802.15.4 MAC
User's Guide
For CC2531DK

Document Number: SWRU307

Texas Instruments, Inc.
San Diego, California USA

Version	Description	Date
1.0	Initial release	10/05/2011
1.1	Updated for 1.4.1 release	01/28/2013
1.2	Updated for 1.5.2 release	02/19/2015

Table of Contents

Table of Figures

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 2006 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 CC2531 USB Dongle boards, programmed via CC Debugger (as shown below), may be used to demonstrate or develop IEEE 802.15.4 applications based on the TIMAC software package. These dongles provide a compact platform to power a TIMAC application from a standard USB port on a development PC or other host device.

Figure 1: CC2531 USB Dongle and CC Debugger

2.3. Cables

All necessary cabling is included with the CC Debugger kit. To support program download and debugging, a USB cable should be connected between each CC Debugger and the host PC.

3. Installation Requirements

3.1. Target Development System Requirements

TIMAC libraries and sample application project are used with the IAR ***Embedded Workbench*** (EW8051) suite of software development tools. This set of tools supports project management, compiling, assembling, linking, downloading, and debugging of CC2531-based devices. The Texas Instruments ***SmartRF Flash Programmer*** is a tool that provides various programming capabilities for use with CC Debugger devices and CC2351 development kits. Required support for TIMAC target development software:

- Texas Instruments *CC2351 USB Dongles*
- Texas Instruments *CC Debugger Module*
- Texas Instruments *TIMAC* for CC2530 System-on-Chip
- IAR Systems *Embedded Workbench for 8051*
- Texas Instruments *SmartRF Flash Programmer*

4. Product Installation Procedures

4.1. Install TIMAC Package

Install the TIMAC files and programs from the downloaded package by running 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. 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 an upgrade to a newer version of EW8051, it will be necessary to verify that installed project and library files are compatible with the newer development tools.

4.3. Install SmartRF Flash Programmer Package

Obtain and install the ***SmartRF Flash Programmer*** from Texas Instruments. Connect one CC Debugger module 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 CC Debugger modules.

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 IEEE 802.15.4 devices in a non-beaconed network and transmitting application data between associated devices. The TIMAC sample application supports 2 configurations on the CC2531 dongle – “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 through 4.3).
- Connect a CC2531 USB Dongle to a CC Debugger module, as shown in Figure 1.
- Power up the CC2531 USB Dongle by plugging it into a USB port on the development PC, a powered USB hub, or another powered device.
- Connect the CC Debugger module, with a USB cable, to the development PC. The LED on the CC Debugger module should light up to green indicating that it recognizes the Dongle.
- 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_cc2531.eww*** file:

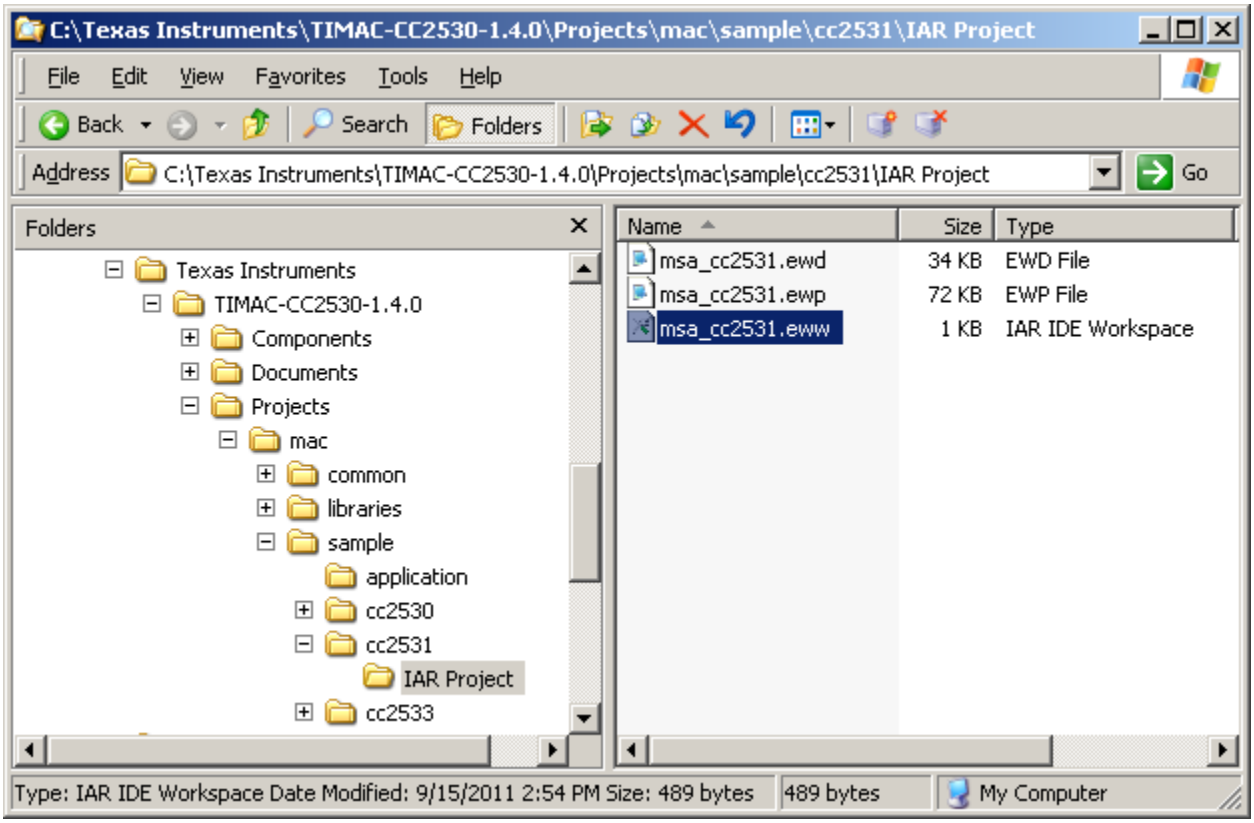


Figure 2: Launch the Sample Application Project

- 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 FFD configuration is selected:

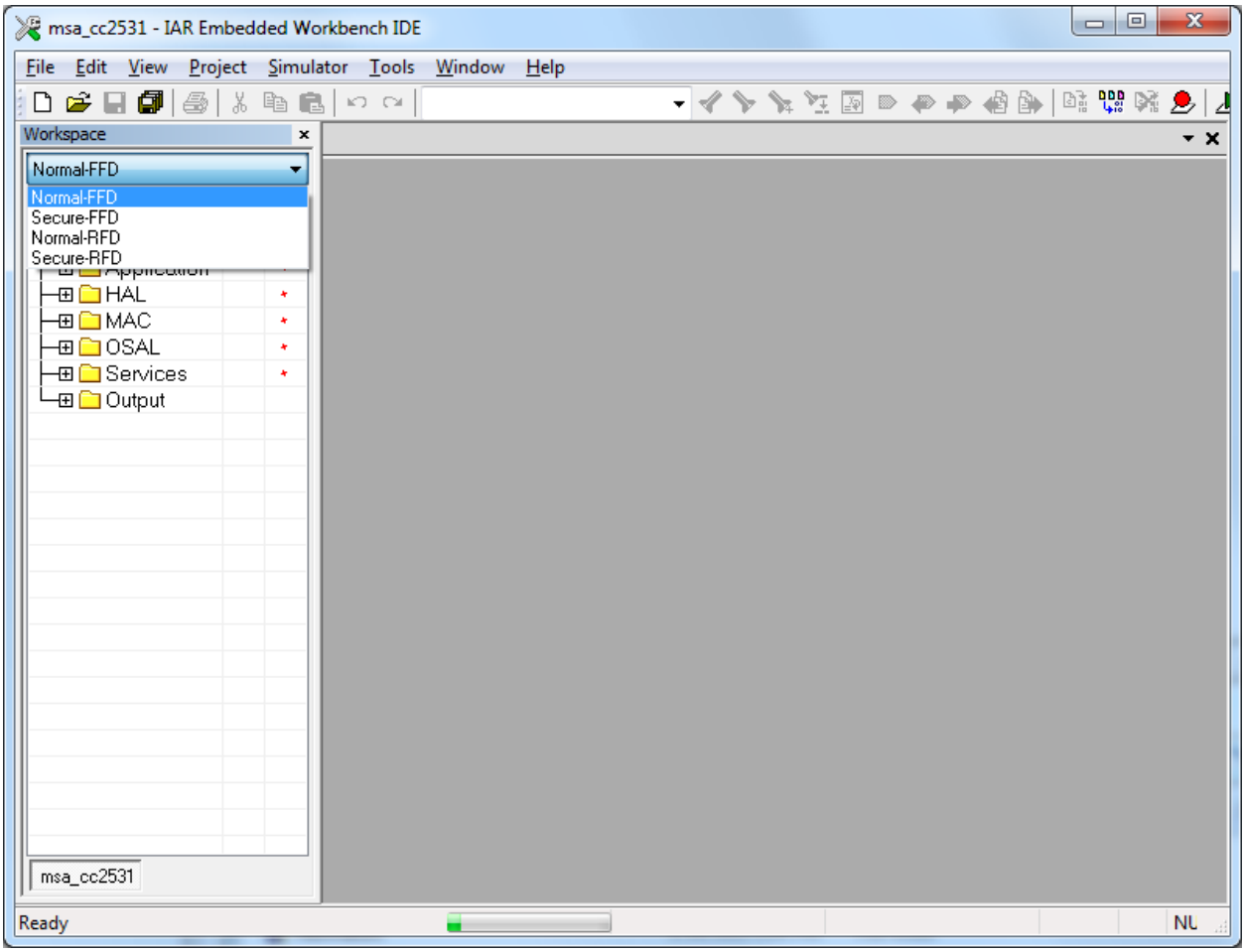


Figure 3: Select a Sample Application Configuration

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

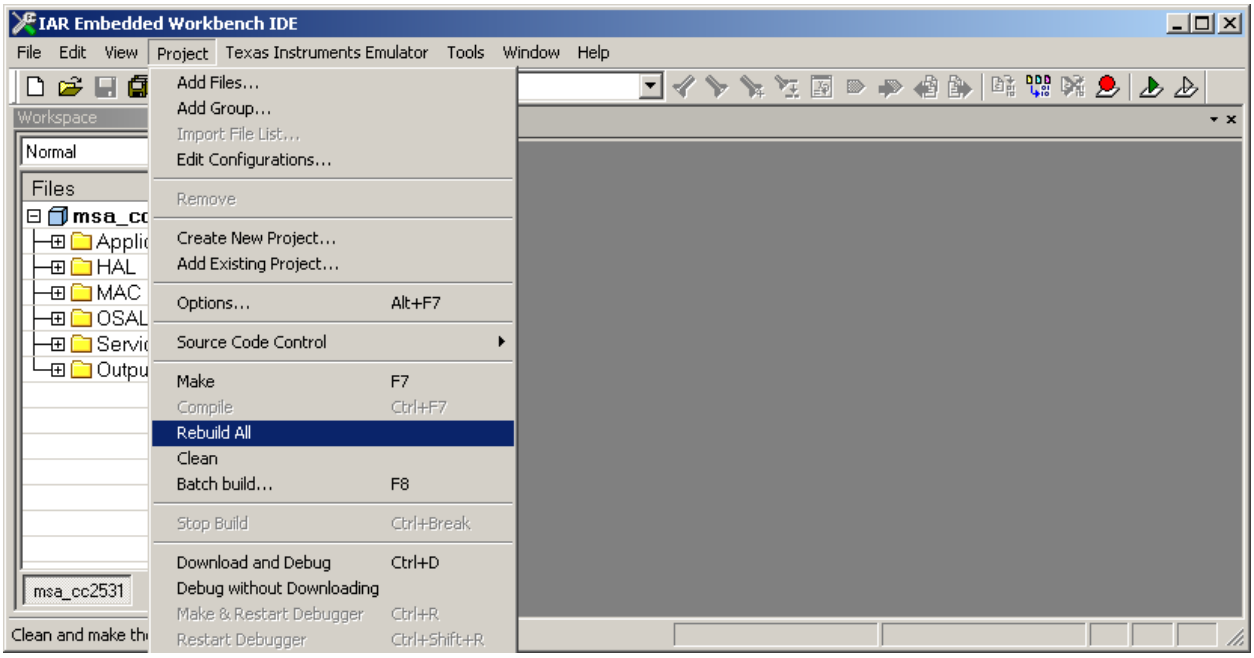


Figure 4: Build the Sample Application

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

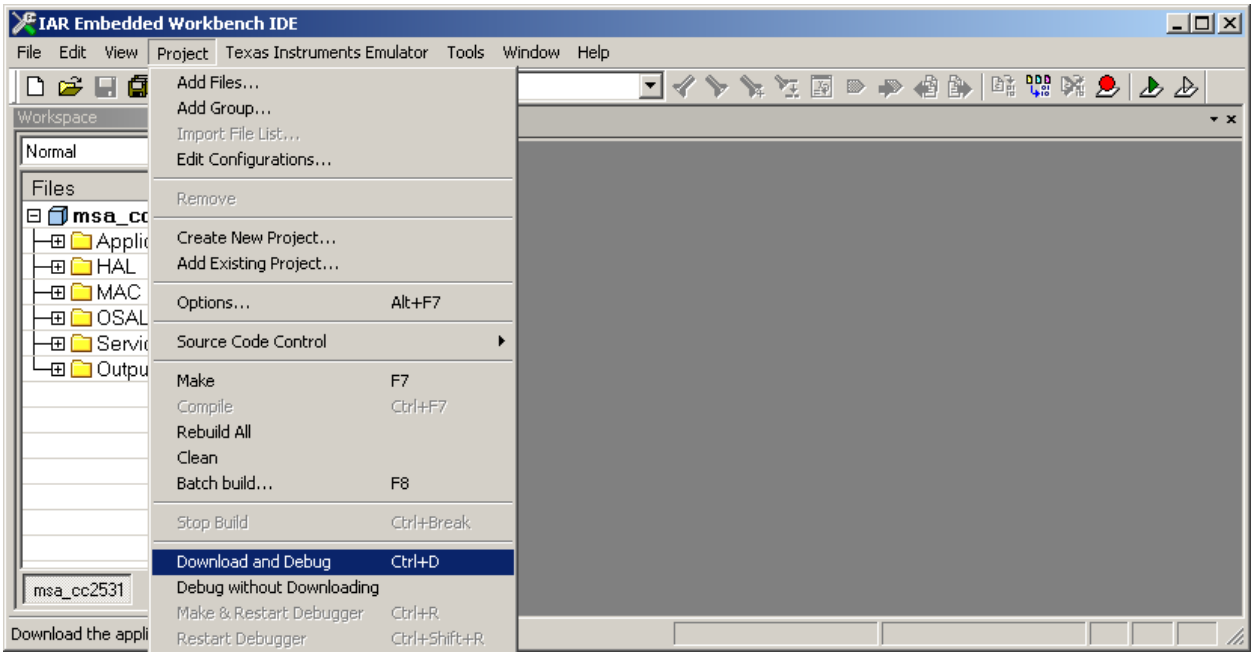


Figure 5: Download the Sample Application

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

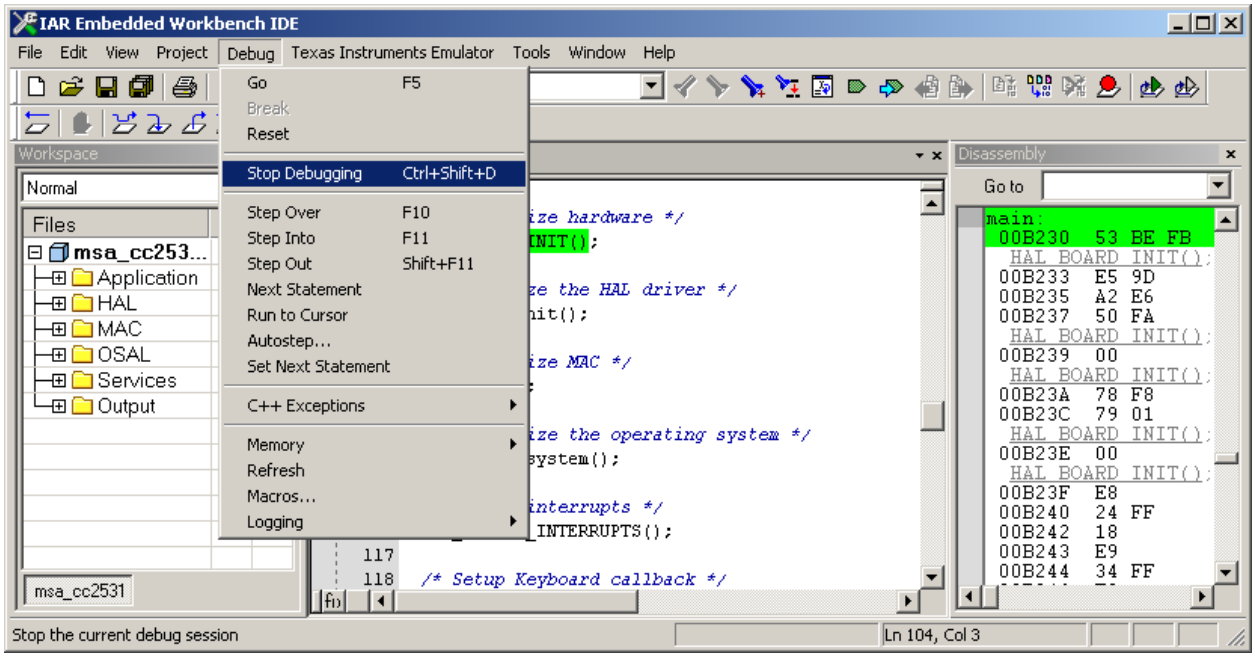


Figure 6: Exit Debugger to Finish Download

- Remove the CC2531 USB Dongle from the development PC or other device. Disconnect the CC2531 dongle from CC Debugger and set it aside.
- Repeat the previous steps to program more CC2531 dongles. At least two dongles 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 various status indications on LEDs. The CC2531 dongles provide two switches (S1 and S2) and two LEDs (LED1 and LED2, next to the S2 button), as shown in Figure 7 below:

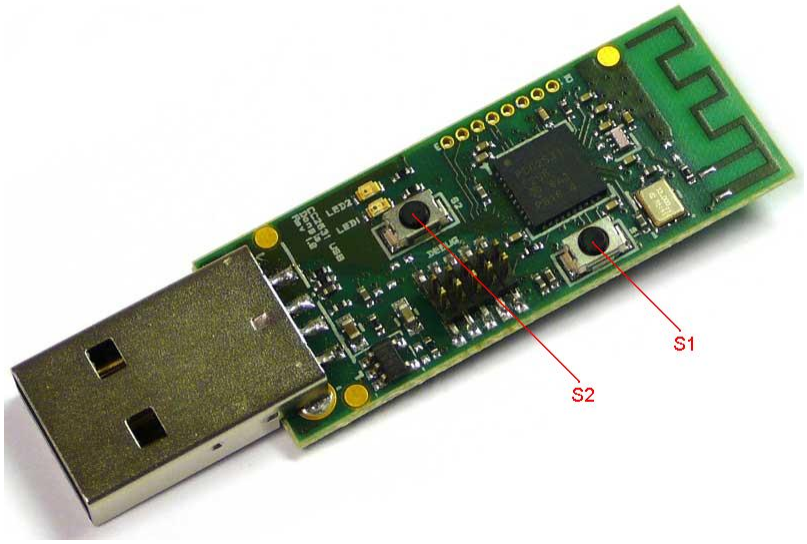


Figure 7: CC2531 USB Dongle

5.3. Running the Sample Application

To begin execution of the TIMAC sample application, apply power to the programmed dongles by plugging them into USB ports. LED1 on each dongle 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 S1 on the board on the board flashed with FFD (in the example above Normal-FFD). 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 S1 again to reset the dongle and retry. If the problem persists, reprogram the dongles to use a different radio channel (see Section 6).

5.3.2. Associating Devices

Press S1 on the board on the board flashed with RFD (in the example above Normal-RFD). LED1 should begin blinking about once per second to indicate that they have associated to the Coordinator as End-Devices. Label these dongles 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 the S2 button on the Coordinator. LED2 on the Coordinator toggles, indicating that data is being transmitted. LED2 on the End-Devices toggles, indicating that data is being received.

Pressing the S2 button on a device while it is transmitting data stops the transmission. Press the S2 button on the Coordinator. Observe that LED2 stops blinking on the Coordinator (no data being transmitted) and LED2 stops blinking on the End-Devices (no data being received).

To transmit data to the Coordinator, press the S2 button on one End-Device. LED2 on that End-Device toggles to indicate that data is being transmitted. LED2 on the Coordinator toggles to indicate that data is being received. Press the S2 button on remaining End-Devices to start data transmission - LED2 on the Coordinator now toggles faster, indicating increased received data.

5.3.4. Resetting Devices

Devices that are part of a network, Coordinator and End-Devices, can be reset to the start-up state by pressing S1. This is equivalent to initially powering up a device (see section 5.3).

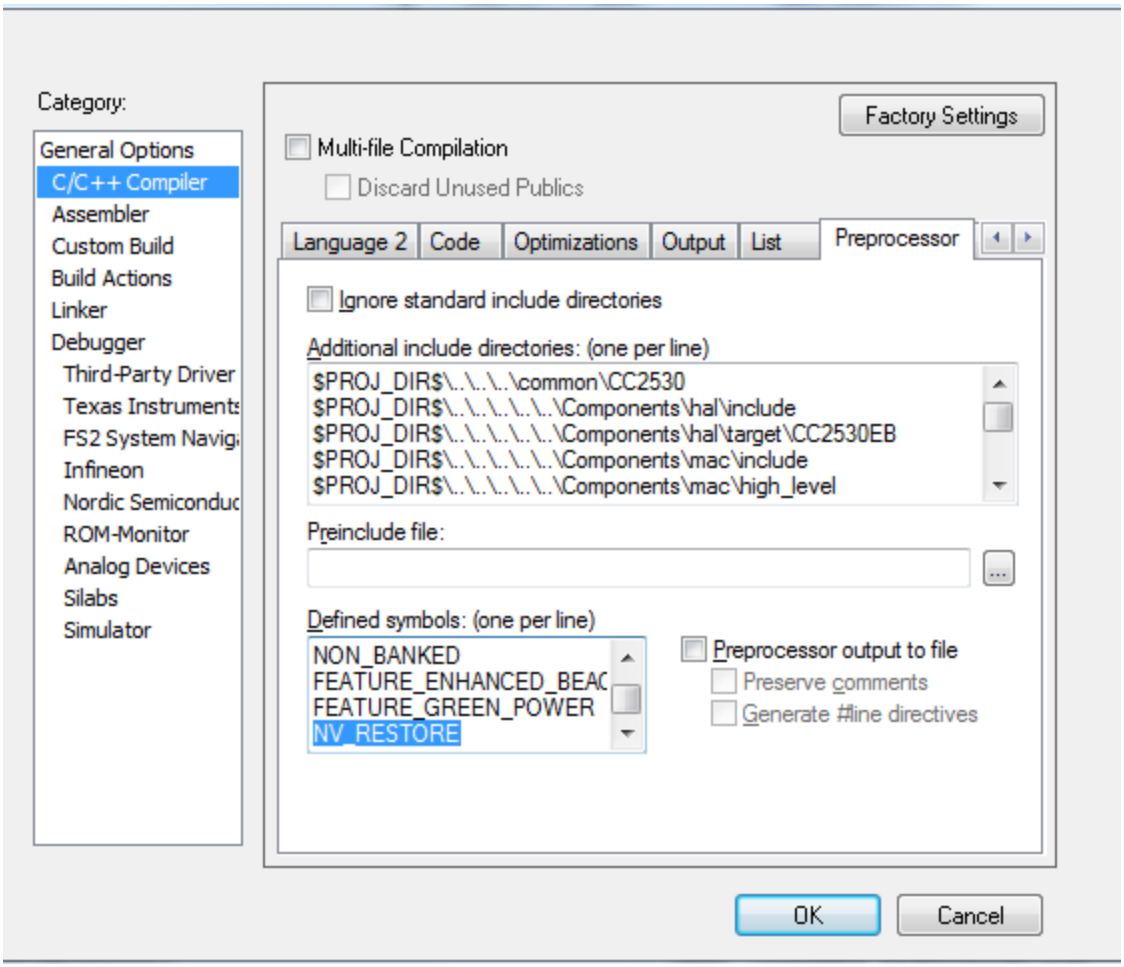
6. Channel Selection

The IEEE 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* definition in the **msa.h** header file. *MSA_MAC_CHANNEL* can be set to MAC_CHAN*_XX* where *XX* is a number from 11 to 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.



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.