MC9S08AW60 Controller Board

User Manual

HCS08 Microcontrollers

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Preface

Chapter 1
Introduction

Chapter 2
Technical Summary

Preface

This reference manual describes the hardware on the MC9S08AW60 controller board. The board is designed for motor/motion control demos and supports specific customer needs, including the PWM interface with dead-time insertion circuit and tacho-dynamo hardware interface.

0.1 Audience

This document is intended for application developers who are creating software for devices using the MC9S08AWXX.

0.2 Organization

This manual is organized into two chapters and three appendixes.

- Introduction provides an overview of the board and its features.
- Technical Summary describes the MC9S08AW60 controller board hardware.
- MC9S08AW60 Controller Board Schematics contains the schematics of the MC9S08AW60 controller board.
- MC9S08AW60 Controller Board PCB contains details on the MC9S08AW60 printed circuit board (PCB).
- MC9S08AW60 Controller Board Bill of Materials lists materials used on the MC9S08AW60 controller board.

0.3 Notation Conventions

This document uses the following conventions:

Table 0-1. Notation Conventions

Term or Value	Symbol	Examples	Exceptions
Active high signals (logic one)	No special symbol attached to the signal name	MOSI1 SCL1	
Active low signals (logic zero)	Noted with an overbar in text and in most figures	$\overline{\text{RESET}}$ $\overline{\text{SS1}}$	In schematic drawings, active low signals may be noted by a slash: /RESET
Hexadecimal values	Begin with a “$” symbol	$0FF0 $80	
Decimal values	No special symbol attached to the number	10 34	
Binary values	Begin with the letter “b” attached to the number	b1010 b0011	
Numbers	Considered positive unless specifically noted as a negative value	5 –10	Voltage is often shown as positive: +3.3 V
Bold	Reference sources, paths, emphasis	...see: http://www.freescale.com/mcu	

0.4 Definitions, Acronyms, and Abbreviations

Definitions, acronyms, and abbreviations used in this document are defined below.

A/D	Analog to digital
D/A	Digital to analog
FLL	Frequency-locked loop
GPIO	General-purpose input and output port on Freescale Semiconductor’s family of microcontrollers
IC	Integrated circuit
LED	Light-emitting diode
LQFP	Low-profile quad flat pack
MCU	Microcontroller unit

MPIO	Multi-purpose input and output port on Freescale Semiconductor's family of microcontrollers; shares package pins with other peripherals on the chip and can function as a GPIO
PCB	Printed circuit board
PWM	Pulse-width modulation
Quadrature encoder	Sensor for the measurement of position and speed based on optical principles
RAM	Random access memory
R/C	Resistor/capacitor network
ROM	Read-only memory
SCI	Serial communications interface
SPI	Serial peripheral interface port on Freescale Semiconductor's microcontrollers
UART	Universal asynchronous receiver/transmitter

0.5 References

The following sources were referenced to produce this manual:

MC9S08AW60 Microcontroller Data Sheet, Freescale Semiconductor

Chapter 1
Introduction

The MC9S08AW60 controller board is used to demonstrate the abilities of the populated MC9S08AW60 part, which can be replaced by the pin compatible MC9S08AW48/32 in LQFP 64-pin footprint, based on an optimized PCB and power-supply design. The MC9S08AW60 contoller board provides a hardware tool allowing the development of applications that use the MC9S08AW60/48/32. This guide refers to MC9S08AW60.

The MC9S08AW60 controller board is an evaluation module board that includes a MC9S08AW60 part, PWM interface with hardware dead-time insertion circuit, encoder interface, tacho-generator interface, communication options, digital and analog power supplies, and peripheral expansion connectors. The expansion connectors are for signal monitoring and feature expansion. Test pads are provided for monitoring critical signals and voltage levels.

The MC9S08AW60 controller board is designed to:

- Familiarize you with the features of the HCS08 architecture.
- Serve as a platform for real-time software development. The tool suite enables you to develop and simulate routines, download the software to on-chip memory, run it, and debug it via the BACKGROUND port. The breakpoint features enable you to easily specify complex break conditions and to execute user-developed software at full speed, until the break conditions are satisfied. The ability to examine and modify all user accessible registers, memory, and peripherals through the BACKGROUND port facilitates the task of the developer.
- Serve as a platform for hardware development. The hardware platform enables you to connect external hardware modules. The BACKGROUND port's unobtrusive design makes all memory on the microcontroller chip available.

1.1 MC9S08AW60 Controller Board Architecture

The MC9S08AW60 controller board facilitates the evaluation of various MC9S08AW60 features. The MC9S08AW60 controller board can be used to develop real-time software and hardware products based on the MC9S08AW60. The MC9S08AW60 controller board provides the features necessary to write and debug software, demonstrate the functionality of that software, and interface with application-specific devices. The MC9S08AW60 controller board is flexible enough to allow you to exploit the MC9S08AW60's features to optimize the performance of the product, as shown in Figure 1-1.

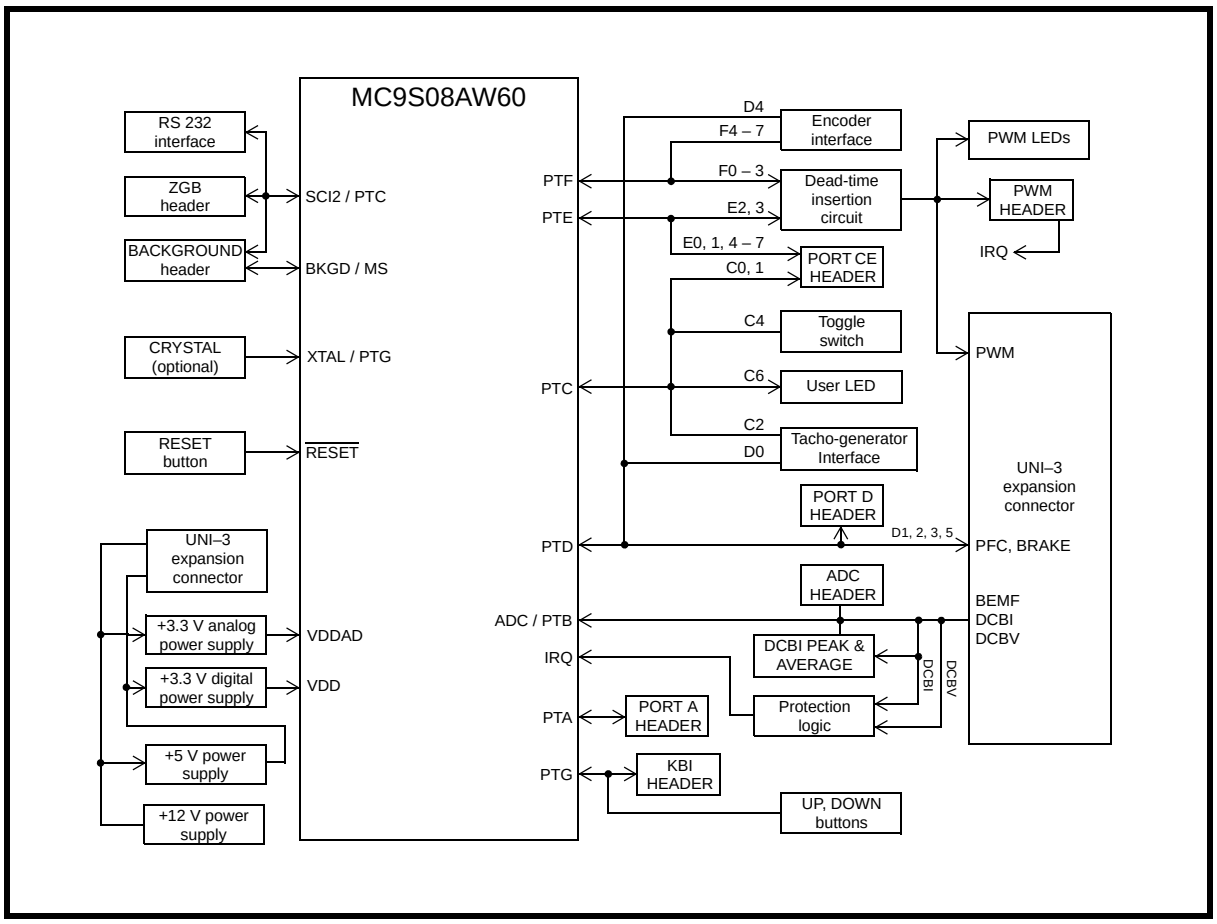


Figure 1-1. Block Diagram of the MC9S08AW60 Controller Board

1.2 MC9S08AW60 Controller Board Configuration Jumpers

Jumper groups and zero ohm resistors[1], shown in Figure 1-2, are used to configure various features on the MC9S08AW60 controller board.

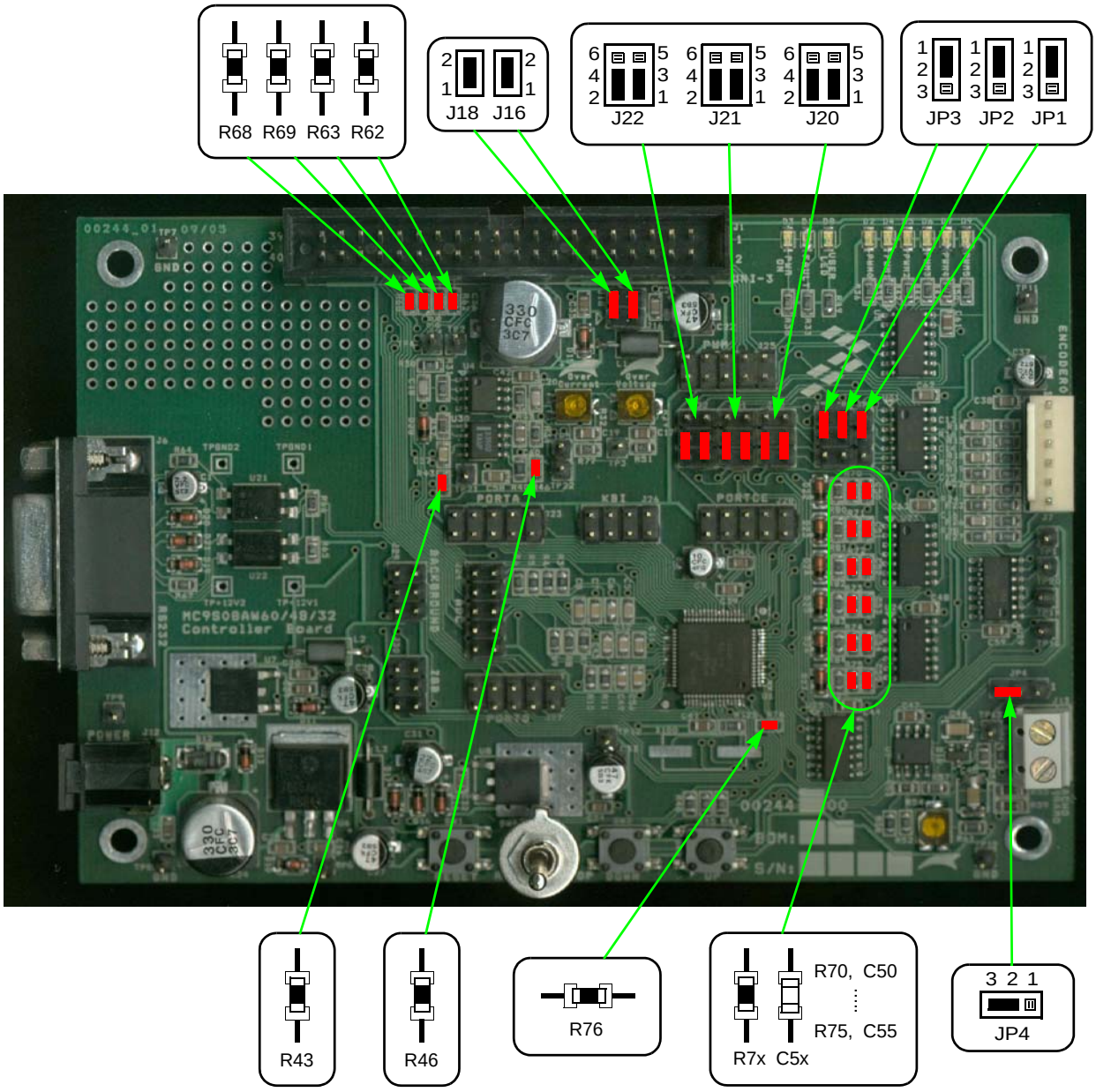


Figure 1-2. MC9S08AW60 Controller Board Jumper Options

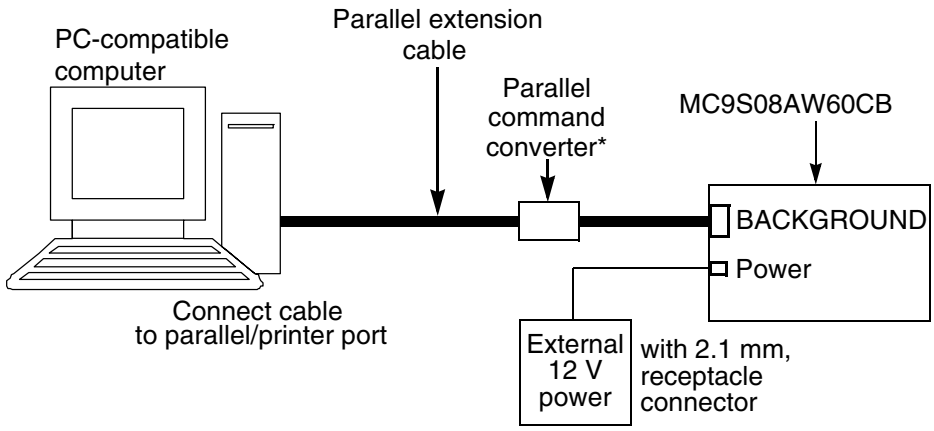
1. Zero ohm resistors are used instead of standard jumpers to minimize distortion of analog signals and to achieve high signal-to-noise ratio.

Table 1-1. MC9S08AW60 Controller Board Jumper Options

#	Selector	Function	Connections
JP1 JP2 JP3	PWM complementary mode	Odd PWM channels generated by hardware from even PWM channels	1–2
		Odd PWM channels generated by odd TPM1CHx channels	2–3
JP4	Tacho-dynamo measurement	Analog sensing by TACHO analog input (AD1P8)	1–2
		Digital sensing by digital input (GPIO PTC2)	2–3
J16	UNI–3 +5 V	Controller board digital power supply from UNI–3 +5 V	closed
J18	UNI–3 +15 V	Controller board analog power supply from UNI–3 +15 V	closed
J20 J21 J22	PWM mode	Complementary PWM mode	1–3, 2–4
		Independent PWM mode	3–5, 4–6
	R43	DC bus current peak value sensed by the AD1P2 analog input	R43 present
		AD1P2 input used as a universal analog input on the ADC header	R43 absent
	R46	DC bus current average value sensed by the AD1P3 analog input	R46 present
		AD1P3 input used as a universal analogue input on the ADC header	R46 absent
	R62	UNI–3 BRAKE signal controlled by the PTD1 output pin	R62 present
		PTD1 used as a universal GPIO pin on PORT D header	R62 absent
	R63	UNI–3 PFC PWM signal controlled by the PTD2 output pin	R63 present
		PTD2 used as a universal GPIO pin on PORT D header	R63 absent
	R68	UNI–3 PFC zero cross output signal connected to the PTD3 input pin	R68 present
		PTD3 used as a universal GPIO pin on PORT D header	R68 absent
	R69	UNI–3 PFC enable signal controlled by the PTD5 output pin	R69 present
		PTD5 used as a universal GPIO pin on PORT D header	R69 absent
	R76	Encoder output connected to the TPM2CLK/PTD4 input	R76 present
		TPM2CLK/PTD4 used as a universal GPIO pin on PORT D header	R76 absent

1.3 MC9S08AW60 Controller Board Connections

Figure 1-3 shows the connection between the PC, external 12 V DC power supply, and the MC9S08AW60 controller board.



* Use optoisolated PCC for high-voltage applications

Figure 1-3. Connecting the MC9S08AW60 Controller Board Cables

When optoisolation is needed to isolate the computer from the motor driver board and the controller board, use the optoisolated parallel command converter instead of the non-isolated parallel command converter. Command converters with ISA, PCI, USB, and ETHERNET interfaces are available.

To connect the MC9S08AW60 controller board cables:

1. Connect the parallel extension cable to the parallel port of the host computer.
2. Connect the other end of the parallel extension cable to the parallel command converter (see Figure 1-3) and connect it to the BACKGROUND header on the MC9S08AW60 controller board. Pin 1 on the command converter must be aligned with pin 1 on the controller board. This provides the connection that allows the host computer to control the board.
3. Connect the 2.1 mm output power plug from the external power supply into the power jack (see Figure 1-3) on the MC9S08AW60 controller board.
4. Apply power to the external power supply. The green power-on LED will illuminate when power is correctly applied.

Chapter 2
Technical Summary

The MC9S08AW60 controller board is designed as a versatile development card for developing real-time software and hardware products to support a new generation of applications in servo and motor control, SMPS, and other general purpose applications. The power of the 8-bit MC9S08AW60 microcontroller unit, combined with the hall-effect/quadrature encoder interface, PWM interface with dead-time insertion circuit, tacho-generator interface for digital/analog sensing, motor over-current logic, and motor over-voltage logic, makes the MC9S08AW60 controller board ideal for developing and implementing many motor controlling algorithms, and for learning the architecture and instruction set of the MC9S08AW60 microcontroller.

The features of the MC9S08AW60 controller board include:

- MC9S08AW60 8-bit +3.3 V microcontroller operating at 40 MHz
- BACKGROUND interface header for an external debug host target interface
- RS-232 interface with galvanic isolation for easy connection to a host computer or PC master development tool
- Header allowing you to attach a port A GPIO compatible peripheral
- Header allowing you to attach a port D (GPIO, ADC, KBI, TPM) compatible peripheral
- Header allowing you to attach a port CE (GPIO, IIC, SCI, SPI) compatible peripheral
- Header allowing you to attach a ADC compatible peripheral
- Header allowing you to attach a PWM compatible peripheral
- Header allowing you to attach a KBI / port G GPIO compatible peripheral
- Header allowing you to attach the ZigBee module or other SCI compatible peripheral
- On-board power regulation from an external 12 V DC supplied power input
- Light-emitting diode (LED) power indicator
- Six on-board PWM monitoring LEDs
- One on-board PWM fault monitoring LED
- One on-board general-purpose LED
- UNI-3 motor interface
  - DC bus voltage sensing
  - DC bus current sensing
  - Back-EMF sensing
  - Temperature sensing
  - Pulse-width modulation
  - BRAKE, PFC PWM signals
- Encoder/gall-effect interface
- Tacho-generator interface
- PWM dead-time insertion circuit
- DC bus over-current and over-voltage protection logic
- DC bus current peak detector and average value sensing
- Manual reset push-button

- General-purpose push-button for up on GPIO PTG1
- General-purpose push-button for down on GPIO PTG0
- General-purpose toggle switch for run/stop control on GPIO PTC4

2.1 MC9S08AW60

The MC9S08AW60 controller board uses a Freescale Semiconductor part, MC9S08AW60, MC9S08AW48, or MC9S08AW32, designated as U1 on the board and in the schematics. This part operates at a maximum speed of 40 MHz. The following documents provide a full description of the MC9S08AW60, including functionality information:

- MC9S08AW60 *Data Sheet*, (MC9S08AW60/D)**:** Provides features list and specifications including signal descriptions, electrical and timing specifications, pin descriptions, device specific peripheral information, and package descriptions. Also provides an overview description of the microcontroller unit and detailed information about the on-chip components, including the memory and I/O maps, peripheral functionality, and control/status register descriptions for each subsystem.

Refer to these documents for detailed information about chip functionality and operation. They can be found at www.freescale.com/mcu.

2.2 RS-232 Serial Communications

The MC9S08AW60 controller board provides an RS-232 interface by the use of RS-232 level converter circuitry (see Figure 2-1). The RS-232 level converter transitions the SCI UART's +3.3 V signal levels to RS-232 compatible signal levels and connects to the host's serial port via the DB9F connector. Table 2-1 lists the pinout of the RS232 connector. The RxD and TxD signals are also wired to the BACKGROUND and ZGB headers so you can connect the external modules with 3.3 V signal levels logic to this SCI UART. If needed, the +12 V can be connected to the RS232 connector, pin number 1, by shorting the TP+12V1 and TP+12V2 test points. Also, the associated TPGND1 and TPGND2 test points have to be shorted.

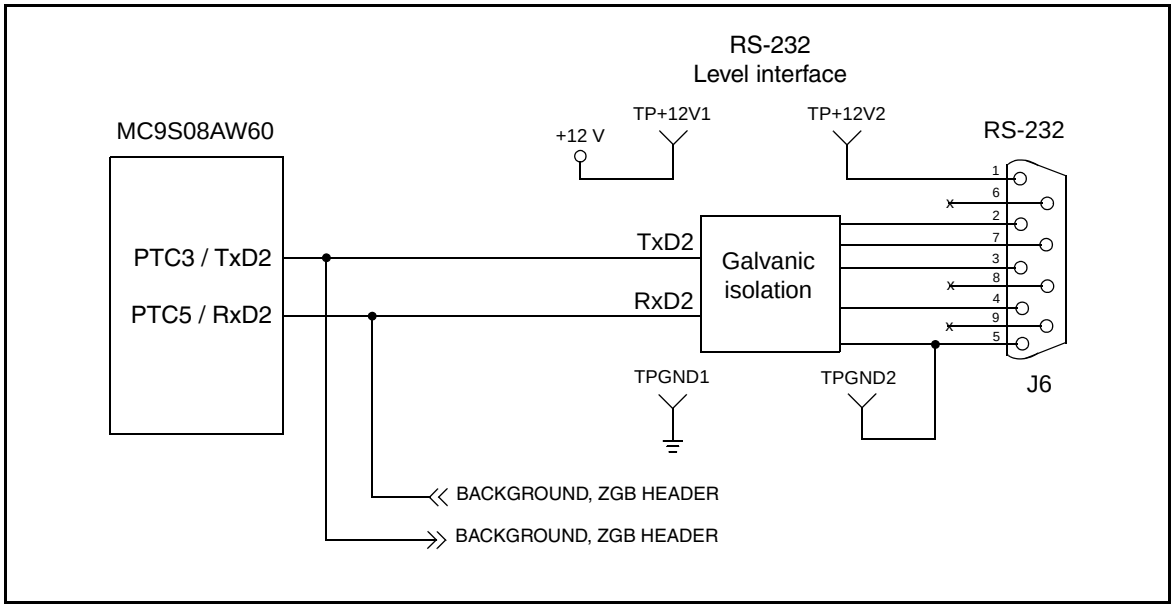


Figure 2-1. Schematic Diagram of the RS-232 Interface

Table 2-1. RS-232 Serial Connector Description

J6			
Pin #	**Signal**	**Pin #**	**Signal**
1	+12 V (optional)	6	NC
2	RxD	7	RTS
3	TxD	8	NC
4	DTR	9	NC
5	GND		

2.3 Clock Source

The MC9S08AW60 uses its internal 243 kHz reference generator and internal FLL to multiply the input frequency and achieve 40 MHz maximum operating frequency. This reference generator can be trimmed for finer accuracy via software when a precisely timed event is input to the MCU. This provides a reliable, low-cost clock source. As an MC9S08AW60 clock source, an optionally connected external crystal or resonator can also be used, attached to pins XTAL and EXTAL.

2.4 User LED

One on-board green LED D8 is provided to be controlled by your program. This diode is accessible via GPIO PTC6 port (see Figure 2-2). Setting GPIO PTC6 to a logic 1 value will turn on the LED.

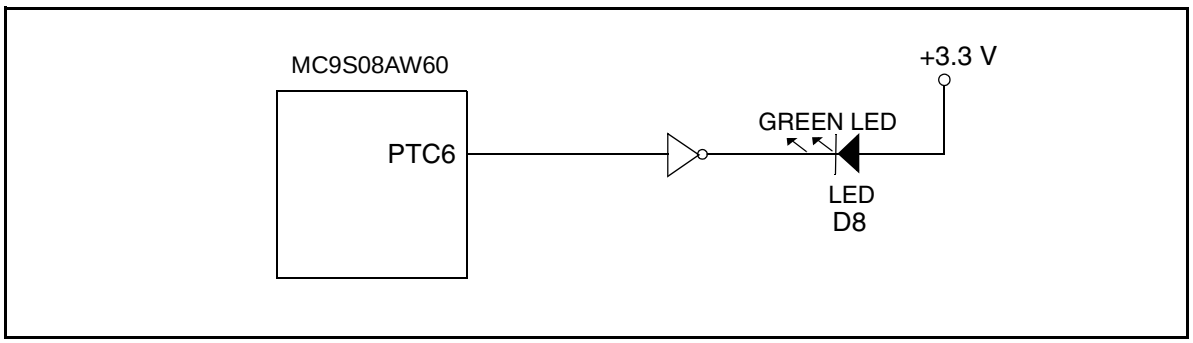


Figure 2-2. Schematic Diagram of LED Connection

2.5 Debug Support

The MC9S08AW60 controller board has a BACKGROUND interface connector for external target interface support.

2.5.1 BACKGROUND Header

The BACKGROUND header on the MC9S08AW60 controller board allows the connection of an external host target interface for downloading programs and working with the MC9S08AW60's registers. This header is used to communicate with an external host target interface passing information and data back and forth to a host processor running a debugger program. Table 2-2 shows the pinout for this header.

Table 2-2. BACKGROUND Header Description

J29			
Pin #	**Signal**	**Pin #**	**Signal**
1	BKGD/MS	2	GND
3	RxD2	4	RESET
5	TxD2	6	+3.3V

2.6 RESET

A RESET push-button is provided for asserting the MC9S08AW60 $\overline{\text{RESET}}$ signal (see Figure 2-3). The $\overline{\text{RESET}}$ signal is also attached to the BACKGROUND header J29, pin number 4.

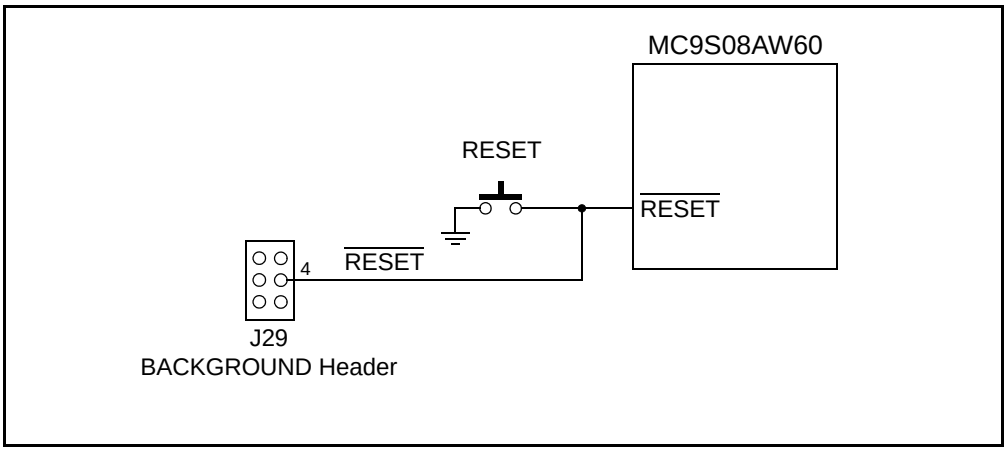


Figure 2-3. RESET Button

2.7 General-Purpose Buttons and Run/Stop Switch

Two on-board push-button switches and one toggle switch are provided for program control. The push-buttons (up, down) are directly connected to the port G GPIO signals PTG1 (up/SW2) and PTG0 (down/SW3). These signals are also attached to the KBI header. A run/stop toggle switch is connected to the port C GPIO signal PTC4 (see Figure 2-4).

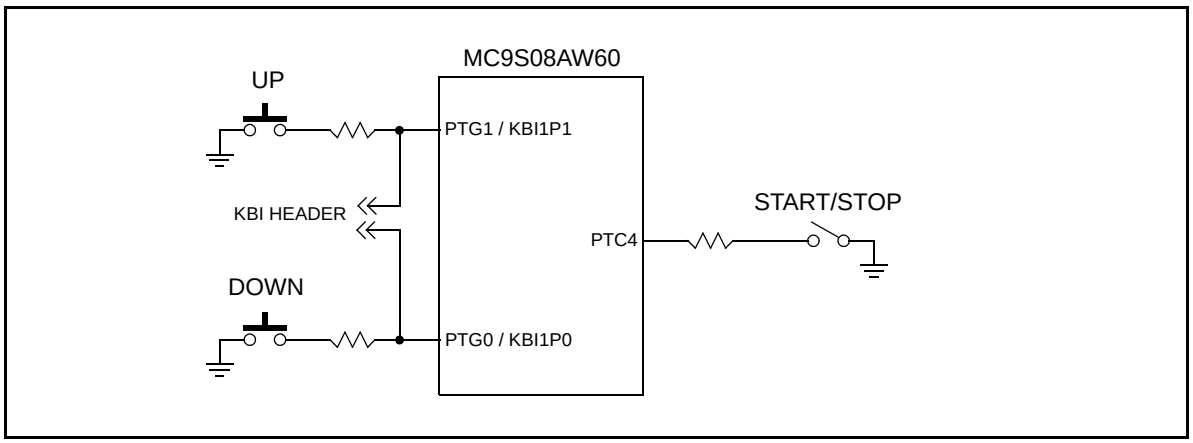


Figure 2-4. Schematic Diagram of the Buttons and Switch

Table 2-3. Connection Description of the Buttons and Switch

SWITCH	SIGNAL
DOWN (SW3)	GPIO PTG0
UP (SW2)	GPIO PTG1
RUN/STOP (SW4)	GPIO PTC4

2.8 Power Supply

The main power supply input 12 V DC to the MC9S08AW60 controller board is through a 2.1 mm coax power jack. The controller board requires less than 100 mA; the remaining current is available via the on-board connectors. The MC9S08AW60 controller board provides +3.3 V DC voltage regulation for the microcontroller and supporting logic. Power applied to the MC9S08AW60 controller board is indicated by a power-on LED. The controller board can also be powered from the UNI-3 interface by closing the J16 and J18 jumpers (see Figure 2-5).

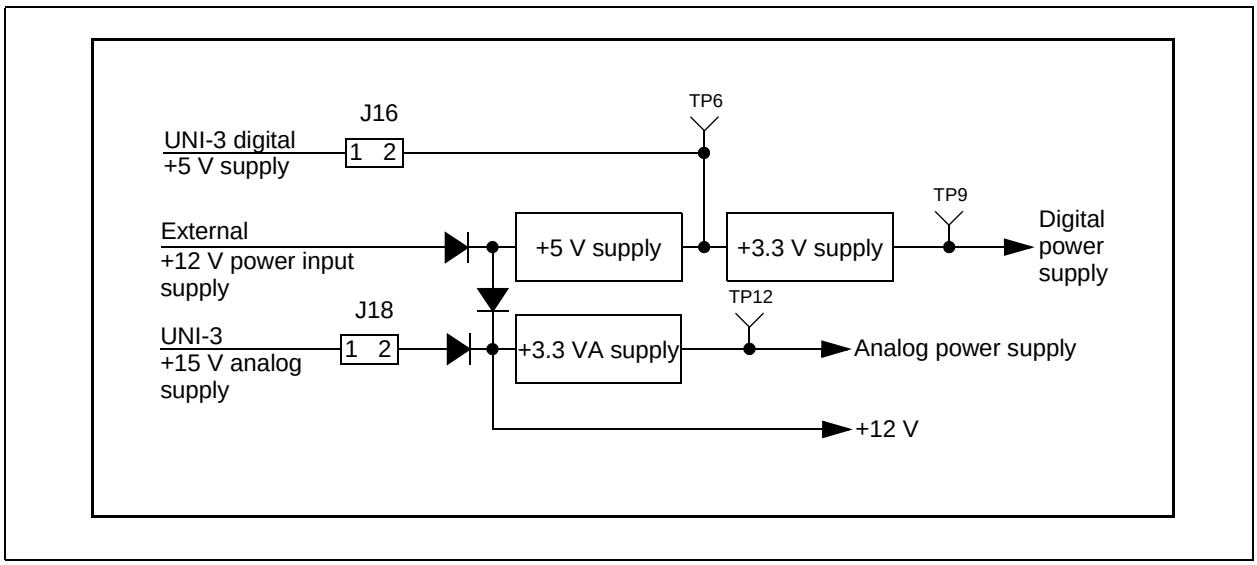


Figure 2-5. Power Supply

2.9 UNI-3 Interface

Motor control signals from a family of motor driver boards can be connected to the board via the UNI-3 connector/interface. The UNI-3 connector/interface contains all of the signals needed to drive and control the motor drive boards. These signals are connected to differing groups of the microcontroller's input and output ports: A/D, TIMER/PWM, and GPIO ports. Table 2-4 shows the pinout of the UNI-3 connector.

Table 2-4. UNI-3 Connector Description

J1			
Pin #	**Signal**	**Pin #**	**Signal**
1	PWM0	2	NC
3	PWM1	4	NC
5	PWM2	6	NC
7	PWM3	8	NC
9	PWM4	10	NC
11	PWM5	12	GND
13	GND	14	+5.0 V DC
15	+5.0 V DC	16	NC
17	Analog GND	18	Analog GND
19	Analog +15V DC	20	NC
21	Motor DC bus voltage sense	22	Motor DC bus current sense
23	NC	24	NC
25	NC	26	Motor drive temperature sense
27	NC	28	NC
29	Motor drive brake control	30	NC
31	PFC PWM	32	PFC EN
33	PFC ZC	34	NC
35	NC	36	NC
37	NC	38	Back-EMF phase A sense
39	Back-EMF phase B sense	40	Back-EMF phase C sense

2.9.1 UNI-3 BRAKE and PFC Signals

Four control signals are connected to the UNI-3 interface: BRAKE, PFC PWM, PFC ENABLE outputs, and PFC zero-cross input. These signals are connected to the MC9S08AW60 controller pins GPIO PTD1, PTD2, PTD3, and PTD5 through the zero-ohm resistors (see Figure 2-6). MC9S08AW60 controller pins GPIO PTD are also connected to the port D header. MC9S08AW60 has no other timer module, therefore the PFCPWM and PFCZC signals are connected to the GPIO for general use.

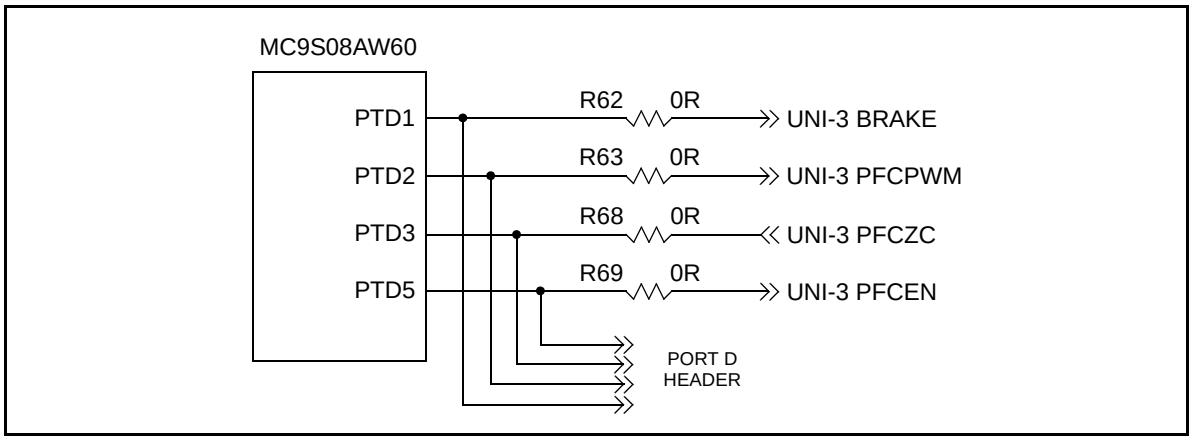


Figure 2-6. Schematic Diagram of the UNI-3 BRAKE and PFC Signals Connection

2.10 Motor Control PWM Signals and LEDs

The MC9S08AW60 controller has two dedicated TIMER/PWM units. The first unit contains six TIMER/PWM channels and the second unit contains two channels. On the MC9S08AW60 controller board, the first unit with the six TIMER/PWM channels is used as the PWM output generator. The PWM outputs can operate independently or in complementary pairs. Table 2-5 shows PWM jumper configuration. When the jumpers J20, J21, and J22 are in positions 1–3, 2–4, and the jumpers JP1, JP2, and JP3 are in position 1–2, the PWM outputs operate in complementary mode with hardware dead-time insertion (see Figure 2-7). All the PWM outputs are driven by the even TIMER/PWM channels TPM1CH0, TPM1CH2, and TPM1CH4 only. Odd PWM output channels complement their associated even channels. When jumpers J20, J21, and J22 are in positions 1–3, 2–4, and jumpers JP1, JP2, and JP3 are in position 2–3, the PWM outputs operate in complementary mode, but each PWM output is connected to its associated TPM1CHx channel (PWM0 is connected to TPM1CH0, PWM1 to TPM1CH1, etc.) with hardware dead-time insertion. The complementary PWM outputs are protected against even and odd active output TPM1CHx channels at the same time. When the even TPM1CHx channel is active, the odd PWM output is inactive, regardless of the state on the odd TPM1CHx channel. This PWM mode of operation can be useful while developing the software driver to control the PWM outputs in complementary mode without external hardware. When the jumpers J20, J21, and J22 are in positions 3–5 and 4–6, the PWM outputs operate independently without hardware dead-time insertion. PWM outputs are directly connected to their associated TPM1CHx channel outputs (PWM0 to TPM1CH0, PWM1 to TPM1CH1, etc.). Dead-time insertion can be done by the MC9S08AW60 software.

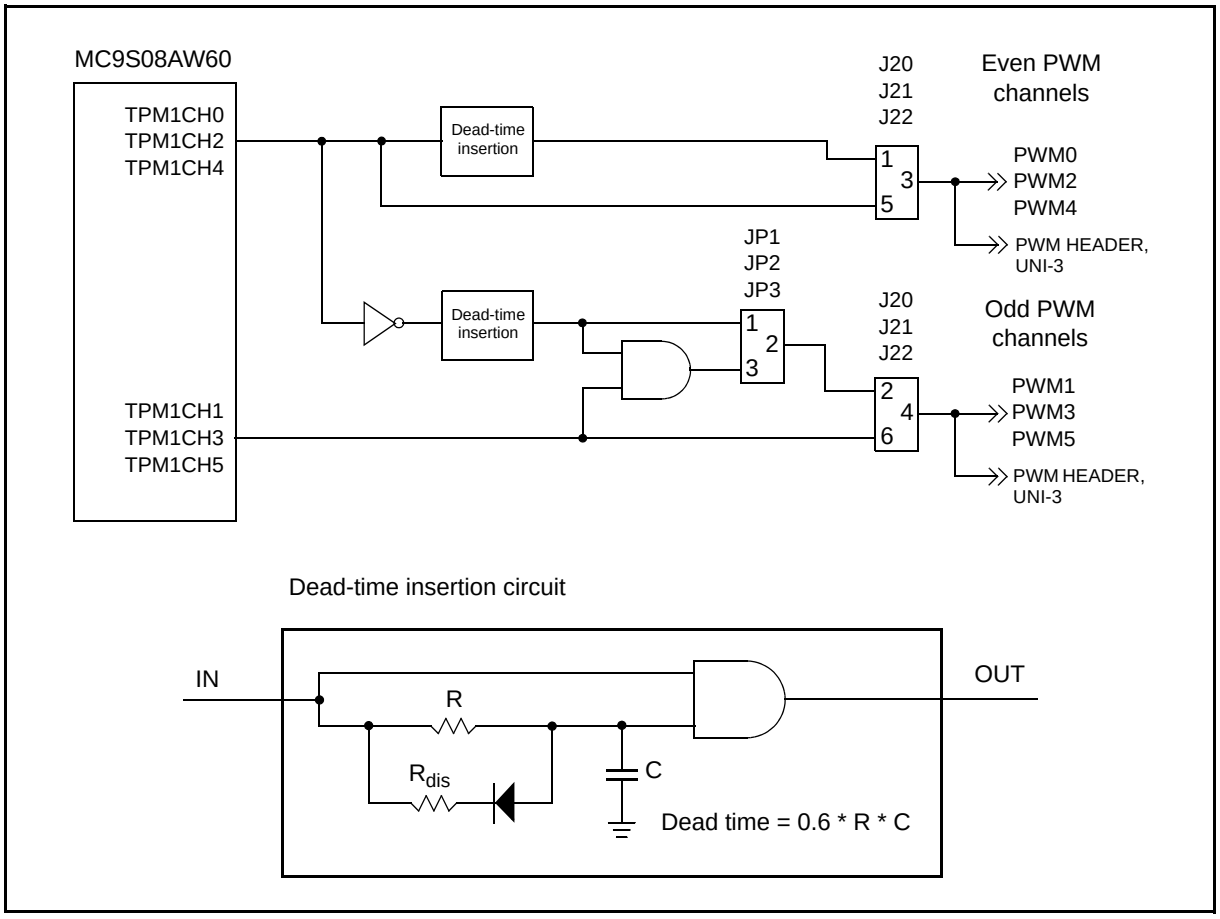


Figure 2-7. PWM Interface

Table 2-5. PWM Configuration Jumper Table

J20, J21, J22	JP1, JP2, JP3	HW dead time	PWM Operation Mode
1–3 2–4	1–2	Yes	Complementary mode: the odd PWM outputs generated by PWM on-board circuitry
1–3 2–4	2–3	Yes	Complementary mode: each PWMx is generated by associated TPM1CHx
3–5 4–6	—	No	Independent mode: PWMx outputs directly connected to TPM1CHx

Dead time can be adjusted by changing the values of the associated R and C electronic components (see Table 2-6).

Table 2-6. PWM Channels and Associated R and C Components

R	C	Associated PWM channel
R70	C50	PWM0
R71	C51	PWM1
R72	C52	PWM2
R73	C53	PWM3
R74	C54	PWM4
R75	C55	PWM5

For calculating the inserted dead time, the following formula should be used:

$$\text{Dead time} = 0.6 * R * C$$

PWM output group lines are connected to the UNI-3 interface connector and to a set of six PWM LEDs via inverting buffers. These PWM LEDs indicate the status of the PWM group signals (see Figure 2-8).

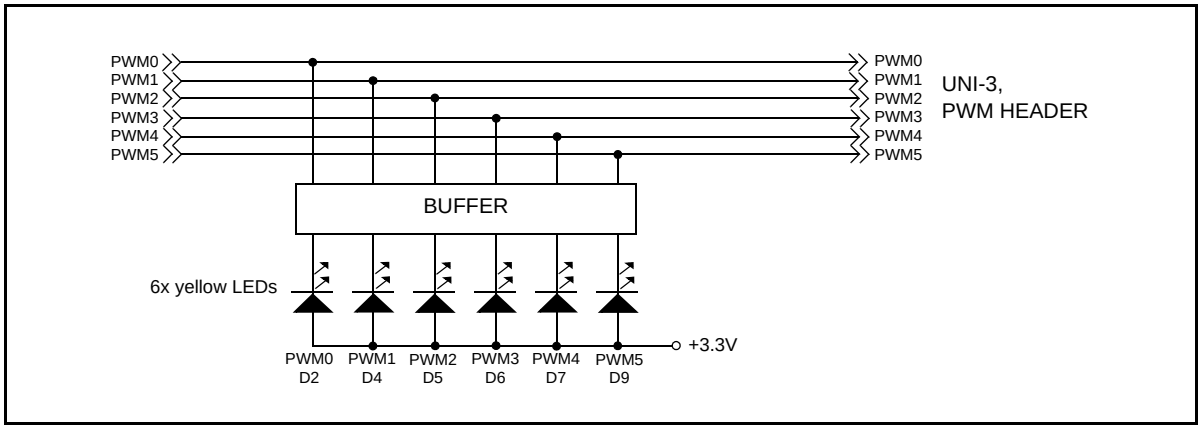


Figure 2-8. PWM LEDs

2.11 Motor Protection Logic

The MC9S08AW60 controller board contains a UNI-3 connector that interfaces with various motor drive boards. The microcontroller can sense error conditions generated by the motor power stage boards via signals on the UNI-3 connector.

2.11.1 Over-Current and Over-Voltage Protection

The motor driver board's DC bus voltage and DC bus current are sensed on the power stage board. The conditioned signals are transferred to the MC9S08AW60 controller board via the UNI-3 connector. DC bus voltage and DC bus current analog input signals are compared to a limit set by trimpots. If the input analog signals are greater than the limit set by the trimpot, a 0 V fault signal is generated. A fault LED monitors the fault states. The UNI-3 DC bus over-voltage and DC bus over-current fault signal is connected to the microcontroller's IRQ input (see Figure 2-9).

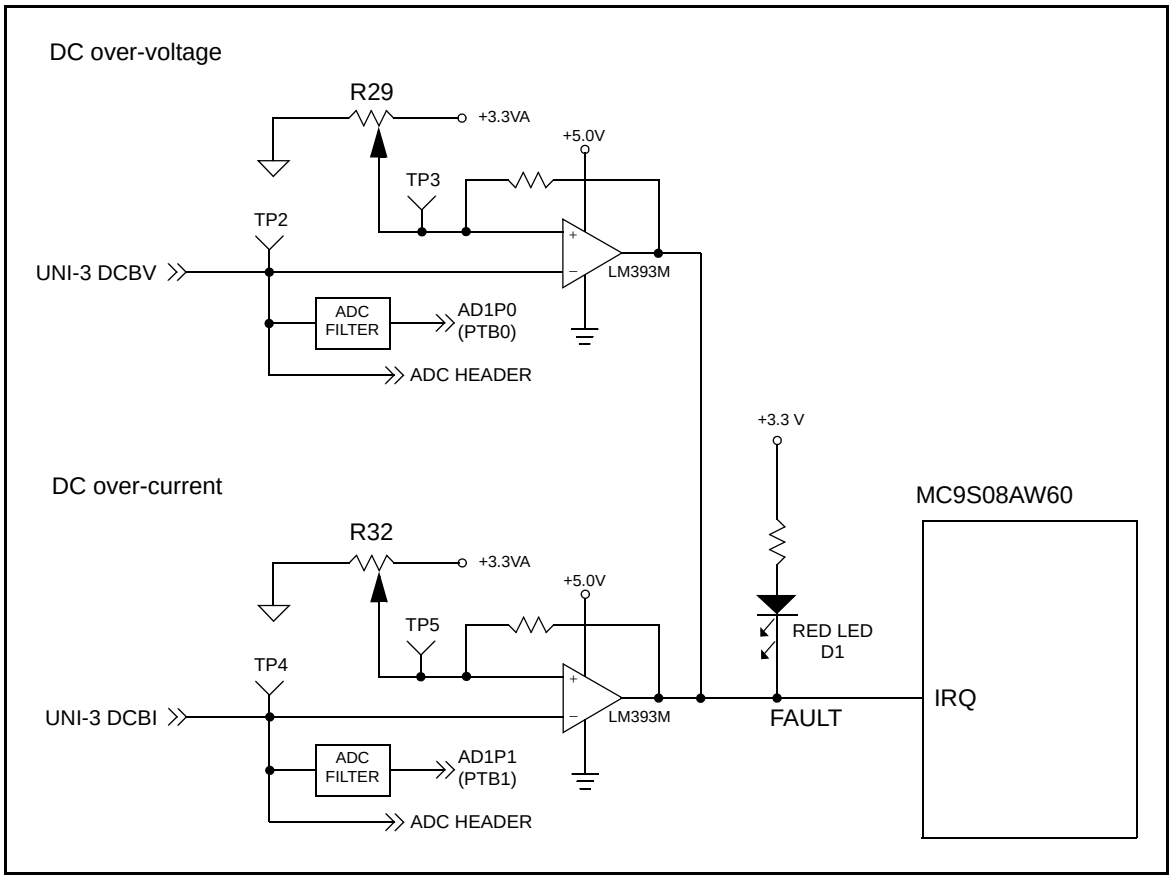


Figure 2-9. FAULT Protection Circuit

The DC bus over-voltage and DC bus over-current threshold levels can be adjusted by the trim-pots R29 and R32.

2.11.2 Temperature Sensing

Analog feedback signal for temperature of power module is transferred to the MC9S08AW60 controller board via the UNI-3 connector. This signal is connected to the controller's AD1P7 analog input.

2.12 DC Bus Current Sensing

The UNI-3 DC bus current value can be directly sensed by the ADC input pin AD1P1. The MC9S08AW60 controller board contains the hardware for sensing the peak and average values of the DC bus current. Figure 2-10 shows the DCBI peak detector and DCBI average value sensing circuitry. DCBI peak current value can be sensed by the ADC input pin AD1P2, and DCBI average value can be sensed by AD1P3. These ADC input pins can also be used as universal analog input pins on the ADC header when the zero ohm resistors R43 and R46 are not present.

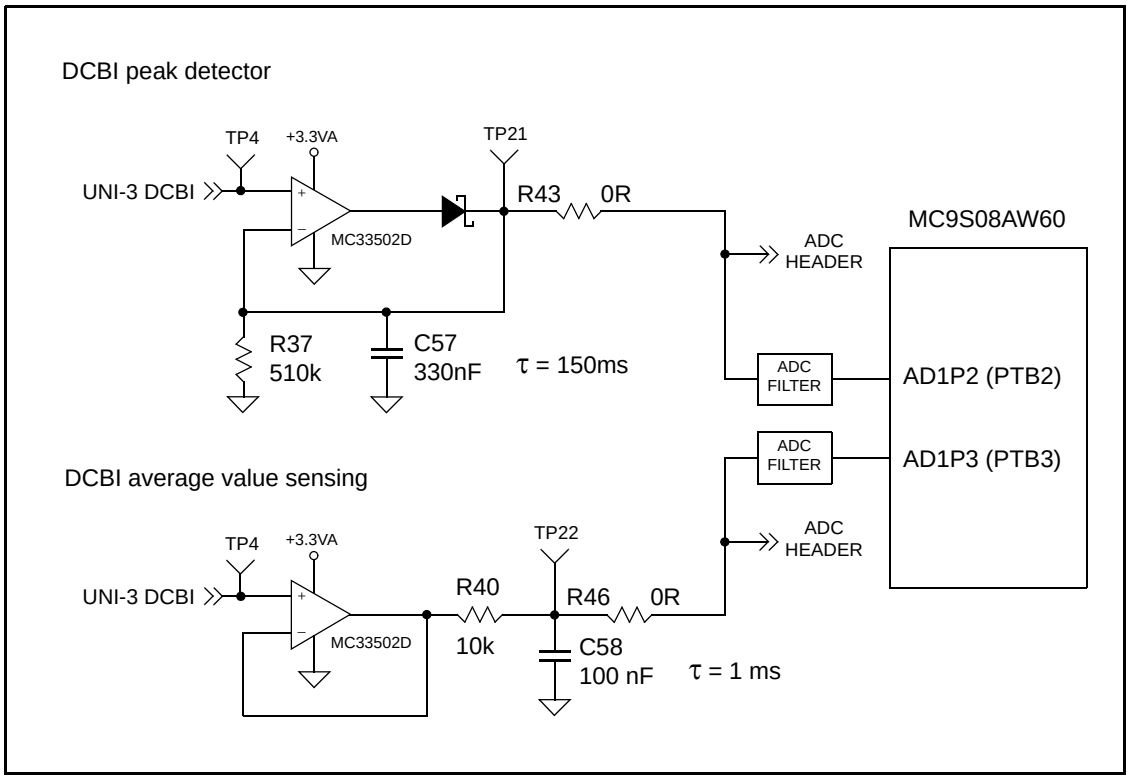


Figure 2-10. DCBI Peak Detector and Average Value Sensing

2.13 Back-EMF Current Sensing

The UNI-3 connector supplies three back-EMF current signals. These back-EMF signals on the UNI-3 connector are derived from a resistor divider network contained in the motor drive unit. These resistors scale down the attached motor's back-EMF voltages to a 0 to +3.3 V level. The back-EMF signals are connected to the controller's AD1P4, AD1P5, and AD1P6 analog inputs (see Table 2-7).

Table 2-7. Back-EMF Signals and Associated Analog Inputs

Back-EMF signal	Associated Analog Input
BEMFA	AD1P4
BEMFB	AD1P5
BEMFC	AD1P6

2.14 Quadrature Encoder/Hall-Effect Interface

The MC9S08AW60 controller board has a quadrature encoder/hall-effect interface connected to the microcontroller's input pins PTF5, PTF6, and PTF7 for the position sensing. When any position changes occur, the TPM2CH0 (PTF4) output turns over its logical value and can generate the interrupt for new position sensing. This output can be optionally connected to the controller's TPM2CLK (PTD4) input, when the zero-ohm resistor R76 is present. This TPM2CLK input can be used for the speed calculation (see Figure 2-11).

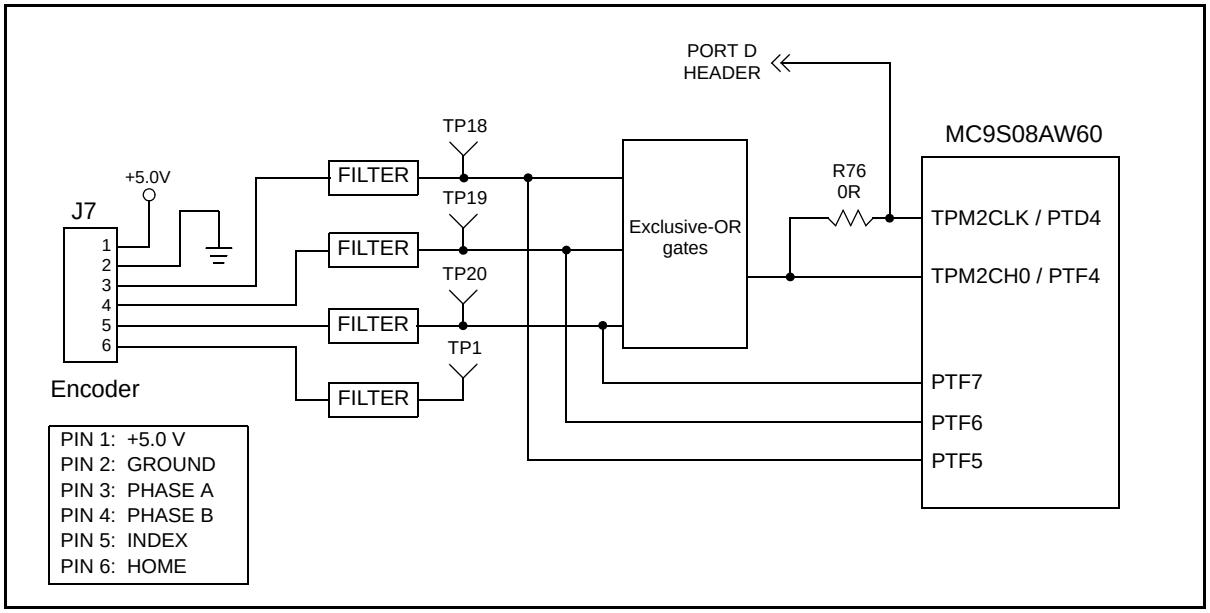


Figure 2-11. Encoder Interface

2.15 Tacho-Generator Interface

The MC9S08AW60 controller board contains a tacho-generator interface for digital/analogue sensing with the external tacho-dynamo input. Input noise filtering is supplied on the input path, then the signal passes through the voltage limiter to avoid damaging the follow on electrical circuitry. The signal can then be passed through jumper JP4 to the ADC analog input AD1P8 for analog sensing if the jumper is in position 1–2, or to the comparator with hysteresis to PTC2 input for digital sensing if the jumper is in position 2–3 (see Figure 2-12). When jumper JP4 is in position 2–3 (digital sensing), the analog input AD1P8 can be used as a universal analog input on the port D header.

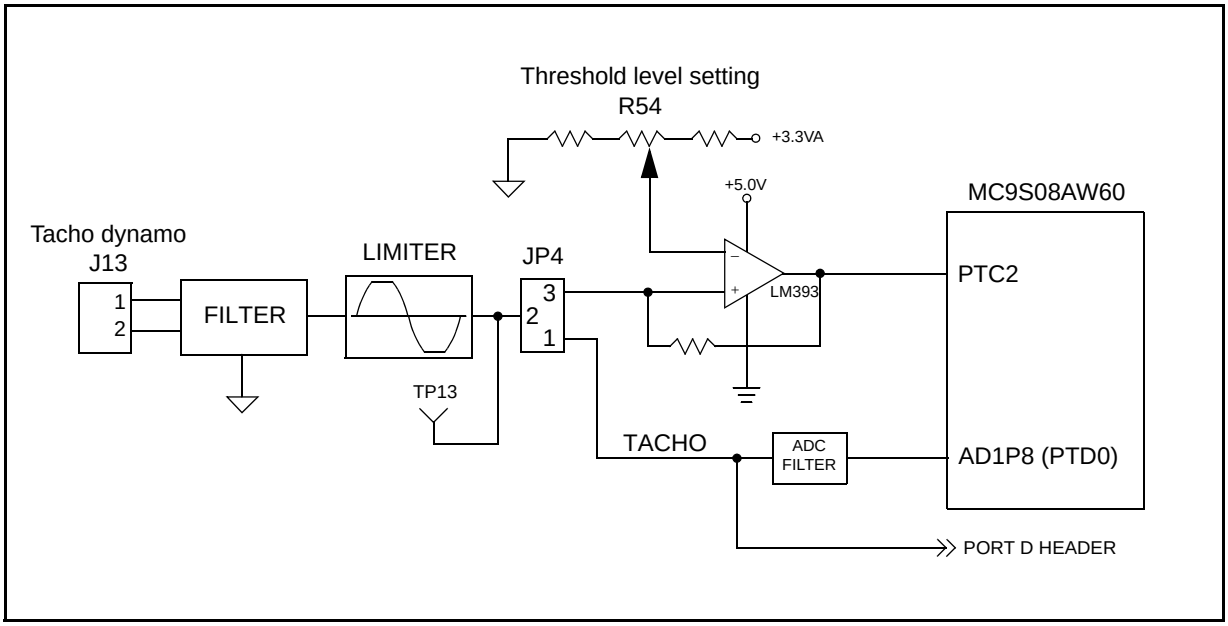


Figure 2-12. Tacho-Generator Interface

The R54 trimpot serves to adjust the working point of the comparator.

2.16 Peripheral Expansion Connectors

The MC9S08AW60 controller board contains a group of peripheral expansion connectors used to gain access to the MC9S08AW60 resources. The following signal groups have expansion connectors:

- Encoder
- Tacho-dynamo input
- Port A header
- Port D header
- Port CE header
- ADC header
- PWM header
- KBI header
- ZGB header

2.16.1 Encoder Expansion Connector

The quadrature encoder interface port is attached to this expansion connector. Table 2-8 shows connection information.

Table 2-8. Encoder Connector Description

J7	
Pin #	**Signal**
1	+5 V
2	GND
3	PHASE A
4	PHASE B
5	INDEX
6	HOME

2.16.2 Tacho-Dynamo Expansion Connector

The tacho-generator interface includes the tacho-dynamo input expansion connector (see Table 2-9).

Table 2-9. Tacho-Dynamo Connector Description

J13	
Pin #	**Signal**
1	Tacho-dynamo Input 1
2	Tacho-dynamo Input 2

2.16.3 Port A Header

The general-purpose input/output port A is attached to this header. Table 2-10 shows connection information

Table 2-10. Port A Header Description

J23			
Pin #	**Signal**	**Pin #**	**Signal**
1	PTA0	2	PTA1
3	PTA2	4	PTA3
5	PTA4	6	PTA5
7	PTA6	8	PTA7
9	GND	10	+3.3 V

2.16.4 Port D Header

The general-purpose input/output port D is attached to this header. Eight pins are shared with ADC1, KBI1 modules, and TPM1 and TPM2 external clock inputs. Refer to Table 2-11 for connection information.

Table 2-11. Port D Header Description

J27			
Pin #	**Signal**	**Pin #**	**Signal**
1	TACHO (PTD0 / AD1P8)	2	PTD1 / AD1P9
3	PTD2 / AD1P10 / KBI1P5	4	PTD3 / AD1P11 / KBI1P6
5	PTD4 / AD1P12 / TPM2CLK	6	PTD5 / AD1P13
7	PTD6 / AD1P14 / TPM1CLK	8	PTD7 / AD1P15 / KBI1P7
9	GND	10	+3.3 V

2.16.5 PORT CE Header

Two general-purpose input/output port C pins and six port E pins are attached to this header. Two port C pins are shared with IIC1 module, and six port E pins are shared with SCI1 and SPI1 modules. Table 2-12 shows connection information.

Table 2-12. Port CE Header Description

J28			
Pin #	**Signal**	**Pin #**	**Signal**
1	SCL1 / PTC0	2	SDA1 / PTC1
3	TxD1 / PTE0	4	RxD1 / PTE1
5	/SS1 / PTE4	6	MISO1 / PTE5
7	MOSI1 / PTE6	8	SPSCK1 / PTE7
9	GND	10	+3.3 V

2.16.6 ADC Header

The eight input channels of the analog-to-digital conversion port are attached to this connector. Refer to Table 2-13 for connection information. There is an RC network on each of the analog port input signals; reference Figure 2-13.

Table 2-13. ADC Header Description

J24			
Pin #	**Signal**	**Pin #**	**Signal**
1	UNI-3 DCBV (AD1P0)	2	UNI-3 DCBI (AD1P1)
3	DCBI PEAK (AD1P2)	4	DCBI AVERAGE (AD1P3)
5	UNI-3 BEMFA (AD1P4)	6	UNI-3 BEMFB (AD1P5)
7	UNI-3 BEMFC (AD1P6)	8	UNI-3 TEMP (AD1P7)
9	GNDA	10	+3.3 V

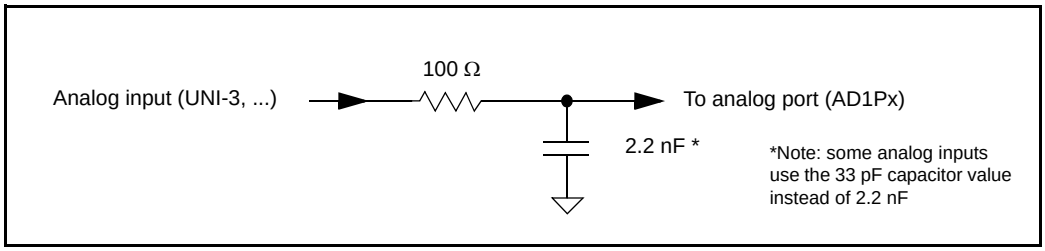


Figure 2-13. Typical Analog Input RC Filter

2.16.7 PWM Header

The six PWM interface output signals and one fault (IRQ) input signal are attached to this header. Table 2-14 shows connection information.

Table 2-14. PWM Header Description

J25			
Pin #	**Signal**	**Pin #**	**Signal**
1	PWM0	2	PWM1
3	PWM2	4	PWM3
5	PWM4	6	PWM5
7	NC	8	IRQ
9	GND	10	+3.3 V

2.16.8 KBI Header

Five general-purpose input/output port G pins are attached to this header. These pins are shared with KBI1 module. Table 2-15 shows connection information.

Table 2-15. KBI Header Description

J26			
Pin #	**Signal**	**Pin #**	**Signal**
1	KBI1P0 / PTG0	2	KBI1P1 / PTG1
3	KBI1P2 / PTG2	4	KBI1P3 / PTG3
5	KBI1P4 / PTG4	6	NC
9	GND	10	+3.3 V

2.16.9 ZGB Header

This header serves to connect the ZigBee module or other external peripherals that use the serial communication protocol. Refer to Table 2-16 for connection information.

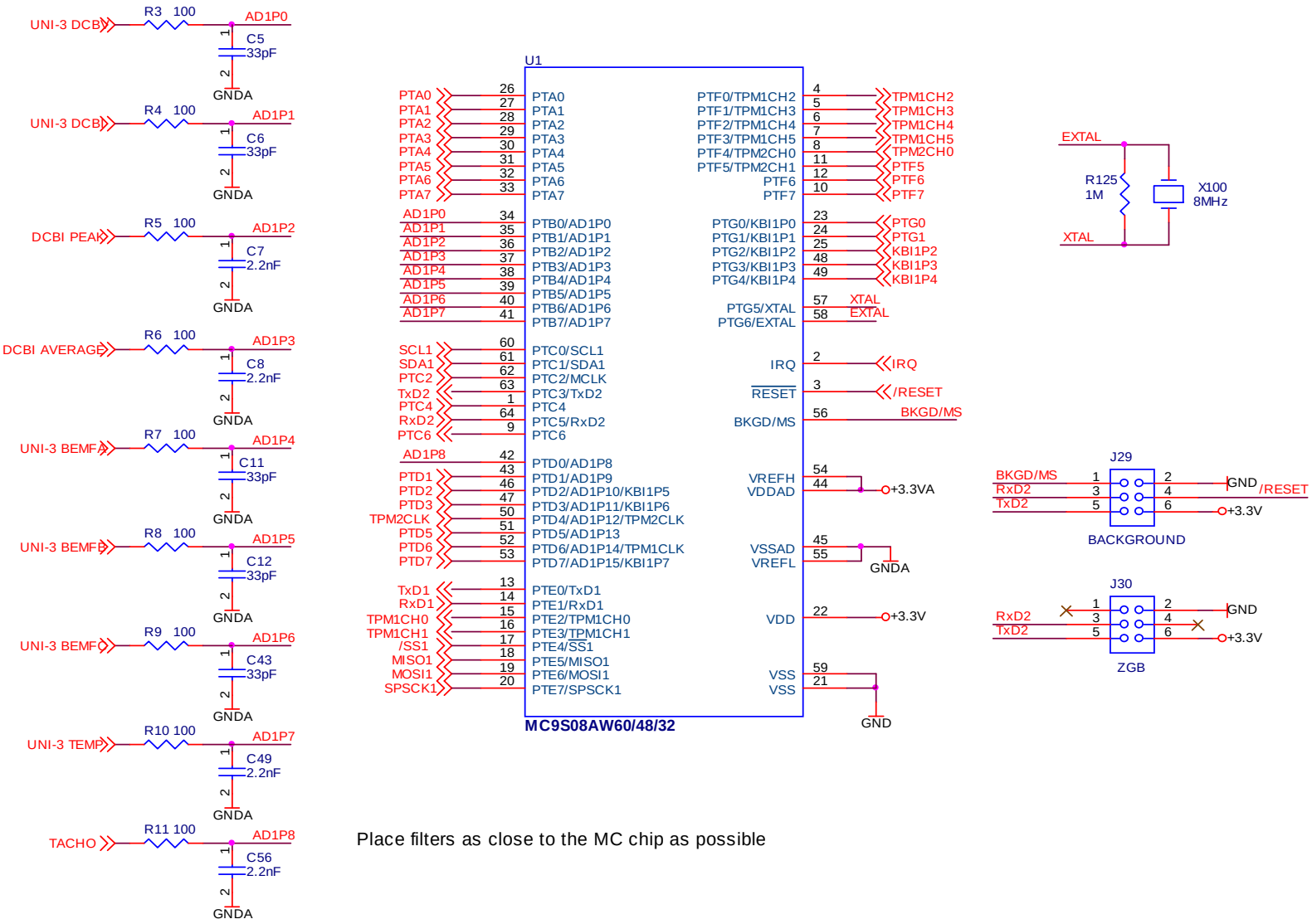
Table 2-16. ZGB Header Description

J30			
Pin #	**Signal**	**Pin #**	**Signal**
1	NC	2	GND
3	RxD2	4	NC
5	TxD2	6	+3.3V

2.17 Test Points

The MC9S08AW60 controller board has 18 test pins. The four test pins are located near the corners of the board and provide a digital ground (GND) signal for easy oscilloscope attachment.

Appendix A. MC9S08AW60 Controller Board Schematics



Place filters as close to the MC chip as possible

Figure A-1. MC9S08AW60 Controller

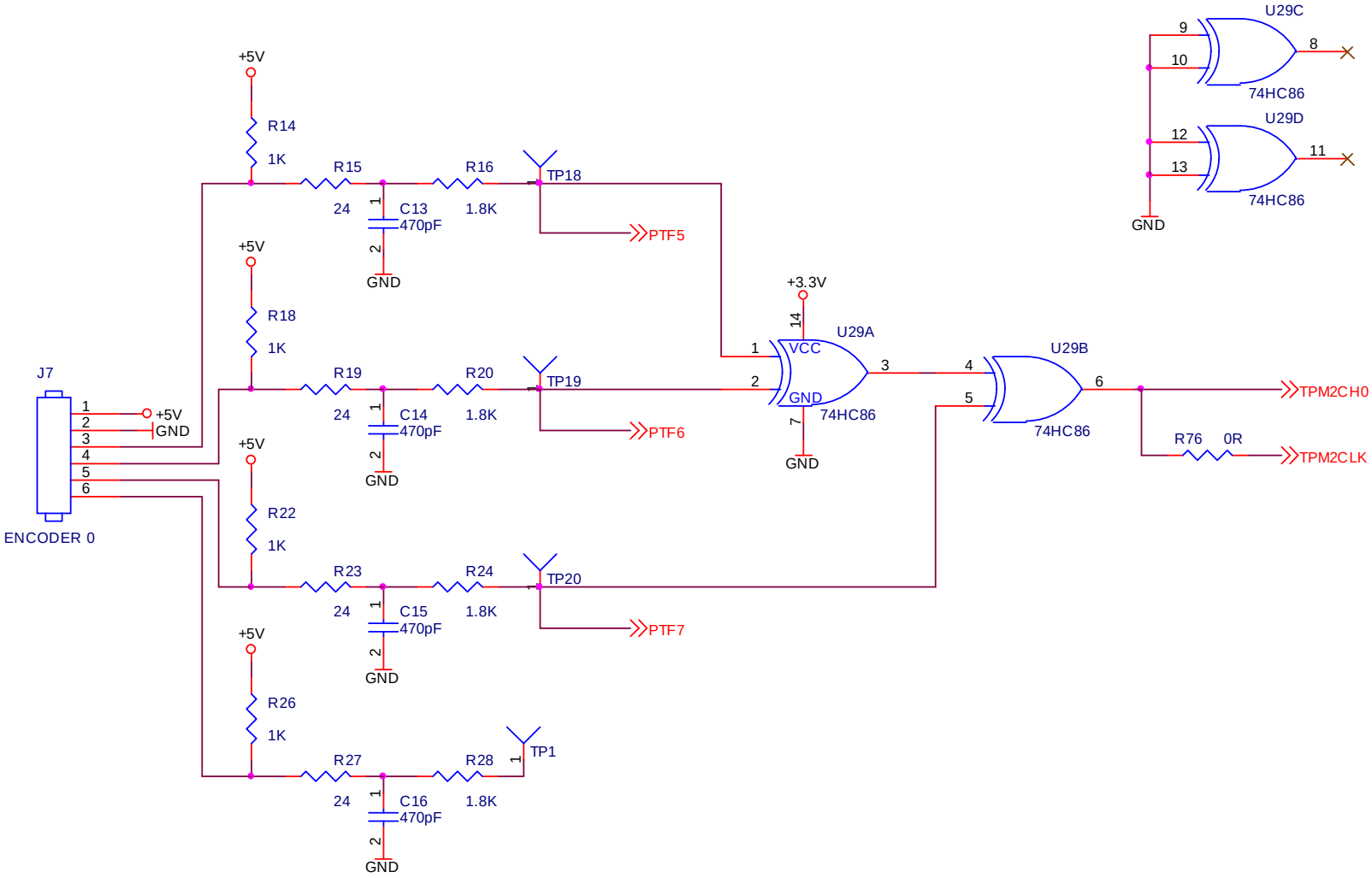


Figure A-2. Encoder Interface

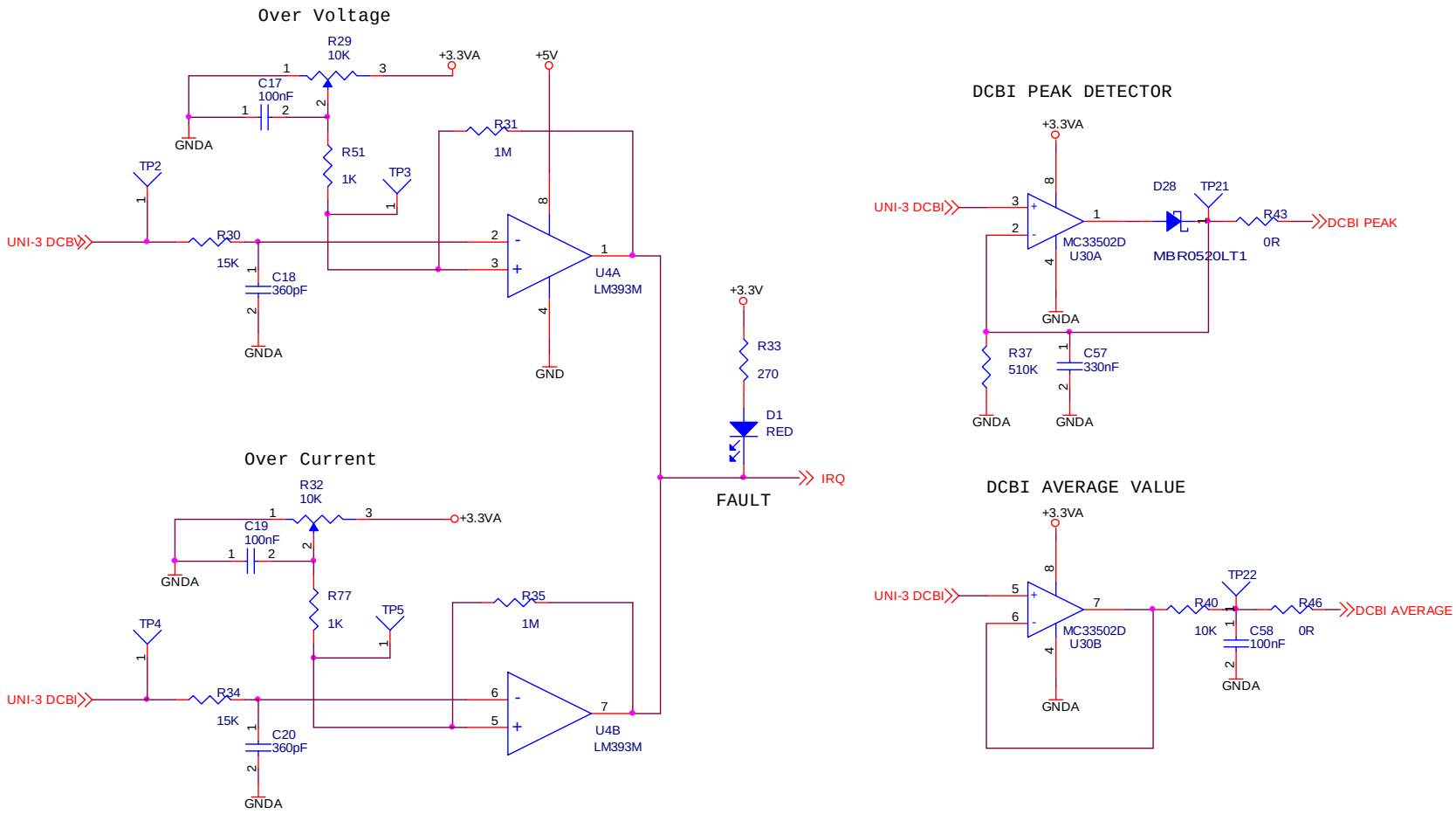


Figure A-3. Fault and DCBI

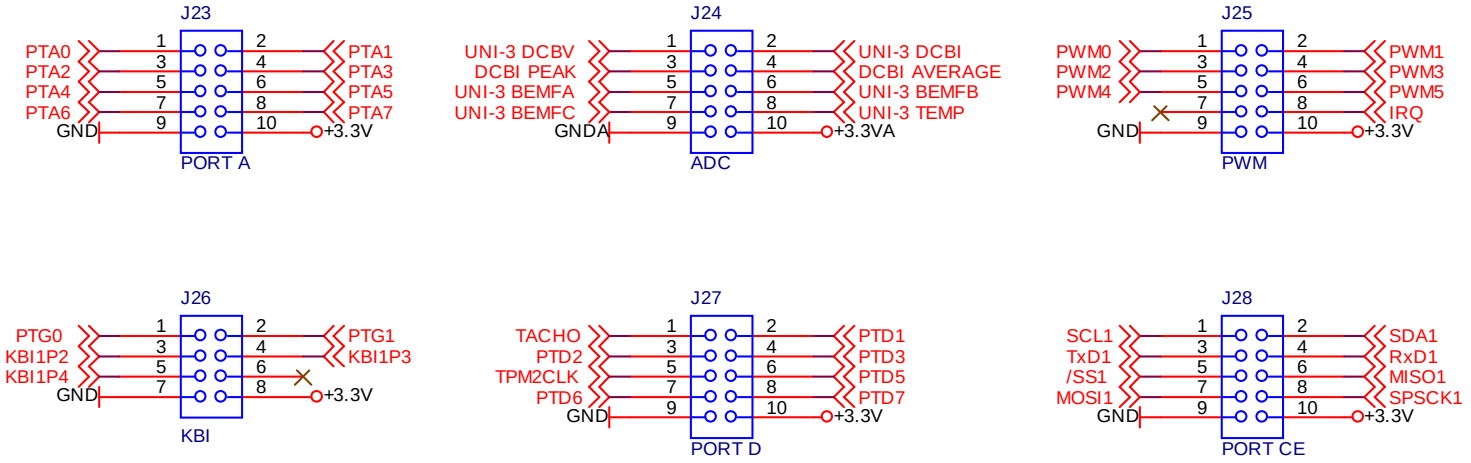


Figure A-4. Headers

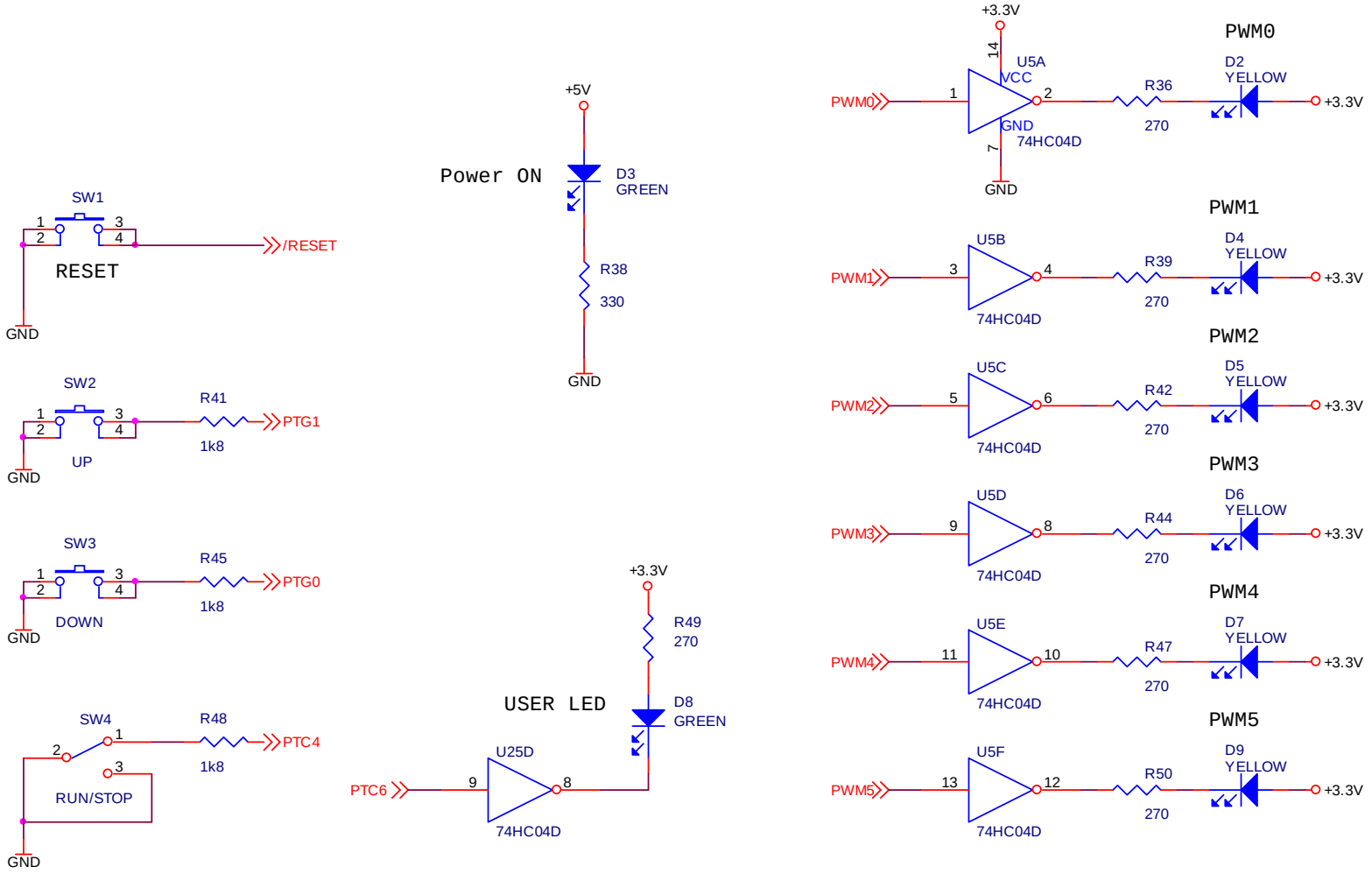


Figure A-5. LEDs and Buttons

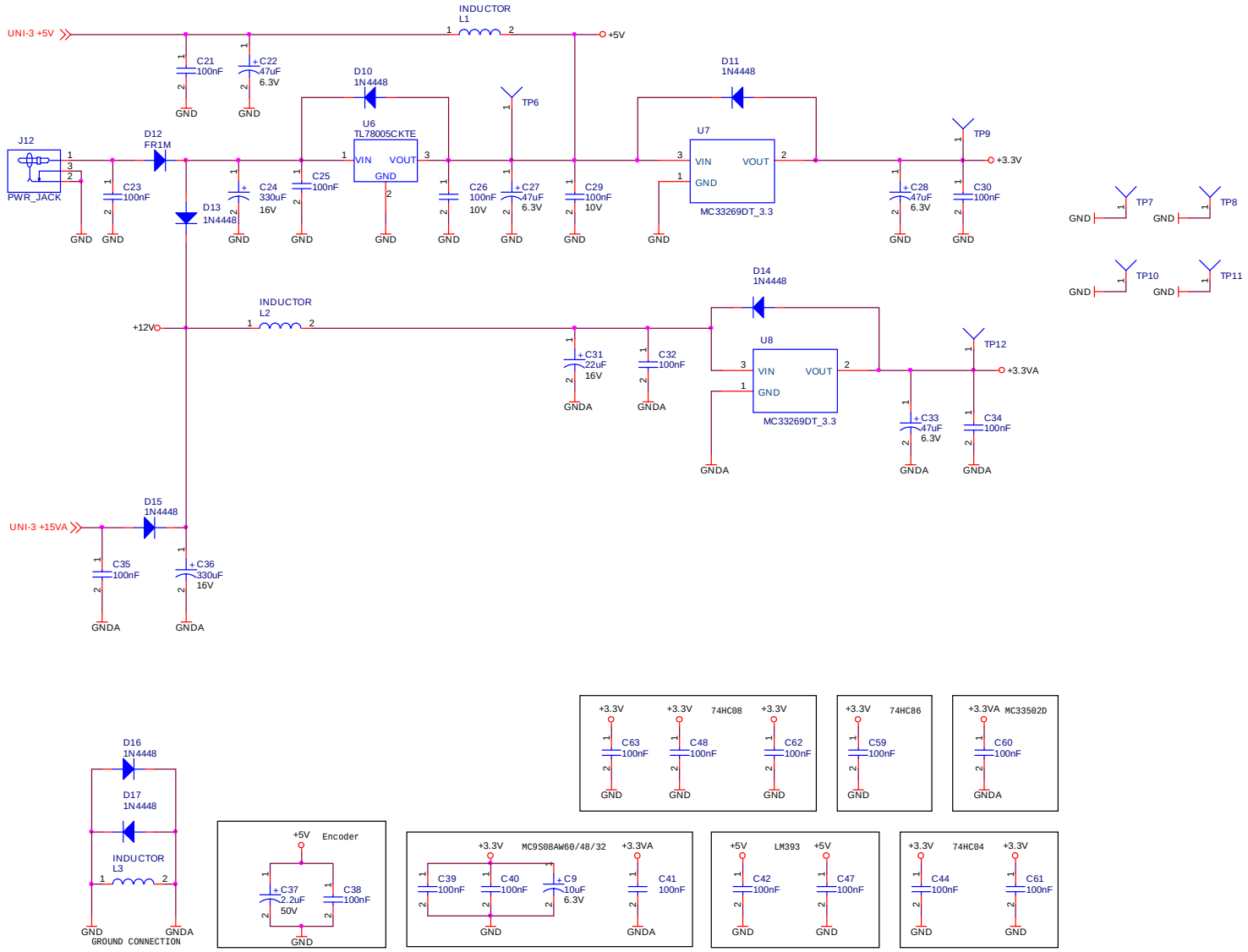


Figure A-6. Power Supply

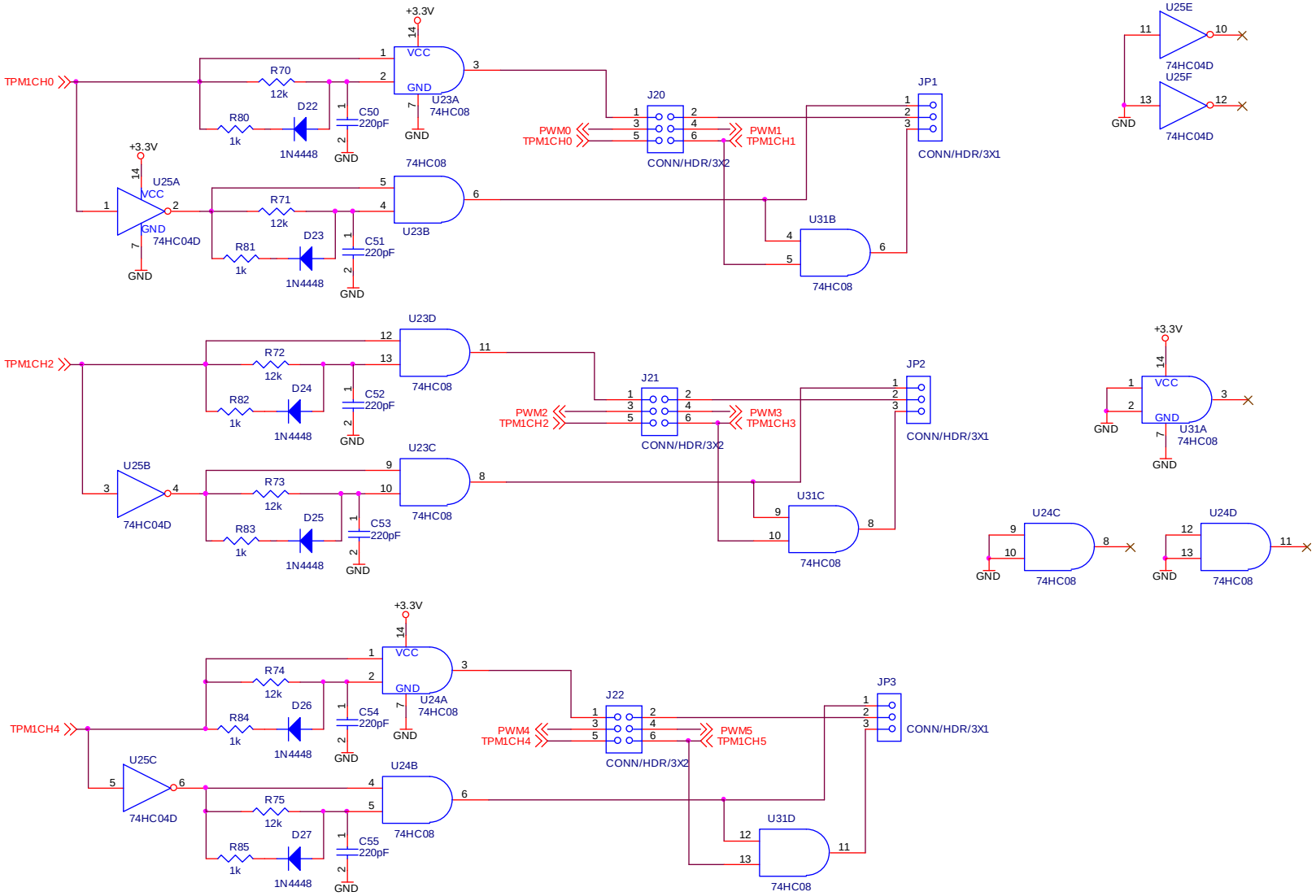


Figure A-7. PWM Interface

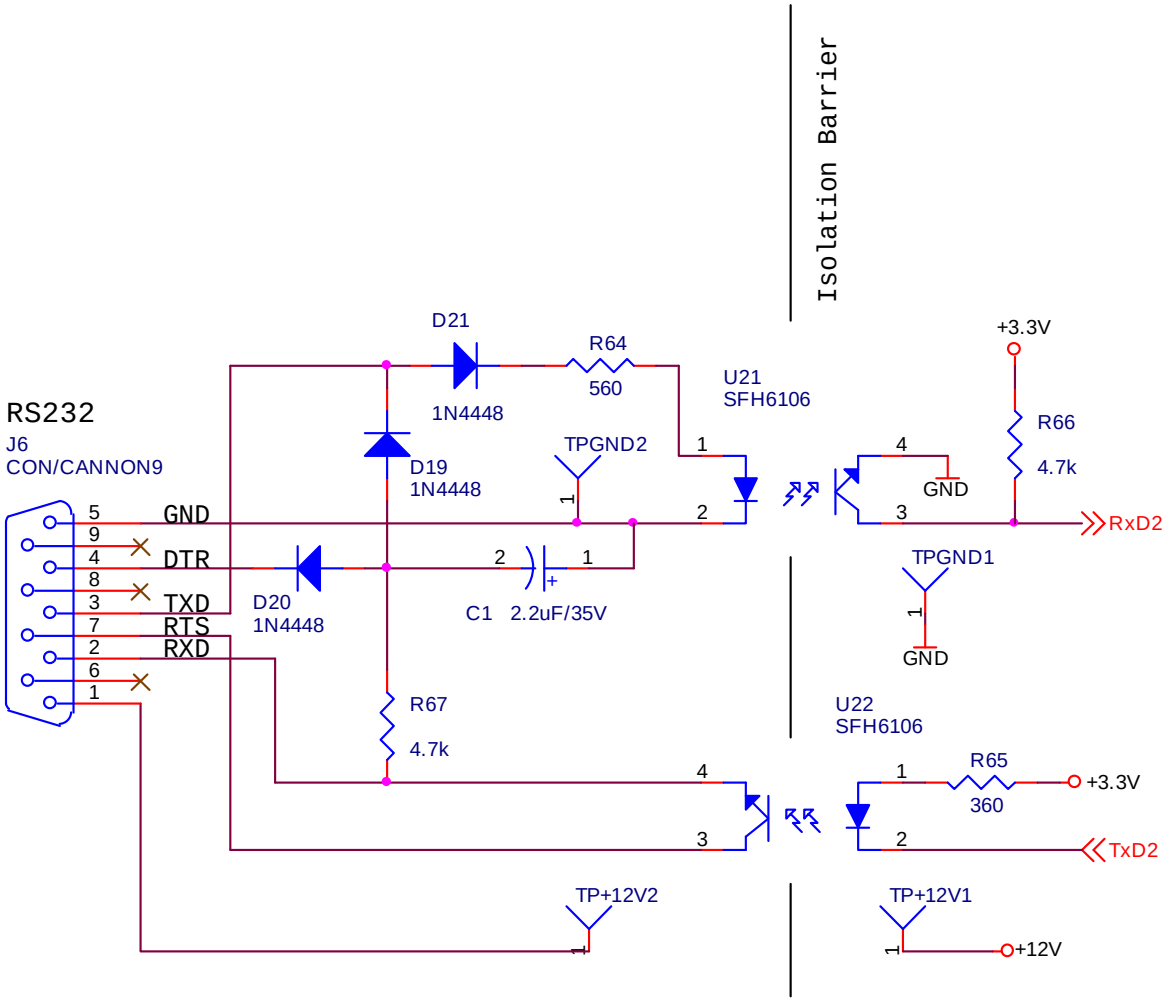


Figure A-8. RS232 Interface

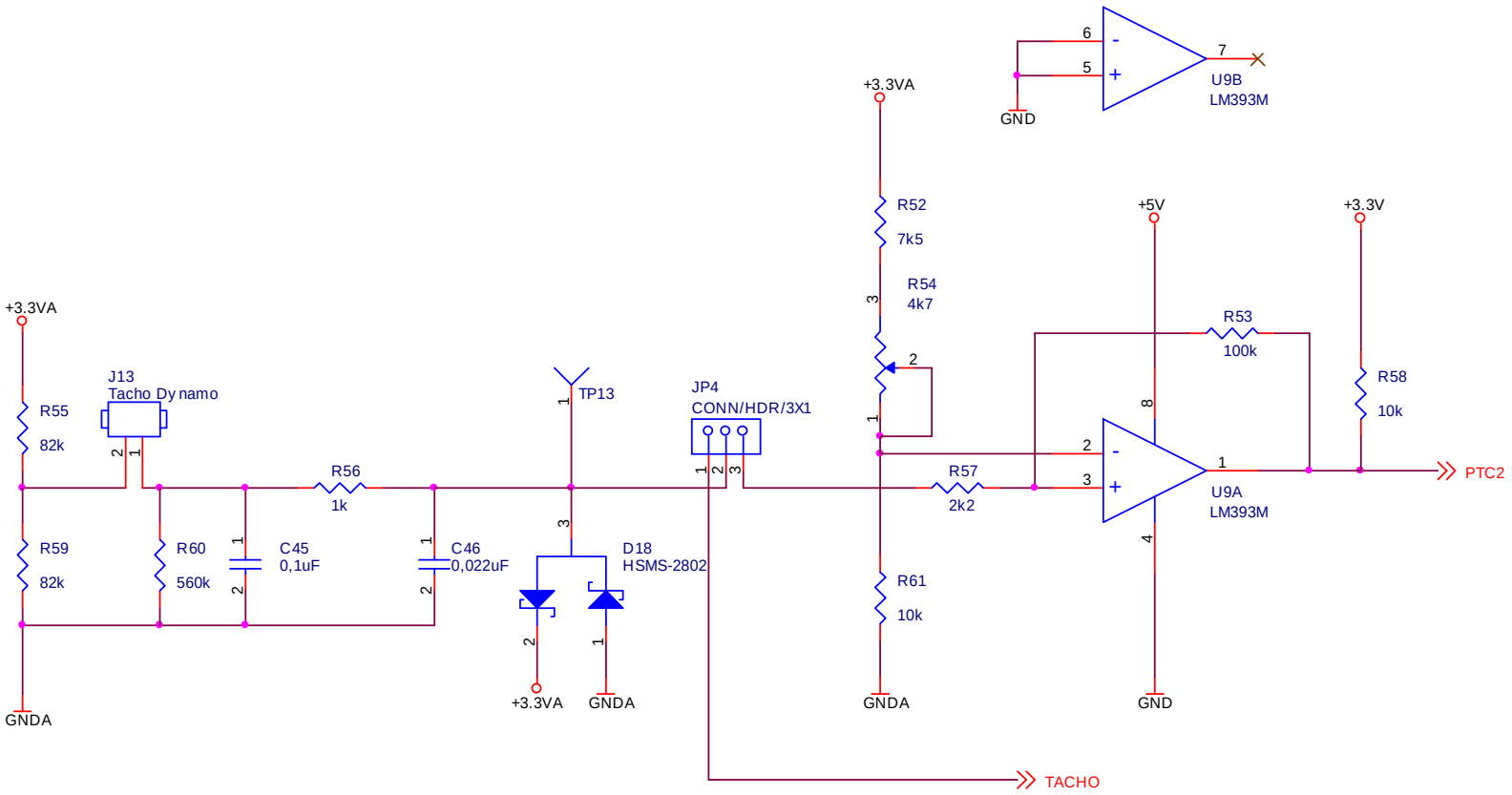


Figure A-9. Tacho-generator Interface

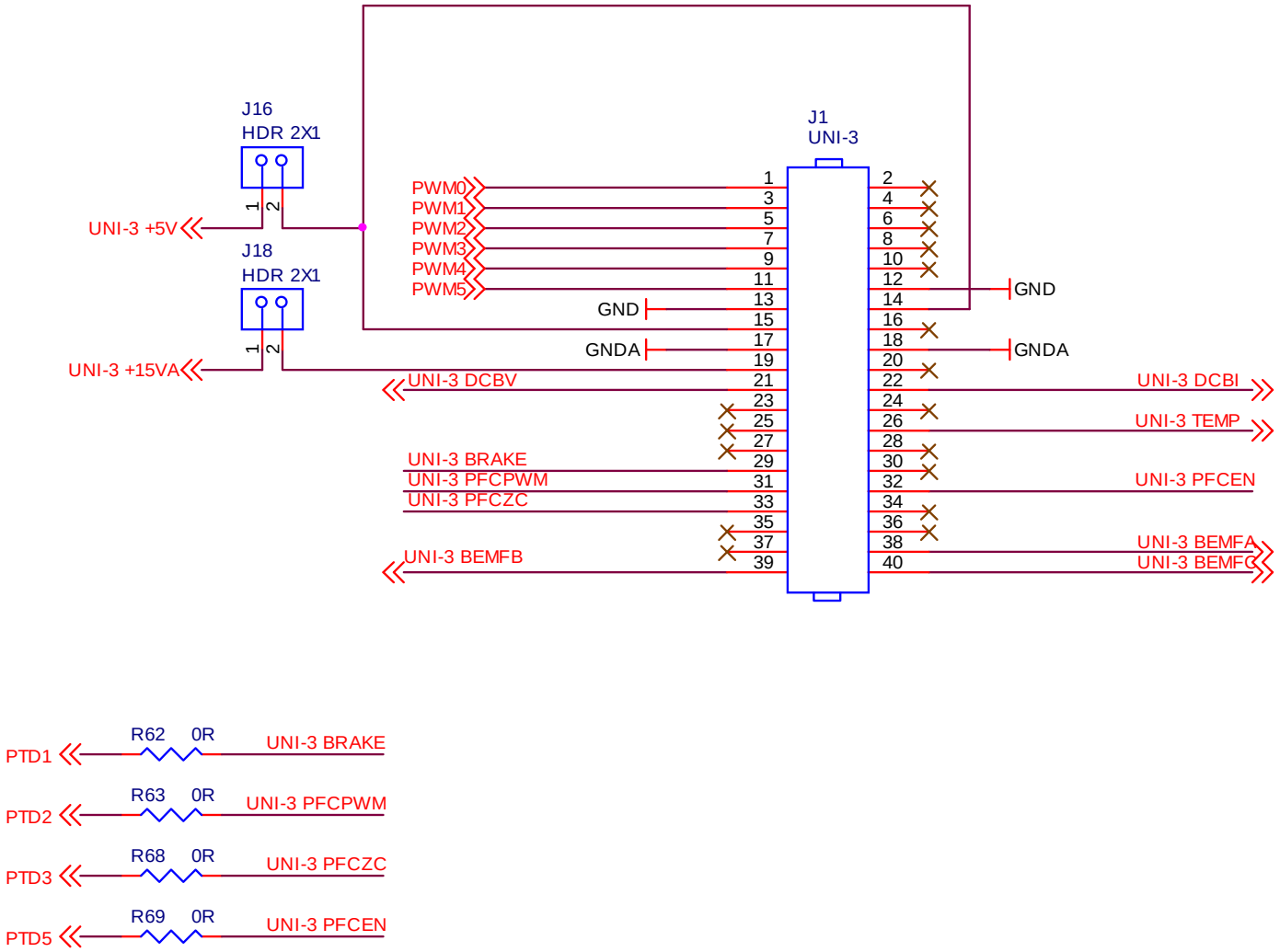


Figure A-10. UNI-3 Connector

Appendix B. MC9S08AW60 Controller Board PCB

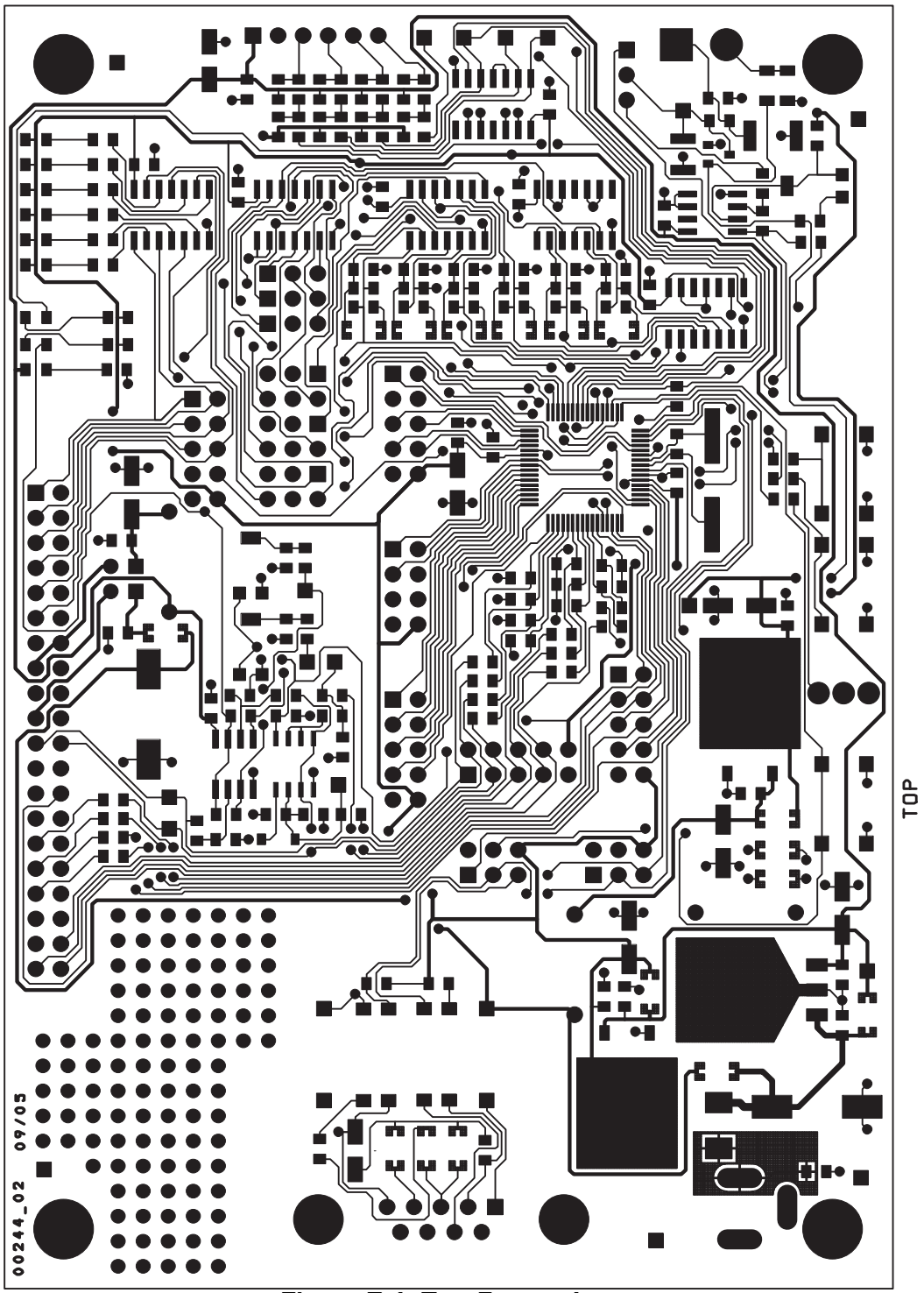


Figure B-1. Top Copper Layer

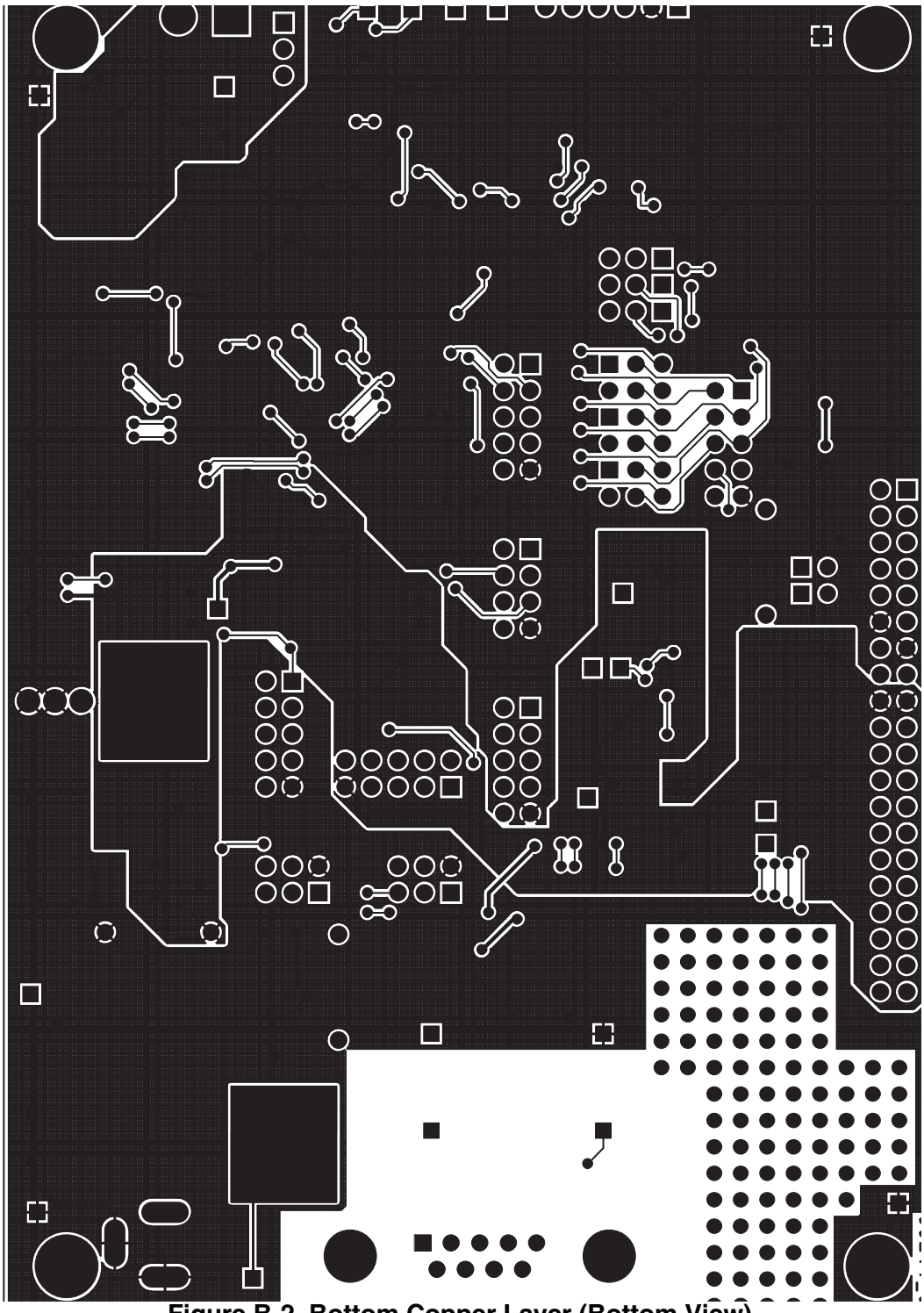
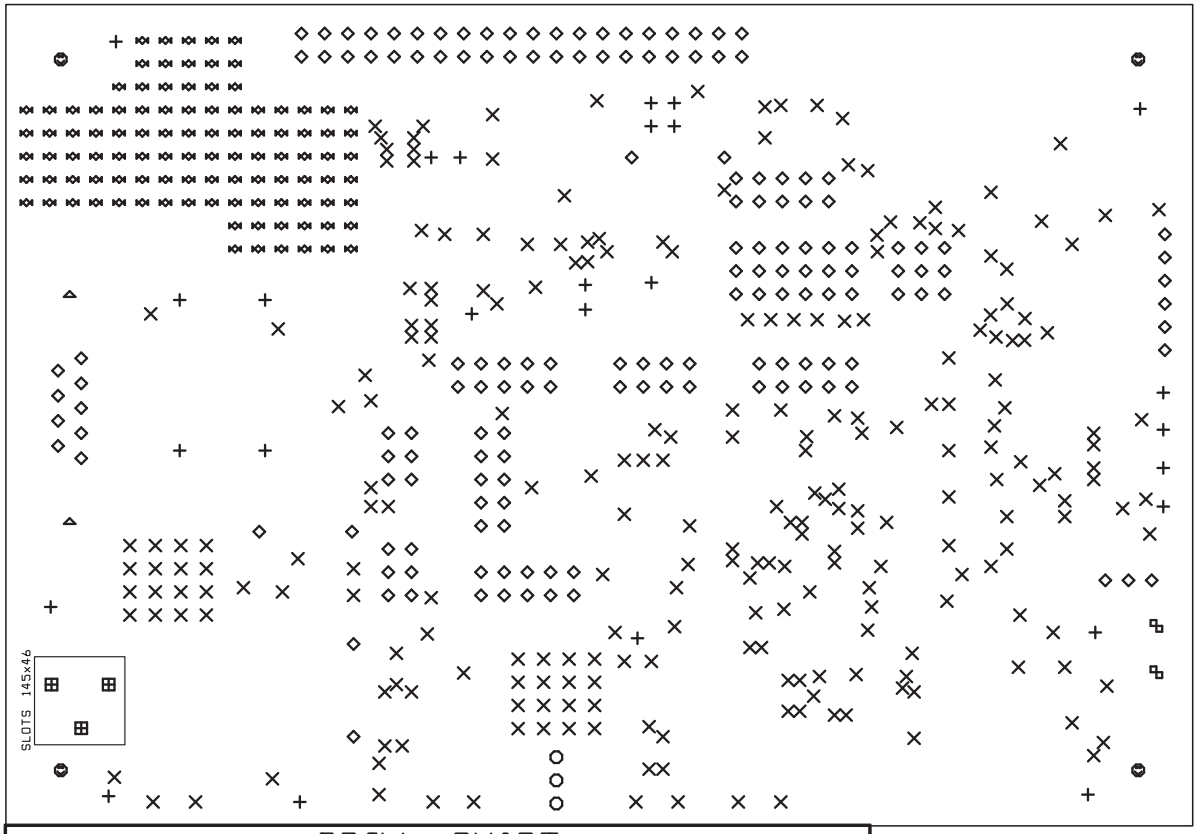


Figure B-2. Bottom Copper Layer (Bottom View)



DRILL CHART				
SYM	DIAM	TOL	QTY	NOTE
×	0.024		248	
⋇	0.034		103	
+	0.039		26	
◇	0.040		161	
⊞	0.046		3	
⧉	0.050		2	
○	0.064		3	
△	0.120		2	
⛑	0.140		4	
TOTAL			552	

Figure B-3. Drill Copper Map

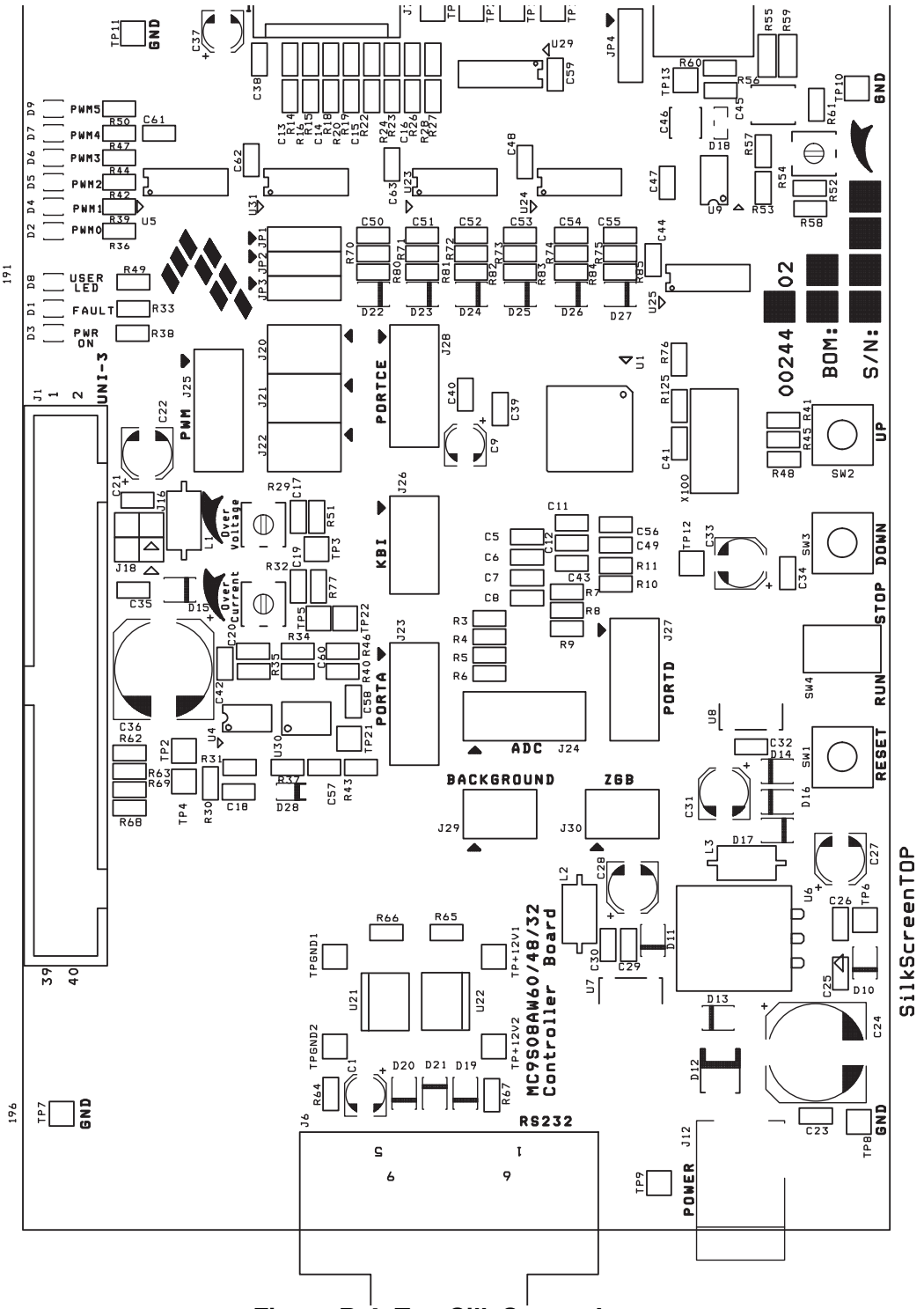


Figure B-4. Top Silk Screen Layer

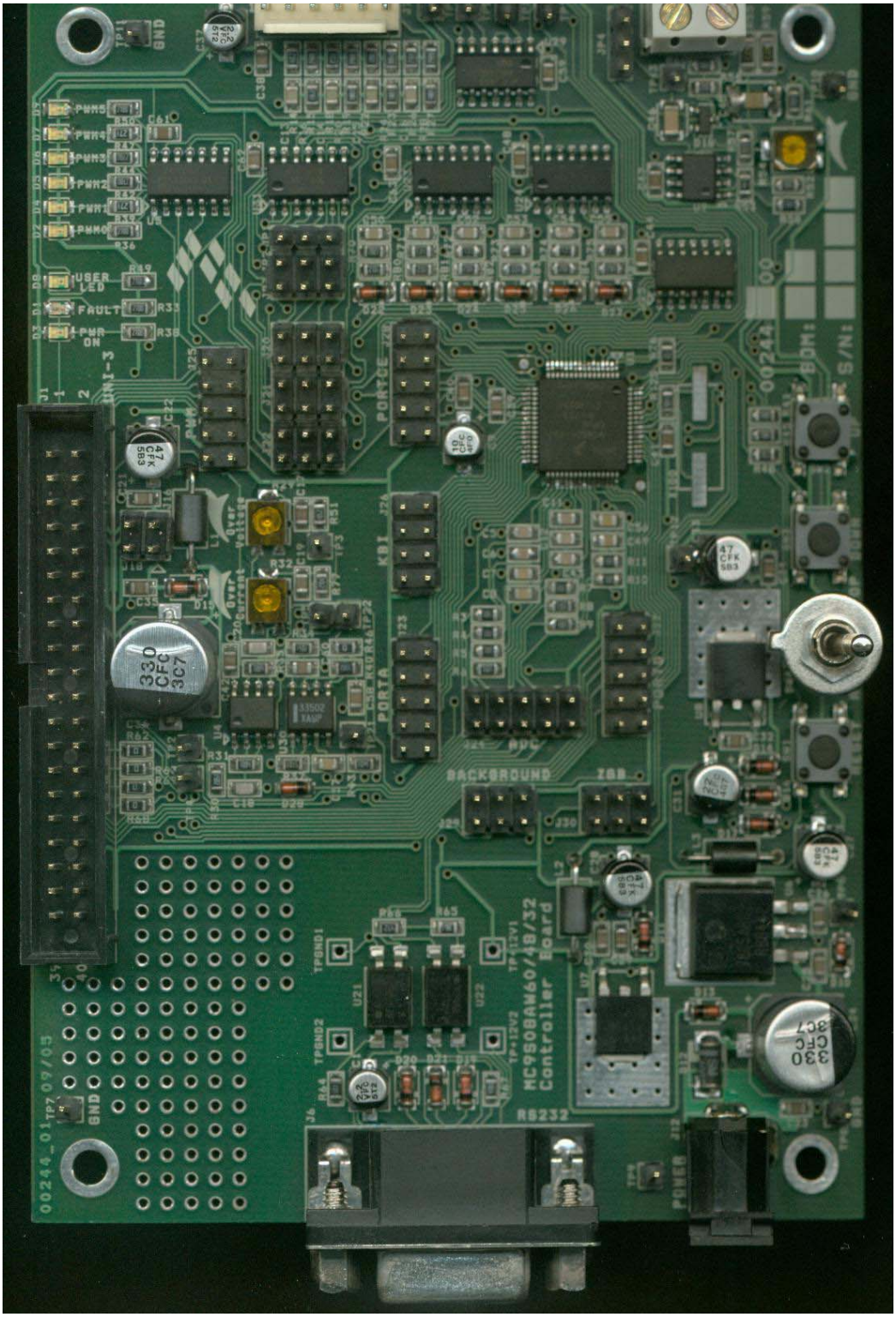


Figure B-5. Top Board View

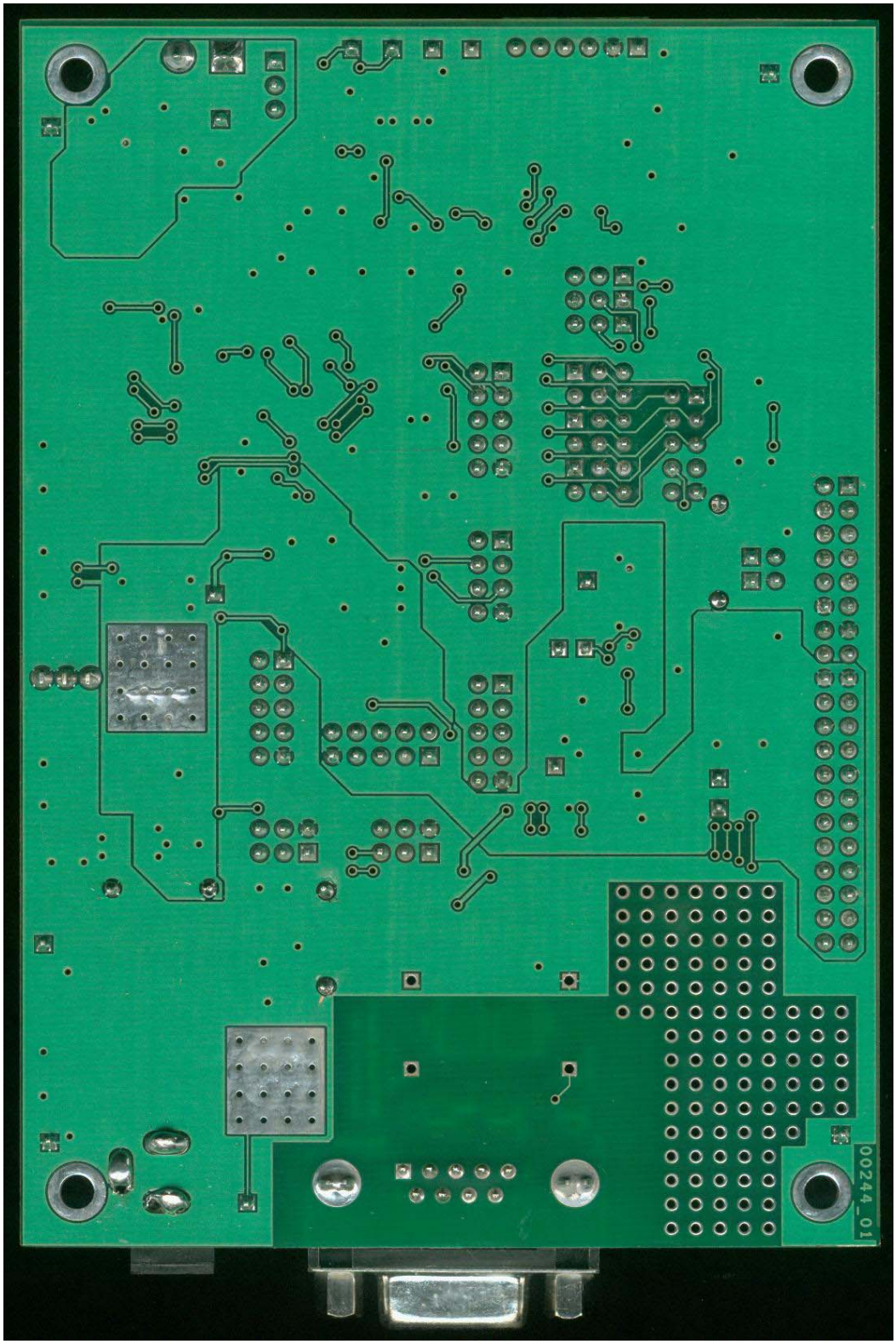


Figure B-6. Bottom Board View

Appendix C. MC9S08AW60 Controller Board Bill of Materials

Item	Qty	Description	Reference Designators	Part #/ Value
Capacitors				
1	1	SMD, Polarized, Aluminum, size B	C1	2.2 uF/35 V
2	5	SMD, Ceramic, size 0805	C5,C6,C11,C12,C43	33 pF
3	4	SMD, Ceramic, size 0805	C7,C8,C49,C56	2. 2nF
4	1	SMD, Polarized, Aluminium, size B	C9	10 uF/6.3 V
5	4	SMD, Ceramic, size 0805	C13,C14,C15,C16	470 pF
6	25	SMD, Ceramic, size 0805	C17,C19,C21,C23,C25,C26, C29,C30,C32,C34,C35,C38, C39,C40,C41,C42,C44,C47, C48,C58,C59,C60,C61,C62, C63	100 nF
7	2	SMD, Ceramic, size 0805	C18,C20	360 pF
8	4	SMD, Polarized, Aluminium, size C	C22,C27,C28,C33	47 uF/6.3 V
9	1	SMD, Polarized, Aluminium, size C	C31	22 uF/16 V
10	2	SMD, Polarized, Aluminium, size G	C24,C36	330 uF/16 V
11	1	SMD, Polarized, Aluminium, size B	C37	2.2 uF/50 V
12	1	SMD, Ceramic, size 1812	C45	0,1 uF
13	1	SMD, Ceramic, size 1210	C46	0,022 uF
14	6	SMD, Ceramic, size 0805	C50,C51,C52,C53,C54,C55	220 pF
15	1	SMD, Ceramic, size 0805	C57	330 nF
Diodes / LEDs				
16	1	SMD LED, size 0805	D1	RED
17	6	SMD LED, size 0805	D2,D4,D5,D6,D7,D9	YELLOW
18	2	SMD LED, size 0805	D3,D8	GREEN
19	16	SMD, minimelf	D10,D11,D13,D14,D15,D16, D17,D19,D20,D21,D22,D23, D24,D25,D26,D27	1N4448
20	1	DO-214AAD	D12	FR1M
21	1	SMD, SOT-23	D18	HSMS-2802
22	1	SMD, SOD-123	D28	MBR0520LT1

Item	Qty	Description	Reference Designators	Part #/ Value
Connectors / Jumpers				
23	4	Header 3X1, male, 2.54 mm	JP1,JP2,JP3,JP4	CONN/HDR/3X1
24	1	MLW40G, 20X2 connector, male, 2.54 mm	J1	UNI-3
25	1	Cannon 9-pin DB9, 90° for PCB, female	J6	CON/CANNON9
26	1	PSH02-06P, 6-pin connector with key and lock	J7	ENCODER 0
27	1	Coax power connector, 2.1 mm, min. 8 A	J12	PWR_JACK
28	1	ARK500/2, 2-pin connector	J13	Tach-dynamo
29	2	Header 2X1, male, 2.54 mm	J16,J18	HDR 2X1
30	5	Header 3X2, male, 2.54 mm	J20,J21,J22, J29, J30	CONN/HDR/3X2
31	5	Header 5X2, male, 2.54 mm	J23, J24, J25, J27, J28	CONN/HDR/5X2
32	1	Header 4X2, male, 2.54 mm	J26	CONN/HDR/4X2
33	18	Header 1X1, male	TP1,TP2,TP3,TP4,TP5,TP6, TP7,TP8,TP9,TP10,TP11, TP12,TP13,TP18,TP19,TP20, TP21,TP22,	TEST POINT
Inductors				
34	3	TH/2PIN_400X140 Ferrite core bead, d3.8x5.3	L1,L2,L3	INDUCTOR
Resistors				
35	9	SMD, size 0805	R3,R4,R5,R6,R7,R8,R9,R10, R11	100R
36	13	SMD, size 0805	R14,R18,R22,R26,R51,R56, R77,R80,R81,R82,R83,R84, R85	1k
37	4	SMD, size 0805	R15,R19,R23,R27	24R
38	7	SMD, size 0805	R16,R20,R24,R28,R41,R45, R48	1.8K
39	2	SMD, size 0805	R30,R34	15K
40	2	SMD, size 0805	R31,R35	1M
41	9	SMD, size 0805	R33,R36,R39,R42,R44,R47, R49,R50	270R
42	1	SMD, size 0805	R38	330R
43	1	SMD, size 0805	R37	510K

Item	Qty	Description	Reference Designators	Part #/ Value
44	3	SMD, size 0805	R40,R58,R61	10k
45	7	SMD, size 0805	R43,R46,R62,R63,R68,R69,R76	0R
46	1	SMD, size 0805	R52	7k5
47	1	SMD, size 0805	R53	100k
48	2	SMD, size 1206	R55,R59	82k
49	1	SMD, size 0805	R57	2k2
50	1	SMD, size 0805	R60	560k
51	1	SMD, size 0805	R64	560
52	1	SMD, size 0805	R65	360
53	2	SMD, size 0805	R66,R67	4.7k
54	6	SMD, size 0805	R70,R71,R72,R73,R74,R75	12k
Trimmers				
55	2	SMD trimmer	R29,R32	10K
56	1	SMD trimmer	R54	4k7
Switches / Push Buttons				
57	1	SMD microswitch, push-button	SW1	RESET
58	1	SMD microswitch, push-button	SW2	UP
59	1	SMD microswitch, push-button	SW3	DOWN
60	1	Lever switch, MS244LC, P-B070B	SW4	RUN/STOP
Integrated Circuits				
61	1	SMD, LQFP64	U1	MC9S08AW60/48/32
62	2	SMD, SOIC8	U4,U9	LM393M
63	2	SMD, SOIC14	U5,U25	74HC04D
64	1	SMD, D2PAK	U6	TL78005CKTE
65	2	SMD, DPAK	U7,U8	MC33269DT_3.3
66	2	SFH6106, Optocoupler, SMD	U21,U22	SFH6106
67	3	SMD, SOIC14	U23,U24,U31	74HC08
68	1	SMD, SOIC14	U29	74HC86
69	1	SMD, SOIC8	U30	MC33502D

Item	Qty	Description	Reference Designators	Part #/ Value
NOT POPULATED PARTS				
70	4	Header 1X1, male	TPGND1,TPGND2,TP+12V1,TP+12V2	
71	1	SMD, size 0805	R125	1M
72	1	8 MHz crystal, SD/HC49	X100	8 MHz

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