2803x C/C++ Header Files and Peripheral Examples Quick Start

1 Device Support:

This software package supports 2803x devices. This includes the following: TMS320F28035, TMS320F28034, TMS320F28033, TMS320F28032, TMS320F28031, and TMS320F28030.

Throughout this document, TMS320F28035, TMS320F28034, TMS320F28033, TMS320F28032, TMS320F28031, and TMS320F28030 are abbreviated as F28035, F28034, F28033, F28032, F28031, and F28030 respectively.

2 Introduction:

The 2803x C/C++ peripheral header files and example projects facilitate writing in C/C++ Code for the Texas Instruments TMS320x2803x devices. The code can be used as a learning tool or as the basis for a development platform depending on the current needs of the user.

- Learning Tool:

  This download includes several example Code Composer Studio™† v 4.0+ projects for a '2803x development platform.

  These examples demonstrate the steps required to initialize the device and utilize the on-chip peripherals. The provided examples can be copied and modified giving the user a platform to quickly experiment with different peripheral configurations.

  These projects can also be migrated to other devices by simply changing the memory allocation in the linker command file.

- Development Platform:

  The peripheral header files can easily be incorporated into a new or existing project to provide a platform for accessing the on-chip peripherals using C or C++ code. In addition, the user can pick and choose functions from the provided code samples as needed and discard the rest.

To get started this document provides the following information:

- Overview of the bit-field structure approach used in the 2803x C/C++ peripheral header files.
- Overview of the included peripheral example projects.
- Steps for integrating the peripheral header files into a new or existing project.
- Troubleshooting tips and frequently asked questions.
- Migration tips for users moving from the 280x header files to the 2803x header files.

† Code Composer Studio is a trademark of Texas Instruments (www.ti.com).

Finally, this document does not provide a tutorial on writing C code, using Code Composer Studio, or the C28x Compiler and Assembler. It is assumed that the reader already has a 2803x hardware platform setup and connected to a host with Code Composer Studio installed. The user should have a basic understanding of how to use Code Composer Studio to download code through JTAG and perform basic debug operations.

2.1 Revision History

Version 1.21

- This version includes minor fixes to a couple of the files. A detailed revision history can be found in Section 9.

Version 1.20

- This version includes minor corrections and comment fixes to the header files and examples. A detailed revision history can be found in Section 9.

Version 1.10

- This version includes minor corrections and comment fixes to the header files and examples, and also adds a separate example folder, DSP2803x_examples_ccsv4, with examples supported by the Eclipse-based Code Composer Studio v4. A detailed revision history can be found in Section 9.

Version 1.01

- This version includes minor corrections to comments in the common files, and adds additional LIN and ADC temperature sensor examples. A detailed revision history can be found in Section 9.

Version 1.00

- This version is the first release of the 2803x header files and examples. It is an internal release used for customer trainings and tools releases.

2.2 Where Files are Located (Directory Structure)

As installed, the *2803x C/C++ Header Files and Peripheral Examples* is partitioned into a well-defined directory structure.

Table 1 describes the contents of the main directories used by 2803x header files and peripheral examples:

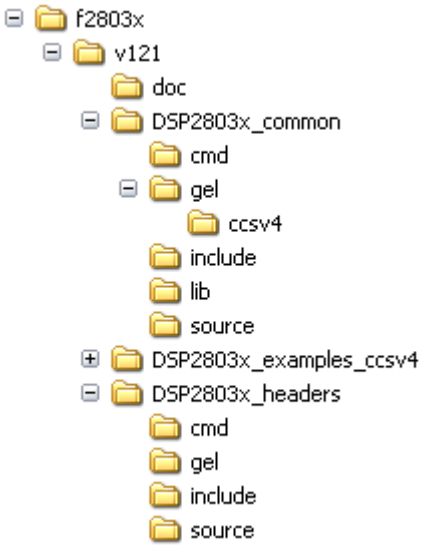


Table 1. DSP2803x Main Directory Structure

Directory	Description
<base>	Base install directory
<base>\doc	Documentation including the revision history from the previous release.
<base>\DSP2803x_headers	Files required to incorporate the peripheral header files into a project . The header files use the bit-field structure approach described in Section 3. Integrating the header files into a new or existing project is described in Section 5.
<base>\DSP2803x_examples_ccsv4	Example Code Composer Studio v4 projects. These example projects illustrate how to configure many of the on-chip peripherals. An overview of the examples is given in Section 4.
<base>DSP2803x_common	Common source files shared across example projects to illustrate how to perform tasks using header file approach. Use of these files is optional, but may be useful in new projects. A list of these files is in Section 8.

Under the *DSP2803x_headers* and *DSP2803x_common* directories the source files are further broken down into sub-directories each indicating the type of file. Table 2 lists the sub-directories and describes the types of files found within each:

Table 2. DSP2803x Sub-Directory Structure

Sub-Directory	Description
DSP2803x_headers\cmd	Linker command files that allocate the bit-field structures described in Section 3.
DSP2803x_headers\source	Source files required to incorporate the header files into a new or existing project.
DSP2803x_headers\include	Header files for each of the on-chip peripherals.
DSP2803x_common\cmd	Example memory command files that allocate memory on the devices.
DSP2803x_common\include	Common .h files that are used by the peripheral examples.
DSP2803x_common\source	Common .c files that are used by the peripheral examples.
DSP2803x_common\lib	Common library (.lib) files that are used by the peripheral examples.
DSP2803x_common\gel\ccsv4	Code Composer Studio v4.x GEL files for each device. These are optional.

3 Understanding The Peripheral Bit-Field Structure Approach

The following application note includes useful information regarding the bit-field peripheral structure approach used by the header files and examples.

This method is compared to traditional #define macros and topics of code efficiency and special case registers are also addressed. The information in this application note is important to understand the impact using bit fields can have on your application code.

Programming TMS320x28xx and 28xxx Peripherals in C/C++ **(**SPRAA85)

4 Peripheral Example Projects

This section describes how to get started with and configure the peripheral examples included in the 2803x Header Files and Peripheral Examples software package.

4.1 Getting Started

4.1.1 Getting Started in Code Composer Studio v4.0+

To get started, follow these steps to load the 32-bit CPU-Timer example. Other examples are set-up in a similar manner.

1. **Have a hardware platform connected to a host with Code Composer Studio installed.**

   NOTE: As supplied, the '2803x example projects are built for the '28035 device. If you are using another 2803x device, the memory definition in the linker command file (.cmd) will need to be changed and the project rebuilt.

2. **Open the example project.**

   Each example has its own project directory which is "imported"/opened in Code Composer Studio v4.

   To open the '2803x CPU-Timer example project directory, follow the following steps:

   a. In Code Composer Studio v 4.x: Project->Import Existing CCS/CCE Eclipse Project.

   b. Next to "Select Root Directory", browse to the CPU Timer example directory: *DSP2803x_examples_ccsv4\cpu_timer*. Select the *Finish* button.

      This will import/open the project in the CCStudio v4 C/C++ Perspective project window.

3. Edit DSP28_Device.h

Edit the DSP2803x_Device.h file and make sure the appropriate device is selected. By default the 28035 is selected.

```
/*-----------------------------------------------------------------------
* DSP2803x_headers\include\DSP2803x_Device.h
-----------------------------------------------------------------------*/

#define   TARGET   1

//---------------------------------------------------------------------------
// User To Select Target Device:

#define   DSP28_28030PAG   0
#define   DSP28_28030PN    0

#define   DSP28_28031PAG   0
#define   DSP28_28031PN    0

#define   DSP28_28032PAG   0
#define   DSP28_28032PN    0

#define   DSP28_28033PAG   0
#define   DSP28_28033PN    0

#define   DSP28_28034PAG   0
#define   DSP28_28034PN    0

#define   DSP28_28035PAG   0
#define   DSP28_28035PN    TARGET
```

4. Edit DSP2803x_Examples.h

Edit DSP2803x_Examples.h and specify the clock rate, the PLL control register value (PLLCR and DIVSEL). These values will be used by the examples to initialize the PLLCR register and DIVSEL bits.

The default values will result in a 60Mhz SYSCLKOUT frequency.

```
/*************************************************************
* DSP2803x_common\include\DSP2803x_Examples.h
*************************************************************/
/*-------------------------------------------------------------------------
      Specify the PLL control register (PLLCR) and divide select (DIVSEL) value.
-------------------------------------------------------------------------*/
//#define DSP28_DIVSEL   0   // Enable /4 for SYSCLKOUT(default at reset)
//#define DSP28_DIVSEL   1   // Disable /4 for SYSCKOUT
#define DSP28_DIVSEL     2   // Enable /2 for SYSCLKOUT
//#define DSP28_DIVSEL   3   // Enable /1 for SYSCLKOUT

  #define DSP28_PLLCR   12
//#define DSP28_PLLCR   11
//#define DSP28_PLLCR   10
//#define DSP28_PLLCR    9
//#define DSP28_PLLCR    8
//#define DSP28_PLLCR    7
//#define DSP28_PLLCR    6
//#define DSP28_PLLCR    5
//#define DSP28_PLLCR    4
//#define DSP28_PLLCR    3
//#define DSP28_PLLCR    2
//#define DSP28_PLLCR    1
//#define DSP28_PLLCR    0  // (Default at reset) PLL is bypassed in this mode
//-------------------------------------------------------------------------
```

In DSP2803x_Examples.h, also specify the SYSCLKOUT rate. This value is used to scale a delay loop used by the examples. The default value is for a 60 Mhz SYSCLKOUT.

```
/*************************************************************
* DSP2803x_common\include\DSP2803x_Examples.h
*************************************************************/
……
#define CPU_RATE     16.667L   // for a 60MHz CPU clock speed (SYSCLKOUT)
//#define CPU_RATE   20.000L   // for a 50MHz CPU clock speed  (SYSCLKOUT)
//#define CPU_RATE   25.000L   // for a 40MHz CPU clock speed  (SYSCLKOUT)
//#define CPU_RATE   33.333L   // for a 30MHz CPU clock speed  (SYSCLKOUT)
……
```

5. Review the comments at the top of the main source file: Example_2803xCpuTimer.c.

A brief description of the example and any assumptions that are made and any external hardware requirements are listed in the comments at the top of the main source file of each example. In some cases you may be required to make external connections for the example to work properly.

6. Perform any hardware setup required by the example.

Perform any hardware setup indicated by the comments in the main source. The CPU-Timer example only requires that the hardware be setup for “Boot to SARAM” mode.

Other examples may require additional hardware configuration such as connecting pins together or pulling a pin high or low.

Table 3 shows a listing of the boot mode pin settings for your reference. Table 4 and Table 5 list the EMU boot modes (when emulator is connected) and the Get Mode boot mode options (mode is programmed into OTP) respectively. Refer to the documentation for your hardware platform for information on configuring the boot mode pins. For more information on the ‘2803x boot modes refer to the device specific *Boot ROM Reference Guide*.

Table 3. 2803x Boot Mode Settings

GPIO37 TDO	GPIO34 CMP2OUT	TRSTn	Mode
X	X	1	EMU Mode
0	0	0	Parallel I/O
0	1	0	SCI
1	0	0	Wait
1	1	0	“Get Mode”

Table 4. 2803x EMU Boot Modes (Emulator Connected)

EMU_KEY 0x0D00	EMU_BMODE 0x0D01	Boot Mode Selected
!= 0x55AA	x	Wait
0x55AA	0x0000	Parallel I/O
	0x0001	SCI
	0x0002	Wait
	0x0003	Get Mode
	0x0004	SPI
	0x0005	I2C
	0x0006	OTP
	0x0007	eCAN
	0x0008	Wait
	0x000A	Boot to RAM
	0x000B	Boot to FLASH
	Other	Wait

Table 5. 2803x GET Boot Modes (Emulator Disconnected)

OTP_KEY 0x3D7BFE	OTP_BMODE 0x3D7BFF	Boot Mode Selected
!= 0x55AA	x	Get Mode - Flash
0x55AA	0x0001	Get Mode - SCI
	0x0003	Get Mode – Flash
	0x0004	Get Mode - SPI
	0x0005	Get Mode - I2C
	0x0006	Get Mode - OTP
	0x0007	Get Mode - eCAN
	Other	Get Mode - Flash

When the emulator is connected for debugging:

TRSTn = 1, and therefore the device is in EMU boot mode. In this situation, the user must write the key value of 0x55AA to EMU_KEY at address 0x0D00 and the desired EMU boot mode value to EMU_BMODE at 0x0D01 via the debugger window according to Table 4. The 2803x gel files in the DSP2803x_common/gel/ directory have a GEL function – EMU Boot Mode Select -> EMU_BOOT_SARAM() which performs the debugger write to boot to "SARAM" mode when called.

When the emulator is not connected for debugging:

SCI or Parallel I/O boot mode can be selected directly via the GPIO pins, or OTP_KEY at address 0x3D7BFE and OTP_BMODE at address 0x3D7BFF can be programmed for the desired boot mode per Table 5.

7. Build and Load the code

Once any hardware configuration has been completed, in Code Composer Studio v4, go to *Target->Debug Active Project*.

This will open the "Debug Perspective" in CCSv4, build the project, load the .out file into the 28x device, reset the part, and execute code to the start of the main function. By default, in Code Composer Studio v4, every time *Debug Active Project* is selected, the code is automatically built and the .out file loaded into the 28x device.

8. Run the example, add variables to the watch window or examine the memory contents.

At the top of the code in the comments section, there should be a list of "Watch variables". To add these to the watch window, highlight them and right-click. Then select *Add Watch expression*. Now variables of interest are added to the watch window.

9. Experiment, modify, re-build the example.

If you wish to modify the examples it is suggested that you make a copy of the entire header file packet to modify or at least create a backup of the original files first. New examples provided by TI will assume that the base files are as supplied.

Sections 4.2 and 4.3 describe the structure and flow of the examples in more detail.

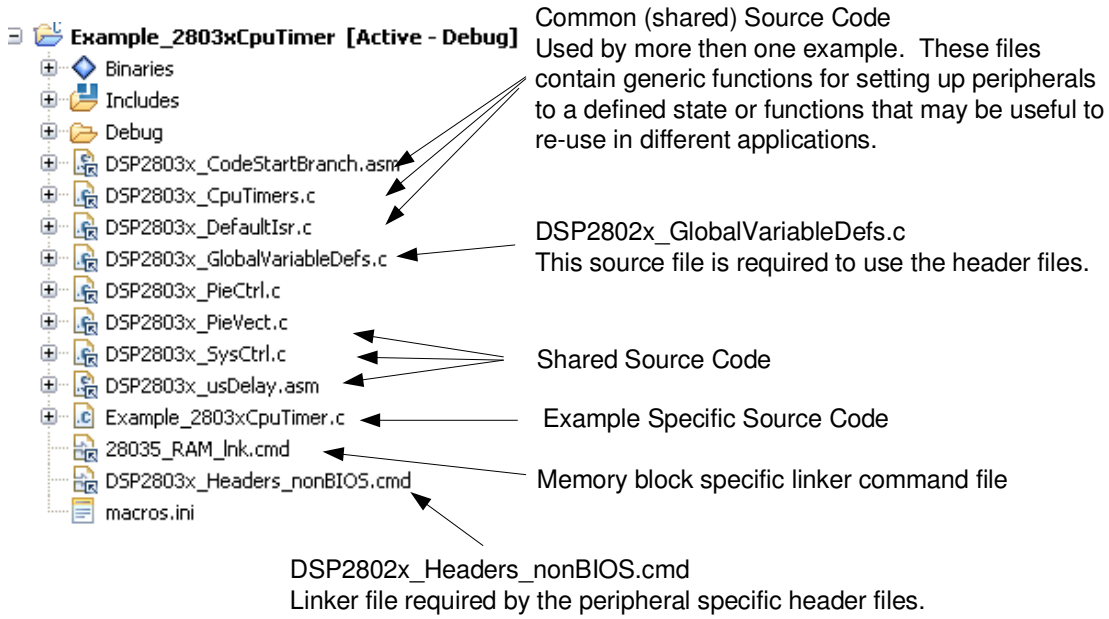
10. When done, delete the project from the Code Composer Studio v4 workspace.

Go *to View->C/C++ Projects* to open up your project view. To remove/delete the project from the workspace, right click on the project's name and select *delete*. Make sure the *Do not delete* contents button is selected, then select *Yes.* This does not delete the project itself. It merely removes the project from the workspace until you wish to open/import it again.

The examples use the header files in the *DSP2803x_headers* directory and shared source in the *DSP2803x_common* directory. Only example files specific to a particular example are located within in the example directory.

Note: Most of the example code included uses the .bit field structures to access registers. This is done to help the user learn how to use the peripheral and device. Using the bit fields has the advantage of yielding code that is easier to read and modify. This method will result in a slight code overhead when compared to using the .all method. In addition, the example projects have the compiler optimizer turned off. The user can change the compiler settings to turn on the optimizer if desired.

4.2 Example Program Structure



Each of the example programs has a very similar structure. This structure includes unique source code, shared source code, header files and linker command files.

```
//###########################################################################
// DSP2803x_examples\cpu_timer\Example_2803xCpuTimer.c
//###########################################################################

#include "DSP28x_Project.h"     // Device Headerfile and Examples Include File
```

- **DSP28x_Project.h**

  This header file includes DSP2803x_Device.h and DSP2803x_Examples.h. Because the name is device-generic, example/custom projects can be easily ported between different device header files. This file is found in the *<base>\DSP2803x_common\include* directory.

- **DSP2803x_Device.h**

  This header file is required to use the header files. This file includes all of the required peripheral specific header files and includes device specific macros and typedef statements. This file is found in the *<base>\DSP2803x_headers\include* directory.

- **DSP2803x_Examples.h**

  This header file defines parameters that are used by the example code. This file is not required to use just the DSP2803x peripheral header files but is required by some of the common source files. This file is found in the *<base>\DSP2803x_common\include* directory.

4.2.1 Source Code

Each of the example projects consists of source code that is unique to the example as well as source code that is common or shared across examples.

- **DSP2803x_GlobalVariableDefs.c**

  Any project that uses the DSP2803x peripheral header files must include this source file. In this file are the declarations for the peripheral register structure variables and data section assignments. This file is found in the *<base>\DSP2803x_headers\source* directory.

- **Example specific source code:**

  Files that are specific to a particular example have the prefix Example_2803x in their filename. For example Example_2803xCpuTimer.c is specific to the CPU Timer example and not used for any other example. Example specific files are located in the *<base>\DSP2803x_examples_ccsv4\<example>* directory.

- **Common source code:**

  The remaining source files are shared across the examples. These files contain common functions for peripherals or useful utility functions that may be re-used. Shared source files are located in the DSP2803x_common\source directory. Users may choose to incorporate none, some, or the entire shared source into their own new or existing projects.

4.2.2 Linker Command Files

Each example uses two linker command files. These files specify the memory where the linker will place code and data sections. One linker file is used for assigning compiler generated sections to the memory blocks on the device while the other is used to assign the data sections of the peripheral register structures used by the DSP2803x peripheral header files.

- **Memory block linker allocation:**

The linker files shown in Table 6 are used to assign sections to memory blocks on the device. These linker files are located in the *<base>\DSP2803x_common\cmd* directory. Each example will use one of the following files depending on the memory used by the example.

Table 6. Included Memory Linker Command Files

Memory Linker Command File Examples	Location	Description
28035_RAM_lnk.cmd	DSP2803x_common\cmd	28035 memory linker command file. Includes all of the internal SARAM blocks on 28035 device. “RAM” linker files do not include flash or OTP blocks.
28034_RAM_lnk.cmd	DSP2803x_common\cmd	28034 SARAM memory linker command file.
28033_RAM_lnk.cmd	DSP2803x_common\cmd	28033 SARAM memory linker command file.
28032_RAM_lnk.cmd	DSP2803x_common\cmd	28032 SARAM memory linker command file.
28031_RAM_lnk.cmd	DSP2803x_common\cmd	28031 SARAM memory linker command file.
28030_RAM_lnk.cmd	DSP2803x_common\cmd	28030 SARAM memory linker command file
28035_RAM_CLA_lnk.cmd	DSP2803x_common\cmd	28035 SARAM CLA memory linker command file. Includes CLA message RAM.
28033_RAM_CLA_lnk.cmd	DSP2803x_common\cmd	28033 SARAM CLA memory linker command file.
F28035.cmd	DSP2803x_common\cmd	F28035 memory linker command file. Includes all Flash, OTP and CSM password protected memory locations.
F28035.cmd	DSP2803x_common\cmd	F28035 memory linker command file.
F28034.cmd	DSP2803x_common\cmd	F28034 memory linker command file.
F28033.cmd	DSP2803x_common\cmd	F28033 memory linker command file.
F28032.cmd	DSP2803x_common\cmd	F28032 memory linker command file.
F28031.cmd	DSP2803x_common\cmd	F28031 memory linker command file.
F28030.cmd	DSP2803x_common\cmd	F28030 memory linker command file.

- **Header file structure data section allocation:**

  Any project that uses the header file peripheral structures must include a linker command file that assigns the peripheral register structure data sections to the proper memory location. These files are described in Table 7.

Table 7. DSP2803x Peripheral Header Linker Command File

Header File Linker Command File	Location	Description
DSP2803x_Headers_BIOS.cmd	DSP2803x_headers\cmd	Linker .cmd file to assign the header file variables in a BIOS project. This file must be included in any BIOS project that uses the header files. Refer to section 5.2.
DSP2803x_Headers_nonBIOS.cmd	DSP2803x_headers\cmd	Linker .cmd file to assign the header file variables in a non-BIOS project. This file must be included in any non-BIOS project that uses the header files. Refer to section 5.2.

4.3 Example Program Flow

All of the example programs follow a similar recommended flow for setting up a 2803x device. Figure 1 outlines this basic flow:

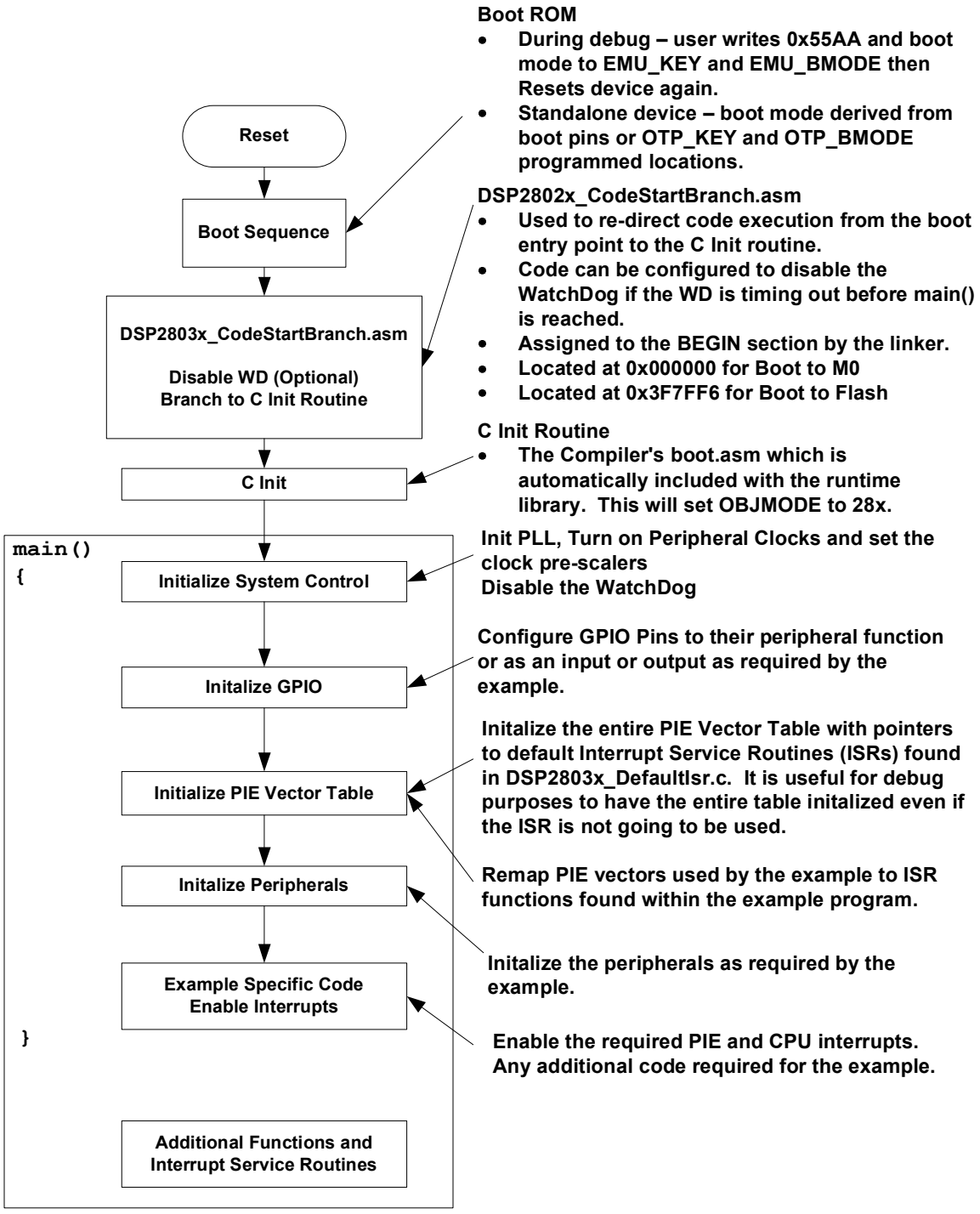


Figure 1. Flow for Example Programs

4.4 Included Examples:

Table 8. Included Examples

Example	Description
adc_soc	ADC example to convert two channels: ADCINA4 and ADCINA2. Interrupts are enabled and PWM1 is configured to generate a periodic ADC SOC – ADCINT1.
adc_temp_sensor	ADC temperature sensor example converts ADC channel: ADCINA5, which is internally connected to temperature sensor.
adc_temp_sensor_conv	ADC temperature sensor example converts ADC channel, ADCINA5 (internally connected to temperature sensor), and converts to Celsius or Kelvins.
cla_adc	CLA example which sets up ePWM1 to generate a periodic ADC SOC. One ADC channel is converted, and CLA task logs result values in a circular buffer.
cla_adc_fir	CLA example which implements an FIR filter from ADC periodic conversion results.
cla_adc_fir_flash	Flash version of the cla_adc_fir example.
cpu_timer	Configures CPU Timer0 and increments a count each time the ISR is serviced.
ecan_back2back	eCAN self-test mode example. Transmits eCAN data back-to-back at high speed without stopping.
ecap_apwm	This example sets up the alternate eCAP pins in the APWM mode
ecap_capture_pwm	Captures the edges of a ePWM signal.
epwm_blanking_window	Demonstrates blanking window by filtering out digital compare events around CTR = 0.
epwm_dceventtrip	Sets up digital compare events, and uses combinations of these events to set ePWM signals to a particular state.
epwm_dcevent_trip_comp	Sets up digital compare events with comparator inputs and uses combinations of these events to set ePWM signals to a particular state.
epwm_deadband	Example deadband generation via ePWM3
epwm_timer_interrupts	Starts ePWM1-ePWM6 timers. Every period an interrupt is taken for each ePWM.
epwm_trip_zone	Uses the trip zone signals to set the ePWM signals to a particular state.
epwm_up_aq	Generate a PWM waveform using an up count time base ePWM1-ePWM3 are used.
epwm_updown_aq	Generate a PWM waveform using an up/down time base. ePWM- ePWM3 are used.
eqep_freqcal	Frequency cal using eQEP1
eqep_pos_speed	Pos/speed calculation using eQEP1
external_interrupt	Configures GPIO0 as XINT1 and GPIO1 as XINT2. The interrupts are fired by toggling GPIO30 and GPIO31 which are connected to XINT1 (GPIO0) and XINT2 (GPIO1) externally by the user.
flash_f28035	ePWM timer interrupt project moved from SARAM to Flash. Includes steps that were used to convert the project from SARAM to Flash. Some interrupt service routines are copied from FLASH to SARAM for faster execution.
gpio_setup	Three examples of different pinout configurations.
gpio_toggle	Toggles all of the I/O pins using different methods – DATA, SET/CLEAR and TOGGLE registers. The pins can be observed using an oscilloscope.
hrpwm	Sets up ePWM1-ePWM4 and controls the edge of output A using the HRPWM extension. Both rising edge and falling edge are controlled.
hrpwm_duty_sfo_v6	Use TI's MEP Scale Factor Optimizer (SFO) library to change the HRPWM duty cycle.
hrpwm_prdup_sfo_v6	Use TI's MEP Scale Factor Optimizer (SFO) library to change the HRPWM period in up-count mode.

Included Examples Continued…

hrpwm_prdupdown_sfo_v6	Use TI's MEP Scale Factor Optimizer (SFO) library to change the HRPWM period in up-down count mode.
hrpwm_slider	This is the same as the hrpwm example except the control of CMPAHR is now controlled by the user via a slider bar. The included .gel file sets up the slider.
i2c_eeprom	Communicate with the EEPROM on the eZdsp F28035 USB platform via I2C
lina_external_loopback	LIN-A external analog loopback example. A transceiver is required.
lina_sci_echoback	LIN-A configured in SCI mode example that can be used to echoback to a terminal program such as hyperterminal. A transceiver and a connection to a PC is required.
lina_sci_loopback_interrupts	LIN-A configured in SCI mode example that uses the peripheral's loop-back test mode to send data. Interrupts are used in this example.
lpm_haltwake	Puts device into low power halt mode. GPIO0 is configured to wake the device from halt when an external high-low-high pulse is applied to it.
lpm_idlewake	Puts device into low power idle mode. GPIO0 is configured as XINT1 pin. When an XINT1 interrupt occurs due to a falling edge on GPIO0, the device is woken from idle.
lpm_standbywake	Puts device into low power standby mode. GPIO0 is configured to wake the device from halt when an external high-low-high pulse is applied to it.
osc_comp	Internal oscillator compensation example – compensates for frequency drift over temperature and re-calibrates internal oscillators to external clock frequency.
sci_echoback	SCI-A example that can be used to echoback to a terminal program such as hyperterminal. A transceiver and a connection to a PC is required.
scia_loopback	SCI-A example that uses the peripheral's loop-back test mode to send data.
scia_loopback_interrupts	SCI-A example that uses the peripheral's loop-back test mode to send data. Both interrupts and FIFOs are used in this example.
spi_loopback	SPI-A example that uses the peripherals loop-back test mode to send data.
spi_loopback_interrupts	SPI-A example that uses the peripherals loop-back test mode to send data. Both interrupts and FIFOs are used in this example.
sw_prioritized_interrupts	The standard hardware prioritization of interrupts can be used for most applications. This example shows a method for software to re-prioritize interrupts if required.
timed_led_blink	This example blinks GPIO34 (LED on the control card) at a rate of 1 Hz using CPU Timer 0.
watchdog	Illustrates feeding the dog and re-directing the watchdog to an interrupt.

4.5 Executing the Examples From Flash

Most of the DSP2803x examples execute from SARAM in "boot to SARAM" mode. One example, *DSP2803x_examples\flash_f28035,* executes from flash memory in "boot to flash" mode. This example is the PWM timer interrupt example with the following changes made to execute out of flash:

1. **Change the linker command file to link the code to flash.**

   Remove 28035_RAM_lnk.cmd from the project and link one of the flash based linker files (ex: F28035.cmd, F28034.cmd, F28033.cmd, F28032.cmd, F28031.cmd, or F28030.cmd). These files are located in the *<base>DSP2803x_common\cmd\ directory*.

2. **Link the *DSP2803x_common\source\DSP2803x_CSMPasswords.asm* to the project.**

   This file contains the passwords that will be programmed into the Code Security Module (CSM) password locations. Leaving the passwords set to 0xFFFF during development is recommended as the device can easily be unlocked. For more information on the CSM refer to the appropriate *System Control and Interrupts Reference Guide*.

3. **Modify the source code to copy all functions that must be executed out of SARAM from their load address in flash to their run address in SARAM.**

   In particular, the flash wait state initialization routine must be executed out of SARAM. In the DSP2803x, functions that are to be executed from SARAM have been assigned to the ramfuncs section by compiler CODE_SECTION #pragma statements as shown in the example below.

```
/*********************************************************************
* DSP2803x_common\source\DSP2803x_SysCtrl.c
*********************************************************************/

#pragma CODE_SECTION(InitFlash, "ramfuncs");
```

   The ramfuncs section is then assigned to a load address in flash and a run address in SARAM by the memory linker command file as shown below:

```
/*********************************************************************
* DSP2803x_common\include\F28035.cmd
*********************************************************************/
SECTIONS
{
   ramfuncs    : LOAD = FLASHA,
                 RUN = RAML0,
                 LOAD_START(_RamfuncsLoadStart),
                 LOAD_END(_RamfuncsLoadEnd),
                 RUN_START(_RamfuncsRunStart),
                 PAGE = 0
}
```

The linker will assign symbols as specified above to specific addresses as follows:

Address	Symbol
Load start address	RamfuncsLoadStart
Load end address	RamfuncsLoadEnd
Run start address	RamfuncsRunStart

These symbols can then be used to copy the functions from the Flash to SARAM using the included example MemCopy routine or the C library standard memcopy() function.

To perform this copy from flash to SARAM using the included example MemCopy function:

a. Add the file *DSP2803x_common\source\DSP2803x_MemCopy.c* to the project.

b. Add the following function prototype to the example source code. This is done for you in the *DSP2803x_Examples.h* file.

```
/*********************************************************************
* DSP2803x_common\include\DSP2803x_Examples.h
*********************************************************************/

MemCopy(&RamfuncsLoadStart, &RamfuncsLoadEnd, &RamfuncsRunStart);
```

c. Add the following variable declaration to your source code to tell the compiler that these variables exist. The linker command file will assign the address of each of these variables as specified in the linker command file as shown in step 3. For the DSP2803x example code this has is already done in *DSP2803x_Examples.h*.

```
/*********************************************************************
* DSP2803x_common\include\DSP2803x_GlobalPrototypes.h
*********************************************************************/

extern Uint16 RamfuncsLoadStart;
extern Uint16 RamfuncsLoadEnd;
extern Uint16 RamfuncsRunStart;
```

d. Modify the code to call the example MemCopy function for each section that needs to be copied from flash to SARAM.

```
/*********************************************************************
* DSP2803x_examples\Flash source file
*********************************************************************/

MemCopy(&RamfuncsLoadStart, &RamfuncsLoadEnd, &RamfuncsRunStart);
```

4. Modify the code to call the flash initialization routine:

This function will initialize the wait states for the flash and enable the Flash Pipeline mode.

```
/*********************************************************************
* DSP2803x peripheral example .c file
*********************************************************************/

InitFlash();
```

5. Set the required jumpers for "boot to Flash" mode.

The required jumper settings for each boot mode are shown in Table 9, Table 10, and Table 11.

Table 9. 2803x Boot Mode Settings

GPIO37 TDO	GPIO34 CMP2OUT	TRSTn	Mode
X	X	1	EMU Mode
0	0	0	Parallel I/O
0	1	0	SCI
1	0	0	Wait
1	1	0	"Get Mode"

Table 10. 2803x EMU Boot Modes (Emulator Connected)

EMU_KEY 0x0D00	EMU_BMODE 0x0D01	Boot Mode Selected
!= 0x55AA	x	Wait
0x55AA	0x0000	Parallel I/O
	0x0001	SCI
	0x0002	Wait
	0x0003	Get Mode
	0x0004	SPI
	0x0005	I2C
	0x0006	OTP
	0x0007	eCAN
	0x0008	Wait
	0x000A	Boot to RAM
	0x000B	**Boot to FLASH**
	Other	Wait

Table 11. 2803x GET Boot Modes (Emulator Disconnected)

OTP_KEY 0x3D7BFE	OTP_BMODE 0x3D7BFF	Boot Mode Selected
!= 0x55AA	**x**	**Get Mode - Flash**
0x55AA	0x0001	Get Mode - SCI
	0x0003	**Get Mode – Flash**
	0x0004	Get Mode - SPI
	0x0005	Get Mode - I2C
	0x0006	Get Mode - OTP
	0x0007	Get Mode - eCAN
	Other	**Get Mode - Flash**

When the emulator is connected for debugging:

TRSTn = 1, and therefore the device is in EMU boot mode. In this situation, the user must write the key value of 0x55AA to EMU_KEY at address 0x0D00 and the desired EMU boot mode value to EMU_BMODE at 0x0D01 via the debugger window according to Table 10.

When the emulator is not connected for debugging:

SCI or Parallel I/O boot mode can be selected directly via the GPIO pins, or OTP_KEY at address 0x3D7BFE and OTP_BMODE at address 0x3D7BFF can be programmed for the desired boot mode per the tables above

Refer to the documentation for your hardware platform for information on configuring the boot mode selection pins.

For more information on the '2803x boot modes refer to the appropriate *Boot ROM Reference Guide*.

6. **Program the device with the built code.**

   In Code Composer Studio v4, when code is loaded into the device during debug, it automatically programs to flash memory.

   This can also be done using SDFlash available from Spectrum Digital's website (www.spectrumdigital.com). In addition the C2000 On-chip Flash programmer plug-in for Code Composer Studio v3.x can be used.

   These tools will be updated to support new devices as they become available. Please check for updates.

7. **In Code Composer Studio v3, to debug, load the project in CCS, select *File->Load Symbols->Load Symbols Only*.**

   It is useful to load only symbol information when working in a debugging environment where the debugger cannot or need not load the object code, such as when the code is in ROM or flash. This operation loads the symbol information from the specified file.

5 Steps for Incorporating the Header Files and Sample Code

Follow these steps to incorporate the peripheral header files and sample code into your own projects. If you already have a project that uses the DSP280x or DSP281x header files then also refer to Section 7 for migration tips.

5.1 Before you begin

Before you include the header files and any sample code into your own project, it is recommended that you perform the following:

1. **Load and step through an example project.**

   Load and step through an example project to get familiar with the header files and sample code. This is described in Section 4.

2. **Create a copy of the source files you want to use.**

   DSP2803x_headers: code required to incorporate the header files into your project
   DSP2803x_common: shared source code much of which is used in the example projects.
   DSP2803x_examples_ccsv4: '2803x floating-point compiled example projects that use the header files and shared code.

5.2 Including the DSP2803x Peripheral Header Files

Including the DSP2803x header files in your project will allow you to use the bit-field structure approach in your code to access the peripherals on the DSP. To incorporate the header files in a new or existing project, perform the following steps:

1. **#include "DSP2803x_Device.h" (or #include "DSP28x_Project.h") in your source files.**

   The DSP2803x_Device.h include file will in-turn include all of the peripheral specific header files and required definitions to use the bit-field structure approach to access the peripherals.

```
/*************************************************************
* User's source file
*************************************************************/

#include "DSP2803x_Device.h"
```

   Another option is to #include "DSP28x_Project.h" in your source files, which in-turn includes "DSP2803x_Device.h" and "DSP2803x_Examples.h" (if it is not necessary to include common source files in the user project, the #include "DSP2803x_Examples.h" line can be deleted). Due to the device-generic nature of the file name, user code is easily ported between different device header files.

```
/*************************************************************************
* User's source file
*************************************************************************/

#include "DSP28x_Project.h"
```

1. **Edit DSP2803x_Device.h and select the target you are building for:**

   In the below example, the file is configured to build for the '28035 device.

```
/*************************************************************************
* DSP2803x_headers\include\DSP2803x_Device.h
*************************************************************************/
#define   TARGET        1
#define   DSP28_28035   TARGET    // Selects '28035
#define   DSP28_28034   0         // Selects '28034
#define   DSP28_28033   0         // Selects '28033… etc
```

   By default, the '28035 device is selected.

2. **Add the source file *DSP2803x_GlobalVariableDefs.c* to the project.**

   This file is found in the *DSP2803x_headers\source* directory and includes:

   – Declarations for the variables that are used to access the peripheral registers.

   – Data section #pragma assignments that are used by the linker to place the variables in the proper locations in memory.

3. **Add the appropriate DSP2803x header linker command file to the project.**

   As described in Section 3, when using the DSP2803x header file approach, the data sections of the peripheral register structures are assigned to the memory locations of the peripheral registers by the linker.

   To perform this memory allocation in your project, one of the following linker command files located in *DSP2803x_headers\cmd* must be included in your project:

   – For non-DSP/BIOS[†] projects: *DSP2803x_Headers_nonBIOS.cmd*

   – For DSP/BIOS projects: *DSP2803x_Headers_BIOS.cmd*

[†] DSP/BIOS is a trademark of Texas Instruments

The method for adding the header linker file to the project depends on preference.

Method #1:

a. Right-click on the project in the project window of the C/C++ Projects perspective.

b. Select *Link Files to Project…*

c. Navigate to the *DSP2803x_headers\cmd* directory on your system and select the desired .cmd file.

Note: The limitation with Method #1 is that the path to <install directory>\DSP2803x_headers\cmd\<cmd file>.cmd is fixed on your PC. If you move the installation directory to another location on your PC, the project will "break" because it still expects the .cmd file to be in the original location. Use Method #2 if you are using "linked variables" in your project to ensure your project/installation directory is portable across computers and different locations on the same PC. (For more information, see: http://tiexpressdsp.com/index.php/Portable_Projects_in_CCSv4_for_C2000)

Method #2:

a. Right-click on the project in the project window of the C/C++ Projects perspective.

b. Select *New->File*.

c. Click on the *Advanced>>* button to expand the window.

d. Check the *Link to file in the file system* checkbox.

e. Select the *Variables…* button. From the list, pick the linked variable (macro defined in your *macros.ini* file) associated with your installation directory. (For the 2803x header files, this is INSTALLROOT_2803X_V<version #>). For more information on linked variables and the macros.ini file, see: http://tiexpressdsp.com/index.php/Portable_Projects_in_CCSv4_for_C2000#Method_.232_for_Linking_Files_to_Project:

f. Click on the *Extend…"* button. Navigate to the desired .cmd file and select *OK.*

4. Add the directory path to the DSP2803x header files to your project.

Code Composer Studio 4.x:

To specify the directory where the header files are located:

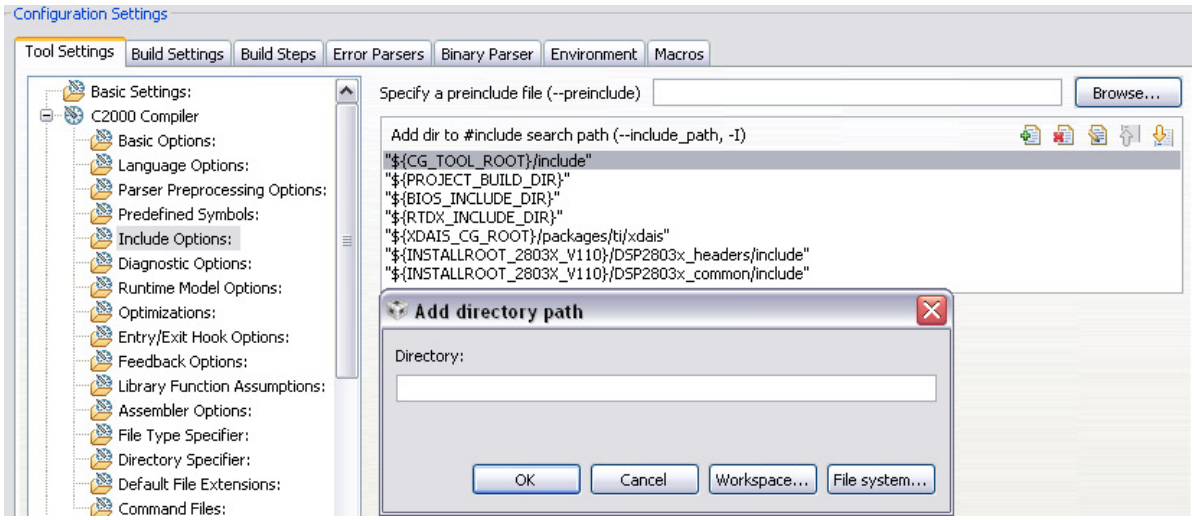
a. Open the menu: *Project->Properties*.

b. In the menu on the left, select "C/C++ Build".

c. In the *"Tool Settings"* tab, Select *"C2000 Compiler -> Include Options:"*

d. In the “Add dir to #include search path (--include_path, -I” window, select the “Add” icon in the top right corner.

e. Select the “*File system…”* button and navigate to the directory path of *DSP2803x_headers\include* on your system.



5. Additional suggested build options:

The following are additional compiler and linker options. The options can all be set via the *Project-> Properties->Tool Settings* sub-menus.

– ***C2000 Compiler:***

❑ **-ml Select *Runtime Modeul Options* and check –ml**

Build for large memory model. This setting allows data sections to reside anywhere within the 4M-memory reach of the 28x devices.

❑ **-pdr Select *Diagnostic Options* and check –pdr**

Issue non-serious warnings. The compiler uses a warning to indicate code that is valid but questionable. In many cases, these warnings issued by enabling -pdr can alert you to code that may cause problems later on.

– ***C2000 Linker:***

❑ **-w Select *Diagnostics* and check –w**

Warn about output sections. This option will alert you if any unassigned memory sections exist in your code. By default the linker will attempt to place any unassigned code or data section to an available memory location without alerting the user. This can cause problems, however, when the section is placed in an unexpected location.

❑ **-e Select *Symbol Management* and enter Program Entry Point –e**

Defines a global symbol that specifies the primary entry point for the output module. For the DSP2802x examples, this is the symbol “code_start”. This symbol is defined in the

DSP2802x_common\source\DSP2802x_CodeStartBranch.asm file. When you load the code in Code Composer Studio, the debugger will set the PC to the address of this symbol. If you do not define a entry point using the –e option, then the linker will use _c_int00 by default.

5.3 Including Common Example Code

Including the common source code in your project will allow you to leverage code that is already written for the device. To incorporate the shared source code into a new or existing project, perform the following steps:

1. **#include "DSP2803x_Examples.h" (or "DSP28x_Project.h") in your source files.**

   The "DSP2803x_Examples.h" include file will include common definitions and declarations used by the example code.

```
/*************************************************************
* User's source file
*************************************************************/

#include "DSP2803x_Examples.h"
```

   Another option is to #include "DSP28x_Project.h" in your source files, which in-turn includes "DSP2803x_Device.h" and "DSP2803x_Examples.h". Due to the device-generic nature of the file name, user code is easily ported between different device header files.

```
/*************************************************************
* User's source file
*************************************************************/

#include "DSP28x_Project.h"
```

2. Add the directory path to the example include files to your project.

To specify the directory where the header files are located:

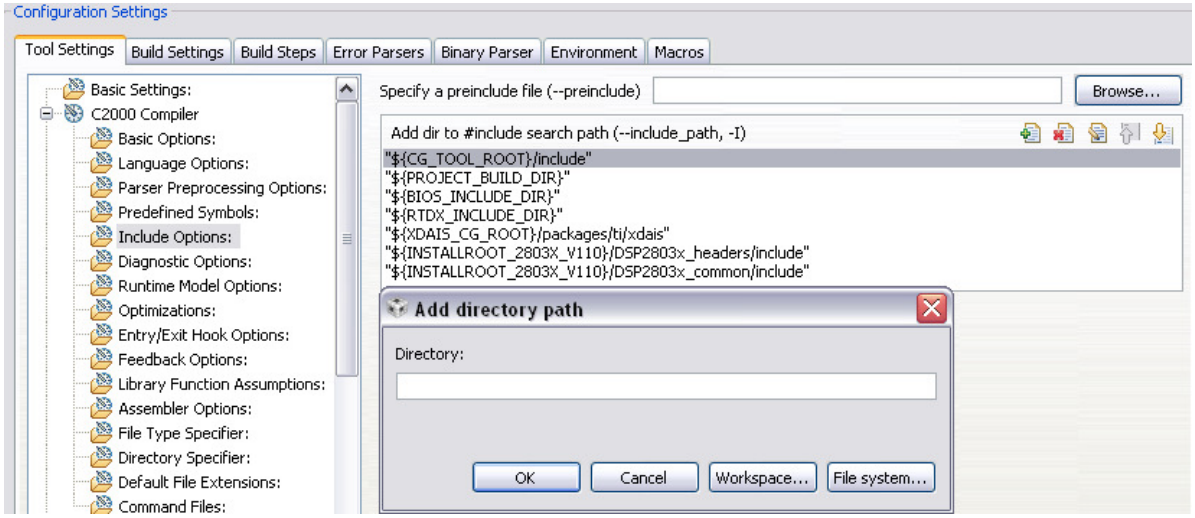
a. Open the menu: *Project->Properties*.

b. In the menu on the left, select “C/C++ Build”.

c. In the *“Tool Settings”* tab, Select *“C2000 Compiler -> Include Options:”*

d. In the “Add dir to #include search path (--include_path, -I” window, select the “Add” icon in the top right corner.

e. Select the “*File system…”* button and navigate to the directory path of *DSP2803x_headers\include* on your system.



3. Link a linker command file to your project.

The following memory linker .cmd files are provided as examples in the *DSP2803x_common\cmd* directory. For getting started the basic *28035_RAM_lnk.cmd* file is suggested and used by most of the examples.

Table 12. Included Main Linker Command Files

Memory Linker Command File Examples	Location	Description
28035_RAM_lnk.cmd	DSP2803x_common\cmd	28035 memory linker command file. Includes all of the internal SARAM blocks on a 28035 device. “RAM” linker files do not include flash or OTP blocks.
28034_RAM_lnk.cmd	DSP2803x_common\cmd	28034 SARAM memory linker command file.
28033_RAM_lnk.cmd	DSP2803x_common\cmd	28033 SARAM memory linker command file.
28032_RAM_lnk.cmd	DSP2803x_common\cmd	28032 SARAM memory linker command file.

28031_RAM_lnk.cmd	DSP2803x_common\cmd	28031 SARAM memory linker command file.
28030_RAM_lnk.cmd	DSP2803x_common\cmd	28030 SARAM memory linker command file.
28035_RAM_CLA_lnk.cmd	DSP2803x_common\cmd	28035 CLA memory linker command file. Includes CLA message RAM
28033_RAM_CLA_lnk.cmd	DSP2803x_common\cmd	28033 SARAM CLA memory linker command file.
F28035.cmd	DSP2803x_common\cmd	F28035 memory linker command file.
F28034.cmd	DSP2803x_common\cmd	F28034 memory linker command file.
F28033.cmd	DSP2803x_common\cmd	F28033 memory linker command file.
F28032.cmd	DSP2803x_common\cmd	F28032 memory linker command file.
F28031.cmd	DSP2803x_common\cmd	F28031 memory linker command file.
F28030.cmd	DSP2803x_common\cmd	F28030 memory linker command file.

4. Set the CPU Frequency

In the *DSP2803x_common\include\DSP2803x_Examples.h* file specify the proper CPU frequency. Some examples are included in the file.

```
/*-----------------------------------------------------------------
* DSP2803x_common\include\DSP2803x_Examples.h
-----------------------------------------------------------------*/
……
#define CPU_RATE   16.667L   // for a 60MHz CPU clock speed (SYSCLKOUT)
//#define CPU_RATE   20.000L   // for a 50MHz CPU clock speed  (SYSCLKOUT)
//#define CPU_RATE   25.000L   // for a 40MHz CPU clock speed  (SYSCLKOUT)
……
```

5. Link desired common source files to the project.

The common source files are found in the *DSP2803x_common\source* directory.

6. Include .c files for the PIE.

Since all catalog ‘2803x applications make use of the PIE interrupt block, you will want to include the PIE support .c files to help with initializing the PIE. The shell ISR functions can be used directly or you can re-map your own function into the PIE vector table provided. A list of these files can be found in section 8.2.1.

6 Troubleshooting Tips & Frequently Asked Questions

- **In the examples, what do "EALLOW;" and "EDIS;" do?**

  EALLOW; is a macro defined in DSP2803x_Device.h for the assembly instruction EALLOW and likewise EDIS is a macro for the EDIS instruction. That is EALLOW; is the same as embedding the assembly instruction asm(" EALLOW");

  Several control registers on the 28x devices are protected from spurious CPU writes by the EALLOW protection mechanism. The EALLOW bit in status register 1 indicates if the protection is enabled or disabled. While protected, all CPU writes to the register are ignored and only CPU reads, JTAG reads and JTAG writes are allowed. If this bit has been set by execution of the EALLOW instruction, then the CPU is allowed to freely write to the protected registers. After modifying the registers, they can once again be protected by executing the EDIS assembly instruction to clear the EALLOW bit.

  For a complete list of protected registers, refer to *TMS320x2803x System Control and Interrupts Reference Guide* .

- **Peripheral registers read back 0x0000 and/or cannot be written to.**

  There are a few things to check:

  - Peripheral registers cannot be modified or unless the clock to the specific peripheral is enabled. The function InitPeripheralClocks() in the DSP2803x_common\source directory shows an example of enabling the peripheral clocks.
  - Some peripherals are not present on all 2803x family derivatives. Refer to the device datasheet for information on which peripherals are available.
  - The EALLOW bit protects some registers from spurious writes by the CPU. If your program seems unable to write to a register, then check to see if it is EALLOW protected. If it is, then enable access using the EALLOW assembly instruction. *TMS320x2803x System Control and Interrupts Reference Guide* for a complete list of EALLOW protected registers.

- **Memory block L0, L1 read back all 0x0000.**

  In this case most likely the code security module is locked and thus the protected memory locations are reading back all 0x0000. Refer to the for information on the code security module.

- **Code cannot write to L0 or L1 memory blocks.**

  In this case most likely the code security module is locked and thus the protected memory locations are reading back all 0x0000. Code that is executing from outside of the protected cannot read or write to protected memory while the CSM is locked. Refer to the *TMS320x2803x Control and Interrupts Reference Guide* for information on the code security module

- **A peripheral register reads back ok, but cannot be written to.**

  The EALLOW bit protects some registers from spurious writes by the CPU. If your program seems unable to write to a register, then check to see if it is EALLOW protected. If it is, then enable access using the EALLOW assembly instruction. *TMS320x2803x System Control and Interrupts Reference Guide* for a complete list of EALLOW protected registers.

- **I re-built one of the projects to run from Flash and now it doesn't work. What could be wrong?**

  Make sure all initialized sections have been moved to flash such as .econst and .switch.

  If you are using SDFlash, make sure that all initialized sections, including .econst, are allocated to page 0 in the linker command file (.cmd). SDFlash will only program sections in the .out file that are allocated to page 0.

- **Why do the examples populate the PIE vector table and then re-assign some of the function pointers to other ISRs?**

  The examples share a common default ISR file. This file is used to populate the PIE vector table with pointers to default interrupt service routines. Any ISR used within the example is then remapped to a function within the same source file. This is done for the following reasons:

  – The entire PIE vector table is enabled, even if the ISR is not used within the example. This can be very useful for debug purposes.

  – The default ISR file is left un-modified for use with other examples or your own project as you see fit.

  – It illustrates how the PIE table can be updated at a later time.

- **When I build the examples, the linker outputs the following: warning: entry point other than _c_int00 specified. What does this mean?**

  This warning is given when a symbol other then _c_int00 is defined as the code entry point of the project. For these examples, the symbol code_start is the first code that is executed after exiting the boot ROM code and thus is defined as the entry point via the –e linker option. This symbol is defined in the DSP2803x_CodeStartBranch.asm file. The entry point symbol is used by the debugger and by the hex utility. When you load the code, CCS will set the PC to the entry point symbol. By default, this is the _c_int00 symbol which marks the start of the C initialization routine. For the DSP2803x examples, the code_start symbol is used instead. Refer to the source code for more information.

- **When I build many of the examples, the compiler outputs the following: remark: controlling expression is constant. What does this mean?**

  Some of the examples run forever until the user stops execution by using a while(1) {} loop The remark refers to the while loop using a constant and thus the loop will never be exited.

- **When I build some of the examples, the compiler outputs the following: warning: statement is unreachable. What does this mean?**

Some of the examples run forever until the user stops execution by using a while(1) {} loop. If there is code after this while(1) loop then it will never be reached.

- **I changed the build configuration of one of the projects from "Debug" to "Release" and now the project will not build. What could be wrong?**

  When you switch to a new build configuration (*Project->Active Build Configuration*) the compiler and linker options changed for the project. The user must enter other options such as include search path and the library search path. Open the build options menu *(Project-> Options)* and enter the following information:

  – C2000 Compiler, Include Options: Include search path

  – C2000 Linker, File Search Path: Library search path

  – C2000 Linker, File Search Path: Include libraries (ie rts2800_ml.lib)

  Refer to section 5 for more details.

- **In the flash example I loaded the symbols and ran to main. I then set a breakpoint but the breakpoint is never hit. What could be wrong?**

  In the Flash example, the InitFlash function and several of the ISR functions are copied out of flash into SARAM. When you set a breakpoint in one of these functions, Code Composer will insert an ESTOP0 instruction into the SARAM location. When the ESTOP0 instruction is hit, program execution is halted. CCS will then remove the ESTOP0 and replace it with the original opcode. In the case of the flash program, when one of these functions is copied from Flash into SARAM, the ESTOP0 instruction is overwritten code. This is why the breakpoint is never hit. To avoid this, set the breakpoint after the SARAM functions have been copied to SARAM.

- **The eCAN control registers require 32-bit write accesses.**

  The compiler will instead make a 16-bit write accesses if it can in order to improve codesize and/or performance. This can result in unpredictable results.

  One method to avoid this is to create a duplicate copy of the eCAN control registers in RAM. Use this copy as a shadow register. First copy the contents of the eCAN register you want to modify into the shadow register. Make the changes to the shadow register and then write the data back as a 32-bit value. This method is shown in the DSP2803x_examples_ccsv4\ ecan_back2back example project.

6.1 Effects of read-modify-write instructions.

When writing any code, whether it be C or assembly, keep in mind the effects of read-modify-write instructions.

The '28x DSP will write to registers or memory locations 16 or 32-bits at a time. Any instruction that seems to write to a single bit is actually reading the register, modifying the single bit, and then writing back the results. This is referred to as a read-modify-write instruction. For most registers this operation does not pose a problem. A notable exception is:

6.1.1 Registers with multiple flag bits in which writing a 1 clears that flag.

For example, consider the PIEACK register. Bits within this register are cleared when writing a 1 to that bit. If more then one bit is set, performing a read-modify-write on the register may clear more bits then intended.

The below solution is incorrect. It will write a 1 to any bit set and thus clear all of them:

```
/*********************************************************************
* User's source file
*********************************************************************/

     PieCtrl.PIEACK.bit.Ack1 = 1;    // INCORRECT! May clear more bits.
```

The correct solution is to write a mask value to the register in which only the intended bit will have a 1 written to it:

```
/*********************************************************************
* User's source file
*********************************************************************/

     #define PIEACK_GROUP1  0x0001
             ……
      PieCtrl.PIEACK.all = PIEACK_GROUP1;   // CORRECT!
```

6.1.2 Registers with Volatile Bits.

Some registers have volatile bits that can be set by external hardware.

Consider the PIEIFRx registers. An atomic read-modify-write instruction will read the 16-bit register, modify the value and then write it back. During the modify portion of the operation a bit in the PIEIFRx register could change due to an external hardware event and thus the value may get corrupted during the write.

The rule for registers of this nature is to never modify them during runtime. Let the CPU take the interrupt and clear the IFR flag.

7 Migration Tips for moving from the TMS320x280x header files to the TMS320x2803x header files

This section includes suggestions for moving a project from the 280x header files to the 2803x header files.

1. **Create a copy of your project to work with or back-up your current project.**
2. **Open the project file(s) in a text editor**

   In Code Composer Studio v4.x:

   Open the *.project*, *.cdtbuild*, and *macros.ini* files in your example folder. Replace all instances of 280x with 2803x so that the appropriate source files and build options are used. Check the path names to make sure they point to the appropriate header file and source code directories. Also replace the header file version number for the paths and macro names as well where appropriate. For instance, if a macro name was INSTALLROOT_**280**X_V**170** for your 280x project using 280x header files V1.70, change this to INSTALLROOT_**2803**X_V**120** to migrate to the 2803x header files V1.20. If not using the default macro name for your header file version, be sure to change your macros according to your chosen macro name in the *.project, .cdtbuild*, and *macros.ini* files.
3. **Load the project into Code Composer Studio**

   Use the Edit-> find in files dialog to find instances of DSP280x_Device.h and DSP280x_Example.h for 280x header files. Replace these with DSP2803x_Device.h and DSP2803x_Example.h respectively (or instead with one DSP2803x_Project.h file).
4. **Make sure you are using the correct linker command files (.cmd) appropriate for your device and for the DSP2803x header files.**

   You will have one file for the memory definitions and one file for the header file structure definitions. Using a 280x memory file can cause issues since the H0 memory block has been split, renamed, and/or moved on the 2803x.
5. **Build the project.**

   The compiler will highlight areas that have changed. If migrating from the TMS320x280x header files, code should be mostly compatible after all instances of DSP280x are replaced with DSP2803x in all relevant files, and the above steps are taken. Additionally, several bits have been removed and/or replaced. See Table 13.

Table 13. Summary of Register and Bit-Name Changes from DSP280x V1.60 DSP2803x V1.00

Peripheral	Register	Bit Name		Comment
		Old	New	
SysCtrlRegs				
	XCLK	Reserved(bit 6)	XCLKINSEL(bit 6)	On 2803x devices, XCLKIN can be fed via a GPIO pin. This bit selects either GPIO38 (default) or GPIO19 as XCLKIN input source.
	PLLSTS	CLKINDIV(bit 1)	DIVSEL (bits 8,7)	DIVSEL allows more values by which CLKIN can be divided.

Additionally, unlike the DSP280x devices, the DSP2803x devices run off an internal oscillator (INTOSC1) by default. To switch between the 2 available internal clock sources and the traditional external oscillator clock source, a new register in the System Control register space – CLKCTL – is available.

8 Packet Contents:

This section lists all of the files included in the release.

8.1 Header File Support – DSP2803x_headers

The DSP2803x header files are located in the *<base>\DSP2803x_headers* directory.

8.1.1 DSP2803x Header Files – Main Files

The following files must be added to any project that uses the DSP2803x header files. Refer to section 5.2 for information on incorporating the header files into a new or existing project.

Table 14. DSP2803x Header Files – Main Files

File	Location	Description
DSP2803x_Device.h	DSP2803x_headers\include	Main include file. Include this one file in any of your .c source files. This file in-turn includes all of the peripheral specific .h files listed below. In addition the file includes typedef statements and commonly used mask values. Refer to section 5.2.
DSP2803x_GlobalVariableDefs.c	DSP2803x_headers\source	Defines the variables that are used to access the peripheral structures and data section #pragma assignment statements. This file must be included in any project that uses the header files. Refer to section 5.2.
DSP2803x_Headers_nonBIOS.cmd	DSP2803x_headers\cmd	Linker .cmd file to assign the header file variables in a non-BIOS project. This file must be included in any non-BIOS project that uses the header files. Refer to section 5.2.

8.1.2 DSP2803x Header Files – Peripheral Bit-Field and Register Structure Definition Files

The following files define the bit-fields and register structures for each of the peripherals on the 2803x devices. These files are automatically included in the project by including *DSP2803x_Device.h.* Refer to section 4.2 for more information on incorporating the header files into a new or existing project.

Table 15. DSP2803x Header File Bit-Field & Register Structure Definition Files

File	Location	Description
DSP2803x_Adc.h	DSP2803x_headers\include	ADC register structure and bit-field definitions.
DSP2803x_BootVars.h	DSP2803x_headers\include	External boot variable definitions.
DSP2803x_Cla.h	DSP2803x_headers\include	CLA register structure and bit-field definitions
DSP2803x_Comp.h	DSP2803x_headers\include	Comparator register structure and bit-field definitions.
DSP2803x_CpuTimers.h	DSP2803x_headers\include	CPU-Timer register structure and bit-field definitions.
DSP2803x_DevEmu.h	DSP2803x_headers\include	Emulation register definitions
DSP2833x_ECan.h	DSP2803x_headers\include	eCAN register structures and bit-field definitions.
DSP2803x_ECap.h	DSP2803x_headers\include	eCAP register structures and bit-field definitions.
DSP2803x_EPwm.h	DSP2803x_headers\include	ePWM register structures and bit-field definitions.
DSP2833x_EQep.h	DSP2803x_headers\include	eQEP register structures and bit-field definitions.
DSP2803x_Gpio.h	DSP2803x_headers\include	General Purpose I/O (GPIO) register structures and bit-field definitions.
DSP2803x_I2c.h	DSP2803x_headers\include	I2C register structure and bit-field definitions.
DSP2833x_Lin.h	DSP2803x_headers\include	LIN register structures and bit-field definitions.
DSP2803x_NmiIntrupt.h	DSP2803x_headers\include	NMI interrupt register structure and bit-field definitions
DSP2803x_PieCtrl.h	DSP2803x_headers\include	PIE control register structure and bit-field definitions.
DSP2803x_PieVect.h	DSP2803x_headers\include	Structure definition for the entire PIE vector table.
DSP2803x_Sci.h	DSP2803x_headers\include	SCI register structure and bit-field definitions.
DSP2803x_Spi.h	DSP2803x_headers\include	SPI register structure and bit-field definitions.
DSP2803x_SysCtrl.h	DSP2803x_headers\include	System register definitions. Includes Watchdog, PLL, CSM, Flash/OTP, Clock registers.
DSP2803x_XIntrupt.h	DSP2803x_headers\include	External interrupt register structure and bit-field definitions.

8.1.3 Variable Names and Data Sections

This section is a summary of the variable names and data sections allocated by the DSP2803x_headers\source\DSP2803x_GlobalVariableDefs.c file. Note that all peripherals may not be available on a particular 2803x device. Refer to the device datasheet for the peripheral mix available on each 2803x family derivative.

Table 16. DSP2803x Variable Names and Data Sections

Peripheral	Starting Address	Structure Variable Name
ADC	0x007100	AdcRegs
ADC Mirrored Result Registers	0x000B00	AdcMirror
CLA1	0x001400	Cla1Regs
Code Security Module	0x000AE0	CsmRegs
Code Security Module Password Locations	0x3F7FF8-0x3F7FFF	CsmPwl
COMP1	0x006400	Comp1Regs
COMP2	0x006420	Comp2Regs
COMP3	0x006440	Comp3Regs
CPU Timer 0	0x000C00	CpuTimer0Regs
CPU Timer 1	0x000C08	CpuTimer1Regs
CPU Timer 2	0x000C10	CpuTimer2Regs
Device and Emulation Registers	0x000880	DevEmuRegs
System Power Control Registers	0x00985	SysPwrCtrlRegs
eCAN-A	0x006000	ECanaRegs
eCAN-A Mail Boxes	0x006100	ECanaMboxes
eCAN-A Local Acceptance Masks	0x006040	ECanaLAMRegs
eCAN-A Message Object Time Stamps	0x006080	ECanaMOTSRegs
eCAN-A Message Object Time-Out	0x0060C0	ECanaMOTORegs
ePWM1	0x006800	EPwm1Regs
ePWM2	0x006840	EPwm2Regs
ePWM3	0x006880	EPwm3Regs
ePWM4	0x0068C0	EPwm4Regs
ePWM5	0x006900	EPwm5Regs
ePWM6	0x006940	EPwm6Regs
ePWM7	0x006980	EPwm7Regs
eCAP1	0x006A00	ECap1Regs
eQEP1	0x006B00	EQep1Regs
External Interrupt Registers	0x007070	XIntruptRegs
Flash & OTP Configuration Registers	0x000A80	FlashRegs
General Purpose I/O Data Registers	0x006fC0	GpioDataRegs
General Purpose Control Registers	0x006F80	GpioCtrlRegs
General Purpose Interrupt Registers	0x006fE0	GpioIntRegs
I2C	0x007900	I2caRegs
LIN-A	0x006C00	LinaRegs
NMI Interrupt	0x7060	NmiIntruptRegs

PIE Control	0x000CE0	PieCtrlRegs
SCI-A	0x007050	SciaRegs
SPI-A	0x007040	SpiaRegs
SPI-B	0x007740	SpibRegs

8.2 Common Example Code – DSP2803x_common

8.2.1 Peripheral Interrupt Expansion (PIE) Block Support

In addition to the register definitions defined in DSP2803x_PieCtrl.h, this packet provides the basic ISR structure for the PIE block. These files are:

Table 17. Basic PIE Block Specific Support Files

File	Location	Description
DSP2803x_DefaultIsr.c	DSP2803x_common\source	Shell interrupt service routines (ISRs) for the entire PIE vector table. You can choose to populate one of functions or re-map your own ISR to the PIE vector table. **Note: This file is not used for DSP/BIOS projects.**
DSP2803x_DefaultIsr.h	DSP2803x_common\include	Function prototype statements for the ISRs in DSP2803x_DefaultIsr.c. **Note: This file is not used for DSP/BIOS projects.**
DSP2803x_PieVect.c	DSP2803x_common\source	Creates an instance of the PIE vector table structure initialized with pointers to the ISR functions in DSP2803x_DefaultIsr.c. This instance can be copied to the PIE vector table in order to initialize it with the default ISR locations.

In addition, the following files are included for software prioritization of interrupts. These files are used in place of those above when additional software prioritization of the interrupts is required. Refer to the example and documentation in *DSP2803x_examples_ccsv4\sw_prioritized_interrupts* for more information.

Table 18. Software Prioritized Interrupt PIE Block Specific Support Files

File	Location	Description
DSP2803x_SWPrioritizedDefaultIsr.c	DSP2803x_common\source	Default shell interrupt service routines (ISRs). These are shell ISRs for all of the PIE interrupts. You can choose to populate one of functions or re-map your own interrupt service routine to the PIE vector table. **Note: This file is not used for DSP/BIOS projects.**
DSP2803x_SWPrioritizedIsrLevels.h	DSP2803x_common\include	Function prototype statements for the ISRs in DSP2803x_DefaultIsr.c. **Note: This file is not used for DSP/BIOS projects.**
DSP2803x_SWPrioritizedPieVect.c	DSP2803x_common\source	Creates an instance of the PIE vector table structure initialized with pointers to the default ISR functions that are included in DSP2803x_DefaultIsr.c. This instance can be copied to the PIE vector table in order to initialize it with the default ISR locations.

8.2.2 Peripheral Specific Files

Several peripheral specific initialization routines and support functions are included in the peripheral .c source files in the *DSP2803x_common\src* directory. These files include:

Table 19. Included Peripheral Specific Files

File	Description
DSP2803x_GlobalPrototypes.h	Function prototypes for the peripheral specific functions included in these files.
DSP2803x_Adc.c	ADC specific functions and macros.
DSP2803x_Comp.c	Comparator specific functions and macros
DSP2803x_CpuTimers.c	CPU-Timer specific functions and macros.
DSP2803x_ECan.c	eCAN module specific functions and macros
DSP2803x_ECap.c	eCAP module specific functions and macros.
DSP2803x_EPwm.c	ePWM module specific functions and macros.
DSP2803x_EPwm_defines.h	#define macros that are used for the ePWM examples
DSP2803x_EQep.c	eQEP module specific functions and macros.
DSP2803x_Gpio.c	General-purpose IO (GPIO) specific functions and macros.
DSP2803x_I2C.c	I2C specific functions and macros.
DSP2803x_I2c_defines.h	#define macros that are used for the I2C examples
DSP2803x_Lin.c	LIN specific functions and macros
DSP2803x_PieCtrl.c	PIE control specific functions and macros.
DSP2803x_Sci.c	SCI specific functions and macros.
DSP2803x_Spi.c	SPI specific functions and macros.
DSP2803x_SysCtrl.c	System control (watchdog, clock, PLL etc) specific functions and macros.

Note: The specific routines are under development and may not all be available as of this release. They will be added and distributed as more examples are developed.

8.2.3 Utility Function Source Files

Table 20. Included Utility Function Source Files

File	Description
DSP2803x_CodeStartBranch.asm	Branch to the start of code execution. This is used to re-direct code execution when booting to Flash, OTP or M0 SARAM memory. An option to disable the watchdog before the C init routine is included.
DSP2803x_DBGIER.asm	Assembly function to manipulate the DEBIER register from C.
DSP2803x_DisInt.asm	Disable interrupt and restore interrupt functions. These functions allow you to disable INTM and DBGM and then later restore their state.
DSP2803x_usDelay.asm	Assembly function to insert a delay time in microseconds. This function is cycle dependant and must be executed from zero wait-stated RAM to be accurate. Refer to *DSP2803x_examples_ccsv4/adc* for an example of its use.
DSP2803x_CSMPasswords.asm	Include in a project to program the code security module passwords and reserved locations.

8.2.4 Example Linker .cmd files

Example memory linker command files are located in the *DSP2803x_common\cmd* directory. For getting started the basic 28035_RAM_lnk.cmd file is suggested and used by many of the included examples.

The L0 SARAM block is mirrored on these devices. For simplicity these memory maps only include one instance of these memory blocks.

Table 21. Included Main Linker Command Files

Memory Linker Command File Examples	Location	Description
28035_RAM_lnk.cmd	DSP2803x_common\cmd	28035 memory linker command file. Includes all of the internal SARAM blocks on a 28035 device. “RAM” linker files do not include flash or OTP blocks.
28034_RAM_lnk.cmd	DSP2803x_common\cmd	28034 SARAM memory linker command file.
28033_RAM_lnk.cmd	DSP2803x_common\cmd	28033 SARAM memory linker command file.
28032_RAM_lnk.cmd	DSP2803x_common\cmd	28032 SARAM memory linker command file.
28031_RAM_lnk.cmd	DSP2803x_common\cmd	28031 SARAM memory linker command file.
28030_RAM_lnk.cmd	DSP2803x_common\cmd	28030 SARAM memory linker command file.
28035_RAM_CLA_lnk.cmd	DSP2803x_common\cmd	28035 CLA memory linker command file. Includes CLA message RAM
28033_RAM_CLA_lnk.cmd	DSP2803x_common\cmd	28033 SARAM CLA memory linker command file.
F28035.cmd	DSP2803x_common\cmd	F28035 memory linker command file.
F28034.cmd	DSP2803x_common\cmd	F28034 memory linker command file.

F28033.cmd	DSP2803x_common\cmd	F28033 memory linker command file.
F28032.cmd	DSP2803x_common\cmd	F28032 memory linker command file.
F28031.cmd	DSP2803x_common\cmd	F28031 memory linker command file.
F28030.cmd	DSP2803x_common\cmd	F28030 memory linker command file.

8.2.5 Example Library .lib Files

Example library files are located in the *DSP2803x_common\lib* directory. For this release the IQMath library is included for use in the example projects. Please refer to the *C28x IQMath Library - A Virtual Floating Point Engine (*SPRC087) for more information on IQMath and the most recent IQMath library. The SFO libraries are also included for use in the example projects. Please refer to *TMS320x2802x, 2803x HRPWM Reference Guide (*SPRUGE8) for more information on SFO library usage and the HRPWM module.

Table 22. Included Library Files

Main Liner Command File Examples	Description
IQmath.lib	Please refer to the *C28x IQMath Library - A Virtual Floating Point Engine (*SPRC087) for more information on IQMath. This is a fixed-point compiled library.
IQmathLib.h	IQMath header file.
SFO_TI_Build_V6.lib	Please refer to the *TMS320x2802x, 2803x HRPWM Reference Guide* (SPRUGE8) for more information on the SFO V6 library. Requires user code to update HRMSTEP register with MEP_ScaleFactor value.
SFO_TI_Build_V6b.lib	Same as v6 lib file, but now automatically updates HRMSTEP register with MEP_ScaleFactor value.
SFO_V6.h	SFO V6 header file

9 Detailed Revision History:

Changes from V1.10 to V1.20

Changes to Header Files:

a) **DSP2803x_Adc.h –** Fixed error – in structure, under ADCCTL2, changed rsvd1 to 2 words wide instead of 3 words wide

Changes to Common Files:

a) **DSP2803x_Cla_defines.h-** Increase repeated NOP's from 2 to 3.

b) **All gel files-** update OnFileLoaded() function to call Device_Cal only if symbols are not being loaded.

Changes from V1.10 to V1.20

Changes to Header Files:

b) **DSP2803x_SysCtrl.h –** Added SysPwrCtrlRegs structure with BORCFG register.

c) **DSP2803x_DevEmu.h –** Removed BORCFG register (does not belong in this space).

d) **DSP2803x_Headers_BIOS.cmd/DSP2803x_Headers_nonBIOS.cmd** – Added SysPwrCtrlRegs to 0x985-0x987, and reduced DevEmuRegs to 0x880-0x984.

e) **DSP2803x_GlobalVariableDefs.c-** Added SysPwrCtrlRegs declaration.

f) **DSP2803x_Adc.c-** Added changes to be implemented in Rev. A silicon (documented in ADC reference guide. Not implemented in Rev. 0 silicon). Added ONESHOT bit to SOCPRICTL register and added ADCCTL2 register. Also added API functions for re-calibrating ADC offset.

g) **DSP2803x_Device.h-** Removed RSH package references.

Changes to Common Files:

c) **DSP2803x_Cla_defines.h-** Increase repeated NOP's from 2 to 3.

d) **F28031.cmd, F28030.cmd, 28031_RAM_lnk.cmd, 28030_RAM_lnk.cmd –** Added these files for the new 28031 and 28030 devices.

e) **28031.gel and 28030.gel-** Added gel files for 28031 and 28030 devices.

f) **All 2803x gel files-** Change comment references to "2802x" to "2803x". Correct MemoryFill function so that it properly fills L3 memory with ESTOP. Fixed Bypass() function so that PLLCR=0 prior to DIVSEL = divide by 1. In CCSv3.3 version of gel files, in Watch Emulation Registers function, changed PARTID address to 0x3d7e80. Added BORCFG register (address 0x985). In CCSv4 version of gel files – removed note about Watch FPU registers in OnPreFileLoaded() function, removed "Peripherals.gel" reference, and fixed Gel_Toolbar5() function for CCSv4 use.

g) **DSP2803x_Examples.h-** Removed RSH package references.

h) **DSP2803x_OscComp.c –** Adds functions required for internal oscillator frequency compensation over temperature. The file is added to the /DSP2803x_common/source/ directory. Also added document in /doc directory explaining various functions defined in this file.

i) **DSP2803x_TempSensorConv.c-** Adds functions required for ADC temp sensor to convert digital ADC samples to Kelvin and Celsius temperature value. The file is added to the /DSP2803x_common/source/ directory.

j) **DSP2803x_GlobalPrototypes.h** – Added function prototypes from DSP2803x_Adc.c, DSP2803x_OscComp.c and DSP2803x_TempSensorConv.c files.

k) **DSP2803x_SysCtrl.c-** Added "EALLOW" for XtalOscSel and ExtOscSel functions so the bit settings take effect when calling these functions.

l) **DSP2803x_Comp.c –** Fixed typo in comments referring to SDAA and SCLA operation – changed this to CMP1OUT and CMP2OUT.

m) **DSP2803x_Epwm.c –** Fixed typo in comments such that GPIO3 refers to EPWM2B and not EPWM3B.

n) **SFO_TI_Build_V6.lib (SFO_TI_Build_V6b.lib) –** Original SFO_TI_Build_V6.lib did not automatically write the MEP_ScaleFactor into the HRMSTEP register. SFO_TI_Build_V6b.lib now updates the HRMSTEP register with the MEP_ScaleFactor value automatically. Additionally, added an errata document to the /doc directory explaining the difference.

o) **DSP2803x_ECan.c-** Removed ambiguous statement in comment concerning shadow register structure.

p) **28032_RAM_CLA_lnk.cmd and 28034_RAM_CLA_lnk.cmd-** Removed these files – there is no CLA module on these devices.

Changes to Example Files:

a) **Example_2803xHRPWM_Duty_SFO_V6.c-** Changed temp to 32-bit unsigned integer. Corrected equations so rounding is correct when AUTOCONV=0. Changed *ePWM array of structs to include only 4 ePWM's.

b) **Example_2803xHRPWM_PrdUp_SFO_V6.c-** Changed *ePWM array of structs to include only 4 ePWM's.

c) **Example_2803xHRPWM_PrdUpDown-** Changed *ePWM array of structs to include only 4 ePWM's.

d) **All CCSv4 example .cdtbuild Files-** Replaced any hardcoded references to "C:/tidcs/c28/DSP2803x/<version>" for OBJ and ASM directories and replaced with "${INSTALLROOT_2803X_<version>}" macro. This did not affect CCSv4 project build in previous version, but improves portability.

e) **Example_28030_Flash/Example_28031_Flash-** Added PJT and GEL files in the CCSv3.3 DSP2803x_examples/flash/ directory.

Changes from V1.01 to V1.10

Changes to Header Files:

h) **DSP2803x_Gpio.h** –Removed GPBPUD register structure from GPBDAT register definition.

i) **DSP2803x_DevEmu.h-** Added BORCFG register.

Changes to Common Files:

q) **SFO_TI_Build_V6.lib and SFO_V6.h** – SFO library updated to generate error code of "2" when MEP_ScaleFactor>255 (previously returned "2" for MEP_ScaleFactor>254). Additionally, the library now only updates the HRMSTEP register used for auto-conversion with the calibrated MEP_ScaleFactor if MEP_ScaleFactor<=255. Otherwise it will use the last "good" value written to HRMSTEP for auto-conversions (previously, if the MEP_ScaleFactor>255, auto-conversion could not be used).

r) **F28035.gel and F28033.gel** – Adjusted certain CLA registers which are 32-bits instead of 16-bits.

s) **All device gel files-** Added 0xD00-0xE00 to Page 0 memory map (specifically to allow CCStudio to access these memories when using DSP/BIOS)

t) **CCSv4 gel files –** Added ccsv4 directory in /gel directory for CCSv4-specific device gel files (GEL_WatchAdd() functions removed).

u) **DSP2802x_CpuTimers.c –** Corrected note that DSP/BIOS reserved CpuTimer2 only and user must comment out CpuTimer2 code when using DSP/BIOS. CpuTimer0 and 1 have no such restriction.

Changes to Example Files:

a) **All PJT Files-** Removed the line: Tool="DspBiosBuilder" from all example PJT files for easy migration path to CCSv4 Microcontroller-only (code-size limited) version users.

b) **Added Example_2803xClaAdcFir.c and flash version of same example-** Added new CLA ADC examples.

c) **Updated CLA.asm file for cla_adc example**- Updated to better match CLA_FIR.asm in new CLA examples (i.e. Cla1T1End instead of ClaT1End).

d) **Example_2803xLPMHaltWake.c** – Updated description comments for wakeup.

e) **Example_2803xLEDBlink-** Removed FPU build options.

f) **Example_2803xSpi_FFDLB_int.c-** Changed FIFO level to 2 (while receiving/interrupting on 2 words, there are 2 remaining FIFO spaces for continuous receiving).

g) **Example_2803xSci_FFDLB_int.c-** Changed FIFO level to 2 (while receiving/interrupting on 2 words, there are 2 remaining FIFO spaces for continuous receiving).

h) **Added DSP2803x_examples_ccsv4 directories** - Added directories for CCSv4.x projects. The example projects in these directories are identical to those found in the normal CCSv3.x DSP2803x_examples directory with the exception that the examples now support the Code Composer Studio v4.x project folder format instead of the Code Composer Studio v3.x PJT files. The example gel files have also been removed for the CCSv4 example projects because the gel file functions used in the example gels are no longer supported.

Changes from V1.00 to V1.01

Changes to Header Files:

v) **DSP2803x_Lin.h** – Corrected comments, removed bits that do not exist in design, and renamed other bits per function.

Changes to Common Files:

w) **DSP2803x_PieVect.c** – Corrected comments pertaining to ADCINT1 and ADCINT2

x) **DSP2803x_Lina.c** – Added initialization function for LIN-A.

y) **DSP2803x_GlobalPrototypes.h** – Added prototypes for LIN from DSP2803x_Lina.c

Changes to Example Files:

a) **Example_2803xAdcTempSensor**– Added one ADC temperature sensor example in adc_temp_sensor directory.

b) **Example_2803xLina_EXALB** – Added LIN-A external analog loopback example in lina_external_loopback directory.

c) **Example_2803xLin_Sci_Echoback**- Added LIN-A SCI echoback example in lina_sci_echoback directory.

d) **Example_2803xLinSci_DLB_int** – Changed SCIGCR1.bit.CLOCK to SCIGCR1.bit.CLK_MASTER to match new bit name defined in DSP2803x_Lin.h

V1.00

- This version is the first release (packaged with development tools and customer trainings) of the DSP2803x header files and examples.

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