
350 W CCM PFC pre-regulator demonstration board based on the L4984D

Data brief



Description

The EVL4984-350W demonstration board, based on the new L4984D continuous conduction mode PFC controller, implements a 350 W wide-range input PFC pre-conditioner. It is suitable for all SMPS from 150 W to several kW, and is compliant with IEC61000-3-2 and JEITA-MITI standards.

Features

- Line voltage range: 90 to 265 V_{ac}
- Minimum line frequency (f_L): 47 Hz
- Regulated output voltage: 400 V
- Rated output power: 350 W
- Maximum 2 fL output voltage ripple: 12.5 V (peak-to-peak)
- Hold-up time: 20 ms (VDROP after hold-up time: 300 V)
- Switching frequency: 70 kHz
- Minimum efficiency: 94% (at V_{in} = 90 V_{ac}, P_{out} = 350 W)
- PCB: single-side, 70 um, CEM-1, 112 x 114 mm

1 General information and electrical schematics

The main purpose of a PFC pre-conditioner is to correct input current distortion in order to decrease the harmonic contents below the limits of the relevant regulations. Therefore, this demonstration board has been tested in accordance with the European standard EN61000-3-2 Class-D and Japanese standard JEITA-MITI Class-D at full load and at both the nominal input voltage mains.

The power stage of the PFC is a traditional boost PFC converter, connected to the output of the rectifier bridge D2. It is made up of the boost inductor L3, the power switch consisting of the parallel of MOSFETs Q1 and Q2, diode D3, and the output capacitors C3 and C4.

The 300 V varistor RV1, connected between the line and neutral, protects the circuit against high input voltage transients, while the F1 fuse disconnects the mains in case of short-circuit.

To meet EMC standards, the board is equipped with an input EMI filter, cutting the switching noise coming from the boost stage. In particular, L2 filters common mode emissions while L1, C1, and C2 reduce differential mode emissions.

The L4984D must be supplied by an external power supply, connected between pin #1 (VCC) and pin #2 (GND) of J3.

The capacitor C14, connected to the TIMER (#7) pin, determines the switching frequency. The resistor divider R12, R16, R22 and R24 provides the information regarding the instantaneous mains voltage to the L4984D multiplier (MULT, #3), which is used to modulate the peak current of the boost and the TOFF duration, and is fed to the VFF block.

The resistors R6, R8, R13 with R17 and R18 are dedicated to sensing the output voltage and feeding, to the inverting input of the error amplifier (INV, #1), the feedback information necessary to keep the output voltage regulated. Between the INV (#1) and COMP (#2) pins, components C8, R21 and C11 form the error amplifier compensation network to maintain the required loop stability.

The inductor peak current is sensed by resistors R27, R30, and R31 placed in series with the MOSFET source and the derived signal is fed into the current sense pin (CS, #4) of the L4984D via the filter by R29 and C13. C15 and R28, connected to the VFF pin (#5), complete an internal peak-holding circuit providing information on the RMS mains voltage, deriving a DC voltage equal to the peak of the MULT (#3) voltage, which is fed to the multiplier to compensate the control loop gain dependence on the mains voltage.

The brownout function is also implemented by this pin. A voltage below 0.8 V on the VFF pin (#5) shuts down (no latch) the IC and brings its consumption to a considerably lower level. The L4984D starts as the voltage at the pin rises above 0.88 V.

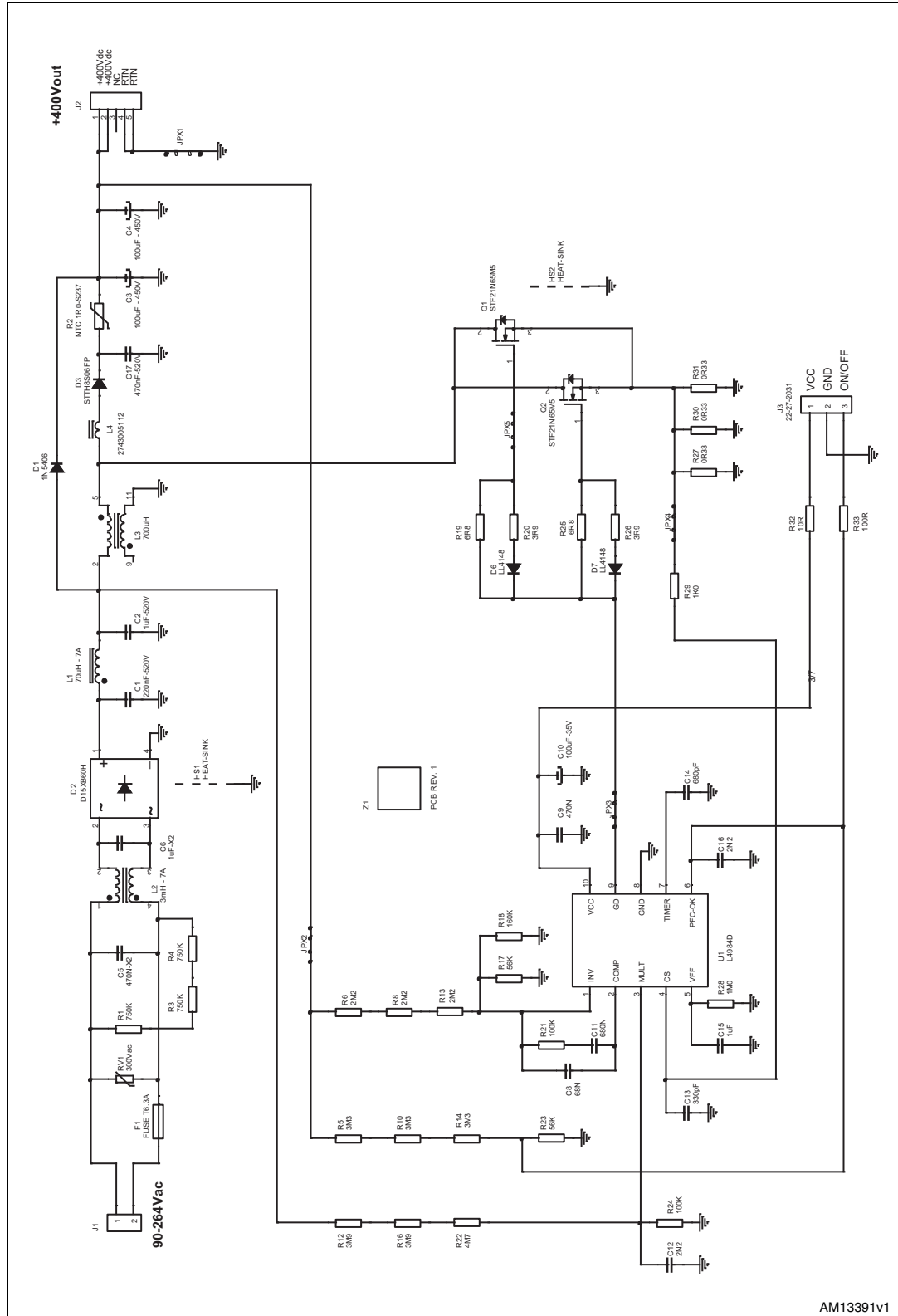
The divider R5, R10, R14 and R23 provides the information regarding the output voltage level to the L4984D PFC_OK pin (#7), to implement the so-called dynamic OVP protection, preventing the output voltage from excessive values during the load transients due to the slow response caused by the intrinsic narrow bandwidth of PFC systems. If the voltage on the PFC_OK pin (#7) exceeds 2.5 V, the L4984D stops switching, and restarts as the voltage on the pin falls below 2.4 V.

The open loop protection (also called feedback failure protection) is realized by monitoring the PFC_OK (#7) and INV (#1) pins. If the voltage on the PFC_OK pin (#7) exceeds 2.5 V, and at the same time the voltage on the INV pin (#1) falls below 1.66 V, a feedback failure is assumed and the device is latched off. Normal operation can be resumed only by cycling

V_{CC} (#10), bringing its value lower than the VCCrestart (6 V, typ), before moving up to the turn-on threshold VCCon (12 V, typ).

Additionally, a remote on/off control input is present. If the voltage on the PFC_OK pin (#7) is tied below the PFC_OK disable threshold (VPFC_OK_D, 0.23 V typ.), the L4984D is shut down and the operation is restarted when the voltage on the PFC_OK pin (#7) increases above the PFC_OK enable threshold (VPFC_OK_E, 0.27 V typ.). L4984D operation can also be disabled or enabled to properly manage light load or failure by the D2D via the PFC_OK pin (#7), using pin #3 of J3 (ON/OFF).

Figure 1. EVL4984-350W CCM PFC demonstration board electrical schematic



2 Test results and significant waveforms

2.1 Harmonic content measurement

As shown in the illustrations that follow, the circuit can reduce the harmonics well below the limits of the previously-mentioned standards, from full load down to light load. An output power of 70 W was chosen because it is near the lowest power limit at which the harmonics must be limited according to these standards.

Figure 2. EVL4984-350W: compliance with EN61000-3-2 standard at full load

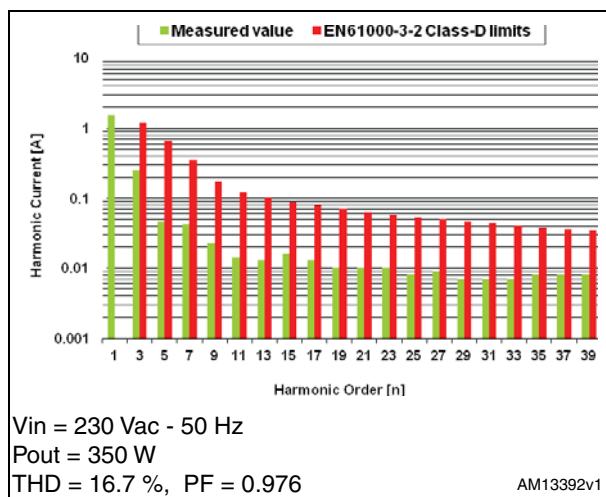


Figure 3. EVL4984-350W: compliance with JEITA-MITI standard at full load

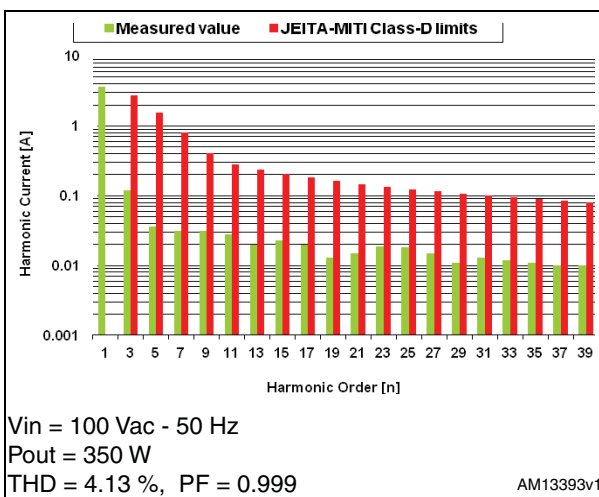


Figure 4. EVL4984-350W: compliance with EN61000-3-2 standard at 70 W load

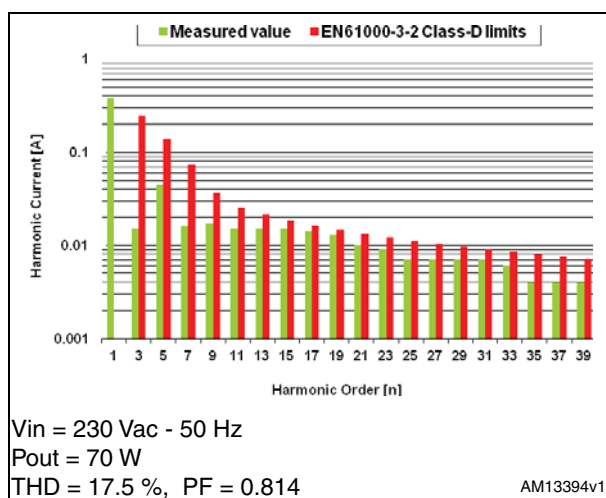
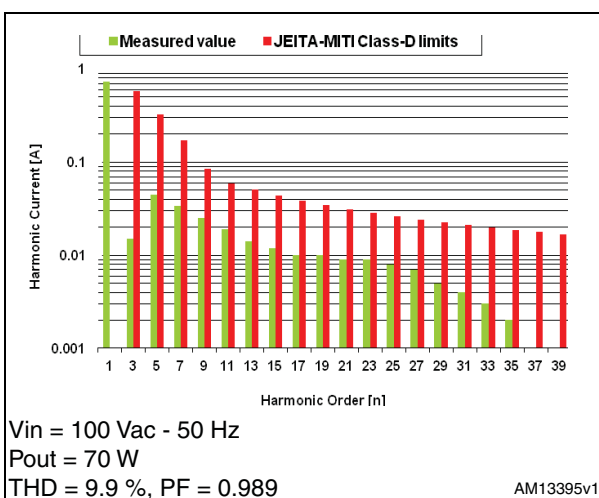


Figure 5. EVL4984-350W: compliance with JEITA-MITI standard at 70 W load



3 Bill of material

Table 1. EVL4984-350W CCM PFC demonstration board bill of material

Des.	Part type/ part value	Case style/ package	Description	Supplier
C1	220 nF-520 V	7.5X26.5 mm	520 V-FLM CAP - B32673T5224	EPCOS
C2	1 uF-520 V	10.5X26.5 mm	520 V-FLM CAP - B32673Z5105	EPCOS
C3	100 uF-450 V	Dia. 18X40 mm	450 V - aluminum ELCAP-KXG series-105 °C	Nippon-Chemicon
C4	100 uF-450 V	Dia. 18X40 mm	450 V - aluminum ELCAP-KXG series-105 °C	Nippon-Chemicon
C5	470N-X2	10.5X26.5 mm	X2-FLM CAP - B32923A3474M	EPCOS
C6	1 uF-X2	11X26.5 mm	X2-FLM CAP - B32923C3105	EPCOS
C8	68N	0805	100 V CERCAP - general purpose - X7R - 10%	AVX
C9	470N	1206	100 V CERCAP - general purpose - X7R - 10%	KEMET
C10	100 uF-35 V	Dia. 8X11 mm	50 V - aluminum ELCAP-YXF series - 105 °C	Rubycon
C11	680N	0805	25 V CERCAP - general purpose - X7R - 10%	KEMET
C12	10N	0805	50 V CERCAP - general purpose - X7R - 10%	KEMET
C13	330 pF	0805	50 V CERCAP - general purpose - COG - 5%	EPCOS
C14	680 pF	0805	50 V CERCAP - general purpose - COG - 5%	EPCOS
C15	1 uF	1206	50 V CERCAP - general purpose - X7R - 10%	TDK
C16	2N2	0805	50 V CERCAP - general purpose - X7R - 10%	KEMET
C17	470 nF-520 V	7X26.5 mm	520 V - FLM CAP - B32673Z5474K***	EPCOS
D1	1N5406	DO-201	Rectifier - general purpose	Vishay
D2	D15XB60H	DWG	Single-phase bridge rectifier	Shindengen
D3	STTH8S06FP	TO-220	Ultrafast high voltage rectifier	ST
D6	LL4148	Mini-melf	High speed signal diode	Vishay
D7	LL4148	Mini-melf	High speed signal diode	Vishay
F1	FUSE T6.3A	4x8.5 mm pitch 5.08 mm	Sub-miniature fuse 392/TE5 - time delay 6.3 A	Littelfuse
HS1	Heatsink	DWG	Heatsink for D2	Meccal
HS2	Heatsink	DWG	Heatsink for Q1, Q2 & D3	Meccal
J1	09-65-2038	DWG	KK PCB Conn. - straight - pitch 3.96 mm - 3 pins (centrally removed)	Molex
J2	10-16-1051	DWG	KK PCB Conn. - straight - pitch 5.08 mm - 5 pins (centrally removed)	Molex
J3	22-27-2031	DWG	KK PCB Conn. - straight, pitch 2.54 mm - 3 pins	Molex
JPX1	Shorted	WIRE	Wire jumper	-

Table 1. EVL4984-350W CCM PFC demonstration board bill of material (continued)

Des.	Part type/ part value	Case style/ package	Description	Supplier
JPX2	Shorted	WIRE	Wire jumper	-
JPX3	Shorted	WIRE	Wire jumper	-
JPX4	Shorted	WIRE	Wire jumper	-
JPX5	Shorted	WIRE	Wire jumper	-
L1	70 uH - 7 A	DWG	DM inductor - 1119.0013	Magnetica
L2	3 mH - 7 A	DWG	EMI filter - 1606.0007	Magnetica
L3	700 uH	DWG	PFC inductor - 2097.0002	Magnetica
L4	2743005112	DWG	Ferrite bead dia. 3.5x6 mm vertical	Fair-Rite
Q1	STF21N65M5	TO-220FP	N-channel power MOSFET	ST
Q2	STF21N65M5	TO-220FP	N-channel power MOSFETpower MOSFET	ST
R1	750 K	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	Vishay
R2	NTC 1R0-S237	Dia. 15x7 p. 7.5 mm	NTC resistor P/N B57237S0109M000	EPCOS
R3	750 K	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	Vishay
R4	750 K	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	Vishay
R5	3M3	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R6	2M2	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R8	2M2	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R10	3M3	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R12	1M0	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R13	2M2	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R14	3M3	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R16	1M0	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R17	56 K	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R18	160 K	1206	SMD standard film res. - 1/4W - 1% - 100 ppm/°C	Vishay
R19	6R8	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R20	3R9	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R21	100 K	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R22	1M0	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	Vishay
R23	56 K	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	Vishay
R24	24 K	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R25	6R8	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R26	3R9	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R27	0R33	PTH	RSMF1TB - metal film res. - 1 W - 2% - 250 ppm/°C	Akaneohm

Table 1. EVL4984-350W CCM PFC demonstration board bill of material (continued)

Des.	Part type/ part value	Case style/ package	Description	Supplier
R28	1M0	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	Vishay
R29	1 K0	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R30	0R33	PTH	RSMF1TB - metal film res. - 1 W - 2% - 250 ppm/°C	Akaneohm
R31	0R33	PTH	RSMF1TB - metal film res. - 1 W - 2% - 250 ppm/°C	Akaneohm
R32	10R	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	Vishay
R33	100R	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	Vishay
RV1	300 V _{ac}	Dia. 15x5 p. 7.5 mm	300 V metal oxide varistor - B72214S0301K101	EPCOS
U1	L4984D	SSOP10	CCM PFC controller	ST
Z1	PCB REV. 1			

4 Revision history

Table 2. Document revision history

Date	Revision	Changes
09-Oct-2012	1	Initial release.
31-May-2013	2	Updated title in cover page. Minor text changes.

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