



# UM10798

## PCA9629A advanced stepper motor controller demo kit (OM13285)

Rev. 1 — 17 June 2014

User manual

### Document information

| Info            | Content                                                                                                                                                                                                                                                                                                                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Keywords</b> | Fm+ I2C-bus, PCA9629A, GPO, LPCXpresso LPC1343 daughter card, sensor, stepper motor, motor direction, speed and ramp control                                                                                                                                                                                                |
| <b>Abstract</b> | PCA9629A demo kit (OM13285) is designed to let customers evaluate the PCA9629A in a realistic application. The demo kit includes a stepper motor board with sensors and the stepper motor demo board with a number of pre-defined functions. The functions are executed by pressing push-button switches on the demo board. |



## Revision history

| Rev | Date     | Description                  |
|-----|----------|------------------------------|
| 1.0 | 20140617 | User manual; initial version |

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## 1. Introduction

The PCA9629A Stepper Motor Controller Demo Board is designed to let customers evaluate the PCA9629A in a realistic application. The demo board kit includes a Stepper Motor board with sensors and the Stepper Motor Demo Board with a number of pre-defined functions. The parameters used by these functions can be easily changed by changing a configuration header file. To customize the application further, the generalized driver functions used in the demo firmware can be easily modified with a free compiler tool, LPCXpresso, available at: [www.lpcware.com/lpcxpresso](http://www.lpcware.com/lpcxpresso).

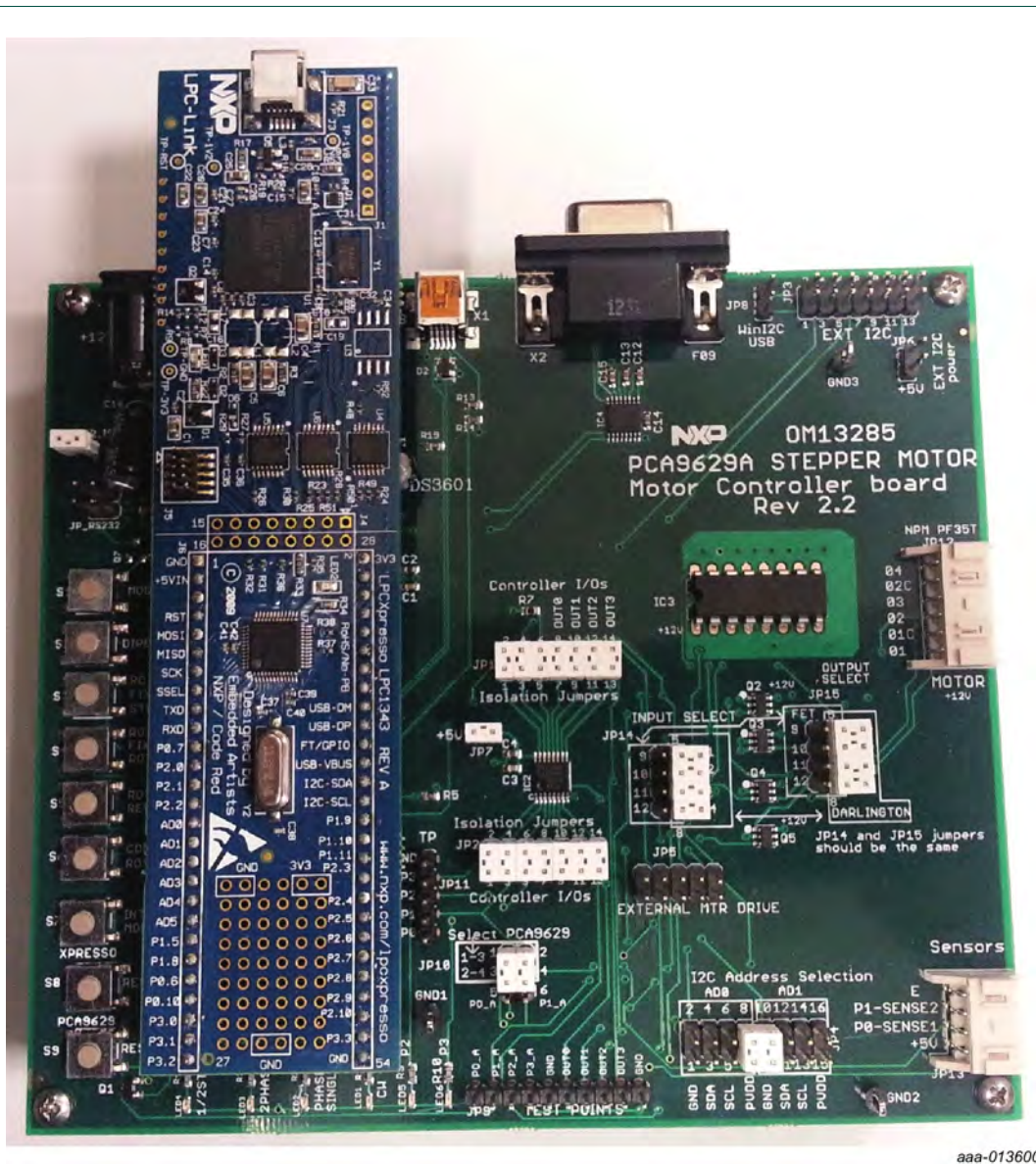


Fig 1. OM13285 PCA9629A stepper motor controller demo board Rev. 2.2

## 1.1 Application overview

The PCA9629A Demo board is designed for easy setup and ease of operation. The demo functions are executed by pressing a control button on the demo board. The PCA9629A Demo functions supported by the demo board and firmware include:

**Mode** — This selects Full Step, Half Step, or Two-Phase drive.

**Direction** — This selects clockwise or counter-clockwise starting direction.

**Rotate Fixed Steps** — This rotates the motor a fixed number of steps or ramp-up and ramp-down control function.

**Rotate Fixed Rotations** — This rotates the motor for a fixed number of rotations or ramp up and down control function.

**Rotate and Reverse** — Rotates the motor for a fixed number of rotations, stops (wait a delay time), reverses, and rotates the same fixed number of rotations in the other direction.

**Continuous Rotation** — Continuously rotate the motor and the button is pressed again to change speed with ramp control.

**Interrupt mode** — This starts the motor rotating in the 'Interrupt Auto clear mode' where it starts one direction until the optical interrupter connected to the motor shaft passes through one of the slotted optical switches. It then stops (wait a delay timer), and reverses until an interrupter passes through the second slotted optical switch. This process continues until the button is pressed again to stop.

Some of the other features of the PCA9629A demo board are:

- Programmable I<sup>2</sup>C-bus address selection up to 16 slave devices
- Optional either MOSFET with Schottky diode or Darlington sink driver
- Access to all PCA9629A I/O, including the ability to isolate any or all device pins
- Test point access to monitor many onboard signals
- Flexibility to use external controller with onboard drive
- Requires +12 V input, has onboard +5 V and +3.3 V regulators
- Flexible reprogramming, firmware updating via several methods
  - USB (X1)
  - LPC-Link USB (J3 in LPCXpresso daughter board)
  - RS-232 (X2)

## 2. PCA9629A stepper motor controller demo kit

### 2.1 PCA9629A demo kit (Rev. 2.2) contents

- PCA9629A demo board with LPC1343 LPCXpresso daughter board
- +12 V DC power adapter
- Stepper motor board with sensor
- Motor cable (6-wire)
- Sensor cable (4-wire)
- Demo board quick start instructions

### 3. System overview

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#### 3.1 The PCA9629A stepper motor controller

Stepper motors can be driven and controlled in a number of different ways, depending on the type of motor being driven and the application requirements for the motor. The most basic form of drive is single-phase drive or 'wave drive'. The other common drive modes include 2-phase,  $\frac{1}{2}$ -step, and micro-step. The main advantage of the  $\frac{1}{2}$ -step or micro-step mode is to break the steps into smaller increments to minimize resonance effects that could be a problem in certain applications. Stepper motor can also be designed for unipolar and/or bipolar drive. The PCA9629A is designed for single-phase, 2-phase, and  $\frac{1}{2}$ -step operation. This application only deals with interface to a unipolar motor.

The PCA9629A has an internal oscillator, so no external components are required. Some of the other features of the PCA9629A include:

- Stand-alone operation: generates motor coil drive phase sequence signals for use with an external high current driver to off-load master controller/micro
- Programmable step rate: 333.3 kpps to 0.3 pps with  $\pm 3\%$  accuracy
- Programmable number of steps and motor action either multiple times (1 to 255) or continuously
- Sensor enabled drive control: linked to interrupt from P0 and P1 inputs with noise filter enable or disable feature
- Programmable four GPIO ports and four GPO ports
- Programmable ramp-up from start and ramp-down to stop
- Programmable re-enable ramp-up or ramp-down to change ramp rate curve on the fly
- Programmable start, ramp-up/ramp-down, stop or reverse the direction either clockwise or counter-clockwise of rotation control of stepper motor
- Programmable restart motor with new speed and operation while motor is still running
- Programmable loop delay timer for motor reversal mode
- Interrupt auto clear function linked extra steps, direction reversal and stop control without microcontroller handling
- 32-bit step counter to count output steps
- Selectable active hold (last state), power on, power off, or released states for motor shaft
- Four balanced push-pull type outputs capable of sinking 25 mA or sourcing 25 mA for glueless connection to external high current drivers needed to drive motor coils
- Up to 1000 pF loads with 100 ns rise and fall times on outputs

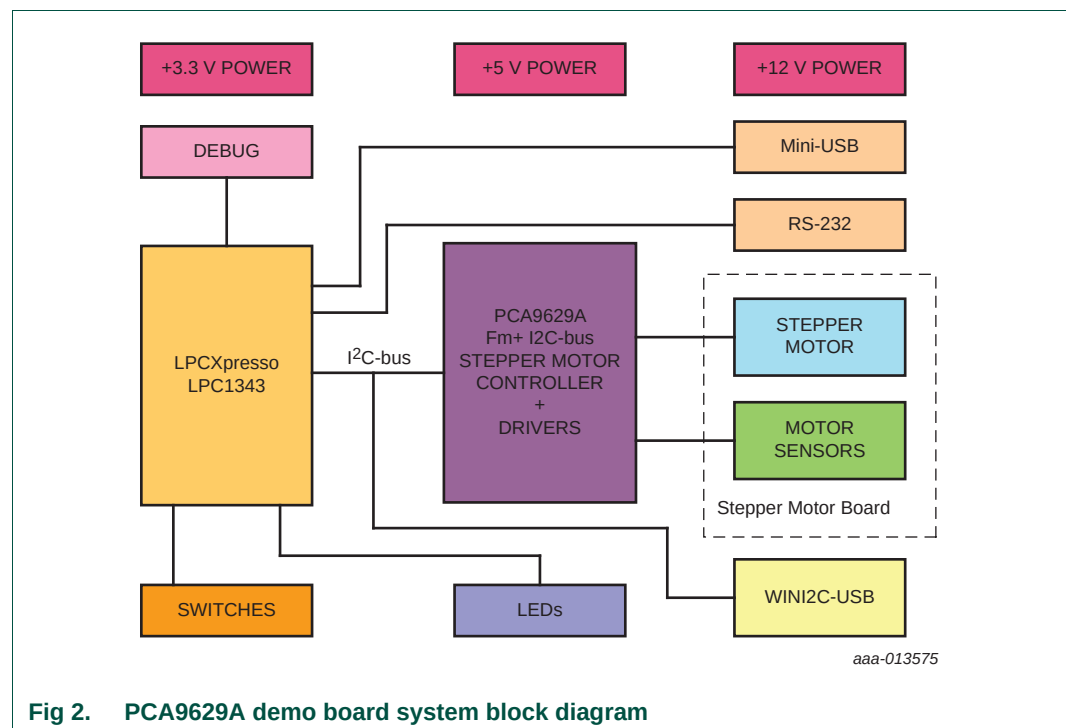
### 3.2 LPCXpresso microcontroller board

The LPCXpresso target board, jointly developed by NXP, Code Red Technologies, and Embedded Artists ([www.embeddedartists.com/products/lpcxpresso/](http://www.embeddedartists.com/products/lpcxpresso/)), includes an integrated JTAG debugger (LPC-Link), so there is no need for a separate JTAG debug probe. The target and debugger can be easily cut apart, allowing them to be used separately. The target portion of the board can connect to expansion boards to provide a greater variety of interfaces, and I/O devices. The LPC-Link debugger provides a high-speed USB to JTAG/SWD interface to the IDE. It can be connected to other debug targets such as a customer prototype. For the PCA9629A demo board application, the debugger portion (LPC-Link) can be cut off, but a connector is installed to allow connection to the debugger if necessary. Two headers are also installed to mate the pin connections on the LPCXpresso board to the PCA9629A main board connectors. The onboard LPC1343 is then programmed with the firmware to support the demo application.

Code was developed for the application using the LPCXpresso IDE. This is based on the popular Eclipse development platform and includes several LPC-specific enhancements. It is an industry-standard GNU tool chain with an optimized C library that gives engineers all the tools necessary to develop high-quality software solutions quickly and cost-effectively. The C programming environment includes professional-level features. There is syntax coloring, source formatting, function folding, online and offline help, and extensive project management automation. If the user wants to customize the demo or write their own application code, the code is free to download at the link above.

### 3.3 System block diagram

A block diagram of the PCA9629A demo system is shown in [Figure 2](#).



### 3.4 I/O, switches and indicators on the PCA9629A demo board

The interface connections, switches and indicators on the PCA9629A demo board are shown in [Figure 3](#).

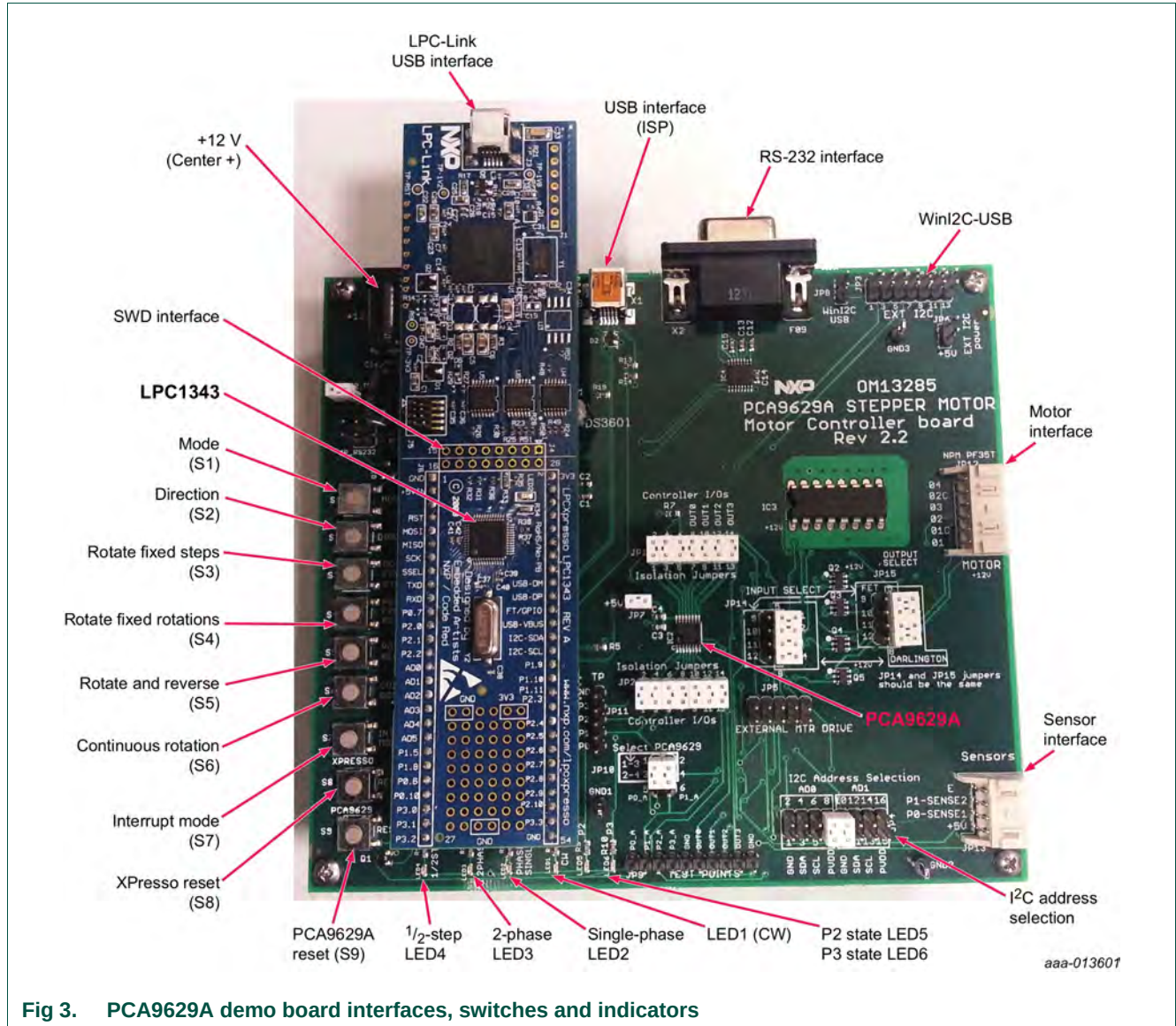


Fig 3. PCA9629A demo board interfaces, switches and indicators

### 3.4.1 Sensor interface

The sensor interface allows connection to slotted optical switches and bias components mounted on the Stepper motor board being connected to the PCA9629A. The sensors are utilized in Interrupt mode to demonstrate the interrupt autoclear capabilities of the PCA9629A. The interrupt autoclear capability allows one sensor to clear the interrupt caused by the other sensor. This action can result in stopping the motor, reversing the motor, or adding extra steps or rotations before stopping or reversing the motor.

### 3.4.2 Motor interface

The motor interface provides power as well as the phased outputs from either the bipolar Darlington driver or the MOSFET drivers. The PCA9629A coil driver outputs, OUT0 to OUT3, are connected to the inputs of the bipolar or MOSFET driver via selectable jumper block (JP14).

### 3.4.3 RS-232 programming interface

An RS-232 interface is provided as a method of programming and updating firmware on the LPC1343 microcontroller ([Ref. 3](#)). The details and required utilities to update the firmware are discussed in the programming section, [Section 7.3](#) of this manual.

### 3.4.4 USB programming interface

A Full Speed USB 2.0 interface is provided as a method of programming and updating firmware on the LPC1343 microcontroller using the Flash Magic programming tool. The details and steps required to update the firmware is discussed in the programming section ([Section 7.1](#)) of this manual.

### 3.4.5 LPC-Link USB debug and programming interface

The on-board LPC-Link debugger provides a high-speed USB to JTAG/SWD interface to the LPCXpresso IDE, which is a highly integrated software development environment. It can be connected to other debug targets, such as a customer prototype. The details and steps required to update and debug the firmware is discussed in the programming section ([Section 7.2](#)) of this manual.

### 3.4.6 SWD debug interface

A Serial Wire Debug (SWD) interface is provided as a method for debugging and programming the LPC1343 microcontroller. Details on SWD and other LPC1343 information can be found in *UM10375, "LPC1311/13/42/43 User manual"* ([Ref. 2](#)).

### 3.4.7 WINI2C-USB interface

WINI2C-USB is an I<sup>2</sup>C tool that provides a USB interface and Graphical User Interface (GUI) to read and write to I<sup>2</sup>C-bus devices. It contains pre-defined GUIs for many NXP I<sup>2</sup>C-bus devices, as well as the ability to have user-defined interfaces. There is a dedicated GUI planned for the PCA9629A. However, until that is available, the user-defined functions of the WINI2C-USB utility can be customized to use with the PCA9629A.

### 3.4.8 Output LED indicators

Several LED indicators are available for status indication on the PCA9629A demo board. These indicators are detailed in [Section 4.2.1](#) of this manual.

### 3.4.9 Push-button switches

Nine push-button switches, S1 to S9, are available for motor operation modes and chip reset control on the PCA9629A demo board. These switches are detailed in [Section 4.2.2](#) of this manual.

### 3.4.10 +12 Volt input

This input is intended as the main power source for the board. The center pin is the +12 volt connection and the shield is Ground. This input provides power for the on-board +5 V and +3.3 V regulators and 12 V for the motor.

## 4. Hardware description

### 4.1 LPC1343 Cortex M3 based LPCXpresso daughter board

The NXP LPC1343 is the heart of the board. It handles all of the 'intelligent' functions of the board and handles all peripheral interfaces. The LPC1343 version of the LPCXpresso board described earlier is used to provide a form factor that could be adapted to other processors with the same LPCXpresso form factor. For the PCA9629A Demo Board application, the primary function of the LPC1343 microcontroller is to detect when a switch has been pressed and execute the command associated with that switch. In this application, most of the commands consist of sending one or more I<sup>2</sup>C messages to the PCA9629A stepper motor controller. The PCA9629A then handles the bulk of the stepper motor control functions. The details of how the LPC1343 handles these tasks are discussed in the firmware portion of the user manual ([Ref. 2](#)).

### 4.2 PCA9629A stepper motor controller mother board

The PCA9629A mother board consists of dual 27-pin socket for the LPCXpresso daughter board, the PCA9629A stepper motor controller, motor drivers, and connections to a Stepper Motor Board. In addition, it provides a number of switches and visual LED indicators to control and monitor the operation of the stepper motor. The flexibility and utility of the board is enhanced by having numerous option jumpers, test points, and external connection capabilities.

#### 4.2.1 On-board visual LED indicators

[Table 1](#) shows the different LEDs and their functions.

**Table 1. LED indicators**

| LED label                     | LED function             | Control drive source | Notes                                                                        |
|-------------------------------|--------------------------|----------------------|------------------------------------------------------------------------------|
| LED2<br>(on LPCXpresso board) | Processor heartbeat      | LPC1343 — PIO0_7     | Blinks per second when it is in normal default MODE 1 operation.             |
| LED1                          | Motor starting direction | LPC1343 — PIO2_0     | CW (clockwise) when LED1 is ON.<br>CCW (counter-clockwise) when LED1 is OFF. |
| LED2                          | Single-phase             | LPC1343 — PIO2_1     | Indicates Single Phase mode.                                                 |
| LED3                          | Two-phase                | LPC1343 — PIO2_2     | Indicates Two-Phase mode.                                                    |
| LED4                          | Half-step                | LPC1343 — PIO2_3     | Indicates Half-Step mode.                                                    |
| LED5                          | P2                       | PCA9629A — P2        | LED5 is ON when P2 drives LOW.                                               |
| LED6                          | P3                       | PCA9629A — P3        | LED6 is ON when P3 drives LOW.                                               |

## 4.2.2 On-board switches

[Table 2](#) shows the different switches and their present operations (power-on default MODE).

**Table 2. On-board switches**

| Switch / Label            | Switch function                                     | Signal destination | Notes                                                                                             |
|---------------------------|-----------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------|
| S1/Mode                   | Motor Drive Mode Select                             | LPC1343 — PIO1_0   | Select 1-Phase, 2-Phase, or Half-Step                                                             |
| S2/Direction              | Motor Direction Select                              | LPC1343 — PIO1_1   | Select CW (clockwise) or CCW (counter-clockwise) direction                                        |
| S3/Rotate Fixed Steps     | Rotate Fixed Steps                                  | LPC1343 — PIO1_2   | Rotate a fixed number of steps then stop.                                                         |
| S4/Rotate Fixed Rotations | Rotate Fixed Rotations                              | LPC1343 — PIO1_4   | Rotate fixed rotations then stop.                                                                 |
| S5/Rotate and Reverse     | Rotate and Reverse                                  | LPC1343 — PIO1_5   | Continuously rotate fixed steps and then Reverse. Press again to stop motor.                      |
| S6/Continuous Rotation    | Continuous Rotation                                 | LPC1343 — PIO1_8   | Continuous rotation. Press either S5 or S8 to stop motor.                                         |
| S7/Interrupt Mode         | Continuous Rotation and reverse driven by interrupt | LPC1343 — PIO3_0   | Continuously rotate and reverse motor on interrupt caused by P0 or P1. Press again to stop motor. |
| S8/Xpresso Reset          | Xpresso Reset                                       | LPC1343 — Reset    | Xpresso/LPC1343 reset. This control also resets the PCA9629A                                      |
| S9/PCA9629A Reset         | PCA9629A Reset                                      | PCA9629A — Reset   | PCA9629A — set all registers to power-on default values.                                          |

## 4.2.3 Power requirements

### 4.2.3.1 Input power

The board is powered by a 12 V power supply connected to power connector labeled '+12V J1'. The polarity is positive (+) for the center terminal and negative (–) for the shield connection. The 12 V supply is required for the +5 V regulator, the motor, and its drive circuits. The current requirements for the 12 V power supply depend on the motor being driven. A 12 V and 0.5 A supply was specified for this application using small stepper motors. A Nippon Pulse PF35T-48 Series stepper motor is used for the initial demo.

### 4.2.3.2 +5 V regulator

An LM317MB linear regulator is used to supply the +5 volts that is required for the PCA9629A stepper motor controller and the +3.3 V regulator.

### 4.2.3.3 +3.3 V regulator

A TDA3663 is used to supply the +3.3 V power required by the LPCXpresso daughter board and the LPC1343 on the LPCXpresso board.

4.2.4 Jumpers, headers, and test point locations

The locations of the jumpers, header connectors, and test points on the PCA9629A demo board are shown in [Figure 4](#), and their functions are described in [Table 3](#).

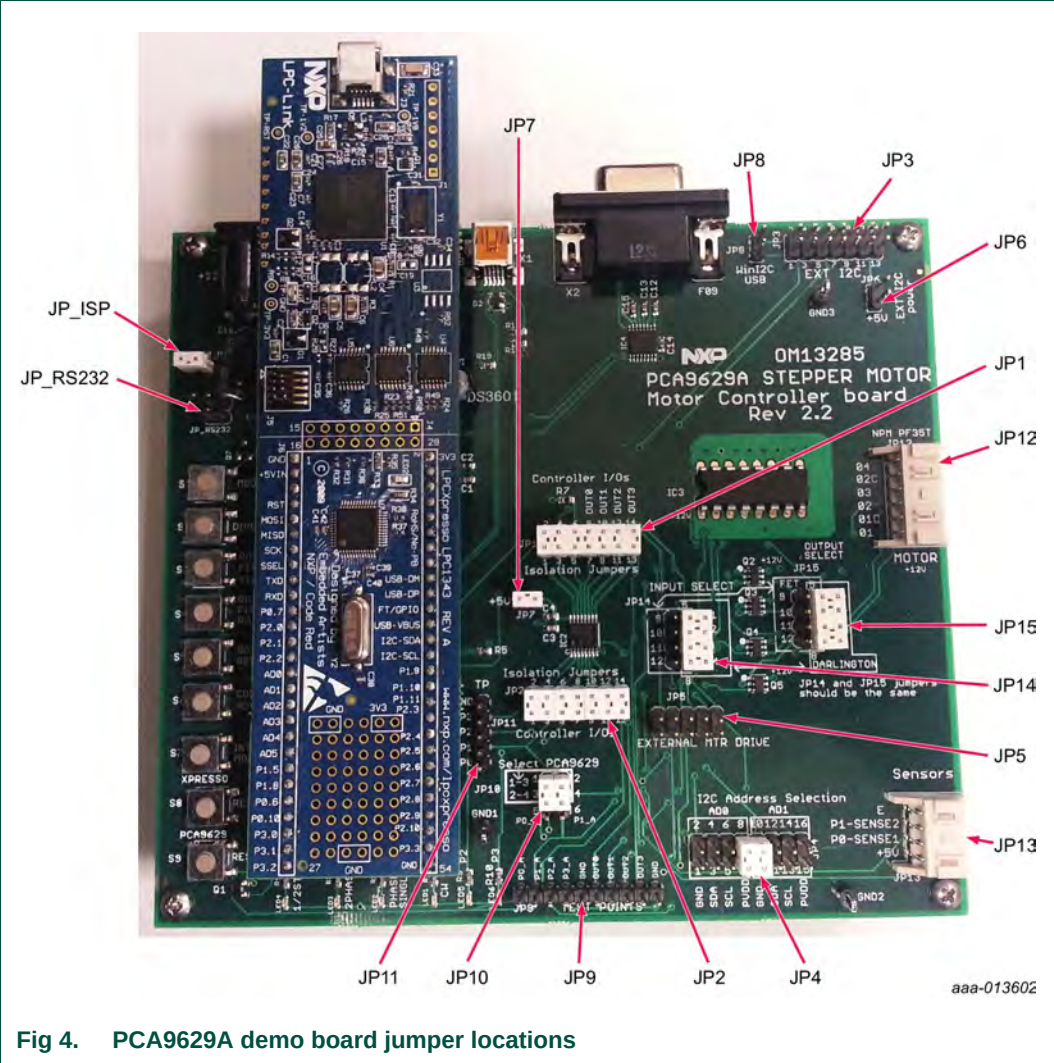


Fig 4. PCA9629A demo board jumper locations

Table 3. On-board jumper functions

| Jumper/header | Function/label                            | Notes                                                                                                               |
|---------------|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| JP1           | Pin isolation jumpers                     | Populated (PCA9629A pins [9:15])                                                                                    |
| JP2           | Pin isolation jumpers                     | Populated (PCA9629A pins [1:7])                                                                                     |
| JP3           | External I <sup>2</sup> C (14-pin header) | No connect (external I <sup>2</sup> C-bus to PCA9629A)                                                              |
| JP4           | I <sup>2</sup> C address selection        | Default is 7-8 and 9-10 populated (slave address 0x42 is selected)                                                  |
| JP5           | External motor driver                     | No connect. Option for external motor driver or controller.                                                         |
| JP6           | External I <sup>2</sup> C power           | NP (Not Populated). Option for external I <sup>2</sup> C +5 V power.                                                |
| JP7           | PCA9629A +5 V power                       | Populated (PCA9629A +5 V power from internal).                                                                      |
| JP8           | WinI2C-USB                                | NP (Not Populated). I <sup>2</sup> C pull-up source for WinI2C-USB interface.                                       |
| JP9           | Test points (10-pin)                      | 10-pin header connect to GND, OUT[0:3] and P[0:3]_A.                                                                |
| JP10          | Sensor output select                      | Default is 1-3 and 2-4 populated (select sensor outputs to P[0:1] pins of PCA9629A).                                |
| JP11          | Test points (5-pin)                       | 5-pin header connect to P[0:3] and GND.                                                                             |
| JP12          | Motor cable interface (6-wire)            | Connect to external stepper motor board.                                                                            |
| JP13          | Sensor cable interface (4-wire)           | Connect to external motor sensors outputs for interrupt mode.                                                       |
| JP14          | Driver input select                       | For Darlington drive, jumper 1-5, 2-6, 3-7, 4-8 (default setting).<br>For FET driver, jumper 5-9, 6-10, 7-11, 8-12. |
| JP15          | Driver output select                      | For Darlington drive, jumper 1-5, 2-6, 3-7, 4-8 (default setting).<br>For FET driver, jumper 5-9, 6-10, 7-11, 8-12. |
| JP_ISP        | ISP select                                | NP (Not Populated). Jumper 1-2 to enter ISP mode on reset.                                                          |
| JP_RS232      | Enable RS-232 ISP                         | NP (Not Populated). Jumper 1-2, 3-4 to enable the RS-232 port to control ISP operation.                             |

### 4.3 Stepper motor board

A Nippon Pulse Motor NPM PF35T-48 Series stepper motor is used for the initial demo. The default parameters for the demo configuration were defined for the 48 steps per rotation (7.5° per step) for this PF35T-48 Series motor. A machined piece of aluminum is mounted on the motor shaft to act as an optical interrupter. Slotted optical switches and bias circuits are also on the motor board to sense when the interrupter connected to the motor shaft passes through the slot of the optical switch. The sensor outputs are connected to the P[0:1] inputs of PCA9629A generating interrupt based motor control. In the interrupt mode of the demo, this causes the motor to stop and reverse when the sensor detects the interrupter entering the slot.

## 5. Demo setup and operation

### 5.1 PCA9629A stepper motor controller demo setup

Connect a +12 V power source to the PCA9629A Stepper Motor Controller demo board and connect Motor/Sensor board cables as shown in [Figure 5](#).



Fig 5. PCA9629A demo kit

If the board is powered up and operating in normal condition, a red LED on the LPCXpresso daughter card blinks once per second. In the present configuration, the 'Single Phase' and 'CW' LEDs illuminate, indicating the default states of motor drive mode and the direction on the PCA9629A demo board. Pressing the 'Mode' switch S1 once changes the mode to  $\frac{1}{2}$ -step mode and illuminate the ' $\frac{1}{2}$  Step' LED. Pressing the 'Mode' switch S1 one more time changes the mode to 2-Phase mode and illuminates the '2-Phase' LED. The starting direction of the motor can be changed to CCW by pressing the 'Direction' switch S2, indicated by the CW LED not being illuminated. All of the PCA9629A Stepper Motor Controller demo functions are then initialized by pressing one of the switches on the demo board, as summarized in [Table 4](#), [Table 5](#) and [Table 6](#).

When 'S1' and 'S2' buttons are pressed at the same time to switch demo function from Demo\_Mode\_1 to Demo\_Mode\_2, a red LED2 on the LPCXpresso LPC1343 daughter card blinks twice per second for Demo\_Mode\_2. The Demo\_Mode\_2 is for the ramp-up/ramp-down control, as well as user-customized operations.

When 'S1' and 'S7' buttons are pressed at the same time to switch demo function from Demo\_Mode\_1 to Demo\_Mode\_3, a red LED2 on the LPCXpresso LPC1343 daughter card blinks faster for Demo\_Mode\_3. The Demo\_Mode\_3 sets output logic levels on OUT[3:0] pins for GPO function.

Table 4. Demo\_Mode\_1 functions (power-on default mode; LED2 blinking once per second)

| Switch/Label              | Demo function                                                    | Notes                                                                                                                                                      | LED indication                                                                                                                    |
|---------------------------|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| S1/Mode                   | Motor Phase Mode Select                                          | Default is Single-phase mode. Press to cycle through 2-Phase and $\frac{1}{2}$ -Step Modes.                                                                | Selected Mode is indicated by the corresponding:<br>LED2 ON = Single-phase<br>LED3 ON = 2-phase<br>LED4 ON = $\frac{1}{2}$ -phase |
| S2/Direction              | Motor Direction Select                                           | Default is CW. Press again to switch between CW and CCW.                                                                                                   | LED1 ON = CW (clockwise)<br>LED1 OFF = CCW (counter-clockwise)                                                                    |
| S3/Rotate Fixed Steps     | Rotate Fixed 12 steps Rotation                                   | Rotate a fixed number of steps. Default is 12 Steps (one rotation is 48 steps).                                                                            | Direction rotated is indicated by CW LED1.                                                                                        |
| S4/Rotate Fixed Rotations | Rotate Fixed Rotations                                           | Rotate a fixed number of rotations. Default is 10 rotations (480 steps). Press again to change the motor speed between 50 pps and 200 pps.                 | Direction is indicated by CW LED1.                                                                                                |
| S5/Rotate and Reverse     | Rotate between CW and CCW with delay interval in continuous loop | Continuously rotate 36 steps CW and CCW with delay interval of 128 ms (after CW) and 512 ms (after CCW). Press again to stop motor operation.              | Direction is indicated by CW LED1. Time delay between changing directions is set by LOOPDLY_CW/CCW registers.                     |
| S6/Continuous Rotation    | Continuous Rotation                                              | Continuously rotate and press again to change the motor speed between 50 pps and 200 pps with ramp control. Press either S5 or S8 to stop motor operation. | Direction is indicated by CW LED1.                                                                                                |
| S7/Interrupt Mode         | Start/Stop Interrupt Mode                                        | Interrupt Mode. Continuous rotation and reverse motor on interrupt caused by P0 or P1 falling edge. Press again to stop motor operation.                   | Direction is indicated by CW LED1. Time delay between changing directions is set by LOOPDLY_CW/CCW registers.                     |
| S8/Xpresso Reset          | To reset LPCXpresso LPC1343                                      | This reset function brings this demo board to power-on reset default state (Demo_Mode_1)                                                                   | Xpresso/LPC1343 Reset; this control also resets the PCA9629A device.                                                              |
| S9/PCA9629A Reset         | To reset PCA9629A device                                         | This reset is only for PCA9629A device.                                                                                                                    | Set all registers to power-on default values.                                                                                     |

**Table 5. Demo\_Mode\_2 functions (LED2 blinking twice per second)**

| Switch/Label      | Demo function <sup>[1]</sup>         | Notes                                                                                              | LED indication                    |
|-------------------|--------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------|
| S1/Mode           | same as Demo_Mode_1                  |                                                                                                    |                                   |
| S2/Direction      | same as Demo_Mode_1                  |                                                                                                    |                                   |
| S3                | Ramp control                         | Ramp-up and ramp-down in 48 steps (1 rotation in 0.5 second) with ramp multiplication value = 9.   | Direction is indicated by CW LED1 |
| S4                | Ramp control                         | Ramp-up and ramp-down in 480 steps (10 rotations in 5 seconds) with ramp multiplication value = 6. | Direction is indicated by CW LED1 |
| S5                | Available for user-defined function. |                                                                                                    |                                   |
| S6                | Available for user-defined function. |                                                                                                    |                                   |
| S7                | Available for user-defined function. |                                                                                                    |                                   |
| S8/Xpresso Reset  | same as Demo_Mode_1                  |                                                                                                    |                                   |
| S9/PCA9629A Reset | same as Demo_Mode_1                  |                                                                                                    |                                   |

[1] Press either S8 (Xpresso Reset) or S1 and S2 at the same time to return Demo\_Mode\_1 function.

**Table 6. Demo\_Mode\_3 functions (LED2 blinking faster)**

| Switch/Label      | Demo function <sup>[1]</sup>                 | Notes                                                               | LED indication |
|-------------------|----------------------------------------------|---------------------------------------------------------------------|----------------|
| S1                | Set OUT0 pin as General Purpose Output (GPO) | Motor output OUT0 (pin 12) goes 'High' while the button is pressed. | n/a            |
| S2                | Set OUT1 pin as General Purpose Output (GPO) | Motor output OUT1 (pin 11) goes 'High' while the button is pressed. | n/a            |
| S3                | Set OUT2 pin as General Purpose Output (GPO) | Motor output OUT2 (pin 10) goes 'High' while the button is pressed. | n/a            |
| S4                | Set OUT3 pin as General Purpose Output (GPO) | Motor output OUT3 (pin 9) goes 'High' while the button is pressed.  | n/a            |
| S5                | not available                                |                                                                     |                |
| S6                | not available                                |                                                                     |                |
| S7                | not available                                |                                                                     |                |
| S8/Xpresso Reset  | same as Demo_Mode_1                          |                                                                     |                |
| S9/PCA9629A Reset | same as Demo_Mode_1                          |                                                                     |                |

[1] Press either S8 (Xpresso Reset) or S1 and S7 at the same time to return Demo\_Mode\_1 function.

Starting the interrupt mode of the demo causes the motor to first start then stop and reverse when the sensor detects the interrupter in the slot. When the interrupter passes through the other sensor, the motor again stops and reverses. This process continues until the 'Interrupt Mode' switch S7 is pressed again in Demo\_Mode\_1.

In '1/2-Step' mode in this demo, the number of steps moved is counted in 1/2 steps. As a result, the 12 steps (7.5° degrees per step) default setting for the 'Rotate Fixed Steps' command results in the shaft rotating 450° instead of the 900° rotation that would be seen with the same command in Single-Phase or 2-Phase mode. The number of rotations and speed of rotation is also halved in '1/2-Step' mode when compared to the other modes with the same parameter settings.

## 6. Firmware overview

The firmware for the PCA9629A demo board is contained in a number of 'C' modules. The modular design and conformance to the CMSIS software standard V1.3 facilitates porting the software to other ARM Cortex versions. The firmware was written and compiled using the free LPCXpresso compiler tools referenced earlier in this document. The modules are discussed individually in the following sections ([Section 6.1](#) through [Section 6.7](#)).

The firmware for the PCA9629A demo uses a simple foreground/background technique. This technique means that most of the processor time is spent in a loop checking flags that are set in interrupt routines to indicate that processing is required when the flag is tested in the main loop.

Application tasks are separated into individual modules. Most of these modules have header files that contain the external declarations for functions called by other modules. To call a function in a module that does not contain the function requires including the header file in the calling module for the module containing the function to be called.

Some of the modules are available from NXP in the 'LPC13xx code bundle' and some of the modules were written specifically for this application.

The firmware is delivered in the format of executable binary and LPCXpresso project with source code. The project contains all source code and library files that are required to rebuild the project.

The firmware project includes readme and history information in 'info' directory, as shown in [Figure 6](#).

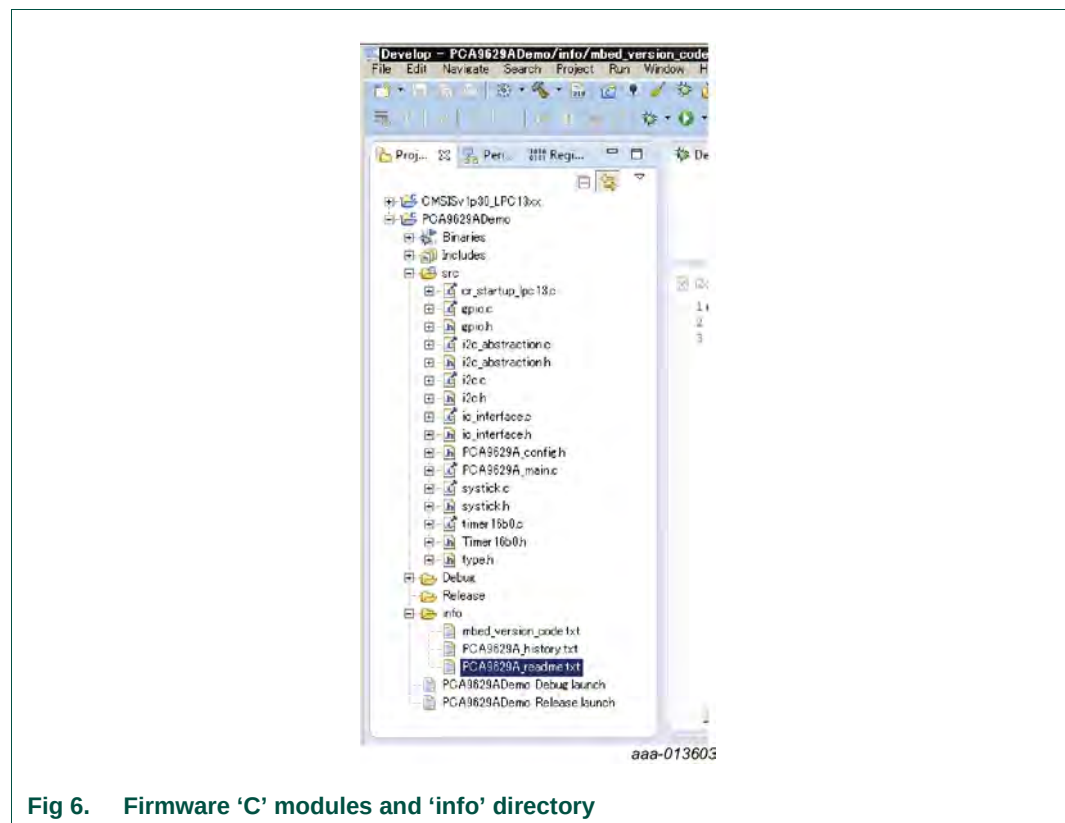


Fig 6. Firmware 'C' modules and 'info' directory

## 6.1 CMSIS V1.3 and start-up modules

The Cortex Microcontroller Software Interface Standard (CMSIS) requires several standard header files and system files to be included in the build to comply with the standard. The CMSIS V1.3 files are provided by ARM for the LPC1343 and are included with this project package.

In addition to the CMSIS V1.3 files, a start-up file is provided from the compiler vendor, Code Red. The start-up file is 'cr\_startup\_lpc13.c'. The start-up file defines the locations of the exception/interrupt handlers, and sets up the default exception handlers.

## 6.2 PCA9629A\_config.h

All definitions of PCA9629A related are defined in this file.

This header file is quite simple that defines PCA9629A slave addressed, register addresses, a few parameters of register bit fields, I<sup>2</sup>C buffer size (because this value is related to the number of the registers) and some common global function prototypes.

A listing of the PCA9629A\_config.h is given in [Section 9 "Appendix A: PCA9629A\\_config.h"](#).

## 6.3 PCA9629A\_main.c module

The main module has all the initialization routines for the other modules, as well as containing the loop that test the application flags. For this application, flags indicating an external interrupt occurred and which pin caused the interrupt are tested in main loop and acted on if it was determined that a switch was pressed generating the external interrupt.

Next 13 functions are predefined functions that are called from io\_interface.c.

All those functions (except MODE\_GPO) have names in format of 'MODEn\_Sn\_DemoFeature'. The function name starts with MODE1\_ or MODE2\_. Those functions are called only when the demo mode is in mode-1 or mode-2. The second part of the name is the switch (button on the demo board) number. So 'MODE1\_S4\_RotationsMode' is a function which is called when the button 4 is pressed in mode-1.

```
void MODEn_S1_SetPhaseMode( void )      : function called when S1 is pressed in mode 1 and 2
void MODEn_S2_SwitchDirection( void )   : function called when S2 is pressed in mode 1 and 2
void MODE1_S3_StepsMode( void )         : function called when S3 is pressed in mode 1
void MODE1_S4_RotationsMode( void )     : function called when S4 is pressed in mode 1
void MODE1_S5_ReverseMode( void )       : function called when S5 is pressed in mode 1
void MODE1_S6_ContinuousMode( void )    : function called when S6 is pressed in mode 1
void MODE1_S7_InterruptMode( void )     : function called when S7 is pressed in mode 1
void MODE2_S3_RampMode( void )          : function called when S3 is pressed in mode 2
void MODE2_S4_RampMode( void )          : function called when S4 is pressed in mode 2
void MODE2_S5_UserCustomFunction( void ) : function called when S5 is pressed in mode 2
void MODE2_S6_UserCustomFunction( void ) : function called when S6 is pressed in mode 2
void MODE2_S7_UserCustomFunction( void ) : function called when S7 is pressed in mode 2
void MODE_GPO( void )                   : function called when the mode is 3
```

Functions of MODE2\_S5\_UserCustomFunction, MODE2\_S6\_UserCustomFunction and MODE2\_S7\_UserCustomFunction are empty functions that are reserved for user custom demo features.

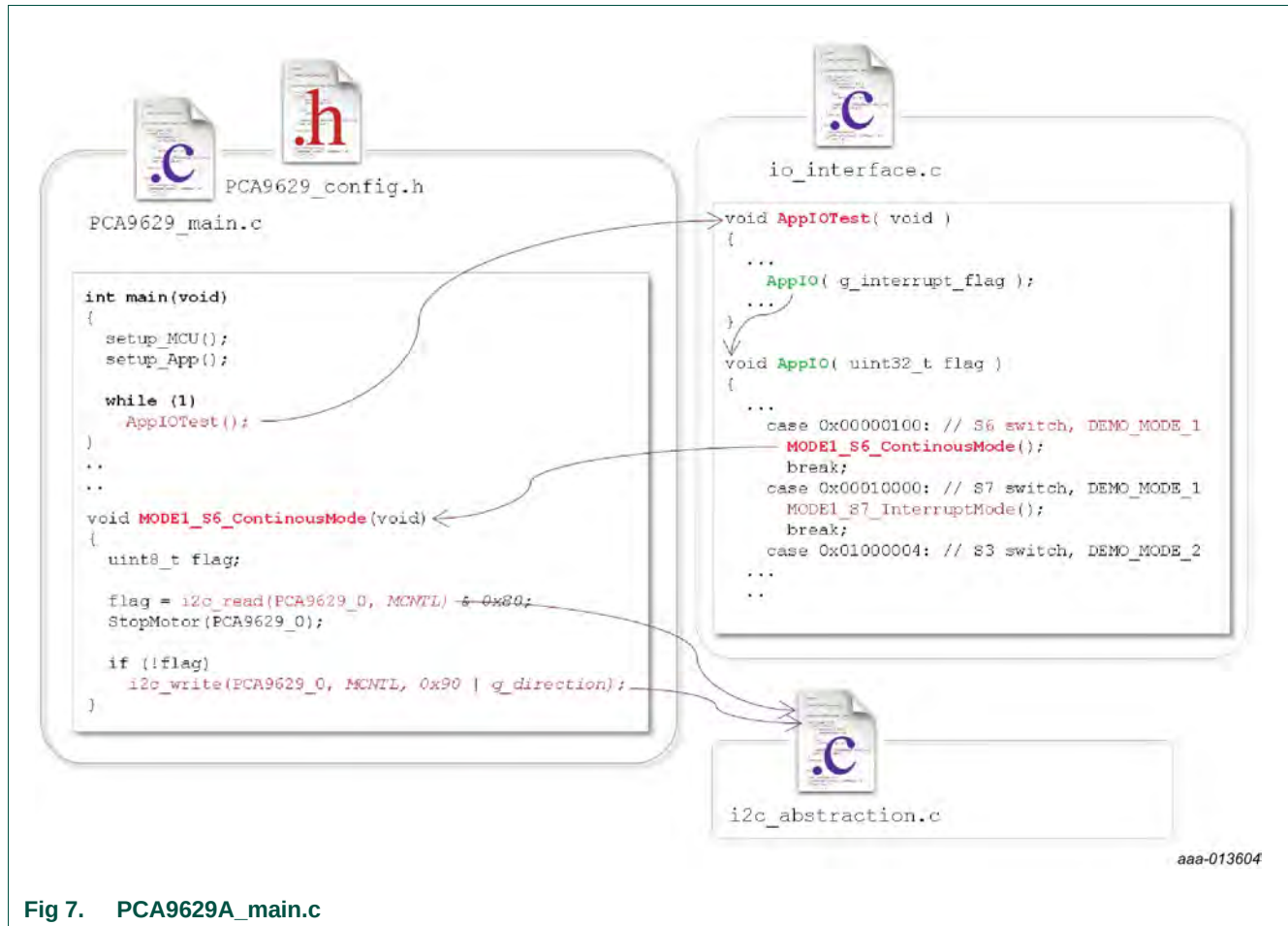


Fig 7. PCA9629A\_main.c

And some functions defined in this module can be used as general commands. These functions take PCA9629A slave address to define the target.

```
void StopMotor( uint8_t i2c_dev )
void PCA9629_HW_reset( void )
void PCA9629_all_register_init( uint8_t i2c_dev )
void WaitForStop( uint8_t i2c_dev )
```

## 6.4 io\_interface.c io\_interface.h

The `io_interface.c` is made to manage button (push switch) related events. This module has interrupt handlers and flag checking routine which is called from main loop.

The interrupt handler gets the event of the buttons and sets flag. The flag checking routine calls functions in `PCA9629A_main.c` to execute demo features.

## 6.5 i2c\_abstraction.c and i2c\_abstraction.h

I<sup>2</sup>C read and write routines are available in this module.

This module abstracts the implementation of the I<sup>2</sup>C master interface in MCU (LPC1343) and simplifies the access of the PCA9629A internal registers.

There are 4 functions for I2C transfers. The first 2 functions are read and write for single-byte data.

The single byte read function 'i2c\_read' takes 2 arguments of I<sup>2</sup>C slave address and register address. Single byte read data is given as a return value.

The single byte write function 'i2c\_write' takes 3 arguments of I<sup>2</sup>C slave address, register address and 1 byte data for the register.

```
uint8_t i2c_read(uint8_t i2c_dev, uint8_t regadd);  
void i2c_write(uint8_t i2c_dev, uint8_t regadd, uint8_t regdata);
```

The other 2 functions are for read and write multiple bytes.

The multiple read function 'i2c\_read\_array' takes 3 arguments. First one is slave address, second is register address of read start and last is size of the reading. The read data is stored in global array in I<sup>2</sup>C driver routines. The function returns pointer to this array. The data inside of the array should be retrieved before next read (both single-byte read and multiple-byte read) because it will be overwritten.

The writing can be done by 'i2c\_write\_array'. It requires 4 arguments of I<sup>2</sup>C slave address, register address, pointer to single byte array and array size.

```
uint8_t *i2c_read_array( uint8_t i2c_dev, uint8_t regadd, uint8_t size )  
void i2c_write_array( uint8_t i2c_dev, uint8_t regadd, const uint8_t *regdata,  
uint8_t size )
```

Usage examples of those functions can be found in PCA9629A\_main.c module.

## 6.6 I2C.c and I2C.h modules

The I2C.c is a driver of the MCU I<sup>2</sup>C peripheral. This module is a layer under i2c\_abstraction.c. It may not be required to touch inside of this module.

## 6.7 GPIO.c, GPIO.h, systick.c, systick.h, timer16b\_0.c and timer16b\_0.h

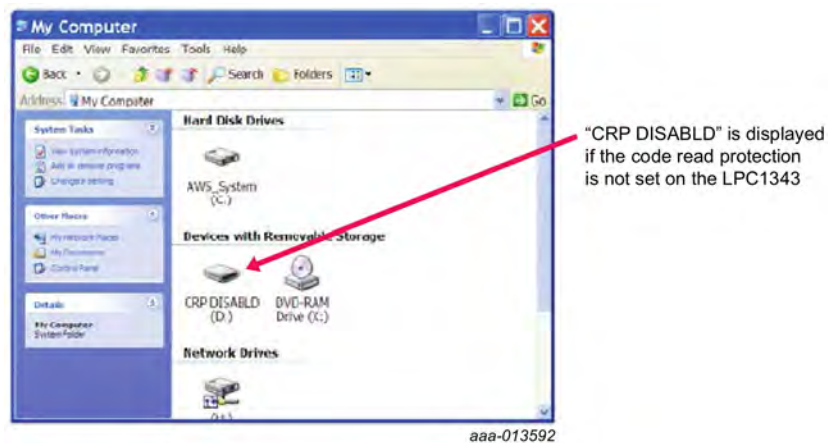
These modules are drivers for the MCU peripherals. They manage GPIO ports and timings.

## 7. Programming the demo board

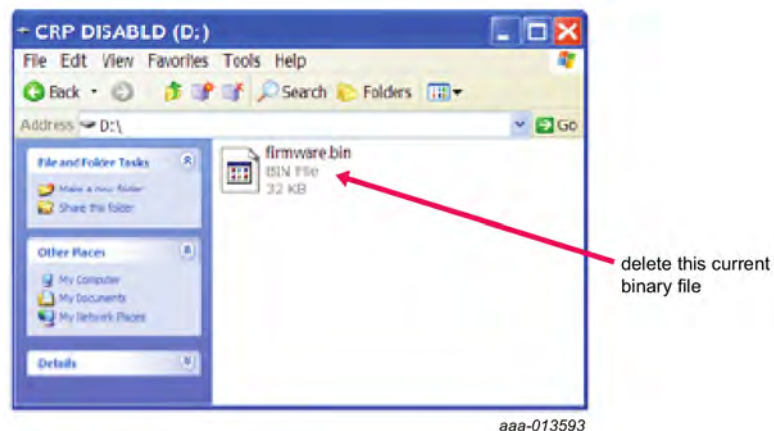
### 7.1 Programming the PCA9629A demo board via USB

If the code read protection (CRP) is not set on the LPC1343 microcontroller, the firmware may be updated via USB. To update via Mini-USB (X1), a PCA9629ADemo.bin (binary) file must be provided or generated. The process to update or program the new firmware to LPC1343 is described as follows:

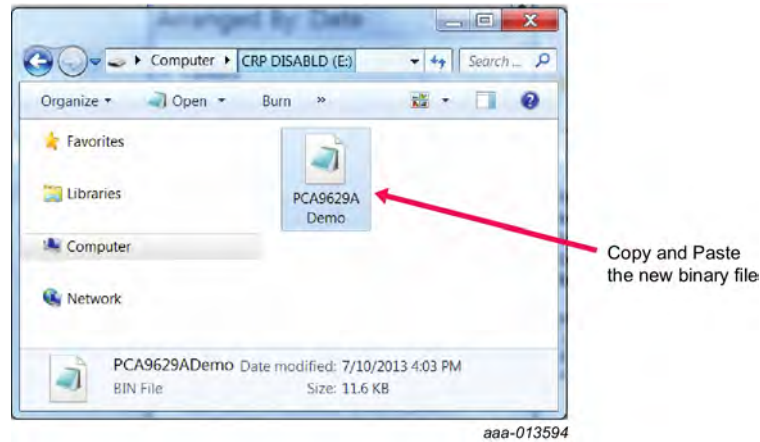
1. Insert a jumper into JP\_ISP (pin 1-2) prior to power-up of the demo board.
2. Connect a Mini-USB cable between the PCA9629A demo board Mini-USB (X1) and a PC.
3. Apply +12 V power to the PCA9629A demo board; this puts the demo board in the USB boot mode.
4. Double-click 'My Computer' to bring up this window. The following should be displayed (It may take a short time for the PC to read the USB info from the target).



5. Double-click 'CRP DISABLD' to open device window as displayed below; then delete the current firmware.bin (binary) file.



6. Copy the new PCA9629ADemo.bin (binary) file and Paste to this window as displayed below; then close this window and safely remove the USB device.



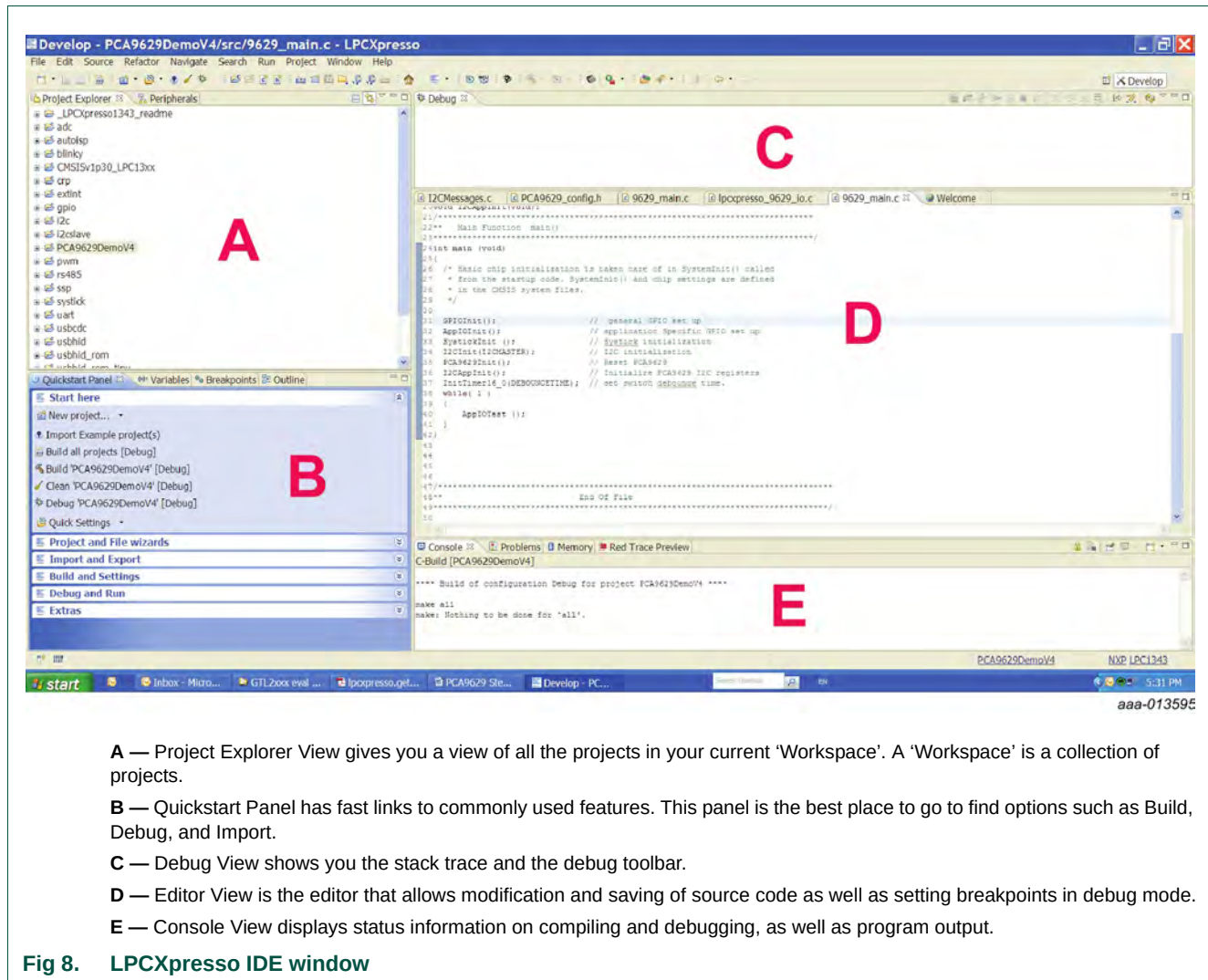
7. To start execution of the new programmed firmware file, remove the jumper from JP\_ISP and cycle the +12 V power on the demo board.

After the code is updated it is renamed 'firmware.bin'. Also note that the size of the code listed for the device is always 32 K (for the LPC1343). This is because the total size of the on-board flash memory is what determines the size reported by the device, even if the size of the programmed firmware is much smaller as indicated by the size of the file to program.

## 7.2 Programming and debugging the PCA9629A demo board via LPC-Link USB interface

The hardware consists of the LPCXpresso development board which has an LPC-Link debug interface and an NXP LPC ARM-based microcontroller target. LPCXpresso is an end-to-end solution enabling embedded engineers to develop their applications from initial evaluation to final production. The LPCXpresso IDE is free for download ([www.lpcware.com/lpcxpresso/download](http://www.lpcware.com/lpcxpresso/download)), and registration is required. The process to debug or program the new firmware to LPC1343 is described below:

1. Connect a Mini-USB cable between the LPC-Link board Mini-USB (J3) and a PC without the +12 V supply on PCA9629A demo board.
2. Open the LPCXpresso IDE window as displayed in [Figure 8](#).
3. Click Import Example project (PCA9629ADemo.zip file) from the Quickstart Panel.
4. Click Build 'PCA9629ADemo'[Debug] from the Quickstart Panel to create binary file 'PCA9629ADemo.bin'.
5. Click Debug 'PCA9629ADemo'[Debug] from the Quickstart Panel to download automatically to the target and be programmed into flash memory via USB interface.
6. To start execution of the new programmed firmware file, remove the USB cable and provide the +12 V power on PCA9629A demo board.



- A** — Project Explorer View gives you a view of all the projects in your current 'Workspace'. A 'Workspace' is a collection of projects.
- B** — Quickstart Panel has fast links to commonly used features. This panel is the best place to go to find options such as Build, Debug, and Import.
- C** — Debug View shows you the stack trace and the debug toolbar.
- D** — Editor View is the editor that allows modification and saving of source code as well as setting breakpoints in debug mode.
- E** — Console View displays status information on compiling and debugging, as well as program output.

**Fig 8. LPCXpresso IDE window**

### 7.3 Programming the PCA9629A demo board via RS-232

An RS-232 interface is provided to program the device via ISP (in system programming) capability. Opening the Flash Magic utility ([www.flashmagictool.com/](http://www.flashmagictool.com/)), should show the following screen:

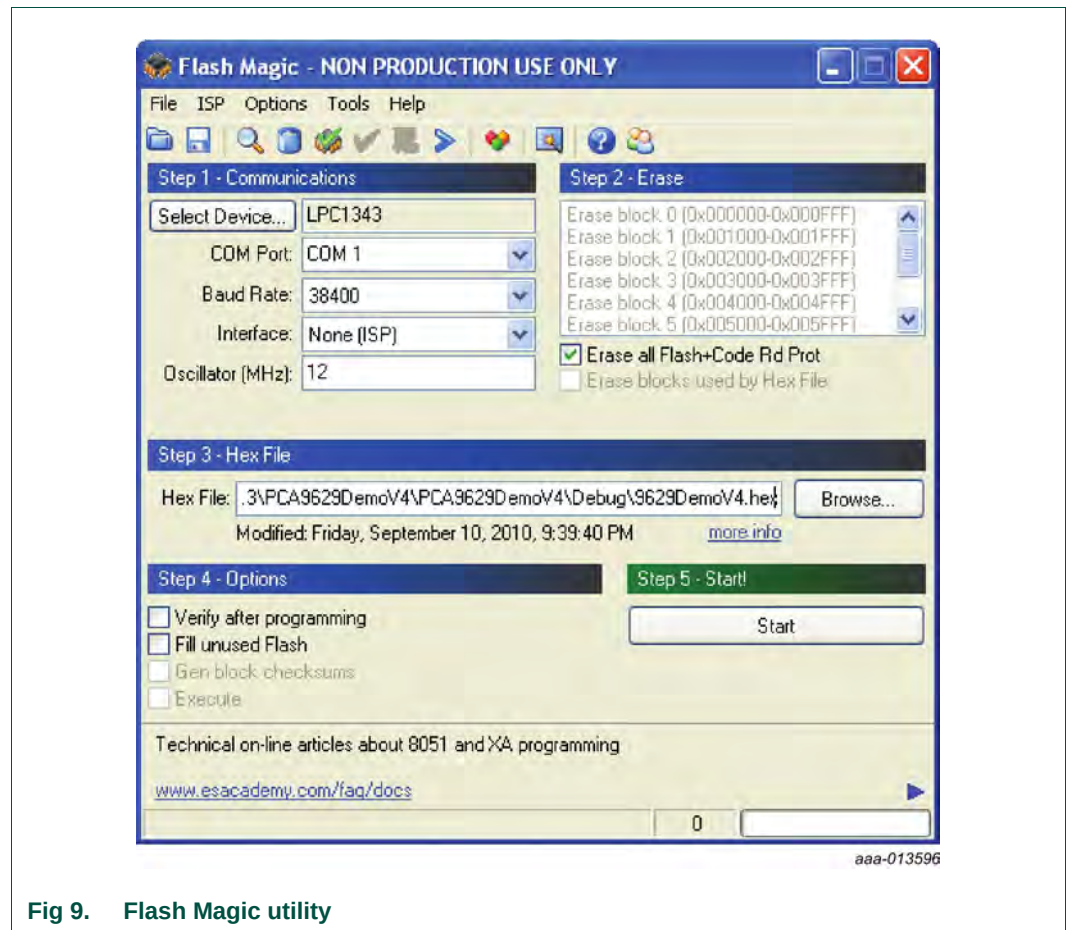


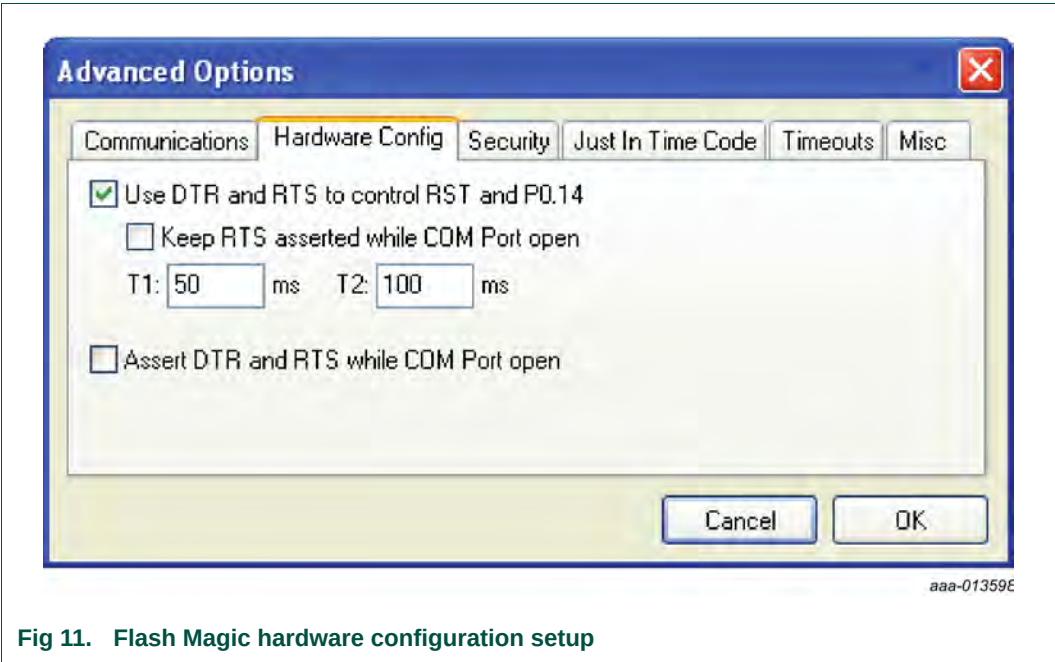
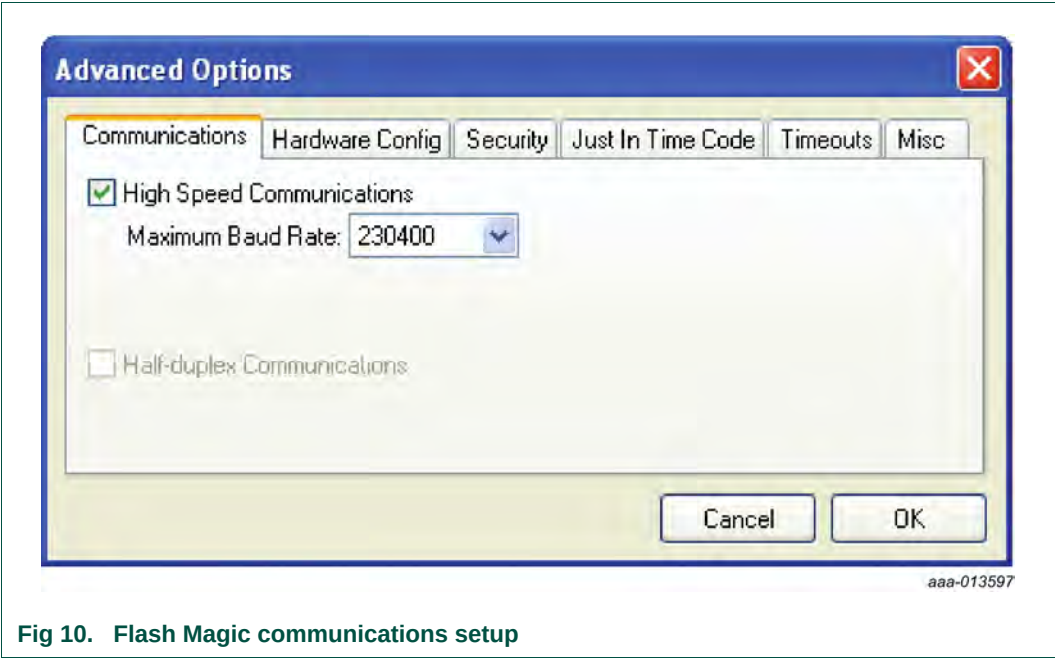
Fig 9. Flash Magic utility

Insert jumpers into JP\_RS232 (pins 1-2, 3-4) prior to powering up the demo board.

For Step 1, The COM port is the RS-232 port assignment for your PC, usually COM1. Fill in the other entries as shown.

For Step 2, check the box as shown.

For Step 3, browse to the hexadecimal file provided for programming. In addition to the above setup values, pull down the 'Options' tab and select 'Advanced Options'. The 'Communications' and 'Hardware Config' configurations should be set as shown in [Figure 10](#) and [Figure 11](#).



To verify that Flash Magic is connected, pull down the 'ISP' tab and select 'Read Device Signature'. If Flash Magic returns a signature similar to [Figure 12](#), then communications are established.

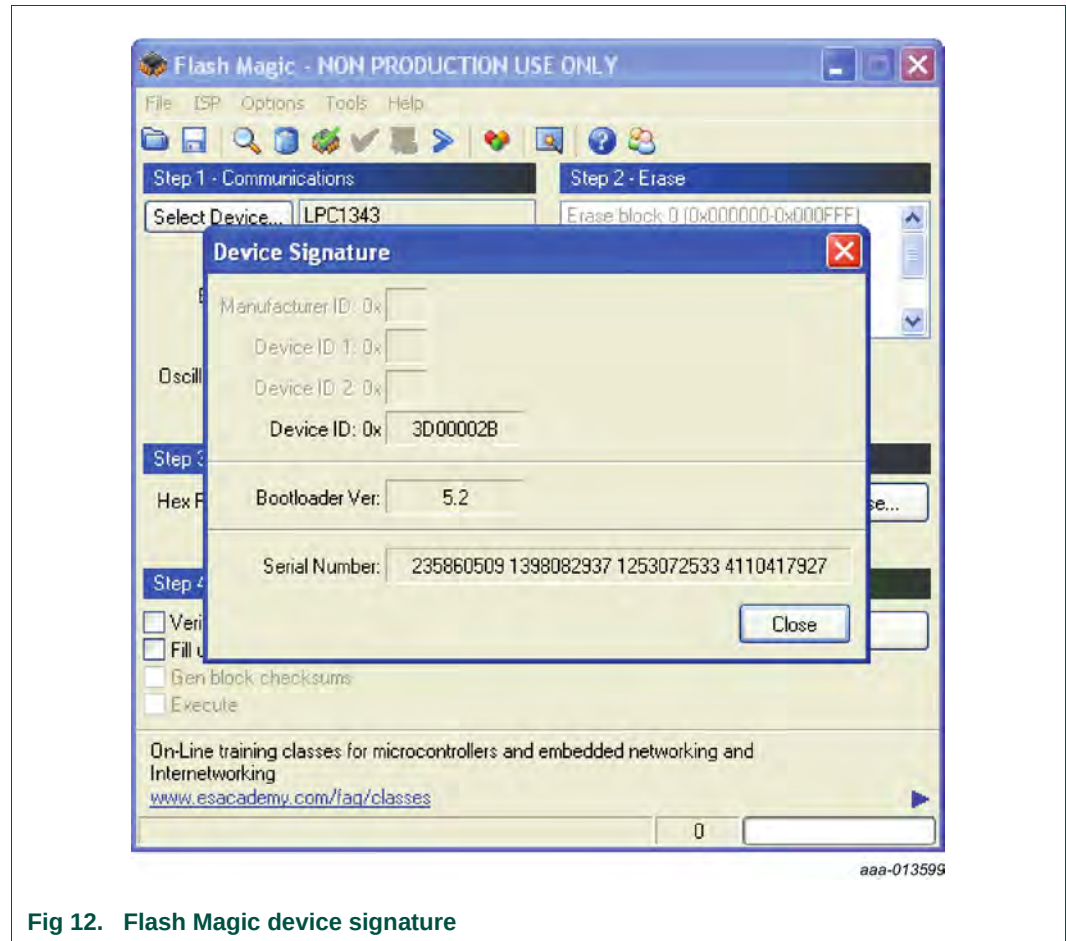


Fig 12. Flash Magic device signature

To complete programming, verify that the correct hexadecimal file is loaded and press 'Start' (Step 5 in the Flash Magic Window).

## 8. Support

Online technical support is available at [www.nxp.com/support](http://www.nxp.com/support).

## 9. Appendix A: PCA9629A\_config.h

```

/* PCA9629A Stepper Motor Controller Demo on LPCXpresso LPC1343
 *
 * @copyrights      NXP Semiconductors, 2010, 2011, 2013
 * @author          Tedd OKANO, NXP Semiconductors
 * @version         0.6 (22-Aug-2013)
 *
 * History
 * 2013.05.31 ver 0.1          PCA9629A demo code (based on PCA9629 demo v.2.01)
 * 2013.06.03 ver 0.2          speed switching demo added
 * 2013.06.05 ver 0.3          register name fix (Phase mode change button bug fix)
 * 2013.06.10 ver 0.4          PCA9629_all_register_init() function updated to fix phase mode problem
 * 2013.07.10 ver 0.5          GPO operation mode added
 * 2013.08.22 ver 0.6          code cleaning done
 */

/*
Overview:
This has all the defines and motor control parameters for the PCA9629A demo application.
The stepper motor parameters entered are for a Nippon Pulse motor but could be changed
to adapt the demo to other motors.

*/

/** Application parameters: defines the behavior
 *
 */
#define STEPS_CW          0x0C    /**< step count for fixed steps rotation */
#define STEPS_CCW         0x0C    /**< step count for fixed steps rotation */

#define PCA9629_0         0x42    // I2C Slave address
#define PCA9629_1         0x44    // I2C Slave address
#define PCA9629_2         0x46    // I2C Slave address
#define PCA9629_3         0x48    // I2C Slave address
#define PCA9629_4         0x4A    // I2C Slave address
#define PCA9629_5         0x4C    // I2C Slave address
#define PCA9629_6         0x4E    // I2C Slave address
#define PCA9629_7         0x50    // I2C Slave address
#define PCA9629_8         0x52    // I2C Slave address
#define PCA9629_9         0x54    // I2C Slave address

#define CW                 0
#define CCW                1

#define I2C_BUFSIZE      38      // this is for i2c.c and i2c_abstraction.c
                                // this value should be "register length + 3"

enum
{
    FULLSTEP,
    HALFSTEP,
    TWOPHASE
} PhaseMode;

// PCA9629 registers

enum

```

```

{
    //      A-version registers
    MODE,          /**< 0x00   Mode register                                */
    WDTOI,         /**< 0x01   WatchDog Time-Out Interval register                        */
    WDCNTL,        /**< 0x02   WatchDog Control register                                    */
    IO_CFG,        /**< 0x03   I/O Configuration register                                  */
    INTMODE,       /**< 0x04   Interrupt Mode register                                       */
    MSK,           /**< 0x05   Mask interrupt register                                       */
    INTSTAT,       /**< 0x06   Interrupt Status register                                     */
    IP,            /**< 0x07   Input Port register                                           */
    INT_MTR_ACT,   /**< 0x08   Interrupt motor action control register                     */
    EXTRASTEPS0,   /**< 0x09   Extra steps count for INTP0 control register                 */
    EXTRASTEPS1,   /**< 0x0A   Extra steps count for INTP1 control register                 */
    OP_CFG_PHS,    /**< 0x0B   Output Port Configuration and Phase control register        */
    OP_STAT_TO,    /**< 0x0C   Output state and time-out control register                   */
    RUCNTL,        /**< 0x0D   Ramp-up control register                                       */
    RDCNTL,        /**< 0x0E   Ramp-down control register                                    */
    PMA,           /**< 0x0F   Perform multiple of actions control register                 */
    LOOPDLY_CW,    /**< 0x10   Loop delay timer for CW to CCW control register             */
    LOOPDLY_CCW,   /**< 0x11   Loop delay timer for CCW to CW control register             */
    CWSCOUNTL,     /**< 0x12   Number of clockwise steps register (low byte)                */
    CWSCOUNTH,     /**< 0x13   Number of clockwise steps register (high byte)              */
    CCWSCOUNTL,    /**< 0x14   Number of counter-clockwise steps register (low byte)       */
    CCWSCOUNTH,    /**< 0x15   Number of counter-clockwise steps register (high byte)      */
    CWPWL,         /**< 0x16   Clockwise step pulse width register (low byte)              */
    CWPWH,         /**< 0x17   Clockwise step pulse width register (high byte)             */
    CCWPWL,        /**< 0x18   Counter-clockwise step pulse width register (low byte)      */
    CCWPWH,        /**< 0x19   Counter-clockwise step pulse width register (high byte)     */
    MCNTL,         /**< 0x1A   Motor control register                                       */
    SUBADR1,       /**< 0x1B   I2C-bus subaddress 1                                          */
    SUBADR2,       /**< 0x1C   I2C-bus subaddress 2                                          */
    SUBADR3,       /**< 0x1D   I2C-bus subaddress 3                                          */
    ALLCALLADR,    /**< 0x1E   All Call I2C-bus address                                     */
    STEPCOUNT0,    /**< 0x1F   Step counter registers: STEPCOUNT0                           */
    STEPCOUNT1,    /**< 0x20   Step counter registers: STEPCOUNT1                           */
    STEPCOUNT2,    /**< 0x21   Step counter registers: STEPCOUNT2                           */
    STEPCOUNT3     /**< 0x22   Step counter registers: STEPCOUNT3                           */
} PCA9629ARegisters;

```

```

extern void MODEn_S1_SetPhaseMode( void );
extern void MODEn_S2_SwitchDirection( void );

```

```

extern void MODE1_S3_StepsMode( void );
extern void MODE1_S4_RotationsMode( void );
extern void MODE1_S5_ReverseMode( void );
extern void MODE1_S6_ContinuousMode( void );
extern void MODE1_S7_InterruptMode( void );

```

```

extern void MODE2_S3_RampMode( void );
extern void MODE2_S4_RampMode( void );
extern void MODE2_S5_UserCustomFunction( void );
extern void MODE2_S6_UserCustomFunction( void );
extern void MODE2_S7_UserCustomFunction( void );

```

```

extern void MODE_GPO( void );

```

```

extern void WaitForStop( uint8_t i2c_dev );
extern void StopMotor( uint8_t i2c_dev );
extern void InitRegisters( void );

```

## 10. Appendix B: Schematics

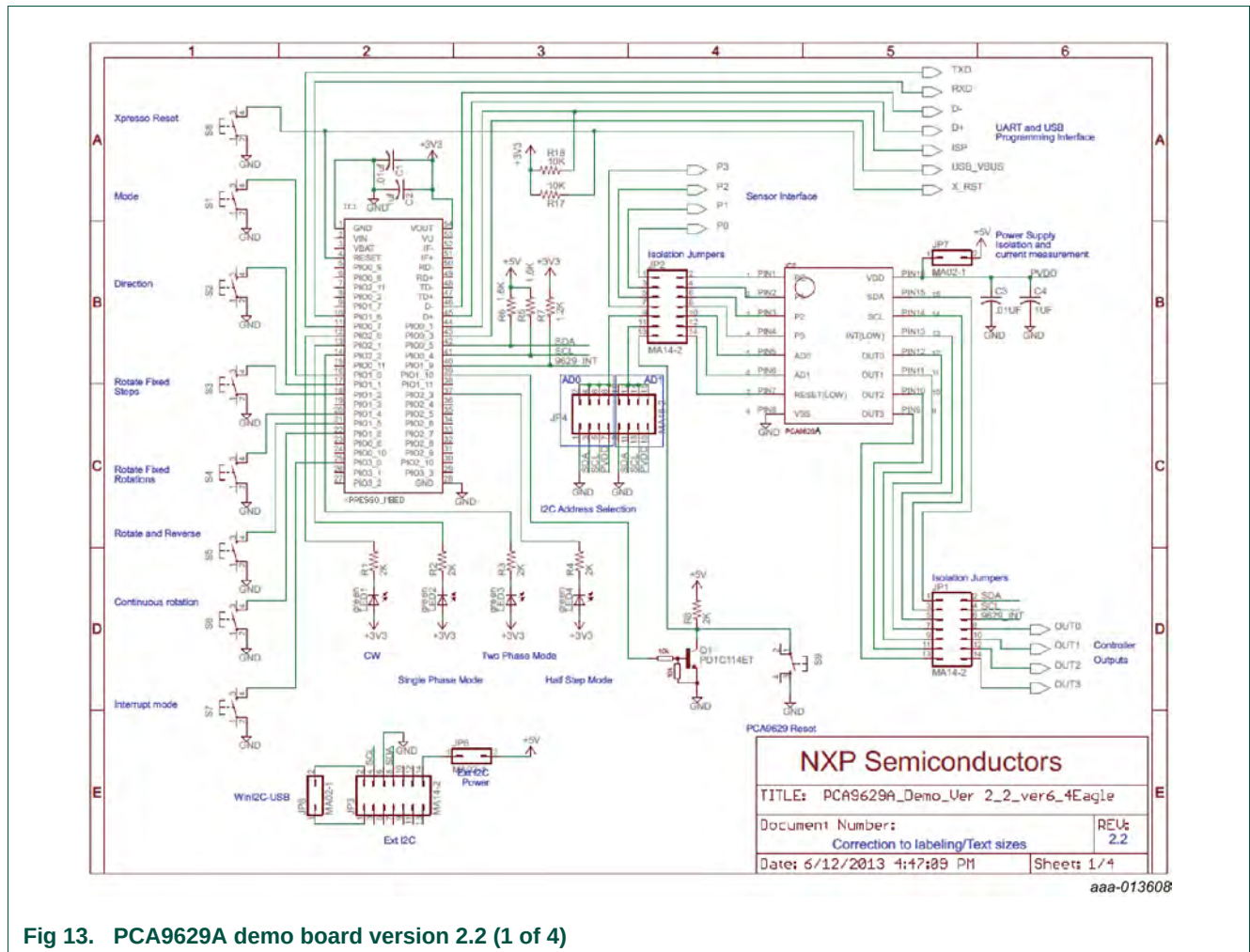


Fig 13. PCA9629A demo board version 2.2 (1 of 4)

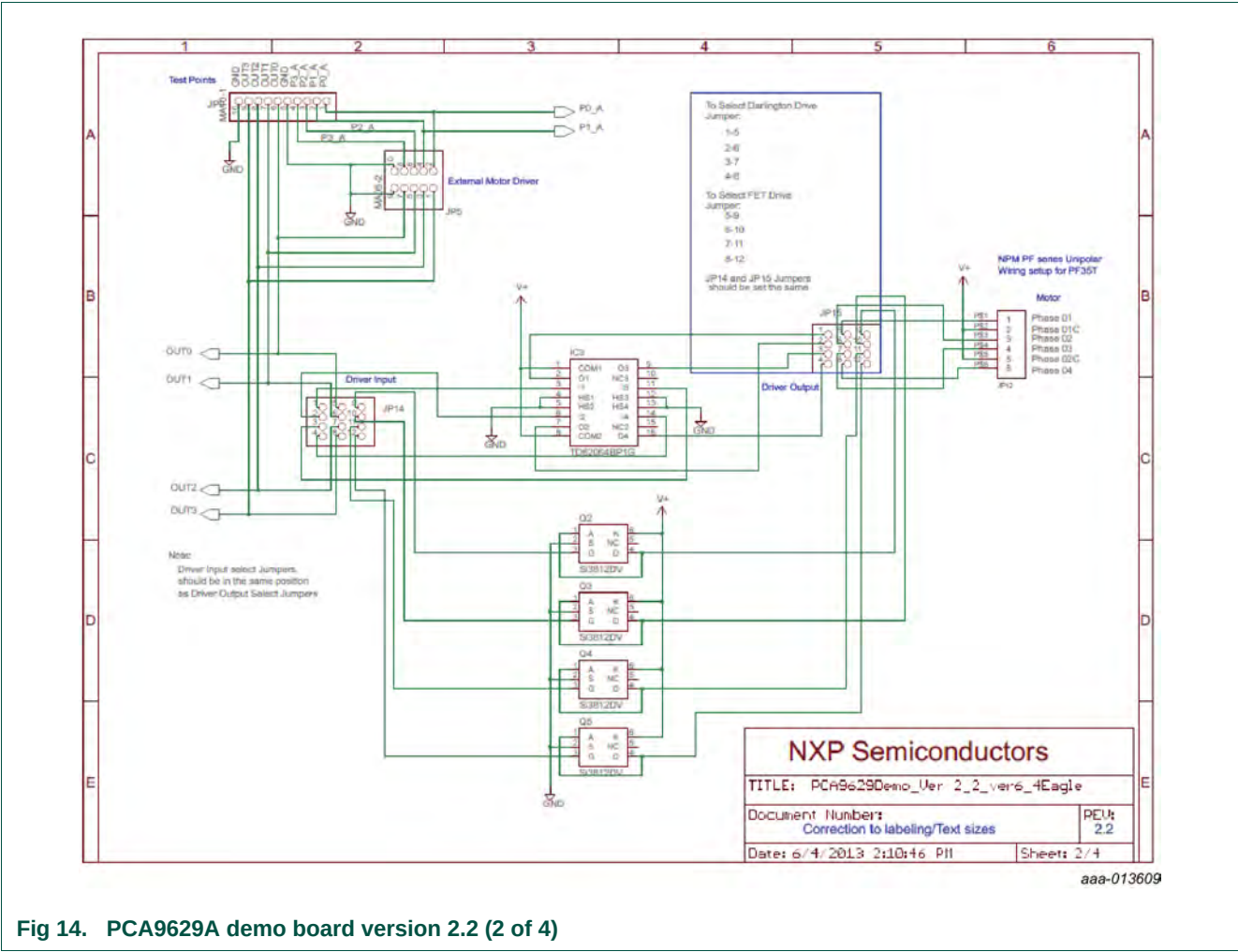


Fig 14. PCA9629A demo board version 2.2 (2 of 4)

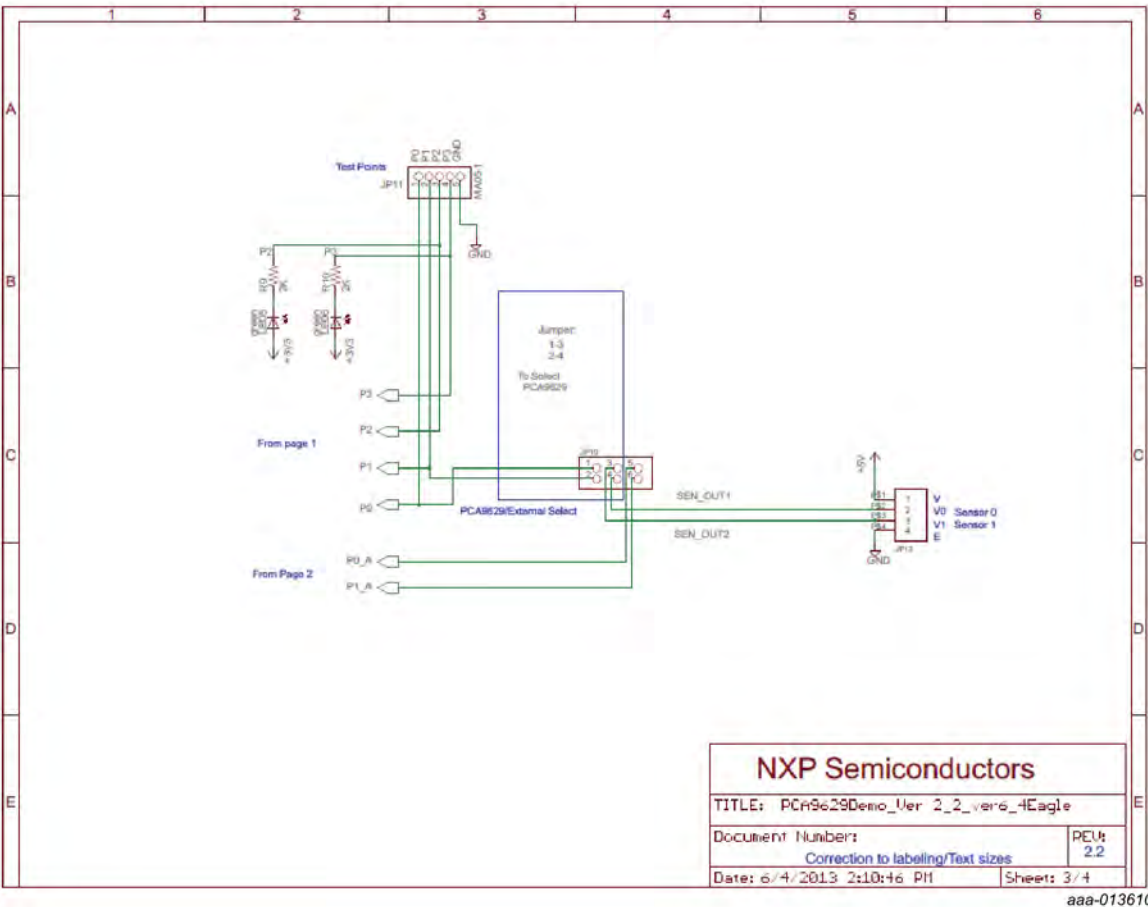


Fig 15. PCA9629A demo board version 2.2 (3 of 4)

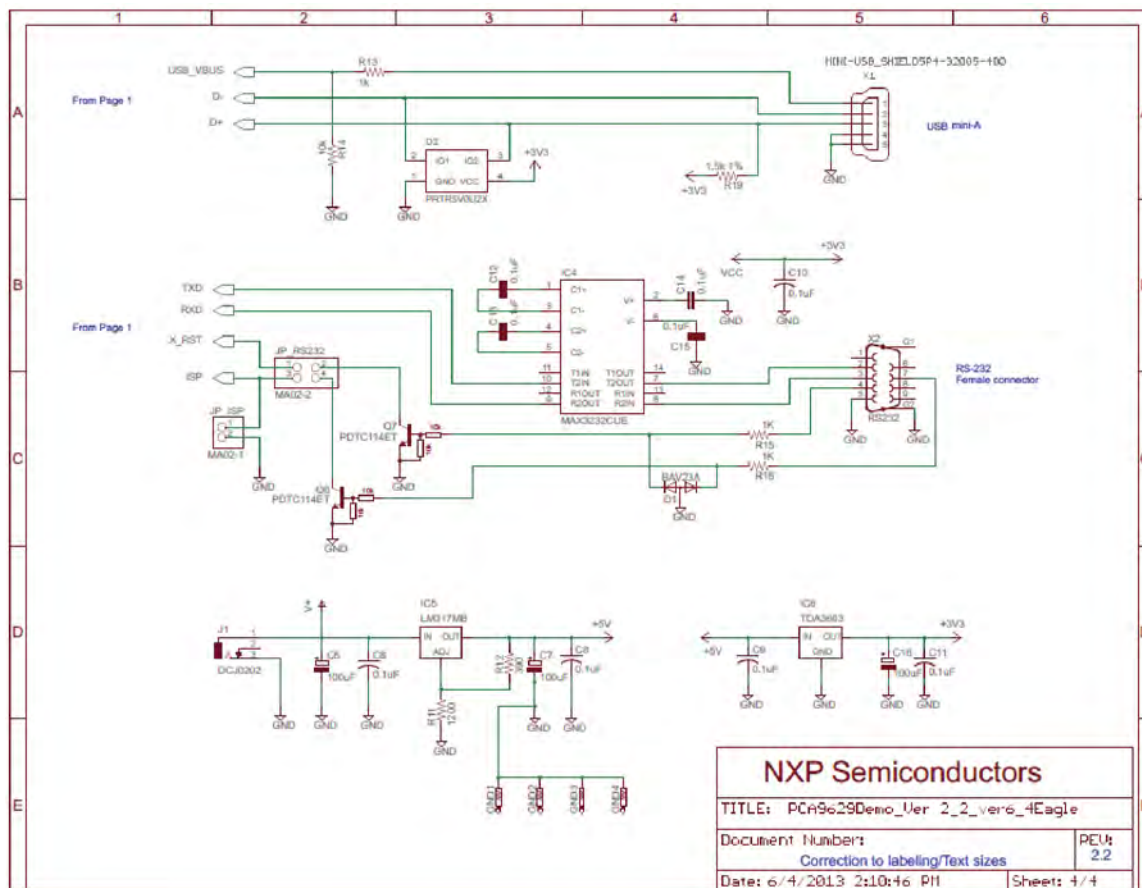


**Fig 16. PCA9629A demo board version 2.2 (4 of 4)**

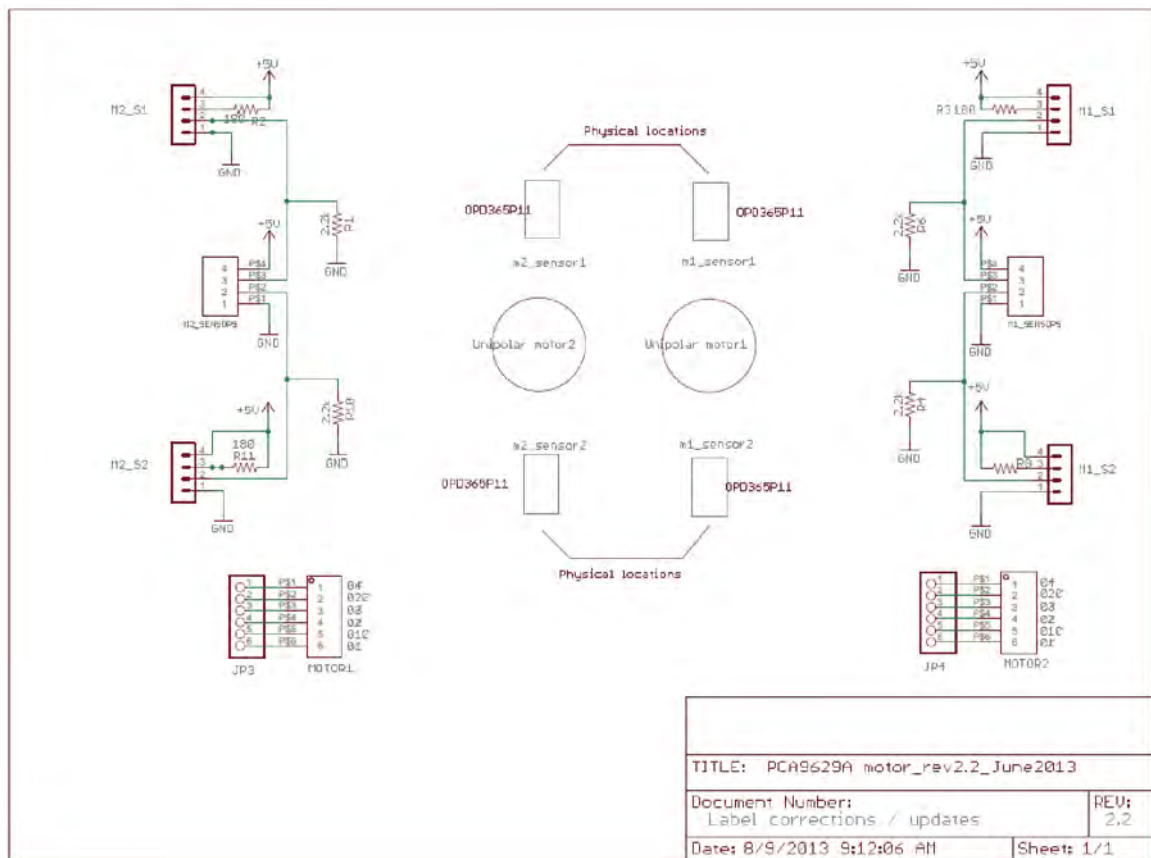


**Fig 17. PCA9629A motor version 2.2**

## 11. Abbreviations

Table 7. Abbreviations

| Acronym              | Description                                        |
|----------------------|----------------------------------------------------|
| CCW                  | counter-clockwise                                  |
| CMSIS                | Cortex Microcontroller Software Interface Standard |
| CW                   | clockwise                                          |
| FET                  | Field-Effect Transistor                            |
| Fm+                  | Fast-mode Plus                                     |
| GNU                  | GNU is Not Unix                                    |
| GPIO                 | General Purpose Input/Output                       |
| GPO                  | General Purpose Output                             |
| GUI                  | Graphical User Interface                           |
| I <sup>2</sup> C-bus | Inter-Integrated Circuit bus                       |
| I/O                  | Input/Output                                       |
| IDE                  | Integrated Development Environment                 |
| ISP                  | In-System Programming                              |
| JTAG                 | Joint Test Action Group                            |
| LED                  | Light-Emitting Diode                               |
| MCU                  | Micro Controller Unit                              |
| MOSFET               | Metal-Oxide Semiconductor Field-Effect Transistor  |
| PC                   | Personal Computer                                  |
| pps                  | pulses per second                                  |
| SWD                  | Serial Wire Debug                                  |
| USB                  | Universal Serial Bus                               |

## 12. References

- [1] **PCA9629A, “Fm+ I<sup>2</sup>C-bus advanced stepper motor controller”** — Product data sheet; NXP Semiconductors; [www.nxp.com/documents/data\\_sheet/PCA9629A.pdf](http://www.nxp.com/documents/data_sheet/PCA9629A.pdf)
- [2] **UM10375, “LPC1311/13/42/43 User manual”** — User manual; NXP Semiconductors; [www.nxp.com/documents/user\\_manual/UM10375.pdf](http://www.nxp.com/documents/user_manual/UM10375.pdf)
- [3] **LPC1311/13/42/43, “32-bit ARM Cortex-M3 microcontroller; up to 32 kB flash and 8 kB SRAM; USB device”** — Product data sheet; NXP Semiconductors; [www.nxp.com/documents/data\\_sheet/LPC1311\\_13\\_42\\_43.pdf](http://www.nxp.com/documents/data_sheet/LPC1311_13_42_43.pdf)

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## 14. Contents

|          |                                                                     |           |           |                                                                              |           |
|----------|---------------------------------------------------------------------|-----------|-----------|------------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Introduction</b>                                                 | <b>3</b>  | <b>7</b>  | <b>Programming the demo board</b>                                            | <b>20</b> |
| 1.1      | Application overview                                                | 4         | 7.1       | Programming the PCA9629A demo board via USB                                  | 20        |
| <b>2</b> | <b>PCA9629A stepper motor controller demo kit</b>                   | <b>4</b>  | 7.2       | Programming and debugging the PCA9629A demo board via LPC-Link USB interface | 21        |
| 2.1      | PCA9629A demo kit (Rev. 2.2) contents                               | 4         | 7.3       | Programming the PCA9629A demo board via RS-232                               | 23        |
| <b>3</b> | <b>System overview</b>                                              | <b>5</b>  | <b>8</b>  | <b>Support</b>                                                               | <b>25</b> |
| 3.1      | The PCA9629A stepper motor controller                               | 5         | <b>9</b>  | <b>Appendix A: PCA9629A_config.h</b>                                         | <b>26</b> |
| 3.2      | LPCXpresso microcontroller board                                    | 6         | <b>10</b> | <b>Appendix B: Schematics</b>                                                | <b>28</b> |
| 3.3      | System block diagram                                                | 6         | <b>11</b> | <b>Abbreviations</b>                                                         | <b>33</b> |
| 3.4      | I/O, switches and indicators on the PCA9629A demo board             | 7         | <b>12</b> | <b>References</b>                                                            | <b>33</b> |
| 3.4.1    | Sensor interface                                                    | 8         | <b>13</b> | <b>Legal information</b>                                                     | <b>34</b> |
| 3.4.2    | Motor interface                                                     | 8         | 13.1      | Definitions                                                                  | 34        |
| 3.4.3    | RS-232 programming interface                                        | 8         | 13.2      | Disclaimers                                                                  | 34        |
| 3.4.4    | USB programming interface                                           | 8         | 13.3      | Trademarks                                                                   | 34        |
| 3.4.5    | LPC-Link USB debug and programming interface                        | 8         | <b>14</b> | <b>Contents</b>                                                              | <b>35</b> |
| 3.4.6    | SWD debug interface                                                 | 8         |           |                                                                              |           |
| 3.4.7    | WINI2C-USB interface                                                | 8         |           |                                                                              |           |
| 3.4.8    | Output LED indicators                                               | 8         |           |                                                                              |           |
| 3.4.9    | Push-button switches                                                | 9         |           |                                                                              |           |
| 3.4.10   | +12 Volt input                                                      | 9         |           |                                                                              |           |
| <b>4</b> | <b>Hardware description</b>                                         | <b>9</b>  |           |                                                                              |           |
| 4.1      | LPC1343 Cortex M3 based LPCXpresso daughter board                   | 9         |           |                                                                              |           |
| 4.2      | PCA9629A stepper motor controller mother board                      | 9         |           |                                                                              |           |
| 4.2.1    | On-board visual LED indicators                                      | 9         |           |                                                                              |           |
| 4.2.2    | On-board switches                                                   | 10        |           |                                                                              |           |
| 4.2.3    | Power requirements                                                  | 10        |           |                                                                              |           |
| 4.2.3.1  | Input power                                                         | 10        |           |                                                                              |           |
| 4.2.3.2  | +5 V regulator                                                      | 10        |           |                                                                              |           |
| 4.2.3.3  | +3.3 V regulator                                                    | 10        |           |                                                                              |           |
| 4.2.4    | Jumpers, headers, and test point locations                          | 11        |           |                                                                              |           |
| 4.3      | Stepper motor board                                                 | 12        |           |                                                                              |           |
| <b>5</b> | <b>Demo setup and operation</b>                                     | <b>13</b> |           |                                                                              |           |
| 5.1      | PCA9629A stepper motor controller demo setup                        | 13        |           |                                                                              |           |
| <b>6</b> | <b>Firmware overview</b>                                            | <b>16</b> |           |                                                                              |           |
| 6.1      | CMSIS V1.3 and start-up modules                                     | 17        |           |                                                                              |           |
| 6.2      | PCA9629A_config.h                                                   | 17        |           |                                                                              |           |
| 6.3      | PCA9629A_main.c module                                              | 17        |           |                                                                              |           |
| 6.4      | io_interface.c io_interface.h                                       | 18        |           |                                                                              |           |
| 6.5      | i2c_abstraction.c and i2c_abstraction.h                             | 19        |           |                                                                              |           |
| 6.6      | I2C.c and I2C.h modules                                             | 19        |           |                                                                              |           |
| 6.7      | GPIO.c, GPIO.h, systick.c, systick.h, timer16b_0.c and timer16b_0.h | 19        |           |                                                                              |           |

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Date of release: 17 June 2014

Document identifier: UM10798

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