

Quick Start Guide

LPC1800/LPC4300 Evaluation board FOC motor control

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Quick Start Guide

Document information

Info	Content
Keywords	LPC1800, NXP, Evaluation board motor control
Abstract	This quick start guide will help you getting started to get the NXP LPC1800 motor control evaluation board setup and running.



Revision history

Rev	Date	Description
1.00	20110808	Initial version
1.01	20111031	Removed dual motor control board, and updated for board rev 4.1

Contact information

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1. Introduction

This getting started guide will help you with the initial setup of you evaluation board. The following topics will be dealt with are:

- Plug and play steps
- Board design
- Board peripherals
- Microcontroller interfaces
- External connections
- Software programming
- Motor Control tool

The source code included in this package contains a FOC dual shunt project running on the NXP LPC1800 evaluation board, connected to the Motor Control board from Embedded Artists. The motor control can be configured using the Motor Control tool. This tool also allows viewing real time data. The connection between the board and the GUI is made by RS232. Since a high serial bus load is needed for real-time data view, the primary communication is based on a direct UART0 to RS232 level shifted connector. A second UART1 connection makes use of an FTDI232 chip for USB connectivity. The FTDI drivers do not allow a high bus load and cause a delay for real-time data view. UART1 is used for debug printf messages.

1.1 Plug and play steps

The following steps can be taken for a plug and play experience. The tool functionality is explained in detail in Chapter 3, Motor Control software tool . It is necessary to go through all the steps **before** running/enabling the motor.

1.1.1 Required components

- NXP evaluationboard rev4.1 with LPC1850 or LPC4350
- Embedded artists motor control baseboard
- 3-phase permanent magnet synchronous motor (PMSM) with encoder
- Computer with the following requirements:
 - Windows XP or Windows 7 x64/x86
 - .NET 3.5 framework
 - RS232 connection
- DB9 RS232 cable
- Poweradapter for 24V supply to the DC jack plug on the motor control baseboard
- KEIL uVision (free evaluation version is sufficient)
- JTAG programmer compatible with 10pins mini-JTAG connector and KEIL uVision.

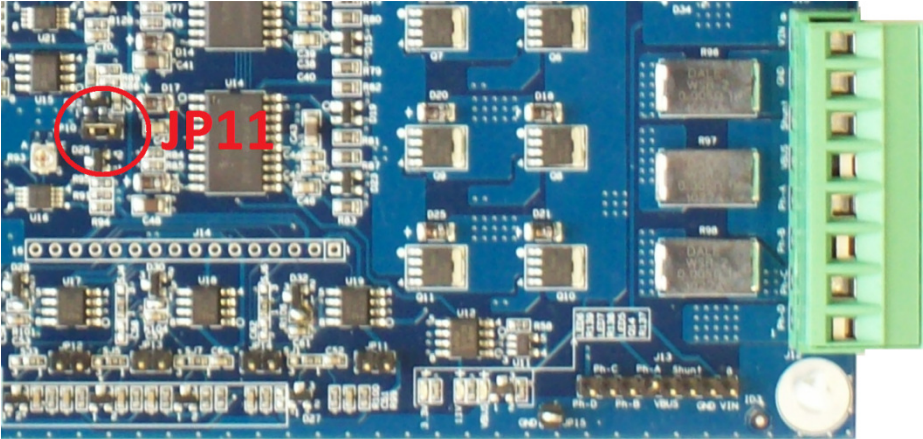
1.1.2 Install the Motor Control software

Install the Motor Control software tool GUI by running Setup.msi from the 'GUI' folder. The support software is only available for Windows XP and Windows 7 and requires the .NET 3.5 framework. If not this is not installed on your computer, the installation will automatically point to an online installer for .NET.

In the final step of the installer asks to automatically copy FLM files to the FLASH directory of the KEIL installation folder. FLM files are used for the external flash target and are configured for use in the Flash Target Options in uVision.

1.1.3 Connect and check hardware

Connect the power source and motor as described in Chapter 2, Connections.. Mount JP10 on the Embedded Artists Motor Control board. This enables filtering of the DC-bus current.



1.1.4 Open the project

Open the KEIL uVision project from the 'Source' folder. A free evaluation version of KEIL uVision is available at <http://www.keil.com/arm/demo/eval/arm.htm>

1.1.5 Adjust user parameters

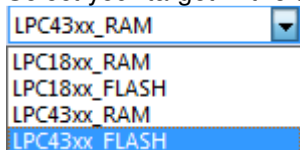
Hard coded user parameters are defined as MACRO's in app_setup.h. The following parameters have to be set correctly for your specific hardware setup.

Table 1. User parameters
Hard coded MACRO's in app_setup.h

Definition	Type	Description
#define POLEPAIRS	Int	The number of polepairs of the connected motor has to be set. Minimum is 1.
#define I_MAX	Float	Software current limit.
#define QEI_COUNTS_PER_TURN	Int	Number of quadrature encoder counts per revolution. With both negative and positive edges counted the total encoder ticks equals this number x 4.
#define QEI_USE_INDEX	Bool	Determines if the encoder uses an index pulse

1.1.6 Target selection

Select your target in the target selection box.



RAM projects can be started by initializing a debug session. Execution code will then be automatically loaded in RAM. The 'program flash' button is not available for RAM projects.

Flash projects run from the external flash on the evaluationboard. This flash is interfaced with a 16bit bus to the external memory controller of the LPC1850 or LPC4350.



The LPC1850 or LPC4350 on the evaluationboard is pre-configured to always boot from 16bit EMC external Flash. This overrules the bootjumper settings described in section 4.4 Boot select.

1.1.7 Compile and run

To compile your project select 'Project → Build target' or click on .

Ram target

For RAM target you can start a debug session.

Select 'Debug → Start / Stop Debug Session' or click on . Then start the program by selecting 'Debug → Run' or click on .

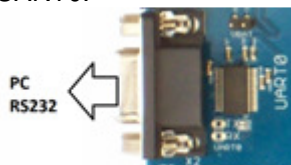
Flash target

For FLASH target you can download the program to flash and start an optional debug session afterwards.

To load the program to flash select 'Flash → Download' or click on .

1.1.8 Connect the board to a PC

Connect a RS232 cable between your computer and the DB9 COM connector for UART0.



A full overview of available connections is available in Chapter 2, Connections.

1.1.9 Open connection

Run the Motor Control software tool.

Select the correct COM port in the menubar->edit->com settings

Open the connection. Make sure the connectivity icon is visible as shown in chapter '3.2 Connecting to a board.'

1.1.10 Check encoder

First make sure that the encoder is working correctly. On the first tab of the program, there is a vector graph. The green line represents the encoder motor stator angle 'alpha'. When turning the motor, the green vector should move correspondingly.

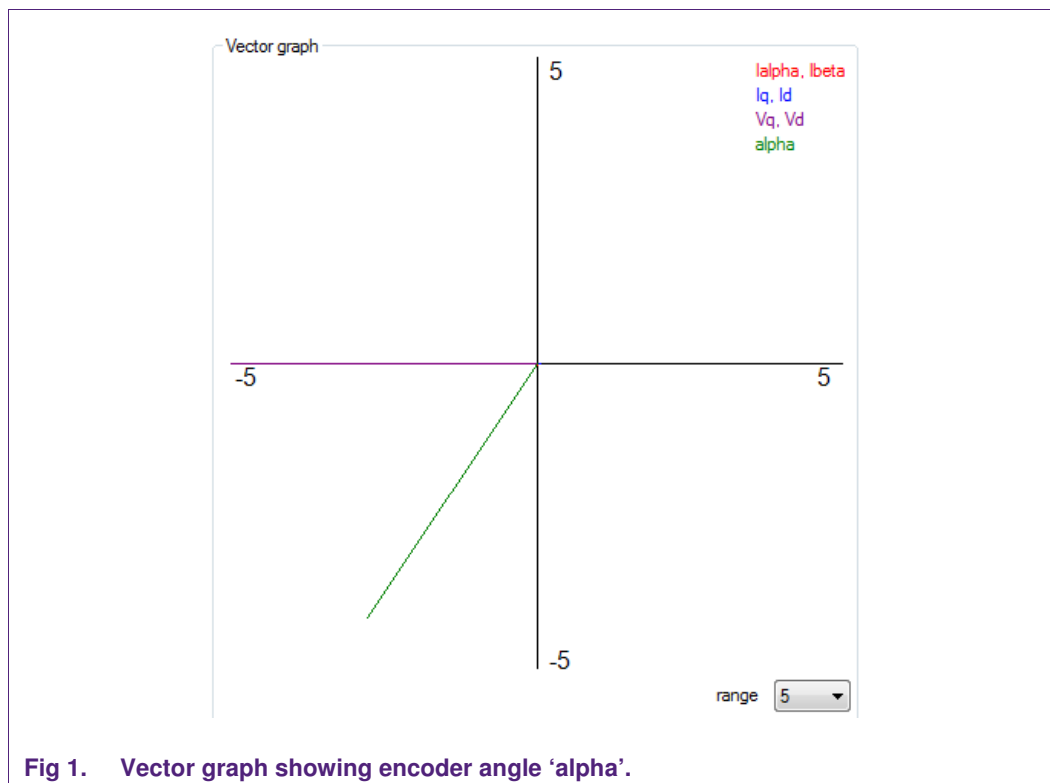


Fig 1. Vector graph showing encoder angle 'alpha'.

1.1.11 Calibrate the encoder

The QEI encoder position needs to be calibrated. Go to the Calibration tab and start an Auto calibration routine. See chapter 3.7, Quadrature Encoder Interface calibration for details.

The calibration values can optionally be hard-coded in the project in Application\app_setup.h:

```
#define QEI_OFFSET      525
#define QEI_INVERT      0
```

1.1.12 Calibrate current measurement

The phase current measurements also need to be calibrated. See chapter 3.6, Current measurement calibration for details.

The calibration values can optionally be hard-coded in the project in Application\app_setup.h:

```
#define ADC_PHA_OFFSET  584
#define ADC_PHB_OFFSET  585
#define ADC_PHC_OFFSET  584
#define ADC_PHASE_GAIN  F6_10_CONST(9.7)
```

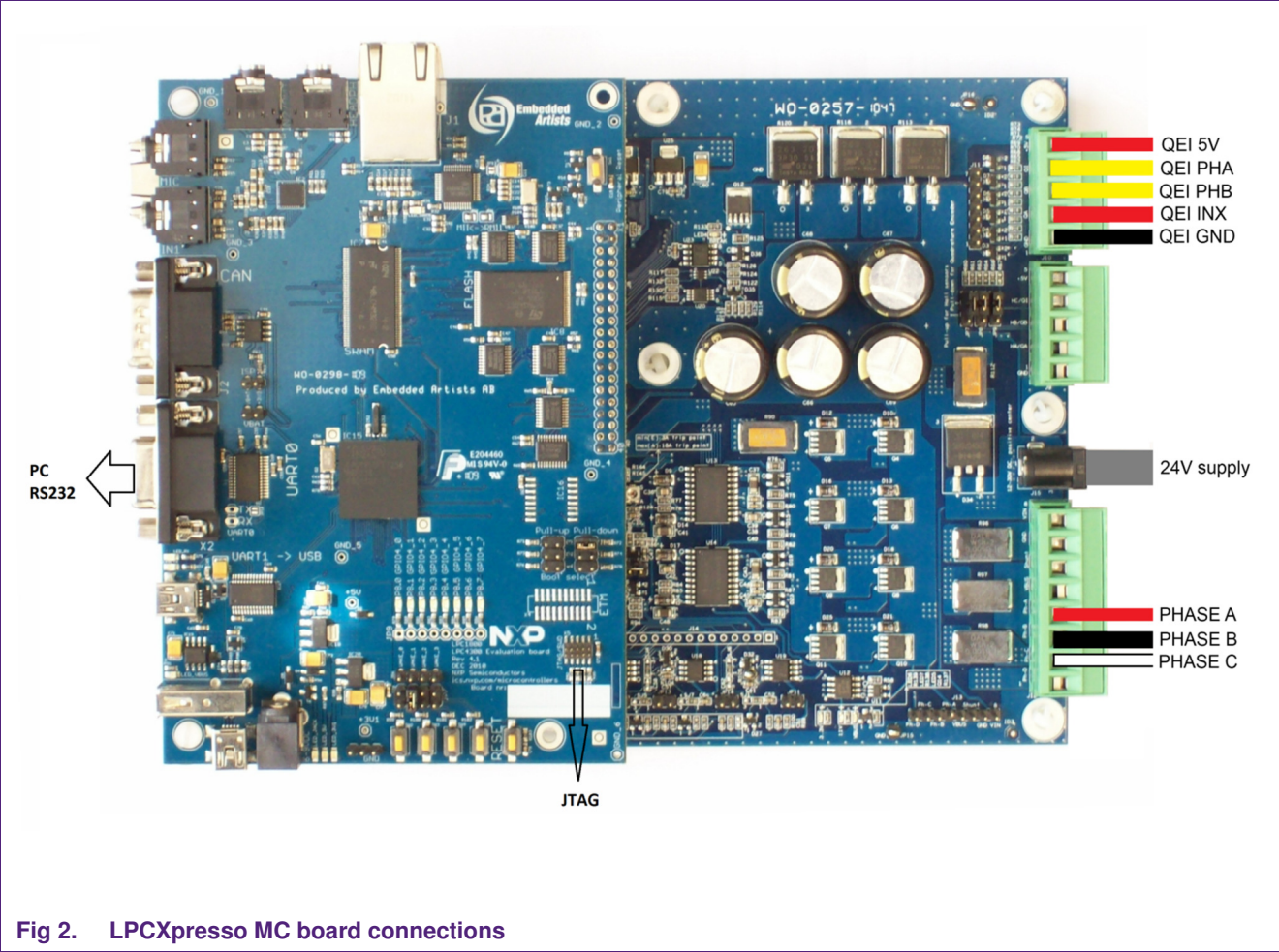
1.1.13 Run the motor

The control algorithm is disabled by default. Once the current measurement and the encoder are properly calibrated, the motor can be started by using SW3 in the target board, or using the 'Control Enabled' button in the Motor Control tool. It is now possible to adjust all the other FOC parameters.

2. Connections

The NXP evaluationboard is connected to the Embedded Artists LPCXpresso motor control baseboard by the motor control connector.

To use the supplied software package only the QEI connections and the phase connections to the baseboard are needed. Be aware that the labels for QEI INX and PHA on the baseboard are swapped in rev A. They are shown correctly in the figure below.



When using a Maxon 118893 80W EC32 motor with a HEDL 5540 encoder, use the following connections.

Table 2. Motor connection
Maxon 118893 80W EC32

Board	Motor
Phase 1	Red wire
Phase 2	Black wire
Phase 3	White wire

The Quadrature Encoder Interface (QEI) is the main interface used for position feedback from the motor. The encoder is connected to the upper right connector which supplies 5V for the encoder.

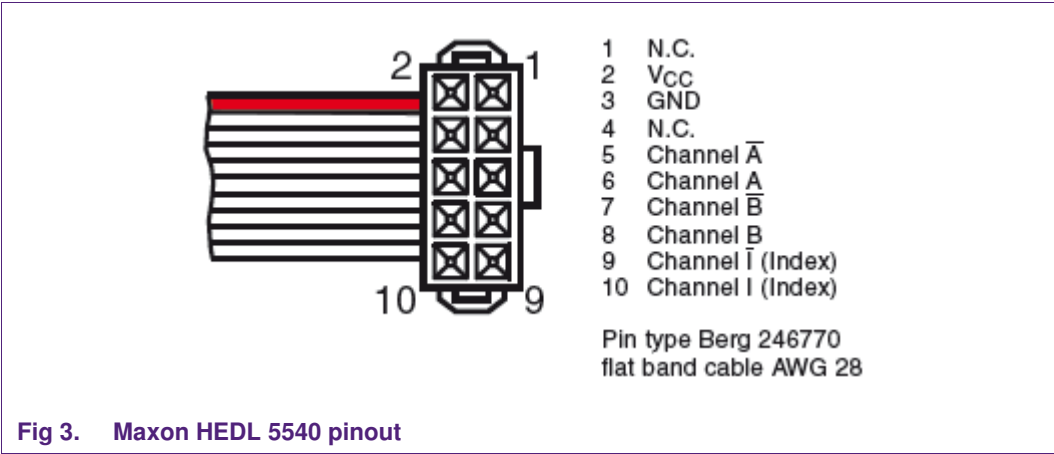


Fig 3. Maxon HEDL 5540 pinout

Other motor/encoder combinations are also possible as long as the motor power rating does not exceed 150W. An index pulse on the encoder is not required.

The middle connector is used for Hall sensor connection that is commonly used for six step BLDC commutation. Hall sensor input is not supported in the supplied FOC dual shunt software package.

3. Motor Control software tool

3.1 Installing

The Motor Control user interface can be installed by running Setup.msi, included in the package zip file in the GUI folder. The installer creates a shortcut in the users program menu to the executable, as well as an uninstaller. Also a shortcut to the quick launch menu is created. Since the tool is written in Microsoft .NET, it needs the .NET 3.5 framework. When the installer detects that this framework is not installed, it will automatically present an option to the user to install the .NET framework.

3.2 Connecting to a board

When the board is not connected, by default all the controls are disabled. They will become automatically enabled when the connection to the board is established. Currently only COM port communication is supported. The COM port can be selected in the menu bar under edit → COM settings.

When the right COM port is set, the connection can be made by using the connect button.



(1)

Fig 4. Connection button

When the tool receives data from the board, the blue connectivity icon lights up. This provides a visual check for incoming data.

3.3 Data scope

The data scope can be opened by clicking the scope button. This is only possible when the board connection is made. The scope can also be opened using the menu bar: Tools → scope.



(2)

Fig 5. Scope window button

Once the scope window is opened, various settings can be made, explained in the following figure.

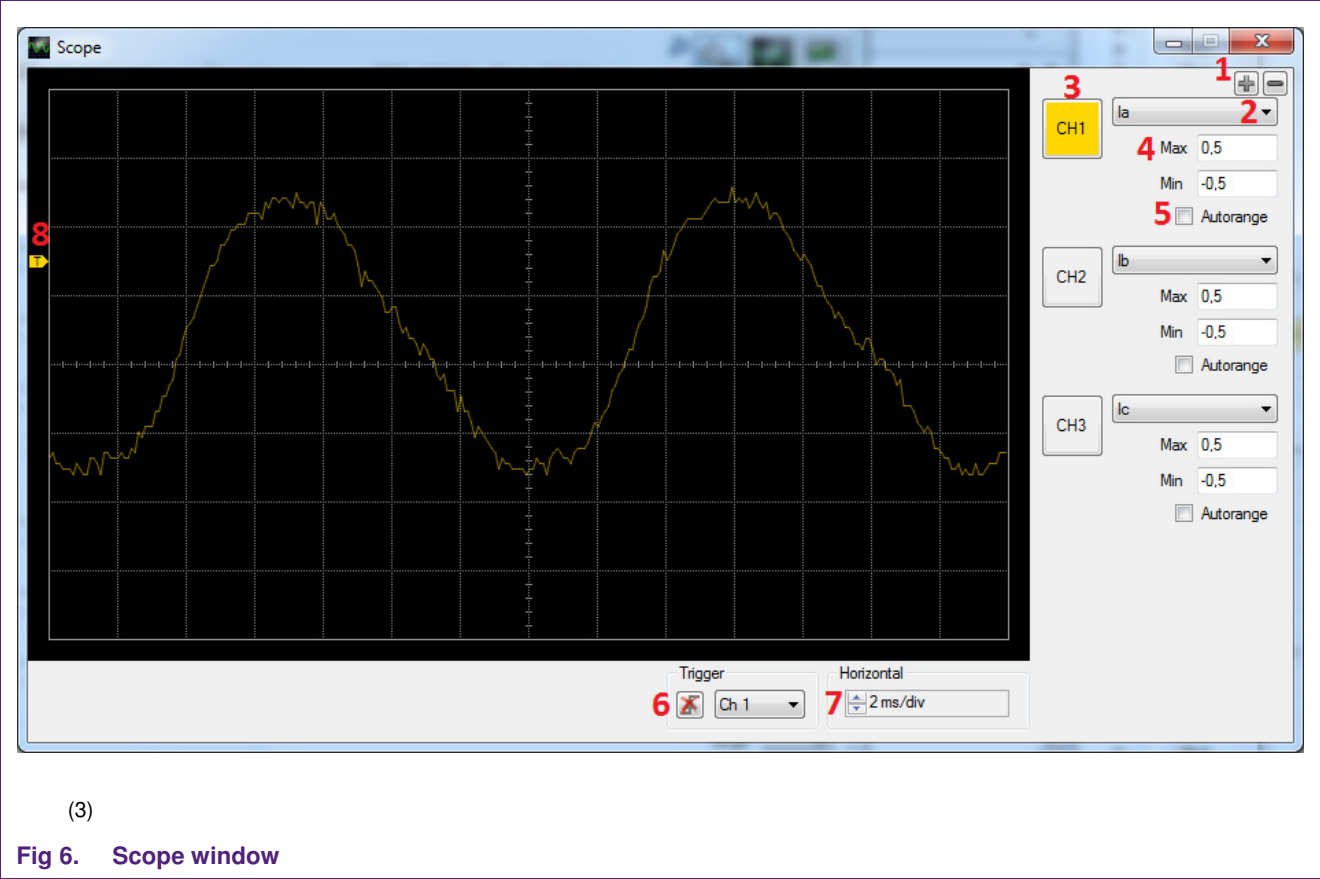


Table 3. Scope options

#	
1	The plus and minus buttons control the number of channels in the scope.
2	Channel selection button
3	Channel enable button. Once the channel is enabled, it will become colored. The color of the button corresponds to the color of the signal.
4	Max and Min values for the vertical range of the signal that is displayed in the scope.
5	Autorange. The range is automatically adjusted to the most extreme values of the channel signal.
6	Channel trigger button. Three trigger modes are available; trigger disabled, rising edge and falling edge. The triggered channel can be selected.
7	Horizontal timebase can be selected. The timebase sets the amount of samples that are transferred for each frame.
8	Trigger level. The trigger level can be adjusted using the trigger level slider. The level value corresponds to the max and min values of the active trigger channel.

3.4 Datalogger

The datalogger is a tool that can be used to export incoming data to a file. The datalogger is opened by the datalogger button.



It can also be opened by using the menu bar: Tools → Datalogger. This is only possible when the board connection is made.

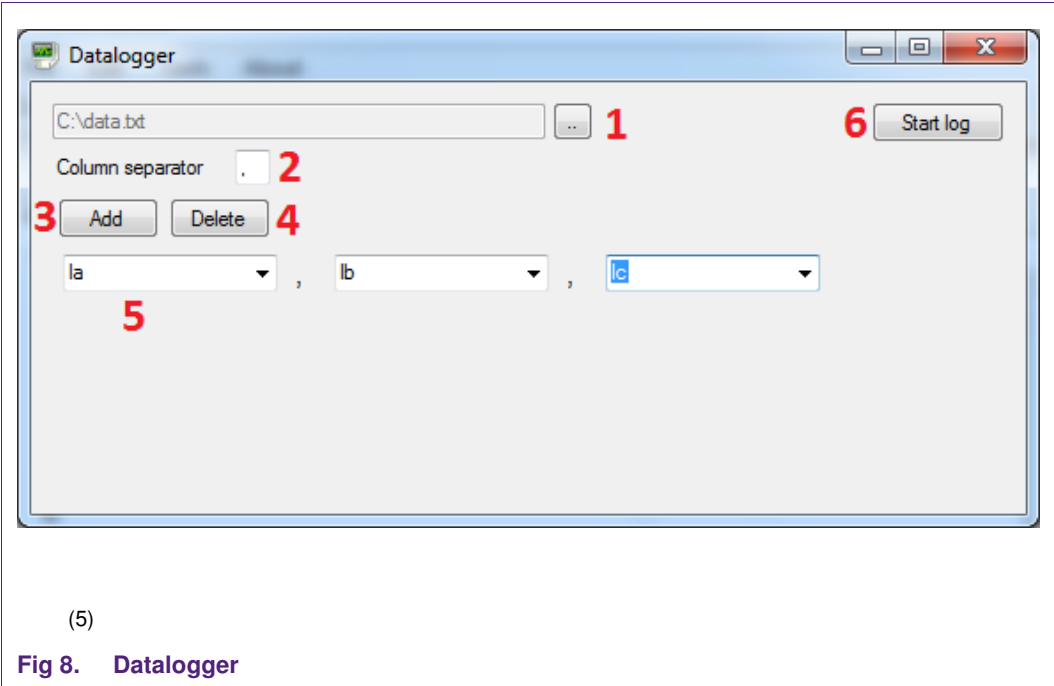
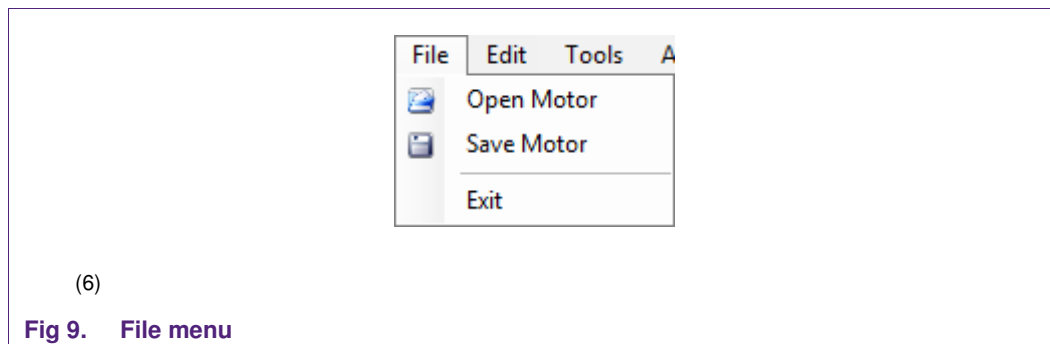


Table 4. Datalogger options

#	
1	Target file selection
2	Separator character between data values
3	Add button to increase the number of variables
4	Delete button to decrease the number of variables
5	Selection of variable

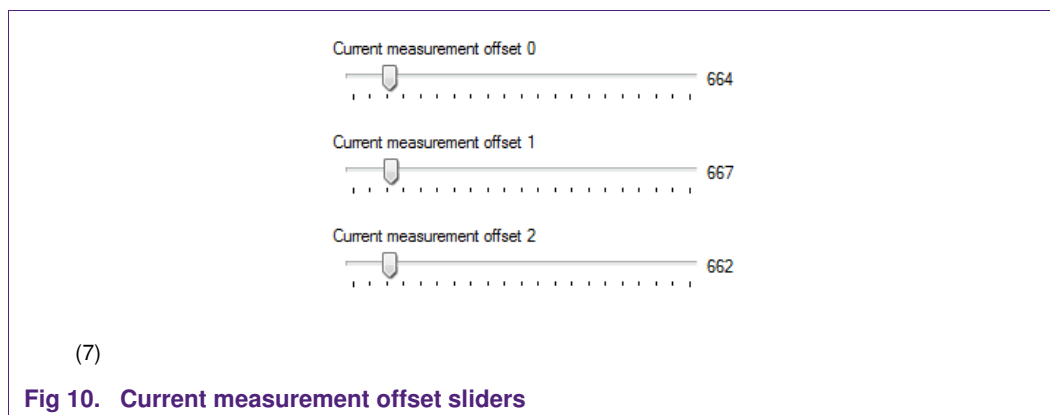
3.5 Open and save motor settings



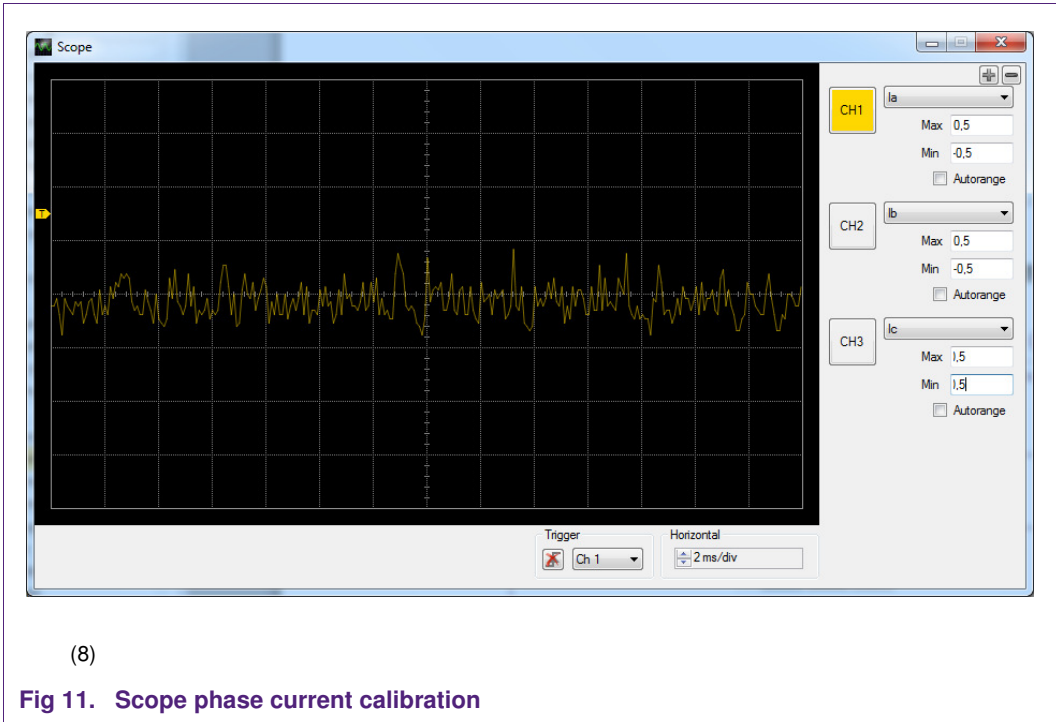
In the menubar under File, there is an option to open and save motor settings. All the control settings from the various control tabs can be stored in a file. When a board is connected and a motor file is loaded, all the settings will be written to the board.

3.6 Current measurement calibration

The phase current measurements can be calibrated by disabling the 'Control Enabled' checkbox, and using the calibration sliders on the calibration tab. When the motor control is disabled, the current should be zero.



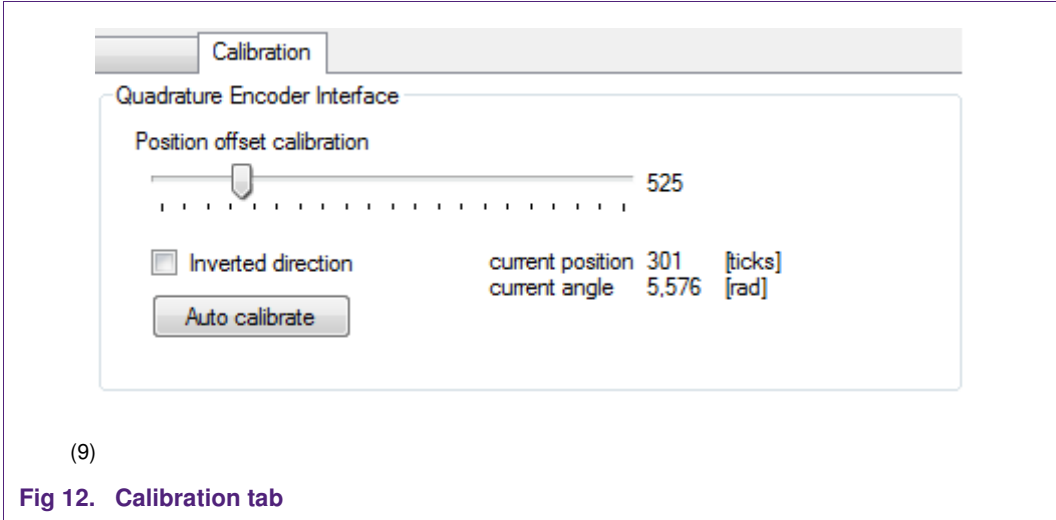
Open a scope window and select the channel which you want to calibrate. Disable auto range, and set the Max and Min values to a fixed value.



You can now adjust the channel ADC offset on the Calibration tab, to trim the current to zero. It is also possible to adjust the gain of the current measurement.

3.7 Quadrature Encoder Interface calibration

The Quadrature Encoder Interface can be calibrated using the Auto calibration function available on the calibration tab. When the Auto calibration routine is started, the motor will automatically rotate a few turns and calibrate the encoder position depending on the phase commutation.



4. Board specifications

This NXP LPC1800 evaluationboard rev4.1 has the following specifications:

- LPC1850 Cortex-M3 microcontroller.
- 16MB External Nor Flash
- 128MB SDRAM
- Audio coder/decoder with MIC, Line and Headphone in- and outputs, based on the NXP UDA1380
- 10/100MBit Ethernet interface
- 1x CAN connector
- 2x UART connections (Header and UART->USB converter)
- 2x USB connector, USB A for host and USB miniB for device. Both connectors will supply the board.
- 10 pins 1,27mm JTAG/SWD connector
- 8x LEDs for UI
- 4x Wakeup buttons
- 1x SCT motor control connector, suitable and pin compatible with the LPCXpresso Motor Control board.
- 1x MCPWM motor control connector, suitable and pin compatible with the LPCXpresso Motor Control board.
- Boot select
- Power supply: 6-9V power Jack, or 2x mini-USB connectors
- Max power consumption 400mA

4.1 Revision marking

The following picture depicts the location for determining your board version.



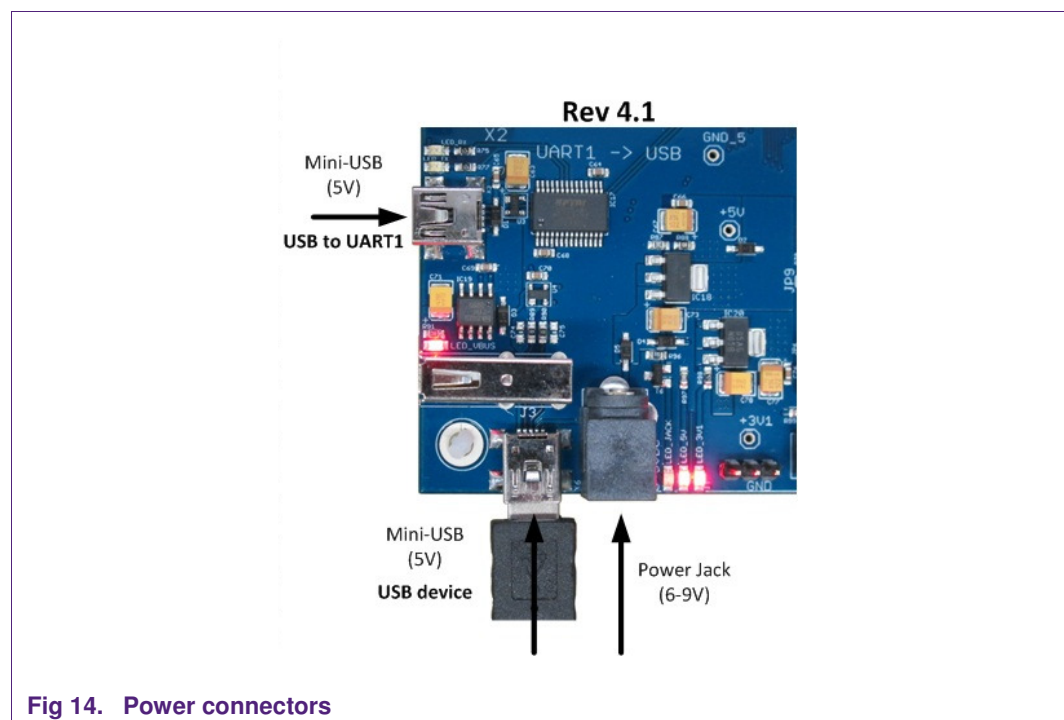
Fig 13. Board version indication

4.2 Board power

Powering the board can be done with 4 different connectors.

1. Motor control connector. When using the board in combination with the Embedded Artists motor control board, the evaluation board is powered by the motor control connector.
2. Upper mini-USB connector, by supplying the board through this connector will also enable the possibility to use UART1 as VCP (Virtual Com Port). Please find the drivers for the VCP on the FTDI website (<http://www.ftdichip.com/Drivers/VCP.htm>)
3. The lower mini-USB connector will power the board but is also connected to USB0 of the microcontroller and therefore it can be used as USB-device.
4. On the lower-side of the board a power jack connector is available to power the board with a PSU.

Note: all three power sources can be connected at the same time; it will not damage the board.



4.3 Debugging

The Evaluation board has a 10 pins JTAG/SWD connector, connector X8. This connector can be used for your normal debugging. As depicted in the picture below and seen in the silkscreen, **pin 1 is right upper pin**.

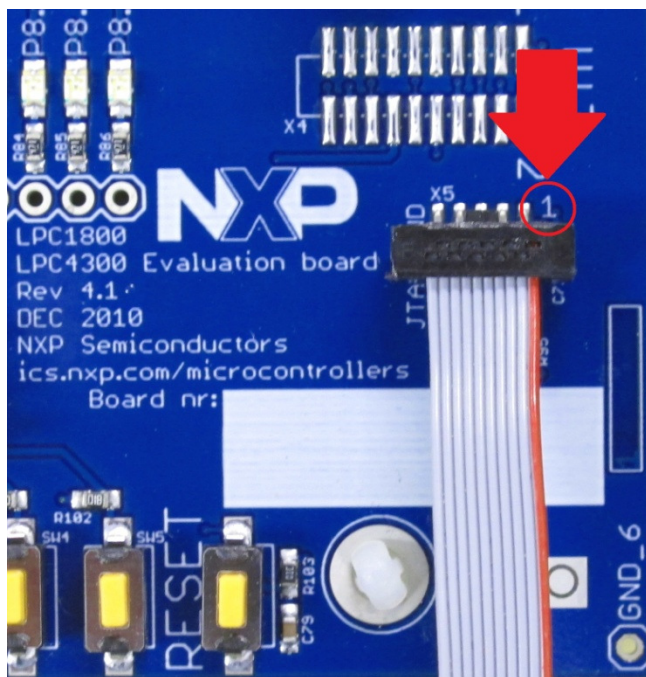


Fig 15. JTAG/SWD connector, pin 1 = right upper pin

4.4 Boot select

LPC1850 and LPC4350's on the evaluation board rev4.1 are OTP configured to always boot from 16bit EMC, regardless of the bootjumpers.

In general the LPC1800 and the LPC4300 have various boot modes. Then the OTP is not preconfigured to boot from a specific source, bootjumpers select the bootdevice.

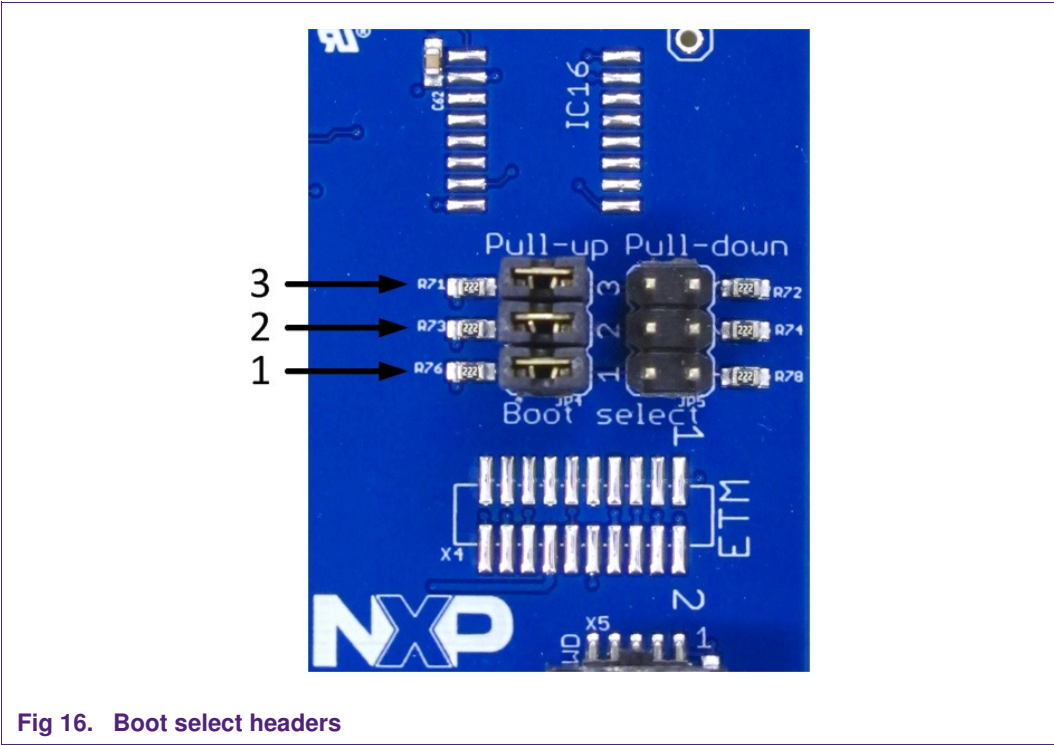


Fig 16. Boot select headers

The table below shows the boot modes:

Table 5. LPC1800 Boot selection

Boot mode	Header		
	1 P1[1]	2 P1[2]	3 P2[8]
UART	0	0	0
SPIFI	0	0	1
EMC 8bits	0	1	0
EMC 16bits ²	0	1	1
EMC 32bits	1	0	0
USB1	1	0	1
USB2	1	1	0
SPI(SSP)	1	1	1

[1] 0 = pull-down, 1 = pull-up

[2] External flash

4.5 Communications

This evaluation board gives you the possibility to connect to various interfaces.

- UART:
 - As described in chapter 4.2 one can use the upper USB connector for VCP on UART1
 - Just above the upper USB connector, an extension header is added to connect to UART0. Please note the level of these signals

4.6 Board layout

The components on this board are described in Table 6.

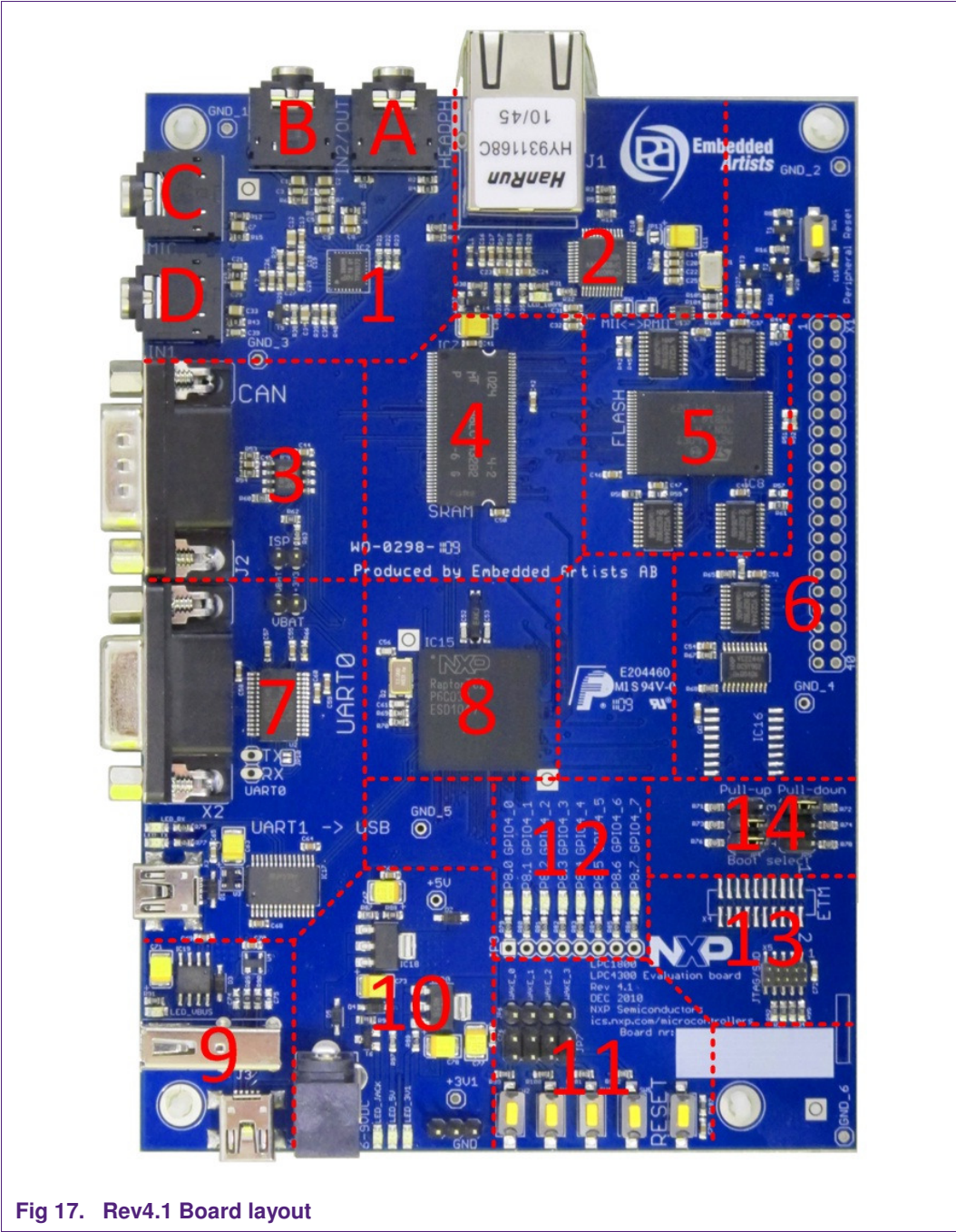


Table 6. Board layout description

Section	Description
1	Stereo audio coder/decoder (UDA1380) connection though I2S. A. Headphone OUT B. Line IN/OUT C. MIC IN D. Line IN
2	10/100MBit Ethernet connection
3	CAN connector
4	128M (1 Meg x 32 x 4 banks) SDRAM
5	16M (1Meg x 16) Nor Flash
6	Extension connector contains analog and digital signals. Pin compatible with LPCXpresso Motor Control board.
7	2x UART connections. • Header connectors = UART0 • UART \leftrightarrow USB = UART1
8	Microcontroller • LPC1800V01 = LPC1800, Cortex-M3
9	2x USB connections both on USB0 • USB A, Host connector • USB mini B, device connector
10	Power supply +connectors
11	Input buttons + Reset button The input buttons can be connected though jumpers onto the WAKEUP pins.
12	8x LEDs
13	10 pins JTAG/SWD connector Not placed: 20 pins ETM connector
14	Boot selection •

See schematics for more detailed information.

5. Software

Programming and debugging the LPC18xx and LPC43xx can be probably done through your preferred IDE. This manual will only describe details and setting using Keil's μ Vision 4.12 using either the ULINK2 or JLINK debuggers.

5.1 Example code

With the "Getting Started" package, some basic example code is available. If not, please ask your NXP contact person for the codebundles.

5.2 Compiling your code for internal RAM

Some μ Vision settings will be needed to get your project external flash. The internal RAM is located in the memory map on address 0x10000000.

So you need to compile your project with the settings as depicted below.

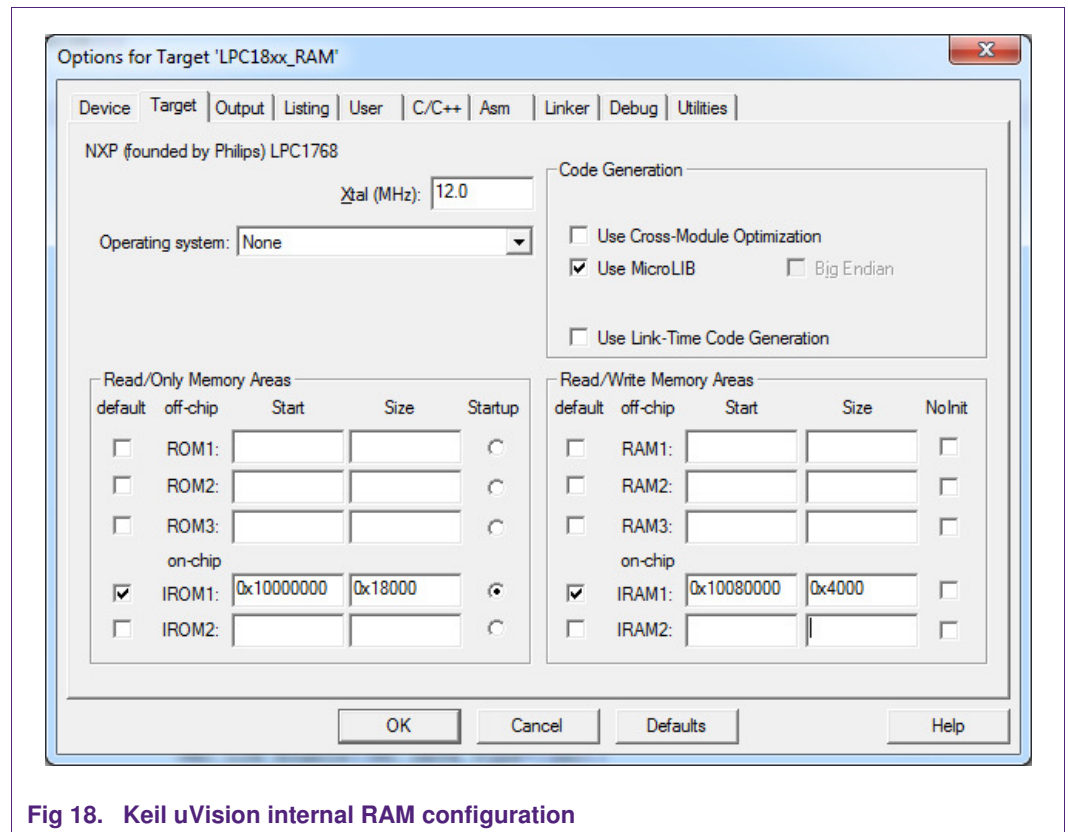


Fig 18. Keil uVision internal RAM configuration

(Optional)

The second step is creating a binary (.bin) file for using your own preferred programmer or as described in [Chapter Fout! Verwijzingsbron niet gevonden.](#) for using the Segger J-Flash ARM tool. This can be done in uVision in the 'User' tab of the Options for Target dialog.

As depicted in the picture below, in the 'Run User Programs Before Build/Rebuild' section a command line can be used to create the binary file. The following line will take care of the binary file creation.

```
fromelf --bin -o $L@L.bin $L@L.axf
```

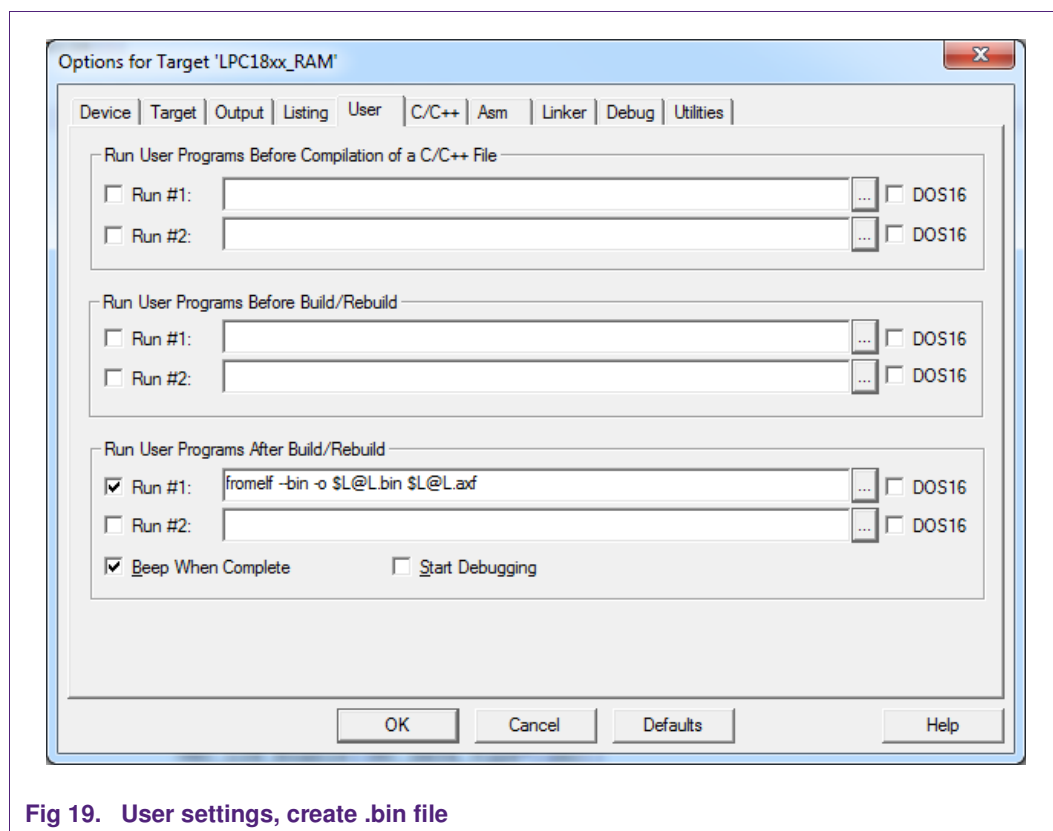


Fig 19. User settings, create .bin file

Please don't forget to check the Run # check box if you place the command line. When compiling your project now, the binary file will be created and placed in the folder the .axf is created.

6. Known bugs

6.1 Hardware bugs

Table 7. Known hardware bugs

Bug #	Board	Description
1	Embedd Artists motor control board	Current measurement not accurate. The current measurement routing picks up a lot of interference from the inverter stage due to indirect routing of the shunts to the amplification stage. This results in poor current measurement performance. To improve performance a little, higher shunt values can be used to increase the sensitivity. This limits the maximum current.
2	Embedd Artists motor control board	QEI A and QEI index text have been swapped.

6.2 Software bugs

Table 8. Known software bugs

Bug #	Description
1	Scope triggering can sometimes result in an unstable scope image. The workaround is to reconnect using the connect button.

6.3 LPC18xx / LPC43xx

Please see the LPC18xx / LPC43xx errata sheets for known bugs.

7. Troubleshooting

7.1 Software

Problem: Keil uVision compilation error:” Error: Q0466E: An output file can only be specified if there is a single input file”

Solution: Eliminate spaces from the project folder.

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9. List of figures

Fig 1.	Vector graph showing encoder angle 'alpha'	6
Fig 2.	LPCXpresso MC board connections	8
Fig 3.	Maxon HEDL 5540 pinout.....	9
Fig 4.	Connection button.....	10
Fig 5.	Scope window button.....	10
Fig 6.	Scope window	11
Fig 7.	Datalogger button	12
Fig 8.	Datalogger	12
Fig 9.	File menu	13
Fig 10.	Current measurement offset sliders.....	13
Fig 11.	Scope phase current calibration.....	14
Fig 12.	Calibration tab.....	14
Fig 13.	Board version indication.....	16
Fig 14.	Power connectors	17
Fig 15.	JTAG/SWD connector, pin 1 = right upper pin	18
Fig 16.	Boot select headers	19
Fig 17.	Rev4.1 Board layout	21
Fig 18.	Keil uVision internal RAM configuration	23
Fig 19.	User settings, create .bin file.....	24

10. List of tables

Table 1. User parameters4

Table 2. Motor connection8

Table 3. Scope options 11

Table 4. Datalogger options..... 12

Table 5. LPC1800 Boot selection 19

Table 6. Board layout description22

Table 7. Known hardware bugs25

Table 8. Known software bugs.....25

11. Contents

1.	Introduction	3	8.5	Trademarks	26
1.1	Plug and play steps	3	9.	List of figures	27
1.1.1	Required components	3	10.	List of tables	28
1.1.2	Install the Motor Control software	4	11.	Contents	29
1.1.3	Connect and check hardware	4			
1.1.4	Open the project	4			
1.1.5	Adjust user parameters	4			
1.1.6	Target selection	5			
1.1.7	Compile and run	5			
1.1.8	Connect the board to a PC	5			
1.1.9	Open connection	5			
1.1.10	Check encoder	6			
1.1.11	Calibrate the encoder	6			
1.1.12	Calibrate current measurement	6			
1.1.13	Run the motor	7			
2.	Connections	8			
3.	Motor Control software tool	10			
3.1	Installing	10			
3.2	Connecting to a board	10			
3.3	Data scope	10			
3.4	Datalogger	12			
3.5	Open and save motor settings	13			
3.6	Current measurement calibration	13			
3.7	Quadrature Encoder Interface calibration	14			
4.	Board specifications	15			
4.1	Revision marking	16			
4.2	Board power	17			
4.3	Debugging	18			
4.4	Boot select	19			
4.5	Communications	20			
4.6	Board layout	21			
5.	Software	23			
5.1	Example code	23			
5.2	Compiling your code for internal RAM	23			
6.	Known bugs	25			
6.1	Hardware bugs	25			
6.2	Software bugs	25			
6.3	LPC18xx / LPC43xx	25			
7.	Troubleshooting	25			
7.1	Software	25			
8.	Legal information	26			
8.1	Definitions	26			
8.2	Disclaimers	26			
8.3	Licenses	26			
8.4	Patents	26			

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