NEW Product

PTV03010 3.3 Vin Single

Application Note 194

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RoHS
2002/95/EC

ARTESYN®
T E C H N O L O G I E S

1. Introduction

The PTH/PTV family of non-isolated, wide-output adjust power modules from Artesyn Technologies are optimized for applications that require a flexible, high performance module that is small in size. These products are part of the "Point-of-Load Alliance" (POLA), which ensures compatible footprint, interoperability and true second sourcing for customer design flexibility. The POLA is a collaboration between Artesyn Technologies, Astec Power and Texas Instruments to offer customers advanced non-isolated modules that provide the same functionality and form factor. Product series covered by the alliance includes the PTHxx050 (6 A), PTHxx060 (10 A), PTHxx010 (15/12 A), PTHxx020 (22/18 A), PTHxx030 (30/26 A), PTHxx040 (50/60 A), PTVxx010 (8 A) and the PTVxx020 (16 A/18 A).

From the basic, "Just Plug it In" functionality of the 6 A modules, to the 30 A rated feature-rich PTHxx030W, series these products were designed to be very flexible, yet simple to use. The features vary with each product series. Table 1 provides a quick reference to the available features by series and input bus voltage.

For simple point-of-use applications, the PTHxx050 series provides operating features such as an on/off inhibit, output voltage trim, pre-bias start-up (3.3/5 V input only), and over-current protection. The PTHxx060 (10 A), and PTHxx010 (15/12 A) series add an output voltage sense, and margin up/down controls. The higher output current, PTHxx020 and PTHxx030 series also incorporates over-temperature and shutdown protection. All of the products referenced in Table 1 include Auto-Track™.

This is a feature unique to the PTH/PTV family, and was specifically designed to simplify the task of sequencing the supply voltage in a power system. These and other features are described in the following sections.

SERIES	INPUT BUS	I OUT	ADJUST TRIM	ON/OFF INHIBIT	OVER-CURRENT	PRE-BIAS STARTUP	AUTO-TRACK™*	OUTPUT SENSE	THERMAL SHUTDOWN
PTVxx010	3.3/5 V	8 A	●	●	●	●	●		
	12 V	8 A	●	●	●	●	●		
PTVxx020	3.3/5 V	18 A	●	●	●	●	●	●	●
	12 V	16 A	●	●	●	●	●	●	●

Table 1 - Operating Features by Series and Input Bus Voltage

RoHS Compliance Ordering Information	
PTV03010WAH	To order Pb-free (RoHS compatible) through-hole parts replace the mounting option 'H' with 'D', e.g. PTV03010WAD.

*Auto-track™ is a trade mark of Texas Instruments

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2. System Interface Information

2.1 Input Capacitor

The required input capacitors are a 10 µF ceramic and a minimum of 100 µF electrolytic type. The 100 µF capacitance must be rated for 300 mA rms ripple current capability. See Table 2.

The above ripple current requirements are conditional that the 10 µF ceramic capacitor is present. The 10 µF X5R/X7R ceramic capacitor is necessary to reduce both the magnitude of ripple current through the electrolytic capacitor and the amount of ripple current reflected back to the input source. Ceramic capacitors should be located within 0.5 inch. (1.3 cm) of the module's input pins. Additional ceramic capacitors can be added to reduce the rms ripple current requirement for the electrolytic capacitor.

Ripple current (Arms) rating, less than 150 mΩ equivalent series resistance (ESR), and temperature are the major considerations when selecting input capacitors. Unlike polymer-tantalum capacitors, regular tantalum capacitors have a recommended minimum voltage rating of 2 x (max. dc voltage + ac ripple). This is standard practice to ensure reliability. Only a few tantalum capacitors were found to have sufficient voltage rating to meet this requirement. At temperatures below 0 °C, the ESR of aluminum electrolytic capacitors increases. For these applications, Os-Con, polymer-tantalum, and polymer-aluminum types should be considered.

2.2 Output Capacitance (Optional)

For applications with load transients (sudden changes in load current), regulator response benefits from external output capacitance. The recommended output capacitance of 100 µF allows the module to meet its transient response specification. For most applications, a high-quality computer-grade aluminum electrolytic capacitor is adequate. These capacitors provide decoupling over the frequency range, 2 kHz to 150 kHz, and are suitable when ambient temperatures are above 0 °C. For operation below 0 °C, tantalum-, ceramic, or Os-Con-type capacitors are recommended. When using one or more non-ceramic capacitors, the calculated equivalent ESR should be no lower than 4 mΩ (7 mΩ using the manufacturer's maximum ESR for a single capacitor). A list of preferred low-ESR-type capacitors are identified in Table 2.

2.2.1 Tantalum Capacitors

Tantalum-type capacitors can only be used on the output bus, and are recommended for applications where the ambient operating temperature can be less than 0 °C. The AVX TPS, Sprague 593D/594/595 and Kemet T495/T510 capacitor series are suggested over many other tantalum types due to their higher rated surge, power dissipation, and ripple current capability. As a caution, many general-purpose tantalum capacitors have considerably higher ESR, reduced power dissipation, and lower ripple current capability. These capacitors are also less reliable as they have reduced power dissipation and surge current ratings. Tantalum capacitors that have no stated ESR or surge current rating are not recommended for power applications.

When specifying Os-con and polymer tantalum capacitors for the output, the minimum ESR limit is encountered before the maximum capacitance value is reached.

2.2.2 Ceramic Capacitors

Above 150 kHz, the performance of aluminum electrolytic capacitors is less effective. Multilayer ceramic capacitors have low ESR and a resonant frequency higher than the bandwidth of the regulator. They can be used to reduce the reflected ripple current at the input as well as improve the transient response of the output. When used on the output, their combined ESR is not critical as long as the total value of ceramic capacitance does not exceed approximately 300 µF. Also, to prevent the formation of local resonances, do not place more than five identical ceramic capacitors in parallel with values of 10 µF or greater.

2.2.3 Capacitor Table

Table 2 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The recommended 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 (at 100 kHz) are critical parameters necessary to insure both optimum regulator per-formance and long-term reliability.

2.2.4 Designing for Very Fast Load Transients

The transient response of the dc-dc converter has been characterized using a load transient with a di/dt of 1 A/µs. The typical voltage deviation for this load transient is given in the datasheet specification table using the optional value of output capacitance. As the di/dt of a transient is increased, the response of a converter regulation circuit ultimately depends on its output capacitor decoupling network. This is an inherent limitation with any dc-dc converter once the speed of the transient exceeds its bandwidth capability. If the target application specifies a higher di/dt or lower voltage deviation, the requirement can only be met with additional output capacitor decoupling. In these cases, special attention must be paid to the type, value, and ESR of the capacitors selected.

If the transient performance requirements exceed that specified in the datasheet, or the total amount of load capacitance is above 3,000 µF, the selection of output capacitors becomes more important.

CAPACITOR VENDOR/ SERIES	CAPACITOR CHARACTERISTICS					QUANTITY		VENDOR PART NUMBER
	WORKING VOLTAGE	VALUE (µF)	(ESR) EQUIVALENT SERIES RESISTANCE	105ºC MAX RIPPLE CURRENT (rms)	PHYSICAL SIZE (mm) (L X W)	INPUT BUS	OPTIONAL OUTPUT BUS	
Panasonic WA (SMD) FK (SMD)	10 V 6.3 V 6.3 V	330 150 470	0.117 Ω 0.035 Ω 0.016 Ω	555 mA 3050 mA 600 mA	8.0 x 11.5 8.0 x 6.9 8.0 x 10.0	1 1 1	1 1 1	EEUFC1A331 EEFWA0J151P EEVFK0J471P
United Chemi-Con PSA (Radial) LXZ (Radial) MVZ (SMD) PXA (SMD)	6.3 V 10 V 16 V 10 V	220 470 680 120	0.02 Ω 0.12 Ω 0.09 Ω 0.027 Ω	3160 mA 555 mA 670 mA 2800 mA	6.3 x 9.8 8.0 x 12.5 10.0 x 10.0 8.0 x 6.7	1 1 1 1	≤3 1 1 ≤3	PSA6.3VB220MF11 LXZ10VB471M8X12LL MVZ16VC681MJ10TP PXA10VC121MH70TP
Nichicon HD (Radial) Sanyo TP, Poscap SP, Os-Con SVP, Os-Con (SMD)	16 V 10 V 10 V 6.3 V 6.3 V	270 470 220 120 100	0.09 Ω 0.072 Ω 0.025 Ω 0.035 Ω 0.04 Ω	575 mA 760 mA 2400 mA >1900 mA 1810 mA	10.0 x 12.5 8.0 x 11.5 7.3 x 4.3 6.3 x 6.8 6.3 x 6.0	1 1 1[(1)] 1	1 1 ≤2 ≤3 ≤3	UPM1C271MHH6 UHD1A471MPR 10TPE220M 6SP120M 6SVP100M
AVX Tantalum Series III TPS (SMD)	10 V 10 V	100 100	0.075 Ω 0.05 Ω	>1090 mA >1559 mA	7.3 x 5.7 7.3 x 5.7	N/R N/R	≤4 ≤4	TPSC107M010R0075 TPSD157M010R0050
Kemet SMD T520, Poly-Tant T530, Poly-Tant/ Organic Vishay-Sprague 94SVP, (Oscon) 595D, Tantalum 94SA, Os-Con	10 V 10 V 10 V 10 V 10 V	100 330 120 220 100	0.055 Ω 0.01 Ω 0.04 Ω 0.14 Ω 0.03 Ω	1500 mA >3800 2120 1040 2670	7.3 x 4.3 7.3 x 4.3 8.0 x 7.0 7.4 x 4.3 10.0 x 10.5	1 1 1 1 1	≤4 ≤1 ≤3 ≤4 ≤3	T520D107M010ASE055 T530X337M010ASE010 94SVP127X0010E7 595D227X0010D2T 94SA107X0010EBP
Kemet Ceramic X5R (SMD)	16 V 6.3 V 6.3 V	10 22 47	0.002 Ω 0.002 Ω 0.002 Ω		3225 3225 3225	≥1[(2)] ≥1[(2)] ≥1[(2)]	≤5 ≤5 ≤5	C1210C106M4PAC C1210C226K9PAC C1210C476K9PAC
Murata, Ceramic X5R (SMD)	6.3 V 6.3 V 16 V 16 V	100 47 22 10	0.002 Ω		3225	≥1[(2)] ≥1[(2)] ≥1[(2)] ≥1[(2)]	≤3 ≤5 ≤5 ≤5	GRM32ER60J107M GRM32ER60J476M GRM32ER61C226K GRM32DR61C106K
TDK, Ceramic X5R (SMD)	6.3 V 6.3 V 16 V 16 V	100 47 22 10	0.002 Ω		3225	≥1[(2)] ≥1[(2)] ≥1[(2)] ≥1[(2)]	≤3 ≤5 ≤5 ≤5	C3225X5R0J107MT C3225X5R0J476MT C3225X5R1C226MT C3225X5R1C106M

Table 2 - Recommended Input/Output Capacitors

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3. Mechanical Information

3.1 Mechanical Outline Drawing
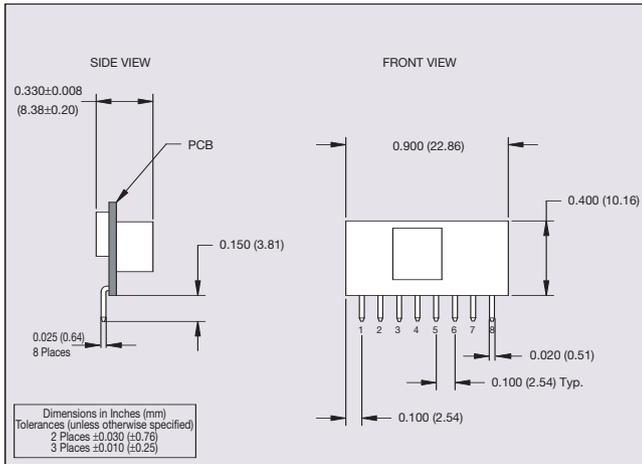
Figure 1 -Mechanical Drawing

3.2 Pin-out Table

PIN CONNECTIONS	
PIN NUMBER	FUNCTION
1	Ground
2	Vout
3	Vout
4	Vo Adjust
5	Track
6	Ground
7	Inhibit
8	Vin

Table 3 - Pin Connections

3.3 Pin Description
3.3.1 Ground
This is the common ground connection for the V_{in} and V_{out} power connections. It is also the 0 Vdc reference for the control inputs. Both pins must be connected to common ground.

3.3.2 Vout
The regulated positive power output with respect to the GND node.

3.3.3 Vo Adjust
A 1 % tolerance (or better) resistor must be connected directly between this pin or pins 1 and 6 (GND) pin to set the output voltage to the desired value. The set point range for the output voltage is from 0.8-2.5 V. The resistor required for a given output voltage may be calculated from the following formula. If left open circuit, the module output will default to its lowest output voltage value. The specification table gives the preferred resistor values for a number of standard output voltages.

$$R_{set} = 10 \text{ K} \times \frac{0.8 \text{ V}}{V_{out} - 0.8 \text{ V}} - 2.49 \text{ k}\Omega$$

3.3.4 Track
This is an analog control input that allows the output voltage to follow another voltage during power-up and power-down sequences. The pin is active from 0 V up to the nominal set-point voltage. Within this range the module's output will follow the voltage at the Track pin on a volt-for-volt basis. When the control voltage is raised above this range, the module regulates at its nominal output voltage. If unused, this input maybe left unconnected. For further information consult section 10.

Note: Due to the undervoltage lockout feature, the output of the module cannot follow its own input voltage during power up.

3.3.5 Inhibit
The Inhibit pin is an open-collector/drain negative logic input that is referenced to GND. Applying a low level ground signal to this input disables the module's output and turns off the output voltage. When the Inhibit control is active, the input current drawn by the regulator is significantly reduced. If the Inhibit pin is left open-circuit, the module will produce an output whenever a valid input source is applied.

3.3.6 Vin
The positive input voltage power node to the module, which is referenced to common GND.

4. Packaging Information

4.1 Packaging
The PTV03010 are packaged individually in anti-static bags and then in anti-static foam in boxes of 84 pieces.
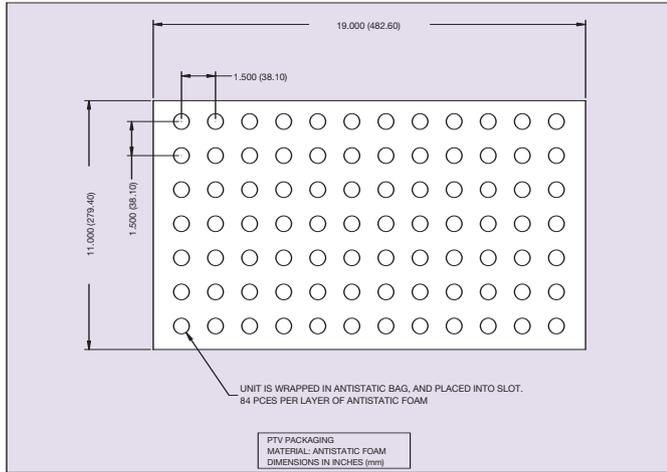

Figure 2 - PTV03010 Packaging Box

4.2 Labels and Part Numbering Sequence
All units in the series will be clearly marked to allow ease of identification for the end user. Figure 3 gives details of all the models.
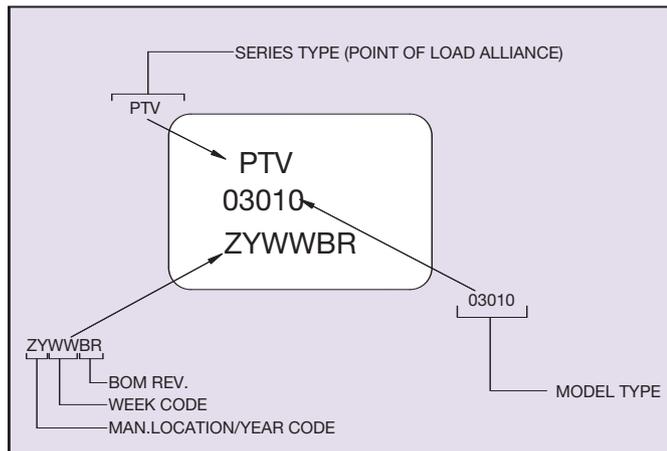

Figure 3 - PTV03010 Part Numbering

5. Safety Information

5.1 Safety Standards and Approvals
All models will have full international safety approval including EN60950 and UL/cUL1950. Models have been submitted to independent safety agencies for approval.

5.2 Fuse Information
Any suitable value fuse (based on the input ratings) maybe used in the unearthed input line. However this is not required for compliance with safety.

5.3 Safety Considerations
The converter must be installed as per guidelines outlined by the various safety agency approvals, if safety agency approval is required for the overall system.

6. Operating Information

6.1 Overcurrent Protection (OCP)
For protection against load faults, the modules incorporate output overcurrent protection. Applying a load that exceeds the overcurrent threshold causes the regulated output to shut down. Following shutdown, a module periodically attempts to recover by initiating a soft-start power up. This is described as a hiccup mode of operation, whereby the module continues in the cycle of successive shutdown and power up until the load fault is removed. During this period, the average current flowing into the fault is significantly reduced. Once the fault is removed, the module automatically recovers and returns to normal operation.

6.2 Soft-Start Power-Up
The Auto-Track feature allows the power up of multiple PTH/PTV modules to be directly controlled from the Track pin. However, in a stand-alone configuration, or when the Auto-Track feature is not being used, the Track pin should be directly connected to the input voltage, V_I (See Figure 4).
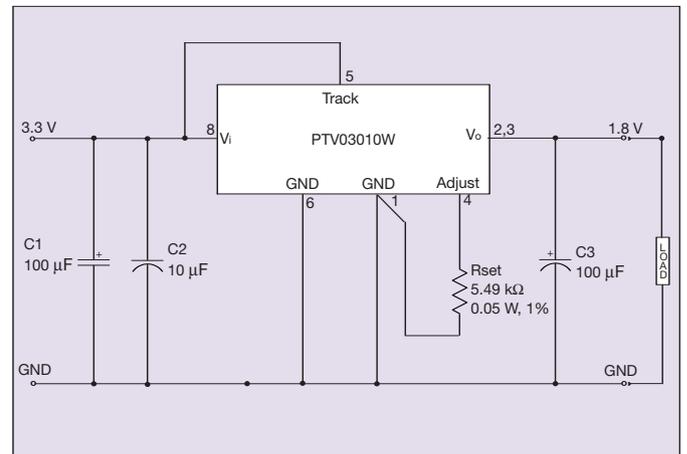

Figure 4 - Soft-Start Power-up

When the Track pin is connected to the input voltage, the Auto-Track function is permanently disengaged. This allows the module to power up entirely under the control of its internal soft-start circuitry. When power up is under soft-start control, the output voltage rises to the set-point at a quicker and more linear rate.
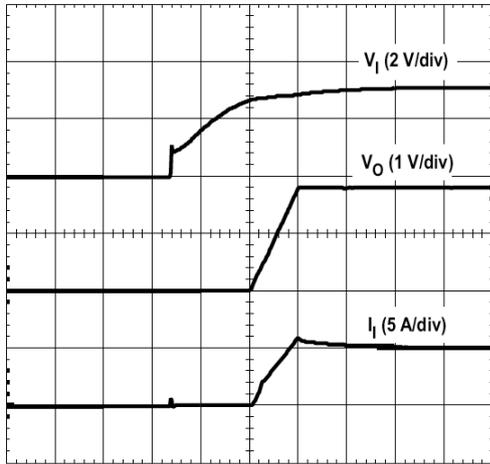
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Figure 5 - Power-up Characteristic

From the moment a valid input voltage is applied, the soft-start control introduces a short time delay (typically 8 ms to 15 ms) before allowing the output voltage to rise. The output then progressively rises to the module's setpoint voltage. Figure 5 shows the soft-start power-up characteristic of the PTV03010, operating from a 3.3 V input bus and configured for a 1.8 V output. The waveforms were measured with a 5 A resistive load and the Auto-Track feature disabled. The initial rise in input current when the input voltage first starts to rise is the charge current drawn by the input capacitors. Power-up is complete within 25 ms.

7. Feature Set

7.1 Adjusting the Output Voltage

The V_o adjust control (pin 4) sets the output voltage of the PTV03010 product. The adjustment range is from 0.8-2.5 V. The adjustment method requires the addition of a single external resistor, R_{set}, that must be connected directly between the $V_{o\ adjust}$ and GND pins[1]. Table 4 gives the preferred value for the external resistor for a number of standard voltages, along with the actual output voltage that this resistance value provides. Figure 6 shows the placement of the required resistor.

For other output voltages the value of the required resistor can either be calculated using the following formula, or simply selected from the range of values given in Table 5.

$$R_{set} = 10\ K \times \frac{0.8\ V}{V_{out} - 0.8\ V} - 2.49\ k\Omega$$

V_{out} Standard	R_{set} (Preferred Value)	V_{out} (Actual)
2.5 V	2.21 kΩ	2.502 V
2.0 V	4.12 kΩ	2.010 V
1.8 V	5.49 kΩ	1.803 V
1.5 V	8.87 kΩ	1.504 V
1.2 V	17.4 kΩ	1.202 V
1.0 V	36.5 kΩ	1.005 V
0.8 V	Open	0.8 V

Table 4 - Preferred Values of R_{set} for Standard Output Voltages
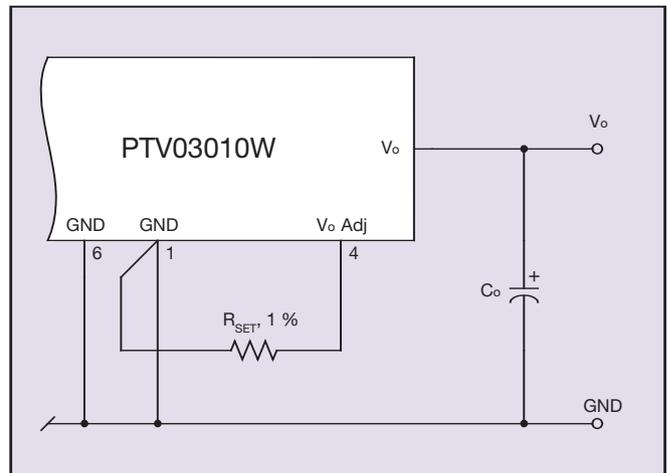
Figure 6 - Adjust Resistor Placement

OUTPUT VOLTAGE SET-POINT RESISTOR VALUES					
Va Req'd	Rset	Va Req'd	Rset	Va Req'd	Rset
0.800	Open	1.225	16.3 kΩ	1.75	5.93 kΩ
0.825	318 kΩ	1.250	15.3 kΩ	1.80	5.51 kΩ
0.850	158 kΩ	1.275	14.4 kΩ	1.85	5.13 kΩ
0.875	104 kΩ	1.300	13.5 kΩ	1.90	4.78 kΩ
0.900	77.5 kΩ	1.325	12.7 kΩ	1.95	4.47 kΩ
0.925	61.5 kΩ	1.350	12.1 kΩ	2.00	4.18 kΩ
0.950	50.8 kΩ	1.375	11.4 kΩ	2.05	3.91 kΩ
0.975	43.2 kΩ	1.400	10.8 kΩ	2.10	3.66 kΩ
1.000	37.5 kΩ	1.425	10.3 kΩ	2.15	3.44 kΩ
1.025	33.1 kΩ	1.450	9.82 kΩ	2.20	3.22 kΩ
1.050	29.5 kΩ	1.475	9.36 kΩ	2.25	3.03 kΩ
1.075	26.6 kΩ	1.50	8.94 kΩ	2.30	2.84 kΩ
1.100	24.2 kΩ	1.55	8.18 kΩ	2.35	2.67 kΩ
1.125	22.1 kΩ	1.60	7.51 kΩ	2.40	2.51 kΩ
1.150	20.4 kΩ	1.65	6.92 kΩ	2.45	2.36 kΩ
1.175	18.8 kΩ	1.70	6.4 kΩ	2.50	2.22 kΩ
1.200	17.5 kΩ				

Notes:
1   A 0.05 W rated resistor may be used. The tolerance should be 1 %, with temperature stability of 100 ppm/°C (or better). Place the resistor as close to the regulator as possible. Connect the resistor between pin 4 and pins 1, using dedicated PCB traces.
2   Never connect capacitors from Vo Adjust to either GND or Vout. Any capacitance added to the Vo Adjust pin will affect the stability of the regulator.

Table 5 - Output Voltage Set-point Resistor Values

7.2 Output ON/OFF Inhibit
For applications requiring output voltage ON/OFF control, each series of the PTH/PTV family incorporates an output Inhibit control pin. The inhibit feature can be used wherever there is a requirement for the output voltage from the regulator to be turned OFF.

The power modules function normally when the Inhibit pin is left open-circuit, providing a regulated output whenever a valid source voltage is connected to Vin with respect to GND. Figure 7 shows the typical application of the inhibit function. Note the discrete transistor (Q1). The Inhibit control has its own internal pull-up to +Vin potential. An open-collector or open-drain device is recommended to control this input.

Turning Q1 on applies a low voltage to the Inhibit control pin and disables the output of the module. If Q1 is then turned off, the module will execute a soft-start power-up sequence. A regulated output voltage is produced within 25 ms. Figure 8 shows the typical rise in both the output voltage and input current, following the turn-off of Q1. The turn off of Q1 corresponds to the rise in the waveform, Q1 V_{DS}. The waveforms were measured with a 5 A load.
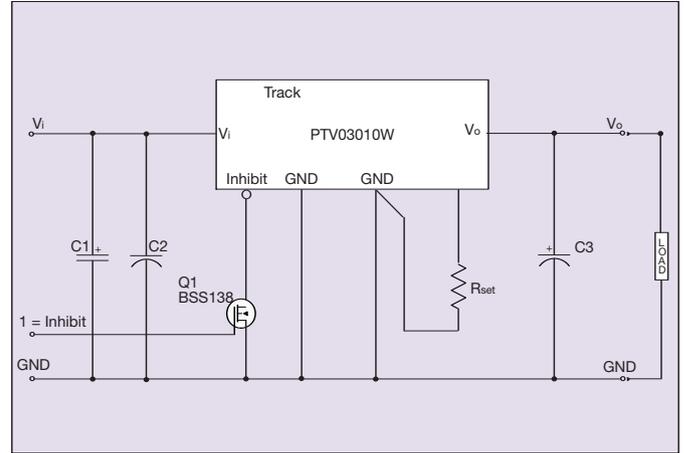
Figure 7 - Typical Application of the Inhibit Function
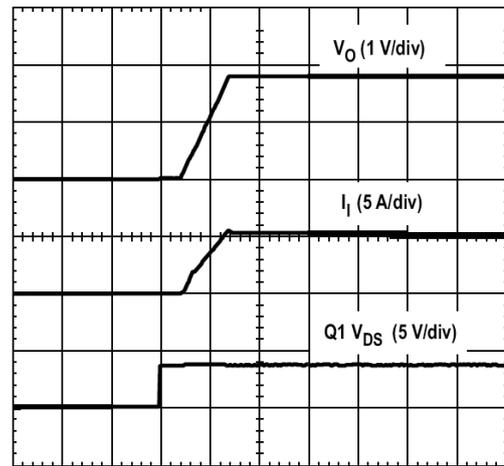
Figure 8 - Typical Rise in Output Voltage and Input Current

7.3 Pre-Bias Startup Capability
A pre-bias start-up condition occurs as a result of an external voltage being present at the output of a power module prior to its output becoming active. This often occurs in complex digital systems when current from another power source is backfed through a dual-supply logic component, such as an FPGA or ASIC. Another path might be via clamp diodes, sometimes used as part of a dual-supply power-up sequencing arrangement. A pre-bias can cause problems with power modules that incorporate synchronous rectifiers. This is because under most operating conditions, such modules can sink as well as source output current. The PTH/PTV modules incorporate synchronous rectifiers but do not sink current during start-up, or whenever the Inhibit pin is held low. Start-up includes an initial delay (approximately 8 to15 ms), followed by the rise of the output voltage under the control of the module internal soft-start mechanism, see Figure 9.

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7.3.1 Conditions for Pre-bias Holdoff

In order for the module to allow an output pre-bias voltage to exist (and not sink current), certain conditions must be maintained. The module holds off a pre-bias voltage when the Inhibit pin is held low, and whenever the output is allowed to rise under soft-start control. Power-up under soft-start control occurs on the removal of the ground signal to the Inhibit pin (with input voltage applied), or when input power is applied with Auto-Track disabled[1]. The input voltage must also be greater than the applied pre-bias source[2].

The soft-start period is complete when the output begins rising above the pre-bias voltage. The module then functions as normal, and sinks current if a voltage higher than its set-point value is applied to its output.

Note If a pre-bias condition is not present, the soft-start period is complete when the output voltage has risen to either the set-point voltage, or the voltage applied at the module Track control pin, whichever is lowest, to its output.

7.3.2 Demonstration Circuit

Figure 9 shows the start-up waveforms for the demonstration circuit shown in Figure 11. The initial rise in VO2 is the pre-bias voltage, which is passed from the VCCIO to the VCORE voltage rail through the ASIC. Note that the output current from the module (Io2) is negligible until its output voltage rises above the applied pre-bias.
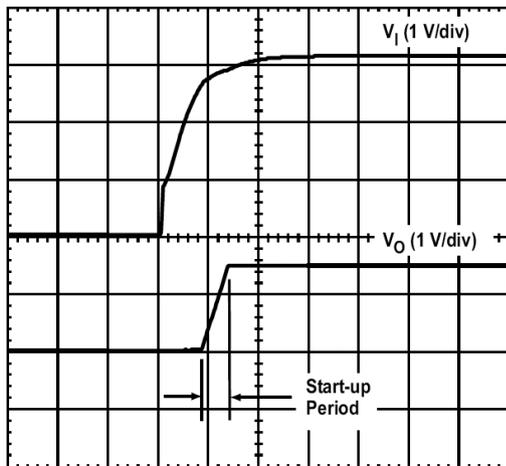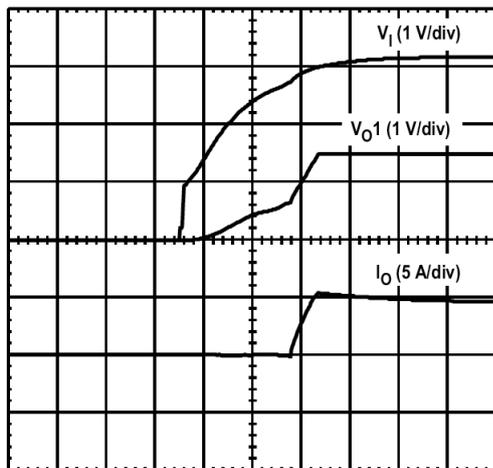

Figure 9 - PTV03010W Start-Up

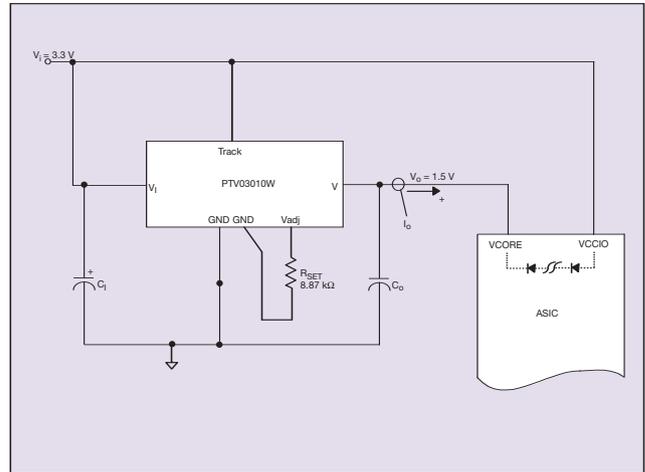**Figure 10 - Pre-bias Start-Up Waveforms**

Figure 11 - Application Circuit Demonstrating Pre-bias Start-up

Notes

1   The pre-bias start-up feature is not compatible with Auto-Track. If the rise in the output is limited by the voltage applied to the Track control pin, the output sinks current during the period that the Track control voltage is below that of the back-feeding source. For this reason, Auto-Track should be disabled when not being used. This is accomplished by connecting the Track pin to the input voltage, V_I. This raises the Track pin well above the set-point. voltage prior to start-up, thereby defeating the Auto-Track feature.

2   To further ensure that the regulator output does not sink current when power is first applied (even with a ground signal applied to the Inhibit control input), the input voltage must always be greater than the applied pre-bias source. This condition must exist throughout the power-up sequence of the power system.

8. Thermal Information

8.1 Thermal Reference Points
The electrical operating conditions namely:

• Input voltage, V_{in}
• Output voltage, V_o
• Output current, I_o

determine how much power is dissipated within the converter. The following parameters further influence the thermal stresses experienced by the converter:

• Ambient temperature
• Air velocity
• Thermal efficiency of the end system application
• Parts mounted on system PCB that may block airflow
• Real airflow characteristics at the converter location

8.2 Safe Operating Area Curve
Thermal characterisation data is presented in the datasheet in a safe operating area curve format which are repeated here in Figure 12. This SOA curve shows the load current versus the ambient air temperature and velocity.
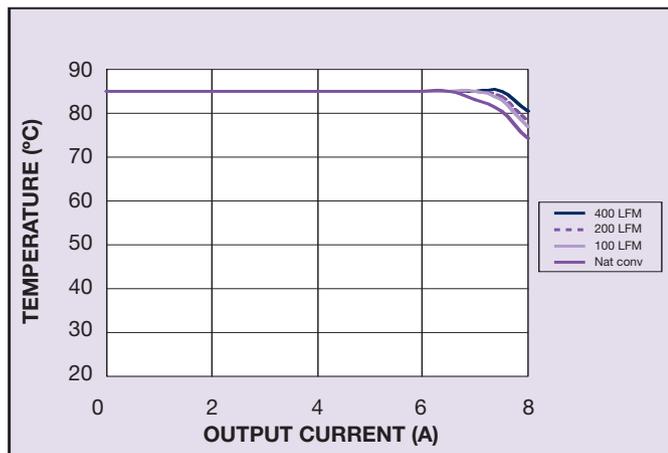

**Figure 12 - Safe Operating Curve
PTV03010 V$_{out}$ = 2.5 V**

8.3 Thermal Test Set-up
All of the data was taken with the converter soldered to a test board which closely represents a typical application. The test board is a 1.6 mm, eight layer FR4 pcb with the inner layers consisting of 2 oz power and ground planes. The top and bottom layers contain a minimal amount of metalisation. A board to board spacing of 1 inch was used. The data represented by the 0 m/s curve indicate a natural convection condition i.e. no forced air. However, since the thermal performance is heavily dependent upon the final system application, the user needs to ensure the thermal reference point temperatures are kept within the recommended temperature rating. It is recommended that the thermal reference point temperatures are measured using either AWG #36 or #40 gauge thermocouples or an IR camera. In order to comply with stringent Artesyn derating criteria, the ambient temperature should never exceed 85 °C. Please contact Artesyn Technologies for further support.

9. Use in a Manufacturing Environment

9.1 Recommended Land Pattern
It is recommended that the customer uses a solder mask defined land pattern similar to that shown in Figure 13.
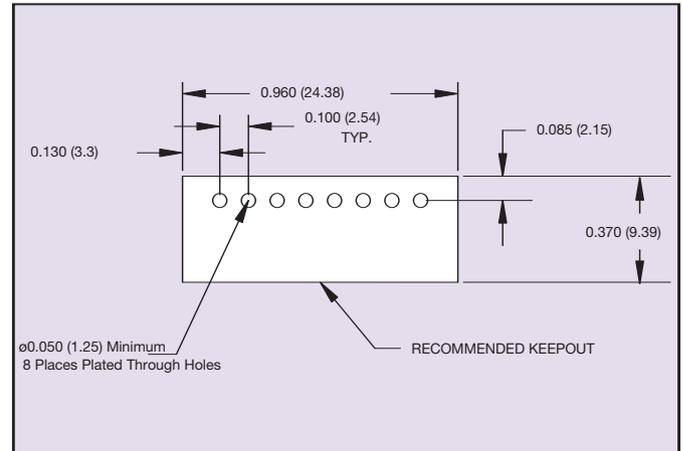

Figure 13 - Recommended Land Pattern

Power pin connection should utilize four or more vias to the interior power plane of 0.025 (0.63) I.D. per input, ground and output pin (or the electrical equivalent.

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10. Auto-Track™

10.1 Auto-Track™ Function

The Auto-Track function is unique to the PTH/PTV family, and is available with all POLA products. Auto-Track was designed to simplify the amount of circuitry required to make the output voltage from each module power-up and power-down in sequence. The sequencing of two or more supply voltages during power-up is a common requirement for complex mixed-signal applications that use dual-voltage VLSI ICs such as DSPs, microprocessors, and ASICs.

10.2 How Auto-Track™ Works

Auto-Track works by forcing the module output voltage to follow a voltage presented at the Track control pin[1]. This control range is limited to between 0 V and the module set-point voltage. Once the Track-pin voltage is raised above the set-point voltage, the module's output remains at its set-point[2]. As an example, if the Track pin of a 2.5 V regulator is at 1 V, the regulated output is 1 V. But if the voltage at the Track pin rises to 3 V, the regulated output does not go higher than 2.5 V.

When under Auto-Track control, the regulated output from the module follows the voltage at its Track pin on a volt-for-volt basis. By connecting the Track pin of a number of these modules together, the output voltages follow a common signal during power-up and power-down. The control signal can be an externally generated master ramp waveform, or the output voltage from another power supply circuit[3]. For convenience, the track input incorporates an internal RC-charge circuit. This operates off the module input voltage to produce a suitable rising waveform at power-up.

10.3 Typical Application

The basic implementation of Auto-Track allows for simultaneous voltage sequencing of a number of Auto-Track compliant modules. Connecting the Track control pins of two or more modules forces the track control of all modules to follow the same collective RC-ramp waveform, and allows them to be controlled through a single transistor or switch; see Q1 in Figure 14.

To initiate a power-up sequence, it is recommended that the track control first be pulled to ground potential. This is done at or before input power is applied to the modules, and then held for at least 10 ms thereafter. This brief period gives the modules time to complete their internal soft-start initialization. Applying a logic level high signal to the circuit On/Off Control turns Q1 on and applies a ground signal to the Track input of the modules. After completing their internal soft-start initialization, the output of all modules remains at zero volts while Q1 is on.

Q1 may be turned off 10 ms after a valid input voltage has been applied to the modules. This allows the Track control voltage to automatically rise to the module input voltage. During this period, the output voltage of each module rises in unison with other modules to its respective set-point voltage.

Figure 15 shows the output voltage waveforms from the circuit of Figure 14 after the On/Off Control is set from a high-level to a low-level voltage. The waveforms, VO1 and VO2 represent the output voltages from the two power modules, U1 (3.3 V) and U2 (1.8 V), respectively. VO1 and VO2 are shown rising together to produce the desired simultaneous power-up characteristic.

The same circuit also provides a power-down sequence. Power-down is the reverse of power-up, and is accomplished by lowering the track control voltage back to zero volts. The important constraint is that a valid input voltage must be maintained until the power-down is complete. It also requires that Q1 be turned off relatively slowly. This is so that the Track control voltage does not fall faster than Auto-Track slew rate capability, which is 1 V/ms. The components R1 and C1 in Figure 14 limit the rate at which Q1 pulls down the Track control voltage. The values of 100 kW and 0.1 µF correlate to a decay rate of about 0.17 V/ms.

The power-down sequence is initiated with a low-to-high transition at the On/Off Control input to the circuit. Figure 16 shows the power-down waveforms. As the track control voltage falls below the nominal set-point voltage of each power module, then its output voltage decays with all the other modules under Auto-Track control.

Notes of the Use Auto-Track™

1　The Track pin voltage must be allowed to rise above the module set-point voltage before the module can regulate at its adjusted set-point voltage prior to start-up, thereby defeating the Auto-Track feature.
2　The Auto-Track function tracks almost any voltage ramp during power-up, and is compatible with ramp speeds of up to 1 V/ms.
3　The absolute maximum voltage that may be applied to the Track pin is the input voltage VI.
4　The module cannot follow a voltage at its track control input until it has completed its soft-start initialization. This takes about 10 ms from the time that a valid voltage has been applied to its input. During this period, it is recommended that the Track pin be held at ground potential.
5　The module is capable of both sinking and sourcing current when following a voltage at its track input. Therefore, start up into an output pre-bias cannot be supported when a module is under Auto-Track control.
　Note: A pre-bias holdoff is not necessary when all supply voltages rise simultaneously under the control of Auto-Track.
6　The Auto-Track function can be disabled by connecting the Track pin to the input voltage (V_I). When Auto-Track is disabled, the output voltage rises at a quicker and more linear rate after input power has been applied.
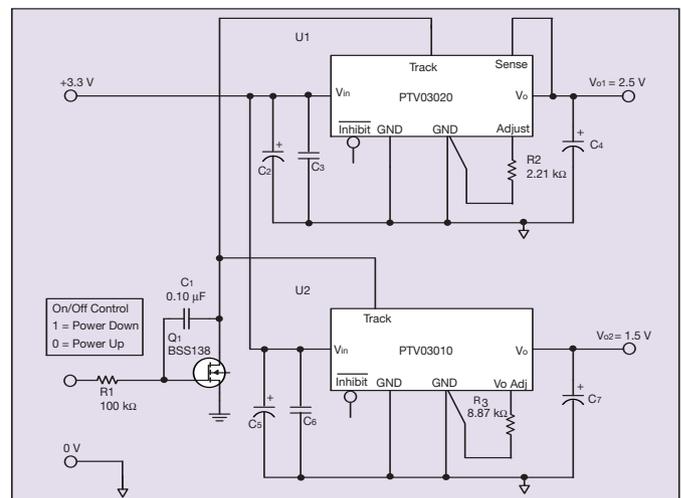

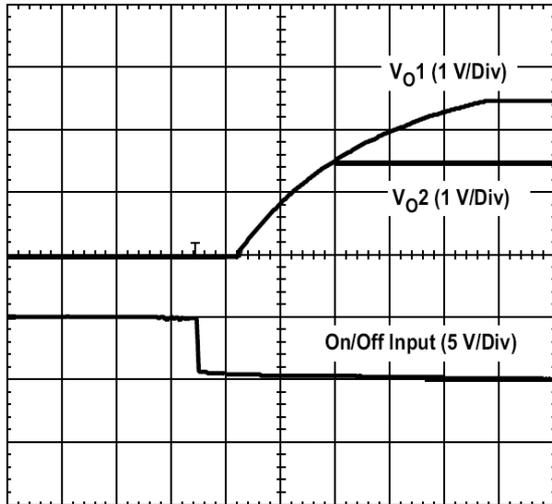**Figure 14 - Sequenced Power Up and Power Down Using Auto-Track**

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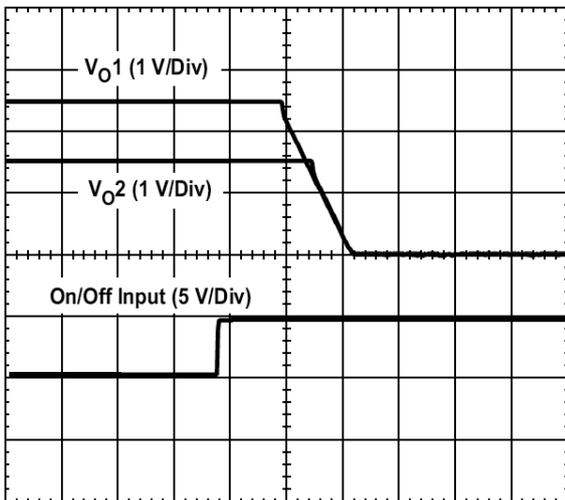
Figure 15 - Simultaneous Power Up With Auto-Track Control

Figure 16 - Simultaneous Power Down With Auto-Track

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