Freescale
User's Guide

Document Number:
MPC560XBMCBUG
Rev. 0, 08/2012

MPC560xB Controller Board User's Guide

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1 About This Book

This document describes the design of the MPC560xB Controller Board, which is targeted for rapid development of motor control applications.

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2 Introduction

The MPC560xB Controller Board is designed to drive a 3-phase BLDC motor, enabling implementation of motor control techniques:

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

Contents

The 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.

The MPC560xB Controller Board can be assembled with other members of the MPC560xB microcontroller family. See Table 1 for device compatibility.

Table 1. Device compatibility

Device	Functionality	Package	Note
MPC5604B	With restrictions	144LQFP	missing ADC1
MPC5605B	Complete	144LQFP	
MPC5606B	Complete	144LQFP	default assembled

2.1 Features

The MPC560xB Controller Board features are as follows:

- MPC560xB microcontroller, 144 LQFP package
- JTAG interface for MCU code download and debugging
- System-basis chip MC33905D
- Motor control interface:
  - UNI-3
  - MC33937A predriver
  - Hall sensors
- Connectivity interface:
  - 2 x LIN
  - 2 x CAN
  - USB interface
- LEDs:
  - Power-on indicators
  - Phase A, B, C PWM control signals
  - Phase A, B, C zero-cross
  - Hall sensor outputs
  - Faults monitoring
  - SBC safe mode
  - User application
  - Serial communication
- Controls:
  - Two general-purpose push buttons

— Two general-purpose switches
- Pin headers for MCU peripheral access.
- Power plug 2.1mm connector.

2.2 MPC560xB Board Architecture

The MPC560xB Controller Board contains the basic building blocks are depicted in Figure 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

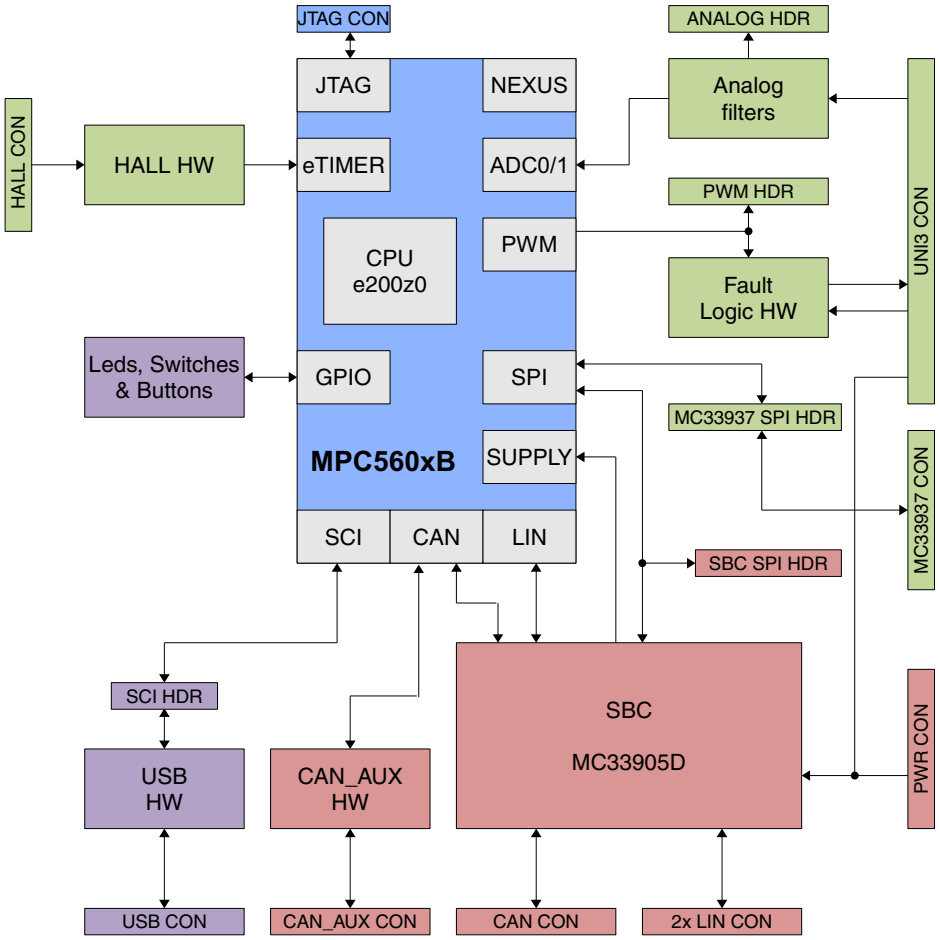


Figure 1. MPC560xB Controller Board Block Diagram

The board is supplied by VBAT voltage in the range of 8V to 18V. The MC33905 provides 5V to the HALL interface. The MCU and on-board logic are supplied by MCU_5V, depending on the assembled SBC version. The board is populated with the 5V SBC version by default.

The MCU generates two PWM signals for each phase. The Fault logic triggers the DC-bus undervoltage and DC-bus overcurrent faults, and forces PWM signals to safe OFF states. For the circuitry behaviour, see Section 4.3, “Board Fault Management.

The user can control the application using the push buttons and switches, USB interface (RS232), CAN and LIN buses.

The JTAG interface is present on-board to enable the download and debugging of MCU code.

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

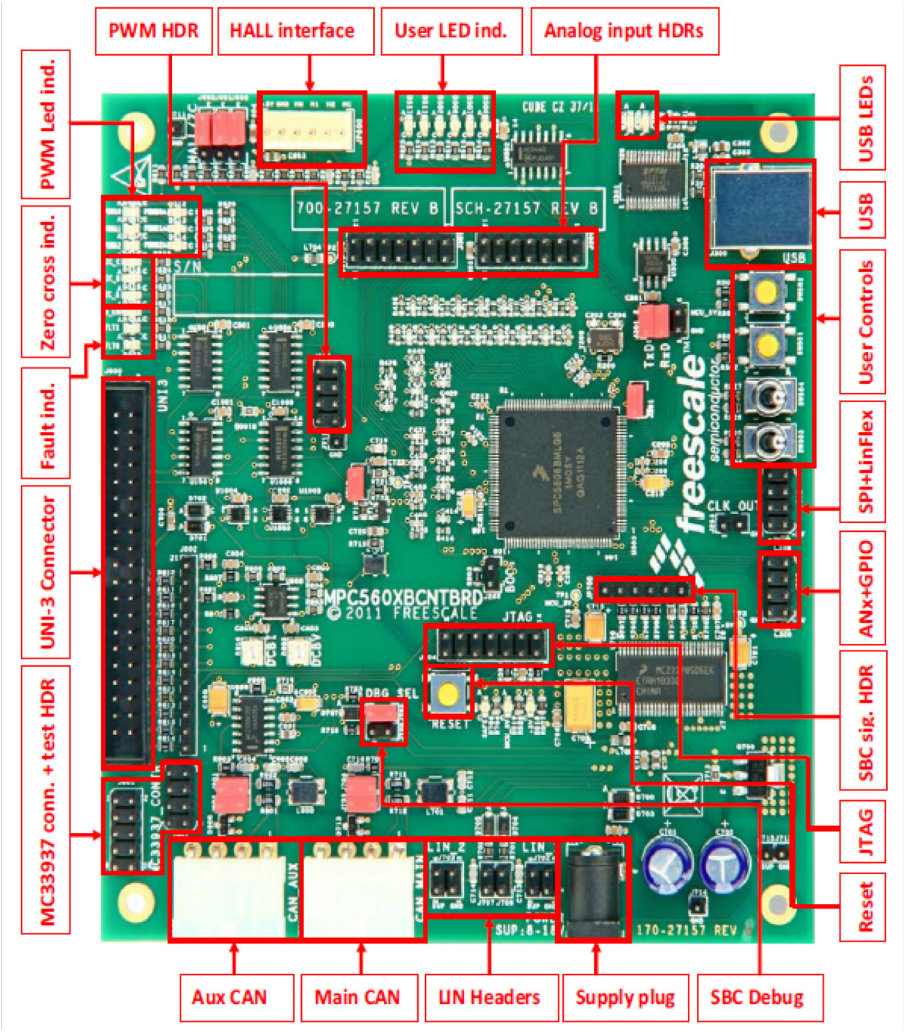


Figure 2. MPC560xB Controller Board Block Location

2.3 Board Jumper Configuration

See Table 2 and Figure 3 for proper jumper configuration.

Table 2. MPC560xB Board Configuration

Jumper	Selector	Function	Connections
J704 J705	MAIN CAN	MAIN CAN bus termination: - 120R, closed (default) - without termination, open	closed
J901 J902	AUX CAN	MAIN CAN bus termination: - 120R, closed (default) - without termination, open	closed
J706	LIN1	LIN_1 master / slave mode selection: - Master, closed - Slave, open (default)	open
J707	LIN2	LIN_2 master / slave mode selection: - Master, closed - Slave, open (default)	open
J708	MC33905D debug mode	Set MC33905D SBC to debug mode: - ON, closed (default) - OFF, open	closed
J709	MC33905D Fail-Safe mode	Set MC33905D SBC to Fail-Safe mode: - ON, closed - OFF, open (default)	open
J710	REF_JMP	Change reference supply voltage for ADCs: - 3.2 V closed (default) - 4.1 V open	closed
J201	EMIOS_JMP	External jumper to interconnect EMIOS0_CH7 and EMIOS1_CH25 signals	closed
J202	BOOT selection	MPC560xB boot from internal Flash.	open
J301	USB	LinFlex6 TxD & RxD connection to opto-isolated USB interface	1–2 closed 3–4 closed
J600	HALL0 / ZCA	HALL_0 input signal is connected to EMIOS0_CH8	1–2 open
		UNI-3 BEMFZCA input signal is connected to EMIOS0_CH8	2–3 closed
J601	HALL1 / ZCB	HALL_1 input signal is connected to EMIOS0_CH9	1–2 open
		UNI-3 BEMFZCB input signal is connected to EMIOS0_CH9	2–3 closed
J602	HALL2 / ZCC	HALL_2 input signal is connected to EMIOS0_CH10	1–2 open
		UNI-3 BEMFZCC input signal is connected to EMIOS0_CH10	2–3 closed
R811	DCBV Voltage	DC-bus Voltage signal from UNI-3 is connected to ADC01_P7	populated
R812	DCBI Current	DC-bus Current signal from UNI-3 is connected to ADC01_P8	populated
R813	BEMFA	UNI-3 Phase A Back-EMF Voltage is connected to ADC01_P4	populated
R814	BEMFB	UNI-3 Phase B Back-EMF Voltage is connected to ADC01_P5	populated
R815	BEMFC	UNI-3 Phase C Back-EMF Voltage is connected to ADC01_P6	populated

Table 2. MPC560xB Board Configuration (continued)

Jumper	Selector	Function	Connections
R816	TEMP	UNI-3 Temperature signal is connected to ADC01_P9	populated
R817	SERIAL	UNI-3 Serial signal is connected to GPIO A[12].	populated
R818	BRAKE	UNI-3 Brake output signal is connected to GPIO A[4].	populated
R819	PFC	UNI-3 PFC signal is connected to EMIOS1_CH0	populated
R820	PFC_EN	UNI-3 PFC Enable signal is connected to GPIO A[13]	populated
R821	PFC_ZC	UNI-3 PFC Zero current signal is connected to EMIOS1_CH1	populated

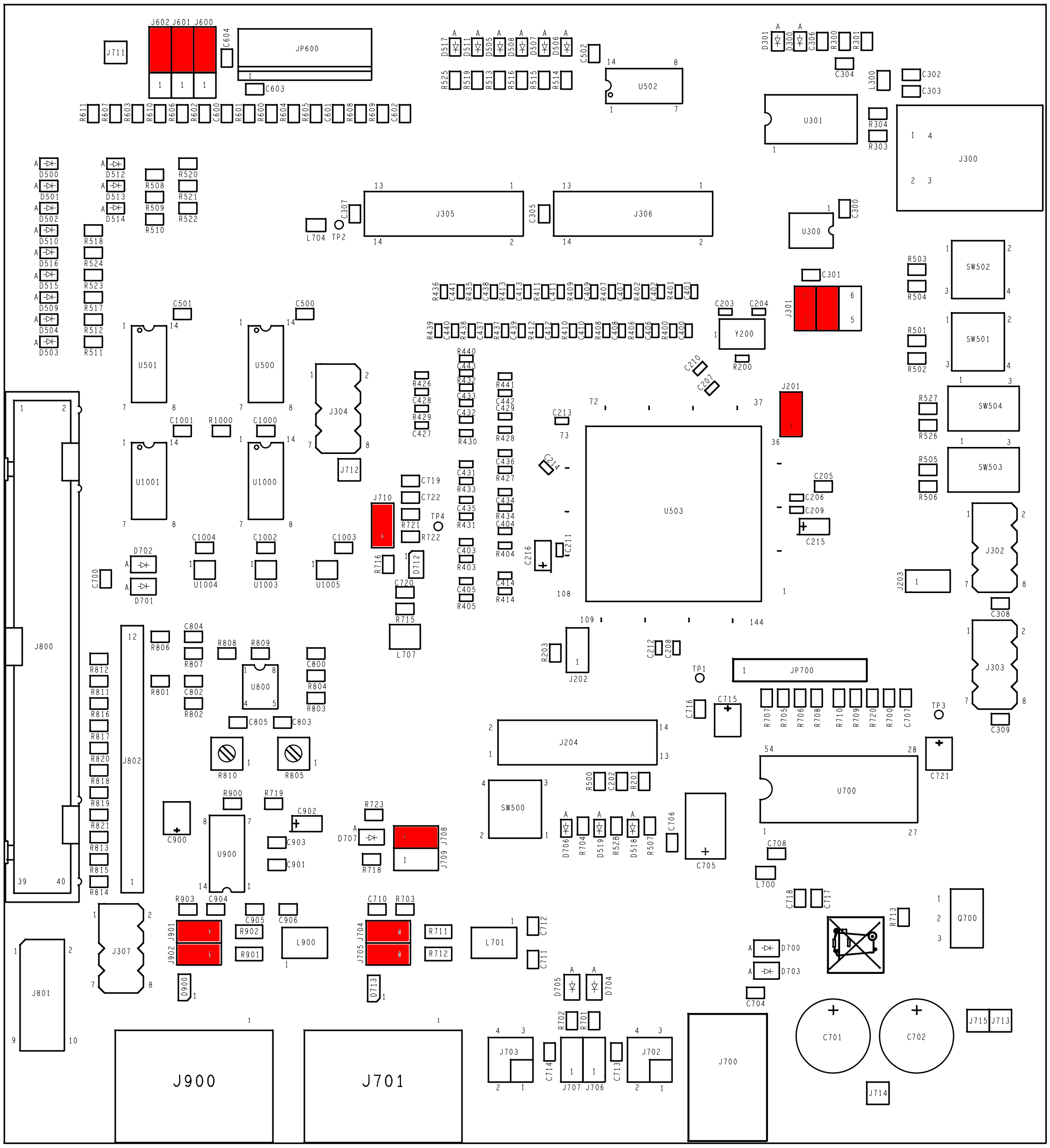


Figure 3. MPC560xB Controller Board Jumper Position and Default Setting

2.4 Board LEDs

The Table 3 displays the on-board LEDs. For on-board LED locations, see Figure 2.

Table 3. On-board LEDs

LED	Signal Name	Description
D518	MCU_5V	+5V MCU and peripheral power supply
D519	+5V	+5V auxiliary power supply
D706	/SAFE	MCZ33905 safe pin state (ON — SBC in safe mode)
D500	PWM0	Phase A0 top switch signal (ON — High Level)
D512	PWM1	Phase B0 bottom switch signal (ON — High Level)
D501	PWM2	Phase A1 top switch signal (ON — High Level)
D513	PWM3	Phase B1 bottom switch signal (ON — High Level)
D502	PWM4	Phase A2 top switch signal (ON — High Level)
D514	PWM5	Phase B2 bottom switch signal (ON — High Level)
D503	FAULT0	DC-bus undervoltage indicator
D504	FAULT1	DC-bus overcurrent indicator
D515	HALL0/ZCA	Hall 0 / Zero-cross Phase A signal (ON — High Level)
D516	HALL1/ZCB	Hall 1 / Zero-cross Phase B signal (ON — High Level)
D510	HALL2/ZCC	Hall 2 / Zero-cross Phase C signal (ON — High Level)
D509	G_ERR	General error indicator (ON — High Level)
D506	PB[0]	User LED 1 (ON — High Level)
D507	PC[10]	User LED 2 (ON — High Level)
D508	PC[11]	User LED 3 (ON — High Level)
D511	PF[9]	User LED 4 (ON — High Level)
D517	PF[8]	User LED 5 (ON — High Level)
D505	PB[1]	User LED 6 (ON — High Level)
D300	CBUS1	USB transmit data indicator
D301	CBUS0	USB receive data indicator

3 Interface Description

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

3.1 Power Supply J700

The MPC560xB Controller Board can be supplied either by using the 2.1 mm DC power plug J700 or the UNI-3 connector (J800, pin 19).

The controller board provides 5V for a Hall interface and 5V for on-board logic. Both voltages are generated by the MC33905D SBC. Proper operation is monitored by LEDs D518, for the supply voltage +5VDC & +5VA, and D519, for the supply voltage 5V_MCU, see Table 3.

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

3.2 UNI3 Interface J800

The Unified Interface Version 3 (UNI-3) defines the interface between the MPC560xB Motor Controller Board and the BLDC motor power stage.

The list of UNI-3 signals 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 4 defines the UNI-3 pin-out and pin assignment to the MCU.

Table 4. UNI-3 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	PWM0	EMIOS0_CH[1]	Phase A top switch control (H -> Turn OFF)	Digital output
3	PWM1	EMIOS0_CH[2]	Phase A bottom switch control (H -> Turn ON)	Digital output
5	PWM2	EMIOS0_CH[3]	Phase B top switch control (H -> Turn OFF)	Digital output
7	PWM3	EMIOS0_CH[4]	Phase B bottom switch control (H -> Turn ON)	Digital output
9	PWM4	EMIOS0_CH[5]	Phase C top switch control (H -> Turn OFF)	Digital output
11	PWM5	EMIOS0_CH[6]	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	—	Analogue power supply ground	—
19	+12/+15V DC	—	Analogue power supply	—
16,20, 23,24,25, 27, 28,37	NC	—	Not connected	—

Table 4. UNI-3 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
21	V_{DCBUS}	ADC0/1_P[7]	DC-bus voltage sensing, 0V – 3.3V	Analog input
22	I_{DCBUS}	ADC0/1_P[8]	DC-bus current sensing, 0V – 3.3V	Analog input
26	TEMP	ADC0/1_P[9]	Analogue temperature 0V – 3.3V	Analog input
29	BRAKE_CONT	PA[4]	DC-bus brake control	Digital output
30	SERIAL	PA[12]	Serial interface	Digital bidirectional
31	PFC	EMIOS1_CH[0]	Power factor correction PWM	Digital output
32	PFCEN	PA[13]	Power factor correction enable	Digital output
33	PFCZC	EMIOS1_CH[1]	Power factor correction zero-cross	Digital input
34	ZCA	EMIOS0_CH[12]	Phase A Back-EMF zero-cross	Digital input
35	ZCB	EMIOS0_CH[14]	Phase B Back-EMF zero-cross	Digital input
36	ZCC	EMIOS0_CH[15]	Phase C Back-EMF zero-cross	Digital input
38	Back-EMF_A	ADC0/1_P[4]	Phase A Back-EMF voltage sensing	Analog input
39	Back-EMF_B	ADC0/1_P[5]	Phase B Back-EMF voltage sensing	Analog input
40	Back-EMF_C	ADC0/1_P[6]	Phase C Back-EMF voltage sensing	Analog input

3.3 MC33937A Interface J801

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 5.

Table 5. MC33937A Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	NC	—	Not connected.	—
2	NC	—	Not connected	—
3	MC33937_EN	PA[14]	Device enable	Digital output
4	MC33937_OC	PF[11]	Overcurrent	Digital input
5	MC33937_/RST	PF[10]	Reset	Digital output
6	MC33937_INT	PF[13]	Interrupt	Digital input
7	MC33937_SOUT	DSPI[4]_SIN	SPI Input data	Digital input
8	MC33937_SCK	DSPI[4]_SCLK	SPI clock	Digital output
9	MC33937_CS	DSPI[4]_CS0	Chip-select	Digital output
10	MC33937_SIN	DSPI[4]_SOUT	SPI output data	Digital output

3.4 Hall Sensor Interface JP600

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 JP600 following the instructions in Table 6, and watch the signal levels on the on-board LEDs as in Table 2, Table 3.

Table 6. Hall Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	+5Vdc	—	+5V sensor supply voltage	—
2	GND	—	Ground	—
3	HALL0	EMIOS0_CH[12]	HALL0 sensor output	Digital input
4	HALL1	EMIOS0_CH[14]	HALL1 sensor output	Digital input
5	HALL2	EMIOS0_CH[15]	HALL 2 sensor output	Digital input
6	NC	—	Not connected	—

3.5 LIN Bus Connectors J702 & J703

The system basis chip MC33905D 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 2.

Table 7 and Table 8 show the LIN connector's pin-out and pin assignment to the MCU.

Table 7. LIN_1 J702 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	GND	—	Ground	—
2	VSUP	—	Power Supply	—
3	GND	—	Ground	—
4	LIN	LIN[4]RX LIN[4]TX	LIN bus	Digital bidirectional

Table 8. LIN_2 J703 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	GND	—	Ground	—
2	VSUP	—	Power Supply	—
3	GND	—	Ground	—
4	LIN	LIN[0]RX LIN[0]TX	LIN bus	Digital bidirectional

3.6 MainCAN and AuxCAN connectors J701 & J900

The system basis chip MC33905D CAN transceiver is used as the main CAN hardware interface. The on-board jumpers J704, J705 enable node termination, with impedance of 120R, see Table 2.

An auxiliary CAN interface is provided by the MC33902 transceiver. The on-board jumpers J900, J901 enable node termination, with impedance of 120R, see Table 2.

Table 9 and Table 10 show the CAN connector's pin-out and pin assignment to the MCU.

Table 9. MainCAN J701 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	CANH	CAN[4]RX CAN[4]TX	CAN bus H	Differential bidirectional
2	CANL	CAN[4]RX CAN[4]TX	CAN bus L	Differential bidirectional
3	GND	—	Ground	—
4	NC	—	Not connected	—

Table 10. AuxCAN J900 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	CANH	CAN[1]RX CAN[1]TX	CAN bus H	Differential bidirectional
2	CANL	CAN[1]RX CAN[1]TX	CAN bus L	Differential bidirectional
3	GND	—	Ground	—
4	NC	—	Not connected	—

3.7 USB Connectivity J300 & J301

The USB line is used for board communication with the PC, when using for example, the Freescale FreeMASTER tool [3] to control the user application. The interface uses a B-type connector and it is isolated from the board environment. See Table 11 for the pin description and pin assignment to the MCU.

Header J301 enables USB communication or can be used for LINFlex_6 signals and power supply pins access. For more details see Table 12.

Table 11. J300 USB Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	VBUS	—	USB Power Supply	—
2	D-	LIN[6]RX LIN[6]TX	Data –	Digital bidirectional

Interface Pin	Signal Name	MCU Signal	Description	Direction
3	D+	LIN[6]RX LIN[6]TX	Data +	Digital bidirectional
4	GND_USB	—	USB Ground	—

Table 12. J301 USB communication enable

Header pins	Jumper settings	Description
1+2	On (default) Off	Enable SCI transmit Disable SCI transmit
3+4	On (default) Off	Enable SCI receive Disable SCI receive
5	GND	Power Supply Ground
6	MCU_5V	Power Supply MCU_5V

NOTE

Pay attention to not short out pins 5 and 6.

3.8 Header J302

The connectivity expansion header J302 contains the LINFlex_7 and DSPI_3 signals, see Table 13.

Table 13. J302 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	HDR_LINFL_RX	LIN[7]_RX	LINFlex Receive Data	Digital input
2	HDR_LINFL_TX	LIN[7]_TX	LINFlex Transmit Data	Digital output
3	HDR_SPI_CS0	DSPI[3]_CS0	Serial Peripheral Interface Chip Select	Digital output
4	HDR_SPI_SOUT	DSPI[3]_SOUT	Serial Peripheral Interface Output	Digital output
5	HDR_SPI_SIN	DSPI[3]_SIN	Serial Peripheral Interface Input	Digital input
6	HDR_SPI_SCK	DSPI[3]_SCK	Serial Peripheral Interface Clock	Digital output
7	GND	—	Ground	
8	+5VDC	—	+5V Digital Power Supply	

3.9 Header J303

Header J303 is primarily dedicated to connecting the external analogue multiplexer hardware which allows expansion of up to 8 additional ADC channels. For multiplexer channels decoding, MA[x] signals are used. Multiplexed channels are connected to the ADC0_X[3] input. In other cases, the header J303 pins can be used as general purpose I/O. See a detailed description in Table 14.

Table 14. J303 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	HRD_PH[8]_MA0	PH[8]/MA[0]	General purpose pin / External MPX channel decoder	Digital I/O
2	HRD_PH[7]_MA1	PH[7]/MA[1]	General purpose pin / External MPX channel decoder	Digital I/O
3	HRD_PH[6]_MA2	PH[6]/MA[2]	General purpose pin / External MPX channel decoder	Digital I/O
4	HRD_PH[5]	PH[5]	General purpose pin	Digital I/O
5	HRD_PH[4]	PH[4]	General purpose pin	Digital I/O
6	HRD_ANX[3]	PB[15]/ADC0_X[3]	Externally multiplexed analogue input	IO / Analog input
7	GND	—	Ground	
8	+5VDC	—	+5V Digital Power Supply	

3.10 Header J304

Monitoring the PWM signal and FAULT signal is possible using J304. The Table 15 summarizes the header pin-out.

Table 15. J304 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	PWM_AT	EMIOS0_CH[1]	Phase A top switch control	Digital output
2	PWM_AB	EMIOS0_CH[2]	Phase A bottom switch control	Digital output
3	PWM_BT	EMIOS0_CH[3]	Phase B top switch control	Digital output
4	PWM_BB	EMIOS0_CH[4]	Phase B bottom switch control	Digital output
5	PWM_CT	EMIOS0_CH[5]	Phase C top switch control	Digital output
6	PWM_CB	EMIOS0_CH[6]	Phase C bottom switch control	Digital output
7	FAULT0	EIRQ[18]	DC-bus Voltage fault signal	Digital input
8	FAULT1	EIRQ[7]	BC-bus Current fault signal	Digital input

3.11 Headers J305 & J306 Analog Inputs

The MPC560xB includes 2 ADC modules, ADC_0 with 10-bit resolution and ADC_1 with 12-bit resolution with 0 ÷ Vref common mode conversion range, see Section 4.2, “Power Supplies and Voltage Reference.” Both ADCs are supplied from the voltage reference.

- Internally multiplexed channels
  - 16 precision channels shared between 10-bit and 12-bit ADCs
  - 3 standard channels shared between 10-bit and 12-bit ADCs
  - 5 dedicated standard channels on 12-bit ADC
  - Up to 29 dedicated standard channels on 10-bit ADC

- Externally multiplexed channels
  - Internal control to support generation of external analogue multiplexer selection
  - 4 internal channels optionally used to support externally multiplexed inputs, providing transparent control for additional ADC channels
  - Each of the 4 channels supports as many as 8 externally multiplexed inputs (ANX3 available on the controller board only)

External analogue signals can be connected through headers J305, J306, see Table 16 and Table 17.

Table 16. J305 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	AN0_S	PA[14]	Standard channel (ADC0/ADC1)	Analog input
2	AN1_S	PF[10]	Standard channel (ADC0/ADC1)	Analog input
3	AN2_S	PF[11]	Standard channel (ADC0/ADC1)	Analog input
4	AN3_P	PF[13]	Precision channel (ADC0/ADC1)	Analog input
5	AN4_P	DSPI[4]_SCK	Precision channel (ADC0/ADC1)	Analog input
6	AN5_P	DSPI[4]_SIN	Precision channel (ADC0/ADC1)	Analog input
7	AN6_P	DSPI[4]_SOUT	Precision channel (ADC0/ADC1)	Analog input
8	AN7_P	DSPI[4]_CS	Precision channel (ADC0/ADC1)	Analog input
9	AN8_P		Precision channel (ADC0/ADC1)	Analog input
10	AN9_P		Precision channel (ADC0/ADC1)	Analog input
11	AN10_P		Precision channel (ADC0/ADC1)	Analog input
12	AN11_P		Precision channel (ADC0/ADC1)	Analog input
13	GNDA		Ground	–
14	+5VA		+5V analog supply voltage	–

Table 17. J306 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	ANA0	PA[14]	Standard channel (ADC0)	Analog input
2	ANA1	PF[10]	Standard channel (ADC0)	Analog input
3	ANA2	PF[11]	Standard channel (ADC0)	Analog input
4	ANA3	PF[13]	Standard channel (ADC0)	Analog input
5	ANA4	DSPI[4]_SCK	Standard channel (ADC0)	Analog input
6	ANA5	DSPI[4]_SIN	Standard channel (ADC0)	Analog input
7	ANA6	DSPI[4]_SOUT	Standard channel (ADC0)	Analog input
8	ANA7	DSPI[4]_CS	Standard channel (ADC0)	Analog input
9	ANA8		Standard channel (ADC0)	Analog input

Interface Pin	Signal Name	MCU Signal	Description	Direction
10	ANA9		Standard channel (ADC0)	Analog input
11	ANA10		Standard channel (ADC0)	Analog input
12	NC		Not connected	Analog input
13	GNDA		Ground	–
14	+5VA		+5V analogue supply voltage	–

3.12 Header J307

Header J307 allows control signals monitoring of the MC33937A, see Table 18.

Table 18. J307 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	MC33937_EN	PA[14]	MC33937 Device Enable	Digital output
2	MC33937_/RST	PF[10]	MC33937 Device Reset	Digital output
3	MC33937_OC	PF[11]	MC33937 Overcurrent indication	Digital input
4	MC33937_INT	PF[13]	MC33937 Interrupt	Digital input
5	MC33937_SCK	DSPI[4]_SCK	MC33937 Serial Peripheral Interface Clock	Digital output
6	MC33937_SIN	DSPI[4]_SIN	MC33937 Serial Peripheral Interface Input	Digital output
7	MC33937_SOUT	DSPI[4]_SOUT	MC33937 Serial Peripheral Interface Output	Digital input
8	MC33937_CS	DSPI[4]_CS	MC33937 Serial Peripheral Interface Chip Select	Digital output

3.13 Header J802

Header J802 is usable for external measurement and monitoring of UNI3 signals, important for the motor control application, see Table 19.

Table 19. J802 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	BEMFB	—	Phase B Back-EMF voltage	
2	BEMFC	—	Phase C Back-EMF voltage	
3	BEMFA	—	Phase A Back-EMF voltage	
4	PFCZC	—	Power factor correction Zero-cross	
5	PFC	—	Power factor correction PWM	
6	BRAKE	—	DC-bus brake control signal	
7	PFCEN	—	Power factor correction enable signal	
8	SERIAL	—	Serial interface	
9	TEMP	—	MC33937A Temperature	

Interface Pin	Signal Name	MCU Signal	Description	Direction
10	DCBV	—	DC-bus voltage	
	DCBI	—	DB-bus current	
	GND	—	Ground	

4 Design Consideration

This chapter provides additional information on the functional blocks of the MPC560xB Motor controller board.

4.1 MPC560xB Features

The Qorivva MPC560xB family of 32-bit microcontrollers is the latest achievement in integrated automotive body application controllers. It belongs to an expanding family of automotive-focused products designed to address the next wave of body electronics applications within the vehicle. The advanced and cost-efficient host processor core of the MPC560xB automotive controller family complies with the Power Architecture embedded category. It operates at speeds of up to 64 MHz and offers high performance processing optimized for low power consumption.

The availability of up to two Enhanced Modular Input/Output Subsystem modules (eMIOS) with enhanced timer capabilities, up to two Analogue-to-Digital Converters (ADC) modules, and a Cross Triggering Unit (CTU) makes the MPC560xB microcontrollers suitable for BLDC motor control applications.

Table 20. Supported MPC560xB device comparison(144 LQFP package)

Feature	Device		
	MPC5604B	MPC5605B	MPC5606B
CPU	e200z0h		
Execution speed	Up to 64MHz		
Code Flash	512 KB	768 KB	1 MB
Data Flash	64 KB		
RAM	48 KB	64 KB	80 KB
eMIOS_0	28 ch, 16-bit	32 ch, 16-bit	
eMIOS_1	28 ch, 16-bit	32 ch, 16-bit	
ADC_0	36 ch, 10-bit	15 ch, 19 ch shared, 10-bit	15 ch, 19 ch shared, 10-bit
ADC_1	No	5 ch, 19 ch shared, 12-bit	5 ch, 19 ch shared, 12-bit
CTU	Yes		
eDMA	No	16 channel	
SCI (LINFlex)	4	6	

Table 20. Supported MPC560xB device comparison(144 LQFP package)

Feature	Device		
	MPC5604B	MPC5605B	MPC5606B
SPI (DSPI)	3	5	
IIC	1		
CAN (FlexCAN)	6		
Debug	JTAG		

The device block diagram is shown in Figure 4. A detailed description of the MCU can be found in the datasheet or reference manual.

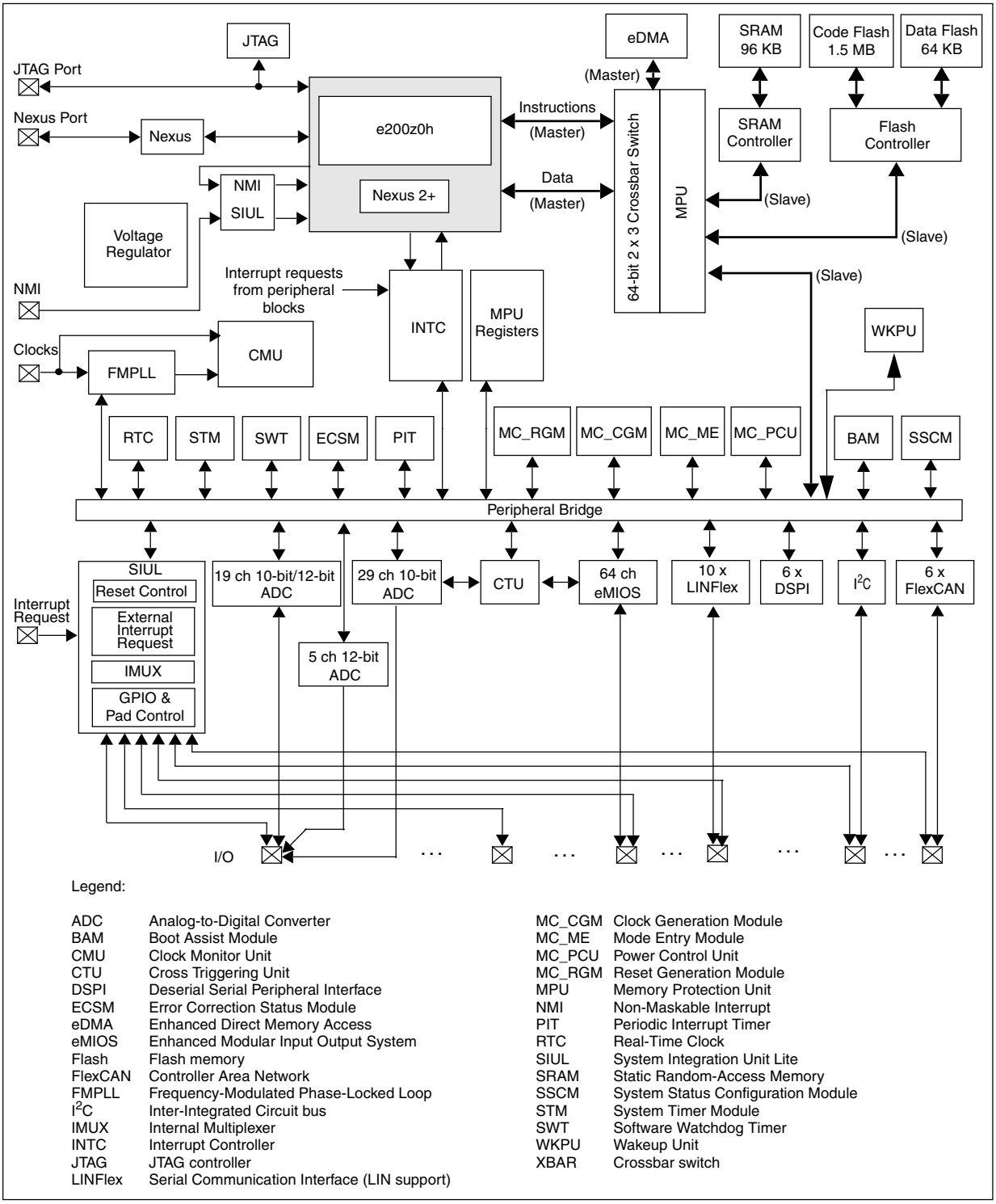


Figure 4. MPC5607B Family Block Diagram

4.2 Power Supplies and Voltage Reference

The MPC560xB Controller Board can be supplied from two main power supply inputs. The first one uses a 2.1 mm DC power plug and the second one uses the UNI-3 connector. Which one is more suitable depends on the application type. The controller board provides a +5V DC-voltage regulation for the HALL sensor interface, LED indicators and a fault logic circuit, MCU_5V for MCU + supporting logic, +5VA to supply external analogue modules and to provide the reference voltage for the ADC module. Power applied to the MPC560xB Controller Board is indicated by a power-on LED. The block diagram is shown in Figure 5.

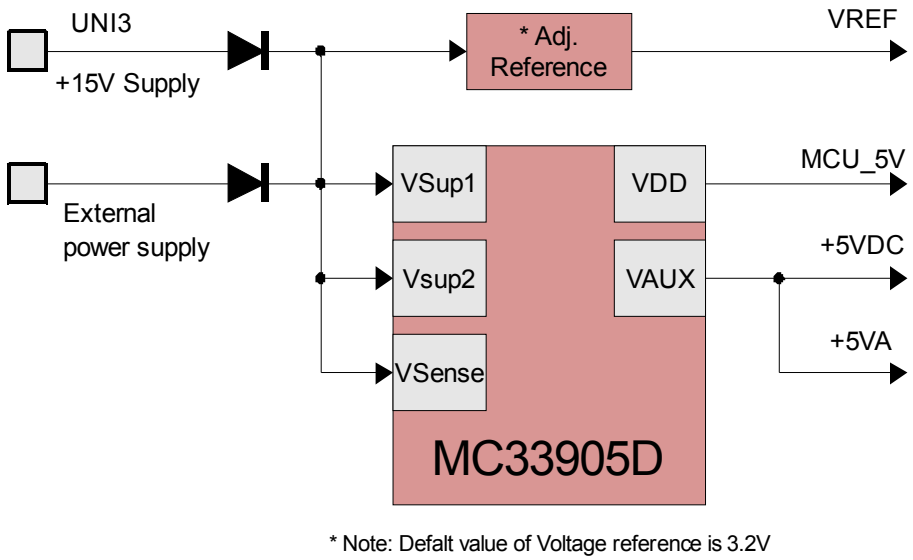


Figure 5. Power supply

4.3 Board Fault Management

Faults can be processed either by MCU software or by the on-board hardware.

To detect error states very quickly, the MPC560xB Controller Board provides two adjustable comparators and a fault logic circuit to force a disconnection of PWM signals from the MCU. The FAULT0 signal indicates an undervoltage state on DC-bus. The error level can be adjusted by trimmer R805. The FAULT1 signal indicates an overcurrent state on DC-bus and the error level can be adjusted by trimmer R810. The fault logic circuit is enabled by default and can be disabled by setting MCU port pin A[15] low. Before starting the motor control application, the fault logic circuit must be set to the default state by generating a positive pulse on the FLT_RESET signal (MCU port pin G[0]). The working principle can be seen in Figure 6.

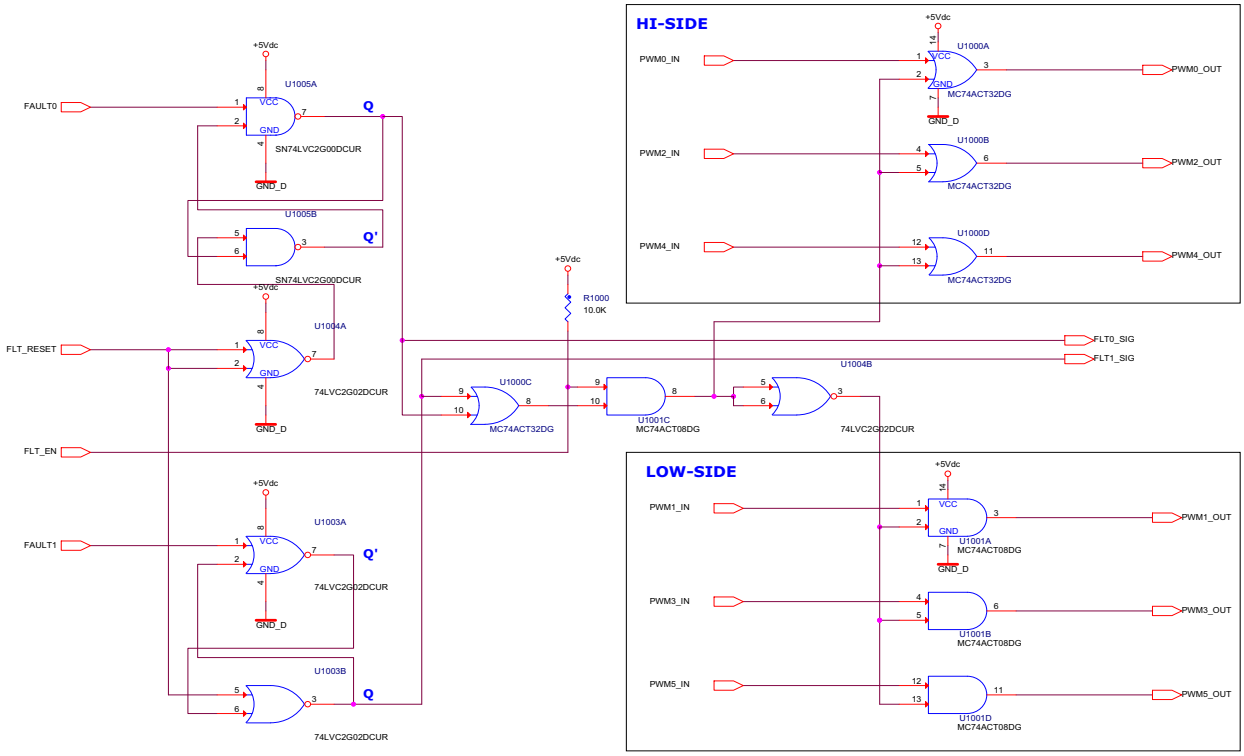


Figure 6. Fault Management Hardware

4.4 Hall Sensor Interface

The Hall sensor interface is used for the BLDC sensor based motor control application. 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 7. A single pole RC low-pass filter is present to reduce the signal noise.

For a detailed JP600 connector signal description, see Table 6.

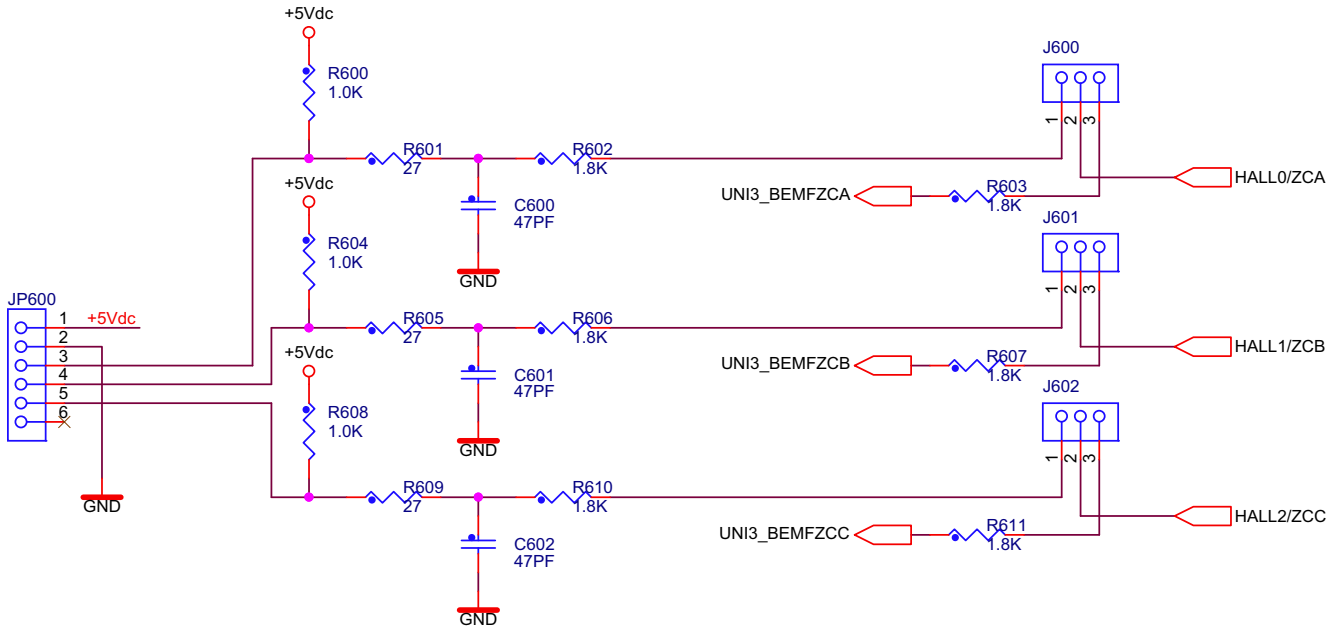


Figure 7. Hall Sensor Interface

The Figure 8 shows the Hall sensor signal alignment to the 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 9. The right-hand side of the table shows the Hall sensors signal, while the left side the applied phase voltage.

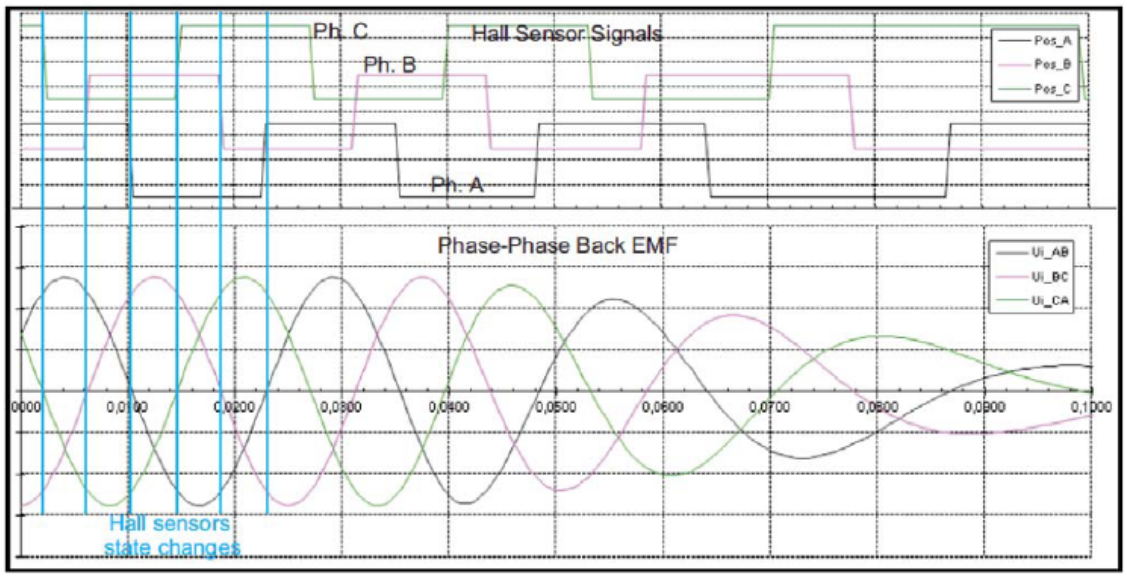


Figure 8. BLDC Motor Back-EMF and Hall Sensor Signal Alignment

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 9. Example of BLDC Motor Commutation

4.5 Analog Signal Sensing

The analog input signals listed in Figure 10, Table 16, and Table 17 are connected to the analogue to digital converters through the RC filters. The time constant of RC filter is set with respect to the input signal bandwidth.

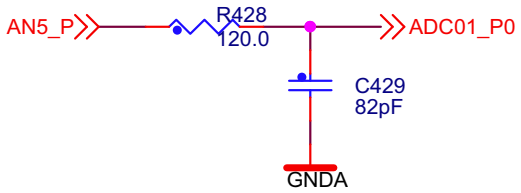


Figure 10. Analog Sensing Circuit

4.6 UNI-3 PFC-PWM Signal (Power Factor Correction)

The PFC-PWM signal is used to control a power stage circuit such as a PFC or a power DC-DC converter (when available). These signals are connected to the MPC560xB controller. For more details, see Table 21.

Table 21. UNI-3 PFC-PWM Signals

Signal	MPC5606B signal	UNI-3 pin
PFC-PWM	EMIOS1_CH0	31
PFC_ENABLE	GPIO A[13]	32
PFC_ZERO_CROSS	EMIOS1_CH1	33

4.7 UNI-3 Brake Signal

The brake signal output is used to control the DC-bus resistor switch. It is controlled via GPIO A[4].

4.8 MainCAN and AuxCAN Bus

The FlexCAN module is a communication controller implementing the CAN protocol according to the CAN 2.0B protocol specification, which supports both standard and extended message frames. A number of Message Buffers (32) is also supported. Please refer to the MPC560xB reference manual for a detailed description. The Freescale system basis chip MCZ33905D with one CAN is used as the main CAN hardware interface, and the Freescale chip MCZ33902 is used as the auxiliary hardware interface. Jumpers (J704, J705) and (J900, J901) define the middle or end node.

4.9 LIN bus interfaces

The LINFlex (Local Interconnect Network Flexible) controller interfaces the LIN network and supports the LIN protocol versions 1.3, 2.0 and 2.1, and J2602 in both Master and Slave modes. Please refer to the MPC560xB reference manual for a detailed description. The Freescale system basis chip MC33905D, with two LIN bus physical interfaces, provides an additional possibility for connection. Both the LIN_1 and LIN_2 interfaces can be configured as master or slave by jumpers (J706, J707).

5 Electrical Characteristics

The electrical characteristics in Table 22 apply to an operation at 25 °C.

Table 22. Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Units
Power supply Voltage	V_{DC}	8	12	18	V
Current consumption(1)	I_{CC}		40		mA
Input Voltage Range	V_{IN}	0	—	5	V
Input Voltage Range Hall and MC33937 interface	V_{IN}	0	—	5	V

1—12V power supply, MCU without software

6 Board Set-up Guide

The board is designed to be supplied either by the UNI-3 interface or by using the on-board J700 connector, with a power supply voltage from 8 to 18V. When using the board as a stand-alone EVB, connect the power supply to J700. In the case of board operation with the power stage, it is recommended to supply the board using the UNI-3 interface.

The MPC560xB Controller Board is designed for operation with the Freescale MC33937A based 3-Phase low-voltage power stage; see Figure 11. The complete 3-phase BLDC Sensor / Sensorless Development Kit can be ordered at http://www.freescale.com/AutoMCDevKits.

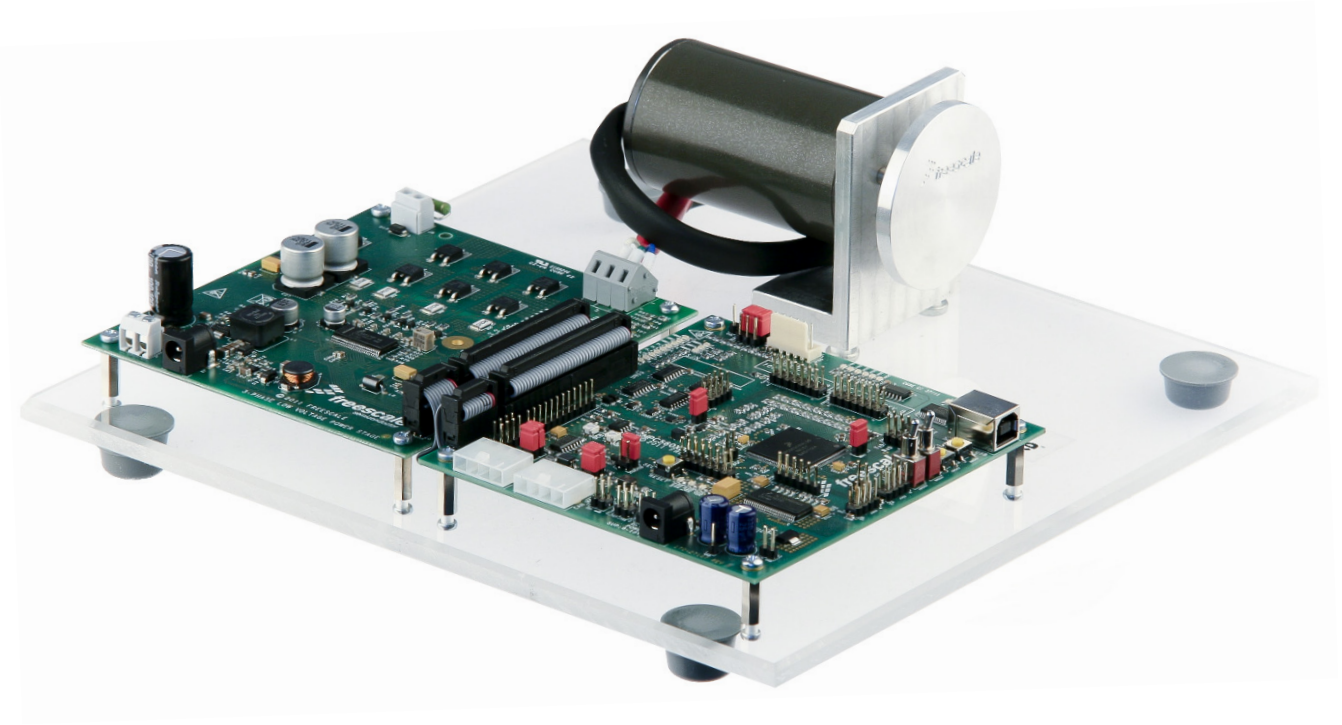


Figure 11. 3-Phase BLDC Sensor / Sensorless Development Kit

Appendix A References

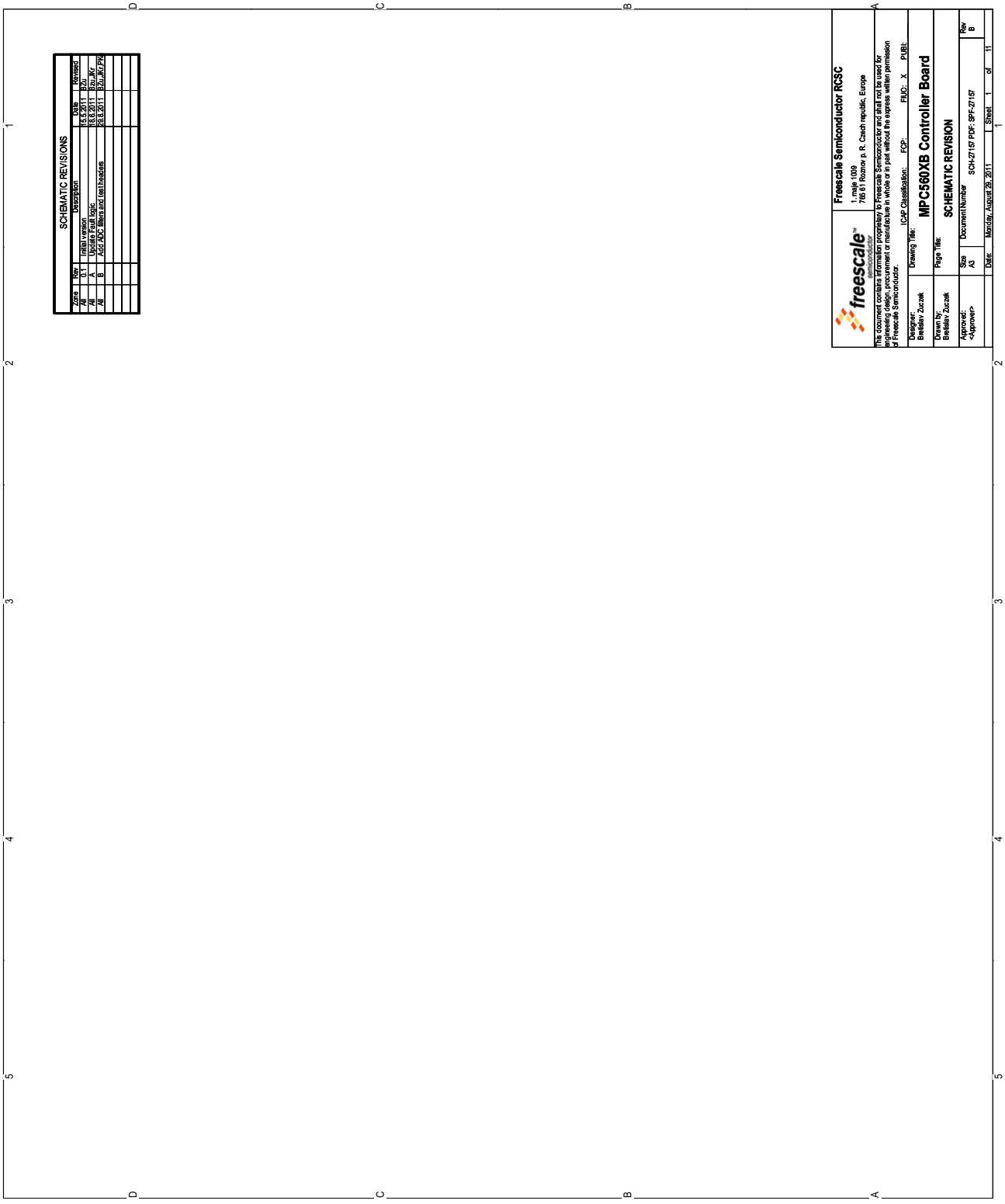
1. 3-phase Low-Voltage Power Stage, www.freescale.com/AutoMCDevKits
2. MPC5607B Family Reference Manual, MPC5607BRM Rev. 7.1, 6 June 2011
3. FreeMASTER Run-time Debugging Tool, www.freescale.com/FREEMASTER
4. MPC560xB documentation is available at the Freescale website www.freescale.com

Appendix B Acronyms

Table 23. Acronyms

Acronyms	Description
ADC	Analog to Digital Converter
BEMF	Back Electromotive Force
BLDC	Brushless DC Motor
CAN	Controller Area Network
LIN	Local Interconnect Network
MCU	Microcontroller Unit
PC	Personal Computer
PWM	Pulse Width Modulation
SBC	System Basis Chip
EVB	Evaluation Board
USB	Universal Serial Bus

Appendix C MPC560xB Controller Board Schematic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BZo
All
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17.8.2011
BZo, JKr
All
B
Add ADC filters and test headers
29.8.2011
BZo, JKr, PKo
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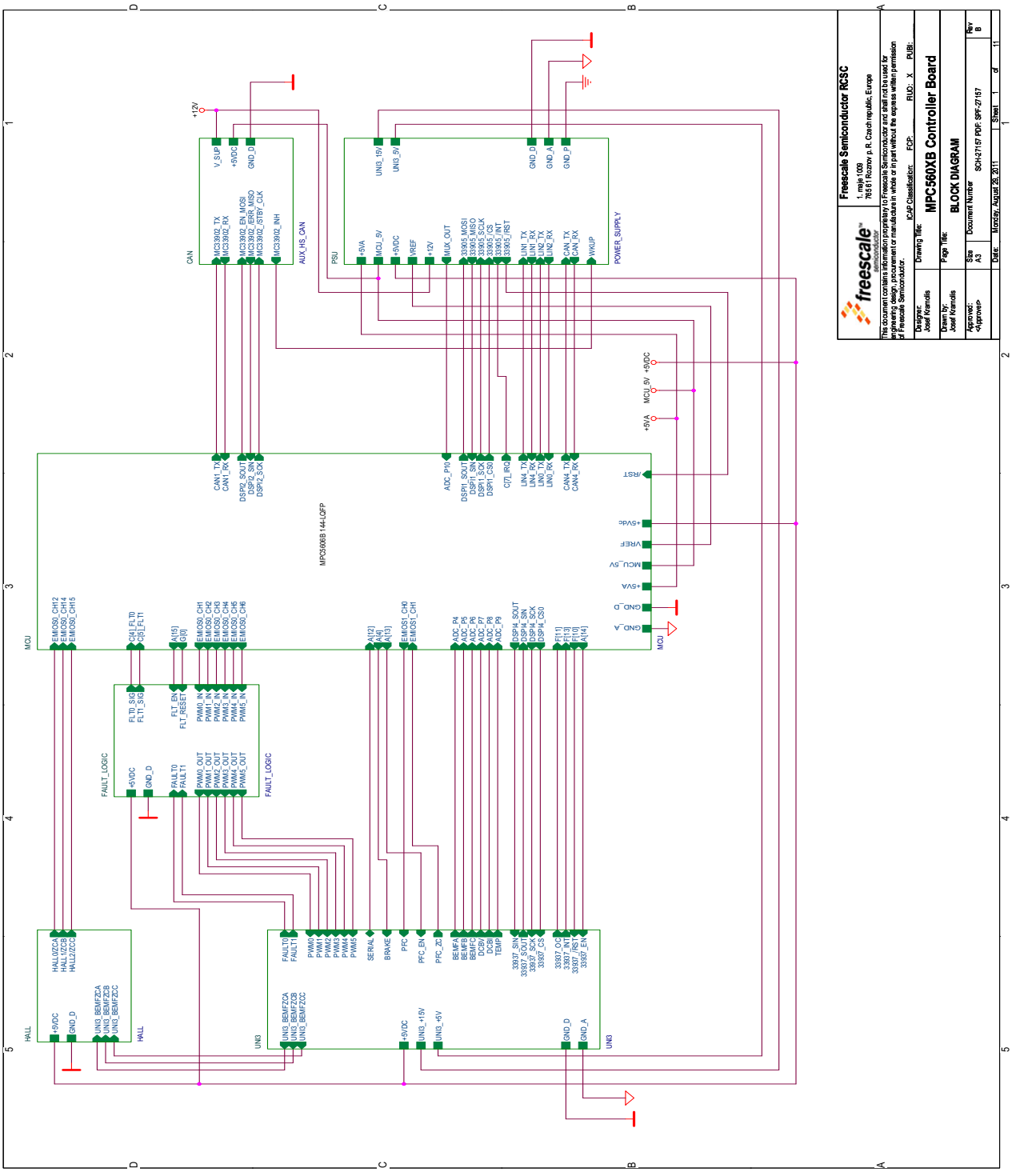
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Rev B
Date: Monday, August 29, 2011
Sheet 1 of 11
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CAN
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POWER_SUPPLY
FAULT_LOGIC
HALL
UN3
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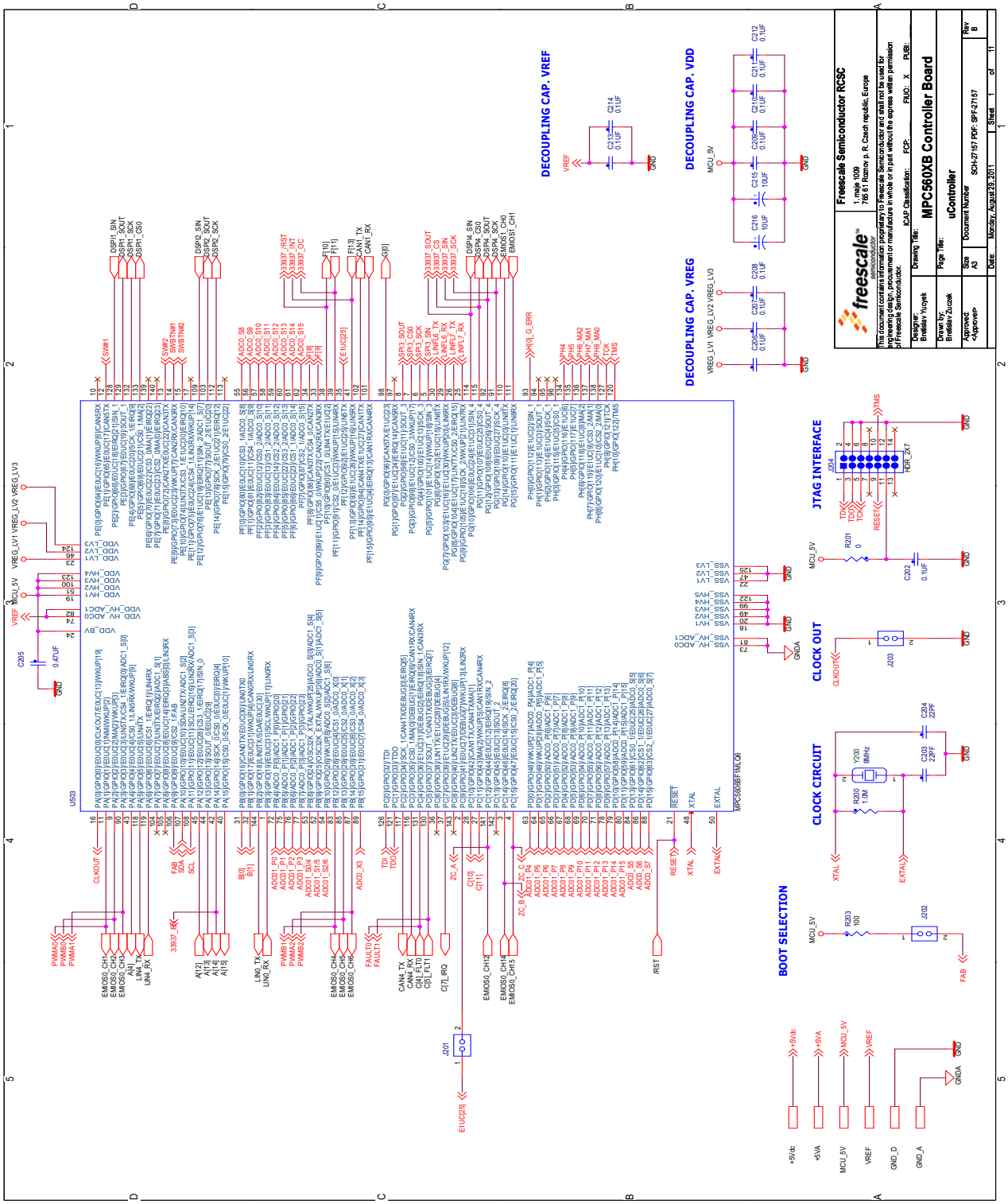
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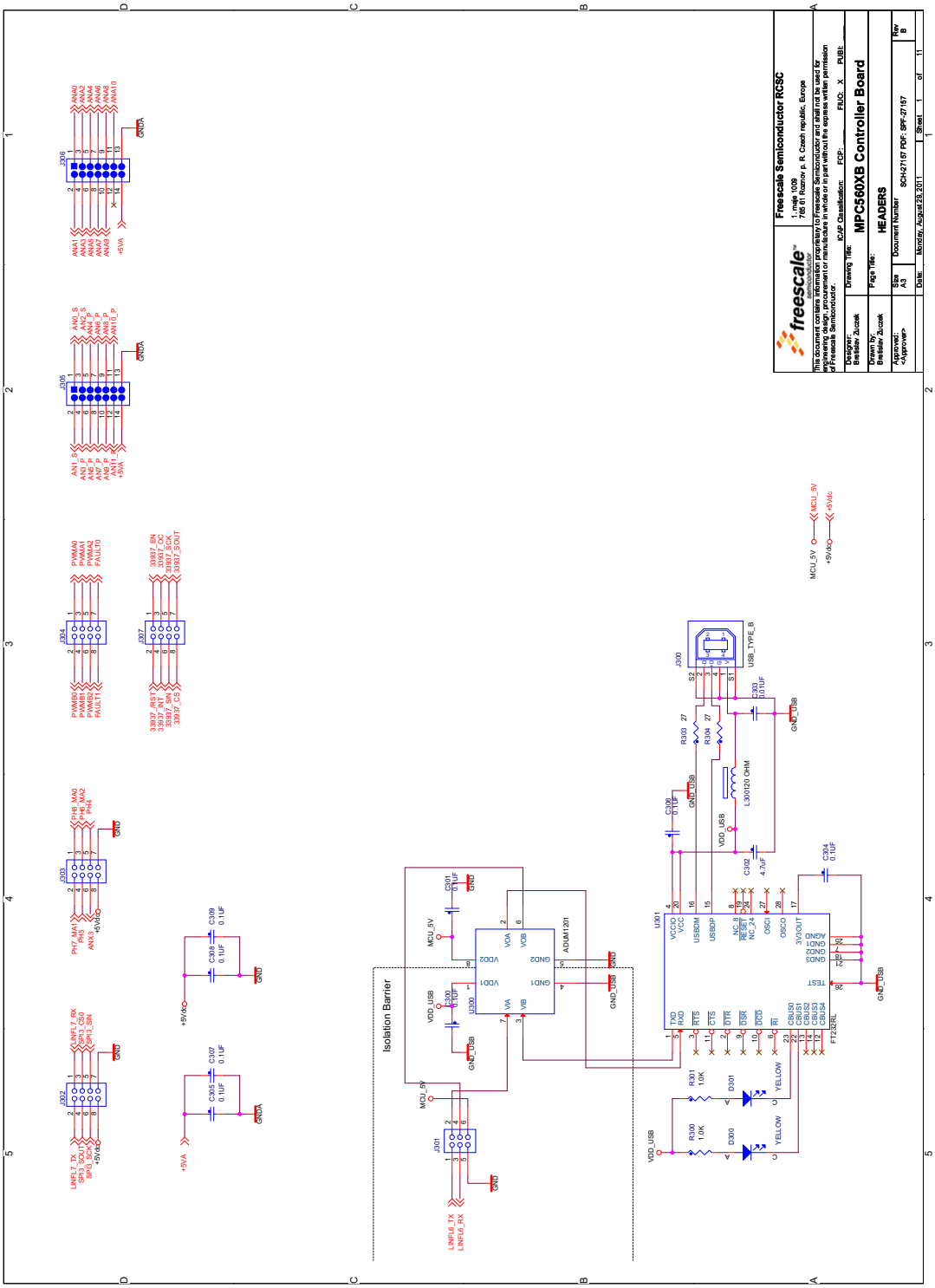
SCH-27157 PDF: SPF-27157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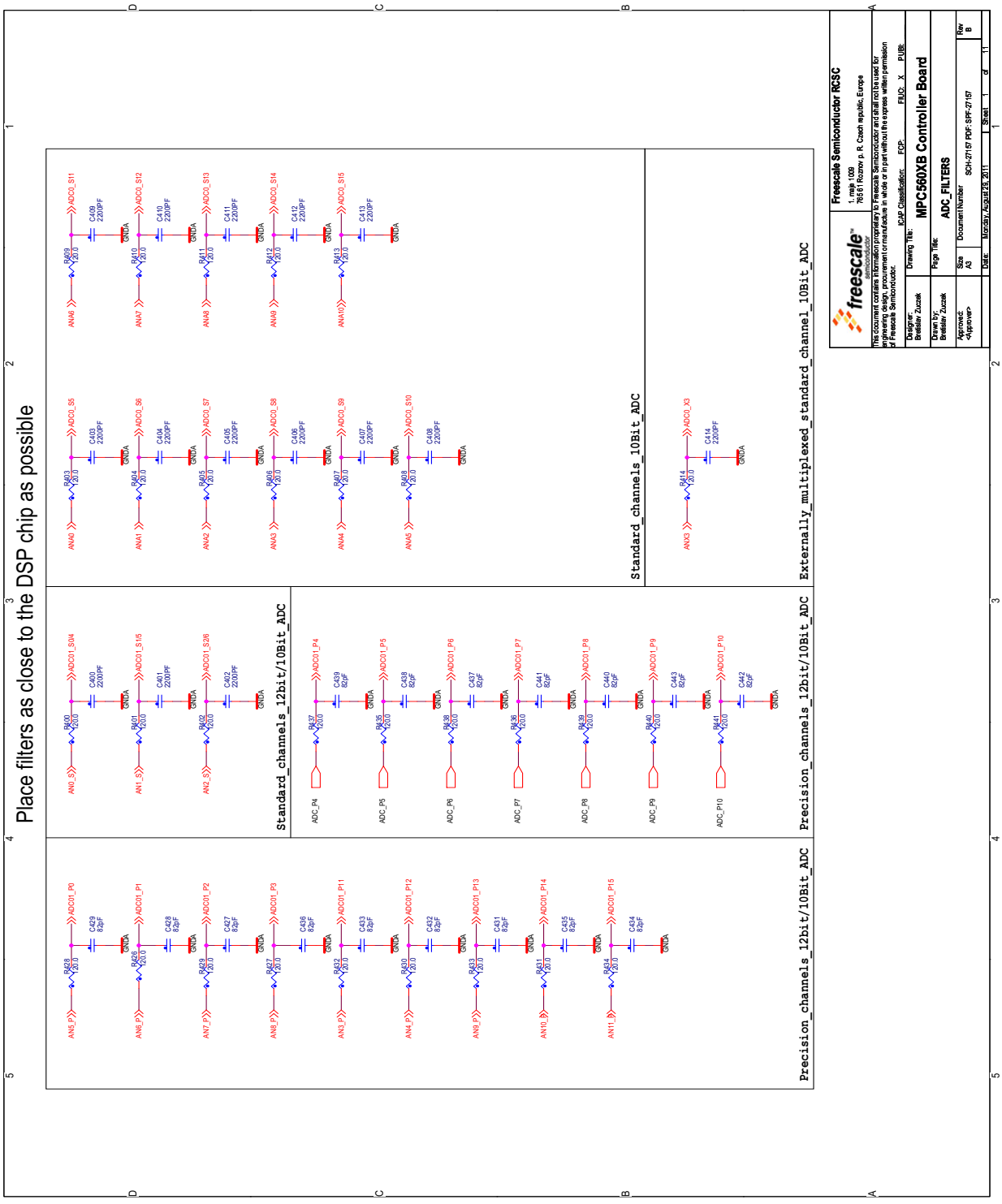
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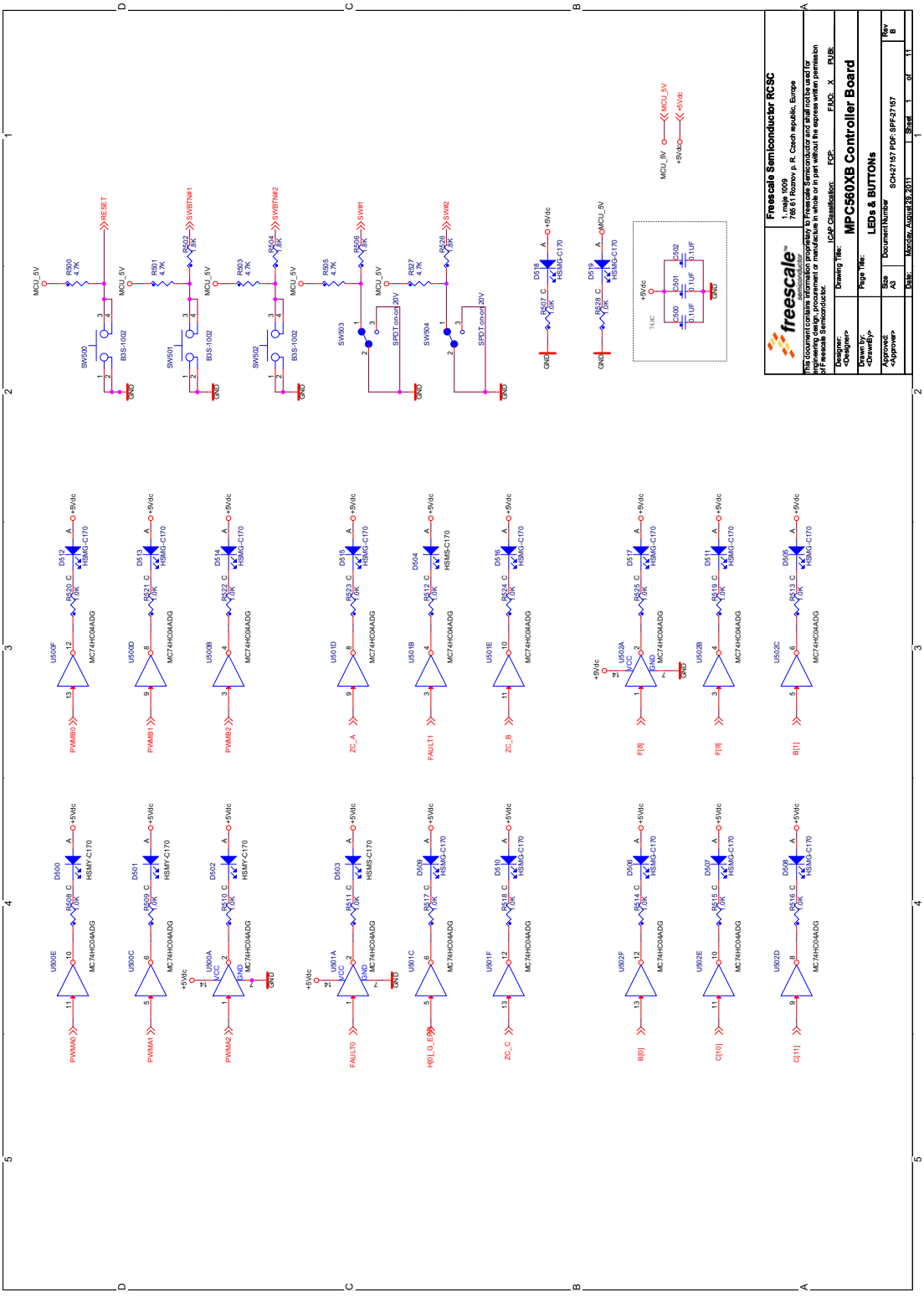
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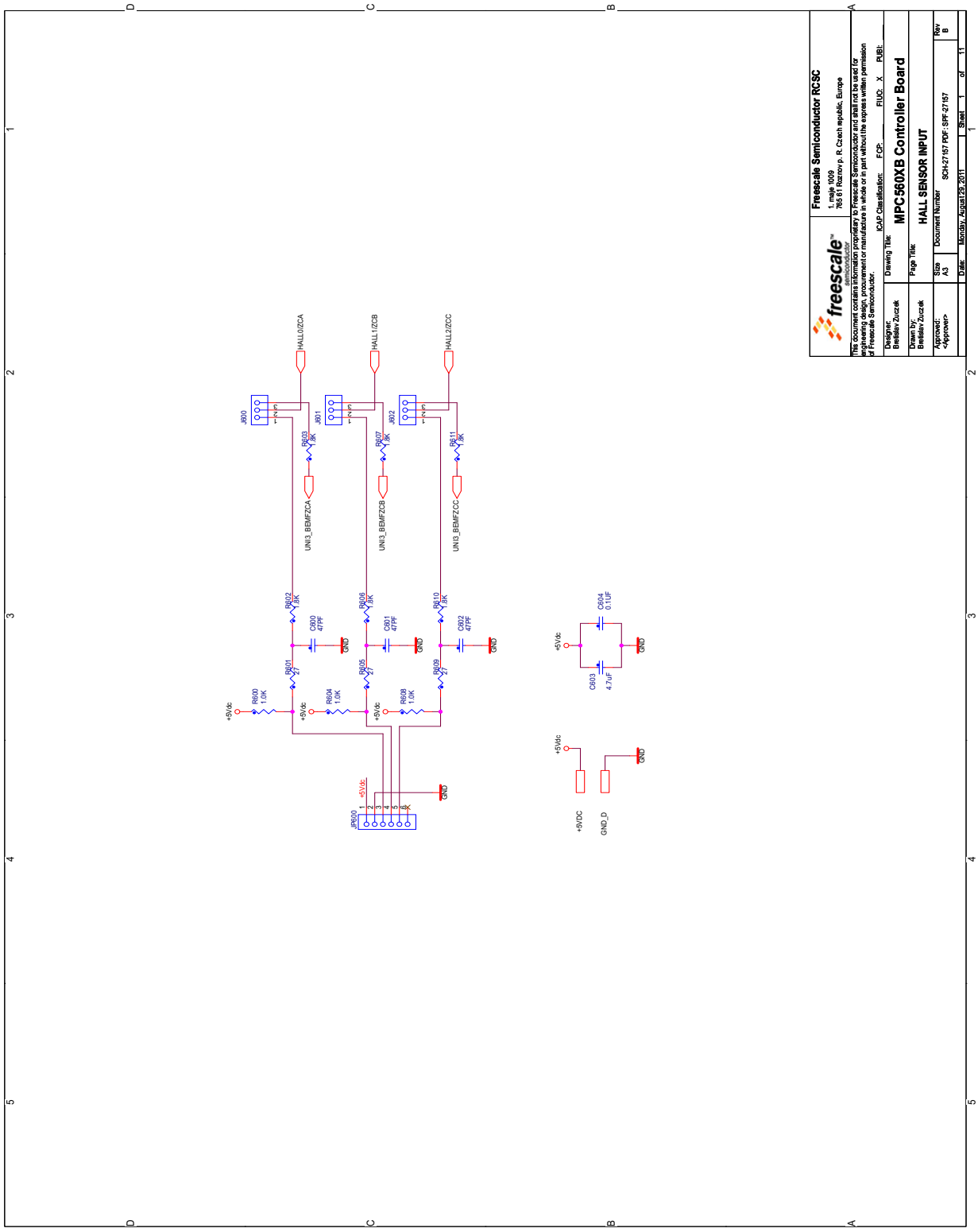
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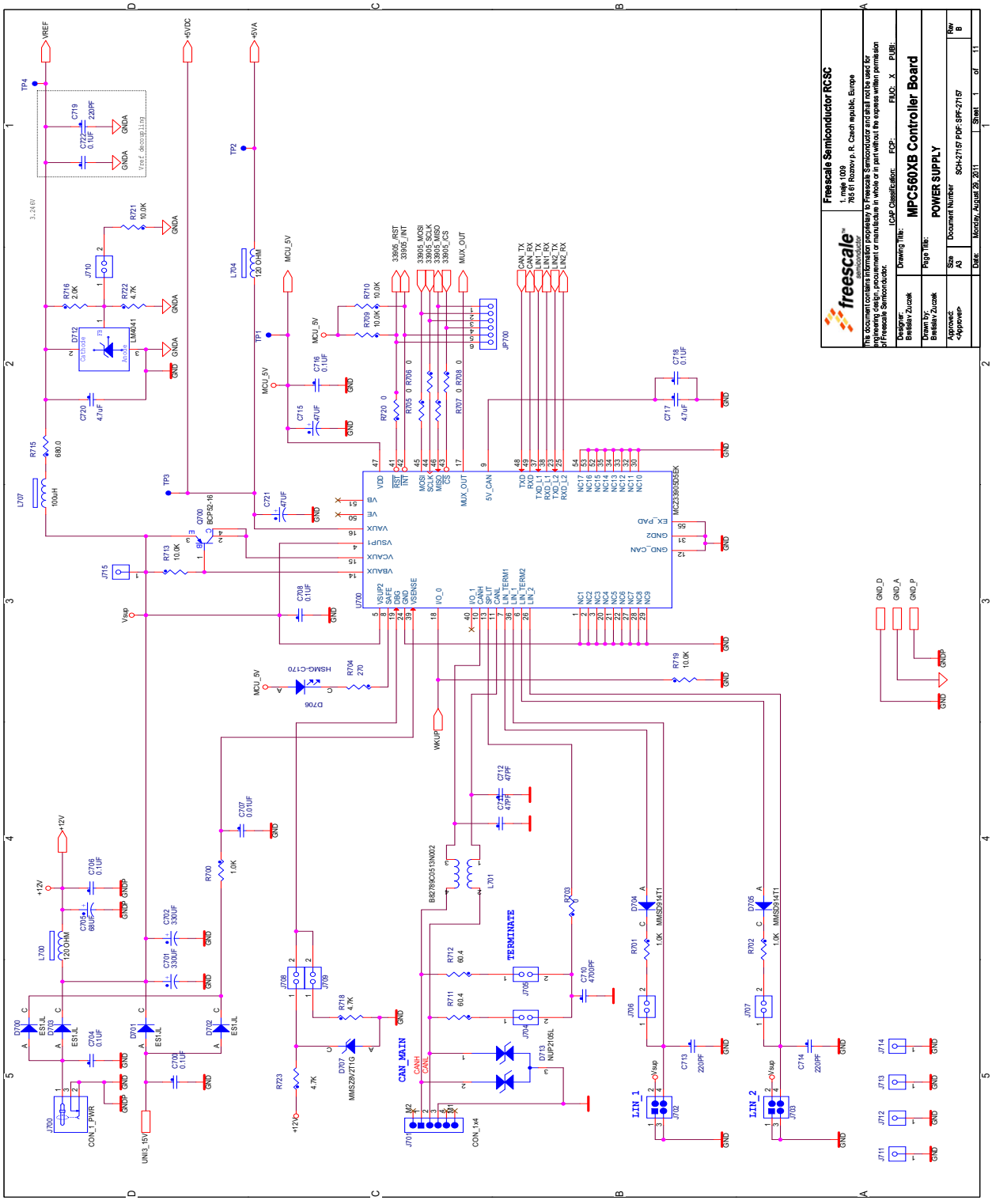
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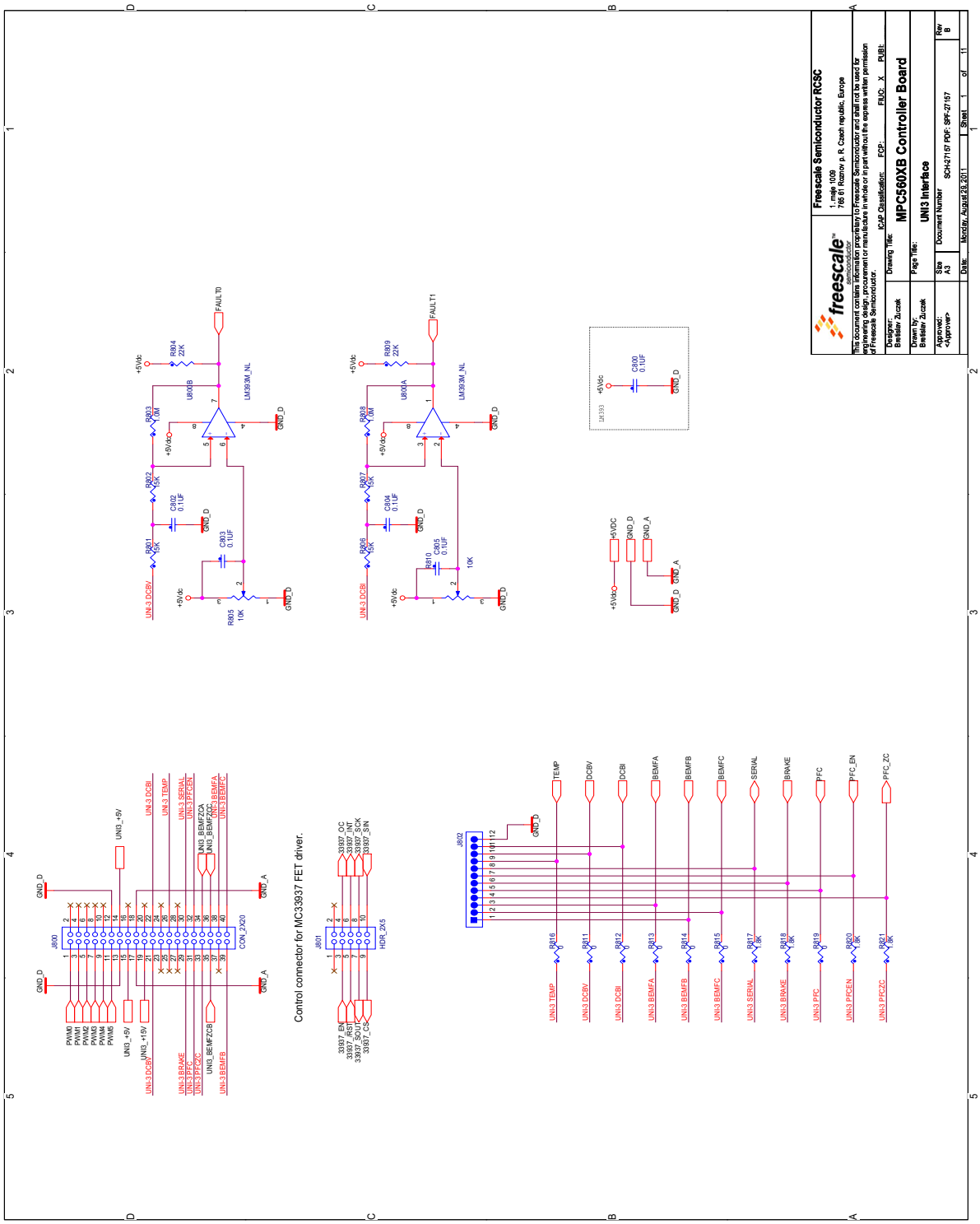
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J801
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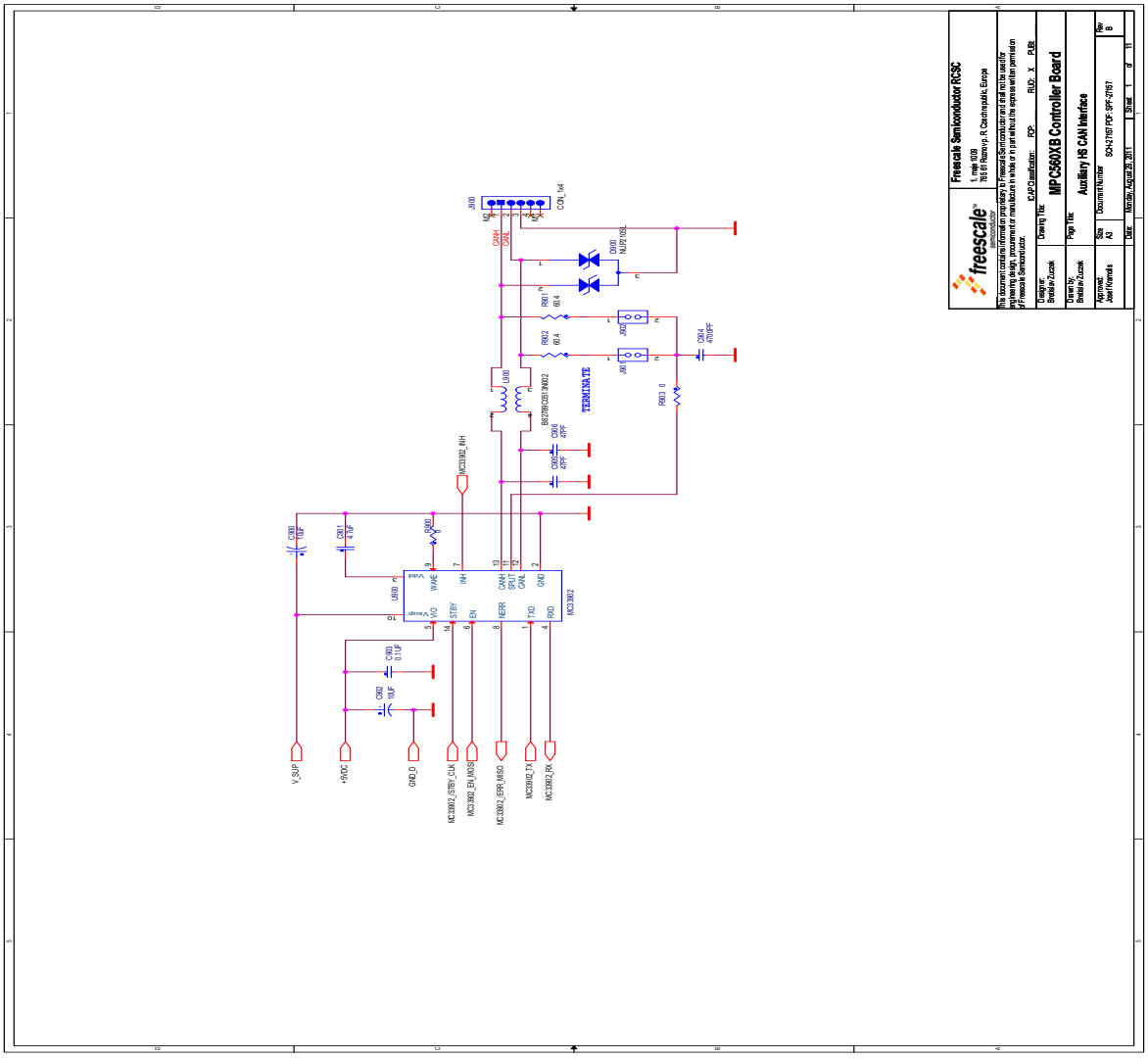

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