# AN11161

## Using the SCT in LPCXpresso, Keil, and IAR

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**Document information**

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| **Abstract** | This document details the procedure for taking SCT code generated in the LPCXpresso IDE, and incorporating it into the Keil and IAR IDEs. |

### Revision history

| Rev | Date | Description |
|---|---|---|
| 1 | 20120419 | Initial version. |

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# 1. Introduction

## 1.1 SCT overview

The State Configurable Time (SCT) is a general purpose peripheral containing the following features:

- Two 16-bit counters or one 32-bit counter
- Counter(s) clocked by bus clock or selected input
- Up counter(s) or up-down counter(s)
- State variable allows sequencing across multiple counter cycles
- Events can be defined by a counter match condition, an input (or output) condition, a combination of a match and/or and input/output condition in a specified state
- Events control outputs, interrupts, and DMA requests
- Selected event(s) can limit, halt, start, or stop a counter
- Supports:
  - 8 inputs
  - 16 outputs
  - 16 match/capture registers
  - 16 events
  - 32 states

The State Configurable Timer (SCT) allows a wide variety of timing, counting, output modulation, and input capture operations.

The most basic user-programmable option is whether an SCT operates as two 16-bit counters or a unified 32-bit counter. In the two-counter case, in addition to the counter value the following operational elements are independent for each half:

- State variable
- Limit, halt, stop, and start conditions
- Values of Match/Capture registers, plus reload or capture control values
- In the two-counter case, the following operational elements are global to the SCT, but events, outputs, interrupts, and DMA requests can use match conditions from either counter:
- Clock selection
- Inputs
- Events
- Outputs
- Interrupts
- DMA requests

Fig 1 shows the SCT block diagram.

 

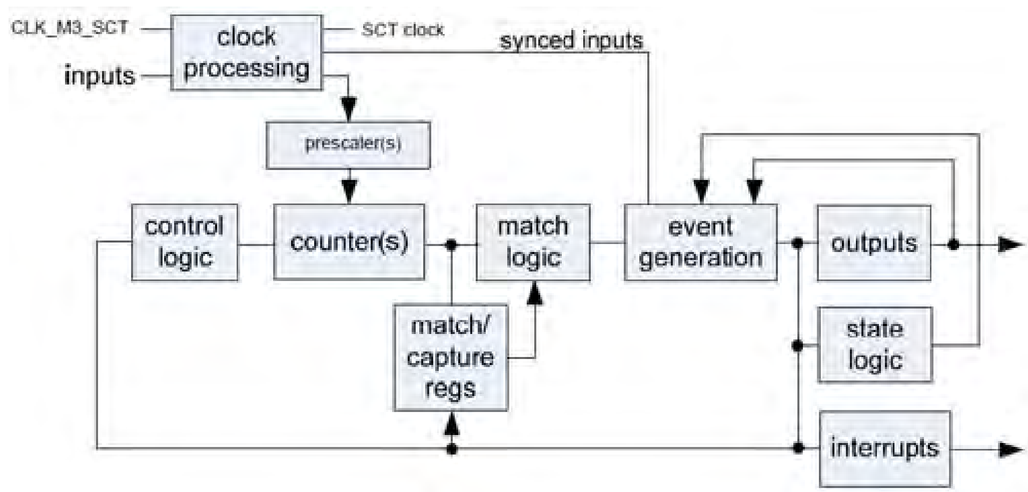


**Fig 1. SCT block diagram**

## 1.2 SCT general description

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- Events
- Outputs
- Interrupts
- DMA requests

### 1.2.1 Using the SCT in Keil and IAR tools

LPCXpresso incorporates a graphical tool for designing state machines and can generate the code required to implement the SCT. This application note will describe a process to use the code generated by LPCXpresso to add SCT functionality into Keil and IAR IDEs.

# 2. SCT project description

## 2.1 Project description

This application note assumes that the reader is familiar with the basic functionality of the SCT peripheral. For those readers needing a better understanding of the SCT peripheral, they should read the LPC18XX or LPC43XX User Manuals.

The example we are going to use is a modified version of the Blinky project found in the Getting Started with Red State manual included with LPCXpresso/Red Suite v4.1 and newer versions.

The examples included in this app note are based on LPC1850 Rev A silicon assembled on a Hitex Rev A4 evaluation board.

The state machine example toggles three RGB LEDs sequentially, with the direction determined by an input signal. The outputs of the SCT, named LED_GREEN, LED_RED, and LED_BLUE are used to drive the LEDs for visual confirmation of the state machine functionality.  An input named DOWN is used to change the direction of the output sequence, and input RESET is used to force all outputs low, turning off the LEDs. The RESET input signal is configured as active low, with an internal pull-up.

The state diagram for the project is shown in Fig 2.

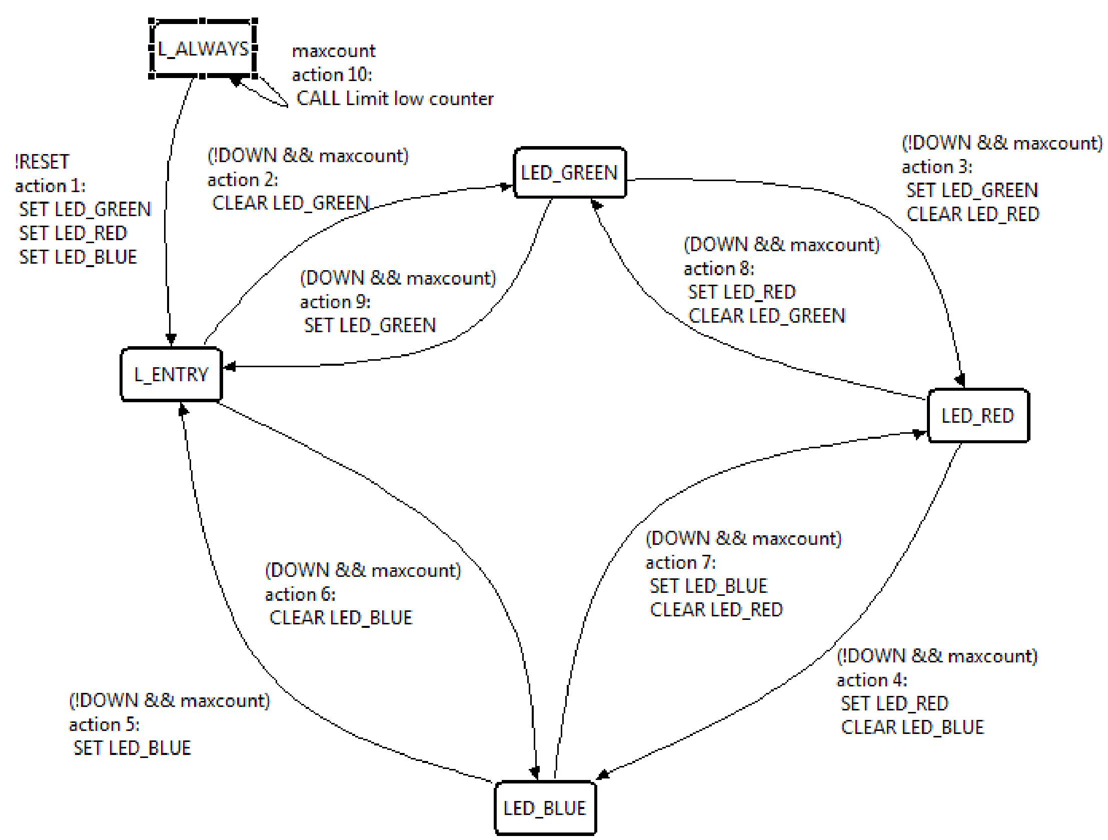



**Fig 2. RGB blinky state machine**

# 3. LPCXpresso / Red State Tool

## 3.1 Importing the example into LPCXpresso

The zip file accompanying this application note contains a folder containing the LPCXpresso project. The project is imported into the LPCXpresso IDE by selecting “Import existing projects” in the QuickStart panel, as shown in Fig 3.

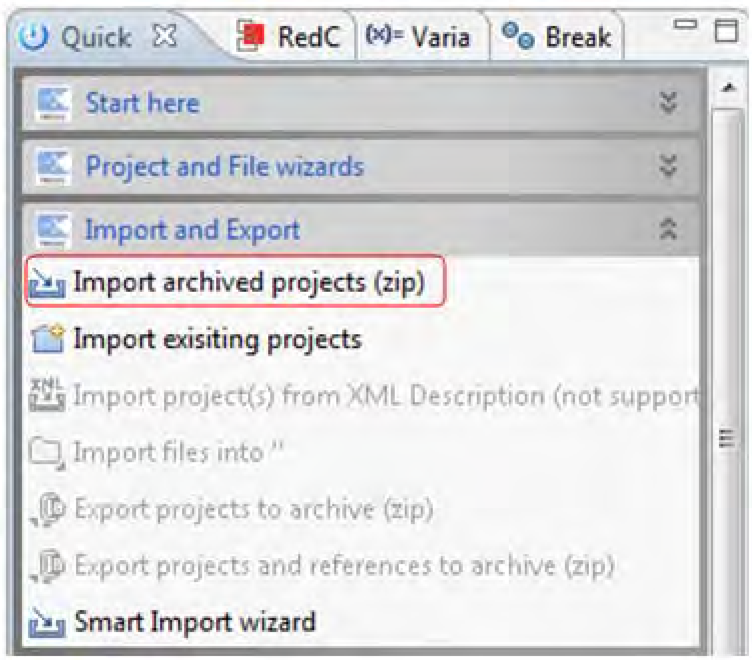



**Fig 3. Importing project into LPCXpresso**

After selecting “Import existing projects”, press the Browse button and then select the archived project named “Hitex_SCT_Blinky.zip”. This file contains two files as shown in Fig 4. After importing the zip file, press the Finish button.

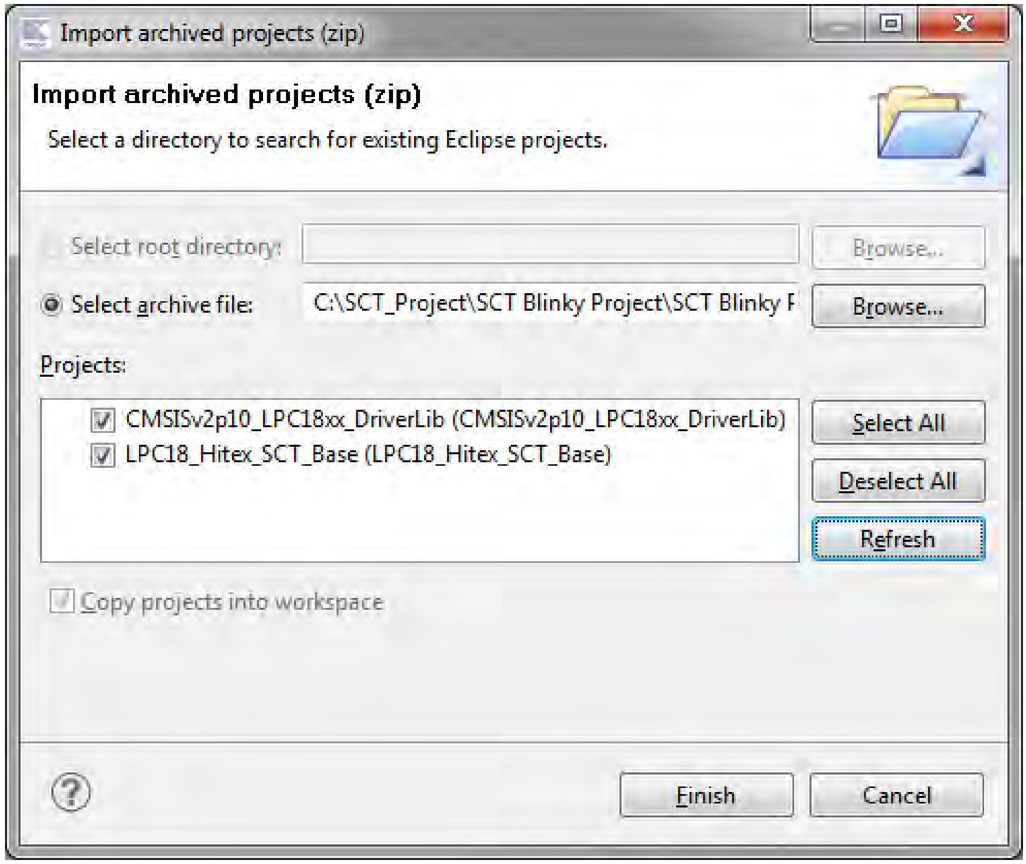
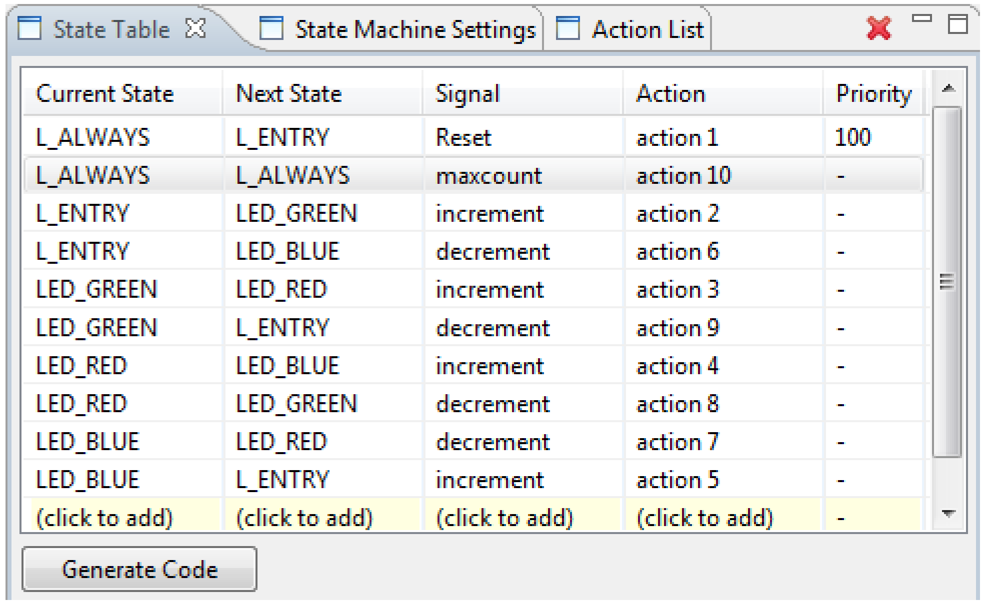



**Fig 4. Import archived projects (zip)**

## 3.2 Running the SCT project in LPCXpresso

The SCT diagram is found in the blinky.rsm file. After completing the diagram, the code is generated by pressing the Generate Code button, as shown in Fig 5. **Note that any changes made to the state machine require you to regenerate the code by pressing the Generate Code button. Building the project does not make any changes to the SCT specific files.**




| Current State | Next State | Signal | Action | Priority |
|---|---|---|---|---|
| L_ALWAYS | L_ENTRY | Reset | action 1 | 100 |
| L_ALWAYS | L_ALWAYS | maxcount | action 10 | - |
| L_ENTRY | LED_GREEN | increment | action 2 | - |
| L_ENTRY | LED_BLUE | decrement | action 6 | - |
| LED_GREEN | LED_RED | increment | action 3 | - |
| LED_GREEN | L_ENTRY | decrement | action 9 | - |
| LED_RED | LED_BLUE | increment | action 4 | - |
| LED_RED | LED_GREEN | decrement | action 8 | - |
| LED_BLUE | LED_RED | decrement | action 7 | - |
| LED_BLUE | L_ENTRY | increment | action 5 | - |
| (click to add) | (click to add) | (click to add) | (click to add) | - |

**Fig 5. Generate code button**

The sct_main.c file shows you where the inputs and outputs have been routed.

For the Hitex board:

```
* Signal   Port   Signal     Connector
* ----------------------------------------------------------------
* CTIN0    PD_13  DOWN       X19-1 or JP29-1
* CTIN1    PD_10  RESET      X19-2 or JP34-1
*
* CTOUT2   PE_6   LED_GREEN   -
* CTOUT3   PE_5   LED_RED     -
* CTOUT4   PE_8   LED_BLUE    -
* ----------------------------------------------------------------
```

The SCT input/output mapping may also be found with the LPCXpresso Red State installation. This document is titled “SCT_PortMapping.pdf”.

## 3.3 Completed Red State project

After completing the Red State example project, you will see the files shown in Fig 6. Four of the files from this project will need to be copied to your new Keil or IAR project:

- sct_main.c
- sct_fsm.c
- sct_fsm.h
- sct_user.h

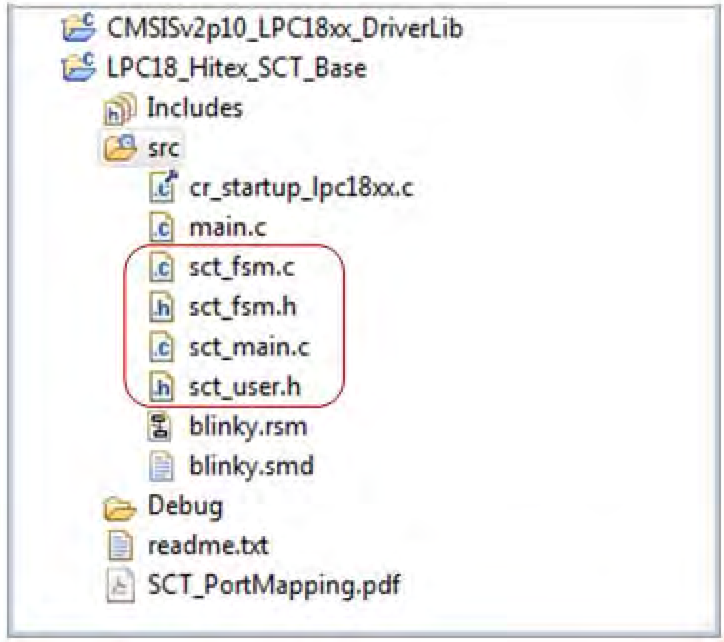



**Fig 6. Files generated by Red State**

You should always keep a copy of the LPCXpresso project, since any changes you want to make to the SCT operation will require you to generate the code in LPCXpresso again.

# 4. Completing the SCT project in the Keil IDE

## 4.1 Minimal Keil project

Fig 7 shows a minimal project that you should have in your project before you add the SCT files. This minimal project can be created using any of the example projects found in the CMSIS-Compliant Standard Peripheral Firmware Driver Library. This library can be found at: http://www.lpcware.com/file_filter/nxpf/lpc18xx

Your project may look different, depending what other modules you have included in the project.

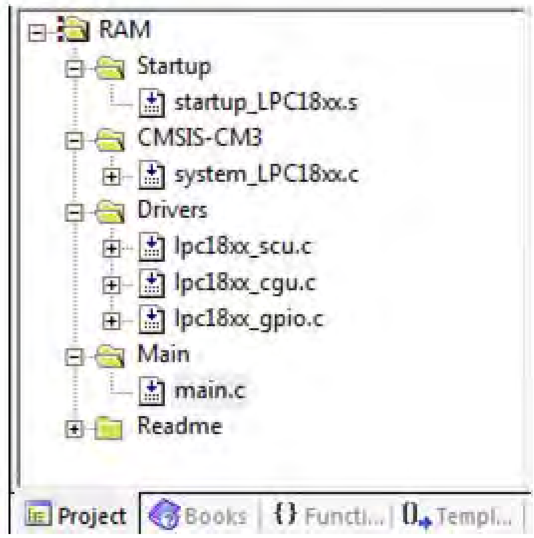



**Fig 7. Minimal Keil project**

## 4.2 Keil project with SCT files included

After copying the four files into the Keil project directory, we added a new group called SCT to the Project Explorer so that it should now look similar to Fig 8. The sct_fsm.c and sct_main.c files can be added to this group.

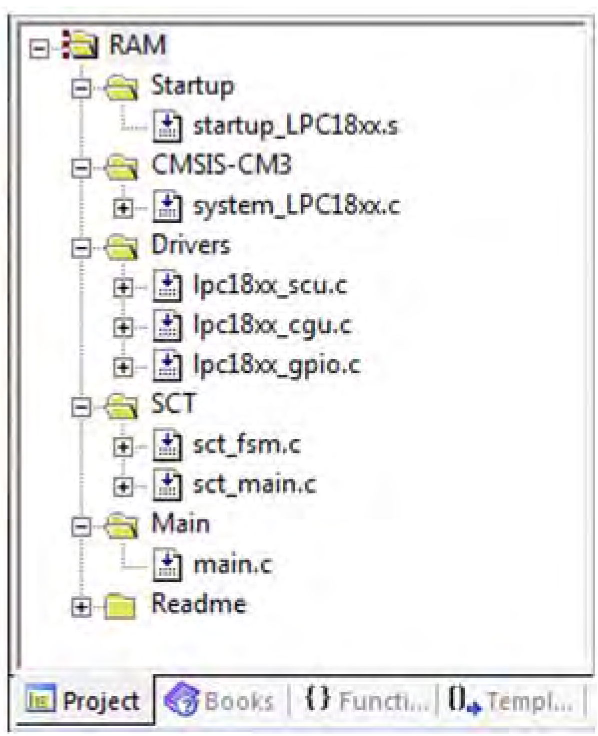



**Fig 8. Keil project with SCT files added**

### 4.3 Completing the Keil project

At this point, you should be able to build and run the project.

## 5. Completing the SCT project in the IAR IDE

### 5.1 Minimal IAR project

Fig 9 shows a minimal project that you should have in your Workspace before you add the SCT files. This minimal project can be created using any of the example projects found in the CMSIS-Compliant Standard Peripheral Firmware Driver Library. This library can be found at http://www.lpcware.com/file_filter/nxpf/lpc18xx

Your project may look different, depending what other modules you have included in the project.

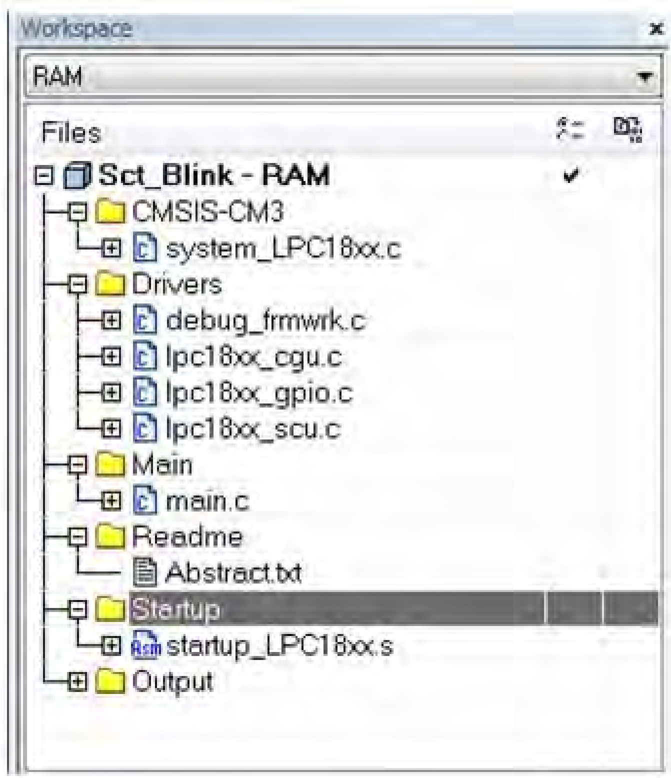



**Fig 9. Minimal IAR project**

### 5.2 IAR Project with SCT files included

After copying the four files into the IAR project directory, we added a new group called SCT to the Workspace so that it should now look similar to Fig 10.

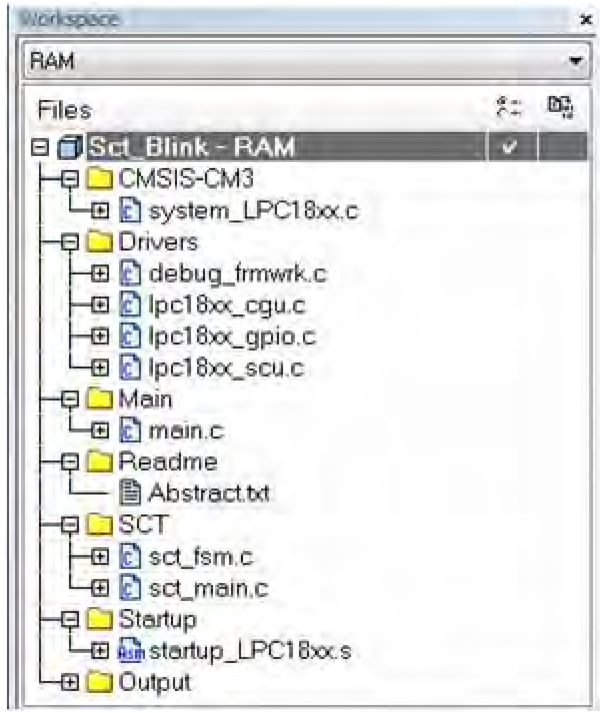



Fig 10. IAR project with SCT files added

## 5.3 Completing the IAR project

After adding the SCT files into the project, you can build and run the code.

# 6. Output waveforms

Fig 11 and Fig 12 show the output from the SCT when the example project is built and run.

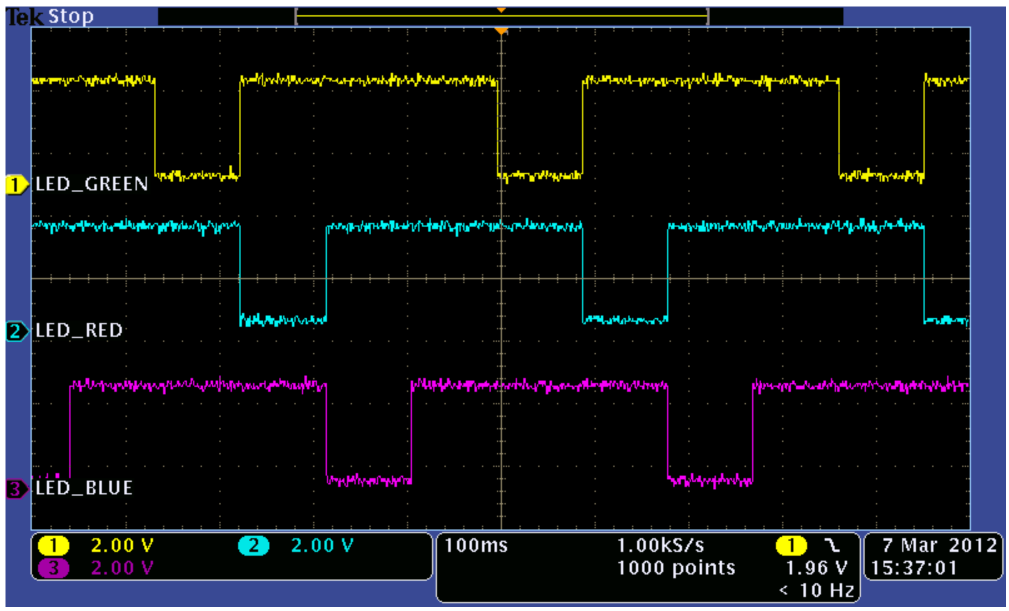



Fig 11. Output waveforms with DOWN = 0

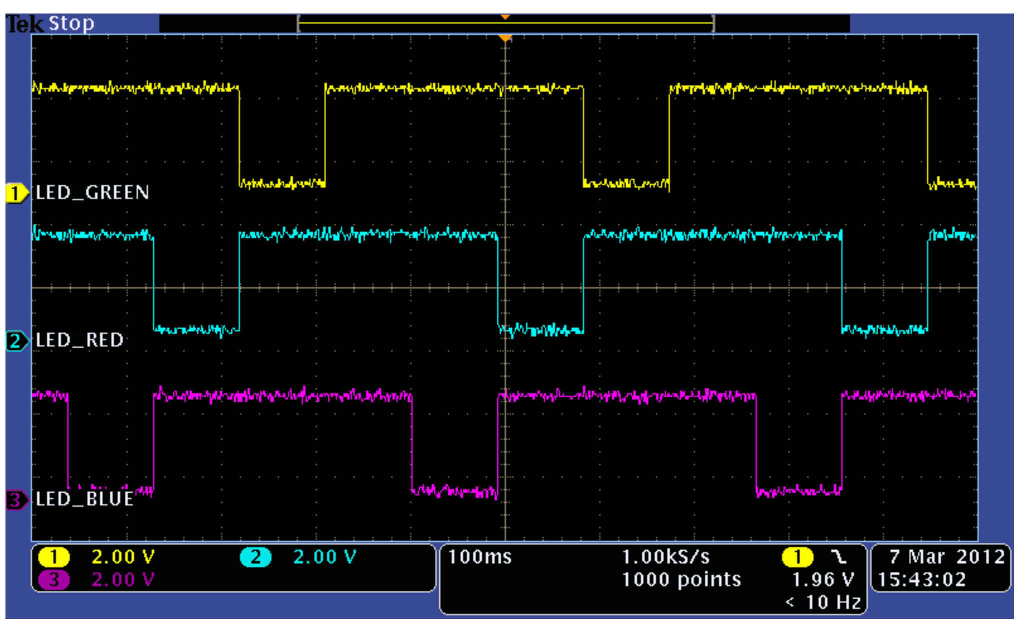



Fig 12. Output waveforms with DOWN = 1

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