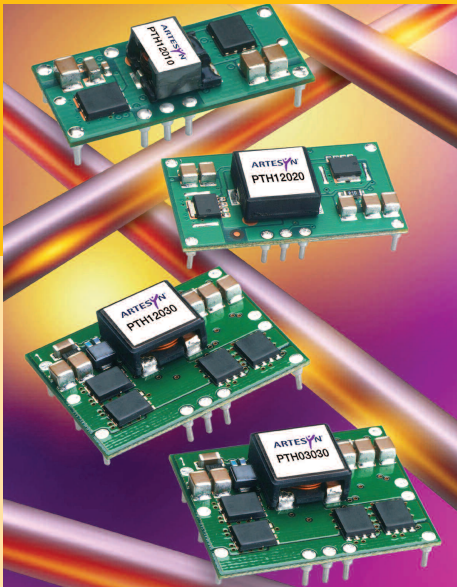




PTH05050 5Vin Single

Application Note 158

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POLA
Point-of-Load Alliance



1. Introduction

The PTH 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 PTHxx050W (6A), PTHxx060W (10A), PTHxx010W (15/12A), PTHxx020W (22/18A), and the PTHxx030W(30/26A).


From the basic, “Just Plug it In” functionality of the 6A modules, to the 30A 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 PTHxx050W series provides operating features such as an ON/OFF inhibit, output voltage trim, pre-bias start-up (3.3/5V input only), and overcurrent protection. The PTHxx060W (10A), and PTHxx010W (15/12A) series add an output voltage sense, and margin up/down controls. The higher output current, PTHxx020W and PTHxx030W series also incorporates overtemperature and shutdown protection. All of the products referenced in Table 1 include Auto-Track™.

This is a feature unique to the PTH 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™*	MARGIN UP/DOWN	OUTPUT SENSE	THERMAL SHUTDOWN
PTHxx050	3.3V	6A	●	●	●	●	●			
	5V	6A	●	●	●	●	●			
	12V	6A	●	●	●	●	●			
PTHxx060	3.3V/5V	10A	●	●	●	●	●	●	●	
	12V	10A	●	●	●	●	●	●	●	
PTHxx010	3.3V/5V	15A	●	●	●	●	●	●	●	
	12V	12A	●	●	●	●	●	●	●	
PTHxx020	3.3V/5V	22A	●	●	●	●	●	●	●	●
	12V	18A	●	●	●	●	●	●	●	●
PTHxx030	3.3V/5V	30A	●	●	●	●	●	●	●	●
	12V	26A	●	●	●	●	●	●	●	●

Table 1 - Operating Features by Series and Input Bus Voltage

RoHS Compliance Ordering Information	
	PTH05050WAST To order Pb-free (RoHS compatible) surface-mount parts replace the mounting option ‘S’ with ‘Z’, e.g. PTH05050WAZT. To order Pb-free (RoHS compatible) through-hole parts replace the mounting option ‘H’ with ‘D’, e.g. PTH05050WADT.

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



2. System Interface Information

2.1 Input Capacitor

The recommended input capacitance is determined by 300mA rms minimum ripple current rating and 100µF minimum capacitance.

Ripple current and <300mΩ 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 2 x (max. DC voltage + AC ripple). This is standard practise for tantalum capacitors to ensure reliability.

2.2 Output Capacitance (Optional)

The recommended ESR of the output capacitor is equal to or less than 300mΩ. Electrolytic capacitors have marginal 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.

2.2.1 Tantalum/Ceramic Capacitors

Tantalum capacitors are acceptable on the output bus. Tantalum, Os-con®, or ceramic capacitor types are recommended for applications where ambient temperatures fall below 0°C. Ceramic capacitors may be used instead of electrolytic types on both the input and output bus. The input bus must have the minimum amount of capacitance. A single 10µF ceramic capacitor may also be used on the output bus to reduce output ripple.

2.2.2 Capacitor Table

Table 2 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 (at 100kHz) are critical parameters necessary to insure both optimum regulator performance and long-term reliability.

CAPACITOR VENDOR/ SERIES	CAPACITOR CHARACTERISTICS					QUANTITY		VENDOR PART NUMBER
	WORKING VOLTAGE	VALUE (µF)	(ESR) EQUIVALENT SERIES RESISTANCE	MAX RIPPLE AT 85°C CURRENT (Irms)	PHYSICAL SIZE (mm) (L X W)	INPUT BUS	OPTIONAL OUTPUT BUS	
Panasonic FC (SMT)	25V	100	0.300Ω	450mA	8 x 10	1	1	EEVFC1E101P
WA (SMT)	10V	120	0.035Ω	2800mA	8.3 x 6.9	1	1	EEFWA1A121P
Panasonic FC FK (SMT)	16V	220	0.150Ω	555mA	10 x 10.2	1	1	EEUFC1C221
	16V	330	0.160Ω	600mA	8 x 10.2	1	1	EEVFK1C331P
United Chemi-Con FS	10V	100	0.040Ω	2100mA	6.3 x 9.8	1	1	10FS100M
PXA (SMT)	10V	120	0.027Ω	2430mA	8 x 6.7	1	1	PXA10VC121MH80TP
MVZ (SMT)	16V	220	0.170Ω	450mA	8 x 10	1	1	MVZ25VC221MH10TP
PS	10V	270	0.014Ω	4420mA	8 x 11.5	1	1	10PS270MH11
Nichicon WG (SMT)	35V	100	0.150Ω	670mA	10 x 10	1	1	UWG1V101MNR1GS
NA	10V	120	0.040Ω	2120mA	8 x 7	1	1	PNA1A121M1
PM	25V	150	0.160Ω	460mA	10 x 11.5	1	1	UPM1E151MPH
SANYO Os-con®: SVP (SMT)	10V	120	0.040Ω	>2500mA	7 x 8	1	1	10SVP120M
SP	16V	100	0.025Ω	>2800mA	6.3 x 9.8	1	1	16SPS100M
TPA	10V	100	0.080Ω	>1200mA	7.3 x 4.8	1	1	10TPA100M
AVX Tantalum TPS	10V	100	0.100Ω	>1090mA	7.3 x 4.3	1	1	TPSD107M010R0100
	10V	220	0.100Ω	>1414mA	7.3 x 4.3	1	1	TPSV227M010R0100
Kemet T520	10V	100	0.080Ω	1200mA	7.3 x 5.7	1	1	T520D107M010AS
T495	10V	100	0.100Ω	>1100mA	7.3 x 5.7	1	1	T495X107M010AS
Sprague 594D/ 595D	10V	150	0.090Ω	1100mA	7.3 x 6.0	1	1	594D157X0010C2T
	10V	120	0.140Ω	>1000mA	7.3 x 6.0	1	1	595D127X0010D2T
TDK Ceramic X5R	6.3V	47	0.002Ω	>1440mA	3.6 x 2.8	2	2	C3225X5R0J476KT/MT
Murata Ceramic X5R 1210 Case	6.3V	47	0.002Ω	>1000mA	3.6 x 2.8	2	2	GRM32ER60J476M/6.3

Table 2 - Recommended Input/Output Capacitors

3. Mechanical Information

3.1 Mechanical Outline Drawings

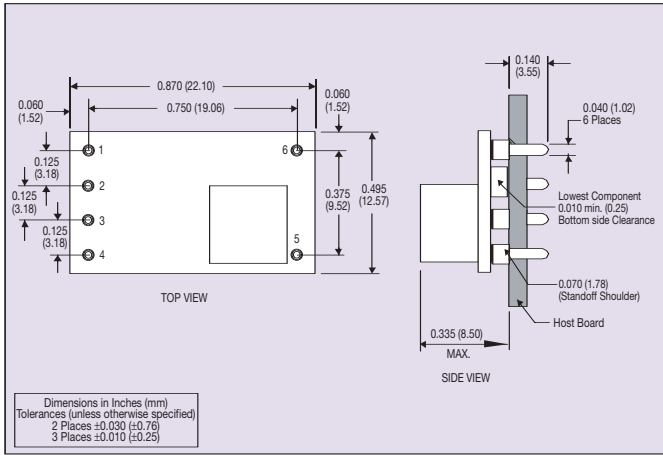


Figure 1 - Plated Through-Hole Mechanical Drawing

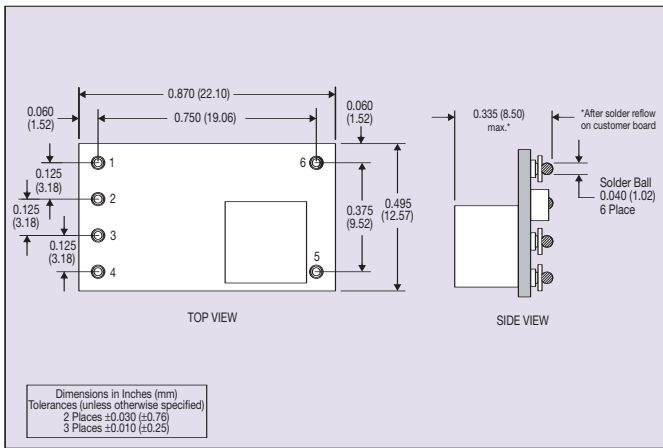


Figure 2 - Surface Mount Mechanical Drawing

3.2 Pin-out Table

PIN CONNECTIONS	
PIN NUMBER	FUNCTION
1	Ground
2	Track
3	V _{in}
4	Inhibit
5	V _o adjust
6	V _{out}

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 0VDC reference for the control inputs.

3.3.2 Track

This is an analog control input that allows the output voltage to follow another voltage during powerup and power-down sequences. The pin is active from 0V 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 may be left unconnected. For further information consult section 10.

3.3.3 V_{in}

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

3.3.4 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.

3.3.5 V_o Adjust

A 0.1W, 1% tolerance (or better) resistor must be connected directly between this pin and pin 1 (GND) pin to set the output voltage to a value higher than 0.8V. The temperature stability of the resistor should be 100ppm/°C (or better). The set point range for this output voltage is from 0.8V to 3.6V. 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.

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

The specification table gives the preferred resistor values for a number of standard output voltages.

3.3.6 V_{out}

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

4. Packaging Information

4.1 Packaging

The PTH05050 are available in trays of 28 units and tape and reel format in quantities of 250 units per reel. Tray and tape dimensions including pick point are shown in Figures 3 and 4.

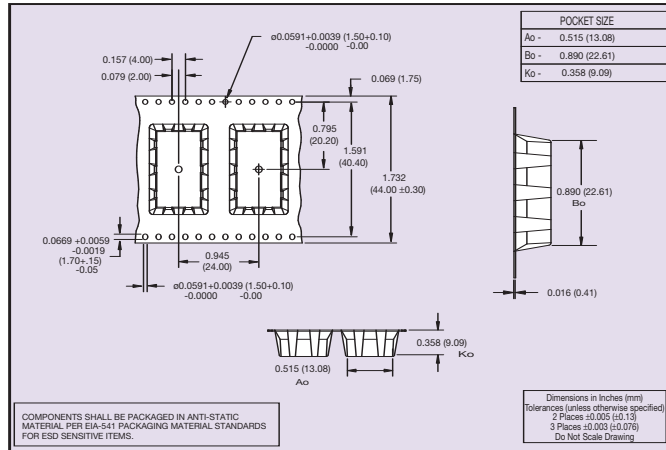


Figure 3 - Tape Dimensions

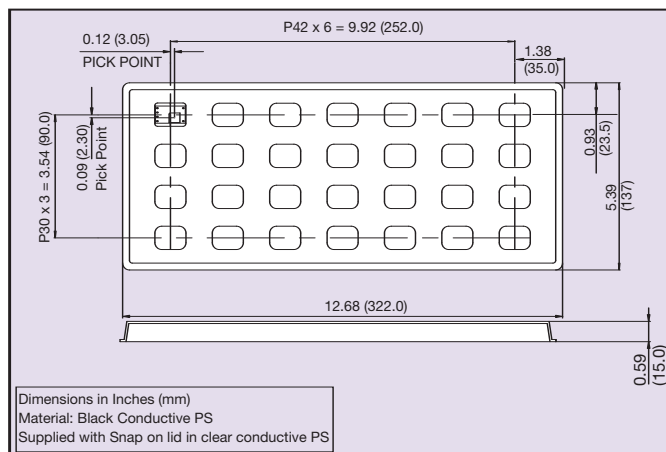


Figure 4 - Tray

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 5 gives details of all the models.

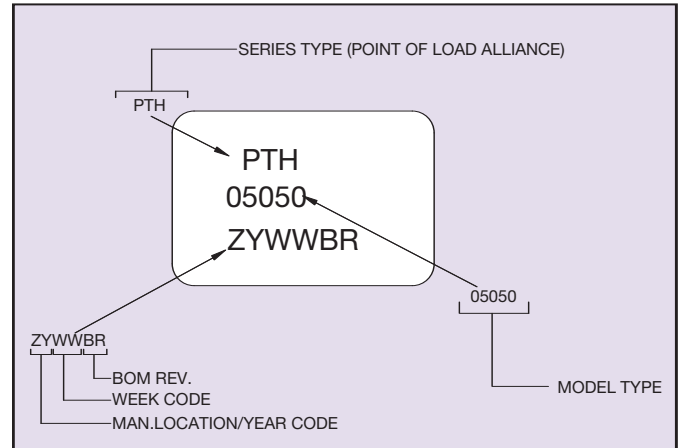


Figure 5 - PTH05050 Part Numbering

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 Overtemperature Protection (OTP)

Only the PTHxx020 and PTHxx030 series of products have overtemperature protection. These products have an on-board temperature sensor that protects the module's internal circuitry against excessively high temperatures. A rise in the internal temperature may be the result of a drop in airflow, or a high ambient temperature. If the internal temperature exceeds the OTP threshold (see data sheet specifications), the module's Inhibit control is automatically pulled low. This disables the regulator allowing the output voltage to drop to zero. (The external output capacitors will be discharged by the load circuit). The recovery is automatic, and begins with a soft-start power up. It occurs when the the sensed temperature decreases by about 10°C below the trip point.

Note

The overtemperature protection is a last resort mechanism to prevent thermal stress to the regulator. Operation at or close to the thermal shutdown temperature is not recommended and will reduce the long-term reliability of the module. Always operate the regulator within the specified Safe Operating Area (SOA) limits for the worst-case conditions of ambient temperature and airflow.

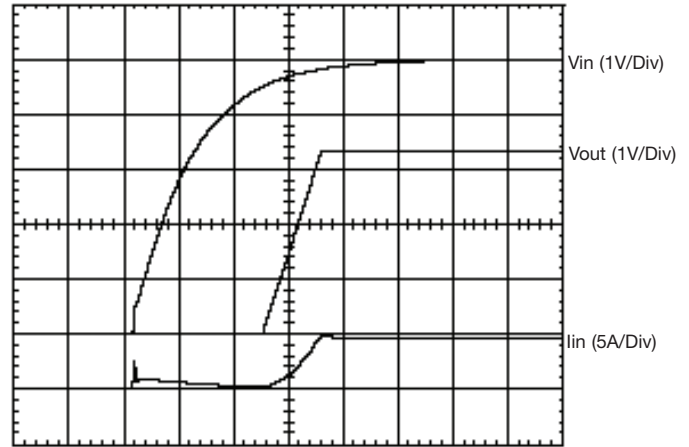
6.2 Overcurrent Protection

For protection against load faults, all modules incorporate output overcurrent protection. Applying a load that exceeds the regulator's overcurrent threshold will cause the regulated output to shut down. Following shutdown a module will periodically attempt 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.

6.3 Soft-Start Power-Up

The Auto-Track feature allows the power-up of multiple PTH 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_{in} (see Figure 6).

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.



HORIZ SCALE:5 ms/Div

Figure 7 - Power-up Characteristic

From the moment a valid input voltage is applied, the soft-start control introduces a short time delay (typically 5ms to 10ms) before allowing the output voltage to rise. The output then progressively rises to the module's setpoint voltage. Figure 7 shows the soft-start power-up characteristic of the 22A output product (PTH05020W), operating from a 5V input bus and configured for a 3.3V output. The waveforms were measured with a 5A resistive load, with Auto-Track 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 15ms

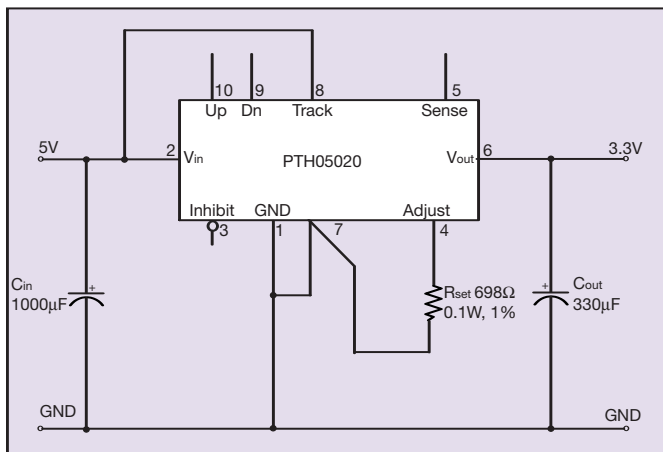


Figure 6 - Soft-Start Power-up

7. Feature Set

7.1 Adjusting the Output Voltage of the PTH05050

The V_o adjust control (pin 5) sets the output voltage of the PTH05050 product to a value higher than 0.8V. The adjustment range (3.3V input) is from 0.8V to 3.6V. 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 pins¹. 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.

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. Figure 8 shows the placement of the required resistor.

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

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

Table 4 - Preferred Values of R_{set} for Standard Output Voltages

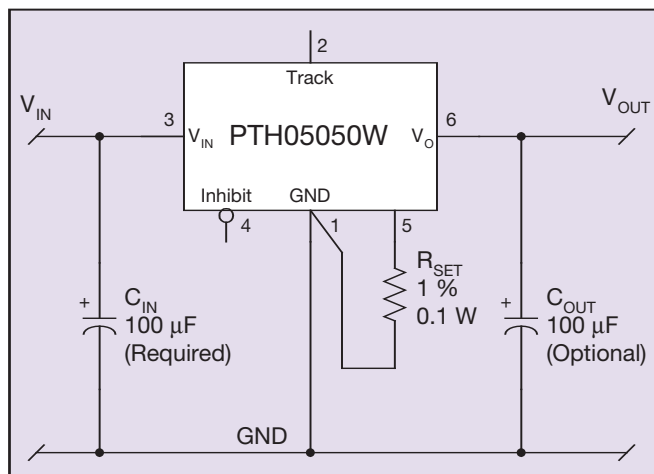


Figure 8 - Adjust Resistor Placement

OUTPUT VOLTAGE SET-POINT RESISTOR VALUES					
V_a Req'd	R_{set}	V_a Req'd	R_{set}	V_a Req'd	R_{set}
0.800	Open	1.400	10.8k Ω	2.50	2.22k Ω
0.825	318k Ω	1.425	10.3k Ω	2.55	2.08k Ω
0.850	158k Ω	1.450	9.82k Ω	2.60	1.95k Ω
0.875	104k Ω	1.475	9.36k Ω	2.65	1.83k Ω
0.900	77.5k Ω	1.50	8.94k Ω	2.70	1.72k Ω
0.925	61.5k Ω	1.55	8.18k Ω	2.75	1.61k Ω
0.950	50.8k Ω	1.60	7.51k Ω	2.80	1.51k Ω
0.975	43.2k Ω	1.65	6.92k Ω	2.85	1.41k Ω
1.000	37.5k Ω	1.70	6.4k Ω	2.90	1.32k Ω
1.025	33.1k Ω	1.75	5.93k Ω	2.95	1.23k Ω
1.050	29.5k Ω	1.80	5.51k Ω	3.00	1.15k Ω
1.075	26.6k Ω	1.85	5.13k Ω	3.05	1.07k Ω
1.100	24.2k Ω	1.90	4.78k Ω	3.10	988 Ω
1.125	22.1k Ω	1.95	4.47k Ω	3.15	914 Ω
1.150	20.4k Ω	2.00	4.18k Ω	3.20	843 Ω
1.175	18.8k Ω	2.05	3.91k Ω	3.25	775 Ω
1.200	17.5k Ω	2.10	3.66k Ω	3.30	710 Ω
1.225	16.3k Ω	2.15	3.44k Ω	3.35	647 Ω
1.250	15.3k Ω	2.20	3.22k Ω	3.40	587 Ω
1.275	14.4k Ω	2.25	3.03k Ω	3.45	529 Ω
1.300	13.5k Ω	2.30	2.84k Ω	3.50	473 Ω
1.325	12.7k Ω	2.35	2.67k Ω	3.55	419 Ω
1.350	12.1k Ω	2.40	2.51k Ω	5.60	367 Ω
1.375	11.4k Ω	2.45	2.36k Ω		

Notes:

- 1 Use a 0.1W resistor. The tolerance should be 1%, with temperature stability of 100 ppm/ $^{\circ}$ C (or better). Place the resistor as close to the regulator as possible. Connect the resistor directly between pins 5 and 1 using dedicated PCB traces.
- 2 Never connect capacitors from V_o Adjust to either GND or V_{out} . Any capacitance added to the V_o 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 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 V_{in} with respect to GND. Figure 9 shows the typical application of the inhibit function. Note the discrete transistor (Q1). The Inhibit control has its own internal pull-up to $+V_{in}$ 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 20ms. Figure 10 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 5A load.

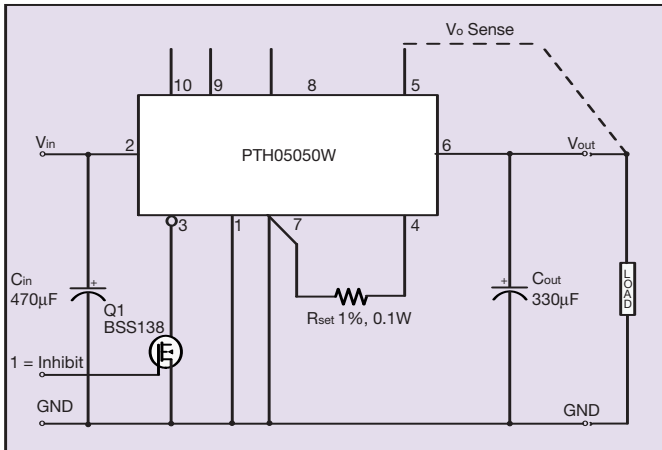


Figure 9 - Typical Application of the Inhibit Function

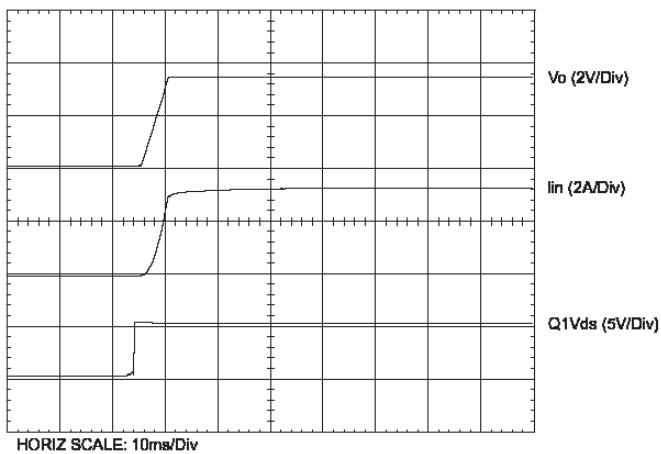


Figure 10 - Typical Rise in Output Voltage and Input Current

7.3 Pre-Bias Start-up Capability

Only selected products in the PTH family incorporate this capability. Consult Table 1 to identify which product series are compliant.

In complex digital systems an external voltage can sometimes be present at the output of the module during power up. This voltage may be backfed through a dual supply logic component, such as an FPGA or ASIC. Another path might be via a clamp diode (to a lower supply voltage) as part of a power-up sequencing implementation.

Although the PTH family of modules can sink current under steady-state operating conditions, those that incorporate this capability will not do so during the soft-start cycle¹, or whenever the Inhibit pin is held low. However, to ensure the satisfactory operation of this feature certain conditions must be maintained during the application of input power².

Note

The pre-bias start-up feature is not compatible with Auto-Track™. This is because when the module is under Auto-Track™ control, it is fully active and will sink current if the output voltage is below that of a back-feeding source. Therefore to ensure a pre-bias hold-off, one of the following two techniques must be followed when input power is first applied to the module. The Auto-Track™ function must either be disabled³, or the module's output held off using the Inhibit pin. The latter allows Auto-Track's internal RC charge ramp to rise above the setpoint voltage.

Notes:

- 1 The soft-start cycle is a relatively short period (up to 20ms) that immediately follows either the application of a valid input source voltage, or the release of a ground signal at the Inhibit pin
- 2 To ensure that the regulator does not sink current when power is first applied (even with a ground signal applied to the Inhibit control pin), the input voltage must always be greater than the output voltage through-out the power-up and power-down sequence.
- 3 The Auto-Track™ function can be disabled at power up by immediately applying a voltage to the module's Track pin that is greater than its set-point voltage. This can be easily accomplished by pulling the Track pin up to Vin through a 1kΩ resistor.

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 is repeated here in Figure 11.

This SOA curve shows the load current versus the ambient air temperature and velocity.

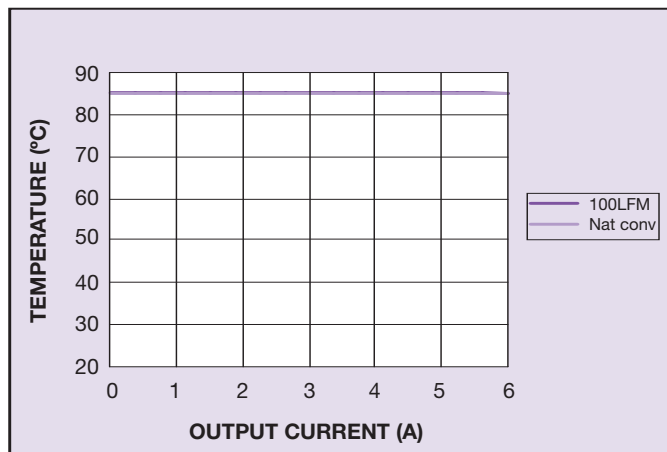


Figure 11 - Safe Operating Curve
PTH05050W $V_{out} = 3.3V$

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 1.6mm, eight layer FR4 pcb with the inner layers consisting of 2oz 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 0m/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 de-rating 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 Figures 12 and 13.

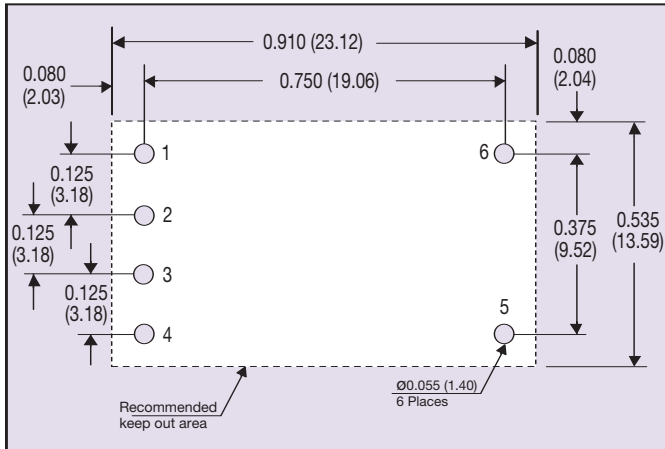


Figure 12 - Recommended Land Pattern (Through - Hole Model)

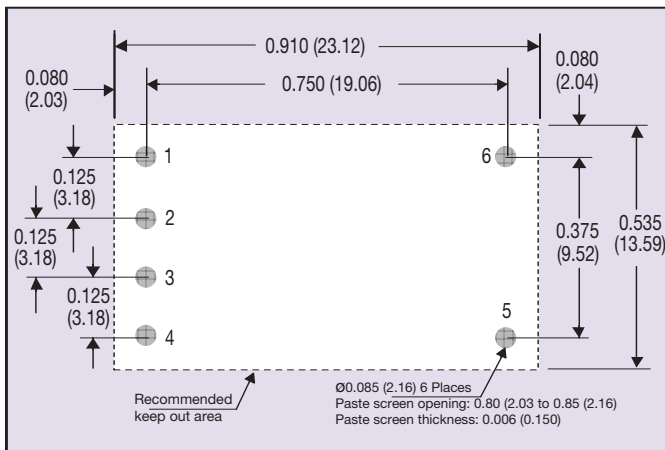


Figure 13 - Recommended Land Pattern (Surface Mount Model)

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

As a surface-mount power component, interconnection to internal power planes will typically be required. This is accomplished by placing a number of vias between the SMT pad and the relevant plane. the number and exact location of these vias should be determined based on electrical resistivity, current flow and thermal requirements.

10. Auto-Track™

10.1 Auto-Track™ Function

The Auto-Track™ function is unique to the PTH family, and is available with the all “Point-of-Load Alliance” (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, micro-processors, and ASICs.

10.2 How Auto-Track™ Works

Auto-Track™ works by forcing the module’s output voltage to follow a voltage presented at the Track control pin. This control range is limited to between 0V and the module’s set-point voltage. Once the track-pin voltage is raised above the set-point voltage, the module’s output remains at its set-point¹. As an example, if the Track pin of a 2.5V regulator is at 1V, the regulated output will be 1V. But if the voltage at the Track pin rises to 3V, the regulated output will not go higher than 2.5V.

As the regulated output from the module simply follows the voltage at the Track pin, it is able to ‘track’ virtually any voltage source during the power-up sequence². This can be the rising voltage of an externally generated master ramp waveform, or the output voltage from another power supply circuit³. For convenience, each Track pin s also provided with an internal RC charge circuit that can produce a compatible voltage ramp from the input source voltage.

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; Q1 in Figure 14.

To initiate a power-up sequence, it is recommended that the Track control be first pulled to ground potential. This should be done at or before input power is applied to the modules, and then held for at least 10ms⁴ thereafter. This brief period gives the modules time to complete their internal soft-start initialization. Applying a logic level high signal to the circuit’s ON/OFF Control turns Q1 on and applies a ground signal to the Track pins. After completing their internal soft-start initialization, the output of all modules will remain at zero volts while Q1 is on.

10ms after a valid input voltage has been applied to the modules, Q1 may be turned off. This allows the track control voltage to automatically rise toward to the modules’ input voltage. During this period the output voltage of each module will rise 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 to a low-level voltage. The waveforms, V_{o1} and V_{o2} represent the output voltages from the two power modules, U1 (3.3V) and U2 (2.0V) respectively. V_{o1} and V_{o2} 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's slew rate capability, which is 5V/ms. The components R1 and C1 in Figure 14 limit the rate at which Q1 can pull down the Track control voltage. The values of 100k Ω and 0.047 μ F correlate to a decay rate of about 0.6V/ms.

The power-down sequence is initiated with a low-to-high transition at the ON/OFF Control input to the circuit. Figure 15 shows the power-up and 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 on the Use Of Auto-Track™

1. The Track pin voltage must be allowed to rise above the module's set-point voltage before the module can regulate at its adjusted set-point voltage.
2. The Auto-Track™ function will track almost any voltage ramp during power up, and is compatible with ramp speeds of up to 5V/ms.
3. The absolute maximum voltage that may be applied to the Track pin is V_{in} .
4. The module output will not follow the voltage at the Track pin until the module has completed its soft-start cycle. The soft-start-cycle takes up to about 20ms to complete. During this time it is recommended that the Track pin be held at ground potential.
5. After the soft-start sequence is complete, the module is capable of both sinking and sourcing current when following the voltage at the Track pin.

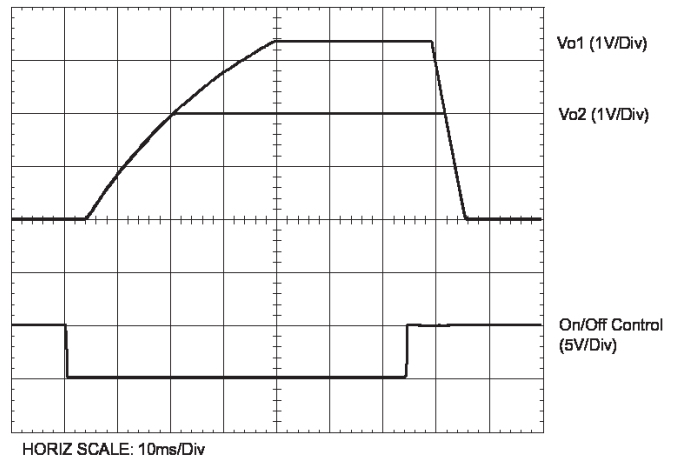


Figure 15 - Power Up & Power Down Waveforms

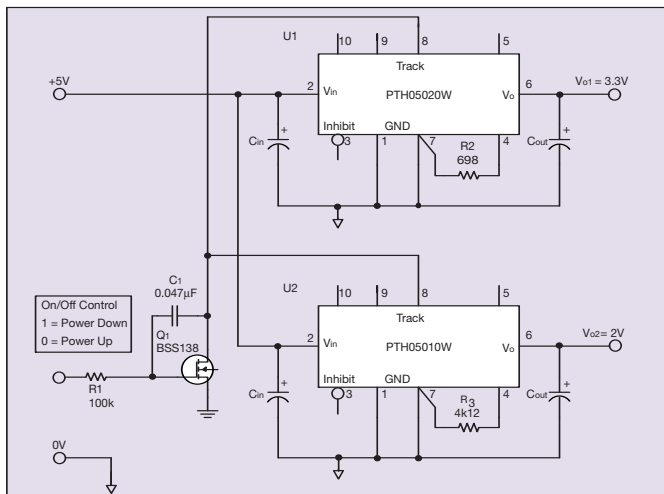


Figure 14 - Sequenced Power Up and Power Down Using Auto-Track™

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