Appendix 6.

User manual

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eZ430-TMS37157 Development Tool

User's Guide

Literature Number: SLAU281B
November 2009–Revised March 2010

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Read This First

If You Need Assistance

Support for MSP430 devices and the eZ430-TMS37157 is provided by the Texas Instruments Product Information Center (PIC). Contact information for the PIC can be found on the TI web site at www.ti.com. Additional device-specific information can be found on the MSP430 web site at www.ti.com/msp430.

NOTE: IAR Embedded Workbench® KickStart is supported by Texas Instruments.

Although IAR Embedded Workbench KickStart is a product of IAR, Texas Instruments provides support for KickStart. Therefore, please do not request support for KickStart from IAR. Please consult all provided documentation with KickStart before requesting assistance.

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eZ430-TMS37157 Development Tool

1 eZ430-TMS37157 Overview

The eZ430-TMS37157 is a complete USB-based MSP430 wireless development tool providing the hardware and software to evaluate the MSP430F2274 microcontroller and the TMS37157 passive low-frequency interface (PaLFI) RFID transponder.

The eZ430-TMS37157 uses Code Composer Essentials (CCE) or IAR Embedded Workbench Integrated Development Environment (IDE) to write, download, and debug an application. The debugger is unobtrusive, allowing the user to run an application at full speed with both hardware breakpoints and single stepping available while consuming no extra hardware resources.

The eZ430-TMS37157 target board is an out-of-the box wireless system that may be used with the USB debugging interface, as a stand-alone system with or without external sensors, or may be incorporated into an existing design.

The new USB debugging interface enables the eZ430-TMS37157 to remotely send and receive data from a PC using the MSP430 application UART.

eZ430-TMS37157 features:

- USB debugging and programming interface featuring a driverless installation and application backchannel
- 14 available development pins
- Highly integrated, ultra-low-power MSP430 MCU with 16-MHz performance
- Two general-purpose digital I/O pins connected to green and red LEDs for visual feedback
- Interruptible push button for user feedback

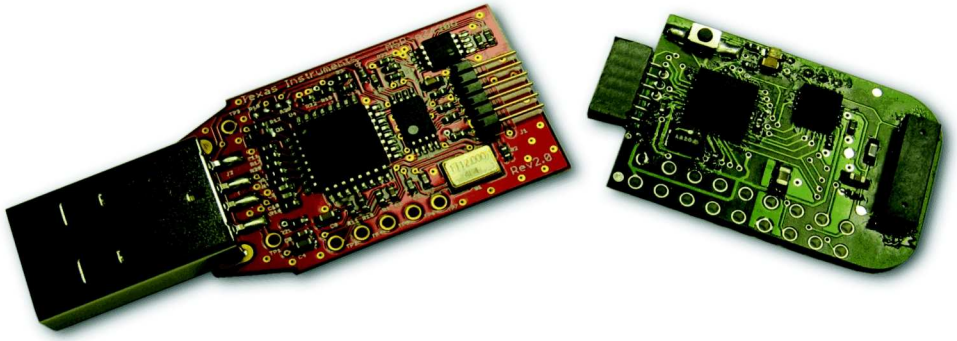

Figure 1. eZ430-TMS37157

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2 Developing With eZ430-TMS37157

The eZ430-TMS37157 can be used as a stand-alone development tool. Additionally, the eZ430-TMS37157 target board also may be detached from the debugging interface and integrated into another design. The target board features an MSP430F2274 and most of its pins are easily accessible. The pins are shown in Figure 2 and described in Table 1 and Table 2:

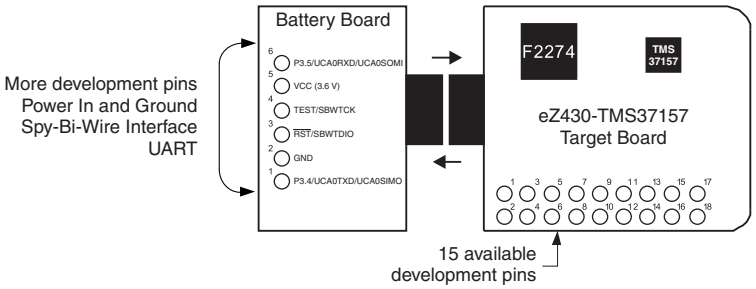

Figure 2. eZ430-TMS37157 Development Tool

Table 1. eZ430-TMS37157 Target Board Pinouts

Pin	Function	Description
1	GND	Ground reference
2	VCC	Supply voltage
3	Not Connected	
4	P2.0 / ACLK / A0 / OA0I0	General-purpose digital I/O pin / ACLK output / ADC10, analog input A0
5	Not Connected	
6	P2.1 / TAINCLK / SMCLK / A1 / A0O	General-purpose digital I/O pin / ADC10, analog input A1 Timer_A, clock signal at INCLK, SMCLK signal output
7	Not Connected	
8	P2.2 / TA0 / A2 / OA0I1	General-purpose digital I/O pin / ADC10, analog input A2 Timer_A, capture: CCI0B input/BSL receive, compare: OUT0 output
9	P4.3 / TB0 / A12 / OA0O	General-purpose digital I/O pin / ADC10 analog input A12 / Timer_B, capture: CCI0B input, compare: OUT0 output
10	P2.3 / TA1 / A3 / V_{REF-} / V_{eREF-} / OA1I1 / OA1O	General-purpose digital I/O pin / Timer_A, capture: CCI1B input, compare: OUT1 output / ADC10, analog input A3 / negative reference voltage output/input
11	P4.4 / TB1 / A13 / OA1O	General-purpose digital I/O pin / ADC10 analog input A13 / Timer_B, capture: CCI1B input, compare: OUT1 output
12	GND	Ground reference
13	P4.5 / TB2 / A14 / OA0I3	General-purpose digital I/O pin / ADC10 analog input A14 / Timer_B, compare: OUT2 output
14	P4.6 / TBOUTH / A15 / OA1I3	General-purpose digital I/O pin / ADC10 analog input A15 / Timer_B, switch all TB0 to TB3 outputs to high impedance
15	P3.2 / UCB0SOMI / UCB0SCL	General-purpose digital I/O pin USCI_B0 slave out/master in when in SPI mode, SCL I2C clock in I2C mode
16	P3.3 / UCB0CLK / UCA0STE	General-purpose digital I/O pin USCI_B0 clock input/output / USCI_A0 slave transmit enable
17	P3.0 / UCB0STE / UCA0CLK / A5	General-purpose digital I/O pin / USCI_B0 slave transmit enable / USCI_A0 clock input/output / ADC10, analog input A5
18	P3.1 / UCB0SIMO / UCB0SDA	General-purpose digital I/O pin / USCI_B0 slave in/master out in SPI mode, SDA I2C data in I2C mode

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Table 2. Battery Board Pinouts

Pin	Function	Description
1	P3.4 / UCA0TXD / UCA0SIMO	General-purpose digital I/O pin / USCI_A0 transmit data output in UART mode (UART communication from MSP430F2274 to PC), slave in/master out in SPI mode
2	GND	Ground reference
3	$\overline{\text{RST}}$ / SBWTDIO	Reset or nonmaskable interrupt input Spy-Bi-Wire test data input/output during programming and test
4	TEST / SBWTCK	Selects test mode for JTAG pins on Port 1. The device protection fuse is connected to TEST. Spy-Bi-Wire test clock input during programming and test
5	VCC (3.6 V)	Supply voltage
6	P3.5 / UCA0RXD / UCA0SOMI	General-purpose digital I/O pin / USCI_A0 receive data input in UART mode (UART communication from 2274 to PC), slave out/master in when in SPI mode

3 RFID Principles

Texas Instruments low-frequency RFID operates at a frequency of 134.2 kHz. A normal RFID system is completely passive—the RFID Reader (the reader is a transceiver but is called only RFID Reader in this document) sends a command to a RFID transponder, and the transponder answers, normally with its serial number. The transponder is not connected to a battery; it is completely powered out of the RF field supplied by the RFID Reader.

The TMS37157 extends this function by a 3 -wire SPI Interface to the MSP430. The TMS37157 is a semi-active transponder. Its memory can be written through the RF interface (normal transponder function) without need for a battery or through the SPI interface from a connected microcontroller. It offers additional functions like a battery check and a battery charge; also it is able to transmit received data from the RF interface directly to the connected microcontroller.

For ultra-low-power consumption, the TMS37157 offers the possibility to completely switch off the microcontroller (if powered from VBATI) resulting in an overall power consumption of typically 60 nA. The eZ430-TMS37157 does not cover this function. The MSP430 is directly connected to the battery.

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4 Kit Contents

Order Number: eZ430-TMS37157

Part Name: PaLFI Evaluation Kit TMS37157

Table 3. eZ430-TMS37157 Kit Content

Count	Description
1	Documentation: Read Me First
1	eZ430 emulator stick
1	eZ430-TMS37157 target board
1	eZ430 battery board
2	AAA battery
1	USB RFID reader board
1	Reader antenna
1	USB cable
1	DC power plug cable

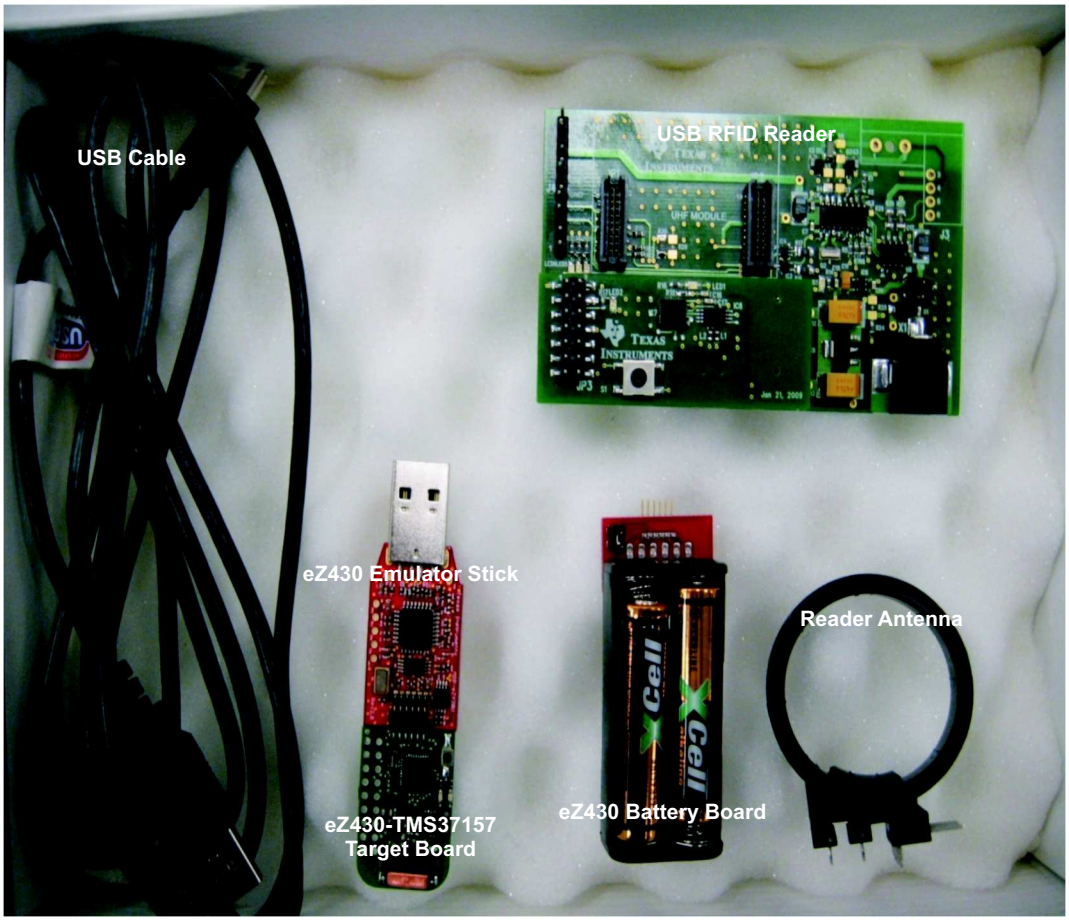

Figure 3. Kit Contents

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5 Download the Software

As first step, download the latest version of the following files:

1. TMS37157 data sheet: SWRS083
2. Demo software (GUI): SWRC164
3. USB device driver:
   For interface board Rev 1.0: SWRC172
   For interface board Rev 2.0: http://www.ftdichip.com/Drivers/VCP.htm
4. eZ430-TMS37157 firmware source code: SWRC165
5. Reader firmware source code: SLAC350
6. MSP430 code composer: http://www.ti.com/msp430
7. Additional documents (application notes, etc): http://www.ti.com/rfid
8. eZ430-TMS37157 Product Folder: http://focus.ti.com/docs/toolsw/folders/print/ez430-tms37157.html

6 Installation

6.1 RFID Base Station Hardware Installation

1. Plug the antenna into the RFID Base Station (J3), there is no need for soldering.
2. Connect the RFID Base Station to a USB port.

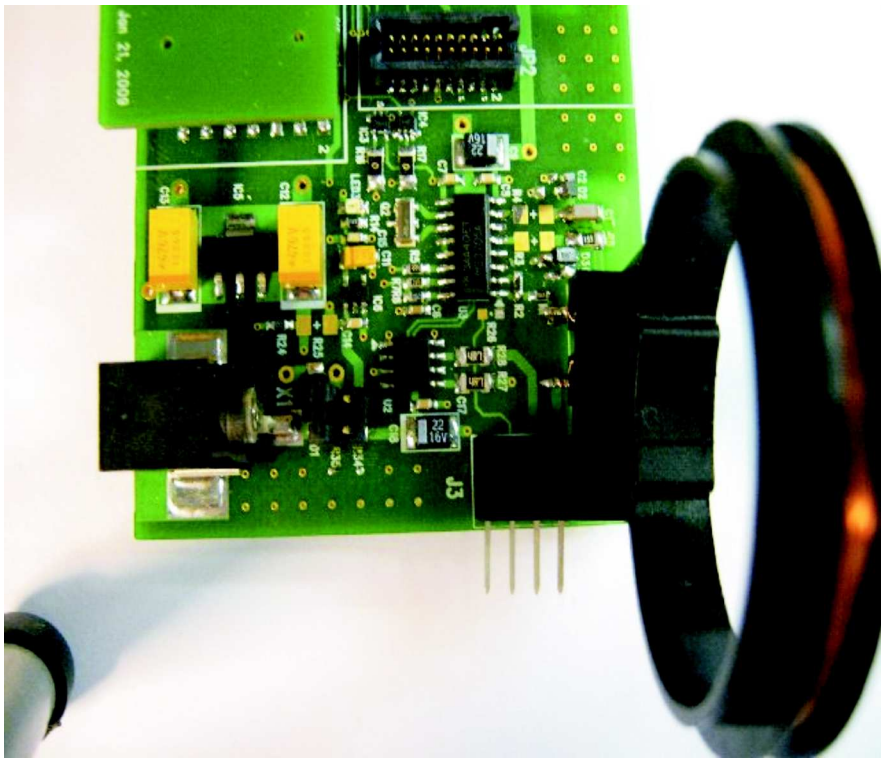

Figure 4. RFID Base Station With Mounted Antenna

NOTE: Do not solder the antenna pins.

Press fit the contacts.

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6.1.1 External Power Supply (Optional)

The base station is delivered to operate with USB power supply (0-Ω resistor R34 is assembled). For longer read range, an external supply can be used. The steps to change to external power supply are:

1. Remove the 0-Ω resistor from R34 position.
2. Solder the same resistor on position R35.
3. Use external power supply of 9 V to 15 V at 1 A.
4. Use a DC power plug pin with a 2.5-mm diameter (RS Order No. 486-634 or 455-097) (see Figure 5).

DC Power Plugs
Rated at 12 V, 1 A

Dimensions (mm)			
Type	A	B	C
1.3	1.4	3.5	9.5
2.1	2.1	5.5	9.0
2.5	2.5	5.5	9.0

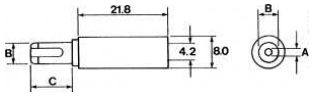

Figure 5. DC Power Plug

6.1.2 Base Station USB Driver Installation

1. Install the RFID demo software by running RFID Demo Software-1.0-Setup.exe on the PC. This also installs the device driver for the base station and the eZ430 USB debugging interface (see Section 5).
2. Plug the base station into the USB port.
3. Windows recognizes the new hardware as Texas Instruments MSP-FET430UIF (see Figure 6). Windows should automatically install the drivers for the MSP-FET430UIF as an HID tool.

Figure 6. Windows XP Hardware Recognition

4. Windows recognizes another new hardware driver to be installed called MSP430 Application UART (see Figure 7).

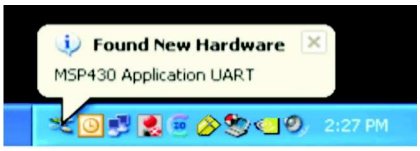

Figure 7. Windows XP Hardware Recognition for MSP430 Application UART

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5. The Found New Hardware Wizard opens (see Figure 8). Select No, not this time and click Next.

Figure 8. Found New Hardware Wizard, Step 1

6. Select Install the software automatically (Recommended), if IAR KickStart R4.64 or higher has already been installed (see Figure 9).

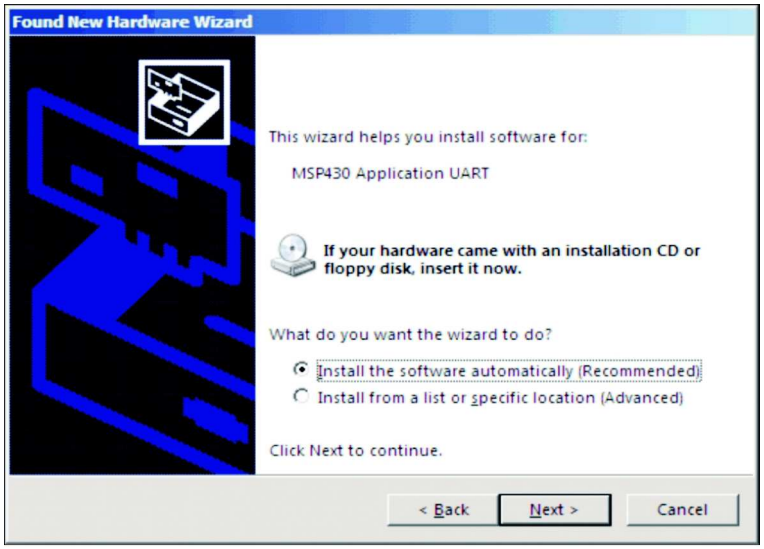

Figure 9. Found New Hardware Wizard, Step 2

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7. The Wizard should find the appropriate driver for a Windows XP system; it shows a warning that Microsoft did not certify the driver (see Figure 10). The drivers have been tested exhaustively, and this warning can be ignored. Click Continue Anyway.

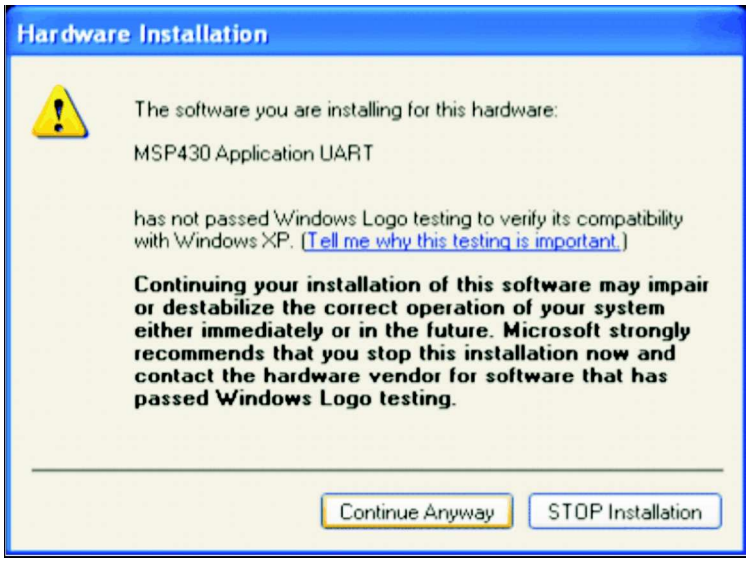

Figure 10. Hardware Installation

8. The Wizard continues to install the driver and then provides notification when it has finished the installation of the software.
9. Find the right Com Port for the RFID Base Station ("Texas Instruments RFID Base Station") in the Windows Device Manager (see Figure 11).

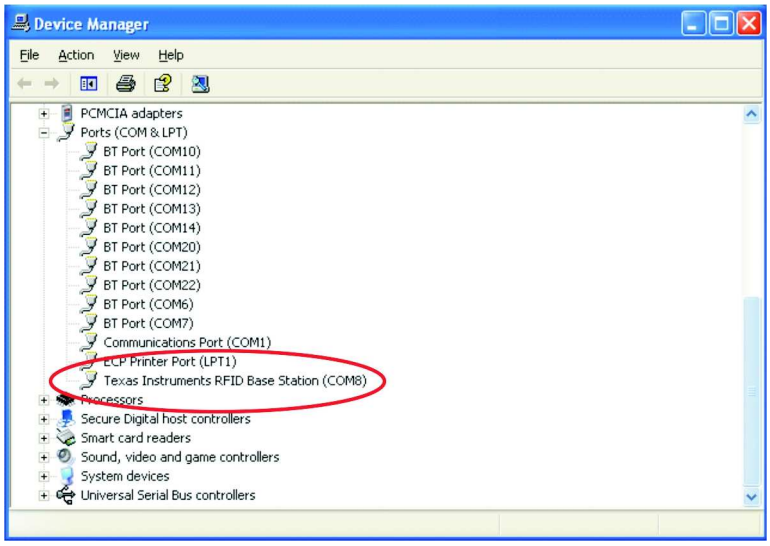

Figure 11. RFID Base Station in Device Manager

10. The USB driver is now installed on your PC. The system is ready for use.

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6.2 TMS37157 Hardware Installation

The eZ430-TMS37157 can be used as a standalone module or connected to the battery board.

Standalone

The eZ430-TMS37157 is used standalone without connection to any other module. In this setting, the target board operates as passive device.

Connected to the Battery Board

The target board can be connected to the battery board. In this setting, it can be operated as:

- Passive device, when jumper JP1 is removed (no voltage supply)
- Active device, when jumper JP1 is connected (battery voltage supply)

NOTE: Make sure the top side of the battery board (red PCB) is connected to the top side of the TMS37157 target board (component side) (see Figure 12).

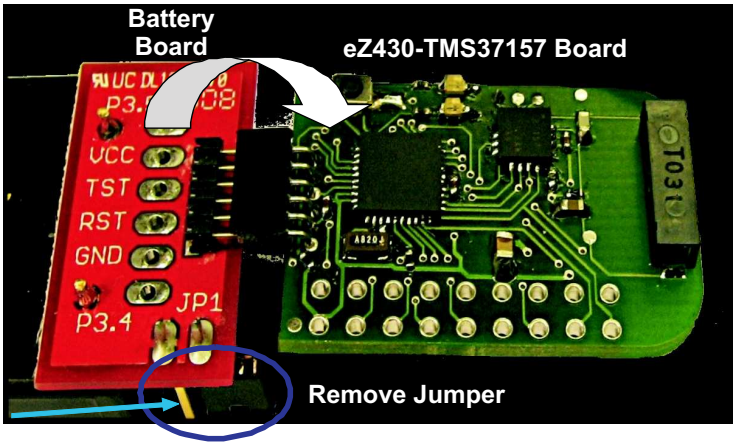

Figure 12. Connection of TMS37157 to the Battery Board

Place eZ430-TMS37157 in front of the reader antenna. The expected operating distance in passive mode (without battery supply) and with the given antenna on the TMS37157 target board is 2 to 3 cm (see Figure 13).

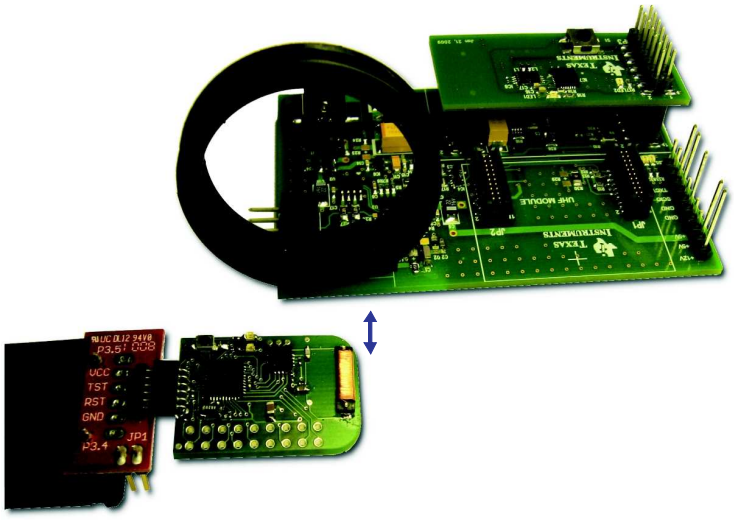

Figure 13. eZ430-TMS37157 in Front of RFID Base Station

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6.3 eZ430-TMS37157 Demo Software (GUI) Installation

1. Unpack RFID Demo Software.zip.
2. Start the eZ430-TMS37157 Demo Reader Software using the shortcut installed on the desktop.

7 eZ430-TMS37157 Demo Software (GUI)

1. Ensure RFID base station is connected to the host PC.
2. Place the target board in front of the antenna of the RFID base station, the distance should not be longer than 3 cm to show all functions; in particular, the extended mode requires a high field strength.
3. Start the RFID Demo Software from the PC (see Figure 14).

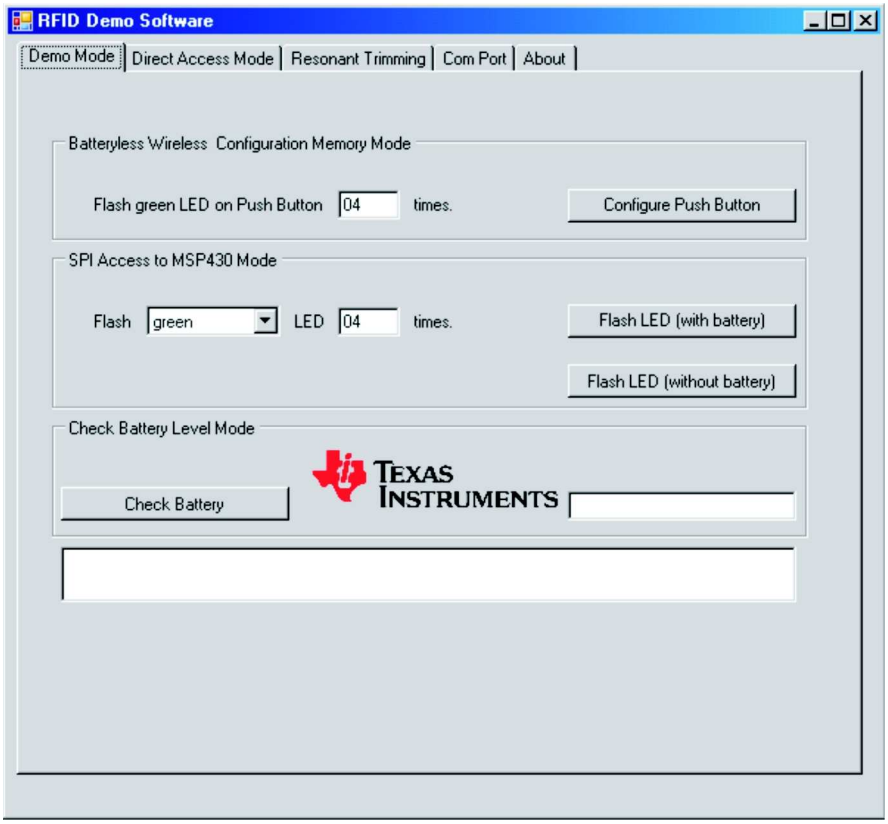

Figure 14. RFID Demo Software: Startup Screen

4. Go to the Com Port tab and choose the right com port for the RFID Base Station (see Figure 15). The base station connects automatically to the right com port on the PC (the right com port can be found as shown in Figure 11).

NOTE: Connection can be tested by pressing Configuration Push Button on the Demo Mode tab. The red LED (LED4) flashes on every execution.

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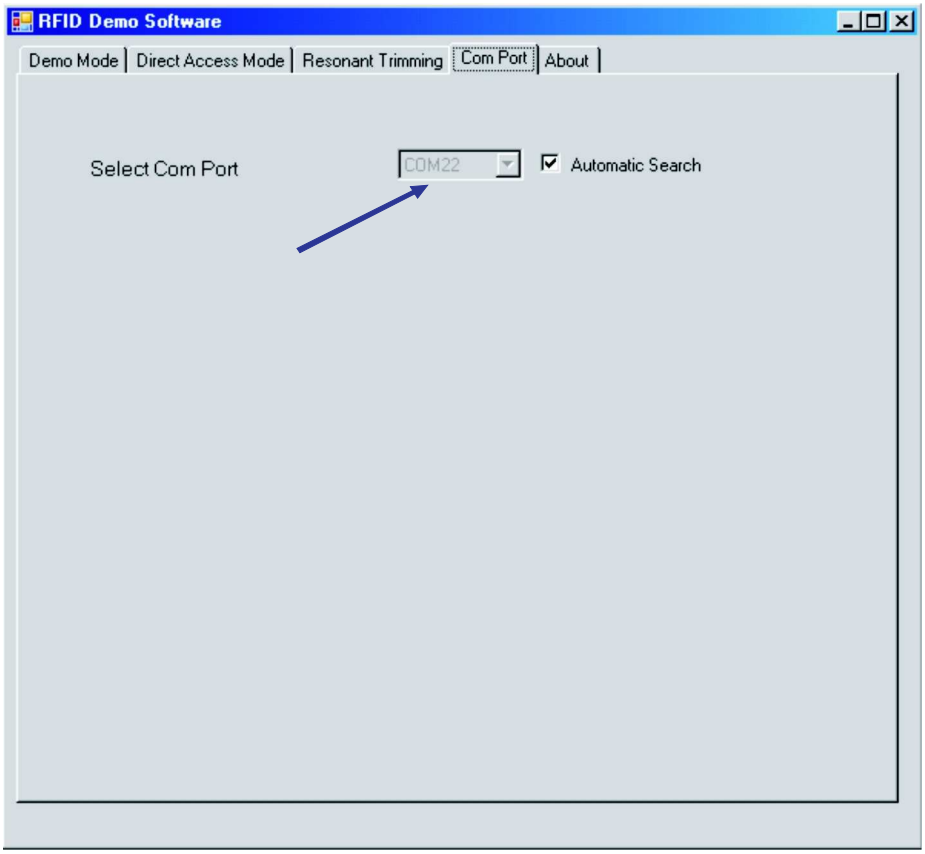

Figure 15. RFID Demo Software: Com Port Tab

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8 eZ430-TMS37157 Demo

8.1 Demo Mode Functions

Choose the Tab "Demo Mode" to see all Demo Functions. This tab offers three different categories of demos (see Figure 16).

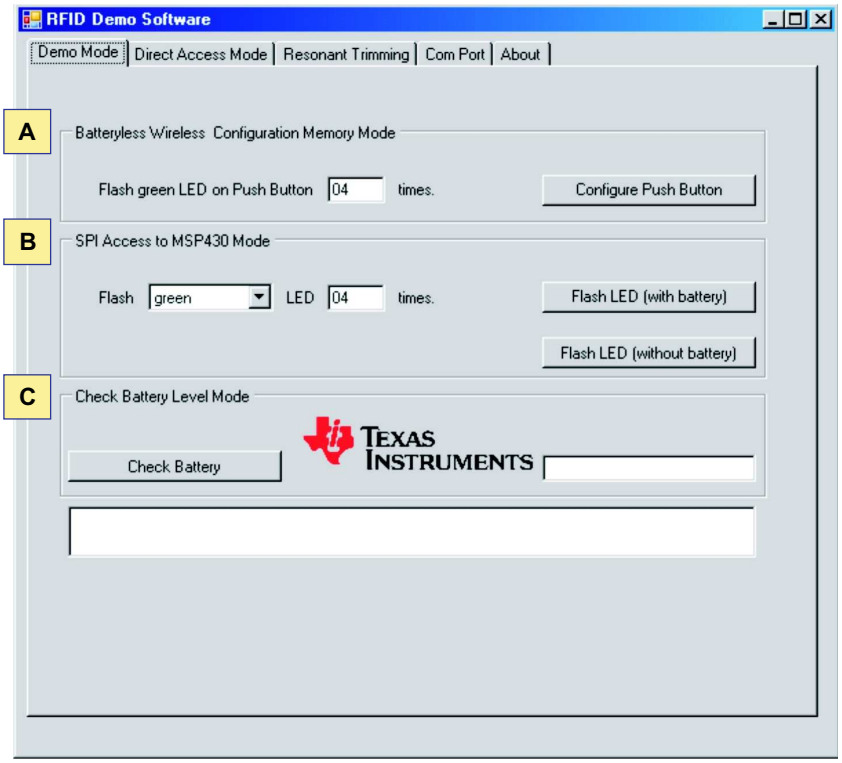

Figure 16. RFID Demo Software: Demo Mode

8.1.1 Batteryless Wireless Configuration Memory Mode

This mode (see Figure 16, field A) shows the main function of the TMS37157 (PaLFI). The memory of the TMS37157 can be altered without having a connection to a battery. Typical applications for this function could be configuration data stored in the TMS37157 memory without involvement of the microcontroller and without supply voltage. The stored data can be accessed after the microcontroller is activated and use the stored date for configuration or calibration purposes.

1. Enter the number of times the green LED should flash.
2. Program the corresponding page in the TMS37157 memory (programs Page 9) by clicking Configure Push Button.
3. Connect the target board to the battery board and set jumper JP1 (or the eZ430-RF connected to the host PC).
4. Press the push button on the target board (see Figure 17).
5. The green LED flashes the programmed number of times.

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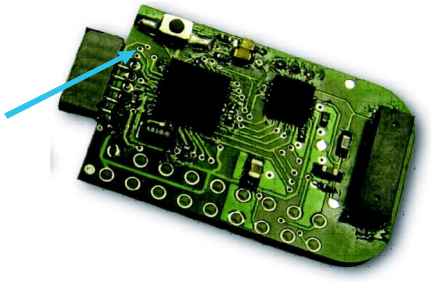

Figure 17. TMS37157 Target Board

8.1.2 SPI Access to MSP430 Mode

This mode (see Figure 16, field B) perform an MSP Access Command to the TMS37157. The RFID base station sends data to the TMS37157, which is forwarded to the MSP430 via the SPI interface. The MSP430 performs a certain action, depending on to the received instruction and sends back the response data to TMS37157 via the SPI and to the base station via the RF interface.

For the button "Flash LED (with battery)":

- The target board must be connected battery board and JP1 must be set. This drives the MSP430 from the battery.
- Choose which LED (green or red) should flash and enter the number of times the LED should flash. A click on the button performs the desired action.

For the button "Flash LED (without battery)":

- The target board must be disconnected from the battery board. The MSP430 is supplied from the induced voltage of the magnetic field generated by the base station.
- Choose which LED (green or red) should flash and enter the number of times the LED should flash. Click on Flash LED (without battery) to perform the desired action. The TMS37157 target board must be within the operating field of the base station (2 to 3 cm).

NOTE: The "Flash LED (without battery)" performs these commands:

1. A Read Page 3 Command (check if TMS37157 is in range)
2. A Battery Charge Command (power up MSP430 and charge capacitor)
3. An MSP Access Command (deliver number of LED flashes to MSP430)
4. A Battery Charge Command (power the MSP430 to drive the LEDs)
5. A Read Page 3 Command (stop charging)

8.1.3 Check Battery Level Mode

This mode (see Figure 16, field C) displays the charge level of the connected battery.

1. Ensure that the battery board is connected to the target board and the jumper is set.
2. Click Check Battery. The battery status appears in the field next to the Texas Instruments logo.

8.2 Direct Access Mode

The Direct Access mode enables the user to use all functions the TMS37157 offers. Every memory page can be read, programmed, or locked. Locked pages are read only and cannot be reprogrammed.

To read a page of the EEPROM, choose the page in the dropdown list and click Read Page.

Figure 18 shows a successful read of Page 3 of an RFID transponder. The Lock Status of the corresponding page is displayed after every Read command execution (field on the right side shows Page Unlocked).

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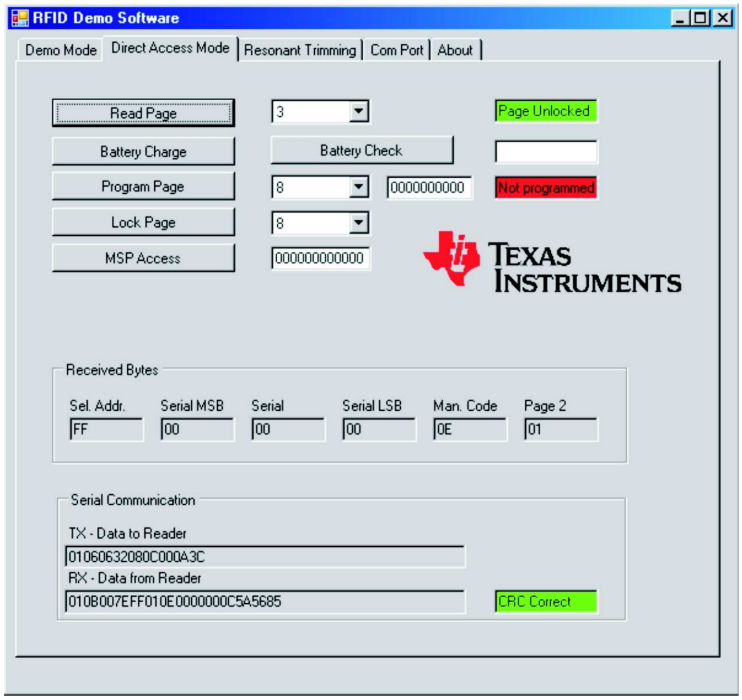

Figure 18. RFID Demo Software: Direct Access Mode

Pages that are not locked can be programmed with the Program Page command (see Figure 19). Choose the corresponding page, enter the data (5 bytes, MSB first) and click Program Page.

The status of the programming is displayed next to the data programmed into the EEPROM page. If the target board is too far away from the base station, a Read Page command may be possible but a Program Page command may not be executed.

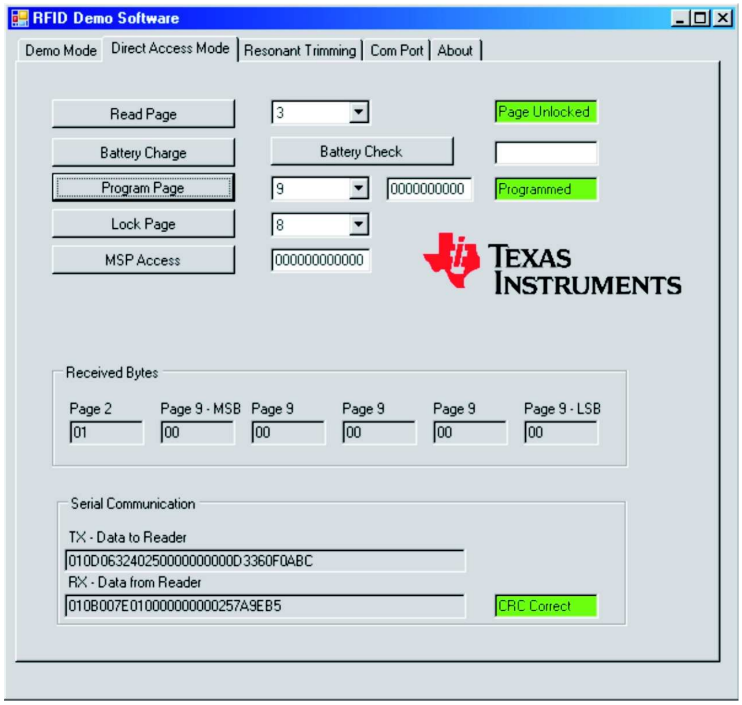

Figure 19. RFID Demo Software: Direct Access Mode, Program Page

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Pages can be locked by choosing the corresponding page and clicking on Lock Page. Locked pages cannot be unlocked and are read only.

8.3 Trimming of the TMS37157 Target board

This demo shows how to trim the TMS37157 target board when a different antenna is used.

NOTE: Trimming of the resonance circuit is needed every time a new antenna is connected or the resonance circuit is detuned. Trimming is needed to tune the resonance to the optimum frequency for best performance. Trimming is done by internal resonance capacitors connected in parallel to the antenna, which can be switched on and off .

The trimming of the TMS37157 target board is done by the MSP430 via the SPI interface. The trimming procedure is implemented in the MSP430 firmware. For more details see Section 9.6.

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9 Demo Examples

With the given antenna, the system has an operating distance of 2 to 3 cm. For a successful communication, the tool reports a Pass. For unsuccessful communication, the tool reports a Fail (see Figure 20). In this case, ensure that the target board is within the operating range (2 to 3 cm) before repeating the command.

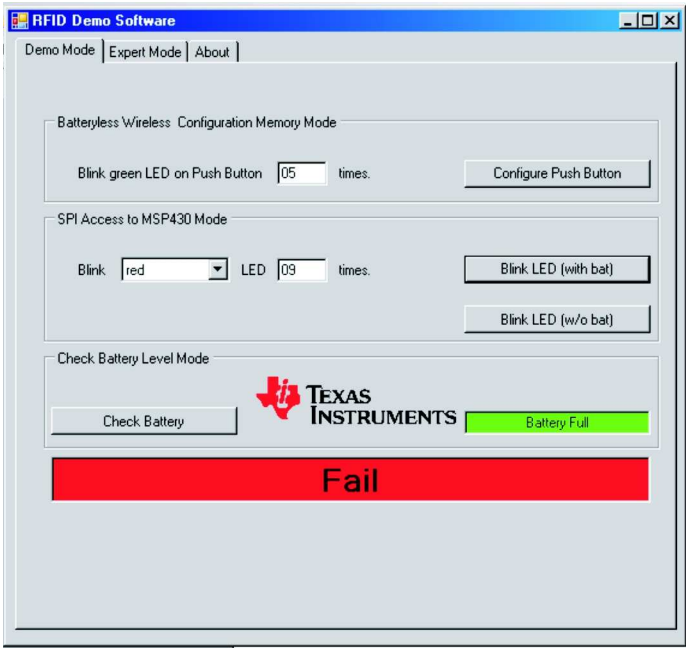

Figure 20. RFID Demo Software: Fail Message

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9.1 Demo 1: SPI Access to MSP430, MSP Access Command

This demo shows the executions of commands and actions using the wireless interface (see Figure 21). This demo causes the LEDs to flash as often as defined in the command. and can be executed with and without battery supply.

With Battery Supply

1. Choose which LED (red or green) should flash and how often.
2. Connect the jumper on the battery board and click the Flash LED (with battery) button.
   The chosen LED flashes as often as was defined by the MSP Access command.

Without Battery Supply

1. Disconnect the jumper on the battery board.
2. Choose which LED (red or green) should flash and how often.
3. Ensure that the eZ430-TMS37157 is in a range of 2-3 cm away from the reader antenna
4. Click the Flash LED (without battery) button.
   The chosen LED flashes as often as it was defined by the MSP Access command.
   The MSP and the LED are powered by the magnetic field generated by the base station.

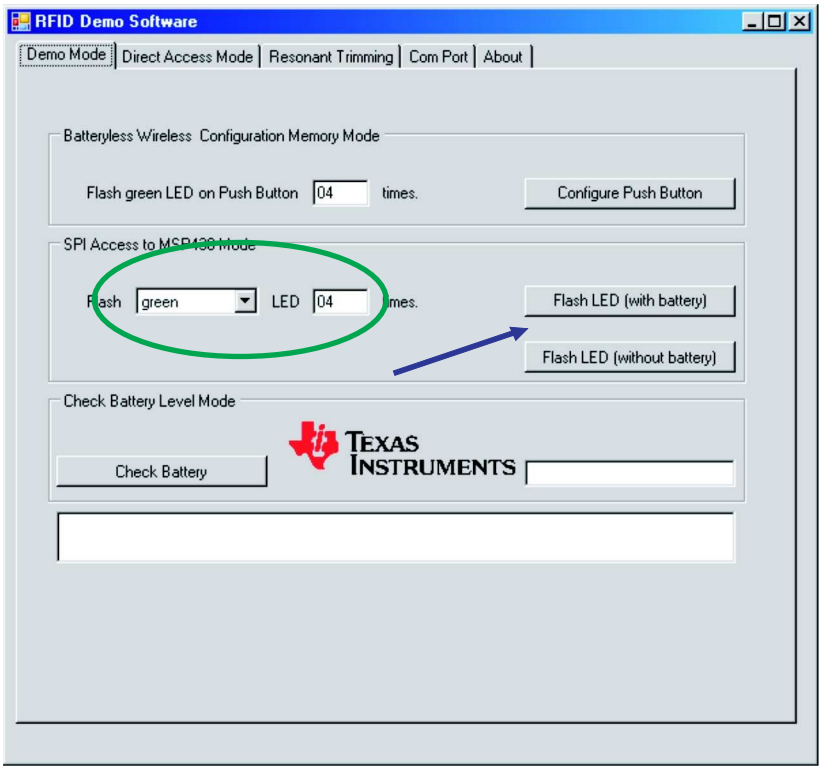

Figure 21. Demo 1 - SPI Access to MSP430 Mode

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9.2 Demo 2: Configuration Memory Mode: Batteryless

This demo shows the execution of write actions, where data can be programmed wireless and without battery supply into a certain memory part (Page) of the TMS37157. These data can be used on any time as, for example, configuration data for the MSP or calibration data for any other device connected to the MSP (see Figure 22).

In this demo, the base station programs data into memory that is used by the MSP on the next wake-up cycle to execute a flashing of the green LED.

1. Disconnect the jumper on the battery board (passive operation)
2. Choose how often the green LED should flash.
3. Program the TMS37157 memory with this information by clicking Configure Push Button.
4. Connect the jumper on the battery board and press the push button on the target board.
   The green LED flashes as often as the value programmed into the TMS37157 memory.

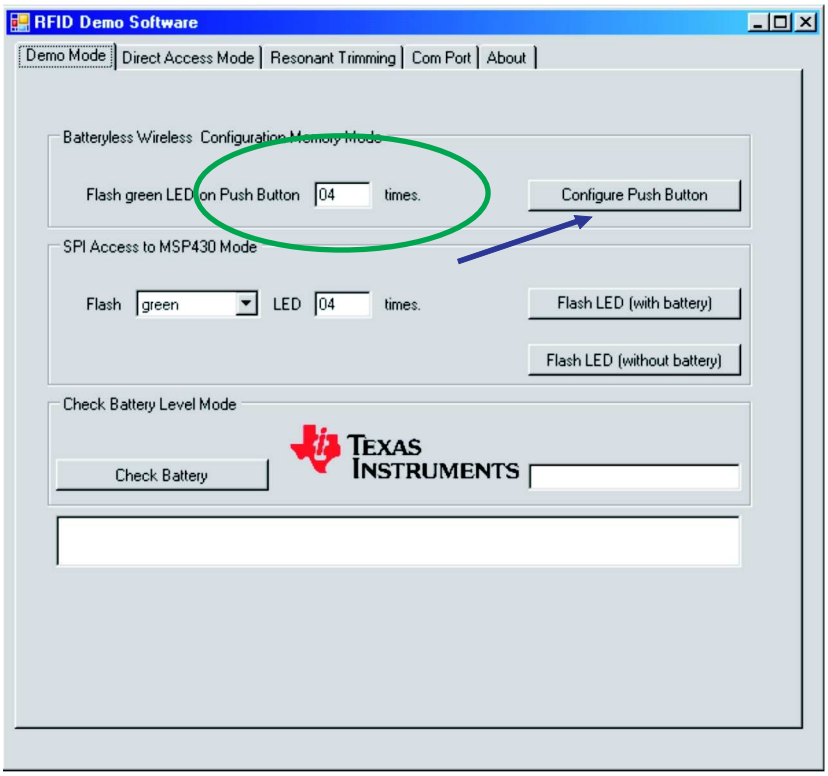

Figure 22. Demo 2 - Configuration Memory Mode

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9.3 Demo 3: Check Battery Level Mode

This demo shows how the battery level status on the TMS37157 board can be checked. High and low level thresholds are set in the TMS37157 device, and voltages between the thresholds are considered medium level.

- Battery voltage > 2.9 V → High voltage level
- Battery voltage < 2.1 V → Low voltage level
- Battery voltage 2.1 V <> 2.9 V → Medium voltage level

To run this demo:

1. Connect the jumper on the battery board
2. Press the Check Battery button. The TMS37157 measures the battery voltage without invoking the MSP430.
3. The color code of the field on the right side represents the battery status:
   - Green: High voltage (see Figure 23)
   - Yellow: Medium voltage (see Figure 24)
   - Red: Low voltage (see Figure 25)

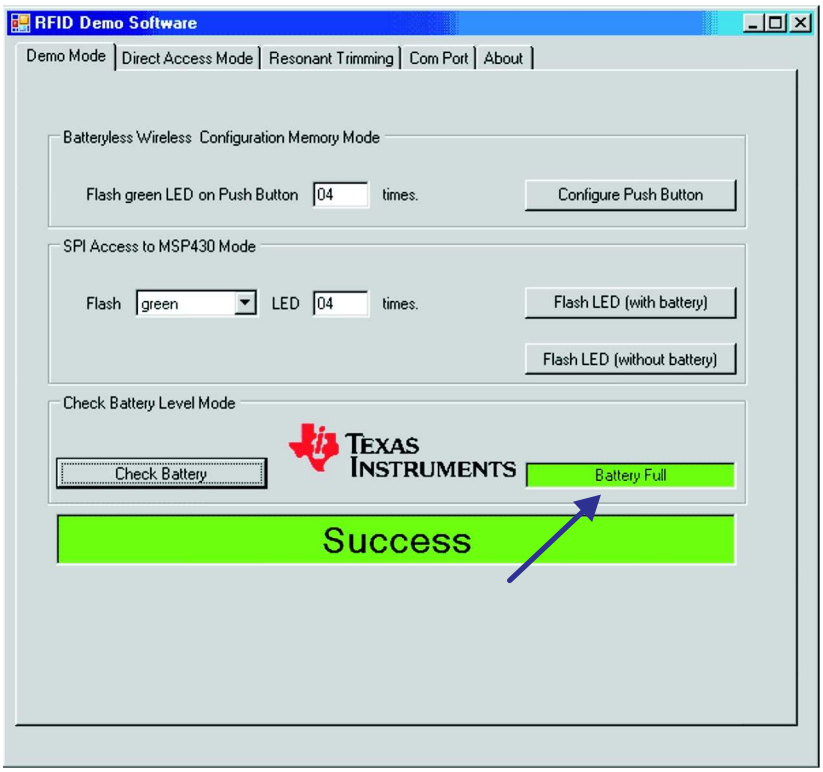

Figure 23. Demo 3 - Check Battery Level Mode: High

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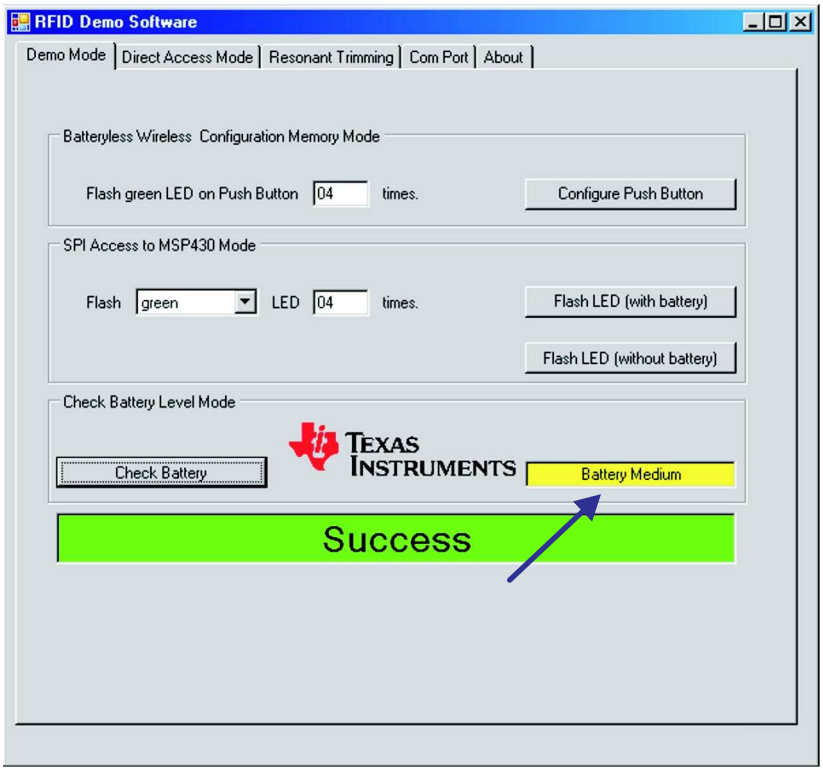

Figure 24. Demo 3 - Check Battery Level Mode: Medium

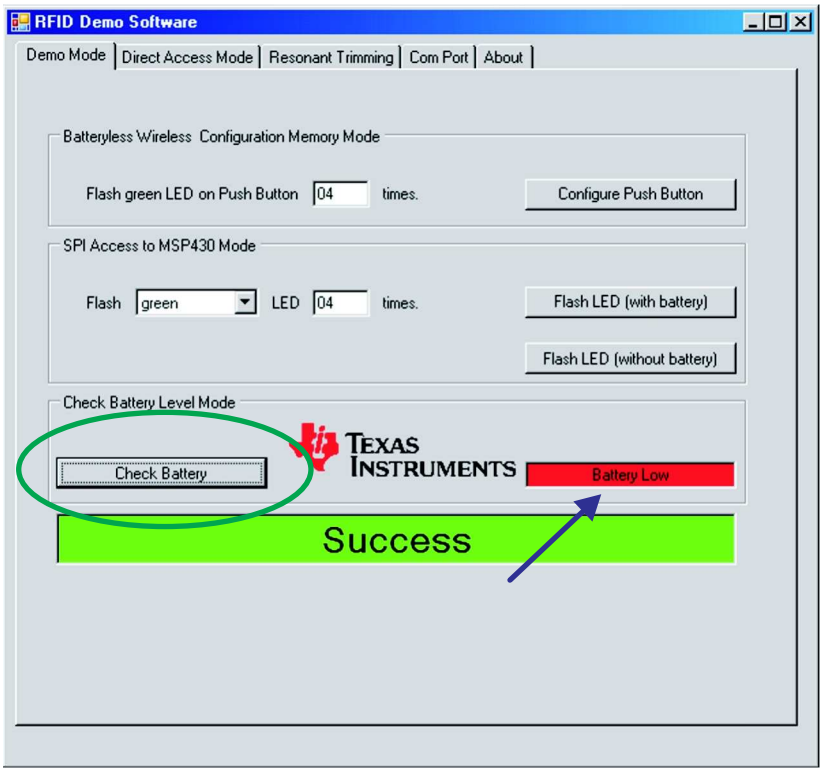

Figure 25. Demo 3 - Check Battery Level Mode: Low

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9.4 Demo 4: Write and Read Data in Memory

This demo shows how to read and write data into the TMS37157 memory. Basic commands are Read Page and Write Page.

To use the Read Page command (see Figure 26):

1. Go to the Expert Mode tab in the RFID Demo Software.
2. Disconnect the jumper on the battery board (no battery supply).
3. On the Read Page field, choose the page to be read (for example, page 8).
4. Press the Read Page button.

   In the Received Bytes field, the received data are shown (01 11 22 33 44 55 MSB).

   The Page Unlocked field shows that this page is not locked and can be reprogrammed. If the page is locked, programming is not possible.

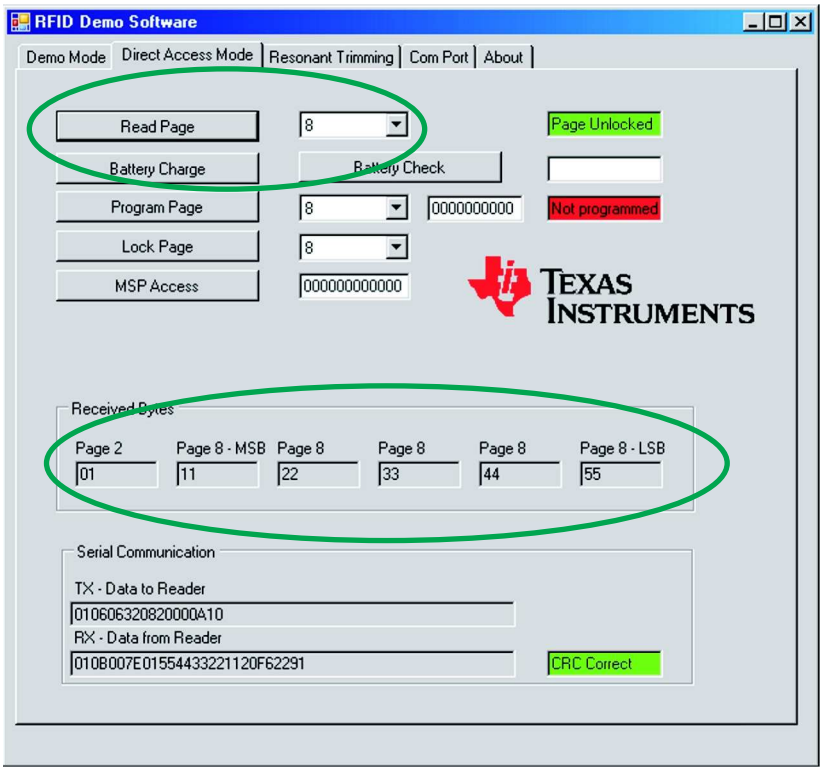

Figure 26. Demo 4 - Read Page

To use the Write Page command:

1. In the Write Page field, enter the page to be programmed (for example, page 8) and the data (for example, 01 02 03 04 05)
2. Press the Write Page button.

   In the Received Bytes field, the received data is shown (01 02 03 04 05 MSB).
3. For validation, the Read Page command can be executed.
4. The same procedure as described for the Write Page can be used to lock pages.

   The Page Unlocked field shows that this page can be reprogrammed. If the page is locked, programming is not possible.

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9.5 Demo 5: Read IC Serial Number

This demo shows how to read the serial number of the TMS37157 device. The serial number is programmed and locked by TI and cannot be changed.

The serial number is stored in page 3 (see Figure 27). Use the Read Page command as described in Section 9.4 for page 3 to read the serial number (see Figure 28). Read page 1 for the Sel. Address and page 2 for the Manufacturer Code (see the TMS37157 data sheet (SWRS083, page 10).

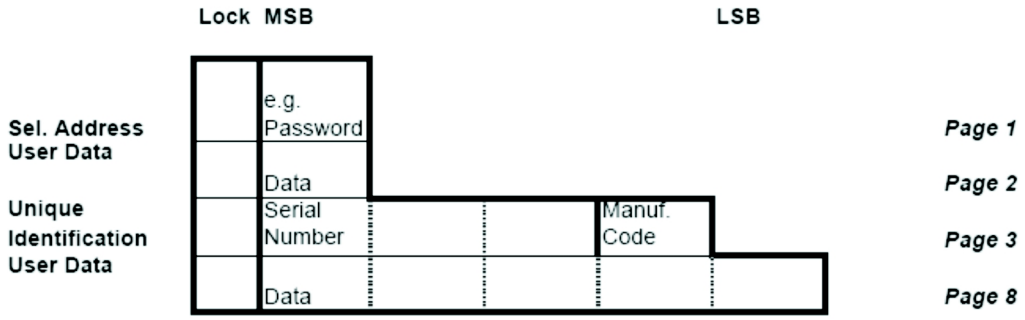

Figure 27. Demo 5 - TMS37157 Memory Map

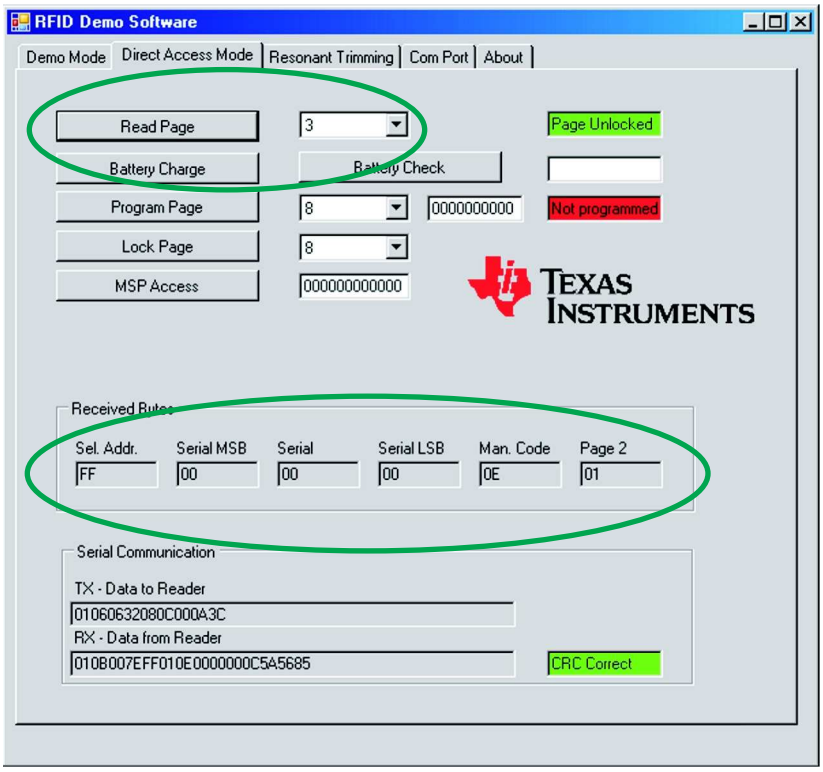

Figure 28. Demo 5 - Read Serial Number

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9.6 Demo 6: Trimming the TMS37157 Target Board

This demo shows how to trim the TMS37157 target board, which is required if a different antenna is used. The trimming of the TMS37157 target board is done by the MSP430 via the SPI interface. The trimming procedure is implemented in the MSP430 firmware.

To determine if trimming is necessary:

1. In the Direct Access Mode tab, read page 2 (see Figure 29).
2. If the TMS37157 is already trimmed, the content of the Page 2 is 0x01.

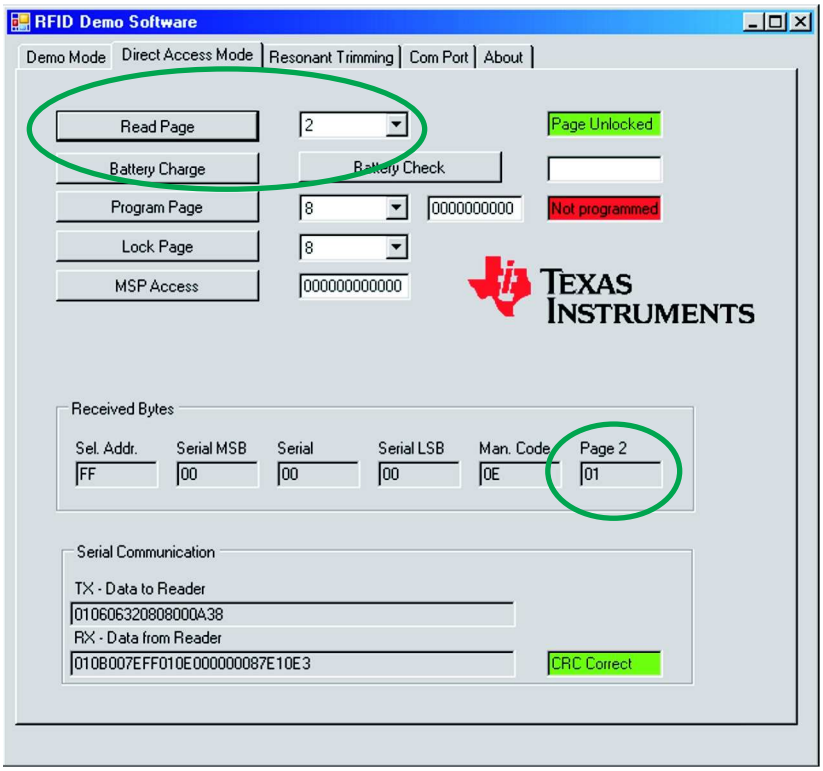

Figure 29. Demo 6 - Read Page 2

To activate the trimming process:

1. Program Page 2 with the value 00 (see Figure 30).
2. After programming, in the Received Byte field, the content of Page 2 is 00.
3. Connect the new antenna.
4. Connect the battery board to the target board.
5. Set the jumper on the battery board to supply the TMS37157.
6. Press the Push Button on the target board.
   The green and red LEDs turn on.
7. Wait while the red LED turns off and the green LED flashes.
8. Trimming is complete when the green LED turns off.

After the trimming, use the Read Page command to verify that the content of Page 2 is 0x01.

The variation of the resonance circuit should be in the range of ±2 kHz and the quality factor of the antenna should be approximately 60 (see SWRS083).

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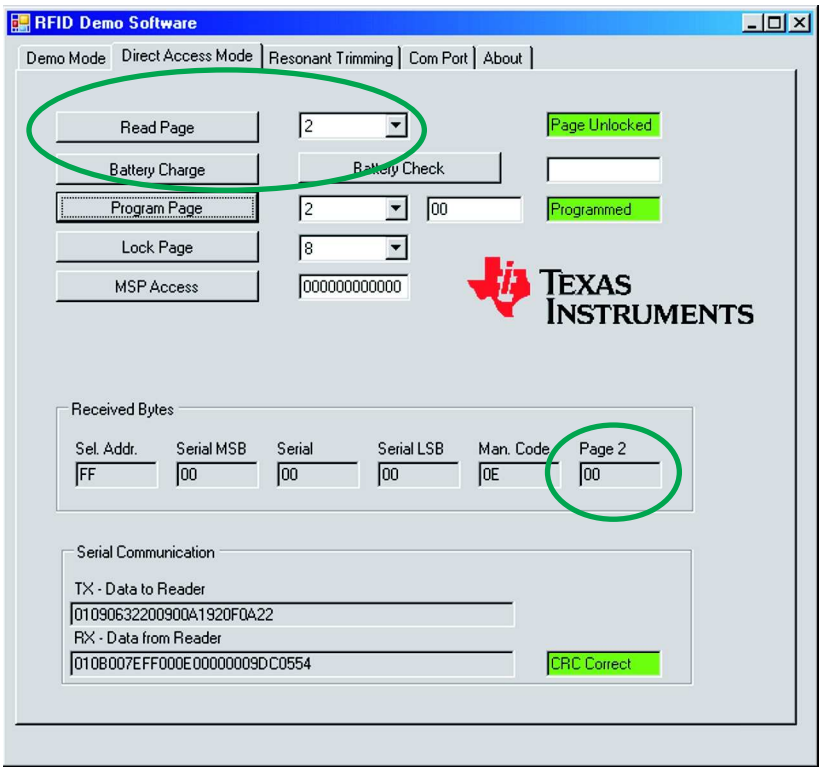

Figure 30. Demo 6 - Program Page 2

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10 Supported Devices

The eZ430-RF USB debugging interface may be used as a standard flash emulation tool through its Spy-Bi-Wire interface. The eZ430-RF USB debugging interface supports the following MSP430 families:

- MSP430F20xx
- MSP430F22xx

The connector on the USB debugging interface is backward compatible with the eZ430-F2013 and T2012 target boards (see Figure 35).

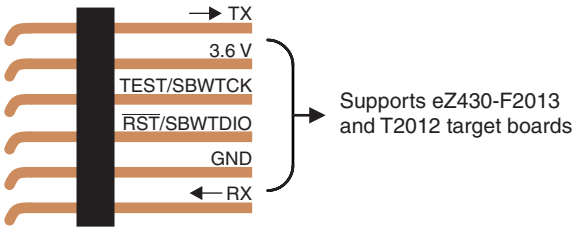

Figure 35. eZ430-RF2500 USB Debugging Interface 6-Pin Male Header

11 MSP430 Application UART

The eZ430-RF USB debugging interface features a back channel MSP430 Application UART that may be used independently of a debug session. This allows the user to transfer serial data to a terminal window at a fixed rate of 9600 bps with no flow control. See Figure 36 for typical settings.

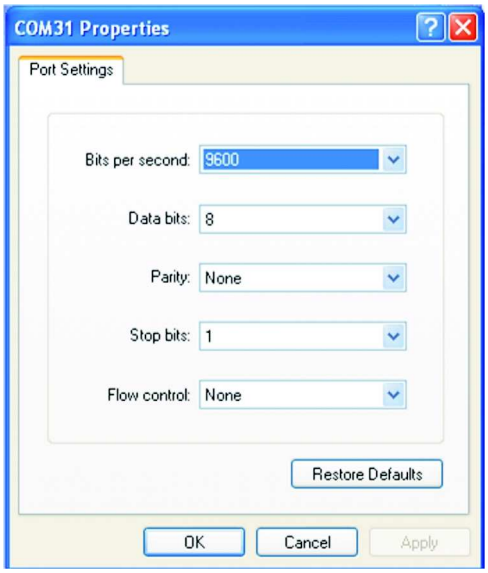

Figure 36. 9600 bps With No Flow Control

Check the Device Manager for COM port assignment of the MSP430 Application UART. For more details, see Section 15).

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12 Software Installation

Two different development software tools for the MSP430—IAR Embedded Workbench KickStart and Code Composer Essentials (CCE) are provided. The term KickStart refers to the limited version of Embedded Workbench that allows up to 4 KB of C-code compilation. The included CCE is also limited, but it allows up to 8 KB of code compilation. The full version of CCE Pro offers unlimited code compilation and can be purchased from www.ti.com/msp430.

To install the IDE:

1. The eZ430-TMS37157 is compatible with Windows® 2000 and Windows XP.
2. Start Code Composer Essentials and follow the instructions.
3. Respond to the prompts to install the software.
4. The installation procedure installs the IDE and TI files.
5. Finish the installation.

13 Hardware Installation

1. Insert the eZ430-RF into USB port. The debugging interface automatically installs itself.
2. When prompted for the software for the MSP430 Application UART, allow Windows to install the software automatically.

   This is possible only if either IAR KickStart R4.64 (or higher) or the RFID Demo Reader Software has already been installed.

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14 IAR Workbench Compatibility Guide

NOTE: In this document, "IAR version" refers to the IAR compiler version. This can be obtained by clicking Help → About → Product Info.

IAR KickStart version 3.42F (FET_R4.64)

Minimum version compatible with eZ430-RF USB debugging interface board

IAR KickStart version 4.09A+ (FET_R5.10+)

Compatible with eZ430-RF USB debugging interface board

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Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com	Wireless	www.ti.com/wireless-apps
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