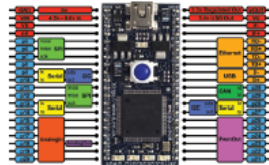




FAST AND EFFECTIVE EMBEDDED SYSTEMS DESIGN

Applying the
ARM mbed



Second Edition

Rob Toulson and Tim Wilmshurst



Chapter 2: Introducing the mbed

tw rev. 26.8.16

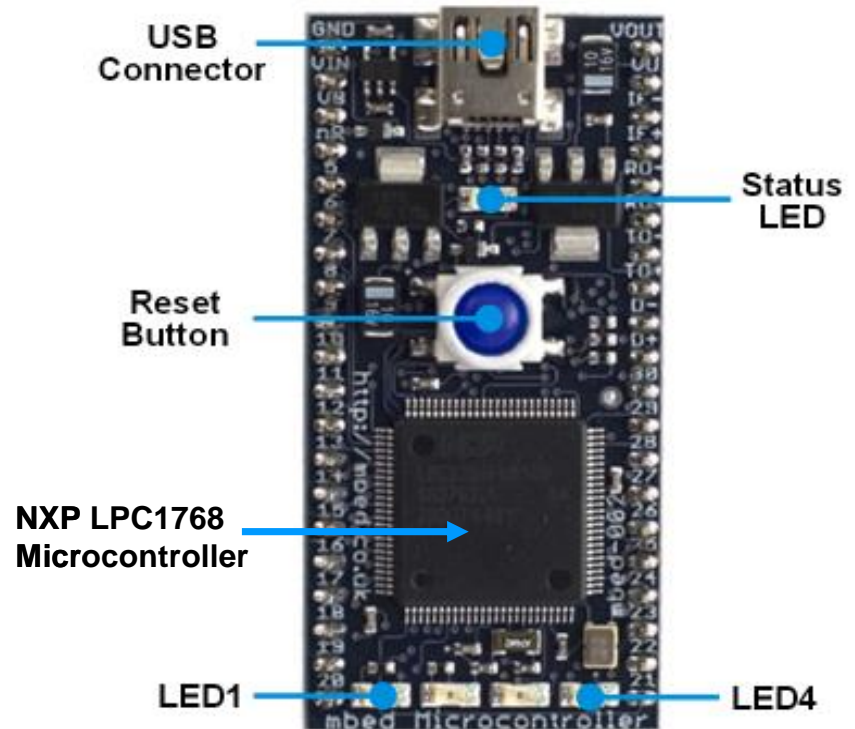
If you use or reference these slides or the associated textbook, please cite the original authors' work as follows:

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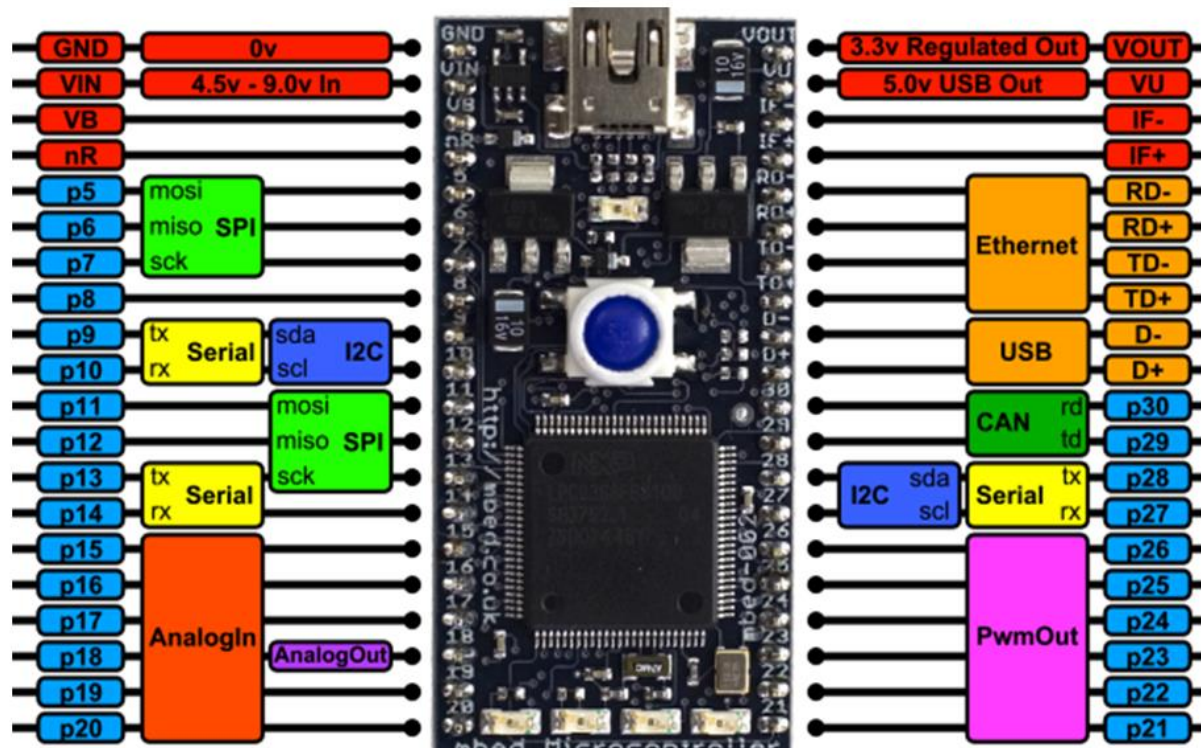
Introducing the mbed LPC1768

The mbed takes a microcontroller, the LPC1768, and surrounds it with some very useful support circuitry. It places this on a conveniently-sized little printed circuit board (PCB), and supports it with an on-line compiler, program library and handbook.



Introducing the mbed

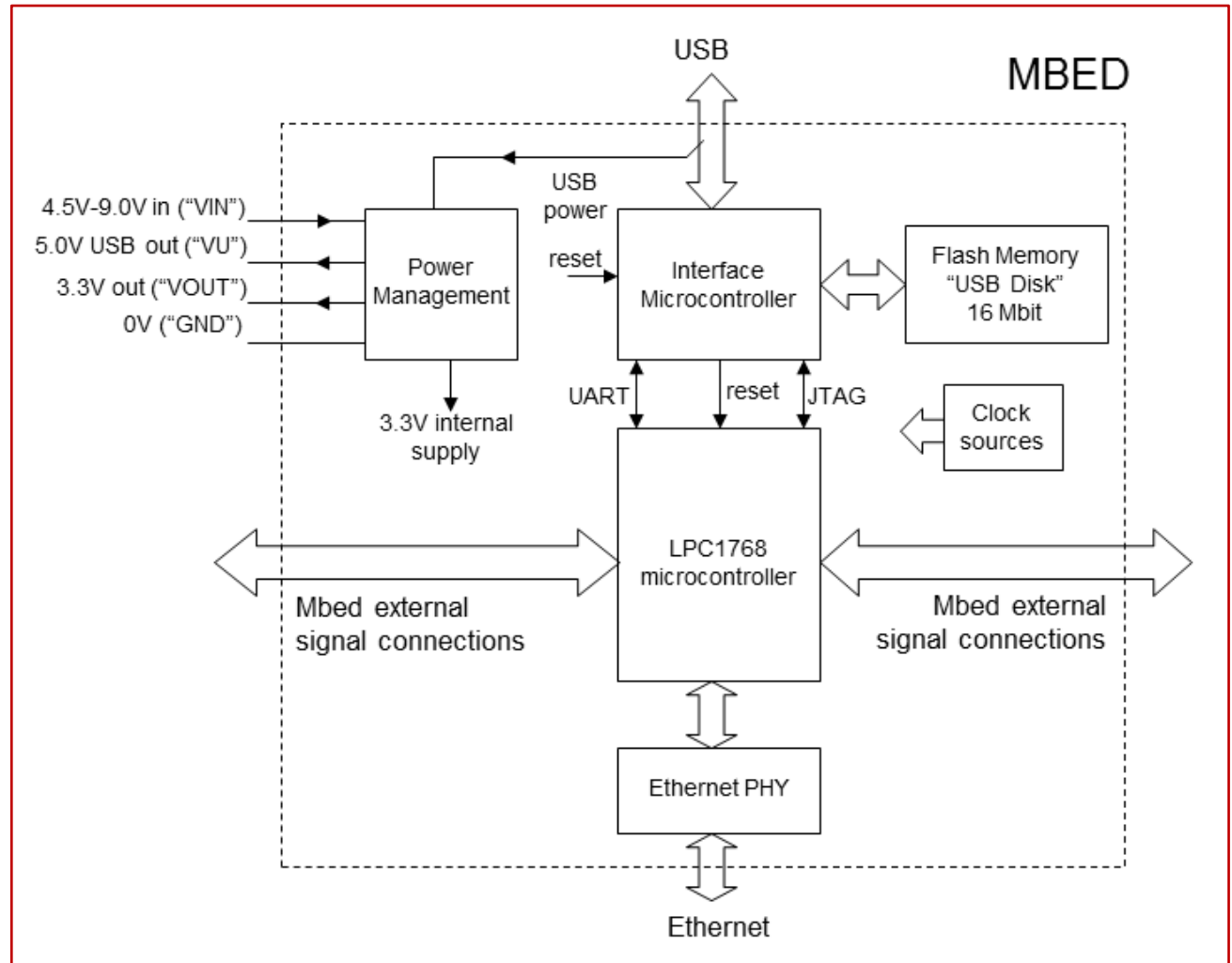
The mbed takes the form of a 2 inch by 1 inch printed circuit board, with 40 pins arranged in two rows of 20, with 0.1 inch spacing between the pins. There are five LEDs on the board, one for status and four which are connected to four microcontroller digital outputs. A reset switch is included, to force restart of the current program.



The mbed Architecture

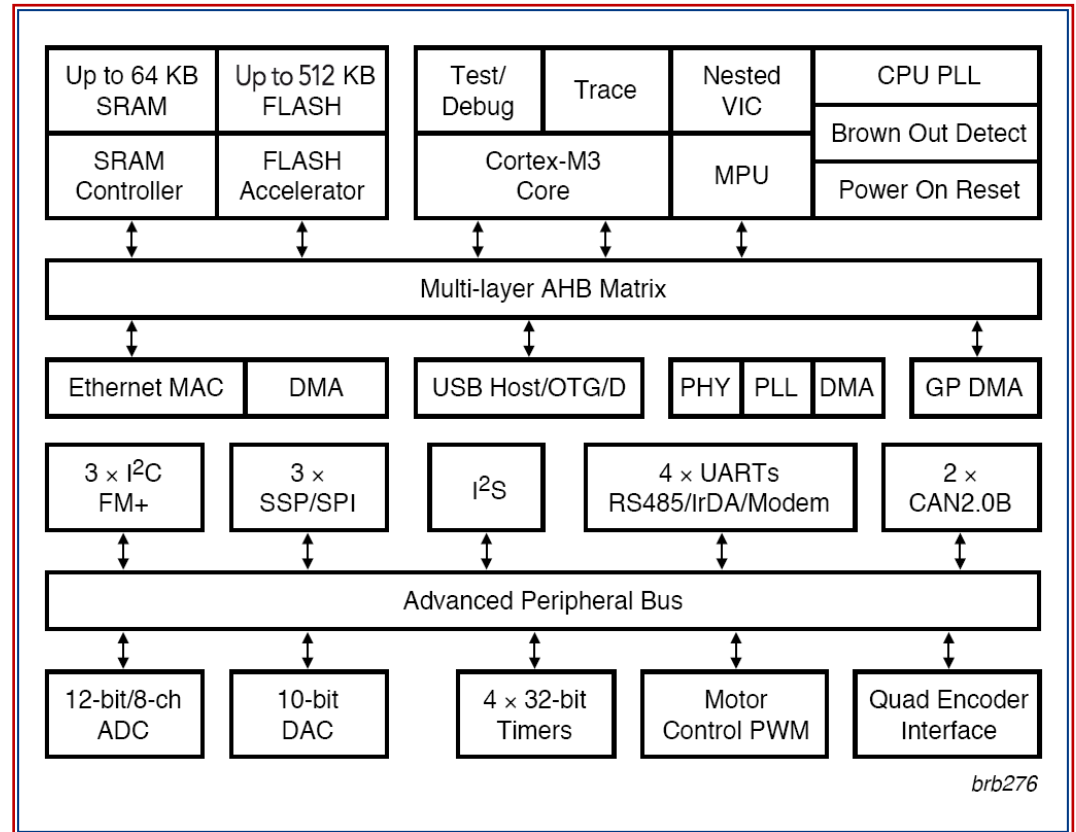
At the heart of the mbed is the LPC1768 microcontroller. The signal pins of the mbed connect directly to the microcontroller. There is a second microcontroller (the “interface microcontroller”) on the mbed, which interfaces with the USB.

This manages the USB link, and acts as a USB terminal to the host computer. It also receives program code files through the USB, and transfers them to a 16 Mbit memory, the “USB Disk”.



The LPC1768 Microcontroller

This figure is complicated, and we don't want to get into all its details. However, it contains the main capability of the mbed, so it's worth getting a feel for its features, remembering that a microcontroller is made up of microprocessor core *plus* memory *plus* peripherals.



Key

ADC: Analog-to-Digital Converter	MAC: Media Access Control
AHB: Advanced High-performance Bus	MPU: Memory Protection Unit
CPU: Central Processing Unit	PHY: Physical Layer
D: Device (USB)	PLL: Phase Locked Loop
DAC: Digital-to-Analog Converter	OTG: On-the-go (USB)
DMA: Direct Memory Access	SPI: Serial Peripheral Interface
FM+: Fast-mode Plus (I2C)	SRAM: Static RAM
GP: General Purpose (DMA)	SSP: Synchronous Serial Port
I2C: Inter Integrated Circuit	UART: Universal Asynchronous Receiver/Transmitter
I2S: Inter Integrated Circuit Sound	VIC: Vectored Interrupt Controller
IrDA: Infrared Data Association	

Notes: The LPC1768 has 64 KB of Static RAM, and 512 KB of Flash
 The Cortex core is made up of those items enclosed within the dashed line
 See also key to Figure 2.1

Reproduced from: mbed NXP LPC1768 prototyping board. 2009. NXP B.V. Document no. 9397 750 16802

The mbed Software Development Kit and API

One thing that makes the mbed special is its Software Development Kit, containing an API (Application Programming Interface). This is the set of programming building blocks, appearing as C++ utilities, which allow programs to be devised quickly and reliably. Therefore, we will write code in C or C++, but draw on the features of the API. Note that you can see all components of the API by opening the mbed handbook, linked from the mbed home page.

The C++ compiler means that all files will carry the .cpp (C plus plus) extension. C however is a subset of C++, and is simpler to learn and apply. This is because it doesn't use the more advanced "object-oriented" aspects of C++. In general, C code will compile on a C++ compiler, but not the other way round.

C is usually the language of choice for any embedded program of low or medium complexity, so will suit us well in this module. For simplicity therefore, we can use only C in the programs we develop. We need to recognise however that the mbed API is written in C++, and uses the features of that language to the full.

Getting Started with the mbed

Go to the mbed home page, connect your mbed, and follow the tutorial instructions to complete these steps:

- Create an account,
- Open the compiler and create a program;
- Compile the program;
- Download to your mbed;
- Run the program!

ARMmbed

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ARM mbed Developer Site

mbed simplifies and speeds up the creation and deployment of devices based on ARM microcontrollers.

The project is being developed by ARM, its Partners and the contributions of the global ARM mbed Developer Community.

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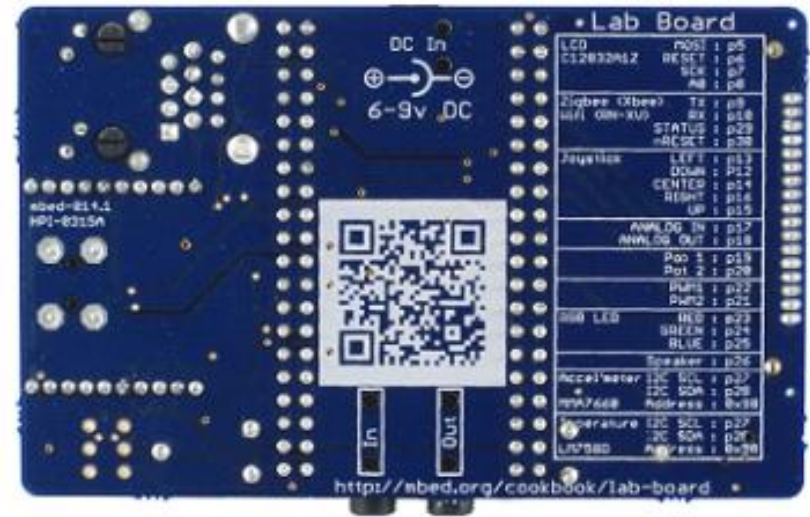
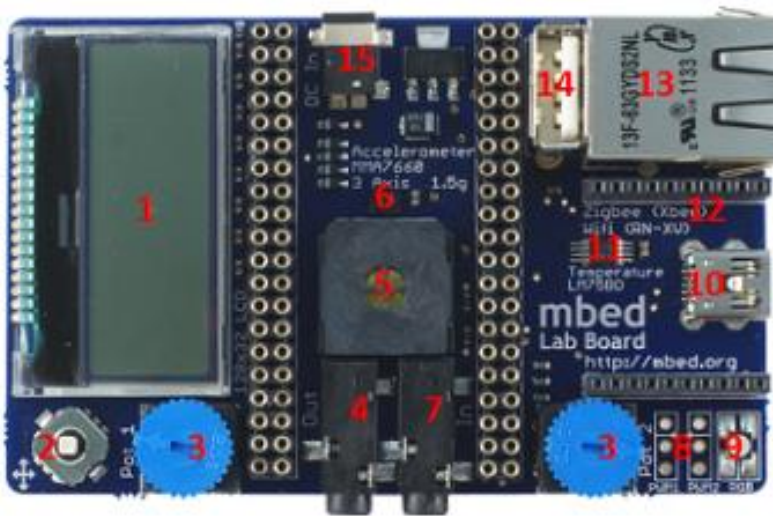
The Opening Program

```
/* Program Example 2.1: Simple LED flashing
 */

#include "mbed.h"
DigitalOut myled(LED1);
int main() {
    while(1) {
        myled = 1;
        wait(0.2);
        myled = 0;
        wait(0.2);
    }
}
```


The mbed Application Board

This board has a number of the most interesting peripheral devices that we might want to connect to the mbed, like display, joystick, potentiometers, certain sensors and connectors. The mbed plugs into the board, and a physical connection with all the peripheral devices is then immediately made. The mbed has to be programmed correctly before it can drive these external devices.



1. Graphics LCD (128x32)
2. 5 Way Joystick
3. 2 x Potentiometers
4. 3.5mm Audio Jack (Analog Out)
5. Speaker, PWM Connected
6. 3 Axis +/- 1.5g Accelerometer
7. 3.5mm Audio Jack (Analog In)
8. 2 x Servo Motor Headers
9. RGB LED, PWM connected
10. USB-mini-B Connector
11. Temperature Sensor
12. Socket for Xbee (Zigbee) or RN-XV (Wifi)
13. RJ45 Ethernet Connector
14. USB-A Connector
15. 1.3mm DC Jack input

Chapter Review

- The mbed platform provides a complete development environment for rapid development of embedded products.
- The mbed LPC1768 is a compact, microcontroller-based hardware platform, designed to work in the mbed development environment.
- Communication to the mbed LPC1768 from a host computer is by USB cable; power can also be supplied through this link.
- The mbed LPC1768 has 40 pins, which can be used to connect to an external circuit. On the board it has 4 user-programmable LEDs, so very simple programs can be run with no external connection to its pins.
- The mbed LPC1768 uses the LPC1768 microcontroller, which contains an ARM Cortex-M3 core. Most mbed connections link directly to the microcontroller pins, and many of the mbed characteristics derive directly from the microcontroller.
- The mbed LPC1768 development environment is hosted on the web. Program development is undertaken while on-line, and programs are stored on the mbed server.
- The mbed application board contains a set of the popular peripheral devices; it is useful for a range of experiments, but is constrained to the devices fitted, and the interconnect available.

