PT7712—3.3V

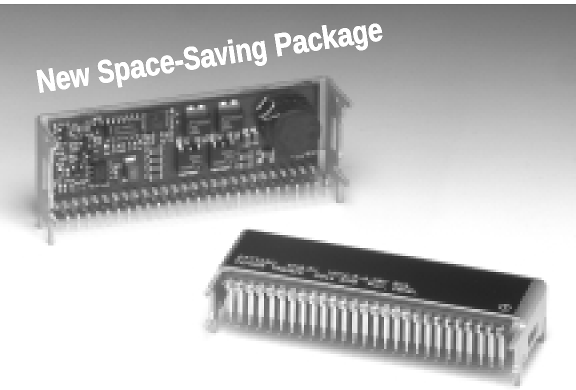
20 Amp Programmable
Next Generation "Big hammer"

EXCALIBUR

Power Trends Products from Texas Instruments

SLTS088

(Revised 6/30/2000)



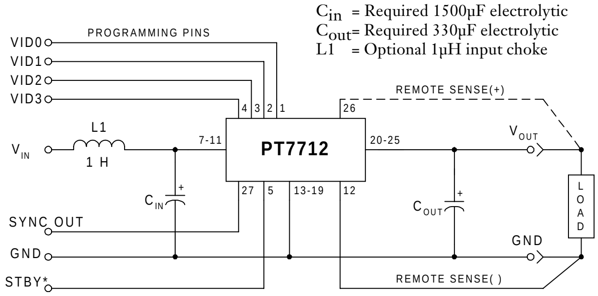
Patent pending on package assembly

- Single-Device: +3.3V Input
- 4-bit Programmable: 1.3V to 2.05V@20A
- High Efficiency
- Differential Remote Sense
- Short-Circuit Protection
- 27-Pin Space-Saving Package
- Solderable Copper Case
- Parallelable with PT7744 20A "Current Booster"

The PT7712 is the next generation "Big Hammer" integrated switching regulator (ISRs), which is housed in the new 27-pin space-saving copper package. The PT7712 operates off a 3.3V input source to provide a 20A low-voltage power source for the industry's latest DSPs, and µPs. The output voltage is also programmable from 1.3V to 2.05V with a 4-bit input, which is compatible with the Intel Pentium® Processor. This regulator includes short-circuit protection.

Standard Application

C_{in} = Required 1500µF electrolytic
C_{out}= Required 330µF electrolytic
L1 = Optional 1µH input choke



Pin-Out Information

Pin	Function	Pin	Function	Pin	Function
1	VID0	10	V_{in}	19	GND
2	VID1	11	V_{in}	20	V_{out}
3	VID2	12	Remote Sense Gnd (4)	21	V_{out}
4	VID3	13	GND	22	V_{out}
5	STBY* - Stand-by	14	GND	23	V_{out}
6	N/C	15	GND	24	V_{out}
7	V_{in}	16	GND	25	V_{out}
8	V_{in}	17	GND	26	Remote Sense V_{out}
9	V_{in}	18	GND	27	Sync Out

For STBY* pin:
open = output enabled
ground = output disabled.

Specifications

Characteristics (T_a = 25°C unless noted)	Symbols	Conditions		PT7712 SERIES Min	Typ	Max	Units
Output Current	I_o	T_a = +60°C, 200 LFM, pkg N T_a = +25°C, natural convection		0.1 (1) 0.1 (1)	— —	TBD 20	A
Input Voltage Range	V_{in}	$0.1A \le I_o \le 20A$	PT7712	3.1	—	3.6	V
Output Voltage Tolerance	ΔV_o	V_{in} = +3.3V, I_o = 20A 0°C ≤ T_a ≤ +65°C		Vo-0.03	—	Vo+0.03	V
Line Regulation	Reg_{line}	Over V_{in} range, I_o = 20A		—	±10	—	mV
Load Regulation	Reg_{load}	V_{in} = +3.3V, $0.1 \le I_o \le 20A$		—	±10	—	mV
V_o Ripple/Noise	V_n	V_{in} = +3.3V, I_o = 20A		—	50	—	mV
Transient Response with C_{out} = 330µF	t_{tr} V_{os}	I_o step between 10A and 20A V_o over/undershoot		— —	50 100	— —	µSec mV
Efficiency	η	V_{in} = +3.3V, I_o = 10A	V_o = 1.8V V_o = 1.5V	— —	86 85	— —	%
		V_{in} = +3.3V, I_o = 20A	V_o = 1.8V V_o = 1.5V	— —	82 80	— —	%
Switching Frequency	f_o	Over V_{in} range $0.1A \le I_o \le 20A$		300	350	400	kHz
Maximum Operating Temperature Range	T_a	Over V_{in} and Range		–40 (2)	—	+85 (3)	°C
Storage Temperature	T_s	—		-40	—	+125	°C
Mechanical Shock		Per Mil-STD-883D, Method 2002.3 1 msec, Half Sine, mounted to a fixture		—	500	—	G's
Mechanical Vibration		Per Mil-STD-883D, Method 2007.2, 20-2000 Hz, Soldered in a PC board		—	10	—	G's
Weight	—	Vertical/Horizontal		—	36	—	grams

Notes: *(1) ISR-will operate down to no load with reduced specifications.*
(2) For operation below 0°C, Cin and Cout must have stable characteristics. Use either low ESR tantalum or Oscon® capacitors.
(3) See safe Operating Area curves or consult factory for the appropriate derating.
(4) If the remote sense ground is not used, pin 12 must be connected to pin 13 for optimum output voltage accuracy.

External Capacitors: *The PT7712 require a minimum output capacitance of 330µF for proper operation. The PT7712 also requires an input capacitance of 1500µF, which must be rated for a minimum of 1.4Arms of ripple current. For transient or dynamic load applications, additional capacitance may be required. For further information refer to the application note regarding capacitor selection for this product.*

Input Filter: *An input filter inductor is optional for most applications. The inductor must be sized to handle 20ADC with a typical value of 1µH.*

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Programming Information

VID3	VID2	VID1	VID0	Vout
1	1	1	1	1.30V
1	1	1	0	1.35V
1	1	0	1	1.40V
1	1	0	0	1.45V
1	0	1	1	1.50V
1	0	1	0	1.55V
1	0	0	1	1.60V
1	0	0	0	1.65V
0	1	1	1	1.70V
0	1	1	0	1.75V
0	1	0	1	1.80V
0	1	0	0	1.85V
0	0	1	1	1.90V
0	0	1	0	1.95V
0	0	0	1	2.00V
0	0	0	0	2.05V

Logic 0 = Pin 12 potential (remote sense gnd)
Logic 1 = Open circuit (no pull-up resistors)
VID3 and VID4 may not be changed while the unit is operating.

PT Series Suffix (PT1234X)

Case/Pin Configuration	
Vertical Through-Hole	N
Horizontal Through-Hole	A
Horizontal Surface Mount	C

Ordering Information

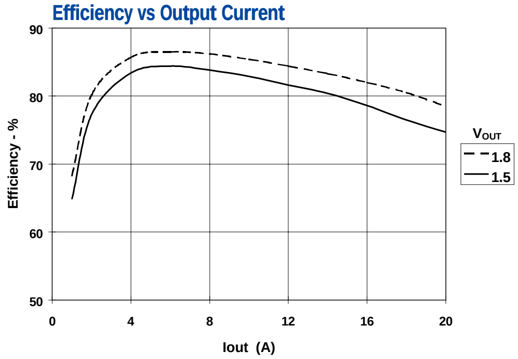
PT7712❑ = 1.3 to 2.05 Volts

(For dimensions and PC board layout, see Package Styles 1420 and 1430.)

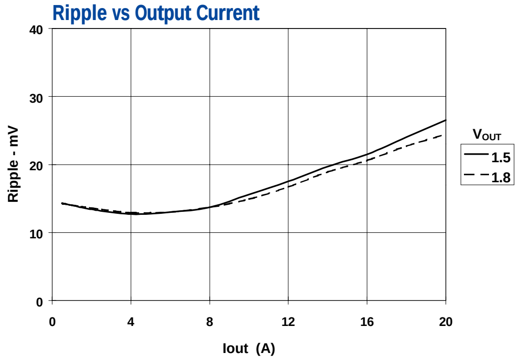
TYPICAL CHARACTERISTICS

PT7712, V_{in} =3.3 (See Note A)

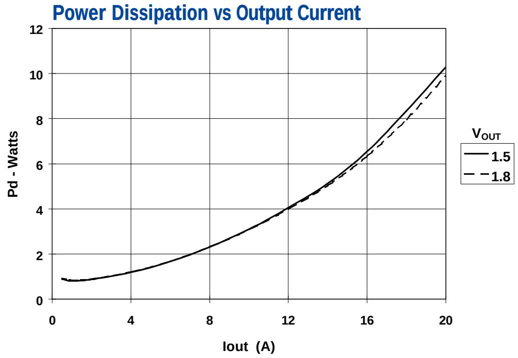
Efficiency vs Output Current



Ripple vs Output Current

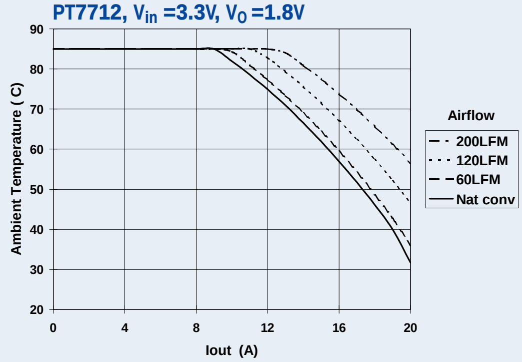


Power Dissipation vs Output Current



Safe Operating Area Curves (See Note B)

PT7712, V_{in} =3.3V, V_O =1.8V



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

Pin-Coded Output Voltage Adjustment on the "Next Generation Big Hammer" ISR Series

The PT7710 is Power Trends' next generation "Big Hammer" ISR series, and is a member of the Excalibur™ family of converters. These converters incorporate a pin-coded control to adjust the output voltage via the control pins VID0 - VID4 (pins 1, 2, 3, 4, & 6) respectively. When the control pins are left open-circuit, the ISR output will regulate at its factory trimmed output voltage. Each control pin is internally connected to a precision resistor, which when grounded changes the output voltage by a fixed magnitude. By selectively grounding VID0 -VID4, the output voltage these ISRs can be programmed in incremental steps over the specified output voltage range. In each case, the program code and output voltage range offered by these ISRs are compatible with the voltage ID specification defined by Intel Corporation for voltage regulator modules (VRMs) used to power Pentium® microprocessors. Refer to Figure 1 below for the connection schematic, and the respective device Data Sheet for the appropriate programming code information.

Notes:

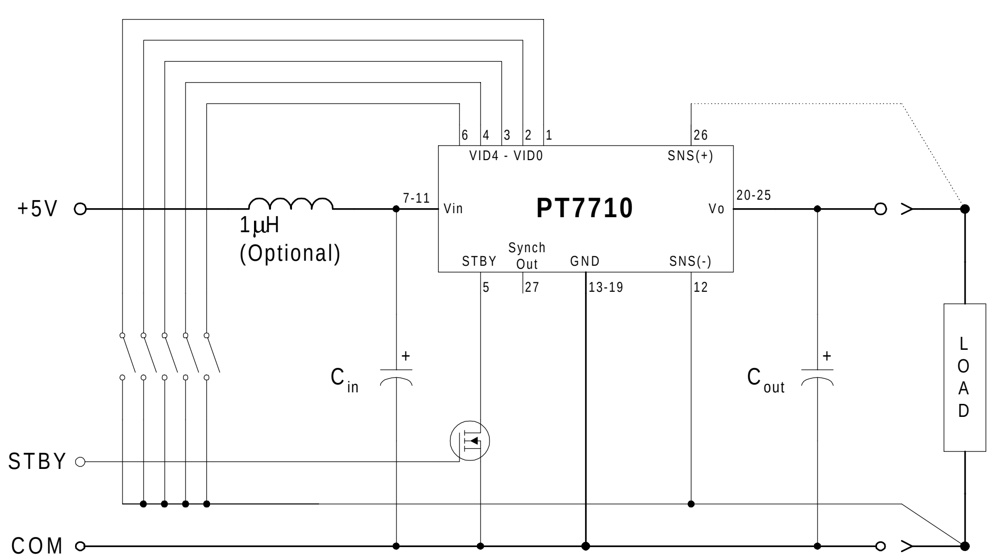
1. The programming convention is as follows:-

   Logic 0: Connect to pin12 (Remote Sense Ground).
   Logic 1: Open circuit/open drain (See notes 2, & 4)
2. Do not connect pull-up resistors to the voltage programming pins.
3. Use pin 12 (Remote Sense Ground) as the logic "0" reference. While the regular ground (pins 13-19) can also be used for programming, doing so will degrade the load reglation of the product. If the remote sense ground is not used, pin 12 must be connected to pin 13 for optimum output voltage accuracy.
4. If active devices are used to ground the voltage control pins, low-level open drain MOSFET devices should be used over bipolar transistors. The inherent V_{ce}(sat) in bipolar devices introduces errors in the device's internal divider network. Discrete transistors such as the BSS138, 2N7002, IRLML2402, or the 74C906 hex open-drain buffer are examples of appropriate devices.

Active Voltage Programming:

Special precautions should be taken when making changes to the voltage control progam code while the unit is powered. It is highly recommended that the ISR be either powered down or held in standby. Changes made to the program code while V_{out} is enabled induces high current transients through the device. This is the result of the electrolytic output capacitors being either charged or discharged to the new output voltage set-point. The transient current can be minimized by making only incremental changes to the binary code, i.e. one LSB at a time. A minimum of 100µs settling time between each program state is also recommended. Making non-incremental changes to VID3 and VID4 with the output enabled is discouraged. If they are changed, the transients induced can overstress the device resulting in a permanent drop in efficiency. If the use of active devices prevents the program code being asserted prior to power-up, pull pin 5 (STBY) to the device GND during the period that the input voltage is applied to V_{in}. Releasing pin 5 will then allow the device output to execute a soft-start power-up to the programmed voltage. For more information on the use of the Standby function, consult the related application note, "Using the Standby Function on the 'Next Generation Big Hammer' Programmable ISR Series."

Figure 1



Using the Standby Function on the Excalibur™ "Next Generation Big Hammer" ISR Series

For applications requiring output voltage On/Off control, the PT7710 "Next Generation Big Hammer" ISRs incorporate a standby function[1] . This feature may be used for power-up/shutdown sequencing, and to change the output voltage while input power is applied. *See related notes:* "Pin-coded Output Voltage Adjustment on the 'Next Generation Big Hammer' ISR Series."

The standby function is provided by the *STBY** control, pin 5. If pin 5 is left open-circuit the regulator operates normally, providing a regulated output whenever a valid supply voltage is applied to V_{in} (pins 7-11) with respect to GND (pins 13-19). Connecting pin 5 to ground [2] will set the regulator output to zero volts[3] . This places the regulator in standby mode, and reduces the input current to typcially 45mA (75mA max). If a ground signal is applied to pin 5 prior to power-up, the regulator output will be held at zero volts during the period that input power is applied.

The standby input is ideally controlled with an open-collector (or open-drain) discrete transistor (See Figure 1). Table 1 gives the threshold requirements.

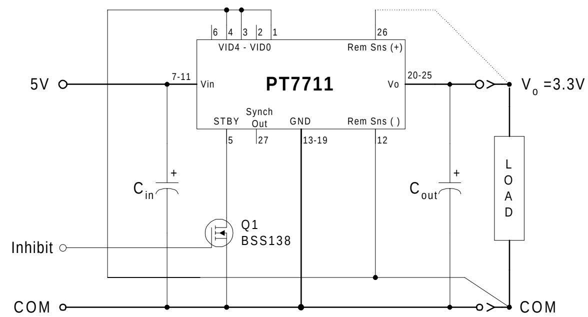
Table 1 Standby Control Circuit Parameters (2, 3)

Parameter	Min	Typ	Max
On/Off Threshold	0.4V		
Istby		0.5mA	
Vstby		12.6V	15V

Notes:

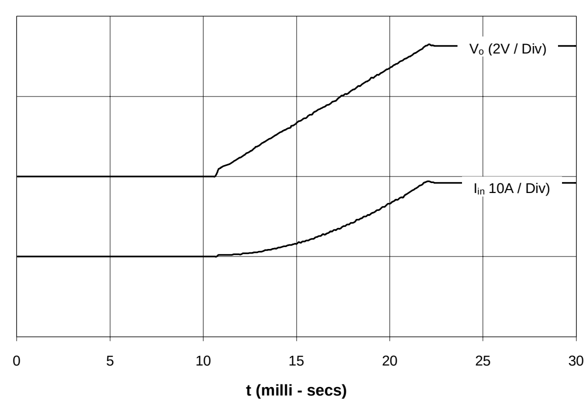
1. The Standby/Inhibit control logic is similar for all Power Trends' modules, but the flexibility and threshold tolerances will be different. For specific information on this function for other regulator models, consult the applicable application note.
2. The Standby input on the PT7710 regulator series can be controlled using an open-collector (or open-drain) discrete transistor. *Do Not* use a pull-up resistor. The control input has an open-circuit voltage of about 12Vdc. To set the regulator output to zero, the control pin must be "pulled" to less than 0.4Vdc with a low-level 0.5mA sink to ground.
3. When placed in the standby mode, the regulator output discharges the output capacitance with a low impedance to ground.
4. The turn-off time of Q_1, or rise time of the standby input is not critical on the PT7710 series. Turning Q_1 off slowly, over periods up to 100ms, will not affect regulator operation. However, a slow turn-off time will increase both the initial delay and rise-time of the output voltage.

Figure 1



Turn-On Time: Turning Q_1 in Figure 1 off, removes the low-voltage signal at pin 5 and enables the output. Following a brief delay of approximately 10ms, the output voltage of the PT7710 series regulators rise to full regulation within 15ms[4] . Figure 2 shows the typical output voltage waveform of a PT7711 following the prompt turn-off of Q_1 at time t =0 secs. The output voltage in Figure 1 is set to 3.3V by connecting VID0 (pin 1), VID2 (pin 3), and VID3 (pin 4) to the Remote Sense Gnd (pin 12)*. The waveform in Figure 2 was measured with a 5V input source voltage, and 10A resistive load.

Figure 2



* Consult the data sheet for details on other VID codes.

Capacitor Recommendations for the PT7711/12 Regulators and PT7744/45 Current Boosters

Input Capacitors

The recommended input capacitance is determined by 1.4 ampere minimum ripple current rating and 1500µF minimum capacitance. Capacitors listed below must be rated for a minimum of 2x the input voltage with +5V operation. Ripple current and ≤100mΩ Equivalent Series Resistance (ESR) values are the major considerations along with temperature when selecting the proper capacitor.

Output Capacitors

The minimum required output capacitance is 330µF with a maximum ESR less than or equal to 100mΩ. 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 with a minimum 10V rating are recommended on the output bus, but only the AVX TPS Series, Sprague 594/595 Series, or Kemet T495/T510 Series. The AVX TPS Series, Sprague Series or Kemet Series capacitors are specified over other types due to their higher surge current, excellent power dissipation and ripple current ratings. As an example, 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 a 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. The table below is a selection guide for input and output capacitors. Other capacitor vendors are available with comparable RMS ripple current rating and ESR (Equivalent Series Resistance at 100kHz). These 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 Number
Panasonic FC Surface Mtg FA	16V 35V 10V 16V	2200 330 680 1800	0.038Ω 0.065Ω 0.090Ω 0.032Ω	2000mA 1205mA 755mA 2000mA	18x16.5 12.5x16.5 10x12.5 18x15	1 1	1 1 1 1	EEVFC1C222N EEVFC1V331LQ EEUFA1A681 EEUFA1C182A
United Chemi -Con LFVSeries	25V 16V 16V	330 2200 470	0.084Ω 0.038Ω 0.084Ω/2=042Ω	825mA 1630mA 825mA x2	10x16 16x20 10x16	1	1 1 1	LXV25VB331M10X16LL LXV16VB222M16X20LL LXV16VB471M10X16LL
Nichicon PL Series PM Series	10V 10V 25V	680 1800 330	0.090Ω 0.044Ω 0.095Ω	770mA 1420mA 750mA	10x15 16x15 10x15	1	1 1 1	UPL1A681MHH6 UPL1A182MHH6 UPL1E331MPH6
Oscon SS SV	10V 10V	330 330	0.025W/4=0.006Ω 0.020/4=0.005Ω	>9800mA >9800mA	10x10.5 10.3x12.6	4 4	N/R (Note)	10SS330M 10SV330M(Sufvace Mtg
AVX Tanatalum TPS- Series	10V 10V	330 330	0.100/5=20Ω 0.060Ω	3500mA 1826mA	7.3Lx 4.3Wx 4.1H	5 5	1 1	TPSV337M010R0100 TPSV337M010R0060
Sprague Tantalum 595D/594D	10V 10V	330 680	0.045W/4=0.011Ω 0.090Ω	>4500mA >1660mA	7.3L x 5.7W x 4.0H	5 2	1 1	594D337X0010R2T Surface Mount 595D687X0010R2T
Kemet Tantalum T510/T495 Series	10V 10V	330 220	0.035Ω 0.070Ω/2=0.035Ω	2000mA >2000mA	4.3Wx7.3L x4.0H	5 6	1 2	510X337M010AS T495X227M010AS Surface Mount
Sanyo Poscap TPB	10V	220	0.040Ω	3000mA	7.2L x 4.3W x 3.1H	6	2	10TPB220M Surface Mount

Note: *(N/R) is not recommended for this application, due to extremely low Equivalent Series Resistance (ESR)*