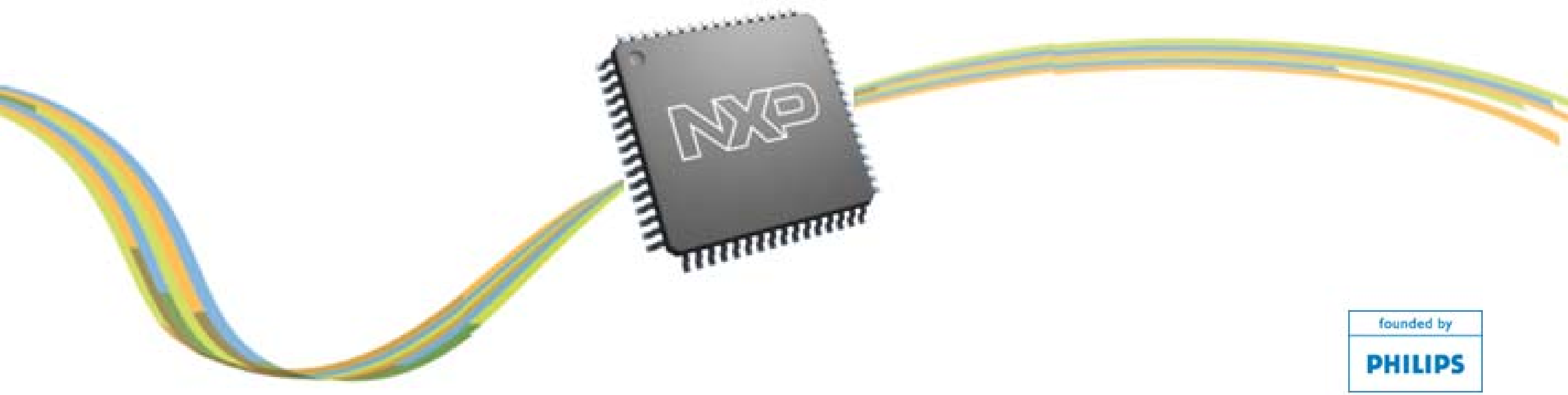
founded by Philips

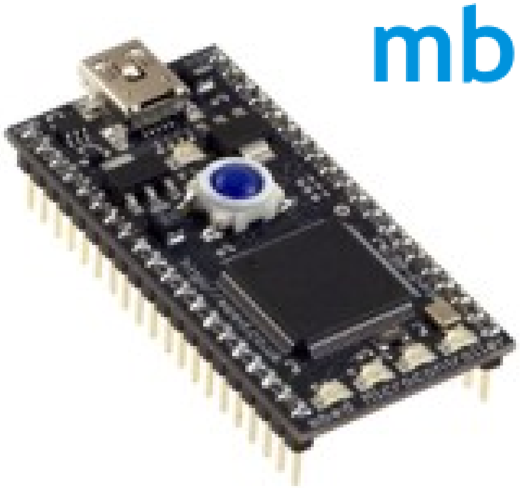
# 'mbed' - Rapid Prototyping for NXP LPC Microcontrollers in Minutes



founded by PHILIPS

# Contents

- The ‘joys’ of a new development kit
- Why ‘mbed’ is different
- How it works
- Getting started
- Compiling a project
- Downloading a file
- Online resources
- FAQ
- Summary
- Q&A



mbed

# The ‘joys’ of a new development kit

- Typical flaws of new development kits with respect to software:
  - Software tools to install
    - Need to learn a new tool interface
  - Licenses needed for commercial use
    - Code limits and / or time limits in place
  - Outdated CD ROMs delivered with the kits
  - Inadequate software examples / firmware libraries delivered with the kit

# The ‘joys’ of a new development kit (cont.)

- Typical flaws of new development kits with respect to hardware:
  - – Too many jumpers – hard to configure
  - – How to get code into the chip?
  - – Not easy to figure out which GPIO pins connect to which on-chip peripherals
  - – Missing cables, power supply, etc.

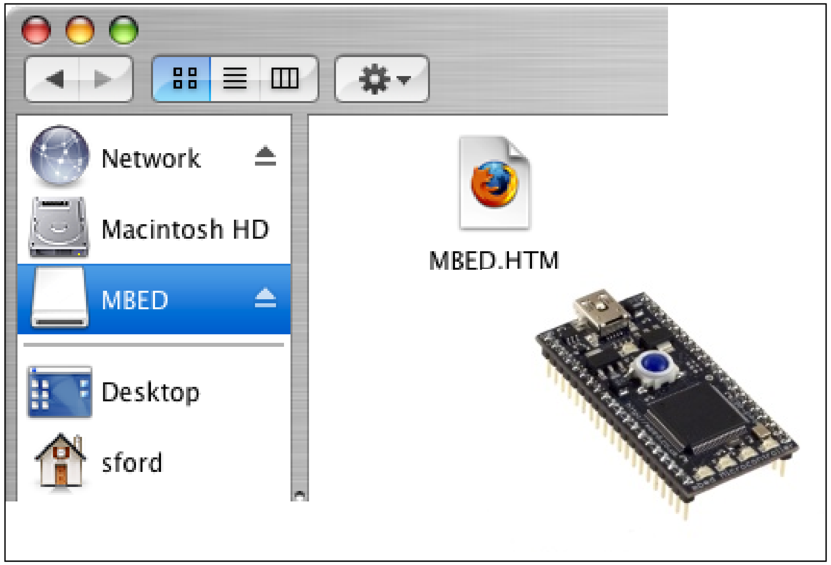
# The ‘joys’ of a new development kit (cont.)

- Typical flaws of new development kits (overall)
  - No dedicated online community (usually)
  - Limited support from tool vendor / chip maker
  - Hard to develop your own applications

- Ordinary development kits are just too hard to use for fast prototyping!

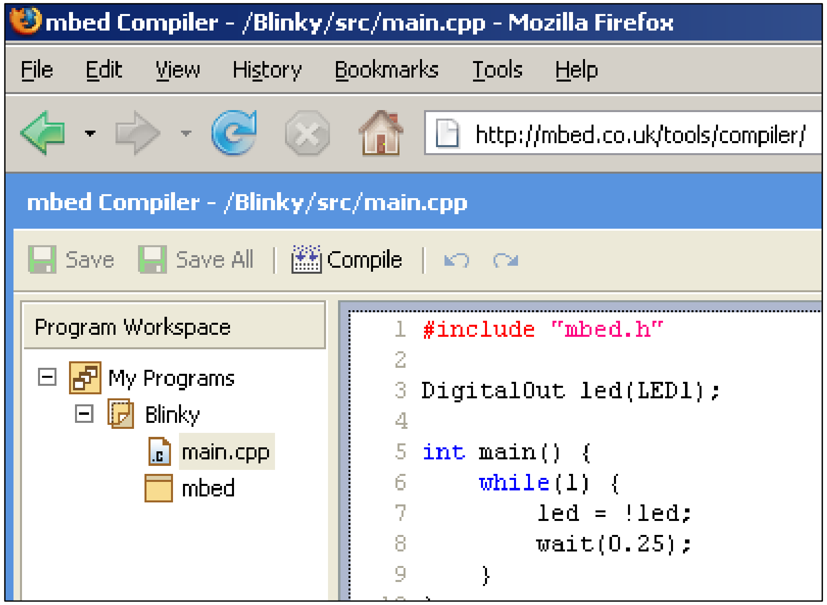
# Why ‘mbed’ is different

- USB Drag ‘n’ Drop Programming Interface
  - – Nothing to Install: Program by copying binaries to disk and pushing one button
  - – Works on Windows, Linux, Mac, without drivers
  - – Links through to website, enables signup validation



# Why ‘mbed’ is different (cont.)

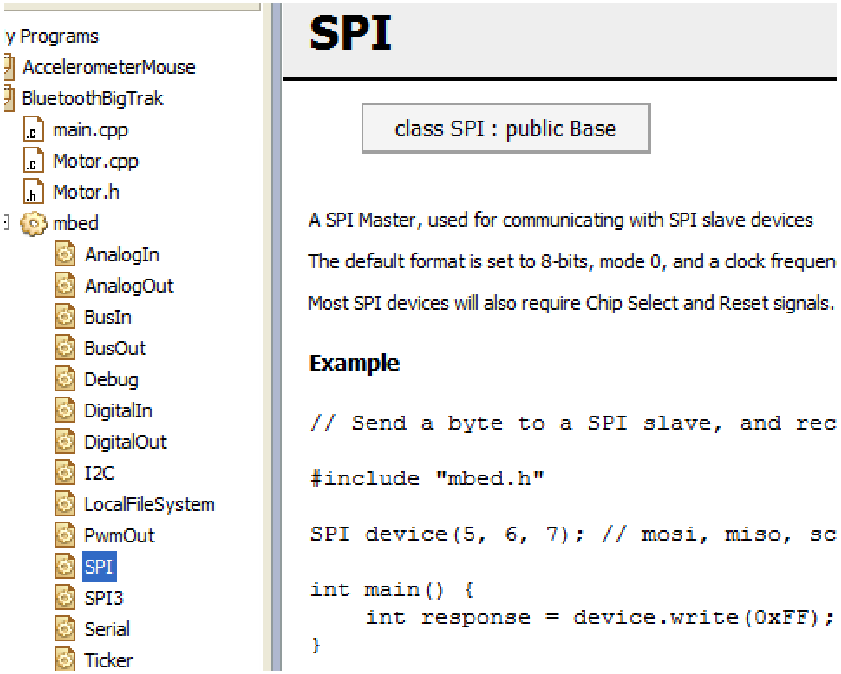
- Entry-level Online Compiler
  - Nothing to Install: Browser-based IDE
  - Immediately compiling examples or writing your own
  - Best in class RealView Compiler in the back end


mbed Compiler - /Blinky/src/main.cpp - Mozilla Firefox
File
Edit
View
History
Bookmarks
Tools
Help
http://mbed.co.uk/tools/compiler/
mbed Compiler - /Blinky/src/main.cpp
Save
Save All
Compile
Program Workspace
My Programs
Blinky
main.cpp
mbed

```
#include "mbed.h"

DigitalOut led(LED1);

int main() {
    while(1) {
        led = !led;
        wait(0.25);
    }
```

# Why ‘mbed’ is different (cont.)

- High-level Peripheral Abstraction Libraries
  - – No specifics to learn: Instantly understandable APIs
  - – Object-oriented hardware/software abstraction
  - – Enables experimentation without knowing MCU details



## SPI

class SPI : public Base

A SPI Master, used for communicating with SPI slave devices

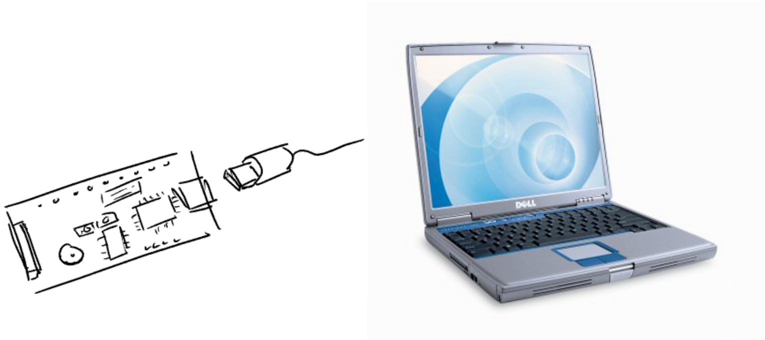
The default format is set to 8-bits, mode 0, and a clock frequen

Most SPI devices will also require Chip Select and Reset signals.

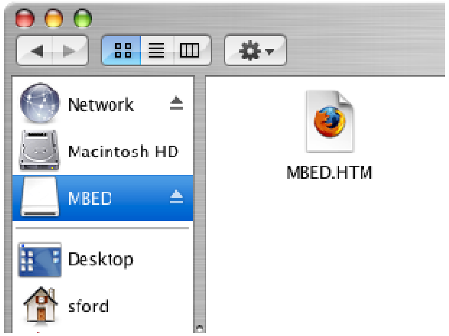
**Example**

```
// Send a byte to a SPI slave, and rec

#include "mbed.h"

SPI device(5, 6, 7); // mosi, miso, sc

int main() {
    int response = device.write(0xFF);
}
```

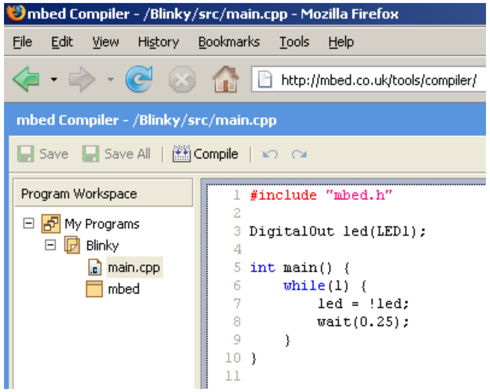
# How it works



*Get an mbed board and plug it in*

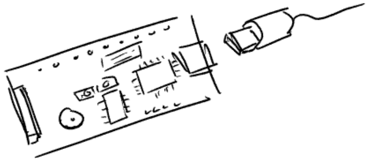


*Up pops a USB Disk linking to mbed website*


mbed Compiler - /Blinky/src/main.cpp - Mozilla Firefox
File
Edit
View
History
Bookmarks
Tools
Help
http://mbed.co.uk/tools/compiler/
mbed Compiler - /Blinky/src/main.cpp
Save
Save All
Compile
Program Workspace
My Programs
Blinky
main.cpp
mbed

```
#include "mbed.h"

DigitalOut led(LED1);

int main() {
    while(1) {
        led = !led;
        wait(0.25);
    }
}

```

*Compile a program online*



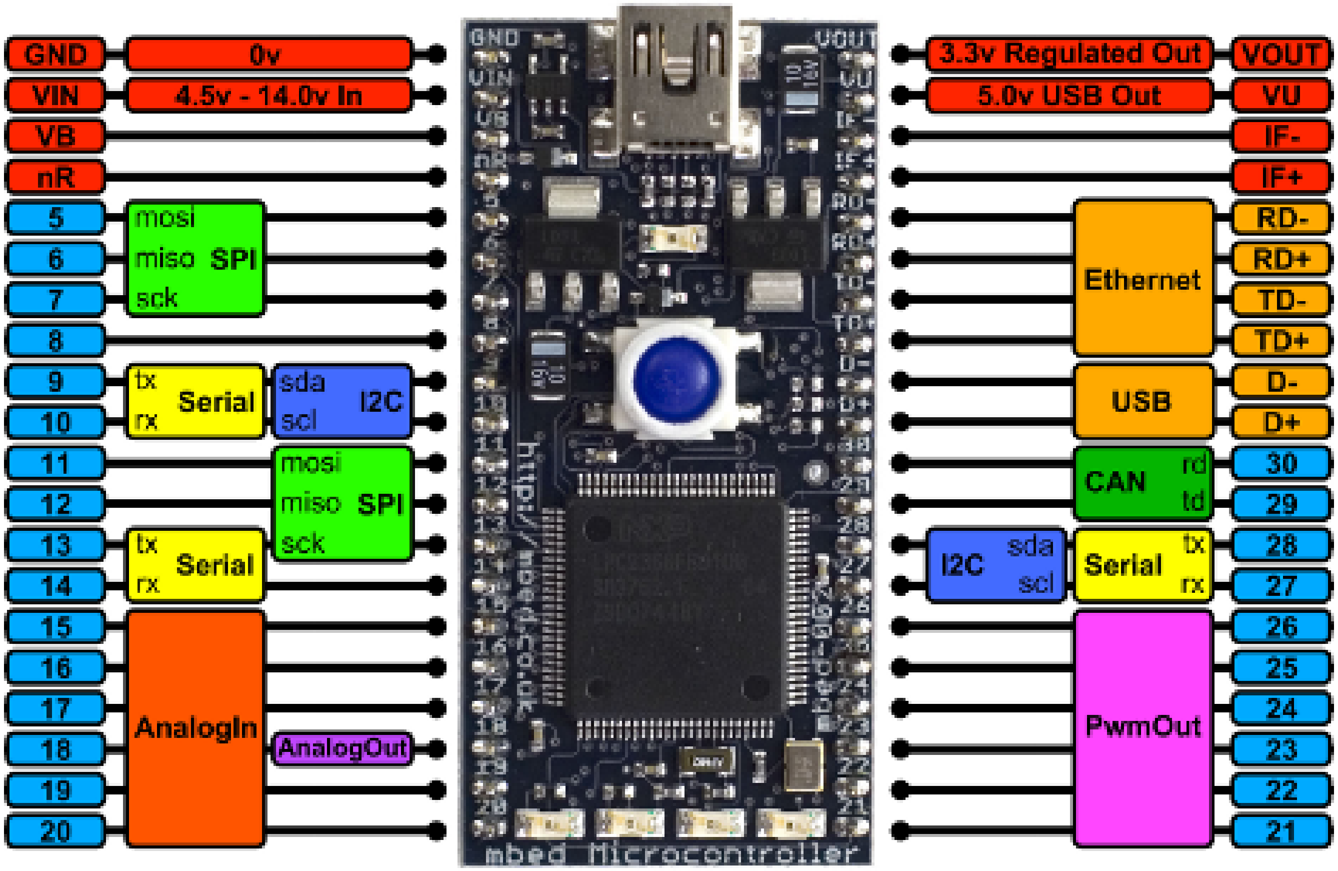
*Save to the board and you’re up and running*

*No Installation!*

*“Hello World!” in 5 minutes*

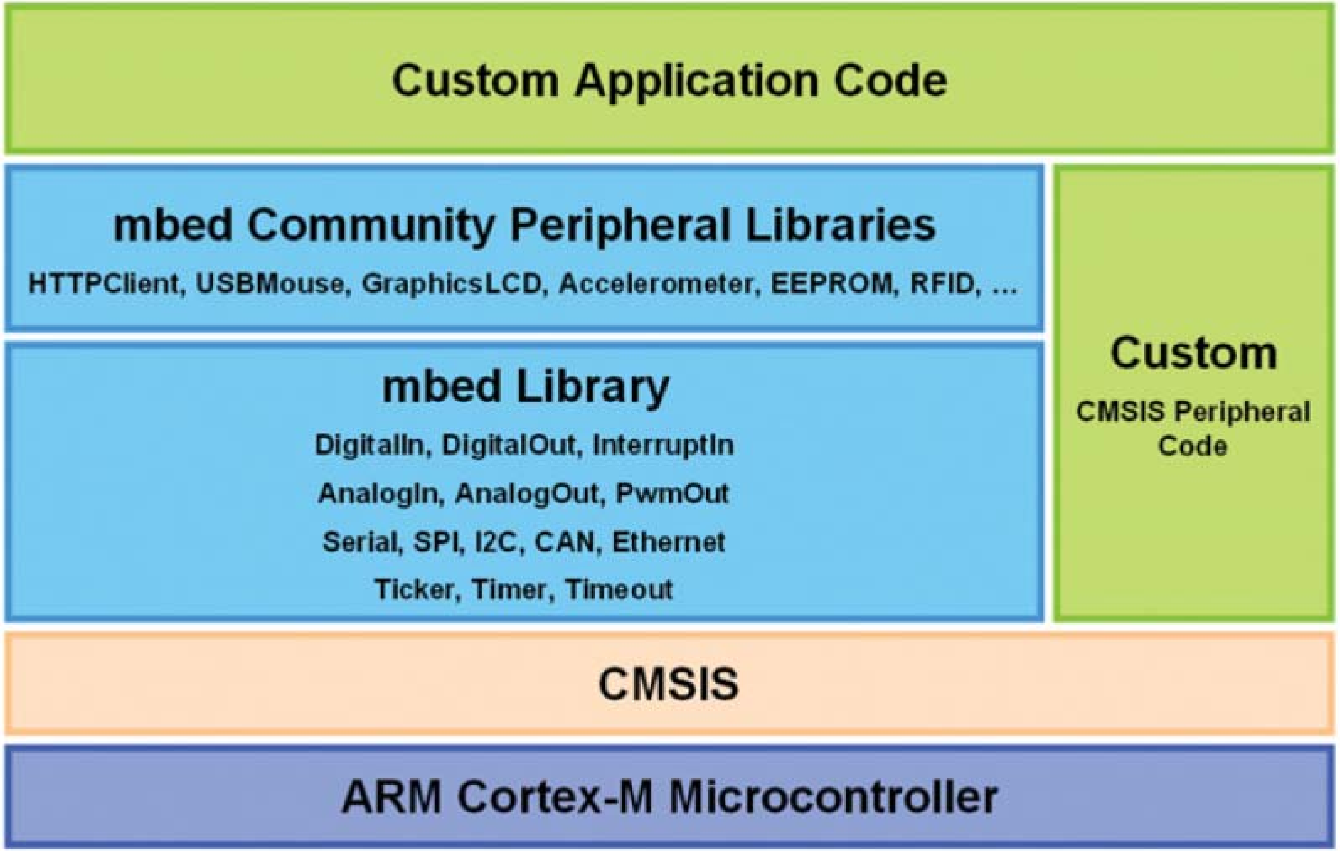
# Getting started

- mbed board overview



# Getting started (cont.)

- mbed Library Architecture


Custom Application Code
mbed Community Peripheral Libraries
HTTPClient, USBMouse, GraphicsLCD, Accelerometer, EEPROM, RFID, ...
mbed Library
DigitalIn, DigitalOut, InterruptIn
AnalogIn, AnalogOut, PwmOut
Serial, SPI, I2C, CAN, Ethernet
Ticker, Timer, Timeout
Custom
CMSIS Peripheral Code
CMSIS
ARM Cortex-M Microcontroller

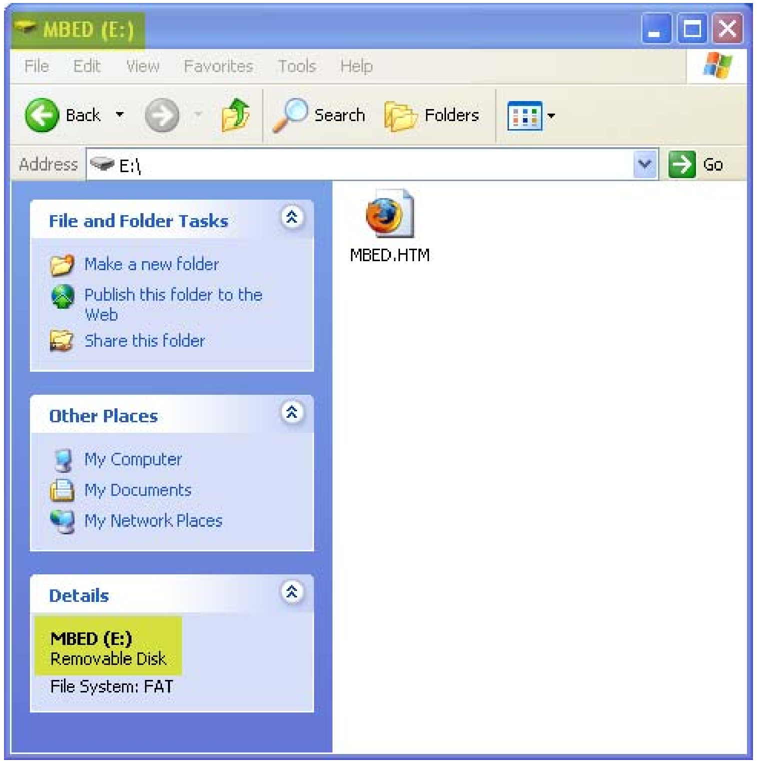
# Getting started (cont.)

- Step 1: Plug in the mbed board

USB Cable (included)

# Getting started (cont.)

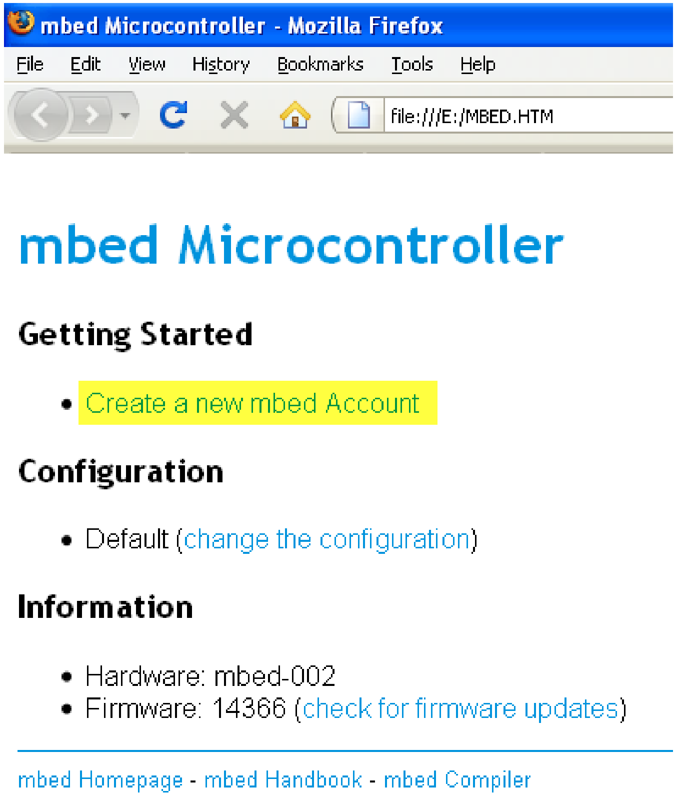
- Step 2: mbed module enumerates as a Mass Storage device (USB disk)



MBED (E:)
Removable Disk
File System: FAT

# Getting started (cont.)

- Step 3: double-click the .htm file on the mbed USB disk and click the link



mbed Microcontroller - Mozilla Firefox
File Edit View History Bookmarks Tools Help
file:///E:/MBED.HTM

## mbed Microcontroller

### Getting Started

- Create a new mbed Account

### Configuration

- Default (change the configuration)

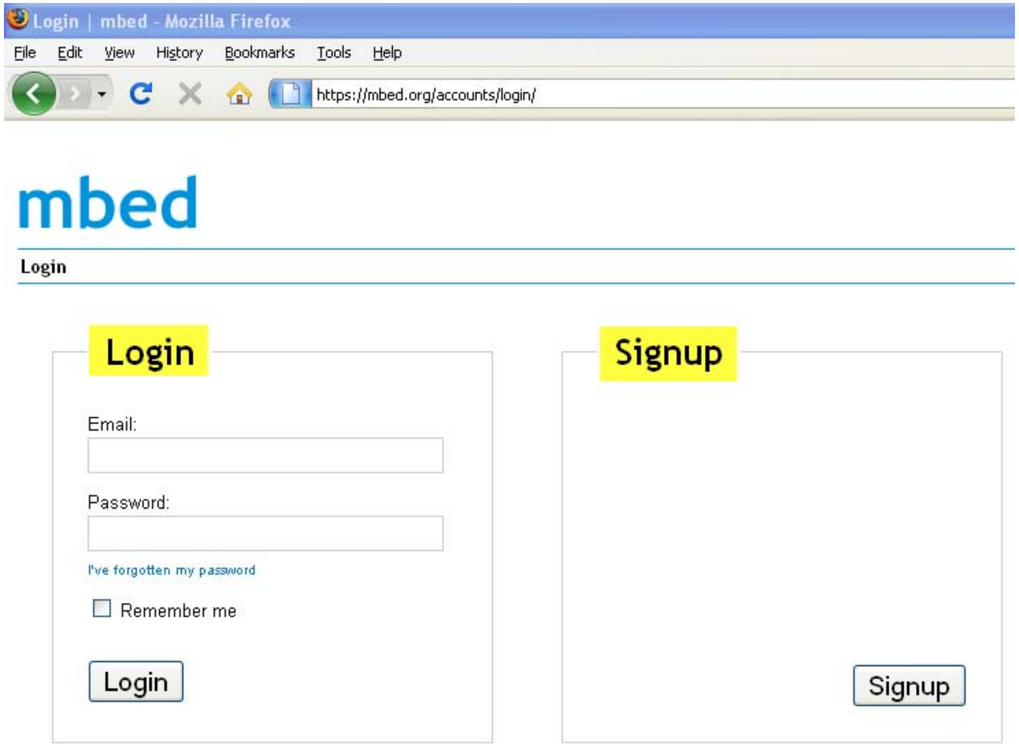
### Information

- Hardware: mbed-002
- Firmware: 14366 (check for firmware updates)

mbed Homepage - mbed Handbook - mbed Compiler

# Getting started (cont.)

- Step 4: Log In or Register for a new account on mbed.org

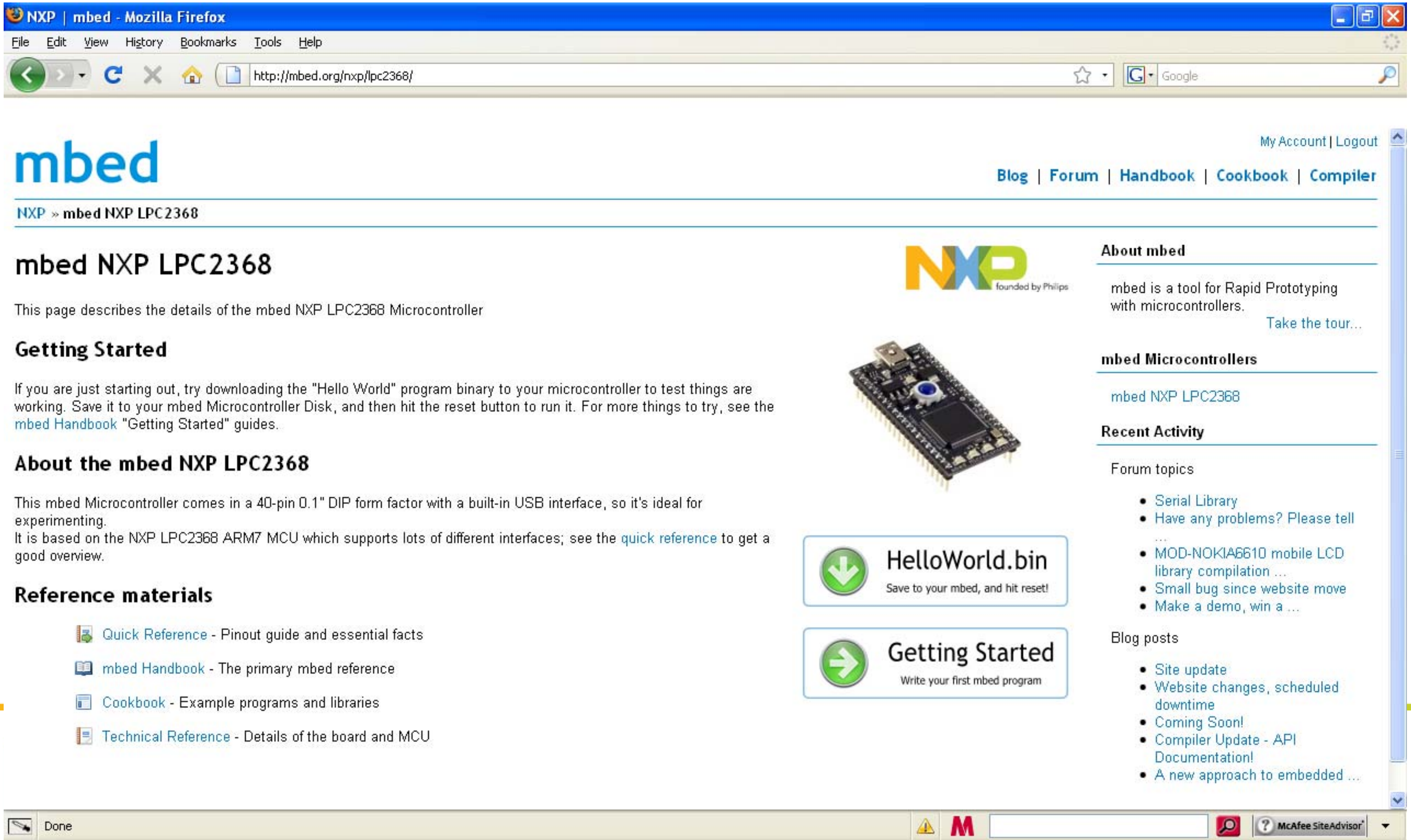


Login | mbed - Mozilla Firefox

https://mbed.org/accounts/login/

# Getting started (cont.)

- You’re on the mbed module’s home page!



NXP | mbed - Mozilla Firefox
File
Edit
View
History
Bookmarks
Tools
Help
http://mbed.org/nxp/lpc2368/
Google
My Account | Logout
Blog | Forum | Handbook | Cookbook | Compiler
Done
McAfee SiteAdvisor

mbed

NXP » mbed NXP LPC2368

## mbed NXP LPC2368

This page describes the details of the mbed NXP LPC2368 Microcontroller

### Getting Started

If you are just starting out, try downloading the "Hello World" program binary to your microcontroller to test things are working. Save it to your mbed Microcontroller Disk, and then hit the reset button to run it. For more things to try, see the mbed Handbook "Getting Started" guides.

### About the mbed NXP LPC2368

This mbed Microcontroller comes in a 40-pin 0.1" DIP form factor with a built-in USB interface, so it's ideal for experimenting.
It is based on the NXP LPC2368 ARM7 MCU which supports lots of different interfaces; see the quick reference to get a good overview.

### Reference materials

- Quick Reference - Pinout guide and essential facts
- mbed Handbook - The primary mbed reference
- Cookbook - Example programs and libraries
- Technical Reference - Details of the board and MCU

HelloWorld.bin
Save to your mbed, and hit reset!

Getting Started
Write your first mbed program

**About mbed**

mbed is a tool for Rapid Prototyping with microcontrollers.
Take the tour...

**mbed Microcontrollers**

mbed NXP LPC2368

**Recent Activity**

Forum topics

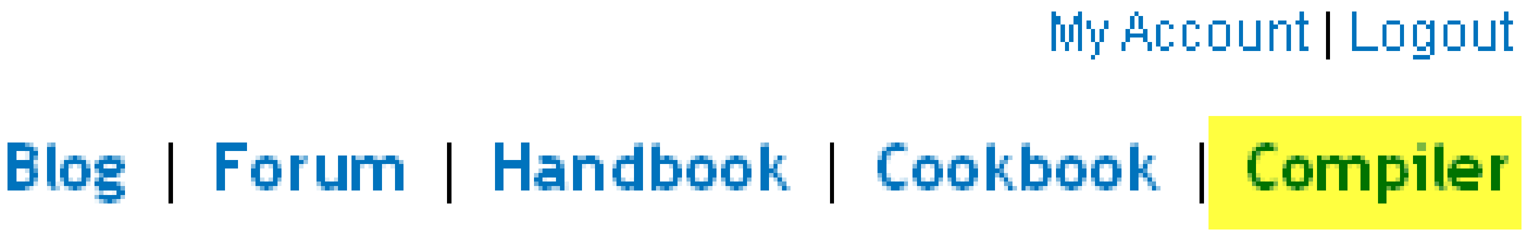
- Serial Library
- Have any problems? Please tell ...
- MOD-NOKIA6610 mobile LCD library compilation ...
- Small bug since website move
- Make a demo, win a ...

Blog posts

- Site update
- Website changes, scheduled downtime
- Coming Soon!
- Compiler Update - API Documentation!
- A new approach to embedded ...

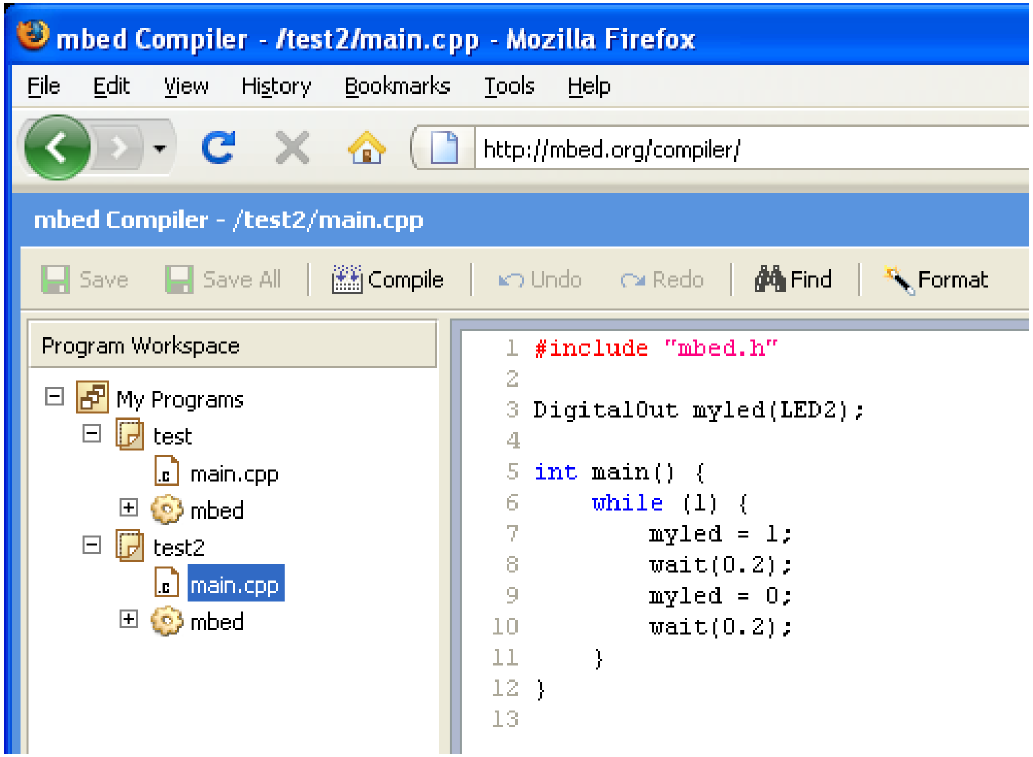
# Compiling a project

- Step 1: Launch the compiler from the home page



# Compiling a project (cont.)

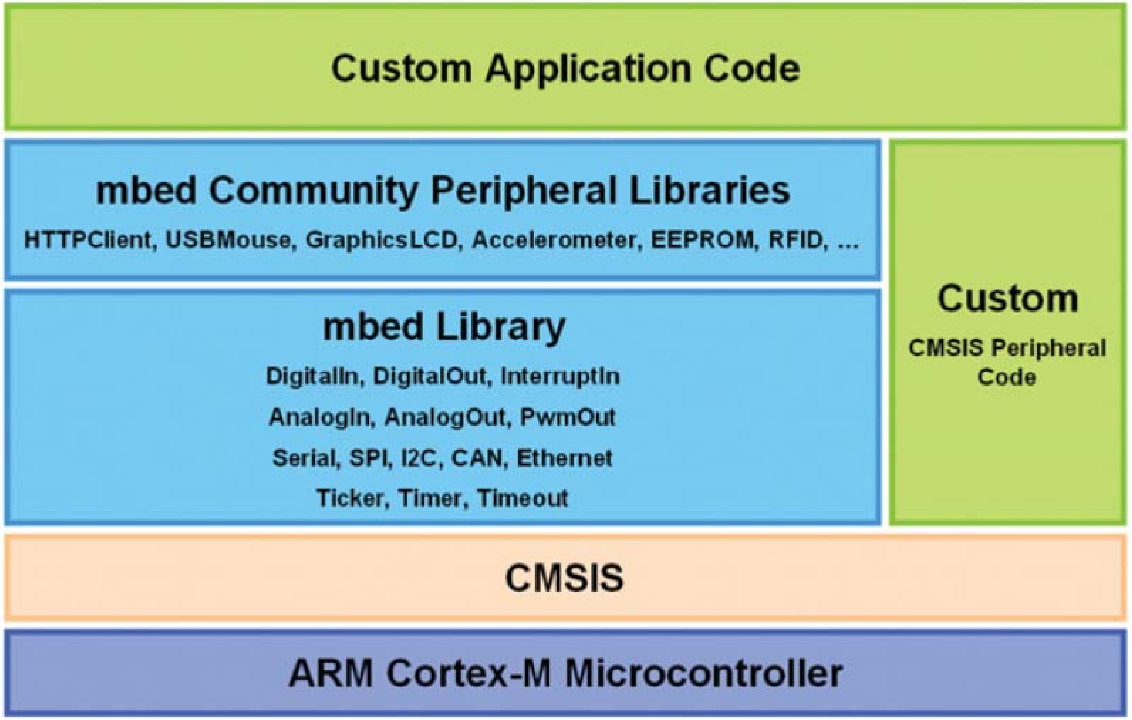
- Step 2: Open a project from the workspace or create a new project



```
#include "mbed.h"

DigitalOut myled(LED2);

int main() {
    while (1) {
        myled = 1;
        wait(0.2);
        myled = 0;
        wait(0.2);
    }
}

```

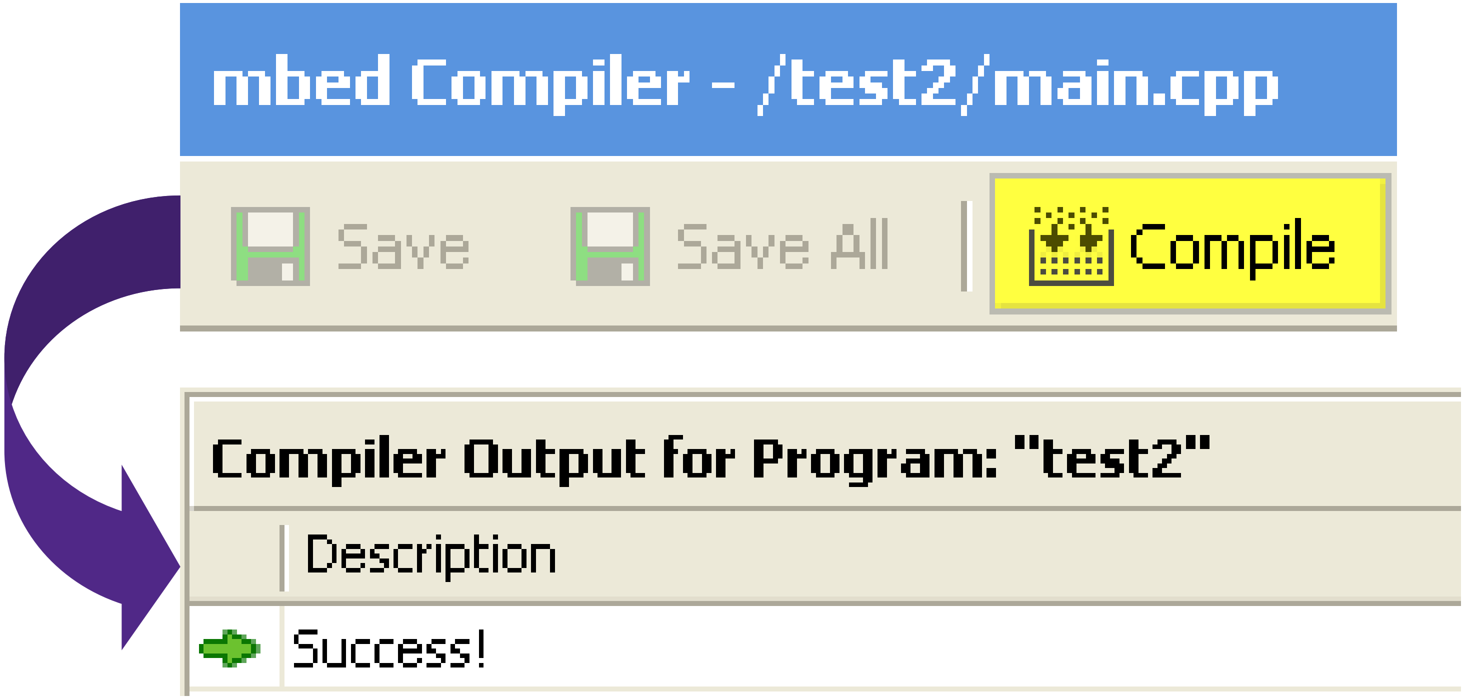
# Compiling a project (cont.)

- Step 3: Add your own code using the mbed library / community peripheral libraries


Custom Application Code
mbed Community Peripheral Libraries
HTTPClient, USBMouse, GraphicsLCD, Accelerometer, EEPROM, RFID, ...
mbed Library
DigitalIn, DigitalOut, InterruptIn
AnalogIn, AnalogOut, PwmOut
Serial, SPI, I2C, CAN, Ethernet
Ticker, Timer, Timeout
Custom
CMSIS Peripheral Code
CMSIS
ARM Cortex-M Microcontroller

# Compiling a project (cont.)

- Step 4: Compile the project online



mbed Compiler - /test2/main.cpp

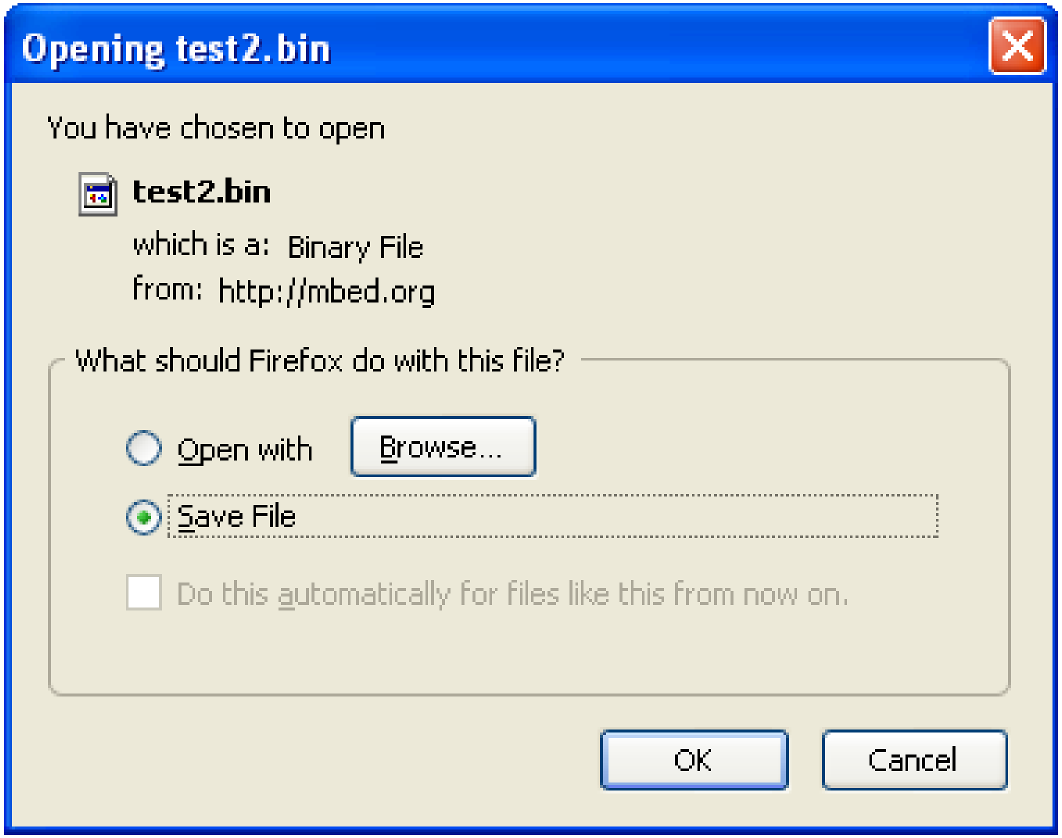
Compiler Output for Program: "test2"

| | Description |
|---|---|
| ➡ | Success! |

- A downloadable .bin file will be created

# Downloading a file

- Step 1: Select .bin file to download



Opening test2.bin

You have chosen to open

test2.bin

which is a: Binary File

from: http://mbed.org

What should Firefox do with this file?

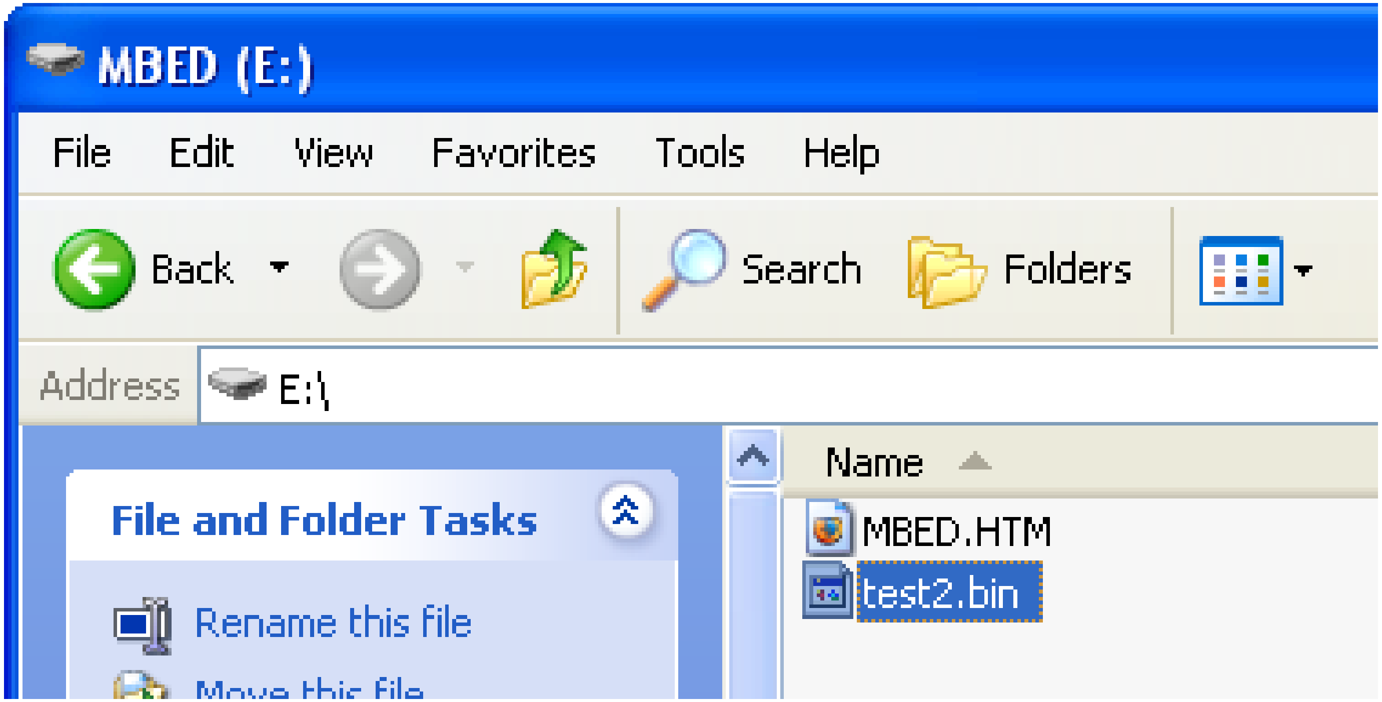
○ Open with

● Save File

□ Do this automatically for files like this from now on.

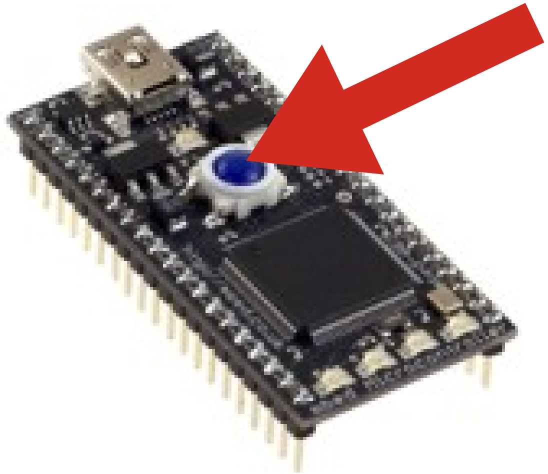
# Downloading a file (cont.)

- Step 2: Save file to mbed USB disk

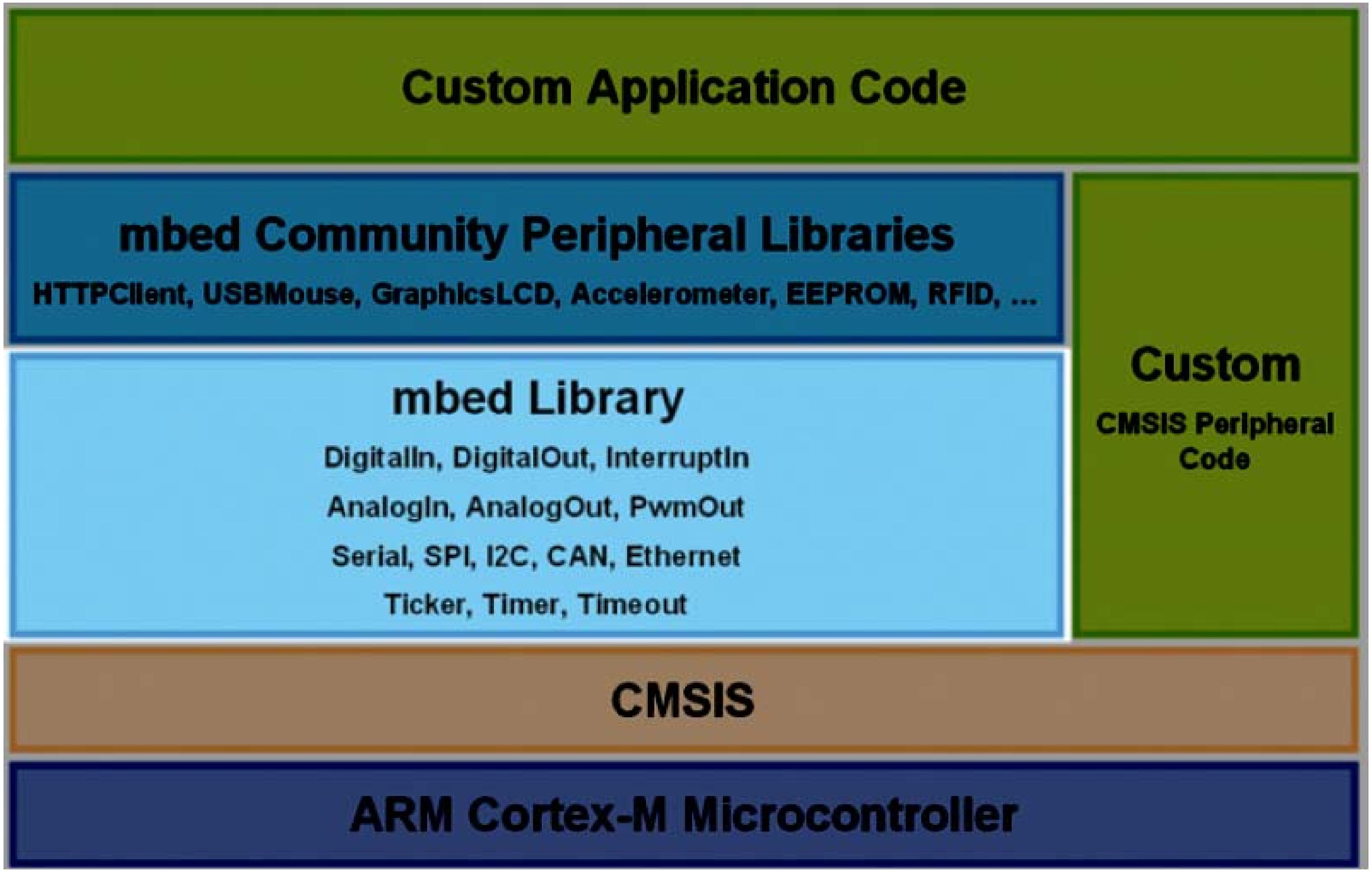


# Downloading a file (cont.)

- Step 3: Program the file into the mbed microcontroller by pressing the blue button on the mbed module
- Your code will start running automatically!



# Online resources – mbed library



Custom Application Code

mbed Community Peripheral Libraries

HTTPClient, USBMouse, GraphicsLCD, Accelerometer, EEPROM, RFID, ...

mbed Library

DigitalIn, DigitalOut, InterruptIn

AnalogIn, AnalogOut, PwmOut

Serial, SPI, I2C, CAN, Ethernet

Ticker, Timer, Timeout

Custom

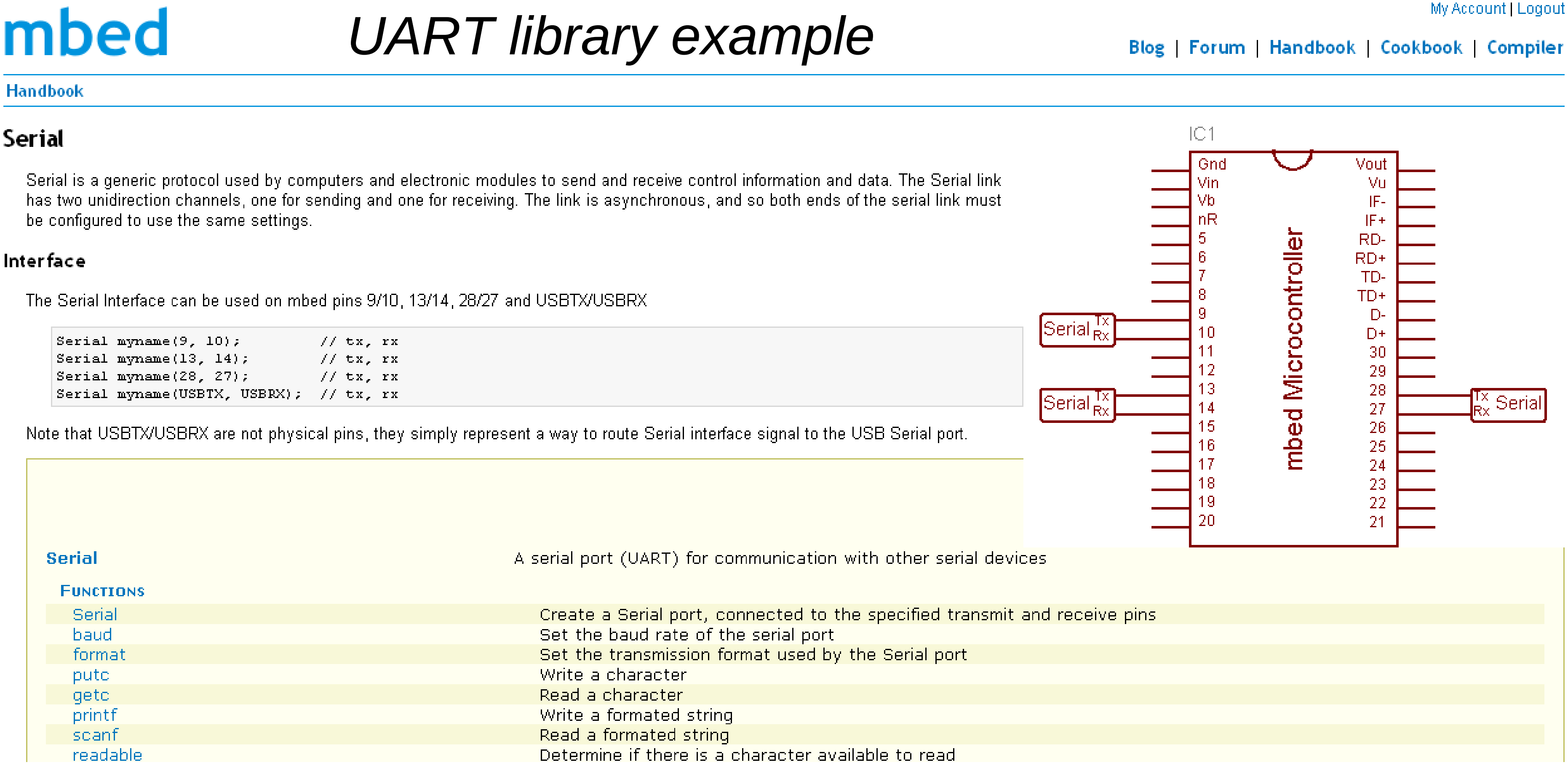
CMSIS Peripheral Code

CMSIS

ARM Cortex-M Microcontroller

# Online resources – mbed library (cont.)

*UART library example*



## Serial

Serial is a generic protocol used by computers and electronic modules to send and receive control information and data. The Serial link has two unidirection channels, one for sending and one for receiving. The link is asynchronous, and so both ends of the serial link must be configured to use the same settings.

### Interface

The Serial Interface can be used on mbed pins 9/10, 13/14, 28/27 and USBTX/USBRX

```
Serial myname(9, 10);          // tx, rx
Serial myname(13, 14);         // tx, rx
Serial myname(28, 27);         // tx, rx
Serial myname(USBTX, USBRX);   // tx, rx
```

Note that USBTX/USBRX are not physical pins, they simply represent a way to route Serial interface signal to the USB Serial port.

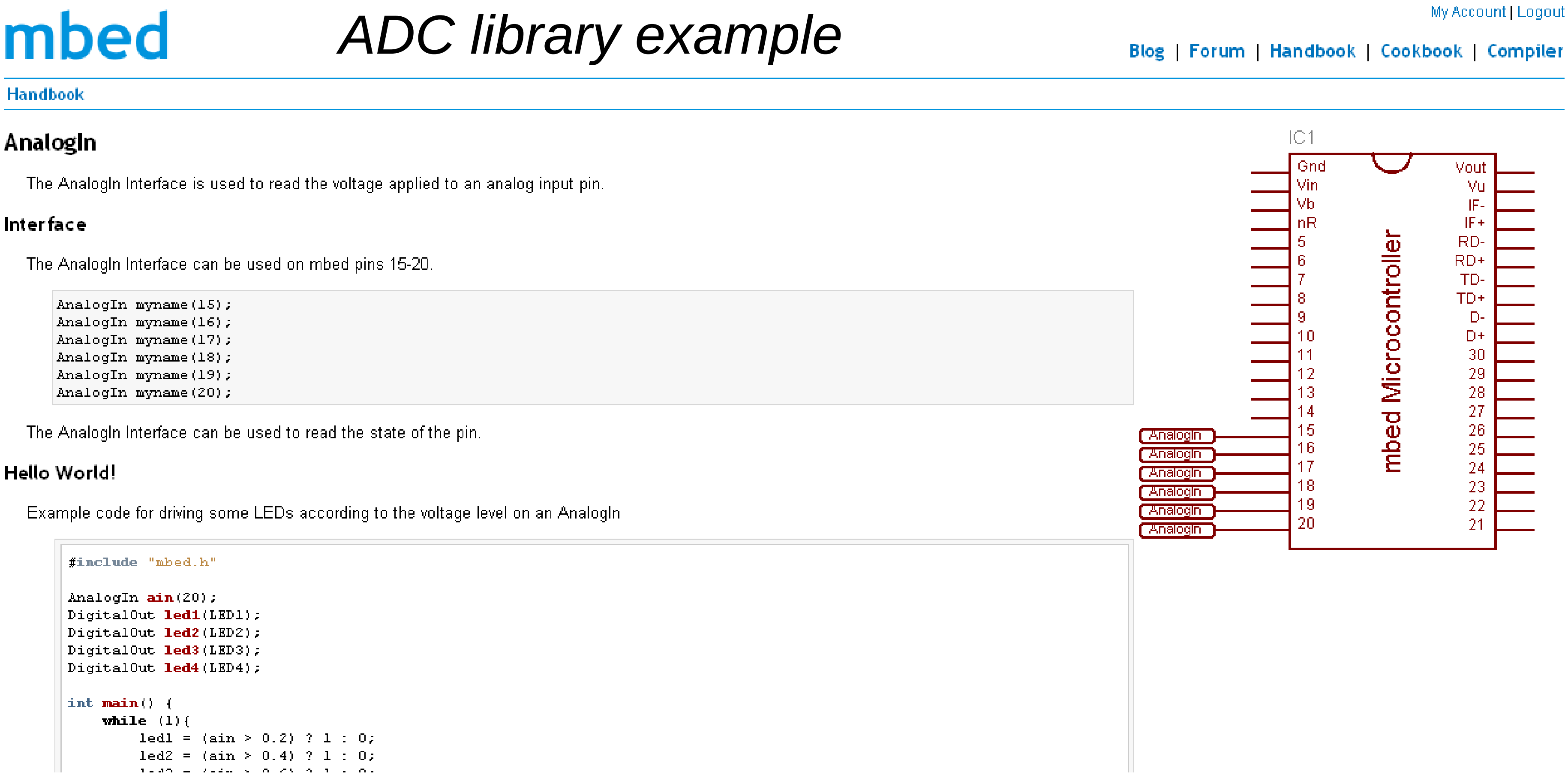
**Serial** A serial port (UART) for communication with other serial devices

**FUNCTIONS**

| | |
|---|---|
| Serial | Create a Serial port, connected to the specified transmit and receive pins |
| baud | Set the baud rate of the serial port |
| format | Set the transmission format used by the Serial port |
| putc | Write a character |
| getc | Read a character |
| printf | Write a formated string |
| scanf | Read a formated string |
| readable | Determine if there is a character available to read |

# Online resources – mbed library (cont.)

*ADC library example*



mbed

My Account | Logout

Blog | Forum | Handbook | Cookbook | Compiler

Handbook

## AnalogIn

The AnalogIn Interface is used to read the voltage applied to an analog input pin.

### Interface

The AnalogIn Interface can be used on mbed pins 15-20.

```
AnalogIn myname(15);
AnalogIn myname(16);
AnalogIn myname(17);
AnalogIn myname(18);
AnalogIn myname(19);
AnalogIn myname(20);
```

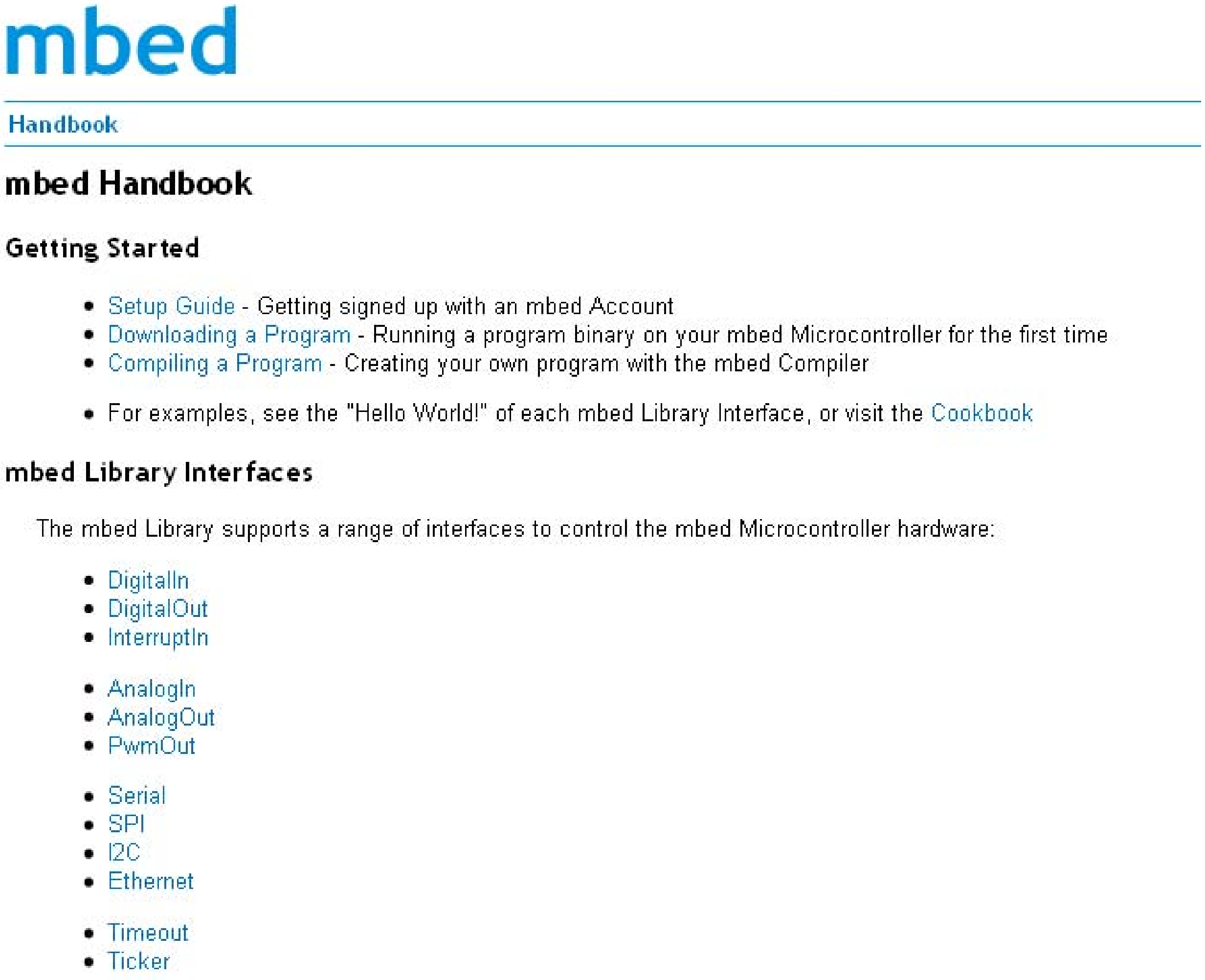
The AnalogIn Interface can be used to read the state of the pin.

### Hello World!

Example code for driving some LEDs according to the voltage level on an AnalogIn

```
#include "mbed.h"

AnalogIn ain(20);
DigitalOut led1(LED1);
DigitalOut led2(LED2);
DigitalOut led3(LED3);
DigitalOut led4(LED4);

int main() {
    while (1){
        led1 = (ain > 0.2) ? 1 : 0;
        led2 = (ain > 0.4) ? 1 : 0;
        led3 = (ain > 0.6) ? 1 : 0;
```

# Online resources – mbed handbook



mbed

Handbook

## mbed Handbook

### Getting Started

- Setup Guide - Getting signed up with an mbed Account
- Downloading a Program - Running a program binary on your mbed Microcontroller for the first time
- Compiling a Program - Creating your own program with the mbed Compiler

- For examples, see the "Hello World!" of each mbed Library Interface, or visit the Cookbook

### mbed Library Interfaces

The mbed Library supports a range of interfaces to control the mbed Microcontroller hardware:

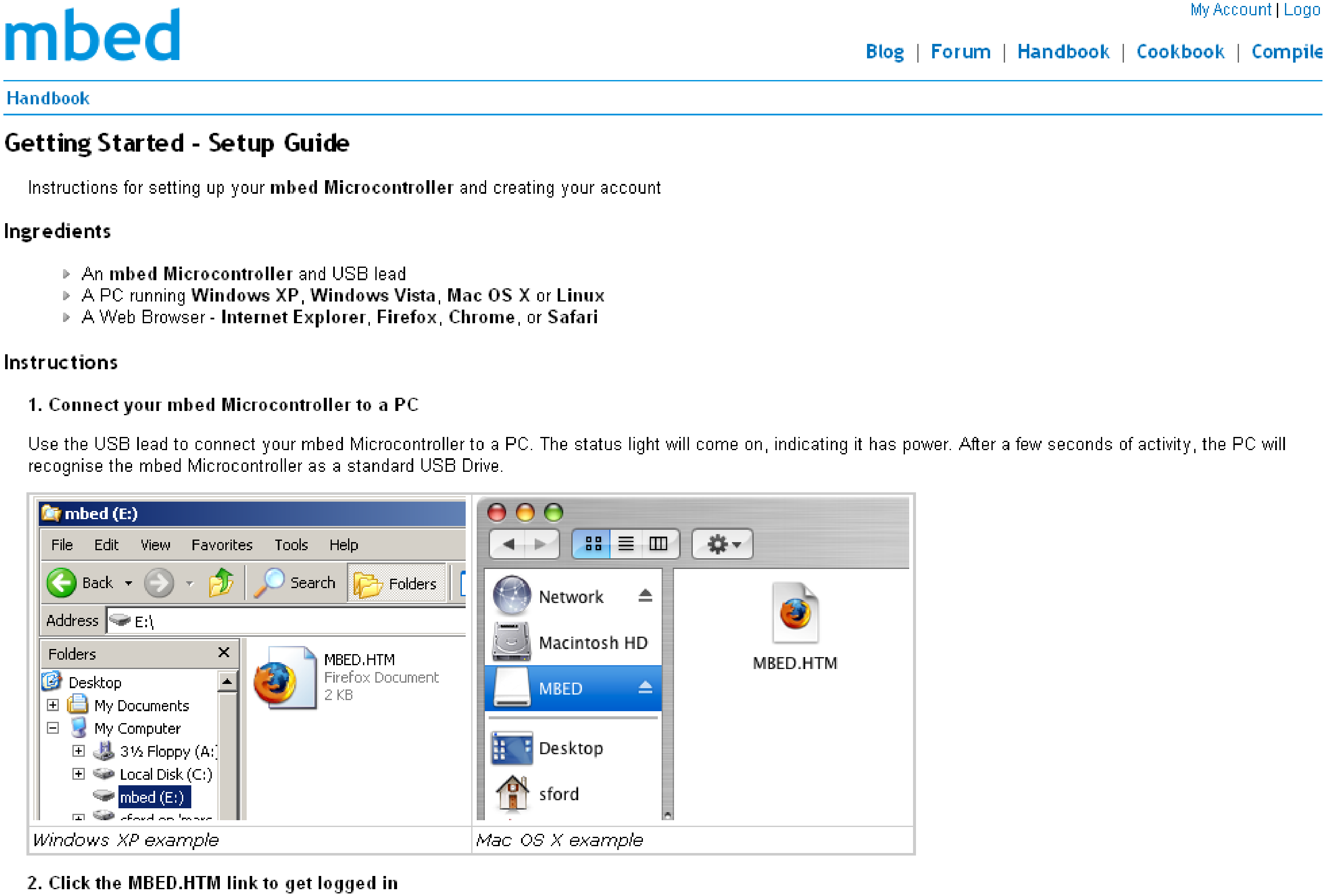
- DigitalIn
- DigitalOut
- InterruptIn

- AnalogIn
- AnalogOut
- PwmOut

- Serial
- SPI
- I2C
- Ethernet

- Timeout
- Ticker

# Online resources – mbed handbook (cont.)



mbed

My Account | Logo

Blog | Forum | Handbook | Cookbook | Compile

Handbook

## Getting Started - Setup Guide

Instructions for setting up your **mbed Microcontroller** and creating your account

### Ingredients

- An **mbed Microcontroller** and USB lead
- A PC running **Windows XP**, **Windows Vista**, **Mac OS X** or **Linux**
- A Web Browser - **Internet Explorer**, **Firefox**, **Chrome**, or **Safari**

### Instructions

**1. Connect your mbed Microcontroller to a PC**

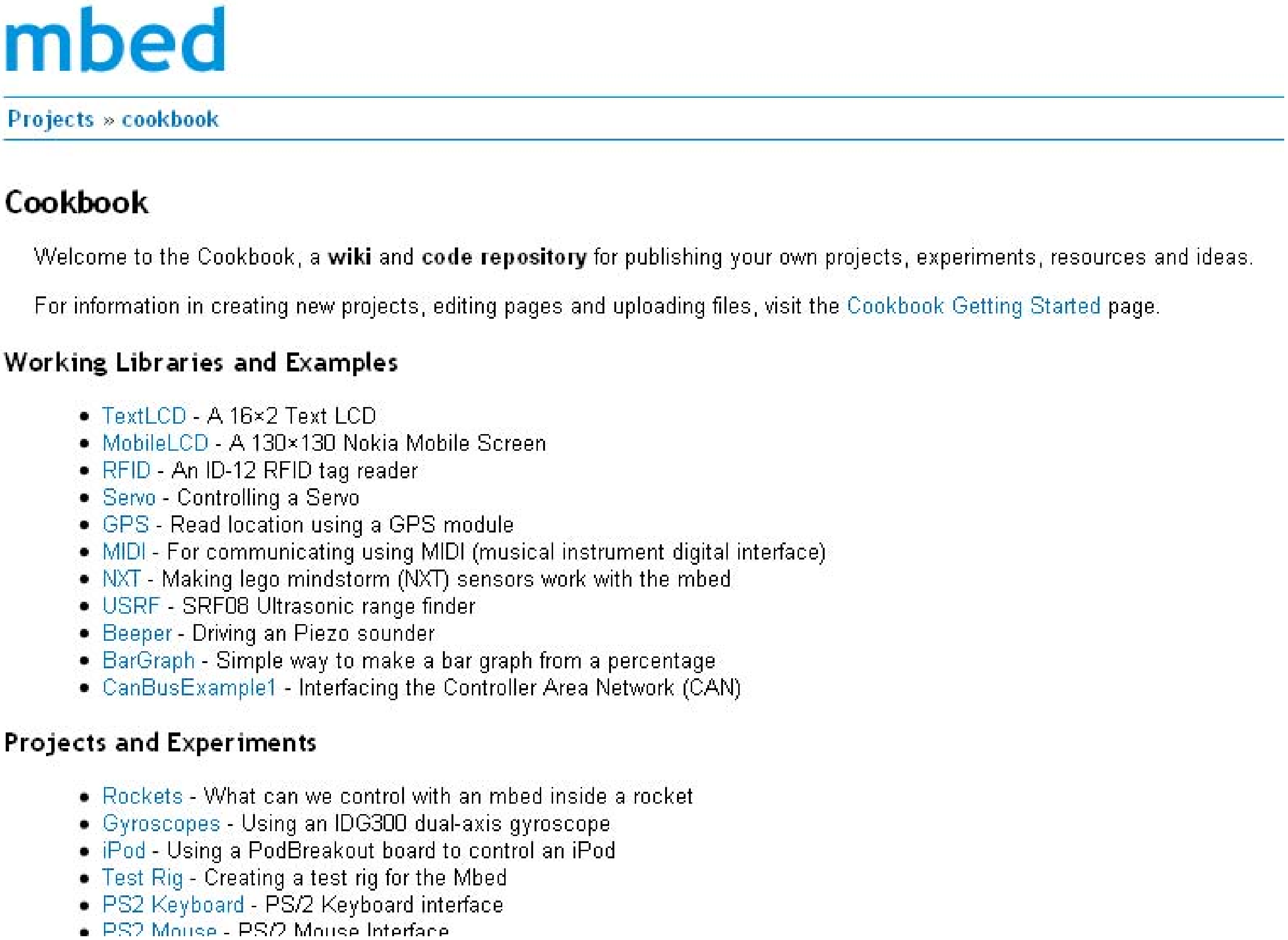
Use the USB lead to connect your mbed Microcontroller to a PC. The status light will come on, indicating it has power. After a few seconds of activity, the PC will recognise the mbed Microcontroller as a standard USB Drive.

*Windows XP example*

*Mac OS X example*

**2. Click the MBED.HTM link to get logged in**

# Online resources – mbed cookbook



mbed

Projects » cookbook

## Cookbook

Welcome to the Cookbook, a **wiki** and **code repository** for publishing your own projects, experiments, resources and ideas.

For information in creating new projects, editing pages and uploading files, visit the Cookbook Getting Started page.

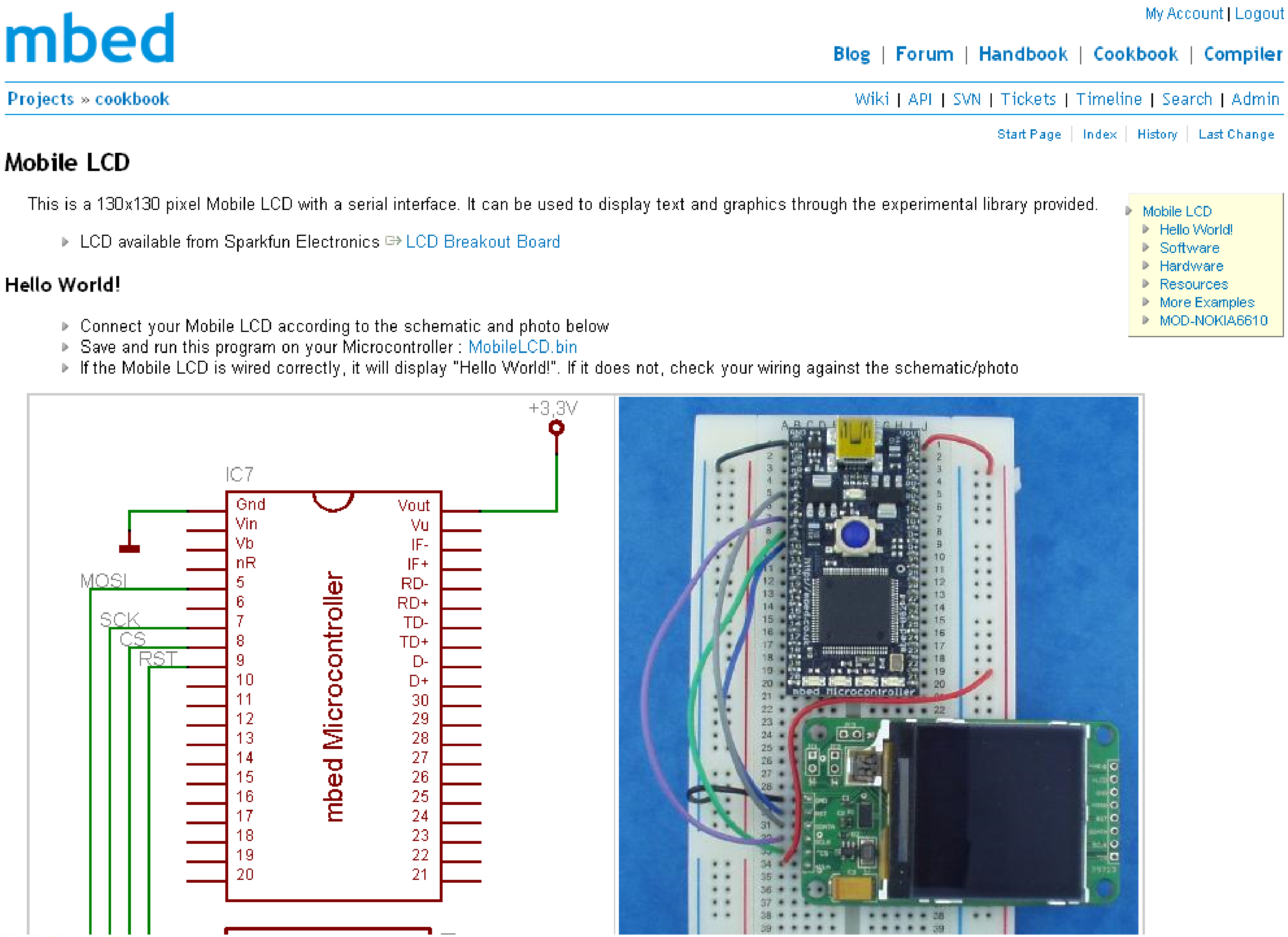
### Working Libraries and Examples

- TextLCD - A 16×2 Text LCD
- MobileLCD - A 130×130 Nokia Mobile Screen
- RFID - An ID-12 RFID tag reader
- Servo - Controlling a Servo
- GPS - Read location using a GPS module
- MIDI - For communicating using MIDI (musical instrument digital interface)
- NXT - Making lego mindstorm (NXT) sensors work with the mbed
- USRF - SRF08 Ultrasonic range finder
- Beeper - Driving an Piezo sounder
- BarGraph - Simple way to make a bar graph from a percentage
- CanBusExample1 - Interfacing the Controller Area Network (CAN)

### Projects and Experiments

- Rockets - What can we control with an mbed inside a rocket
- Gyroscopes - Using an IDG300 dual-axis gyroscope
- iPod - Using a PodBreakout board to control an iPod
- Test Rig - Creating a test rig for the Mbed
- PS2 Keyboard - PS/2 Keyboard interface
- PS2 Mouse - PS/2 Mouse Interface

# Online resources – mbed cookbook (cont.)



mbed

My Account | Logout

Blog | Forum | Handbook | Cookbook | Compiler

Projects » cookbook

Wiki | API | SVN | Tickets | Timeline | Search | Admin

Start Page | Index | History | Last Change

## Mobile LCD

This is a 130x130 pixel Mobile LCD with a serial interface. It can be used to display text and graphics through the experimental library provided.

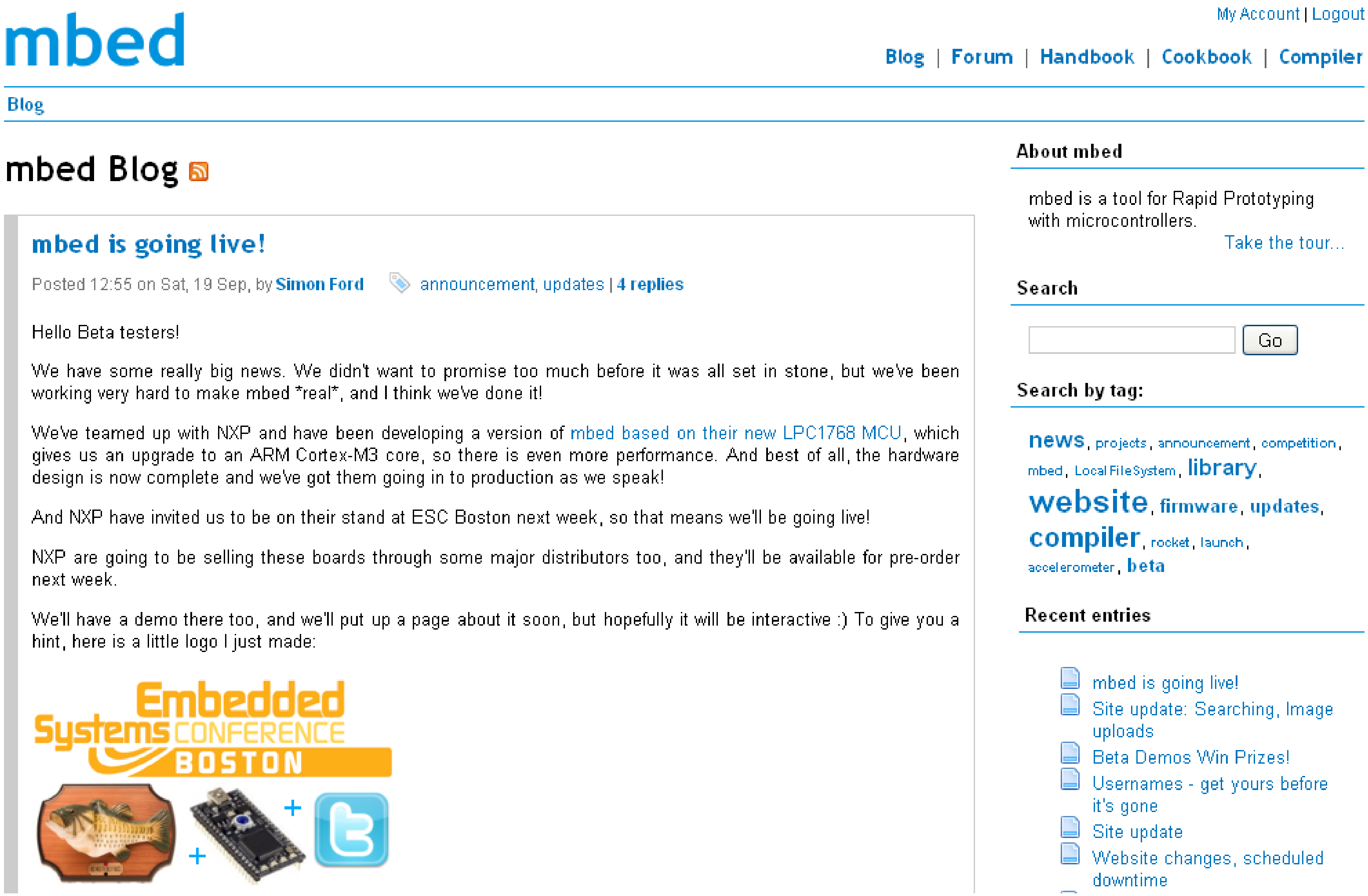
- LCD available from Sparkfun Electronics ⇨ LCD Breakout Board

- Mobile LCD
  - Hello World!
  - Software
  - Hardware
  - Resources
  - More Examples
  - MOD-NOKIA6610

## Hello World!

- Connect your Mobile LCD according to the schematic and photo below
- Save and run this program on your Microcontroller : MobileLCD.bin
- If the Mobile LCD is wired correctly, it will display "Hello World!". If it does not, check your wiring against the schematic/photo

# Online resources – mbed blog



mbed

My Account | Logout

Blog | Forum | Handbook | Cookbook | Compiler

Blog

## mbed Blog

### mbed is going live!

Posted 12:55 on Sat, 19 Sep, by **Simon Ford** announcement, updates | **4 replies**

Hello Beta testers!

We have some really big news. We didn't want to promise too much before it was all set in stone, but we've been working very hard to make mbed *real*, and I think we've done it!

We've teamed up with NXP and have been developing a version of mbed based on their new LPC1768 MCU, which gives us an upgrade to an ARM Cortex-M3 core, so there is even more performance. And best of all, the hardware design is now complete and we've got them going in to production as we speak!

And NXP have invited us to be on their stand at ESC Boston next week, so that means we'll be going live!

NXP are going to be selling these boards through some major distributors too, and they'll be available for pre-order next week.

We'll have a demo there too, and we'll put up a page about it soon, but hopefully it will be interactive :) To give you a hint, here is a little logo I just made:

**About mbed**

mbed is a tool for Rapid Prototyping with microcontrollers.

Take the tour...

**Search**

Go

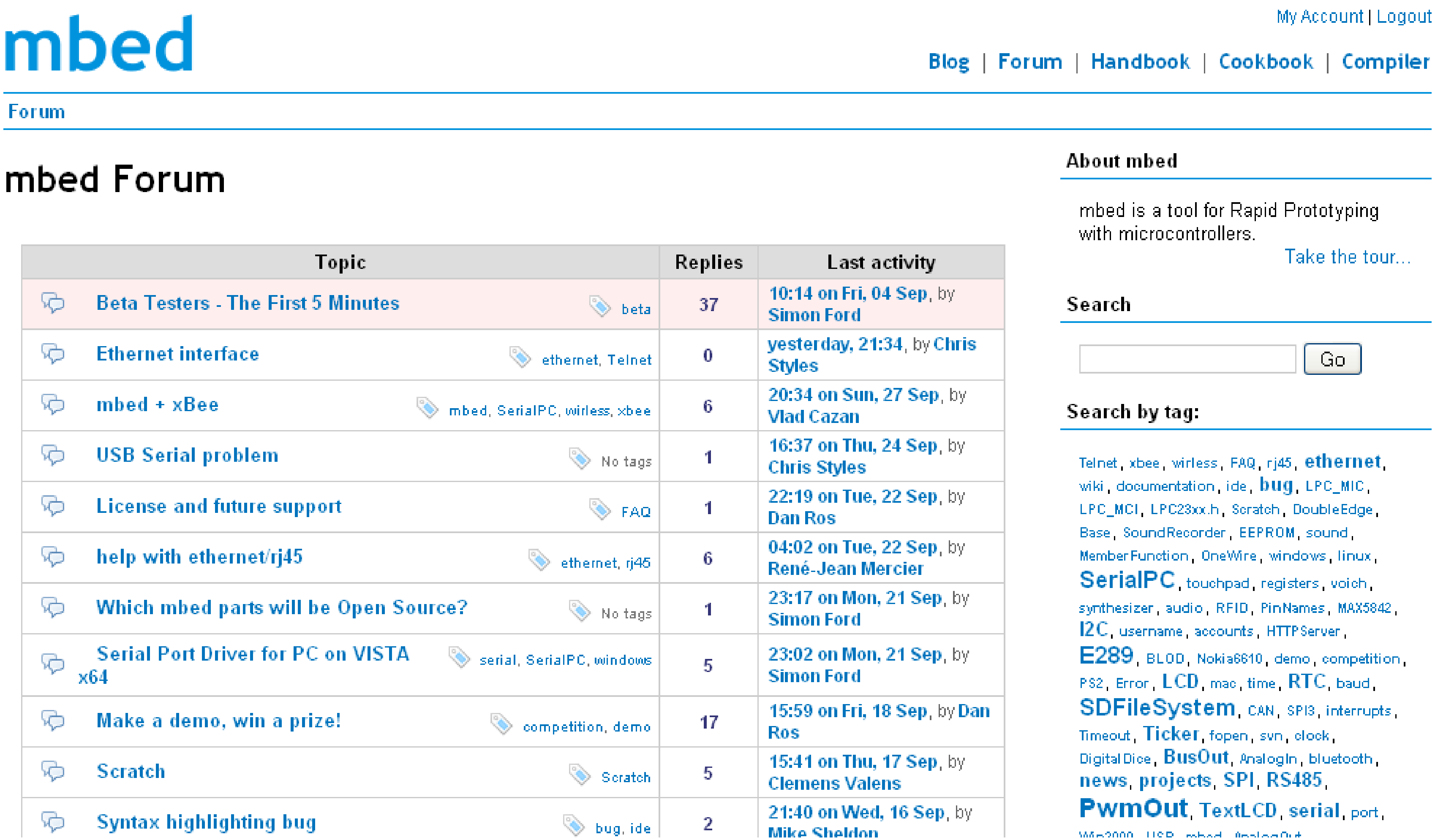
**Search by tag:**

news, projects, announcement, competition, mbed, LocalFileSystem, library, website, firmware, updates, compiler, rocket, launch, accelerometer, beta

**Recent entries**

- mbed is going live!
- Site update: Searching, Image uploads
- Beta Demos Win Prizes!
- Usernames - get yours before it's gone
- Site update
- Website changes, scheduled downtime

# Online resources – mbed forum



mbed

My Account | Logout

Blog | Forum | Handbook | Cookbook | Compiler

Forum

## mbed Forum

| Topic | Replies | Last activity |
|---|---|---|
| Beta Testers - The First 5 Minutes<br>beta | 37 | 10:14 on Fri, 04 Sep, by Simon Ford |
| Ethernet interface<br>ethernet, Telnet | 0 | yesterday, 21:34, by Chris Styles |
| mbed + xBee<br>mbed, SerialPC, wirless, xbee | 6 | 20:34 on Sun, 27 Sep, by Vlad Cazan |
| USB Serial problem<br>No tags | 1 | 16:37 on Thu, 24 Sep, by Chris Styles |
| License and future support<br>FAQ | 1 | 22:19 on Tue, 22 Sep, by Dan Ros |
| help with ethernet/rj45<br>ethernet, rj45 | 6 | 04:02 on Tue, 22 Sep, by René-Jean Mercier |
| Which mbed parts will be Open Source?<br>No tags | 1 | 23:17 on Mon, 21 Sep, by Simon Ford |
| Serial Port Driver for PC on VISTA x64<br>serial, SerialPC, windows | 5 | 23:02 on Mon, 21 Sep, by Simon Ford |
| Make a demo, win a prize!<br>competition, demo | 17 | 15:59 on Fri, 18 Sep, by Dan Ros |
| Scratch<br>Scratch | 5 | 15:41 on Thu, 17 Sep, by Clemens Valens |
| Syntax highlighting bug<br>bug, ide | 2 | 21:40 on Wed, 16 Sep, by Mike Sheldon |

### About mbed

mbed is a tool for Rapid Prototyping with microcontrollers.

Take the tour...

### Search

Go

### Search by tag:

Telnet, xbee, wirless, FAQ, rj45, ethernet, wiki, documentation, ide, bug, LPC_MIC, LPC_MCI, LPC23xx.h, Scratch, DoubleEdge, Base, SoundRecorder, EEPROM, sound, MemberFunction, OneWire, windows, linux, SerialPC, touchpad, registers, voich, synthesizer, audio, RFID, PinNames, MAX5842, I2C, username, accounts, HTTPServer, E289, BLOD, Nokia6610, demo, competition, PS2, Error, LCD, mac, time, RTC, baud, SDFileSystem, CAN, SPI3, interrupts, Timeout, Ticker, fopen, svn, clock, DigitalDice, BusOut, AnalogIn, bluetooth, news, projects, SPI, RS485, PwmOut, TextLCD, serial, port, Win2000, USB, mbed, AnalogOut

# Frequently Asked Questions

- **Q. How does mbed help me build prototypes quickly and easily?**
  - The mbed Microcontroller packages an NXP LPC1768 Cortex-M3 processor-based MCU and support components in a practical 40-pin 0.1" pitch DIP form-factor, ideal for experimenting on solderless breadboard, stripboard and through-hole PCBs.
  - The mbed C/C++ Libraries provide high-level interfaces to microcontroller peripherals, enabling a clean, compact, API-driven approach to coding.
  - This combination gives immediate connectivity to peripherals and modules for prototyping and iteration of microcontroller-based system designs, providing developers with the freedom to be more innovative and more productive.

# Frequently Asked Questions (cont.)

- **Q. Who is mbed for?**
  - Engineers new to embedded applications can use mbed to experiment and test product ideas that could benefit from advanced microcontrollers.
  - Experienced engineers can be more productive and adventurous in the proof-of-concept stages of development.
  - Marketing, Sales, Application Engineers and Distributors can use mbed as a consistent platform for demonstration, evaluation and support of microcontrollers, middleware and associated components.
  - Education, Enthusiasts and Inventors can use mbed as an accessible way to experiment with the application of microcontrollers without worrying about implementation details.
  - As a result, the mbed tools will help a diverse audience exploit the opportunities presented by advanced microcontrollers when introduced to their own area of expertise.

# Frequently Asked Questions (cont.)

- **Q. Can I use the code I develop with mbed for production?**
  - The libraries are designed for prototyping as part of mbed; they are provided "as is," but could theoretically be used in a production system at no cost.

# Frequently Asked Questions (cont.)

- **Q. Is there a JTAG debugger?**
  - No, the mbed tools don’t support JTAG debugging. Where this feature is deemed essential, mbed is not the solution.
  - With mbed takes the approach of doing as much as possible to avoid firing up a debugger. The API-driven approach means the peripherals are all abstracted to their core concepts, and the implementations are reliable.
  - With mbed, things like printf work out-of-the-box over the same USB interface, so this provides a easily accessible way to debug logical problems in a familiar fashion.
  - You can even access the mbed USB file system, such as to dump log files.

# Frequently Asked Questions (cont.)

- **Q. Is there an offline compiler?**
  - No, everything is online. If you need to work offline, mbed is not the solution.
  - Online tools avoid the installation, configuration or platform issues, and also has the advantage everyone is using the same setup, so official and community support works better.

# Frequently Asked Questions (cont.)

- **Q. Am I able to use my existing ARM application code with the mbed tool?**
  - The mbed Compiler is a C/C++ compiler, and the mbed Microcontroller simply runs a raw binary suitable for the target MCU.
  - Therefore, existing ARM application code or middleware should be portable to mbed with a little effort.

# Frequently Asked Questions (cont.)

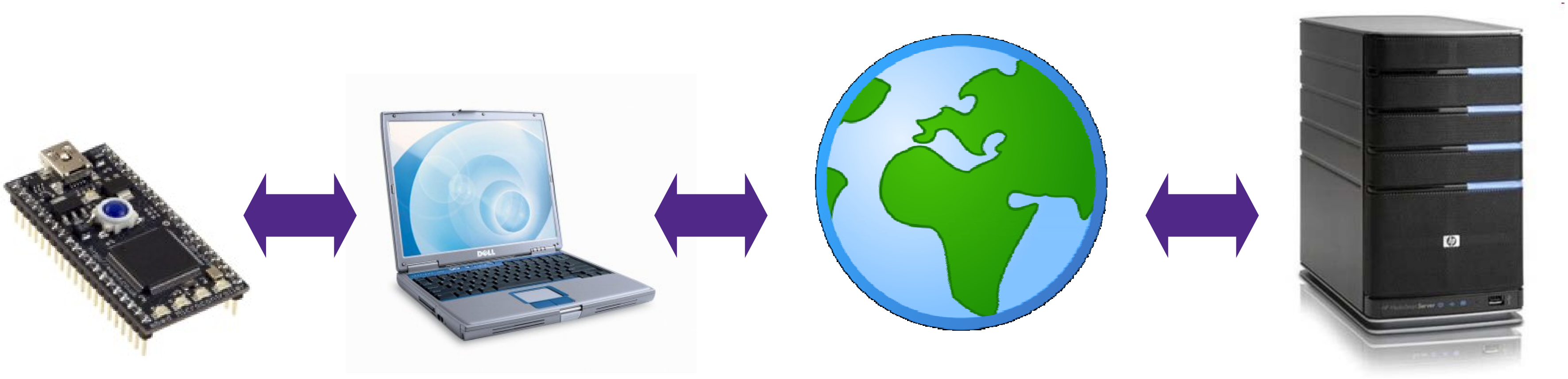
- **Q. Won't the free online compiler yield bloated, inefficient code?**
  - The mbed Compiler uses the same compiler technology found in the ARM RealView and Keil MDK tool suites, so it is the best in the industry.
  - The mbed Libraries are focused on providing the abstractions needed to optimize time to prototype, rather than code size.
  - But even still, combined with an optimizing compiler it really isn't much of an overhead. You can always go in and optimize the critical components, so mbed gives a great way to avoid falling in to the early optimization trap and only spend the effort where needed.

# Frequently Asked Questions (cont.)

- **Q. Does mbed support the USB and Ethernet functions? Are stacks provided? Is it possible to use my own 3rd-party stacks?**
  - The mbed Library supports Ethernet within the API, and there are a number of USB, TCP/IP and HTTP contributed library examples.
  - You are certainly free to incorporate 3rd-party or open source stacks, and ARM/NXP are working with middleware vendors to make this process very smooth.

# Summary - Enabling Rapid Evaluation of microcontrollers with mbed

- Hassle-free evaluation
  - No / Low cost
  - No installation
  - No learning curve
- Differentiation
  - Ultra-fast methodology
  - Real ease of use
  - Leading technology



# Additional resources

- mbed web site: http://mbed.org
- Circuit Cellar Magazine mbed article
- Elektor Magazine mbed article
- ElectronicsWeekly.com mbed article
- EETimes UK mbed article
- New Electronics mbed article

# Thank you!

- More questions?