MEMCOBUM/D

Motorola Embedded Motion Control

Optoisolation Board

User's Manual

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Section 1. Introduction and Setup

1.1 Contents

1.2 Optoisolation Introduction

Motorola's embedded motion control series optoisolation board is an optoisolator that is an integral part of a development tool set for motor control. It is supplied in kit number ECOPT, along with a 40-pin ribbon cable and mounting hardware. The optoisolation board's purpose is to provide galvanic isolation between a control board and a high-voltage power stage. It fits into the systems' configurations that are shown in **Figure 1-1**. A photograph of the board appears in **Figure 1-2**.

1.3 About this Manual

Key items can be found in the following locations in this manual:

- Setup instructions are found in **1.5 Setup Guide**.
- Schematics are found in **4.3 Schematics**.
- Pin assignments are shown in **Figure 3-1. 40-Pin Output Connector** and **Figure 3-2. 40-Pin Input Connector**, and a pin-by-pin description is contained in **3.3 Signal Descriptions**.
- For those interested in the reference design aspects of the board's circuitry, a description is provided in **Section 5. Design Considerations**.

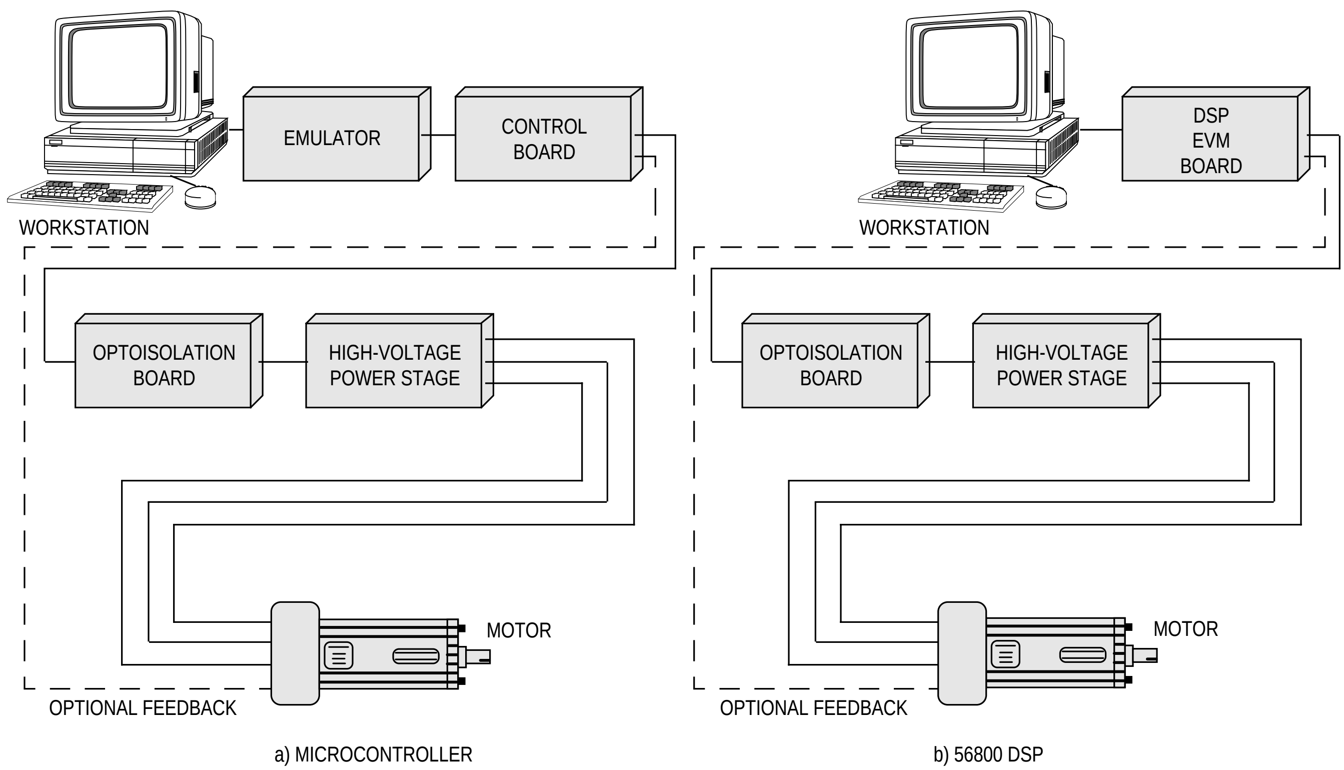


Figure 1-1. Systems' Configurations

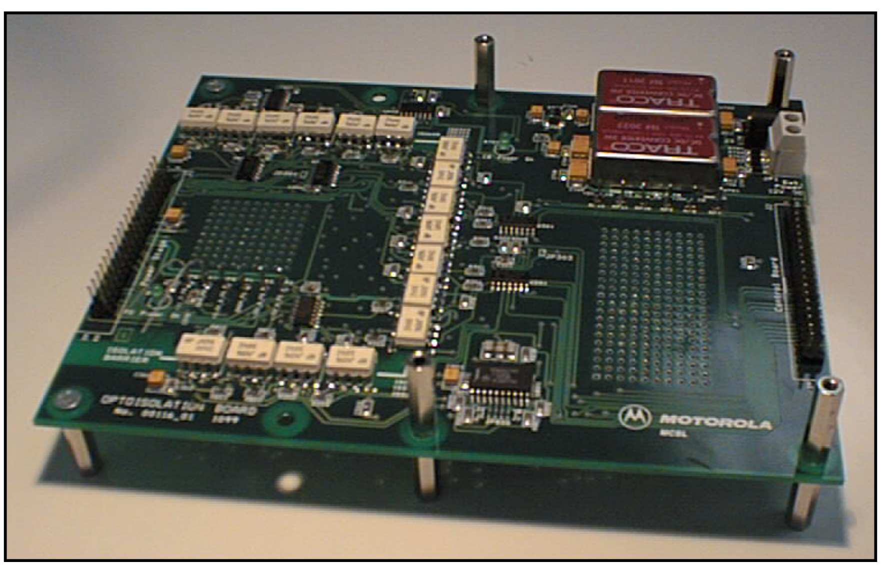


Figure 1-2. Optoisolation Board

1.4 Warnings

This development tool set operates in an environment that includes dangerous voltages and rotating machinery.

To facilitate safe operation, input power for the high-voltage power stage should come from a current-limited dc laboratory power supply, unless power factor correction is specifically being investigated.

When operating from an ac line, power stage grounds and oscilloscope grounds are at different potentials, unless the oscilloscope is floating. Note that probe grounds and, therefore, the case of a floated oscilloscope are subjected to dangerous voltages.

The user should be aware that:

- Before moving scope probes, making connections, etc., it is generally advisable to power down the high-voltage supply.
- When high voltage is applied, using only one hand for operating the test setup minimizes the possibility of electrical shock.
- Operation in lab setups that have grounded tables and/or chairs should be avoided.
- Wearing safety glasses, avoiding ties and jewelry, using shields, and operation by personnel trained in high-voltage lab techniques are also advisable.

1.5 Setup Guide

Setup and connections for the optoisolation board are straightforward. The optoisolation board connects to a Motorola embedded motion control series high-voltage power stage via a 40-pin ribbon cable with a Motorola embedded motion control series control board to form a mother/daughter board arrangement. **Figure 1-3** depicts a completed setup.

Follow these steps to set up the board:

1. Mount four standoffs to the optoisolation board at the locations indicated in **Figure 1-3**. Standoffs, screws, and washers are included in the ECOPT kit. This step and step 3 are optional when making connections with DSP control boards such as the DSP56F805EVM. The DSP boards may be placed flat on a bench, next to the optoisolation board.
2. Plug one end of the 40-pin ribbon cable that is supplied with Motorola embedded motion control series control boards into input connector J2, labeled “control board.”
3. Mount the control board on top of the standoffs with screws and washers from the ECOPT kit. This step is optional with DSP control boards.
4. Plug the free end of the cable connected to input connector J2 into the control board’s 40-pin connector.
5. Plug one end of the ECOPT kit’s 40-pin ribbon cable into output connector J1, labeled “power stage.” The other end of this cable goes to the power stage’s 40-pin input connector.
6. Connect a 12-Vdc power supply either to connector JP1, labeled “Ext. Power 12V DC,” or power jack J3. Either one, but not both, may be used. These connectors are located immediately above 40-pin connector J2 on the right side of the optoisolation board. The 12-volt power supply should be rated for at least 1 amp.
7. Apply power first to the optoisolation board, and then to the power stage. Note that the optoisolation board powers the control board and that the optoisolation board is not fully powered until power is applied to the power stage.

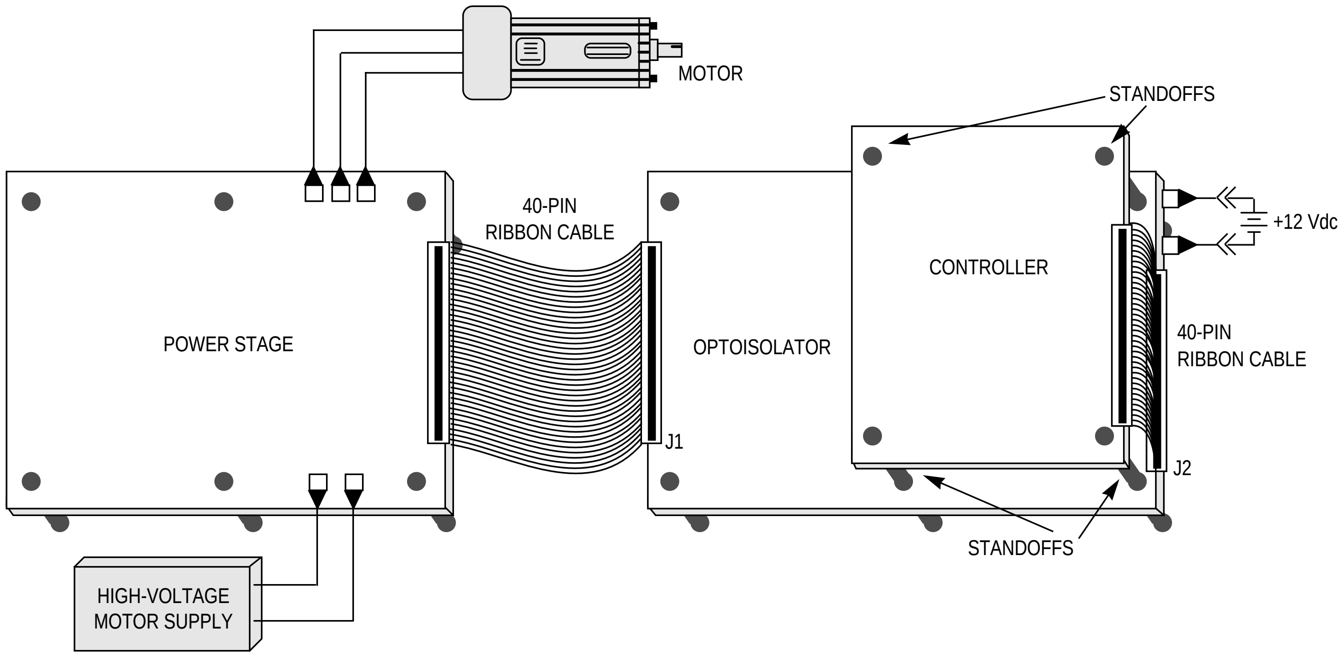


Figure 1-3. Optoisolation Board Setup

Section 2. Operational Description

2.1 Contents

2.2 Introduction

Motorola's embedded motion control series optoisolation board links signals from a controller to a high-voltage power stage. The board isolates the controller, and peripherals that may be attached to the controller, from dangerous voltages that are present on the power stage. The optoisolation board's galvanic isolation barrier also isolates control signals from high noise in the power stage and provides a noise-robust systems architecture.

Signal translation is virtually one-for-one. Gate drive signals are passed from controller to power stage via high-speed, high dv/dt, digital optocouplers. Analog feedback signals are passed back through HCNR201 high-linearity analog optocouplers. Delay times are typically 250 ns for digital signals, and 2 µs for analog signals. Grounds are separated by the optocouplers' galvanic isolation barrier.

Both input and output connections are made via 40-pin ribbon cable connectors. The pin assignments for both connectors are the same. For example, signal PWM_AT appears on pin 1 of the input connector and also on pin 1 of the output connector. In addition to the usual motor control signals, an MC68HC705JJ7CDW serves as a serial link, which allows controller software to identify the power board.

Power requirements for controller side circuitry are met with a single external 12-Vdc power supply. Power for power stage side circuitry is supplied from the power stage through the 40-pin output connector.

A summary of the information needed to use Motorola's embedded motion control series optoisolation board is presented below. For design information, see **Section 5. Design Considerations**.

2.3 Electrical Characteristics

The electrical characteristics in **Table 2-1** apply to operation at 25°C, and a 12-Vdc power supply voltage.

Table 2-1. Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Units	Notes
Power Supply Voltage	Vdc	10	12	30	V	
Quiescent Current	I_{CC}	70[(1)]	200[(2)]	500[(3)]	mA	dc/dc converter
Min Logic 1 Input Voltage	V_{IH}	2.0	—	—	V	HCT logic
Max Logic 0 Input Voltage	V_{IL}	—	—	0.8	V	HCT logic
Analog Input Range	V_{In}	0	—	3.3	V	
Input Resistance	R_{In}	—	10	—	kΩ	
Analog Output Range	V_{Out}	0	—	3.3	V	
Digital Delay Time	t_{DDLY}	—	0.25	—	µs	
Analog Delay Time	t_{ADLY}	—	2	—	µs	

1. Power supply powers optoisolation board only.
2. Current consumption of optoisolation board plus DSP EMV board (powered from this power supply)
3. Maximum current handled by dc/dc converters

Section 3. Pin Descriptions

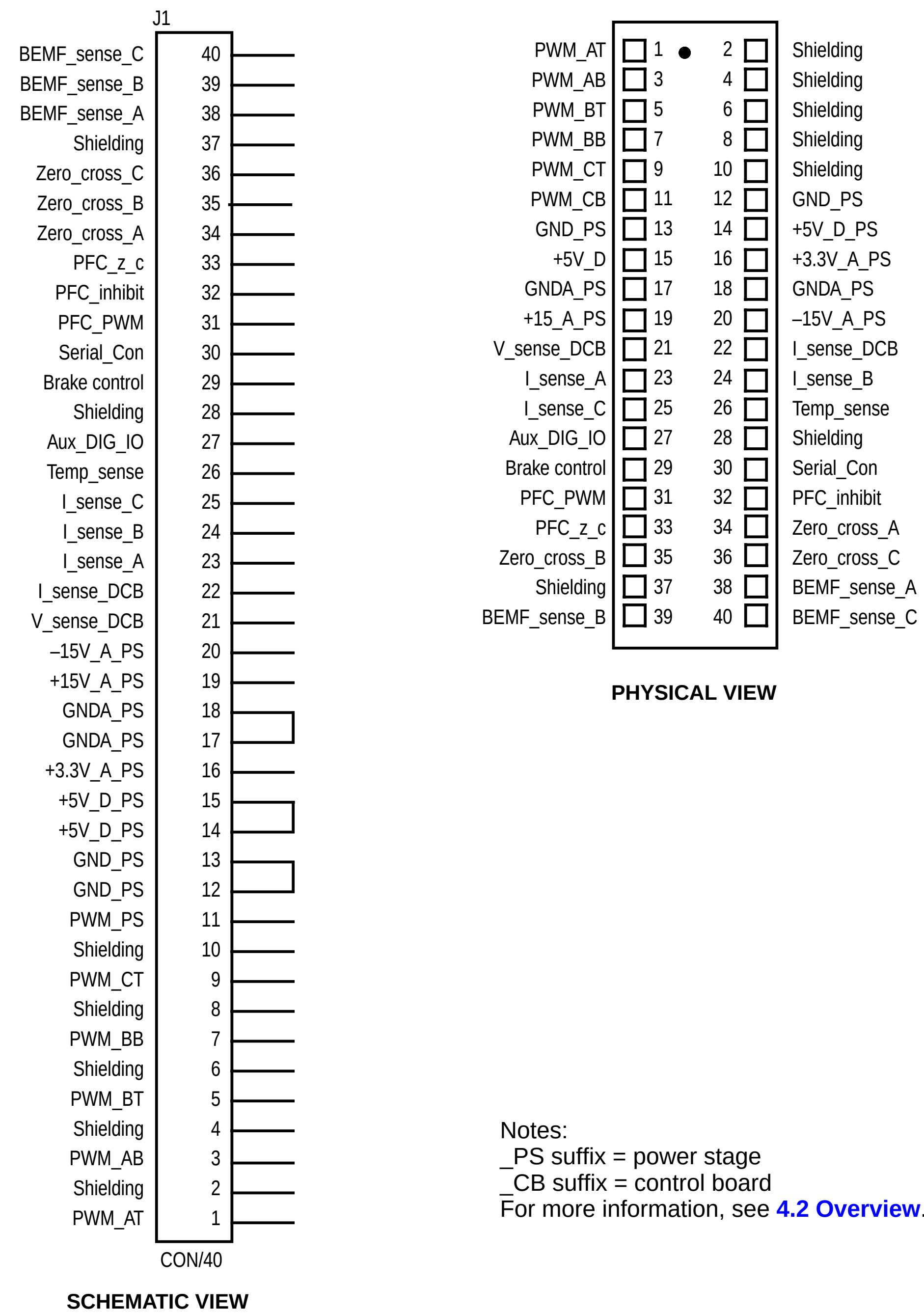
3.1 Contents

3.2 Introduction

Inputs and outputs are located on four connectors. They are listed as follows. Location descriptions assume that the board is oriented such that its title is read from left to right.

- J2 — Signal inputs are grouped together on 40-pin ribbon cable connector J2, located on the right side of the board.
- J1 — Signal outputs are provided on 40-pin ribbon cable connector, J1, located on the left.
- JP1 and J3 — Two connectors, labeled JP1 and J3, are provided for the 12-volt power supply. JP1 and J3 are located immediately above input connector J2. Power is supplied to one or the other, but not both.

Pin assignments for the input and output connectors are shown in **Figure 3-1** and **Figure 3-2**. In these figures, a schematic representation appears on the left, and a physical layout of the connector appears on the right. The physical view assumes that the board is oriented such that its title is read from left to right. Signal descriptions are provided in **Table 3-1**. Note that each signal has the same pin assignment on both connectors. Power supply and ground connections go to different power supplies, due to the isolation barrier. However, pin locations for similar power supply voltages remain the same. For example, +15 volts on the input connector and +15 volts on the output connector come from physically different power supplies, but occupy pin 19 on both connectors.



Notes:
_PS suffix = power stage
_CB suffix = control board
For more information, see **4.2 Overview**.

Figure 3-1. 40-Pin Output Connector

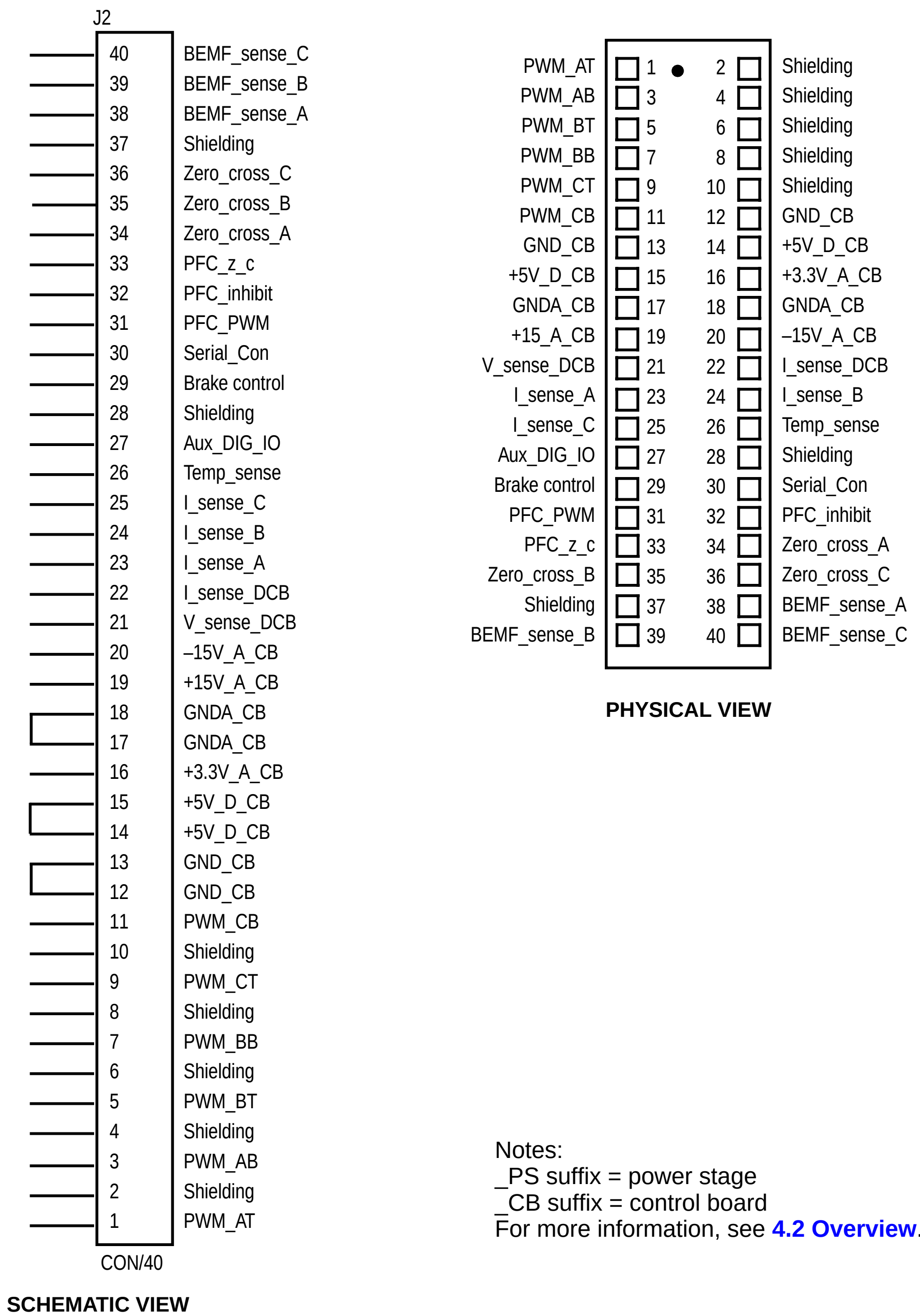


Figure 3-2. 40-Pin Input Connector

3.3 Signal Descriptions

Table 3-1. Signal Descriptions (Sheet 1 of 3)

Pin No.	Signal Name	Description
1	PWM_AT	PWM_AT is the gate drive signal for the top half-bridge of phase A. A logic high at input connector J2 produces a logic high at output connector J1, which turns the power stage's phase A top switch on.
2	Shielding	Pin 2 is connected to an unused wire that helps prevent cross-talk between adjacent signals.
3	PWM_AB	PWM_AB is the gate drive signal for the bottom half-bridge of phase A. A logic high at input connector J2 produces a logic high at output connector J1, which turns the power stage's phase A bottom switch on.
4	Shielding	Pin 4 is connected to an unused wire that helps prevent cross-talk between adjacent signals.
5	PWM_BT	PWM_BT is the gate drive signal for the top half-bridge of phase B. A logic high at input connector J2 produces a logic high at output connector J1, which turns the power stage's phase B top switch on.
6	Shielding	Pin 6 is connected to an unused wire that helps prevent cross-talk between adjacent signals.
7	PWM_BB	PWM_BB is the gate drive signal for the bottom half-bridge of phase B. A logic high at input connector J2 produces a logic high at output connector J1, which turns the power stage's phase B bottom switch on.
8	Shielding	Pin 8 is connected to an unused wire that helps prevent cross-talk between adjacent signals.
9	PWM_CT	PWM_CT is the gate drive signal for the top half-bridge of phase C. A logic high at input connector J2 produces a logic high at output connector J1, which turns the power stage's phase C top switch on.
10	Shielding	Pin 10 is connected to an unused wire that helps prevent cross-talk between adjacent signals.
11	PWM_CB	PWM_CB is the gate drive signal for the bottom half-bridge of phase C. A logic high at input connector J2 produces a logic high at output connector J1, which turns the power stage's phase C bottom switch on.
12	GND_CB and GND_PS	Digital power supply ground
13	GND_CB and GND_PS	Digital power supply ground, redundant connection

Table 3-1. Signal Descriptions (Sheet 2 of 3)

Pin No.	Signal Name	Description
14	+5V_D_CB and +5V_D_PS	Digital +5-volt power supply. +5V_D_PS originates on the power stage board
15	+5V_D_CB and +5V_D_PS	Digital +5-volt power supply, redundant connection
16	+3.3V_A_CB and +3.3V_A_PS	Analog +3.3-volt power supply. +3.3V_A_PS originates on the power stage.
17	GNDA_CB and GNDA_PS	Analog power supply ground
18	GNDA_CB and GNDA_PS	Analog power supply ground, redundant connection
19	+15V_A_CB and +15V_A_PS	Analog +15-volt power supply. +15V_A_PS originates on the power stage.
20	-15V_A_CB and –15V_A_PS	Analog -15 V power supply. –15V_A_PS originates on the power stage.
21	V_sense_DCB	V_sense_DCB is an analog sense signal that measures the power stage's dc bus voltage.
22	I_sense_DCB	I_sense_DCB is an analog sense signal that measures the power stage's dc bus current.
23	I_sense_A	I_sense_A is an analog sense signal that measures current in phase A.
24	I_sense_B	I_sense_B is an analog sense signal that measures current in phase B.
25	I_sense_C	I_sense_C is an analog sense signal that measures current in phase C.
26	Temp_sense	Temp_sense is an analog sense signal that measures power module temperature.
27	AUX_DIG_IO	This is an unused spare digital link that can be configured to send a signal in either direction.
28	Shielding	Pin 28 is connected to an unused wire that helps prevent cross-talk between adjacent signals.
29	Brake_control	Brake_control is the gate drive signal for the power stage's brake transistor.
30	Serial_Con	Serial_Con is a bidirectional digital serial interface that is used to identify the power stage to the controller. This information is then used by the controller's software to scale analog feedback signals.
31	PFC_PWM	PFC_PWM is a digital signal that controls the power factor correction circuit's switch.
32	PFC_inhibit	PFC_inhibit is a digital output that is used to enable or disable the power factor correction circuit.

Table 3-1. Signal Descriptions (Sheet 3 of 3)

Pin No.	Signal Name	Description
33	PFC_z_c	PFC_z_c is a digital signal. Its edges represent power line voltage zero crossing events.
34	Zero_cross_A	Zero_cross_A is a digital signal that is used for sensing phase A back-EMF zero crossing events.
35	Zero_cross_B	Zero_cross_B is a digital signal that is used for sensing phase B back-EMF zero crossing events.
36	Zero_cross_C	Zero_cross_C is a digital signal that is used for sensing phase C back-EMF zero crossing events.
37	Shielding	Pin 37 is connected to an unused wire that helps prevent cross-talk between adjacent signals.
38	BEMF_sense_A	BEMF_sense_A is an analog sense signal that measures phase A back EMF.
39	BEMF_sense_B	BEMF_sense_B is an analog sense signal that measures phase B back EMF.
40	BEMF_sense_C	BEMF_sense_A is an analog sense signal that measures phase C back EMF.

Section 4. Schematics and Parts List

4.1 Contents

4.2 Overview

A set of schematics for the optoisolation board appears in **Figure 4-1** through **Figure 4-9**. An overview of the whole board is shown in **Figure 4-1**. Digital isolation blocks appear in **Figure 4-2** through **Figure 4-4**. Analog isolation blocks are shown in **Figure 4-5** through **Figure 4-7**. The serial link appears in **Figure 4-8**, and an on-board power supply that converts +12 volts into +5 V, +3.3 V, +15 V and –15 V is shown in **Figure 4-9**.

Unless otherwise specified, resistor values are in ohms, resistors are specified as 1/8 watt ± 5%, and interrupted lines coded with the same letters are electrically connected.

The high-level schematic in **Figure 4-1** identifies individual signals with the same designation upon both entering and leaving the board. For example, temperature sense signal "Temp_sense" comes into the board on pin 26 of connector J2, leaves on pin 26 of J1, and is labeled "Temp_sense" in both places. Since the power supplies connected to J1 and J2 are physically different, power supply and ground designations include "_PS" or "_CB." "_PS" refers to the power stage side of the isolation barrier. Similarly, "_CB" refers to the control board side of the isolation barrier. For example, the +15-volt analog supply is labeled "+15V_A_CB" on pin 19 of input connector J2. Similarly, the +15-volt connection on pin 19 of output connector J1 is labeled "+15V_A_PS."

In the detail-level schematics, signals also get "_CB" or "_PS" adders to indicate which connector they are coming from. For example, the signal identified as "Temp_sense" in high-level schematic **Figure 4-1** appears on the left-hand side of **Figure 4-6** as "Temp_sense_PS." The "_PS" adder indicates that the signal "Temp_sense" at the input to U500A comes from output connector J1. Similarly, "Temp_sense_CB" on the right hand side of **Figure 4-6** indicates that a connection is made to input connector J2.

4.3 Schematics

The schematics for the optoisolation board appear on the following pages.

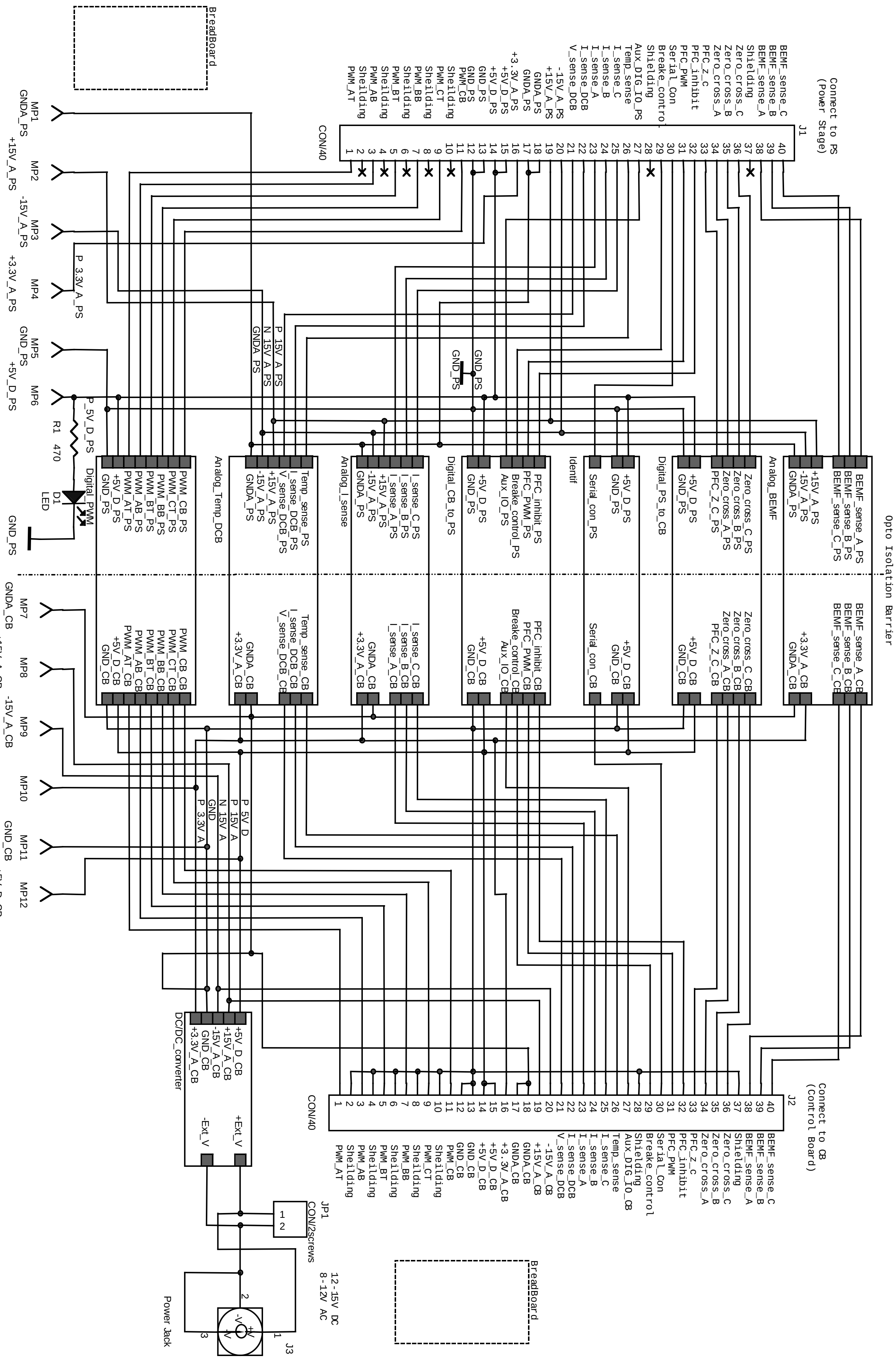


Figure 4-1. Optoisolator Board Overview

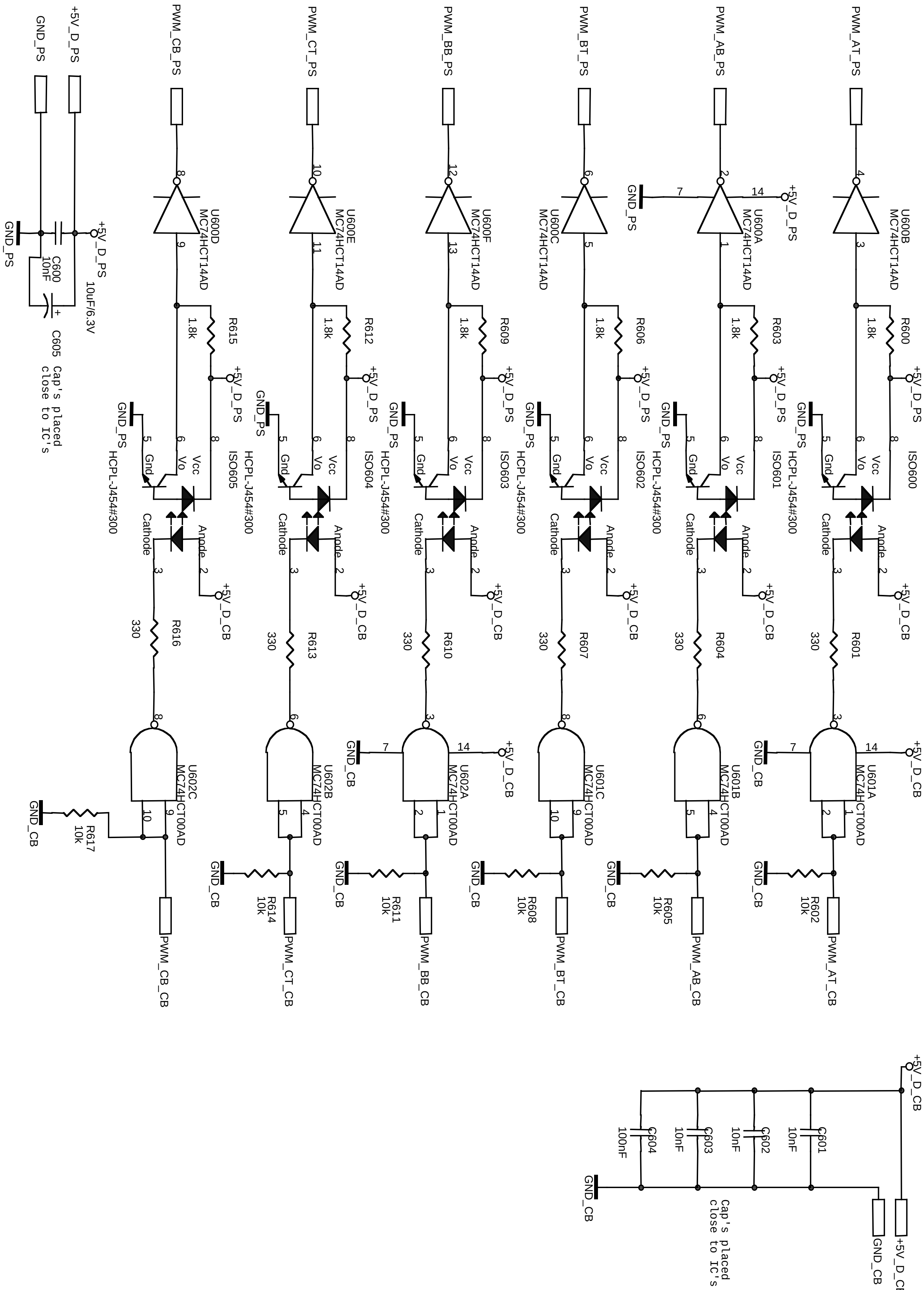


Figure 4-2. Control Board to Power Stage Digital Signals (Page 1)

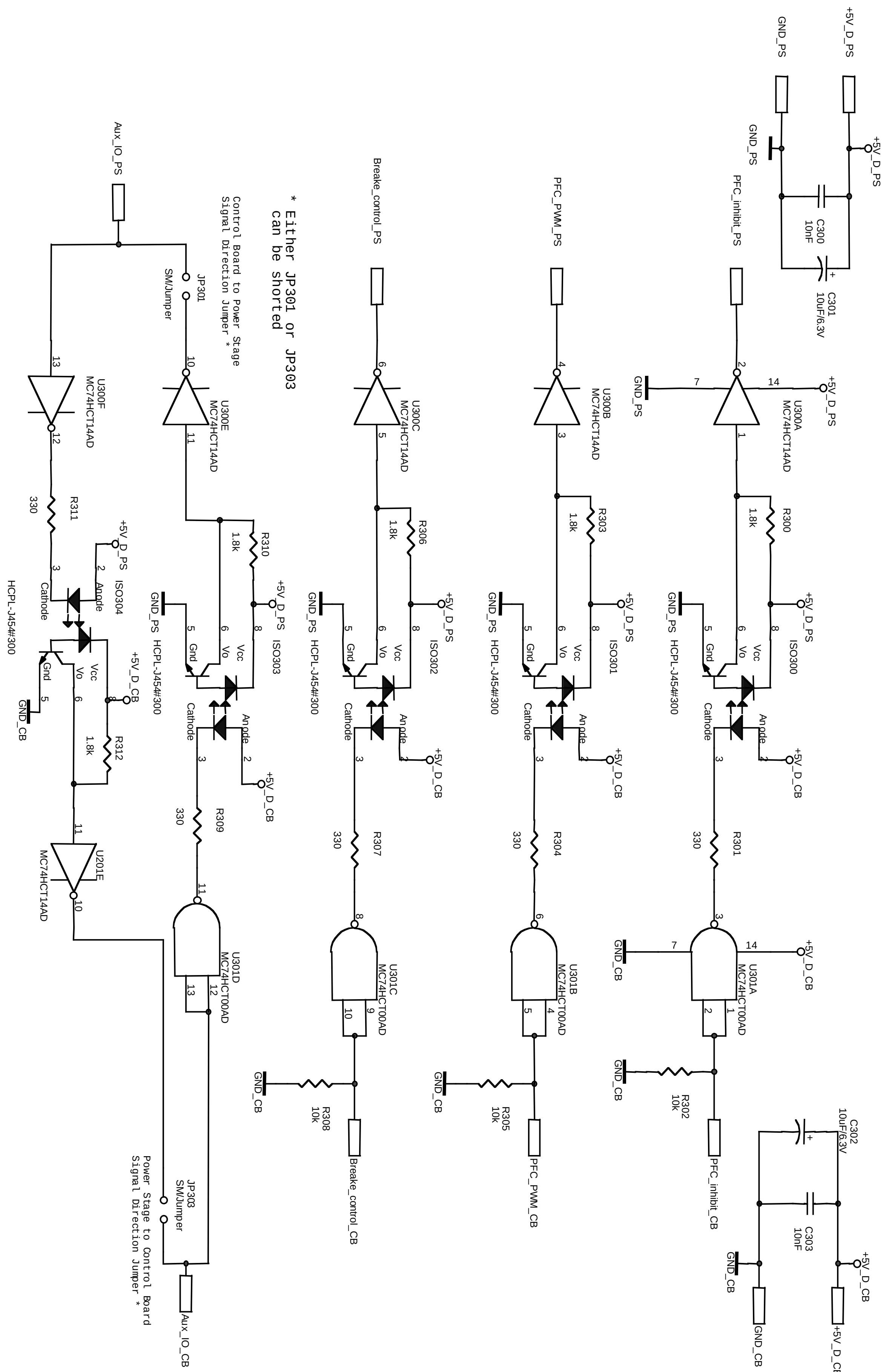


Figure 4-3. Control Board to Power Stage Digital Signals (Page 2)

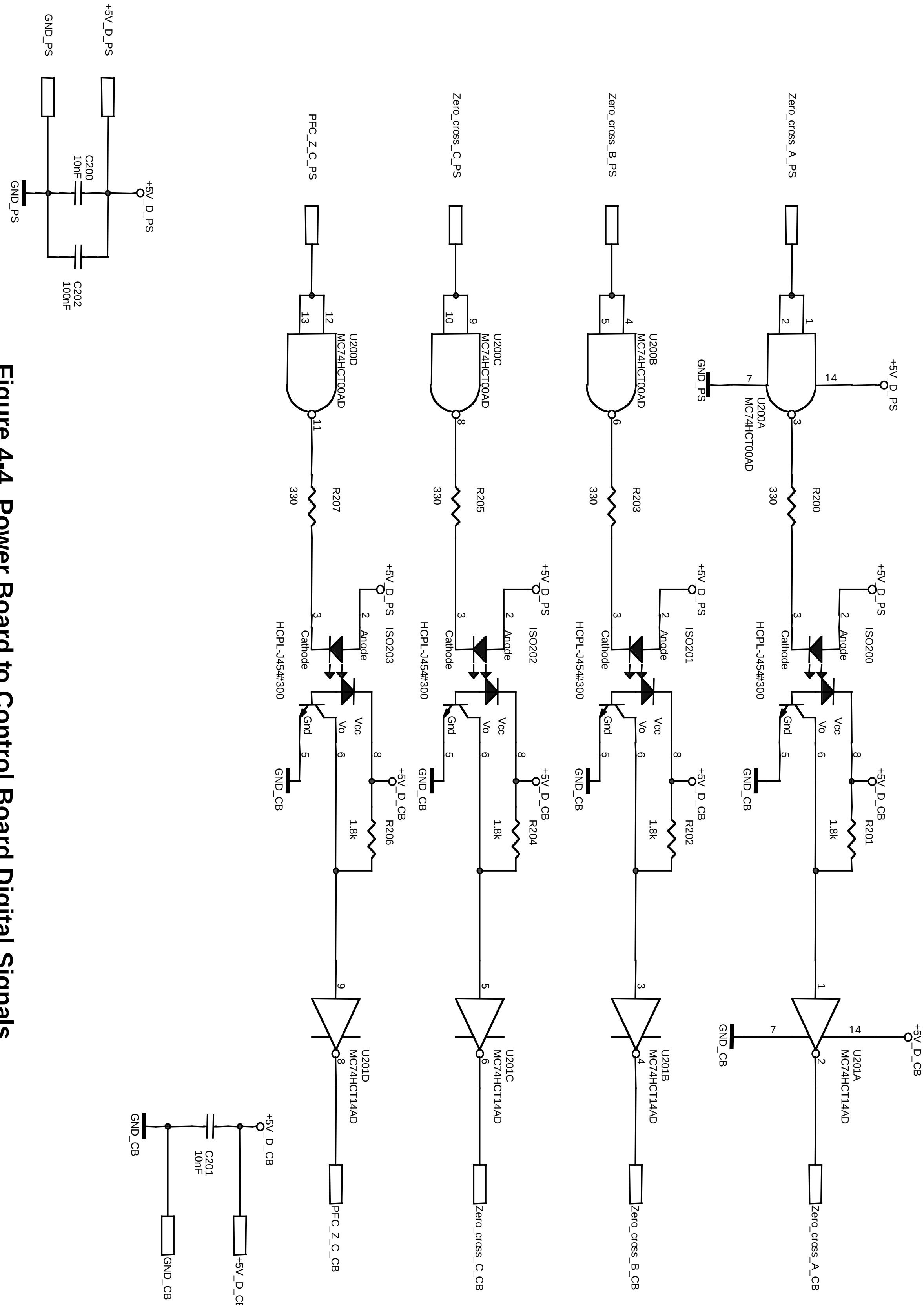


Figure 4-4. Power Board to Control Board Digital Signals

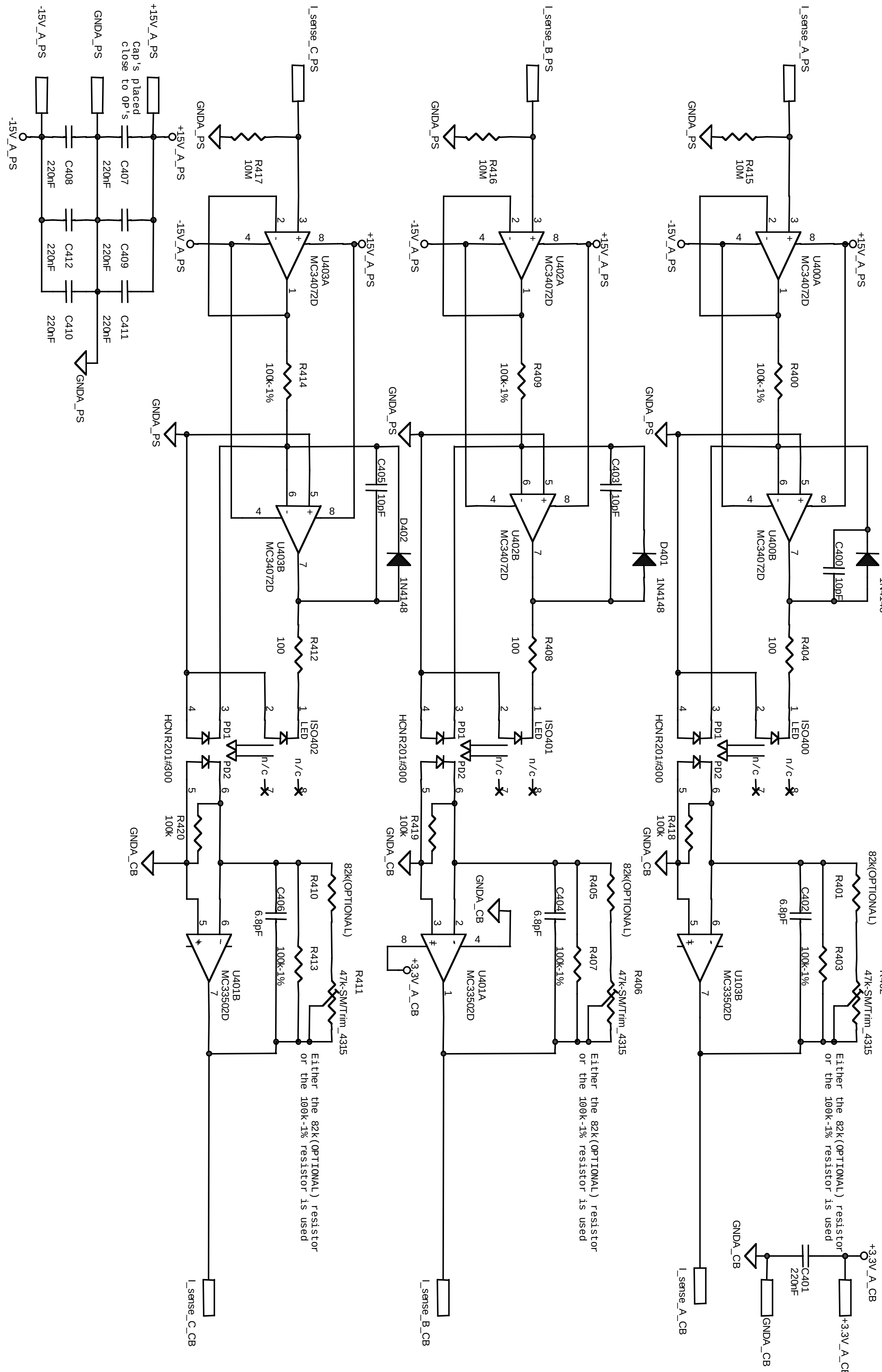


Figure 4-5. Analog Current Sense Signals

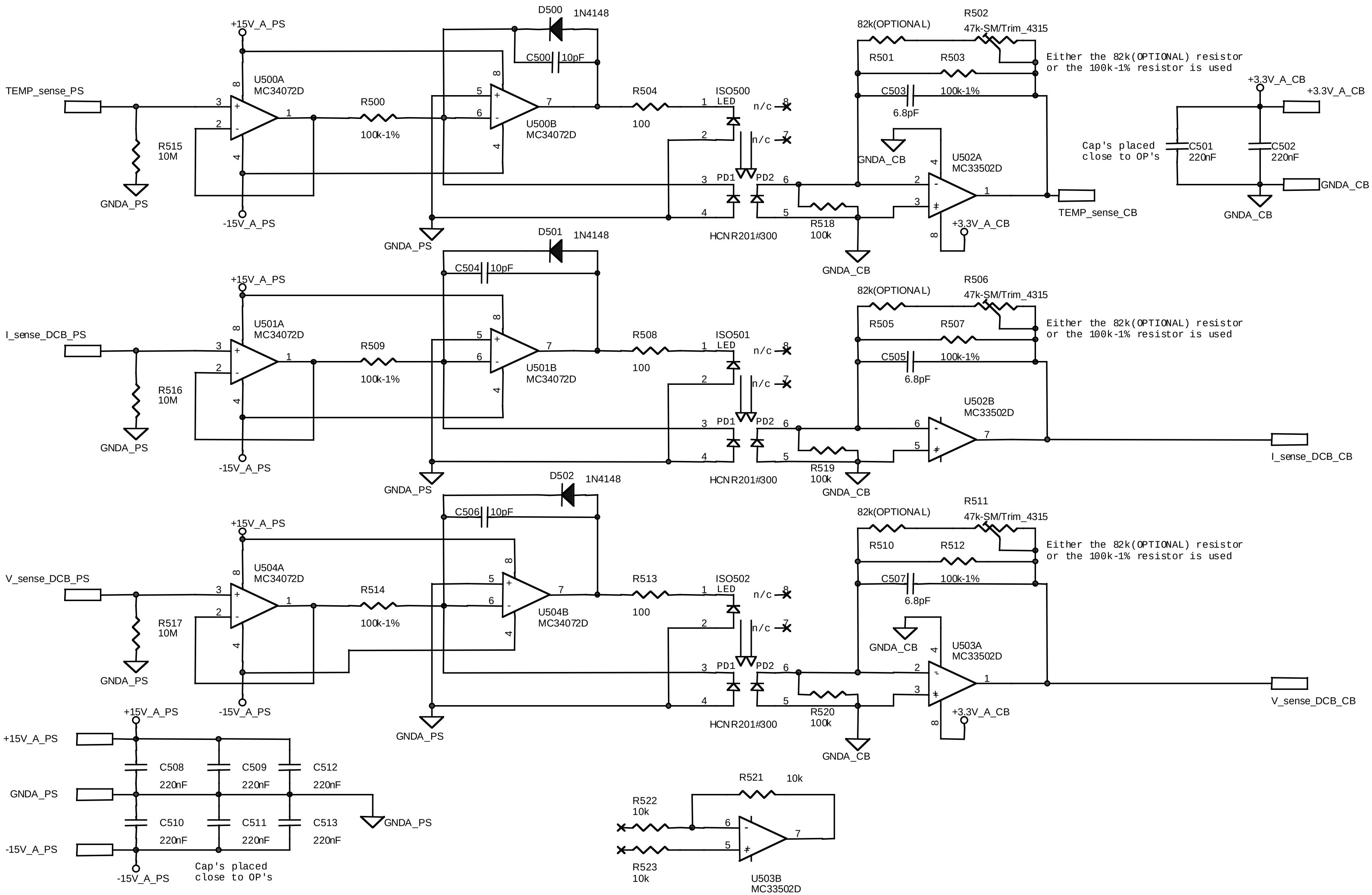


Figure 4-6. Analog Temperature and dc Bus Sense Signals

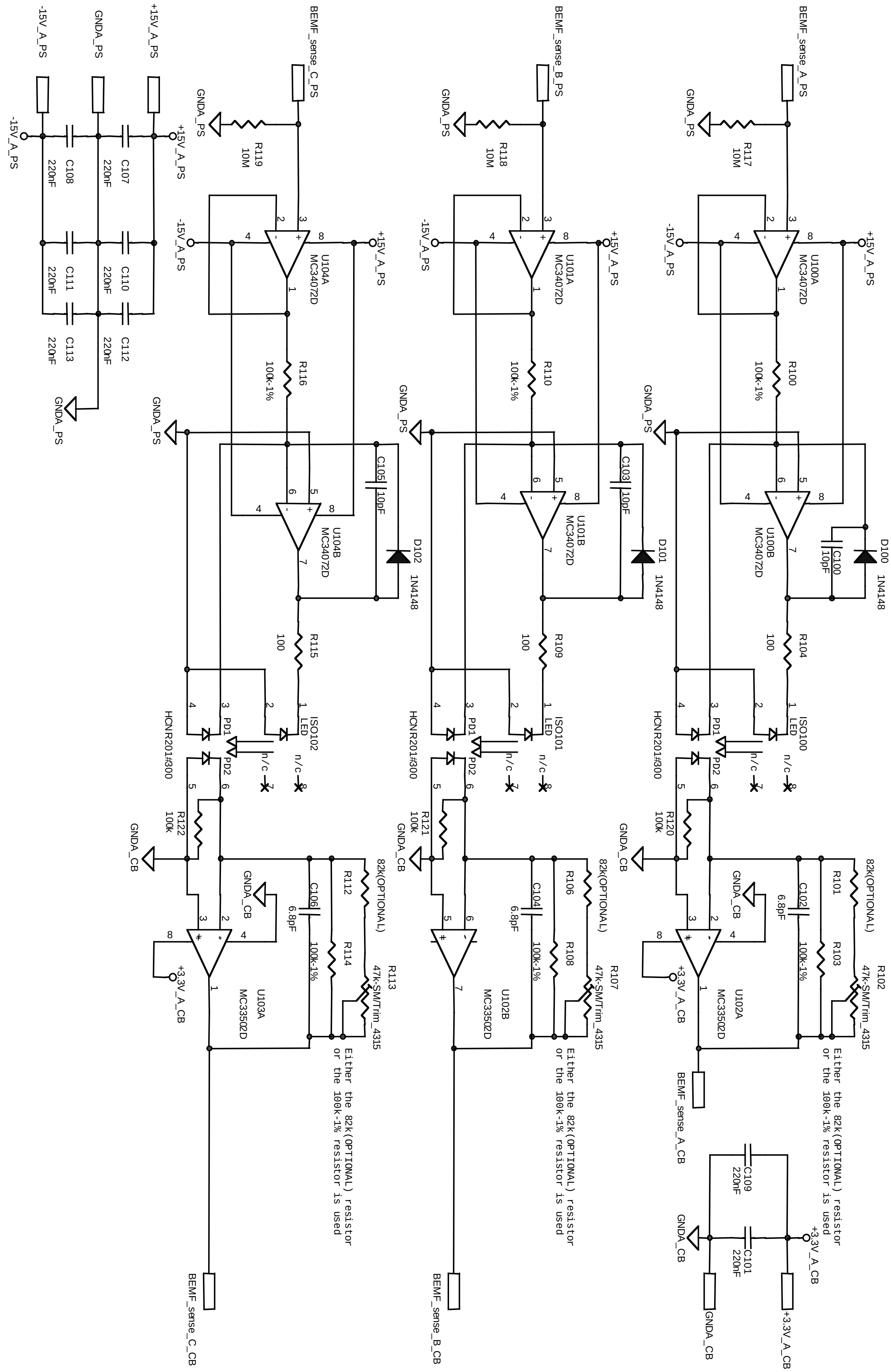
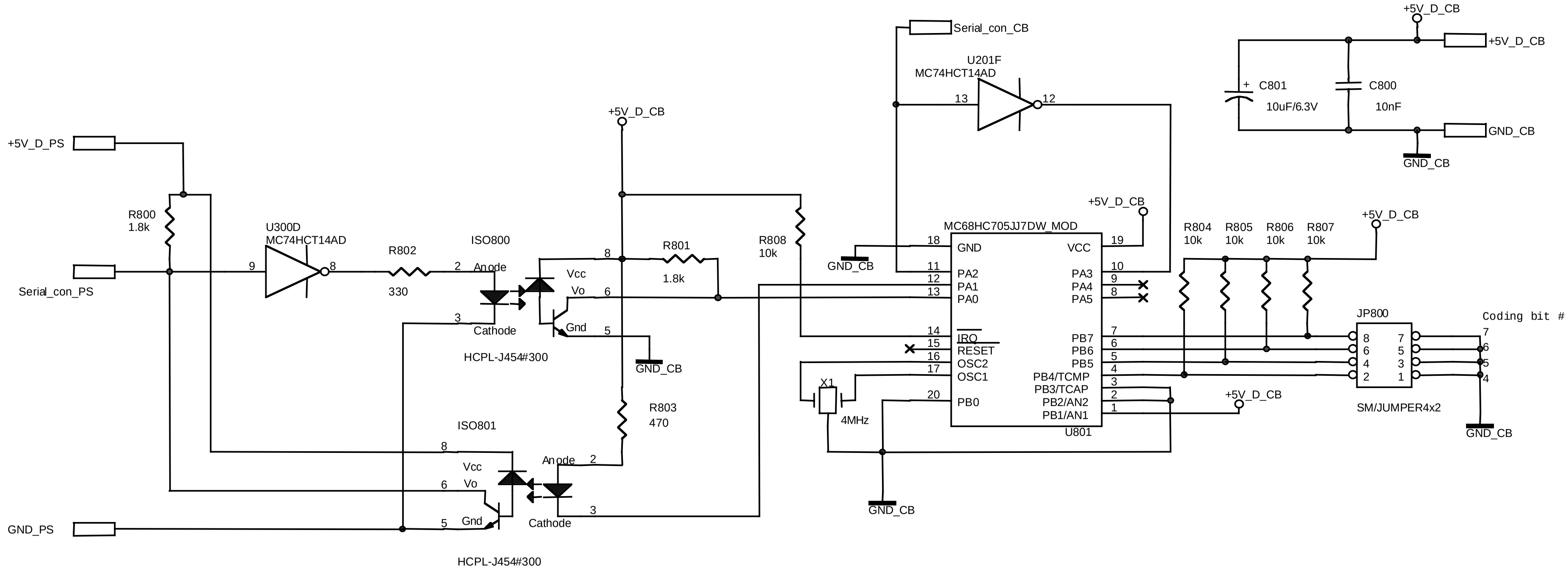


Figure 4-7. Analog Back EMF Signals



DEFAULT SETTINGS
FOR OPTOBOARD:
0 - PB0 = L
1 - PB1 = H
2 - PB2 = L
3 - PB3 = L
4 - PB4 = H
5 - PB5 = H
6 - PB6 = H
7 - PB7 = H

Figure 4-8. Identification Block

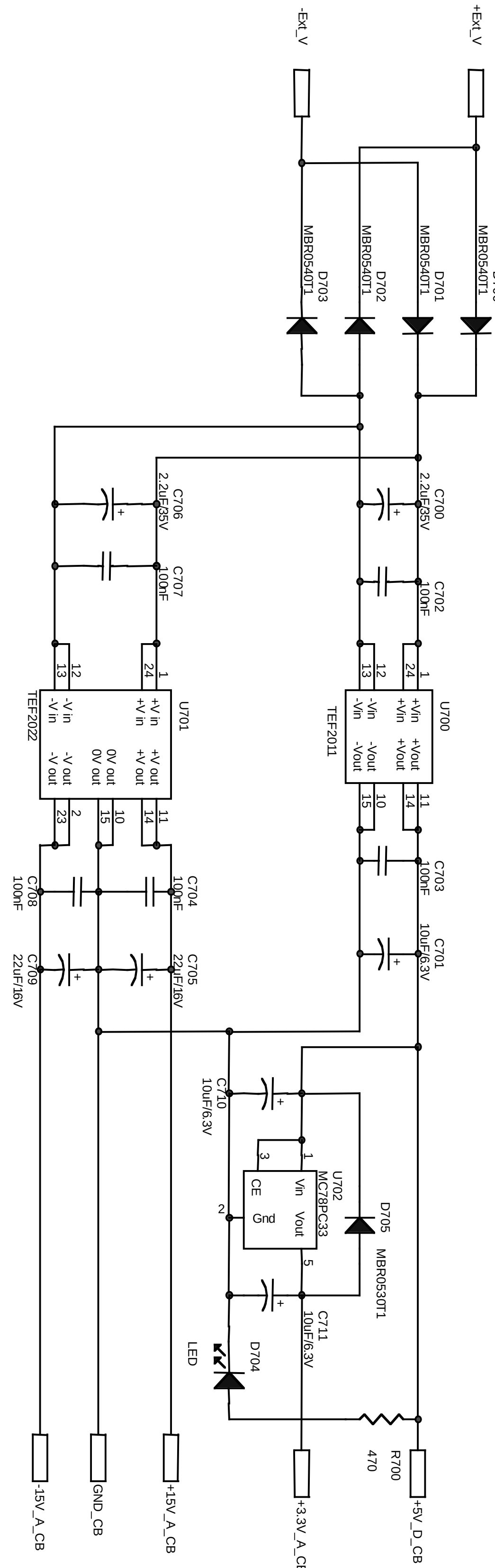


Figure 4-9. dc/dc Converter

4.4 Parts List

The Optoisolation Board's parts content is described by the following parts list.

Table 4-1. Parts List (Sheet 1 of 4)

Qty.	Reference	Part Value	Description	Mfg.	Mfg. Part No.
9	C100, C103, C105, C400, C403, C405, C500, C504, C506	10 pF	Capacitor, ceramic 10 pF	Vitramon/ Vishay	VJ0805A100DXA_
23	C101, C107, C108, C109, C110, C111, C112, C113, C401, C407, C408, C409, C410, C411, C412, C501, C502, C508, C509, C510, C511, C512, C513	220 nF	Capacitor, ceramic 220 nF/25 V, Z5U, ± 20%	Vitramon/ Vishay	VJ0805U224MXXA_
9	C102, C104, C106, C402, C404, C406, C503, C505, C507	6.8 pF	Capacitor, ceramic 6.8 pF	Vitramon/ Vishay	VJ0805A6R8DXA_
9	C200, C201, C300, C303, C600, C601, C602, C603, C800	10 nF	Capacitor, ceramic 10 nF/25 V, Z5U, ± 20%	Vitramon/ Vishay	VJ0805U103MXXA_
7	C202, C604, C702, C703, C704, C707, C708	100 nF	Capacitor, ceramic 100 nF/25 V, Z5U, ± 20%	Vitramon/ Vishay	VJ0805U104MXXA_
7	C301, C302, C605, C701, C710, C711, C801	10 µF/6.3 V	Tantalum capacitor 10 µF/6.3 V	Commonwealth Sprague	293D106X06R3B2
2	C700, C706	2.2 µF/35 V	Tantalum capacitor 2.2 µF/35 V	Commonwealth Sprague	293D225X0035C2
2	C705, C709	22 µF/16 V	Tantalum capacitor 22 µF/16 V	Commonwealth Sprague	293D226X0016D2
2	D704, D1	Green LED	Green LED 10 mA	Kingbright LED	L-934GT
9	D100, D101, D102, D400, D401, D402, D500, D501, D502	1N4148	SMD/1N4148	Fairchild Semiconductor	1N4148LL-34
4	D700, D701, D702, D703	MBR0540T1	Schottky diode	ON Semiconductor	MBR0540T1

Table 4-1. Parts List (Sheet 2 of 4)

Qty.	Reference	Part Value	Description	Mfg.	Mfg. Part No.
1	D705	MBR0530T1	Schottky diode	ON Semiconductor	MBR0530T1
9	ISO100, ISO101, ISO102, ISO400, ISO401, ISO402, ISO500, ISO501, ISO502	HCNR201#300	Linear optoisolator	HP	HCNR201#300
17	ISO200, ISO201, ISO202, ISO203, ISO300, ISO301, ISO302, ISO303, ISO304, ISO600, ISO601, ISO602, ISO603, ISO604, ISO605, ISO800, ISO801	HCPL-J454#300	Digital optoisolator	HP	HCPL-J454#300
1	JP1	CON/2screws	2 screws PCB terminal, 200 mils	WAGO	237-132
2	J2, J1	CON/40	Header 40 pins breakaway conn.	Fischer Elektronik GmbH	ASLG40G
1	J3	Power jack	Power jack type connector 2.1	CUI Stack, Inc.	PJ-002A
18	R100, R103, R108, R110, R114, R116, R400, R403, R407, R409, R413, R414, R500, R503, R507, R509, R512, R514	100 k	Resistor 100 kΩ, 1%	Dale	CRCW0805-1003F
9	R102, R107, R113, R402, R406, R411, R502, R506, R511	47 k	SMT trimmer potentiometer	Panasonic	—
9	R104, R109, R115, R404, R408, R412, R504, R508, R513	100	Resistor 100 Ω, 5%	Dale	CRCW0805-101J
9	R117, R118, R119, R415, R416, R417, R515, R516, R517	10 M	Resistor 10 MΩ, 5%	Dale	CRCW0805-106J

Table 4-1. Parts List (Sheet 3 of 4)

Qty.	Reference	Part Value	Description	Mfg.	Mfg. Part No.
9	R120, R121, R122, R418, R419, R420, R518, R519, R520	100 k	Resistor 100 kΩ, 5%	Dale	CRCW0805-104J
16	R200, R203, R205, R207, R301, R304, R307, R309, R311, R601, R604, R607, R610, R613, R616, R802	330	Resistor 330 Ω, 5%	Dale	CRCW0805-331J
17	R201, R202, R204, R206, R300, R303, R306, R310, R312, R600, R603, R606, R609, R612, R615, R800, R801	1.8 k	Resistor 1.8 kΩ, 5%	Dale	CRCW0805-182J
17	R302, R305, R308, R521, R522, R523, R602, R605, R608, R611, R614, R617, R804, R805, R806, R807, R808	10 k	Resistor 10 kΩ, 5%	Dale	CRCW0805-103J
3	R803, R700, R1	470	Resistor 470 Ω, 5%	Dale	CRCW0805-471J
9	U100, U101, U104, U400, U402, U403, U500, U501, U504	MC34072D	Operational amplifier	ON Semiconductor	MC34072D
5	U102, U103, U401, U502, U503	MC33502D	Operational amplifier	ON Semiconductor	MC33502D
4	U200, U301, U601, U602		4x NAND Logic Gate		
3	U201, U300, U600	MC74HCT14AD	6x Schmitt trigger inverter	ON Semiconductor	MC74HCT14AD
1	U700	TEF2011	dc/dc convertor	Traco Power Products	TEF2011
1	U701	TEF2022	dc/dc convertor	Traco Power Products	TEF2022
1	U702	MC78PC33NTR	Linear voltage regulator	ON Semiconductor	MC78PC33NTR

Table 4-1. Parts List (Sheet 4 of 4)

Qty.	Reference	Part Value	Description	Mfg.	Mfg. Part No.
	U801		Programmed MCU Made from Part Program file IDENT_V01.S19	Motorola	MC68HC708JJ7CDW
1	X1	4 MHz	Chip ceramic resonator 4 MHz	muRata	CSTCC4.00MG
1	FAB00116		Printed wiring board		
1	ASST00116A		Danger high voltage — warning label — 10x30 mm max.		
	NO POPULATES	JP800, JP303, JP301, MP1-MP12, R101, R106, R112, R401, R405, R410, R501, R505, R510			

Section 5. Design Considerations

5.1 Contents

5.2 Overview

From a systems point of view, the optoisolation board fits into an architecture that is optimized for noise robustness. All drive and feedback signals that flow between the processor and power stage are optocoupled. This configuration physically separates the processor's ground from the power stage, where di/dt's of 100 A/ns are not uncommon.

The optoisolation board transfers 14 digital signals, nine analog signals, and one bidirectional signal across a galvanic isolation barrier. Digital signals use a common circuit block, which is repeated once for each signal. Similarly, the analog circuitry uses a common block that is repeated. Descriptions of each of these blocks are contained in the following subsections.

5.3 Digital Optoisolation Block

The digital optoisolation block is relatively straightforward. It is based on Agilent Technologies' HCPL-J454 high dv/dt coupler. A simplified schematic is shown in **Figure 5-1**.

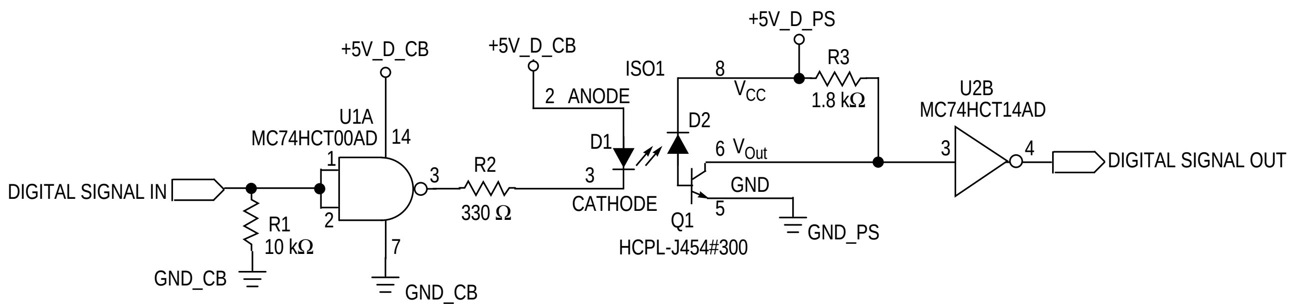


Figure 5-1. Simplified Digital Isolation Block

At the input, pull-down resistor R1, sets a logic low in the absence of a signal. Open input pull-down is important for gate drive signals, where it is desirable to keep power transistors off in case of either a broken connection or absence of power on the control board.

Next, NAND gate U1A, inverts the input signal. Assuming a logic low at the input, U1A's output is high, which puts both the anode and cathode of the optocoupler's input diode at +5 volts. With no forward bias on the input diode, the optocoupler's output transistor is off, producing a logic high. This logic high is inverted by U2B to produce a logic low at the output. Conversely, when the input is high, the output of U1A is low, which forward biases the optocoupler's input diode. Forward bias at the input causes light to shine on photodiode D2, which produces a leakage current that flows into Q1's base. With base current supplied, Q1 is on, the optocoupler's output is low, and the output of U2B is high. The block as a whole, therefore, is non-inverting. In other words, a logic high at the input produces a logic high at the output.

HCPL-J454 optocouplers have been selected for their noise immunity and high dv/dt withstand capability. They provide a robust buffer between power stage noise and the control circuitry.

5.4 Analog Optoisolation Block

A simplified schematic of the analog optoisolation block is shown in **Figure 5-2**.

It is based upon Agilent Technologies' HCNR201 high-linearity optocoupler. The HCNR201 consists of an LED and two photodiodes. The LED and one of the photodiodes (PD1) is on the input side of the optoisolation barrier, and the other photodiode (PD2) is on the output side. The package is constructed so that each photodiode receives approximately the same amount of light from the LED. Feedback amplifier A1 is configured with PD1 to monitor the light output of the LED and automatically adjust LED current to compensate for any non-linearity. The output photodiode then converts the LED's stable, linear light output into a current, which is then converted back into a voltage by amplifier A2.

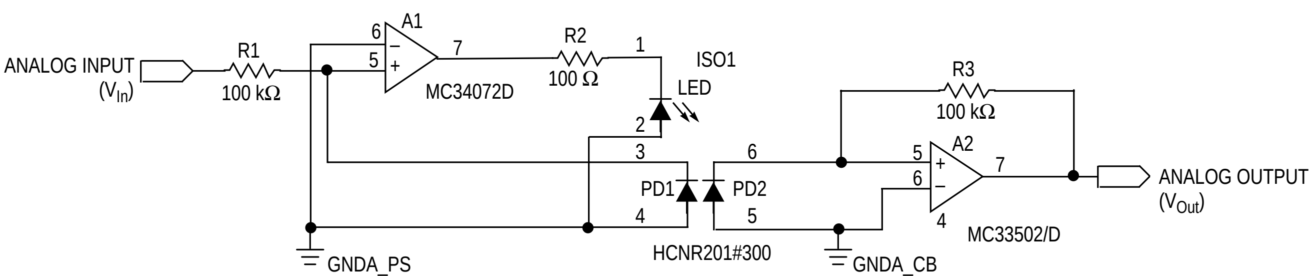


Figure 5-2. Simplified Analog Isolation Block

Circuit operation may not be immediately obvious from inspecting **Figure 5-2**, particularly the input part of the circuit. Stated briefly, amplifier A1 adjusts LED forward current (I_F) such that the current in PD1 (I_{PD1}) is equal to V_{In}/R1.

Analysis of the input circuit reveals that increasing the input voltage increases the voltage at the inverting input terminal of A1. Amplifier A1 amplifies that increase, causing I_F and I_{PD1} to increase. Given the way that PD1 is connected, I_{PD1} will pull the inverting input of the op-amp back toward ground. A1 will continue to increase I_F until its inverting input voltage stabilizes near its ground reference voltage. Assuming that no current flows into the inputs of A1, all of the current flowing through R1 will flow through PD1. Since the inverting input of A1 is at approximately 0 volts, the current through R1, and therefore $I_{PD1,}$ is equal to V_{In}/R1. Essentially, amplifier A1 adjusts I_F such that $I_{PD1} = -V_{In}$/R1.

Note that I_{PD1} depends only on the input voltage and the value of R1 and is independent of the optocoupler's characteristics. Also note that I_{PD1} is directly proportional to V_{In}, giving a very linear relationship between the input voltage and the photodiode current.

The physical construction of the optocoupler's package determines the relative amounts of light that fall on the two photodiodes and, therefore, the ratio of the photodiode currents. This results in a current, I_{PD2}, that is nearly equal to I_{PD1}. Amplifier A2 and resistor R3 form a trans-resistance amplifier that converts I_{PD2} back into a voltage, V_{Out}, where $V_{Out} = I_{PD2} \times R3$. Combining input and output equations results in an expression that relates the output voltage to the input voltage, $V_{Out} / V_{In} = (R3/R1)$. Therefore, with R1 = R3, the output signal closely matches the input.

5.5 Serial Link

The serial link connected to pin 30 of connector J1 is somewhat different than the other digital links in that it is capable of transferring signals in both directions. **Figure 5-3** shows that two optocouplers are used to provide bidirectional signal transfer. On the left hand side of **Figure 5-3**, the open collector of optoisolator ISO801 is tied to the input of U300D and pullup resistor R800. This wired-OR configuration allows transfer of an input signal when ISO801 is off, and also it allows output signals to pass through ISO801, when an input signal is not present. On the other side of the isolation barrier, the output of ISO800 and the input of ISO801 go to separate digital ports, providing for signal transfer in both directions.

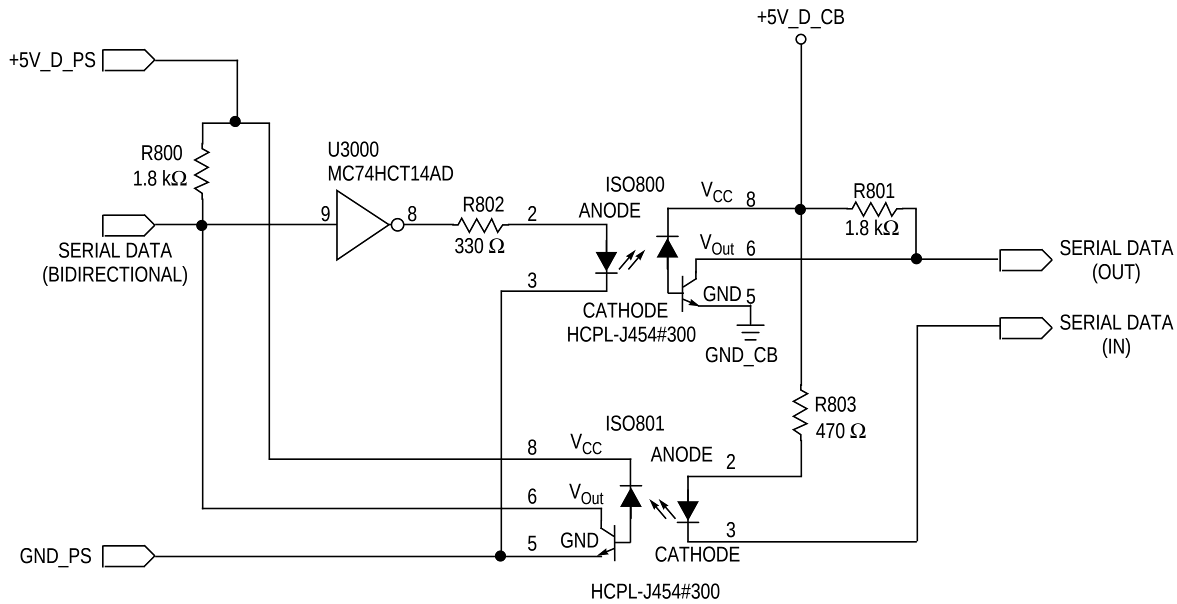


Figure 5-3. Bidirectional Serial Link

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