

# IEC60730 DSC Example v4.1



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# Chapter 1

## Introduction

The IEC60730 v4.1 package for DSCs contains example projects for MC56F81768 (MC56F81000-EVK board) and MC56F83789 (FRDM-MC56F83000 board). These projects are built using the CodeWarrior for MCU IDE v11.1. If your toolchain is not ready yet, install it according to the instructions in the following chapter.

### 1.1 Installing the toolchain

Find the web pages for your development board (for example MC56F81000-EVK) and click the getting started user's guide document in the "Documents" section (see [Support](#)). The "Get Software" section contains all the necessary steps to set up the toolchain.

# Chapter 2

## Hardware setup

With the `safety_iec60730b` example, the default hardware configuration uses an external PE-Micro Multilink debugger. For other hardware configuration possibilities, see the web pages for the respective development board.

### 2.1 MC56F81000-EVK HW setup



Figure 1. MC56F81000-EVK development board configured for an external debug probe

- external Multilink for loading and debugging
- Micro USB -J26- for power supply and serial port communication (Silicon Labs CP210x USB to UART Bridge) !! DRIVER INSTALLATION FROM INTERNET MAY BE NEEDED !!
- default UART baud rate: 115200

Default connections for ADC test:

- GPIO pin A4 configured as ANA4 channel, connected to 4th pin of J4 connector. Use a wire to connect to VDD voltage, for example 8th pin of J3 connector
- GPIO pin A5 configured as ANA5 channel, connected to 6th pin of J4 connector. Use a wire to connect to GND, for example 12th pin of J3 connector

## 2.2 FRDM-56F83000 hardware setup

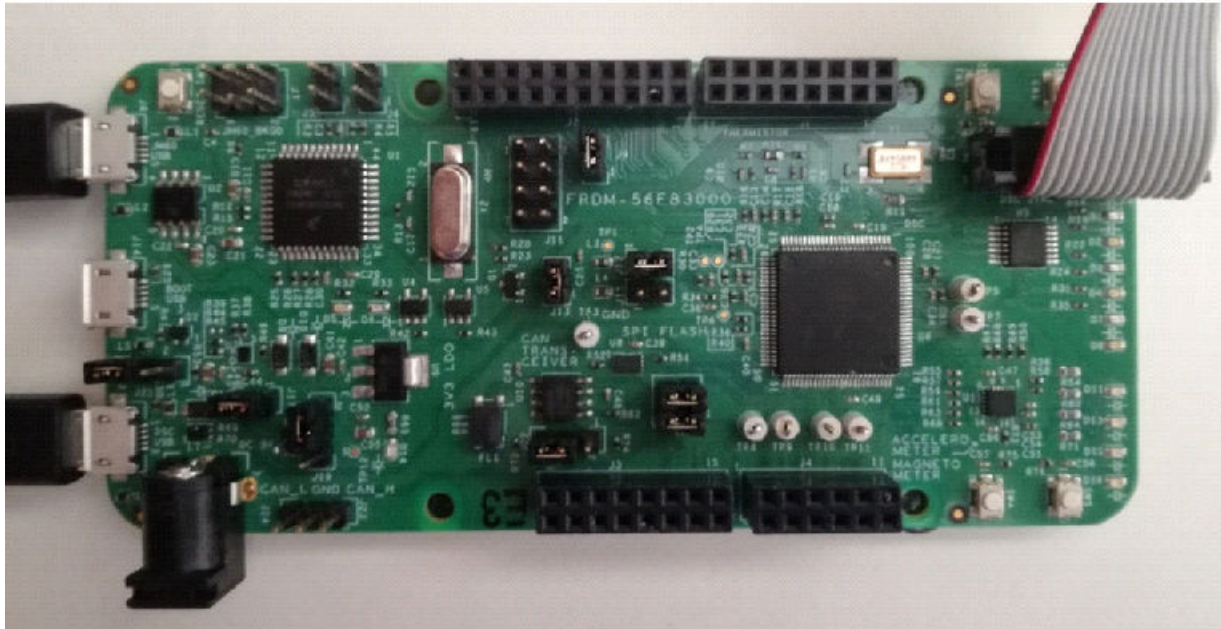


Figure 2. FRDM-MC56F83000 development board configured for an external debug probe

- External Multilink for loading and debugging
- Micro-USB J21 for the power supply
- Default UART baud rate of 115200
- Micro-USB J8 for the serial port communication

The default connections for the ADC test are as follows:

- The GPIO pin A4 is configured as the ANA4 channel, connected to the 4<sup>th</sup> pin of connector J4. Use a wire to connect the VDD voltage, for example the 8<sup>th</sup> pin of connector J3.
- The GPIO pin A5 is configured as the ANA5 channel, connected to the 6<sup>th</sup> pin of connector J4. Use a wire to connect the GND, for example the 12<sup>th</sup> pin of connector J3.

## Chapter 3

# Opening the project

When the toolchain is prepared, add the project from the downloaded package into your workspace. Click on the “import project” icon in the commander menu and then the “Browse” option in the “Select root directory” list. Navigate to the downloaded and unpacked folder. Go to the “boards/your board” file and click the “OK” button. The example project for the selected board shall appear in the “Projects” window.

Leave the “Copy projects into workspace” and “Add project to working sets” options unchecked and click the “Finish” button.

Now the "safety\_iec60730b : flash\_Idm\_lpm\_debug" project appears in the "Projects" window in your workspace. After building the project, the *safety\_iec60730.elf* binary file is created and the project is ready to be loaded into your device.

# Chapter 4

## Project files structure

The example project is a simple application which demonstrates the use of IEC60730 safety tests. The *main.c* file is a central file with the initialization (after-reset) and runtime parts. The runtime part consists of an endless loop (background) and a periodical interrupt routine. All these project parts are used to call safety test routines or their handling functions, respectively.

### 4.1 Files engaged in safety tests

*safety\_config.h* – header file with general configurations for safety tests and the application.

*main.c* – central file, contains references from the linker file, global variables definition, and software loops

*safety\_dsc.c* – handling functions for the safety tests; contains references from the linker and global variables' definitions

*safety\_dsc.h* – header file for the *safety\_dsc.c* file

*IEC60730\_DSC\_Class\_B\_CW\_v4.1.lib* – precompiled binary file with the IEC60730 Class B tests

*safety/...* – folder with library header files and the remaining source files

*project\_setup\_mcXXXXXX.c* – configuration of peripherals that are related to the safety tests

*project\_setup\_mcXXXXXX.h* – header file for the *project\_setup\_mcXXXXXX.c* file

*safety\_test\_items.c* – configuration of the GPIO pins used for the digital input/output tests

*safety\_test\_items.h* – header file for the *safety\_test\_items.c* file

*MCXXXXXXXXX\_Internal\_PFlash\_LDM.cmd* – linker configuration file

# Chapter 5

## Project configuration

For a basic setup, use the *safety\_config.h* file. When starting, turn off the watchdog test and also the watchdog itself. To do so, make sure that the WATCHDOG\_ENABLED and WATCHDOG\_TEST\_ON macros are not defined. It is recommended to leave the SAFETY\_ERROR\_ACTION macro value at zero. Otherwise, if any safety tests recognize an error, it is most probably due to incorrect setup and the software becomes stuck in an endless loop.

### 5.1 Linker configuration

Some of the key project configurations are made in the CMD file.

#### NOTE

The names of the symbols from the CMD file that are referenced in the application start with a capital "F" letter. In the application code, they are referenced without the "F" letter.

#### 5.1.1 Placing variables into a dedicated section

Placing the selected variables into a specific section in RAM can look as follows:

- In the CMD file, place a definition of your own section into the field that specifies the RAM area:

```
F_safety_ram = .;
* (.safety_ram.data)
. = ALIGN(4);
F_end_safety_ram = .;
```

- Reference and fill the section in the application code:

```
#pragma define_section safety_ram ".safety_ram.data" RW
#pragma section safety_ram begin
cop_test_t g_sSafetyCopTest;
crc_config_t sCrcConfig;
safety_common_t g_sSafetyCommon;
fs_clock_test_t g_sSafetyClockTest;
#pragma section safety_ram end
```

#### 5.1.2 Placing a linkable object into RO memory

In this case, this technique is used for the Program Counter test. It is necessary to choose a valid, available, and accessible part of memory, where the linkable object file will be placed and recognized by the application.

- Define and place the section using the CMD file:

```
PC_test_address_1 = 0x05555;
...
PC_test_address_1 = .;
*(.pc_test_1.text)
```

This definition allows for a specific placement of the *iec60730b\_dsc\_pc\_object1.c* file. The same approach is repeated for the *iec60730b\_dsc\_pc\_object2.c* file.



### 5.1.3 Calculating CRC of specified part of binary file before loading into device

This is a very useful feature, widely used in safety-related applications. The CodeWarrior linker allows you to configure such calculation in the CMD file.

```
Fstart_text = . ;           # calculate CRC from ...
...
Fend_text = . ;           # ... calculate CRC to
Fg_crc_linker = CRC16(Fstart_text, Fend_text, 0x1021);
```

*Fstart\_text* and *Fend\_text* bind the area for which the CRC is calculated.

The reference in the application code is as follows:

```
extern __pmem CRC16_record g_crc_linker;
extern uint32_t start_text;
extern uint32_t end_text;
```

### 5.1.4 Stack overflow and underflow test

The stack overflow and underflow test is a part of the safety library. It is an additional test that watches the application stack for the overflow and underflow situations.

In the CMD file, an optionally wide test area is defined below and above the stack.

```
_min_stack_size = 0x00000100;
F_stack_test_block_size = 0x8;
F_stack_test_p_1      = _HEAP_END + 1;
F_stack_test_p_2      = F_stack_test_p_1 + F_stack_test_block_size;
. = F_stack_test_p_2;
. = ALIGN(4);
_stack_addr = . + 1;
....
. = _stack_end;
F_stack_test_p_3      = _stack_end + 1;
F_stack_test_p_4      = F_stack_test_p_3 + F_stack_test_block_size;
. = F_stack_test_p_4 + 1;
```

The symbols are then referenced in the application code.

```
extern uint16_t _stack_test_p_2; /* symbol from Linker command file */
extern uint16_t _stack_test_p_3; /* symbol from Linker command file */
```

These are the basic linker configurations that are used in the "safety\_iec60730b" example project. For more information see the library user's guide.

## 5.2 MCUXpresso configuration tool

The example project is compatible with the MCUXpresso configuration tool. The setup of pins and clocks was done using this tool. The configuration MEX file is in the project folder. For more information, see the MCUXpresso configuration tool pages.

# Chapter 6

## Loading project into device and debugging

When the project is ready and the binary ELF file is built, you can load the software into the device. Click "Run->Debug Configurations" and choose the most suitable configuration from the left-hand side window. In our case, it is "\*\*\*\*flash\_idm\_lpm\_debug\_PnE U-MultiLink". Then click the "Debug" icon. To become more familiar with the example project, standard debugging features can be used. If the watchdog test is enabled (WATCHDOG\_TEST\_ON is defined), the watchdog resets the processor and the debugger loses the connection. When debugging, the watchdog test must be disabled.

### 6.1 FreeMASTER monitoring

Download and install FreeMASTER v3.x from [www.nxp.com/freemaster](http://www.nxp.com/freemaster).

For a correct hardware setup, see [Hardware setup](#).

Open the *safety\_iec60730b.pmpx* file from the project folder.

- Set the correct port and speed in "Project->Options->Comm", under "RS232".
- Check if the correct ELF file is selected in "Project->Options->MAP Files". See [Figure 3](#).

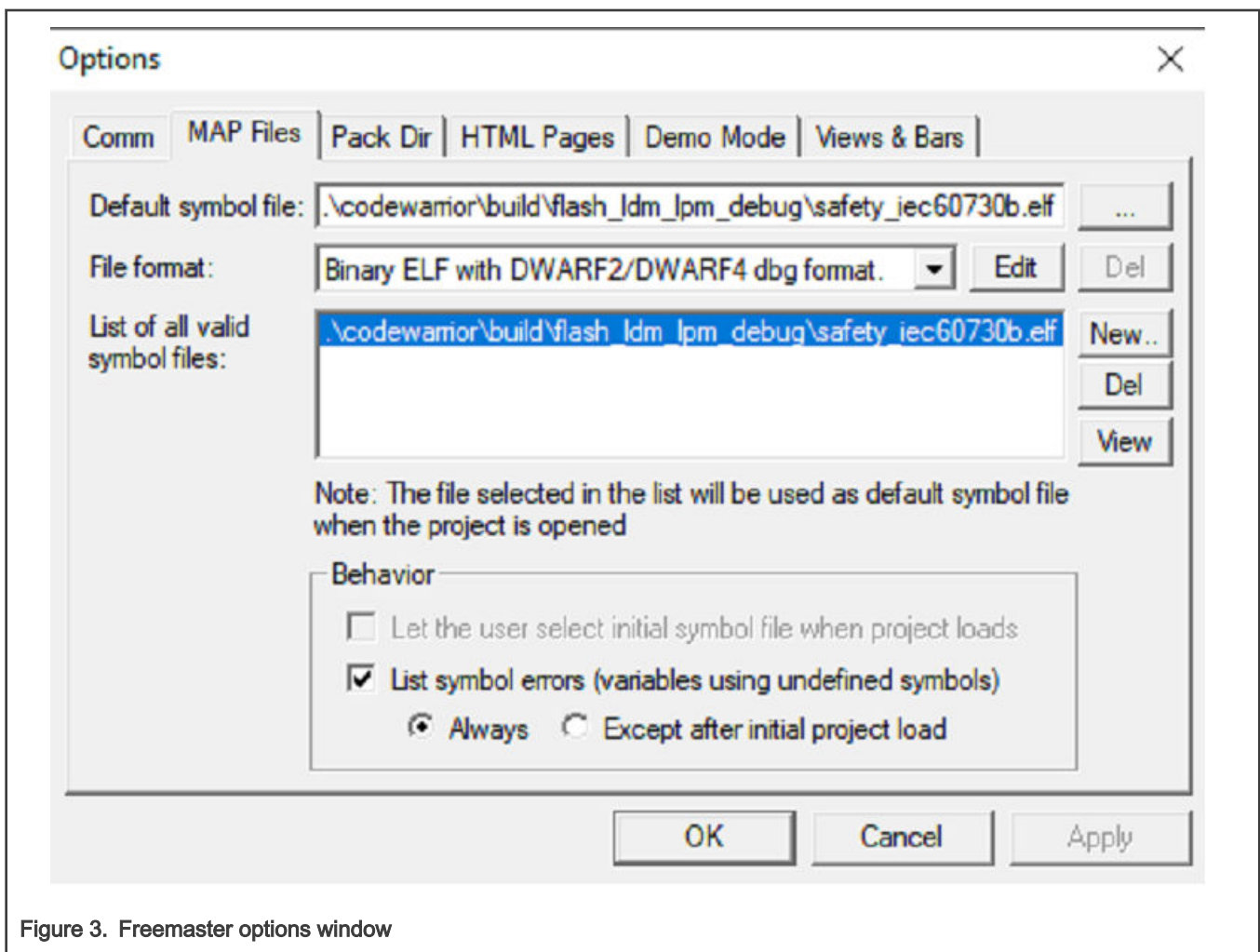


Figure 3. Freemaster options window

- Click the "OK" button and then the green "GO!" button.

In the "Variable Watch" window, you shall see some variables with their values.

To add or remove monitored variables, click "Project->Variables->Generate" and select the variables to be added to the "Watch" window.

Move the mouse cursor anywhere into the "Variable Watch" window, right click, and select "Watch properties". By moving from the "Available variables" window to the "Watched variables" window, the desired variables become monitored.

# Chapter 7

## Support

1. Main pages about the IEC60730 safety test routines <https://nxp.com/iec60730>
2. MC56F81000-EVK evaluation board <https://www.nxp.com/design/software/development-software/development-board-for-mc56f81xxx-digital-signal-controllers:MC56F81000-EVK>
3. MC56F83000-EVK evaluation board <https://www.nxp.com/design/development-boards/freedom-development-boards/mcu-boards/development-board-for-mc56f83xxx-digital-signal-controllers:MC56F83000-EVK>
4. CodeWarrior IDE development tools [https://www.nxp.com/design/software/development-software/codewarrior-development-tools:CW\\_HOME](https://www.nxp.com/design/software/development-software/codewarrior-development-tools:CW_HOME)
5. FreeMASTER visualization tool <https://nxp.com/freemaster>
6. MCUXpresso configuration tools <https://www.nxp.com/design/software/development-software/mcuxpresso-software-and-tools-/mcuxpresso-config-tools-pins-clocks-peripherals:MCUXpresso-Config-Tools>
7. NXP Community; if you have not found the answer to your question <https://community.nxp.com/>

# Chapter 8

## Revision history

Table 1. Revision history

Revision number	Date	Substantive changes
0	03/2021	Initial release

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