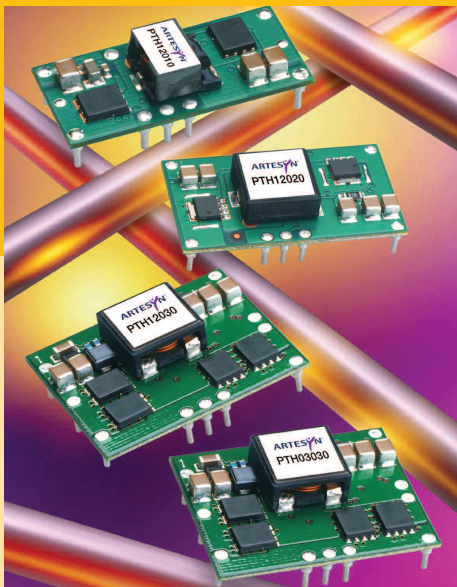




# PTH12020 12Vin Single

## Application Note 161

|   |   |  |    |
|---|---|--|----|
| <b>1. Introduction</b>                  | 2 | <b>3. Mechanical Information Cont'd</b>      |    |
| <b>2. System Interface Information</b>  |   | V <sub>out</sub> Track                       | 5  |
| Input Capacitor                         | 3 | Margin Down                                  | 6  |
| Output Capacitance (Optional)           | 3 | Margin Up                                    | 6  |
| Tantalum Capacitors                     | 3 | <b>4. Packaging Information</b>              |    |
| Ceramic Capacitors                      | 3 | Packaging                                    | 6  |
| Capacitor Table                         | 3 | Labeling and Part Numbering Sequence         | 6  |
| Designing for Very Fast Load Transients | 3 | <b>5. Safety Information</b>                 |    |
| Recommended Input/Output Capacitors     | 4 | Safety Standards and Approvals               | 6  |
| <b>3. Mechanical Information</b>        |   | Fuse Information                             | 6  |
| Mechanical Outline Drawings             | 5 | Safety Considerations                        | 6  |
| Pin-out Table                           | 5 | <b>6. Operating Information</b>              |    |
| Pin Description                         | 5 | Overtemperature Protection (OTP)             | 7  |
| Ground                                  | 5 | Overcurrent Protection                       | 7  |
| V <sub>in</sub>                         | 5 | Soft-Start Power-up                          | 7  |
| Inhibit                                 | 5 | <b>7. Feature Set</b>                        |    |
| V <sub>o</sub> Adjust                   | 5 | Adjusting the Output Voltage                 | 8  |
| V <sub>o</sub> Sense                    | 5 | Output ON/OFF Inhibit                        | 9  |
|   |   | Margin Up/Down Controls                      | 9  |
|   |   | Up/Down Adjust Resistance Calculation        | 9  |
|   |   | Remote Sense                                 | 10 |
|   |   | <b>8. Thermal Information</b>                |    |
|   |   | Thermal Reference Points                     | 10 |
|   |   | Safe Operating Area Curves                   | 10 |
|   |   | Thermal Test Set-up                          | 11 |
|   |   | <b>9. Use in a Manufacturing Environment</b> |    |
|   |   | Recommended Land Pattern                     | 11 |
|   |   | <b>10. Auto-Track™</b>                       |    |
|   |   | Auto-Track™ Function                         | 12 |
|   |   | How Auto-Track™ Works                        | 12 |
|   |   | Typical Application                          | 12 |
|   |   | Notes on the Use of Auto-Track™              | 12 |
|   |   | <b>11. Pre-Bias Start-up</b>                 |    |
|   |   | Pre-Bias Start-up Capability                 | 13 |
|   |   | Conditions for Pre-Bias Holdoff              | 14 |
|   |   | Demonstration Circuit                        | 14 |



**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 Texas Instruments and Ericsson Power Modules to offer customers advanced non-isolated modules that provide the same functionality and form factor. Product series covered by the alliance includes the PTHxx050W (6 A), PTHxx060 W (10 A), PTHxx010W (15/12 A), PTHxx020W (22/18 A), and the PTHxx030W (30/26 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 PTHxx050W series provides operating features such as an ON/OFF inhibit, output voltage trim, pre-bias start-up (3.3/5 V input only), and overcurrent protection. The PTHxx060W (10 A), and PTHxx010W (15/12 A) 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 <sub>OUT</sub> | ADJUST TRIM | ON/OFF INHIBIT | OVER-CURRENT | PRE-BIAS START-UP | AUTO-TRACK™* | MARGIN UP/DOWN | OUTPUT SENSE | THERMAL SHUTDOWN |
|----------|-----------|------------------|-------------|----------------|--------------|-------------------|--------------|----------------|--------------|------------------|
| PTHxx050 | 3.3 V     | 6 A              | ●           | ●              | ●            | ●                 | ●            |                |              |                  |
|          | 5 V       | 6 A              | ●           | ●              | ●            | ●                 | ●            |                |              |                  |
|          | 12 V      | 6 A              | ●           | ●              | ●            | ●                 | ●            |                |              |                  |
| PTHxx060 | 3.3/5 V   | 10 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            |                  |
|          | 12 V      | 10 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            |                  |
| PTHxx010 | 3.3/5 V   | 15 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            |                  |
|          | 12 V      | 12 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            |                  |
| PTHxx020 | 3.3/5 V   | 22 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            | ●                |
|          | 12 V      | 18 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            | ●                |
| PTHxx030 | 3.3/5 V   | 30 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            | ●                |
|          | 12 V      | 26 A             | ●           | ●              | ●            | ●                 | ●            | ●              | ●            | ●                |

Table 1 - Operating Features by Series and Input Bus Voltage

| RoHS Compliance Ordering Information  |   |
|---|---|
|  | PTH12020WAST To order Pb-free (RoHS compatible) surface-mount parts replace the mounting option ‘S’ with ‘Z’, e.g. PTH12020WAZT. To order Pb-free (RoHS compatible) through-hole parts replace the mounting option ‘H’ with ‘D’, e.g. PTH12020WADT. |

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



## 2. System Interface Information

### 2.1 Input Capacitor

The recommended input capacitor(s) is determined by the 560  $\mu\text{F}$ <sup>(1)</sup> minimum capacitance and 800 mA rms minimum ripple current rating.

Ripple current, less than 100 m $\Omega$  equivalent series resistance (ESR), and temperature are major considerations when selecting input capacitors. Unlike polymer-tantalum capacitors, regular tantalum capacitors are not recommended for the input bus. These capacitors require a recommended minimum voltage rating of 2 x (max. dc voltage + ac ripple). This is standard practice to ensure reliability. There were no tantalum capacitors, with sufficient voltage rating, found to meet this requirement. When the operating temperature is below 0 °C, the ESR of aluminum electrolytic capacitors increases. For these applications Os-Con, polymer-tantalum, and polymertantalum types should be considered.

Adding a 10  $\mu\text{F}$  ceramic capacitor to the input will reduce the ripple current reflected into the input source.

### 2.2 Output Capacitance (Optional)

For applications with load transients (sudden changes in load current), regulator response will benefit from external output capacitance. The recommended output capacitance of 330  $\mu\text{F}$  will allow the module to meet its transient response specification (see product datasheet). 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 m $\Omega$  (7 m $\Omega$  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 will be encountered well before the maximum capacitance value is reached.

#### 2.2.2 Ceramic Capacitors

Above 150 kHz the performance of aluminum electrolytic capacitors becomes less effective. To further improve the reflected input ripple current or the output transient response, multilayer ceramic capacitors can also be added. Ceramic capacitors have very low ESR and their resonant frequency is higher than the bandwidth of the regulator. When used on the output their combined ESR is not critical as long as the total value of ceramic capacitance does not exceed 300  $\mu\text{F}$ . Also, to prevent the formation of local resonances, do not place more than five identical ceramic capacitors in parallel with values of 10  $\mu\text{F}$  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 performance and long capacitor life.

### 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/ $\mu\text{s}$ . 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's 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  $\mu\text{F}$ , the selection of output capacitors becomes more important.

| CAPACITOR<br>VENDOR/<br>SERIES         | CAPACITOR CHARACTERISTICS |                     |                        |  |                                  | QUANTITY           |                           | VENDOR<br>PART<br>NUMBER        |
|--|---------------------------|---------------------|------------------------|--|----------------------------------|--------------------|---------------------------|---------------------------------|
|  | WORKING<br>VOLTAGE        | VALUE<br>( $\mu$ F) | MAX. ESR<br>AT 100 kHz | MAX RIPPLE<br>CURRENT AT<br>85 °C (Irms) | PHYSICAL<br>SIZE (MM)<br>(L X W) | INPUT<br>BUS       | OPTIONAL<br>OUTPUT<br>BUS |                                 |
| Panasonic,<br>Aluminum<br>FC (Radial)  | 25 V                      | 330                 | 0.090 $\Omega$         | 755 mA                                   | 10.0 x 12.5                      | 2                  | 1                         | EEUFC1E331                      |
|  | 25 V                      | 560                 | 0.065 $\Omega$         | 1205 mA                                  | 12.5 x 15.0                      | 1                  | 1                         | EEUFC1E561S                     |
|  | 25 V                      | 1,000               | 0.060 $\Omega$         | 1100 mA                                  | 12.5 x 13.5                      | 1                  | 1                         | EEVFK1E102Q                     |
|  | 35 V                      | 680                 | 0.060 $\Omega$         | 1100 mA                                  | 12.5 x 13.5                      | 1                  | 1                         | EEVFK1V681Q                     |
| United Chemi-Con                       | 16 V                      | 330                 | 0.018 $\Omega$         | 4500 mA                                  | 10.0 x 10.5                      | 2                  | $\leq 3$                  | 16FX330M                        |
|  | 16 V                      | 330                 | 0.090 $\Omega$         | 760 mA                                   | 10.0 x 12.5                      | 2                  | 1                         | LXZ25VB331M10X12LL              |
|  | 25 V                      | 680                 | 0.068 $\Omega$         | 1050 mA                                  | 10.0 x 16.0                      | 1                  | 1                         | LXZ16VB681M10X16LL              |
|  | 16 V                      | 330                 | 0.014 $\Omega$         | 5060 mA                                  | 10.0 x 12.5                      | 2                  | $\leq 3$                  | 16PS330MJ12                     |
|  | 16 V                      | 330                 | 0.014 $\Omega$         | 5050 mA                                  | 10.0 x 12.2                      | 2                  | $\leq 3$                  | PXA16VCMJ12                     |
| Nichicon                               | 25 V                      | 560                 | 0.060 $\Omega$         | 1060 mA                                  | 12.5 x 15.0                      | 1                  | 1                         | UPM1E561MHH6                    |
|  | 25 V                      | 680                 | 0.038 $\Omega$         | 1430 mA                                  | 10.0 x 16.0                      | 1                  | 1                         | UHD1C681MHR                     |
|  | 35 V                      | 560                 | 0.048 $\Omega$         | 1360 mA                                  | 16.0 x 15.0                      | 1                  | 1                         | UPM1V561MHH6                    |
| Panasonic,<br>Poly-Aluminum<br>A (SMD) | 16 V                      | 330                 | 0.022 $\Omega$         | 4100 mA                                  | 10.0 x 10.2                      | 2                  | $\leq 3$                  | EEFWA1C331P                     |
|  | 6.3 V                     | 180                 | 0.005 $\Omega$         | 4000 mA                                  | 7.3 x 4.3                        | N/R <sup>(2)</sup> | $\leq 1$                  | EEFSE0J181R <sup>(4)</sup>      |
| SANYO Os-Con                           | 10 V                      | 330                 | 0.025 $\Omega$         | 3000 mA                                  | 7.3 x 5.7                        | N/R <sup>(2)</sup> | $\leq 4$                  | 10TPE330M                       |
|  | 16 V                      | 270                 | 0.018 $\Omega$         | >3500 mA                                 | 10.0 x 10.5                      | 2 <sup>(1)</sup>   | $\leq 3$                  | 16SP270M                        |
|  | 16 V                      | 330                 | 0.016 $\Omega$         | 4700 mA                                  | 11.0 x 12.0                      | 2                  | $\leq 3$                  | 16SVP330M                       |
| AVX Tantalum                           | 10 V                      | 470                 | 0.045 $\Omega$         | >1723 mA                                 | 7.3 x 5.7                        | N/R <sup>(2)</sup> | $\leq 5$                  | TPSE477M010R0045 <sup>(4)</sup> |
|  | 10 V                      | 330                 | 0.045 $\Omega$         | >1723 mA                                 | 7.3 x 5.7                        | N/R <sup>(2)</sup> | $\leq 5$                  | TPSE337M010R0045 <sup>(4)</sup> |
| Kemet (SMD)                            | 10 V                      | 330                 | 0.040 $\Omega$         | 1800 mA                                  | 7.3 x 4.3                        | N/R <sup>(2)</sup> | $\leq 5$                  | T520X337M010AS                  |
|  | 10 V                      | 330                 | 0.015 $\Omega$         | >3800 mA                                 | 7.3 x 4.3                        | N/R <sup>(2)</sup> | $\leq 2$                  | T530X337M010AS                  |
|  | 6.3 V                     | 470                 | 0.012 $\Omega$         | 4200 mA                                  | 7.3 x 4.3                        | N/R <sup>(2)</sup> | $\leq 2$                  | T530X477M006AS <sup>(4)</sup>   |
| Vishay-Sprague                         | 10 V                      | 470                 | 0.100 $\Omega$         | 1440 mA                                  | 7.2 x 6.0                        | N/R <sup>(2)</sup> | $\leq 5$                  | 595D477X0010R2T <sup>(4)</sup>  |
|  | 16 V                      | 1,000               | 0.015 $\Omega$         | 9740 mA                                  | 16.0 x 25.0                      | 1                  | $\leq 2$                  | 94SA108X0016HBP                 |
| Kemet, Ceramic,<br>X5R (SMD)           | 16 V                      | 10                  | 0.002 $\Omega$         |  | 1210 case                        | 1 <sup>(3)</sup>   | $\leq 5$                  | C1210C106M4PAC                  |
|  | 6.3 V                     | 47                  | 0.002 $\Omega$         |  | 3225mm                           | N/R <sup>(2)</sup> | $\leq 5$                  | C1210C476K9PAC                  |
| Murata, Ceramic<br>X5R (SMD)           | 6.3 V                     | 100                 | 0.002 $\Omega$         |  | 1210 case                        | N/R <sup>(2)</sup> | $\leq 3$                  | GRM32ER60J107M                  |
|  | 6.3 V                     | 47                  |                        |  | 3225 mm                          | N/R <sup>(2)</sup> | $\leq 5$                  | GRM32ER60J476M                  |
|  | 16 V                      | 22                  |                        |  |                                  | 1 <sup>(3)</sup>   | $\leq 5$                  | GRM32ER61C226K                  |
|  | 16 V                      | 10                  |                        |  |                                  | 1 <sup>(3)</sup>   | $\leq 5$                  | GRM32DR61C106K                  |
| TDK, Ceramic<br>X5R (SMD)              | 6.3 V                     | 100                 | 0.002 $\Omega$         |  | 1210 case                        | N/R <sup>(2)</sup> | $\leq 3$                  | C3225X5R0J107MT                 |
|  | 6.3 V                     | 47                  |                        |  | 3225 mm                          | N/R <sup>(2)</sup> | $\leq 5$                  | C3225X5R0J476MT                 |
|  | 16 V                      | 22                  |                        |  |                                  | 1 <sup>(3)</sup>   | $\leq 5$                  | C3225X5R1C226MT                 |
|  | 16 V                      | 10                  |                        |  |                                  | 1 <sup>(3)</sup>   | $\leq 5$                  | C3225X5R1C106MT                 |

(1) Total capacitance of 540  $\mu$ F is acceptable based on the combined ripple current rating.

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

(3) Ceramic capacitors may be used to compliment electrolytic types at the input to further reduce high-frequency ripple current.

**Table 2 - Recommended Input/Output Capacitors**

## 3. Mechanical Information

### 3.1 Mechanical Outline Drawings

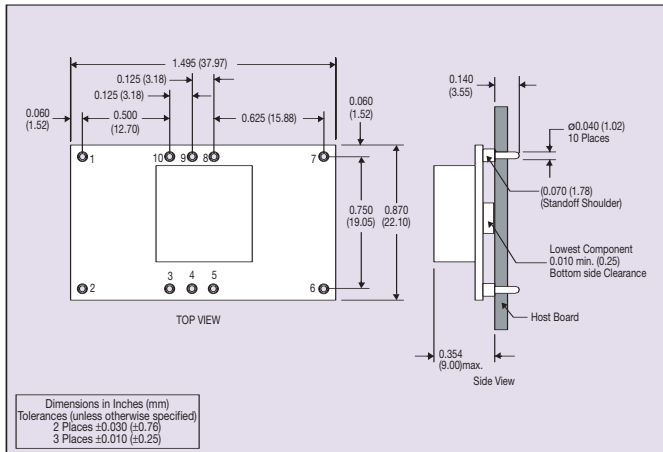


Figure 1 - Plated Through-Hole Mechanical Drawing

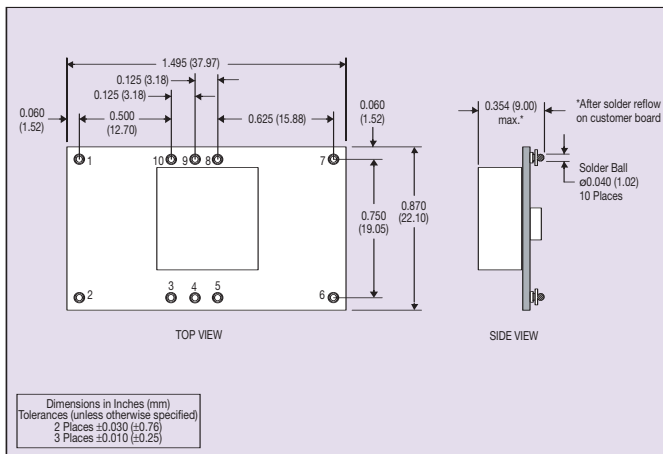


Figure 2 - Surface Mount Mechanical Drawing

### 3.2 Pin-out Table

| PIN CONNECTIONS |              |
|-----------------|--------------|
| PIN NUMBER      | FUNCTION     |
| 1               | Ground       |
| 2               | $V_{in}$     |
| 3               | Inhibit      |
| 4               | $V_o$ Adjust |
| 5               | $V_o$ Sense  |
| 6               | $V_{out}$    |
| 7               | Ground       |
| 8               | Track        |
| 9               | Margin Down  |
| 10              | Margin Up    |

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.

#### 3.3.2 $V_{in}$

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

#### 3.3.3 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.

#### 3.3.4 $V_o$ Adjust

A 1% tolerance (or better) resistor must be connected directly between this pin and pin 7 (GND) to set the output voltage to the desired value. The set-point range is from 1.2 V to 5.5 V for the Suffix 'W' model and 0.8 Vdc to 1.8 Vdc for the Suffix 'L' model. The resistor required for a given output voltage may be calculated from the equations in Section 7.1. If left open-circuit the output voltage will default to its lowest value. For further information on output voltage adjustment please see Section 7.1.

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

#### 3.3.5 $V_o$ Sense

The sense input allows the regulation circuit to compensate for voltage drop between the module and the load. For optimal voltage accuracy  $V_o$  Sense should be connected to  $V_{out}$ . It can also be left disconnected.

#### 3.3.6 $V_{out}$

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

#### 3.3.7 Track

This is an analog control input that enables the output voltage to follow an external voltage. This pin becomes active typically 20 ms after the input voltage has been applied, and allows direct control of the output voltage from 0 V up to the nominal set-point voltage. Within this range the 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 set-point voltage. The feature allows the output voltage to rise simultaneously with other modules powered from the same input bus. If unused this input should be connected to  $V_{in}$ .

Note: Due to the undervoltage lockout feature, the output of the module cannot follow its own input voltage during power-up. For more information, consult the Section 10.

#### 3.3.8 Margin Down

When this input is asserted to GND, the output voltage is decreased by 5% from the nominal. The input requires an open-collector (open-drain) interface. It is not TTL compatible. A lower percent change can be accommodated with a series resistor, See Section 7.3.

#### 3.3.9 Margin Up

When this input is asserted to GND, the output voltage is increased by 5%. The input requires an open-collector (open-drain) interface. It is not TTL compatible. The percent change can be reduced with a series resistor, See Section 7.3.

## 4. Packaging Information

### 4.1 Packaging

The PTH12020 are available in trays of 15 units and tape and reel format in quantities of 150 units per reel.

Tray and tape dimensions including pick point are shown in the following diagrams.

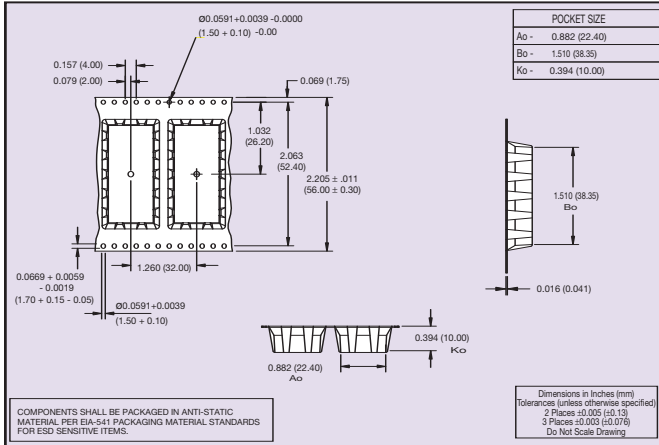


Figure 3 - Tape Dimensions

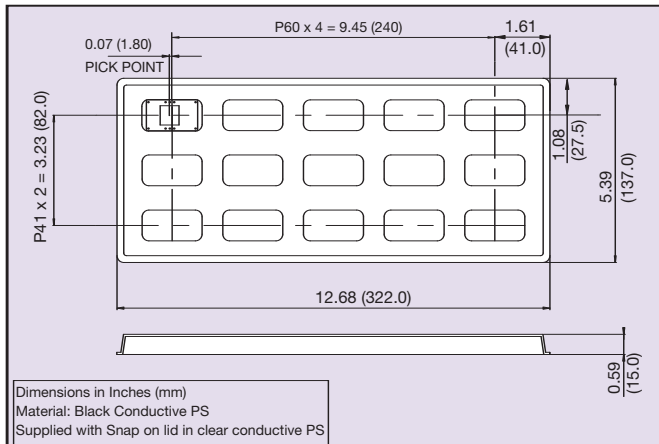


Figure 4 - Tray

### 4.2 Labeling 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.

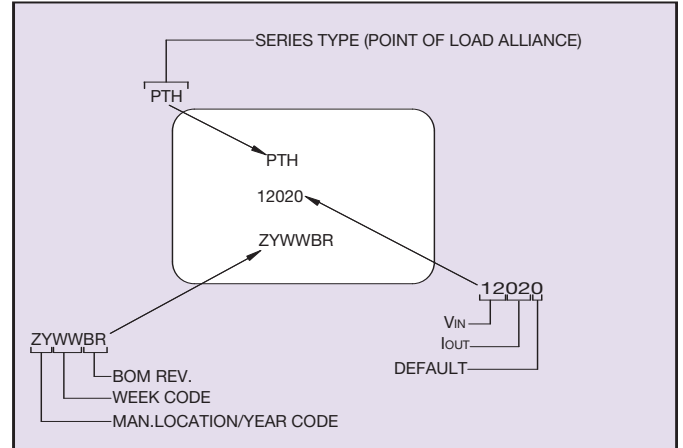


Figure 5 - PTH12020 Part Numbering

## 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 datasheet 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 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).

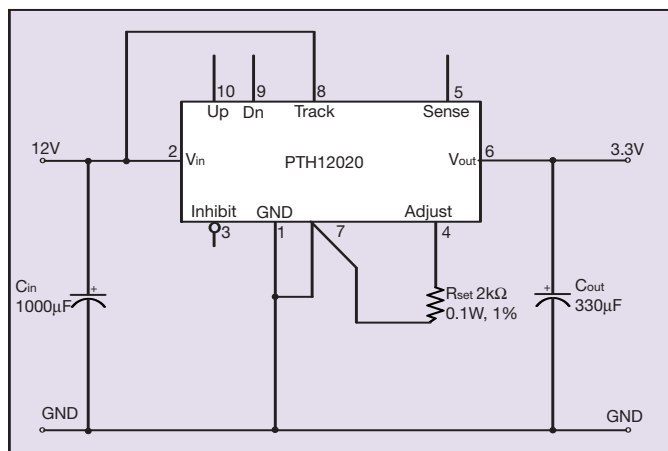
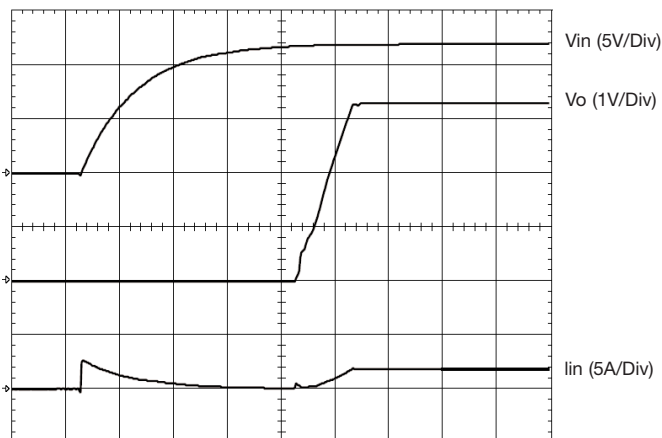


Figure 6 - Soft-start Power-up

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.



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 8 ms to 15 ms) before allowing the output voltage to rise. The output then progressively rises to the module's set-point voltage. Figure 7 shows the soft-start power-up characteristic of the 18 A output product (PTH12020W), operating from a 12 V input bus and configured for a 3.3 V output. The waveforms were measured with a 5 A 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 25 ms.

## 7. Feature Set

### 7.1 Adjusting the Output Voltage

The Vo adjust control (pin 4) sets the output voltage of the PTH12020 product. The adjustment range is from 1.2 Vdc to 5.5 Vdc for the Suffix 'W' model and 0.8 Vdc to 1.8 Vdc for the Suffix 'L' model. To adjust the output voltage above 1.2 V a single external resistor, Rset, must be connected directly between the Vo Adjust and GND pins<sup>(1)</sup>. 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 equations, or simply selected from the range of values given in Tables 5A and 5B. Figure 8 shows the placement of the required resistor.

$$R_{set} = 10K \times \frac{0.8V}{V_{out} - 1.2V} - 1.82 K \Omega$$

Equation 1 - 'W' Suffix Models

$$R_{set} = 10K \times \frac{0.8V}{V_{out} - 0.8V} - 7.87 K$$

Equation 2 - 'L' Suffix Models

| V <sub>out</sub> Standard | R <sub>set</sub> (Preferred Value) | V <sub>out</sub> (Actual) |
|---------------------------|------------------------------------|---------------------------|
| 5.0 V                     | 280 Ω                              | 5.009 V                   |
| 3.3 V                     | 2 kΩ                               | 3.294 V                   |
| 2.5 V                     | 4.32 kΩ                            | 2.503 V                   |
| 2.0 V                     | 8.06 kΩ                            | 2.010 V                   |
| 1.8 V                     | 11.5 kΩ                            | 1.801 V                   |
| 1.5 V                     | 24.3 kΩ                            | 1.506 V                   |
| 1.2 V                     | Open                               | 1.200 V                   |

Table 4A - Preferred Values of R<sub>set</sub> for Standard Output Voltages 'W' Suffix Models

| V <sub>out</sub> Standard | R <sub>set</sub> (Pref'd Value) | V <sub>out</sub> (Actual) |
|---------------------------|---------------------------------|---------------------------|
| 1.8 V                     | 130 Ω                           | 1.800 V                   |
| 1.5 V                     | 3.57 kΩ                         | 1.499 V                   |
| 1.2 V                     | 12.1 kΩ                         | 1.201 V                   |
| 1.1 V                     | 18.7 kΩ                         | 1.101 V                   |
| 1.0 V                     | 32.4 kΩ                         | 0.999 V                   |
| 0.9 V                     | 71.5 kΩ                         | 0.901 V                   |
| 0.8 V                     | Open                            | 0.800 V                   |

Table 4B - Preferred Values of R<sub>set</sub> for Standard Output Voltages 'L' Suffix Models

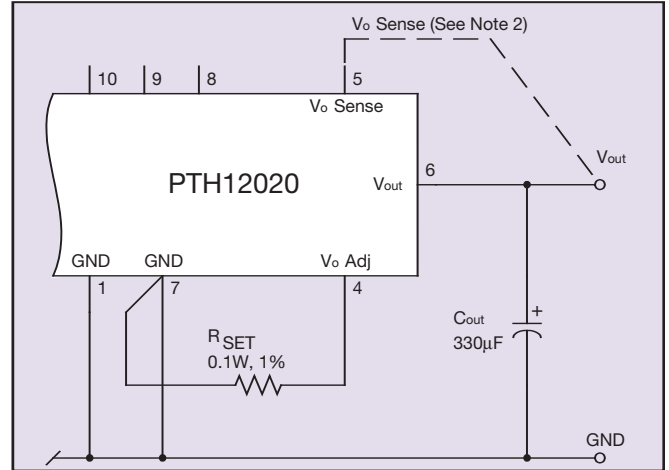


Figure 8 - Adjust Resistor Placement

| OUTPUT VOLTAGE SET-POINT RESISTOR VALUES |                  |                      |                  |                      |                  |
|--|------------------|----------------------|------------------|----------------------|------------------|
| V <sub>a</sub> Req'd                     | R <sub>set</sub> | V <sub>a</sub> Req'd | R <sub>set</sub> | V <sub>a</sub> Req'd | R <sub>set</sub> |
| 1.200                                    | Open             | 2.15                 | 6.6 kΩ           | 3.40                 | 1.82 kΩ          |
| 1.225                                    | 318 kΩ           | 2.20                 | 6.18 kΩ          | 3.45                 | 1.74 kΩ          |
| 1.250                                    | 158 kΩ           | 2.25                 | 5.8 kΩ           | 3.50                 | 1.66 kΩ          |
| 1.275                                    | 105 kΩ           | 2.30                 | 5.45 kΩ          | 3.55                 | 1.58 kΩ          |
| 1.300                                    | 78.2 kΩ          | 2.35                 | 5.14 kΩ          | 3.60                 | 1.51 kΩ          |
| 1.325                                    | 62.2 kΩ          | 2.40                 | 4.85 kΩ          | 3.70                 | 1.38 kΩ          |
| 1.350                                    | 51.5 kΩ          | 2.45                 | 4.85 kΩ          | 3.80                 | 1.26 kΩ          |
| 1.375                                    | 43.9 kΩ          | 2.50                 | 4.33 kΩ          | 3.90                 | 1.14 kΩ          |
| 1.400                                    | 38.2 kΩ          | 2.55                 | 4.11 kΩ          | 4.00                 | 1.04 kΩ          |
| 1.425                                    | 33.7 kΩ          | 2.60                 | 3.89 kΩ          | 4.10                 | 939 Ω            |
| 1.450                                    | 30.2 kΩ          | 2.65                 | 3.70 kΩ          | 4.20                 | 847 Ω            |
| 1.475                                    | 27.3 kΩ          | 2.70                 | 3.51 kΩ          | 4.30                 | 761 Ω            |
| 1.50                                     | 24.8 kΩ          | 2.75                 | 3.34 kΩ          | 4.40                 | 680 Ω            |
| 1.55                                     | 21.0 kΩ          | 2.80                 | 3.18 kΩ          | 4.50                 | 604 Ω            |
| 1.60                                     | 18.2 kΩ          | 2.85                 | 3.03 kΩ          | 4.60                 | 533 Ω            |
| 1.65                                     | 16.0 kΩ          | 2.90                 | 2.89 kΩ          | 4.70                 | 466 Ω            |
| 1.70                                     | 14.2 kΩ          | 2.95                 | 2.75 kΩ          | 4.80                 | 402 Ω            |
| 1.75                                     | 12.7 kΩ          | 3.00                 | 2.62 kΩ          | 4.90                 | 342 Ω            |
| 1.80                                     | 11.5 kΩ          | 3.05                 | 2.50 kΩ          | 5.00                 | 285 Ω            |
| 1.85                                     | 10.5 kΩ          | 3.10                 | 2.39 kΩ          | 5.10                 | 231 Ω            |
| 1.90                                     | 9.61 kΩ          | 3.15                 | 2.28 kΩ          | 5.20                 | 180 Ω            |
| 1.95                                     | 8.85 kΩ          | 3.20                 | 2.18 kΩ          | 5.30                 | 131 Ω            |
| 2.00                                     | 8.18 kΩ          | 3.25                 | 2.08 kΩ          | 5.40                 | 85 Ω             |
| 2.05                                     | 7.59 kΩ          | 3.30                 | 1.99 kΩ          | 5.50                 | 41 Ω             |
| 2.10                                     | 7.07 kΩ          | 3.35                 | 1.90 kΩ          |                      |                  |

Table 5A - Output Voltage Set-point Resistor Values for Suffix 'W' Model



| OUTPUT VOLTAGE SET-POINT RESISTOR VALUES |                  |                      |                  |                      |                  |
|--|------------------|----------------------|------------------|----------------------|------------------|
| V <sub>a</sub> Req'd                     | R <sub>set</sub> | V <sub>a</sub> Req'd | R <sub>set</sub> | V <sub>a</sub> Req'd | R <sub>set</sub> |
| 0.800                                    | Open             | 1.100                | 18.8 kΩ          | 1.400                | 5.46 kΩ          |
| 0.825                                    | 312 kΩ           | 1.125                | 16.7 kΩ          | 1.425                | 4.93 kΩ          |
| 0.850                                    | 152 kΩ           | 1.150                | 15 kΩ            | 1.450                | 4.44 kΩ          |
| 0.875                                    | 98.8 kΩ          | 1.175                | 13.5 kΩ          | 1.475                | 3.98 kΩ          |
| 0.900                                    | 72.1 kΩ          | 1.200                | 12.1 kΩ          | 1.500                | 3.56 kΩ          |
| 0.925                                    | 56.1 kΩ          | 1.225                | 11 kΩ            | 1.550                | 2.80 kΩ          |
| 0.950                                    | 45.5 kΩ          | 1.250                | 9.91 kΩ          | 1.600                | 2.13 kΩ          |
| 0.975                                    | 37.8 kΩ          | 1.275                | 8.97 kΩ          | 1.650                | 1.54 kΩ          |
| 1.000                                    | 32.1 kΩ          | 1.300                | 8.13 kΩ          | 1.700                | 1.02 kΩ          |
| 1.025                                    | 27.7 kΩ          | 1.325                | 7.37 kΩ          | 1.750                | 0.551 kΩ         |
| 1.050                                    | 24.1 kΩ          | 1.350                | 6.68 kΩ          | 1.800                | 0.130 kΩ         |
| 1.075                                    | 21.2 kΩ          | 1.375                | 6.04 kΩ          |                      |                  |

**Table 5B - Output Voltage Set-point Resistor Values for Suffix 'L' Model**

**Notes:**

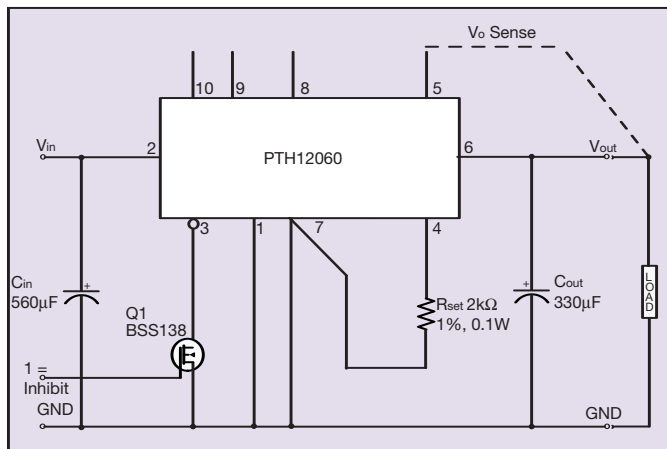
- 1 Use a 0.1 W resistor, with a tolerance of 1%, with temperature stability of 100 ppm/°C (or better). Place the resistor as close to the regulator as possible. Connect the resistor directly between pins 4 and 7 using dedicated PCB traces.
- 2 Never connect capacitors from V<sub>o</sub> Adjust to either GND or V<sub>out</sub>. Any capacitance added to the V<sub>o</sub> Adjust pin will affect the stability of the regulator.

**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.

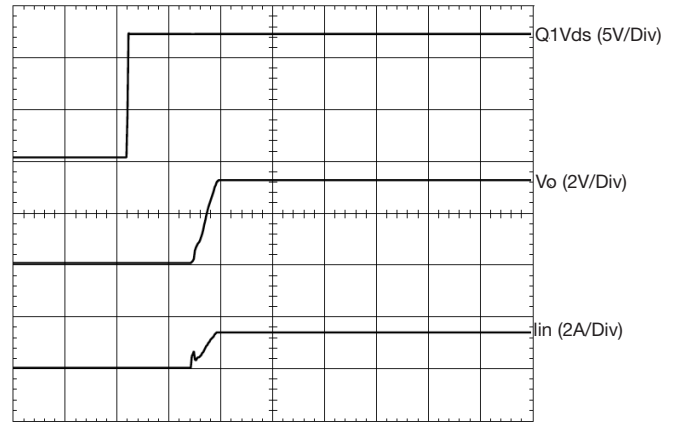
The power modules function normally when the Inhibit pin is left open-circuit, providing a regulated output whenever a valid source voltage is connected to V<sub>in</sub> with respect to GND.

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<sub>in</sub> potential (12 V). An open-collector or open-drain device is recommended to control this input. The input is not compatible with TTL logic devices.



**Figure 9 - Typical Application of the Inhibit Function**

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 20 ms. 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<sub>DS</sub>. The waveforms were measured with a 5 A load.



HORIZ SCALE: 10 ms/Div

**Figure 10 - Typical Rise in Output Voltage and Input Current**

**7.3 Margin Up/Down Controls**

The PTHxx060W, PTHxx010W, PTHxx020W, and PTHxx030W module series incorporate Margin Up and Margin Down control inputs. These controls allow the output voltage set-point to be momentarily adjusted <sup>(1)</sup>, either up or down, by a nominal 5%. This provides a convenient method for dynamically testing the operation of the load circuit over its power supply margin or range. The ±5% change is applied to the adjusted output voltage as set by the external resistor, R<sub>set</sub> at the V<sub>o</sub> Adjust pin.

The 5% adjustment is made by driving the appropriate margin control input directly to the GND terminal <sup>(2)</sup>. A low-leakage open-drain device, such as a MOSFET or p-channel JFET is recommended for this purpose. Adjustments of less than 5% can also be accommodated by adding series resistors to the control inputs (See Figure 11). The value of the resistor can be selected from Table 6 or calculated using the following formula.

**7.3.1 Up/Down Adjust Resistance Calculation**

To reduce the margin adjustment to something less than 5%, series resistors are required (See R<sub>D</sub> and R<sub>U</sub> in Figure 10). For the same amount of adjustment, the resistor value calculated for R<sub>D</sub> and R<sub>U</sub> will be the same. The formula is as follows.

$$R_u \text{ or } R_d = \frac{499}{\Delta\%} - 99.8 \text{ k}\Omega$$

Where Δ% = The desired amount of margin adjust in percent.

**Notes:**

- 1 The Margin Up and Margin Down controls were not intended to be activated simultaneously. If they are their affects on the output voltage may not completely cancel, resulting in the possibility of a slightly higher error in the output voltage set-point.
- 2 The ground reference should be a direct connection to the module GND at pin 7 (pin 1 for the PTHxx050). This will produce a more accurate adjustment at the load circuit terminals. The transistors Q1 and Q2 should be located close to the regulator.

3 The Margin Up and Margin Dn control inputs are not compatible with devices that source voltage. This includes TTL logic. These are analog inputs and should only be controlled with a true open-drain device (preferably a discrete MOSFET transistor). The device selected should have low off-state leakage current. Each input sources 8  $\mu$ A when grounded, and has an open-circuit voltage of 0.8 V.

| % ADJUST | $R_U/R_D$        |
|----------|------------------|
| 5        | 0.0 k $\Omega$   |
| 4        | 24.9 k $\Omega$  |
| 3        | 66.5 k $\Omega$  |
| 2        | 150.0 k $\Omega$ |
| 1        | 397.0 k $\Omega$ |

Table 6 - Margin Up/Down Resistor Values

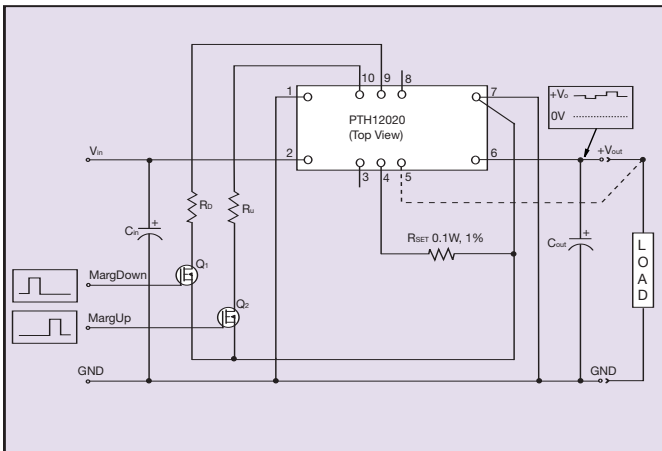


Figure 11 - Margin Up/Down Application Schematic

**7.4 Remote Sense**

The PTHxx010W, PTHxx020W, and PTHxx030W products incorporate an output voltage sense pin,  $V_o$  Sense. The  $V_o$  Sense pin should be connected to  $V_{out}$  at the load circuit (see datasheet standard application). A remote sense improves the load regulation performance of the module by allowing it to compensate for any ‘IR’ voltage drop between itself and the load. An IR drop is caused by the high output current flowing through the small amount of pin and trace resistance. Use of the remote sense is optional. If not used, the  $V_{out}$  Sense pin can be left open-circuit. An internal low-value resistor (15  $\Omega$  or less) is connected between the  $V_o$  Sense and  $V_{out}$ , ensures that the output voltage remains in regulation.

With the sense pin connected, the difference between the voltage measured directly between the  $V_{out}$  and GND pins, and that measured from  $V_{out}$  Sense to GND, is the amount of IR drop being compensated by the regulator. This should be limited to a maximum of 0.3 V.

Note: The remote sense feature is not designed to compensate for the forward drop of non-linear or frequency dependent components that may be placed in series with the converter output. Examples include OR-ing diodes, filter inductors, ferrite beads, and fuses. When these components are enclosed by the remote sense connection they are effectively placed inside the regulation control loop, which can adversely affect the stability of the regulator.

**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 Curves**

Thermal characterization data is presented in the datasheet in a safe operating area curve format which is repeated here in Figures 12 and 13. This SOA curve shows the load current versus the ambient air temperature and velocity.

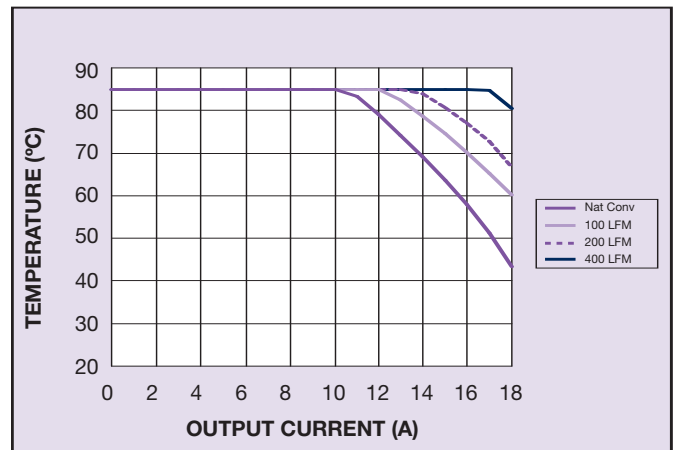


Figure 12 - Safe Operating Curve  
PTH12020W  $V_{out}$  = 5.0 V

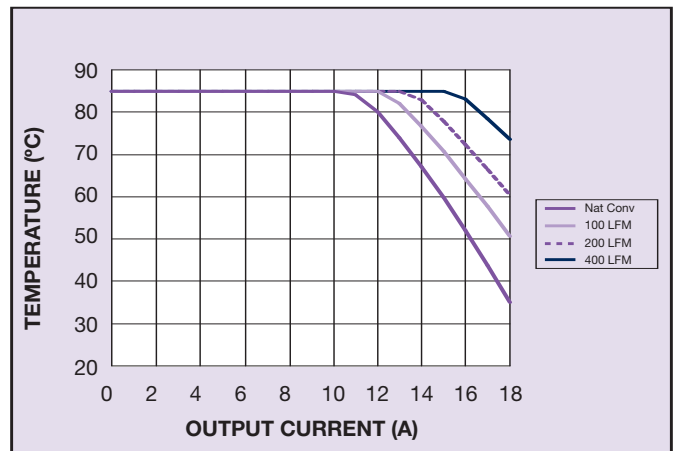


Figure 13 - Safe Operating Curve  
PTH12020W  $V_{out}$  = 3.3 V

## 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 Figures 14 and 15.

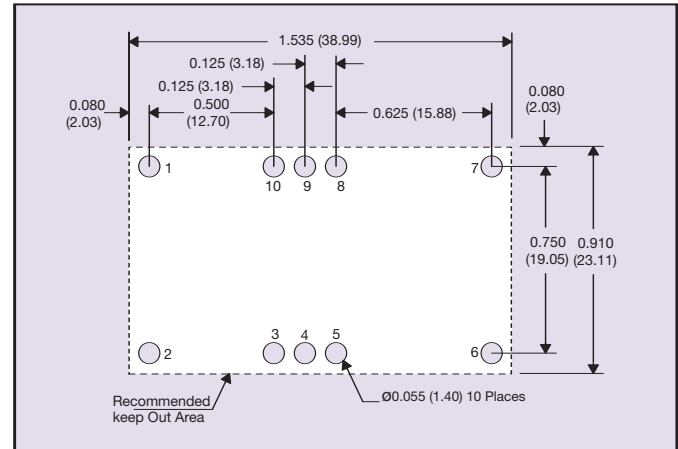


Figure 14 - Recommended Land Pattern (Through - Hole Model)

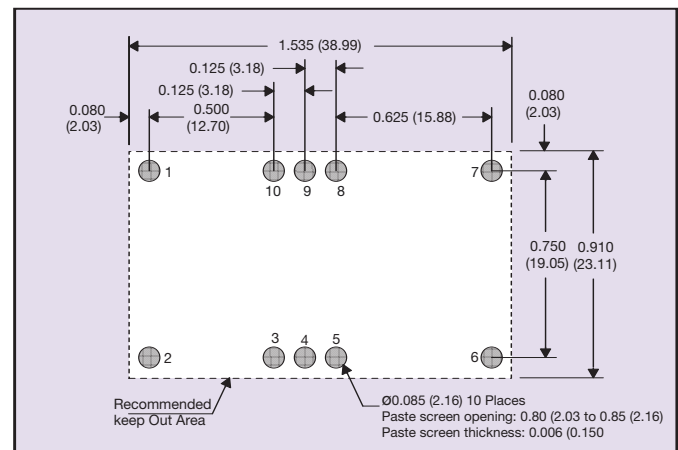


Figure 15 - Recommended Land Pattern (Surface Mount Model)

Power pin connection should utilize four or more vias to the interior power plane of 0.025 (0.63) I.D. per input, ground and output 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 0 V 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-point<sup>1</sup>. As an example, if the Track pin of a 2.5 V regulator is at 1 V, the regulated output will be 1 V. But if the voltage at the Track pin rises to 3 V, the regulated output will not go higher than 2.5 V.

When under 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 will 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<sup>(3)</sup>. For convenience the Track control incorporates an internal RC charge circuit. This operates off the module's 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; Q1 in Figure 16.

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 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'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.

10 ms 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 17 shows the output voltage waveforms from the circuit of Figure 16 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 (3.3 V) and U2 (2.0 V) 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 1 V/ms. The components R1 and C1 in Figure 16 limit the rate at which Q1 can pull down the Track control voltage. The values of 100 k $\Omega$  and 0.1  $\mu$ F 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 18 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 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 1 V/ms.
- 3 The absolute maximum voltage that may be applied to the Track pin is  $V_{in}$ .
- 4 The module will not follow a voltage at its Track control input until it has completed its soft-start initialization. This takes about 10ms from the time that the module has sensed that a valid voltage has been applied 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 pin. Therefore start-up into an output prebias 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 ( $V_{in}$ ). When Auto-Track is disabled, the output voltage will rise at a quicker and more linear rate after input power is applied.

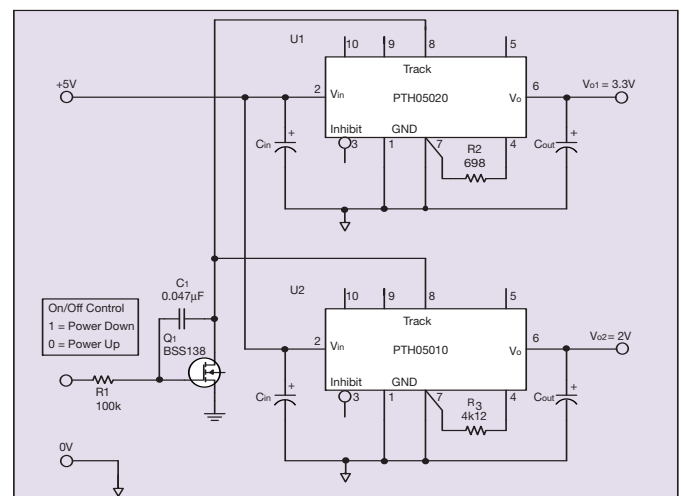
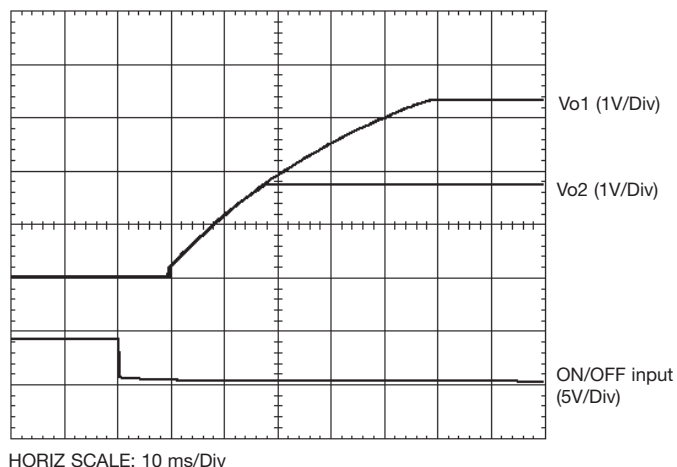
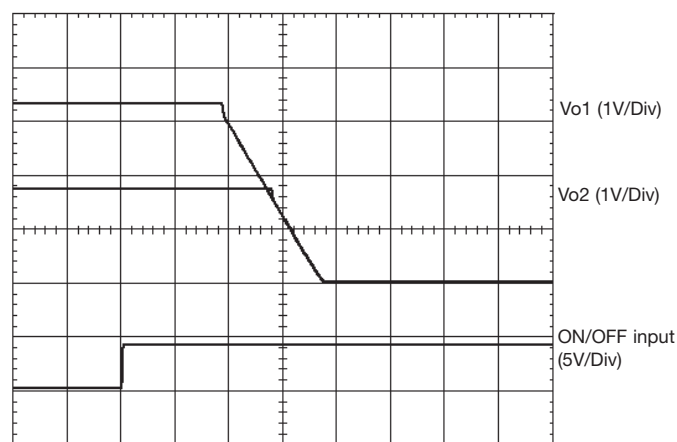


Figure 16 - Sequenced Power-up and Power-down Using Auto-Track™



HORIZ SCALE: 10 ms/Div

Figure 17 - Power-up with Auto-Track Control



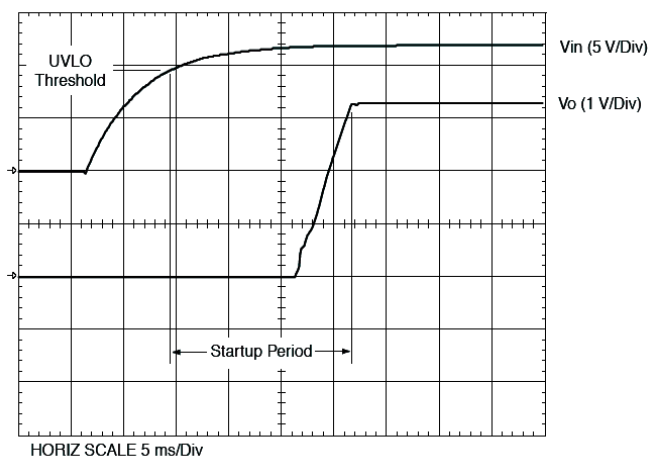
HORIZ SCALE: 10 ms/Div

Figure 18 - Power-down with Auto-Track Control

## 11. Pre-Bias Start-up Capability

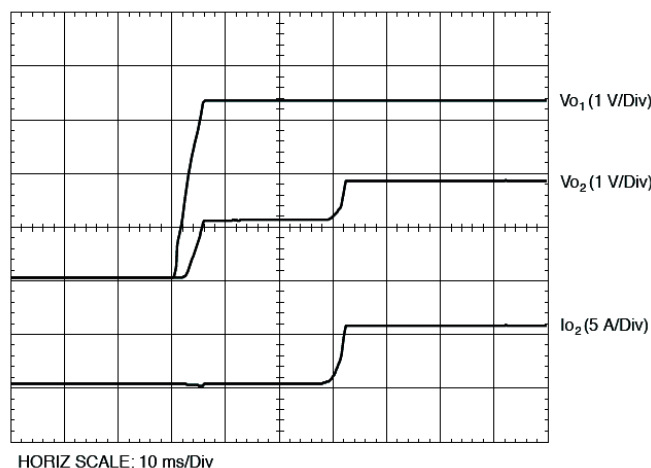
### 11.1 Pre-bias Start-up Capability

The capability to start-up into an output pre-bias condition is now available to all the 12 V input, PTH series of power modules. (Note that this is a feature enhancement for the many of the 'W' suffix products)<sup>(1)</sup>. A pre-bias startup 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 backed 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 prebias 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 12 V input PTH modules all incorporate synchronous rectifiers, but will not sink current during start-up, or whenever the Inhibit pin is held low. Start-up includes an initial delay (approx. 8 ms to 15 ms), followed by the rise of the output voltage under the control of the module's internal soft-start mechanism; see Figure 19.



HORIZ SCALE 5 ms/Div

Figure 19 - PTH12020W Start-up



HORIZ SCALE: 10 ms/Div

Figure 20 - Pre-Bias Start-up Waveforms

**11.2 Conditions for Pre-Bias Holdoff**

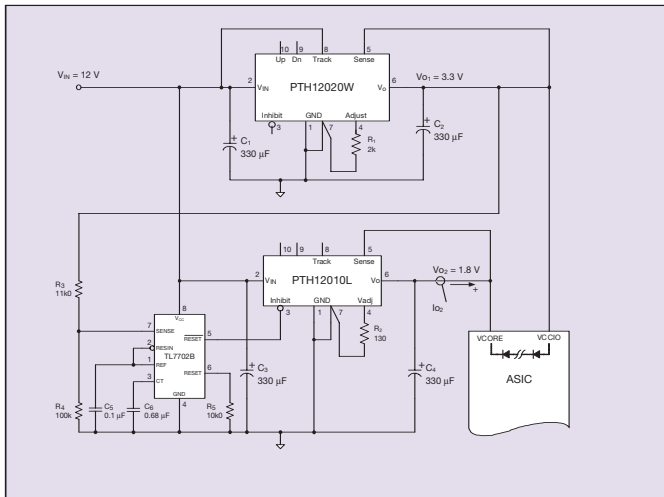
In order for the module to allow an output pre-bias voltage to exist (and not sink current), certain conditions must be maintained. The module holds off a pre-bias voltage when the Inhibit pin is held low, and whenever the output is allowed to rise under soft-start control. Power up under soft-start control occurs upon the removal of the ground signal to the Inhibit pin (with input voltage applied), or when input power is applied with Auto-Track disabled<sup>(2)</sup>. To further ensure that the regulator doesn't sink output current, (even with a ground signal applied to its Inhibit), the input voltage must always be greater than the applied pre-bias source. This condition must exist throughout the power-up sequence<sup>(3)</sup>.

The soft-start period is complete when the output begins rising above the pre-bias voltage. Once it is complete the module functions as normal, and will sink current if a voltage higher than the nominal regulation value is applied to its output.

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

**11.3 Demonstration Circuit**

Figure 20 shows the startup waveforms for the demonstration circuit shown in Figure 21. The initial rise in  $V_{O2}$  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 PTH12010L module ( $I_{O2}$ ) is negligible until its output voltage rises above the applied pre-bias.



**Figure 21 - Application Circuit Demonstrating Pre-Bias Start-up**

**Notes:**

- 1 Output pre-bias holdoff is an inherent feature to all PTH120x0L and PTV120x0W/L modules. It has now been incorporated into all modules (including 'W' suffix modules with part numbers of the form PTH120x0W), with a production lot date code of '0530' or later.
- 2 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 will sink current during the period that the track control voltage is below that of the back-feeding source. For this reason, it is recommended that Auto-Track be disabled when not being used. This is accomplished by connecting the Track pin to the input voltage,  $V_{in}$ . This raises the Track pin voltage well above the set-point voltage prior to the module's start up, thereby defeating the Auto-Track feature.
- 3 To further ensure that the regulator's output 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 applied pre-bias source. This condition must exist throughout the power-up sequence of the power system.

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