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Tandem Motion-Power 48 V Board Reference Manual

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About the Tandem Motion-Power 48 V Board

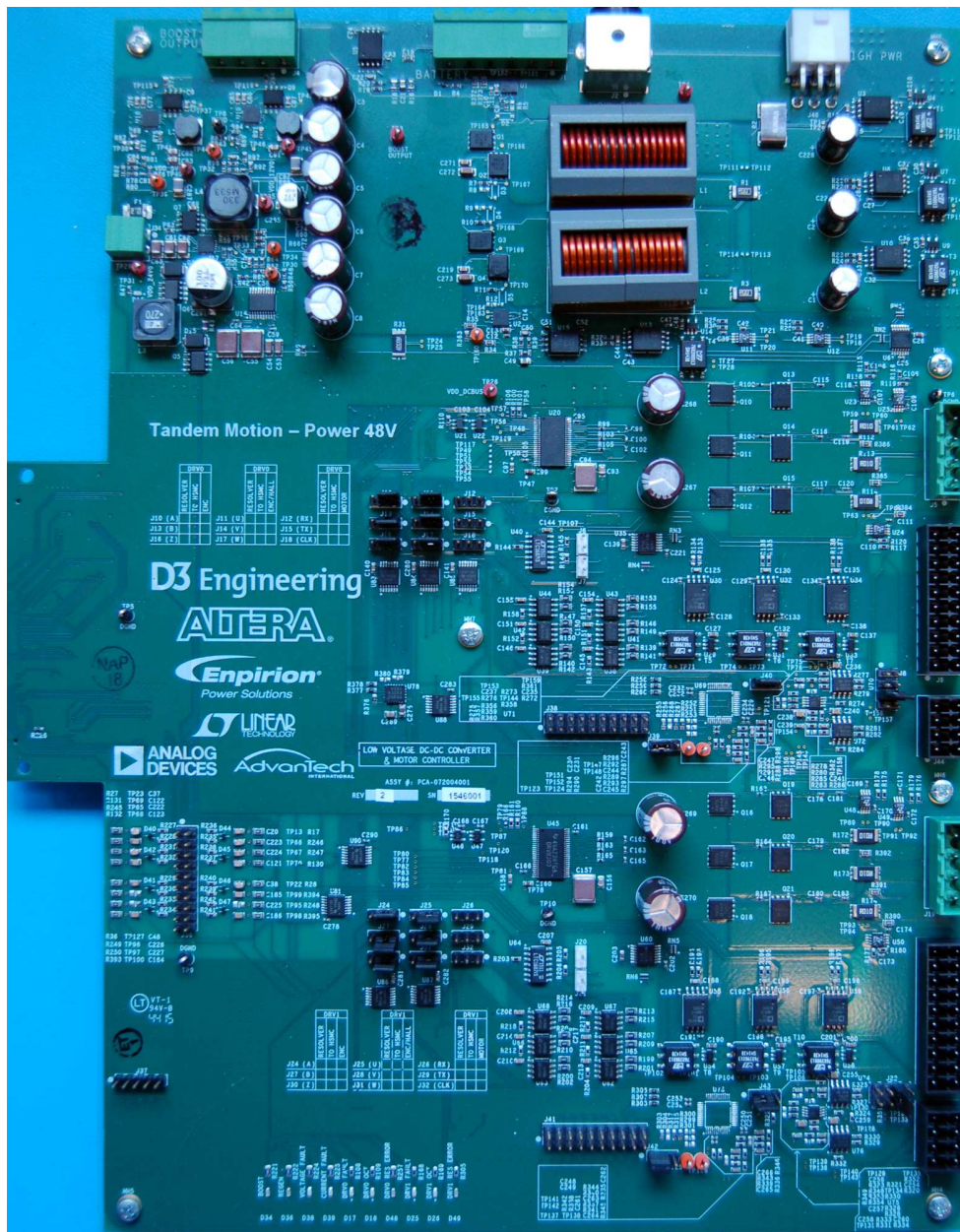
The Tandem Motion-Power 48 V Board demonstrates control of DC-DC conversion and high-speed 12 to 48 V motors by a single FPGA. These applications are important in the automotive, medical, and industrial markets.

The Tandem Motion-Power 48 V Board contains a bidirectional DC-DC boost-buck converter to generate the DC link voltage and six half-bridge inverter outputs. The board sends three half-bridge outputs to each output connector to create two three-phase motor inverters. You can use the half bridges in alternative arrangements for motors with different numbers of phases. The board provides MOSFET power electronics for DC-DC conversion and DC Link inversion, current and voltage sensing for DC-DC and motor control feedback, and connections for motor position feedback. You can use the Tandem Motion-Power 48 V Board to develop a single or dual-axis motor control application that supports multiple motor types and multiple position feedback interfaces. The Tandem Motion-Power 48 V Board includes an HSMC interface connector for connection to a variety of Altera FPGA and SoC-FPGA development kits.

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Figure 1: Tandem Motion-Power 48 V Board



About Motor Control

Efficient control of torque and speed of AC motors requires corresponding control of voltage and current that you supply to the motor. In a typical motor control system, you generate a DC voltage known as the DC link or DC bus voltage. You then invert the DC voltage through switching of power electronics, such as insulated-gate bipolar transistors (IGBTs) or MOSFETs to create the appropriate variable AC voltages for the motor. Control algorithms such as field oriented control (FOC) require you to measure motor current and voltages, to provide the required feedback to the controller.

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 servo drives,

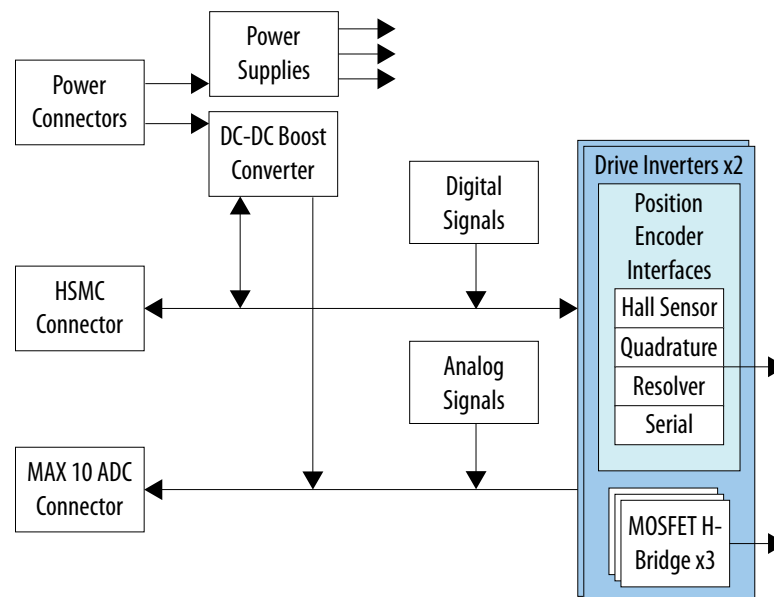
high-precision position feedback sensors, such as optical encoders, enable accurate position and speed control.

Tandem Motion-Power 48 V Board Features

- Two motor axes, each with three-phase MOSFET power stages operating up to 125 kHz
- Input voltage range 9 to 16 V DC
- DC link voltage of 12 to 48 V from DC-DC boost-buck converter
 - Variable 62.5 to 125 kHz switching frequency
 - Two-phase conversion for smoother output
 - Bidirectional, allowing regeneration with buck conversion to 12 V
- Enpirion[®] switch mode power supplies for logic, position sensors, MOSFET gate drives and regulated 12 V output
- Sigma-delta ADCs for sensing voltages and currents
- Direct analog connection to suitable development kits such as the MAX[®] 10M50 Development Kit
- Sensed motor phase currents and voltages to enable sensorless control
- Position feedback interfaces for each axis:
 - Quadrature incremental encoder
 - Resolver with Tamagawa resolver-to-digital converter (RDC)
 - Hall effect (6-step position feedback)
 - EnDat absolute encoder
 - BiSS absolute encoder

Tandem Motion-Power 48 V Board Functional Description

Figure 2: Block Diagram



Power Connectors

The DC inputs are a 6-pin Molex (up to 200W), 4-pin DIN (up to 100W) or 6-pin pluggable terminal block to suit a range of standard power supplies. The board offers directly wired connection to other power supplies or batteries and a direct connection to the DC link, bypassing the DC-DC boost converter.

HSMC Connector

Signals connecting the Tandem Motion board to the development kit are buffered and level shifted for compatibility with a number of development kits. A configurable I/O power supply allows interfacing with common I/O standards implemented on Altera FPGAs.

MAX 10 ADC Connector

Analog signals are available on a 20-pin header for connection to a suitable development kit that includes ADCs. The pinout matches that of J20 on the Altera MAX 10 10M50 development kit.

DC-DC Boost Converter

The DC-DC boost converter hardware consists of two phases that both provide bidirectional power flow from a low voltage power source or battery (typically 12 V DC) to a DC bus (typically 48 V DC) that feeds the motor drive inverters. The DC-DC provides the boost function to increase the voltage of the DC link. It also provides a buck function during periods of regenerative braking to deliver power from the DC bus back to the low voltage source (i.e. battery in this case). Enable regeneration by pulling down pin 3 of the battery connector, J1. If you do not attach an energy storage element to the DC bus, disable regeneration.

The DC input voltage, DC link voltage, DC link current and the currents in each DC-DC phase are sensed and converted to digital signals which must be used to implement a control loop for the DC-DC boost function in the FPGA on the attached development kit. Altera reference designs targeting the Tandem Motion board contain a controller developed using Altera's DSP Builder Advanced Blockset for Simulink, which enables model-based design, automatic HDL code generation and automatic ModelSim testbench generation.

Power Supplies

A switch-mode buck-boost converter provides a 24 V supply, which drives a number of downstream regulators. This arrangement enables the board to operate with variable DC link voltages or with power input through the DC-DC bypass connector.

Multiple Enpirion ER3125 devices provide 12 V, 5 V and 3.3 V supplies to logic and other circuits on the board.

The board provides a configurable I/O voltage for the connections to the development kit. You configure I/O voltage by populating one or more zero-ohm resistors.

Drive Inverters

The board has six N-channel MOSFET half bridges, nominally arranged as two three-phase inverters for driving three-phase motors. You can use the half bridges in other arrangements, e.g. to drive stepper motors.

Encoder Interfaces

The encoder interfaces apply the appropriate voltage translation and buffering for each encoder type. Quadrature and Hall sensor encoders use three differential pairs to connect to the board.

EnDAT and BiSS encoders are connected via an RS-485 serial bus.

A Tamagawa AU6805 Resolver-Digital Converter (RDC) provides the resolver interface for each drive axis. The AU6805 supports 12- and 16-bit absolute position over a serial interface together with quadrature equivalent and Hall sensor equivalent feedback signals in parallel.

Analog Signal Conditioning and Conversion

In addition to the analog connector for MAX10 ADCs, the board also includes sigma-delta modulators to support digital connections to FPGAs that do not have integrated ADCs. You must implement a suitable demodulator in the FPGA, as described in Altera application note AN 773 and datasheet DS-1038.

The board implements current sensing with low Ohmic value shunt resistors. The board connects the resulting sense voltage directly to the sigma-delta modulator or through a sense amplifier to the MAX10 ADC input.

You can add a low-pass filter to the inputs to the sigma-delta ADCs but in all cases the demodulator IP in the FPGA filters them.

For the direct MAX10 inputs, sense amplifiers scale and offset the inputs to allow bipolar signals (e.g., bidirectional current flow) to be sampled with the MAX 10 ADC that can only convert signals between 0 V and its reference voltage. Remove the offset during processing of the samples in software. The sense amplifier circuit has a low-pass filter, scaled by five times and offset by 1.25 V.

The input current and DC bus current are only available via sigma-delta ADCs. Both sense circuits employ analog anti-aliasing circuitry with cut-off frequencies around 7 kHz before the sigma-delta ADC, for consistency with other DC-DC converter signals that are sampled at 16 kHz.

The board implements voltage sensing with voltage dividers connected directly to the sigma-delta or MAX 10 ADC inputs, with low pass filtering.

The input current and DC bus current are not available as analog signals to the MAX 10 ADCs, so do not have filter cut-off frequencies. The board samples motor phase currents at the quiet points of the PWM waveforms (refer to Altera application notes AN669, AN773, and datasheet DS-1038). The filtering inherent in the sigma-delta demodulation is sufficient, so the board uses no additional analog anti-aliasing filters.

Table 1: Analog Low Pass Filtering

Shows details of cut-off frequencies for analog anti-aliasing filters.

Signal	Anti-aliasing cut-off frequency for	
	Sigma-delta ADCs (kHz)	MAX 10 ADCs (kHz)
Motor phase voltages	0.73	754
DC bus voltage	7.3	6.2
Input voltage	7.4	6.8
Input current	7.7	N/A
Boost inductor current	7.7	6.8
DC bus current	7.7	N/A
Motor phase currents	N/A	14

Tandem Motion-Power 48 V Board Connectors

Table 2: Tandem Motion-Power 48 V Board Connectors

Jumper	Axis	Function
J1	-	Power – battery
J2	-	Power – low power (100 W) DIN
J4	-	Power – DC link
J5	DRV0	Motor
J9	DRV0	Encoder
J19	DRV1	Motor
J23	DRV1	Encoder
J33	-	HSMC interface
J34	-	Power – Output 1.1 A
J35	-	Analog feedback signals
J44	DRV0	Resolver
J45	DRV1	Resolver
J46	-	Power – high power (200 W) Molex

Table 3: Battery Power Connector (J1) Pin Assignments

You can connect a rechargeable battery to J1 a 6-pin 5.08 mm pitch pluggable terminal block.

Note: Using Battery requires you to load a suitable design, which supports regeneration, in the development kit FPGA. To enable regeneration, you must link pins 3 and 5 of the battery power connector.

Pin	Function
1	9 – 16 V
2	9 – 16 V
3	REGEN_EN
4	VDD_IO
5	0V
6	0V

Table 4: Low Power Connector (J2) Pin Assignments

You can connect a power supply of 9 – 16 V DC, up to 100 W to the DIN connector J2 using a KYCON KPPX-4P, or equivalent, DIN connector.

Pin	Function
1	0 V

Pin	Function
2	9 to 16 V
3	0 V
4	9 to 16 V

Table 5: High Power Connector (J46) Pin Assignments

You can connect a power supply of 9 – 16 V DC, up to 200 W to the Molex connector J46 using a MOLEX 39-01-2061, or equivalent. Always use all power poles and ground poles in the chosen connector.

Note: Connect only one power supply to either J2 or J46.

Pin	Function
1	9 to 16 V
2	9 to 16 V
3	9 to 16 V
4	0 V
5	0 V
5	0 V

Table 6: DC Link Connector (J4) Pin Assignments

You can use the DC link power connector, J4, a 4-pin 5.08mm pitch pluggable terminal block, to inject power into the DC link, bypassing the DC-DC boost converter.

Note: Only use J4 if you disable the DC-DC boost converter.

Pin	Function
1	12 to 48 V
2	12 to 48 V
3	0 V
4	0 V

Table 7: Output Power Connector (J34) Pin Assignments

You can use the output power connector, J34, a 2-pin 3.81mm pitch pluggable terminal block to supply 12V DC power to the attached FPGA development kit. The power output has a 1.1 A fuse.

Note: Ensure that the attached FPGA development kit power requirement is less than 1.1 A before using J34.

Pin	Function
1	12 V, 1.1 A
2	0 V

Table 8: HSMC Connector Pin Assignments

The table lists direction relative to the Tandem Motion-Power 48 V Board. This table only lists signal pins; power pins are not listed.

Pin	Signal	Direction	Function
1 – 38	-	-	Not used
39	SD_MCLK	Input	Sigma Delta Clock
40	DRV1_SER_TX_EN	Input	Motor 2 FB Serial CLK
41	REGEN_EN	Input	Regen Enable Signal
42	BOOST_DRV0_PWM_H	Input	Boost Phase 1 Gate PWM +
43	OUTPUT_CURRENT_MDAT	Output	Input Current SD Data
44	BOOST_DRV0_PWM_L	Input	Boost Phase 1 Gate PWM -
47	OUTPUT_VOLTAGE_MDAT	Output	Input Voltage SD Data
48	BOOST_DRV1_PWM_H	Input	Boost Phase 2 Gate PWM +
49	BOOST_DRV0_CURRENT_MDAT	Output	Boost Phase 1 Current SD Data
50	BOOST_DRV1_PWM_L	Input	Boost Phase 2 Gate PWM -
53	BOOST_DRV1_CURRENT_MDAT	Output	Boost Phase 2 Current SD Data
54	DCBUS_CURRENT_MDAT	Output	DC Bus Current SD Data
55	DCBUS_VOLTAGE_MDAT	Output	DCBUS Voltage SD Data
56	VOLTAGE_FAULT	Input	Voltage Fault LED
59	DRV_SCLK	Input	Motor Drive SPI Clock
60	DRV_SOMI	Output	Motor Drive SPI
61	DRV0_FAULTh	Output	Motor Drive 1 Fault
62	DRV_SIMO	Input	Motor Drive SPI
65	DRV0_SER_RX	Output	Motor 1 FB Serial RX
66	DRV0_CS _n	Input	Motor Drive 1 Chip Select
67	DRV0_SER_TX	Input	Motor 1 FB Serial TX
68	DRV0_SER_CLK	Input	Motor 1 FB Serial CLK
71	DRV0_EN_GATE_P	Input	Motor Drive 1 Gate Enable +
72	DRV0_EN_GATE_N	Input	Motor Drive 1 Gate Enable -
73	HSMC_DRV0_PWM_UH	Input	Motor Drive 1 Phase U Gate +
74	HSMC_DRV0_PWM_UL	Input	Motor Drive 1 Phase U Gate -
77	HSMC_DRV0_PWM_VH	Input	Motor Drive 1 Phase V Gate +
78	HSMC_DRV0_PWM_VL	Input	Motor Drive 1 Phase V Gate -
79	HSMC_DRV0_PWM_WH	Input	Motor Drive 1 Phase W Gate +

Pin	Signal	Direction	Function
80	HSMC_DRV0_PWM_WL	Input	Motor Drive 1 Phase W Gate -
83	DRV0_U_VOLTS_MDAT	Output	Motor Drive 1 U Phase Voltage FB
84	DRV0_U_CURRENT_MDAT	Output	Motor Drive 1 U Phase Current FB
85	DRV0_V_VOLTS_MDAT	Output	Motor Drive 1 V Phase Voltage FB
86	DRV0_V_CURRENT_MDAT	Output	Motor Drive 1 V Phase Current FB
89	DRV0_W_VOLTS_MDAT	Output	Motor Drive 1 W Phase Voltage FB
90	DRV0_W_CURRENT_MDAT	Output	Motor Drive 1 W Phase Current FB
91	DRV0_QR_A	Output	Motor 1 FB Quad/Resolver A
92	DRV0_QHR_U	Output	Motor 1 FB Quad/Hall/Resolver U
95	DRV0_QR_B	Output	Motor 1 FB Quad/Resolver B
96	DRV0_QHR_V	Output	Motor 1 FB Quad/Hall/Resolver V
97	DRV0_QR_Z	Output	Motor 1 FB Quad/Resolver Z
98	DRV0_QHR_W	Output	Motor 1 FB Quad/Hall/Resolver W
101	CURRENT_FAULT	Input	Current fault LED
102	BOOST_STATUS	Input	Boost Status LED
103	DRV1_FAULTn	Output	Motor Drive 2 fault
104	REGEN_STATUS	Input	Regen status LED
107	DRV1_SER_RX	Output	Motor 2 FB Serial RX
108	DRV1_CSn	Input	Motor drive 2 chip Select
109	DRV1_SER_TX	Input	Motor 2 FB serial TX
110	DRV1_SER_CLK	Input	Motor 2 FB serial CLK
113	DRV1_EN_GATE_P	Input	Motor drive 2 gate Enable +
114	DRV1_EN_GATE_N	Input	Motor drive 2 gate enable -
115	HSMC_DRV1_PWM_UH	Input	Motor drive 2 phase U gate +
116	HSMC_DRV1_PWM_UL	Input	Motor drive 2 phase U gate -
119	HSMC_DRV1_PWM_VH	Input	Motor drive 2 phase V gate +
120	HSMC_DRV1_PWM_VL	Input	Motor drive 2 phase V gate -
121	HSMC_DRV1_PWM_WH	Input	Motor drive 2 phase W Gate +
122	HSMC_DRV1_PWM_WL	Input	Motor drive 2 phase W gate -
125	DRV1_U_VOLTS_MDAT	Output	Motor drive 2 U phase Voltage FB
126	DRV1_U_CURRENT_MDAT	Output	Motor drive 2 U phase current FB
127	DRV1_V_VOLTS_MDAT	Output	Motor drive 2 V phase voltage FB
128	DRV1_V_CURRENT_MDAT	Output	Motor Drive 2 V phase current FB
131	DRV1_W_VOLTS_MDAT	Output	Motor Drive 2 W phase voltage FB

Pin	Signal	Direction	Function
132	DRV1_W_CURRENT_MDAT	Output	Motor Drive 2 W phase current FB
133	DRV1_QR_A	Output	Motor 2 FB quad/resolver A
134	DRV1_QHR_U	Output	Motor 2 FB quad/Hall/resolver U
137	DRV1_QR_B	Output	Motor 2 FB quad/resolver B
138	DRV1_QHR_V	Output	Motor 2 FB quad/Hall/resolver V
139	DRV1_QR_Z	Output	Motor 2 FB Quad/Resolver Z
140	DRV1_QHR_W	Output	Motor 2 FB quad/Hall/resolver W
143	GPIO_0	-	Supply Over Current LED
144	DRV0_SER_TX_EN	Input	Motor 1 FB serial CLK
145	DRV1_RESOLVER_SSCS	Input	Resolver
146	DRV0_RESOLVER_SSCS	Input	Resolver
149	DRV1_RESOLVER_SCSB	Input	Resolver
150	DRV0_RESOLVER_SCSB	Input	Resolver
151	DRV1_RESOLVER_OutputHB	Input	Resolver
152	DRV0_RESOLVER_OutputHB	Input	Resolver
155	DRV1_RESOLVER_ERRHLD	Input	Resolver
156	DRV0_RESOLVER_ERRHLD	Input	Resolver
157	DRV1_RESOLVER_ERRSTB	Input	Resolver
158	DRV0_RESOLVER_ERRSTB	Input	Resolver
160	HSMC_PRSENTn	Output	HSMC presence detect

Table 9: Motor Connector (J5, J19) Pin Assignments

The motor connectors (J5, J19) are 4-pole 5.08 mm pitch pluggable terminal blocks for motor phase U, V, W and 0 V.

Pin	Function
1	Motor phase W
2	Motor phase V
3	Motor phase U
4	0V

Table 10: Encoder Connector (J9, J23) Pin Assignments

Pin	Function
1	Supply voltage
2	U_P

Pin	Function
3	U_N
4	V_P
5	V_N
6	W_P
7	W_N
8	A_P
9	A_N
10	B_P
11	B_N
12	Z_P
13	Z_N
14	CLK_P
15	CLK_N
16	TX_P
17	TX_N
18	RX_P
19	RX_N
20	0 V

Table 11: Resolver Connector (J44, J45) Pin Assignments

Pin	Function
1	S1 In
2	S3 In
3	S2 In
4	S4 In
5	R1 Out
6	R2 Out
7	0 V
8	0 V

Table 12: Analog Feedback Connector (J36) Pin Assignments

You can use the analog feedback connector (J36) to connect analog feedback signals to a suitable development kit with ADCs. The pinout of the analog feedback connector matches the pinout of the 2x10 way 0.1" pitch header, J20, on the Altera MAX 10 10M50 development kit.

Pin	Function
1	Inductor current phase 0
2	Input voltage
3	Voltage feedback DRV0 phase V
4	Current feedback DRV0 phase V
5	Current feedback DRV0 phase U
6	Current feedback DRV0 phase W
7	Voltage feedback DRV0 phase U
8	Voltage feedback DRV0 phase W
9	0 V
10	0 V
11	DC link voltage
12	Inductor current phase 1
13	Current feedback DRV1 phase V
14	Voltage feedback DRV1 phase V
15	Current feedback DRV1 phase W
16	Current feedback DRV1 phase U
17	Voltage feedback DRV1 phase W
18	Voltage feedback DRV1 phase U
19	0 V
20	0 V

Changing the Motors and Encoders

Altera supplies the Tandem Motion-Power 48 V Board configured for Anaheim Automation SMH40S-0010-30AAK-4DKH motors with quadrature encoders or Tamagawa TS4747N3200E600 motors with resolver encoders.

1. Remove all power from the Tandem Motion-Power 48 V Board.
2. Unplug the existing motor and encoder cables.
3. Configure the jumpers to select the encoder power supply.
4. Configure the jumpers for the encoder type and signal connections.
5. Prepare the motor cable with the 4-way pluggable screw terminal block.
6. Prepare the encoder cable with the 8- or 20-way push fit pluggable terminal block.
7. Plug in the motor and encoder cables.

Tandem Motion-Power 48 V Board Jumper Settings

Table 13: Tandem Motion-Power 48 V Board Jumper Settings

Jumper	Axis	Function
J6	DRV0	EnDAT operation
J7	DRV0	EnDAT operation
J8	DRV0	Encoder power supply selection
J10	DRV0	Quadrature encoder A source
J11	DRV0	Hall sensor U source
J12	DRV0	Serial encoder Rx source
J13	DRV0	Quadrature encoder B source
J14	DRV0	Hall sensor V source
J15	DRV0	Serial encoder Tx source
J16	DRV0	Quadrature encoder Z source
J17	DRV0	Hall sensor W source
J18	DRV0	Serial encoder CLK source
J20	DRV1	EnDAT operation
J21	DRV1	EnDAT operation
J22	DRV1	Encoder power supply selection
J24	DRV1	Quadrature encoder A source
J25	DRV1	Hall sensor U source
J26	DRV1	Serial encoder Rx source
J27	DRV1	Quadrature encoder B source
J28	DRV1	Hall sensor V source
J29	DRV1	Serial encoder Tx source
J30	DRV1	Quadrature encoder Z source
J31	DRV1	Hall sensor W source
J32	DRV1	Serial encoder CLK source
J39	DRV0	RDC BIST
J40	DRV0	Resolver excitation voltage
J42	DRV1	RDC BIST
J43	DRV1	Resolver excitation voltage

Quadrature Encoder and Hall Sensor Operation

You can select quadrature encoder and Hall sensor motor feedback operation by populating these six jumpers, per axis. You can set up the Tamagawa RDC to emulate a quadrature encoder.

Figure 3: DRV0 Motor Feedback Jumpers, Quadrature and Hall Operation

Located midboard.

J10, J13 and J16 select the A, B and Z quadrature paths for DRV0 motor.

J11, J14 and J17 select the U, V and W Hall sensor paths for DRV0 motor.

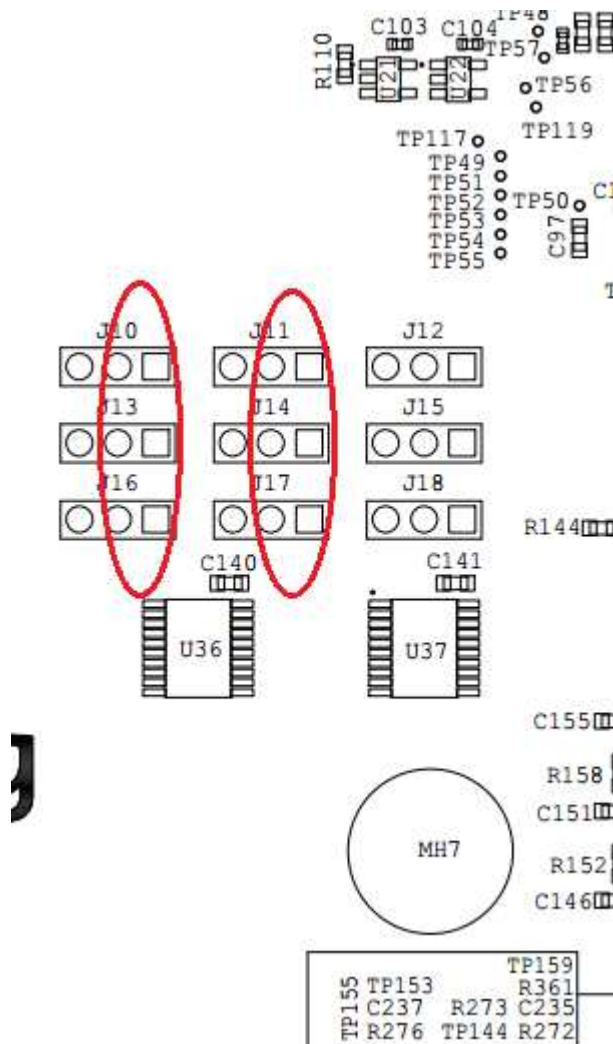
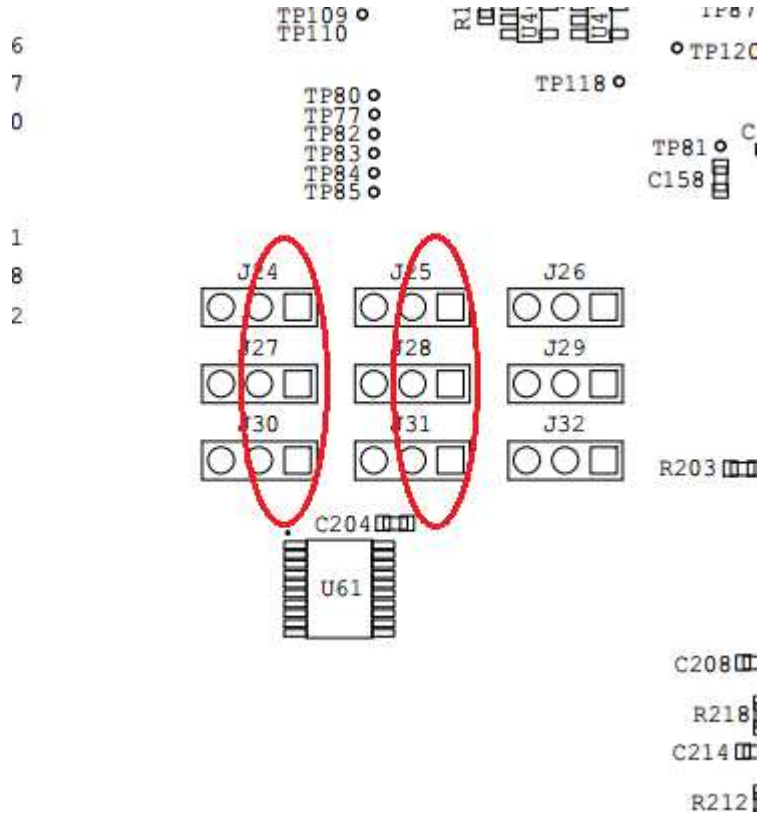


Figure 4: DRV1 Motor Feedback Jumpers Quadrature and Hall operation

Located middle-bottom of board.

J24, J27 and J30 select the A, B and Z quadrature path for DRV1 motor.

J25, J28 and J31 select the U, V and W Hall sensor path for DRV1 motor.



RDC Quadrature Encoder Emulation Operation

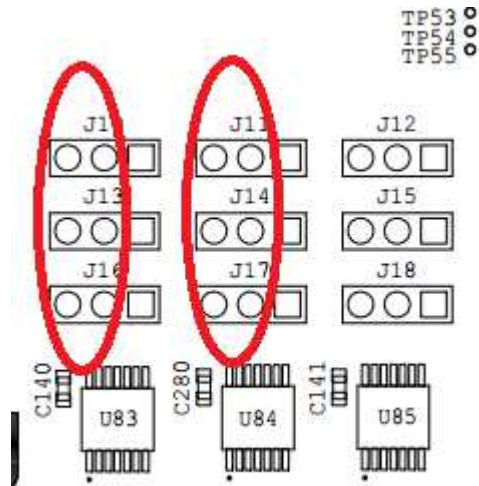
You can setup the Tamagawa RDC to emulate a quadrature encoder and or Hall sensor encoder.

Figure 5: DRV0 Motor Feedback Jumpers Quadrature Emulation Operation

Located mid board.

J10, J13 and J16 select the A, B and Z paths for DRV0 Resolver.

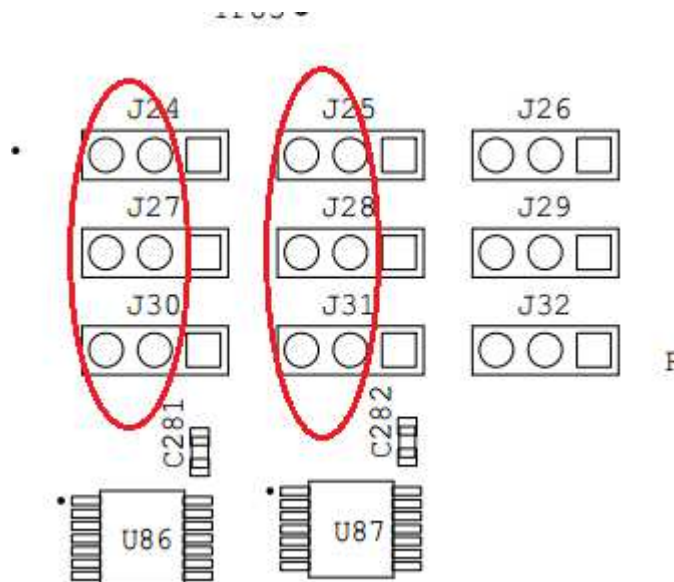
J11, J14 and J17 select the U, V and W paths for DRV0 Resolver.

**Figure 6: DRV1 Motor Feedback Jumpers Quadrature Emulation Operation**

Located middle-bottom of board.

J24, J27 and J30 select the A, B and Z paths for DRV1 Resolver.

J25, J28 and J31 select the U, V and W paths for DRV1 Resolver.



BiSS and EnDAT Operation

You can select BiSS or EnDAT position feedback data coming from the motor.

Figure 7: DRV0 Motor Feedback Jumpers BiSS and EnDAT Operation

Located mid board.

J12, J15 and J18 select the RX, TX and CLK paths for the DRV0 motor.

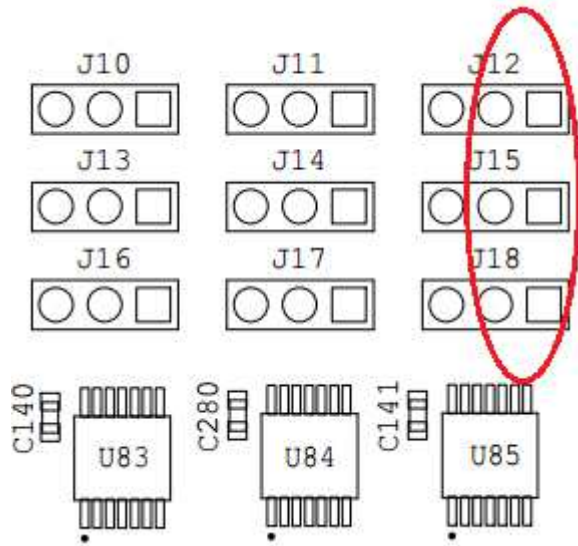
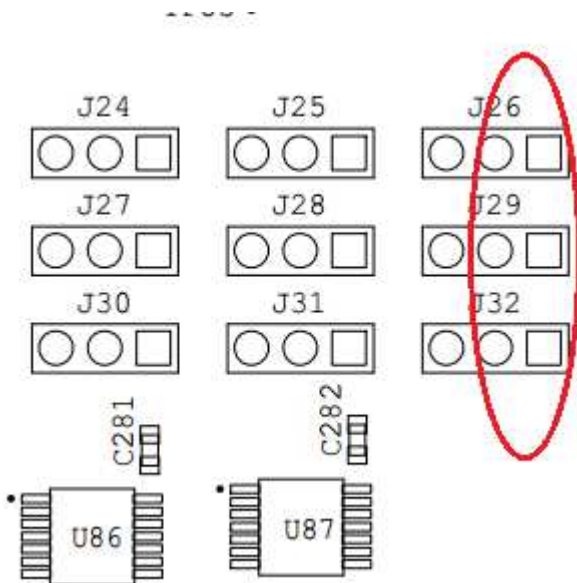


Figure 8: DRV1 Motor Feedback Jumpers BiSS and EnDAT Operation

Located middle-bottom of board.

J26, J29 and J32 select the RX, TX and CLK paths for the DRV1 motor.



Note: In addition to the feedback path jumpers, you must set some additional jumpers for EnDAT operation. For BiSS operation you must remove these jumpers.

Figure 9: DRV0 Feedback Data Flow Control Jumpers EnDAT operation

Located mid board.

J6 and J7 select EnDAT for DRV0.

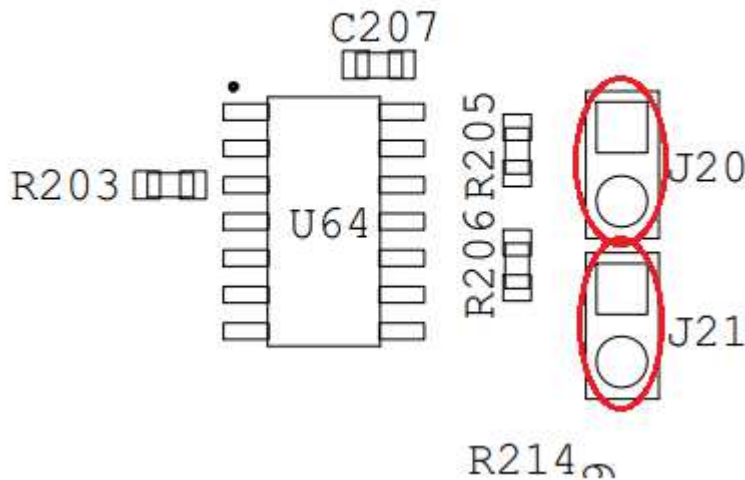
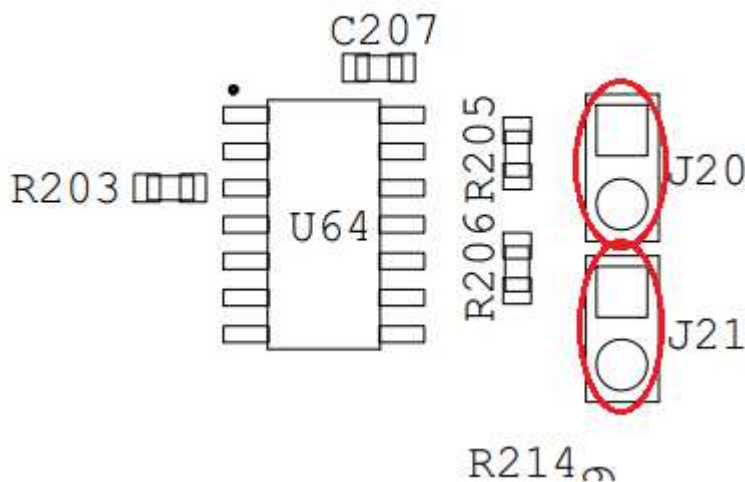


Figure 10: DRV1 Feedback Data Flow Control Jumpers EnDAT Operation

Located middle-bottom of board.

J20 and J21 select EnDAT for DRV1.



RDC Serial Feedback Operation

The Tamagawa RDC can be set up to provide serial feedback data.

Figure 11: DRV0 Motor Feedback Jumpers RDC Serial Feedback

Located mid board

J12, J15 and J18 select the RX, TX and CLK paths for the DRV0 Resolver serial data.

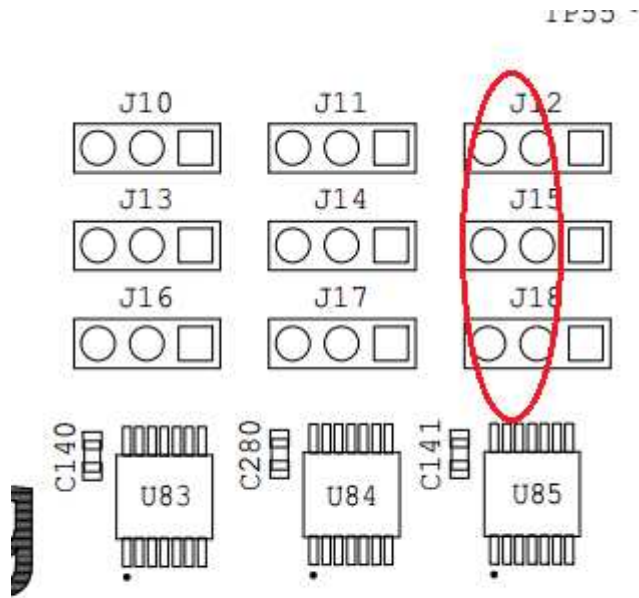
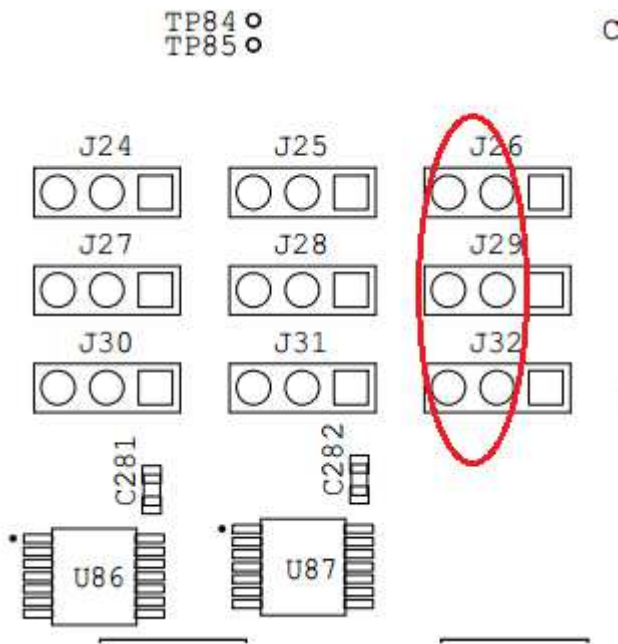


Figure 12: DRV1 Motor Feedback Jumpers RDC Serial Feedback

Located middle-bottom of board.

J26, J29 and J32 select the RX, TX and CLK paths for the DRV1 Resolver serial data.

**Encoder Power Supply Selection**

You can select the power supply voltage connected for the encoder interface. The available options are 24V, 12V, 5V and 3.3V.

Figure 13: DRV0 Encoder Power Selector, mid board right edge

Mid board right edge.

J8 selects the voltage for encoders on DRV0.

Note: Do not fit more than one jumper link at a time to J8. Do not fit jumpers to J8 in any other orientation.

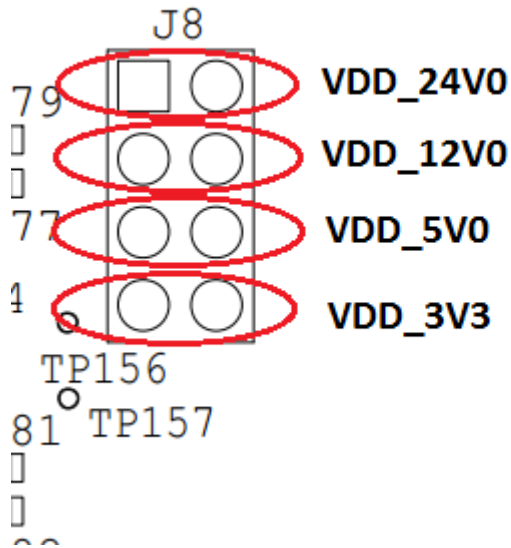
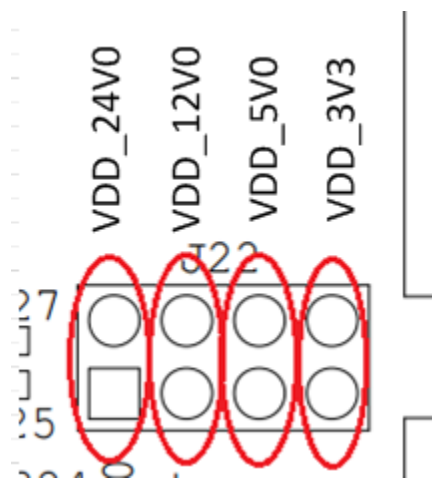


Figure 14: DRV1 Encoder Power Selector

Bottom of board right edge.

J22 selects the voltage for encoders on DRV1.

Note: Do not fit more than one jumper link at a time to J22. Do not fit jumpers to J22 in any other orientation.



Tamagawa RDC Built-In Self Test (BIST)

The Tamagawa RDC has a BIST feature that you can access.

the population of the no BIST position is not required as the board has an internal pull-down resistor in the RDC to disable BIST.

Altera reference designs do not support the RDC BIST feature.

Figure 15: DRV0 RDC BIST Jumper

Located mid board

J39 Selects BIST operation for DRV0 RDC. (DRV0) and J42 (DRV1).

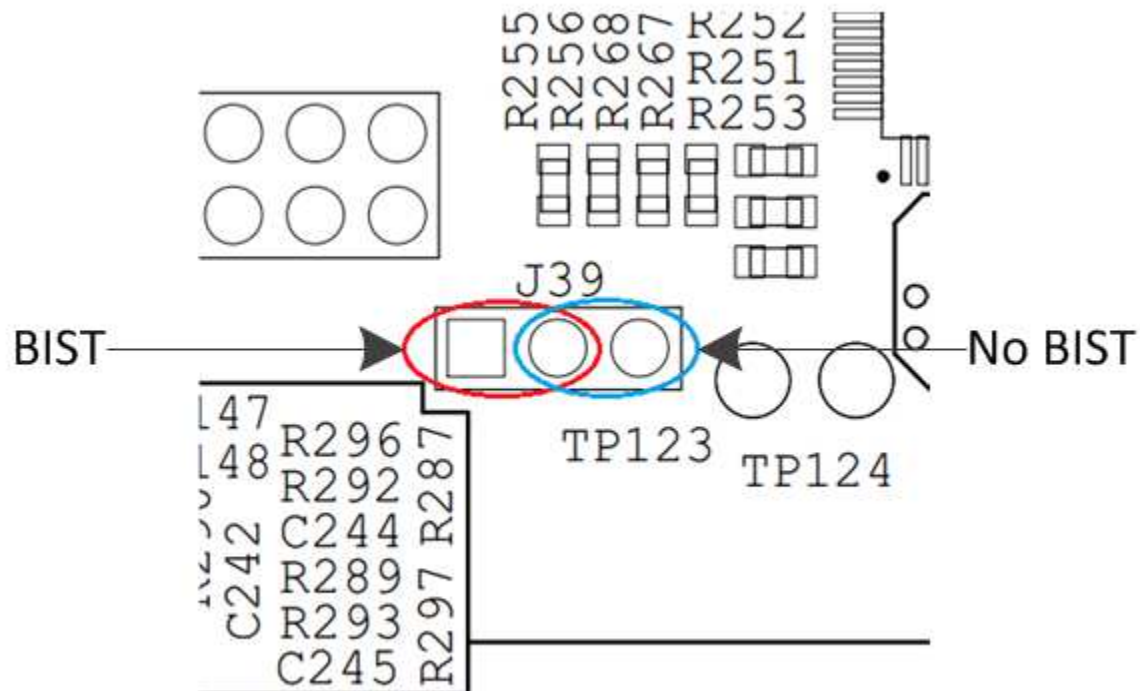
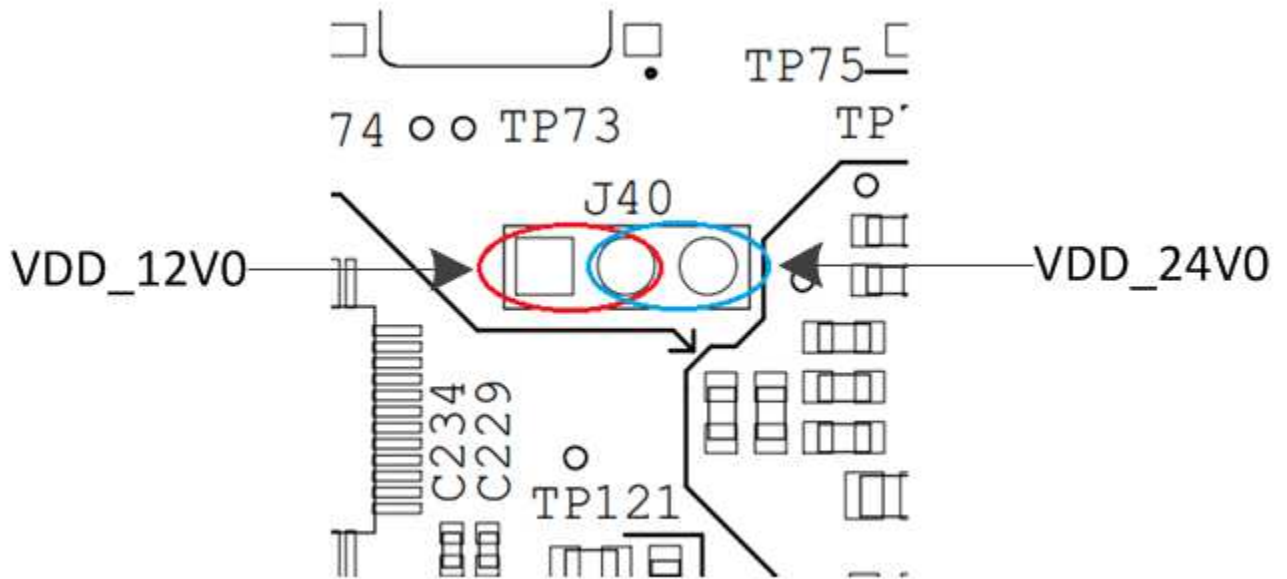


Figure 17: DRV0 Resolver Excitation Voltage Selection

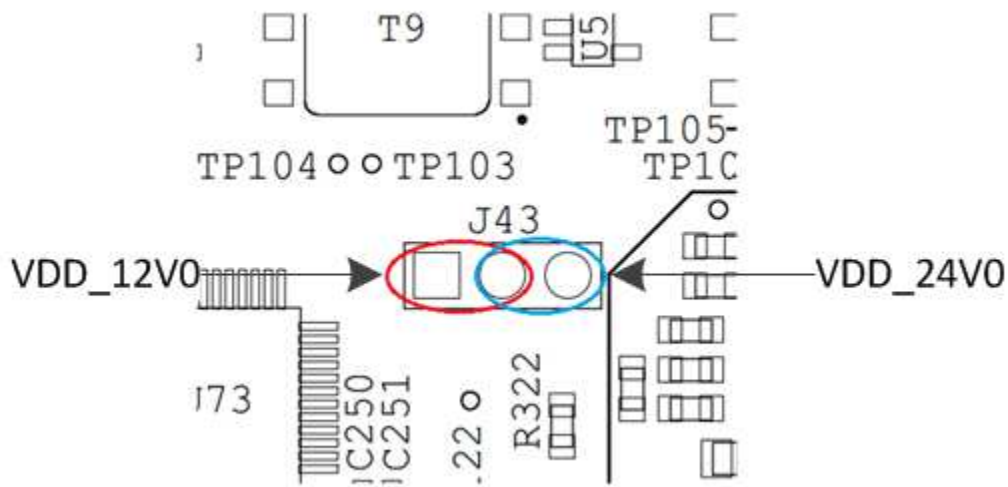
Located mid board.

J40 selects the excitation voltage for DRV0.

**Figure 18: DRV1 Resolver Excitation Voltage Selection**

Located at bottom of board.

J43 selects the excitation voltage for DRV1.



I/O Voltage Supply

R378, R377, R376

Tandem Motion-Power 48 V Board Reference Documents

Related Information

- [Altera HSMC Specification](#)
- [AN:773: Drive-On-Chip Reference Design v16.0](#)
- [Analog Devices AD7403 Isolated Sigma-Delta Modulator Data Sheet](#)
- [Analog Devices ADS1205 Two 1-Bit, 10MHz, 2nd-Order, Delta-Sigma Modulator A-to-D Converter Data Sheet](#)
- [Enpirion EP5352QI/EP5362QI/EP5382QI 500/600/800mA PowerSoC Synchronous Buck Regulators Data Sheet](#)
- [Enpirion ER3125QI 2.5 A Regulator Data Sheet](#)
- [Texas Instruments LM5118, LM5118-Q1 Wide Voltage Range Buck-Boost Controller Data Sheet](#)
- [Texas Instruments SN6501 Transformer Driver for Isolated Power Supplies Data Sheet](#)
- [Texas Instruments DRV8303 Three Phase Pre-Driver With Dual Current Shunt Amplifiers Data Sheet](#)
- [Texas Instruments UCC2720x 120-V Boot, 4-A Peak, High-Frequency High-Side and Low-Side Driver Data Sheet](#)
- [Vishay Siliconix SiR870DP N-Channel 100 V \(D-S\) MOSFET Data Sheet](#)