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User Manual

EVAL6470H-RPi : Dual stepper motor driver board, based on the L6470, for Raspberry Pi

Introduction

The EVAL6470H-RPi board is an expansion board dedicated for Raspberry Pi platform. Up to 4 boards can be stacked on the Raspberry Pi.

It is an evaluation board for motor control applications in the range of 8V to 45V of DC bus voltage using the L6470H fully integrated solution suitable for driving two-phase bipolar stepper motors up to 1/128 microstepping.

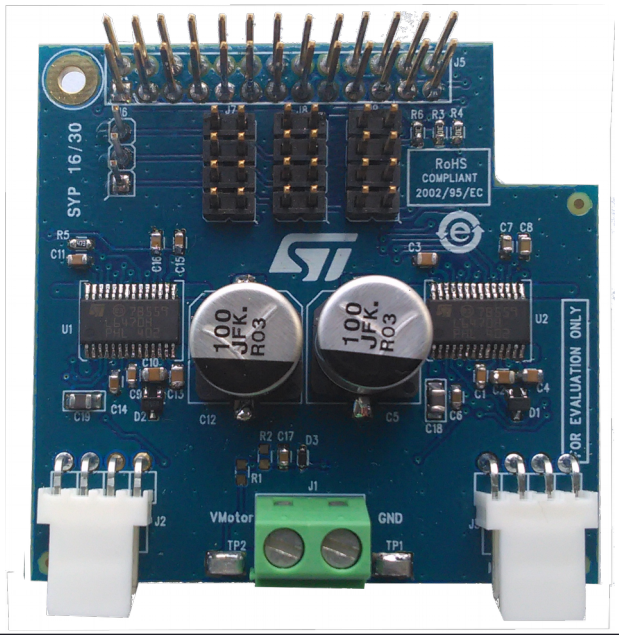
Each board contains 2 L6470H so up to 8 stepper motors can be driven with 4 stacked boards.

The L6470H integrated a dual DMOS full bridge with all of the power switches equipped with an accurate on-chip current sensing circuitry suitable for non-dissipative current control and overcurrent protection.

The EVAL6470H-RPi board is designed to help developers evaluate the device and develop their own applications. It comes with a complete library, developed on Linux, to drive up to 8 stepper motors.

The EVAL6470H-Rpi board is provided under the Open Hardware license.

Figure 1 Image of the board



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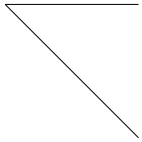


1. Main features

The characteristics of the EVAL6470H-RPi board are the following:

- DC voltage range from 8 V to 45 V
- Maximum load phase current at 3 Arms
- Up to 1/128 micro stepping
- Extension connector compatible with all existing version of Raspberry Pi : Zero, A+, B, B+, RPi2 and RPi3.
- Possibility to stack up to 4 EVAL6470H-RPi boards : 8 stepper motors.
- Optimized layout on 2 layers board – low cost and high thermal performance

1.1 Target applications

The demonstration board is designed to fit all typical stepper motor applications, using a Raspberry Pi platform.

1.2 Description

The EVAL6470H-RPi is controlled by the Raspberry Pi platform on which it is plugged.

2. Electrical characteristics of the board

Table 1 Electrical specifications

Name	Value
Supply voltage (V_S)	8 to 45 V
Maximum output current (each phase)	3 A r.m.s
Logic supply voltage (V_{REG})	3 V (internal supply)
Logic interface voltage (V_{DD})	3.3 V (internal supply)
Low level logic inputs voltage	0 V
High level logic input voltage	V_{DD}
Stepping	Up to 1/128 micro stepping
Operating temperature	0 to 85°C

3. **Schematic, layout and bill of material**

Figure 2 Schematic (Motion control part)

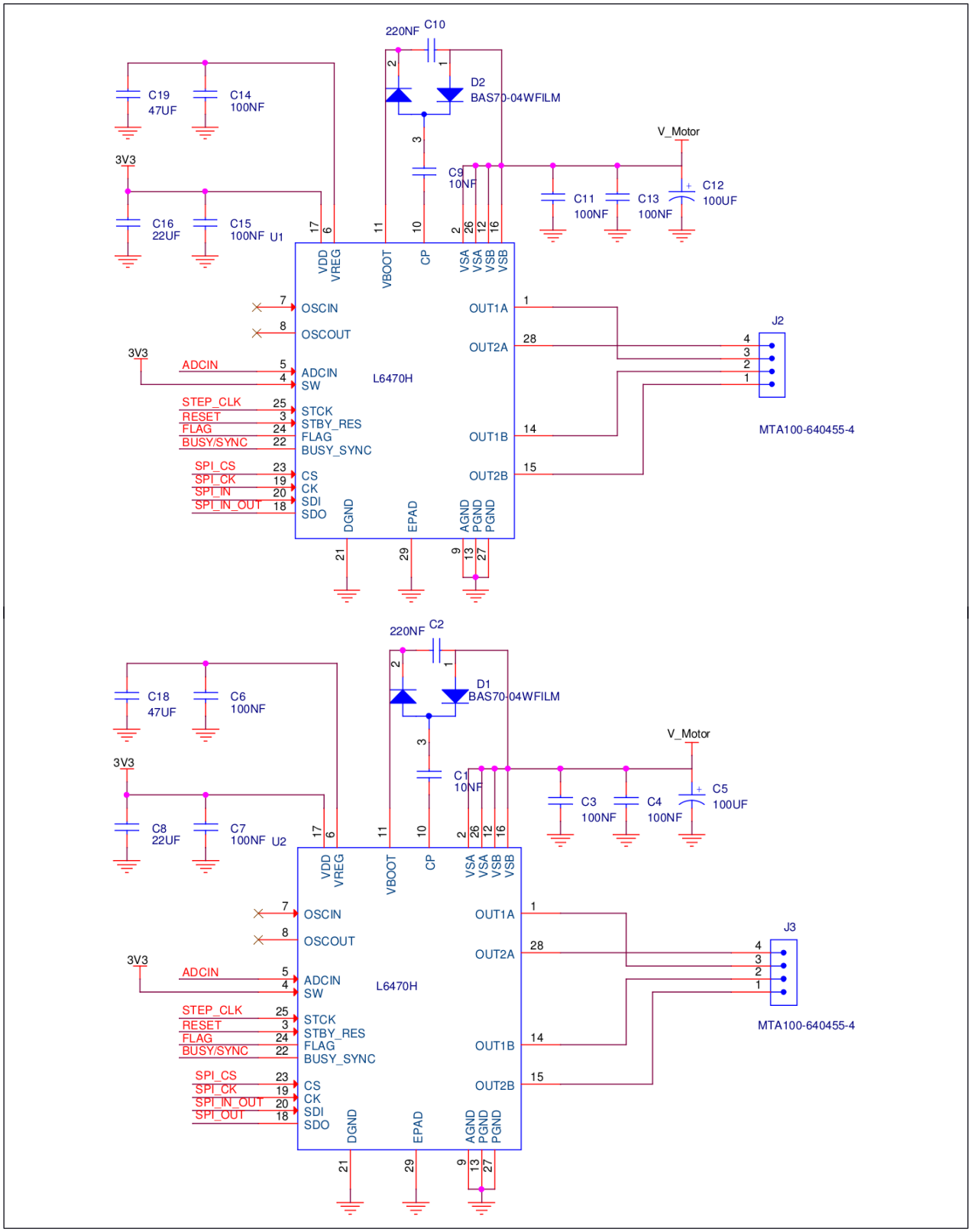


Figure 3 Schematic (Raspberry Pi connector part)

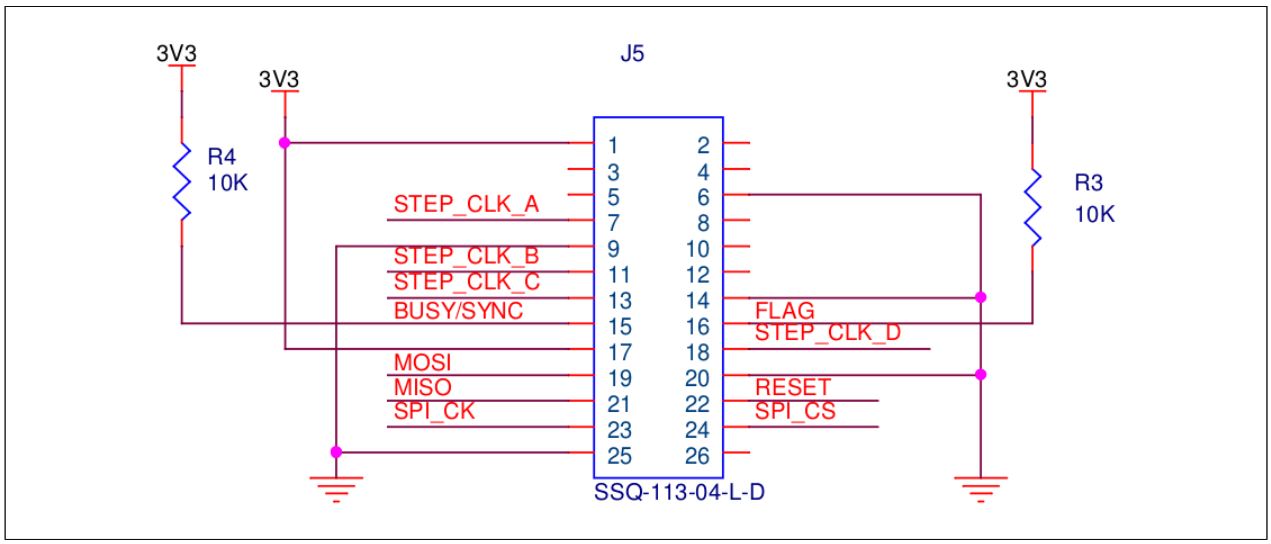


Figure 4 Layout (silk screen)

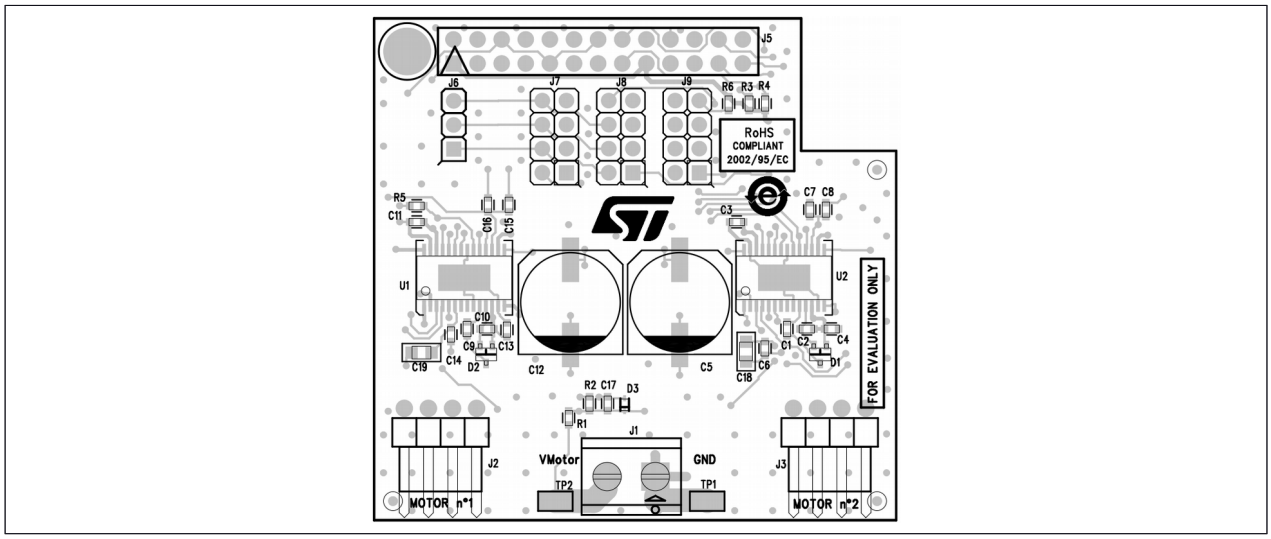


Figure 5 Layout top layer and bottom layer

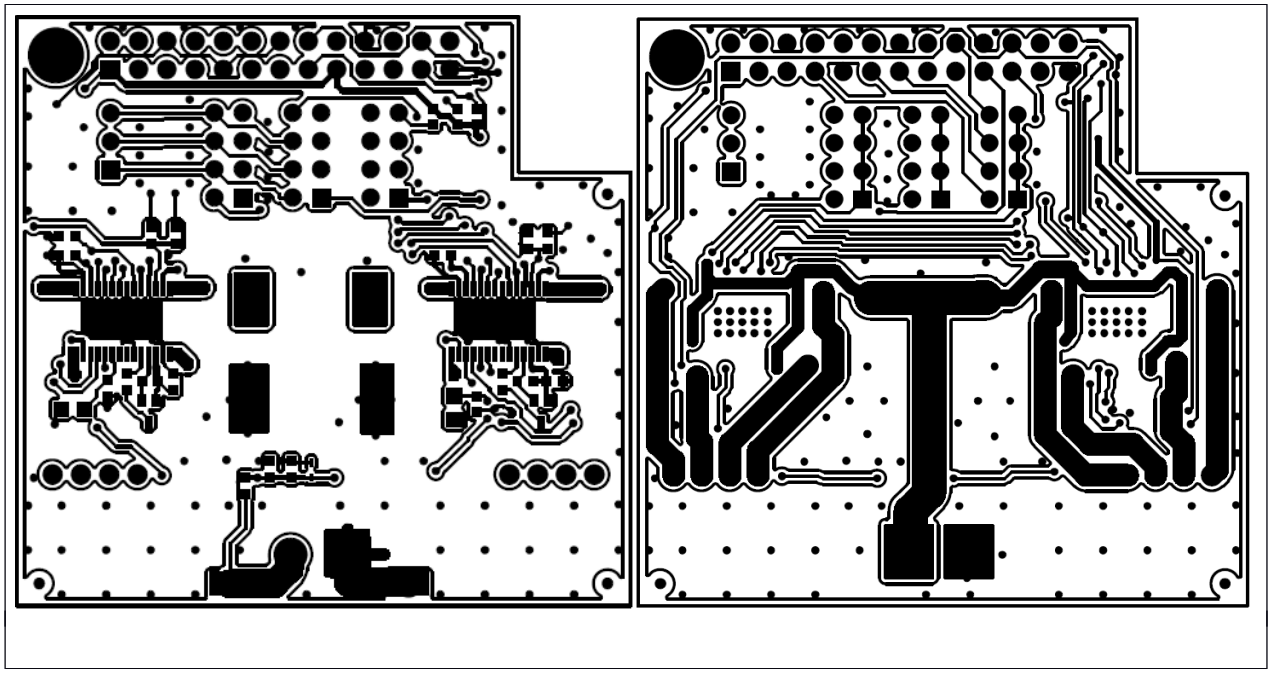


Table 2 Bill of material

Item	Quantity	Reference	Value	Package
C1,C9	2	10NF_50V_X7R_0603	10NF	603
C2,C10	2	220NF_50V_X7R_0603	220NF	603
C3,C4,C11,C13	4	100NF_100V_X7R_0603	100NF	603
C5,C12	2	EEE1JA101P	100UF	D10_H10.2
C6,C7,C14,C15,C17	5	100NF_50V_X7R_0603	100NF	603
C8,C16	2	22UF_6V3_X5R_0603	22UF	603
C18,C19	2	47UF_10V_X5R_0805	47UF	805
D1,D2	2	BAS70-04WFILM	BAS70-04WFILM	SOT323
D3	1	BZX585-B3V6	3.6V	SOD523
J1	1	691213510002	691213510002	
J2,J3	2	640455-4	MTA100-640455-4	

J5	1	SSQ-113-04-L-D	SSQ-113-04-L-D	
J6	1	SSQ-103-04-F-S	SSQ-103-04-F-S	
J7,J8,J9	3	61300821121	61300821121	
M1,M2,M3	3	OPTICAL_TARGET	OPTICAL_TARGET	
M4	1	HOLE_2.6MM_5	HOLE_2.6MM_5	
R1,R2	2	R_NP_0603	NP	603
R3,R4,R6	3	10K_5%_0603	10K	603
R5	1	47K_5%_0603	47K	603
TP1,TP2	2	S1751-46R	S1751-46R	
U1,U2	2	L6470H	L6470H	HTSSOP28

4. General description

4.1 Power supply

The EVAL6470H-RPi board is designed to be powered by

- by the Raspberry Pi that provides the 3v3 and
- by the connector J1 that provides power of the motor.

The motor power must be set according the voltage required by the user motor.

If several boards are stacked, motor power shall be connected to each board.

4.2 L6470 stepper motor driver

The L6470 is an advanced fully integrated solution suitable for driving two-phase bipolar stepper motors with micro-stepping. It integrates a dual low Rds(on) DMOS full bridge.

1. Features :
   - Operating voltage : 8 – 45V
   - 7.0 A out peak current (3.0 A r.m.s.)
   - Low RDS(on) Power MOSFETs
   - Programmable speed profile and positioning
   - Programmable power MOS slew rate
   - Up to 1/128 micro stepping
   - Sensor less stall detection
   - SPI interface
   - Low quiescent and standby currents
   - Programmable non-dissipative overcurrent
   - Two-levels of over temperature protection

Figure 6 L6470 block diagram

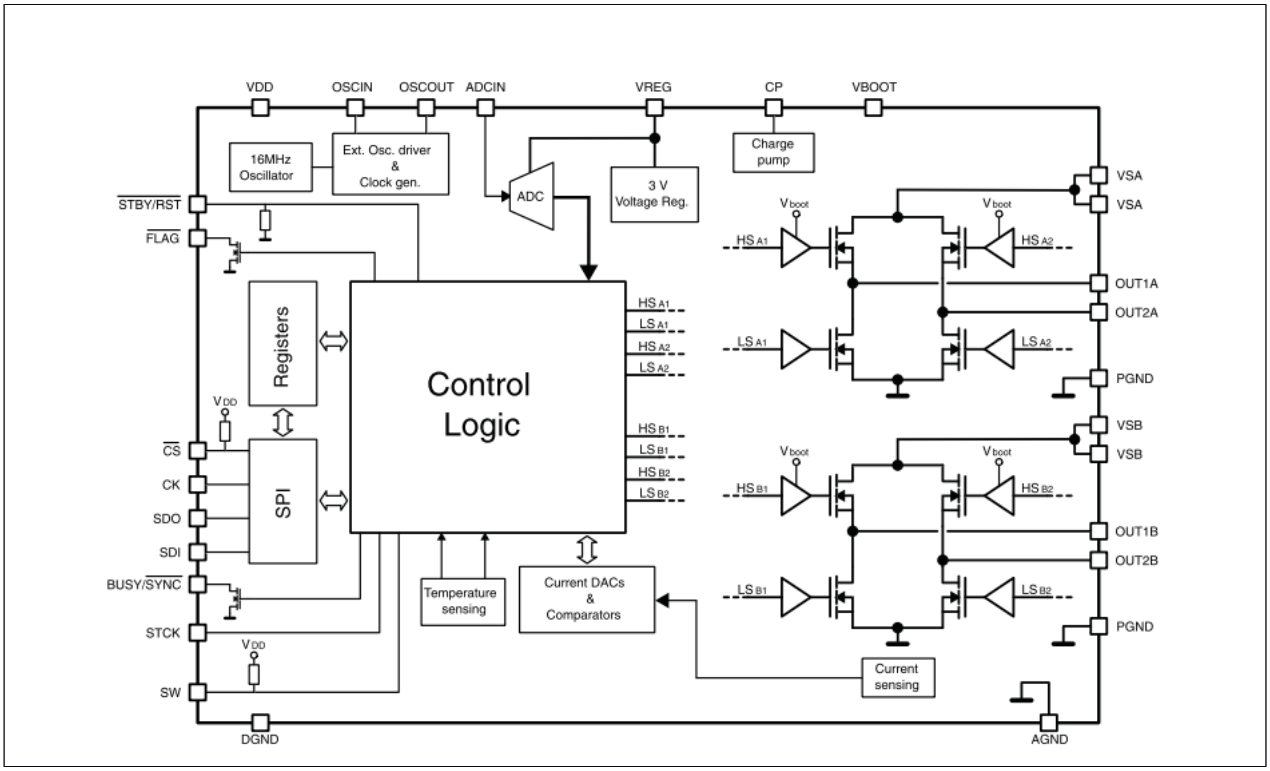


Table 3 L6470 Recommended operating conditions

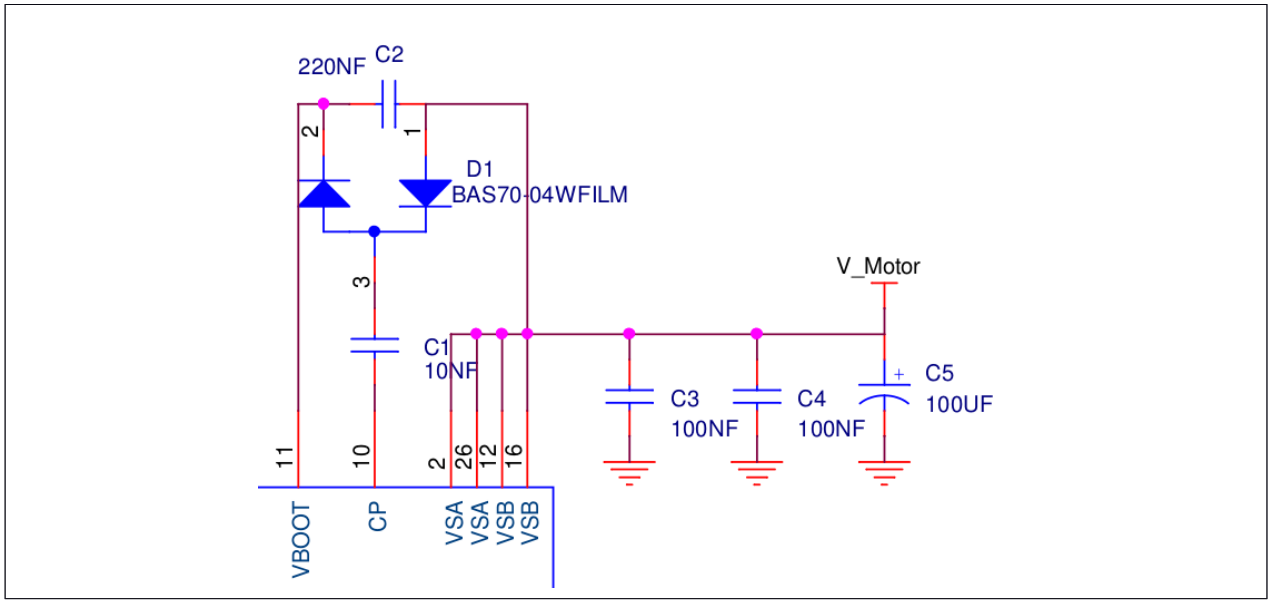
Symbol	Parameter	Test condition	Value	Unit
V_{DD}	Logic Interface supply voltage		3.3	V
V_S	Motor supply voltage	$V_{SA}=V_{SB}=V_S$	Mini: 8 Maxi: 45	V
V_{OUT_diff}	Differential between voltage VsA, OUTI1A, OUT2A,PGND and VSB,OUT1B,OUT2B, PGND pins	$V_{SA}=V_{SB}=V_S$	Maxi: 45	V
$V_{REG\ in}$	Logic supply voltage	V_{REG} internal	3	V
V_{ADC}	Integrated ADC input voltage range (ADCIN pin)		Mini 0 Maxi: V_{REG}	V

4.3 L6470 description

4.3.1 Charge pump

The L6470H use an internal charge pump for driving correctly the integrated MOSFETs, a voltage higher than the motor power supply. The charge pump is obtained through an oscillator and few external components.

Figure 7 Charge pump circuitry



Charge pump of one L6470H. Similar circuitry is used for the second.

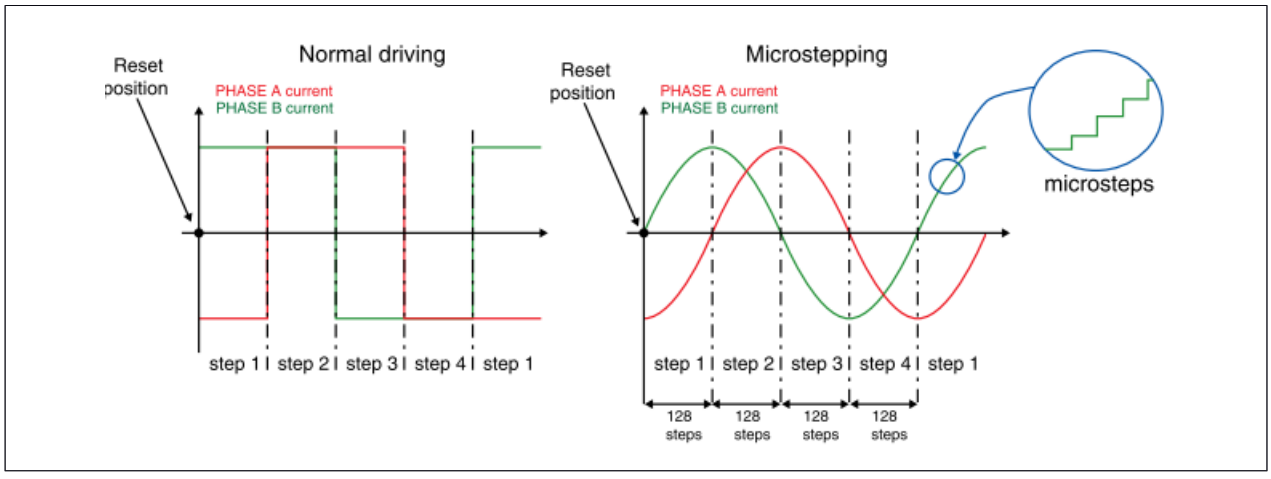
4.3.2 Micro-stepping

The EVAL6470H-RPi is able to divide the single step into up to 128 micro-steps. The stepping mode could only be change when bridges are disables.

We could also control several functions of motor:

- Automatic full step mode : the board switch automatically to full step mode when motor speed is greater than a programmable speed – and come back in micro-stepping when the motor is lower than this programmable speed.
- Position of motor : the current position is following by the board
- Speed profiles : the user could program customized profile defining independently acceleration, deceleration, maximum and minimum speed.

Figure 8 Normal mode and micro-stepping (128 micro-steps)



4.3.3 Control detection

The EVAL6470H-RPi provide warnings and flags for control of main motor features

- Overcurrent detection : a Flag Over Current detection is set if exceeds programmed overcurrent is detect on the power MOSFETs

- Under-voltage lockout : this flag is set if the motor voltage is too low
- Thermal warning and thermal shutdown : an internal sensor detect when the device internal temperature exceeds a thermal warning or an over-temperature threshold
- External switch : this switch input may be used by specific command (GoUntil and ReleaseSW)
- Analog to digital converter: an integrated ADC 5 bit compares the voltage from ADCIN pin with a reference voltage equal to VREG.

4.3.4 Phase current control

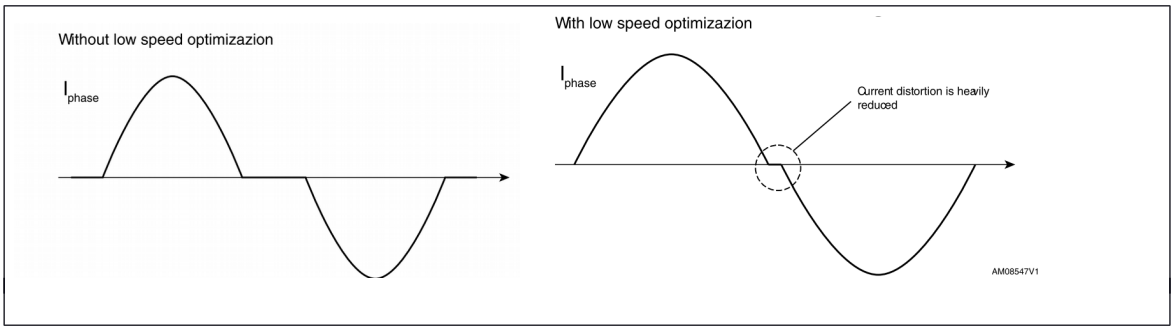
The EVAL6470H-RPi controls the phase current applying a sinusoidal voltage to motor windings. Phase current amplitude is not directly controlled but depends on phase voltage amplitude, load torque, motor electrical characteristics and rotation speed.

The two voltage sine waves applied to the stepper motor phases are generated by two PWM modulators – the system offers various methods to guarantee a stable current value allowing the compensation of:

- Low speed optimization :

  The system removes the sine-wave distortion due the low motor speed

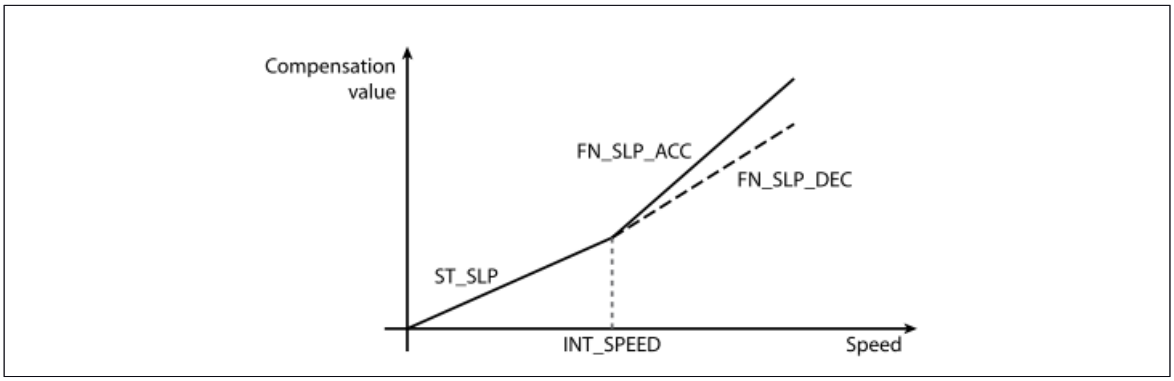
Figure 9 Current distortion and compensation



- Back electromotive force value :

  Using the speed information, a compensation curve is added to the amplitude of the voltage waveform applied to the motor winding in order to compensate the BEMF variations during acceleration and deceleration

Figure 10 BEMF compensation curve

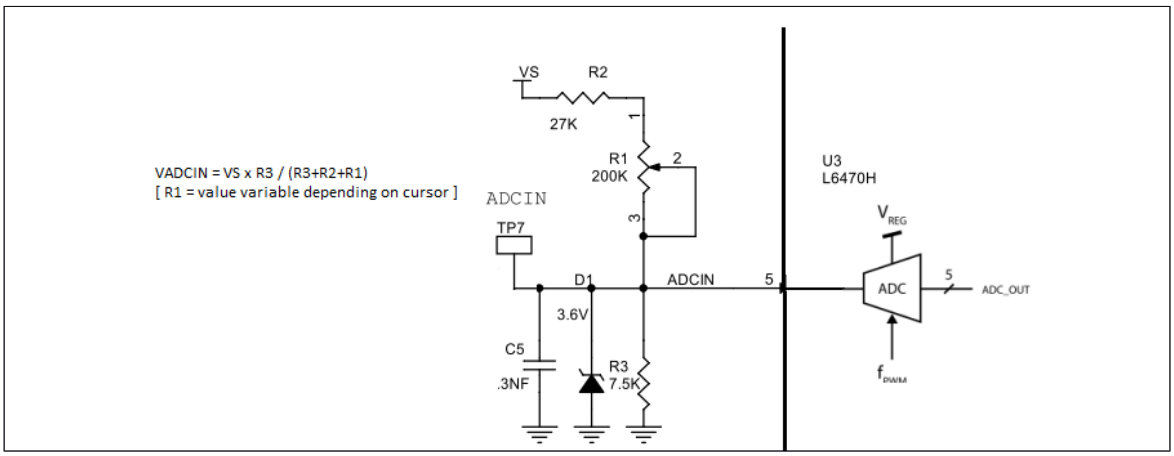


- Motor supply voltage variation

  When the motor supply voltage is different from its nominal value, the system can compensate motor supply voltage variations to avoid driven by incorrect voltage.

The trimmer allow to have a fine voltage at VREG/2 (1.50 Volts) at ADC pin

Figure 11 Motor supply voltage compensation circuit



- Windings resistance variation

  The system compensate phase resistance increment due to temperature rising.

4.3.5 Advances features

Several functions provided by L6470 enable the following advanced features:

- Motor positioning
  The user could define a motor position
- Speed profiles
  User can easily program acceleration, deceleration, maximum and minimum speed.
- Motion command
  Possibility to send directly command as Move – Run – Go Until – HardStart –SoftStart –HardHiz and SoftHiz
- Voltage mode driving
  Several threshold secure the equipment (overcurrent detection – under voltage protection – thermal warning and thermal shunt down)

These advanced features are independent and are controlled by different types of commands and by several registers. All details are available in the data sheet L6470H available on ST site.

The Linux library provides an API for all of these features. This API is described in the “L647X Linux Library User Manual”. This library works with the L6470 and also with the L6472.

4.4 Raspberry Pi © platform

The Raspberry Pi is a small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation. A series of Raspberry Pi (RPi) has be developed: RPi A+, RPi B, RPi B+, RPi 2, RPi 3 and RPi Zero.

The Raspberry Pi expansion connector is compatible between model revisions as shown by the Figure 12.

More information on Raspberry Pi can be found at: https://www.raspberrypi.org/

Figure 12 Raspberry Pi expansion connector

Raspberry Pi B rev. 2

	Pin No.		
3.3V	1	2	5V
GPIO2	3	4	5V
GPIO3	5	6	GND
GPIO4	7	8	GPIO14
GND	9	10	GPIO15
GPIO17	11	12	GPIO18
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
GPIO10	19	20	GND
GPIO9	21	22	GPIO25
GPIO11	23	24	GPIO8
GND	25	26	GPIO7

Key

Power +	UART
GND	SPI
I²C	GPIO

Raspberry Pi Zero, A+, B+, 2 and 3

	Pin No.		
3.3V	1	2	5V
GPIO2	3	4	5V
GPIO3	5	6	GND
GPIO4	7	8	GPIO14
GND	9	10	GPIO15
GPIO17	11	12	GPIO18
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
GPIO10	19	20	GND
GPIO9	21	22	GPIO25
GPIO11	23	24	GPIO8
GND	25	26	GPIO7
DNC	27	28	DNC
GPIO5	29	30	GND
GPIO6	31	32	GPIO12
GPIO13	33	34	GND
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
GND	39	40	GPIO21

5. **Board configurations : SPIn In / SPIn Out**

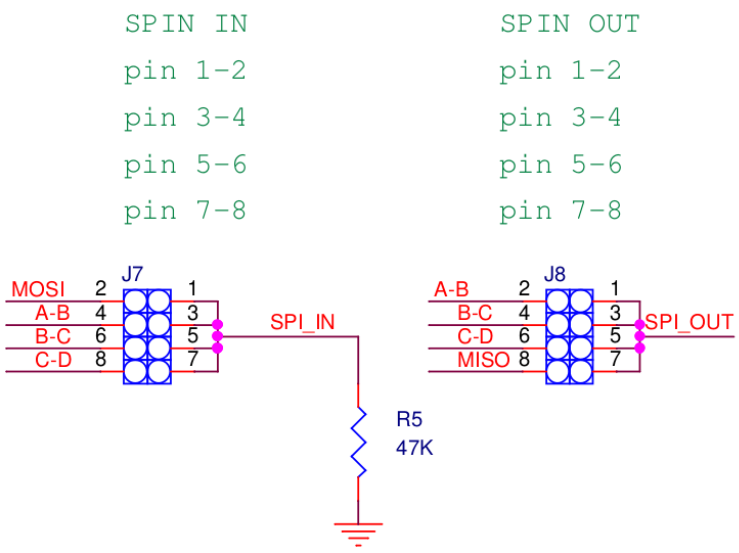
This chapter describes how to stack and configure the EVAL6470H-RPi board, depending on the number of board.

Up to 4 boards can be stacked. Each board contains 2 L6470H motor driver, so up to 8 L6470H can be driven by the Raspberry Pi.

On an EVAL6470H_RPi board, the SPI of the two L6470H are already chained. SPI In of the first L6470H comes from J7 jumper. SPI Out of the first L6470H is connected to SPI In of the second L6470H and SPI Out of the second L6470H goes to J8 jumper.

Jumper schematic is shown by the Figure 13

Figure 13 SPI jumper



The configuration of jumper, depending on the number of stacked board, is given by the Table 4.

Table 4 Jumper configuration

	Board n°1		Board n°2		Board n°3		Board n°4	
	J7	**J8**	**J7**	**J8**	**J7**	**J8**	**J7**	**J8**
1 board	Pin 1-2	Pin 7-8						
2 boards	Pin 1-2	Pin 1-2	Pin 4-3	Pin 7-8				
3 boards	Pin 1-2	Pin 1-2	Pin 3-4	Pin 3-4	Pin 5-6	Pin 7-8		
4 boards	Pin 1-2	Pin 1-2	Pin 3-4	Pin 3-4	Pin 5-6	Pin 5-6	Pin 7-8	Pin 7-8

6. Using the EVAL6470H-RPi with the Raspberry Pi demonstration distribution

In order to demonstrate the capabilities of the EVAL6470H-RPi board in association with the Raspberry Pi platform, a dedicated RPi distribution is provided. This distribution is based on a Raspbian Jessie Lite.

A quick start guide is available to ease setup of the demonstration platform. This document identifier can be find in reference section under number .

7. References

This user manual provides information on the hardware features and use of the EVAL6470H-DISC board along with the demonstration firmware and software. For additional information, refer to documents listed in Table 5.

Table 5 References

Reference	Document Id	Name
1	CD00220364	TM32F105xx datasheet
2	RM0008	STM32F105xx reference manual
3	XXXXX	EVAL6470H-Rpi Quick Start Guide

8. **Revision history**

Table 6. Revision history

Date	Revision	Changes
2/23/2017	1.0	First release