



Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!



Contact us

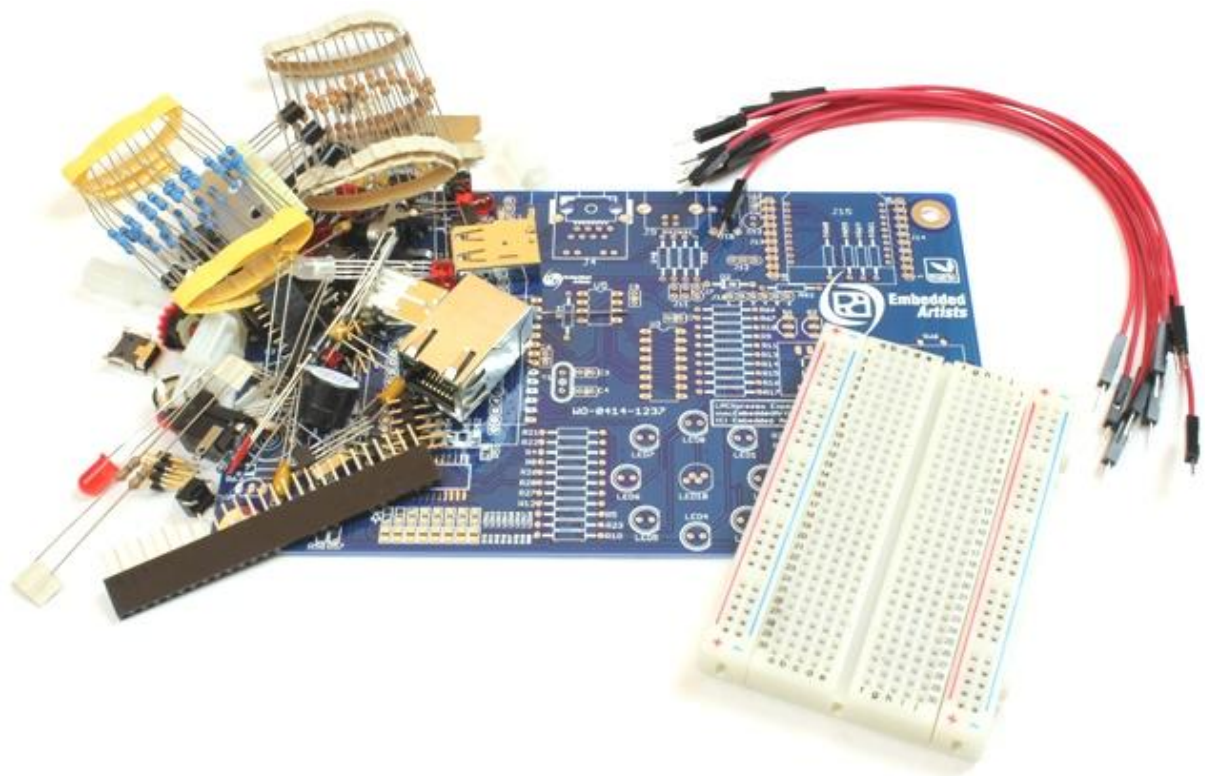
Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



LPCXpresso Experiment Kit User's Guide



Learn embedded programming with NXP's LPC1000 family of Cortex-M0/M3 microcontrollers!

Embedded Artists AB

Davidshallsgatan 16
211 45 Malmö
Sweden

info@EmbeddedArtists.com
<http://www.EmbeddedArtists.com>

Copyright 2013 © Embedded Artists AB. All rights reserved.

No part of this publication may be reproduced, transmitted, transcribed, stored in a retrieval system, or translated into any language or computer language, in any form or by any means, electronic, mechanical, magnetic, optical, chemical, manual or otherwise, without the prior written permission of Embedded Artists AB.

Disclaimer

Embedded Artists AB makes no representation or warranties with respect to the contents hereof and specifically disclaim any implied warranties or merchantability or fitness for any particular purpose. Information in this publication is subject to change without notice and does not represent a commitment on the part of Embedded Artists AB.

Feedback

We appreciate any feedback you may have for improvements on this document. Please send your comments to support@EmbeddedArtists.com.

Trademarks

All brand and product names mentioned herein are trademarks, services marks, registered trademarks, or registered service marks of their respective owners and should be treated as such.

Table of Contents

1	Document Revision History	7
2	Introduction	8
2.1	Features	8
2.2	ESD Precaution	9
2.3	General Handling Care	9
2.4	Code Read Protection	9
2.5	CE Assessment	9
2.6	Other Products from Embedded Artists	9
2.6.1	Design and Production Services	9
2.6.2	OEM / Evaluation / QuickStart Boards and Kits	10
3	LPCXpresso Experiment Kit	11
3.1	Embedded Systems Programming	12
4	Kit Content	13
5	Powering Options	25
6	Soldering	26
6.1	Component Placement	26
7	Experiments	28
7.1	Preparation	28
7.2	Control a LED	28
7.2.1	Lab 1a: Control LED	29
7.2.2	Lab 1b: GPIO and Bit Masking	34
7.2.3	Lab 1c: Delay Function – LED Flashing	35
7.2.4	Lab 1d: Morse Code	36
7.3	Read a Digital Input	37
7.3.1	Lab 2a: Read Push-button	37
7.3.2	Lab 2b: GPIO and Bit Masking	40
7.3.3	Lab 2c: Logic between inputs and output	40
7.3.4	Lab 2d: Toggling LED	43
7.3.5	Lab 2e: Sampling of Inputs	43
7.4	Control Multiple LEDs	45
7.4.1	Lab 3a: LEDs in Running-One Pattern	45
7.4.2	Lab 3b: Control of Running-One Pattern	46
7.4.3	Lab 3c: Rotary Switch Control of Running-One Pattern	47
7.5	Print Messages	48
7.5.1	Lab 4a: Semihosting and printf()	48
7.5.2	Lab 4b: Semihosting Performance Test	50
7.5.3	Lab 4c: Printing Events	50
7.5.4	Lab 4d: Reading from the Console	50

7.6	Read an Analog Input	52
7.6.1	Lab 5a: Read Trimming Potentiometer	52
7.6.2	Lab 5b: Event Threshold	55
7.6.3	Lab 5c: Read Light Sensor	55
7.6.4	Lab 5d: ADC Noise Test	56
7.7	Pulse Width Modulation	57
7.7.1	Lab 6a: PWM Control of a LED	57
7.7.2	Lab 6b: PWM Control of a LED, cont. 1	58
7.7.3	Lab 6c: PWM Control of a LED, cont. 2	58
7.7.4	Lab 6d: PWM Control of two LEDs	59
7.8	Control an RGB-LED	60
7.8.1	Lab 7a: Test RGB-LED	60
7.8.2	Lab 7b: Control RGB-LED	61
7.9	Control a 7-segment Display	62
7.9.1	Lab 8a: Test 7-segment Display	63
7.9.2	Lab 8b: Control 7-segment Display	63
7.9.3	Lab 8c: Control 7-segment Display, cont.	65
7.9.4	Lab 8d: Control Dual Digit 7-segment Display	65
7.9.5	Lab 8e: Control 7-segment Display via Shift Register	67
7.10	Work with a Timer	70
7.10.1	Lab 9a: Create Exact Delay Function	70
7.11	PWM via a Timer	71
7.11.1	Lab 10a: Control RGB-LED	73
7.11.2	Lab 10b: Buzzer and Melodies	73
7.11.3	Lab 10c: Control a Servo Motor	74
7.12	Work with a Serial Bus – SPI	76
7.12.1	Lab 11a: Access Shift Register	79
7.12.2	Lab 11b: Control 7-segment Display	80
7.12.3	Lab 11c: Access SPI E2PROM	80
7.13	Work with Interrupts	84
7.13.1	Lab 12a: Generate IRQ via GPIO	86
7.13.2	Lab 12b: Timer IRQ	87
7.13.3	Lab 12c: Timer IRQ with Callback	88
7.13.4	Lab 12d: Nested Interrupts	89
7.13.5	Lab 12e: Control Dual Digit 7-segment Display	90
7.14	Work with a Serial Bus – I2C	91
7.14.1	Lab 13a: Solder Surface Mounted Components	92
7.14.2	Lab 13b: Read LM75 Temperature Sensor	93
7.14.3	Lab 13c: Control LEDs via PCA9532	94
7.15	Work with a Serial Bus – UART	97
7.15.1	Lab 14a: Transmitting and Receiving via the UART	103
7.15.2	Lab 14b: Direct printf() to UART	103
7.15.3	Lab 14c: Interrupt driven UART handling and ring buffers	104
7.16	Extra: Work with RF-module	109
7.16.1	Lab 15a: XBee™ RF-Module	109
7.16.2	Lab 15b: GPS Receiver	109

7.17	Extra: Work with Serial Expansion Connector	109
7.17.1	Lab 16a: 128x128 OLED Graphical Display	109
7.17.2	Lab 16b: GSM Module	109
7.18	Extra: Work with USB Device	109
7.18.1	Lab 17a: USB Device – HID	109
7.18.2	Lab 17b: USB Device – Mouse HID	109
7.19	Extra: Work with USB Host	109
7.19.1	Lab 18a: USB Host	109
7.20	Extra: Work with Ethernet Interface	109
7.20.1	Lab 19a: lwIP TCP/IP Stack and Web Server	109
7.21	Differences between LPCXpresso LPC111x and LPC1114 in DIL28	110
7.22	NXP Specifics for LPC111x Family	111
8	Real-time Programming	112
9	Projects	113
9.1	Interface a Color Sensor	113
9.2	Interface a Real-time Clock (RTC)	113
9.3	Interface a GPS Module	113
9.4	Interface an SD/MMC Memory Card	113
9.5	Interface an Accelerometer and Gyro	113
9.6	Control a LED Matrix	114
9.7	Create a Game with Display + Accelerometer or Gyro	114
9.8	Create General Menu System for a Display	114
9.9	Retrieve Information from Web Servers	114
9.10	USB Mouse Emulation	114
9.11	Registry in E2PROM	115
9.12	Real-Time Dynamic Data with JAVA Applet	115
9.13	Multiplayer Game via RF-module	115
9.14	Home Alarm System	115
9.15	Polyphonic Audio Generation	116
9.16	Audio Processing	116
9.17	Home Automation	116
9.18	Control a Robot	116
9.19	RS-485 Network	116
9.20	Interface an FPGA/CPLD Chip	116
9.21	Analog Electronic Experiments	116
10	LPCXpresso IDE – How to get Started	117
10.1	Importing Projects	117
10.2	Working with a Project and Compiling	119
10.3	Debugging a Project and Downloading	120
10.3.1	Downloading Just Code	124
10.4	Create own Projects by Copy Existing Project	128

10.5	Common Problems	129
10.5.1	Error message: Failed on chip setup	130
11	Further Information	131

1 Document Revision History

<i>Revision</i>	<i>Date</i>	<i>Description</i>
PA1	2012-07-16	Work in progress.
PA2	2013-01-14	Work in progress.
PA3	2013-01-25	First version to be released. All experiments are still not complete.
PA4	2013-01-29	Minor corrections/clarifications.
PA5	2013-02-25	Completed section 7.9 - 7.10.
PA6	2013-03-19	Completed section 7.11-7.14. Cleanup in variable declarations in code fragments. Added instructions about creating driver structured source code.
PA7	2013-04-08	Completed section 7.15. Changed all code fragments to use predefined typedefs for variable declaration. Minor corrections.

2 Introduction

Thank you for buying Embedded Artists' *LPCXpresso Experiment Kit* designed to work with NXP's ARM Cortex-M0/M3 LPCXpresso target boards.

This document is a User's Guide that describes the *LPCXpresso Experiment Kit* that describes hardware as well as software related to the kit.

2.1 Features

The kit has been created as a guided tour to learn embedded programming with NXP's LPC1000 microcontroller family with Cortex-M0/M3 cores from ARM. The experiments can be performed on a breadboard for maximum flexibility and ease of use. It is also possible to solder the components to a printed circuit board (pcb) and learn soldering at the same time.

Components included in the kit are:

- 8x LEDs
- 2x Trimming potentiometers
- 7x push-buttons
- RGB-LED
- Light sensor (analog)
- Temperature sensor (analog)
- 7-segment LED, dual digit
- E2PROM with SPI interface
- Temperature sensor with I2C interface (only for pcb mounting)
- Piezo buzzer
- Rotary quadrature encoder (only for pcb mounting)
- Shift register
- I2C ports expander (PCA9532, only for pcb mounting)
- USB Host connector (only for pcb mounting)
- USB Device connector (only for pcb mounting)
- RJ45 connector for Ethernet (only for pcb mounting)
- 14-pos serial expansion connector, for interface to for example graphical displays
- 3x servo connectors. Note that servos are not included.
- XBee™ compatible socket (for ZigBee and WiFi modules). Note that RF module is not included.
- LPC1114 in DIL28 package, with 12MHz crystal and SWD connector (only for pcb mounting)
- Local +3.3V voltage regulator
- Miscellaneous resistors, capacitors, transistors and connectors
- Breadboard with cables
- Naked PCB

2.2 ESD Precaution

Please note that the *LPCXpresso Experiment Kit* 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.

Always work with the LPCXpresso Experiment Kit in a place with proper ESD protection.

Avoiding electrostatic discharge is all about having the same electric potential and to avoid building up charges between different areas where you work. This is easily accomplished by having a conductive surface on your workbench and connecting yourself with this surface via a wrist wrap.



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

2.3 General Handling Care

Handle the *LPCXpresso Experiment Kit* and all included components with care. The board is not mounted in a protective case/box and is not designed for rough physical handling. Connectors and components can wear out after excessive use. The LPCXpresso Experiment Kit is designed for prototyping use, and not for integration into an end-product.

2.4 Code Read Protection

The LPC1000 family has a Code Read Protection function (specifically CRP3, see datasheet for details) that, if enabled, will make the microcontroller impossible to reprogram (unless the user program has implemented such functionality).

Note that Embedded Artists does not replace LPC1000 family chip where the chip has CRP3 enabled. It's the user's responsibility to not invoke this mode by accident.

2.5 CE Assessment

The *LPCXpresso Experiment Kit* is CE marked. See separate *CE Declaration of Conformity* document.

The *LPCXpresso Experiment Kit* 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 *LPCXpresso Experiment Kit*. Standard interfaces like Ethernet, USB, serial have been in use. 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 *LPCXpresso Experiment Kit*.

Due to the nature of the *LPCXpresso Experiment Kit* – 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 LPC1000/2000/3000/4000 based boards that are very low cost and developed for prototyping / development as well as for OEM applications. 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 LPC1000/2000/3000/4000 microcontroller families in specific. Our competence also includes wireless and wired communication for embedded systems. For example IEEE802.11b/g (WLAN), Bluetooth™, ZigBee™, ISM RF, Ethernet, CAN, RS485, and Fieldbuses.

2.6.2 OEM / Evaluation / QuickStart Boards and Kits

Visit Embedded Artists' home page, www.EmbeddedArtists.com, for information about other *OEM / Evaluation / QuickStart* boards / kits or contact your local distributor.

3 LPCXpresso Experiment Kit

The *LPCXpresso Experiment Kit* has been created as a guided tour to learn embedded programming with NXP's LPC1000 microcontroller family with Cortex-M0/M3 cores from ARM. The experiments can be performed on a breadboard for maximum flexibility and ease of use. It is also possible to solder the components to a printed circuit board (pcb) and learn soldering at the same time. Figure 1 illustrates the two ways of working with the kit. To the left, all components have been soldered to the pcb and the LPCXpresso board is mounted in a socket on the pcb. To the right, a bread board is used and wires connect directly between the bread board and the LPCXpresso board. Note that the LPCXpresso board is not included in the normal *LPCXpresso Experiment Kit*.

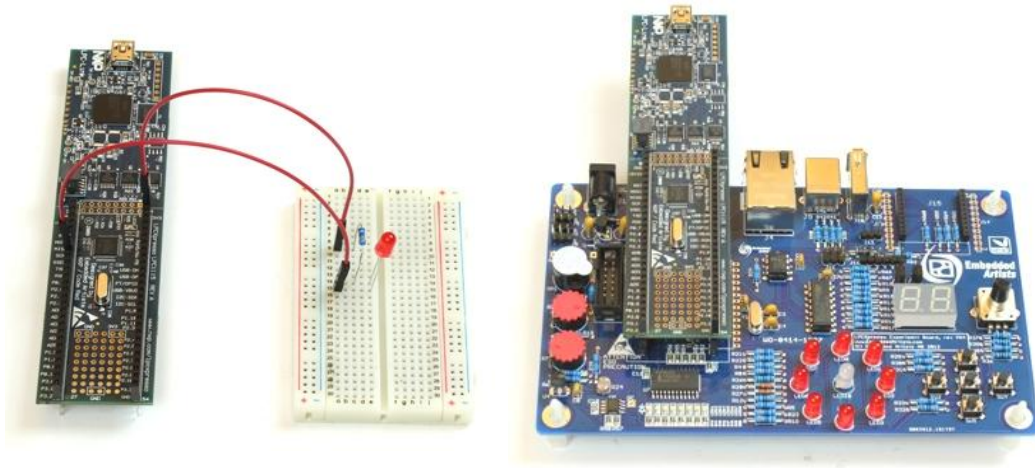


Figure 1 – Breadboard Experiments and Working with PCB

The kit is based on the LPC1000 LPCXpresso evaluation boards, which is a whole family of boards. **All experiments are based around the LPCXpresso LPC1115/1114 board** unless otherwise noted. The term *LPC111x* will be used for the rest of the document to indicate both LPC1115 and LPC1114. Some of the experiments (Ethernet and USB related) are based on the LPCXpresso LPC1769 board. It is also possible to work with the LPC1114 in DIL28 package, which is a breadboard friendly package.

The suggested work flow is as follows: first start with performing the experiments with a group of components on the bread board together with an LPCXpresso board. When done with the experiments, solder the components to the pcb. Continue with the next group of components. Some components only work on the pcb, simply because they do not fit into the bread board. Perform the experiments related to these components when they have been soldered to the pcb. There are of course other ways of working, for example soldering all components to the pcb at the end of all experiments or work separately with the LPC1114 in DIL28 package instead of an LPCXpresso board. Note that in the latter case, an LPC-Link™ is needed to program the LPC1114. The LPC-Link is the “debugger half” of an LPCXpresso board.

The LPC111x is built around a Cortex-M0™ core from ARM and the LPC1769 has a Cortex-M3™ core. Most things addressed with the experiments are general to all microcontrollers and embedded systems programming in general. The details are however slightly different between different microcontrollers, for example the different functionality and registers in the on-chip peripherals.

After having worked with the *LPCXpresso Experiment Kit*, and completed the experiments, you will have gained several competences at basic level:

- embedded programming
- professional debugging techniques
- microcontrollers and how they interact with their environment

- electronic design in general
- how to work with a breadboard
- how to solder

It is assumed that you know how to program in C. You do not have to be an experienced user but at least know about the basics. If not, the Internet is full of ANSI-C tutorials. A good start can be https://en.wikibooks.org/wiki/C_Programming.

The program development environment (also called Integrated Development Environment – IDE, for short) used is the **LPCXpresso IDE**, which is a Eclipse-based IDE, a GNU C-compiler, linker, libraries and an enhanced GDB debugger. For more information see [5].

3.1 Embedded Systems Programming

Embedded systems programming is truly multi-disciplinary. An engineer must master many knowledge areas in order to do a good job. There are at least five of these areas:

- 1) General programming knowledge
(C, algorithms and data structures, understanding the development environment, debugging techniques, safe programming styles, version handling, documentation, etc.)
- 2) Knowledge about programming close to the hardware / Firmware programming
(interrupts, memory mapped accesses for control registers, types of memories, etc.)
- 3) Knowledge about the specific hardware
(details about microcontroller used incl. all peripherals, I/O, communication interfaces, etc.)
- 4) Application programming
(real-time operating systems, program frameworks, user interfaces, drivers, logging, field updates, boot loader structures, factory calibration/settings, configuration management, communication protocols, graphical programming, security, etc.)
- 5) Last but not least, the domain knowledge – the functional that the product under development shall implement.

When working through the experiments in the LPCXpresso Experiment Kit you will increase your knowledge in the first three areas.

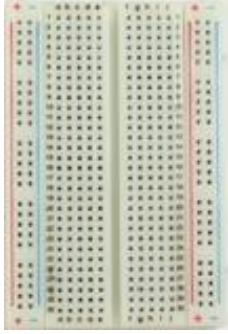


Enjoy working with the LPCXpresso Experiment Kit!

4 Kit Content






In this chapter we will take a closer look at the different components included in the *LPCXpresso Experiment Kit*.

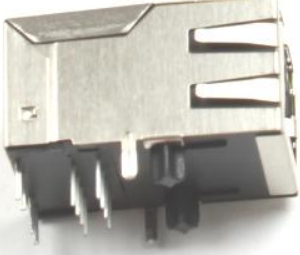
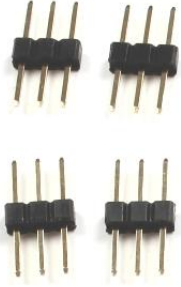


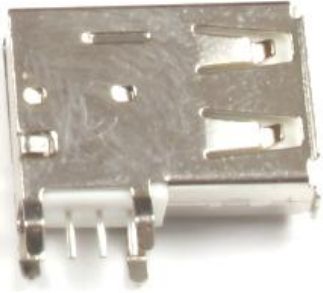
The table below contains photos and a description of all components in order to simplify identification. Note that photos are only typical in the sense that they illustrate how the components typically look like. Exact appearance can differ for the components kit that you have received. The number of components shown in a picture can also differ from delivered quantity.

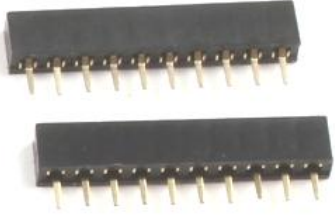
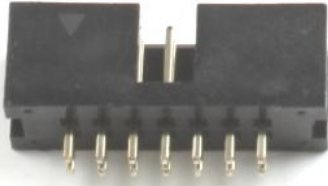



Most components are specified with a Digikey or Mouser equivalent. If a component gets damaged, a new one can typically be ordered from Digikey, Mouser or any preferred component distributor. The Digikey/Mouser number is just to get the key data of the component. The actual components in the component kit might very well be of different brands.




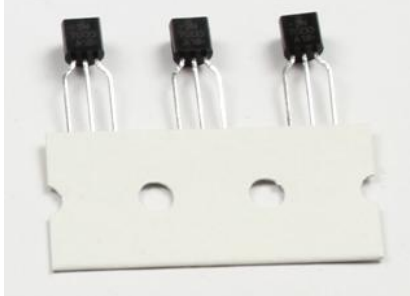
Component	Description	Note
	Breadboard	Digikey: 438-1109-ND Mouser: 854-BB400T
	Cables, male-to-male	Prototype cables can be ordered from Embedded Artists web shop in 50 pcs packages (EA-ACC-017).
	Connectors for LPCXpresso board 11mm long pins	There is another pair of headers that looks very similar. This pair of connectors has longer pins. The other pair has shorter pins. This air of connectors shall be soldered to an LPCXpresso board to make it <i>experiment friendly</i> – make it simple to connector cables to the pins. There is no distributor equivalent for this component.





	<p>Tantal capacitor C1, C2, C12 22uF</p>	<p>This component is polarized. One of the two pins is longer than the other. This is the positive side. There is also a small plus sign printed on the components on the long pin side.</p> <p>AVX: TAP226K010SCS Digikey: 478-1874-ND Mouser: 581-TAP226K010SCS</p>
	<p>Ceramic capacitor C3, C4 18pF</p>	<p>The printed numbers on this component is "180".</p> <p>This is not a polarized component.</p> <p>Murata: RPE5C2A180J2P1Z03B Digikey: 490-3632-ND Mouser: 81-RPE5CA180J2P1Z03B</p>
	<p>Ceramic capacitor C5, C6, C7, C8, C9, C13 100nF</p>	<p>The printed numbers on this component is "106".</p> <p>This is not a polarized component.</p> <p>Kemet: C320C104K5R5TA Digikey: 399-4264-ND Mouser: 80-C320C104K5R</p>
	<p>Ceramic capacitor C10, C11 100nF SMT</p>	<p>This is a surface mounted component and can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>This is not a polarized component.</p> <p>Murata: GRM21BR71E104KA01L Digikey: 490-1673-1-ND Mouser: 81-GRM40X104K25L</p>





	<p>Schottky diode D1, D2 1N5817</p>	<p>This component is polarized. There is a ring on one pin-side of the components (upper side in the picture). This is the cathode of the diode. The other side (bottom side) is the anode.</p> <p>Diodes Inc: 1N5817-T Digikey: 1N5817DICT-ND Mouser: 621-1N5817</p>
	<p>Stand-offs H1, H2, H3, H4</p>	<p>These stand-offs are mounted in each corner of the pcb.</p> <p>AVC: BS-13S Any standard stand-off for 4mm holes will work.</p>
	<p>Power jack J1</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>CUI Inc: PJ-102A Digikey: CP-102A-ND</p>
	<p>Connectors for LPCXpresso board J2</p>	<p>There is another pair of headers that looks very similar. This pair of connectors has shorter pins. The other pair has longer pins.</p> <p>This pair of connectors shall be soldered to the pcb as a socket to the LPCXpresso board.</p> <p>Sullins: PPTC271LFBN-RC Digikey: S7025-ND</p>
	<p>Debug connector J3</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>There is no distributor equivalent for this component.</p>

	<p>RJ45, Ethernet connector J4</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>Stewart: SI-50170-F Digikey: 380-1103-ND</p>
	<p>Pin list, 1x3 J5, J6, J8, J12</p>	<p>Sullins: PEC03SAAN Digikey: S1012E-03-ND</p>
	<p>Pin list, 2x3 J7 and J11 combined</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>Sullins: PEC03DAAN Digikey: S2012E-03-ND</p>
	<p>USB-B connector J9</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>TE Connectivity: 292304-2 Digikey: A98573-ND Mouser: 571-292304-2</p>
	<p>USB-A connector J10</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>TE Connectivity: 292336-1 Digikey: 292336-1-ND Mouser: 571-292336-1</p>

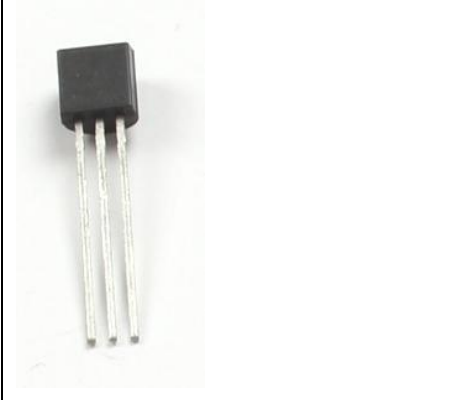
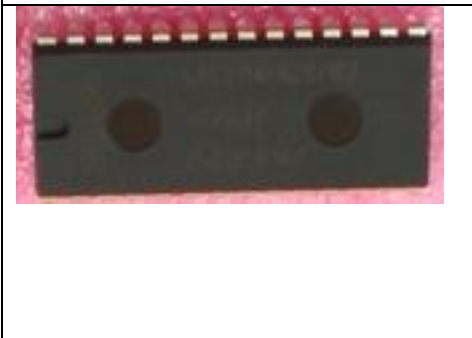
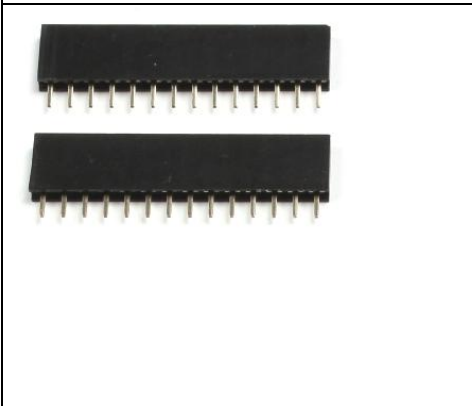

	<p>socket connector for wireless module J15</p>	<p>This component and can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>Sullins: NPPN101BFCN-RC Digikey: S5751-10-ND</p>
	<p>Shrouded pin list, 2x7 J16</p>	<p>This component and can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>Sullins: SBH11-PBPC-D07-ST-BK Digikey: S9170-ND</p>
	<p>USB mini-B connector J17</p>	<p>This component and can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>Hirose: UX60-MB-5ST Digikey: H2959CT-ND Mouser: 798-UX60-MB-5ST</p>
	<p>Pin list, 1x6 J18</p>	<p>Sullins: PEC06SAAN Digikey: S1012E-06-ND</p>
	<p>LEDs LED1-LED8</p>	<p>This component is polarized. One of the two pins is longer than the other. This is the positive side, the anode. There is also a small cut on the side of the plastic package. This is on the short pin side, which is the negative side, the cathode.</p> <p>Any 5mm LED with V_f around 1.7V and 150mcd at 20mA current will work, for example: Digikey: 1080-1136-ND</p>

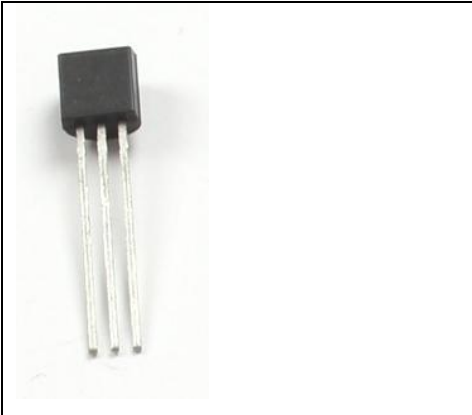


	<p>RGB-LED LED10</p>	<p>This component is polarized. There is a small cut on one side of the plastic package. In the component picture to the left, the cut is on the left side of the package.</p> <p>From left to right the four pins in the picture are:</p> <p>Red-LED cathode All LEDs anode (positive side) Blue-LED cathode Green-LED cathode</p> <p>Harvatek: HT-333RGBW-A Any RGB-LED with common anode and a low value of blue LED V_f (around 3.2V) will work.</p>
	<p>7-segment LED, dual digit LED9</p>	<p>This component is polarized. Pin 1 is in the lower left corner in the picture to the left.</p> <p>Lite-On Inc: LTD-4608JF Digikey: 160-1536-5-ND Mouser: 859-LTD-4608JF</p>
	<p>LEDs LED11-LED18, SMT</p>	<p>This is a surface mounted component and can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>This component is polarized. There are green marks on the cathode side.</p> <p>Harvatek: HT17-2102SURC Possible substitute is Kingbright: APT2012SURCK Digikey: 754-1133-1-ND Mouser: 604-APT2012SURCK</p>
	<p>PNP transistor, BC557B Q1, Q2, Q3</p>	<p>This component is polarized. One side of the plastic package is flat and the other side is rounded. When mounting this component make sure it is turned correctly.</p> <p>ON Semiconductor: BC557BRL1G Digikey: BC557BRL1GOSCT-ND Mouser: 863-BC557BRL1G</p>



	<p>Resistor, 15 Kohm, 7 pcs R1, R3, R35, R36, R41, R42, R59</p>	<p>Color: Brown, Green, Black, Red This is not a polarized component. Yageo: MFR-25FBF-52-15K0 Digikey: 15.0KXBK-ND</p>
	<p>Resistor, 0 ohm, 1 pcs R2</p>	<p>Color: Black This is not a polarized component. Yageo: ZOR-25-B-52-0R Digikey: 0.0QBK-ND</p>
	<p>Resistor, 330 ohm, 30 pcs R4, R5, R6, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R21, R22, R23, R25, R29, R30, R31, R32, R33, R34, R37, R38, R62, R63, R64</p>	<p>Color: Orange, Orange, Black, Black This is not a polarized component. Yageo: CFR-25JB-52-330R Digikey: 330QBK-ND</p>
	<p>Trimming potentiometer, 22 Kohm, 2 pcs R7, R20</p>	<p>10Kohm equivalent from Bourns Inc.: 3352E-1-103LF Digikey: 3352E-103LF-ND</p>

	<p>Photo resistor, 1 pcs R24</p>	<p>This is not a polarized component. Advanced Photonix: PDV-P9002-1 Digikey: PDV-P9002-1-ND</p>
	<p>Resistor, 220 ohm, 2 pcs R27, R28</p>	<p>Color: Red, Red, Black, Black This is not a polarized component. Yageo: FMP100JR-52-220R Digikey: 220WCT-ND</p>
	<p>Resistor, 1.5 Kohm, 8 pcs R26, R39, R40, R60, R61, R65, R66, R67</p>	<p>Color: Brown, Green, Black, Brown This is not a polarized component. Yageo: FMP100JR-52-1K5 Digikey: 1.5KWCT-ND</p>
	<p>Resistor, 2 Kohm, 16 pcs R43, R44, R45, R46, R47, R48, R49, R50, R51, R52, R53, R54, R55, R56, R57, R58</p>	<p>This is a surface mounted component and can only be soldered to the pcb (i.e., not used on the bread board). This is not a polarized component. Panasonic: ERJ-6ENF2001V Digikey: P2.00KCCT-ND</p>

	<p>Piezo buzzer, 1 pcs SP1</p>	<p>This component is polarized. One pin is longer than the other. The longer pin is the positive side. The top label also indicates this side with a small plus sign.</p> <p>CUI Inc.: CEP-2242 Digikey: 102-1115-ND</p>
	<p>Pushbuttons, 5 pcs SW1-SW5</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board). The reason for this is that the pins are too short to get reliable connection on the bread board. There are two other special switches in the component kit that are suitable for bread board usage.</p> <p>Omron: B3F-1000 Digikey: SW400-ND Mouser: 653-B3F-1000</p>
	<p>Pushbuttons for breadboard, 2 pcs</p>	<p>These switches are for breadboard usage.</p> <p>Panasonic: EVQ-11L05R Digikey: P8079SCT-ND Mouser: 667-EVQ-11L05R</p>
	<p>Rotary encoder, 1 pcs SW6</p>	<p>This component can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>Below is without center switch. Panasonic: EVE-GA1F1724B Digikey: P10859-ND Mouser: 667-EVE-GA1F1724B</p>

	<p>Voltage regulator, MCP1700-330, 1 pcs U1</p>	<p>This component is polarized. One side of the plastic package is flat and the other side is rounded. When mounting this component, make sure it is turned correctly.</p> <p>Microchip: MCP1700-3302E/TO Digikey: MCP1700-3302E/TO-ND Mouser: 579-MCP1700-3302E/TO</p>
	<p>Microcontroller, LPC1114FN28, 1 pcs U2</p>	<p>This component is polarized. There is a cut in one end of the plastic package, on the short side. This indicates where pin 1 is located. When mounting this component make sure it is turned correctly.</p> <p>NXP: LPC1114FN28/102 Digikey: LPC1114FN28/102,12-ND Mouser: 771-LPC1114FN28/1021</p>
	<p>Headers for U2</p>	<p>This pair of connector headers can (optionally) be soldered to the pcb as a socket for U2. By adding these connectors/headers it is possible to either mount the LPCXpresso board (in J2 headers) or mount U2 in these headers. If J2 headers are mounted but these headers are not, then it is not possible to mount U2.</p> <p>Sullins: PPTC141LFBN-RC Digikey: S7012-ND</p>
	<p>Shift register, 74HC595, 1 pcs U3</p>	<p>This component is polarized. There is a cut in one end of the plastic package, on the short side. This indicates where pin 1 is located – lower left side in the picture to the left. When mounting this component make sure it is turned correctly.</p> <p>NXP: 74HC595N Digikey: 568-1484-5-ND Mouser: 771-74HC595N</p>

	<p>Temperature sensor, MCP9701, 1 pcs U4</p>	<p>This component is polarized. One side of the plastic package is flat and the other side is rounded. When mounting this component make sure it is turned correctly.</p> <p>Microchip: MCP9701-E/TO Digikey: MCP9701-E/TO-ND Mouser: 579-MCP9701-E/TO</p>
	<p>SPI flash, 25LC080, 1 pcs U5</p>	<p>This component is polarized. There is a cut in one end of the plastic package, on the short side. This indicates where pin 1 is located. When mounting this component, make sure it is turned correctly.</p> <p>Microchip: 25LC080D-I/P Digikey: 25LC080D-I/P-ND Mouser: 579-25LC080D-I/P</p>
	<p>Temperature sensor, LM75, 1 pcs U6</p>	<p>This is a surface mounted component and can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>This component is polarized. When rotating the components so that the printed text on the package can be read, pin 1 is in the lower left side on the package. When mounting this component make sure it is turned correctly.</p> <p>NXP: LM75BD Digikey: 568-4688-1-ND Mouser: 771-LM75BD118</p>

	<p>I2C port expander, PCA9532, 1 pcs U7</p>	<p>This is a surface mounted component and can only be soldered to the pcb (i.e., not used on the bread board).</p> <p>This component is polarized. When rotating the components so that the printed text on the package can be read, pin 1 is in the lower left side on the package. When mounting this component make sure it is turned correctly.</p> <p>NXP: PCA9532D Digikey: 568-1039-5-ND Mouser: 771-PCA9532D-T</p>
	<p>12MHz HC49 crystal, 1 pcs Y1</p>	<p>This is not a polarized component.</p> <p>CTS-Freq. Controls: ATS120B Digikey: CTX904-ND</p>

5 Powering Options

There are a couple of different options how to powering the experiments. Read through all different options to determine which powering option fits your needs.

- The simplest and most common way is to let the LPCXpresso board generate the +3.3V supply that is needed. This voltage is available on pin 29 on the LPCXpresso expansion connector (see schematic for details). R2 should not be mounted in this case.
 - The LPCXpresso board can supply up to about 100 mA on the +3.3V supply. Note that by turning on all LEDs and activating all features on the board it is possible to consume more than 100 mA.
 - Note that the voltage is not exactly 3.3V, but a Schottky diode forward voltage drop less, so around 3.15V.
- In case the LPCXpresso board is not powered via its USB connector an external +5V DC supply is needed. Connect the external supply to J1 or J17 (as described below).
 - If the internal +3.3V voltage regulator on the LPCXpresso board is used, R2 shall not be mounted. Else R2 shall be mounted (and U1 is the +3.3V regulator in use).
- If current consumption on the +3.3V supply is higher that the LPCXpresso board can provide an external +5V DC supply is needed. This is typically true when working with wireless/RF modules and/or with the USB Host interface (J10 connector). When working with servo motors an external +5V supply is absolutely needed.
 - An external +5V DC supply can connect to J1, which is a 2.1mm power jack with positive center pin. Note that there is no overvoltage protection in the design. Make sure that the connected power supply does not supply more than +5V DC. The current capability of the external +5V DC supply should be in the region of 1-2 Ampere.
 - Connector J17 (mini-B USB connector on the back side of the pcb) can also be used to supply an external +5V DC supply via the USB Host port on a PC/laptop/USB hub.
- When using the LPC1114 in DIL28 package an external +5V DC supply is needed. Feed the +5V via J1 or J17 (as described above) and mount R2 (in order to let U1 be the +3.3V regulator in use).
- When using an mbed module, this module can generate the needed +3.3V supply (supply comes from its own USB connector). R2 should not be mounted in this case.
 - The mbed module can supply much more current on the +3.3V supply than an LPCXpresso board can.
 - In case the mbed module is not powered via its USB connector, it is possible to power it with an external +5V DC supply via connector J1 or J17 (as described above).

Below is a short list, summarizing the options:

Mbed module: do not mount R2, power via mbed module USB connector or external +5V supply.

LPC1114 in DIL28: mount R2, power via external +5V supply.

Using servo interface, USB Host interface and/or RF module: power via external +5V supply.

LPCXpresso board: do not mount R2, power via mini-B USB interface or external +5V supply.