## **TI Designs** Wi-Fi Link for Energy Monitoring

# Texas Instruments

### **TI Designs**

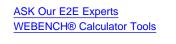
TI Designs provide the foundation that you need including methodology, testing and design files to quickly evaluate and customize the system. TI Designs help you accelerate your time to market.

### **Design Resources**

TIDC-WIFI-METER- READING	Design Folder
MSP430i2040	Product Folder
CC3200MOD	Product Folder
UN2003LV	Product Folder
<u>UCC28910</u>	Product Folder
TIDM-3OUTSMTSTRP	Tools Folder



Product Folder Product Folder Product Folder Product Folder **Tools Folder** 

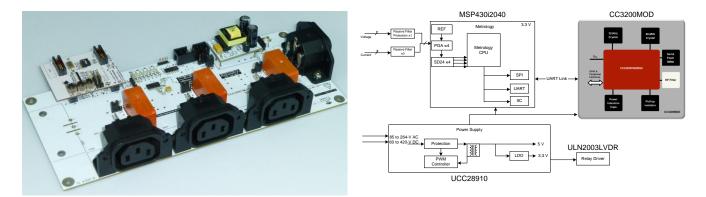


### **Design Features**

- Reading of Energy Monitor's Parameters With Wi-Fi® Link
- Control Relay Switch Over Wi-Fi Link
- Interface to Energy Monitoring Device Through UART

### **Featured Applications**

- Utility Energy Monitoring
- Industrial Embedded Energy Monitoring
- Home Automation
- Home Security
- Appliances





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### 1 System Description

### 1.1 Cautions and Warnings

This TI design operates the hardware powered directly from AC supply; therefore, only professionals who received appropriate technical training should operate the hardware.

Before operating the hardware, read the safety related documents that come with the user's guide before operating the hardware.











CAUTION

Read the user's guide before use.

CAUTION

Do not leave the EVM powered when unattended.

### CAUTION

HOT SURFACE: Contact may cause burns. Do not touch.

#### CAUTION

HIGH VOLTAGE: Electric shock is possible when connecting the board to a live wire. The board should be handled with care by a professional. For safety, use isolated equipment with overvoltage and overcurrent protection.



### 1.2 System Description

This design guide discusses an application that reads an energy monitor device over a Wi-Fi link. This design uses the Texas Instruments CC3200MOD and MSP430i2040 as the development platform for communication and electrical metering, respectively. Starting from the TI Design TIDM-3OUTSMTSTRP as the metering data source, a communication board designed using the CC3200MOD is added for Wi-Fi communication. The metering data can then be read and the relay can be controlled by using a browser.

This guide explains the process of coding the CC3200 to add the communication to the TIDM-3OUTSMTSTRP.

### 1.3 MSP430i2040 — 16-Bit Mixed Signal Microcontroller

The MSP430i2040 is used in this design as the metrology processor. Its four 24-bit sigma-delta analog-todigital converters (ADCs) allow accurate energy measurements, providing read of voltage, current, power (active, reactive, apparent), power factor, and frequency of three AC outlets. The MSP430i2040 requires only a few passive external components to interface directly to the voltage divider and current shunt for voltage and current measurements.

#### 1.4 CC3200 — SimpleLink™ Wi-Fi CC3200 Internet-on-a-Chip™ Wireless MCU Module

The CC3200MOD is used in this design as the Wi-Fi controller that integrates an ARM® Cortex<sup>™</sup>-M4 MCU, allowing customers to develop an entire application with a single device. With on-chip Wi-Fi, Internet, and robust security protocols, no prior Wi-Fi experience is required for faster development.



Block Diagram

### 2 Block Diagram

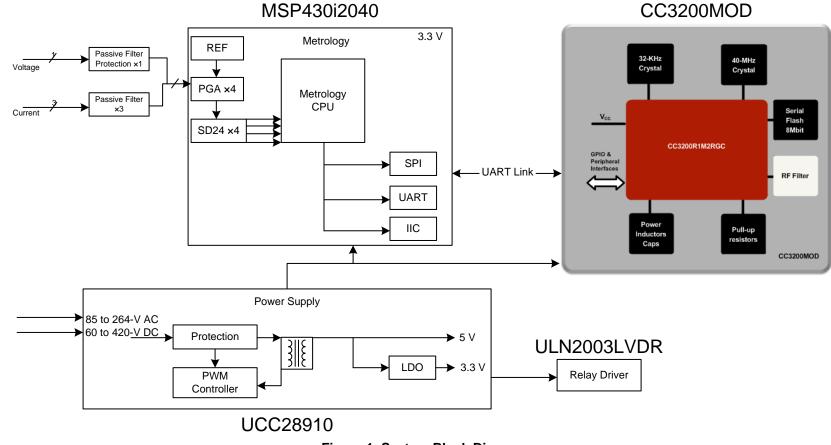


Figure 1. System Block Diagram



### 2.1 Highlighted Products

### 2.1.1 MSP430i2040 — 16-Bit Mixed Signal Microcontroller

- Supply voltage range: 2.2 to 3.6 V
- 16-bit RISC architecture, up to 16.384-MHz system clock
- Memory
  - Up to 32KB of Flash main memory
  - 1KB of Flash information memory
  - Up to of 2KB of RAM
- Clock system
  - 16.384-MHz internal DCO
  - DCO operation with internal or external resistor
  - External digital clock source
- Up to four 24-bit sigma-delta ADCs with differential PGA inputs
- Two 16-bit timers with three capture/compare registers each
- Enhanced universal serial communication interfaces (eUSCIs)
  - eUSCI\_A0
    - Enhanced UART with automatic baud-rate detection
    - IrDA encoder and decoder
    - Synchronous SPI
  - eUSCI\_B0
    - Synchronous SPI
    - I<sup>2</sup>C
- 16-bit hardware multiplier

### 2.1.2 CC3200 — SimpleLink Wi-Fi CC3200 Internet-on-a-Chip Wireless MCU Module

- Consists of the CC3200R1M2RGC single-chip wireless MCU and all required clocks, SPI flash, and passives.
- Modular FCC, IC, and CE certifications save customer effort, time, and money
- Wi-Fi certified modules, with ability to request certificate transfer for Wi-Fi alliance members
- 1.27-mm pitch LGA package for easy assembly and low-cost PCB design
- Efficient code size architecture, placing drivers, *Bluetooth*® low-energy controller, IEEE 802.15.4 MAC, and Bootloader in ROM

5

Block Diagram



Block Diagram

### 2.1.3 UCC28910, UCC28911 High-Voltage Flyback Switcher

- Constant-voltage (CV) and constant-current (CC) output regulation without optical coupler
- ±5% output voltage regulation accuracy
- ±5% output current regulation with AC line and primary inductance tolerance compensation
- 700-V start-up and smart power management enables <30-mW standby power
- 115-kHz maximum switching frequency design for high-power density
- Valley switching and frequency dithering to ease EMI compliance
- Thermal shutdown
- Low line and output overvoltage protection

### 2.1.4 ULN2003LV 7-Channel Relay and Inductive Load Sink Driver

- 7-channel high current sink drivers
- Supports up to 8-V output pullup voltage
- Supports a wide range of 3- to 5-V relay and inductive coils
- Low output  $V_{OL}$  of 0.4 V (typical) with
  - 100-mA/140-mA (typical) current sink per channel at 3.3-V/5.0-V logic input
- Compatible to 3.3-V and 5.0-V MCUs and logic interface
- Internal free-wheeling diodes for inductive kick-back protection
- Input pulldown resistors allows 3-stating the input driver
- Input RC-snubber to eliminate spurious operation in noisy environments
- Low input and output leakage currents
- Easy-to-use parallel interface
- ESD protection exceeds JESD 22: 2-kV HBM, 500-V CDM
- Available in 16-Pin SOIC and TSSOP packages



### 3 System Design Theory

### 3.1 Metering

This TI Design uses the MSP430i2040 as the metrology processor. The TI Design TIDM-3OUTSMTSTRP is used as the platform of the metering part. The hardware and firmware are slightly modified to add relay control alighted to zero crossing. Find details on the hardware and firmware of the TIDM-3OUTSMTSTRP in its TI Design folder; the modification to hardware is discussed in Section 4.

**NOTE:** The software package includes the modified firmware with the source code (except the metrology source code, which is only provided upon request). Please contact a local sales office for details on obtaining the metrology source code.

### 3.2 Metering Data Access

This TI Design uses the HTTP Web Server on the CC3200 transfer data from the MSP430i2040 metering hardware. This transfer allows metering data to be accessed using a web browser on any platform.

The HTTP server listens on the HTTP socket (default to 80) then handles the request (HTTP GET or HTTP POST) by retrieving the web page files from the serial flash. The server then calls to an HTTP event handler to operate on the variable contents. It then composes an HTTP response and sends back to the client over the Wi-Fi link.

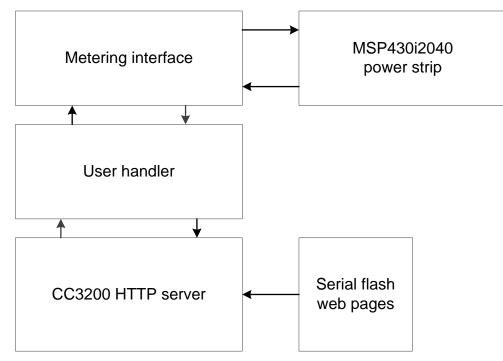


Figure 2. Metering Data Access



### 3.3 Handling Dynamic Data Items

To allow the metering data to be read with an HTML file with dynamic contents, the HTTP web server supports a set of predefined tokens, which will be replaced on-the-fly by the server, with dynamically generated content. Some tokens are predefined in the HTTP server with additional tokens that can be defined in user application.

The HTTP server scans the HTML page for the "\_\_SL\_G\_" prefix. If the server finds a prefix, it checks the complete token. Once it matches a known token, it replaces the token in the HTML with the appropriate data (string) that matches that token. If the token is not in the predefined list, the server generates a get\_token\_value asynchronous event with the token name. This request eventually calls to the HTTP event handler in the main.c code file. The handler then interprets the token and responds to the token value with a send\_token\_value. The HTTP web server uses this token value and returns it to the client.

To send data from client to the HTTP server, the server will check for the "\_\_SL\_P\_" prefix. Then the server goes over the parameters list and checks each variable name to see if it matches one of the known predefined tokens. If the variable names match the predefined tokens, the server processes the values. If the HTTP web server receives an HTTP POST request that contains tokens not in the predefined list, the server generates a post\_token\_value asynchronous event to the host, which contains the following information: form action name, token name, and token value. The host can then process the required information.

#### 3.4 Implementation of HTTP Event Handler

According to Section 3.3, the HTTP event handler is implemented. To facilitate dynamic data, the userdefined token is defined for the set of data to be retrieved:

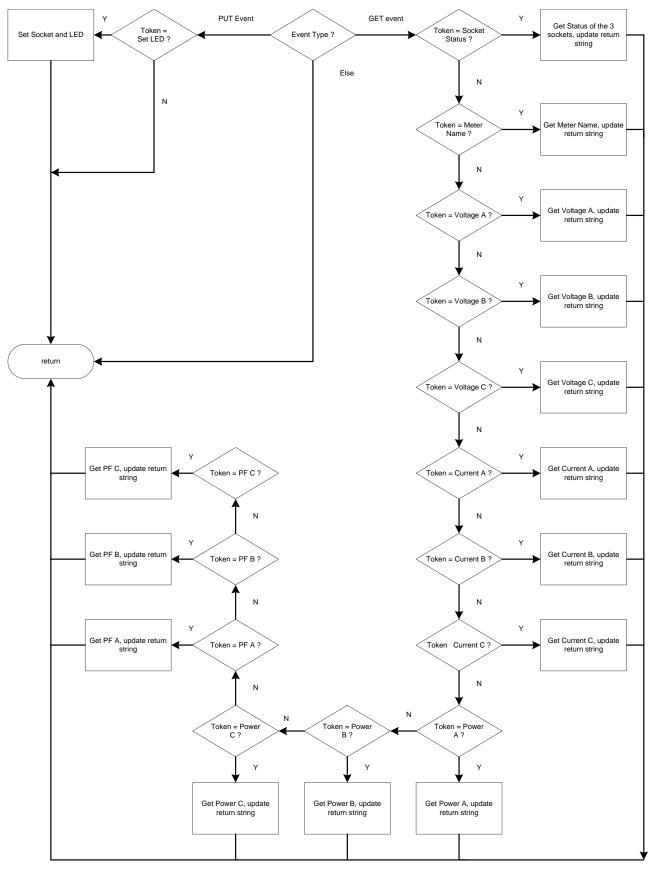
User defined tokens:

- \_SL\_G\_SST: Get Socket Status
- \_\_SL\_G\_VSA: Get Socket A Voltage
- \_\_SL\_G\_VSB: Get Socket B Voltage
- \_\_SL\_G\_VSC: Get Socket C Voltage
- \_\_SL\_G\_ISA: Get Socket A Current
- \_\_SL\_G\_ISB: Get Socket B Current
- \_\_SL\_G\_ISC: Get Socket C Current
- \_\_\_SL\_G\_PSA: Get Socket A Active Power
- \_\_\_SL\_G\_PSB: Get Socket B Active Power
- \_\_\_\_SL\_G\_PSC: Get Socket C Active Power
- \_\_SL\_G\_PFA: Get Socket A Power Factor
- \_\_\_SL\_G\_PFB: Get Socket B Power Factor
- \_\_\_SL\_G\_PFC: Get Socket C Power Factor
- \_\_\_SL\_G\_H.D: Get Meter Name
- \_\_\_\_SL\_P\_ULD: Set Socket Status

The HTTP event handler first checks for the type of event; in this application, only SL\_NETAPP\_HTTPGETTOKENVALUE\_EVENT and SL\_NETAPP\_HTTPPOSTTOEKNVALUE\_EVENT need to be handled. The process of the handling is illustrated in Figure 3.



System Design Theory





### 4 Getting Started: Hardware

### 4.1 TIDM-3OUTSMTSTRP Hardware Modification

#### 4.1.1 Power Supply Circuit

The TIDM-3OUTSMTSTRP LDO circuit requires minor modifications to allow for more current to supply the 3.3-V rail for driving the Wi-Fi block.

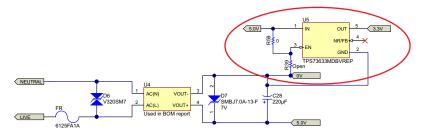


Figure 4. TIDM-3OUTSMTSTRP Hardware Modification

Change the LDO to TPS73633DBVREP . As this LDO is high enabled, the 0- $\Omega$  resistor R39 should be opened and R59 should be added to connect pin3 to 5.0 V instead.

In addition to the LDO, replace the original power supply block to provide a more reliable relay operation, although the block power supply in the original TIDM-3OUTSMTSTRP is sufficient to drive the whole circuit.

Figure 5 shows the power supply design. This design is laid out with the same footprint as the original power supply block (see Section 8 for detail of the layout) for drop in replacement.

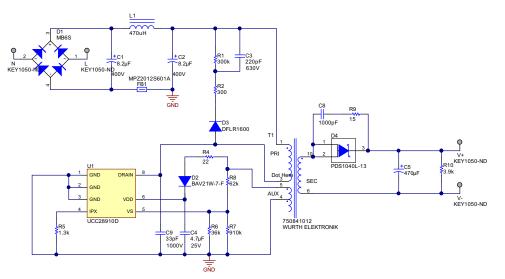


Figure 5. 5-V Power Supply Block Schematic

#### 4.1.2 Protection Circuit

Remove the following protection diodes (MOV) from the TIDM-3OUTSMTSTRP board: D11, D12, D2A, D2B, D2C, D3A, D3B, and D3C.

#### 4.2 Wi-Fi Module

The Wi-Fi module is designed using the CC3200MOD to facilitate attaching to the communication connector on the TIDM-3OUTSMTSTRP board while providing the debugging and programming facility for the CC3200. For details about the design of the Wi-Fi module, see Section 8.



### 5 Getting Started: Firmware

After the hardware is connected, download the firmware to its corresponding hardware.

### 5.1 Loading Firmware to Wi-Fi Module

### 5.1.1 Prerequisites

To debug with the CC3200MOD or to download the firmware to the flash memory on CC3200MOD, the user needs:

- CC3200-LAUNCHXL or CC3200MODLAUNCHXL
- Code Composer Studio<sup>™</sup> (CCS) Uniflash for CC3100/CC3200 installed on PC
- CCS 6.0.1 installed on PC
- Example code package unzipped and the folder "httpserver-powerstrip" copied into the cc3200dsk example folder (located as default in C:\ti\CC3200SDK\_1.0.0\cc3200-sdk\example\)
- Example code project imported to CCS and built

### 5.1.2 Connecting Board for Programming

On the CC3200-LAUNCHXL:

- 1. Disconnect the jumpers as indicated in Figure 6.
- 2. Locate the pins on J1 and J2 of the Wi-Fi module (Figure 7).
- 3. Connect the pins with a blue dot to the correspondingly labeled pin on the Wi-Fi module (Figure 6 and Figure 7).

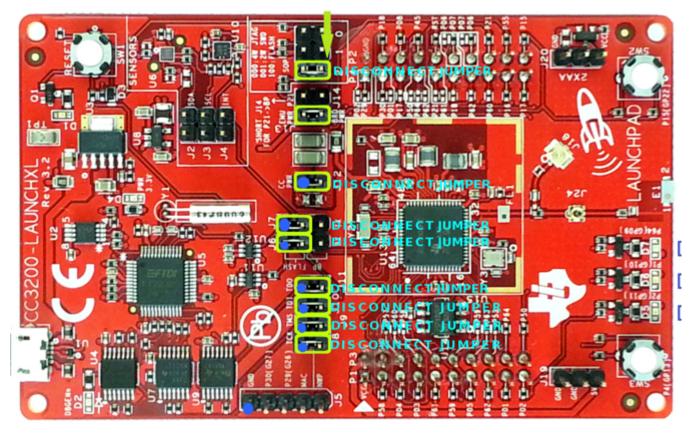


Figure 6. CC3200-LAUNCHXL Jumper Preparation for Connection to Wi-Fi Module



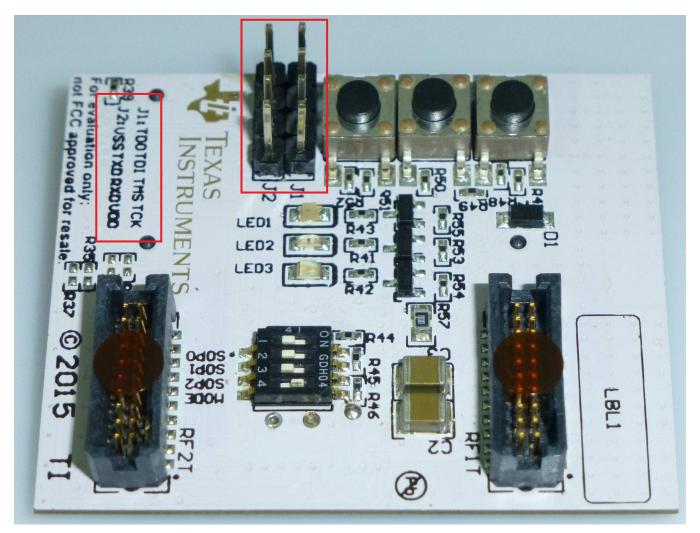


Figure 7. Locate Pins on Wi-Fi Module



### 5.1.3 Programming

Once connected as described in Section 5.1.2, set the Wi-Fi module to programming mode by switching the SOP2 DIP switch on the Wi-Fi module to the ON position. Then:

- 1. Connect to the USB on PC with a USB cable to the micro-USB port on the CC3200-LAUNCHXL.
- 2. Launch CCS UniFlash for CC3100/CC3200 on PC.
- 3. Click on File  $\rightarrow$  Open Configuration.

🖡 CCS UnFlash	
File Window Help	
New Configuration     Open Configuration     Save Configuration As     Exit	Quick Start Guide:         New Target Configuration 1 to start a session, you will need a target configuration which specifies your connection and target device. You can create a new target configuration to start a session.         Open Target Configuration 1 Or, you can also open an existing target configuration to start a session.         Once the session is configured, the GUI will be populated. Here you can customize the settings to your flash operation, and carry out flash load and erase operations.         Recent Sessions:         CMM_CC32005DK.1.0.0/.cc3200-skk/example/httpserver-powentrip/htm/httpserver-powentrip.ucf         CMM_CC32005DK.cc3200-skk/example/httpserver-powentrip/htm/httpserver.ucf         CMM_CC32005DK.cc3200-skk/example/httpserver-powentrip/htm/httpserver.ucf         CMM_CC32005DK.cc3200-skk/example/httpserver-powentrip/htm/httpserver.ucf         CMM_CC32005DK.cc3200-skk/example/httpserver.powentrip/htm/httpserver.ucf         CMM_CC32005DK.cc3200-skk/example/httpserver.powentrip/htm/httpserver.ucf         CMM_CC32005DK.cc3200-skk/example/httpserver.powentrip/htm/httpserver.ucf
Console 38 No consoles to display at this time.	

### Figure 8. CCS UniFlash Open Configuration

4. Locate the configuration file "httpserver-powerstrip.ucf" (usually located in C:\ti\CC3200SDK\_1.0.0\cc3200-sdk\example\httpserver-powerstrip\html).



#### Getting Started: Firmware

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5. When the screen shown in Figure 9 appears, put the correct COM port number of the LAUNCHXL board connected to the "COM Port" box.

CCS UniFlash - C1th/CC32005DK_1.0.0kc3200-sdk/example/httpsen	ver-powerstripl/html/httpserver-powerstrip.ucf	×
File Operation Window Help		
Type your filter text here CC31xx/CC32xx Flash Setup and Control	CC31xx/CC32xx Flash Setup and Control	
<ul> <li>System Files         /sys/mouimg.bin</li> </ul>	COM Port:	
/cet/capem /cet/client.pem /cet/private.key	Format - Format the serial flash on the target device.	
User Files     /www/main.html	Program Program the serial flash on the target device.	
/www.fled_demo.html /www.fimages/demo-lightswitch.jpg /www.fReadings.html	Service Pack Programming         - Apply a service pack bundle to the device (Available for download here.)           Get Version         - Display the bootloader version on the device.	
/www.finter.html	Add File • Add a new file to the session file list.	
Station AP		
P2P Profiles HTTP Server		
DHCP Server mDNS Client		
Smart Config		
Console 31		년 월 <b>- 13 - 7 8</b>
No consoles to display at this time.		

Figure 9. CCS UniFlash Screen After Configuration File Loaded

- 6. If this is the first time the board is being programmed, click "Format". Otherwise, go to Step 12.
- 7. When prompted to reset the device, push the button S1 once on the Wi-Fi module.
- 8. Wait for process to finish with the prompt "Operation Format returned".
- 9. Click on "Service Pack Programming" and locate the service pack bin file when prompted (located as default in C:\ti\CC31xx\_CC32xx\_ServicePack\_1.0.0.1.1\servicepack\_1.0.0.1.1.bin).
- 10. When prompted to reset the device, push the button S1 once on the Wi-Fi module.
- 11. Wait for the process to finish with the prompt "Operation ServicePackProgramming returned".
- 12. Click on "Program" to start programming.
- 13. When prompted to reset the device, push the button S1 once on the Wi-Fi module.
- 14. Wait for the process to finish with the prompt "Operation Program returned".
- 15. Disconnect the Wi-Fi module and set SOP2 on the Wi-Fi board to the OFF position.

The Wi-Fi module is now programmed with the demo code and ready for use.



### 5.2 Loading Firmware to TIDM-3OUTSMTSTRP

Perform the following steps to download the firmware to the TIDM-3OUTSMTSTRP hardware. Use an MSP-FET430UIF MSP430 USB-Debug-Interface to perform the download.

- 1. Do not connect the Wi-Fi module to the metering board at this stage to program the TIDM-3OUTSMTSTRP board.
- 2. Connect the MSP-FET430UIF to P1 of the TIDM-3OUTSMTSTRP and have J8 with position 1-2 shorted with a jumper. C21 may need to be removed temporarily for programming.
- 3. If Elprotronic FET-Pro-430 Lite is installed on PC, go to Step 7.
- 4. Go to https://www.elprotronic.com/productdata to download the FET-Pro-430 Lite Software.
- 5. Unzip the downloaded file and run setup.exe.
- 6. Follow the instructions to complete the install.
- 7. Launch FET-Pro-430 Lite.
- 8. Update the firmware if prompted for the MSP-FET430UIF Firmware Update.
- 9. Click on "Open Code File" and select "emeter-app-i2041.d43" inside the install folder of this design. Then check the settings in the boxes Microcontroller Type, Power Device from Adapter, and Device Action as shown in Figure 10.
  - **NOTE:** To modify code, use IAR 5.52 to compile the project "emeter-app-i2040". A compilation of "emeter-metrology-i2040" and "emeter-toolkit-i2040" is *not required*. The library code of this project is already provided. Contact a local Texas Instruments Sales office if the source code for emeter-metrology-i2040 is required.

🔚 FET-Pro430 (FET MSP430 Flash Programmer) - Elprotronic Inc.		and a la <b>X</b>
File View Setue Entertain Tools Mout/Help		
Open Code File -> emeter-app-i2041.d43 path:	D:\Users\a0283112\Desktop\	Blow Security Fuse
SN File		Enable
	Power, Device from Adapte.	BLOW FUSE
Microcontroller Type	<mark> 3.3∨</mark>	Device Action
Group: MSP430i2x Pass	POWER ON/OFF	🧧 Reload Code File
MSP430i2041		🗖 Enable Blank Check
Target MSP430i2041 Balance: 0		AUTO PROG.
BSL: ver. 0.00	Check Sum	
Selected Device Information	Source: 0x072D5903	Verify Security Fuse
RAM - 2048 bytes; FLASH - 32 kB;	Memory:	ERASE FLASH
Report		
Reading Code File	Device Serialization	BLANK CHECK
0000 322 000000 (10100) bytes		WRITE FLASH
	Read SN	
	Next Model-Group-Revision:	WRITE SN / Model
	Next SN: 00000000	
	Format yyyy1234	READ / COPY
Port: USB Automatic	Erase / Write memory option:	
Spy-Bi-Wire (2-wires)	*All Memory*	- READ / COPY
		NEXT (F5)

Figure 10. TIDM-3OUTSMTSTRP Programming Setup



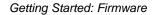
#### Getting Started: Firmware

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10. Click "READ/COPY" to copy the original code. When the Flash Memory Data window appears, click the "Copy" button, paste the data to an open notepad application, and save it as a text file named "original.txt". Use this file to restore the code to original in case of any errors.

Open Code File -> emeter-app-i2041.d43 p	path: C:\Users\a0283112\Desktop\	Blow Security Fuse
SN File	Power Device from Adapter	T Enable BLOW FUSE
Microcontroller Type Status Status MSP430i2041 Target: MSP430i2041 BSL: ver. 0.00 Selected Device Information RAM - 2048 bytes; FLASH - 32 kB;	3.3V     Device Voltage       POWER ON/OFF     Image       RESET     Image       Check Sum     Source:       0x072D5903       Memory:	Device Action
eport eading Code File done Code size = 0x3385 (13189) bytes	Device Serialization Read SN	BLANK CHECK
	Next Model-Group-Revision: Next SN: 00000000 Format: yyyy1234	READ / COPY
Port: USB Automatic	Erase / Write memory option:	
Spy-Bi-Wire (2-wires)	* All Memory *	- READ / COPY

Figure 11. Read Original Firmware





```
X
Flash Memory Data
  Addr: 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E OF <--- Ascii ---->
                                                                    1
   === Information Memory Segments 0x1000 - 0x13FF ======
                                                                   E
   0x1000:
              ----- b l a n k ---- (all 0xFF)------
  0x13B0:
             ----- b l a n k ---- (all 0xFF)------
  0x13C0: E1 D3 01 0A FF 02 02 | .....
  0x13D0: 00 3F 03 04 82 C0 6B 00 04 02 0C FF FE 22 FF FF | .?...k....."..
  0x13E0:
             ----- b l a n k ---- (all 0xFF)------
   ======= Main Memory Segments 0x8000 - 0xFFFF ======
  0x8000:
              ----- b l a n k ---- (all 0xFF)------
  0xC000: FF FF 00 00 00 00 70 64 08 00 0E 00 B4 3F 54 31
                                                    .....pd....?T1
   0xC020: 0E 00 67 40 F3 31 F0 FF 00 00 00 00 A4 5E 00 00 |
                                                    ...g@.1.....^..
   0xC030: 00 00 70 64 08 00 0E 00
                              03 3F CF 30 F0 FF 00 00 |
                                                    ..pd....?.0....
  0xC050:
              ----- b l a n k ---- (all 0xFF)----
  0xC400: FF 7F 06 20 11 7C 86 20 41 78 06 21 8E 74 86 21 | .I. . |. Ax. I.t.!
                                                    .p."zm.".j.#.f.#
  0xC410: F6 70 06 22 7A 6D 86 22 16 6A 05 23 CC 66 85 23 |
  0xC420: 98 63 05 24 7B 60 85 24
                              73 5D 05 25 80 5A 85 25
                                                    .c.${`.$s].%.Z.%
  0xC430: A1 57 05 26 D5 54 85 26 1B 52 04 27 73 4F 84 27
                                                    .W.&.T.&.R.'80.'
  0xC440: DC 4C 04 28 55 4A 84 28 DE 47 04 29 76 45 84 29
                                                    .L.(UJ.(.G.)vE.)
   0xC450: 1D 43 04 2A D2 40 83 2A
                              94 3E 03 2B 64 3C 83 2B
                                                    .C.*.@.*.>.+d<.+
                             1D 36 03 2D 1D 34 83 2D |
  0xC460: 40 3A 03 2C 29 38 83 2C
                                                    @:.,)8.,.6.-.4.-
             TI hex (*.txt)
                             INTEL (*.hex)
                                             Copy
                                                     Notepad
                                                              Exit
  Skip blank
```

Figure 12. Flash Memory Data Window; Copy and Save Original Firmware



#### Getting Started: Firmware

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11. Close the Flash Memory Data window and click on "AUTO PROG". FET-Pro430 (FET MSP430 Flash Programmer) - Elprotronic Inc. File View Setup Serialization Tools About/Help

Open Code File       →       emeter-app-i2041.d43       path:         SN File	C:\Users\a0283112\Desktop\ Power Device from Adapter 3.3 V V Device Voltage POWER ON/OFF RESET Check Sum Source: 0x072D5903 Memory:	Blow Security Fuse  Enable  BLOW FUSE  Device Action  Reload Code File  Enable Blank Check  AUTO PROG.  Verify Security Fuse  ERASE FLASH  BLANK OUTOR
Reading Code Filedone done - Code size = 0x3385 (13189) bytes	Device Serialization     Read SN     Read SN     Next Model-Group-Revision:     Next SN: 00000000     Format yyyy1234	BLANK CHECK       WRITE FLASH       WRITE SN / Model       VERIFY FLASH       READ / COPY
Port: USB Automatic Spy-Bi-Wire (2-wires)	Erase / Write memory option: *All Memory*	NEXT (F5)

Figure 13. Start Firmware Programming



12. It will prompt the window shown in Figure 14. Check that everything else is okay except for "Verifying Flash Memory".

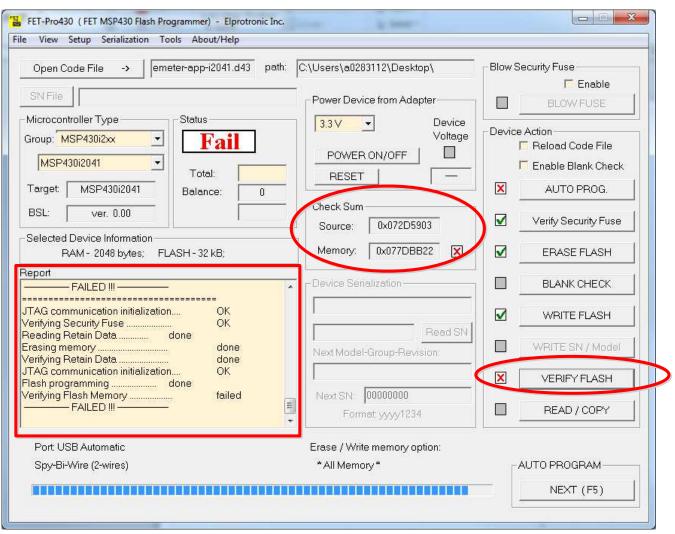


Figure 14. Note Failure on Verify and Confirm Check Sum



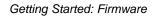
Getting Started: Firmware

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13. Click on View → Compare Code File and Flash Data. Select "Yes" when prompted to read the data from the device first. Check for "==== No differencies found. ====" on the last line of the Comparation Code and Flash Memory Data window (see Figure 16).

Verifying Flash Memory     failed       FAILED III     Format: yyyy1234	ANK CHECK RITE FLASH TE SN / Model RIFY FLASH EAD / COPY
Port: USB Automatic Erase / Write memory option:	

Figure 15. Perform Direct Code Comparison to Verify Written Firmware





Addr:	00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E OF < Ascii -	>
	<pre>: ====================================</pre>	^
-	: ==== No differencies found. ====	
		-

Figure 16. Comparation Code and Flash Memory Data Window

This completes the firmware programming of the TIDM-3OUTSMTSTRP.



#### Getting Started: Firmware

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14. After the code is downloaded onto both boards, the application is ready to run. Put the Wi-Fi module onto the communication connector of the TIDM-3OUTSMTSTRP board. Set the jumpers as shown in Figure 17 and set DIP switch 4 on the Wi-Fi module to the ON position.

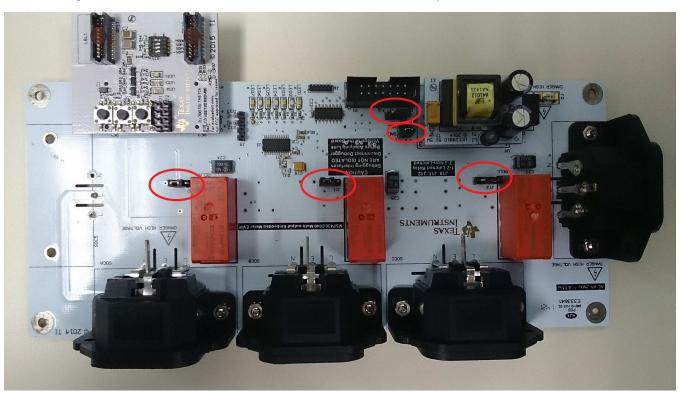


Figure 17. TIDM-3OUTSMTSTRP Board Jumper Settings



### 6 Test Setup

To test the design, set up the hardware loaded with the firmware as described in Section 4 and Section 5. Then apply AC voltage to the AC input of the power strip. The LEDs on the TIDM-3OUTSMTSTRP will light up; the LED on the Wi-Fi should flash as well.

To start testing, use a smartphone, tablet, or PC with Wi-Fi. Look for the SSID "mysimplelink-XXXXX" (where "XXXXXX" is a six-digit hexadecimal number) and connect to it. Launch a browser and type in the URL "mysimplelink.net".

The main page will be shown with the name of the meter in the upper left hand corner (which is "MSP430i2040 3 SOCKET POWER STRI"). Then click on "Reading" so the following screen will appear:

0 days 00:01:15		Socket B	Socket C	
Vrms Irms	0.000594 A	223.235000 V 0.000864 A		
Active Power Power Factor	-0.014000 W		-0.011000 W	
Switch	ON	ON	ON	

Figure 18. Meter Reading Screen

### 7 Test Data

### 7.1 Reading Test

The voltage, current, active power, and power factor on each socket can be read from the displayed page and is updated periodically (five-second intervals). Note if proper calibration is not done with the metering hardware, the reading may not be accurate. To calibrate, follow the instructions in the TIDM-30UTSMTSTRP user's guide.

### 7.2 Control Test

The power output to each socket can be controlled by clicking "ON" and "OFF" of the switches on the page.



Design Files

### 8 Design Files

### 8.1 Schematics

To download the schematics, see the design files at <u>TIDC-WIFI-METER-READING</u>.

### 8.1.1 Metering Board

To download the schematics for the metering board, see the design files at <u>TIDM-3OUTSMTSTRP</u>.



Design Files

8.1.2 Wi-Fi Module

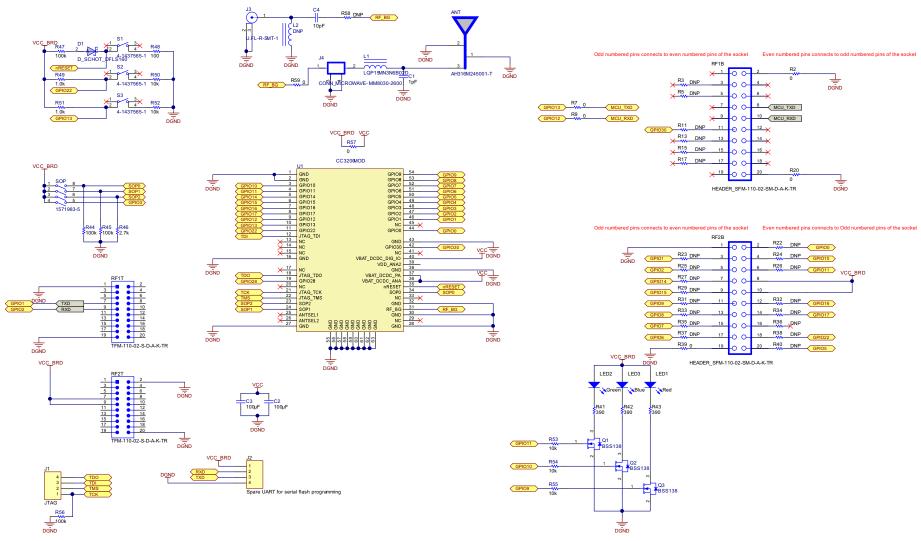


Figure 19. Schematic of Wi-Fi Module



Design Files

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### 8.1.3 Power Supply Module

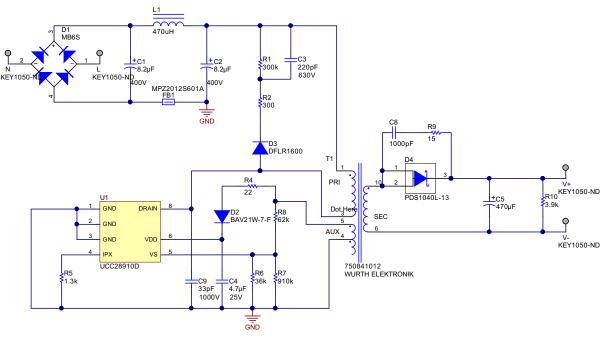


Figure 20. Schematic of Power Supply Module



### 8.2 Bill of Materials

To download the bill of materials (BOM), see the design files at <u>TIDC-WIFI-METER-READING</u>.

### 8.2.1 Metering Board

To download the BOM for the metering board, see the design files at <u>TIDM-3OUTSMTSTRP</u>.

### 8.2.2 Wi-Fi Module

ITEM	QTY	DESIGNATOR	VALUE	DESCRIPTION	MANUFACTURER	PARTNUMBER	FOOTPRINT
1	1	!PCB		Printed Circuit Board	Any	TIDM- CC3200MOD_CONV	
2	1	ANT	2.45-GHz Ant	Chip antenna	Taiyo Yuden	AH316M245001-T	AH316M
3	1	C1	1pF	CAP, CERM, 1 pF, 50 V, +/- 10%, C0G/NP0, 0402	MuRata	GRM1555C1H1R0BA0 1D	0402
4	2	C2, C3	100uF	CAP, CERM, 100 µF, 6.3 V, +/- 20%, X5R, 1210	MuRata	GRM32ER60J107ME2 0L	1210
5	1	C4	DNP	CAP, CERM, 10 pF, 50 V, +/- 5%, C0G/NP0, 0402	MuRata	GRM1555C1H100JA01 D	0402
6	1	D1	DFLS160	Diode, Schottky, 1A, 60V	Diodes	DFLS160	POWERDI_123
7	1	J1		Header, 4-Pin		3-644456-4	HDR1X4
8	1	J2		Header, 4-Pin		3-644456-4	HDR1X4
9	1	J3		Connector, Ultra-Mini Coaxial, SMD	Hirose Electric Co. Ltd.	U.FL-R-SMT-1	CONN_UFL-R-SMT- 1
10	1	J4	MM8030-2600RJ3	Connector, Micrwave, 50 Ohm Coax	murata	MM8030-2600RJ3	CONN_MICRO- MM8030-2600
11	1	L1	3.6nH	Inductor, Film, 3.6 nH, 0.1 A, 1.3 ohm, SMD	MuRata	LQP15MN3N6B02D	LQP_0402
12	1	L2	DNP	Inductor, Film, 3.6 nH, 0.1 A, 1.3 ohm, SMD	MuRata	LQP15MN3N6B02D	LQP_0402
13	1	LBL1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Brady	THT-14-423-10	Label_650x200
14	1	LED1		Red	Liteon	LTST-C170KRKT	0805-LED
15	1	LED2		Green	Liteon	LTST-S220KGKT	0805-LED
16	1	LED3		Blue	Liteon	LTST-C170TBKT	0805-LED
17	3	Q1, Q2, Q3	50V	MOSFET, N-CH, 50 V, 0.22 A, SOT-23	Fairchild Semiconductor	BSS138	SOT-23
18	6	R2, R7, R9, R20, R39, R59	0	RES, 0, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04020000Z0ED	0402

#### Table 1. Wi-Fi Module BOM



Design Files

### Table 1. Wi-Fi Module BOM (continued)

ITEM	QTY	DESIGNATOR	VALUE	DESCRIPTION	MANUFACTURER	PARTNUMBER	FOOTPRINT
19	23	R3, R5, R11, R13, R15, R17, R22, R23, R24, R25, R26, R27, R29, R31, R32, R33, R34, R35, R36, R37, R38, R40, R58	DNP	RES, DNP, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04020000Z0ED (Phantom)	0402
20	3	R41, R42, R43	390	RES, 390, 5%, 0.063 W, 0402	Vishay-Dale	CRCW0402390RJNED	0402
21	4	R44, R45, R47, R56	100k	RES, 100 k, 5%, 0.063 W, 0402	Vishay-Dale	CRCW0402100KJNED	0402
22	1	R46	2.7k	RES, 2.7 k, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04022K70JNED	0402
23	1	R48	100	RES, 100, 5%, 0.063 W, 0402	Vishay-Dale	CRCW0402100RJNED	0402
24	2	R49, R51	1.0k	RES, 1.0 k, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04021K00JNED	0402
25	5	R50, R52, R53, R54, R55	10k	RES, 10 k, 5%, 0.063 W, 0402	Vishay-Dale	CRCW040210K0JNED	0402
26	1	R57	0	RES, 0, 5%, 0.125 W, 0805	Vishay-Dale	CRCW08050000Z0EA	0805_HV
27	2	RF1B, RF2B	SFM-110-02-SM-D-A- K-TR	Header, SMT 10X2 pin, Shrouded	Samtec	SFM-110-02-SM-D-A- K-TR	HEADER_TFM-110- 02-SM
28	2	RF1T, RF2T		CONN SHRD HDR HDR 20 POS 1.27MM SLDR ST SMD	Samtec	TFM-110-02-S-D-A-K- TR	Samtec_TFM-110- 02-S-D-A-K
29	3	S1, S2, S3		Switch, Tactile, SPST-NO, 0.05A, 12V, SMT	TE Connectivity	4-1437565-1	SW_FSM4JSMA
30	1	SOP		Switch, SPST, 4 Pos, Top Actuated, SMD	TE Connectivity	1571983-5	SW_1571983-5
31	1	U1					CC3200MOD

### 8.2.3 Power Supply Module

### Table 2. Power Supply Module BOM

ITEM	QTY	DESIGNATOR	VALUE	DESCRIPTION	MANUFACTURER	PARTNUMBER	FOOTPRINT
1	2	C1, C2	6.8uF	CAP, AL, 6.8uF, 400V, +/-20%, TH	Rubycon	400AX6R8M8x11(Alter nate: 400AX8.2M8X16	CAPPRD350W60D800 H1100
2	1	СЗ	220pF	CAP, CERM, 220pF, 630V, +/- 5%, U2J, 1206	MuRata	GRM31A7U2J221JW3 1D	1206
3	1	C4	4.7uF	CAP, CERM, 4.7uF, 25V, +/- 10%, X6S, 0805	MuRata	GRM21BC81E475KA1 2L	0805_HV
4	1	C5	470uF	CAP, TA, 470uF, 10V, +/-10%, 0.045 ohm, SMD	AVX	TPSE477K010R0045	7343-43
5	1	C8	1000pF	CAP, CERM, 1000pF, 50V, +/- 5%, C0G/NP0, 0603	TDK	C1608C0G1H102J	0603



ITEM	QTY	DESIGNATOR	VALUE	DESCRIPTION	MANUFACTURER	PARTNUMBER	FOOTPRINT
6	1	C9	33pF	CAP, CERM, 33pF, 1000V, +/- 5%, U2J, 1206	MuRata	GRM31A7U3A330JW3 1D	1206
7	1	D1	600V	Diode, Switching-Bridge, 100V, 0.5A, SOIC-4	Fairchild Semiconductor	MB6S	TO-269AA
8	1	D2	200V	Diode, Switching, 200V, 0.2A, SOD-123	Diodes Inc.	BAV21W-7-F	SOD-123
9	1	D3	600V	Diode, Superfast Rectifier, 600V, 1A, PowerDI123	Diodes Inc.	DFLR1600	powerDI123
10	1	D4	40V	Diode, Schottky, 40V, 10A, PowerDI5	Diodes Inc.	PDS1040L-13	PowerDI5
11	1	FB1	600 ohm	2A Ferrite Bead, 600 ohm @ 100MHz, SMD	TDK	MPZ2012S601A	0805_HV
12	1	L1	470uH	Inductor, Unshielded Drum Core, Ferrite, 470uH, 0.35A, 1.58 ohm, TH	Wurth Elektronik eiSos	7447462471	IND_WE-TI_XS
13	1	R1	300k	RES, 300k ohm, 1%, 0.25W, 1206	Yageo America	RC1206FR-07300KL	1206
14	1	R2	300	RES, 300 ohm, 1%, 0.25W, 1206	Yageo America	RC1206FR-07300RL	1206
15	1	R4	22	RES, 22 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060322R0JNEA	0603
16	1	R5	1.3k	RES, 1.3k ohm, 5%, 0.1W, 0603	Yageo America	RC0603JR-071K3L	0603
17	1	R6	36k	RES, 36k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060336K0JNEA	0603
18	1	R7	910k	RES, 910k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603910KJNEA	0603
19	1	R8	62k	RES, 62k ohm, 5%, 0.125W, 0805	Vishay-Dale	CRCW080562K0JNEA	0805
20	1	R9	15	RES, 15 ohm, 5%, 0.125W, 0805	Panasonic	ERJ-6GEYJ150V	0805_HV
21	1	R10	3.9k	RES, 3.9k ohm, 5%, 0.1W, 0603	Yageo America	RC0603JR-073K9L	0603
22	1	T1		Transformer	WURTH ELEKTRONIK	750841012	
23	1	U1		LOW STAND-BY POWER, CV / CC PWM HV SWITCHER WITH PRIMARY SIDE REGULATION, D0007A	Texas Instruments	UCC28910D	D0007A_N

TEXAS INSTRUMENTS

#### Design Files

### 8.3 PCB Layout

To download the layer plots, see the design files at <u>TIDC-WIFI-METER-READING</u>.

### 8.3.1 Metering Board

To download the PCB layout for the metering board, see the design files at <u>TIDM-3OUTSMTSTRP</u>.

### 8.3.2 Wi-Fi Module

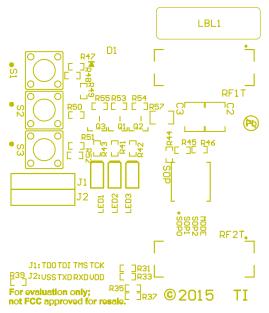


Figure 21. Top Overlay

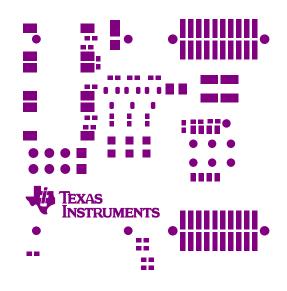


Figure 22. Top Solder

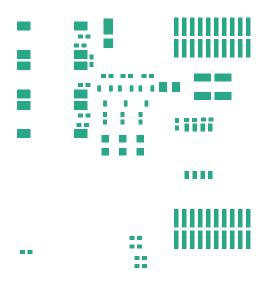


Figure 23. Top Paste

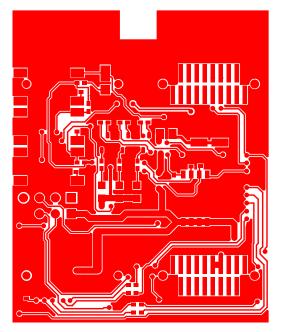
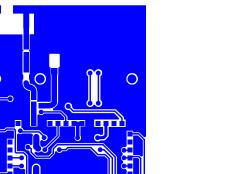


Figure 24. Top Layer





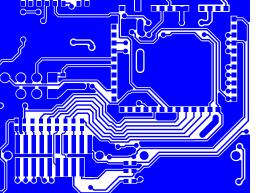


Figure 25. Bottom Layer

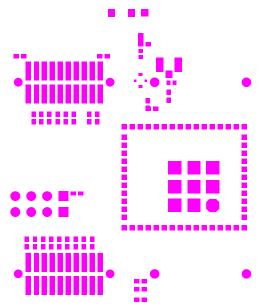


Figure 27. Bottom Solder

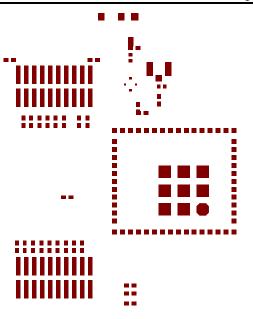


Figure 26. Bottom Paste

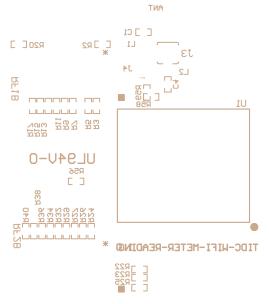
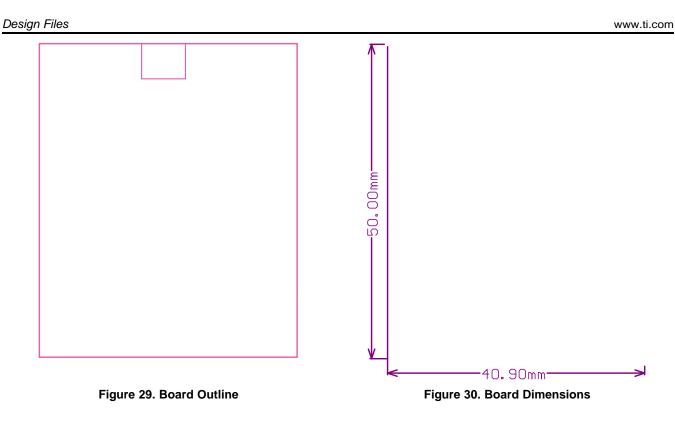


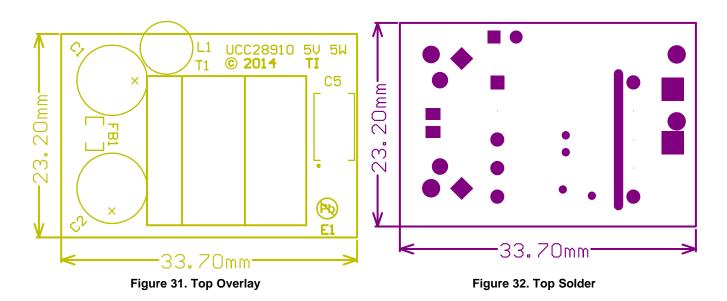
Figure 28. Bottom Overlay

Design Files





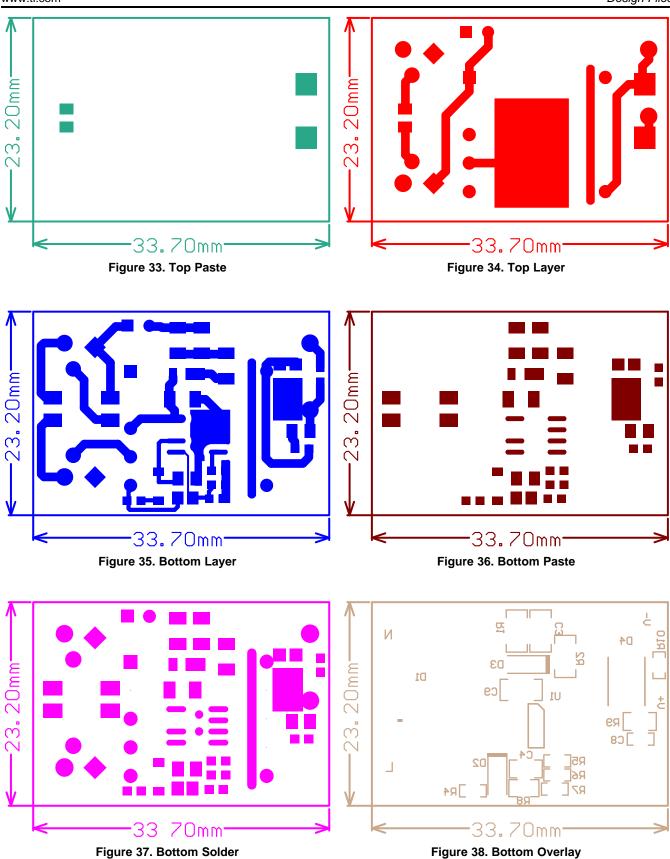
### 8.3.3 Power Supply Module







Design Files





Design Files

### 8.4 Altium Project

To download the Altium project files, see the design files at <u>TIDM-3OUTSMTSTRP</u> and <u>TIDC-WIFI-METER-READING</u>.

### 8.5 Gerber Files

To download the Gerber files, see the design files at <u>TIDM-3OUTSMTSTRP</u> and <u>TIDC-WIFI-METER-</u> <u>READING</u>.

### 8.6 Assembly Drawings

To download the assembly drawings, see the design files at <u>TIDM-3OUTSMTSTRP</u> and <u>TIDC-WIFI-METER-READING</u>.



### 9 Distributing Software Files

To download the software files, see the link at TIDC-WIFI-METER-READING.

The software files are distributed using a self-extracting executable file, which default to install onto TIDC-WIFI-METER-READING-SOFTWARE on the user's desktop.

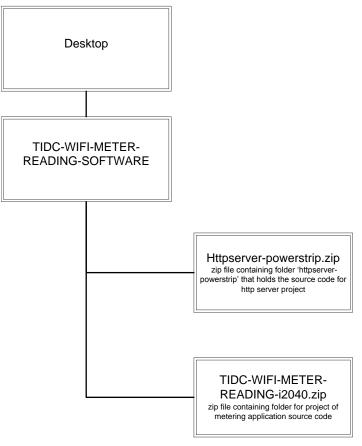


Figure 39. Distribution Software

### 10 References

- 1. Texas Instruments, *Three-Output Smart Power Strip Reference Design*, TIDM-3OUTSMTSTRP Design Guide (TIDU453)
- 2. Texas Instruments, CC3100/CC3200 SimpleLink<sup>™</sup> Wi-Fi® Internet-on-a-Chip User's Guide, CC3200MOD User's Guide (<u>SWRU368</u>)

### 11 About the Author

**MARS LEUNG** received his bachelor of engineering from Hong Kong Polytechnic University and his master of science from Chinese University of Hong Kong. He has been a field application engineer specialized in MCU application support and development; a senior smart card application engineer specialized in smart card payment system definition and implementation; a staff engineer specialized in MCU and new module definition; and a staff engineer in analog system application specialized in digital system and video processing of dynamic LED backlight control. He is now staff engineer in Texas Instruments MSP430 application team specialized in embedded electricity metering application.



### Appendix A Importing Example to CCS

Before importing the example CCS project httpserver-powerstrip, it is assumed that:

- 1. CCS 6.0.1 with CC3200 support has been installed.
- 2. CC3200SDK 1.0.0 has been installed.
- 3. The software package for this TI Design has been downloaded and unzipped, and the "httpserverpowerstrip" folder has been copied into the proper directory (default is: C:\ti\CC3200SDK\_1.0.0\cc3200-sdk\example).

To import the project:

- 1. Launch CCS 6.0.1.
- 2. When prompted for a workspace, select "C:\ti\CC3200SDK\_1.0.0\cc3200-sdk\example" and click "OK".

Workspace Launcher	<b>x</b>
Select a workspace	
Code Composer Studio stores your projects in a folder called a workspace. Choose a workspace folder to use for this session.	
Workspace: C:\ti\CC3200SDK_1.0.0\cc3200-sdk\example	▼ <u>B</u> rowse
Use this as the default and do not ask again	OK Cancel

Figure 40. Opening Workspace for CCS



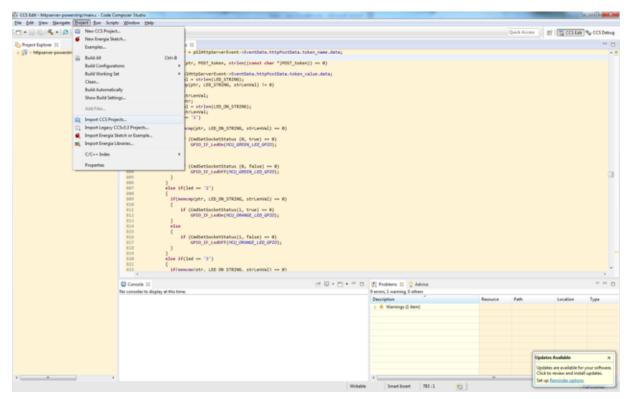


Figure 41. Importing Project to CCS

Appendix A

4. Choose "Select search-directory" and click "Browse" to import the project.

Import CCS Eclipse Projects	
Select CCS Projects to Import Select a directory to search for existing CCS Eclipse projects.	
Select s <u>e</u> arch-directory:     Select <u>a</u> rchive file:	Browse Browse
Discovered projects:	
	<u>S</u> elect All <u>D</u> eselect All <u>R</u> <u>e</u> fresh
Automatically import referenced projects found in same search-director          Copy projects into workspace         Open the Resource Explorer and browse available example projects	Ŋ
? <u>Einish</u>	Cancel

Figure 42. Project Import Window

- 5. When prompted, select the directory "C:\ti\CC3200SDK\_1.0.0\cc3200-sdk\example" and click "OK".
- 6. In the "Discovered projects" box, check "httpserver-powerstrip" and click "Finish".



### **Revision History**

Changes from Original (September 2015) to A Revision				
•	Added Section 2.1.3	6		
• ,	Added Section 2.1.4	6		

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

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