CFE400M

AC/DC Power Supply Series

APPLICATION NOTE

TDK·Lambda

Contents

1. INPUT

AC INPUT LINE REQUIREMENTS

See datasheet for specification of input line requirements (including Input voltage range, Input frequency, Input harmonics, Input current and leakage current)

The power supply will automatically recover from AC power loss and shall be capable of start-up under peak loading at 90VAC.
Repetitive ON/OFF cycling of the AC input voltage shall not damage the power supply or cause the input fuse to blow.

- Input Fuse
  Not user serviceable. Fast Acting, high breaking capacity, ceramic fuse.
- Input Undervoltage
  The power supply is protected against the application of an input voltage below the minimum specified so that it shall not cause damage to the power supply.
  The typical turn on voltage is 80V.
  The typical turn off voltage is 63V.

LOW LEAKAGE OPTIONS

	Target Spec (µA)	
Option	**Normal**	**Single Fault**
L	300.0	500.0

The conducted EMC performance shown in section 5 is with an L option.
Please contact technical sales for details of the EMC performance with other lower leakage options.

2. DC OUTPUT

OUTPUT VOLTAGES

All output channels except the fan supply are isolated from each other. The fan supply shares a common 0V with channel 1. See the datasheet for full specifications of the output, including setting range, output current, regulation, ripple & noise and setting accuracy.

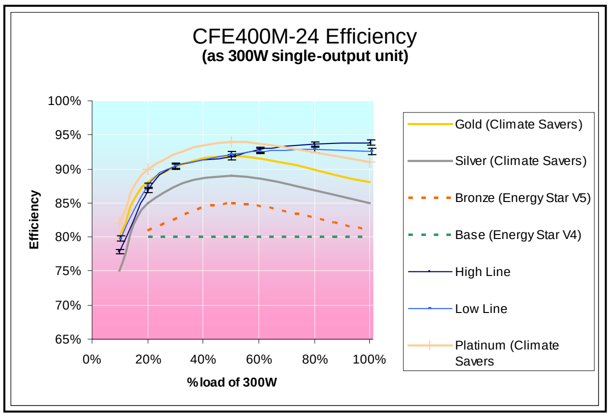
REMOTE SENSE

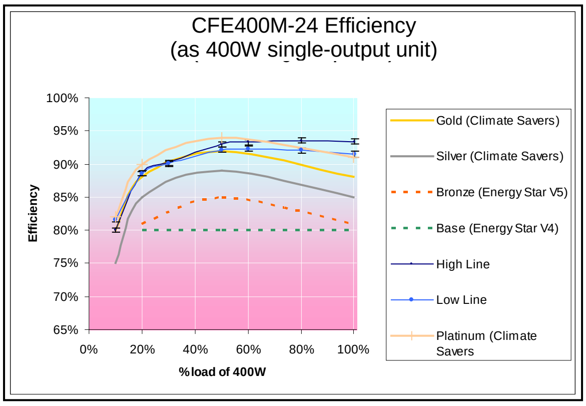
The remote sense connections can be used to compensate for cable drops of up to 0.5V total on Ch1.
The sense cables should be twisted together if possible.

EFFICIENCY

Note that the following charts show the efficiency of the main output channel. The efficiency chart will be slightly different if the Standby and fan supplies are used.

Figure 1. CFE400M Typical Efficiency





NO LOAD OPERATION

No minimum load is required for the power supply to operate within specification.

CAPACITIVE LOAD OPERATION

Maximum capacitance is 1000µF/A for 12 and 24V models, 500µF/A for 48V. For example CFE400-12 will supply 33.3A continuously (with forced air cooling) so will operate correctly with up to 33300µF of capacitance connected to the output.

SERIES CONNECTION

It is possible to connect multiple CFE in series. Do not exceed 1200V for the total voltage of outputs connected in series.
The outputs connected in series are non-SELV (Safety Extra Low Voltage) if the total output voltage + 30% of the highest maximum rated output voltage exceeds 60V (the 30% addition allows for a single fault in any one individual channel).

PARALLEL CONNECTION

Outputs must not be connected in parallel unless ORing Fets are used. There is an option to select an ORing FET Internal to the unit, which enables parallel connection without the need for additional, external ORing diodes. An ORing diode has a typical volt drop of 0.4-0.5 volts, for the CFE300M-12 this would result in a power loss in excess of 10 watts (at 25A) being dissipated into a heatsink fixed to the diode. The ORing FET scheme has a RDS on of typically 4-5mOhms, this results in a power dissipation of 2.5 watts.
To ensure correct operation of the Oring fet external capacitance must be fitted across the output.
The minimum value required is given in the table below

Nom Voltage	Minimum capacttance
12V	3300uF
24V	820uF
48V	220uF

This configuration can then be used to provide redundant N+1 operation, where the total output power is < the output power from 1 unit. Do not connect more than 2 power supplies in parallel. Because, if more than 2 units are in parallel in an N+1 redundant system, then 2 or more units are required to deliver the output power.
E.g. If 3 units are paralleled only 2 of them, units 1 & 2, may be delivering current. If unit 1 failed then unit 2 may enter current limit protection before unit 3 starts to deliver current. This would cause the whole system to fail.

If the total output power exceeds the output capability of 1 unit, then droop sharing should also be specified. It is possible to request units with current sharing provided by droop method. This relaxes the load regulation specification to provide improved sharing between parallel connected power supplies. Please contact technical sales for details.

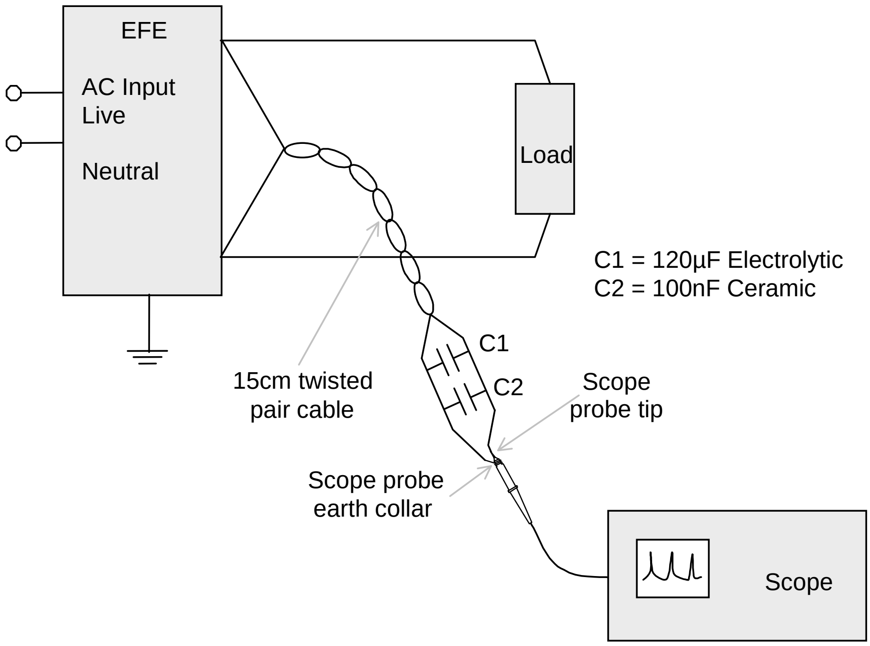
Improved sharing accuracy can be achieved by setting the output voltage of the 2 units as close together as possible. We recommend setting the voltage to the nominal required voltage with an accuracy of +/- 0.5% or better. This can be done by adjusting the potentiometer located by the output terminals.
To achieve the best sharing accuracy we recommend that remote sense connections are not used in parallel applications.
If units are paralleled for power then the Max power from the parallel pair is 720W.
Load transients that exceed 50% of the max power rating should be in the 30% to 100% range. With Io < 30% it is possible that only one unit will be delivering current, and it may enter current limit protection before the second unit can start to deliver current.
At start up if the load is > 50% of the max total power then the load should be held off until the power good signal goes high. (Otherwise one unit may enter current limit and prevent the pair from starting.)

OUTPUT CHARACTERISTICS

Ripple/Noise

Ripple and noise is defined as periodic or random signals over a frequency range of 10Hz to 20MHz. Measurements are to be made with an 20MHz bandwidth oscilloscope. Measurements are taken at the end of a 150mm length of a twisted pair of cables, terminated with a 100nF ceramic capacitor and a 120µF electrolytic capacitor. The earth wire of the oscilloscope probe should be as short as possible, winding a link wire around the earth collar of the probe is the preferred method.

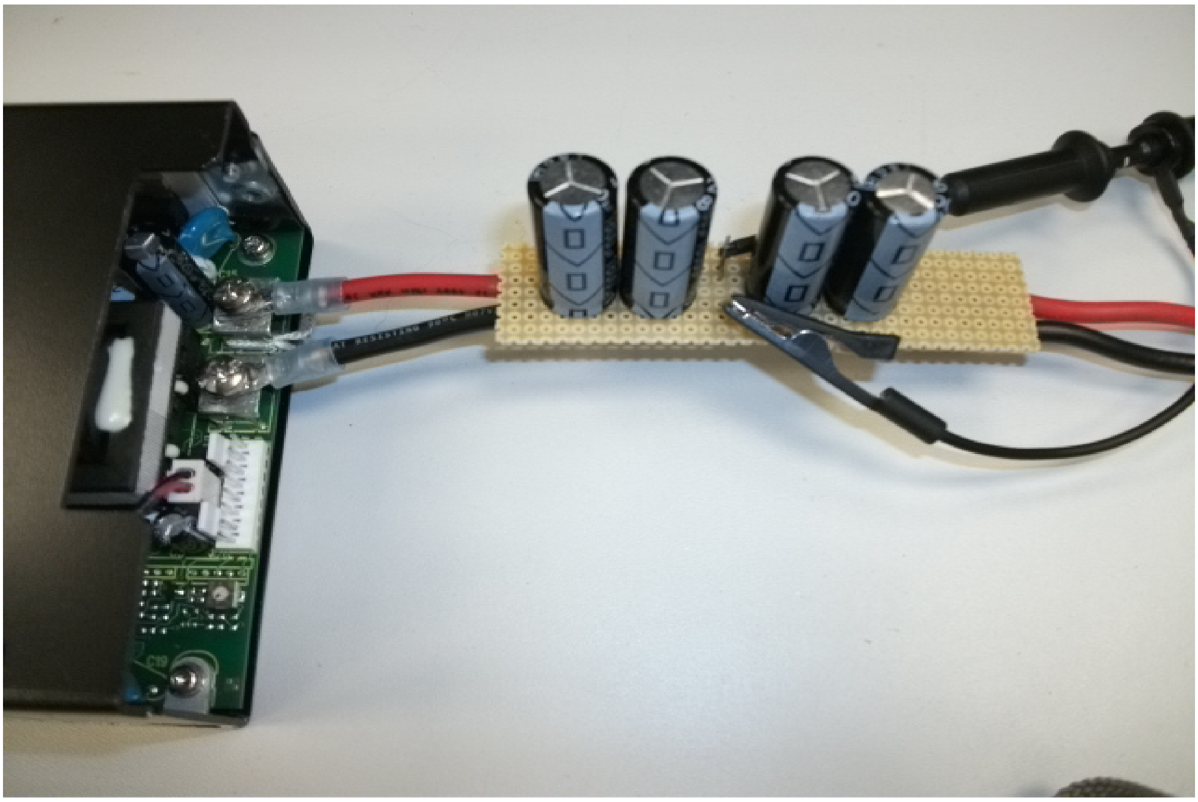
Figure 2. Ripple & Noise Measurement Method



Transient Response Performance

The transient response specification given on the data sheet refers to a single (non-repetitive) load transition. It states that for a 300W unit the output will remain within 5% of the set point for a transient = 50% (of 300W) within the 25% to 100% load range.

For a 400W unit the output will remain within 5% of the set point for a transient = 50% (of 400W) within the 25% to 100% load range, with additional external capacitance.
E.g. A 12V unit needs 7200uF. (4 x 1800uF/25V low esr caps.)



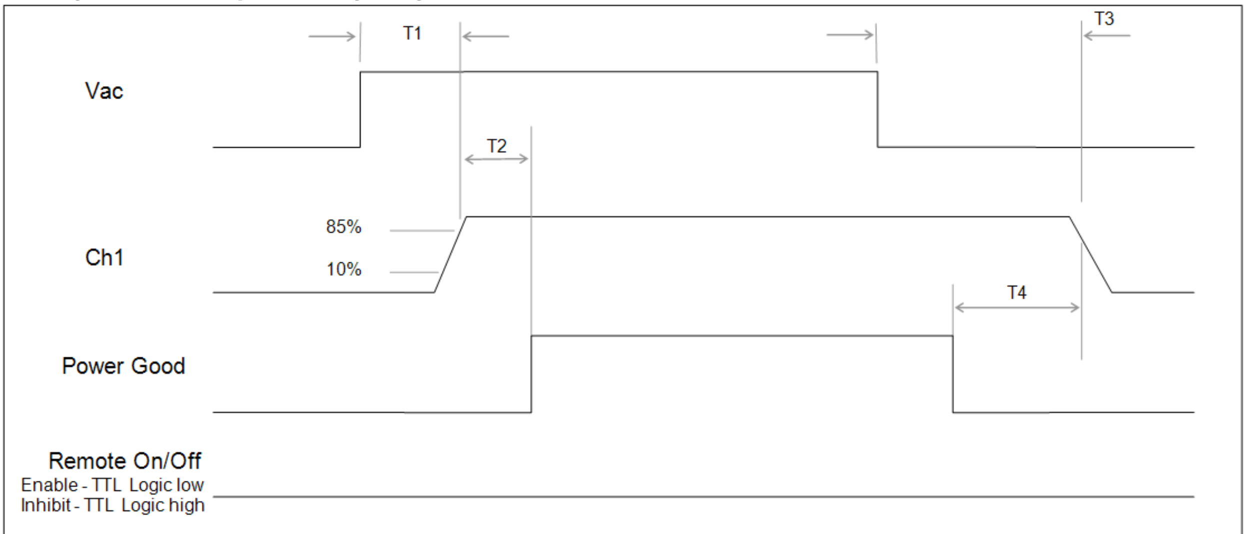
Test set up

Load transients cause the output voltage to momentarily deviate from the set point, while the control circuit adjusts to the new conditions to achieve regulation.

If a load transient goes to no load the output voltage will rise, and it will take a significant time to discharge the output capacitors. If a positive load transient is applied before the output has got back to the set point, then a larger voltage deviation can occur.
To prevent this, a minimum load is required to discharge the output capacitors before the next transient is applied.
E.g. A 12V, 400W unit with 7200uF of external capacitance and a load transient of 50%, with a repetition rate of 100Hz and a 50% duty cycle. Will need a minimum load of 5% to keep the voltage deviations to <5%. Larger transients and / or faster repetition rates would require a larger minimum load.

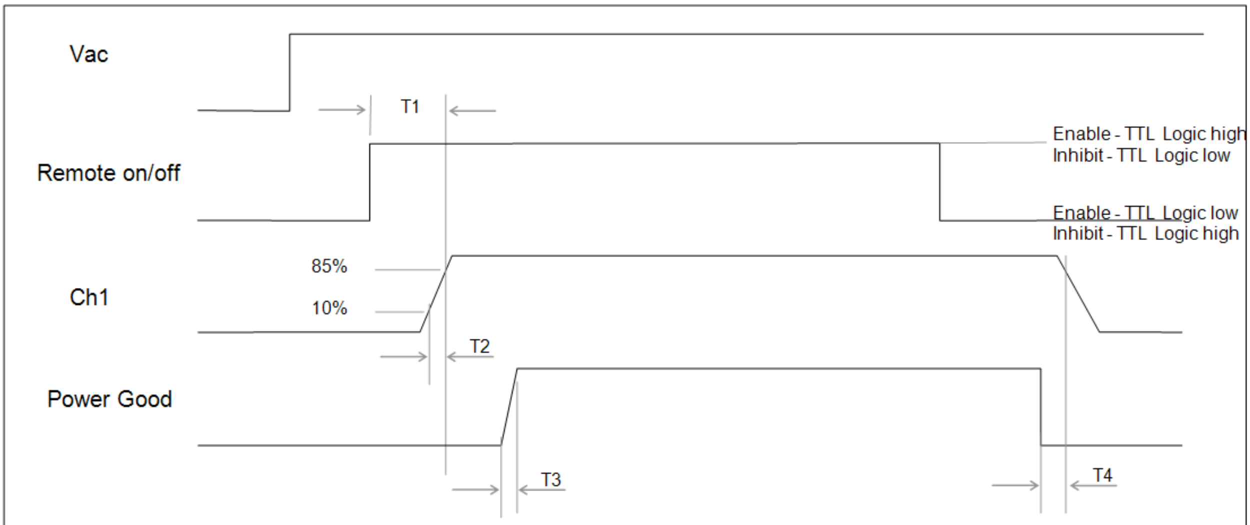
POWER SUPPLY TIMING

Figure 3. Output timing diagram



	min	Typical	max	Description
T1			1.5s	Turn on time
T2	100ms		500ms	Power good hold off time
T3		17ms		Hold up time @ 400W
T4	5ms			Power good warning time

Figure 4. Output Timing Diagram (Remote ON/OFF Control)



	min	Typical	max	Description
T1			500ms	Power-on time (enable to Ch1 in regulation)
T2	0.1ms		25ms	Ch1 rise time
T3		10ms		Power good rise time
T4	1ms			Power down warning

STANDBY SUPPLY

An output that is isolated from the other output channels. It is not affected by the remote on/off.
5V / 0.08A and 5V / 2A versions are available (selectable at time of ordering)

FAN SUPPLY

The type of fan supply available is determined by the Case/Fan Option.
The return (-Ve) lead of the fan supply should be connected to the main 0V terminal.
The fan supply is a nominal 12V supply rated at 0.25A. The fan supply requires a minimum load on the main channel of 1.2W.
The fan supply voltage varies with the load and voltage on the main channel.

POWER GOOD SIGNAL

The Power Good signal is a TTL level signal. Logic high indicates ac supply is good and Channel 1 is within regulation. It is delayed after start-up to ensure that sufficient primary side energy is stored by the power supply for continuous power operation within the specified hold-up time. When the AC power is removed the Power Good Signal will go to a logic low. The specifications for the Power Good Signal are contained below

Signal Type	TTL referenced to 0V of standby supply
Source Current	1mA
Sink Current	5mA

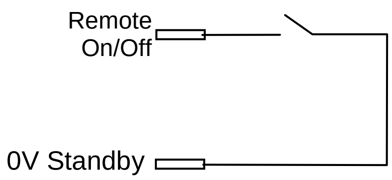
REMOTE ON/OFF – GLOBAL ON/OFF

The Standby supply is not affected by the Remote On/Off input.

Maximum input voltage – 5V
The remote On/Off pin has an internal 10Kohm pull up resistor connected to the standby supply.

Max source current = 0.55mA
Logic Low < 1.5V
Logic High > 3.5V

Figure 5. Example uses of 'Remote On/Off'



	Remote on/off type	
Switch State	Inhibit (T)	Enable (E)
Open	On	Off
Closed	Off	On

'On' indicates power supply operating.
'Off' indicates channel 1 and fan supply not operating. Standby continues to operate

TDK·Lambda

OVERSHOOT AT TURN ON/OFF

The output voltage overshoot upon the application or removal of the input mains voltage shall be less than 10% above the nominal voltage. No voltage of opposite polarity shall be present on any output during turn on or turn off.

OUTPUT PROTECTION

No Load Operation

The power supply will operate with no load on all outputs with no damage, hazardous condition or reduction in performance.

Overload Protection

The power supply will operate for up to 10 seconds at the peak output power specified on the datasheet. After this time, the power supply will shut down for approximately 75 seconds before resuming output. To prevent this shut down, remove the overload condition

Over current protection

If a load is applied which takes the power supply into over current then the power supply will enter a hiccup state. This will turn the output on for approximately 50ms then off for approximately 2 seconds. This state will continue until the over current is removed.

Short-Circuit Protection

A short circuit is defined as an impedance of <0.1 Ohms placed between the DC return and any output. A short circuit on the main output or the standby supply will cause no damage to the power supply and will cause it to shutdown. The power supply will attempt to restart until the short-circuit is removed. After removal of the short circuit, the power supply will maintain normal operation.
A short circuit on the Fan Supply will stop the fan, but the other outputs will be unaffected. The unit may then enter over temperature protection.

Over temperature protection

If the CFE is operated without adequate cooling, it will cause an over temperature condition and the power supply will either shut down or enter a thermal hiccup mode of operation. To correct this, improve the cooling of the power supply, remove the ac supply for 10 seconds and then reapply.

Over voltage protection

An overvoltage on CH1 will cause the whole power supply to shutdown. To restart the PSU, remove the ac supply for 10 seconds and then reapply.

3. COOLING REQUIREMENTS

Convection Cooling

The maximum continuous rating of the main channel (Ch1) is 300W up to 40°C, with the power supply mounted on an aluminium plate 480mm x 130mm x 3mm. The ambient temperature is measured 20mm above the base plate 50mm from the input connector. This rating is not affected by the mounting orientation. Please see the handbook for allowable orientations

Above this temperature, the total output power (and individual output currents) must be derated by 2.5%/°C up to 60°C.

Forced Air Cooling

The maximum continuous rating of the main channel (Ch1), with the power supply mounted in a 1U tray 135mm wide, is 400W up to 50°C with a minimum of 1.5m/s (approximately 10CFM) of forced-air cooling. Above this temperature, the total output power (and individual output currents) must be derated by 2.5%/°C up to 70°C. The fan supply and standby supply are in addition to this power. The recommended air flow direction is from input to output.

Refer to the de-rating curve in the temperature section of the data sheet.

Refer to the handbook for the test method and components to be monitored to ensure safe, reliable operation.

Top Fan Option

The fan blows air down into the unit. There should be no obstructions within 50mm of the fan intake or either end of the unit, to allow unimpeded movement of air.

Refer to the data sheet for the dimensions and position of the fan.

Fan Noise

The charts show the sound pressure level spectrum of typical units. The sound measurements were taken 1 metre away from and directly in line with the fan. Results are 'A' weighted.

Figure 6. Microphone horizontal to unit:

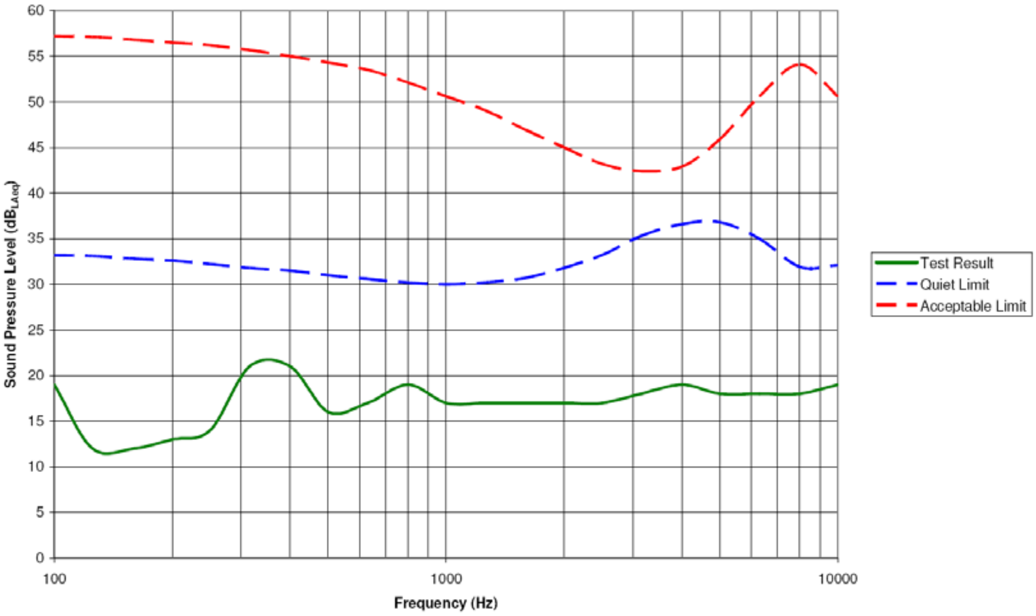
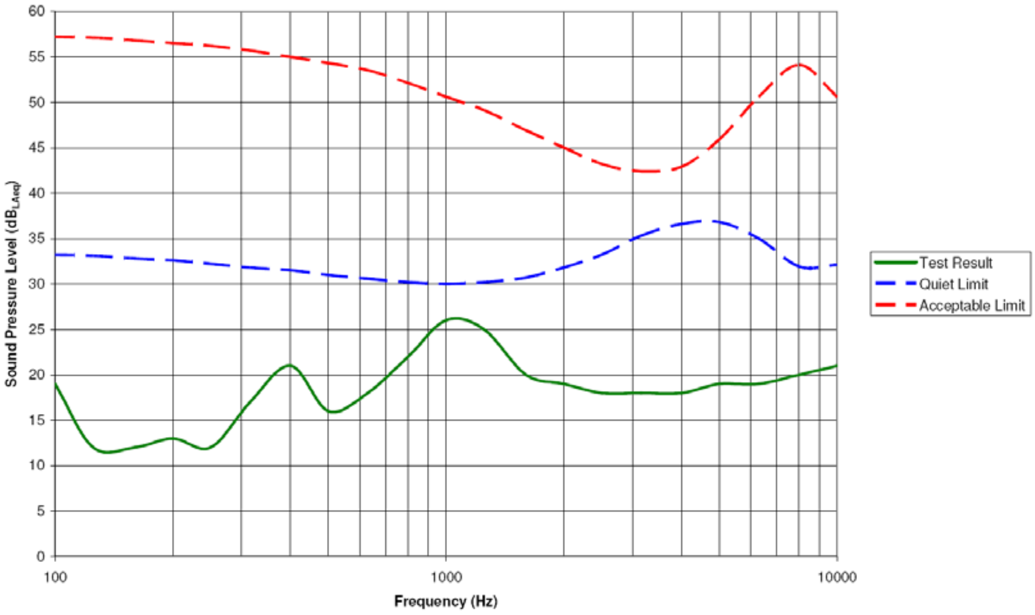


Figure 7. Microphone vertical (directly above fan) to unit.



TDK-Lambda

4. RELIABILITY

Calculated to Telcordia Issue 1, Method I, Case 3, Ground Benign, Controlled at 100% duty cycle, in Failures Per Million Hours (FPMH):

	300W Convection							
Block Description	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C
Common Component block	0.9068	1.2494	1.8125	2.4957	3.6261	5.3585	8.0267	12.1320
12V Channel 1	0.1717	0.2298	0.3138	0.4361	0.6137	0.8708	1.2402	1.7664
24V Channel 1	0.1585	0.2194	0.3062	0.4302	0.6068	0.8572	1.2104	1.7046
5V 0.1A Standby	0.0274	0.0376	0.0517	0.0712	0.0979	0.1343	0.1834	0.2491
5V 2A Standby	0.1239	0.2110	0.3679	0.6479	1.1390	1.9821	3.3964	5.7141

	400W Forced Air							
Block Description	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C
Common Component block	0.6621	0.8874	1.2566	1.6166	2.2091	3.0549	4.2826	6.0888
12V Channel 1	0.1011	0.1263	0.1614	0.2114	0.2838	0.3892	0.5434	0.7680
24V Channel 1	0.0831	0.1108	0.1503	0.2074	0.2907	0.4126	0.5907	0.8495
5V 0.1A Standby	0.0119	0.0164	0.0228	0.0316	0.0441	0.0614	0.0855	0.1186
5V 2A Standby	0.0374	0.0538	0.0801	0.1238	0.1990	0.3303	0.5599	0.9573
Cover + Top Fan	0.1107	0.2232	0.4464	0.6266	1.7722	3.5444	7.0888	14.1776

All selectable options, except the communications option, not shown in above tables contributed less than 1% to the total figure, so for simplicity are included in the common component block. The communications option is still under development.

To calculate the MTBF, sum the FPMH for the component parts at the required temperature, the common component block is required with all configurations. This gives total failures per million hours (FPMH). Convert this to MTBF by dividing 1,000,000 by the total FPMH.

For example:-
To calculate the MTBF for **CFE400M-12V-5C**, convection cooled at 300W, at 20°C ambient.
(5C = 0.1A standby supply)

Common component block	1.8125
12V channel 1	0.3138
5V 0.1A standby	0.0517
Total FPMH	2.1780

Therefore MTBF = 1,000,000 / 2.1780 = **459,137** hours (459k hours)

To calculate the MTBF for **CFE400M-24V-5H**, fan cooled at 400W, at 30°C ambient.
(5H = 2A standby supply)

Common component block	1.6166
24V channel 1	0.2074
5V 2A standby	0.1238
Cover + Top Fan	0.6266
Total FPMH	2.5744

Therefore MTBF = 1,000,000 / 2.5744 = **388,440** hours (388k hours)

5. ELECTROMAGNETIC COMPATIBILITY

Figure 8. Typical Conducted Emissions result at 300W convection cooled:

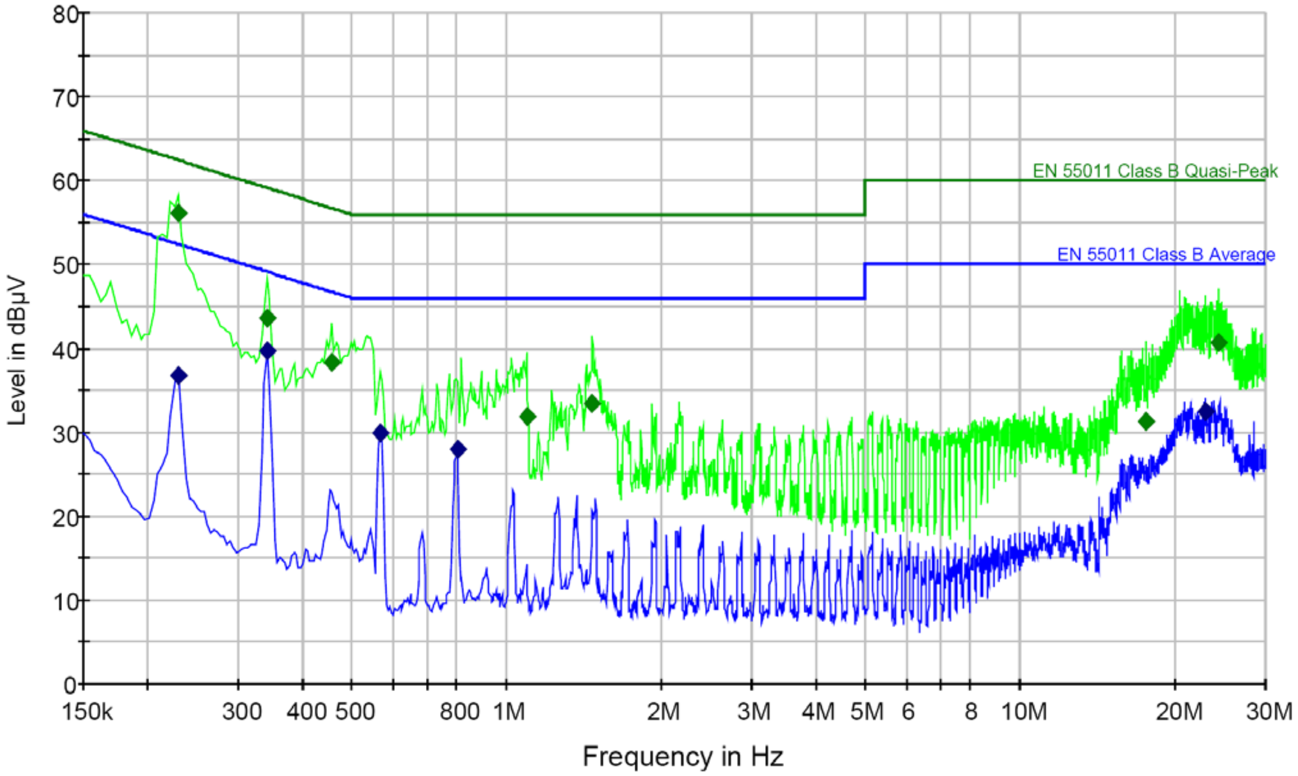
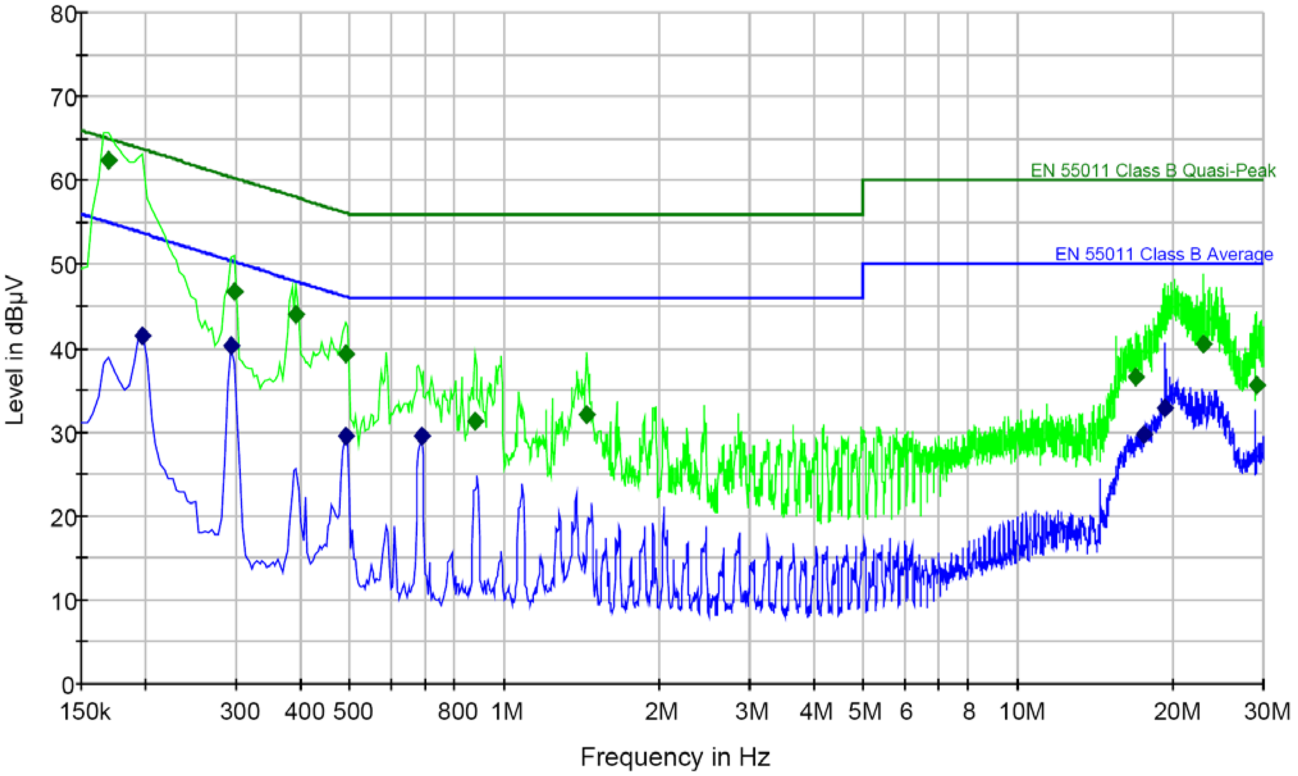


Figure 9. Typical Conducted Emissions result at 400W fan cooled:



INSTALLATION FOR OPTIMUM EMC PERFORMANCE

Mounting

All equipment should be mounted inside an earthed metal box.
If this is not possible then use an earthed metal plane to mount the power supply and load.

Cables

All cables (both ac input and dc output) should be run as close as possible to the earthed metal box/plane.
AC input cable should be a twisted group laid as flat to the earthed metal box/plane as possible.

All output cables should be routed as far away from input cables as possible.
If the input and output cables must be run close to each other then screen one or other (or ideally both).

The positive and negative supply cables should be twisted together.
All cable run loops should be kept as small as possible (this should be implemented in PCB design also).

Connecting between boxes

If cables must be connected between equipment boxes then at the closest possible point to the port where the cables exit the 1st enclosure connect 100nF decoupling Y caps (between the output and earth). Note that these capacitors must be rated at the working voltage. Ideally these capacitors should be between all signal cables which have to connect between boxes although this may not be practical if fast switching [digital] signals are involved (if this is the case then smaller value Y capacitors should be used).

Earth star point

Where the ac supply enters the equipment, this should be taken to a 'star point' chassis mounted earth point (Note compliance with EN60950-1 practices which require the main protective earth to have its own dedicated spring washer and nut) as close as possible to the mains inlet. All other earth points should be taken back to this point only.

ESD Protection

Where signal or control ports are connected to a user accessible panel (for example PSU inhibit to a switch, module good to an indicator circuit, etc), these ports must be protected from electrostatic discharges. This can be done by selecting suitable panel controls or by fitting ESD suppression devices to the connections on the panel.

Switching frequency

The resonant converter has a variable switching frequency. The minimum frequency (at full load) is typically 80KHz, increasing to 400KHz. Frequencies up to 700KHz may occur during large scale transients e.g. start up.

The PFC converter has a variable switching frequency. It contains 2 interleaved critical conduction (or boundary) mode converters running 180 deg out of phase. The frequency varies over a half cycle of mains and also with input voltage and output power. The minimum frequency of each converter, occurring at the peak of the mains at low line voltage and maximum load, is 60KHz. Giving a combined fundamental frequency of 120KHz.

The standby supply and internal house keeping supply run at a fixed frequency of 100KHz.

6. CONNECTION

AC Input Connector (J1)

Molex kk	
09-50-8051	Molex housing part number
08-52-0113	Molex crimp part number
94910	TDK-Lambda part number for 1 housing + 3 crimps

AC Input Connector (J1) Pin Definition (All units)

Pin	Function
J1-1	Earth – chassis/safety ground
J1-2	Do not connect
J1-3	Live
J1-4	Do not connect
J1-5	Neutral

Output (J2)

Molex part numbers		Crimps required	TDK-Lambda Kit Part Number (kit includes 1 housing and sufficient crimps for the connector)
Housing	Crimp		
22-01-2085	0850-0032	8	95109

Output Connector (J2) Pin Definition CFE400M

See datasheet for drawing of output connector.

Pin	Connection
J2-1	Fan supply
J2-2	Remote on/off
J2-3	Power good
J2-4	Fan supply return
J2-5	Standby supply return
J2-6	Standby supply +Ve
J2-7	-Ve sense
J2-8	+Ve sense

7. MOUNTING

Please refer to handbook for allowable orientations.

versions to be mounted using all four fixings on the bottom of the unit or the fixing holes on the side of the unit.

8. WEIGHTS

Unit	Unit	Weight (g) typ
CFE400M	U chassis	729
CFE400M	U Chassis + cover	793
CFE400M	U Chassis + Top fan	

9. TEST RESULTS

Detailed test results are available online from: -

http://testcert.emea.tdk-lambda.com/

You will need the serial number and product code of the unit to retrieve the test results for the unit. Test results are not packaged with the unit. This ensures that the test results will be available for the CFE unit for the whole life of the power supply (not just when the unit is unpacked as with the more traditional printed test results).