802.15.4 MAC User's Guide For EXP5438

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Version	Description	Date
1.0	Initial release	06/18/2009
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1. Introduction

1.1. Scope

This document is a user's guide for Texas Instruments' TIMAC™ software and accompanying sample application. TIMAC is an implementation of the IEEE 802.15.4 MAC specification. The sample application demonstrates how devices can associate and transmit application data using the Texas Instruments TIMAC.

2. Product Package Description

2.1. Installation Package Contents

The downloaded TIMAC installation package contains all of the documentation and software required to install, configure, and develop applications using TIMAC. The package employs a Microsoft Windows-based installation application which guides the installation process.

2.2. Development Boards

Two Texas Instruments MSP-EXP430F5438 evaluation boards, fitted with a CC2520EM radio module and antenna, may be used to demonstrate or develop IEEE 802.15.4 applications based on the TIMAC software package. These boards provide a versatile development platform, including a graphical LCD display and various I/O devices (LEDs, joystick, etc).

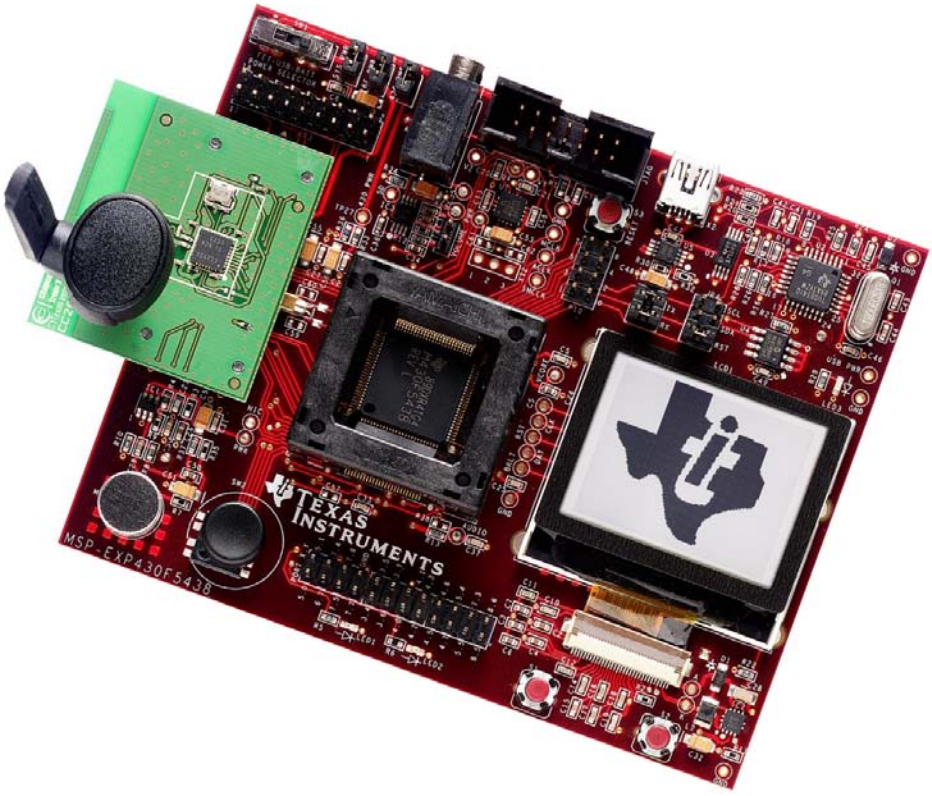

Figure 1: MSP-EXP430F5438 Evaluation Board with CC2520EM

2.3. Development Board Jumpers

The CC2520EM radio module has no jumpers for the user to configure. The EXP5438 board has three jumpers and one switch that need to be set up properly:

- JP1 – MSP430 power: ON if pins 1&2 are connected, OFF otherwise.
- JP2 – System power: ON if pins 1&2 are connected, OFF otherwise.
- JP3 – RF power: ON if pins 1&2 are connected, OFF otherwise.
- SW1 – Power selection: FET/USB/BATT

3. Installation Requirements

3.1. Development System Requirements

The TIMAC sample application projects are used with the IAR Embedded Workbench (EW430) suite of software development tools. These tools support project management, compiling, assembling, linking, downloading, and debugging for MSP430-based processors, including the MSP430F5438. Required support for TIMAC target software development:

- Texas Instruments *TIMAC* for MSP430F5438 + CC2520
- Two EXP5438 Evaluation Boards *MSP430F5438 Experimenter Board*
- Two CC2520EM radio modules *CC2520 Evaluation Module Kit*
- One USB debug module *MSP430 USB Debugging Interface*
- IAR Embedded Workbench for MSP430 http://www.iar.com

4. Product Installation Procedures

4.1. Install TIMAC Package

Install the Texas Instruments TIMAC files and programs from the downloaded package. Run the windows-based installation program, ***TIMAC-x.x.x.exe*** (substitute ***x.x.x*** for the version of installer that was downloaded), which will create the required directory structure and load all software and documentation files. Review the Release Notes file for a synopsis of new features and changes with this release.

4.2. Install IAR EW430 Package

Install the ***Embedded Workbench for MSP430*** from IAR Systems: http://www.iar.com. The project and library files included in this release of TIMAC were built and tested with the EW430 version listed in the Release Notes. When considering use of a different version of EW430, it will be necessary to verify that installed project and library files are compatible with those development tools.

5. Using the TIMAC Sample Application

The remainder of this document describes building and running the TIMAC sample application. The sample application demonstrates association between two IEEE 802.15.4 devices in a non-beaconed network and transmitting application data between the associated devices. The sample application supports 2 configurations – “Normal” and “Secure”. The “Normal” configuration can be used when message encryption is not necessary and the “Secure” configuration provides IEEE 802.15.4 security features. For proper operation of the sample application described in this document, all devices must be programmed to use the same IEEE 802.15.4 channel (see Section 6) and security configuration. In the tutorial that follows, the “Normal” configuration is shown but the user can substitute “Secure” if desired.

5.1. Building the Sample Application

- Make sure all software and tools have been installed (Sections 4.1 and 4.2)
- Navigate to the sample application project directory:
  C:\Texas Instruments\TIMAC-x.x.x\Projects\mac\sample\exp5438\IAR Project

  PLEASE NOTE: The '***x.x.x***' in '***TIMAC-x.x.x***' above has to be substituted with the version of the installer that was downloaded.
- Launch the IAR Embedded Workshop: double click on the **msa_msp430.eww** file:

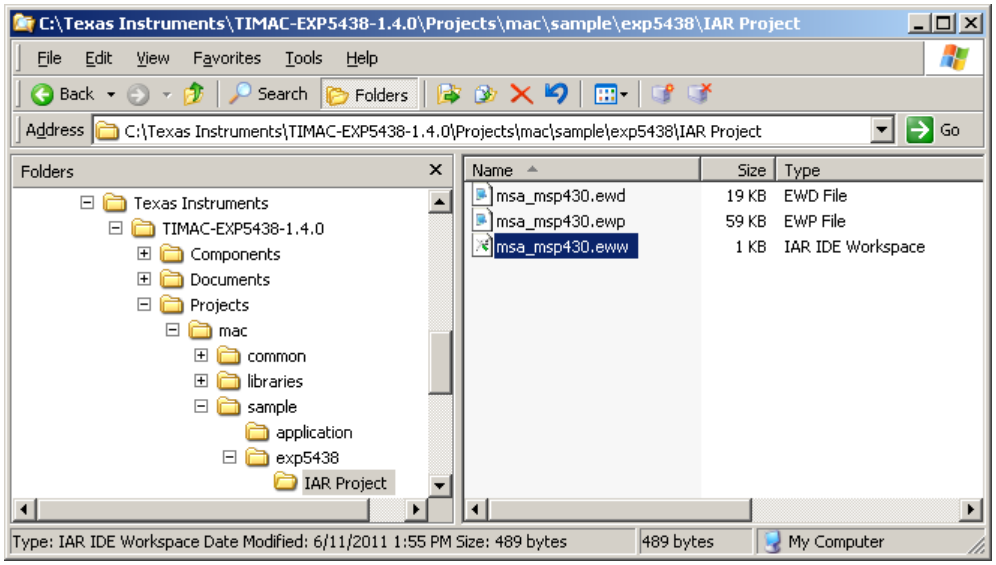

Figure 2: Launch the Sample Application Project

- Select the **Normal** configuration from the ***Workspace*** pull-down menu. In this example, the non-secure configuration for the ***msa_msp430*** application is selected:

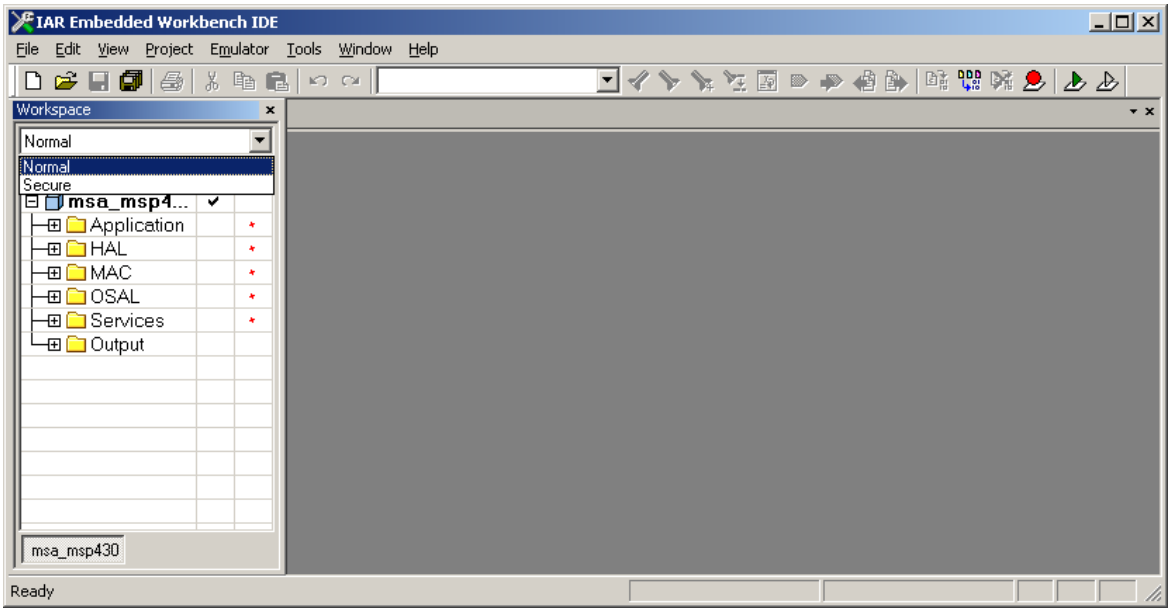

Figure 3: Select a Sample Application Configuration

- Build the application - pull down the ***Project*** menu and click on **Rebuild All**:

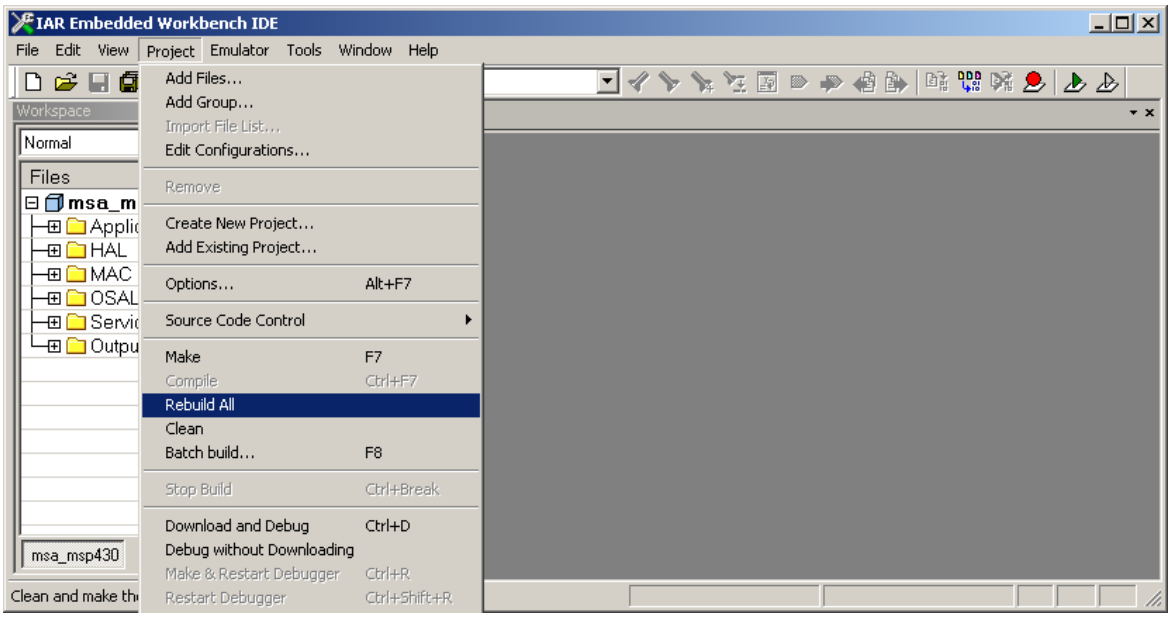

Figure 4: Build the Sample Application

- Connect the MSP430 USB-Debug-Interface module to the development PC with a USB cable. If you get a warning that the MSP430 firmware is out of date, simply choose "Yes" to allow the IAR debugger to update it. Then connect the USB-Debug-Interface to the EXP-MSP430F5438 board **JTAG** connector with a 14-pin ribbon cable.

- Load the application: pull down the ***Project*** menu and click on **Download and Debug**:

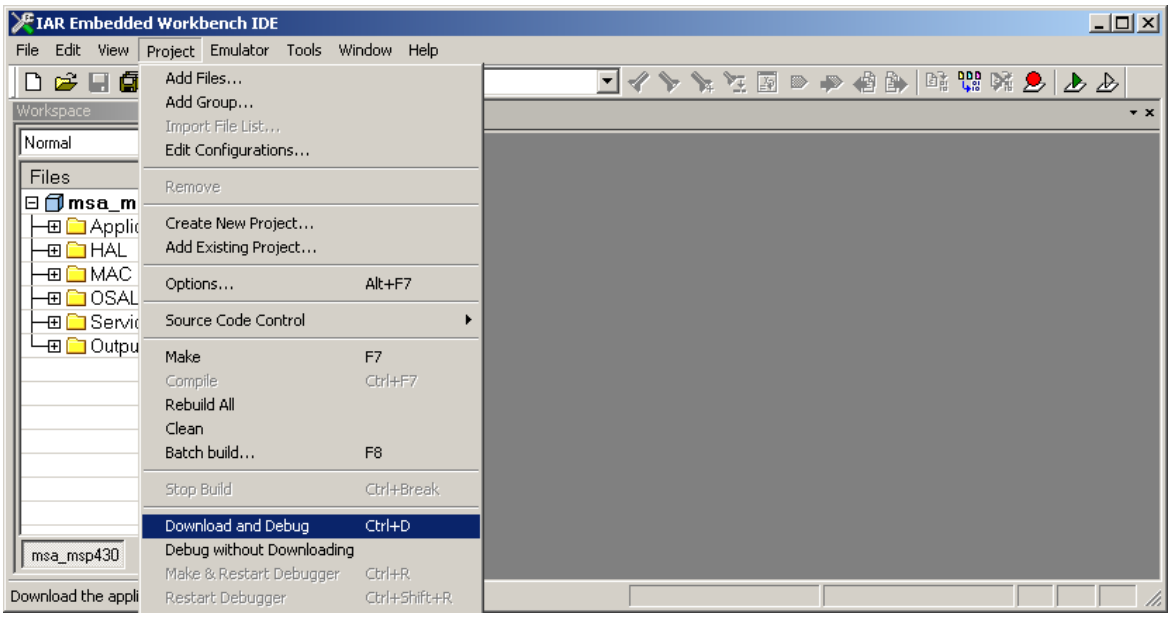

Figure 5: Download the Sample Application

- After downloading is complete, exit the debugger by pulling down the ***Debug*** menu and clicking on **Stop Debugging**:

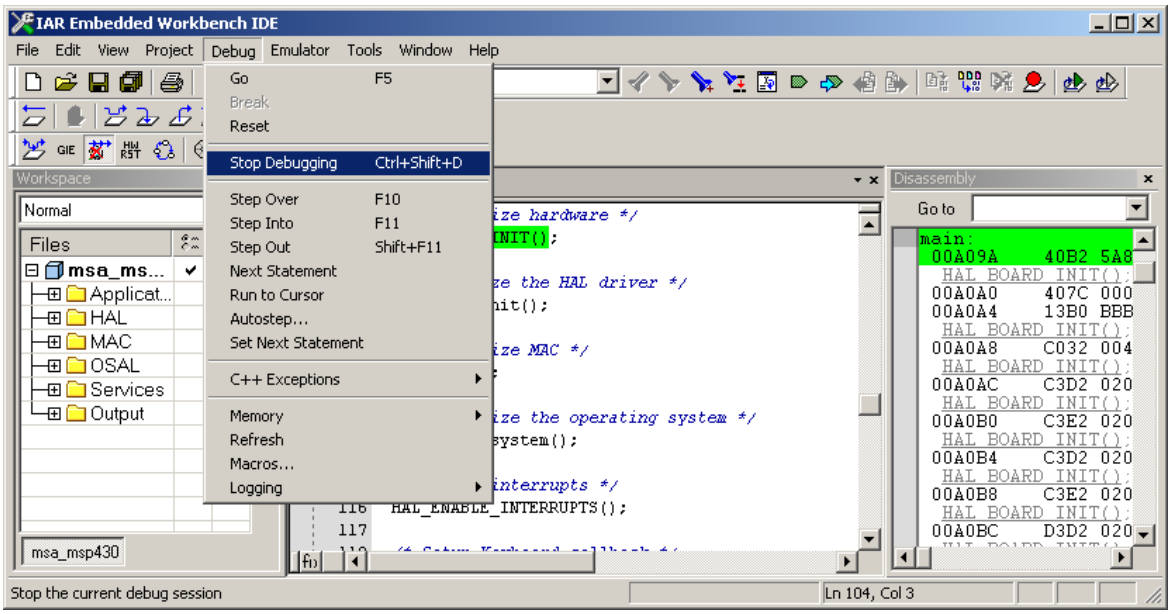

Figure 6: Exit Debugger to Finish Download

- Disconnect the EXP430F5438 from the development PC and set it aside.
- Repeat the previous four steps to program more EXP430F5438 boards.

5.2. Switches and LEDs

In this, and other TIMAC sample application documents, references are made to switches and LEDs that are located on evaluation boards. These devices are used to control certain TIMAC features and to display device/application status information. Figure 7 below, shows the lower left corner of the EXP430F5438 board, highlighting the joystick (for switches) and the LEDs.

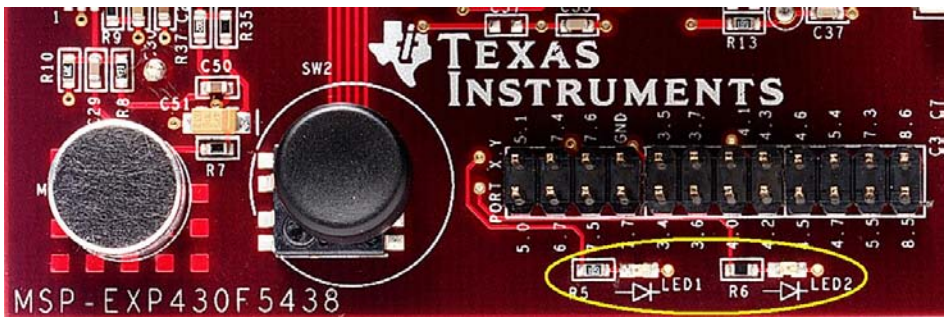

Figure 7: MSP-EXP430F5438 Joystick and LEDs

The TIMAC sample application requires user input via switches, provided on EXP430F5438 development boards by a 5-position joystick (circled white in Figure 7), which produces logical switch inputs as shown in the table below. Pressing the joystick toward the MCU socket (up position) activates the logical SW1 input. Switch inputs SW2–SW4 result from pressing the

joystick to the right (toward the LCD), down, and left positions, respectively. SW5 occurs when the joystick is pressed straight down when in the center position.

SWITCH	JOYSTICK
SW1	Up position
SW2	Right position
SW3	Down position
SW4	Left position
SW5	Press down

Table 1: Logical Joystick Switch Mapping

Application and operational status are displayed via two "logical" LEDs, commonly referred to as LED1 and LED2. The EXP430F5438 board has 2 colored LEDs, designated LED1 and LED2 (circled yellow in Figure 7), which provide these LED indications as shown in the table below.

LED	LABEL	COLOR
LED1	***LED1***	Red
LED2	***LED2***	Yellow

Table 2: Logical LED Mapping

5.3. Running the Sample Application

To begin execution of the TIMAC sample application, apply power to each programmed board and press the RESET (S3) button on each board. LED2 on each board should blink several times per second to indicate that it is waiting to start or join a network.

5.3.1. Starting a Network

Press SW1 (joystick 'up') on one of the boards. LED2 should stop blinking and stay lit. This device is now configured as IEEE 802.15.4 Coordinator. Label this board as the 'Coordinator'. If LED2 begins blinking, the device found an existing network to join and did not become a Coordinator. Press RESET (S3) again to reset the board and retry. If the problem persists, reprogram the boards to use a different radio channel (see Section 6).

5.3.2. Associating Devices

Press SW1 on the remaining boards. Their LED2 should begin blinking about once per second to indicate that they have associated to the Coordinator as End-Devices. Label these boards as 'End-Device'. At this point, a simple "star" network has been formed, with all devices waiting to send and/or receive data with their associated device.

5.3.3. Sending Application Data

After all devices have successfully associated, data can be transmitted between the Coordinator and End-Devices. To begin transmitting data, press SW2 (joystick 'right') on the Coordinator. LED1 on the Coordinator toggles quickly, indicating that data is being transmitted. LED1 on the End-Devices toggles a little slower, indicating that data is being received.

Pressing SW2 on a device while it is transmitting data stops the transmission. Press SW2 on the Coordinator. LED1 stops blinking on the Coordinator (no data transmitted) and LED1 stops blinking on the End-Devices (no data received).

To transmit data to the Coordinator, press SW2 on one End-Device. LED1 on that End-Device toggles quickly to indicate that data is being transmitted. LED1 on the Coordinator toggles a little slower to indicate that data is being received. Press SW2 on remaining End-Devices to start data transmission – LED1 on the Coordinator toggles faster, indicating increased received data.

6. Channel Selection

The 802.15.4 specification defines 16 channels in the 2.4 GHz frequency range. These channels are assigned numbers 11 through 26. The TIMAC Sample Application defaults to channel 11, but the user can select a different channel by changing the *MSA_MAC_CHANNEL* in the **msa.h** header file. *MSA_MAC_CHANNEL* can be set to MAC_CHAN_*XX* where *XX* is a number from 11-26 indicating the desired channel.

Applicable Documents

TIMAC Documents

1. 802.15.4 MAC API, TI Document SWRA192
2. MAC Sample Application Design, TI Document SWRA200

Other Documents

3. IEEE Std 802.15.4-2006, Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs), September 8, 2006.