PT6703—3.3V/5V

13-A Low-Voltage Programmable Integrated Switching Regulator

EXCALIBUR

SLTS151

(Revised 6/26/2001)



Features

- +3.3V/5V Input
- 13-A Output Current
- 5-Bit Programmable Output: 1.1V to 1.85V (25mV Steps)
- VRM 9.0 Compatible
- 86% Efficiency
- Standby On/Off Control
- Differential Remote Sense
- Over-Voltage Protection Drive
- Power Good Signal
- Short Circuit Protection
- Space Saving Solderable Case
- 4.7·10⁶ Hrs. MTBF

Description

The PT6703 is a fully integrated 13 A switching regulator housed in a space-saving solderable package. The PT6703 will operate from either a 3.3V or 5V input to provide a high-performance low-voltage output that is programmable over the range 1.1V to 1.85V. This output voltage range is specifically suited to high performance µP and DSP applications that require core supply voltages below 1.3V. The voltage control inputs are also TTL compatible. Additional features include output short circuit protection, a "Power Good" output, and an over-voltage protection (OVP) drive.

Ordering Information

PT6703❑ = 1.1 to 1.85 Volts

(For dimensions and PC board layout, see Package Styles 1300 & 1310.)

PT Series Suffix (PT1234X)

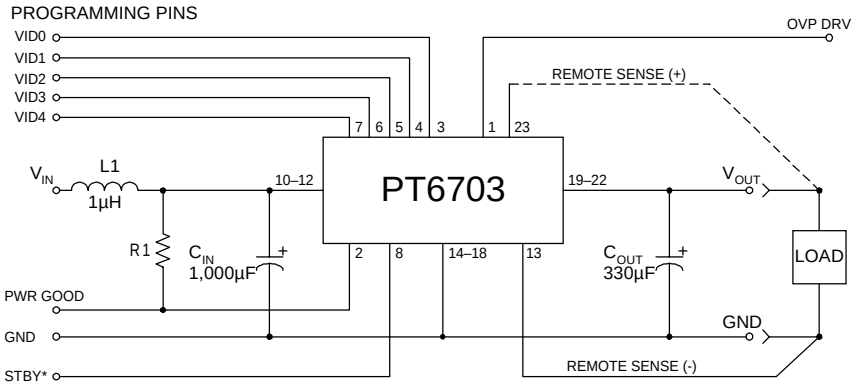
Case/Pin Configuration	
Vertical Through-Hole	**N**
Horizontal Through-Hole	**A**
Horizontal Surface Mount	**C**

Pin-Out Information

Pin	Function	Pin	Function
1	OVP Drive	13	Remote Sense Gnd (2)
2	Pwr Good	14	GND
3	VID0	15	GND
4	VID1	16	GND
5	VID2	17	GND
6	VID3	18	GND
7	VID4	19	V_{out}
8	STBY*	20	V_{out}
9	Do not connect	21	V_{out}
10	V_{in}	22	V_{out}
11	V_{in}	23	Remote Sense V_{out}
12	V_{in}		

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

Standard Application



C_{in}/C_{out}: Required electrolytic capacitors –see footnotes.
L_1: Optional 1µH input choke –see footnotes
R_1: 10-kΩ pull-up for Pwr Good signal.
Pwr Good is high when the output is within specification.

Programming Information

VID3	VID2	VID1	VID0	VID4=1 Vout	VID4=0 Vout
1	1	1	1	0.000V	1.475V
1	1	1	0	1.100V	1.500V
1	1	0	1	1.125V	1.525V
1	1	0	0	1.150V	1.550V
1	0	1	1	1.175V	1.575V
1	0	1	0	1.200V	1.600V
1	0	0	1	1.225V	1.625V
1	0	0	0	1.250V	1.650V
0	1	1	1	1.275V	1.675V
0	1	1	0	1.300V	1.700V
0	1	0	1	1.325V	1.725V
0	1	0	0	1.350V	1.750V
0	0	1	1	1.375V	1.775V
0	0	1	0	1.400V	1.800V
0	0	0	1	1.425V	1.825V
0	0	0	0	1.450V	1.850V

Logic 0 = Pin 13 potential (remote sense gnd)
Logic 1 = Open circuit (no pull-up resistors)
VID4 may not be changed while the unit is operating.

PT6700 Product Family Comparison

		Input Voltage	Adjust Method	Program Range	OVP/ Pwr Good	+12V Bias Required
	PT6701	5V	5-Bit	1.3V– 3.5V	✓	
	PT6702	3.3V	4-Bit	1.3V– 2.05V	✓	
	PT6703	3.3V/5V	5-Bit	1.1V– 1.85V	✓	
#	**PT6705**	5V	Resistor	1.5V–3.3V		✓
#	**PT6715**	5V	Resistor	1.5V–3.3V		
	PT6721	12V	5-Bit	1.3V– 3.5V	✓	
	PT6722	12V	5-Bit	1.1V– 1.85V	✓	
#	**PT6725**	12V	Resistor	1.5V–5.0V		

–Indicates a series of products that have a nominal output voltage set-point and may be adjusted with an external resistor.

Specifications (Unless otherwise stated, T_a =25°C, V_{in} =3.3V, C_{out} =330µF, and I_o =$I_o$max)

Characteristic	Symbol	Conditions		PT6703 SERIES Min	Typ	Max	Units
Output Current	I_o	Ta =+60°C, 200LFM Ta =+25°C, natural convection		0.1 (1) 0.1 (1)	— —	13.0 13.0	A
Input Voltage Range	V_{in}	Over I_o Range		3.1	—	5.5	VDC
Set Point Voltage Tolerance	V_o tol			—	±10	±20 (2)	mV
Temperature Variation	Reg_{temp}	–40° >T_a > +85°C		—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range		—	±2.5	±5	mV
Load Regulation	Reg_{load}	Over I_o range		—	±2.5	±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° >T_a > +85°C		—	±25	—	mV
Efficiency	η	I_o =8A	V_o =1.8V V_o =1.2V	— —	86 81	— —	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth		—	25	—	mV_{pp}
Transient Response	t_{tr}	0.1A/µs load step, 6A to 12A		—	50	—	µs
	ΔV_{tr}	V_o over/undershoot		—	±100	—	mV
Short Circuit Current	I_{sc}			—	20	—	A
Switching Frequency	f_o	Over V_{in} range		300	350	400	kHz
Standby Control (pin 8) Input High Voltage Input Low Voltage Input Low Current	 V_{IH} V_{IL} I_{IL}	 Referenced to GND (pin 14) Pin 8 to GND		 — –0.2 —	 — 0.4 10	 Open (3) 1.0 –	 V µA
Standby Input Current	I_{in} standby	pins 8 & 14 connected		—	20	30	mA
External Output Capacitance	C_{out}			330 (4)	—	15,000	µF
Maximum Operating Temperature Range	T_a	Over V_{in} range		-40	—	+85 (5)	°C
Storage Temperature	T_s	—		-40	—	+125	°C
Reliability	MTBF	Per Bellcore TR-332 50% stress, T_a =40°C, ground benign		4.7	—	—	10^6 Hrs
Mechanical Shock	—	Per Mil-Std-883D, method 2002.3, 1mS, half-sine, mounted to a fixture		—	500	—	G's
Mechanical Vibration	—	Per Mil-Std-883D, method 2007.2, 20-2000Hz, soldered in a PC board		—	15	—	G's
Weight	—	—		—	26	—	grams
Flammability	—	Materials meet UL 94V-0					

Notes: *(1) ISR-will operate down to no load with reduced specifications.*
(2) If the remote sense ground is not used, pin 13 must be connected to pin 14 for optimal output voltage accuracy.
(3) The Standby control (pin 8) 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 must be used to control this input. The open-circuit voltage is less than 10V. See application notes for further information.
(4) For operation below 0°C, Cin and Cout must have stable characteristics. Use either low ESR tantalum or Oscon® capacitors.
(5) See Safe Operating Area curves.

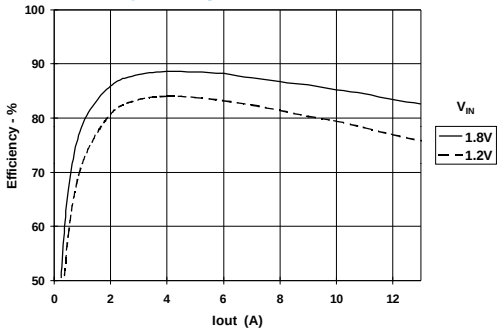
External Capacitors: *The PT6703 requires a minimum ouput capacitance of 330µF, and a minimum input capacitance of 1,000µF for proper operation. The input capacitance must be rated for a minimum of 1.0Arms of ripple current. For transient or dynamic load applications, additional input and output capacitance may be required.The maximum allowable output capacitance is 15,000µF. For more information refer to the application note regarding capacitor selection for this product.*

Input Inductor: *An input filter inductor is optional for most applications. The inductor must be sized to handle 10.0ADC with a typical value of 1µH.*

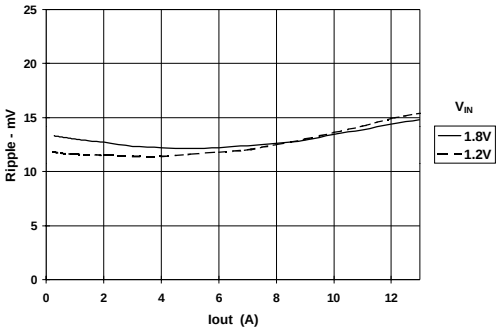
Typical Characteristics

PT6703 Characterization, V_{in} =3.3V (See Note A)

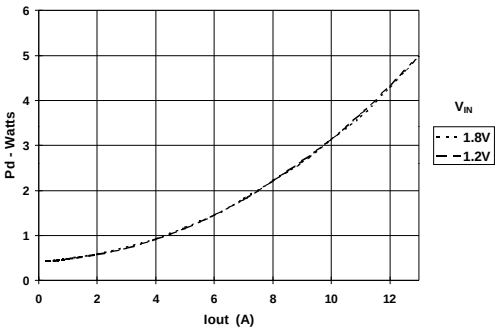
Efficiency vs Output Current



Ripple vs Output Current

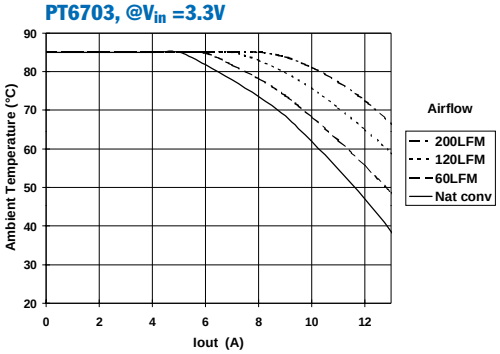


Power Dissipation vs Output Current



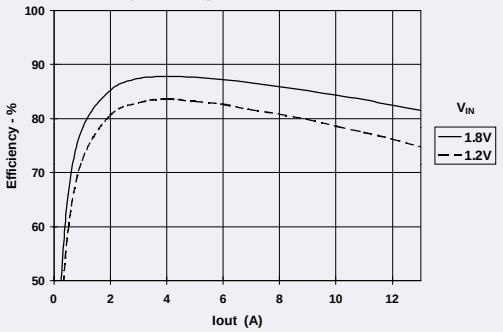
Safe Operating Area Curve (See Note B)

PT6703, @V_{in} =3.3V

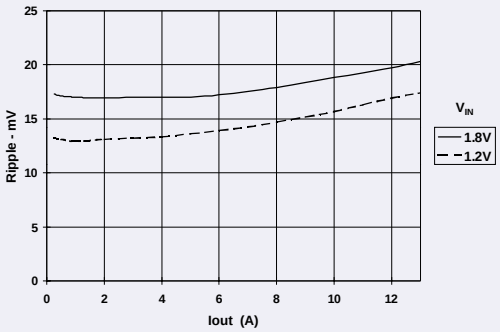


PT6703 Characterization, V_{in} =5V (See Note A)

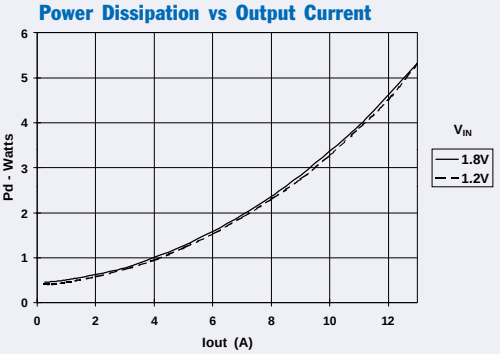
Efficiency vs Output Current



Ripple vs Output Current

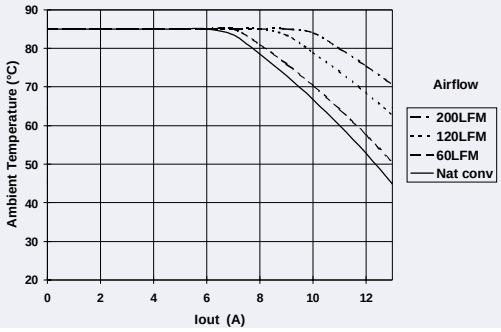


Power Dissipation vs Output Current



Safe Operating Area Curve (See Note B)

PT6703, @V_{in} =5.0V



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*

Operating Features of the Programmable PT6700 "Excalibur™" Series ISRs

Power Good

Programmable versions of the PT6700 Series regulators incorporate a *PWR Good* output (pin 2). This output is open-drain and generates an acitve-high signal when the sensed output from the ISR is within a nominal ±10% of the programmed set point. When the regulated output is outside this range, pin 2 asserts a logic low (typically <0.1V). A 10-kΩ pull-up resistor to a valid bus voltage is required. If the power good feature is not used, the pull-up resistor can be omitted. The maximum voltage that may be applied to the pull-up resistor is 15V.

Over-Voltage Protection (OVP)

The PT6700 programmable regulators also incorporate an OVP function. The *OVP DRV* (pin 1) normally has a logic low output (typically <0.1V). When the ISR's sensed output exceeds the programmed output setting by 15%, pin 1 produces a 60mA, +12V drive signal. This drive signal can trigger an SCR, which can be used to disable the input voltage (via a fuse), or alternatively interface to another external monitoring device. When the ISR output voltage returns to within 15% of its programmed setting, pin 1 reverts back to its low state. If the OVP function is not used, pin 1 may be left open circuit.

Stand-By Function

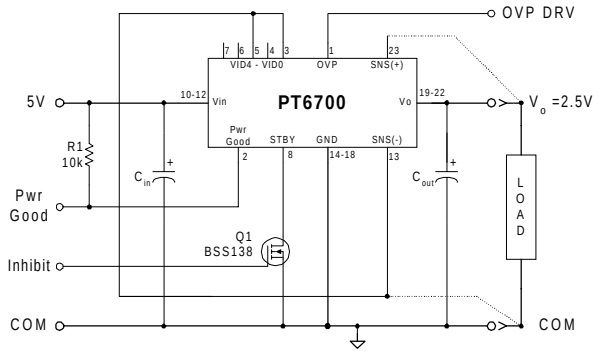
The PT6700 series ISRs incorporate a standby function. This feature may be used for power-up sequencing, or wherever there is a requirement for the output voltage to be controlled by external circuitry.

If the *STBY** input (pin 8) is left open-circuit the regulator operates normally, providing a regulated output when a valid supply voltage is applied to V_{in} (pins 10-12) with respect to GND (pins 14-18). Connecting pin 8 to ground[1] places the regulator in standby mode [2], and reduces the input current to typically 20mA (30mA max). Applying a ground signal to pin 8 prior to power-up, will disable the output during the period that input power is applied. To ensure that the regulator output is properly enabled, pin 8 must be open circuit.

Table 1 Standby Control Requirements [2]

Parameter	Min	Typ	Max
Enable	Open Cct. [1]		
Disable	-0.1V	0.4V	1.0V
I_{stby}		10µA	

Figure 1



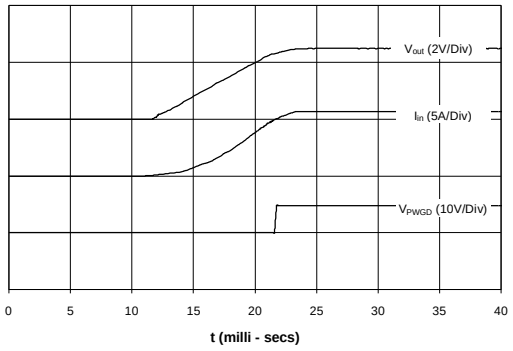
Notes:

1. The standby on a PT6700 series regulator must be controlled with an open-drain low-leakage (<100nA) MOSFET (See fig. 1). Table 1 gives the threshold requirements. *Do Not* use a pull-up resistor. The control input has an open-circuit voltage of between 4Vdc and 5Vdc. To set the regulator output to zero, the control pin must be "pulled" to less than 1.0Vdc by sinking current to ground.
2. When placed in the standby mode, the regulator output may assert a low impedance to ground. If an external voltage is applied to the output, it will sink current and possibly overstress the part.

Turn-On Time

Turning Q_1 in Figure 1 off, removes the low-voltage signal at pin 8. After a 10-15ms delay the regulator output rises and reaches full output voltage within 30ms. Fig. 2 shows the typical waveforms of a PT6701 following the prompt turn-off of Q_1 at time t =0 secs. The output voltage was set to 2.5V, and the waveforms were measured with a 5V input source, and 10A resistive load.

Figure 2



Pin-Coded Output Voltage Adjustment on the Non-Isolated "Excalibur™" Series ISRs

The PT6701/6702/6703, and PT6721/6722 Excalibur™ ISRs incorporate a pin-coded control to program the output voltage. Depending on the resolution and adjustment range, there are up to five control pins. They are identified VID0–VID4 (pins 3–7) respectively. When the control pins are left open-circuit the ISR output will regulate at its factory trimmed output voltage. By selectively grounding VID0-VID4, the output voltage can be programmed in incremental steps over the specified output voltage range. The program code and output voltage range of these ISRs may also be compatible with the "Voltage ID" specification defined for popular microprocessors. Refer to Figure 1 below for the connection schematic, and the applicable Data Sheet for the program code.

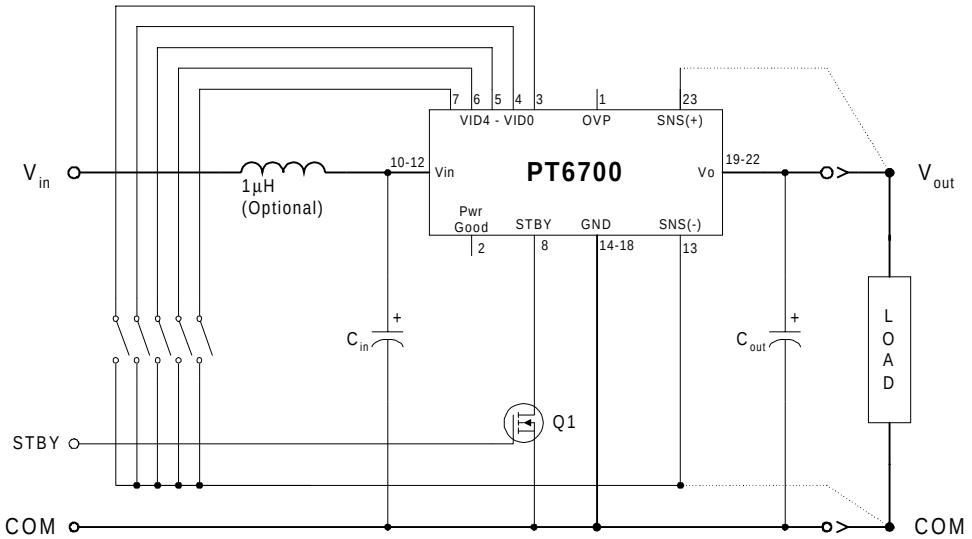
Notes:

1. The programming convention is as follows:-
   Logic 0: Connect to pin13 (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. To minimize output voltage error, always use pin 13 (Remote Sense Ground) as the logic "0" reference. While the regular ground (pins 14-18) can also be used for programming, doing so will degrade the load regulation of the product.
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 voltage control circuit. 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 8 (STBY) to the device GND during the period that the input voltage is applied to V_{in}. Releasing pin 8 will then allow the device output to initiate a soft-start power-up to the new program voltage.

Figure 1



Capacitor Recommendations for the Non-Isolated 13-A Excalibur™ Series of Regulators

Input Capacitors

The recommended input capacitance is determined by the 1.0 ampere minimum ripple current rating and 1000µF 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 high frequency noise components apparent during higher current excursions. Preferred low ESR type capacitor part numbers are identified in 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 a caution, 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 suggested 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	85°C Maximum Ripple Current(Irms)	Physical Size(mm)	Input Bus	Output Bus	Vendor Number
Panasonic FC Surface Mtg	10V 35V	1000 330	0.065Ω 0.065Ω	1205mA 1205mA	12.5x16.5 12.5x16.5	1	1 1	EEVFC1A102LQ EEVFC1V331LQ
FC Radial	25V 10V	330 1200	0.090Ω 0.065Ω	765mA 1205mA	10x12.5 12.5x15	1	1 1	EEUFA1E331 EEUFC1A122S
United Chemi -Con LFZ Radial FX Surface Mtg	25V 10V 6.3V 10V	330 1000 1000 680	0.090Ω 0.068Ω 0.013Ω 0.015Ω/2=0.007Ω	760mA 1050mA 4935mA >7000mA	10x12.5 10x16 10x10.5 10X10.5	1 1 2	1 1 1 1	LXZ25VB331M10X12LL LXZ35VB102M10X16LL 6FX1000M(Vin 3.3V) 10FX680M(Os-con)
Nichicon PL Series PM Series	25V 10V 25V	330 1000 330	0.095Ω 0.065Ω 0.095Ω	750mA 1040mA 750mA	10x15 12.5x15 10x15	1	1 1 1	UPL1E331MPH6 UPL1A102MHH6 UPM1E331MPH6
Oscon SS SV	10V 10V	330 330	0.025Ω/3=0.008Ω 0.020Ω/3=0.007Ω	>7000mA >7000mA	10x10.5 10.3x12.6	3 3	1 1	10SS330M 10SV330M(Surface Mtg)
AVX Tanatalum TPS- Series	10V 10V	330 330	0.100Ω/3=0.034Ω 0.060Ω/3=0.02Ω	>3500mA >3500mA	7.0Lx 5.97Wx 3.45H	3 3	1 1	TPSV337M010R0100 TPSV337M010R0060
Vishay/Sprague Tantalum 595D/594D	10V 10V	330 680	0.045Ω/3=0.015Ω 0.090Ω/4=0.023Ω	>4600mA >2500mA	7.2L x 6.0W x 3.5H	3 2	1 1	594D337X0010R2T Surface Mount 595D687X0010R2T
Kemet Tantalum T510/T495 Series	10V 10V	330 220	0.035Ω/3=0.012Ω 0.070Ω/5=0.035Ω	>5000mA >3000mA	4.3Wx7.3L x4.0H	3 5	1 2	T510X337M010AS T495X227M010AS Surface Mount
Sanyo Poscap TPB	10V	220	0.040Ω/5=0.008Ω	>3000mA	7.2L x 4.3W x 3.1H	5	2	10TPB220M Surface Mount

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