CY3276

Cypress High Voltage Programmable Powerline Communication Development Kit Guide

Doc. # 001-55116 Rev. *B

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[+] Feedback

Contents

1.   Introduction

1.1   Safety precautions

CAUTION: **High Voltage (Risk of Electric Shock)**
Extreme care is necessary when you work wih powerline communications equipment.
Use caution when using power supplies or power related equipment.

- Use the board with expert technical supervision. There is high voltage (110V /240V AC) power on the board.
- Accidental human contact with high voltage is dangerous.
- The capacitors on the board can be energized even after disconnecting the board from main power supply. Be careful to not touch any parts on the board immediately after you disconnect the main power supply.
- Safety plastic casing is provided on the top of HV section. Do not touch the protected area during live operation for debugging, probing, or for any other purpose.

Cypress bears no responsibility for any consequences that may result from the improper or hazardous use of this board.

1.2   Using the PLC Kit

Cypress's Powerline Communication Solution (PLC) makes it possible to transmit command and control data over high voltage and low voltage powerlines. This solution is developed for low bandwidth powerline communication.

The PLC CY3276 high voltage (HV) Development Board is a tool that allows for system design by using the Cypress PLC family of devices to transmit data up to 2400 bps over high voltage (90V to 264V AC) powerlines.

- Chapter 1 provides a brief overview of the Cypress PLC solution. It describes the contents of the CY3276 development kit and lists special features of the PLC Demonstration kit.
- Chapter 2 gives the functional overview of the PLC board and describes the setup and operating procedure of PLC HV board. It provides a high level hardware description of the board.

1.3   The Cypress PLC Solution

Powerlines are available everywhere in the world. This makes them one of the most widely available communication mediums for PLC technology. The pervasiveness of powerlines also makes it difficult to predict their characteristics and noise. Because of the variability of powerline quality, implementing robust communication over powerline has been an engineering challenge for years. With this in mind, the Cypress PLC solution is designed to enable secure, reliable, and robust communication over powerlines.

1.3.1 Cypress PLC Features

■ An integrated powerline PHY modem with optimized filters and amplifiers that work with rugged high and low voltage powerlines

■ Powerline optimized network protocol that supports bidirectional communication with acknowledgement based signaling and multiple retries

■ Support for 8-bit packet CRC and 4-bit header CRC for error detection and data packet retransmission

■ Carrier Sense Multiple Access (CSMA) scheme that minimizes collisions between packet transmissions on the powerline

The Cypress PLC solution consists of three key elements as shown in Figure 1-1

■ Powerline Network Protocol Layer

■ Physical Layer FSK Modem

■ Power Amplification and Coupling Circuits

Figure 1-1. Cypress PLC Solution Block Diagram
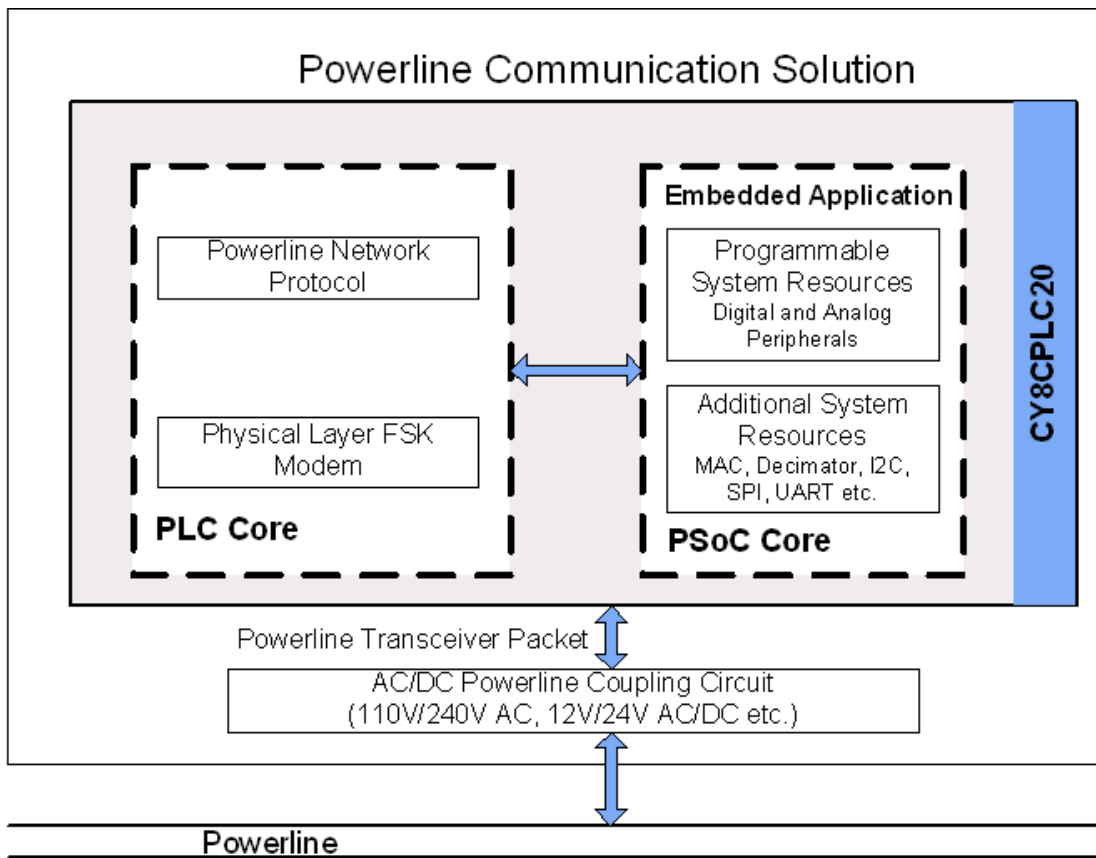
The powerline network protocol layer and the physical layer FSK modem are implemented on the CY8CLED16P01 chip. The chip also contains a PSoC core in addition to the PLC core. The power amplification and coupling circuits are built using discrete components.

The network protocol layer allows you to address multiple nodes on the network. This enables point-to-multipoint communication. The protocol layer also provides a defined packet structure for trans-

mitting data packets from one node to the other. It also provides error detection and packet retransmit functionalities.

A two node system level diagram is shown in Figure 1-2.

Figure 1-2. PLC System Level Block Diagram - Two Nodes
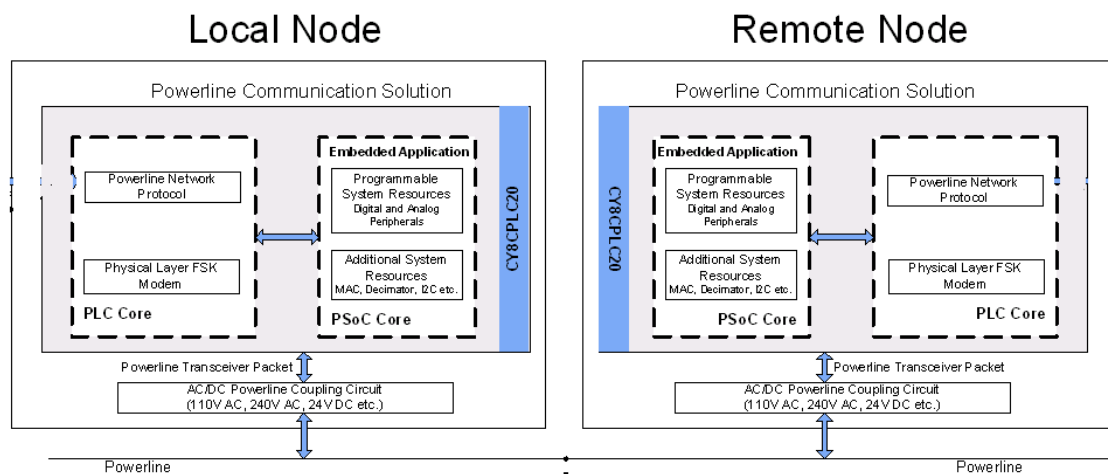
1.4 Kit Contents

The CY3276 PLC HV Development kit contains:

- CY3276 Quick start guide
- CY3276 PLC HV Development Board
- CD-ROM containing:
  - ❒ Packet Test software - PLC Control Panel application
  - ❒ LED Control software - PLC RGB control
  - ❒ CY8CLED16P01 datasheet
  - ❒ Development Board User Guide
  - ❒ CY3276 Board Altium Design Project
  - ❒ CY3276 Board BOM
  - ❒ Application note - *Using CY8CLED16P01 in Powerline Communication (PLC) Applications*
  - ❒ CY3276 Board schematics
  - ❒ CY3276 Board Gerbers
  - ❒ LED Daughter card schematics
  - ❒ LED Daughter card gerbers
  - ❒ PSoC Designer
  - ❒ PSoC Programmer
- AC Power Cable
- MiniProg1 for programming the CY8CLED16P01 device
- 25 Jumper wires
- LCD module
- LED Daughter Card
- 12V DC supply
- USB-I^{2}C Bridge

■ Retractable USB cable

■ 2" metal standoffs - to raise the board's height when using the LED daughter card

1.5   Document Revision History

Table 1-1. Revision History

Revision	PDF Creation Date	Origin of Change	Description of Change
**	8/14/09	IUS	New kit guide.
*A	9/3/09	IUS	Rework for external release.
*B	12/10/09	RARP	Content updates

1.6   Documentation Conventions

Table 1-2. Document Conventions for Guides

Convention	Usage
Courier New	Displays file locations, user entered text, and source code: `C:\ ...cd\icc\`
Italics	Displays file names and reference documentation: Read about the *sourcefile.hex* file in the *PSoC Designer User Guide*.
[**Bracketed, Bold**]	Displays keyboard commands in procedures: [**Enter**] or [**Ctrl**] [**C**]
File > Open	Represents menu paths: File > Open > New Project
Bold	Displays commands, menu paths, and icon names in procedures: Click the **File** icon and then click **Open**.
Times New Roman	Displays an equation: $2 + 2 = 4$
Text in gray boxes	Describes cautions or unique functionality of the product.

2.   PLC Development Board

This chapter explains the key features of the CY3276 development board.

2.1   Features

The Cypress CY3276 development board is a versatile tool with these features.

- User friendly PLC control panel and PLC RGB Control application available on the kit CD-ROM
- CY8CLED16P01-OCD chip – 100-pin TQFP on chip debug (OCD) device that allows for the quick design and debug of PLC applications
- Chip power supply derived from 90V to 264V AC
- User configurable general purpose LEDs
- General purpose 8-bit DIP switch
- On board surge protection and isolation circuit
- RJ45 connector to use ICE debugger
- RS232 COM port for communication
- Header to attach the LCD card
- Header to attach the LED card
- I^2C header for communicating to external devices
- ISSP header for programming the CY8CLED16P01 chip

2.2   PLC Development Board Functional Overview

The PLC development board is designed as a product development platform for low bandwidth (up to 2400 bps) powerline communication.

The application residing on CY8CLED16P01 generates the data. The PLC core encapsulates this data into a PLC network packet. The FSK modem modulates this packet and the coupling circuitry incorporates the resulting sinusoidal waveform onto the existing waveform on the high voltage bus.

2.2.1   Operating Conditions:

- Input Voltage: 110VAC/240VAC
- Input Current: 100 mA/50 mA
- Operating Temperature: 0°C to 40°C
- Operating Humidity Condition: 5% to 95% RH, non-condensing

2.3 Hardware Description

The programmable high voltage PLC development board is shown in Figure 2-1. The key sections are highlighted. The board identifies and isolates the HV and LV sections. The board can be divided into six main sections:

■ High voltage section with power supply

■ Transmit amplifier, filters, and coupling circuit section

■ Development section for user

■ LCD and LED daughter cards

■ Debugger

■ RS232 COM section

Figure 2-1. Front View of Cypress Programmable PLC HV Development Board
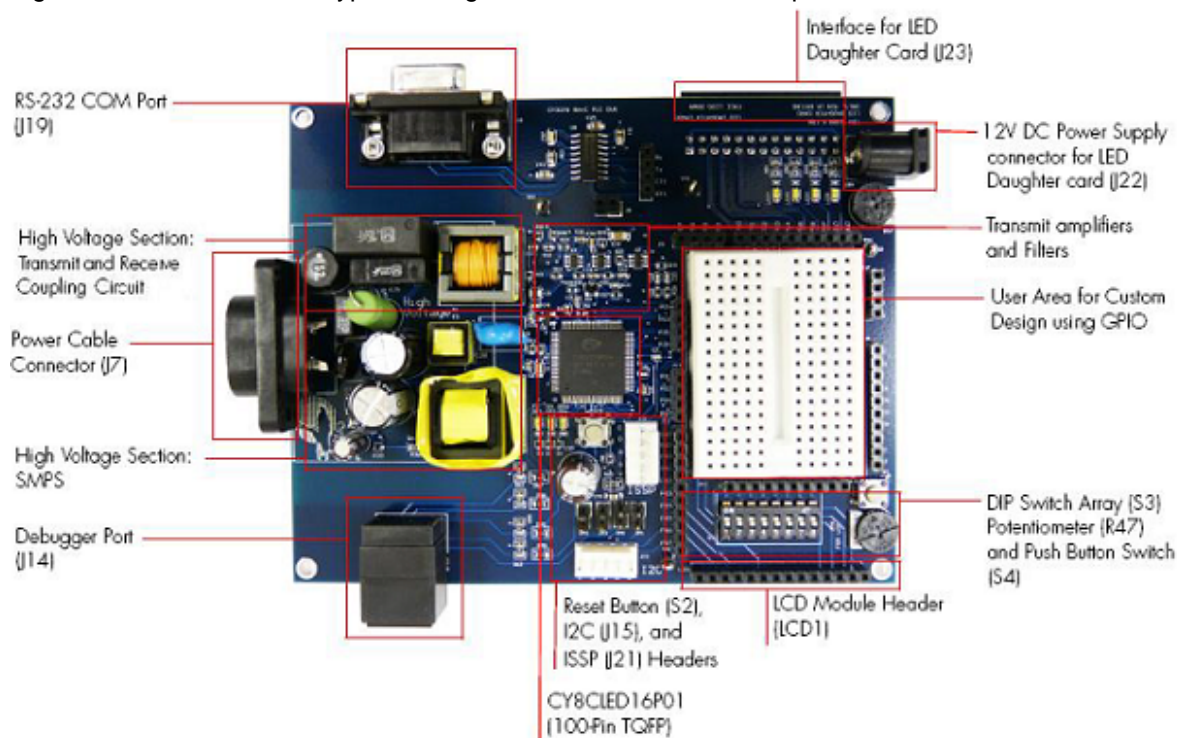
The HV board communication signal flow:

Transmit: CY8CLED16P01 TX pin → Transmitter Filter Circuitry → Power Amplifier Circuitry → High Voltage Powerline Coupling Circuitry → High Voltage Powerline (90V to 264V AC)

Receive: High Voltage Powerline (90V to 264V AC) → High Voltage Powerline Coupling Circuitry → Passive Low Pass Filtering → Centre Biasing → CY8CLED16P01 RX pin

The core of the PLC HV board is the CY8CLED16P01 chip. The board can be divided into seven main sections.

■ High Voltage with SMPS

■ Transmit Amplifier and Filtering

■ Transmit and Receive Coupling Circuit

■ Receive Filtering and Center Biasing

■ Development

- Daughter Card
- RJ45 Connector for Debugging

2.3.1 High Voltage Section with SMPS

This section gets power from the powerline and generates necessary low DC voltage for the operation of the PLC transceiver and other components on the chip.

Table 2-1. Key High Voltage with SMPS Components

Component	Description
J7	This is the two pin connector where the AC cable hooks up to the powerline.
F1	Protection fuse for the circuit.
D7	Full wave bridge rectifier diode IC.
T3	Common mode choke.
U6	iW1690-07 – iWatt high performance AC/DC power supply controller.
T2	Flyback transformer.
U5	5V regulator.

2.3.2 Transmit Amplifier and Filtering Section

This section takes the output signal from the transceiver chip. The circuit amplifies the signal and filters it for compliance purposes only. The amplification is to drive the signal on long cables or in low impedance networks. Filtering is done in three stages.

Table 2-2. Key Transmit Amplifier and Filtering Components

Component	Description
U2, U3	These opamps are used to filter the signal from the CY8CLED16P01 removing the harmonics. The filter stages are only required to meet the European CENELEC EN50065-1:2001 signaling specification. They are not required to achieve robust PLC communication.
U4, Q1, Q2	These opamp and high gain transistors are used for the power amplification stage.

2.3.3 Transmit and Receive Coupling Circuit

This circuit couples the signal from the board on to the powerline. On the receive side, the same circuit couples the carrier on the powerline into the board rejecting the actual 50 and 60 Hz powerline signal. The isolation transformer in the circuit is required for safety.

Table 2-3. Key Transmit and Receive Components

Component	Description
T1	This is the isolation transformer which provides isolation between the HV and LV sections of the board. It is 1:1 ratio transformer.
C9	This is the coupling capacitor which couples the communication signal and rejects the low frequency noise. The voltage and X1 safety rating of this component are important parameters.

2.3.4 Development

2.3.4.1 Bread Board

This section is the area where you create custom designs. All GPIO pins (excluding those required for PLC communication) are routed to this bread board space.

Figure 2-2. Bread Board
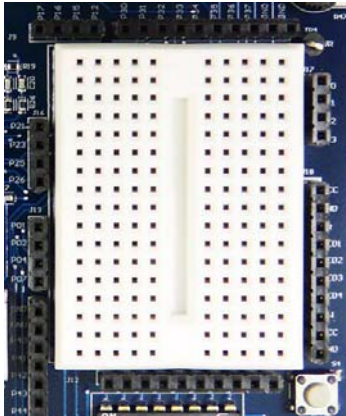
2.3.4.2 CY8CLED16P01 Device

This section has the CY8CLED16P01-OCD chip. which has the integrated transmit/receive modem and network protocol and the application layer. It also has the I^2C header to communicate to the external host processor. The ISSP header is provided to program the part. The part also has built-in debug support using the RJ45 connector which can be used with the ICE debugger. There are also three dedicated LEDs, which can be used to indicate communication on the powerline: green LED for TX, red LED for RX, and yellow LED for BIU.

Figure 2-3. Development Section

Table 2-4. Headers and Jumpers

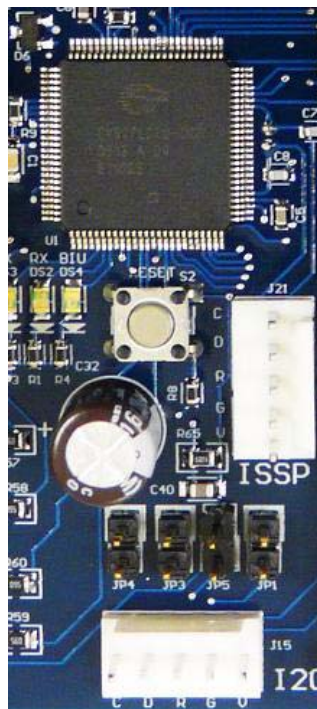| Headers and Jumpers	Description
CY8CLED16P01-OCD	This is the Cypress Powerline transceiver chip. It is a 100-pin OCD device
PWR LED[DS1]	This is a blue LED that glows when the board is powered on
TX LED[DS3]	This is a green LED that can be used to indicate when the board is transmitting packets on to the powerline
RX LED[DS2]	This is a red LED that can be used to indicate when the signal is received over the powerline on to the board
BIU LED[DS4]	This is a yellow LED that can be used to indicate when the transmit frequency band is in use
TP1, TP2, TP3, TP4	Grounded test points to facilitate probing/debugging
S2	Reset switch for resetting the CY8CLED16P01-OCD chip
J8	2-pin header for connecting to Vcc and Gnd
LED1-LED4	Headers connected to general purpose configurable LEDs
JP1 (PWR)	Connect this jumper to power an external board. Once this jumper has been connected, power for the external board can be derived from the V and G connectors on the I2C header (J15). The CY3276 board can provide a maximum of 50mA at 5V to an external board through the V and G pins on the I2C header(J15).
JP5 (Reset)	The jumper is for enabling the reset of the PLC chip through an external board. Once this jumper has been connected, the external board reset can be connected to the R pin on the I2C header (J15).
JP4 (I2C-SDA)	This is a pull up jumper. While communicating through I2C(J15), one side has to pull up the line. When the jumper is connected, the SDA line will get pulled high. This needs to be done when the user wants the I2C link to be pulled up by CY3276 board. This jumper does not need to be placed if the USB-I2C bridge is used for communication to the host.
JP3 (I2C-SCL)	This is a pull up jumper. While communicating through I2C(J15), one side has to pull up the line. When the jumper is connected, the SCL line will get pulled high. This needs to be done when the user wants the I2C link to be pulled up by CY3276 board. This jumper does not need to be placed if the USB-I2C bridge is used for communication to the host.
P40-P46	Port pins connected to the LCD card
P47	Free port pin
P01,P02,P04	Port pins connected to LED card used for current sensing feedback for accurate color control
P07	Free port pin
P21	Port pin connected to the yellow LED for BIU
P23	Port pin connected to the red LED for Rx
P25	Port pin connected to the green LED for Tx
P26	Free port pin
P17	Port pin connect to SCL for I2C
P15	Port pin connect to SDA for I2C
P16, P12	Free port pins
P30,P31,P32,P33,P34,P35	Port pins connected to LED card
P36,P37	Free port pins

Table 2-4. Headers and Jumpers

Headers and Jumpers	Description
P50,P51,P52,P53	Free port pins
SW	Header connected to the switch S4. S4 is a general purpose switch.
VR	Header connected to the potentiometer
J15	V - Vdd pin: This pin provideS a maximum of 50mA at 5V to an external board. This pin is only to source the current. DO NOT SUPPLY POWER TO THIS PIN FOR POWERING CY8CLED16P01 DEVICE. Please note that PWR jumper needs to be connected for enabling this functionality
	G - Gnd Pin: This pin can provide the ground reference to an external board. This pin connects to the ground pin of the external board.
	D - I2C Data (SDA): This is the data line for the I2C communication. This pin is directly connected to the CY8CLED16P01 device
	C - I2C Clock (SCL): This is the clock line for the I2C communication. This pin is directly connected to the CY8CLED16P01 device.
	R – Reset: Connecting the reset of an external board to this pin will enable the resetting of the CY8CLED16P01 chip via external board. This way, on resetting the external board, the CY8CLED16P01 device on CY3276 board will also get resetted. Please note that RES jumper needs to be connected for enabling this functionality.

2.3.4.3   Potentiometer and Dip Switches

There are 8-bit dip switches (S3). They are general purpose and are user programmable. A general purpose potentiometer (R46) is next to the dip switches. This potentiometer can be routed to the chip using the GPIO pins. The second potentiometer (R46) is specifically meant to control the contrast for the LCD daughter card in the LCD1 slot.

Figure 2-4. Potentiometer and Dip Switches
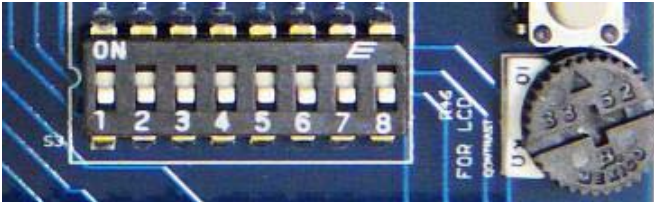
Table 2-5. Key Potentiometer and Dip Switch Components

Component	Description
S3[7-0]	These dip switches are general purpose and can be routed to any port of the CY8CLED16P01 chip.
Potentiometer [R47]	This is a variable resistor that connects to the VR header. It can be used to generate a voltage between +5V and GND.
LCD Contrast[R46]	Adjusting this potentiometer adjusts the contrast on the LCD Daughter Card.

2.3.5   Daughter Cards with the Board

There are two daughter cards provided with the kit.

■   LED Daughter Card

■   LCD Daughter Card

2.3.5.1   *LED Daughter Card*

This card has three LEDs along with its constant current drive circuits for each channel. It also has a built in temperature sensor, which can be used via I2C on P34 and P35. It requires an external 12V supply on the board when this card is attached.

Figure 2-5. LED Daughter Card
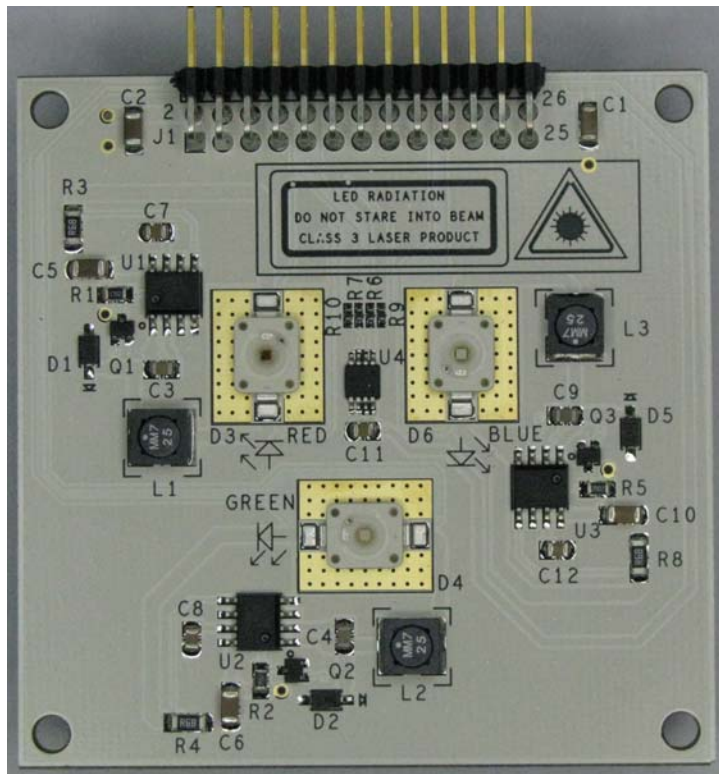
The reverse side of the daughter card is shown in .

Figure 2-6. Daughter Card Reverse Side
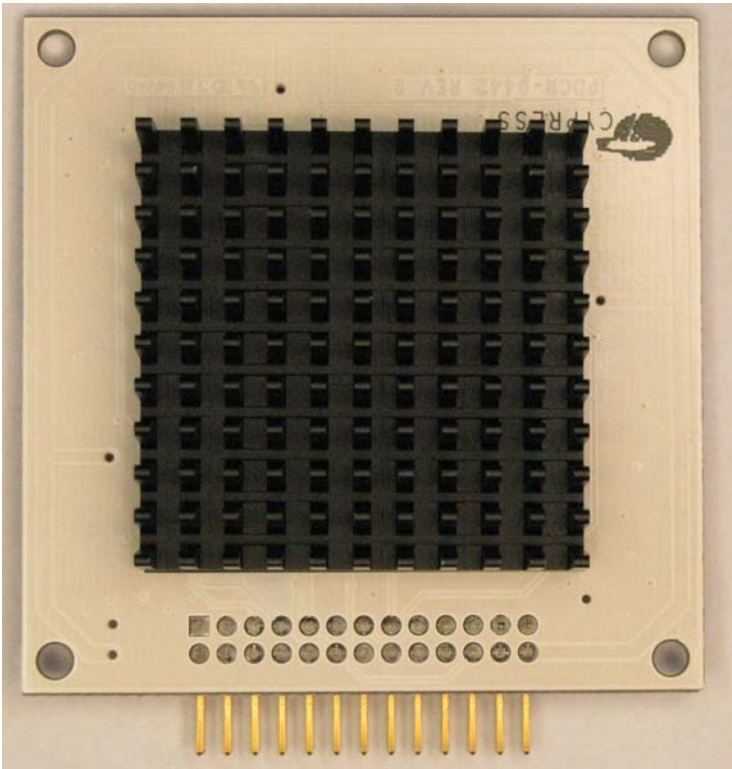
It is attached to the CY3276 board using the J23 header on the bottom side of the board. The J23 header is in Figure 2-8.

Figure 2-7. J23 header at the bottom of the board for connecting LED daughter card
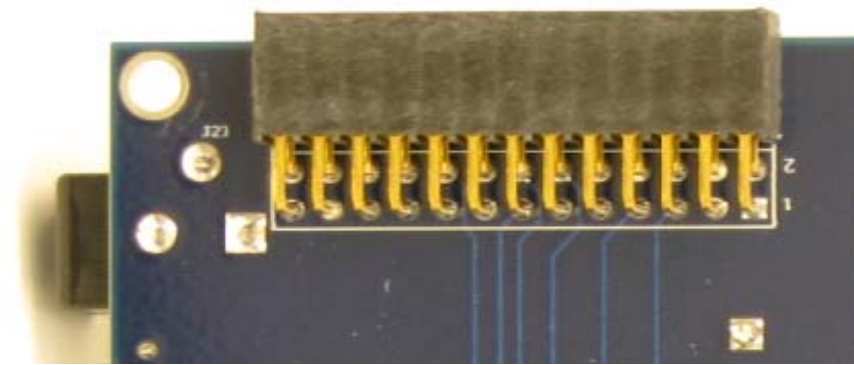
Figure 2-8. J22 Connector

Note Connect the LED daughter card so that the LEDs are facing down as shown in Figure 2-9 on page 17. The 12V power supply for powering the LED daughter card should be connected at J22 as shown in Figure 2-9.

Figure 2-9. LED Daughter Card Connection
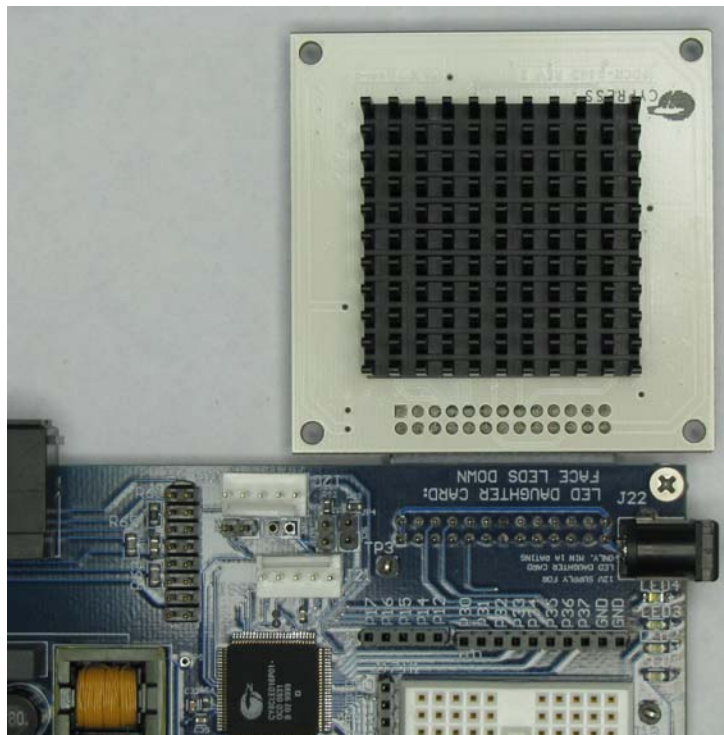
2.3.5.2   LCD Daughter Card

This card is an LCD module which can be connected to the board. It can be connected to header LCD1 and controlled by using the CY8CLED16P01 GPIOs .

Figure 2-10. LCD Daughter Card

The LCD daughter card is connected to the main board as shown in Figure 2-11.

Figure 2-11. LCD Daughter Card -Board Connection

2.3.6   RJ45 Connector for Debugging

The RJ45 ICE Cube Emulation Connector provides a debug interface between the CY8CLED16P01 -OCD device and the ICE Cube emulation tool using the PSoC Designer software application.

Figure 2-12. RJ45 Connector
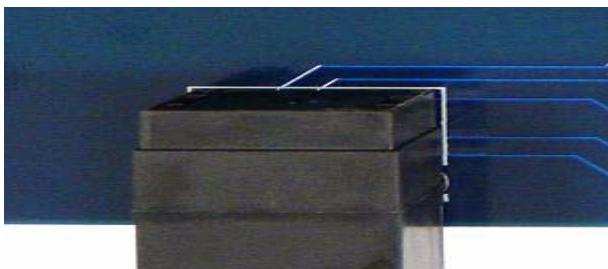
2.3.7   RS232 COM Port

The RS232 COM port can be used with a standard RS232 cable to connect two RS232 capable devices together. The RS232 header is a four pin header that has connections for RX, TX, RTS and CTS lines. These need to be wired to port pins to connect the CY8CLED16P01 device to the respective pins on the RS232 DB9 port.

Figure 2-13. RS232- COM
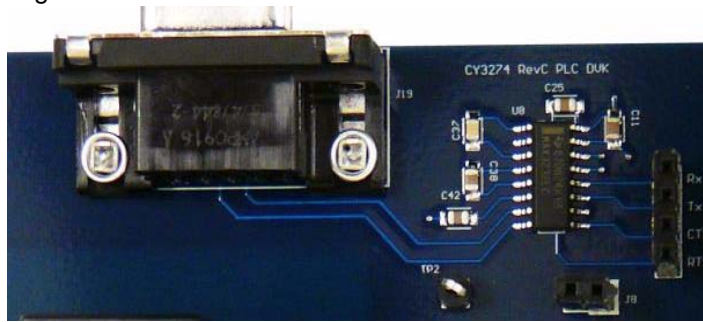
Controls associated with this port:

Table 3:

Control	Description
RX	The board receives the RS232 information through this pin.
TX	The board transmits the RS232 information through this pin.
RTS	The host asks the chip if it can send information through this pin.
CTS	The chip signals that it is ready to accept information through RX.

[+] Feedback

A.   Appendix

A.1   Schematics

A.1.1   Board Overview

A.1.2   User Interface
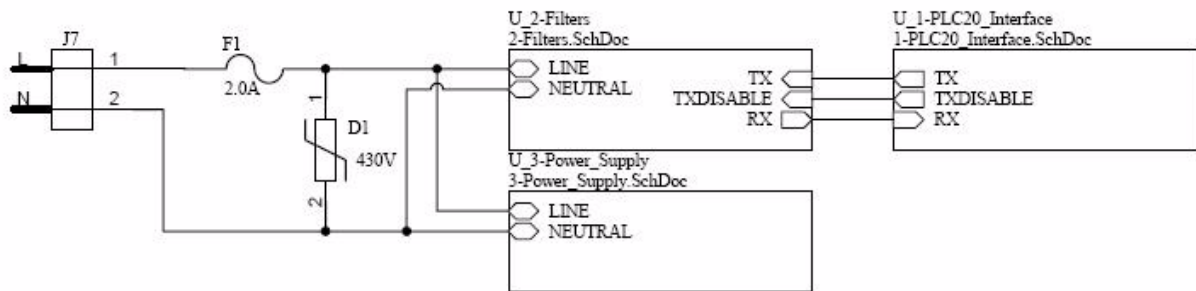
A.1.3　　　Transmit and Receive Filters

A.1.4 Power Supply
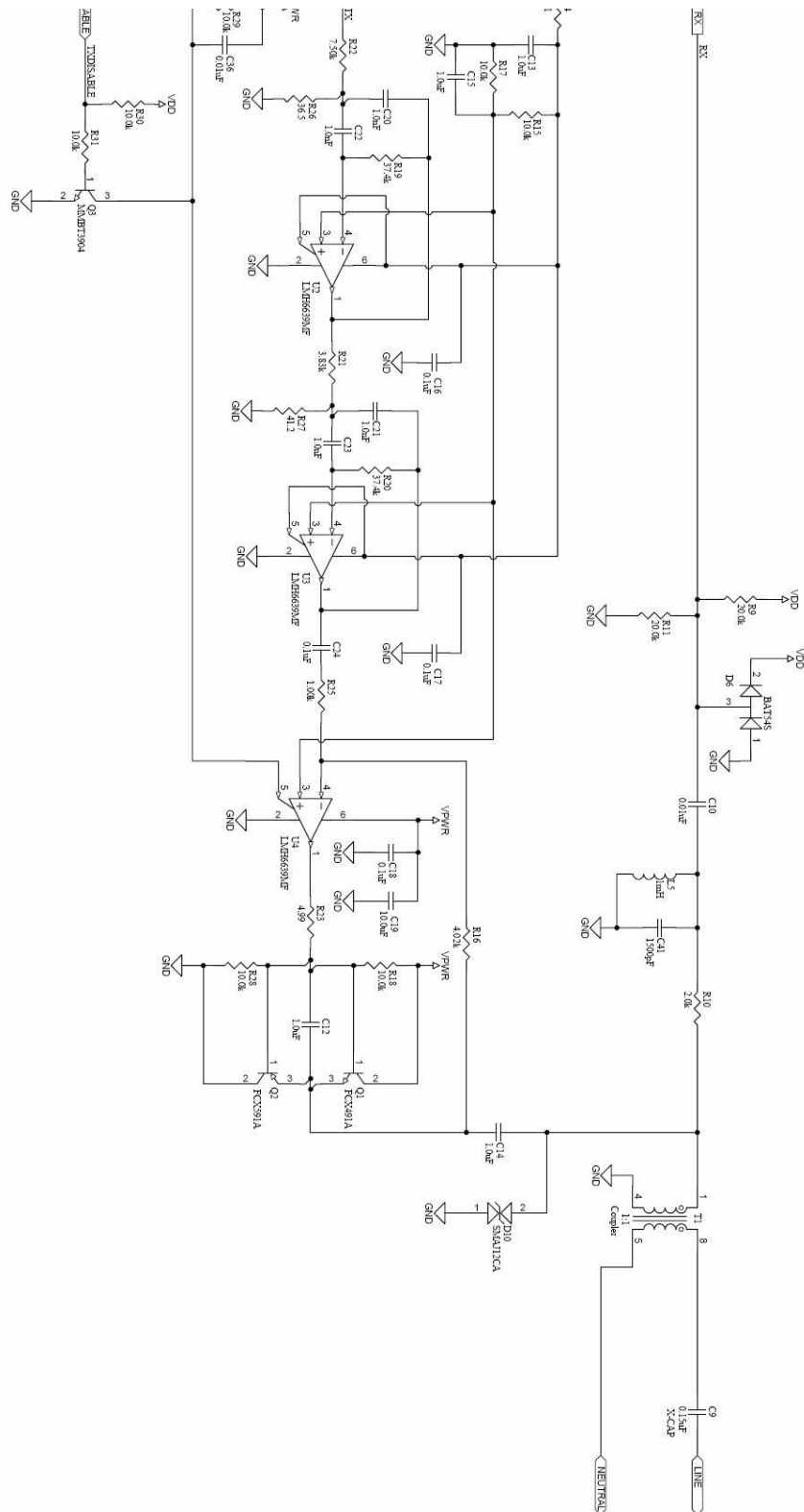
A.2 Layout

A.2.1 Top Layer
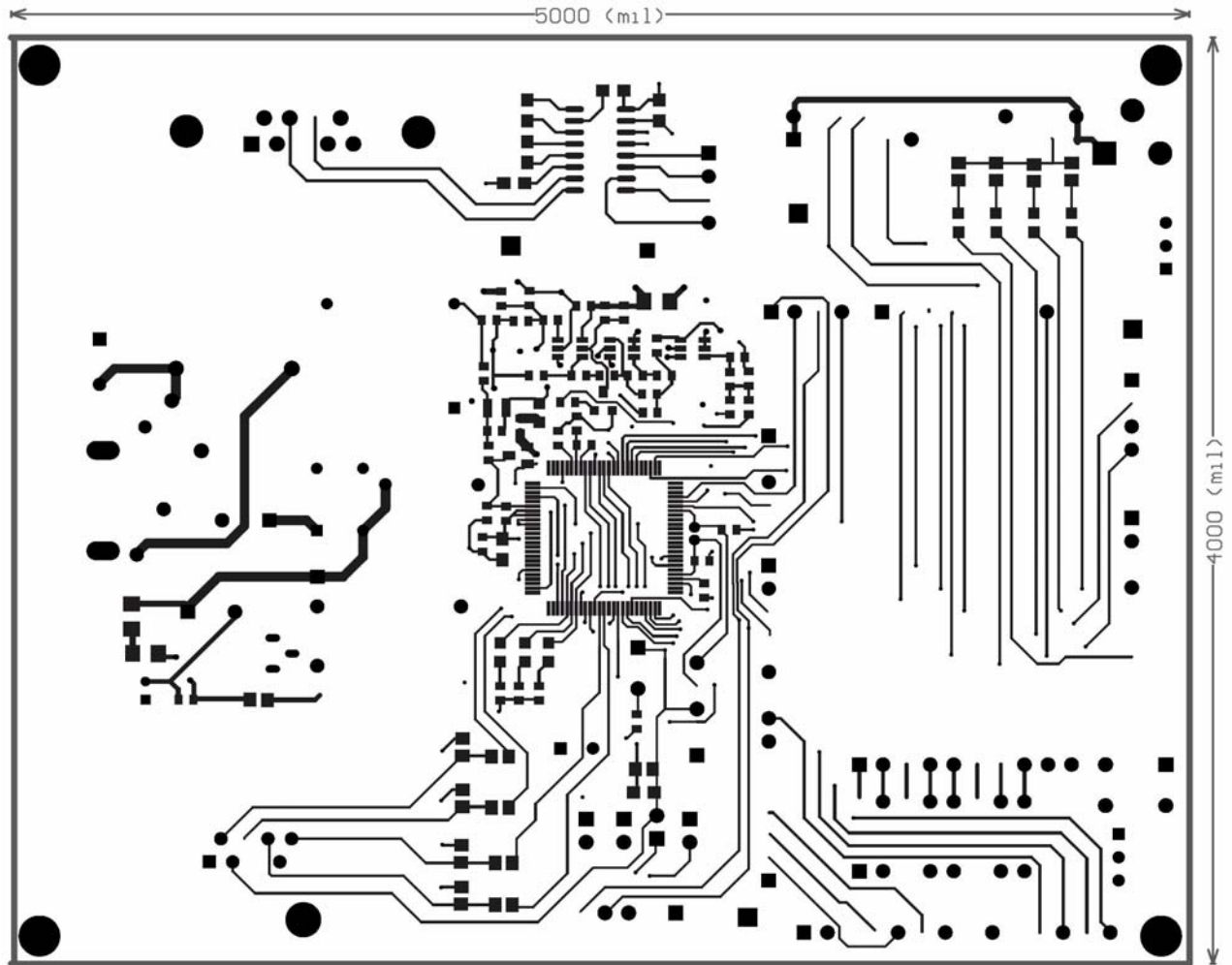
A.2.2 Ground Layer
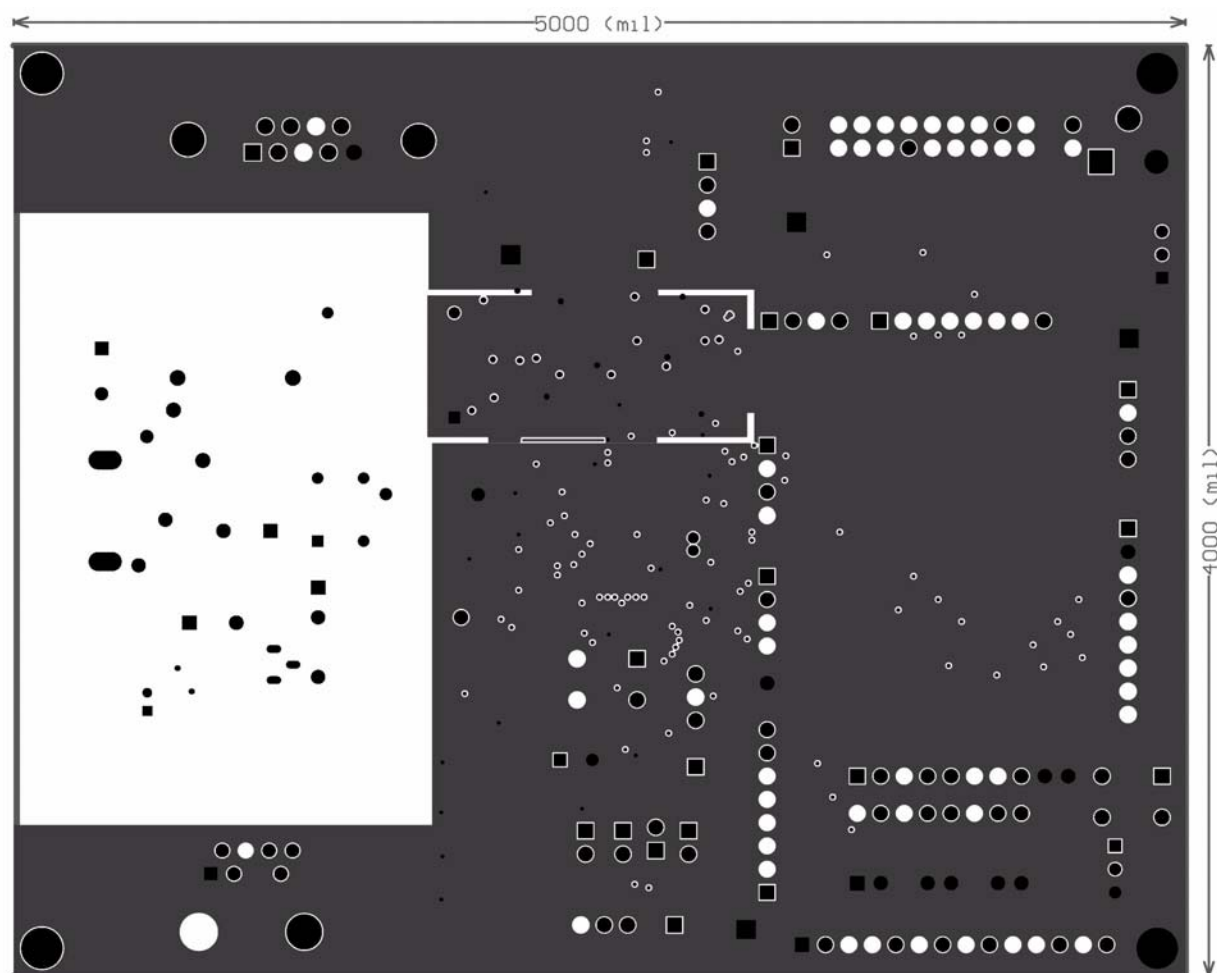
A.2.3　　Power Layer
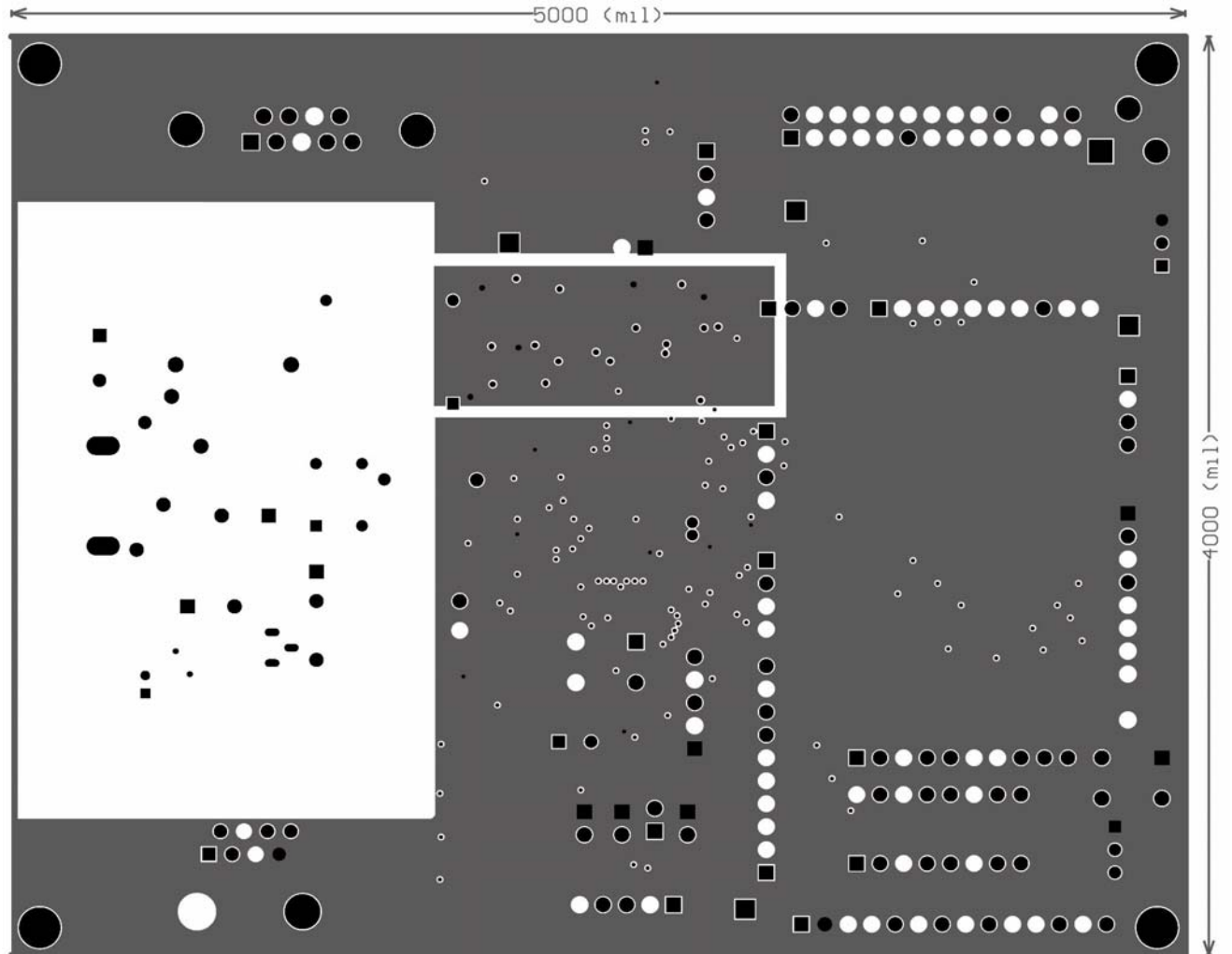
A.2.4   Bottom Layer

A.2.5　Top Silkscreen
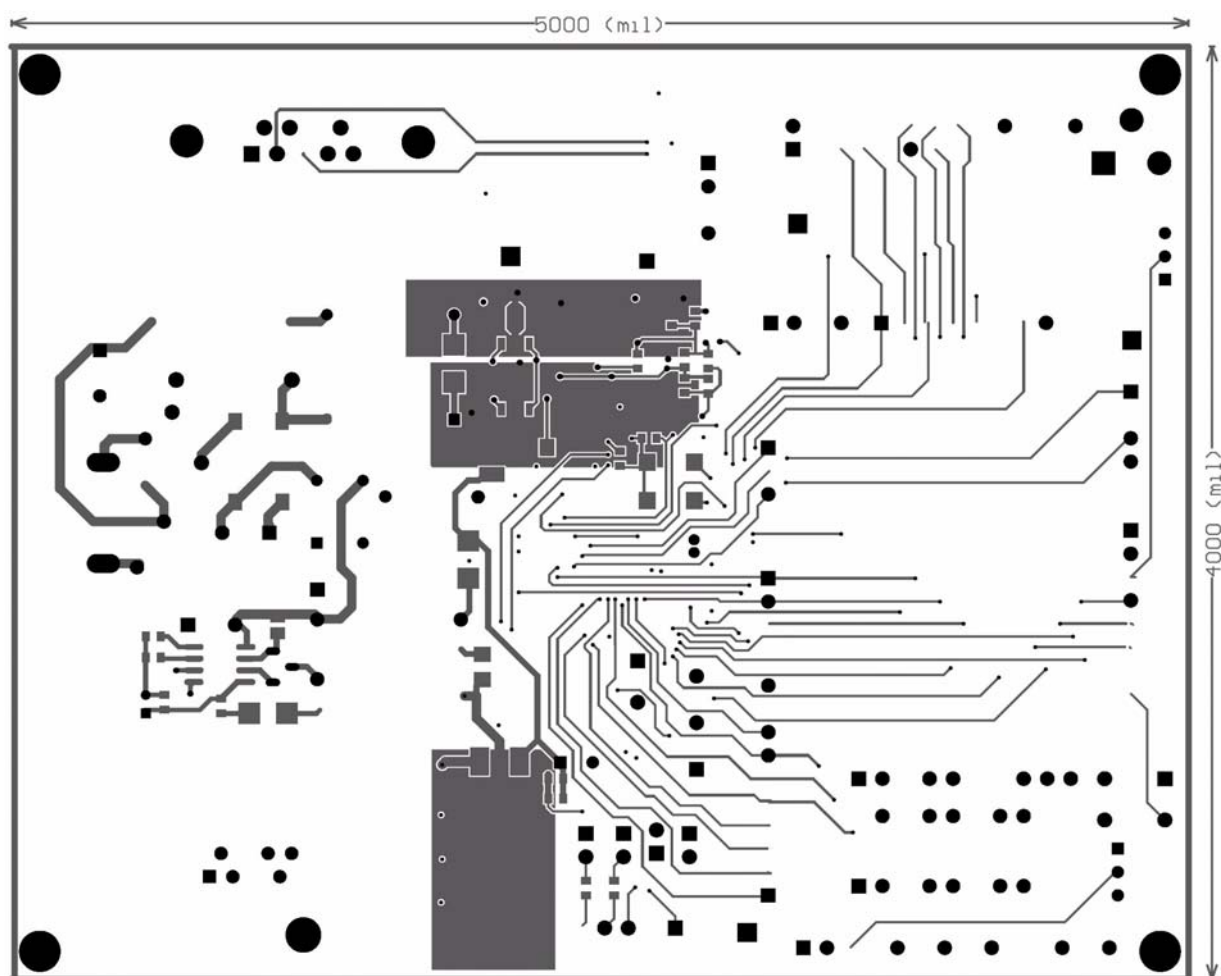
A.2.6   Bottom Silkscreen
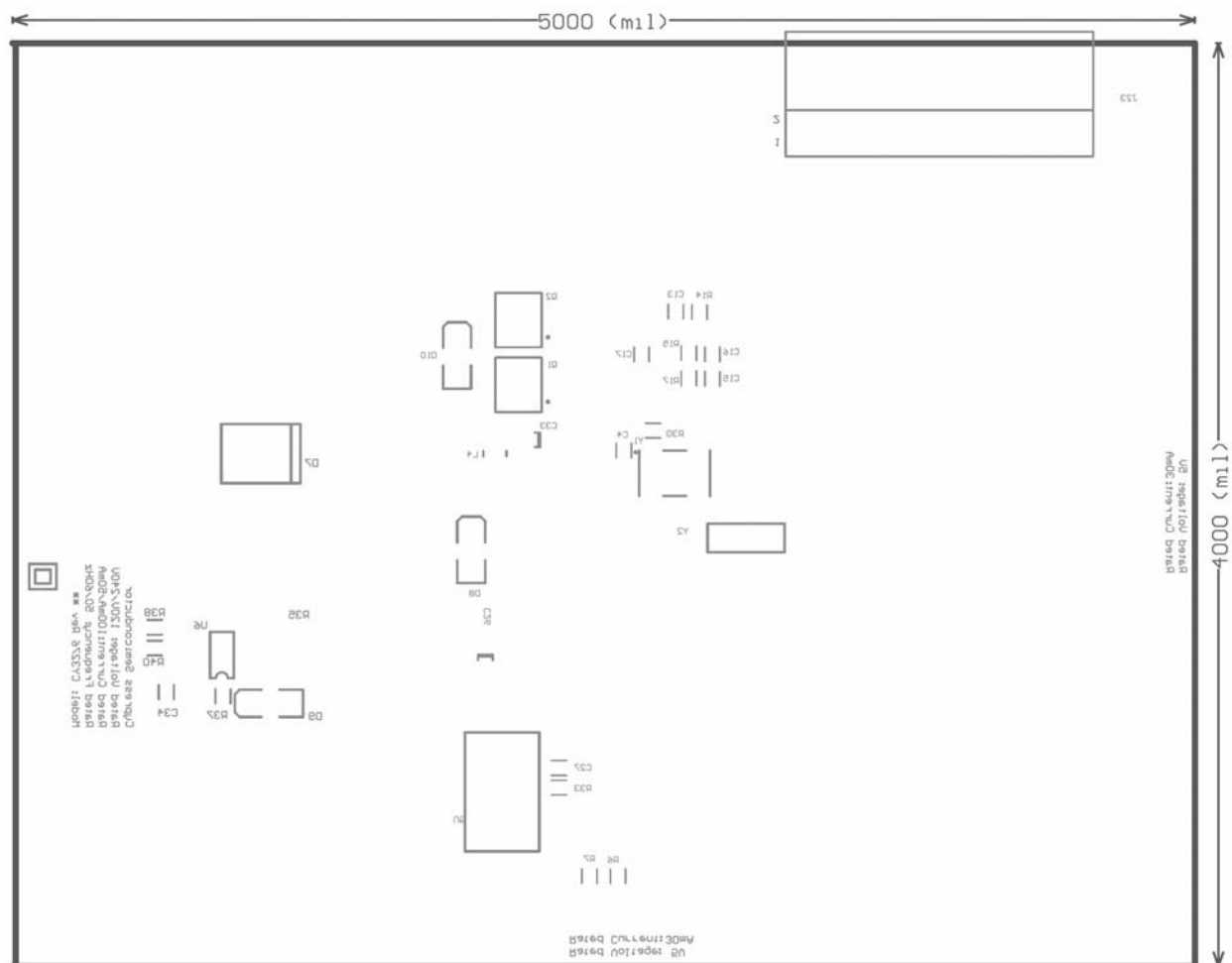
A.3 Bill of Materials

Description	Designator	Quantity	Value	Manufacturer	Manufacturer Part#	Digi-Key#
Capacitor 0.1uF	C1	1	0.1uF			PCC1864TR-ND
Capacitor Ceramic 1.0nF X7R 10% 25V C0603	C2	1	1.0nF	Murata	GRM033R71E102KA01D	490-3184-1-ND
Capacitor Ceramic 0.01uF 25V X7R 0603	C3, C4, C10, C36	4	0.01uF	AVX	06033C103JAT2A	06033C103JAT2A-ND
Capacitor Ceramic 0.1uF 25V X7R 0603	C5	1	0.1uF	AVX	06033C104JAT2A	478-3713-1-ND
Capacitor Ceramic 1.0uF 16V X7R 0603	C6, C12, C13, C14, C15	5	1.0uF, 1uF	Taiyo Yuden	EMK107B7105KA-T	587-1241-1-ND
Capacitor Ceramic 22pF 100V C0G 0603	C7, C8	2	22pF	Murata	GRM1885C2A220JA01D	490-1335-1-ND
CAP .15UF 300VAC INTER SUPP X1	C9	1	0.15uF	Murata	ECQ-U3A154MG	P11117-ND
Capacitor 1.0uF, 16V	C11	1	1.0uF, 16V			PCC1849TR-ND
CAP CERM 0.10UF 10% 16V X7R 0603	C16, C17, C18, C24, C27, C34	6	0.1uF	Panasonic	ECJ-1VB1C104K	PCC1762CT-ND
CAP CERM 10.0UF 10% 25V X5R 1206	C19, C26, C33	3	10.0uF	Taiyo Yuden	TMK316BJ106KL-T	587-1337-1-ND
Capacitor Ceramic 1000PF 1% 5V NP0 0603	C20, C21, C22, C23	4	1.0nF	AVX	06033A102FAT2A	06033A102FAT2A-ND
Capacitor 0.47uF, 16V	C25, C38, C42	3	0.47uF ,16V			PCC1847TR-ND
Capacitor Ceramic 470PF 250VAC X1Y1 RAD	C28	1	470pF	TDK	CD95-B2GA471KYNS	445-2407-ND
CAP .022UF 300VAC INTER SUPP X1	C29	1	0.022uF	Panasonic	ECQ-U3A223MG	P11112-ND
Capacitor Electrolytic 4.7uF, 400V	C30, C31	2	4.7uF, 400V	Nichicon	UVR2G4R7MPD	493-1229-ND
	C30, C31 (2nd Source, 105C rated)		4.7uF, 400V	United Chemi-Con	EKMG401ELL4R7MJ16S	565-1411-ND
Capacitor Electrolytic 330uF 16V 20%	C32	1	330uF, 16V	Nichicon	UPW1C331MPD	493-1784-ND

Description	Designator	Quantity	Value	Manufacturer	Manufacturer Part#	Digi-Key#
Capacitor Electrolytic 10uF 50V 20%	C35	1	10uF, 50V	Nichicon	UPW1H100MDD	493-1890-ND
Capacitor 0.1uF, 16V	C37	1	0.1uF, 16V			PCC1864TR-ND
Capacitor 100pF	C40	1	100pF			399-1121-2-ND
Capacitor Ceramic 1500pF 10% 50V X7R 0603	C41	1	1500pF	Yageo	CC0603KRX7R9BB152	311-1184-2-ND
Transorb Voltage Suppressor 430V 1250A ZNR	D1	1	430V	Panasonic	ERZ-V07D431	P7251-ND
Dual Schottky Diode	D6	1		ST Micro	BAT54SFILM	497-2522-1-ND
Full Wave Diode Bridge	D7	1		Fairchild	DF10S	DF10SCT-ND
Schottky Diode 100V 1A SMA	D8, D9	2		Diodes Inc	B1100-13-F	B1100-FDICT-ND
Transient Voltage Suppressor 400W 12V BIDIRECT SMA	D10	1		Micro Commercial Co	SMAJ12CA-TP	SMAJ12CA-TPMSCT-ND
LED Blue Clear 0603	DS1	1		Rohm	SML-E12BC7TT86	511-1589-1-ND
LED Red Clear 0805	DS2	1		Lite-On	LTST-C170KRKT	160-1415-1-ND
LED Green Clear 0805	DS3	1		Lite-On	LTST-C170KGKT	160-1414-1-ND
LED Yellow Clear 0805	DS4	1		Lite-On	LTST-C170KSKT	160-1416-1-ND
Fuse 2A Slow Blow 250VAC	F1	1	2.0A	Bel Fuse	RST 2	507-1179-ND
3M solderless breadboard super strip	H1	1		Parallax	700-00012	923273-ND
Header, 10-Pin	J1, J10, J12, J18	4	10			929850E-01-36-ND
AC Power Connector	J7	1		Schurter	4300.0097	
Header, 2-Pin, Female	J8	1	2	Generic Components		929850E-01-36-ND
Header, 4-Pin	J9, J13, J17, J20	4	4			929850E-01-36-ND
ICE Connection	J14	1		Tyco	5557785-1	A31457-ND
5-pin ISSP Header	J15, J21	2		Molex	22-23-2051	WM4203-ND
Header, 4-Pin	J16	1	4			929850E-01-36-ND
Female DB-9	J19	1	DB9-F			A23301-ND

Description	Designator	Quantity	Value	Manufacturer	Manufacturer Part#	Digi-Key#
Power connector	J22	1		CUI Inc	PJ-102A	CP-102A-ND
Right Angle 2X13 header 0.1" Spacing	J23	1			SSQ-113-02-G-D-RA	SAM1186-13-ND
Header, 2-Pin, Male	JP1, JP3, JP4, JP5	4	2	Generic Components		S1011E-36-ND
Inductor 1500uH 0.2A 5% Radial	L3	1	1.5mH	Taiyo Yuden	LHL08TB152J	LHL08TB152J-ND
Inductor 22uH 20% 1210	L4	1	22uH	Taiyo Yuden	CBC3225T220MR	587-1626-1-ND
Inductor 1mH 10% 1007	L5	1	1mH	Taiyo Yuden	CB2518T102K	587-2195-1-ND
14-Pin header, Female	LCD1	1	14	3M/ESD	929850-01-36-RA	929850E-01-36-ND
Red LED	LED1, LED2, LED3, LED4	4	Red	Lumex Opto	SML-LXT0805IW-TR	67-1552-2-ND
Mounting Holes	MTG1, MTG2, MTG3, MTG4	4				
Transistor NPN HV 40V 1A SOT-89	Q1	1		Zetex	FCX491ATA	FCX491ACT-ND
Transistor PNP HV 40V 1A SOT-89	Q2	1		Zetex	FCX591A	FCX591ACT-ND
Transistor NPN SOT-23	Q3	1		Fairchild	MMBT3904LT1	MMBT3904LT1INCT-ND
NPN Silicon Planar Medium Power High-Gain Transistor	Q4	1		TSC	TS13003HVCT	
	Q4 (2nd source)			ST Micro	STX616-AP	497-7625-1-ND
Resistor 1.00k 1% 1/10W 0603	R1, R3, R4, R25	4	1.00k	Yageo	RC0603FR-071KL	311-1.00KHRTR-ND
Resistor 2.1k 1% 1/10W 0603	R2	1	2.10k	Rohm	MCR03EZPFX2101	RHM2.10KHCT-ND
Resistor 402 1% 1/10W 0603	R5	1	402	Yageo	RC0603FR-07402RL	311-402HRTR-ND
Resistor 7.50k 1% 1/10W 0603	R6, R7, R22	3	7.50k	Yageo	RC0603FR-077K5L	311-7.50KHRTR-ND

Description	Designator	Quantity	Value	Manufacturer	Manufacturer Part#	Digi-Key#
Resistor 330 Ohm 1% 1/10W 0603	R8	1	330	Rohm	MCR03EZPFX3300	RHM330HCT-ND
Resistor 20.0k 1% 1/10W 0603	R9, R11	2	20.0k	Yageo	RC0603FR-0720KL	311-20.0KHRCT-ND
Resistor 2.0k 1% 1/10W 0603	R10	1	2.0k	Yageo	RC0603FR-072KL	311-2.00KHRCT-ND
Resistor 22.1 1% 1/10W 0603	R14	1	22.1	Yageo	RC0603FR-0722R1L	311-22.1HRCT-ND
Resistor 10.0k 1% 1/10W 0603	R15, R17, R18, R28, R29, R30, R31, R33	8	10.0k	Yageo	RC0603FR-0710KL	311-10.0KHRTR-ND
Resistor 4.02k 1% 1/10W 0603	R16	1	4.02k	Yageo	RC0603FR-074K02L	311-4.02KHRTR-ND
Resistor 37.4k 1% 1/10W 0603	R19, R20	2	37.4k	Yageo	RC0603FR-0737K4L	311-37.4KHRCT-ND
Resistor 3.83k 1% 1/10W 0603	R21	1	3.83k	Yageo	RC0603FR-073K83L	311-3.83KHRCT-ND
Resistor 4.99 1% 1/10W 0603	R23	1	4.99	Yageo	RC0603FR-074R99L	311-4.99HRCT-ND
Resistor 36.5 1% 1/10W 0603	R26	1	36.5	Yageo	RC0603FR-0736R5L	311-36.5HRCT-ND
Resistor 41.2 1% 1/10W 0603	R27	1	41.2	Yageo	RC0603FR-0741R2L	311-41.2HRCT-ND
750k 1% Resistor 1206	R32	1	750k, 1%	Yageo	RC1206FR-07750KL	311-750KFRCT-ND
820k 1% Resistor 1206	R34	1	820k, 1%	Yageo	RC1206FR-07820KL	311-820KFRCT-ND
3.9 Ohm 1% Resistor 0805	R35	1	3.9	Yageo	RC0805FR-073R9L	311-3.90CRCT-ND
RES 68.0K OHM 1/8W 1% 0805 SMD	R36	1	68k, 1%	Yageo	RC0805FR-0768KL	311-68.0KCRTR-ND
RES 1.00 OHM 1/10W 1% 0603 SMD	R37	1	1.0	Yageo	RC0603FR-071RL	311-1.00HRCT-ND
RES 100k OHM 1/10W 1% 0603 SMD	R38	1	100k	Yageo	RC0603FR-07100KL	311-100KHRTR-ND

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Description	Designator	Quantity	Value	Manufacturer	Manufacturer Part#	Digi-Key#
RES 12.0K OHM 1/10W 1% 0603 SMD	R39	1	12k, 1%	Yageo	RC0603FR-0712KL	311-12.0KHRCT-ND
6.8k, 1% Resistor 0603	R40	1	6.8k, 1%	Yageo	RC0603FR-076K8L	311-6.80KHRTR-ND
RESISTOR 10.0 OHM 5W 5% WIREWND	R41	1	10, 5W	Vishay	AC05000001009JAC00	PPC5W10.0CT-ND
Potentiometer	R46, R47	2		Bourns Inc	3352T-1-103LF	3352T-103LF-ND
Resistor 1.0K, SMT	R48, R49, R50, R51, R61, R62, R63, R64, R65	9	1K	Panasonic	ERJ-6GEYJ102V	P1.0KACT-ND
Resistor 56 Ohm, SMT	R57, R58, R59, R60	4	56			P56ACT-ND
Swtich, SPST	S2, S4	2		Omron	B3F-1022	SW403-ND
4009 Series DIP Switch, Raised actuator	S3	1		ESwitch	KAJ08LAGT	EG4441-ND
Isolation Transformer	T1	1		Precision Components	0505-0821G	
Power Trasnsformer EE-16	T2	1	3.2mH	Shenzen Goldenway	EE-16 (5+5) (rev-A)	
24mH Common Mode Choke	T3	1	24mH	Shenzen Goldenway	EE8.3(2+2)-hori, (rev-A)	
Simple Test point	TP1, TP2, TP3, TP4	4				5006K-ND
CY8CLED16P01 OCD Part	U1	1		Cypress	CY8CLED16P01-OCD	
Op-Amp 190MHz	U2, U3, U4	3		National Semiconductor	LMH6639MF/NOPB	LMH6639MFCT-ND
Voltage Regulator 5 Volt	U5	1		ST Micro	LD1117DT50CTR	497-1237-1-ND
Off-Line Switcher	U6	1		iWatt	iW1690-07	
RS-232 tranceiver (1.0uF Caps)	U8	1			MAX3232ECDR	296-19851-2-ND
Oscillator	Y1	1	24.00 MHz	Crystek	C3290-24.000	C3290-24.000-ND

Description	Designator	Quantity	Value	Manufacturer	Manufacturer Part#	Digi-Key#
	Y1 (2nd Source)			Citizen	CSX750FCC24.000M-UT	300-7214-2-ND
Crystal 32.768kHz 12.5pF	Y2	1	32.768 kHz	ECS Inc.	ECS-3X8X	X1123-ND
LCD Module	LCD1	1		Cypress Semiconductor	1187-00003	

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