Multiaxis Motor Control Board

This reference manual describes the Altera® Multiaxis Motor Control Board.

Efficient control of torque and speed of AC motors requires corresponding control of voltage and frequency that you supply to the motor. Typically, you filter the AC input voltage for electromagnetic interference (EMI), correct it to achieve unity power factor, then rectify it to yield a DC voltage. You then invert the rectifier output again through switching of power electronics, such as insulated-gate bipolar transistors (IGBTs) to create the appropriate variable AC voltages and frequency for the motor. Control algorithms such as Field Oriented Control (FOC) of PMSMs require you to measure and analog to digitally A/D convert motor current and voltages, to provide the required feedback to the controller. In addition, you use analog-to-digital converters (ADCs) to monitor the DC link voltage and current. Multiaxis drives achieve either a high degree of coordination of control across motors or, in some applications, integrate control of multiple independent motors to reduce overall system cost. In closed-loop control systems, modern drive requirements continue to evolve the need for higher precision position and velocity encoder feedback devices. Standard encoder interfaces, 7such as EnDat, BiSS, and HiperFace, are based on traditional sin and cosine encoder techniques. These encoder interfaces incorporate communication controllers that can transmit information back to the drive digitally, which enhances their performance in noisy environments. Encoder interfaces support features, such as online inspection of motor parameters and line delay measurement, which you can incorporate into the motor control algorithm.

The Multiaxis Motor Control Board contains all the power electronics, current and voltage sensing, and connections for motor position feedback. You can use the motor Control Board to develop a motor control system that supports permanent magnet synchronous motors (PMSMs) or brushless DC (BLDC) motors. The Multiaxis Motor Control Board is suitable for single-axis and multiaxis motor control applications and supports multiple position feedback interfaces..

Features

The Multiaxis Motor Control Board has the following features:

- Power factor correction (PFC) and EMI filter
- DC link power supply of 400 V
- Switch mode power supplies for logic
- IGBT power stages
- Sigma-delta ADCs for sensing voltages and currents
- Brake (chopper) switch

101 Innovation Drive
San Jose, CA 95134
www.altera.com

- Position feedback interfaces for:
  - EnDat
  - Bidirectional synchronous serial (BiSS)
  - HIPERFACE
  - Resolver
  - Quadrature
  - Hall effect

Setting Up the Multiaxis Motor Control Board

WARNING The Multiaxis Motor Control Board operates at high voltages and currents that can result in hazardous electrical shock. Ensure you understand and follow all necessary safety precautions before you operate the board.

Altera supplies the Multiaxis Motor Control Board configured for EnDat interfaces, to change these settings, perform the following steps:

1. Use the jumpers to select the encoder power supply.
2. Use the jumpers to configure the encoder RS485.
3. Configure the Multiaxis Motor Control Board to match the interface type that the host board implements, otherwise unexpected damage may occur.

Connecting Encoders

To connect the EnDat encoder and motor, perform the following steps:

1. Consult the data sheet for your encoder and set the encoder power supply jumpers to generate the required supply voltage (Table 10).
2. Set the **DRV_x_SER_DATA** jumpers for bidirectional signalling on the RX pair for the channel you intend to use (Table 12)
3. Use the 20-way terminal block to connect each encoder. Table 1 lists the four terminal blocks.

Table 1. Encoder terminal Blocks

Channel	Encoder Terminal Block
0	J9
1	J23
2	J37
3	J51

4. Connect the encoder cable to the screw terminal on the relevant terminal block for channel you intend to use (Table 2).

Table 2. Screw Terminal Connections for BiSS and EnDat Encoders

Signal Name	Cable Color		Screw Terminal (J9, J23, J37, J51)
	BiSS	EnDat	
`Data+`	PInk	Grey	18
`Data-`	Grey	Pink	19
`Clock+`	Yellow	Violet	14
`Clock-`	Green	Yellow	15
`Power`	White	Blue and brown/green	1
`Ground`	Brown	White and white/green	20

Connecting the Motors

To prevent electrical shocks before connecting or disconnecting the motor:

1. Always shut down the motor control application on the host board.
2. Disconnect the Multiaxis Motor Control Board from the mains supply.
3. Ensure the DC link capacitors are discharged.
4. Use the four-way screw terminal block to connect each motor. Table 3 lists motor connectors.

Table 3. Motor Connectors

Channel	Motor Connector
0	J2
1	J16
2	J30
3	J44

5. Connect the motor to the screw terminal connector for the channel you intend to use (Table 6).

Functional Description

Figure 1 shows the Multiaxis Motor Control Board.

Figure 1. Multiaxis Motor Control Board

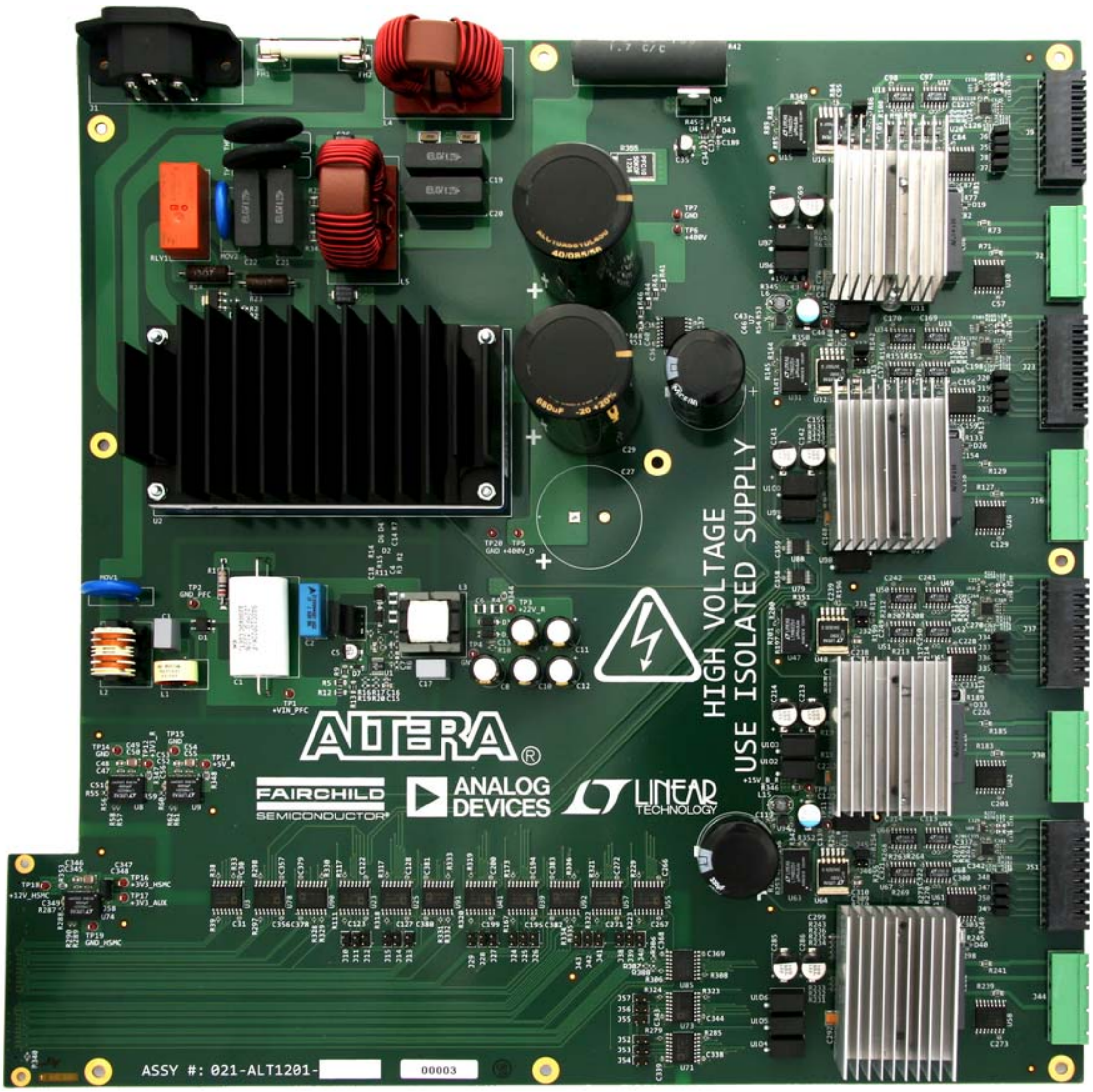
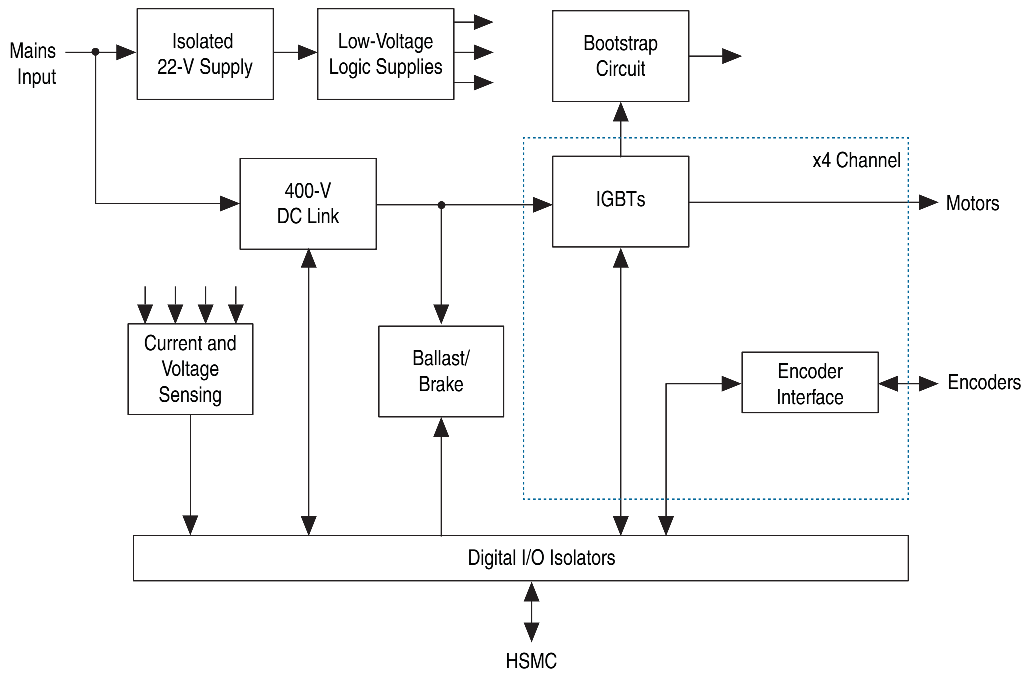


Figure 2 shows a high-level block diagram of the Multiaxis Motor Control Board.

Figure 2. Block Diagram



The following sections describe the functional blocks.

Digital I/O Isolators

Analog Devices ADuM1401 digital isolators isolate all digital I/O signals on the Multiaxis Motor Control Board. They provide complete electrical isolation between the host FPGA board and the power electronics on the Multiaxis Motor Control Board. In some circuit locations, the board uses Silicon Labs Si8440 or Si8441 digital isolators for their output behavior during power down, to prevent transient control signals on the IGBT drivers.

One side of each isolator connects to the HSMC connector and takes power from the HSMC connector. The other side of each isolator takes power from an isolated power supply on the Multiaxis Motor Control Board.

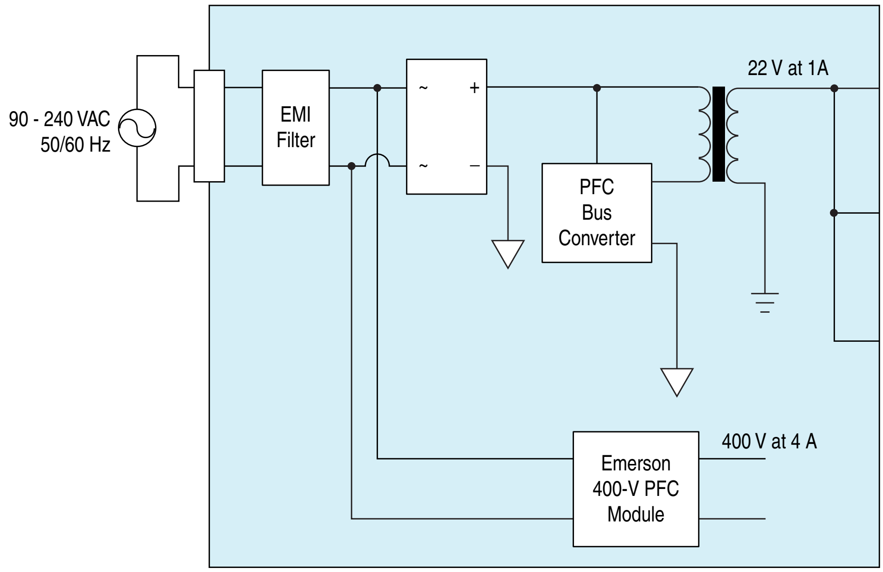
Power Supplies

The Multiaxis Motor Control Board converts mains input to the DC link and a number of lower voltages for logic and interfacing.

Mains Input

The Multiaxis Motor Control Board filters the mains input (Figure 3) and then splits to the DC link and the 22-V power supply. Both power supplies incorporate PFC. The Multiaxis Motor Control Board works with mains input voltages of 85 to 264 VAC, 50 or 60 Hz. The mains input includes an EMI filter.

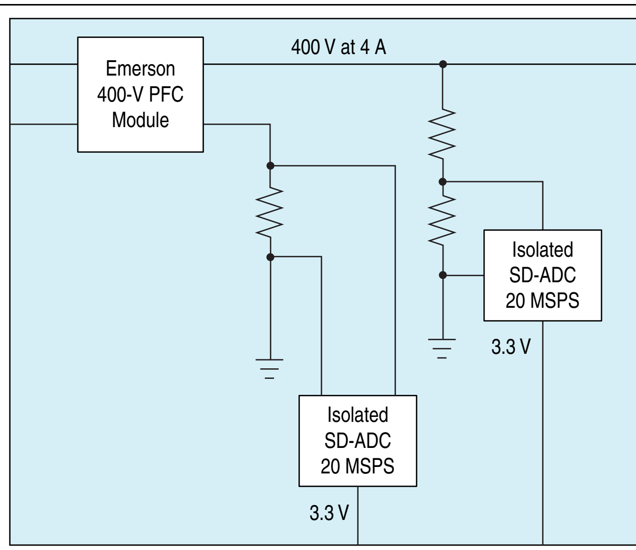
Figure 3. Mains Input Filtering



DC Link and PFC

To provide unity power factor with very low-level harmonic distortion in line current, an Emerson AIF04ZPFC-01L module produces the 400-V DC link voltage (Figure 4). The PFC works over all typical line voltages used worldwide.

Figure 4. DC Link Voltage PFC Supply



The DC link can supply up to 1.5 kW in total, across all four motor channels with a mains input of 240 V. At lower mains voltages, the Multiaxis Motor Control Board reduces the maximum power. For example, 1 kW at 110 V input. Isolated sigma-delta ADCs allow you to monitor the DC link voltage and current.

Isolated 22 V Supply

A Linear Technology LT3798 provides an isolated 22-V supply that feeds further switch mode regulators to generate all of the required voltages on the Multiaxis Motor Control Board.

15 V IGBT Gate Drive Supply

Two Linear Technology LTC3631EDD#PBF generate the 15-V supplies that the IGBT modules require. One LTC361 supplies motor channels 0 and 1; the other one supplies motor channels 2 and 3.

3.3 V and 5 V Logic Supplies

The 3.3-V and 5-V supplies for logic devices both use Linear Technology LTM8022 DC/DC micromodules.

3.3 V Isolator Supply

The isolators connected to the HSMC connector can receive power directly from the HSMC 3.3-V pins or from the HSMC 12-V pin via a Linear Technology LTM8022 micromodule switch mode power supply.

Encoder Power Supplies

Each motor channel includes a power supply (LTM8025 micromodule) for the encoder interface that you can configure for 3.3 V, 5 V, or 12 V as required by the encoder.

Brake

The Multiaxis Motor Control Board includes incorporates a brake circuit with a Fairchild FAN3111E gate driver, Fairchild FGP15N60 IGBT, and 100-Ohm brake resistor.

During braking, the kinetic energy of the motor feeds back into the DC link circuit as extra stored energy in the DC link capacitor. You can turn on the brake resistor to dissipate excess energy and prevent the DC link voltage from rising too high.

The peak power dissipation in the brake resistor is:

$V^2/R = V_{DCLINK}^2/100 = 1.6$ kW

As the brake resistor is rated for only 20 W continuous power dissipation, only use it for only a few milliseconds. The gate drive to the brake circuit is AC coupled.The FPGA must drive a square wave on the `HSMC_MOTOR_BRAKE` signal to activate the brake. A steady signal, either high or low, results in the Power Supply turning off the brake. Furthermore, the FPGA should implement some form of time out to prevent you from activating the brake for too long.

The time constant of the AC coupling allows the brake resistor to be active for no more than 1 ms if the `HSMC_MOTOR_BRAKE` signal remains asserted.

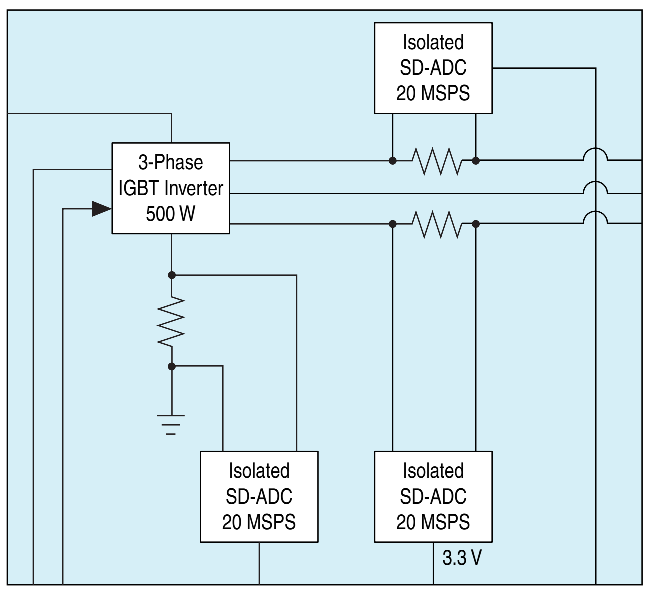
IGBTs

The Multiaxis Motor Control Board uses Fairchild FNB41560/B2 600V/15A smart power modules for each of the four motor channels (Figure 5). These modules are three-phase IGBT inverter bridges including control ICs for gate driving and protection.

Murata MEE1S2415SC isolated DC/DC converters generate floating bootstrap supplies for the gate drivers from the 15V supply. The bootstrap voltages also power the ADCs that sample the motor current, via simple zener diode regulators.

The Multiaxis Motor Control Board uses software to ensure that the low side IGBT activates long enough to produce the correct bootstrap voltage (refer to the *Fairchild AN-9070 Smart Power Module Motion-SPM Products Application Note)*. The bootstrap capacitor for each channel on the Multiaxis Motor Control Board is 22 µF.

Figure 5. IGBTs



Sigma-Delta Modulator ADCs

The Multiaxis Motor Control Board includes multiple Analog Devices AD7401 differential input sigma-delta modulators, each clocked at 20 MHz to monitor and measure key voltage, current, and resolver output quantities. The Multiaxis Motor Control Board uses isolated ADCs except the resolver encoder feedback conversion. The Multiaxis Motor Control Board demodulates the bit streams from the ADCs in the FPGA on the host board. The Multiaxis Motor Control Board isolates the digital encoded data at the HSMC connector.

DC Link Monitor

The Multiaxis Motor Control Board measures the DC Link voltage, $V_{DCLINK,}$ by sensing the voltage across a resistor divider chain representing:

82/199682 * V_{DCLINK}

For example, a voltage of 41 mV corresponds to a DC link voltage of 100 V. The sigma-delta modulated reading is available on the HSMC connector `HSMC_ADC_400V_PFC_V_DATA` signal.

After filtering in the FPGA, the Multiaxis Motor Control Board calculates the DC link voltage, according to the equation:

DC link voltage (V) = ADC value × 0.048

The reference design software uses an equivalent formula based on integer arithmetic.

The Multiaxis Motor Control Board measures the ground return current of the PFC by sensing the voltage across a 0.01 Ohm resistor in the ground return path. The sigma-delta modulated reading is available on the HSMC connector `HSMC_ADC_400V_PFC_I_DATA` signal.

After filtering in the FPGA, the Multiaxis Motor Control Board calculates the the DC link return current, according to the equation:

DC Link return current (mA) = ADC value × 1.95

The reference design software uses an equivalent formula based on integer arithmetic.

IGBT Return Current

The Multiaxis Motor Control Board measures the ground return currents of the IGBT modules by sensing the voltage across 0.05 Ohm resistors in the ground return paths. The sigma-delta modulated readings are available on the HSMC connector `DRV_x_HSMC_MOTOR_RTN_DATA_OUT` signals.

After filtering in the FPGA, the Multiaxis Motor Control Board calculates the IGBT return current according to the equation:

I (mA) = ADC value × 0.195

The drive on chip reference design software uses an equivalent formula based on integer arithmetic.

Motor Phase Currents

Currents are measured in two of the three phases, U and W, by sensing the voltages across 0.05 Ohm shunt resistors in series with the motor connections. The Vin+ terminals of the ADCs are connected nearest the motor. The Vin– terminals of the ADCs are connected nearest the IGBT module.

After filtering in the FPGA, the Multiaxis Motor Control Board calculates motor phase current according to the equation:

I (mA) = ADC value × 0.195

The reference design software uses an equivalent formula based on integer arithmetic.

The sigma-delta modulated readings are available on the HSMC connector `DRV_x_HSMC_U_DATA_OUT` and `DRV_x_HSMC_W_DATA_OUT` signals.

The following equation calculates the current in the third, V, phase:

$I_v = -I_u - I_w$

ADC Clock Tree

The 20-MHz ADC sample clock from the HSMC connector, `CLK_HSMC_ADC`, is buffered by a tree of CDCLVC1106 low-skew clock buffers (Figure 6).

To compensate for the isolator device propagation delays, the HSMC connector provides a feedback clock, `CLK_HSMC_FEEDBACK`, to the FPGA. The Multiaxis Motor Control Board compensates for the isolator propagation delays, but you must still account for the part-to-part skew when creating I/O timing constraints for the FPGA design.

Alternatively, you can use a PLL in the FPGA to create a phase shifted version of the ADC clock for sampling the inputs.

Figure 6. Clock Tree

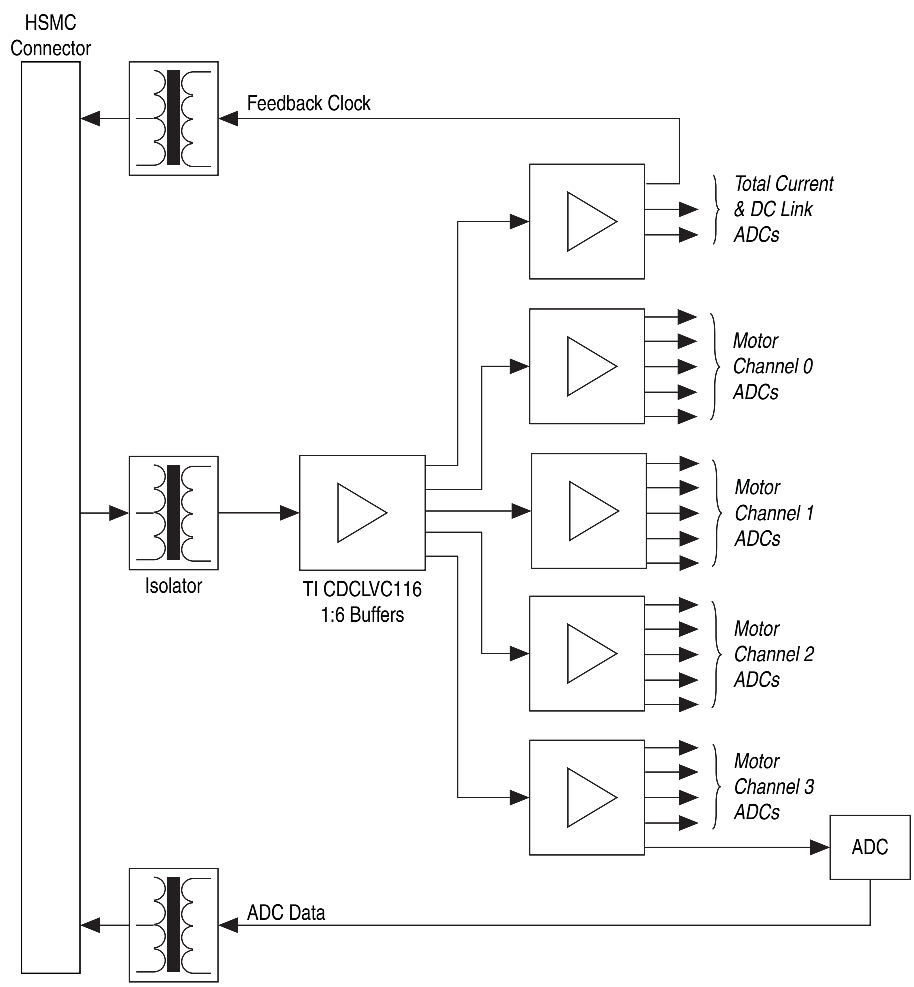


Table 4 lists the ADCs.

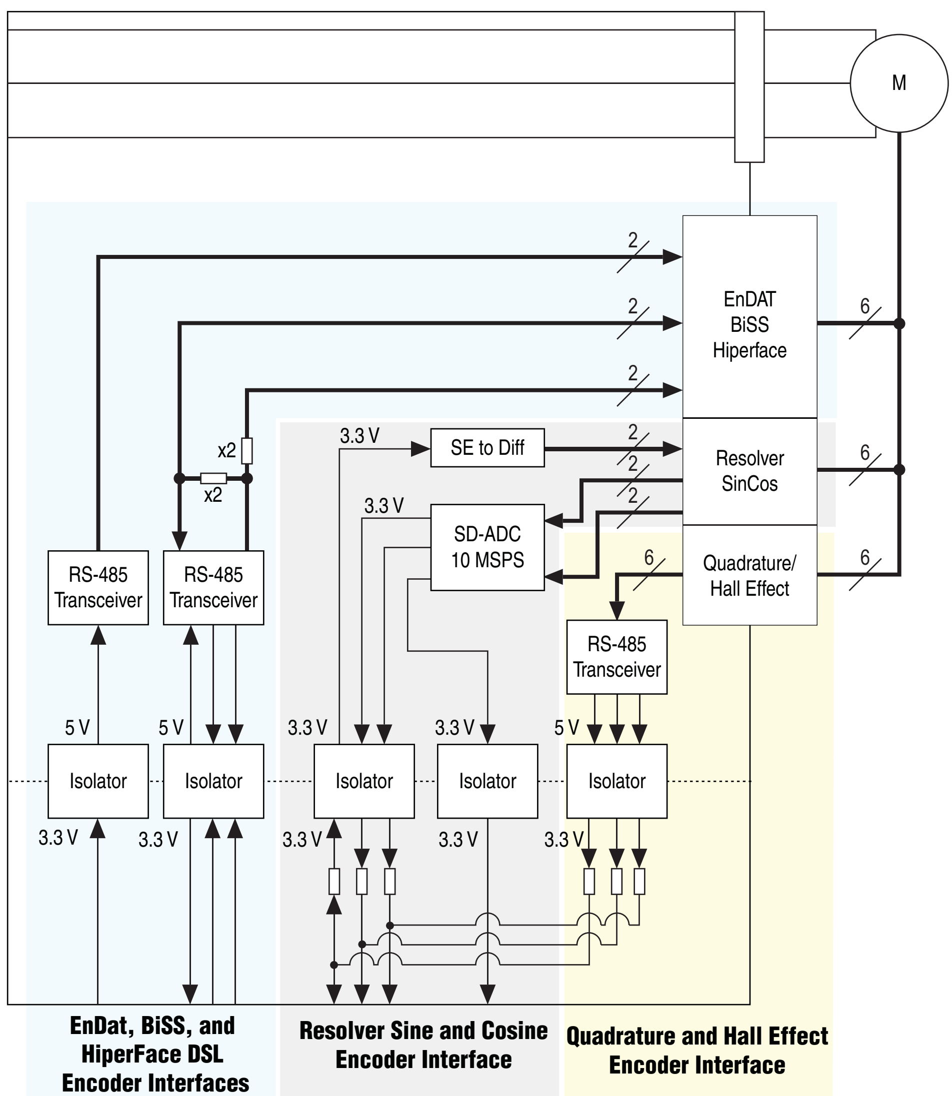
Table 4. ADCs

ADC	Measured Quantity	Scaling Factor	HSMC Signals
DC-link monitor	DC-link voltage	0.048	HSMC_ADC_400V_PFC_V_DATA
DC-link monitor	DC-link current	1.95	HSMC_ADC_400V_PFC_I_DATA
IGBT return	IGBT return current	0.195	DRV_x_HSMC_MOTOR_RTN_DATA_OUT
Motor phase U	Motor phase U current	0.195	DRV_x_HSMC_U_DATA_OUT
Motor phase W	Motor phase W current	0.195	DRV_x_HSMC_W_DATA_OUT

Encoder Interfaces

Figure 7 shows the encoder interface.

Figure 7. Encoder Interface



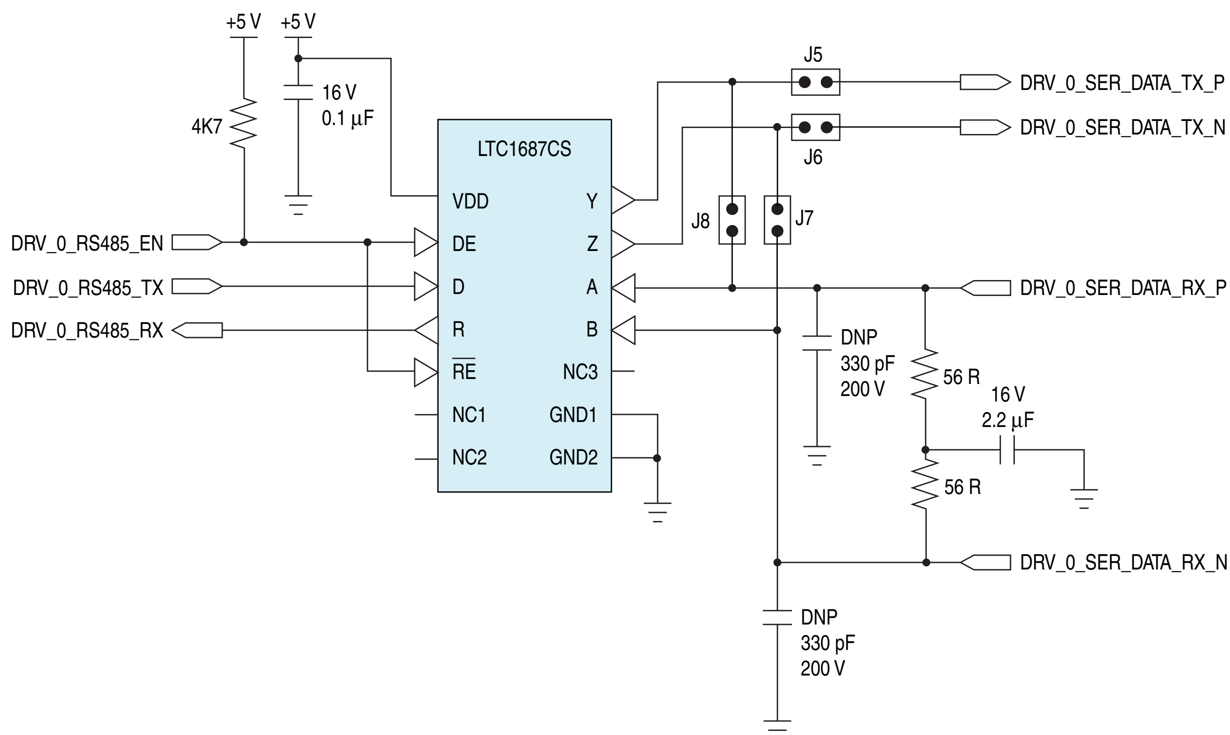
EnDat, BiSS, HIPERFACE DSL Encoder Interface

The Multiaxis Motor Control Board supports connection of encoders with RS485 interfaces. You may configure each motor channel independently for any of the encoder interface types.

Each encoder interface type requires you to implement the appropriate interface IP cores in the FPGA on the host board. Altera partners provide appropriate IP cores with the reference design.

The Multiaxis Motor Control Board includes different electrical termination schemes for the encoder interfaces. Figure 8 shows an example a channel (channel 0) interface termination. Capacitors C107 and C111 are not fitted, Resistors R103, R106 and capacitor C109 are fitted. The jumpers allow for independent pairs for TX and RX or one common pair. Refer to Table 11 for other channel jumper settings.

Figure 8. Encoder Interface Termination



Resolver Sine and Cosine Encoder Interface

The FPGA on the host board implements IP cores to drive the single-ended resolver stimulus signal with a sigma-delta encoded 8-kHz sine wave. The Multiaxis Motor Control Board converts and filters this signal to a differential drive for the resolver.

ADS1205 dual channel 10-MHz sigma-delta ADCs, with a ±2.5-V input range, clocked at 20 MHz, digitize resolver encoder sine and cosine feedback signals. The ADS1205 divides the applied clock internally to generate the 10-Mbps data rate. The Multiaxis Motor Control Board passes the resulting bitstreams through isolators for isolation.

Quadrature and Hall Effect Encoder Interface

The Multiaxis Motor Control Board allows you to connect two- and three-channel quadrature encoders with RS485 interfaces.

IP cores in the FPGA on the host board decode the encoder signals.

HSMC Connector

The HSMC connector allows you to connect the Multiaxis Motor Control Board to an FPGA host board.

For more information on the HSMC connector, refer to the *High Speed Mezzanine Card (HSMC) Specification*.

Table 5 lists the pin assignments for the HSMC connector. I/O direction is relative to the Multiaxis Motor Control Board: input indicates input to the Multiaxis Motor Control Board from the host board; output indicates an output signal from the Multiaxis Motor Control Board to the host board.

Table 5. HSMC Connector Pin Assignments

Pin	Signal	Direction	Function
1 to 38	—	—	Not used.
39	CLK_HSMC_ADC	Input	Clock input for sigma-delta ADCs.
40	CLK_HSMC_FEEDBACK	Output	Feedback clock compensating for isolator delays.
41	400V_PFC_PFW	Output	PFC power fail warning.
42	DRV_0_HSMC_DRV_WH	Input	Channel 0 phase W high side.
43	400V_PFC_LD_EN	Output	PFC load enable.
44	DRV_0_HSMC_DRV_VH	Input	Channel 0 phase V high side.
45	3.3 V	—	Power.
46	12 V	—	Power.
47	HSMC_MOTOR_BRAKE	Input	Brake (chopper) enable.
48	DRV_0_HSMC_DRV_UH	Input	Channel 0 phase U high side.
49	400V_PFC_PF_EN	Input	PFC enable.
50	DRV_0_HSMC_W_DATA_OUT	Output	Channel 0 phase W ADC data.
51	3.3 V	—	Power.
52	12 V	—	Power.
53	HSMC_ADC_400V_PFC_I_DATA	Output	PFC return current ADC data.
54	DRV_0_HSMC_MOTOR_RTN_DATA_OUT	Output	Channel 0 IGBT return current ADC data.
55	HSMC_ADC_400V_PFC_V_DATA	Output	PFC voltage ADC data.
56	DRV_0_HSMC_U_DATA_OUT	Output	Channel 0 phase U ADC data.
57	3.3 V	—	Power.
58	12 V	—	Power.
59	DRV_0_HSMC_RS485_TX	Input	Channel 0 RS485 encoder TX data.
60	DRV_0_HSMC_RSLVR_DRV_HALL_QUAD_A	Input/Output	Encoder dependent.

Table 5. HSMC Connector Pin Assignments

Pin	Signal	Direction	Function
61	DRV_0_HSMC_RS485_EN	Input	Channel 0 RS485 encoder TX enable.
62	DRV_0_HSMC_RSLVR_COS_HALL_QUAD_B	Output	Encoder dependent.
63	3.3 V	—	Power.
64	12 V	—	Power.
65	CLK_DRV_0_HSMC_SER	Input	Channel 0 encoder clock.
66	DRV_0_HSMC_RSLVR_SIN_HALL_QUAD_C	Output	Encoder dependent.
67	DRV_0_HSMC_RS485_RX	Output	Channel 0 RS485 encoder RX data.
68	DRV_0_HSMC_MOTOR_DRV_FAULT	Output	Channel 0 IGBT fault status.
69	3.3 V	—	Power.
70	12 V	—	Power.
71	DRV_1_HSMC_RS485_TX	Input	Channel 1 RS485 encoder TX data.
72	DRV_0_HSMC_DRV_WL	Input	Channel 0 phase W low side.
73	DRV_1_HSMC_RS485_EN	Input	Channel 0 RS485 encoder TX enable.
74	DRV_0_HSMC_DRV_VL	Input	Channel 0 phase V low side.
75	3.3 V	—	Power.
76	12 V	—	Power.
77	CLK_DRV_1_HSMC_SER	Input	Channel 1 encoder clock.
78	DRV_0_HSMC_DRV_UL	Input	Channel 0 phase U low side.
79	DRV_1_HSMC_RS485_RX	Output	Channel 1 RS485 encoder RX data.
80	DRV_1_HSMC_W_DATA_OUT	Output	Channel 1 phase W ADC data.
81	3.3 V	—	Power.
82	12 V	—	Power.
83	DRV_1_HSMC_RSLVR_COS_HALL_QUAD_B	Output	Encoder dependent.
84	DRV_1_HSMC_MOTOR_RTN_DATA_OUT	Output	Channel 1 IGBT return current ADC data.
85	DRV_1_HSMC_RSLVR_DRV_HALL_QUAD_A	Input/Output	Encoder dependent..
86	DRV_1_HSMC_U_DATA_OUT	Output	Channel 1 phase U ADC data.
87	3.3 V	—	Power.
88	12 V	—	Power.
89	DRV_2_HSMC_RS485_EN	Input	Channel 1 RS485 encoder TX enable.
90	DRV_1_HSMC_MOTOR_DRV_FAULT	Output	Channel 1 IGBT fault status.
91	DRV_1_HSMC_RSLVR_SIN_HALL_QUAD_C	Output	Encoder dependent.
92	DRV_1_HSMC_DRV_WL	Input	Channel 1 phase W low side.
93	3.3 V	—	Power.
94	12 V	—	Power.
95	DRV_2_HSMC_RS485_TX	Input	Channel 2 RS485 encoder TX data.
96	CLK_DRV_0_HSMC_ADC_OUT	Output	Channel 0 Resolver ADC output clock.
97	DRV_2_HSMC_RS485_RX	Output	Channel 2 RS485 encoder RX data.
98	CLK_DRV_1_HSMC_ADC_OUT	Output	Channel 1 resolver ADC output clock.
99	3.3 V	—	Power.

Table 5. HSMC Connector Pin Assignments

Pin	Signal	Direction	Function
100	12 V	—	Power.
101	DRV_2_HSMC_U_DATA_OUT	Output	Channel 2 phase U ADC data.
102	DRV_1_HSMC_DRV_VL	Input	Channel 1 phase V low side.
103	DRV_2_HSMC_MOTOR_RTN_DATA_OUT	Output	Channel 2 IGBT return current ADC data.
104	DRV_1_HSMC_DRV_UL	Input	Channel 1 phase U low side.
105	3.3 V	—	Power.
106	12 V	—	Power.
107	CLK_DRV_2_HSMC_SER	Input	Channel 2 encoder clock.
108	DRV_1_HSMC_DRV_WH	Input	Channel 1 phase W high side.
109	DRV_2_HSMC_W_DATA_OUT	Output	Channel 2 phase W ADC data.
110	DRV_1_HSMC_DRV_VH	Input	Channel 1 phase V high side.
111	3.3 V	—	Power.
112	12 V	—	Power.
113	DRV_2_HSMC_RSLVR_COS_HALL_QUAD_B	Output	Encoder dependent.
114	DRV_1_HSMC_DRV_UH	Input	Channel 1 phase U high side.
115	DRV_2_HSMC_RSLVR_DRV_HALL_QUAD_A	Input/Output	Encoder dependent.
116	DRV_3_HSMC_RS485_RX	Output	Channel 3 RS485 encoder RX data.
117	3.3 V	—	Power.
118	12 V	—	Power.
119	DRV_2_HSMC_DRV_WH	Input	Channel 2 phase W high side.
120	DRV_3_HSMC_RS485_TX	Input	Channel 3 RS485 encoder TX data.
121	DRV_2_HSMC_RSLVR_SIN_HALL_QUAD_C	Output	Encoder dependent.
122	DRV_3_HSMC_RS485_EN	Input	Channel 3 RS485 encoder TX enable.
123	3.3 V	—	Power.
124	12 V	—	Power.
125	DRV_2_HSMC_DRV_UH	Input	Channel 2 phase U high side.
126	DRV_3_HSMC_RSLVR_SIN_HALL_QUAD_C	Output	Encoder dependent.
127	DRV_2_HSMC_DRV_VH	Input	Channel 2 phase V high side.
128	DRV_3_HSMC_RSLVR_COS_HALL_QUAD_B	Output	Encoder dependent.
129	3.3 V	—	Power.
130	12 V	—	Power.
131	DRV_2_HSMC_DRV_WL	Input	Channel 2 phase W low side.
132	DRV_3_HSMC_RSLVR_DRV_HALL_QUAD_A	Input/Output	Encoder dependent.
133	DRV_2_HSMC_MOTOR_DRV_FAULT	Output	Channel 2 IGBT fault status.
134	DRV_3_HSMC_MOTOR_DRV_FAULT	Output	Channel 3 IGBT fault status.
135	3.3 V	—	Power.
136	12 V	—	Power.
137	DRV_2_HSMC_DRV_UL	Input	Channel 2 phase U low side.
138	DRV_3_HSMC_DRV_WL	Input	Channel 3 phase W low side.

Table 5. HSMC Connector Pin Assignments

Pin	Signal	Direction	Function
139	DRV_2_HSMC_DRV_VL	Input	Channel 2 phase V low side.
140	DRV_3_HSMC_DRV_VL	Input	Channel 3 phase V low side.
141	3.3 V	—	Power.
142	12 V	—	Power.
143	DRV_3_HSMC_DRV_VH	Input	Channel 3 phase V high side.
144	DRV_3_HSMC_DRV_UL	Input	Channel 3 phase U low side.
145	DRV_3_HSMC_DRV_UH	Input	Channel 3 phase U high side.
146	DRV_3_HSMC_W_DATA_OUT	Output	Channel 3 phase W ADC data.
147	3.3 V	—	Power.
148	12 V	—	Power.
149	CLK_DRV_3_HSMC_SER	Input	Channel 3 encoder clock.
150	DRV_3_HSMC_MOTOR_RTN_DATA_OUT	Output	Channel 3 IGBT return current ADC data.
151	DRV_3_HSMC_DRV_WH	Input	Channel 3 phase W high side.
152	DRV_3_HSMC_U_DATA_OUT	Output	Channel 3 phase U ADC data.
153	3.3 V	—	Power.
154	12 V	—	Power.
155	—	—	Not used.
156	CLK_DRV_2_HSMC_ADC_OUT	Output	Channel 2 resolver ADC output clock.
157	—	—	Not used.
158	CLK_DRV_3_HSMC_ADC_OUT	Output	Channel 3 Resolver ADC output clock.
159	3.3 V	—	Power.
160	PSNTn	Input	Presence.
161 to 172	0 V	—	Ground.

Mains Input Fuse

A fuse, replacement part number LittleFuse 0324015 250V AC 15A, or equivalent protects the mains input.

Motor Connectors

Table 6 lists the pin assignments for each channel.

Table 6. Motor Connector Pin Assignments

Pin	Signal
1	Earth ground.
2	Motor phase U.
3	Motor phase V.
4	Motor phase W.

Encoder Connectors

Table 7 lists the pin assignments for each channel. Not every encoder type requires all connections to be made.

You may link the TX and RX pairs on pins 16, 17 and 18, 19 by jumpers on the Multiaxis Motor Control Board to create a single bidirectional data pair.

Table 7. Encoder Connector Pin Assignments

Pin	Signal	I/O	Encoder Type(s)	SIgnal
1	Supply	—	—	—
2	DRV_x_SIN_DRV_P	O	Resolver	Stimulus+
3	DRV_x_SIN_DRV_N	O	Resolver	Stimulus–
4	DRV_x_RESOLVER_COS_N	I	Resolver	Cosine- signal
5	DRV_x_RESOLVER_COS_P	I	Resolver	Cosine+ signal
6	DRV_x_RESOLVER_SIN_N	I	Resolver	Sine- signal
7	DRV_x_RESOLVER_SIN_P	I	Resolver	Sine+ signal
8	DRV_x_HALL_QUAD_A_P	I	Hall, Quadrature	Channel A+
9	DRV_x_HALL_QUAD_A_N	I	Hall, Quadrature	Channel A–
10	DRV_x_HALL_QUAD_B_P	I	Hall, Quadrature	Channel B+
11	DRV_x_HALL_QUAD_B_N	I	Hall, Quadrature	Channel B–
12	DRV_x_HALL_QUAD_C_P	I	Hall, Quadrature	Channel C+
13	DRV_x_HALL_QUAD_C_N	I	Hall, Quadrature	Channel C–
14	CLK_DRV_x_SER_P	O	EnDat/BiSS/HIPERFACE	Clock+
15	CLK_DRV_x_SER_N	O	EnDat/BiSS/HIPERFACE	Clock–
16	DRV_x_SER_DATA_TX_P	O	EnDat/BiSS/HIPERFACE	TX+ data
17	DRV_x_SER_DATA_TX_N	O	EnDat/BiSS/HIPERFACE	TX– data
18	DRV_x_SER_DATA_RX_P	I	EnDat/BiSS/HIPERFACE	RX+ data
19	DRV_x_SER_DATA_RX_N	I	EnDat/BiSS/HIPERFACE	RX– data
20	Ground	—	—	—

Jumper Settings

Table 8 lists the jumpers.

Table 8. Jumpers

Jumper	Function
J3	Channel 0 encoder power supply.
J4	Channel 0 encoder power supply.
J5	Channel 0 encoder RS485 data configuration.
J6	Channel 0 encoder RS485 data configuration.
J7	Channel 0 encoder RS485 data configuration.
J8	Channel 0 encoder RS485 data configuration.
J10	Channel 0 encoder interface selection.

Table 8. Jumpers

Jumper	Function
J11	Channel 0 encoder interface selection.
J12	Channel 0 encoder interface selection.
J13	Channel 0 encoder interface selection.
J14	Channel 0 encoder interface selection.
J15	Channel 0 encoder interface selection.
J17	Channel 1 encoder power supply.
J18	Channel 1 encoder power supply.
J19	Channel 1 encoder RS485 data configuration.
J20	Channel 1 encoder RS485 data configuration.
J21	Channel 1 encoder RS485 data configuration.
J22	Channel 1 encoder RS485 data configuration.
J24	Channel 1 encoder interface selection.
J25	Channel 1 encoder interface selection.
J26	Channel 1 encoder interface selection.
J27	Channel 1 encoder interface selection.
J28	Channel 1 encoder interface selection.
J29	Channel 1 encoder interface selection.
J31	Channel 2 encoder power supply.
J32	Channel 2 encoder power supply.
J33	Channel 2 encoder RS485 data configuration.
J34	Channel 2 encoder RS485 data configuration.
J35	Channel 2 encoder RS485 data configuration.
J36	Channel 2 encoder RS485 data configuration.
J38	Channel 2 encoder interface selection.
J39	Channel 2 encoder interface selection.
J40	Channel 2 encoder interface selection.
J41	Channel 2 encoder interface selection.
J42	Channel 2 encoder interface selection.
J43	Channel 2 encoder interface selection.
J45	Channel 3 encoder power supply.
J46	Channel 3 encoder power supply.
J47	Channel 3 encoder RS485 data configuration.
J48	Channel 3 encoder RS485 data configuration.
J49	Channel 3 encoder RS485 data configuration.
J50	Channel 3 encoder RS485 data configuration.
J52	Channel 3 encoder interface selection.
J53	Channel 3 encoder interface selection.
J54	Channel 3 encoder interface selection.
J55	Channel 3 encoder interface selection.

Table 8. Jumpers

Jumper	Function
J56	Channel 3 encoder interface selection.
J57	Channel 3 encoder interface selection.
J58	3.3V isolated power supply.

Encoder Power Supply

The Multiaxis Motor Control Board can supply 3.3V, 5V or 12V encoder power supply voltages. You may configure each channel's encoder power supply independently. Table 9 lists the jumpers to set for each channel. Table 10 lists the jumper positions for encoder power supplies. Out means fit no jumper; in means fit a jumper.

Table 9. Jumpers for Encoder Power Supply

Channel	Jumpers	
	A	B
0	J3	J4
1	J17	J18
2	J31	J32
3	J45	J46

Table 10. Encoder Power Supply Selection

Jumper Position		Voltage (V)	Encoder
A	B		
Out	Out	12	EnDat
Out	In	3.3	—
In	Out	5	EnDat, BiSS
In	In	Invalid	—

Encoder RS485

For encoders that use an RS485 interface, configure the data pins for full-duplex operation with combined TX and RX data or half-duplex operation with separate TX and RX data. You may configure each channel independently. Table 11 lists the jumpers to set for each channel. Table 12 lists the jumper positions for encoder RS485s. Out means fit no jumper; in means fit a jumper.

Table 11. Jumpers for Each Channel for Encoder RS485 Data Configuration

Channel	Jumpers	
	A	B
0	J5, J6	J7, J8
1	J19, J20	J21, J22
2	J33, J34	J35, J36
3	J47, J48	J49, J50

Table 12. Encoder RS485 Data Configuration

Jumper Position		Data Configuration	Encoder
A	b		
Out	Out	RX only.	—
Out	In	Bidirectional on RX pair.	EnDat
In	Out	Separate RX and TX.	—
In	In	Bidirectional on TX pair.	—

Encoder Interface

The Multiaxis Motor Control Board supports RS485, resolver, Hall effect and quadrature encoders. You can configure each channel independently to support one of these encoder standards at any one time. Table 13 lists the jumpers to set for each channel. Table 14 lists the jumper positions for encoder interface selection.

Table 13. Jumpers for Each Channel for Encoder Selection

Channel	Jumpers					
	A	B	C	D	E	F
0	J10	J11	J12	J13	J14	J15
1	J24	J25	J26	J27	J28	J29
2	J38	J39	J40	J41	J42	J43
3	J52	J53	J54	J55	J56	J57

Table 14. Encoder Interface Selection

Jumper Positions						Encoder Interface
A	B	C	D	E	F	
In	In	In	Out	Out	Out	Resolver.

Table 14. Encoder Interface Selection

Jumper Positions						Encoder Interface
A	B	C	D	E	F	
Out	Out	Out	In	In	In	Hall effect, quadrature.
All other combinations						Invalid.

The function of the three `DRV_x_HSMC_RSLVR_DRV_HALL_QUAD_y` signals on the HSMC changes according to the jumper settings for resolver (Table 15) and Hall effect and quadrature (Table 16).

Table 15. Resolver Interface Signals

Signal	Direction	Function
`DRV_x_HSMC_RSLVR_DRV_HALL_QUAD_A`	Input	Resolver drive.
`DRV_x_HSMC_RSLVR_COS_HALL_QUAD_B`	Output	Resolver cosine ADC bitstream.
`DRV_x_HSMC_RSLVR_SIN_HALL_QUAD_C`	Output	Resolver sine ADC bitstream.

Table 16. Hall Effect and Quadrature Signals

Signal	Direction	Function
`DRV_x_HSMC_RSLVR_DRV_HALL_QUAD_A`	Output	Channel A.
`DRV_x_HSMC_RSLVR_COS_HALL_QUAD_B`	Output	Channel B.
`DRV_x_HSMC_RSLVR_SIN_HALL_QUAD_C`	Output	Channel C.

HSMC Isolator Power Supply

You may source the power supply for the host FPGA board side of the isolators directly from the HSMC 3.3-V supply or derive it from the HSMC 12-V supply by a switching regulator module (Table 17). This feature allows for situations where insufficient power is available from one or the other of the HSMC supplies.

Table 17. Isolator Isolated Power Supply

J58 Pins Linked	Isolator 3.3V_ISO Power Supply
1 to 2	3.3-V auxiliary from HSMC 12 V via LTM8022 module.
2 to 3	Direct from HSMC 3/3 V.

References

- *Altera HSMC Specification*
- Altera Multiaxis Motor Control Board Schematics
- *Astec AIF – PFC 1600W AC-DC Converter Module Technical Reference Note*
- *Fairchild FNB41560/B2 Smart Power Module Data Sheet*
- *Fairchild AN-9070 Smart Power Module Motion-SPM Products Application Note*
- *Analog Devices AD7401 Isolated Sigma-Delta Modulator Data Sheet*

- *Analog Devices ADS1205 Two 1-Bit, 10MHz, 2nd-Order, Delta-Sigma Modulator A-to-D Converter Data Sheet*
- *Analog Devices ADuM1401 Quad-Channel Digital Isola2014tors Data Sheet*
- *Silicon Laboratories Si844x Digital Isolators Data Sheet*

Document Revision History

Table 18 lists the revision history for this document.

Table 18. Document Revision History

Date	Version	Changes
February 2014	1.1	Replaced iCouplers with isolators.
August 2012	1.0	Initial release.