

DEMO-BOARD OPTIMIZATION AND PRE-COMPLIANCE REPORT



NXP TEA2016DB1519v2 12V - 240W

High efficiency | Wide input range | Low stand-by power
PFC + LLC resonant power supply

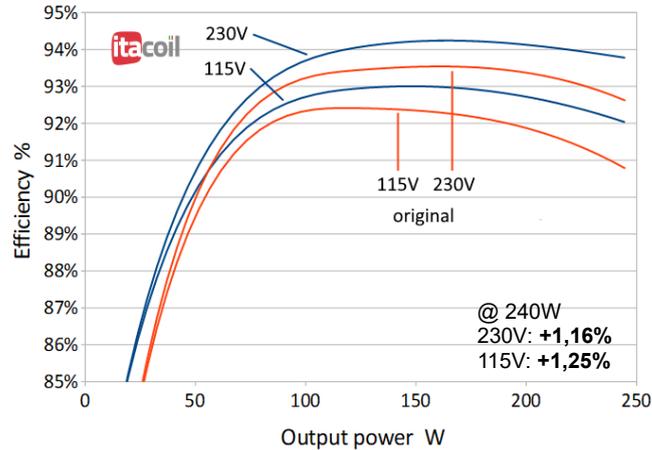
GOALS:

- cost saving;
- improved efficiency;
- same general properties of the original board.

OPTIMIZATION AND ADAPTION:

- replacement of the original inductive components with Itacoil LLC resonant transformer, PFC inductor, common mode and differential noise mains filters;
- in order to avoid the necessity of air cooling to run up to 240W and guarantee a better comparison, minor changes were applied to the board before every test so to have identical test conditions.

OVERALL EFFICIENCY



COST

- 10-20%

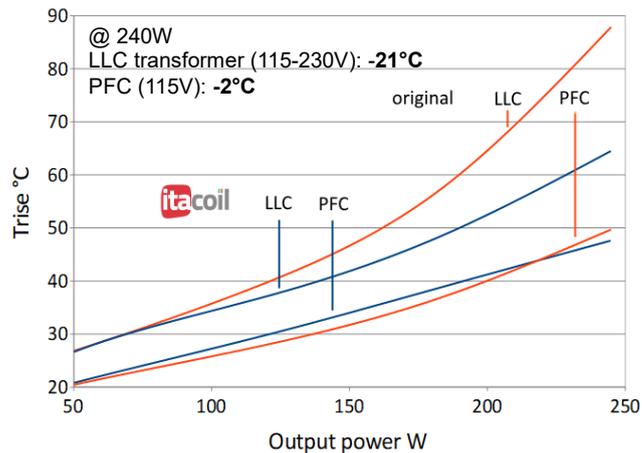
COMPONENTS ENCUMBRANCE

- 40%

EMC PRE-COMPLIANCE

5dB μ V more margin against EN55022
maximum noise limits

TEMPERATURE RISE



STAND-BY POWER

- 14% worst case no load consumption



Components encumbrance

		Footprint (cm ²)				Volume (cm ³)		
		Original	Itacoil			Original	Itacoil	
Resonant transformer	T1	12,3	7,25	-41%		31,1	15,0	-52%
PFC inductor	L104	11,5	8,03	-30%		24,4	23,0	-6%
Common mode filter	LF102	6,59	2,678	-59%		20,1	6,3	-68%
Differential noise filter	L103	2,48	1,85	-25%		5,65	3,83	-32%
Total		32,8	19,8	-40%		81,3	48,2	-41%



- Powerful **proprietary software tools** developed by Itacoil, with Spice class simulations and optimization algorithms;
- examples of simulation reports at rated load for **Itacoil components**:
 - PFC inductor;
 - LLC integrated resonant transformer;in the following slides.

PFC - Transition Mode

INPUT DATA

```

Vline min      : 90,0 Vrms
Vline max      : 264,0 Vrms
Main frequency  : 50,0 Hz
Vout           : 400,0 V
Pout continuous : 275,0 W
Pout peak      : 390,0 W
Inductance     : 130,0 µH
Input cap.     : 0,470 µF
Expected PF    : 0,99
Expected Efficiency : 0,95
    
```

AUX

```

I : 0,020 Arms
    
```

OUTPUT DATA

Functional Parameters

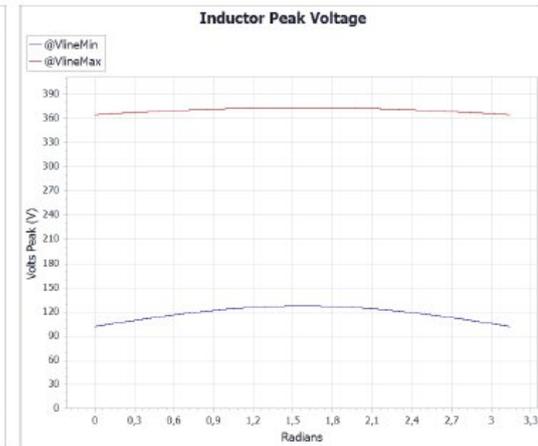
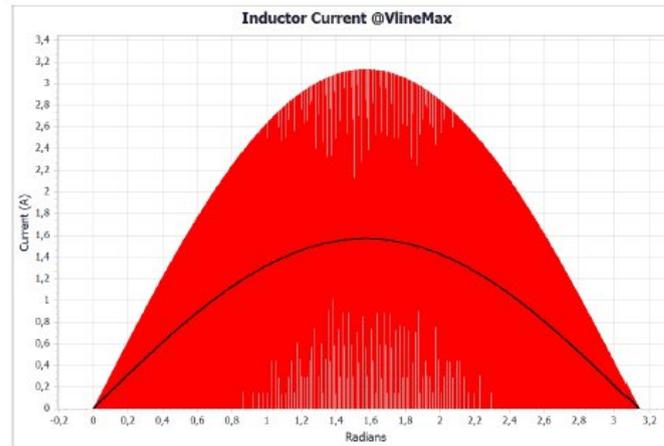
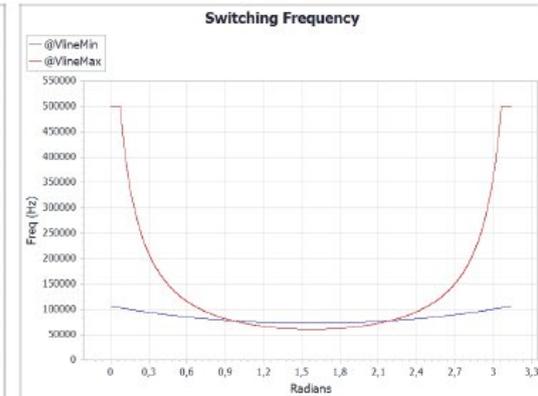
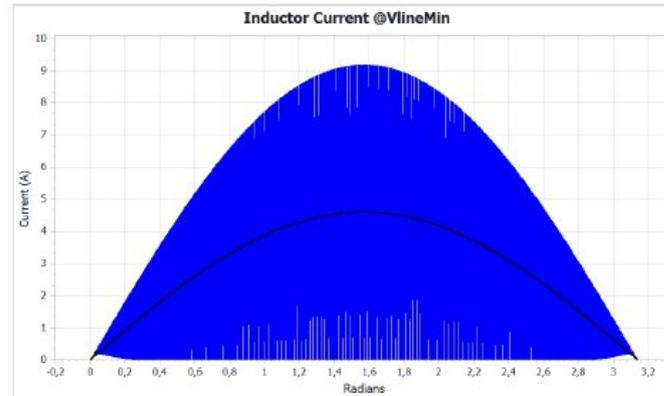
```

@VlineMin, Pout continuous
Iin      : 3,249 Arms
ILrms    : 3,751 Arms
ILpk     : 9,189 Apk
Fmin     : 72,6 KHz
Fmax     : 106,5 KHz
TON      : 9,386 µs
TOFF max : 4,380 µs
    
```

Functional Parameters

```

@VlineMax, Pout continuous
Iin      : 1,108 Arms
ILrms    : 1,279 Arms
ILpk     : 3,133 Apk
Fmin     : 61,1 KHz
Fmax     : 500,0 KHz
TON      : 1,091 µs
TOFF max : 15,283 µs
    
```



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1* Italian Manufacturer of PCB transformers with ISO Certified QS

Quality System UNI EN ISO 9001 Certified

CEI Member

Powered by zero impact* renewable energy



Transformer code: Tank:

Name	Vout (V)	Vf (V)	Iout (A)	Pout (W)
Aux(>CT)	17,98	0,70	0,030	0,539
SecCTP	12,30	0,15	20,000	246,000

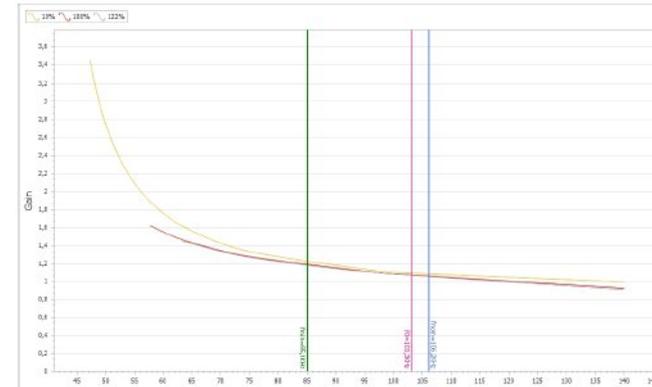
Pmin: 0,3 W
 Pmin ZVS: 0,3 W
 Pout tot: 246,5 W
 Pout tot pk: 300,0 W

Cr: 33,0nF ±5%
 Cshb: 870 pF
 Dead time: ADAPTIVE NXP TEA2016
 RdsOn: 0,920 Ω
 Gate rise: 120 ns
 Gate fall: 120 ns

Vnom: 400,0 V
 Fnom: 106,2 KHz
 Vmin (temp): 375,0 V
 Vmin (cont): 360,0 V
 Vmax: 400,0 V
 V@F0: 391,0 V
 Fmin: 85,1 KHz
 F0: 103,3 KHz
 Icr rms: 1,643 A
 Vcr pk: 105,5 V
 Vcr pp: 211,2 V

WORST CASE FREQUENCIES
 Min freq (@Vmin): 77,8 KHz
 Max freq (@Vmax): 136,1 KHz (1)

Burst mode enabled: YES
 %ON nom. cond.: 100%
 Full ZVS Compliant: YES



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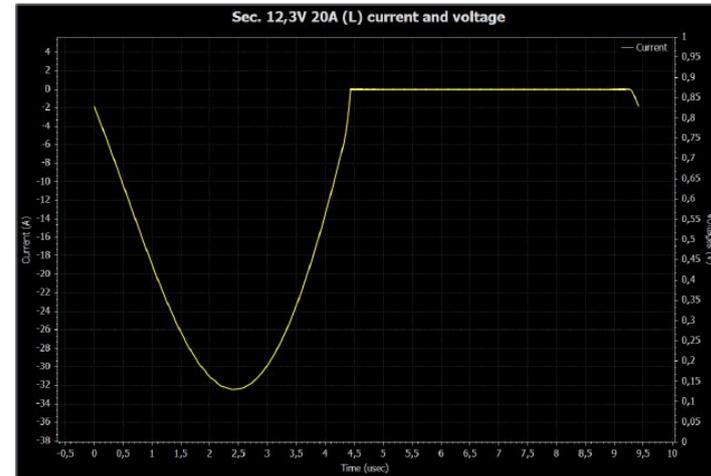
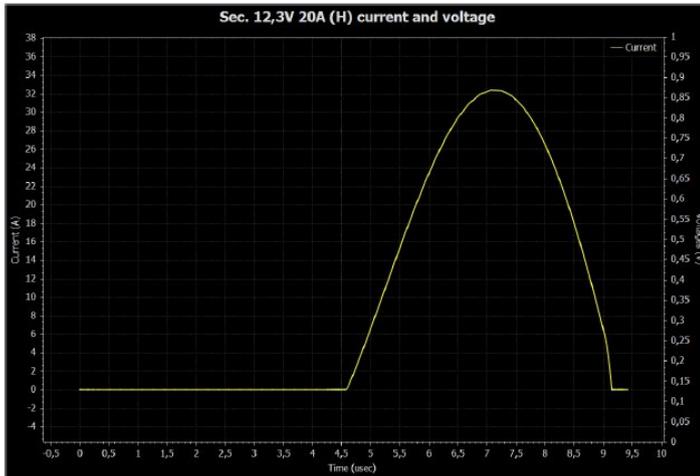
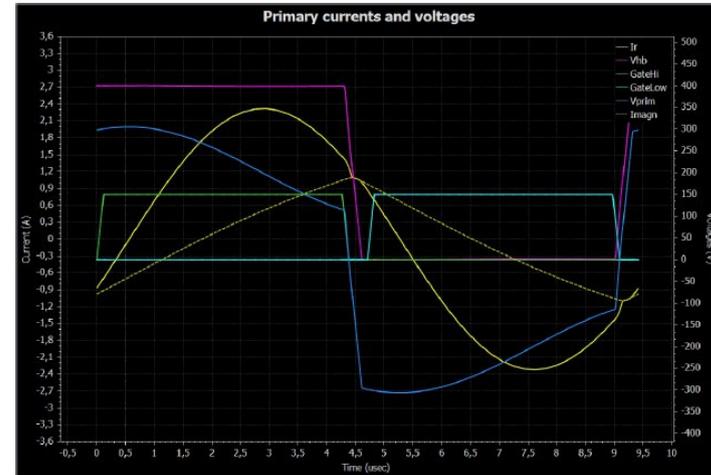
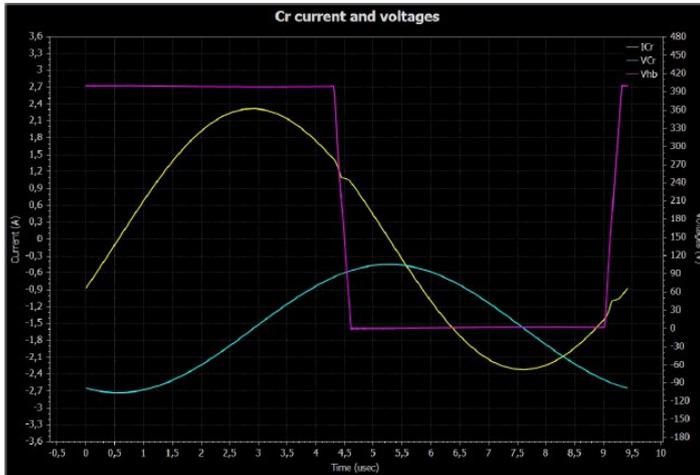
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Waveform simulation at Vnom and Pout tot

For good readability, the gate voltages are plotted with amplitude higher than real



- Steady-state tests at thermal regime performed on **original board vs. Itacoil version** at various output power levels;
- extrats from the tests reports** showing the record at nominal power in the following images:

Original - 115Vac

Vin Nom (Vac)	Pout Nom (W)	Vin (Vac)	Iin (Arms)	Pin (W)	Vout (Vdc)	Iout (Adc)	Pout (W)	Eff	F_sw (KHz)	Ta (°C)	Notes	T.Pri (°C)	T.Sec (°C)	T.Core (°C)	Mains Freq (Hz)	PF	THD	Oscill. img	Thermal img
115,0	240,0	114,53	2,376	269,70	12,25	19,987	244,84	90,78%	85,3	28,6	PFC 78.3°	98,2	115,0	84,8	50,000	0,991	12,830		

Itacoil - 115Vac

Vin Nom (Vac)	Pout Nom (W)	Vin (Vac)	Iin (Arms)	Pin (W)	Vout (Vdc)	Iout (Adc)	Pout (W)	Eff	F_sw (KHz)	Ta (°C)	Notes	T.Pri (°C)	T.Sec (°C)	T.Core (°C)	Mains Freq (Hz)	PF	THD	Oscill. img	Thermal img
115,0	240,0	114,54	2,344	265,86	12,24	19,989	244,68	92,03%	103,8	27,4	PFC 75°	85,2	92,7	85,4	49,999	0,990	13,205		

Original - 230Vac

Vin Nom (Vac)	Pout Nom (W)	Vin (Vac)	Iin (Arms)	Pin (W)	Vout (Vdc)	Iout (Adc)	Pout (W)	Eff	F_sw (KHz)	Ta (°C)	Notes	T.Pri (°C)	T.Sec (°C)	T.Core (°C)	Main Freq (Hz)	PF	THD	Oscil. img	Thermal img
230,0	240,0	229,85	1,218	264,40	12,25	19,987	244,88	92,62%	87,3	27,1		97,5	115,0	84,3	50,000	0,944	31,692		

Itacoil - 230Vac

Vin Nom (Vac)	Pout Nom (W)	Vin (Vac)	Iin (Arms)	Pin (W)	Vout (Vdc)	Iout (Adc)	Pout (W)	Eff	F_sw (KHz)	Ta (°C)	Notes	T.Pri (°C)	T.Sec (°C)	T.Core (°C)	Mains Freq (Hz)	PF	THD	Oscil. img	Thermal img
230,0	240,0	229,87	1,204	261,01	12,24	19,993	244,78	93,78%	110,3	25,7		82,3	90,2	82,8	50,000	0,943	32,054		

Original - 115Vac

Test Report No 201005-020450-F

Measurement of Standby Power to IEC 62301 Ed. 2.0

Customer	Issuer
Name: NXP Address:	Name: ITACOIL Address: via delle Gerole, 7 Caponago (MB) Italy I-20867 Date of issue: 2020-Oct-05
Unit Under Test	Reference Instrument
Manufacturer: NXP Description: Demo board 12V 240W TEA2016 LLC+PFC Model: TEA2016DB1519 Serial Number: 161 Rated Voltage: 85-265Vac/12Vdc Rated Frequency: 50-60Hz Documentation ref: UM11234 Configuration:	Manufacturer: Tektronix Description: Power Analyzer Model: PA4000 Serial Number: B020175 Firmware Version: Ver.2.004.008 Test Software: PWRVIEW ver. 3.1.0.14
Test Conditions	Test Summary
Time of Test: 2020-Oct-05 02:04:50 PM Test Voltage: 115V ±1% Test Frequency: 50Hz ±1% Voltage Distortion: < 2% THC Voltage Crest Factor: 1.34 < Vcf < 1.49 Temperature: 23°C ±3°C Humidity: < 75%	Average Power: 51.943 mW Power Limit: 500.00 mW Power Stability: -525.20 µW/h Uncertainty*: 9.4096 mW Test Period: 00:15:00 Test Method: Sampling (IEC 62301 Ed. 2.0) Test Status: PASS

Power measurements were carried out in accordance with the requirements of IEC 62301 Ed. 2 "Measurement of standby power" and EN 50564:2011 "Electrical and electronic household and office equipment - Measurement of low power consumption" in the laboratory environment, using equipment traceable to national or international standards. All testing was performed under computer control.

* Uncertainty quoted is an average of power measurement uncertainties from the last 2/3 of the test which are due only to the accuracy of the reference instrument used. If Uncertainty is marked as FAIL it means that at least one power measurement uncertainty in the last 2/3 of the test exceeded the limit prescribed in the standard.

Test Notes	Test Officer
	Full Name: Signature: _____

Itacoil - 115Vac

Test Report No 201005-032529-F

Measurement of Standby Power to IEC 62301 Ed. 2.0

Customer	Issuer
Name: NXP Address:	Name: ITACOIL Address: via delle Gerole, 7 Caponago (MB) Italy I-20867 Date of issue: 2020-Oct-05
Unit Under Test	Reference Instrument
Manufacturer: NXP Description: Demo board 12V 240W TEA2016 LLC+PFC Model: TEA2016DB1519 Serial Number: 161 Rated Voltage: 85-265Vac/12Vdc Rated Frequency: 50-60Hz Documentation ref: UM11234 Configuration:	Manufacturer: Tektronix Description: Power Analyzer Model: PA4000 Serial Number: B020175 Firmware Version: Ver.2.004.008 Test Software: PWRVIEW ver. 3.1.0.14
Test Conditions	Test Summary
Time of Test: 2020-Oct-05 03:25:29 PM Test Voltage: 115V ±1% Test Frequency: 50Hz ±1% Voltage Distortion: < 2% THC Voltage Crest Factor: 1.34 < Vcf < 1.49 Temperature: 23°C ±3°C Humidity: < 75%	Average Power: 48.775 mW Power Limit: 500.00 mW Power Stability: 4.7334 mW/h Uncertainty*: 9.3862 mW Test Period: 00:15:21 Test Method: Sampling (IEC 62301 Ed. 2.0) Test Status: PASS

Power measurements were carried out in accordance with the requirements of IEC 62301 Ed. 2 "Measurement of standby power" and EN 50564:2011 "Electrical and electronic household and office equipment - Measurement of low power consumption" in the laboratory environment, using equipment traceable to national or international standards. All testing was performed under computer control.

* Uncertainty quoted is an average of power measurement uncertainties from the last 2/3 of the test which are due only to the accuracy of the reference instrument used. If Uncertainty is marked as FAIL it means that at least one power measurement uncertainty in the last 2/3 of the test exceeded the limit prescribed in the standard.

Test Notes	Test Officer
	Full Name: Signature: _____

Original - 230Vac

Test Report No 201005-022532-F

Measurement of Standby Power to IEC 62301 Ed. 2.0

Customer		Issuer	
Name:	NXP	Name:	ITACOIL
Address:		Address:	via delle Gerole, 7 Caponago (MB) Italy I-20867
		Date of issue:	2020-Oct-05
Unit Under Test		Reference Instrument	
Manufacturer:	NXP	Manufacturer:	Tektronix
Description:	Demo board 12V 240W TEA2016 LLC+PFC	Description:	Power Analyzer
Model:	TEA2016DB1519	Model:	PA4000
Serial Number:	161	Serial Number:	B020175
Rated Voltage:	85-265Vac/12Vdc	Firmware Version:	Ver.2.004.008
Rated Frequency:	50-60Hz	Test Software:	PWRVIEW ver. 3.1.0.14
Documentation ref:	UM11234		
Configuration:			
Test Conditions		Test Summary	
Time of Test:	2020-Oct-05 02:25:32 PM	Average Power:	70.268 mW
Test Voltage:	230V ±1%	Power Limit:	500.00 mW
Test Frequency:	50Hz ±1%	Power Stability:	6.5588 mW/h
Voltage Distortion:	< 2% THC	Uncertainty*:	25.840 mW
Voltage Crest Factor:	1.34 < Vcf < 1.49	Test Period:	00:20:27
Temperature:	23°C ±3°C	Test Method:	Sampling (IEC 62301 Ed. 2.0)
Humidity:	< 75%	Test Status:	PASS

Power measurements were carried out in accordance with the requirements of IEC 62301 Ed. 2 "Measurement of standby power" and EN 50564:2011 "Electrical and electronic household and office equipment - Measurement of low power consumption" in the laboratory environment, using equipment traceable to national or international standards. All testing was performed under computer control.

* Uncertainty quoted is an average of power measurement uncertainties from the last 2/3 of the test which are due only to the accuracy of the reference instrument used. If Uncertainty is marked as FAIL it means that at least one power measurement uncertainty in the last 2/3 of the test exceeded the limit prescribed in the standard.

Test Notes	Test Officer
	Full Name:
	Signature: _____

Itacoil - 230Vac

Test Report No 201005-030815-F

Measurement of Standby Power to IEC 62301 Ed. 2.0

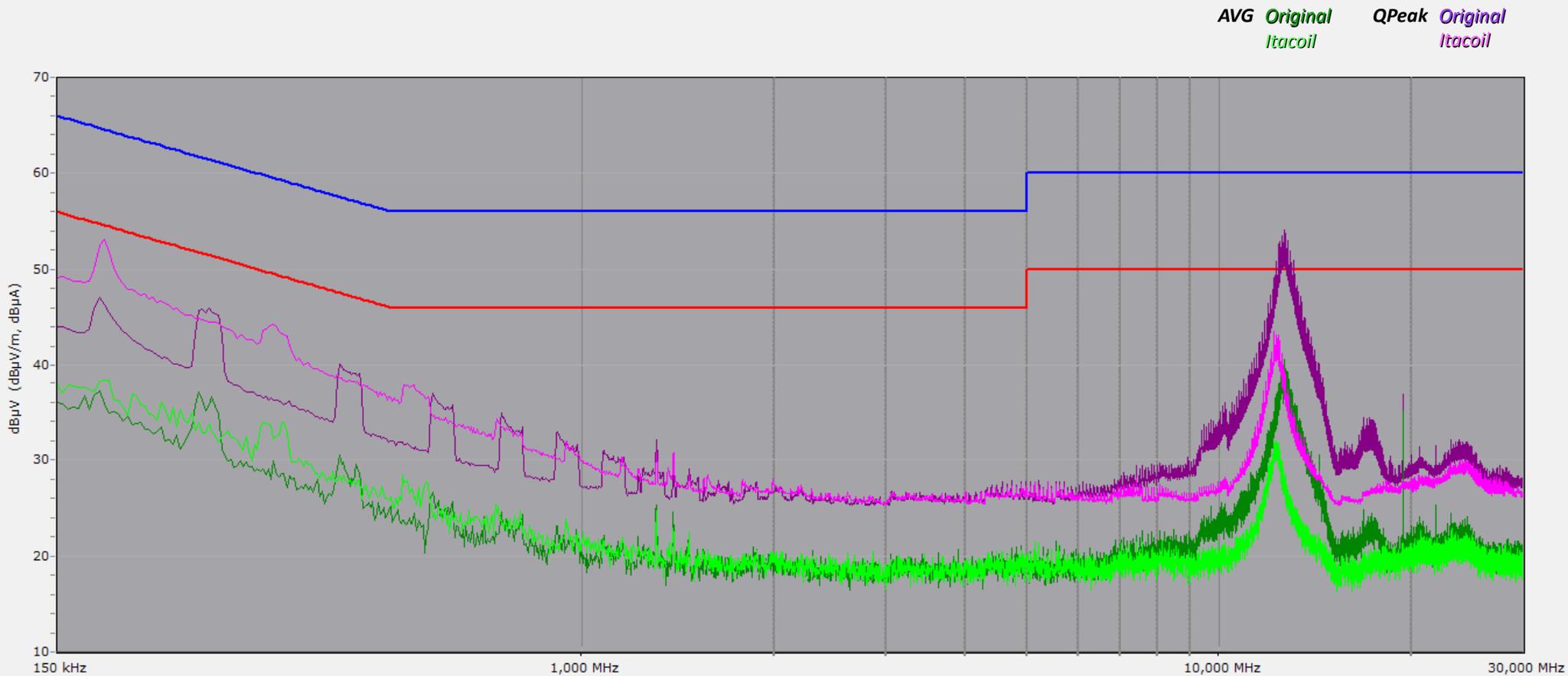
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Name:	NXP	Name:	ITACOIL
Address:		Address:	via delle Gerole, 7 Caponago (MB) Italy I-20867
		Date of issue:	2020-Oct-05
Unit Under Test		Reference Instrument	
Manufacturer:	NXP	Manufacturer:	Tektronix
Description:	Demo board 12V 240W TEA2016 LLC+PFC	Description:	Power Analyzer
Model:	TEA2016DB1519	Model:	PA4000
Serial Number:	161	Serial Number:	B020175
Rated Voltage:	85-265Vac/12Vdc	Firmware Version:	Ver.2.004.008
Rated Frequency:	50-60Hz	Test Software:	PWRVIEW ver. 3.1.0.14
Documentation ref:	UM11234		
Configuration:			
Test Conditions		Test Summary	
Time of Test:	2020-Oct-05 03:08:15 PM	Average Power:	60.391 mW
Test Voltage:	230V ±1%	Power Limit:	500.00 mW
Test Frequency:	50Hz ±1%	Power Stability:	4.8163 mW/h
Voltage Distortion:	< 2% THC	Uncertainty*:	40.633 mW
Voltage Crest Factor:	1.34 < Vcf < 1.49	Test Period:	00:15:03
Temperature:	23°C ±3°C	Test Method:	Sampling (IEC 62301 Ed. 2.0)
Humidity:	< 75%	Test Status:	PASS

Power measurements were carried out in accordance with the requirements of IEC 62301 Ed. 2 "Measurement of standby power" and EN 50564:2011 "Electrical and electronic household and office equipment - Measurement of low power consumption" in the laboratory environment, using equipment traceable to national or international standards. All testing was performed under computer control.

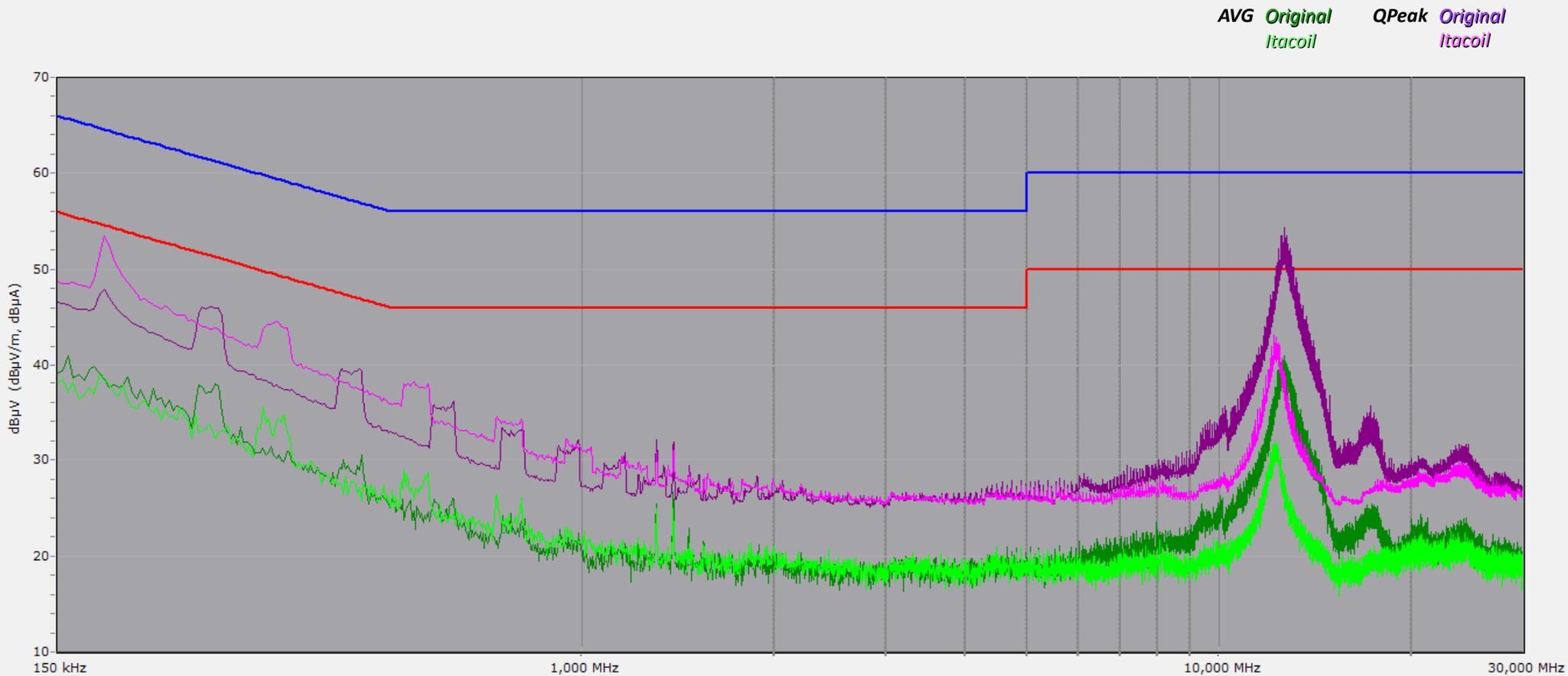
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Test Notes	Test Officer
	Full Name:
	Signature: _____

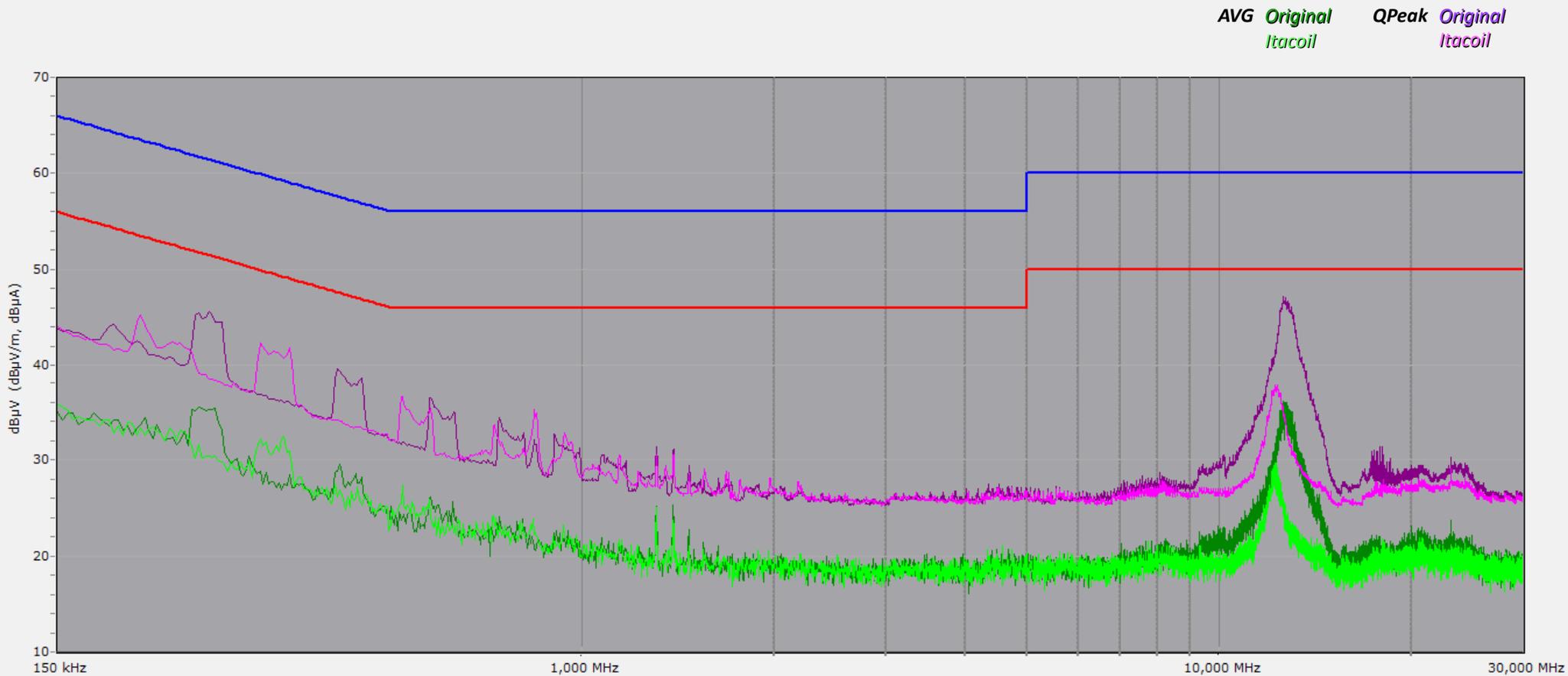
115V Neutral - Comparison



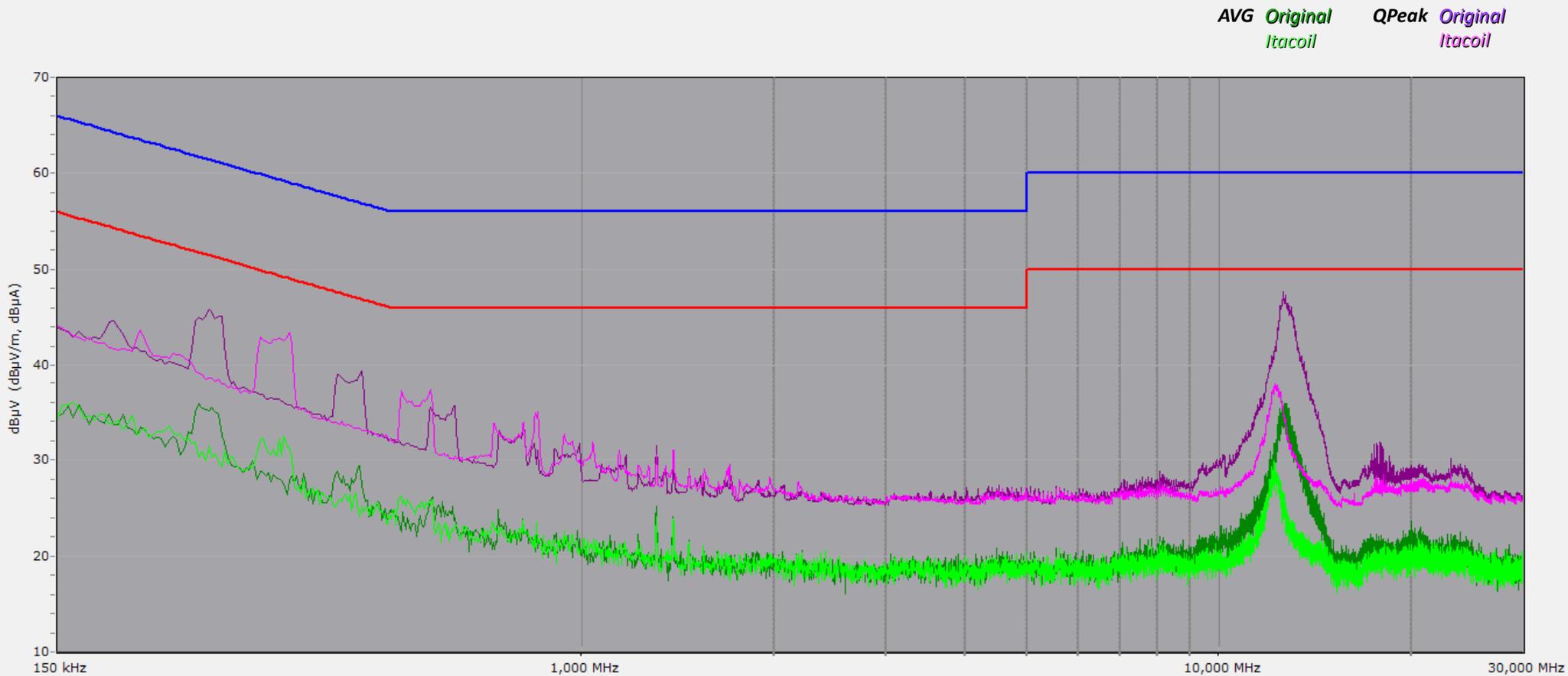
115V Phase - Comparison



230V Neutral - Comparison



230V Phase - Comparison



Original - 115Vac

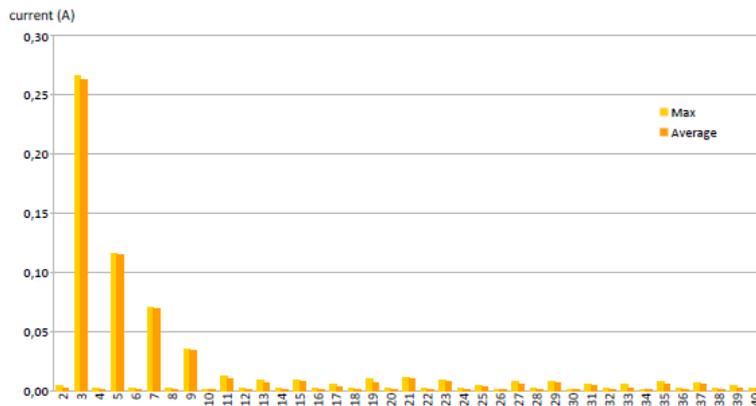


Harmonics pre-compliance test report

Customer:		Equipment setup:	Device PA4000
Standard ref:	IEC61000-3-2:2014 Ed.4 – Class A		Serial No. S/N B020175
Description:	PFC+LLC power supply		F/W Ver. Ver.2.004.008
Model:	TEA2016DB1519v2 demo board	Test duration:	10 min.
Serial #:	161	Temperature:	23±3°C
Documentation ref.:	UM11234	Humidity:	<75 %
Rated input voltage:	90-264V 50/60Hz	Mains voltage:	114,8Vrms
Rated output voltage:	12Vdc	Mains frequency:	50Hz
Rated power:	240W	Load:	244W

Overall result: **PASS**

		Target	Limits	Test results			Pass/Fail
				Min	Max	Average	
Input voltage	Vrms	115	2,00%	114,76	114,76	114,76	PASS
Input current	Arms	2,3	2,00%	2,371	2,374	2,373	PASS
Input current fundamental	Arms			2,350	2,355	2,353	-
Input power	W			269,75	269,93	269,84	-
Output voltage	Vdc			12,206	12,215	12,210	-
Output power	W			243,95	244,10	244,02	-
Power factor		0,9	>0,9	0,9910	0,9912	0,9911	PASS
Frequency	Hz	50	0,50%	49,999	50,001	50,000	PASS
Input voltage crest factor		1,41	±0,01	1,421	1,422	1,421	PASS
Input current THD	%			12,43	12,62	12,54	-



Itacoil - 115Vac

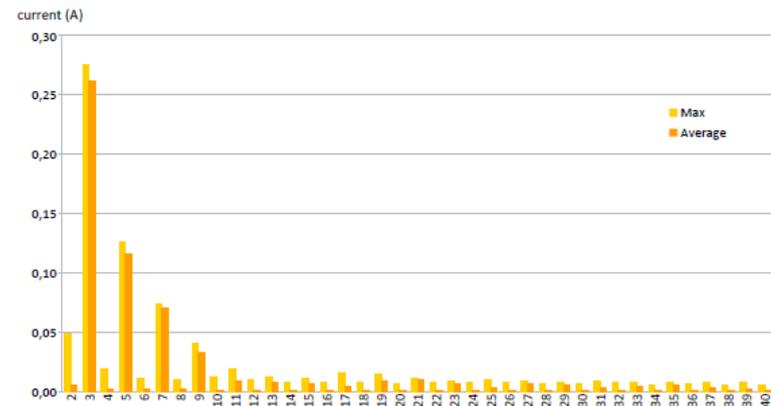


Harmonics pre-compliance test report

Customer:		Equipment setup:	Device PA4000
Standard ref:	IEC61000-3-2:2014 Ed.4 – Class A		Serial No. S/N B020175
Description:	PFC+LLC power supply		F/W Ver. Ver.2.004.008
Model:	TEA2016DB1519v2 demo board	Test duration:	10 min.
Serial #:	161	Temperature:	23±3°C
Documentation ref.:	UM11234	Humidity:	<75 %
Rated input voltage:	90-264V 50/60Hz	Mains voltage:	114,8Vrms
Rated output voltage:	12Vdc	Mains frequency:	50Hz
Rated power:	240W	Load:	244,3W

Overall result: **PASS**

		Target	Limits	Test results			Pass/Fail
				Min	Max	Average	
Input voltage	Vrms	115	2,00%	114,77	114,78	114,78	PASS
Input current	Arms	2,3	2,00%	2,353	2,358	2,354	PASS
Input current fundamental	Arms			2,296	2,363	2,328	-
Input power	W			266,89	267,44	267,04	-
Output voltage	Vdc			12,223	12,230	12,226	-
Output power	W			244,28	244,44	244,35	-
Power factor		0,9	>0,9	0,9882	0,9883	0,9883	PASS
Frequency	Hz	50	0,50%	49,999	50,001	50,000	PASS
Input voltage crest factor		1,41	±0,01	1,446	1,448	1,447	PASS
Input current THD	%			12,31	12,76	12,62	-



Original - 230Vac



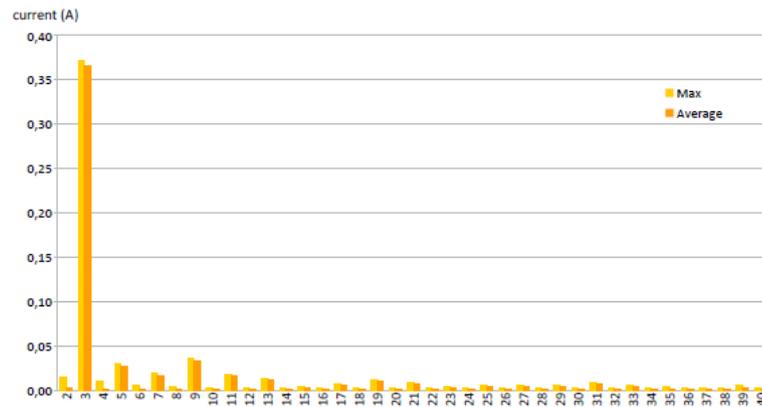
Harmonics pre-compliance test report

Customer: Equipment setup: Device PA4000
 Standard ref: IEC61000-3-2:2014 Ed.4 – Class A
 Description: PFC+LLC power supply
 Model: TEA2016DB1519v2 demo board
 Serial #: 161
 Documentation ref.: UM11234
 Rated input voltage: 90-264V 50/60Hz
 Rated output voltage: 12Vdc
 Rated power: 240W

Test duration: 10 min.
 Temperature: 23±3°C
 Humidity: <75 %
 Mains voltage: 229,9Vrms
 Mains frequency: 50Hz
 Load: 244W

Overall result: **PASS**

		Target	Limits	Test results			Pass/Fail
				Min	Max	Average	
Input voltage	Vrms	230	2,00%	229,94	229,95	229,95	PASS
Input current	Arms	1,14	2,00%	1,220	1,221	1,220	PASS
Input current fundamental	Arms			1,159	1,165	1,162	-
Input power	W			264,87	264,97	264,92	-
Output voltage	Vdc			12,207	12,216	12,211	-
Output power	W			243,93	244,11	244,02	-
Power factor		0,9	>0,9	0,9439	0,9442	0,9441	PASS
Frequency	Hz	50	0,50%	49,999	50,001	50,000	PASS
Input voltage crest factor		1,41	±0,01	1,412	1,414	1,413	PASS
Input current THD	%			30,15	30,39	30,29	-



Itacoil - 230Vac



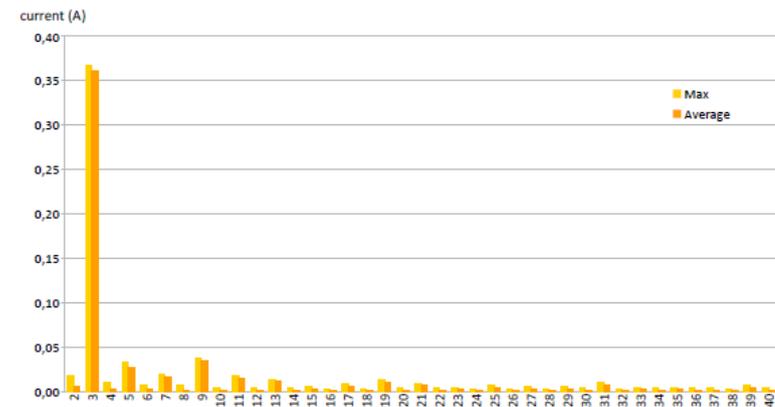
Harmonics pre-compliance test report

Customer: Equipment setup: Device PA4000
 Standard ref: IEC61000-3-2:2014 Ed.4 – Class A
 Description: PFC+LLC power supply
 Model: TEA2016DB1519v2 demo board
 Serial #: 161
 Documentation ref.: UM11234
 Rated input voltage: 90-264V 50/60Hz
 Rated output voltage: 12Vdc
 Rated power: 240W

Test duration: 10 min.
 Temperature: 23±3°C
 Humidity: <75 %
 Mains voltage: 230Vrms
 Mains frequency: 50Hz
 Load: 244,4W

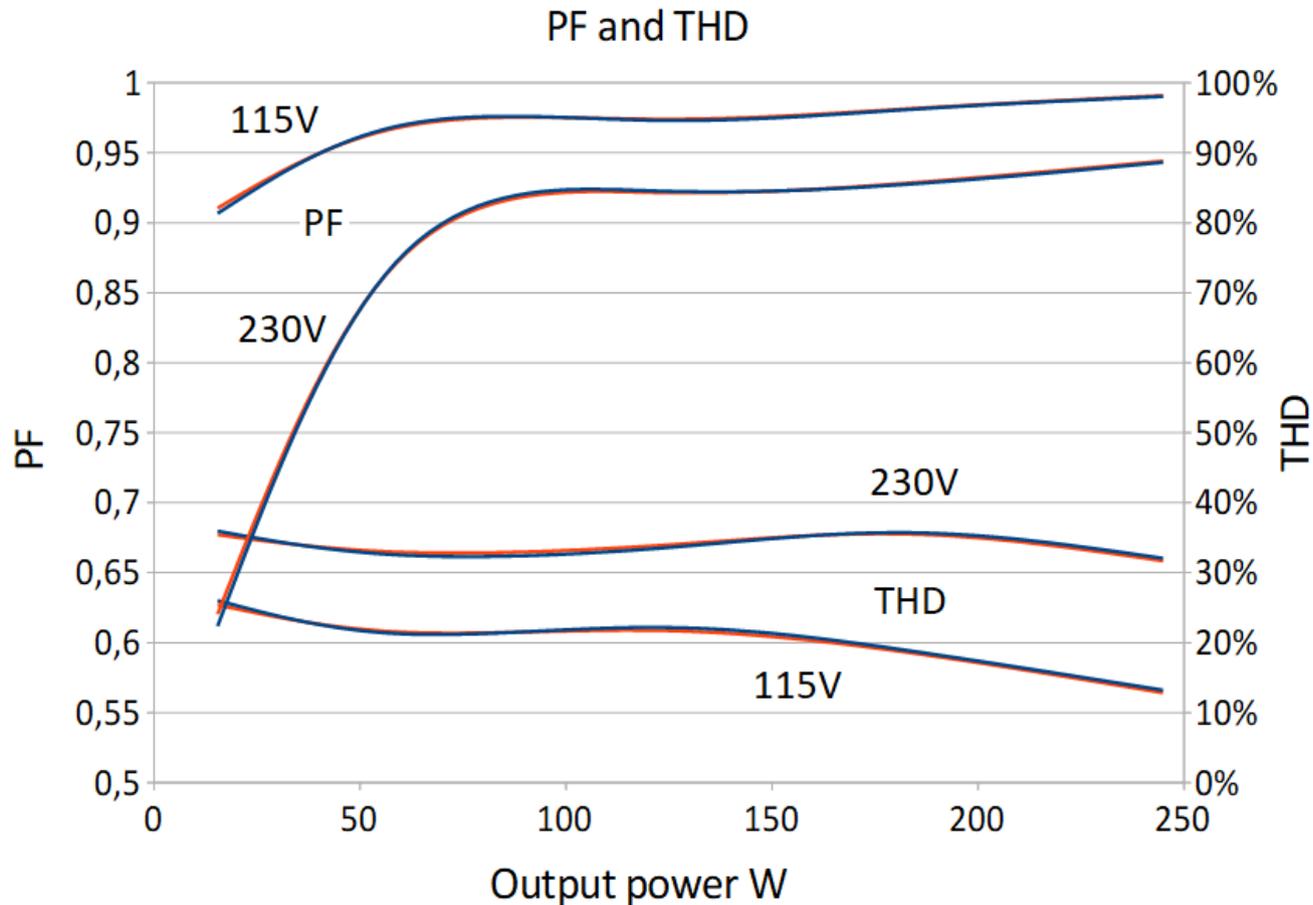
Overall result: **PASS**

		Target	Limits	Test results			Pass/Fail
				Min	Max	Average	
Input voltage	Vrms	230	2,00%	229,95	229,96	229,95	PASS
Input current	Arms	1,14	2,00%	1,208	1,210	1,209	PASS
Input current fundamental	Arms			1,141	1,158	1,150	-
Input power	W			262,02	262,79	262,29	-
Output voltage	Vdc			12,223	12,229	12,226	-
Output power	W			244,28	244,44	244,36	-
Power factor		0,9	>0,9	0,9434	0,9441	0,9436	PASS
Frequency	Hz	50	0,50%	49,999	50,001	50,000	PASS
Input voltage crest factor		1,41	±0,01	1,413	1,415	1,414	PASS
Input current THD	%			29,95	30,42	30,21	-



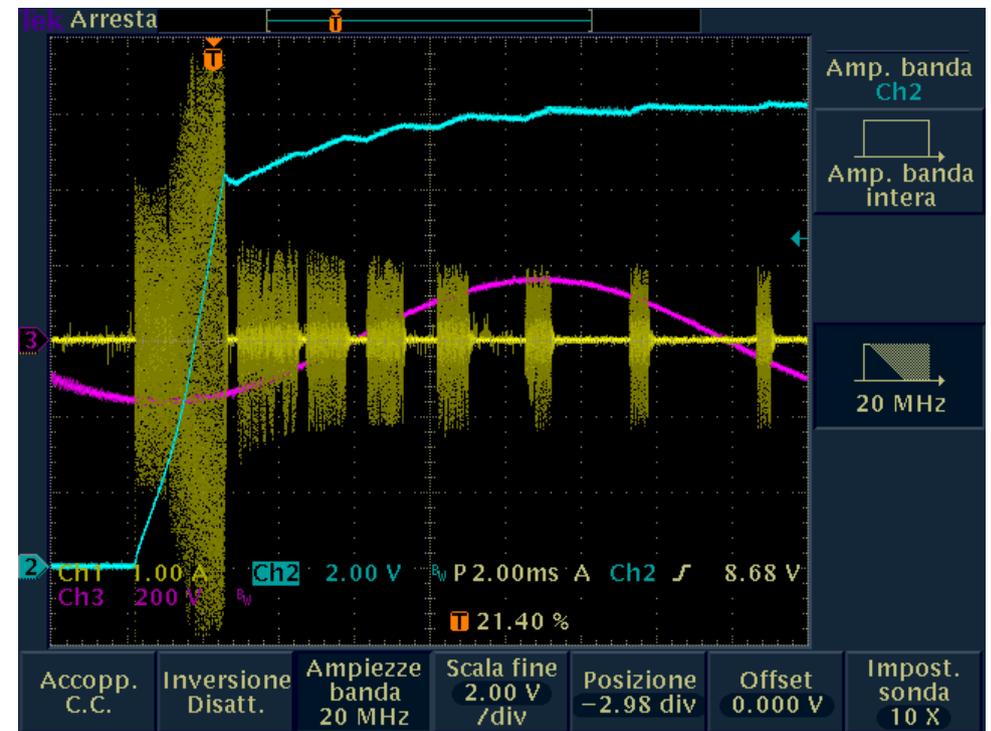
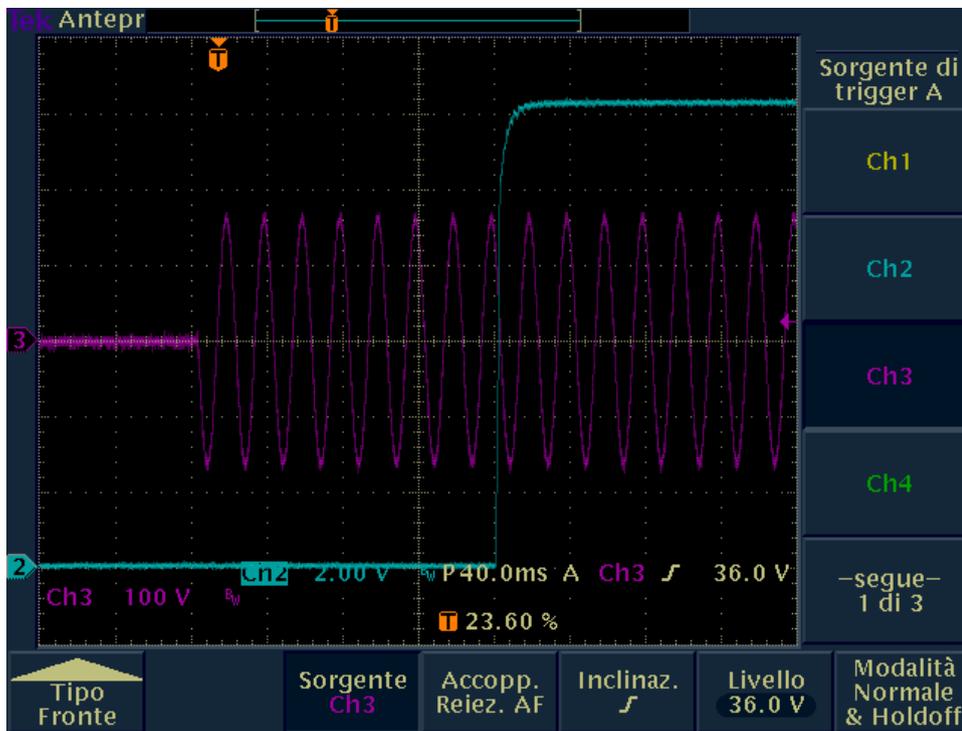
The mains filter has not been entirely revised since it is not in the scope of this optimization, so THD of the Itacoil version is no different than that of the original board.

Also Power Factor has not changed.



Waveforms	CH1	Yellow	LLC transformer prim. current
	CH2	Ligth blue	Output voltage
	CH3	Purple	Mains voltage
	CH4	Green	DC link voltage

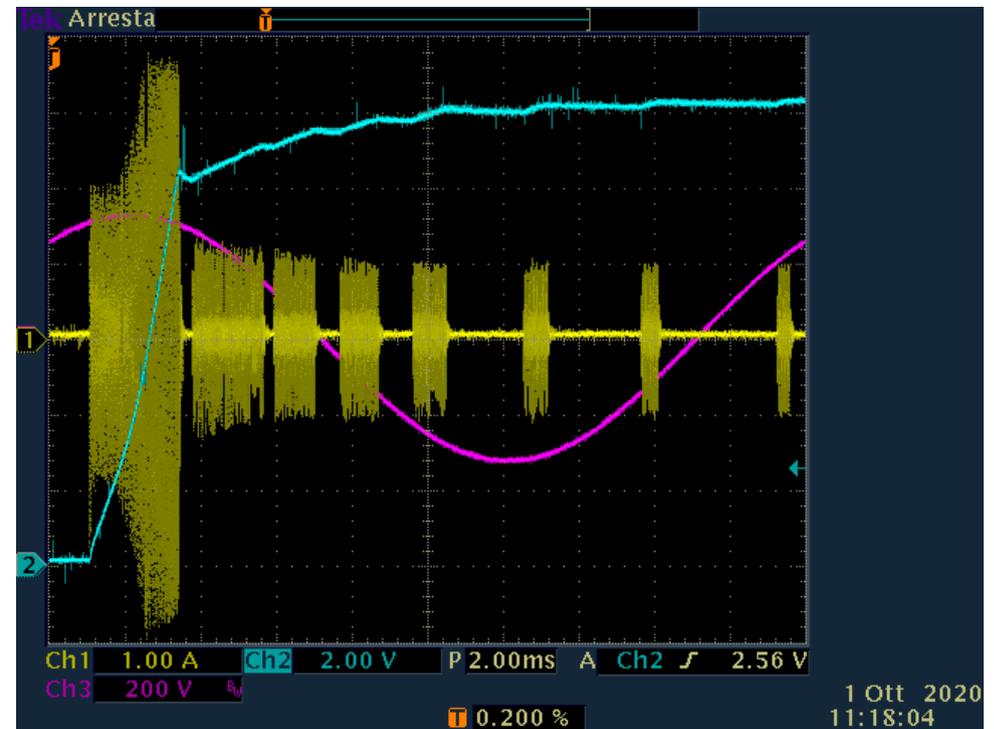
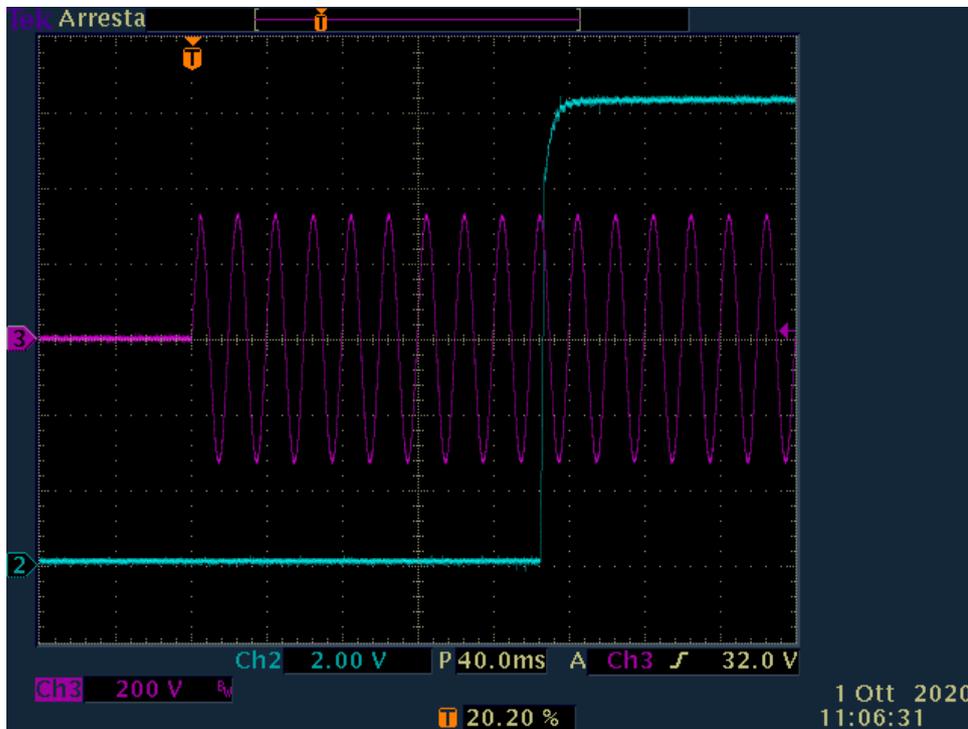
115V/50Hz, 240W load - **turn-on delay**¹: about 165mSec



¹ Performed only on Itacoil components; no significant differences expected on original components.

Waveforms	CH1	Yellow	LLC transformer prim. current
	CH2	Ligth blue	Output voltage
	CH3	Purple	Mains voltage
	CH4	Green	DC link voltage

230V/50Hz, 240W load - **turn-on delay**¹: about 190mSec



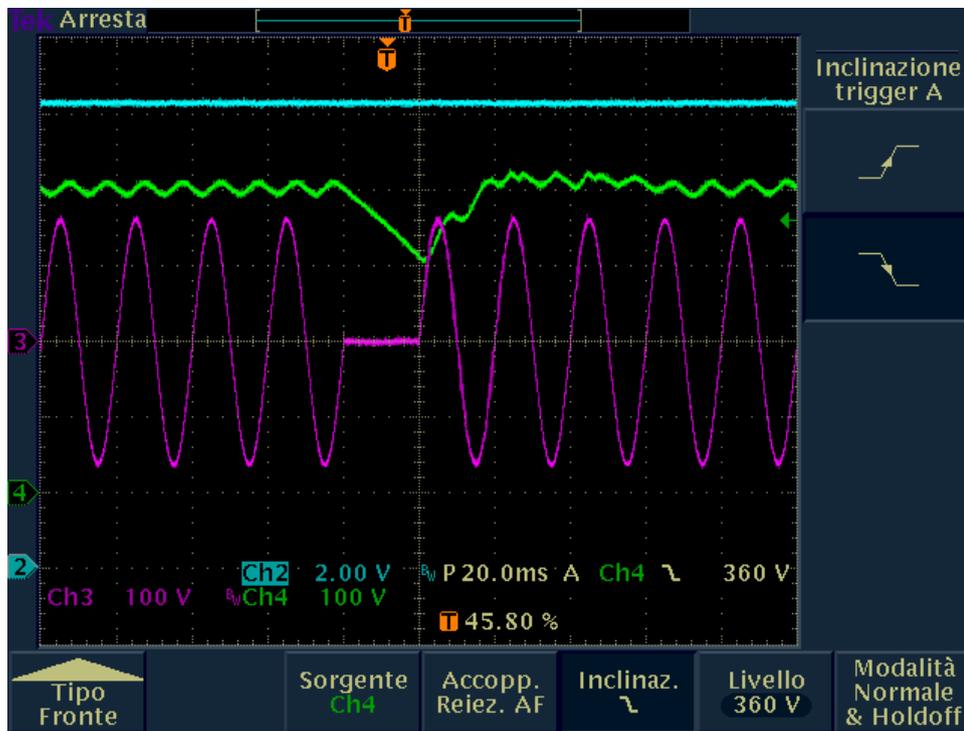
¹ Performed only on Itacoil components; no significant differences expected on original components.

Waveforms	CH2	Ligth blue	Output voltage
	CH3	Purple	Mains voltage
	CH4	Green	DC link voltage

The converter supports 20mSec hold-up time with very stable output voltage and no intervention of capacitive protection.

Mains loss¹

115V/50Hz, 240W load



230V/50Hz, 240W load

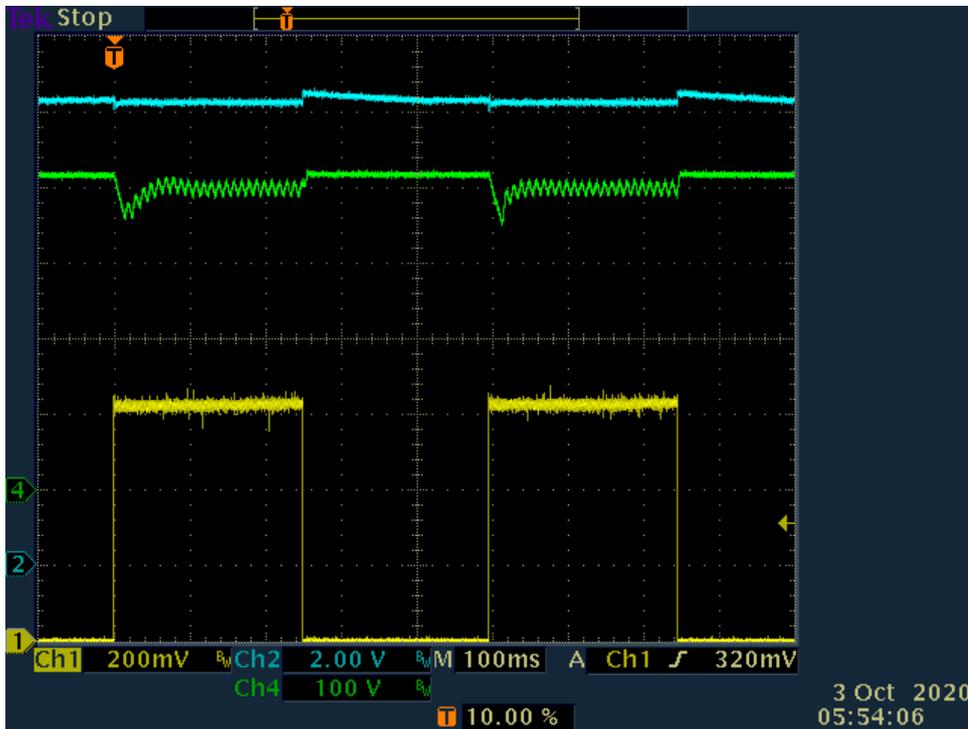


¹ Performed only on Itacoil components; no significant differences expected on original components.

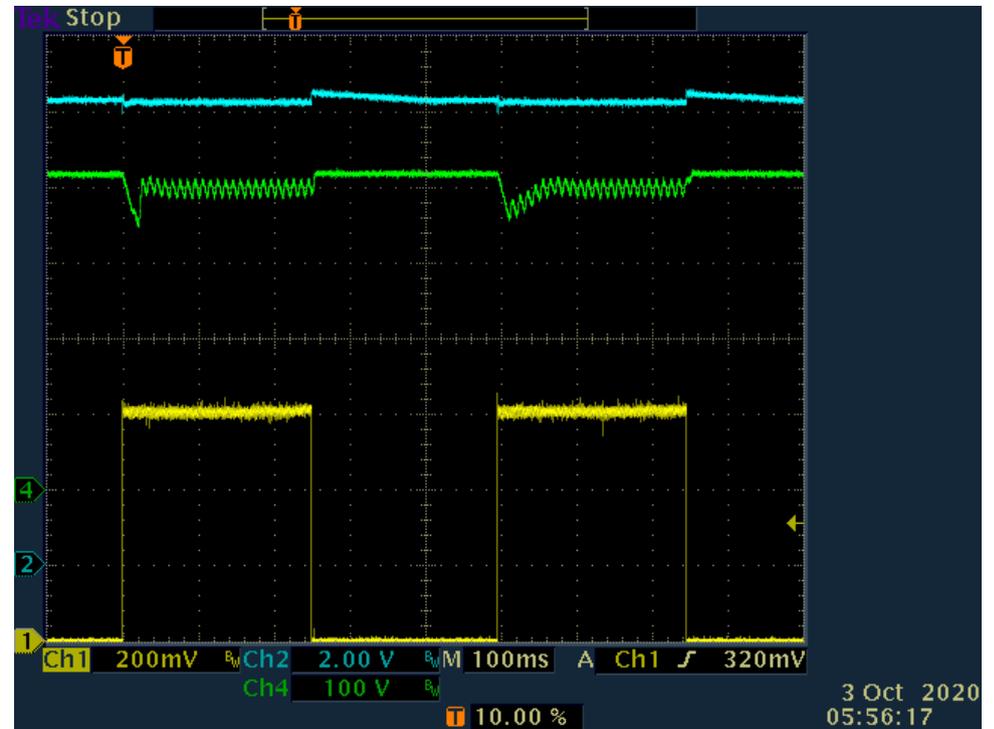
Waveforms	CH1	Yellow	Output current 0-20A _{dc} and vice-versa (not to scale)
	CH2	Ligth blue	Output voltage
	CH4	Green	DC link voltage

Loadstep¹

115V/50Hz, 0-240W steps



230V/50Hz, 0-240W steps



¹ Performed only on Itacoil components; no significant differences expected on original components.

DEMO-BOARD OPTIMIZATION AND PRE-COMPLIANCE REPORT

Request the [test report extended version](#)

Demo Board documents: [NXP TEA2016DB1519v2](#)

Other Demo Board reports: https://www.itacoilweb.com/portfolio_category/demo-boards/

LLC resonant transformers: https://www.itacoilweb.com/portfolio_category/llc-integrated-resonant-transformers/

PFC inductors: https://www.itacoilweb.com/portfolio_category/active-pfc-inductors/

Common Mode inductors: https://www.itacoilweb.com/portfolio_category/common-mode-inductors/

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Contact us at contatto@itacoilmail.it

Notes

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