User Manual

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RH850/F1KM-S1 (BLDC) Starter Kit V2

User Manual: Hardware

RENESAS MCU
RH850 F1x Series

Y-BLDC-SK-RH850F1KM-S1-V2

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http://www.renesas.eu/update?oc=Y-BLDC-SK-RH850F1KM-S1-V2

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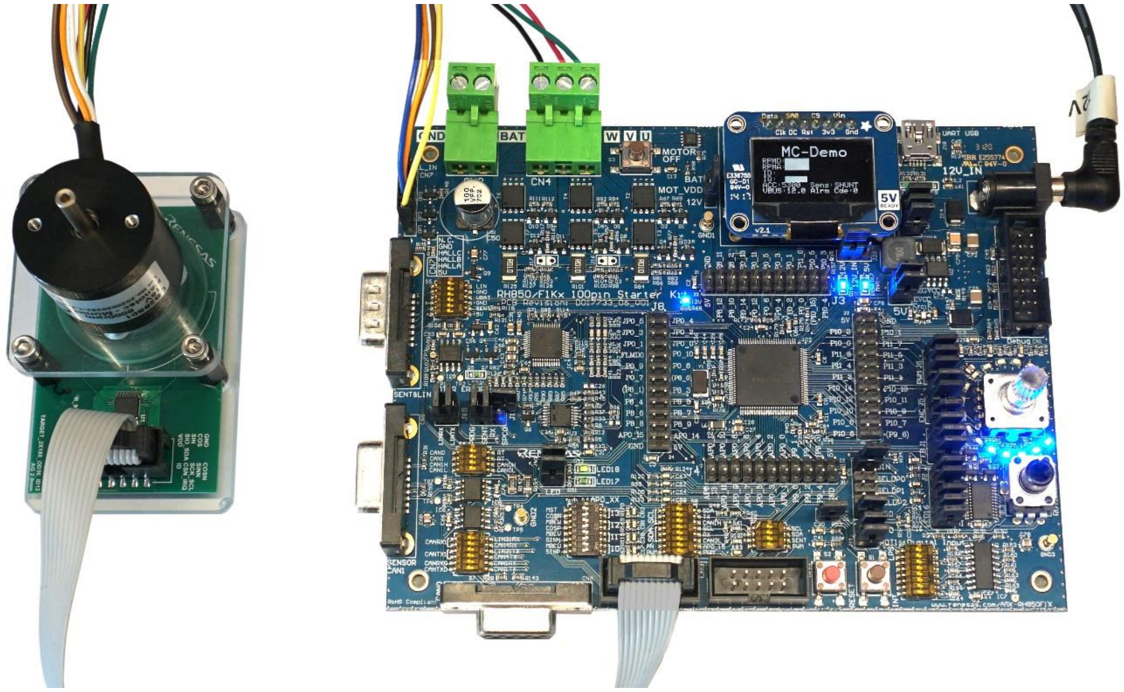
Table of Contents

1. Introduction

The 'RH850/F1KM-S1 Starter Kit' serves as a simple and easy to use platform for evaluating the features and performance of Renesas Electronics' 32-bit RH850/F1KM-S1' microcontroller.



Features:

- Connections for on-chip debugging and flash memory programming
- Access to all microcontroller I/O pins
- User interaction through potentiometer, rotary switch, buttons and LEDs
- Serial interface connections for
  - 1x UART/USB
  - 1x LIN
  - 1x SENT
  - 2x CAN-FD
  - 2x Position sensor
- Multiple power supply options by
  - Provided 12V DC power supply via DC jack
  - Motor control part can be powered additionally by an external power supply
  - RENESAS E1 or E2 On-Chip debugging emulator (5V/200mA), for debugging without motor control part

This document will describe the functionality provided by the Starter Kit and guide the user through its operation. For details regarding the operation of the microcontroller refer to the RH850/F1KM-S1 Hardware User Manual.

As the motor control part is quite extensive, it is excluded to a “Motor Control Application Note”, which is included on the CD of the starter kit package.

Renesas provides a SENT Extension Board “**Y-RH850-SENT-EXT-BRD-V2**” that comes with a sample software, which receives the SENT messages from an Renesas ZSSC4161 IC.

See below a short overview of the related documents:

Table 1 Related documents

Description	**DOC-Number**
1. Hardware User Manual of RH850/F1KM-S1	R01UH0684EJxxxx
2. Datasheet of RH850/F1KM-S1	Included in above document
3. QSG for RH850/F1KM-S1 Starter Kit V2	D017733-06
4. Motor Control Application Note	R11AN0284EDxxxx
5. User Manual of SENT Extension Board	R12UT0014EDxxxx
6. SENT Application Note	R01AN3963EDxxxx

2. Cautions

1. **When power supply of E1 or E2 on-chip debugging emulator is used for debugging without motor control part, please note that the maximum current provided by the emulator is limited to 200mA. Thus, an external power supply is required in case all functions on the Starter Kit are used to full extend.**
2. **If you are connecting an external power supply to the motor control part (CN2), be sure to set the jumpers correct, as described in "4.1.2.1 Power supply configuration".**

3. Quick Start Information

3.1 Connector and jumper overview

3.1.1 Microcontroller assembled and Port Pin Interfaces

On the RH850/F1KM-S1 Starter Kit the following device is assembled:

R7F701684

As external clock supply of the microcontroller, a 16MHz crystal is mounted.

Each microcontroller I/O pin is connected to a pin header interface. The pin header interfaces allow easy probing of I/O pins and provide the ability to selectively connect the I/O pins to power, ground or other signals. Table 2 and Table *3* are showing the assignment of the pin header interface.

Table 2 J3 – J4 – Signal Assignment

J3			
Pin	*Function*		*Pin*
1	P10_3	P10_4	2
3	P10_5	P10_15	4
5	P11_0	P0_0	6
7	P0_1	P0_2	8
9	P0_3	P0_4	10
11	P0_5	P0_6	12
13	P0_11	P0_12	14
15	P0_13	P0_14	16
17	P8_2	P8_10	18
19	P8_11	P8_12	20
21	GND	VDD_5V	22

J4			
Pin	*Function*		*Pin*
1	AP0_13	AP0_12	2
3	AP0_11	AP0_10	4
5	AP0_9	AP0_8	6
7	AP0_7	AP0_6	8
9	AP0_5	AP0_4	10
11	AP0_3	AP0_2	12
13	AP0_1	AP0_0	14
15	P9_0	P9_1	16
17	P9_2	P9_3	18
19	P9_4	P9_5	20
21	GND	VDD_5V	22

Table 3 J7 – J8 – Signal Assignment

J7			
Pin	*Function*		*Pin*
1	P9_6	P10_6	2
3	P10_7	P10_8	4
5	P10_9	P10_10	6
7	P10_11	P10_12	8
9	P10_13	P10_14	10
11	P11_1	P11_2	12
13	P11_3	P11_4	14
15	P11_5	P11_6	16
17	P11_7	P10_0	18
19	P10-1	P10_2	20
21	GND	VDD_5V	22

J8			
Pin	*Function*		*Pin*
1	JP0_5	JP0_4	2
3	JP0_3	JP0_2	4
5	JP0_1	JP0_0	6
7	FLMD0	P0_10	8
9	P0_9	P0_8	10
11	P0_7	P8_3	12
13	P8_4	P8_5	14
15	P8_6	P8_7	16
17	P8_8	P8_9	18
19	AP0_15	AP0_14	20
21	GND	VDD_5V	22

Table 4. Jumper / Connector Settings Overview

Jumper	Description	Setting	Note
FB J1	RGB LED connector	**1 – 2**	R: PWM feedback ↔ AP0_5
		3 – 4	G: PWM feedback ↔ AP0_6
		5 – 6	B: PWM feedback ↔ AP0_7
LED16 J2	Blue LED Circle to MCU connector	**1 – 2**	LA: SPI driver LE↔P8_10
		3 – 4	BL: SPI driver OE#↔P8_11
		5 – 6	MC: SPI driver CLK↔ P11_3
		7 – 8	MO: SPI driver SDI↔ P11_2
		9 – 10	MI: SPI driver SDO↔ P11_4
ENC J5	Encoder to MCU connector	**1 – 2**	a: Encoder input 0 ↔ P10_9
		3 – 4	b: Encoder input 1 ↔ P10_10
		5 – 6	B: Encoder button ↔ P0_13
PWM J6	PWM output to RGB LED connector	**1 – 2**	R: PWM signal ↔ P11_7
		3 – 4	G: PWM signal ↔ P11_6
		5 – 6	B: PWM signal ↔ P11_5
J9 INT	Interrupt Button to MCU connector	**1 – 2**	INT: Button ↔ P8_2
J10 LED	Indication LED to MCU connector	**1 – 2**	LED18 ↔ P0_14
		3 – 4	LED17 ↔ P8_5
J11	Potentiometer to MCU connector	**1 – 2**	POT1 ↔ AP0_4
		3 – 4	APO ↔ P0_1
J12	MCU power distribution	**1 – 2**	REG: REGVCC supply
		3 – 4	EVCC: EVCC/A0VREF supply
J13	MOT_VDD selector	1 – 2	BAT: 5.3V-18V external supply ↔ MOT_VDD
		2 – 3	10V-15V DC Jack ↔ MOT_VDD
J14 UART	UART to USB connector	**1 – 2**	UART/USB TX ↔ P0_2
		3 – 4	UART/USB RX ↔ P0_3
		5 – 6	UART/USB EN ↔ AP0_9
J15	LIN Transceiver to MCU connector	**1 – 2**	LIN RX ↔ P0_7
		3 – 4	LIN TX ↔ P0_8
J19	SENT interface connector	**1 – 2**	SENT SPCO ↔ P9_1
		3 – 4	SENT RX ↔ P9_0
		5 – 6	SENT_PROG ↔ AP0_14

J21	Digital LPS input to MCU connector	**1 – 2**	DIN ↔ P8_3
		3 – 4	SELDP0 ↔P0_4
		5 – 6	SELDP1 ↔ P0_5
		7 – 8	SELDP2 ↔ P0_6
		9 – 10	DPO ↔ P0_0
J22	VBAT selector	1 – 2	12V: VBAT ↔ 12V_IN
		2 – 3	5V: VBAT ↔ VDD_5V

Note: Default jumper setting (Power Supply by E1 or E2 emulator) is indicated by **bold font**.

3.1.2 Board Overview Y-BLDC-SK-RH850F1KM-S1-V2

The RH850/F1KM-S1 Version of the V2 Starter Kit is shown in the figure below.

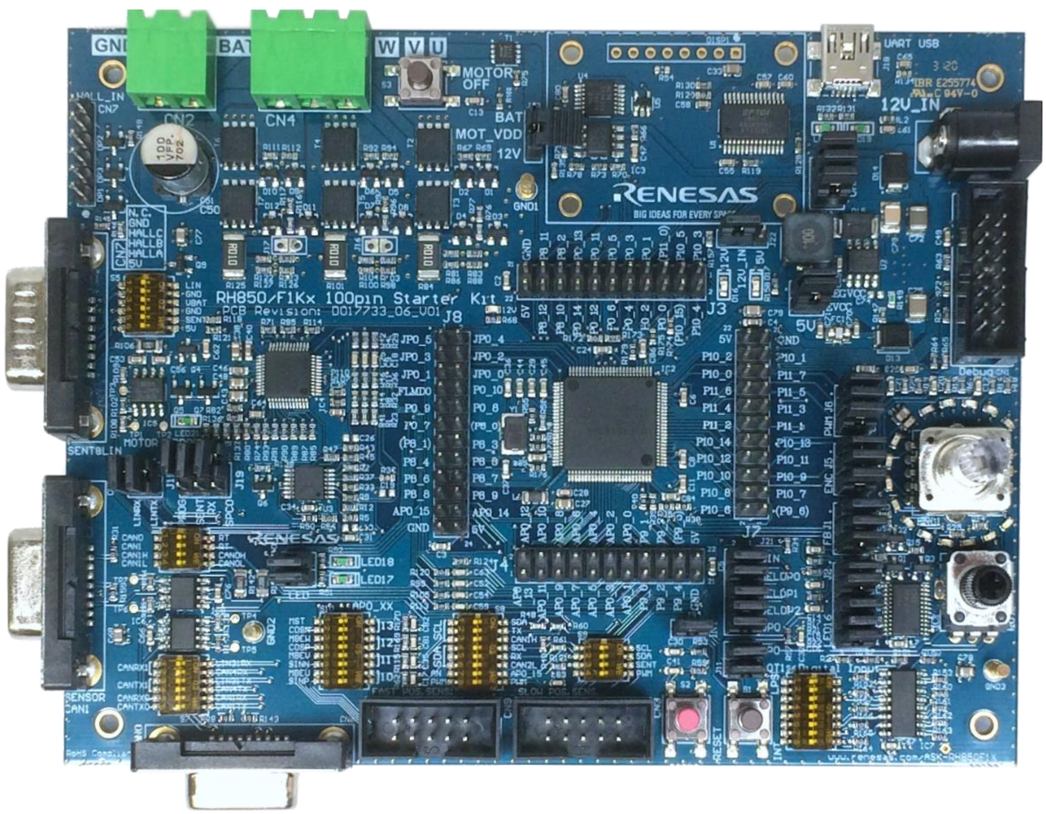


Figure 1. Starter Kit top view RH850/F1KM-S1-V2

4. Starter Kit Hardware

4.1 Starter Kit functions

4.1.1 RH850/F1KM-S1 Starter Kit

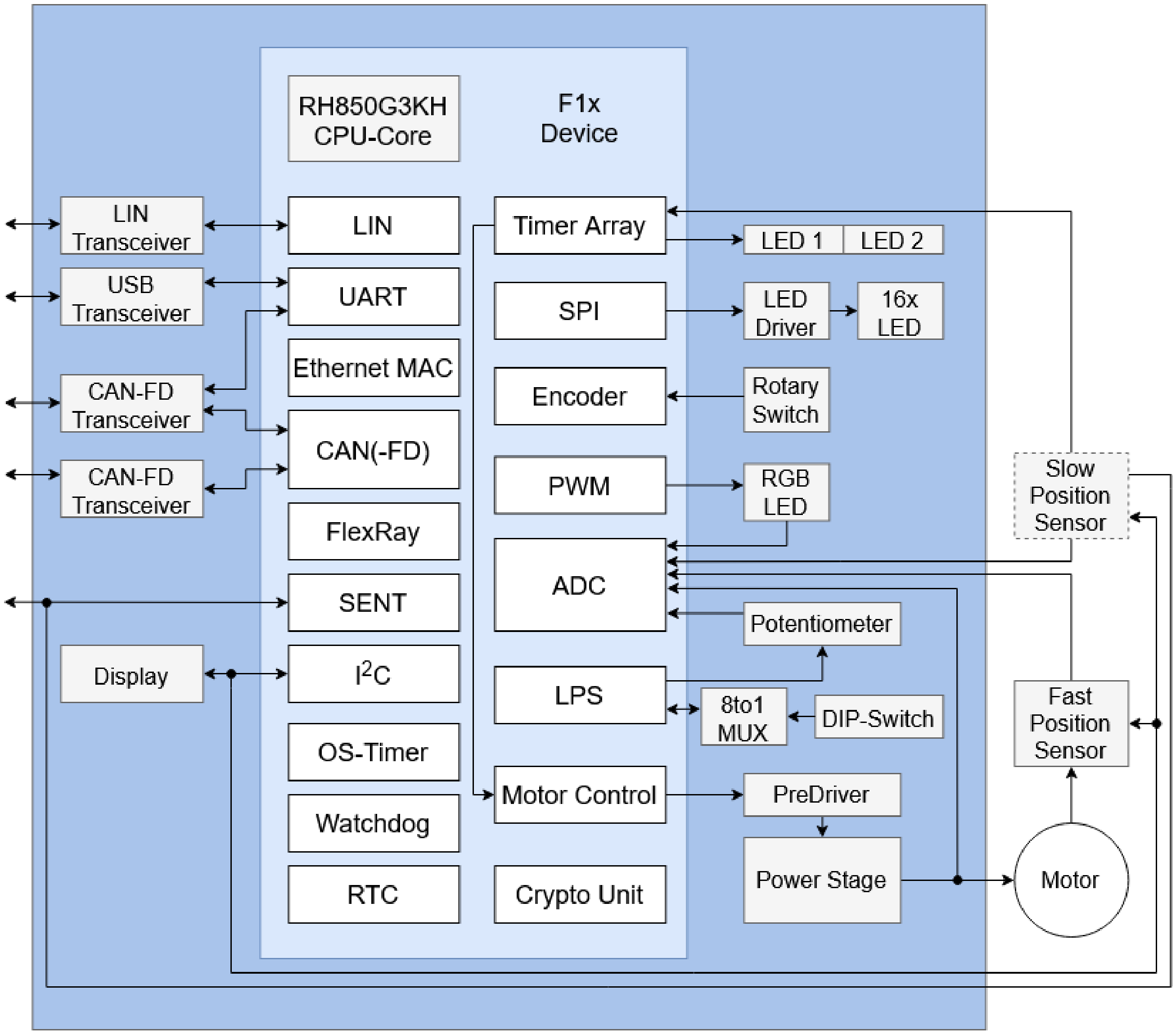


Figure 2. Functional overview

Note: Modules with dashed lines are optional and not included in the kit.

Functional Areas

The functional areas provide various circuits and components useful for interacting with the microcontroller's I/O:

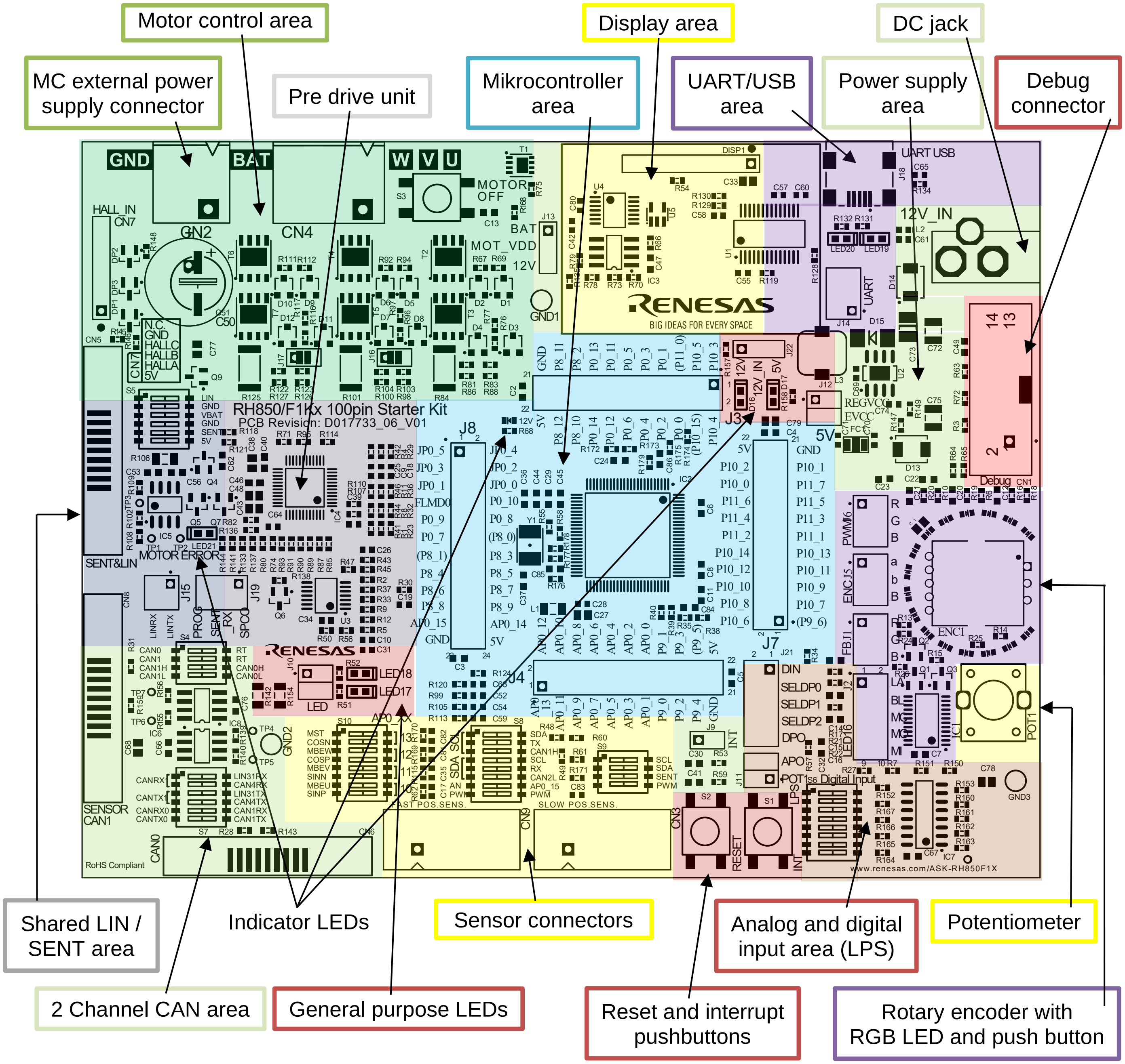


Figure 3. Functional Areas

4.1.2 Power Supply

4.1.2.1 Power supply configuration

The Starter Kit provides three options for powering the board's integrated circuits. It is possible to supply the Starter Kit by using the E1 or E2 debugging emulator or by connecting the provided external 12 Volt power supply to the DC jack.

With the default jumper setting (see Table 5) the Starter Kit is configured to be power supplied by the E1 or E2 debugging emulator for debugging without the motor control part.

To use the motor control unit, you can either use the provided 12 Volt power supply to power the whole board (intended to use with provided motor) or connect an external power supply with up to 18 Volt *additionally* to the E1 or E2 or to the provided 12V power supply. (To reach the 8000 RPM of the included motor you have to apply 15V).

The operation of the LIN interface is only possible by using the provided external 12 Volt power supply.

Important Note: If you connect an external voltage supply to the motor control connector, the e-Fuse is bypassed. Do not change the power supply jumpers while the Starter Kit is powered. Do not exceed a power supply current of 5A due to trace thickness!

When the board is supplied ***only*** **by the E1- or E2-Emulator**, it is not possible to use the motor control unit. Use the following jumper setting:

Table 5 Jumper setting for power supply by E1- o E2-Emulator

Jumper	Description	Setting	Note
J22	VBAT selector	1-2, 12V – 12V_IN	open
		2-3, 5V – 12V_IN	closed

When the board is supplied ***only*** **via the DC jack**, please choose the following jumper settings:

Table 6. Jumper setting for power supply over DC jack

Jumper	Description	Setting	Note
J22	VBAT selector	1-2, 12V – 12V_IN	closed
		2-3, 5V – 12V_IN	open
J13	MOT_VDD selector	1-2, BAT – MOT_VDD	open
		2-3, 12V – MOT_VDD	closed

When the board is supplied by **E1 or E2** ***and*** **an external power supply (not provided)** for the motor control unit, please choose the following jumper:

Table 7. Jumper setting for external 12 volt power supply

Jumper	Description	Setting	Note
J13	MOT_VDD selector	1-2, BAT – MOT_VDD	closed
		2-3, 12V – MOT_VDD	open

When the board is supplied by the **provided power supply *and* an external power supply (not provided),** please choose the following jumper settings:

Table 8. Jumper setting for external 12 volt power supply

Jumper	Description	Setting	Note
J22	VBAT selector	1-2, 12V – 12V_IN	closed
		2-3, 5V – 12V_IN	open
J13	MOT_VDD selector	1-2, BAT – MOT_VDD	closed
		2-3, 12V – MOT_VDD	open

The power supply area includes a DC Jack type connector for providing external power supply to the Starter Kit and its components. The external supply is reversibly protected against overvoltage. Nevertheless, please always observe the right polarity and voltage.

Table 9. Power supply connector specification

Connector	Description	Input Voltage Range
DC Jack*	DC Power Jack ID=2.0mm, center positive	+10V to +15V

Note: If you use the DC Jack to supply the motor control unit, note that the internal e-Fuse will limit the current to the motor to maximal ~400mA.

Caution: If you use an external power supply on CN2, make sure not to exceed 5A power supply current, due to trace thickness!

4.1.2.2 Power supply measurement

The current which is consumed by MCU can be measured by using J12. Please find below a description of the jumper.

RH850/F1KM-S1:

Table 10. RH850/F1KM-S1 MCU power measurement

Jumper	Description	Pins	Note
J12	MCU power measurement	1-2	REGVCC power supply (5 V)
		3-4	EVCC, AV0REF power supply (5 V)

4.1.3 LEDs

4.1.3.1 RGB LED

A RGB LED is provided to allow visual observation of microcontroller output port state and to show the functionality of the PWM diagnostic macro. The RGB LED, which is part of the rotary encoder, is driven by three N-channel transistors. A feedback for each RGB LED channel is connected to the A/D converter of the microcontroller to evaluate the LED drive state. The LED PWM signals are active high.

Please use the following jumper configuration to activate the full RGB LED functionality:

Table 11. White RGB Signals Configuration

Jumper	Description	Setting	Note
J1	RGB LED connector	1-2	R_PWM feedback ↔ AP0_5
		3-4	G_PWM feedback ↔ AP0_6
		5-6	B_PWM feedback ↔ AP0_7
J6	PWM output to RGB LED connector	1-2	R_PWM signal ↔ P11_7
		3-4	G_PWM signal ↔ P11_6
		5-6	B_PWM signal ↔ P11_5

4.1.3.2 Green Indicator LEDs

Two green low power LEDs (LED1 and LED2) are provided to allow visual observation of microcontroller output port states. The LED signals are active high.

Table 12. Green Indicator LED Signals

Jumper	Setting	LED	Device Port
J10	1-2	LED18	P0_14
	3-4	LED17	P8_5

4.1.3.3 Blue Power Supply LEDs

The three indicator LEDs are showing which power supply voltages are available:

Table 13. Power Indicator LEDs

Name on board	Signal Name	Meaning
D16	VDD_12V	Microcontroller area powered by DC jack
D17	VDD_5V	Microcontroller area powered by E1 or E2
12V	VCC12	Motor control area powered

4.1.3.4 Blue LED Circle

Sixteen blue LEDs are driven by the TLC5925, which can be controlled by the SPI command to change the output states.

Table 14. Blue LED Circle Signals

Jumper	Setting	Signal	Device Port
J2	1-2	LAT	P8_10
	3-4	BLNK	P8_11
	5-6	MCLK	P11_3
	7-8	MOSI	P11_2
	9-10	MISO	P11_4

4.1.4 Digital inputs for Low Power Sampler (LPS)

Eight digital input signals, which are generated by a DIP switch array (S3), are provided to trigger the microcontroller's Low Power Sampler. The input signals are connected to the microcontroller via 8 to 1 multiplexer (IC4). When the DIP switches (S3) are changed during low power mode (DeepSTOP mode), the microcontroller will wake up.

Please use the following jumper configuration to connect the DIP Switch and multiplexer to the microcontroller:

Table 15. LPS Jumper Configuration

Jumper	Description	Setting	Note
J21	Digital LPS input to MCU connector	1 – 2	DIN ↔ P8_3
		3 – 4	SELDP0 ↔P0_4
		5 – 6	SELDP1 ↔ P0_5
		7 – 8	SELDP2 ↔ P0_6
		9 – 10	DPO ↔ P0_0

The multiplexer selection signals SELDP0, SELDP1 are shared with UART signals by the MCU, which may be supplied to the fast position sensor connector CN9 or CAN1 transceiver IC8. Ensure to disconnect the signals by switching off the connection by opening S7_4, S7_6, S8_2 and S8_5:

Table 16. LPS Switch Configuration

Switch	Description	Setting	Note
S7	Disconnect UART signals	1 = off	CAN transceiver IC8 RXD
		3 = off	CAN transceiver IC8 TXD
S8		2 = off	Fast position sensor connector CN9 Pin 4
		5 = off	Fast position sensor connector CN9 Pin 5

4.1.5 Pushbutton Switches

Two pushbutton switches (S1, S2) are provided to allow the switching of microcontroller input port states. Those switches are active low and normally open. A third pushbutton switch is used to switch off the motor control area when powered by the provided external power supply via the DC jack.

Table 17. Pushbutton Switch Signals

Switch	Device signal	Active Level	Inactive State
S1	P8_2 (INTP6)	low	open
S2	RESET	low	open
S3	Power for Motor Control Area	low	open

Please use the following jumper configuration to connect the interrupt pushbutton switch (S1) to the microcontroller.

Table 18. Interrupt Pushbutton Jumper Configuration

Jumper	Description	Setting	Note
J9	Interrupt pushbutton to MCU connector	1-2	Button ↔ P8_2

Additionally, a pushbutton is provided with the rotary encoder. For details, please refer to “Rotary Encoder with Pushbutton”.

4.1.6 Analog Input - Potentiometer

A potentiometer (POT1) is provided to generate an analog voltage, which can be delivered to the microcontroller’s analog input pins.

By turning the potentiometer POT1, a voltage derived from the MCU output signal APO (P0_1) can be adjusted. The APO signal can be controlled by the Low Power Sampler (LPS) macro. If the LPS macro is not used, APO has to be set to high manually (use P0_1 as general-purpose digital output).

Table 19. Analog Input Signal

Potentiometer	Analog Input MCU
POT1	AP0_4

Please use the following jumper configuration to connect the potentiometers to the microcontroller:

Table 20. Potentiometer Jumper Configuration

Jumper	Description	Setting	Note
J11	Potentiometer to MCU connector	1-2	POT1 ↔ AP0_4
		3-4	POT1 supply ↔ APO

4.1.7 Rotary Encoder with Pushbutton Switch

An incremental rotary encoder (ENC1) is provided on the starter kit. The outputs *ENC1_a* and *ENC1_b* of the rotary encoder can be connected to the microcontroller internal encoder timer via jumpers. In addition, the rotary encoder (ENC1) incorporates a pushbutton switch *ENC1_Switch*, which can also be connected to a pin of the microcontroller via jumper. The switch is active low and normally open.

Table 21. Encoder Jumper Configuration

Jumper	Description	Setting	Note
J5	Encoder to MCU connector	1-2	P10_9 ↔ ENC1_a
		3-4	P10_10 ↔ ENC1_b
		5-6	P0_13 ↔ ENC1_Switch

4.1.8 Serial Communication Interfaces

4.1.8.1 SENT and LIN

Local Interconnect Network (LIN) transceiver (IC5) is supplied to provide a LIN interface. The transceiver can be connected to the microcontroller's LIN macro (RLIN21).

The DB9 connector CN5 is shared between the board's LIN and SENT interface. Renesas provides a SENT Extension Board "**Y-RH850-SENT-EXT-BRD-V2**" that can be connected to the DB9 connector and also comes with a sample software, to evaluate the SENT messages from a Renesas ZSSC4161 signal conditioner IC. You can connect the Pin 1 of CN5 directly to VDD_5V by closing switch 6 of S5. If you want to control the power supply to the Pin 1 of CN5 by a port pin, you must open the switch 6 of S5. In this case you can control the power supply to the Pin 1 of the DB9 connector via AP0_14. Please make sure, that the Jumper J19 5-6 is closed.

Please close the following jumpers to connect the LIN transceiver to the microcontroller:

Table 22. LIN Transceiver Jumper Configuration

Jumper	Description	Setting	Note
J15	LIN Transceiver to MCU connector	1-2	LIN RX ↔ P0_7
		3-4	LIN TX ↔ P0_8

Please close the following jumpers to connect the SENT interface to the microcontroller:

Table 23. SENT Jumper Configuration

Jumper	Description	Setting	Note
J19	SENT interface connector	1-2	SENT SPCO ↔ P9_1
		3-4	SENT RX ↔ P9_0
		5-6	SENT PROG ↔ AP0_14

Note: The SENT signal which is connected to the DB9 connector CN5 can also be connected to the slow position sensor connector CN3, Pin 3 via the switch S9_3. Please ensure not to use both connections in parallel. Either connect a sensor to the DB9 connector CN5 via closed switch S5_5, or to the slow position sensor connector CN3 via closed switch S9_3.

The serial interfaces are connected to the DB9 connector CN5 via DIP switch S5.

Only one interface can be used at the same time. Please see the configuration for LIN in **Table 24** and for SENT in **Table 25**.

Table 24. Switch S5 configuration for LIN

Switch		Configuration	Signal	DB9 pin (CN5)
S5	1	on	LIN	7
	2	on	GND	3
	3	on	VBATF (12V DC)	9
	4	off	-	6
	5	off	-	8
	6	off	-	1

Table 25. Switch S5 configuration for SENT

Switch		Configuration	Signal	DB9 pin (CN5)
S5	1	off	-	7
	2	off	-	3
	3	off	-	9
	4	on	GND	6
	5	on	SENT_RX (SENT_SPCO)	8
	6	on/off	VDD_5V	1

Note: Please ensure that only one interface is configured for operation at the same time (either LIN or SENT) by using DIP switch S5.

4.1.8.2 UART/USB Interface

UART TO USB transceiver (U1) is supplied to provide a serial interface. The transceiver can be connected to the microcontroller’s UART macro (RLIN30).

Please close the following jumpers to connect the *UART/USB* transceiver to the microcontroller:

Table 26. UART/USB Transceiver Jumper Configuration

Jumper	Description	Setting	Note
J14	UART to USB connector	1-2	UART/USB TX ↔ P0_2
		3-4	UART/USB RX ↔ P0_3
		5-6	UART/USB EN ↔ AP0_9

4.1.8.3 CAN Interfaces

Controller Area Network (CAN) transceivers (IC6 and IC8) are supplied to provide two CAN bus interfaces. Each transceiver can be connected to one of the microcontroller's CAN interfaces (CAN1, CAN4). The CAN bus interfaces are connected to the DB9 connectors CN6 and CN8. The CAN0/1 transceiver is enabled by default and able to transmit and receive data via the CANH and CANL bus lines. This receive-only mode can be used to test the connection of the bus medium. In silent mode it can still receive data from the bus, but the transmitter is disabled and therefore no data can be sent to the CAN bus. DIP switch S4 provides additional CAN bus interface configuration options including the ability to selectively interconnect CAN bus interfaces on-board.

Additionally, it is possible to supply UART signals instead of the CAN signals to the CAN1 transceiver. This is intended to use a UART-over-CAN interface for external devices (e.g. Renesas UART-over-CAN position sensors). To choose the UART signals instead of the CAN signals, switch S7 must be configured accordingly. Only CAN1 connector supports the possibility to use UART signals instead of CAN signals. Please do not connect both CAN interfaces at the on-board CAN bus (→ S4_3/4 off), if CAN1 uses UART signals instead of CAN signals.

If an external device shall be supplied with power, zero Ohm resistors (R28, R31) can be mounted to the board to get 5V at pin 9 of the Sub-D connectors CN6 or CN8. This allows the connection of an external sensor (e.g. UART-over-CAN position sensor) without the need to route additional wires for power supply.

The CAN transceiver support CAN and CAN-FD communication.

Please close the following jumpers to connect the CAN0 transceiver (IC6) and CAN1 transceiver (IC8) to the microcontroller:

Table 27. CAN0 and CAN1 Transceiver Switch S7 Configuration

	Selection	
Switch S7	CAN0 transceiver TX/RX to MCU CAN1 signals	
S7_6	on	CANTX0 ↔ P10_7 (CAN1TX)
S7_5	on	CANRX0 ↔ P10_6 (CAN1RX)

	Selection			
Switch S7	CAN1 transceiver TX/RX to MCU CAN4 signals *1		CAN1 transceiver TX/RX to MCU UART1 signals *1, *2	
S7_4	on	CANTX1 ↔ P0_10 (CAN4TX)	off	↔ P0_10 (CAN4TX)
S7_3	off	↔ P0_5 (RLIN31TX)	on	CANTX1 ↔ P0_5 (RLIN31TX)
S7_2	on	CANRX1 ↔ P0_9 (CAN4RX)	off	↔ P0_9 (CAN4RX)
S7_1	off	↔ P0_4 (RLIN31RX)	on	CANRX1 ↔ P0_4 (RLIN31RX)

Note 1. Please do not switch on S7_1 and S7_2 at the same time or S7_3 and S7_4 at the same time. Please either connect the CAN signals (S7_2/4 = on; S7_1/3 = off) or the UART signals (S7_2/4 = off; S7_1/3 = on).

Note 2. The UART signals are shared with the multiplexer selection signals of the digital inputs for the Low Power Sampler (LPS). The digital inputs for the LPS cannot be used if the UART is used for the CAN transceiver.

The on-board CAN bus and the terminal resistors of each CAN channel can be activated by DIP switch S4.

Table 28. DIP Switch S4 - CAN Interfaces Signals

Transceiver	CAN channel	Switch	Note
IC6	CAN0	1	Enable termination resistor
IC8	CAN1	2	Enable termination resistor
All	All	3	Connect to on-board CAN bus
		4	Connect to on-board CAN bus

4.1.9 On-chip Debug and Flash Programming Connector

Connector CN1 is provided to allow the connection of microcontroller debug and flash programming tools. Connector CN1 is a 14 pin, 0.1” pin pitch connector. The pinout of this connector supports the Renesas E1 or E2 On-chip debug emulator. For more information about E1 or E2, please see Chapter 5.1 *E1 On-Chip Debug Emulator* [R0E000010KCE00] or 5.2 E2 Emulator [RTE0T00020KCE00000R] (Successor of E1).

4.1.10 OLED Board (optional)

The Starter Kit offers a pin header to optionally connect an external display to the board. For example, following *OLED* Display is compatible to the connector:
https://www.adafruit.com/product/326

Table 29. OLED header (optional)

Connector	PCB	Display
1	GND	GND
2	5V	VIN
3	M_DISPLAY_3V3 (AP0_8)	3.3V
4		CS
5	M_DISPLAY_RESET2 (P8_6)	RST
6		DC
7	M_DISPLAY_SCL (P0_12)	SCL
8	M_DISPLAY_SDA (P0_11)	SDA

4.1.11 Motor Control Area

The motor control area comprises the power stage, the motor and VBAT connectors and the Hall sensor connectors. The Predriver is described under 4.1.12 Predrive Area.

The power stage area is a complete 3-phase bridge composed with discrete low voltage and high current MOSFETs. The MOSFETs are the Renesas NP75N04YUG n-channel power MOSFETs. The Gate of the MOSFETs is directly connected to the Predriver.

For more information about the power stage as well as for the Predriver please refer to the “Motor Control Application Note”.

For motor control purposes different signals can be used for position sensing:

- External fast position sensor inputs via connector CN9 (signals SENSOR_SINP, SENSOR_SINN, SENSOR_COSP, SENSOR_COSN)
- Back-EMF analog signals (signals M_BEU, M_BEV, M_BEW, M_ST)
- Zero crossing detection signals via Back-EMF (signals M_ZDU, M_ZDV, M_ZDW)
- Hall sensor inputs via connector CN7 (signals M_MOTOR_HALLA, M_MOTOR_HALLB, M_MOTOR_HALLC)
- Motor currents from shunt resistors (signals M_MOTOR_IUM, M_MOTOR_IVM, M_MOTOR_IWM)

As the MCU does not have enough pins to connect each of the above listed signals in parallel, a selection must be made for some signals by using switches or jumpers. This selection depends on the motor control software requirement. If you want to use an external fast position sensor (connector CN9), the analog signals of the Back-EMF cannot be used in parallel. Please choose either position sensing by using an external fast position sensor or the on-board Back-EMF circuit. Switch S10 can be used to assign the signals which should be connected to the ADC inputs.

Table 30. Analog Input Switch S10 Configuration

Switch	Description	Setting	Note	
S10	Fast Position Sensor signals to MCU analog input signals *1	1 = on	AP0_10	↔ SENSOR_SINP
		2 = off		↔ M_BEU
		3 = on	AP0_11	↔ SENSOR_SINN
		4 = off		↔ M_BEV
		5 = on	AP0_12	↔ SENSOR_COSP
		6 = off		↔ M_BEW
		7 = on	AP0_13	↔ SENSOR_COSN
		8 = off		↔ M_ST
	Back-EMF analog signals to MCU analog input signals *1	1 = off		↔ SENSOR_SINP
		2 = on	AP0_10	↔ M_BEU
		3 = off		↔ SENSOR_SINN
		4 = on	AP0_11	↔ M_BEV
		5 = off		↔ SENSOR_COSP
		6 = on	AP0_12	↔ M_BEW
		7 = off		↔ SENSOR_COSN
		8 = on	AP0_13	↔ M_ST

Note 1. Please switch either all even switches on, while odds to off, or vice versa. Please do not switch even ***and*** odd switches on to avoid a short circuit between two analog sources.

4.1.11.1 Motor- and External Power Supply Connectors

There are some additional connectors in the motor control area to connect an external power supply and also three hall sensors.

You can connect your own external power supply with up to 18V to the CN2 connector.

If you want to use the delivered motor, you have to connect it to CN4 as follows:

Table 31. Connector CN4

CN4 Name	Motor Wire Colour
U	Green
V	Red
W	Black

Note: If you use the CN2 connector to supply the motor, the e-Fuse is bypassed and therefore the current is not limited anymore.

Caution:

The Starter Kit is designed and intended to use with the delivered components. If you want to connect your own motor, please be informed that this happens on your own responsibility!

Always stay within the specified voltage and current ranges!

No guarantee or support can be provided when connecting your own motor/external power supply!

4.1.11.2 Position Sensor Connectors

Two kind of position sensors can be connected to the starter kit. The fast sensor connector CN9 is intended to be used together with the motor control functionality. It is bundled with the motor. It returns two complementary analog signals (sin+, sin-, cos+, cos-) which can be easily calculated via an arctan-function to a precise angle position. Alternatively, an optional external sensor which provide the motor position via an UART interface (UART directly or UART-over-CAN interface) can be chosen.
The slow position sensor connector CN3 is available for optional position sensors, which outputs any position via one analog value (representing the angle), via the SENT protocol or via a PWM output. To choose the desired signals, you can use the switches S8 and S9.
Both connectors share the same I²C interface for configuration purposes and the same interrupt line for an optional event signalization of the sensor.

Fast position sensor connector CN9

As the MCU does not have enough pins to connect each possible signal for position sensing in parallel, a selection is mandatory. Switch S10 can be used to assign the signals of the fast position sensor to the ADC inputs. Please see Table 30. Analog Input Switch S10 Configuration for details.

- Support for direct motor control
- 4x analog inputs (sinp/cosp / sinn/cosn)
- UART-over-CAN inputs (UART or CAN signals can be chosen)
- I²C support for configuration; Share same I²C signals for slow sensor connector; (Shared with UART-over-CAN signals; Cannot be used in parallel)
- Interrupt input optional (shared with slow position sensor connector)

Table 32. Fast position sensor connector CN9 pin assignment

Pin	Functionality	Signal / Connection
1	**GND**	GND
2	**VDD**	VDD_5V
3	IRQ *1	Close S8_8 to connect this pin to MCU port P10_11 / **INTP**11 / TAUB0I1
4	SDA / UART_TX / CAN_H*2	Select signal by exclusively closing switch: S8_1: P0_11 / RIIC0**SDA** S8_2: P0_5 / RLIN31**TX** (SELDP1) S8_3: **CANH** (IC8_7)

5	SCL / UART_RX / CAN_L*2	Select signal by exclusively closing switch: S8_4: P0_12 / RIIC0**SCL** S8_5: P0_4 / RLIN31**RX** (SELDP0) S8_6: **CANL** (IC8_6)
6	SINP*3	Connect this pin to MCU port AP0_10 by exclusively closing switch S10_1. Open switch S10_2 to disconnect the back-EMF signal M_BEU from the MCU port.
7	SINN	Connect this pin to MCU port AP0_11 by exclusively closing switch S10_3. Open switch S10_4 to disconnect the back-EMF signal M_BEV from the MCU port.
8	COSP	Connect this pin to MCU port AP0_12 by exclusively closing switch S10_5. Open switch S10_6 to disconnect the back-EMF signal M_BEW from the MCU port.
9	COSN	Connect this pin to MCU port AP0_13 by exclusively closing switch S10_7. Open switch S10_8 to disconnect the back-EMF signal M_ST from the MCU port.
10	**GND**	GND

Note 1. IRQ signal is shared with the PWM input from the Slow position connector CN8. IRQ and PWM functionality cannot be used at the same time.

Note 2. If I^2C selection (S8_1/4 = on): SDA/SCL may be shared with Slow sensor connector CN3
If UART selection (S8_2/5 = on): RX/TX may be shared with Low Power Sampler (LPS) (See 4.1.4 for details)
If CAN selection (S8_3/6 = on): CAN_H/L are shared with CAN 1 connector CN3 (See 4.1.8.3 for details)

Note 3. SINP signal may be shared with Slow sensor connector CN3, Pin 6

Slow position sensors connector CN3 (for future improvement)

This connector is for future improvements. E.g., for a slow speed position sensor, which sends its data via SENT or PWM as the reference speed.

- Used for Position / Speed setting
- Supports SENT
- Supports PWM
- Interrupt input optional (shared with fast sensor connector)
- Support Analog (1x) (Use same pin as SINP at fast sensor connector, but different signal)
- I^2C support for configuration; Share same signals of fast position sensor connector

Table 33. Slow position sensor connector pin assignment

Pin	Functionality	Signal / Connection
1	**GND**	GND
2	**VDD**	VDD_5V

3	IRQ / SENT / PWM *1	Select signal by exclusively closing switch: S9_1: P10_11 / **INTP**11 / **TAUB0I1(PWM)** S9_2: **SENT**
4	SDA *2	Close S9_3 to connect this pin to MCU port P0_11 / RIIC0**SDA**
5	SCL *2	Close S9_4 to connect this pin to MCU port P0_12 / RIIC0**SCL**
6	Analog *3	Close S8_7 to connect this pin to MCU port AP0_15
7	-	Not connected
8	-	Not connected
9	-	Not connected
10	**GND**	GND

Note 1. IRQ/PWM signals are shared with Fast position connector CN9. IRQ and PWM functionality cannot be used together, even if used on different connectors, as the same MCU pin is used. The SENT signal is shared with DB9 connector CN5. (See 4.1.8.1 for details)

Note 2. SDA/SCL may be shared with Fast sensor connector CN9.

Note 3. Analog signal may be shared with Fast sensor connector CN9, Pin 6, SINP signal.

4.1.11.3 Hall Sensor Connectors

Via the CN7 connector, you have the possibility to connect digital hall sensors with the MCU. The input pins are protected against overvoltage (>5V or <0V) with two Schottky diodes per input pin. For the use of the internal Hall sensors of the delivered motor, it is necessary to activate the internal pull up resistors of the controller.

If you want to connect the hall sensors of the delivered motor, connect the colored wires as described below:

Table 34. Hall Sensor Connector

Board connector CN7 (HALL_IN) / MCU	Motor Wire Color
Not connected	-
GND	White
HALLC/ P10_14	Brown
HALLB/ P10_13	Orange
HALLA/ P10_12	Blue
5V	Yellow

4.1.12 Predrive Area

The mounted R2A25108KFP device contains three sets of MOSFET-drivers, charge pump circuit for the gate drive of external power MOSFET, three channels of current sense amplifier and safety functions.

Please find below the connection between the MCU and the Predriver.

Table 35 Predriver connection

Description	**Connection MCU <-> Predriver**
Predriver-Input for UT Signals	P10_0 <-> IUT
Predriver-Input for UB Signals	P10_1 <-> IUB
Predriver-Input for VT Signals	P10_2 <-> IVT
Predriver-Input for VB Signals	P10_3 <-> IVB
Predriver-Input for WT Signals	P10_4 <-> IWT
Predriver-Input for WB Signals	P10_5 <-> IWB
ERR1 Signal	P8_7 <-> ERR1
ERR2 Signal	P8_8 <-> ERR2
Mute the output of the Predriver	P8_9 <-> MUTE
W Phase Current	AP0_2 <-> VOW
V Phase Current	AP0_1 <-> VOV
U Phase Current	AP0_0 <-> VOU

Note: For details about the signals, please see the Predriver datasheet.

5. Development tools

5.1 E1 On-Chip Debug Emulator [R0E000010KCE00] (discontinued product)

The *E1 On-Chip Debug Emulator* is a powerful debugging tool with flash programming functions which supports various Renesas microcontrollers.

Updates and User Manuals for this tool can be found on the Renesas website:

http://www.renesas.com/e1

5.2 E2 Emulator [RTE0T00020KCE00000R] (Successor of E1)

The *E2 On-Chip Debug Emulator* is a powerful debugging tool with flash programming functions which supports various Renesas microcontrollers.

Updates and User Manuals for this tool can be found on the Renesas website:

http://www.renesas.com/e2

5.3 Development Software

The following development software tools are included in the Starter Kit package:

- Green Hills MULTI IDE (90 day evaluation version)
- IAR Embedded Workbench for Renesas RH850 (128KB Kickstart version)
- iSYSTEM winIDEA with E1 or E2 support
- CS+ integrated development environment (Evaluation version via download)
- Renesas Flash Programmer (RFP)
- Renesas Smart Configurator (SC)

More information about the usage of these software tools is shown in the Quick Start Guide which is also part of the Starter Kit package.

6. RH850/F1KM-S1 Starter Kit Example Software

The included demo software (Mode 1 and 2) provides the following functions:

- Basic MCU initialization
- PWM generation for user LEDs and RGB LEDs
- PWM diagnostic function for RGB LEDs
- A/D-Converter for PWM-Diagnostics and Potentiometers
- Standby modes including Low Power Sampler (LPS)
- Push-Button function
- Encoder function
- CAN frame transmission
- LIN frame transmission
- UART/USB transmission
- SENT transmission
- SPI transmission
- Operating System Timer
- Timer Array Unit J
- Timer Array Unit B

The motor control software uses the motor control area/ predriver and other peripherals of the starterkit.

6.1 Framework Description

Renesas provides a software framework with its Starter Kits, so that the customer can easily access and use the modules of the controller. The Starter Kits are equipped with a lot of peripheral devices like encoder, potentiometer, LEDs, display, CAN-, LIN- and UART/USB-transceivers, buttons and an optional motor control part. To use these modules, the Starter Kit contains software functions which allows an easy and fast use.

The framework is divided in 3 layers:

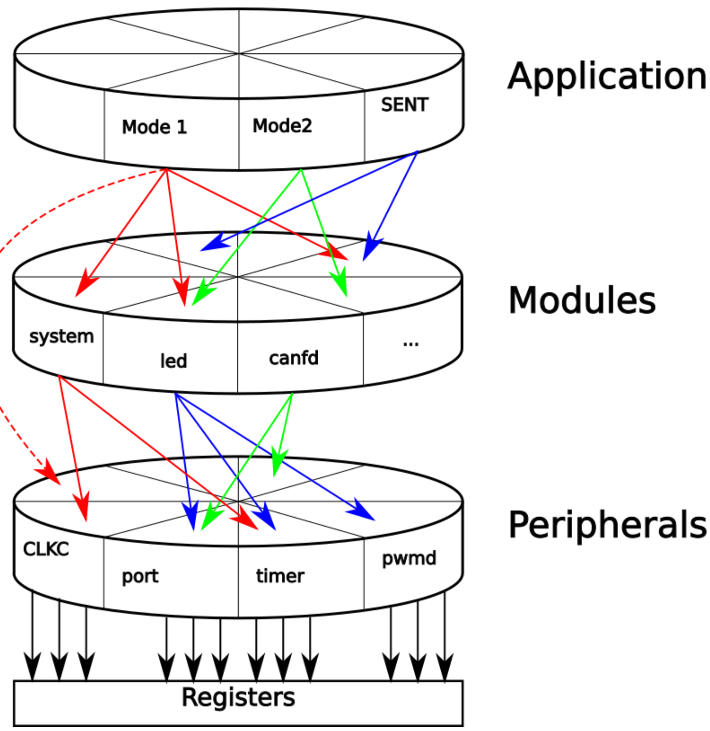


Figure 4. Framework Layers

In the peripherals layer you can find the source code related to the peripherals of the microcontroller. For example, you can find all related functions for the ports in the *"r_port.c"*. Only the functions defined in this source file should set or read the port registers.
In the modules layer, you can find modules like "*canfd"*, which accesses not only the functions for the RS-CANFD peripheral of the MCU, but also for example the functions of the port peripheral. It can also contain a not controller specific module like "*led*". This module for example uses functions of the *port*-, *timer*- and "*pwmd"* peripheral to achieve the desired behavior of the led.
The highest layer is the application layer which contains the actual application. For example, the sample application for the Starter Kit uses the lower layer modules to write to the display, turn on some LEDs and checks the transceivers of the Starter Kit.
It is intended that a higher layer should only access the lower layers and not the other way around.

6.2 Sample Software Classic

The software contains a test function executed at the start and two run modes.

For live documentation of the RH850 actions connect a USB-Port of your computer via a USB Cable to the USB connector “J18” of the board. You can use a terminal program like “putty” to receive the messages.

Note: Use a USB 1.0/2.0 Type A to mini USB 1.0/2.0 mini-B computer cable and a baud-rate of 9600 Bd for the virtual COM port.

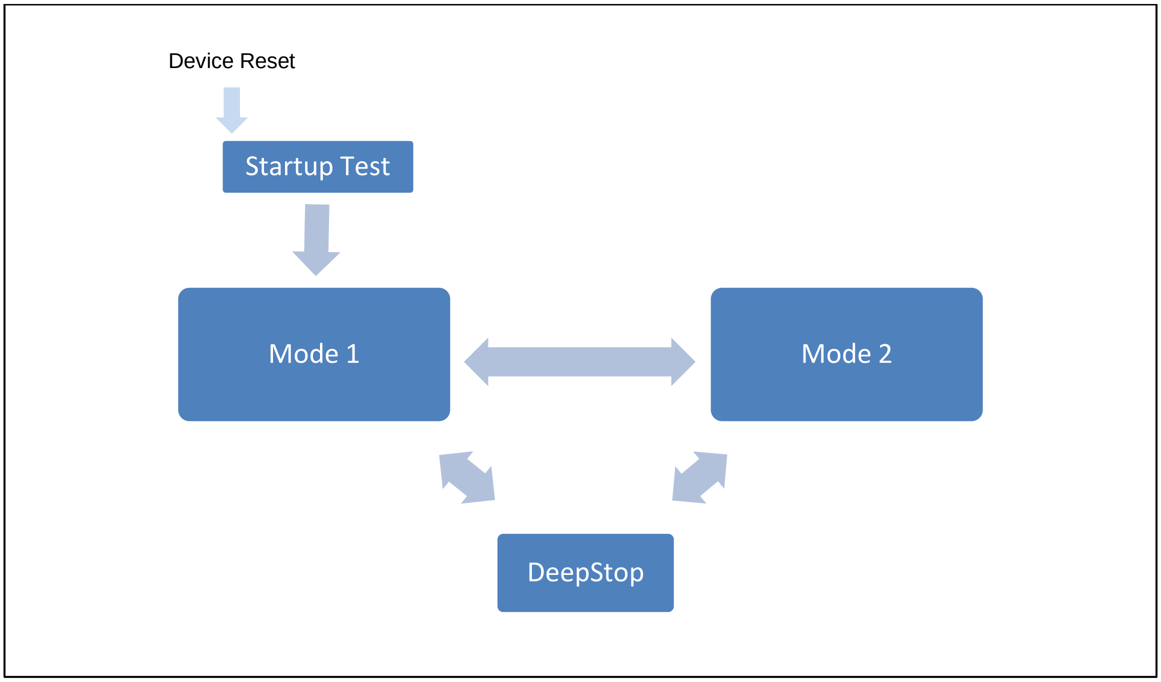


Figure 5. Software flow

A motor control software is flashed by default. This software is described in “6.7 Motor Control Software Example” and in the “Motor Control Application Note”, which is also included in this starter kit package. Both packages including both source codes can be flashed manually via the E1 or E2 debugging emulator (see Quick Start Guide).

6.3 Start Up Test

Once started, the clock will be initialized, and a start-up test is performed. During the test, the LEDs of the blue LED circle will successively be turned on and then turned off in the same pattern. Simultaneously the RGB LED will sweep through different colors and then turn off. Afterwards the RGB LED will light up in white for 500ms, as well as the whole blue LED circle. LED1 and LED2 will light during the whole test. The serial interfaces CAN, LIN and the RGB LED PWM feedback signals are checked. The result is printed out in the debugger and via UART/USB. Also, a test picture will be shown on the display. After this the SW continues with Mode 1.

6.4 Mode 1

LED1 and LED2 glow in different intensities depending on the potentiometer POT1 position. The converted analog value of POT1 is used to update the duty cycle of the PWM module which drives these LEDs. The LEDs of the blue LED circle are following the rotary encoder ENC1. By pressing the rotary encoder pushbutton, the color of the RGB LED is changed.

The load current through each of the RGB LEDs is evaluated by converting feedback/sense signal into digital values and applying conversion result upper / lower limit check function of ADC (PWM diagnostic function). In case the measured current is either too high or too low, a fault is assumed and in turn the PWM of the corresponding LED is switched OFF. By switching to Mode 2 the PWM output and diagnostic is started again.

A short push on pushbutton S1 will switch to Mode 2, keeping it pressed for 3s or more will switch to DeepSTOP mode.

After 30s without user action, the microcontroller will enter DeepSTOP mode on its own.

Mode 1 is called in a 1ms cycle using the Operating System Timer (OSTM).

6.5 Mode 2

LED1 and LED2 blink alternately and the LEDs of the Blue LED Circle run around the rotary encoder in a specific frequency. The frequency is determined by the analog value of POT1 which is converted to a corresponding Timer Array Unit J interval time. After each interval, the duty cycle of the LEDs LED1 and LED2 is adjusted to generate the alternatively blinking pattern, as well as the positions of the blue LED circle. The number of blue LEDs which are circling can be increased/decreased by the rotary encoder ENC1.

The load current through each of the RGB LEDs is evaluated by converting feedback/sense signal into digital values and applying conversion result upper / lower limit check function of ADC (PWM diagnostic function). In case the measured current is either too high or too low, a fault is assumed and in turn the PWM signals of the corresponding LED is switched OFF. By switching to mode 1 the PWM output and diagnostic is started again.

A short push on pushbutton S1 will switch to mode 1, keeping it pressed for 3s or more will switch to DeepSTOP mode.

After 30s without user action, the microcontroller will enter DeepSTOP mode on its own.

Mode 2 is called in a 1ms cycle using the Operating System Timer.

6.6 StandBy

Entering standby mode will turn off all not mandatory functions and switch the controller into DeepSTOP for low power consumption. This is indicated by a 2s interval of LED2 generated by the Timer Array Unit J.

A wake-up can be performed by a short push of the pushbutton S1, the rotary encoder pushbutton, changing the configuration of the DIP switch S6 or turning potentiometer POT1 more than 25% of the actual state. DIP switch and POT1 related wake-up events are generated by using the Low Power Sampler triggered by Timer Array Unit J in a 500ms interval. Performing a wake-up will resume the last mode the SW was in before standby was entered.

6.7 Motor Control Software Example

On the RH850/F1KM-S1 Starter Kit V2 , a field-oriented-control motor control (FOC) example software will be flashed to the controller by default. This software is described in detail in the “Motor Control Application Note”, which is why it is only described in a brief way here.

After a small Startup Test, including blue LED Circle, RGB LED, display test picture, CAN and LIN the motor control mode will be entered (see 6.3 Start Up Test for details to the Start Up Test).

From now on the board is ready to use and control the connected motor if the motor control unit is powered (see 4.1.2.1 Power supply configuration).

Now the encoder can be used to increase the rotation speed (turn right for counterclockwise rotation and turn left for clockwise rotation of the motor). The display and the surrounding Blue LEDs will give you feedback about the actual RPM (500 RPM per LED, - 8000 RPM to 8000 RPM). The equipped Potentiometer (Pot1) will allow you to change the acceleration and the deceleration at the same time. You can change it between ~0 ∆RPM/sec and ~10000 ∆RPM/sec. The current value is shown on the display and via the RGB LED in the encoder (blue – zero, green – slow, red – fast).

The motor control starter kit software uses an advanced field-oriented-control technique which uses either the Renesas high precision Inductive Position Sensor (IPS2550), Hall sensors or a sensor-less flux estimation, which are described in more detail in the “Motor Control Application Note”.

If you are pressing the encoder button, the used position detecting method is switched. Which Sensor is used, can be seen on the display and is shown via the LED 17 and LED18

- IPS2550 — LED18 off, LED17 off
- Position estimation via shunts — LED18 on, LED17 off
- Hall sensors (only if connected) — LED18 on, LED17 on

Display Description

The display shows some information about the main motor control parameters which are described below:

Table 36. Display Description

Name	Meaning
RPMD	Rotation Per Minute Desired
RPMA	Rotation Per Minute Actual
ID	ID current of FOC (controlled to 0 at normal control)
IQ	IQ current of FOC (~used current of Motor)
ACC	Acceleration/Deceleration (in ∆RPM/sec)
Sens	The currently used sensor for position detection (IPS, HALL or SHUNT)
VBUS	Bus Voltage
Alrm Cde	Alarm Code (described in App Note)

Note: You can find a detailed description of the motor control parameters in the “Motor Control Application Note” in the Starter Kit software package.

The motor control unit allows to connect the hall sensors of the delivered motor but using hall sensors in an FOC aren’t advantageous against a trapezoidal control, because of their low precision. But you can write your own software using the hall sensors for example with trapezoidal control.

7. Component Placement and Schematics

7.1 Component placement

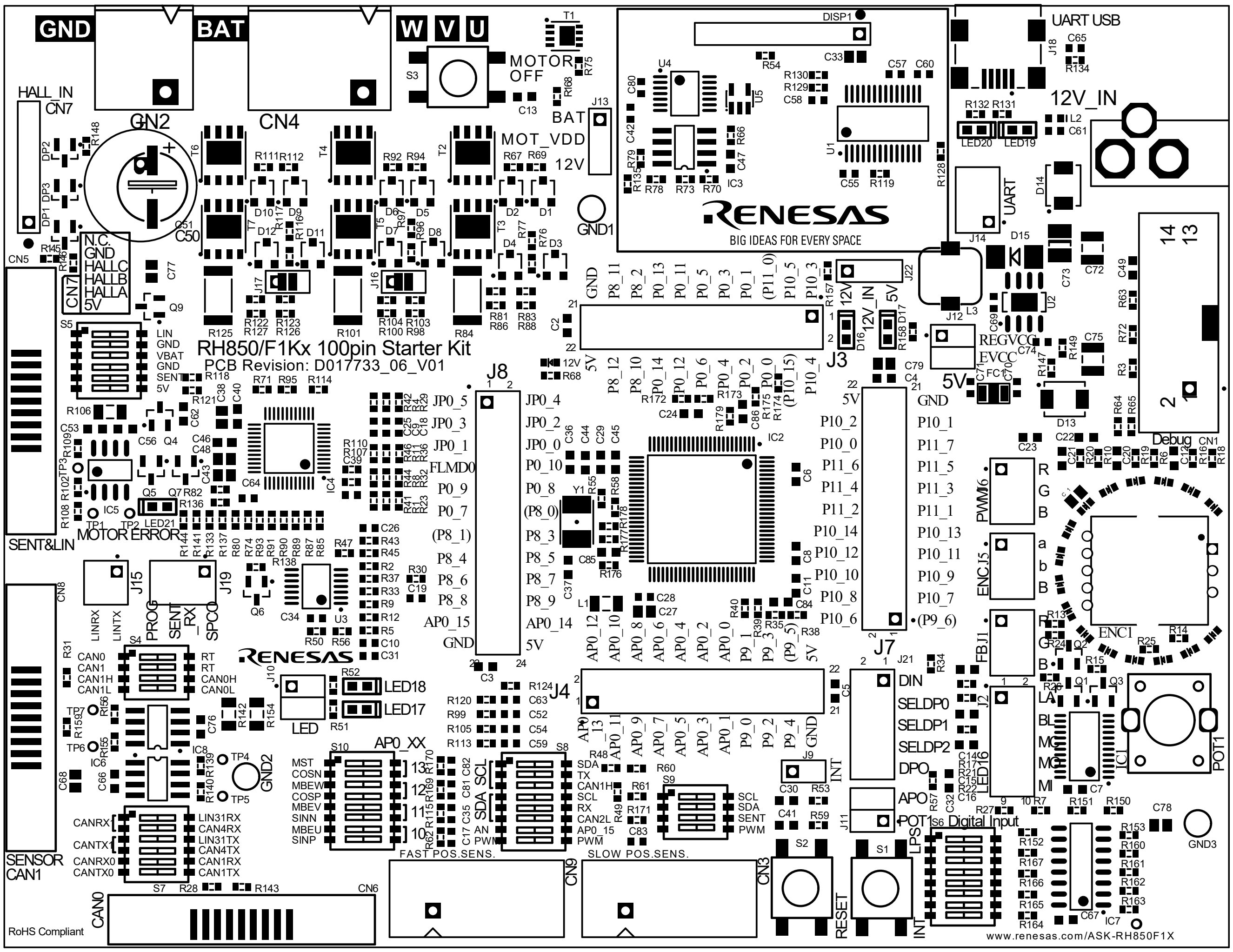


Figure 6. Component Placement

Note: This component placement is related to the following release version of the PCB: “D017733_06_V01”

7.2 Schematics

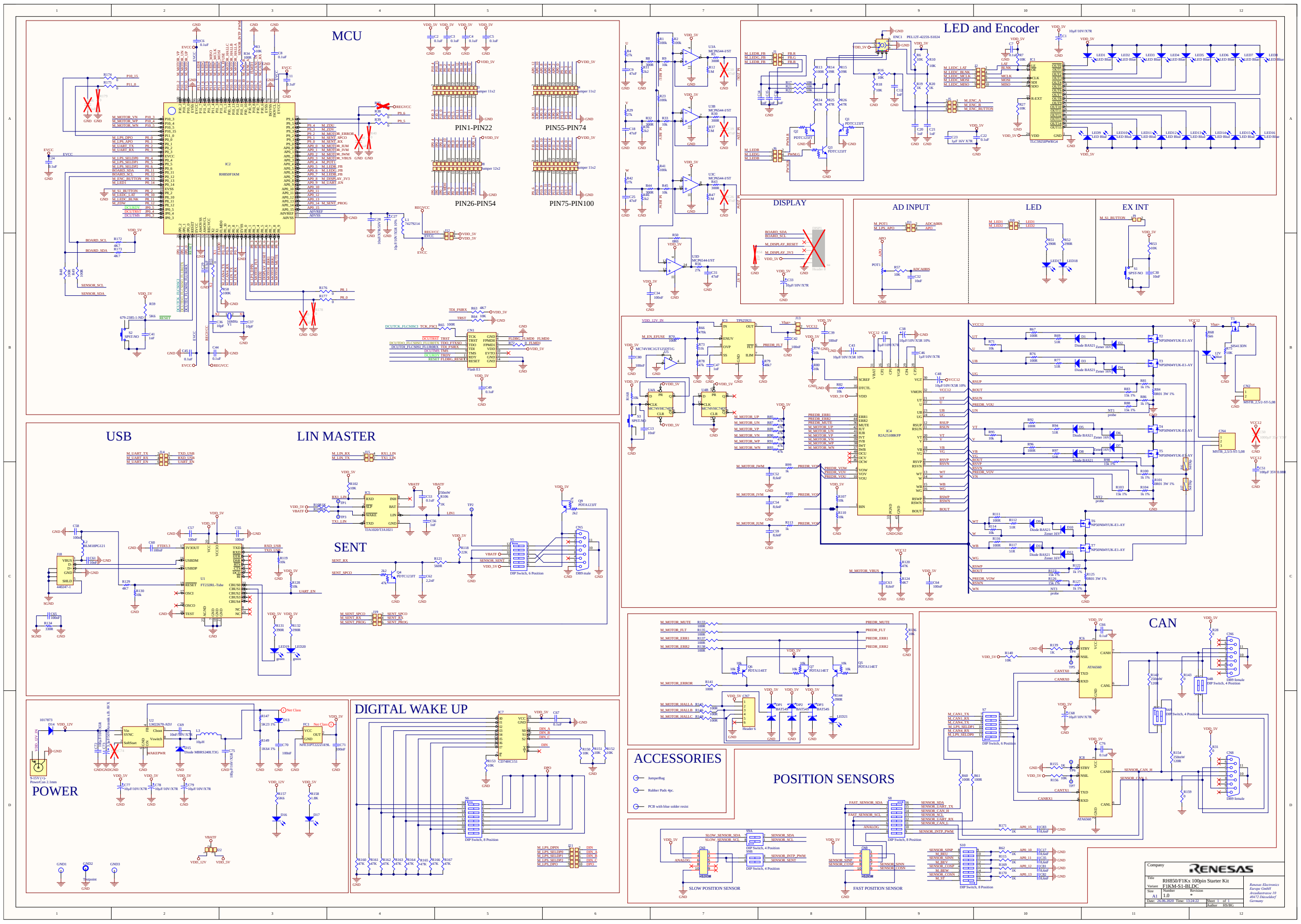


Figure 7. Schematics

Note: This Schematic is related to the following release version of the PCB: “D017733_06_V01”

Revision History

RH850/F1KM-S1 (BLDC) Starter Kit V2 User Manual: Hardware			
Rev.	**Date**	**Description**	
		Page	**Summary**
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Colophon 1.0

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