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 number: C2471LX2 (SOT23-6)

This report describes a low cost charger/adapter (reference AD-2079, see Figure 1) for cordless phone products. It operates from a 230 Vac 50 Hz nominal line input and delivers 3 W (nominal rated power) at 9 Vdc. Representative test measurement results are given to show typical performance.

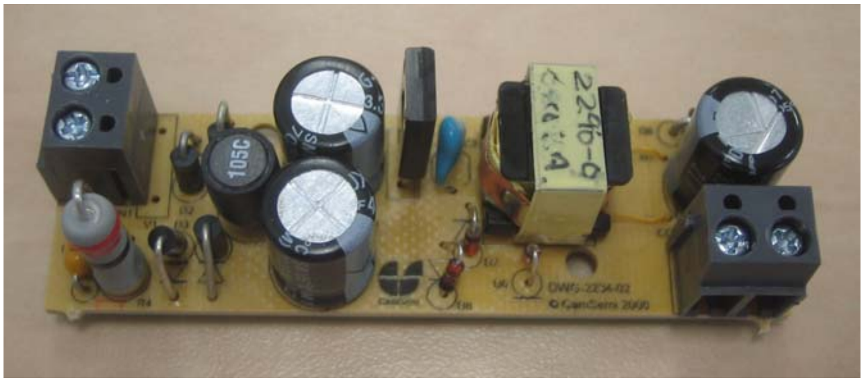

Figure 1: AD-2079 Adapter for Cordless Phones

AD-2079 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.

ADR-2364-0806W
23-Jun-2008

Contents

1 SPECIFICATION

Description	Symbol	Min	Typ	Max	Units	Comments
Line Input Voltage	V_{IN}	195	230	265	Vac	
Line Frequency	F_L	47	50	53	Hz	
Output Voltage	V_{OUT}	6.75	9	11.25	V	Under no load conditions with 265 Vac input, the output voltage reaches 12.5 Vdc
Continuous Output Current	I_{OUT}	0		0.33	A	
Peak Output Current	I_{OUTPK}			0.67	A	230 Vac/50 Hz input voltage
Output Ripple Voltage - Line Frequency	$V_{RIPPLEFL}$			600	mV	Pk-pk
Output Ripple Voltage - Switching Frequency	$V_{RIPPLEF}$			60	mV	Pk-pk
Maximum continuous output power	P_{OUT}			3	W	
Peak output power	P_{OUTPK}			6	W	
Full Power Conversion Efficiency	η	69.1	80		%	Energy Star 2.0
No-Load Consumption	$P_{NO\text{-}LOAD}$		150	300	mW	Energy Star 2.0
Switching frequency	F		55		kHz	

Table 1: AD-2079 Design Parameters

2 CIRCUIT SCHEMATIC

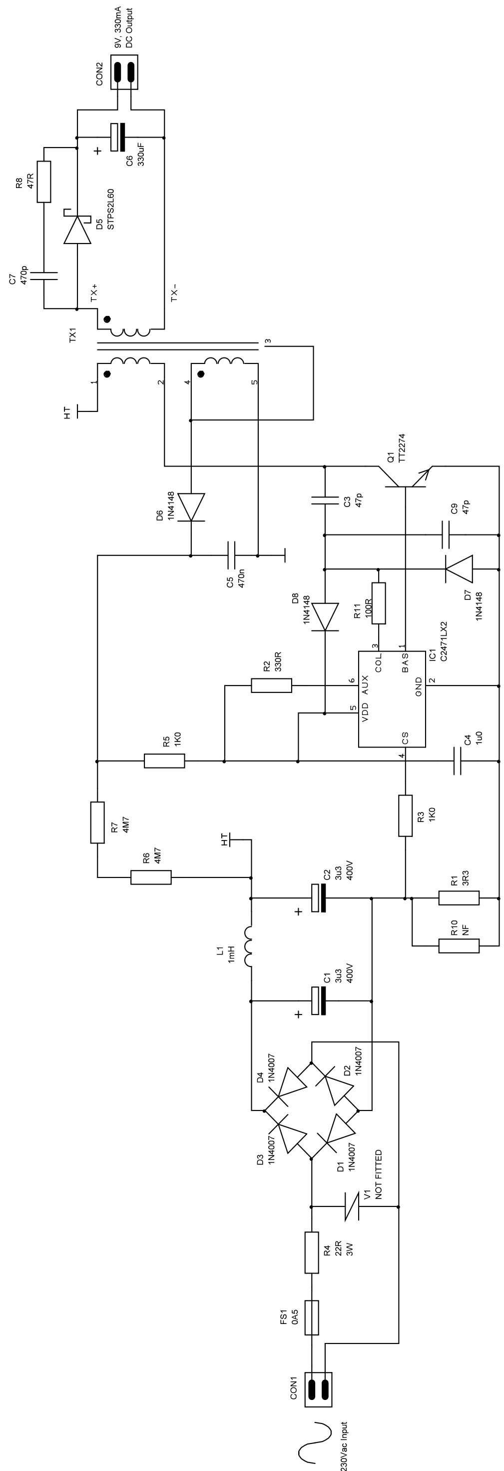

Figure 2: Application Circuit Schematic

3 BILL OF MATERIALS

Qty	Value	Ref	Description	Mfr	Mfr Number
1	470p	C7	CAP 0805 470p NPO 100V 5% 125C	AVX	08051A471JAT2A
1	47p	C9	CAP 0805 47p NPO 100V 5% 125C	AVX	08051A470JAT2A
1	470n	C5	CAP 0805 470n X7R 16V 10% 125C	AVX	0805YC474KAT2A
1	1u0	C4	CAP 0805 1u0 X7R 25V 10% 125C	AVX	08053C105KAZ2A
1	330u	C6	CAPACITOR ALEL 330uF 35V 20% -40-105C	RUBYCON	35ZLH330M10X12.5
2	3u3	C1	CAP ALEL TH 3u3 400V -40-105C	Luxon	ESM335M400S1A5H1C0
	3u3	C2		Luxon	ESM335M400S1A5H1C0
1	47p	C3	CAP CER TH 47pF 2kV	MURATA	DEA1X3D470JA2B
2	2 WAY	CON1	CON TERM BLOCK 2-WAY 415V/16A -40 TO +105C	IMO	20.501M/2
	2 WAY	CON2		IMO	20.501M/2
2	1N4007	D1	DIODE EPI AXIAL 1N4007 1000V 1A	MULTICOMP	1N4007
	1N4007	D2		MULTICOMP	1N4007
2	1N4007	D3	DIODE EPI AXIAL 1N4007 1000V 1A	MULTICOMP	1N4007
	1N4007	D4		MULTICOMP	1N4007
1	1N4148	D6	DIODE EPI AXIAL 1N4148 75V 0A2 4ns	PHILIPS	1N4148
1	1N4148	D8	DIODE EPI AXIAL 1N4148 75V 0A2 4ns	PHILIPS	1N4148
1	1N4148	D7	DIODE EPI AXIAL 1N4148 75V 0A2 4ns	PHILIPS	1N4148
1	STPS2L60	D5	DIODE SCHOTTKY AXIAL STPS2L60 60V 2A	STMICROELECTRONICS	STPS2L60
1	0A5	FS1	FUSE A/SURGECERAMIC AXIAL 0A5 125V	LITTELFUSE	473.500HAT1L
1	C2471LX2	IC1	IC CAMSEMI C2471LX2 FCCL SOT23-6	CamSemi	C2471LX2
1	100R	R11	RES 0805 100R 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 100R
1	330R	R2	RES 0805 330R 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 330R
1	47R	R8	RES 0805 47R 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 47R
2	1K0	R3	RES 0805 1K 1% 0W1	MULTICOMP	MC 0.1W 0805 1% 1K
	1K0	R5		MULTICOMP	MC 0.1W 0805 1% 1K
1	3R3	R1	RES 1206 3R3 1% 0W25 -55-125C	PHYCOMP	232272463308
2	4M7	R6	RES 1206 4M7 1% 0W25	PHYCOMP	232272464705
	4M7	R7		PHYCOMP	232272464705
1	22R	R4	RES TH 22R 5% 3W	WELWYN	WA84-22RJI
1	DWG-2234-05	PCB1		CAMSEMI	DWG-2234-05
1	CW-2295-02	TX1	TRANSFORMER E13	CAMSEMI	CW-2295-02
1	1m	L1	WOUND IND TH RAD 1mH 170mA 10%	C&D TECHNOLOGIES	22R105C
1	TT2274	Q1	XSTR NPN TT2274A TO126 1400V 1A	SANYO	TT2274A

Table 2: Bill of Materials

4 TRANSFORMER DETAILS

4.1 Overview

The transformer uses a low cost E13 core and vertical bobbin with safety isolation provided by secondary triple insulated wire. Creepage and clearance is maintained by using flying leads for the secondary.

For further transformer details, contact your CamSemi representative.

4.2 Materials

Item	Type	Material	Approved Part Number
1	Core	Pair of E13 ferrite. P4 Material from Himeda, gapped for 220 nH/T^2 +/-10% (Approx 0.1 mm Gap in Center Leg)	P4 EE13 (Himeda)
2	Bobbin	10-pin, E13, ULV94V-0.	EI-13(10P) (Himeda)
3	Tape	3M 56 Polyester Film Tape 8 mm wide	3M 56 8 mm.
4	Wire	Triple insulated wire. TEX-E 0.2 mm diameter	Furukawa TEX-E 0.2 mm
5	Wire	ECW Grade 2, Class B, enamelled copper wire. 0.1 mm, 0.4 mm.	Generic
6	Foil	Copper, 5 mm wide, 0.05 mm thick	
7	Glue		3M DP760
8	Varnish	Impregnation Varnish	Dolph's AC-43 or equivalent

Table 3: Transformer Materials List

4.3 Testing

	Pin Connections	L Min	L Max	Conditions / Connections
Primary	1 to 2	50 mH	60 mH	Secondary open, 10 kHz test freq
Leakage Inductance	1 to 2	200 uH	400 uH	Secondary shorted, 10 kHz test freq

Table 4: Basic Transformer Test Parameters

Test	Connection 1	Connection 2	Voltage (V)	Current (mA)	Duration (s)
Pri - Sec	1, 2, 3, 4, 5	Tx-, Tx+	4245 V DC	1 mA	3 s

Table 5: Hi Pot Transformer Testing Parameters

5 PCB LAYOUT

Pictures not to scale.

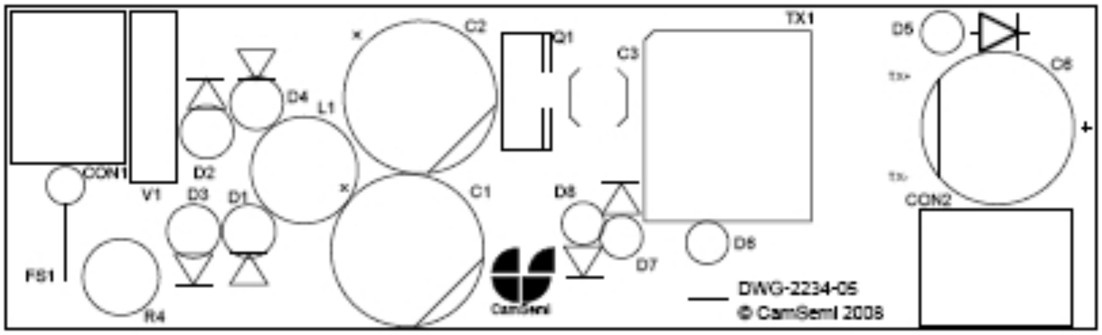

Figure 3: PCB Layout - Top Silk Screen

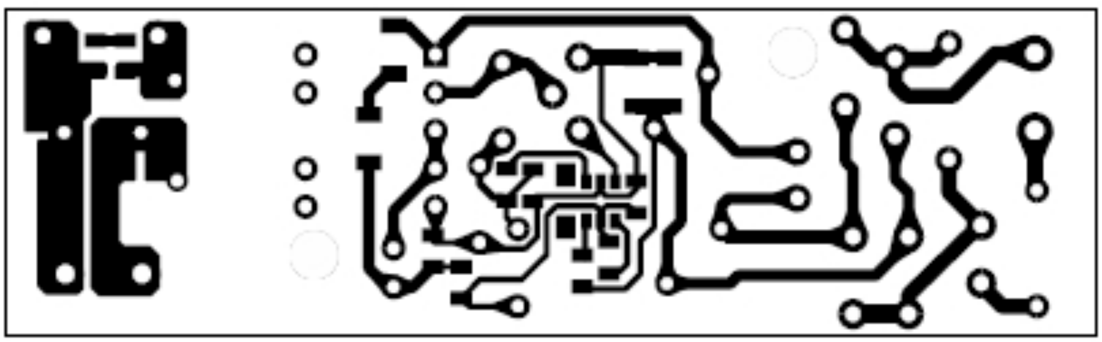

Figure 4: PCB Layout - Bottom Copper

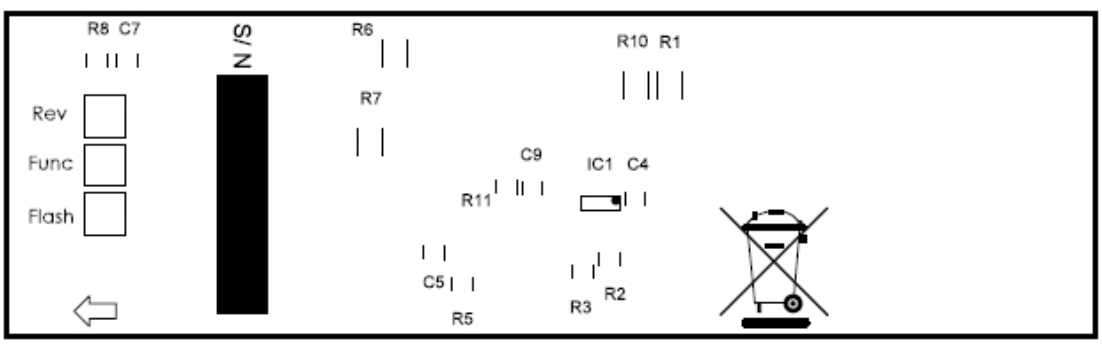

Figure 5: PCB Layout - Bottom Silk Screen

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

In accordance with the Energy Star V2.0, efficiency was measured at 25, 50, 75 and 100% of rated current under nominal ambient conditions. The numerical average of the four measurements was 80%. In this case, rated power is 3 W.

Efficiency as a function of load current is shown in Figure 6 below for 230 Vac input.

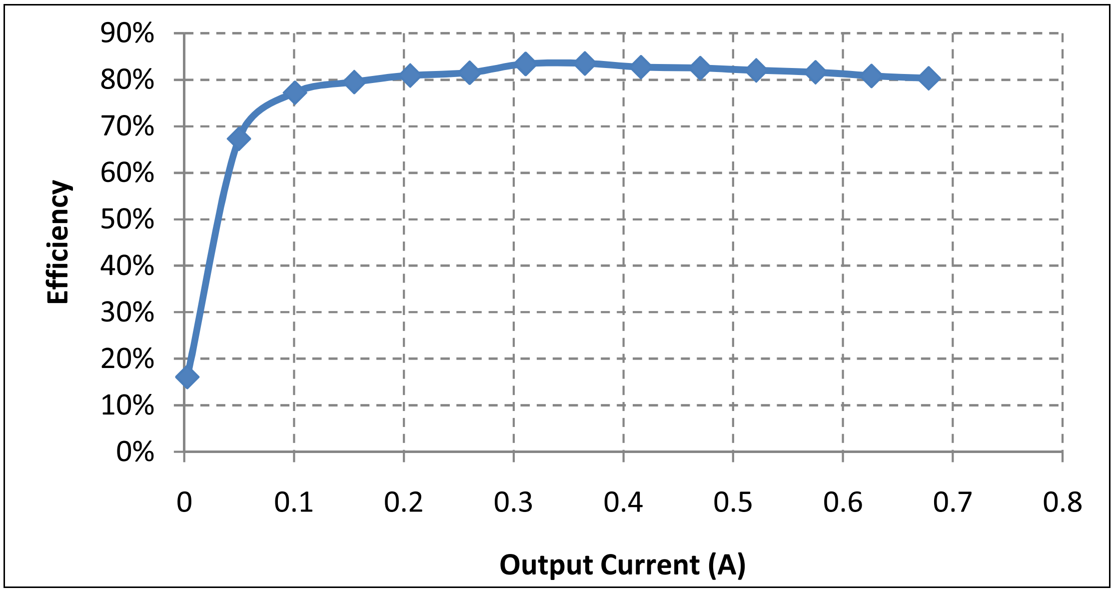

Figure 6: Conversion Efficiency as a Function of Load

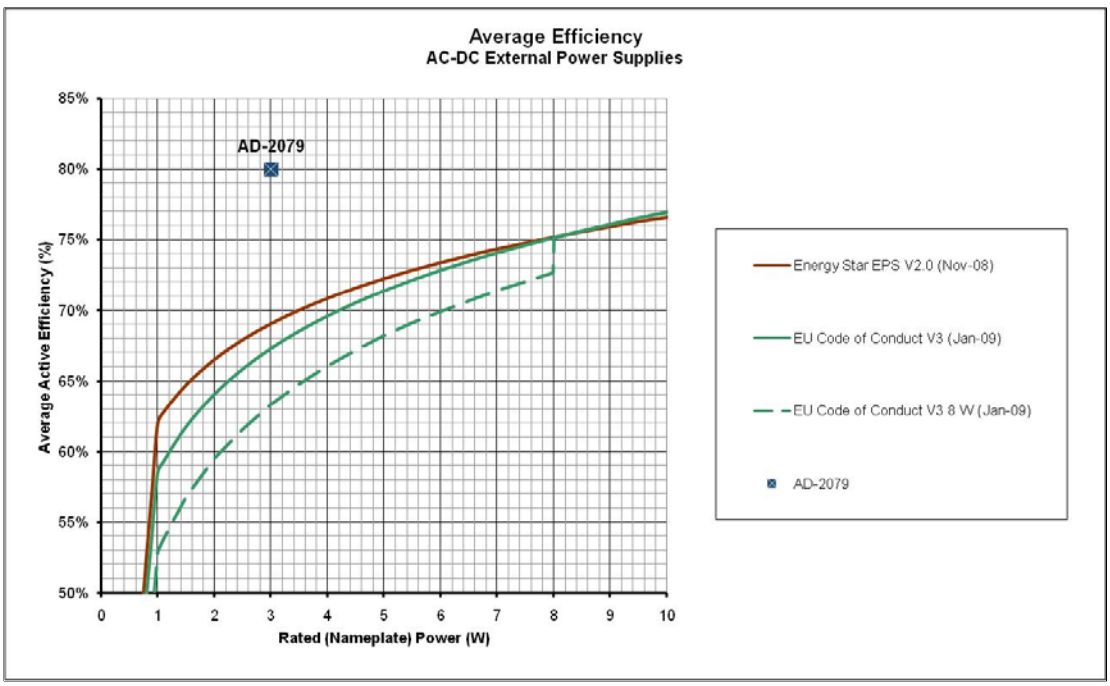

Figure 7: Comparison of Average Efficiency with Existing and Proposed Standards

6.3 Load and Line Regulation

The V-I curves shown in Figure 8 represent the operating envelope for the output characteristic of this design. The centre plot represents the nominal output characteristic whilst the min and max lines represent the total variation expected with changes in input voltage, line frequency and ambient temperature.

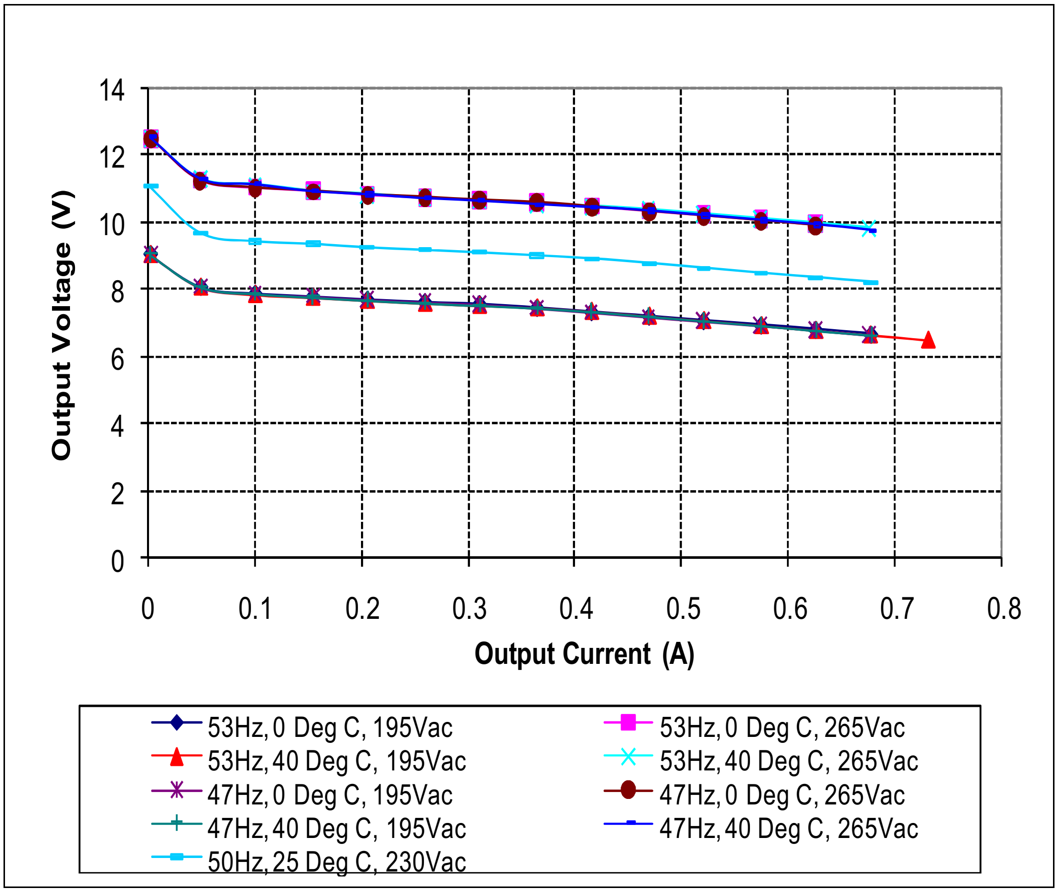

Figure 8: Output V-I Envelope over Line, Load, Temperature and Line Frequency

6.4 No-Load Consumption

The average no-load power consumption is 150 mW.

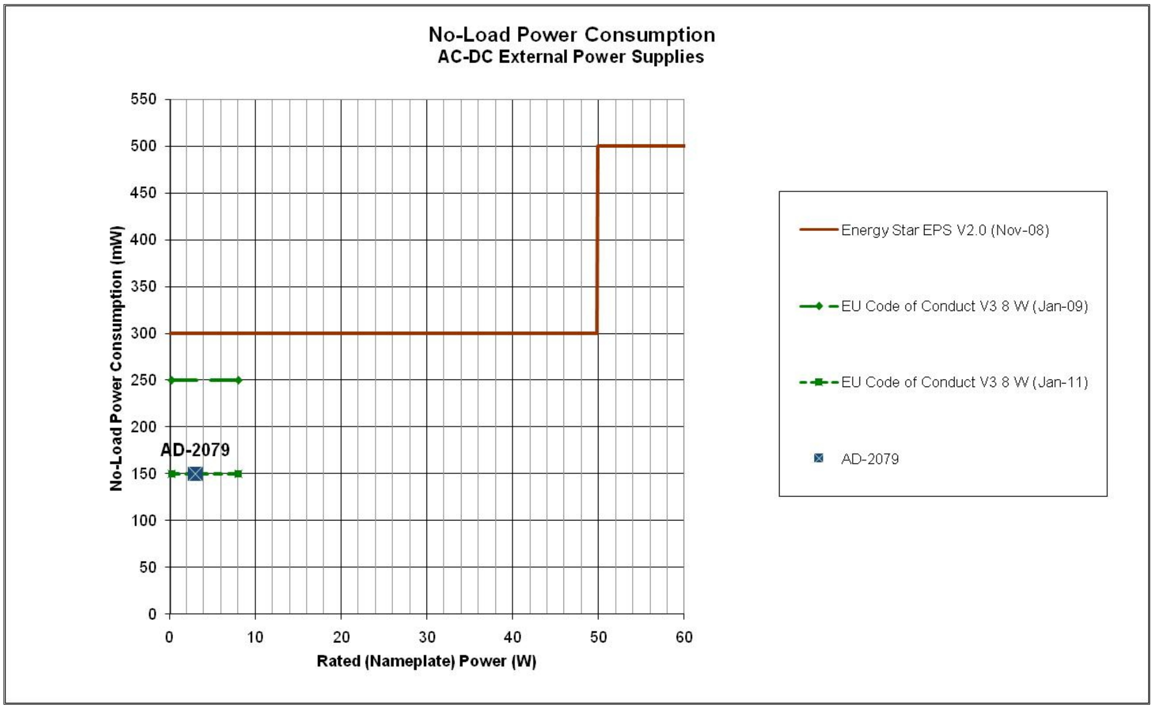

Figure 9: Comparison of No-load Power Consumption with Existing and Proposed Standards

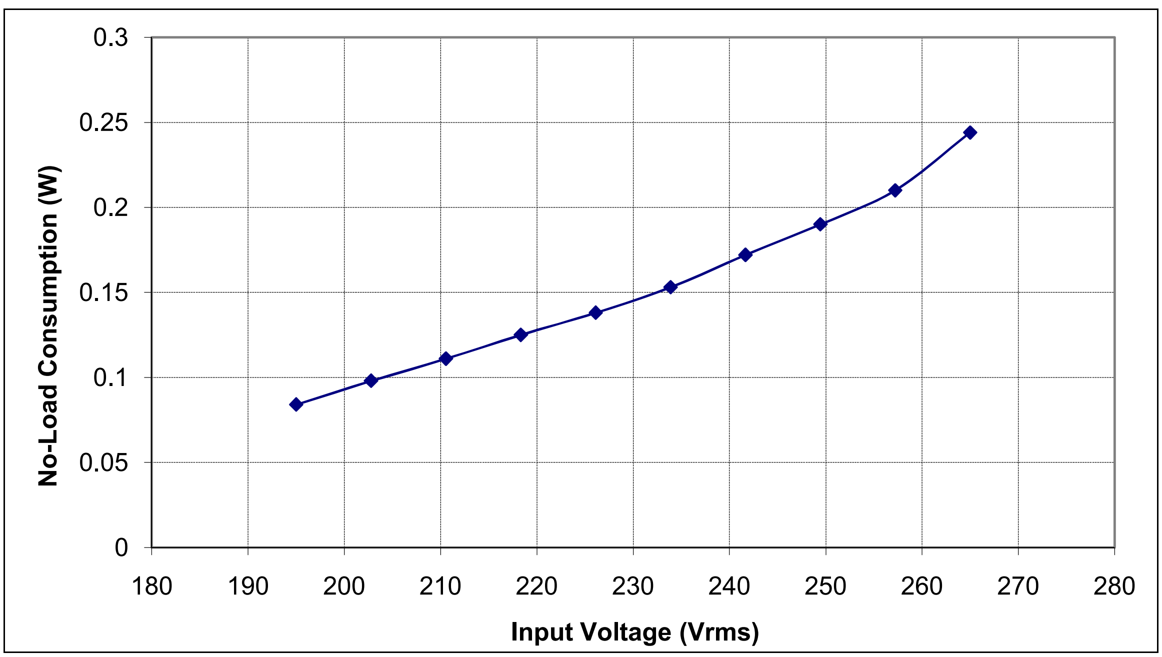

Figure 10: No-Load Power Consumption as Function of Input Voltage

6.5 Output Voltage Ripple

The output voltage ripple component at low frequency (100 Hz) and PSU switching frequency were measured both with and without the additional 1000 μF load capacitance applied. In all cases, the input signal was 230 Vac/50 Hz and the output load a 27 Ω resistor.

6.5.1 Output Ripple - Line Frequency

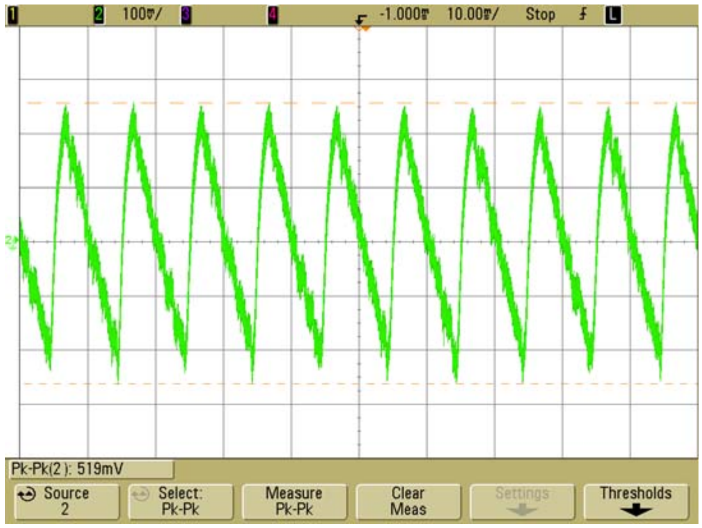

Figure 11: 100 Hz Output Voltage Ripple Without Additional Load Capacitance

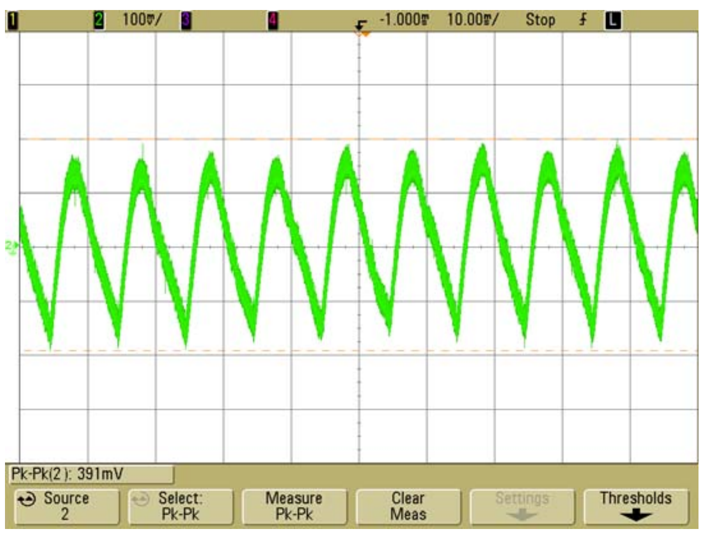

Figure 12: 100 Hz Output Voltage Ripple with 1000 μF Extra Load Capacitance

With no extra load capacitance, the 100 Hz ripple content measures around 500 mV_{pk-pk}. With 1000 μF additional load capacitance, the 100 Hz ripple content measures around 300 mV_{pk-pk}.

6.5.2 Output Ripple - Switching Frequency

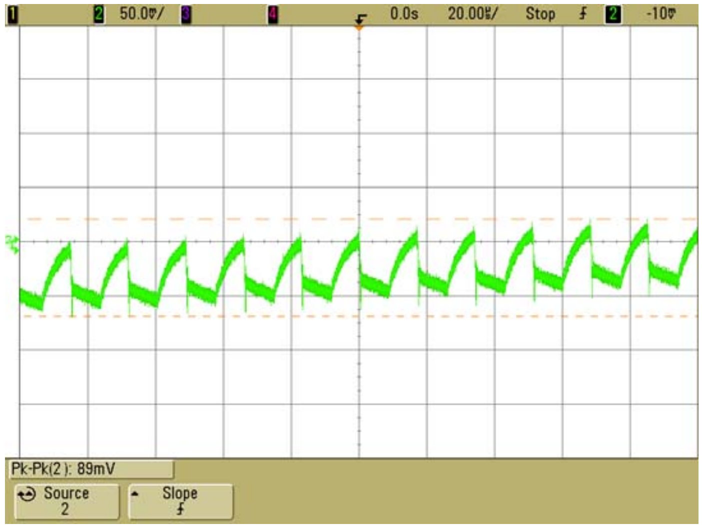

Figure 13: Switching Frequency Output Voltage Ripple without Extra Load Capacitance

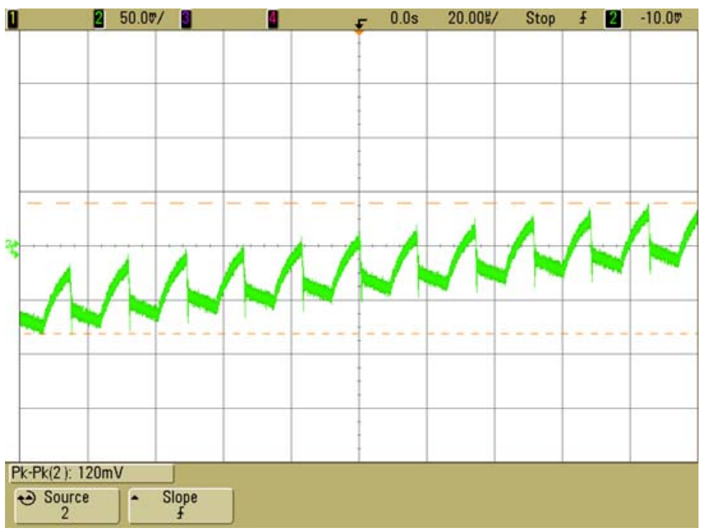

Figure 14: Switching Frequency Output Voltage Ripple with 1000 µF Extra Load Capacitance

With no extra load capacitance, the switching frequency content measures around 60 $mV_{pk\text{-}pk}$. With 1000 µF additional load capacitance, the switching frequency content still measures around 60 $mV_{pk\text{-}pk}$.

7 OPERATIONAL WAVEFORMS

All data presented in this section was captured with the PSU sitting in free air at a lab ambient of 25°C and 50 Hz input line frequency unless otherwise specified.

7.1 Primary BJT Waveforms

Figure 15 shows the collector-emitter voltage of the switching transistor and the voltage across current sense resistor R1.

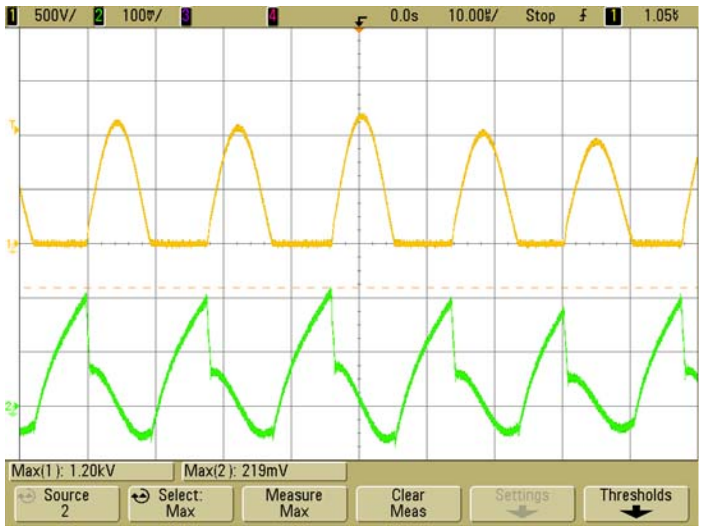

Figure 15: 265 Vac Input. Q1 Collector-Emitter Voltage (C1 at at 500 V/div) and
Voltage across R1 (C2 at 100 mV/div). 10 µs/div timebase

The voltage across the current sense resistor represents the collector current during the on-time of the BJT with an effective scale of 30 mA/div. Worst case peak transistor collector-emitter voltage stress is 1.2 kV and peak collector current is 66 mA.

7.2 Start-up Behaviour

7.2.1 Start-up Behaviour with No Additional Load Capacitance

The envelope of the voltage and current stress on Q1 during start-up was measured using a resistive load of 27 Ω on the output and 230 Vac applied to the input.

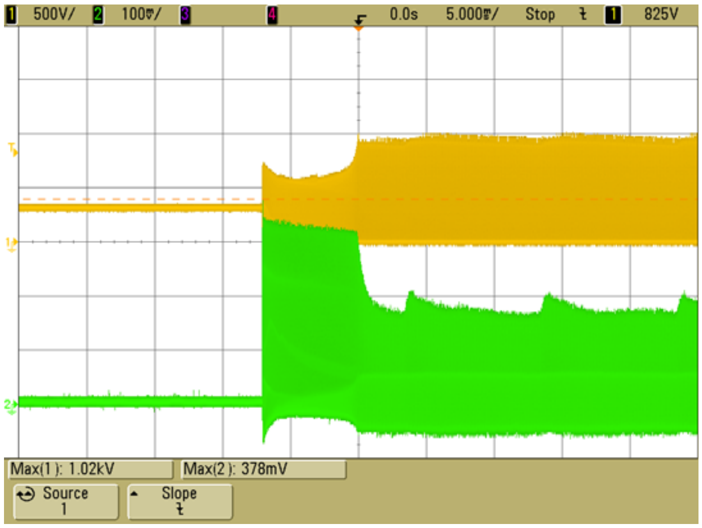

Figure 16: Start-up Switching Transistor Voltage (C1 at 500 V/div) and Voltage across R1 (C2 at 100 mV/div), 5 ms/div

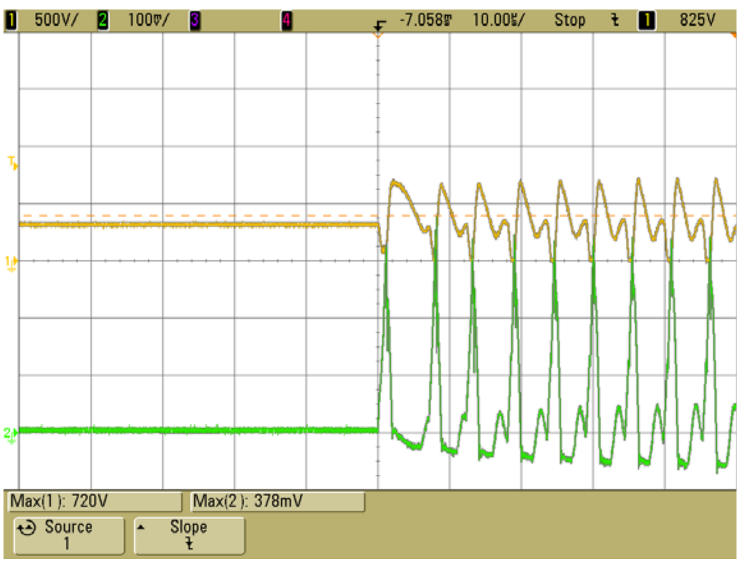

Figure 17: Zoom of First Few Switching Cycles of Figure 16

During start-up, the peak collector-emitter voltage on Q1 never exceeds the maximum observed in Figure 15. Peak collector current reaches 115 mA during start-up.

7.2.2 Start-up Behaviour with Additional Load Capacitance

The envelope of the voltage and current stress on Q1 during start-up was measured using a resistive load of 27 Ω on the output and 230 Vac applied to the input. 1000 µF of additional output capacitance was placed in parallel with the resistive load.

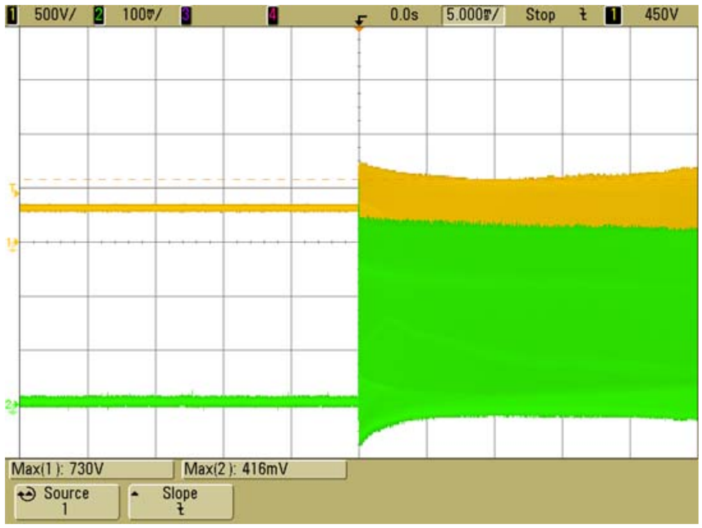

Figure 18: Start-up Switching Transistor Voltage (C1 at 500 V/div) and Voltage across R1 (C2 at 100 mV/div), 5 ms/div

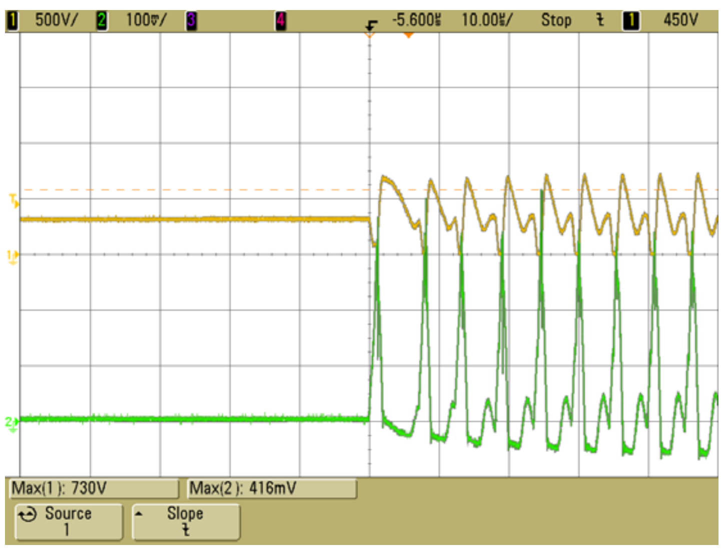

Figure 19: Zoom of First Few Switching Cycles of Figure 18

During start up, the peak collector-emitter voltage on Q1 never exceeds the maximum observed in Figure 15. Peak collector current reaches 126 mA during start-up.

7.3 Output Short Circuit Recovery

Short circuit recovery behaviour was measured both with and without the additional 1000 μF output load capacitor. In both cases, the input voltage was set to 230 Vac/50Hz and the output was a resistive load of 27 Ω.

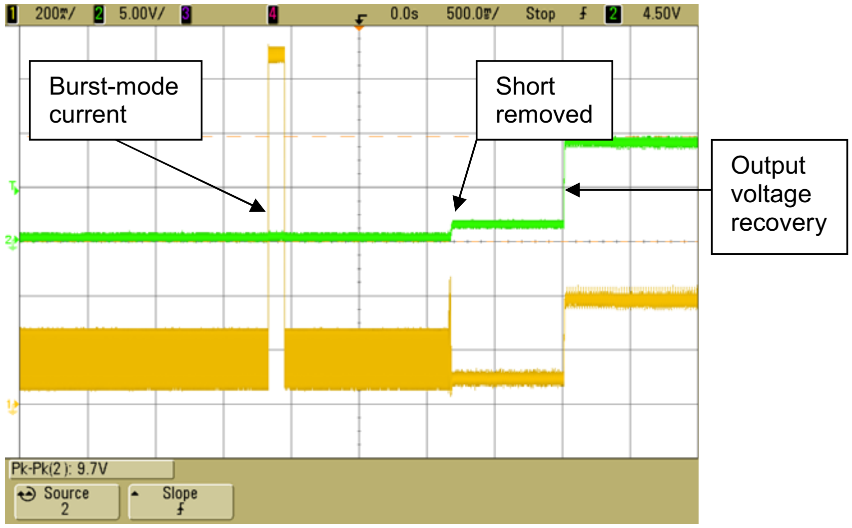

Figure 20: Output Short-Circuit Recovery without Extra 1000 μF Load Capacitance.
C1 is output current at 200 mA/div and C2 is Output Voltage at 5 V/div

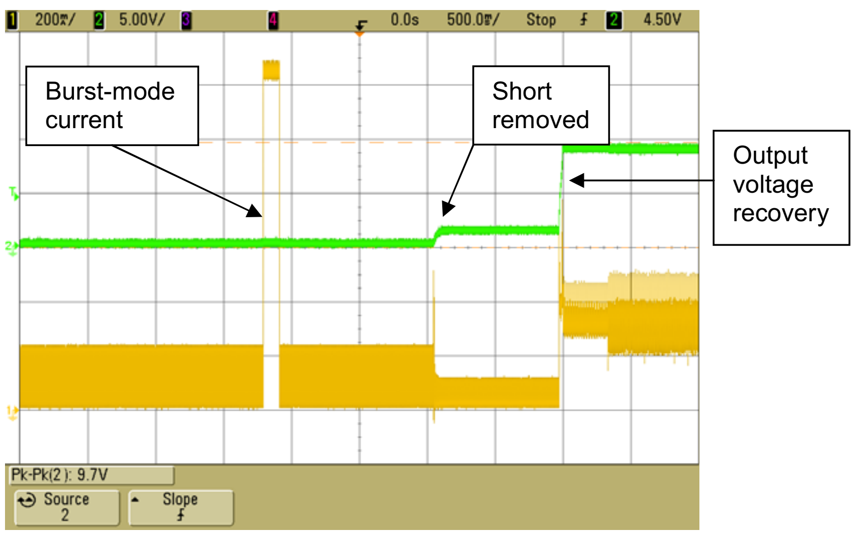

Figure 21: Output Short-Circuit Recovery with Extra 1000 μF Load Capacitance.
C1 is output current at 200 mA/div and C2 is Output Voltage at 5 V/div

Both with and without the extra output capacitance, the PSU recovers from a fault during the first auto-restart pulse following the removal of the output short.

8 EMI AND SURGE MEASUREMENTS

The conducted EMI plots below were captured with the PSU powered with 230 Vac 50 Hz input with a nominal 3W load on the output. The output ground was connected back to earth on the LISN to represent worst case for common-mode noise, Lab ambient was 25°C.

8.1 Conducted Emissions

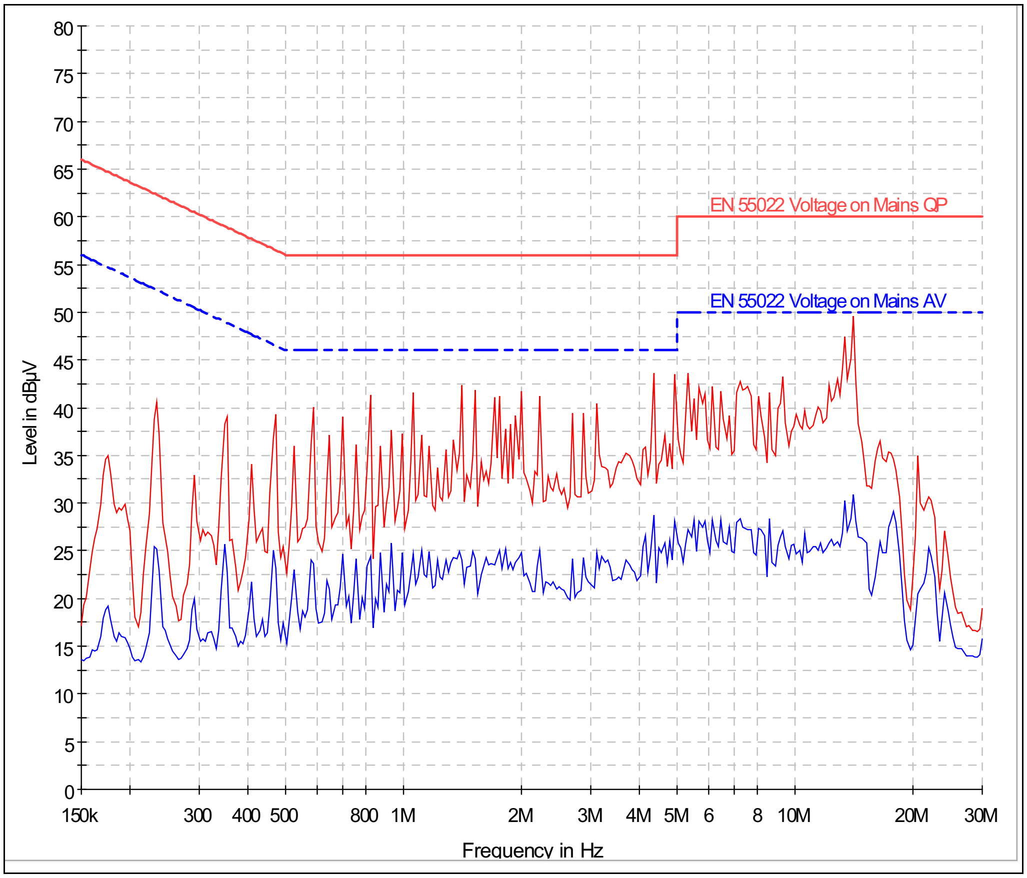

Figure 22: Neutral Line Conducted Emissions

Worst case emissions show that the prototype is compliant with a minimum of 10dB margin.

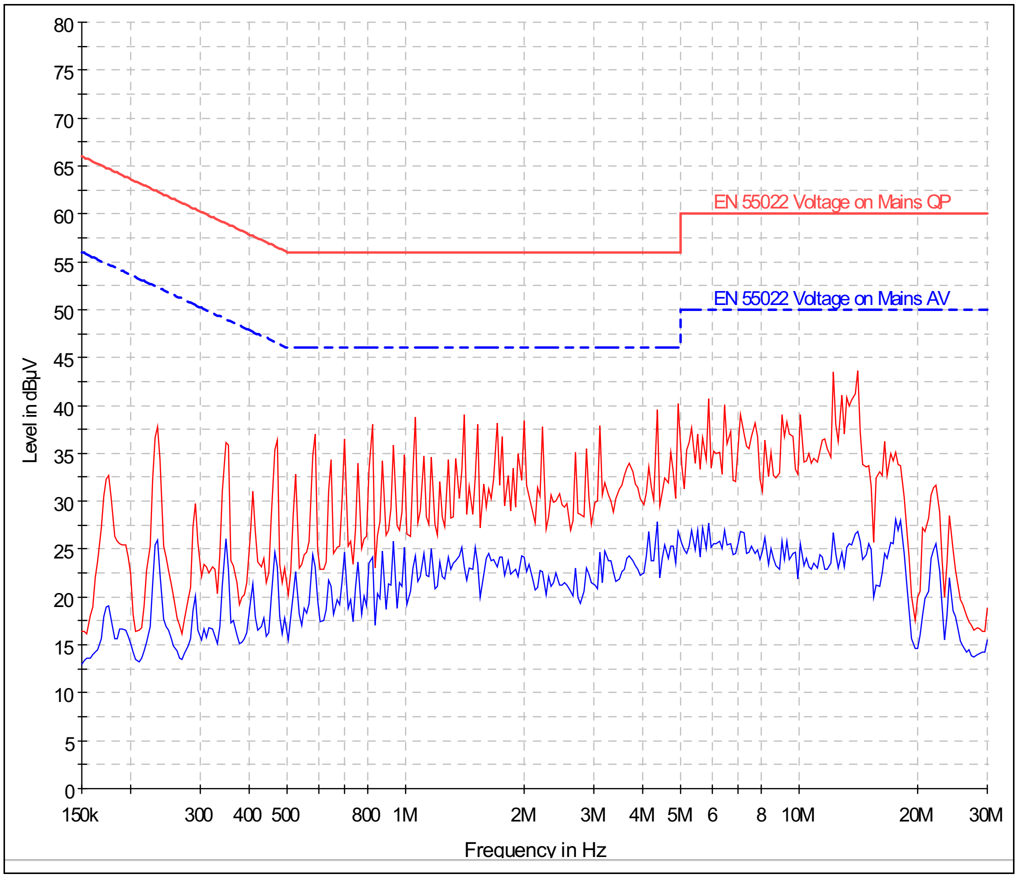

Figure 23: Live Line Conducted Emissions

9 THERMAL SURVEY

With the prototype supply mounted inside a representative sealed plastic enclosure, the operating temperatures of key power stage devices were recorded as a function of load current with 265 Vac, 53 Hz input and a local ambient of 40°C.

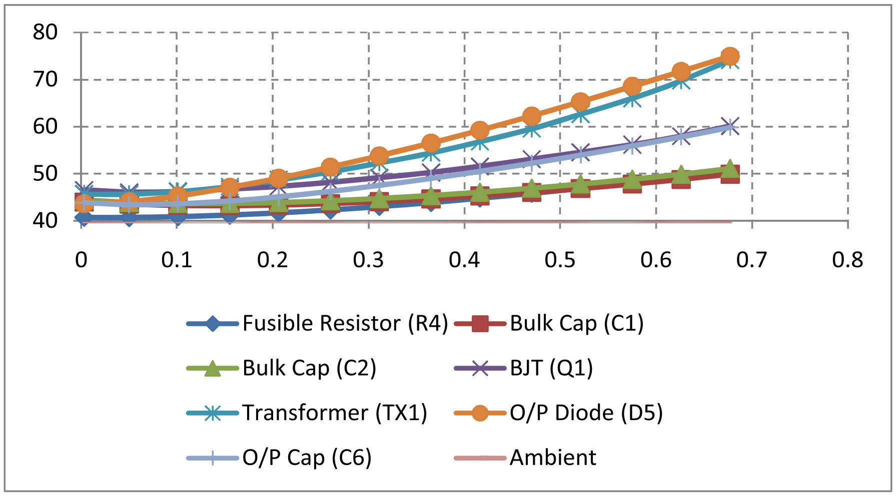

Figure 24: Power Stage Operating Temperatures Under Worst Case Conditions
(high line, maximum ambient temperature)

All components operated well within normal operating temperatures.

10 FCC PART 68 TEST RESULTS

Three representative AD-2079 PSUs were tested for compliance to the following sections detailed in the FCC68 requirements [TIA-968-A, "Technical Requirements for the Connection of Terminal Equipment to the Telephone Network", Telecoms Industry Association, October 2002]:

Section 4.2.4 - Power Line Surge

Section 4.5.5.1 - Metallic Voltages in the Frequency Band of 4 kHz to 30 MHz

Section 4.5.5.2 - Longitudinal Voltages in the Frequency Band of 4 kHz to 30 MHz

Section 4.6.2 - Transverse Balance limitations for voice band equipment

In all cases, a representative DECT phone and base-station were used to form the complete FCC part 68 test set-up. The model used was an I-DECT M1 with the power supply replaced by the AD-2079 prototype unit.

10.1 Power Line Surge

Three prototype units were subjected to the differential surge voltage specified in FCC68 section 4.2.4.

Figure 25 gives the results from the test house report.

TIA-968-A Clause 4.2.4 – Power Line Surge (Sample S01)		
Condition	Line State / Polarity	Result
Switched On	On-hook / +ve	PASS
Switched On	On-hook / -ve	PASS
Overall Result		**PASS**
Comments:		

TIA-968-A Clause 4.2.4 – Power Line Surge (Sample S02)		
Condition	Line State / Polarity	Result
Switched On	On-hook / +ve	PASS
Switched On	On-hook / -ve	PASS
Overall Result		**PASS**
Comments:		

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 25: FCC68 Differential Surge Test Results

All three samples operated during and after the surge test with no loss of function to the DECT phone.

10.2 Metallic Voltages from 4 kHz to 30 MHz

Three samples were tested for metallic noise voltages according to FCC68 section 4.5.5.1.

TIA-968-A Clause 4.5.5.1 Signal power limitations - Non-LADC Metallic Voltage - 4kHz to 30MHz (Sample S01)			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	-70.66		
12kHz to 266kHz	See Note 2	56.45kHz	-68.23		
270kHz to 6MHz	≤ -15	495.61kHz	-60.02		
6MHz to 30MHz	≤ -15	11.97MHz	-68.02		
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	-70.55		
12kHz to 266kHz	See Note 2	64.38kHz	-70.09		
270kHz to 6MHz	≤ -15	4.14MHz	-61.44		
6MHz to 30MHz	≤ -15	12.00MHz	-66.20		
Overall Result			**PASS**		

Comments:

Note 1:

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

Note 2:

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

90kHz to 266kHz Limit ≤ -55

Figure 26: Sample S01 FCC68 Section 4.5.5.1 Test Results

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	-70.62		
12kHz to 266kHz	See Note 2	250.78kHz	-71.78		
270kHz to 6MHz	≤ -15	4.16MHz	-57.56		
6MHz to 30MHz	≤ -15	12.00MHz	-66.70		
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	-69.98		
12kHz to 266kHz	See Note 2	65.34kHz	-73.67		
270kHz to 6MHz	≤ -15	4.16MHz	-60.10		
6MHz to 30MHz	≤ -15	12.00MHz	-67.20		
Overall Result			**PASS**	**N/T**	**N/T**

Comments:

Note 1:

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

Note 2:

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

90kHz to 266kHz Limit ≤ -55

Figure 27: Sample S02 FCC68 Section 4.5.5.1 Test Results

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					
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	-70.92		
12kHz to 266kHz	See Note 2	126.30kHz	-69.12		
270kHz to 6MHz	≤ -15	4.18MHz	-58.71		
6MHz to 30MHz	≤ -15	26.97MHz	-74.70		
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	-69.94		
12kHz to 266kHz	See Note 2	71.69kHz	-67.19		
270kHz to 6MHz	≤ -15	4.26MHz	-62.26		
6MHz to 30MHz	≤ -15	9.98MHz	-75.10		
Overall Result			**PASS**	**N/T**	**N/T**

Comments:

Note 1:

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

Note 2:

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

90kHz to 266kHz Limit ≤ -55

Figure 28 – Sample S03 FCC68 Section 4.5.5.1 Test Results

All three samples passed the requirements for FCC68 Metallic Noise Voltage (section 4.5.5.1).

10.3 Longitudinal Voltages from 4 kHz to 6 MHz

Three samples were tested for longitudinal noise voltages according to FCC68 section 4.5.5.2.

TIA-968-A Clause 4.5.5.2 Signal power limitations - Non-LADC Longitudinal Voltage - 4kHz to 6MHz (Sample S01)				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	56.10kHz	-66.83		
270kHz to 6MHz	≤ -34	617.30kHz	-61.68		
Signalling condition = Line Seized					
Centre frequency of 8kHz band	Requirement limit (dBVrms)	Worst case Frequency	Before surge simulation		
8kHz to 12kHz	See Note 1	8kHz	-70.58		
12kHz to 266kHz	See Note 2	63.91kHz	-68.00		
270kHz to 6MHz	≤ -34	5.23MHz	-69.10		
Overall Result			**PASS**	**N/T**	**N/T**

Comments:

1)

Note 1:

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

Note 2:

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

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.

Table 6: Sample S01 FCC68 Section 4.5.5.2 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	-71.54		
12kHz to 266kHz	See Note 2	240.75kHz	-72.62		
270kHz to 6MHz	≤ -34	649.61kHz	-62.80		
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	-71.15		
12kHz to 266kHz	See Note 2	65.49kHz	-73.15		
270kHz to 6MHz	≤ -34	6.00MHz	-67.07		
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.

Table 7: Sample S02 FCC68 Section 4.5.5.2 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					
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	-71.21		
12kHz to 266kHz	See Note 2	71.69kHz	-66.93		
270kHz to 6MHz	≤ -34	542.17kHz	-60.28		
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	-71.80		
12kHz to 266kHz	See Note 2	71.84kHz	-66.39		
270kHz to 6MHz	≤ -34	5.54MHz	-68.26		
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.

Table 8: Sample S03 FCC68 Section 4.5.5.2 Test Results

All three samples passed the noise level requirements for FCC68 part 4.5.5.2.

10.4 Transverse Balance

Three samples were tested for transverse balance according to FCC68 section 4.6.2

TIA-968-A, Subpart 4 Clause 4.6.2 – Transverse balance limitations (Sample S01)		Minimum measured balance (dB)		
On-Hook				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 60	96.02		
500	≥ 60	96.81		
1000	≥ 60	85.78		
2000	≥ 40	73.69		
3000	≥ 40	82.89		
4000	≥ 40	81.40		
Off-Hook Worst case Off-hook current = 78 mA				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 40	87.51		
500	≥ 40	88.16		
1000	≥ 40	84.64		
2000	≥ 40	65.81		
3000	≥ 40	78.37		
4000	≥ 40	75.24		
Overall Result		**PASS**		
Comments:				

Table 9: Sample S01 Transverse Noise Measurements

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	102.89		
500	≥ 60	91.04		
1000	≥ 60	87.33		
2000	≥ 40	76.48		
3000	≥ 40	81.64		
4000	≥ 40	78.32		
Off-Hook Worst case Off-hook current = 77 mA				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 40	86.73		
500	≥ 40	103.43		
1000	≥ 40	86.88		
2000	≥ 40	67.55		
3000	≥ 40	82.12		
4000	≥ 40	75.59		
Overall Result		**PASS**		
Comments:				

Table 10: Sample S02 Transverse Noise Measurements

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	103.20		
500	≥ 60	92.69		
1000	≥ 60	86.51		
2000	≥ 40	75.44		
3000	≥ 40	81.72		
4000	≥ 40	78.57		
Off-Hook Worst case Off-hook current = 78 mA				
Frequency (Hz)	Requirement limit (dB)	Before surge simulation	After 'B' type surge	After 'A' type surge
200	≥ 40	90.21		
500	≥ 40	89.26		
1000	≥ 40	84.79		
2000	≥ 40	65.10		
3000	≥ 40	78.34		
4000	≥ 40	74.80		
Overall Result		**PASS**		
Comments:				

Table 11: Sample S03 Transverse Noise Measurements

All three samples passed the transverse noise test specified in FCC68 section 4.6.2

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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