Freescale
User's Guide

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MPC5604P Controller Board User's Guide

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1 About This Book

This document describes the design of MPC5604P Controller Board, which is targeted for rapid development of motor control applications.

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2 Introduction

Freescale MPC5604P Controller Board is a controller board integrated to Freescale embedded motion-control series of development tools. It is supplied with universal interface interconnecting with, among others, one of the embedded motion-power stages or evaluation boards, providing a ready-made software-development platform for a various electrical motors, DC converters.

The MPC5604P Controller Board is an evaluation-module type of board which includes an MPC5604P device, a various position sensing interfaces,

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communications options, digital and analog power supplies, and peripheral expansion connectors. The expansion connectors are intended for signal monitoring and user expandability. Test pads are provided for monitoring critical signals and voltage levels.

The MPC5604P Controller Board facilitates the evaluation of various features present in the MPC5604P. It can be used to develop real-time software and hardware products based on MPC5604P in TQFP144 package. It provides the features necessary for the user to write and debug software, demonstrate the functionality of that software, and to interface with the customer's application specific device(s). The MPC5604P Controller Board is flexible enough to allow the users to fully exploit the MPC5604P features to optimize the performance of their product, as shown in Figure 1.

2.1 Features

The MPC5604P Controller Board facilitates the evaluation of various features present in the MPC5604P. Following are the board features:

- MPC5604P microcontroller, TQFP144 package
- JTAG/NEXUS interfaces for MCU code download and debugging
- System-basis chip MCZ33905D
- Motor control interface:
  - UNI-3
  - MC33937A predriver
  - Resolver
  - two Encoder/Hall sensors
- Connectivity interface:
  - LIN
  - CAN
  - FlexRay
  - USB interface
- LEDs:
  - Power-supply indicators
  - PWM control signals
  - Faults monitoring
  - SBC safe mode
  - User application
- Two push buttons and switch for application control
- MCU pins accessible via pin headers
- Power plug 2.1mm connector.

2.2 MPC5604P Controller Board Architecture

The MPC5604P Controller Board is flexible enough to allow the user to fully exploit the MPC5604P features to optimize a performance of their product. Its 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

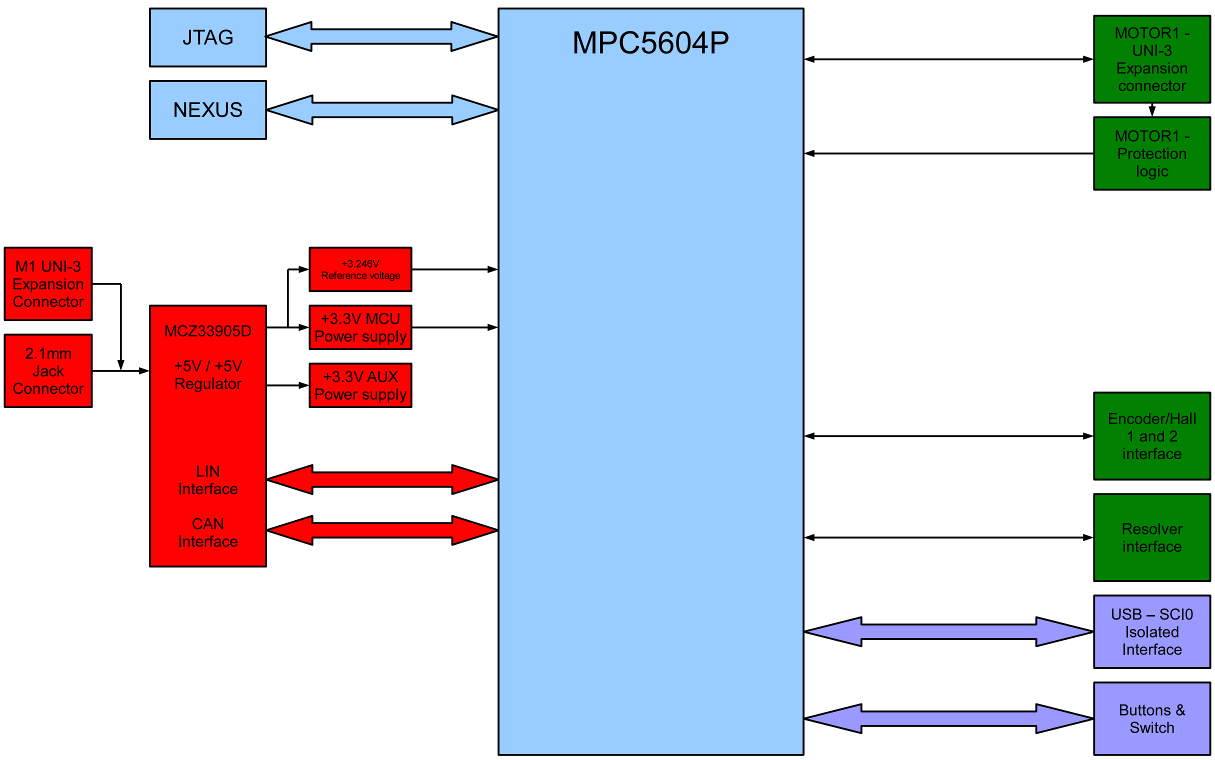


Figure 1. MPC5604P Controller Board Block Diagram

The board can be supplied by VBAT voltage in the range of 8V to 18V. The MC33905 provides two independent voltage sources, one for supplying MCU and second for auxiliary logic. Both sources provides either 3.3V or 5V, depending on the assembled SBC version.

The UNI-3 expansion interface enables MCU to direct control of the electrical motor or DC/DC converters.

The Fault logic triggers several important system faults as described in a particular chapter. The circuitry behavior depends on the selected configuration. For more info, see Section 3, “Interface Description.

The user can control the application using the rotary switch, USB interface (RS232), CAN and LIN buses.

The JTAG/NEXUS interfaces is present on-board to enable download and debugging of MCU code.

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

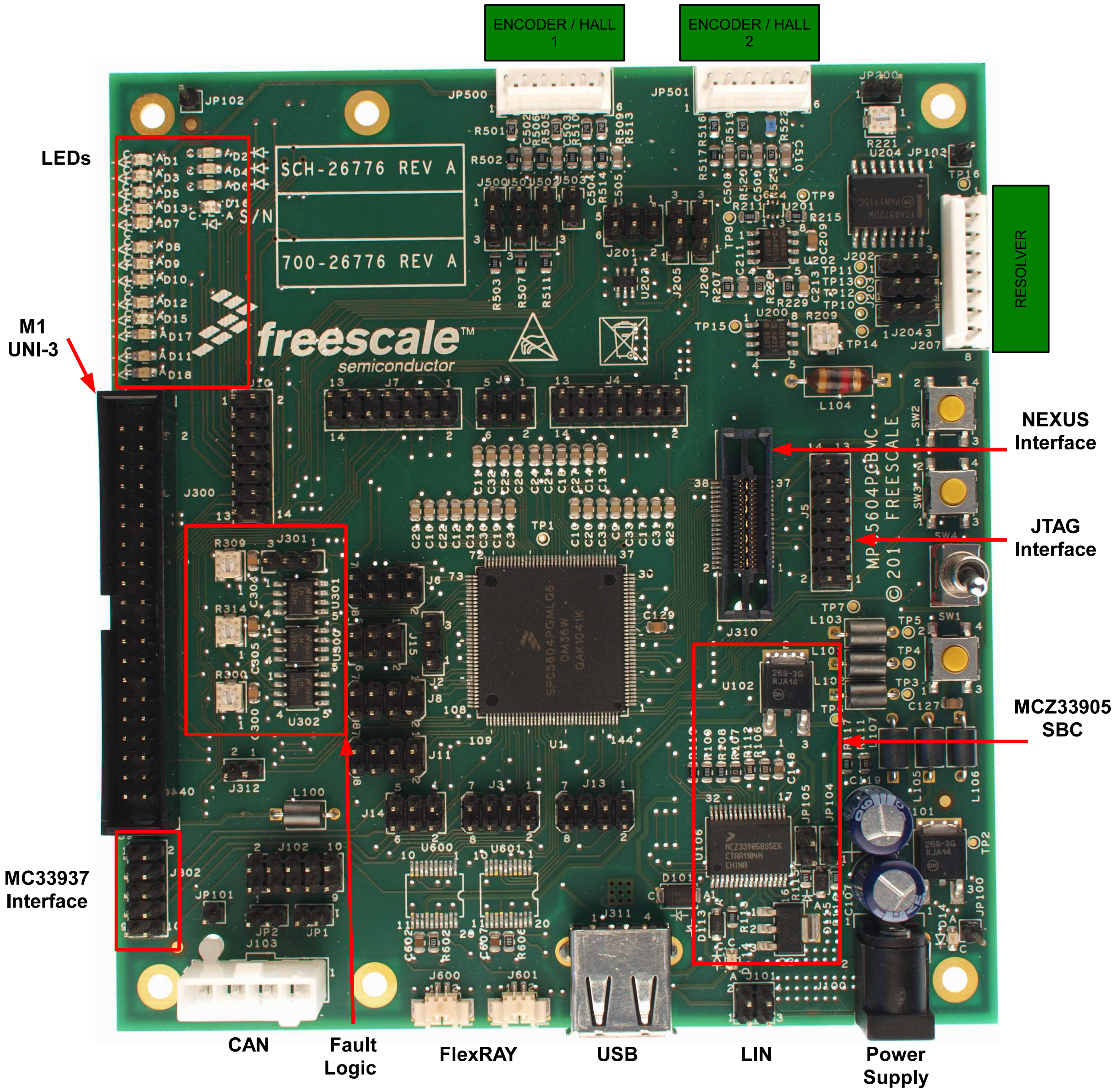


Figure 2. MPC5604P Controller Board Block Location

2.3 Board Jumper Configuration

See Table 1 and Figure 3 for proper jumper configuration.

Table 1. MPC5604P Controller Board Jumper Options

#	Selector	Function	Connections
JP1, JP2	CAN	Terminate CAN bus node.	closed
JP104	MC33905 debug mode	Enter SBC driver MC33905 to debug mode.	closed
JP105	MC33905 save mode	Enter SBC driver MC33905 to safe mode.	closed
JP200	Resolver Enable	Resolver reference input signal from MCU disabled.	open
		Resolver reference input signal from MCU enabled	closed
J203	Resolver REFSIN input	Positive input for SIN OPAM is DC offset voltage set up by trimmer R209.	1–2
		Positive input for SIN OPAM is REFSIN input of resolver.	2–3
J204	Resolver COS input	Positive input for COS OPAM is DC offset voltage set up by trimmer R209.	1–2
		Positive input for COS OPAM is REFCOS input of resolver.	2–3
J205	Phase A digital signal	Resolver Phase A signal is connected to GPIO F[13].	1–2
		SIN/COS Phase A signal is connected to GPIO F[13].	2–3
J206	Phase B digital signal	Resolver Phase A signal is connected to GPIO A[5].	1–2
		SIN/COS Phase A signal is connected to GPIO A[5].	2–3
J2	Resolver input signal	Resolver reference signal is generated by GPIO C[11].	2–3
		Resolver reference signal is generated by GPIO C[12].	1–2
J301	FAULT1 selection	UNI-3 Phase A over-current signal is connected to FAULT1 input G[9].	1–2
		UNI-3 DC-bus over-current signal is connected to FAULT1 input G[9].	2–3
J312	BOOT selection	MPC5604P boot from internal Flash.	closed

Table 1. MPC5604P Controller Board Jumper Options (continued)

#	Selector	Function	Connections
J500	Encoder 0 Phase A	Encoder0 JP500 pin three PHASE A input signal is connected to GPIO A[0].	1–2
		UNI-3 BEMFZCA input signal is connected to GPIO A[0].	2–3
J501	Encoder 0 Phase B	Encoder0 JP500 pin four PHASE B input signal is connected to GPIO A[1].	1–2
		UNI-3 BEMFZCB input signal is connected to GPIO A[1].	2–3
J502	Encoder 0 Index	Encoder0 JP500 pin five INDEX input signal is connected to GPIO A[2].	1–2
		UNI-3 BEMFZCC input signal is connected to GPIO A[2].	2–3
J503	Encoder 0 Home	Encoder0 JP500 pin six HOME input signal is connected to GPIO A[3].	closed
	DC BUS Voltage	DC BSUS Voltage signal from UNI-3 is connected to GPIO B[13], ADC 1 input zero.	R315 populated
	DC BUS Current	DC BUS Current signal from UNI-3 is connected to GPIO B[15], ADC 1 input two.	R316 populated
	Analog input 11	UNI-3 Phase A current is connected to GPIO B[9], ADC 0/1 input 11.	R318 populated
		UNI-3 Phase A Back-EMF Voltage is connected to GPIO B[9]m ADC 0/1 input 11.	R320 populated
	Analog input 12	UNI-3 Phase B current is connected to GPIO B[10], ADC 0/1 input 12	R322 populated
		UNI-3 Phase B Back-EMF Voltage is connected to GPIO B[10]m ADC 0/1 input 12.	R324 populated

Table 1. MPC5604P Controller Board Jumper Options (continued)

#	Selector	Function	Connections
	Analog input 13	UNI-3 Phase C current is connected to GPIO B[11], ADC 0/1 input 13.	R325 populated
		UNI-3 Phase C Back-EMF Voltage is connected to GPIO B[11]m ADC 0/1 input 13.	R326 populated
	TEMP	UNI-3 Temperature signal is connected to ADC0 input zero.	R328 populated
	SERIAL	UNI-3 Serial signal is connected to GPIO D[5].	R330 populated
	BRAKE	UNI-3 Brake output signal is connected to GPIO C[3].	R333 populated
	PFC	UNI-3 PFC output signal is connected to GPIO G[6] (PWMA3).	R334 populated
	PFC_EN	UNI-3 PFC Enable signal is connected to GPIO G[7] (PWMB3).	R335 populated
	PFC_ZC	UNI-3 PFC zero current signal is connected to GPIO G[5] (PWMX3).	R336 populated

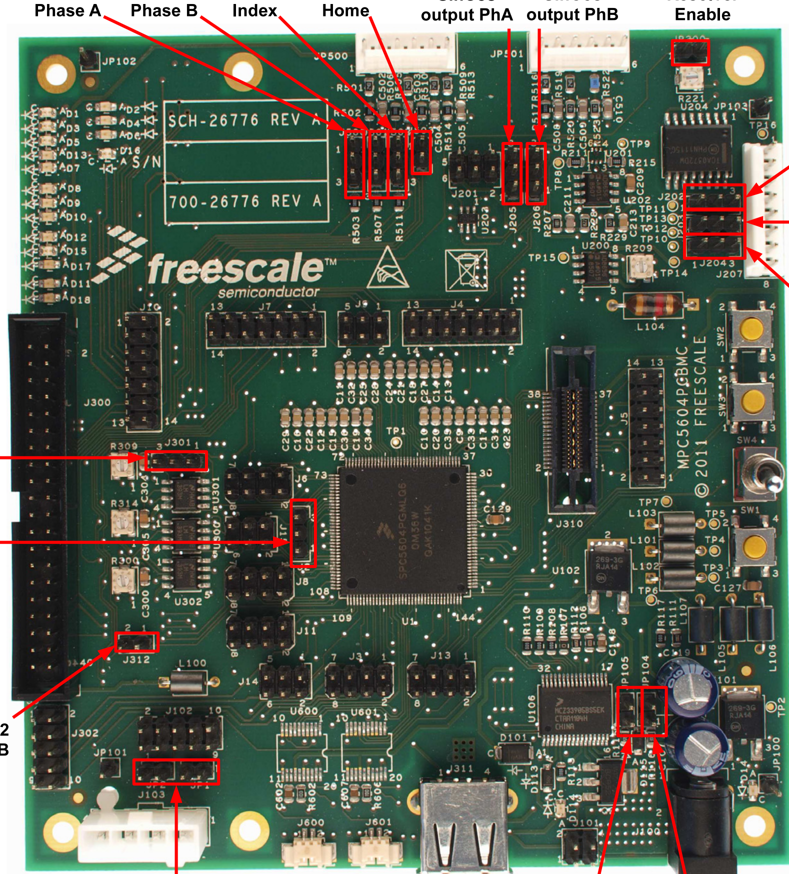


Figure 3. MPC5604P Controller Board Jumper Position

2.4 Board LEDs

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

Table 2. On-board LEDs

LED	Signal Name	Description
D114	/SAFE	MCZ33905 safe pin state (ON - SBC in safe mode)
D14	+3.3Vdc	+ 3.3V AUX power supply
D1	PWM0 A0	Motor 1 Phase A bottom switch signal
D2	PWM0 B0	Motor 1 Phase B bottom switch signal
D3	PWM0 A1	Motor 1 Phase C bottom switch signal

Table 2. On-board LEDs (continued)

LED	Signal Name	Description
D4	PWM0 B1	Motor 1 Phase C top switch signal
D5	PWM0 A2	Motor 1 Phase B top switch signal
D6	PWM0 B2	Motor 1 Phase A top switch signal
D7	FAULTB0	Motor 1 FAULTB0 signal
D8	FAULTB1	Motor 1 FAULTB1 signal
D9	FAULTB2	Motor 1 FAULTB2 signal
D10	FAULTB3	Motor 1 FAULTB3 signal
D11	A12	User LED 1
D12	PHASEA0	Encoder 1 input A signal
D15	PHASEB0	Encoder 1 input B signal
D17	INDEX0	Encoder 1 input INDEX signal
D13	PWM0 A3	PWM module 0, A3 output
D16	PWM0 B3	PWM module 0, B3 output
D18	A13	User LED 1

3 Interface Description

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

3.1 Power Supply J100

The MPC5604P Controller Board can be supplied either by using the 2.1 mm DC power plug J100 or the UNI-3 connector (J300, pin 19).

The controller board is powered from two independent voltage regulators which provides 5V for a auxiliary logic and 5V for MCU and debugger logic. Both voltages are generated by the MC33905 SBC integrated circuit. Proper operation is monitored by LED D114 for the AUX 3.3V line, see Table 2.

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 J300

The UNI-3 interface (connector J300) defines the interface between the MPC5604P Controller Board and a 3 phase electrical motor power stages.

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

Table 3. Motor 1 — UNI-3 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	PWM_AT	PWM_A0	Phase A top switch control (H -> Turn OFF)	Digital output
3	PWM_AB	PWM_B0	Phase A bottom switch control (H -> Turn ON)	Digital output
5	PWM_BT	PWM_A1	Phase B top switch control (H -> Turn OFF)	Digital output
7	PWM_BB	PWM_B1	Phase B bottom switch control (H -> Turn ON)	Digital output
9	PWM_CT	PWM_A2	Phase C top switch control (H -> Turn OFF)	Digital output
11	PWM_CB	PWM_B2	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	—
16,20,27,28,37	NC	—	Not connected	—
21	V_{DC}BUS	B[13]	DC-bus voltage sensing, 0V – 3.3V, ADC1 channel 0	Analog input

Table 3. Motor 1 — UNI-3 Signal Description (continued)

Interface Pin	Signal Name	MCU Signal	Description	Direction
22	$I_{DC}BUS$	B[15]	DC-bus current sensing, 0–3.3 V, ADC1 channel 2	Analog input
23	I_A	B[9]	Phase A current sensing, 0–3.3 V, ADCx channel 11	Analog input
24	I_B	B[10]	Phase B current sensing, 0–3.3 V, ADCx channel 12	Analog input
25	I_C	B[11]	Phase C current sensing, 0–3.3 V, ADCx channel 13	Analog input
26	TEMP	B[7]	Analog temperature 0–3.3 V, ADC0 channel 0	Analog input
29	BRAKE_CONT	EIRQ#22	DC-bus brake control	Digital output
30	SERIAL	D[5]	Serial interface	Digital bi-directional
31	PFC	PWM_A3	Power factor correction PWM	Digital output
32	PFCEN	PWM_B3	Power factor correction enable	Digital output
33	PFCZC	PWM_X3	Power factor correction Zero-cross	Digital input
34	ZCA	D[9] or A[0]	Phase A Back-EMF zero crossing	Digital input
35	ZCB	D[12] or A[1]	Phase B Back-EMF zero crossing	Digital input
36	ZCC	G[2] or A[2]	Phase C Back-EMF zero crossing	Digital input
38	Back-EMF_A	B[9]	Phase A Back-EMF voltage sensing	Analog input
39	Back-EMF_B	B[10]	Phase B Back-EMF voltage sensing	Analog input
40	Back-EMF_C	B[11]	Phase C Back-EMF voltage sensing	Analog input

3.3 MC33937A Interface J302

When using a Freescale 3-phase power stages, the electrical inverter switches are controlled by the MC33937A pre-driver. The device behavior is configured by this interface, see Table 4.

Table 4. Motor 1 — MC33937A Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	NC	—	Not connected.	—
2	NC	—	Not connected.	—
3	33937_EN	G[0]	Motor 1 device-enable output.	Digital output
4	33937_OC	C[8]	Over-current input.	Digital input
5	33937_/RST	C[10]	Reset output. Active in low.	Digital output
6	33937_INT	C[9]	Interrupt pin.	Digital input
7	33937_SOUT	DSPI3_SIN	Input data from MC33937 SPI port. Tri-state until CS becomes low.	Digital input
8	33937_SCK	DSPI3_SCK	Clock for SPI port. Output.	Digital output
9	33937_CS	DSPI3_/CS0	Chip-select 0 output. It frames SPI command and enables SPI port.	Digital output
10	33937_SIN	DSPI3_SOUT	Output data for MC33937 SPI port. Clocked on the falling edge of SCLK, MSB first.	Digital output

3.4 Resolver Connector J207

The controller board is able to calculate motor rotor position from resolver or SIN/COS sensor. They are connected to the board through connectors J207, Table 5 shows pin description.

Table 5. Resolver Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	RES_GEN		Positive sinusoidal reference signal for resolver Signal output range from 0 V up to +12 V	Output
2	GNDP		Ground for reference signal	—
3	SIN		SIN input signal	Differential analog input
4	REFSIN		SIN reference input signal	Differential analog input

Table 5. Resolver Signal Description (continued)

Interface Pin	Signal Name	MCU Signal	Description	Direction
5	COS		COS input signal	Differential analog input
6	REFCOS		COS reference input signal	Differential analog input
7	GNDA		Analog ground	—
8	+5VA		+5V Analog Power supply	—

3.5 Encoder/Hall Connector J500 and J501

The motor rotor position can be transformed from encoder or Hall rotor position sensor. They can be connected to the board through connector J500 and J501. For proper signal connection, see Table 6.

Table 6. Encoder/Hall Signal Description

Interface Pin	Signal Name	MCU Port	Description	Direction
1	+5Vdc	—	+5V sensor supply voltage	—
2	GND	—	Ground	—
3	ENC1_PhaseA / HALL0 ENC2_PhaseA / HALL0	A[0] C[13]	Digital input signal phase A or Hall 0 input signal	Digital input
4	ENC1_PhaseB / HALL1 ENC2_PhaseB / HALL1	A[1] C[14]	Digital input signals phase B or Hall 1 input signal	Digital input
5	ENC1_INDEX / HALL2 ENC2_INDEX / HALL2	A[2] F[12]	Digital input signals INDEX or Hall 2 input signal	Digital input
6	ENC1_HOME	A[3]	Digital input signals HOME	Digital input

Table 7. J6 Header Signal Description

Interface Pin	Signal Name	MCU Port	Description	Direction
1	PHASEB0	A[1]	Encoder 1 digital input signal phase B.	Digital input
2	PHASEA0	A[0]	Encoder 1 digital input signal phase A.	Digital input
3	HOME0	A[3]	Encoder 1 digital input signal Home.	Digital input
4	INDEX0	A[2]	Encoder 1 digital input signal Index.	Digital input

Table 7. J6 Header Signal Description (continued)

Interface Pin	Signal Name	MCU Port	Description	Direction
5	ET0_4	C[11]	eTimer0 channel 4 output/input	Digital I/O
6	ET0_5	C[12]	eTimer0 channel 5 output/input	Digital I/O
7	+3.3Vdc	—	+3.3Vdc power supply	—
8	GND	—	Ground	—

Table 8. J8 Header Signal Description

Interface Pin	Signal Name	MCU Port	Description	Direction
1	PHASEB1	C[14]	Encoder 2 digital input signal phase B.	Digital input
2	PHASEA1	C[13]	Encoder 2 digital input signal phase A.	Digital input
3	NC	—	—	—
4	INDEX1	F[12]	Encoder 2 digital input signal Index.	Digital input
5	PHASE_A	F[13]	eTimer1 channel 4 output/input	Digital I/O
6	PHASE_B	A[5]	eTimer1 channel 5 output/input	Digital I/O
7	+3.3Vdc	—	+3.3Vdc power supply	—
8	GND	—	Ground	—

3.6 LIN Connector J101

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

A Table 9 shows the LIN connector pin-out and pin assignment to the MCU.

Table 9. LIN Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	GND	—	Ground	—
2	VSUP	—	Power Supply	—
3	GND	—	Ground	—
4	LIN	LIN1_RXD / LIN1_TXD	LIN bus	Digital bi-directional

Table 10. Header J14 Signal Description

Interface Pin	Signal Name	MCU Port	Description	Direction
1	GPIOA13	A[13]	Digital input / output	Digital I/O
2	GPIOA12	A[12]	Digital input / output	Digital I/O
3	LIN1_TXD	F[14]	LIN module 1 transmit output	Digital output
4	LIN1_RXD	F[15]	LIN module 1 receive input	Digital input
5	GND	—	Ground	—
6	+3.3Vdc	—	+3.3Vdc power supply	—

3.7 CAN Connector J103

The system basis chip MC33905 CAN transceiver is used as the CAN hardware interface. An on-board jumpers JP1, JP2 enable node termination, impedance of 120R, see Table 1.

Table 11 shows the CAN connector pin-out and pin assignment to the MCU.

Table 11. CAN Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	CANH	CAN0_RXD / CAN0_TXD	CAN bus H	Differential bidirectional
2	CANL	CAN0_RXD / CAN0_TXD	CAN bus L	Differential bidirectional
3	GND	—	Ground	—
4	NC	—	Not connected	—

Table 12. Header J11 Signal Description

Interface Pin	Signal Name	MCU Port	Description	Direction
1	CAN0_RX_PHY			
2	CAN0_TX_PHY			
3	CAN0_RXD	B[1]	CAN module 0 receive input	Digital input
4	CAN0_TXD	B[0]	CAN module 0 receive output	Digital output
5	GND	—	Ground	—
6	GND	—	Ground	—
7	+5Vdc	—	+5Vdc power supply	—
8	+3.3Vdc	—	+3.3Vdc power supply	—

3.8 USB Connector J311

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

The interface uses a A type connector and it is isolated from the board environment. See Table 13 for the pin description and pin assignment to the MCU.

Table 13. USB Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	VBUS	—	USB Power Supply	—
2	D-	LIN0_RXD / LIN0_TXD	Data-	Dig. bidirectional
3	D+	LIN0_RXD / LIN0_TXD	Data+	Dig. bidirectional
4	GNDB	—	USB Ground	—

3.9 Header J10 and J15

Monitoring the PWM signals is possible using J10. Table 14 summarizes the header pinout.

Table 14. J10- Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	PWMA0	D[10]	Motor 1 — Phase A top switch control	Digital output
2	PWMB0	D[11]	Motor 1 — Phase A bottom switch control	Digital output
3	PWMA1	D[13]	Motor 1 — Phase B top switch control	Digital output
4	PWMB1	D[14]	Motor 1 — Phase B bottom switch control	Digital output
5	PWMA2	G[3]	Motor 1 — Phase C top switch control	Digital output
6	PWMB2	G[4]	Motor 1 — Phase C bottom switch control	Digital output
7	FAULTB0	G[8]	PWM module fault input 0	Digital input
8	FAULTB1	G[9]	PWM module fault input 1	Digital input
9	FAULTB2	G[10]	PWM module fault input 2	Digital input
10	FAULTB3	G[11]	PWM module fault input 3	Digital input
11	PWM_X0	D[9]	PWM module 0 auxiliary PWM signal 0	Digital input/output
12	PWM_X1	D[12]	PWM module 0 auxiliary PWM signal 1	Digital input/output
13	PWM_X2	G[2]	PWM module 0 auxiliary PWM signal 2	Digital input/output
14	GND	—	Ground	—

Table 15. J15 Signal Description

Interface Pin	Signal Name	MCU Port	Description	Direction
1	PWMA3	G[6]	Digital input/output	Digital I/O
2	PWMB3	G[7]	Digital input/output	Digital I/O
3	PWM_X3	G[4]	Digital input/output	Digital I/O
4	NCs	—	—	—
5	+3.3Vdc	—	+3.3V voltage	—
6	GND	—	Ground	—

3.10 Header J4, J7, and J9

Headers J4, J6, and J7 allows monitoring the analog-to-digital converter signals, see Table 16.

Table 16. Header J4 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	ADC0_AN0	B[7]	ADC module 0 channel 0 input	Analog input
2	ADC0_AN1	B[8]	ADC module 0 channel 1 input	Analog input
3	ADC0_AN2	C[1]	ADC module 0 channel 2 input	Analog input
4	ADC0_AN3	C[2]	ADC module 0 channel 3 input	Analog input
5	ADC0_AN4	E[1]	ADC module 0 channel 4 input	Analog input
6	ADC0_AN5	E[2]	ADC module 0 channel 5 input	Analog input
7	ADC0_AN6	E[3]	ADC module 0 channel 6 input	Analog input
8	ADC0_AN7	E[4]	ADC module 0 channel 7 input	Analog input
9	ADC0_AN8	E[5]	ADC module 0 channel 8 input	Analog input
10	ADC0_AN9	E[6]	ADC module 0 channel 9 input	Analog input
11	ADC0_AN10	E[7]	ADC module 0 channel 10 input	Analog input
12	NC	—	—	—
13	GNDA	—	Analog ground	—
14	+3.3VA2	—	+3.3V analog voltage	—

Table 17. Header J7 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	ADC1_AN0	B[13]	ADC module 1 channel 0 input	Analog input
2	ADC1_AN1	B[14]	ADC module 1 channel 1 input	Analog input
3	ADC1_AN2	B[15]	ADC module 1 channel 2 input	Analog input
4	ADC1_AN3	C[0]	ADC module 1 channel 3 input	Analog input
5	ADC1_AN4	D[15]	ADC module 1 channel 4 input	Analog input
6	ADC1_AN5	E[0]	ADC module 1 channel 5 input	Analog input
7	ADC1_AN6	E[8]	ADC module 1 channel 6 input	Analog input
8	ADC1_AN7	E[9]	ADC module 1 channel 7 input	Analog input
9	ADC1_AN8	E[10]	ADC module 1 channel 8 input	Analog input
10	ADC1_AN9	E[11]	ADC module 1 channel 9 input	Analog input
11	ADC1_AN10	E[12]	ADC module 1 channel 10 input	Analog input
12	NC	—	—	—
13	GNDA	—	Analog ground	—
14	+3.3VA2	—	+3.3V analogue voltage	—

Table 18. Header J9 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	ADC0/1_AN11	B[9]	ADC module 0/1 channel 11 input	Analog input
2	ADC0/1_AN12	B[10]	ADC module 0/1 channel 12 input	Analog input
3	ADC0/1_AN13	B[11]	ADC module 0/1 channel 13 input	Analog input
4	ADC0/1_AN14	B[12]	ADC module 0/1 channel 14 input	Analog input
5	+3.3VA2	—	+3.3V analogue voltage	—
6	GNDA	—	Analog ground	—

3.11 Header J3

Headers J3 allows monitoring the miscellaneous digital signals, see Table 19.

Table 19. Header J12 Signal Description

Interface Pin	Signal Name	MCU Port	Description	Direction
1	SCI0_TX	B[2]	Digital input/output	Digital I/O
2	SCI0_RX	B[3]	Digital input/output	Digital I/O
3	SPI3_SCK	E[13]	Digital input/output	Digital I/O
4	SPI3_SOUT	E[14]	Digital input/output	Digital I/O
5	SPI3_SIN	E[15]	Digital input/output	Digital I/O
6	SPI3_CS0	F[3]	Digital input/output	Digital I/O
7	GND	—	Ground	—
8	+3.3Vdc	—	+3.3V voltage	—

4 Design Consideration

The MPC5604P Controller Board is designed for demonstration of the ability of Freescale MPC5604P device to control various electrical motors and for easier development of the motor-control applications. In addition to the hardware needed to run a motor, a variety of feedback signals that facilitate control-algorithm development are provided. A set of schematics for the controller board appears in the following section.

4.1 MPC5604P Features

The MPC5604P is the first member of family of microcontrollers based on Power Architecture®, targeted at chassis and safety market segment, specifically at lower-end Electrical Power Steering and airbag-application market space. The used core is the Harvard-bus interface version of the e200z0.

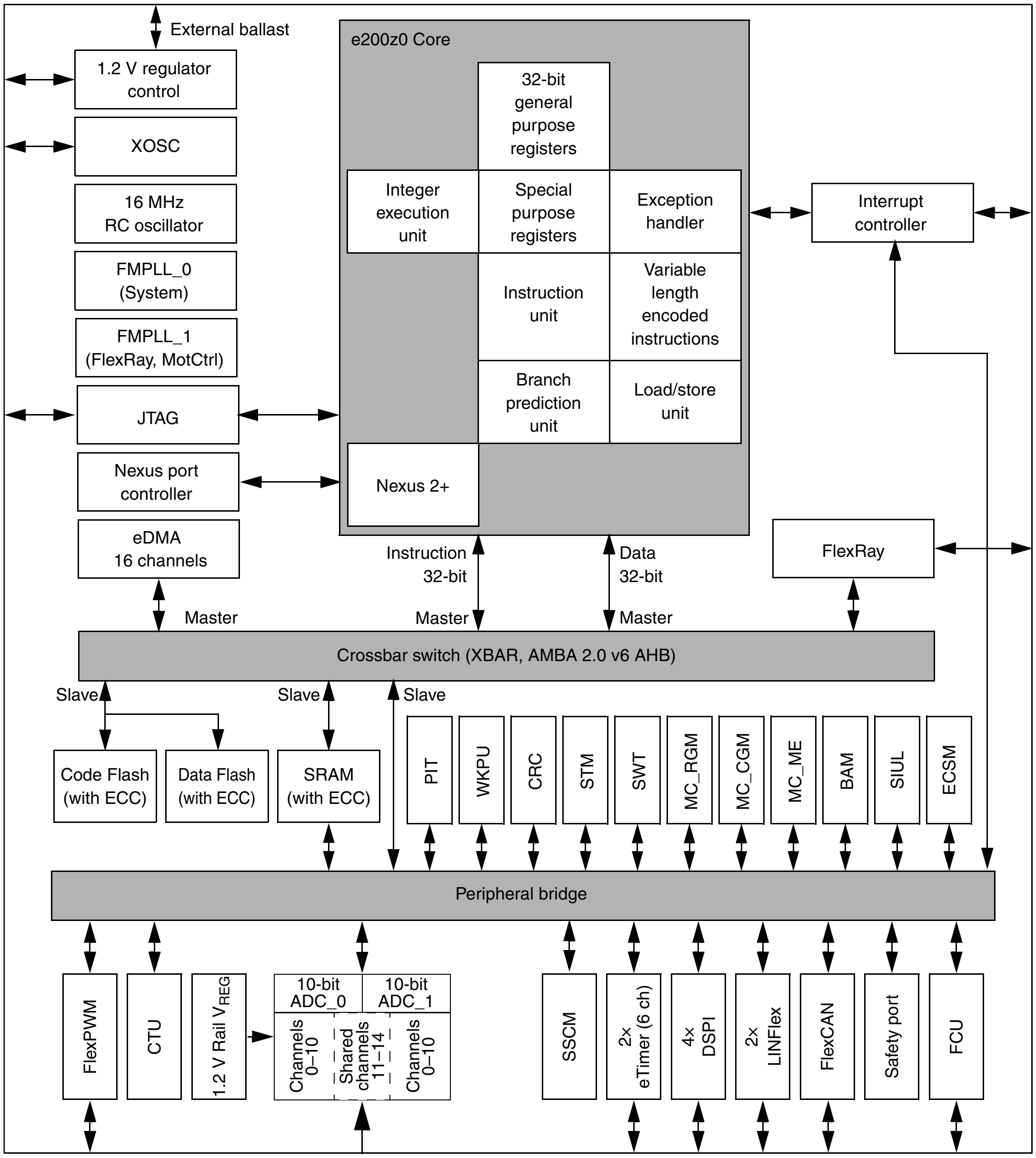
The MPC5604P has a single level of memory hierarchy consisting of 40 KB on-chip SRAM, 512+64 KB of on-chip Flash memory. Both SRAM and Flash memory can hold instruction and data.

The timer functions of MPC5604P are performed by the eTimer — Modular Timer System and FlexPWM. The two eTimer modules implement enhanced timer features (six channels each for a total of 12) including dedicated motor-control quadrature-decode functionality and DMA support; FlexPWM module consists of four submodules controlling a pair of PWM channels each; three submodules may be used to control the three phases of a motor and the additional pair to support DC-DC converter width modulation control.

Off-chip communication is performed by a suite of serial protocols including FlexRay, CANs, enhanced SPIs (DSPI), and SCIs (LinFlex).

The System Integration Unit Lite (SIUL) performs several chip-wide configuration functions. Pad configuration and General-Purpose Input and Output (GPIO) are controlled from SIUL. External interrupts and reset control are also found in the SIUL. The internal Multiplexer sub-block (IOMUX) provides multiplexing of daisy chaining the DSPIs and external interrupt signal.

You can find detailed description of the MCU in the datasheet or reference manual.



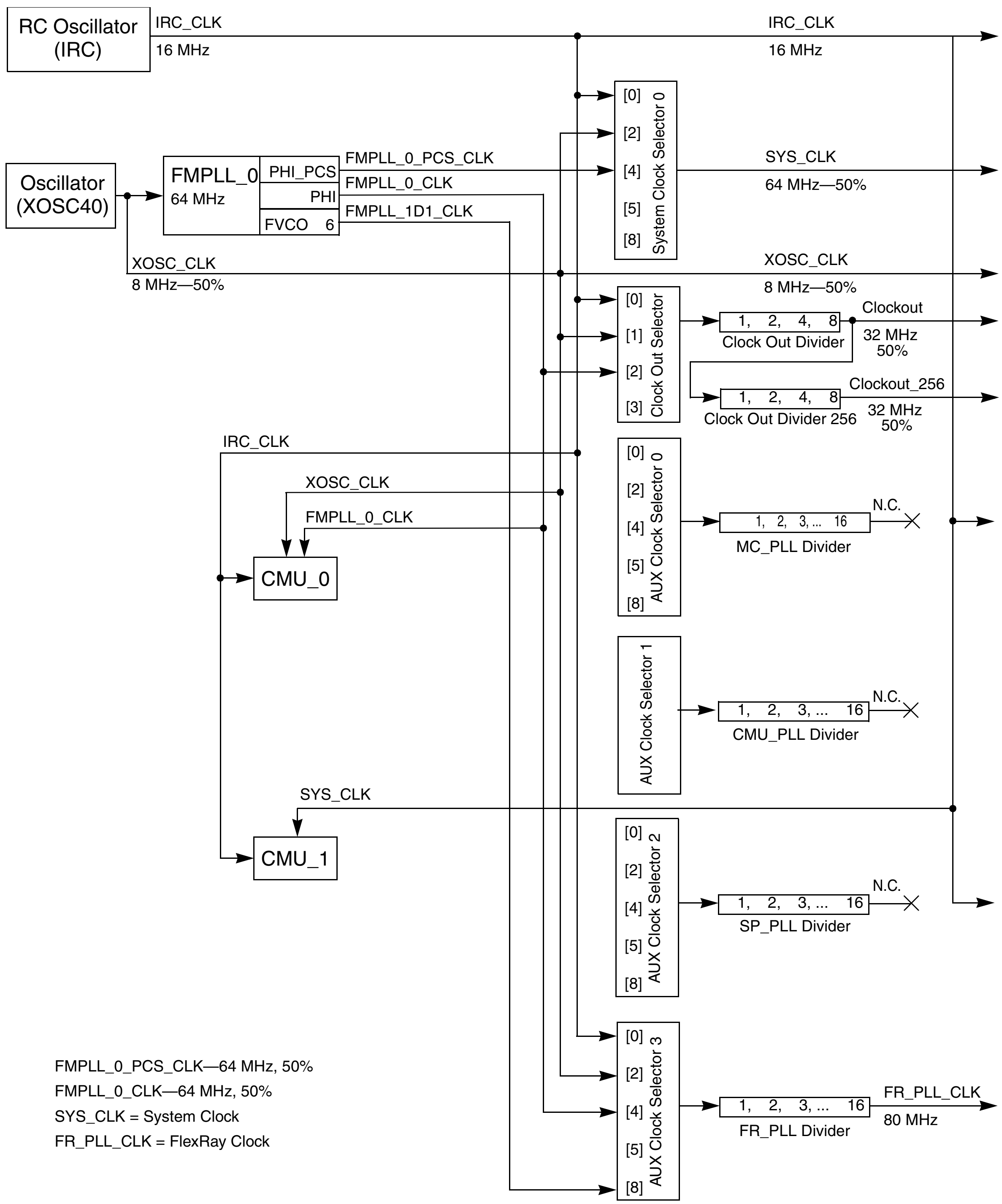
Legend:

ADC	Analog-to-digital converter	LINFlex	Serial communication interface (LIN support)
BAM	Boot assist module	MC_CGM	Clock generation module
CRC	Cyclic redundancy check	MC_ME	Mode entry module
CTU	Cross triggering unit	MC_PCU	Power control unit
DSPI	Deserial serial peripheral interface	MC_RGM	Reset generation module
ECSM	Error correction status module	PIT	Periodic interrupt timer
eDMA	Enhanced direct memory access	SIUL	System integration unit Lite
eTimer	Enhanced timer	SRAM	Static random-access memory
FCU	Fault collection unit	SSCM	System status and configuration module
Flash	Flash memory	STM	System timer module
FlexCAN	Controller area network	SWT	Software watchdog timer
FlexPWM	Flexible pulse width modulation	WKPU	Wakeup unit
FMPLL	Frequency-modulated phase-locked loop	XOSC	External oscillator
INTC	Interrupt controller	XBAR	Crossbar switch
JTAG	JTAG controller		

Figure 4. MPC5604P Block Diagram

4.2 Clock Source

The MPC5604P uses external 8.00 MHz crystal oscillator mounted on the board and internal PLL0 to multiply the input frequency, to achieve its 64 MHz maximum operating frequency. The second PLL1 is used to achieve suitable frequency (120MHz) for internal Motor control, SWG, and communication modules. The MPC5604P can also use internal 16 MHz RC oscillator as clock source, in this mode FlexRAY protocol clock does not support IRCOSC as a clock source.



NOTE: FlexRay protocol clock does not support IRC as a clock source.

Figure 5. MPC5604P Block Diagram

4.3 UNI3 Interfaces and External Fault Management

The motor power stages are controlled by microcontroller boards through two UNI3 and MC33937 connectors. The connector pin description was mentioned before in Section 3, “Interface Description. Analog or digital signals from the power stage M1 can be processed by hardware to maintain fault management. The MPC5604P has four fault inputs and switch off PWM output signals in module.

The FAULT0 signal can be set up as under- or over-voltage. Whether the output signals from Phase A or DCBUS over-current comparator can be asserted to the input FAULT1, depends on jumper position J301. The FAULT2 and FAULT3 inputs can be used as over-current signals from phase B and C. The phase OC level is set up by trimmer R300, as given in Figure 6.

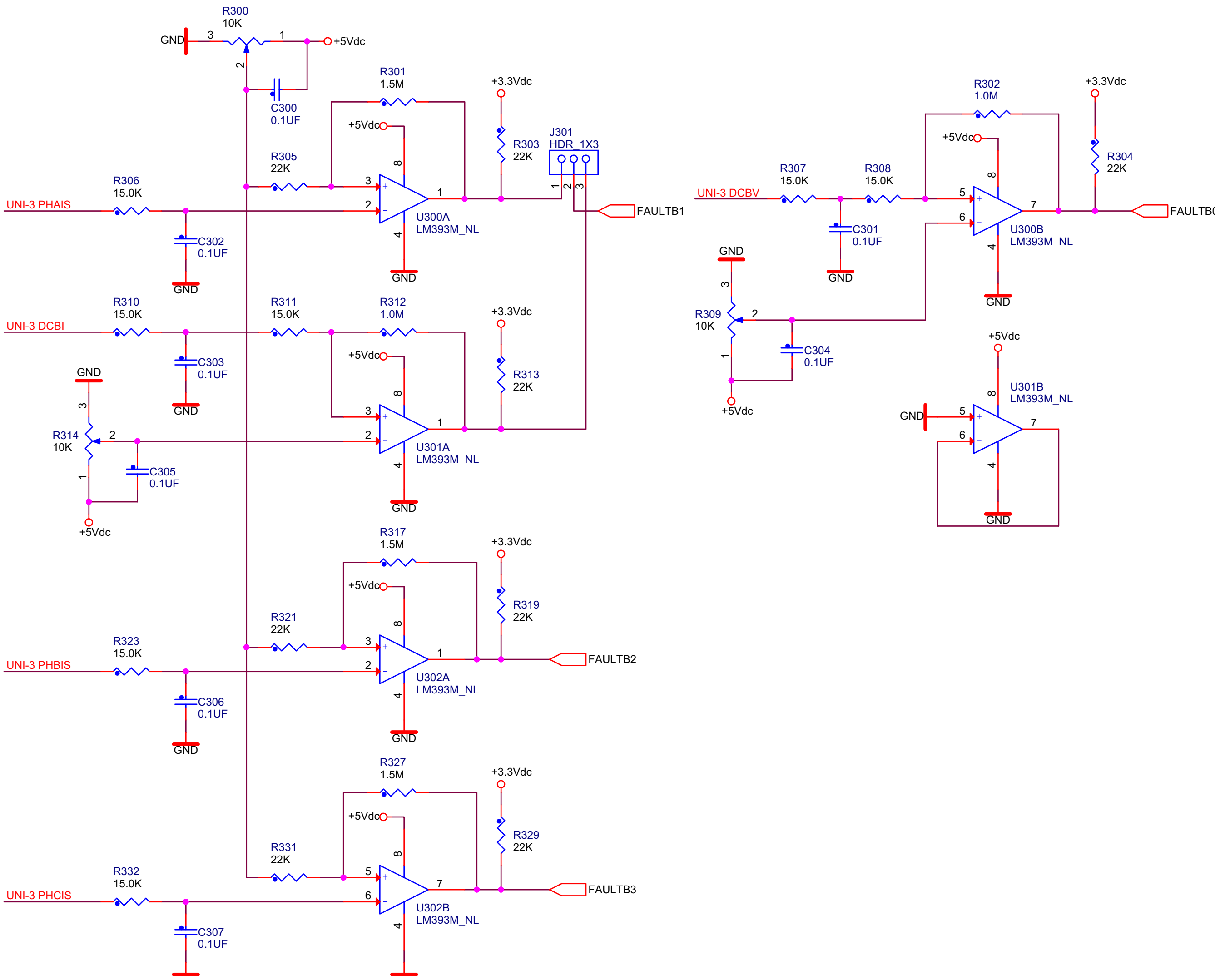


Figure 6. FAULT Management

Table 20. Header J301 — FAULT1 Signal Assignment

Jumper Position	Description
1–2	Phase A over-current
2–3	DC-bus-over current

4.4 Encoder/Hall Sensor Interface

The motor control application can read position or speed from up to two independent encoders or HALL sensors. The on-board interfaces 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 a signal noise.

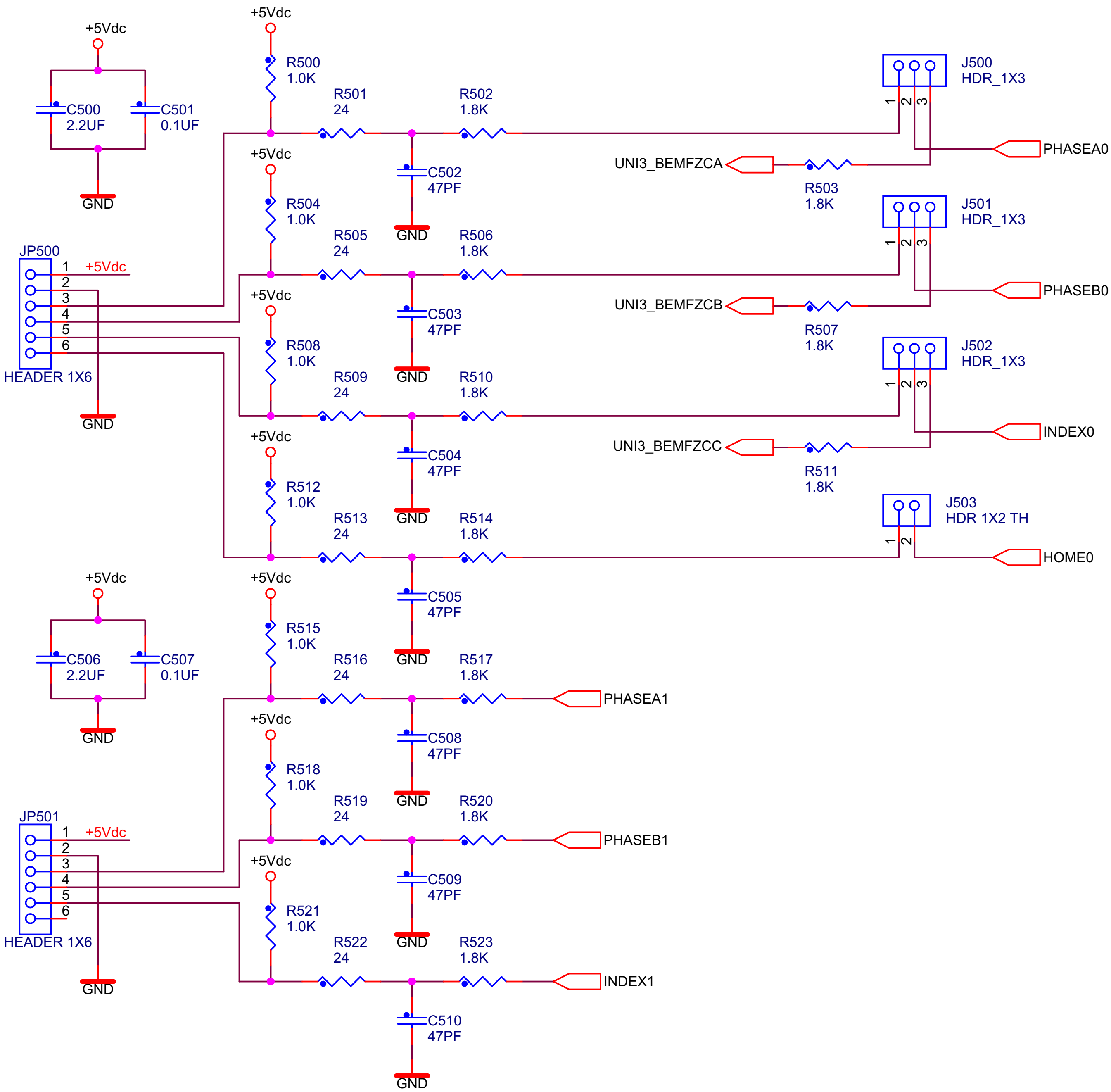


Figure 7. Encoder/Hall Sensor Interface Circuit

4.5 Resolver and SinCos Sensor Interface

The resolver or SinCos interface is present on the board to observe actual motor rotor position.The board is populated with hardware interface to allow measurement of motor rotor position and speed. Figure 8 shows resolver hardware circuitry. The resolver sensor can be connected through J207 connector. The jumpers J203 and J204 provide selection of the positive input signal for differential amplifiers. In case of use a resolver sensor, pins two and three should be shorted. The excitation signal output level (terminals

RES_GEN and GNDP) is set up by trimmer R221. The resolver excitation signal for resolver circuitry can be selected by J2, the source signals are outputs from eTimer0.channel4 and eTimer0.channel5.

For detailed J207 connector signal description, see Table 8.

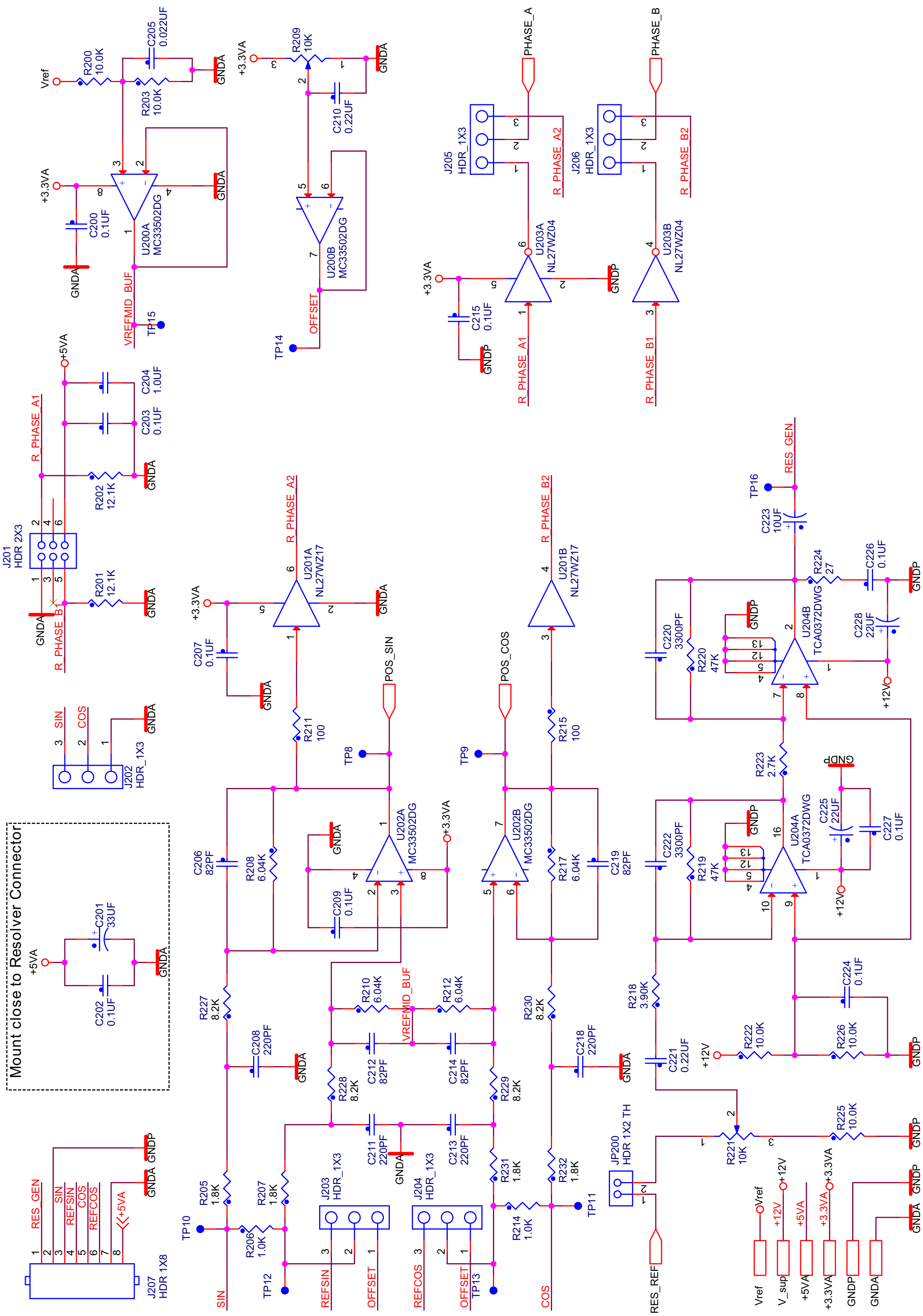


Figure 8. Resolver Interface Schematic

The resolver is an electro-mechanical transformer whose analog output voltages are a function of shaft angle. It is, therefore, an absolute position transducer, providing true angular information at any time. The reference winding (R1 and R2 terminals) is excited by an alternating signal Vref and output is taken from the two stator windings, as is depicted in Figure 9. The two stator windings fixed at right (90°) angles to each other on the stator, produce a sine and co-sine feedback voltages Vsin, Vcos, respectively. However, their amplitudes are modulated by sine and cosine as the shaft rotates, see Figure 10 in other words, the voltages induced into the stator winding will be Vsin=K*sin(Θ)*sin(ωt) and Vsin=K*cos(Θ)*sin(ωt), where K is the transformation ratio, Θ is the shaft rotation from reference zero-degree position, and ω =2πf carrier frequency.

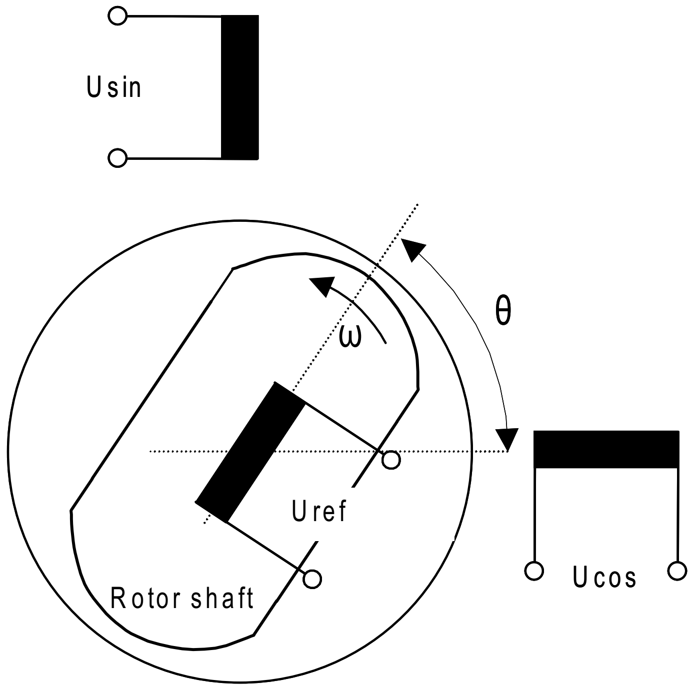


Figure 9. Resolver Basics

These outputs are modified by a differential amplifiers and fed to an analog-to-digital converter. The rotor angle Θ can be extracted from these voltages using a digital approach. For detailed description, see application note AN1942.

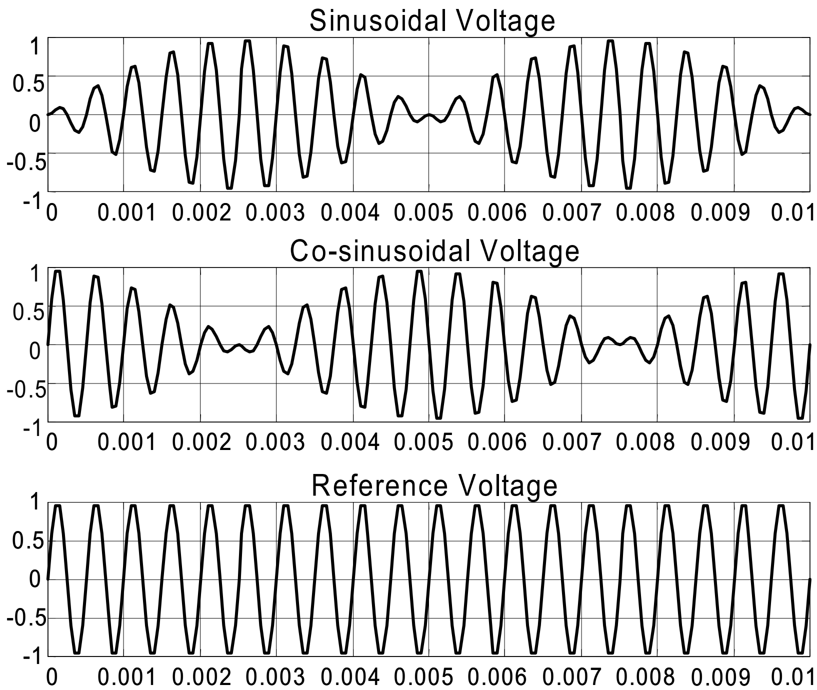


Figure 10. Resolver Excitation Signals

4.6 Analog Signal Sensing

The MPC5604P can sample up to 2×16 analog signals. External 2×11 channels are connected through RC filters directly to ADC converters zero and one, next four channels are common and can be internally switched between both converters. They can be used to sample phase motor currents. The ADC0 channel 15 is dedicated for internal 1.2 V rail, and ADC1 channel 15 for the temperature sensor.

The time constant of RC filter should be set according to system requirements. The default time constant was set to approximately 1.2 µs on the inputs zero to ten, and shared inputs are set to approximately 50 ns.

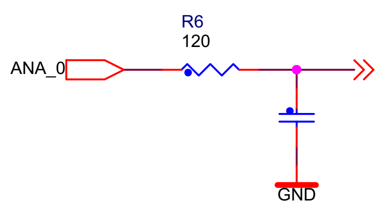


Figure 11. Analog Sensing Circuit

4.7 Power Supplies and Voltage Reference

The MPC5604P Controller Board can be supplied from three main power supply inputs. The first one uses a 2.1 mm coaxial power jack and other one uses UNI-3 connector. Which one is more suitable depends on application type. The controller board provides a +5 V DC-voltage regulation for the resolver, encoder, and FlexRAY driver, a +3.3 V DC-voltage regulation for MCU and supporting logic, and it provides reference voltage for ADC module. The block diagram is shown in Figure 12.

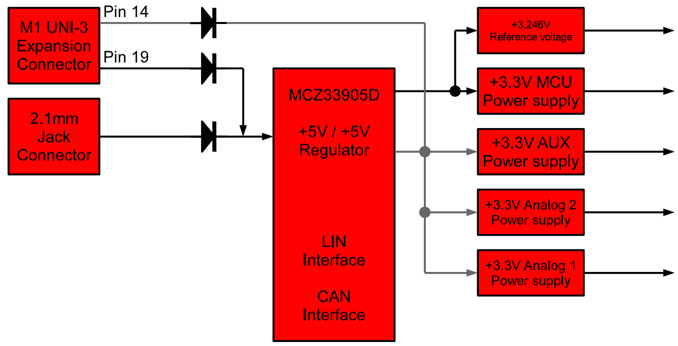


Figure 12. Power Supply

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

The PFC-PWM signal is used to additionally control the power stage circuit like PFC or power DC-DC converter. These signals are connected to the MPC5604P controller pins GPIO G[6], and G[7].

4.9 UNI-3 Brake Signal

The brake signal is used to control the DC-bus resistor switch on connected power stage. It is accessible via GPIO C[3].

4.10 CAN 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 MPC5604P reference manual for detailed description. Freescale system basis chip MC33905S with one CAN and one LIN interface is used as the hardware interface for FlexCAN module. Jumpers JP1 and JP2 define middle or end node. The Safety CAN module (Safety Port) doesn't have a physical interface populated on the board but the signals are accessible via header J13.

4.11 FlexRAY Interface

The FlexRAY module implements the FlexRay Communications System Protocol Specification, Version 2.1 Rev A. The hardware interface consists of two TJA1080 ICs.

5 Electrical Characteristics

The electrical characteristics in Table 21 apply to an operation at 25 °C.

Table 21. Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Units
Power supply Voltage	VDC	8	12	18	V
Current consumption[1]	ICC	—	TBD	—	mA
Minimum Logic one Input Voltage	VIH	—	—	—	mA
Maximum Logic zero Input Voltage	VIL	—	—	—	mA
Input Logic Resistance	RIN	—	4.7	—	KΩ
Analog Input Range		0	—	3.3	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 J100 connector, with a power supply voltage from 8 to 18V. When using the board as a standalone EVB, connect the power supply to J100. In the case of board operation with the power stage is strongly recommended to supply the board using the UNI-3 interface.

The MPC5604P Controller Board is designed for operation with the Freescale MC33937A based 3-Phase low voltage power stage, see Figure 13 Development Kit can be ordered at. The complete 3-phase BLDC/PMSM Sensor/Sensorless http://www.freescale.com.

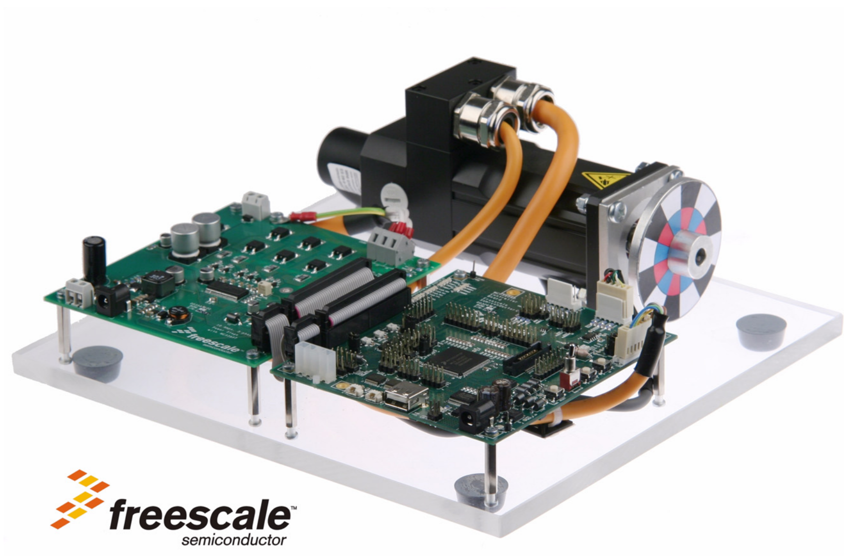


Figure 13. 3-Phase Single PMSM Development Kit

7 MPC5604P Controller Board Schematics

REVISIONS

Zone	Rev	Description	Date	Approved
	A	BLDC varian from 26776	27-Jan, 12	PK
	A1	1X2 headers instead of jumpers	19-Jul, 12	MB

Variant table

Agile #	Variant
27475	BLDC
27476	PMSM

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Drawing Title: **MPC5604P Controller Board**

Page Title: **REVISIONS**

Size	Document Number	Rev
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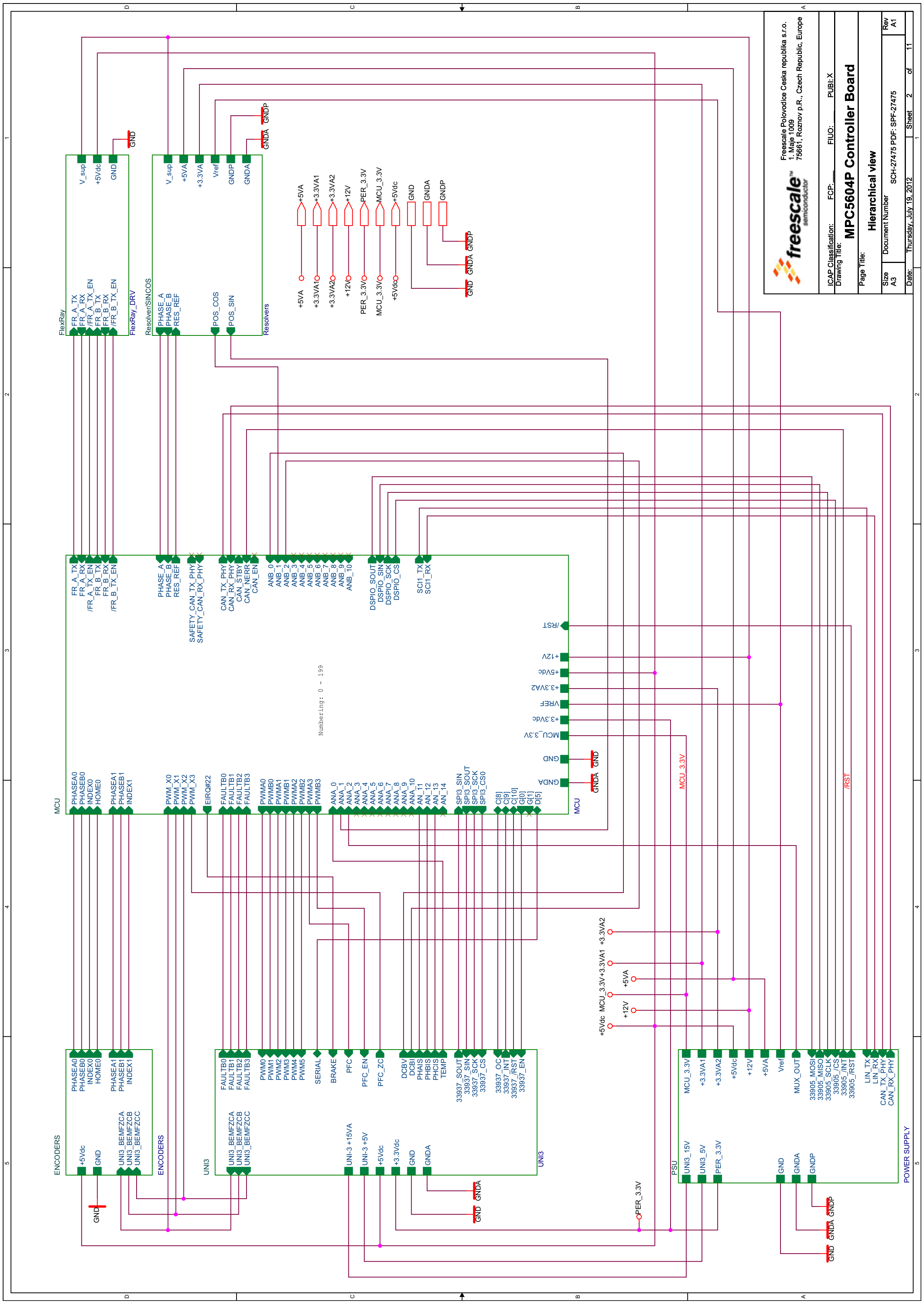
Date: Thursday, July 19, 2012 Sheet 1 of 11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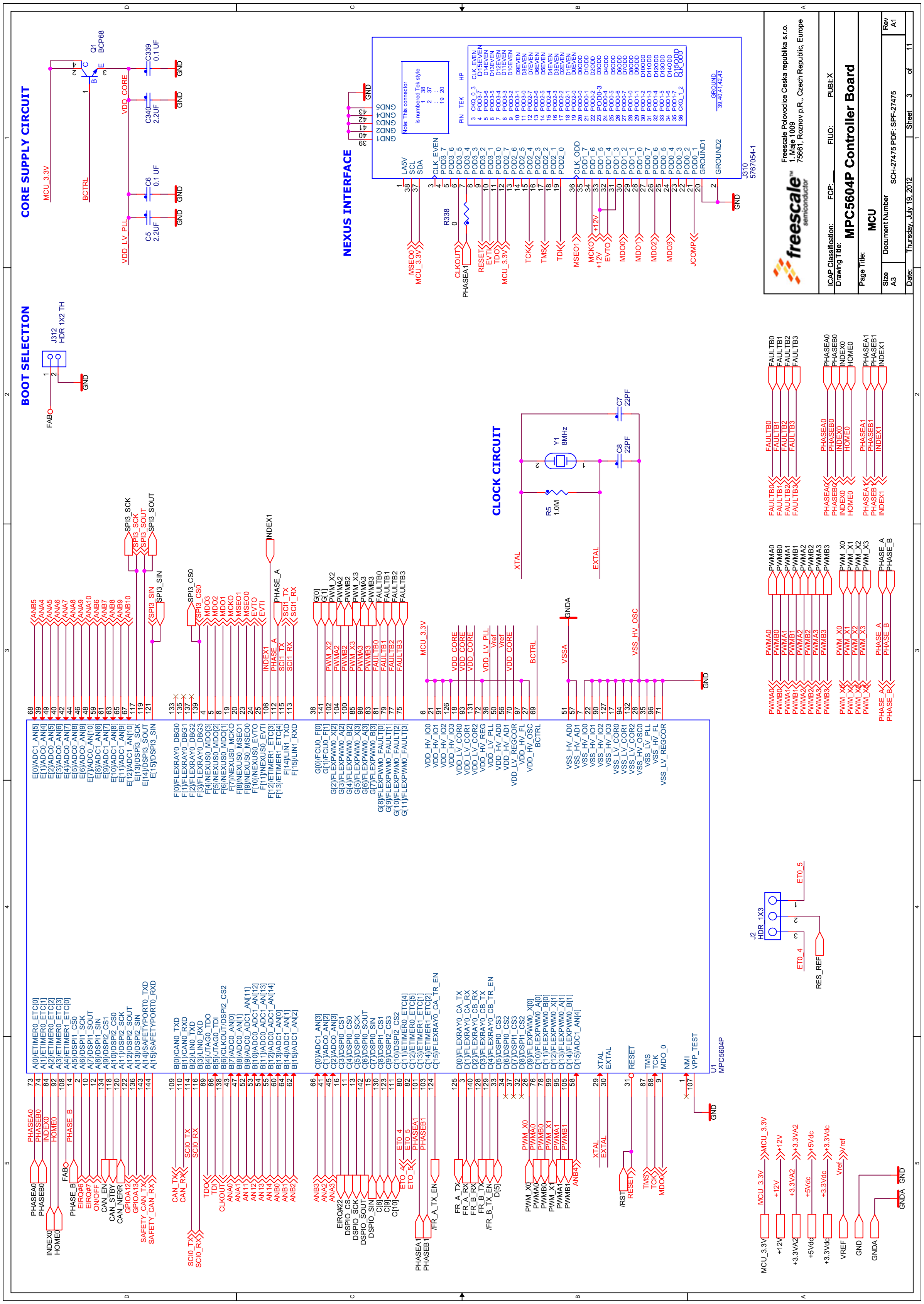
MPC5604P Controller Board
Page Title:
Hierarchical view
Size A3
Document Number SCH-27475 PDF: SPF-27475
Rev A1
Date: Thursday, July 19, 2012
Sheet 2 of 11
FlexRay
Resolver/SINCOS
Resolvers
MCU
ENCODERS
UNI3
PSU
POWER SUPPLY


CORE SUPPLY CIRCUIT
BOOT SELECTION
NEXUS INTERFACE
CLOCK CIRCUIT
Freescale Polovodice Ceska republika s.r.o.
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MCU
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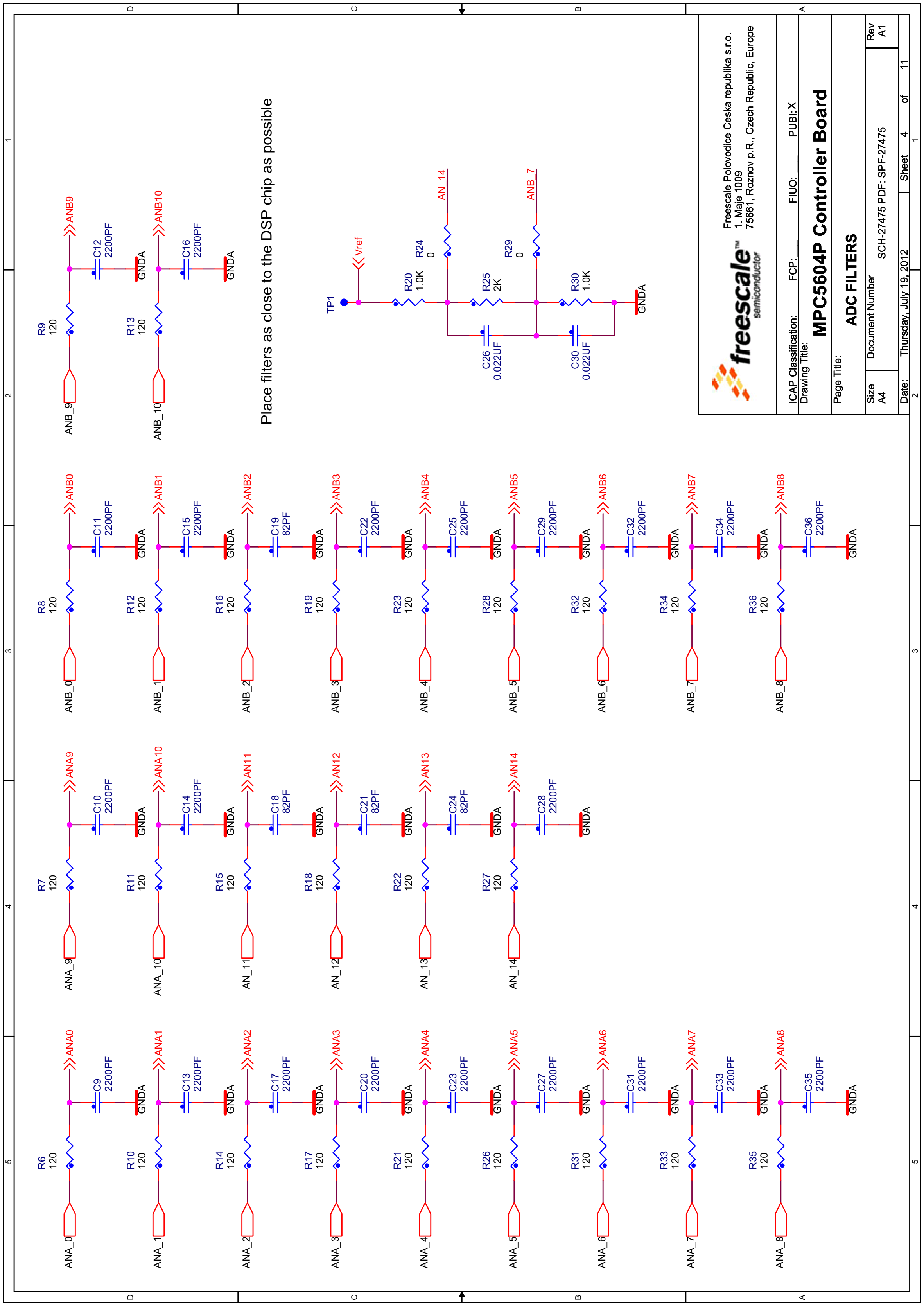
Place filters as close to the DSP chip as possible
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75661, Roznov p.R., Czech Republic, Europe
freescale semiconductor
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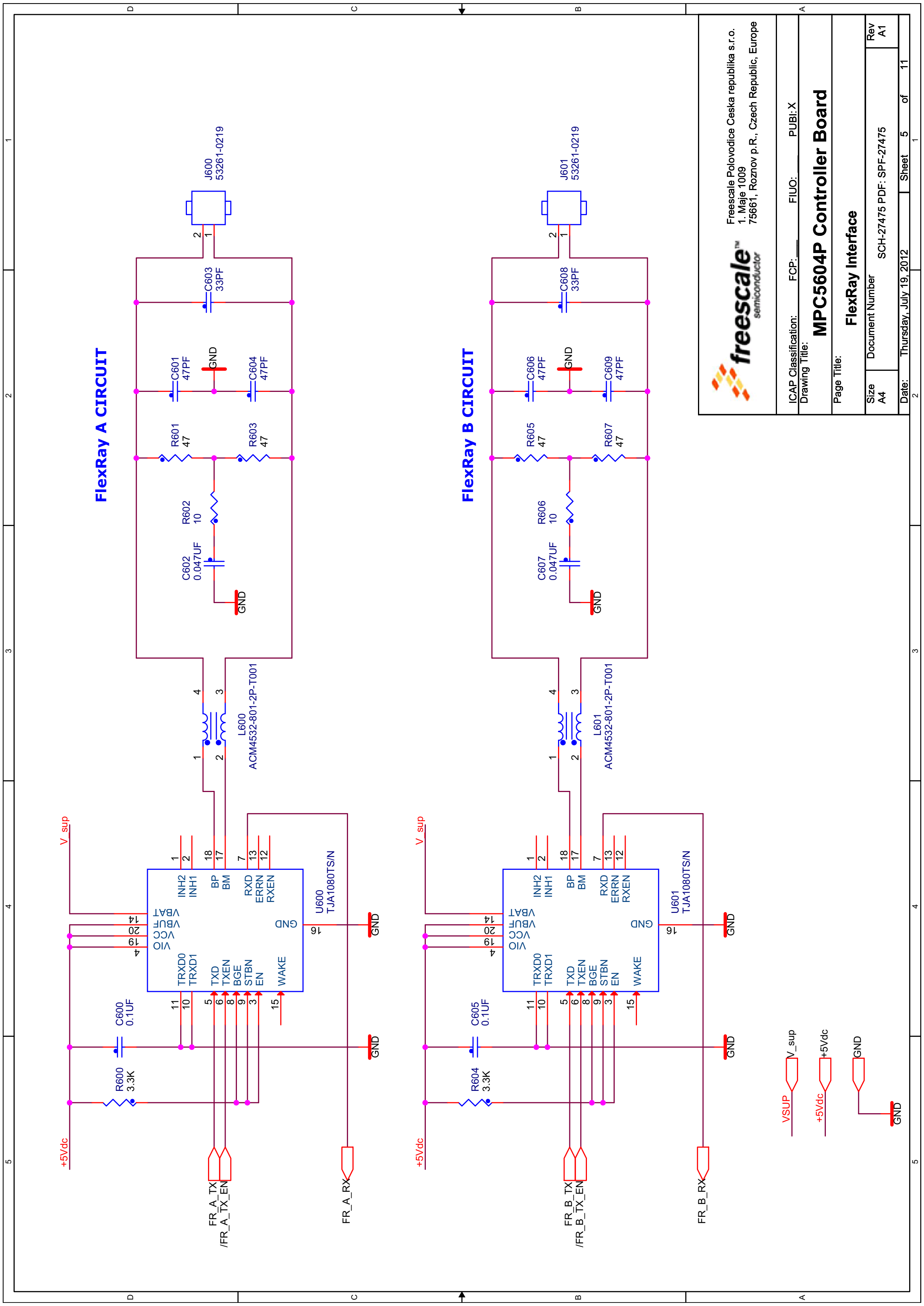
Rev A1
Date: Thursday, July 19, 2012
Sheet 4 of 11


FlexRay A CIRCUIT
FlexRay B CIRCUIT
J600
53261-0219
J601
53261-0219
C603
33PF
C608
33PF
C601
47PF
C604
47PF
C606
47PF
C609
47PF
R601
47
R603
47
R605
47
R607
47
R602
10
R606
10
C602
0.047UF
C607
0.047UF
L600
ACM4532-801-2P-T001
L601
ACM4532-801-2P-T001
U600
TJA1080TS/N
U601
TJA1080TS/N
INH2
INH1
BP
BM
RXD
ERRN
RXEN
VBAT
VBUF
VCC
VIO
GND
TRXD0
TRXD1
TXD
TXEN
BGE
STBN
EN
WAKE
V_sup
+5Vdc
C600
0.1UF
C605
0.1UF
R600
3.3K
R604
3.3K
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FR_A_RX
FR_B_TX
/FR_B_TX_EN
FR_B_RX
VSUP
GND
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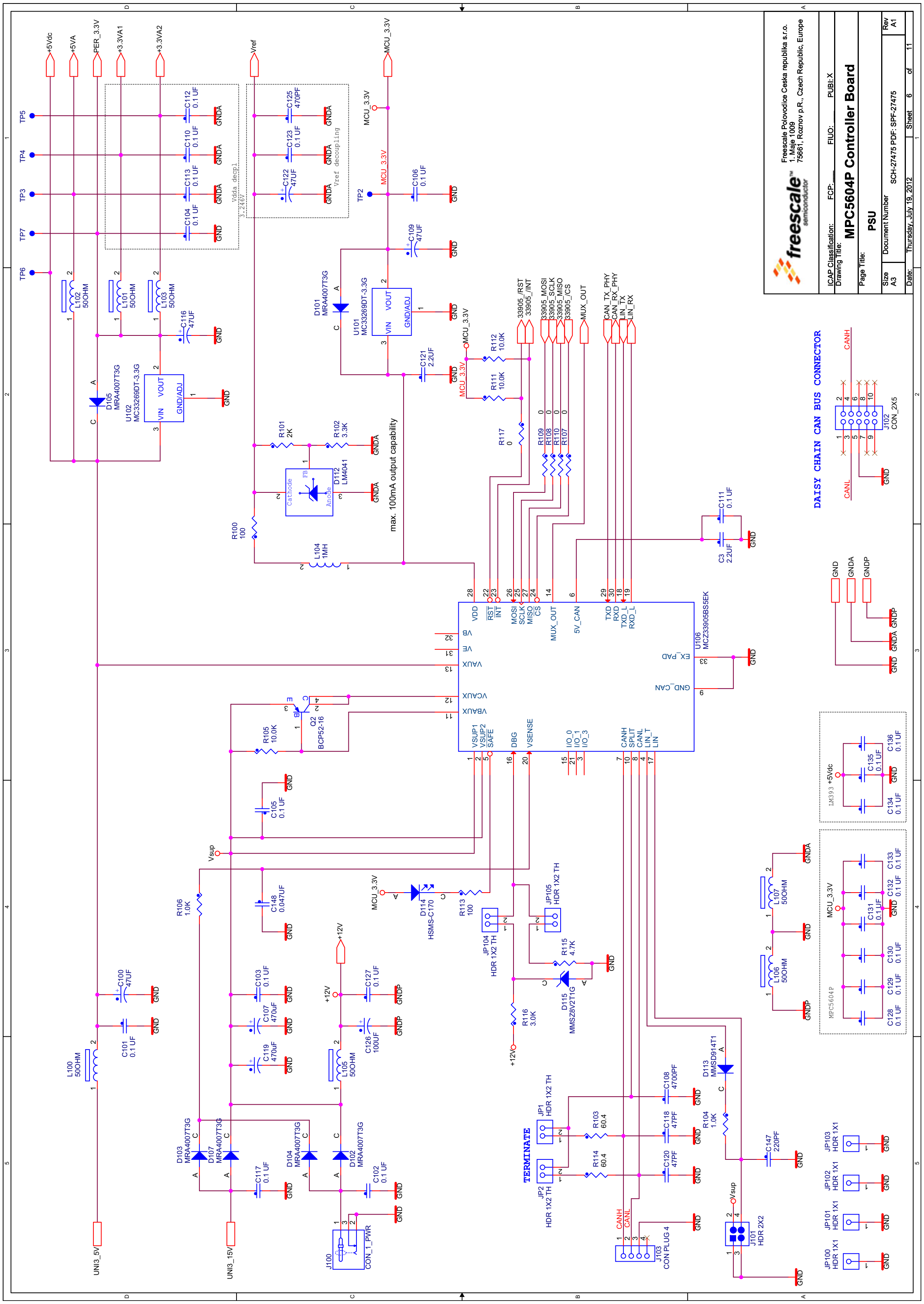

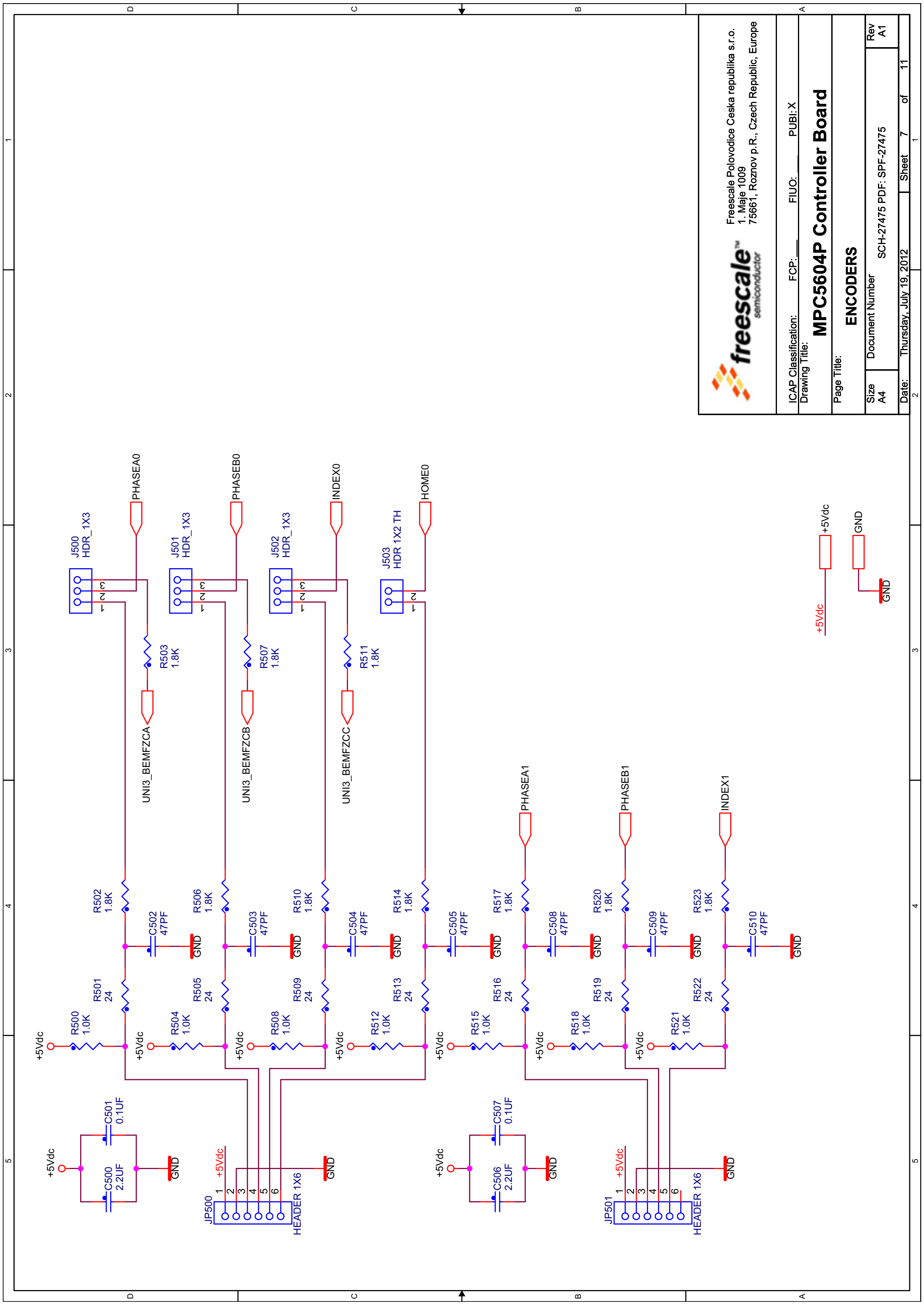

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MPC5604P Controller Board
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ENCODERS
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Document Number SCH-27475 PDF: SPF-27475
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Sheet 7 of 11
J500 HDR_1X3
J501 HDR_1X3
J502 HDR_1X3
J503 HDR 1X2 TH
PHASEA0
PHASEB0
INDEX0
HOME0
PHASEA1
PHASEB1
INDEX1
UNI3_BEMFZCA
UNI3_BEMFZCB
UNI3_BEMFZCC
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R507 1.8K
R511 1.8K
R502 1.8K
R506 1.8K
R510 1.8K
R514 1.8K
R517 1.8K
R520 1.8K
R523 1.8K
C502 47PF
C503 47PF
C504 47PF
C505 47PF
C508 47PF
C509 47PF
C510 47PF
R501 24
R505 24
R509 24
R513 24
R516 24
R519 24
R522 24
R500 1.0K
R504 1.0K
R508 1.0K
R512 1.0K
R515 1.0K
R518 1.0K
R521 1.0K
C500 2.2UF
C501 0.1UF
C506 2.2UF
C507 0.1UF
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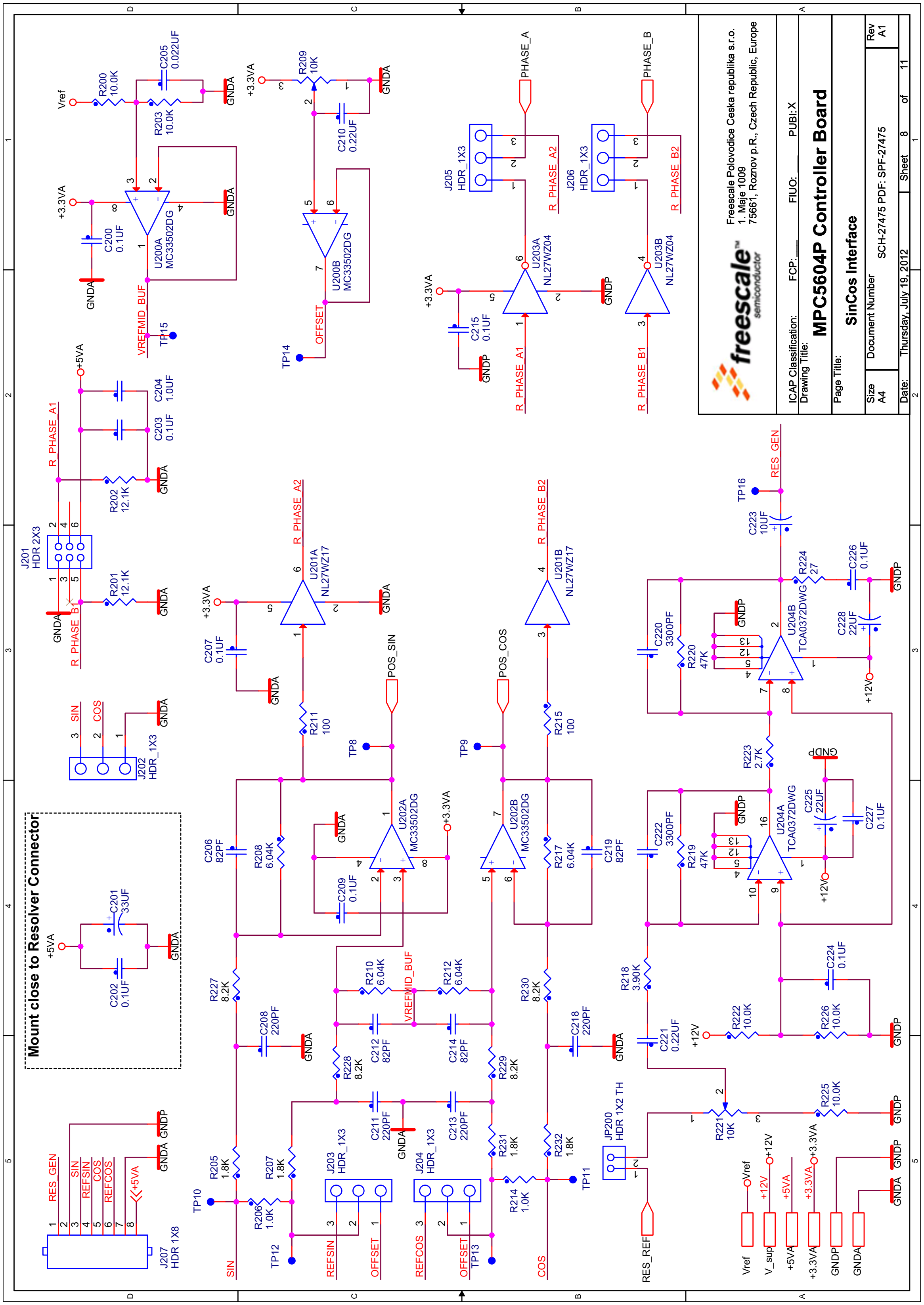
GND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SinCos Interface
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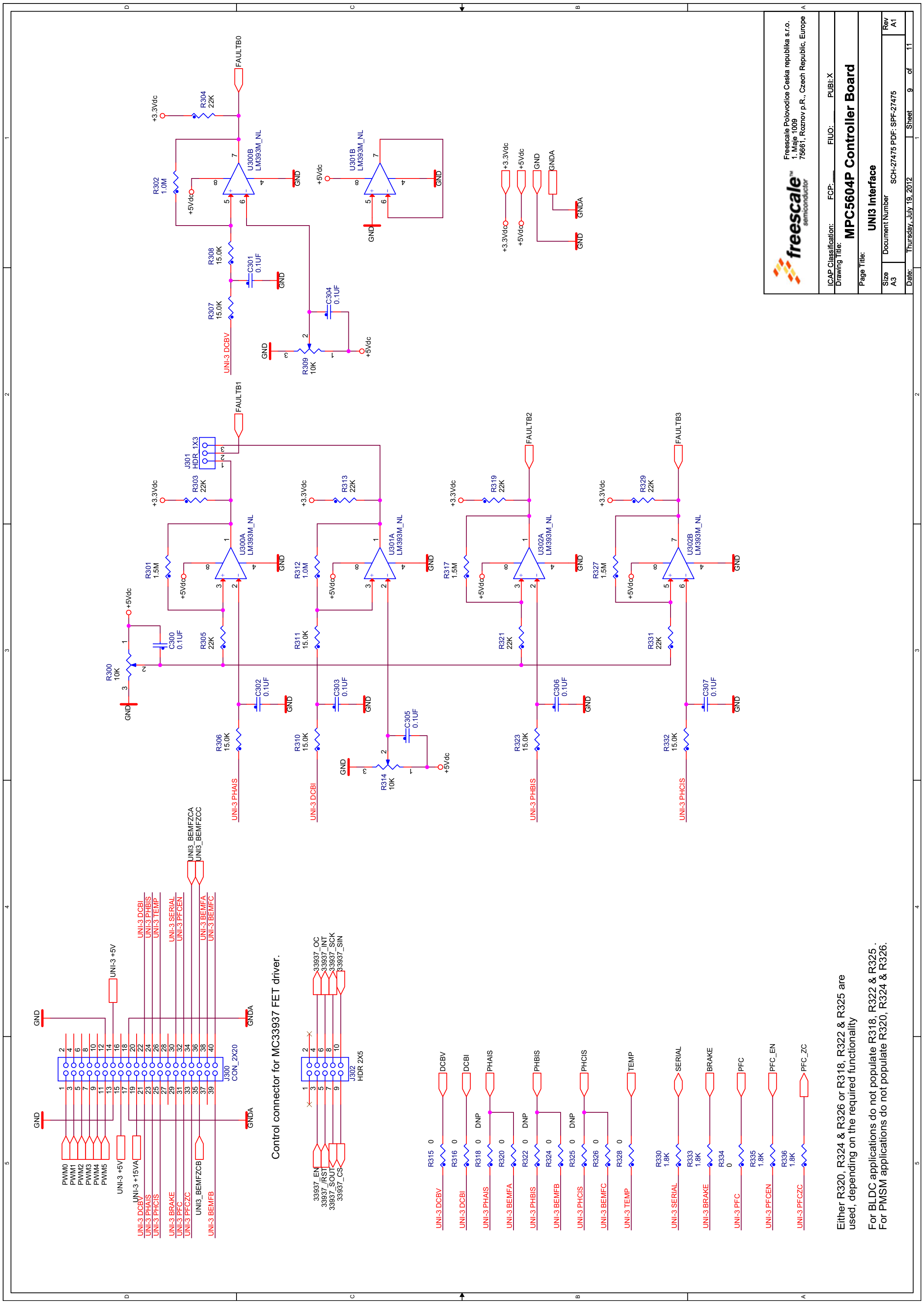
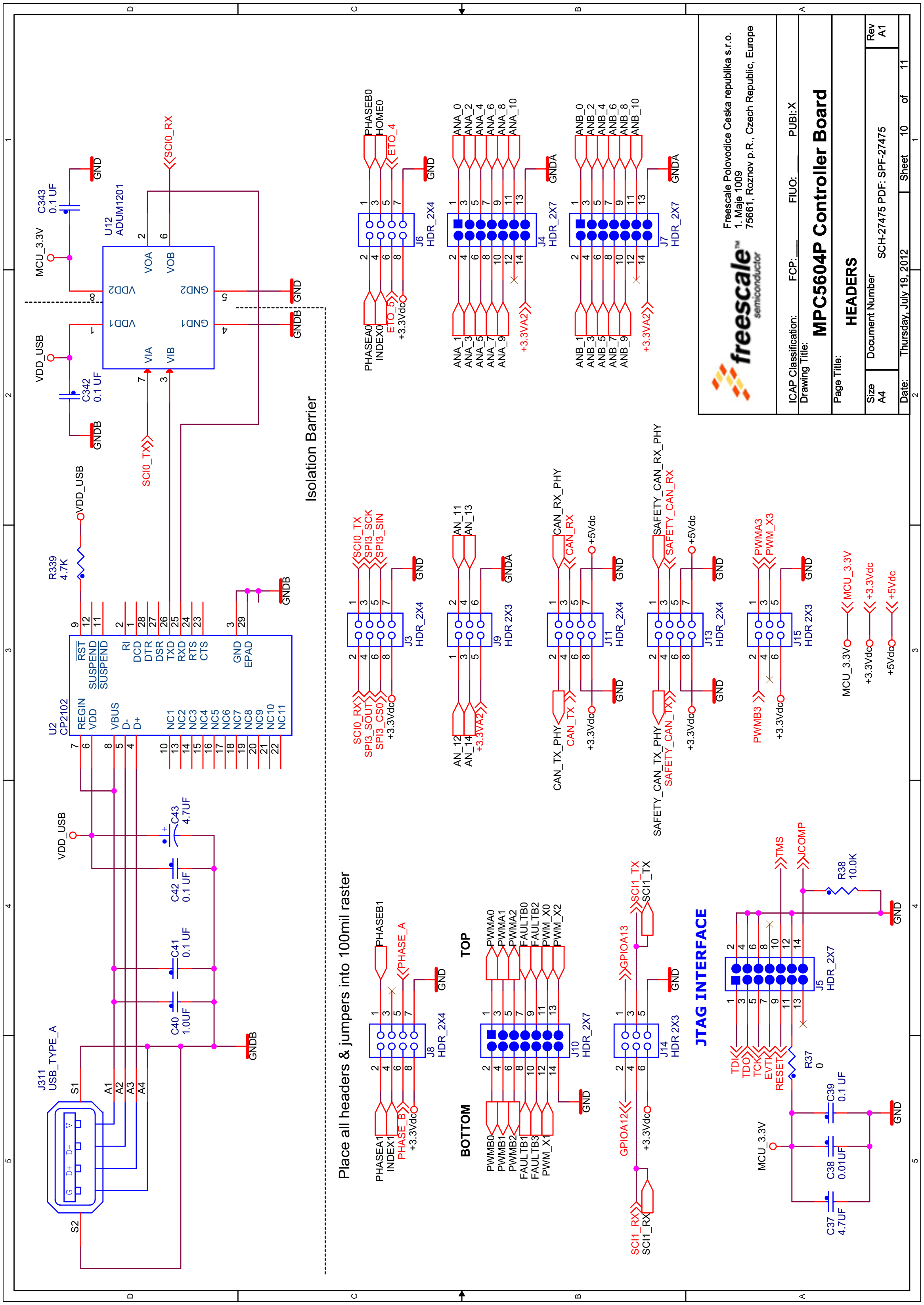
Rev A1
Date: Thursday, July 19, 2012
Sheet 8 of 11
Mount close to Resolver Connector


MPC5604P Controller Board
UNI3 Interface
Control connector for MC33937 FET driver.
Either R320, R324 & R326 or R318, R322 & R325 are used, depending on the required functionality
For BLDC applications do not populate R318, R322 & R325 .
For PMSM applications do not populate R320, R324 & R326.


Isolation Barrier
Place all headers & jumpers into 100mil raster
TOP
BOTTOM
JTAG INTERFACE
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MPC5604P Controller Board
HEADERS
SCH-27475 PDF: SPF-27475
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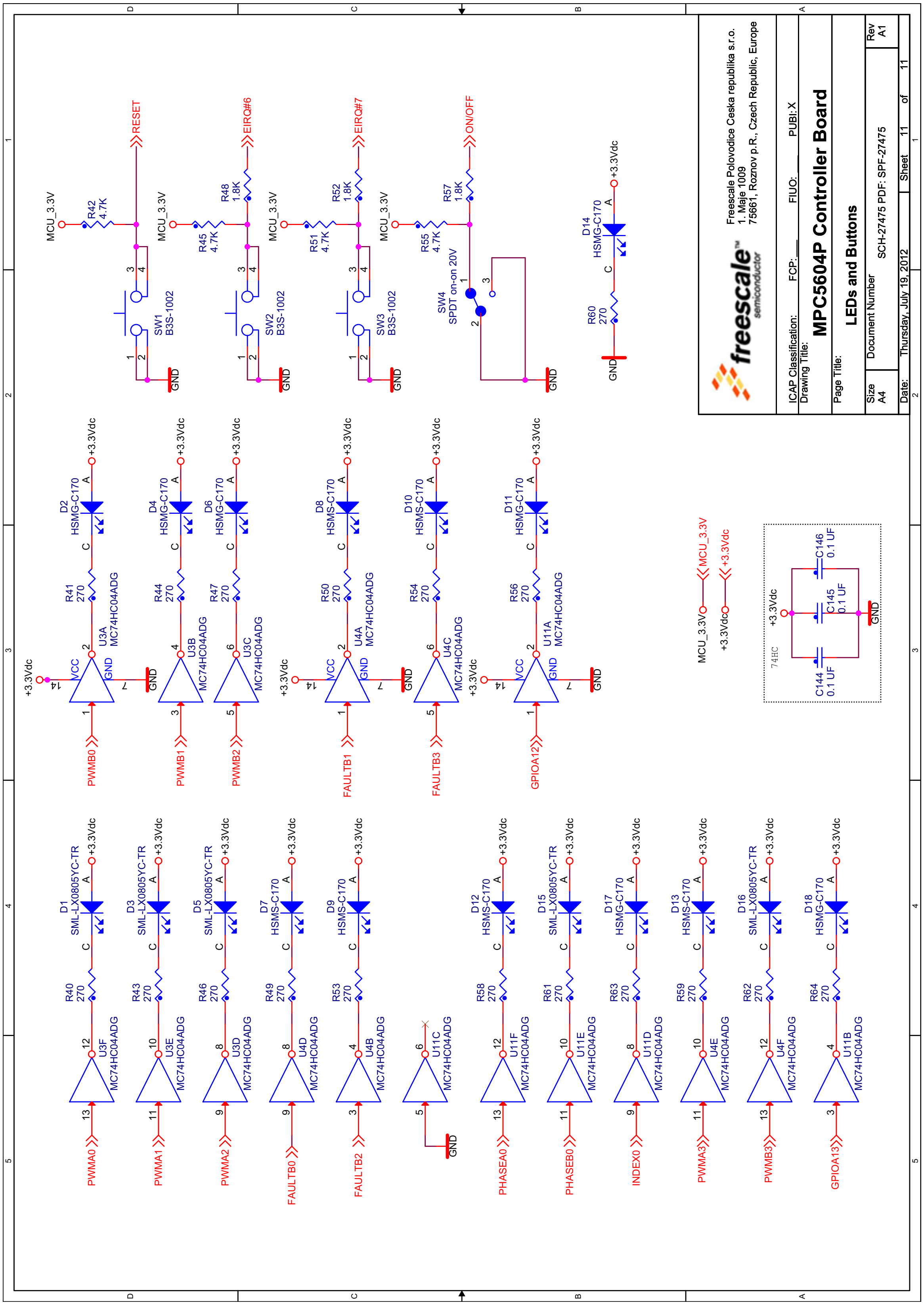
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MPC5604P Controller Board
Page Title:
LEDs and Buttons
Size A4
Document Number SCH-27475 PDF: SPF-27475
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Date: Thursday, July 19, 2012
Sheet 11 of 11

8 References

The MPC5604P documentation is available at the web site, http://www.freescale.com. as follows:

- Reference manuals — MPC5604P modules in detail
- Data sheets — information mainly on the device’s AC, DC, thermal characteristics and packages pinout
- Product briefs — device overview
- Application notes — address specific design issues

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