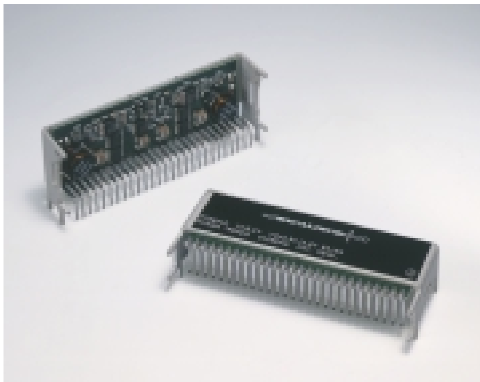
THE DATASHEET OF

PT6942C



Features

- High Efficiency Dual Output *(See Ordering Information)*
- Ideal Power Source for DSPs
- 5V/3.3V Input
- 6A Rated (Both Outputs)
- Internal Power-up Sequencing
- Single On/Off Control
- Independent Adjust/Trim
- Remote Sensing (Vo_1 & Vo_2)
- Soft-Start
- Short-Circuit Protection (coordinated shutdown)
- 27-pin Space-Saving Package
- Solderable Copper Case

Description

The PT6940 Excalibur™ power modules are a series of high-efficiency dual-output regulators, housed in a solderable space-saving package. The dual output is ideal for DSP applications that require a second voltage source for a processor core.

Both outputs from the PT6940 regulator modules are rated to deliver a full 6A load current simultaneously, and are internally sequenced to comply with the power-up requirements of popular DSP ICs.

Each output can be independently adjusted with a single external resistor, and incorporates an output sense to compensate for voltage drop between the regulator and load. A short-circuit load fault at either output will result in the coordinated shutdown of both voltages.

Ordering Information

PT6941❑ = +3.3/2.5 Volts
PT6942❑ = +3.3/1.8 Volts
PT6943❑ = +3.3/1.5 Volts
PT6944❑ = +3.3/1.2 Volts
† PT6946❑ = +2.5/1.8 Volts
† PT6947❑ = +2.5/1.5 Volts
† PT6948❑ = +2.5/1.2 Volts

† -Denotes models that will also operate off 3.3V input bus.

PT Series Suffix (PT1234x)

Case/Pin Configuration	Order Suffix	Package Code
Vertical	N	(ENE)
Horizontal	A	(ENF)
SMD	C	(ENG)

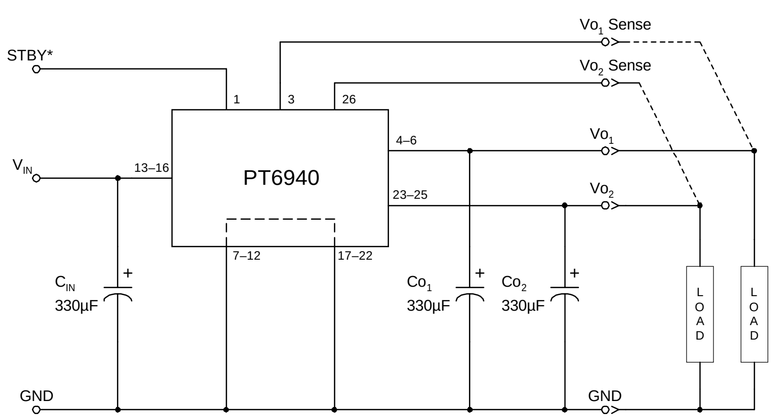
(Reference the applicable package code drawing for the dimensions and PC layout)

Pin-Out Information

Pin	Function	Pin	Function
1	STBY* †	15	V_{in}
2	Vo_1 Adjust	16	V_{in}
3	Vo_1 Sense	17	GND
4	Vo_1	18	GND
5	Vo_1	19	GND
6	Vo_1	20	GND
7	GND	21	GND
8	GND	22	GND
9	GND	23	Vo_2
10	GND	24	Vo_2
11	GND	25	Vo_2
12	GND	26	Vo_2 Sense
13	V_{in}	27	Vo_2 Adjust
14	V_{in}		

† STBY pin: Open = Outputs enabled*
Ground = Outputs disabled

Standard Application



C_{in} = Req'd 330µF * electrolytic
Co_1/Co_2 = Req'd 330µF * electrolytic
*300µF for Oscon® or low ESR tantalum (see application notes)

General Specifications (Unless otherwise stated, T_a =25°C, V_{in} =5V, C_{in} =330µF, Co_1 =330µF, Co_2 =330µF, and Io_1/Io_2 =Iomax)

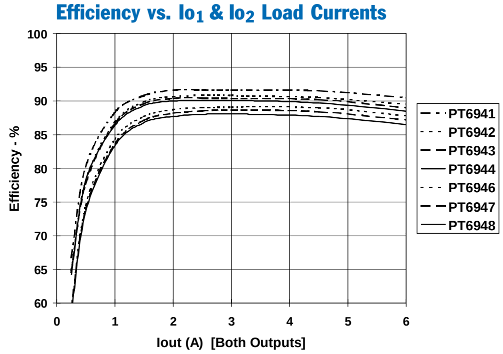
Characteristic	Symbol	Conditions		PT6940 Series Min	Typ	Max	Units
Output Current	I_o (1)	T_a =25°C, natural convection T_a =60°C, 200LFM airflow		0.1 (2) 0.1 (2)	— —	6 6	A
Input Voltage Range	V_{in}	Over I_o Range	Vo_1 ≤2.5V Vo_1 >2.5V	3.1 4.5	— —	5.5 5.5	V
Set Point Voltage Tolerance	V_o tol			—	±0.5	±2	%V_o
Temperature Variation	Reg_{temp}	–40° ≤T_a≤ +85°C, I_o =$I_o$min		—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range		—	±5	±10	mV
Load Regulation	Reg_{load}	Over I_o range		—	±5	±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° ≤T_a ≤ +85°C	V_o =3.3V V_o =2.5V V_o =1.8V V_o =1.5V V_o =1.2V	— — — — —	±43 ±35 ±28 ±25 ±22	±100 ±75 ±54 ±45 ±36	mV
Efficiency	η	V_{in} =5V, Io_1 = Io_2 =4A	PT6941 PT6942 PT6943 PT6944 PT6946 PT6947 PT6948	— — — — — — —	92 91 90 90 89 88 87	— — — — — — —	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth		—	35	—	mV_{pp}
Transient Response	t_{tr}	1A/µs load step, 50% to 100% $I_o$max		—	60	—	µs
	ΔV_{tr}	V_o over/undershoot		—	±70	—	mV
Short Circuit Threshold	I_{sc}(pk)	Reset followed by auto-recovery		—	13 (3)	—	A
Switching Frequency	f_o	Over V_{in} range		300	350	400	kHz
STBY* (Pin 1) Input High Voltage Input Low Voltage	 V_{IH} V_{IL}	Referenced to GND (pin 7)		 — –0.1	 — —	 Open (4) +0.4	V
Input Low Current	I_{IL}			—	-0.5	–	mA
Quiescent Current	I_{in} standby	pin 1 to GND		—	10	20	mA
External Output Capacitance		Both outputs		330	—	TBD	µF
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, ½ Sine, mounted		—	TBD	—	G's
Mechanical Vibration		Mil-STD-883D Method 2007.2, 20-2000 Hz	Vertical Horizontal	— —	TBD (7) TBD (7)	— —	G's
Weight	—	Vertical/Horizontal		—	34	—	grams
Flammability	—	Meets UL 94V-O					

Notes: *(1) The outputs, Vo_1 and Vo_2, have similar characteristics. The applicable performance parameters are defined according to output voltage.*
(2) The minimum output current applies to each output. The module will operate at no load with reduced specifications.
(3) A short-circuit load fault at either output causes the module to continuously reset, affecting both outputs.
(4) The STBY control (pin 1) has an internal pull-up, and if it is left open circuit the module will operate when input power is applied. The open-circuit voltage is approximately the input voltage, V_{in}. Refer to the application notes for interface considerations.*
(5) For operating temperatures below 0°C, Cin, Co_1, and Co_2 must have stable characteristics. Use either tantalum or Oscon® capacitors.
(6) See Safe Operating Area curves for the specific output voltage combination, or contact the factory for the appropriate derating.
(7) Only the case pins on through-hole pin configurations (N & A) must be soldered. For more information see the applicable package outline drawing.

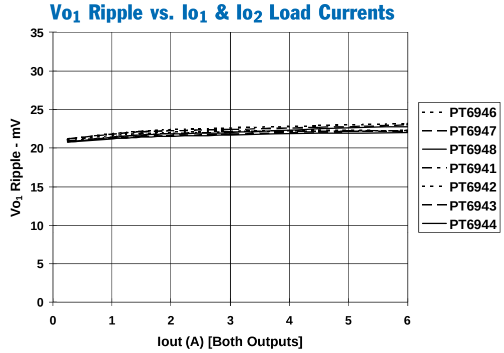
Input/Output Capacitors: *The PT6940 series requires a 330µF electrolytic capacitor at the input and both outputs for proper operation (300µF for Oscon® or low ESR tantalum). In addition, the input capacitance must be rated for a minimum of 1.0Arms ripple current. For transient or dynamic load applications, additional capacitance may be required. Refer to the application notes for more information.*

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

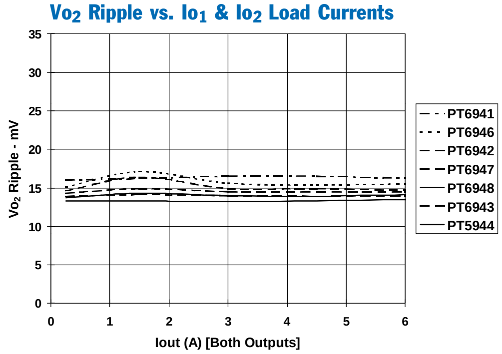
Efficiency vs. Io_1 & Io_2 Load Currents



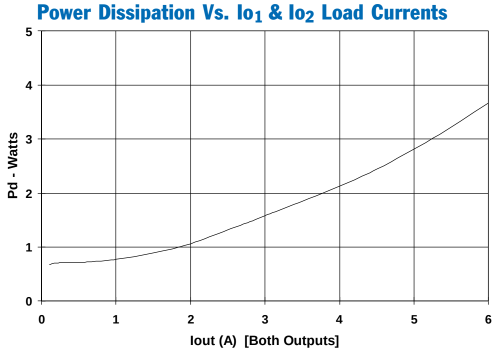
Vo_1 Ripple vs. Io_1 & Io_2 Load Currents



Vo_2 Ripple vs. Io_1 & Io_2 Load Currents

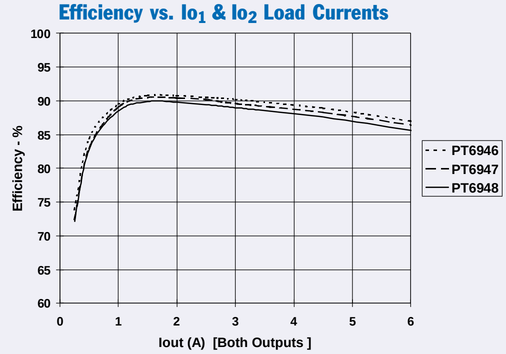


Power Dissipation Vs. Io_1 & Io_2 Load Currents

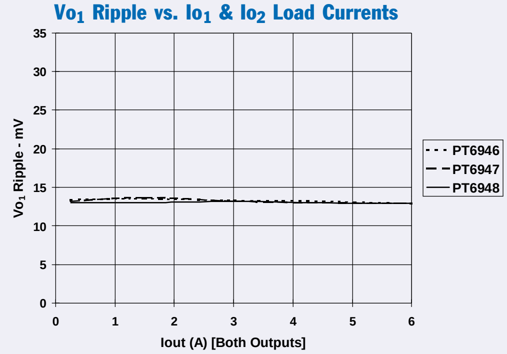


Performance Characteristics; V_{in} =3.3V (See Note A)

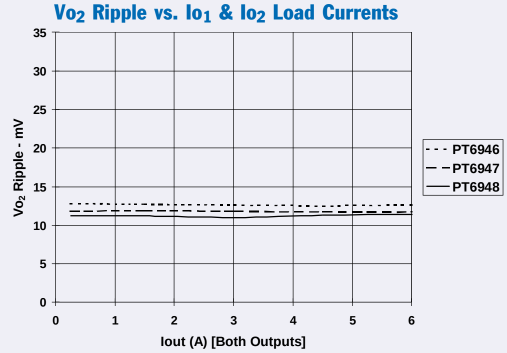
Efficiency vs. Io_1 & Io_2 Load Currents



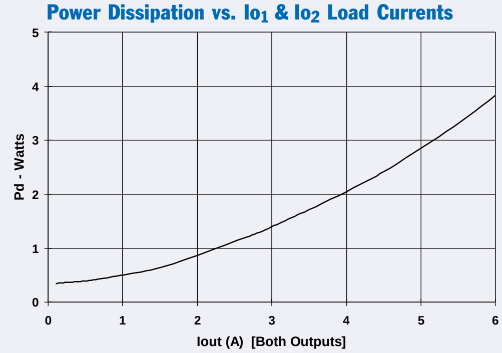
Vo_1 Ripple vs. Io_1 & Io_2 Load Currents



Vo_2 Ripple vs. Io_1 & Io_2 Load Currents



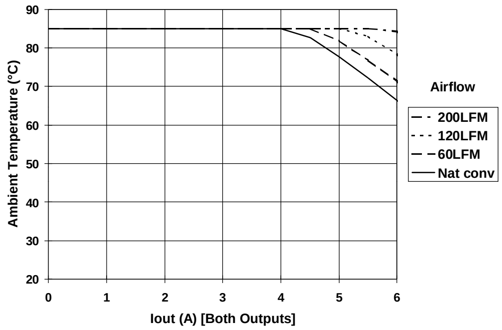
Power Dissipation vs. Io_1 & Io_2 Load Currents



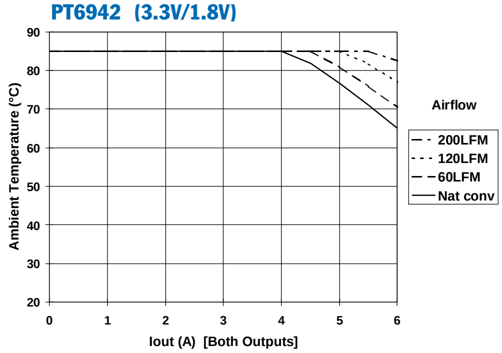
Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*

Safe Operating Area Curves; V_{in} =5V (See Note B)

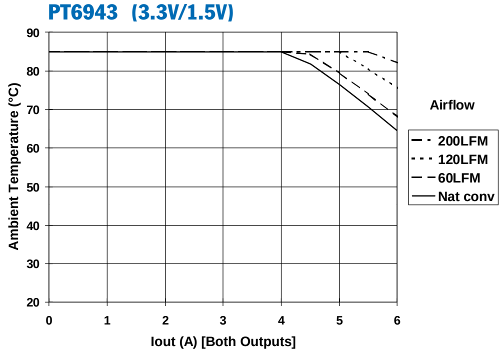
PT6941 (3.3V/2.5V)



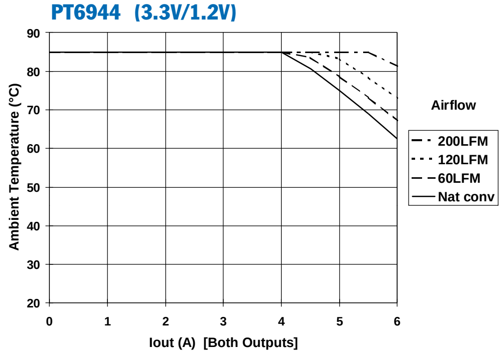
PT6942 (3.3V/1.8V)



PT6943 (3.3V/1.5V)

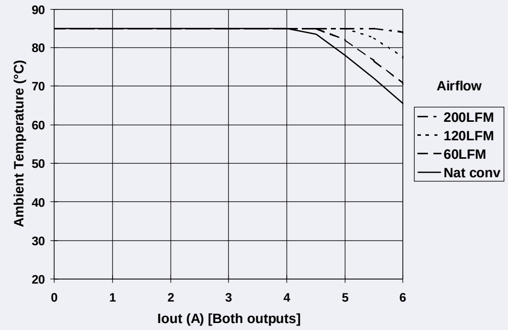


PT6944 (3.3V/1.2V)

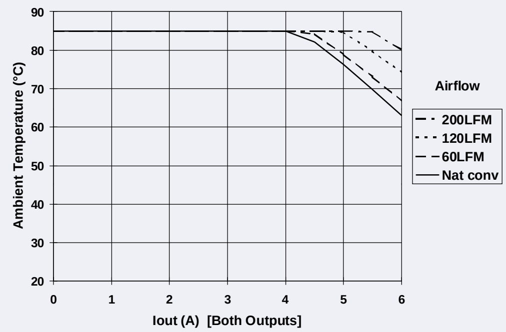


Safe Operating Area Curves; V_{in} =3.3V/5V (See Note B)

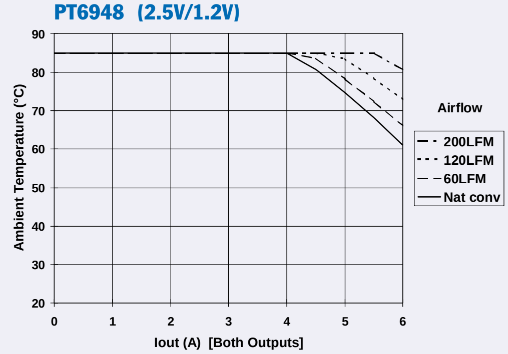
PT6946 (2.5V/1.8V)



PT6947 (2.5V/1.5V)



PT6948 (2.5V/1.2V)



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 PT6940 Series of Dual-Output Voltage Regulators

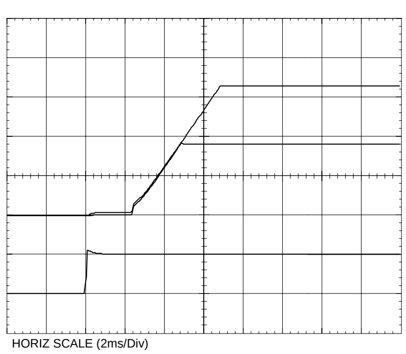
Over-Current Protection

The PT6940 series of regulators incorporate independent current limit protection at both outputs (Vo_1 & Vo_2) with a periodic shutdown of both outputs. Applying a load current, in excess of the current limit threshold to either output, results in the shutdown of both voltages after a short period; typically 15ms. Following shutdown the module periodically attempts to recover by executing a soft start power-up at intervals of approximately 100ms. If the over-current fault persists, each attempted restart will result in a corresponding over-current trip and shutdown. During the 15ms period prior to each successive shutdown, the output with the load fault may not reach full regulation.

Power-Up Voltage Sequencing

The output voltages from the PT6940 series regulators are independently regulated, and internally sequenced to meet the power-up requirements of popular microprocessors and DSP chipsets. Figure 1 shows the output voltage waveforms of a PT6942 (3.3V/1.8V) after either input power is applied, or the regulator is enabled. In this example turning Q_1 off in Figure 2, removes the low-voltage signal at pin 1 and enables the regulator. Following a delay of about 3–5ms, Vo_1 and Vo_2 rise together until the lower voltage, Vo_2, reaches its regulation voltage. Vo_1 then continues to rise until both outputs reach full regulation. The total power-up time is less than 15ms, and is relatively independent of load, temperature, and output capacitance. The turn-off of Q_1 corresponds to the rise in V_{STBY}. The waveforms were measured with a 5V input voltage, and with resistive loads of 4A at both the Vo_1 and Vo_2 outputs.

Figure 1

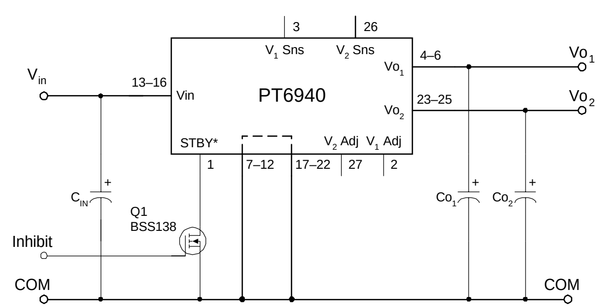


Standby Control

The output voltages from the PT6940 may be disabled using the regulator's *Standby* control. The standby function is provided by the *"STBY*"* control (pin 1). If pin 1 is left open-circuit the regulator operates normally, and provides a regulated output at both Vo_1 (pins 4–6) and Vo_2 (pins 23–25) whenever a valid input source voltage is applied to V_{in} (pins 13–16) with respect to GND (pins 7-12 & 17–22). Applying a low-impedance sink to ground[1] at pin 1, simultaneously disables both regulated outputs. This places the regulator in standby mode, and reduces the input current drawn by the ISR to typically 10mA. The *Standby* control may also be used to maintain both regulator outputs at zero volts during the period that input power is applied.

The standby pin is ideally controlled using an open-collector (or open-drain) discrete transistor (See Figure 2). The open-circuit voltage is the input voltage, V_{in}.

Figure 2



Notes:

1. The standby control input is *Not* compatible with TTL or other devices that incorporate a totem-pole output drive. Use only a true open-collector device, preferably a discrete bipolar transistor (or MOSFET). To ensure the regulator output is disabled, the control pin must be pulled to less than 0.4Vdc with a low-level 0.5mA sink to ground.

2 Do not use an an external pull-up resistor. The control pin has its own internal pull-up. Adding an external pull-up could disable the over-current protection. The open-circuit voltage of the *"STBY*"* pin is the input voltage, V_{in}.

Capacitor Recommendations for the Dual-Output PT6940 Regulator Series

Input Capacitor:
The recommended input capacitance is determined by 1.0 ampere minimum ripple current rating and 330µF minimum capacitance (300µF for Oscon® or low ESR tantalum). Ripple current and <100mΩ equivalent series resistance (ESR) values are the major considerations, along with temperature, when designing with different types of capacitors. Tantalum capacitors have a recommended minimum voltage rating of twice the maximum DC voltage + AC ripple. This is necessary to insure reliability for input voltage bus applications

Output Capacitors: Co_1/Co_2
The ESR of the required capacitors, Co_1 & Co_2 must not be greater than 150mΩ. Electrolytic capacitors have poor ripple performance at frequencies greater than 400kHz but excellent low frequency transient response. Above the ripple frequency, ceramic 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.

Tantalum Capacitors
Tantalum type capacitors can be used for the output but only the AVX TPS series, Sprague 593D/594/595 series or Kemet T495/T510 series. These capacitors are recommended over many other tantalum types due to their higher rated surge, power dissipation, and ripple current capability. As a caution the TAJ series by AVX is not recommended. This series has considerably higher ESR, reduced power dissipation, and lower ripple current capability. The TAJ series is less reliable than the AVX TPS series when determining power dissipation capability. Tantalum or Oscon® types are recommended for applications where ambient temperatures fall below 0°C.

Capacitor Table
Table 1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The number of capacitors required at both the input and output buses is identified for each capacitor type.

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

Table 1: Input/Output Capacitors

Capacitor Vendor/ Component 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	25V 35V 35V	560µF 390µF 330µF	0.0065Ω 0.065Ω 0.117Ω	1205mA 1205mA 555mA	12.5x15 12.5x15 8x11.5	1 2 N/R	1 1 1	EEUFC1E561S EEUFC1V391S EEUFC1C331
United Chemi-Con LXV/FS/ LXZ	16V 35V 10V 20V	330µF 470µF 330µF 150µF	0.120Ω 0.052Ω 0.025Ω 0.030÷2 Ω	555mA 1220mA 3500mA 3200mA	8x12 10x20 10x10.5 10x10.5	N/R 1 1 2	1 1 1 2	LXZ16VB331M8X12LL LXZ35VB471M10X20LL 10FS330M 20FS150M
Nichicon PL/ PM	35V 35V 50V	560µF 330µF 470µF	0.048Ω 0.065÷2 Ω 0.046Ω	1360mA 1020mA 1470mA	16x15 12.5x15 18x15	1 1 1	1 1 1	UPL1V561MHH6 UPL1V331MHH6 UPM1H4711MHH6
Panasonic FC (Surface Mtg)	10V 35V 16V	1000µF 330µF 330µF	0.043Ω 0.065Ω 0.150Ω	1205mA 1205mA 670mA	12x16.5 12.5x16 10x10.2	1 1 N/R	1 1 1	EEVFC1A102LQ EEVFC1V331LQ EEVFC1C331P
Oscon- SS SV	10V 10V 20V	330µF 330µF 150µF	0.025Ω 0.025Ω 0.024÷2 Ω	>3500mA >3800mA 3600mA	10.0x10.5 10.3x10.3 10.3x10.3	1 1 2	1 1 2	10SS330M 10SV300M 20SV150M SV= Surface Mount
AVX Tantalum TPS	10V 10V 10V	330µF 330µF 220µF	0.100÷2 Ω 0.100÷2 Ω 0.095Ω	>2500mA >3000mA >2000mA	7.3Lx 4.3Wx 4.1H	2 2 2	1 1 2	TPSV337M010R0100 TPSV337M010R0060 TPSV227M0105R0100
Kemet T510/ T495	10V 10V	330µF 220µF	0.033Ω 0.07Ω÷2 =0.035Ω	1400mA >2000mA	7.3Lx5.7W x 4.0H	2 2	1 2	T510X337M010AS T495X227M010AS
Sprague 594D	10V 10V	330µF 220µF	0.045Ω 0.065Ω	2350mA >2000mA	7.3Lx 6.0Wx 4.1H	2 2	1 2	4D337X0010R2T 594D227X0010D2T

N/R –Not recommended. The voltage rating does not meet the minimum operating limits.

Adjusting the Output Voltages of the PT6940 Dual-Output ISRs

Each output voltage from the PT6940 series of integrated switching regulators (ISRs) can be independently adjusted higher or lower than the factory trimmed pre-set voltage. The voltages, Vo_1 and Vo_2 may each be adjusted either up or down using a single external resistor [1]. Table 1 gives the adjustment range for both Vo_1 and Vo_2 for each model in the series as V_a(min) and V_a(max). Note that Vo_2 must always be lower than Vo_1 [2].

Vo_1 Adjust Up: To increase the output, add a resistor R_2 between pin 2 (Vo_1 Adjust) and pins 7-12 (GND) [3].

Vo_1 Adjust Down: Add a resistor (R_1), between pin 2 (Vo_1 Adjust) and pin 3 (Vo_1 Sense).

Vo_2 Adjust Up: Add a resistor R_4 between pin 27 (Vo_2 Adjust) and pins 17–22 (GND).

Vo_2 Adjust Down: Add a resistor (R_3) between pin 27 (Vo_2 Adjust) and pin 26 (Vo_2 Sense).

Refer to Figure 1 and Table 2 for both the placement and value of the required resistor.

The adjust up and adjust down resistor values can also be calculated using the following formulas. Be sure to select the correct formula parameter from Table 1 for the output and model being adjusted.

$$(R_1) \text{ or } (R_3) = \frac{10\,(V_a - 0.9)}{V_o - V_a} - R_s \quad \text{k}\Omega$$

$$R_2 \text{ or } R_4 = \frac{9}{V_a - V_o} - R_s \quad \text{k}\Omega$$

Where: V_o = Original output voltage, (Vo_1 or Vo_2)
V_a = Adjusted output voltage
R_s = The series resistance from Table 1

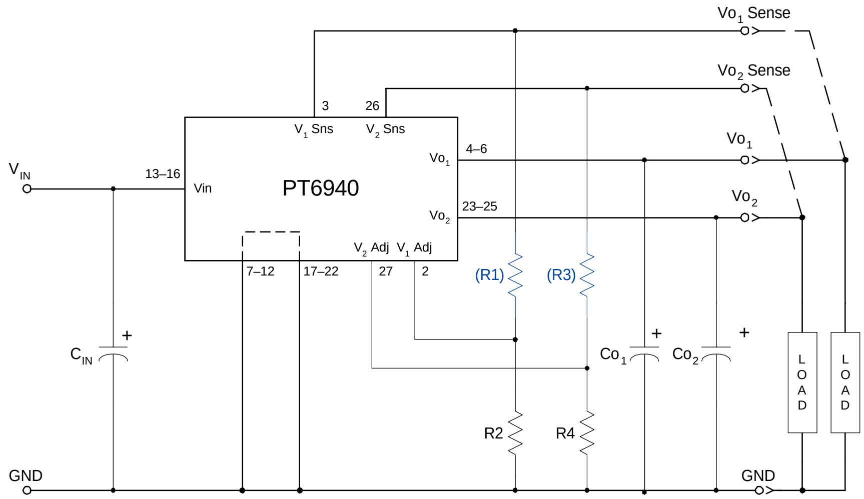
Notes:

1. Use only a single 1% resistor in either the (R_1) or R_2 location to adjust Vo_1, and in the (R_3) or R_4 location to adjust Vo_2. Place the resistor as close to the module as possible.
2. Vo_2 must always be at least 0.3V lower than Vo_1.
3. When adjusting Vo_1 higher than the factory pre-set output voltage the minimum input voltage must be revised as follows.

   Vo_1 =3.3V:
   V_{in}(min) = (Vo_1 + 1)V or 4.5V, whichever is greater.

   Vo_1 =2.5V:
   Vo_1 =2.5V is the maximum output voltage allowed for operation off a 3.3V input bus. If Vo_1 is adjusted above 2.5V, the input voltage must be a minimum of 4.5V.
4. Vo_1 and Vo_2 may be adjusted down to an alternative bus voltage by making, (R_1) or (R_3) respectively, a zero ohm link. Refer to the Table 1 footnotes for guidance.
5. Never connect capacitors to either the Vo_1 Adjust or Vo_2 Adjust pins. Any capacitance added to these control pins will affect the stability of the respective regulated output.

Figure 1



TEXAS INSTRUMENTS

Table 1

ADJUSTMENT RANGE AND FORMULA PARAMETERS

Vo1 Bus			**Vo2 Bus (2)**			
Series Pt #	**PT6941/42/43/44**	**PT6946/47/48**	**PT6941**	**PT6942/46**	**PT6943/47**	**PT6944/48**
Adj. Resistor	**(R1)/R2**	**(R1)/R2**	**(R3)/R4**	**(R3)/R4**	**(R3)/R4**	**(R3)/R4**
V_o(nom)	3.3V	2.5V	2.5V	1.8V	1.5V	1.2V
Va(min)	2.5V *	1.8V *	1.8V *	1.5V *	1.2V *	1.15V
Va(max)	3.5V	2.5V	3.1V	2.2V	2.4V	1.5V †
R_s (kΩ)	20.0	13.0	13.0	20.0	10.0	29.4

Ref. Note 4: * (R1) = Zero-ohm link
†(R3) = Zero-ohm link

Table 2

ADJUSTMENT RESISTOR VALUES

Vo1 Bus		
Series Pt #	**PT6941/42/43/44**	**PT6946/47/48**
Adj. Resistor	**(R1)/R2**	**(R1)/R2**
V_o(nom)	3.3V	2.5V
V_a(req'd)		
1.8		(0.0)
1.85		(1.6)kΩ
1.9		(3.7)kΩ
1.95		(6.1)kΩ
2.0		(9.0)kΩ
2.05		(12.6)kΩ
2.1		(17.0)kΩ
2.15		(22.7)kΩ
2.2		(30.3)kΩ
2.25		(41.0)kΩ
2.3		(57.0)kΩ
2.35		(83.7)kΩ
2.4		(137.0)kΩ
2.45		(297.0)kΩ
2.5	(0.0)kΩ	
2.55	(2.0)kΩ	167.0kΩ #
2.6	(4.3)kΩ	77.0kΩ #
2.65	(6.9)kΩ	47.0kΩ #
2.7	(10.0)kΩ	32.0kΩ #
2.75	(13.6)kΩ	23.0kΩ #
2.8	(18.0)kΩ	
2.85	(23.3)kΩ	
2.9	(30.0)kΩ	
2.95	(38.6)kΩ	
3.0	(50.0)kΩ	
3.1	(90.0)kΩ	
3.2	(210.0)kΩ	
3.3		
3.4	70.0kΩ	
3.5	25.0kΩ	
3.6	10.0kΩ	
3.7	2.5kΩ	

Vo2 Bus				
Series Pt #	**PT6941**	**PT6942/46**	**PT6943/47**	**PT6944/48**
Adj. Resistor	**(R3)/R4**	**(R3)/R4**	**(R3)/R4**	**(R3)/R4**
V_o(nom)	2.5V	1.8V	1.5V	1.2V
V_a(req'd)				
1.15				(20.6)kΩ
1.2			(0.0)kΩ	
1.25			(4.0)kΩ	151.0kΩ
1.3			(10.0)kΩ	60.6kΩ
1.35			(20.0)kΩ	30.6kΩ
1.4			(40.0)kΩ	15.6kΩ
1.45			(100.0)kΩ	6.6kΩ
1.5		(0.0)kΩ		0.0kΩ
1.55		(6.0)kΩ	170.0kΩ	
1.6		(15.0)kΩ	80.0kΩ	
1.65		(30.0)kΩ	50.0kΩ	
1.7		(60.0)kΩ	35.0kΩ	
1.75		(150.0)kΩ	26.0kΩ	
1.8	(0.0)kΩ		19.6kΩ	
1.85	(1.6)kΩ	160.0kΩ	15.7kΩ	
1.9	(3.7)kΩ	70.0kΩ	12.5kΩ	
1.95	(6.1)kΩ	40.0kΩ	10.0kΩ	
2.0	(9.0)kΩ	25.0kΩ	8.0kΩ	
2.05	(12.6)kΩ	16.0kΩ	6.4kΩ	
2.1	(17.0)kΩ	10.0kΩ	5.0kΩ	
2.15	(22.7)kΩ	5.7kΩ	3.9kΩ	
2.2	(30.3)kΩ	2.5kΩ	2.9kΩ	
2.25	(41.0)kΩ		2.0kΩ	
2.3	(57.0)kΩ		1.3kΩ	
2.35	(83.7)kΩ		0.6kΩ	
2.4	(137.0)kΩ		0.0kΩ	
2.45	(297.0)kΩ			
2.5				
2.55	167.0kΩ			
2.6	77.0kΩ			
2.65	47.0kΩ			
2.7	32.0kΩ			
2.75	23.0kΩ			
2.8	17.0kΩ			
2.85	12.7kΩ			
2.9	9.5kΩ			
2.95	7.0kΩ			
3.0	5.0kΩ			
3.1	2.0kΩ			

R_1/R_3 = (Blue), R_2/R_4 = Black
See Note 3

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