RX23T inverter ref. kit

Deep Dive   October 2015
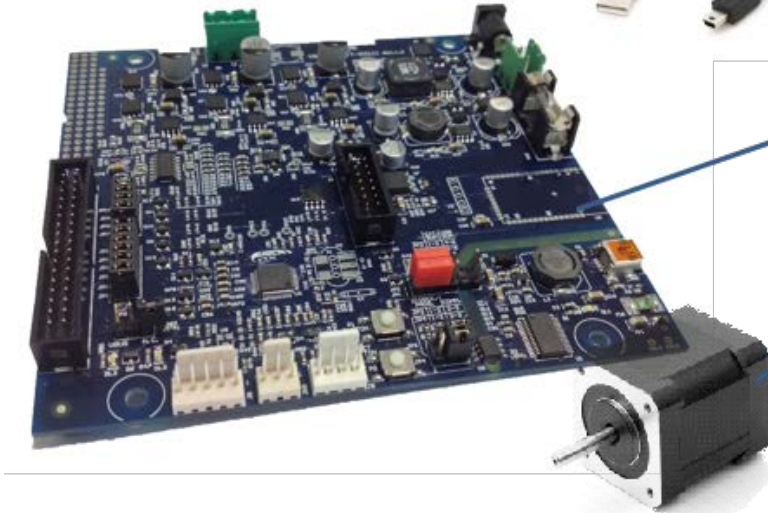
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YROTATE-IT-RX23T kit content

Quick Start Guide

Mini USB cable

RX23T inverter board
Max 48V_{DC}, 7A_{max}

Nanotec AC Brushless
Motor: DB42S03

# YROTATE-IT-RX23T kit: 3-ph. Brushless Motor Specs

Nanotec® PLUG & DRIVE

DB42S03

SPECIFICATION \ CONNECTION	DELTA
NO. OF POL./PHASE	8/3
VOLTAGE RATED (VDC)	24
CURRENT NO LOAD/RATED/PEAK (AMP)	0.2/1.79/5.4
RESISTANCE/PHASE TO PHASE (Ohms) @25°C	1.5±15%
INDUCTANCE/PHASE TO PHASE (mH) @1KHz	2.1±20%
TORQUE RATED/PEAK (Nm) [lb-in]	0.0625/0.19 [0.553/1.68]
TORQUE/VOLTAGE CONSTANT (Nm/A)/(Vrms/KRPM)	0.035/2.78=BACK EMF ⚠
POWER RATED (W)	26
SPEED RATED/NO LOAD (U/min)	4000/6200
ROTOR INERTIA (Kg-m²) [lb-in²]	2.4×10^{-6} [8.2×10^{-3}]
WEIGHT (Kg) [lb]	0.3 [0.661]

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Motors & driving methods supported
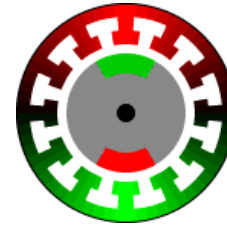
Brushless DC
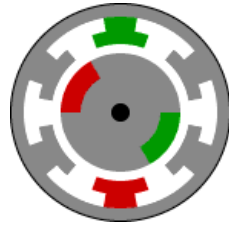
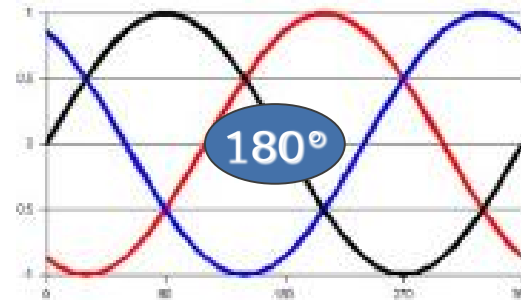### Block commutation

120°
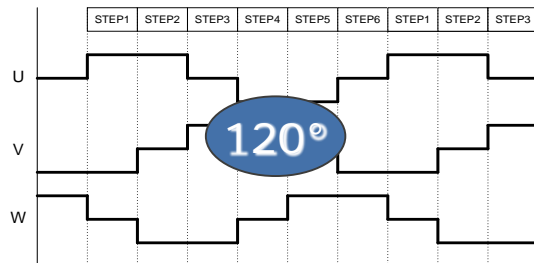
Sensorless ✓
⇨ 3 Back EMF
Sensored ✓
⇨ Hall, encoder
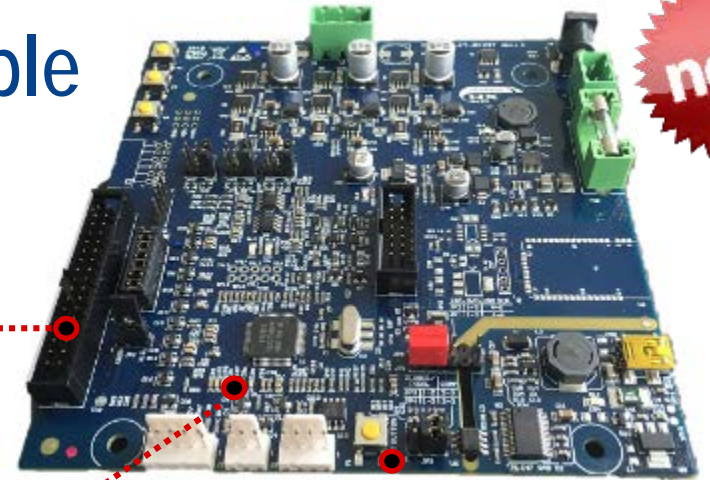
Permanent Magnet Synchronous

Vector controlled

180°

By default on the kit

Sensorless ✓
⇨ 1 or 3 shunts
Sensored ✓
⇨ Hall, encoder

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Auto-tuning & automatic identification enable

new

Vector control Algorithm in Floating Point arithmetic

3-phase Permanent Magnet AC motors

Sensorless Control Closed loop

1 or 3 shunts

Renesas MOSFETs inverter

USB powered

E1 Prog/debug connector

150W @ 48V$_{DC}$

External. stage 1.5KW @ 300V$_{DC}$ Or 3.6KW @ 60V$_{DC}$

Hall & Encoder connectors

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YROTATE-IT-RX23T PCB in details

Up to 48V$_{DC}$
Up to 6A

Six MOSFETS
RJK0654DPB (60V/30A)

ICS connection

E1 connector
Debug/prog.

USB connection
Fully isolated

RX23T
64-pin, 5V

External power
Stage connection

Encoder, hall sensor connection
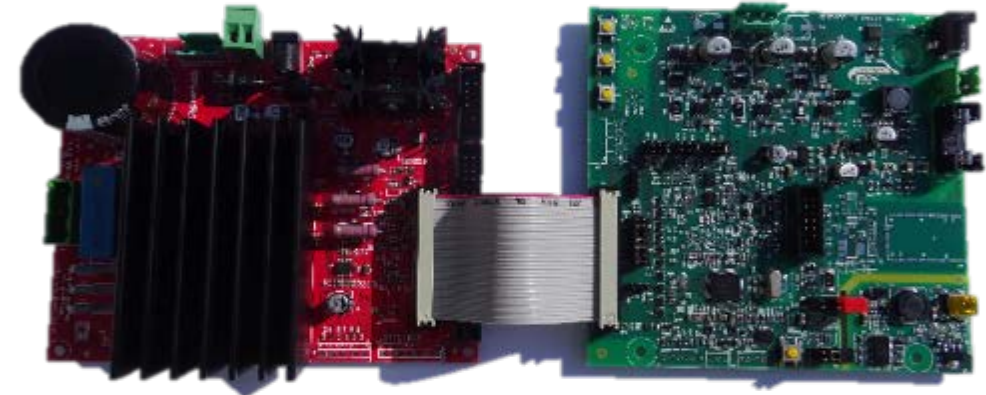
RENESAS
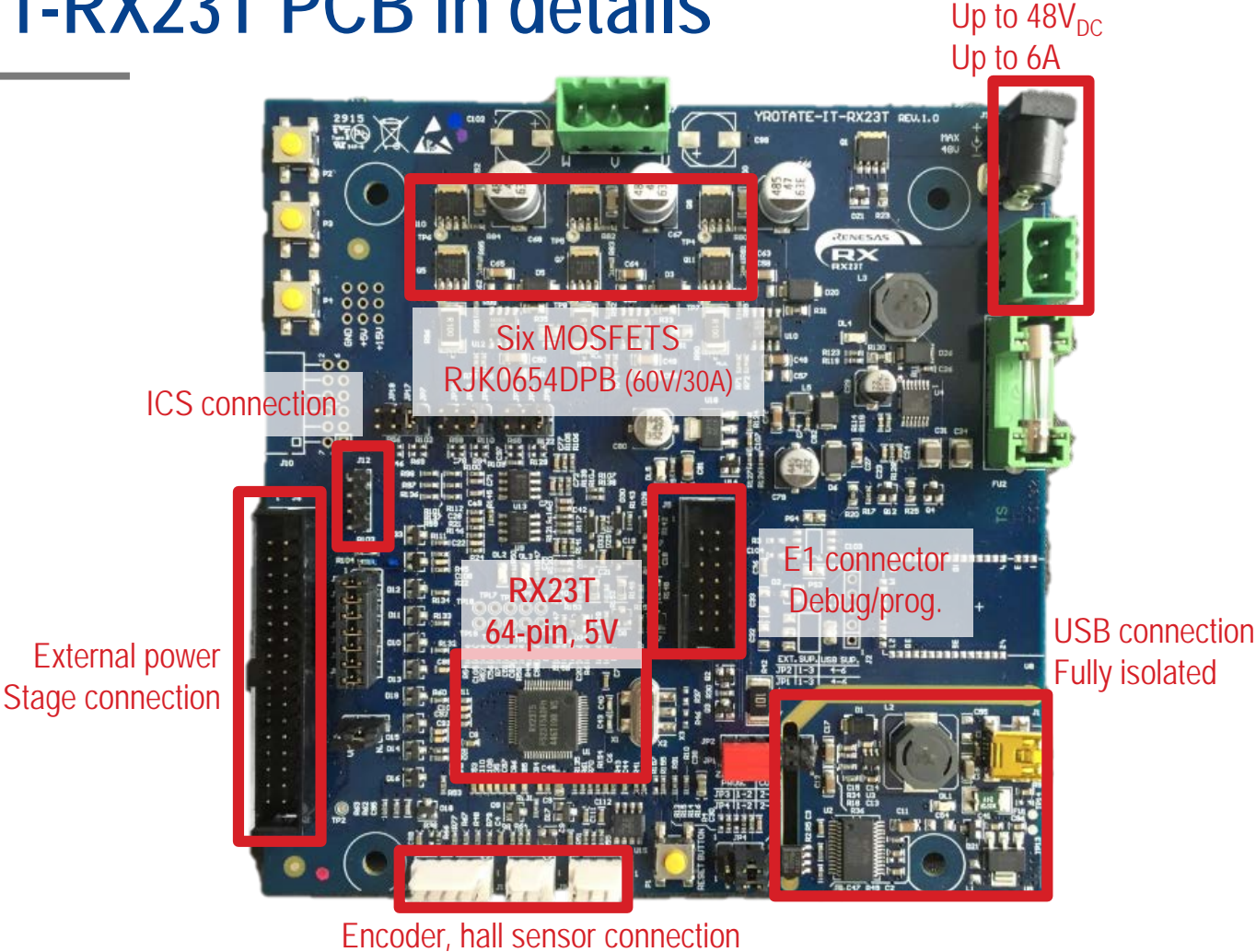
Three power stage classes

$48V_{DC}$
$6A_{Peak}$

Scalable solution:
- From low voltage, low current
- Up to high voltage, high current

$300V_{DC}$
$20A_{Peak}$

$60V_{DC}$
$100A_{Peak}$

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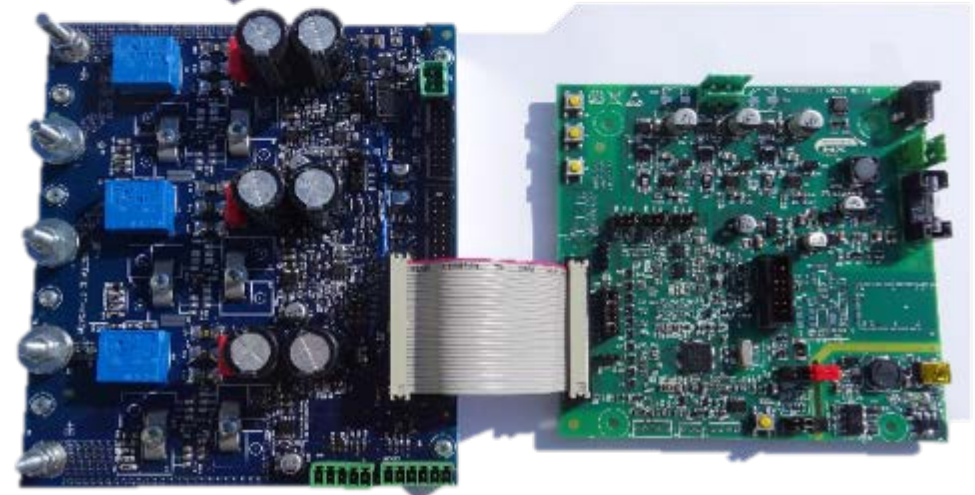
Auto-tuning s/w for all RX inverter kits

Current PI coefficients tuned !

Oscilloscope to display Motor Phase and current

Stator resistance, synchronous inductance, permanent magnet flux tuned !
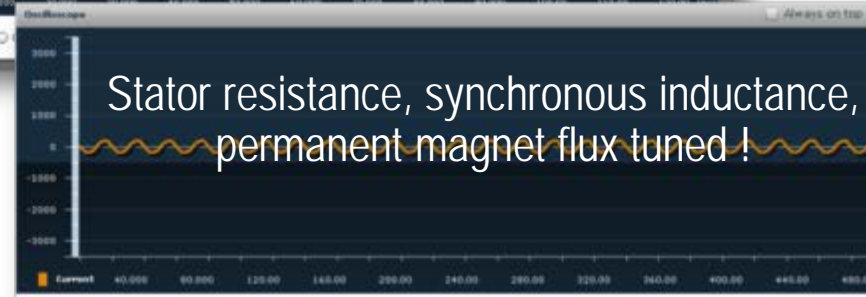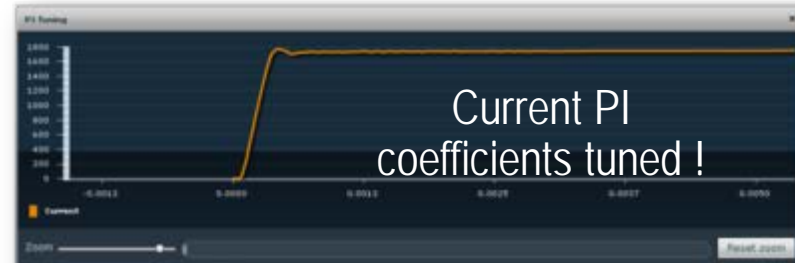
- Partname: YROTATE-IT-RX23T
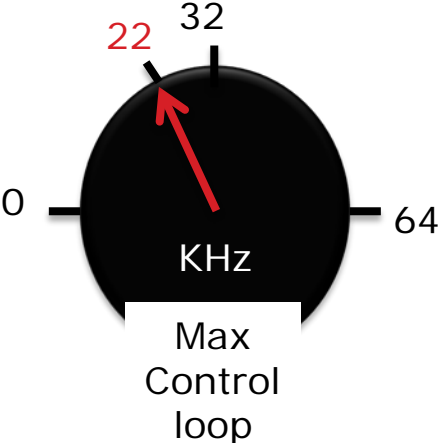- Lead-time: 10 days
- Price: EUR 179,00
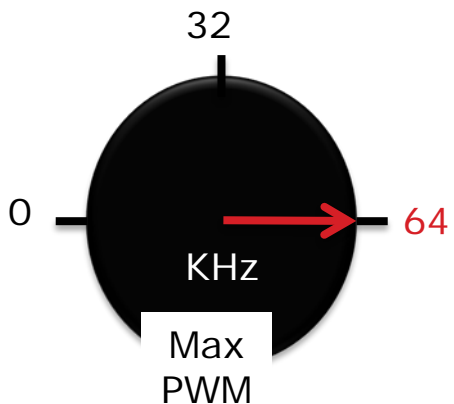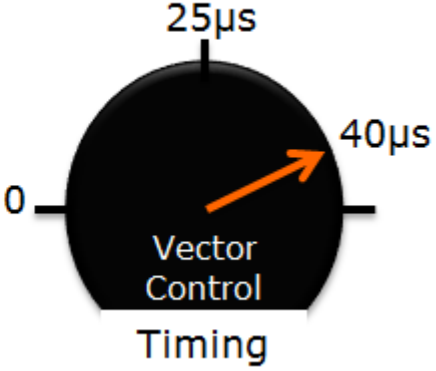
45 seconds to drive unknown PMSM motors !

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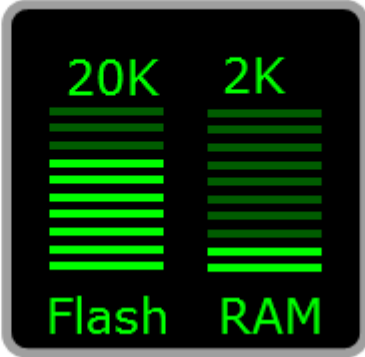
High Performance & dynamics at competitive price

RX23T
32-bit @ 40MHz
80 DMIPS with FPU

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RX
RX200

new

Memory footprint

20K   2K

Flash   RAM

25µs
40µs
0
Vector
Control
Timing

32
0   64
KHz
Max
PWM

22   32
0   64
KHz
Max
Control
loop

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Vector Control s/w routines implemented

Auto-tuning

- Current PI automatic calibration
- Parameters self-identification
- Stator resistance compensation
- Bus Voltage automatic compensation
- Position control/torque control/ speed control
- Dead-time compensation
- Sensorless drive at low-speed

Sensorless estimation

| Method using Integral estimation | Model using Direct Integration |

Vector Control Algorithm

Current control

| Max. torque control | Flux weakening control |
| Max. efficiency control | Power factor control |

Direct Current control

| Position detection Speed detection | dq conversion |
| | $\alpha\beta$ conversion |

PI control Current & Speed

Anti-windup

Modulation

Clamped Modulation

Centred Modulation

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Overview

		RX111	RX23T	RX62T
Microcontrollers Specifications		32-bit @ 32MHz 50 DMIPS	32-bit @ 40MHz 80 DMIPS with FPU	32-bit @ 100MHz 165 DMIPS with FPU
Inverter System dynamics	PWM frequency: Control loop speed: Vector Control loop: Sensorless:	Max. 64KHz Max. 15KHz 57µs 1 or 3 shunts	Max. 64KHz Max. 20KHz 40µs 1 or 3 shunts	Max. 64KHz Max. 25KHz 35µs 1 or 3 shunts
Microcontroller resources used by algo.	CPU load @ 8KHz Flash footprint: RAM usage: Arithmetic Peripherals:	45% 25KB 3KB Fixed-point MTU2 12-bit A/D	32% 20KB 3KB Floating-point MTU3 12-bit A/D Comp.	28% 20KB 3KB Floating-point MTU3 12-bit A/D PGA, Comp.

Overview

		RENESAS RX RX100	**RENESAS RX** RX200 *new*	**RENESAS RX** RX600
Sensorless Algorithm capabilities	Torque & speed control: Flux Weakening support: Efficient PWM Modulation: PI current auto-tuning: Motor para. Identification:	✔ YES	✔ YES	✔ YES
Development Tools	Compilers: IDE:	CC RX Renesas E²Studio	CC RX Renesas E²Studio CubeSuite+ CS+	CC RX Renesas E²Studio HEW
3-ph inverter capabilities	Isolated USB connection: Drive one or two motors: Motor Voltage capability: Debugger connector:	Yes Single $24V_{DC}$ E1	Yes Single **$48V_{DC}$** E1	Yes **Dual** $24V_{DC}$ E1

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Bill of Material in details

Renesas devices:

PART-NAMES	DESCRIPTION	QUANTITY
R5F523T3ADFM	RX23T MCU	1
RJK0654DPB	MOSFETs	6
R1EX2400-2A-SA-S0A	EEPROM	1
	TOTAL	**8**

PART-NAMES	DESCRIPTION	QUANTITY
Cxx	Capacitor	110
JPxx	Jumper/connector	33
Dxx	Diode/LED	37
Fux	Fuse, connector	2
Lx	Inductance	4
Px	Push button	4
Qx	Transistor	6
Rx	Resistor	155
U10, U11, U12	MOSFET driver	3
Ux	Op-amp, IC	9
X1	Quartz	1
	TOTAL	**364**

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Schematics Hints
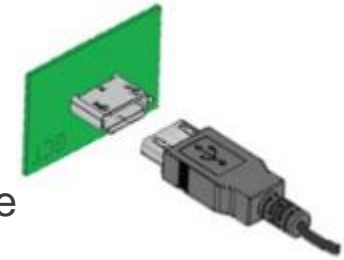
Easy connection to PC via USB and Micro-USB conne

Serial to USB IC used for easy reuse of the serial protocol

FDTI chip used to ensure Windows drivers compatibility: W7, W8

LED DL1 used to indicate the connection traffic

Max. baud rate is: **76.6 KBd** to ensure fluid oscilloscope window
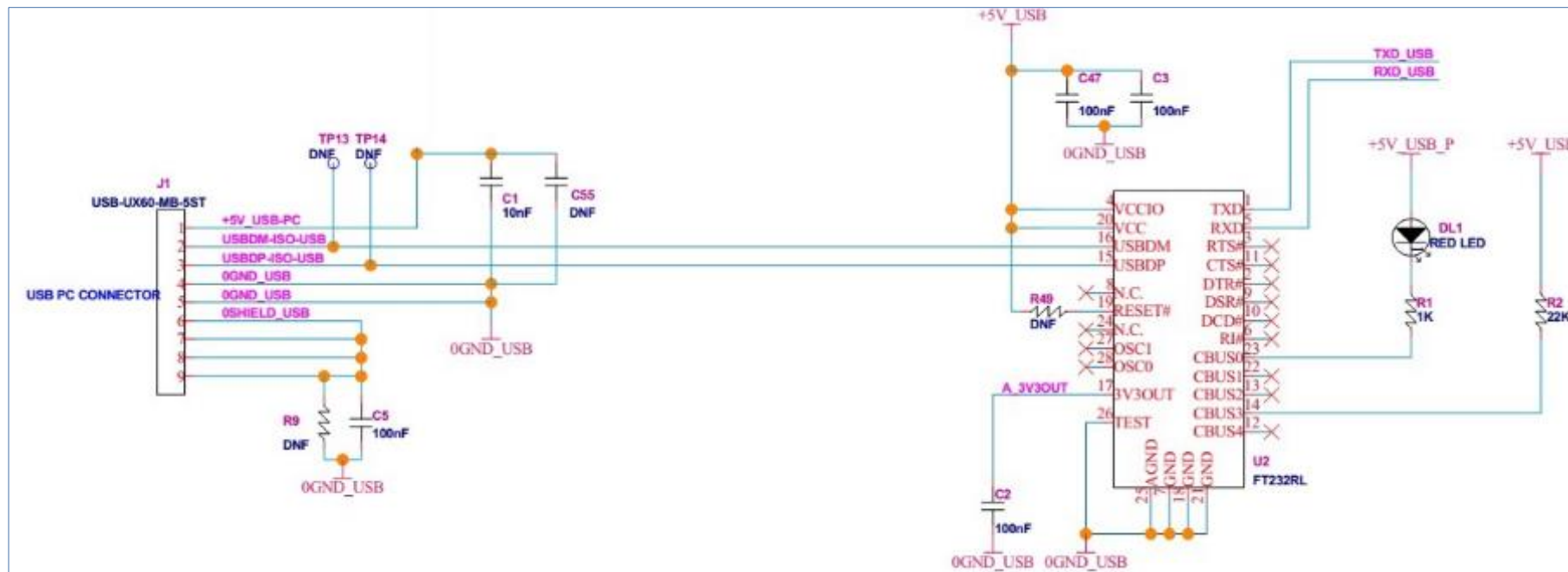
Schematics Hints
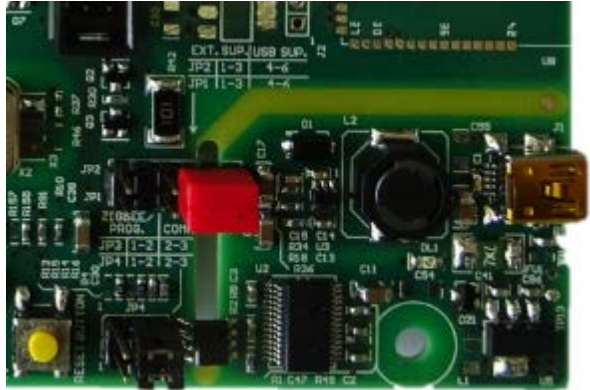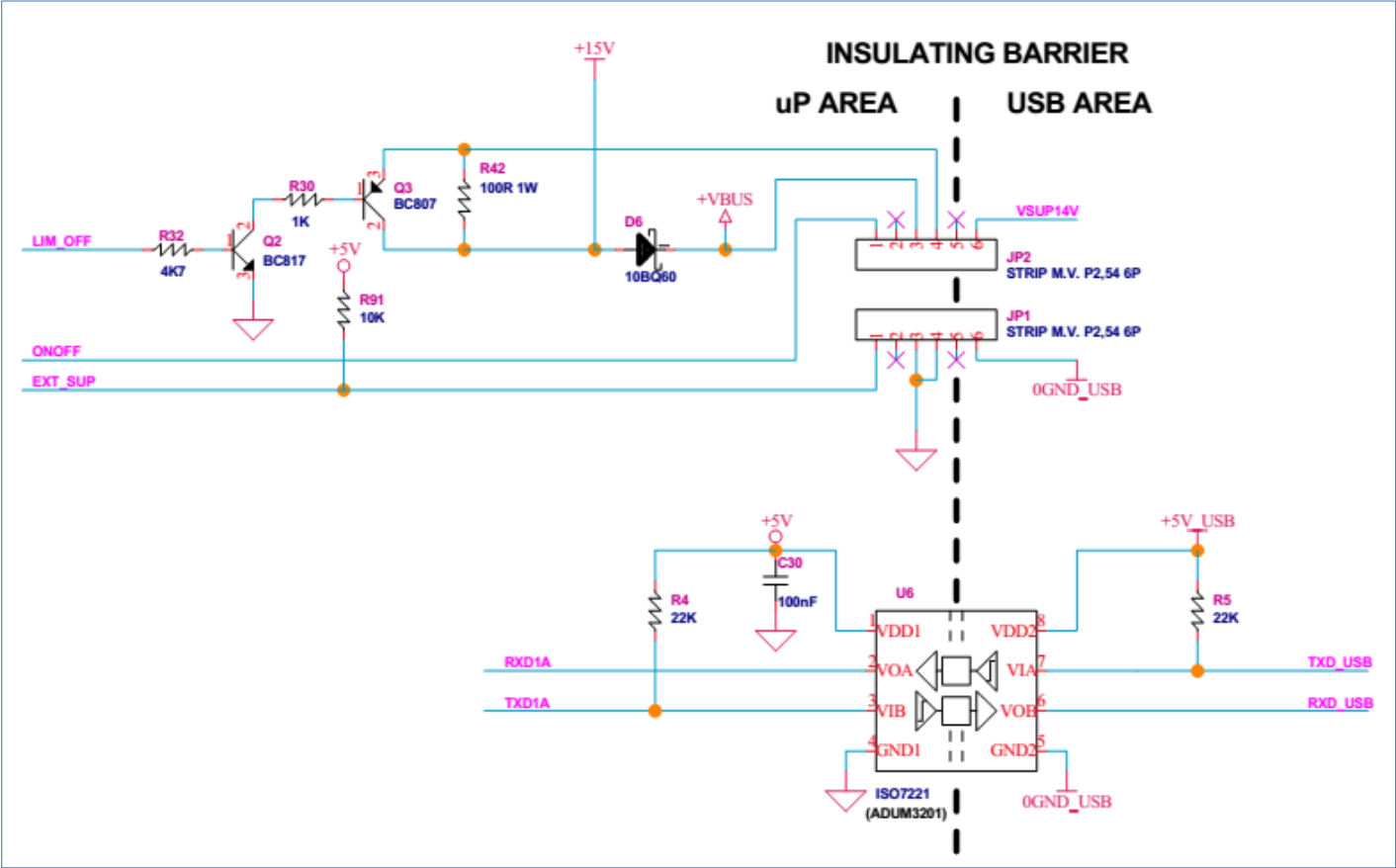
USB connection is galvanic isolated

Ensure maximum safety for user when high voltage or high current motor used

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Schematics Hints

E1 connection for debug and programming

Parameters management in EEPROM

It stores:

- the motor parameters

- The algorithms specific data

- the application specific parameters

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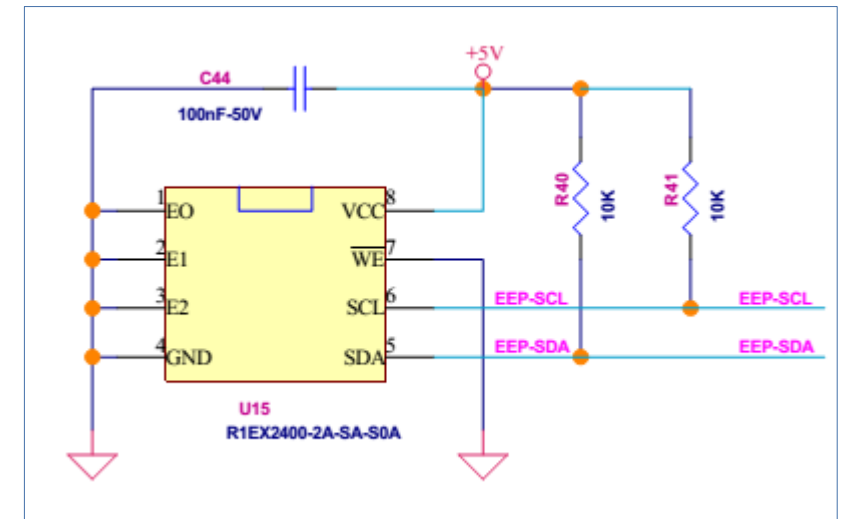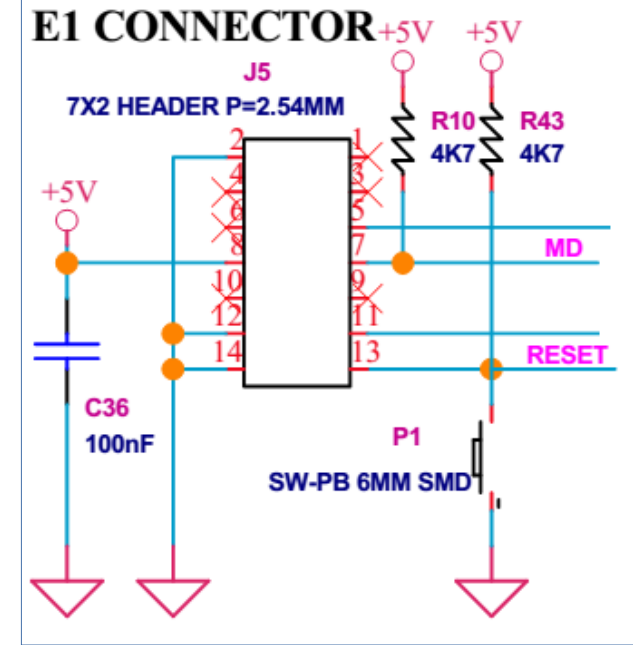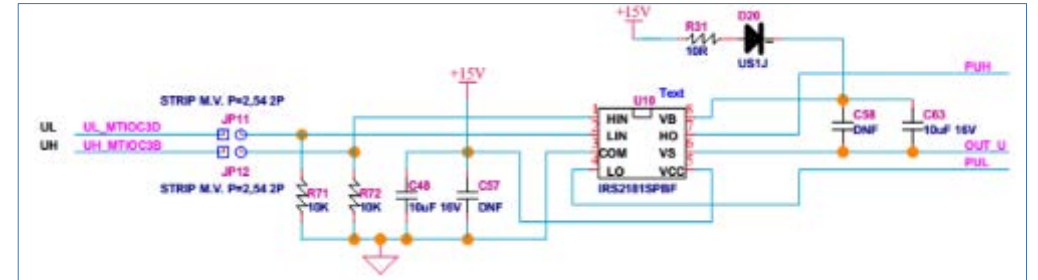
Schematics Hints

Three driving circuits for the 6 x low voltage MOSFETS

Over-current circuit management using gate driver signals, linked to Port Output Enable of the RX23T to stop the PWM signal in hardware
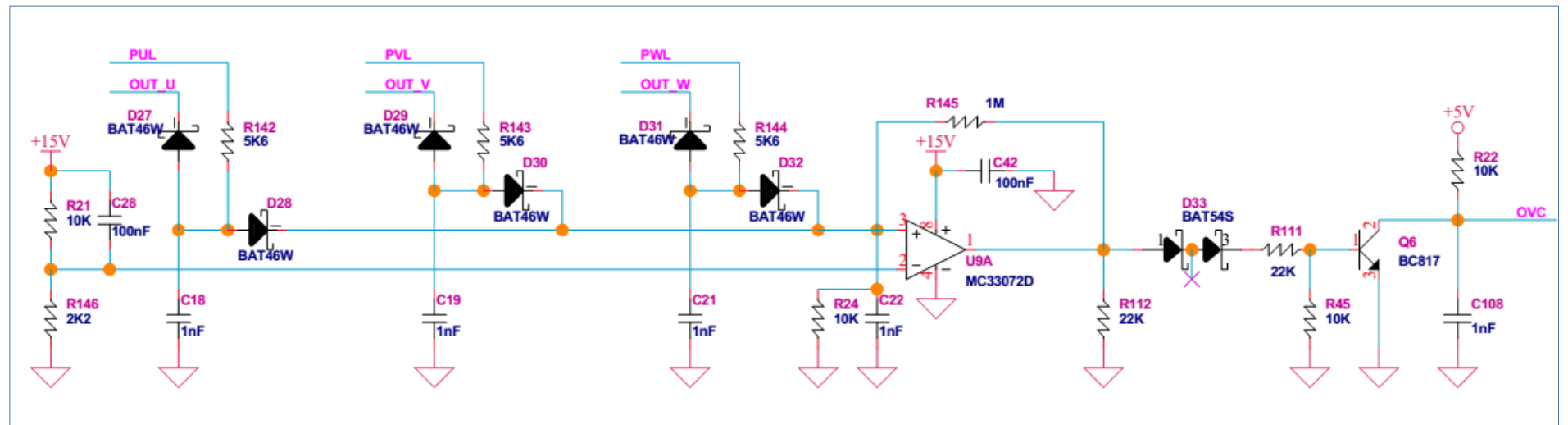
Schematics Hints

Three shuts used for the motor current reading and motor speed estimation
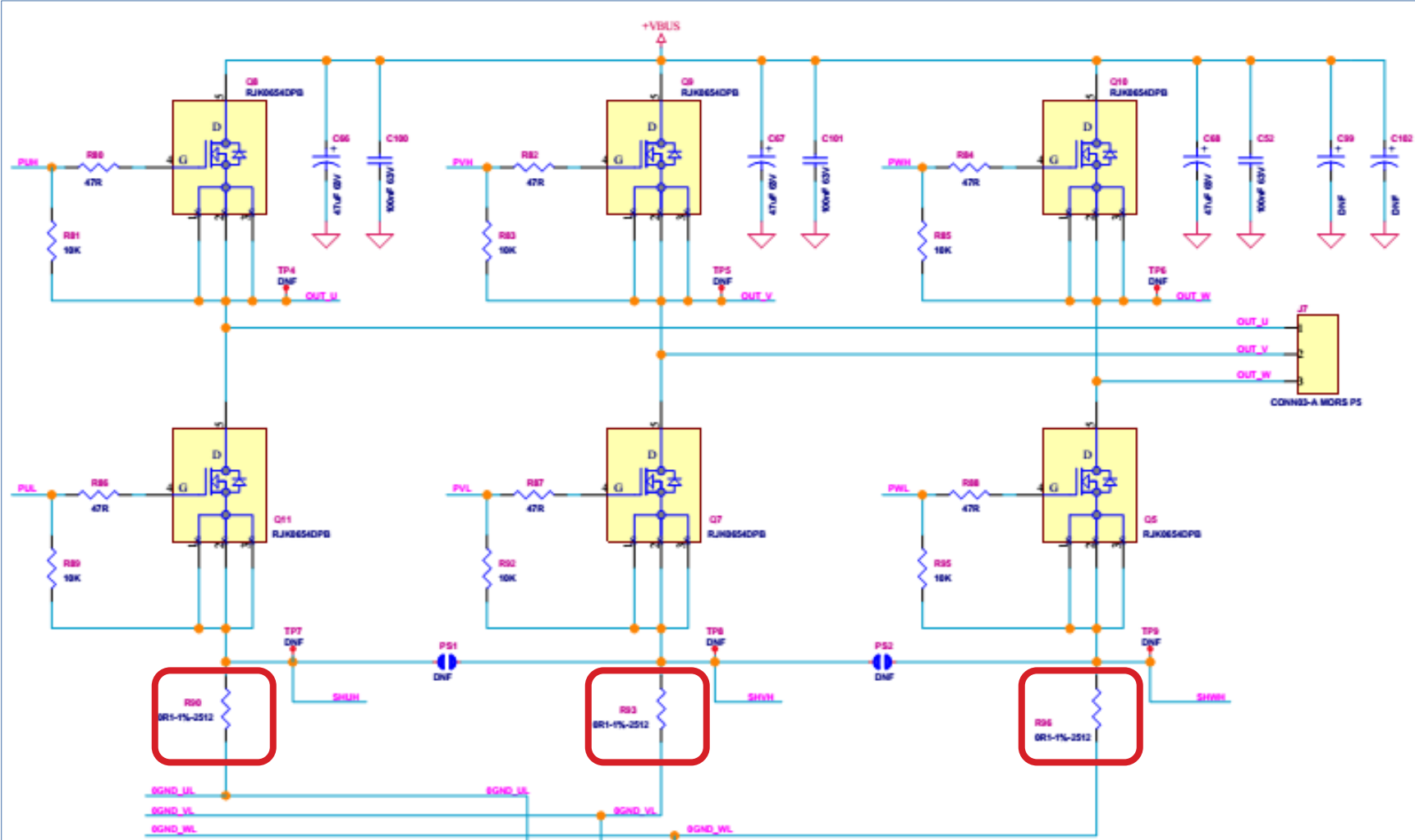
Schematics Hints
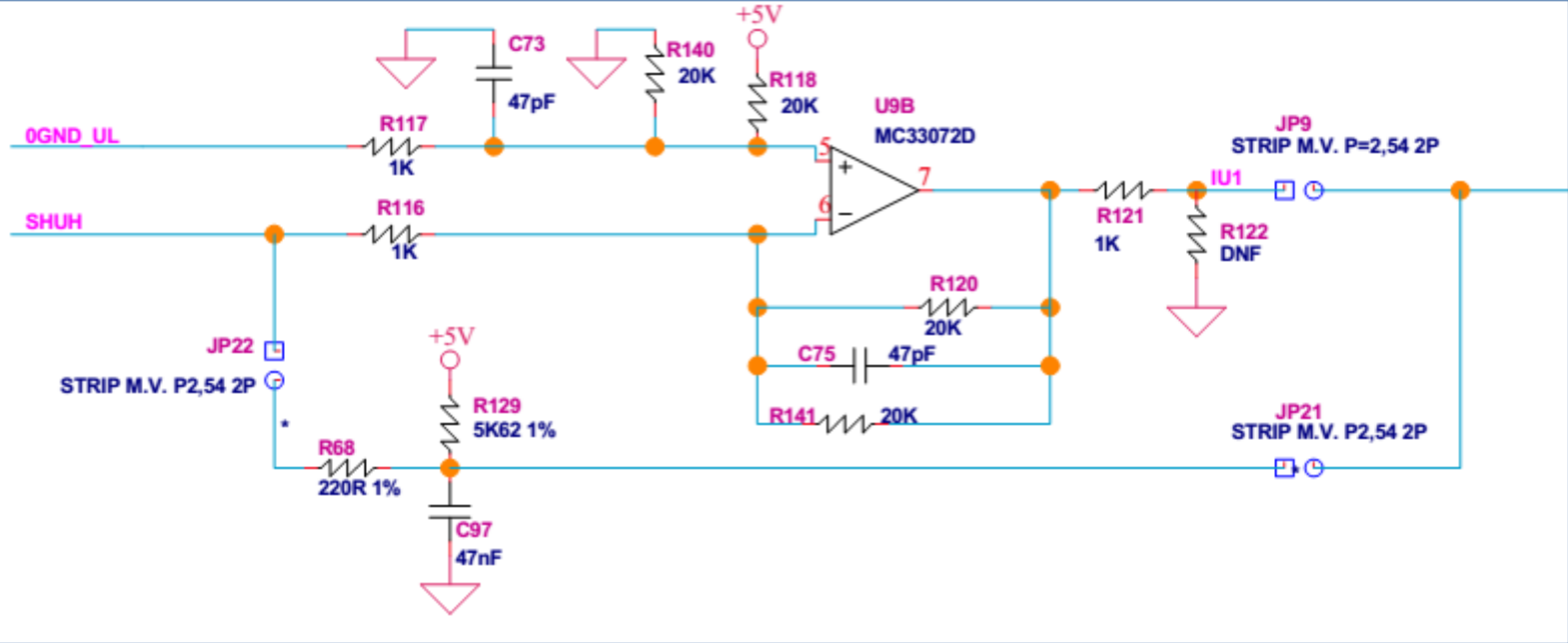
Three circuit using Op. amplifier action as signal conditioning.

Option to remove two shunts and use a single shunt to reduce bill of material cost.
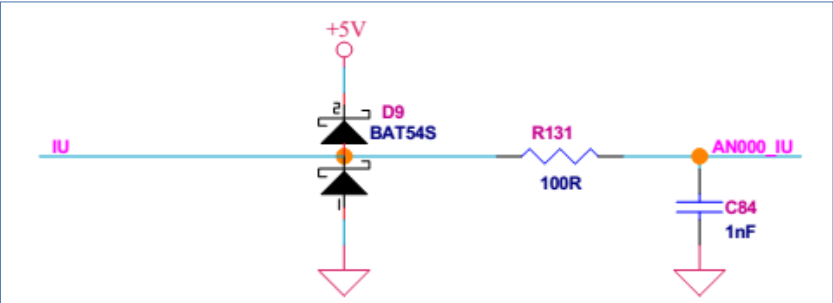
Shunt current measurements and Bus voltage connected to A/D inputs: AN000 to AN003

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Schematics Hints

Phases voltage are measured for the back EMF signals detection

A/D inputs: AN100 to AN102

Use for Brushless DC motor

Sensorless controlled
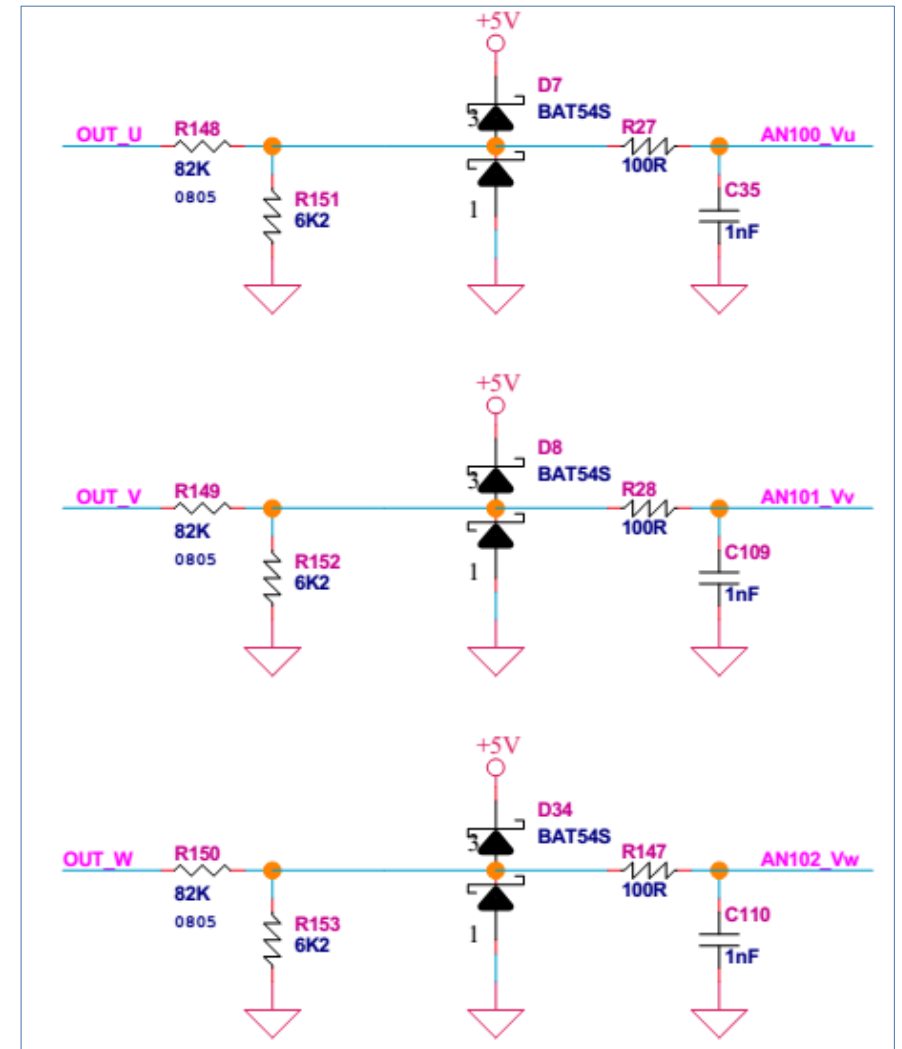
Schematics Hints: Power stage connection
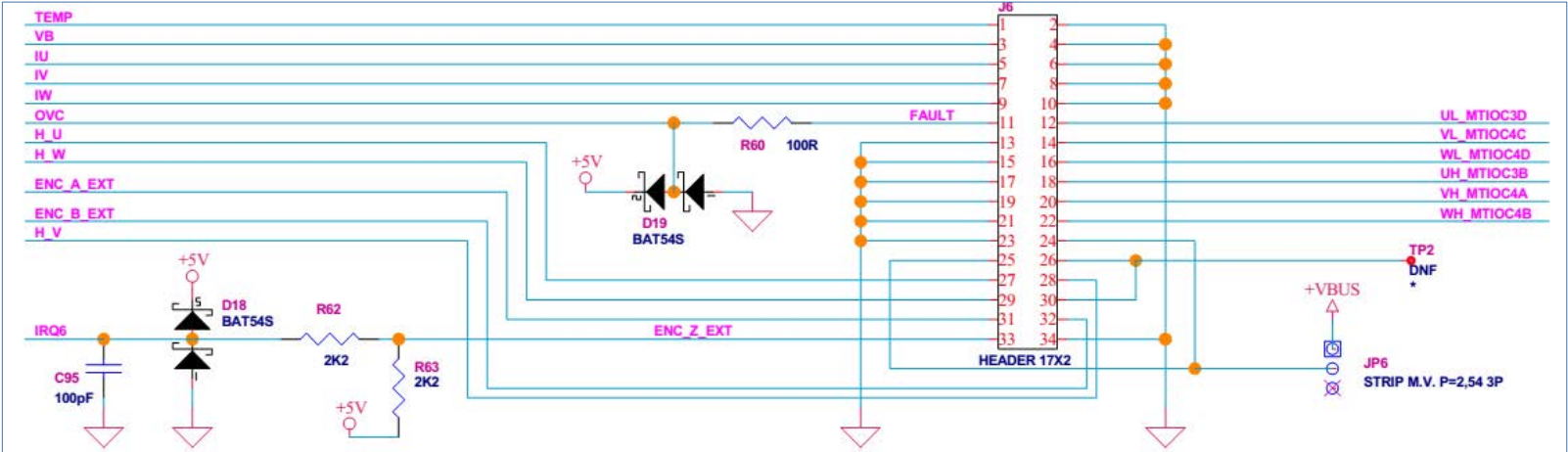
$300V_{DC}/20A$ or $60V_{DC}/100A$
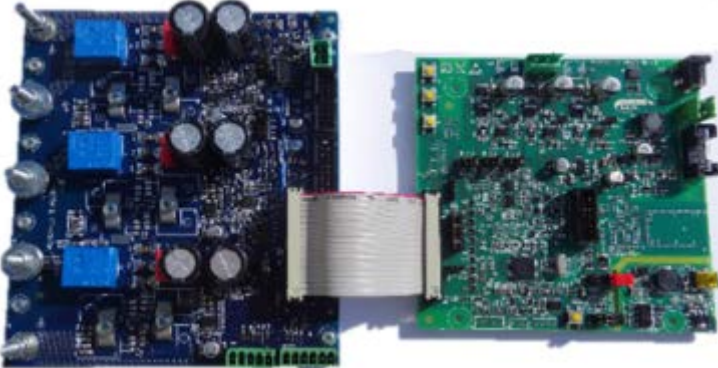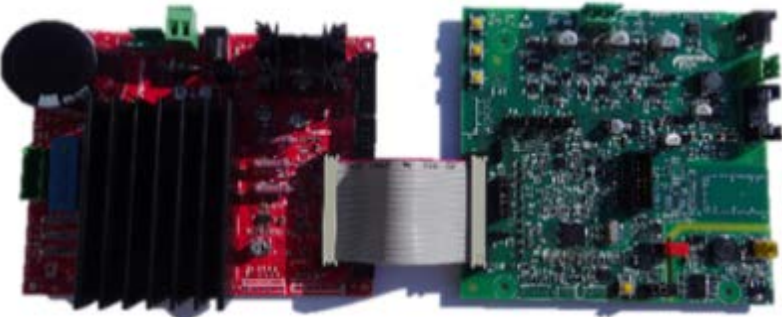
Schematics: Feedback, Hall sensors & encoders
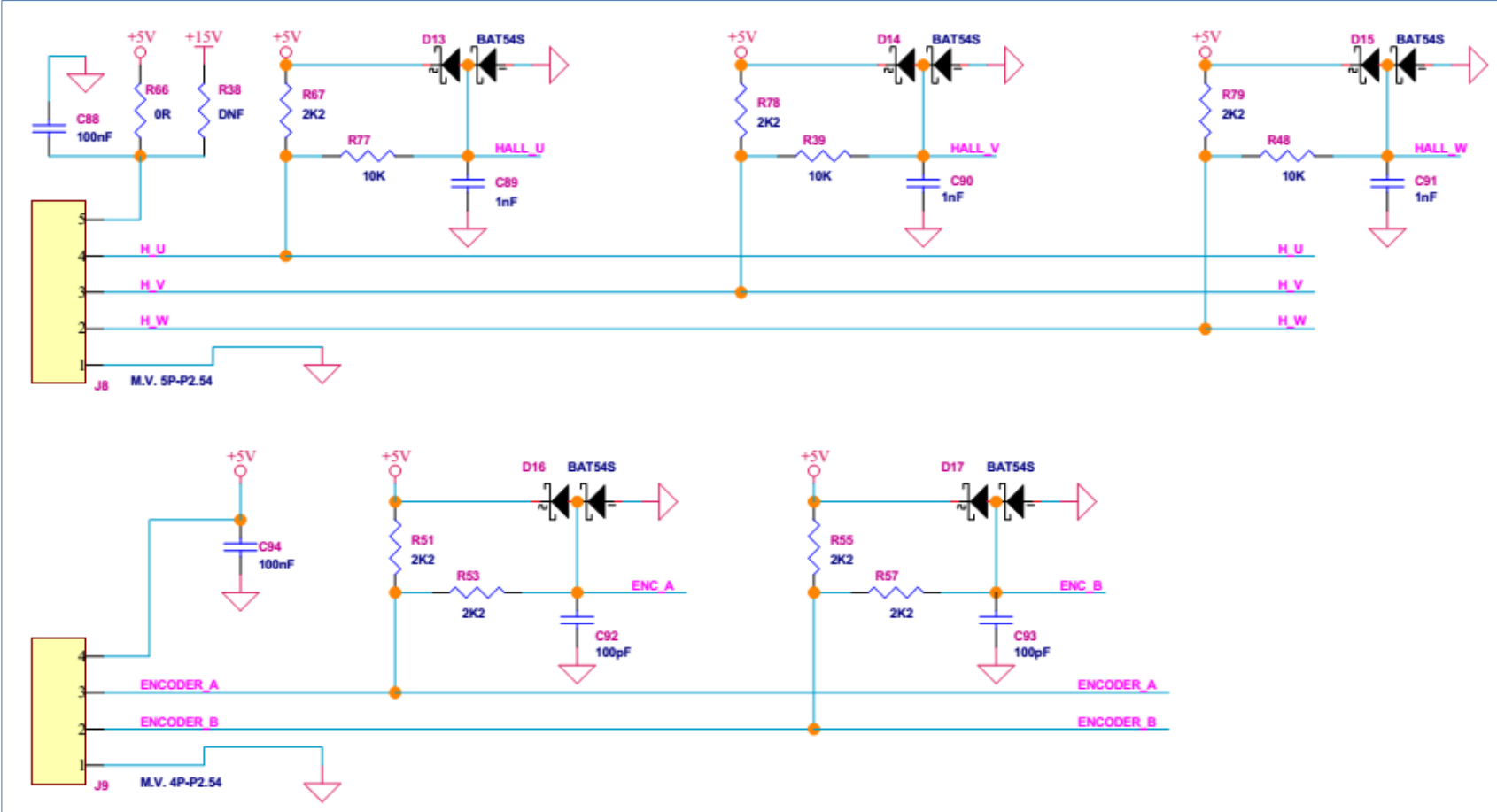
Schematics hints: RX23T, 64-pin resources used
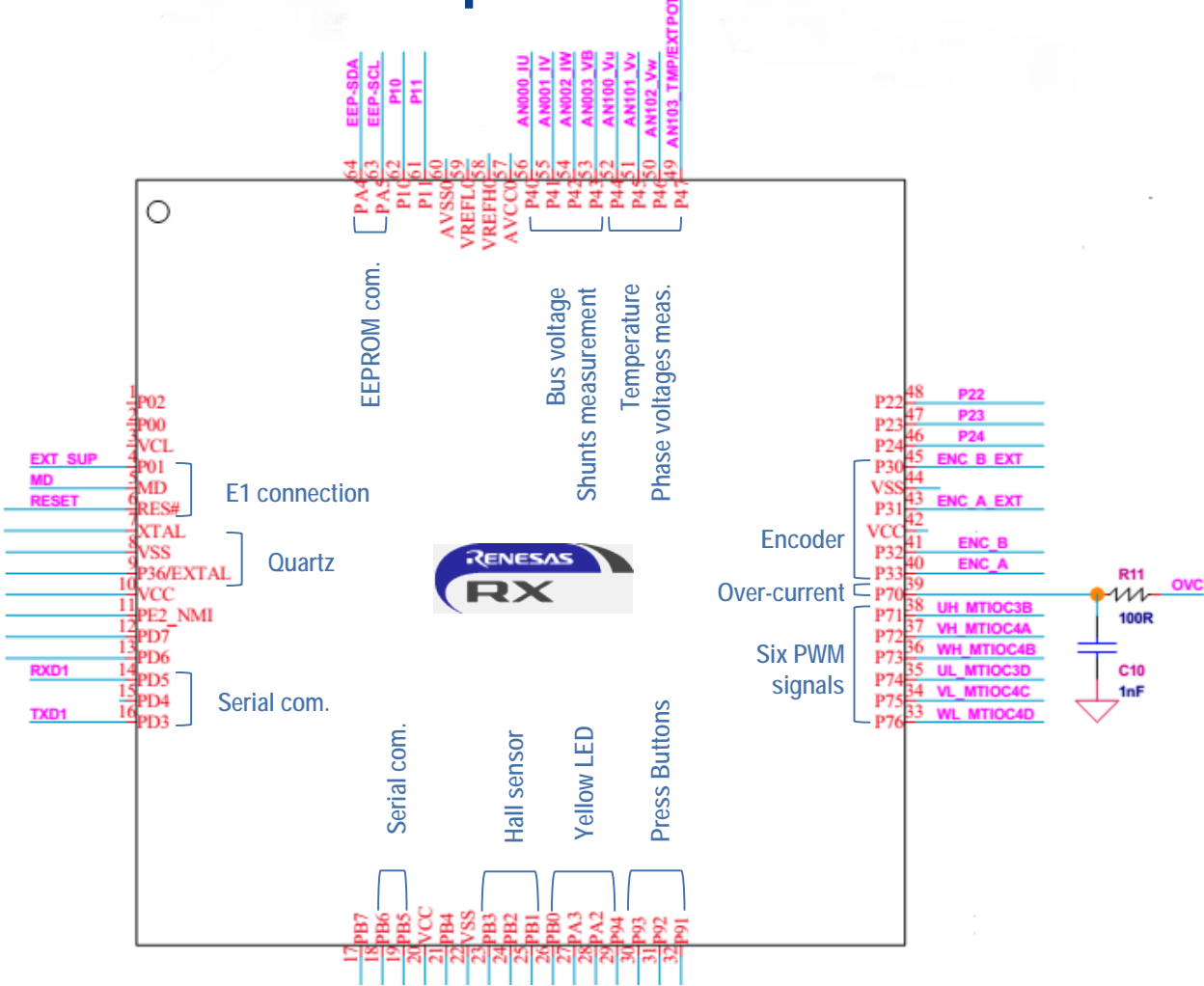
RX23T Embedded Software project structure

📁 **YRotateItRX23T_Library** ➡️ Contains PI auto-tuning, Motor identification and estimators routines

📄 **dbsct.c** ➡️ Renesas Project Generator: setting of B, R sections

📄 **ges_eqp.c** ➡️ External EEPROM management functions: read, write via I²C up to 64 parameters. By default, 21 are used by the PC GUI

📄 **hardware_setup.c** ➡️ Hardware setup definition for each MCU pins and SFRs

📄 **interrupt_handlers.c** ➡️ Interrupt Service Routines definition: linked to the A/D converter to launch the control loop

📄 **main.c** ➡️ Main loop including initialisation of PWM, measurements, enable interrupt, serial communication, LED management…

📄 **motorcontrol.c** ➡️ Complete FOC algorithm in interrupt, including POE management, modulation, etc.

📄 **reset_program.c** ➡️ Reset procedure

📄 **userif.c** ➡️ Serial protocol used to manage the PC GUI communication

📄 **vector_table.c** ➡️ Define addresses for each interrupt service routines

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
YRotateItRX23T_Library Description

YRotateItRX23T_Library

mcrplibf.h	→ Header file for the Math Library block
mot_ident.h	→ Header file for the Motor Self-identification
PI_tun.h	→ Header file for the PI Coefficients auto-tuning
YRotateItRX23T_LIB_LE_V1.lib	→ Library file containing the three blocks above

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Important header files

File	Description
const_def.h	Def. of constants: Base Timing, PWM parameters, dead-time, Duty cycles, trigger delay for A/D, conversions constants, alarms , interrupts prio.
customize.h	Definition application parameters, switches to enable Auto-tuning, over-modulation, estimators selection, flux weakening, etc.
defpar.h	3-phase Permanent Magnet Motor – Default parameters used by the kit: NANOTEC DB42S3, 24V, 4000RPM nominal speed.
dtc_typedef.h	Data Transfer Control (DTC): data structure definition
ges_eqp.h	EEPROM management functions, variables and constants
globdef.h / globvar.h	Global Definitions
iodefine.h	Microcontroller I/O definitions
mask.h	Mask definitions used
motorcontrol.h	Definition of functions used in the Interrupt service routines
pws_E6108A.h	Parameters used to drive the External power stage using IPM
pws_E6132.h	Parameters used to drive the internal power stages using MOSFETS
stacksct.h / typedefine.h	Stack and data types definition
userif.h	Parameters used in the serial protocol
vect.h	Vectors definition

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THANKS FOR YOUR ATTENTION

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