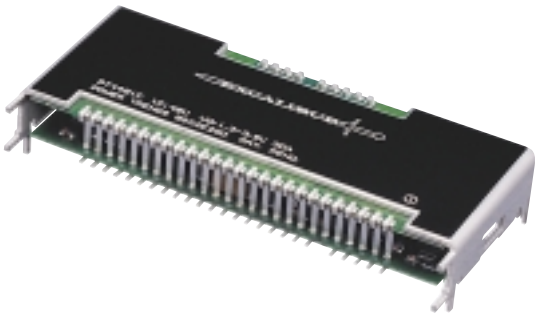
PT4680 Series

20-A 24-V Input Dual Output Isolated DC/DC Converter

SLTS141A

(Revised 1/28/2002)



Features

- Dual Outputs *(Independently Regulated)*
- Power-up/Down Sequencing
- Input Voltage Range: 18V to 36V
- 1500 VDC Isolation
- Temp Range: –40° to 100°C
- High Efficiency: 88%
- Fixed Frequency Operation
- Over-Current Protection (Both Outputs)
- Dual Logic On/Off Control
- Over-Temperature Shutdown
- Over-Voltage Protection *(Coordinated Shutdown)*
- Under-Voltage Lockout
- Input Differential EMI Filter
- Solderable Copper Case
- Safety Approvals (Pending): UL 60950 CSA 22.2 60950

Description

The PT4680 Excalibur™ Series is a dual-output isolated DC/DC converter that combine state-of-the-art power conversion technology with unparalleled flexibility. Operating from a (–24V) industry standard input bus, the PT4680 series provides up to 20 ADC of output current from two independently regulated voltages (each output 15 ADC max).

The PT4680 series is characterized with high efficiencies and ultra-fast transient response, and incorporates many features to facilitate system integration. These include a flexible "On/Off" enable control, output current limit, over-temperature protection, and an input under-voltage lock-out. In addition, both output voltages are designed to meet the power-up/power -down sequencing requirements of popular DSP ICs.

The PT4680 series is housed in space-saving solderable copper case. The package does not require a heatsink and is available in both vertical and horizontal configurations, including surface mount. The 'N' configuration occupies less than 2 in² of PCB area.

Ordering Information

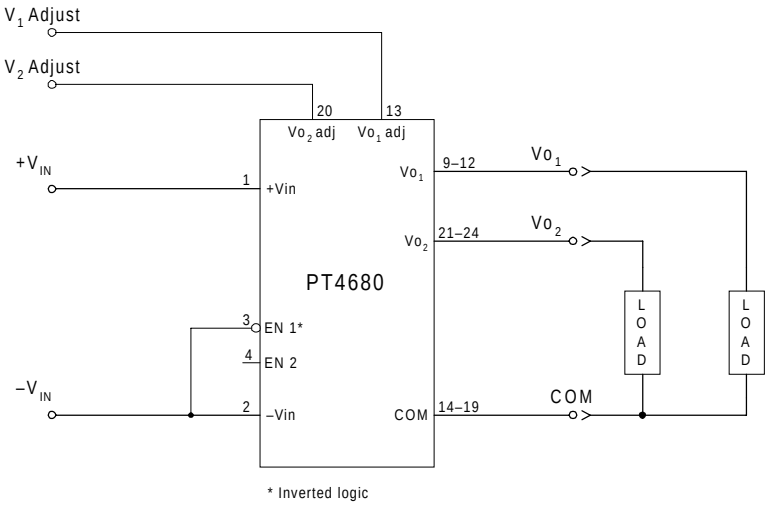
Pt. No.	Vo_1/Vo_2
PT4681❑	= 5.0/3.3 Volts
PT4682❑	= 3.3/2.5 Volts
PT4683❑	= 3.3/1.8 Volts
PT4685❑	= 3.3/1.5 Volts
PT4686❑	= 2.5/1.8 Volts
PT4687❑	= 5.0/1.8 Volts

PT Series Suffix (PT1234x)

Case/Pin Configuration	Order Suffix	Package Code
Vertical	**N**	(EKD)
Horizontal	**A**	(EKA)
SMD	**C**	(EKC)

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

Typical Application



Pin-Out Information

Pin	Function
1	+Vin
2	-Vin
3	EN 1
4	EN 2
5	TEMP
6	AUX
7	Do Not Connect
8	Do Not Connect
9	$+Vo_1$
10	$+Vo_1$
11	$+Vo_1$
12	$+Vo_1$
13	Vo_1 Adjust
14	COM
15	COM
16	COM
17	COM
18	COM
19	COM
20	Vo_2 Adjust
21	$+Vo_2$
22	$+Vo_2$
23	$+Vo_2$
24	$+Vo_2$
25	Do Not Connect
26	Do Not Connect

Note: Shaded functions indicate signals that are referenced to the input (-Vin) potential.

On/Off Logic

Pin 3	Pin 4	Output Status
1	×	Off
0	1	On
×	0	Off

Notes:
Logic 1 =Open collector
Logic 0 = –Vin (pin 2) potential

For positive Enable function, connect pin 3 to pin 2 and use pin 4.

For negative Enable function, leave pin 4 open and use pin 3.

Pin Descriptions

+Vin: The positive input supply for the module with respect to $-V_{in}$. If powering the module from a -24V telecom central office supply, this input is connected to the primary system ground.

–Vin: The negative input supply for the module, and the 0VDC reference for the EN 1, EN 2, TEMP, and AUX signals. When the module is powered from a +24V supply, this input is connected to the 24V Return.

EN 1: The negative logic input that enables the module output. This pin is TTL compatible and referenced to $-V_{in}$. A logic '0' at this pin enables the module's outputs. A logic '1' or high impedance disables the module's outputs. If not used, the pin must be connected to $-V_{in}$.

EN 2: The positive logic input that enables the module output. This pin is TTL compatible and referenced to $-V_{in}$. A logic '1' or high impedance enables the module's outputs. If not used, the pin should be left open circuit.

TEMP: This pin produces an output signal that tracks the module's metal case temperature. The output voltage is referenced to $-V_{in}$ and rises approximately 10mV/°C from an intital value of 0.1VDC at -40°C ($V_{Temp} = 0.5 + 0.01 \cdot T_{Case}$). The signal is available whenever the module is supplied with a valid input voltage, and is independant of the enable logic status. (**Note:** *A load impedance of less than 1MΩ will adversly affect the module's over-temperature shutdown threshold. Use a high-impedance input when monitoring this signal.)*

AUX: Produces a regulated output voltage of 11.6V ±5%, which is referenced to $-V_{in}$. The current drawn from the pin must be limited to 10mA. The voltage may be used to indicate the output status of the module to a primary referenced circuit, or power a low-current amplifer.

Vo_1: The higher regulated output voltage, which is referenced to the COM node.

Vo_2: The lower regulated output voltage, which is referenced to the COM node.

COM: The secondary return reference for the module's two regulated output voltages. It is DC isolated from the input supply pins.

Vo_1 Adjust: Using a single resistor, this pin allows Vo_1 to be adjusted higher or lower than the preset value. If not used, this pin should be left open circuit.

Vo_2 Adjust: Using a single resistor, this pin allows Vo_2 to be adjusted higher or lower than the preset value. If not used, this pin should be left open circuit.

Specifications (Unless otherwise stated, T_a =25°C, V_{in} =24V, & Io_1=Io_2=10A)

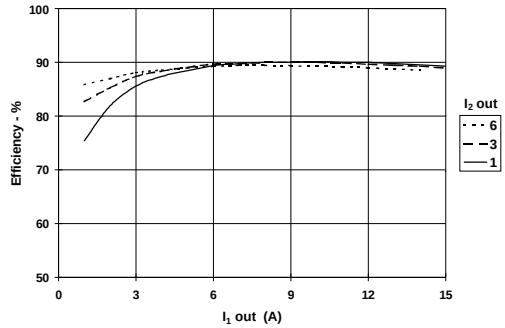
Characteristics	Symbols	Conditions		PT4680 SERIES Min	Typ	Max	Units
Output Current	Io_1 Io_2		Vo_1 Vo_2	0 0	— —	15 15	A
	Io_1+Io_2	Total (both outputs)		0	—	20 (1)	A
Input Voltage Range	V_{in}			18	24	36	V
Set Point Voltage Tolerance	$V_o$tol			—	±1	±2	%V_o
Temperature Variation	ΔReg_{temp}	–40 to +100°C Case, Io_1 =Io_2 =0A		—	±0.5	—	%V_o
Line Regulation	ΔReg_{line}	Over V_{in} range with Io_1=Io_2=5A		—	±5	±10	mV
Load Regulation	ΔReg_{load}	1A ≤Io_1 ≤15A, Io_2 =1A 1A ≤Io_2 ≤15A, Io_1 =1A	ΔVo_1 ΔVo_2	— —	±2 ±2	±10 ±10	mV
Cross Regulation	ΔReg_{cross}	1A ≤Io_2 ≤15A, Io_1 =1A 1A ≤Io_1 ≤15A, Io_2 =1A	ΔVo_1 ΔVo_2	— —	±2 ±2	±10 ±5	mV
Total Output Variation	ΔV_otol	Includes set-point, line load, –40°C to +100°C case	ΔVo_1 ΔVo_2	— —	±2 ±2	±3 ±3	%V_o
Efficiency	η	Io_1 =Io_2 =10A	PT4681 PT4682 PT4683 PT4685 PT4686 PT4687	— — — — — —	88 87 87 86 85 86	— — — — — —	%
V_o Ripple (pk-pk)	V_r	Io_1=Io_2=5A, 20MHz bandwidth	V_o=5V V_o<5V	— —	— —	75 50	mV_{pp}
Transient Response	t_{tr}	1A/µs load step from 50% to 100% $I_o$max (either output)		— —	25 6.0	100 —	µSec %V_o
Current Limit	I_{lim}	Each output with other unloaded		15.5	18	—	A
Output Rise Time	V_{on}	At turn-on to within 90% of V_o		—	5	10	mSec
Output Over-Voltage Protection	OVP	Either output; shutdown and latch off		—	125 (2)	—	%V_o
Switching Frequency	f_s			280	—	320	kHz
Under-Voltage-Lockout	UVLO	Rising Falling		— 15	17 16	18 —	V
Internal Input Capacitance	C_{in}			—	2	—	µF
On/Off Control Input High Voltage Input Low Voltage	 V_{IH} V_{IL}	Referenced to –V_{in}		 3.5 0	 — —	 — 0.8 (3)	V
Input Low Current	I_{IL}			—	0.5	—	mA
Quiescent Current	I_{in} standby	Pins 2, 3, & 4 connected		—	3	5	mA
External Output Capacitance	C_{out}	Per each output		0	—	5,000	µF
Primary/Secondary Isolation	V_{iso} C_{iso} R_{iso}			1500 — 10	— 1500 —	— — —	V pF MΩ
Temperature Sense	V_{temp}	Output voltage at temperatures:-	–40°C 100°C	— —	0.1 (4) 1.5 (4)	— —	V
Over-Temperature Shutdown	OTP	Case temperature (auto restart)		—	110	—	°C
Operating Temperature Range	T_a	Over V_{in} range		–40	—	+85 (5)	°C
Storage Temperature	T_s	—		–40	—	+125	°C
Mechanical Shock	—	Per Mil-STD-883D, Method 2002.3		—	500	—	G's
Mechanical Vibration Per Mil-STD-883D, 20–2,000Hz	—	Vertical Horizontal		— —	10 (6) 20 (6)	— —	G's
Weight	—	—		—	90	—	grams
Flammability	—	Materials meet UL 94V-0					

Notes: *(1) The sum-total current from Vo_1 & Vo_2 must not exceed 20ADC.*
(2) This is a fixed parameter. Adjusting Vo_1 or Vo_2 higher will increase the module's sensitivity to over-voltage detection. For more information, see the application note on output voltage adjustment.
(3) The EN_1 and EN_2 control inputs (pins 3 & 4) have internal pull-ups and may be controlled with an open-collector (or open-drain) transistor. Both inputs are diode protected and can be connected to +V_{in}. The maximum open-circuit voltage is 5.4V.
(4) Voltage output at "TEMP" pin is defined by the equation:- $V_{TEMP} = 0.5 + 0.01 \cdot T$, where T is in °C. See pin descriptions for more information.
(5) See SOA curves or consult the factory for the appropriate derating.
(6) The case pins on the through-holed package types (suffixes N & A) must be soldered. For more information see the applicable package outline drawing.

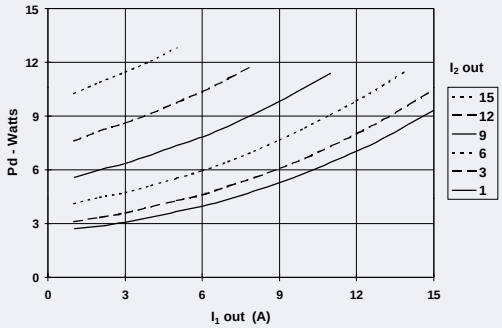
Typical Characteristics

PT4681 (Vo_1/Vo_2 =5.0V/3.3V); V_{in} =24V (See Notes A & B)

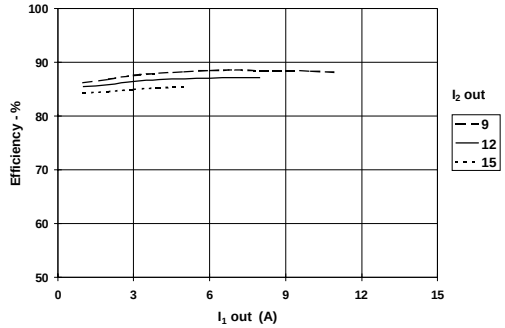
Efficiency vs Io_1; Io_2 @1A, 3A, and 6A



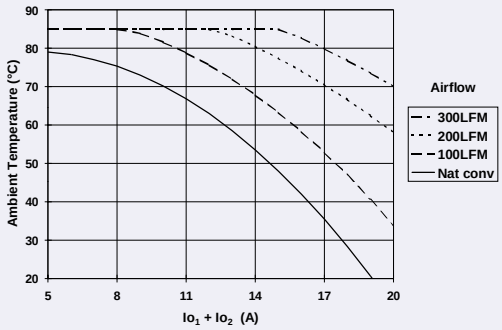
Power Dissipation vs Io_1 and Io_2



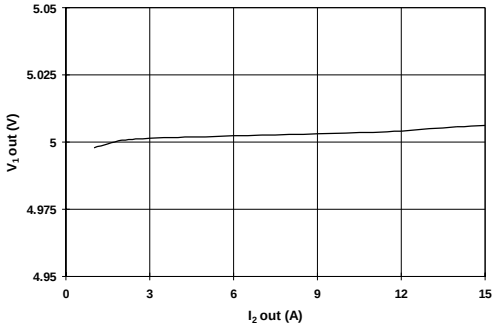
Efficiency vs Io_1; Io_2 @9A, 12A, and 15A



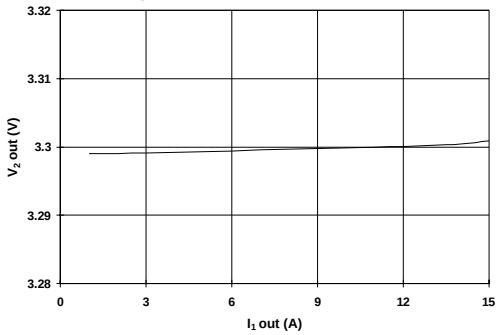
Safe Operating Area: (Io_1 + Io_2)



Cross Regulation: Vo_1 vs Io_2 @Io_1 =1A



Cross Regulation: Vo_2 vs Io_1 @Io_2 =1A

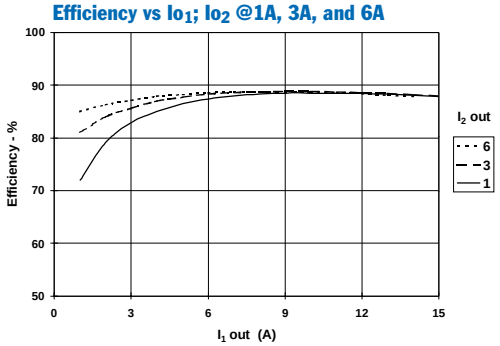


Note A: *All Characteristic data in the above graphs has been developed from actual products tested at 25°C. This data is considered typical data for the converter.*
Note B: *SOA curves represent operating conditions at which internal components are at or below manufacturer's maximum rated operating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

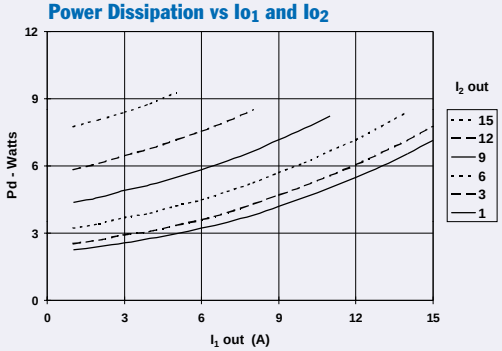
Typical Characteristics

PT4682 (Vo_1/Vo_2 =3.3V/2.5V); V_{in} =24V (See Notes A & B)

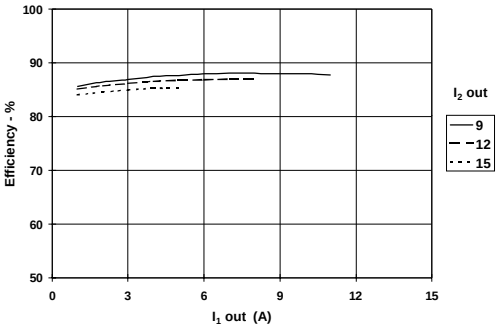
Efficiency vs Io_1; Io_2 @1A, 3A, and 6A



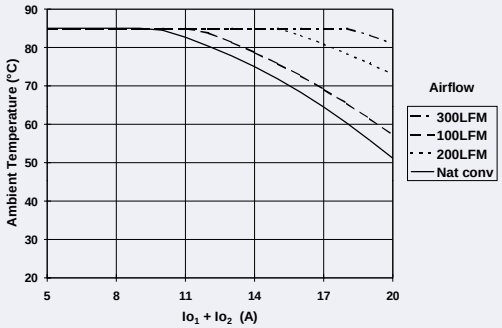
Power Dissipation vs Io_1 and Io_2



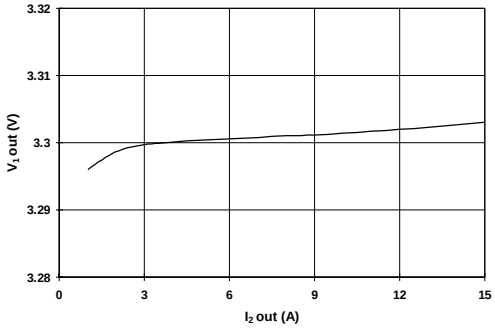
Efficiency vs Io_1; Io_2 @9A, 12A, and 15A



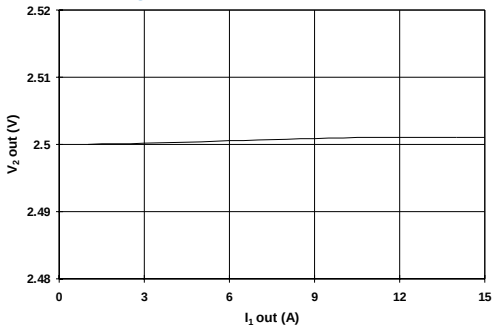
Safe Operating Area: (Io_1 + Io_2)



Cross Regulation: Vo_1 vs Io_2 @I_1out =1A



Cross Regulation: Vo_2 vs Io_1 @Io_2 =1A

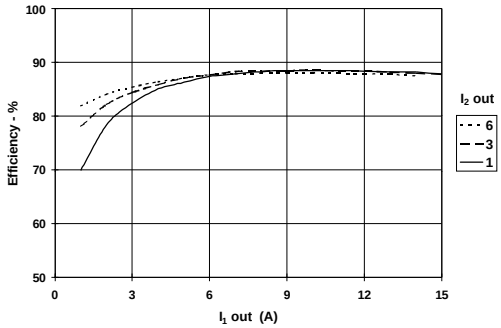


Note A: *All Characteristic data in the above graphs has been developed from actual products tested at 25°C. This data is considered typical data for the converter.*
Note B: *SOA curves represent operating conditions at which internal components are at or below manufacturer's maximum rated operating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

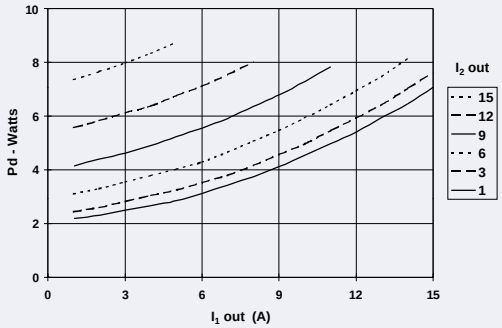
Typical Characteristics

PT4683 (Vo_1/Vo_2 =3.3V/1.8V); V_{in} =24V (See Notes A & B)

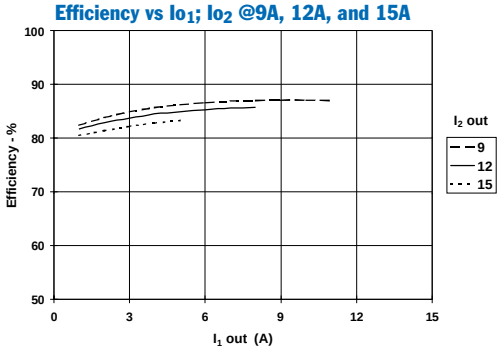
Efficiency vs Io_1; Io_2 @1A, 3A, and 6A



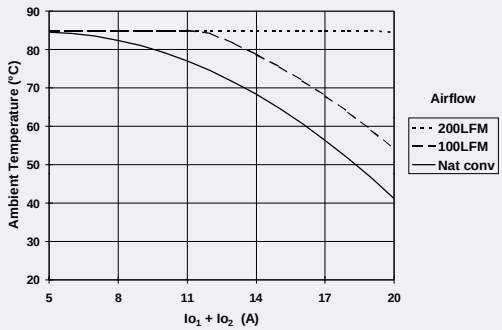
Power Dissipation vs Io_1 and Io_2



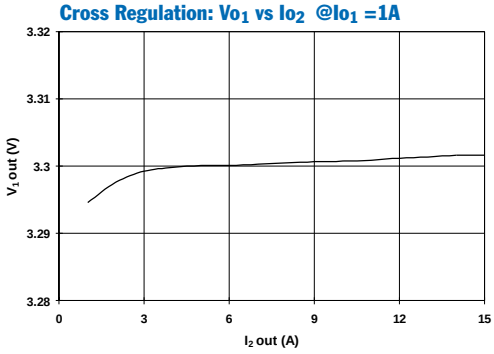
Efficiency vs Io_1; Io_2 @9A, 12A, and 15A



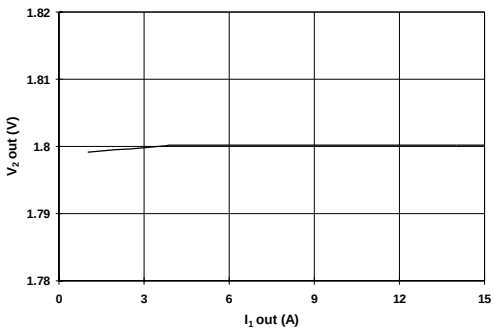
Safe Operating Area: (Io_1 + Io_2)



Cross Regulation: Vo_1 vs Io_2 @Io_1 =1A



Cross Regulation: Vo_2 vs Io_1 @Io_2 =1A

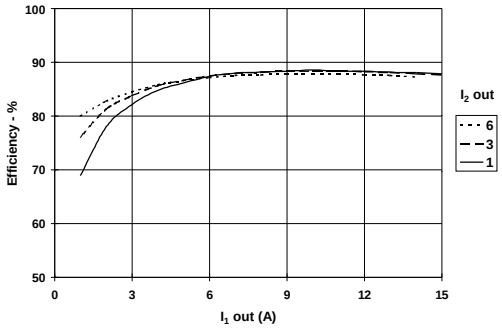


Note A: *All Characteristic data in the above graphs has been developed from actual products tested at 25°C. This data is considered typical data for the converter.*
Note B: *SOA curves represent operating conditions at which internal components are at or below manufacturer's maximum rated operating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

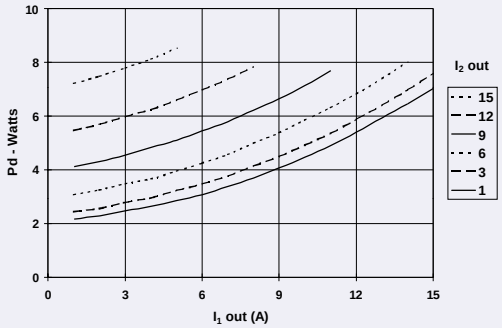
Typical Characteristics

PT4685 (Vo_1/Vo_2 =3.3V/1.5V); V_{in} =24V

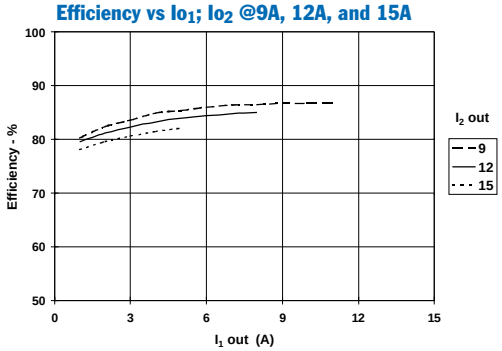
Efficiency vs Io_1; Io_2 @1A, 3A, and 6A



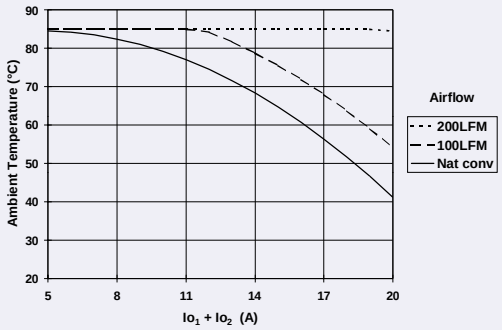
Power Dissipation vs Io_1 and Io_2



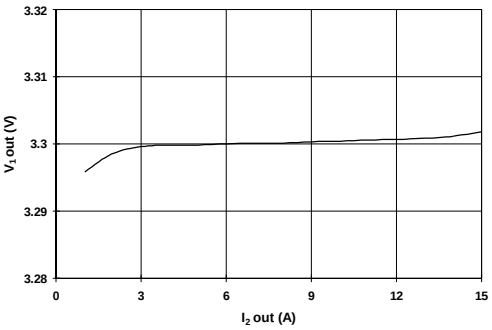
Efficiency vs Io_1; Io_2 @9A, 12A, and 15A



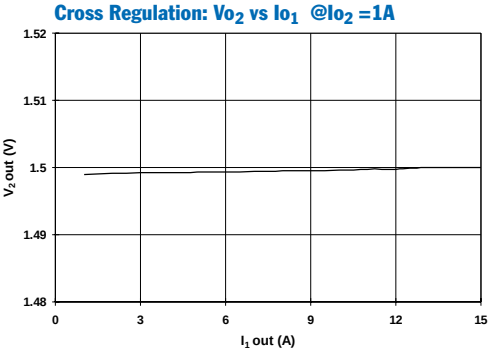
Safe Operating Area: (Io_1 + Io_2)



Cross Regulation: Vo_1 vs Io_2 @Io_1 =1A



Cross Regulation: Vo_2 vs Io_1 @Io_2 =1A

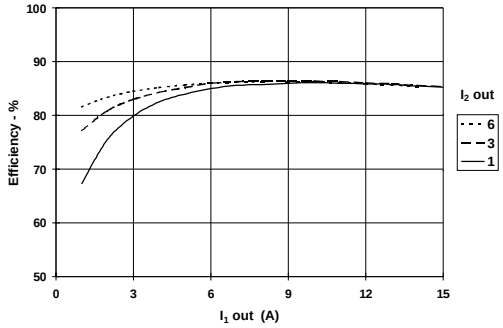


Note A: *All Characteristic data in the above graphs has been developed from actual products tested at 25°C. This data is considered typical data for the converter.*
Note B: *SOA curves represent operating conditions at which internal components are at or below manufacturer's maximum rated operating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

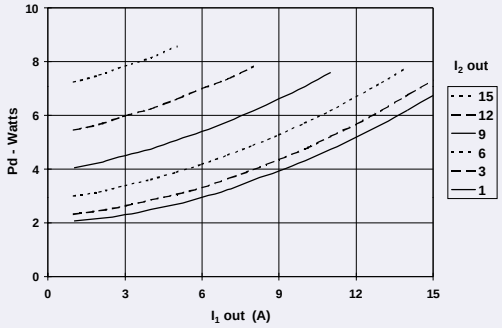
Typical Characteristics

PT4686 (Vo_1/Vo_2 =2.5V/1.8V); V_{in} =24V

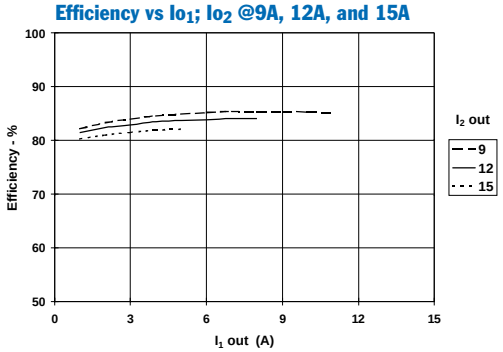
Efficiency vs Io_1; Io_2 @1A, 3A, and 6A



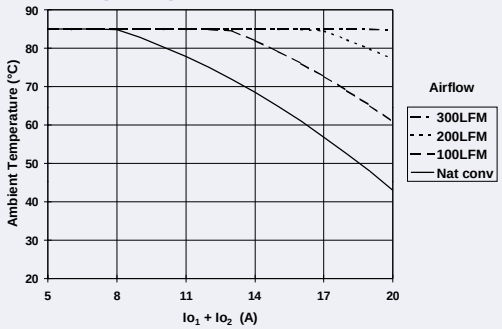
Power Dissipation vs Io_1 and Io_2



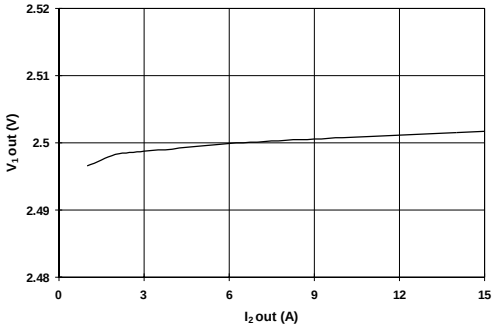
Efficiency vs Io_1; Io_2 @9A, 12A, and 15A



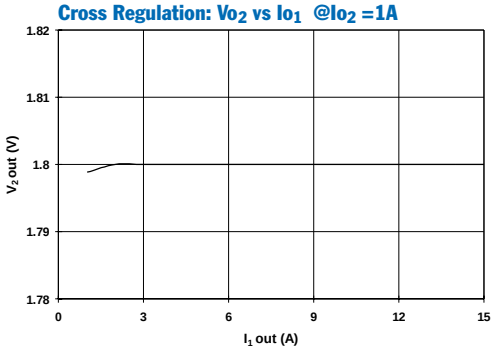
Safe Operating Area: (Io_1 + Io_2)



Cross Regulation: Vo_1 vs Io_2 @Io_1 =1A



Cross Regulation: Vo_2 vs Io_1 @Io_2 =1A

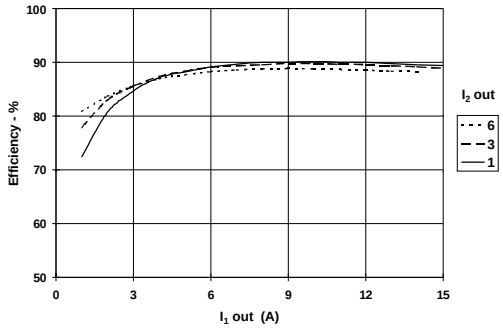


Note A: *All Characteristic data in the above graphs has been developed from actual products tested at 25°C. This data is considered typical data for the converter.*
Note B: *SOA curves represent operating conditions at which internal components are at or below manufacturer's maximum rated operating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

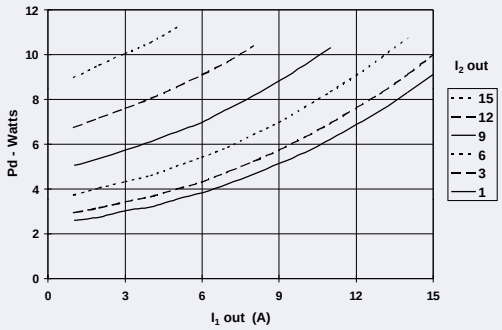
Typical Characteristics

PT4687 (Vo_1/Vo_2 =5V/1.8V); V_{in} =24V

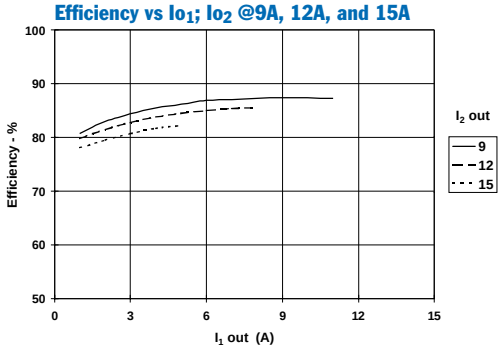
Efficiency vs Io_1; Io_2 @1A, 3A, and 6A



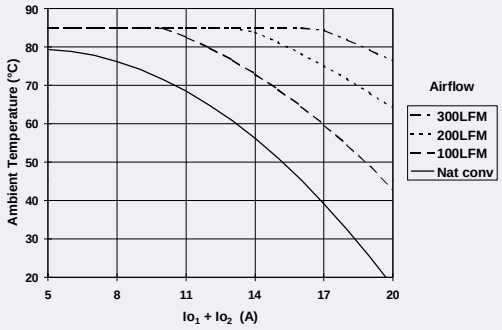
Power Dissipation vs Io_1 and Io_2



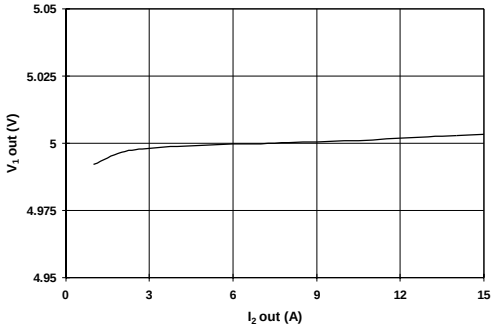
Efficiency vs Io_1; Io_2 @9A, 12A, and 15A



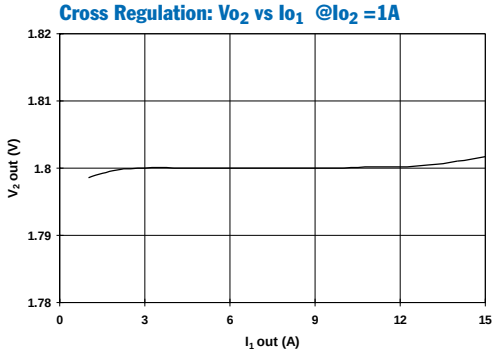
Safe Operating Area: (Io_1 + Io_2)



Cross Regulation: Vo_1 vs Io_2 @Io_1 =1A



Cross Regulation: Vo_2 vs Io_1 @Io_2 =1A



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

Operating Features & System Considerations for the PT4660/PT4680 Dual-Output DC/DC Converters

Over-Current Protection

The dual-outputs of the PT4660 and PT4680 series of DC/DC converters have independent output voltage regulation and current limit control. Applying a load current in excess of the current limit threshold at either output will cause the respective output voltage to drop. However, the voltage at Vo_2 is derived from Vo_1. Therefore a current limit fault on Vo_1 will also cause Vo_2 to drop. Conversely, a current limit fault applied to Vo_2 will only cause Vo_2 voltage to drop, and Vo_1 will remain in regulation.

The current limit circuitry incorporates a limited amount of foldback. The fault current flowing into an absolute short circuit is therefore slightly less than the current limit threshold. Recovery from a current limit fault is automatic and the converter will not be damaged by a continuous short circuit at either output.

Output Over-Voltage Protection

Each output is monitored for over voltage (OV). For fail safe operation and redundancy, the OV fault detection circuitry uses a separate reference to the voltage regulation circuits. The OV threshold is fixed, and set nominally 25% higher than the set-point output voltage. If either output exceeds the threshold, the converter is shutdown and must be actively reset. The OV protection circuit can be reset by momentarily turning the converter off. This is accomplished by either cycling one of the output enable control pins (EN1 or EN2), or by removing the input power to the converter. *Note: If Vo_1 or Vo_2 is adjusted to a higher voltage, the margin between the respective steady-state output voltage and its OV threshold is reduced. This can make the module sensitive to OV fault detection, that may result from random noise and load transients.*

Over-Temperature Protection

The PT4660/80 DC/DC converters have an internal temperature sensor, which monitors the temperature of the module's metal case. If the case temperature exceeds a nominal 115°C the converter will shut down. The converter will automatically restart when the sensed temperature returns to about 100°C. The analog voltage generated by the sensor is also made available at the 'TEMP' output (pin 5), and can be monitored by the host system for diagnostic purposes. Consult the 'Pin Descriptions' section of the data sheet for further information on this feature.

Under-Voltage Lock-Out

The Under-Voltage Lock-Out (UVLO) circuit prevents operation of the converter whenever the input voltage to the module is insufficient to maintain output regulation. The UVLO has approximately 2V of hysterisis. This is to prevent oscillation with a slowly changing input voltage. Below the UVLO threshold the module is off and the enable control inputs, EN1 and EN2 are inoperative.

Primary-Secondary Isolation

The PT4460/80 series of DC/DC converters incorporate electrical isolation between the input terminals (primary) and the output terminals (secondary). All converters are production tested to a withstand voltage of 1500VDC. The isolation complies with UL60950 and EN60950, and the requirements for operational isolation. This allows the converter to be configured for either a positive or negative input voltage source.

The regulation control circuitry for these modules is located on the secondary (output) side of the isolation barrier. Control signals are passed between the primary and secondary sides of the converter via a proprietory magnetic coupling scheme. This eliminates the use of opto-couplers. The data sheet 'Pin Descriptions' and 'Pin-Out Information' provides guidance as to which reference (primary or secondary) that must be used for each of the external control signals.

Fuse Recommendations

If desired an input fuse may be added to protect against the application of a reverse input voltage.

Using the On/Off Enable Controls on the PT4660 and PT4680 Series of DC/DC Converters

The PT4660 (48V input) and PT4680 (24V input) series of 75-W dual-output DC/DC converters incorporates both positive and negative logic *Output Enable* controls. EN1 (pin 3) is the positive enable input, and EN2 (pin 4) is the negative enable input. Both inputs are TTL logic compatible, and are electrically referenced to $-V_{in}$ (pin 2) on the primary (input) side of the converter. A pull-up resistor is not required, but may be added if desired. Adding a pull-up resistor from either input, up to $+V_{in}$, will not damage the converter.

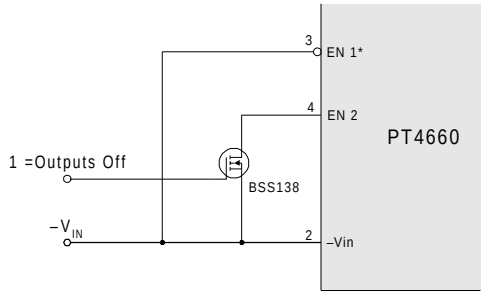
Automatic (UVLO) Power-Up

Connecting EN1 (pin 3) to $-V_{in}$ (pin 2) and leaving EN2 (pin 4) open-circuit configures the converter for automatic power up. (See data sheet "Typical Application"). The converter control circuitry incorporates an "Under Voltage Lockout" (UVLO) function, which disables the converter until the minimum specified input voltage is present at $\pm V_{in}$. (See data sheet Specifications). The UVLO circuitry ensures a clean transition during power-up and power-down, allowing the converter to tolerate a slow-rising input voltage. For most applications EN1 and EN2, can be configured for automatic power-up.

Positive Output Enable (Negative Inhibit)

To configure the converter for a positive enable function, connect EN1 (pin 3) to $-V_{in}$ (pin 2), and apply the system On/Off control signal to EN2 (pin 4). In this configuration, a logic '0' ($-V_{in}$ potential) applied to pin 4 disables the converter outputs. An example of this configuration is detailed in Figure 1.

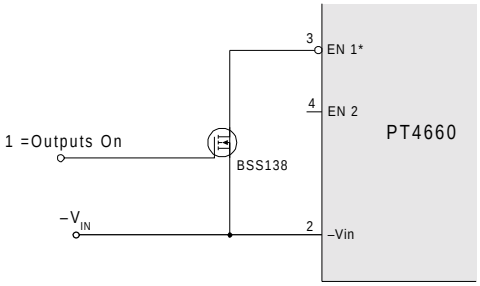
Figure 1; Positive Enable Configuration



Negative Output Enable (Positive Inhibit)

To configure the converter for a negative enable function, EN2 (pin 4) is left open circuit, and the system On/Off control signal is applied to EN1 (pin 3). A logic '0' ($-V_{in}$ potential) must then be applied to pin 3 in order to enable the outputs of the converter. An example of this configuration is detailed in Figure 2. *Note: The converter will only produce and output voltage if a valid input voltage is applied to* $\pm V_{in}$.

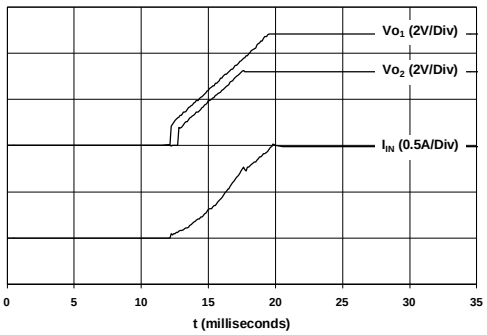
Figure 2; Negative Enable Configuration



On/Off Output Voltage Sequencing

The output voltages from the PT4660 series of DC/DC converters are independantly regulated, and are internally sequenced to meet the power-up requirements of popular microprocessor and DSP chipsets. Figure 3 shows the waveforms from a PT4661 after the converter is enabled at t=0s. During power-up, the Vo_1 and Vo_2 voltage waveforms typically track within 0.4V prior to Vo_2 reaching regulation. The waveforms were measured with a 5-Adc resistive load at each output, and with a 48-VDC input source applied. The converter typically produces a fully regulated output within 25ms. The actual turn-on time will vary slightly with input voltage, but the power-up sequence is independent of the load at either output.

Figure 3; Vo_1, Vo_2 Power-Up Sequence



During turn-off, both outputs drop rapidly due to the discharging effect of actively switched rectifiers. The voltage at Vo_1 remains higher than Vo_2 during this period. The discharge time is typically 100µs, but will vary with the amount of external load capacitance.

Adjusting the Output Voltage of the PT4660 and PT4680 Dual Output Voltage DC/DC Converters

The output voltages Vo_1 and Vo_2 from the PT4680 (24V Bus) and PT4660 (48V Bus) series of DC/DC converters can be independantly adjusted higher or lower than the factory trimmed pre-set voltage by up to ±10%. The adjustment requires the addition of a single external resistor[1]. Table 1 gives the adjustment range of Vo_1 and Vo_2 for each model in the series as V_a(min) and V_a(max).

Vo_1 Adjust Down: Add a resistor (R_1), between pin 13 (V_1 Adj) and pin 12 (Vo_1) [2].

Vo_1 Adjust Up: To increase the output, add a resistor R_2 between pin 13 (V_1 Adj) and pin 14 (COM) [2, 4].

Vo_2 Adjust Down: Add a resistor (R_3) between pin 20 (V_2 Adj) and pin 21 (Vo_2) [2].

Vo_2 Adjust Up: Add a resistor R_4 between pin 20 (V_2 Adj) and pins 19 (COM) [2, 4].

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

Notes:

1. Adjust resistors are not required if Vo_1 and Vo_2 are to remain at their respective nominal set-point voltage. In this case, V_1 Adj (pin 13) and V_2 Adj (pin 20) are left open-circuit
2. 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 DC/DC converter as possible.
3. Vo_2 must always be at least 0.3V lower than Vo_1.
4. **The over-voltage protection** threshold is fixed, and is set nominally 25% above the set-point output voltage. Adjusting Vo_1 or Vo_2 higher will reduce the voltage margin between the respective steady-state output voltage and its over-voltage (OV) protection threshold. This could make the module sensitive to OV fault detection, as a result of random noise and load transients.
   Note: An OV fault is a latched condition that shuts down both outputs of the converter. The fault can only be cleared by cycling one of the Enable control pins (EN_1 / EN_2), or by momentarily removing the input power to the module.*
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.

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.

$$(R_1) \text{ or } (R_3) = \frac{K_o (V_a - V_r)}{V_r (V_o - V_a)} - R_s \quad k\Omega$$

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

Where: V_o = Original output voltage, (Vo_1 or Vo_2)
V_a = Adjusted output voltage
V_r = The reference voltage from Table 1
K_o = The multiplier constant in Table 1
R_s = The series resistance from Table 1

Figure 1

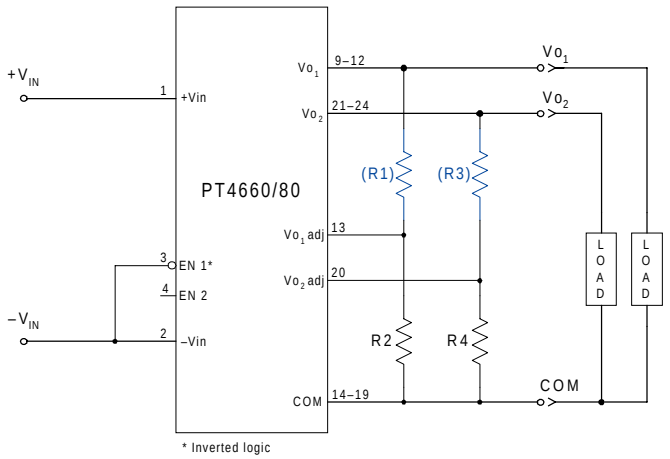


Table 1; ADJUSTMENT RANGE AND FORMULA PARAMETERS

V_{O1} Bus					V_{O2} Bus (2)				
24V Bus Pt.#	**PT4681/7**	**PT4682/3/5**	**PT4688**	**PT4686**	**PT4681**	**PT4682**	**PT4683/6/7**	**PT4685**	**PT4688**
48V Bus Pt.#	**PT4661/7**	**PT4662/3/5**	**PT4668**	**PT4666**	**PT4661**	**PT4662**	**PT4663/6/7**	**PT4665**	**PT4668**
Adj. Resistor	**(R1)/R2**	**(R1)/R2**	**(R1)/R2**	**(R1)/R2**	**(R3)/R4**	**(R3)/R4**	**(R3)/R4**	**(R3)/R4**	**(R3)/R4**
V_o(nom)	5.0V	3.3V	3.3V	2.5V	3.3V	2.5V	1.8V	1.5V	1.2V
Va(min)	4.5V	2.97V	2.97V	2.25V	2.97V	2.25V	1.62V	1.35	1.08
Va(max)	5.5V	3.63V	3.63V	2.75V	3.63V	2.75V	1.98V	1.65	1.32
Vr	2.5V	1.65V	2.5V	1.25	1.5V	1.5V	1.5V	TBD	0.6V
K_o (V·kΩ)	1.248	8.234	10.96	6.24	1.8	2.0	1.9	TBD	0.726
R_s (kΩ)	20.0	20.0	4.99	20.0	4.99	3.32	3.32	TBD	4.22

Table 2A; ADJUSTMENT RESISTOR VALUES, V_{O1}

24V Bus Pt.#	**PT4681/7**		**PT4682/3/5**	**PT4688**		**PT4686**
48V Bus Pt.#	**PT4661/7**		**PT4662/3/5**	**PT4668**		**PT4666**
Adj. Resistor	**(R1)/R2**		**(R1)/R2**	**(R1)/R2**		**(R1)/R2**
V_o(nom)	5.0V		3.3V	3.3V		2.5V
V_a(req'd)		**V_a(req'd)**			**V_a(req'd)**	
5.5	5.0kΩ	3.6	7.4kΩ	31.5kΩ	2.75	5.0kΩ
5.4	11.2kΩ	3.54	14.3kΩ	40.7kΩ	2.7	11.2kΩ
5.3	21.6kΩ	3.48	25.7kΩ	55.9kΩ	2.65	21.6kΩ
5.2	42.4kΩ	3.42	48.6kΩ	86.3kΩ	2.6	42.4kΩ
5.1	105.0kΩ	3.36	117.0kΩ	178.0kΩ	2.55	105.0kΩ
5.0		3.3			2.5	
4.9	(99.8)kΩ	3.24	(112.0kΩ)	(49.1kΩ)	2.45	(99.8kΩ)
4.8	(37.4)kΩ	3.18	(43.6kΩ)	(19.9kΩ)	2.4	(37.4kΩ)
4.7	(16.6)kΩ	3.12	(20.8kΩ)	(10.1kΩ)	2.35	(16.6kΩ)
4.6	(6.2)kΩ	3.06	(9.3kΩ)	(5.2kΩ)	2.3	(6.2kΩ)
4.5	(0.0)	3.0	(2.5kΩ)	(2.3kΩ)	2.25	(0.0kΩ)

R_1/R_3 = (Blue), R_2/R_4 = Black

Table 2B; ADJUSTMENT RESISTOR VALUES, V_{O2}

24V Bus Pt.#	**PT4681**	**PT4682**		**PT4683/6/7**	**PT4685**	**PT4688**
48V Bus Pt.#	**PT4661**	**PT4662**		**PT4663/6/7**	**PT4665**	**PT4668**
Adj. Resistor	**(R3)/R4**	**(R3)/R4**		**(R3)/R4**	**(R3)/R4**	**(R3)/R4**
V_o(nom)	3.3V	2.5V		1.8V	1.5V	1.2V
V_a(req'd)			**V_a(req'd)**			
3.6	1.0kΩ		1.95	9.4kΩ		
3.54	2.5kΩ		1.9	15.7kΩ		
3.48	5.0kΩ		1.85	34.7kΩ		
3.42	10.0kΩ		1.8			
3.36	25.0kΩ		1.75	(3.0)kΩ		
3.3			1.7			
3.24	(29.8)kΩ		1.65		TBD	
3.18	(11.8)kΩ		1.6		TBD	
3.12	(5.8)kΩ		1.55		TBD	
3.06	(2.8)kΩ		1.5			
3.0	(1.0)kΩ		1.45		(TBD)	
2.75		4.7kΩ	1.4		(TBD)	
2.7		6.7kΩ	1.35		(TBD)	
2.65		10.0kΩ	1.3			3.0kΩ
2.6		16.7kΩ	1.275			5.5kΩ
2.55		36.7kΩ	1.25			10.3kΩ
2.5			1.225			24.8kΩ
2.45		(22.0)kΩ	1.2			
2.4		(8.7)kΩ	1.175			(23.6)kΩ
2.35		(4.2)kΩ	1.15			(9.1)kΩ
2.3		(2.0)kΩ	1.125			(4.3)kΩ
2.25		(0.7)kΩ	1.1			(1.8)kΩ

R_1/R_3 = (Blue), R_2/R_4 = Black

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