Freescale Semiconductor
Application Note

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Writing your First MQX-Lite Application

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Contents

1 Introduction

The time invested to develop applications in a new environment can be significant. It is necessary to understand how the environment works and be able to generate applications. This application note will provide the knowledge that enables developers to start quickly and easily to develop your first application on Freescale MQX-Lite RTOS. It will provide the bases that developers need to understand to create basic Freescale MQX-Lite applications, based on the KL2: Kinetis KL2 USB MCUs Family, specifically, the KL25Z128VLK4 microcontroller. The Freescale Freedom development platform board (FREEDOM – KL25Z) is also used in this application note.

2 CodeWarrior 10.3 Start up

After CodeWarrior 10.3 is installed and starts, it is necessary to define a workspace where all the projects are allocated and administrated by CodeWarrior. In Figure 1 workspace D:\workspace_MQXLite is configured.

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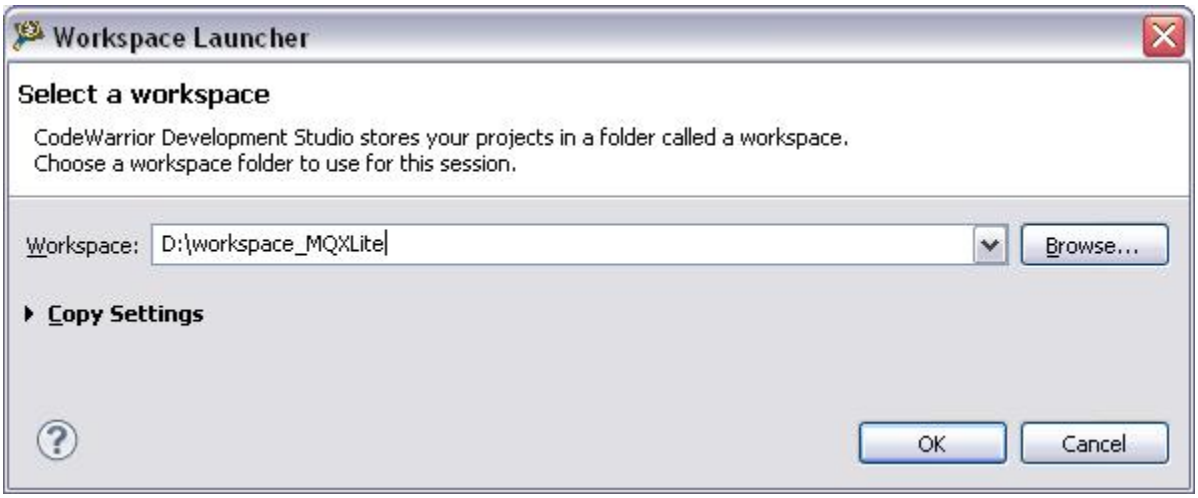


Figure 1. Setup workspace for CodeWarrior 10.3

Figure 2 shows CodeWarrior appearance when it finishes the start up. One of the new features in CodeWarrior 10.3 version is the Commander window located on the bottom left of the screen.

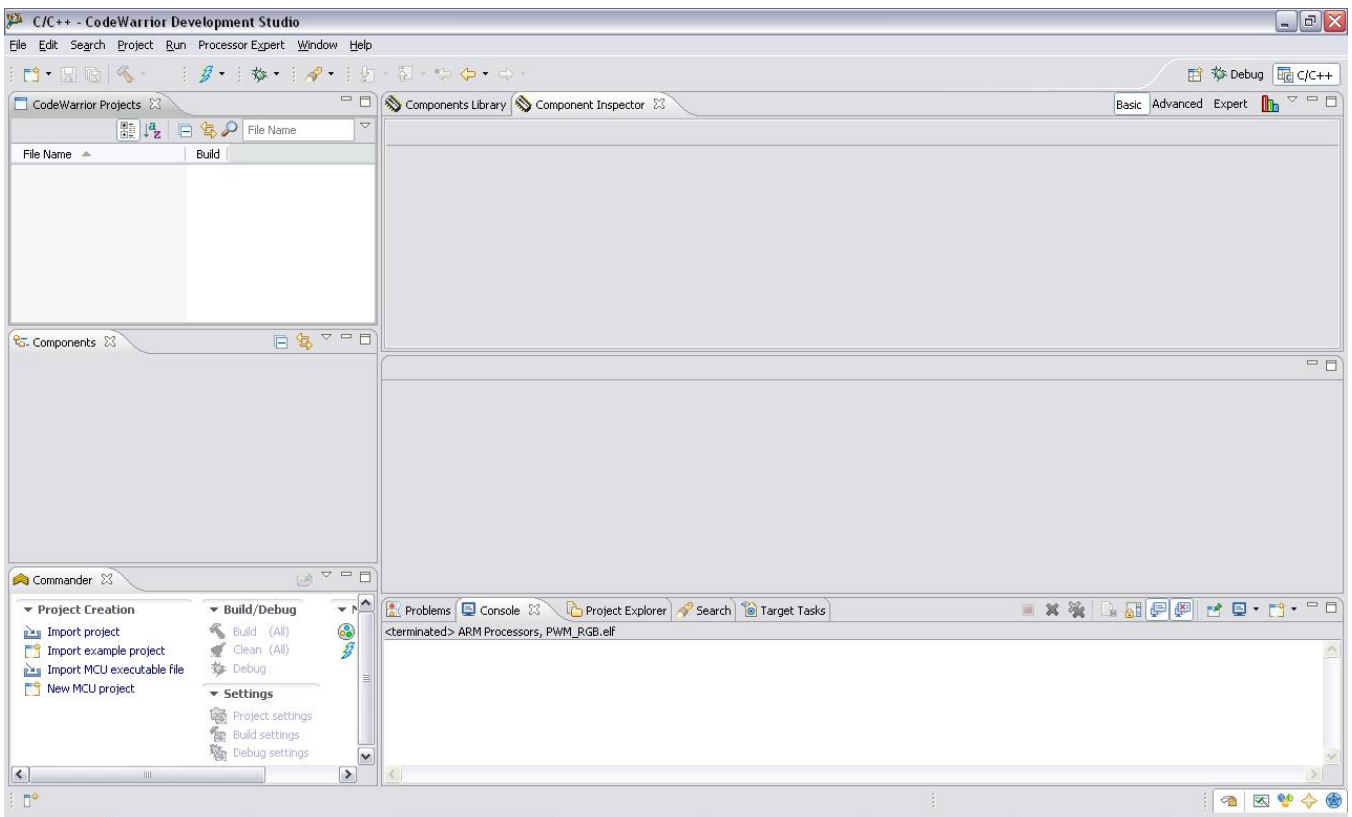


Figure 2. CodeWarrior 10.3

3 Creating projects

There are two possible paths to follow. The first path is to create an MQX-Lite project and the second is to create it from zero. Both options are described in this document. The first option uses the wizard to create an MQX-Lite project.

3.1 Creating a MQX-Lite base project

Follow the steps to create and configure an MQX-Lite project for the MKL25Z128 (48 MHz) derivative:

1. The Commander window includes an option to create a new project for MQX-Lite. See Figure 3.

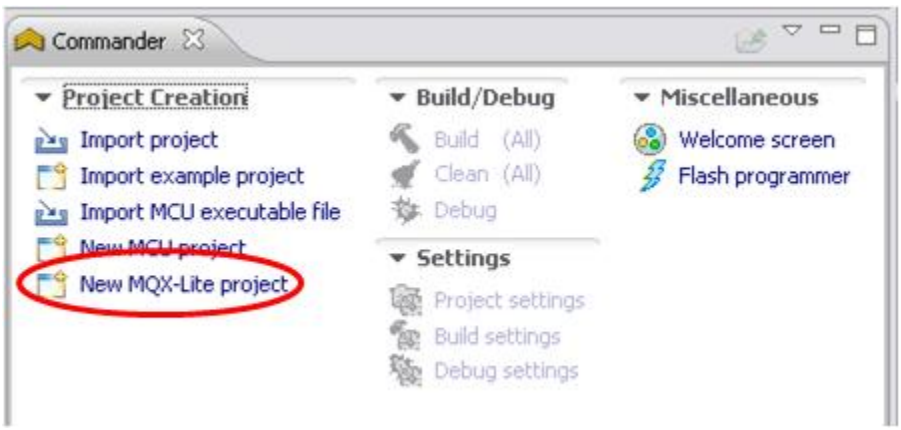


Figure 3. Commander window

2. The New MQX-Lite Project wizard starts and requests a name and location for the project. In this case the name MQX-Lite_Freedom and D:\workspace_MQXLite are used. To finish this step click on the Next > button at the bottom of the window. See Figure 4.

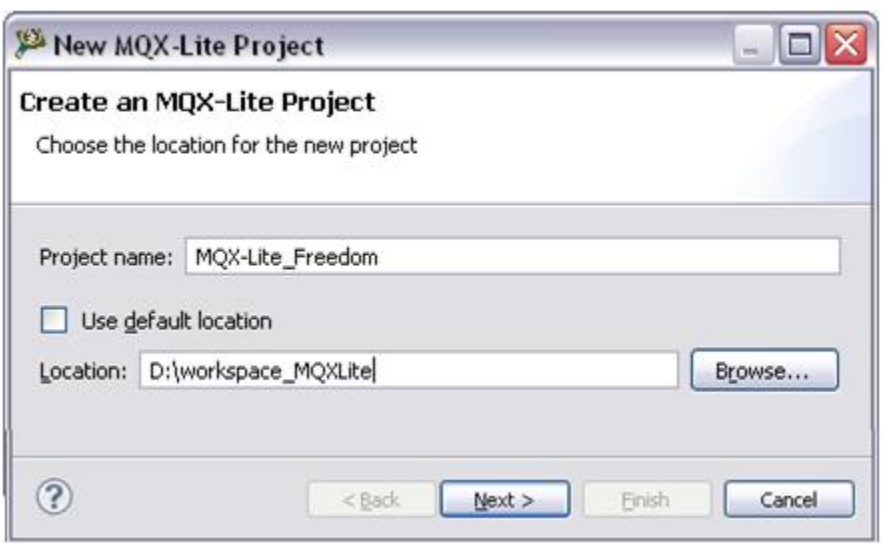


Figure 4. New MQX-Lite project wizard – Name and Location

3. In the following window select the desired MCU. In this case the MKL25Z128 (48 MHz) derivative is selected. To perform this selection navigate in the tree. See Figure 5. After the MKL25Z128 option is selected click the Next > button.

Figure 5. Kinetis L family tree

4. The following step allows you to choose the connection. The Freedom – KL25Z board uses the Open source SDA connection and must be selected as indicated. See Figure 6. Click Next > to go on.

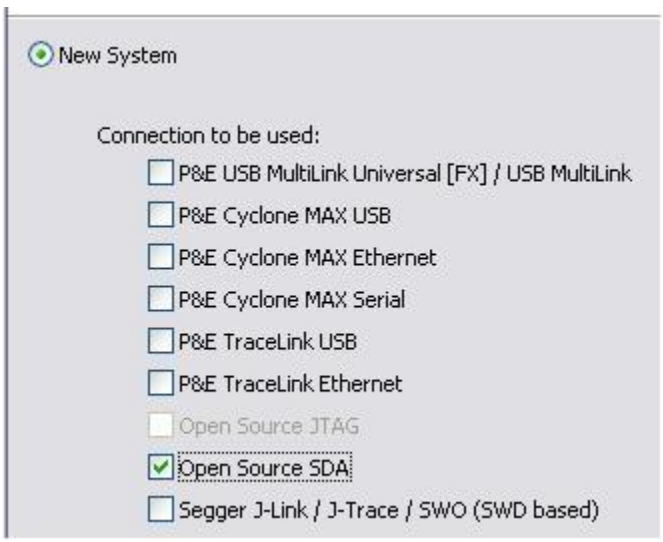


Figure 6. Selecting connection

5. The next window has the options set by default. For this window you need to click on the Finish button. See Figure 7.

Figure 7. Programming language and build options selection

6. When the wizard finishes, CodeWarrior has a new appearance see Figure 8. There are two main changes. The CodeWarrior Projects window has a new project included and the Components window shows the Processor Expert added components.

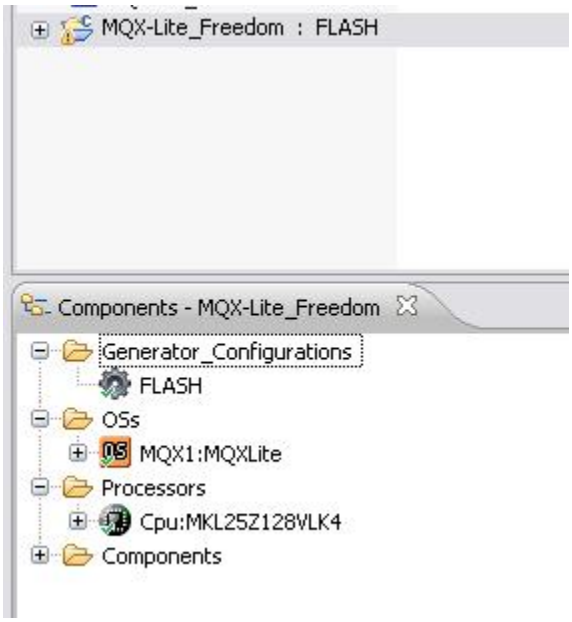


Figure 8. CodeWarrior Projects and Components window

3.2 Creating an empty base project

The following steps demonstrate how to create and configure a project for the MKL25Z128 (48 MHz) derivative:

1. The Commander window includes an option to create a new project for the MCU. See Figure 9.

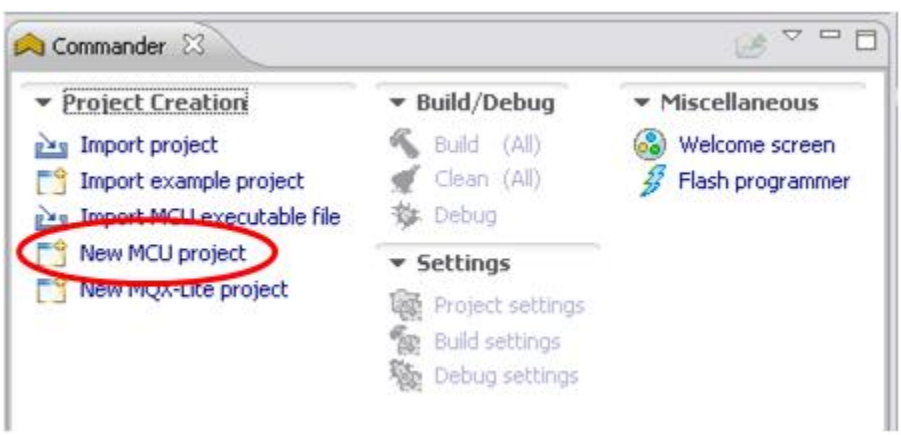


Figure 9. Commander window

2. The New Bareboard Project wizard starts and requests a name for the project and a location. In this case the name MQXLite_Freedom and D:\workspace_MQXLite. To finish this step click on the Next > button at the bottom of the window. See Figure 10.

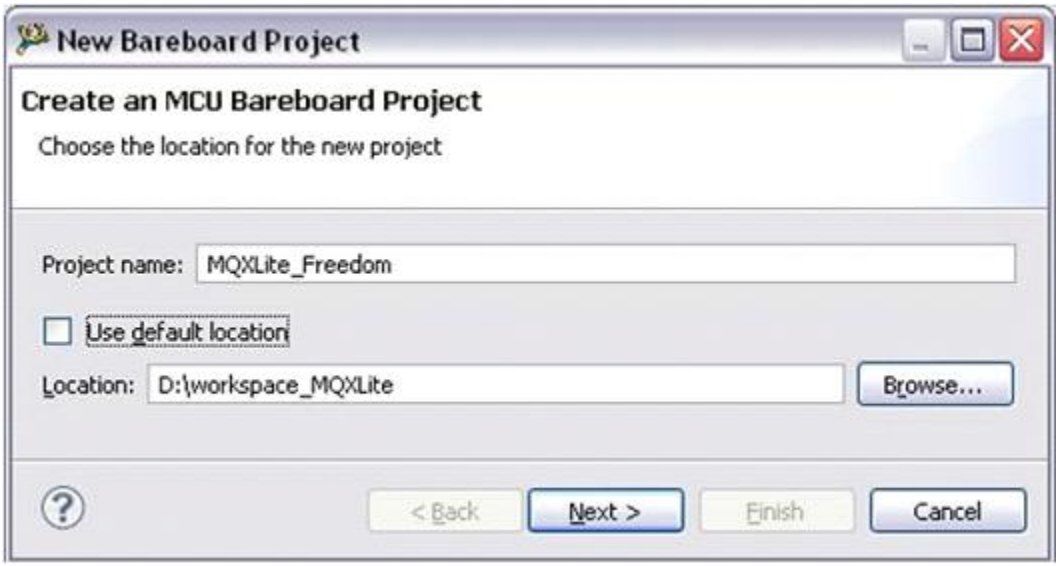


Figure 10. New project wizard – Name and Location

3. The next window in the wizard allow you to select the desired MCU. For this case the MKL25Z128 (48 Mhz) derivative is selected. To perform this selection navigate in the tree. See Figure 11.

Figure 11. Kinetis L Family Tree

4. The following step allows you to choose the connection. The Freedom – KL25Z board uses the Open source SDA connection and this must be selected. See Figure 12. Click Next >.

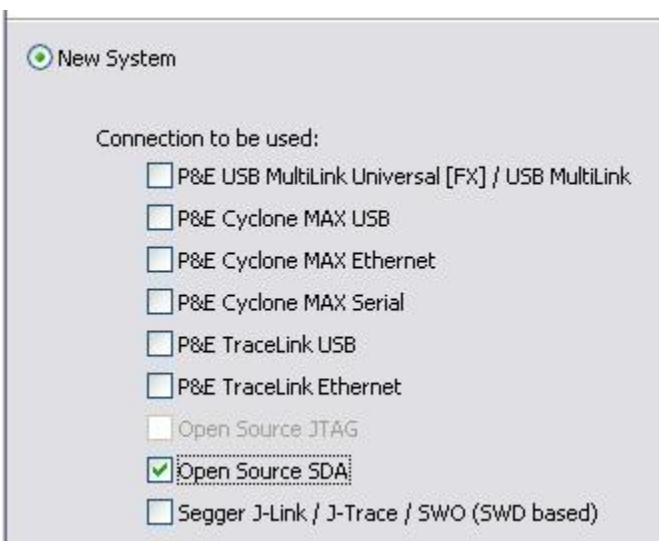


Figure 12. Selecting connection

5. The next window has the option to select the programming language. C language must be selected. See Figure 13.

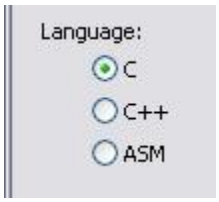


Figure 13. Programming language selection

6. The final step is to choose the rapid application development. In this case the option Processor Expert should be selected. The Processor Expert can generate for you all the device initialization code. It includes many low-level drivers. The rest of the options must remain with the default settings. To end the wizard click the Finish button.

Figure 14. Selecting Rapid Application Development

7. When the wizard finishes CodeWarrior has a new appearance. See Figure 15. There are two main changes. The CodeWarrior Projects window has a new project included and the Components window shows the Processor Expert added components.

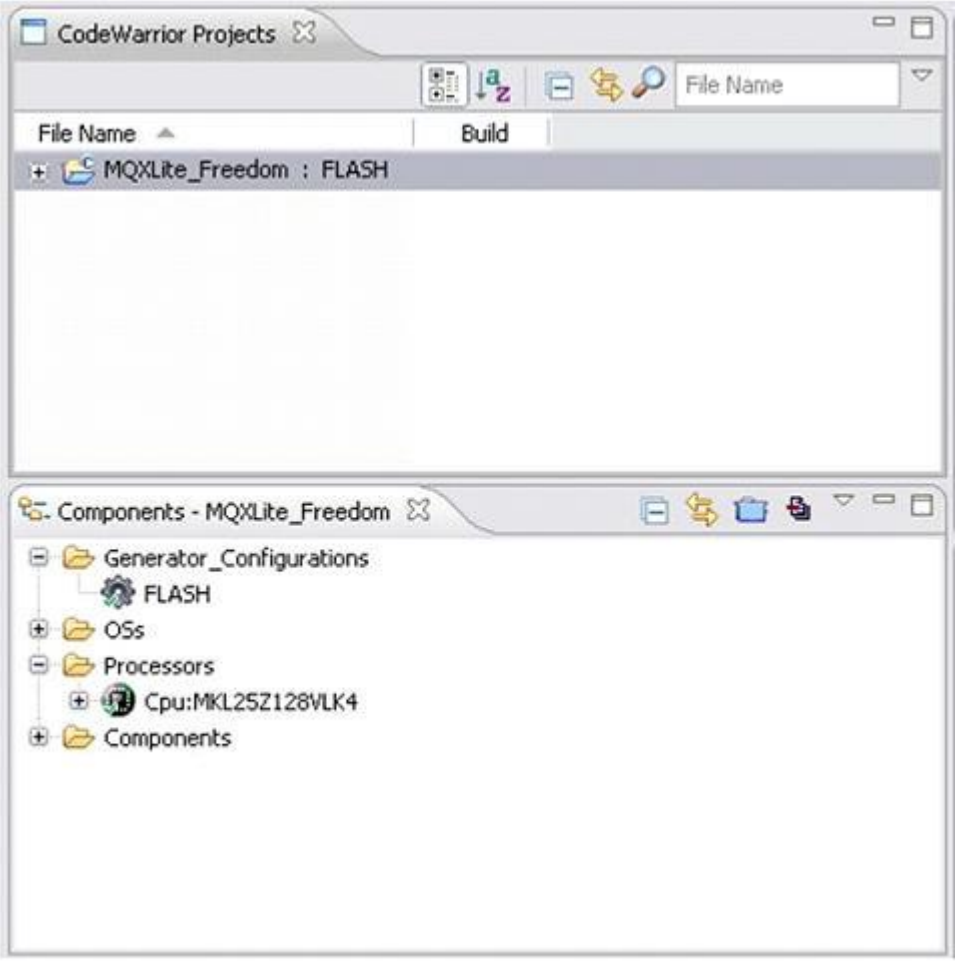


Figure 15. CodeWarrior Projects and Components windows

4 Configuring projects

First, it is necessary to setup the correct configurations for the hardware used in the Freedom – KL25Z board. Here are all the necessary steps to configure the clock settings and configurations. See Figure 16

1. Double click in the ProcessorExpert.pe item under the CodeWarrior project window. This updates the content of the Components window where the Cpu: MKL25Z128VLK4 component must be selected. This enables the content in the Component Inspector to the right of the windows. There are five things that need to be modified. Demonstrated here in detail are the options and the values modified. See Figure 16

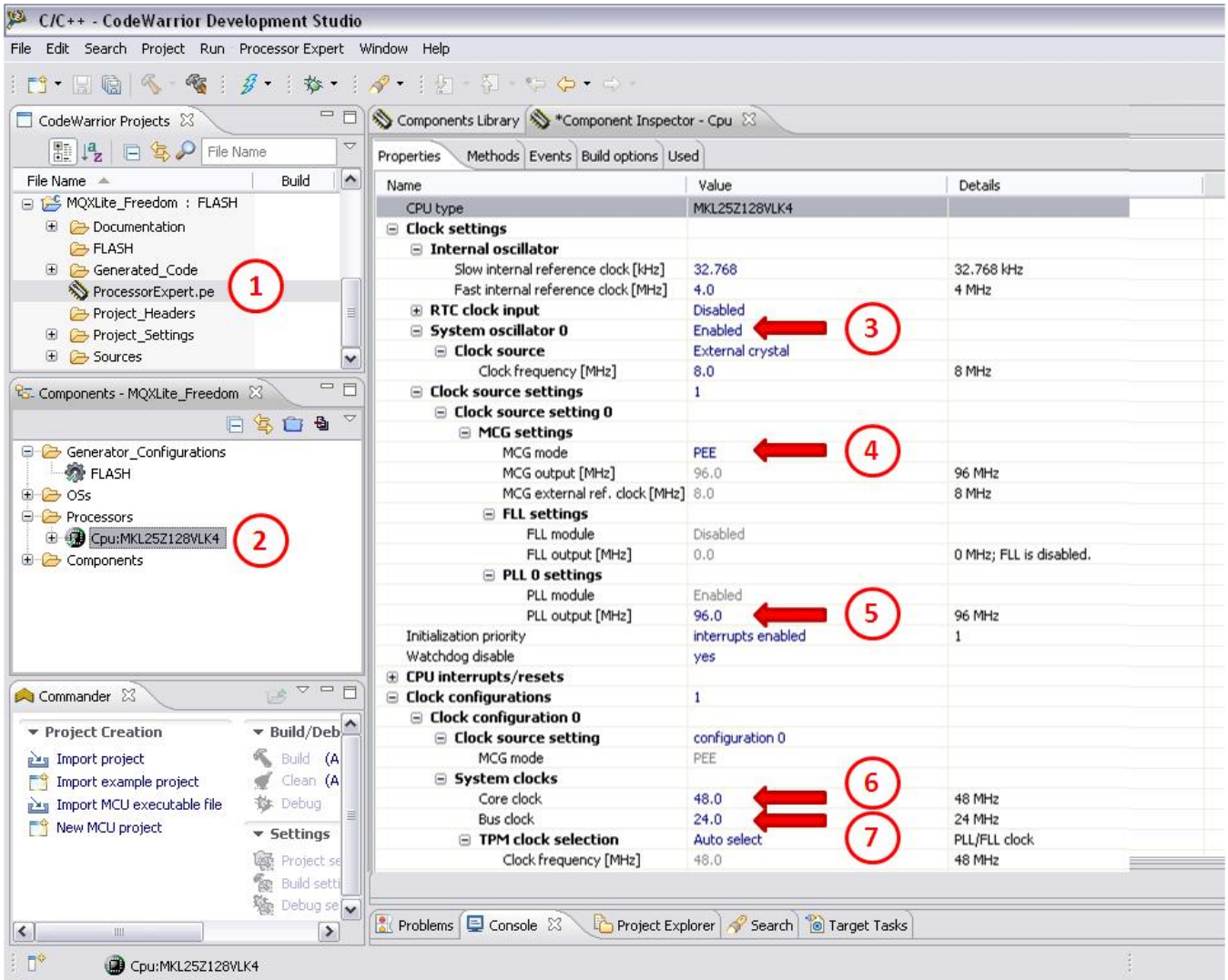


Figure 16. Clock settings and configurations

2. After the changes, it is possible to generate code using Processor Expert. To do this click on the generate code button located in the upper right corner of the Components window. See Figure 17.

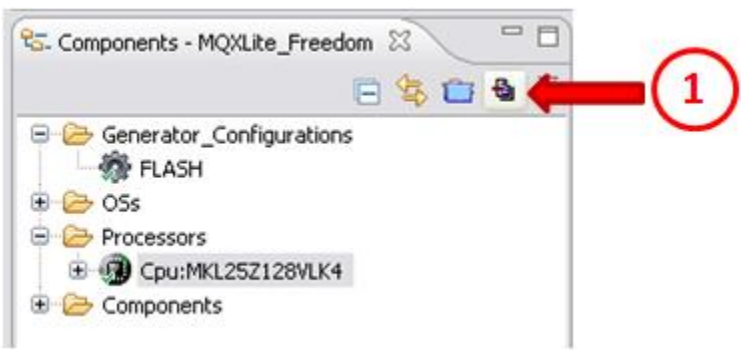


Figure 17. Generating Processor Expert code

3. It is necessary to compile the project to verify that there are no errors while using the generated code. To compile the project go to the CodeWarrior Projects window. Click on the Project name and then click on the compile button. See Figure 18.

Figure 18. Compiling the project

4. Validate that the Problems tab has no errors listed to ensure a successful compilation. Figure 19 shows a Problems tab with 0 error or warnings.

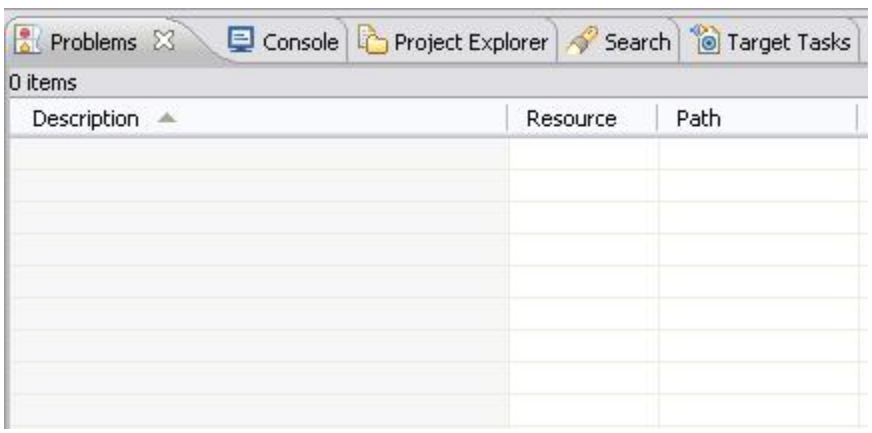


Figure 19. Problems tab with 0 errors

5 Your first Freescale MQX-Lite Application

The application architecture is to configure three PWM timers for the RGB LED and the communication using I2C to read data from the inertial sensor, MMA8451Q. Each one of the PWMs controls each one of the LEDs in the RGB LED. The I2C is used to read the data coming from the inertial sensor. The RGB LED color changes while the board is moving. If the board stops moving the RGB LED holds the current color.

The Stationery project is now ready to add the MQX-Lite application. The first step is to add a console that can help to debug and output data from the MCU using the UART port. To add and configure the Processor Expert component it is necessary to follow these steps.

1. Click in the Components Library tab. See Figure 20. Then click in the Alphabetical tab and look for the ConsoleIO component. Double clicking in the ConsoleIO component includes it in the project. See Figure 21.

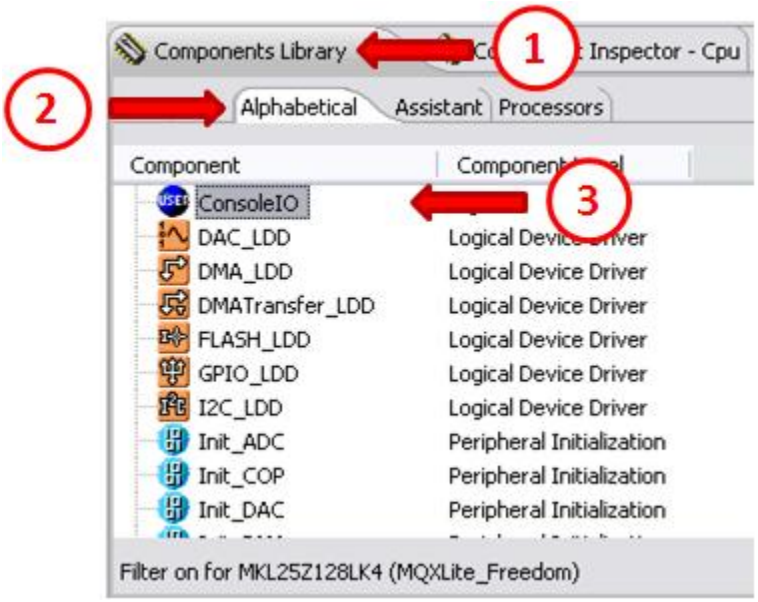


Figure 20. Components Library

Figure 21. New component added to Processor Expert project: ConsoleIO

2. It is necessary to configure the newly added component. To do this expand the CsIO1:ConsoleIO component added in the prior step. By clicking in the IO1:Serial_LDD[ConsoleIO\ConsoleIO_Serial_LDD] option from the CsIO1:ConsoleIO component (see Figure 22) the Component Inspector tap is updated and the values are updated as Figure 23 shows.

Figure 22. Subcomponents expand

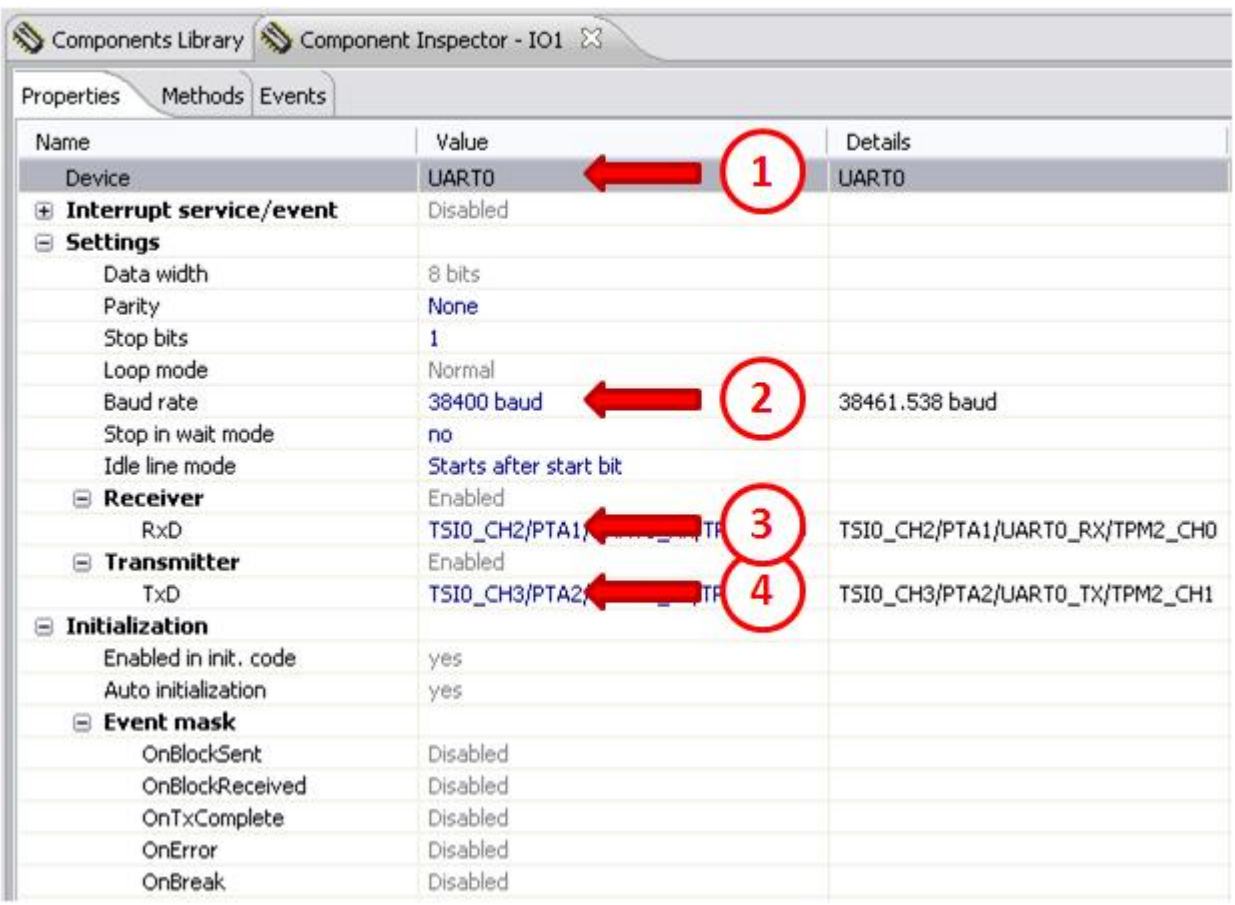


Figure 23. ConsoleIO component settings

3. After the modifications, it is ready to generate updated code using Processor Expert. To do this click in the generate code button located in the upper right corner of the Components window.
4. It is necessary to compile the project to verify that there are no errors while using the generated code. To compile the project go to the CodeWarrior Projects window. Click in the Project name and then click in the compile button. See Figure 24 for the steps.

Figure 24. Compiling the project

5. Compiling the project
6. Now add the MQXLite component. Click in the Components Library tab. See Figure 25. Then click on the Alphabetical tab and look for the MQXLite component. Double clicking on the MQXLite component includes it in the project. See Figure 21.

NOTE

Skip this step if you used the wizard to create an MQX-Lite project.

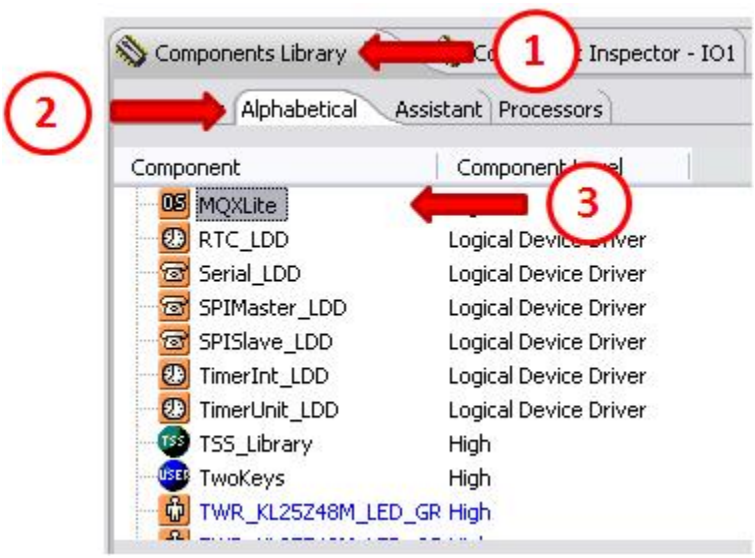


Figure 25. Components Library

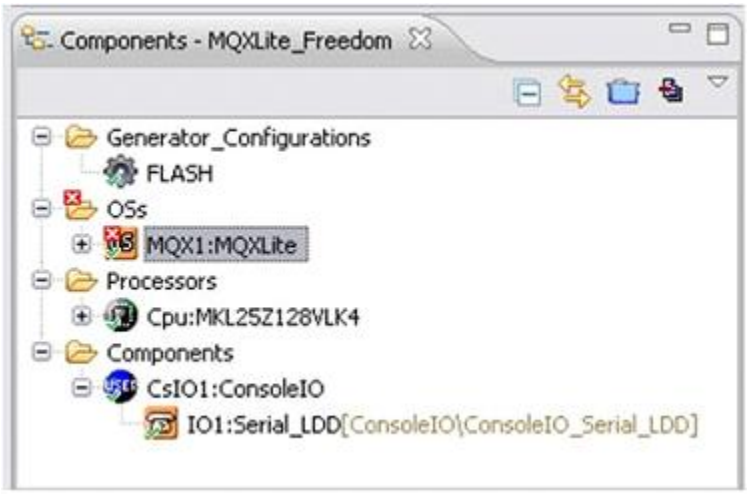


Figure 26. New component added to Processor Expert project: MQXLite

7. The MQXLite default configuration includes 2 basic subcomponents; a system tick and at least one task. By expanding the MQX1:MQXLite, notice that the first two subcomponents are already mentioned. Figure 27 verifies this.

Figure 27. MQXLite subcomponents

8. The first MQXLIte subcomponent is the SystemTimer1:TimerUnit_LDD. This is the heart of the system. The system tick is generated with the SystemTimer1:TimerUnit_LDD. Figure 27 shows that the SystemTimer1:TimerUnit_LDD subcomponent is marked with errors. This is because it is necessary to provide configure information for the clocks. This way the timer can configure the module correctly. Figure 28 shows the values to be updated in the Component Inspector tab when a click is given in the SystemTimer1:TimerUnit_LDD subcomponent.

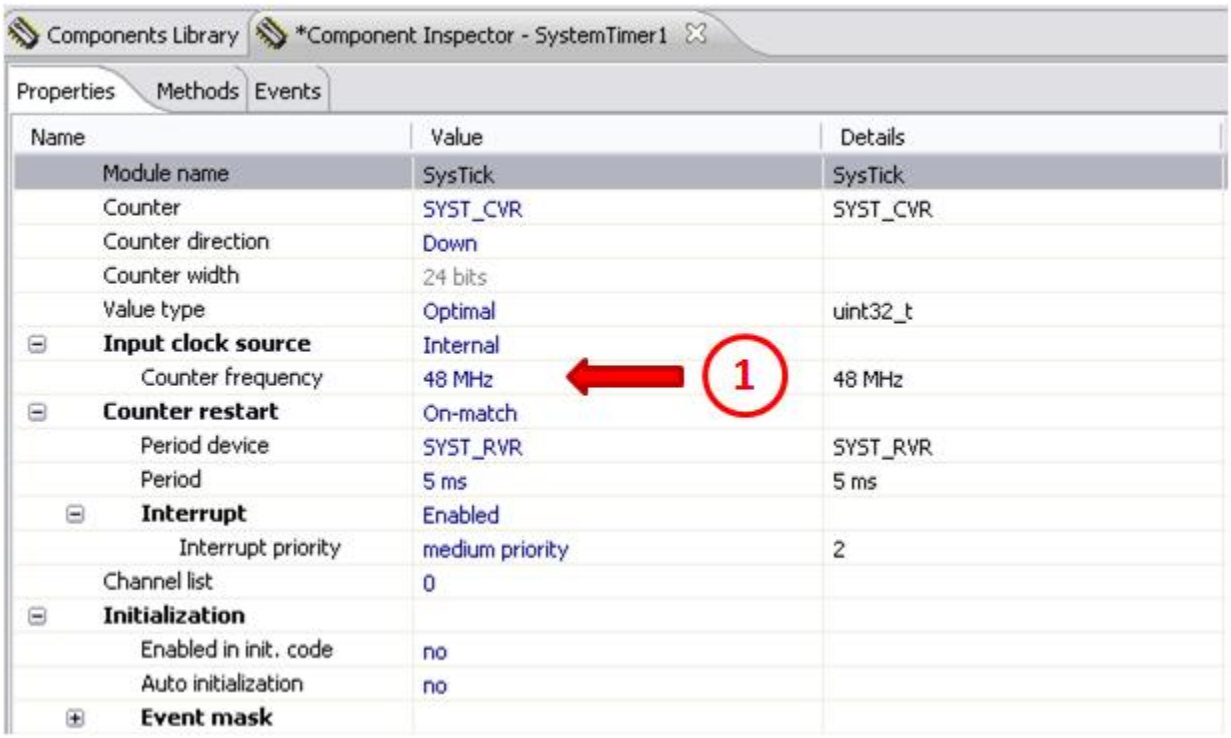


Figure 28. Configuring System Tick for MQXLite

9. At this point it is possible to re-generate code and re-compile to ensure that everything is configured correctly. Repeat steps 3, 4, and 5 to perform these operations.
10. By default, when the MQXLite component is added a task is also included in this component. To identify where the default task is located see Figure 29 .

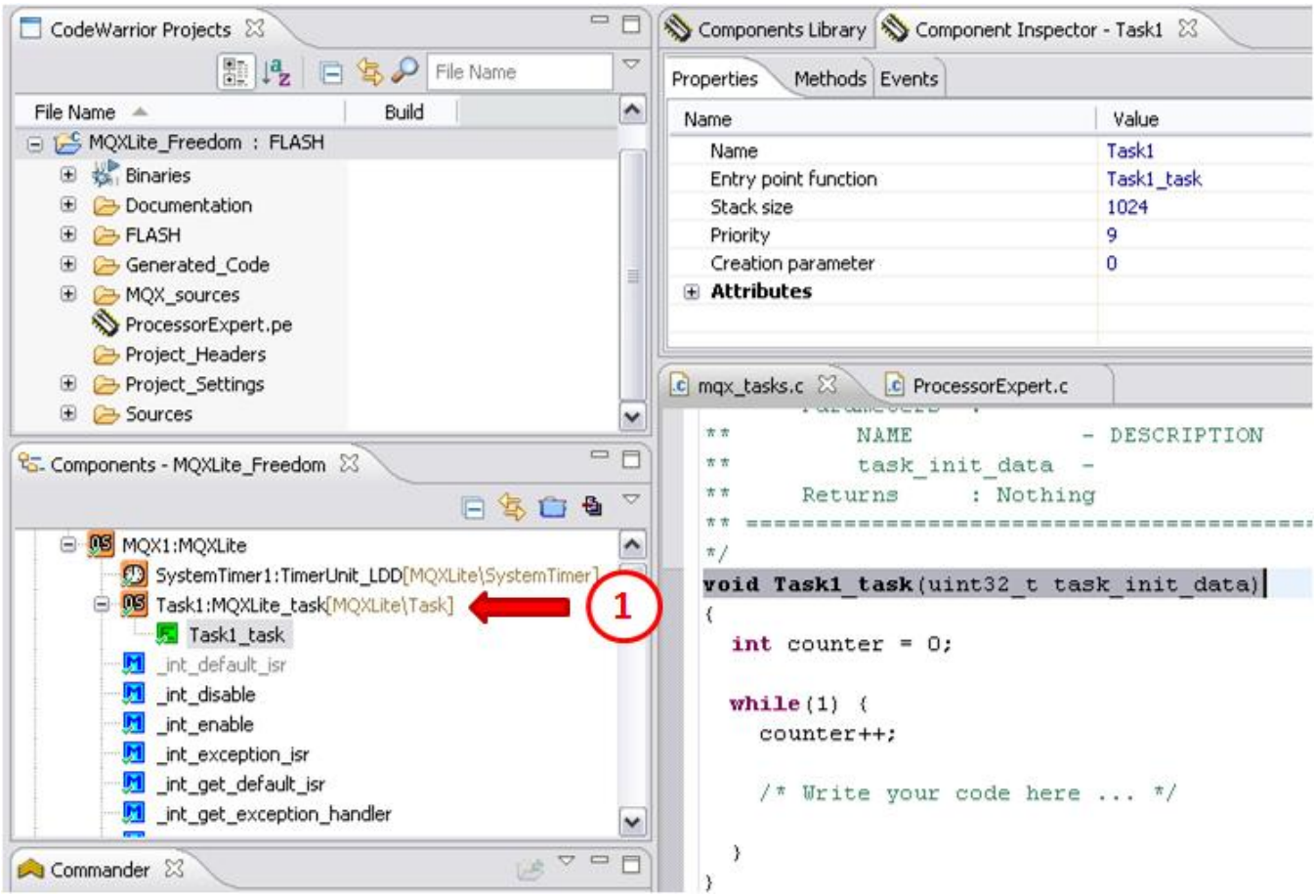


Figure 29. Default first MQXLite task

To access the source code of this default task it is necessary to double click in the name of the task component. In this case it is Task1_task. The code opens on the right side of the CodeWarrior screen that shows the definition of the task source code.

6 Controlling the RGB LED

The Freedom – KL25Z board includes an RGB LED connected to three PWMs from the MCU. See Figure 30.

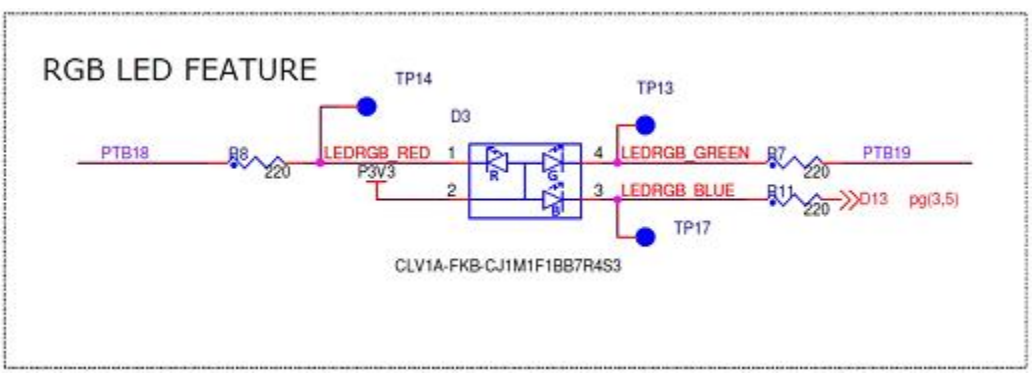


Figure 30. RGB LED schematics connections in the Freedom – KL25Z

The schematic above shows that the RGB LED is connected to PTB18, PTB19, and D13. This information is used to configure the three PWMs. The board also includes an I2C Inertial sensor. The data from this sensor is used to control the RGB LED.

1. The first step is to create two timer components. The first timer controls the R (red) G (green) and the second timer controls the B (blue)
2. Look for the TimerUnit_LDD in the component library and add it to the Processor Expert window with a double click.
3. It is necessary to change the name to standardize the source code. To modify the name of the component right click on it and then name it PWMTimerRG. This name means that this PWM controls the Red and Green LED inside the RGB LED. See Figure 31.

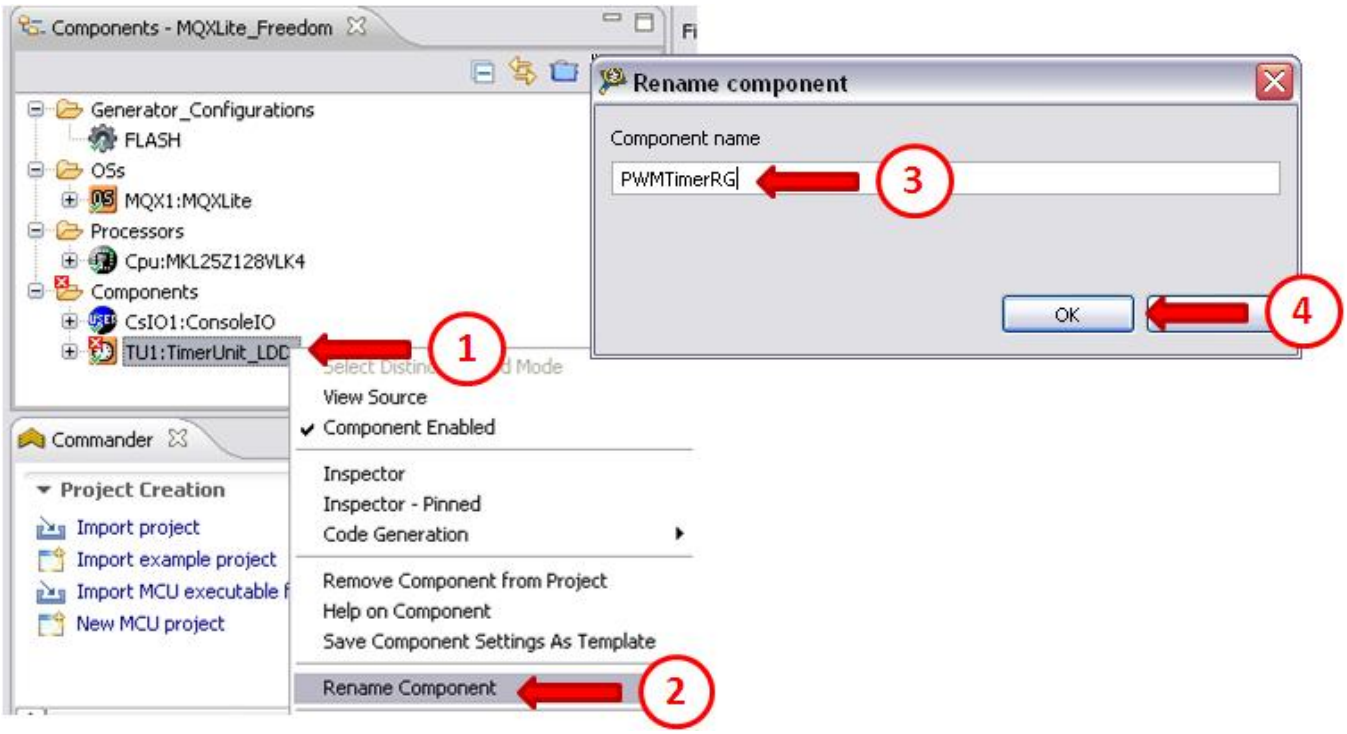
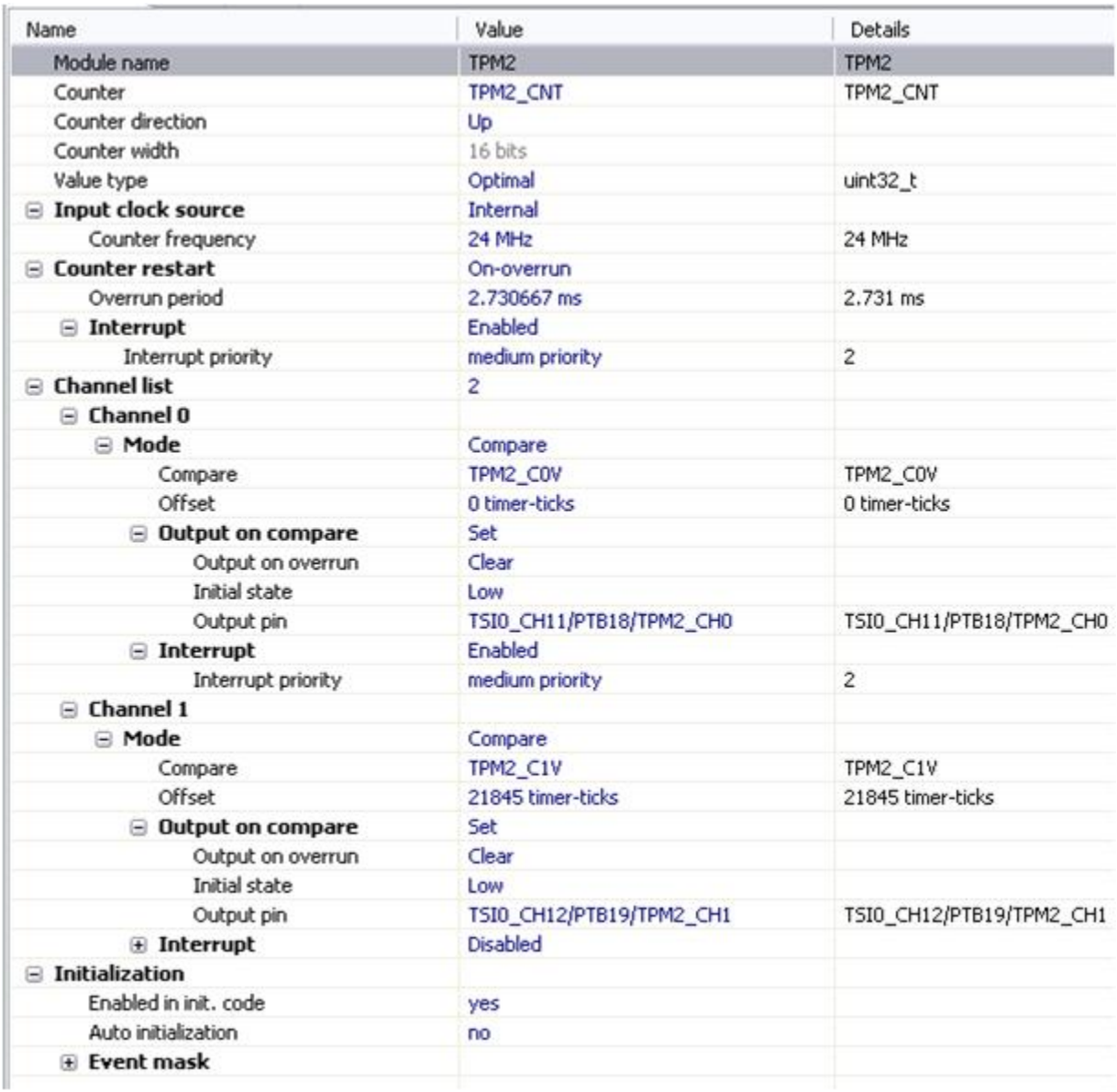


Figure 31. Modify component name

4. By clicking on the new component the Component Inspector appears allowing configuration. The configuration is the same as Figure 32 .



Name	Value	Details
Module name	TPM2	TPM2
Counter	TPM2_CNT	TPM2_CNT
Counter direction	Up	
Counter width	16 bits	
Value type	Optimal	uint32_t
Input clock source	Internal	
Counter frequency	24 MHz	24 MHz
Counter restart	On-overrun	
Overrun period	2.730667 ms	2.731 ms
Interrupt	Enabled	
Interrupt priority	medium priority	2
Channel list	2	
Channel 0		
Mode	Compare	
Compare	TPM2_C0V	TPM2_C0V
Offset	0 timer-ticks	0 timer-ticks
Output on compare	Set	
Output on overrun	Clear	
Initial state	Low	
Output pin	TSI0_CH11/PTB18/TPM2_CH0	TSI0_CH11/PTB18/TPM2_CH0
Interrupt	Enabled	
Interrupt priority	medium priority	2
Channel 1		
Mode	Compare	
Compare	TPM2_C1V	TPM2_C1V
Offset	21845 timer-ticks	21845 timer-ticks
Output on compare	Set	
Output on overrun	Clear	
Initial state	Low	
Output pin	TSI0_CH12/PTB19/TPM2_CH1	TSI0_CH12/PTB19/TPM2_CH1
Interrupt	Disabled	
Initialization		
Enabled in init. code	yes	
Auto initialization	no	
Event mask		

Figure 32. Configuring the PWMTimerRG component

5. Look for the TimerUnit_LDD in the component library and add it to the Processor Expert window with a double click.
6. It is necessary to change the name to standardize the source code. To modify the name of the component right click on it and then name it PWMTimerB. This name means that this PWM controls the Blue LED inside the RGB LED. See Figure 33.

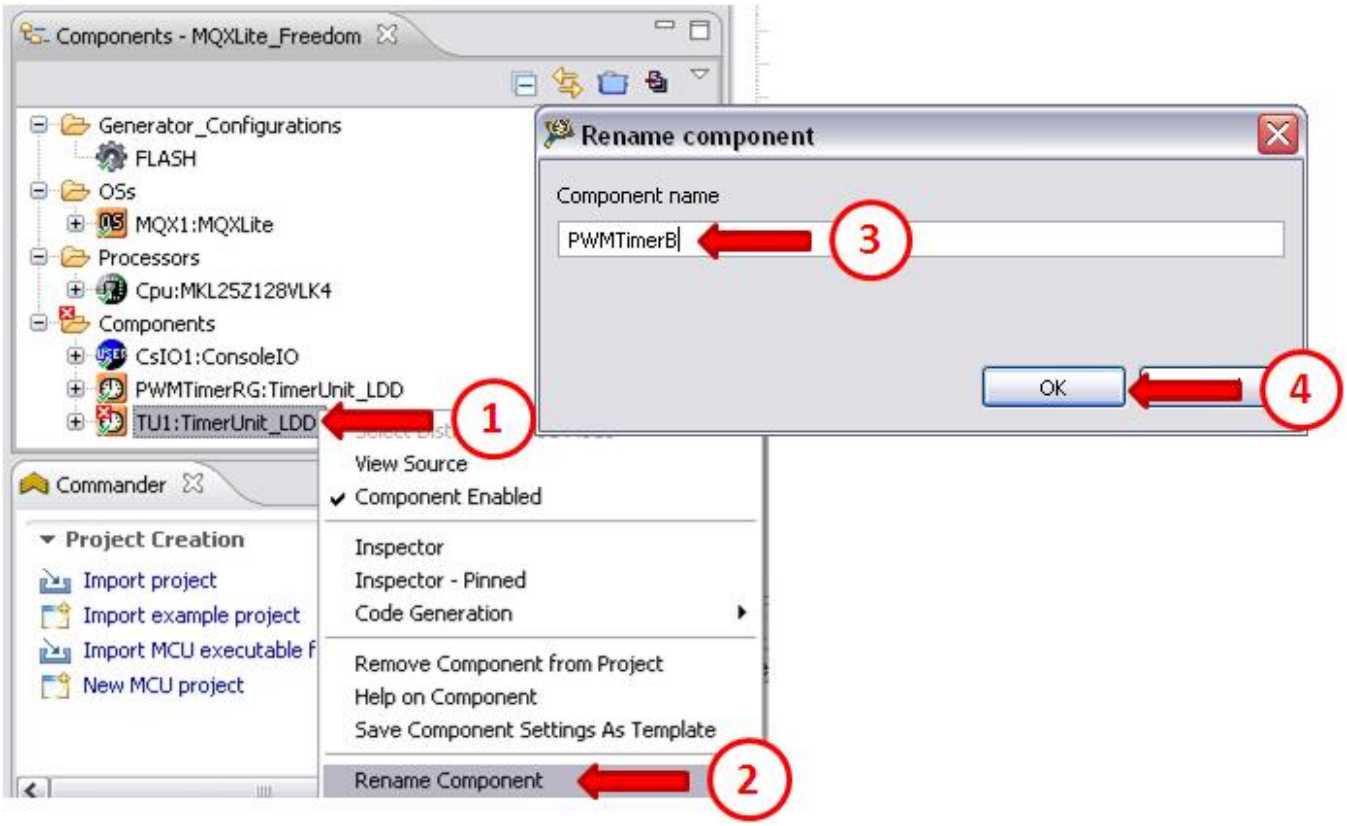


Figure 33. Modify component name

7. By clicking in the new component the Component Inspector window appears to do the configuration. The configuration is the same as Figure 34 .

Name	Value	Details
Module name	TPM0	TPM0
Counter	TPM0_CNT	TPM0_CNT
Counter direction	Up	
Counter width	16 bits	
Value type	Optimal	uint32_t
Input clock source	Internal	
Counter frequency	24 MHz	24 MHz
Counter restart	On-overrun	
Overrun period	2.730667 ms	2.731 ms
Interrupt	Disabled	
Channel list	1	
Channel 0		
Mode	Compare	
Compare	TPM0_C1V	TPM0_C1V
Offset	43690 timer-ticks	43690 timer-ticks
Output on compare	Set	
Output on overrun	Clear	
Initial state	Low	
Output pin	ADC0_SE5b/PTD1/SPI0_SCK/TPM0_CH1	ADC0_SE5b/PTD1/SPI0_SCK/TPM0_C...
Interrupt	Disabled	
Initialization		
Enabled in init. code	yes	
Auto initialization	no	
Event mask		

Figure 34. Configuring the PWMTimerB component

8. For the TimerUnit_LDD components it is necessary to define the functions added by the auto-generated code. To do this, click in the Methods tab under the Component Inspector. These settings apply for the PWMTimerRG and the PWMTimerB. Shown is the correct configuration for the methods creation. See Figure 35.

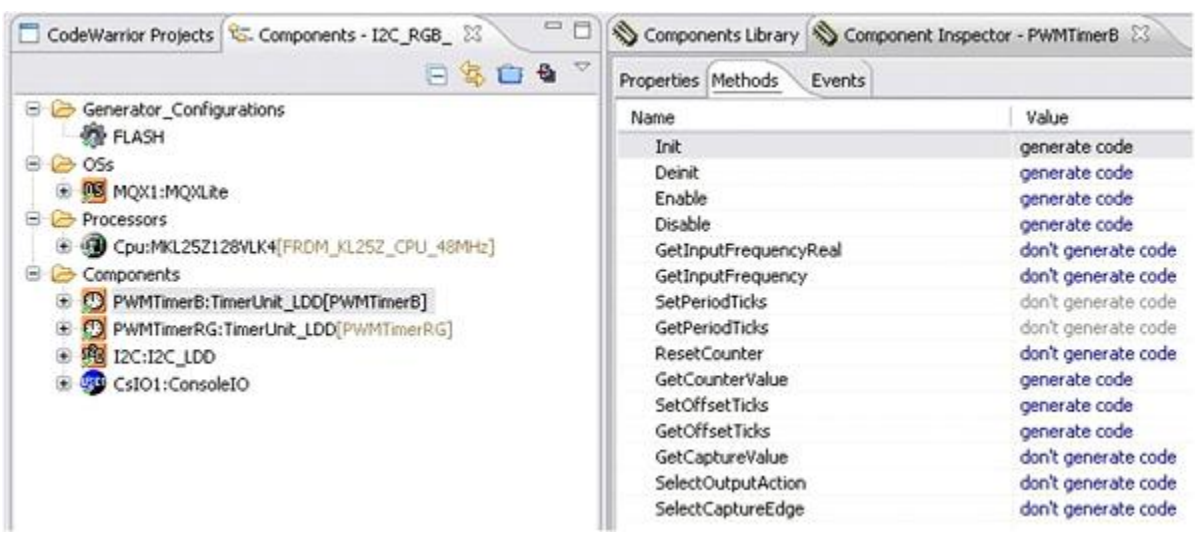


Figure 35. PWMTimerRG and the PWMTimerB methods creation definition

9. Look for the I2C_LDD in the component library and add it to the Processor Expert window with a double click.
10. It is necessary to change the name to standardize the source code. To modify the name right click on it and name it I2C.
11. By clicking on the new component the Component Inspector appears allowing configuration. The configuration is the same as Figure 36.

Name	Value	Details
I2C channel	I2C0	I2C0
Interrupt service	Enabled	
Interrupt priority	medium priority	2
Settings		
Mode selection	MASTER	
MASTER mode	Enabled	
Initialization		
Address mode	7-bit addressing	
Target slave address init	1D H	
SLAVE mode	Disabled	
Pins		
SDA pin		
SDA pin	PTE25/TPM0_CH1/I2C0_SDA	PTE25/TPM0_CH1/I2C0_SDA
SCL pin		
SCL pin	PTE24/TPM0_CH0/I2C0_SCL	PTE24/TPM0_CH0/I2C0_SCL
Internal frequency (multiplier factor)	24 MHz	24 MHz
Bits 0-2 of Frequency divider register	101	
Bits 3-5 of Frequency divider register	100	
SCL frequency	75 kHz	Clock conf. 0: 75 kHz
SDA Hold	2.042 us	Clock conf. 0: 2.042 us
SCL start Hold	6.583 us	Clock conf. 0: 6.583 us
SCL stop Hold	6.708 us	Clock conf. 0: 6.708 us
Initialization		
Enabled in init code	yes	
Auto initialization	no	

Figure 36. Configuring the I2C component

12. For the I2C_LDD components it is necessary to define the functions added by the auto-generated code. To do this click on the Methods tab under the Component Inspector. Figure 37 shows the correct configuration for the methods creation.

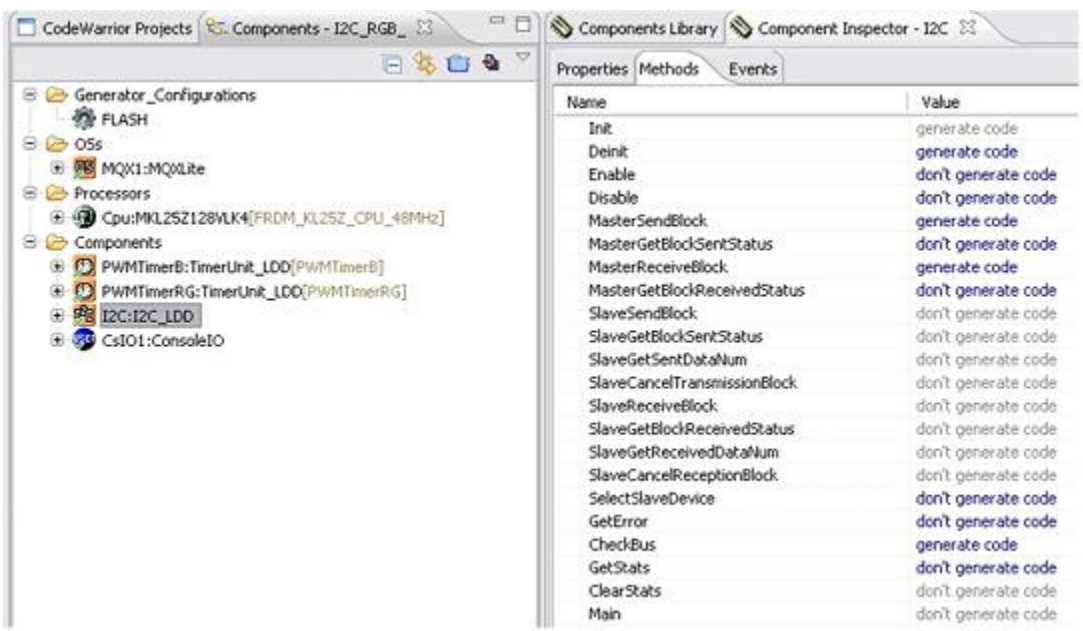


Figure 37. The I2C methods creation definition

13. All the needed components were added at this point. To validate that everything is correct, re-generate and compile the code. Check that the Problems tab for no errors listed to ensure a successful compilation.

6.1 Adding the source code

The source code to develop this application is divided in two sections; the code for the I2C, and the code for the PWMs. The first code enables communication with the inertial sensor through the I2C. The PWM code is then added. The full source code can be found in the appendix.

The following steps emphasize key sections of the source code.

1. All the steps must occur in the MQXLite task. Expand the MQXLite component until you reach the Task1_task subcomponent. Double click on it to make the source code appear on the right hand of the screen. Figure 38 is an example of how it looks.

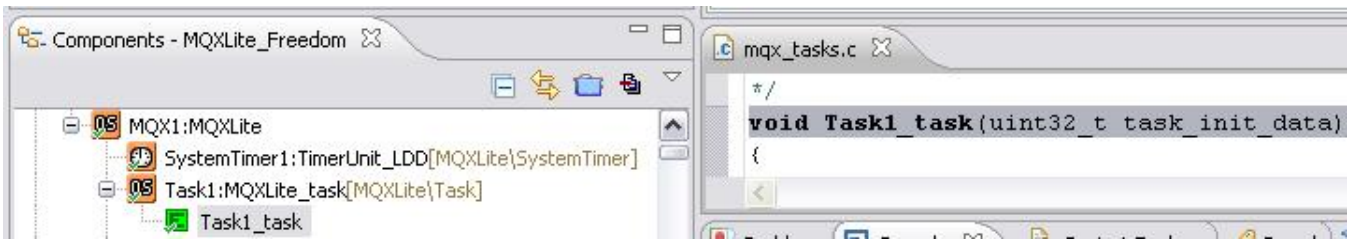


Figure 38. Accessing the MQXLike task source code

2. The Task1_task holds the source code for the only MQXLite task configured. The following code initializes the I2C and is added at the beginning of the Task1_task() function.

```
I2C_DeviceData = I2C_Init(&DataState);
Error = !ReadAccRegs(I2C_DeviceData, &DataState, CTRL_REG_1, ACC_REG_SIZE, &Data);
if (!Error) {
  Data = (ACTIVE_BIT_MASK | F_READ_BIT_MASK); /* Set active mode bit and fast read mode bit *
  Error = !WriteAccRegs(I2C_DeviceData, &DataState, CTRL_REG_1, ACC_REG_SIZE, &Data);
}
if (!Error) {
  Data = 0;
  Error = !ReadAccRegs(I2C_DeviceData, &DataState, CTRL_REG_1, ACC_REG_SIZE, &Data);
  if (!Error) {
    if (Data != (ACTIVE_BIT_MASK | F_READ_BIT_MASK)) {
      Error = TRUE;
    }
  }
}
```

Figure 39. I2C initialization source code

The function I2C_Init() starts the low level driver. The function ReadAccRegs() ensures communication with the device (in this case, the inertial sensor). You need to activate the device and set the fast read mode and validate that these values were written correctly in the device register.

The I2C driver is configured as an interrupt. It is necessary to open the Event.c file to add the source code of the I2C interrupt service routine. Figure 40 shows the interrupt routines source code that need to be modified. The function declarations are already in the Event.c file. It is necessary to only add the body of the function.

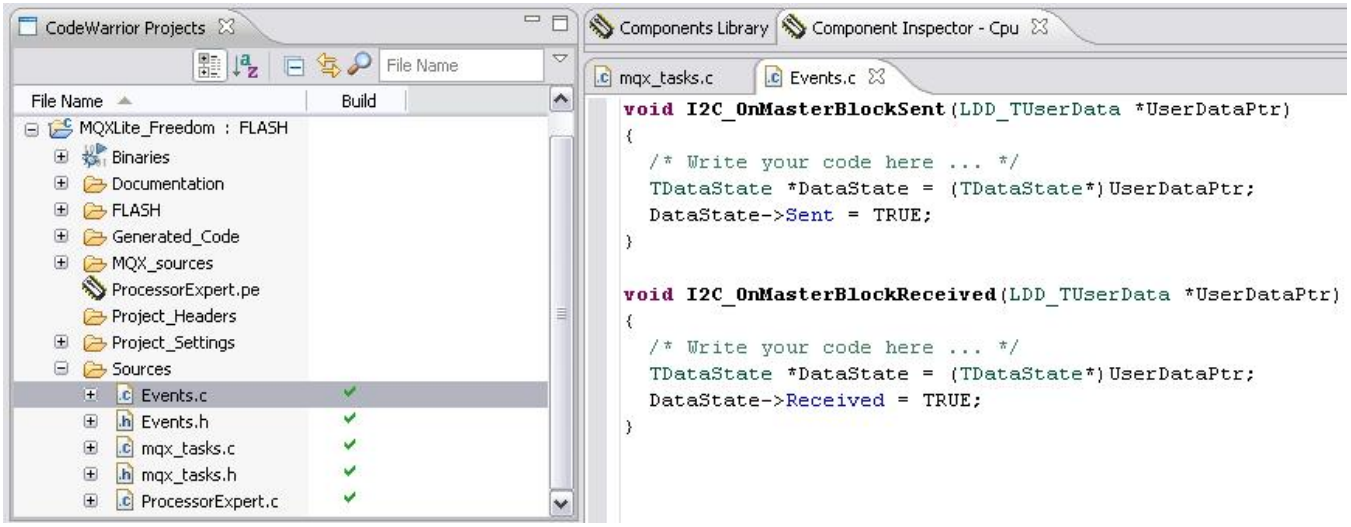


Figure 40. ISR Source code

The function I2C_OnMasterBlockSent() is called when I2C is in master mode and finishes the transmission of the data successfully. The function I2C_OnMasterBlockReceived() is called when I2C is in master mode and finishes the reception of the data successfully. Then both functions update the state and data sent to the application.

3. Now the PWMs are initialized.

```
PWMTimerRG_DeviceData = PWMTimerRG_Init(NULL);
PWMTimerB_DeviceData = PWMTimerB_Init(NULL);
```

Figure 41. PWM initialization source code

4. Then the code enters into an infinite loop where it reads for any update from the I2C device. This data is then used to modify the ticks in the PWM and give a different color in the RGB LED. See Figure 42.

```
while(1)
{
  Error = !ReadAccRegs(I2C_DeviceData, &DataState, OUT_X_MSB, 3 * ACC_REG_SIZE, (uint8_t*) Color);
  if (!Error) {

      PWMTimerRG_Enable(PWMTimerRG_DeviceData);
      PWMTimerB_Enable(PWMTimerB_DeviceData);
      PWMTimerRG_SetOffsetTicks(PWMTimerRG_DeviceData, 0,1000*(1<<(abs(Color[0]/10))));
      PWMTimerRG_SetOffsetTicks(PWMTimerRG_DeviceData, 1, 1000*(1<<(abs(Color[1]/10))));
      PWMTimerB_SetOffsetTicks(PWMTimerB_DeviceData, 0, 1000*(1<<(abs(Color[2]/10))));

  }
_time_delay_ticks(1);
}
```

Figure 42. Main infinite loop

5. After all the code changes are finished it is necessary to recompile the project and validate that there are no errors. A strong suggestion is to replace the content of the files mqx_tasks.c, mqx_tasks.h and Events.c from the appendixes into the CW project. This ensures that no code is missing.

6.2 Debugging the source code

The source code is ready for debugging. The following steps explain how to perform this operation.

1. Go to the debug button (bug icon) in the tools bar and expand the debugging menu just like Figure 43 demonstrates. Then click on the Debug Configuration option to enter into the available debug settings for the project.

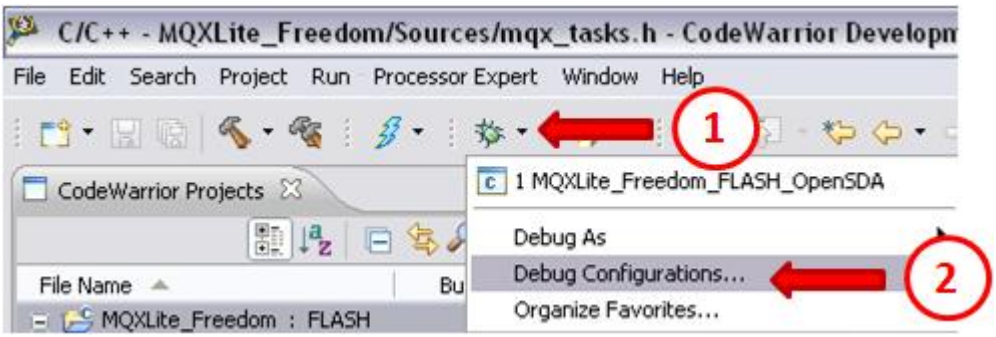


Figure 43. Entering into Debug Configurations.

2. Select the options MQXLite_Freedom_Flash_OpenSDA and then click Debug.

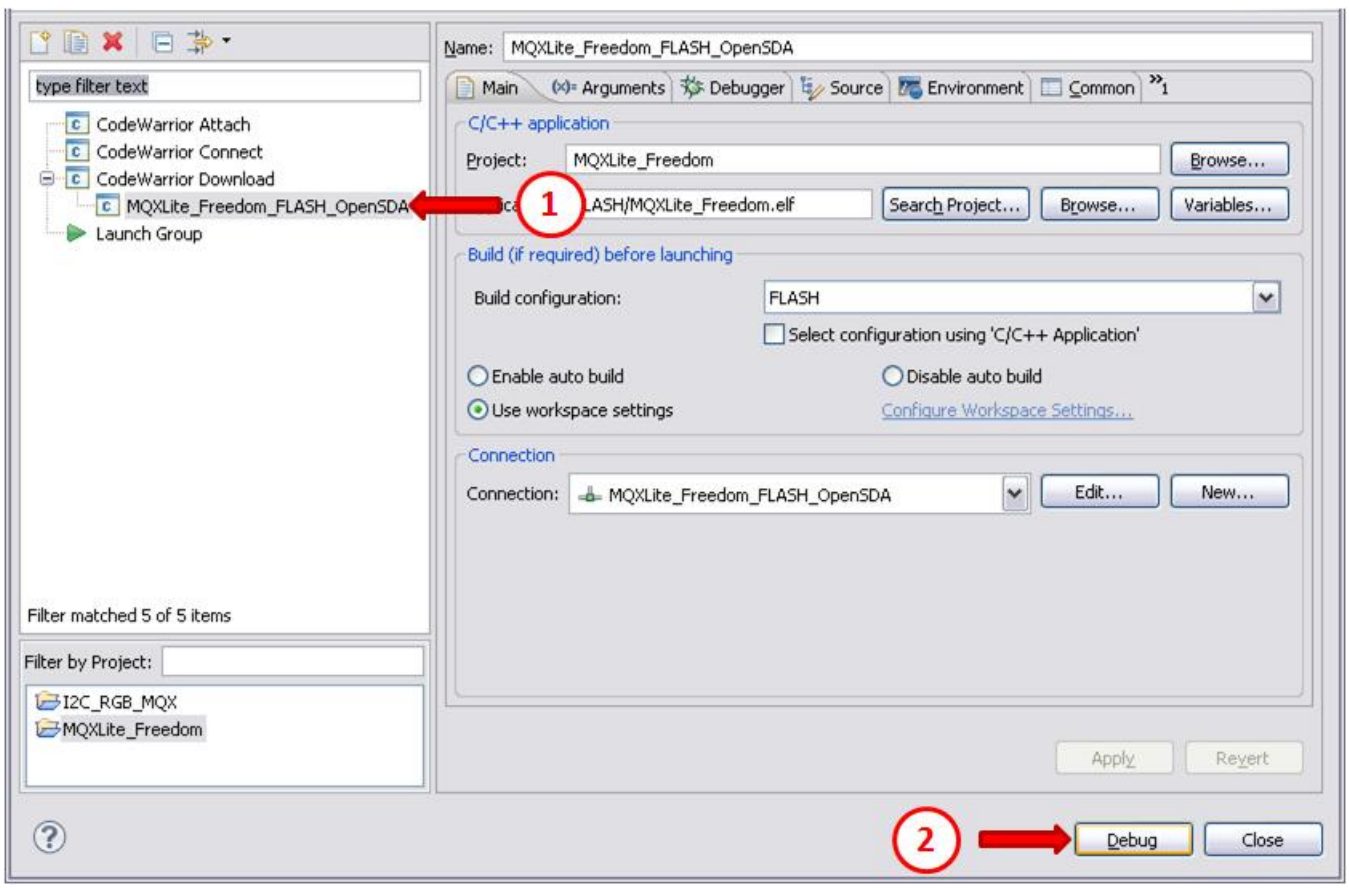


Figure 44. Starting debugging session

3. Here the CodeWarrior perspective view changes and after the source code is downloaded to the board it is able to start the debugging. Figure 45 illustrates a debugging session.

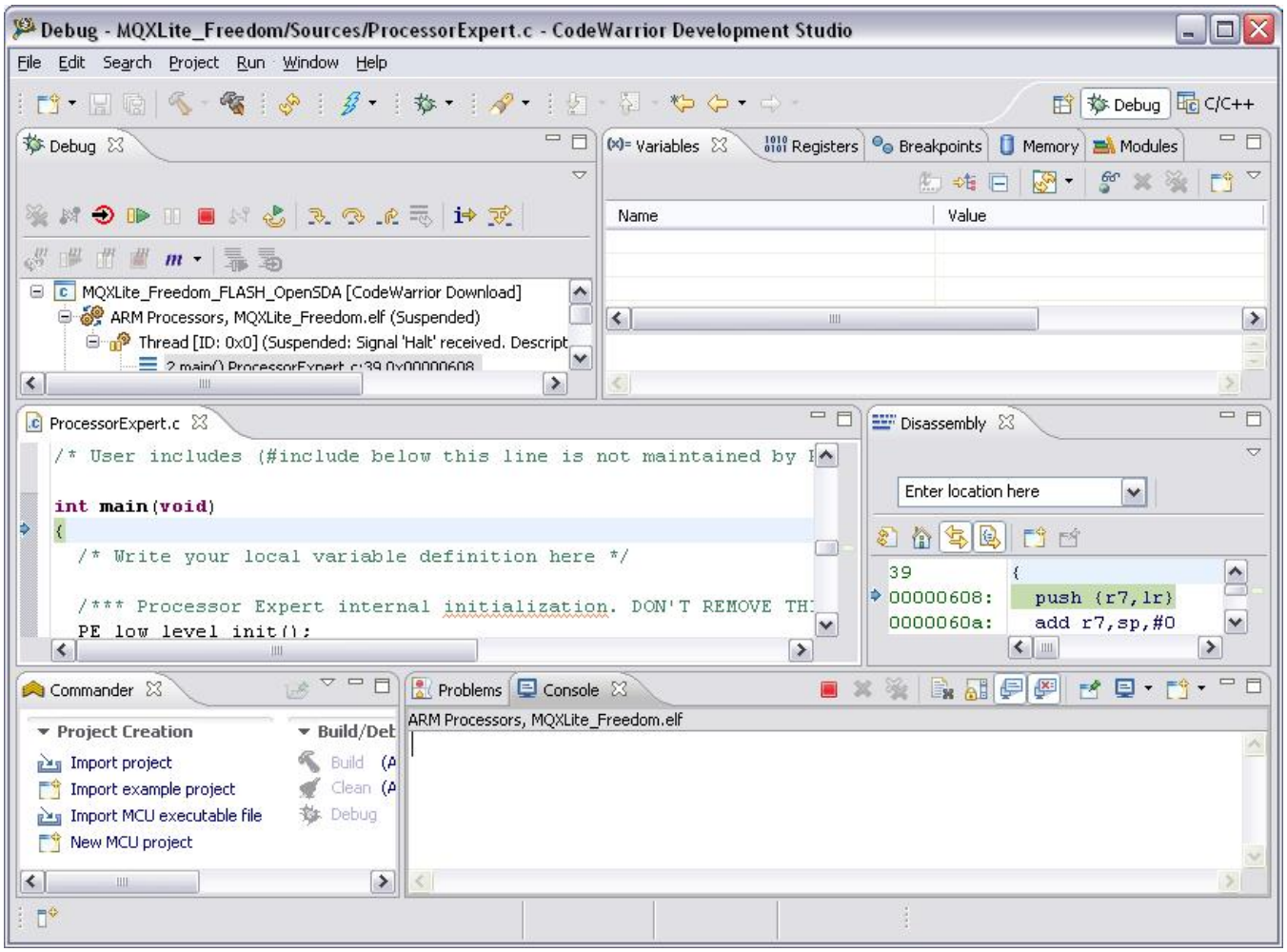


Figure 45. CodeWarrior debugging perspective view

4. At this point it is possible to let the code run free by pressing the F8 key or debug it step-by-step by pressing the F6 key.

7 Conclusion

This document describes the steps needed to start an MQXLite project and make use of the I2C and PWM module from the KL25Z128VLK4 microcontroller (found in the FREEDOM – KL25Z board).

The addition of new components and source code using Processor Expert and MQXLite is simple and fast. This helps to spend less time in the environment tools which allows more time to develop the application architecture.

The introduction of the MQXLite plus the Processor Expert plus the KL25Z board is a key combination for prototyping new products.

Appendix A Events.c

```
/** ###################################################################
**     Filename    : Events.c
**     Project     : ProcessorExpert
**     Processor   : MKL25Z128VLK4
```

```
**     Component   : Events
**     Version     : Driver 01.00
**     Compiler    : GNU C Compiler
**     Date/Time   : 2012-09-11, 22:14, # CodeGen: 0
**     Abstract    :
**         This is a user's event module.
**         Put your event handler code here.
**     Settings    :
**     Contents    :
**         Cpu_OnNMIINT - void Cpu_OnNMIINT(void);
**
** ###################################################################*/
/* MODULE Events */

#include "Cpu.h"
#include "Events.h"
#include "mqx_tasks.h"

/* User includes (#include below this line is not maintained by Processor Expert) */

/*
** ===================================================================
**     Event       :  Cpu_OnNMIINT (module Events)
**
**     Component   :  Cpu [MKL25Z128LK4]
**     Description :
**         This event is called when a Non maskable interrupt has
**         occurred. This event is automatically enabled when the <NMI
**         interrrupt> property is set to 'Enabled'.
**     Parameters  : None
**     Returns     : Nothing
** ===================================================================
*/
void Cpu_OnNMIINT(void)
{
  /* Write your code here ... */
}

/*
** ===================================================================
**     Event       :  IO1_OnBlockReceived (module Events)
**
**     Component   :  IO1 [Serial_LDD]
**     Description :
**         This event is called when the requested number of data is
**         moved to the input buffer.
**     Parameters  :
**         NAME            - DESCRIPTION
**       * UserDataPtr     - Pointer to the user or
**                           RTOS specific data. This pointer is passed
**                           as the parameter of Init method.
**     Returns     : Nothing
** ===================================================================
*/
void IO1_OnBlockReceived(LDD_TUserData *UserDataPtr)
{
  /* Write your code here ... */
}

/*
** ===================================================================
**     Event       :  IO1_OnBlockSent (module Events)
**
**     Component   :  IO1 [Serial_LDD]
**     Description :
**         This event is called after the last character from the
**         output buffer is moved to the transmitter.
**     Parameters  :
**         NAME            - DESCRIPTION
**       * UserDataPtr     - Pointer to the user or
```

```
**                          RTOS specific data. This pointer is passed
**                          as the parameter of Init method.
**     Returns     : Nothing
** ===================================================================
*/
void IO1_OnBlockSent(LDD_TUserData *UserDataPtr)
{
  /* Write your code here ... */
}

/*
** ===================================================================
**     Event       :  PWMTimerRG_OnCounterRestart (module Events)
**
**     Component   :  PWMTimerRG [TimerUnit_LDD]
**     Description :
**         Called if counter overflow/underflow or counter is
**         reinitialized by modulo or compare register matching.
**         OnCounterRestart event and Timer unit must be enabled. See
**         <SetEventMask> and <GetEventMask> methods. This event is
**         available only if a <Interrupt> is enabled.
**     Parameters  :
**         NAME            - DESCRIPTION
**       * UserDataPtr     - Pointer to the user or
**                           RTOS specific data. The pointer passed as
**                           the parameter of Init method.
**     Returns     : Nothing
** ===================================================================
*/
void PWMTimerRG_OnCounterRestart(LDD_TUserData *UserDataPtr)
{
  /* Write your code here ... */
}

/*
** ===================================================================
**     Event       :  PWMTimerRG_OnChannel0 (module Events)
**
**     Component   :  PWMTimerRG [TimerUnit_LDD]
**     Description :
**         Called if compare register match the counter registers or
**         capture register has a new content. OnChannel0 event and
**         Timer unit must be enabled. See <SetEventMask> and
**         <GetEventMask> methods. This event is available only if a
**         <Interrupt> is enabled.
**     Parameters  :
**         NAME            - DESCRIPTION
**       * UserDataPtr     - Pointer to the user or
**                           RTOS specific data. The pointer passed as
**                           the parameter of Init method.
**     Returns     : Nothing
** ===================================================================
*/
void PWMTimerRG_OnChannel0(LDD_TUserData *UserDataPtr)
{
  /* Write your code here ... */
}

/*
** ===================================================================
**     Event       :  I2C_OnMasterBlockSent (module Events)
**
**     Component   :  I2C [I2C_LDD]
**     Description :
**         This event is called when I2C in master mode finishes the
**         transmission of the data successfully. This event is not
**         available for the SLAVE mode and if MasterSendBlock is
**         disabled.
**     Parameters  :
**         NAME            - DESCRIPTION
```

```
**       * UserDataPtr     - Pointer to the user or
**                           RTOS specific data. This pointer is passed
**                           as the parameter of Init method.
**     Returns     : Nothing
** ===================================================================
*/
void I2C_OnMasterBlockSent(LDD_TUserData *UserDataPtr)
{
  /* Write your code here ... */
  TDataState *DataState = (TDataState*)UserDataPtr;
  DataState->Sent = TRUE;
}

void I2C_OnMasterBlockReceived(LDD_TUserData *UserDataPtr)
{
  /* Write your code here ... */
  TDataState *DataState = (TDataState*)UserDataPtr;
  DataState->Received = TRUE;
}

/*
** ===================================================================
**     Event       :  I2C_OnError (module Events)
**
**     Component   :  I2C [I2C_LDD]
**     Description :
**         This event is called when an error (e.g. Arbitration lost)
**         occurs. The errors can be read with GetError method.
**     Parameters  :
**         NAME            - DESCRIPTION
**       * UserDataPtr     - Pointer to the user or
**                           RTOS specific data. This pointer is passed
**                           as the parameter of Init method.
**     Returns     : Nothing
** ===================================================================
*/
void I2C_OnError(LDD_TUserData *UserDataPtr)
{
  /* Write your code here ... */
}

/* END Events */

/*
** ###################################################################
**
**     This file was created by Processor Expert 10.0 [05.02]
**     for the Freescale Kinetis series of microcontrollers.
**
** ###################################################################
*/
```

Appendix B mqx_task.c

```
/** ###################################################################
**     Filename    : mqx_tasks.c
**     Project     : ProcessorExpert
**     Processor   : MKL25Z128VLK4
**     Component   : Events
**     Version     : Driver 01.00
**     Compiler    : GNU C Compiler
**     Date/Time   : 2012-09-12, 23:41, # CodeGen: 3
**     Abstract    :
**         This is user's event module.
**         Put your event handler code here.
**     Settings    :
**     Contents    :
```

```
**         Task1_task - void Task1_task(uint32_t task_init_data);
**
** ###################################################################*/
/* MODULE mqx_tasks */

#include "Cpu.h"
#include "Events.h"
#include "mqx_tasks.h"

/* User includes (#include below this line is not maintained by Processor Expert) */
/* MMA8451Q IOMap */
/* External 3-axis accelerometer data register addresses */
#define OUT_X_MSB 0x01
#define OUT_X_LSB 0x02
#define OUT_Y_MSB 0x03
#define OUT_Y_LSB 0x04
#define OUT_Z_MSB 0x05
#define OUT_Z_LSB 0x06
/* External 3-axis accelerometer control register addresses */
#define CTRL_REG_1 0x2A
/* External 3-axis accelerometer control register bit masks */
#define ACTIVE_BIT_MASK 0x01
#define F_READ_BIT_MASK 0x02

#define ACC_REG_SIZE 1U
#define READ_COUNT 5U

LDD_TDeviceData *I2C_DeviceData = NULL;
TDataState DataState;

LDD_TDeviceData *PWMTimerRG_DeviceData = NULL;
LDD_TDeviceData *PWMTimerB_DeviceData = NULL;

bool ReadAccRegs(LDD_TDeviceData *I2CPtr,
    TDataState *DataState, uint8_t Address, uint8_t RegCount, uint8_t *Buffer)
{
  LDD_I2C_TBusState BusState;
  DataState->Sent = FALSE;
  I2C_MasterSendBlock(I2CPtr, &Address, sizeof(Address), LDD_I2C_NO_SEND_STOP);
  while (!DataState->Sent) {}
  if (!DataState->Sent) {
    return FALSE;
  }
  DataState->Received = FALSE;
  I2C_MasterReceiveBlock(I2CPtr, Buffer, RegCount, LDD_I2C_SEND_STOP);
  while (!DataState->Received) {}
  do {I2C_CheckBus(I2CPtr, &BusState);}
  while (BusState != LDD_I2C_IDLE);
  if (!DataState->Received) {
    return FALSE;
  }
  return TRUE;
}

bool WriteAccRegs(LDD_TDeviceData *I2CPtr,
    TDataState *DataState, uint8_t Address, uint8_t RegCount, uint8_t *Data)
{
  LDD_I2C_TBusState BusState;
  const uint8_t MAX_REG_COUNT = 16;
  uint8_t SendBuffer[MAX_REG_COUNT];

  SendBuffer[0] = Address;
  memcpy(&SendBuffer[1], Data, RegCount);
  DataState->Sent = FALSE;
  I2C_MasterSendBlock(I2CPtr, &SendBuffer, RegCount + 1, LDD_I2C_SEND_STOP);
  while (!DataState->Sent) {}
  do {I2C_CheckBus(I2CPtr, &BusState);}
  while(BusState != LDD_I2C_IDLE);
  if (!DataState->Sent) {
    return FALSE;
```

```
  }
  return TRUE;
}

/*
** ===================================================================
**     Event       :  Task1_task (module mqx_tasks)
**
**     Component   :  Task1 [MQXLite_task]
**     Description :
**         MQX task routine. The routine is generated into mqx_tasks.c
**         file.
**     Parameters  :
**         NAME            - DESCRIPTION
**         task_init_data  -
**     Returns     : Nothing
** ===================================================================
*/
void Task1_task(uint32_t task_init_data)
{
  byte Data;
  LDD_TError Error = 0;
  signed char Color[3] = {0,127,127};  // initialize to turqoise

  printf("Project description:\n");
  printf("I2C example of communication with external accelerometer.\n");
  printf("PWM is used for dimming the RGB LED in dependence on tilt of the board.\n");
  printf("\n");

  // Initialize Accelerometer

  I2C_DeviceData = I2C_Init(&DataState);
  Error = !ReadAccRegs(I2C_DeviceData, &DataState, CTRL_REG_1, ACC_REG_SIZE, &Data);
  if (!Error) {
    Data = (ACTIVE_BIT_MASK | F_READ_BIT_MASK); /* Set active mode bit and fast read mode
bit */
    Error = !WriteAccRegs(I2C_DeviceData, &DataState, CTRL_REG_1, ACC_REG_SIZE, &Data);
  }
  if (!Error) {
    Data = 0;
    Error = !ReadAccRegs(I2C_DeviceData, &DataState, CTRL_REG_1, ACC_REG_SIZE, &Data);
    if (!Error) {
      if (Data != (ACTIVE_BIT_MASK | F_READ_BIT_MASK)) {
        Error = TRUE;
      }
    }
  }
    /* Initialization passed? */
  if (!Error) {
    printf("PASSED.\n");
  } else {
    printf("FAILED.\n");
  }

  if (!Error) {
 printf("Tilt your Freedom Board to change the RGB LED colors.\n");
  }

  PWMTimerRG_DeviceData = PWMTimerRG_Init(NULL);
  PWMTimerB_DeviceData = PWMTimerB_Init(NULL);

  while(1)
  {
    Error = !ReadAccRegs(I2C_DeviceData, &DataState, OUT_X_MSB, 3 * ACC_REG_SIZE, (uint8_t*)
Color);  // Read x,y,z acceleration data.
    if (!Error) {

        PWMTimerRG_Enable(PWMTimerRG_DeviceData);
        PWMTimerB_Enable(PWMTimerB_DeviceData);
        PWMTimerRG_SetOffsetTicks(PWMTimerRG_DeviceData, 0,1000*(1<<(abs(Color[0]/10)))); //
```

```
x axis - red LED
        PWMTimerRG_SetOffsetTicks(PWMTimerRG_DeviceData, 1, 1000*(1<<(abs(Color[1]/
10)))); // y axis - green LED
        PWMTimerB_SetOffsetTicks(PWMTimerB_DeviceData, 0, 1000*(1<<(abs(Color[2]/10)))); //
z axis - blue LED

    }
  _time_delay_ticks(1);
  }

}

/* END mqx_tasks */

/*
** ###################################################################
**
**     This file was created by Processor Expert 10.0 [05.02]
**     for the Freescale Kinetis series of microcontrollers.
**
** ###################################################################
*/
```

Appendix C mqx_tasks.h

```
/** ###################################################################
**     Filename    : mqx_tasks.h
**     Project     : ProcessorExpert
**     Processor   : MKL25Z128VLK4
**     Component   : Events
**     Version     : Driver 01.00
**     Compiler    : GNU C Compiler
**     Date/Time   : 2012-09-12, 23:41, # CodeGen: 3
**     Abstract    :
**         This is user's event module.
**         Put your event handler code here.
**     Settings    :
**     Contents    :
**         Task1_task - void Task1_task(uint32_t task_init_data);
**
** ###################################################################*/

#ifndef __mqx_tasks_H
#define __mqx_tasks_H
/* MODULE mqx_tasks */

#include "PE_Types.h"
#include "PE_Error.h"
#include "PE_Const.h"
#include "IO_Map.h"
#include "CsIO1.h"
#include "IO1.h"
#include "MQX1.h"
#include "SystemTimer1.h"
#include "PWMTimerRG.h"
#include "PWMTimerB.h"
#include "I2C.h"
#include "PE_LDD.h"

typedef struct {
  volatile bool Sent;
  volatile bool Received;
} TDataState;

void Task1_task(uint32_t task_init_data);
/*
** ===================================================================
```

```
**     Event       :  Task1_task (module mqx_tasks)
**
**     Component   :  Task1 [MQXLite_task]
**     Description :
**         MQX task routine. The routine is generated into mqx_tasks.c
**         file.
**     Parameters  :
**         NAME            - DESCRIPTION
**         task_init_data  -
**     Returns     : Nothing
** ===================================================================
*/


/* END mqx_tasks */
#endif /* __mqx_tasks_H*/

/*
** ###################################################################
**
**     This file was created by Processor Expert 10.0 [05.02]
**     for the Freescale Kinetis series of microcontrollers.
**
** ###################################################################
*/
```

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