Teridian Smart Grid Solutions

78M6613 Split-Phase Evaluation Board User Manual

December 2011
Rev. 2
UM_6613_069

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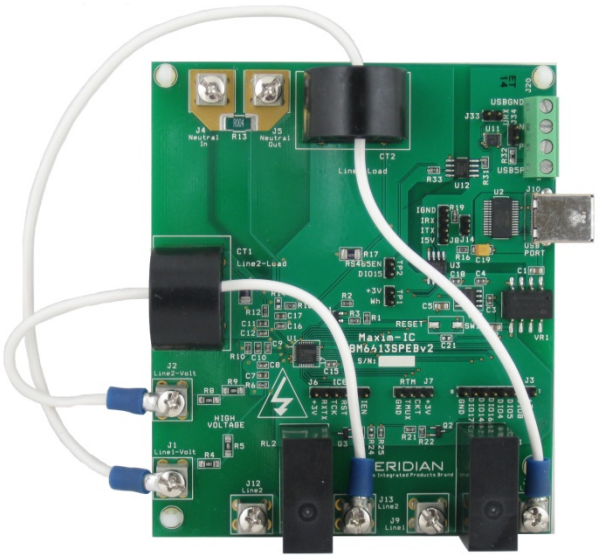
1 Introduction

The Teridian™ 78M6613 split-phase evaluation board is an electrical measurement unit for performing measurements of a high-power split-phase (or dual-phase) load. It incorporates the 78M6613 power and energy measurement IC loaded with firmware for high-power load monitoring. The board is connected to a PC through a USB cable. Optionally, the 78M6613 UART TX and RX signals can be accessed via a header for communicating with an external controller or wireless communications module.



The energy measurement data and status is read back over the serial interface. A Windows®-based graphical user interface (GUI) is provided for simplified access to the following measurement data and controls:

- Power, current, voltage, and power factor
- Line frequency and phase information
- Alarm indicators
- Programmable alarm thresholds and relay outputs

1.1 Package Contents

The 78M6613 split-phase evaluation board demo kit includes:

- 78M6613 split-phase evaluation board
- USB cable assembly USB A-B 28/24 1.8M (Tyco/Amp 1487588-3)
- GUI software and documentation

1.2 System Requirements

The 78M6613 split-phase evaluation board requires use of a PC with the following features:

- PC (1 GHz, 1 GB) with Microsoft Windows XP®, Windows Vista®, or Windows® 7 operating systems, equipped with USB port
- Minimum 1024 x 768 video display resolution

1.3 Safety and ESD Notes

EXERCISE CAUTION WHEN LIVE AC VOLTAGES ARE PRESENT!

Standard ESD precautions must be taken when handling electronic equipment. The 78M6613 contains ESD protected interfaces.

Do not connect test equipment, ICE emulators or external development boards directly to the 78M6613 split-phase hardware. Damage to the 78M6613 and external equipment will occur due to the 78M6613's "high side" reference topology. The 78M6613's V3P3 (i.e., "high side") is connected directly to Neutral (Earth Ground) creating a ground reference disparity with any properly grounded external equipment.

The board components and firmware settings are designed to operate with the following nominal AC electrical ranges:

Voltage	Current	Line Frequency
110-240 VAC	10 mA – 20A	46-64 Hz

1.4 Firmware Demo Code Introduction

The Firmware Demo Code provides the following features:

- Basic energy measurement data such as Watts, Volts, current, VAR, VA, phase angle, power factor, accumulated energy, frequency, date/time, and various alarm statuses.
- Control of alarm thresholds, calibration coefficients, temperature compensation, etc.
- Control of relay output pins

The 78M6613 split-phase evaluation board is shipped with demo code. The code revision can be verified via the 'info' command in the GUI application. Firmware for the evaluation board can be updated using either the Teridian TFP2 or an in-circuit emulator such as the Signum Systems ADM51 (www.signum.com/Signum.htm).

1.5 Testing the 78M6613 Split-Phase Evaluation Board Prior to Shipping

Before every 78M6613 split-phase evaluation board is shipped, the following procedures have been performed at the factory:

- Full Calibration – Precise energy source equipment is used to calibrate the current and voltage. The temperature is also calibrated at the same time.
- Accuracy Test – This "bench" level test ensures the energy accuracy is within ±0.5%.

2 Installation

The 78M6613 split-phase evaluation board is intended for use with a 3-wire single-phase distribution system. This 3-wire single-phase distribution system is typically sourced from a distribution transformer with a single-phase input (primary) winding. The distribution transformer's secondary winding has a center tap which is defined as Neutral. Line 1 and Line 2 exist on either side of Neutral exhibiting a 180° phase shift between them.

The 78M6613 is referenced to Neutral and measures both voltages present on Line1 and Line 2 with respect to Neutral. Additionally, load currents flowing in both Line 1 and Line 2 are measured. The following figure shows the 78M6613 split-phase evaluation board's measurement inputs with various load configurations.

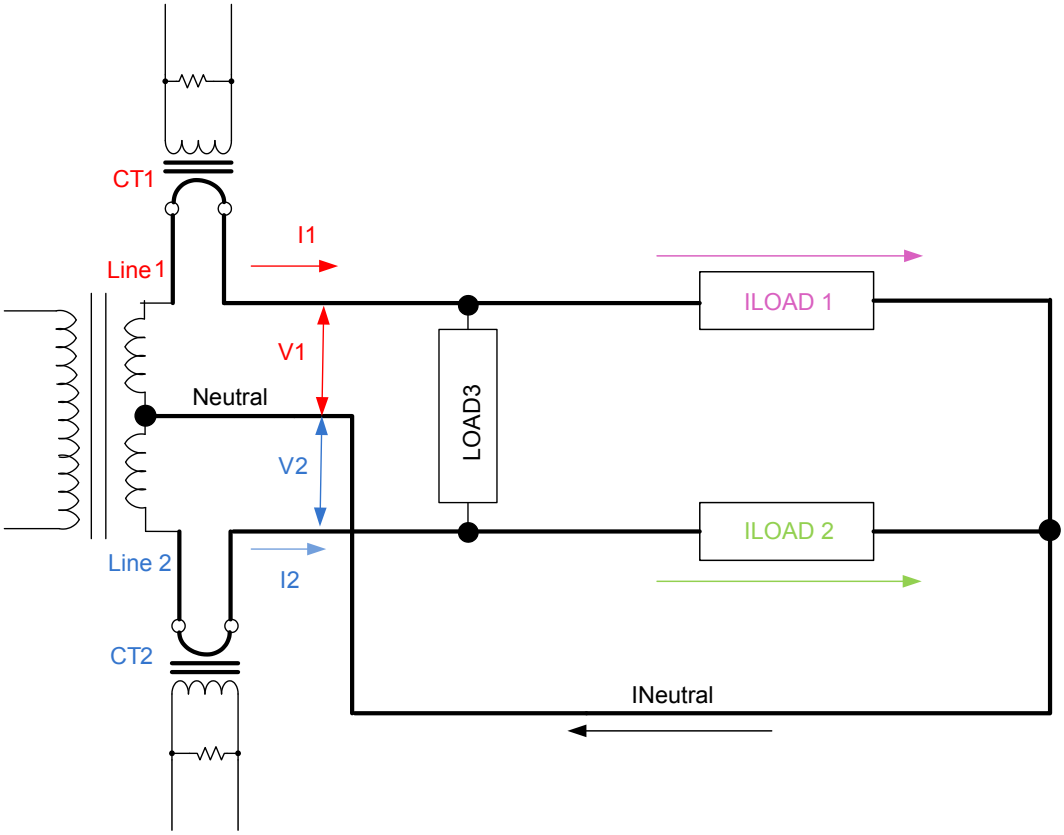


Figure 1: Split-Phase Energy Measurement Configuration

2.1 Basic Connection Setup

Figure 2 shows the basic connections of the 78M6613 split-phase evaluation board for use with external equipment. The 78M6613 split-phase evaluation board is powered from the USB cable. Additionally, the USB cable provides the communications link between the host PC and the 78M6613 split-phase evaluation board. The high voltage AC source and load wires connect to screw terminals mounted along the board edge.

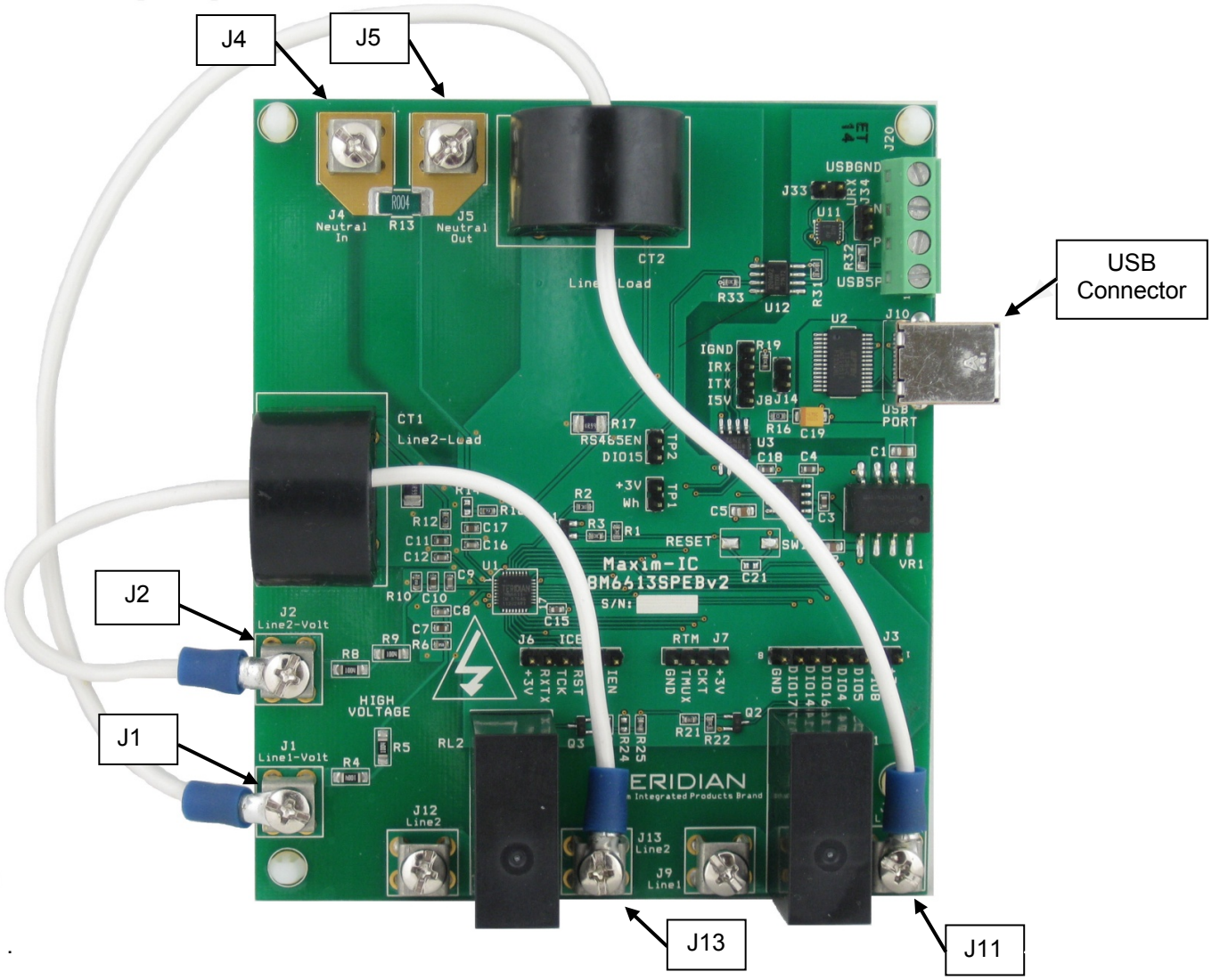


Figure 2: 78M6613 Split-Phase Evaluation Board Connections

Table 1 describes the wiring connections.

Table 1: High Voltage AC Connections

Connector	External Circuit
J4	Neutral – from Source
J5	Neutral – to load
J1	Line 1 – from Source
J2	Line 2 - from Source
J11	Line 1 – to Load
J13	Line 2 – to Load

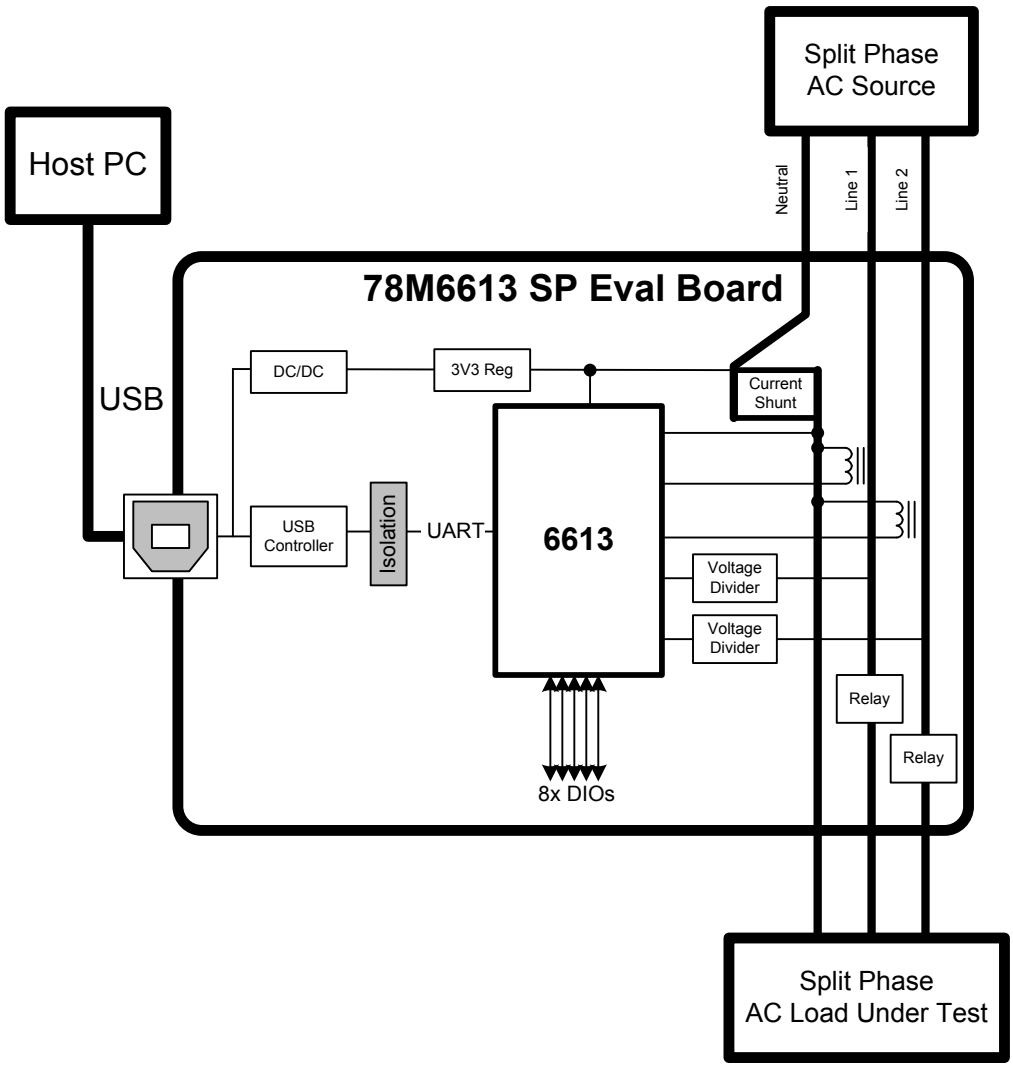


Figure 3: 78M6613 Split-Phase Evaluation Board Application Diagram

The 78M6613 split-phase evaluation board is preconfigured to measure the Load currents present on Line 1 and Line 2 using two current transformers (CT). Alternatively, the board has provisions to replace the Line 1 CT with a current sensing shunt in series with the Neutral wire. Two resistors (R14 and R18) provide the sensor selection. The following table provides the resistor population options for selecting the CT versus the shunt.

Table 2: Line 1 versus Neutral Current Sensing Configuration

Sensor Configuration	R14	R18
CT – Line 1	No Component	Install 750Ω
Shunt - Neutral	Install 750Ω	No Component

Presently the firmware only supports the CT–Line1 configuration.

2.2 Relay Configuration

The CLI command and the 78M6613 split-phase evaluation board support separate Line 1 and Line 2 relays. However, the default configuration of the evaluation board is such that DIO7 control both Line 1 and Line 2 relays so that control of power to both phases remain in sync. If individual relay operation is needed, remove R25 and install R24. This enables DIO19 to control Q3, which enables the Line 2 relay driver.

2.3 Optional UART Interface

The 78M6613 split-phase evaluation board provides an option to bypass the onboard serial USB controller. This option is useful for communicating with an external controller or attachment of a wireless module.

The optional UART interface is accessible via connector J8. Remove the jumper J14 to prevent TX contention with the onboard isolator's output, U3.

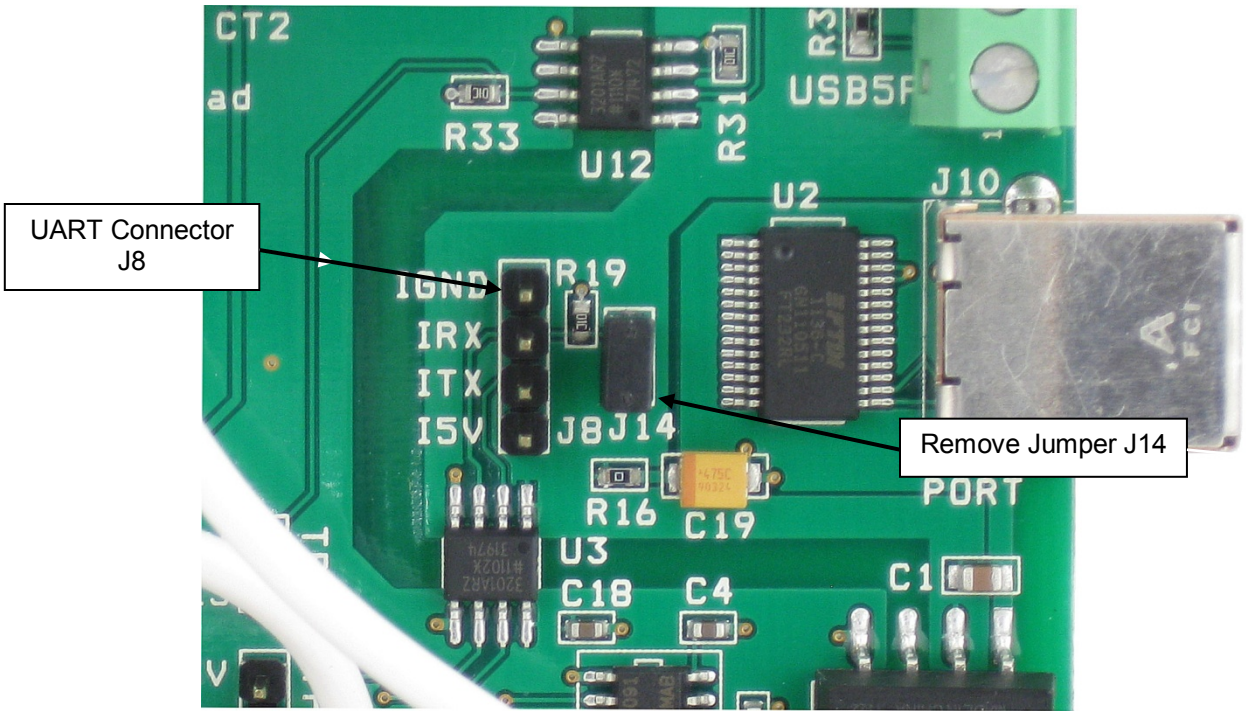


Figure 4: UART Connector

The following table provides the signal connections to the isolated UART connector J8.

Table 3: J8 UART Connector Pin Assignments

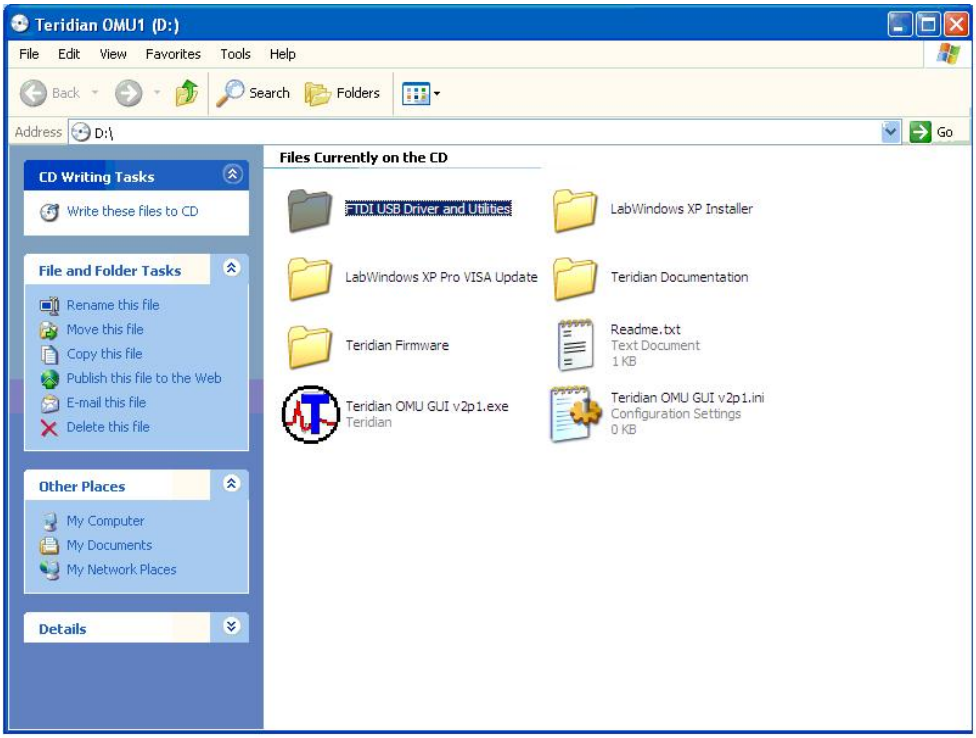
J8 Pin Number	Identifier	Function
1	I5V	External +5.0VDC
2	ITX	78M6613 TXD output
3	IRX	78M6613 RXD input
4	IGND	GND to daughter card

DC power is still provided from the USB cable when the J14 jumper is removed. Alternatively, an external +5VDC @ 100ma source can be attached to the I5V pin of J8. Remove R16 to not supply power to U2.

2.4 USB Driver Installation

This evaluation kit includes an isolated USB interface for serial communications with a PC. The FTDI USB controller IC FT232R performs the USB functions. The FTDI Windows driver presents a virtual COM port for enabling serial communications. Control of the 78M6613 split-phase evaluation board can be managed using either a terminal emulation program or using the supplied Windows GUI. The FTDI Windows driver is a certified driver for Windows 2000 and XP.

1. Upon attaching the 78M6613 split-phase evaluation board to the PC, the Found New Hardware Wizard automatically launches and installs the appropriate driver files. If your PC does not find the FTDI driver files on its local hard disk drive, locate and reference the FTDI USB Driver and Utilities subdirectory on the CD. The FT232R controller is powered from the USB cable and is active even when no power is applied to the 78M6613 split-phase evaluation board.

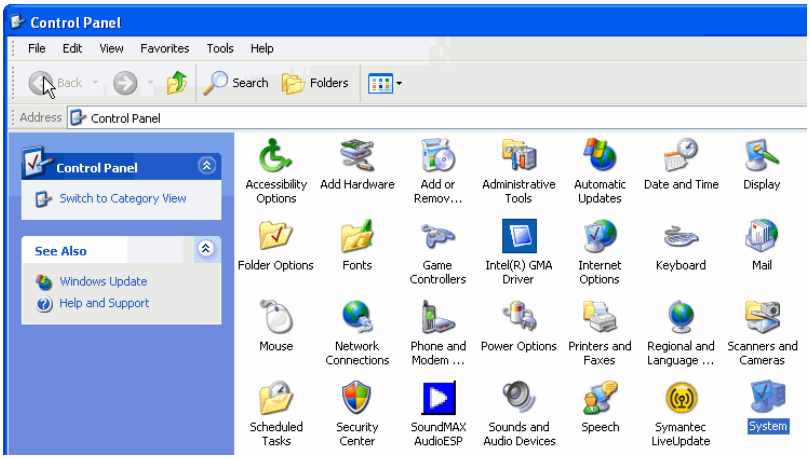


Notes: If an older FTDI driver has been previously installed, it is recommended to remove the older version before installing this newer FTDI driver. Execute the **ftdiClean.exe** utility from the FTDI USB Driver and Utilities subdirectory.

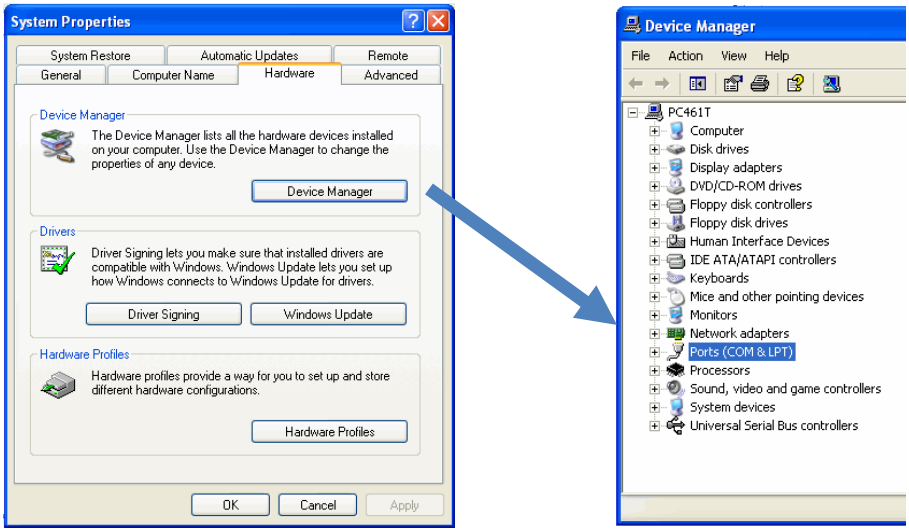
For FTDI driver support on other operating systems, please check FTDI's website at (http://www.ftdichip.com/FTDrivers.htm).

2.5 Confirm COM Port Mapping

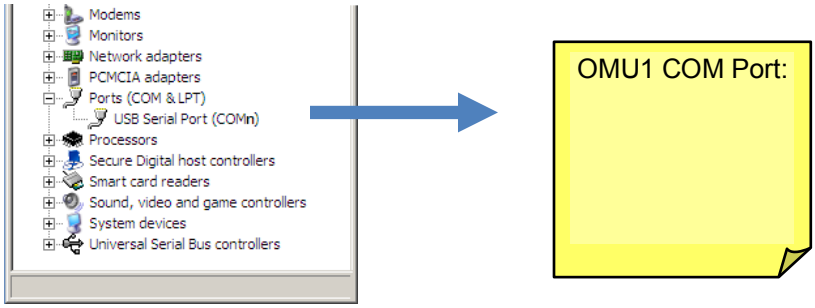
- Launch the ***Control Panel*** and click on the ***System*** icon.



- The **System Properties** screen appears. Click on the ***Hardware*** tab. Click on ***Device Manager***. Under **Ports (COM & LPT)**, look for the **USB Serial Port** assignment.



- Take note of the COM port assignment for the USB Serial Port.



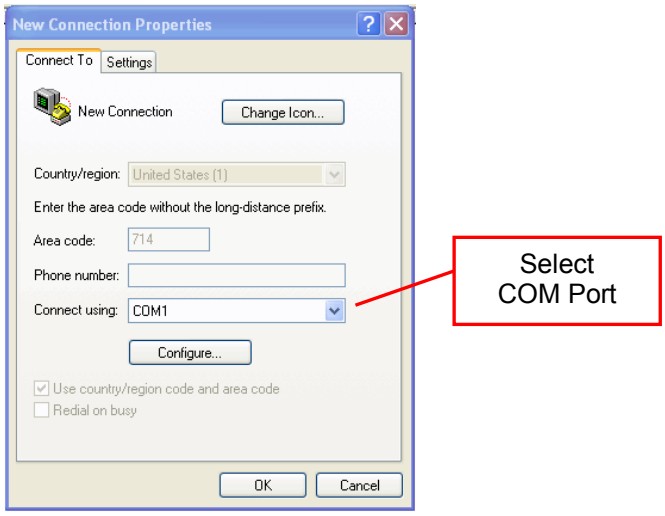
2.6 Verify Serial Connection to the PC

After connecting the USB cable from the 78M6613 split-phase evaluation board to the host PC, start the HyperTerminal application (or another suitable communication program) and create a session using the communication parameters show in Table 4.

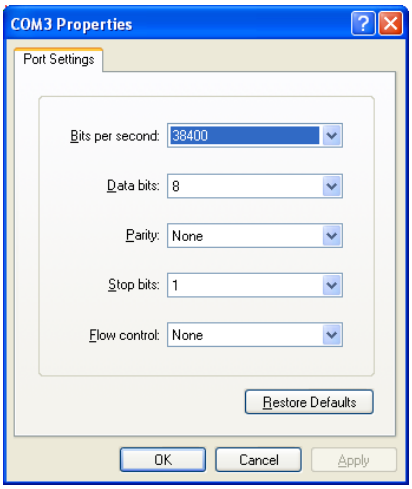
Table 4: COM Port Setup Parameters

Setup Parameter	78M6613
Port speed (baud)	38400
Data bits	8
Parity	None
Stop bits	1
Flow control	None

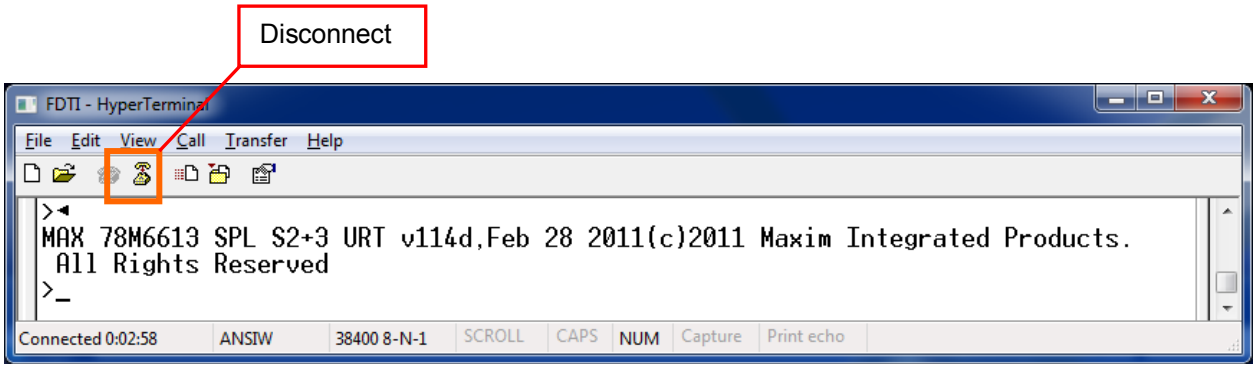
HyperTerminal can be found in Windows by selecting ***Start →All Programs →Accessories → Communications →HyperTerminal***. The connection parameters are configured by selecting ***File → Properties***. The **New Connection Properties** menu appears.



Select the appropriate ***COM port*** and click ***Configure***. The **COMn Properties** menu appears.



Note that port parameters can only be adjusted when the connection is not active. It may be necessary to click the ***Disconnect Button*** to disconnect the port.



FTDI COM Port Trouble-Shooting

If the FTDI device driver did not install properly, there would be no assigned COM port number for the FTDI controller. Repeat the USB Driver Installation, see Section 2.3.

Microsoft Windows may associate a Ball Point device to the FTDI USB controller. When this occurs a FTDI device COM port assignment is available via HyperTerminal but there is no communications data. Verify if a Ball Point device has been added to the "Human Interface Devices" via the Device manager. Refer to Section 2.4 for access to the Device Manager. If a Ball Point device exists, delete it and unplug and replug the evaluation board's USB cable.

For descriptions of the CLI commands, CE and MPU registers, status registers, and configuration registers, refer to the *78M6613 Split-Phase Firmware Description Document*.

3 Initialization and Calibration

The 78M6613 split-phase firmware includes a relay control routine that initializes the relays in the 'off' position. To globally turn on or off relays with the split-phase firmware, the following commands should be used.

```
>TC0 (turn on all relays)
>TC3 (turn off all relays)
```

The split-phase firmware also includes built in calibration routines. Using the precision source method, a known external voltage source, ambient temperature, and current source (load) is provided to the evaluation board during factory calibration. The routine automatically adjusts coefficients until measured values match known (target) values and saves them to flash memory. It is recommended the user read back and record these calibration coefficients. This will allow the user to re-store the calibration settings should the firmware for the evaluation board be updated in the future. There are four calibration coefficients: one for each voltage input and one for each current input. These four coefficients are read back using the ***]8????*** command.

```
>]8????
+11290 +11294 +16542 +16544
>_
```

4 Schematics, Bill of Materials and PCB Layouts

This section includes the schematics, bill of materials and PCB layouts for the 78M6613 split-phase evaluation board.

4.1 78M6613 Split-Phase Evaluation Board Schematics

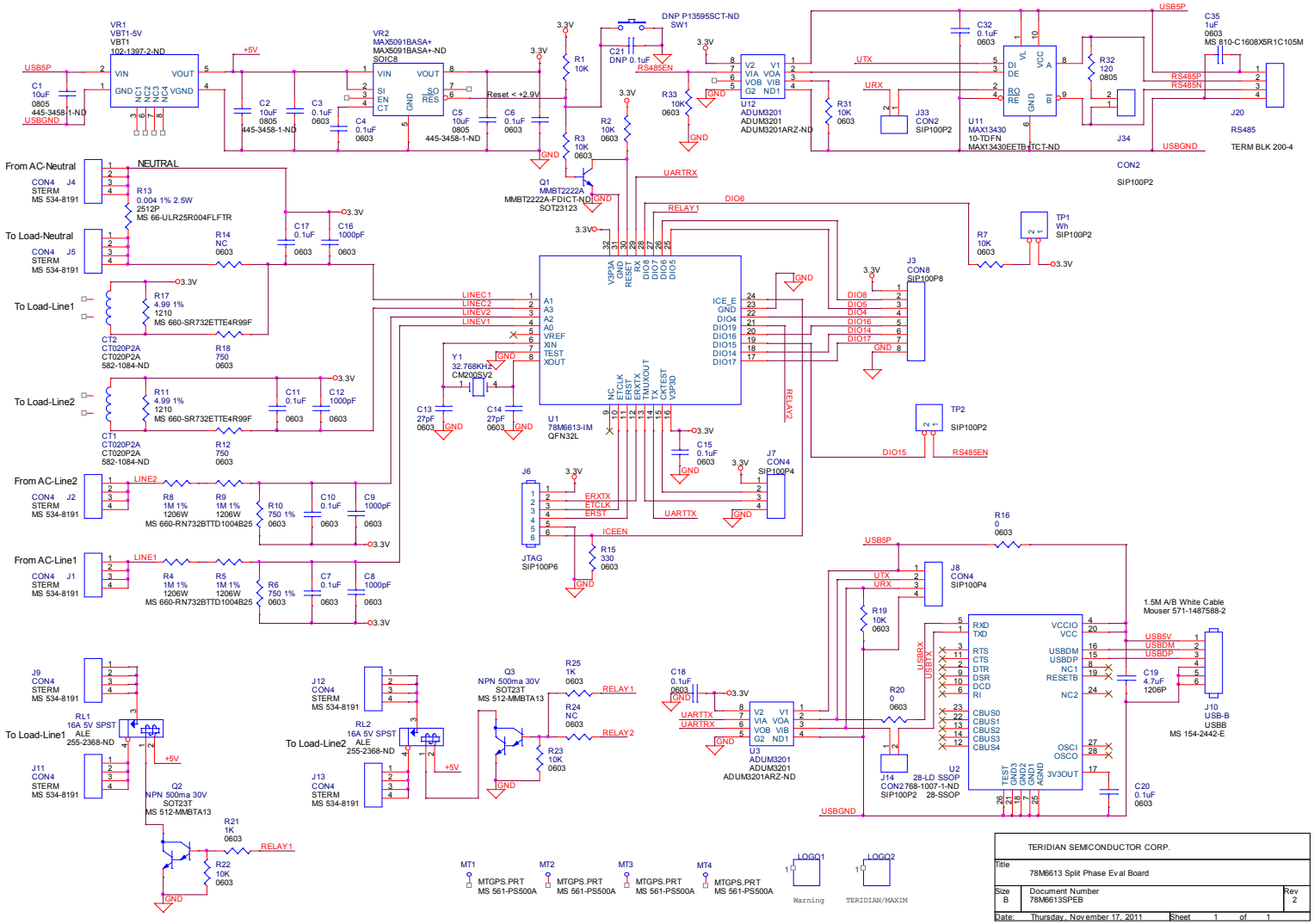


Figure 5: 78M6613 Split-Phase Evaluation Board Electrical Schematic

4.2 78M6613 Split-Phase Evaluation Board Bill of Materials

Item	Qty	Reference	Part	PCB Footprint	Digi-Key/Mouser	Part Number	RoHS	Manufacturer
1	2	CT1,CT2	CT020P2A	CT020P2A	582-1084-ND	CR8349-1000-N	NO	CR Magnetics
2	3	C1,C2,C5	10uF	0805	445-3458-1-ND	C2012Y5V1C106Z	YES	TDK
3	11	C3,C4,C6,C7,C10,C11,C15, C17,C18,C20, 32	0.1uF	0603	490-1519-1-ND	GRM188R71H104KA93D	YES	Murata Elect.
4	4	C8,C9,C12,C16	1000pF	0603	445-1298-1-ND	C1608X7R2A102K	YES	TDK
5	2	C13,C14	27pF	0603	311-1063-1-ND	CC0603JRNP09BN270	YES	Yageo
6	1	C19	4.7uF	1206P	478-2396-1-ND	TPSB475K016R1500	YES	AVX Corp
7	1	C21	DNP	0603				
8	1	C35	1uF	0603	587-1248-1-ND	TMK107BJ105KA-T	YES	Taiyo Yuden
9	8	J1,J2,J4,J5,J9,J11,J12,J13	CON4	STERM	MS 534-8191	8191	YES	Keystone
10	1	J3	CON9	SIP100P9	S1011E-36-ND	PBC36SAAN	YES	Sullins
11	1	J6	JTAG	SIP100P6	S1011E-36-ND	PBC36SAAN	YES	Sullins
12	2	J7,J8	CON4	SIP100P4	S1011E-36-ND	PBC36SAAN	YES	Sullins
13	1	J10	USB-B	USBB	MS 154-2442-E	154-2442-E	YES	Kobiconn
14	3	J14,J33,J34	CON2	SIP100P2	S1011E-36-ND	PBC36SAAN	YES	Sullins
15	1	J20	Terminal block	5.08 mm/4	277-1249-ND	1729144	YES	Phoenix Contact
16	4	MT1,MT2,MT3,MT4	TP	MTGPS.PRT	MS 561-PS500A	561-PS500A	YES	Eagle Plastic
17	1	Q1	MMBT2222A	SOT23123	MMBT2222A-FDICT-ND	MMBT2222A-7-F	YES	Diodes Inc
18	2	Q2,Q3	NPN 500ma 30V	SOT23T	MS 512-MMBTA13	MMBTA13	YES	Fairchild Semi.
19	2	RL1,RL2	16A 5V SPST	ALE	255-2368-ND	ALE1PB05	YES	Panasonic
20	9	R1,R2,R3,R7,R19,R22,R23, R31,R33	10K	0603	P10.0KHCT-ND	ERJ-3EKF1002V	YES	Panasonic
21	4	R4,R5,R8,R9	1M 1%	1206W	MS 660-RN732BTTD1004B25	RN732BTTD1004B25	YES	KOA Speer
22	2	R6,R10	750 1%	0603	P750YCT-ND	ERA-3YEB751V	YES	Panasonic
23	2	R11,R17	4.99 1%	1210	MS 660-SR732ETTE4R99F	SR732ETTE4R99F	YES	KOA Speer
24	2	R12,R18	750	0603	P750GCT-ND	ERJ-3GEYJ751V	YES	Panasonic

Item	Qty	Reference	Part	PCB Footprint	Digi-Key/Mouser	Part Number	RoHS	Manufacturer
25	1	R13	0.004 1% 2.5W	2512P	66-ULRG25R004FLFSLT	ULRG25R004FLFSLT	YES	IRC
26	2	R14,R24	DNP	0603				
27	1	R15	330	0603	P330HCT-ND	ERJ-3EKF3300V	YES	Panasonic
28	2	R16,R20	0	0603	P0.0GCT-ND	ERJ-3GEY0R00V	YES	Panasonic
29	2	R21,R25	1K	0603	P1.00KHCT-ND	ERJ-3EKF1001V	YES	Panasonic
30	1	R32	120	0603	P120HCT-ND	ERJ-3EKF1200V	YES	Panasonic
31	1	SW1	DNP	through hole	P13597SCT-ND	EVQ-PNF04M	YES	Panasonic
32	2	TP1,TP2	CON2	SIP100P2	S1011E-36-ND	PBC36SAAN	YES	Sullins
33	1	U1	78M6613-IM	QFN32L		78M6613-IM	YES	Maxim
34	1	U2	FTDI	28-SSOP	768-1007-1-ND	FT232RL-REEL	YES	FTDI
35	2	U3,U12	ADUM3201	ADUM3201	ADUM3201ARZ-ND	ADUM3201ARZ	YES	Analog Devices
36	1	U11	max13430	10-WFDFN	MAX13430EETB+TCT-ND	MAX13430EETB+T	YES	Maxim
37	1	VR1	VBT1-5V	VBT1	102-1397-2-ND	VBT1-S5-S5-SMT	YES	CUI Inc
38	1	VR2	MAX5091BASA+	SOIC8	MAX5091BASA+-ND	MAX5091BASA+	YES	Maxim
39	1	Y1	32.768KHz	CM200SV2	535-9166-1-ND	ABS25-32.768KHZ-T	YES	Abracon

4.3 78M6613 Split-Phase Evaluation Board PCB Layouts

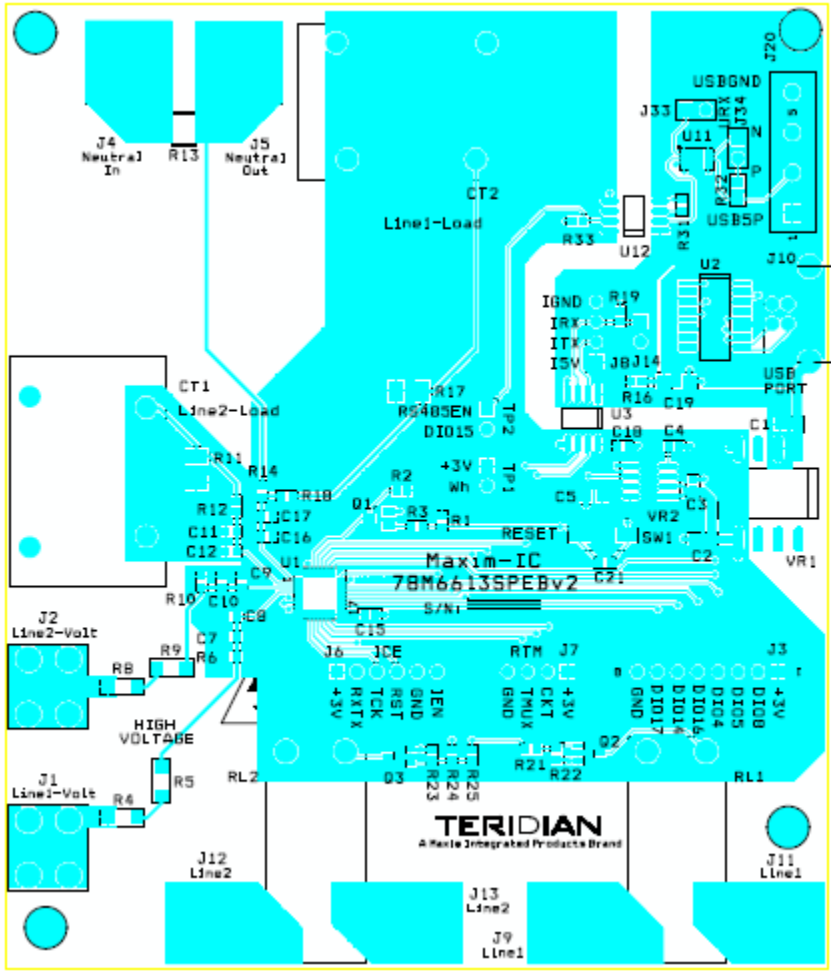


Figure 6: 78M6613 Split-Phase Evaluation Board PCB Top View

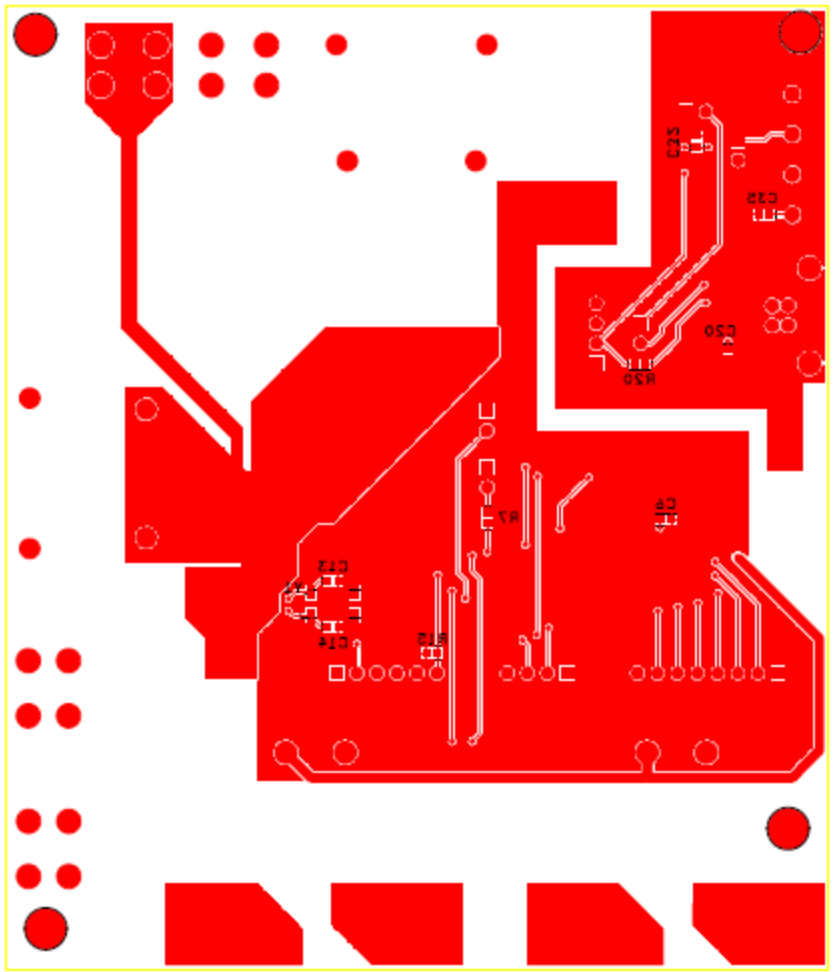


Figure 7: 78M6613 Split-Phase Evaluation Board PCB Bottom View

5 Ordering Information

Part Description	Order Number
78M6613 Split-Phase Evaluation Board	78M6613-SP-1

6 Included Documentation

The following 78M6613 documents are included on the CD:

78M6613 Data Sheet
78M6613 Split-Phase Evaluation Board User Manual
78M66xx GUI User Guide
78M6613 Split-Phase Firmware Description Document

7 Contact Information

For more information about Maxim products or to check the availability of the 78M6613, contact technical support at www.maxim-ic.com/support.

Revision History

Revision	Date	Description
1.0	6/11	First publication.
2	12/11	Update pictures for the Rev. 2. Board. In Section 1.4, updated the code revision information. In Section 2.6, changed the Flow Control to “None”. In Section 3, corrected the relay information. In Section 5, corrected the Order Number. Removed the Windows Graphical User Interface (GUI) section. See the *78M66xx GUI User Guide*.