# PT5520 Series

**1.5-A 5-V/3.3-V Input Adjustable Integrated Switching Regulator**

EXCALIBUR

**SLTS147A**

***(Revised 10/5/2001)***

## Features

- Single-Device: 5V/3.3V Input
- DSP Compatible
- 89% Efficiency
- Small Footprint
- Space-Saving package
- Adjustable Output Voltage
- Output Inhibit Function
- Short Circuit Protection
- Solderable Copper Case

## Description

The PT5520 Excalibur™ power modules are a series of high-performance Integrated Switching Regulators (ISRs). Rated 1.5A, these modules operate from input voltages as low as 3.1V to provide a local step-down power source. They are an ideal compliment to the industry's latest high-performance DSPs and microprocessors. The series includes output voltage options as low as 1.0VDC.

The PT5520 series is packaged in a 5-pin thermally efficient copper case. The case is solderable, has a small footprint, and can accommodate both through-hole and surface mount pin configurations.

The product features external output voltage adjustment, an inhibit function, and short circuit protection. A 100µF capacitor is required for proper operation.

## Ordering Information

| | |
|---|---|
| PT 5521☐ | =3.3 Volts |
| PT 5522☐ | =2.5 Volts |
| PT 5523☐ | =2.0 Volts |
| PT 5524☐ | =1.8 Volts |
| PT 5525☐ | =1.5 Volts |
| PT 5526☐ | =1.2 Volts |
| PT 5527☐ | =1.0 Volts |

## PT Series Suffix (PT1234x)

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

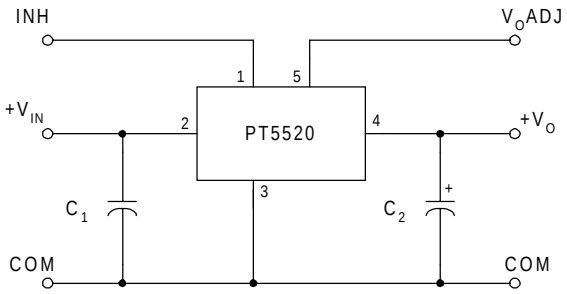
*(Reference the applicable package code drawing for the dimensions and PC board layout)*

## 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




$C_1$ = Optional 1µF ceramic
$C_2$ = Required 100µF (See Notes)

## Specifications (Unless otherwise stated, $T_a$ =25°C, $V_{in}$ =5V, $C_{out}$ =100µF, and $I_o$ =$I_o$max)

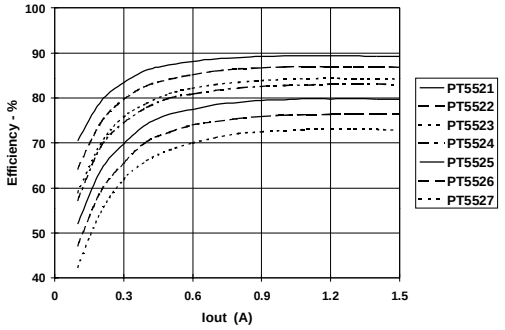
| Characteristics | Symbols | Conditions | | PT5520 SERIES Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| Output Current | $I_o$ | Over $V_{in}$ range | | 0.1 (1) | — | 1.5 | A |
| Input Voltage Range | $V_{in}$ | Over $I_o$ range | $V_o$ =3.3V<br>$V_o$≤2.5V | 4.5<br>3.1 | —<br> | 5.5<br>5.5 | V |
| Set-Point Voltage Tolerance | $V_o$ tol | | | — | — | ±2 | %$V_o$ |
| Temperature Variation | $\Delta Reg_{temp}$ | –40°C <$T_a$ <+85°C | | — | ±0.5 | — | %$V_o$ |
| Line Regulation | $\Delta Reg_{line}$ | Over $V_{in}$ range | | — | — | ±6 | mV |
| Load Regulation | $\Delta Reg_{load}$ | Over $I_o$ range | | — | — | ±10 | mV |
| Total Output Variation | $\Delta Reg_{tot}$ | Includes set-point, line, load,<br>–40°C ≤ $T_a$ ≤ +85°C | | — | — | ±3 | %$V_o$ |
| Efficiency | η | | PT5521<br>PT5522<br>PT5523<br>PT5524<br>PT5525<br>PT5526<br>PT5527 | —<br>—<br>—<br>—<br>—<br>—<br>— | 89<br>86<br>84<br>83<br>81<br>79<br>76 | —<br>—<br>—<br>—<br>—<br>—<br>— | % |
| $V_o$ Ripple (pk-pk) | $V_r$ | 20MHz bandwidth | | — | 15 | 30 | mV |
| Transient Response | $t_{tr}$<br>$\Delta V_{tr}$ | 1A/µs load step from 50% to 100% $I_o$max<br>$V_o$ over/undershoot | | —<br>— | 50<br>50 | —<br>100 | µSec<br>mV |
| Current Limit | $I_{lim}$ | | | — | 4 | — | A |
| Switching Frequency | $f_o$ | Over $V_{in}$ and $I_o$ ranges | | — | 600 (2) | — | kHz |
| Inhibit Control (pin1)<br>Input High Voltage<br>Input Low Voltage<br>Input Low Current | <br>$V_{IH}$<br>$V_{IL}$<br>$I_{IL}$ | <br>Referenced to GND (pin3)<br><br>Pin 1 to GND | | <br>$V_{in}$ –0.5<br>–0.2<br>— | <br>—<br><br>–0.5 | <br>Open (3)<br>0.5<br>— | <br>V<br><br>mA |
| External Capacitance | $C_{out}$ | | | 100 (4) | — | — | µF |
| Absolute Maximum<br>Operating Temperature Range | $T_a$ | Over $V_{in}$ range | | –40 (5) | — | +85 (6) | °C |
| Storage Temperature | $T_s$ | — | | -40 | — | +125 | °C |
| Mechanical Shock | | Per Mil-STD-883D, Method 2002.3 , 1 msec,<br>Half Sine, mounted to a fixture | | — | 500 | — | G's |
| Mechanical Vibration | | Per Mil-STD-883D, Method 2007.2,<br>20-2000 Hz, Soldered in a PC board | | — | 15 (7) | — | G's |
| Weight | — | — | | — | 6.5 | — | grams |
| Flammability | — | Materials meet UL 94V-0 | | | | | |

***Notes:*** *(1) The ISR will operate down to no load with reduced specifications.*
*(2) This is a typical value only. The switching frequency will vary with input voltage.*
*(3) 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 (<100nA) MOSFET is recommended to control this input. Ensure an On/Off transition time of ≤10µs. See application notes for more information.*
*(4) The PT5520 Series requires a 100µF electrolytic or tantalum output capacitor for proper operation in all applications.*
*(5) For operation below 0°C, the output capacitor $C_2$ must have stable characteristics. Use either a low ESR tantalum or Oscon® capacitor.*
*(6) See SOA curves or consult factory for the appropriate derating.*
*(7) The case pins on the through-hole package types (suffixes N & A) must be soldered. For more information see the applicable package outline drawing.*

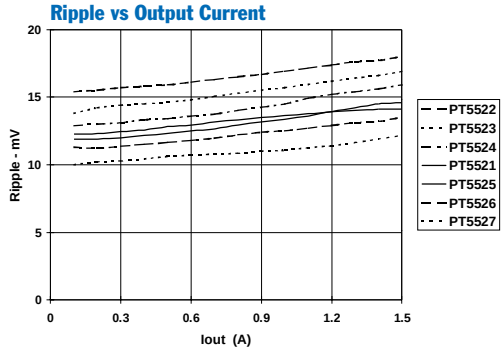
# Typical Characteristics

## Performance Data; $V_{in}$ =5.0V (See Note A)

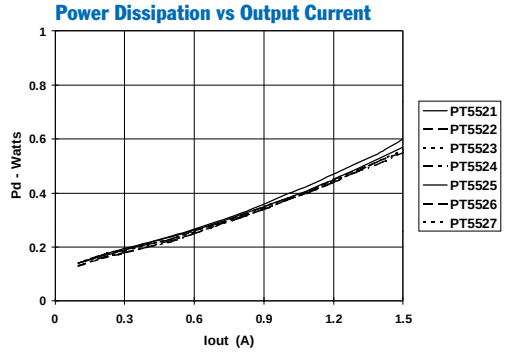
### Efficiency vs Output Current



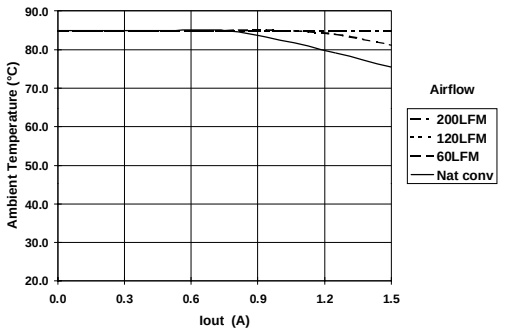

### Ripple vs Output Current




### Power Dissipation vs Output Current

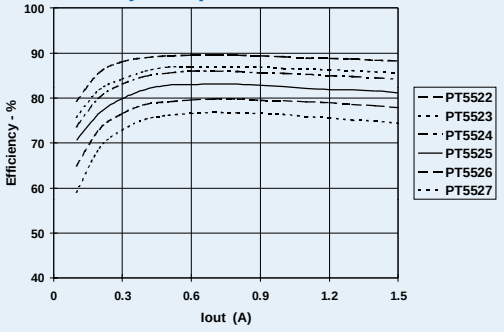



## Safe Operating Area; $V_{in}$ =5.0V (See Note B)

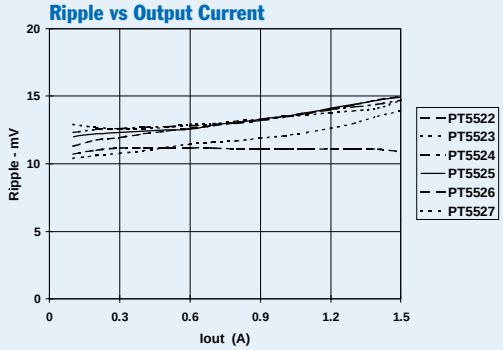



## Performance Data; $V_{in}$ =3.3V (See Note A)

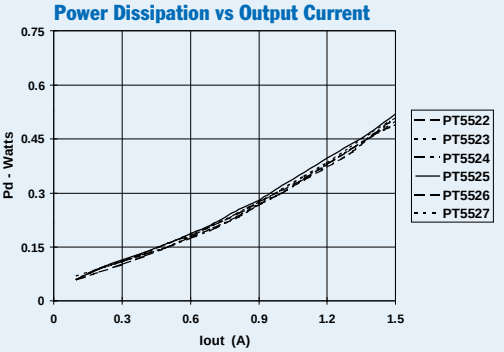
### Efficiency vs Output Current



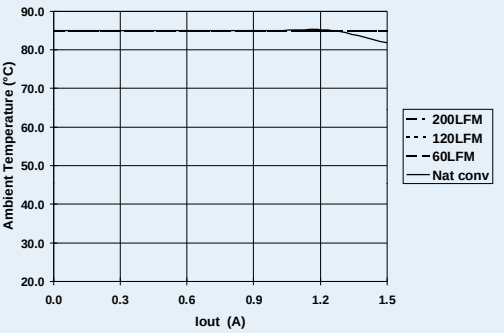

### Ripple vs Output Current




### Power Dissipation vs Output Current




## Safe Operating Area; $V_{in}$ =3.3V (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.*

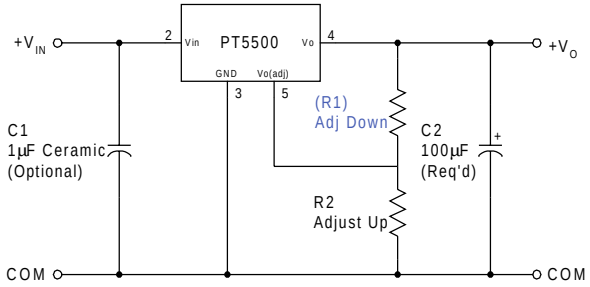
## Adjusting the Output Voltage of the PT5500/20 Series of Excalibur™ Step-Down ISRs

The output voltage of both the PT5500 and PT5520 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 for either 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 1***




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

$$(R_1) = \frac{R_o\,(V_a - 0.9)}{V_o - V_a} - R_s \quad k\Omega$$

$$R_2 = \frac{0.9\,R_o}{V_a - V_o} - R_s \quad k\Omega$$

Where: $V_o$ = Original output voltage
$V_a$ = Adjusted output voltage
$R_o$ = The resistance value from Table 1
$R_s$ = The series resistance from Table 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 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) = ($V_a$ + 0.5)V or as specified in the data sheet, whichever is greater.

***Table 1***

**ISR ADJUSTMENT RANGE AND FORMULA PARAMETERS**

| 3.0 Adc Rated | PT5501 | PT5502 | PT5503 | PT5504 | PT5505 | PT5506 | PT5507 |
|---|---|---|---|---|---|---|---|
| 1.5 Adc Rated | PT5521 | PT5522 | PT5523 | PT5524 | PT5525 | PT5526 | PT5527 |
| $V_o$ (nom) | 3.3 | 2.5 | 2.0 | 1.8 | 1.5 | 1.2 | 1.0 |
| $V_a$ (min) | 2.88 | 1.97 | 1.64 | 1.5 | 1.3 | 1.08 | 0.97 |
| $V_a$ (max) | 3.5 | 2.95 | 2.45 | 2.25 | 1.95 | 1.65 | 1.45 |
| $R_o$ (kΩ) | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.2 |
| $R_s$ (kΩ) | 49.9 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |

***Table 2***

| ISR ADJUSTMENT RESISTOR VALUES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **3.0 Adc Rated** | **PT5501** | **PT5502** | **PT5503** | **PT5504** | **PT5505** | **PT5506** | **PT5507** |
| **1.5 Adc Rated** | **PT5521** | **PT5522** | **PT5523** | **PT5524** | **PT5525** | **PT5526** | **PT5527** |
| **$V_o$ (nom)** | **3.3** | **2.5** | **2.0** | **1.8** | **1.5** | **1.2** | **1.0** |
| **$V_a$ (req.d)** | | | | | | | |
| 0.97 | | | | | | | (0.0)kΩ |
| 1.0 | | | | | | | |
| 1.05 | | | | | | | 164.0kΩ |
| 1.1 | | | | | | (0.0)kΩ | 72.8kΩ |
| 1.15 | | | | | | (30.0)kΩ | 41.2kΩ |
| 1.2 | | | | | | | 25.9kΩ |
| 1.25 | | | | | | 160.0kΩ | 16.7kΩ |
| 1.3 | | | | | (0.0)kΩ | 70.0kΩ | 10.6kΩ |
| 1.35 | | | | | (10.0)kΩ | 40.0kΩ | 6.2kΩ |
| 1.4 | | | | | (30.0)kΩ | 25.0kΩ | 3.0kΩ |
| 1.45 | | | | | (90.0)kΩ | 16.0kΩ | 0.4kΩ |
| 1.5 | | | | (0.0)kΩ | | 10.0kΩ | |
| 1.55 | | | | (6.0)kΩ | 160.0kΩ | 5.7kΩ | |
| 1.6 | | | | (15.0)kΩ | 70.0kΩ | 2.5kΩ | |
| 1.65 | | | (1.4)kΩ | (30.0)kΩ | 40.0kΩ | 0.0kΩ | |
| 1.7 | | | (6.7)kΩ | (60.0)kΩ | 25.0kΩ | | |
| 1.75 | | | (14.0)kΩ | (150.0)kΩ | 16.0kΩ | | |
| 1.8 | | | (25.0)kΩ | | 10.0kΩ | | |
| 1.85 | | | (43.3)kΩ | 160.0kΩ | 5.7kΩ | | |
| 1.9 | | | (80.0)kΩ | 70.0kΩ | 2.5kΩ | | |
| 1.95 | | | (190.0)kΩ | 40.0kΩ | 0.0kΩ | | |
| 2.0 | | (2.0)kΩ | | 25.0kΩ | | | |
| 2.05 | | (5.6)kΩ | 160.0kΩ | 16.0kΩ | | | |
| 2.1 | | (10.0)kΩ | 70.0kΩ | 10.0kΩ | | | |
| 2.15 | | (15.7)kΩ | 0.0kΩ | 5.7kΩ | | | |
| 2.2 | | (23.3)kΩ | 25.0kΩ | 2.5kΩ | | | |
| 2.25 | | (34.0)kΩ | 16.0kΩ | 0.0kΩ | | | |
| 2.3 | | (50.0)kΩ | 10.0kΩ | | | | |
| 2.35 | | (76.7)kΩ | 5.7kΩ | | | | |
| 2.4 | | (130.0)kΩ | 2.5kΩ | | | | |
| 2.45 | | (284.0)kΩ | 0.0kΩ | | | | |
| 2.5 | | | | | | | |
| 2.55 | | 160.0kΩ | | | | | |
| 2.6 | | 70.0kΩ | | | | | |
| 2.65 | | 40.0kΩ | | | | | |
| 2.7 | | 25.0kΩ | | | | | |
| 2.75 | | 16.0kΩ | | | | | |
| 2.8 | | 10.0kΩ | | | | | |
| 2.85 | | 5.7kΩ | | | | | |
| 2.9 | (0.0kΩ | 2.5kΩ | | | | | |
| 2.95 | (8.5)kΩ | 0.0kΩ | | | | | |
| 3.0 | (20.1)kΩ | | | | | | |
| 3.05 | (36.1)kΩ | | | | | | |
| 3.1 | (60.1)kΩ | | | | | | |
| 3.15 | (100.0)kΩ | | | | | | |
| 3.2 | (180.0)kΩ | | | | | | |
| 3.25 | (420.0)kΩ | | | | | | |
| 3.3 | | | | | | | |
| 3.35 | 130.0kΩ | | | | | | |
| 3.4 | 40.1kΩ | | | | | | |
| 3.45 | 10.1kΩ | | | | | | |
| 3.48 | 0.0kΩ | | | | | | |

R1 = (Blue) R2 = Black

## Using the Inhibit Control on the PT5500/PT5520 Series of Excalibur™ Step-Down ISRs

For applications requiring output voltage On/Off control, both the PT5500 and PT5520 series of power modules incorporate an inhibit function. This function can be used for power-up sequencing or 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 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 pin.

The Inhibit pin control thresholds are given in Table 1. Equation 1 may be used to determine the approximate current drawn from the input source, and by $Q_1$ when the regulator is in the inhibit state.

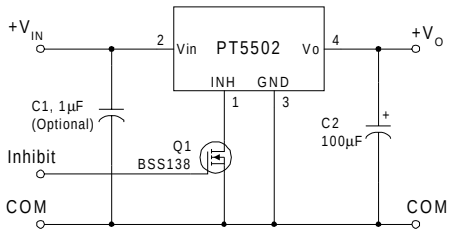
***Table 1; Inhibit Control Requirements***

| Parameter | Min | Max |
|---|---|---|
| Enable (VIH) | Vin – 0.5 | Open |
| Disable (VIL) | –0.2V | +0.5V |

***Equation 1***

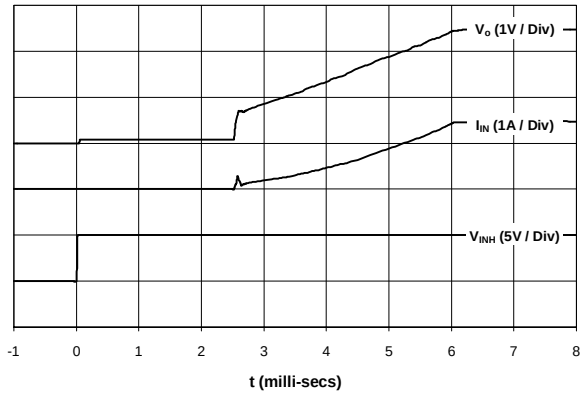
$$I_{inh} = V_{in} \div 10k\Omega \pm 20\%$$

***Figure 1***




**Turn-On Time:** In the circuit of Figure 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 *Inhibit* control pin to be pulled high by its internal pull-up resistor. The ISR produces a fully regulated output voltage within 10-msec of the release of the Inhibit control pin. The actual turn-on time will vary with input voltage, output load, and the total amount of load capacitance. Figure 2 shows the typical rise in both output voltage and input current for a PT5502 (2.5V) following the turn-off of $Q_1$ at time t =0. The waveform was measured with a 5Vdc input voltage, and 2.5A resistive load.

***Figure 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.
2. Do not control the Inhibit input with an external DC voltage. This will lead to erratic operation of the ISR and may over-stress the regulator.
5. Avoid capacitance greater than 500pF at the Inhibit control pin. Excessive capacitance at this pin will cause the ISR to produce a pulse on the output voltage bus at turn-on.
6. Keep the On/Off transition to less than 10µs. This prevents erratic operation of the ISR, which could cause a momentary high output voltage.

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Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265