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## 4.5W FLYBACK CONVERTER FOR POWER LINE MODEM APPLICATIONS

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## 4.5W FLYBACK CONVERTER FOR POWER LINE MODEM APPLICATIONS

### I - SWITCHING POWER SUPPLY DESCRIPTION

The power supply described in this document has been realised in order to powering the Power Line Modem ST7537 applications. It provides 5V and 10V to supply the ST7537 and a microcontroller. This power supply has the advantage of its small size, that is very important for Home System devices.

### I.1 - General Description

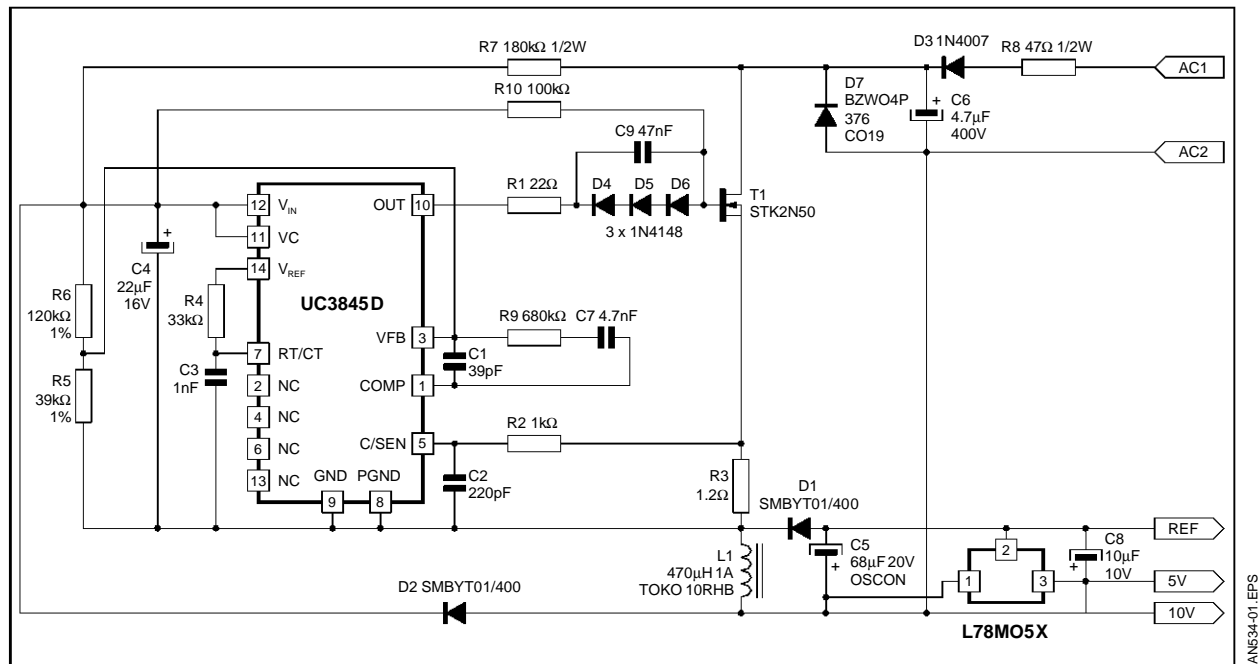
The power supply is a 4.5W flyback converter which supply 10V DC with a switching supply process. Its uses a UC3845 circuit that generate a 32.5kHz square signal which drives a STK 2N50 MOS or equivalent. The 5V DC is provided by a regulator L78M05 CS. In the version of the supply tested the supply board side is less than 4cm.

**Table 1 :** Flyback Converter Specifications

Parameter	Test Conditions	Value	Unit
Output Voltage	20% of load 100% of load	10.15 and 5 9.75 and 5	V
Output Maximum Power		4.5	W
Dynamic of Input Voltage		130 to 264	V DC
Precision of Regulation	Between 20% and 100% of load	4	%
Variation in Voltage According to Mains	At 75% of load	0.4	%
Yield	80% of max. power, 0.218A on 10V and 0.15A on 5V 100% of max. power, 0.3A on 10V and 0.15A on 5V 100% of max. power 0.45A on 10V	59 61 74	%
Working Temperature	Ambient temperature : 25°C	55	°C
Maximum Life Time	Ambient temperature : 85°C Ambient temperature : 55°C	8000 64000	Hours
Output Noise Level	$I_0 = 450\text{mA}$ before regulator	80 peak-peak	mV
Protective Measure	Short cut protected		

### I.2 - Schematic

**Figure 1 :** Flyback Converter



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**Table 2** : Bill of Materials

Item	Quantity	Reference	Part
1	1	C1	39pF
2	1	C2	220pF
3	1	C3	1nF
4	1	C4	22 $\mu$ F 16V
5	1	C5	68 $\mu$ F 20V OSCON SANYO
6	1	C6	4.7 $\mu$ F 400V
7	1	C7	4.7nF
8	1	C8	10 $\mu$ F 10V
9	1	C9	47nF
10	2	D1 D2	BYT01/400 BYT01/400
11	1	D3	1N4007
12	3	D4 D5 D6	1N4148 1N4148 1N4148
13	1	D7	BZWO4P 376 CO19
14	1	L1	10RHB 470 $\mu$ H TOKO or equivalent
15	1	R1	22 $\Omega$
16	1	R2	1k $\Omega$
17	1	R3	1.2 $\Omega$
18	1	R4	33k $\Omega$
19	1	R5	39k $\Omega$ 1%
20	1	R6	120k $\Omega$ 1%
21	1	R7	180k $\Omega$ 1/2W
22	1	R8	47 $\Omega$ 1/2W
23	1	R9	680k $\Omega$
24	1	R10	100k $\Omega$
25	1	T1	STK 2N50 MOS (SOT-82) 600 $\Omega$ 500V
26	1	U1	UC3845D (SGS-THOMSON)
27	1	U2	L78M05X

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### II - SWITCHING POWER SUPPLY TESTS

Several tests have been done on the flyback converter and this section describes the way the tests have been done and shows the results.

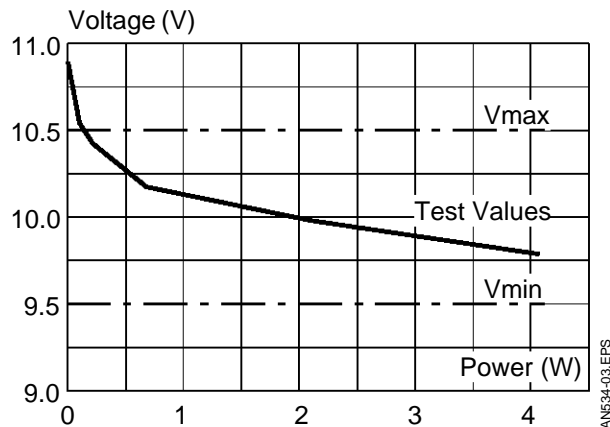
#### II.1 - Voltage versus Power

The power supply has been loaded on its 10V output by resistors of different values. The 5V DC has not been connected. The power has been calculated and results are shown below.

**Table 3 :** Voltage, Current and Power Consumption

Load ( $\Omega$ )	Voltage (V)	Intensity ( $10^{-3}$ A)	Power (W)
Nothing	10.87		
23.5	9.78	420	4.07
47	9.97	210	2.11
150	10.17	68	0.68
500	10.42	20.8	0.22
1,000	10.54	10.5	0.11
Demo-board Tx	10.02	86.8	
Demo-board Rx	10.18	28.5	

**Figure 2 :** Voltage Versus Power



#### II.2 - Current Consumption

The consumptions of the ST7537 demo-board have been tested during the B.E.R. test with the flyback converter powering the transmitter, and then the receiver. Values are given in the table below. In the Worst case, the load on the mains was only a few Ohms: all the laboratory devices were connected to the mains (with a personal computer which has a switching supply). The 5V does not depend on the impedance of the mains, it is only powering the microcontroller (ST90E28L6), the 3 LED's, and the RS232 driver (MAX 232).

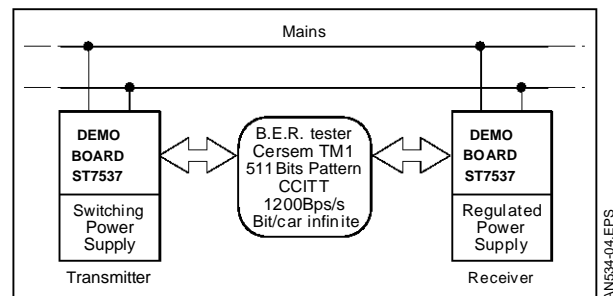
**Table 4 :** Flyback Converter with Demo-board Consumption

Voltage	Transmitting	Receiving
220V AC	25.8mA	19mA
220V AC (worst case)	31mA	19mA
10V DC	86.8mA	28.5mA
10V DC (worst case)	133mA	28.5mA
5V DC	32mA	35.4mA

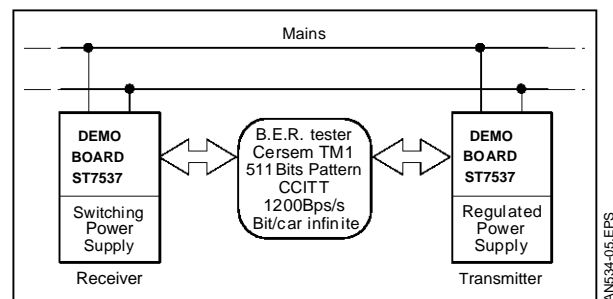
#### II.3 - B.E.R. with Switching Power Supply

The Bit Error Rate test needs two demo-boards, one for transmission, the other one for reception. The board with the switching supply has been set in receive mode and in transmit mode. Each time the B.E.R. results are the same as with regulated supply. On the transmitting demo board the pin TEST1 is set to 1 to allow continuous transmission.

**Figure 3 :** Switching Power Supply Powering Transmitter



**Figure 4 :** Switching Power Supply Powering Receiver



### Results

Measurements are made using the laboratory power network. On this network, several devices were producing noise:

- Tektronix 2247A oscilloscope,
- HP 3225B synthesiser,
- Weller WECF-20 soldering iron,
- Topward TPS 4000 power supply,
- A light.

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There has been no error for more than a 15 minutes test period (in the two conditions). In 15 minutes there is :

$$15 \cdot 60 \cdot 1200 = 1080000 \text{ bits.}$$

That means a B.E.R.  $< 10^{-6}$ .

**B.E.R.  $< 10^{-6}$**

### II.4 - Spectrum Frequency and Cenelec

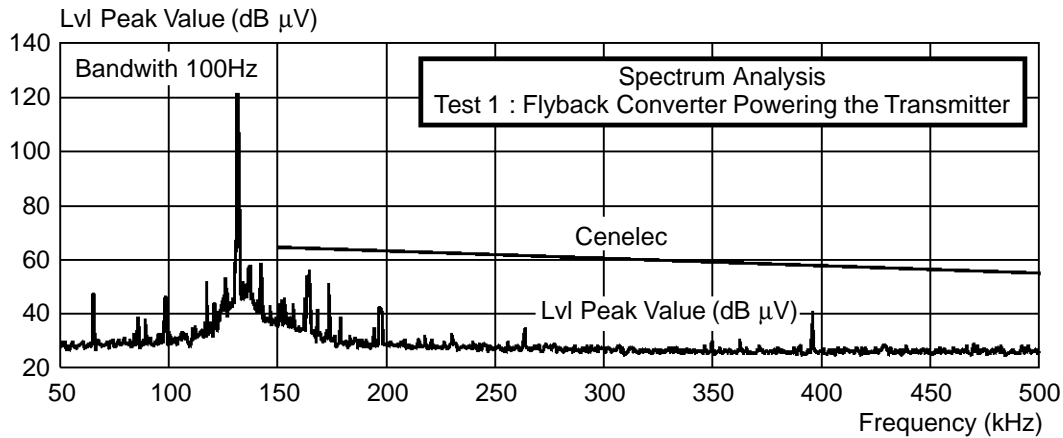
The P.L.M. has been connected to a spectrum analyser in order to see the influences of the flyback converter. The Cenelec specification n° EN 50065-1 PEAK values limit has been drawn (see the

following table). The spectrum has been done with a HP 3585 spectrum analyser, configured according to Cenelec ; that means a bandwidth of 100Hz, and the use of the MAX HOLD function in order to keep the peak values.

**Table 5 : Cenelec Specifications**

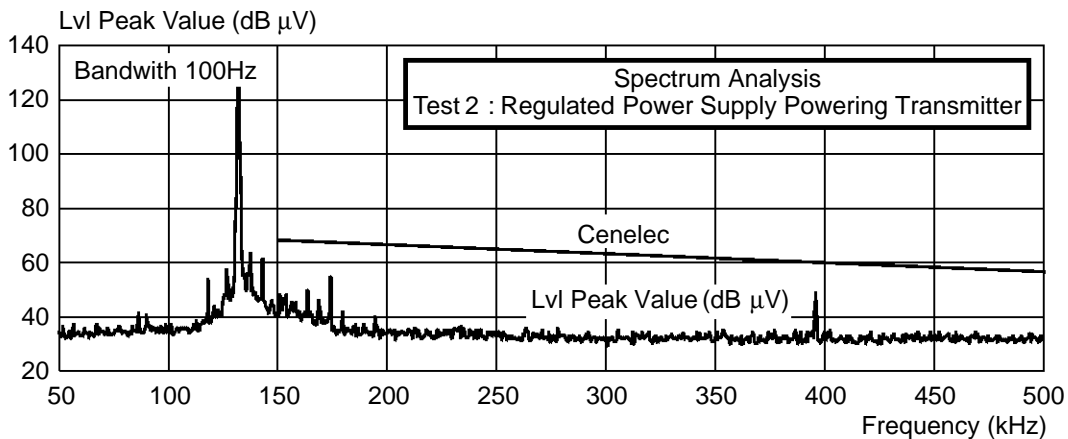
Frequency Band (MHz)	Limits (dB $\mu$ V) Peak Values	Limits (dB $\mu$ V) Means
0.15 to 0.5	66 to 46	56 to 46
0.5 to 5	56	46
5 to 30	60	50

**Figure 5 : ST7537 Demo-board with Flyback Converter**



AN534-06.A1

**Figure 6 : ST7537 Demo-board with Regulated Supply**



AN534-07.A1

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### III - MEASURE ON MAINS

During these tests, the transmit signal has been measured by connecting a spectrum analyser as described in Figure 7. This operation needs to isolate the analyser from the earth and to connect its ground level to the neutral. A capacitor of 2.2nF is used to filter the 50Hz and a voltage divider (resistors) is used to measure the signal. The supply is shielded to avoid radiation.

The values give these results :  
 $R_{TOTAL} = 4800 + 1450 = 6250\Omega$   
 $F_C = (R_{TOTAL} \cdot C \cdot 2 \cdot \pi) = 1.1\text{kHz}$

$$F_C = 1.1\text{kHz}$$

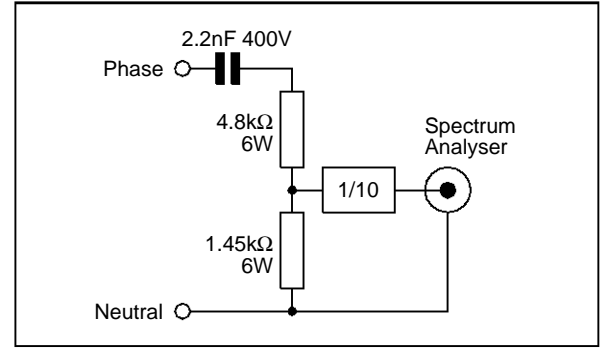
$$V_{REAL} = 10 \cdot V_{MES} \cdot \frac{R_{TOTAL}}{1450}$$

$$V_{REALdB} = V_{MESdB} + 32.7\text{dB}$$

The values read on the spectrum analyser are 32.7dB under the real values. The values on all the

following spectrums has been corrected and take into account the 32.7dB gain.

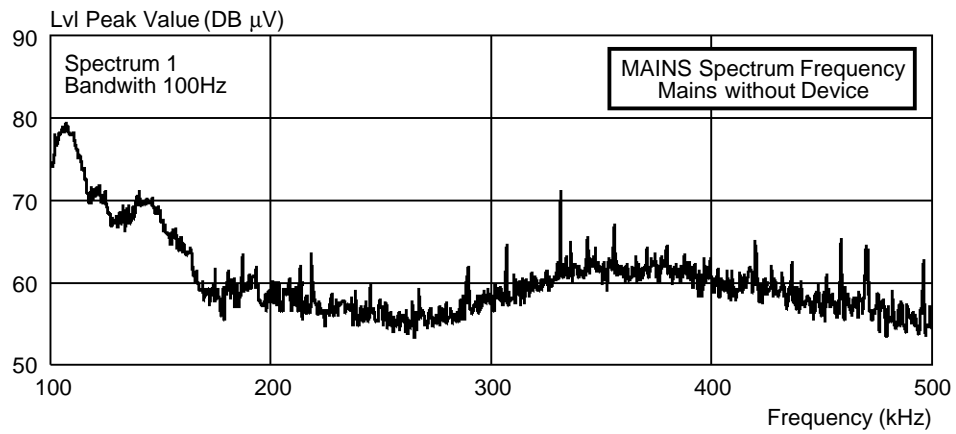
**Figure 7 :** Connecting the Spectrum Analyser to the Mains



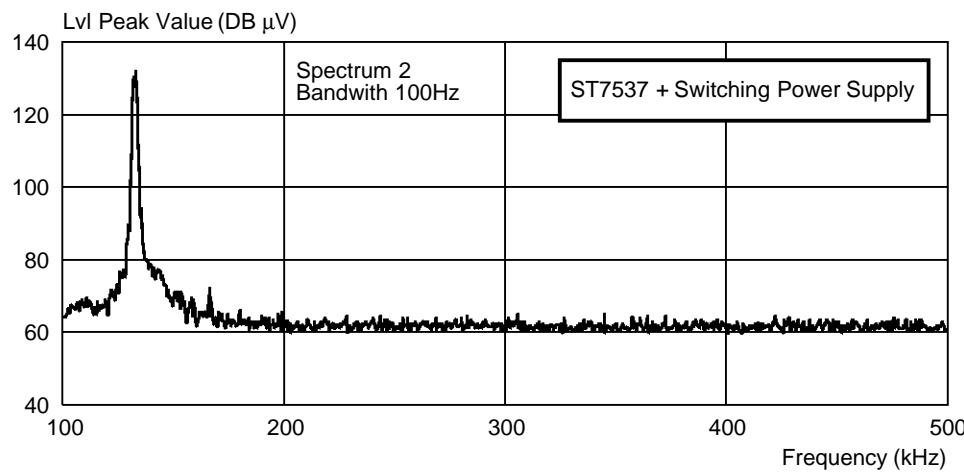
### III.1 - Mains Alone

In this case, the spectrum analyser has been connected to a laboratory mains without device on. This test gives an idea of the noise you can get on the mains.

**Figure 8 :** Mains without Device



**Figure 9 :** The P.L.M. is Alone on the Mains



AN634-08.AI

AN634-09.AI

AN634-10.AI

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### III.2 - Mains with P.L.M. Communication

This spectrum has been realised while the B.E.R. test was in progress. The two ST7537 demo-board were the only devices connected to the mains. The peak values have been obtained by using the MAX HOLD function of the spectrum analyser. The carrier frequency is at 132.45kHz.

### III.3 - Mains with P.L.M. Communication and Several Generators

These tests have been realised with several de-

vices such as drill, Hoover, ... So the noise appears on the spectrum, and it is possible to compare the noise level and the signal level. During all these tests, the B.E.R. test was in progress.

**No errors has been detected.**

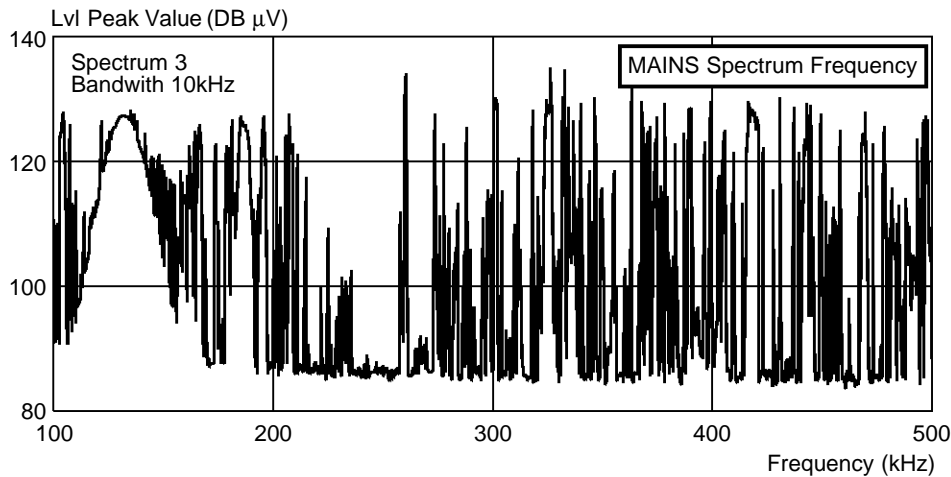
The table on the following page gives the conditions at the moment of the realisation of the spectrum. The values have been registered by the use of the spectrum analyser HPIB interface, and are peak values. Each graph is realised with 1001 points.

**Table 6 :** Conditions of the Tests

Spectre	Device	Conditions	Frequency Range
Figure 11	DRILL BOSCH 420W REF. 1123-7	Several Switch ON/OFF Accelerating	100kHz to 500kHz
Figure 12	DRILL BOSCH 420W REF. 1123-7	Several Switch ON/OFF Accelerating	1kHz to 5MHz
Figure 13	Neon Lighting OSRAM15W REF. RZ2	Several Switch ON/OFF	50kHz to 500kHz
Figure 14	Hoover NILFISK 700W MODEL GST	Several Switch ON/OFF	50kHz to 500kHz
Figure 15	All Laboratory Devices	Normal Use	50kHz to 500kHz

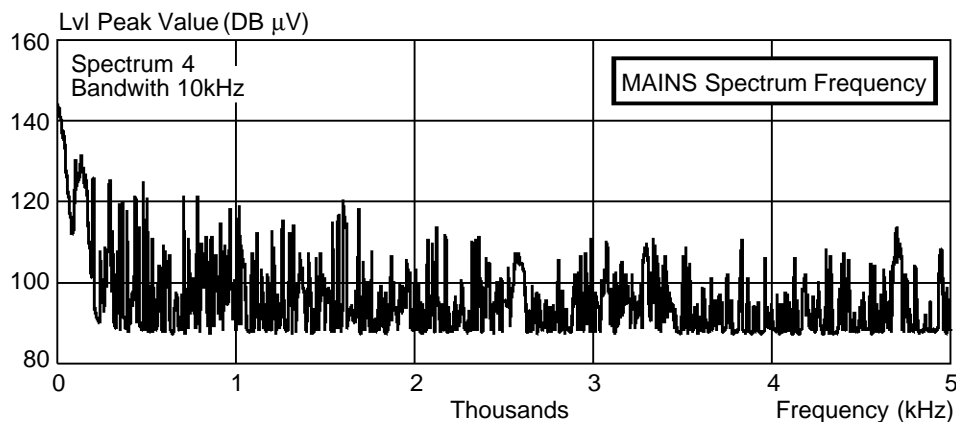
All the devices are operating under 220V 50Hz. The analyser bandwidth has been set to 10kHz. The different spectrum are given below.

**Figure 10 :** Transmitting while Using a Drill



AN534-11.A1

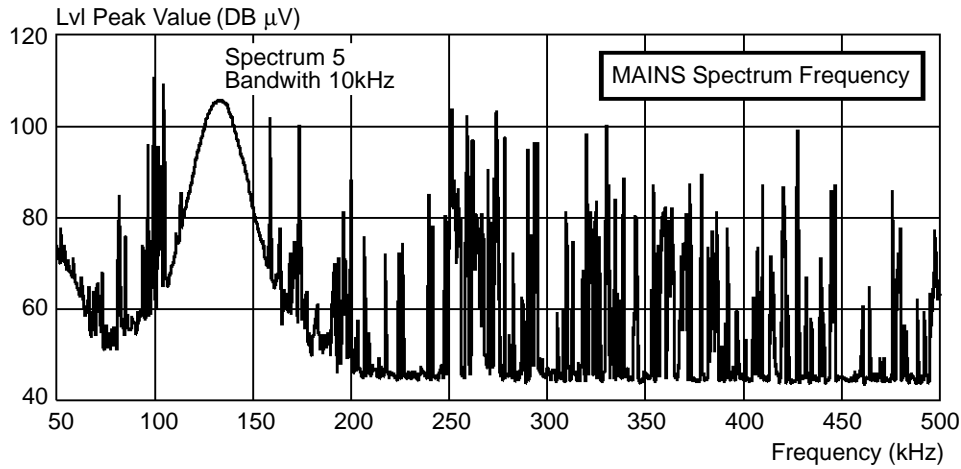
**Figure 11 :** Transmitting while Using a Drill (wide Spectrum)



AN534-12.A1

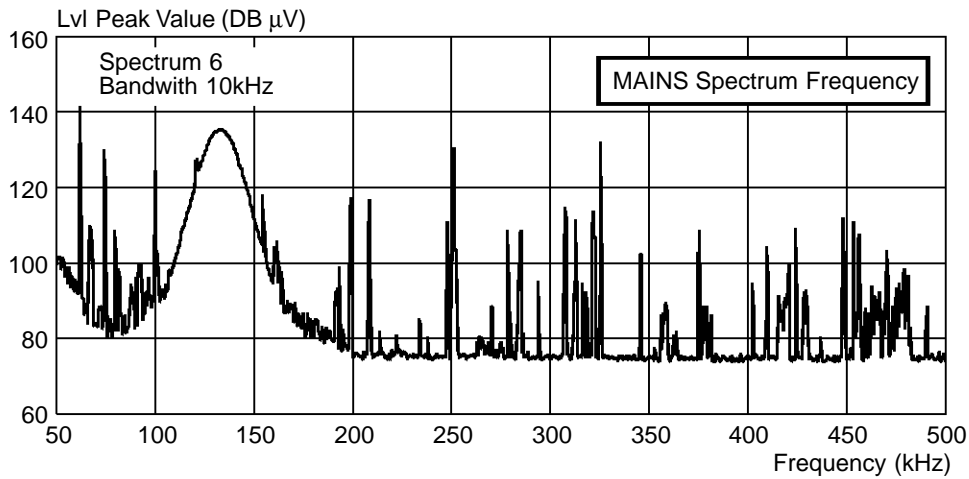
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**Figure 12 :** Transmitting while Using a Neon Lighting



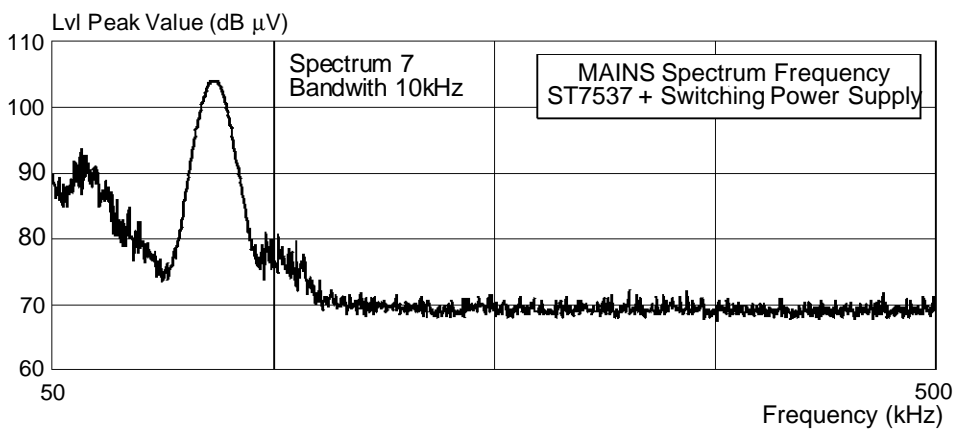
AN534-13.A1

**Figure 13 :** Transmitting while Using a Hoover



AN534-14.A1

**Figure 14 :** All the Laboratory Devices on Use



AN534-15.EPS

In this last graph, the level of the ST7537 carrier has fallen to 104dB μV because of the load on the mains (we have connected a personal computer which has a switching power supply). Nevertheless, the communications occurs without any errors.



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### IV - CONCLUSION

Even with a high level noise or important disturbance on mains, or even a load under  $5\Omega$ , the ST7537 has a B.E.R. under  $10^{-6}$  (we have not detected any error during all the test period). Power line system communication needs a ST7537, a power line interface, a control system, and a 10V DC supply. The power line interface is already existing, and SGS-Thomson provides a large range of microcontrollers (interface between ST9 microcontroller and ST7537 has been realised). The flyback converter comes to provides 10V DC for P.L.M. (and a 5V DC for the microcontroller) and replace the classical regulated supply. The ST7537 and power line interface consumption lets more

than 2.5W for microcontroller and application, available in both 5 and 10V. The 10V fluctuations are under the ST7537 specifications (which needs  $10V \pm 10\%$ ).

In fact, the flyback converter is really suited to ST7537 applications :

- Its voltages complies with ST7537 specifications,
- It does not disturb the transmit spectrum,
- The performances of the power line modem are the same as with regulated supply,
- Its size allows its use in small systems, like home system applications,
- The 4.5W power provides supply for both P.L.M and microcontroller.

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