4-1



The values of (R_1) [adjust down], and R_2 [adjust up], can either be calculated using the following formulas, or may be looked up from the range of values in Table 4-2. Refer to Figure 4-1 for the placement of the required resistor; either (R_1) or R_2 as appropriate.

$$(R_1) = \frac{R_o\,(V_a - 0.891)}{V_o - V_a} - 18.2 \quad k\Omega$$

$$R_2 = \frac{0.891\,R_o}{V_a - V_o} - 18.2 \quad k\Omega$$

Where: V_o = Original output voltage
V_a = Adjusted output voltage
R_o = The resistance value from Table 4-1

Notes:

1. Use a 1% (or better) tolerance 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 adj to either GND or V_{out}. Any capacitance added to the V_o adjust pin will affect the stability of the ISR.
3. For each model, adjustments to the output voltage may place additional limits on the minimum input voltage. The revised minimum input voltage must comply with the following requirement.

   $V_{in}(min)$ = $(V_a + 1.1)$ V or as specified in the data sheet, whichever is greater.
4. The PT5408 operates only from a 3.3-V input bus. The limited input to output voltage differential of this model does not allow it to be adjusted higher than its trimmed output voltage.

Table 4-1

ISR OUTPUT VOLTAGE ADJUSTMENT RANGE AND FORMULA PARAMETERS

Series Pt. No.	PT5401	PT5402	PT5408	PT5403	PT5404	PT5405	PT5406	PT5407
Input Bus	5 V	5 V	3.3 V 4	3.3/5 V	3.3/5 V	3.3/5 V	3.3/5 V	3.3/5 V
V_o (nom)	3.3 V	2.5 V	2.5 V	2 V	1.8 V	1.5 V	1.2 V	1 V
V_a (min)	2.9 V	2.0 V	2.0 V	1.65 V	1.5 V	1.3 V	1.1 V	0.97 V
V_a (max)	3.5 V	2.95 V	2.5 V 4	2.45 V	2.25 V	1.95 V	1.65 V	1.45 V
R_o (kΩ)	10.2	10.2	10.2	10.0	10.0	10.2	9.76	10.2

Table 4-2

ISR ADJUSTMENT RESISTOR VALUES

Series Pt. No.	**PT5401**	**PT5402/8**	**PT5403**	**PT5404**	**PT5405**	**PT5406**	**PT5407**
V_o (nom)	**3.3 V**	**2.5 V**	**2 V**	**1.8 V**	**1.5 V**	**1.2 V**	**1 V**
V_a (req.d)							
0.97							(8.7) kΩ
1.0							
1.05							164.0 kΩ
1.1						(2.2) kΩ	72.7 kΩ
1.15						(32.4) kΩ	42.4 kΩ
1.2							27.2 kΩ
1.25						156.0 kΩ	18.2 kΩ
1.3					(2.7) kΩ	68.8 kΩ	12.1 kΩ
1.35					(13.0) kΩ	39.8 kΩ	7.8 kΩ
1.4					(33.7) kΩ	25.3 kΩ	4.5 kΩ
1.45					(95.8) kΩ	16.6 kΩ	2.0 kΩ
1.5				(2.1) kΩ		10.8 kΩ	
1.55				(8.2) kΩ	164.0 kΩ	6.7 kΩ	
1.6				(17.3) kΩ	72.7 kΩ	3.5 kΩ	
1.65			(3.5) kΩ	(32.4) kΩ	42.4 kΩ	1.1 kΩ	
1.7			(8.8) kΩ	(62.7) kΩ	27.2 kΩ		
1.75			(16.2) kΩ	(154.0) kΩ	18.2 kΩ		
1.8			(27.3) kΩ		12.1 kΩ		
1.85			(45.7) kΩ	160.0 kΩ	7.8 kΩ		
1.9			(82.7) kΩ	70.9 kΩ	4.5 kΩ		
1.95			(194.0) kΩ	41.2 kΩ	2.0 kΩ		
2.0		(4.4) kΩ		26.4 kΩ			
2.05		(8.1) kΩ	160.0 kΩ (3)	17.4 kΩ (3)			
2.1		(12.6) kΩ	70.9 kΩ	11.5 kΩ			
2.15		(18.5) kΩ	41.2 kΩ	7.3 kΩ			
2.2		(26.3) kΩ	26.4 kΩ	4.1 kΩ			
2.25		(37.2) kΩ	17.4 kΩ	1.6 kΩ			
2.3		(53.7) kΩ	11.5 kΩ				
2.35		(81.0) kΩ	7.3 kΩ				
2.4		(136.0) kΩ	4.1 kΩ				
2.45		(300.0) kΩ	1.6 kΩ				
2.5							
2.55		(Note 4) 164.0 kΩ					
2.6		72.7 kΩ					
2.65		42.4 kΩ					
2.7		27.2 kΩ					
2.75		18.2 kΩ					
2.8		12.1 kΩ					
2.85		7.8 kΩ					
2.9	(33.0) kΩ	4.5 kΩ					
2.95	(41.8) kΩ	2.0 kΩ					
3.0	(53.5) kΩ						
3.05	(69.9) kΩ						
3.1	(94.5) kΩ						
3.15	(135.0) kΩ						
3.2	(217.0) kΩ						
3.25	(463.0) kΩ						
3.3							
3.35	164.0 kΩ						
3.4	72.7 kΩ						
3.45	42.4 kΩ						
3.48	32.3 kΩ						
3.50	27.2 kΩ						

R1 = (Blue) R2 = Black

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