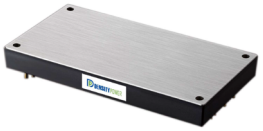
Technical Specification

AFF1K6W2 Series

Full Brick 1600Watts PFC Module

FEATURES

- Input voltage range: 85-264VAC
- Input frequency range: 45-65Hz
- 1600W output power
- Efficiency up to 96%
- Power factor ⩾ 0.99
- Single output: 390VDC
- Fixed switching frequency, predictable EMI
- Build-in inrush current limit
- Stable no-load operation
- Industry standard full brick footprint (4.20" × 2.40" × 0.50")
- Extensive self-protection, UVLO, OVP and OTP
- Auxiliary 12V bias supply
- Operating temperature range:-40°C to +100°C (baseplate temperature)
- Fully encapsulated, high reliability
- Flexible extra heat-sink mount type
- Compliance with IEC/EN 62368-1 standard



RoHS COMPLIANT CE

PRODUCT OVERVIEW

The AFF1K6W2 power factor correction module is a fundamental building block of an AC/DC power supply. Used in conjunction with bus capacitor, Density Power's DC/DC converters and recommended AC input filter, the PFC module draws high power factor (>0.99) nearly perfect sinusoidal current from AC input.

Universal input voltage range of 85-264VAC (230V nominal)/85-140VAC (115V nominal) is ideal for automation, power grid, railway, semiconductor equipment, instrumentation, test and measurement, and distribution power system.

A wealth of self-protection features included input UVLO, OTP and OVP. Threaded or through holes are provided to allow easy mount or the addition of a heat sink for extended temperature operation. The operation temperature is -40°C to 100°C (baseplate temperature).

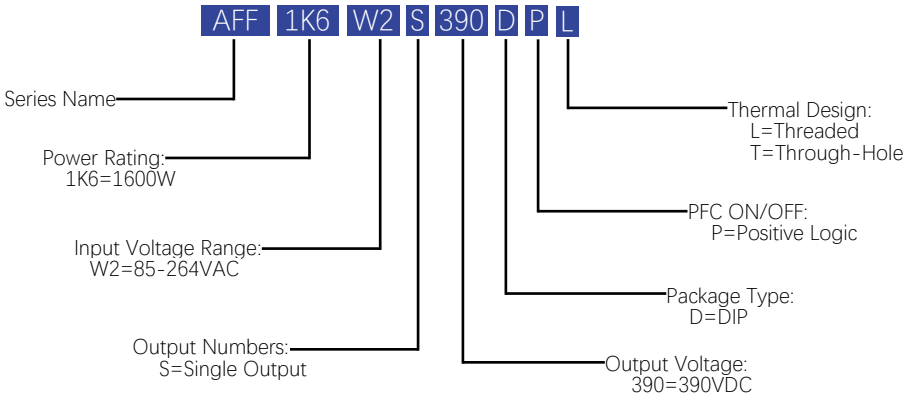
Aluminum baseplate with fully encapsulation technologies provide high reliability and outstanding thermal performance, is ideal for harsh environments applications which requie robust power converters.

The AFF1K6W2 series are designed to meet safety standards IEC/EN 62368-1.

Models Selections

Basic Models	Input Voltage [VAC]	Input Voltage Range [VAC]	Output Voltage [VDC]	Output Current [A]	Power Factor typ.	Efficiency typ. [%]	Capacitive Load Max [μF]	Package [inch]
AFF1K6W2S390	230	85-264	390	4.1	0.99	96	2200	Full Brick

Model Numbering



Absolute Maximum Ratings

Parameters	Conditions	Min.	Typ.	Max.	Units
Input Voltage Continuous				290	VAC
Input Voltage Transient	< 100ms			300	VAC
Enable Pin Voltage	Referred to -Vout or GND	-0.3		35	VDC
Enable Pin Sink Current		0		100	mA
AUX Pin Sourcing Current		0		100	mA
ON/OFF Pin Voltage		-0.3		15	VDC
Operating Baseplate Temperature		-40		100	°C
Operating Environment Temperature		-40		85	°C
Storage Temperature		-55		125	°C
Soldering Temperature	Wave Soldering < 10s			260	°C

Safety and EMC Compliance

Conducted Emission	EN55032	Class B (with external filter)
Radiated Emission	EN55032	Class B (with external filter)
Conducted Susceptibility	IEC/EN61000-4-6	Level 3 Criteria A
Radiated Susceptibility	IEC/EN61000-4-3	10V/m Criteria A
EFT	IEC/EN61000-4-4	±2KV Criteria A (With external filter)
Surge	IEC/EN61000-4-5	±2KV Criteria A (With external filter)
ESD	IEC/EN61000-4-2	±6KV Contact ±8KV Air Criteria A
Line Frequency Harmonics	IEC/EN61000-3-2	Class A
Voltage Fluctuations	IEC/EN61000-3-3	EN61000-3-3
Power Frequency Magnetic Field	IEC/EN61000-4-8	1 A/m, Criteria A
Voltage DIP Immunity	IEC/EN61000-4-11	>30% 10ms, 60% 100ms,100% 5000ms, Criteria A,B,B

General Specifications					
Parameters	Conditions	Min.	Typ.	Max.	Units
Isolation Voltage	Input to output	Non-isolation			
	Input to case		2250		VDC
	Output to case		2250		VDC
Isolation Resistance (Viso=500VDC)	Input to output	Non-isolation			
	Input to case	100			MΩ
	Output to case	100			MΩ
Switching Frequency			130		KHz
Start Up Delay Time ①			3	5	S
Start-up Threshold		75	80	85	VAC
Under Voltage Shutdown		60	70	80	VAC
Thermal Protection	Case temperature	100	105	110	℃
Thermal Protection Recover	Case temperature	85	90	95	℃
Vibration	IEC61373:1999 Category I, Body mounted				
Shock	IEC61373:1999 Category I, Body mounted				

Signal Specifications					
Parameters	Conditions	Min.	Typ.	Max.	Units
PFC ON/OFF Signal					
Enable On Voltage		0		0.3	VDC
Enable Off Voltage		5		15	VDC
Internal Pull-down Resistance			10		kΩ
Load Enable Signal	Normally open drain				
Active	Low				
Disable	Floating				
Sink Current Max.				100	mA

Notes
① R3=20Ω, C1=1000μF, Aluminium electrolytic Capacitor, refer to Typical Application Connection on page 7.

Performance Data (390 Vout)

Input Specifications

Parameters	Conditions	Min.	Typ.	Max.	Units
Input Voltage		85	115/230	264	VAC
Input Frequency		45	60/50	65	Hz
Power Factor	@230VAC & 115VAC	0.98	0.99		
THD	@230VAC & 115VAC		5	8	%
Input Current Max.	Vin=100VAC, Pout=1000W			12.5	A
Input Current @ No Load	Vin=115VAC/230VAC ON/OFF: ON			600	mA
Power Dissipation @ No Load	Vin=115VAC/230VAC ON/OFF: ON			10	W
Input Current Standby Mode	Vin=115VAC/230VAC ON/OFF: OFF			500	mA
Power Dissipation Standby Mode	Vin=115VAC/230VAC ON/OFF: OFF			5	W
Inrush Current-limiting Resistor	Rated power 5-10Watts	10		20	Ω
Inrush Current	Vin=230VAC, Cout=1000μF, typical input filter			25	A

Output Specifications

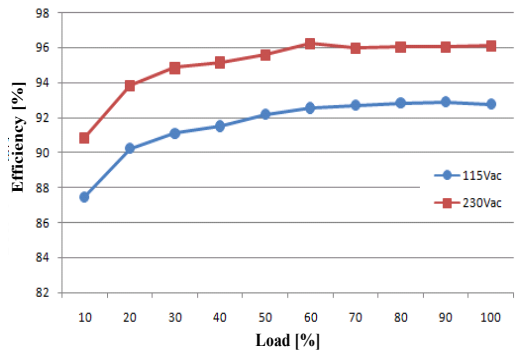
Parameters	Conditions	Min.	Typ.	Max.	Units
Output Voltage Setpoint		370	390	400	VDC
Vout Accuracy		-5.1		+2.6	% of Vout
Line Regulation		-1.5		+1.5	%
Load Regulation		-2.5		+2.5	%
Temperature Coefficient		-1.5		+1.5	%
Over Voltage Protection	Hiccup	105		110	% of Vout
Ripple & Noise Max.①				30	V pk-pk
Aux Power Output Voltage	Referred to -Vout or GND	10	12	15	VDC
Aux Power Output Current		0		100	mA
Hold Up Capacitance		660		2200	μF

Notes
① Ripple & noise is tested with 1000μF electrolytic capacitor at output.

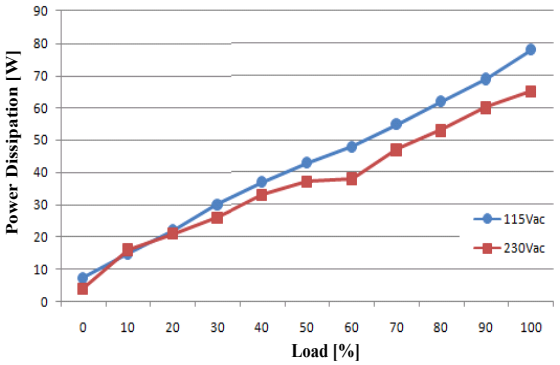
All specifications are tested at 25 ℃ ambient temperature, nominal input voltage, rated output current conditions unless otherwise specified.

Performance Data (390 Vout)

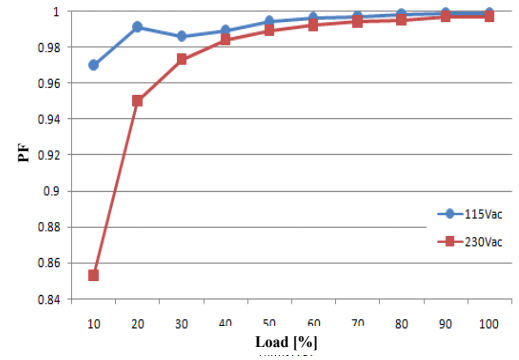
EFFICIENCY VS LOAD



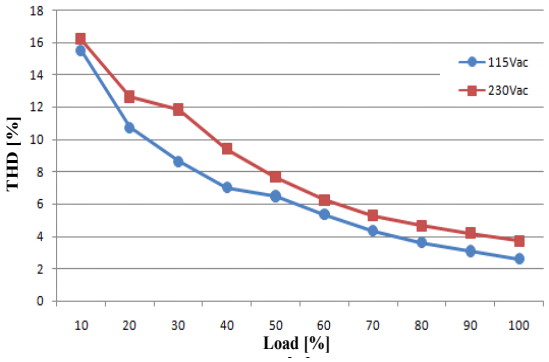
POWER LOSS VS LOAD



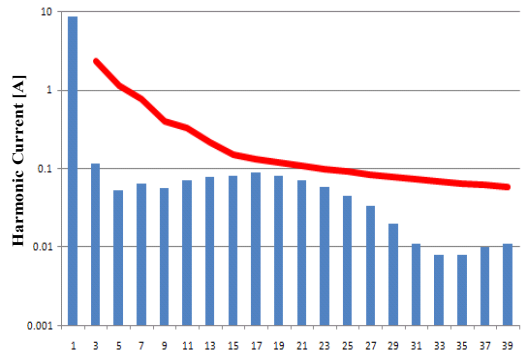
PF VS LOAD



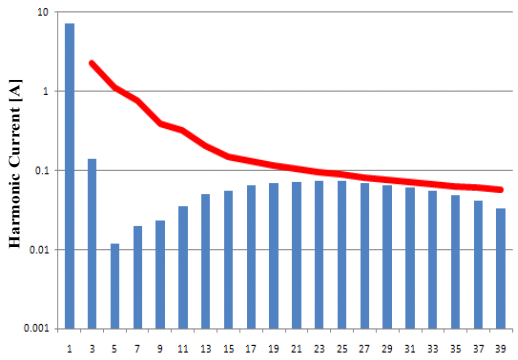
THD VS LOAD



HARMONIC CURRENT (115VAC)

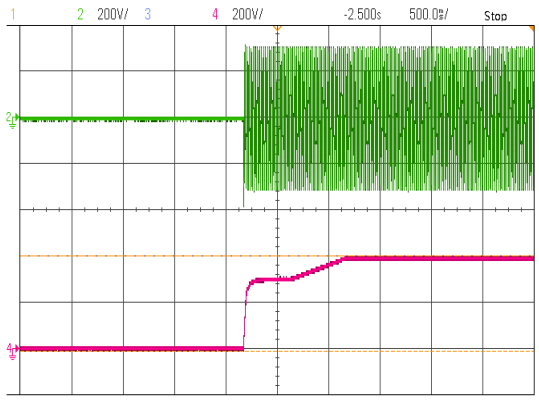


HARMONIC CURRENT (230VAC)

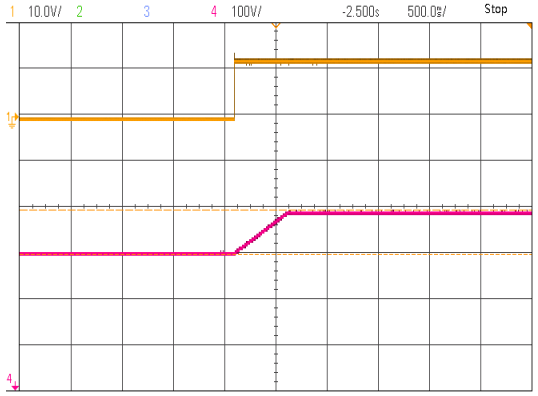


Performance Data (390 Vout)

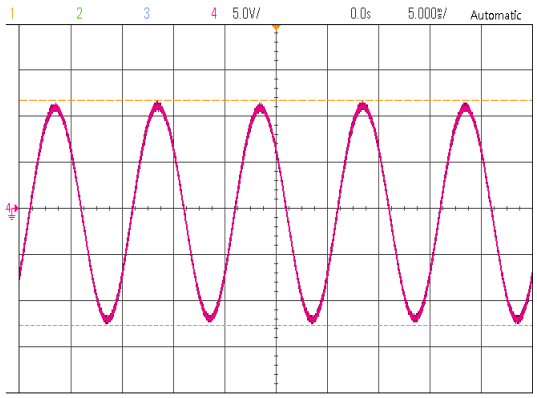
START UP (Vin) CH2: Vin CH4: Vout



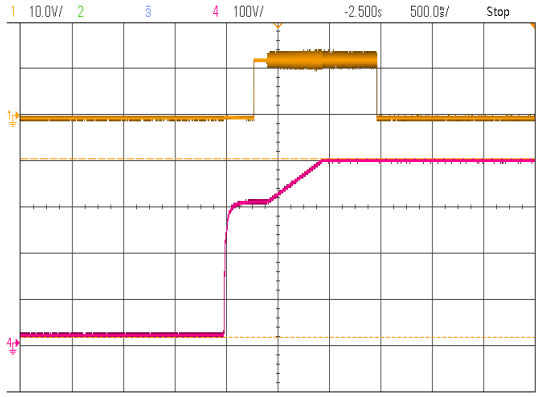
START UP (ON/OFF) CH1: Von/off CH4: Vout



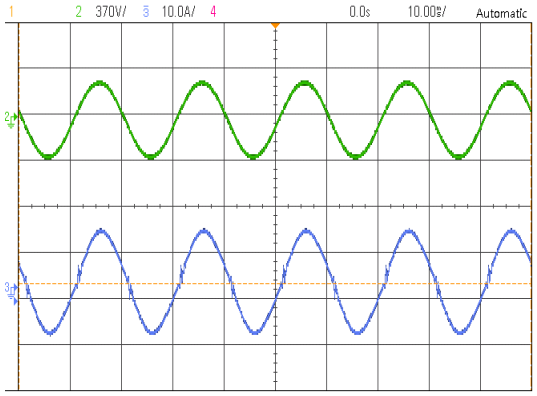
RIPPLE & NOISE CH4: Vout



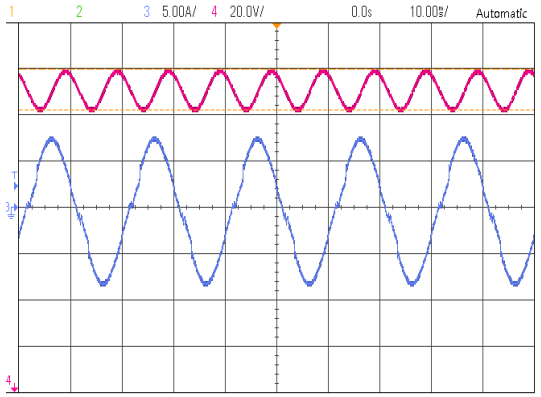
LOAD ENABLE SIGNAL CH1: Ven CH4: Vout



Iin & Vin @ FULL LOAD CH2: Vin CH3: Iin

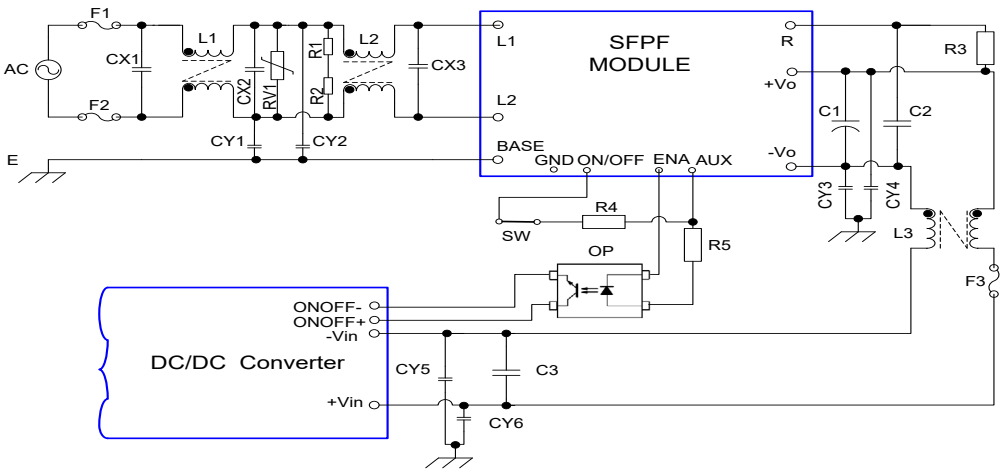


Iin & Vout @ HALF LOAD CH3: Iin CH4: Vout



Typical Application Connection (390 Vout)

The typical application of the PFC module is shown as below:



Typical Application Connection

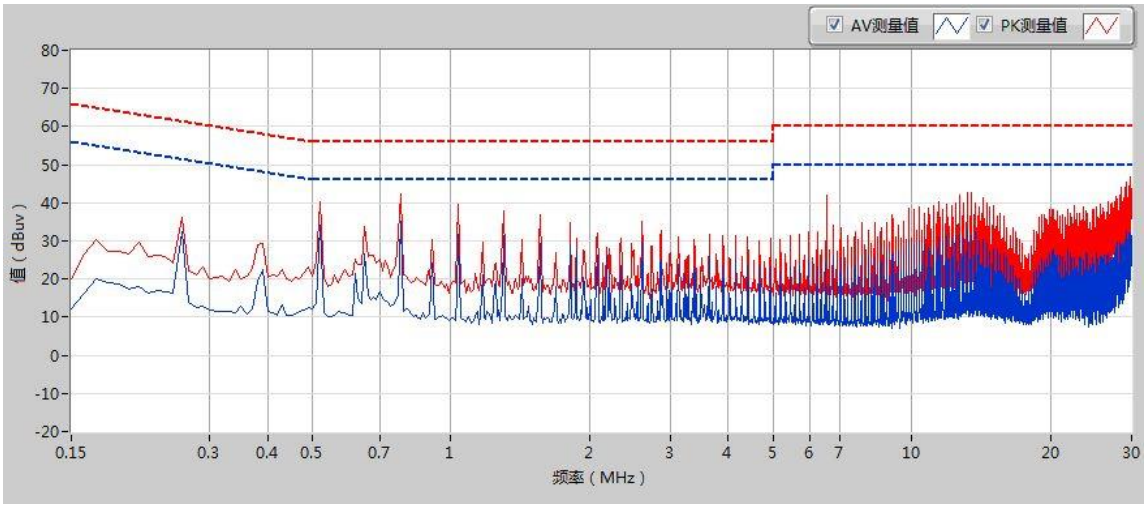
Recommended Parameters:

REFERENCE	DESCRIPTION	MODEL NUMBER	MANUFACTURER
F1/2	FUSE, 15A, 250V, Slow-blown	GBP_A(15A)	CONQUER
CX1/2/3	2.2μF/275VAC, X2	C42P2225M9FC000	FALA
CY1/2/3/4	4700pF/250VAC, Y2	F2GA472MYGS	TDK
L1	3.5mH*2		Customized
L2	3.5mH*2		Customized
L3	200uH*2		Customized
R1/2	470K, 1/4W	RC4703F1206KI	YAGEO
RV1	D20, 510V	TVR20511KSY	TKS
R3	20Ω/10W		
C1	470μF/450VDC*2, aluminium electrolytic capacitor	CAE477V450MD35L30L45T2E	SEACON
C2	2.2μF/450VDC, thin-film capacitor	CCBB225V450K1T3C1	FALA
R5	510Ω	RC5100F1206KI	YAGEO
OP	Optocoupler		
R4	10Ω	RC1000F1206KI_YAGEO	YAGEO
SW	Switch		

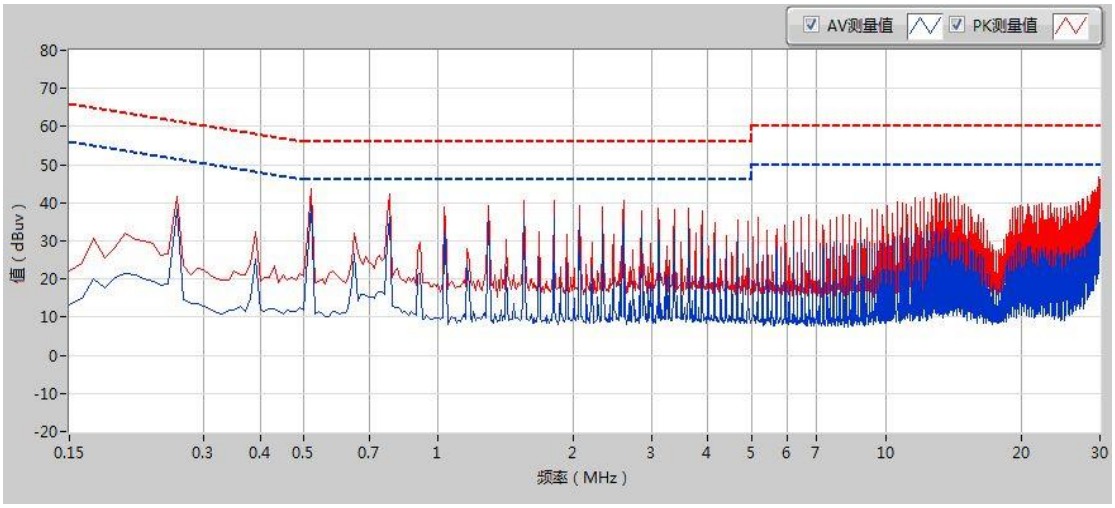
Typical Application Connection (390 Vout)

The PFC modules will require additional EMI filters to meet EMI standard EN55032 -Class B. Please refer to above application connection method and recommended parameters, the Conduction Emission test results at 230VAC are as follows:

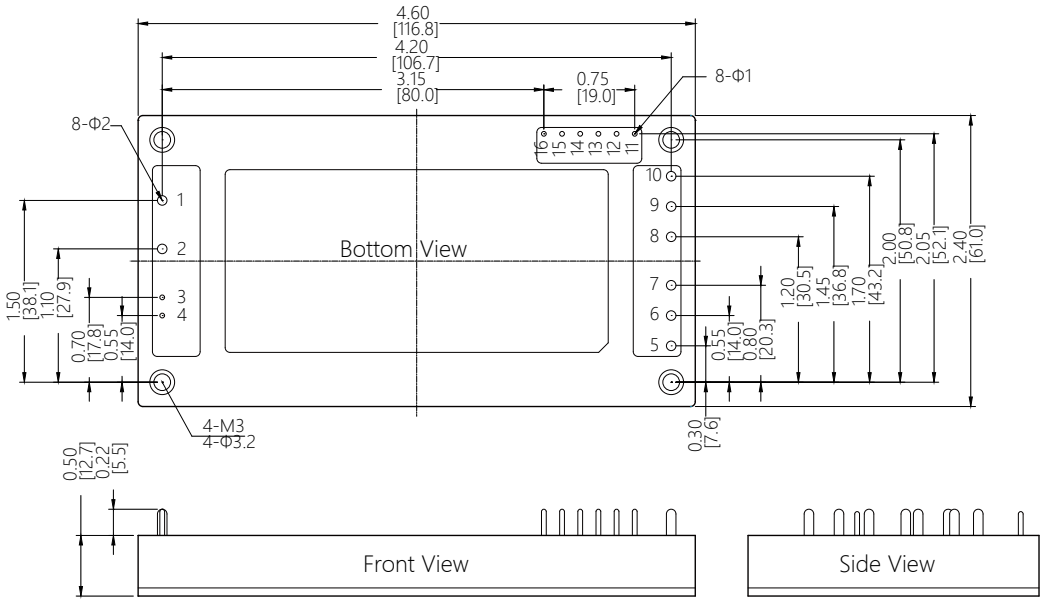
Half Load (800W) Conduct Test Waveform:



Full Load (1600W) Conduct Test Waveform:



Mechanical Specifications



PIN:
PIN1, PIN2, PIN6, PIN7, PIN9: Φ0.078inch
Force: Applied force not exceed 9.8N
PIN3, PIN4, PIN11~PIN16 : Φ0.040inch
Force: Applied force not exceed 4.9N
Material: Copper alloy
Finish: Gold 3 ~ 5μm(min.) over nickel 50μm(Min.)

TOLERANCE:
X.XX=±0.02[0.5]
X.XXX= ±0.010[0.25]

Dimensions are in inches [mm]
Weight: ~300g.

PIN CONNECTIONS		
Pin	Function	Description
1	L1	AC input, no phase sequence requirement
2	L2	
3	GND	Signal/AUX ground, same level as -Vout
4	ON/OFF	Control PFC ON/OFF
5	NC	
6	+Vout	+DC output
7	R	External resistor for inrush current protection
8	NC	
9	-Vout	-DC output
10-14	NC	
15	ENABLE	Load enable signal
16	AUX	Auxiliary power supply, 12VDC, Iout max, 100mA

Technical Notes

TIMING SEQUENCE

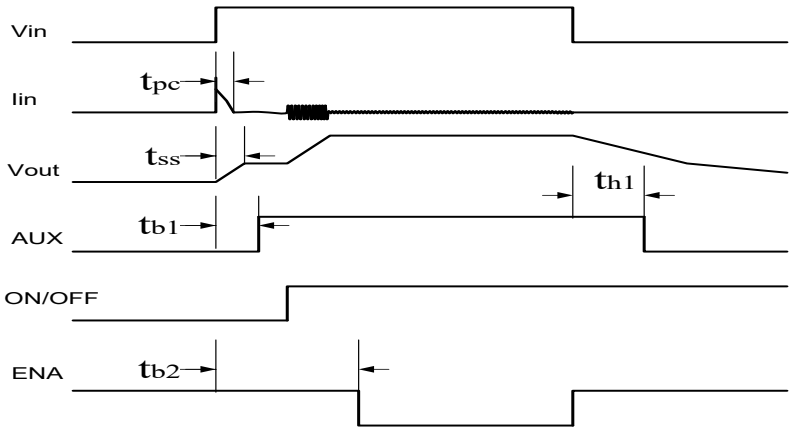


Figure 1· Timing

Parameters	Condition	Min.	Max.	Units
Vin	Input voltage, a high level indicates that the input is active			
Iin	Input current			
Vout	Output voltage			
AUX	Auxiliary power supply, a high level indicates that the auxiliary power supply is active			
ENA	A low level indicates that the enable is active			
ON/OFF	Positive Logic PFC Enable			
t_{pc}	Duration of surge current, depending on hold-up capacitor and current limiting resistor	0.5	20	mS
t_{ss}	Soft start time, depending on the input voltage, hold-up capacitor and limiting resistor	20	300	mS
t_{b1}	Auxiliary power supply setup time	100	1000	mS
t_{b2}	BUS voltage setup time	100	5000	mS
t_{h1}	Auxiliary power hold up time, depending on hold-up capacitor and load	10		mS

Technical Notes

When the AC input voltage (Vin) is switched on, the AFF module will charge the external hold up capacitor through the external current-limiting resistor, it will generate the inrush current with duration around 20ms t_{pc}, it is essential to refer to the formular $I^2 * t_{pc}$ to select the input fuse specification, at this time the PFC ON/OFF is logically low and the load module connected to the output of AFF is diabled, once the PFC ON/OFF input pin is high, the AFF module will start operating and the BUS voltage increases gradually to its nominal regulted value, after the voltage level reaches the minimum startup voltage requirement of the auxiliary power supply, the auxiliary power supply (AUX) will be presented, once the auxiliary power supply is active, the internal main controller of AFF module starts to work and self-test the PFC ON/OFF status. If startup conditions are all set (no input undervoltage, over temperature, over voltage, etc.), the controller starts the Boost circuit and controls the internal switch to short the external current limiting resistor.When the controller detects that the BUS voltage (Vout) reaches the setting value, it pulls enable signal (ENA) to low level, this signal should be used to enable the load modules so that they can begain to draw power from the AFF module. If the controller detects the disable state of PFC ON/OFF signal or any other fault conditions (input undervoltage, overtemperature, output overvoltage, etc.), AFF module will immediately shut down the Boost circuit and cut in the current limiting resistance, the enable signal output pin will return to a high logic and the load module will be disabled. At this condition, it is suggested to disable the load module, otherwise the AFF module may be damaged. Please refer to startup sequence on page 10.

Technical Notes

LOAD ENABLE FUNCTION (PIN15: ENA)

Load enable signal ENA is open drain output. Only when ENA signal is low, PFC Module can be loaded. When ENA signal is open, load should be disabled. ENA signal can be used to control the load ON/OFF, as shown in figure 2. ENA signal also can be used as remote on/off function of load module to enable/disable the load module, as shown in figure 3.

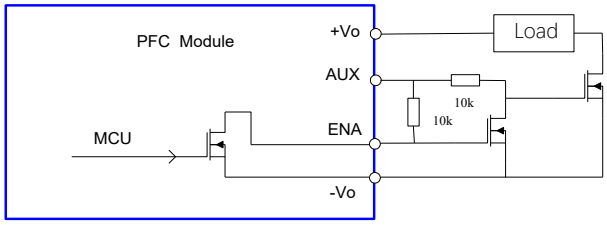


Figure 2· ENA For Connection The General Load

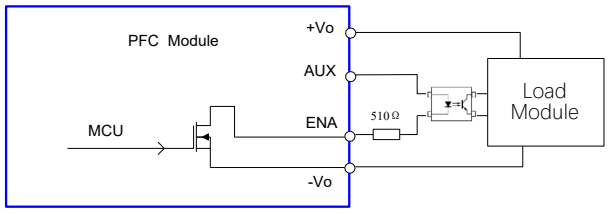


Figure 3· ENA For Load Module With Remote ON/OFF

PFC ON/OFF FUNCTION (PIN4: ON/OFF)

When ON/OFF is open or short to -Vo (GND), the PFC module's PFC function is disabled, the output voltage is the rectified voltage of AC input, and Vout cannot be loaded.

When the ON/OFF pin is connected to high level (relative to GND or -Vo, 3V~15V), the PFC function of the PFC module works with output voltage of 390VDC (typical value), and the load can be enabled after ENA is enabled (see "load enable function" for details).

If there is no need to control PFC function, the ON/OFF pin can be connected to AUX pin through a 10~100Ω resistance, as shown in the figure 4.

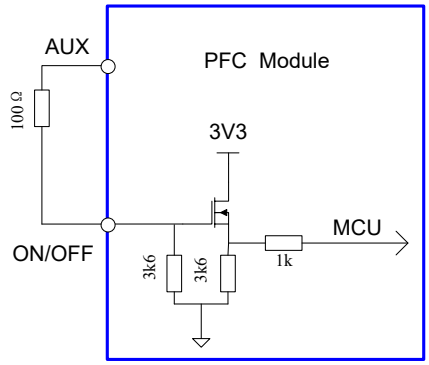


Figure 4· No Control PFC ON/OFF Function Connection

If PFC function needs to be controlled, a switch (optocoupler, small signal mosfet, etc.) and 10~100Ω resistance can be added between the ON/OFF pin and AUX pin, as shown in figure 5.

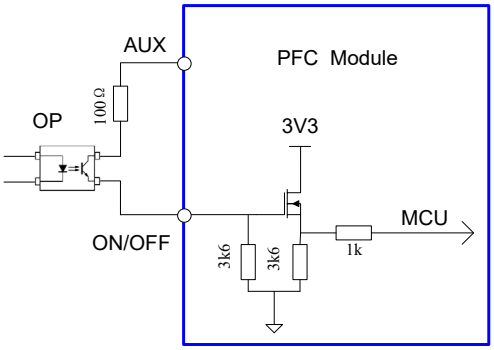


Figure 5· Controllable PFC ON/OFF Function Connection

INPUT VOLTAGE DERATING

The input voltage derating curve is shown in figure 6 below. The maximum output power should be within the limit of the derating curve, otherwise the AFF1K6W2 modules could be damaged.

Technical Notes

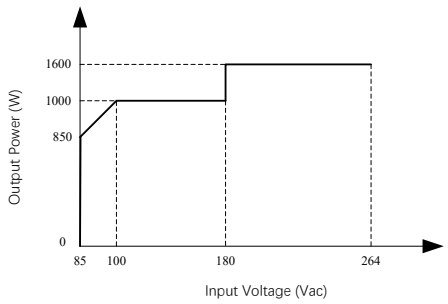


Figure 6· Input Voltage Derating Curve

AC INPUT FUSING

Certain applications may require fuse at the inputs of power conversion components. The AFF1K6W2 modules are not internally fused. We strongly recommend a slow-blown fuse to be used.
For safety agency approvals, the installer must install the converter in compliance with the end user safety standard.

INPUT UNDERVOLTAGE SHUTDOWN AND START-UP THRESHOLD

Once operating, module will not turn off until the input voltage drops below the Undervoltage Shutdown threshold. Subsequent re-start will not occur until the input is brought back up to the Start-Up Threshold. This built in hysteresis prevents any unstable on/off situations from occurring at a single input voltage.

THERMAL SHUTDOWN

These AFF1K6W2 converters are equipped with thermal shutdown circuit. If environmental conditions cause the internal temperature of the converter to rise above the designed operating temperature, a precision temperature sensor will power down the unit. When the internal temperature decreases below the threshold of the temperature sensor, the unit will auto restart.

HOLD-UP CAPACITOR

It requires 680~2200uF capacitor at the output to ensure the PFC module stable operation. It is strongly recommend to place the output capacitor as close as possible to the PFC module output, keep the trace less than 50mm to minimize the ESR. The specification of output capacitance is determined by customers' requirements on output voltage ripple, output voltage hold-up time, working life time of ouput capacitance and other factors.

Please follow up the hold-up capacitance formula to calculate the capacitance value according to the desired hold-up time.

$$Cmin = \frac{2 \times P \times Thold}{Vo^2 - Vf^2}$$

For example, when output power P=1600W, hold-up time Thold=20ms, output voltage Vo=400V, output minimum voltage Vf=250V, the minimum capacitance of the output hold-up capacitor Cmin=660μF.

The formula for calculating the RMS value of ripple current of the output hold-up capacitor is shown below:

$$Icrms = \frac{P}{2^{0.5} \times Vo}$$

For example, when output power P=1600W, output voltage Vo=400V, the RMS value of ripple current of the output hold-up capacitor Icrms=2.9A.

The formula for calculating the output voltage ripple is shown below:

$$Vpp = \frac{P}{4 \times \pi \times f \times C \times Vo}$$

For example, output power P=1600W, output voltage Vo=400V, input voltage frequency f=50Hz, output capacitance C=660μF, by the above formula, output voltage ripple is Vpp=9.7V.

INRUSH CURRENT SUPPRESSION

When the power supply is switched on and the capacitors (mainly the output hold-up capacitors) are charged, there will be inrush current. Excessive

Technical Notes

Inrush current may damage the fuse or other devices. The build-in Inrush current limit circuit can effectively suppress the peak inrush current. The current limiting resistor should be connected between R and +Vo. Reference connection circuit is shown in figure 7 below.

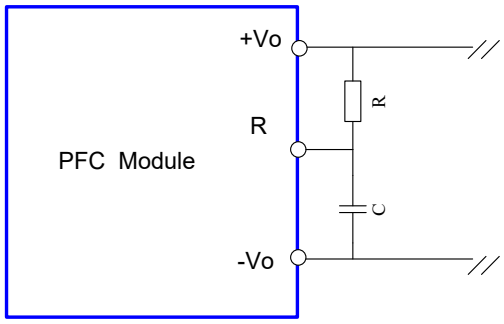


Figure 7· The Reference Connection of the Current-limiting Resistance

The recommended resistor is 10-20Ω with 10W power rating and the capacitor C is 1.0uf or plus with appropriate voltage rating. The maximum Inrush current can be evaluated by the following formula:

$$Irush = \frac{2^{0.5} \times Vac}{R}$$

The peak inrush current should be evaluated at 90° or 270° phase of AC input. In addition, the effect of X capacitance and inductance on inrush current in the filter circuit should also be considered.

TEMPERATURE DERATING

The temperature derating curve is shown below:

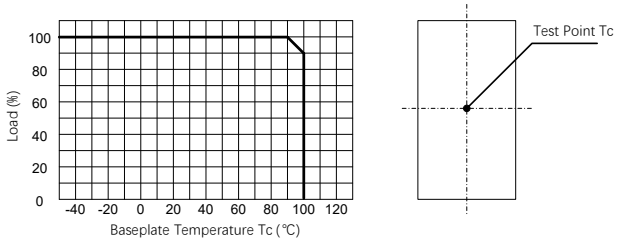


Figure 8· Temperature Derating Curve

In case that the recommended test point on the top of baseplate is not accessible, please measure the temperature at the edge of the baseplate, meanwhile, the thermal derating performance should be 5℃ less than the data presents on figure 8.

AC INPUT FILTER

Please refer to "typical application connection" on page 7.

CURRENT SHARE

The AFF1K6W2 PFC module does not support current share and parallel operating functions.

This product is subject to the following operating requirements and the Life and Safety Critical Application Sales Policy:
Refer to: http://www.densitypower.com

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