DC Motor Control Shield with TLE94112EL

For Arduino

About this document

Scope and purpose

This user manual describes the DC motor control shield for Arduino equipped with the TLE94112EL, a twelve-fold half-bridge driver with integrated power stages. This document provides detailed information on the board's content, layout and use. It should be used in conjunction with the TLE94112EL datasheet, which contains full technical details on the device specification and operation.

Intended audience

Engineers, hobbyists and students who want to add a powerful motor control to Arduino projects.

Related information

Table 1 Supplementary links and document references

Reference	Description
TLE94112EL datasheet	Product page which contains reference information for the multiple half-bridge driver TLE94112EL
TLE941xy SPI interface	Application note for the SPI interface of the multiple half-bridge driver family TLE941xy
XMC1100 Boot Kit	Information page for the XMC1100 Boot Kit
Infineon shields for Arduino	Information page for Infineon shields for Arduino
DC motor shield with TLE94112EL	Information page for DC Motor Control Shield with TLE94112EL
Arduino Home Page	All information on Arduino
Arduino Uno Product Page	Arduino Uno R3 description
Arduino IDE Download	Download page for Arduino Integrated Development Environment
Sample code for TLE94112EL	Arduino Uno sample code for Motor Control Shield with TLE94112EL TLE94112EL_Shield_Arduino_Example_Sketch.ino

Table of Contents

1 Introduction

1.1 DC Motor Control Shield overview

The DC Motor Control Shield with TLE94112EL for Arduino Uno makes it easy to control up to six independent or eleven cascaded bidirectional DC motors.

The shield can be controlled by a microcontroller via an SPI interface. For example, either an Arduino Uno R3 or the XMC1100 Boot Kit from Infineon can be used as master.

The board features an Infineon TLE94112EL, a twelve-fold half-bridge driver with integrated MOSFETs. Each half-bridge can drive peak currents up to 0.9 A and DC current in the range of 200 mA to 500 mA, depending on the application conditions and the number of activated outputs.

The DC Motor Control Shield has an active reverse polarity protection with the p-channel MOSFET IPD50P04P4L-11.

The DC Motor Control Shield can be easily connected e.g. to any Arduino board or to the XMC1100 Boot Kit via headers.

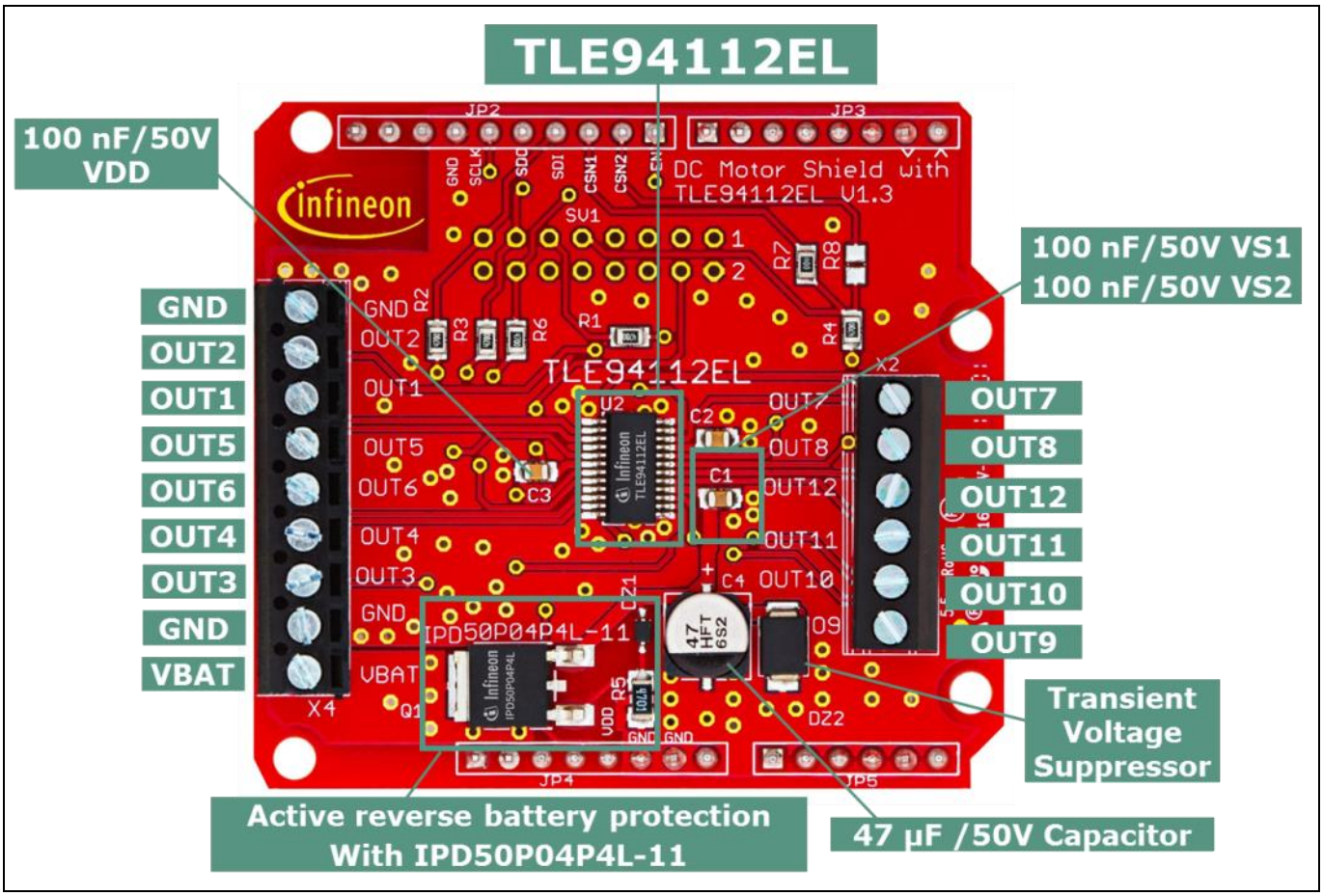

Figure 1 DC Motor Shield with TLE94112EL

1.2 Key features

The DC Motor Control Shield has the following features:

- An Arduino Uno R3, XMC1100 Boot Kit, or similar board connected to the shield can control twelve half-bridges via the SPI interface
- Brushed DC Motor Control up to 0.9 A peak
    - 5.5 – 18 V normal operating input voltage
    - 18 – 20 V extended operating input voltage
    - Maximum input voltage up to 40V (absolute max. rating)
- Control of:
    - Six independent bidirectional DC motors
    - Eleven cascaded bidirectional DC motors
- SPI interface for high configurability and detailed diagnosis
- Protections:
    - Overtemperature
    - Overcurrent
    - Undervoltage
    - Overvoltage
- Detailed diagnosis per MOSFET:
    - Individual open load detection
    - Individual overcurrent detection
- Paralleling outputs for higher current capability
- Motor speed control by PWM
    - Three independent PWM generators
    - PWM frequency: 80 Hz, 100 Hz or 200 Hz
    - 8-bit resolution, 0.5% duty cycle steps
    - Active freewheeling for lower power dissipation
- Two shields can be stacked to control an increased number of motors
- Reverse polarity protection with IPD50P04P4L-11

1.3 Application diagram for bi-directional DC motor applications

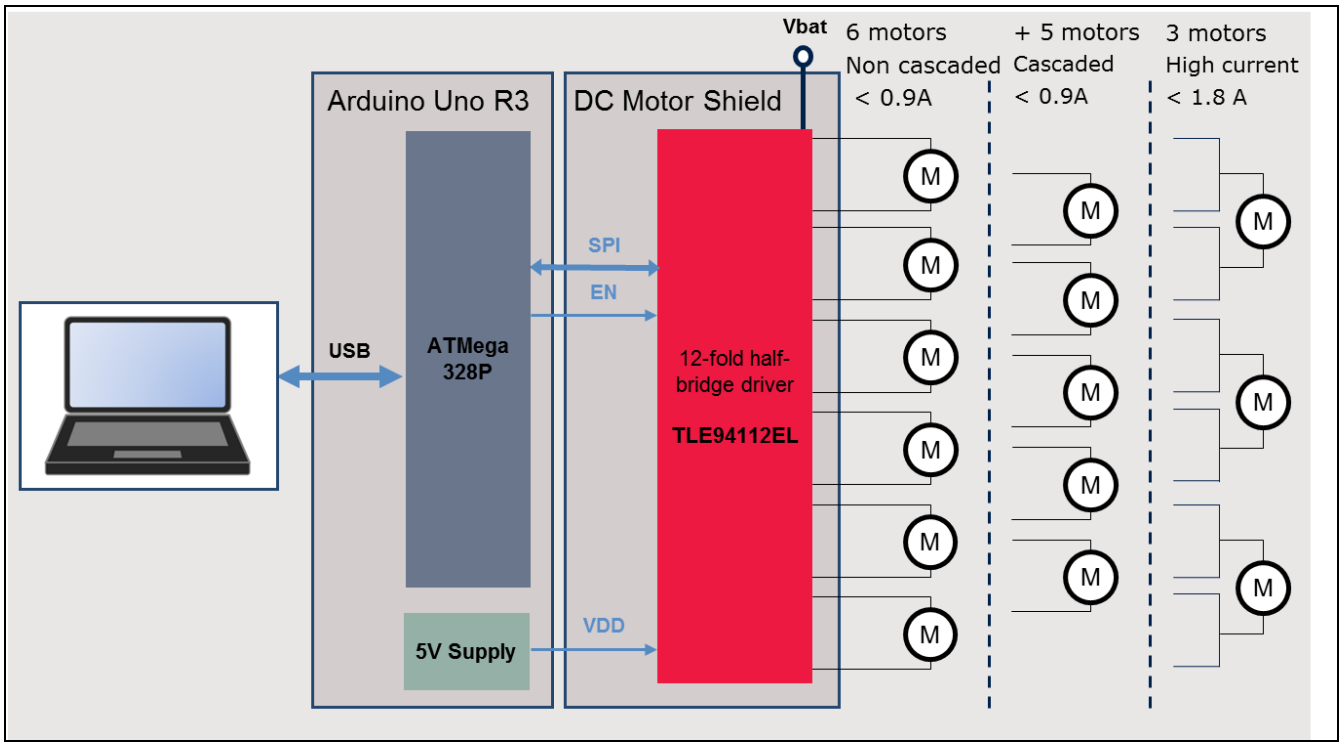

Figure 2 Simplified application diagram with TLE94112EL driving DC motors

Refer to the TLE94112EL datasheet for more information.

2 DC Motor Control Shield description

For a safe and optimized motor control design, some discrete components are needed. Some of them are dedicated to the motor application and some to the TLE94112EL.

Figure 4, Figure 5 and Figure 6 show the schematics and the corresponding layout of the DC Motor Control Shield with TLE94112EL.

2.1 Overview

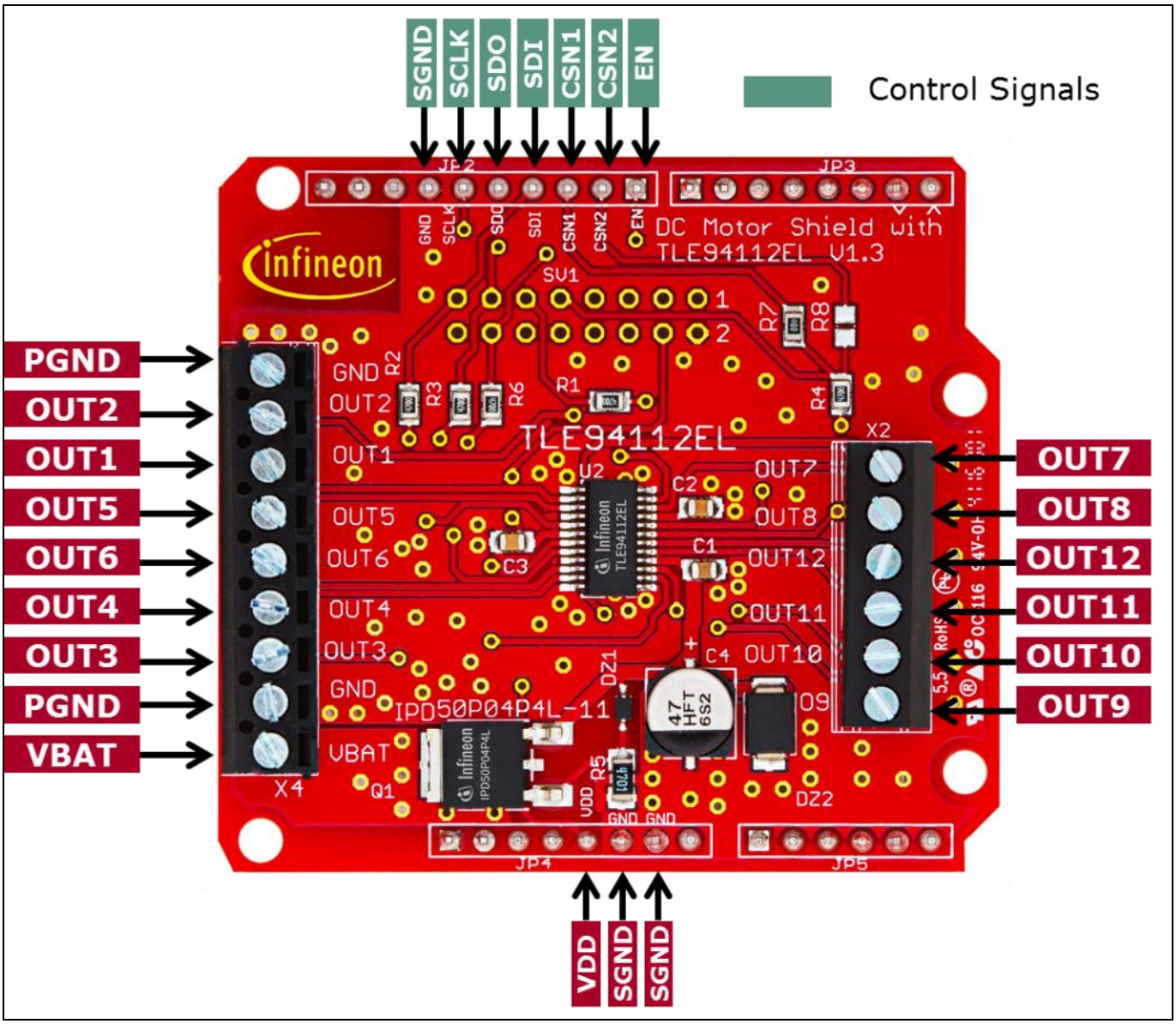

Figure 3 DC Motor Control Shield connectors

2.2 Schematics

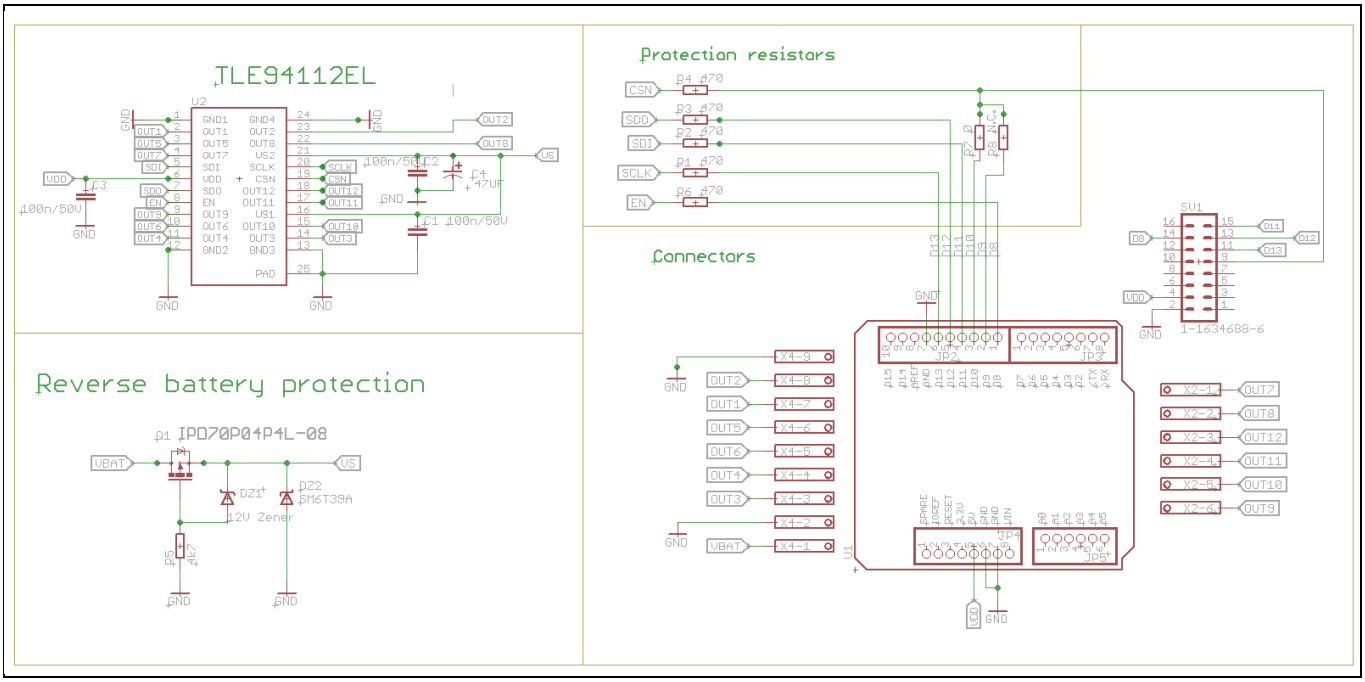

Figure 1 Figure 4 Schematics Motor Control Shield for Arduino with TLE94112EL

2.3 Layout

Figure 5 and Figure 6 show the layout of the DC Motor Shield with TLE94112EL.

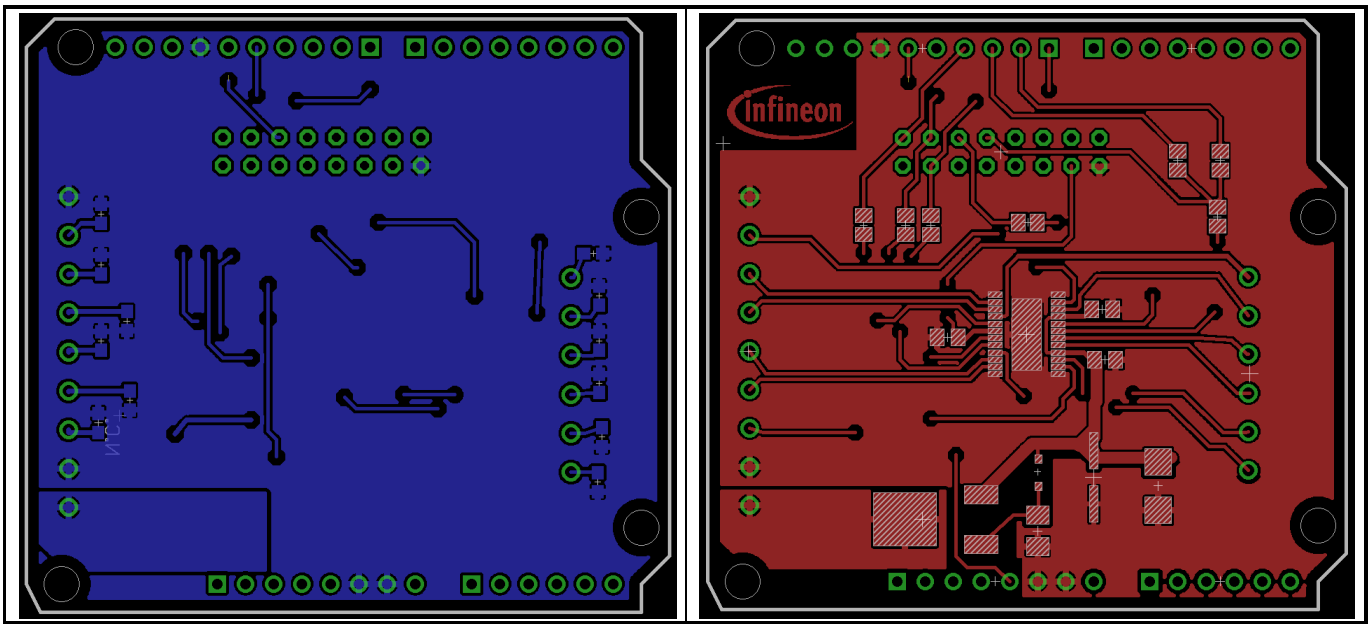

Figure 2 Figure 5 DC Motor Control Shield – Bottom and top layers

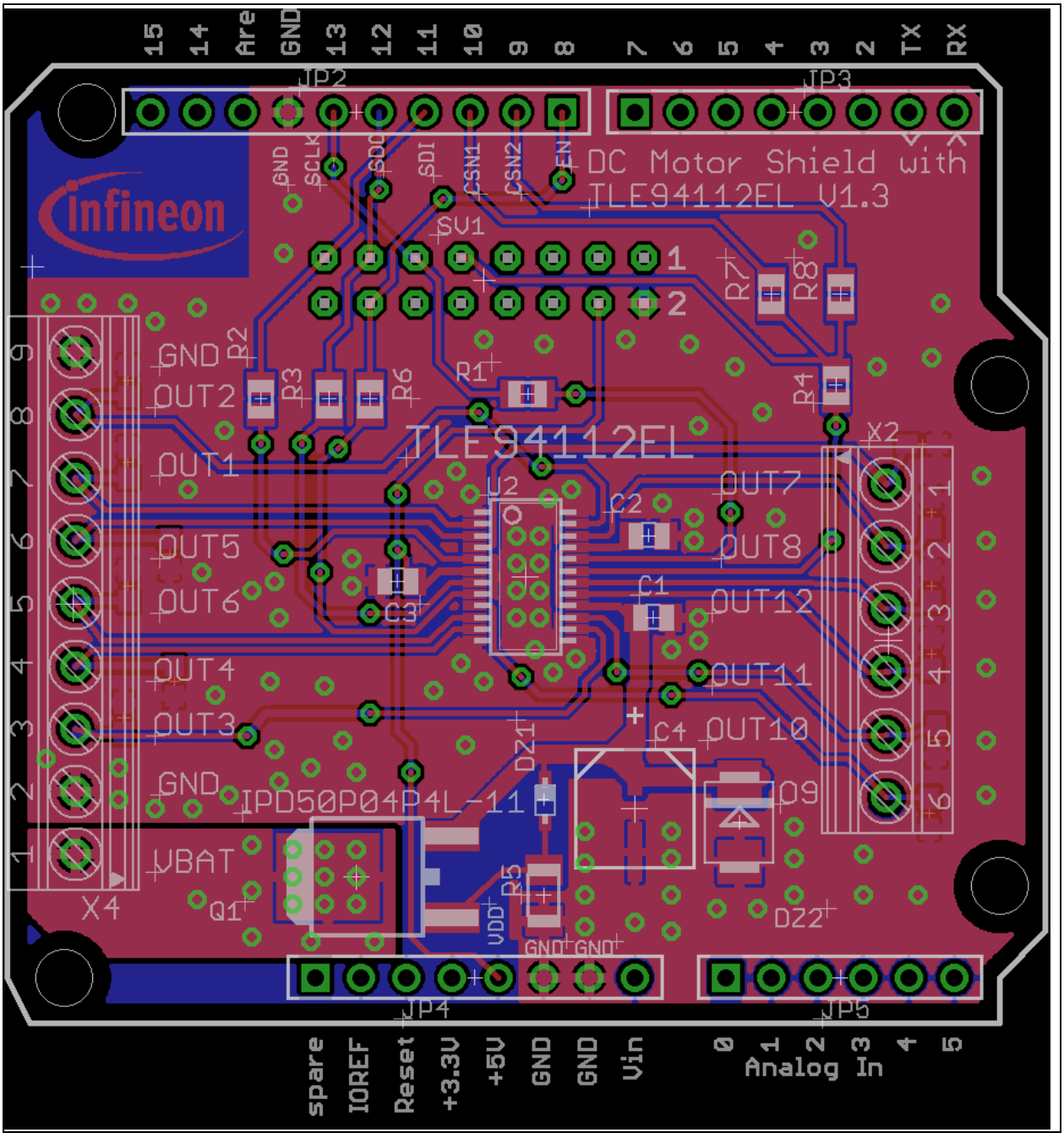

Figure 3 Figure 6 DC Motor Control Shield for Arduino with TLE94112EL – Layout

2.4 Bill of Material of the DC Motor Shield

Part	Part number	Manufacturer	Description	Qty	Distributor	Order Number	Comment
C1, C2, C3	C0805C104K5RAC	Kemet	Capacitors 100n/50V	3	Farnell	2070445	
C4	EEE-FT1H470AP	Panasonic	Capacitor 47µF/50V	1	Farnell	1868425	
DZ1	MM3Z12VT1G	ON Semiconductor	Zener 12V	1	Farnell	1431191	
DZ2	SM6T39A	STMicroelectronics	Transient suppressor diode, 39V	1	Farnell	9802703	
IC1	TLE94112EL	Infineon	12-fold half-bridge driver	1	Mouser	726-TLE94112ELXUMA1	
JP2	JT254F-D180-850-110-10DO-G	MTCONN	Stacking header - 10 pins	1			
JP3, JP4	JT254F-D180-850-108-10DO-G	MTCONN	Stacking header - 8 pins	2			
JP5	JT254F-D180-850-106-10DO-G	MTCONN	Stacking header - 6 pins	1			
Q1	IPD50P04P4L-11	Infineon	40V p-channel MOSFET	1	Farnell	2443434	
R1, R2, R3, R4, R6	WR08X4700FTL	Walsin	Resistor	5	Farnell	2502730	
R5	CRCW12064K70FKEA	Vishay	Resistor	1	Farnell	1470013	
R7	WR08X000	Walsin	Resistor	1	Farnell	2502664	
R8	WR08X000	Walsin	Resistor	1	Farnell	2502664	Not mounted
X2	31059106	Metz Connect	6-Position terminal block, 3.5mm	1	Farnell	2434247	
X4	OSTTE090104	On Shore Technology	9-Position terminal block, 3.5mm	1	Digikey	ED2747	

Figure 7 DC Motor Control Shield with TLE94112EL – Bill of Material (BOM)

2.5 CSN1 and CSN2 Selection

The Pin 10 of the Arduino Uno is used by default to control CSN (Negated Chip Select) input of the TLE94112EL (Figure 8).

Alternatively, the pin 9 of the Arduino Uno can be used instead to stack two shields (refer to section 2.6). In this case, the resistor R7 (0 Ω, case 0805) must be desoldered (Figure 9) and a 0 Ω resistor (case 0805) must be soldered on the footprint of R8 (Figure 9)

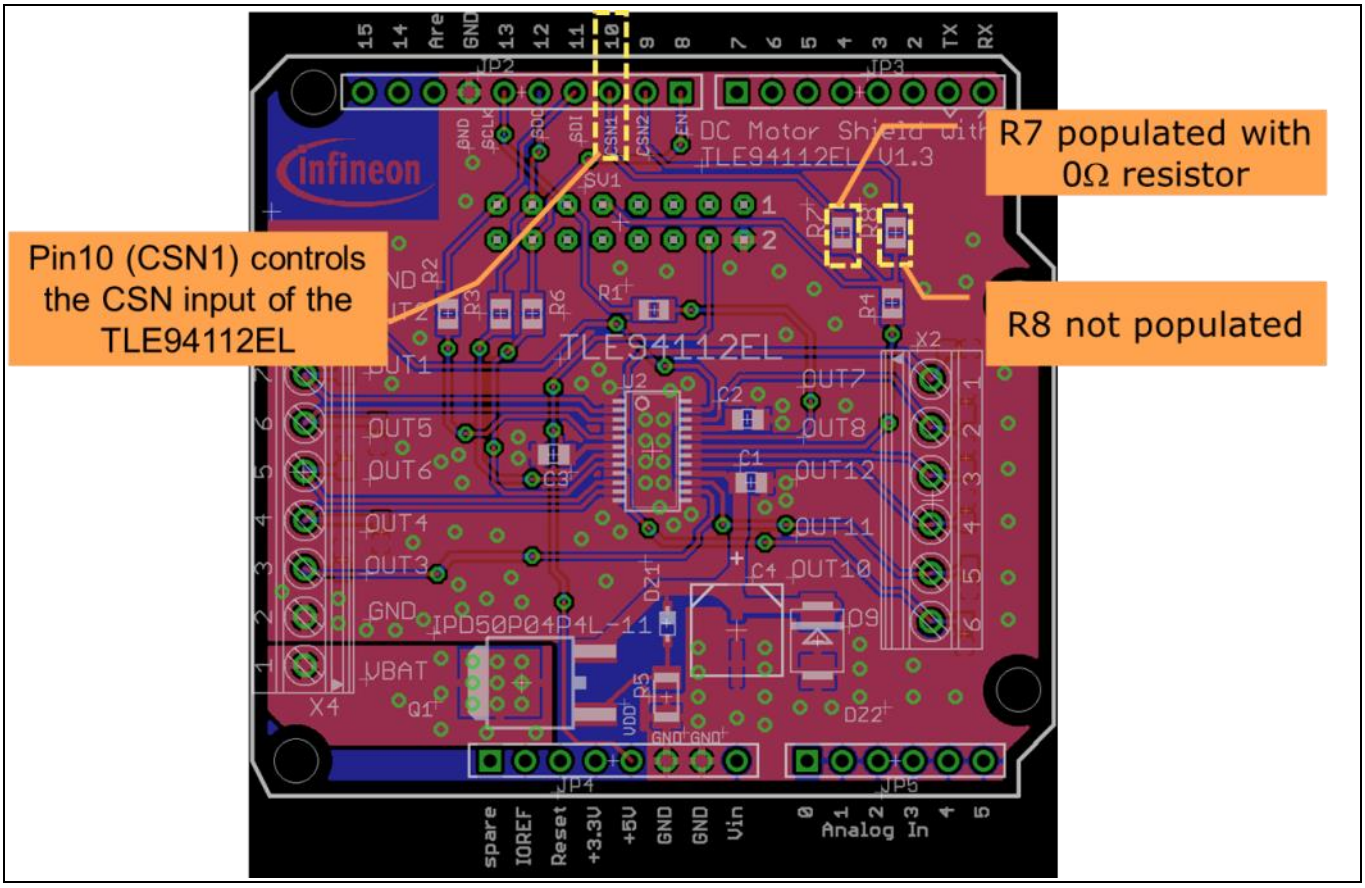

Figure 4 Figure 8 Control of CSN of TLE94112EL by Pin 10 (CSN1)

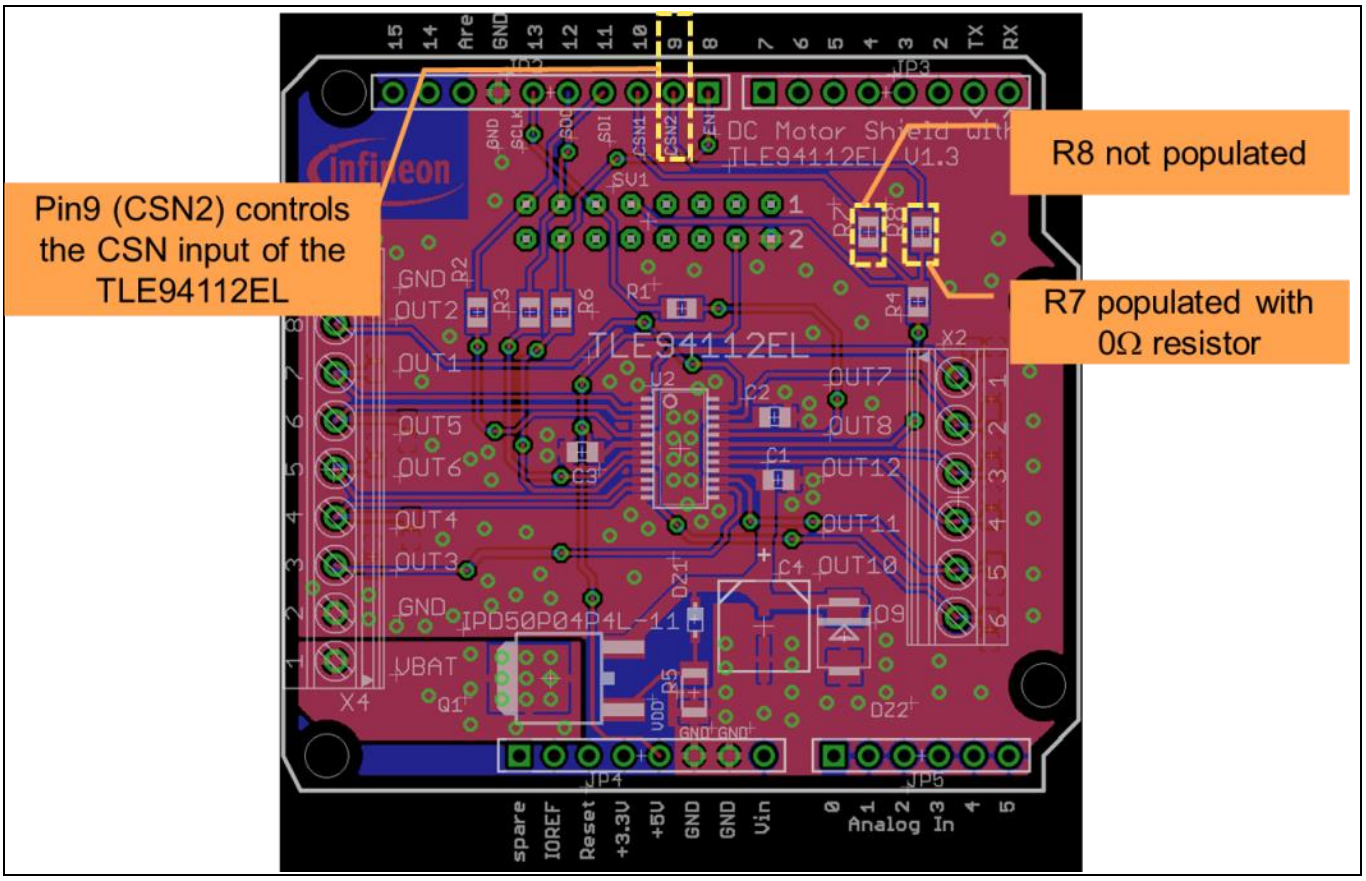

Figure 5 Figure 9 Control of CSN of TLE94112EL by Pin 9 (CSN2)

2.6 Stacking two DC Motor Shields

It is possible to stack two DC Motor Shields to double the number of controlled motors.

In this configuration, the CSN input of each TLE94112EL must be controlled individually by different microcontroller GPIOs:

- The TLE94112EL of one DC Motor shield is controlled by the pin 10 (default setting, Figure 8).
- The TLE94112EL of the other DC Motor shield is controlled by the pin 9 (Figure 9).

2.7 Pin assignment

To use the DC Motor Control Shield, the necessary control signals can be applied directly at the Arduino™ connectors with an Arduino, an XMC 1100 Boot Kit or any other microcontroller.

Figure 10 shows the pinout/connectors of the DC Motor Shield with TLE94112EL.

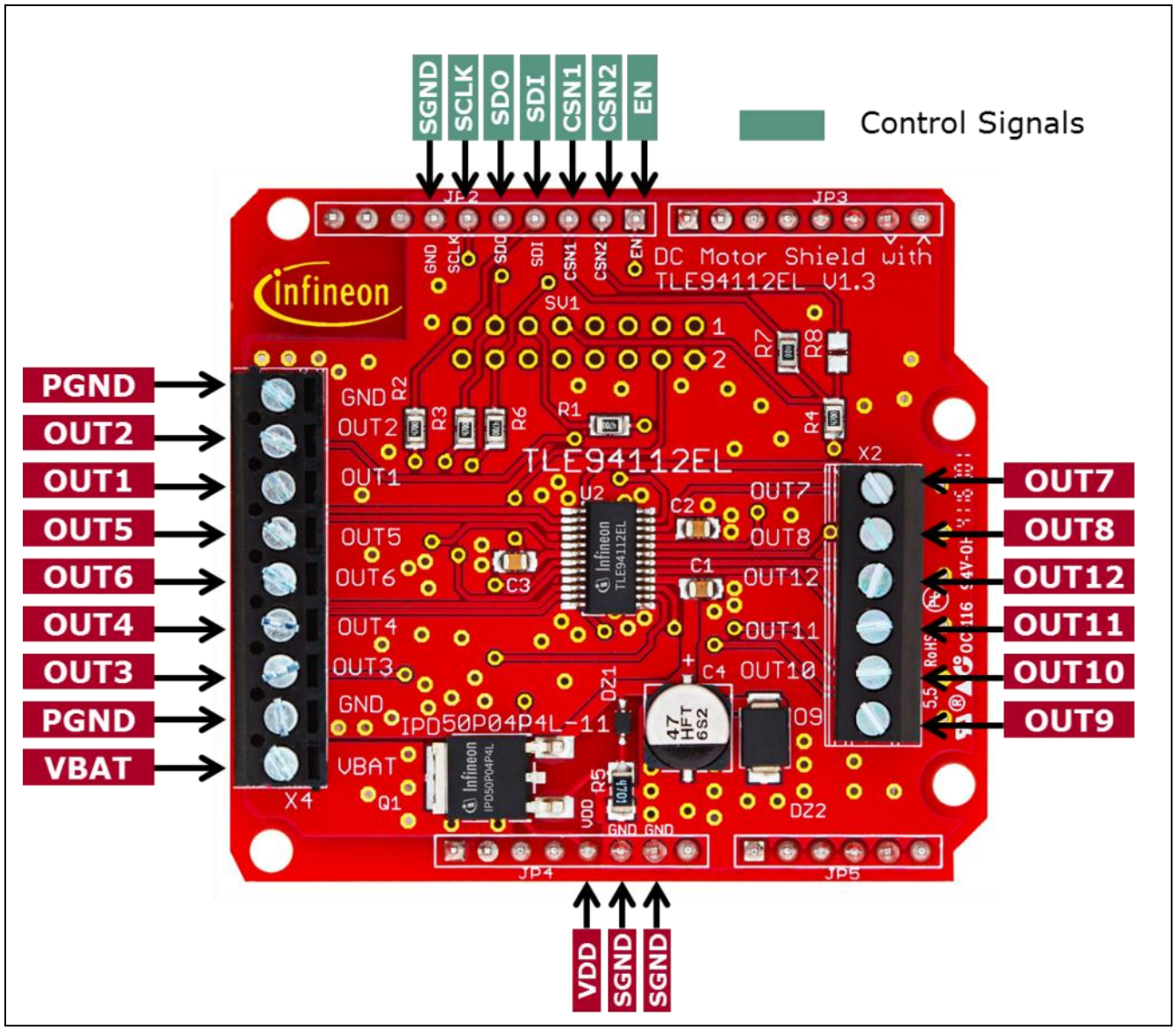

Figure 10 Connectors of DC Motor Shield

2.8 Pin definitions and functions

Pin	I/O [1]	Function
SGND	-	Signal GND Connect to the signal GND of the microcontroller
PGND	-	Power GND Connect one of the connector to the power GND the application
VBAT	-	Battery supply (5.5 – 20 V operating, 40V absolute max. rating) Connect to the battery voltage of the application
VDD	-	Logic supply (5V for Arduino Uno)
SCLK	I	Serial Clock Input [2]
SDI	I	Serial Data Input [2]
SDO	O	Serial Data Output [2]
CSN1	I	Negated Chip Select 1 [2,3]
CSN2	I	Negated Chip Select 2 [2,3]
EN	I	Enable Input Connect to a GPIO of the microcontroller. When set to low device goes in sleep mode with low current consumption.
OUT1-12	O	Connectors for outputs of the half-bridges 1-12

[1] With respect to the TLE94112EL

[2] Connect these signals to an SPI interface of the microcontroller

[3] Refer to chapters CSN1 and CSN2 Selection and 2.6

3 TLE94112EL overview

The TLE94112EL is a protected twelve-fold half-bridge driver designed especially for automotive motion control applications such as heating, ventilation and air conditioning (HVAC) flap DC motor control. It is part of a larger family offering half-bridge drivers from three outputs to twelve outputs with direct interface or SPI interface.

The half bridge drivers are designed to drive DC motor loads in sequential or parallel operation. Operation modes forward, reverse, brake and high impedance are controlled from a 16-bit SPI interface. It offers diagnosis features such as short circuit, open load, power supply failure and overtemperature detection.

In combination with its low quiescent current, this device is attractive among others for automotive applications. The small fine pitch exposed pad package, PG-SSOP-24, provides a good thermal performance and reduces PCB-board space and costs.

3.1 Key features of the TLE94112EL

- Twelve half-bridge power outputs
- Optimized EMC behavior
- Very low power consumption in sleep mode
- 3.3V / 5V compatible inputs with hysteresis
- All outputs with overload and short circuit protection
- Independently diagnosable outputs (overcurrent, open load)
- Open load diagnostics in ON-state for all high-side and low-side
- Outputs with selectable open load thresholds (HS1, HS2)
- 16-bit Standard SPI interface with daisy chain and in-frame response capability for control and diagnosis
- Fast diagnosis with the global error flag
- PWM capable outputs for frequencies 80Hz, 100Hz and 200Hz with 8-bit duty cycle resolution
- Overtemperature pre-warning and protection
- Over- and Undervoltage lockout
- Cross-current protection
- AEC-100 Qualified

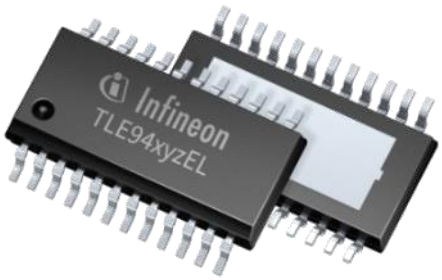

Figure 11 PG-SSOP-24 Package

3.2 Block diagram

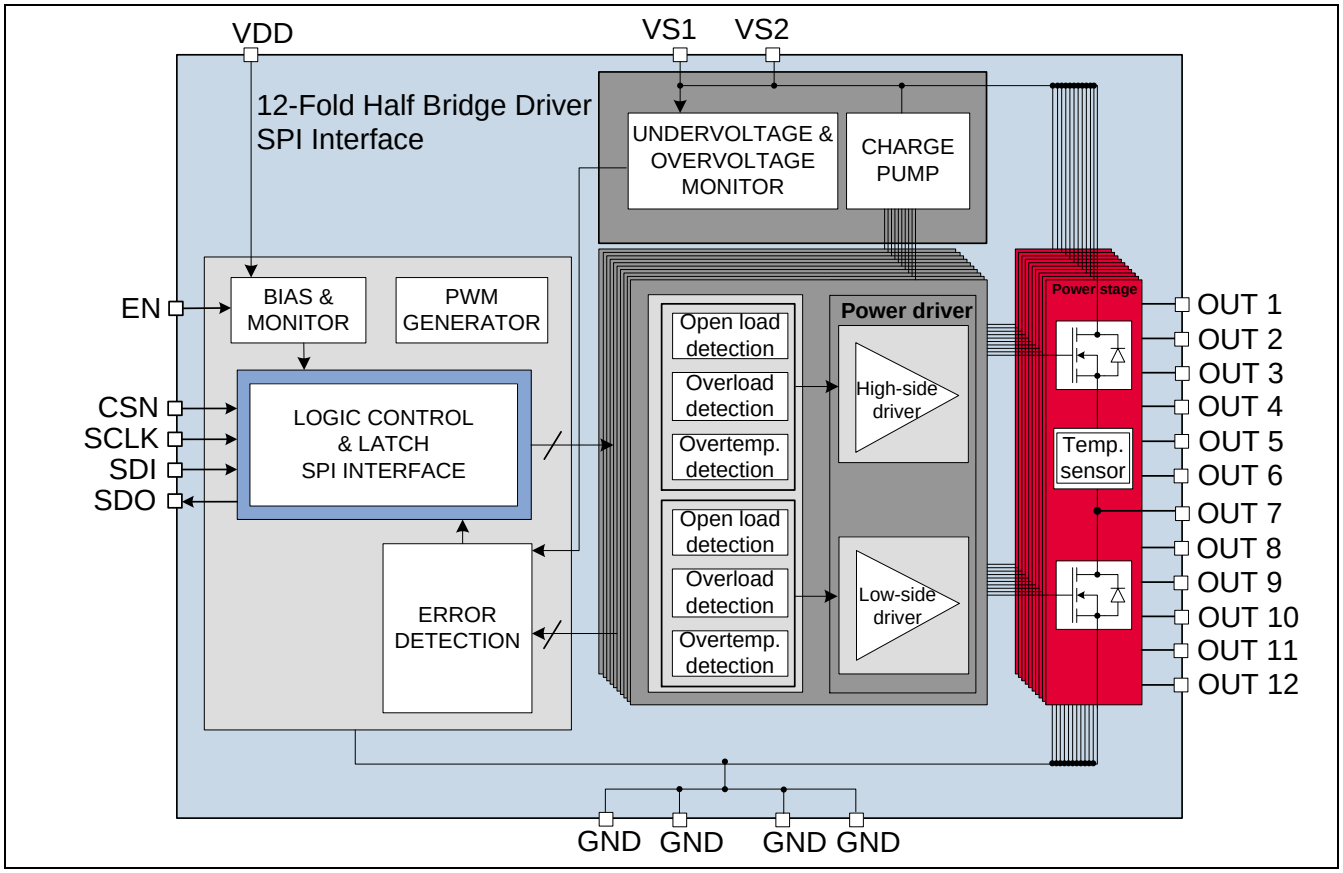

Figure 12 Block diagram TLE94112EL

3.3 Pin assignment

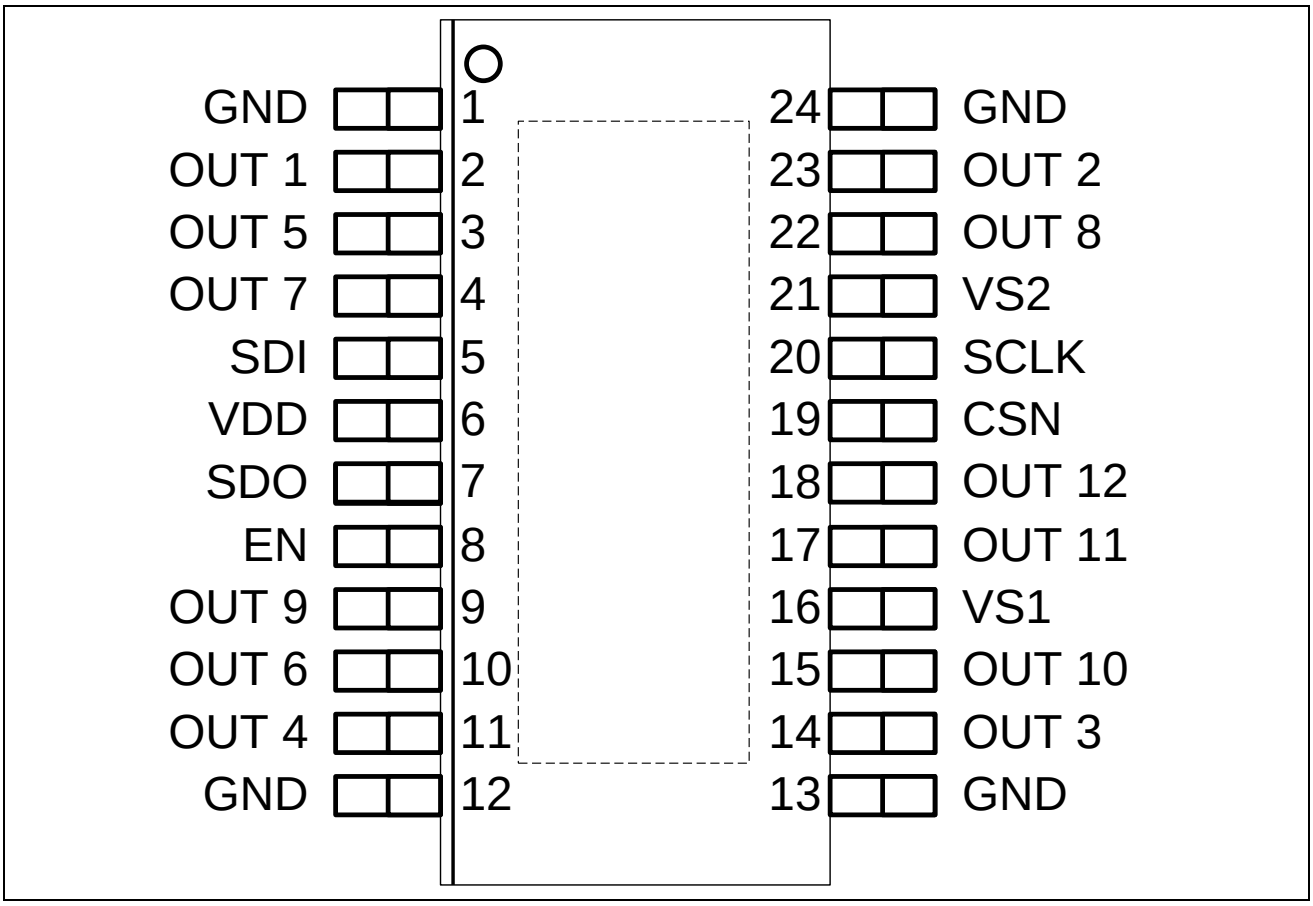

Figure 13 Pin assignment TLE94112EL (top view)

3.4 Pin definitions and functions

Pin	Symbol	Function
1	GND	Ground. All ground pins should be externally connected together.
2	OUT 1	Power half-bridge 1
3	OUT 5	Power half-bridge 5
4	OUT 7	Power half-bridge 7
5	SDI	Serial data input with internal pull down
6	VDD	Logic supply voltage
7	SDO	Serial data output
8	EN	Enable with internal pull-down; Places device in standby mode by pulling the EN line Low
9	OUT 9	Power half-bridge 9
10	OUT 6	Power half-bridge 6
11	OUT 4	Power half-bridge 4
12	GND	Ground. All ground pins should be externally connected together.
13	GND	Ground. All ground pins should be externally connected together.
14	OUT 3	Power half-bridge 3
15	OUT 10	Power half-bridge 10
16	VS1	Main supply voltage for power half bridges. VS1 should be externally connected to VS2.
17	OUT11	Power half-bridge 11
18	OUT12	Power half-bridge 12
19	CSN	Chip select Not input with internal pull up
20	SCLK	Serial clock input with internal pull down
21	VS2	Main supply voltage for power half bridges. VS1 should be externally connected to VS1.
22	OUT 8	Power half-bridge 8
23	OUT 2	Power half-bridge 2
24	GND	Ground. All ground pins should be externally connected together.
EDP	-	Exposed Die Pad; For cooling purpose only - not usable as electrical ground. Electrical ground must be provided by pins 1, 12, 13, 24

4 Getting started

4.1 Target applications

The main application targeted by the TLE94112EL is brushed DC motor control with peak currents below 0.9A. Several outputs can be connected in parallel to increase the current capability.

Besides motor control, the TLE94112EL can drive any other inductive, capacitive and resistive loads within the device electrical characteristics such as monostable relays, bistable relays and LEDs.

4.2 Getting started: Shield

- Connect the brushed DC motors to the corresponding output connectors (OUTx, x=1… 12). Refer to Figure 14.
- Choose a DC adapter
    - The extended operating input range of the shield (VBAT) is 5.5 V – 20 V DC.
    - The absolute maximum rating is 40 V.
- Connect the DC Motor Shield to e.g. an Arduino Uno R3 or an XMC 1100 Boot Kit. The control signals between the TLE94112EL and the Arduino Uno R3 or XMC1100 are linked to each other (Figure 15).
- Connect the USB cable to e.g. the Arduino Uno R3 (Figure 16) or the micro USB to the XMC 1100 Boot Kit.
    - Once the software is flashed to the microcontroller a, a standard mobile phone charger can be used to supply the XMC 1100 Boot Kit
- Program the controller board with the motor control software with the corresponding IDE.
- Connect the DC adapter to the Power Shield (VBAT and GND, see Figure 16).
- Turn on the power.

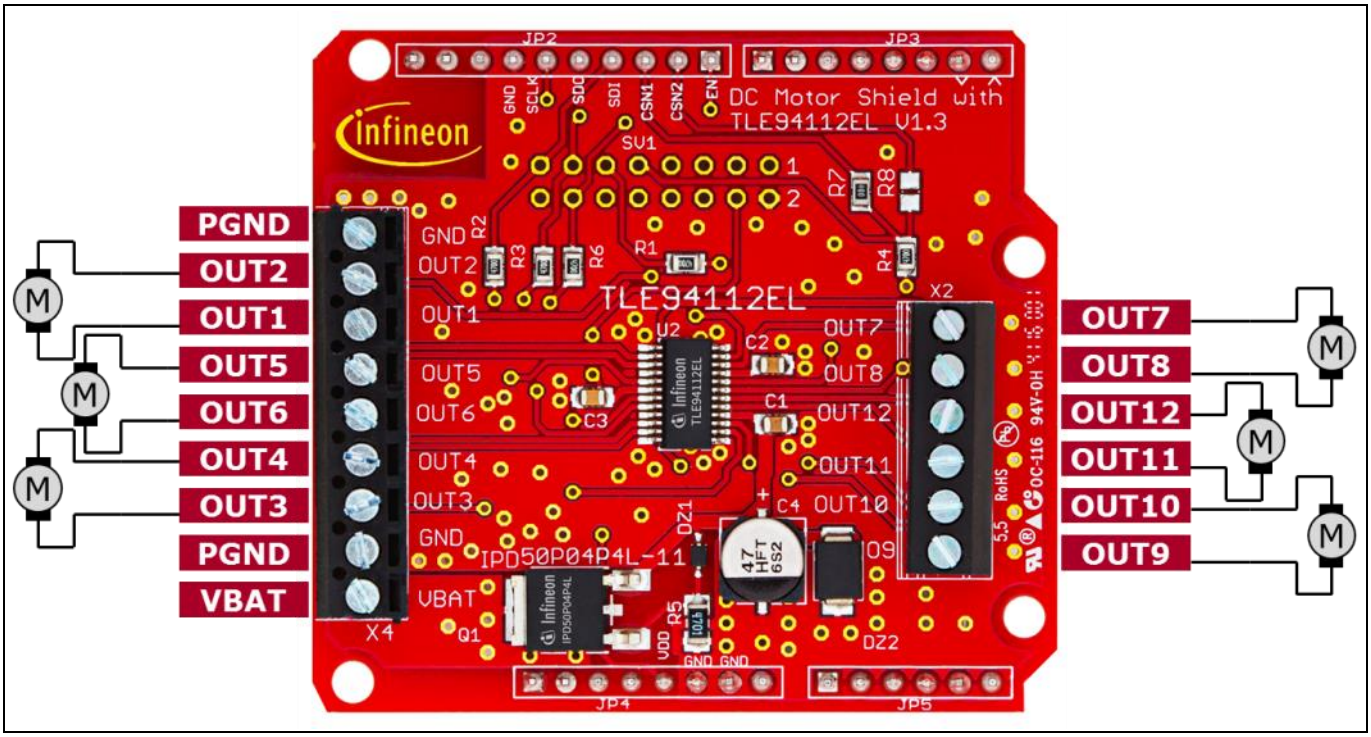

Figure 14 Motor Control Shield connectors

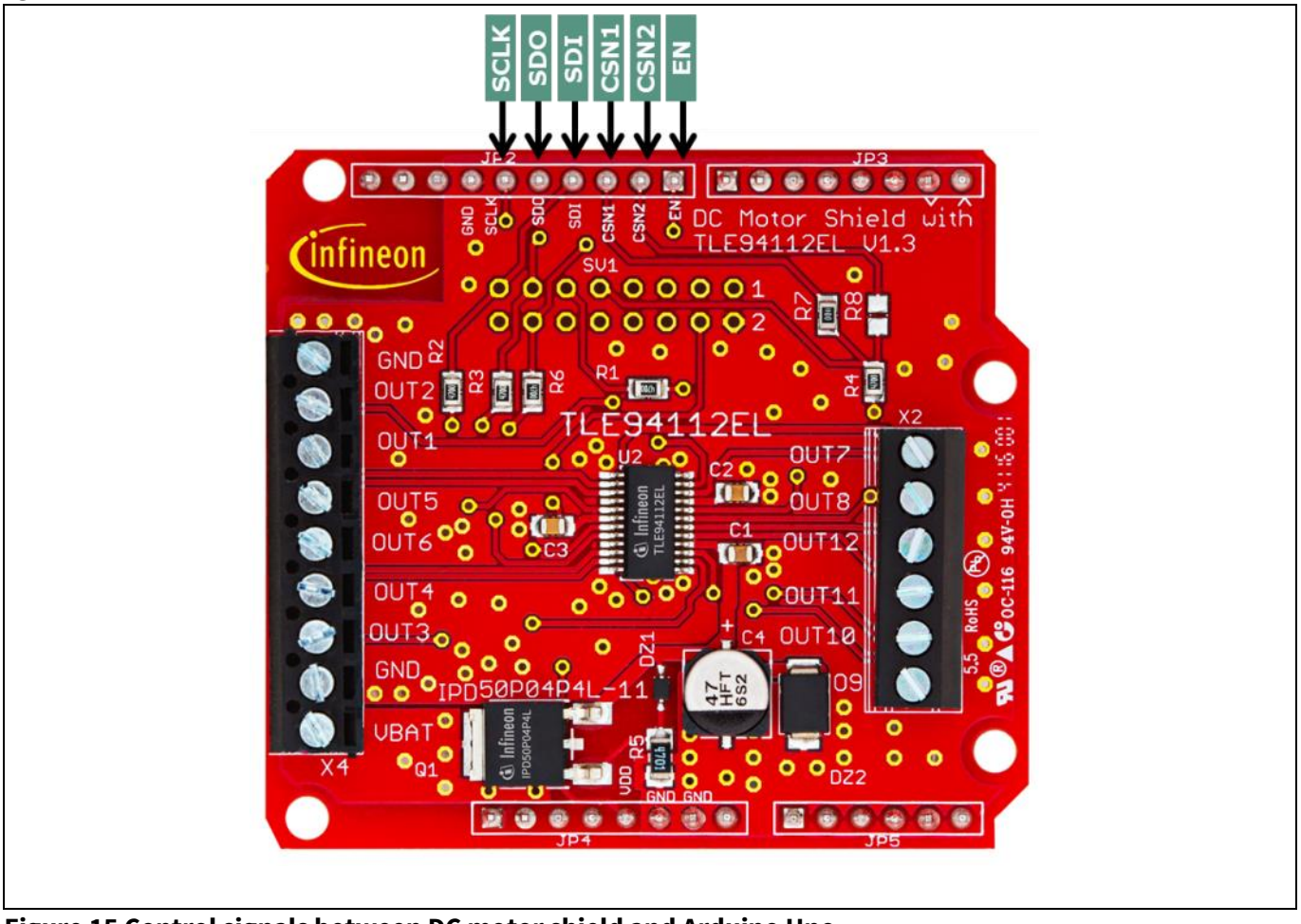

Figure 15 Control signals between DC motor shield and Arduino Uno

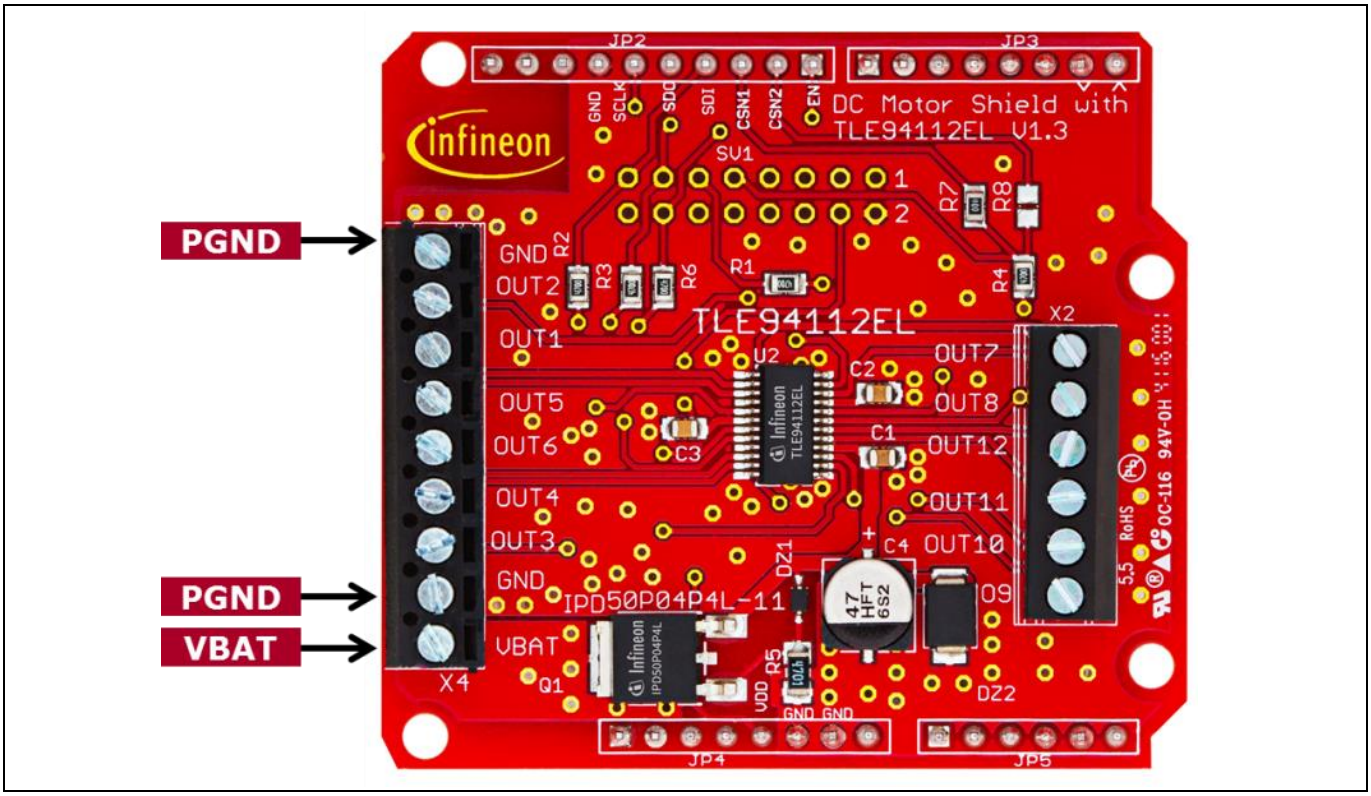

Figure 16 Supply connection

4.3 Getting started: Software

Download the sketch example for the DC Motor Shield with TLE94112 for Arduino (TLE94112EL_Shield_Arduino_Example_Sketch Link).

Connect the Arduino Uno with a USB cable to the USB port of your PC.

- Download and install the Arduino IDE: free Development Platform for Code Generation from Arduino. Link: **Arduino IDE**
- Start the Arduino IDE and import the project file: TLE94112EL_Shield_Arduino_Example_Sketch (Link).
- Upload the sketch to the Arduino Uno

4.4 Sketch example for DC motor shield

The TLE94112EL-Sketch example (Link) is intended to operate with shields configured as shown in Figure 4: The CSN input of the TLE94112EL is controlled by the Pin 10 of the Arduino Uno board.

Sketch content:

- Declarations of register addresses
- Functions to read / write and clear registers of the TLE94112EL
- Function to display the SPI frames sent/received by the TLE94112EL on the IDE Serial Monitor
- Motors activation in loop:
    1. The motor connected between OUT1/OUT2 operates in PWM mode / 100 Hz
        - During 2 seconds: Low-Side 2 (LS2) ON, High-Side 1 (HS1) ON with 90 % duty cycle / 100 Hz
        - During 2 seconds: LS2 ON, HS1 ON with 20 % duty cycle / 100 Hz
        - Brake to GND for 300 ms: LS1 and LS2 ON
    2. Activation of six motors (connected to OUT1/2, OUT3/4, OUT5/6, OUT7/8, OUT9/10 and OUT11/12)
        - During 1 second:
            - LS1, LS3, LS5, LS7, LS9, LS11 ON
            - HS2, HS4, HS6, HS8, HS10, HS12 ON
        - Brake to GND for 300 ms:
            - LS1-12 ON
        - During 1 second:
            - HS1, HS3, HS5, HS7, HS9, HS11 ON
            - LS2, LS4, LS6, LS8, LS10, LS12 ON
        - Brake to GND for 300 ms:
            - LS1-12 ON

5 Revision History

Major changes since the last revision

Page or Reference	Description of change
V1.0, 2017-02-13	First release

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