

### 18-36V Input, 12V / 4.2A / 50W Output

### Very High Density Isolated DC-DC Converter (334W/in<sup>3</sup>)

#### Description

The Cool-Power® PI3106-01-HVIZ is a very high density isolated DC-DC converter implementing a high efficiency soft-switching power architecture. The PI3106-01-HVIZ operates over an input range of 18V to 36Vdc, delivering ~50W of output power (12Vout @ 4.2A), yielding an unprecedented power density of 334W/in<sup>3</sup>. The PI3106-01-HVIZ is available in a space saving surface mountable 0.87" x 0.65" x 0.265" package, achieving ~50% space reduction versus conventional solutions.

The switching frequency of 900kHz allows for small input and output filter components which further reduces the total size and cost of the overall system solution. The output voltage is sensed and fed back to the internal controller using a proprietary isolated magnetic feedback scheme which allows for high bandwidth and good common mode noise immunity. The PI3106-01-HVIZ requires no external feedback compensation and offers a total solution with a minimum number of external components. A rich feature set is offered, including output voltage trim capability, output over-voltage protection, adjustable soft-start, over-current protection with auto-restart, over and under input voltage lockout and a temperature monitoring and protection function that provides an analog voltage proportional to the die temperature as shut down and alarm capabilities.

#### Features

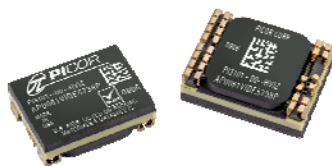
- Efficiency up to 88.5%
- High switching frequency minimizes input filter requirements and reduces output capacitance
- Proprietary "Double-Clamped" ZVS Buck-Boost Topology
- Proprietary isolated magnetic feedback
- Small footprint (0.57 in<sup>2</sup>) enables PCB area savings
- Very low profile (0.26 in)
- Industrial input voltage range (18-36Vdc)
- On/Off Control, positive logic
- +10/-20% Trim
- Temperature Monitor (TM) & Over-Temperature Protection (OTP)
- Input UVLO & OVLO and output OVP
- Over current protection with auto restart
- Adjustable soft-start
- Starts up into high capacitive loads
- 2250V input to output isolation

#### Applications

- Industrial DC-DC power conversion

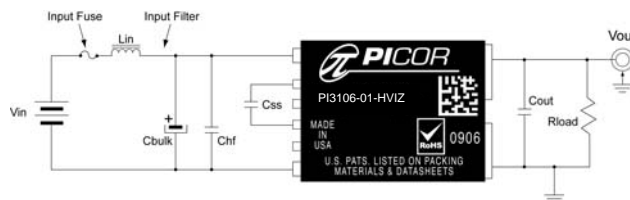
#### Package Information

- Surface Mountable 0.87" x 0.65" x 0.265" package



**PI3106-01-HVIZ**  
18V-36Vin, 12Vout, 4.2A  
Very High Density Isolated DC-DC Converter

#### Typical Application Schematic Diagram



**Figure 1** Picor PI3106-01-HVIZ Shown With System Fuse, Filter, Decoupling And Extended Soft Start

## Pin Description And Maximum Ratings



Figure 2 Picor PI3106-01-HVIZ Pin Out

### Pin Description

Pin Name	Description
+IN	Primary side positive input voltage terminals.
-IN	Primary side negative input voltage terminals.
ENABLE	Converter enable option, functions as 5V reference and on/off control pin. Pull low for off.
TRIM/SS	External soft start pin and trim function. Connect to SGND or ENABLE through resistor for trim up or trim down.
TM	Temperature measurement output pin.
SGND	Signal ground, primary side referenced.
+OUT	Isolated secondary DC output voltage positive terminals.
-OUT	Isolated secondary DC output voltage negative terminals.

### Absolute Maximum Ratings

+IN to -IN Max Operating Voltage	-1.0 to 41Vdc (operating)
+IN to -IN Max Peak Voltage	45Vdc (non-operating, 100ms)
ENABLE to -IN	-0.3 to 6.0Vdc
TM to -IN	-0.3 to 6.0Vdc
TRIM/SS to -IN	-0.3 to 6.0Vdc
+OUT to -OUT	-0.5 to 14.5.0Vdc
Isolation Voltage (+IN/-IN to +OUT/-OUT)	2250Vdc
Isolation Capacitance (+IN/-IN to +OUT/-OUT)	280 pF
Continuous Output Current	4.2A DC (Tcase < 100°C)
Peak Output Current	12A DC (11mm heatsink, 600LFM)
Operating Junction Temperature	-40 to 125°C
Storage Temperature	-50 to 125°C
Case Temperature During Reflow	245°C

Functional Block Diagram

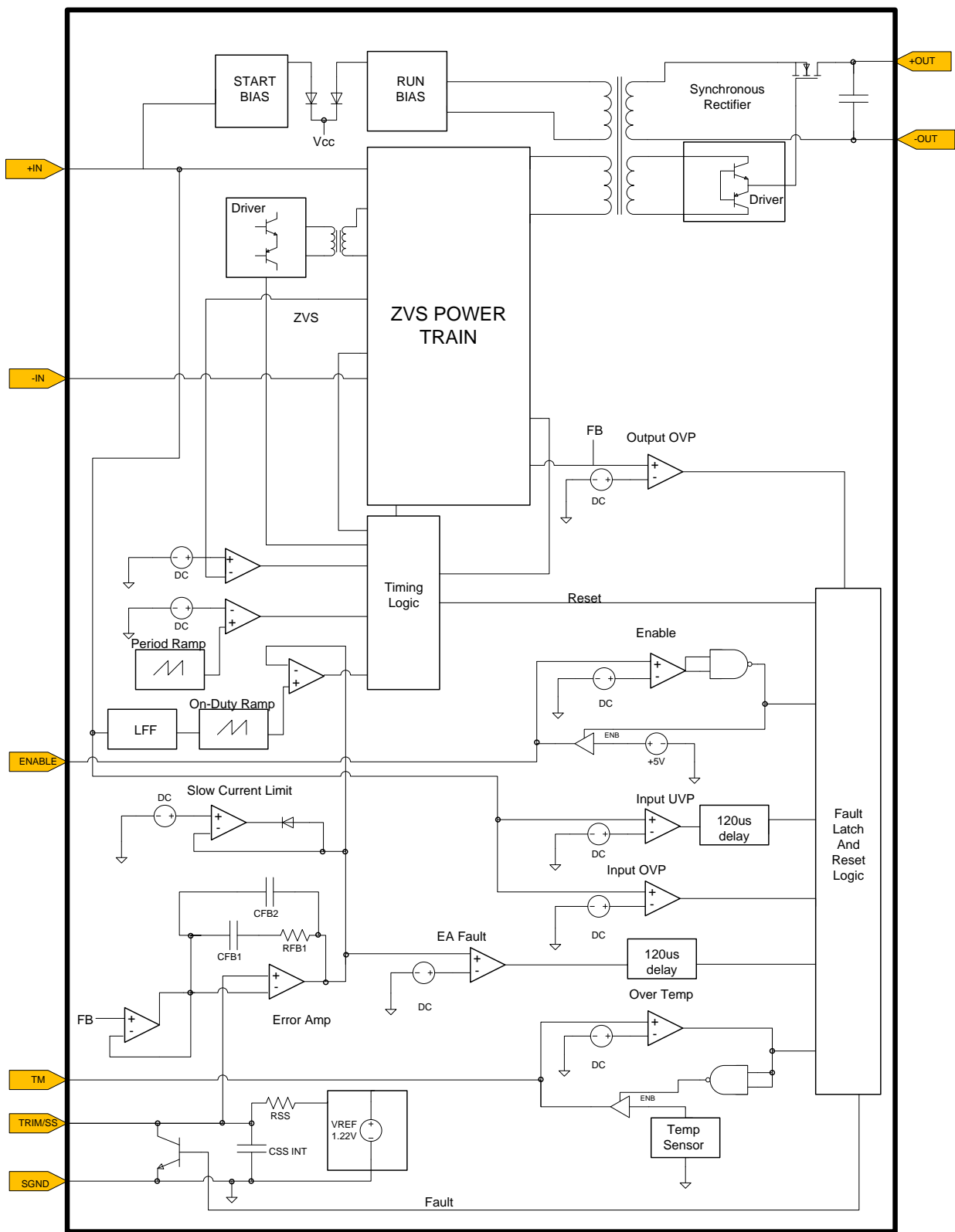


Figure 3 PI3106-01-HVIZ Functional Block Diagram

## Electrical Specifications

Unless otherwise specified:  $18V < V_{IN} < 36V$ ,  $0A < I_{OUT} < 4.2A$ ,  $-40^{\circ}C < T_{CASE} < 100^{\circ}C^{(1)}$

Parameter	Symbol	Min	Typ	Max	Units	Conditions
<b>Input Specifications</b>						
Input Voltage Range	$V_{IN}$	18	24	36	Vdc	
Input dv/dt <sup>(1)</sup>	$V_{INDVDT}$			1.0	V/ $\mu$ s	$V_{IN} = 36V$
Input Under-Voltage Turn-on	$V_{UVON}$		17		Vdc	$I_O = 4.2A$
Input Under-Voltage Turn-off	$V_{UVOFF}$		16		Vdc	$I_O = 4.2A$
Input Under-Voltage Hysteresis	$V_{UVH}$		1		Vdc	$I_O = 4.2A$
Input Over-Voltage Turn-on	$V_{OVON}$		40		Vdc	$I_O = 4.2A$
Input Over-Voltage Turn-off	$V_{OVOFF}$		41		Vdc	$I_O = 4.2A$
Input Over-Voltage Hysteresis	$V_{OVH}$		1			$I_O = 4.2A$
Input Quiescent Current	$I_Q$		2		mAdc	$V_{IN} = 24V$ , ENABLE = 0V
Input Idling Power	$P_{IDLE}$		3.8		W	$V_{IN} = 24V$ , $I_{OUT} = 0A$
Input Standby Power	$P_{SBY}$		0.225		W	$V_{IN} = 24V$ , ENABLE = 0V
Input Current Full Load	$I_{IN}$		2.38		Adc	$T_{CASE} = 100^{\circ}C$ $I_{OUT} = 4.2A$ $\eta_{FL} = 88.2\%$ typical $V_{IN} = 24V$
Input Reflected Ripple Current	$I_{INRR}$		13		mApp	$L_{IN} = 0.47\mu H$ $C_{IN} = 100\mu F$ 63V electrolytic + 2x4.7 $\mu F$ 50V X7R ceramic
Recommended Ext Input Capacitance	$C_{IN}$		109.4		$\mu F$	$C_{IN} = 100\mu F$ 50V electrolytic + 2x4.7 $\mu F$ 50V X7R ceramic $C_{IN} = C_{bulk} + C_{hf}$
<b>Output Specifications</b>						
Output Voltage Set Point	$V_{OUT}$		12.0		Vdc	$I_{OUT} = 2.1 A$
Total Output Accuracy	$V_{OA}$	-3		+3	%	
Line Regulation	$V_{RLI}$		0.25		%	$V_{IN} = 18V-36V$ , $I_{OUT} = 4.2A$
Load Regulation	$V_{RLO}$		1.5		%	$V_{IN} = 24V$ , $I_{OUT} = 0-4.2A$
Output Voltage Trim Range	$V_{OAJ}$	-20%		10%	%	
Output Current Range	$I_{OUT}$			4.2	Adc	
Over Current Protection	$I_{OCP}$		7.7	12	Adc	$V_{IN} = 52V$
Efficiency – Full Load	$\eta_{FL}$		88.2		%	$T_{CASE} = 100^{\circ}C$ , $V_{IN} = 24V$
Efficiency – Half Load	$\eta_{HL}$		84.6		%	$T_{CASE} = 100^{\circ}C$ , $V_{IN} = 24V$
Output OVP Set Point	$V_{OVP}$		14.5		Vdc	
Output Ripple Voltage	$V_{ORPP}$		120		mVpp	$C_{OUT} = 6x2.2\mu F$ 16V X7R DC-20MHz
Switching Frequency	$f_{SW}$		900		kHz	
Output Turn-on Delay Time	$t_{ONDLY}$		80		ms	$V_{IN} = V_{UVON}$ to ENABLE = 5V

**Electrical Specifications (continued)**

Unless otherwise specified:  $18V < V_{IN} < 36V$ ,  $0A < I_{OUT} < 4.2A$ ,  $-40^{\circ}C < T_{CASE} < 100^{\circ}C^{(1)}$

Parameter	Symbol	Min	Typ	Max	Units	Conditions
<b>Output Specifications (continued)</b>						
Output Turn-off Delay Time	$t_{OFFDLY}$		10		$\mu s$	$V_{IN} = V_{UVOFF}$ to $ENABLE < 1.8V$
Soft-Start Ramp Time	$t_{SS}$		380		$\mu s$	$ENABLE = 5V$ to 90% $V_{out}$ $C_{SS} = 0$
Maximum Load Capacitance	$C_{OUT}$			10000	$\mu F$	$C_{SS} = 0$ , $C_{OUT} = Al$ Electrolytic
Load Transient Deviation	$V_{ODV}$		360		mV	$I_{OUT} = 50\%$ step $0.1A/\mu S$ $C_{OUT} = 6 \times 2.2\mu F$ 16V X7R
Load Transient Recovery Time	$t_{OVR}$		100		$\mu s$	$I_{OUT} = 50\%$ step $0.1A/\mu S$ $C_{OUT} = 6 \times 2.2\mu F$ 16V X7R $V_{OUT} - 1\%$
Maximum Output Power	$P_{OUT}$		50		W	
<b>Auxiliary Control Pins</b>						
<b>ENABLE</b>						
DC Voltage Reference Output	$V_{ERO}$	4.65	4.9	5.15	Vdc	
Output Current Limit <sup>(2)</sup>	$I_{ECL}$	-3.3	-2.6	-1.9	mAdc	$ENABLE = 3.3V$
Start Up Current Limit <sup>(2)</sup>	$I_{ESL}$	-120	-90	-60	$\mu A$	$ENABLE = 1V$
Module Enable Voltage	$V_{EME}$	1.95	2.5	3.05	Vdc	
Module Disable Voltage	$V_{EMD}$	1.8	2.35	2.9	Vdc	
Disable Hysteresis	$V_{EDH}$		150		mV	
Enable Delay Time	$t_{EE}$		10		$\mu s$	
Disable Delay Time	$t_{ED}$		10		$\mu s$	
Maximum Capacitance	$C_{EC}$			1500	pF	
Maximum External Toggle Rate	$f_{EXT}$			1	Hz	
<b>TRIM/SS</b>						
Trim Voltage Reference	$V_{REF}$		1.22		Vdc	
Internal Capacitance	$C_{REFI}$		10		nF	
External Capacitance	$C_{REF}$			1	$\mu F$	
Internal Resistance	$R_{REFI}$		10		k $\Omega$	
<b>TM (Temperature Monitor)</b>						
Temperature Coefficient	$TM_{TC}$		10		mV/ $^{\circ}K$	
Temperature Full Range Accuracy	$TM_{ACC}$	-5		5	$^{\circ}K$	
Drive Capability	$I_{TM}$	-100			$\mu A$	
TM Output Setting	$V_{TM}$		3.00		V	Ambient Temperature = $300^{\circ}K$

**Electrical Specifications (continued)**

Unless otherwise specified:  $18V < V_{IN} < 36V$ ,  $0A < I_{OUT} < 4.2A$ ,  $-40^{\circ}C < T_{CASE} < 100^{\circ}C^{(1)}$

Parameter	Symbol	Min	Typ	Max	Units	Conditions
<b>Thermal Specification</b>						
Junction Temperature Shutdown	$T_{MAX}$	130	135	140	$^{\circ}C$	$V_{IN} = 36V$ , Full 4.2A load
Junction-to-Case Thermal Impedance	$R\Theta_{J-C}$		3		$^{\circ}C/W$	
Case-to-Ambient Thermal Impedance	$R\Theta_{C-A}$		15		$^{\circ}C/W$	Mounted on 4.2 in <sup>2</sup> 1oz. Cu 6 layer PCB 25 $^{\circ}C$
<b>Regulatory Specification</b>						
IEC 60950-1:2005 (2 <sup>nd</sup> Edition),						
EN 60950-1:2006						
IEC 61000-4-2						
UL 60950-1:2007						
CAN/CSA C22.2 NO. 60950-1-07						
Recommended Input Fuse Rating	$I_{FUSE}$	4		10	A	Fast acting LITTLEFUSE Nano <sup>2</sup> Series Fuse

**Mechanical Specifications**

Parameter	Symbol	Min	Typ	Max	Units	Conditions
<b>Mechanical Parameters</b>						
PI3106-01-HVIZ Package Weight	$M_{PKG}$		7.2		g	No heat sink
PI3106-01-HVIZ Package Length	$L_{PKG}$		2.2		cm	No heat sink
			0.87		in	No heat sink
PI3106-01-HVIZ Package Width	$W_{PKG}$		1.65		cm	No heat sink
			0.65		in	No heat sink
PI3106-01-HVIZ Package Height	$H_{PKG}$		0.673		cm	No heat sink
			0.265		in	No heat sink

**Note (1):** These parameters are not production tested but are guaranteed by design, characterization and correlation with statistical process control. Unless otherwise specified, ATE tests are completed at room temperature.

**Note (2):** Current flow sourced by a pin has a negative sign.

## Functional Description:

### Input Power Pins IN(+) and IN(-):

The input power pins on the PI3106-01-HVIZ are connected to the input power source which can range from 18V to 36V DC. Under surge conditions, the PI3106-01-HVIZ can withstand up to 45V DC for 100 ms without incurring damage. The user should take care to avoid driving the input rails above the specified ratings. Since the PI3106-01-HVIZ is designed with high reliability in mind, the input pins are continuously monitored. If the applied voltage exceeds the input over-voltage trip point (typically 41V) the conversion process shall be terminated immediately. The converter initiates soft-start automatically within 80ms after the input voltage is reduced back to the appropriate value. The input pins do not have reverse polarity protection. If the PI3106 is operated in an environment where reverse polarity is a concern, the user should consider using a polarity protection device such as a suitably rated diode. To avoid the high losses of using a diode, the user should consider the much higher efficiency Picor family of intelligent Cool-ORing<sup>®</sup> solutions that can be used in reverse polarity applications. Information is available at [picorpower.com](http://picorpower.com).

The PI3106-01-HVIZ will draw nearly zero current until the input voltage reaches the internal start up threshold. If the ENABLE pin is not pulled low by external circuitry, the output voltage will begin rising to its final value of 12V about 80ms after the input UV lockout releases. This will occur automatically even if the ENABLE pin is floating.

To help keep the source impedance low, the input to the PI3106-01-HVIZ should be bypassed with (2) 4.7uF 50V ceramic capacitors of X7R dielectric in parallel with a low Q 100uF 50V electrolytic capacitor. To reduce EMI and reflected ripple current, a series inductor of 0.2 to 0.47uH can be added. The input traces to the module should be low impedance configured in such a manner as to keep stray inductance minimized.

### ENABLE Pin:

The ENABLE pin serves as a multi-function pin for the PI3106-01-HVIZ. During normal operation, it outputs the on-board 4.9V regulator which can be used for trimming the module up. The ENABLE pin can also be used as a remote enable pin either from the secondary via an optocoupler and some external isolated bias supply or from the primary side through a small signal transistor, FET or any device that sinks 3.3mA, minimum. If the ENABLE pin is lower than 2.35V typical, the converter will be held off or

shut down if already operating. A third feature is offered in that during a fault condition such as output OVP, input UV or OV, or output current limit, the ENABLE pin is pulled low internally. This can be used as a signal to the user that a fault has occurred. Whenever the ENABLE pin is pulled low, the TRIM/SS pin follows, resetting the internal and external soft-start circuitry. All faults will pull ENABLE low including over temperature. If increased turn on delay is desired, the ENABLE pin can be bypassed with a small capacitor up to a maximum of 1500pF.

### TRIM/SS Pin:

The TRIM/SS pin serves as another multi-purpose pin. First, it is used as the reference for the internal error amplifier. Connecting a resistor from TRIM/SS to SGND allows the reference to be margined down by as much as -20%. Connecting a resistor from TRIM/SS to ENABLE will allow the reference and output voltage to be margined up by 10%. If the user wishes a longer start up time, a small ceramic capacitor can be added to TRIM/SS to increase it. It is critical to connect any device between TRIM/SS and SGND and not -IN, otherwise high frequency noise will be introduced to the reference and possibly cause erratic operation.

### TM Pin:

The TM pin serves as an output indicator of the internal package temperature which is within approximately +/- 5 °K of the hottest junction temperature. Because of this, it is a good indicator of a thermal overload condition. The output is a scaled, buffered analog voltage which indicates the internal temperature in degrees Kelvin. Upon a thermal overload, the TM pin is pulled low, indicating a thermal fault has occurred. Upon restart of the converter, the TM pin reverts back to a buffered monitor. The thermal shutdown function of the PI3106-01-HVIZ is a fault feature which interrupts power processing if a certain maximum temperature is exceeded. TM can be monitored by an external microcontroller or circuit configured as an adaptive fan speed controller so that air flow in the system can be conveniently regulated.

### SGND Pin:

The PI3106-01-HVIZ SGND pin is the "quiet" control circuitry return. It is basically an extension of the internal signal ground. To avoid contamination and potential ground loops, this ground should NOT be connected to -IN since it is already star connected inside the package. Connect signal logic to SGND, not -IN.

### **Output Power Pins +OUT And -OUT:**

The output power terminals OUT(+) and OUT(-) deliver the 4.2A maximum output current from the PI3106-01-HVIZ through the J-lead output pins. This configuration allows for a low impedance output and should be connected to multi-layer PCB parallel planes for best performance. Due to the high switching frequency, output ripple and noise can be easily attenuated by adding just a few high quality X7R ceramic capacitors while retaining adequate transient response for most applications. The PI3106-01-HVIZ does not require any feedback loop compensation nor does it require any opto-isolation. All isolation is contained within the package. This greatly simplifies the use of the converter and eliminates all outside influences of noise on the quality of the output voltage regulation and feedback loop. It is important for the user to minimize resistive connections from the load to the converter output and to keep stray inductance to a minimum for best regulation and transient response. The very small size footprint and height of the PI3106-01-HVIZ allows the converter to be placed in the optimum location to allow for tight connections to the point of load. For those applications absolutely requiring very tight regulation, contact Picor Engineering at [picorpower.com](http://picorpower.com) for a remote sense application circuit which can be used.



Typical Performance Characteristics:

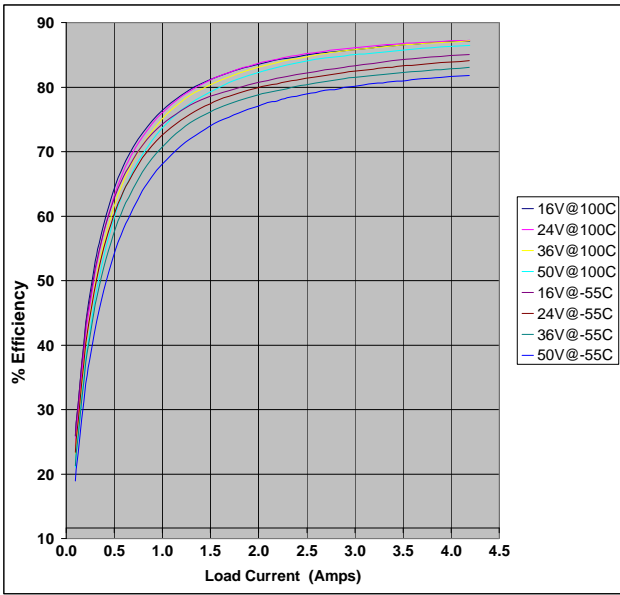


Figure 4 Conversion Efficiency

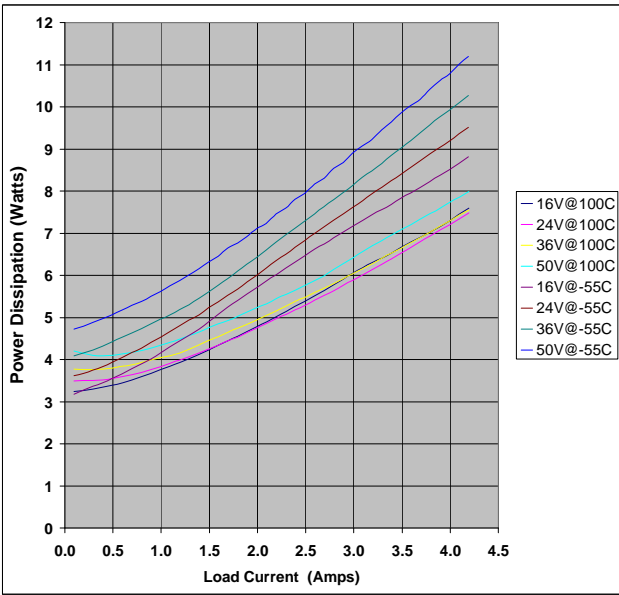


Figure 6 Power Dissipation Vs Load

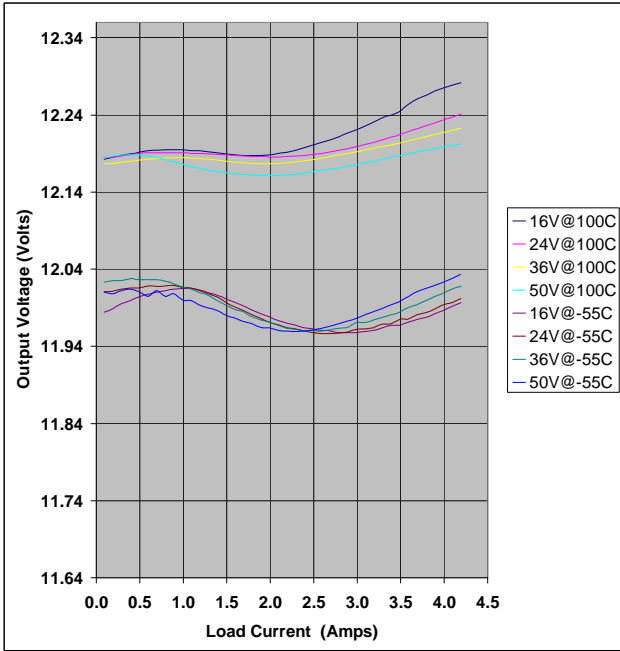


Figure 5 Line And Load Regulation

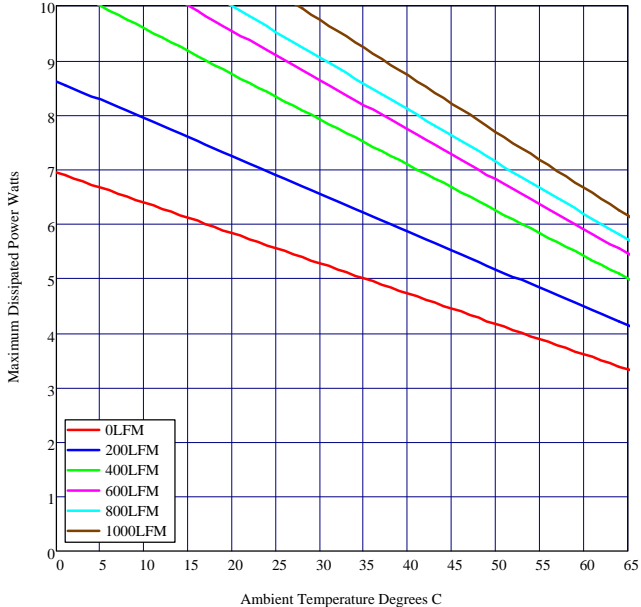


Figure 7 Maximum Power Dissipation No Heatsink

## Typical Performance Characteristics:

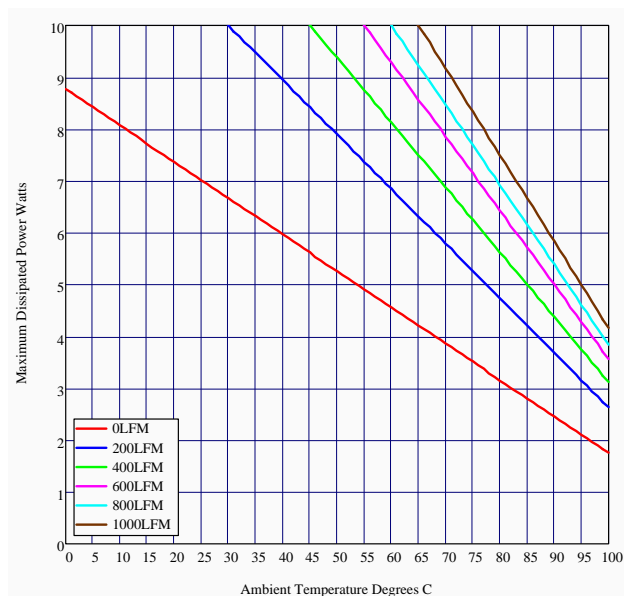


Figure 8 Max Power Dissipation (6.3mm Heat Sink)

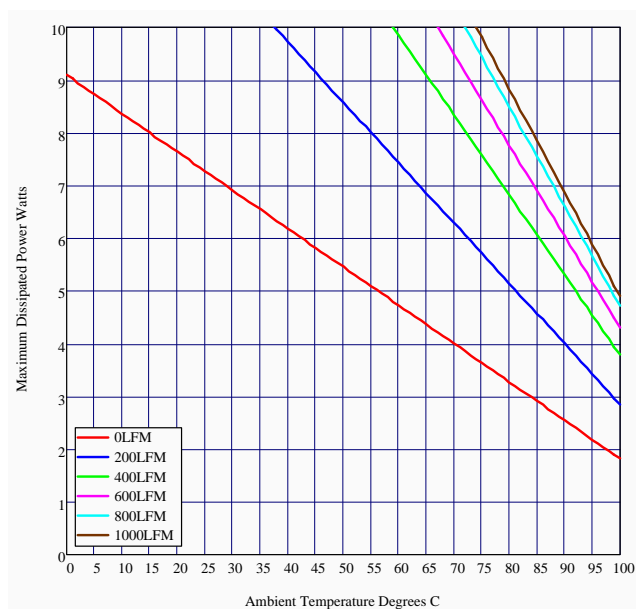


Figure 9 Max Power Dissipation (11mm Heat Sink)

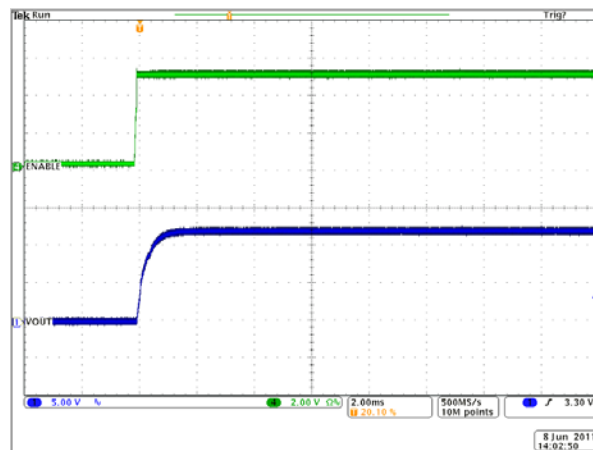


Figure 10 Start Up  $C_{REF} = 22nF$   
( $V_{IN} = 16V$   $I_O = 4.2A$  CC  $C_{OUT} = 6X2.2\mu F$  X7R Ceramic)

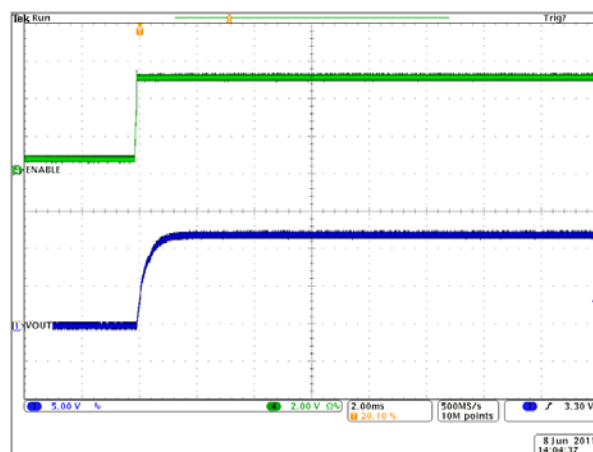


Figure 11 Start Up  $C_{REF} = 22nF$   
( $V_{IN} = 24V$   $I_{OUT} = 4.2A$  CC  $C_{OUT} = 6X2.2\mu F$  X7R Ceramic)

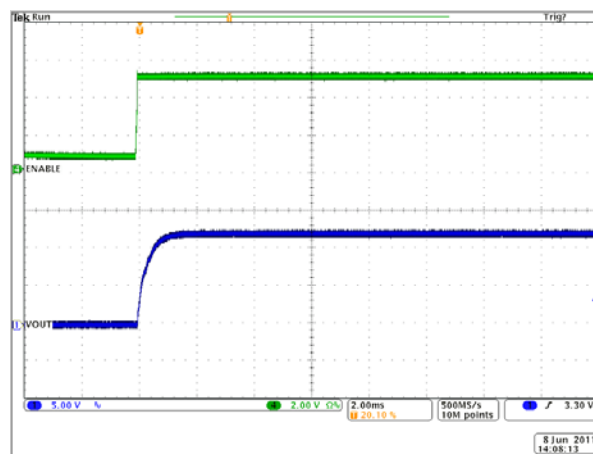
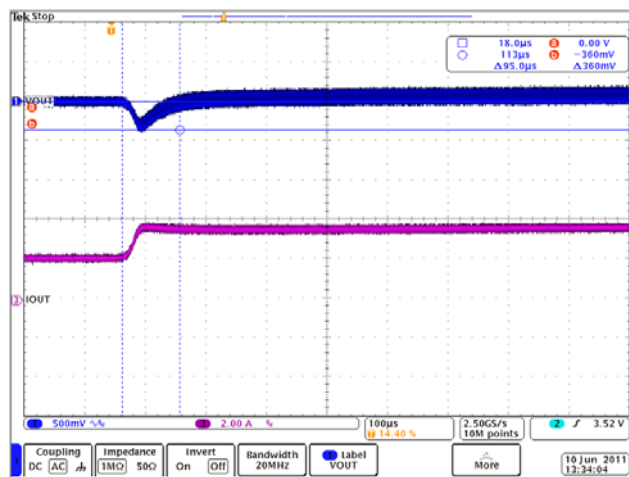
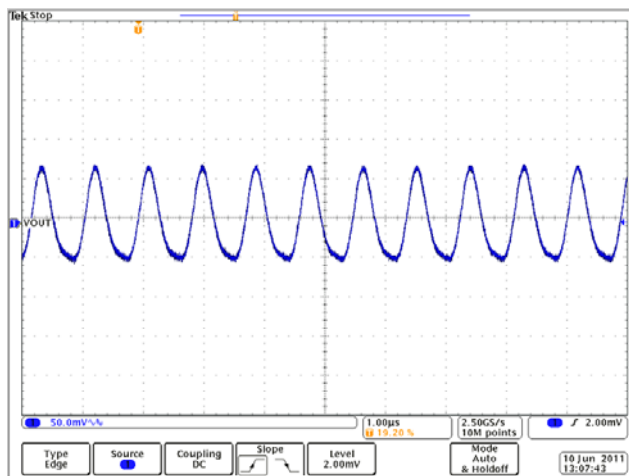


Figure 12 Start Up  $C_{REF} = 22nF$   
( $V_{IN} = 36V$   $I_{OUT} = 4.2A$  CC  $C_{OUT} = 6X2.2\mu F$  X7R Ceramic)

## Typical Performance Characteristics:



**Figure 13 Transient Response 0.1A/µs**  
**( $V_{IN} = 24V$   $I_{OUT} = 2.1-4.2A$   $C_{OUT} = 6X2.2\mu F$  X7R Ceramic)**



**Figure 14 Output Ripple**  
**( $V_{IN} = 24V$   $I_{OUT} = 4.2A$   $C_{OUT} = 6X2.2\mu F$  X7R Ceramic)**

The image displays the mechanical specifications for the 100/1 1004 component through four distinct views:

- TOP VIEW (COMPONENT SIDE):** Shows the component's footprint with an overall width of 22.0 [ .87 ] and a height of 16.5 [ .65 ]. It identifies the 'INPUT' and 'OUTPUT' regions.
- BOTTOM VIEW:** Provides a detailed view of the component's underside, showing the input and output pads with various dimensions such as 2X7.10 [ .280 ], 8.00 [ .315 ], 2X.70 [ .028 ], 1.49 [ .059 ] (8) PL, 9.50 [ .374 ], 15.99 [ .630 ], 3.01 [ .118 ], 1.12 TYP [ .044 ], 1.33 [ .052 ] (4) PL, 4X.94 [ .037 ], 2X3.05 [ .120 ], 12.05 [ .474 ], 7.55 [ .297 ], 7.08 [ .279 ], 6.08 [ .239 ], 5.08 [ .200 ], 4.08 [ .161 ], and 3.26 [ .128 ].
- RECOMMENDED LAND PATTERN (COMPONENT SIDE SHOWN):** Illustrates the recommended solder pad layout for the component. It includes dimensions for the pads and the spacing between them, such as 2X3.24 [ .128 ], 4X1.32 [ .052 ], 2X12.24 [ .482 ], 7.74 [ .305 ], 7.08 [ .279 ], 6.08 [ .239 ], 5.08 [ .200 ], 4.08 [ .161 ], 2X3.43 [ .135 ], 3.26 [ .128 ], 1.38 [ .054 ] TYP, 15.74 [ .620 ], 3.26 [ .128 ], .51 [ .020 ] TYP, 4X7.48 [ .295 ], 2X8.00 [ .315 ], and 2X3.05 [ .120 ]. It also indicates the 'SEATING PLANE' and 'ALL LEADS'.
- Side View:** Shows the component's profile with a height of 6.73±.25 [ .265±.010 ] and a width of 1.12 TYP [ .044 ].

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## Ordering Information And Available Options:

### Available Options – Heat Sinks:

At present, Picor offers four different heat sink options to accommodate the customers space and cooling needs. Heat sinks are available in two sizes, one with 6.3mm fins and the other with 11mm fins. Each of those heat sinks can be ordered with a specific air flow direction in mind, both X-Flow and longitudinal are supported.

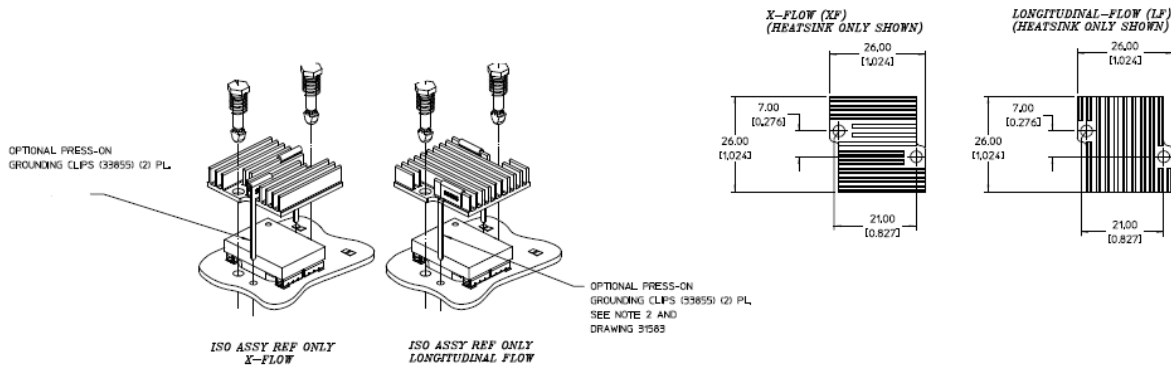


Figure 16 Picor PI3106-01-HVIZ Heat Sink Options:

Part Number	Package
PI3106-01-HVIZ	0.87"(w) x 0.65"(l) x 0.265"(h)
32784	Transverse Fins Heatsink 11 mm *
32786	Transverse Fins Heatsink 6.3mm *
32783	Longitudinal Fins Heatsink 11 mm *
32785	Longitudinal Fins Heatsink 6.3 mm *

- \* Assorted spring loaded push pins (not provided) are available to accommodate various PCB thicknesses. Please visit [www.vicorpower.com](http://www.vicorpower.com) for ordering information and details.



## Warranty

Vicor products are guaranteed for two years from date of shipment against defects in material or workmanship when in normal use and service. This warranty does not extend to products subjected to misuse, accident, or improper application or maintenance. Vicor shall not be liable for collateral or consequential damage. This warranty is extended to the original purchaser only.

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Vicor will repair or replace defective products in accordance with its own best judgment. For service under this warranty, the buyer must contact Vicor to obtain a Return Material Authorization (RMA) number and shipping instructions. Products returned without prior authorization will be returned to the buyer. The buyer will pay all charges incurred in returning the product to the factory. Vicor will pay all reshipment charges if the product was defective within the terms of this warranty.

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**Vicor's comprehensive line of power solutions includes high density AC-DC and DC-DC modules and accessory components, fully configurable AC-DC and DC-DC power supplies, and complete custom power systems.**

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**Specifications are subject to change without notice.**

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The products described in this data sheet are protected by the following U.S. Patents Numbers:  
6,788,033; 7,154,250; 7,561,446; 7,361,844; D496,906; D506,438; 6,940,013; 7,038,917; 6,969,909; 7,166,898;  
6,421,262; 7,368,957; RE 40,072

Vicor Corporation  
25 Frontage Road  
Andover, MA 01810  
USA

Picor Corporation  
51 Industrial Drive  
North Smithfield, RI 02896  
USA

Customer Service: [custserv@vicorpower.com](mailto:custserv@vicorpower.com)  
Technical Support: [apps@vicorpower.com](mailto:apps@vicorpower.com)  
Tel: 800-735-6200  
Fax: 978-475-6715