

BLDC Shield with TLE9879QXA40 for Arduino

About this document



Scope and purpose

This application note describes the BLDC shield for Arduino equipped with the TLE9879QXA40, a single chip 3-phase motor driver that integrates the industry standard Arm® Cortex®*-M3 core.

This document provides detailed information on the board's content, layout and use. It should be used along with the [TLE9879QXA40 datasheet](#), which contains full technical details on the device specification and operation.

An Arduino baseboard is mandatory for operation.

Intended audience

This document is intended for anyone working with the BLDC shield for Arduino equipped with the TLE9879QXA40.

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1 Acronyms

1 Acronyms

The following acronyms and terms are used within this document.

Table 1 Acronyms

Acronyms	Names
ADC	Analog Digital Converter
BLDC	Brushless Direct Current
DC	Direct Current
EMC	Electro Magnetic Compatibility
GND	Ground
IDE	Integrated Development Environment
I/O	Input/Output
LIN	Local Interconnect Network
n.u.	not used
NFET	Negative Channel Field Effect Transistor
PWM	Pulse Width Modulation
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver Transmitter
VDDEXT	External Voltage Supply Output

2 Introduction

2 Introduction

2.1 TLE9879 BLDC shield for Arduino overview

The BLDC Motor Control shield with TLE9879QXA40 for Arduino Uno makes it easy to control and drive a BLDC motor. It features an Infineon TLE9879QXA40, a single chip 3-phase motor driver with integrated MOSFETs. The shield can be controlled by a microcontroller via an SPI interface - here the Arduino Uno R3 is used as master. Both the shield and the Arduino board are connected via the pin headers. Up to four shields can be stacked via the pin headers, to control up to four BLDC motors. Dedicated pins are used to select the relevant shield (see [Chapter 3.5](#) on page 14).

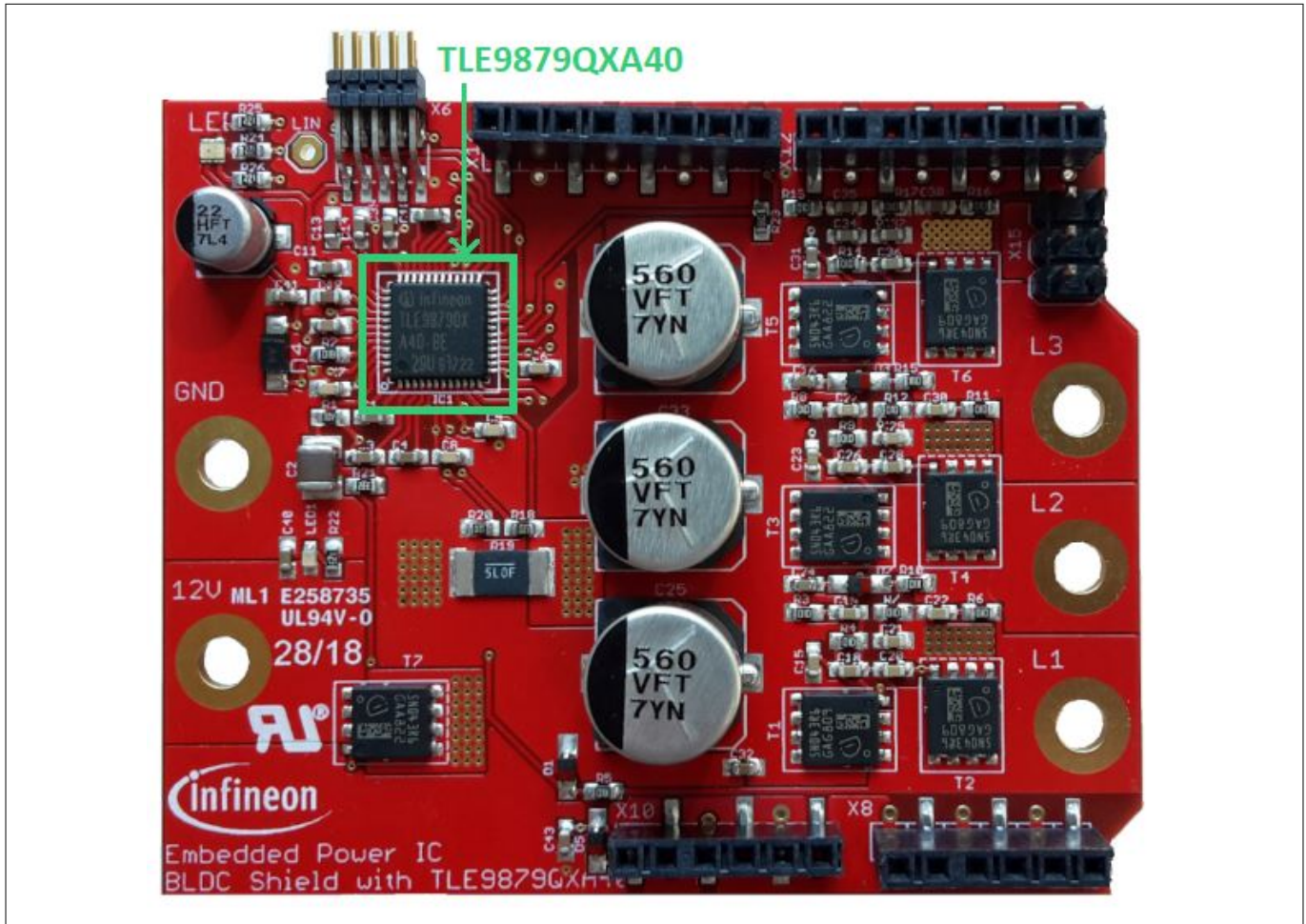


Figure 1 TLE9879 BLDC shield for Arduino overview

2 Introduction

2.2 Key features

The TLE9879 BLDC shield for Arduino has the following features:

- An Arduino Uno R3 connected to the shield can control a single chip 3-phase motor driver via the SPI interface
- BLDC motor control
 - 5.5 V - 28 V normal operating input voltage
 - 28 V - 40 V extended operating input voltage
- Possibility to stack up to four shields
- SPI interface for high configurability and detailed diagnosis
- Protections:
 - Overtemperature
 - Overcurrent
 - Undervoltage
 - Overvoltage
- Motor speed control

2.3 Application and block diagrams

The BLDC shield is meant to be controlled with an Arduino Uno or Arduino compatible baseboard. The application diagram ([Figure 2](#) on page 5) shows the simplified connection scheme.

The auto-addressing functionality will configure a dedicated chip select, regarding the board position in the stack. An external 12 V supply voltage has to be attached to the BLDC shields to provide the right amount of current for the motor control.

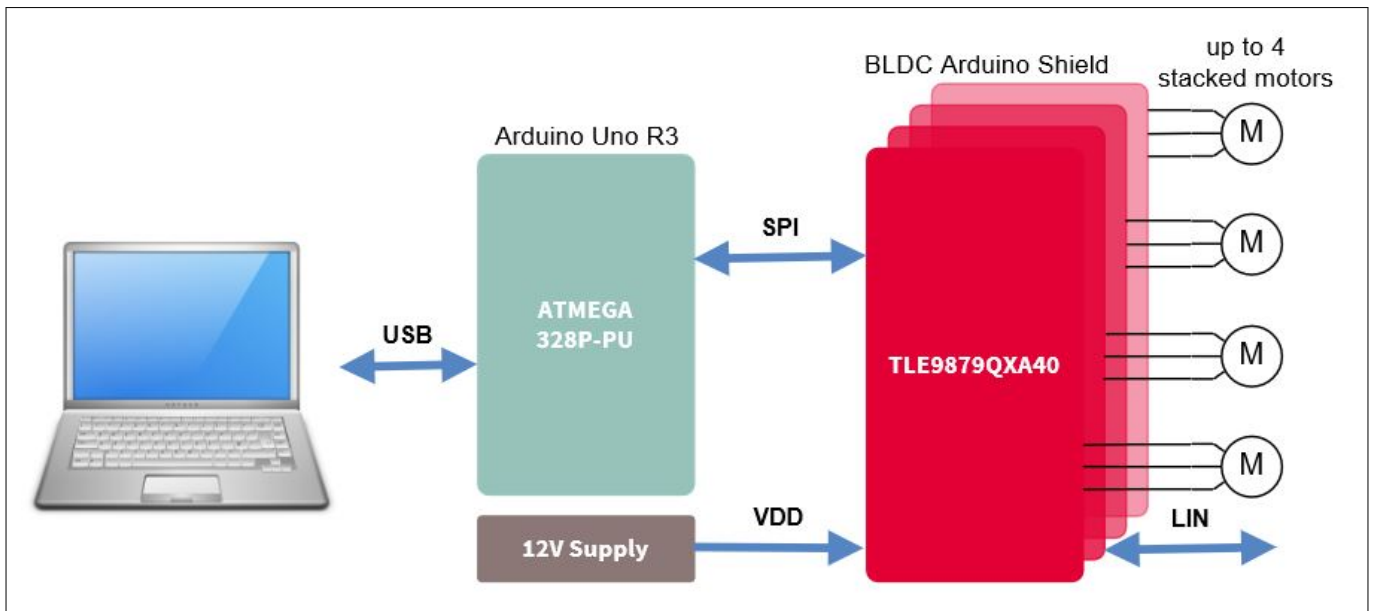


Figure 2 Simplified application diagram for TLE9879 BLDC shield for Arduino

2 Introduction

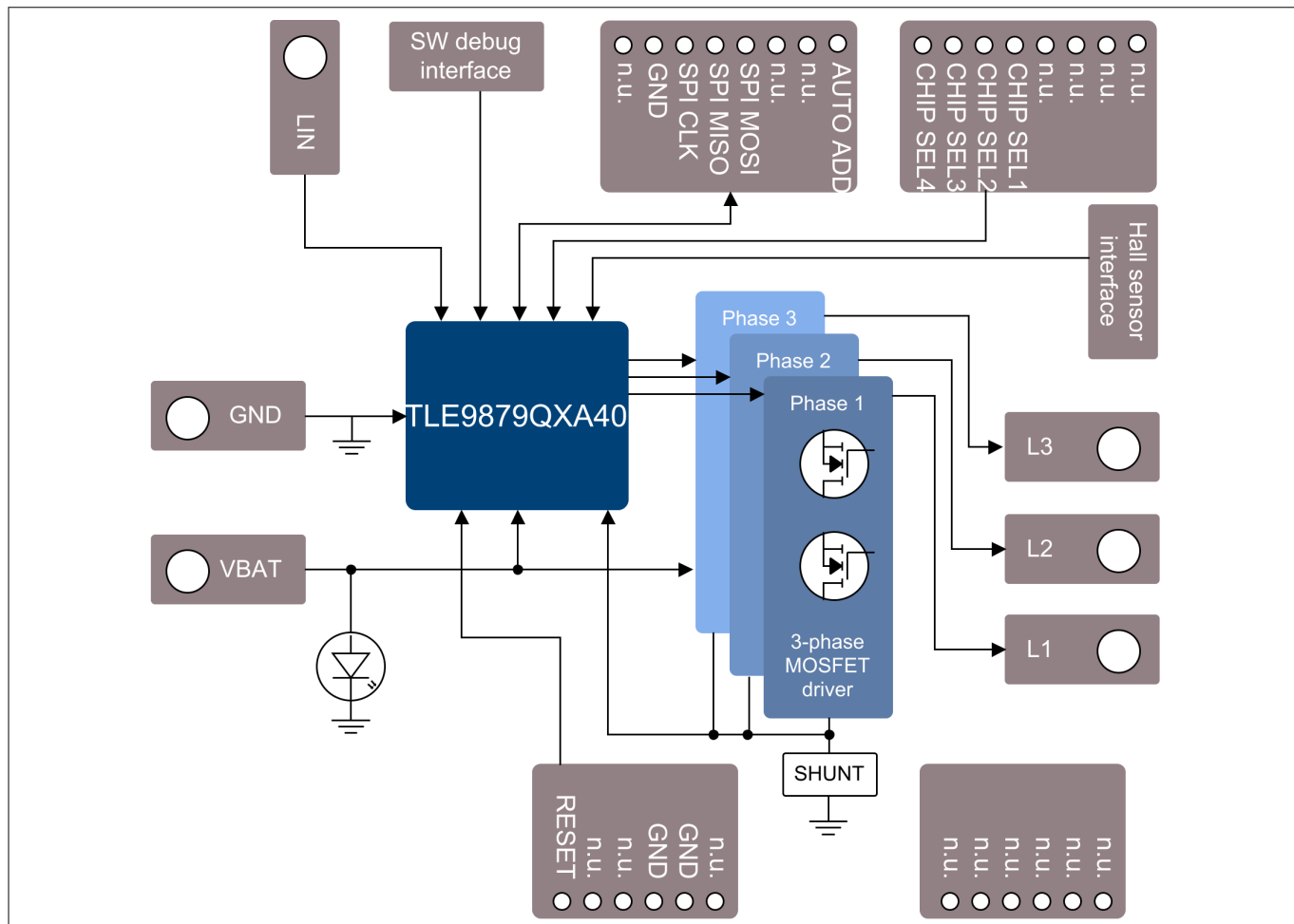


Figure 3 Block diagram for TLE9879 BLDC shield for Arduino

Refer to [Chapter 5](#) on page 25 or the corresponding datasheet for more information.

3 TLE9879 BLDC shield for Arduino description

3 TLE9879 BLDC shield for Arduino description

3.1 Overview

The TLE9879 BLDC shield for Arduino provide the following features (see *Figure 4* on page 7):

- A single chip 3-phase motor driver, TLE9879QXA40
- Solder holes to connect a BLDC motor - marked red
- Several communication interfaces:
 - Pin headers to connect the shield to the Arduino board - X8, X10, X12, X14, marked yellow. See the pin assignment *Chapter 3.5* on page 14.
 - LIN via a test point - marked green. It is not populated yet and has to be soldered in the designated solder hole.
 - Debug pin headers - X6, marked blue. It can be used by connecting a Segger J-Link debugger.
 - Hall connector - X15, marked purple. It can be used by connecting a Hall sensor for motor control purpose.
- A RGB LED - marked orange - in the upper left corner, which indicates that the shield is working properly.

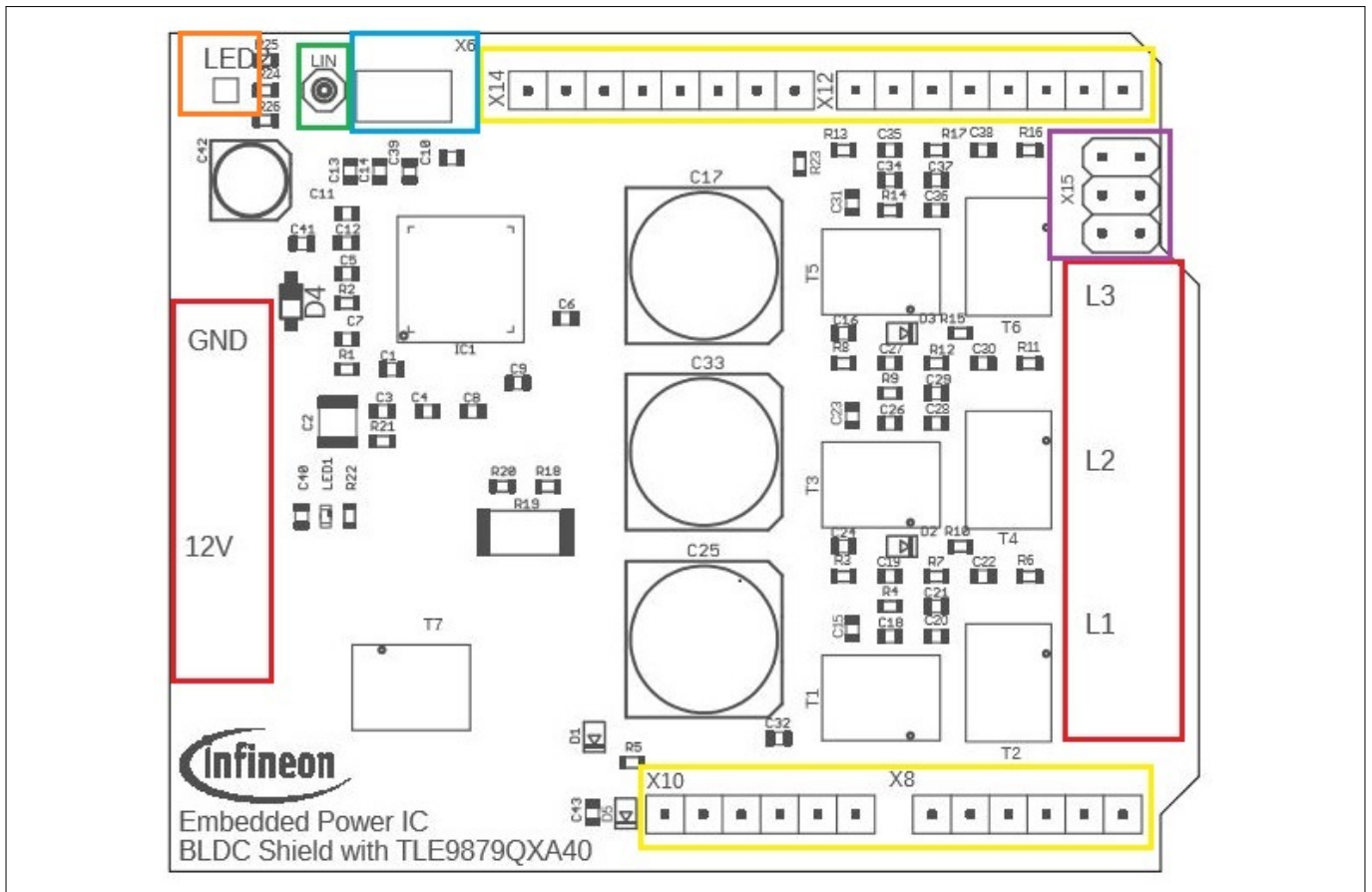


Figure 4 TLE9879 BLDC shield for Arduino placements

3 TLE9879 BLDC shield for Arduino description

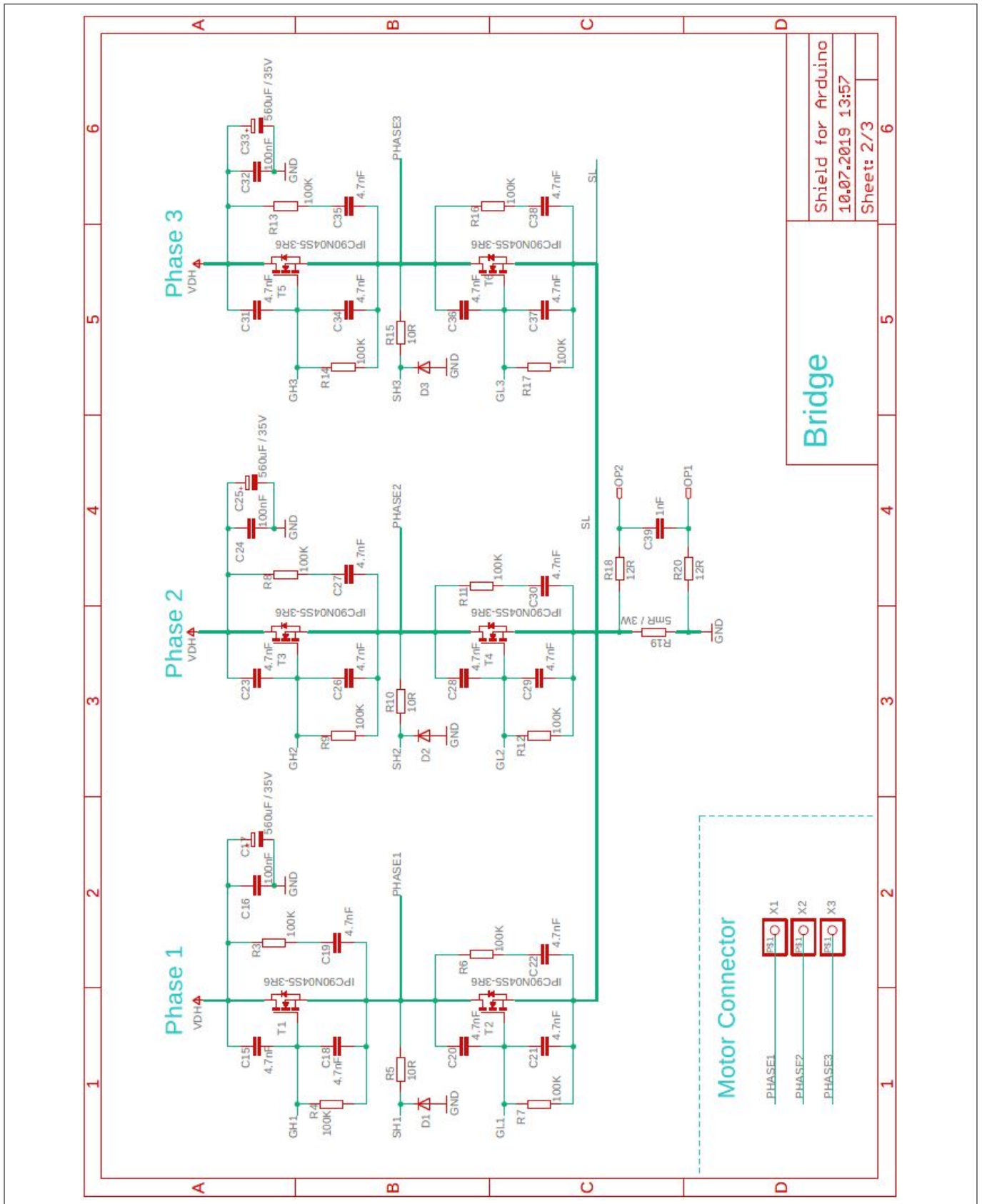


Figure 6 Schematics TLE9879 BLDC shield for Arduino (2/3)

3 TLE9879 BLDC shield for Arduino description

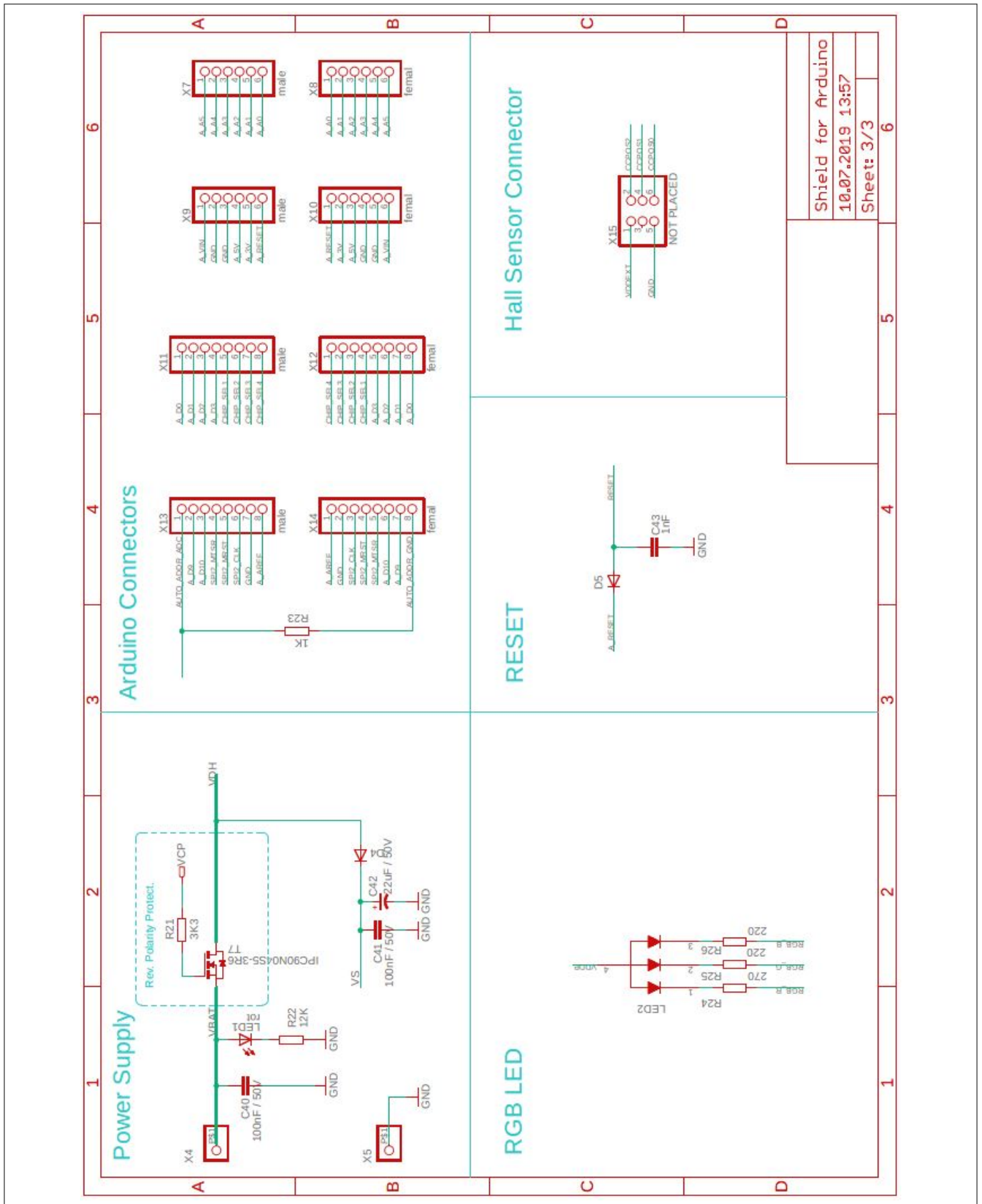


Figure 7 Schematics TLE9879 BLDC shield for Arduino (3/3)

3 TLE9879 BLDC shield for Arduino description

3.3 Layout

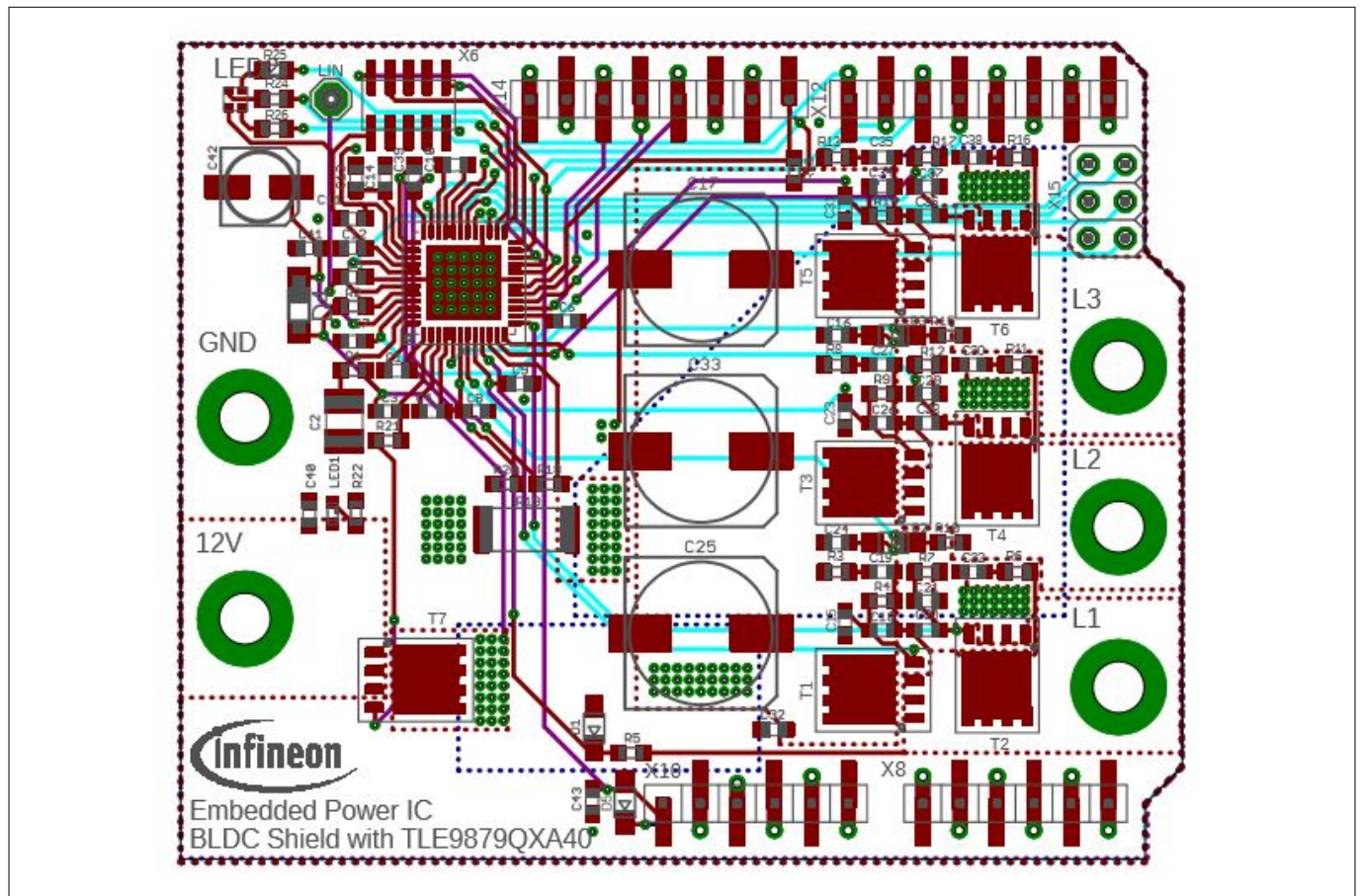


Figure 8 Top layout

3 TLE9879 BLDC shield for Arduino description

3.4 Bill of material

Table 2 Bill of material TLE9879 BLDC shield for Arduino

Part	Value	Device	Package	Description
C1, C3, C4	220 nF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C2	10 uF / 35 V	C-EUC1210	C1210	CAPACITOR, European symbol
C5	220 pF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C6	10 nF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C7, C8, C9	470 pF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C10, C11, C14, C16, C24, C32, C40, C41	100 nF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C12	1 uF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C13	300 nF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C15, C18, C19, C20, C21, C22, C23, C26, C27, C28, C29, C30, C31, C34, C35, C36, C37, C38	4.7 nF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C17, C25, C33	560 uF / 35 V	CPOL- EU153CLV-1014	153CLV-1014	POLARIZED CAPACITOR, European symbol
C39, C43	1 nF / 50 V	C-EUC0603	C0603	CAPACITOR, European symbol
C42	22 uF / 50 V	CP-153CLV-0505	153CLV-0505	POLARIZED CAPACITOR, European symbol
D1, D2, D3, D5	BAS3010B03WE6 327HTSA1	DIODE-SOD323- W	SOD323-W	DIODE
D4	SM4004	DIODE- DO-214AC	DO-214AC	DIODE
IC1	TLE9879QXA40	TLE9879QXA40	VQFN48-15_7X7	Infineon SoC
LED1	red	LEDSML0603	SML0603	LED
LED2	GM5WA94310A	GM5WA94310A	GM5WA94310A	Chip LED RGB
LSP1	MCS10B	MCS10B	MCS10B	SOLDER PAD
R1	2 / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
R2, R23	1K / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
R3, R4, R6, R7, R8, R9, R11, R12, R13, R14, R16, R17	100K / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
R5, R10, R15	10R / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
R18, R20	12R / 1%	R-EU_R0603	R0603	RESISTOR, European symbol

3 TLE9879 BLDC shield for Arduino description

Table 2 Bill of material TLE9879 BLDC shield for Arduino (continued)

Part	Value	Device	Package	Description
R19	5mR / 3 W / 0.5%	R-EU_R6332	R6332	RESISTOR, European symbol
R21	3K3 / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
R22	12K / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
R24, R26	220 / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
R25	270 / 1%	R-EU_R0603	R0603	RESISTOR, European symbol
T1, T2, T3, T4, T5, T6, T7	IPC90N04S5-3R6	IPC90N04S5-3R6	PG-TDSON-8	
X1, X2, X3, X4, X5	SCREW HOLE	SCREW HOLE	SCREW HOLE	SCREW HOLE
X6	FTSH-105-01-L-DH	SWD	SWD	SWD
X7, X9	TSM-106-03-L-SV	PINHD-1X6_2.54-SMD	SAMTEC	PINHD
X8, X10	SSM-106-L-SV	PINHD-1X6_2.54-SMD	SAMTEC	PINHD
X11, X13	TSM-108-03-L-SV	PINHD-1X8_2.54-SMD	SAMTEC	PINHD
X12, X14	SSM-108-L-SV	PINHD-1X8_2.54-SMD	SAMTEC	PINHD
X15	PINHD-2X3_2.54	PINHD-2X3_2.54	2X03	PINHD

3 TLE9879 BLDC shield for Arduino description

3.5 Pin assignment and functions

Figure 9 on page 14 shows the pin-out/connectors of the TLE9879 BLDC shield for Arduino.

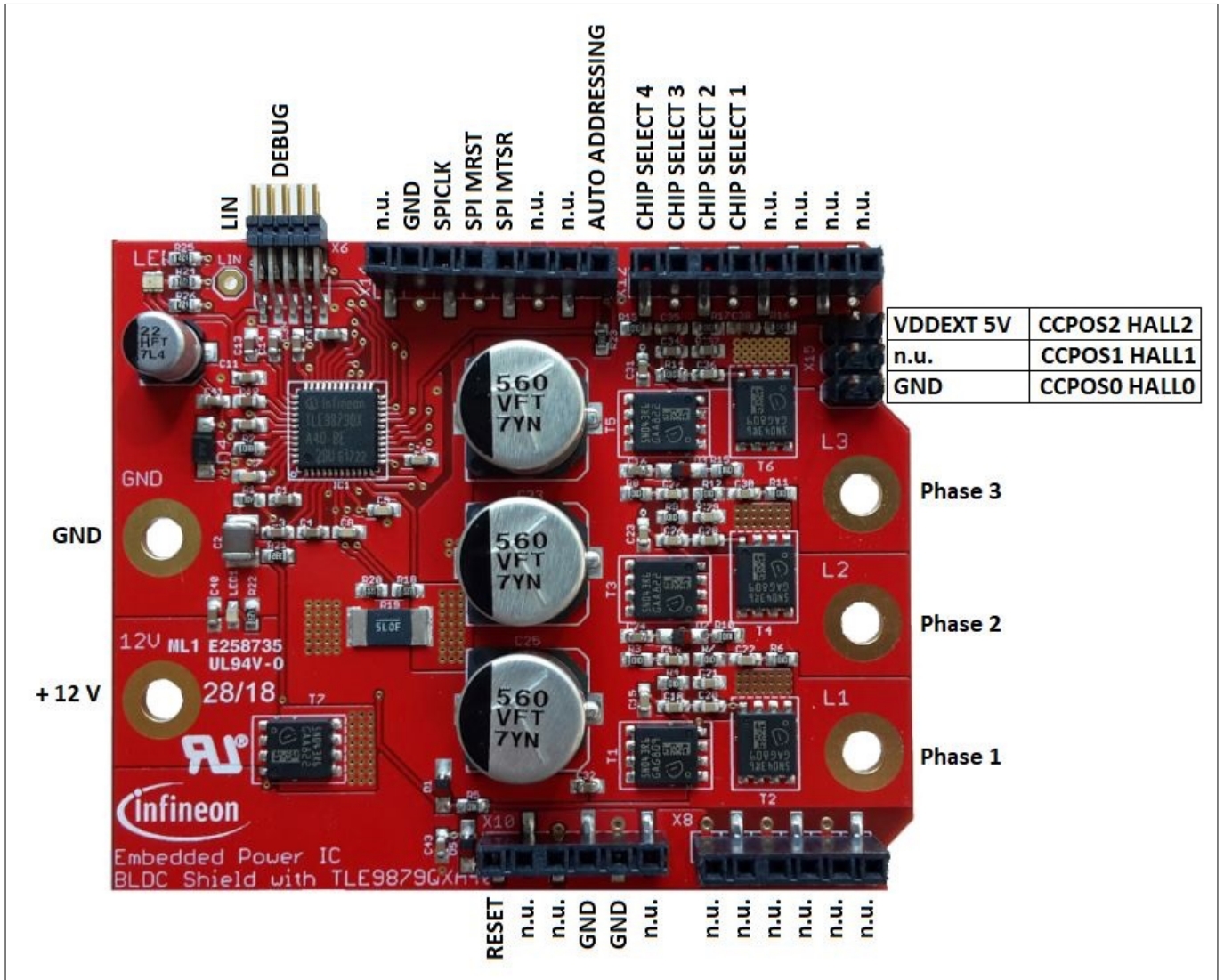


Figure 9 Pin assignment TLE9879 BLDC shield for Arduino

3 TLE9879 BLDC shield for Arduino description

Table 3 **Pin assignment**

Pin	Function
GND	Ground
SPICLK	Serial clock
SPI MRST	SPI Master Receive Slave Transmit (similar to MISO)
SPI MTSR	SPI Master Transmit Slave Receive (similar to MOSI)
Auto Addressing	When starting after a reset, gets which shield (out of the four possible) is active
CHIP SELECT 1,2,3,4	Enables to select the shield to control
RESET	Resets the shield
VDDEXT 5V	Supply voltage for the Hall sensor
CCPOS 0,1,2 HALL 0,1,2	Inputs for the Hall sensors
Phase 1,2,3	Inputs for the motor phases

4 Arduino software documentation

4 Arduino software documentation

The TLE9879QX BLDC shield comes with several software examples for 3-phase motor control. The shield can be controlled using the SPI. Infineon provides the software library for Arduino Uno.

This chapter describes the application programming interface to control either one or multiple shields.

4.1 Constructor

At the beginning a pointer to a class TLE9879_Group needs to be created. A single shield or all of them can be addressed.

There can be up to four boards used with the Arduino library and the constructor sends a reset-request to all connected boards.

Example:

```
TLE9879_Group *shields;  
shields = new TLE9879_Group(2);
```


4 Arduino software documentation

4.2 Commands

setMode

With setMode the mode can be changed or the current mode can be found out. A single shield or all of them can be addressed.

The following modes exist:

- BOOTLOADER: is started at the beginning as standard. Not all commands are available here only modeControl, boardControl, LEDOn and LEDOff).
- BEMF: control motor using block commutation with back-EMF.
- HALL: control motor using block commutation with hall sensors.
- FOC: control motor using FOC.
- GETCURRENTMODE: returns the current mode.

Example:

```
shields->setMode(FOC, BOARD1);
```

setMotorMode

With setMotorMode the motor can be started and stopped. A single shield or all of them can be addressed.

- START_MOTOR
- STOP_MOTOR

With invalid parameters the motor may not run.

Example:

```
shields->setMotorMode(START_MOTOR, BOARD1);
```

setMotorSpeed

SetMotorSpeed changes the motor speed in rpm. It can be changed while the motor is running. A single shield or all of them can be addressed.

Example:

```
shields->setMotorspeed(2000, BOARD1);
```

setParameter

setParameter sets a parameter of the current dataset to a specific value. A single shield or all of them can be addressed. A list of all addressable parameter can be found in chapter [Parameter sets for BEMF, FOC and HALL](#).

Example:

```
shields->setParameter(FOC_MAX_SPEED, 5000, BOARD1);
```

4 Arduino software documentation

saveDataset

With saveDataset the current dataset will be saved in ROM of the shield, the position needs to be named. A single shield or all of them can be addressed. See [Table 4](#) for ROM allocation.

- POSITION0
- POSITION1
- POSITION2
- POSITION3

These datasets are the custom datasets. DATASET0 will be saved at position POSITION0 etc.

Example:

```
shields->saveDataset(POSITION0, BOARD1);
```

Table 4 ROM allocation

4k-block	NVM sector number	Start address	End address	Comment
---	32	0x1101F000		0x1101EFFF
FOC Custom Data Set	31	0x1101E000		
HALL Custom Data Set	30	0x1101D000		
BEMF Custom Data Set	29	0x1101C000		
	28	0x1101B000		
	27	0x1101A000		
	26	0x11019000		
	25	0x11018000		
FOC Infineon Data Set	24	0x11017000	0x11017FFF	End FOC
FOC	23	0x11016000		
FOC	22	0x11015000		
FOC	21	0x11014000		
FOC	20	0x11013000		
FOC	19	0x11012000		
FOC	18	0x11011000		
FOC	17	0x11010000		Start FOC
	16	0x1100F000		
Hall Infineon Data Set	15	0x1100E000	0x1100EFFF	End BC Hall
BC Hall	14	0x1100D000		
BC Hall	13	0x1100C000		
BC Hall	12	0x1100B000		
BC Hall	11	0x1100A000		Start BC Hall
	10	0x11009000		
BEMF Infineon Data Set	9	0x11008000	0x11008FFF	End BC BEMF

4 Arduino software documentation

Table 4 ROM allocation (continued)

4k-block	NVM sector number	Start address	End address	Comment
BC BEMF	8	0x11007000		
BC BEMF	7	0x11006000		
BC BEMF	6	0x11005000		
BC BEMF	5	0x11004000		
BC BEMF	4	0x11003000		Start BC BEMF
	3	0x11002000		
Bootloader	2	0x11001000	0x001FFF	End BL
Bootloader	1	0x11000000		Start BL

loadDataset

The requested dataset is loaded and used. A single shield or all of them can be addressed.

There are prepared Infineon datasets:

- DATASET0
- DATASET1
- DATASET2
- DATASET3

And custom datasets:

- CUSTOMDATASET0
- CUSTOMDATASET1
- CUSTOMDATASET2
- CUSTOMDATASET3

Custom datasets are empty by default and need to be adapted before use.

Example:

```
shields->loadDataset(DATASET0, BOARD1);
```

readDataset

With readDataset the currently used dataset is sent to the master (Arduino).

Then it is stored in the appropriate class variable:

- data_BMEF
- data_FOC
- data_HALL

Example:

```
shields->readDataset(BOARD1);
```

4 Arduino software documentation

writeDataset

When requesting writeDataset, the values currently in data_BMEF, data_FOC or data_HALL will be sent to the TLE9879_Board. A single shield or all of them can be addressed.

After correct transfer the data will be used.

Example:

```
shields->writeDataset (BOARD1);
```

copyDataset

With copyDataset dataset can be transferred from one shield to another.

Example:

```
shields->copyDataset (BEMF, BOARD1, BOARD2);
```

sendMessageToAll

With sendMessageToAll a message can be send to all connected shields.

Example:

```
shields->sendMessageToAll (XXX);
```

setLed

With settLed the mode of the onboard LED can be set. A single shield or all of them can be addressed.

The modes are:

- LED_ON: switches the LED on
- LED_OFF: switches the LED off

Example:

```
shields->setLed(LED_ON, BOARD1);
```

setLedColor

With settLedColor the color of the onboard LED can be set. A single shield or all of them can be addressed.

The colors are:

- LED_RED: LED flashes red
- LED_BLUE: LED flashes blue
- LED_GREEN: LED flashes green

Example:

```
shields->setLedColor(LED_RED, BOARD1);
```

4.3 Code example

```
#include " TLE9879_Group.h"
TLE9879_Group *shields;

void setup()
{
    shields = new TLE9879_Group(1);
    // the command "start" sets motor speed to 1000 and starts the motor.
    // The configuration from the ConfigWizard is used.
    shields->setMode(FOC, BOARD1);
    // FOC is used for motor control
    shields->setMotorSpeed(1000, BOARD1);
    // motor speed is set to 1000 rpm
    shields->setMotorMode(START_MOTOR, BOARD1);
}

void loop()
{
    // do nothing here
}
```

4.4 Parameter sets for BEMF, FOC and HALL

BEMF

Table 5 BEMF parameter set

Parameter	Range
BEMF_PWM_FREQ	all
BEMF_SPIKE_FILTER	1/2/4/8
BEMF_BLANK_FILTER	3/6/8/12/16
BEMF_POLE_PAIRS	integer numbers
BEMF_SPEED_KP	integer numbers
BEMF_SPEED_KI	integer numbers
BEMF_SPEED_FILTER_TIME	0.01-1
BEMF_SPEED_TEST_ENABLE	0/1
BEMF_RUNBEGIN_SPEED_PWM_MIN	0-0.95
BEMF_START_FREQ_ZERO	0/1
BEMF_ZERO_VEC_TIME	all
BEMF_START_SPEED_PWM_MIN_OFFSET	0-0.95
BEMF_END_SPEED_PWM_MIN	0-0.95
BEMF_SWITCH_ON_SPEED	all
BEMF_END_START_SPEED	all
BEMF_START_ACCEL	all
BEMF_RUN_SPEED_PWM_MIN	0-0.95
BEMF_RUN_ACCEL	all

4 Arduino software documentation

FOC

Table 6 FOC parameter set

Parameter	Range
FOC_R_SHUNT	all
FOC_NOM_CUR	all
FOC_PWM_FREQ	all
FOC_R_PHASE	all
FOC_L_PHASE	all
FOC_POLE_PAIRS[7:0]	0-255
FOC_MAX_SPEED	all
FOC_CUR_ADJUST	0.01-1
FOC_FLUX_ADJUST	0.01-1
FOC_SPEED_KP	integer numbers >0
FOC_SPEED_KI	integer numbers >0
FOC_SPEED_FILT_TIME	0.01-1
FOC_SWITCH_ON_SPEED	all
FOC_END_START_SPEED	all
FOC_START_ACCEL	all
FOC_START_CUR_IF	all
FOC_START_FREQ_ZERO	0/1
FOC_ZERO_VEC_TIME	all
FOC_MIN_POS_REF_CUR	all
FOC_MAX_CUR_SPEED	all
FOC_MAX_POS_REF_CUR	all
FOC_MIN_NEG_REF_CUR	<0
FOC_MIN_CUR_SPEED	<0
FOC_MAX_NEG_REF_CUR	<0

4 Arduino software documentation
HALL**Table 7 HALL parameter set**

Parameter	Range
HALL_PWM_FREQ	all
HALL_POLE_PAIRS	integer numbers
HALL_INIT_DUTY	integer numbers 0-100
HALL_INPUT_A	0/1/2
HALL_INPUT_B	0/1/2
HALL_INPUT_C	0/1/2
HALL_OFFSET_60DEGREE_EN	0/1
HALL_ANGLE_DELAY_EN	0/1
HALL_DELAY_ANGLE	integer numbers 0-59
HALL_DELAY_MINSPEED	integer numbers 0-2000
HALL_SPEED_KP	integer numbers
HALL_SPEED_KI	integer numbers
HALL_SPEED_IMIN	0-100
HALL_SPEED_IMAX	0-100
HALL_SPEED_PIMIN	0-100
HALL_SPEED_PIMAX	0-100

5 TLE9879QXA40 overview

5 TLE9879QXA40 overview

The TLE9879QXA40 is a single chip 3-phase motor driver that integrates the industry standard Arm® Cortex®-M3 core, enabling the implementation of advanced motor control algorithms such as field-oriented control.

It includes six fully integrated NFET drivers optimized to drive a 3-phase motor via six external power NFETs, a charge pump enabling low voltage operation and programmable current along with current slope control for optimized EMC behavior. Its peripheral set includes a current sensor, a successive approximation ADC synchronized with the capture and compare unit for PWM control and 16-bit timers. A LIN transceiver is also integrated to enable communication to the device along with a number of general purpose I/Os. It includes an on-chip linear voltage regulator to supply external loads.

It is a highly integrated automotive qualified device enabling cost and space efficient solutions for mechatronic BLDC motor drive applications such as pumps and fans.

5.1 Key features

- Six current programmable drivers with charge pump for N-Channel MOSFET
- Integrated LIN transceiver compatible with LIN 2.2 and SAEJ2602
- Two full-duplex serial interface (UART) with LIN support
- Two synchronous serial channel (SSC)
- On-chip OSC and PLL for clock generation
- One high-voltage monitoring input with wake up functionality
- High-speed operational amplifier for motor current sensing via shunt
- Measurement unit:
 - 8-bit ADC module with 10 multiplexed inputs
 - 10-bit ADC module with 8 multiplexed inputs, 5 external analog inputs
 - On-chip temperature and battery voltage measurement unit
- Independent programmable window watchdog
- 5 V/1.5 V internal supplies
- External supply (VDDEXT): 5 V \pm 2% @ 20 mA
- Power saving modes:
 - MCU slow-down mode
 - Sleep mode
 - Stop mode
 - Cyclic wake-up Sleep mode

5 TLE9879QXA40 overview

5.2 Block diagram

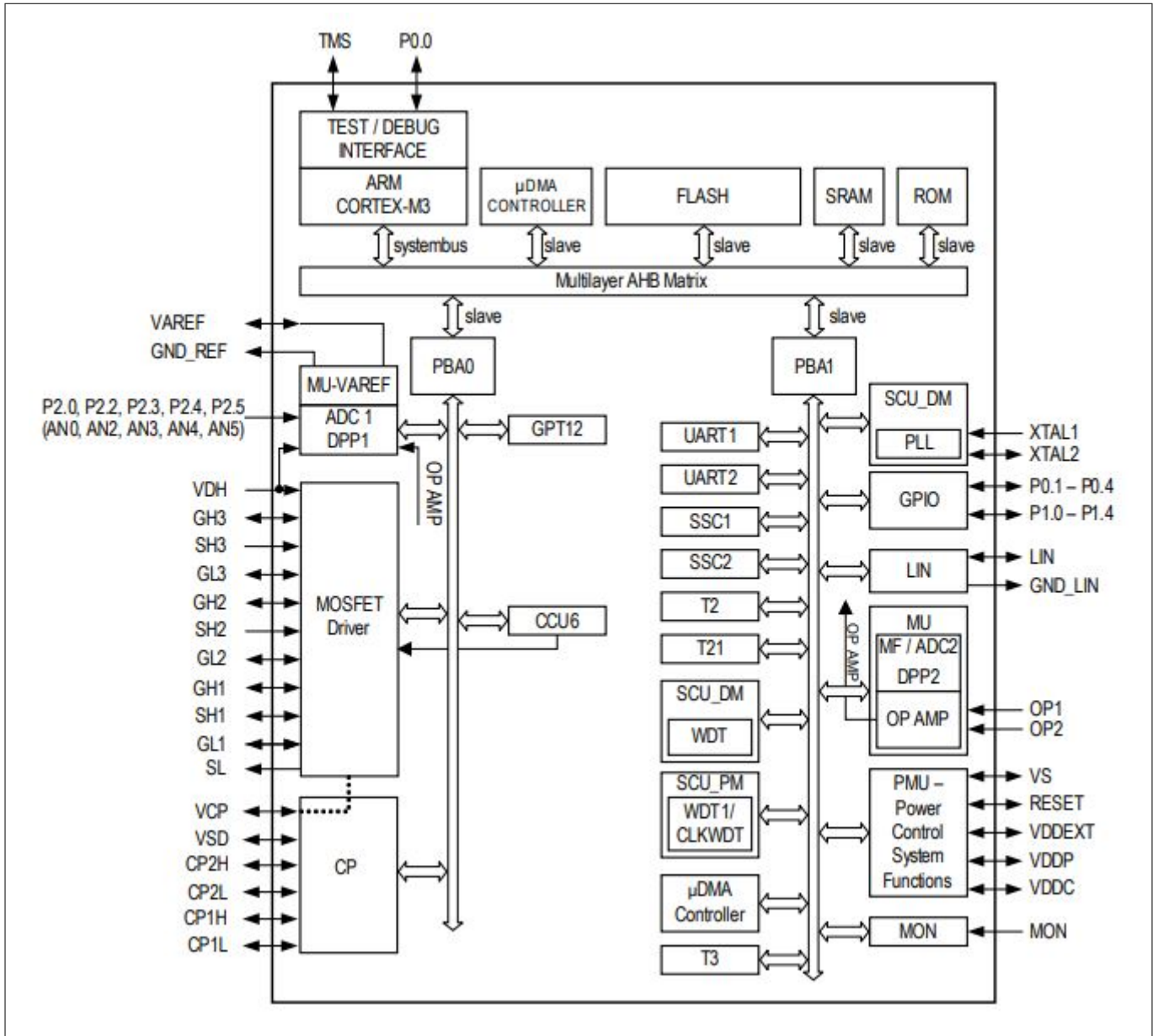


Figure 10 Block diagram TLE9879QXA40

5 TLE9879QXA40 overview

5.3 Pin assignment

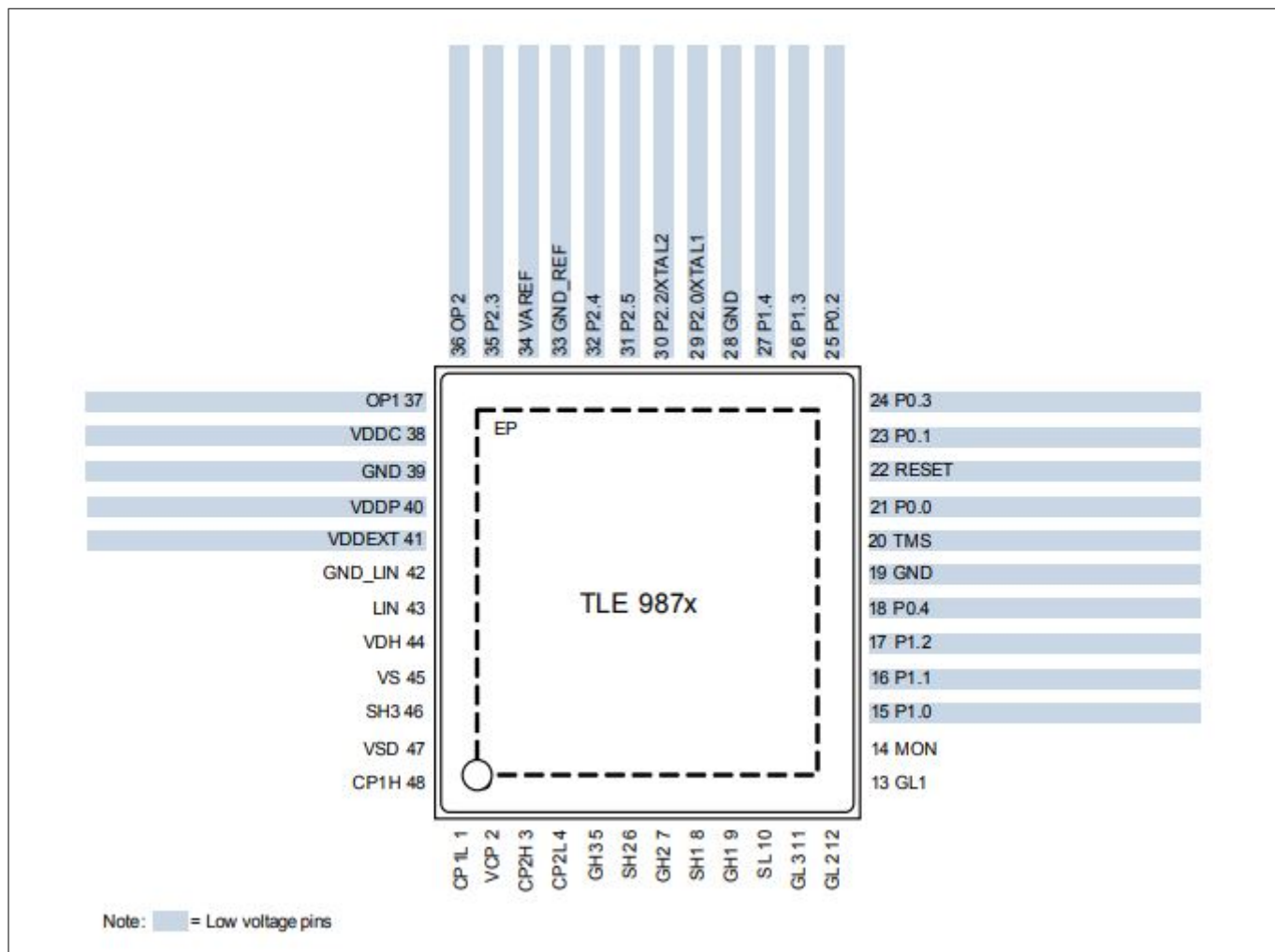


Figure 11 Device pinout TLE9879QXA40

5 TLE9879QXA40 overview
5.4 Pin definitions and functions
Table 8 Pin definitions and functions

Pins	Symbols	Functions
1	CP1L	Charge Pump Capacity 1 Low, connect external C
2	VCP	Charge Pump Capacity
3	CP2H	Charge Pump Capacity 2 High, connect external C
4	CP2L	Charge Pump Capacity 2 Low, connect external C
5	GH3	Gate High Side FET 3
6	SH2	Source High Side FET 2
7	GH2	Gate High Side FET 2
8	SH1	Source High Side FET 1
9	GH1	Gate High Side FET 1
10	SL	Source Low Side FET
11	GL3	Gate Low Side FET 3
12	GL2	Gate Low Side FET 2
13	GL1	Gate Low Side FET 1
14	MON	High Voltage Monitor Input
15	P1.0	GPIO
16	P1.1	GPIO
17	P1.2	GPIO
18	P0.4	GPIO
19	GND	GND Digital
20	TMS	Test Mode Select Input
21	P0.0	Serial Wire Debug Clock
22	RESET	Reset Input, not available during Sleep Mode
23	P0.1	GPIO
24	P0.3	GPIO
25	P0.2	GPIO
26	P1.3	GPIO
27	P1.4	GPIO
28	GND	GND Digital
29	P2.0/XTAL1	ADC Analog Input 0
30	P2.2/XTAL2	ADC Analog Input 2
31	P2.5	ADC Analog Input 5
32	P2.4	ADC Analog Input 4
33	GND_REF	GND for VAREF

5 TLE9879QXA40 overview

Table 8 Pin definitions and functions (continued)

Pins	Symbols	Functions
34	VAREF	5 V ADC1 Reference Voltage
35	P2.3	ADC Analog Input 3
36	OP2	Positive Operational Amplifier Input
37	OP1	Negative Operational Amplifier Input
38	VDDC	Core Supply
39	GND	GND Analog
40	VDDP	I/O Port Supply
41	VDDEXT	External Voltage Supply Output
42	GND_LIN	GND for LIN
43	LIN	LIN Bus Interface I/O
44	VDH	Voltage Drain High Side MOSFET Driver
45	VS	Battery Supply Input
46	SH3	Source High Side FET 3
47	VSD	Battery Supply Input for Charge Pump
48	CP1H	Charge Pump Capacity 1 High, connect external C
-	EP	Exposed Pad, connect to GND

6 Revision history

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Revision	Date	Changes
v1.2	2020-05-25	Added chapter <i>Arduino software documentation</i> . Editorial changes.
v1.1	2019-09-26	Added 2nd and 3rd pages of <i>Schematics</i> .
v1.0	2018-08-23	Initial creation.