Low Power RDFC Application Design Report

110 Vac, 9 V, 6 W Cordless Phone Adapter
(Type AD-2057)

A low cost adapter for cordless phones using CamSemi's low power resonant discontinuous forward converter (low power RDFC) topology and advanced controller IC

Low power RDFC controller IC product type number: C2471LX2 (SOT23-6)

This report describes a low cost charger/adapter (reference AD-2057, see Figure 1) for cordless phone products. It operates from a 110 Vac 60 Hz nominal line input and delivers 6 W (nominal rated power) at 9 Vdc.

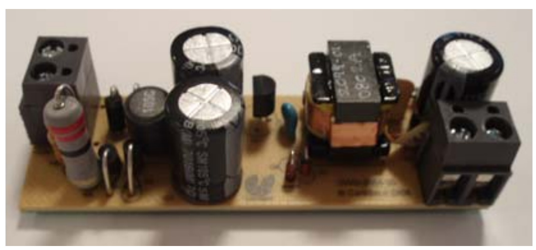

Figure 1: AD-2057 Adapter for Cordless Phones

AD-2057 uses CamSemi's advanced, mixed signal, low power RDFC controller type C2471LX2 in a SOT23-6 package. For further information about the Low Power RDFC topology and to obtain the C2471LX2 datasheet (reference DS-1639), visit www.camsemi.com.

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1 SPECIFICATION

Description	Symbol	Min	Typ	Max	Units	Comments
Line Input Voltage	V_{IN}	94	110	127	Vac	
Line Frequency	F_L	57	60	63	Hz	
Output Voltage	V_{OUT}		9		V	
Continuous Output Current	I_{OUT}		0.66		A	
Peak Output Current	I_{OUTPK}			1	A	
Output Ripple Voltage - Line Frequency	$V_{RIPPLEFL}$			500	mV	
Output Ripple Voltage - Switching Frequency	$V_{RIPPLEF}$			100	mV	
Maximum continuous output power	P_{OUT}		6		W	
Full Power Conversion Efficiency	η		80		%	
No-Load Consumption	$P_{NO\text{-}LOAD}$		150		mW	
Switching frequency	F		50		kHz	

Table 1: AD-2057 Specifications

2 CIRCUIT SCHEMATIC

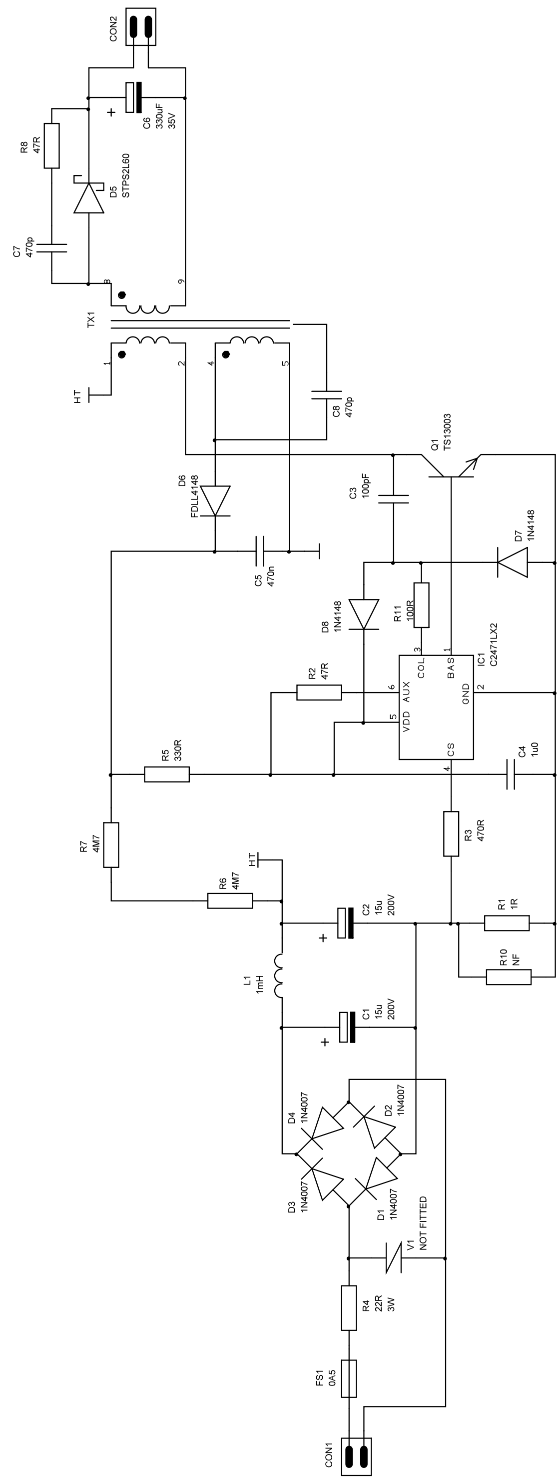

Figure 2: AD-2057 Schematic

3 BILL OF MATERIALS

Qty	Value	Ref	Description	Mfr	Mfr Number
2	470 pF	C7	CAP 0805 470 pF NPO 100V 125C	AVX	08051A471JAT2A
	470 pF	C8		AVX	08051A471JAT2A
1	470 nF	C5	CAP 0805 470 nF X7R 16V 125C	AVX	0805YC474KAT2A
1	1 uF	C4	CAP 0805 1 uF X7R 25V 125C	AVX	08053C105KAZ2A
1	330 uF	C6	CAP ALEL 330 uF 35V 20%	RUBYCON	35ZLH330M10X12.5
2	15 uF	C1	CAP ALEL TH 15 uF 200V GLUXON	Luxon	ESM156M200S1A5H150
	15 uF	C2		Luxon	ESM156M200S1A5H150
1	100 pF	C3	CAP TH 100 pF 1000V	MURATA	DEBB33A101KC1B
2	2 WAY	CON1	CON TERM BLOCK 2 WAY 415 V	IMO	20.501M/2
	2 WAY	CON2		IMO	20.501M/2
4	1N4007	D1	DIO EPI 1N4007 1000 V 1 A	MULTICOMP	1N4007
	1N4007	D2		MULTICOMP	1N4007
	1N4007	D3		MULTICOMP	1N4007
	1N4007	D4		MULTICOMP	1N4007
2	1N4148	D7	DIO EPI 1N4148 75 V 0.2 A	PHILIPS	1N4148
	1N4148	D8		PHILIPS	1N4148
1	FDLL4148	D6	DIO EPI FDLL4148 75 V 0.2 A	FAIRCHILD	FDLL4148
1	STPS2L60	D5	DIO SCH STPS2L60 60 V 2 A	STMICROELECTRONICS	STPS2L60
1	0A5	FS1	FSE TH CERAMIC 0.5 A 125 V	LITTELFUSE	473.500HAT1L
1	C2471LX2	IC1	IC CAMSEMI C2471LX2 SOT23	CamSemi	C2471LX2
1	100R	R11	RES 0805 100R 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 100R
1	330R	R5	RES 0805 330R 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 330R
1	470R	R3	RES 0805 470R 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 470R
2	47R	R2	RES 0805 47R 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 47R
	47R	R8		MULTICOMP	MC 0.1W 0805 1% 47R
2	4M7	R6	RES 0805 4M7 1% 0W125	PHYCOMP	232273464705
	4M7	R7		PHYCOMP	232273464705
1	1R	R1	RES 1206 1R 1% 0W25	PHYCOMP	232272461008
1	NF	R10	RES 1206 NOT FITTED	RES 1206 NOT FITTED	RES 1206 NOT FITTED
1	22R	R4	RES 3W 22R 5%	WELWYN	WA84-22RJI
1	NF	V1	VAR NOT FITTED	NOT FITTED	VAR NOT FITTED
1	CW-2099	TX1	WOUND E13 CW-2099	CAMSEMI	CW-2099
1	1 mH	L1	WOUND IND TH RAD 1 mH 170 mA 10%	C&D TECHNOLOGIES	22R105C
1	TS13003	Q1	XSTR NPN TS13003 TO92	TSC	TS13003CT

Figure 3: AD-2057 Bill of Materials

4 TRANSFORMER DETAILS

4.1 Overview

The transformer uses a low cost E13 core and bobbin with safety isolation provided by secondary triple insulated wire. Creepage and clearance is maintained by using flying leads for the secondary whilst a flux band is used to reduce EMI levels.

For further transformer details, contact your CamSemi representative.

4.2 Materials

Part	Material Description	Approved Part Number
Core	Pair of E13 ferrite. P4 Material from Himeda, ungapped	P4 EE13 (Himeda)
Bobbin	10-pin, E13, ULV94V-0 approved.	EI-13(10P) (Himeda)
Tape	3M Type 56 Polyester Film Tape 8 mm wide	3M Type 56 8 mm.
ECW	Grade 2, Class B, enamelled copper Wire.	Generic
Wire	Triple insulated wire. TEX-E 0.3 mm diameter	TEX-E 0.3 mm
Varnish	Impregnation Varnish	Dolphs AC-43
Foil	Copper, 5 mm wide, 0.05 mm thick	

Table 2: Transformer Materials List

4.3 Testing

	Pin Connections	L Min	L Max	Conditions / Connections
Primary	1 to 2	45 mH	65 mH	Secondary open, 1 kHz test freq
Leakage Inductance	1 to 2	200 uH	400 uH	Secondary shorted, 10 kHz test freq

Table 3: Transformer Inductance Test Parameters

Test	Connection 1	Connection 2	Volts	Amps	Time
Pri - Sec	1,2, 3, 4, 5	Tx-, Tx+	4245	1 mA	3 s

Table 4: Hi Pot Transformer Test Parameters

5 PCB LAYOUT

The PCB was realised using single sided CEM1 material. The silk screens and bottom side copper layout are shown below. The board measures 68 mm by 21 mm with 16 mm component build height.

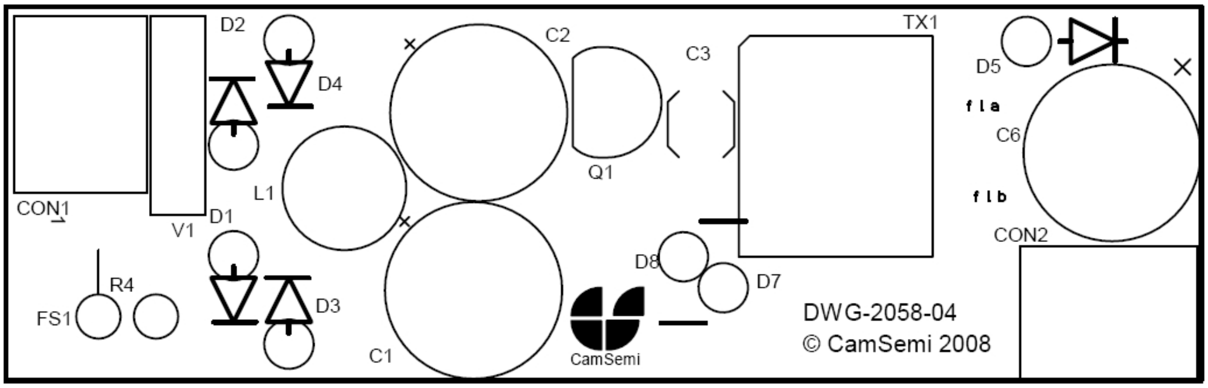

Figure 4: Top side Silk Screen

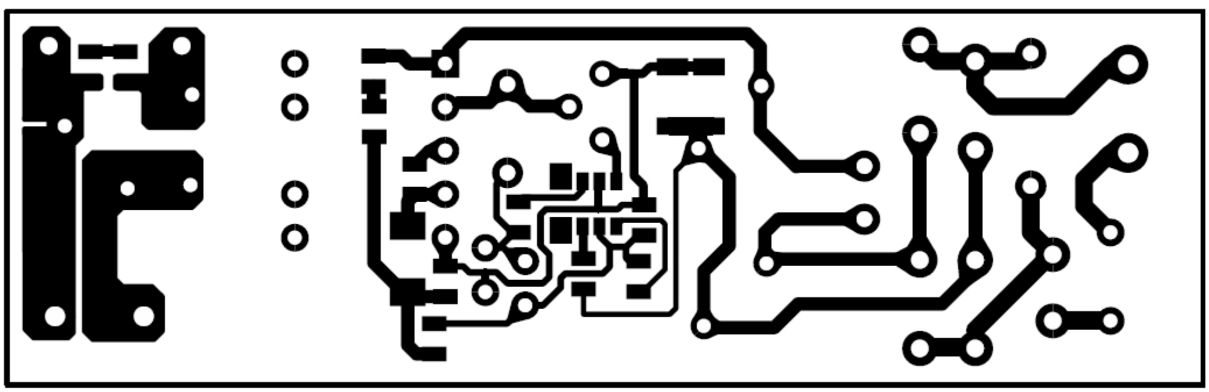

Figure 5: Bottom Side Copper

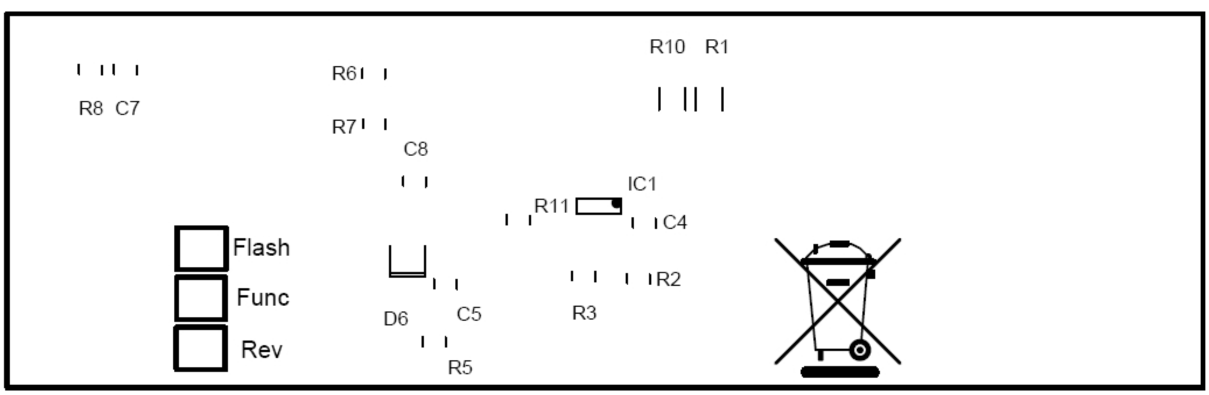

Figure 6: Bottom Side Silk Screen

6 PERFORMANCE MEASUREMENTS

All measurements were taken with the PCB mounted horizontally in free air at an ambient temperature of approximately 25°C.

6.1 Safety

Offline power supply prototypes may exhibit safety hazards including, but not limited to, electric shock, high temperatures, fire and smoke. Indeed, some standard procedures deliberately take the unit under test to the point of destruction. Prototypes should be tested and worked on only by competent and suitably trained personnel. The following general advice is offered but cannot take account of risks associated with any particular prototype or test set up. If you are in any doubt as to the safety of any unit or test procedure, please consult a competent adviser before proceeding.

- Before operating the unit:
    - Ensure that the documentation matches the unit to be tested and familiarise yourself with both. If there is a discrepancy or any doubt do not proceed with testing but contact your CamSemi representative for assistance;
    - Prototypes are often modified in the course of development. Check the unit to be tested for design or build errors before connecting it to the supply. Only proceed if you are satisfied that the unit is as intended and in a suitable condition for the testing to be performed;
    - Ensure general safety of the test set-up. For example, minimise the risk of inadvertent contact with the unit under test and injury from material which may be ejected from it in the event of a "catastrophic" failure;
- While operating the unit:
    - Do not connect the unit direct to the mains utility. Use a suitable isolated supply for the type of unit and the tests to be performed;
    - Remember that insulation between high voltage and low voltage parts of a prototype may not provide full safety isolation;
    - Regard all parts of the unit as potentially LIVE and HAZARDOUS;
- After disconnecting the supply:
    - Hazardous voltages will persist for some time after the supply is disconnected due to charge stored in capacitors. If necessary, capacitors can be safely and quickly discharged using a suitable resistor.
    - Allow the unit to cool before handling it.

6.2 Conversion Efficiency

Conversion efficiency was measured at minimum, nominal and maximum input voltage as a function of output load power. In each case, the load power was taken up to the point just before the PSU entered foldback protection (i.e. peak overload).

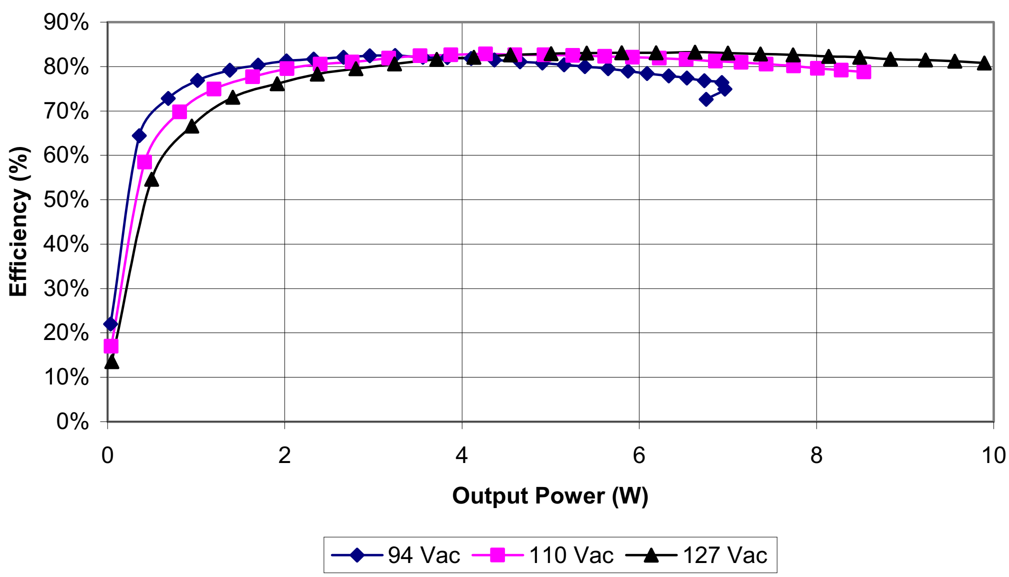

Figure 7: Conversion efficiency as a function of load

6.3 Energy Star Version 2.0 Compliance

Performance of the PSU was checked against the efficiency and no-load power consumption level specified in the Energy Star version 2.0 standards.

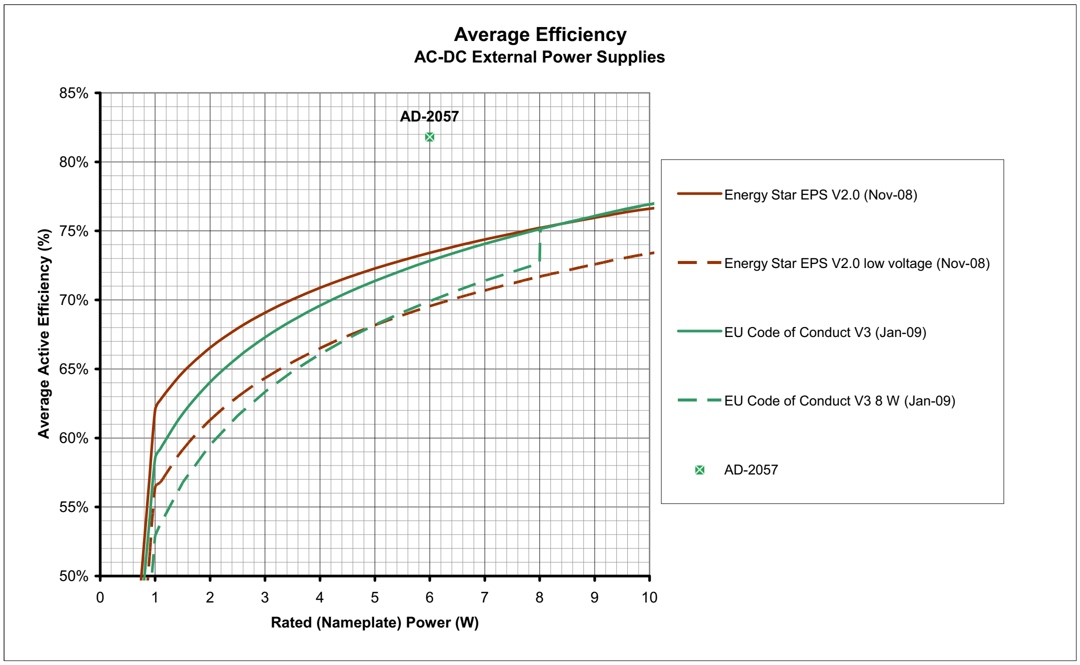

Figure 8: AD-2057 Prototype Compliance to Energy Star V2.0 Average Efficiency Requirements

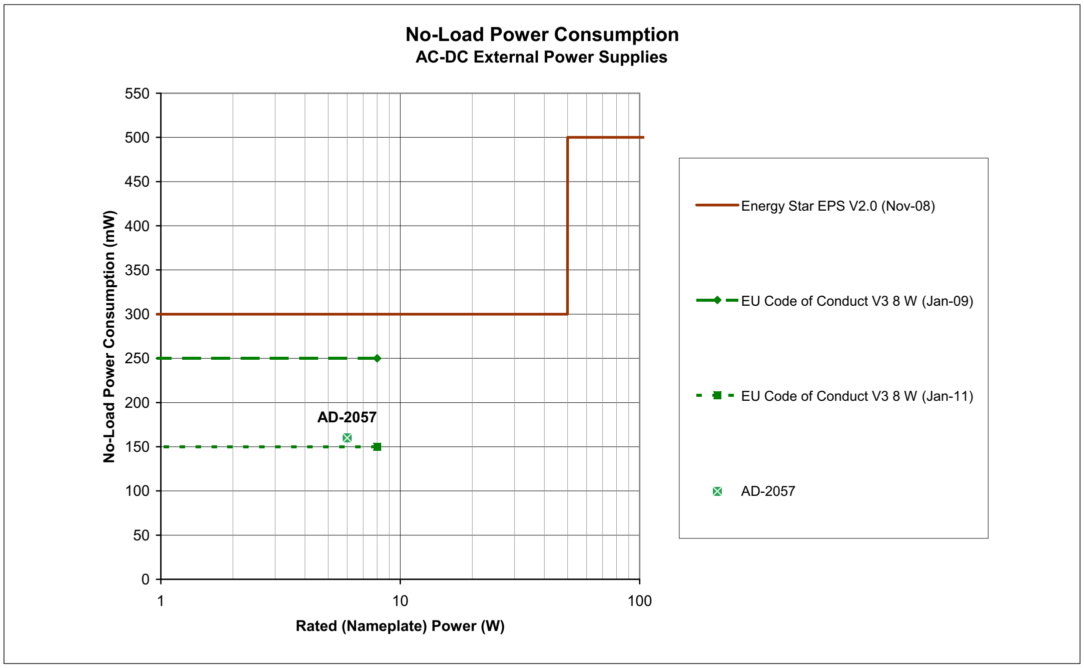

Figure 9: AD-2057 Prototype Compliance to Energy Star V2.0 No-Load Power Consumption Requirements

The figures show that AD-2057 is compliant with the Energy Star Version 2.0 specifications.

6.4 Load Regulation

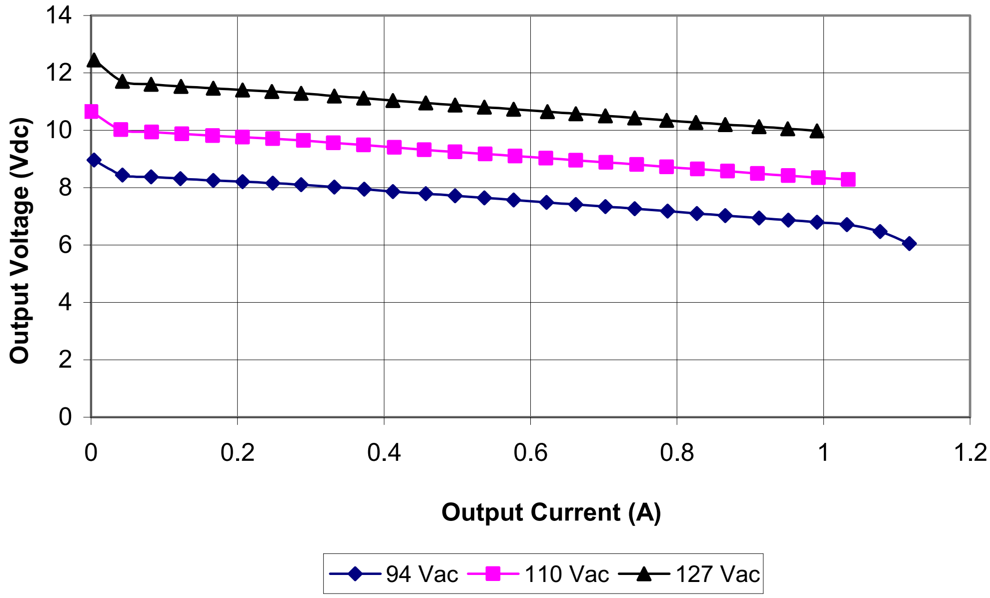

Figure 10: Load Regulation

Load regulation was measured at minimum, nominal and maximum input voltage. In each case, the load regulation was measured up to the point just before the PSU entered foldback protection. At nominal 110 Vac input and 660 mA rated load current, the output voltage is well centred at 9 V.

6.5 No-Load Power Consumption

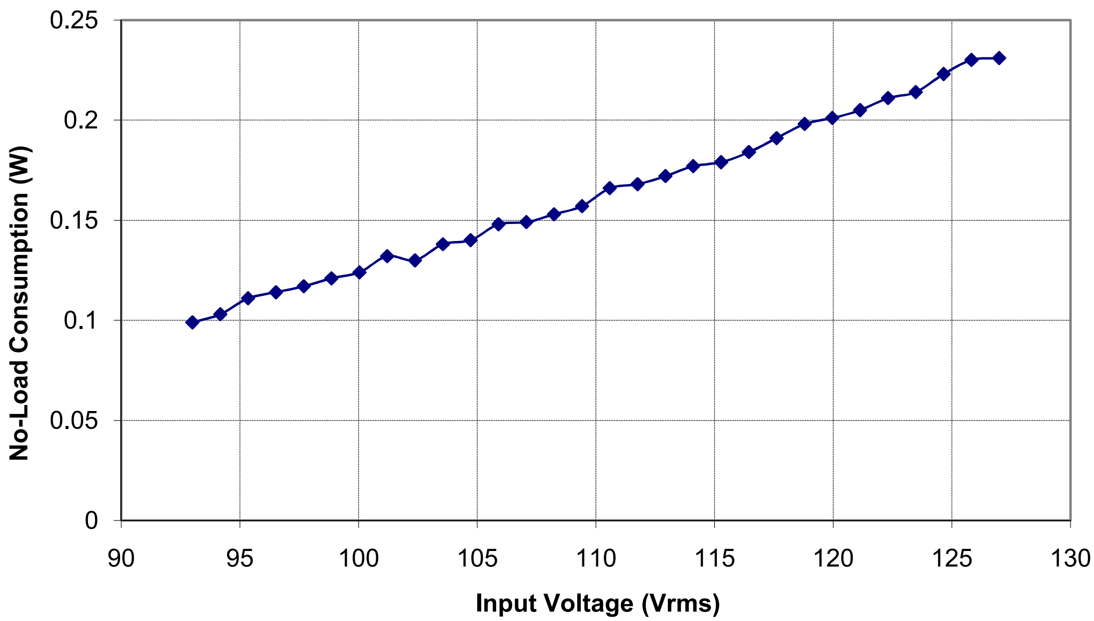

Figure 11: No-Load Power Consumption as Function of Line Voltage

7 OPERATIONAL WAVEFORMS

7.1 Primary Switch Waveforms

7.1.1 Nominal Operation

The switching behaviour of the primary side BJT (Q2) was measured under nominal input and load conditions. The collector-emitter voltage on Q2 and voltage across R1 (representative of the collector current) are shown in Figure 12.

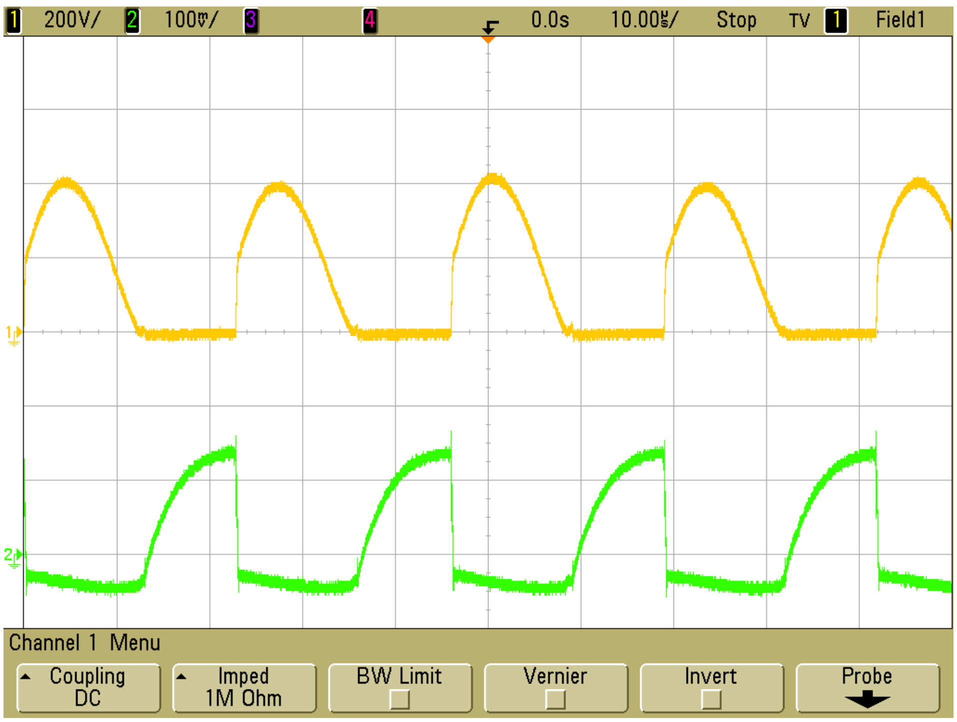

Figure 12: PSU Switching Behaviour Under Nominal Conditions. Q2 Collector-Emitter Voltage (CH1 at 200 V/div) and Voltage Across R1 (CH2 at 100 mV/div). Timebase is 10 us/div.

Under nominal conditions, the peak collector voltage is measured as 410 V and the peak collector current is 150 mA. The switching frequency is 45 kHz.

7.1.2 Start-up Behaviour

The collector-emitter voltage of Q2 and voltage across R1 were measured whilst starting up with nominal mains into a resistive load representative of nominal power. Waveforms were captured both with and without the additional 1000 µF load capacitance.

7.1.2.1 Resistive Load Start-Up

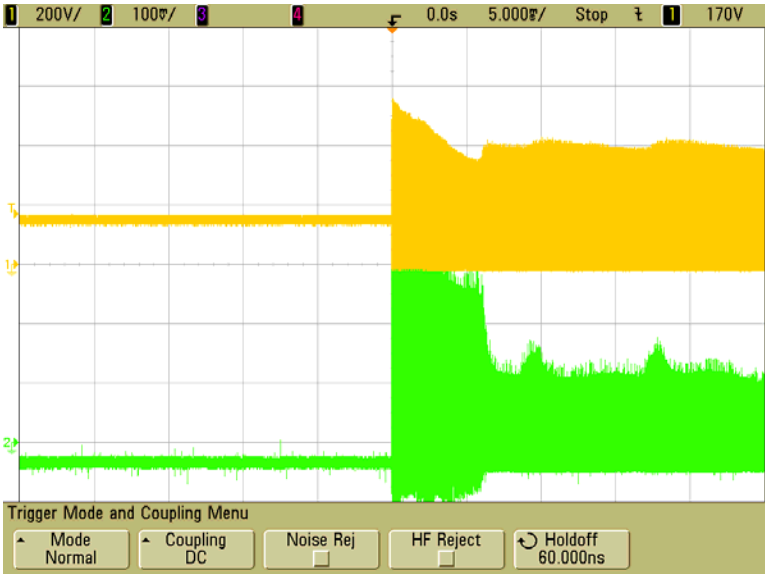

Figure 13: Start-up Waveforms Without Additional Load Capacitance. Q2 Collector-Emitter Voltage (CH1 at 200 V/div) and Voltage Across R1 (CH2 at 100 mV/div). Timebase is 5 ms/div.

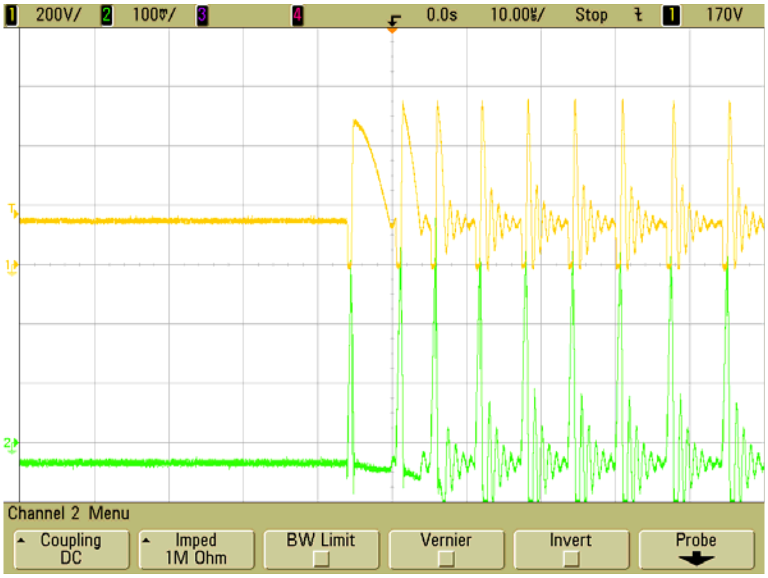

Figure 14: Zoom of Figure 13 First Few Cycles at 10 µs/div.

During this start-up sequence, the peak collector-emitter voltage is 550 V and the peak collector current is 400 mA.

7.1.2.2 Start-up with Resistive Load and 1000 µF Capacitance in Parallel

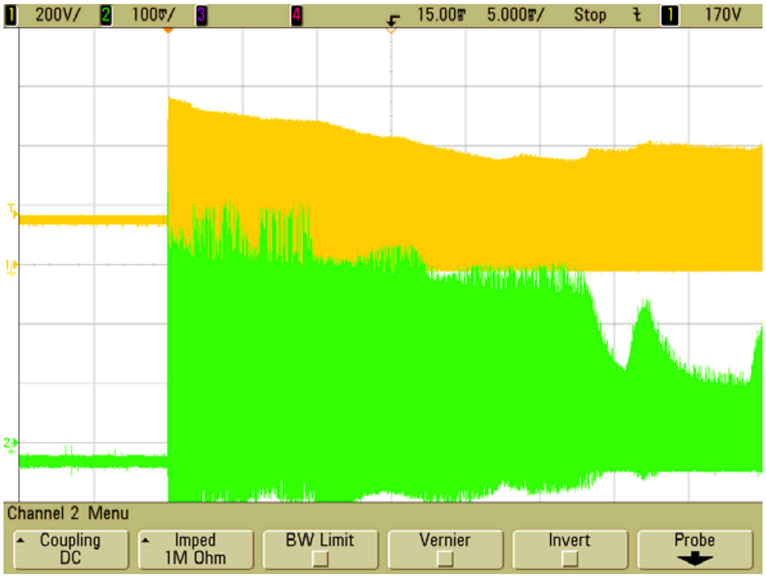

Figure 15: Start-up Waveforms With 1000 µF Additional Load Capacitance. Q2 Collector-Emitter Voltage (CH1 at 200 V/div) and Voltage Across R1 (CH2 at 100 mV/div). Timebase is 5 ms/div.

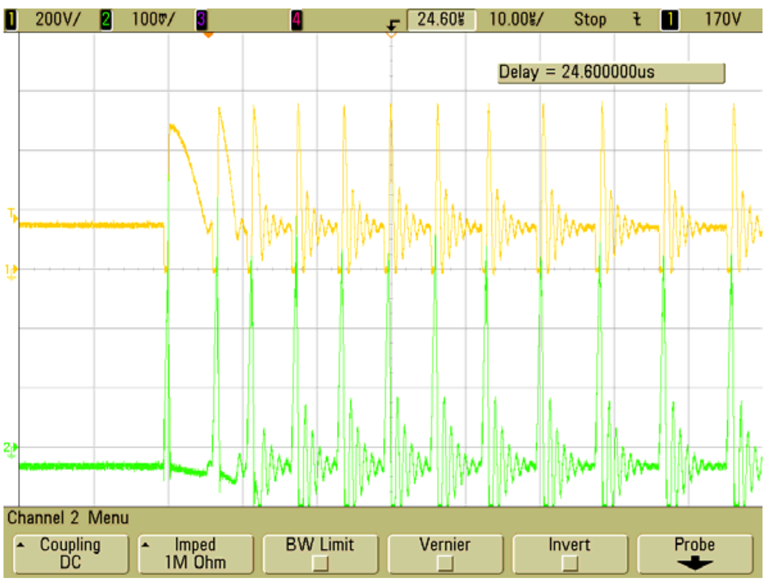

Figure 16: Zoom of Figure 15 First Few Cycles at 10 µs/div.

The peak collector voltage is 550 V and peak collector current is 400 mA.

7.2 Output Voltage Start-Up Behaviour

7.2.1 Start-Up Behaviour with No Additional Load Capacitance

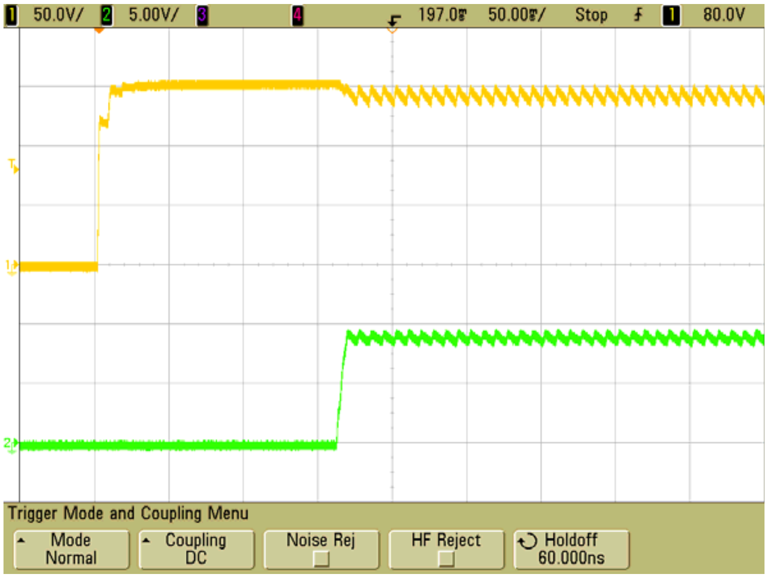

Figure 17: Output Voltage Start-up Behaviour into Resistive Load. Input Rectified Voltage (CH1 at 50 V/div) and Output Voltage (CH2 at 5 V/div). Timebase is 50 ms/div.

7.2.2 Start-up Behaviour with Additional Load Capacitance

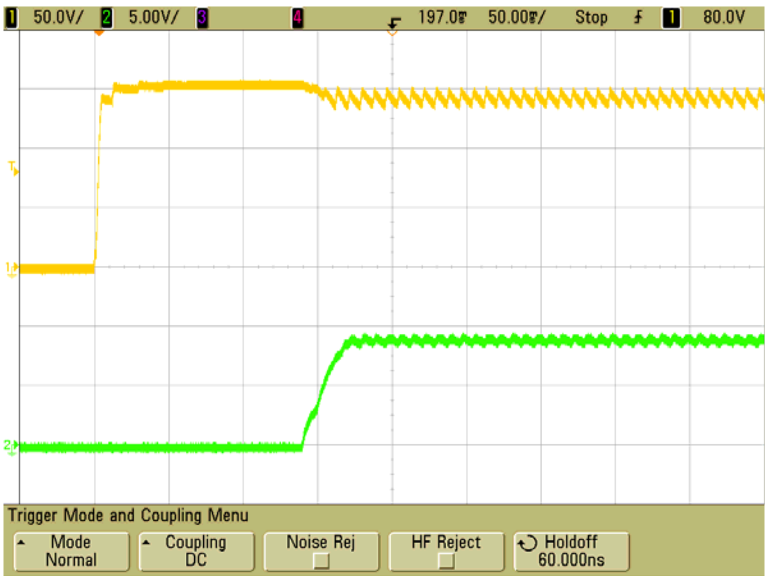

Figure 18: Output Voltage Start-up Behaviour with Additional 1000 µF Load Capacitance. Input Rectified Voltage (CH1 at 50 V/div) and Output Voltage (CH2 at 5 V/div). Timebase is 50 ms/div.

In both cases, the output voltage is operating within specified tolerances within 200 ms of mains power being applied.

7.3 Output Ripple

Output ripple was measured with nominal mains input and nominal 660 mA load. Ripple was measured both with and without the additional 1000 µF load capacitance.

7.3.1 Output Ripple - Line Frequency

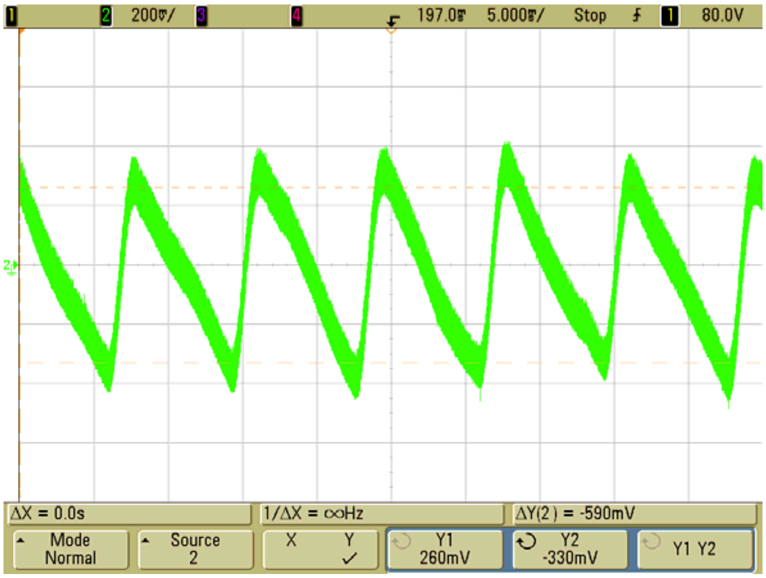

Figure 19: Line Frequency Output Voltage Ripple Without Additional Load Capacitance (CH2 at 200 mV/div). Timebase is 5 ms/div.

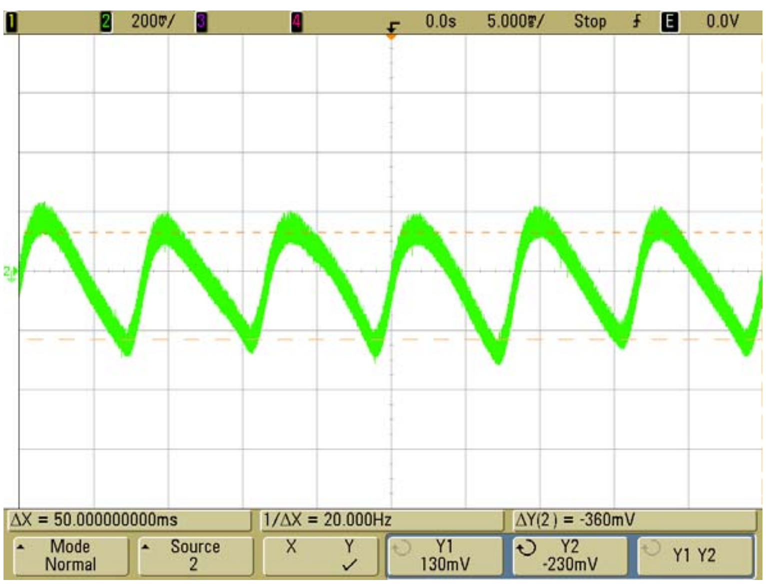

Figure 20: Line Frequency Output Voltage Ripple With 1000 µF Additional Load Capacitance (CH2 at 200 mV/div). Timebase is 5 ms/div.

Without additional load capacitance, the peak-peak line frequency output ripple is 600 mV and with the extra 1000 µF load capacitance, this reduces to about 350 mV. With the extra 1000 µF load capacitance the unit meets the required 500 mV pk-pk ripple requirement.

7.3.2 Output Ripple - Switching Frequency

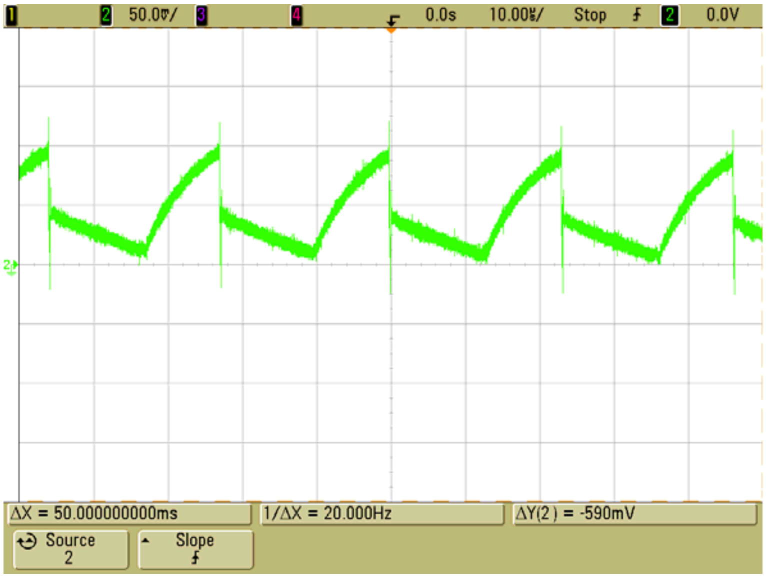

Figure 21: Switching Frequency Ripple Without Additional Load Capacitance (CH2 at 50 mV/Div). Timebase is 10 µs/div.

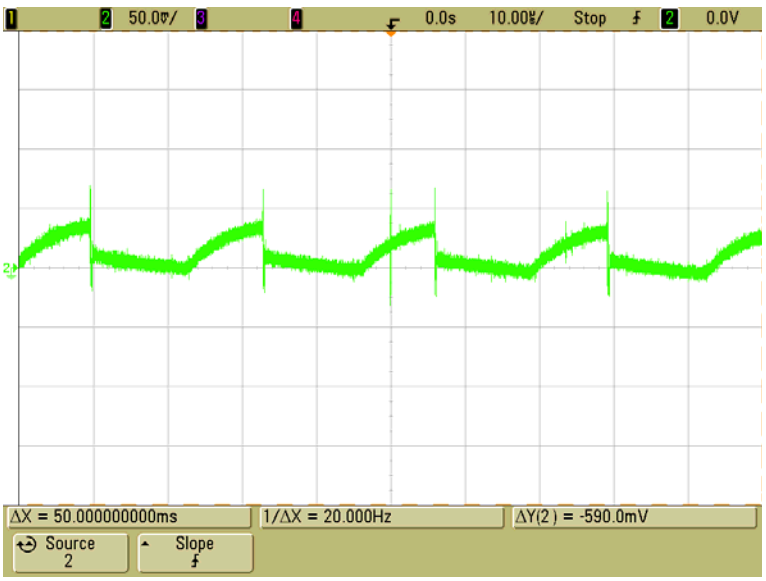

Figure 22: Switching Frequency Ripple With 1000µF Additional Load Capacitance (CH2 at 50mV/Div). Timebase is 10µs/div.

Without additional load capacitance, the switching frequency output voltage ripple is 100 mV peak to peak whilst with 1000 µF of extra load capacitance, this falls to 50 mV. With the load capacitance of 1000 µF, the combined output pk-pk ripple of 400 mV meets the specification requirements.

7.4 Output Short Circuit Recovery

Automatic recovery from a hard short circuit was measured by monitoring the output short circuit current and output voltage just before and just after the short circuit fault is removed. This measurement was taken both with and without the additional 1000 µF load capacitance.

7.4.1 Output Over-Load Recovery with No Additional Load Capacitance

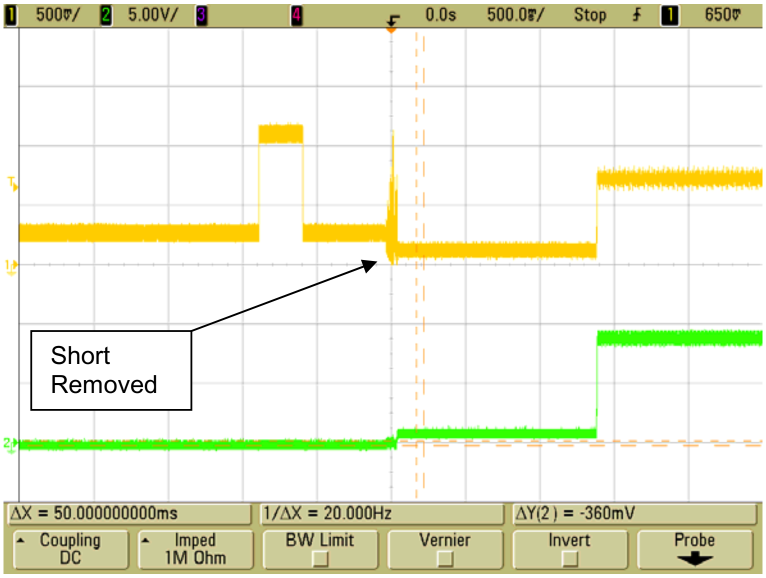

Figure 23: Output Short-Circuit Recovery Without Extra Capacitance. Short Circuit Current (CH1 at 0.5 A/div) and Output Voltage (CH2 at 5 V/div). Timebase is 0.5 s/div.

7.4.2 Output Over-Load Recovery with Additional Load Capacitance

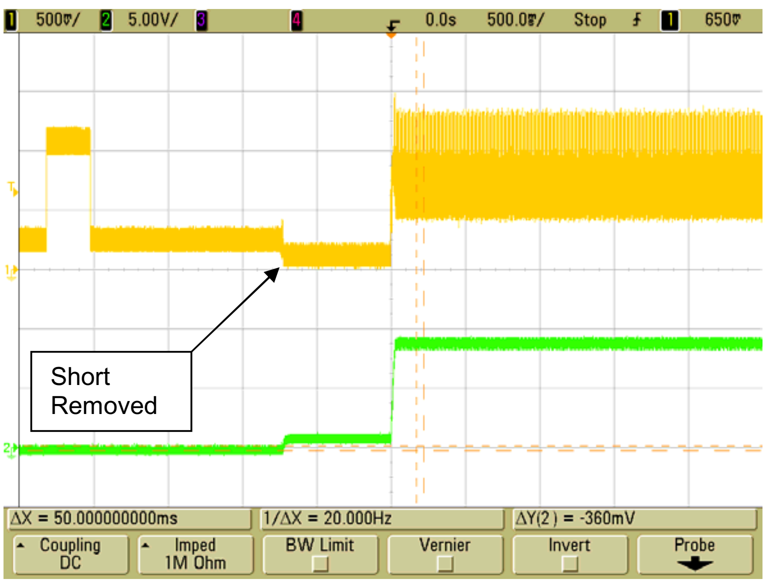

Figure 24: Output Short-Circuit Recovery With 1000 µF Extra Load Capacitance. Short Circuit Current (CH1 at 0.5 A/div) and Output Voltage (CH2 at 5 V/div). Timebase is 0.5 s/div.

8 EMI MEASUREMENTS

8.1 Conducted Emissions

Conducted emissions were measured with 110 Vac input and a resistive load representative of full nominal power connected to the output. The output ground of the power supply was connected to Earth, which is the worst case condition for EMI.

Conducted EMI was measured in both live and neutral lines.

8.1.1 Live Phase

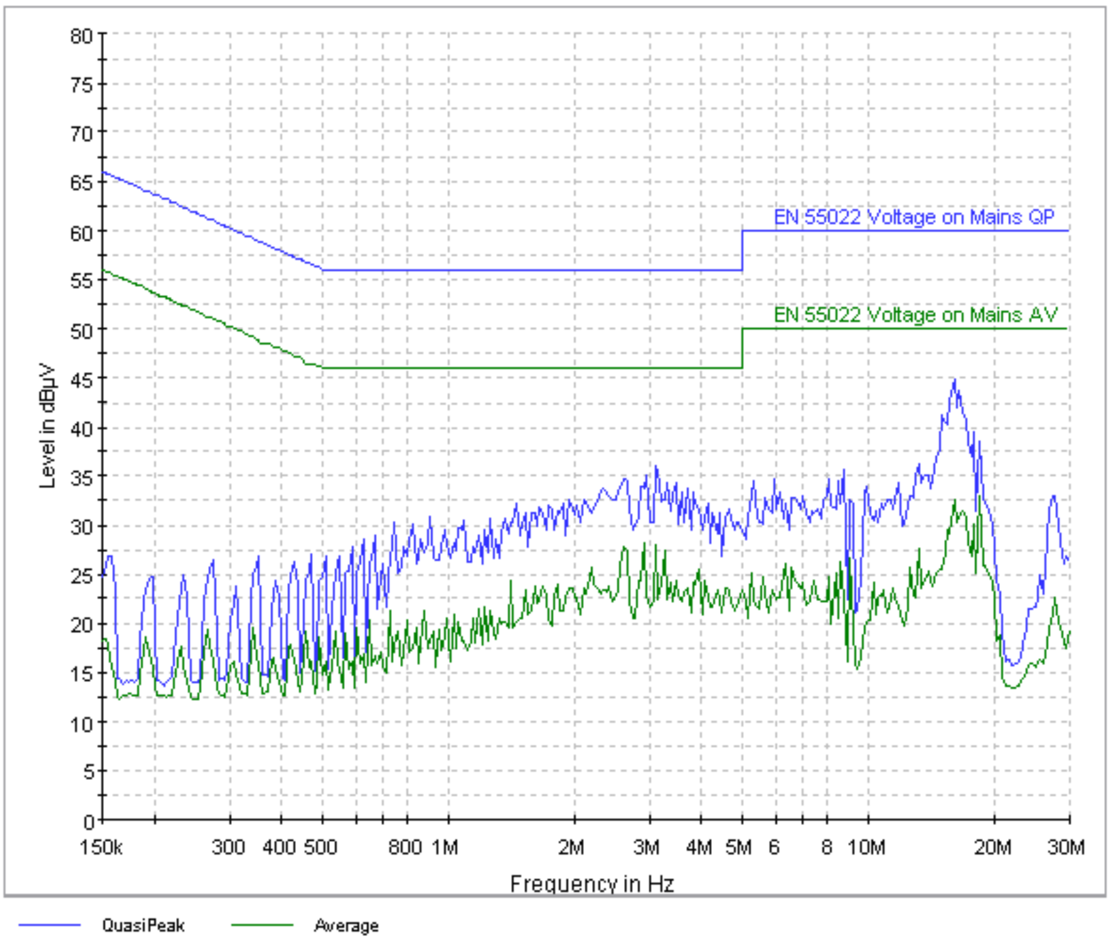

Figure 25: Conducted EMI Measured in Live Line

8.1.2 Neutral Phase

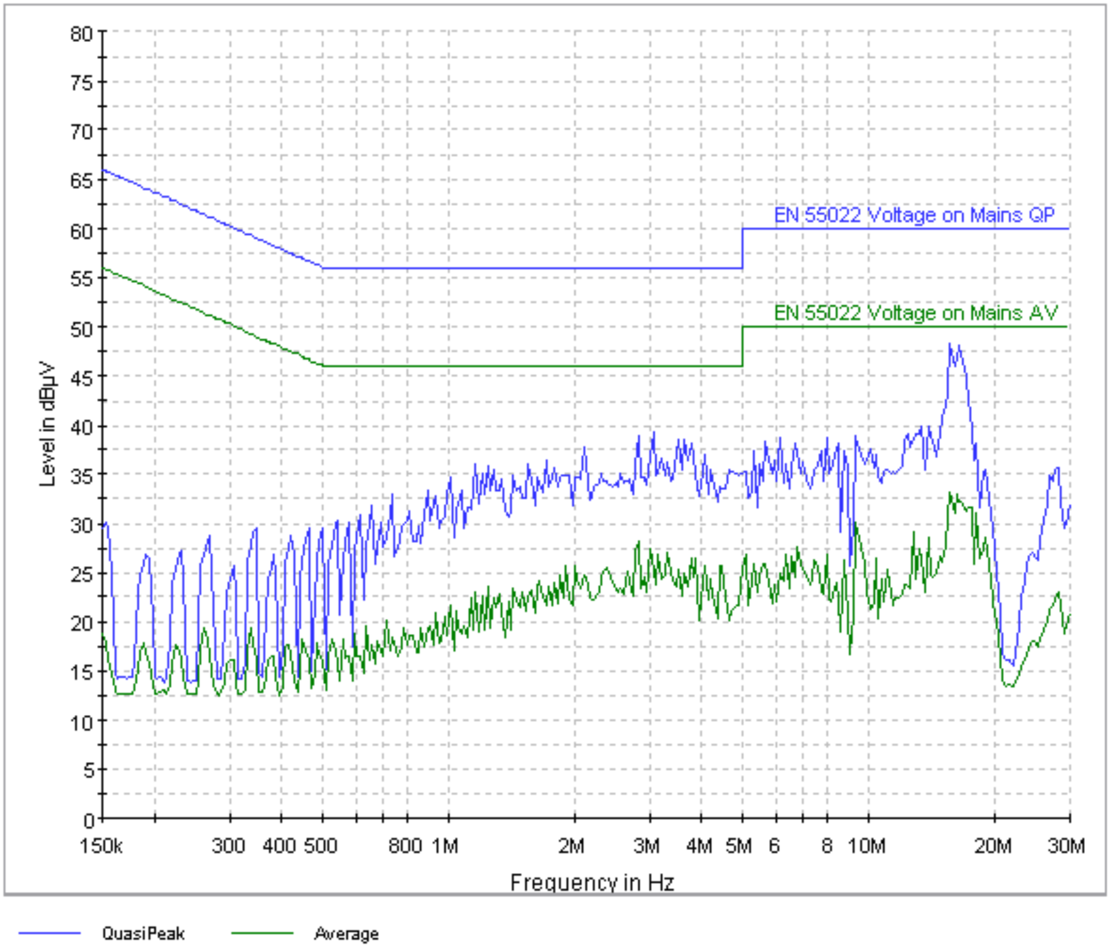

Figure 26: Conducted EMI Measured in Neutral Line

9 COMPONENT TEMPERATURE RISE

Key component temperatures were measured with the power supply mounted inside a sealed plug-top enclosure to emulate a worst case thermal situation. Temperatures were measured as a function of output current at minimum, nominal and maximum mains voltage. External ambient was approximately 25°C. In all cases, load current was increased up to the point just before the PSU entered foldback protection.

9.1 94 Vac Input

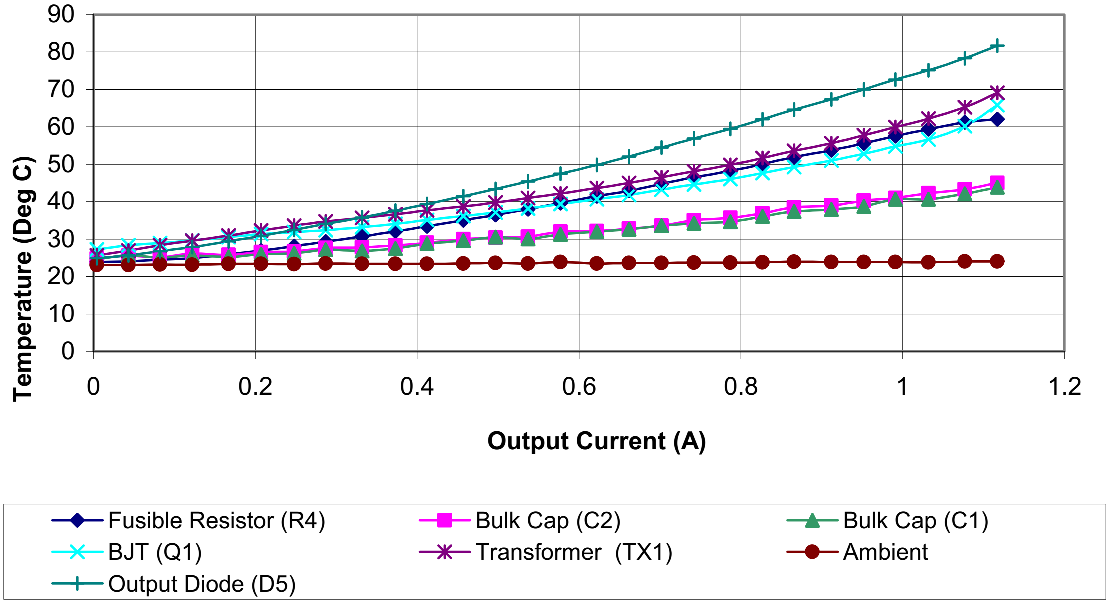

Figure 27: Key Component Temperature Rise as a Function of Power at 94 Vac

At maximum overload power with 94 Vac input, the highest device temperature is the output diode, which is 82°C.

9.2 110 Vac Input

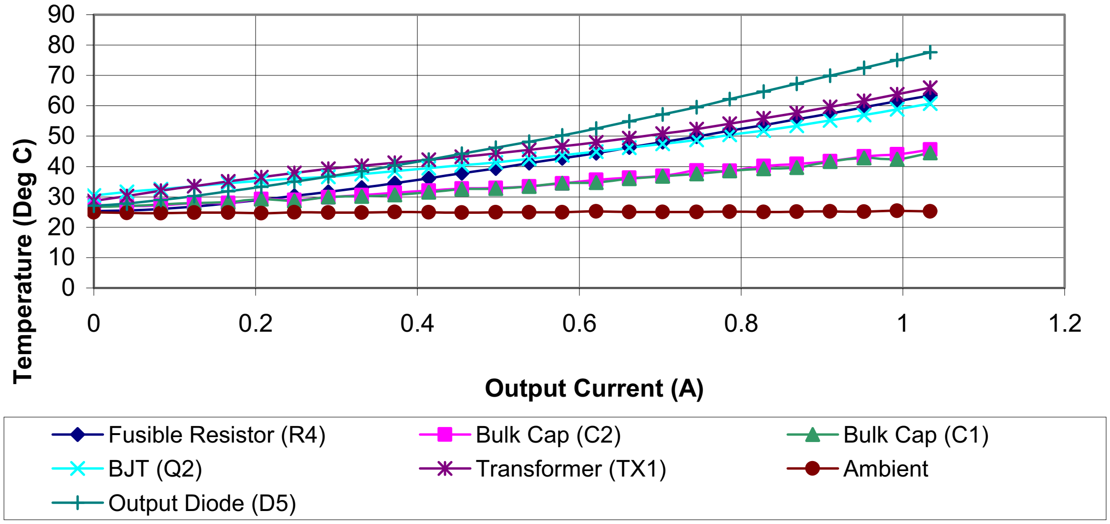

Figure 28: Key Component Temperature Rise as a Function of Power at 110 Vac

At maximum overload power with 110 Vac input, the highest device temperature is the output diode, which is 78°C.

9.3 127 Vac Input

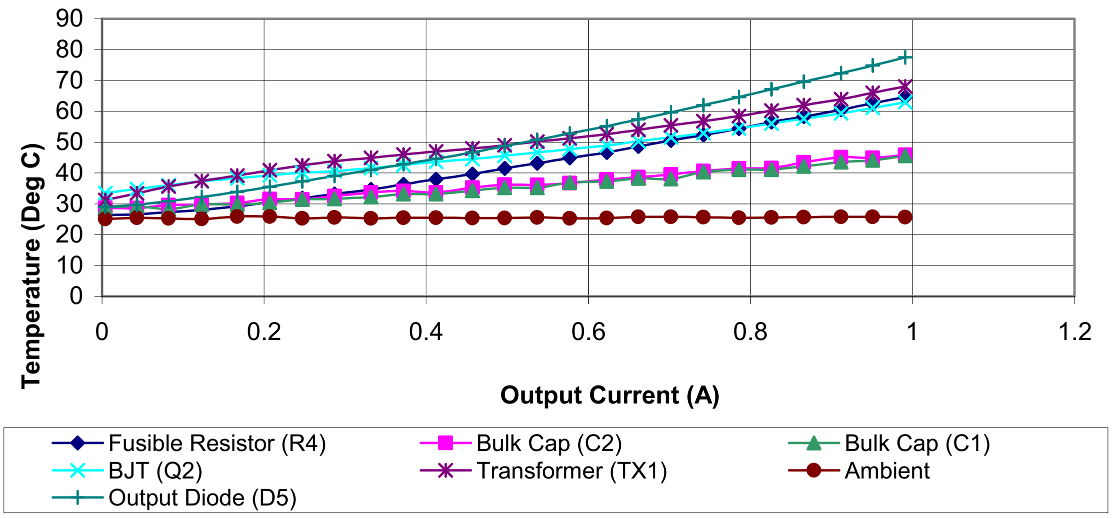

Figure 29: Key Component Temperature Rise as a Function of Load Current at 127 Vac

At maximum overload power with 127 Vac input, the highest device temperature is the output diode, which is 78°C.

10 FCC PART 68 PRE-COMPLIANCE TEST RESULTS

A prototype unit was pre-compliance tested to FCC part 68 clauses 4.2.4, 4.5.5 and 4.6.2. For the test, a cordless phone (iDECT model M1) was used to represent a typical system. Two AD-2057s (samples SO2 and SO3) were used to check for consistency in measured results.

The FCC68 clauses for which the PSU was tested against were those considered important for the power supply of a typical DECT cordless phone.

10.1 Clause 4.2.4

Clause 4.2.4 tests the capability of the power supply to withstand a differential surge between the live and neutral mains input terminals. The FCC68 surge applied has an open circuit peak voltage capability of 2.5 kV and a short circuit current capability of 1000 A. The open circuit wave shape has a 2 µs rise time and a 10 µs fall time.

10.2 Clause 4.5.5

Clause 4.5.5 measures the level of noise that the PSU generates in frequency bands of interest for telecoms applications. Both output differential noise, known as metallic, and common-mode, known as longitudinal, are tested over the frequency band of 8 kHz to 30 MHz. Different limits are specified over sub-bands of interest and the most demanding band is 12 kHz to 266 kHz since this is the region in which the power supply operates.

10.3 Clause 4.6

Clause 4.6.2 measures how much of a signal injected across the tip and ring terminals appears as longitudinal (common-mode) noise. The longitudinal component should be very small and measured as a logarithmic ratio of the applied signal.

10.4 Sample S02

4.5.5.1	METALLIC OUT OF BAND VOLTAGES	4.5.5.1

TIA-968-A Clause 4.5.5.1 Signal power limitations - Non-LADC Metallic Voltage - 4kHz to 30MHz (Sample S02)			Maximum measured signal power (dBVrms)		
Signalling condition = Idle					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-71.07		
12kHz to 266kHz	See Note 2	242.0kHz	-79.71		
270kHz to 6MHz	≤ -15	486kHz	-55.18		
6MHz to 30MHz	≤ -15	10.7MHz	-80.80		
Signalling condition = Line Seized					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-70.07		
12kHz to 266kHz	See Note 2	244kHz	-69.70		
270kHz to 6MHz	≤ -15	5.46MHz	-66.90		
6MHz to 30MHz	≤ -15	10.6MHz	-80.60		
Overall Result			**PASS**	**N/T**	**N/T**

Comments:

Note 1:

8kHz to 12kHz Limit $\leq -\left(6.4 + 12.6 \times \text{Log}_{10}\left(\text{Frequency}(\text{kHz})\right)\right)$

Note 2:

12kHz to 90kHz Limit $\leq \left(23 - 40 \times \text{Log}_{10}\left(\text{Frequency}(\text{kHz})\right)\right)$

90kHz to 266kHz Limit ≤ -55

Figure 30: Clause 4.5.5.1 (Metallic Noise) Test Results

TIA-968-A Clause 4.5.5.2 Signal power limitations - Non-LADC Longitudinal Voltage - 4kHz to 6MHz (Sample S02)			Maximum measured signal power (dBVrms)		
Signalling condition = Idle					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-71.10		
12kHz to 266kHz	See Note 2	239.5kHz	-70.94		
270kHz to 6MHz	≤ -34	567kHz	-59.90		
Signalling condition = Line Seized					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-71.20		
12kHz to 266kHz	See Note 2	12kHz	-71.70		
270kHz to 6MHz	≤ -34	5.95MHz	-69.80		
Overall Result			**PASS**	**N/T**	**N/T**

Comments:
1)
Note 1:

8kHz to 12kHz Limit $\leq \left(-\left(18.4 + 20 \times \mathrm{Log}_{10}\left(\mathrm{Frequency}(\mathrm{kHz})\right)\right)\right) - 1.4$

Note 2:

12kHz to 42kHz Limit $\leq \left(3 - 40 \times \mathrm{Log}_{10}\left(\mathrm{Frequency}(\mathrm{kHz})\right)\right) - 4$

42kHz to 266kHz Limit ≤ -66

2) The above limits allow for the correction factor of 1.4dB (4 to 16kHz), and 4.0dB (12kHz to 6MHz) as shown in TIA-968-A figure 4.5 due to the measurement terminations.

Figure 31: Clause 4.5.5.2 (Longitudinal Noise) Test Results

TIA-968-A, Subpart 4 Clause 4.6.2 – Transverse balance limitations (Sample S02)		Minimum measured balance (dB)		
On-Hook				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 60	100.00		
500	≥ 60	84.78		
1000	≥ 60	76.50		
2000	≥ 40	76.10		
3000	≥ 40	84.00		
4000	≥ 40	88.30		
Off-Hook Worst case Off-hook current = IMAX				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 40	95.70		
500	≥ 40	104.90		
1000	≥ 40	87.00		
2000	≥ 40	69.40		
3000	≥ 40	70.90		
4000	≥ 40	69.90		
Overall Result		**PASS**	**N/T**	**N/T**

Comments: Readings greater than 90dB are shown as 90.0.

Figure 32: Clause 4.6.2 (Transverse Balance) Test Results

10.5 Sample S03

The performance of sample S03 was measured both before and after application of power line surge so that the effect of surge on noise levels could be analysed. Tests after surge were performed only in the band of 12 kHz to 266 kHz since this was the band were noise levels were closest to the limits.

4.5.5.1	METALLIC OUT OF BAND VOLTAGES	4.5.5.1

TIA-968-A Clause 4.5.5.1 Signal power limitations - Non-LADC Metallic Voltage - 4kHz to 30MHz (Surge Sample S03)			Maximum measured signal power (dBVrms)		
Signalling condition = Idle (Before Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-70.75		
12kHz to 266kHz	See Note 2	248.0kHz	-72.57		
270kHz to 6MHz	≤ -15	463kHz	-61.07		
6MHz to 30MHz	≤ -15	10.7MHz	-82.00		
Signalling condition = Line Seized (Before Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-70.10		
12kHz to 266kHz	See Note 2	12kHz	-78.24		
270kHz to 6MHz	≤ -15	5.88MHz	-68.67		
6MHz to 30MHz	≤ -15	10.7MHz	-83.00		
Signalling condition = Idle (After Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation		
8kHz to 12kHz	See Note 1				
12kHz to 266kHz	See Note 2	240kHz	-72.00		
270kHz to 6MHz	≤ -15				
6MHz to 30MHz	≤ -15				
Signalling condition = Line Seized (After Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation		
8kHz to 12kHz	See Note 1				
12kHz to 266kHz	See Note 2	12.0kHz	-66.80		
270kHz to 6MHz	≤ -15				
6MHz to 30MHz	≤ -15				
Overall Result			**PASS**	**N/T**	**N/T**

Comments:

Note 1:

$$8\text{kHz to }12\text{kHz Limit} \le -\left(6.4 + 12.6 \times \mathrm{Log}_{10}\left(\mathrm{Frequency}(\mathrm{kHz})\right)\right)$$

Note 2:

$$12\text{kHz to }90\text{kHz Limit} \le \left(23 - 40 \times \mathrm{Log}_{10}\left(\mathrm{Frequency}(\mathrm{kHz})\right)\right)$$

$$90\text{kHz to }266\text{kHz Limit} \le -55$$

Figure 33: Clause 4.5.5.1 (Metallic Noise) Test Results

TIA-968-A Clause 4.5.5.2 Signal power limitations - Non-LADC Longitudinal Voltage - 4kHz to 6MHz (Sample S03)				Maximum measured signal power (dBVrms)	
Signalling condition = Idle (Before Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-71.71		
12kHz to 266kHz	See Note 2	12.00kHz	-71.60		
270kHz to 6MHz	≤ -34	506.3kHz	-46.70		
Signalling condition = Line Seized (Before Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation	After 'B' type surge	After 'A' type surge
8kHz to 12kHz	See Note 1	8kHz	-94.50		
12kHz to 266kHz	See Note 2	12.00kHz	-72.20		
270kHz to 6MHz	≤ -34	2.30MHz	-66.56		
Idle (After Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation		
8kHz to 12kHz	See Note 1				
12kHz to 266kHz	See Note 2	12.00kHz	-72.00		
270kHz to 6MHz	≤ -34				
Line Seized (After Power Line Surge)					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation		
8kHz to 12kHz	See Note 1				
12kHz to 266kHz	See Note 2	12.00kHz	-72.00		
270kHz to 6MHz	≤ -34				
Overall Result			**PASS**	**N/T**	**N/T**

Comments:

1)

Note 1:

8kHz to 12kHz Limit $\leq \left[-\left(18.4 + 20 \times \mathrm{Log}_{10}\left[\mathrm{Frequency}(\mathrm{kHz})\right)\right)\right] - 1.4$

Note 2:

12kHz to 42kHz Limit $\leq \left(3 - 40 \times \mathrm{Log}_{10}\left[\mathrm{Frequency}(\mathrm{kHz})\right)\right) - 4$

42kHz to 266kHz Limit ≤ -66

2) The above limits allow for the correction factor of 1.4dB (4 to 16kHz), and 4.0dB (12kHz to 6MHz) as shown in TIA-968-A figure 4.5 due to the measurement terminations.

Figure 34: Clause 4.5.5.2 (Longitudinal Noise) Test Results

TIA-968-A, Subpart 4 Clause 4.6.2 – Transverse balance limitations (Sample S03)		Minimum measured balance (dB)		
On-Hook				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 60	102.40		
500	≥ 60	85.40		
1000	≥ 60	78.00		
2000	≥ 40	76.80		
3000	≥ 40	84.00		
4000	≥ 40	89.00		
Off-Hook Worst case Off-hook current = IMAX				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 40	103.10		
500	≥ 40	92.50		
1000	≥ 40	83.40		
2000	≥ 40	68.80		
3000	≥ 40	70.10		
4000	≥ 40	68.60		
Overall Result		**PASS**	**N/T**	**N/T**
Comments: Readings greater than 90dB are shown as 90.0.				

Figure 35: Clause 4.6.2 (Transverse Balance) Test Results

TIA-968-A Clause 4.2.4 – Power Line Surge (Sample S03)		
Condition	Line State / Polarity	Result
Switched On	On-hook / +ve	PASS
Switched On	On-hook / -ve	PASS
Overall Result		**PASS**
Comments:		

Figure 36: Clause 4.2.4 (Power Line Surge) Test Results

APPLICATION DESIGN REPORT STATUS

Application design information and specifications provided in this Application Design Report (e.g., circuit schematics, board layouts and custom wound component drawings) have not been fully developed for production and have not been subjected to safety or EMC approvals testing. Hence, design information contained herein should not be used for production without further development, verification, validation, approvals and certification appropriate for the intended application.

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