ARTESYN AIH03ZPFC SERIES

1100 W Half Brick PFC Converter

PRODUCT DESCRIPTION

Advanced Energy's Artesyn AIH03ZPFC series half-brick power factor correction module accepts a wide 90 to 264 VAC input and presents a unity power factor. Rated at 1100 W, the module has a high conversion efficiency of 97.3% minimum at 230 VAC and provides a nominal non-isolated output voltage of 390 VDC. Featuring an industry-standard 2.3" (L) x 2.4" (W) in half-brick form factor and a height of only 0.52", they have a power density of 383 W/in^3.

AT A GLANCE

Total Power

1100 W

Input Voltage

90 to 264 VAC

127 to 373 VDC

# of Outputs

Single

RoHS

SPECIAL FEATURES

- 1100 W continuous power high-line
- Ultra high efficiency: 97.3%
- 90 to 264 Vac input range
- Baseplate optimized for contact cooling or heatsink mounting
- Startup at -40^{O}C, operation at -25^{O}C
- Pre-bias startup capability
- High reliability
- RoHS 6 compliant
- PMBus^{TM} communication
- Non-isolated PFC
- Feature rich control functions
- Standard half brick outline
- Internal inrush limit control
- Two-year warranty (consult factory for extended terms)

SAFETY

- CSA C22.2 No.62368-1
- CE EN62368-1
- UL 62368-1

TYPICAL APPLICATIONS

- Industrial
- Medical

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SECTION 1 MODEL NUMBERS

Standard	Input Voltage	Output Voltage	Minimum Load	Maximum Load	Efficiency
AIH03ZPFC-01L	90 to 264VAC	390VDC	0A	2.82A	97.3%

Order Information

AIH	03	ZPFC	-	01	-	-	L
①	②	③		④	⑤	⑥	⑦

①	Model series	Half brick size unit, AIH, half brick.
②	Output current	03: 2.82A rated output current
③	Output voltage	ZPFC: Power factor correction module, the output is 390Vdc
④	Model variant	01: The variant that can be stand-alone
⑤	Remote on/off logic	Blank is default and Positive enable. N: Negative enable
⑥	Structure	Blank is default with M3 thread. NT: Non-threaded-inserts for mounting
⑦	RoHS status	L: RoHS R6

Options

None

SECTION 2 ELECTRICAL SPECIFICATIONS

2.1 Absolute Maximum Ratings

Stress in excess of those listed in the "Absolute Maximum Ratings" may cause permanent damage to the power supply. These are stress ratings only and functional operation of the unit is not implied at these or any other conditions above those given in the operational sections of this TRN. Exposure to any absolute maximum rated condition for extended periods may adversely affect the power supply's reliability.

Table 1. Absolute Maximum Ratings

Parameter		Model	Symbol	Min	Typ	Max	Unit
Input Voltage - AC	Operating-Continuous Surge Voltage (100ms)	All modules	$V_{IN,AC}$	85[1] -	- -	264 300	Vac Vac
Input Voltage - DC	Operating-Continuous Surge Voltage (100ms)	All modules	$V_{IN,DC}$	120[2] -	- -	373 420	Vdc Vdc
Input Frequency		All modules		47	50/60	63	Hz
Maximum Output Power		All modules	$P_{O,max}$	-	-	1100	W
Operating Ambient Temperature		All modules	T_A	-40[3]	-	85	°C
Operating Baseplate Temperature		All modules	$T_{\_BP}$	-40[3]	-	100	°C
Startup Case Temperature		All modules	$T_{\_BP}$	-40	-	100	°C
Storage Temperature		All modules	T_{STG}	-40	-	105	°C
Humidity (non-condensing)	Operating Storage	All modules All modules		5 5	- -	90 95	% %
Altitude	Operating Storage	All modules All modules		- -	- -	5,000 12,192	m m
MTBF Telcordia Issue 4, Method 1 Case1		All modules		1.0	-	-	M Hours
Audible Noise[4]		$V_{IN,AC}$ = 85 to 264Vac		-	-	30	dBA

Note 1 - PSU can extend the operation down to 85Vac after it's turned on at nominal input voltage range and output power shall be de-rated from 1100W max to TBD W max when operating at 85Vac (or less than 90Vac).
Note 2 - PSU can extend the operation down to 120Vdc after it's turned on at nominal input voltage range and output power shall be de-rated from 1100W max to TBD W max when operating at 120Vdc (or less than 127Vdc).
Note 3 - Startup at -40°C, and operation at -25°C.
Note 4 - Measured 1 meter high and 1 meter away from the power supply.

SECTION 2 ELECTRICAL SPECIFICATIONS

2.2 Input Specifications

Table 2. Input Specifications

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, AC	All	$V_{IN,AC}$	90[1]	100 - 240	264	Vac
Operating Input Voltage, DC	All	$V_{IN,DC}$	127[2]	-	373	Vdc
Operating Input Surge, AC	100 ms minimum	$V_{IN,AC}$	-	-	300	Vac
Operating Input Surge, DC	100 ms minimum	$V_{IN,DC}$	-	-	420	Vdc
Maximum Input Current ($I_O = I_{O,max}$)	V_{IN} = 100Vac/127Vdc V_{IN} = 200Vac/254Vdc	$I_{IN,max}$	- -	- -	13 6.5	A
AC Input Leakage Current[3]	$V_{IN,AC}$ = 240Vac f_{IN} = 60Hz		-	-	1.0	mA
AC Line Inrush Current	$V_{IN,AC}$ = 240Vac		-	22	-	A
No Load Input Current (V_O Enable I_O = 0A)	All	I_{IN,no_load}	-	TBD	-	A
No Load Input Power (V_O Enable I_O = 0A)	All	P_{IN,no_load}	-	TBD	-	W
Harmonic Line Currents	All	THD	IEC 61000-3-2 Class A at full load condition			
Power Factor	$I_O > 20\% I_{O,max}$	PF	0.95	-	-	
Startup Surge Current (Inrush)[3]	V_{IN} = 240Vac/340Vdc	$I_{IN,surge}$	-	-	22	A
Input AC Low Line Start-up Voltage	$I_O = I_{O,max}$	$V_{IN,AC}$	80	83	86	Vac
Input AC Undervoltage Lockout Voltage	$I_O = I_{O,max}$	$V_{IN,AC}$	73	76	79	Vac
Input DC Low Line Start-up Voltage	$I_O = I_{O,max}$	$V_{IN,DC}$	113	117.4	112	Vdc
Input DC Undervoltage Lockout Voltage	$I_O = I_{O,max}$	$V_{IN,DC}$	103	107.5	112	Vdc
Efficiency	Vo = 390Vdc, T_A = 25°C $V_{IN,AC}$ = 115Vac, 60Hz $V_{IN,AC}$ = 230Vac, 50Hz	η	96.0 97.3	- -	- -	% %
PF ENABLE	Module enabled Module disabled	V_{PF_H} V_{PF_L}	2.2 0	- -	- 0.8	V V

Note 1 - PSU can extend the operation down to 85Vac after it's turned on at Nominal Input voltage range and output power shall be de-rated from 1100 W max to TBD W max when operating at 85Vac (or less than 90Vac)

Note 2 - PSU can extend the operation down to 120Vdc after it's turned on at Nominal Input voltage range and Output power shall be de-rated from 1100 W max to TBD W max when operating at 120Vdc (or less than 127Vdc).

Note 3 - Tested with Advanced Energy recommended external EMI filter.

SECTION 2 ELECTRICAL SPECIFICATIONS

2.3 Output Specifications

Table 3. Output Specifications

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Factory Set Voltage	Full load	V_O V_{AUX}	380 10.4	390 11.6	398 12.7	Vdc Vdc
Maximum Output Power	90 to 264Vac	$P_{O,max}$	-	-	1100	W
Rated Output Current	All	I_O I_{AUX}	0 0	- -	2.82 20	A mA
V_O Load Capacitance	All	C_O[1] C_{AUX}	560 1	-	1000 100	µF µF
Total Regulation (tested with 1000µF/560µF cap)	Inclusive of set-point, line, load temperature change, warm-up drift	$\pm\%V_O$ $\pm\%V_{AUX}$	- -	- -	2 10	% %
Output Voltage Adjust Range	All	V_O	350	-	420	Vdc
Output Voltage Ripple, pk-pk	20MHz bandwidth	V_O[2] V_{AUX}[3]	-	-	30 200	V_{PK-PK} mV_{PK-PK}
Output Current, peak	All	$I_{O,peak}$	0	-	6	A
Dynamic Response[4] Peak Deviation Settling Time	25% load change Slew rate: 1A/us	$\pm\%V_O$ $T_{Settling}$	- -	12.5 -	- 1	% ms
Over Voltage Protection	All	V_O V_{AUX}	- -	440 NA[5]	- -	Vdc
Over Temperature Protection	All	T	103	108	113	°C
Over Current Protection		I_O $\%I_{AUX,max}$	3.2 105	- -	3.8 150	A %
Overshoot		$\%V_{O,nom}$ $\%V_{AUX}$	-	1	12.5[6] 10	% %

Note 1 - Recommended low ESR high ripple current electrolytic capacitors at 475VDC rated with capacitance range from 560 µF to 1000 µF plus MLCC 630V X7R 220nF x 3pcs for applications up to 1100W full load. The control loop is stable under the recommended capacitor range. If hold up period is not critical to the design, 560 µF is sufficient to have a hold up period up to 12ms at 390Vdc, 1100W output.
Note 2 - Measure with a 560 µF/1000 µF bulk capacitor plus 3 x MLCC 630V X7R 220nF cap, nominal 115Vac/230Vac input and full load.
Note 3 - Measured at 0.1 µF of ceramic and 10 µF of tantalum capacitance, with 1 µF of Load Capacitance
Note 4 - Tested with Advanced Energy recommended external output capacitors. The power supply must operate within specified limits over the capacitive load range at 50 to 5kHz. Minimum Load: 0% of maximum Load. Step Load Size: 25% of maximum Load.
Note 5 - No OVP designed for PV_Aux output. Only internal 12V bias is designed to have hardware over voltage protection in bouncing mode when > 13.2V.
Note 6 - Tested with 475V 560 µF cap.

SECTION 2 ELECTRICAL SPECIFICATIONS

2.4 System Timing Specifications

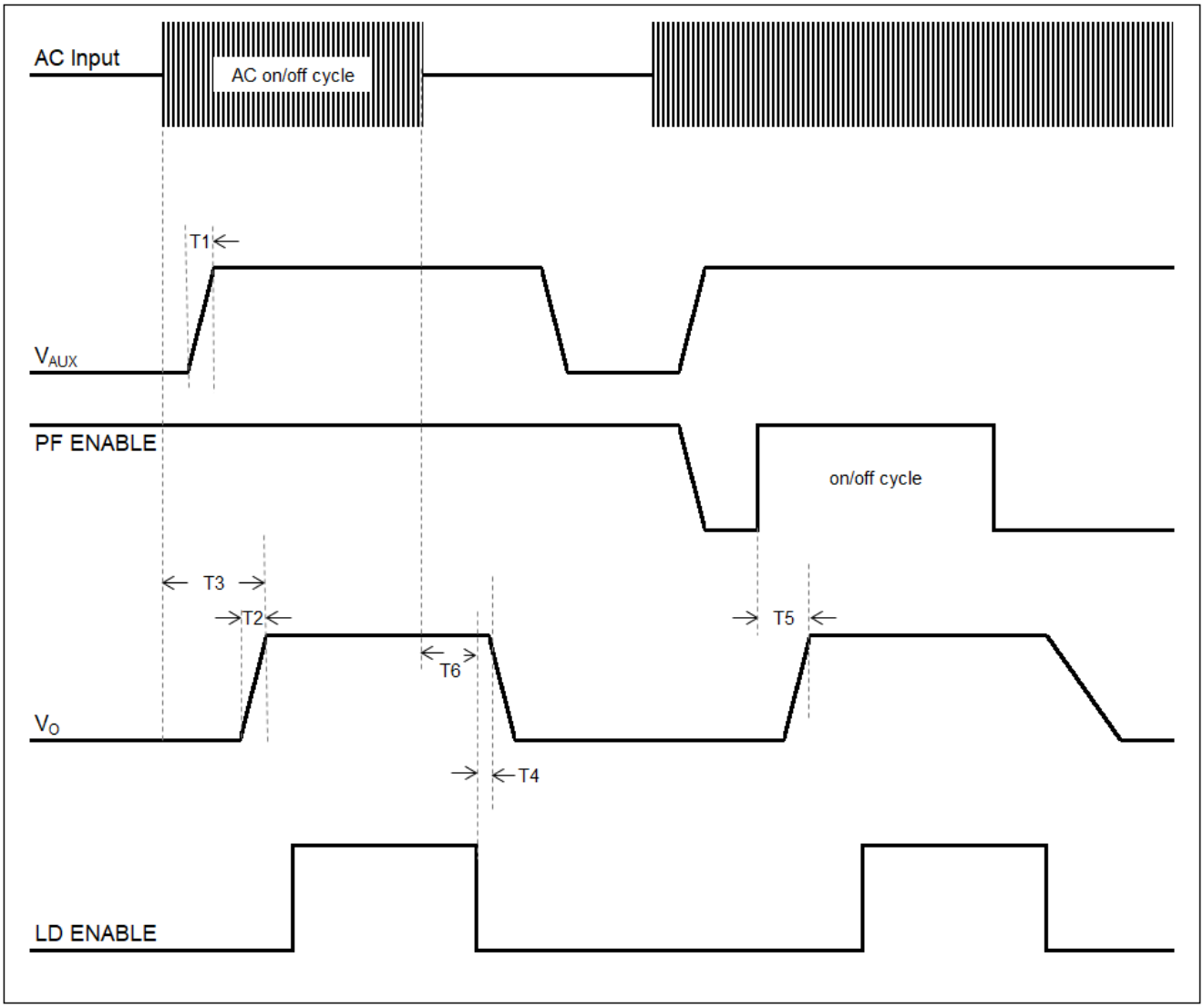
Table 4. System Timing Specifications

Label	Parameter	Min	Typ	Max	Unit
T1	Aux 12V output voltage rise time from 10% to 90% of the voltage level.	-	-	50	ms
T2	Main output voltage (boost region only) rise time from 10% to 90% of the voltage level.	-	-	1500	ms
T3	Delay from AC being applied to all outputs being within regulation.	-	-	2000	ms
T4	Delay from LD Enable de-assertion to main output voltage dropping out of regulation limits (bulk capacitor dependent)	1	-	-	ms
T5	Delay from PF_Enable_ON active to output voltages within regulation limits.	-	-	1000[1]	ms
T6	Output Ride through Time – measured from input loss to LD Enable (tested with external 475V 1000 µF bulk cap)	20	-	-	ms

Note 1 - Tested with 475V 1000 µF cap. Measured from PF_ENABLE to output voltage rise up to 390Vdc.

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 System Timing Diagram



SECTION 2 ELECTRICAL SPECIFICATIONS

2.6 AIH03ZPFC-01L Performance Curves

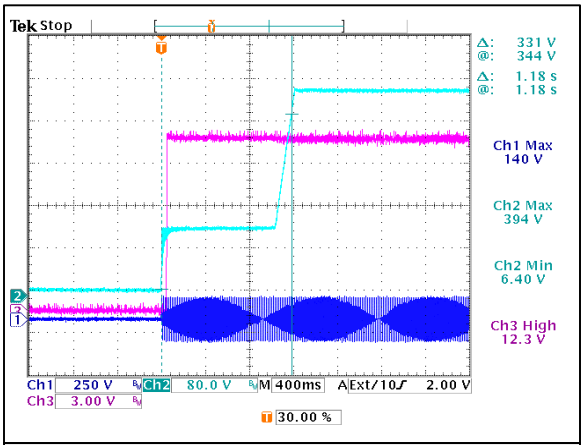


Figure 1: AIH03ZPFC-01L Turn-on Delay via AC mains
Vin = 90Vac Load: Io = 0A Co = 560µF
Ch 1: Vin Ch 2: Vo Ch 3: Vaux

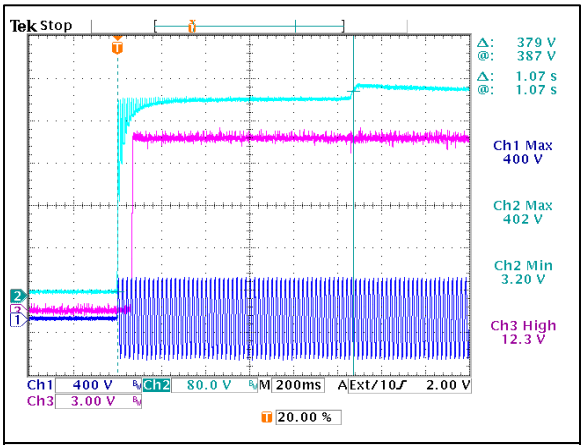


Figure 2: AIH03ZPFC-01L Turn-on Delay via AC mains
Vin = 264Vac Load: Io = 0A Co = 560µF
Ch 1: Vin Ch 2: Vo Ch 3: Vaux

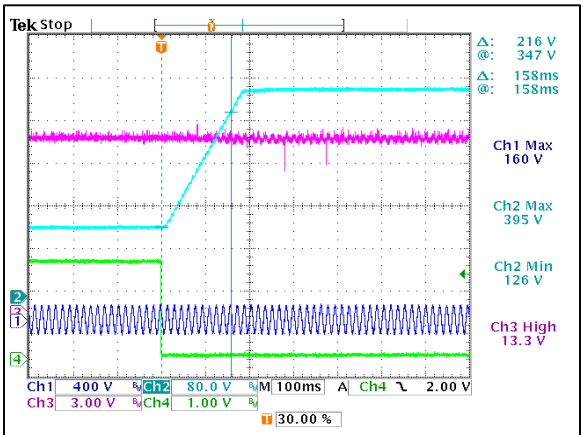


Figure 3: AIH03ZPFC-01L Turn-on delay via PF ENABLE
Vin = 90Vac Load: Io = 0A Co = 560µF
Ch 1: Vin Ch 2: Vo Ch 3: Vaux Ch 4: PF_ENABLE

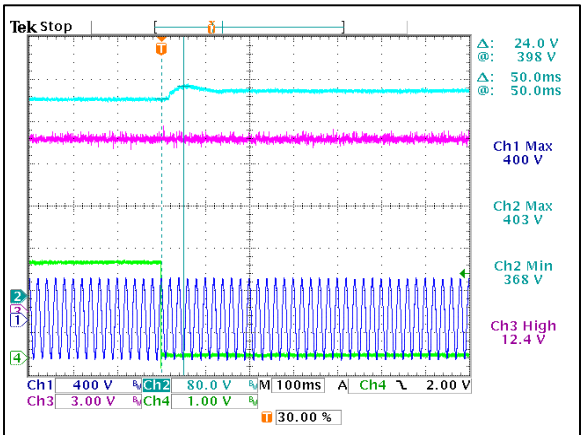


Figure 4: AIH03ZPFC-01L Turn-on delay via PF ENABLE
Vin = 264Vac Load: Io = 0A Co = 560µF
Ch 1: Vin Ch 2: Vo Ch 3: Vaux Ch 4: PF_ENABLE

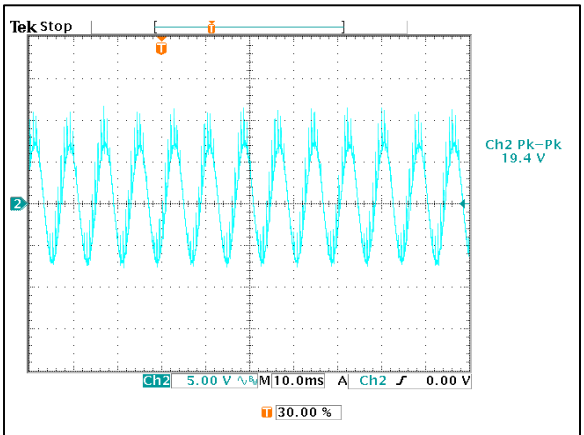


Figure 5: AIH03ZPFC-01L Ripple and Noise Measurement
Vin = 90Vac Load: Io = 2.8A Co = 560µF
Ch 2: Vo

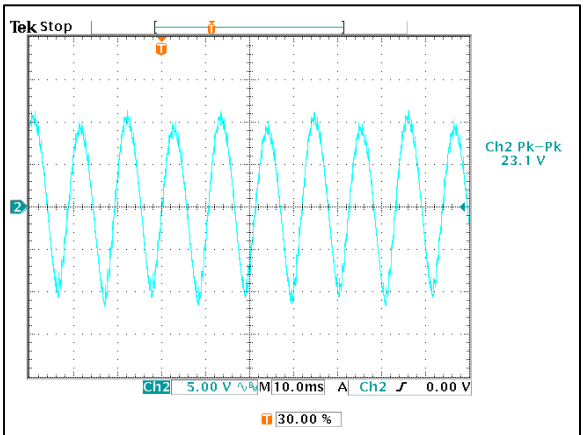


Figure 6: AIH03ZPFC-01L Ripple and Noise Measurement
Vin = 264Vac Load: Io = 2.8A Co = 560µF
Ch 2: Vo

SECTION 2 ELECTRICAL SPECIFICATIONS

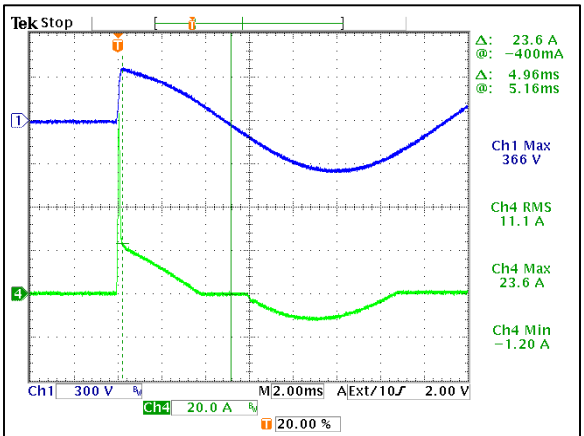


Figure 7: AIH03ZPFC-01L Input Inrush Current
Vin = 240Vac Load: Io = 2.8A Co = 560µF
Ch 1: Vin Ch 4: Iin

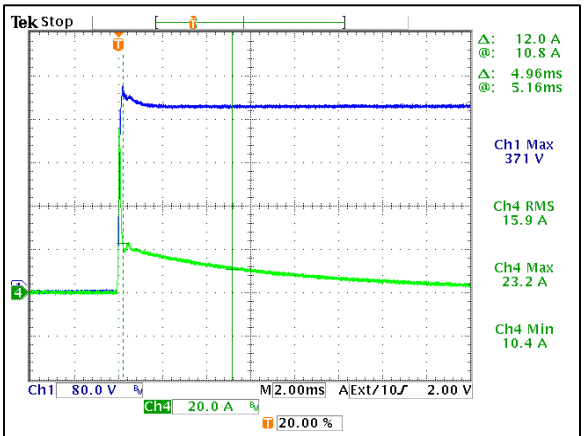


Figure 8: AIH03ZPFC-01L Input Inrush Current
Vin = 340Vdc Load: Io = 2.8A Co = 560µF
Ch 1: Vin Ch 4: Iin

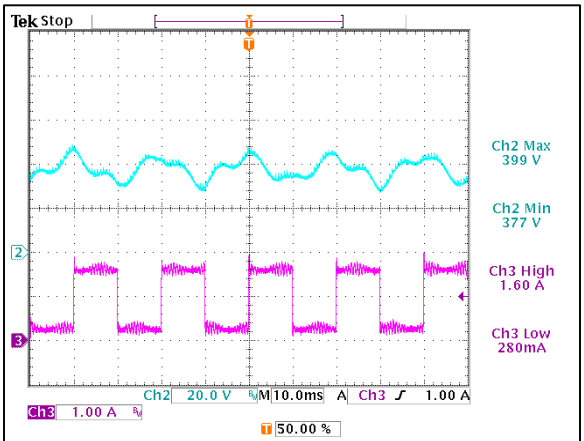


Figure 9: AIH03ZPFC-01L Transient Response - Vo Deviation
Vin = 90Vac, 10% to 60% load change, Slew rate: 1A/µs, Co = 560µF
Ch 2: Vo Ch 3: Io

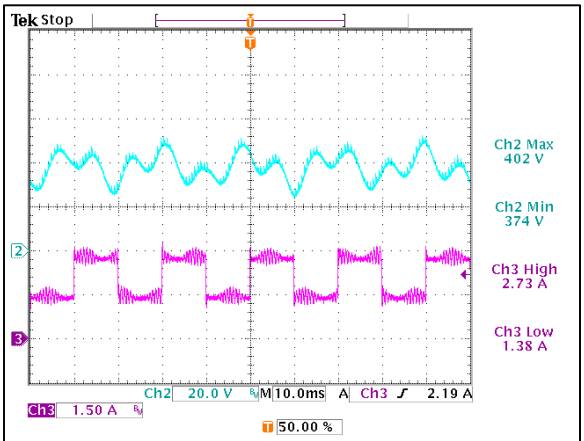


Figure 10: AIH03ZPFC-01L Transient Response - Vo Deviation
Vin = 90Vac, 50% to 100% load change, Slew rate: 1A/µs, Co = 560µF
Ch 2: Vo Ch 3: Io

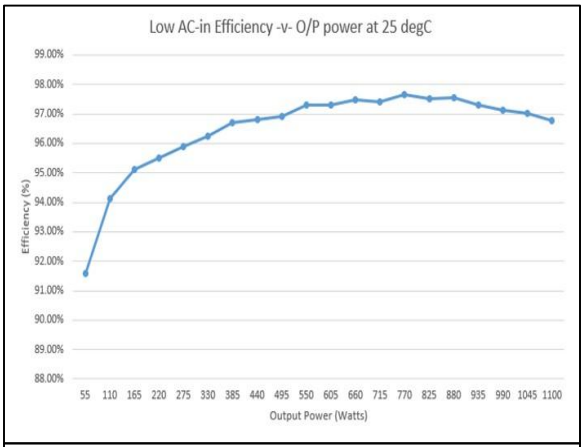


Figure 11: AIH03ZPFC Efficiency Curve @ 25°C
— 115Vac/60Hz
Loading: $P_{O,\,max}$= 1100W 5% increment to $P_{O,max}$

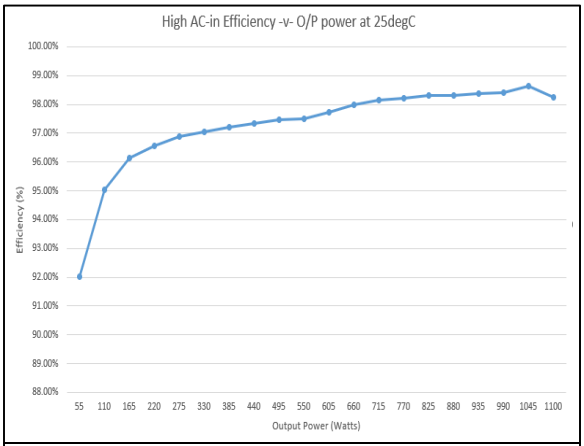


Figure 12: AIH03ZPFC Efficiency Curve @ 25°C
— 230Vac/50Hz
Loading: $P_{O,max}$ = 1100W 5% increment to $P_{O,max}$

SECTION 2 ELECTRICAL SPECIFICATIONS

2.7 Protection Function Specifications

Input Fuse

The AIH03ZPFC series modules do not have an in-line fuse fitted internally. In order to comply with safety regulations, it is recommended that a fuse of 250Vac 20A maximum fast blow type is connected at the front end EMI filter.

Hardware Over Voltage Protection (OVP)

The over voltage point is 453Vdc (typical). The power supply will be latched off. The OVP can be reset by toggling the PF Enable pin or using PMBus clear fault command if and only if the bulk voltage is lower than 390Vdc (Typical).

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	446	453	460	Vdc

OVP Fault Status	
PFW	Asserted (Low)
LD Enable/BOK	Low when the bulk voltage drop to 292V (Typ) or after 1.5s (Typ) if the bulk voltage is not lower than 292V (Typ)
Inrush by pass circuit	Remains ON

Software Over Voltage Protection (OVP)

The software over voltage setpoint is below the hardware over voltage threshold, tentative at 440Vdc. PFC will be OFF at OVPand auto-recover when the output is less than Vadj set voltage plus 5Vdc. The OVP fault can be cleared if and only if the bulk voltage is lower than the software OVP recovery voltage (Vadj set voltage + 5Vdc). Auxiliary output shall not be affected.

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	-	440	-	Vdc

OVP Fault Status	
PFW	No Change
LD Enable	No Change
Inrush by Pass Circuit	Remains ON

Over Temperature Protection (OTP)

The power supply have a thermal sensor to monitor its internal temperature. If the module's internal temperature exceeds 108°C (typical), the module will shut down itself, and auto recovery once internal temperature is less than 75°C (typical).

OTP Fault Status	
PFW	Asserted (Low) and shut down in 5ms
LD Enable Signal	Asserted (Low) when the measured temperature exceeds 108°C and auto recover at 75°C
Inrush by-pass Circuit	Remains ON

SECTION 2 ELECTRICAL SPECIFICATIONS

Input Over Voltage Protection (Input OVP)

An input overvoltage protection circuit protects the module under over input voltage conditions. PFC modules will be off whenthe input exceeds 305Vac with 500ms validation time. The PFC will auto recovery when the input is lower than the 270Vac.

Input OVP Fault status	
PFW	Low
LD Enable Signal	Asserted (Low) after 1.5s if the input voltage is not lower than 270Vac
Inrush by-pass Circuit	Remains ON

Input Under Voltage Protection (Input UVP)

An input under voltage protection protects the PFC module from over stressed by operating at low input voltage conditions. Hysteresis is built into the PFC module to allow for high levels of variation on the input supply voltage without causing themodule to cycle on and off. PFC modules will operate when the input exceeds 83Vac (Typ) and turn off when input below 76Vac (Typ). For the AC cycling or missing cycle, the under voltage fault will be triggered if the brown out condition is longer than 500ms.

Input UVP Fault status	
PFW	Asserted (Low) at 340Vdc or low after 500ms if input undervoltage fault is detected.
LD Enable Signal	Asserted (Low) when the bulk voltage drops to 292V or after 1.5s if the output voltage is not lower than 292V
Inrush by Pass Circuit	Turn OFF at 290V bulk voltage

Note: Since the inrush by-pass circuit may have reset, inrush control restart and output soft start are necessary.

Output Under Voltage Protection

The output under voltage protection is triggered if the bulk voltage is lower than 292V. LD Enable will be asserted. The PFC module shall recover by following methods: 1. AC power recycling, 2. the fault clear by PMBUS command, 3. remote on/off. The auxiliary output always remains on.

Output UVP Fault status	
PFW	Asserted (Low) at 340Vdc
LD Enable Signal	Asserted (Low) when the bulk voltage drops to 292V or after 1.5s if the bulk voltage is not lower than 292V.
Inrush by Pass Circuit	Turn off at 290V bulk voltage

SECTION 2 ELECTRICAL SPECIFICATIONS

Over Current Protection (OCP)

The AIH03ZPFC has an output current monitor function to protect from over loading condition. Once the OCP is triggered, the module will be off and disable the load via LD enable signal. It is important that the loading of the module shall be controlled by LD enable. The latency between LD Enable signal and the load off response should be less than 10ms. The module is not capable to protect from excessive over current or short circuit as no isolating power switch to disconnect the current flow from the input to output. It is not supported to protect output short circuit or output loading over the rating in the absolute maximum ratings section. Exceeding the device ratings may cause unrecoverable permanent damage to module.

The output shall shut down and will retry to recover for 5 times then latch off if the fault is still present. The PFC module will recover by following methods: 1. AC power recycling, 2. the fault clear by PMBUS command, 3. Toggling PF_ENABLE. Auxiliary output always remains on.

Module	OCP Warning (Typ)	OCP (Typ)	OCP Validation Time (Typ)	Fault Mode
AIH03ZPFC	3.2A	3.5A	250ms	5 times retry then latched

OCP Fault Status	
PFW	Asserted (Low) when OCP activated
LD Enable signal	Asserted (Low) when the bulk voltage drops to 292V or after 1.5s if the bulk voltage is not lower than 292V.
Inrush by-pass Circuit	Remains ON

Output Over Power Protection (OPP)

The AIH03ZPFC has the function to adjust the output voltage in the range of 350V to 420V. Over current protection is not sufficient to protect the module from over stress. Output voltage and current are continuously monitored so that the output power is computed. Protection against output over the maximum set point is feasible. Once the OPP is triggered, the module will be OFF and disable the load via LD enable signal.

The PFC module will recover by following methods: 1. AC power recycling, 2. the fault clear by PMBUS command, 3. Toggling PF_ENABLE. Auxiliary output always remains on.

Module	OPP Warning	OPP	OPP Validation Time	Fault Mode
AIH03ZPFC (15% over power)	>1150W	>1250W	1s	Latched

OCP Fault Status	
PFW	Asserted (Low)
LD Enable signal	Asserted (Low) after OPP activated
Inrush by-pass Circuit	Remains ON

SECTION 2 ELECTRICAL SPECIFICATIONS

Auxiliary Output Over Current and Short Circuit Protections

The auxiliary output shares the same converter as the internal control power supply. The feedback regulation is on the internal 12V output for powering the circuit inside the module. Fault disturbance on this output will affect the normal operation of the main output if not protected. The auxiliary output is designed to have hardware protection from over current and short circuit faults. During over current or short circuit on the output terminal of this output, protection circuit will isolate the output from the terminal to avoid disturbance to the internal control power.

Internal 12V supply Under Voltage and Over Voltage Protections

The internal 12V supply is designed to be monitored by the MCU to provide programmable software under voltage protection from turning ON the PWM signal to gate drive of the power switches. If the output is lower than 8V, PWM will stop and will resume normal at 9V. The protection is in auto-recovery mode and auxiliary output will keep ON during this internal protection but may be at voltage out of regulation.

Output Sequencing

The Auxiliary +12V will be available shortly after the application of AC input around 70Vrms. The main output shall be available when PF_Enable is asserted if all the turn ON conditions are satisfied.

Loop Stability

The feedback loop shall be unconditionally stable under the following conditions:

any line and load conditions including no load

operating temperature range before over temperature protection

in the range of recommended output load capacitance

Minimum Phase Margin under normal operating conditions shall be at least 45o at zero gain crossover frequency and at least -6dB of gain margin above 0-phase crossover frequency under load from 5% to 100%.

The test setup is based on the recommended external capacitance load range in standalone operation.

Grounding

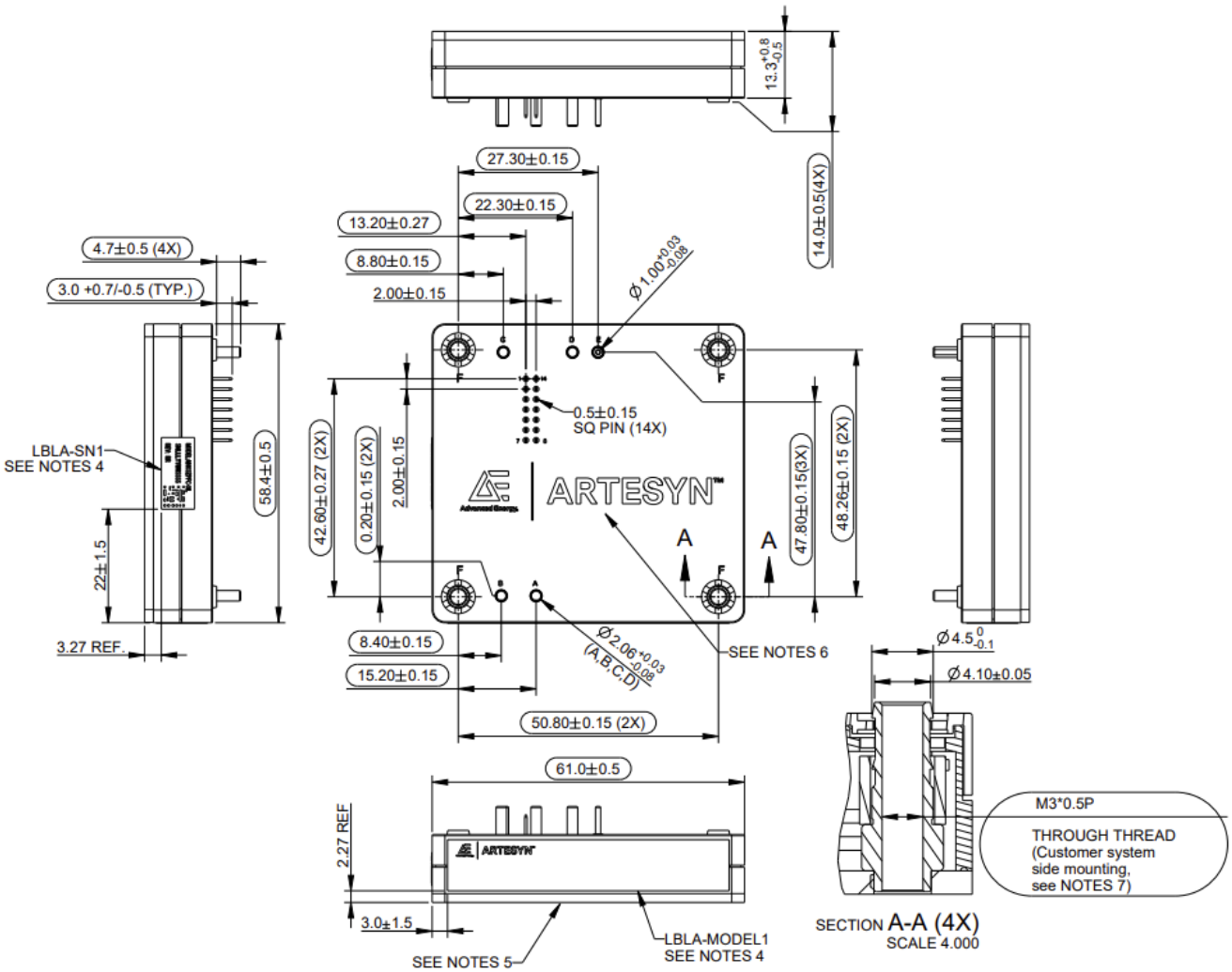
The signal ground (S GND) and Vout- (the Main Output Return) are tied together internally. All external control signals are referred to the S GND.

Power and Cooling

The module will have conduction-cooling by mounting a heatsink on the baseplate of the module. The baseplate at the center location shall be controlled less than 100^{O}C for any operating conditions.

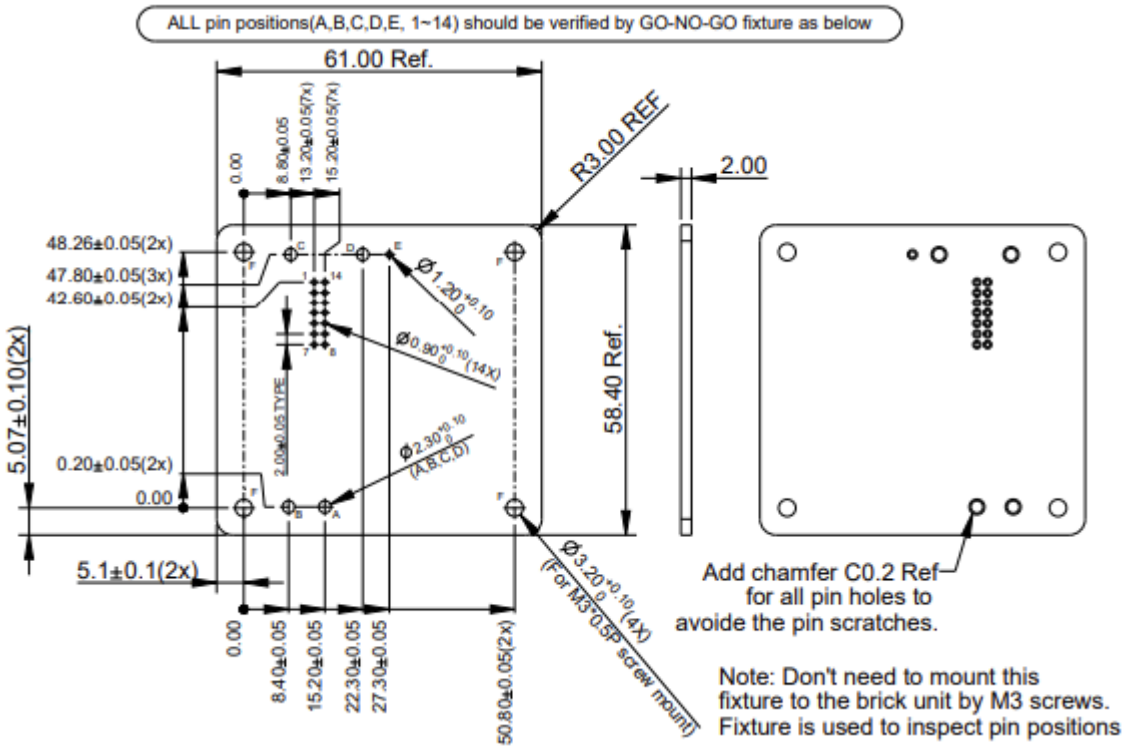
SECTION 3 MECHANICAL SPECIFICATIONS

3.1 Mechanical Outlines (unit: mm)



SECTION 3 MECHANICAL SPECIFICATIONS

3.1 Mechanical Outlines (unit: mm)



SECTION 3 MECHANICAL SPECIFICATIONS

3.2 Pin Assignments

Pin Assignments		
Input (AC)	Output (DC)	Control Pin
A. L1 (L)	C. Vout+	1. PV AUX+
B. L2 (N)	D. Vout+	2. LD ENABLE
F. EARTH (4x metal surface mounting holes)	E. CAP-	3. PFW
		4. S GND
		5. V ADJ
		6. PF ENABLE
		7. SCL/TX
		8. SDA/TX
		9. I2C ADDRESS
		10. CLK IN/OUT
		11. C MON
		12. Reserved
		13. TEMP MON
		14. PV AUX-

3.3 Mechanical Data

Table 5. Mechanical Data	
Dimensions (L x W x D)	58.4 x 61 x 14mm with tolerance ±0.5mm
Weight	140 g typical (160 g maximum)
Cooling	Conduction cool via heatsink
Screw Tightening Torque for Mounting	6~8kgf-cm
Material	Plastic case with aluminum baseplate.
Surface Flatness	Concave inwards: 0.2mm max Convex outwards: 0.38mm max

SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.1 EMC Immunity

The AIH03ZPFC is an AC input power supply for which the Telco Standards & Approvals are not required. Target to meet the following requirement with Advanced Energy recommended EMI filter.

Table 6. EMC Compliance

Requirement	Specification
Conducted Radiation	Class A with 6db margin min. with Advanced Energy recommended EMI filter
Electrical Fast Transients (EFT)	2kV min
Lightning Surges	IEC 61000-4-5 2kV DM No temporary degradation or loss of function or performance (criterion A) 4kV CM No temporary degradation or loss of function or performance (criterion A)
Hi-Pot	Primary (all Input/Output pins) to Baseplate: 2500Vdc

4.2 Safety Certifications

The AIH03ZPFC series power supply has the following agency marks according to 5Km Overvoltage Category II of IEC62368 for compliance.

Table 7. Safety Certifications for AIH03ZPFC Series Module

Standard	Agency	Description
IEC 62368-1	UL mark	US Requirements
EN 62368-1	TUV	Europe Requirements
EN 62368-1	CE	CE Marking by Internal Verification/Certificate
RoHS	-	2015/863/EU
REACH	-	EC 1907/2006

ENVIRONMENTAL SPECIFICATIONS

4.3 EMI Emissions

The AIH03ZPFC series module will require additional EMI filtering to enable the system to meet relevant EMI standards. PFC modules have an effective input to ground (baseplate) capacitance of 940pF maximum. This should be accounted for when calculating the maximum EMI 'Y' capacitance to meet ground leakage current specifications. An example filter circuit is shown below. EMI filter shielding may be required for better EMI performance.

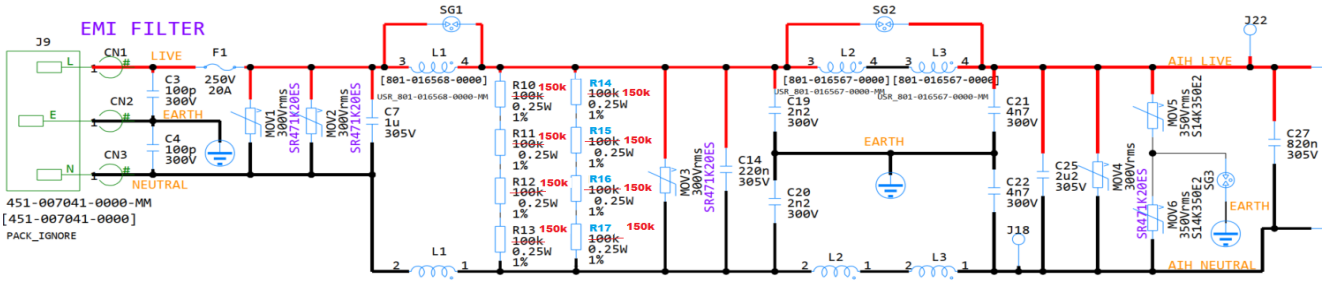


Figure 13: Reference EMI Filter Circuit

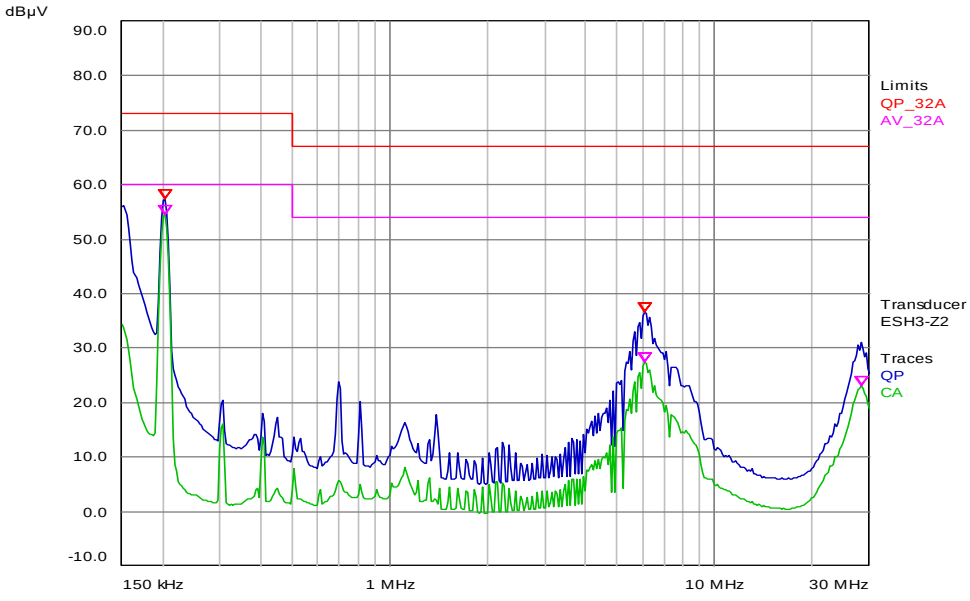


Figure 15: Conducted Emissions

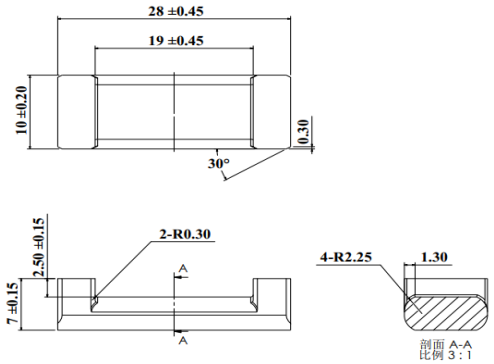
ENVIRONMENTAL SPECIFICATIONS

EMI Filter Component MPN List

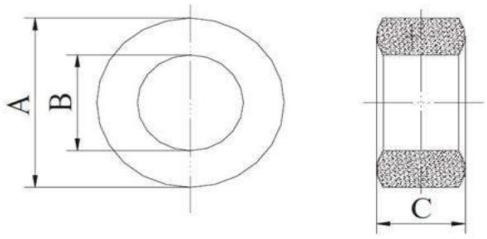
Component	MPN
C3, C4	100 pF, MURATA COMPANY - DE2B3SA101KA3BX02F
F1	LITTELFUSE - 0324020.MXP
MOV1, MOV2, MOV3, MOV4	WALSIN - SR471K20ES
C7	1 uF, HUA JUNG COMPONENTS-MKP - 105K0305AB1151-P
L1	Refer below
R10, R11, R12, R13, R14, R15, R16, R17	KOA - RK73H2BTTD1503F
C14	220 nF, TDK - EPCOS-B32922C3224K000
L2, L3	Refer below
C21, C22	4.7 nF, MURATA COMPANY - DE2E3SA472MN3AX02F
C25	2.2uF, HUA JUNG COMPONENTS - MKP-225K0305AB1221-PV
MOV5, MOV6	THINKING - TVR14561KSY
SG1, SG2	MITSUBISHI MATERIAL CORP - DSP-201M-A21R
SG3	SANKOSHA - Y08SV-312BTR
C27	820 nF, HUA JUNG COMPONENTS - MKP-824K0305AB1151-P

	L1
UF28	R7KC
Turn Ratio	14:14
Magnet Wire Gauge (mm)	Dia: 0.7
Dimension(mm) [refer figure below]	Refer below

	L2, L3
Toroid	R7KC
Turn Ratio	22:22
Magnet Wire Gauge (mm)	Dia: 1.2
Dimension(mm) [refer figure below]	A=25; B=15; C=10



Toroid Dimension:



SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.4 Operating Temperature

The AIH03ZPFC series power supply will start and operate at an ambient temperature from -40°C to 85°C, or baseplate temperature at center location from -40°C to 100°C. The operating temperature gradient is 0.5°C per minute minimum.

The PSU may not meet spec during the warm-up period when it cold starts at -40°C, and the operation starts at -25°C.

4.5 Storage and Shipping Temperature

The AIH03ZPFC series power supply can be stored or shipped at temperatures between -40°C and +105°C.

4.6 Altitude

The AIH03ZPFC series power supply will operate within specifications at altitudes from 0m to 5,000m (16,404 feet) above sea level. The power supply will not be damaged when stored at altitudes from 0m to 12,192m (40,000 feet) above sea level.

4.7 Humidity

The AIH03ZPFC series power supply will operate within specifications when subjected to a relative humidity from 5% to 90% non-condensing. It exceeds ASHRAR class 2 requirement as below, and the operating humidity temperature gradient is 10% per hour minimum.

Operating Temperature Range	Operating Humidity Range
6°C to 10°C	5 to 85% RH
10°C to 28°C	10 to 90% RH
29°C to 50°C	15 to 50% RH

The AIH03ZPFC series power supply can be stored in a relative humidity from 5% to 95% at 65°C for 24 hours, non-condensing, and the non-operating humidity temperature gradient is 10% per hour maximum.

4.8 Vibration

Non-Operating Random Vibration

Acceleration	3.8	gRMS
Duration	30 per axes	Mins
Direction	3 mutually perpendicular axis	

Operating Random Vibration (Per IEC 60068-2-64)

Acceleration	2.4	gRMS
Duration	30 per axes	Mins
Direction	3 mutually perpendicular axis	

SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.9 Shock

Non-Operating Half-Sine Shock

Acceleration	40	G
Duration	15	ms
Pulse	Half-Sine	
Number of Shock	3 times in each of 6 faces	

Operating Half-Sine Shock

Acceleration	30	G
Duration	11	ms
Pulse	Half-Sine	
Number of Shock	3 times in each of 3 axes	

SECTION 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

5.1 AC Input Pin

These pins provide the AC Mains to the AIH03ZPFC series module.

A - L1 (L)	-	AC Input Line or DC Input +
B - L2 (N)	-	AC Input Neutral or DC Input -
E - CAP-	-	Bulk capacitor negative terminal
F - EARTH	-	Connected to Safety Earth (Metal surface mounting holes)

5.2 DC Output Pin

These pins provide the main output for the AIH03ZPFC series module. The "+" and the "-"pins are the output positive and output negative rails. The output (V_O) pins are electrically isolated from the power supply chassis.

C - Vout+	-	PFC output and bulk capacitor positive terminal
D - Vout-	-	PFC output negative terminal

5.3 Control Signals

The AIH03ZPFC series module contains a 16 pins control signal header providing an analogue control interface, temperature monitor and PFC module status warning interface.

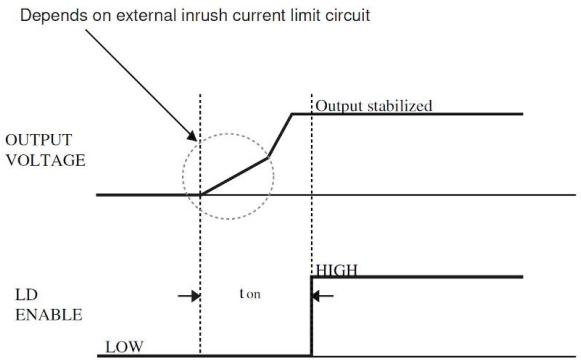
PV AUX+ / PV AUX- - (pins 1,14)

PV AUX+ /PV AUX- provides an auxiliary power source for logic circuit. It supports 12V at 20mA. PV AUX+ and PV AUX- are isolated with power rail & signal ground, and the isolated voltage is 800V max. It can't support current share, and PV AUXs from different PFC modules cannot be directly tied together. External Oring diode connection method can be used to support PV AUX redundant application.

LD ENABLE - (pin 2)

Output signal to inform downstream converter that the PFC module is ready for load. After the PFC power up sequence, the power to the load can be enabled, and the PFC can automatically enable the load using the LD ENABLE signal.

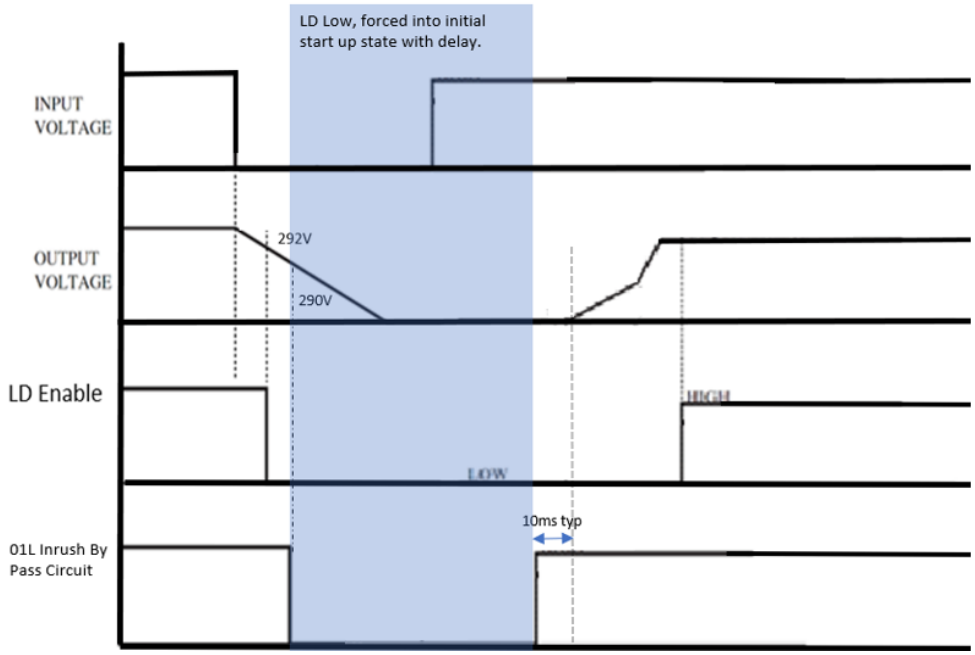
LD_DISABLE (Bit 0) reporting under STATUS_MFR_SPECIFIC (80h) is based on LD ENABLE.



SECTION 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

Similar with PFW, the LD signal can drive an opto-coupler to provide an isolated signal from the primary side to the secondary side. The LD voltage sensing threshold is set at 292Vdc (Typ). Once the LD is lower than the threshold, the modules will be forced into the initial PFC start up sequence. For 01L only, the internal by pass circuit will be off at bulk voltage 290Vdc (Typ).

For the faults (refer to the Protection Function Specifications) are detected, this LD Enable will override the 292Vdc (Typ) voltage sensing condition.

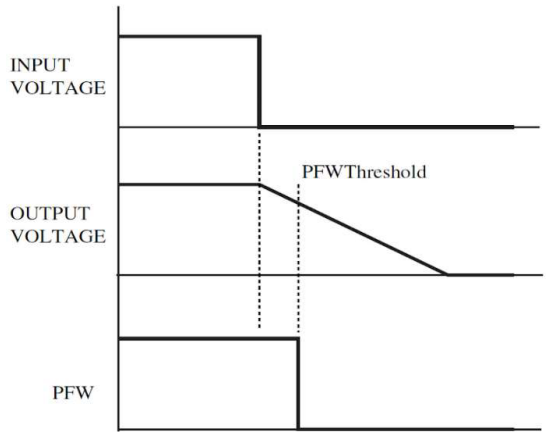


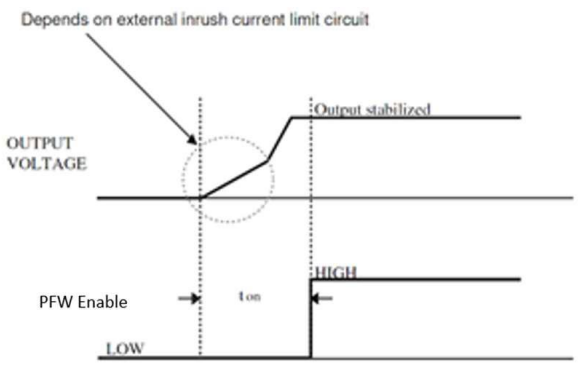
PFW (Power Fail Warning) - (pin 3)

The PFW signal can drive a LED to provide the power fail warning of the unit. When AIH03ZPFC is powered up, the PFW is high once the output is in regulation. When the output voltage is out of the PFW limit or is latched by the protection faults aredetected, this signal state will be changed from High to Low.

The output of the PFW signal can be used to drive an opto-coupler and provide an isolated signal from the primary side to the secondary side. Factory defaulted PFW voltage threshold, which is set at 340Vrms typical, can be trimmed from 300Vrms to 340Vrms via PMBus command. The PFW will be recovered if the output voltage is 20Vrms greater than the PFW threshold limit before LD Enable go to low.

PFW (Bit 1) reporting under STATUS_MFR_SPECIFIC (80h) is based on PFW.





SECTION 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

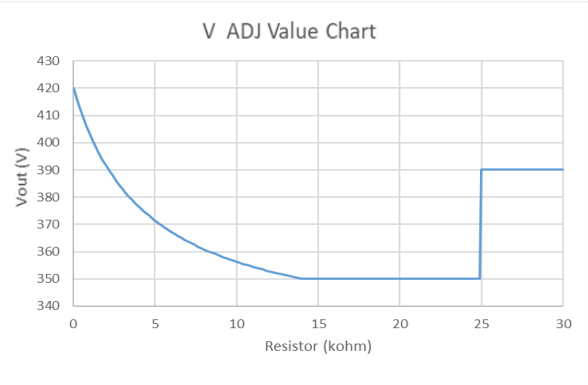
S GND - (pin 4)

The S GND pin internally connected to the -O/P terminals via a 1.5 ohm resistor. And, it's mainly used for VADJ, PFW ADJ and and I2C ADDRESS / phase shift resistor setting as a reference GND on each of the PFC modules, and can be separated or disconnected for parallel application.

Note: Recommend no connection between S GND and Vout- power return on external circuit.

V ADJ - (pin 5)

The output voltage of the AIH03ZPFC series module can be accurately adjusted from 350V to 420V. Adjustment can be made using a 0.1% resistor with low temperature coefficient to set the output voltage for stability to operate the module in full temperature range.



Vo = 424.3 – 96.86 * (Radj + 0.2) / (Radj + 4.52)

Where Radj is the resistor value in the range 0 to 14 kohm connected between the Vadj pin to S GND (units in kohm)

Examples
1. Radj = 0 ohm; Vout = 420V
2. Radj = 13.8 to 24.9k ohm; Vout = 350V
3. Radj = 25k ohm or above; Vout = 390V

The main output adjustment function can be overridden by PMBus command.

PF ENABLE - (pin 6)

The PF ENABLE pin is a TTL compatible input used to turn the output of the module on or off.

The output is enabled when the PF ENABLE is open or driven to a logic High of > 2.2V. The output is disabled when the PF ENABLE is connected to S GND or driven to a logic low of < 0.8V.

PF ENABLE (Bit 2) reporting under PF ENABLE (Bit 2) reporting under STATUS_MFR_SPECIFIC(80h) is based on PF ENABLE.

SCL/TX - (pin 7)

I²C Clock or UART TX pin. I²C bit rate 100kHz – 400kHz / UART baud rate at 19200 bps

SDA/RX - (pin 8)

I²C Data or UART RX pin. I²C bit rate 100kHz – 400kHz / UART baud rate at 19200 bps

SECTION 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

I2C ADDRESS - (pin 9)

The I2C Address pin supports PMBus address selection with multiple modules. It also serves as the selection of PMBus or UART communication and the phase shift with multiple modules. Refer to the I2C address selection table.

CLK IN/OUT - (pins 10)

For PWM clock synchronization

C MON - (pin 11)

The C MON pin provides an indication of the amount of current supplied by the module. The output of the C MON pin is a voltage source proportional to the output current of the module.

where $V_{C\ MON}$ / Io = 0.6V/A

For example $V_{C\ MON}$ = 1.692V Typ at 2.82A load.

C mon Voltage Output Accuracy: ±5% plus ±2% of PMBus reading when the output load >20% of full load (or 0.564A).

C mon voltage tolerance is ±0.02V when the output load ≤20% of the full load.

The C mon signal will only support up to 5A. C mon voltage will be clamped at its maximum when Iout > 5A.

TEMP MON - (pin 13)

The TEMP MON pin provides an indication of the module's internal temperature. The voltage at the TEMP MON pin is proportional to the temperature of the module baseplate at 10mV per ^{O}C. Where:

Module temperature (^{O}C) = (V_TEMP_MON - 0.5) / 0.01

The temperature monitor signal can be used by thermal management systems (e.g. to control a variable speed fan). It can also be used for over temperature warning circuits and for thermal design verification of prototype power supplies and heatsink.

The temperature tolerance is ±5^{O}C to the temperature of the base plate.

SECTION 6 PMBUS™ SPECIFICATIONS

6.1 PMBus™, SMBus and UART Requirements

PMBus™ Sensor Accuracy[1]

Output Load	Line Voltage (at module input pin)	Input line Current	Input Power[2] (at module input pin)	Output Voltage	Output Current	Output Power[3]
1% to <= 5% Load	±3%	±0.3A	±20W	±2%	±0.3A	±20W
>5% to <=20% Load	±3%	±15%	±10%	±2%	±10%	±10%
>=20% to 100% Load	±3%	±5%	±5%	±2%	±5%	±5%

Note 1 - PMBus sensors accuracy is evaluated under sinusoidal AC input.
Note 2 - Input range at 100 to 240Vac.
Note 3 - Reported output power should not exceed the reported input power at any output load conditions.

PMBus™ Addresses

The I²C address pin supports PMBus module addressing and phase shift of parallel connected modules. Please refer to I²C address table below.

R_address (Ohm), 1%	Address (HEX)	Number of Parallel Connected Modules	Phase Shift with Reference to Synchronized Clock
0	B0	1,2,3,4,5,6	0
365	B2	1,6	60
751	B4	1,5	72
1180	B6	1,4	90
1650	B8	1,3,6	120
2150	BA	1,5	144
2670	BC	1,2,4,6	180
3240	BE	1,5	216
3920	C0	1,3,6	240
4640	C2	1,4	270
5490	C4	1,5	288
6340	C6	1,6	300

SECTION 6 PMBUS™ SPECIFICATIONS

UART Setting

In UART communication mode, the I²C address pin supports phase shift between parallel connected modules. Please refer to UART setting table below.

R_address (Ohm), 1%	Number of Parallel Connected Modules	Phase Shift with Reference to Synchronized Clock
9090	1,2,3,4,5,6	0
10500	1,6	60
12100	1,5	72
14000	1,4	90
16200	1,3,6	120
19100	1,5	144
22100	1,2,4,6	180
26700	1,5	216
31600	1,3,6	240
39200	1,4	270
49900	1,5	288
64900	1,6	300

SECTION 6 PMBUS™ SPECIFICATIONS

6.2 PMBus™ Command List

The AIH03ZPFC series module is compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the I2C interface port. PEC is supported, PMBUS™ clock speed supports up to 400Kbps.

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
01h	OPERATION	80h	R/W	1	-	Used to turn the unit ON/OFF
	b7:6	10				01 - PSU OFF 10 - PSU ON
	b5:0	000000				Reserved
03h	CLEAR_FAULTS	-	W	-	-	Clears faults
12h	RESTORE_DEFAULT_ALL	-	W	0	-	Restores values to default store
15h	STORE_USER_ALL	-	W	0	-	Stores values to user store
19h	CAPABILITY	A0h	R	1	Binary integer	Stores values to user store
	b7 - Packet Error Checking	1				0 - PEC not supported 1 - PEC supported
	b6:5 - Maximum Bus Speed	01				01 - Maximum supported bus speed, 400kHz
	B4:0 - Others	0				Reserved
20h	VOUT_MODE	07h	R	1	-	Scaling factor on voltage data for commanding or reading the output voltage
21h	VOUT_COMMAND	0	R/W	2	Linear16	Adjust bulk regulation range from 350 to 420Vdc
40h	VOUT_OV_FAULT_LIMIT	450V	R/W	2	Linear16	Sets the VOUT overvoltage fault threshold (370 to 450Vdc)
44h	VOUT_UV_FAULT_LIMIT	292V	R/W	2	Linear16	Sets the VOUT under voltage fault threshold (280 to 320Vdc)
46h	IOUT_OC_FAULT_LIMIT	7.2A High 4.2A Low	R/W	2	Linear11	Sets the IOUT over current fault threshold (1.5 to 4.0A)
4Ah	IOUT_OC_WARN_LIMIT	6.7A high 3.9A Low	R/W	2	Linear11	Sets the IOUT over current warning threshold (1.5 to 3.5A)
4Fh	OT_FAULT_LIMIT	108degC	R/W	2	Linear11	Sets the over-temperature fault limit. (55 to 108degC)
55h	VIN_OV_FAULT_LIMIT	>305Vac	R/W	2	Linear11	Sets input over-voltage fault limit (150 to 295Vac)
59h	VIN_UV_FAULT_LIMIT	<73Vac	R/W	2	Linear11	Sets the VIN under voltage fault threshold (70 to 80Vac)
60h	TON_DELAY	0	R/W	2	Linear11	Sets the delay time from PF enable signal to VOUT Rise Range: 0 to 60000ms
64h	TOFF_DELAY	0	R/W		Linear11	Sets the delay time from PF disable to start of VOUT turn off Range: 0 to 60000ms
78h	STATUS_BYTE	-	R	1	-	First byte of STATUS_WORD
79h	STATUS_WORD	-	R	2	-	Summary of critical faults
7Ah	STATUS_VOUT	-	R	1	-	Reports VOUT faults
	b7 - VOUT_OV_FAULT	0				Set: >= VOUT_OV_FAULT_LIMIT Reset :<= VOUT_OV_FAULT_LIMIT-20Vdc
	b4 - VOUT_UV_FAULT	0				Set: <= VOUT_UV_FAULT_LIMIT Reset : LD Enable
	Others	0				Reserved

SECTION 6 PMBUS™ SPECIFICATIONS

AIH03ZPFC Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
7Bh	STATUS_IOUT	-	R	1	-	Reports IOUT warnings/faults
	b7 - IOUT_OC_FAULT					Set: >= IOUT_OC_FAULT_LIMIT
	b5 - IOUT_OC_WARNING					Set: <= IOUT_OC_WARN_LIMIT
	Others					Reserved
7Ch	STATUS_INPUT	-	R	1	-	Reports input warnings/faults
	b7 - VIN_OV_FAULT					Set: >= VIN_OV_FAULT_LIMIT Reset: <=265Vac
	b4 - VIN_UV_FAULT					Set: <=VIN_UV_FAULT_LIMIT Reset: >=83Vac
	b3 - Same as b4					Unit off for insufficient
	Others					Reserved
7Dh	STATUS_TEMPERATURE	-	R	1	-	Reports temperature warnings/faults
	b7 - OT_FAULT					Set: >=OT_FAULT_LIMIT Reset: <=75degC
	Others					Reserved
7Eh	STATUS_CML	-	R	1	-	Reports communication, memory, logic errors
80h	STATUS_MFR_SPECIFIC	-	R	1		Reports I/O pin status
	b7:4 Reserved					
	b3 - UNIT ON/OFF STATUS					1 - OFF 0 - ON
	b2 - PF ENABLE					Report pin status of PF ENABLE (Pin 11) 1 - Enable 0 – Disable
	b1 - PFW					Report pin status of PFW (pin 5) 1 - Active (Vout <PFW_ON_LIMIT) 0 - Inactive (Vout>PFW_OFF_LIMIT)
	b0 - LD_DISABLE					Report pin status of LD ENABLE (Pin3) 1 - Disable 0 - Enable
88h	READ_VIN	-	R	2	Linear11	Returns input voltage in Volts ac.
89h	READ_IIN	-	R	2	Linear11	Reports input current
8Bh	READ_VOUT	-	R	2	Linear16	Reports output voltage (bulk cap)
8Ch	READ_IOUT	-	R	2	Linear11	Reports output current (bulk cap)
8Dh	READ_TEMPERATURE_1	-	R	2	Linear11	Reports PFC temperature
96h	READ_POUT	-	R	2	Linear11	Reports output power (bulk cap)
97h	READ_PIN	-	R	2	Linear11	Reports input power
98h	PMBUS_REVISION	22	R	1	-	Reports the PMBus revision 1.2
99h	MFR_ID	AEI	BR	16	ASCII	Manufacturer identifier, 00 for unused bytes
9Ah	MFR_MODEL_ID	AIH03ZPFC-01L	BR	16	ASCII	Manufacturer model ID, 00 for unused bytes
9Bh	MFR_REVISION	BBBSSSHHHH	BR	10	ASCII	Manufacturer revision, 00 for unused bytes TLA revision

SECTION 6 PMBUS™ SPECIFICATIONS

AIH03ZPFC Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
9Ch	MFR_LOCATION	PH	BR	16	ASCII	Manufacturer location identifier, 00 for unused bytes PH for Philippines factory
9Dh	MFR_DATE	YYMMDD	BR	6	ASCII	Manufacturer date
9Eh	MFR_Serial	-	BR	11	ASCII	Serial number: refer to factory format, 00 for unused bytes
A0h	MFR_VIN_MIN	100V	R	2	Linear11	
A1h	MFR_VIN_MAX	240V	R	2	Linear11	
A2h	MFR_IIN_MAX	14A	R	2	Linear11	
A3h	MFR_PIN_MAX	1160W	R	2	Linear11	
A4h	MFR_VOUT_MIN	350Vdc	R	2	Linear16	
A5h	MFR_VOUT_MAX	420Vdc	R	2	Linear16	
A6h	MFR_IOUT_MAX	3.15A	R	2	Linear11	
A7h	MFR_POUT_MAX	1100W	R	2	Linear11	
A8h	MFR_T_BASEPLATE_MAX	100°C	R	2	Linear11	
A9h	MFR_ T_BASEPLATE_MIN	-40°C	R	2	Linear11	
ECh	MAIN_VOUT_OVERRIDDEN	-	R/W	1	Binary integer	0x55: HW Resistor Adjustment 0xAA: PMBus VOUT_COMMAND Other values: reserved Get current setting of output voltage Adjustment 0x55:HW Resistor Adjustment(Default) 0xAA: PMBus VOUT_COMMAND Other values: reserved
E1h	PFW_ON_LIMIT		R/W	2	Linear11	Sets the Power Failure Warning ON threshold When Vout < this limit, PFW will active Range: 300Vdc - 340Vdc
E2h	PFW_OFF_LIMIT		R/W		Linear11	Sets the Power Failure Warning OFF threshold When Vout > this limit, PFW will inactive Range: PFW_ON_LIMIT+20Vdc
D5h	PSU_FW_REVISION	-	BR	9	ASCII	Returns the PS FW revision. 1MMT Primary side major, minor rev and test revision 2MMT Secondary side major, minor rev and test revision

SECTION 6 PMBUS™ SPECIFICATIONS

Linear11 Data Format

The Linear Data Format is a two byte value with:

- An 11 bit, two's complement mantissa and
- A 5 bit, two's complement exponent (scaling factor).

The format of the two data bytes is illustrated in Figure 4.

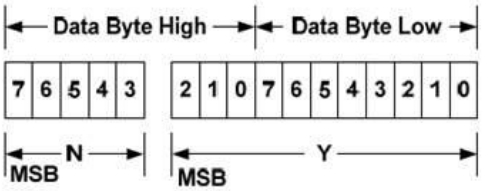


Figure 4. Linear Data Format Data Bytes

The relation between *Y*, *N* and the "real world" value is:

$X = Y \cdot 2^N$

Where, as described above:

X is the "real world" value;

Y is an 11 bit, two's complement integer; and

N is a 5 bit, two's complement integer.

Devices that use the Linear format must accept and be able to process any value of *N*.

Linear16 Data Format

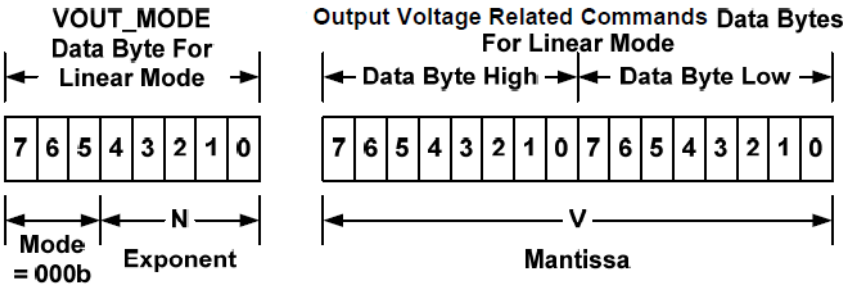


Figure 6. Linear Format Data Bytes

The Mode bits are set to 000b.

The Voltage, in volts, is calculated from the equation:

$Voltage = V \cdot 2^N$

Where:

Voltage is the parameter of interest in volts;

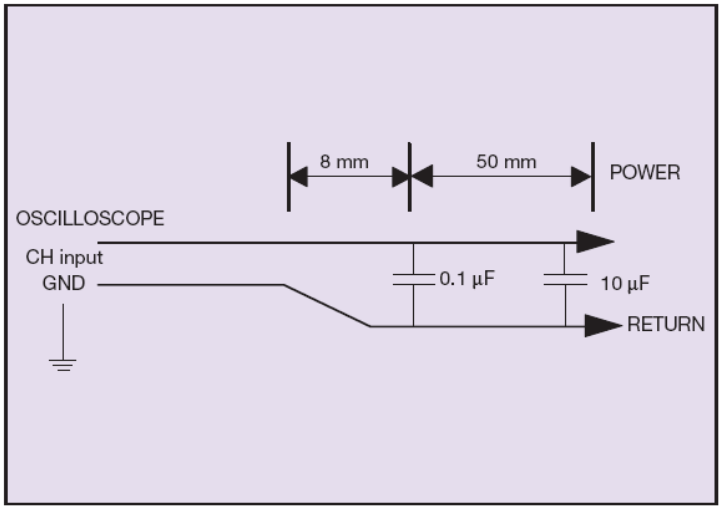
V is a 16 bit unsigned binary integer; and

N is a 5 bit two's complement binary integer.

SECTION 7 APPLICATION NOTES

7.1 Output Ripple and Noise Measurement

The setup outlined in the diagram below has been used for output voltage ripple and noise measurements on the AIH03ZPFC series module. When measuring output ripple and noise, a scope jack in parallel with a 0.1 µF ceramic chip capacitor, and a 10 µF aluminum electrolytic capacitor should be used. Oscilloscope should be set to 20MHz bandwidth for this measurement.



SECTION 8 RECORD OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	01.13.2026	First Issue	A. Zhang

ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than four decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

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