PICOR

Semiconductor Power Solutions

Cool-Power®
28 Volt
M Grade

28 V_{IN}, 3.3 V to 15 V_{OUT}, Cool-Power ZVS Isolated DC-DC Converter Modules

Product Description

The Cool-Power ZVS Isolated Converter Module Series consists of high density isolated DC-DC converters implementing Zero Voltage Switching topology.

The 28Vin Cool-Power series operates over a wide range input of 16 V to 50 Vdc, delivering 50 W of output power, yielding an unprecedented power density of 334 W/in^3.

These converter modules are surface mountable and only ~.5" square in area achieving ~50% space reduction versus conventional solutions.

Device	Output Voltage		I_{OUT} Max
	Set	Range	
PI3108-00-HVMZ	3.3 V	2.97 to 3.63 V	10 A
PI3109-00-HVMZ	5 V	4 to 5.5 V	10 A
PI3106-00-HVMZ	12 V	9.6 to 13.2 V	4.2 A
PI3111-00-HVMZ	15 V	12 to 16.5 V	3.33 A

The switching frequency of 900 kHz 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 high performance isolated magnetic feedback scheme which allows for high bandwidth and good common mode noise immunity.

The PI31xx-00-HVMZ series 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 well as shut down and alarm capabilities.

Features

- Efficiency up to 88%
- 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^2) enables PCB area savings
- Very low profile (0.265 in)
- Wide input voltage range operation (16-50 Vdc)
- On/Off Control, positive logic
- Wide trim range +10/-20% most models
- Temperature Monitor (TM) &
  Over-Temperature Protection (OTP)
- Input UVLO & OVLO and output OVP
- Over current protection with auto restart
- Adjustable soft-start
- 2250 V input to output isolation
- Surface Mountable 0.87" x 0.65" x 0.265"

Applications

- Wide Temperature,
  Aerospace & Defense Applications
- Space Constrained Systems
- Isolated Board Level Power

Package Information

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

Contents

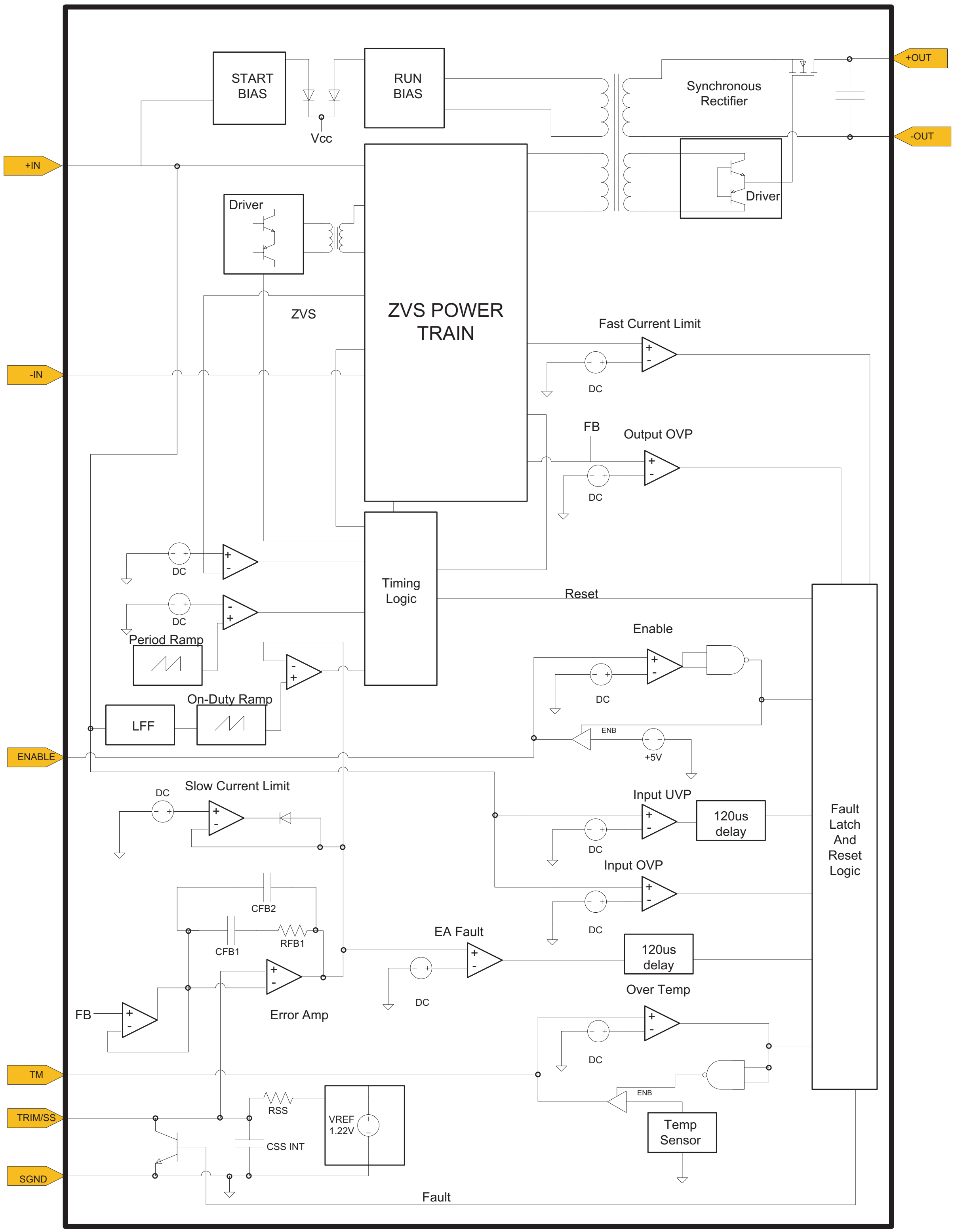
Order Information

Cool-Power	VIN	Vout	Iout Max	Package	Transport Media
PI3108-00-HVMZ	16 - 50 V	3.3 V	10 A	0.87″ x 0.65″ x 0.265″	TRAY
PI3109-00-HVMZ	16 - 50 V	5 V	10 A	0.87″ x 0.65″ x 0.265″	TRAY
PI3106-00-HVMZ	16 - 50 V	12 V	4.2 A	0.87″ x 0.65″ x 0.265″	TRAY
PI3111-00-HVMZ	16 - 50 V	15 V	3.33 A	0.87″ x 0.65″ x 0.265″	TRAY
Also Available					
PI3101-00-HVIZ	36 - 75 V	3.3 V	18 A	0.87″ x 0.65″ x 0.265″	TRAY
PI3105-00-HVIZ	36 - 75 V	12 V	5 A	0.87″ x 0.65″ x 0.265″	TRAY
PI3110-01-HVIZ	41 - 57 V	18 V	3.3 A	0.87″ x 0.65″ x 0.265″	TRAY
PI3109-01-HVIZ	18 - 36 V	5 V	10 A	0.87″ x 0.65″ x 0.265″	TRAY
PI3106-01-HVIZ	18 - 36 V	12 V	4.2 A	0.87″ x 0.65″ x 0.265″	TRAY

Absolute Maximum Ratings

Name	Rating
+IN to -IN Max Operating Voltage	-1.0 to 50 Vdc (operating)
+IN to -IN Max Peak Voltage	55 Vdc (non-operating, 12.5ms)
ENABLE to –IN	-0.3 to 6.0 Vdc
TM to –IN	-0.3 to 6.0 Vdc
TRIM/SS to –IN	-0.3 to 6.0 Vdc
+OUT to –OUT	See relevant model output section
Isolation Voltage (+IN/-IN to +OUT/-OUT)	2250 Vdc
Continuous Output Current	See relevant model output section
Peak Output Current	See relevant model output section
Operating Junction Temperature	-55 to 125°C
Storage Temperature	-65 to 125°C
Case Temperature During Reflow	245°C

Functional Block Diagram



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.

Package Pin-Out

Preliminary PI3108-00-HVMZ Electrical Characteristics

Unless otherwise specified: 16 V < V_{IN} < 50 V, 0 A < I_{OUT} < 10 A, -55°C < T_{CASE} < 100°C[(1)]

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Specifications						
Input Voltage Range	V_{IN}		16	28	50	Vdc
Input dv/dt (1)	V_{INDVDT}	V_{IN} = 50 V			1.0	V/µs
Input Under-Voltage Turn-on	V_{UVON}	I_O = 10 A	14.5	15.3	16	Vdc
Input Under-Voltage Turn-off	V_{UVOFF}	I_O = 10 A	13.5	14.1	15.2	Vdc
Input Under-Voltage Hysteresis	V_{UVH}	I_O = 10 A		1.2		Vdc
Input Over-Voltage Turn-on	V_{OVON}	I_O = 10 A	50	52.5	54	Vdc
Input Over-Voltage Turn-off	V_{OVOFF}	I_O = 10 A	51	53.7	55	Vdc
Input Over-Voltage Hysteresis	V_{OVH}	I_O = 10 A		1.2		Vdc
Input Quiescent Current	I_Q	V_{IN} = 28 V, ENABLE = 0 V		2		mAdc
Input Idling Power	P_{IDLE}	V_{IN} = 28 V, I_{OUT} = 0 A		2.6		W
Input Standby Power	P_{SBY}	V_{IN} = 28 V, ENABLE = 0 V		0.048		W
Input Current Full Load	I_{IN}	T_{CASE} = 100°C I_{OUT} = 10 A η_{FL} = 86% typical V_{IN} = 28 V		1.37		Adc
Input Reflected Ripple Current	I_{INRR}	L_{IN} = 0.47 µH C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic		15		mApp
Recommended Ext Input Capacitance	C_{IN}	C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic C_{IN} = Cbulk + Chf		109.4		µF
Output Specifications						
Output Voltage Set Point	V_{OUT}	I_{OUT} = 5 A		3.3		Vdc
Total Output Accuracy	V_{OA}	-0°C < T_{CASE} < 100°C	-3		+3	%
		-55°C < T_{CASE} < 0°C	-5		+3	%
Output Voltage Trim Range	V_{OADJ}		-10%		10%	%
Output Current Range	I_{OUT}				10	Adc
Over Current Protection	I_{OCP}		11.0	15	20	Adc
Efficiency – Full Load	η_{FL}	T_{CASE} = 100°C, V_{IN} = 28 V	84	86		%
Efficiency – Half Load	η_{HL}	T_{CASE} = 100°C, V_{IN} = 28 V	80	82		%
Output OVP Set Point	V_{OVP}		3.9	4.1	4.3	Vdc
Output Ripple Voltage	V_{ORPP}	C_{OUT} = 6 x 10 µF 10 V X7R DC-20 MHz		90		mVpp
Switching Frequency	f_{SW}			900		kHz
Output Turn-on Delay Time	t_{ONDLY}	V_{IN} = V_{UVON} to ENABLE = 5 V; V_{IN} rise time < 1 ms		80		ms
Output Turn-off Delay Time	t_{OFFDLY}	V_{IN} = V_{UVOFF} to ENABLE < 2.35 V		375		µs
Soft-Start Ramp Time	t_{SS}	ENABLE = 5 V to 90% V_{OUT} C_{REF} = 0		380		µs
Maximum Load Capacitance	C_{OUT}	C_{REF} = 0.22 µF, C_{OUT} = Al Electrolytic			4700	µF
Load Transient Deviation	V_{ODV}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x10 µF 10 V X7R		145		mV
Load Transient Recovery Time	t_{OVR}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x10 µF 10 V X7R V_{OUT} - 1%		100		µs
Maximum Output Power	P_{OUT}			33		W

Name	Absolute Maximum Output Ratings Rating
+OUT to -OUT	-0.5 V to 6.8 Vdc
Continuous Output Current	10 Adc
Peak Output Current	20 Adc

[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.

[2] Current flow sourced by a pin has a negative sign.

Preliminary PI3108-00-HVMZ Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
ENABLE						
DC Voltage Reference Output	V_{ERO}		4.65	4.9	5.15	Vdc
Output Current Limit(2)	I_{ECL}	ENABLE = 3.3 V	-3.3	-2.6	-1.9	mAdc
Start Up Current Limit(2)	I_{ESL}	ENABLE = 1 V	-120	-90	-60	µA
Module Enable Voltage	V_{EME}		1.95	2.5	3.05	Vdc
Module Disable Voltage	V_{EMD}			2.35		Vdc
Disable Hysteresis	V_{EDH}			150		mV
Enable Delay Time	t_{EE}			10		µs
Disable Delay Time	t_{ED}			10		µs
Maximum Capacitance	C_{EC}				1500	pF
Maximum External Toggle Rate	f_{EXT}				1	Hz
TRIM/SS						
Trim Voltage Reference	V_{REF}			1.240		Vdc
Internal Capacitance	C_{REFI}			10		nF
External Capacitance	C_{REF}				0.22	µF
Internal Resistance	R_{REFI}			10		kohms
TM (Temperature Monitor)						
Temperature Coefficient[1]	TM_{TC}			10		mV/°K
Temperature Full Range Accuracy[1]	TM_{ACC}		-5		5	°K
Drive Capability	I_{TM}		-100			µA
TM Output Setting	V_{TM}	Ambient Temperature = 300°K		3.00		V
Thermal Specification						
Junction Temperature Shutdown[1]	T_{MAX}		130	135	140	°C
Junction-to-Case Thermal Impedance	$R\Theta_{J-C}$			3		°C/W
Case-to-Ambient Thermal Impedance	$R\Theta_{C-A}$	Mounted on 9 in^2 1oz. Cu 6 layer PCB 25°C		9.6		°C/W
Regulatory Specification						
IEC 60950-1:2005 (2nd 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}	Fast acting LITTLEFUSE Nano^2 Series Fuse	4		10	A

[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.

[2] Current flow sourced by a pin has a negative sign.

Preliminary PI3108-00-HVMZ Electrical Characteristics

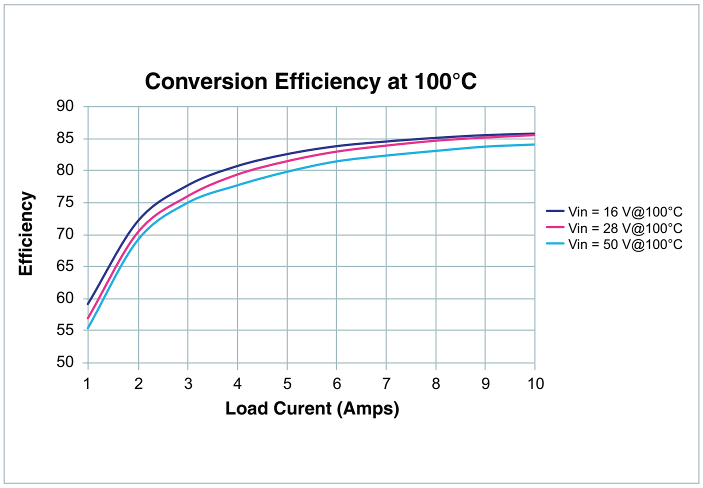


Figure 1 *— Conversion Efficiency*

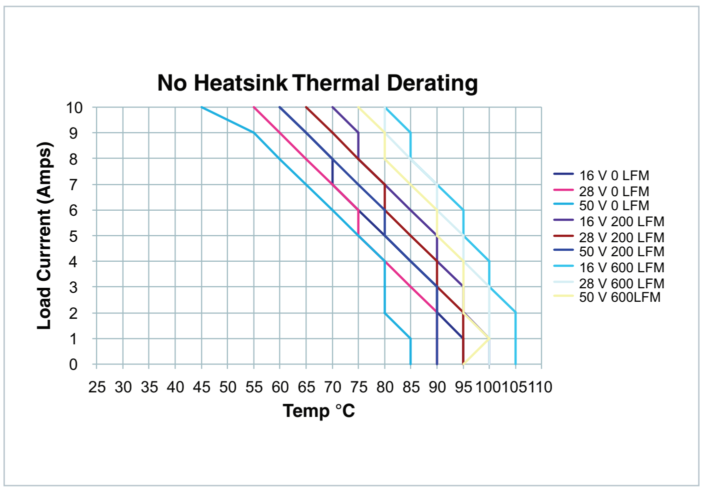


Figure 2 *— Load Current vs Temperature (without Heat Sink)*

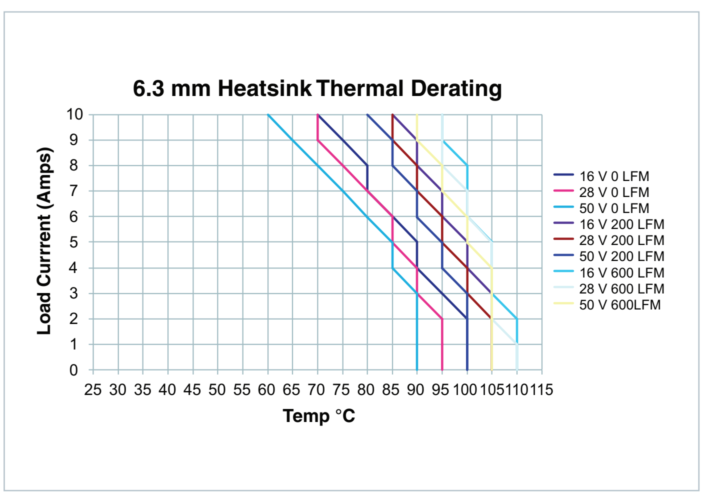


Figure 3 *— Load Current vs Temperature (6.33mm Heat Sink)*

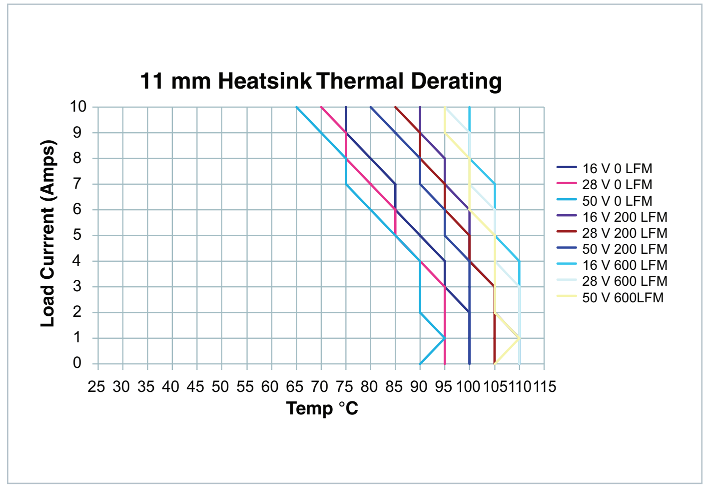


Figure 4 *— Load Current vs Temperature (11mm Heat Sink)*

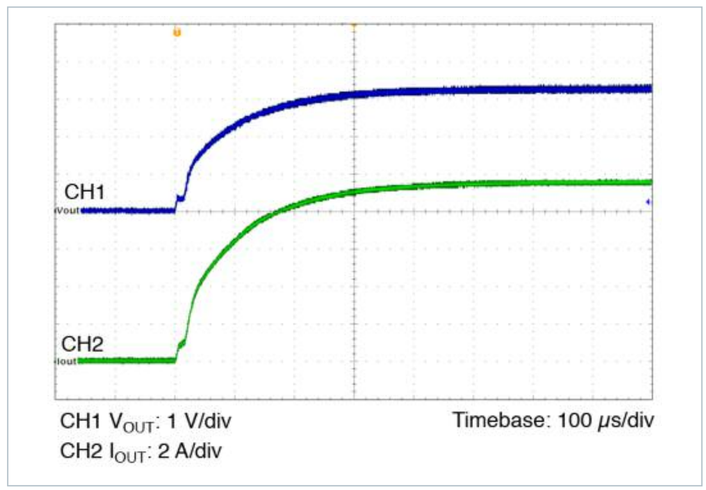


Figure 5 *— Start Up, $C_{REF} = 0$*
($V_{IN} = 16$ V, $I_{OUT} = 10$ A, CR, $C_{OUT} = 6 \times 10$ µF X7R Ceramic)

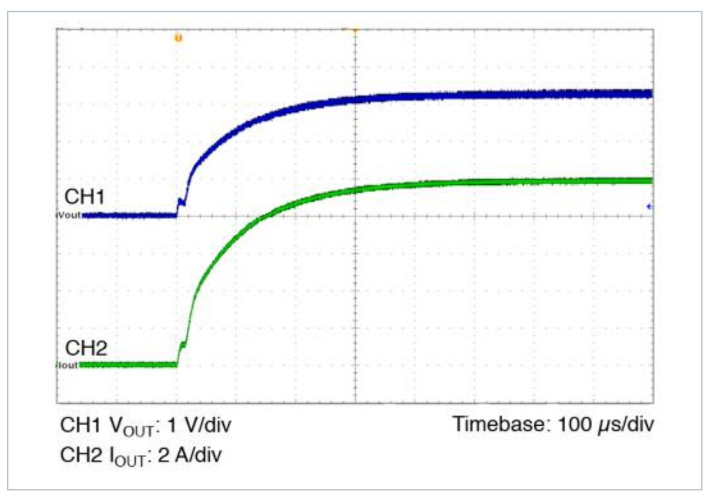


Figure 6 *— Start Up, $C_{REF} = 0$*
($V_{IN} = 28$ V, $I_{OUT} = 10$ A, CR, $C_{OUT} = 6 \times 10$ µF X7R Ceramic)

Preliminary PI3108-00-HVMZ Electrical Characteristics

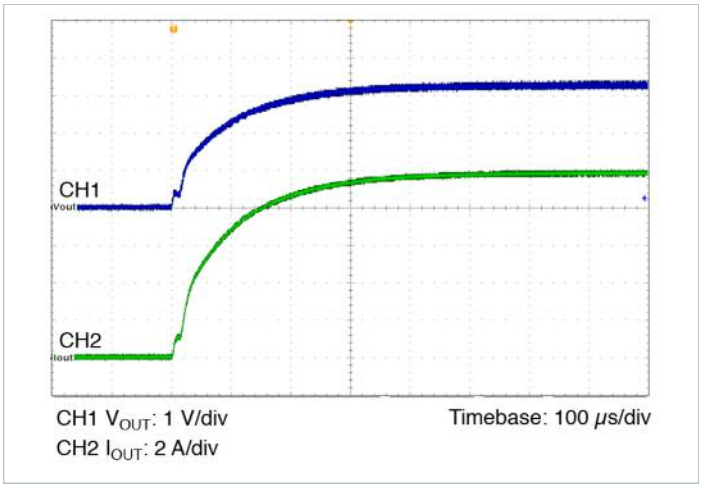


Figure 7 *— Start Up, C_{REF} = 0*
(V_{IN} = 50 V, I_{OUT} = 10 A, CR, C_{OUT} = 6 x 10 µF X7R Ceramic)

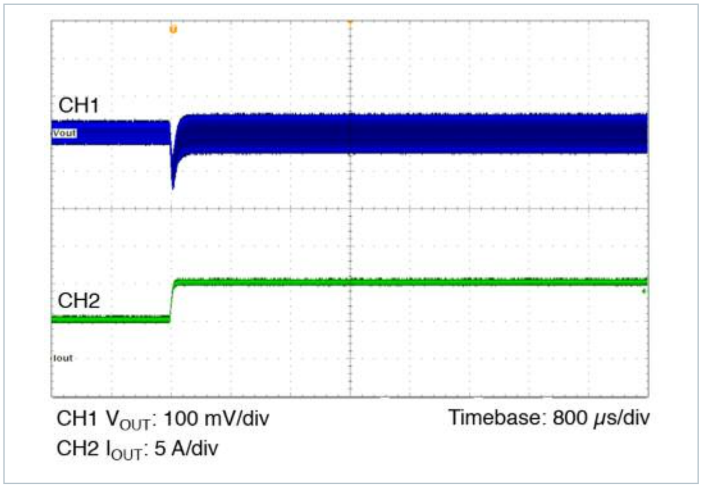


Figure 8 *— Transient Response*
(V_{IN} = 28 V, I_{OUT} = 5-10 A 0.1 A/µs, C_{OUT} = 6 x 10 µF X7R Ceramic)

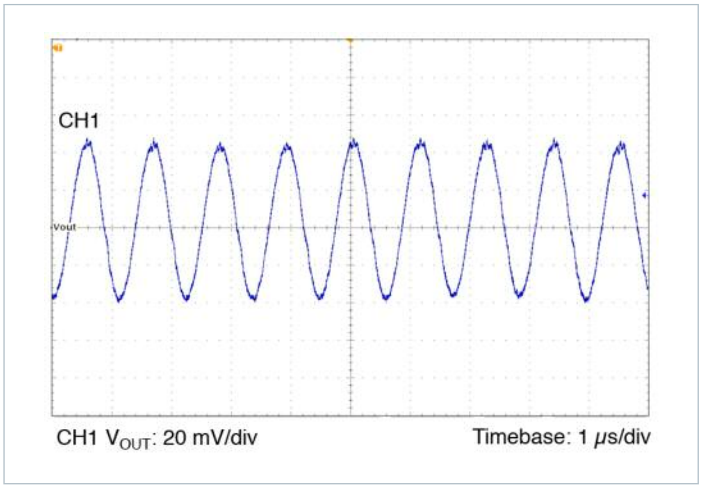


Figure 9 *— Output Ripple*
(V_{IN} = 28 V, I_{OUT} = 10 A, CR, C_{OUT} = 6 x 10 µF X7R Ceramic)

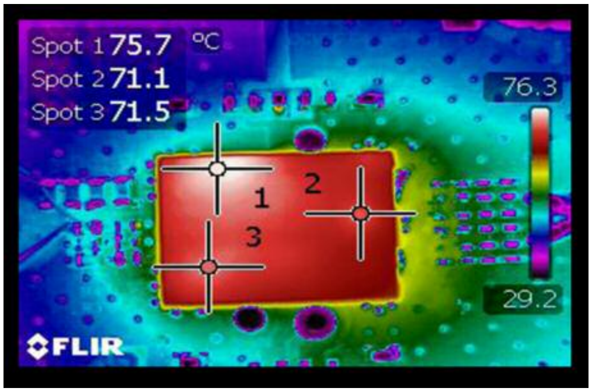


Figure 10 *— Thermal Image*
(V_{IN} = 28 V, I_{OUT} = 10 A, CR, 0 LFM Evaluation PCB)

PI3109-00-HVMZ Electrical Characteristics

Unless otherwise specified: 16 V < V_{IN} < 50 V, 0 A < I_{OUT} < 10 A, -55°C < T_{CASE} < 100°C(1)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Specifications						
Input Voltage Range	V_{IN}		16	28	50	Vdc
Input dv/dt (1)	V_{INDVDT}	V_{IN} = 50 V			1.0	V/µs
Input Under-Voltage Turn-on	V_{UVON}	I_O = 10 A	14.5	15.3	16	Vdc
Input Under-Voltage Turn-off	V_{UVOFF}	I_O = 10 A	13.5	14.1	15.2	Vdc
Input Under-Voltage Hysteresis	V_{UVH}	I_O = 10 A		1.2		Vdc
Input Over-Voltage Turn-on	V_{OVON}	I_O = 10 A	50.0	52.5	54	Vdc
Input Over-Voltage Turn-off	V_{OVOFF}	I_O = 10 A	51	53.7	55	Vdc
Input Over-Voltage Hysteresis	V_{OVH}	I_O = 10 A		1.2		Vdc
Input Quiescent Current	I_Q	V_{IN} = 28 V, ENABLE = 0 V		2		mAdc
Input Idling Power	P_{IDLE}	V_{IN} = 28 V, I_{OUT} = 0 A		3.5		W
Input Standby Power	P_{SBY}	V_{IN} = 28 V, ENABLE = 0 V		0.056		W
Input Current Full Load	I_{IN}	T_{CASE} = 100°C I_{OUT} = 10 A η_{FL} = 88% typical V_{IN} = 28 V		2.03		Adc
Input Reflected Ripple Current	I_{INRR}	L_{IN} = 0.47 µH C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic		13		mApp
Recommended Ext Input Capacitance	C_{IN}	C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic C_{IN} = Cbulk + Chf		109.4		µF
Output Specifications						
Output Voltage Set Point	V_{OUT}	I_{OUT} = 5 A		5.0		Vdc
Total Output Accuracy	V_{OA}	-0°C <T_{CASE} < 100°C	-3		+3	%
		-55°C <T_{CASE} < 0°C	-5		+3	%
Output Voltage Trim Range	V_{OADJ}		-20%		10%	%
Output Current Range	I_{OUT}				10	Adc
Over Current Protection	I_{OCP}		10.8	15	20	Adc
Efficiency – Full Load	η_{FL}	T_{CASE} = 100°C, V_{IN} = 28 V	86	88		%
Efficiency – Half Load	η_{HL}	T_{CASE} = 100°C, V_{IN} = 28 V	83.5	85.5		%
Output OVP Set Point	V_{OVP}		6.0	6.3	6.6	Vdc
Output Ripple Voltage	V_{ORPP}	C_{OUT} = 6 x 10 µF 10 V X7R DC-20 MHz		135		mVpp
Switching Frequency	f_{SW}			900		kHz
Output Turn-on Delay Time	t_{ONDLY}	V_{IN} = V_{UVON} to ENABLE = 5 V; V_{IN} rise time < 1 ms		80		ms
Output Turn-off Delay Time	t_{OFFDLY}	V_{IN} = V_{UVOFF} to ENABLE < 2.35 V		375		µs
Soft-Start Ramp Time	t_{SS}	ENABLE = 5 V to 90% V_{OUT} C_{REF} = 0		230		µs
Maximum Load Capacitance	C_{OUT}	C_{REF} = 0.22 µF, C_{OUT} = Al Electrolytic			4700	µF
Load Transient Deviation	V_{ODV}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x10 µF 10 V X7R		90		mV
Load Transient Recovery Time	t_{OVR}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x10 µF 10 V X7R V_{OUT} - 1%		100		µs
Maximum Output Power	P_{OUT}			50		W

	Absolute Maximum Output Ratings
Name	Rating
+OUT to -OUT	-0.5 V to 6.8 Vdc
Continuous Output Current	10 Adc
Peak Output Current	20 Adc

[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.

[2] Current flow sourced by a pin has a negative sign.

PI3109-00-HVMZ Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
ENABLE						
DC Voltage Reference Output	V_{ERO}		4.65	4.9	5.15	Vdc
Output Current Limit[2]	I_{ECL}	ENABLE = 3.3 V	-3.3	-2.6	-1.9	mAdc
Start Up Current Limit[2]	I_{ESL}	ENABLE = 1 V	-120	-90	-60	µA
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		µs
Disable Delay Time	t_{ED}			10		µs
Maximum Capacitance	C_{EC}				1500	pF
Maximum External Toggle Rate	f_{EXT}				1	Hz
TRIM/SS						
Trim Voltage Reference	V_{REF}			1.240		Vdc
Internal Capacitance	C_{REFI}			10		nF
External Capacitance	C_{REF}				0.22	µF
Internal Resistance	R_{REFI}			10		kohms
TM (Temperature Monitor)						
Temperature Coefficient[1]	TM_{TC}			10		mV/°K
Temperature Full Range Accuracy[1]	TM_{ACC}		-5		5	°K
Drive Capability	I_{TM}		-100			µA
TM Output Setting	V_{TM}	Ambient Temperature = 300°K		3.00		V
Thermal Specification						
Junction Temperature Shutdown[1]	T_{MAX}		130	135	140	°C
Junction-to-Case Thermal Impedance	$R\Theta_{J-C}$			3		°C/W
Case-to-Ambient Thermal Impedance	$R\Theta_{C-A}$	Mounted on 9 in^2 1oz. Cu 6 layer PCB 25°C		9.1		°C/W
Regulatory Specification						
IEC 60950-1:2005 (2nd 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}	Fast acting LITTLEFUSE $Nano^2$ Series Fuse	4		10	A

[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.

[2] Current flow sourced by a pin has a negative sign.

PI3109-00-HVMZ Electrical Characteristics

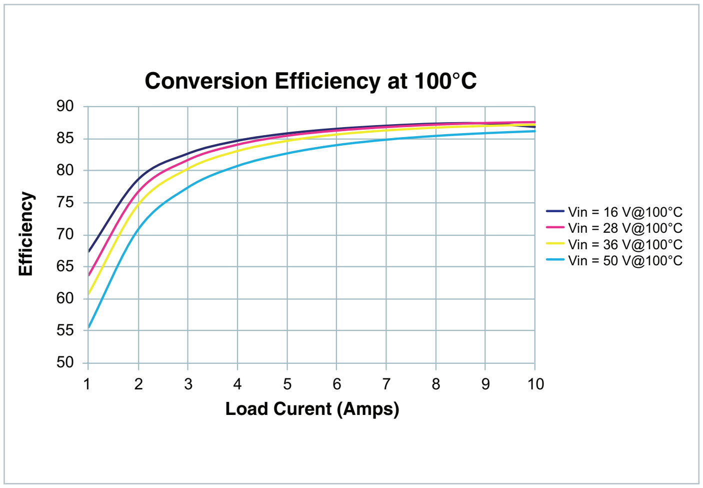


Figure 11 *— Conversion Efficiency*

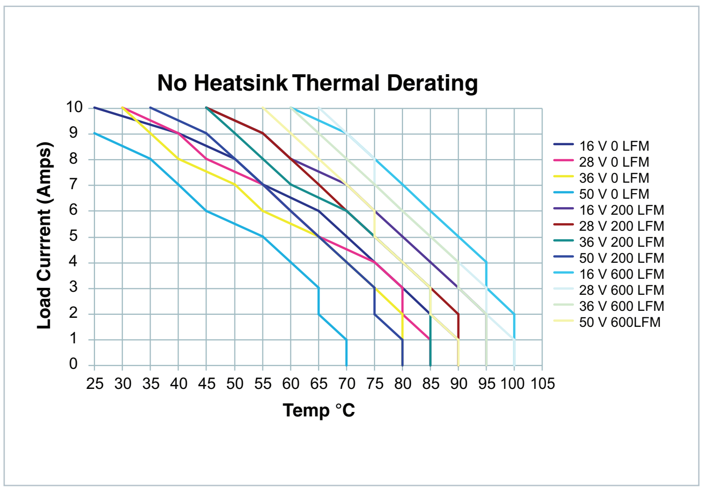


Figure 12 *— Load Current vs Temperature (without Heat Sink)*

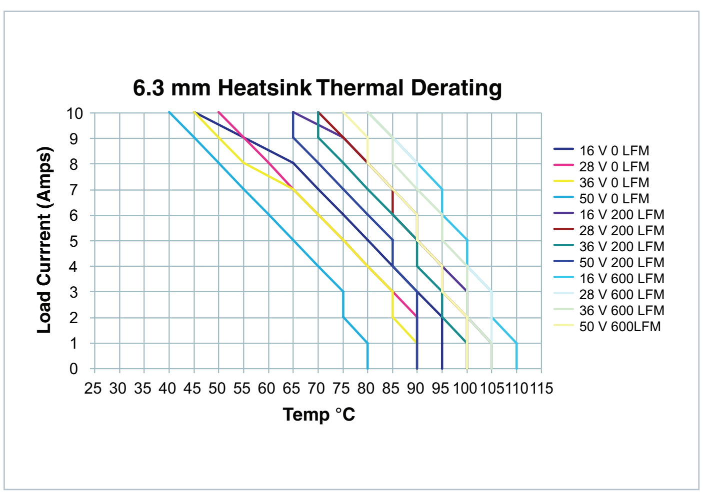


Figure 13 *— Load Current vs Temperature (6.33mm Heat Sink)*

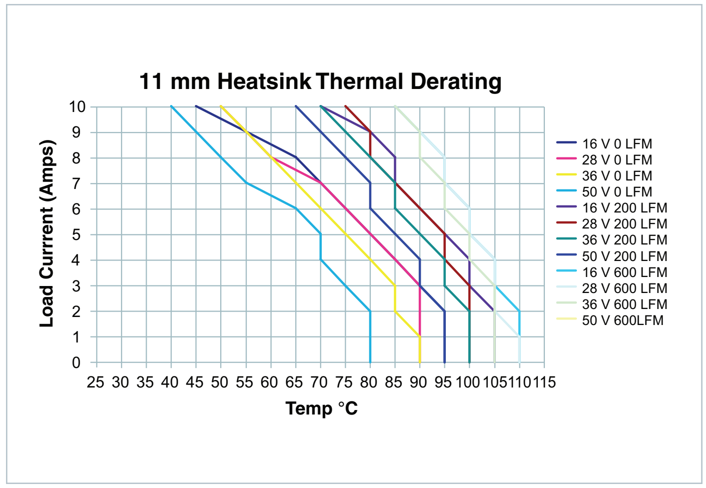


Figure 14 *— Load Current vs Temperature (11mm Heat Sink)*

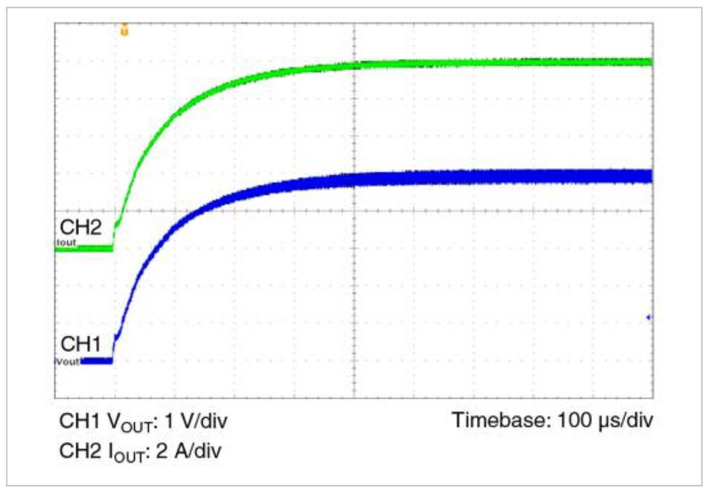


Figure 15 *— Start Up, C_{REF} = 0*
(V_{IN} = 16 V, I_{OUT} = 10 A, CR, C_{OUT} = 6 x 10 µF X7R Ceramic)

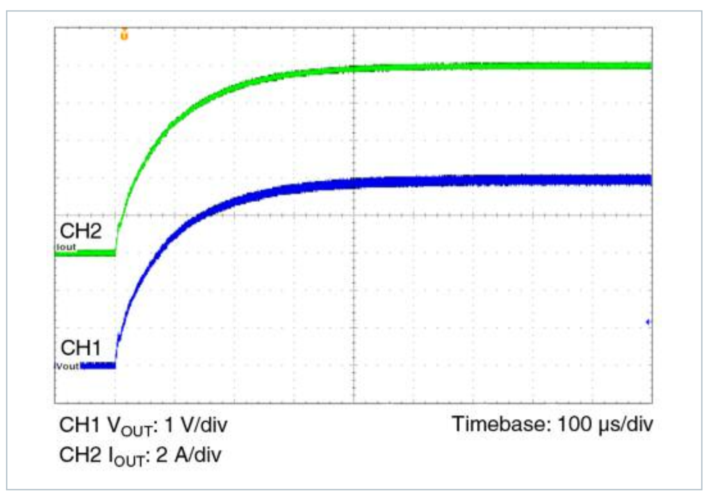


Figure 16 *— Start Up, C_{REF} = 0*
(V_{IN} = 28 V, I_{OUT} = 10 A, CR, C_{OUT} = 6 x 10 µF X7R Ceramic)

PI3109-00-HVMZ Electrical Characteristics

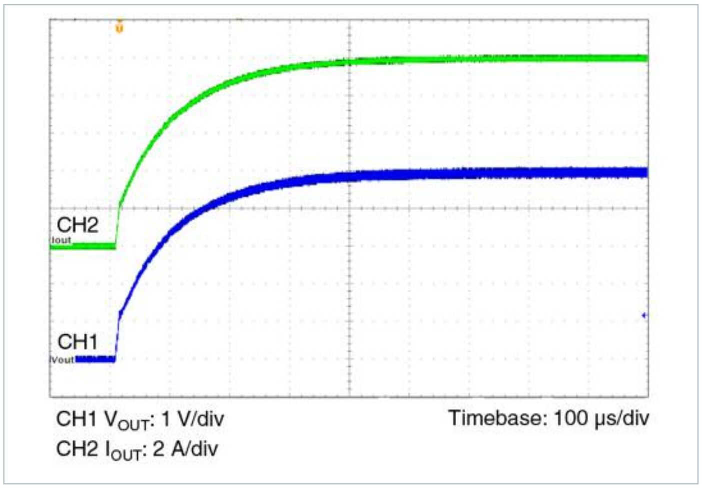


Figure 17 *— Start Up, $C_{REF} = 0$*
(V_{IN} = 50 V, I_{OUT} = 10 A, CR, C_{OUT} = 6 x 10 µF X7R Ceramic)

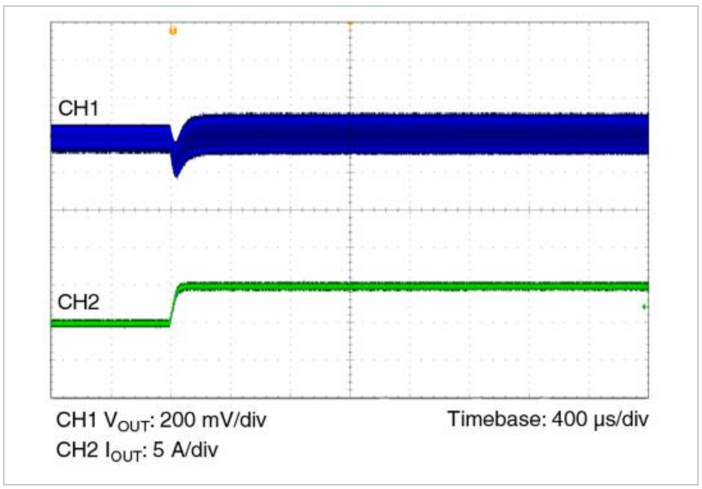


Figure 18 *— Transient Response*
(V_{IN} = 28 V, I_{OUT} = 5-10 A 0.1 A/µs, C_{OUT} = 6 x 10 µF X7R Ceramic)

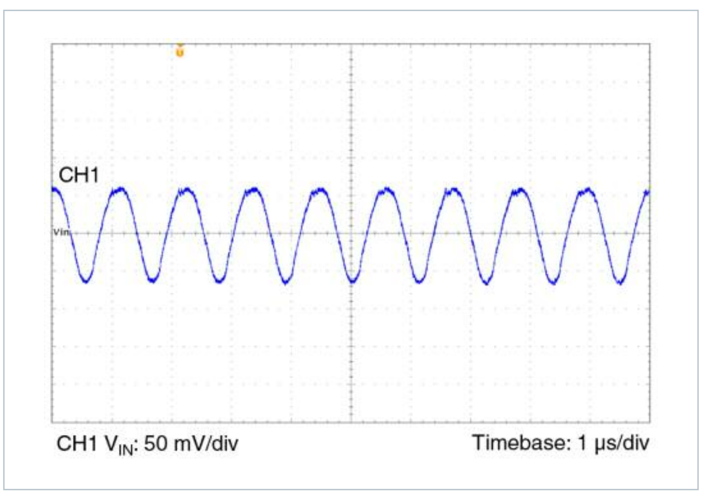


Figure 19 *— Output Ripple*
(V_{IN} = 28 V, I_{OUT} = 10 A, CR, C_{OUT} = 6 x 10 µF X7R Ceramic)

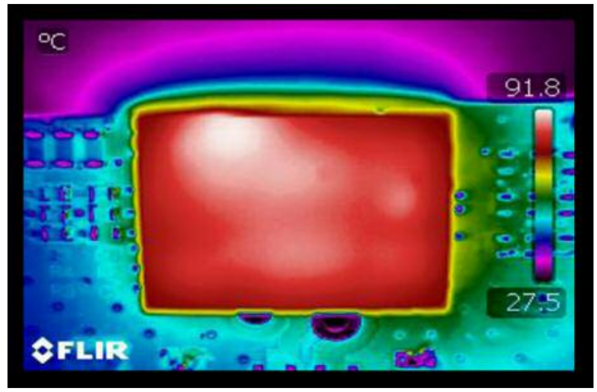


Figure 20 *— Thermal Image*
(V_{IN} = 28 V, I_{OUT} = 10 A, CR, 0 LFM Evaluation PCB)

PI3106-00-HVMZ Electrical Characteristics

Unless otherwise specified: 16 V < V_{IN} < 50 V, 0 A < I_{OUT} < 4.2 A, -55°C < T_{CASE} < 100°C(1)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Specifications						
Input Voltage Range	V_{IN}		16	28	50	Vdc
Input dv/dt (1)	V_{INDVDT}	V_{IN} = 50 V			1.0	V/µs
Input Under-Voltage Turn-on	V_{UVON}	I_O = 4.2 A	14.5	15.4	16	Vdc
Input Under-Voltage Turn-off	V_{UVOFF}	I_O = 4.2 A	13.5	14.4	15.2	Vdc
Input Under-Voltage Hysteresis	V_{UVH}	I_O = 4.2 A		1.0		Vdc
Input Over-Voltage Turn-on	V_{OVON}	I_O = 4.2 A	50	52.3	54	Vdc
Input Over-Voltage Turn-off	V_{OVOFF}	I_O = 4.2 A	51	53.5	55	Vdc
Input Over-Voltage Hysteresis	V_{OVH}	I_O = 4.2 A		1.2		Vdc
Input Quiescent Current	I_Q	V_{IN} = 28 V, ENABLE = 0 V		2		mAdc
Input Idling Power	P_{IDLE}	V_{IN} = 28 V, I_{OUT} = 0 A		3.5		W
Input Standby Power	P_{SBY}	V_{IN} = 28 V, ENABLE = 0 V		0.056		W
Input Current Full Load	I_{IN}	T_{CASE} = 100°C I_{OUT} = 4.2 A η_{FL} = 88% typical V_{IN} = 28 V		2.045		Adc
Input Reflected Ripple Current	I_{INRR}	L_{IN} = 0.47 µH C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic		13		mApp
Recommended Ext Input Capacitance	C_{IN}	C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic C_{IN} = Cbulk + Chf		109.4		µF
Output Specifications						
Output Voltage Set Point	V_{OUT}	I_{OUT} = 2.1 A		12.0		Vdc
Total Output Accuracy	V_{OA}	-0°C < T_{CASE} < 100°C	-3		+3	%
		-55°C < T_{CASE} < 0°C	-5		+3	%
Output Voltage Trim Range	V_{OADJ}		-20%		10%	%
Output Current Range	I_{OUT}				4.2	Adc
Over Current Protection	I_{OCP}		4.6	6.8	12	Adc
Efficiency – Full Load	η_{FL}	T_{CASE} = 100°C, V_{IN} = 28 V	86	88		%
Efficiency – Half Load	η_{HL}	T_{CASE} = 100°C, V_{IN} = 28 V	83	85		%
Output OVP Set Point	V_{OVP}		13.8	14.6	15.3	Vdc
Output Ripple Voltage	V_{ORPP}	C_{OUT} = 6 x 2.2 µF 16 V X7R DC-20 MHz		300		mVpp
Switching Frequency	f_{SW}			900		kHz
Output Turn-on Delay Time	t_{ONDLY}	V_{IN} = V_{UVON} to ENABLE = 5 V; V_{IN} rise time < 1 ms		80		ms
Output Turn-off Delay Time	t_{OFFDLY}	V_{IN} = V_{UVOFF} to ENABLE < 2.35 V		375		µs
Soft-Start Ramp Time	t_{SS}	ENABLE = 5 V to 90% V_{OUT} C_{REF} = 0		230		µs
Maximum Load Capacitance	C_{OUT}	C_{REF} = 0.22 µF, C_{OUT} = Al Electrolytic			1000	µF
Load Transient Deviation	V_{ODV}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x 2.2 µF 16 V X7R		360		mV
Load Transient Recovery Time	t_{OVR}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x 2.2 µF 16 V X7R V_{OUT} - 1%		100		µs
Maximum Output Power	P_{OUT}			50		W

	Absolute Maximum Output Ratings
Name	Rating
+OUT to -OUT	0.5 to 16 Vdc
Continuous Output Current	4.2 Adc
Peak Output Current	12 Adc

[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.

[2] Current flow sourced by a pin has a negative sign.

PI3106-00-HVMZ Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
ENABLE						
DC Voltage Reference Output	V_{ERO}		4.65	4.9	5.15	Vdc
Output Current Limit(2)	I_{ECL}	ENABLE = 3.3 V	-3.3	-2.6	-1.9	mAdc
Start Up Current Limit(2)	I_{ESL}	ENABLE = 1 V	-120	-90	-60	µA
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		µs
Disable Delay Time	t_{ED}			10		µs
Maximum Capacitance	C_{EC}				1500	pF
Maximum External Toggle Rate	f_{EXT}				1	Hz
TRIM/SS						
Trim Voltage Reference	V_{REF}			1.235		Vdc
Internal Capacitance	C_{REFI}			10		nF
External Capacitance	C_{REF}				0.22	µF
Internal Resistance	R_{REFI}			10		kohms
TM (Temperature Monitor)						
Temperature Coefficient[1]	TM_{TC}			10		mV/°K
Temperature Full Range Accuracy[1]	TM_{ACC}		-5		5	°K
Drive Capability	I_{TM}		-100			µA
TM Output Setting	V_{TM}	Ambient Temperature = 300°K		3.00		V
Thermal Specification						
Junction Temperature Shutdown[1]	T_{MAX}		130	135	140	°C
Junction-to-Case Thermal Impedance	$R\Theta_{J-C}$			3		°C/W
Case-to-Ambient Thermal Impedance	$R\Theta_{C-A}$	Mounted on 9 in^2 1oz. Cu 6 layer PCB 25°C		8.15		°C/W
Regulatory Specification						
IEC 60950-1:2005 (2nd 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}	Fast acting LITTLEFUSE Nano^2 Series Fuse	4		10	A

[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.

[2] Current flow sourced by a pin has a negative sign.

PI3106-00-HVMZ Electrical Characteristics

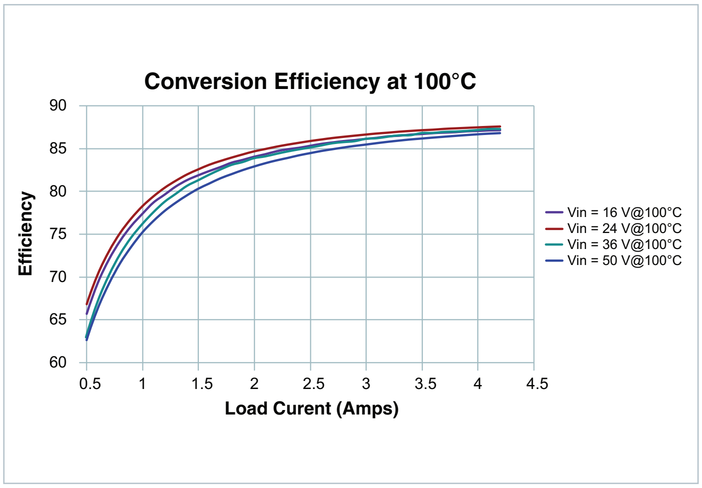


Figure 21 *— Conversion Efficiency*

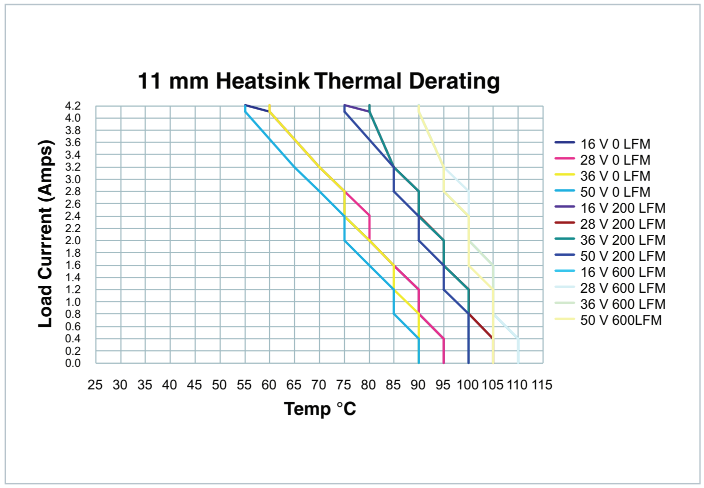


Figure 24 *— Load Current vs Temperature (11mm Heat Sink)*

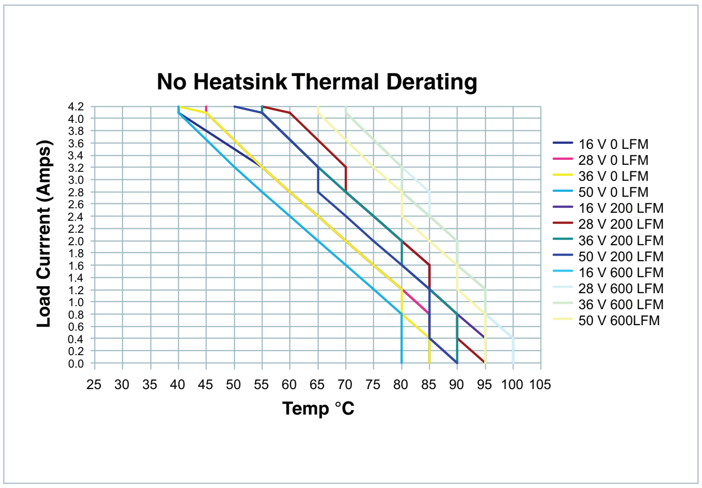


Figure 22 *— Load Current vs Temperature (without Heat Sink)*

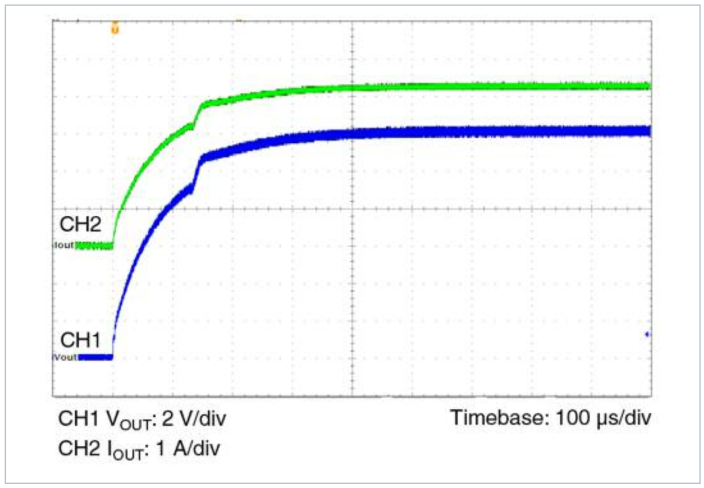


Figure 25 *— Start Up, C_{REF} = 0*
(V_{IN} = 16 V, I_{OUT} = 4.2 A, CR, C_{OUT} = 6 x 2.2 μF X7R Ceramic)

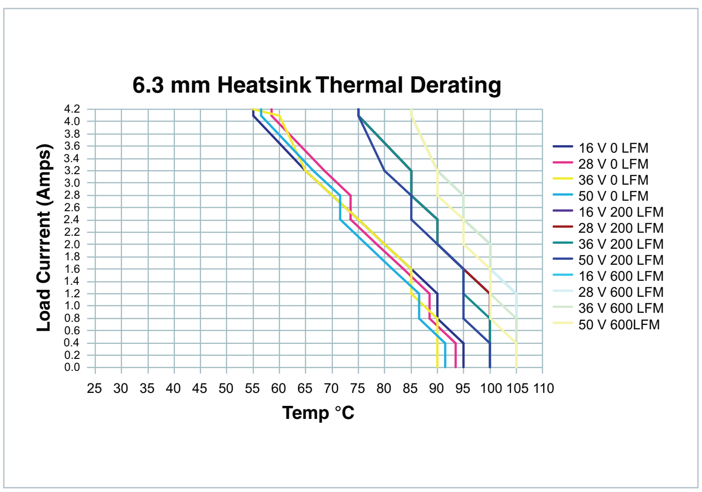


Figure 23 *— Load Current vs Temperature (6.3mm Heat Sink)*

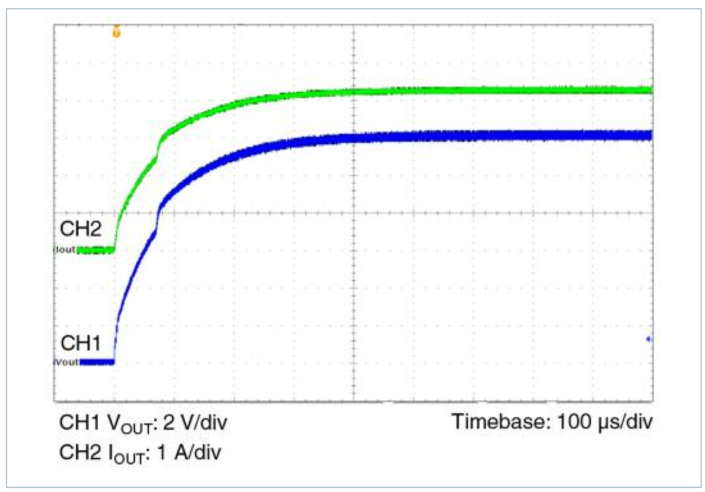


Figure 26 *— Start Up, C_{REF} = 0*
(V_{IN} = 28 V, I_{OUT} = 4.2 A, CR, C_{OUT} = 6 x 2.2 μF X7R Ceramic)

PI3106-00-HVMZ Electrical Characteristics

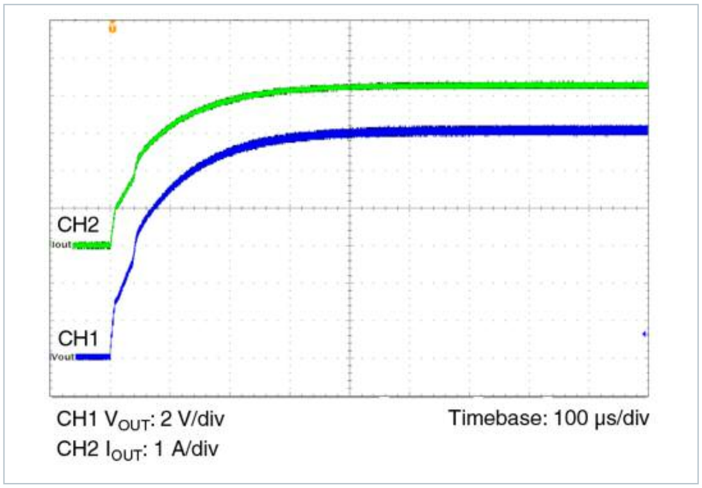


Figure 27 *— Start Up, C_{REF} = 0 (V_{IN} = 50 V, I_{OUT} = 4.2 A, CR, C_{OUT} = 6 x 2.2 µF X7R Ceramic)*

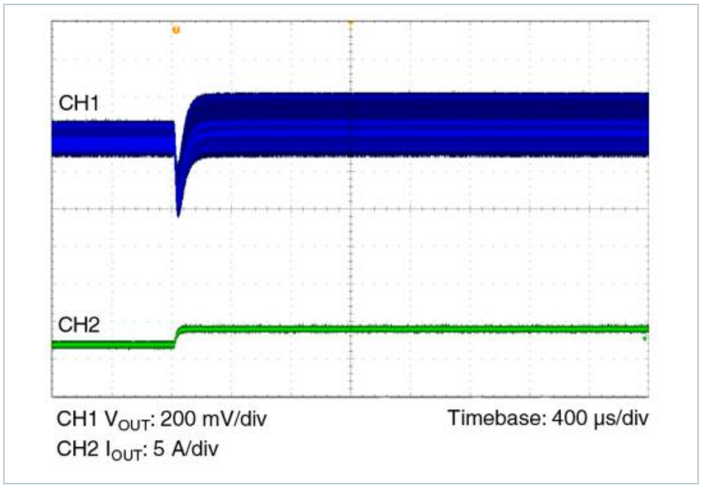


Figure 28 *— Transient Response (V_{IN} = 28 V I_{OUT} = 2.1 - 4.2 A 0.1 A/µs, C_{OUT} = 6 X 2.2 µF X7R Ceramic)*

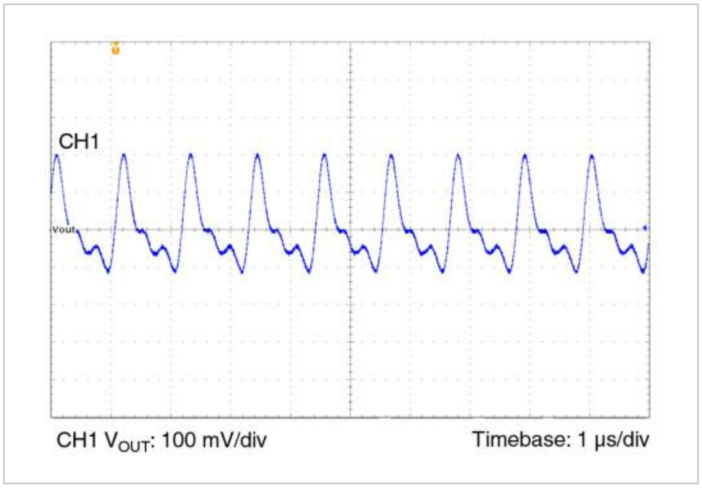


Figure 29 *— Output Ripple (V_{IN} = 28 V I_{OUT} = 4.2 A, C_{OUT} = 6 X 2.2 µF X7R Ceramic)*

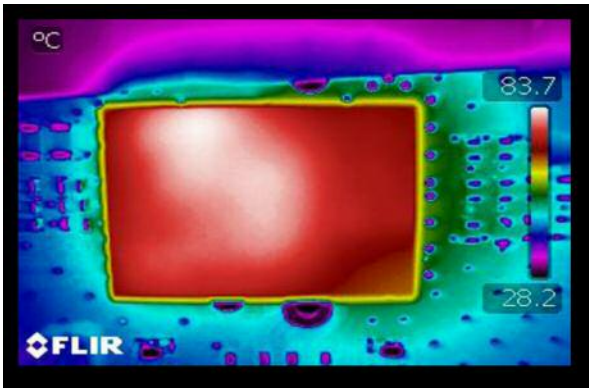


Figure 30 *— Thermal Image (V_{IN} = 28 V, I_{OUT} = 4.2 A, CR, 0 LFM Evaluation PCB)*

PI3111-00-HVMZ Electrical Characteristics

Unless otherwise specified: 16 V < V_{IN} < 50 V, 0 A < I_{OUT} < 3.3 A, -55°C < T_{CASE} < 100°C[(1)]

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Specifications						
Input Voltage Range	V_{IN}		16	28	50	Vdc
Input dv/dt (1)	V_{INDVDT}	V_{IN} = 50 V			1.0	V/µs
Input Under-Voltage Turn-on	V_{UVON}	I_O = 3.3 A	14.5	15.4	16	Vdc
Input Under-Voltage Turn-off	V_{UVOFF}	I_O = 3.3 A	13.5	14.3	15.2	Vdc
Input Under-Voltage Hysteresis	V_{UVH}	I_O = 3.3 A		1.1		Vdc
Input Over-Voltage Turn-on	V_{OVON}	I_O = 3.3 A	50	52.4	54	Vdc
Input Over-Voltage Turn-off	V_{OVOFF}	I_O = 3.3 A	51	53.5	55	Vdc
Input Over-Voltage Hysteresis	V_{OVH}	I_O = 3.3 A		1.1		Vdc
Input Quiescent Current	I_Q	V_{IN} = 28 V, ENABLE = 0 V		2		mAdc
Input Idling Power	P_{IDLE}	V_{IN} = 28 V, I_{OUT} = 0 A		4.1		W
Input Standby Power	P_{SBY}	V_{IN} = 28 V, ENABLE = 0 V		0.056		W
Input Current Full Load	I_{IN}	T_{CASE} = 100°C I_{OUT} = 3.3 A η_{FL} = 87.5% typical V_{IN} = 28 V		2.039		Adc
Input Reflected Ripple Current	I_{INRR}	L_{IN} = 0.47 µH C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic		13		mApp
Recommended Ext Input Capacitance	C_{IN}	C_{IN} = 100 µF 63 V electrolytic + 2 x 4.7 µF 50 V X7R ceramic C_{IN} = Cbulk + Chf		109.4		µF
Output Specifications						
Output Voltage Set Point	V_{OUT}	I_{OUT} = 1.65 A		15.0		Vdc
Total Output Accuracy	V_{OA}	-0°C < T_{CASE} < 100°C	-3		+3	%
		-55°C < T_{CASE} < 0°C	-5		+3	%
Output Voltage Trim Range	V_{OADJ}		-20%		10%	%
Output Current Range	I_{OUT}				3.3	Adc
Over Current Protection	I_{OCP}		3.8	5.6	9.6	Adc
Efficiency – Full Load	η_{FL}	T_{CASE} = 100°C, V_{IN} = 28 V	85.5	87.5		%
Efficiency – Half Load	η_{HL}	T_{CASE} = 100°C, V_{IN} = 28 V	82.3	84.3		%
Output OVP Set Point	V_{OVP}		17.6	18.2	18.8	Vdc
Output Ripple Voltage	V_{ORPP}	C_{OUT} = 6 x 2.2 µF 16 V X7R DC-20 MHz		275		mVpp
Switching Frequency	f_{SW}			900		kHz
Output Turn-on Delay Time	t_{ONDLY}	V_{IN} = V_{UVON} to ENABLE = 5 V; V_{IN} rise time < 1 ms		80		ms
Output Turn-off Delay Time	t_{OFFDLY}	V_{IN} = V_{UVOFF} to ENABLE < 2.35 V		375		µs
Soft-Start Ramp Time	t_{SS}	ENABLE = 5 V to 90% V_{OUT} C_{REF} = 0		230		µs
Maximum Load Capacitance	C_{OUT}	C_{REF} = 0.22µF, C_{OUT} = Al Electrolytic			1000	µF
Load Transient Deviation	V_{ODV}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x 2.2 µF 16 V X7R		375		mV
Load Transient Recovery Time	t_{OVR}	I_{OUT} = 50% step 0.1 A/µS C_{OUT} = 6 x 2.2 µF 16 V X7R V_{OUT} - 1%		100		µs
Maximum Output Power	P_{OUT}			50		W

	Absolute Maximum Output Ratings
Name	**Rating**
+OUT to -OUT	-0.5 to 20 Vdc
Continuous Output Current	3.3 Adc
Peak Output Current	9.6 Adc

[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.

[2] Current flow sourced by a pin has a negative sign.

PI3111-00-HVMZ Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
ENABLE						
DC Voltage Reference Output	V_{ERO}		4.65	4.9	5.15	Vdc
Output Current Limit(2)	I_{ECL}	ENABLE = 3.3 V	-3.3	-2.6	-1.9	mAdc
Start Up Current Limit(2)	I_{ESL}	ENABLE = 1 V	-120	-90	-60	µA
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		µs
Disable Delay Time	t_{ED}			10		µs
Maximum Capacitance	C_{EC}				1500	pF
Maximum External Toggle Rate	f_{EXT}				1	Hz
TRIM/SS						
Trim Voltage Reference	V_{REF}			1.230		Vdc
Internal Capacitance	C_{REFI}			10		nF
External Capacitance	C_{REF}				0.22	µF
Internal Resistance	R_{REFI}			10		kohms
TM (Temperature Monitor)						
Temperature Coefficient[1]	TM_{TC}			10		mV/°K
Temperature Full Range Accuracy[1]	TM_{ACC}		-5		5	°K
Drive Capability	I_{TM}		-100			µA
TM Output Setting	V_{TM}	Ambient Temperature = 300°K		3.00		V
Thermal Specification						
Junction Temperature Shutdown[1]	T_{MAX}		130	135	140	°C
Junction-to-Case Thermal Impedance	$R\Theta_{J-C}$			3		°C/W
Case-to-Ambient Thermal Impedance	$R\Theta_{C-A}$	Mounted on 9 in^2 1oz. Cu 6 layer PCB 25°C		9.39		°C/W
Regulatory Specification						
IEC 60950-1:2005 (2nd 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}	Fast acting LITTLEFUSE Nano^2 Series Fuse	4		10	A

[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.

[2] Current flow sourced by a pin has a negative sign.

PI3111-00-HVMZ Electrical Characteristics

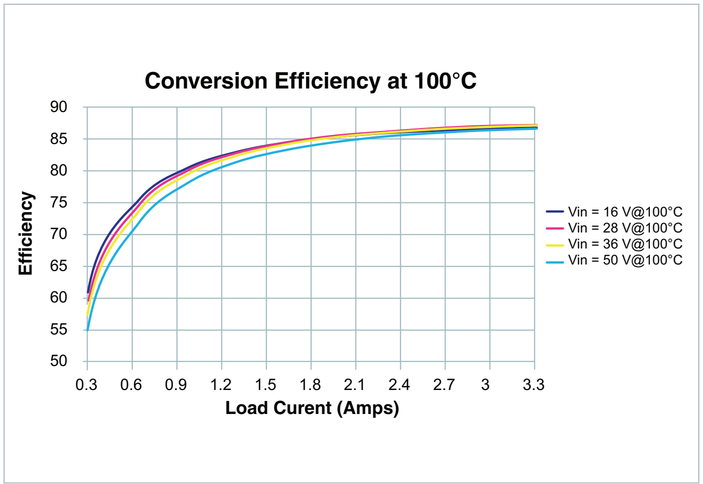


Figure 31 *— Conversion Efficiency*

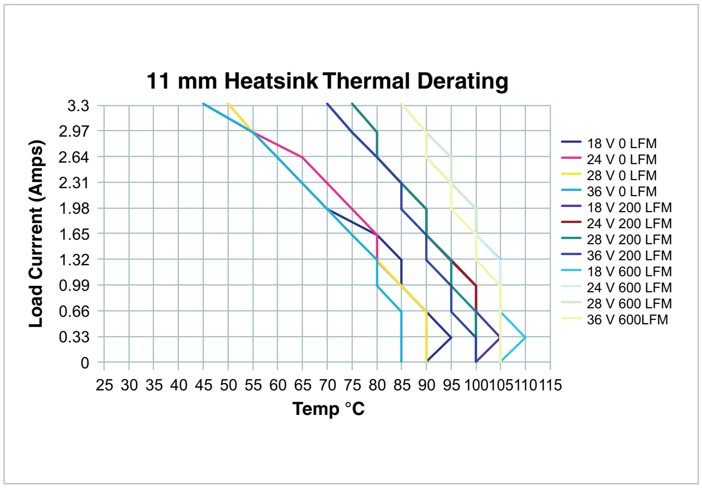


Figure 34 *— Load Current vs Temperature (11mm Heat Sink)*

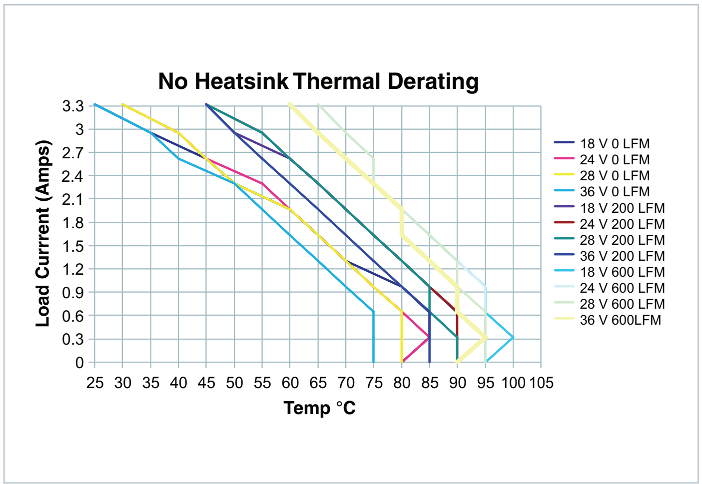


Figure 32 *— Load Current vs Temperature (without Heat Sink)*

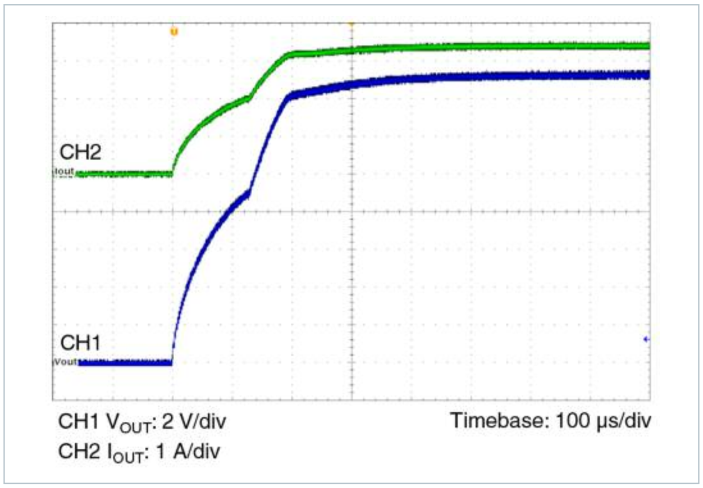


Figure 35 *— Start Up,* $C_{REF} = 0$
($V_{IN} = 16$ *V,* $I_{OUT} = 3.3$ *A, CR,* $C_{OUT} = 6 \times 2.2$ *µF X7R Ceramic)*

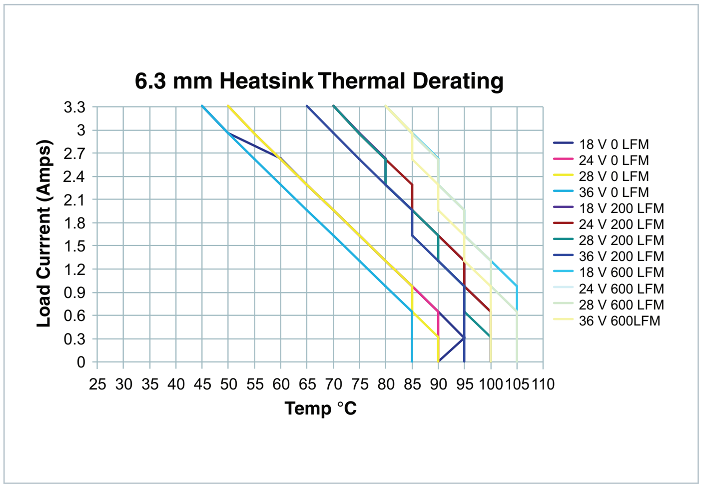


Figure 33 *— Load Current vs Temperature (6.33mm Heat Sink)*

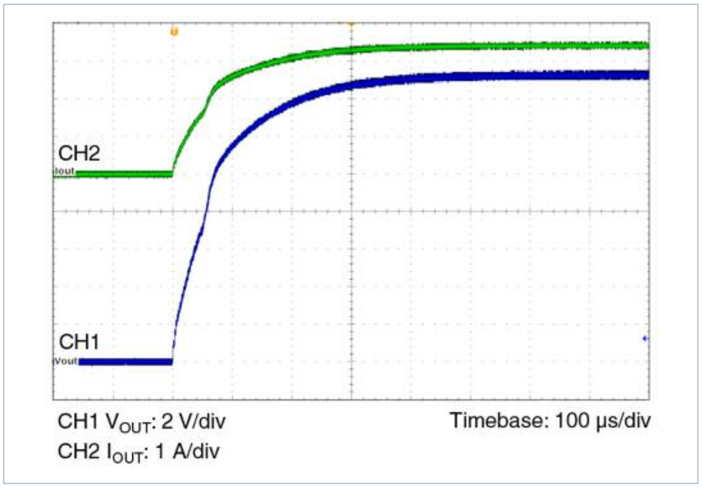


Figure 36 *— Start Up,* $C_{REF} = 0$
($V_{IN} = 28$ *V,* $I_{OUT} = 3.3$ *A, CR,* $C_{OUT} = 6 \times 2.2$ *µF X7R Ceramic)*

PI3111-00-HVMZ Electrical Characteristics

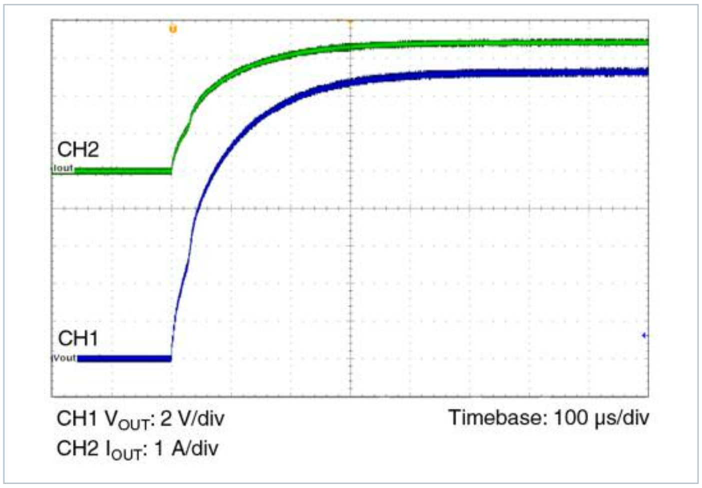


Figure 37 *— Start Up, C_{REF} = 0 (V_{IN} = 50 V, I_{OUT} = 3.3 A, CR, C_{OUT} = 6 x 2.2 µF X7R Ceramic)*

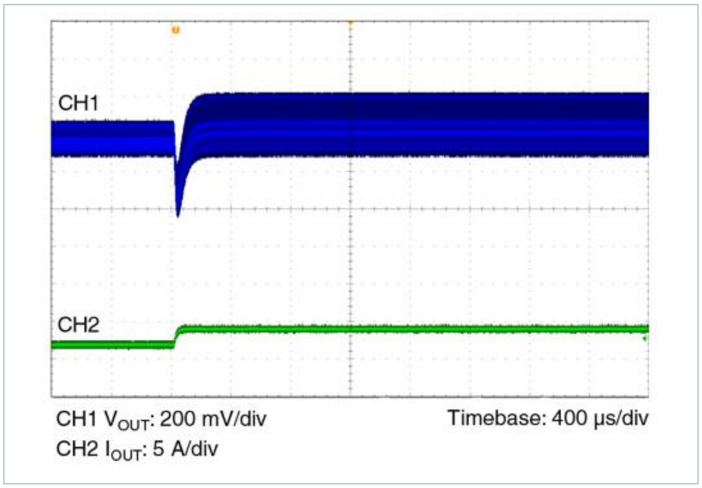


Figure 38 *— Transient Response (V_{IN} = 28 V, I_{OUT} = 1.65 - 3.3 A,* 0.1 A/µs, *C_{OUT} = 6 X 2.2 µF X7R Ceramic)*

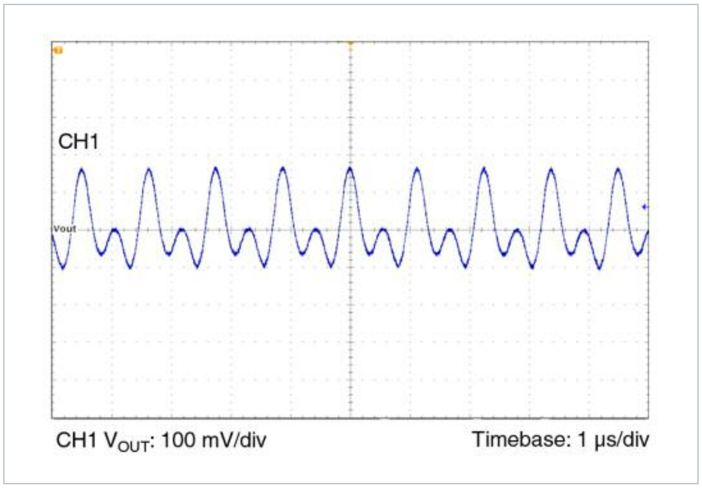


Figure 39 *— Output Ripple (V_{IN} = 28 V, I_{OUT} = 3.3 A, C_{OUT} = 6 X 2.2 µF X7R Ceramic)*

Figure 40 *— Thermal Image (V_{IN} = 28 V, I_{OUT} = 3.33 A, CR, 0 LFM Evaluation PCB)*

Functional Description

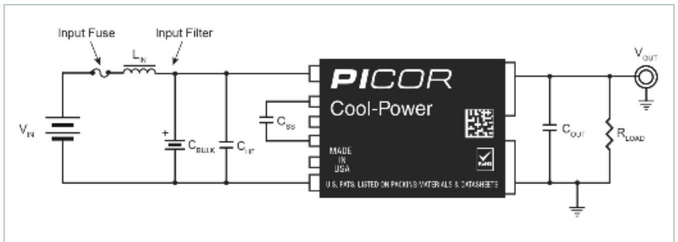


***Figure 41** — Picor PI31xx-00-HVMZ Shown With System Fuse, Filter, Decoupling And Extended Soft Start*

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

The input power pins on the PI31xx-00-HVMZ are connected to the input power source which can range from 16 V to 50 V DC. Under surge conditions, the PI31xx-00-HVMZ can withstand up to 55 V DC for 12.5 ms without incurring damage. The user should take care to avoid driving the input rails above the specified ratings. Since the PI31xx-00-HVMZ 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 53.5 V) 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 PI31xx-00-HVMZ 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® solutions that can be used in reverse polarity applications. Information is available at vicorpower.com.

The PI31xx-00-HVMZ 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 output value about 80ms after the input UV lockout releases. This will occur automatically even if the ENABLE pin is floating.

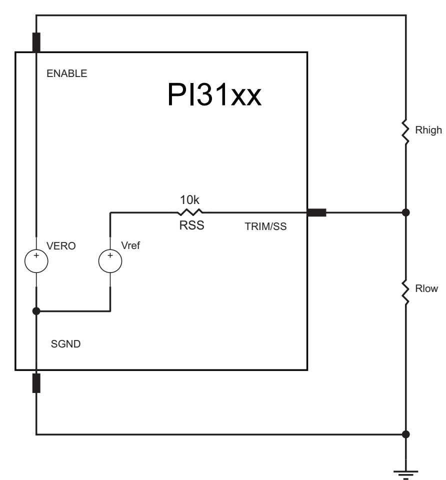
To help keep the source impedance low, the input to the PI31xx-00-HVMZ should be bypassed with (2) 4.7uF 50 V ceramic capacitors of X7R dielectric in parallel with a low Q 100uF 63 V electrolytic capacitor. To reduce EMI and reflected ripple current, a series inductor of 0.2 to 0.47 uH can be added. The input traces to the module should be low impedance configured in such a manner as to keep stray inductance minimized.

ENABLE

The ENABLE pin serves as a multi-function pin for the PI31xx-00-HVMZ. During normal operation, it outputs the on-board 4.9 V 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 an external isolated bias supply or from the primary side through a small signal transistor, FET, or any device that sinks 3.3 mA, minimum. If the ENABLE pin is lower than 2.35 V 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 1500 pF.

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. Referring to the figures below, the appropriate trim up or trim down resistor can be calculated using the equivalent circuit diagram and the equations. When trimming up, the trim down resistor is not populated. When trimming down, the trim up resistor is not populated. The soft start time is adjustable within the limits defined by the data tables and has a default value of 500us to reach steady state. The internal soft start capacitor value is 10nF.



$$R_{low} = (-V_{desired}) \cdot \frac{R_{INT}}{(-Vout_{nom}) + V_{desired}}$$

$$R_{high} = (-RSS) \cdot \frac{(-Vout_{nom}) \cdot V_{ERO} + V_{desired} \cdot V_{ref}}{V_{ref}\left[(-Vout_{nom}) + V_{desired}\right]}$$

***Figure 42** — Trim Equations And Equivalent Circuit*

$$C_{REF} = \frac{T_{ssdesired} - 230 \cdot 10^{-6}}{23000}$$

TM
The TM pin serves as an output indicator of the internal package temperature which is within +/- 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 PI31xx-00-HVMZ 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
The PI31xx-00-HVMZ 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 maximum output current from the PI31xx-00-HVMZ 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 PI31xx-00-HVMZ 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 PI31xx-00-HVMZ 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 vicorpower.com for a remote sense application circuit which can be used.

Package Outline & Recommended PCB Land Pattern

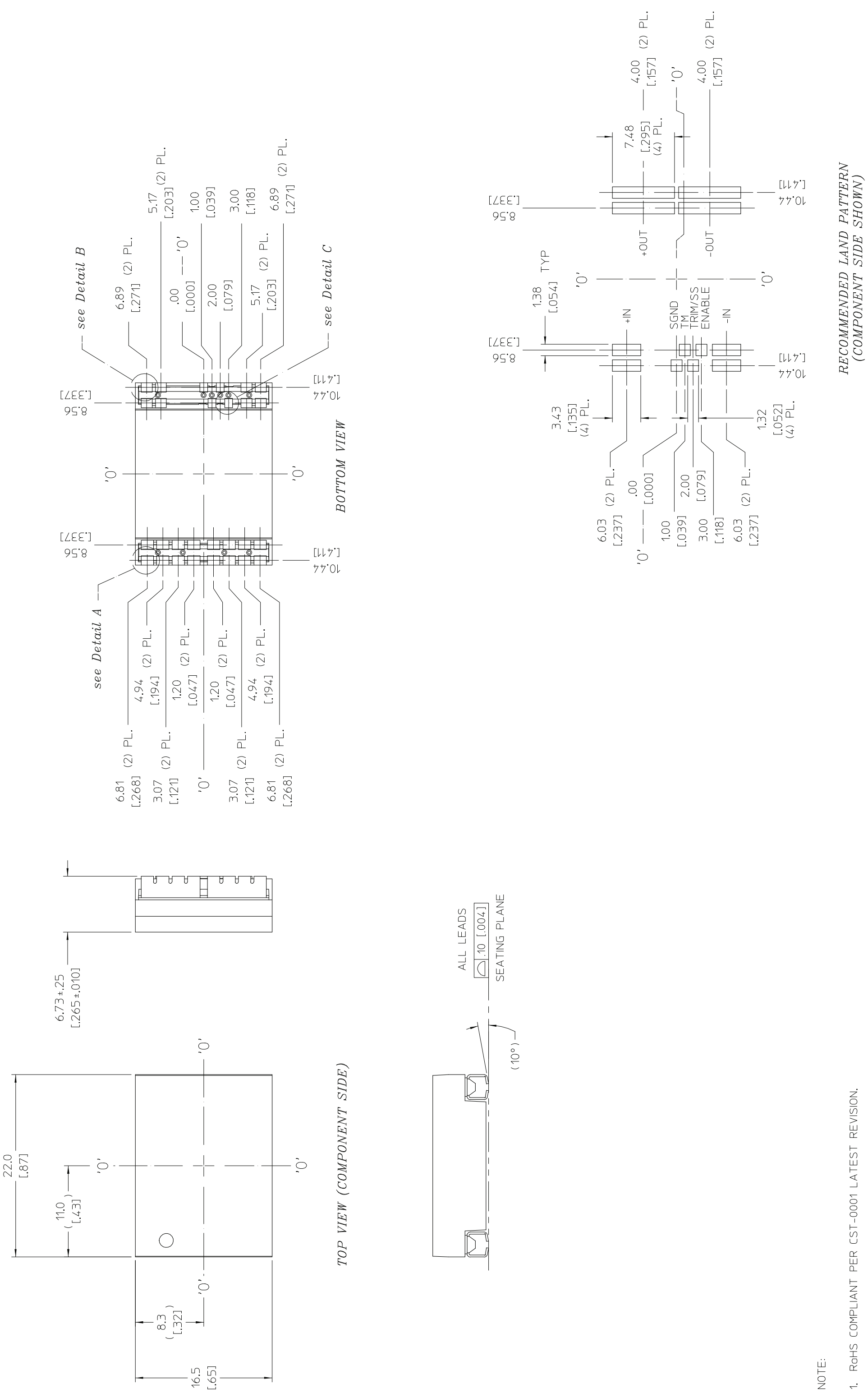


Figure 33 — Package Outline & Recommended PCB Land Pattern

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