Description

The AS025-HVPAK Motor Driver Pmod™ - Stepper Motor board combines a highly integrated HVPAK ™ IC, Current monitor, and protection function. The board can provide a quick configuration of Stepper motor. The board will be configured with one of the Quick connect boards on PMOD6A architecture. The motors like Stepper motor with direction and Step with Full steps/micro-steps are easily configurable. This will reduce the development and turnaround time of any customer.

Kit Contents

- AS025-HVPAK STM CONTROL BOARD

Features

- It will be suitable for a quick connect platform using the Pmod™ architecture.
- The same can be used as standalone development solution for HVPAK™ motor driver.
- The system solution can be extended for 1 Stepper motor driver.
- External current protection circuit provided using ISL28025 for additional system level hard reset and protection.
- I2C gives options for multiple dynamic configurations like Direction, Steps, Mode etc.

Evaluation Board

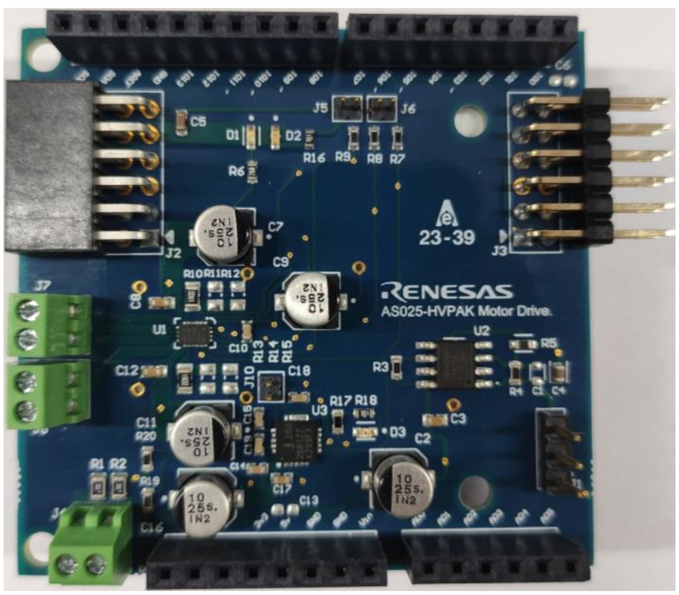


Figure 1: AS025-HVPAK

Contents

Table of Figures

List of Tables

AS025-HVPAK Overview

The AS025-HVPAK Motor Driver Pmod™ - Stepper Motor board combines a highly integrated HVPAK ™ IC. This design can provide Quick configuration with Stepper motor. ISL28025 is used to provide external current and voltage protection for the circuit. Design has low idle current consumption in combination with a compact size. Speed, direction control options provided using I2C.

The block diagram below highlights the main parts of the system:

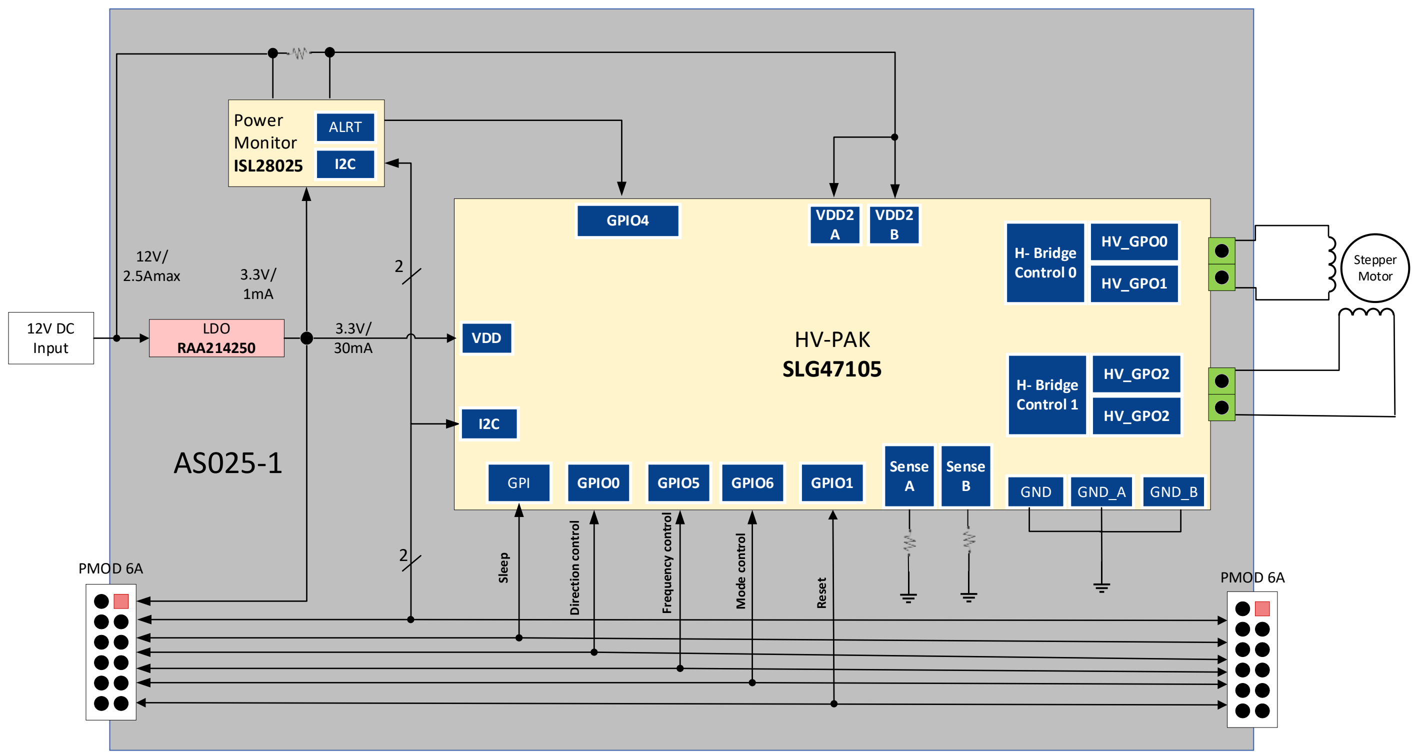


Figure 2: Block Diagram of AS025-HVPAK

The building blocks of the AS025-HVPAK and their functionality are listed below:

1. SLG47105: HVPAK™ Programmable Mixed-Signal Matrix with Four Outputs with Operating Voltage up to 13.2 V and up to 2 A Current per Output. SLG47105 has Full H-Bridge and Independent Half-Bridge Control.

2. RAA214250: The RAA214250 is a low-dropout linear voltage regulator that operates from 2.5V to 20V and provide up to 500mA of output current with a typical dropout of 269mV. The output voltage is adjustable with external feedback resistors anywhere from 1.224V to 18V.

3. ISL28025: Precision Digital Power Monitor with Real Time Alerts. The ISL28025 is a bidirectional high-side and low-side digital current sense and voltage monitor with a serial interface. The device monitors power supply current and voltage, which provides digital results along with calculated power.

Hardware Overview

The following block diagrams have specific applications explained below.

1. Power monitor Alert

The internal comparators of the ISL28025 can be configured to monitor the input supply voltage for undervoltage and overvoltage conditions. The comparator can signal the microcontroller to perform an action. A sense resistor, R1 & R2, is used to monitor the current delivered to the circuit load. The sense resistor is connected between the FB (feedback) and the VOUT pin of the ISL28025.

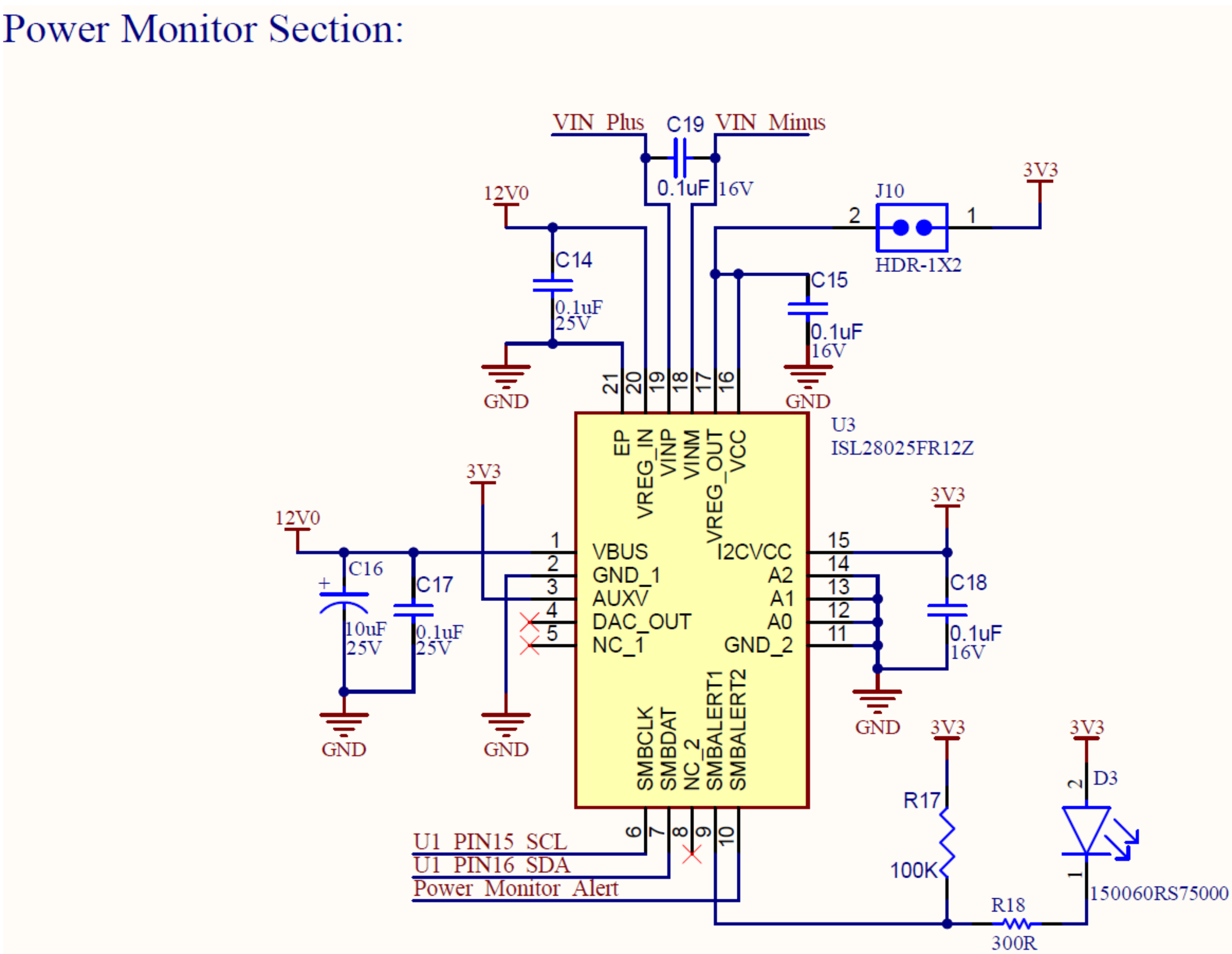


Figure 3: Power monitor section ISL28025FR12Z

2. LDO:

The RAA214250 output voltage (VOUT) used to programmed down to 3.3 V from12 v input using the feedback (FB) resistors, R4 and R5 and Low Dropout of 269mV at 500mA. RAA21450 has feature as short circuit current limit protection with fold-back at higher input voltage.

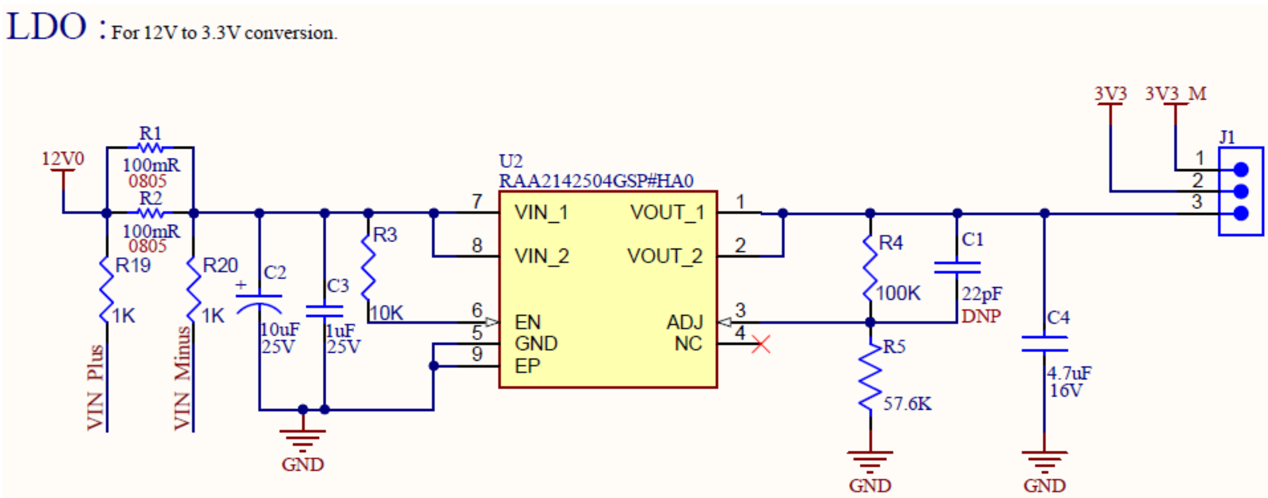


Figure 4: LDO Section

3. SLG47105V (HVPAK IC):

SLG47105 V provides Independent half-bridge control which allows dual bidirectional or four unidirectional motor operations. Build-in overcurrent and over-temperature protection reduces design complexity and enables higher system reliability, Flexible motor control with a programmable current sense comparator for current limiting or programmable overcurrent protection and R10, R13 used to limit the current. Low power consumption of Analog and Digital allows doing more in one IC. Smaller board space/smaller form factors; Constant motor speed with the variable Vin.

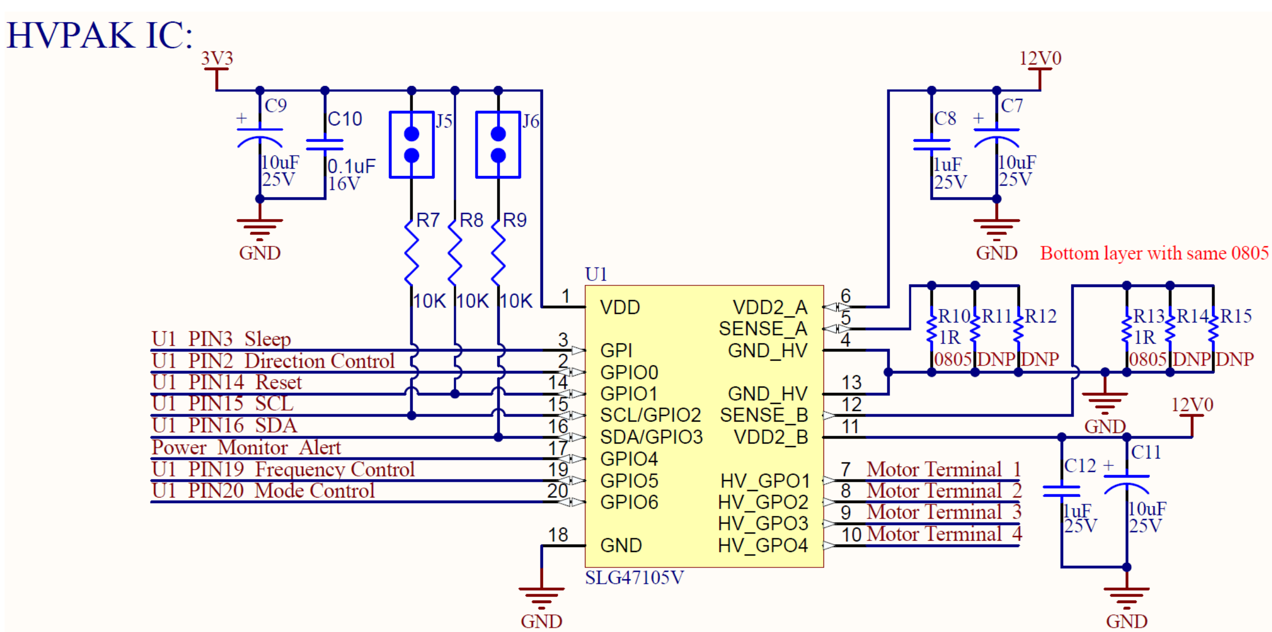


Figure 5: SLG47105 HVPAK

4. Pmod:

This interface conforms to the I2C specification, with an optional interrupt and reset pin plus some optional control signals. If these optional pins are not used, they will have no connection. The pull-up resistors used to provide the logic high level for SCL and SDA are provided on the modules and can be attached to or detached from the bus via onboard jumpers. Pull-ups on INT and RESET, if used, are also provided on the module, and can be attached or detached from the bus via onboard jumpers to enable daisy chaining.
An optional passthrough female Pmod connector may be added to the Pmod opposite to the side with the male connector. This connector may be a six-pin or 12-pin connector, though it should be considered that extra control signals, such as those on the lower row on a 12-pin connector, may not be appropriate for a pass-through connector due to the potential signal conflict if other modules in a daisy chain also used these control signal pins.

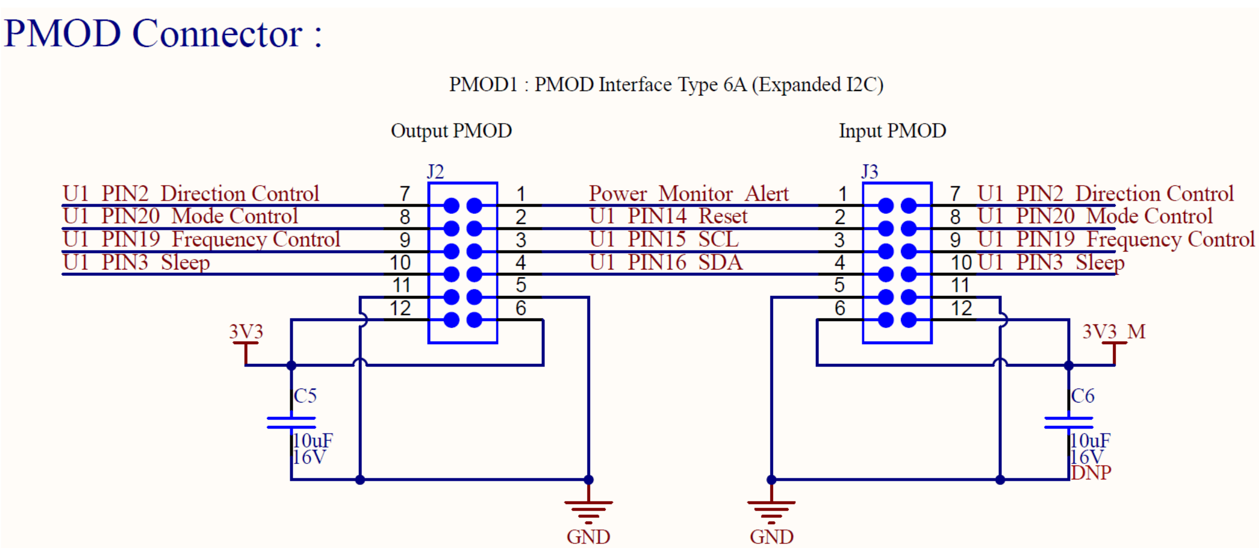


Figure 6: Pmod Interface Type 6A

5. LED: LEDs are used for power on indication and 3.3 v output indication.

Description of LEDs:

LED Color	Reference Designator	Function
Green	D1	Power up
Yellow	D2	3.3 v output indication

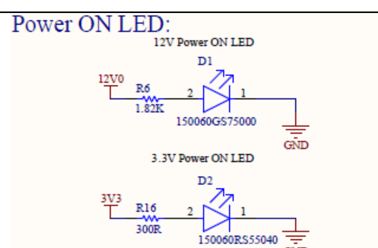


Figure 7: LED

6. Arduino connectors:

Near the center of the system control and ecosystem access is an Arduino uno R3 compatible connector interface.

Connector	Pin No.	Arduino Connection description
IOH	J-24-1	IO8/GPIO/CLKOUT
	J-24-2	IO9/GPIO/PWM(GTIOC7B)
	J-24-3	IO10/SSLA0/CTS_RTS9/PWM(GTIOC4A)
	J-24-4	IO11/MOSIA/TXD9/PWM(GPIOC5A)
	J-24-5	IO12/MISOA/RXD9/PWM(GTIOC5B)
	J-24-6	IO13/RSPCKA/SCK9/PWM(GTIOC4B)
	J-24-7	GND
	J-24-8	AREF
	J-24-9	SDA1
	J-24-10	SCL
IOL	J-23-1	IO0/RXD7
	J-23-2	IO1/TXD7
	J-23-3	IO2/IRQ13-DS/AN009
	J-23-4	IO3/IRQ3/PWM/(GTIOC3A)
	J-23-5	IO4/GPIO/PWM/(GTIOC2A)
	J-23-6	IO5/GPIO/PWM/(GTIOC2B)
	J-23-7	IO6/GPIO/PWM/(GTIOC6B)
	J-23-8	IO7/GPIO/PWM/(GTIOC7A)
POWER (J18)	J_18-1	VIN
	J_18-2	GND
	J_18-3	GND
	J_18-4	5v
	J_18-5	3.3V
	J_18-6	RESET
	J_18-7	IOREF
	J_18-8	NC
AD (J19)	J_19_1	AD0/AN000
	J_19_2	AD1/AN001
	J_19_3	AD2/AN003
	J_19_4	AD3/AN007
	J_19_5	AD4/DAC/AN012
	J_19_6	AD5/DAC/AN013

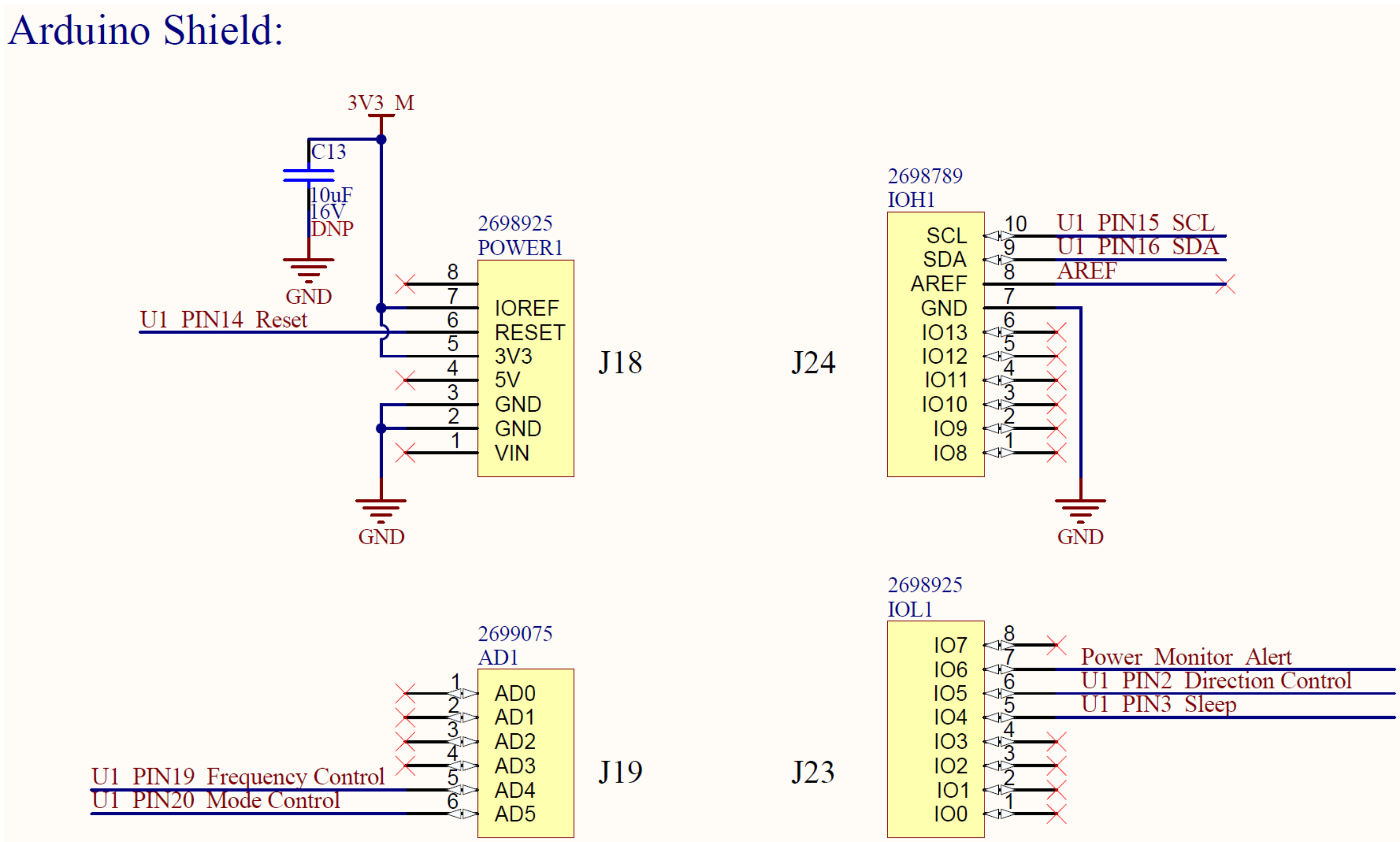


Figure 8: Arduino shield

Software Overview

Debugging using CS+

1. RL78/F14 can be programmed and debugged using CS+. Below are the steps to debug RL78/F14 using CS+. Open the RL78/F14 project in CS+ by double clicking the xxx.mtpj.

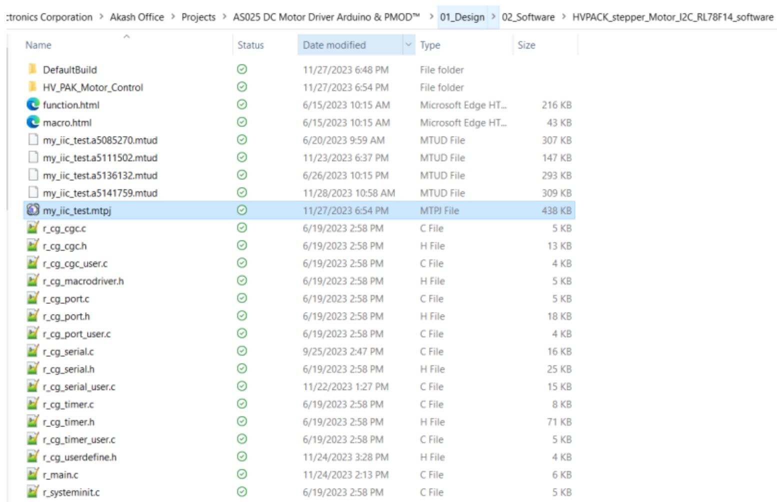


Figure 9: .mtpj file in the project

2. Once the project opens, click on build icon (marked as 1 in Figure: 10), or press F7 to build the project. Once build is successful, click on download icon (marked as 2 in Figure: 10), or press F6 to download the project.

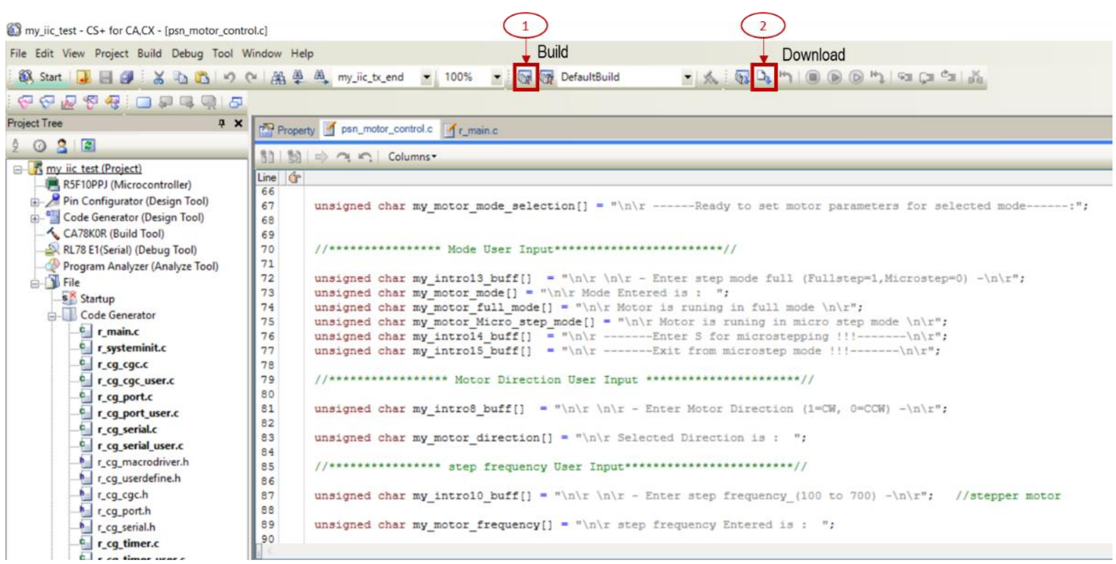


Figure 10: Build and Download the project

3. Once download is successful CS+ will open debug window as below:

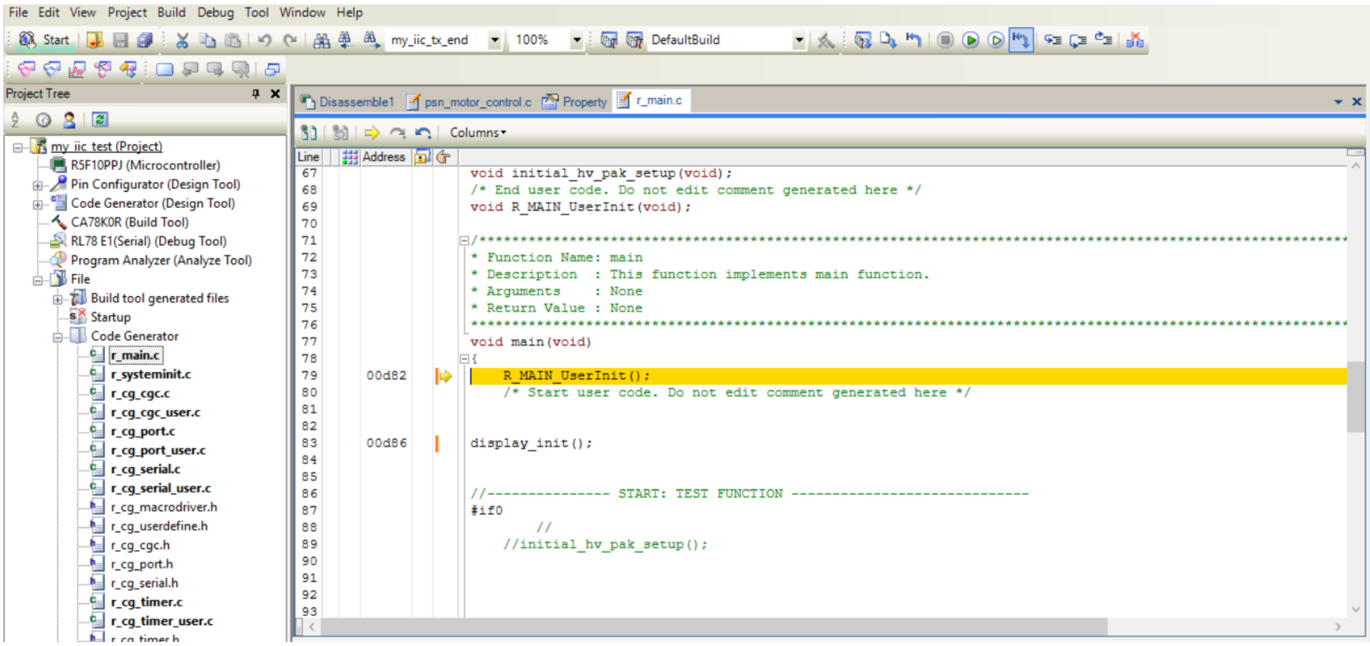


Figure 11: Debug window

4. Once the download is completed click on Execute command as highlighted in Figure:12.

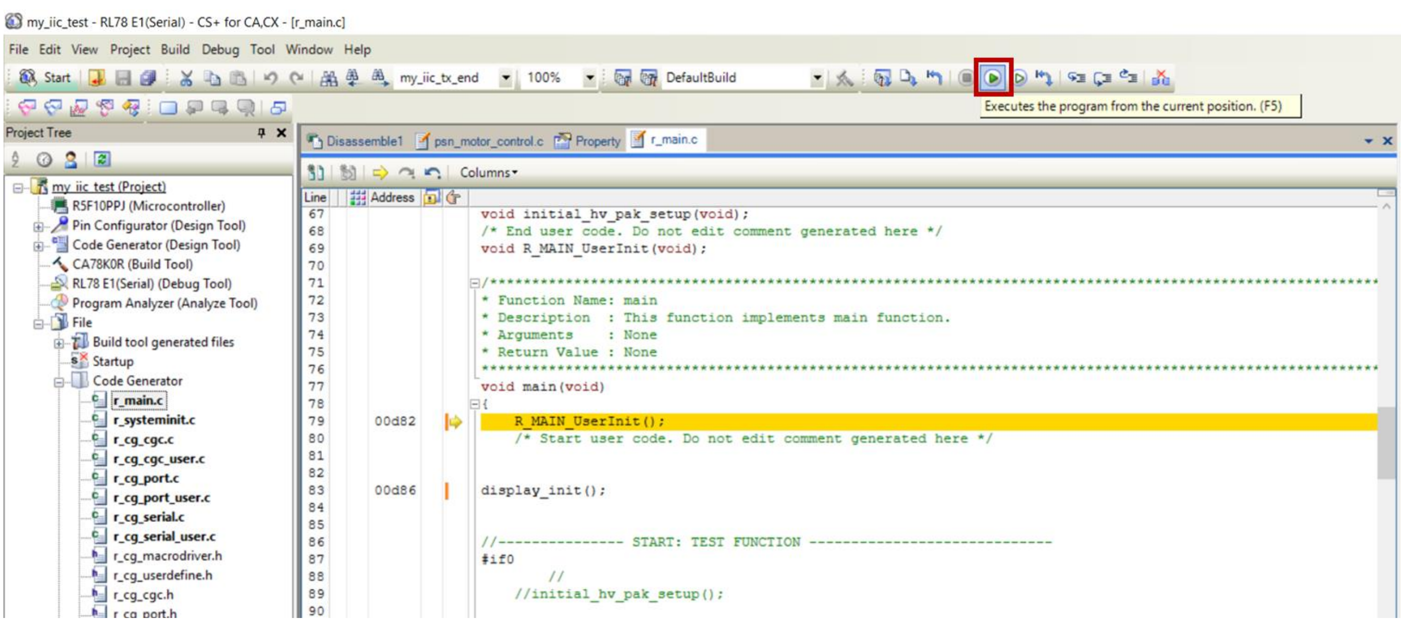


Figure 12: Execute the Program

5. After Execute Command, use TTL to USB Adapter and Tera-term terminal software to give serial commands to the device. Select the Serial Port and navigate to Serial Port and specify the baud rate setting as 19200.

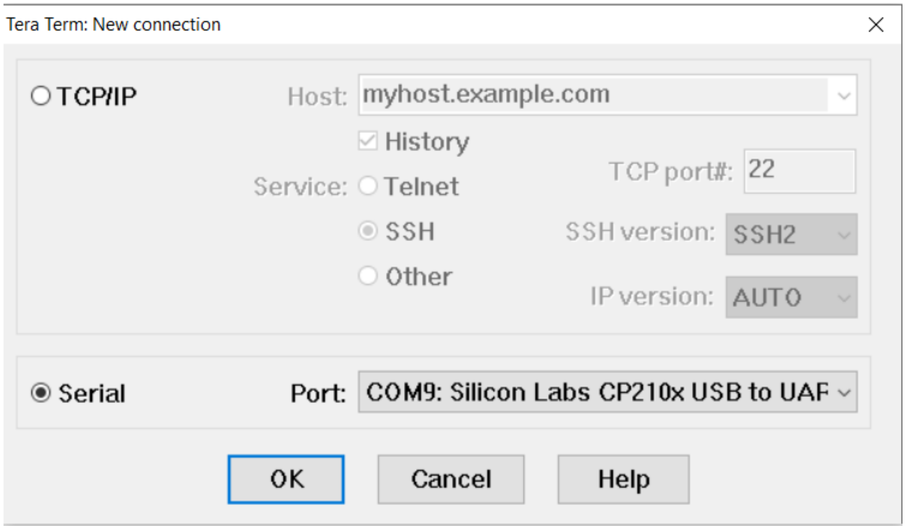


Figure 13: Serial Port Setting

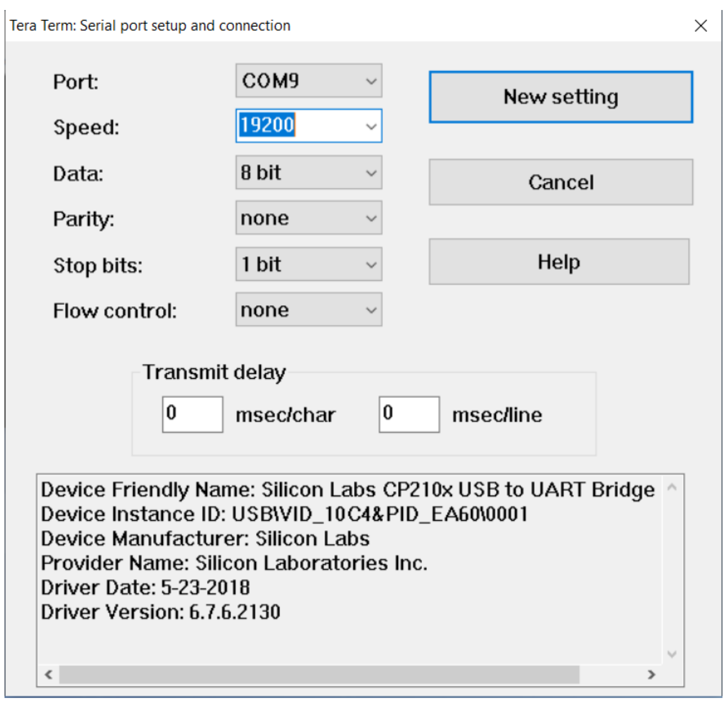


Figure 14: COM Port Settings

HVPAK Pin Configurations

1. **Pin Configurations:**

Table 1: Motor control Method:

MOTOR Control mode	I2C_Write Data			
	No.	Address Byte [hex]	Write Data [hex]	Function
PINs Control: MODE SLEEP DIRECTION STEP	1	0xF5	0x01	I2C reset with reloading NVM into Data register (soft reset)
I2C Control: I2C_MODE I2C_SLEEP I2C_DIRECTION STEP Frequency	1	0x15	0xA3	I2C Control design setting
	2	0x18	0xE3	
	3	0x27	0xE3	
	4	0x28	0x78	
	5	0x2D	0x60	
	6	0x2E	0x98	
	7	0x30	0xC5	
	8	0x31	0xA8	
	9	0x34	0x25	
	10	0x35	0x52	
	11	0x36	0x14	
	12	0x38	0x88	
	13	0x42	0xE3	
	14	0x70	0x8E	
	15	0x71	0x6F	
	16	0x7F	0xC7	

Table 2: Chip I2C Address

HEX	BIN	DEC
0x08	0001000	8

2. **I2C STEP frequency setting:**

STEP frequency [Hz] = 100 000Hz / (Counter Data [dec] + 1)
Where Counter Data is from 1 to 65535

3. **Step Mode**
   The step mode is selected by applying logic high and low voltages to the MODE PIN or Register in Table 3.

Table 3: Stepping Format

MODE	STEP MODE
0	Full step with 71% current
1	16 micro steps per step

Table 4: I2C Control Registers

Address Byte	Register Bit	Block	Function	Default
0x4C	reg<608>	Virtual Input <0>	I2C_Reset	0
	reg<609>	Virtual Input <1>	I2C_SLEEP	0
	reg<610>	Virtual Input <2>	I2C_MODE	0
	reg<611>	Virtual Input <3>	I2C_DIRECTION	0
	reg<615:612>	Virtual Inputs <4..7>	X	0000
0x7F	reg<1031:1016>	CNT0/LDY0 (16bits) Counter Data	Counter Data: from 1 to 65535 STEP Frequency [Hz] = 100000Hz / (Counter Data + 1)	0xC7
0x80				0x00

Go Configuration Block Design and Firmware Flashing Steps

Connect SLG47105 chip using socket to programming board and design block using go configure GUI and flash firmware to us as Stepper motor controller.

1. Design block for Stepper motor –
    1. Open GO configure GUI to design block.
    2. Add PWM block for duty control.
    3. Add Enable disable function block for reset functionality.
    4. Add Step Control Block for Full/Micro Step Control of Stepper Motor.

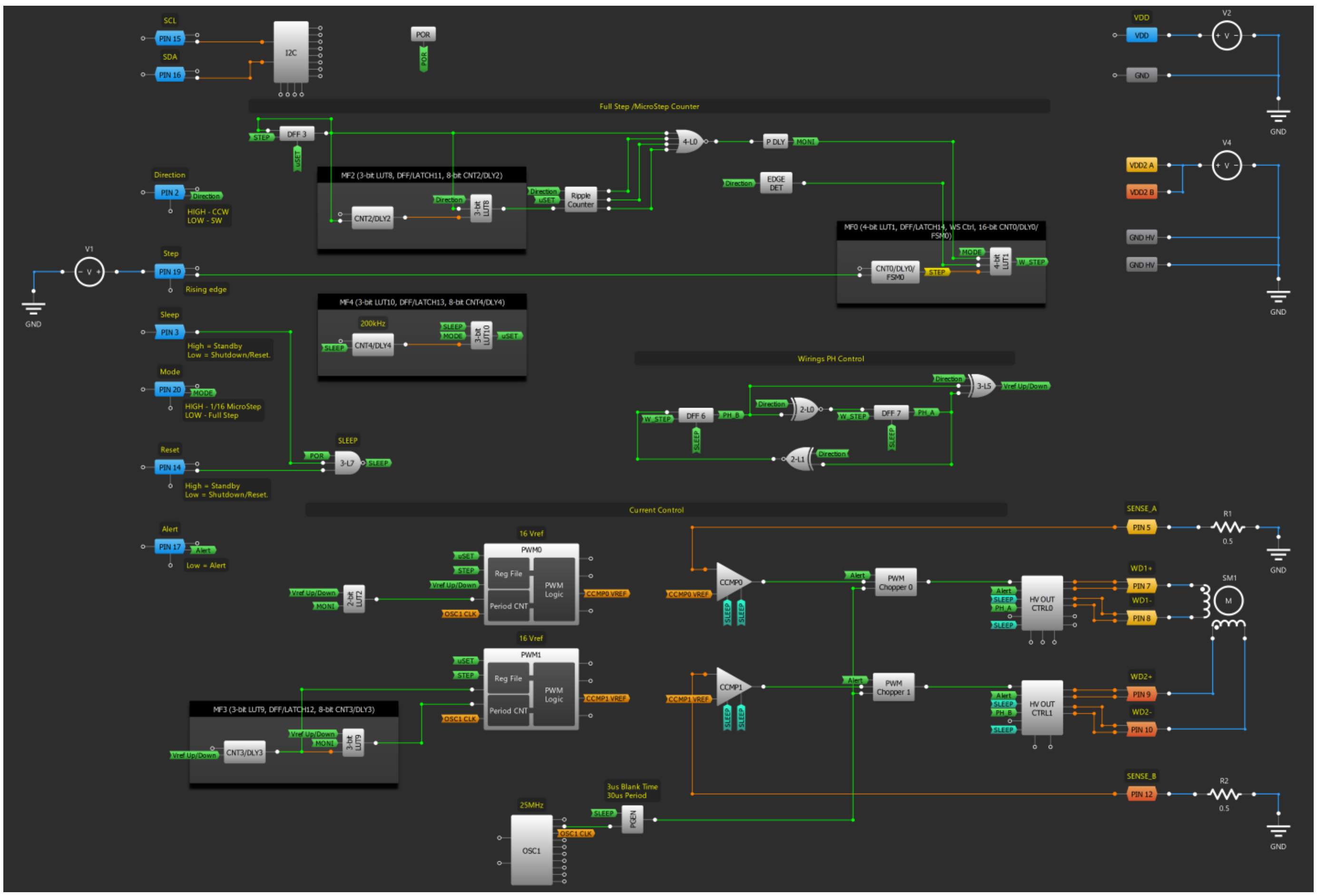
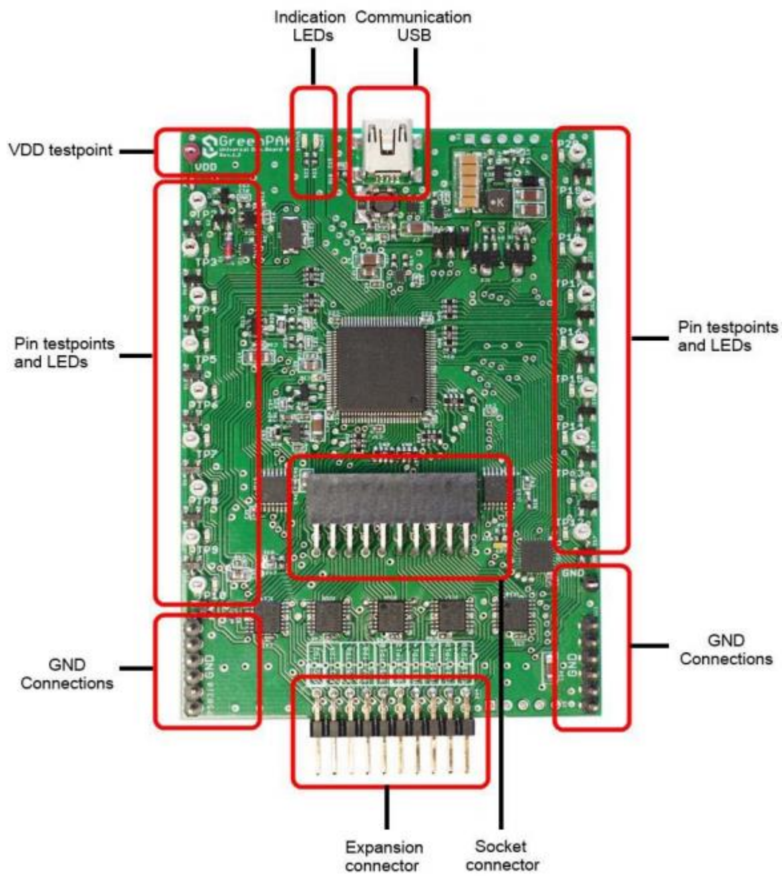


Figure 15: Design block for Stepper motor

2. Follow below settings for configure HVPAK (SLG47105) as Stepper Motor controller.
    1. Place Unprogrammed SLG47105 chip into socket.
    2. Connect Board and socket using USB & power up the board.
    3. Design blocks using go configure GUI.
    4. Press debug button to run program.
    5. Press program from debugging control panel.
    6. Confirm Configuration.



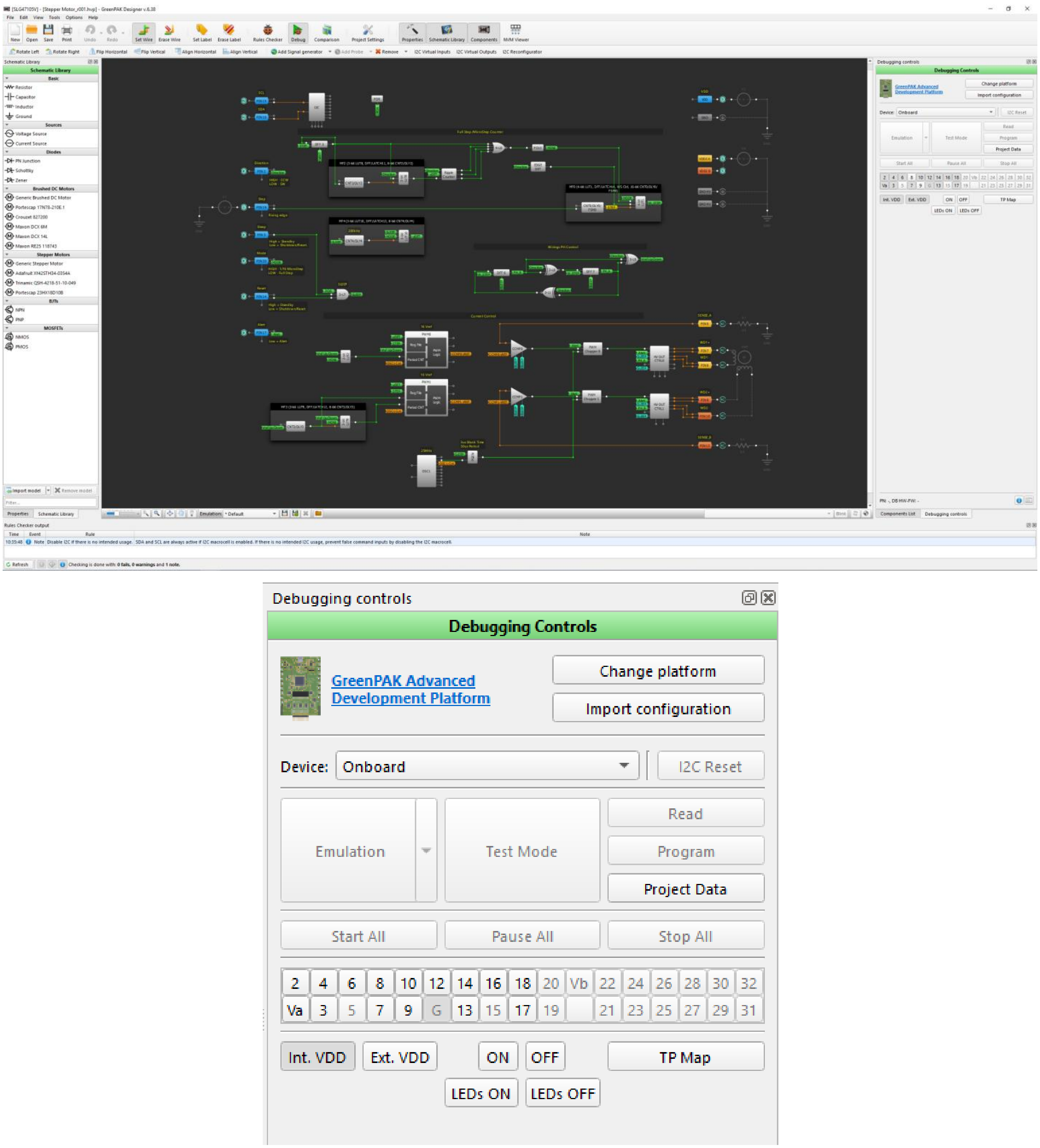


Figure 16: HVPAK Configuration Setup

Test Setup

Method 1: I2C Configuration (In this method the board is fully functional using software mode.)

Follow these procedures to set up the kit as shown in Figure 13

1. Connect AS025-HVPAK board with the RL78/F14 EVK board. The RL78/F14 and AS025-HVPAK board are communicated by I2C communication.
2. Connect 12V DC supply to jumper J4 of AS025-HVPAK board.
3. Connect the E1 emulator to build and debug the project.
4. Connect the USB to TTL converter to give the user commands.
5. Open the Tera term software and give the commands for Stepper Motor Run Mode either Full Step/Micro Step as 0 0r 1, Motor Direction, Stepper Motor Step Frequency, and to Enable the Motor.
6. After the user specifies the commands, the motor runs with the specified commands given to it.
7. The serial commands are shown in Figure: 14 and Figure: 15.

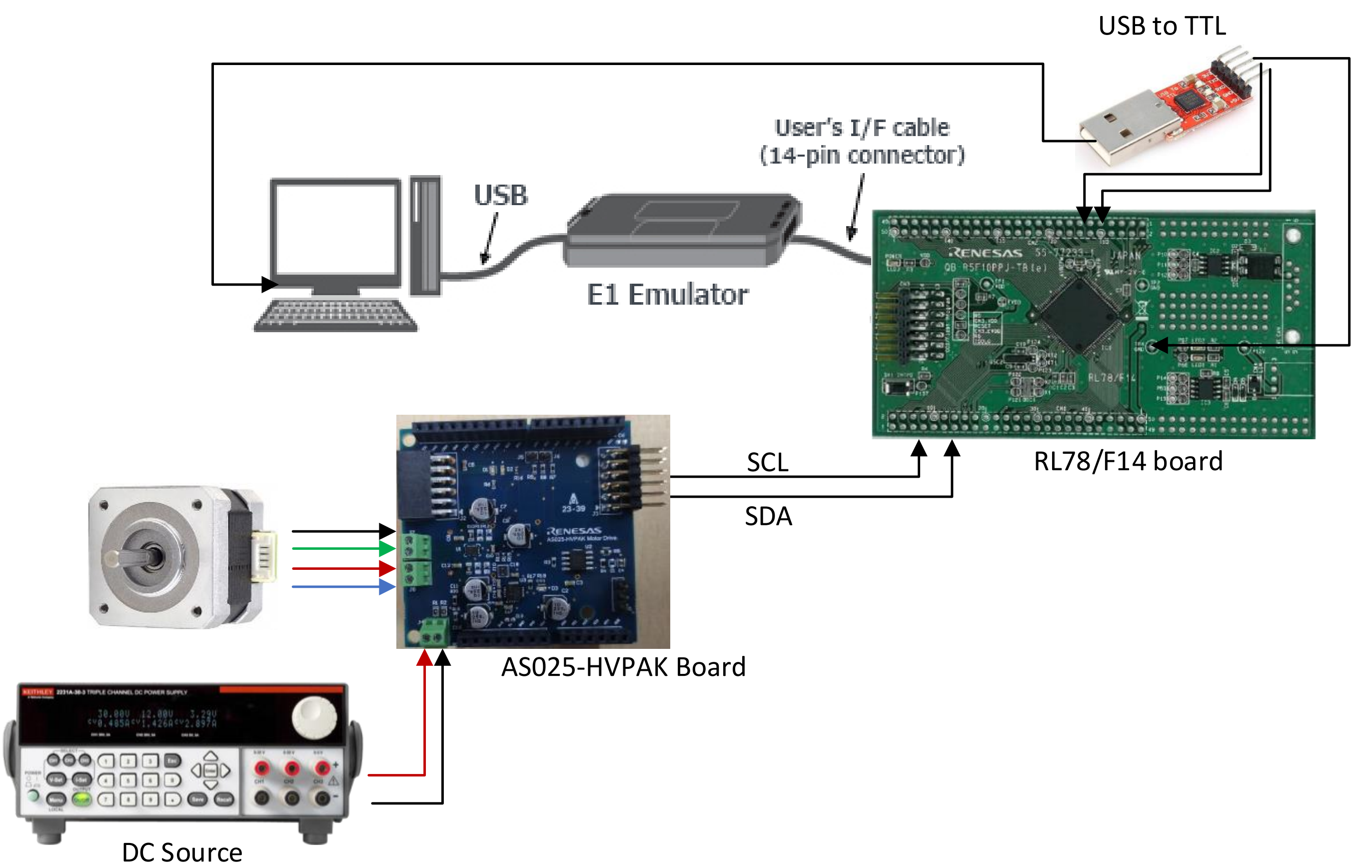


Figure 17: Design Setup

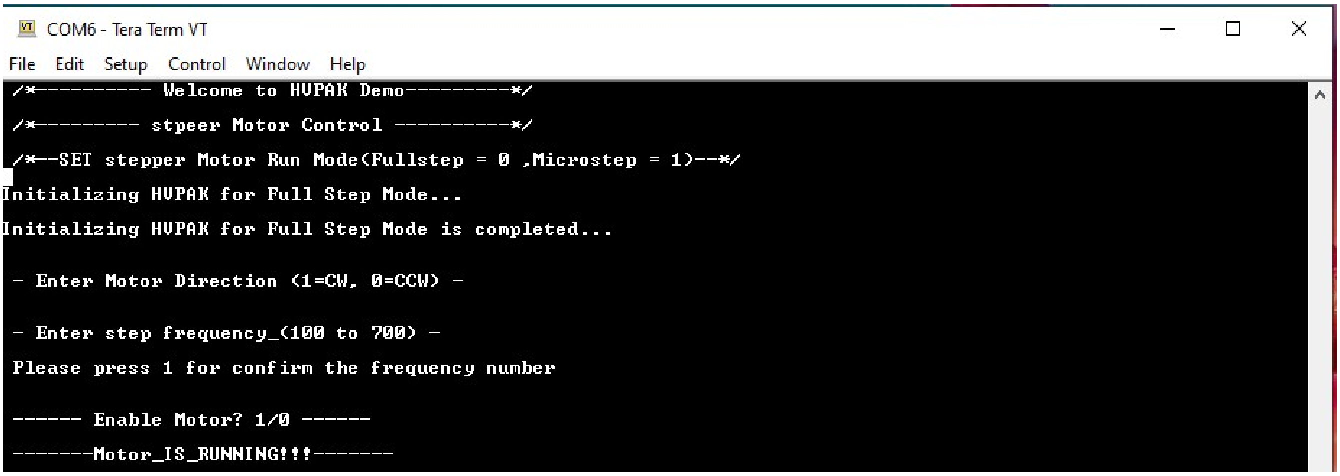


Figure 18: Stepper Motor Serial Data to Run Motor for Full Step

Steps to enter commands in Tera Term to Run the Stepper Motor in Full Step Mode.

1. Enter Stepper Motor Run Mode Full Step/Micro Step. Give command as 0 to run the Motor in Full Step Mode.
2. The HVPAK will initialize the Motor to Full Step Mode.
3. Enter Motor Direction as 1 to Clockwise and 0 for Counterclockwise.
4. Enter Motor Step Frequency from 100 to 700 Hz. (Note: Step Frequency range depends on the type of Stepper Motor. We are using 17PM-K210-10V Stepper Motor.)
5. Press 1 to confirm the Step frequency entered.
6. Press 1 to Enable the Motor.

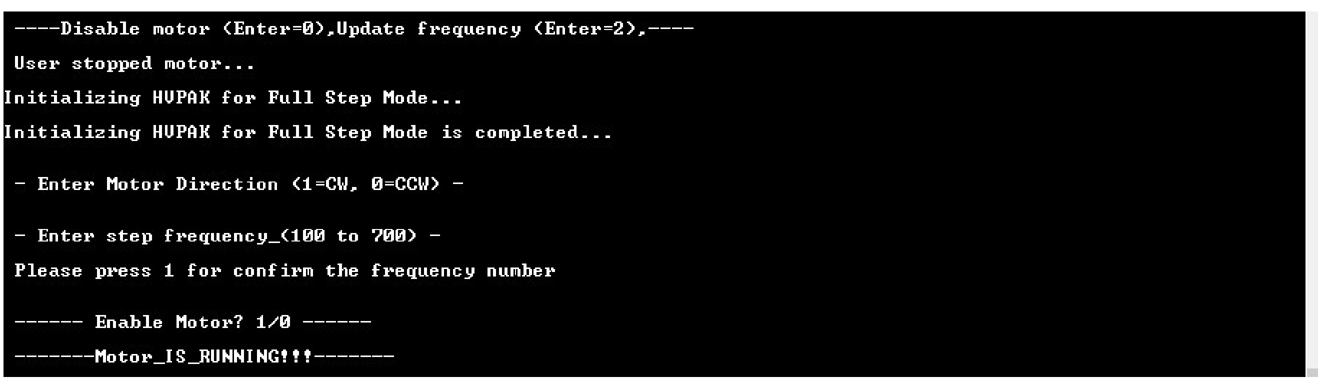


Figure 19: Stepper Motor Serial Data to Stop/Disable Motor

Steps to enter commands in Tera Term to Disable/Stop the Motor or to Update the Step Frequency.

1. Enter 0 to Disable the Motor.
2. Enter 2 to update the Step Frequency.

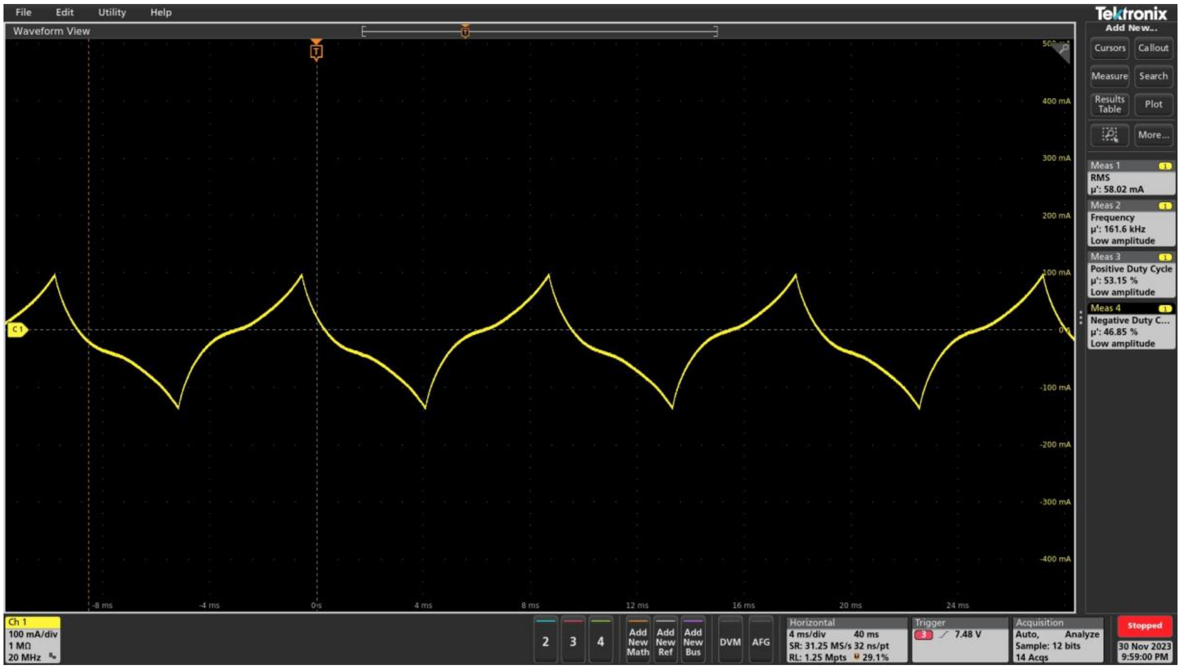


Figure 20: Current Waveform for Full Step Mode

Figure 21: Stepper Motor Serial Data to Run Motor for Micro Step

Steps to enter commands in Tera Term to Run the Motor in Micro step Mode.

1. Enter Stepper Motor Run Mode Full Step/Micro Step. Give command as 1 to run the Motor in Micro Step Mode.
2. The HVPAK will initialize the Motor to Micro Step Mode.
3. Enter Motor Direction as 1 to Clockwise and 0 for Counterclockwise.
4. Enter Motor Step Frequency from 100 to 700 Hz. (Note: Step Frequency range depends on the type of Stepper Motor. We are using 17PM-K210-10V Stepper Motor.)

5. Press 1 to confirm the Step frequency entered.
6. Press 1 to Enable the Motor.

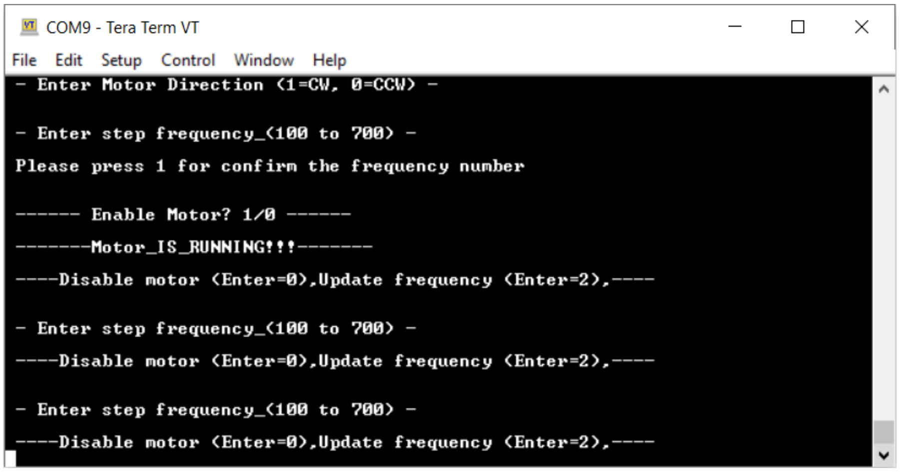


Figure 22: Stepper Motor Serial Data to Stop/Disable Motor

Steps to enter commands in Tera Term to Disable/Stop the Motor or to Update the Step Frequency.

1. Enter 0 to Disable the Motor.
2. Enter 2 to update the Step Frequency.

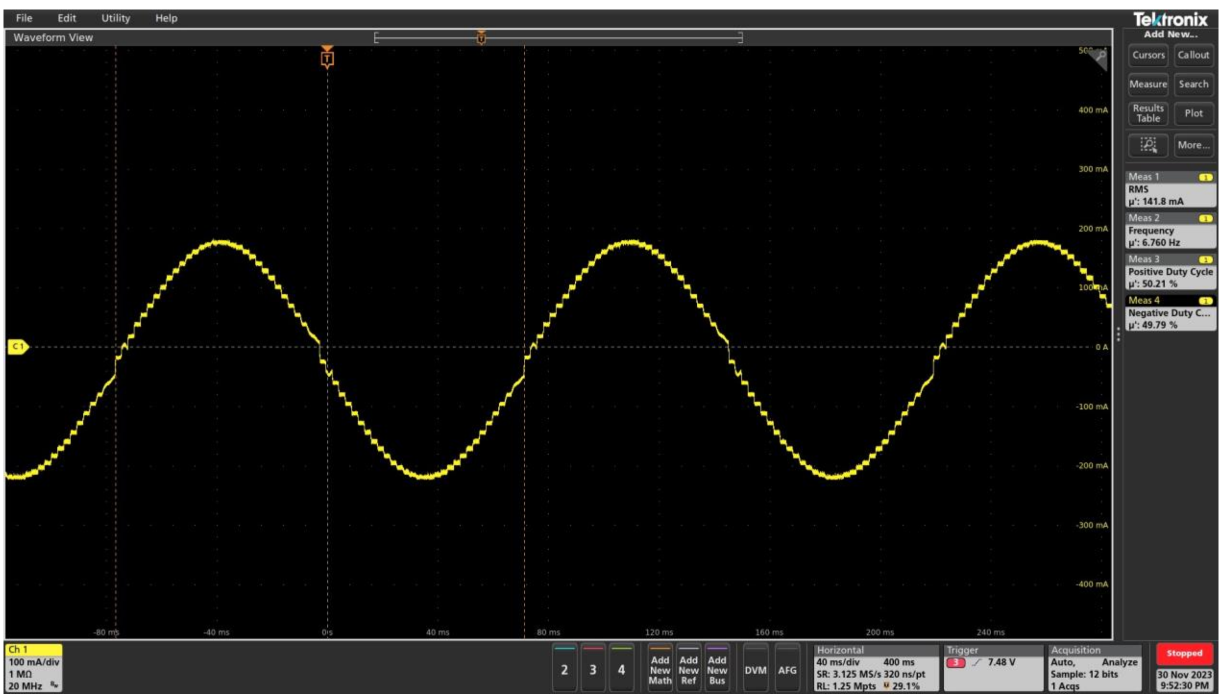


Figure 23: Current Waveform for Micro Step Mode

Method 2: Pin Configuration Method: (In this method the board is fully functional using external input without software. External Inputs: Function Generator and DC Source)

Follow these procedures to set up the kit as shown in Figure 16.

1. Connect 12V DC supply to jumper J4 of AS025-HVPAK board.
2. Connect Stepper motor to connectors J7 and J8.
3. Connect Waveform generator and provide the PWM signal to 9 of Pmod connector, i.e., J3 connector. Pin 9 of Pmod Interface are used for Frequency control of the motor.
4. Pin 8 of Pmod interface connector J3 are used for Mode Control of Stepper motor. The motor will run in Full Step Mode for Low Signal, and it will run in Micro Step Mode for High Signal. For Micro Step Control provide 3V supply from the DC Source.
5. Pin 7 of Pmod interface connector J3 are used for Direction Control of Stepper motor. To control the direction of Stepper Motor, provide 3V from the DC Source.

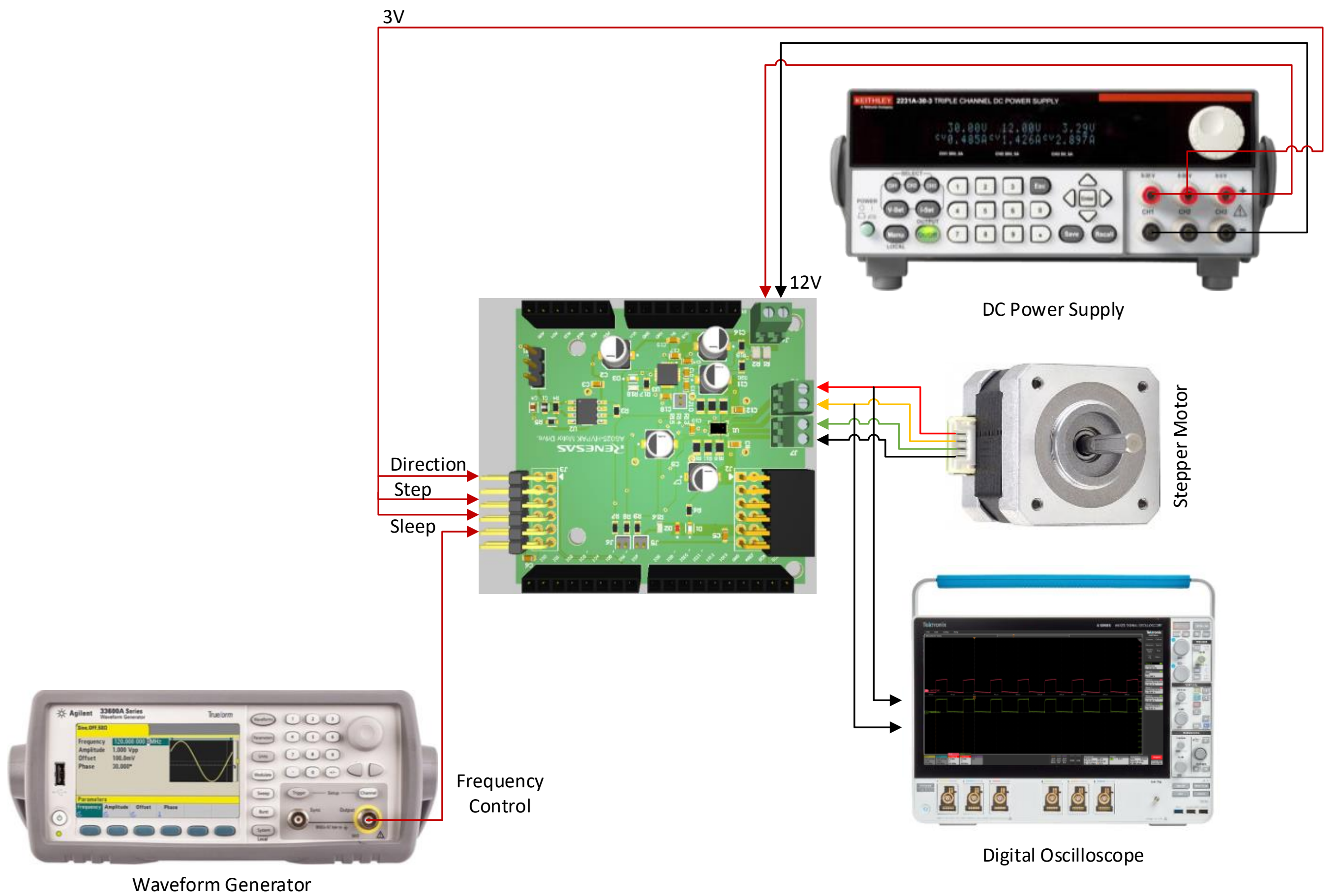


Figure 24: Test Setup

AS025-HVPAK Application Schematic

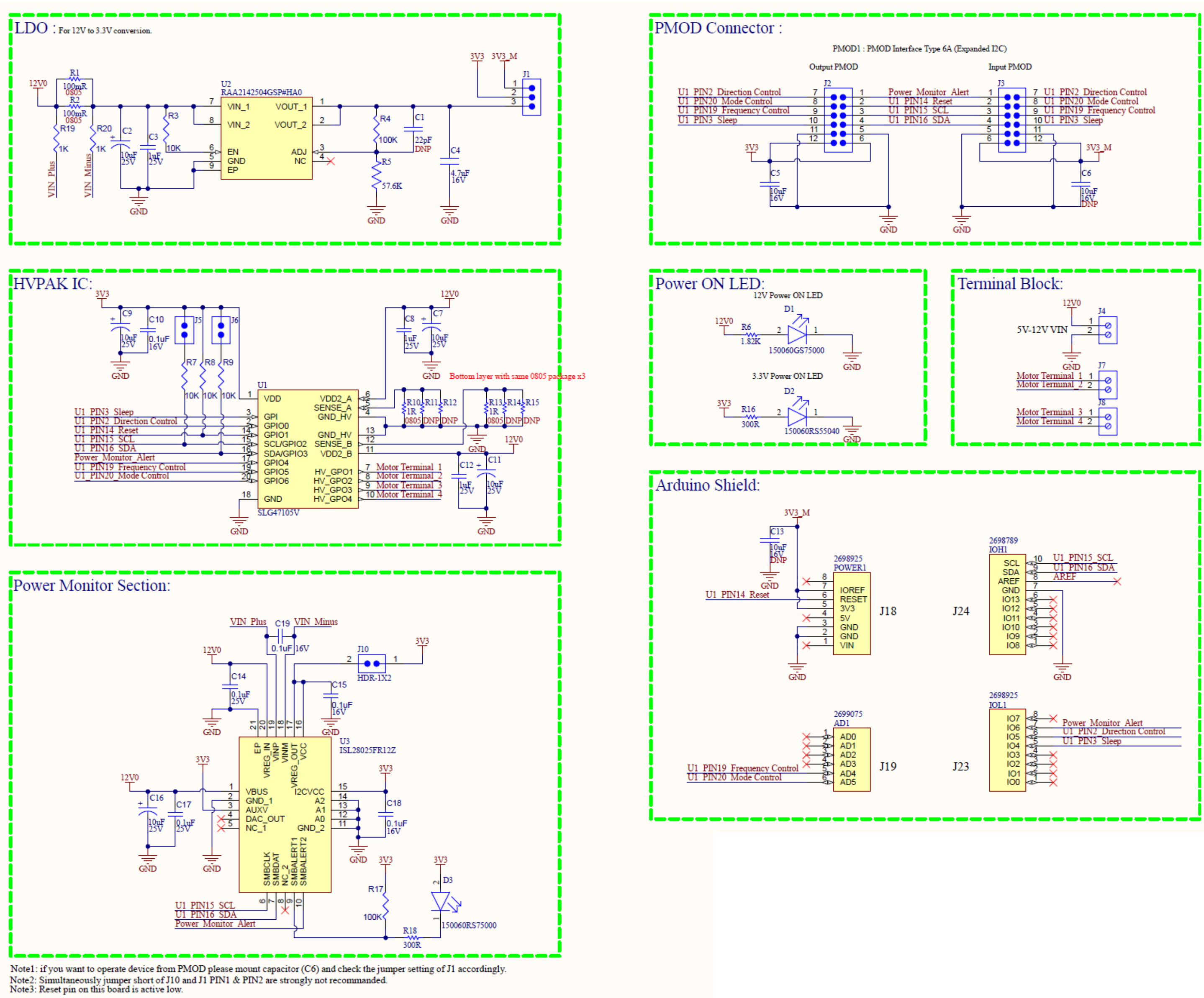


Figure 25: Schematic

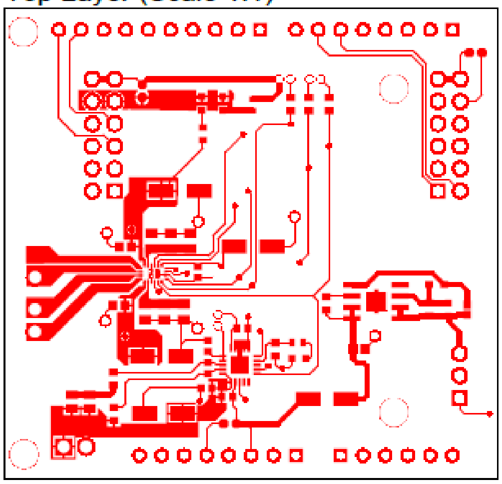
Bill of Materials (BOM)

Table 5. AS025-HVPAK BOM

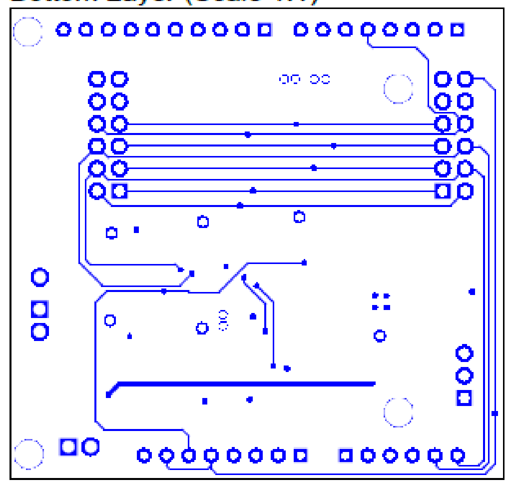
Quantity	Designator	Description	Manufacturer	Manufacturer Part #
1	AD1	6 Position Receptacle Connector 0.100" (2.54mm) Through Hole Gold	Samtec	SSQ-106-03-G-S
0	C1	Capacitor, 22pF, 25V, SM 0603	Kemet	C0603C220K3GACTU
5	C2, C7, C9, C11, C16	CAP ALUM 10UF 20% 25V SMD	Panasonic	EEE-1EA100SR
3	C3, C8, C12	1 µF ±10% 25V Ceramic Capacitor X7R 0603 (1608 Metric)	Yageo	CC0603KRX7R8BB105
1	C4	Multilayer Ceramic Capacitors 4.7µF ±10% 16V X5R SMD 0603	TDK Corporation	C1608X5R1C475K080AC
1	C5	10 µF ±10% 16V Ceramic Capacitor X5R 0603 (1608 Metric)	Yageo	CC0603KRX5R7BB106
0	C6, C13	10 µF ±10% 16V Ceramic Capacitor X5R 0603 (1608 Metric)	Yageo	CC0603KRX5R7BB106
3	C10, C15, C18	0.1 µF ±10% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	YAGEO	CC0603KPX7R7BB104
2	C14, C17	0.1 µF ±10% 25V Ceramic Capacitor X7R 0603 (1608 Metric)	YAGEO	CC0603KPX7R8BB104
1	D1	LED GREEN CLEAR 0603 SMD	Wurth Electronics	150060GS75000
1	D2	LED RED DIFFUSED 0603 SMD	Würth Elektronik	150060YS55040
1	D3	LED RED CLEAR 0603 SMD	Wurth Electronics	150060RS75000
1	IC1	Digital Power Monitors Precision Digital Power Monitor with Real Time Alerts	Renesas Electronics	ISL28025FR12Z
1	IOH1	10 Position Receptacle Connector 0.100" (2.54mm) Through Hole Gold	Samtec	SSQ-110-03-G-S
1	IOL1	8 Position Receptacle Connector 0.100" (2.54mm) Through Hole Gold	Samtec	SSQ-108-03-G-S
1	J1	Connector Header Through Hole 3 position 0.100" (2.54mm)	FCI	77311-818-03LF
1	J2	12 Position Receptacle Connector 0.100" (2.54mm) Through Hole, Right Angle Gold	Würth Elektronik	SSW-106-02-F-D-RA
1	J3	Connector Header Through Hole, Right Angle 12 position 0.100" (2.54mm)	Würth Elektronik	61301221021
3	J4, J7, J8	Series 101 - 5.00 mm Horizontal Entry Modular with Pressure Clamp WR-TBL, 2 pin	Wurth Elektronik	691101710002
4	J5, J6, J9, J10	CONN HEADER VERT 2POS 1.27 MM	Samtec Inc.	FTS-102-01-L-S
1	POWER1	8 Position Receptacle Connector 0.100" (2.54mm) Through Hole Gold	Samtec	SSQ-108-03-G-S
2	R1, R2	220 mOhms ±1% 0.333W, 1/3W Chip Resistor 0805 (2012 Metric) Automotive AEC-Q200, Current Sense Thick Film	Panasonic	ERJ-6DSFR10V
4	R3, R7, R8, R9	Chip Resistor, 10 KOhm, +/- 1%, 01 W, -55 to 155 degC, 0603 (1608 Metric)	Yageo	RC0603FR-0710KL
2	R4, R17	Chip Resistor, 100 KOhm, +/- 1%, 0.1 W, -55 to 155 degC, 0603 (1608 Metric)	Yageo	RC0603FR-07100KL
1	R5	RES SMD 57.6K OHM 1% 1/10W 0603	Yageo	RT0603FRE0759KL
1	R6	1.82 kOhms ±1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Moisture Resistant Thick Film	YAGEO	RC0603FR-071K82L
2	R10, R13	Chip Resistor, 1 Ohm, +/- 1%, 125 mW, -55 to 155 degC, 0805 (2012 Metric), RoHS, Tape and Reel	Yageo	RC0805FR-071RL
0	R11, R12, R14, R15	Chip Resistor, 1 Ohm, +/- 1%, 125 mW, -55 to 155 degC, 0805 (2012 Metric), RoHS, Tape and Reel	Yageo	RC0805FR-071RL
2	R16, R18	300 Ohms ±1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Moisture Resistant Thick Film	Yageo	RC0603FR-07300RL
1	U1	GreenPAK Programmable Mixed-Signal Matrix	Renesas Electronics	SLG47105V
1	U2	500mA 20V Wide Input Voltage Range LDO Linear Regulator	Renesas Electronics	RAA2142504GSP#HA0

Board Layout

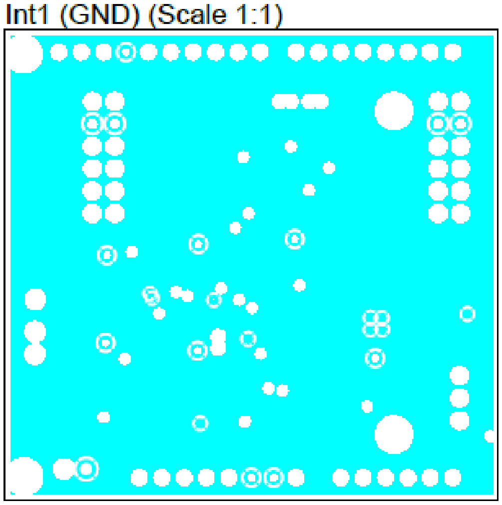
Top Layer (Scale 1:1)



Bottom Layer (Scale 1:1)



Int1 (GND) (Scale 1:1)



Int2 (PWR) (Scale 1:1)

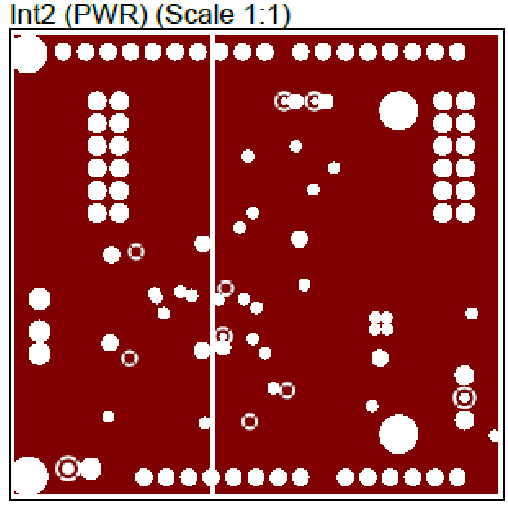


Figure 26: Board Layout- 2 Layer

Ordering Information

Orderable Part Number[a]	Description
AS025HVPAKSTM-POCZ	AS025-HVPAK: Stepper Motor Driver Pmod™

Revision History

Revision Date	Description of Change
Nov 25, 2023	Initial release.