MPC5744P Motor Controller Board User Manual

Devices Supported:
MPC5744P

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About This Book

This document describes the design of the MPC5744P Controller Board, which is targeted for rapid 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	Page number(s)
June 2015	1.0	Initial release	50

Documentation

The MPC5744P documentation is available at the web site, http://www.freescale.com. as follows:

- Reference manuals — MPC5744P 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

Chapter 2 Interface Description

Chapter 3 Design Consideration

Chapter 4 Electrical Characteristics

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Appendix A References

Appendix B Abbreviations

Appendix C MPC5744P Controller Board Schematic

Chapter 1 Introduction

The MPC5744P Motor Controller Board is designed to drive up to two 3-phase BLDC / PMSM motors, enabling implemetation 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
  - Encoder sensor signal monitoring

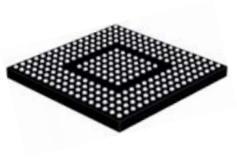
The two on-board PCI-Express interfaces enable control of the BLDC / PMSM motor power stages.

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

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

The Controller Board is assembled with MPC5744P in 257 MAPBGA package.

1.1 Features



The MPC5744P Controller Board features are as follows:

- MPC5744P microcontroller, 257 MAPBGA package (14 x 14 mm)
- JTAG & NEXUS interface for MCU code download and debugging
- System-basis chip MC33908
- Motor control interfaces:
  - 2x PCI-Express
- Connectivity interfaces:
  - 1x CAN
  - 2x SENT + 2x SENT SPC
  - USB interface
- LEDs:
  - Power-on indicators
  - SBC safe mode indicator
  - 6x user free indicators
- Controls:
  - Reset button
- Pin headers for MCU peripheral access.
- Power plug universal 2.1/2.5mm connector.

1.2 MPC5744P Board Architecture

The MPC5744P Controller Board contains the basic building blocks are depicted in (see Figure 1-1): The block colour 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

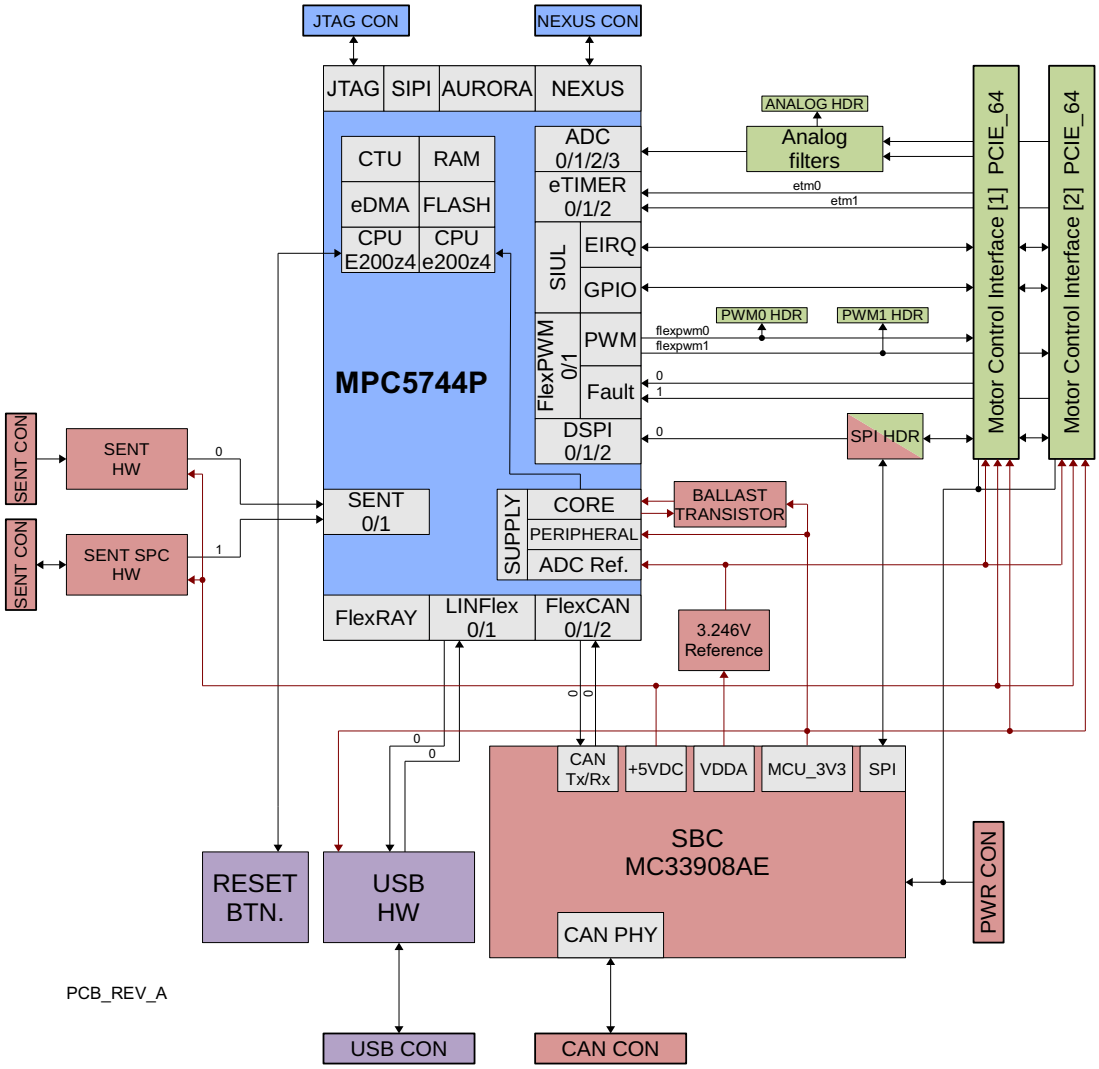


Figure 1-1. MPC5744P Controller Board Block Diagram

The board is supplied by VBAT voltage in the range of 8V to 18V. The MC33907 provides 5V to the Encoder / HALL interface. The MCU and on-board logic are supplied by MCU_3.3V. The MCU generates two independent PWM signals for each phase. The user can control the application using the I/O signals from PCI-Express interface, USB interface (RS232), CAN and SENT buses.

The JTAG, NEXUS interfaces are present on-board to enable the download and debugging of MCU code. For the on-board block location, see Figure 1-2.

Block description:

1. MCU MPC5744P
2. RESET button
3. DEBUG interfaces
4. SBC MC33908AN
5. USB interface
6. Analog filters
7. SENT bus headers
8. CAN bus header
9. Power LED indicators
10. USER LEDs [1]
11. USER LEDs [2]
12. Motor control interface [1]
13. Motor control interface [2]
14. Test headers
15. Power plug

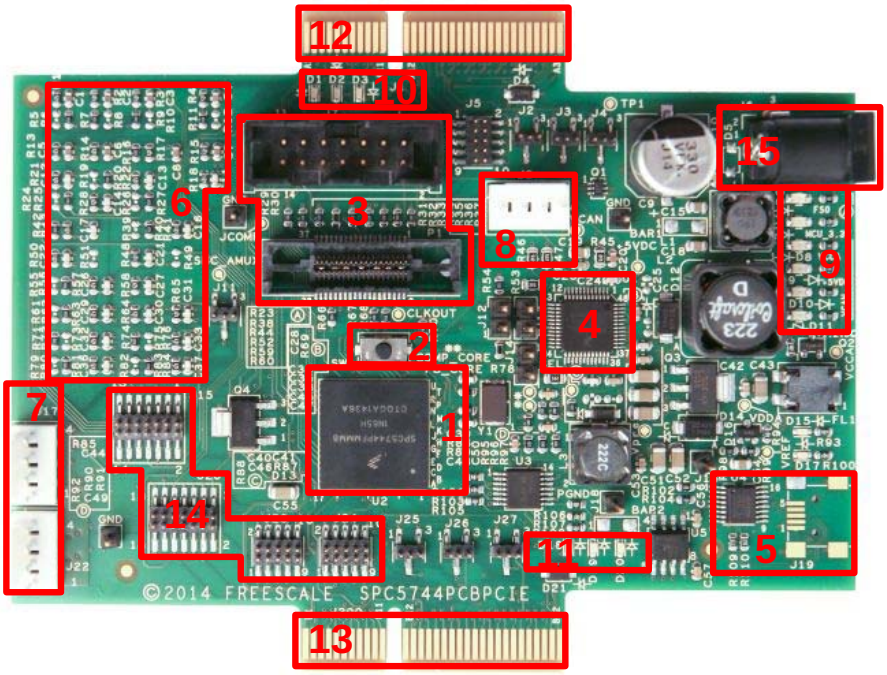


Figure 1-2. MPC5744P Controller Board - Block Location

1.3 Board Jumper Configuration

See Table 1-1, Table 1-2 and Figure 1-3 for proper jumper configuration.

Table 1-1. MPC5744P Board Configuration

Jumper	Selector	Function	Connections
J4	BOOT selection	Boot Mode Selection: - Single chip (default) - Serial Boot Loader	1-2 closed 2-3 open
J2 J3	ABS_1 ABS_2	Alternate Boot Mode Selector 1 & 2: for detail description see	1-2 open 3-4 open
J11	AMUX	Analog signal from SBC	1-2 close
J12	SBC MODE	SBC MODE selection - DUBUG, (default) - NORMAL,	 1-2 closed 1-2 open
J13	IGNITION	Emulation of the IGNITION signal for SBC	open
J14	RESET	SBC RESET signal for MCU - RESET enable, closed - RESET disable, open	closed
J25 J27	PCI-Express interface selection	Serial communication - interface selector - M1_PCI-Express - M2_PCI-Express	 1-2 closed 2-3 closed
J26	SIN-WAVE signal interface selection	Sinusoidal signal - interface selector - M1_PCI-Express - M2_PCI-Express	 1-2 closed 2-3 closed

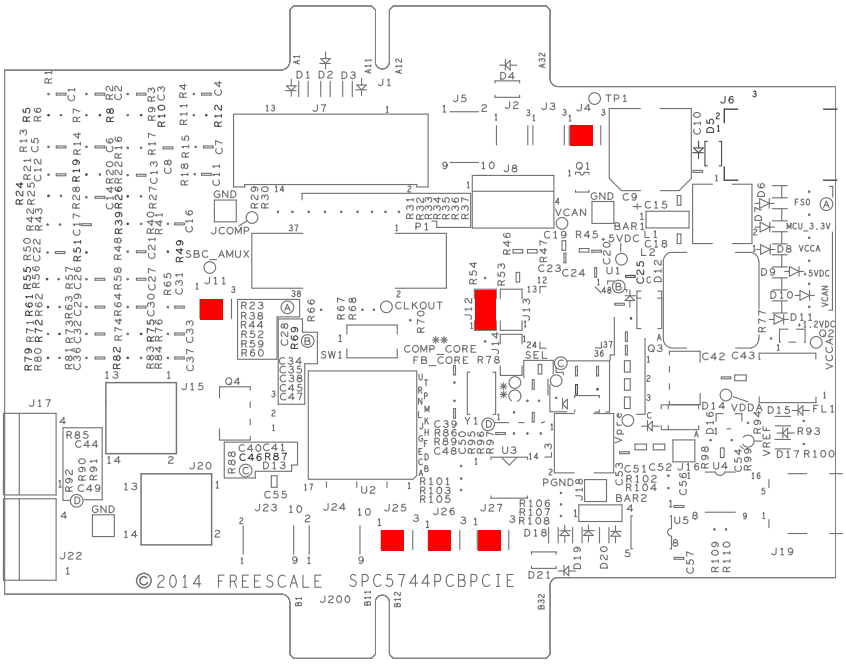


Figure 1-3. MPC5744P Controller Board Jumper Position and Default Setting

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
D1	APP_LED_1	Application LED_1
D2	APP_LED_2	Application LED_2
D3	APP_LED_3	Application LED_3
D6	/FS0	MC33908 safe pin state (ON - SBC in safe mode)
D7	MCU_3.3V	+3.3V MCU and peripheral power supply
D8	VCCA	Analog power supply
D9	+5VDC	+5V power supply
D10	VCAN	CAN driver voltage regulator
D11	+1.2VDC	+1.2V MCU core supply
D15	M1_PWM_A0	Phase A0 top switch signal (ON - High Level)
D17	M1_PWM_B0	Phase B0 bottom switch signal (ON - High Level)
D18	APP_LED_4	Application LED_4
D19	APP_LED_5	Application LED_5
D20	APP_LED_6	Application LED_6

Chapter 2 Interface Description

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

2.1 Power Supply J6

The MPC5744P Controller Board can be supplied either by using the univesal 2.1/2.5 mm DC power plug J6 or the PCIE connector (J1, J200, pin# B31). see Table 1-1

The controller board provides MCU_3.3V for MCU and on-board logic, 5V for the exrenal interfaces and 5V for analog peripheral supply. Supply 1.2V for MCU core is derivated from MCU_3.3V. All supply voltages and its proper operation is monitored by LEDs (see Table 1-2).

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

2.2 PCI-Express Interfaces J1, J200

The PCIE Motor controll interface defines the interface between the MPC5744P Motor Controller Board and the BLDC / PMSM motor power stage.
The list of PCI-Express 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 2-1defines the PCI-Express motor control interface pin-out and pin assignment to the MCU.

Table 2-1. PCI-E MC Interface Signal Description

J1 & J200 Interface Pin	Signal Name	J1 PCIE#1 MCU Signal	J200 PCIE#2 MCU Signal	Description	Direction
A1	VDDA	-	-	Positive Analog power supply	Power out
A2	GND_A	-	-	Analog power supply ground	Analog GND
A3	I_A / BEMF_A	ADC0/1_AN11	ADC2/3_AN0	Phase A current / Phase A BEMF signal	Analog input
A4	I_B / BEMF_B	ADC0/1_AN12	ADC2/3_AN1	Phase B current / Phase B BEMF signal	Analog input
A5	I_C / BEMF_C	ADC0/1_AN13	ADC1/3_AN5	Phase Ccurrent / Phase C BEMF signal	Analog input
A6		ADC1/3_AN6	ADC0/1_AN12		Analog input
A7		ADC1_AN1	ADC1_AN1		Analog input
A8	RES_SIN	ADC0_AN0	ADC2/3_AN2	Resolver SIN	Analog input
A9	RES_COS	ADC1_AN0	ADC1/3_AN4	Resolver COS	Analog input
A10	RES_EXT_SIG	SWG_OUT	SWG_OUT	Resolver excitation analog signal	Analog outout
A11	GND_A			Analog power supply ground	Analog GND
A12	+5VDC			Digital peripheral +5V power supply	Power out
A13	GND			Digital peripheral ground	Digital GND
A14	PWM0	FLEXPWM0_A0	FLEXPWM1_A0	Phase A top switch control (H -> Turn OFF)	Digital output
A15	PWM1	FLEXPWM0_B0	FLEXPWM1_B0	Phase A bottom switch control (H -> Turn ON)	Digital output
A16	PWM2	FLEXPWM0_A1	FLEXPWM1_A1	Phase B top switch control (H -> Turn OFF)	Digital output
A17	PWM3	FLEXPWM0_B1	FLEXPWM1_B1	Phase B bottom switch control (H -> Turn ON)	Digital output
A18	PWM4	FLEXPWM0_A2	FLEXPWM1_A2	Phase C top switch control (H -> Turn OFF)	Digital output
A19	PWM5	FLEXPWM0_B2	FLEXPWM1_B2	Phase C bottom switch control (H -> Turn ON)	Digital output
A20	Mx_PWM_A3	FLEXPWM0_A3	FLEXPWM1_A3		Digital output
A21	Mx_PWM_B3	SIUL_GPIO[103]	SIUL_GPIO[107]	DC Link brake signal	Digital output
A22	Mx_PWM_X0	FLEXPWM0_X0	FLEXPWM1_X0	Phase A auxiliary PWM / Phase A zero-cross signal	Dig. bidirectional
A23	Mx_PWM_X1	FLEXPWM0_X1	FLEXPWM1_X1	Phase B auxiliary PWM / Phase B zero-cross signal	Dig. bidirectional
A24	Mx_PWM_X2	FLEXPWM0_X2	FLEXPWM1_X2	Phase C auxiliary PWM / Phase C zero-cross signal	Dig. bidirectional
A25	Mx_PWM_X3	FLEXPWM0_X3	FLEXPWM1_X3		Dig. bidirectional
A26	Mx_FLT0	FLEXPWM0_ FAULT0	FLEXPWM1_ FAULT0	Over-current fault signal	Digital input
A27	Mx_FLT1	FLEXPWM0_ FAULT1	FLEXPWM1_ FAULT1	Over-voltage fault signal	Digital input
A28	Mx_FLT2	FLEXPWM0_ FAULT2	FLEXPWM1_ FAULT2		
A29	Mx_FLT3	FLEXPWM0_ FAULT3	FLEXPWM1_ FAULT3		
A30	Mx_IO_6	SIUL_GPIO[133]	SIUL_GPIO[134]		
A31	Mx_SW_UP	SIUL_GPIO[148]	SIUL_GPIO[77]	Application push button UP	Digital input

J1 & J200 Interface Pin	Signal Name	J1 PCIE#1 MCU Signal	J200 PCIE#2 MCU Signal	Description	Direction
A32	Mx_SW_DOWN	SIUL_GPIO[92]	SIUL_GPIO[42]	Application push button DOWN	Digital input
B1	VREF	-	-	Positive analog reference voltage	Power out
B2	GND_A	-	-	Analog power supply ground	Analog GND
B3	DCBI	ADC0_AN1	ADC1/3_AN7	DC Link current signal	Analog input
B4	DCBV	ADC0/1_AN14	ADC1/3_AN6	DC Link voltage	Analog input
B5	-	ADC0_AN2	ADC0_AN2	-	
B6	-	ADC0_AN3	ADC0_AN3	-	
B7	-	ADC0_AN4	ADC0_AN4	-	
B8	-	ADC0_AN6	ADC0_AN6	-	
B9	-	ADC0_AN7	ADC0_AN7	-	
B10	TEMP	ADC0_AN8	ADC1/3_AN8	Temperature of the power stage	
B11	GND_A	-	-	Analog power supply ground	Analog GND
B12	+3.3VDC			+3.3V MCU power supply	Power out
B13	GND			Digital peripheral ground	Digital GND
B14	ENCx_PHA	ETIMER0_ETC0	ETIMER1_ETC0	Encoder A / HALL phase A / Phase A zero-cross signal	Digital input
B15	ENCx_PHB	ETIMER0_ETC1	ETIMER1_ETC1	Encoder B / HALL phase B / Phase B zero-cross signal	Digital input
B16	ENCx_INDEX	ETIMER0_ETC2	ETIMER1_ETC2	Encoder C / HALL phase C / Phase C zero-cross signal	Digital input
B17	-	ETIMER0_ETC3	ETIMER1_ETC3		
B18	-	ETIMER0_ETC4	ETIMER1_ETC4		
B19	RES REF	ETIMER0_ETC5	ETIMER1_ETC5	Resolver excitation digital signal	Digital output
B20	Mx_SW_RUN	SIUL_GPIO[12]	SIUL_GPIO[15]	Application switch RUN / STOP	Digital input
B21	33937 SOUT	DSPI[0]_SIN	DSPI[0]_SIN	SPI input data	Digital input
B22	33937_SIN	DSPI[0]_SOUT	DSPI[0]_SOUT	SPI output data	Digital output
B23	33937 SCK	DSPI[0]_SCK	DSPI[0]_SCK	SPI clock	Digital output
B24	33937 CS	DSPI[0]_CS**1**	DSPI[0]_CS**2**	SPI Chip-select	Digital output
B25	-	-	-	-	
B26	USB TxD	LIN[1]_RxD	LIN[1]_RxD	Isolated USB periph. TxD	Digital input
B27	USB RxD	LIN[1]_TxD	LIN[1]_TxD	Isolated USB periph. RxD	Digital output
B28	33937 EN	SIUL_GPIO[11]	SIUL_GPIO[132]	Device enable signal	Digital output
B29	33937 RST	SIUL_GPIO[10]	SIUL_GPIO[49]	Device RESET signal	Digital output
B30	33937 INT	REQ[12]	REQ[13]	Device Interrupt signal	Digital input

J1 & J200 Interface Pin	Signal Name	J1 PCIE#1 MCU Signal	J200 PCIE#2 MCU Signal	Description	Direction
B31	+12V POWER	-	-	Controller board power supply	Power in
B32	GND_POWER			Contrller board power ground	Power GND

2.3 CAN connector J8

The system basis chip MC33908 provide CAN physical layer transceiver which is used as the CAN hardware interface. A Table 2-2 show the CAN connector pin-out and pin assignment to the MCU.

Table 2-2. CAN J8 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	CANH	CAN[0]RX CAN[0]TX	CAN bus H	Diff. bidirectional
2	CANL	CAN[0]RX CAN[0]TX	CAN bus L	Diff. bidirectional
3	+5VDC	-	Supply voltage	-
4	GND	-	Ground	-

2.4 USB Connectivity J19

The USB line is used for board communication with the PC, when using e.g. the Freescale FreeMASTER tool [3] to control the user application. The interface uses a 5 pin mini USB B-type connector and it is isolated from the board environment. See Table 2-3 for the pin description and pin assignment to the MCU.

Table 2-3. J206 USB Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	VBUS	-	USB Power Supply	-
2	D-	LINFlex[0]RX LINFlex[0]TX	Data –	Dig. bidirectional
3	D+	LINFlex[0]RX LINFlex[0]TX	Data +	Dig. bidirectional
4	ID		Not connected	
5	GND_USB	-	USB Ground	-

2.5 Boot modes selection J2, J3 & J4

The MPC5744P supports the following boot modes:

- Single Chip (SC) mode—the microcontroller boots from the first bootable section of the flash memory main array.
- Serial Boot Loader (SBL) mode—the microcontroller downloads boot code from either theLINFlexD or FlexCAN interface and then executes it. Serial boot can be performed with or without autobaud.

Details see in Table 2-4.

Table 2-4. J4, J3 & J2 Hardwarer configuration

FAB [J24]	ABS2 [J3]	ABS1 [J2]	Description
1-2 closed	-	-	Boot from internal Flash
1-2 open	1-2 closed	1-2 closed	Serial boot from LINFlexD
1-2 open	1-2 closed	2-3 closed	Serial boot from FlexCAN

2.6 PWM monitoring Header's J5 & J24

Monitoring the PWM signal is possible using J5 resp. J24. The Table 2-5 , Table 2-6 summarizes the header pin-out.

Table 2-5. J5 Motor 1 PWM Header Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	M1_PWM_A0	FlexPWM0_A[0]	Phase A top switch control	Digital output
2	M1_PWM_B0	FlexPWM0_B[0]	Phase A bottom switch control	Digital output
3	M1_PWM_A1	FlexPWM0_A[1]	Phase B top switch control	Digital output
4	M1_PWM_B1	FlexPWM0_B[1]	Phase B bottom switch control	Digital output
5	M1_PWM_A2	FlexPWM0_A[2]	Phase C top switch control	Digital output
6	M1_PWM_B2	FlexPWM0_B[2]	Phase C bottom switch control	Digital output
7	M1_PWM_A3	FlexPWM0_A[3]	Phase D top switch control	Digital output
8	M1_PWM_B3	FlexPWM0_B[3]	Phase D bottom switch control	Digital output
9	CLKOUT			
10	GPIO_15			

Table 2-6. J24 Motor 2 PWM Header Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	M2_PWM_A0	FlexPWM1_A[0]	Phase A top switch control	Digital output
2	M2_PWM_B0	FlexPWM1_B[0]	Phase A bottom switch control	Digital output
3	M2_PWM_A1	FlexPWM1_A[1]	Phase B top switch control	Digital output
4	M2_PWM_B1	FlexPWM1_B[1]	Phase B bottom switch control	Digital output
5	M2_PWM_A2	FlexPWM1_A[2]	Phase C top switch control	Digital output
6	M2_PWM_B2	FlexPWM1_B[2]	Phase C bottom switch control	Digital output
7	M2_PWM_A3	FlexPWM1_A[3]	Phase D top switch control	Digital output
8	M2_PWM_B3	FlexPWM1_B[3]	Phase D bottom switch control	Digital output
9				
10				

2.7 ADC Inputs & Header J15 & J20

The MPC5744P device has four ADC instances: ADC_0, ADC_1, ADC_2, and ADC_3. All ADC modules are with 12-bit resolution with 0 ÷ Vref common mode conversion range (see Chapter 3.3, “Power Supplies and Voltage Reference"). ADC modules are supplied from the voltage reference.

The MPC5744P (257 MAPBGA) ADC modules provide the following external inputs:

- Internally multiplexed channels 25 chanels
  - 9 channels on ADC_0
  - 4 channels on ADC_1
  - 4 channels shared between ADC_0 and ADC_1
  - 5 channels shared between ADC_1 and ADC_3
  - 3 channels shared between ADC_2 and ADC_3

2.7.1 ADC signal description

Table 2-7. ADC0 Signal Description

Interface	Signal Name	Channels	Description	Direction
MOTOR1	AN0_0	ADC0_AN0	POS_SIN_RESOLVER_1	Analog input
MOTOR1	AN0_1	ADC0_AN1	PCIE#1_DCBI	Analog input
MOTOR1	AN0_2	ADC0_AN2	PCIE#1_Vsup_meas	Analog input
MOTOR1	AN0_3	ADC0_AN3	M1_RES_GEN_POS_TST	Analog input
Free for use	AN0_4	ADC0_AN4	ANALOG HEADER #1 [J15] PIN_9	Analog input

Table 2-7. ADC0 Signal Description

Interface	Signal Name	Channels	Description	Direction
AMUX	AN0_5	ADC0_AN5	SBC analog parameters meas. or free analog input	Analog input
Free for use	AN0_6	ADC0_AN6	ANALOG HEADER #1 [J15] PIN_13	Analog input
Free for use	AN0_7	ADC0_AN7	ANALOG HEADER #1 [J15] PIN_2	Analog input
MOTOR1	AN0_8	ADC0_AN8	PCIE#1_TEMP	Analog input

Table 2-8. ADC1 & ADC0/ADC1 Signal Description

Interface	Signal Name	Channels	Description	Direction
MOTOR1	AN1_0	ADC1_AN0	POS_COS_RESOLVER_1	Analog input
Free for use	AN1_1	ADC1_AN1	ANALOG HEADER #2 [J211] PIN_3	Analog input
MOTOR2	AN1_2	ADC1_AN2	PCIE#2_Vsup_meas	Analog input
MOTOR1	AN1_3	ADC1_AN3	M1_RES_GEN_NEG_TST	Analog input
MOTOR1	AN01_11	ADC01_AN11	PCIE#1 BEMFA voltage / PHASE_A current	Analog input
MOTOR1	AN01_12	ADC01_AN12	PCIE#1 BEMFB voltage / PHASE_B current	Analog input
MOTOR1	AN01_13	ADC01_AN13	PCIE#1 BEMFC voltage / PHASE_C current	Analog input
MOTOR1	AN01_14	ADC01_AN14	PCIE#_1_DCBV	Analog input

Table 2-9. ADC1/ADC3 Signal Description

Interface	Signal Name	Channels	Description	Direction
MOTOR_2	AN13_4	ADC13_AN4	POS_COS_RESOLVER_2	Analog input
MOTOR_2	AN13_5	ADC13_AN5	PCIE#2 BEMFC voltage / PHASE_C current	Analog input
MOTOR_2	AN13_6	ADC13_AN6	PCIE#2_DCBV	Analog input
MOTOR_2	AN13_7	ADC13_AN7	PCIE#2_DCBI	Analog input
MOTOR_2	AN13_8	ADC13_AN8	PCIE#2_TEMP	Analog input

Table 2-10. ADC2/ADC3 Signal Description

Motor Interface	Signal Name	MCU Signal	Description	Direction
MOTOR_2	AN23_0	ADC23_AN0	PCIE#2 BEMFA voltage / PHASE_A current	Analog input

Motor Interface	Signal Name	MCU Signal	Description	Direction
MOTOR_2	AN23_1	ADC23_AN1	PCIE#2 BEMFB voltage / PHASE_B current	Analog input
MOTOR_2	AN23_2	ADC23_AN2	POS_SIN_RESOLVER_2	Analog input

2.7.2 Jumper J11

Header J11 is primarily dedicated to connect the external analog signal from MC33908 to ADC for measurement the internal analog parameters of the MC33908. The ouptut pararameters of the MC33908 are selectable thru the SPI. In any case Pin[1] of the J11 could be used as independent analog input. See a detailed description in Table 2-11.

Table 2-11. J204 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	AN0_5	ADC0_AN5	ADC0_AN5 Analog input with filter	
2	AMUX	-	Analog output from SBC MC33908	
3	TP5			

Note: For MC33908 analog parameters measurement the J11 pins 1 & 2 must be shorted.

2.7.3 Analog Header's J15 & J20

Either of analog headers J15 & J20 could be used for connection of the external analog signals to the MCU or could be used as testpoint for measurement of the analog values from PCIE#1 and PCIE#2.

Detail description see in Table 2-12 & Table 2-13.

Table 2-12. Analog Header J15 Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	HDR_AN0_0	ADC0_AN0	Analog digital converter module 0 channel 0	Analog input
2	HDR_AN0_7	ADC0_AN7	Analog digital converter module 0 channel 7	Analog input
3	HDR_AN0_1	ADC0_AN1	Analog digital converter module 0 channel 1	Analog input
4	HDR_AN0_8	ADC0_AN8	Analog digital converter module 0 channel 8	Analog input
5	HDR_AN0_2	ADC0_AN2	Analog digital converter module 0 channel 2	Analog input
6	HDR_AN01_11	ADC0/1_AN11	Analog digital converter module 0/1 channel 11	Analog input
7	HDR_AN0_3	ADC0_AN3	Analog digital converter module 0 channel 3	Analog input

Table 2-12. Analog Header J15 Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
8	HDR_AN01_12	ADC0/1_AN12	Analog digital converter module 0/1 channel 12	Analog input
9	HDR_AN0_4	ADC0_AN4	Analog digital converter module 0 channel 4	Analog input
10	HDR_AN01_13	ADC0/1_AN13	Analog digital converter module 0/1 channel 13	Analog input
11	HDR_AN0_5	ADC0_AN5	Analog digital converter module 0 channel 5	Analog input
12	HDR_AN01_14	ADC0/1_AN14	Analog digital converter module 0/1 channel 14	Analog input
13	HDR_AN0_6	ADC0_AN6	Analog digital converter module 0 channel 6	Analog input
14	GND	-	Ground	-

Table 2-13. Analog Header J20 Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	HDR_AN1_0	ADC1_AN0	Analog digital converter module 1 channel 0	Analog input
2	HDR_AN13_7	ADC1/3_AN7	Analog digital converter module 1/3 channel 7	Analog input
3	HDR_AN1_1	ADC1_AN1	Analog digital converter module 1 channel 1	Analog input
4	HDR_AN13_8	ADC1/3_AN8	Analog digital converter module 1/3 channel 8	Analog input
5	HDR_AN1_2	ADC1_AN2	Analog digital converter module 1 channel 2	Analog input
6	HDR_AN23_0	ADC2/3_AN0	Analog digital converter module 2/3 channel 0	Analog input
7	HDR_AN1_3	ADC1_AN3	Analog digital converter module 1 channel 3	Analog input
8	HDR_AN23_1	ADC2/3_AN1	Analog digital converter module 2/3 channel 1	Analog input
9	HDR_AN13_4	ADC1/3_AN4	Analog digital converter module 1/3 channel 4	Analog input
10	HDR_AN23_2	ADC2/3_AN2	Analog digital converter module 2/3 channel 2	Analog input
11	HDR_AN13_5	ADC1/3_AN5	Analog digital converter module 1/3 channel 5	Analog input
12	-	-	-	-
13	HDR_AN13_6	ADC1/3_AN6	Analog digital converter module 1/3 channel 6	Analog input
14	GND	-	Ground	-

2.8 SPI Header J23

SPI header J23 allows connect others SPI devices such as sensors, external EEPROM etc. or could be used as GPIO pin header. See Table 2-14.

Table 2-14. SPI Header J23 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
1	HDR_DSPI3_CS0	DSPI[3]_CS0	Serial Peripheral Interface Chip Select 0	Digital output
2	HDR_DSPI3_SIN	DSPI[3]_SIN	Serial Peripheral Interface Input	Digital input
3	HDR_DSPI3_CS1	DSPI[3]_CS1	Serial Peripheral Interface Chip Select 1	Digital output
4	HDR_DSPI3_SCK	DSPI[3]_SCK	Serial Peripheral Interface Clock	Digital ouput
5	HDR_DSPI3_CS2	DSPI[3]_CS2	Serial Peripheral Interface Chip Select 2	Digital output
6	HDR_DSPI3_SOUT	DSPI[3]_SOUT	Serial Peripheral Interface Output	Digital output
7	HDR_DSPI3_CS3	DSPI[3]_CS3	Serial Peripheral Interface Chip Select 3	Digital output
8	HDR_ET2_CH2/4	ETIMER2_ETC_2/4		

Table 2-14. SPI Header J23 Signal Description

Interface Pin	Signal Name	MCU Signal	Description	Direction
9	HDR_ET1_CH5	ETIMER1_ETC_5		
10	GND		Ground	–

Chapter 3 Design Consideration

This chapter provides additional information on the functional blocks of the MPC5744P Motor controller board.

3.1 MPC5744P Features

The Qorivva MPC5744P microcontroller, a SafeAssure solution, is a 32-bit embedded controller designed for advanced driver assistance systems with RADAR, CMOS imaging, LIDAR and ultrasonic sensors, and multiple 3-phase motor control applications as in hybrid electric vehicles (HEV) in automotive and high temperature industrial applications.

The availability of up to three FlexPWM modules with a four 12bit Analog-to-Digital Converters (ADC) modules, and a Cross Triggering Unit (CTU) makes the MPC5744P microcontrollers suitable for 3-phase PMSM and BLDC motor control applications.

Table 3-1. MPC5744P device features (257 MAPBGA package)

Feature	Device
	MPC5744P
Process	C55
CPU	e200z4201n3 and e200z419 (cut 1) e200z4251n3 and e200z424 (cut 2)
Execution speed	Up to 180MHz
Code Flash/ Data Flash	2.5 MB
RAM	384 KB
eTimer	3 modules, 6 channels
PIT	1 Module x 4 Channels
ADC	4 x 12-bit (25 external channels)
CTU	2 Modules
eDMA	32 channels in delayed lock-step
LINFlex	2 Modules
SPI (DSPI)	3 Modules
FlexRay	1 Module x 64 message buffers
SENT	2 Modules x 2 Channels
FlexCAN	3 Modules x 64 message buffers
FlexPWM	2 Modules x 4 Channels
Sine - wave generator	32 Point
Debug	JTAG; NEXUS Class 3+; AURORA

The device block diagram is shown in Figure 3-1. A detailed description of the MCU can be found in the datasheet or reference manual.

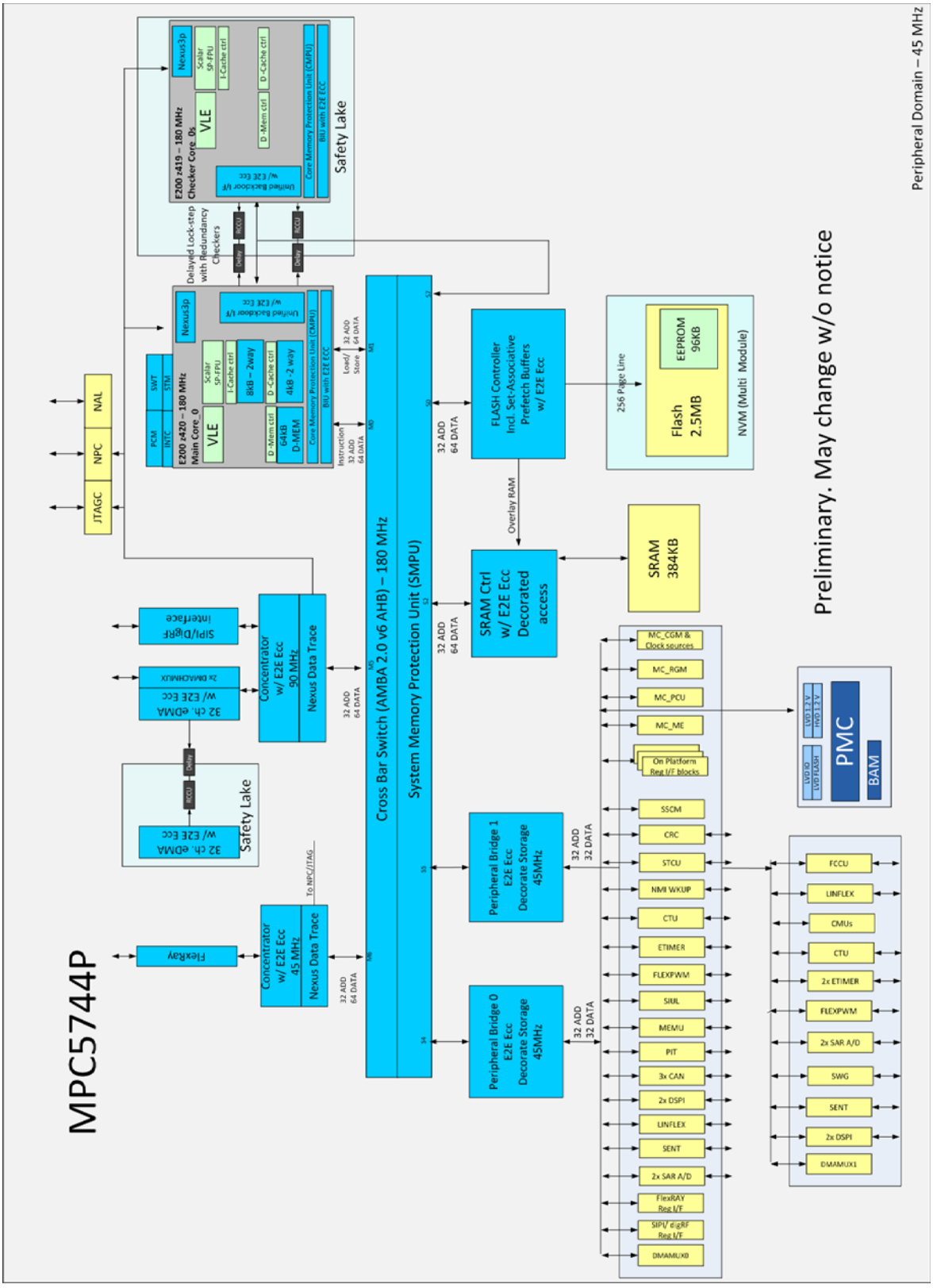


Figure 3-1. Family Block Diagram

3.2 Clock source

The MPC5744P uses an external 40.00 MHz crystal oscillator mounted on the board and internal PLL0 to multiply the input frequency and achieve its 180 MHz maximum operating frequency. The second PLL1 is used to achieve suitable frequency for internal Motor control and communication modules. The MPC5744P can also use internal 16 MHz RC oscillator as a clock source. For detailed clock distribution architecture see Figure 3-2.

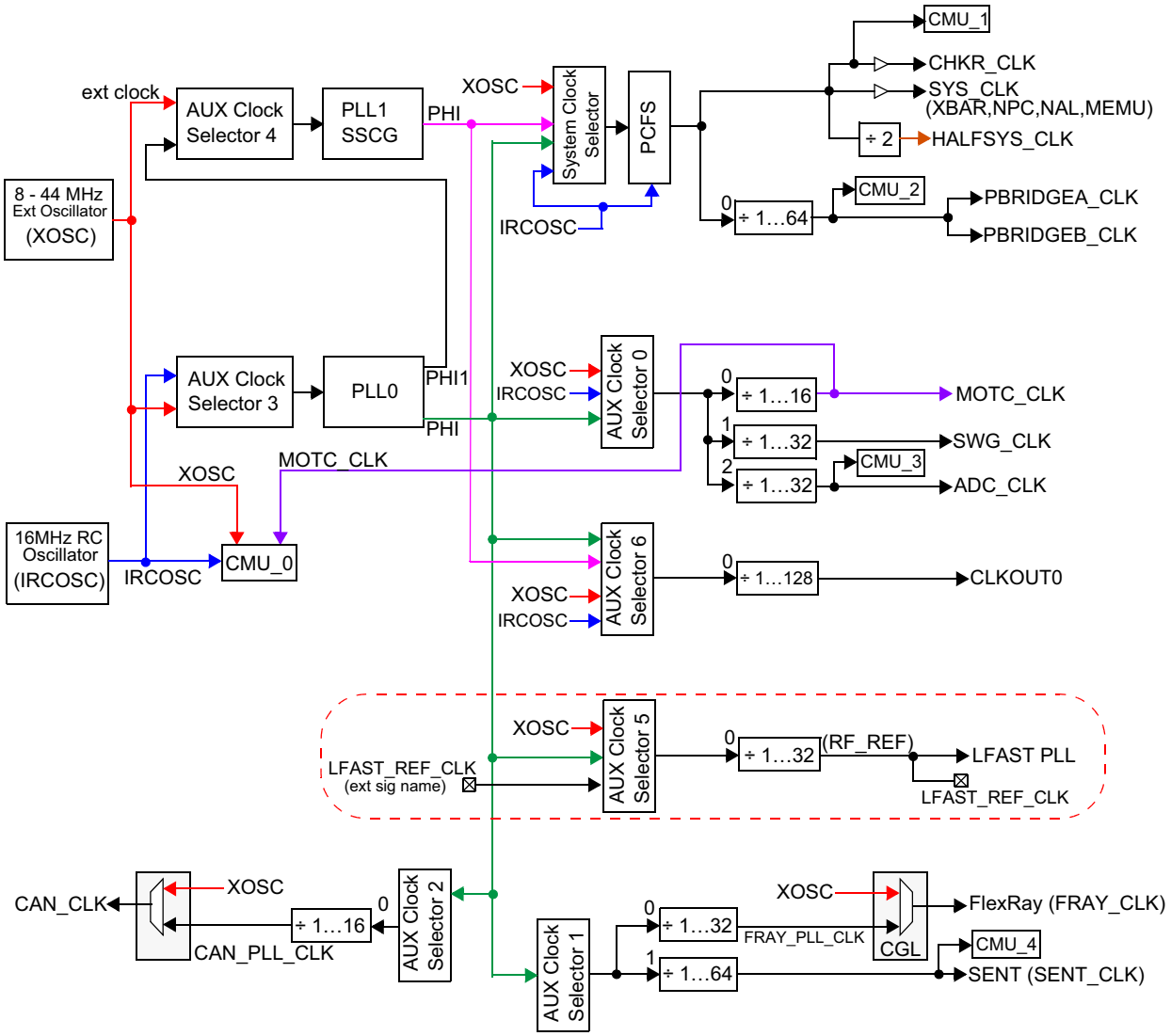


Figure 3-2. MPC5744P clock distribution

3.3 Power Supplies and Voltage Reference

The MPC5744P Dual Motor Controller Board can be supplied from two different power supply inputs. The first one uses a 2.1/2.5 mm DC power plug and the second option is to use a one of the PCIE connectors. Which one is more suitable depends on the application type. The controller board provides a +5VDC voltage regulation for the SENT interface, MCU_3.3V for the MCU, MCU supporting logic and LED indicators, Vdda to supply external analog modules and Vref to provide the reference voltage for the ADC module. Power applied to the MPC5744P Controller Board is indicated by a power-on LEDs. The block diagram is shown in Figure 3-3.

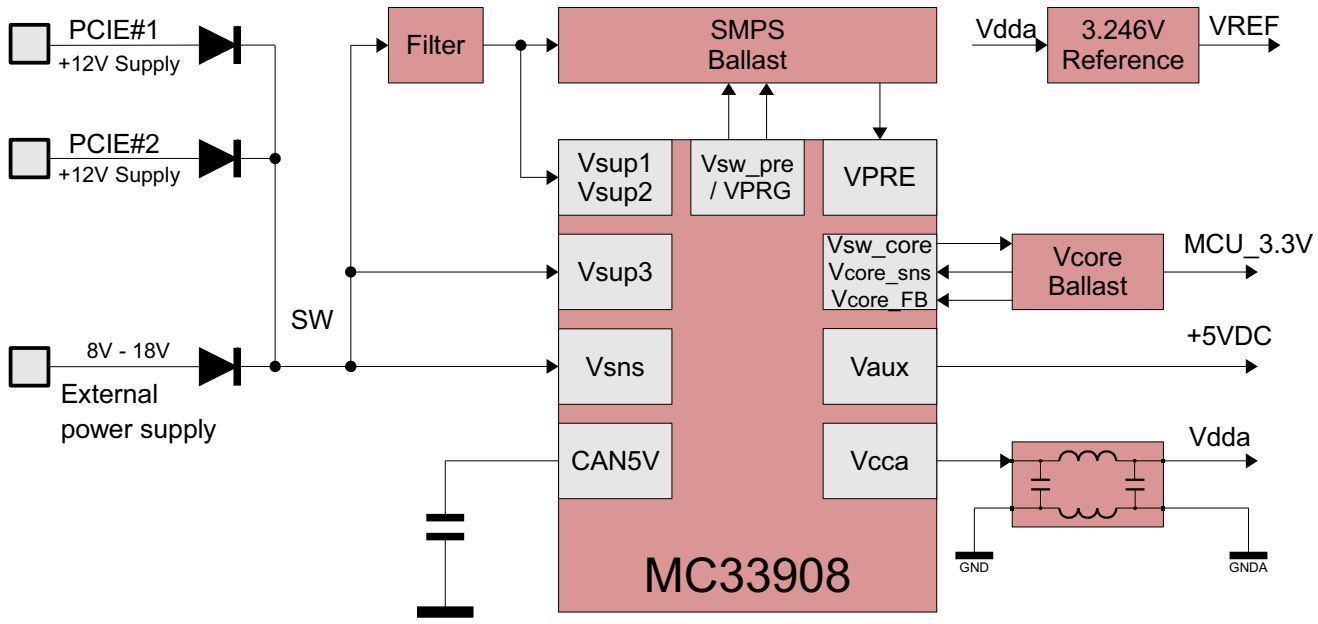


Figure 3-3. Power supply

3.4 Analog Signal Sensing

The analog input signals listed in Table 2-1, Table , and Table 2-10 are connected to the analog to digital converters through the RC filters. The time constant of RC filter is set with respect to the input signal bandwidth.

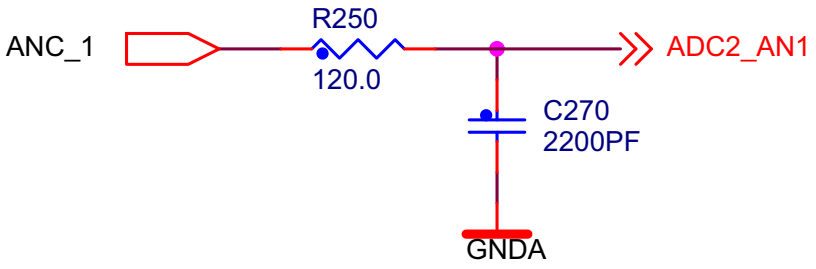


Figure 3-4. Analog Sensing Circuit example

3.5 Brake Signal

The brake signal output is used to control the DC-bus resistor switch. See Table 3-2 .

Table 3-2. UNI3 Brake Signals

Interface Pin	Signal	J600 UNI3_1 to MCU Signal	J700 UNI3_1 to MCU Signal	Direction
A21	Mx_PWM_B3	SIUL_GPIO[103]	SIUL_GPIO[107]	Digital output

3.6 CAN Bus interface

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 MPC5744P reference manual for a detailed description. The Freescale system basis chip MC33908 with CAN physical layer is used as the CAN hardware interface.

3.7 SENT Interfaces

The Single Edge Nibble Transmission (SENT) Receiver (SRX) module is a multichannel receiver for receiving serial data frames which are being transmitted by a sensor implementing the SENT encoding scheme and present them to the CPU for further processing.This module is based on the SAE J2716. As per this standard, the SENT protocol is intended for use in applications where high resolution sensor data needs to be communicated from a sensor to an Engine Control Unit (ECU). It is intended as a replacement for the lower resolution methods of 10 bit A/Ds and PWM and as a simpler low-cost alternative to CAN or LIN. The implementation assumes that the sensor is a smart sensor containing a microprocessor or dedicated logic device (ASIC) to create the signal. Please refer to the MPC5744P reference manual for a detailed description.

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}		40		mA
Input Voltage Range	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 PCIE#1 or PCIE#2 interface or by using the on-board J6 connector, with a power supply voltage from 8 to 18V. When using the board as a stand-alone EVB, connect the power supply to J6. In the case of board operation with the power stage, it is recommended to supply the board using the PCIE interface.

The MPC5744P PCIE Controller Board is designed for operation with up to two the Freescale MC33937A based 3-Phase low-voltage power stages, see Figure 5-1. The complete 3-phase PMSM / BLDC Development Kit can be ordered at http://www.freescale.com/AutoMCDevKits.

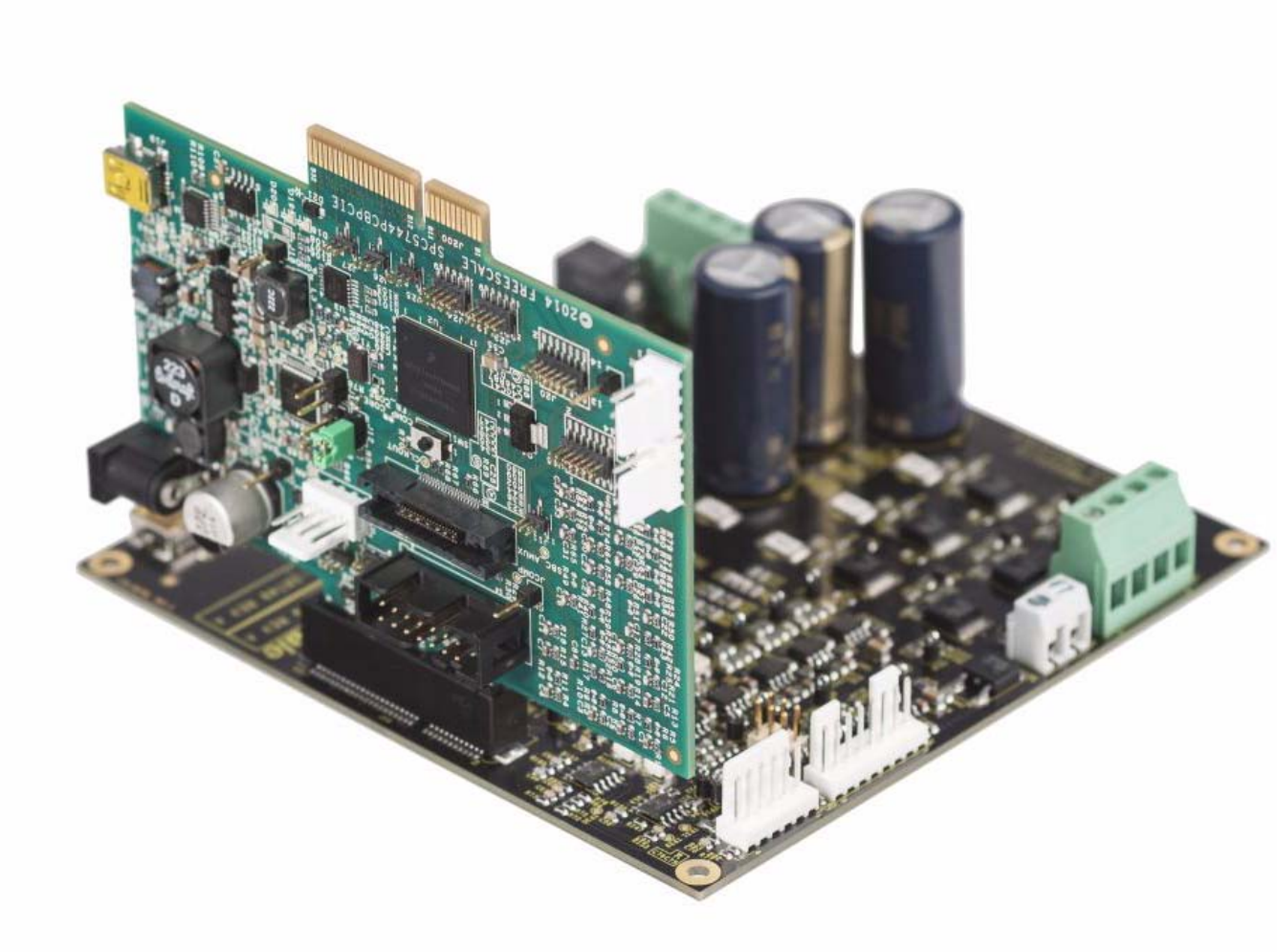


Figure 5-1. 3-Phase PMSM Sensor / Sensorless Development Kit

Appendix A References

1. 3-phase Low-Voltage Power Stage, www.freescale.com/AutoMCDevKits
2. MPC5744P Family Reference Manual, MPC5744PRM Rev. 1, 02/2013
3. FreeMASTER Run-time Debugging Tool, www.freescale.com/FREEMASTER

Appendix B Abbreviations

ADC ..... Analog to Digital Converter

BEMF..... Back Electromotive Force

BLDC..... Brushless DC Motor

CAN..... Controller Area Network

EVB ..... Evaluation Board

LIN..... Local Interconnect Network

MCU ..... Microcontroller Unit

PC..... Personal Computer

PCI-E .....PCI Express

PMSM..... Permanent Magnet Sychronous Motor

PWM..... Pulse Width Modulation

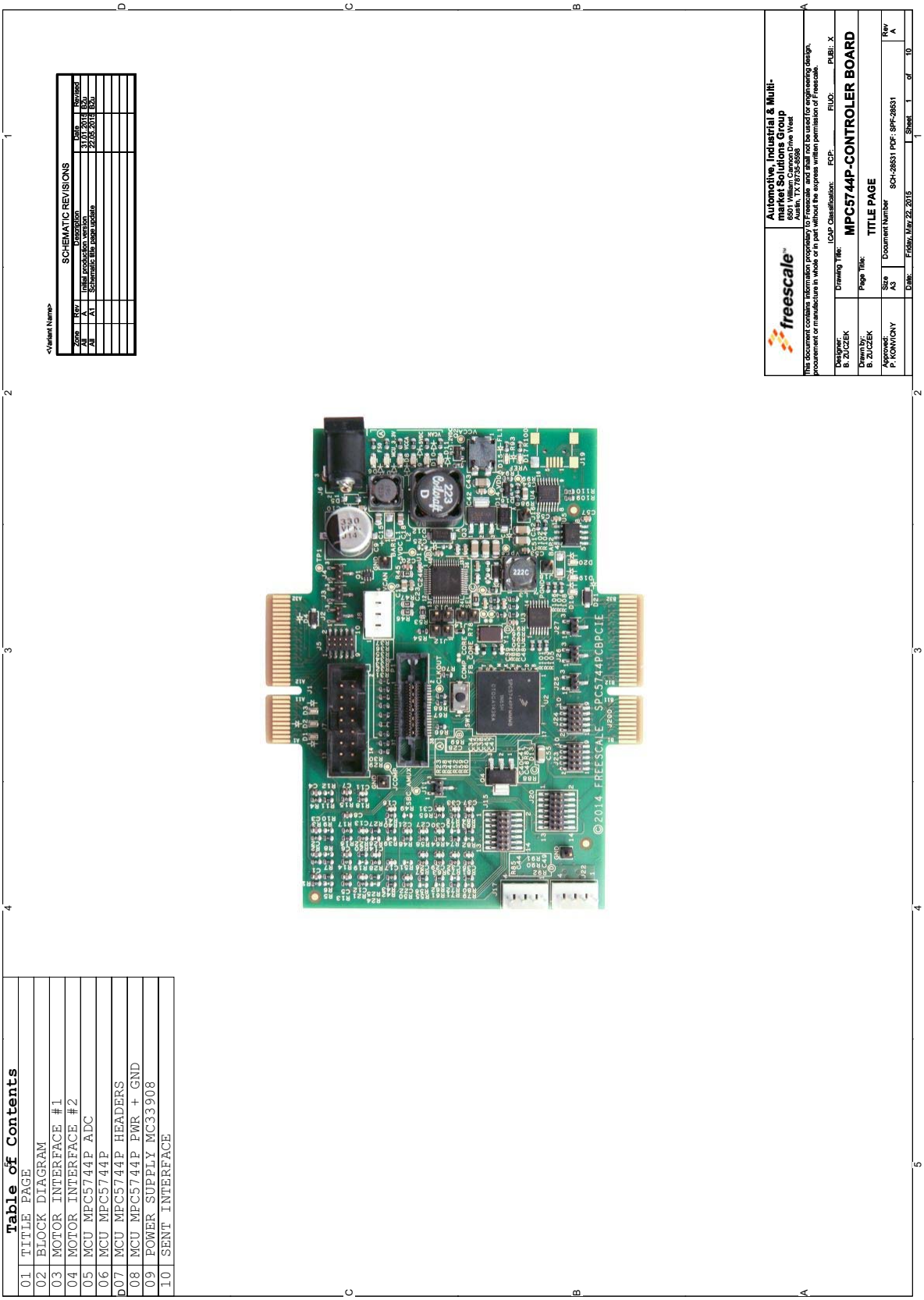
SBC..... System Basis Chip

SENT ..... Single Edge Nibble Trasmission

SMPS ..... Switch Mode Power Supply

USB..... Universal Serial Bus

Appendix C MPC5744P Controller Board Schematic



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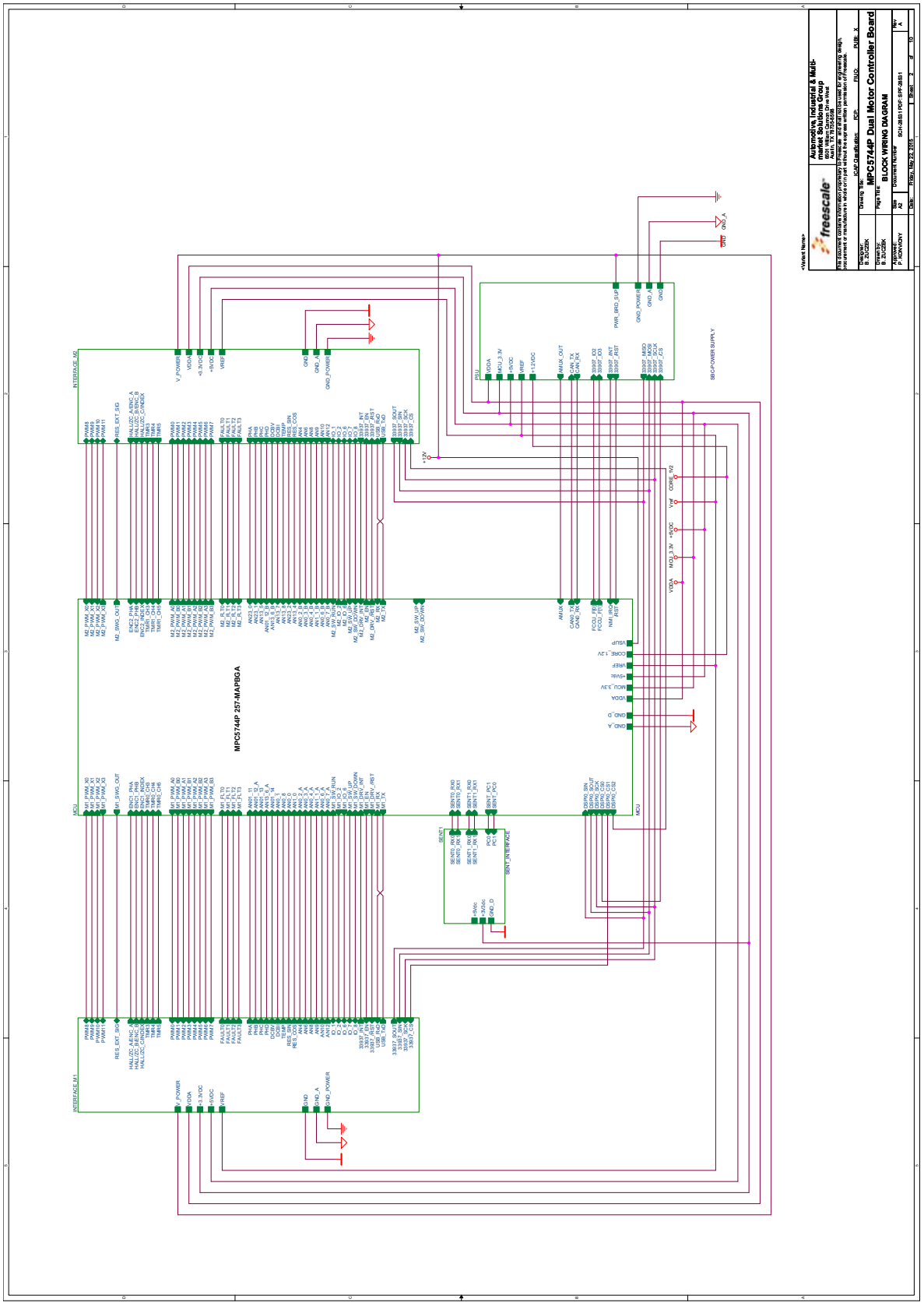

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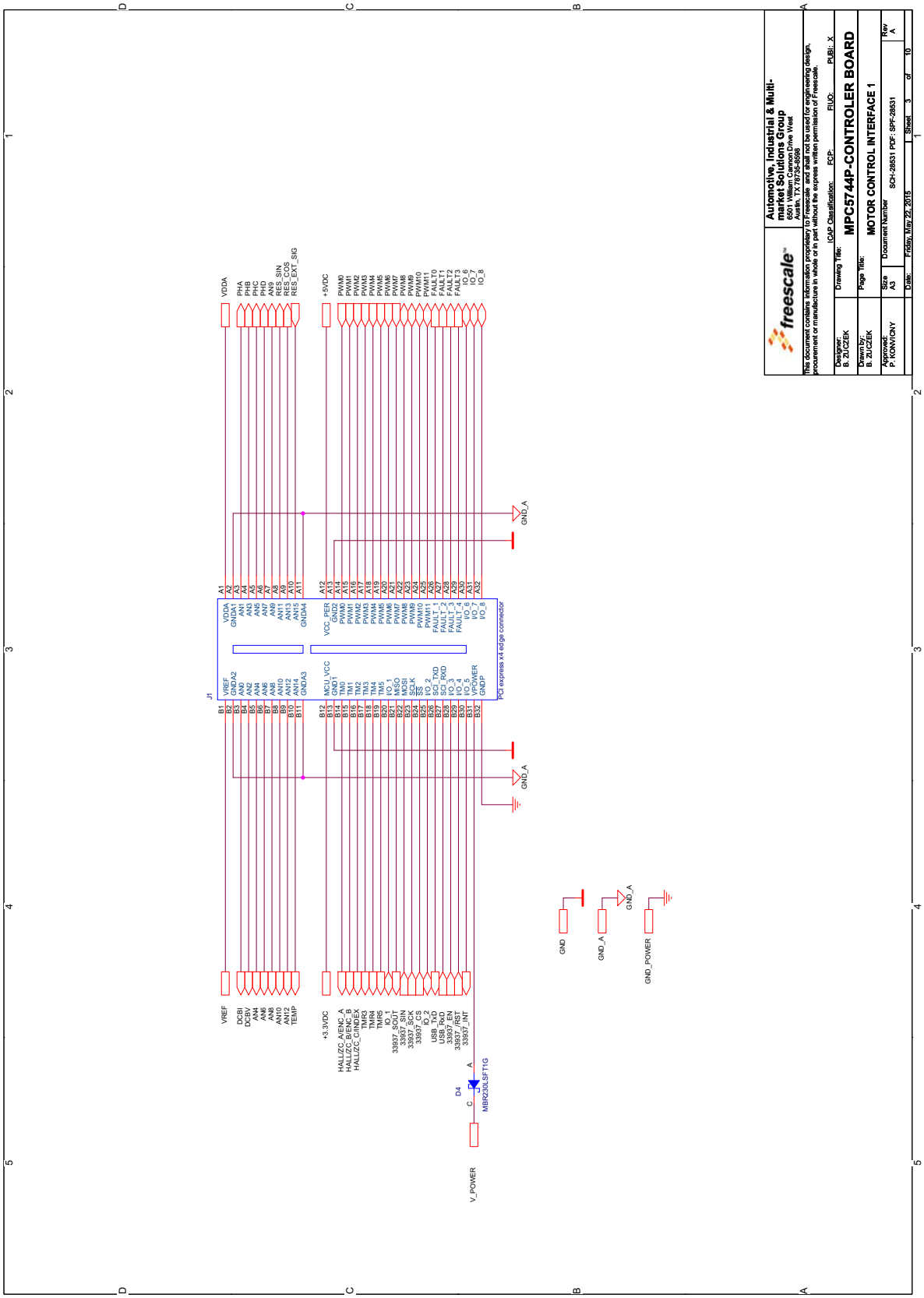

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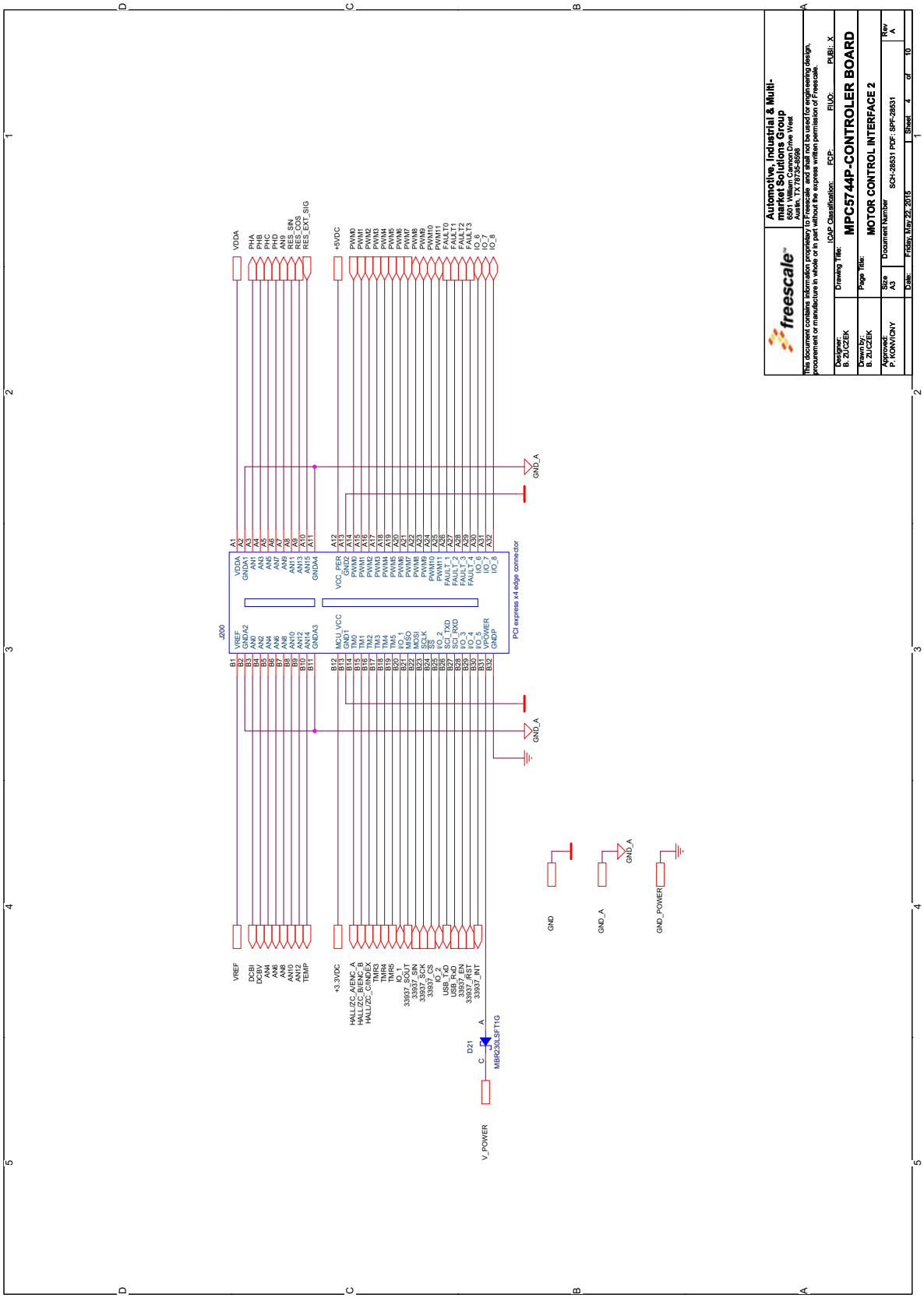

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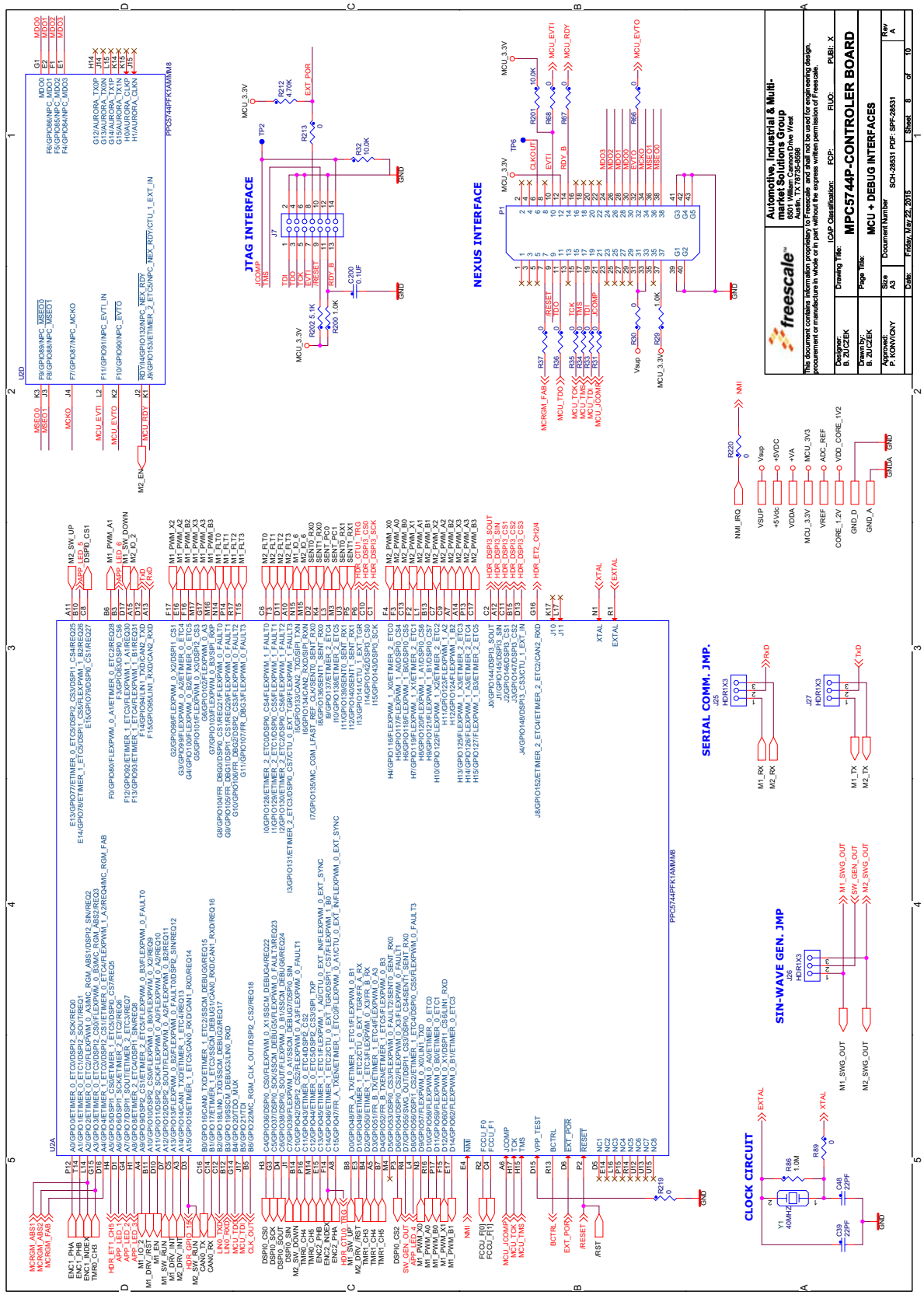

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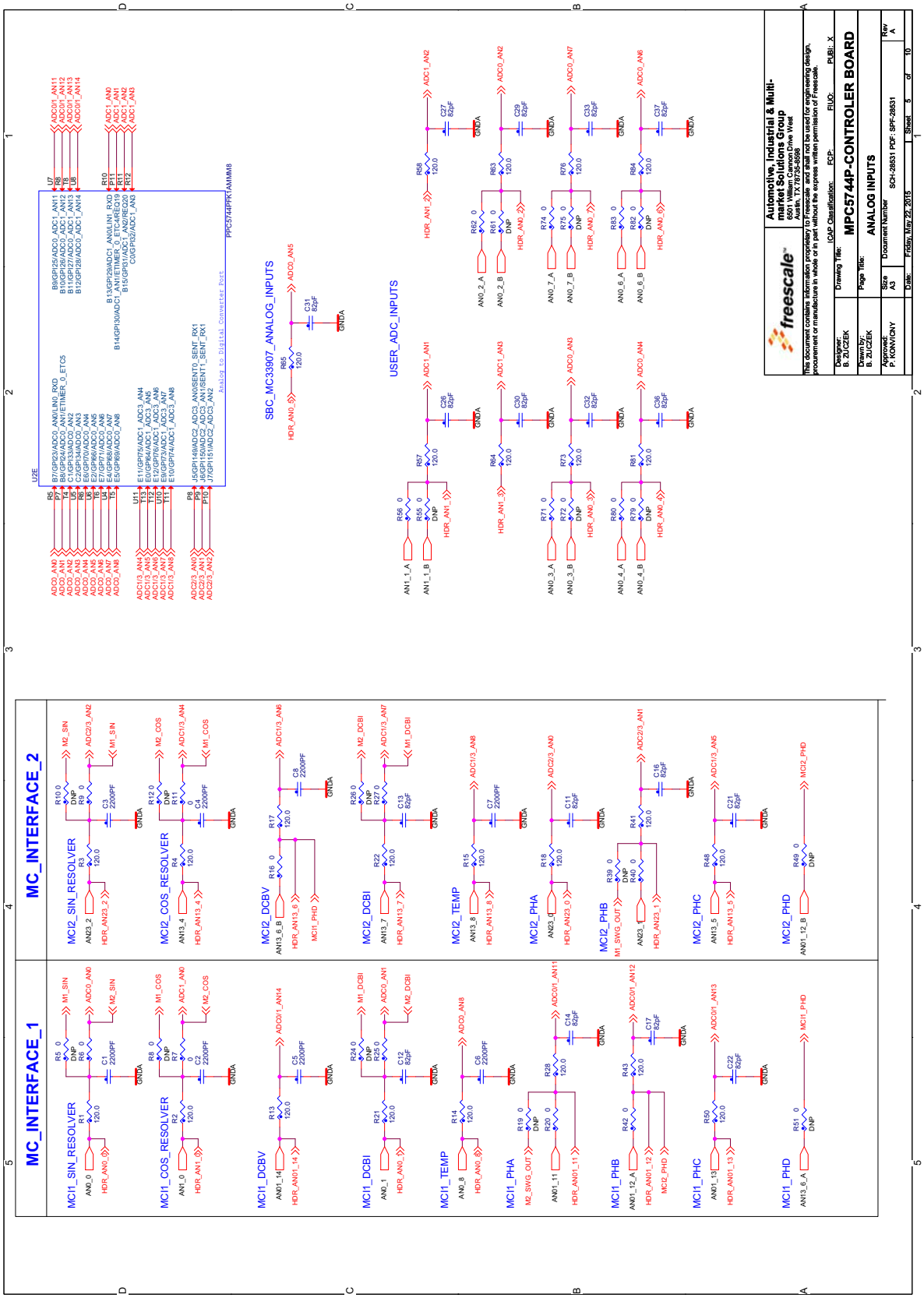
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MCI1_PHA
MCI1_PHB
MCI1_PHC
MCI1_PHD
MCI2_SIN_RESOLVER
MCI2_COS_RESOLVER
MCI2_DCBV
MCI2_DCBI
MCI2_TEMP
MCI2_PHA
MCI2_PHB
MCI2_PHC
MCI2_PHD
SBC_MC33907_ANALOG_INPUTS
USER_ADC_INPUTS
U2E
PPC5744PFK1AMMM8
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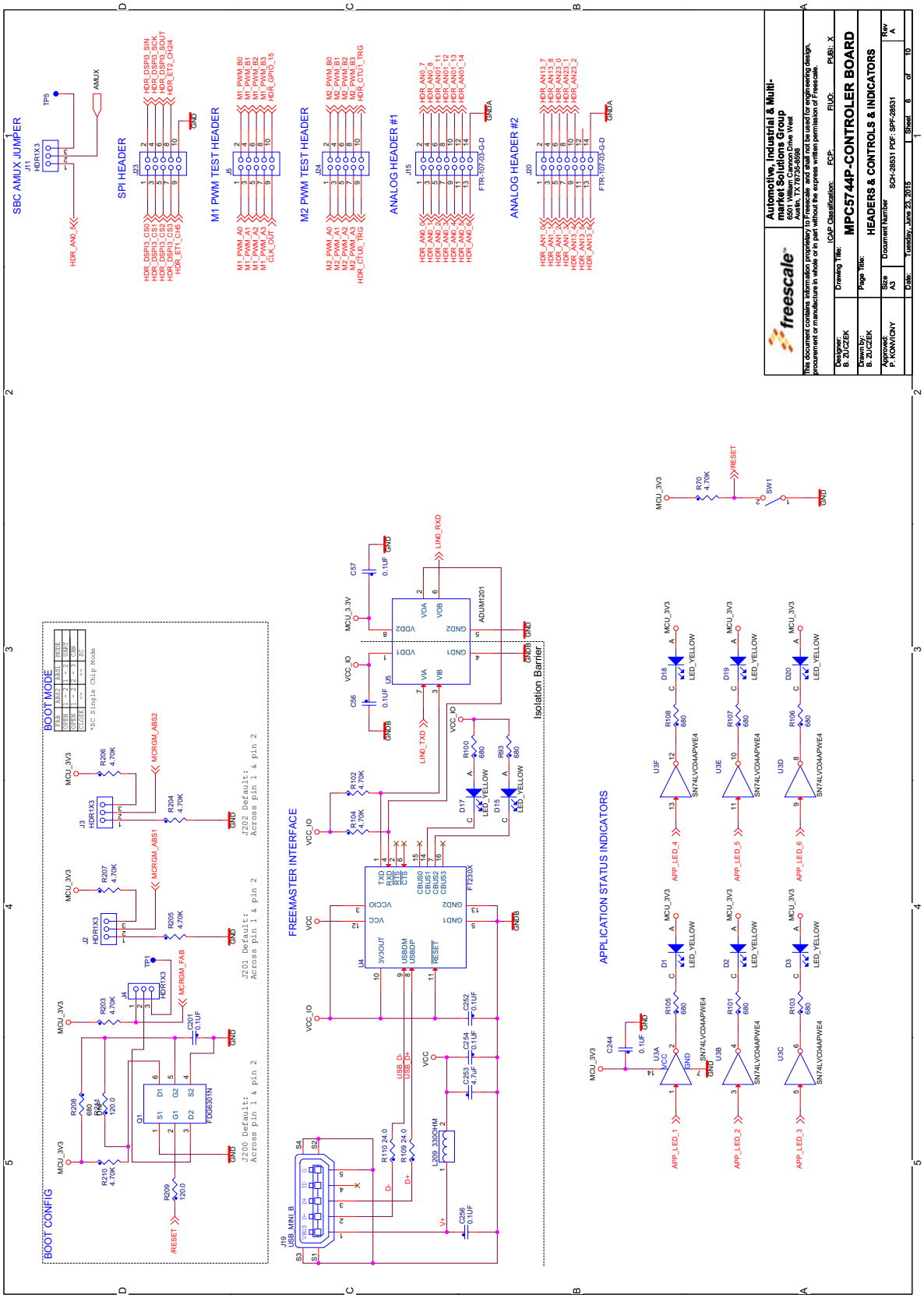

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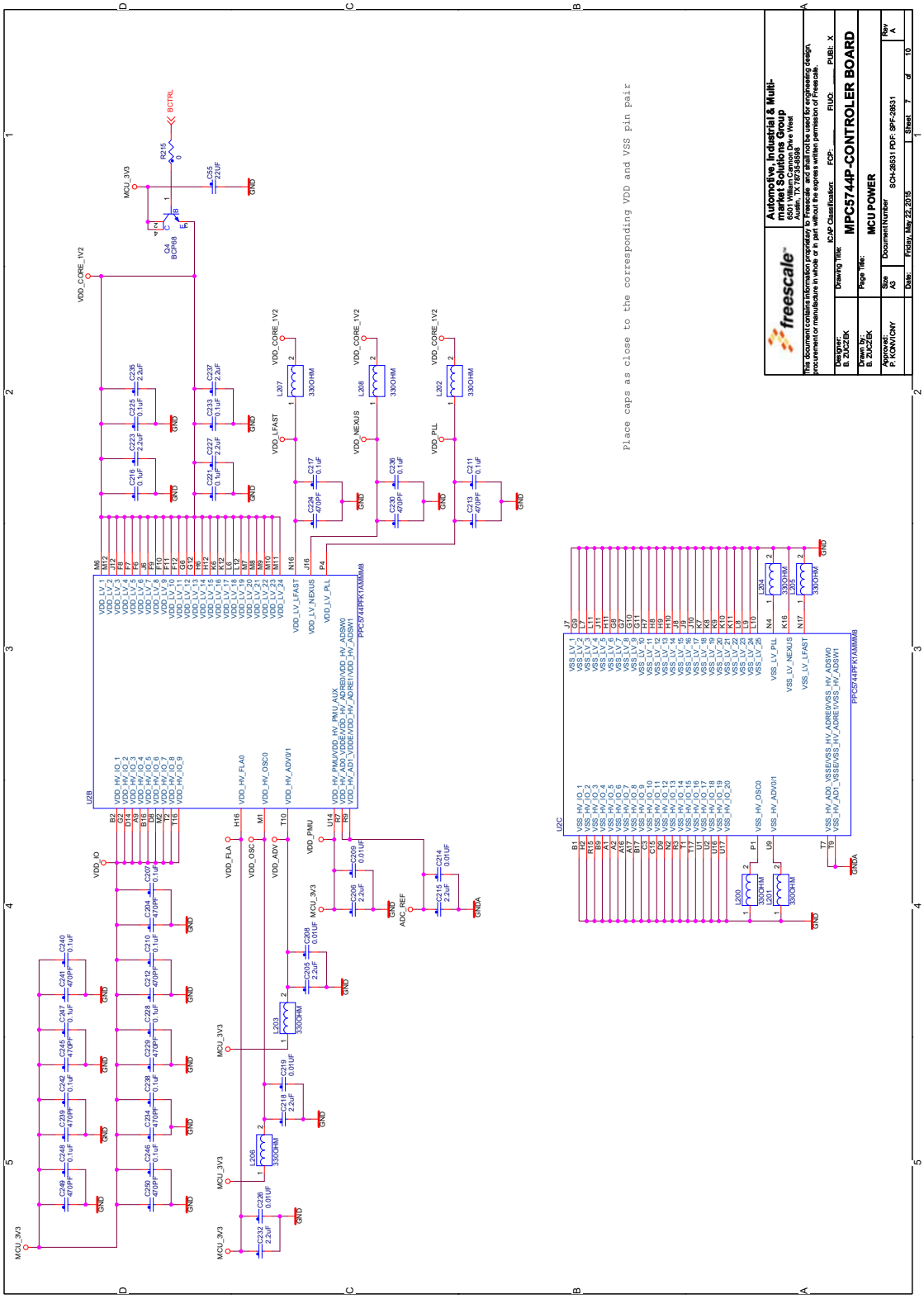

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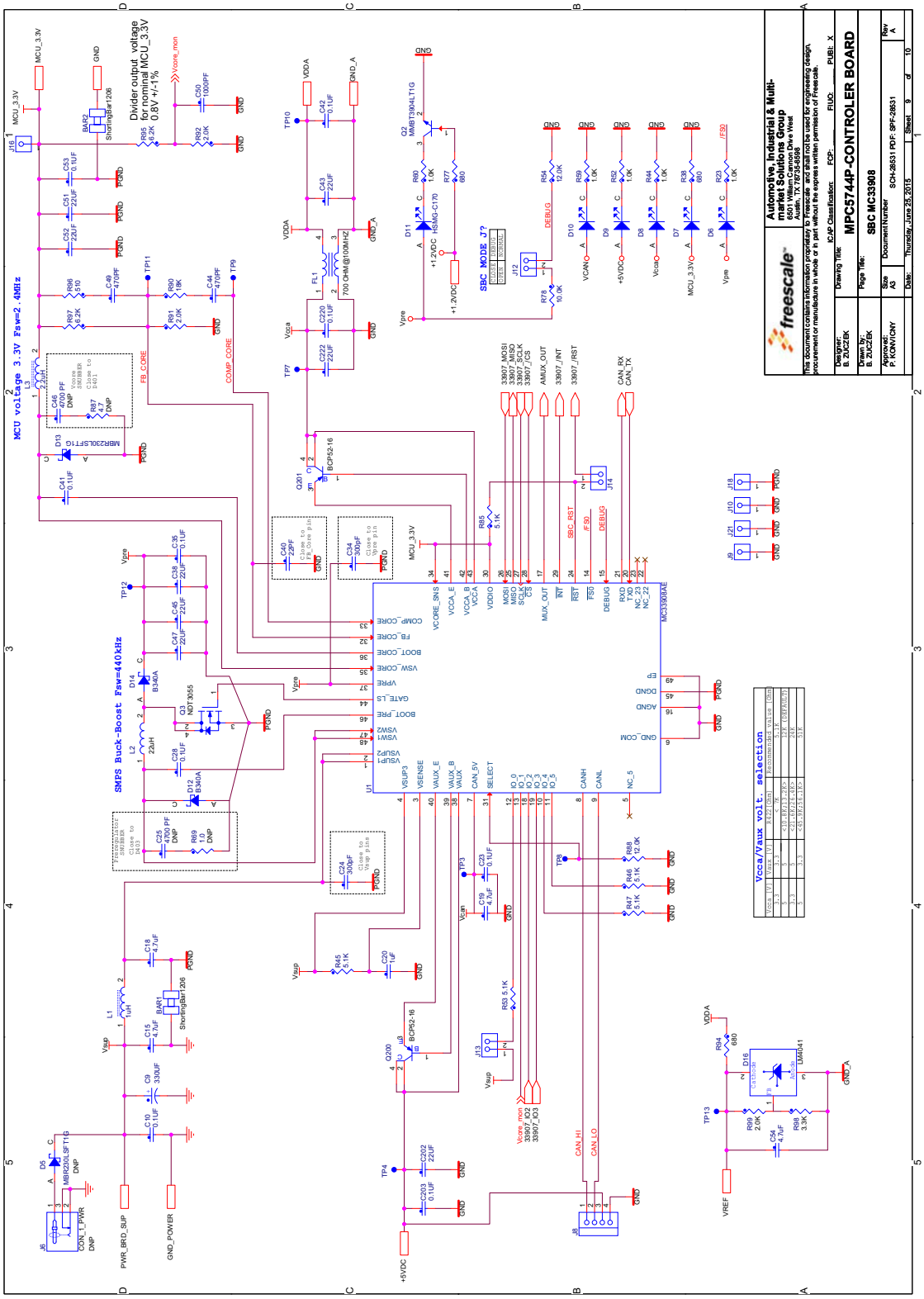

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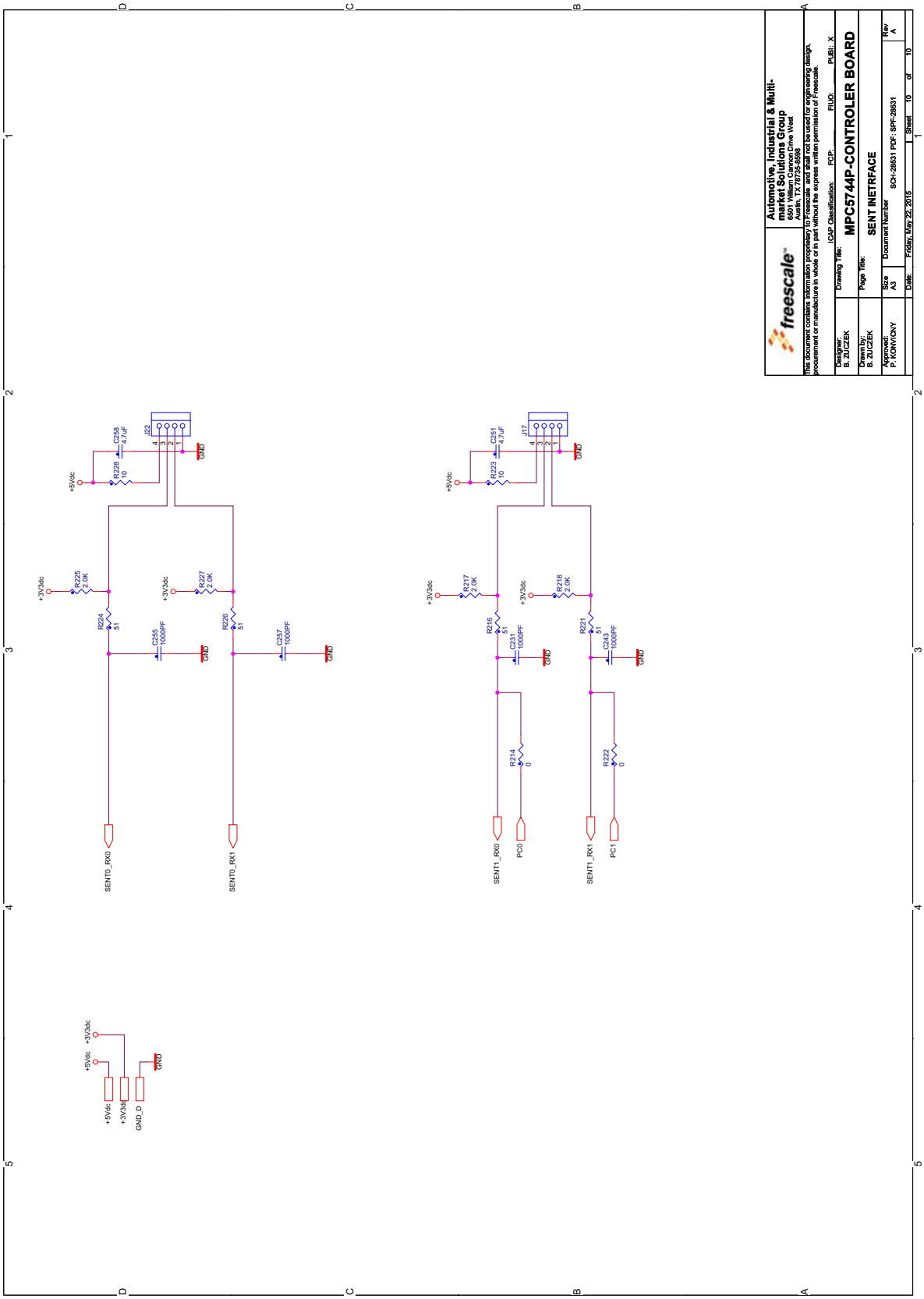

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