

**ARM<sup>®</sup> Cortex<sup>®</sup>-M**  
**32-bit Microcontroller**

**MuMaker-PFM-M453**  
**User Manual**  
**NuMicro<sup>®</sup> M453 Series**

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## 1 OVERVIEW

This user manual is aimed to give users a fast introduction to the use of ARM® mbed™ and NuMaker-PFM-M453 board.

### 1.1 Introduction to ARM® mbed™

The ARM® mbed™ IoT Device Platform provides the operating system, cloud services, tools and developer ecosystem to make the creation and deployment of commercial, standards-based IoT solutions possible.

The ARM® mbed™ allows IoT devices to collaborate and communicate with each other on the basis of transparency - otherwise each of the devices will not be able to talk to each other or to the cloud. For more detailed information about ARM® mbed™, user can visit the related ARM® mbed™ websites as the follows:

ARM® mbed™ homepage: [www.mbed.com/en/](http://www.mbed.com/en/)

Software homepage: [developer.mbed.org/handbook/Homepage](http://developer.mbed.org/handbook/Homepage)

Official C/C++ SDK: [developer.mbed.org/users/mbed\\_official/code/mbed/](http://developer.mbed.org/users/mbed_official/code/mbed/)

### 1.2 Introduction to NuMaker-PFM-M453 Board

The NuMaker-PFM-M453 is a development board based on a Cortex®-M4 microcontroller (MCU) – M453 series which has very rich peripherals.

This board is provided by Nuvoton and created specially to support the ARM® mbed™ IoT Device Platform, and let user easily to develop the IoT application program on this board. The NuMaker-PFM-M453 also provides user many useful and powerful learning materials for how to develop and verify the application programs through the peripherals and interfaces on MCU and this board.

Furthermore, this board also provides an Arduino UNO compatible interface for user to develop the specific function with any of Arduino modules or kits. Regarding to the Arduino, user can link directly to the Wikipedia website: [en.wikipedia.org/wiki/Arduino](http://en.wikipedia.org/wiki/Arduino) to get more detailed introductions.

The NuMaker-PFM-M453 board consists of M453 Platform and Nu-Link-Me ICE Bridge. Figure 1-1 shows the NuMaker-PFM-M453 board.



Figure 1-1 NuMaker-PFM-M453 Board

The left portion of this board is the M453 Platform that includes the target chip M453 MCU which embedded Cortex<sup>®</sup>-M4 core with DSP extensions and a Floating Point Unit (FPU) and the other related on-board application parts and connectors.

The right portion of this board is a Nu-Link-Me ICE Bridge based on the SWD (Serial Wire Debug) interface connected with the target chip, allowing user to program the application code to the flash of target chip through the USB port from PC Host.

For more information on the NuMaker-PFM-M453 board for the ARM<sup>®</sup> mbed<sup>™</sup> Device Platform, please visit the ARM<sup>®</sup> mbed<sup>™</sup> hardware board website:

[www.mbed.com/en/development/hardware/boards/nuvotontechnology/nuvotonM453/](http://www.mbed.com/en/development/hardware/boards/nuvotontechnology/nuvotonM453/)

### 1.3 M453 Series MCU Features

- M453VG6AE in LQFP100 package
- High performance ARM<sup>®</sup> Cortex<sup>®</sup>-M4F core running up to 72 MHz
- Build-in LDO for wide operating voltage ranged from 2.5 V to 5.5 V
- 256 KB application ROM (APROM)
- 32 Kbytes embedded SRAM
- 4 KB Flash for loader (LDROM)
- External Bus Interface (EBI)
- GPIO
- Peripheral DMA (PDMA)
- Timer (4)
- PWM
- WDT and WWDT
- RTC
- UART (5)
- PS/2 Device
- I2C (2)
- SPI (3)
- I2S (2)
- USB OTG / FS Host / FS Device
- CAN (2)
- Cryptographic Accelerator
- CRC
- ADC (16 x 12bit with mux)
- Comparator
- OP (2)
- DAC (12bit)

For more detailed information about the NuMicro® Family M453 series, please directly visit Nuvoton website:

Nuvoton ARM® Cortex®-M4 MCUs: [www.nuvoton.com/hq/products/microcontrollers/arm-cortex-m4-mcus/?\\_locale=en](http://www.nuvoton.com/hq/products/microcontrollers/arm-cortex-m4-mcus/?_locale=en)

M453 Series Datasheet (DS): [www.nuvoton.com/hq/products/microcontrollers/arm-cortex-m4-mcus/Data-Sheet/?\\_locale=en&resourcePage=Y](http://www.nuvoton.com/hq/products/microcontrollers/arm-cortex-m4-mcus/Data-Sheet/?_locale=en&resourcePage=Y)

M453 Series Technical Reference Manual (TRM): [www.nuvoton.com/hq/products/microcontrollers/arm-cortex-m4-mcus/Technical-Reference-Manual/?\\_locale=en&resourcePage=Y](http://www.nuvoton.com/hq/products/microcontrollers/arm-cortex-m4-mcus/Technical-Reference-Manual/?_locale=en&resourcePage=Y)

#### 1.4 NuMaker-PFM-M453 Board Features

- On board Nu-Link-Me ICE Bridge (Mass storage as USB Disk drive) for drag and drop programming
- Arduino UNO compatible interface
- Audio codec (NAU8822LYG) with Microphone, Line In and Headphone Out
- USB OTG
- 3-axis Accelerometer and 3-axis Gyroscope (MPU6500)
- RS485 transceiver with connectors
- CAN transceiver with connectors
- Two push buttons
- Buzzer
- RGB LED
- Battery for RTC



## 2 NUMAKER-PFM-M453 BOARD OVERVIEW

### 2.1 Front View

Figure 2-1 shows the main components and connectors from the front side of NuMaker-PFM-M453 board.

The following lists components and connectors from the front view:

- Target Chip: M453VG6AE (U1)
- Nu-Link-Me ICE Bridge: ICE Controller NUC12SRE3DE (ICEU2), USB Mini-B connector (ICEJ1) to PC Host
- Audio: Audio Codec NAU8822LYG (U7), Microphone (MIC1), Aux Line In (J2), Headphone (J3)
- Arduino UNO compatible interface connectors (NU1, NU2, NU3, NU4 and NU5)
- USB: USB OTG Micro-AB connector (CON1)
- 3-axis Accelerometer and 3-axis Gyroscope: MPU6500 (U6)
- Push buttons (SW2, SW3)
- Buzzer (BZ1)
- RGB LED (RGBLED2)
- Battery (BT1)

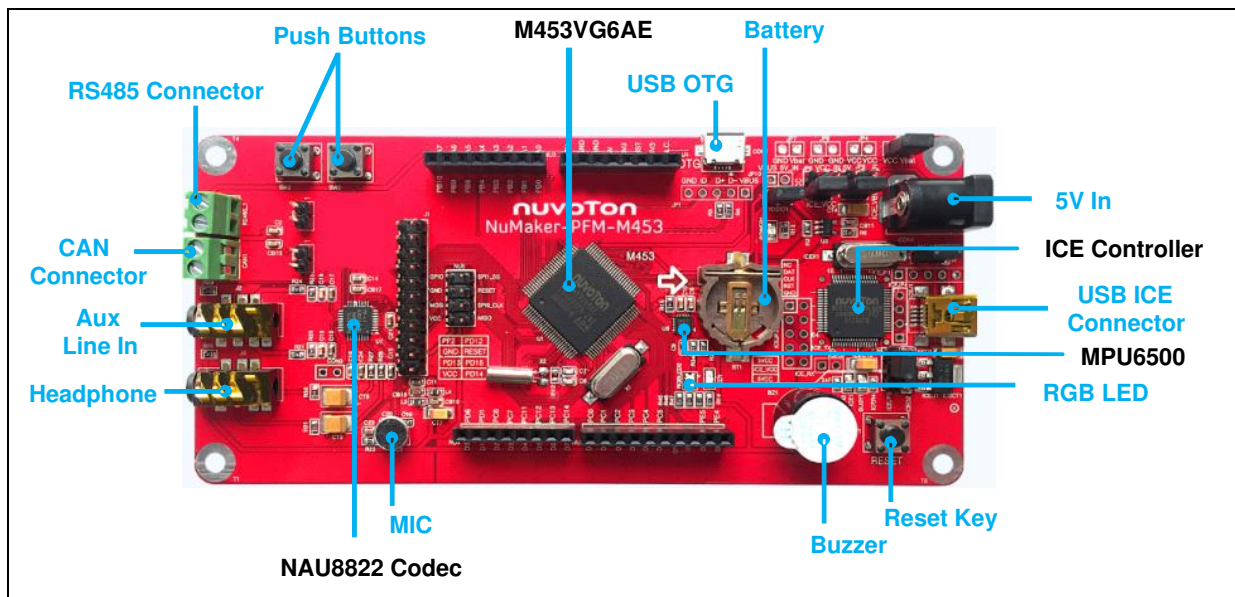


Figure 2-1 Front View of NuMaker-PFM-M453 Board



### 2.3 Arduino UNO Compatible Interface

Figure 2-3 shows the Arduino UNO compatible interface.

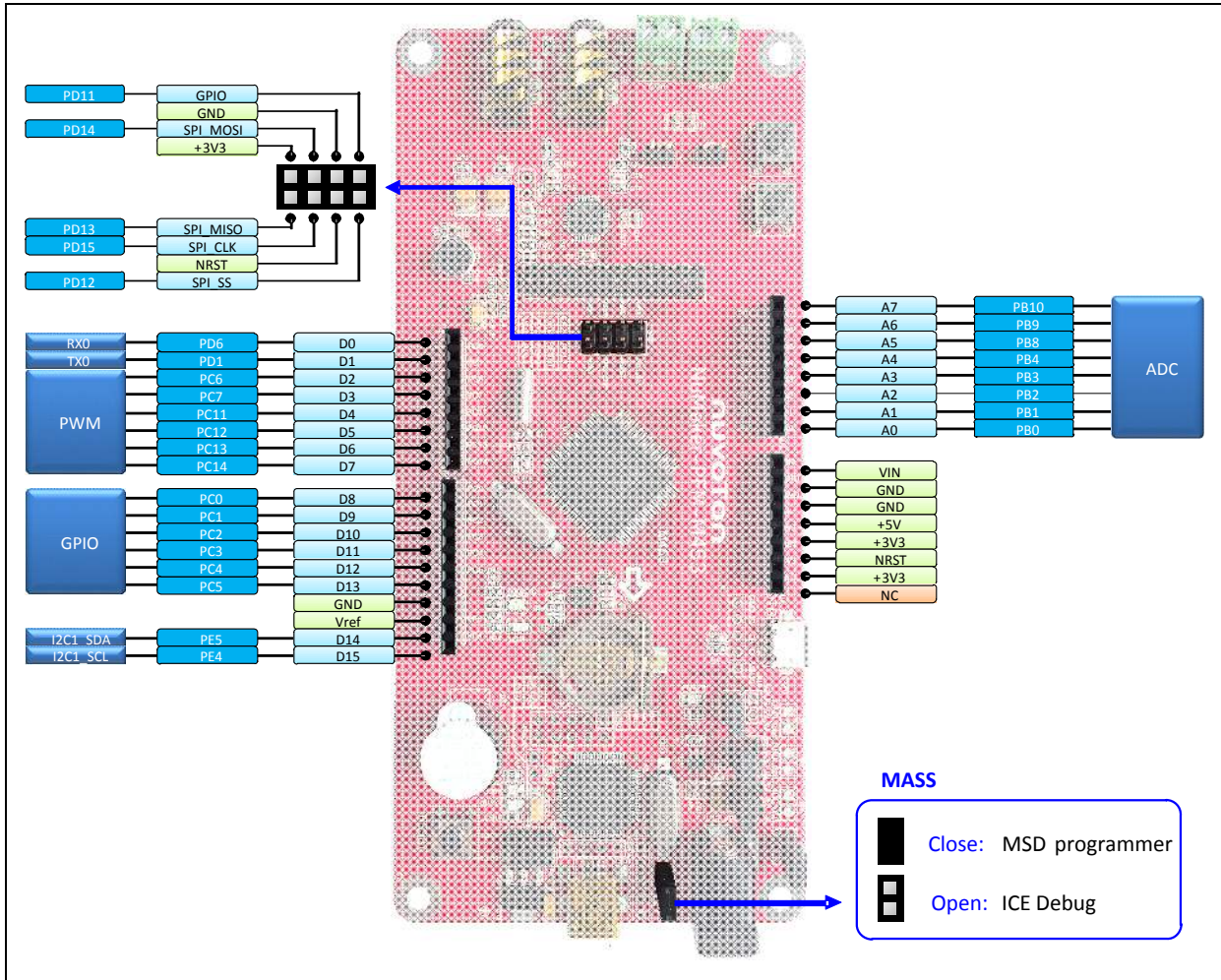


Figure 2-3 Arduino UNO Compatible Interface

| Header     |        | NuMaker-PFM-M453          |                  | Header     |       | NuMaker-PFM-M453          |                  |
|------------|--------|---------------------------|------------------|------------|-------|---------------------------|------------------|
|            |        | Compatible to Arduino UNO | GPIO Pin of M453 |            |       | Compatible to Arduino UNO | GPIO Pin of M453 |
| <b>NU1</b> | NU1.1  | NC                        | NC               | <b>NU4</b> | NU4.1 | ADC0                      | PB.0             |
|            | NU1.2  | VDD                       | VCC              |            | NU4.2 | ADC1                      | PB.1             |
|            | NU1.3  | MCU_RESET                 | RESET            |            | NU4.3 | ADC2                      | PB.2             |
|            | NU1.4  | 3VCC                      | 3VCC             |            | NU4.4 | ADC3                      | PB.3             |
|            | NU1.5  | 5VCC                      | 5VCC             |            | NU4.5 | ADC4                      | PB.4             |
|            | NU1.6  | VSS                       | GND              |            | NU4.6 | ADC5                      | PB.8             |
|            | NU1.7  | VSS                       | GND              |            | NU4.7 | ADC6                      | PB.9             |
|            | NU1.8  | VIN                       | VIN              |            | NU4.8 | ADC7                      | PB.10            |
| <b>NU2</b> | NU2.1  | PWM6                      | PC.0             | <b>NU5</b> | NU5.1 | UART_RX0                  | PD.6             |
|            | NU2.2  | PWM7                      | PC.1             |            | NU5.2 | UART_TX0                  | PD.1             |
|            | NU2.3  | PWM8                      | PC.2             |            | NU5.3 | PWM0                      | PC.6             |
|            | NU2.4  | PWM9                      | PC.3             |            | NU5.4 | PWM1                      | PC.7             |
|            | NU2.5  | PWM10                     | PC.4             |            | NU5.5 | PWM2                      | PC.11            |
|            | NU2.6  | PWM11                     | PC.5             |            | NU5.6 | PWM3                      | PC.12            |
|            | NU2.7  | VSS                       | GND              |            | NU5.7 | PWM4                      | PA.13            |
|            | NU2.8  | VREF                      | VREF             |            | NU5.8 | PWM5                      | PA.14            |
|            | NU2.9  | I2C1_DAT                  | PE.5             |            |       |                           |                  |
|            | NU2.10 | I2C1_SCL                  | PE.4             |            |       |                           |                  |
| <b>NU3</b> | NU3.1  | SPI1_MISO                 | PD.14            |            |       |                           |                  |
|            | NU3.2  | VCC                       | VCC              |            |       |                           |                  |
|            | NU3.3  | SPI1_CLK                  | PD.15            |            |       |                           |                  |
|            | NU3.4  | SPI1_MOSI                 | PD.13            |            |       |                           |                  |
|            | NU3.5  | MCU_RESET                 | RESET            |            |       |                           |                  |
|            | NU3.6  | VSS                       | GND              |            |       |                           |                  |
|            | NU3.7  | SPI1_SS                   | PD.12            |            |       |                           |                  |
|            | NU3.8  | GPIO                      | PD.11            |            |       |                           |                  |

Table 2-1 Arduino UNO Interface Mapping with M453 GPIO

## 2.4 System Configuration

### 2.4.1 Power Settings

- **ICEJ1**: USB Mini-B connector in Nu-Link-Me to program code and supplies 5V power from PC Host.
- **CON1**: USB OTG Micro-AB connector in NuMaker-PFM-M453 to supply 5V power from PC Host when this USB is a device that be decided by the ID pin of OTG cable and this ID pin is low.
- **CON2**: 5V\_IN Power JACK connector in NuMaker-PFM-M453.
- **JP8, JP10**: VDD5V voltage connectors in NuMaker-PFM-M453.

X: Unused.

| Power Model | ICEJ1 USB Port (Mini) | CON1 USB Port (Micro)                     | CON2 DC JACK (5V)    | JP8/JP10 VDD5V | MCU Voltage | Comment   |
|-------------|-----------------------|---|----------------------|----------------|-------------|---|
| Model 1     | Connected to PC       | X   | X                    | DC 5V Output   | DC 3.3 V    | ICEJ1 supplies the power from PC.   |
| Model 2     | X                     | Connected to PC (this USB port is device) | X                    | DC 5V Output   | DC 3.3 V    | CON1 supplies the power from PC.<br><b>Note:</b> JP10 should be shorted 0R, and both pin2 and pin4 of JP8 should be shorted 0R too. |
| Model 3     | X                     | X   | Connected to DC JACK | DC 5V Output   | DC 3.3V     | <b>Note:</b> JP10 should be shorted 0R, and both pin2 and pin4 of JP8 should be shorted 0R too.                                     |

Table 2-2 Power Mode Settings

### 2.4.2 USB Connectors

- **ICEJ1**: USB Mini-B connector (ICE) in Nu-Link-Me that connects to a PC’s USB Host port to program code and supply power.
- **CON1**: USB Micro-AB connector (OTG) in NuMaker-PFM-M453 for USB OTG application use.

### 2.4.3 Arduino UNO Compatible Interface Connectors

- **NU1, NU2, NU3, NU4 and NU5**: Arduino UNO compatible pins in the NuMaker-PFM-M453 board.

### 2.4.4 Buttons

- **SW2, SW3**: Only for application use.
- **SW1**: Reset button to reset the target chip in NuMaker-PFM-M453.

#### 2.4.5 Power Connectors

- **VCC**: VCC connector in the NuMaker-PFM-M453 board.
- **GND**: GND connector in the NuMaker-PFM-M453 board.

## 2.5 PCB Placement

Figure 2-4 and Figure 2-5 show the front and back placement of NuMaker-PFM-M453 board.

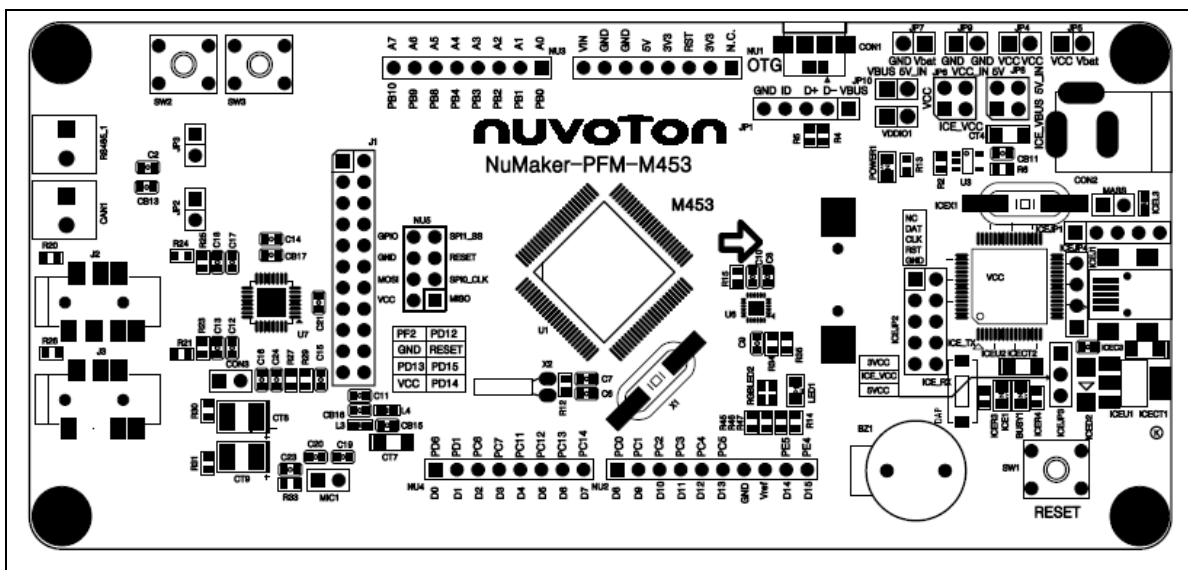


Figure 2-4 Front Placement

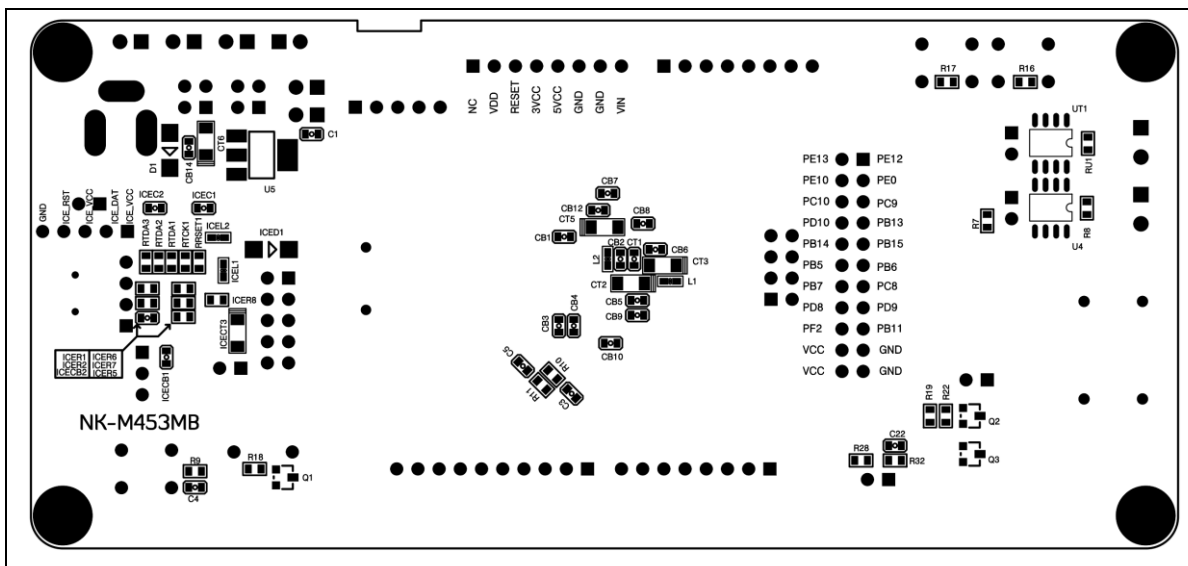


Figure 2-5 Back Placement



### 3 GETTING STARTED

This chapter describes the steps of using the NuMaker-PFM-M453 board.

#### 3.1 Connect to the PC Host

Connect the USB Mini-B port (ICEJ1) in Nu-Link-Me to the PC Host as Figure 3-1. The PC Host will supply 5V power to this NuMaker-PFM-M453 board and recognize this board as USB composite device named as Nu-Link which has both Mass Storage and Virtual COM (VCOM) Port functions. The Mass Storage function is easy for user to program the bin file to the flash of target chip and user just only drags and drops the bin file to this Mass Storage disk to update program. The VCOM port function is used to print some messages on PC API, like Tera Term, through the standard UART protocol to help user to debug program.

User can check the device status from the “Devices and Printers” or “Device Manager” in your “Computer” of OS as shown in Figure 3-2.

After connecting successfully with PC Host, your PC will add-in an extra disk named as “MBED”, as shown in Figure 3-3.

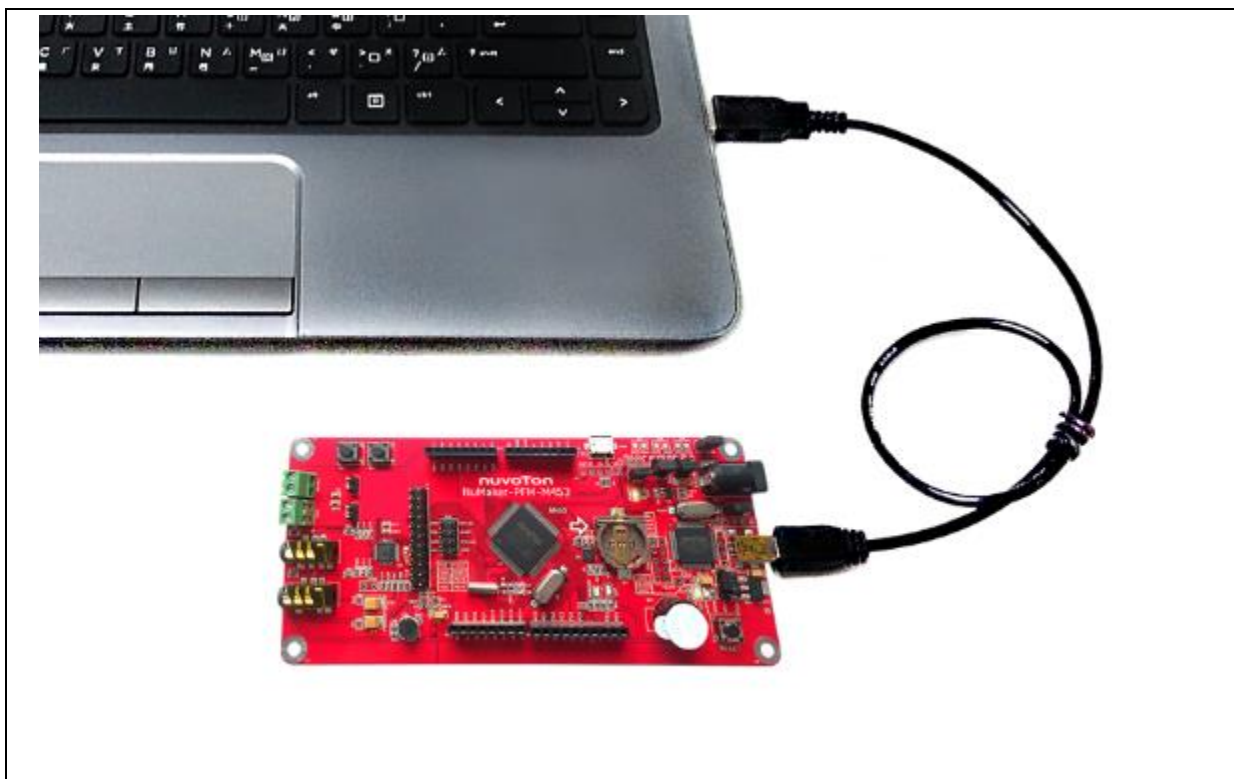


Figure 3-1 Connect to PC Host



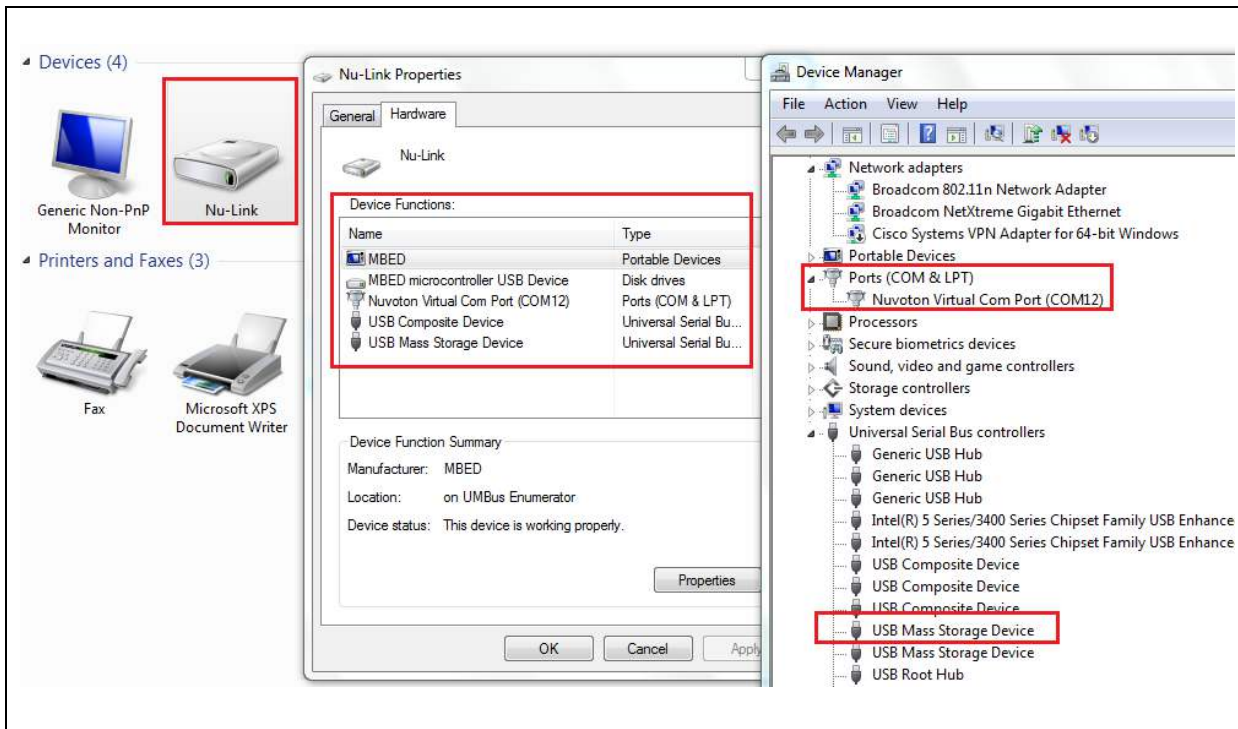


Figure 3-2 Nu-Link in “Devices and Printers” and “Device Manager”

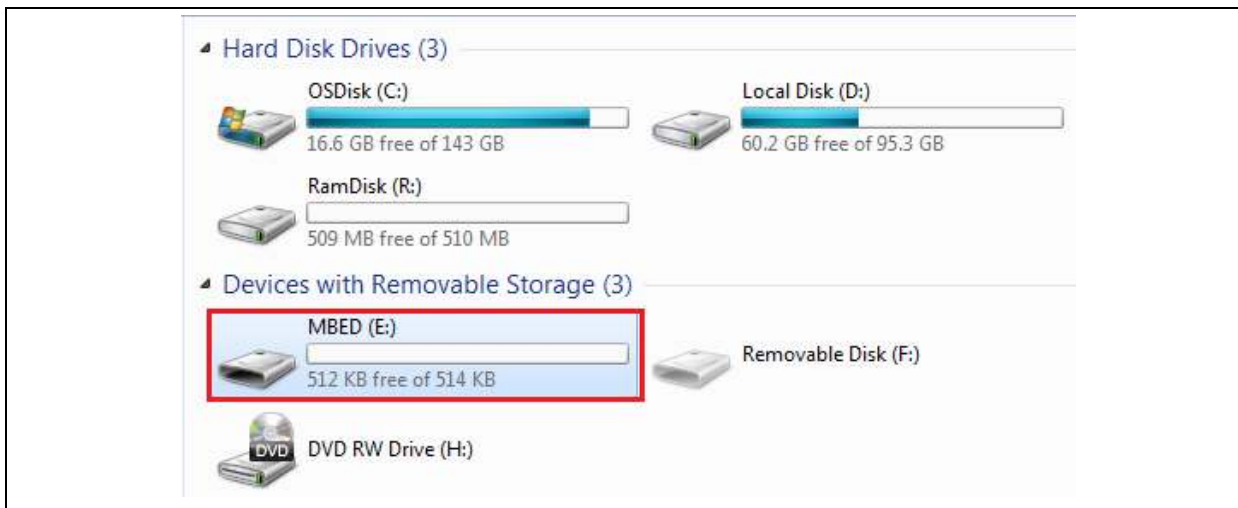


Figure 3-3 “MBED” Disk

### 3.2 Confirm Your PC can Access the Internet

The ARM<sup>®</sup> mbed<sup>™</sup> platform provides free and online compiler for all users. User must firstly confirm own PC can access the Internet unlimitedly.

### 3.3 Login the ARM® mbed™

User can double-click the “mbed.htm” in the MBED disk as shown in Figure 3-4 to link or directly link ([developer.mbed.org/account/login](http://developer.mbed.org/account/login)) to the ARM® mbed™ login web-page as shown in Figure 3-5.

If you have an account created before, please login your account directly. Otherwise, choose the “Signup” icon to create a new account to register the ARM® mbed™ platform as Figure 3-6.

After logging in the ARM® mbed™ platform, user will see as the contents as shown in Figure 3-7.

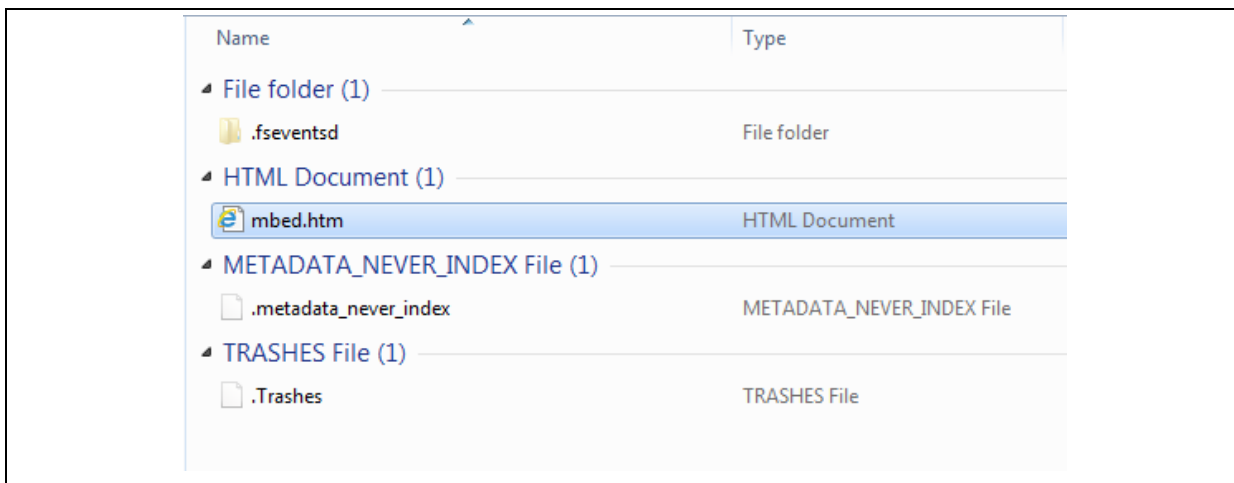


Figure 3-4 Contents in “MBED” Disk

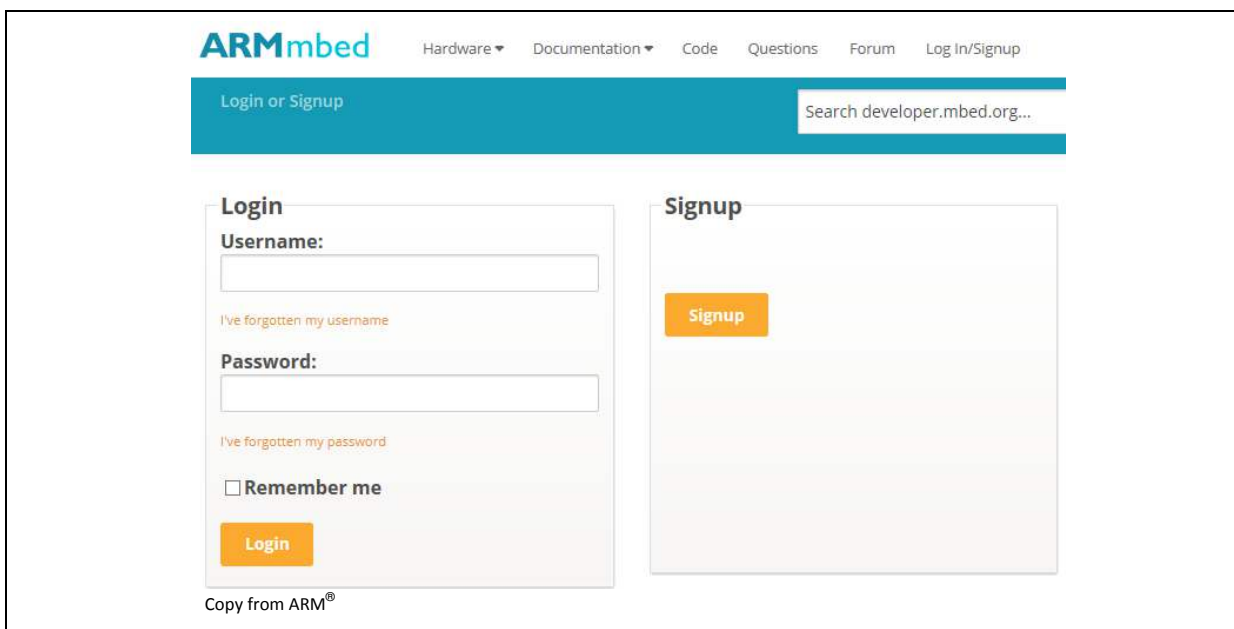


Figure 3-5 Login Web-page in ARM® mbed™

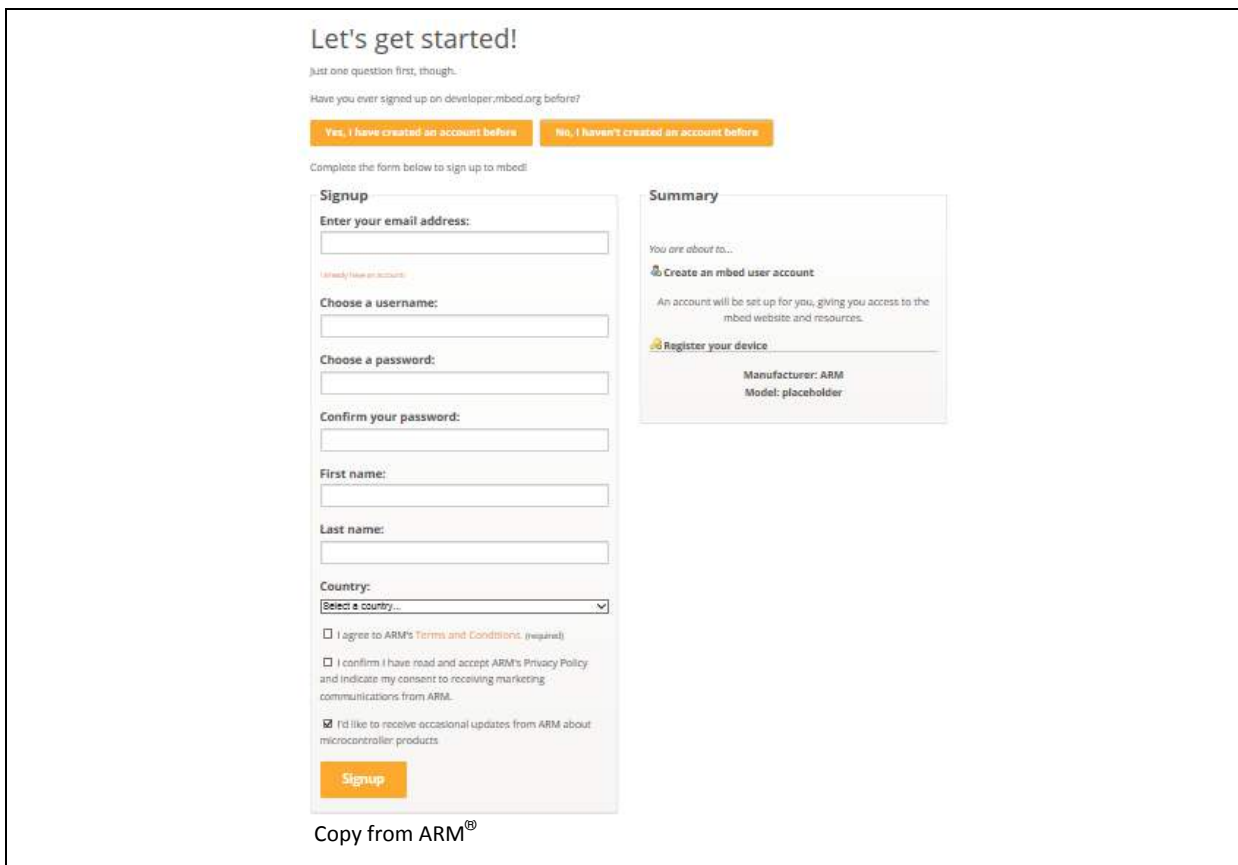


Figure 3-6 Signup to Create A New Account

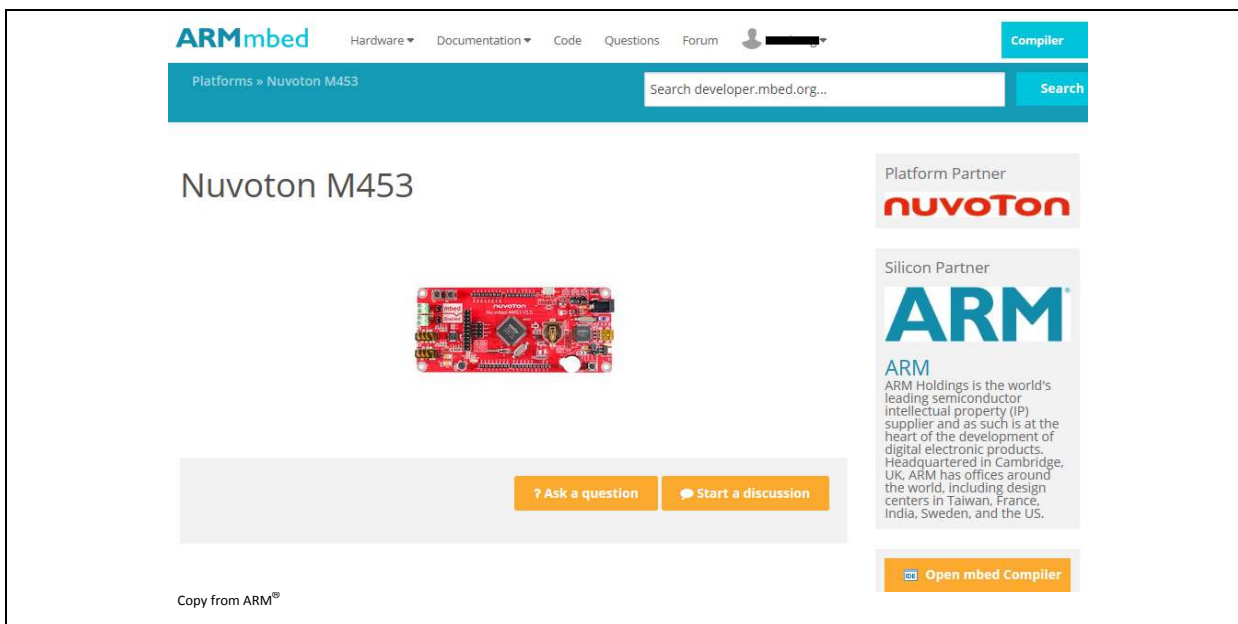


Figure 3-7 Log in ARM® mbed™ on M453

### 3.4 Open Mbed Compiler

To open the free and on-line mbed Compiler as shown in Figure 3-8, user can import a program or create a new one to develop the specific application based on the NuMaker-PFM-M453 board.

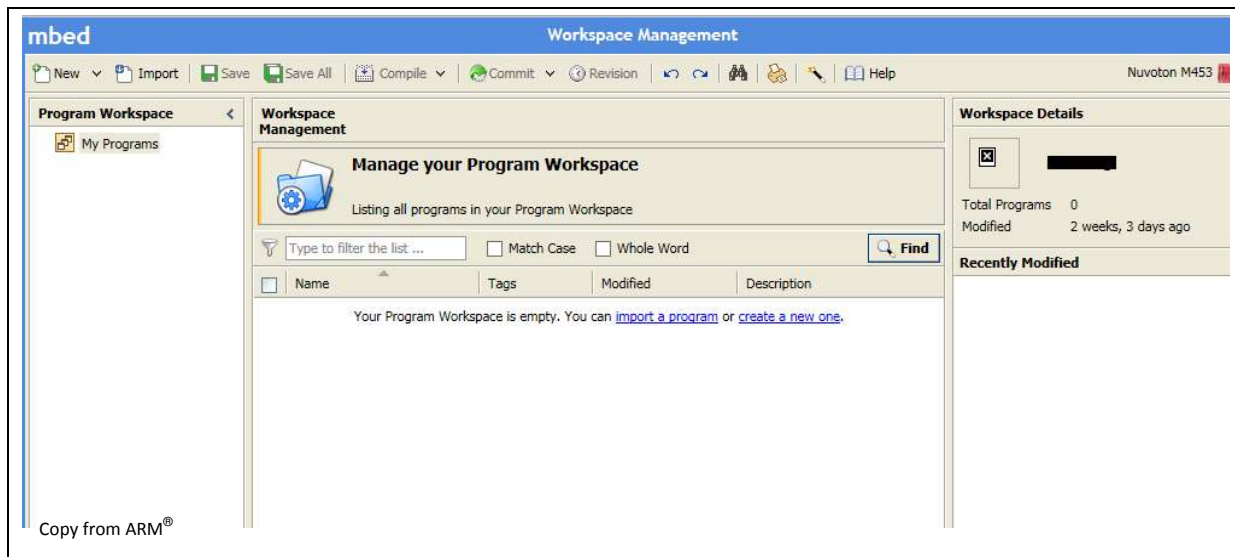


Figure 3-8 ARM® mbed™ Compiler Based on M453

### 3.5 Compile Program

User can click the “Compile” icon to compile the program on-line and check the compile results and fix the errors if needed.

### 3.6 Download Program

User just needs to drag and drop the bin file to the “MBED” disk to program the flash of target chip on the NuMaker-PFM-M453 board.

### 3.7 Run Program

User can press the RESET button (SW1) to reset the target chip and run the program freely on the NuMaker-PFM-M453 board.

### 3.8 Debug Program

User can write some printf() functions to show messages in the program to debug the program. The Nu-Link-Me ICE Bridge also supports the VCOM Port function to print some messages on PC API, like Tera Term, through the standard UART protocol.

## 4 NUMAKER-PFM-M453 SCHEMATICS

### 4.1 M453 Series MCU

Figure 4-1 shows the pin assignment of the M453 series MCU.

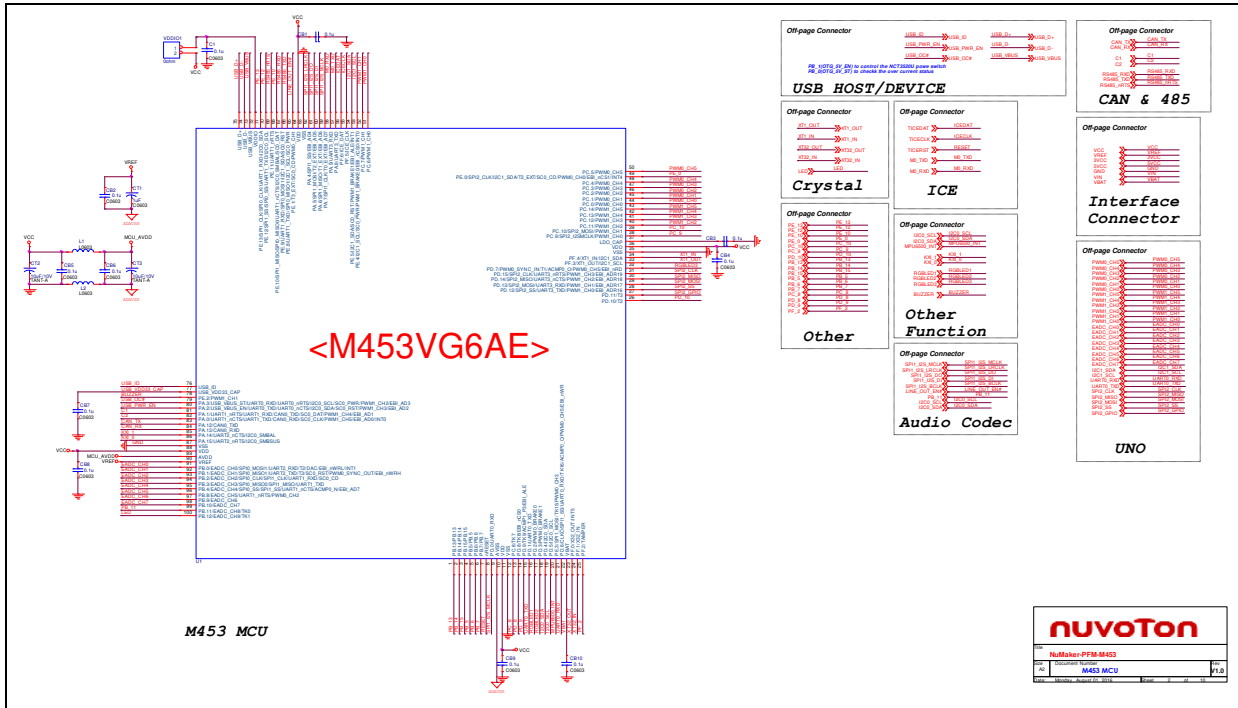


Figure 4-1 M453 Series Pin Assignment

### 4.2 Nu-Link-Me

Figure 4-2 shows the Nu-Link-Me circuit which is a USB-to-SWD bridge used to program code to the target chip.

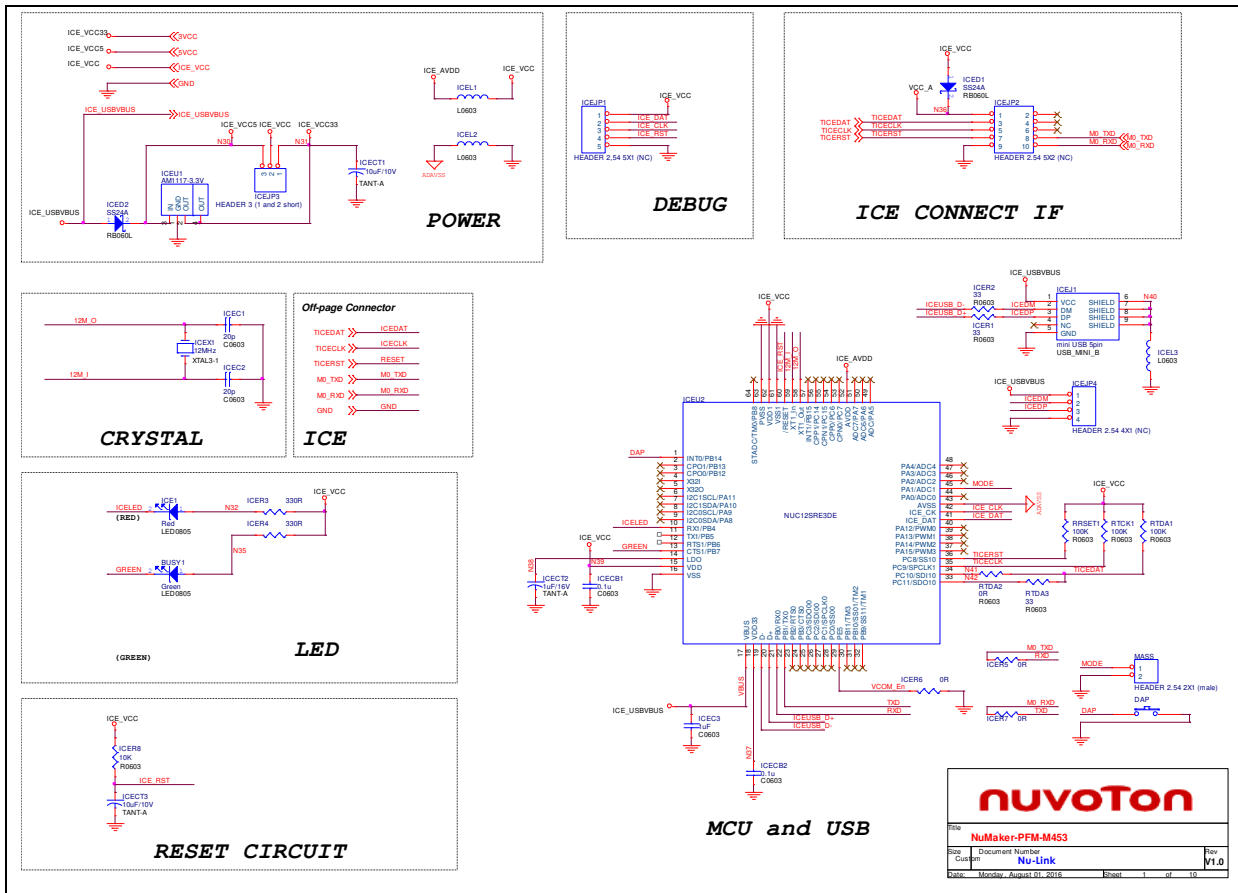


Figure 4-2 Nu-Link-Me Circuit

### 4.3 Power Supply

Figure 4-3 shows power configurations of NuMaker-PFM-M453 board.

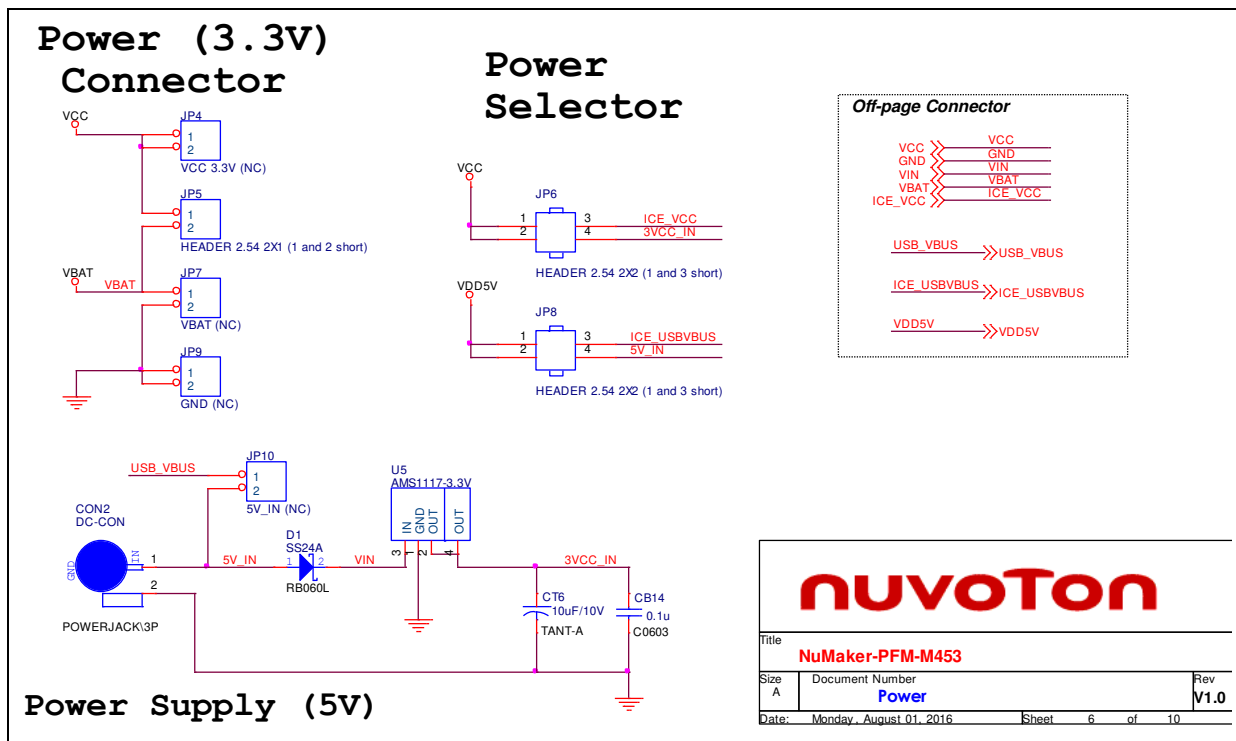


Figure 4-3 Power Circuit and Configurations

### 4.4 Arduino UNO Compatible Interface

Figure 4-4 shows the Arduino UNO compatible interface of NU1~5 connectors.

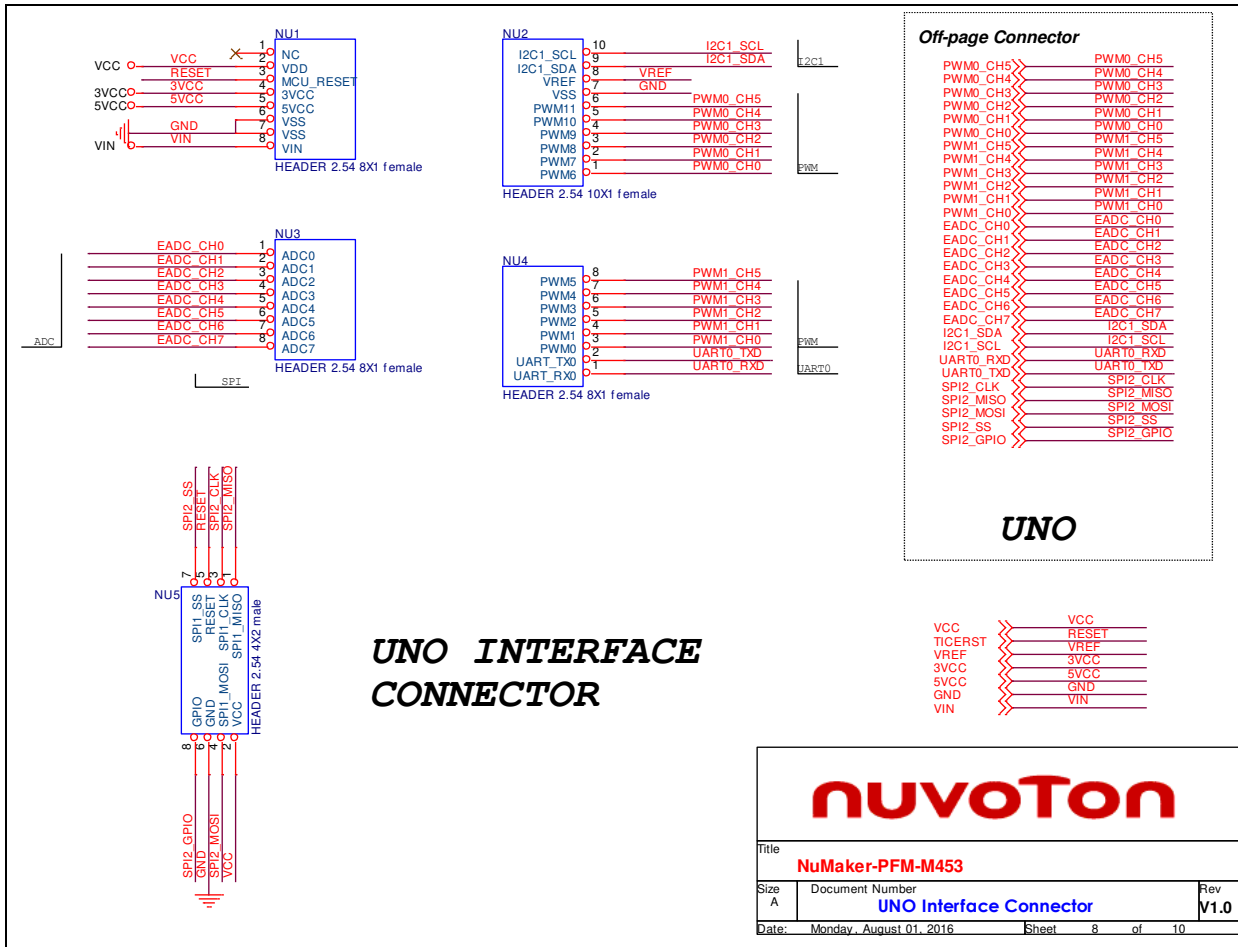


Figure 4-4 Arduino UNO Compatible Interface



### 4.5 Reset

Figure 4-5 shows the reset circuit for the M453 series MCU.

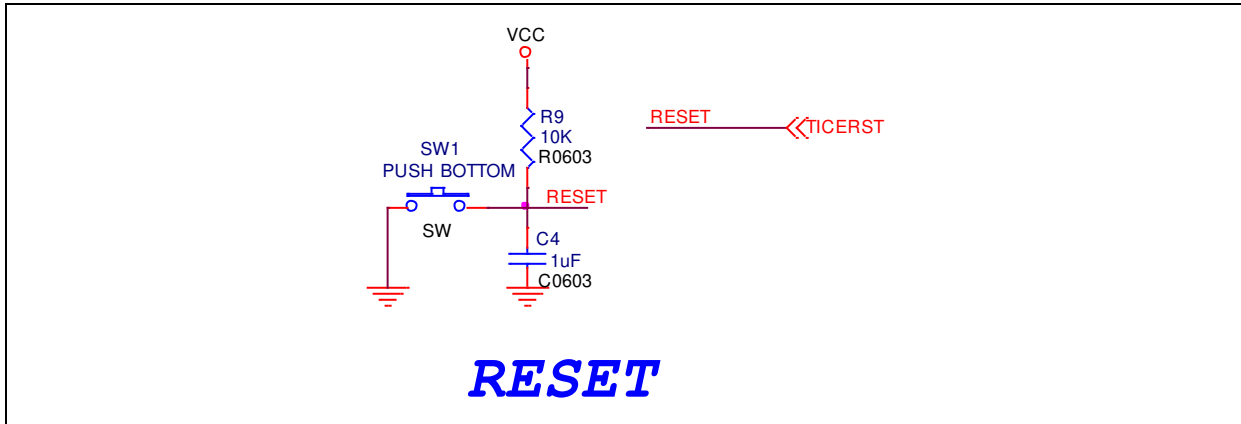


Figure 4-5 Reset Circuit

### 4.6 Crystal

Figure 4-6 shows two external crystal circuits for the M453 series MCU.

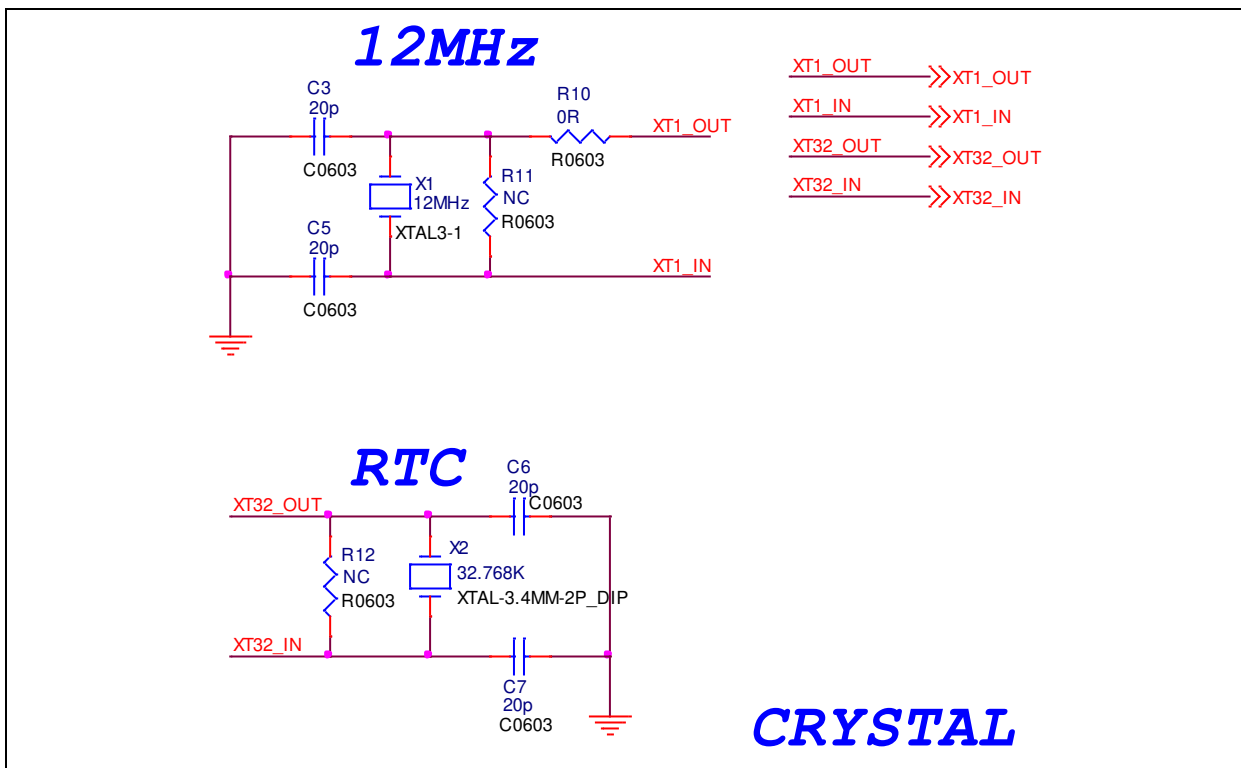


Figure 4-6 External Crystal Circuit

### 4.7 Battery

Figure 4-7 shows the battery circuit for the M453 series MCU.

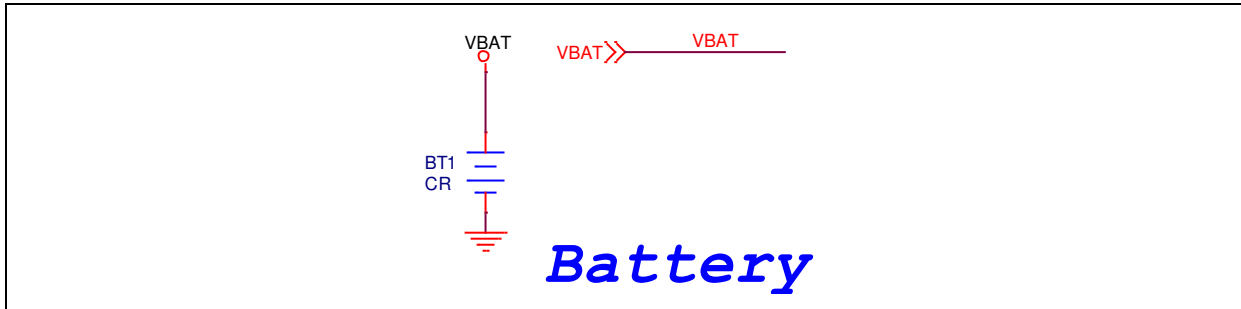


Figure 4-7 Battery Circuit

### 4.8 LED

Figure 4-8 shows the power LED and an IO LED that be controlled by GPIO PB.12 pin of the M453 series MCU.

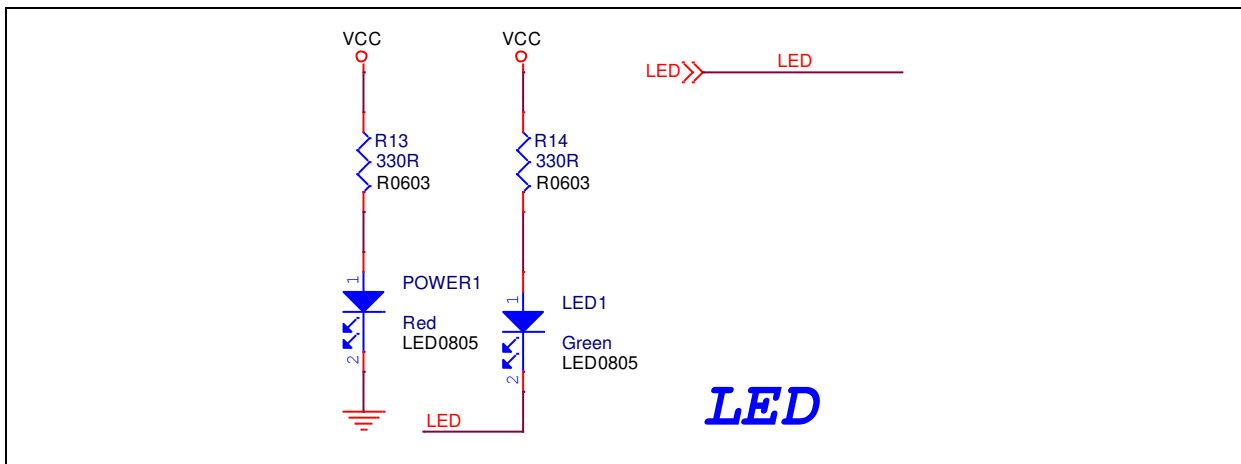


Figure 4-8 Power LED and IO LED Circuit

### 4.9 RGB LED

Figure 4-9 shows the RGB LED circuit for the M453 series MCU.

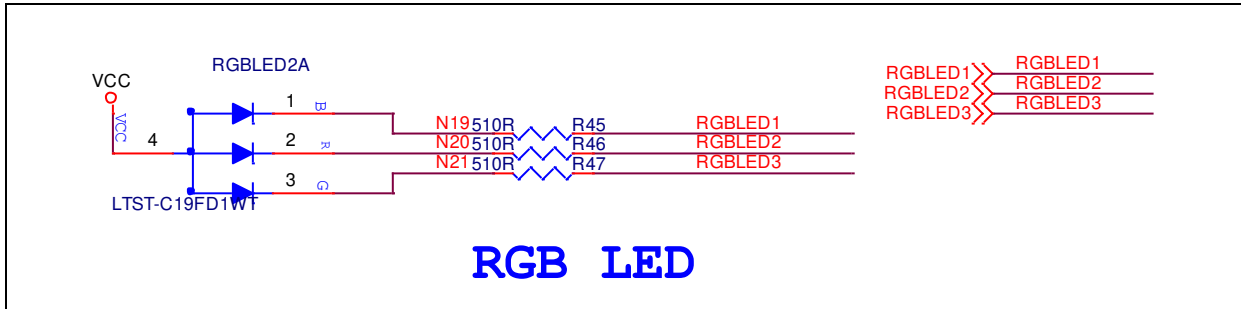


Figure 4-9 RGB LED Circuit

### 4.10 Push Buttons

Figure 4-10 shows the push buttons circuit for the M453 series MCU.

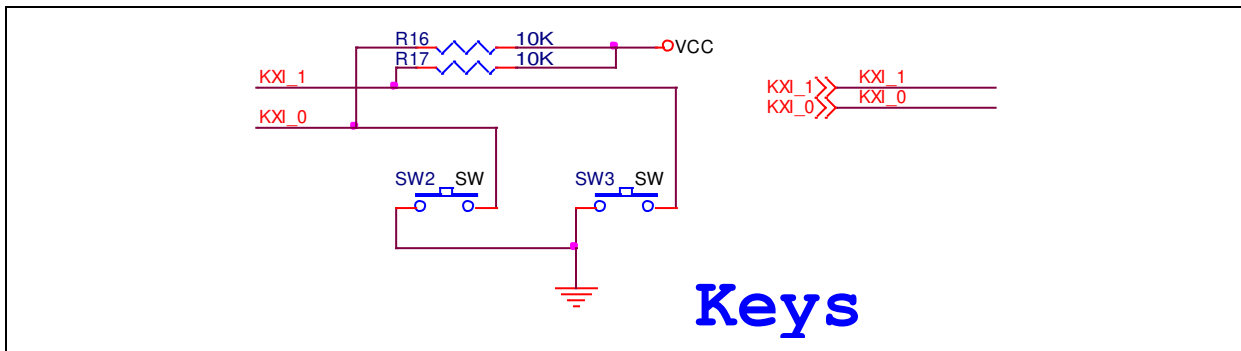


Figure 4-10 Push Buttons Circuit

### 4.11 Buzzer

Figure 4-11 shows the buzzer circuit for the M453 series MCU.

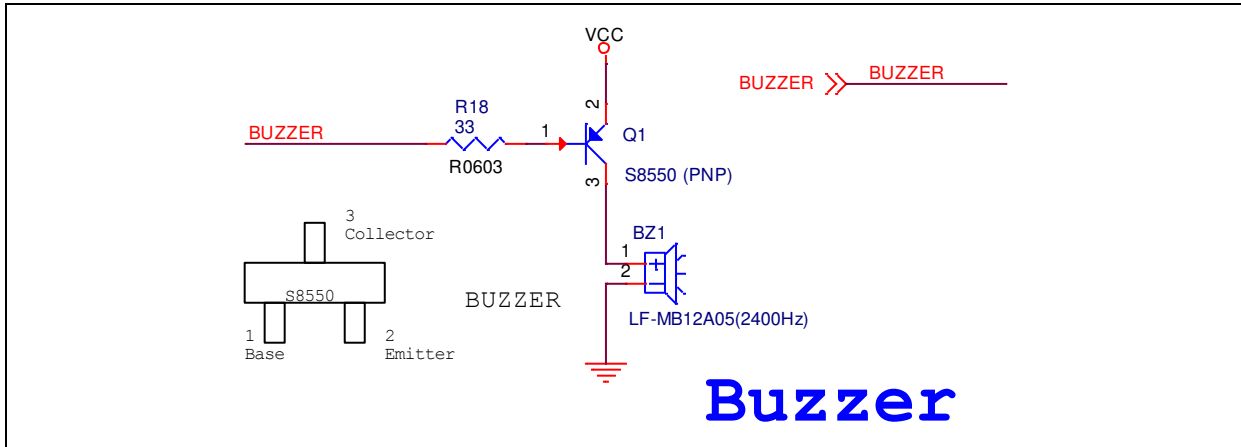


Figure 4-11 Buzzer Circuit

### 4.12 USB OTG

Figure 4-12 shows the USB OTG circuit for the M453 series MCU.

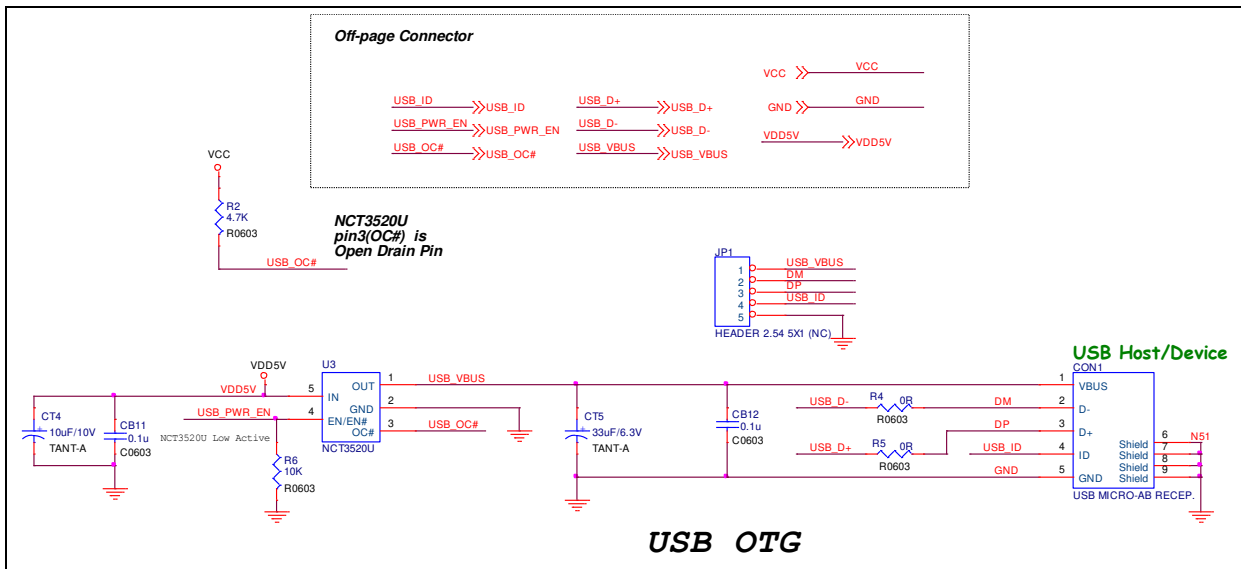


Figure 4-12 USB OTG Circuit

### 4.13 RS-485

Figure 4-13 shows the RS-485 interface circuit and connectors for the M453 series MCU.

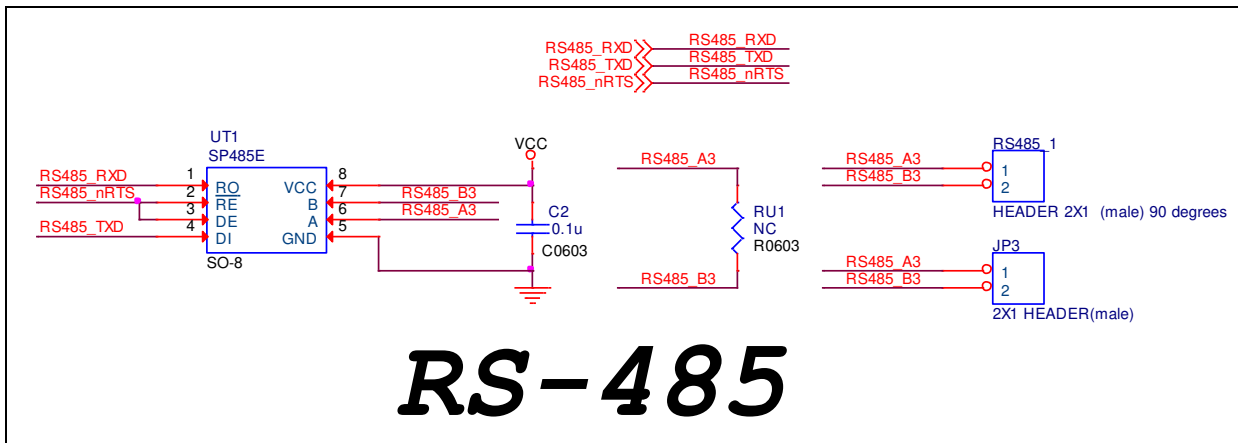


Figure 4-13 RS-485 Circuit and Connectors

### 4.14 CAN

Figure 4-14 shows the CAN interface circuit and connectors for the M453 series MCU.

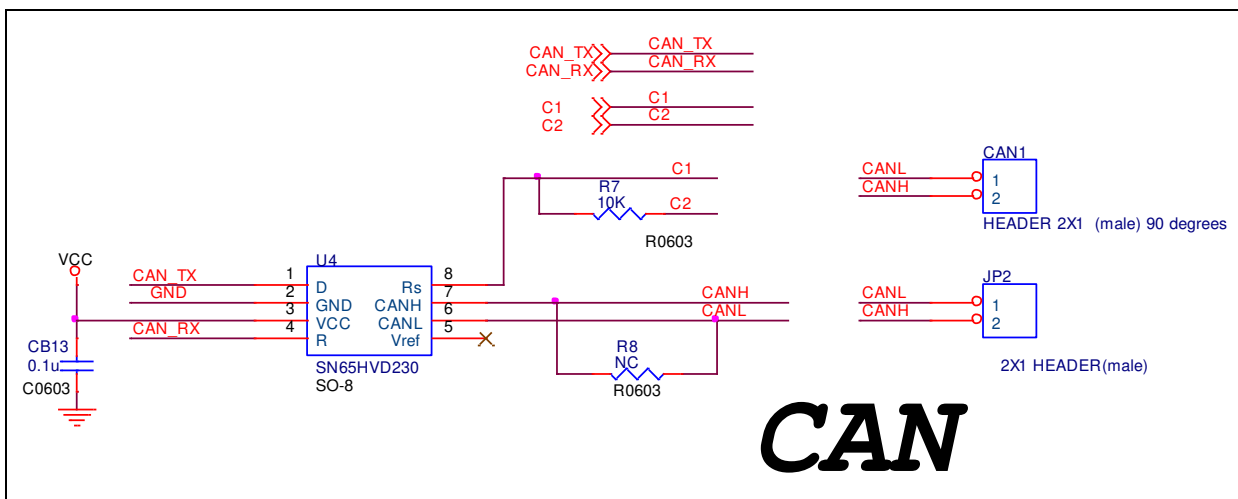


Figure 4-14 CAN Circuit and Connectors

### 4.15 24-bit Stereo Audio Codec

Figure 4-15 shows the audio codec application circuit based on NAU8822L to simplify implementation of complete audio system solutions.

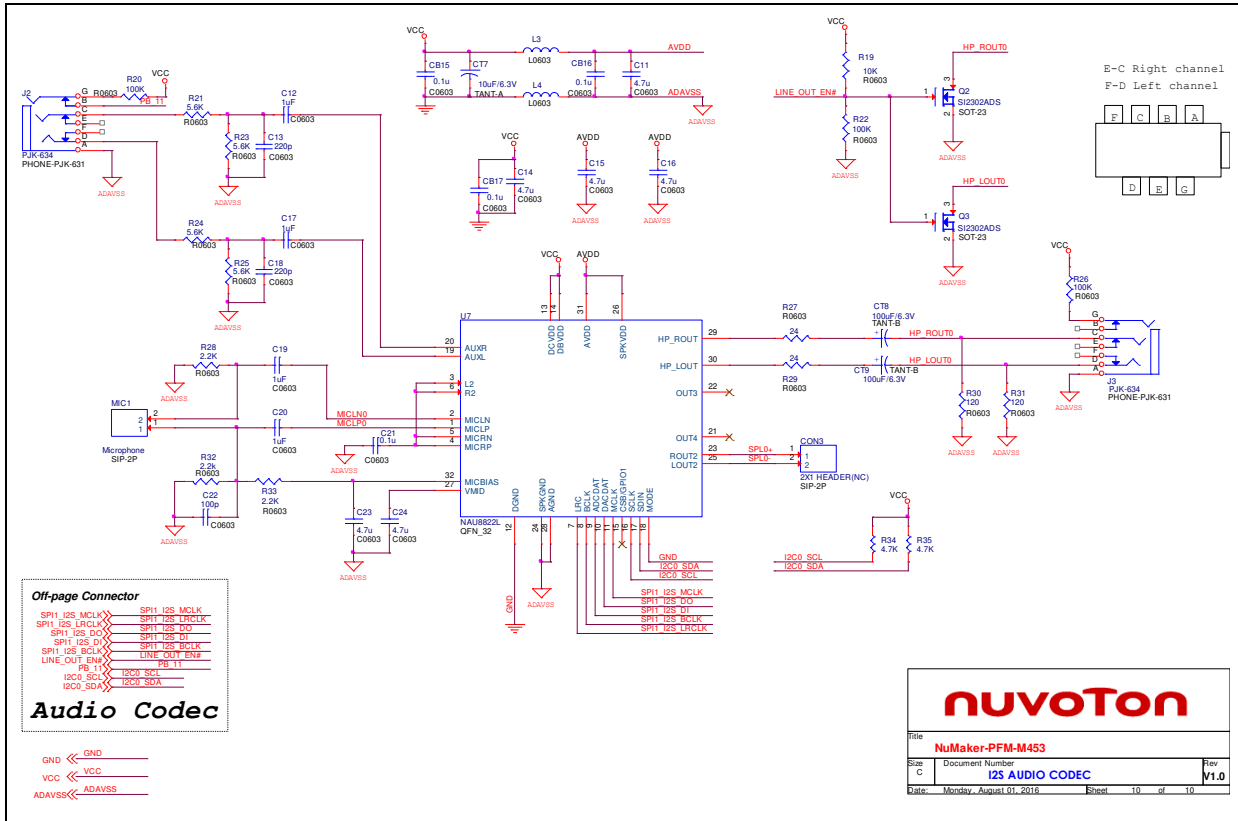


Figure 4-15 Audio Codec Circuit

4.16 MPU6500

Figure 4-16 shows the MPU6500 (3-axis Accelerometer and 3-axis Gyroscope) circuit for the M453 series MCU.

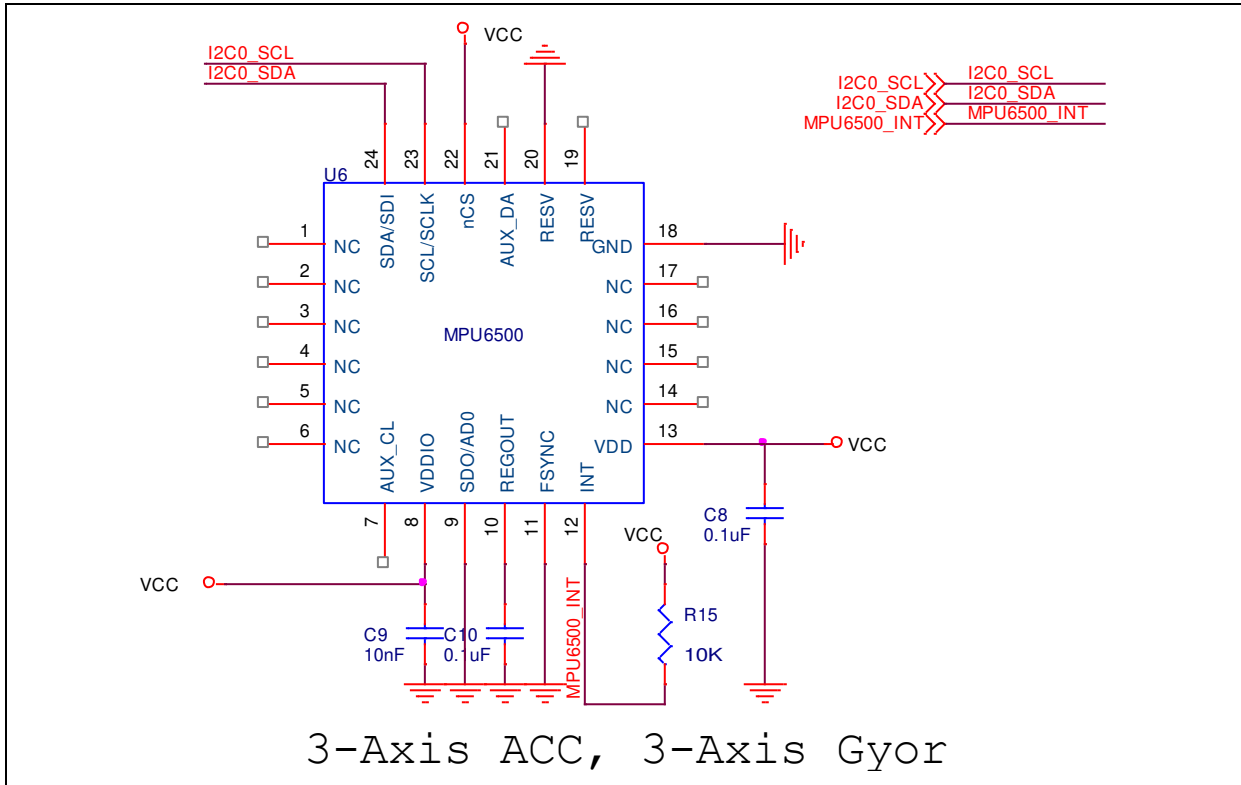


Figure 4-16 MPU6500 Circuit

**5 REVISION HISTORY**

| Date       | Revision | Description          |
|------------|----------|----------------------|
| 2016.07.14 | 1.00     | 1. Initially issued. |



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