MC9S12G128 Controller Board User Guide

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About This Book

This document describes the MC9S12G128 Controller Board design, which is targeted for development of motor control applications.

To locate any published updates for this document, refer to the world-wide web at: http://www.freescale.com/.

Revision History

Table i. Revision History Table

Date	Revision level	Description
August 2012	1.0	Initial release

Documentation

The MC9S12G128 documentation is available at the web site, http://www.freescale.com. as follows:

- Reference manuals — MC9S12G128 modules in detail
- Data sheets — information mainly on the device's AC, DC, thermal characteristics and packages pin-out
- Product briefs — device overview
- Application notes — address specific design issues

Chapter 1 Introduction

The MC9S12G128 Controller Board is designed to a drive 3-phase BLDC motor, enabling implementation of motor control techniques:

- Sensorless:
  - Back-EMF signal sensing using an MCU ADC module
  - Back-EMF zero-cross signal monitoring
- Sensor based:
  - Hall sensor signal monitoring

On-board UNI-3 interface enables control of the BLDC motor power stage.

The LIN and CAN communication interfaces connect the board to the other automotive network nodes.

The USB interface is targeted at FreeMASTER PC-based application control.

1.1 Features

The MC9S12G128 Controller Board features follows:

- MC9S12G128 microcontroller, 100 LQFP package
- BDM interface for MCU code download and debugging
- MC33905 System-basis chip (power supply, connectivity)
- Motor control interface:
  - UNI-3
  - MC33937A predriver
  - Hall sensors
- Connectivity interface:
  - LIN (MC33905)
  - CAN (MC33905)
  - USB interface
- LEDs:
  - Power-on indicators
  - Phase A, B, C PWM control signals
  - Phase A, B, C zero-cross
  - Hall sensor outputs
  - Fault monitoring
  - SBC safe mode
  - User application
- Rotary encoder switch for an application control
- On-board PWM dead time generation
- MCU pins accessible via pin headers

1.2 Board Architecture

The MC9S12G128 Controller Board basic building blocks are depicted in Figure 1-1. The block color differentiates a block function:

- Blue - MCU and application software download and the debug interface
- Green - Motor control related hardware
- Red - Board power supply and connectivity
- Violet - Application control

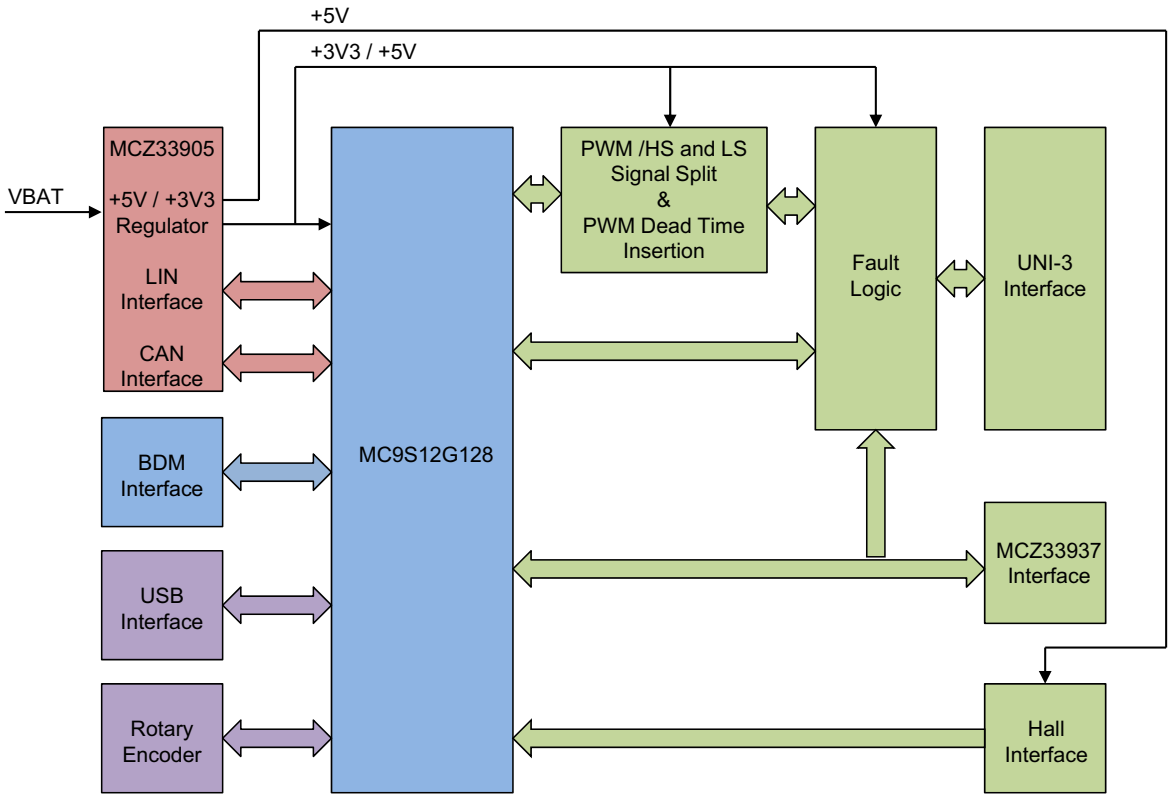


Figure 1-1. MC9S12G128 Controller Board Block Diagram

The board is supplied by VBAT voltage in the range of 8 V to 18 V. The MCZ33905 provides 5 V to Hall interface. The MCU and on-board logic are supplied by either 3.3 V or 5 V, depending on the assembled SBC version. The board is populated with the 3.3 V SBC version by default.

The MCU generates one PWM signal for each phase. An additional on-board logic is used to split the PWM signals to control power stage top and bottom switches separately. A PWM dead time is inserted by additional hardware, if required.

The Fault logic triggers the DC bus undervoltage and DC bus overcurrent faults, and turns OFF the power stage top and bottom switches. The circuitry behaviour depends on the selected configuration. For more info, see Chapter 3.3, “Board Fault Management".

The user can control the application using the rotary switch, USB interface (RS232), CAN and LIN buses. The BDM interface is present on-board to enable the download and debugging of the MCU code.

For the on-board block location, see Figure 1-2.

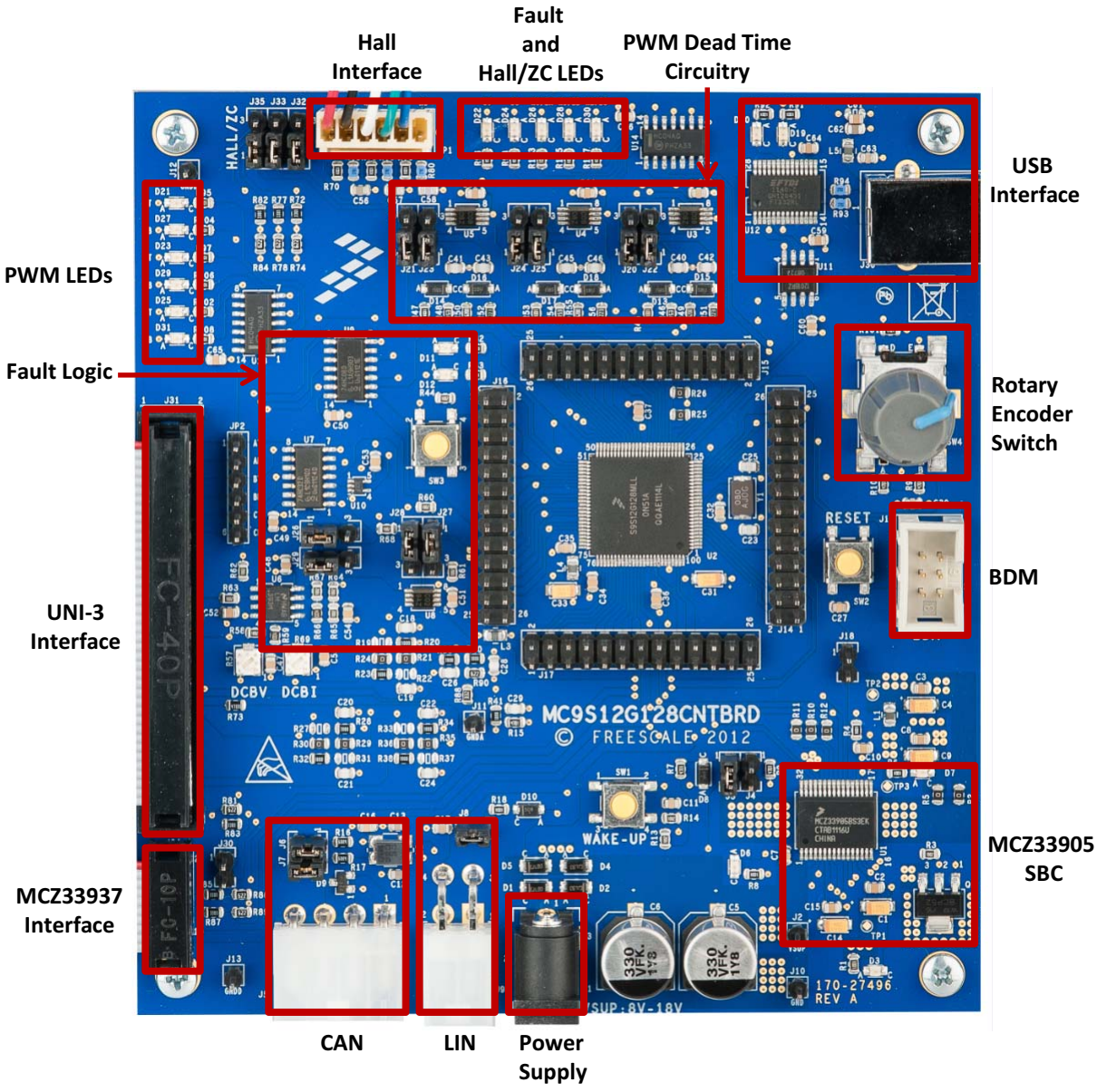


Figure 1-2. MC9S12G128 Controller Board Block Location

1.3 Board Jumper Configuration

See Table 1-1 and Figure 1-3 for proper jumper configuration.

Table 1-1. MC9S12G128 Board Configuration

Jumper	Selector	Function	Connection
J3	SBC Debug Mode	SBC Debug mode (J4 not placed): - ON, placed - OFF, unplaced	Placed
J4	SBC Fail-Safe Mode	SBC Normal mode (J3 not placed): - ON, placed - OFF, unplaced	Unplaced
J6, J7	CAN Termination	CAN bus termination: - 120R, placed - without termination, unplaced	Placed
J8	LIN Master/Slave	LIN mode: - Master, placed - Slave, unplaced	Placed
J18	/RESET	SBC and MCU /RESET pins connected: - connected, placed - unconnected, unplaced	Unplaced
J20, J22	PHASE A Dead Time	Dead time ~2µs generated by on-board HW: - ON, placed pins 1-2 - OFF, placed pins 2-3	Placed, pins 1-2
J21, J23	PHASE C Dead Time	Dead time ~2µs generated by on-board HW: - ON, placed pins 1-2 - OFF, placed pins 2-3	Placed, pins 1-2
J24, J25	PHASE B Dead Time	Dead time ~2µs generated by on-board HW: - ON, placed pins 1-2 - OFF, placed pins 2-3	Placed, pins 1-2
J26	FAULTS	Fault is processed by: - on-board HW, placed pins 1-2 - MCU software (/IRQ), placed pins 2-3	Placed, pins 1-2
J27, J28	FAULTS	In case of Fault, the power stage switched turned OFF by: - on-board HW, placed pins 1-2 - power stage HW (EN pin), placed pins 2-3	Placed, pins 1-2
J29	FAULTS	Overcurrent diagnostic input: - on-board comparator, placed pins 1-2 - power stage MC33972 comparator, placed pins 2-3	Placed, pins 1-2
J32	HALL/ZC PHASE A	BLDC sensor control based on: - Hall sensors, placed pins 1-2 - Zero-cross, placed pins 2-3	Placed, pins 1-2
J33	HALL/ZC PHASE B	BLDC sensor control based on: - Hall sensors, placed pins 1-2 - Zero-cross, placed pins 2-3	Placed, pins 1-2

Table 1-1. MC9S12G128 Board Configuration (continued)

Jumper	Selector	Function	Connection
J35	HALL/ZC PHASE C	BLDC sensor control based on: - Hall sensors, placed pins 1-2 - Zero-cross, placed pins 2-3	Placed, pins 1-2

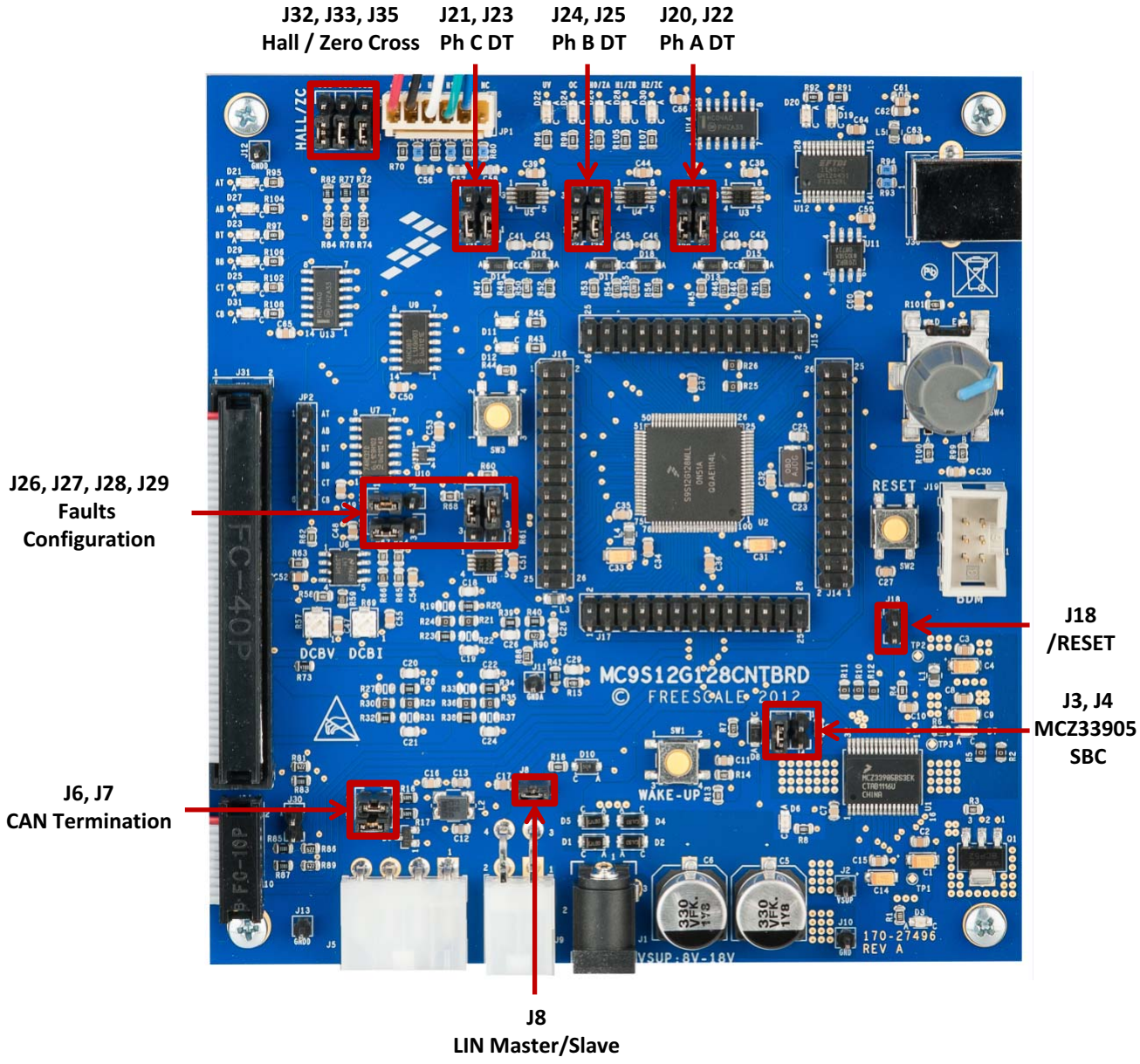


Figure 1-3. MC9S12G128 Controller Board Jumper Position and Default Setting

1.4 Board LEDs

The Table 1-2 displays the on-board LEDs. For on-board LED locations, see Figure 1-2.

Table 1-2. on-board LEDs

LED	Signal Name	Description
D3	+5V	5 V Hall power supply
D6	/SAFE	MCZ33905 safe-pin state (ON - SBC in safe mode)
D7	+3V3	3.3 V board power supply
D11	-	User LED1
D12	-	User LED2
D21	AT	Phase A top switch signal (ON - High Level)
D22	UV	DC bus undervoltage fault (ON - Fault)
D23	BT	Phase B top switch signal (ON - High Level)
D24	OC	DC bus overcurrent fault (ON - Fault)
D25	CT	Phase C top switch signal (ON - High Level)
D26	H0 / ZA	Hall 0 / Zero-cross Phase A signal (ON - High Level)
D27	AB	Phase A bottom switch signal (ON - High Level)
D28	H1 / ZB	Hall 1 / Zero-cross Phase B signal (ON - High Level)
D29	BB	Phase B bottom switch signal (ON - High Level)
D30	H2 / ZC	Hall 2 / Zero-cross Phase C signal (ON - High Level)
D31	CB	Phase C bottom switch signal (ON - High Level)

Chapter 2 Interface Description

The following chapters summarize the on-board connectors and header pin-outs, signal meanings and MCU pins assignments.

2.1 Power Supply J1

The MC9S12G128 Controller Board can be supplied either by using the 2.1 mm DC power plug J1 or the UNI-3 connector (J31, pin 19).

The controller board provides 5 V for a Hall interface and 3.3 V for on-board logic. Both voltages are generated by the MC33905 SBC. Proper operation is monitored by LEDs D3 for the 5V line and D7 for the 3.3V line (see Table 1-2).

The board is designed to operate in the voltage range from 8 V to 18 V. The board is protected against a reverse battery.

2.2 UNI3 Interface J31

The Unified Interface Version 3 (UNI-3) defines the interface between the MC9S12G128 Controller Board and the BLDC motor power stage.

The list of UNI-3 signal is as follows:

- Control signals:
  - PWM phase A, B, C top and bottom switches control
  - Brake signal control
  - Power Factor Correction (PFC)
- Monitor signals
  - DC-bus voltage
  - DC-bus current
  - Phase A, B, C current
  - Zero-cross signals
  - Back-EMF phase A, B, C
  - Temperature monitoring
- Power Supply +12V
- Serial line - a bidirectional communication line between the Controller Board and Power Stage

The Table 2-1 defines the UNI-3 pin-out and pin assignment to the MCU.

Table 2-1. UNI-3 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	PWM_AT	PWM3	Phase A top switch control (H -> Turn OFF)	Digital output
3	PWM_AB	PWM3 & PA0	Phase A bottom switch control (H -> Turn ON)	Digital output
5	PWM_BT	PWM5	Phase B top switch control (H -> Turn OFF)	Digital output
7	PWM_BB	PWM5 & PA1	Phase B bottom switch control (H -> Turn ON)	Digital output
9	PWM_CT	PWM7	Phase C top switch control (H -> Turn OFF)	Digital output
11	PWM_CB	PWM7 & PA2	Phase C bottom switch control (H -> Turn ON)	Digital output
2, 4, 6, 8, 10	Shield	-	PWM signals shield (grounded on the power stage side only)	-
12,13	GND_D	-	Digital power supply ground	-
14, 15	+5V DC	-	+5V digital power supply	-
17, 18	AGND	-	Analog power supply ground	-
19	+12/+15V DC	-	Analog power supply	-
16,20, 23,24,25, 27, 28,37	NC	-	Not connected	-
21	V_{DCBUS}	PAD6	DC-bus voltage sensing, 0V – 3.3V	Analog input
22	I_{DCBUS}	PAD1 PAD3 PAD5	DC-bus current sensing, 0V – 3.3V	Analog input
26	TEMP	PAD7	Analog temperature 0V – 3.3V	Analog input
29	BRAKE_CONT	PA5	DC-bus brake control	Digital output
30	SERIAL	-	Serial interface	Dig. bidirectional
31	PFC	-	Power factor correction PWM	Digital output
32	PFCEN	-	Power factor correction enable	Digital output
33	PFCZC	-	Power factor correction Zero-cross	Digital input
34	ZCA	KWP2	Phase A Back-EMF zero crossing	Digital input
35	ZCB	KWP4	Phase B Back-EMF zero crossing	Digital input
36	ZCC	KWP6	Phase C Back-EMF zero crossing	Digital input
38	Back-EMF_A	PAD0	Phase A Back-EMF voltage sensing	Analog input
39	Back-EMF_B	PAD2	Phase B Back-EMF voltage sensing	Analog input
40	Back-EMF_C	PAD4	Phase C Back-EMF voltage sensing	Analog input

2.3 MC33937A Interface J34

When using a Freescale 3-phase low voltage power stage [1.], the phase top and bottom switches are controlled by the MC33937A pre-driver. The device is configured by the SPI, see Table 2-2.

Table 2-2. MC33937 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	NC	-	Not connected.	-
2	NC	-	Not connected	-
3	MC33937_EN	PA4	Device enable	Digital output
4	MC33937_OC	-	Over-current	Digital input
5	MC33937_/RST	PC4	Reset	Digital output
6	MC33937_INT	PC5	Interrupt	Digital input
7	MC33937_SOUT	MISO0	SPI Input data	Digital input
8	MC33937_SCK	SCK0	SPI clock	Digital output
9	MC33937_CS	/SS0	Chip-select	Digital output
10	MC33937_SIN	MOSI0	SPI output data	Digital output

2.4 Hall Sensor Interface JP1

When developing the sensor based BLDC application, the Hall sensors are used to determine the actual motor rotor sector.

Connect the motor Hall sensors outputs to JP1 following the instructions in Table 2-3. and watch the signal levels by on-board LEDs (Table 1-2, Table 1-1).

Table 2-3. HALL Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	+5Vdc	-	+5 V sensor supply voltage	-
2	GND	-	Ground	-
3	HALL0	KWP2	HALL0 sensor output	Digital input
4	HALL1	KWP4	HALL1 sensor output	Digital input
5	HALL2	KWP6	HALL 2 sensor output	Digital input
6	NC	-	Not connected	-

2.5 LIN Connector J9

The MC33905 LIN transceiver is used as an on-board LIN interface hardware. The LIN node can be configured to either the Master or Slave mode, see Table 1-1.

A Table 2-4 shows the LIN connector pin-out and pin assignment to the MCU.

Table 2-4. LIN Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	GND	-	Ground	-
2	GND	-	Ground	-
3	VSUP	-	Power Supply	-
4	LIN	RXD1/TXD1	LIN bus	Dig. bidirectional

2.6 CAN Connector J5

The system basis chip on the MC33905 CAN transceiver is used as the CAN hardware interface. The on-board jumpers J6, J7 enable node termination, impedance of 120R, see Table 1-1.

Table 2-5 shows the CAN connector pin-out and pin assignment to the MCU.

Table 2-5. CAN Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	CANH	RXCAN/TXCAN	CAN bus H	Diff. bidirectional
2	CANL	RXCAN/TXCAN	CAN bus L	Diff. bidirectional
3	GND	-	Ground	-
4	NC	-	Not connected	-

2.7 USB Connector J36

The USB line is used for board communication with the PC, when using e.g. the Freescale FreeMASTER tool to control the user application.

The interface uses a B type connector and is isolated from the board environment. See Table 2-6 for the pin description and pin assignment to the MCU.

Table 2-6. USB Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	VBUS	-	USB Power Supply	-
2	D-	RXD0/TXD0	Data –	Dig. bidirectional
3	D+	RXD0/TXD0	Data +	Dig. bidirectional
4	GNDB	-	USB Ground	-

2.8 Header JP2

Monitoring the PWM signal is possible using JP2. The Table 2-7 summarizes header pin-out.

Table 2-7. JP2 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	PWM_AT	PWM3	Phase A top switch control	Digital output
2	PWM_AB	PWM3 & PA0	Phase A bottom switch control	Digital output
3	PWM_BT	PWM5	Phase B top switch control	Digital output
4	PWM_BB	PWM5 & PA1	Phase B bottom switch control	Digital output
5	PWM_CT	PWM7	Phase C top switch control	Digital output
6	PWM_CB	PWM7 & PA2	Phase C bottom switch control	Digital output

2.9 Header J30

Header J30 allows monitoring the MC33937A EN and OC pins, see Table 2-8.

Table 2-8. J30 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	MC33937_OC	-	Over-current	Digital input
2	MC33937_EN	PA4	Device enable	Digital output

2.10 Headers J14, J15, J16, J17

The MC9S12G128 MCU signals can be monitored using headers J14, J15, J16, J17, see board schematic.

Chapter 3 Design Consideration

This chapter provides an additional information on functional blocks of the MC9S12G128 controller board.

3.1 MC9S12G128 Features

The MC9S12G-Family is an automotive 16-bit microcontroller product line focused on low-cost, high-performance and low pin-count [2.]. This family is intended to bridge between high-end 8-bit microcontrollers and high-performance 16-bit microcontrollers, such as the MC9S12XS-Family. The MC9S12G-Family is targeted at generic automotive applications requiring CAN or LIN/J2602 communication.

The MC9S12G128 MCU 100 LQFP features follows (see Figure 3-1):

- CPU12V1 core
- Memory
  - 128 KB of Flash memory
  - 4096 bytes of EEPROM
  - 8192 bytes of RAM
- Clock modules:
  - External oscillator
  - Internal 1MHz RC oscillator
  - PLL
- Connectivity:
  - MSCAN, 1 module
  - SCI, 3modules
  - SPI, 3modules
- 16-bit timer, 8 channels
- 8-bit PWM, that can be configured as either 8 channel 8-bit PWM or 4 channel 16-bit PWM.
- 10-bit ADC, 16 channels
- MCU Supply voltage from 3.13 V to 5.5 V
- Execution speed 50MHz

The MC9S12G128 Controller Board is designed to use MCU PWM3, PWM5, PWM7 channels as power stage phase A, phase B and phase C signals. The PWM1 channel is used primarily for proper timing of the power stage DC-bus current and BLDC motor Back-EMF ADC conversion.

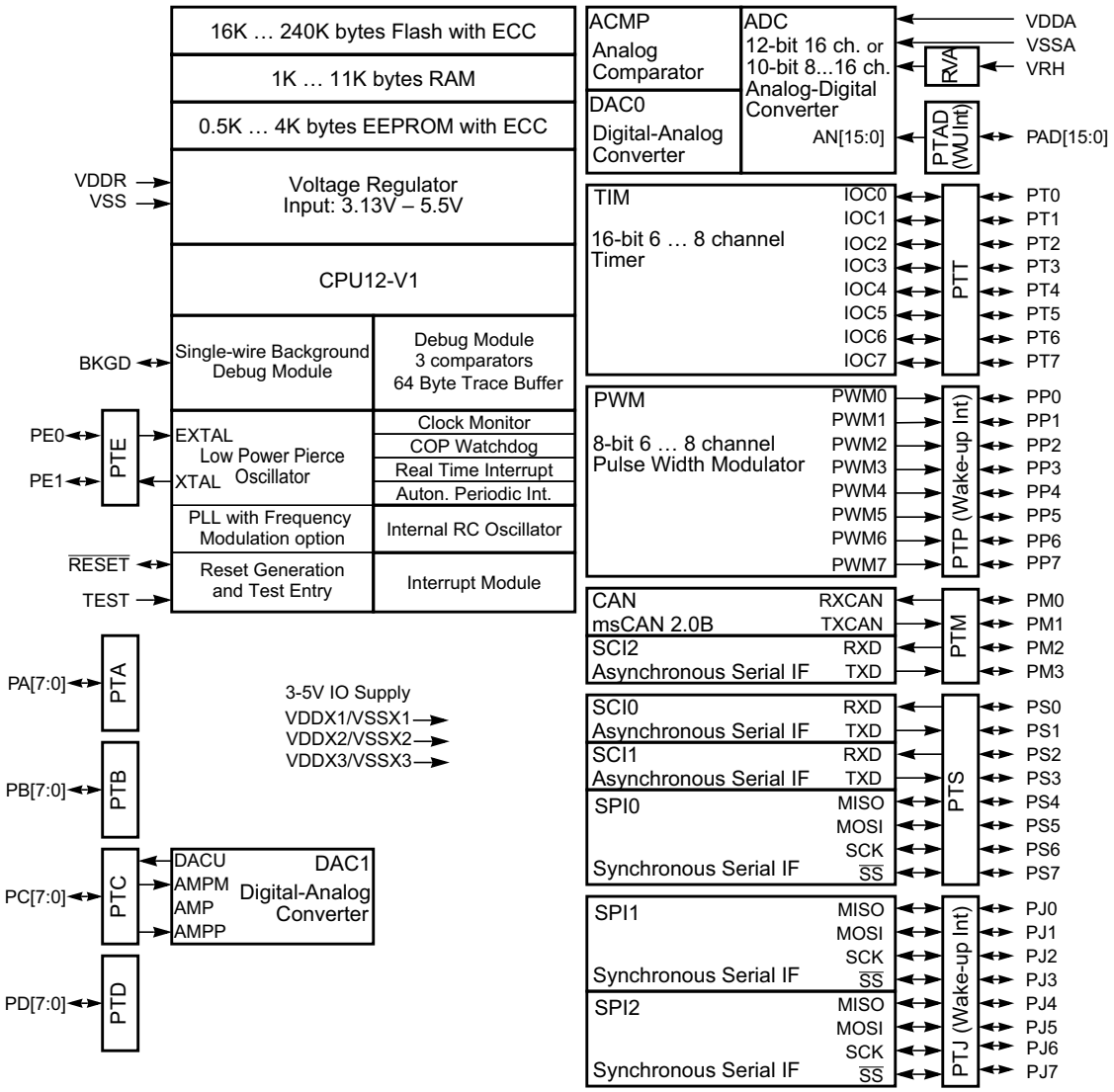


Figure 3-1. S12G Family Block Diagram

3.2 PWM /HS and LS Signal Split and Phase Dead Time Generation

The MC9S12G128 MCU PWM module generates one PWM signal per each phase. The power stage requires separate PWM signals for each phase top and bottom switch.

The Figure 3-2 shows how the PWM signals are generated for motor phase A. The other motor phases are controlled using the same logic circuitry.

The PWMA signal is split using the dual AND gate U3 into:

- PWMA_/HS signal:
  - turn ON the power stage top switch, when reaches a low level
  - turn OFF the power stage top switch, when reaches a high level
- PWMA_LS signal:
  - turn ON the power stage bottom switch, when reaches a high level
  - turn OFF the power stage bottom switch, when reaches a low level

In case of need to turn OFF the top and bottom switch simultaneously, the CTRLA signal is driven by MCU low level and PWMA signal is driven high level.

The RC cell and diode are present on-board to insert a dead time approximately 2 micro seconds into the phase PWM signal. Optionally this can be disabled using on-board jumpers, see Section 1.3, “Board Jumper Configuration.”

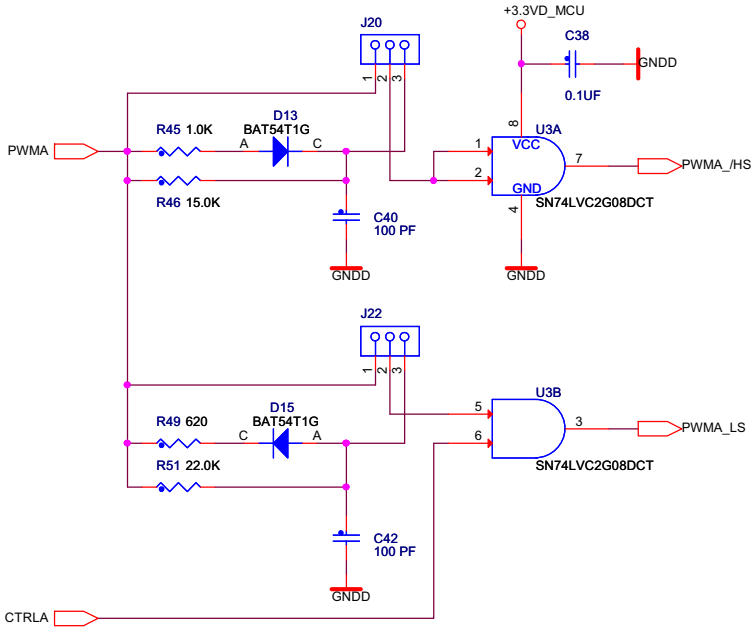


Figure 3-2. PWM Signal Split and Phase Dead Time Generation

3.3 Board Fault Management

The Faults can be processed either by MCU software or by an on-board hardware. The action depends on jumper configuration, see Figure 3-3. and Table 1-1 J26, J27, J28, J29.

There are two sources of Fault condition (U6 comparator output high level):

- /FLT_DET0 - fault is triggered whenever the signal level is below limit set by R57
- FLT_DET1 - fault is triggered whenever the signal level is above limit set by R69

The /FLT_DET0 can be used for the DC bus undervoltage fault detection. The FLT_DET1 is designed for the DC bus overcurrent detection.

The jumper J29 selects the source of overcurrent fault. Either the on-board comparator or the power stage overcurrent fault signal, e.g. when using the MC33937A, determine the fault condition.

In fact, there are three options of fault processing, i.e. turning OFF power stage the top and bottom switches:

1. MCU using the /IRQ pin - MCU software is responsible for the power stage switches turn OFF
2. Power Stage Enable pin - when the fault is captured by U8 the RS Flip-Flop, the EN signal goes low. The power stage is responsible for turning OFF the switches.
3. on-board hardware - when the fault is captured by the U8 RS Flip-Flop, the U7 and U9 turn OFF the power stage top and bottom switches.

For configuration, see Table 3-1.

Table 3-1. Fault Jumper Configuration

Fault Action Responsibility	Fault Action Signals	J26	J27	J28
Software	MCU /IRQ pin, low level	Placed, pins 2-3	Unplaced	Unplaced
Power Stage	J34 EN pin, low level	Placed, pins 1-2	Placed, pins 2-3	Unplaced
Controller Board HW	RS Flip-Flop signals	Placed, pins 1-2	Placed, pins 1-2	Placed, pins 1-2

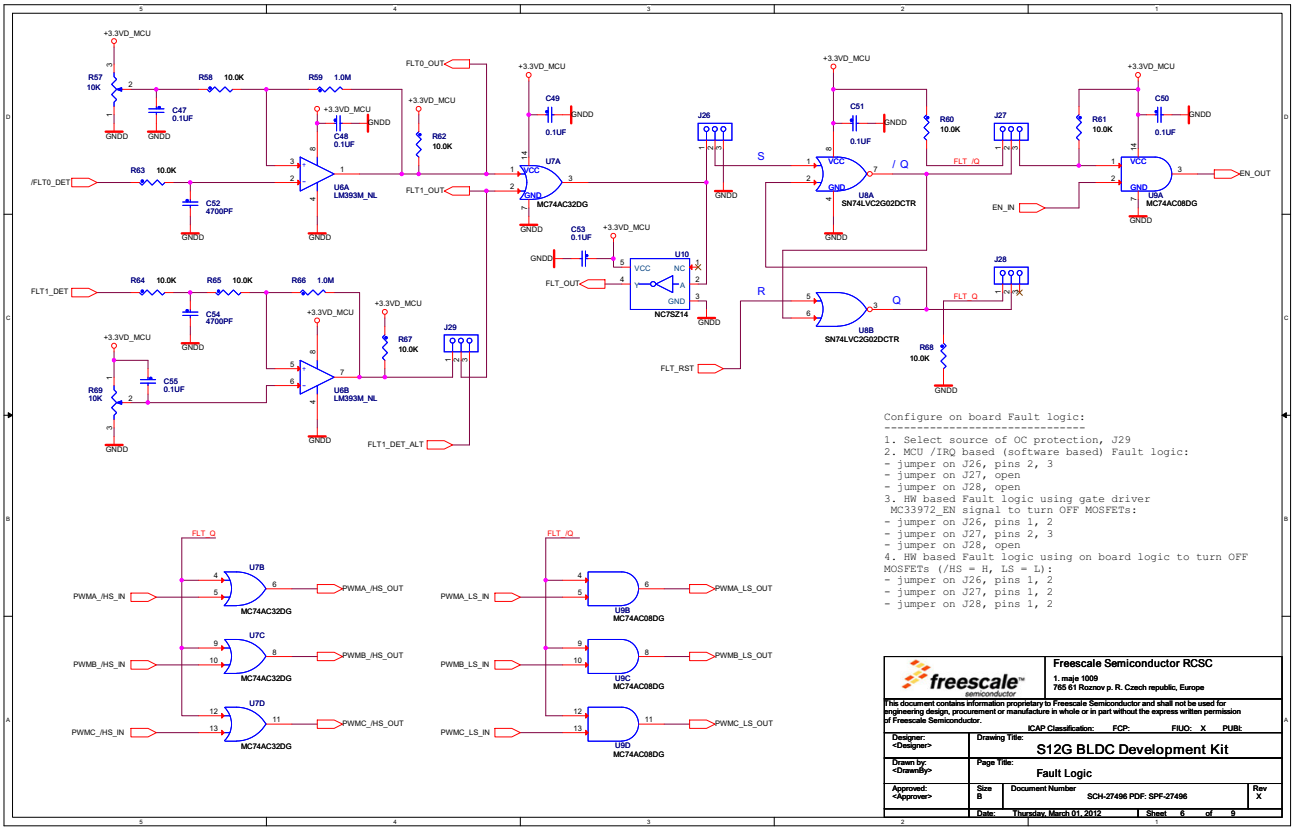


Figure 3-3. Fault Management Hardware

3.4 Hall Sensor Interface

The Hall sensor interface is used for BLDC sensor based motor control applications. The Hall sensors are used to determine the actual motor rotor sector.

The on-board interface provides the 5V power supply voltage to supply the sensors. The Hall interface inputs are designed to support an open collector as well as push-pull Hall sensors outputs (see Figure 3-4). A single pole RC low pass filter is present to reduce a signal noise.

For a detailed JP1 connector signal description, see Table 2-3.

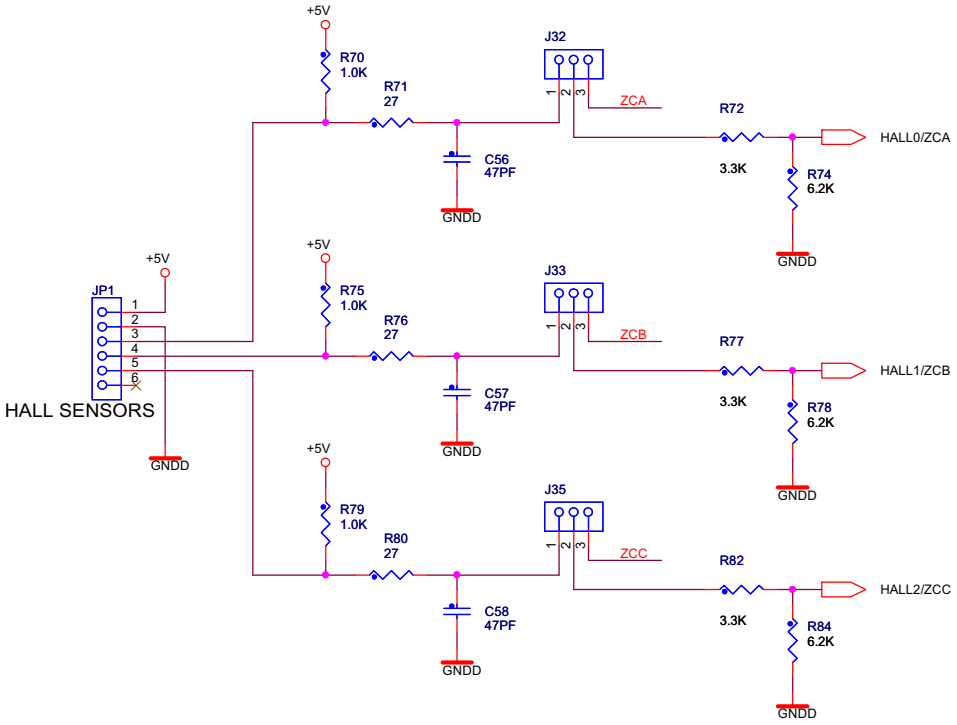


Figure 3-4. Hall Sensor Interface

The Figure 3-5 shows the Hall sensor signal alignment to BLDC motor Back-EMF signal. The Hall sensors detect the rotor flux, so their actual state is not influenced by stator current. The Hall effect outputs in BLDC motors divide the electrical revolution into three equal sections of 120°. In this so-called 120° configuration, the Hall states 111 and 000 never occur.

Based on the Hall sensor signal, the BLDC motor commutation table is developed. An example is shown in Figure 3-6. The right-hand side of the table shows the Hall sensors signal, while the left side applied phase voltage.

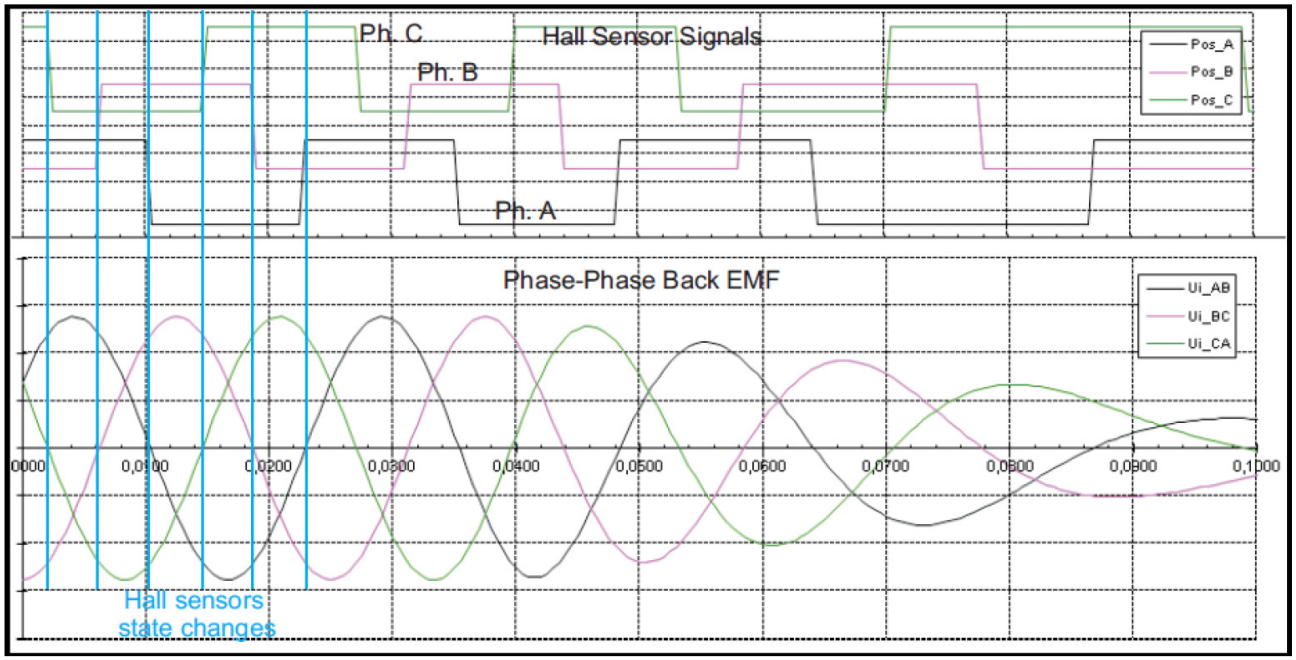


Figure 3-5. BLDC Motor Back-EMF and Hall Sensor Signal Alignment

Commutation vector			Vector	Hall sensor pattern definition			Hall sensor pattern result
Phase A	Phase B	Phase C		Hall Sensor C	Hall Sensor B	Hall Sensor A	
NC	$+V_{DCB}$	$-V_{DCB}$	A	1	0	1	5
$-V_{DCB}$	$+V_{DCB}$	NC	B	1	0	0	4
$-V_{DCB}$	NC	$+V_{DCB}$	C	1	1	0	6
NC	$-V_{DCB}$	$+V_{DCB}$	D	0	1	0	3
$+V_{DCB}$	$-V_{DCB}$	NC	E	0	1	1	2
$+V_{DCB}$	NC	$-V_{DCB}$	F	0	0	1	1

Figure 3-6. BLDC Motor Commutation Table

Chapter 4 Electrical Characteristics

The electrical characteristics in Table 4-1 apply to an operation at 25 °C.

Table 4-1. Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Units
Power supply Voltage	V_{DC}	8	12	18	V
Current consumption(1)	I_{CC}		30		mA
Input Voltage Range	V_{IN}	0	–	3.3	V
Input Voltage Range Hall and MC33937 interface	V_{IN}	0	–	5	V

1—12V power supply, MCU without software

Chapter 5 Board Set-up Guide

The board is designed to be supplied either by the UNI-3 interface or by using the on-board J1 connector, power supply voltage from 8 V to 18 V. When using board as a standalone EVB, connect the power supply to J1. In case of board operation with the power stage, it is recommended to supply board using UNI-3 interface.

The MC9S12G128 Controller Board (blue board) is designed for operation with the FSL MC33937A based 3-Phase low voltage power stage (green board), see Figure 5-1. The complete 3-phase BLDC Sensor/Sensorless Development Kit can be ordered at http://www.freescale.com/AutoMCDevKits.

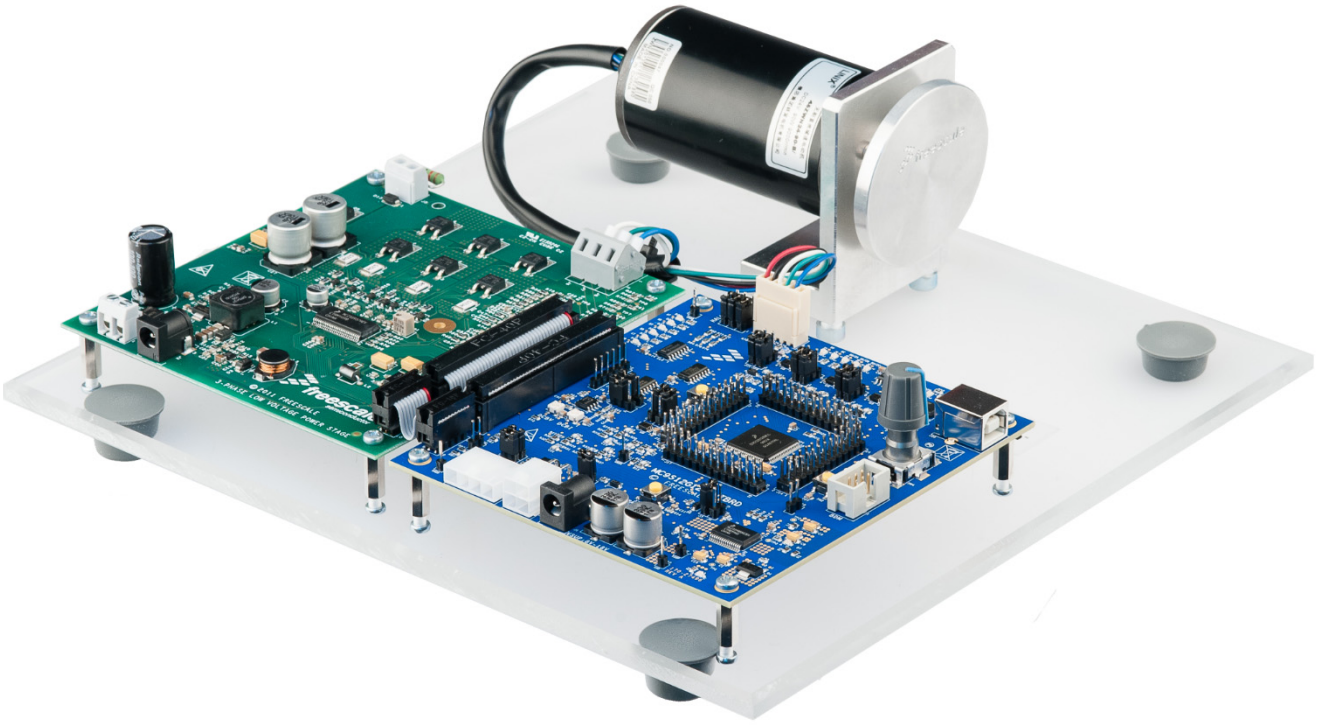


Figure 5-1. 3-Phase BLDC Sensor/Sensorless Development Kit

Chapter 6 References

1. 3-phase Low Voltage Power Stage User Manual, Rev. 0, 31 March 2009, http://www.freescale.com/AutoMCDevKits.
2. MC9S12G Family Reference Manual, MC9S12GRMV1 Rev. 1.06, 8 November 2011

Chapter 7 Acronyms

ADC	Analog to Digital Converter
BEMF	Back Electromotive Force
BLDC	Brushless DC Motor
CAN	Controller Area Network
DT	Dead Time
LIN	Local Interconnect Network
MCU	Microcontroller Unit
PC	Personal Computer
PWM	Pulse Width Modulation
USB	Universal Serial Bus

Chapter 8 MC9S12G128 Controller Board Schematic

Notes:

Sheet 4: Configure BLDC motor BEMF and current sensing.
Sheet 5: Insert Dead time ~2us.
Sheet 6: Configure Fault logic.
Sheet 7: Select either Hall sensor or Zero Cross based sensing.

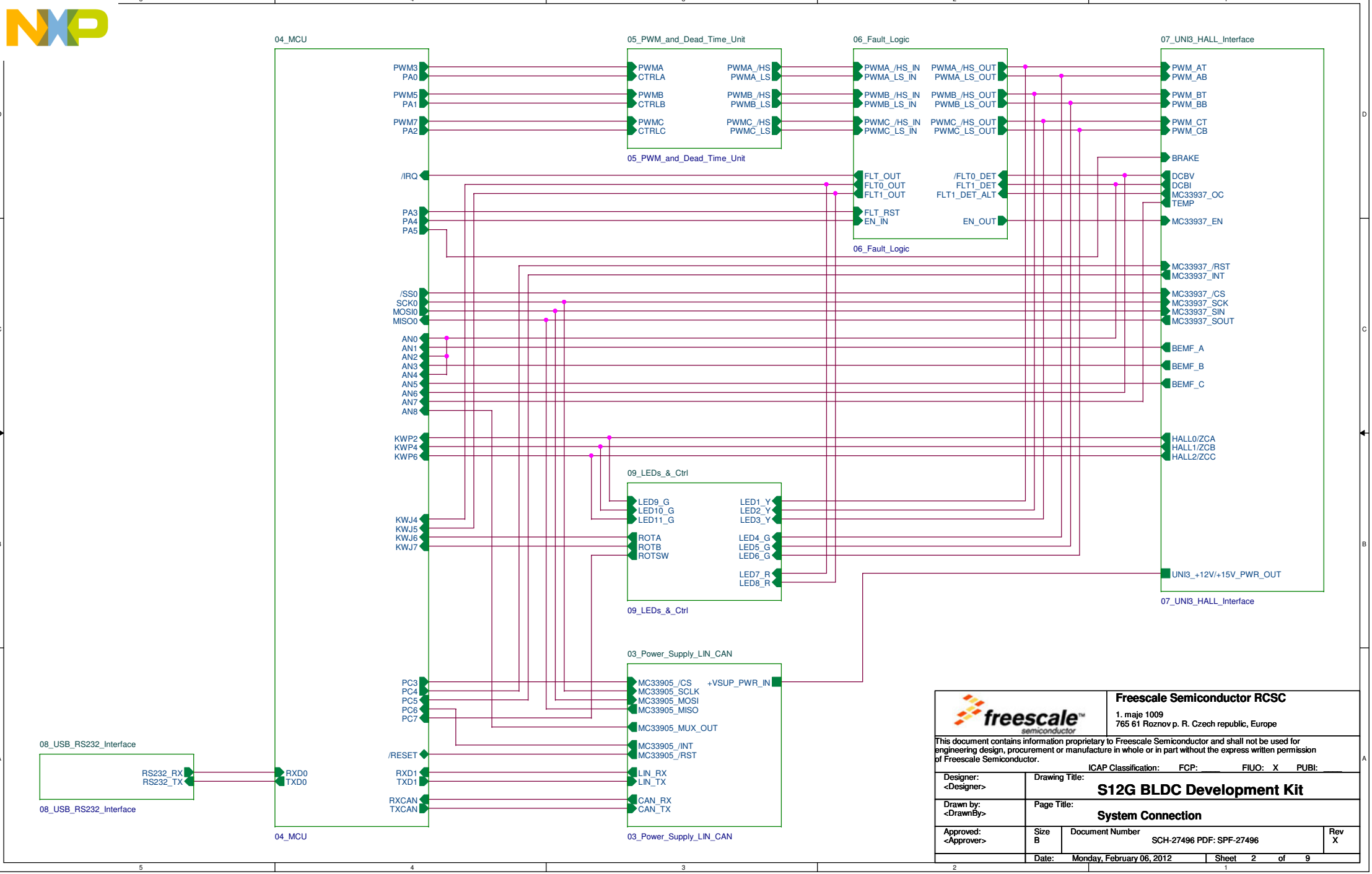
SCHEMATIC REVISIONS

Zone	Rev	Description	Date	Revised
All	0.1	Initial version	11.01.2012	PCh
All	1.0	Release version	13.01.2012	JK, PCh

Freescale Semiconductor RCSC
1. maje 1009
765 61 Roznov p. R. Czech republic, Europe

ICAP Classification: FCP: ____ FIUO: X PUBI: ____

Designer: <Designer>	Drawing Title: S12G BLDC Development Kit
Drawn by: <DrawnBy>	Page Title: Info
Approved: <Approver>	Size B; Document Number SCH-27496 PDF: SPF-27496; Rev X
	Date: Monday, February 06, 2012; Sheet 1 of 9



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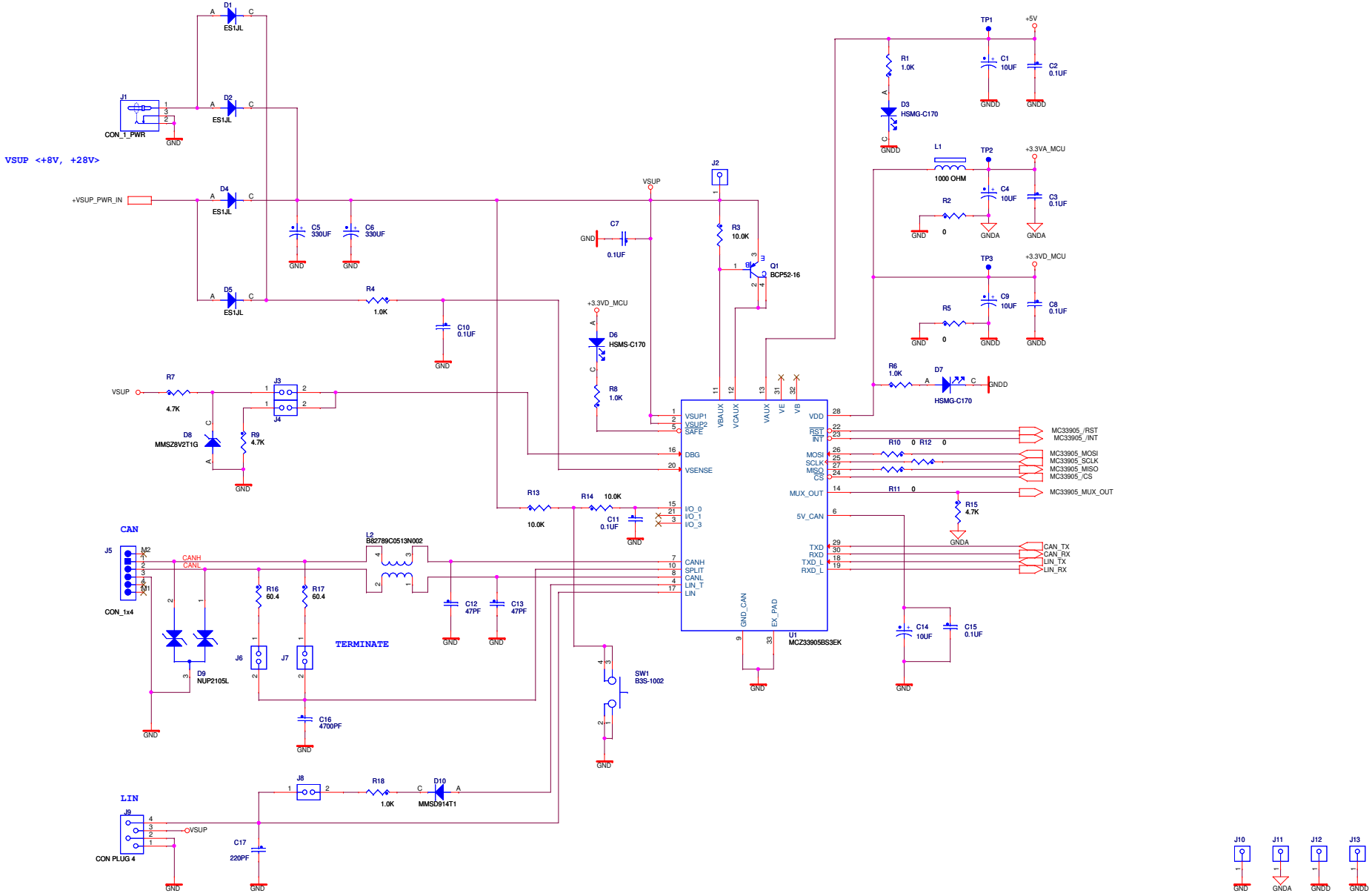

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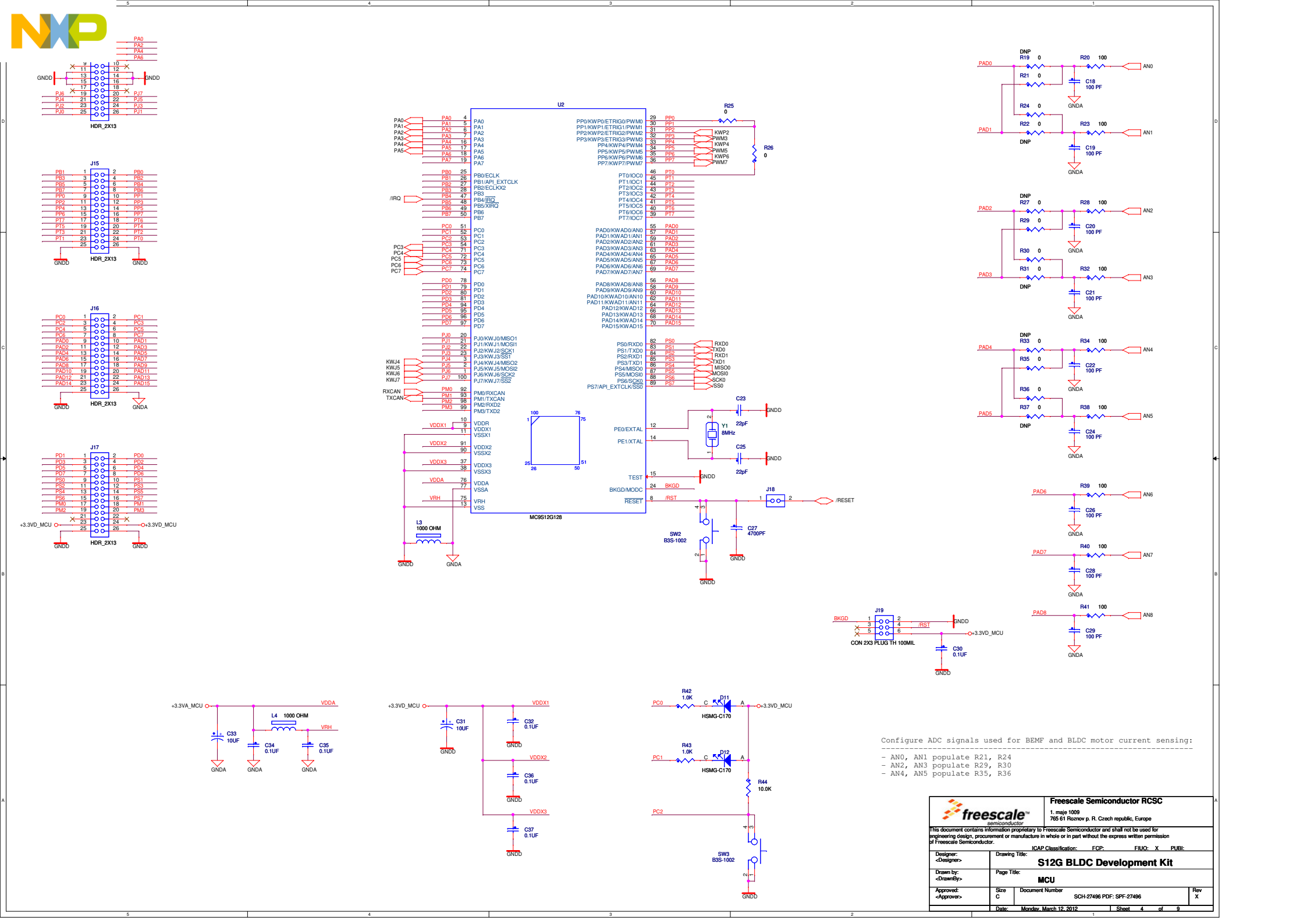

Configure ADC signals used for BEMF and BLDC motor current sensing:

- AN0, AN1 populate R21, R24
- AN2, AN3 populate R29, R30
- AN4, AN5 populate R35, R36

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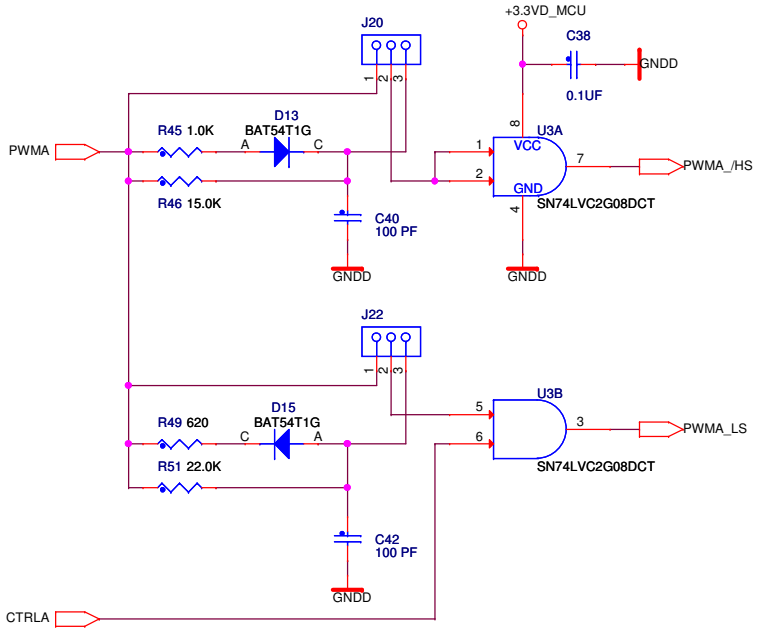
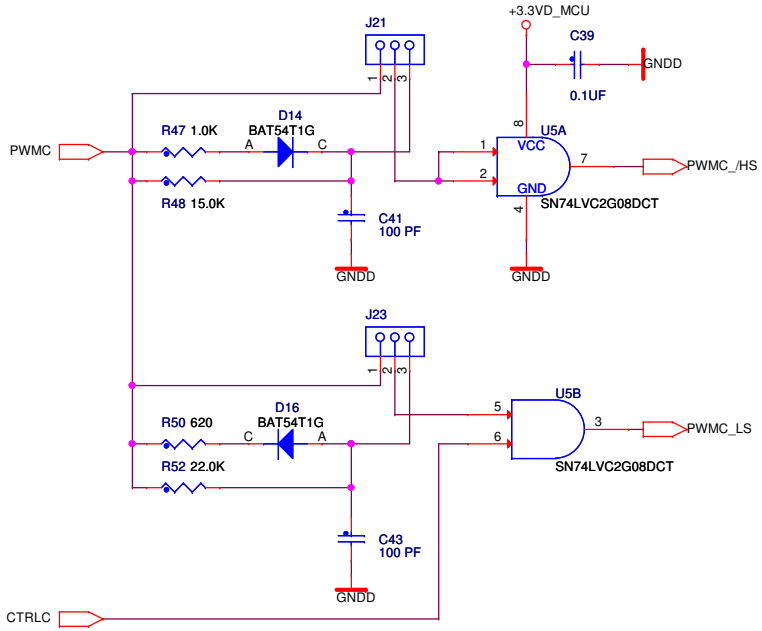
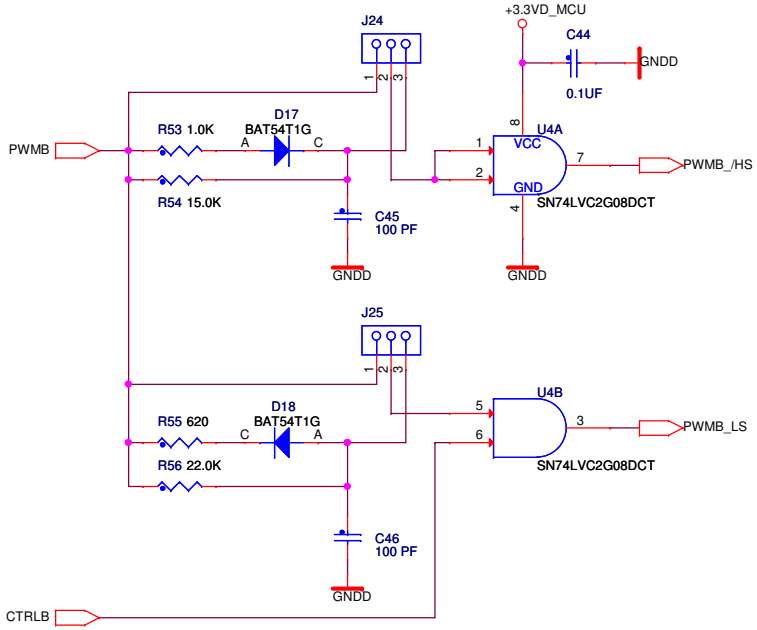
	Date: Monday, March 12, 2012	Sheet 4 of 9	








```
Insert Dead time ~2us:
----------------------
Yes - Place jumper on J2x headers, pins 2,3
No - Place jumper on J2x headers, pins 1,2
```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Drawn by: <DrawnBy>	Page Title: **PWM and Dead Time Unit**	
Approved: <Approver>	Size B / Document Number SCH-27496 PDF: SPF-27496	Rev X
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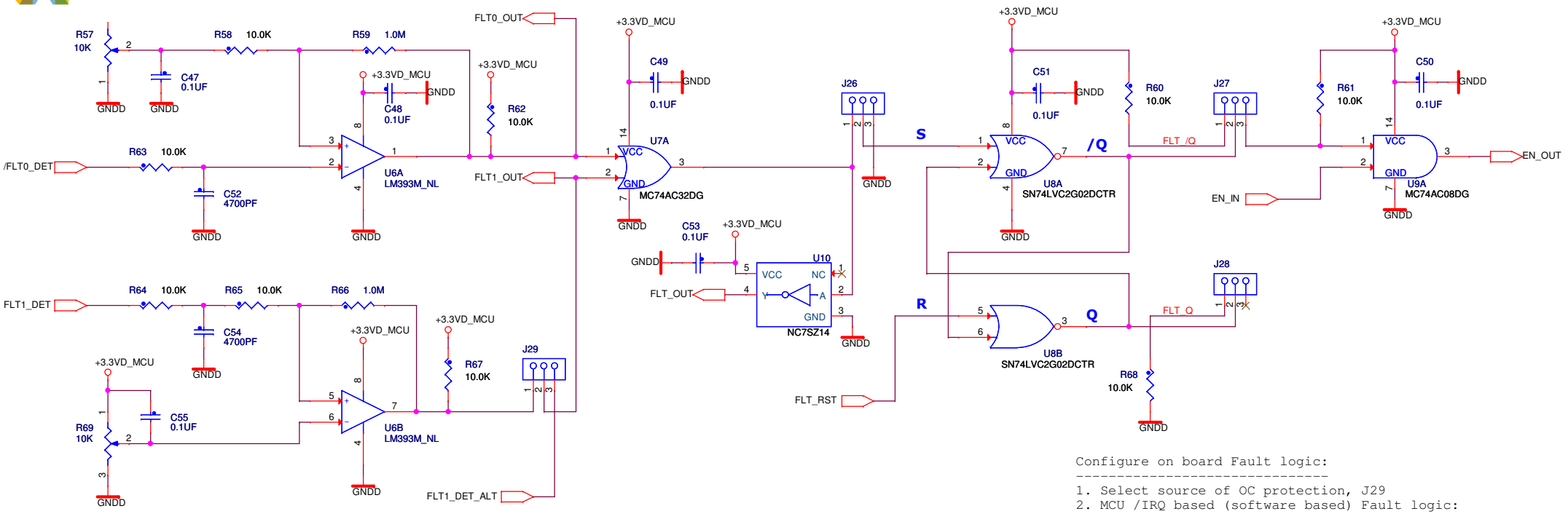

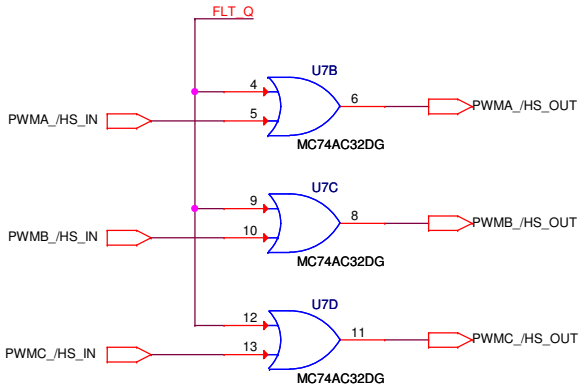

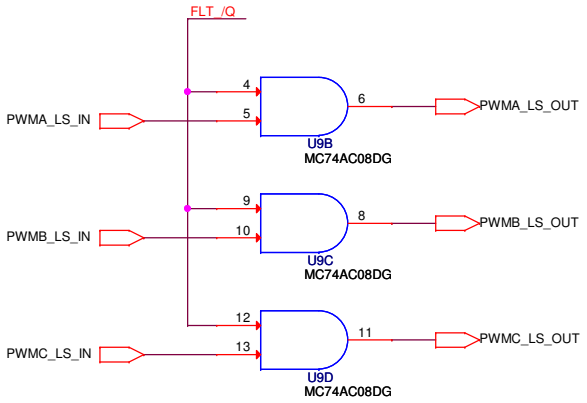


```
Configure on board Fault logic:
-------------------------------
1. Select source of OC protection, J29
2. MCU /IRQ based (software based) Fault logic:
- jumper on J26, pins 2, 3
- jumper on J27, open
- jumper on J28, open
3. HW based Fault logic using gate driver
 MC33972_EN signal to turn OFF MOSFETs:
- jumper on J26, pins 1, 2
- jumper on J27, pins 2, 3
- jumper on J28, open
4. HW based Fault logic using on board logic to turn OFF
 MOSFETs (/HS = H, LS = L):
- jumper on J26, pins 1, 2
- jumper on J27, pins 1, 2
- jumper on J28, pins 1, 2
```


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Drawn by: <DrawnBy>	Page Title: Fault Logic		
Approved: <Approver>	Size B	Document Number SCH-27496 PDF: SPF-27496	Rev X
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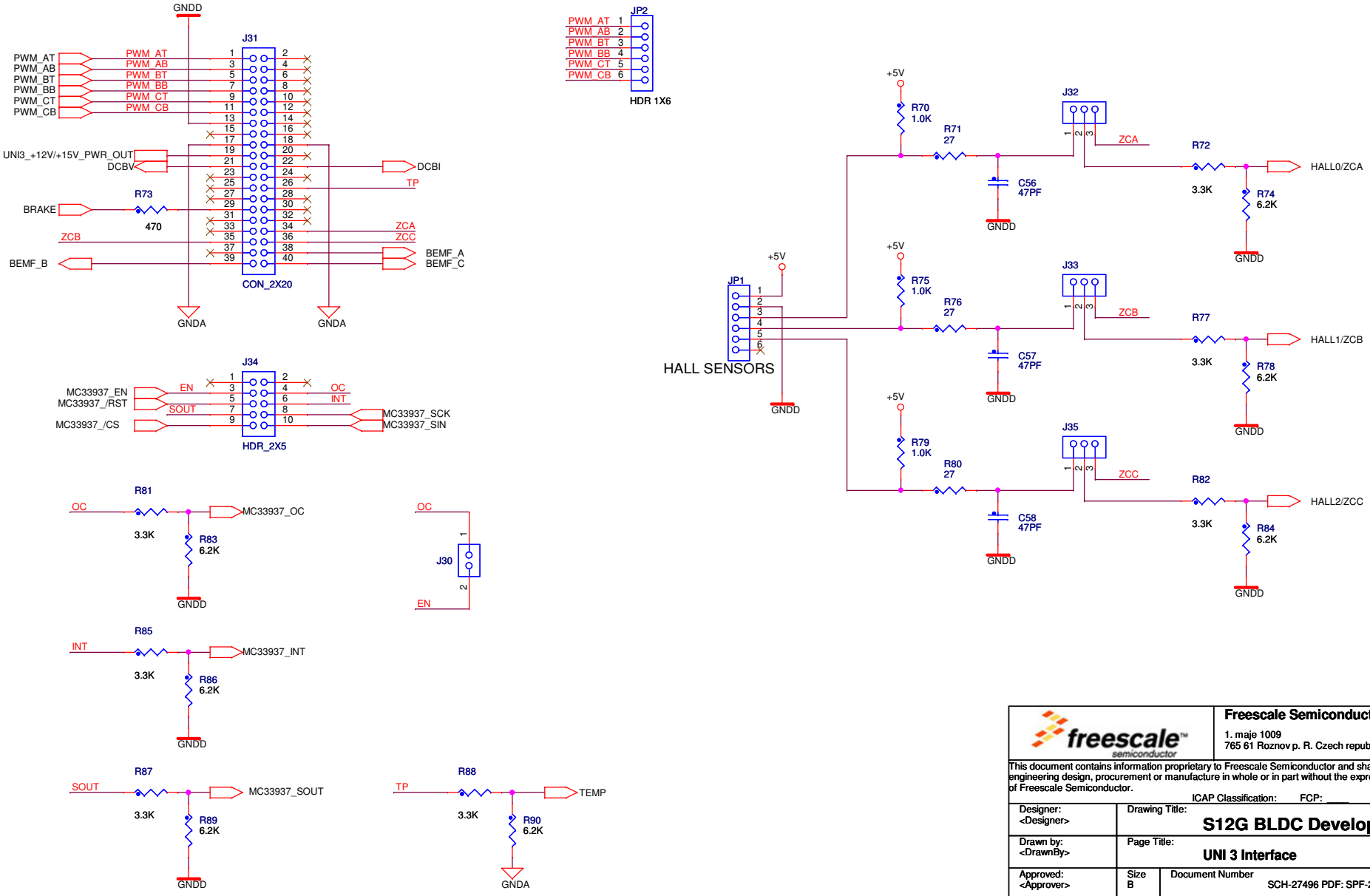

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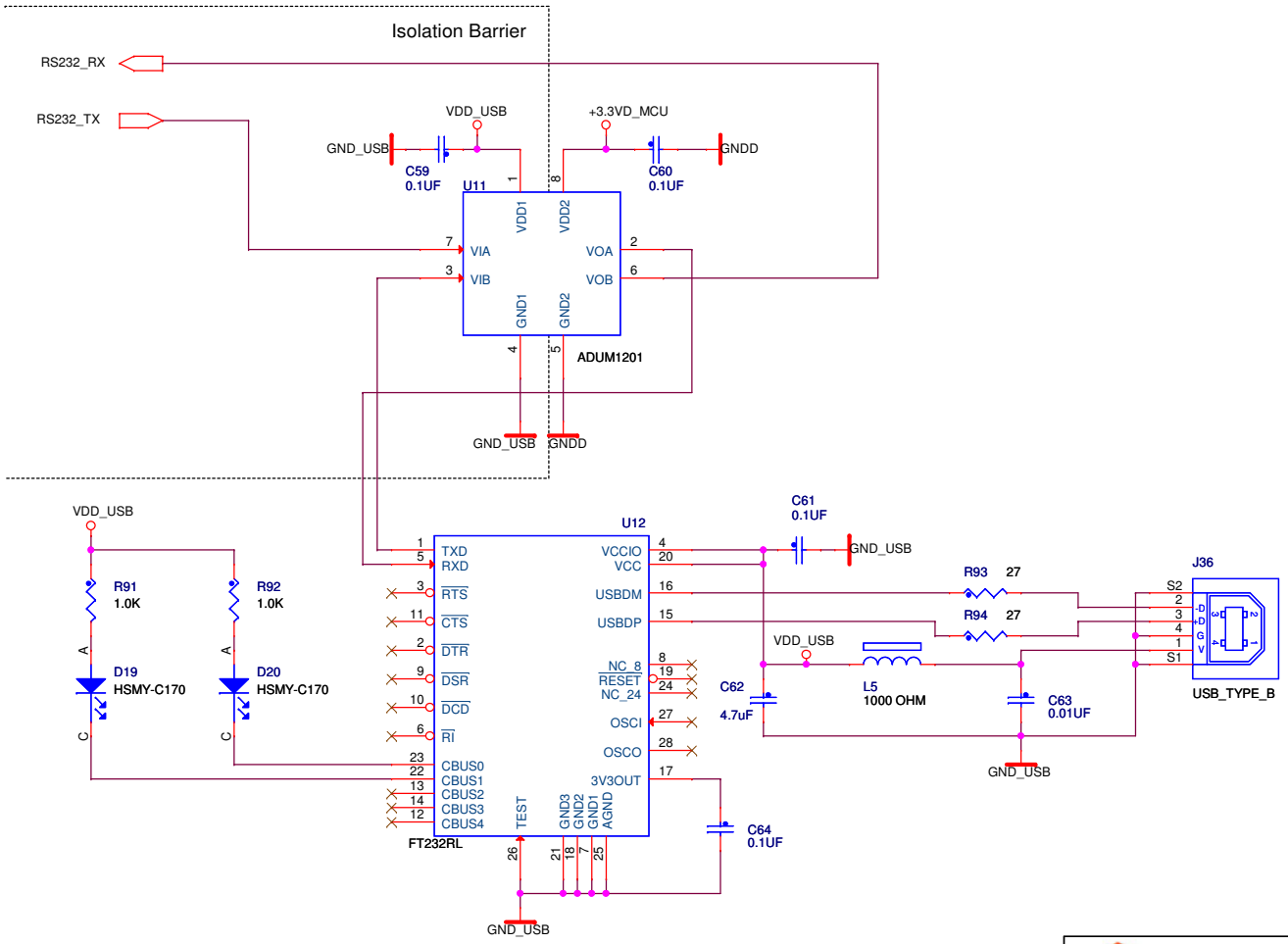
Approved: <Approver>	Size B; Document Number SCH-27496 PDF: SPF-27496; Rev X
	Date: Monday, February 06, 2012; Sheet 7 of 9



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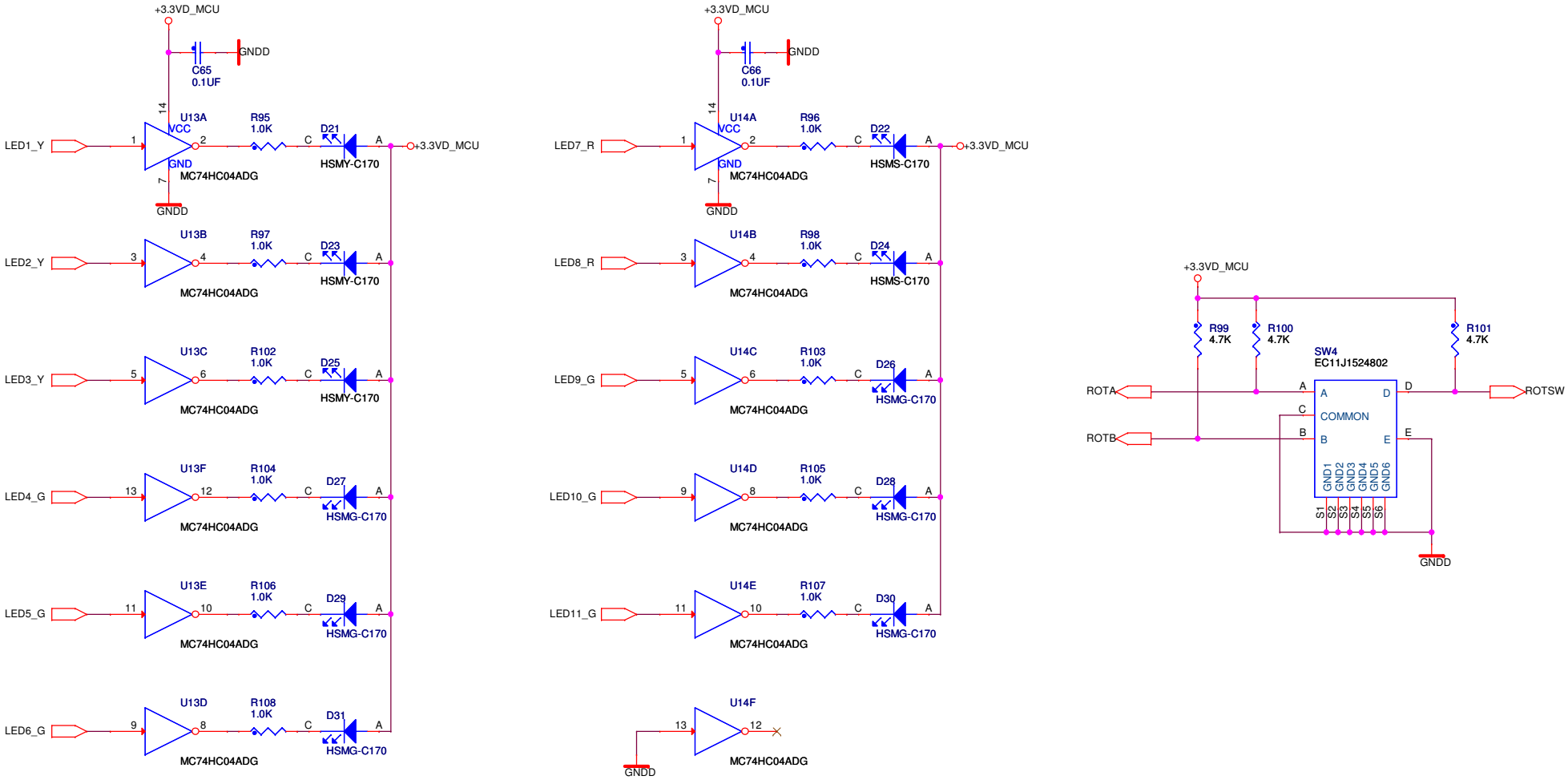

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