TI Designs
UART to Wi-Fi® Bridge With 24-V AC Power

TI Designs

The UART to Wi-Fi Bridge With 24-V AC Power is a subsystem designed to provide Wi-Fi connectivity to existing hardware.

Design Resources

TIDA-00375	Design Folder
CC3200MOD	Product Folder
LMR16006	Product Folder
SN74LV1T34	Product Folder
TPD1E10B06	Product Folder

TI E2E™ Community

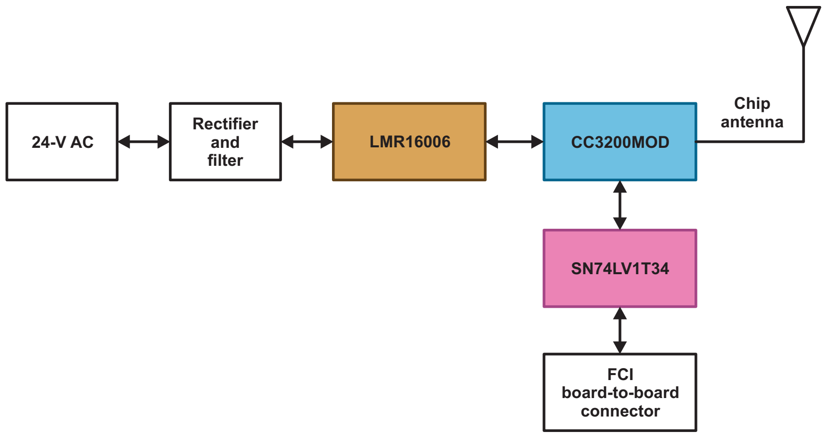
ASK Our E2E Experts
WEBENCH® Calculator Tools

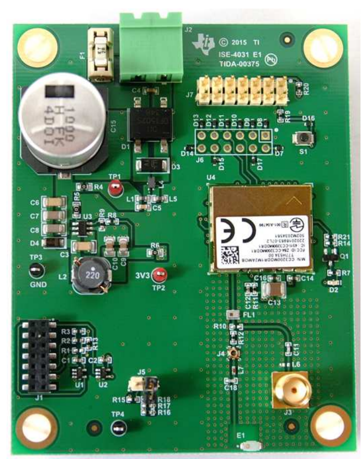
Design Features

- Wide Input Voltage Range: 18-V to 30-V AC, 12-V to 45-V DC
- Cortex M4 Provides Adaptability to Customer Communication Protocols
- UART Input With Logic Level Translator Can be Used With 3.3-V or 5-V Logic
- Add-on Board for Adding a Wi-Fi Data Stream to Existing Hardware Without Needing a Hardware Redesign

Featured Applications

- Building Automation
- Zone Controllers
- Thermostats
- Data Acquisition and Control
- HVAC





An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

1 Key System Specifications

Table 1. Key System Specifications

PARAMETER	SPECIFICATION	DETAILS
Input voltage	24 V nominal, AC or DC	See Section 4.1, Section 4.2
	8-V to 45-V DC	
	24-V AC + 25%	
Power connector	Phoenix contact 1757242	See Section 4.1
Interface	UART TX and RX signals	See Section 4.4
Interface connector	FCI 55510-114TRLF	See Section 4.4

2 System Description

The TIDA-00375 reference design is a UART to Wi-Fi Bridge that is powered by 24-V AC nominally. The input voltage can range from 8-V to 45-V DC or 18-V_{RMS} to 30-V_{RMS} AC. It is intended for use with industrial and building automation systems that need to add Wi-Fi capability to an existing product. The UART to Wi-Fi Bridge can be used as a cable replacement or to add wireless functions to an existing installation. This reference design has a bridge rectifier, input voltage filter, and a 3.3-V output step-down regulator to supply the primary system voltage.

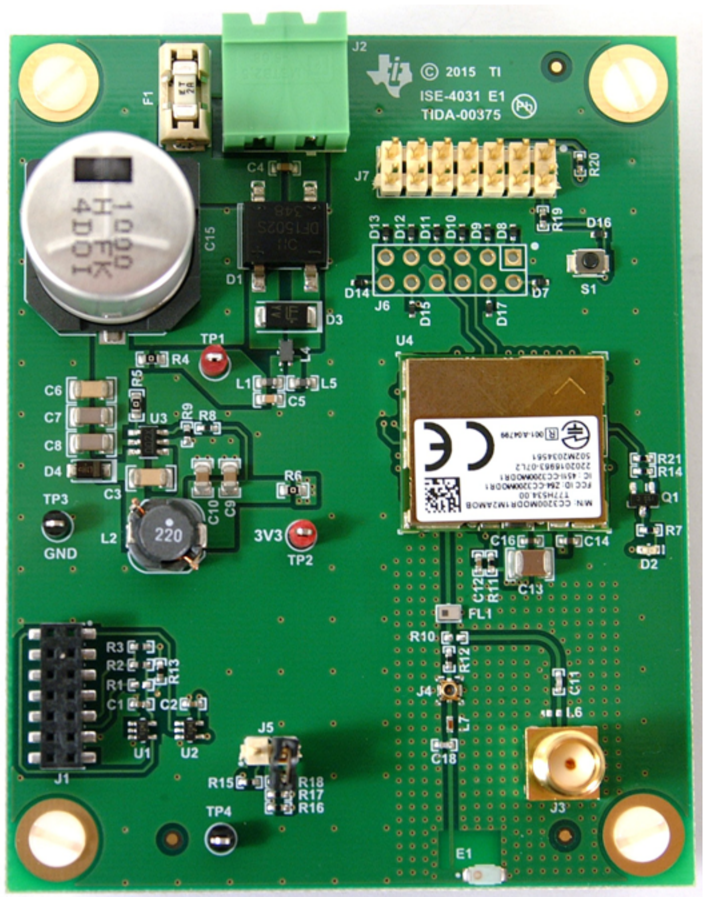


Figure 1. UART to Wi-Fi Bridge With 24-V AC Power

3 Block Diagram

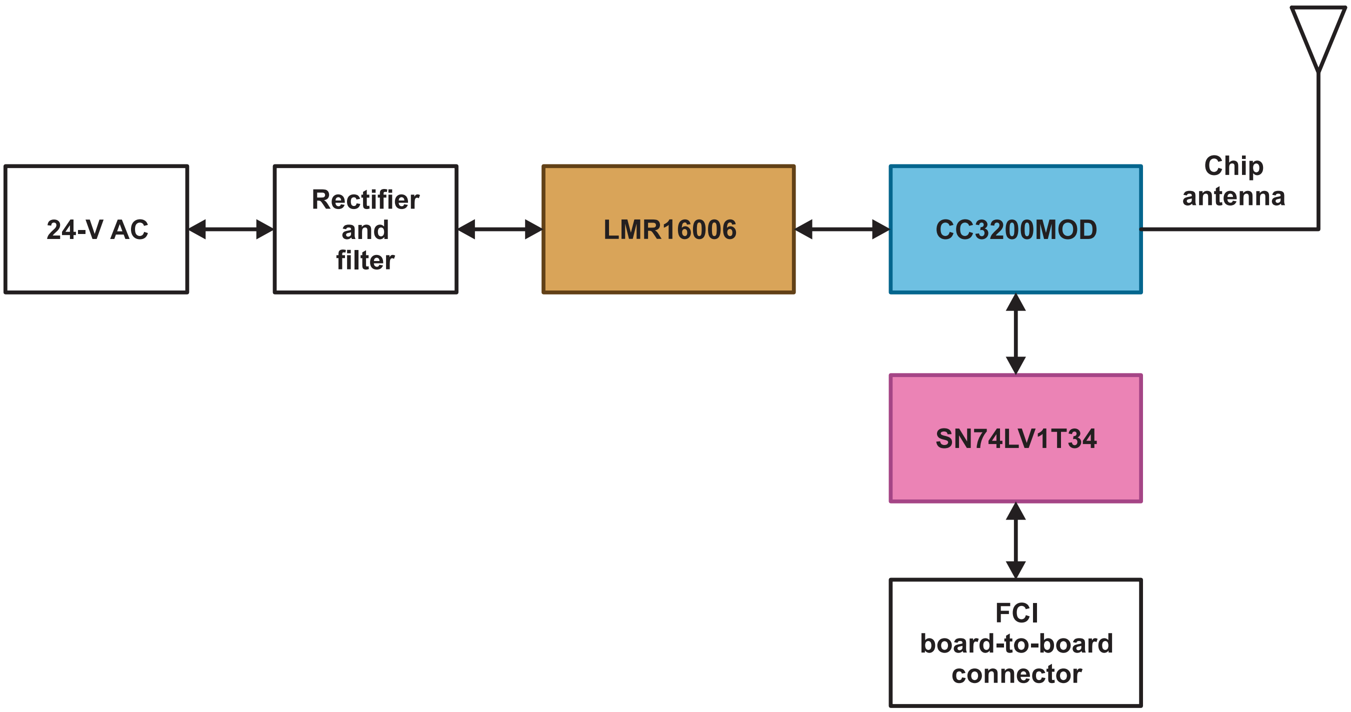


Figure 2. TIDA-00375 Block Diagram

3.1 Highlighted Products

3.1.1 CC3200MOD SimpleLink Wi-Fi and Internet-of-Things Module Solution, a Single-Chip Wireless MCU

This device is the industry's first programmable FCC, IC, CE, and Wi-Fi Certified Wireless microcontroller (MCU) module with built-in Wi-Fi connectivity. Created for the Internet of Things (IoT), the SimpleLink CC3200MOD is a wireless MCU module that integrates an ARM® Cortex®-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. The CC3200MOD integrates all required system-level hardware components including clocks, SPI flash, RF switch, and passives into an LGA package for easy assembly and low-cost PCB design. The CC3200MOD is provided as a complete platform solution including software, sample applications, tools, user and programming guides, reference designs, and the TI E2E support community.

The applications MCU subsystem contains an industry-standard ARM Cortex-M4 core running at 80 MHz.

The device includes a wide variety of peripherals, including a fast parallel camera interface, I2S, SD/MMC, UART, SPI, I^2C, and four-channel ADC. The CC3200 family includes flexible embedded RAM for code and data; ROM with external serial flash bootloader and peripheral drivers; and SPI flash for Wi-Fi network processor service packs, Wi-Fi certificates, and credentials.

The Wi-Fi network processor subsystem features a Wi-Fi Internet-on-a-chip™ and contains an additional dedicated ARM MCU that completely off-loads the applications MCU. This subsystem includes an 802.11 b/g/n radio, baseband, and MAC with a powerful crypto engine for fast, secure Internet connections with 256-bit encryption. The CC3200MOD supports station, access point, and Wi-Fi Direct™ modes. The device also supports WPA2 personal and enterprise security and WPS 2.0. The Wi-Fi Internet-on-a-chip includes embedded TCP/IP and TLS/SSL stacks, HTTP server, and multiple Internet protocols. The power-management subsystem includes integrated DC-DC converters supporting a wide range of supply voltages. This subsystem enables low-power consumption modes, such as the hibernate with RTC mode requiring less than 7 µA of current.

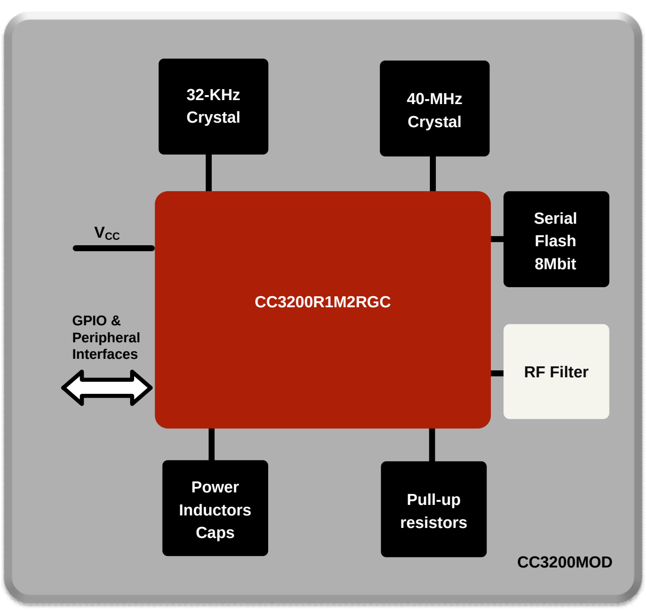


Figure 3. CC3200MOD Module Functional Block Diagram

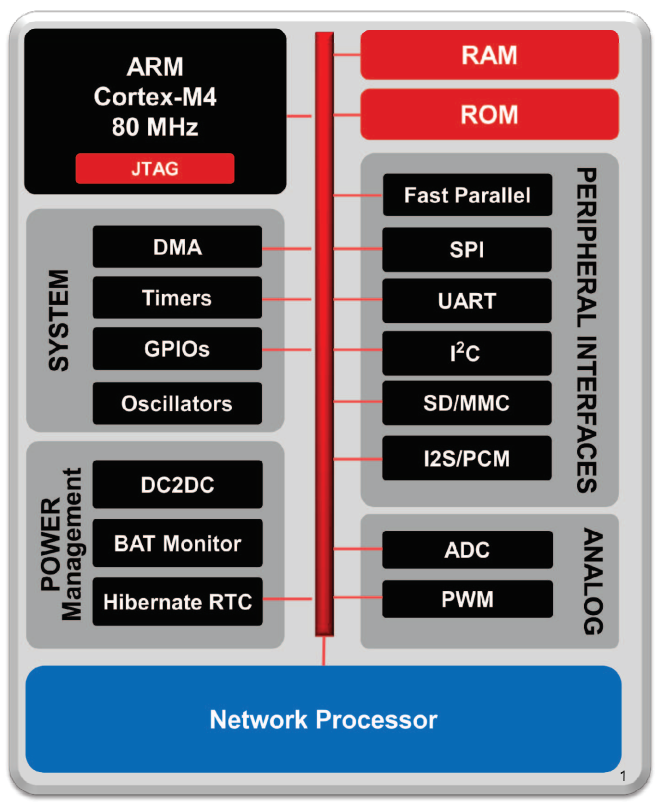


Figure 4. CC3200 Hardware Overview

3.1.2 LMR16006 SIMPLE SWITCHER® 60-V Buck Regulator With High Efficiency ECO Mode

The LMR16006 is a PWM DC/DC buck (step-down) regulator. With a wide input range of 4 to 60 V, it is suitable for a wide range of application from industrial to automotive for power conditioning from an unregulated source. The regulator's standby current is 28 μA in ECO mode, which is suitable for battery operating systems. An ultra-low 1-μA shutdown current can further prolong battery life. Operating frequency is fixed at 0.7 MHz (X version) and 2.1 MHz (Y version) allowing the use of small external components while still being able to have low output ripple voltage. Soft-start and compensation circuits are implemented internally, which allows the device to be used with minimized external components. The LMR16006 is optimized for up to 600 mA load currents. It has a 0.765-V typical feedback voltage. The device has built-in protection features such as pulse-by-pulse current limit, thermal sensing, and shutdown due to excessive power dissipation. The LMR16006 is available in a low profile SOT-6L package.

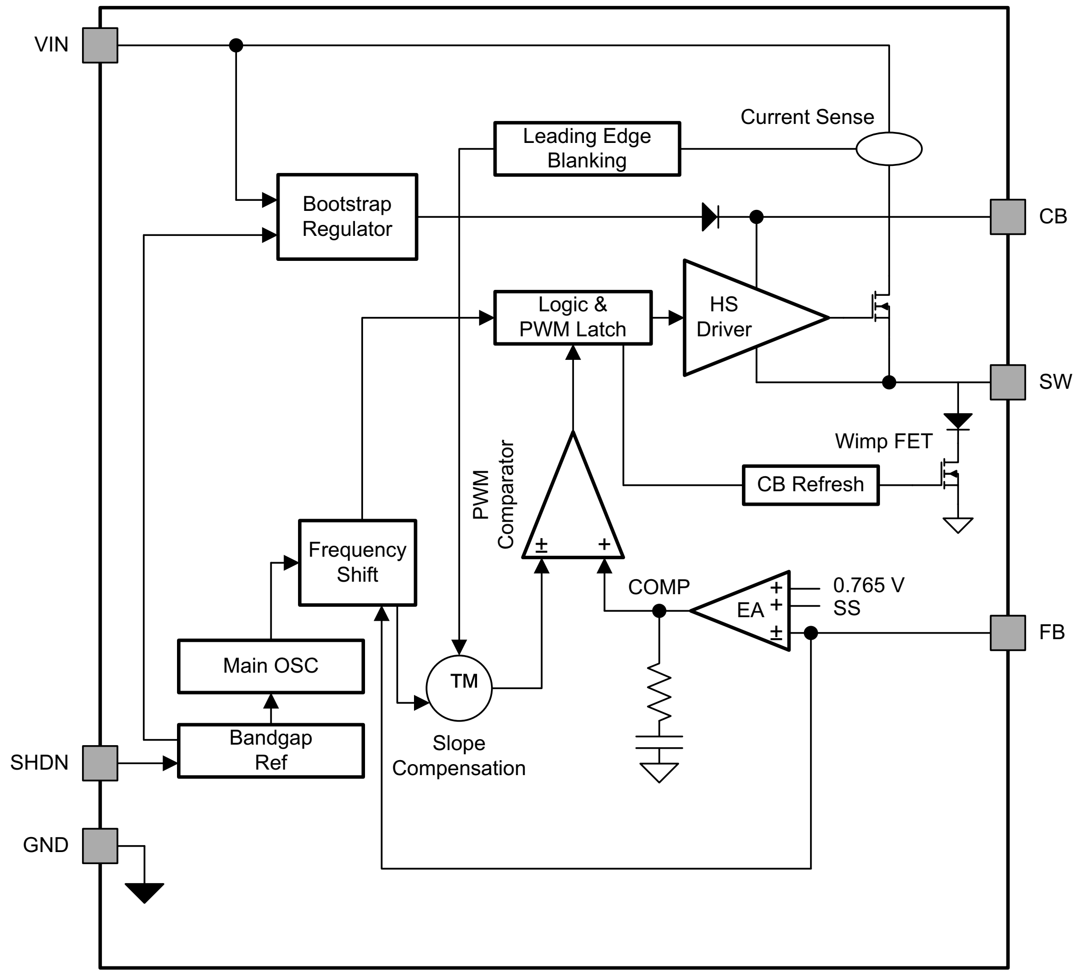


Figure 5. LMR16006 Functional Block Diagram

3.1.3 SN74LV1T34 Single Power Supply Buffer GATE CMOS Logic Level Shifter

The SN74LV1T34 is a low-voltage CMOS gate logic that operates at a wider voltage range for industrial, portable, telecom, and automotive applications. The output level is referenced to the supply voltage and is able to support 1.8, 2.5, 3.3, and 5-V CMOS levels.

The input is designed with a lower threshold circuit to match 1.8-V input logic at V_{CC} = 3.3 V and can be used in 1.8 to 3.3-V level up translation. In addition, the 5-V tolerant input pins enable down translation (for example, 3.3-V to 2.5-V output at V_{CC} = 2.5 V). The wide VCC range of 1.8 to 5.5 V allows generation of desired output levels to connect to controllers or processors.

The SN74LV1T34 is designed with current-drive capability of 8 mA to reduce line reflections, overshoot, and undershoot caused by high-drive outputs.

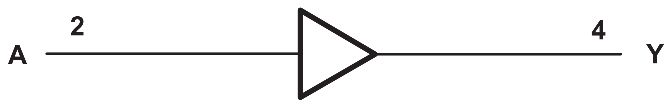


Figure 6. SN74LV1T34 Logic Diagram

3.1.4 TPD1E10B06 Single Channel ESD in 0402 Package With 10-pF Capacitance and 6-V Breakdown

The TPD1E10B06 device is a single-channel electrostatic discharge (ESD) transient voltage suppression (TVS) diode in a small 0402 package. This TVS protection product offers ±30-kV contact ESD, ±30-kV IEC air-gap protection, and has an ESD clamp circuit with a back-to-back TVS diode for bipolar or bidirectional signal support. The 12-pF line capacitance of this ESD protection diode is suitable for a wide range of applications supporting data rates up to 400 Mbps. The 0402 package is an industry standard and is convenient for component placement in space-saving applications.

Typical applications of this ESD protection product are circuit protection for audio lines (microphone, earphone, and speaker phone), SD interfacing, keypad or other buttons, VBUS pin and ID pin of USB ports, and general-purpose I/O ports. This ESD clamp is good for the protection of the end equipment like ebooks, tablets, remote controllers, wearables, set-top boxes, and electronic point of sale equipment.

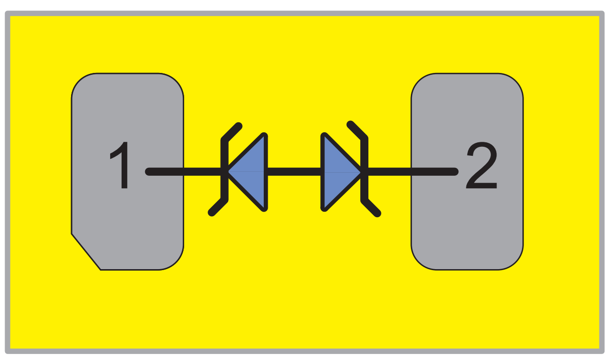


Figure 7. TPD1E10B06 Device Configuration

4 System Design Theory

The UART to Wi-Fi Bridge with 24-V AC Power reference design has two primary circuit functions: converting a 24-V AC or DC input to 3.3-V DC and providing a bridge between a UART interface and a Wi-Fi network. Secondary circuit functions are filtering the input voltage and matching logic levels of the UART signals to external signals.

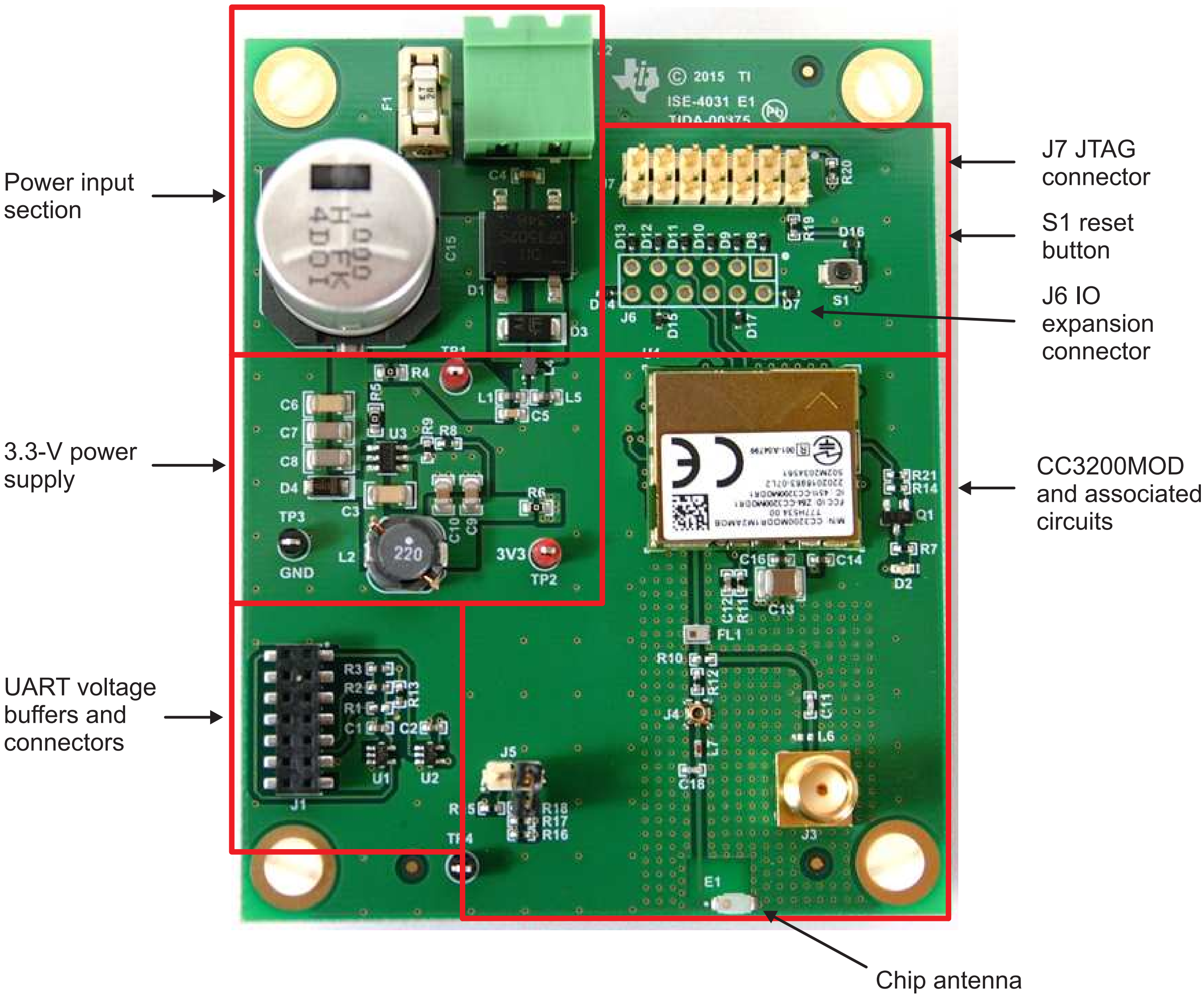


Figure 8. UART to Wi-Fi Bridge Printed Circuit Board Partition

4.1 Power Input

D1 is a bridge rectifier to convert the AC input to DC for use by the step-down regulator. D3 is a transient absorber with a 45-V break-down voltage, which limits the input voltage range to 45 V. C4, L1, L4, L5, and C5 form an input filter to reduce conducted RF both into and out of the system. L1 and L5 are ferrites to reduce differential mode RF, and L4 is a common-mode filter. The capacitors are included to further reduce high frequency signal content. C15 is a 1000-μF, 50-V aluminum electrolytic capacitor provided to maintain the DC voltage between the AC voltage peaks. This is somewhat higher than normally applied to similar circuits.

This design is not suitable for systems where the 24-V AC source has one connection grounded. Grounding the board to this common ground would burn up D1.

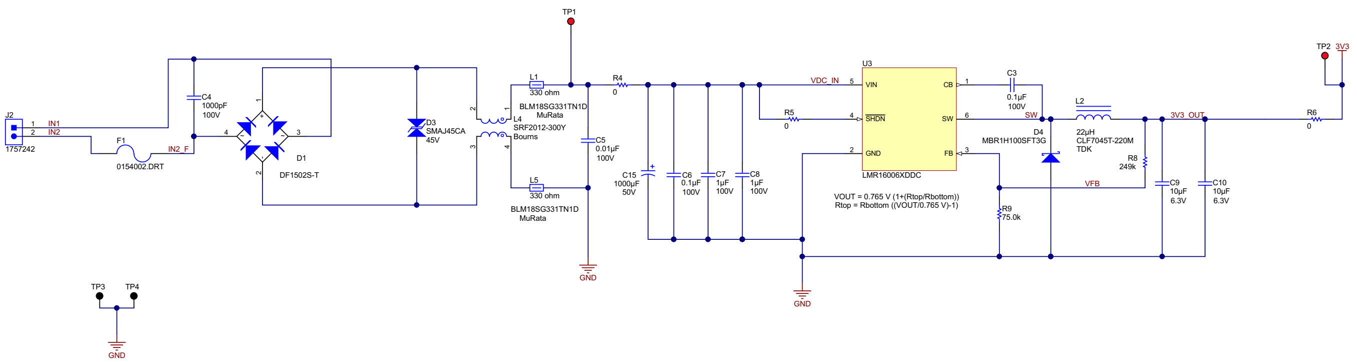


Figure 9. Power Input and 3.3-V Power Supply Schematic

4.2 3.3-V Power Supply

The 3.3-V power supply is provided by the LMR16006 circuit. The LMR16006 was chosen for this design for several reasons. The LMR16006 is an easy-to-use and inexpensive SIMPLE SWITCHER part with an input voltage range that extends from 4 to 60 V. The 600-mA capacity of the LMR16006 is more than adequate for this design. The CC3200MOD has its maximum current load of 450 mA when the input voltage is 3.3 V. This occurs during radio calibration at power on. The maximum load during data transmission is less than 300 mA.

The design procedure for the LMR16006 circuit follows the procedure in the LMR16006 datasheet. The target conditions for the LMR16006 design are very similar to the example conditions on the datasheet. There are some exceptions: the output voltage is 3.3 V and the voltage ripple target is 0.5% or 16.5 mV. The inductor used is a TDK CLF7045T-220M. This 22-μH inductor has a current rating of 1.9 A, which is slightly higher than the recommended 1.6 A rating suggested in the LMR16006 design procedure. The 20-μF total output capacitance provided by C9 and C10 ensures that the voltage ripple is low under all load conditions. The input capacitance provided by ceramic capacitors C7 and C8 totals 2 μF. C15 is effectively part of this input capacitance. The input capacitors have a voltage rating of 100 V to insure the capacitance remains above 1 μF when the input voltage approaches 40 V. C3 is the bootstrap capacitor and is the required 0.1 μF. It is rated for 100 V because the SW node will reach nearly 45 V when the board is operated at 30-V_{RMS} AC. D4 is a Schottky diode that is rated for 100 V and 1 A and serves as the freewheeling diode for the circuit.

R4 and R6 are provided to allow current measurements.

4.3 CC3200MOD

The CC3200MOD is an easy-to-use module that contains the serial memory and crystals required for a CC3200-based system. External components are the necessary bypass capacitors and pulldown resistors. The UART interface is used for both system programming and communication.

There are several connectors provided for test and expansion. J5 is provided for FLASH programming. J5 is shorted for programming operations and is left open during normal operation. J6 is an expansion connector that allows adding extra peripheral circuits to the CC3200MOD GPIOs. J7 is a JTAG connector for system debugging. It follows the TI 14-pin JTAG format. The RESET button S1 provides a manual reset capability. Diodes D7 through D17 provide ESD protection for the GPIOs and reset.

The RF antenna output section has two antenna options. The PCB is populated with the parts for the onboard chip antenna E1. Connector J4 is an RF test connector. J3 is an SMA connector for use with an external antenna. Capacitor C11 is installed, but L6 and R10 in the SMA path are not installed. To use the SMA connector, R12 should be removed and R10 installed. L6 can be installed if it is needed.

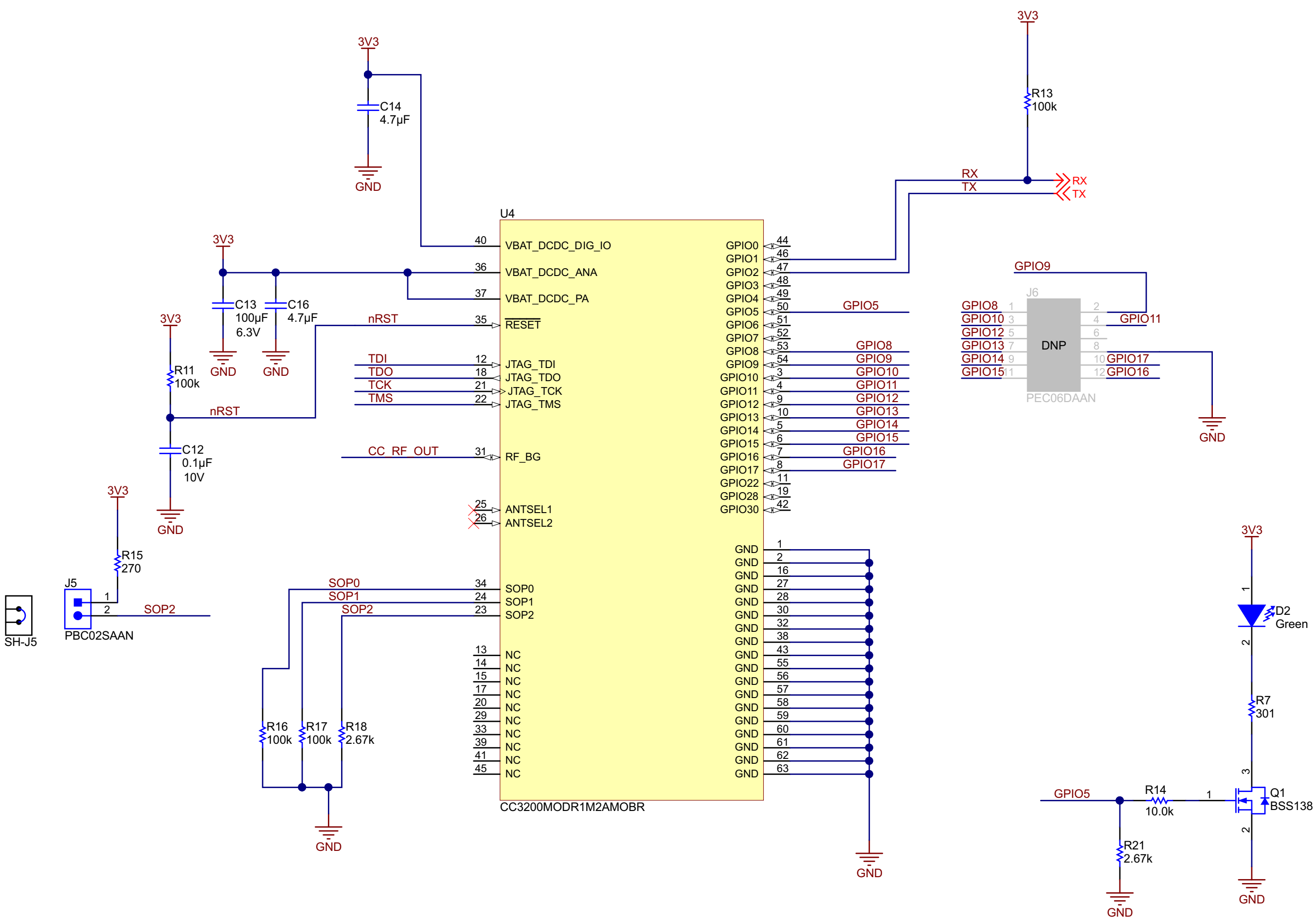


Figure 10. CC3200MOD Schematic

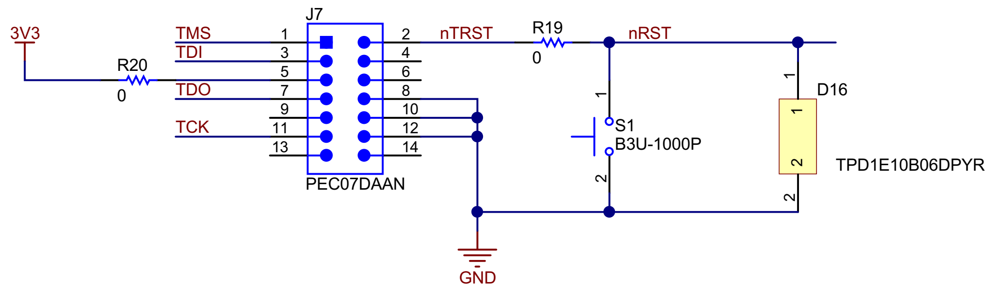


Figure 11. JTAG Connector Schematic

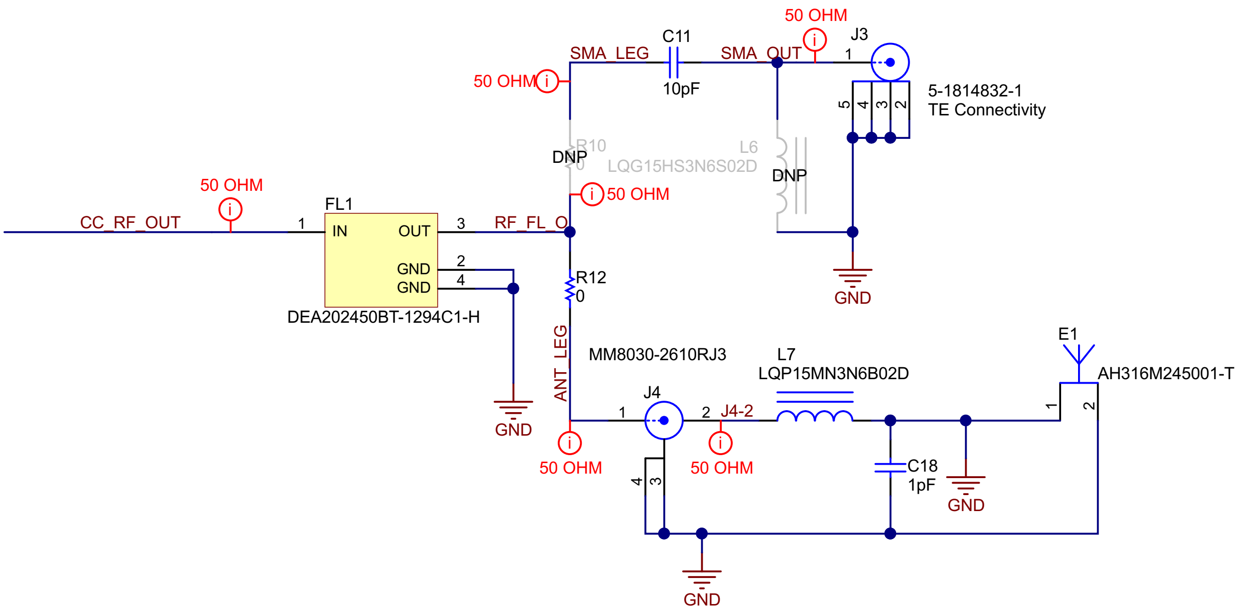


Figure 12. Antenna Section Schematic

4.4 UART Voltage Buffers and Other Circuits

The UART connection to the CC3200MOD is made through J1, an FCI 55510-114TRLF 14-pin board-to-board socket with 2-mm pin spacing. U1 and U2 are buffers that provide IO voltage matching between the CC3200MOD and an external system. U1 can be powered from a voltage used for the external system's IO or from the onboard 3.3-V power supply. R1 is not populated by default but can be used if an external IO voltage is connected to J1 pin 10. R2 is used to connect an external IO voltage at J1 pin 9. R1 and R2 should not be populated at the same time. R3 connects J1 pin 9 to the internal 3.3-V supply. If R2 and R3 are both installed, U1 is powered by the TIDA-00375 PCB's 3.3-V supply.

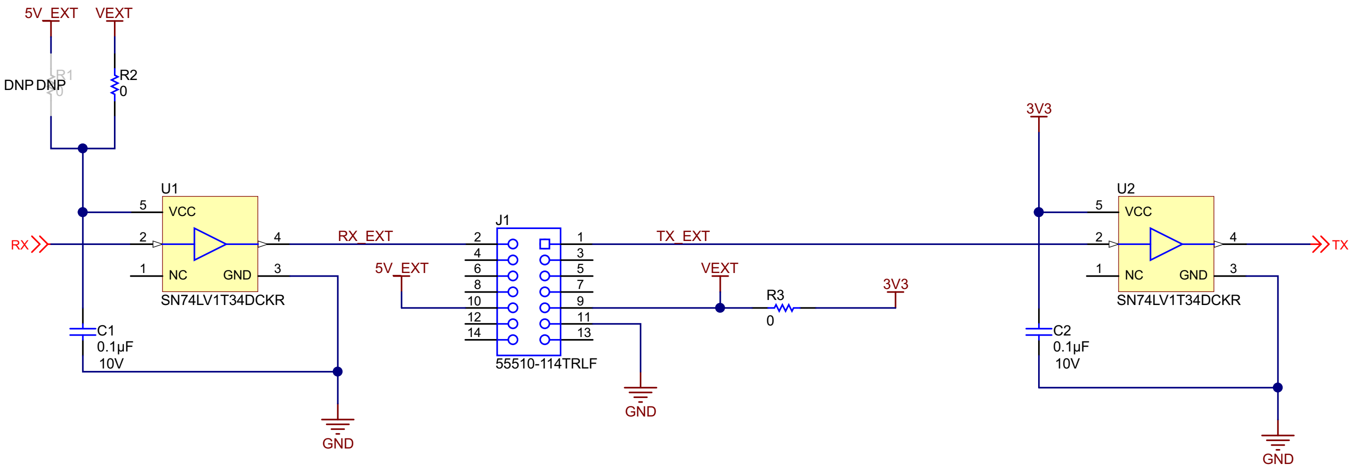


Figure 13. UART Interface Connector Schematic

5 Getting Started: Firmware

In order for the TIDA-00375 reference design to work, CC3200MOD software must be able to receive data from the UART port and transmit that data using a socket to another end node connected in the same network. The software must also be able to receive data from socket and write the data to the UART port. For this application, the serial-Wi-Fi application from CC3200 SDK was reused. Note that this is from SDK version 1.1.0 for CC3200 silicon revision R1.

5.1 Application Overview

The serial-Wi-Fi application showcases the capability of the CC3200MOD to provide easy, self-contained terminal access behavior over a UART interface. The application provides a driver-less solution and allows operation based on ASCII character set interpretation. This application runs over the UART interface and behaves as a command line interpreter. Leveraging the complete network stack integration of the CC3200, it allows secure, robust end-to-end communication.

5.2 Application Features

The following features are provided in the application:

- Support to connect to an Enterprise or Personal network using OPEN, WEP, or WPA authentication.
- Automatic network discovery of an available peer using mDNS.
- Once a network is configured, the CC3200MOD can auto connect to the AP on every boot.
- Ability to use optional secure sockets.

5.3 Operating Modes

The application operates in three modes:

1. Terminal/Interpreter mode

   Interpreter mode behaves as pure point-to-point cable replacement. This is the most common use in which a serial cable formerly used to carry information is replaced by SimpleLink devices on both ends of the line. This mode can also be used to extend an existing line farther without additional serial communication cable being installed.

2. Local control mode

   This allows issuing commands to the locally connected device. These commands encompass a close set of options to control the SimpleLink device. The mode is entered using a predefined escape sequence (//<).

3. Remote control mode

   This allows issuing commands to the remotely connected device. These commands encompass the same set of options to control the remote SimpleLink as the local device. The mode is entered using a predefined escape sequence (//>).

6 Getting Started

The following assumes that the user has installed the CC3200 SDK, Code Composer Studio™ (CCS), and UniFlash™ to program the FLASH device on the UART to Wi-Fi Bridge PCB. It is recommended that the user be familiar with CC3200 Project 0 from the CC3200 wiki site. This will insure that CCS is set up correctly, the CCS UniFlash utility is installed, and the drivers (simplelink, ti_rtos_config, driverlib, oslib) have been built. The drivers must be built before the procedure in Section 6.2 can be run. If application debugging capability is needed, a TI TMDSEMU100V2U-14T JTAG Emulator can be connected to J7 on the PCB.

6.1 Hardware Setup

In order to test the UART to Wi-Fi Bridge reference design, either two UART to Wi-Fi Bridge PCBs must be used, or one UART to Wi-Fi Bridge can be used for one node and a CC3200MOD LaunchPad can be used for the other. Each board must have a terminal program such as Tera Term running on a host computer. If available, use two host computers with the terminal program running, one for each UART-to-Wi-Fi node. However, a single host running two terminal windows can be used.

To power the board, connect a power supply to the power connector J2. A suitable mating connector for J2 is the Phoenix 1757019. The power supply can be any AC or DC supply between 6 and 48 V. Choose a power supply with a 1-A capacity for voltages from 6 to 12 V or a 0.5-A capacity above 12 V.

To monitor the UART traffic, an interface board or a cable with an FCI 98414-F06-14ULF connector is required to connect the UART signals to the UART to Wi-Fi Bridge PCB. To connect the UART to the host computer, a UART-to-USB connector must be used to connect the UART signals into the host. The UART connection is also the programming connection for the UART to Wi-Fi Bridge PCB. Make sure that the jumper is installed on J5 before applying power to the PCB.

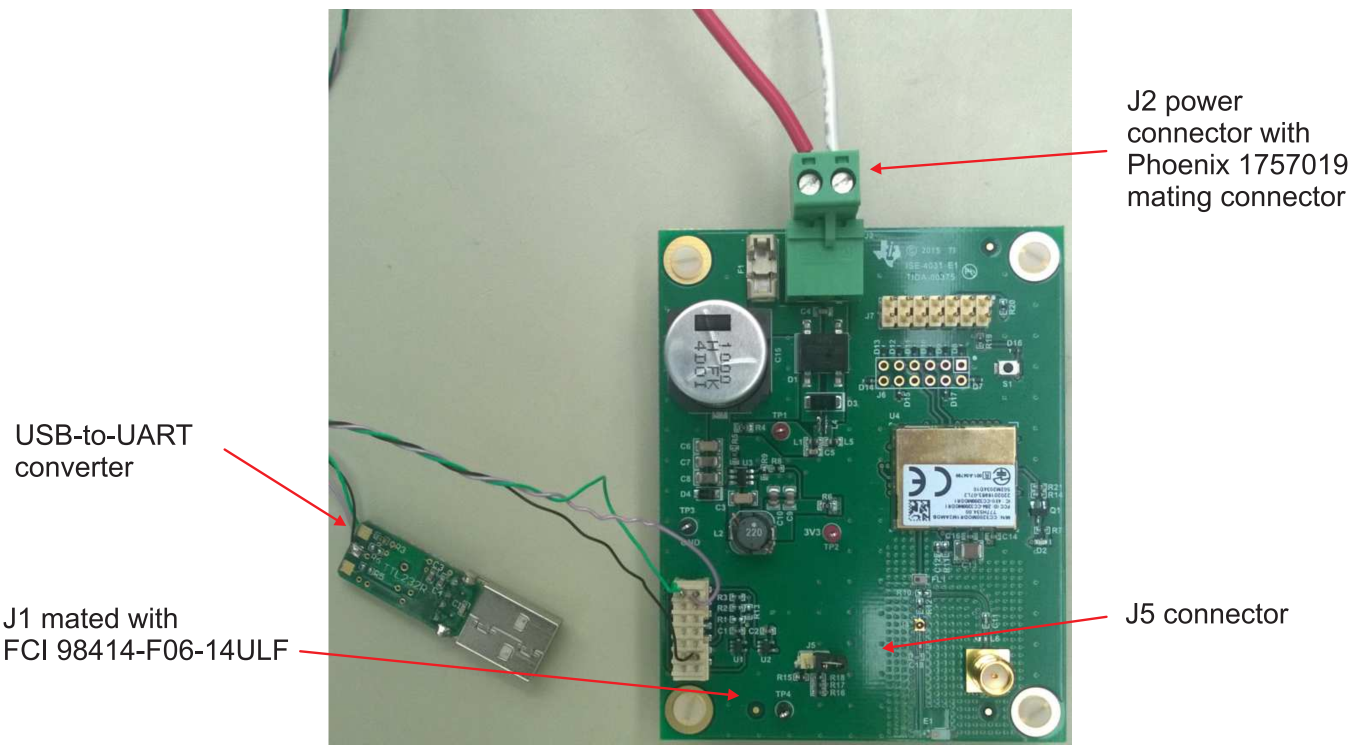


Figure 14. Board With Power and FCI Connector Plus USB-to-UART Converter

6.2 Software Setup

For testing purposes, the serial-Wi-Fi application will be used. For simplicity, the application will use non-secure sockets for the communication. The following steps describe the procedure to configure the application for non-secure sockets, build the binary, flash onto the TIDA-00375 PCB, configure, and test.

For more information about the serial-Wi-Fi application and the use of secure sockets for communication, see the CC32xx Serial Wi-Fi documentation that is provided in the CC3200 SDK.

6.2.1 Configure the Application

1. Open CCS and import serial_wifi example application from CC3200 SDK.
2. Configure the application for non-secure sockets:
   (a) Open serial_wifi.h.
   (b) On line 95 (line 87 in SDK 1.1.0), comment out "#define SECURE_SOCKETS".
   (c) Open serial_wifi.c.
   (d) In function StartTcpServer, comment out #ifdef SECURE_SOCKETS (line 1585 (line 1605 in SDK 1.1.0)) and #endif (line 1587 (line 1607 in SDK 1.1.0)) to initialize variable lRetVal.
3. Build project:
   (a) Go to Project → Build Project.
   (b) If using default settings, this should generate the file, serial_wifi.bin.
4. Flash binary:
   (a) Enable programming mode (pulling SOP2 high) by placing jumper on J5.
   (b) Connect the USB-to-UART converter and adapter cable from the TIDA-00375 PCB to the laptop.
   (c) Power on TIDA-00375 PCB.
   (d) Look in Device Manager and note the TIDA-00375 PCB's COM port.
   (e) Open CCS UniFlash program.
   (f) Click File → New Configuration:
      - Connection: CC3x Serial (UART) Interface.
      - Board or Device: SimpleLink Wi-Fi CC3100/CC3200.
   (g) Change COM Port to match the COM port found from Device Manager.
   (h) If first time booting the hardware, perform a Service Pack Update:
      (i) Click on Service Pack Update.
      (ii) Find the CC3200 Service Pack binary.
   (i) Flash the serial-Wi-Fi application.
      (i) Click on "/sys/mcuimg.bin".
      (ii) Change URL to point to serial_wifi.bin file generated from Step 3: Build project.
      (iii) Make sure only the Update box is checked.
      (iv) Go to Operation → Program.
   (j) Power off the TIDA-00375 PCB.
   (k) Change back to run mode (pulling SOP2 low) by removing jumper from J5.
5. Repeat Steps 1 through 4 on the second TIDA-00375 PCB or a CC3200 LaunchPad. The LaunchPad will require a USB cable instead of the USB adapter board and cable.

6.2.2 Run the Application

1. Open a terminal with the following settings:
   - Port: COM port from Device Manager
   - Baud Rate: 115200
   - Data: 8 bit
   - Parity: None
   - Stop: 1 bit
   - Flow control: None

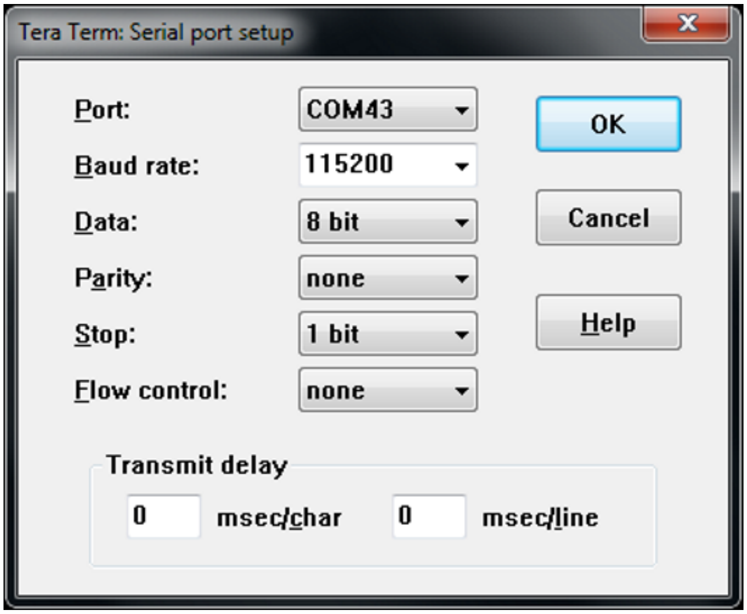


Figure 15. Tera Term Port Setup

2. Start the serial-Wi-Fi application:
   (a) Power on the TIDA-00375 PCB.
   (b) The terminal should show "CC3200 SERIAL WiFi Application".
   (c) If not, go back to Step 4: Flash binary from Section 6.2.1 and try flashing the application again.

3. Connect to Access Point (AP):

(a) Upon reset, the device will connect to the stored AP using the AUTO connect policy. If the device connects to AP, go to Step 4: Configure mDNS. If the device does not connect to an AP in six seconds, the application will prompt the user to connect to a known AP using the local control mode.

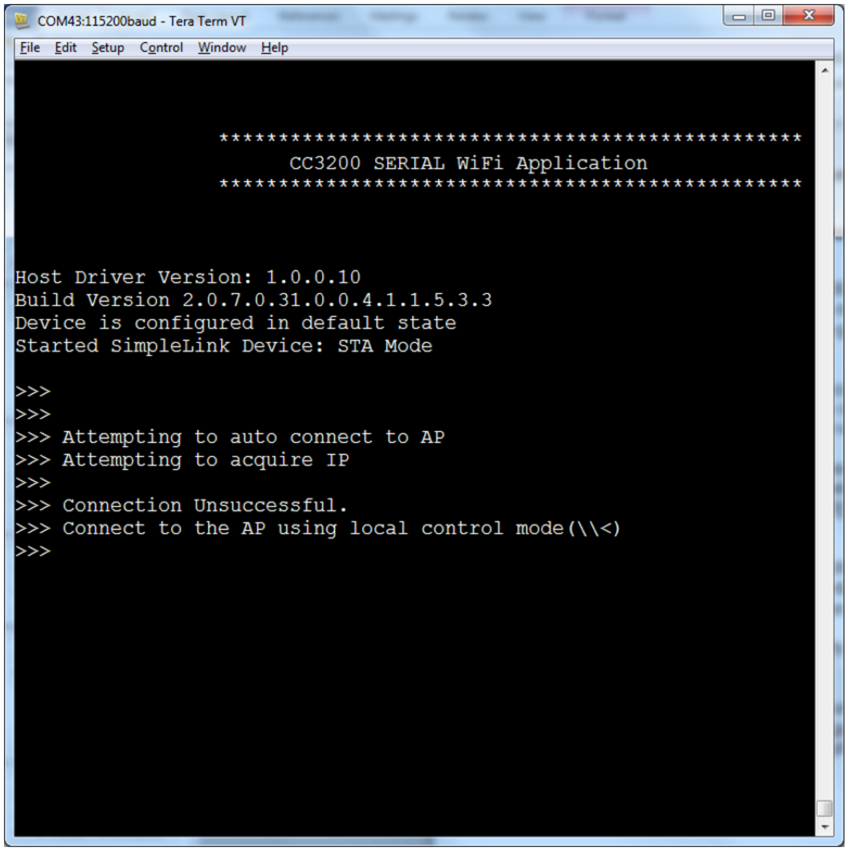


Figure 16. Terminal Information With No AP

(b) Enter local control mode (\\<).

(c) Use the following command to connect to an AP:
Format: wlan_connect [SSID] [Type] [Sec] [User] [Key]
SSID: Name of AP
Type: 0-Personal, 1-ENT
Sec: 0-OPEN, 1-WEP, 2-WPA
User: Username, only needed if using ENT
Key: Password for WEP and WPA
Example:
"TI_AP" SSID with no security
wlan_connect TI_AP 0 0

"TI_AP" SSID with WPA security and password "TI_password"
wlan_connect TI_AP 0 2 TI_password

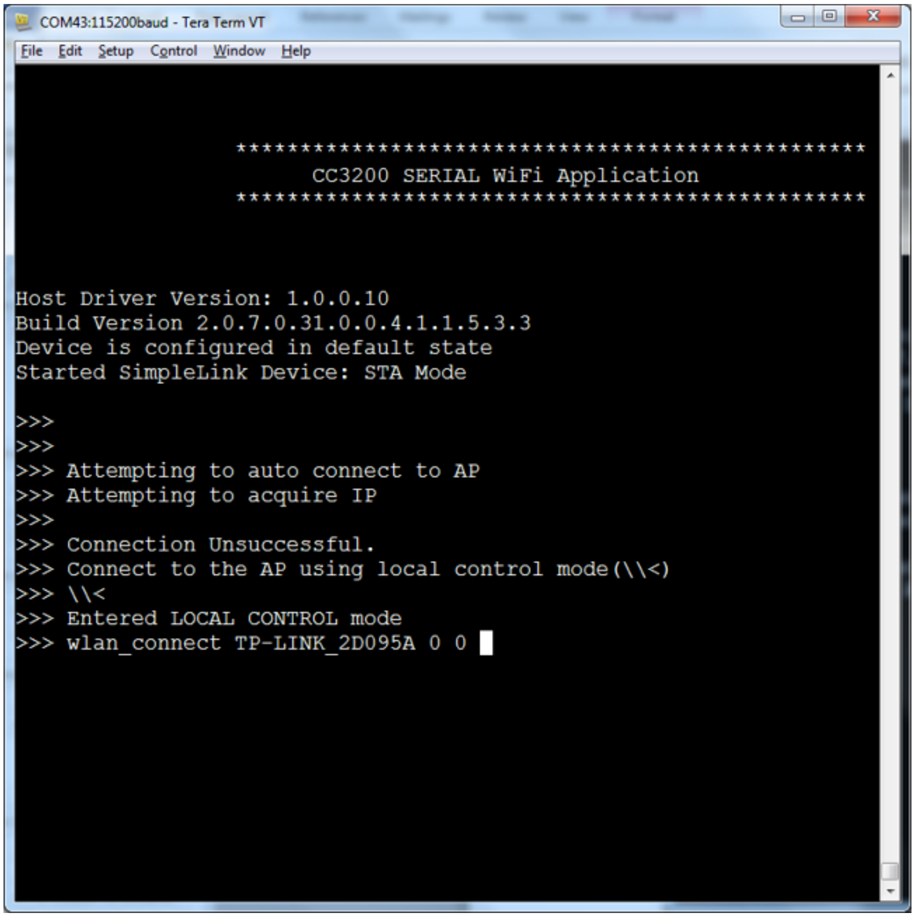


Figure 17. Setting Up the Access Point SSID

(d) Once completed, the application will show that it was able to connect to the AP and an IP address has been acquired.

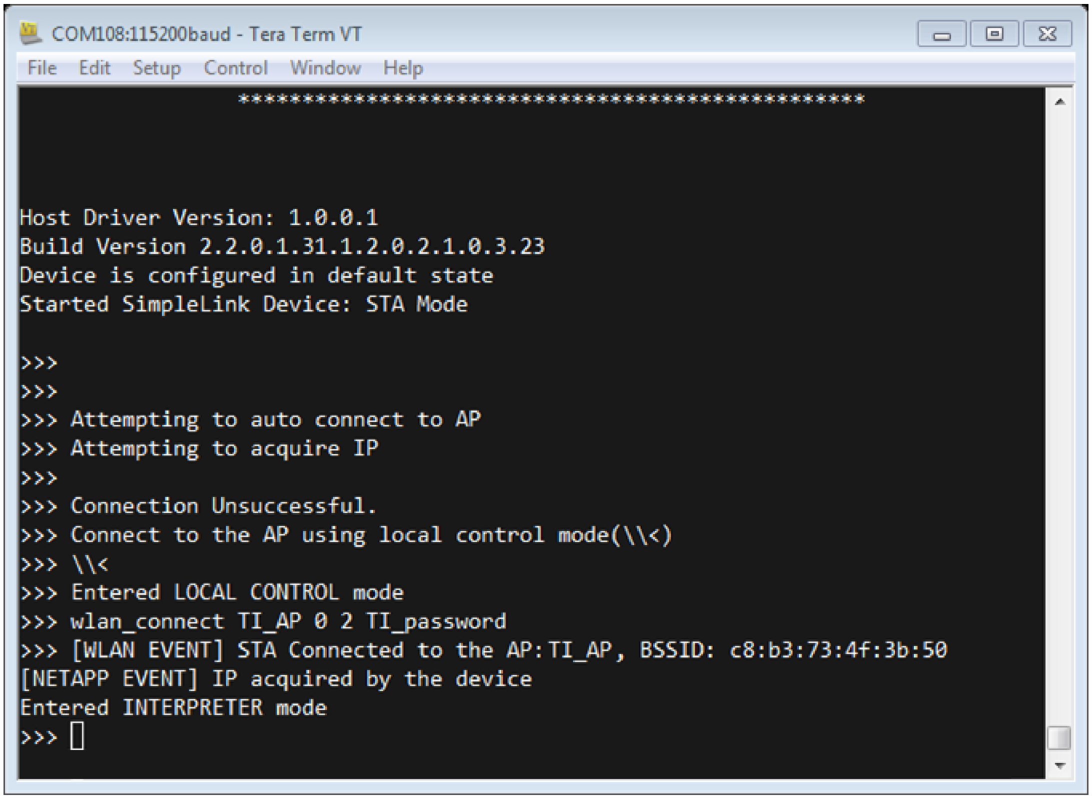


Figure 18. Terminal Window Screenshot Showing UART to Wi-Fi End Node Console

4. Configure mDNS:
   (a) This step only needs to be done the first time after performing a serial erase.
   (b) One node must be configured as mDNS server. Use local control mode to program.
   (c) Enter local control mode (\\<).
   (d) Configure for client or server:
   mDNS 0 <0-server, 1-client>
5. Repeat Steps 1 through 5 for the second TIDA-00375 PCB or LaunchPad.

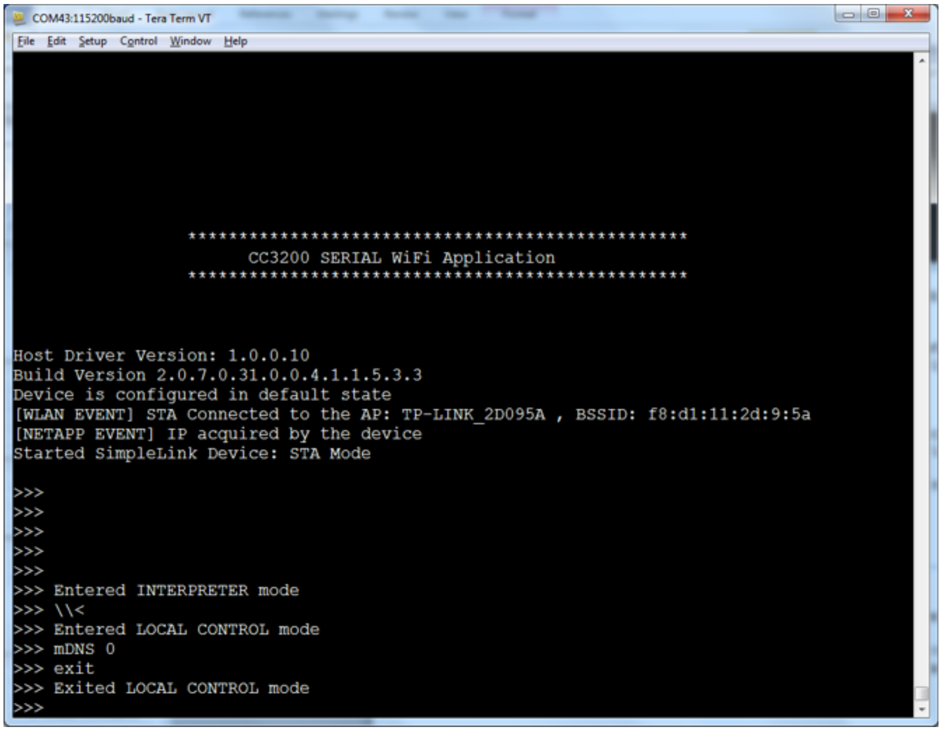


Figure 19. Setting DNS as Server

Devices should now be in interpreter mode. If the device is still in control mode, type "exit" to resume interpreter mode.

6.3 Communication Test

1. Reset both nodes.
2. Both nodes should connect to the same AP and acquire an IP address.
3. Verify that "TCP connection established" appears on both nodes.
4. Type on the server terminal and press <Enter> to see the same characters on the client.
5. Type on the client terminal and press <Enter> to see the same characters on the server.

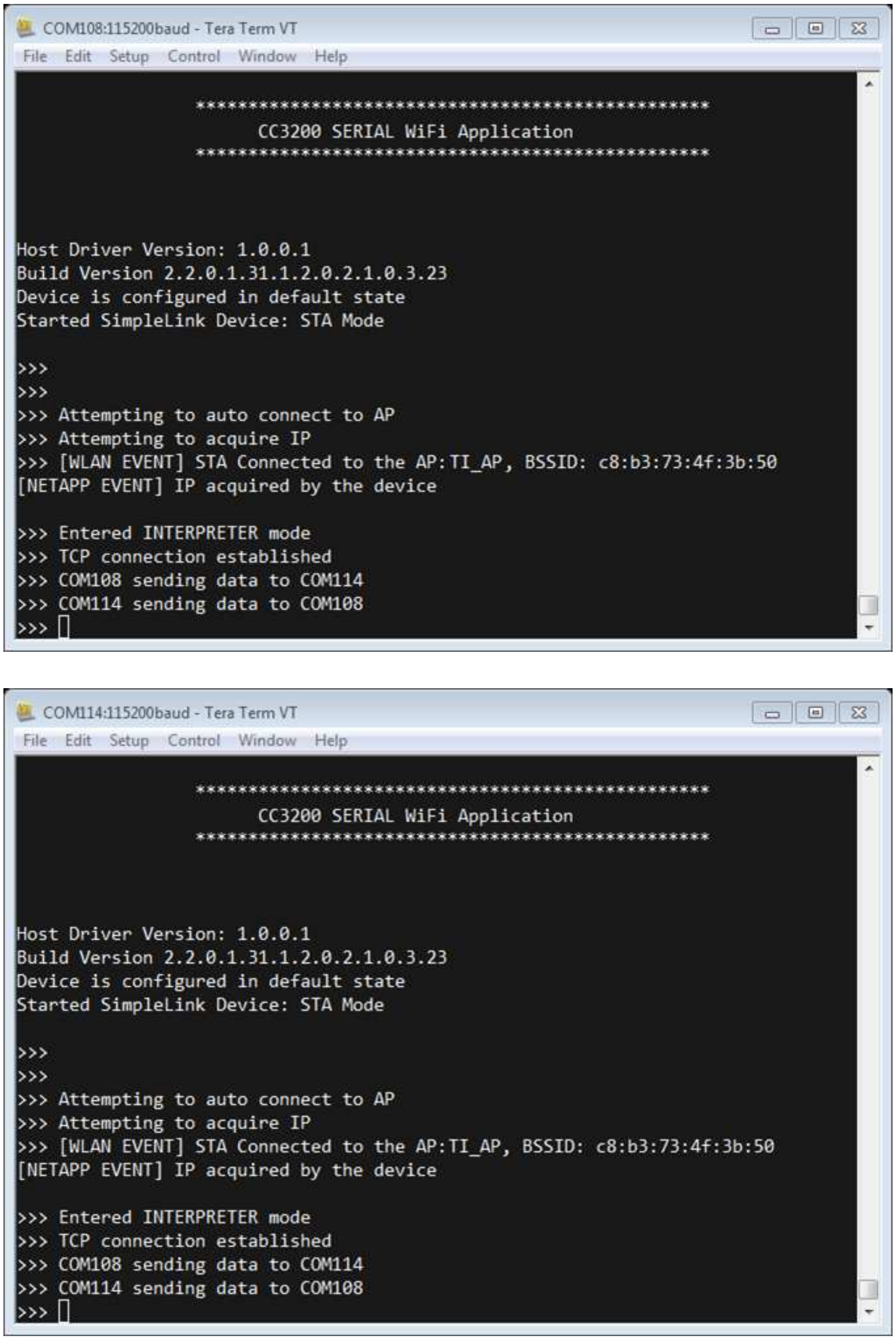


Figure 20. Terminal Window Screenshots Showing Both Consoles

7 Testing

7.1 Power Supply DC Testing

In order to test the power supply efficiency, DC input voltage was used to simplify the measurements. Efficiency is calculated by taking the ratio of the output power to the input power of the power supply.

$$\text{Efficiency} = \left(\frac{\text{Input power}}{\text{Output power}} \right) \times 100\% \tag{1}$$

The power is calculated from voltage and current measurements. For the efficiency test, the input power is applied at J2 and the input voltage is measured at TP1. Input current is measured by inserting a digital multimeter (DMM) between the input power source and J2. To measure the output current, R6 is removed and the output currents are measured by connecting a DMM across the two pads of the resistor. Input voltage was measured at TP1. Output voltage was measured across the output capacitors C9 and C10. The input voltage was adjusted to different voltages in the operating range by setting the voltage measured at TP1. The power was measured under two conditions: with the UART communication idle and while transmitting continuous UART data by Wi-Fi. In both cases, the calculated data shows the power supply efficiency decreases as the input voltage increases.

Table 2. Power Supply Efficiency, UART Idle

INPUT VOLTAGE (V)	INPUT CURRENT (mA)	INPUT POWER (mW)	OUTPUT VOLTAGE (V)	OUTPUT CURRENT (mA)	OUTPUT POWER (mW)	EFFICIENCY
5.00	23.50	117.5	3.336	31.9	106.4184	90.57%
7.50	17.10	128.25	3.336	32.2	107.4192	83.76%
10.00	13.20	132	3.336	32.1	107.0856	81.13%
12.00	10.90	130.8	3.336	30.8	102.7488	78.55%
15.01	9.00	135.09	3.339	30.3	101.1717	74.89%
18.00	7.60	136.8	3.344	31.1	103.9984	76.02%
18.00	7.63	137.34	3.344	30.6	102.3264	74.51%
20.00	6.88	137.6	3.344	30.0	100.3200	72.91%
24.00	6.02	144.48	3.344	30.5	101.9920	70.59%
30.01	4.99	149.7499	3.342	30.3	101.2626	67.62%
35.00	4.44	155.4	3.341	30.5	101.9005	65.57%
40.01	4.04	161.6404	3.341	30.4	101.5664	62.83%
42.50	3.90	165.75	3.342	30.6	102.2652	61.70%

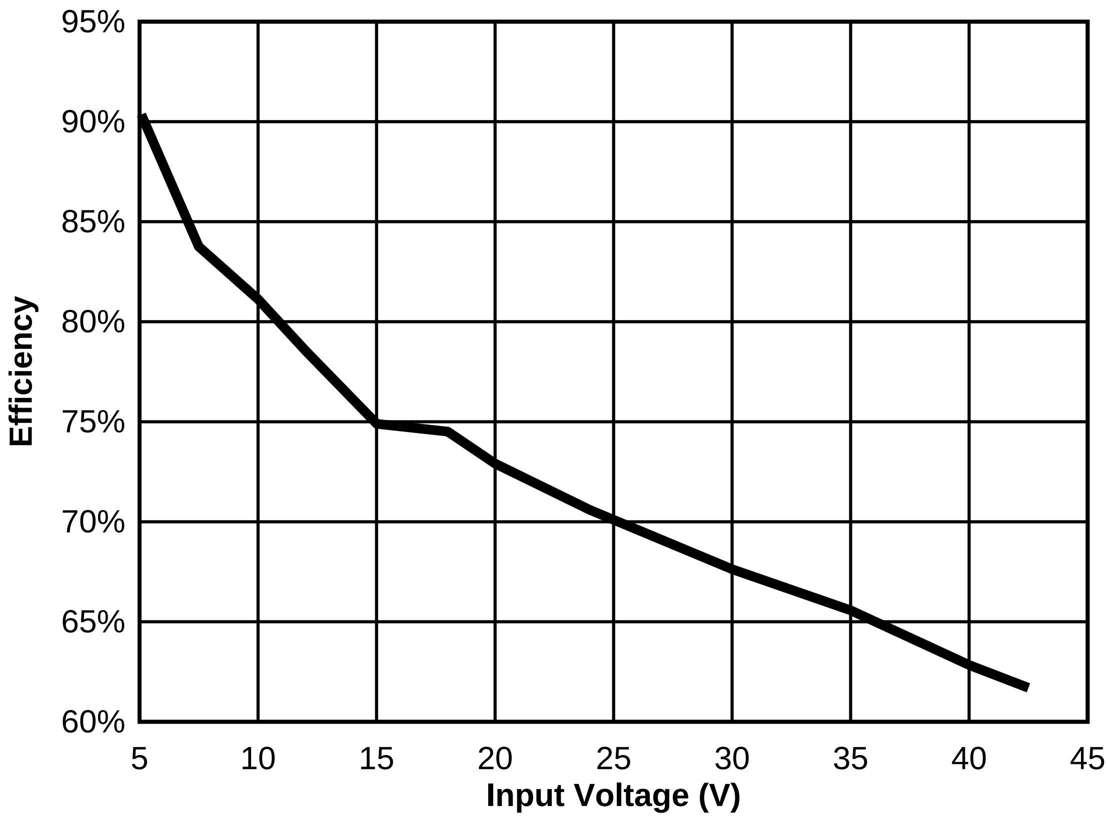


Figure 21. Power Supply Efficiency for UART Idle

Table 3. Power Supply Efficiency UART Continuous Data

INPUT VOLTAGE (V)	INPUT CURRENT (mA)	INPUT POWER (mW)	OUTPUT VOLTAGE (V)	OUTPUT CURRENT (mA)	OUTPUT POWER (mW)	EFFICIENCY
5.05	56.6	285.83	3.336	78.9	263.2104	92.09%
7.55	39.7	299.735	3.336	78.4	261.5424	87.26%
10.03	30.7	307.921	3.336	78.5	261.876	85.05%
12.03	25.7	309.171	3.336	78.5	261.876	84.70%
15.02	21.5	322.93	3.336	78.4	261.5424	80.99%
18.04	18.2	328.328	3.336	78.2	260.8752	79.46%
20.04	16.71	334.8684	3.336	78.2	260.8752	77.90%
24.09	14.3	344.487	3.336	78.3	261.2088	75.83%
30.02	11.9	357.238	3.336	78.2	260.8752	73.03%
35.03	10.54	369.2057	3.336	78.2	260.8752	70.66%
40.04	9.55	382.382	3.336	78.3	261.2088	68.31%
42.49	9.18	390.0582	3.336	78.3	261.2088	66.97%

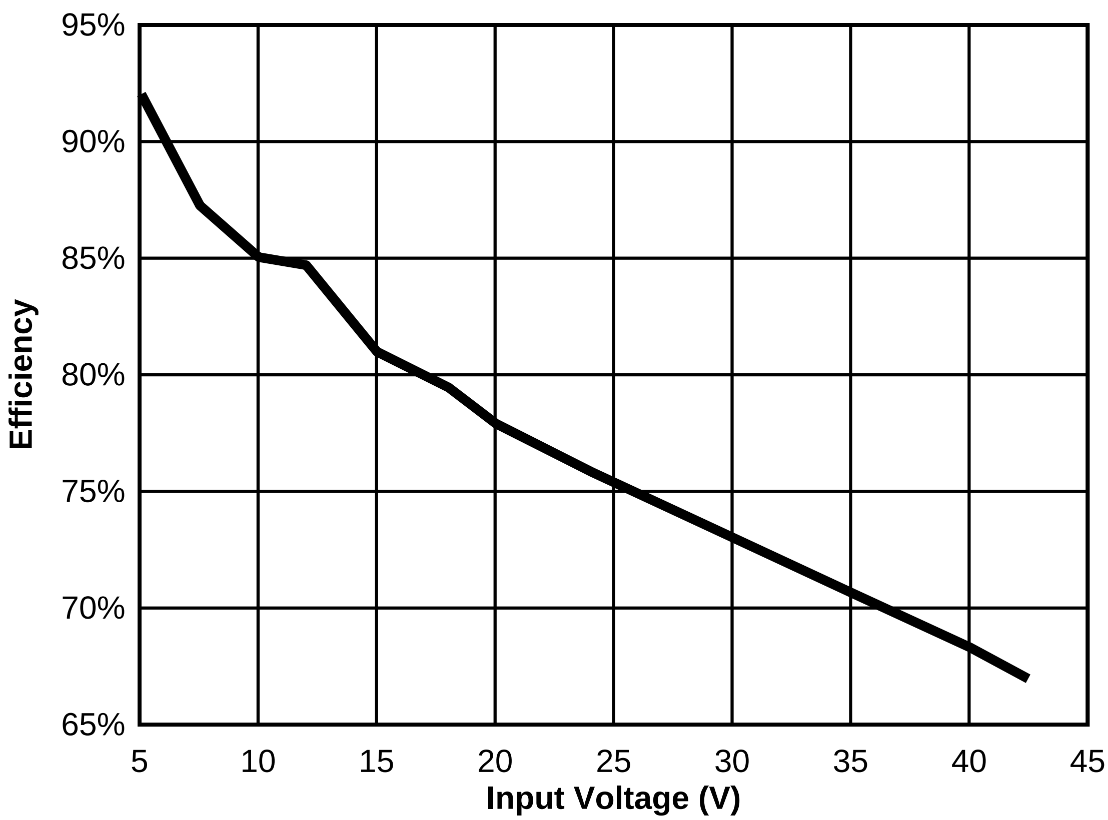


Figure 22. Power Supply Efficiency for UART Sending Data Continuously

The current measurements shown are average current measurements over time. They are low compared to the maximum current expected for the CC3200MOD. The instantaneous current is much higher during Wi-Fi transmissions.

Figure 23 shows current peaks as high as 534 mA when the CC3200 is transmitting Wi-Fi data. These high peaks drive the power supply current capacity requirement.

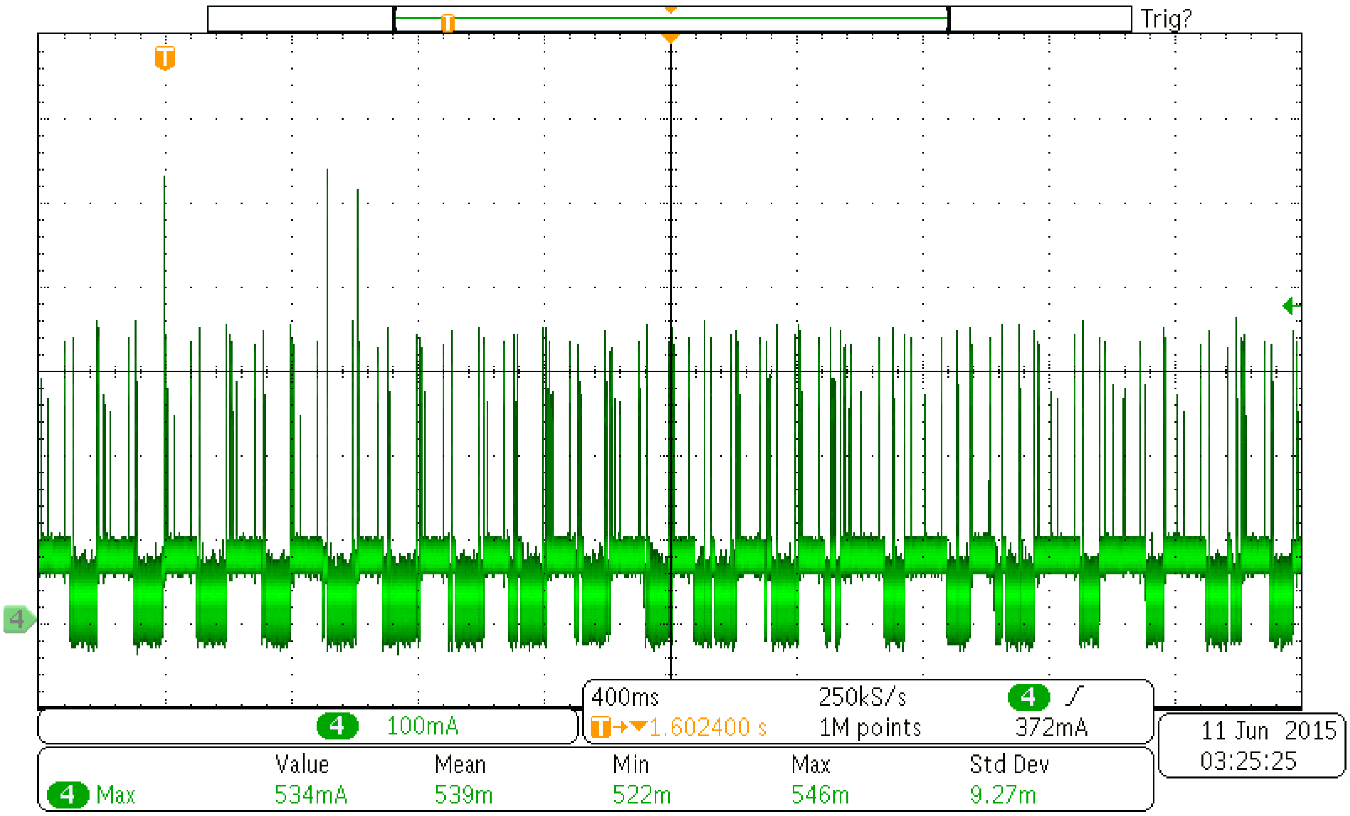


Figure 23. 3.3-V Supply Current Peaks During Wi-Fi Transmission

7.2 Power Supply AC Testing

The UART to Wi-Fi Bridge was tested with a Kikusui PCR500M AC Power Supply. The minimum AC voltage that the system worked at was 4-V AC, 60 Hz. The rectified and filtered input voltage at TP2 was about 4-V DC with the 4-V AC input. Lowering the voltage to 4-V AC leads to the processor resetting due to the 3.3-V power supply loosing regulation. The system would not start up again unless the input voltage was 4.4-V AC.

The voltage on the filter capacitor C15 was measured with an oscilloscope to see the performance of the input filter. The ripple voltage for an input voltage of 18-V AC on C15 is shown in Figure 24.

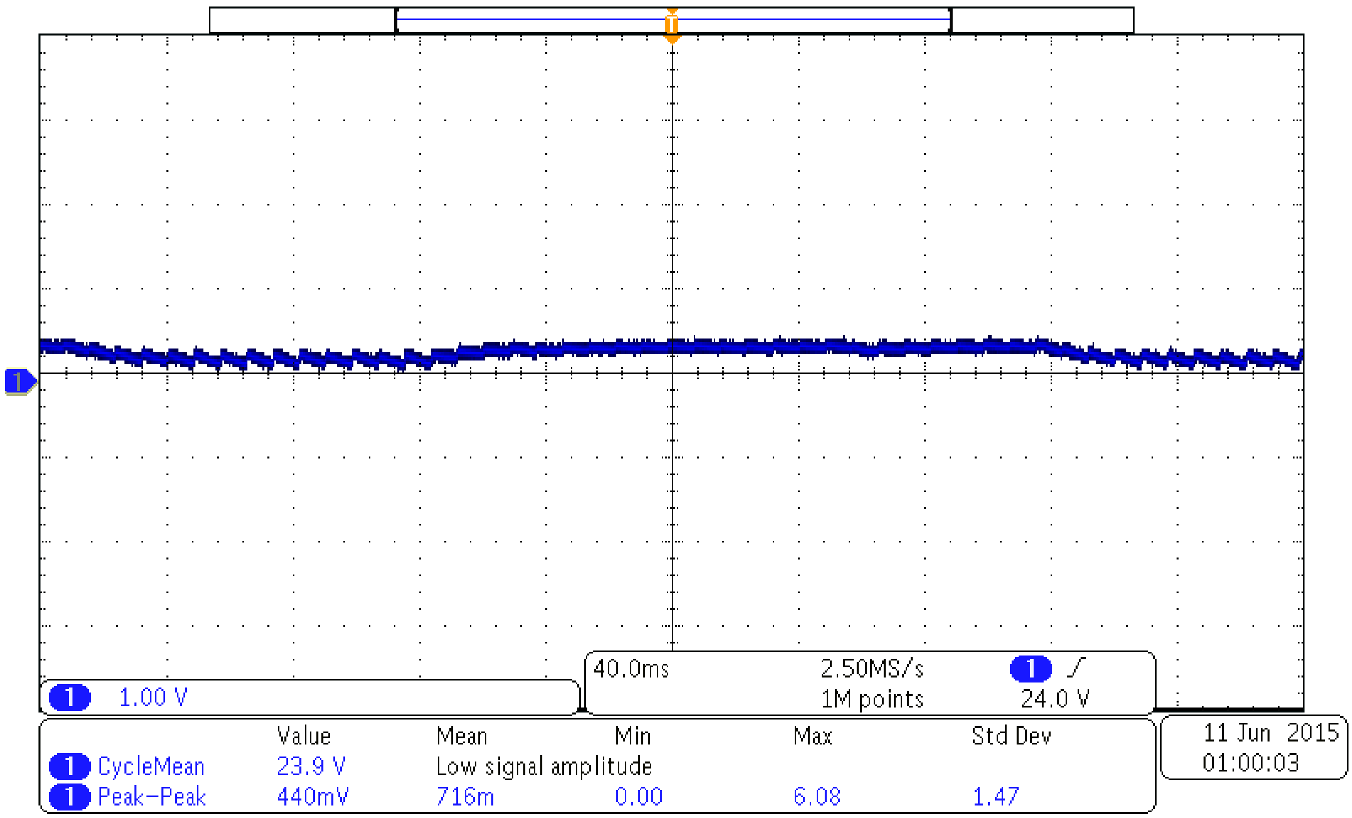


Figure 24. Ripple Voltage at C15 for an 18-V AC, 60-Hz Input

For the measurement in Figure 24, the system was transmitting constantly as it was for the efficiency measurement, ensuring a maximum ripple. The peak-to-peak voltage ripple is only 440 mV in this case.

For an 18-V AC at 50-Hz input, the voltage ripple on C15 is 280 mV (see Figure 25).

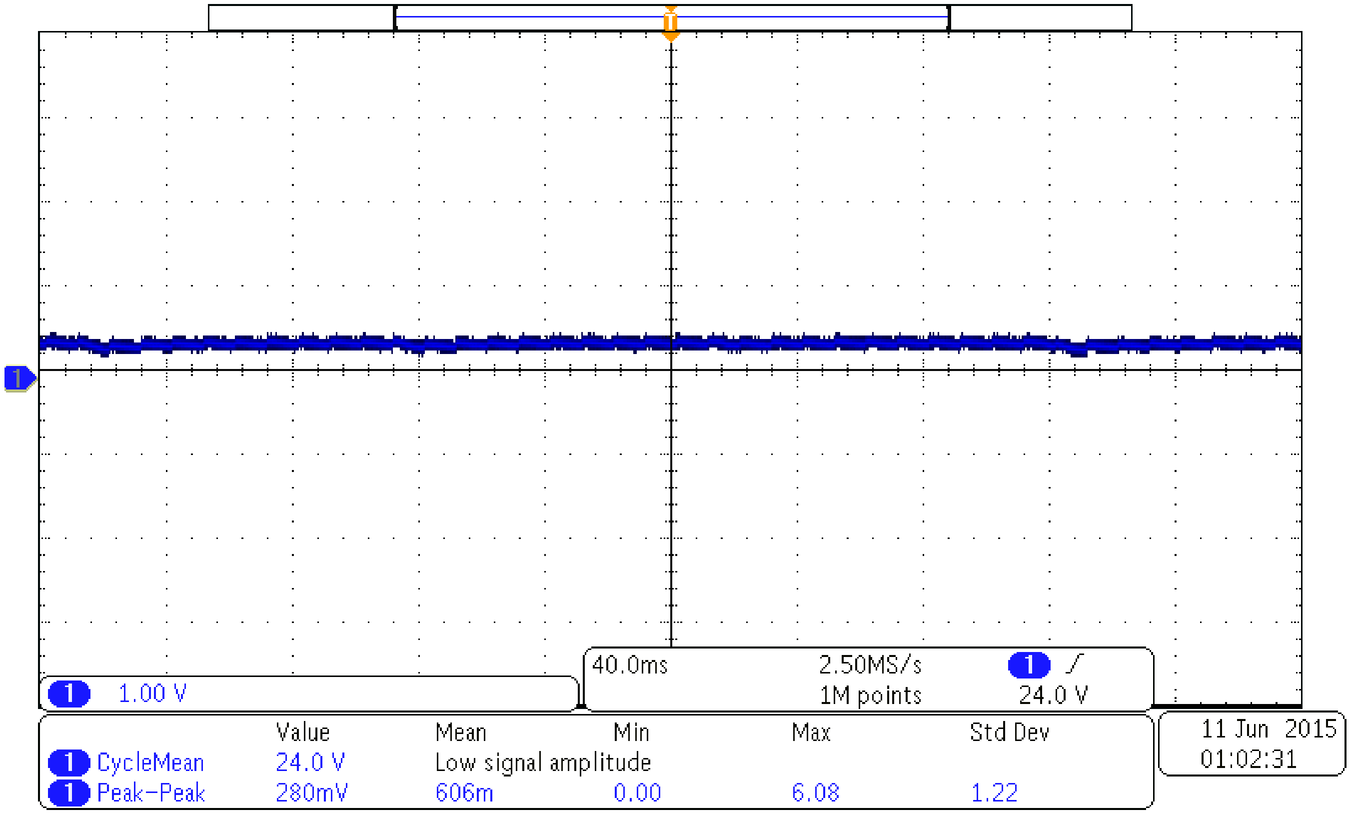


Figure 25. Ripple Voltage at C15 for an 18-V AC, 50-Hz Input

7.3 CC3200 Performance

7.3.1 Data Throughput

The data in this section was provided by the CC3100 and CC3200 design team. It is included to show the Wi-Fi performance.

The following two graphs show data throughput measurements with the hardware set up as both an AP and a Station. The data was not taken on the hardware described in this document. It was taken with a CC3100-based system that includes the CC3100 BoosterPack. The CC3100 and CC3200 have the same network processor subsystems, so their performance will be the same. The antenna on the PCB for the UART to Wi-Fi Bridge is the same antenna used in the CC3100 BoosterPack, and great care has been taken to ensure the UART to Wi-Fi Bridge RF output circuit matches the CC3100 BoosterPack, including the trace width, the thickness of the PCB dielectric between the RF output traces and the ground plane, and the overall board thickness.

The CC3100 system was tested in a chamber using a Cisco AP 1252 router and a Cisco-Linksys AE1000 router. The test measures throughput versus path loss (range) where the AP or Station is placed in a chamber. Range is simulated by using an attenuator to reduce the module output power.

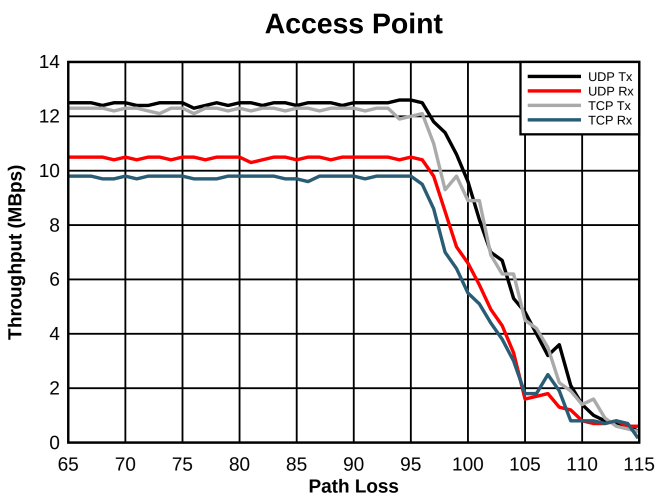


Figure 26. Data Throughput versus Path Loss (CC3100 AP)

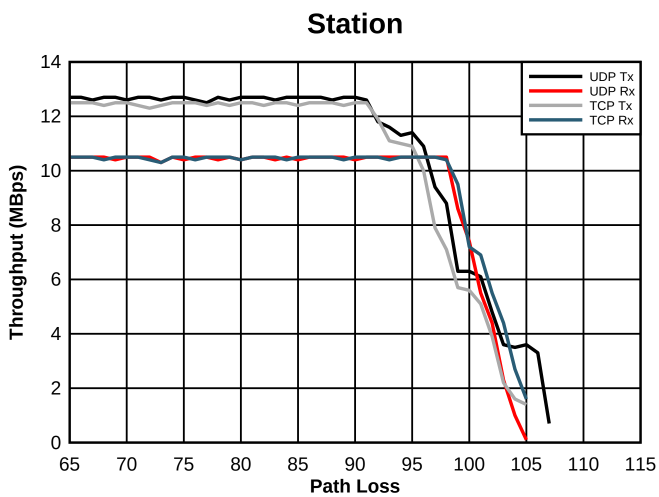


Figure 27. Data Throughput versus Path Loss (CC3100 Station)

The UART to Wi-Fi Bridge is limited in its throughput by the CC3200 UART module. The UART module has a maximum bit rate of 3 Mbits per second.

7.3.2 In-Office Range Test

For these tests, the UART in the UART to Wi-Fi Bridge was tested at 115,200 bits per second.

In order to see how the UART to Wi-Fi Bridge can perform in an office environment, tests were run with the hardware set up as described in Section 6.2. Using a TP-Link model TL-WR740N router at the AP, one of the systems was moved away from the router and communication was re-checked. In one test, communication was still possible with one system at a distance of 83.3 meters from the AP. There were no obstructions between the system and the AP, though the RF line of sight was down a narrow corridor with walls and cubicles lining the corridor. Another test had the system 25.4 meters form the AP, but the RF signal had to penetrate four walls and several rows of cubicles to get from the AP to the system.

This test is not meant to be a performance test. Actual user performance depends upon many factors, such as the model of the AP used, the amount of RF interference in the environment in which the hardware is installed, the location of the hardware in relation to walls or metal objects, and other factors unique to each installation.

8 Other Applications

The software used to test the UART to Wi-Fi Bridge With 24-V AC Power acts as a cable bridge between two disconnected sections of a network. The UART to Wi-Fi Bridge was also tested with an RS-485-to-Wi-Fi bridge that was designed for another TI Design and they interoperate seamlessly. There are also many other uses for this hardware that were not developed for this project. This hardware can be used as an AP and could serve a web page with information about the devices connected to the UART. This could be accessed by a technician using a smart phone, a tablet, or a laptop computer. Another use is to have the hardware set up as a station connected to an external AP that is connected to the internet. In this way, the UART to Wi-Fi Bridge would provide data to a cloud server that can be remotely accessed or used for data analysis.

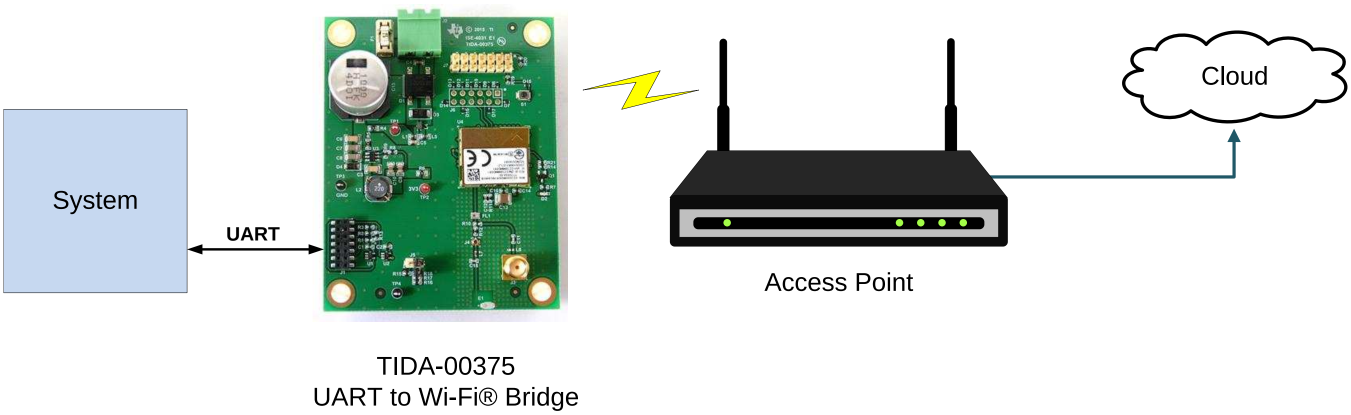


Figure 28. UART to Cloud System

9 Design Files

9.1 Schematics

To download the schematics, see the design files at TIDA-00375.

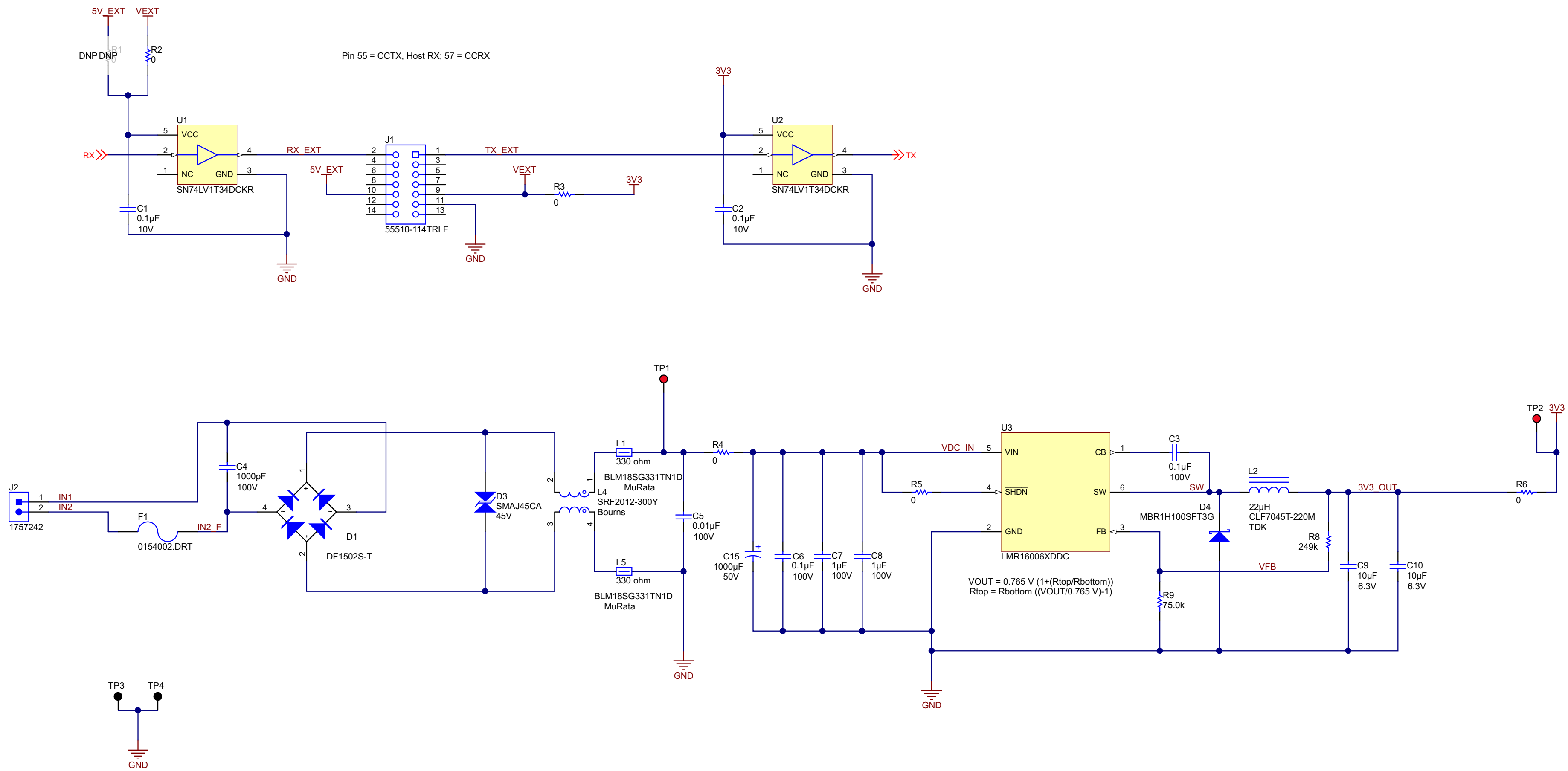


Figure 29. Power and Interface Schematic

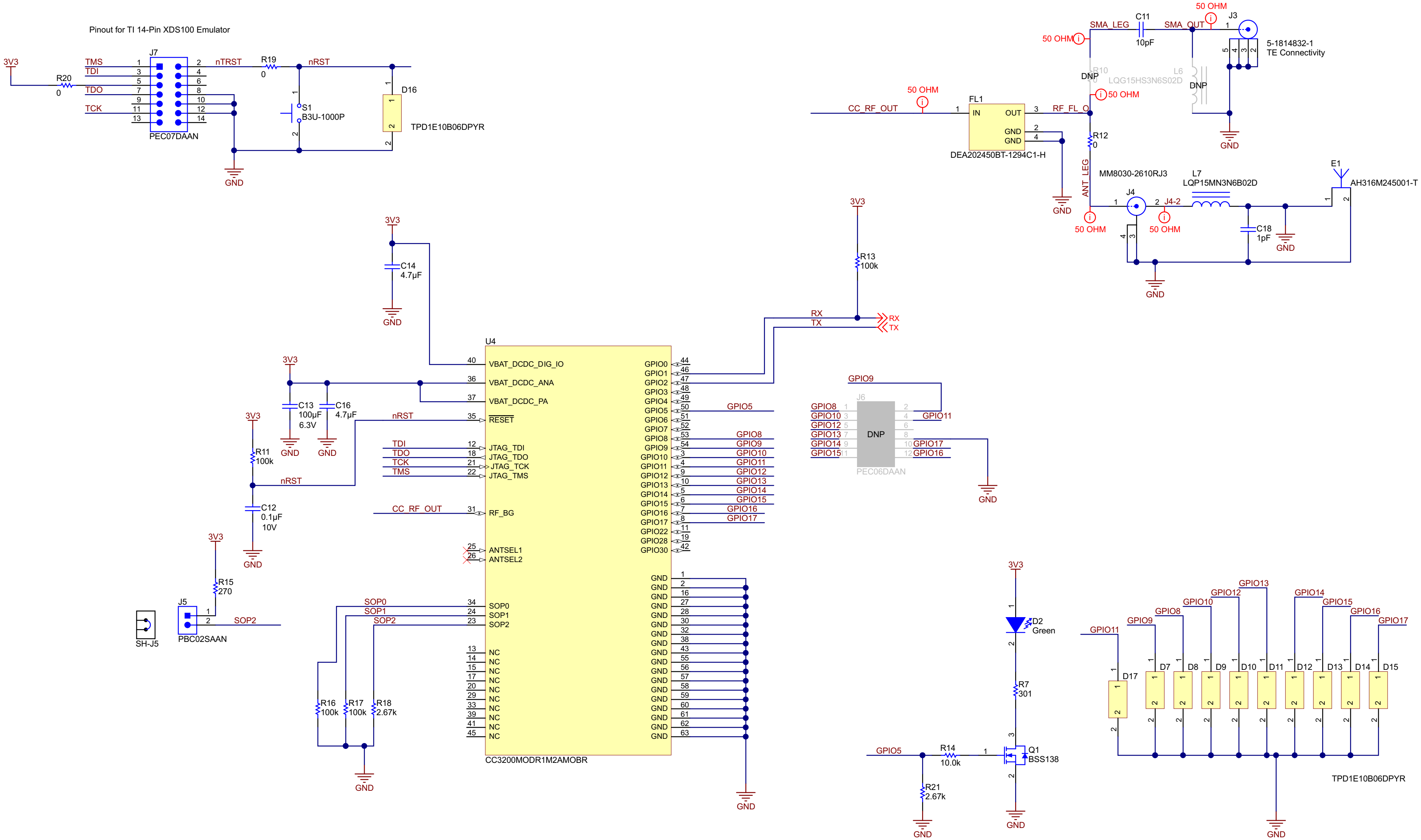


Figure 30. CC3200MOD Schematic

9.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-00375.

9.3 PCB Layout Recommendations

The layout of this PCB was done by carefully following the recommended guidelines for the LMR16006, the CC3200MOD, and the Taiyo Yuden AH316M245001-T chip antenna. The power nets from J2 through to the 3V3 net are made as wide as practical. For the CC3200MOD, follow the *Hardware Design Review Process and PCB Layout Design Guidelines* found on the SimpleLink™ Wi-Fi® CC31xx/CC32xx Main Page for best results.

9.3.1 Layer Plots

To download the layer plots, see the design files at TIDA-00375.

9.4 Altium Project

To download the Altium project files, see the design files at TIDA-00375.

9.5 Gerber Files

To download the Gerber files, see the design files at TIDA-00375.

9.6 Assembly Drawings

To download the Gerber files, see the design files at TIDA-00375.

10 Software Files

To download the software files, see the design files at TIDA-00375.

11 References

1. Texas Instruments, *CC3200MOD SimpleLink™ Wi-Fi® and Internet-of-Things Module Solution, a Single-Chip Wireless MCU*, CC3200MOD Datasheet (SWRS166)
2. Texas Instruments, *SimpleLink™ Wi-Fi® CC31xx/CC32xx Main Page* (link)
3. Texas Instruments, *SimpleLink Wi-Fi CC3100 BoosterPack* (http://www.ti.com/tool/cc3100boost)
4. Texas Instruments, *LMR16006 SIMPLE SWITCHER® 60 V 0.6 A Buck Regulators With High Efficiency ECO Mode*, LMR16006 Datasheet (SNVSA24)
5. Texas Instruments, *SN74LV1T34 Single Power Supply Buffer GATE CMOS Logic Level Shifter*, SN74LV1T34 Datasheet (SCLS743)

12 Acknowledgments

The authors would like to thank Ben Gilboa, Moshe Leibo, and all of the members of the CC3100/CC3200 SimpleLink team for their support for this project and especially for the throughput data.

13 About the Authors

MARK KNAPP is a Systems Architect at Texas Instruments Incorporated where he is responsible for developing reference design solutions for the Building Automation segment. He has an extensive background in video camera systems and infrared imaging systems for Military, Automotive and Industrial applications. Mark earned his BSEE at the University of Michigan-Dearborn and his MSEE at the University of Texas at Dallas.

CHRISTINA S. LAM is a Systems Architect at Texas Instruments where she is responsible for developing firmware for reference design solutions in the industrial segment. Christina has broad experience with applications processors, microcontrollers, and digital-signal processors with specialties in embedded firmware. Christina earned her BS in electrical and computer engineering from the University of Texas at Austin.

Revision History

Changes from Original (June 2015) to A Revision	Page
• Changed from preview page	1

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

IMPORTANT NOTICE FOR TI REFERENCE DESIGNS

Texas Instruments Incorporated ("TI") reference designs are solely intended to assist designers (“Buyers”) who are developing systems that incorporate TI semiconductor products (also referred to herein as “components”). Buyer understands and agrees that Buyer remains responsible for using its independent analysis, evaluation and judgment in designing Buyer’s systems and products.

TI reference designs have been created using standard laboratory conditions and engineering practices. **TI has not conducted any testing other than that specifically described in the published documentation for a particular reference design.** TI may make corrections, enhancements, improvements and other changes to its reference designs.

Buyers are authorized to use TI reference designs with the TI component(s) identified in each particular reference design and to modify the reference design in the development of their end products. HOWEVER, NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY THIRD PARTY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT, IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI REFERENCE DESIGNS ARE PROVIDED "AS IS". TI MAKES NO WARRANTIES OR REPRESENTATIONS WITH REGARD TO THE REFERENCE DESIGNS OR USE OF THE REFERENCE DESIGNS, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ACCURACY OR COMPLETENESS. TI DISCLAIMS ANY WARRANTY OF TITLE AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, QUIET ENJOYMENT, QUIET POSSESSION, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS WITH REGARD TO TI REFERENCE DESIGNS OR USE THEREOF. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY BUYERS AGAINST ANY THIRD PARTY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON A COMBINATION OF COMPONENTS PROVIDED IN A TI REFERENCE DESIGN. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR INDIRECT DAMAGES, HOWEVER CAUSED, ON ANY THEORY OF LIABILITY AND WHETHER OR NOT TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, ARISING IN ANY WAY OUT OF TI REFERENCE DESIGNS OR BUYER’S USE OF TI REFERENCE DESIGNS.

TI reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques for TI components are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

Reproduction of significant portions of TI information in TI data books, data sheets or reference designs is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards that anticipate dangerous failures, monitor failures and their consequences, lessen the likelihood of dangerous failures and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in Buyer’s safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed an agreement specifically governing such use.

Only those TI components that TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components that have ***not*** been so designated is solely at Buyer's risk, and Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265