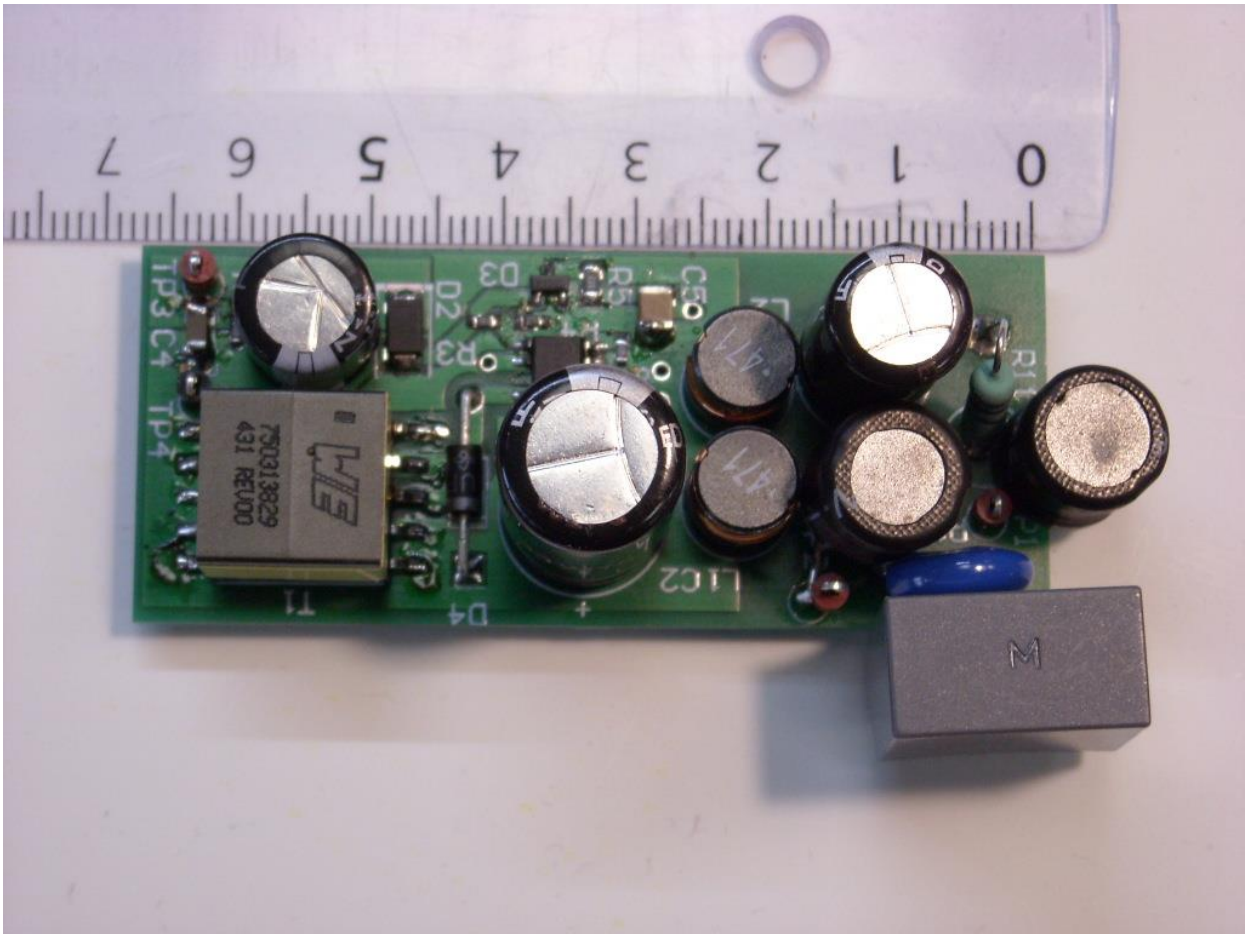
1 Photo of the prototype:

The reference design PMP10083 Rev_B has been built on PMP8583 Board

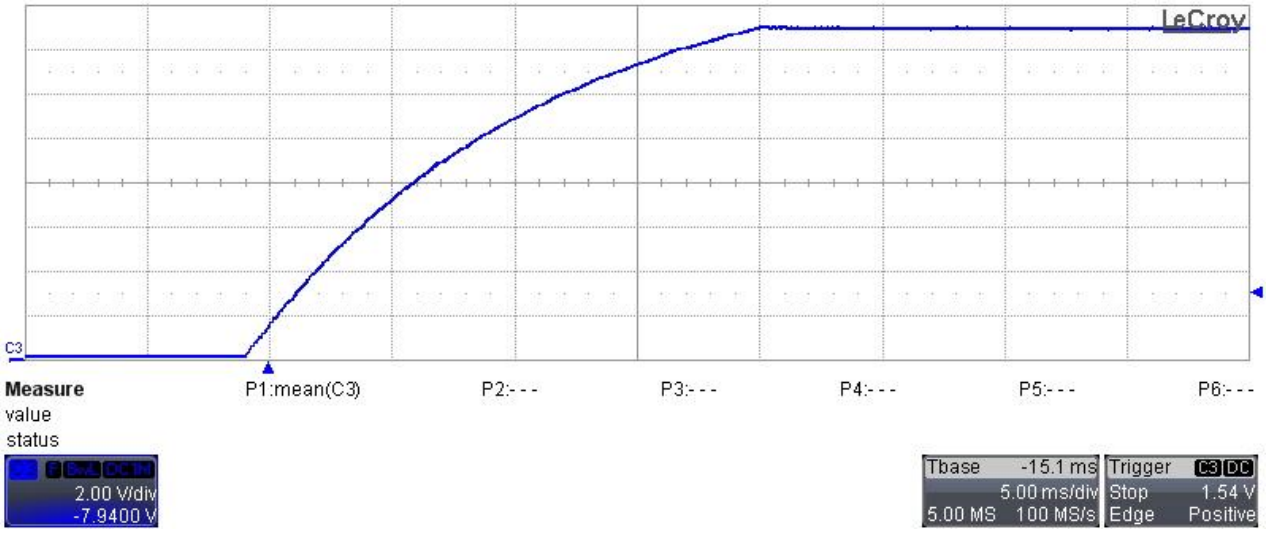


2 Startup

The output voltage behavior versus load and input DC voltage is shown in the images below. The input voltage was set respectively to 130Vdc and 375Vdc.

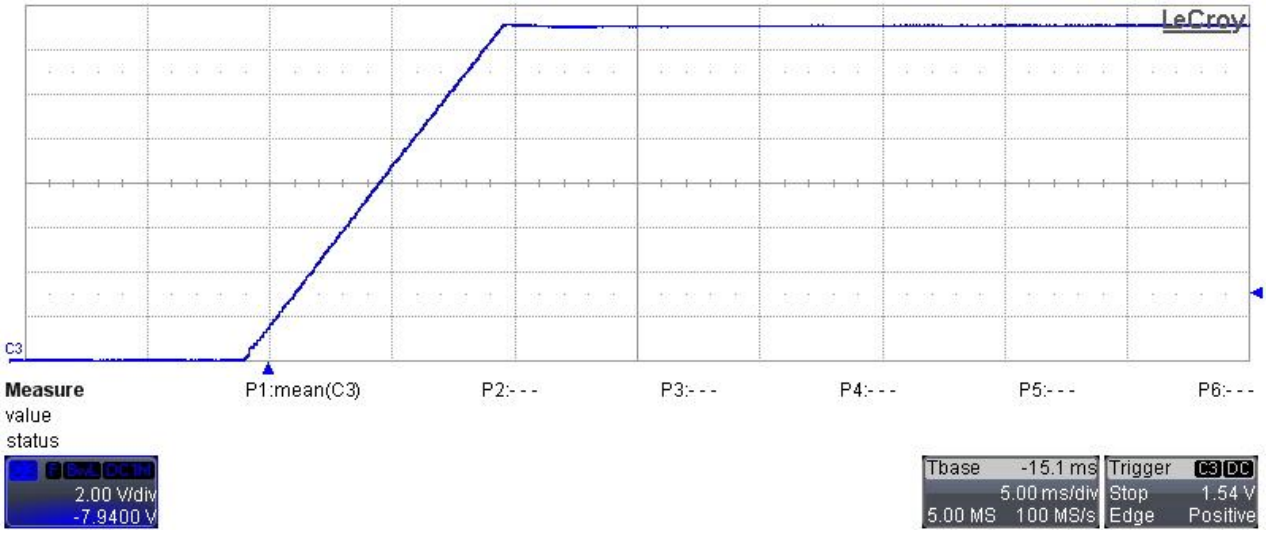
Ch.3: Output voltage (2V/div, 5ms/div, 20MHz BWL)

Resistive load = 37 Ohm, Vin = 130Vdc:

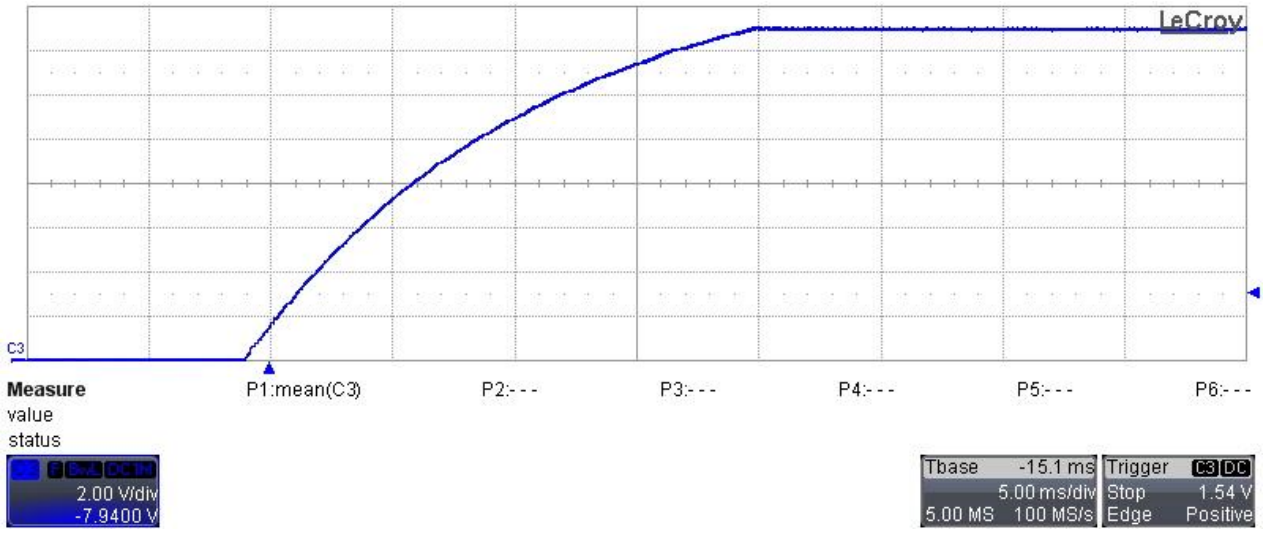


Ch.3: Output voltage (2V/div, 5ms/div, 20MHz BWL)

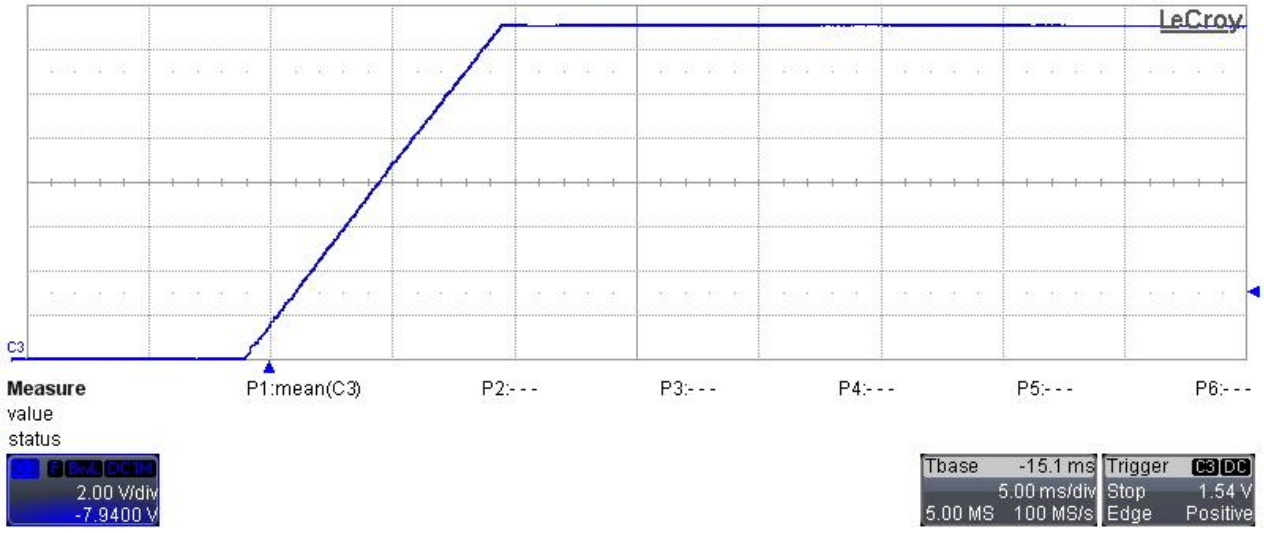
Zero load, Vin = 130Vdc:



Ch.3: Output voltage (2V/div, 5ms/div, 20MHz BWL)
Resistive load = 37 Ohm, Vin = 375Vdc:

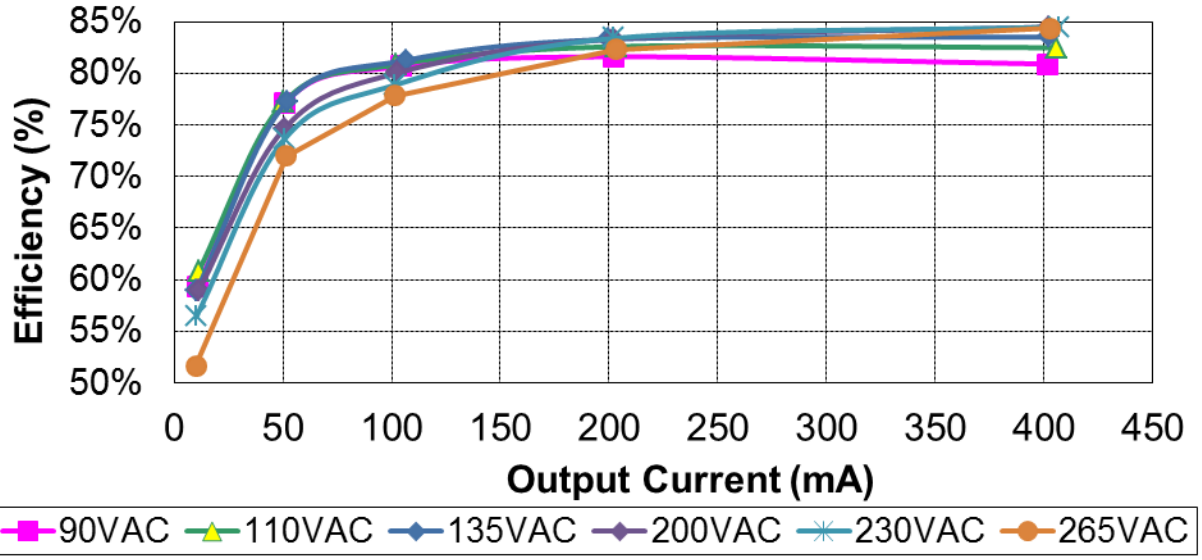


Ch.3: Output voltage (2V/div, 5ms/div, 20MHz BWL)
Zero load, Vin = 375Vdc:



3 Efficiency

The efficiency data, versus Vin and load, are shown in the tables and graph below.
The input voltage has been set respectively to 90VAC, 110VAC, 135VAC, 200VAC, 230VAC and 265VAC.



VAC (Vrms)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
90	0.0422	15.11	0	0	0.0%
90	0.272	14.95	10.8	0.161	59.4%
90	0.983	14.92	50.8	0.758	77.1%
90	1.929	14.92	104.3	1.56	80.7%
90	3.690	14.92	201.8	3.01	81.6%
90	7.42	14.95	401.5	6.00	80.9%

VAC (Vrms)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
110	0.0442	15.10	0	0	0.0%
110	0.275	14.93	11.2	0.167	60.8%
110	0.976	14.92	50.5	0.753	77.2%
110	1.879	14.92	101.8	1.52	80.8%
110	3.673	14.92	203.3	3.03	82.6%
110	7.35	14.95	405.5	6.06	82.5%

VAC (Vrms)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
135	0.0459	15.10	0	0	0.0%
135	0.261	14.94	10.3	0.154	59.0%
135	1.002	14.92	51.9	0.774	77.3%
135	1.959	14.92	106.7	1.59	81.3%
135	3.585	14.93	200.0	2.99	83.3%
135	7.198	14.95	402.1	6.01	83.5%

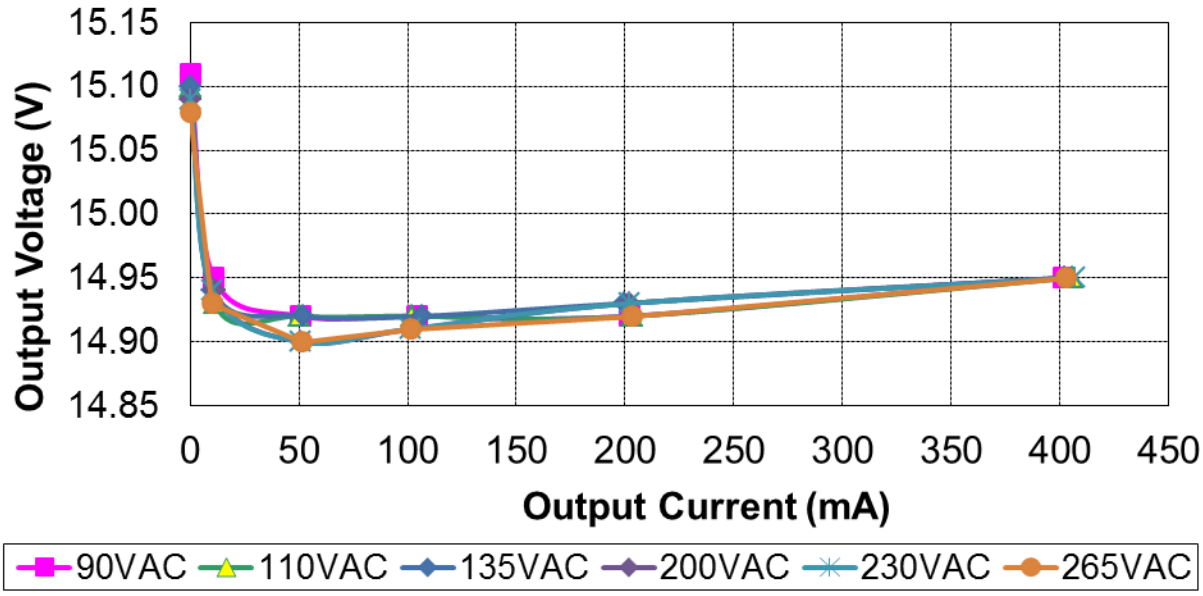
VAC (Vrms)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
200	0.0523	15.09	0	0	0.0%
200	0.284	14.94	11.2	0.167	58.9%
200	1.012	14.90	50.7	0.755	74.6%
200	1.913	14.91	102.7	1.53	80.0%
200	3.625	14.93	202.3	3.02	83.3%
200	7.116	14.95	402.1	6.01	84.5%

VAC (Vrms)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
230	0.0560	15.09	0	0	0.0%
230	0.275	14.94	10.4	0.155	56.5%
230	1.026	14.90	50.7	0.755	73.6%
230	1.919	14.91	101.5	1.51	78.9%
230	3.622	14.93	202.3	3.02	83.4%
230	7.206	14.95	407.2	6.09	84.5%

VAC (Vrms)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
265	0.0727	15.08	0	0	0.0%
265	0.292	14.93	10.1	0.151	51.6%
265	1.066	14.90	51.5	0.767	72.0%
265	1.946	14.91	101.6	1.51	77.8%
265	3.682	14.92	203.1	3.03	82.3%
265	7.143	14.95	402.9	6.02	84.3%

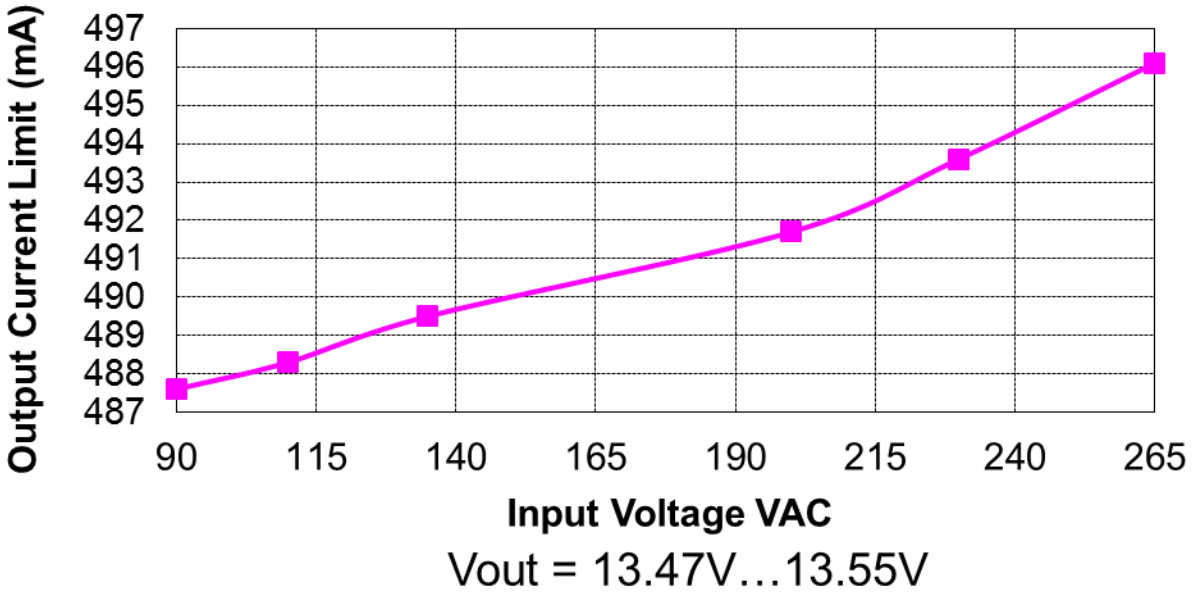
4 Output Voltage Regulation versus Load Current

The output voltage variation versus load current, for different input voltages, is plotted below.



5 Output Current Limit Point versus Input AC voltage

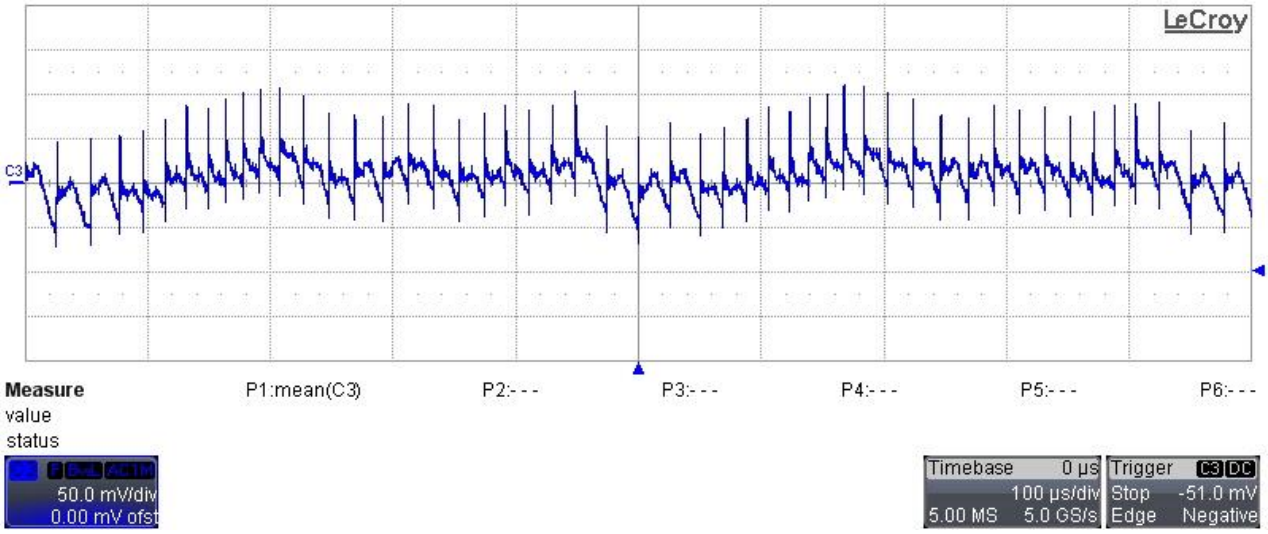
The load has been increased until the output voltage dropped by 10% below the nominal value, which shows the current limit of the converter. The input AC voltage has been varied and a plot created.



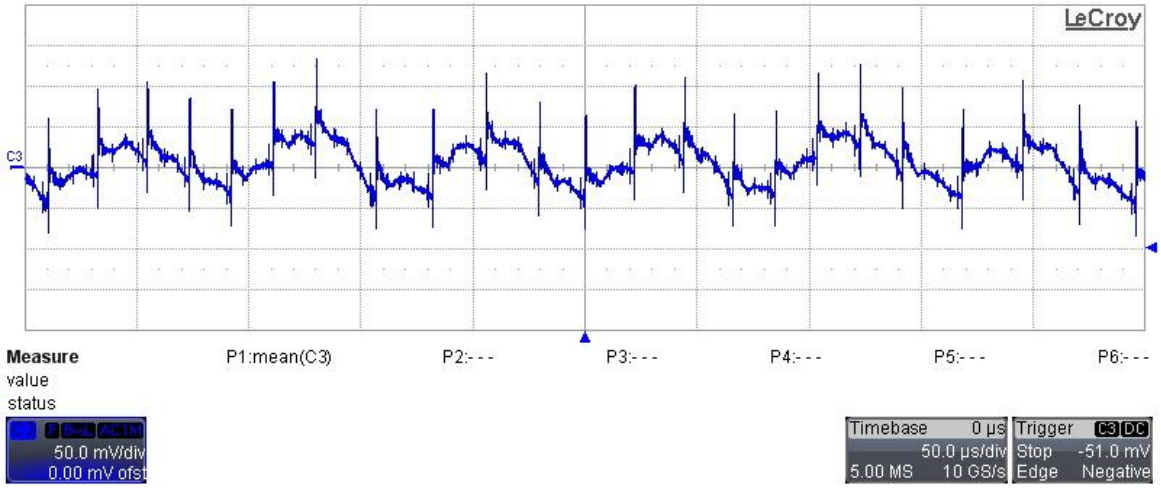
6 Output Ripple Voltage

The output ripple voltage has been measured by supplying the converter at 130Vdc and 325Vdc in full load condition and very light load as well to detect any low frequency ripple. All screenshots have been taken with 20MHz bandwidth, AC coupling.

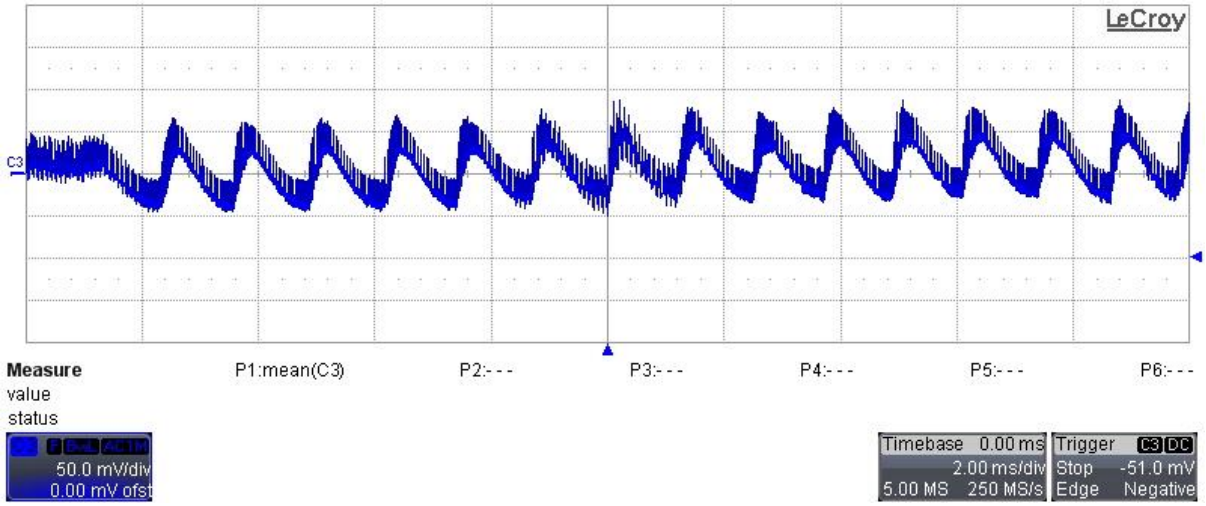
Ch.3: Output voltage (50mV/div, 100us/div)
Full load, Vin = 135Vdc:



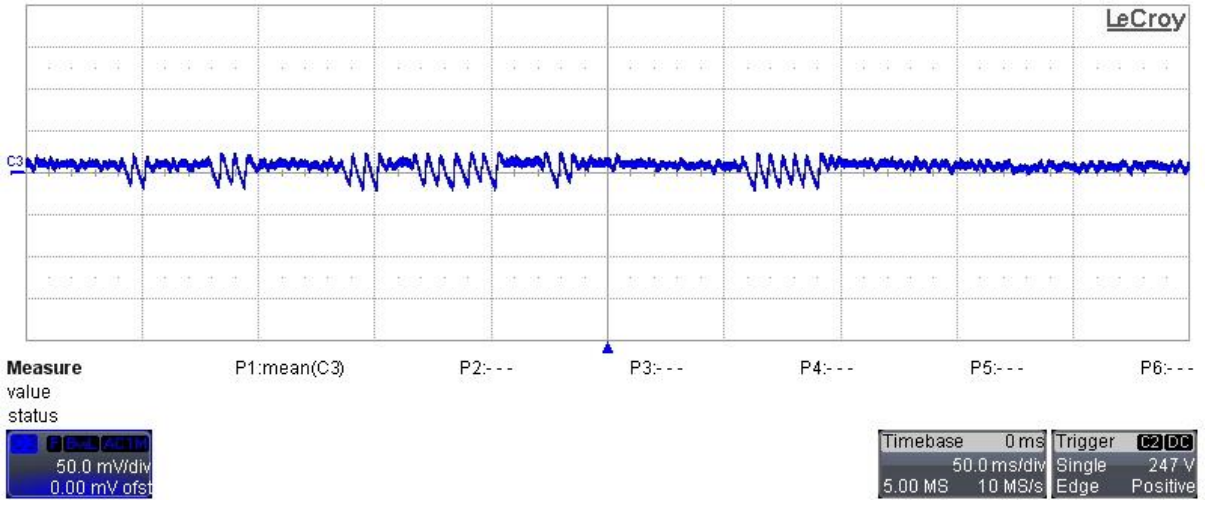
Ch.3: Output voltage (50mV/div, 50us/div), Full load, Vin = 325Vdc:



Ch.3: Output voltage (50mV/div, 2ms/div), 70mA load, Vin = 325Vdc:



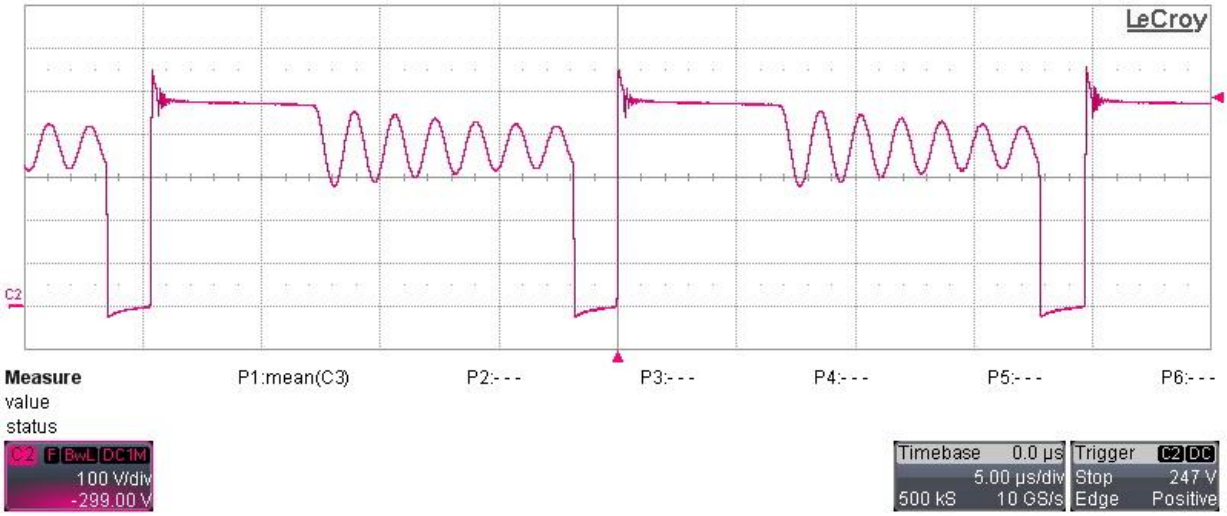
Ch.3: Output voltage (50mV/div, 50ms/div), 10mA load, Vin = 325Vdc:



7 Switch nodes

The image below shows the switch node of U1 (pin 8), taken at 375Vdc (peak value of 265VAC) while the output was fully loaded.

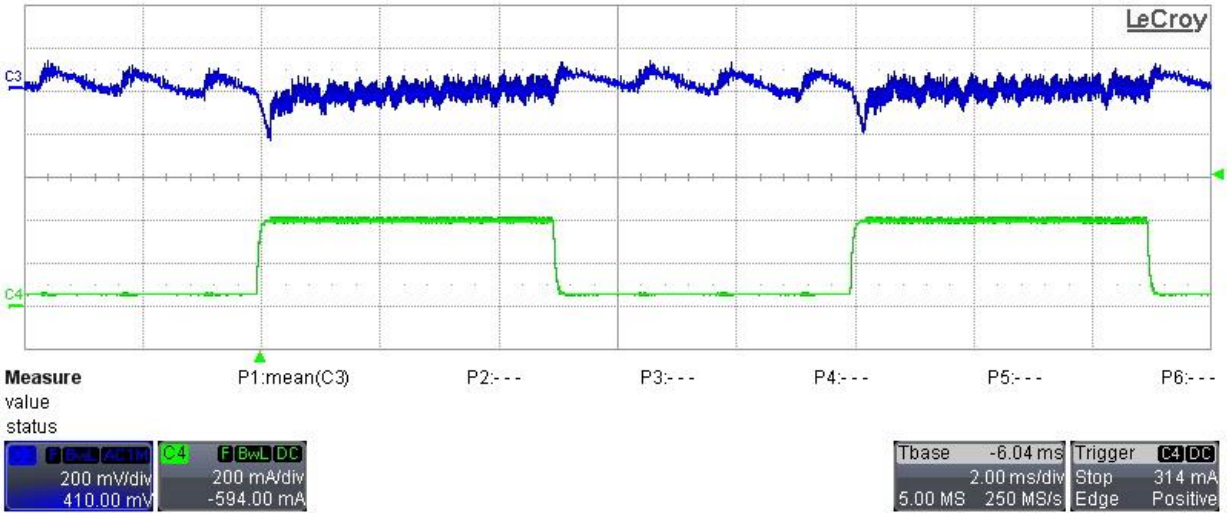
Ch.2: Pin 8, U1 (100V/div, 5us/div, 200MHz BWL)



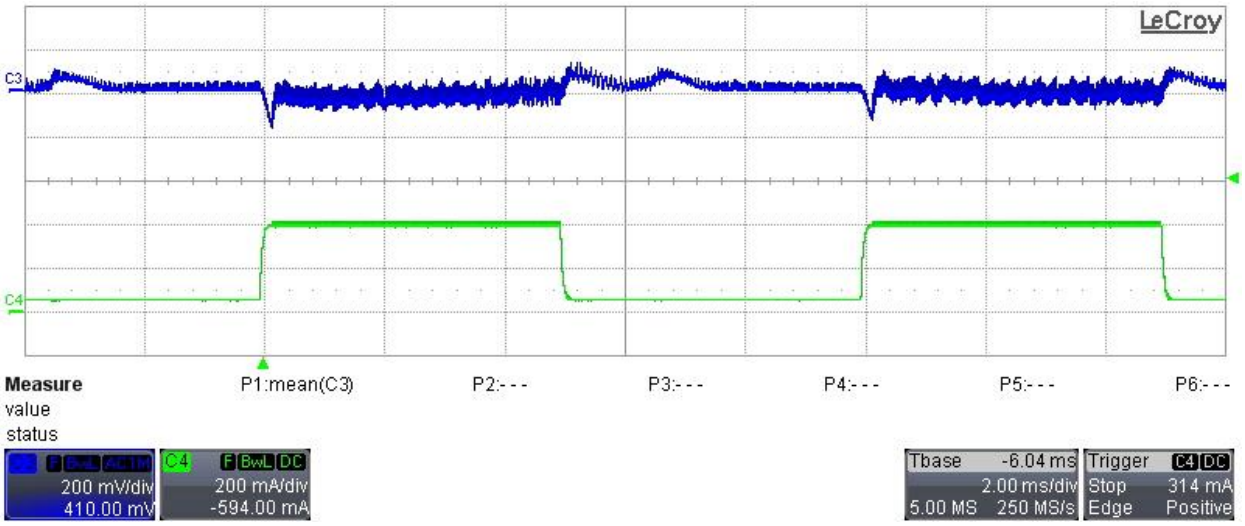
8 Transient Response

The images below show the transient response on output voltage. The load has been switched between 50mA and 400mA.

Ch.3: Output voltage (200mV/div, 2ms/div, AC coupling, 20MHz BWL)
Ch.4: Output current (200mA/div, DC coupling, 20MHz BWL)
Vin = 130Vdc



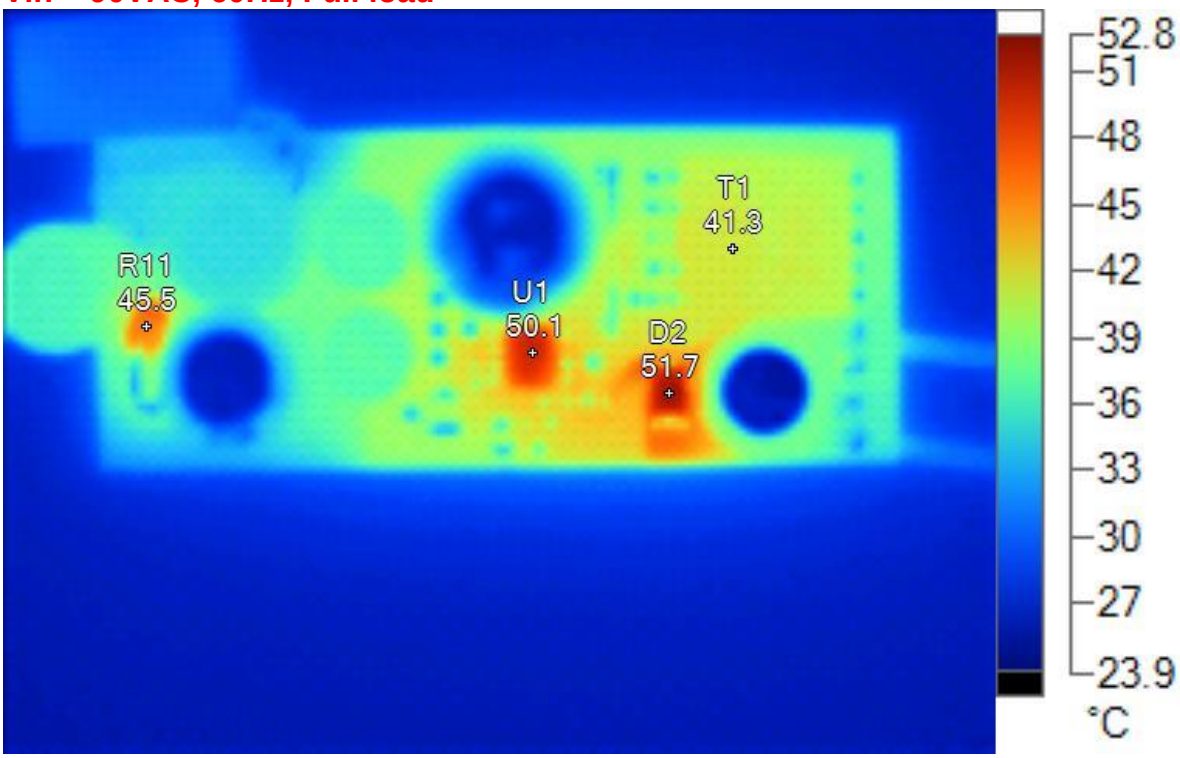
Ch.3: Output voltage (200mV/div, 2ms/div, AC coupling, 20MHz BWL)
Ch.4: Output current (200mA/div, DC coupling, 20MHz BWL)
Vin = 325Vdc



9 Thermal Analysis

During the thermal analysis, the converter has been placed horizontally on the bench in still air conditions, while fully loaded and supplied @ 90Vrms, 50Hz.

Vin = 90VAC, 60Hz, Full load



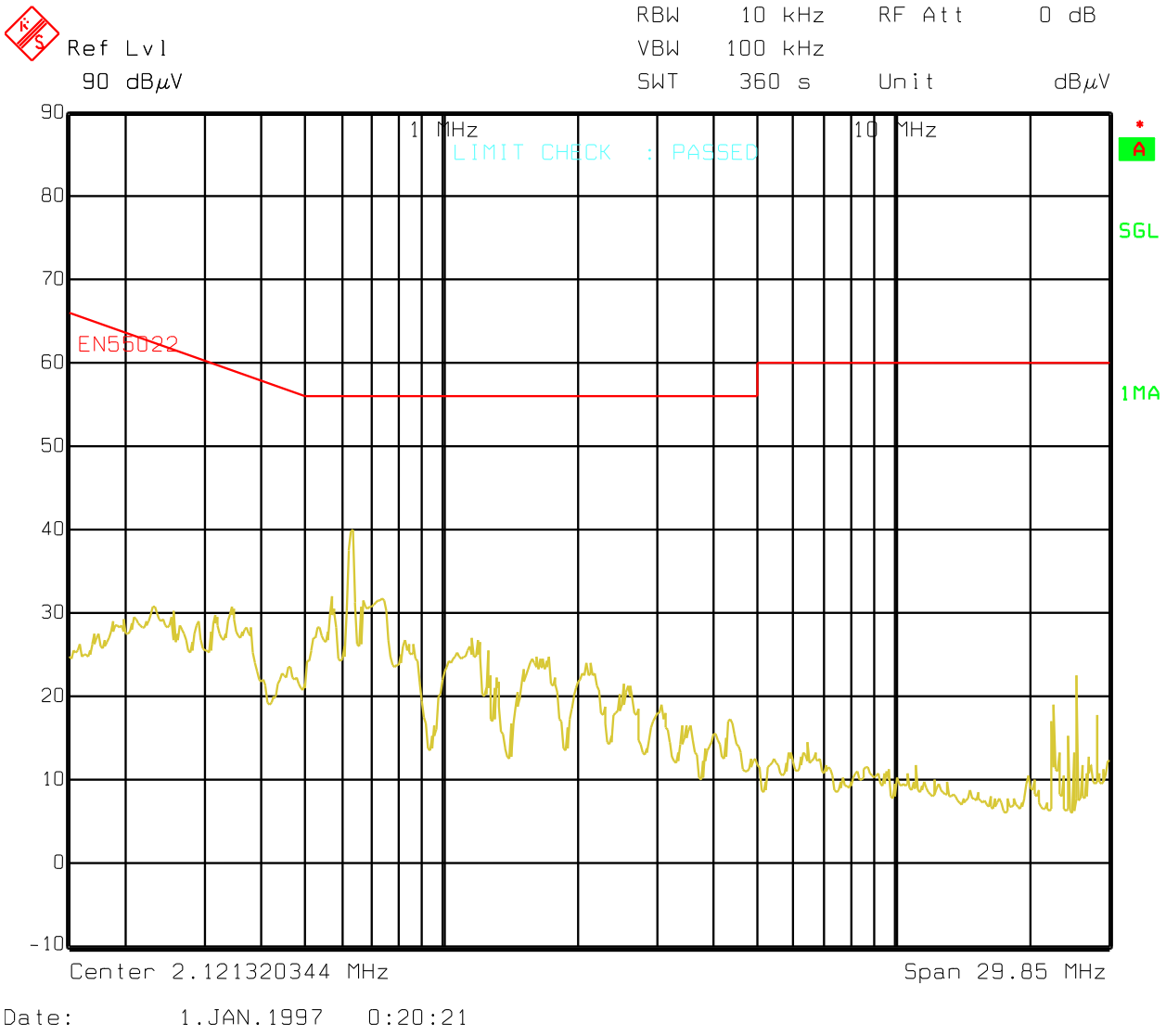
Main Image Markers:

Name	Temperature	Emissivity	Background
R11	45.5°C	0.95	23°C
U1	50.1°C	0.95	23°C
D2	51.7°C	0.95	23°C
T1	41.3°C	0.95	23°C

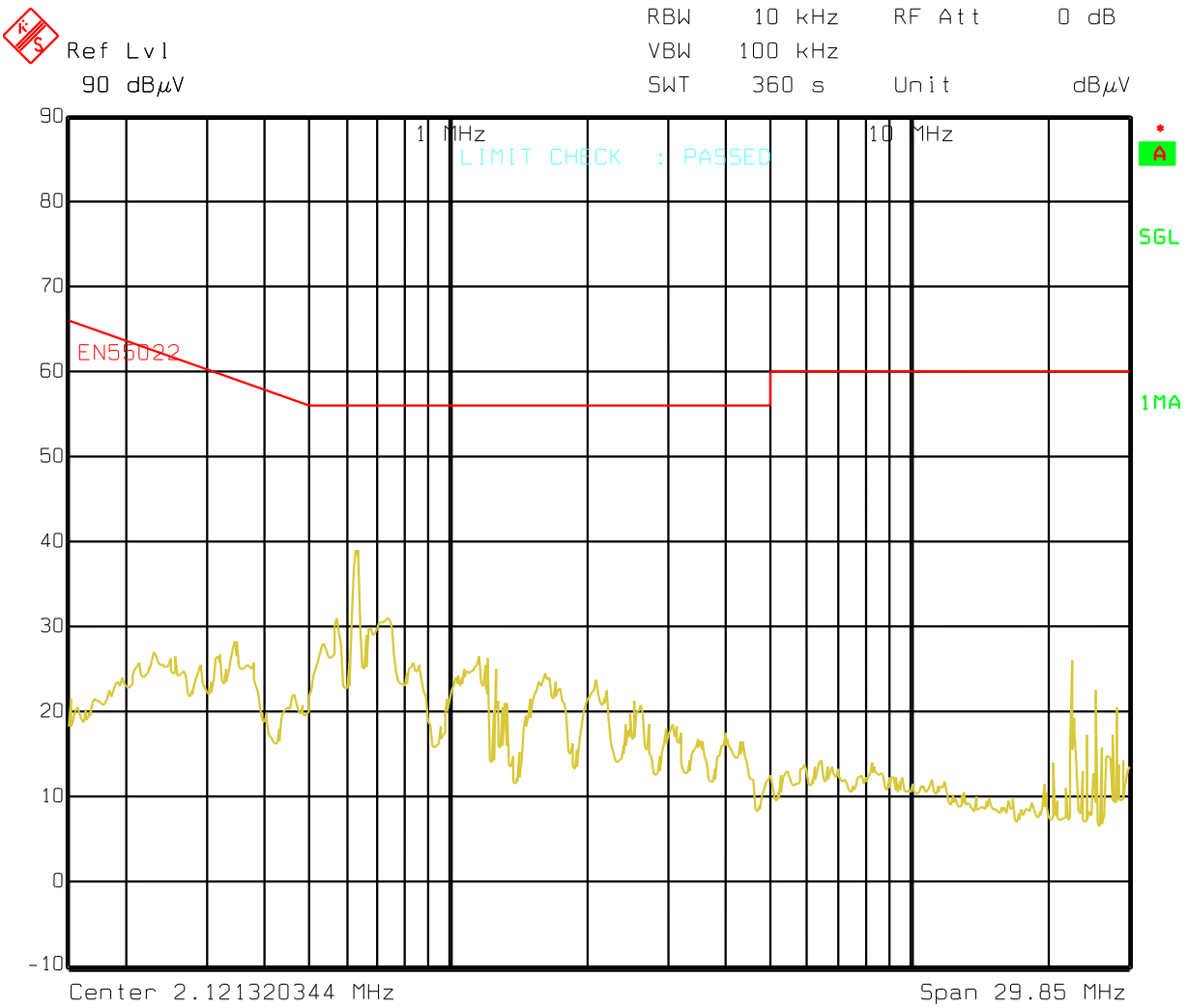
10 EMI measurement

The graph below shows the EMI measurement of the converter connected to an isolation transformer by means of a Hameg HM6050-2 LISN. The supply voltage was 230VAC. The converter has been loaded with a 37 Ohm power resistor, left floating since this power supply is not isolated from mains. The detector of the receiver was set to “quasi-peak” and the limit is the equivalent EN55022 grade B.

Vin = 230Vac, neutral terminal



Vin = 230Vac, phase terminal



11. Conformance with EN 50065

11.1. Output voltage level with 50 Ohm line impedance

This test verifies the output voltage level limits for the CENELEC A band using the procedure specified in [2]. The set up for test is shown in Figure 1.

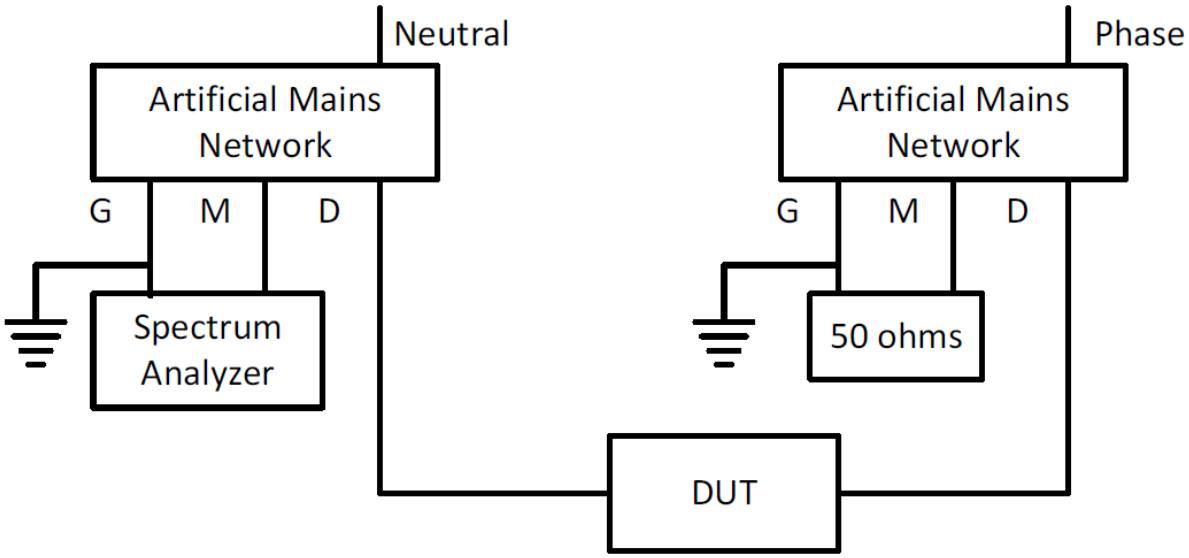


Figure 1: Test setup for measuring output voltage level with 50 Ohm impedance

For this test, the device under test (DUT) needs to continuously transmit frames carrying random data. The DUT transmit the frames at the maximum emission level allowed by [2]. To pass this test, the measured signal in a band corresponding to the transmitter bandwidth cannot exceed 134 dBµV and the signal spectrum cannot exceed 120 dBµV when measured with a peak detector having a bandwidth of 200 Hz.

Results:

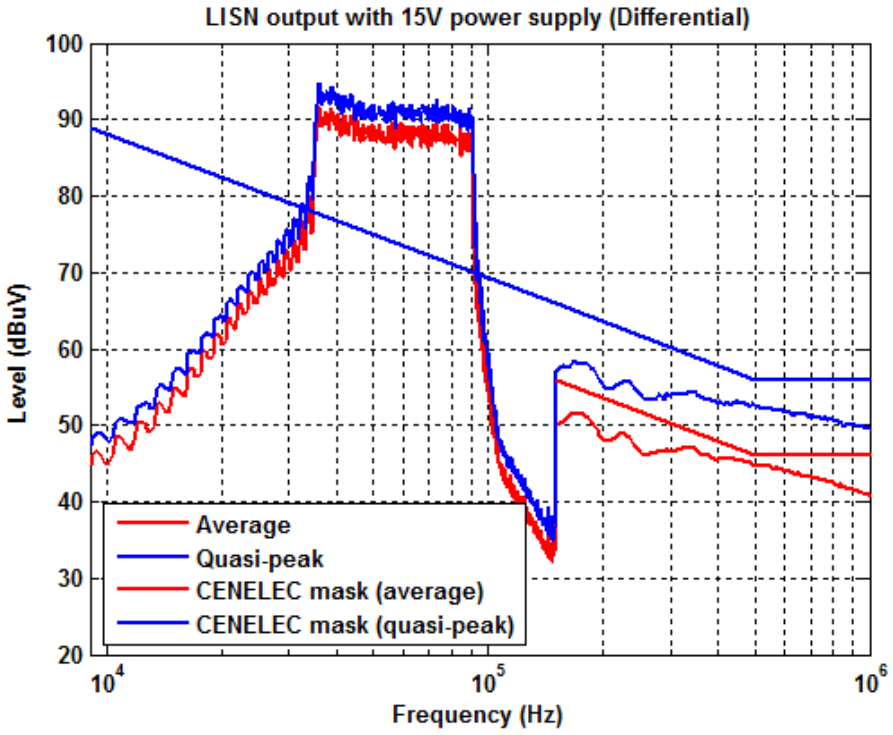
Measured Value	Allowed Value	Result (Pass/Fail)
120.88 dBuV	≤ 134 dBuV	Pass
96.77 dBuV	≤ 120 dBuV	Pass

11.2. Conducted emissions

This test verifies that the DUT complies with the requirements of [2] regarding inductive conducted emissions. For this test, the DUT needs to continuously transmit frames carrying random data. The DUT transmits the frames at the maximum emission level allowed by [2]. To pass this test, the measured values must be below the values given in the following table:

Frequency Band	Measurement Type	Limits
3 kHz – 9 kHz	Quasi-Peak	89 dBuV
95 kHz – 500 kHz	Quasi-Peak	Linear decrease as function of logarithm of frequency: 95 kHz → 69.74 dBuV 100 kHz → 69.32 dBuV 150 kHz → 66 dBuV 500 kHz → 56 dBuV
500 kHz – 5 MHz	Quasi-Peak	56 dBuV
5 MHz – 30 MHz	Quasi-Peak	60 dBuV
150 kHz – 500 kHz	RMS	Linear decrease as function of logarithm of frequency: 150 kHz → 56 dBuV 500 kHz → 46 dBuV
500 kHz – 5 MHz	RMS	46 dBuV
5 MHz – 30 MHz	RMS	50 dBuV

Results: PASS



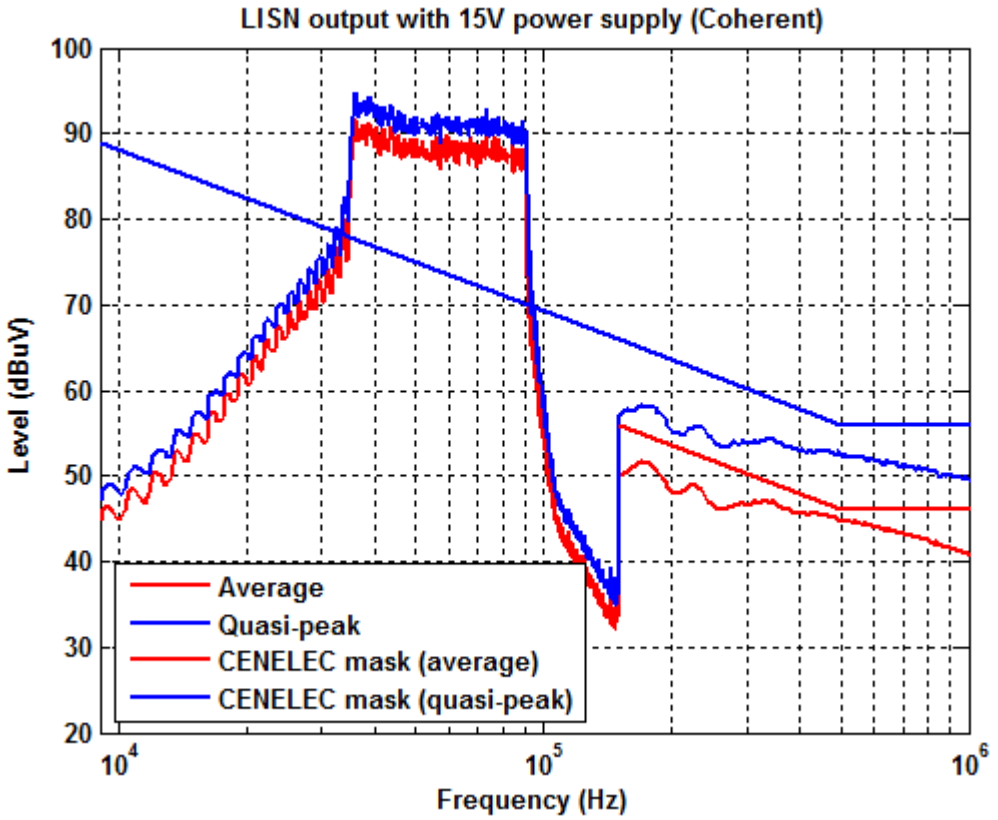


Table 1 – Reference documents

Ref	Title / source	Owner	Version
[1]	Specification for PoweRline Intelligent Metering Evolution	PRIME Alliance	July 2013
[2]	EN 50065-1: Signaling on Low-Voltage Electrical Installations in the Frequency Range 3 kHz to 148.5 kHz – Part 1: General Requirements, Frequency Bands and Electromagnetic Disturbances	CENELEC	04-22-2011
[3]	EN 50065-7: Signaling on Low-Voltage Electrical Installations in the Frequency Range 3 kHz to 148.5 kHz - Part 7: Equipment Impedance	CENELEC	06-01-2001
[4]	PRIME Certification	PRIME Alliance	05-18-2010

12. Standalone Power Supply EMI Compliance (0 ÷ 3W)

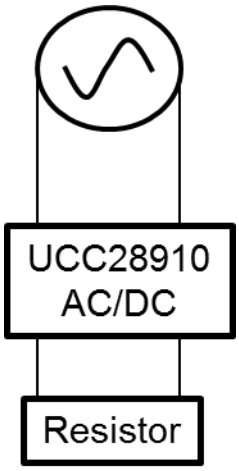
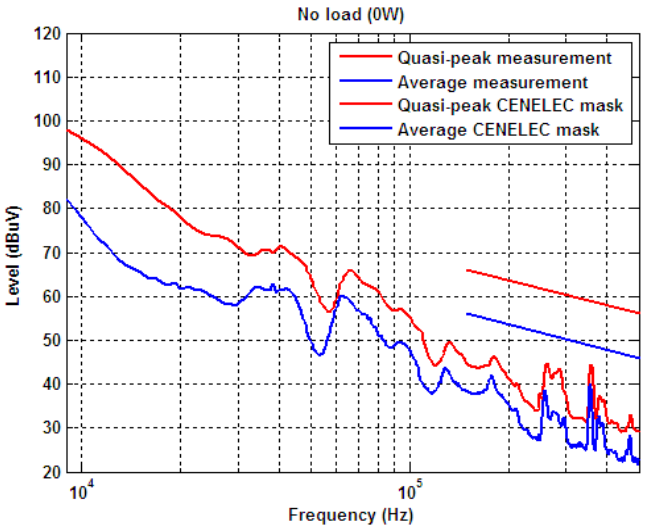
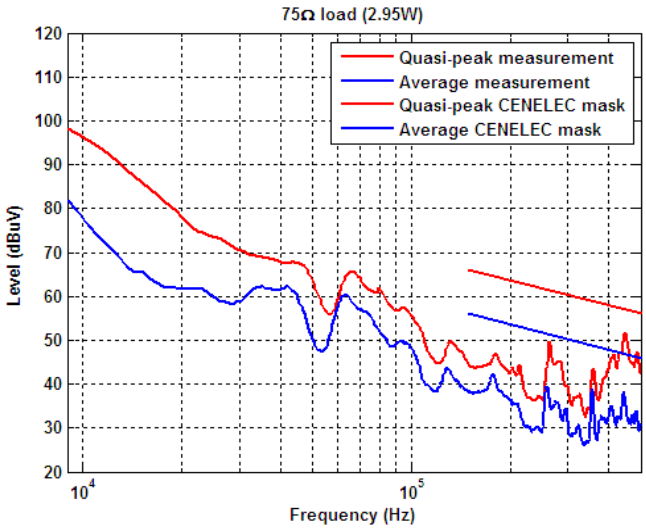


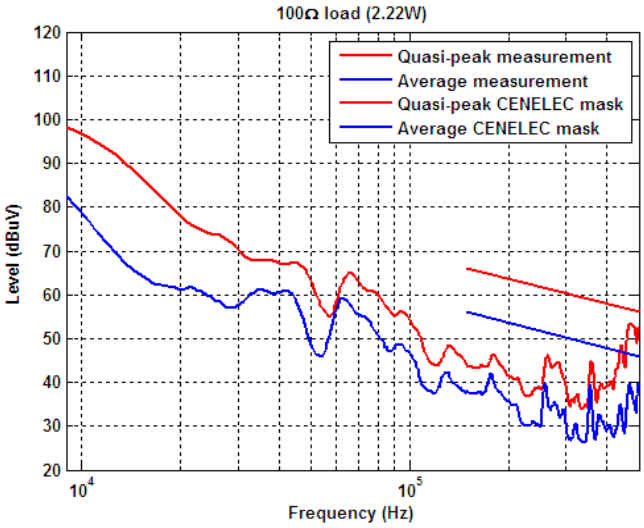
Figure 2: Test setup used for EMI compliance in power range 0…3W

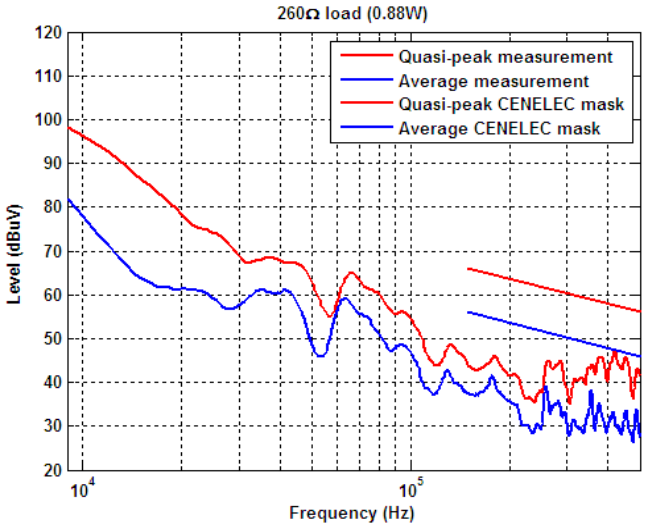
In order to verify the power supply regarding EMI compliance, the setup of figure 2 has been tested; the resistor value has been changed to deliver 0W, 0.8W, 2.22W and 2.95W.
The results are shown in the graphs below and confirm that:

1) The AC/DC power supply is fully compliant with EN55022 Class-B as well as EN50065-1. In 40-90KHz
2) In 40-90kHz communication band, the standalone Power Supply EMI emission is <60dBuV
3) The low emission level provides **> 20dBuV margin** to OFDM signal amplitude which is 96dBuV, thus supporting reliable communication

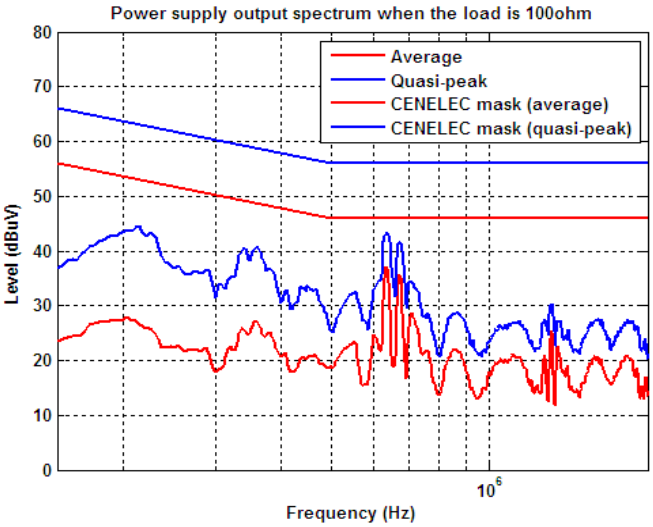


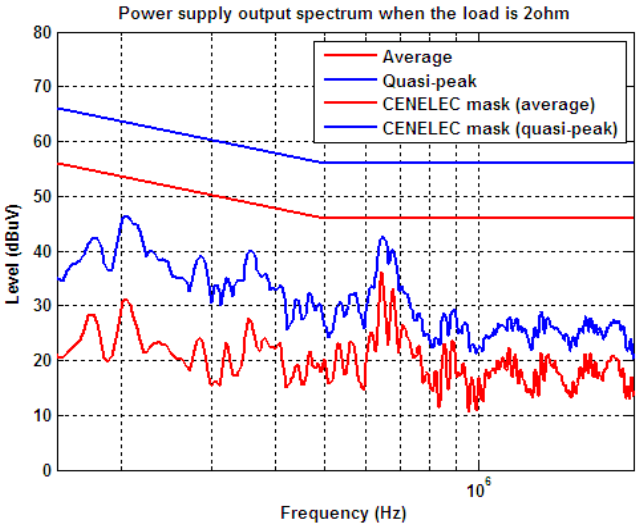


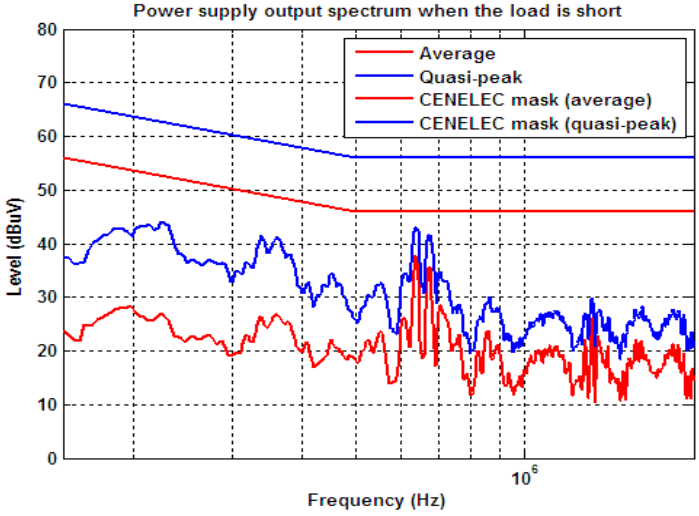




PLC System with AC/DC Power Supply is fully compliant with CENELEC EN50065-1:







IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (https:www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265