EU068-MCTRIPSPOCZ

Motor Control Kit with RX13T and IPS2200

Contents

Figures

Tables

1. Introduction

The Y-MotorControl_RX13T kit is a design and evaluation system based on the RX13T device of the 32-bit RX microcontroller family.

The kit enables engineers to test and evaluate the performance of the RX13T in a laboratory environment where the IPS2200 sensor device is used for sending position feedback from the rotor of any 3-phase Permanent Magnet Synchronous Motor (for example, DC Brushless Motor).

The board is designed to be as small as possible, eventually allowing to use in a customer's target system. All BoM, Schematics and Gerber collaterals are part of the kit package.

The Graphical User Interface (GUI) gives real time access to key motor performance parameters and provides a unique motor auto-tuning facility. The on-board buttons are used in standalone operation without the GUI control.

The power supply of the board allows input voltages between 12V and 36V DC, with 5A maximum DC current.

The included Nanotech BLDC motor requires a sufficient 24V 2A DC power supply for operation.
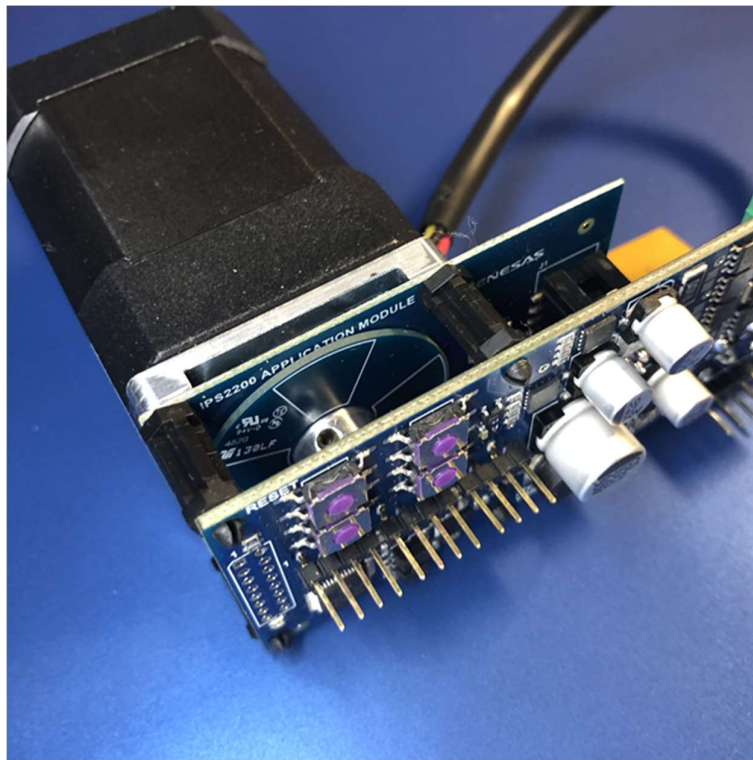
Figure 1. Y-MotorControl-RX13T

2. EU068 Motorcontrol Kit RX13T and IPS2200 – Hardware Overview

2.1 MCU

The MCU used on the board has the following parts:

- RX13T (ordering part name: R5F513T5ADFL)
- RX100 RXV1 Core derivate device with FPU running at maximum 32MHz clock frequency

The part used has the following features:

- 128KB Flash
- 12KB RAM
- 4KB Data Flash Memory to store the motor control settings
- 48-pin LFQFP package

For more information visit www.renesas.com\RX13T.

2.2 Inductive Position Sensor

The IPS2200 (ordering part name: IPS2200BI1W) is an Inductive Position Sensor for High-Speed Motor Commutation. The sensor is configured using a digital SPI or I2C interface to the RX13T and provides rotor angle feedback over an analog high-speed Sine and Cosine voltage output.

For more information visit www.renesas.com/IPS2200.

2.3 Connectivity

External control of the board is achieved via an isolated USB-to-Serial interface connecting to a standard GUI, obtained with the RL78/G1C device (ordering part name: R5F10JBCANA). This part allows full control of a UART port from the USB input.

For more information visit www.renesas.com/RL78G1C.

The galvanic isolation between the board and a controlling MS Windows™ PC is achieved with two high speed (15Mbps) optocouplers (ordering part name: RV1S9160A) on the Tx and Rx lines of the RX13T MCU.

For more information visit www.renesas.com/RV1S9160A.

2.4 Half-Bridge Mosfet Drivers

The PWM outputs from the RX13T device are adjusted to the correct control voltages for the Mosfets with three HIP2211 MOSFET drivers (ordering part name: HIP2211FRTZ).

For more information visit www.renesas.com/HIP2211.

2.5 Mosfets

The controlling Mosfets are 6 x N-channel single power, maximum voltage is 60V at 30A (ordering part name: RJK0654DPB). The LFPAK device package allows a small PCB footprint while enabling heat transportation and dissipation via the PCB layers.

For more information visit www.renesas.com/RJK0654DPB.

2.6 Power Supply

Note: the board works with the Nanotech DB42M03 24V BLDC motor, therefore the DC power input cannot exceed 24V.
The board contains a DCDC step down device (allowing an input voltage between 3.5V and 40V) to provide an

intermediate voltage of 10V powering the half bridge drivers (ordering part name: ISL85413FRTZ-T). The DCDC can only work with an input voltage between ~11V to 40V$_{max}$.

For more information visit www.renesas.com/ISL85413.

The MCU and the position sensor are powered at 5V DC, this is achieved with a low I$_q$ LDO (ordering part name: RAA214220)

For more information visit www.renesas.com/RAA214220.

2.7   Push Buttons

The following buttons are used on the device:

- Three general purpose push button connected to the RX13T
- RX13T MCU reset button

2.8   Indicator LEDs

The following LEDs are used on the device:

- Green LED on the motor control board driven by a GPIO on the microcontroller. It shows the correct functioning of the RX13T firmware.
- Green power LED on the sensor board.

3. EU068 Motor Control Kit Content

The motor controller kit is delivered pre-assembled with the RX13T motor controller board, inductive position sensor board, and sensor target that is mounted on the BLDC motor.

Items included in the EU068 motor control kit:

- RX13T motor control board
- IPS2200 inductive position sensor board
- Inductive position sensor target mounted on a target holder
- Nanotech DB42S03 BLDC motor

Required items not included in the kit:

- 24V power supply
- Micro USB cable

Optional items not included in the kit:

- E1 or compatible debugger
- Potentiometer for stand-alone speed control
- IPS communication board for sensor demonstration

4. Quick Start Guide

The board is delivered with a factory default firmware tuned to the connected Nanotech motor, and a tuned IPS2200 inductive position sensor offset. The default setting can be launched to spin the motor by connecting a 24V DC power supply and pressing the push buttons on the board.

4.1 Using Buttons
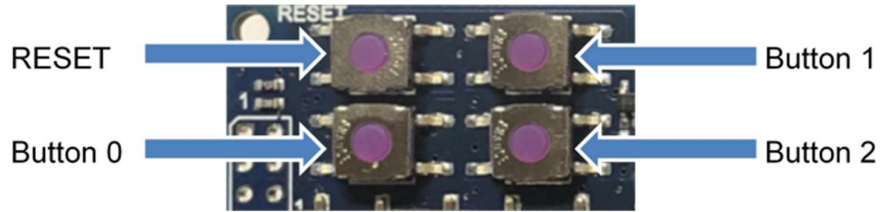
Figure 2: board detail with buttons

After connecting the external power supply, select one of the following options by pressing the relevant button:

- Button 0: starts/stops the spinning of the motor in the following sequence (see Figure 3):
  1. Enables the spinning of the motor with position feedback from the IPS2200.
     The RPM of the motor can be increased/decreased by Button 1 and 2.
  2. Stops the motor.
  3. Enable the spinning of the motor without position feedback from the IPS2200.
     In Sensorless mode, the RPM of the motor can be increased/decreased by Button 1 and 2.
  4. Stops the motor.
  5. Enables the spinning of the motor with position feedback from the IPS2200.
     The RPM of the motor can be increased/decreased by Button 1 and 2.
- Button 1: increases the requested RPM in steps up to the maximum RPM (set via the GUI).
- Button 2: decreases the RPM, passing through 0RPM increases the speed in the other direction.

Note that in Sensorless mode, the minimum RPM is 150. It is possible to run at 10RPM with IPS2200 support.
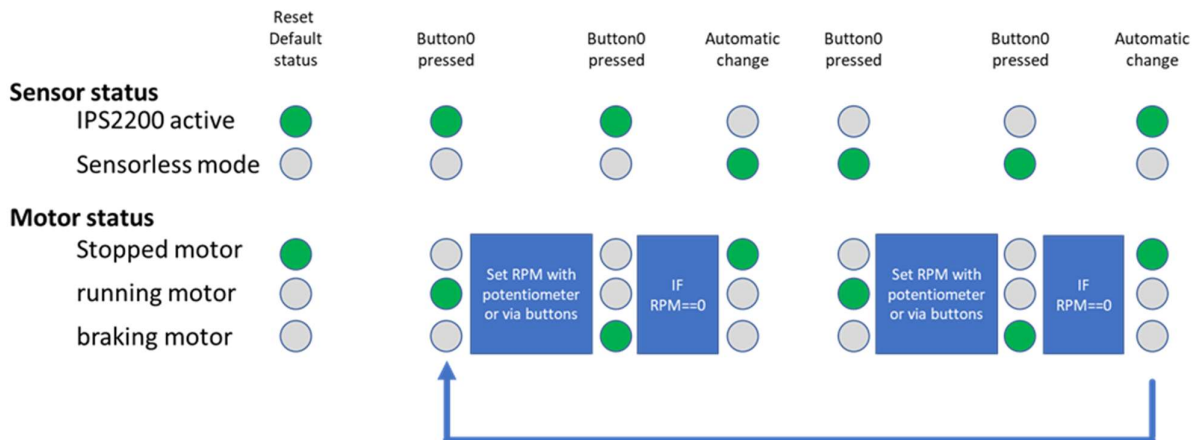
Figure 3: Detail of the Sequence of Button 0

4.2 Using Potentiometer

To set the board to potentiometer use, hold Button 1 while pressing the Reset button shortly.

In potentiometer use, the potentiometer or an DC voltage between 0 and 5V is connected on Pin 2 of connector J5, Pins 2 and 3 of connector J4 must be bridged by a jumper.
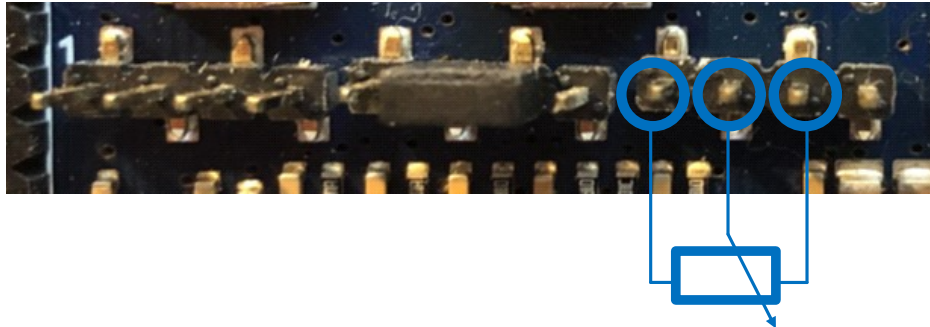
Figure 4: board detail, potentiometer connection

Button 0 starts/stops the spinning of the motor in the following sequence:

1. Enables the spinning of the motor with position feedback from the IPS2200.
   The RPM of the motor can be controlled by moving the slider of the potentiometer as the following:

- Middle setting (approximately 2.5V on Pin 2 of J5) is 0 RPM
- Moving the slider to either end spins the rotor at the maximum speed
- Direction is set by the direction of the slider (0V is max left, 5V is max right).

2. Stops the motor.

3. Enable the spinning of the motor without position feedback from the IPS2200.
   In Sensorless mode, the RPM of the motor can be controlled by moving the slider of the potentiometer.

4. Stops the motor.

5. Enables the spinning of the motor with position feedback from the IPS2200.
   The RPM of the motor can be controlled by moving the slider of the potentiometer.

Note that in Sensorless mode, the minimum RPM is 150. It is possible to run at 10RPM with IPS2200 support.

4.3 Using GUI

Additional setting of the device can be done on the GUI, which can be downloaded from the YROTATE-IT-RX23T PC Control GUI site. Note: the INI file required to this board must be stored in the same directory as the 'MotorController.exe' file.

To set the board to GUI use, hold Button 1 and 2 while pressing the Reset button shortly. The Mode (parameter 0 in the GUI) is now set to '1' and allows the GUI to connect to the board as described below.

Follow these steps to operate the board using the GUI:

1. Connect power (24V) via the barrel connector to the board.
   The green LED on the MCU board lights up, indicating that the RX13T Microcontroller has booted successfully.
   The green LED on the Sensor board lights up.

2. Connect the USB cable to a free PC USB port.
   The PC connects to the RL78/G1C.
   If required, download the MS Windows™ driver files for this USB device from the USB Drivers | Renesas site.
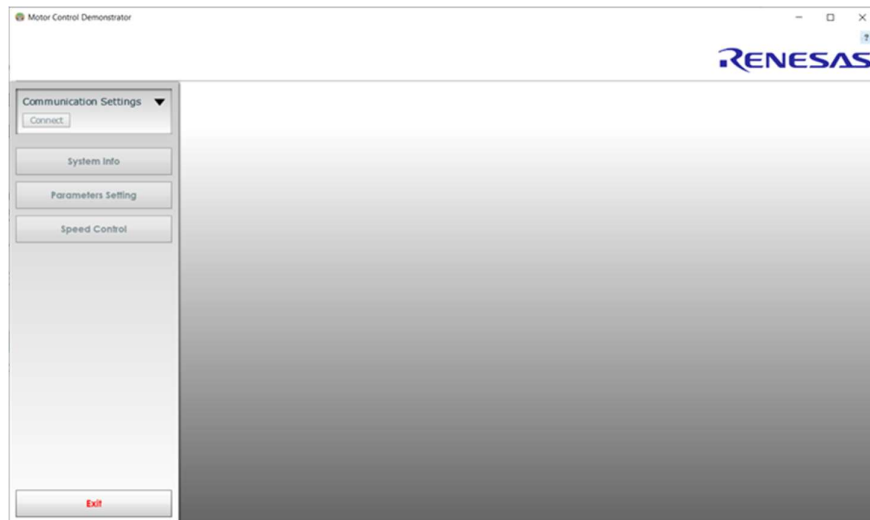
Figure 5. GUI Startup Screen

3. Start the GUI in MS Windows™ Administrator mode.

4. Open the 'Communication Settings' drop-down list.

5. Select "RX13T_IPS2200" for the control settings.

6. Select "Auto Detect" for the COMx port.
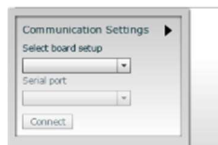
Figure 6. Communication Settings (1)

Figure 7. Communication Settings (2)

7. Click 'Connect'.

8. If necessary, click 'Parameter Setting' and edit values.
    The default system settings allows an immediate use of the board.
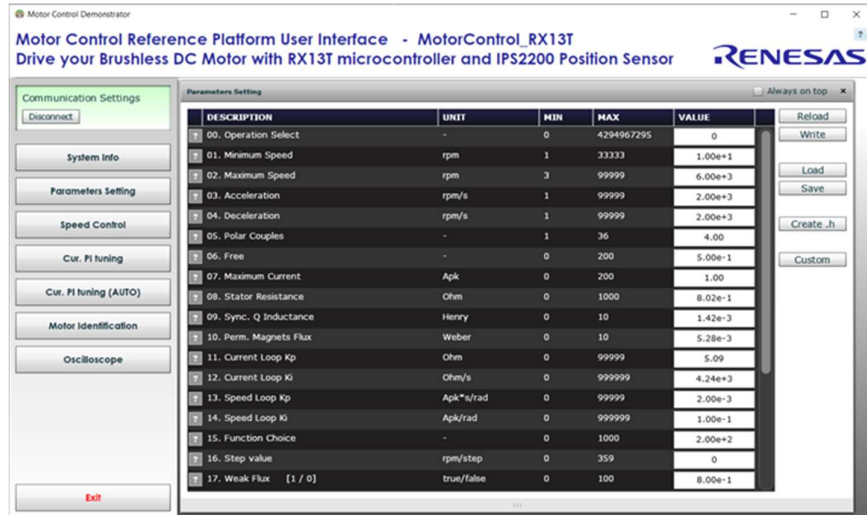
Figure 8. Parameter Settings Screen

Important Notes:

- If the mechanical connection of the rotating IPS2200 reflector board is changed, run 'motor identification' command again to checks the sensor encoder offset on the rotor. Neglecting this can result in damage of the system, as the rotary field/current is not in sync with the actual position of the rotor.

- Enabling the GUI activity from the factory default button control stores '1' in parameter 00. To lock setting to GUI, program a '0' in this parameter first.
  When keeping '1' in parameter 00, the motor control setting is 'Sensorless'. To enable IPS2200 support, Parameter 00 must be '0'.
  Return to button control by programming '22' into parameter 00.

9. Run the motor.

10. Click 'Speed Control'.
    The Speed Control screen appears, see Figure 9.
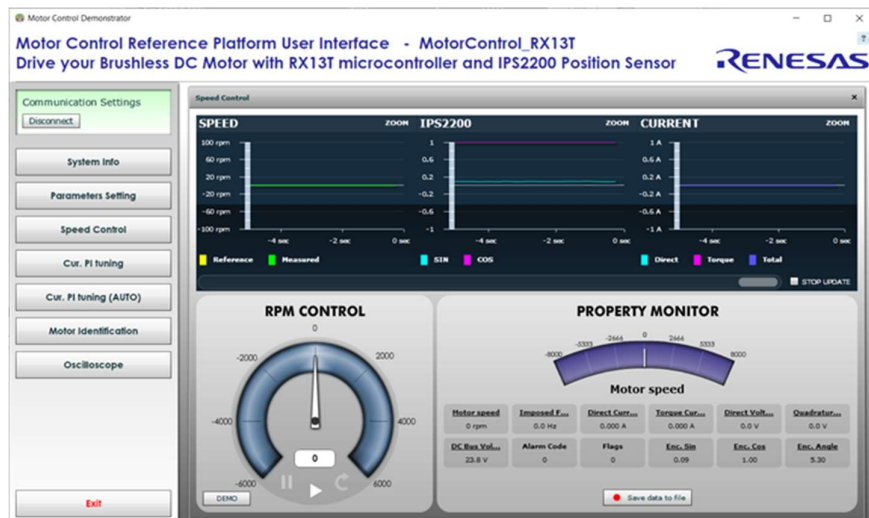
Figure 9. Speed Control Screen

11. Enter the desired value into the 'RPM control' and press the Tab button on the keyboard.
    The rotor starts turning and the feedback values are showing the measured and set data from the RX13T firmware.

Values for sine/cosine are showed both in the graph output for IPS2200 and in the value outputs 'Enc.Sin' and 'Enc.Cos' fields. The rotor position value is shown in the 'Enc.Angle' field.

Note: manually slowing the rotor results in increased current to keep the torque/position on the rotor as the system maintains the set RPM speed.

Output values of the IPS2200 screen that look like sine/cosine curves are achieved with very few RPM speeds, as the data update repetition rate needs to correlate with the measurement trigger speed.

Figure 10 shows an example for RPM speeds that show sine/cosine values using the factory default motor and firmware, running at 4495RPM.
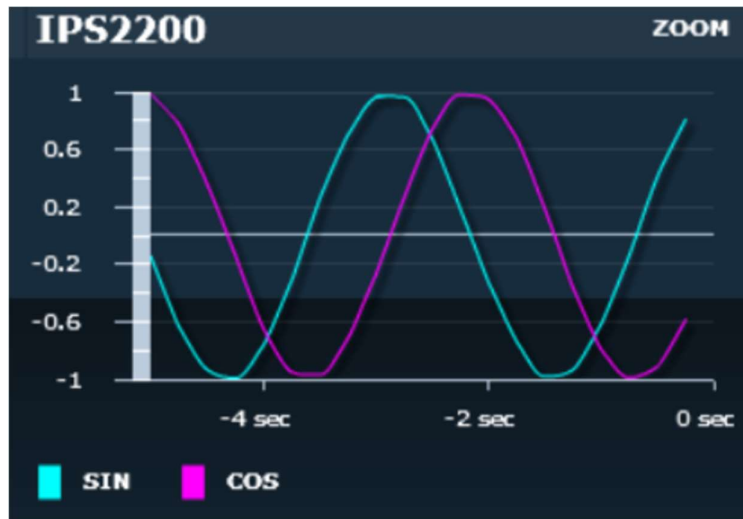
Figure 10: Sine/Cosine output from IPS2200

4.3.1. Additional GUI Options

The default settings (stored in the RX13T_IPS2200.ini file) can be edited according to the customer needs. To set additional options, follow these setps:

1. Open the GUI.
    For more information on initial GUI launch and communication settings, see section 4.3.
2. Select "Parameters Settings" (see Figure 5).
    A parameter list opens on the main screen.
3. Set the relevant values to the parameters and select an option by clicking on either of the following buttons:
    • Reload: get the latest values from the RX13T dataflash into the display.
    • Write: store the display settings into the RX13T dataflash.
    • Create .h: create and store a C-source header file with the settings. The file can be added to the project at compile time for fixing settings of the customer specific motor.
    • Custom: Reload/Write system parameters from specific address

Figure 11: parameter options

Important note: the value for "21. Encoder Offset" parameter is detected during the self-tuning of the kit. If the connection of the rotating board (with the 2 HEX (Allen) screws) is modified, the Encoder Offset needs to be readjusted by clicking the "Motor Identification" (see Figure 5). It checks the motor parameters and recalculates the IPS2200 position sensor offset (in full degrees).

Figure 12: motor tuning button, on main control screen

Make sure to click the "Write Values in EEPROM" (dataflash), otherwise the value is not considered when turning the motor.

For more information on settings, controls, and mathematical background of the system refer to the *YROTATE-IT-RX23T User Manual* document.

4.4 Operation Modes

To allow specific test sequences with the RX13T board, a set of functions are included into the default RX13T firmware. These functions can be initiated using 'operation mode numbers' to be programmed via the GUI in parameter 00.

The mode number control sequence allows data output without the graphical GUI interface. There is a basic 'fall back' mechanism built into the system that allows an easy return control back to the GUI and reprogram specific motor settings of the system. For further details, refer to section 4.

4.5 Factory Default Setting

Upon delivery the GUI parameter 00 setting is "22", which allows control of the board by using buttons. Alternative output settings are described in Table 1.

Table 1. Mode Settings Overview

Parameter 00 value	Action	Output to GUI 19200Bd	Output to Terminal 5600Bd
0	Full control by GUI	Yes	No
1 fallback value, return from button control	Full control by GUI, allows reprogramming default value into parameter 00 setting	Yes	No
10	Potentiometer control, bidirectional: ▪ 0%: maximum RPM counter-clockwise	Yes	No
20	▪ 50%: stopped motor	No	Yes

Parameter 00 value	Action	Output to GUI 19200Bd	Output to Terminal 5600Bd
	▪ 100%: maximum RPM clockwise		
11	Potentiometer control, one direction: ▪ speed 0%~100% is 0RPM to max RPM ▪ direction change is done with Button 1	Yes	No
21		No	Yes
12	Button control: ▪ speed clockwise with Button 1 decrease and Button 2 increase ▪ speed counterclockwise, with Button 1 increase and Button 2 decrease	Yes	No
22 Default factory setting		No	Yes

When NOT in GUI mode, starting/stopping the motor is always done with Button 0, see sections 4.1 and 4.2 for details.

Switching between the different modes (see Table 1) without permanently changing the setting via the GUI can be achieved with button combinations. See

Table 2 for the button combinations while cycling RESET.

Table 2. Button Combinations for Switching Control Options

Button 0	Button 1	Button 2	Results in Parameter 00 Setting:
Pressed	Not pressed	Not pressed	21
Not pressed	Pressed	Not pressed	20
Not pressed	Not pressed	Pressed	22
Not pressed	Pressed	pressed	**1** (return to GUI control)
Not pressed	Not pressed	Not pressed	Original programmed value from parameter 00

4.6   Terminal Data Output

Setting "2x" to Parameter 00 outputs board data to a simple terminal (Tera Term terminal or similar) with 57600Baud. Note that this is transmit to the terminal only, it is not possible to control the board in these modes.

When sending board data to the terminal, one data package is sent every 100ms, using semicolon between reported data. Table 3 shows the data output to the terminal, packet end is a '$' sign, all values are in ASCII as readable form.

Table 3. Data Packet Detail

Data Value	Explanation
Counter	Timer tick, counts up in 100ms intervals
Board control mode	Active mode value from parameter 00
Sensor mode	0: Sensorless mode 1: IPS2200 active
Motor status	0: stopped motor 1: running enabled (RPM setting via potentiometer or buttons) 2: braking motor
Rotor direction	-1: counterclockwise rotation +1: clockwise rotation
RPM setting	Induced rotor speed
RPM actual	Measured rotor speed
PWM frequency	Frequency of the 3-phase voltage signal to the motor
Direct current	Id (in mA)
Quad current	Iq (in mA)
Direct voltage	Vd (in mV)

Data Value	Explanation
Quad voltage	Vq (in mV)
Board voltage	Vb (in Volt)
IPS2200 sine	Measured IPS2200 sine value (multiplied by 100)
IPS2200 cosine	Measured IPS2200 cosine value (multiplied by 100)
$	Packet terminator

4.7   Default GUI Settings

The default settings are chosen to allow an effortless use of the system. Note that the boards have been reset at factory, storing the IPS2200 position offset into data flash (at position 21).

When a system data reset is invoked, the position 21 value is reset to '0' (zero). Readjustment of the offset is done using the 'Motor Identification' menu, see Figure 9.

Table 4 shows the default settings of the GUI controlled RX13T firmware, running with the IPS2200 as position sensing system and the Nanotech DB42S03 motor.

Table 4. Default Firmware Settings

Name	Unit	Min	Max	Default [1]	Description	Type	Decimal
00. Operation select	n/a	0	32768	0	Special operating modes selection	UInt32	0
01. Minimum speed	rpm	1	3000	10	Minimum allowable speed	Float	0
02. Maximum speed	rpm	100	100000	7000	Maximum allowable speed	Float	0
03. Acceleration	rpm/s	1	10000	2000	Speed increasing ratio	Float	0
04. Deceleration	rpm/s	1	10000	2000	Speed decreasing ratio	Float	0
05. Polar couples	n/a	1	24	4	Number of motor pole pairs	Float	0
06. Startup current	n/a	0	10	0.5	Startup current at speed = 0 RPM		
07. Maximum current	Apk	0	10	1	Maximum allowable current	Float	3
08. Stator resistance	Ohm	0	30000	0.803	Stator resistance	Float	3
09. Synchronous Q inductance	Henry	0	30000	0.001426	Synchronous inductance (q axis)	Float	6
10. Permanent magnets flux	Weber	0	30000	0.005283	Permanent magnets flux vector amplitude	Float	6
11. Current loop Kp	Ohm	0	30000	5.090	Current PI control loop proportional constant	Float	3
12. Current loop Ki	Ohm/s	0	30000	4242.022	Current PI control loop integral constant	Float	3
13. Speed loop Kp	Apk*s/rad	0	30000	0.002	Speed PI control loop proportional constant	Float	3
14. Speed loop Ki	Apk/rad	0	30000	0.1	Speed PI control loop integral constant	Float	3
15. Flux feedback gain	n/a	0	1000	200	Feedback gain for the integration of the flux estimation method	Float	0
16. Free	n/a						
17. Weak flux	n/a	0	1	0	Setup countermeasure for weak flux	Float	1

Name	Unit	Min	Max	Default [1]	Description	Type	Decimal
18. Free	n/a						
19. Sampling frequency	Hz	4000	16000	8000	Sampling frequency	Float	0
20. PWM/SAM frequency ratio	n/a	1	4	1	Ratio between PWM frequency and sampling frequency	Float	0
21. Encoder offset	degree	0	360	0[2]	Encoder offset angle	Float	1
22. Encoder direction	n/a	0	1	0	Encoder offset angle direction	Float	0
23. Free	n/a						
24. Reserved	n/a	0	256			Float	0
25. Free	n/a						

1. Values are specific for the Nanotech DB42S03 BLDC motor

2. Offset value from the IPS2200 is evaluated using the 'Motor Identification' from the GUI and set when running the 'autotune' by the GUI.

5. Component Layout Map

5.1 MCU PCB
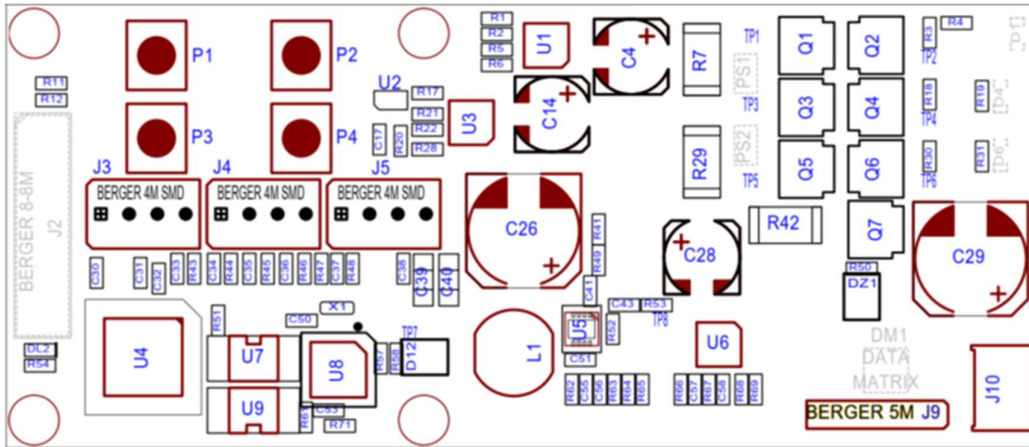
Figure 13. Top Side MCU PCB Assembly
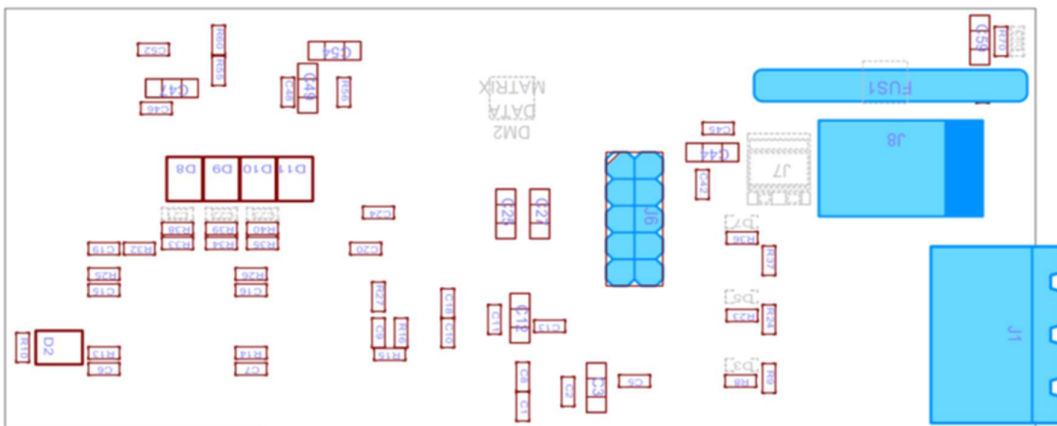
Figure 14. Bottom Side MCU PCB Assembly

Table 5. Board Connector Descriptions

U1	Half bridge HIP2211 (U)		J2	Auxiliary connector (spare GPIO)
U2	Dual diode		J3	Debug RX13T
U3	Half bridge HIP2211 (V)		J4	Jumper analog In or IPS Differential COS Input
U4	RX13T		J5	Potentiometer connector
U5	DCDC power supply		J6	IPS2200 sensor connector
U6	Half bridge HIP2211 (W)		J7	Direct power connection

U7/U9	Optocoupler		J8	Power supply barrel connector
U8	USB-to-Serial RL78/G1C		J9	Debug RL78/G1C
J1	Motor connector		J10	USB connector

5.2 IPS2200 Sensor Board
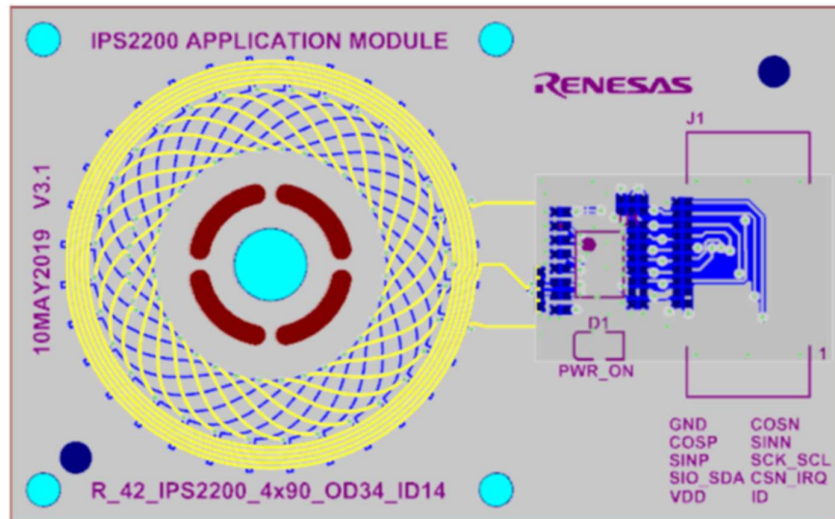
Figure 15. IPS2200 Sensor Board

Table 6. IPS2200 Board Contentions

U1	IPS2200 device		J1	Connection to MCU board
D1	Power LED			

6. Boards Overview

6.1 Schematics
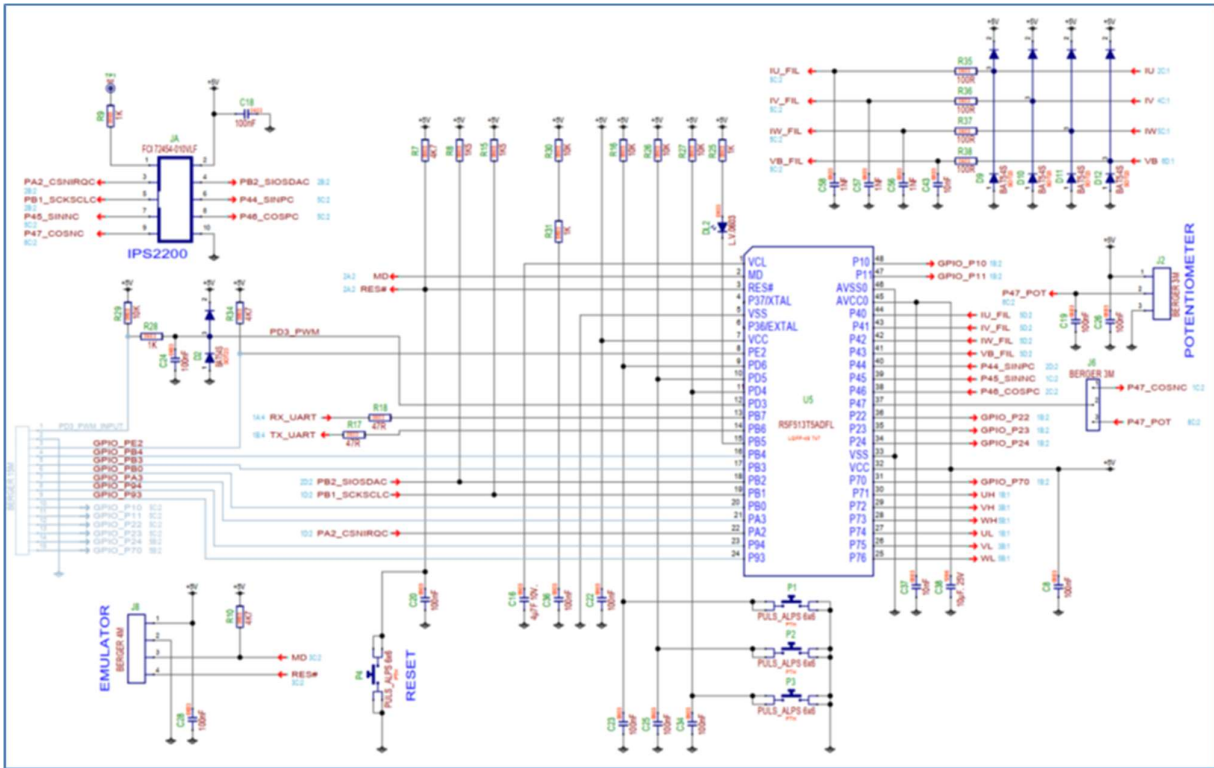
Figure 16. MCU
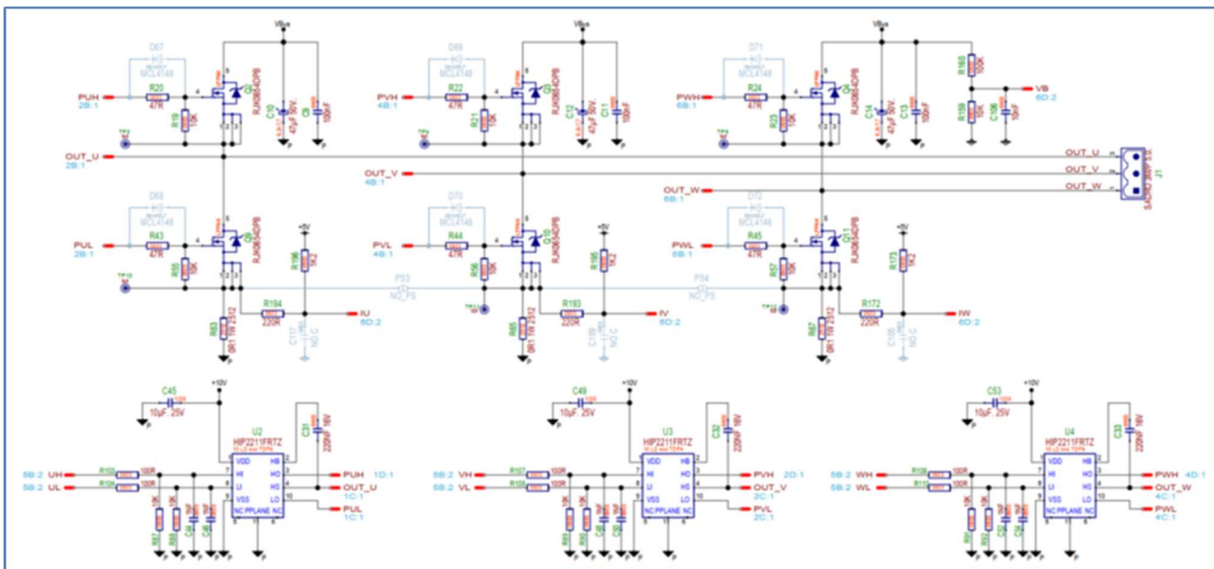
Figure 17. Power Stage
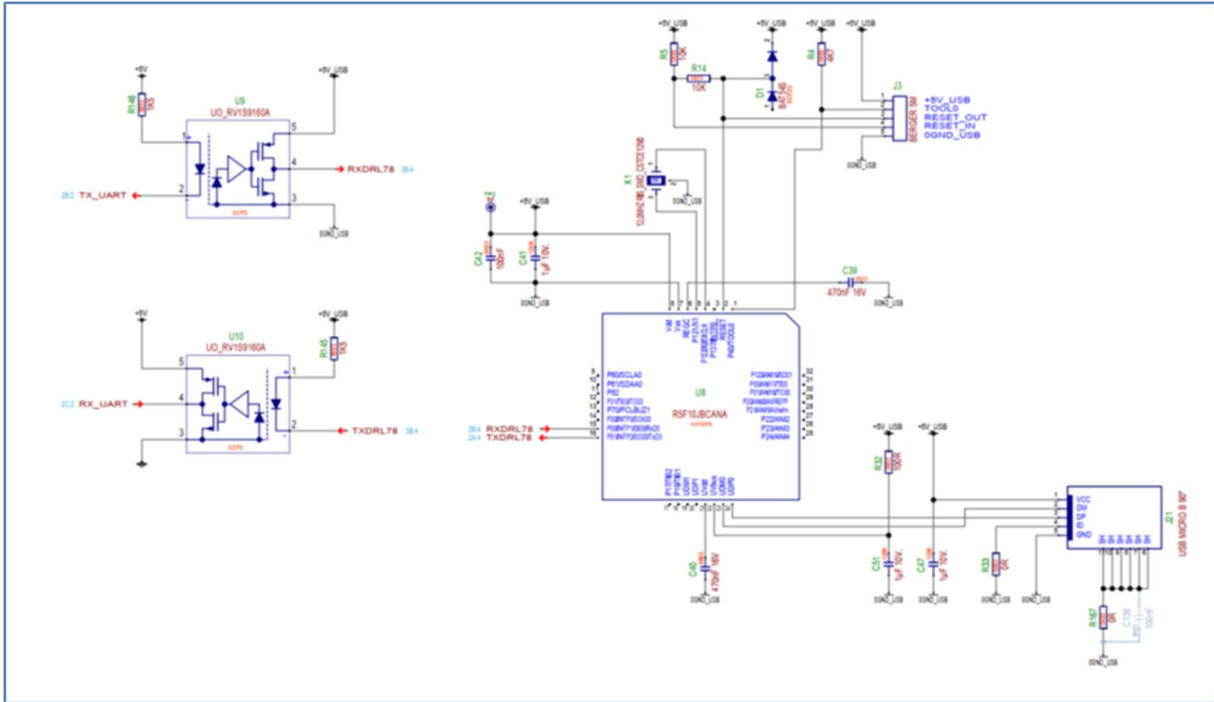
Figure 18. USB-to-Serial
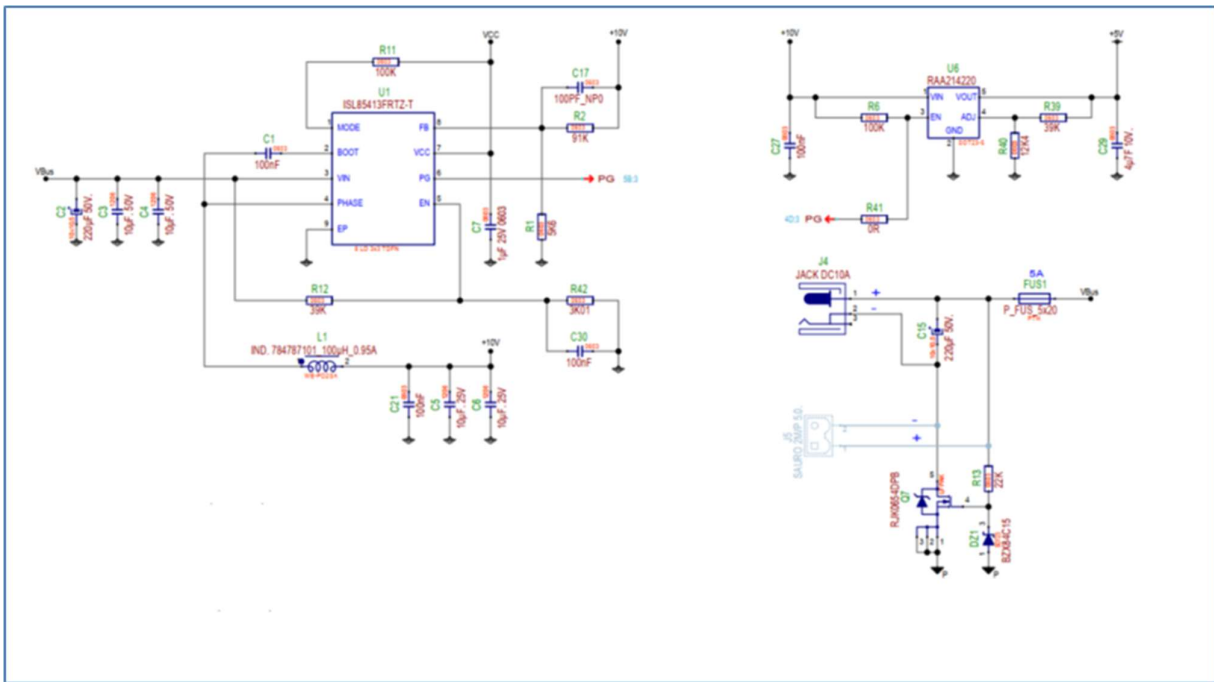
Figure 19. Power Supply

6.2   Microcontroller and motor driver board
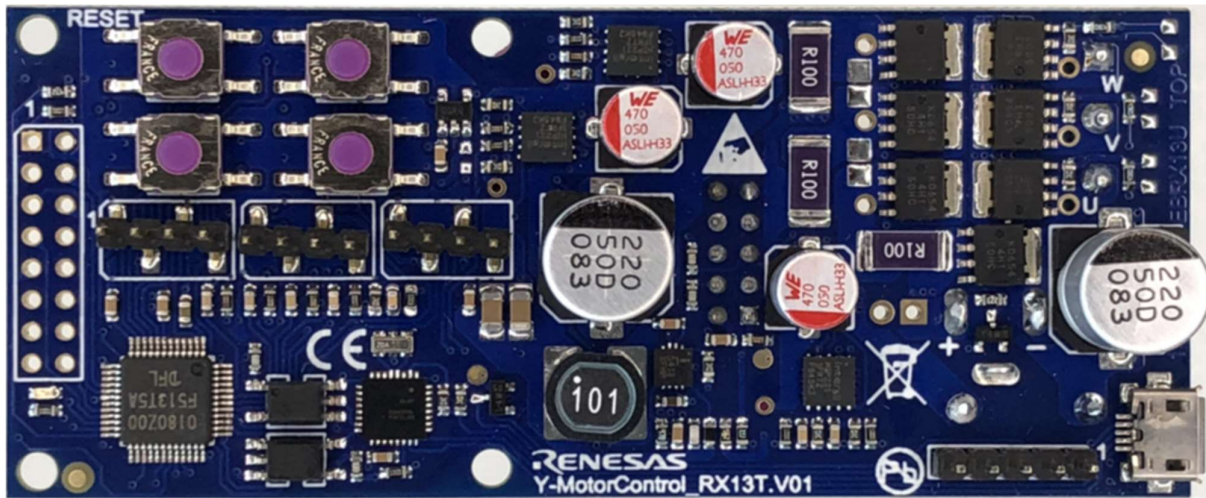
Figure 20. Microcontroller Board (Top Side)
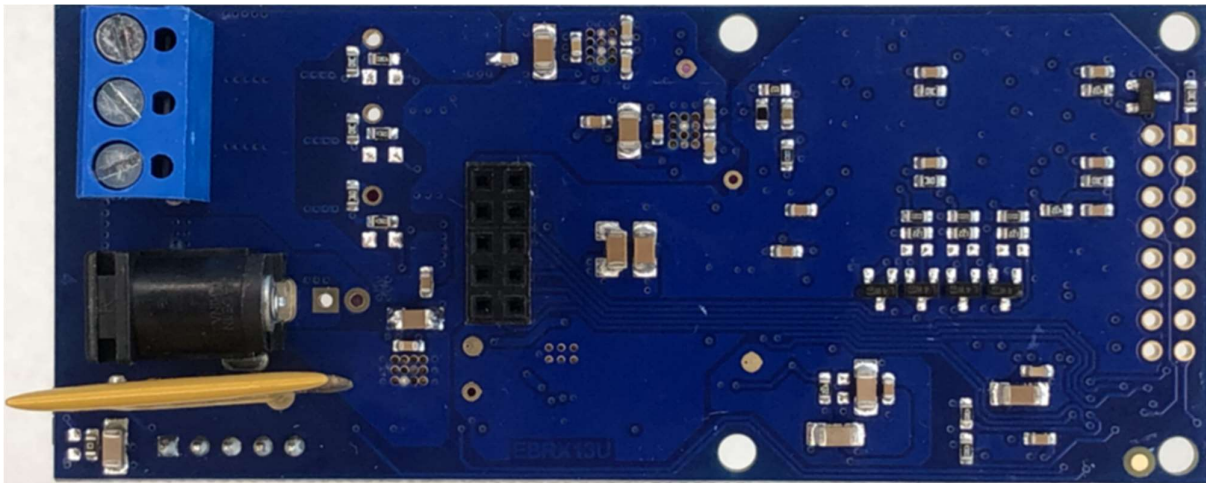
Figure 21. Microcontroller Board (Bottom Side)

6.3   Sensor Board
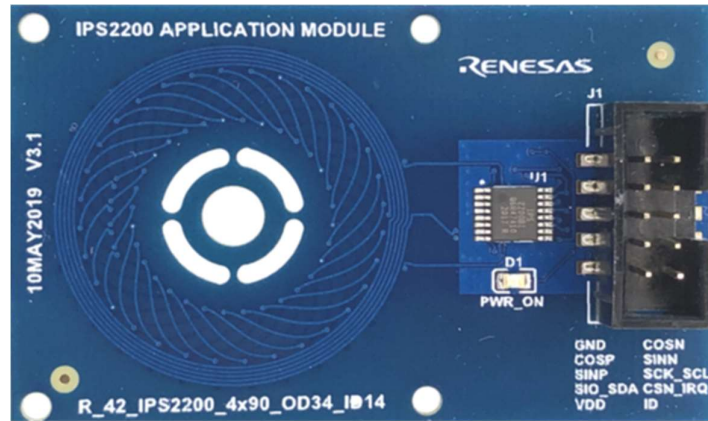
Figure 22. IPS2200 Sensor Board

Figure 23. Reflector Board, Mounted onto Rotor

6.4   Mechanical Construction

A mechanical construction is designed to allow relative closeness of the (rotating) disc to the IPS2200 coils. The minimum system allows to remove the IPS2200 board to the motor housing and the disc to the rotor.

When using distance holders, the MCU board can also be mounted to this construction, allowing a fixed connection (connector J6, on the backside of the MCU PCB) between the sensor board and MCU transmitting the IPS2200 signals.
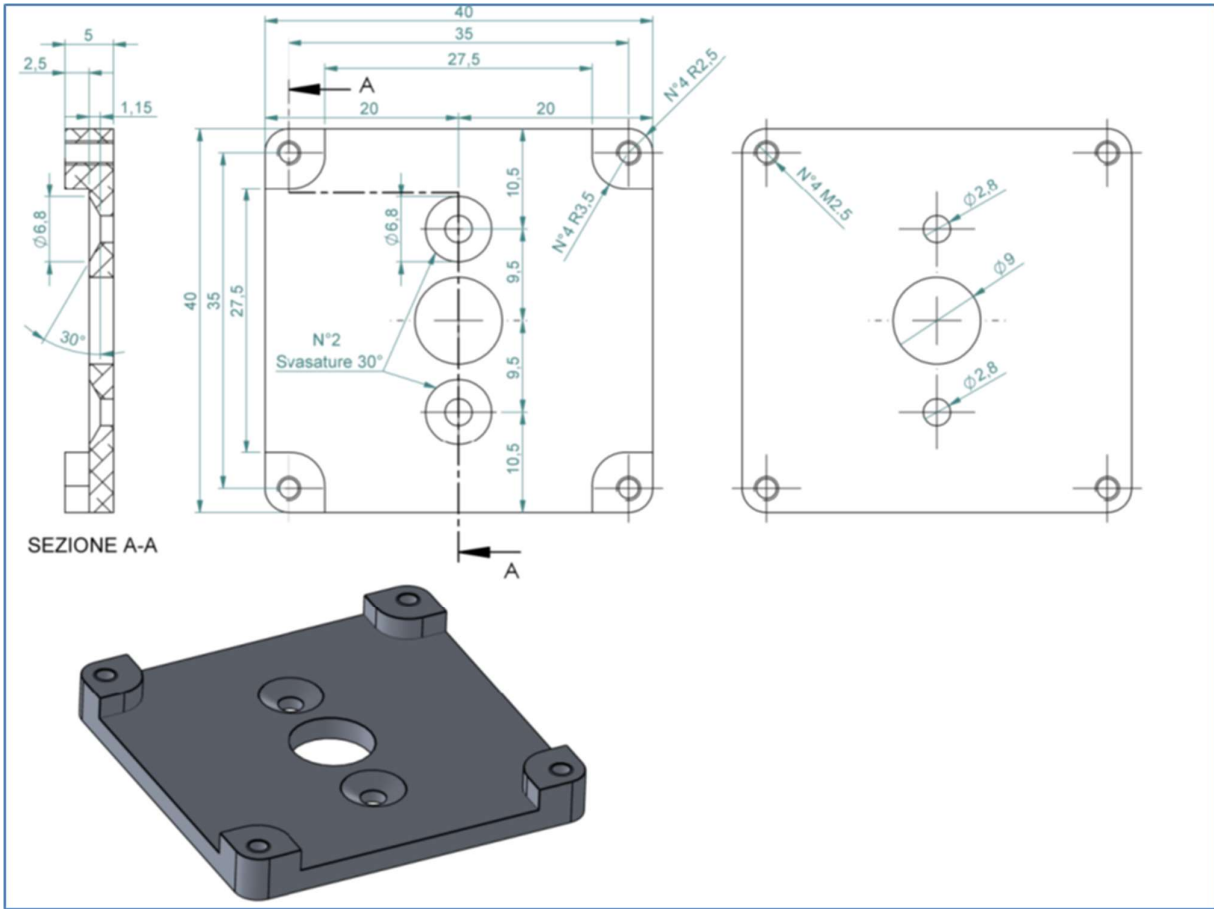
Figure 24. PCB Holder Mechanics

The middle screws fit to prepared holes in the backside of the Nanotech motor, while the holes on the corners are threaded and allow fixing of the sensor board with M2.5 screws.
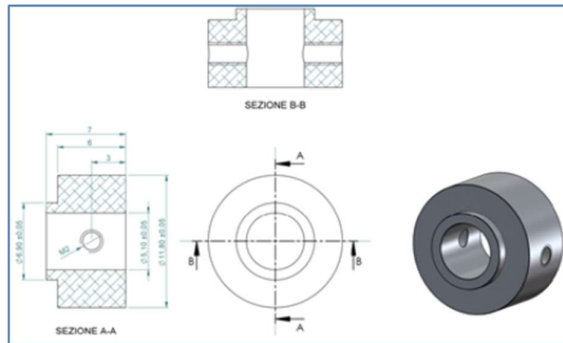
Figure 25. Reflector Holder, Fits on the Rotor

7. RX13T Connections

The MotorControl-RX13T kit is a single board inverter, based on the 48pin RX13T. The hardware includes a low-voltage MOSFETs power stage, a communication section to a PC GUI, and an alternative speed control inputs independent of the GUI.

To obtain the maximum flexibility, the PoC board includes:

▪ A complete 3-phase inverter on-board with a low voltage motor to allow testing the several available algorithms on the RX13T.

▪ USB communication with the PC via a RL78/G1C microcontroller. The Rx and Tx lines to the RX13T are optically/galvanically isolated.

▪ IPS2200 device for position sensing

Further input signals are the 3 general purpose buttons, analog input/potentiometer speed control, and PWM input for speed control. Spare GPIO pins are available on connector J2.

Debugging is possible via a 4-pin connection to E1/E2 emulator.
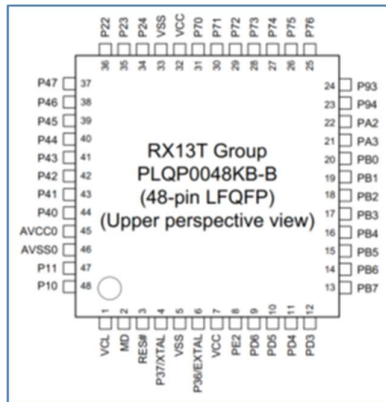
Figure 26. RX13T - 48pin Layout

Table 7 shows the RX13T pin layout matching the usage on the board.

Table 7. RX13T Pin Layout

Pin No.	Pin Name	I/O Port	Timers (MTU, POE, CAC)	Communications (SCI,IIC)	Board Use
1	VCL				
2	MD	FINED			EML mode pin
3	RES#				EML RESET pin / reset Button
4	XTAL	P37			NC
5	VSS				GND
6	EXTAL	P36			NC
7	VCC				VCC
8	PE2	POE10#	NMI/IRQ0		J2 - pin 3
9	PD6	MTIOC0D	CTS1#/RTS1#/SS1#	**IRQ5**/ADST0	Button 2
10	PD5	MTIOC0C	RXD1/SMISO1/SSCL1	IRQ3	Button 1
11	PD4	MTIOC0B	SCK1	IRQ2	Button 3
12	PD3	MTIOC0A	TXD1/SMOSI1/SSDA1		J2 - pin 1 - PWM in
13	PB7	MTIOC3C/MTCLKD	**RXD1**/SMISO1/SSCL1/RXD5/ SMISO5/SSCL5	IRQ5	UART Rx
14	PB6	MTIOC1B/MTIOC3A	**TXD1**/SMOSI1/SSDA1/TXD5/ SMOSI5/SSDA5		UART Tx

Pin No.	Pin Name	I/O Port	Timers (MTU, POE, CAC)	Communications (SCI,IIC)	Board Use
15	PB5	ADTRG0#			Green LED DL2
16	PB4	POE8#	IRQ3		J2 - pin 4
17	PB3	MTIOC0A/CACREF	SCK5/SCK12		J2 - pin 5
18	PB2	MTIOC0B/MTCLKC/ADSM0	TXD5/**SMOSI5**/SSDA5/SDA0		IPS2200 SIOSDAC
19	PB1	MTIOC0C/MTIC5W/MTCLKA	RXD5/**SMISO5**/SSCL5/SCL0	IRQ2	IPS2200 SCKSCLC
20	PB0	MTIOC0D/MTIOC2A/MTCLKB	TXD12/TXDX12/SIOX12/ SMOSI12/SSDA12		J2 - pin 6
21	PA3	MTIOC1B/MTIOC2A	CTS12#/RTS12#/SS12#		J2 - pin 7
22	PA2	MTIOC1A/MTIOC2B	CTS5#/RTS5#/SS5#	IRQ4	IPS2200 CSNIRQC
23	P94	MTIOC2B/MTIC5U/MTCLKA	RXD12/RXDX12/SMISO12/ SSCL12	IRQ1	J2 - pin 8
24	P93	MTIOC1A/MTIC5V	SCK5/SCK12	IRQ0/ADTRG0#	J2 - pin 9
25	P76	MTIOC4D			HIP2211 - WL
26	P75	MTIOC4C			HIP2211 - VL
27	P74	MTIOC3D			HIP2211 - UL
28	P73	MTIOC4B			HIP2211 - WH
29	P72	MTIOC4A			HIP2211 - VH
30	P71	MTIOC3B			HIP2211 - UH
31	P70	POE0#	IRQ5		J2 - pin 15
32	VCC				VCC
33	VSS				GND
34	P24	MTIC5U	RXD5/SMISO5/SSCL5	IRQ3/COMP0	J2 - pin 14
35	P23	MTIC5V/CACREF	TXD5/SMOSI5/SSDA5	IRQ4/COMP1	J2 - pin 13
36	P22	MTIC5W	IRQ2/COMP2		J2 - pin 12
37	P47*1	**AN007**/CMPC13			J4 - pin 2 (pot/IPS2200 COSNC)
38	P46*1	**AN006**/CMPC03			IPS2200 COSPC
39	P45*1	**AN005**/CMPC22			IPS2200 SINNC
40	P44*1	**AN004**/CMPC12			IPS2200 SINPC
41	P43*1	**AN003**/CMPC02			High Voltage Ref
42	P42*1	**AN002**/CMPC20			Shunt W
43	P41*1	**AN001**/CMPC10			Shunt V
44	P40*1	**AN000**/CMPC00			Shunt U
45	AVCC0				VCC
46	AVSS0				GND
47	P11	MTIOC3A/MTCLKA/POE8#	IRQ1/CVREFC0		J2 - pin 11
48	P10	MTCLKB	IRQ0		J2 - pin 10

8. Board Connections

The MCU board has several connections to communicate with the environment.
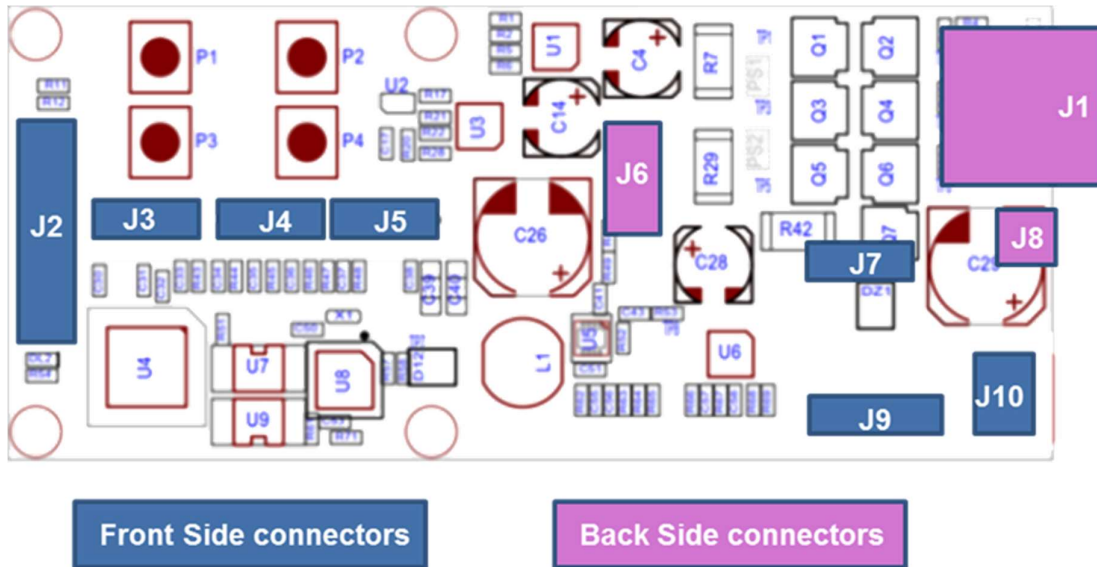
Figure 27. Position of Connectors

8.1 J1 3 Pin Motor Connector

The 3 pin motor connector allows to transport up to 5A.

8.2 J2 Auxiliary Connector (Spare GPIO)

The spare pins from the RX13T are available on J2 connector.

Table 8. Auxiliary Connector

J2	RX13T Pin No.	Pin Name
1	12	PD3
2	5	GND
3	8	PE2
4	16	PB4
5	17	PB3
6	20	PB0
7	21	PA3
8	23	P94
9	24	P93
10	48	P10
11	47	P11
12	36	P22
13	35	P23
14	34	P24
15	31	P70
16		NC

8.3 J3 Debug RX13T

Connector J3 allows connection to an E1/E2 emulator.

Note that the emulator cannot be used either during programming of the flash memory or to power the board. The system is safe to connect 24V on the barrel connector to program or to debug code on the RX13T device.

Table 9. Debug Connector

J3	RX13T Pin No.	Pin Name	E1 Pin Connection
1	7	Vcc (+5V)	8 - 9
2	5	GND	2 – 12 - 14
3	2	MD	7
4	3	Reset	13

8.4 J4 Jumper Analog IN / IPS Differential COSN Input

The RX13T has only 7 ADC channels available (the factory default firmware uses single ended input only). The IPS2200 can only be used in single ended mode if the motor speed is set with an external potentiometer or analog DC voltage in non-GUI control.

Table 10. AN7 Analog IN

J4	Connection
1	IPS2200 COSCN
2	RX13T pin37
3	ANALOG IN
4	Not connected

When using the IPS2200 in differential mode, ensure to connect pins 1 and 2. When connecting a potentiometer or provide the board with an external DC control voltage, ensure to connect pins 2 and 3.

8.5 J5 Potentiometer Connector

When using an external analog DC voltage, the external control voltage must be connected to pin 2 of J5. When using a potentiometer, connect the slider to pin 2, while the outer pins must be connected to pins 1 and 3. Note that the used potentiometer must be >10kOhm.

Table 11. Analog Speed Control

J5	Connection
1	Board +5V
2	Analog IN (potentiometer slider)
3	Board GND
4	Not connected

8.6 J6 IPS2200 Sensor Connector

The IPS2200 connects directly to the MCU board via J6. All pins of the device are wired to the connector.

Table 12. IPS2200 Connection

J6	IPS2200 Signal Name	RX13T Connection Name
1	Test point TP8	Not connected
2	Board +5V	N/A
3	CSN IRQ	PA2
4	Serial SDA	PB2
5	Serial SCL	PB1
6	SIN P signal	P44
7	SIN N signal	P45
8	COS P signal	P46
9	COS N signal	P47 (via J4 pin 1)
10	Board GND	N/A

8.7 J7 Direct Power Connection

The board allows to use a wired 24V connection (without using the barrel connector) with the following restrictions:

- Voltage Rating: 12VDC to 36VDC
- Power Rating: $5A_{max}$

Table 13. External Power

J7	Connection
1	+ 24V DC
2	Board GND

8.8 J8 Power Supply Barrel Connector (24V / maximum 36V)

Do not exceed 3A when using the barrel connector from the power supply. Use the power connectors on the board when using the board to the maximum current.
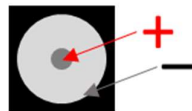
Figure 28: Barrel Connector

Power supply restrictions:

- Board voltage Rating: 12VDC to 36VDC
- Barrel connector current rating: $3A_{max}$

8.9 J9 Debug RL78/G1C

The board has a debug connector to program the RL78/G1C device (USB 2 serial) – **RL78/G1C device is factory programmed and does not need debugging or reprogramming**.

8.10 J10 USB Connector

The USB connector on the board allows to connect to a controlling MS Windows™ environment. When using the GUI, the control signals are transferred here. When using non-GUI mode, the firmware feedback is sent to a terminal by using a 115kBaud transfer rate.

9. System BOM List

Table 14. System Bill of Material

Quantity	Manufacturer	MFR Part Number	Description	Component Names
1	Würth Elektronik	694106301002	CONN. JACK 5A 2,1mm DC-10A 5A 12VDC	J8
1	NAC	2CSI9M03	C.SAURO CIM/9P-03 M.POL.90GR.	J1
1	STP F DP 5-5	2CV00149	STP F DP 5+5 H8.5 P.2,54 SS14S(F1593490)	J6
1	BERGER 5M	2CV00165	STRIP 5P.M.VERT.p.2,54mm	J9
3	Harwin	M20-8770442R	ST.4M p2.54 h9.65 M20-8770442R	J3, J4, J5
1	Würth Elektronik	629105150921	USB MICRO B 90°	J10
4	PULS_KSEM31G LFS	4AAP0040	KSEM31G LFS - Interruttore Tattile, Non Illuminato, 32 V, 50 mA, 1.5 N, SMD	P1, P2, P3, P4
1	Würth Elektronik	784787101	784787101 (SMD) AEC-Q200 100µH 950mA Schermato 870mA WE-PD2SA Series	L1
1	Würth Elektronik	885012006057	COND. SMD 50V 0603 NP0 "100pF"	C56
9	Würth Elektronik	885012206083	COND. SMD 50V 0603 X7R "1nF"	C1, C8, C10, C18, C33, C34, C35, C57, C58
3	Würth Elektronik	885012206089	COND. SMD 50V 0603 X7R "10nF"	C36, C37, C46
19	Würth Elektronik	885012206095	COND. SMD 50V 0603 X7R "100nF"	C5, C6, C7, C13, C15, C16, C17, C19, C20, C24, C30, C31, C38, C41, C42, C43, C48, C52, C55
3	Würth Elektronik	885012206048	COND. SMD 16V X7RK 0603 "220nF"	C2, C11, C45
2	Würth Elektronik	885012206050	COND. SMD 16V 0603 X7R "470nF"	C50, C53
3	Würth Elektronik	885012208093	COND. SMD 1µF 50V X7R 1206	C49, C54, C59
1	Würth Elektronik	885012106022	C.SMD 1µF 25V 0603 X5R	C51
2	Würth Elektronik	885012106012	C.SMD 4.7µF 10V 0603 X5R	C9, C32
6	Würth Elektronik	885012208069	COND. SMD 10µF 25V X7R (Package 1206)	C3, C12, C39, C40, C44, C47
2	Würth Elektronik	885012108022	C.SMD 10µF 50V X5R 1206	C25, C27
3	Würth Elektronik	865060645008	COND. SMD ELETTR. 47µF 50V	C4, C14, C28
2	Würth Elektronik	865060657012	COND. SMD ELETTR. 220µF 50V	C26, C29
6	Onsemi	BAT54S	D.SMD BAT54S 200mA 30V SCHOTTKY SOT-23	D2, D8, D9, D10, D11, D12
2	Renesas	RV1S9160A	OPT. RV1S9160A SOP-5 CMOS	U7, U9
3	Renesas	HIP2211FRTZ	C.I.SMD HIP2211FRTZ 100V 3A 10DFN 4X4	U1, U3, U6
1	Renesas	ISL85413FRTZ-T	ISL85413FRTZ-T Integrated FET Regulators Wide Vin, 300mA Synchronous Buck Regulator	U5
1	Renesas	RAA214220	RAA214220 150mA 20V Wide Input Voltage Range LDO Linear Regulator	U2

Quantity	Manufacturer	MFR Part Number	Description	Component Names
1	Renesas	R5F10JBCANA	R5F10JBCANA RL78 Microcontroller for USB to UART Conversion	U8
1	Renesas	R5F513T5ADFL	R5F513T5ADFL RX Family RX13T Group Microcontrollers	U4
1	DIALIGHT	4ALV0603	LED.SMD VERDE 0603 DIALIGHT	DL2
7	Renesas	RJK0654DPB	MOSFET RJK0654DPB LFPAK 60V 30A Rds=6.5mOhm	Q1, Q2, Q3, Q4, Q5, Q6, Q7
1	Murata	CSTCE12M0G52A-R0	RIS.CER.SMD CSTCE12M0G52A-R0 12.0Mhz MURATA-AVX AUTOMOTIVE	X1
3	0R	4AR00006	RESIST.SMD 0603 "0R 1%"	R20, R59, R70
3	0R1 1W 2512	4AR00125	RESIST.SMD 2512 "0R1" 1% 200V 100PPM/°C	R7, R29, R42
8	47R	4AR04706	RESIST.SMD 0603 "47R 1%"	R4, R8, R19, R23, R31, R36, R55, R60
11	100R	4AR11006	RESIST.SMD 0603 "100R 1%"	R2, R5, R21, R22, R43, R44, R45, R46, R66, R69, R71
3	220R	4AR12006	RESIST.SMD 0603 "220R 1%"	R33, R34, R35
3	1K	4AR21006	RESIST.SMD 0603 "1K 1%"	R12, R53, R54
3	1K2	4AR21206	RESIST.SMD 0603 "1K2 1%"	R38, R39, R40
4	1K5	4AR21506	RESIST.SMD 0603 "1K5 1%"	R41, R49, R51, R61
1	3K01	4AR23316	R.SMD 3K01 0603 1% 100PPM	R62
4	4K7	4AR24706	RESIST.SMD 0603 "4K7 1%"	R11, R13, R32, R56
1	5K6	4AR25606	RESIST.SMD 0603 "5K6 1%"	R64
19	10K	4AR31006	RESIST.SMD 0603 "10K 1%"	R1, R3, R6, R9, R10, R14, R17, R18, R24, R25, R26, R28, R30, R37, R47, R57, R58, R67, R68
1	12K4	4AR31246	R.SMD 12K4 0603 1% 100PPM	R16
1	22K	4AR32206	RESIST.SMD 0603 "22K 1%"	R50
2	39K	4AR33906	RESIST.SMD 0603 "39K 1%"	R15, R65
1	91K	4AR39106	RESIST.SMD 0603 "91K 1%"	R63
3	100K	4AR41006	RESIST.SMD 0603 "100K 1%"	R27, R48, R52
1	Onsemi	BZX84C15	D. ZENER 15V 350mW SOT-23	DZ1
1	Bourns	MF-R800	PTC Bourns MF-R800_0_99 8A/16A multifuse	FUS1

10. Operation Modes

To allow specific test sequences with the RX13T board, a set of functions are included into the default RX13T firmware. These functions can be initiated using 'operation mode numbers' to be programmed via the GUI in parameter 00, see section 4.5 for details.

The mode number control sequence allows data output without the graphical GUI interface. There is a basic 'fall back' mechanism built into the system that allows an easy return control back to the GUI and reprogram specific motor settings of the system. For further details, refer to section 4.

11. Certifications

The EU068 Motorcontrol Kit RX13T & IPS2200 Kit complies with the laws and regulations described below.

12. References

[1] RX13T Group User's Manual: Hardware RENESAS 32-Bit MCU RX Family／RX100 Series

[2] IPS2200 Inductive Position Sensor IC, Datasheet

[3] RL78/G1C User's Manual: Hardware Rev.1.21 Dec 2020 16 16-Bit Single-Chip Microcontrollers

[4] RV1S9160A, 15Mbps CMOS OUTPUT, 5-PIN SOP PHOTOCOUPLER, Datasheet

[5] HIP2210, HIP2211 100V, 3A Source, 4A Sink, High Frequency Half-Bridge Drivers, Datasheet

[6] RJK0654DPB 60V, 30A, Silicon N Channel Power MOS FET, Datasheet

[7] ISL85413 Wide VIN 300mA Synchronous Buck Regulator, Datasheet

[8] RAA214220 150mA 20V Wide Input Voltage Range LDO Linear Regulator, Datasheet

[9] Renesas Electronics, "E1/E20/E2 Emulator, E2 Emulator Lite - Additional Document for User's Manual - (Notes on Connection for RL78)", Jul. 2020 - R20UT1994EJ0702.

[10] Renesas Electronics, "YROTATE-IT-RX23T User Manual" Oct. 2015, UM-YROTATE-IT-RX23T

13. Glossary

Term	Description
BOM	Bill of Material
DC	Direct Current
EML	Emulator
GPIO	General Purpose Input Output
GUI	Graphical User Interface
I2C	Inter Integrated Circuit Interface
LDO	Low Dropout (voltage regulator)
MCU	Microcontroller Unit
PCB	Printed Circuit Board
PI	Proportional Integral (control loop)
PoC	Proof of Concept
PWM	Pulse Width Modulation
RMP	Ramp Up
SAM	Sampling Frequency
SCL	Serial Clock Line
SDA	Serial Data Line
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver Transmitter

14. Revision History

Revision	Date	Description
1.0	Oct 18, 2021	Initial release.