802.15.4 MAC
User's Guide
For CC2530/CC2533

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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 SmartRF05 evaluation boards, fitted with CC2530EM radio modules (as shown below), may be used to demonstrate or develop IEEE 802.15.4 applications based on the TIMAC software package. Everything needed to get started is in the CC2530 Development Kit. These boards provide a rich development platform, including an LCD display and RS232 serial port. TIMAC supports two revisions (1.3 and 1.7) of SmartRF05EB boards. Figure 1 shows the Rev. 1.3 board on the left and the Rev. 1.7 board on the right.

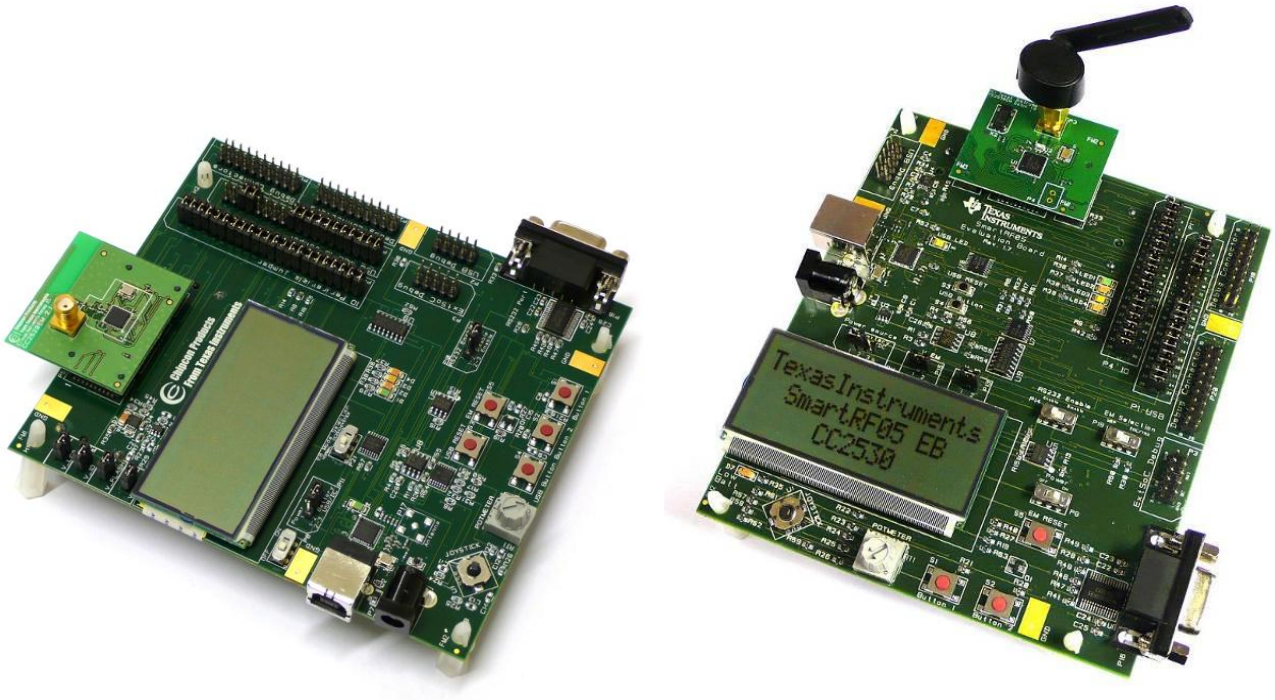


Figure 1: SmartRF05 Evaluation Boards – Rev 1.3 and Rev 1.7

2.3. Cables

All necessary cabling has been included with the development kit. To support program download and debugging with SmartRF05EB, a USB cable should be connected between each target board to the host PC. An RS232 cable may be also connected between the serial port on SmartRF05EB (9-pin) and the host. Note: RS232 cables are not required for the TIMAC Sample Application.

3. Installation Requirements

3.1. Target Development System Requirements

TIMAC libraries and sample application projects are used with the IAR ***Embedded Workbench*** (EW8051) suite of software development tools. These tools support project management, compiling, assembling, linking, downloading, and debugging of CC2530-based devices. The Texas Instruments ***SmartRF Flash Programmer***, is a tool that provides various programming capabilities when using SmartRF05-based development kits. Required support for TIMAC target development software:

- Texas Instruments *TIMAC* for CC2530 System-on-Chip
- Texas Instruments *SmartRF Flash Programmer*
- IAR Embedded Workbench for 8051 (http://www.iar.com)

4. Product Installation Procedures

4.1. Install TIMAC Package

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

4.2. Install IAR EW8051 Package

Obtain and install ***Embedded Workbench for 8051*** from IAR Systems. The project and library files included in this release of TIMAC were built and tested with the EW8051 version listed in the Release Notes. When considering use of a different version of EW8051, it will be necessary to verify that installed project and library files are compatible with those development tools.

4.3. Install SmartRF Flash Programmer Package

Obtain and install the ***SmartRF Flash Programmer*** from Texas Instruments. Connect one of the SmartRF05EB boards to the PC (via USB cable) and run this program. This will install required Windows drivers and verify that the PC is ready to communicate with the SmartRF05EB boards.

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 associated devices. The TIMAC sample application provides support for two different memory configurations on the CC2530 – banked and non-banked. The banked configuration is used when developing larger applications that require up to 256 Kbytes of program memory (using CC2530F256 devices). The non-banked

configuration is provided for smaller applications, using up to 64 Kbytes of memory, and targeting CC2530F64 or CC2533F64 devices.

5.1. Building the Sample Application

- Make sure all software and tools have been installed (Sections 4.1 through 4.3)
- Connect a SmartRF05EB board to the development PC with a USB cable.
- Power up the SmartRF05EB. There are 3 ways to supply power to the board: batteries, USB connection, or a DC power supply. To provide power from batteries, pins ***1-2*** of jumper block **P11** must be connected. Otherwise, connect pins ***2-3*** to use USB or a DC supply (note below the slight P11 difference on Rev 1.3 and Rev 1.7 boards). The board can be turned **ON** or **OFF** using switch **P8.**

Figure 2: Power Switch and Power Source Selection (Rev 1.3 / Rev 1.7)

- If prompted by Windows for a SmartRF05EB device driver, don't let Windows connect to Windows Update. Let Windows try to find the driver automatically. If that fails, browse to: ***C:\Program Files\IAR Systems\Embedded Workbench x.x \8051\drivers\Texas Instruments*** to locate needed files.

  PLEASE NOTE: Substitute the '***x.x***' in the link above with the version of IAR Embedded Workbench that was downloaded.

- Navigate to the sample application project directory:
  C:\Texas Instruments\TIMAC-x.x.x\Projects\mac\sample\cc2530\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_cc2530.eww** file:

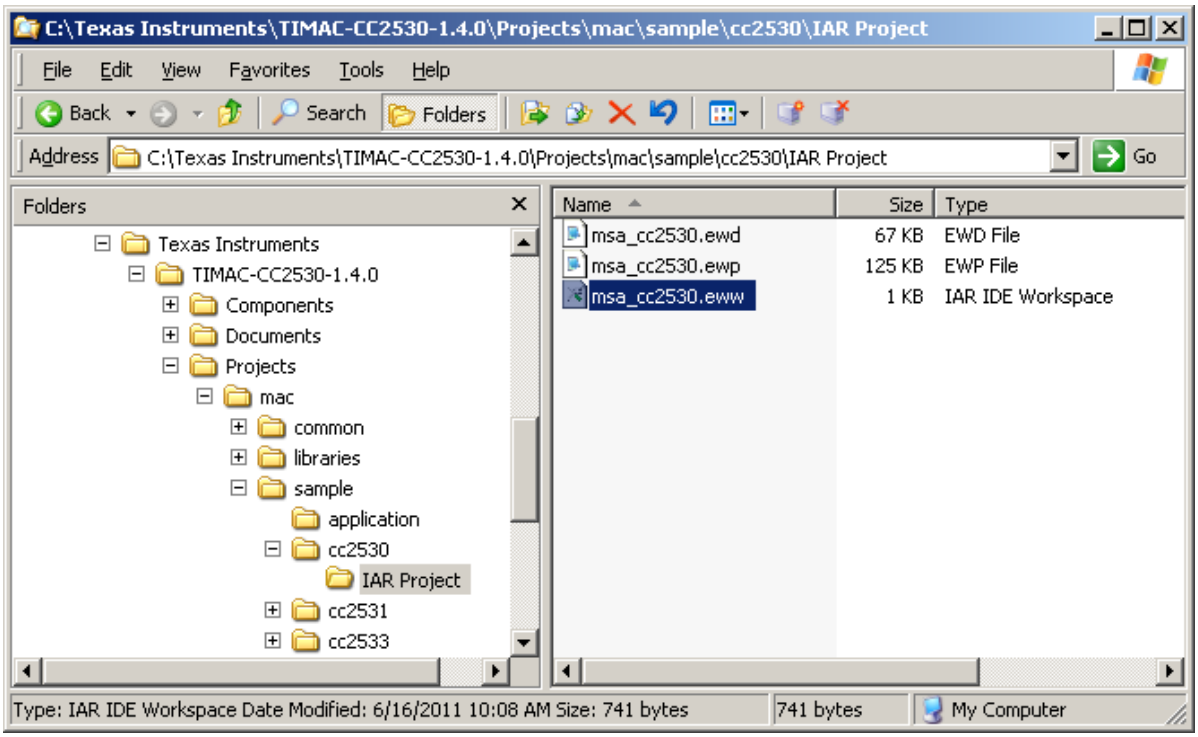


Figure 3: Launch the Sample Application Project

- For PAN Coordinator, select the **Normal-FFD** configuration from the ***Workspace*** pull-down menu. For End Device, select the **Normal-RFD** configuration from the ***Workspace*** pull-down menu. In this example, the non-security, non-banked FFD configuration is selected:

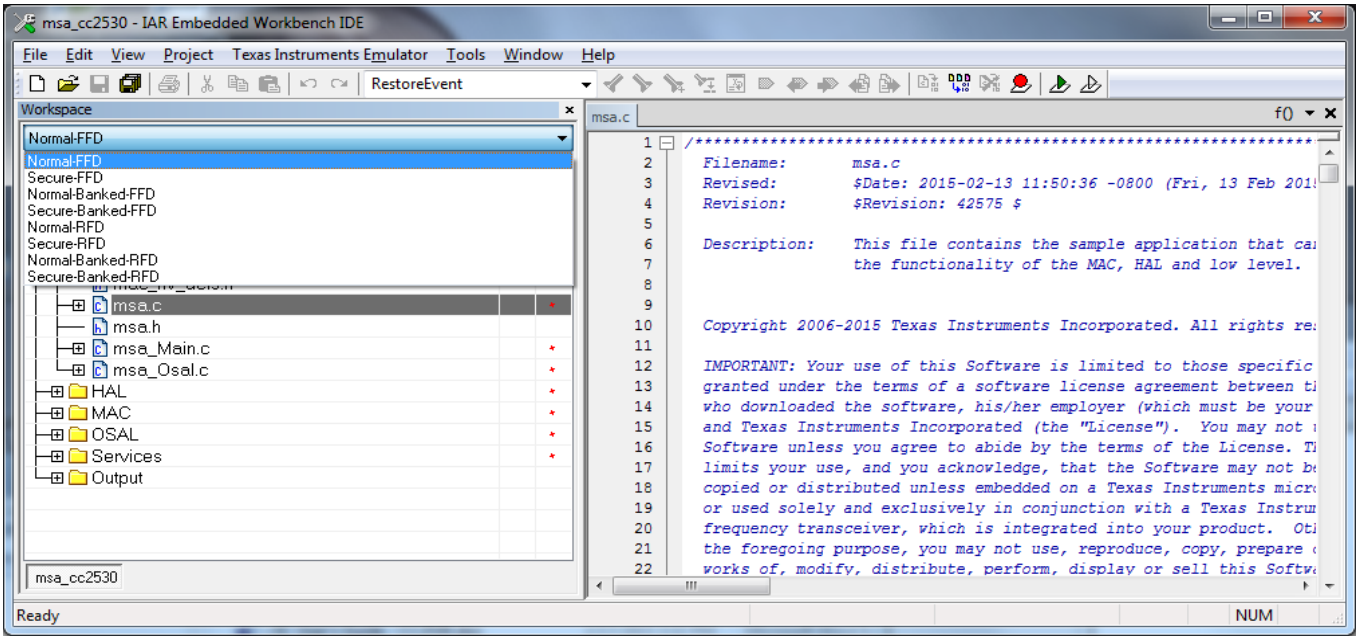


Figure 4: Select a Sample Application Configuration

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

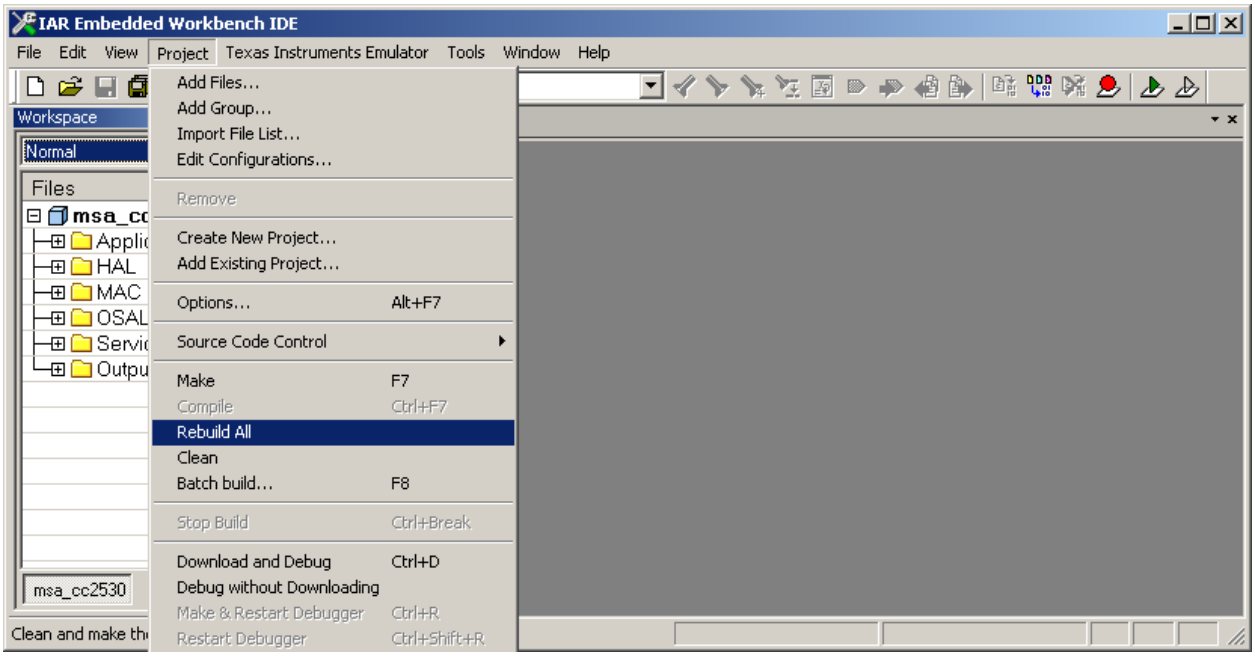


Figure 5: Build the Sample Application

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

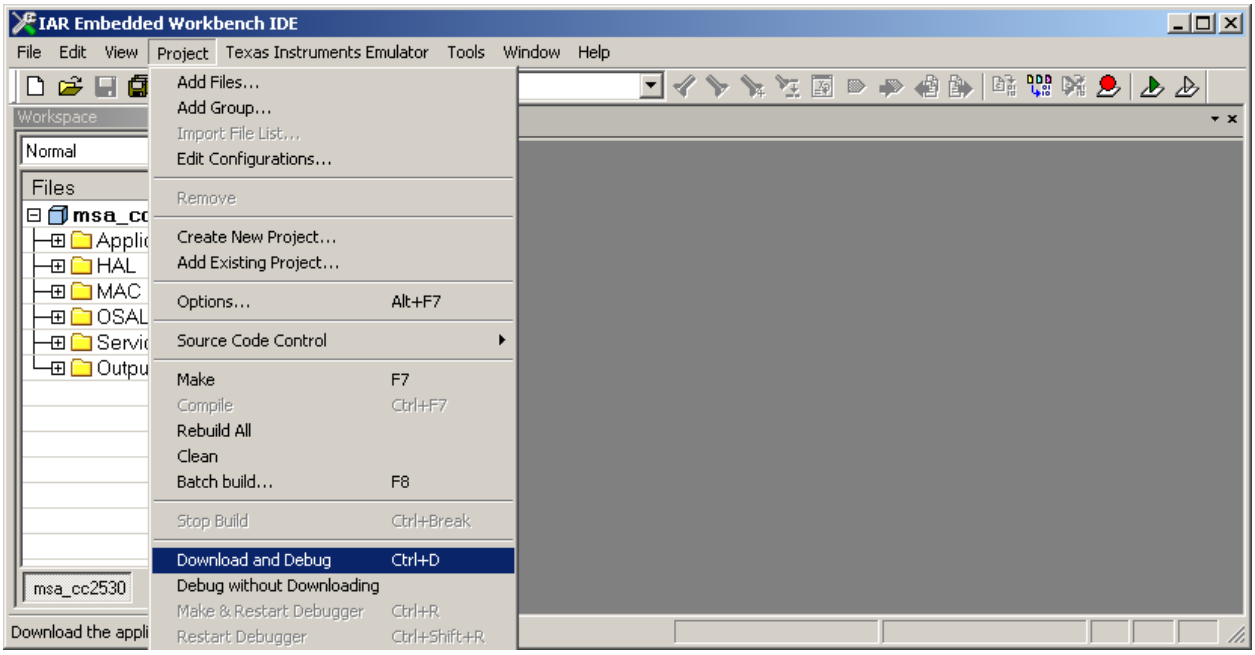


Figure 6: Download the Sample Application

- Select the ***Debug*** menu and click on **Stop Debugging** to exit the debugger:

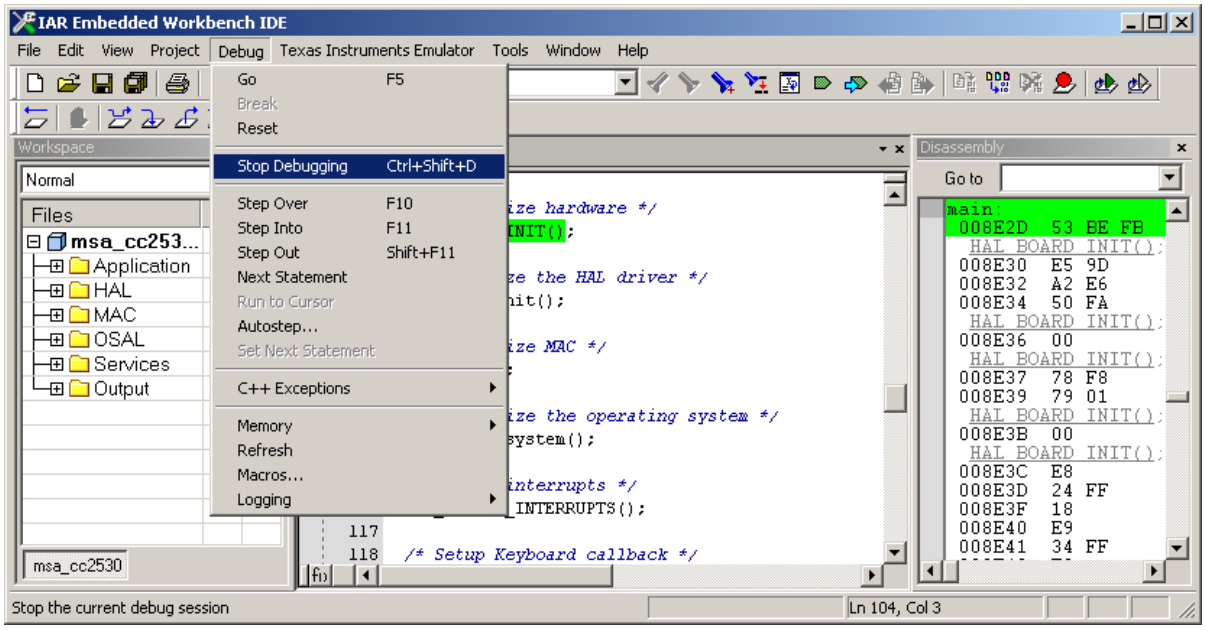


Figure 7: Exit Debugger to Finish Download

- Remove power from the SmartRF05EB by switching P8 to the OFF position. Disconnect the SmartRF05EB from the USB cable and set it aside.

- Repeat the previous steps to program more CC2530EM boards. At least two boards must be programmed to run the TIMAC sample application.

5.2. Switches and LEDs

The TIMAC sample application requires user input via switches and displays status on LEDs located on the SmartRF05 development boards. Switches and LEDS are illustrated below in pairs of screenshots - Figures 8 and 9 show Rev 1.3 boards on the left and Rev 1.7 boards on the right.

The TIMAC sample application requires user input via switches. CC2530 development boards have a 5-position joystick, designated U1, which provides logical switch inputs as shown in the table below. Pressing the joystick toward the U1 label (up position) activates the SW1 input. Switch inputs SW2 – SW4 result from pressing the joystick to the right, down (away from U1), and left positions, respectively. SW5 occurs when the joystick is pressed straight down when in the center position.

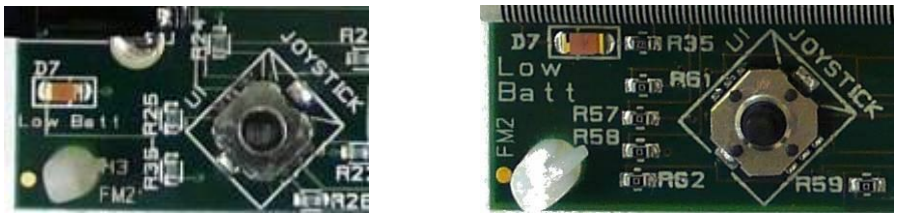


Figure 8: SmartRF05EB Joystick on Rev 1.3 / 1.7 Boards

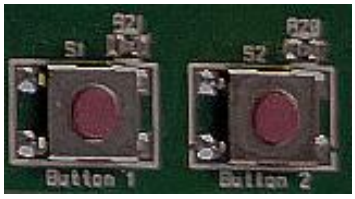


Figure 9: SmartRF05EB Buttons S1 and S2 on Rev 1.7 Boards

Joystick/Button	Software Mapping	Description
UP	SW1	Joystick UP
RIGHT	SW2	Joystick RIGHT
DOWN	SW3	Joystick DOWN
LEFT	SW4	Joystick LEFT
PRESS	SW5	Joystick CENTER

Table 1: Joystick/Button Logical Switch Mapping

Joystick/Button	Software Mapping	Description
S1	SW1	Button 1
UP/ RIGHT/ DOWN/ LEFT	SW2	Joystick UP, RIGHT, DOWN, LEFT

Table 2: Joystick/Button Logical Switch Mapping for cc2533

TIMAC sample applications use “logical” LEDs to display status information. SmartRF05EB boards have four 4 colored LEDs, referred to in application software as LED1 - LED4.

Figure 10: SmartRF05EB LEDs on Rev 1.3 / 1.7 Boards

LED	Software Mapping	Color
D1/LED1	LED1	Green
D2/LED2	LED2	Red
D3/LED3	LED3	Yellow
D4/LED4	LED4	Blue/Red

Table 3: Logical LED Mapping on Rev 1.3 / 1.7 Boards

5.3. Running the Sample Application

To begin execution of the TIMAC sample application, apply power to each programmed board and press the EM RESET (S5) button on each board. LED1 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 on the board flashed with FFD (in the example above Normal-FFD) image. LED1 should stop blinking and stay lit. This device is now configured as an IEEE 802.15.4 Coordinator. Label this board as the 'Coordinator'. If LED1 begins blinking, the device found an existing network to join and did not become a Coordinator. Press EM RESET 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 board on the board flashed with RFD (in the example above Normal-RFD). Their LED1 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 on the Coordinator. LED1 on the Coordinator toggles quickly, indicating that data is being transmitted. LED3 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 LED3 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. LED3 on the Coordinator toggles a little slower to indicate that data is being received. Press SW2 on remaining End-Devices to start data transmission – LED3 on the Coordinator now toggles faster, indicating increased received data.

6. Channel Selection

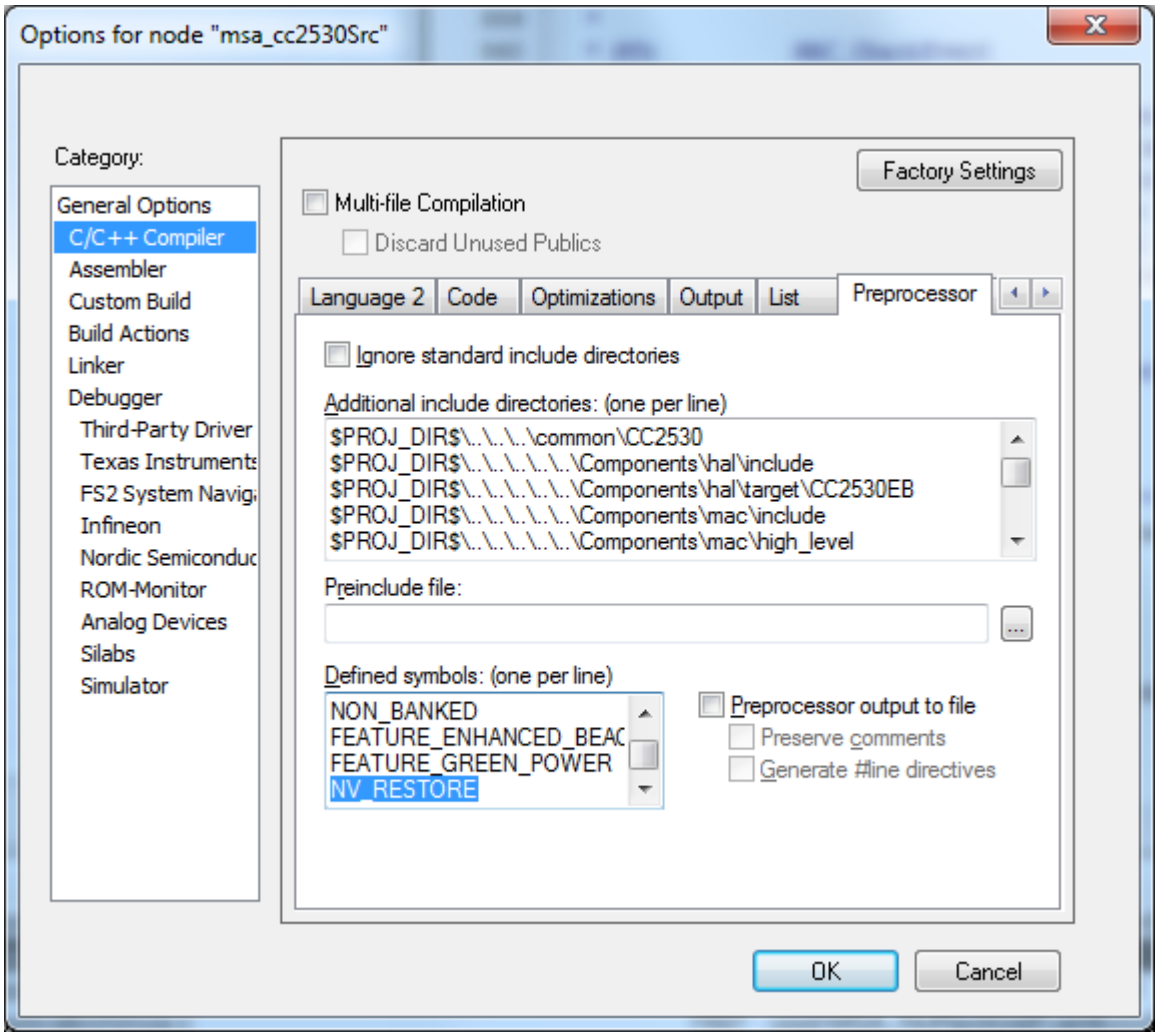
The 802.15.4 specification defines 16 channels in the 2.4 GHz frequency range. These channels are assigned numbers 11 through 26. The TIMAC sample application defaults to channel 11, but the user can select a different channel by changing the *MSA_MAC_CHANNEL* in the **msa.h** header file. *MSA_MAC_CHANNEL*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

7. Non Volatile Restore

This feature allows the device to remember its settings even when power is turned off and turned back on. This is achieved by storing all the network settings of the device in Non Volatile

memory. So, when the device loses power or is powered off and then powered back on, the settings are restored and the device behaves the same way as before.

- To enable this feature, go to Project->Options->C/C++Compiler->Defined Symbols and add NV_RESTORE
- To clear NV, i.e. reset device to default, turn off the device, hold SW_1 key and turn on the device. This should bring the device to its default configuration, before being on the network.
- PLEASE NOTE: NV_RESTORE feature is not available on the CC2533.



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.