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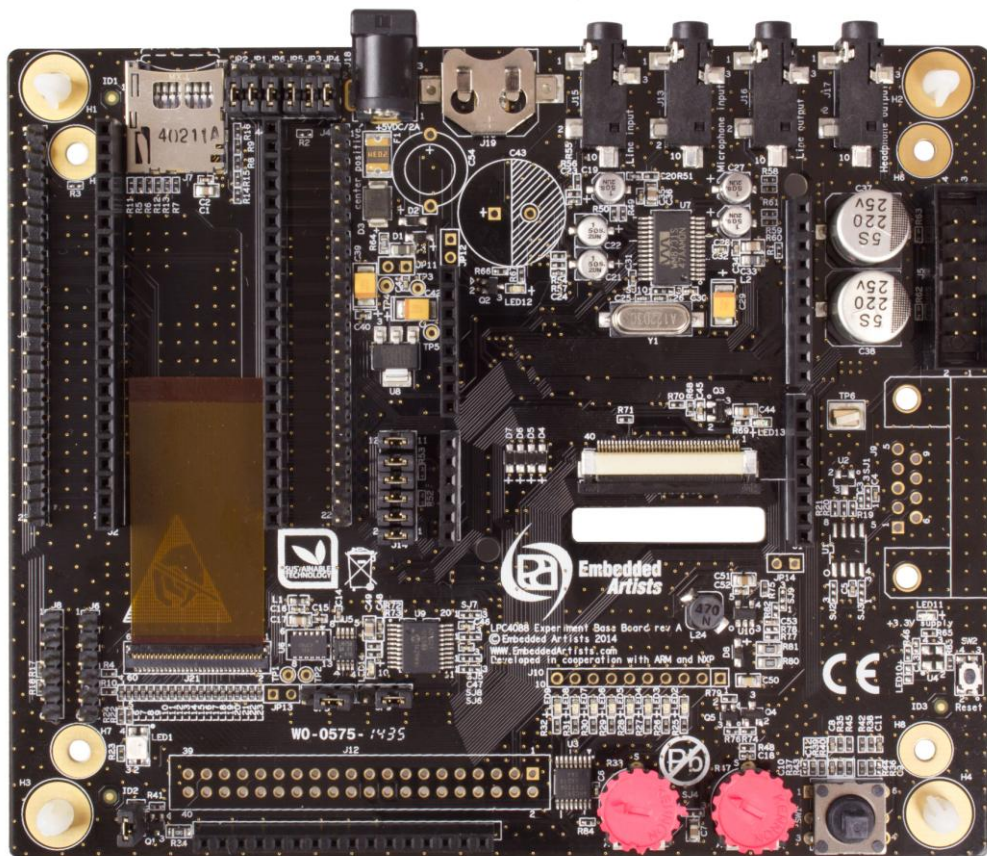
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LPC4088 Experiment Base Board - User's Guide

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LPC4088 Experiment Base Board User's Guide



*Get Up-and-Running Quickly and
Start Developing Your Application On Day 1!*



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1 Document Revision History

<i>Revision</i>	<i>Date</i>	<i>Description</i>
PA1	2014-09-29	First version.
PA2	2014-10-02	Corrected default jumpers.

2 Introduction

Thank you for buying Embedded Artists' *LPC4088 Experiment Base Board*. The board has been designed to operate together with the *LPC4088 QuickStart board*, which is based on NXP's ARM Cortex-M4 LPC4088 microcontroller.

This document is a User's Guide that describes the *LPC4088 Experiment Base Board* hardware design. It also describes how the board function together with the *LPC4088 QuickStart Board*, which together form the *LPC4088 Experiment Bundle*.

2.1 Features

Embedded Artists' *LPC4088 Experiment Base Board* lets you get up-and-running quickly with the mbed-platform and Cortex-M4 programming in general. The features of the board are:

- Interfaces and Connectors
 - Dual 22-pos headers and 61-pos FPC/FFC connector for the *LPC4088 QuickStart Board*
 - Dual 22-pos pin-list for accessing the *LPC4088 QuickStart Board* pins
 - Arduino™ compatible expansion connectors (for Arduino shields)
 - Serial Expansion Connector, 14-pos connector with UART/I2C/SPI/GPIO pins
 - micro-SD (uSD) interface & connector (both MCI and SPI interface versions)
 - Connector to 1.8" TFT LCD 128x160 pixels (LCD not included)
 - Connector for character LCD (with standard 16-pin interface, display not included)
- Audio Interface
 - WM8731 Audio codec, with microphone input, Line in, Line out and Headphone out
- LCD Interface
 - 40-pos FPC connector for 4.3" and 5" LCD interfaces (LCD expansion kits sold separately)
 - Touch screen interface controller based on AR1021
 - LCD backlight voltage generator
- Other
 - UART interfaces for UART0/UART3 via FTDI cables (not included)
 - Shift register on SPI bus controlling 8 LEDs
 - Above shift register also creating a character LCD interface
 - RGB-LED
 - 5-key Joystick
 - MMA7455 3-axis accelerometer (I2C connected)
 - LM75 temperature sensor (I2C connected)
 - Trimming potentiometer on analog input
- Power
 - Power supply, either via USB or external +5V DC (2.1mm jack)

- 12mm coin cell powering supported (CR1216 battery not included) for RTC and LED on ALARM signal
- Dimensions
 - Compact size: 134 x 114 mm

2.2 ESD Precaution

Please note that the *LPC4088 Experiment Base Board* and *LPC4088 QuickStart Board* come without any case/box and all components are exposed for finger touches – and therefore extra attention must be paid to ESD (electrostatic discharge) precaution.

Make it a habit always to first touch the metal surface of one of the USB or Ethernet connectors for a few seconds with both hands before touching any other parts of the boards. That way, you will have the same potential as the board and therefore minimize the risk for ESD.



In general touch as little as possible on the boards in order to minimize the risk of ESD damage.

Note that Embedded Artists does not replace boards that have been damaged by ESD.

2.3 General Handling Care

Handle the *LPC4088 Experiment Base Board* and *LPC4088 QuickStart Board* with care. The boards are not mounted in a protective case/box and are not designed for rough physical handling. Connectors can wear out after excessive use. The *LPC4088 Experiment Base Board* is designed for prototyping use, and not for integration into an end-product. The *LPC4088 QuickStart Board* is however designed for integration into end-products.

For boards with the LCD expansion kit mounted, do not exercise excessive pressure on the LCD glass area. That will damage the display. Also, do not apply pressure on the flex cables connecting the LCD/touch screen. These are relatively sensitive and can be damaged if too much pressure is applied to them.

Note that Embedded Artists does not replace boards where the LCD has been improperly handled.

2.4 Code Read Protection

The LPC4088 has a Code Read Protection function (specifically CRP3, see datasheet for details) that, if enabled, will make the LPC4088 impossible to reprogram (unless the user program has implemented such functionality).

Note that Embedded Artists does not replace LPC4088 QuickStart Boards where the LPC4088 has CRP3 enabled. It's the user's responsibility to not invoke this mode by accident.

2.5 CE Assessment

The *LPC4088 Experiment Bundle* (consisting of the *LPC4088 Experiment Base Board* and *LPC4088 QuickStart Board*) is CE marked. See separate *CE Declaration of Conformity* document.

The *LPC4088 Experiment Bundle* is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

EMC emission test has been performed on the *LPC4088 Experiment Bundle*. Standard interfaces like Ethernet, USB, serial have been in use. General expansion connectors where internal signals are made available (for example processor pins) have been left unconnected. Connecting other devices to the product via the general expansion connectors may alter EMC emission. It is the user's

responsibility to make sure EMC emission limits are not exceeded when connecting other devices to the general expansion connectors of the *LPC4088 Experiment Bundle*.

Due to the nature of the *LPC4088 Experiment Bundle* – an evaluation board not for integration into an end-product – fast transient immunity tests and conducted radio-frequency immunity tests have not been executed. Externally connected cables are assumed to be less than 3 meters. The general expansion connectors where internal signals are made available do not have any other ESD protection than from the chip themselves. Observe ESD precaution.

2.6 Other Products from Embedded Artists

Embedded Artists have a broad range of LPC based boards that are very low cost and developed for prototyping / development as well as for OEM applications (i.e., for integration). Modifications for OEM applications can be done easily, even for modest production volumes. Contact Embedded Artists for further information about design and production services.

2.6.1 Design and Production Services

Embedded Artists provide design services for custom designs, either completely new or modification to existing boards. Specific peripherals and I/O can be added easily to different designs, for example, communication interfaces, specific analog or digital I/O, and power supplies. Embedded Artists has a broad, and long, experience in designing industrial electronics in general and with NXP's LPC microcontroller families in specific. Our competence also includes wireless and wired communication for embedded systems.

2.6.2 OEM / LPCXpresso / QuickStart Boards and Kits

Visit Embedded Artists' home page, www.EmbeddedArtists.com, for information about other products or contact your local distributor.

3 Getting Started

This chapter contains information about how to get acquainted with the *LPC4088 Experiment Bundle*. **Please read this section first before you start using the board - it will be well spent time!**

3.1 LPC4088 Experiment Bundle

The *LPC4088 Experiment Base Board* cannot function on its own. It is designed to be connected to the *LPC4088 QuickStart Board* and together they form the *LPC4088 Experiment Bundle*, see picture below.

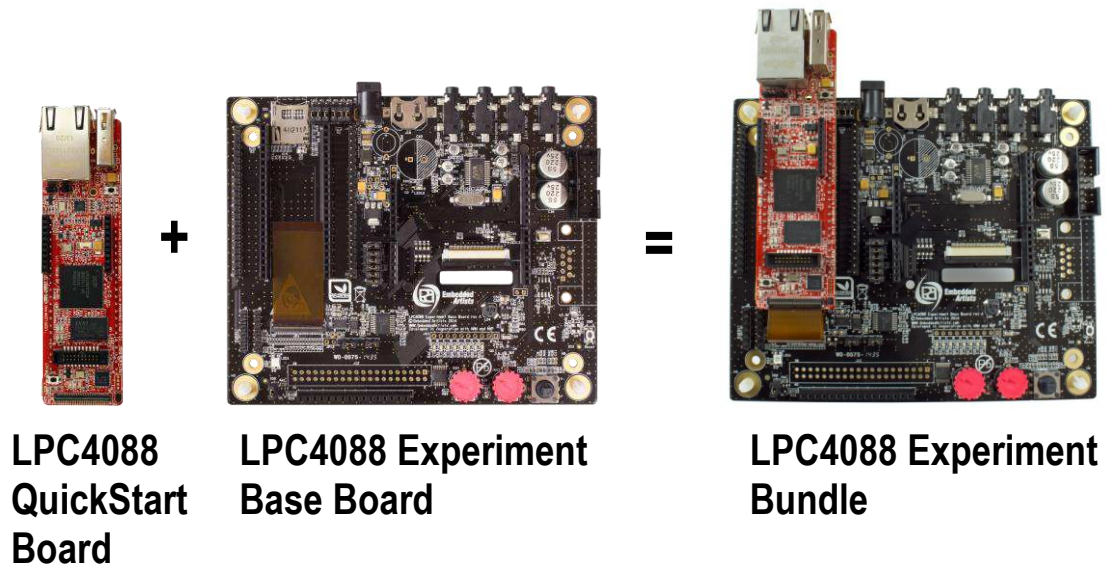


Figure 1 – LPC4088 Experiment Bundle Definition

For more information about hardware design of the *LPC4088 Experiment Base Board* see chapter 4 .

For more information about display expansion see chapter 5 .

For more information about the *LPC4088 QuickStart Board* see chapter 6 .

For more information about the program development see section 3.5 .

For more information about how to get started with mbed see chapter 7 .

3.2 Mounting the LPC4088 QuickStart Board

Mounting the *LPC4088 QuickStart Board* on the *LPC4088 Experiment Base Board* is very straightforward with the dual 22 pos edge connectors. It is the FPC/FFC (Flexible Flat Cable) connector that is a little more challenging, so follow these steps:

1. Start with connecting the 61-pos FFC on the *LPC4088 Experiment Base Board*. The open metal connectors shall be facing down. Open the FFC connector carefully. See the picture below for details about how far in the connector the FFC can be expected to be inserted. Carefully close the connect with two fingers pressing at each end of the connector.
2. Mount the *LPC4088 QuickStart Board* on the *LPC4088 Experiment Base Board* (via the dual edge row connectors).
3. Open the FFC connector carefully on the *LPC4088 QuickStart Board* can insert the free end of the FFC. See the picture below for details about how far in the connector the FFC can be expected to be inserted. Carefully close the connect with two fingers pressing at each end of the connector.

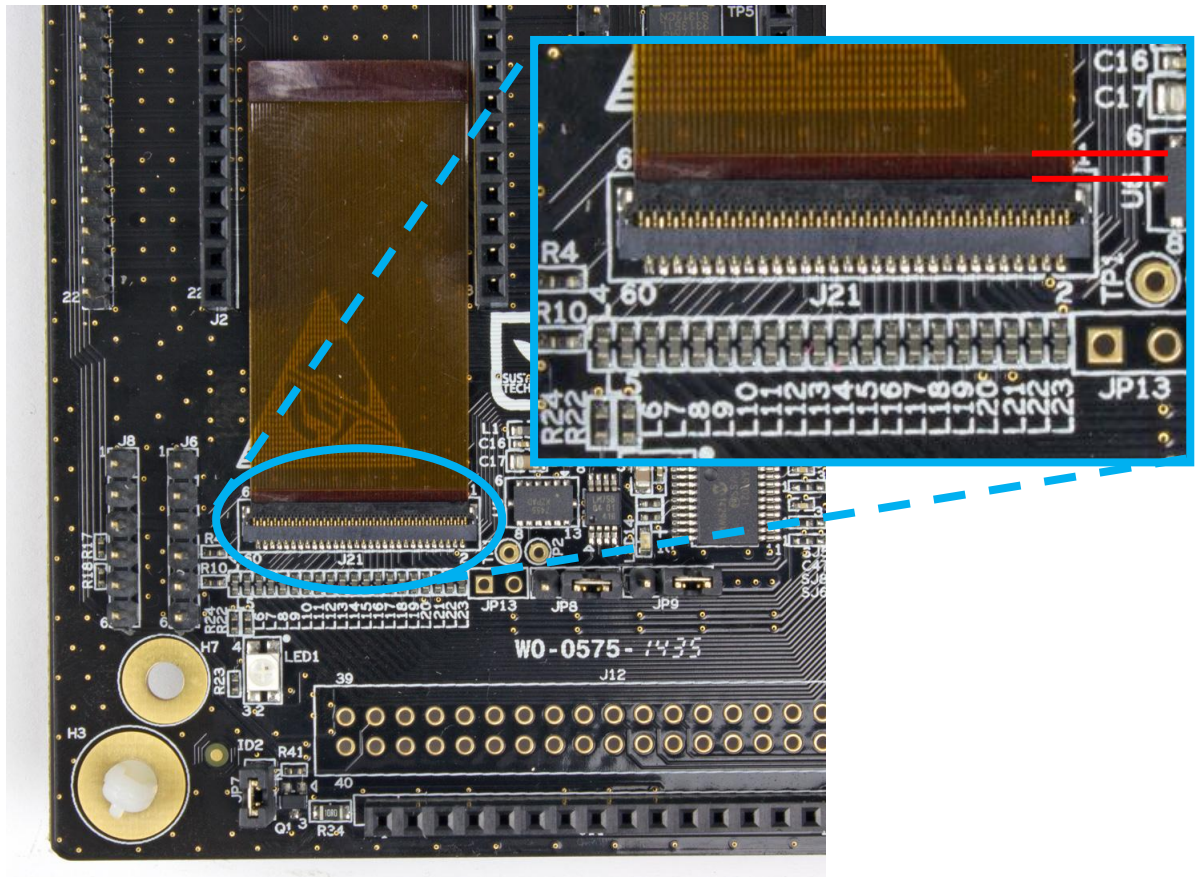


Figure 2 – FFC on LPC4088 Experiment Base Board

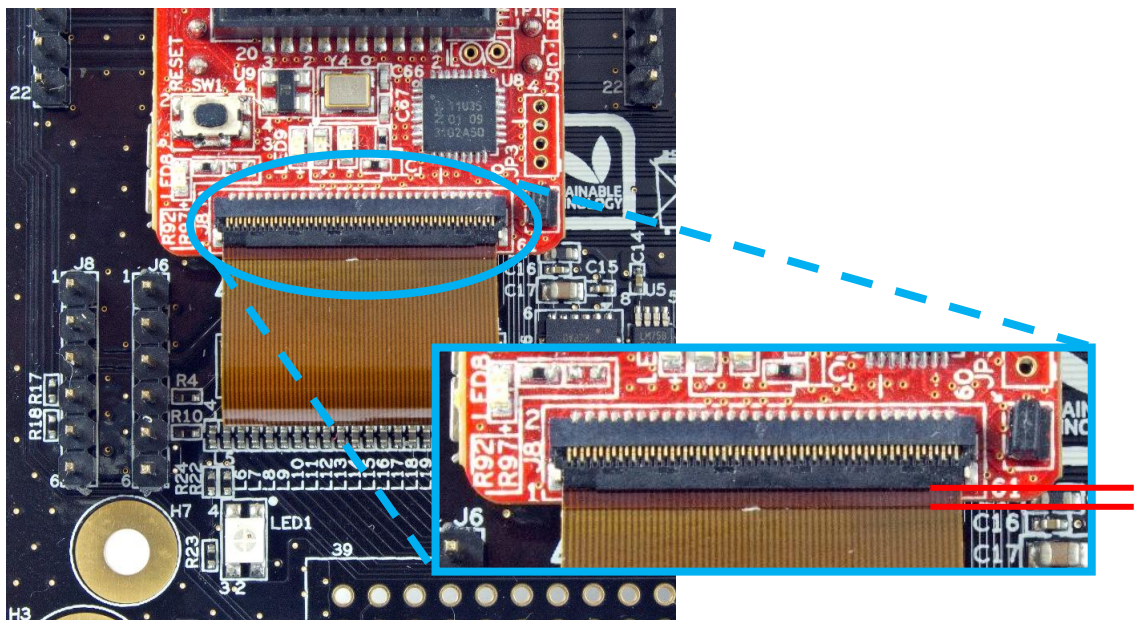


Figure 3 – FFC on LPC4088 QuickStart Board

Do not forget to follow standard ESD precaution routines when mounting/removing the boards. To get same electrical potential between the boards (before connecting them), hold the *LPC4088 QuickStart Board* in one hand. Make sure this hand has at least one finger on the metal surfaces of the Ethernet and/or USB connectors. With the same hand, then touch the metal surface of the uSD connector on the *LPC4088 Experiment Base Board* for a while. Now both boards have the same potential and can be connected together without any electrostatic discharges.

3.3 Powering

Powering is very flexible. Either the *LPC4088 QuickStart Board* powers the *LPC4088 Experiment Base Board*, or vice versa. The picture below illustrates the two principal powering options.

- The simplest powering option is to power the *LPC4088 Experiment Bundle* via the HDK micro-B USB connector on the LPC4088 QuickStart Board. This cable is typically always connected when doing program development. Note that not all PC/laptops can provide enough current. An externally powered USB hub can be used in this case or use the other option (see next point below).
- Alternatively an external +5V DC / 1A power supply (5W) is connected to J18. A 2.1mm standard power plug is used to connect to the board. Center pin is positive.

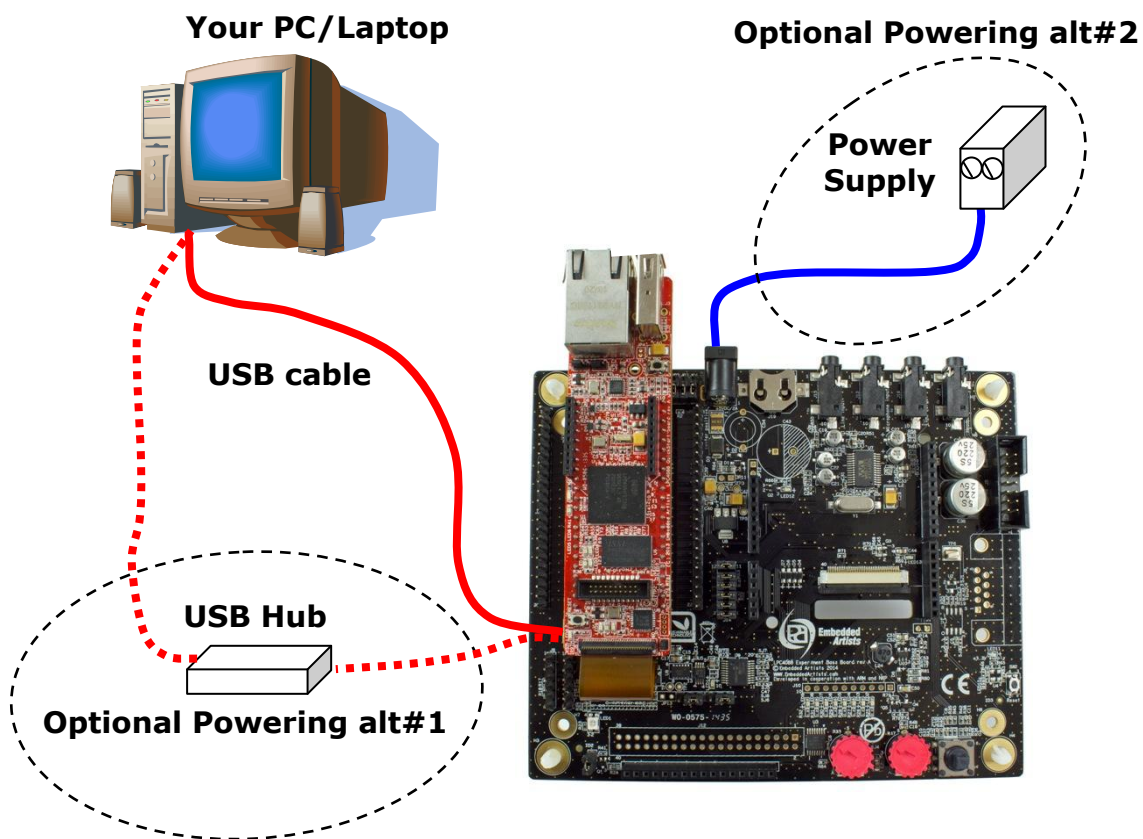


Figure 4 – Powering of LPC4088 Experiment Bundle

There is a third, less common, powering option and that is via one of the UART interface connectors. The FTDI TTL-232R-3V3 cable provides a +5V supply. Note that only one FTDI cable should be connected at a time since both UART interface connectors share the same supply net.

3.4 Demo/Test Application

A simple demo/test application has been created. It can also be used as a troubleshooting application. The application is not pre-loaded so follow the guidelines for how to download a program in section 3.5. The source code and pre-compiled binary file (*.bin) is available from the support site. Section 8.3 describe the behavior of the application.

Make sure the jumpers are correctly set when running the demo/troubleshooting application. See section 3.8 for details.

3.5 Program Development

When starting program development two initial selections must be done - which program framework to start working in and which tool chain to use. Sometimes the choices are linked together.

Three different framework solutions for the *LPC4088 Experiment Bundle* are presented in the following sub sections. The different tool chains are presented in each sub-section, since the choices are somewhat different between the frameworks

3.5.1 mbed Framework

The mbed framework[12] might seem like to only natural choice since the *LPC4088 QuickStart board* is marketed as an mbed-enabled board. This is true and the mbed framework will be described in this sub-section, but there are other alternatives as well. The mbed framework has its strengths and weaknesses, just like any other solution.

The mbed site (<http://mbed.org>) points to four cornerstones in the framework:

- The **mbed Software Development Kit (SDK)**, which is an open source C/C++ microcontroller software platform designed for a suitable level of hardware abstraction to simplify microcontroller programming.
- The **mbed Compiler** is a powerful online IDE that is tightly integrated with the mbed SDK and Developer's Website (mbed.org).
- The **mbed Hardware Development Kit (HDK)**, which is an interface design that provides simple USB drag-n-drop programming and CMSIS-DAP debug interface for the LPC4088 microcontroller. The *LPC4088 QuickStart Board* has an on-board HDK.
- The **mbed.org community**, with extensive documentation in the form of handbooks, cookbooks, project pages, User Forums for getting help and advice from other mbed users, etc.

The mbed Compiler gives you instant access to lightweight C/C++ microcontroller development. It is an online web application IDE (Integrated Development Environment) that you can log in from anywhere and work on Windows, Mac, iOS, Android or Linux. For a quick guide how to write code, compile and download to the *LPC4088 QuickStart Board*, see chapter 7 .

The mbed Compiler has some limitations, mainly when it comes to debugging. There are alternatives to the online compiler when more professional program development and debugging is needed. The mbed framework and the application code can be exported from the online compiler and imported into an offline tool chain. For more details, see here: <http://mbed.org/handbook/Exporting-to-offline-toolchains>

Currently there are guides for exporting to:

- uVision
- LPCXpresso IDE
- CodeSourcery
- GCC ARM Embedded
- IAR Embedded Workbench

Under these tool chains it is possible to perform advanced debugging with breakpoints, inspecting variable values, dumping memory regions and even trace the program execution flow (provided the debug probe supports the feature).

3.5.2 LPCOpen Framework

LPCOpen[10] has been created by NXP. It is a platform consisting of a large number of libraries and examples that allows you to get started quickly. The platform uses common APIs that work equally across all NXP microcontroller families. It supports the common development tool chains; uVision from Keil/ARM, Embedded Workbench from IAR, and LPCXpresso IDE from NXP.

There is a core driver library containing three important sections:

- Chip Driver Layer - Peripheral drivers for the microcontroller
- Board Layer - Board specific functions and low level setup code
- Examples - Chip family specific examples for peripherals, interfaces, libraries, etc.

LPCOpen also contains some important larger program packages/libraries, like FreeRTOS, LWIP (TCP/IP stack), USB driver and graphical library - all together with bigger project examples.

Embedded Artists has created an LPCOpen port for the *LPC4088 QuickStart Board*.

3.5.3 Setup Own Framework

There is always the option to roll your own solution and start from scratch to build the needed framework. Most tool chains (LPCXpresso IDE from NXP, uVision from Keil/ARM, Embedded Workbench from IAR, etc.) can create empty program skeletons. Besides an empty main()-function, only the most important startup code for initializing clocks and the very basic functions in the microcontroller is given.

This approach is definitively a possibility and might be a preferred option if for example there is legacy code to be ported to the new platform. The approach will require more reading, and understanding, of the LPC4088 User's Manual from NXP.

3.6 Program Download

This section describes some basic methods for downloading application code to the LPC4088. Note that this section does not describe how to create the application code (write the program and compile it). It is assumed that a binary file exist that represent the application program.

Most program development environments create files that also contains debug information (*.elf file or *.axf file). This way, the integrated debuggers have the information needed when debugging. When these files are stripped from the debug information and just the pure binary file is left, it is often also called hex-file, which is a file format that Intel created a long time ago. It can also be a pure binary file (which is typically called a bin-file).

Note that the on-line mbed compiler create pure binary files without debug information (since this environment does not support debugging in the traditional meaning).

There are four basic methods for program download (the top two methods are the recommended that will give a quick start since it is support by on-board functionality):

- **On-board HDK: USB drag-n-drop**
The on-board HDK (see section 6.4 for more information) creates a USB drag-n-drop programming function. A USB Mass Storage Device (MSD) is created and the binary image that the on-line mbed compiler creates can just be dragged and dropped on this drive on the PC-side. The image will then automatically be flashed to the LPC4088 on the board.
Note that any binary file can be dragged and dropped - and programmed. It is not only the on-line mbed compiler that can generate binary files. Normally, however, the generated files also contains debug information. This must be stripped to generate a binary file that can be used.

See the documentation for the used program development environment for details.

- **On-board HDK: CMSIS-DAP Interface (SWD/JTAG)**

The on-board HDK (see section 6.4 for more information) also creates a CMSIS-DAP debug interface, which basically creates an SW debug interface to the LPC4088. The CMSIS-DAP interface is supported by major program development tool vendors.

This interface is not the fastest available (due to limitation of the LPC11U35, the MCU that implements the HDK), but it works very well for hobbyists and semi-professional users. For higher download speed, needed for professional use, an external debug probe is recommended. See next alternative for more details.

- **SWD/JTAG via External Debugger**

The *LPC4088 QuickStart Board* also offers direct access to the Serial Wire (SW) and trace debug interface of the LPC4088 MCU. Any external debug probe that supports the LPC4088 and the 20-pin SW interface, called the Cortex Debug+ETM Connector, can be connected to this interface.

The LPC-Link 2 debug probe directly supports the 20-pin connector, see picture below. The cheap 20 EUR package of EA-XPR-200 (LPC-Link 2) and EX-ACC-014 (20-pos flat cable) is needed to connect to the 20-pin SW interface (J7 in the *LPC4088 QuickStart Board*) and creates a powerful, professional quality debug interface.

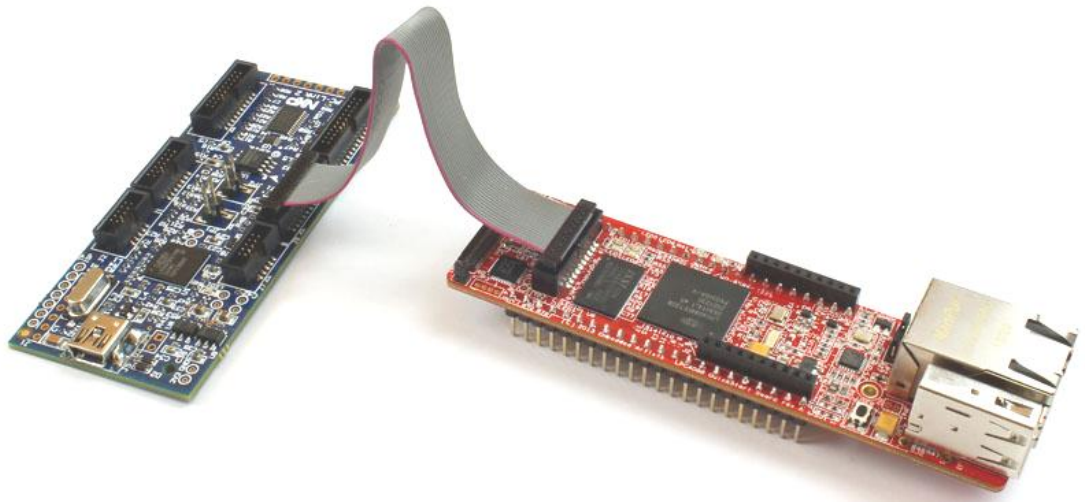


Figure 5 – LPC-Link2 Connected To LPC4088 QuickStart Board

The 10-pin SW interface, called the Cortex Debug Connector, is common on many debug probes. This interface can easily be supported via a special cable that connect only the first 10 position on the 20-pos connector on the *LPC4088 QuickStart Board*. The picture below shows how the cable looks like (included in the ULINK-PRO package).

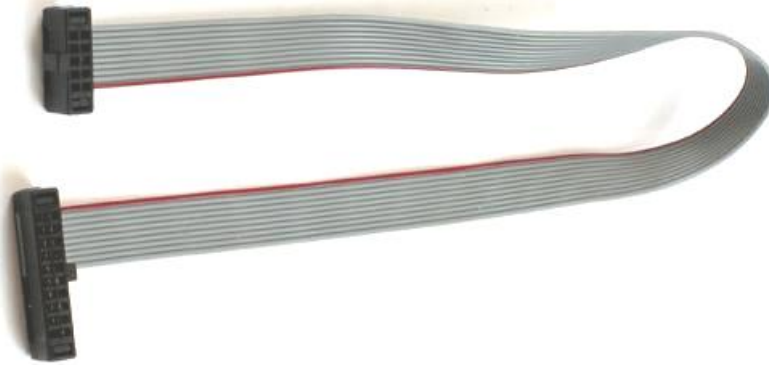


Figure 6 – 10-pos to 20-pos Debug Cable

There are many other SWD/JTAG interfaces on the market, for example ULINK and ULINK-Pro from Keil, JLINK from Segger, I-Jet from IAR. There is also OpenOCD, which is an open source project. Consult the respective manual for the SWD/JTAG interface used to get instructions how to download a hex/binary file via SWD/JTAG.

Using this method, the application can be downloaded to (internal) SRAM, to (internal) flash memory or (external) qspi flash. Note that the debugger needs special download functionality in order to download to external qspi flash memory. Check the supported functions in the program development environment/IDE that is used.

- **ISP over UART**

ISP is short for In-System Programming. The LPC4088 contains a bootloader in ROM that is activated by pulling pin P2_10 low during reset. This is easily accomplished by pressing the user pushbutton during reset/power-up. UART0 pins P0.2 (U0_TXD) and P0.3 (U0_RXD) are then used to download the program. An application is needed on the PC for downloading the application code, for example Flash Magic (<http://www.flashmagictool.com/>).

This method is only included to make the list of options complete, but it is not recommended since the other options are simpler and faster alternatives.

See Figure 21 for details how to connect an FTDI USB-to-UART cable to P0.2/P0.3.

3.7 How to Debug

The debug options are given by the development environment selected. If mbed is selected as framework and the on-line compiler is used, the debug options are very few - basically only printf()-style and flashing LED debugging. This is not acceptable for professional users. If the mbed project is exported to an external development environment, for example the LPCXpresso IDE, then the full debug options are available (like breakpoints, watch-points, etc).

The on-board HDK implements a CMSIS-DAP debug interface that is supported by most development tool vendors. It is not as fast as an external debug probe would be but still acceptable for many applications.

3.8 Default Jumper Positions

Figure 7 illustrates the default jumper positions as mounted when the board is delivered from Embedded Artists.

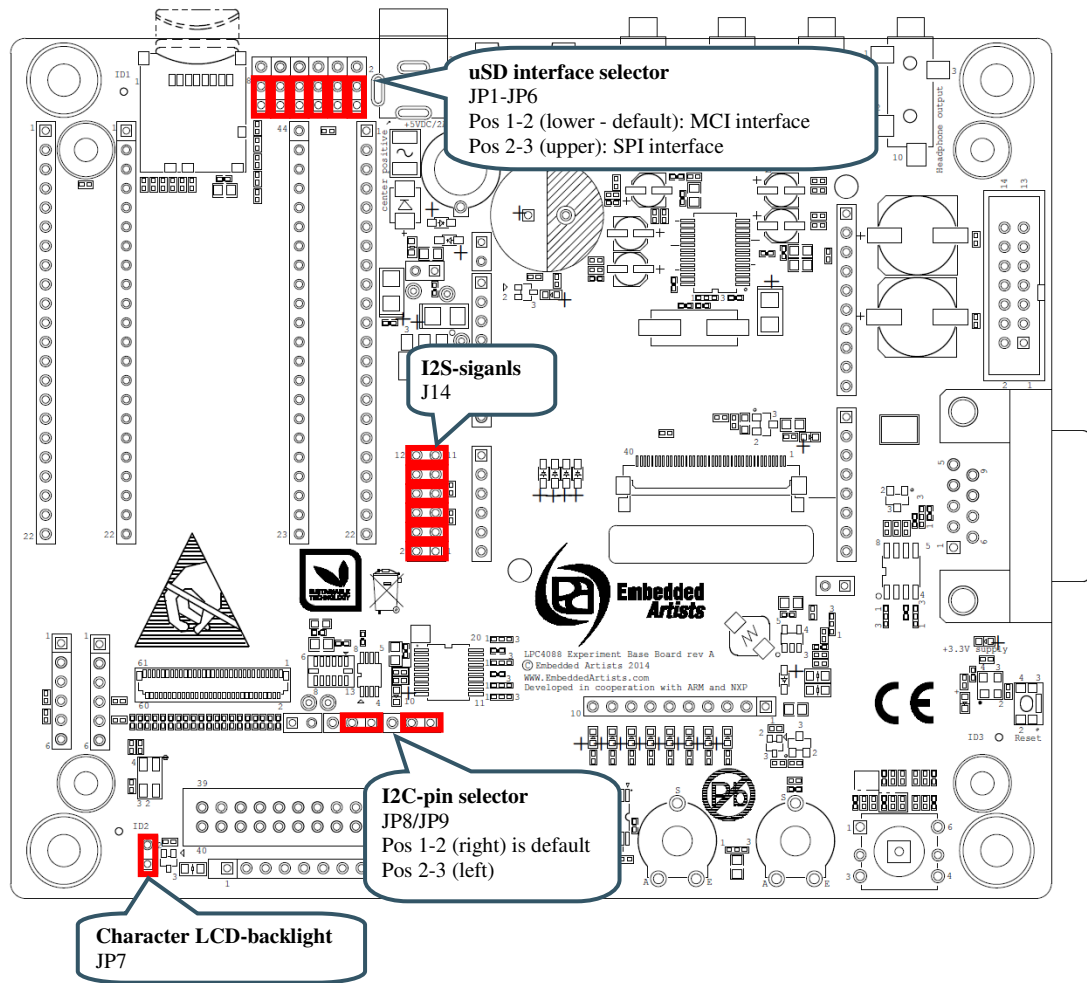


Figure 7 – LPC4088 Experiment Base Board, Default Jumpers

3.9 Things to Note

This section lists things to note when using the *LPC4088 Experiment Bundle*.

3.9.1 Current Consumption and Limits of USB Ports

The current consumption for the *LPC4088 Experiment Bundle* is in the region of 150-200 mA. The current consumption for the *LPC4088 Experiment Bundle* and the *5.0 inch LCD Board* is in the region of 365-410 mA. This is very close to what some USB Host port can supply. If the boards are powered from a USB Host port (for example a PC or laptop) and there are problems, like spontaneous resets or other strange things, it is likely that an external power supply is needed.

3.9.2 USB Mass-storage Does Not Work On Mac - LPC4088 Locks Up

This note affects the *LPC4088 QuickStart Board*.

The HDK is not compatible with how a Mac writes the binary file to the USB mass-storage device (that the HDK creates). If a Mac is used to download a binary file, the LPC4088 will be flashed with a partial binary that is in no way correct. When the LPC4088 starts executing this program it can lock up. Further, the HDK gives an error message (error file on the USB mass-storage device).

If this happens, place the LPC4088 in ISP mode. This is accomplished by pressing the user push-button when powering up the board (or resetting it). Alternatively ground pin 23 (carrying signal P2.10). After that it is possible for the HDK to communicate again with the LPC4088 and download the binary correctly (if a Windows/Linux PC is used). Note that the user push-button must be pressed whenever the LPC4088 is power cycled or reset to keep the board in ISP mode. It is not until a new, correct

binary has been downloaded that the "enter ISP mode" operation can be ignored after a power cycle or reset.

3.9.3 USB Virtual Serial Channel Behavior

This note affects the LPC4088 QuickStart Board.

A known behavior of the HDK USB device is that it restarts after downloading any file to the mass storage device. If a virtual serial channel is active it will of course stop during the restart. A power cycle of the HDK is needed in order to restart the virtual serial channel after this. The simplest way to accomplish this is to open (and then short) JP3 on the *LPC4088 QuickStart Board*. This jumper can be found just beside the FPC/FFC connector.

3.9.4 Cannot Download Binary To LPC4088 Via HDK Or Cortex Debug Connector

This note affects the LPC4088 QuickStart Board.

If it is impossible to download a new binary to the LPC4088 via the HDK/external debugger, it is likely that the LPC4088 is in a mode where it is impossible for the HDK/debugger to take control over it.

Press the user push-button while powering the board. That will place the LPC4088 in ISP/bootloader mode. After that it should be possible for the HDK/debugger to download a new binary.

Note that from rev B of the *LPC4088 QuickStart Board* and with latest HDK firmware, the HDK can put the LPC4088 in ISP/bootloader mode automatically, so this will be an issue that no longer exist in newer versions of the hardware.

3.10 Updating the HDK

It is a good idea to always have the latest version of the HDK firmware on the *LPC4088 QuickStart Board*. The first step is to identify which HDK firmware version that is running.

Connect the *LPC4088 QuickStart Board* to a computer to get the MBED drive and then open the mbed.htm file in an editor e.g. notepad (don't double click the file as it will launch a web browser and that will not help).

The first firmware version (from 2013-10-02) has a mbed.htm file that looks like below (the value of the code= will be different):

```
<!-- mbed Microcontroller Website and Authentication Shortcut -->
<html>
<head>
<meta http-equiv="refresh" content="0;
url=http://mbed.org/platforms/EA-LPC4088/?code=..."/>
<title>mbed Website Shortcut</title>
</head>
<body></body>
```

Subsequent version of the firmware looks like below (a version number, build date and release date - in this case it is the release from 2014-01-07):

```
<!-- Version: 0200 Build: Jan 7 2014 10:48:51 -->
<!-- Released by Embedded Artists on 2014-01-07 -->
```

The latest firmware version is available from the product support on Embedded Artists website or from the mbed.org site (more specifically the documentation pages for the LPC4088 QuickStart Board).

3.10.1 Update Procedure

The location of the RESET pushbutton and the USB interface to use for firmware update is shown in the picture below.

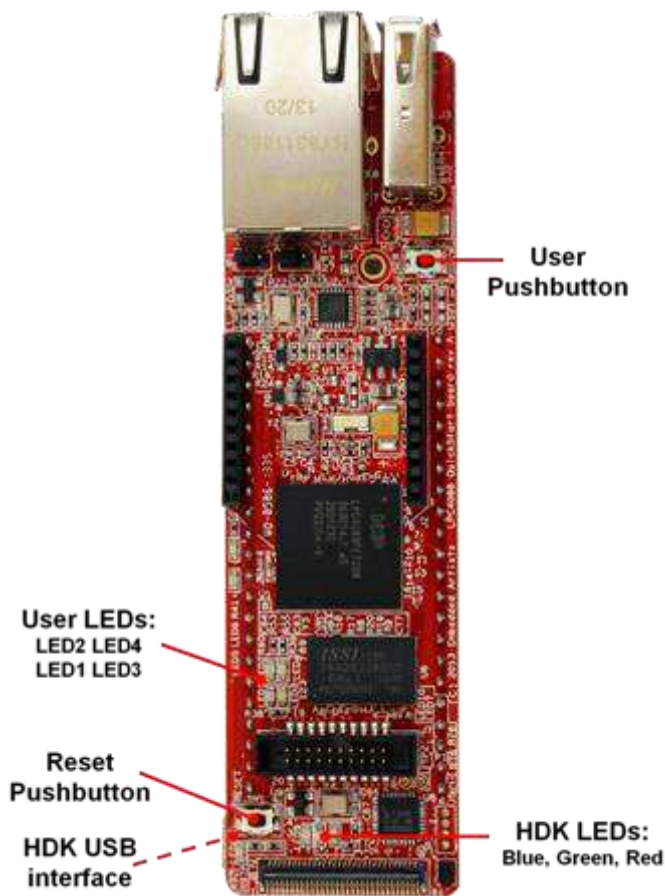


Figure 8 – LPC4088 QuickStart Board, LEDs and Push-buttons

Windows (or Linux)

1. Start by downloading the firmware that you want (links above)
2. Connect the *LPC4088 QuickStart Board* to a Windows machine (Linux does not always work - this is a limitation of the LPC11U35 MCU)
3. Press and hold down the RESET button on the *LPC4088 QuickStart Board*
4. Insert the USB cable
5. Release the RESET button
6. You should now have a CRP_DISABLED drive (if not unplug and redo steps 2, 3 and 4)
7. Delete the firmware.bin file from the CRP_DISABLED drive
8. Copy the binary that you downloaded in step 1 to the CRP_DISABLED drive
9. Disconnect and then connect the USB cable to get the normal MBED drive

Mac

It is not possible to update the HDK firmware on the LPC4088 QuickStart Board from a Mac computer.

4 LPC4088 Experiment Board Design

This chapter contains information about the peripherals and general design of the *LPC4088 Experiment Base Board* and how to set the different jumpers on the board. The schematic can be downloaded in pdf format from the support page, and is recommended to have printed out while reading this chapter.

Section naming begins with *SPx*, which is short for *Schematic Page x*.

The picture below gives an overview of the *LPC4088 Experiment Base Board* design.

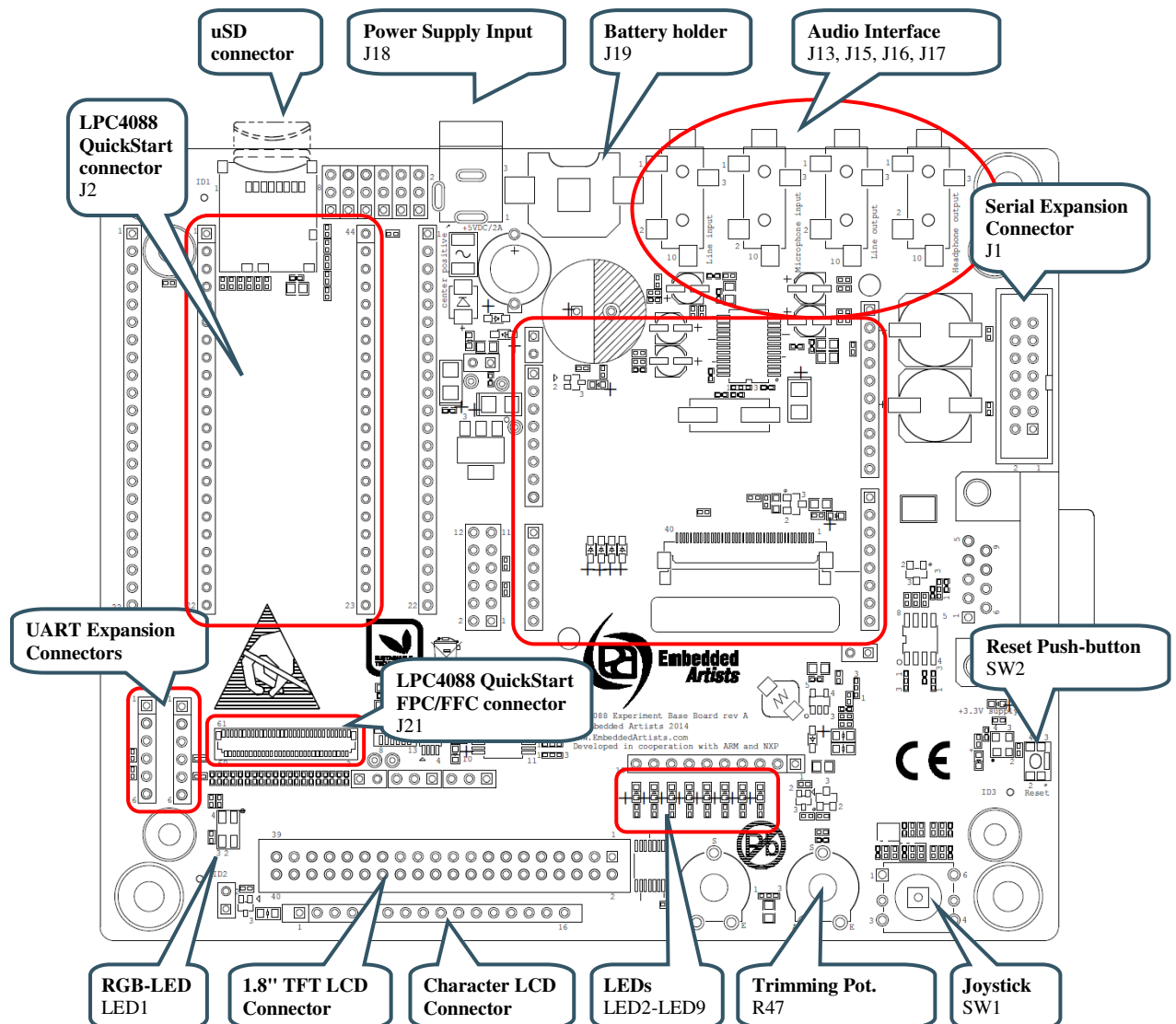


Figure 9 – LPC4088 Experiment Base Board Overview

4.1 Modifications to LPC4088 Experiment Base Board

The *LPC4088 Experiment Base Board* has been designed to be flexible. Most options can be controlled via jumpers but there are a few options that need soldering. Note that modifications to the board are done at own risk and void all warranties.

4.2 SP2: Pin Usage

The second page of the schematic lists how the *LPC4088 QuickStart Board* expansion pins are used. This also include the signals available over the 61-pos FPC display expansion connector.

The information is included to ease programming and general understanding of the board.

Note: Always consult the pin usage list so that there is no pin usage contention when starting a new project!

For example, the RGB-LED and the uSD interface in MCI mode cannot be used simultaneous. The shift register and uSD interface in SPI cannot be used simultaneous.

4.3 SP3: LPC4088 QuickStart Board Connectors

The *LPC4088 QuickStart Board* has two 22-pos edge connectors that are pin lists facing down. J2 is a header (female) connector that allows the *LPC4088 QuickStart Board* to be mounted on the board. Note that the *LPC4088 QuickStart Board* also has a 61-pos FPC connector. This is J21, found on schematic page 9.

All 44 edge signals are accessible via pin headers (J3/J4) just beside the *LPC4088 QuickStart Board*.

4.3.1 Powering of LPC4088 QuickStart Board

Powering is very flexible. Either the *LPC4088 QuickStart Board* powers the *LPC4088 Experiment Base Board*, or vice versa. The +5V net (pin 43 on J2) is shared between the boards to accomplish this. Both boards can also be powered separately.

The *LPC4088 QuickStart Board* has its own 3.3V voltage regulator and powers its internal circuits. The 3.3V supply from the *LPC4088 QuickStart Board* is **not** used to power the *LPC4088 Experiment Base Board*. Similarly the *LPC4088 Experiment Base Board* has its own 3.3V supply.

Note that signal VIN (pin 2, J2) on the *LPC4088 QuickStart Board* is not connected to EXT_VIN (since the board is sharing power via the +5V net).

4.4 SP3: Arduino™ Shield Connector

J1 is an Arduino UNO R3 compatible shield connector (or actually four separate headers). It is not 100% compatible, but close to. Note that several of the pins connected are also used on other interfaces on the board. Consult page 2 of the schematic for an overview. Before connecting an Arduino shield make sure there are no signal contentions between the shield and the *LPC4088 Experiment Base Board*.

Arduino Signal	LPC4088 pin	LPC4088 QuickStart Board pin number	Note
SCL	P1.31	p20	Same signal as A5
SDA	P1.30	p19	Same signal as A4
D13: GPIO/SPI-SCK	P0.7	p13	
D12: GPIO/SPI-MISO	P0.8	p12	
D11: GPIO/PWM/SPI-MOSI	P0.9	p11	
D10: GPIO/PWM/SPI-SSEL	P0.6	p14	
D9: GPIO/PWM	P5.4	p37	
D8: GPIO	P5.3	p31	Minimize capacitive loading on this net when using it as output, since it is an open-drain output (with 1500 ohm

			pull-up).
D7: GPIO	P0.4	p34	
D6: GPIO/PWM	P5.1	p38	
D5: GPIO/PWM	P5.0	p39	
D4: GPIO	P0.5	p33	
D3: GPIO/PWM	P5.2	p32	Minimize capacitive loading on this net when using it as output, since it is an open-drain output (with 1500 ohm pull-up).
D2: GPIO	P0.21	p8	
D1: GPIO/UART-TXD	P0.0	p9	
D0: GPIO/UART-RXD	P0.1	p10	
A5: GPIO/AIN/I2C-SCL	P1.31	p20	
A4: GPIO/AIN/I2C-SDA	P1.30	p19	
A3: GPIO/AIN	P0.26	p18	
A2: GPIO/AIN	P0.25	p17	
A1: GPIO/AIN	P0.24	p16	
A0: GPIO/AIN	P0.23	p15	

4.5 SP3: Serial Expansion Connector

The *Serial Expansion Connector* is a standardized serial interface connector that is included on many boards from Embedded Artists, including this board. The purpose is to provide a simple expansion connector for smaller expansion modules. Such modules are typically sensors of different kinds and communication modules, but can also be smaller displays.

The connector contains 14 pins that support SPI, UART and I2C communication. Four additional pins exist for specific functionality, like module reset, interrupt pins, analog signals and pwm signals. Power (3.3V) is also provided. Maximum current consumption of the external module is 250mA. All signals are protected with 470 ohm series resistors to minimize current in case of shorts to ground, +3.3V, or similar.

Usage of the different signals is specific for each module connected. All signals can be configured as either main function or alternatively as a general purpose input/output signal (GPIO). The picture below show where the connector can be found and the table lists which pins are connected. The application program has the responsibility to program the individual pins to correct state/function.

Note that several of the pins connected are also used on other interfaces on the board. Consult page 2 of the schematic for an overview. Before connecting to the Serial Expansion Connector make sure there are no signal contentions between the used signals and the *LPC4088 Experiment Base Board*.

Serial Expansion Connector Signal	LPC4088 pin	LPC4088 QuickStart Board pin number
Pin 3: SPI-SCK	P0.7	p13
Pin 4: SPI-MOSI	P0.9	p11

Pin 5: SPI-MISO	P0.8	p12
Pin 6: SPI-SSEL	P0.6	p14
Pin 7: UART-RX/GPIO	P0.1	p10
Pin 8: UART-TX/GPIO	P0.0	p9
Pin 9: I2C-SCL	P1.31	p20
Pin 10: I2C-SDA	P1.30	p19
Pin 11: GPIO	P5.4	p37
Pin 12: GPIO	P5.1	p38
Pin 13: AIN0/GPIO	P0.25	p17
Pin 14: AIN3/AOUT/GPIO	P0.26	p18

4.6 SP4: uSD Memory Card Interface

The board has a uSD memory card interface, J7. Supply voltage to the external memory card is always enabled (+3.3V). The Card Detect (CD) switch in the card connector is not connected.

It is possible to select either an SPI or a MCI interface to the uSD memory card, via jumpers JP1-JP6. See picture below for locating where JP1-JP6 are located on the board.

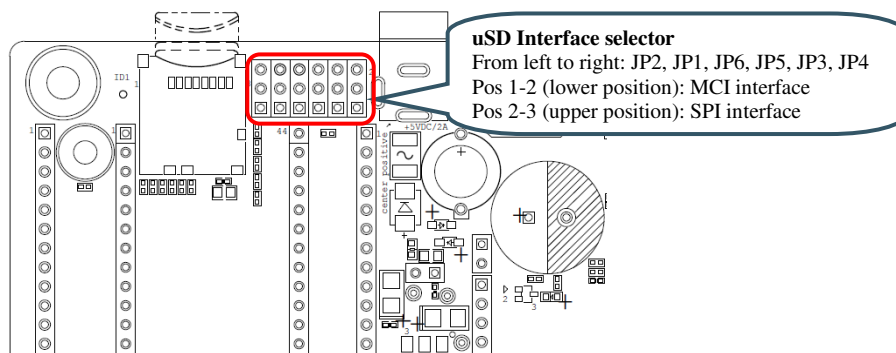


Figure 10 – LPC4088 Experiment Base Board, uSD Interface Jumpers

4.7 SP4: UART Interfaces

There are two UART interfaces via J6 and J8. These are 6-pos pin lists that are supposed to be connected to FTDI cables, to be exact the TTL-232R-3V3 cable. These cables will create a virtual COM port when connected to a PC (provided the FTDI driver has been installed).

There is no keying on the 6-pos connectors so make sure they are turned the correct way when connected. Pin 1 is connected to a black cable and pin 6 to a green cable. Both pin 1 and 6 are marked on the pcb.

P6 are connected to signals P4.28/P4.29. These signals can carry UART3. Note that these signals are only available when the FPC cable is connected between the *LPC4088 QuickStart Board* and the *LPC4088 Experiment Base Board*.

P8 are connected to signals P0.0/P0.1 (P9 and P10 edge signals). These signals can carry UART0 or UART3, depending on set pin multiplexing on the LPC4088.

Note that it is also possible to power the *LPC4088 Experiment Bundle* via the FTDI TTL-232R-3V3 cable. Note that only one FTDI cable should be connected at a time since the UART_USB_PWR net is shared between the connectors.

4.8 SP4: CAN Interface

There is a CAN interface in the schematic but for production cost reasons the components are not mounted. It is possible to mount the components if the interface is needed. U1 can be either TJA1042T or TJF1051/T3. SJ1 must be set accordingly. J9 is typically a male, right-angled 9-pos DSUB connector.

4.9 SP5: SPI Shift Register and LEDs / Character LCD

The shift register, U3, is connected to the SPI bus (available on p5/p7 with p30 as SSEL). Eight LEDs are connected to the shift register outputs. The shift register has been included on the design to give output signal expansion without using a lot of GPIO-pins and also to give

Besides controlling eight LEDs it is possible to control a Character LCD, in 4-databit mode, via the shift register. The fairly standard 16-pos single row interface is supported via connector J11. Contrast can be controlled via the trimming potentiometer, R33, connected to pin 3 of J11. Note that not all character LCD's contrast can be controlled via this pin and it is not always R33 is the correct way of controlling the contrast. R84 can be removed to connect other voltages to pin 3 of J11, if needed. Check the datasheet of the character LCD selected to be sure it is compatible with the hardware interface.

Backlight can be constantly on by shorting JP7. It can alternatively be controlled (for example for dimming or SW control) via a P2.1.

4.10 SP5: RGB-LED

The RGB-LED, LED1, is controlled by three GPIO signals. Note that the RGB-LED and uSD interface in MCI mode cannot be used simultaneously since the three pins are used on both circuits.

4.11 SP5: 5-key Joystick Switch

The 5-key joystick switch, SW1, is connected to five GPIO signals. The signals are debounced via 100nF capacitors. The series resistors are included to minimize risk for short circuits in case the GPIO pins are configured as outputs.

4.12 SP5: 1.8" LCD Interface Connector

The board has an interface connector, J12, for the 1.8" TFT LCD **DM-TFT18-101** from www.DisplayModule.com. The display is a quality, low-cost color LCD with 128x160 pixel resolution.

The display has an SPI interface with two additional GPIOs (for reset and command/data control).

4.13 SP5: Reset Push-button

The reset push-button, SW2, is connected to the global reset signal.

4.14 SP6: I2C Interface Selector

It is possible to select between two sets of pins, via jumpers JP8/JP9, for I2C channel#0 to connect to the I2C bus on the board.

- JP8/JP9 in position 1-2: I2C channel#0 available on P0.27/P0.28 is used for the I2C bus on the board. Note that these signals are only available when the FPC cable is connected between the *LPC4088 QuickStart Board* and the *LPC4088 Experiment Base Board*.
- JP8/JP9 in position 2-3: I2C channel#0 available on P1.30/P1.31 is used for the I2C bus on the board.

4.15 SP6: I2C Sensors (LM75 and MMA7455)

There are some I2C peripherals on the board. that can be accessed from a common I2C bus. The I2C addresses for the individual components are given in the schematic. The I2C components are:

- LM75 Temperature sensor.
- 3-axis Accelerometer (MMA7455). Note that the two interrupt outputs are not connected but available on JP5.
- Audio Codec (WM8731), see description for schematic page 7.
- Touch screen controller (AR1021), see description for schematic page 9.

4.16 SP6: Analog Input

The board contains a trimming potentiometer (R47) for manually generating an adjustable voltage (between GND and +3.3V).

4.17 SP7: Audio Codec

The board contains an audio codec based on WM8731 from Wolfson. The codec is controlled via I2C and audio data is transferred over the I2S bus.

The audio codec provides a mono microphone input, a stereo line input, a stereo line output and a stereo headphone output.

The audio codec must be setup to be the I2S master, generating the WS and sample/bit clock signals to the LPC4088. The codec can generate the sample/bit clock from a local 12.288MHz crystal oscillator (default) or a clock signal via P2.27 from the LPC4088 (typically a 12.000MHz clock).

By removing the six jumpers in J14 the audio codec is isolated from driving the I2S signals.

See picture below for locating relevant components. The table below lists signal connections.