User's Guide
SLUUAY8E–March 2014–Revised April 2018

# TPS23861EVM-612: Auto-Mode Evaluation Module for TPS23861

This user's guide describes the evaluation modules (EVM) for the TPS23861 (TPS23861EVM-612). The EVM contains evaluation and reference circuitry for the TPS23861. The TPS23861 is a Power-over-Ethernet (PoE) device for power sourcing equipment (PSE).

**Contents**



**List of Figures**

**List of Tables**



## Trademarks

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# 1 Description

The TPS23861EVM-612 features the quad port, TPS23861, IEEE 802.3at PoE PSE controller. The EVM consists of a motherboard (TPS23861EVM-612) and daughter board (TPS23861EVM-613) containing two TPS23861 devices. The TPS23861EVM-612 provides a multi-port base platform interface for TPS23861EVM-613, MSP-EXP430G2 (LaunchPad™), and USB-TO-GPIO (USB Interface Adapter).

## 1.1 Features

- TPS23861 PSE devices default to auto-mode operation so no operator interface over $I^2C$ is required.
- Four IEEE802.3at, Type 2 (30 W) ports with 1000BASE-T (gigabit Ethernet data pass through)
- Two non-standard, high power ports with 1000BASE-T (gigabit Ethernet data pass through)
- Fully certified using UNH-IOL Clause #33 PSE Conformance Test Suite
- Single DC power supply input
- On board 3.3-V regulator
- On board $I^2C$ interface to both TPS23861PW devices from either USB-TO-GPIO or MSP-EXP430G2.
- Port ON status LEDs
- User test points

## 1.2 Applications

- Ethernet switches and routers
- Surveillance VDRs
- High power PoE
- PoE pass-through systems

# 2 Quick Start

## 2.1 Input Power

### 2.1.1 Input Power (Labeled VPWR)

DC input voltage is provided through J1 (screw jack). A dc power supply or laptop adapter with sufficient current capacity can power the EVM.

**CAUTION**

Reverse voltage protection is not provided; ensure that the correct polarity is applied to J1.

This dc input is labeled *VPWR* in the schematics and is used for port VBUS as well as for the TPS23861 devices. The VPWR connections to the PoE ports are not fused. Each two pair port is capable of furnishing at least 30 W and each four pair port can furnish 60 W. The power supply requirements are summarized in Table 1.

The minimum PSE port voltage is 44 VDC for type 1 and 50 V for type 2. The nominal dc voltage at VPWR is 48 VDC for a type 1 and 54 VDC for a type 2. During evaluation, choose the appropriate dc power supply for the type 1 or type 2 environment.

### 2.1.2 Local 3.3 V (Labeled 3.3V)

Local 3.3 V for local devices (labeled as 3.3V) is provided by the on-board LM5019 buck converter. The LM5019 provides a basic power-on sequence and provides a well-controlled and consistent startup in order to prevent erratic operation. This is described in detail in SLVA723. In addition to 48 V, the TPS23861 requires 3.3 V for the digital circuitry and this is routed up to TPS23861EVM-613 over the connector interface. The current consumption is 25-mA typical and 30-mA maximum.

### 2.1.3 External 3.3 V (Labeled 3.3V_USB)

The TPS23861EVM-612 provides galvanic isolation between PoE power side and host side using digital isolators (ISO7241CD). The host side power is provided either from J2 (from USB-TO-GPIO) or J5 (from LaunchPad). The current consumption is 3-mA typical and 5-mA maximum.

**CAUTION**

Do not use USB-TO-GPIO and LaunchPad simultaneously.

**Table 1. TPS23861EVM-612 Voltage Rail Current Requirements**

| Voltage Rail | Typical (mA) | Maximum (mA) |
|---|---|---|
| 3.3V_USB | 2.5 | 3 |
| 3.3V | 25 | 30 |
| VPWR (Miscellaneous) | 35 | 57 |
| VPWR (8x Type 1 Output Ports) | 2992 | 3142 |
| VPWR (8x Type 2 Output Ports) | 5160 | 5418 |
| VPWR Total (8x Type 1 Ports) | 3027 | 3202 |
| VPWR Total (8x Type 2 Ports) | 5195 | 5478 |

## 2.2 PoE Port Interfaces

The TPS23861 devices are pre-configured to operate in auto mode and, as such, no external communication interface is required to enable or configure the TPS23861EVM-612. A standard PD can be plugged into ports 1–4 and be expected to operate automatically.

### 2.2.1 Standard 30 W, IEEE802.3at Type 2 ports

Four standard ports are provided at J19, J20, J8, and J7 for two pair ports 1, 2, 3, and 4 respectively. The power furnished is according to alternative A with MDI-X polarity.

### 2.2.2 Nonstandard 60-W Ports

Two non-standard ports are provided at J21 and J9 for four pair ports 1 and 2, respectively. The power furnished is according to alternative A with MDI-X polarity and alternative B on a single port connector. A standard PD may not power on at this interface, but a PD which can process power on all of the Ethernet conductors (refer to TI application report, SLVA625) can power on and consume up to 60 W.

## 2.3 I²C Interfaces

Two I²C interfaces to the TPS23861 are provided on the EVM.

### 2.3.1 USB-TO-GPIO

J2 provides an interface with the USB-TO-GPIO adapter when using a PC and GUI.

### 2.3.2 MSP-EXP430G2

J3, J4, and J5 provide an interface with the MSP-EXP430G2 or LaunchPad when using a PC to develop custom power management code.

## 2.4 Basic Test Setup (Out-of-the-box Auto-Mode Operation)

Figure 1 shows the basic test setup for the TPS23861EVM. All that is required is a dc power supply (44–57 VDC, 5 A), Ethernet patch cable, and any PD load.

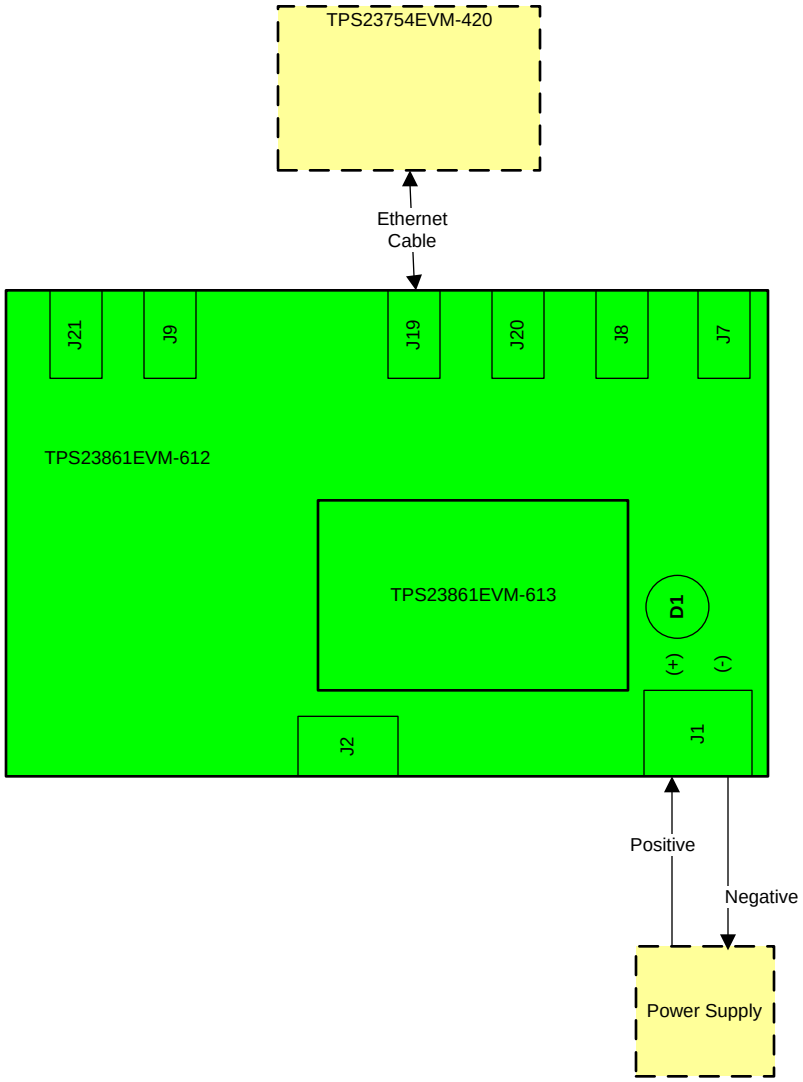


**Figure 1. Basic Test Setup**

## 2.5 Basic Test Setup Using USB-TO-GPIO for I²C Interface (Auto-Mode Operation with I²C Monitoring)

An I²C interface is provided through J2 to the TPS23861PW devices on the TPS23861EVM-613. The USB-TO-GPIO adapter (not included) can be used with any TI GUI which uses USB-TO-GPIO to read and write over an I²C bus. Figure 2 illustrates the basic setup using USB-TO-GPIO.

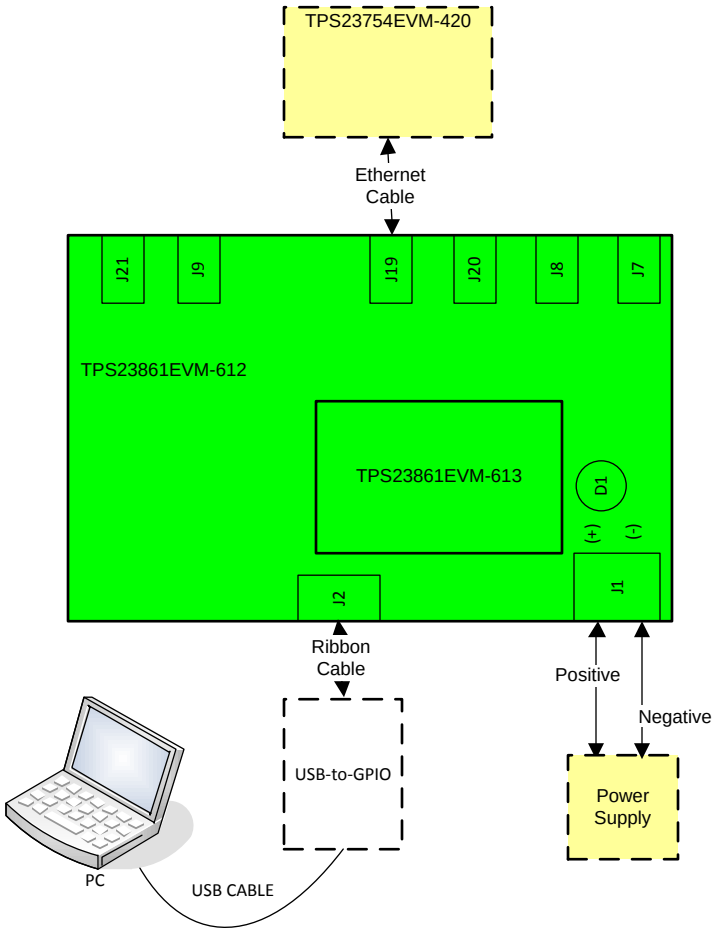


**Figure 2. Basic Setup Using USB-TO-GPIO**

## 2.6 Advanced Test Setup Using MSP-EX430G2 (LaunchPad)

The LaunchPad (not included) running a custom software program can communicate with the TPS23861PW devices on the TPS23861EVM-613. Figure 3 shows the advanced setup using LaunchPad.

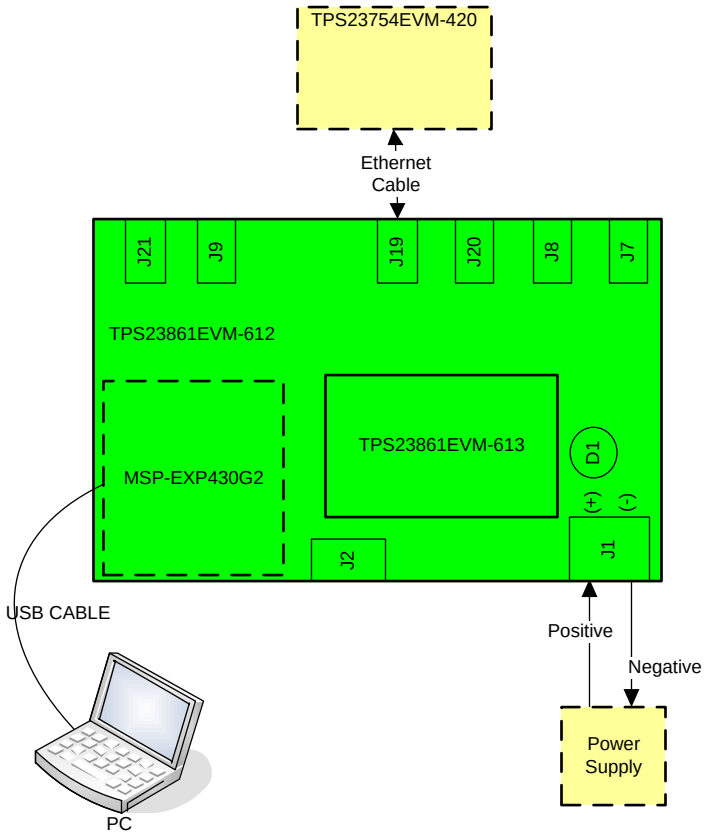


**Figure 3. Advanced Setup Using LaunchPad**

# 3 General Use Features

## 3.1 EVM Input/Output Connectors and Switches

Table 2 lists the EVM input and output connectors.

**Table 2. EVM Input/Output Connectors**

| Connector/Switch | Label | Description |
|---|---|---|
| J1 | J1 | DC power supply screw jack. (44–57 VDC, 5 A). Use a 48 VDC (nominal) for type 1 and 54 VDC (nominal) for type 2 PSE operation. |
| J2 | J2 | Ribbon cable connection to USB-TO-GPIO adapter |
| J3 | J3 | LaunchPad Control (mates with LaunchPad J1) |
| J4 | J4 | LaunchPad $I^2C$ (mates with LaunchPad J2) |
| J5 | J5 | LaunchPad Power (mates with LaunchPad J6) |
| J6 | J6 | TPS23861EVM-613 Control (mates with TPS23861EVM-613 J3) |
| J17 | J17 | TPS23861EVM-613 Port 5-8 (mates with TPS23861EVM-613 J2) |
| J18 | J18 | TPS23861EVM-613 Port 1-4 (mates with TPS23861EVM-613 J1) |
| J22 | J22 | Two-pair port 1 data only |
| J19 | 2 Pair Port 1 | Two-pair port 1 power and data |
| J23 | J23 | Two-pair port 2 data only |
| J20 | 2 Pair Port 2 | Two-pair port 2 power and data |
| J11 | J11 | Two-pair port 3 data only |
| J8 | 2 Pair Port 3 | Two-pair port 3 power and data |
| J10 | J10 | Two-pair port 4 data only |
| J7 | 2 Pair Port 4 | Two-pair port 4 power and data |
| J24 | J24 | Four-pair port 1 data only |
| J21 | 4 Pair Port 1 | Four -pair port 1 power and data |
| J12 | J12 | Four -pair port 2 data only |
| J9 | 4 Pair Port 2 | Four -pair port 2 power and data |
| J29 | J29 | Chassis ground tie point |

## 3.2 EVM LEDs

Table 3 lists the EVM LEDs and their descriptions.

**Table 3. EVM LEDs**

| LED | Color | Label | Description |
|---|---|---|---|
| D1 | GREEN | 48V | 48-V ON indicator |
| D16 | BLUE | D16 | Two-pair port 1 power is ON. For J19 supplier #1 (see the bill of materials (BOM)), J19 internal port LED is active. For supplier #2, D16 is active. |
| D17 | BLUE | D17 | Two-pair port 2 power is ON. For J20 supplier #1 (see the BOM), J20 internal port LED is active. For supplier #2, D17 is active. |
| D13 | BLUE | D13 | Two-pair port 3 power is ON. For J8 supplier #1 (see the BOM), J8 internal port LED is active. For supplier #2, D13 is active. |
| D12 | BLUE | D12 | Two-pair port 4 power is ON. For J7 supplier #1 (see the BOM), J7 internal port LED is active. For supplier #2, D12 is active. |
| D18 | BLUE | D18 | Four-pair port 1A power is ON. For J21 supplier #1 (see the BOM), J21 internal port LED is active. For supplier #2, D18 is active. |
| D14 | BLUE | D14 | Four-pair port 2A power is ON. For J9 supplier #1 (see the BOM), J9 internal port LED is active. For supplier #2, D14 is active. |

## 3.3 EVM Test Points

Table 4 lists and describes the EVM test points.

**Table 4. EVM Test Points**

| TP | Color | Label | Description |
|---|---|---|---|
| Motherboard: TPS23861EVM-612 | | | |
| TP1 | RED | VPWR | Used for VPWR |
| TP2 | RED | 3.3V | Used for TPS23861 VDD |
| TP3 | SMT | GND | VPWR ground |
| TP4 | WHT | SDA | $I^2C$ Data from LaunchPad and USB-TO-GPIO |
| TP5 | WHT | SCL | $I^2C$ Clock from LaunchPad and USB-TO-GPIO |
| TP6 | WHT | PSE_SDAO | $I^2C$ data out from TPS23861 |
| TP7 | WHT | PSE_SCL | $I^2C$ clock to TPS23861 |
| TP8 | WHT | PSE_SDAI | $I^2C$ data in to TPS23861 |
| TP9 | BLK | GND1 | Ground from LaunchPad and USB-TO-GPIO |
| TP11 | SMT | TP11 | Chassis ground test point |
| TP14 | SMT | GND | VPWR ground test point |
| TP15 | SMT | GND | VPWR ground test point |
| TP16 | SMT | GND | VPWR ground test point |
| Daughterboard: TPS23861EVM-613 | | | |
| TP4 | RED | 2P4D | Two-pair port 4 DRAIN |
| TP12 | WHT | 2P4G | Two-pair port 4 GATE |
| TP5 | WHT | 4P1AG | Four-pair port 1A GATE |
| TP6 | RED | 4P1AD | Four-pair port 1A DRAIN |
| TP9 | WHT | 4P1BG | Four-pair port 1B GATE |
| TP10 | RED | 4P1BD | Four-pair port 1B DRAIN |
| TP1 | BLK | GND | VPWR ground |
| TP8 | SMT | GND | VPWR ground |

## 3.4 EVM Test Jumpers

The EVM is equipped with shunts on the jumper positions identified in Table 5, in the Default Pin Position column. Shunts can be moved and removed, as required, during use.

**Table 5. EVM Jumpers(1)**

| Jumper | Default Pin Position | Label | Description |
|---|---|---|---|
| J27 | 1-2 | P1 | Two-pair port 1 LED bias |
| J28 | 1-2 | P2 | Two-pair port 2 LED bias |
| J16 | 1-2 | P3 | Two-pair port 3 LED bias |
| J15 | 1-2 | P4 | Two-pair port 4 LED bias |
| J26 | 1-2 | P5 | Four-pair port 1A LED bias |
| J25 | 1-2 | P6 | Four-pair port 1B LED bias |
| J14 | 1-2 | P7 | Four-pair port 2A LED bias |
| J13 | 1-2 | P8 | Four-pair port 2B LED bias |

(1) Remove the jumpers listed in this table when doing SIFOS or UNH DC MPS testing.

# 4 TPS23861EVM-612 PI Commander GUI Setup

## 4.1 TPS23861EVM-612 GUI Installation

The Texas Instruments PI Commander graphical user interface (GUI) can be used with TPS23861EVM-612 to provide real time feedback on port telemetry. PI Commander (*PI Commander - TPS23861-setup.exe*) can be downloaded from the TPS23861 product page in the Software section.

Follow the onscreen instructions to complete the installation. PI Commander uses the USB-TO-GPIO as an interface between the PC USB port and TPS23861EVM-612 J2 connector (I2C interface). Before starting PI Commander, make sure the USB-TO-GPIO is properly connected to TPS23861EVM-612 as shown in Figure 2.

## 4.2 TPS23861EVM-612 GUI Operation

Start Texas Instruments PI Commander - TPS23861 by clicking START → All Programs → Texas Instruments → PI-Commander-n.n.n-n, then PI-Commander-PoE. A command window opens as the program starts and scans for devices (note that the *Scanning for devices ….* message displays in the window footer until the scan is complete). Once the scan is complete, click on the *UNKNOWN 30* device (Figure 4).


**Figure 4. PI Commander Device Menu Window**

TPS23861 shows up in the *Device Selector* window. Click the **OK** button.

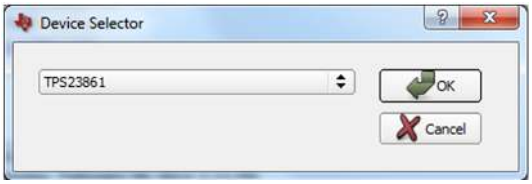


**Figure 5. PI Commander Device Selection Window**

As the program GUI starts, the window in Figure 6 appears showing the devices found in the scan. Device #1 (two-pair ports 1-4) is at address 20 and device #2 (four-pair ports 1 and 2) is at address 28. Click the **OK** button.


**Figure 6. Devices Found in Scan**

Choose device #1 (UNKNOWN 20) or device #2 (UNKNOWN 28).

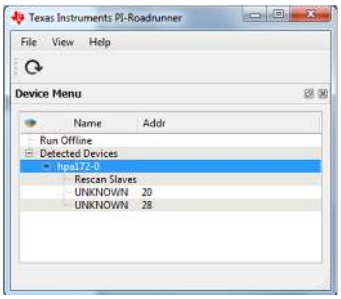


**Figure 7. Detected Devices Selection**

Once the following window pops up, click the **OK** button.


**Figure 8. Device Selector Approval**

PI Commander launches and starts the Telemetry Page as shown in Figure 9 for device #1. Note that more than one device window can be opened at the same time by choosing another device from the device menu.

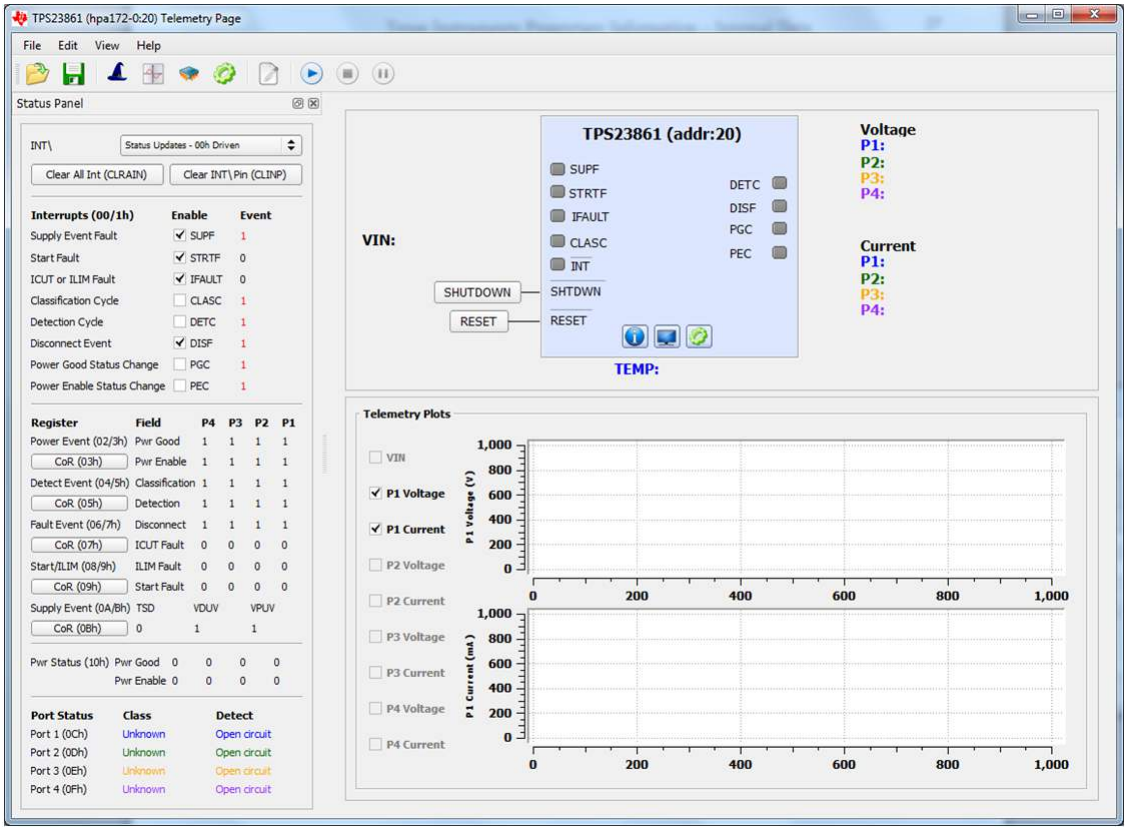


**Figure 9. Telemetry Page**

At any time, insert the ethernet cable connected to the PD load device into the two-pair port jacks. For the case in Figure 10, type two PDs are installed into ports 1, 2, 3, and 4 respectively and are successfully detected, classified, and powered up.

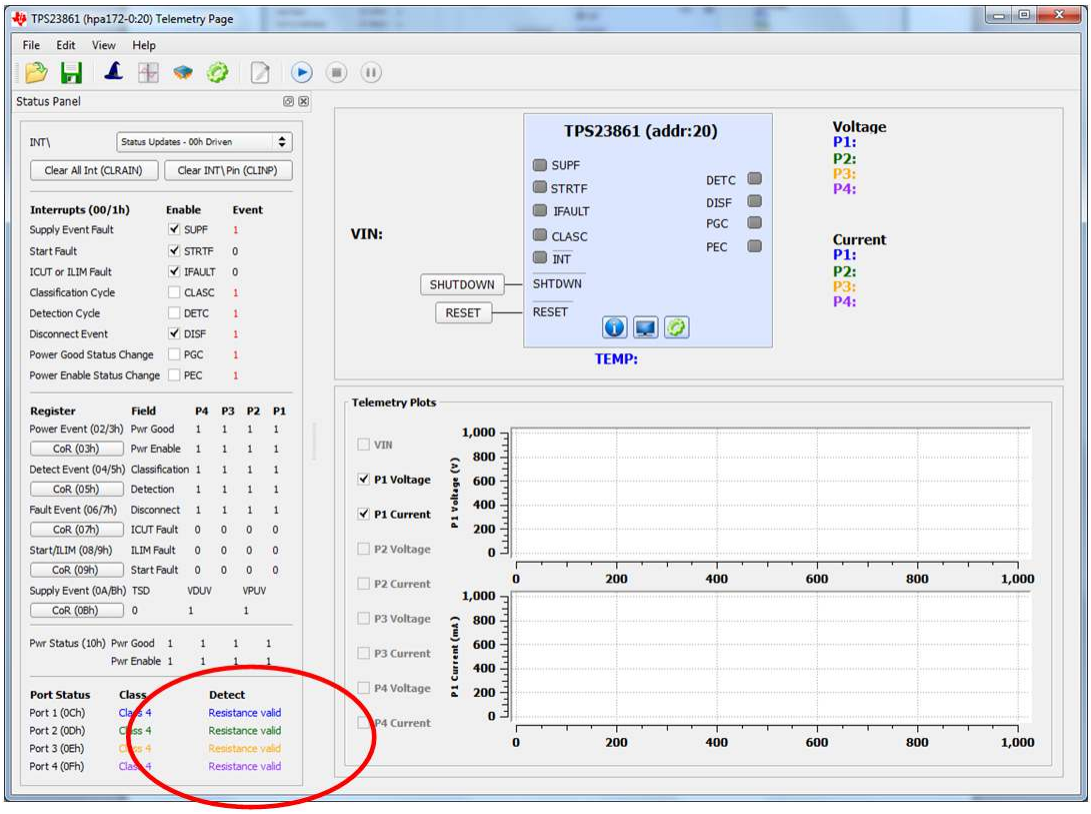


**Figure 10. PD Detection**

Clicking the **Run** button (blue arrow in the header bar) starts telemetry data collection and graphs (Figure 11).

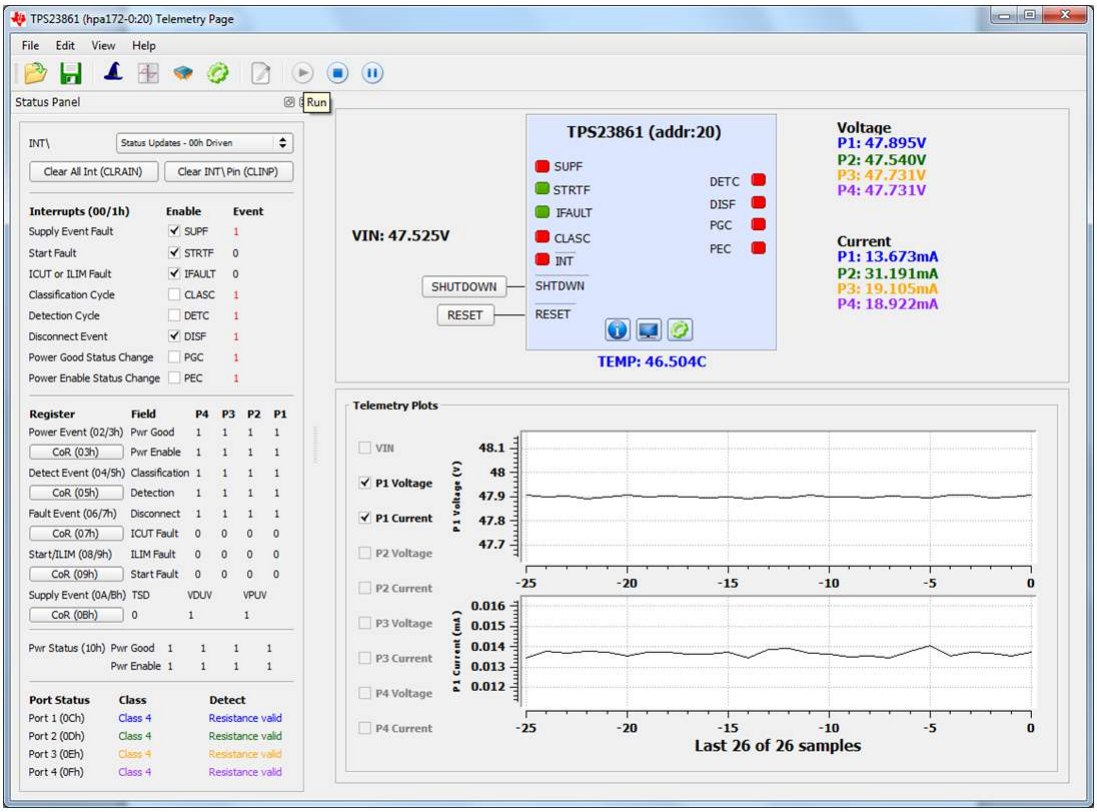


**Figure 11. Telemetry Data Collection and Graphs**

Following a similar procedure, device #2 can be viewed. For the case in Figure 12, two forced-four pair PDs are installed into ports 1 and 2 respectively and are successfully detected, classified, and powered up.

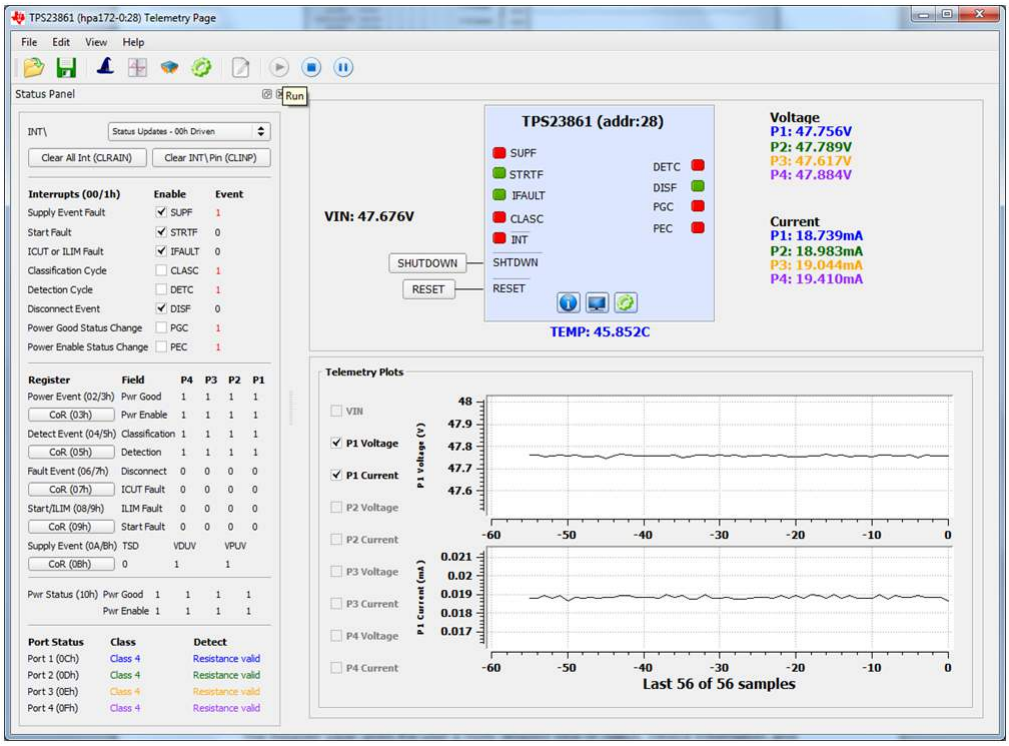


**Figure 12. Telemetry Data Collection and Graphs, Device 2**

The Dashboard window is also available showing a high level status (two devices shown).

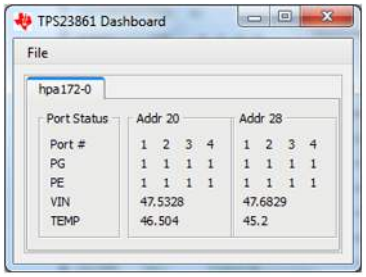


**Figure 13. High-Level Status, 2 Devices**

The I2C Register Page (Figure 14) provides a detailed view of Status, Device, and Telemetry information.

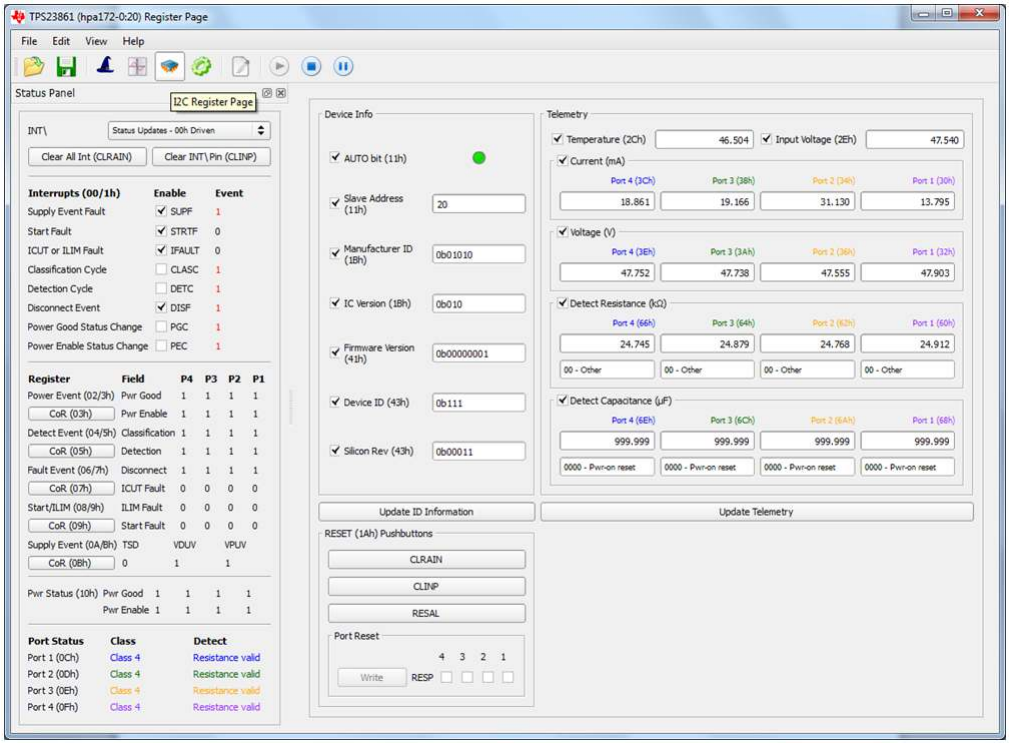


**Figure 14. I2C Register Page**

The Device Configuration Page provides users with an additional level of access.

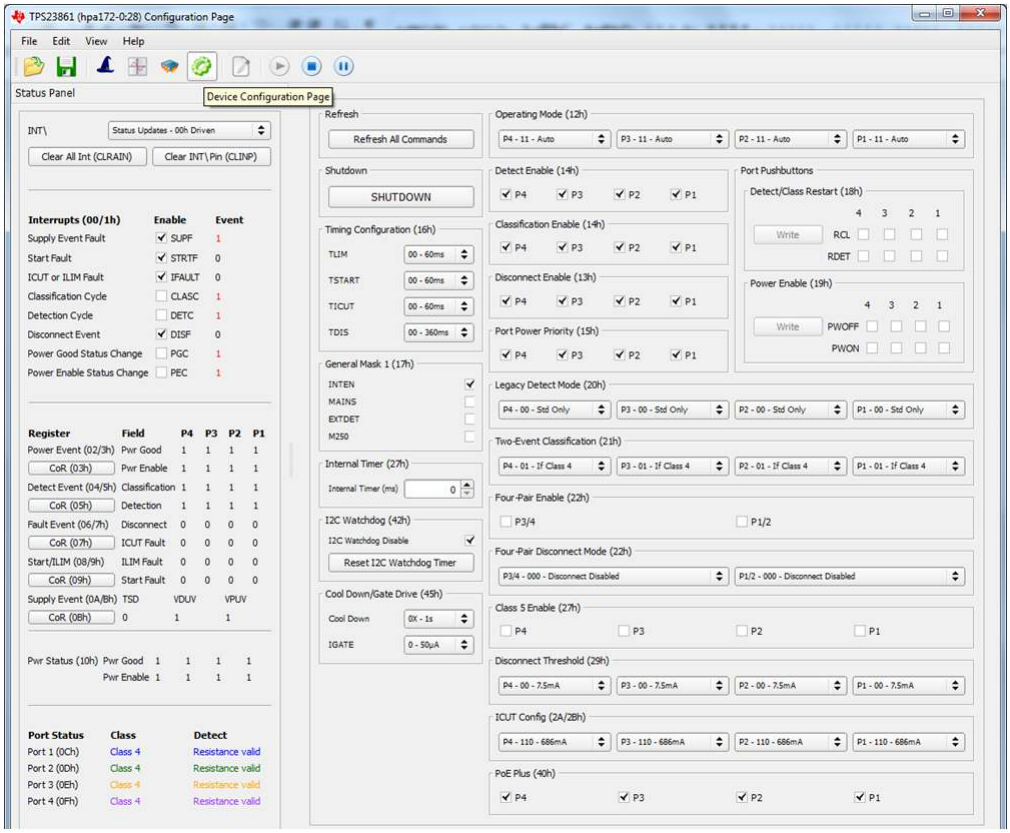


**Figure 15. Device Configuration Page**

The Configuration Wizard provides a quick way to set up ports in semi-auto or manual modes without much knowledge of the device register-specific details.

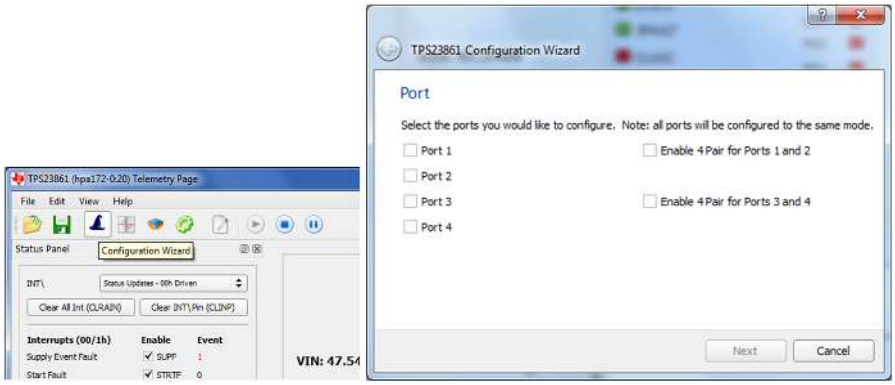


**Figure 16. Configuration Wizard**

## 4.3 MSP-EXP430G2 Details

The TPS23861EVM-612 accepts the MSP-EXP430G2 evaluation module when the application requires management of the TPS23861 devices with an external controller. Before inserting the MSP-EXP430G2 into the TPS23861EVM-612, make the following jumper changes and ensure that the target MSP430 (MSP430G2553) device is installed:

1. Remove the shunt on J5 in the P1.6 slot
2. Remove the shunts on J3 in the RXD and TXD slot. Re-install these in the vertical position as described in the MSP-EXP430G2 LaunchPad user guide (SLAU318C, page 10).
3. Install MSP-EXP430G2 onto TPS23861EVM-612 and ensure that the USB-TO-GPIO ribbon cable is NOT installed into J2
4. Connect the PC to the LaunchPad as shown in Figure 3.
5. The source code was developed for the MSP430 LaunchPad Development Kit (MSP-EXP430G2 http://www.ti.com/tool/msp-exp430g2) using the Code Composer Studio™ (CCS) version 5.3 (http://www.ti.com/tool/ccstudio-msp430) development environment. The target MSP430 can be programmed within this environment.
6. Once CCS is installed, then use the basic set of instructions listed in Section 4.3.1 to import, build, and run the project. CCS version 5.3.0 is used in the following examples. Note that a terminal program such as HyperTerminal or Teraterm is required to view the output from the EVM when it is running.

### 4.3.1 Basic CCS and Terminal Setup

1. Launch the CCS program on the PC: Start → Texas Instruments → Code Composer Studio 5.3.0 → Code Composer Studio 5.3.0.
2. OK the workspace location and CCS starts
3. Import the project: File → Import Existing CCS Eclipse Project
4. Navigate to the project location, then click the **Finish** button
5. Set the active project: Project, Build Configurations, Set Active, Auto, Manual, or Semi-Auto
6. Build the project by clicking the hammer symbol
7. Launch debug session from CCS to activate the current project: Run, Debug (or F11).
8. Run the active project: Run, Resume (or play button, F8)
9. Determine the PC COM port connected to the LaunchPad by going into the Device Manager Ports (COM and LPT) section. Launch the terminal program.
10. Once the terminal program is properly connected to the LaunchPad running the POE firmware, then text similar to the following image appears

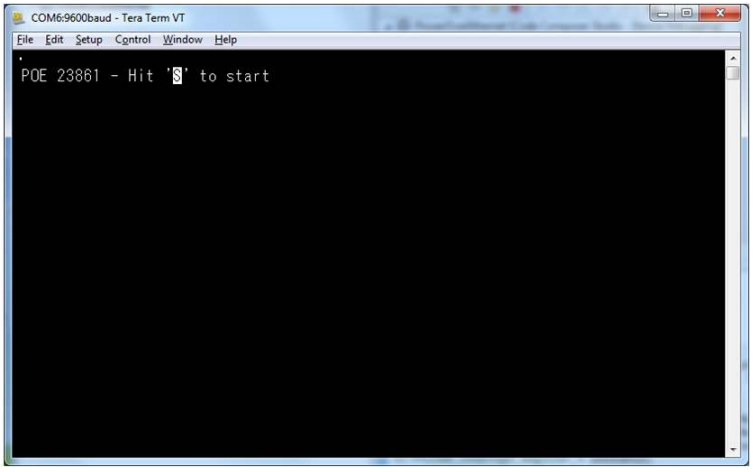


**Figure 17. Hit 'S' to Start**

11. Pressing the “S” key on the keyboard starts the program

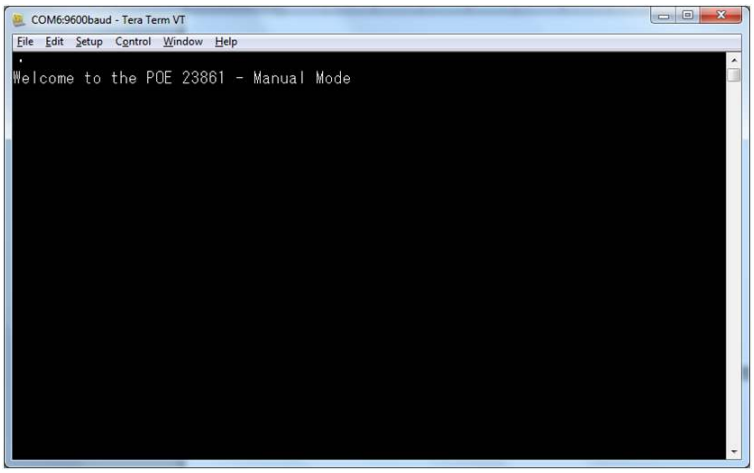


**Figure 18. Program Started**

12. The TPS23861EVM-612 is now waiting for a PD load to be installed. As ports are installed, the firmware automatically detects, classifies, and powers up the port as shown in the following image. Port status is updated on the screen approximately every 8 seconds

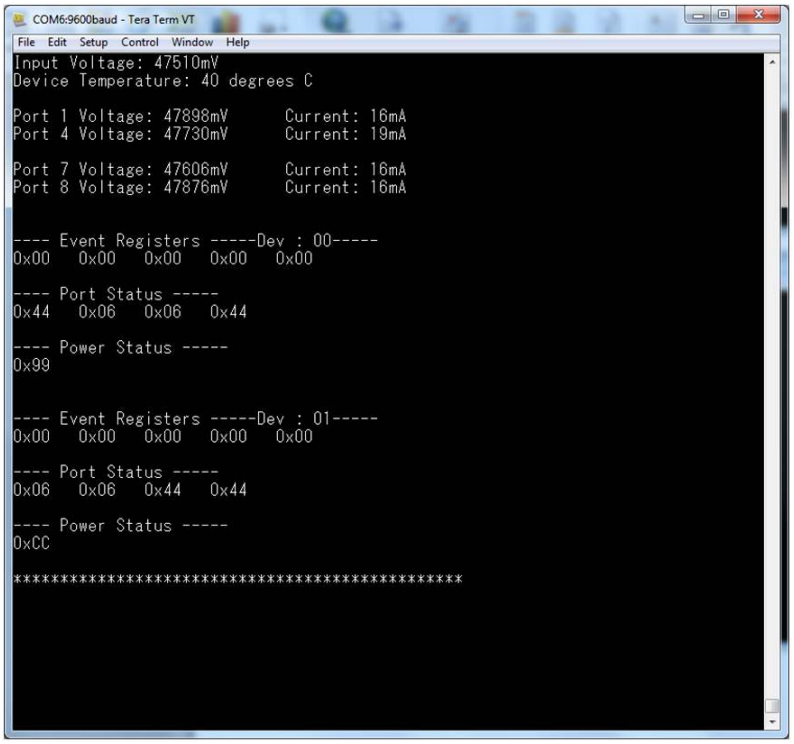


**Figure 19. Terminal Response with Connected Ports**

13. In similar fashion, the builds for Semi-auto and auto mode operation can be configured and launched. The terminal welcome screen indicates which build is running on the LaunchPad.

### 4.3.2 Documentation

Figure 20 illustrates the documentation contained within the \POE-TPS23861\Document\doxy\html\index.html file.

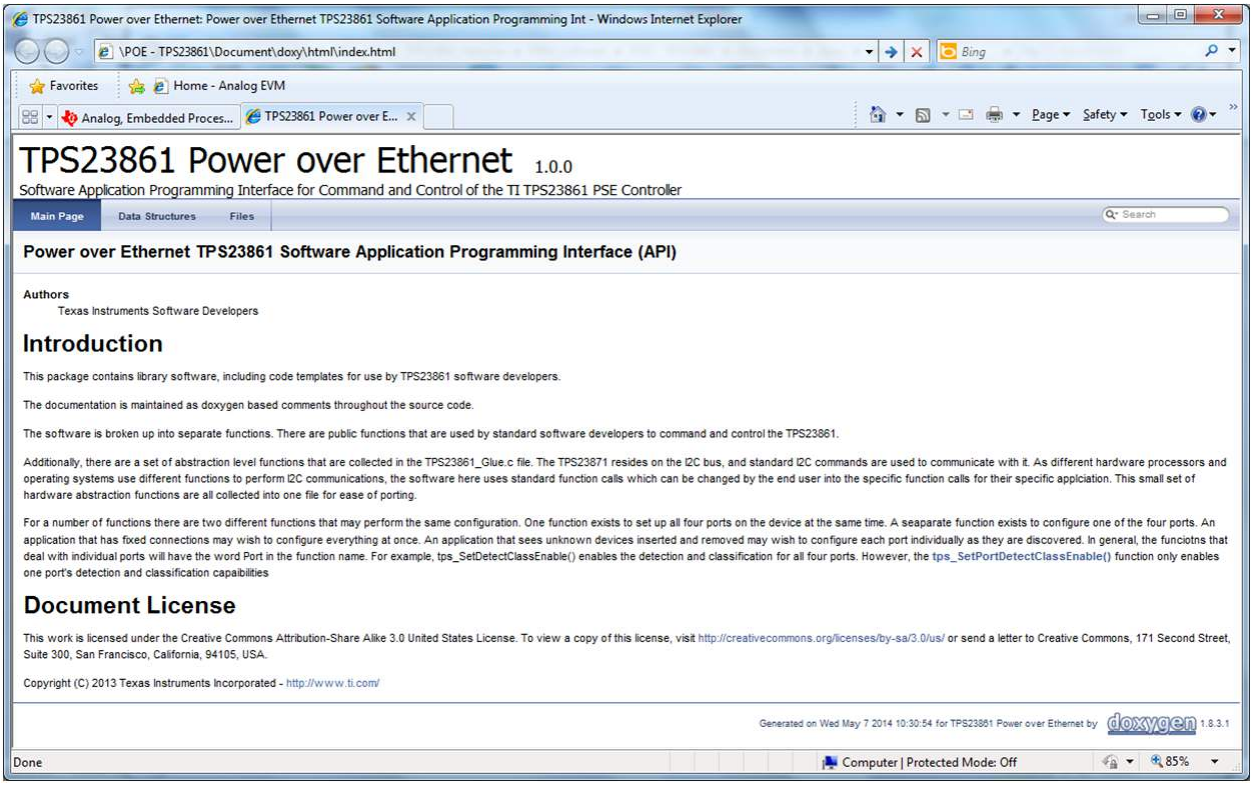


**Figure 20. TPS23861 POE Documentation**

## 4.4 MSP430 Reference Code

### 4.4.1 Overview

There are two versions of *MSP430 reference code* published on TI web. One is for basic applications and the other is focused on multi-port power management applications. The reference code for multi-port power management applications will be discussed in detail since it has more flexibility and complexity.

The system software supports the following features:

- Fully compliant to IEEE802.3at Power over Ethernet specification
- Device detection and classification
- DC disconnect
- Multi-port power management

The reference code can support PSE systems with up to 48 ports. It keeps track of all system level parameters as well as port level parameters for each TPS23861 device within the system.

The main actions are interrupts triggered. As long as MSP430 receives an interrupt signal from TPS23861 devices, it checks the interrupt status and proceeds with related actions.

The system software also keeps track of system and devices error conditions that occur, as well as any events that affect the port states. The MSP430 communicates with PC through UART, reporting port's parameters and status.

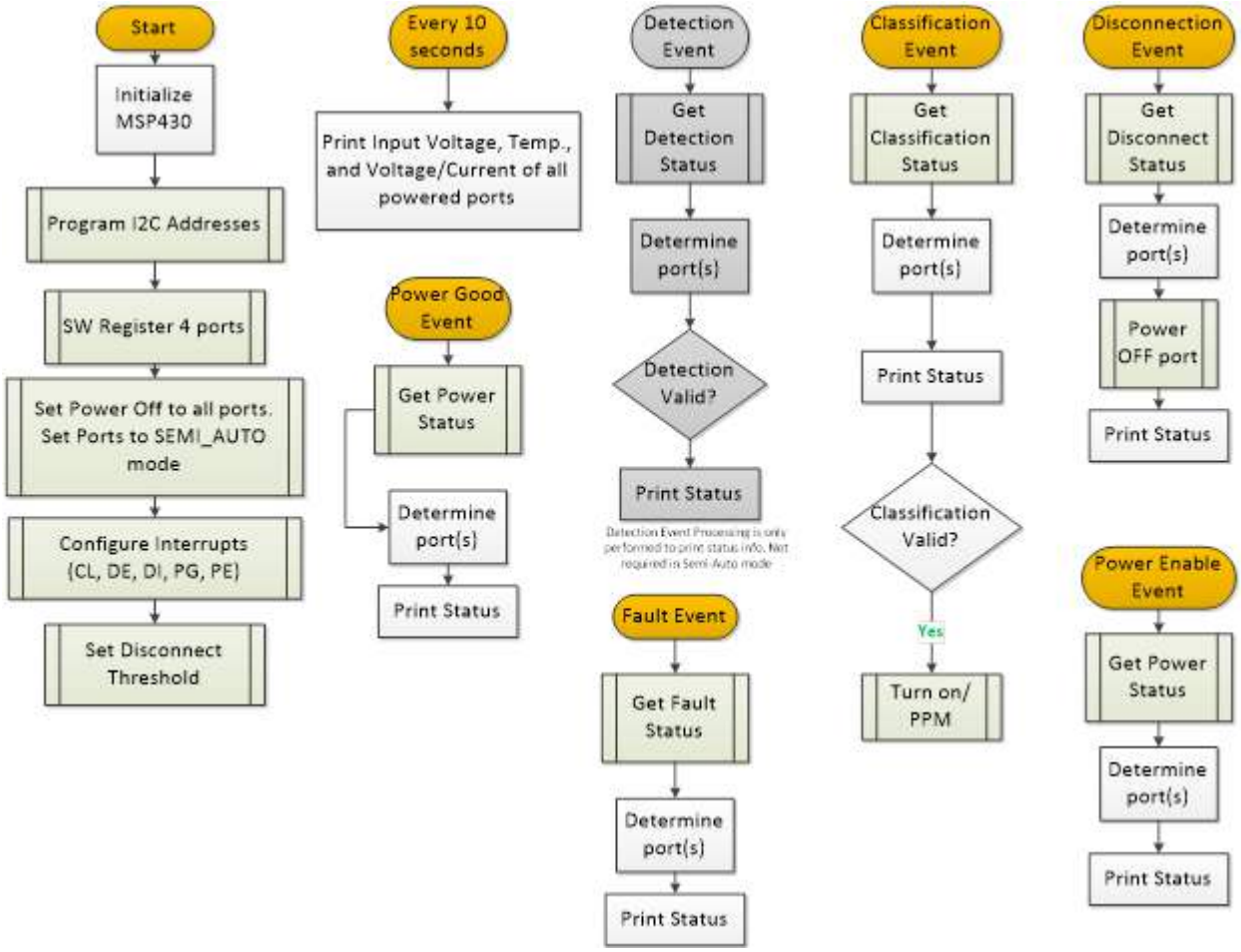


**Figure 21. Overall System Software Structure**

### 4.4.2 Multi-Port Power Management Module

Multi-Port Power Management methods are used to manage the distribution and prioritization of PDs. Power Management itself is not defined by the IEEE specification. Instead, it is a policy that takes advantage of the POE specification as it defines such terms as port and system power.

The goals of Multi-Port Power Management in a POE enabled system are two-fold:

- Power as many PDs as possible
- Limit power cycling of PDs

In many systems, the maximum system power available limits the total number of ports that may be powered. For example, each PD can draw a maximum of 30W, and a 48-port system can draw more than 1440W total system power. If the maximum system power available is less than 1440W then Power Management becomes necessary so that the available system power may be used in the most efficient manner while meeting the goals.

In this reference code, Multi-Port Power Management Module is implemented in Semi-Auto Mode reference code (main_semi-auto.c).

#### 4.4.2.1 Definitions and Formulas

Table 6 defines terms used in the Power Management algorithm.

**Table 6. Terminology**

| TERM | DEFINITION |
|---|---|
| sysPower | The current total power consumed by PDs |
| portPowerEstimate | The estimated power the current port(finished detection and classification) is going to consume |
| lowestPrioPort | The lowest priority port among all turned on ports |
| powerOffPort | Port will be powered off |
| powerOnPort | Port will be turned on |

#### 4.4.2.2 State Definitions

The Power Management algorithm operates as a state machine, whereby the algorithm is a certain state at any given point in time. Table 7 shows the state definitions for the algorithm.

**Table 7. State Definitions**

| STATE | DEFINITION |
|---|---|
| PM_CHECK | Calculate existing ON ports' total power, get current port estimate power, compare total power + port estimate power and Power budget |
| PM_POWERUP | Power up current port |
| PM_OVERLIMIT | Power demand has exceeded the power budget. Calculate whether the remaining power is enough to turn on current port after turning off all lower priority ports |
| PM_POWERDOWN | Power down the lowest priority port. Entered from PM_OVERLIMIT |

#### 4.4.2.3 Function Definitions

The power management function is called after a valid classification is performed. It includes the functions below to implement the algorithm.

**Table 8. Function Definitions**

| FUNCTION | DEFINITION |
|---|---|
| uint32_t PM_calSysPower(void) | Calculate current total power consumed by PDs |
| uint8_t PM_getActLowestPrioPort(void) | Find lowest priority port among all turned on ports |
| uint32_t PM_getPowerofPortsHigherPriority(uint8_t PM_sysPortNumber) | Calculate total power of ports that have the same or higher priority |
| uint32_t PM_getRequestPower(uint8_t PM_sysPortNumber) | Get estimate power of current port(finished detection and classification) is going to consume based on classification results |
| void PM_powerManagement(uint8_t PM_sysPortNumber) | Power management function called in main function |
| void PM_monitorSysPower(void)<br>Note: running in background, software interrupt triggered | Real-time check if current total power consumed by PDs exceeds power budget (to prevent load step change on any ports). |

#### 4.4.2.4 User Configurable Parameters

The PPM module gives user some flexibility to configure. Table 9shows the user configurable parameters.

**Table 9. User Configurable Parameters**

| TERM | DEFINITION | LOCATION |
|---|---|---|
| #define PM_EN | Enable PPM feature. Enable=1, disable=0. | power_manage.h |
| #define PM_POWER_BUDGET | Total system power budget. Unit: mW | power_manage.h |
| #define NUM_OF_TPS23861 | Total number of TPS23861 in the system | system_init.h |
| #define PM_POWER_MONITOR_TIMER | The timer that host monitor the actual system power | system_init.h |
| #define PM_DETECT_CLASS_RESTART_TIMER | The timer that host restart detection/ classification of the ports which are turned off | system_init.h |
| uint8_t i2cAddList[NUM_OF_TPS23861] | I2C address of TPS23861s | system_init.c |
| TPS238x_On_Off_t autoMode[NUM_OF_TPS23861] | AUTO bit setting of each TPS23861 | system_init.c |
| uint8_t PM_setPriority[NUM_OF_TPS23861 x PM_NUM_OF_PORT] | The port priority setting of each port | system_init.c |

#### 4.4.2.5 Design Flow

The Power Management algorithm is shown in Figure 22, in the form of a flow chart.

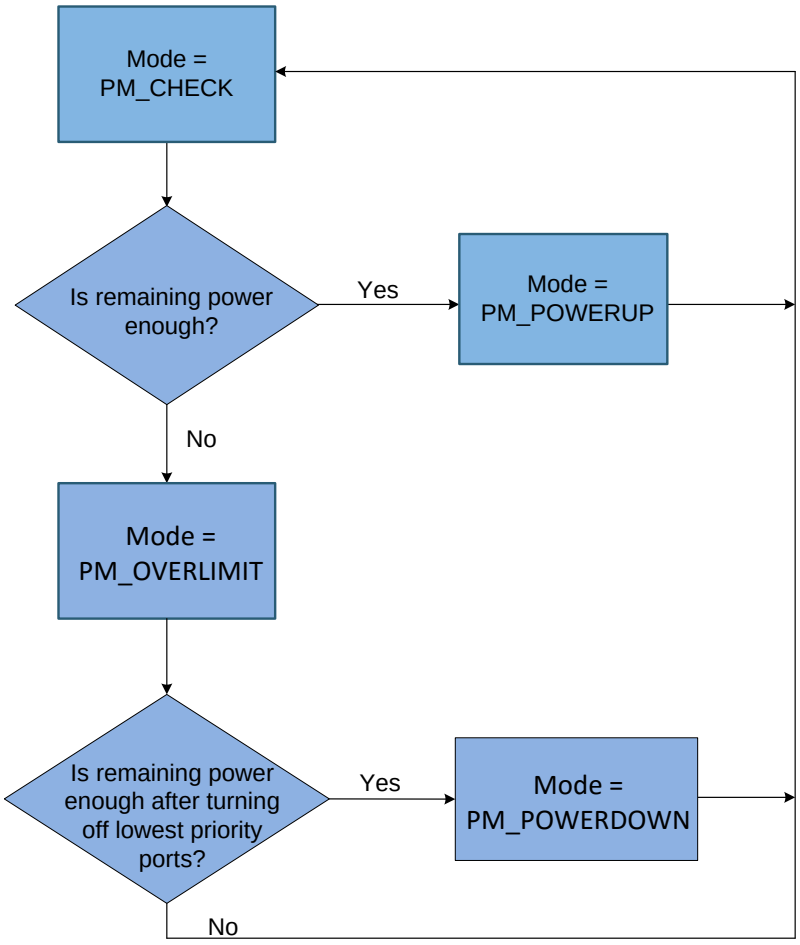


**Figure 22. Power on Decision Flow Chart**

Real-time system power monitor to protect the system when step change happening on any ports (1s timer triggered):

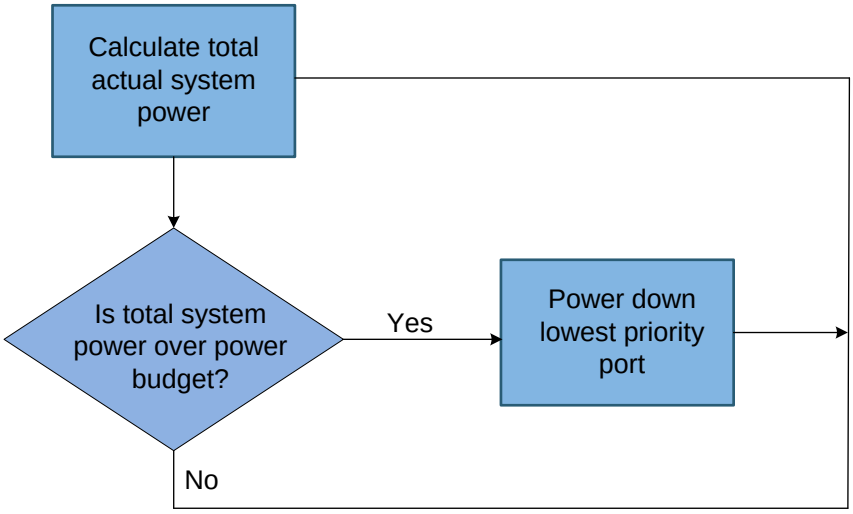


**Figure 23. System Power Monitor Flow Chart**

#### 4.4.2.6 Pseudo-Code

The Power Management algorithm can also be represented by the following pseudo-code.

```
//This part is inserted after each port's successful classification

if (Mode == Check)
{
   Get RequesPortPower;
   Calculate SystemPower;
   if (systemPower + RequesPortPower > PowerBudget)
     {
        Mode = OverLimit;
     }
     else
     {
        Mode = PowerUP;
     }
}

if (Mode == OverLimit)
{

   //If the remaining power is enough to turn on current port after powering down all ports that
have lower priority,
   //then turn off the lowest priority port; otherwise, wait for the next cycle
   if (powerofHigherPriorityPorts + RequesPortPower <= PowerBudget)
   {
       Mode = PowerDown;
   }
   else
   {
       Mode = Check
   }
}

if (Mode == PowerDown
{
    Power down the port with lowest priority;
    Restart port's detection/classification;
    Mode = Check;
}

if (Mode == PowerUp)
}
    Power on the port which is requesting power;
    Mode = Update;
}

//This part is inserted in a timer (every 1s or 2s) intrerrupt

 if (system power > PowerBudget)
 {
     Turn off the port with lowest priority;
     Restart port's detection/classification;

}
```

# 5 EVM Schematic, Layout Guidelines and PCB Assembly, Layer Plots

This section contains the TPS23861EVM-612 schematic, layout guidelines, and printed-circuit board (PCB) assembly and layer plots.

## 5.1 Schematic

Figure 24 through Figure 26 illustrate the TPS23861EVM-613 schematics.

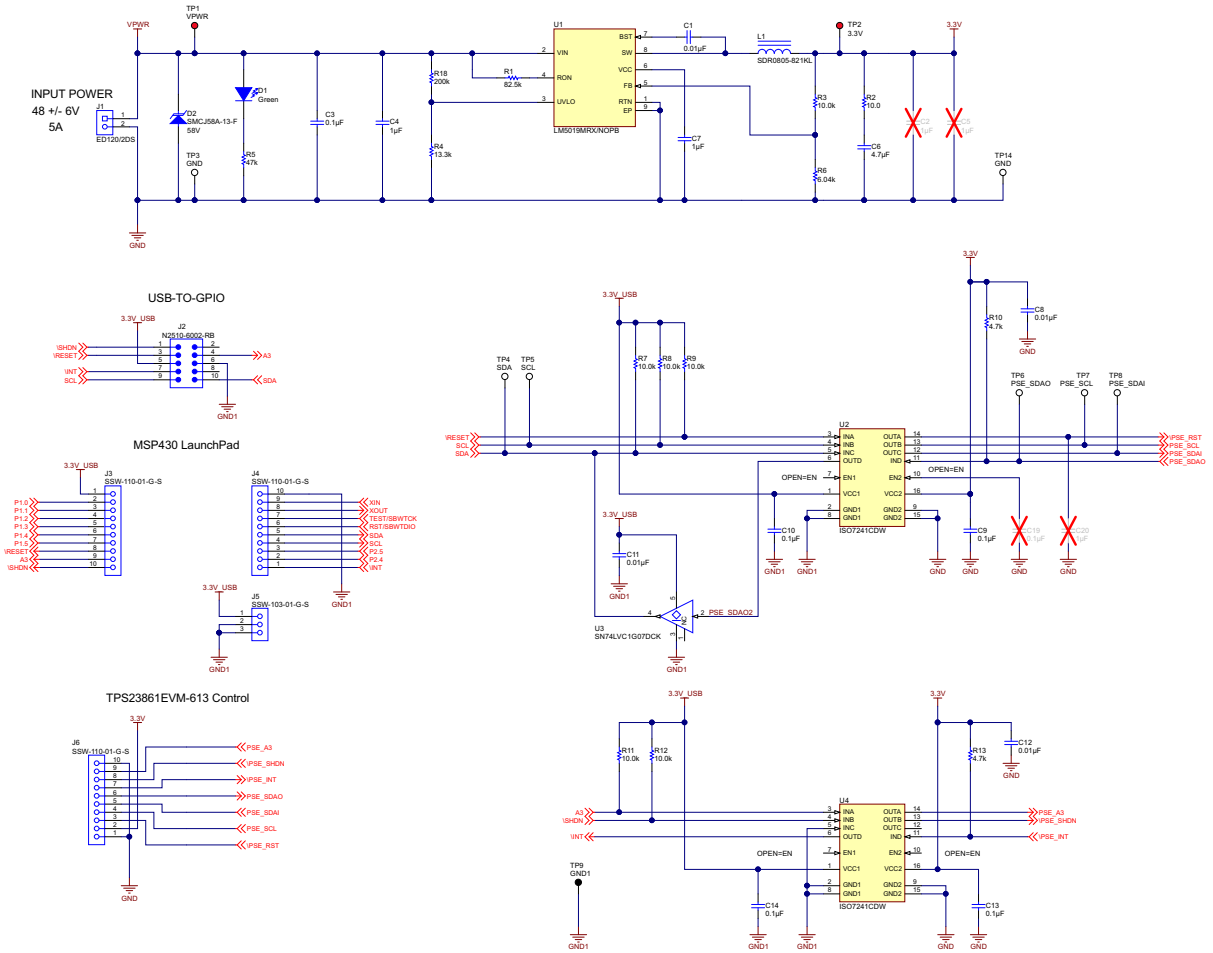


**Figure 24. TPS23861EVM-612 (Motherboard) Schematic: Control**

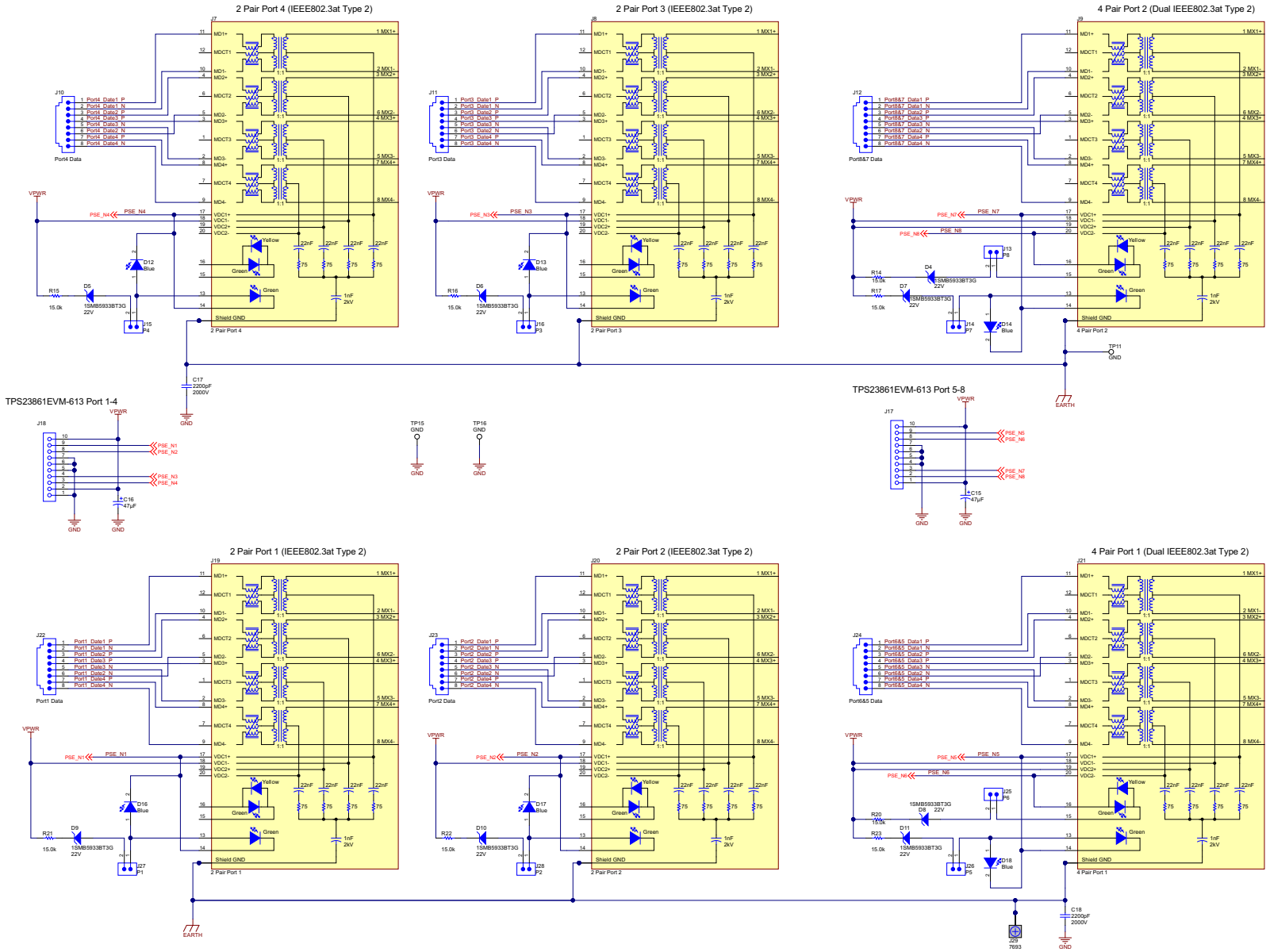


**Figure 25. TPS23861EVM-612 (Motherboard) Schematic: Power Ports**

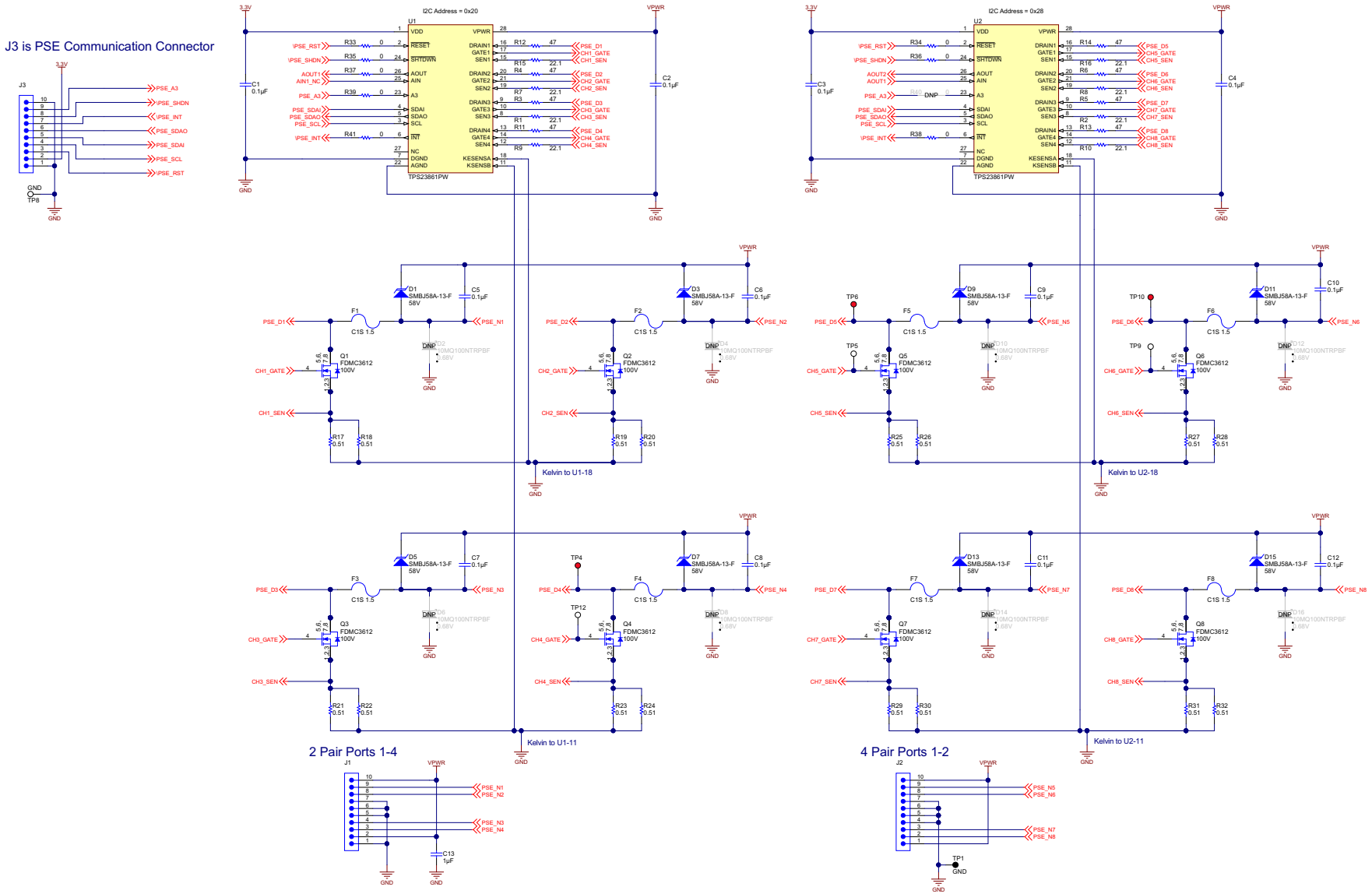


**Figure 26. TPS23861EVM-613 (Daughterboard) Schematic**

## 5.2 Layout Guidelines

### 5.2.1 Supply Voltage Decoupling

Provide power supply pin bypass to the TPS23861 device as follows:

- 0.1 µF, 100 V, X7R ceramic at pin 28 (VPWR)
- 0.1 µF, 50 V, X7R ceramic at pin 1 (VDD)

### 5.2.2 Port Current Kelvin Sensing

KSENSA is shared between SEN1 and SEN2, while KSENSB is shared between SEN3 and SEN4. In order to optimize the accuracy of the measurement, the PCB layout must be done carefully to minimize the impact of PCB trace resistance. Refer to Figure 33 as an example.

### 5.2.3 Ground Plane Spacing and Isolation (GND, GND1, and EARTH nets)

Appropriate spacing should be provided between the GND, GND1, and EARTH nets as shown in Figure 29.

## 5.3 PCB Drawings

Figure 27 through Figure 35 show the PCB layouts and assemblies for this EVM.

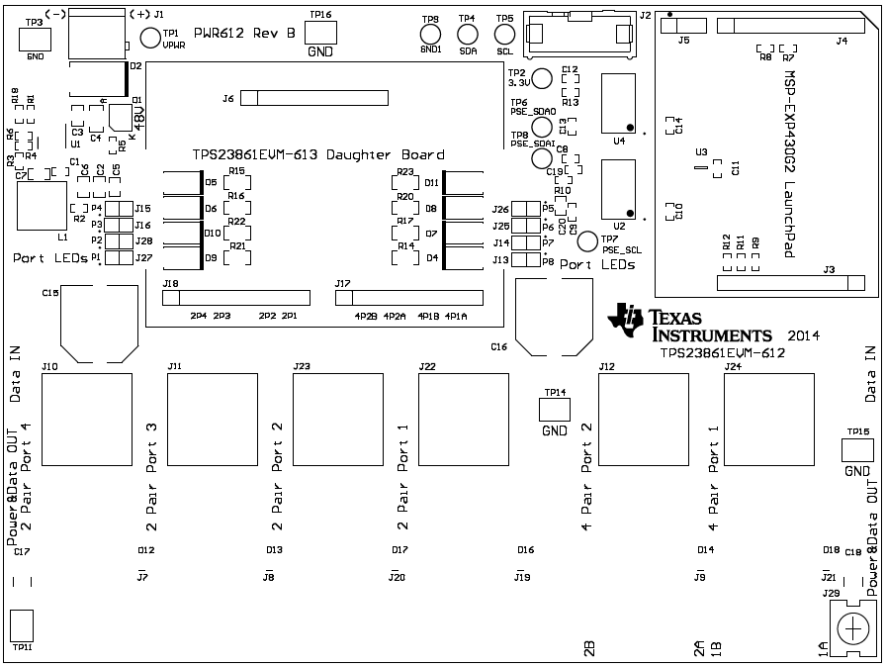


**Figure 27. TPS23861EVM-612 (Motherboard) Top Side Assembly**

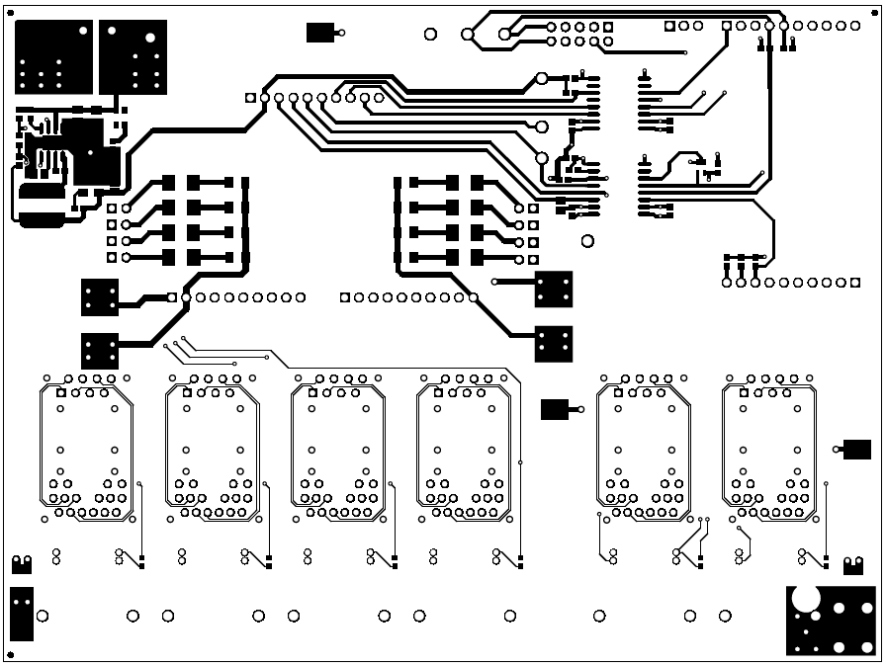

**Figure 28. TPS23861EVM-612 (Motherboard) Top Side Routing**

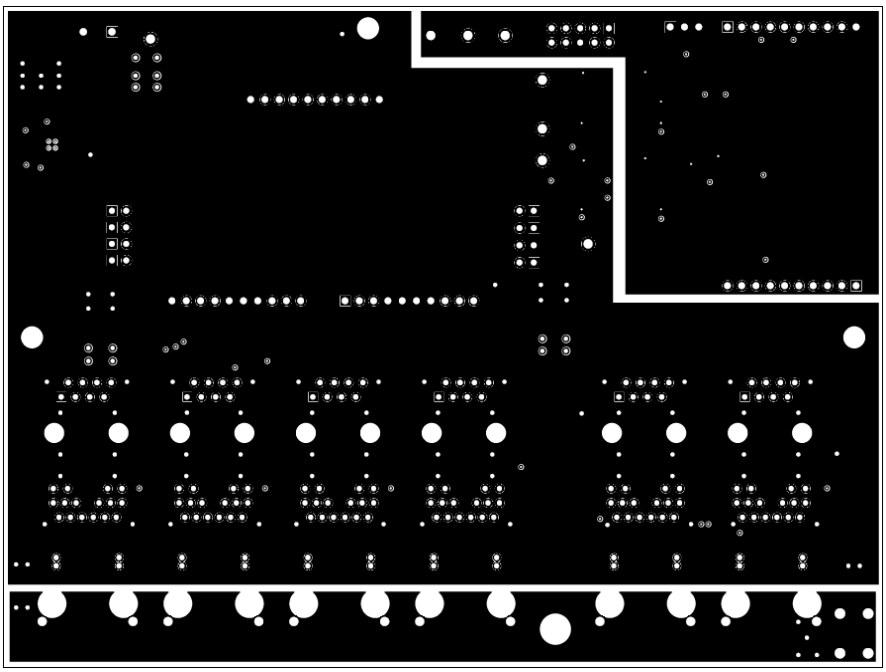

**Figure 29. TPS23861EVM-612 (Motherboard) Layer 2 Routing**

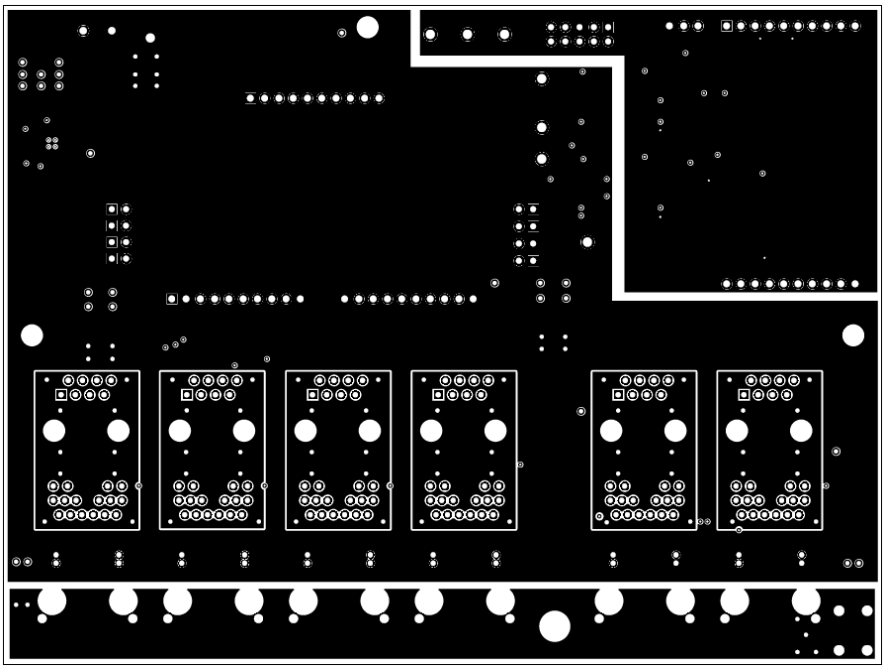

**Figure 30. TPS23861EVM-612 (Motherboard) Layer 3 Routing**

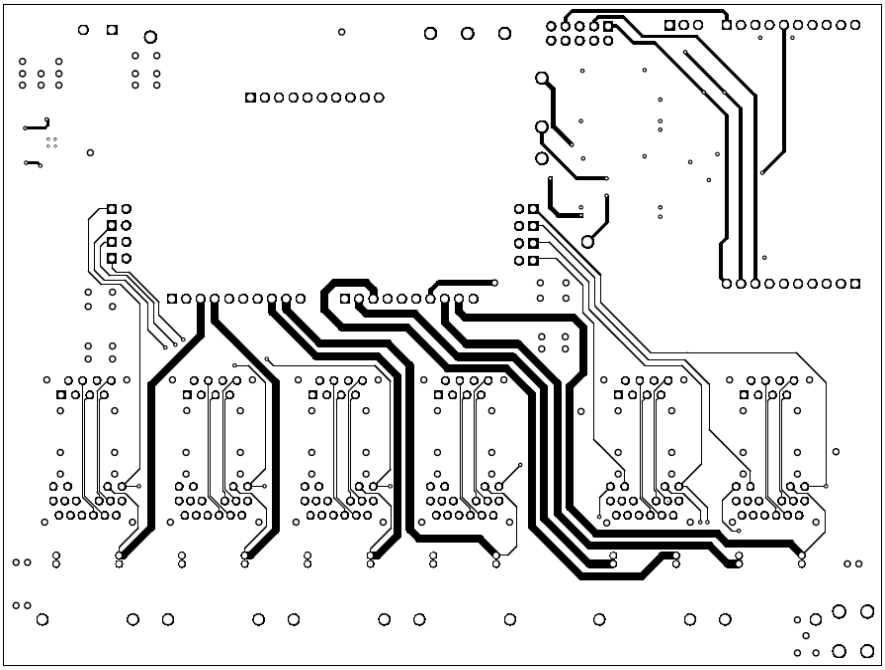

**Figure 31. TPS23861EVM-612 (Motherboard) Bottom Side Routing**

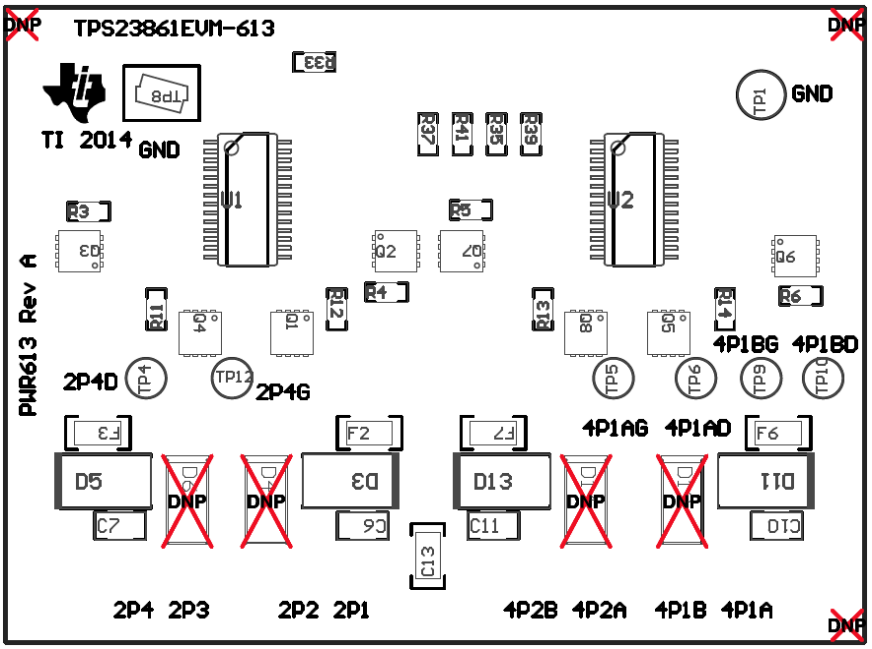


**Figure 32. TPS23861EVM-613 (Daughterboard) Top Side Assembly**

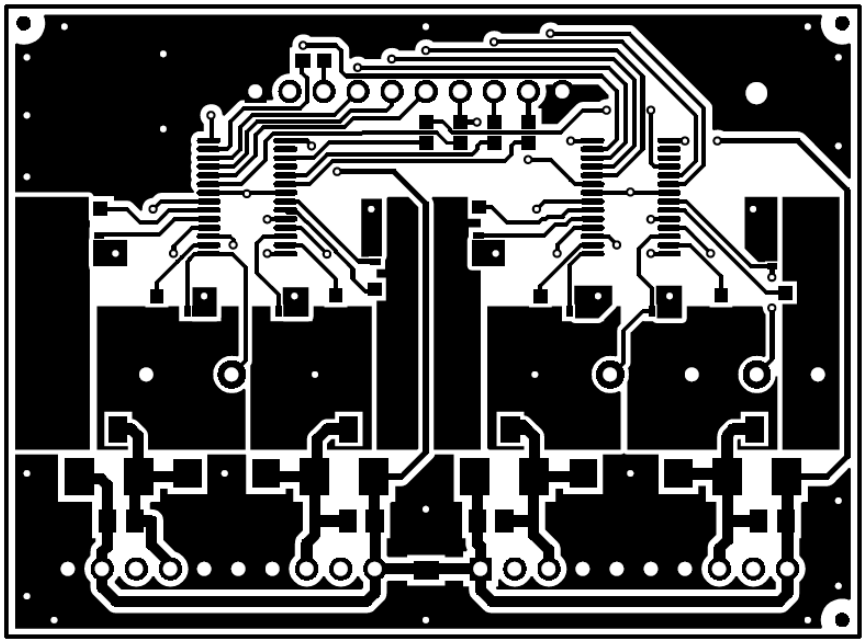

**Figure 33. TPS23861EVM-613 (Daughterboard) Top Side Routing**

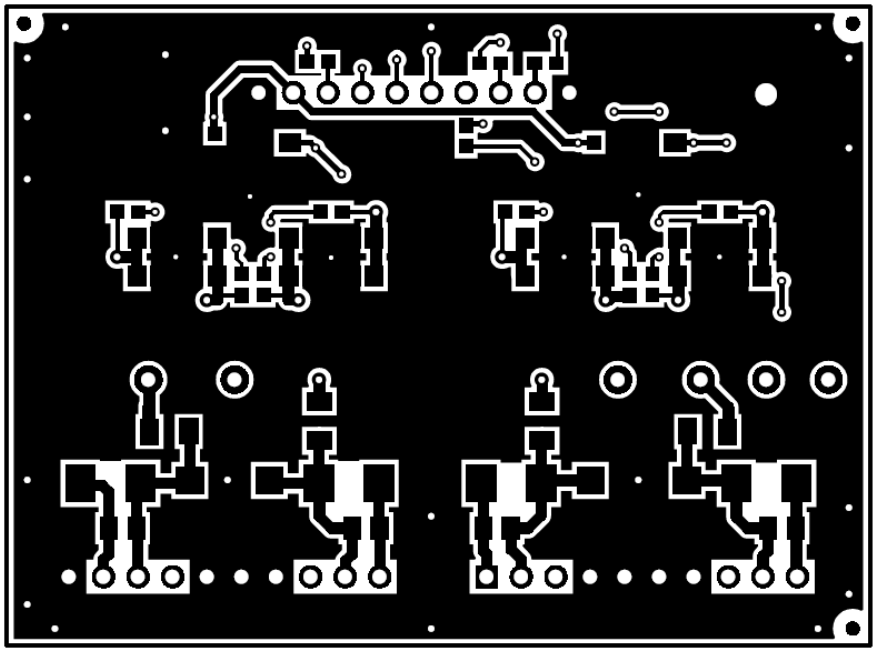

**Figure 34. TPS23861EVM-613 (Daughterboard) Bottom Side Routing**

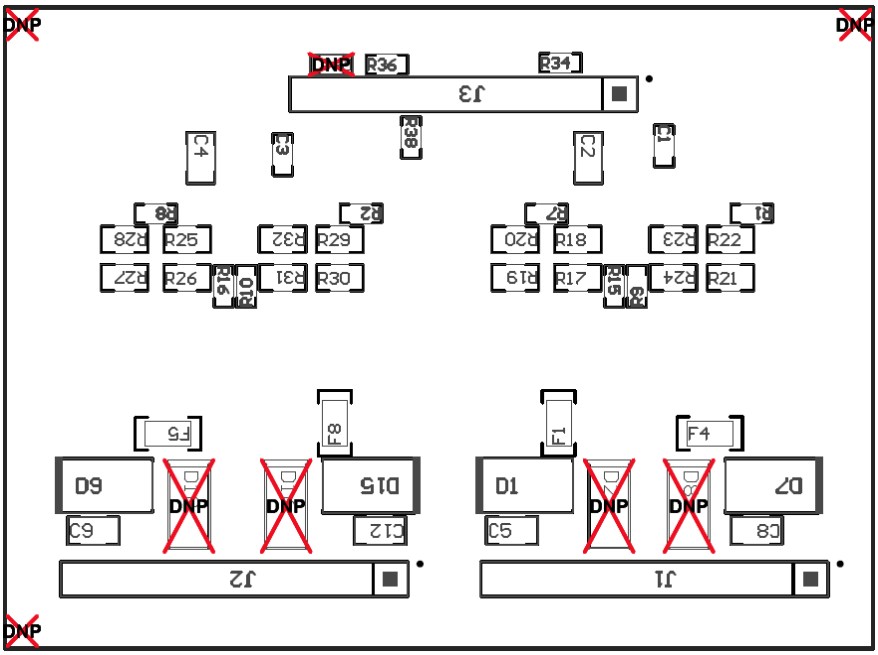


**Figure 35. TPS23861EVM-613 (Daughterboard) Bottom Side Assembly**

# 6 Bill of Materials

The BOMs for the TPS23861EVM-612 and TPS23861EVM-613 are listed in Table 10 and Table 11, respectively.

**Table 10. TPS23861EVM-612 Bill of Materials(1)**

| Designator | Qty | Value | Description | Package Reference | PartNumber | MFR | Alternate Part Number | Alternate MFR |
|---|---|---|---|---|---|---|---|---|
| !PCB | 1 | | Printed Circuit Board | | PWR612 | Any | | |
| C1, C8, C11, C12 | 4 | 0.01uF | CAP, CERM, 0.01uF, 100V, +/-10%, X7R, 0603 | 0603 | 06031C103KAT2A | AVX | | |
| C3 | 1 | 0.1uF | CAP, CERM, 0.1uF, 100V, +/-10%, X7R, 0805 | 0805 | C2012X7R2A104K | TDK | | |
| C4 | 1 | 1uF | CAP, CERM, 1uF, 100V, +/-10%, X7R, 1206 | 1206 | GRM31CR72A105KA01L | MuRata | | |
| C6 | 1 | 4.7uF | CAP, CERM, 4.7 µF, 10 V, +/- 10%, X5R, 0805 | 0805 | C0805C475K8PACTU | Kemet | | |
| C7 | 1 | 1uF | CAP, CERM, 1uF, 10V, +/-10%, X7R, 0805 | 0805 | 0805ZC105KAT2A | AVX | | |
| C9, C10, C13, C14 | 4 | 0.1uF | CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603 | 0603 | 06035C104KAT2A | AVX | | |
| C15, C16 | 2 | 47uF | CAP, AL, 47uF, 100V, +/-20%, 0.32 ohm, SMD | SMT Radial H13 | EEV-FK2A470Q | Panasonic | | |
| C17, C18 | 2 | 2200pF | CAP, CERM, 2200pF, 2000V, +/-10%, X7R, 1812 | 1812 | C4532X7R3D222K | TDK | | |
| D1 | 1 | Green | LED, Green, SMD | Power TOPLED w/lens | LT E63C-CADB-35-L-Z | OSRAM | | |
| D2 | 1 | 58V | Diode, TVS, Uni, 58V, 1500W, SMC | SMC | SMCJ58A-13-F | Diodes Inc. | | |
| D4, D5, D6, D7, D8, D9, D10, D11 | 8 | 22V | Diode, Zener, 22V, 550mW, SMB | SMB | 1SMB5933BT3G | ON Semiconductor | | |
| D12, D13, D14, D16, D17, D18 | 6 | Blue | LED, Blue, SMD | BLUE 0603 LED | LB Q39G-L2N2-35-1 | OSRAM | | |
| H1, H2, H3, H4, H5, H6, H7, H8, H9 | 9 | | Bumpon, Cylindrical, 0.312 X 0.200, Black | Black Bumpon | SJ61A1 | 3M | | |
| J1 | 1 | | TERMINAL BLOCK 5.08MM VERT 2POS | TERM_BLK, 2pos, 5.08mm | ED120/2DS | On-Shore Technology, Inc. | | |
| J2 | 1 | | Header (shrouded), 100mil, 5x2, High-Temperature, Gold, TH | 5x2 Shrouded header | N2510-6002-RB | 3M | | |
| J3, J4, J6, J17, J18 | 5 | | Connector, Receptacle, 100mil, 10x1, Gold plated, TH | HEADER, RECEPTACLE, 100mil, 10x1 | SSW-110-01-G-S | Samtec, Inc. | | |
| J5 | 1 | | Receptacle 100mil 3x1, Gold, TH | Receptacle, 100mil, 3x1 | SSW-103-01-G-S | Samtec, Inc. | | |
| J7, J8, J9, J19, J20, J21 | 6 | | RJ-45 with integrated magnetics | RJ-45 Jack | JK0-0177NL | Pulse Engineering | 7499511611 or 7499511611A | Wurth Elektronik |
| J10, J11, J12, J22, J23, J24 | 6 | | RJ-45, Vertical, TH | RJ-45 Jack, 8Pos Right Angle | SS-7188V-A-NF | Stewart Connector | | |
| J13, J14, J15, J16, J25, J26, J27, J28 | 8 | | Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator | TSW-102-07-G-S | TSW-102-07-G-S | Samtec, Inc. | | |
| J29 | 1 | 15A | Terminal screw, vertical, snap-in | 7693 | 7693 | Keystone | | |
| L1 | 1 | 820uH | Inductor, Drum Core, Ferrite, 820 µH, 0.23 A, 4 ohm, SMD | SDR0805 | SDR0805-821KL | Bourns | | |
| R1 | 1 | 82.5k | RES, 82.5 k, 1%, 0.1 W, 0603 | 0603 | CRCW060382K5FKEA | Vishay-Dale | | |
| R2 | 1 | 10.0 | RES, 10.0, 1%, 0.1 W, 0603 | 0603 | CRCW060310R0FKEA | Vishay-Dale | | |
| R3, R7, R8, R9, R11, R12 | 6 | 10.0k | RES, 10.0k ohm, 1%, 0.1W, 0603 | 0603 | CRCW060310K0FKEA | Vishay-Dale | | |
| R4 | 1 | 13.3k | RES, 13.3k ohm, 1%, 0.1W, 0603 | 0603 | CRCW060313K3FKEA | Vishay-Dale | | |
| R5 | 1 | 47k | RES, 47k ohm, 5%, 0.1W, 0603 | 0603 | CRCW060347K0JNEA | Vishay-Dale | | |

(1) Unless otherwise noted in the Alternate Part Number and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

**Table 10. TPS23861EVM-612 Bill of Materials[(1)] (continued)**

| Designator | Qty | Value | Description | Package Reference | PartNumber | MFR | Alternate Part Number | Alternate MFR |
|---|---|---|---|---|---|---|---|---|
| R6 | 1 | 6.04k | RES, 6.04k ohm, 1%, 0.1W, 0603 | 0603 | CRCW06036K04FKEA | Vishay-Dale | | |
| R10, R13 | 2 | 4.7k | RES, 4.7k ohm, 5%, 0.1W, 0603 | 0603 | CRCW06034K70JNEA | Vishay-Dale | | |
| R14, R15, R16, R17, R20, R21, R22, R23 | 8 | 7.50k | RES, 7.50k ohm, 1%, 0.25W, 1206 | 1206 | CRCW12067K50FKEA | Vishay-Dale | | |
| R18 | 1 | 200k | RES, 200k ohm, 1%, 0.1W, 0603 | 0603 | CRCW0603200KFKEA | Vishay-Dale | | |
| SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8 | 8 | 1x2 | Shunt, 100mil, Flash Gold, Black | Closed Top 100mil Shunt | SPC02SYAN | Sullins Connector Solutions | | |
| TP1, TP2 | 2 | Red | Test Point, Multipurpose, Red, TH | Keystone5010 | 5010 | Keystone | | |
| TP3, TP11, TP14, TP15, TP16 | 5 | SMT | Test Point, Compact, SMT | Testpoint_Keystone_Compact | 5016 | Keystone | | |
| TP4, TP5, TP6, TP7, TP8 | 5 | White | Test Point, Multipurpose, White, TH | Keystone5012 | 5012 | Keystone | | |
| TP9 | 1 | Black | Test Point, Multipurpose, Black, TH | Keystone5011 | 5011 | Keystone | | |
| U1 | 1 | | 100V, 100mA Constant On-Time Synchronous Buck Regulator, DDA0008B | DDA0008B | LM5019MRX/NOPB | Texas Instruments | LM5019MR/NOPB | Texas Instruments |
| U2, U4 | 2 | | 25 Mbps Quad Channels, 3 / 1, Digital Isolator, 3.3 V / 5 V, -40 to +125 degC, 16-pin SOIC (DW), Green (RoHS & no Sb/Br) | DW0016A | ISO7241CDW | Texas Instruments | Equivalent | None |
| U3 | 1 | | SINGLE BUFFER/DRIVER WITH OPEN-DRAIN OUTPUT, DCK0005A | DCK0005A | SN74LVC1G07DCK | Texas Instruments | | None |
| PWR613 | 1 | | TPS23861EVM-613 Daughter Board | PWR613 | PWR613 | Texas Instruments | | |
| C2, C5, C20 | 0 | 1uF | CAP, CERM, 1uF, 10V, +/-10%, X7R, 0805 | 0805 | 0805ZC105KAT2A | AVX | | |
| C19 | 0 | 0.1uF | CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603 | 0603 | 06035C104KAT2A | AVX | | |
| H10, H11, H12, H13 | 0 | | Standoff, Hex, 1"L #6-32 Nylon, M-F | 1" Nylon Hex Standoff | 4820 | Keystone | | |

**Table 11. TPS23861EVM-613 Bill of Materials**

| QTY | RefDes | Value | Description | Size | Part Number | MFR |
|---|---|---|---|---|---|---|
| 2 | C1, C3 | 0.1uF | CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603 | 0603 | 06035C104KAT2A | AVX |
| 10 | C2, C4, C5, C6, C7, C8, C9, C10, C11, C12 | 0.1uF | CAP, CERM, 0.1uF, 100V, +/-10%, X7R, 0805 | 0805 | C2012X7R2A104K | TDK |
| 1 | C13 | 1uF | CAP, CERM, 1uF, 100V, +/-10%, X7R, 1206 | 1206 | GRM31CR72A105KA01L | MuRata |
| 8 | D1, D3, D5, D7, D9, D11, D13, D15 | 58V | Diode, TVS, Uni, 58V, 600W, SMB | SMB | SMBJ58A-13-F | Diodes Inc. |
| 8 | F1, F2, F3, F4, F5, F6, F7, F8 | | Fuse, 1.5A, 63V, SMD | 1206 | C1S 1.5 | Bel Fuse |
| 3 | J1, J2, J3 | | Header, TH, 100mil, 10x1, Gold plated, 230 mil above insulator | TSW-110-07-G-S | TSW-110-07-G-S | Samtec, Inc. |
| 8 | Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8 | 100V | MOSFET, N-CH, 100V, 3.3A, 3.3x1x3.3mm | 3.3x1x3.3mm | FDMC3612 | Fairchild Semiconductor |
| 8 | R1, R2, R7, R8, R9, R10, R15, R16 | 22.1 | RES, 22.1 ohm, 1%, 0.1W, 0603 | 0603 | CRCW060322R1FKEA | Vishay-Dale |
| 8 | R3, R4, R5, R6, R11, R12, R13, R14 | 47 | RES, 47 ohm, 5%, 0.1W, 0603 | 0603 | CRCW060347R0JNEA | Vishay-Dale |
| 16 | R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32 | 0.51 | RES, 0.51 ohm, 1%, 0.25W, 0805 | 0805 | CRM0805-FX-R510ELF | Bourns |
| 8 | R33, R34, R35, R36, R37, R38, R39, R41 | 0 | RES, 0 ohm, 5%, 0.1W, 0603 | 0603 | CRCW06030000Z0EA | Vishay-Dale |
| 1 | TP1 | Black | Test Point, Multipurpose, Black, TH | Keystone5011 | 5011 | Keystone |
| 3 | TP4, TP6, TP10 | Red | Test Point, Miniature, Red, TH | Keystone5000 | 5000 | Keystone |
| 3 | TP5, TP9, TP12 | White | Test Point, Miniature, White, TH | Keystone5002 | 5002 | Keystone |

**Table 11. TPS23861EVM-613 Bill of Materials (continued)**

| QTY | RefDes | Value | Description | Size | Part Number | MFR |
|---|---|---|---|---|---|---|
| 1 | TP8 | SMT | Test Point, Compact, SMT | Testpoint_Keystone_Compact | 5016 | Keystone |
| 2 | U1, U2 | | QUAD IEEE 802.3at POWER-OVER-ETHERNET PSE CONTROLLER, PW0028A | PW0028A | TPS23861PW | Texas Instruments |

## A.1

Figure 36 illustrates the revision A, TPS23861EVM-612 (Motherboard) schematic.

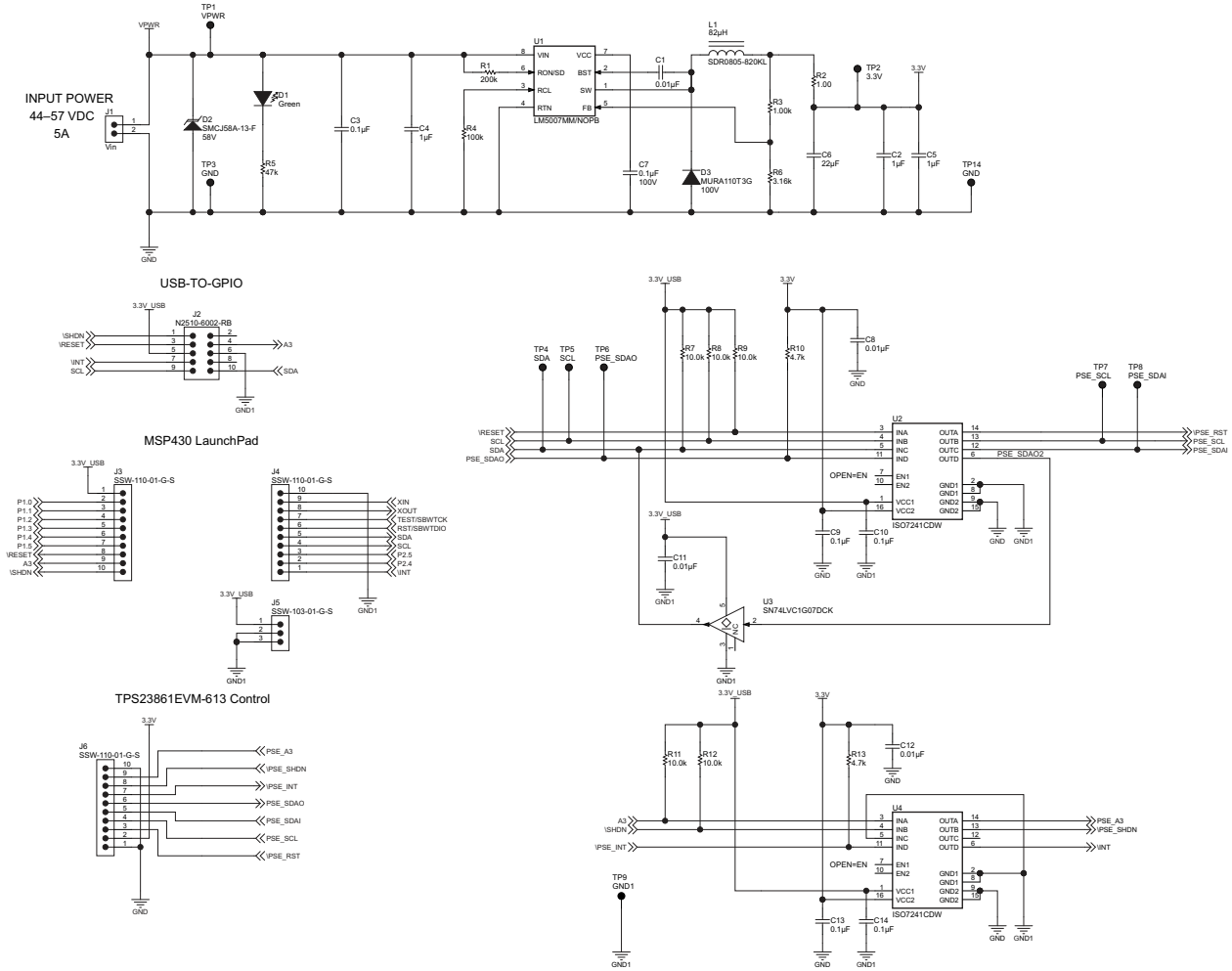


**Figure 36. TPS23861EVM-612 (Motherboard) Schematic: Control**

## Revision History

| Changes from Original (March 2014) to A Revision | Page |
|---|---|
| • Added bullet 4 to the *Features*. | 3 |
| • Changed 48-VDC to just DC, globally. | 3 |
| • Added a paragraph to the end of the *Input Power* subsection. | 3 |
| • Changed third sentence in *Input Power (Labeled VPWR)* to a Caution. | 3 |
| • Changed last paragraph in *Input Power (Labeled VPWR)*. | 3 |
| • Added current consumption information to the end of the *Local 3.3 V (Labeled 3.3V)* subsection. | 3 |
| • Changed sentence to a Caution in *External 3.3 V (Labeled 3.3V_USB)*. | 4 |
| • Changed content of first paragraph of *Basic Test Setup (Out-of-the-box Auto-Mode Operation)*. | 5 |
| • Added *TPS23861EVM-612 PI Commander GUI Setup* section. | 10 |

## Revision History

| Changes from A Revision (June 2014) to B Revision | Page |
|---|---|
| • Changed n'ame on pin 18 to KSENSA on the daughterboard schematic. | 28 |

## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from B Revision (June 2014) to C Revision | Page |
|---|---|
| • Changed text in *Local 3.3 V (Labeled 3.3V)* section and changed part number. | 3 |
| • Added table note on *EVM Jumpers* table and changed labels column from P0–P7 to P1–P8. | 9 |
| • Changed path for PI Commander start instructions. | 10 |
| • Changed *TPS23861EVM-612 (Motherboard) Schematic: Control* to Rev. B. | 26 |
| • Changed PCB Motherboard images, figures 24–28. | 29 |
| • Changed BOM for PWR612B revision. | 34 |
| • Added appendix C. | 37 |

## Revision History

| Changes from C Revision (November 2015) to D Revision | Page |
|---|---|
| • Added section *MSP430 Reference Code* | 20 |

## Revision History

| Changes from D Revision (November 2016) to E Revision | Page |
|---|---|
| • Replaced Figure 24 | 26 |
| • Replaced Figure 25 | 27 |
| • Replaced Figure 26 | 28 |

# STANDARD TERMS FOR EVALUATION MODULES

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   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      **FCC NOTICE:** This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      **CAUTION**

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      **FCC Interference Statement for Class A EVM devices**

      *NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

**FCC Interference Statement for Class B EVM devices**

*NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

**Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

**Concernant les EVMs avec appareils radio:**

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

**Concerning EVMs Including Detachable Antennas:**

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

**Concernant les EVMs avec antennes détachables**

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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