UM10422

TDA5051A power line modem evaluation board

Rev. 2 — 1 June 2011 **User manual**

Document information

Info	Content
Keywords	Mains supply, TDA5051A, zero cross detector
Abstract	This document is a user manual for the TDA5051A power line modem stand-alone evaluation board.

Revision history

Rev	Date	Description
v.3	20110601	user manual; third release Added waveforms in Section 5
v.2	20110104	user manual; second release Evaluation board, PCB layout, and BOM are updated to V2.
v.1	20101102	user manual; first release

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1. Introduction

The TDA5051A is a Power Line Modem (PLM) IC, specifically dedicated to ASK transmission by means of home power line network at 600 baud or 1200 baud data rate. It operates from a single 5 V supply.

The TDA5051A employs control logic which provides full digital carrier generation and shaping, a high clock rate of 6-bit D/A (Digital-to-Analog) converter which provides rejection of aliasing components. The IC contains a fully integrated output power stage with overload protection. The receiver employs an AGC (Automatic Gain Control), 8-bit A/D (Analog-to-Digital) converter and narrowband digital baseband filtering and digital demodulator. The modulation and demodulation frequency is set by clock source from microcontroller or on-chip crystal oscillator.

Easy compliance with EN50065-1 is afforded with simple coupling networks. Low cost applications are realized with few external components. The TDA5051A is housed in the SO16 plastic package.

2. Safety warning

WARNING

Lethal voltage and fire ignition hazard

The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel that is qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

The board needs to be connected to mains voltage. Touching the reference board during operation must be avoided at all times. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. This isolation is not according to any regulated norm. Galvanic isolation of the mains phase using a variable transformer is always recommended. These devices can be recognized by the symbols shown in Figure 1.

a. Isolated

b. Not isolated

Fig 1. Variac isolation symbols

3. Specifications

Table 1 gives specifications for TDA5051A Power Line Modem (PLM) IC.

Table 1. Quick reference data

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{DD}	supply voltage			4.75	5.0	5.25	V
$I_{DD(tot)}$	total supply current	f_{osc} = 8.48 MHz					
		Reception mode		-	28	38	mA
		Transmission mode; DATA_IN = 0; Z_L = 30 Ω	[1]	-	47	68	mA
		Power-down mode		-	19	25	mA
f_{cr}	carrier frequency		[2]	-	132.5	-	kHz
f_{osc}	oscillator frequency			6.08	-	9.504	MHz
$V_{o(rms)}$	output carrier signal (RMS value)	$\overline{DATA\_IN}$ = LOW; Z_L = CISPR16		120	-	122	dBµV
$V_{i(rms)}$	input signal (RMS value)		[3]	82	-	122	dBµV
THD	total harmonic distortion on CISPR16 load with coupling network			-	–55	-	dB
T_{amb}	ambient temperature			–10	-	+80	°C

[1] The value of the total transmission mode current is the sum of $I_{DD(RX/TX)(tot)}$ + $I_{DD(PAMP)}$ in Table 5 “Characteristics” of the TDA5051A data sheet.

[2] Frequency range corresponding to the EN50065-1 band. However, the modem can operate at any lower oscillator frequency.

[3] The minimum value can be improved by using an external amplifier.

4. Evaluation board

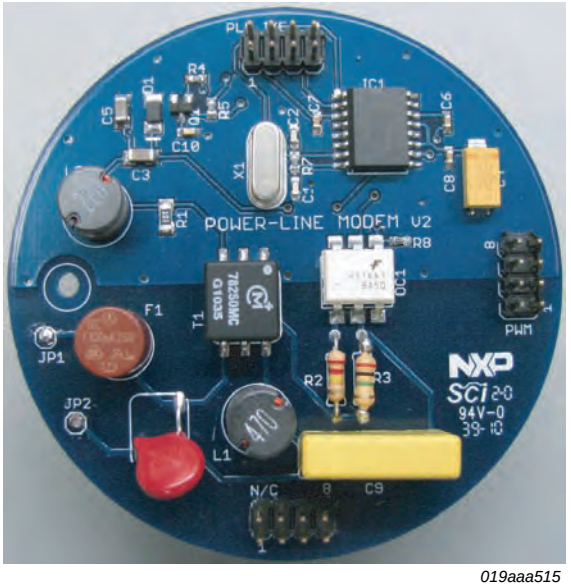

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Fig 2. Evaluation board photo

5. Connecting the board

The PLM evaluation board can be used for a 230 A (AC) (50 Hz) or for a 120 V (AC) (60 Hz) mains power line. If a galvanic isolated power transformer is used, it should be placed between the AC power line and the PLM evaluation board.

Select a power line plug/cable depending on power line supply voltage and safety enclosure used in test bench setup.

Remark: When the board is placed in a metal enclosure, the middle pin of the power plug can be connected to the metal casing for grounding.

5.1 PLM test setup

Table 2. General setup

General setup
Connect Line to Line, and Neutral to Neutral.
Connect +5 V DC to pin 1.
Connect GND to pin 3 and pin 5.
Set pulse generator to square wave (0 V to 5 V), 1200 Hz, 50 % duty cycle.

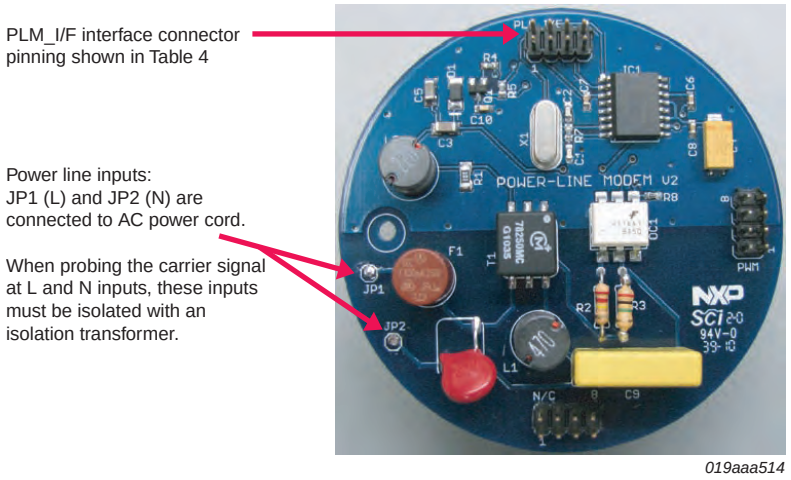


Fig 3. PLM test setup (board to board)

Table 3. Transmission test setup

Transmission test (A to B)	Transmission test (B to A)
Connect pin 4 of board A to pulse generator	Connect pin 4 of board B to pulse generator
Connect pin 4 of board B to +5 V DC (disables Tx)	Connect pin 4 of board A to +5 V DC (disables Tx)
Connect a scope probe to pin 4 of board A	Connect scope probe to pin 4 of board B
Connect a scope probe to pin 6 of board B	Connect scope probe to pin 6 of board A

[1] The average current (I) for each chip is approximately 30 mA to 40 mA.

[2] You will experience higher currents if you do not disable the Tx pin of the receiving device.

[3] You can also monitor the ASK signaling on the L and N pins **(no line voltage applied)**.

CAUTION: You must use an isolated scope if you apply 110 V AC to the L and N inputs.

Table 4. PLM_I/F connector pin description

Pin	Description
1	+5 V DC supply input
2	Oscillator 1
3	GND
4	$\overline{\text{DATA\_IN}}$; data input, active LOW
5	GND
6	$\overline{\text{DATA\_OUT}}$; data output, active LOW
7	zero cross detector
8	power down (active HIGH)

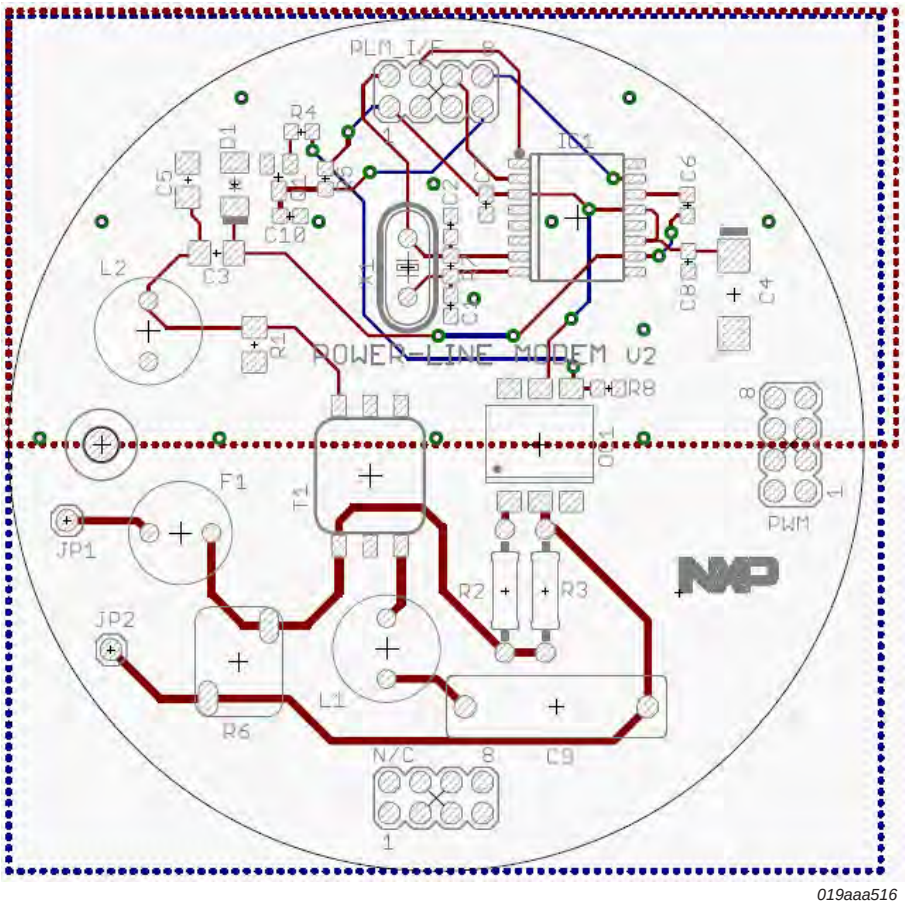
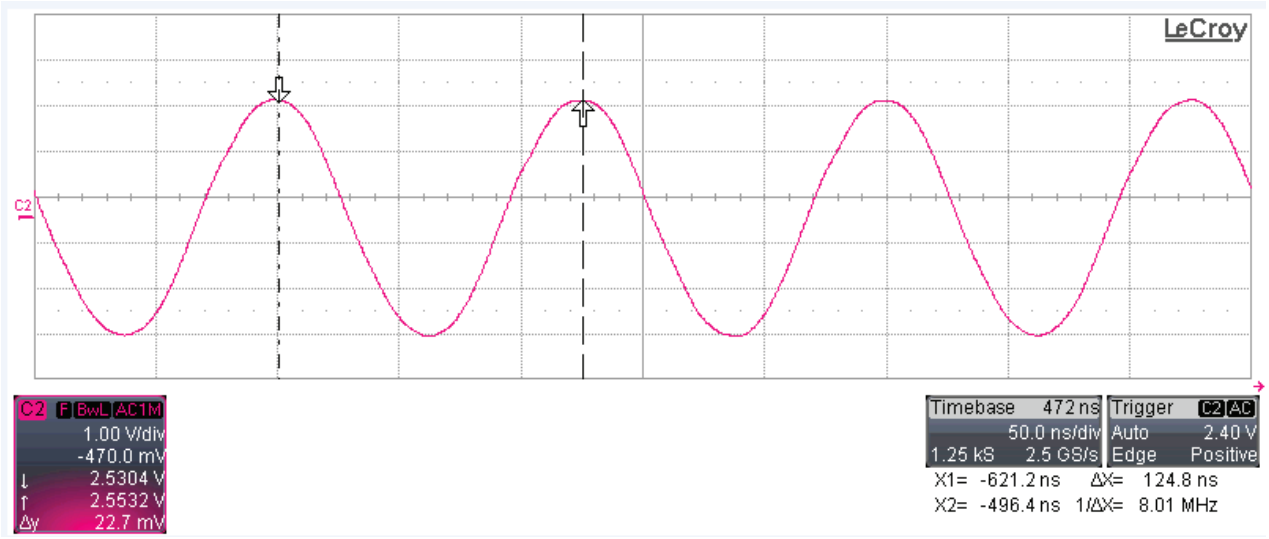


Fig 4. Printed-circuit board layout

5.2 Waveforms on pins of PLM_I/F connector

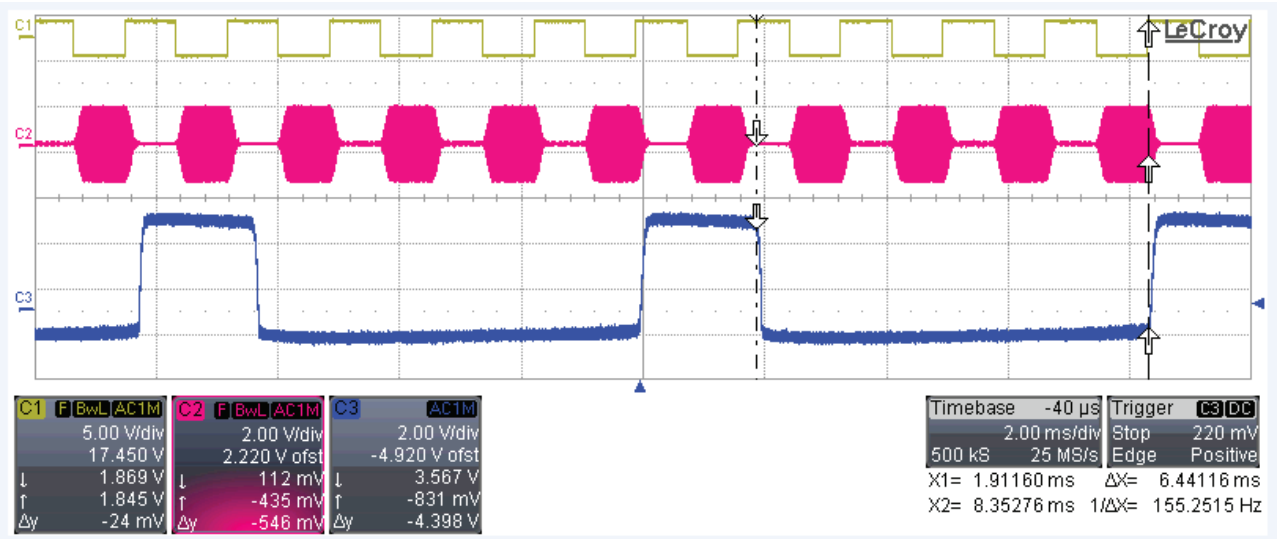


Vertical axis: oscillator output voltage (1.0 V / division).

Horizontal axis: time base (50 ns / division).

Marker shows 8.01 MHz reference frequency.

Fig 5. Reference crystal oscillator output at pin 2 of PLM_I/F connector

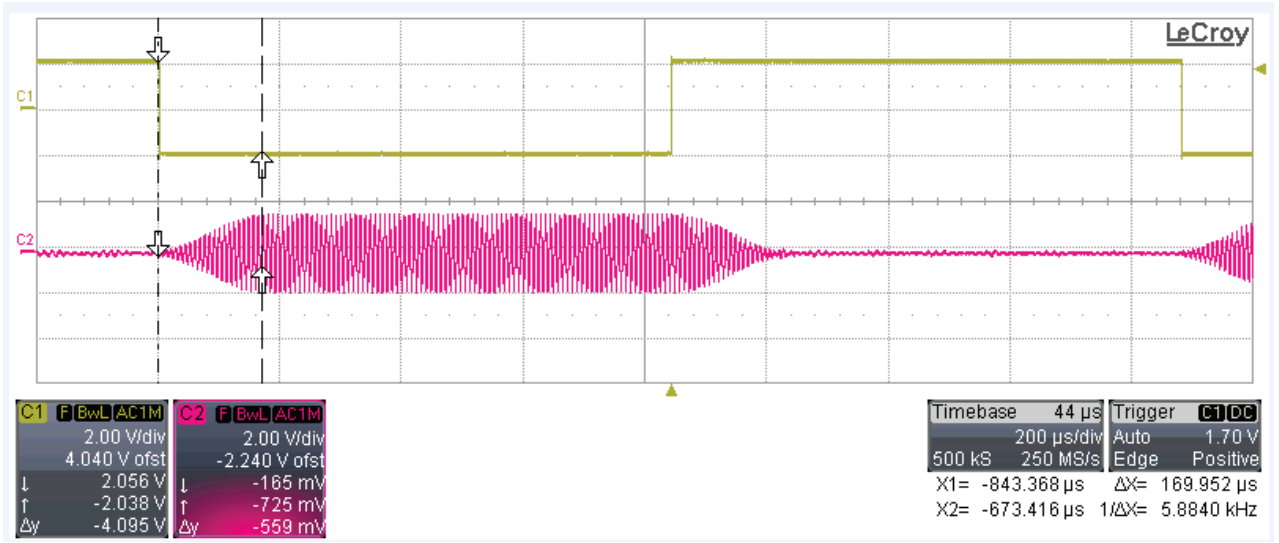


TDA5051A PLM Board A as transmitter: C1 — $\overline{\text{DATA\_IN}}$ (pin 4 PLM_I/F connector); C2 — Tx carrier output (at TDA5051A side of transformer T1); C3 — zero cross detector output (pin 7 of PLM_I/F connector); cursor shows zero crossing OFF time of 6.44 ms; ON time is 2 ms.

Y axis: C1 is 5.0 V / division; C2 is 2.0 V / division.

X axis is time base of 2.0 ms.

Fig 6. $\overline{\text{DATA\_IN}}$, Tx carrier output and zero cross detector output versus time



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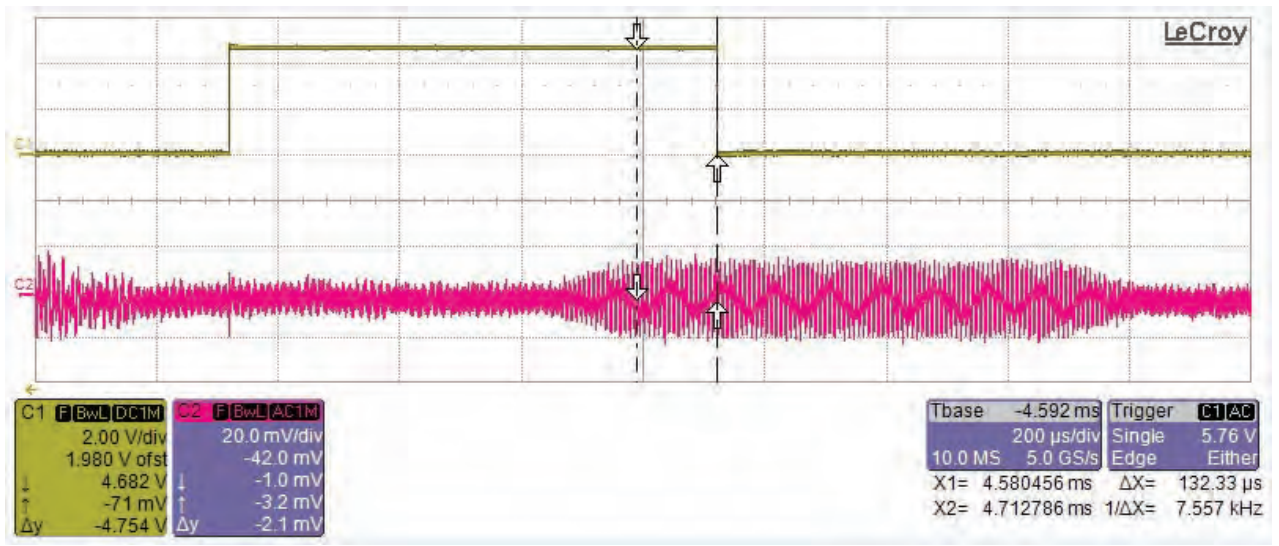
Board A as transmitter: C1 — $\overline{\text{DATA\_IN}}$ (pin 4 of PLM_I/F connector); C2 — Tx carrier output (at TDA5051A side of transformer T1); cursor shows $\overline{\text{DATA\_IN}}$ to Tx carrier output lead of 169.95 µs.

Y axis: C1 is 2.0 V / division; C2 is 2.0 V / division.

X axis is time base of 200 µs.

Fig 7. $\overline{\text{DATA\_IN}}$ to Tx carrier output delay



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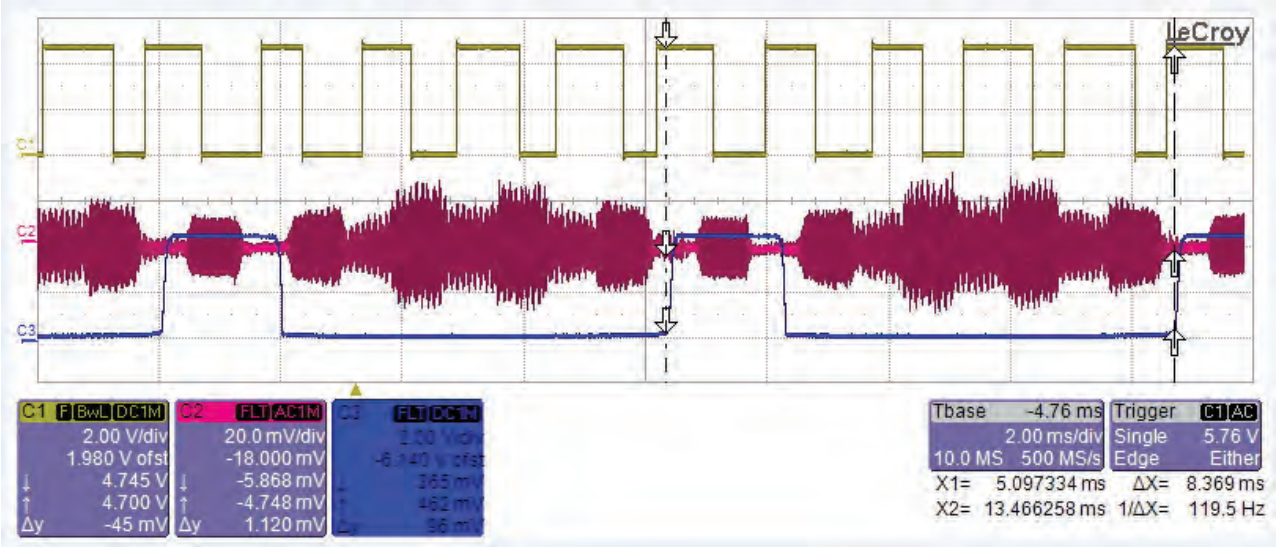
Board B as receiver: C1 — $\overline{\text{DATA\_OUT}}$ (pin 6 of PLM_I/F connector); C2 — Rx carrier input (at TDA5051A side of transformer T1); cursor shows $\overline{\text{DATA\_OUT}}$ to Rx carrier input delay of 132.3 µs.

Y axis: C1 is 2.0 V / division; C2 is 20 mV / division.

X axis is time base of 200 µs.

Fig 8. Rx carrier input to $\overline{\text{DATA\_OUT}}$ delay



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Board B as receiver: C1 — $\overline{\text{DATA\_OUT}}$ (pin 6 of PLM_I/F connector); C2 — Rx carrier input (at TDA5051A side of transformer T1); cursor shows zero cross detector peak-to-peak period of approximately 120 Hz.

Y axis: C1 is 2.0 V / division; C2 is 20 mV / division; C3 is 2.0 V / division.

X axis is time base of 2.0 µs.

Fig 9. Rx carrier input noise is greater at peaks of AC power line waveform

6. Functional description

Refer to data sheet TDA5051A for functional description.
www.nxp.com/pip/TDA5051A.html

7. Board schematic

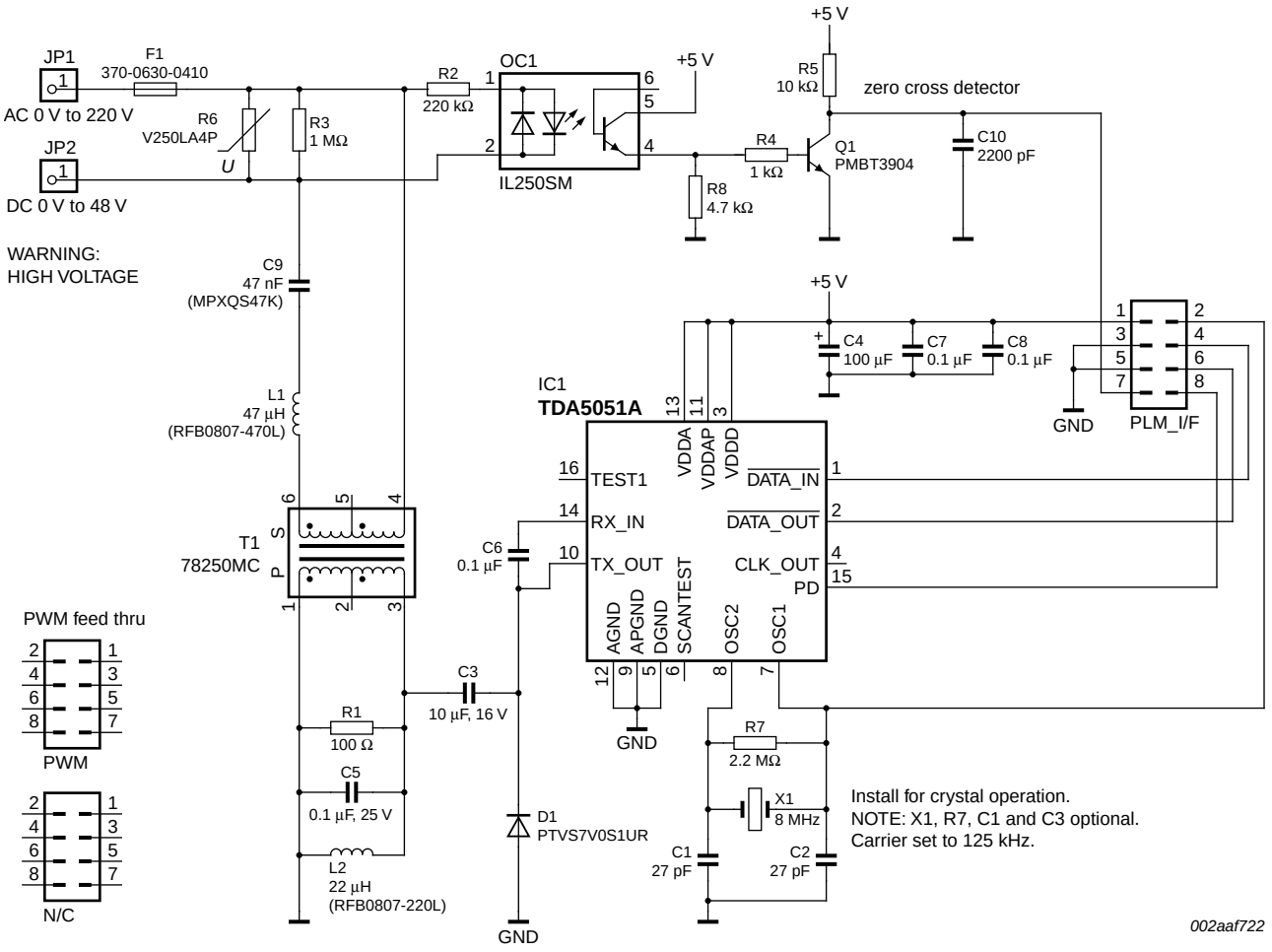

Fig 10. PLM evaluation board schematic

8. Bill Of Materials (BOM)

Table 5. Power line modem Bill Of Materials (BOM)

Component	Description	Manufacturer	Package	Type number
C1[1]	27 pF		C0603	
C2[1]	27 pF		C0603	
C3	10 µF, 16 V		C1206	
C4	100 µF		CT7343	
C5	0.1 µF at 25 V		C1206	
C6	0.01 µF		C0603	
C7	0.1 µF at 25 V		C0603	
C8	0.1 µF at 25 V		C0603	
C9	47 nF (MPXQS47K)			C150-054X183
C10	2200 pF		C0603	
D1	PTVS7V0S1UR	NXP	SOD123, Mini-SMA	CGRM4001-G
F1	FUSELITTLEFUSE_S370	Little Fuse	LITTLE_S370	370-0630-0410
IC1	Power Line Modem	NXP	SO16W	TDA5051AT
JP1	header		1X01	
JP2	header		1X01	
L1	47 µH inductor	Coilcraft	RFB0807	RFB0807-470L
L2	22 µH inductor	Coilcraft	RFB0807	RFB0807-220L
N/C			MA04-2	MA04-2
OC1	IL250SM		IL250SM	DIL6-SMD
PLM_I/F			MA04-2	MA04-2
PWM			MA04-2	MA04-2
Q1	transistor	NXP	SOT23	PMBT3904
R1	100 Ω resistor		R1206	
R2	220 kΩ resistor		0207/10	
R3	1 MΩ resistor		0207/10	
R4	1 kΩ resistor		R0603	
R5	10 kΩ resistor		R0603	
R6	V250LA4P resistor		V250LA4P	
R7[1]	2.2 MΩ resistor		R0603	
R8	4.7 kΩ resistor		R0603	
T1[2]	transformer	Murata	78250	78250MC
X1	8.00 MHz crystal		HC49U-V	CRYSTALHC49U-V

[1] Optional for XTAL.

[2] Specifications for component T1 signal transformer can be found at www.nxp.com/redirect/murata-ps.com/data/magnetics.

9. Abbreviations

Table 6. Abbreviations

Acronym	Description
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control
ASK	Amplitude Shift Keying
CMOS	Complementary Metal-Oxide Semiconductor
DAC	Digital-to-Analog Converter
HF	High-Frequency
IC	Integrated Circuit
LC	inductor-capacitor filter
PLM	Power Line Modem
RMS	Root Mean Squared
TTL	Transistor-Transistor Logic

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