ECEN 5803- Mastering Embedded System Architecture

Homework set 2 – Practical with the FRDM-KL25Z

Due 2021/09/12

Practical Homework:
In this homework, you will establish 2 development environments for the Freedom KL25Z development kit. The first is a standard PC hosted IDE owned by ARM known as the KEIL MDK. The second is an online compiler supported by ARM known as mBed.

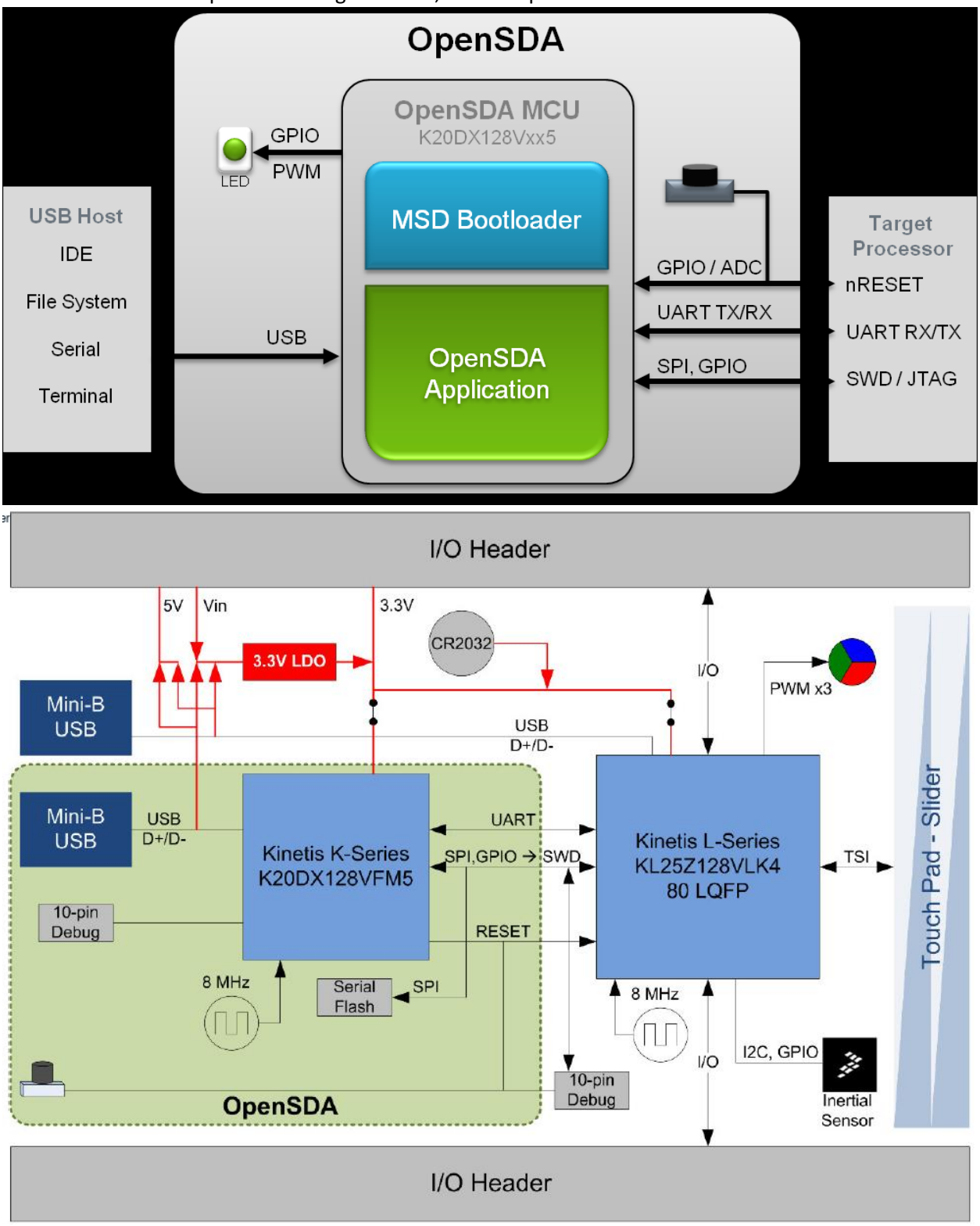
Note: Please Submit screenshots (maximum 5) and the zipped code for grading purposes.

CAUTION: If you have a new FRDM-KL25Z board, you will likely need to update several pieces of software. This can be confusing if you do not keep close track of what you are doing. You must follow the directions precisely. Do not be afraid to ask for help.

By way of background, historically (you know, like 10 or more years ago) microcontroller evaluation boards had a 10 or 20 pin JTAG header that you plugged a cable into with a header connector on one end for the board, and USB on the other. The cable usually included a circuit board that contained a microcontroller that converted USB signals from a PC application or IDE to JTAG commands for the board. One used the JTAG cable to program the MCU FLASH memory, and to launch and debug programs. JTAG cables would cost you $49-$199.
In recent time, the JTAG cable has been removed by including the JTAG cable MCU on the evaluation board. This saves cost, because now an ordinary USB cable can be used instead of a special cable, and there is now 1 board instead of 2 in the debug chain. However, this does complicate the software somewhat. Software you need to be aware of:

1) USB Driver for the evaluation board Debug Interface. This runs on your PC. (Don't laugh, you will see why we need to tell you this in a moment.) You may need to install this manually.
2) USB Driver for the evaluation board Mass Storage Device Bootloader. This runs on the PC, usually auto-installed.
3) USB Driver for the Virtual Serial Port. You won't need this initially, but will eventually. Typically auto-installs, but for some of you it may not.
4) Mass Storage Device (MSD) Bootloader. When you plug the USB cable to the eval board, the eval board will enumerate as a USB thumb drive. You can now copy target demo programs directly to the drive to run them after a board reset. The Bootloader runs on the JTAG MCU on the eval board, the target demos run on the target processor.
5) JTAG MCU Firmware. This provides a run-control debugging interface. More than one type is available, and must be paired with an IDE that is compatible. In the KL25Z case, the MCU is a Kinetis K20 MCU. Freescale provides the PE-Micro debug interface with the board, MBED provides the CMSIS-DAP debug interface. Either will work with the Keil IDE.
6) USB virtual serial port. Converts a UART interface on the target processor to USB serial port, runs on the JTAG MCU.
7) Target Processor Firmware. This can be programmed in the FLASH on the KL25Z processor, or loaded into RAM for a debug session.

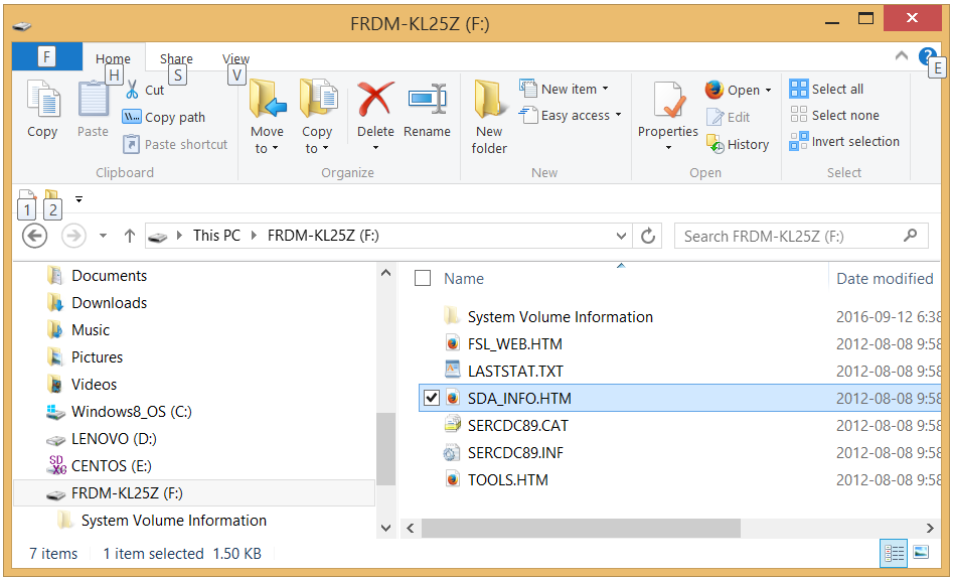
This is known as the OpenSDA debug interface, and is depicted below:



When you first connect your board to the PC, you may see it create a new drive called FRDM-KL25Z: You may also see MBED: as the drive label. New boards will show the FRDM-KL25Z because they come with the Freescale MSD Bootloader; however this doesn't mean you for certain have a new board

because sometimes this Bootloader is reinstalled. If you have a new board, you will likely need to update the JTAG MCU Bootloader, as older versions (1.10 or older) of the PEMicro Bootloader are not compatible with Windows 8 or 10. Here is a definitive way to tell what you have:
If the board drive enumerates as FRDM-KL25Z, the double click on the SDA_INFO.HTM and a browser window will open with the bootloader version number. If the number is less than 1.11 then you need to update the bootloader. If this is the case, see a TA or the instructor for help.

Freescale Board Good Install



Double click on SDA_INFO.HTM to get:

Your Hardware Information

Board Name is: FRDM-KL25Z
MicroBoot Kernel Version is: 1.01
Bootloader Version is: 1.11
Installed Application: PEMicro FRDM-KL25Z Mass Storage/Debug App
Application Version is: 1.14
DUID is: 74823937-473181DF-375AF805-B66DE678
EUID is: 6AE3D036-A84B876D-1859DA22-947668D6
TUID is: 74823938-4732819C-3922E804-A46CDC77
TOA is: 86B6E505-A24C3690-637FDE17-0CFC42C0
TOA2 is: 86B6E505-472B8B3C-16D2E1CF-27FFE868
SUID is: 86B6E505-6C47961D-37239804-8003EC65

Board registered to University of Colorado Boulder.

Not Good looks like this:

Your Hardware Information

Board Name is: FRDM-KL25Z
MicroBoot Kernel Version is: 1.05
Bootloader Version is: 1.09

Application Version is: 0.00
DUID is: 2F533938-97B381BE-37801819-B860E678
EUID is: 27D1A239-15998750-18813A0E-925968D6
TUID is: 74823938-473281A5-375E980F-B85CE678
TOA is: 86B6E505-F4EC35F6-41E6B687-13C314A6
TOA2 is: 86B6E505-8F2592E8-CDE430D7-488BB005
SUID is: 86B6E505-6C47A61D-37239804-8003EC65

I. KEIL MDK SETUP

Q1. This part deals with the installation of KEIL MDK and interfacing the FRDM-KL25Z hardware with KEIL MDK.

- Use the helpful instructions in the Keil Download and InstallationSu2020.docx on Canvas to install KEIL MDK. For hardware setup you may want to see the instructions here: Freedom KL25Z board (http://mbed.org/platforms/KL25Z/). While holding down the RESET button (small button between the USB connectors), plug in the KL25Z board into the connector marked SDA, and it will be recognized as a removable storage device.
- Please Contact a TA for inquiries and doubts.

1. From Canvas, download the word document Lab_Exercise_1.docx and Code1.zip.
2. Unplug and plug in the board again, without holding reset to put it in the normal operational state. Follow the Lab_Exercise_1 directions.
3. In the asm window, what code is listed at address 0x000000000, 0x000000002, and 0x000000004?
4. Choose Reset the CPU. At what address is the program now?
5. Single-Step 2 times. Now what address is the program at?

Q2. This part deals with creating an account in mbed and compiling a program using the online mbed compiler and also running a sample code in the FRDM-KL25Z board.

II. SETUP MBED

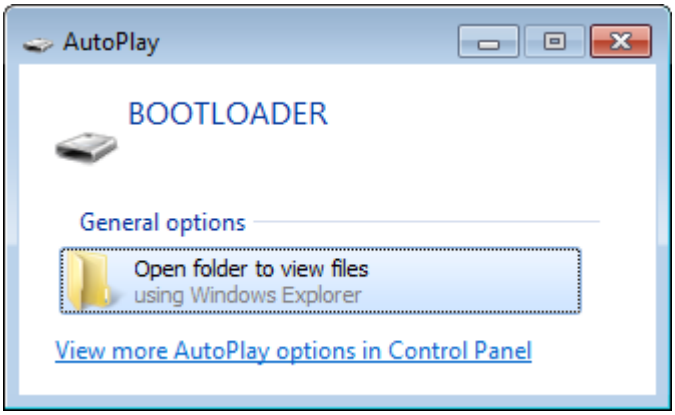
STEP 1

You may need to do a firmware update. The latest MBED firmware version for the FRDM-KL25Z is: **0243**.
To check your firmware version, open the MBED.HTM file on your mbed Microcontroller.
These instructions below explain how to upgrade your firmware.

1. SAVE THE LATEST FIRMWARE IN BOOTLOADER MODE

While **holding down the small button between the USB connectors**, **plug the Freedom board into the connector marked SDA** - the bottom one as shown.

When the FRDM-KL25Z is plugged in this way, it will appear as a disk called BOOTLOADER which you can simply copy the update file (firmware.s19) onto.



BOOTLOADER FIRMWARE UPDATE FOR LINUX, MAC, WINDOWS8+

WARNING! If you are using Linux or Mac or Windows 8 or 10, according to the version of the bootloader of your board, the BOOTLOADER might not appear. If you experience this problem, you have no choice but to use a Linux, Windows 7 or older machine to update the firmware. See a TA or the instructor if this is your situation.

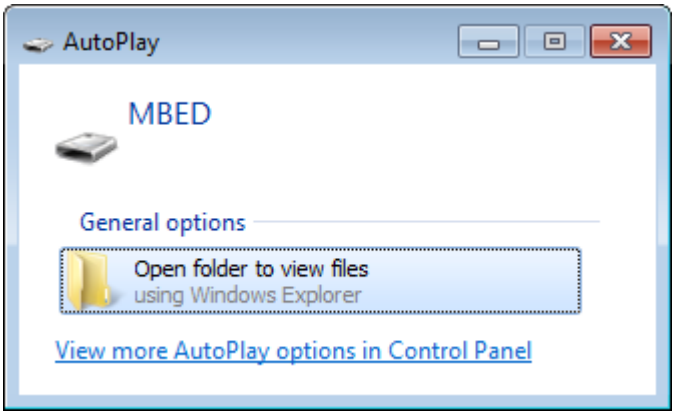
PE Micro has release an update for the bootloader. Version 1.11+ now supports Linux and MAC [here]. Please update your board for cross platform support.

The latest mbed interface upgrade file for the Debug Firmware for the FRDM-KL25Z is 20140530_k20dx128_kl25z_if_opensda which can also be found on Canvas.

Try this first. If you are still experiencing problems after updating the bootloader try updating the mbed interface application via the link above. You can also use the DAPLink interface by copying over the file 0251_k20dx_frdmkl25z_0x8000.bin found on Canvas.

2. POWER CYCLE THE BOARD TO UPDATE THE FIRMWARE

After you have copied on the file onto the FRDM-KL25Z, simply unplug it, and plug it back in again, and the USB disk will appear as an mbed disk (unless you are using the DAPLink file, then it will say DAPlink).



3. FINISHED! (AT LEAST WITH STEP 1)

STEP 2

Note: We are using Mbed version 2 for this exercise. Do not use Mbed versions 5 or 6 or Mbed OS.

MBED FRDM KL25Z GETTING STARTED

GETTING STARTED

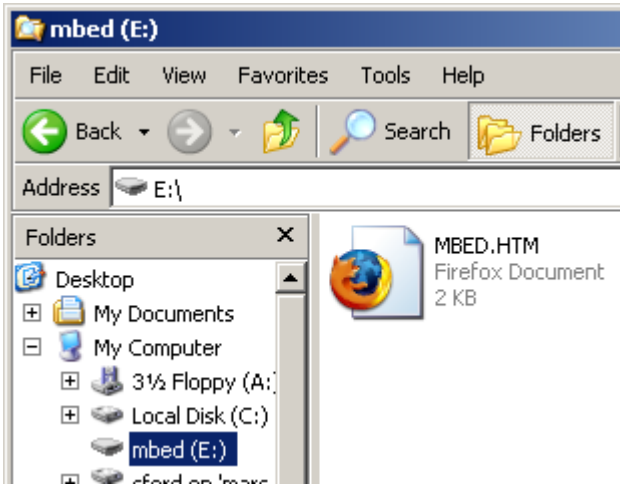
1. **GETTING STARTED**
2. Downloading a Program
3. Creating a Program
4. Communicating with your mbed

See also: mbed FRDM KL25Z Introduction
This guide takes you through mbed-enabling your FRDM-KL25Z board, and getting started with the mbed online tools platform. An mbed-enabled Freedom-KL25Z board gives you:
USB drag and drop programming
USB Virtual COM port for serial terminal
CMSIS-DAP interface for programming and debugging from offline tools
Free access to the mbed online compiler, mbed C/C++ SDK, and developer community
It's really simple to get setup, and it's free, so let's get started!

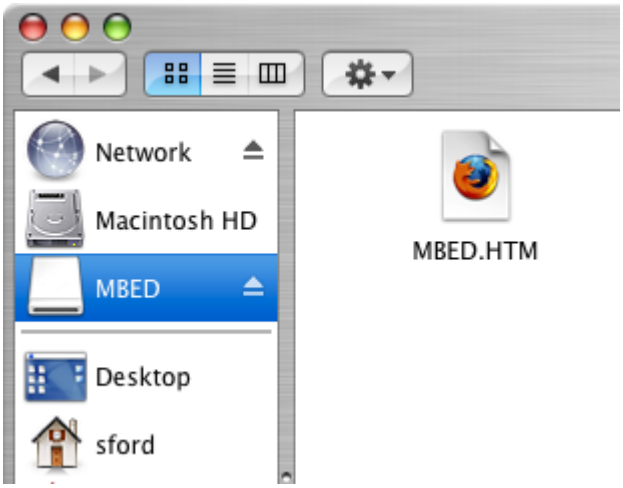
GETTING STARTED WITH MBED

1. CONNECT YOUR MBED-ENABLED FRDM-KL25Z TO A PC

Use the USB lead to connect your KL25Z to a PC, using the USB connector labelled "SDA". The status light will come on, indicating it has power. After a few seconds of activity, the PC will recognize the mbed Microcontroller as a standard USB drive.



WINDOWS XP EXAMPLE



MAC OS X EXAMPLE

2. CLICK THE MBED.HTM LINK TO GET LOGGED IN

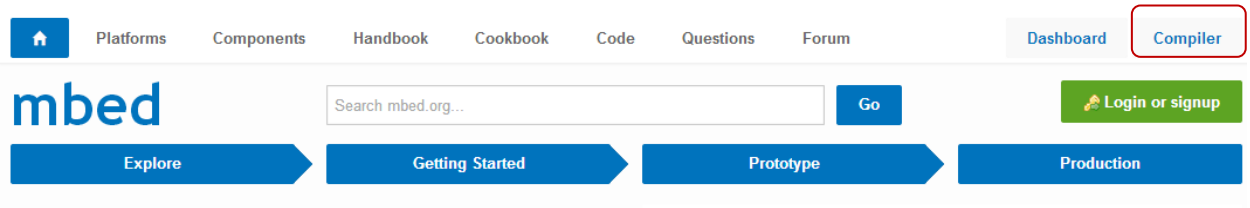
Go to the new USB Drive, and click MBED.HTM to open it in a web browser.
If you do not have an mbed account, choose "Signup", and create your mbed Account. Otherwise, log in with your normal username and password.
This will give you access to the website, tools, libraries and documentation.

Using the mbed Compiler:

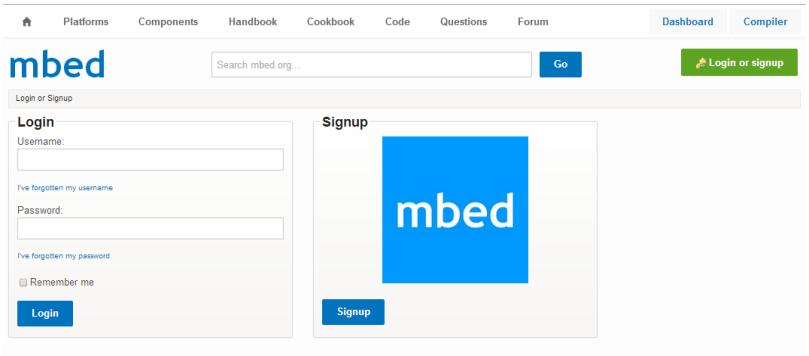
The mbed online Compiler provides a lightweight online C/C++ IDE that is pre-configured to let you quickly write programs, compile and download them to run on your mbed Microcontroller. The mbed online compiler is web based hence you don't have to install or set up anything to get running with mbed.

CREATE YOUR FIRST MBED ONLINE PROJECT

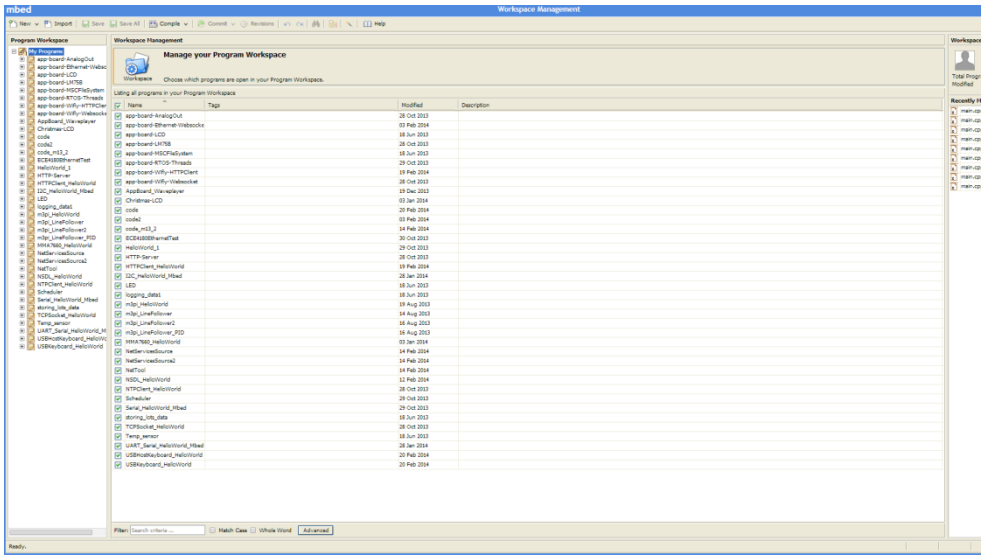
1. Go to mbed.org, and click “compiler”



2. Register an account and then login

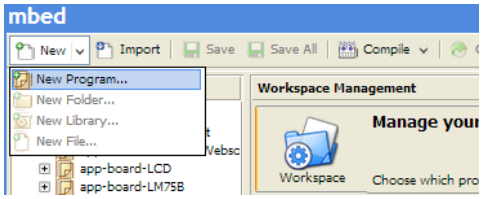


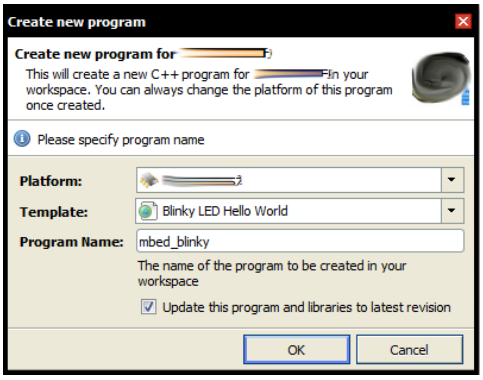
3. The main IDE of mbed online compiler will be displayed



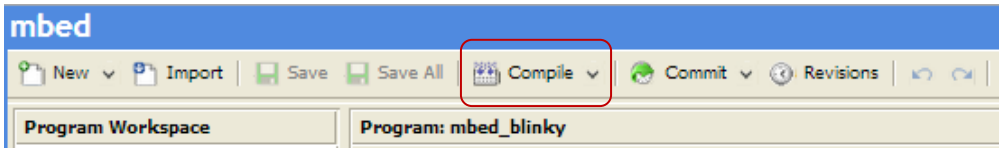
You can select the board by clicking option on the top-right. In our case, we use Freedom KL25Z.

4. Create a helloworld project (blinky LED program)



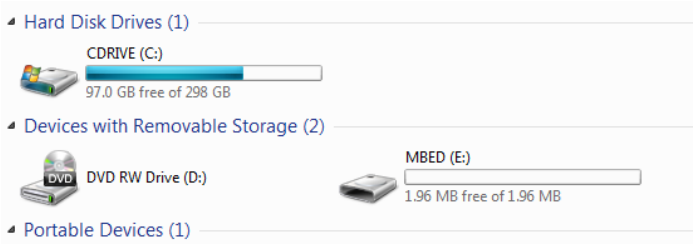


5. Compile the program

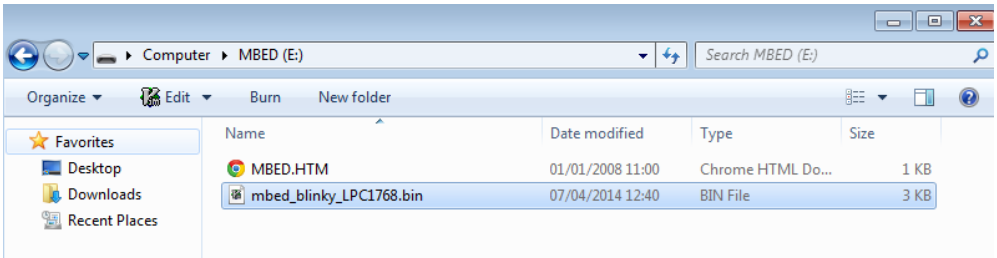


6. The program file will be generated and downloaded to your default download directory (set by your web browser)

7. Connect the BOARD_SERIES board to your PC via an USB cable, the mbed will appear as a removable storage device



8. Copy the downloaded program file to the mbed root directory



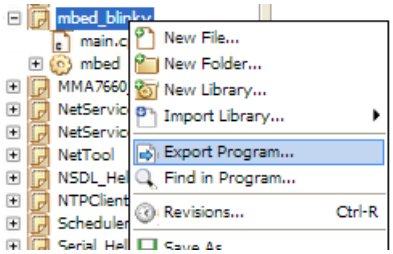
9. Reset the mbed board, the latest copied program file will be the default program to run.

   More detail can be found at https://mbed.org/handbook/mbed-Compiler-Getting-Started
   Note that we are using Mbed 2 – not 5 or 6. Despite it being deprecated 2 actually works better for the things we are going to do.

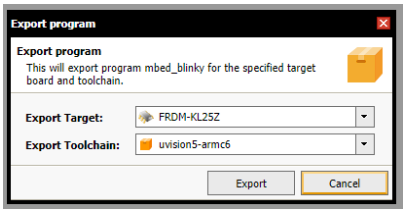
EXPORTING TO OFFLINE TOOLCHAINS

The online project can be exported to offline toolchains, such as Keil MDK in our case.

1. Right click the project and select “export program”



2. Select Keil MDK project, and click “export”, the project folder will be downloaded to your local machine



Note: The local Keil MDK project allows you to download and debug your program (see getting started). In this set of teaching material, all the lab projects have been exported to local Keil MDK project, making it easier for you to start with.

Grading Rubric

Q1) - [10 points]

[4 points] Question 4 of Lab1

[6 points] Question 3 of Q1

Q2) - [10 points]

[4 points] mBed project file

[6 points] Blinky C code