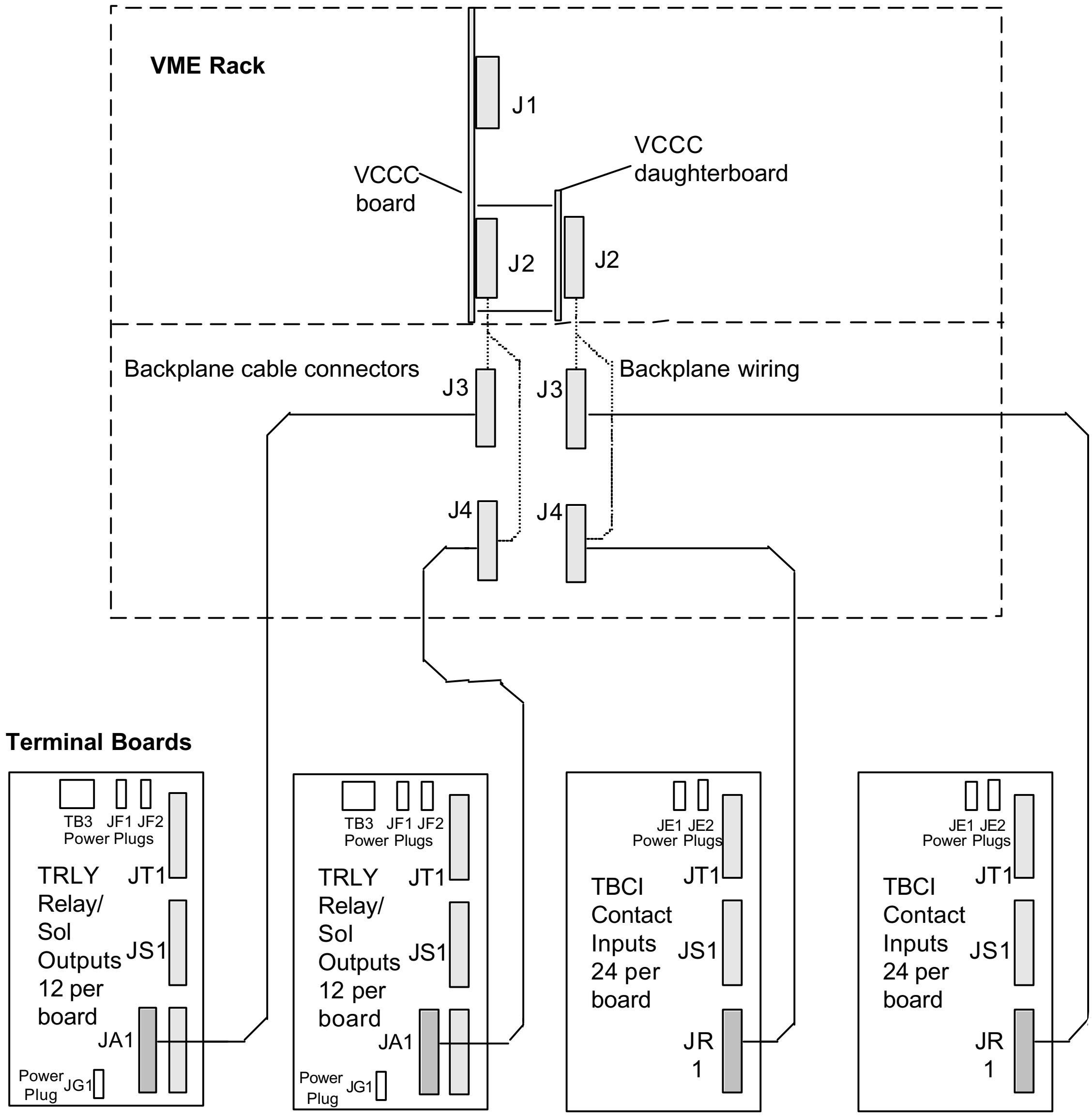
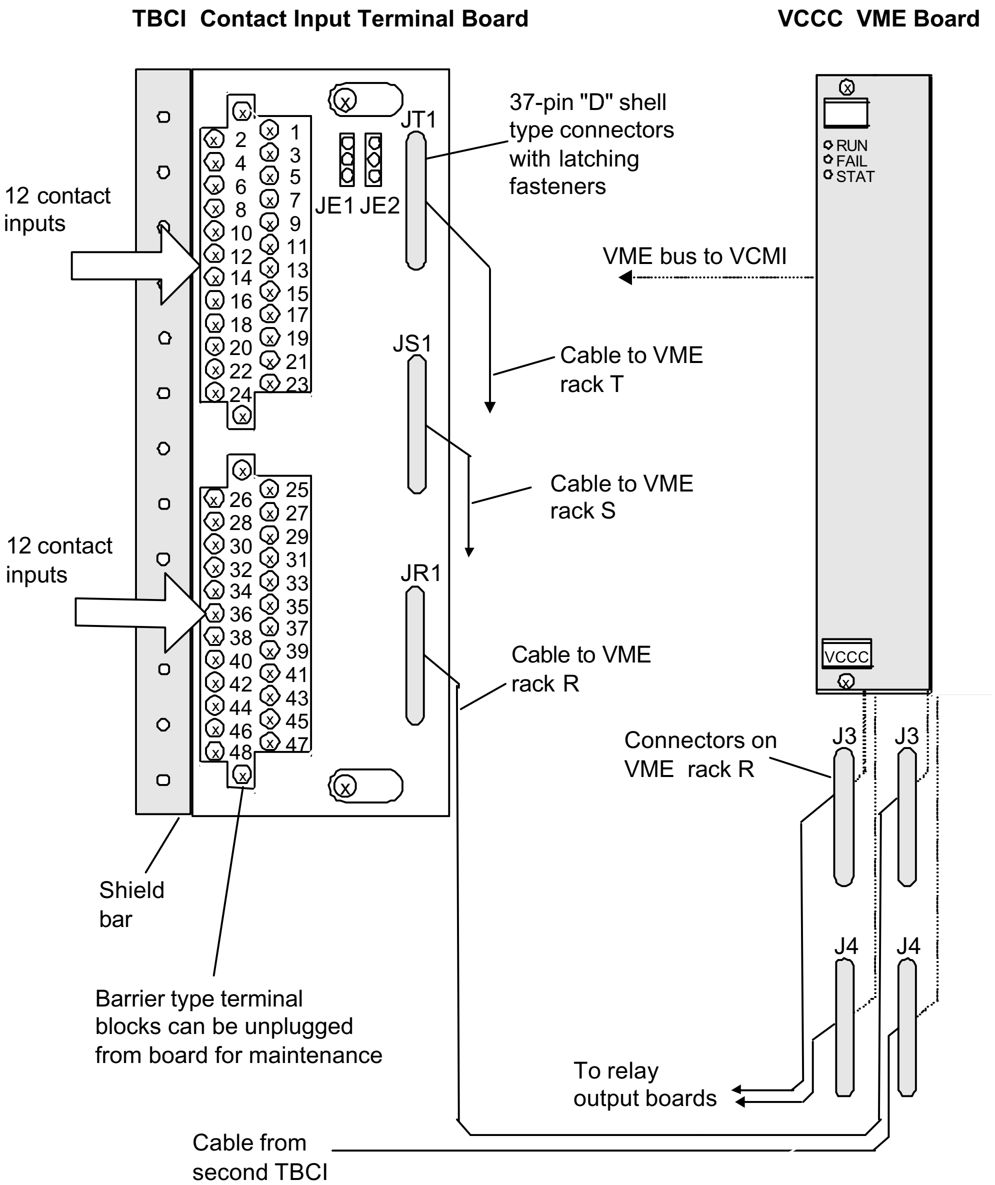


Simplex Boards and Cabling for Contact Inputs and Relay Outputs

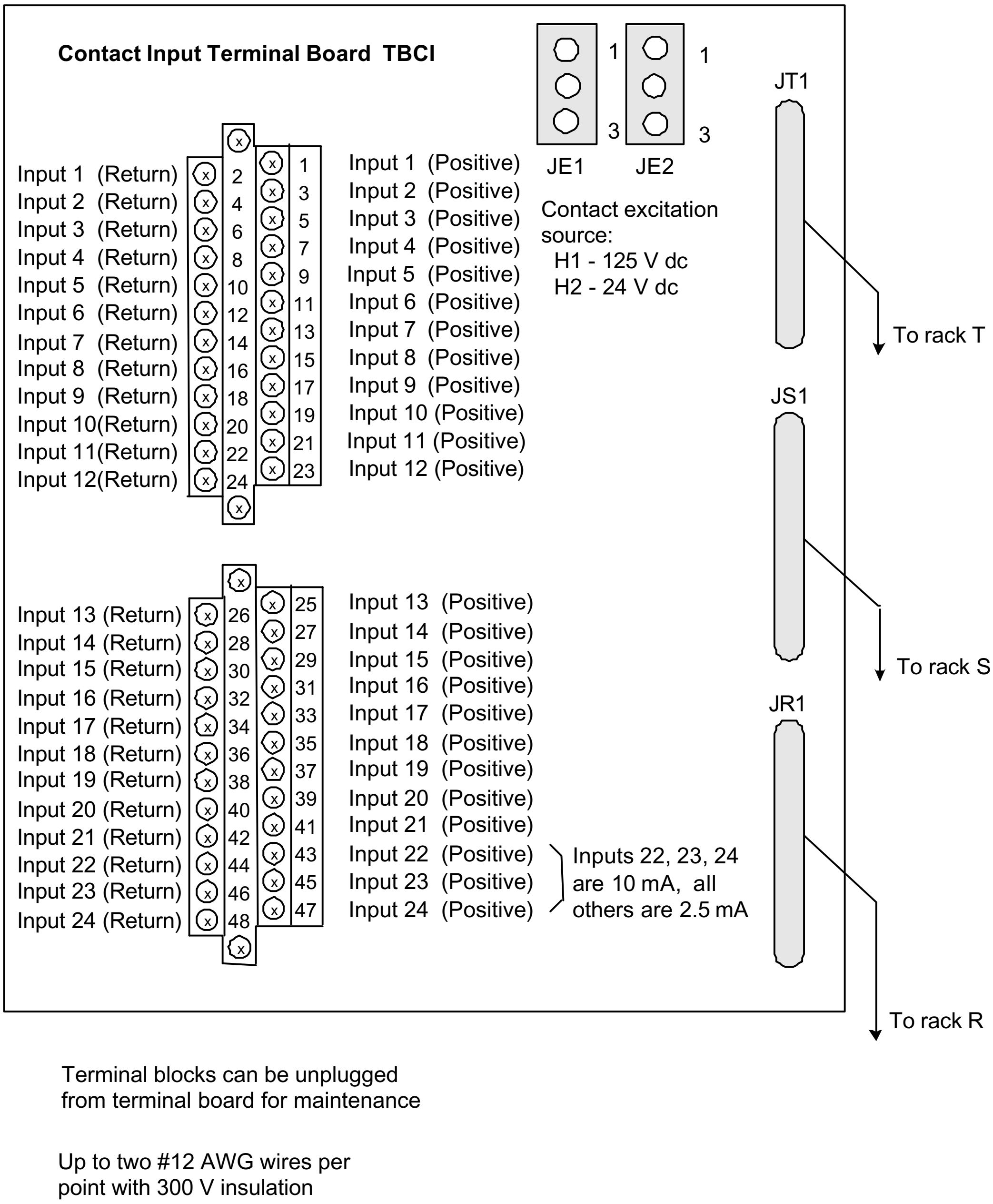
The first 24 dry contact inputs are wired to two barrier type blocks on the TBCI, and a second terminal board is required for inputs 25 – 48. Dc power for the contacts is provided. Contact inputs have noise suppression circuitry to protect against surge and high frequency noise. Cables with molded plugs connect the terminal board to the VME rack where the VCCC processor board is located.



Contact Input Terminal board, I/O Board, and Cabling

Installation

The 24 dry contact inputs are wired directly to two I/O terminal blocks mounted on the terminal board. Each block is held down with two screws and has 24 terminals accepting up to #12 AWG wires. A shield termination strip attached to chassis ground is located immediately to the left of each terminal block. The 125 V dc excitation voltage is cabled in through plugs JE1 and JE2.

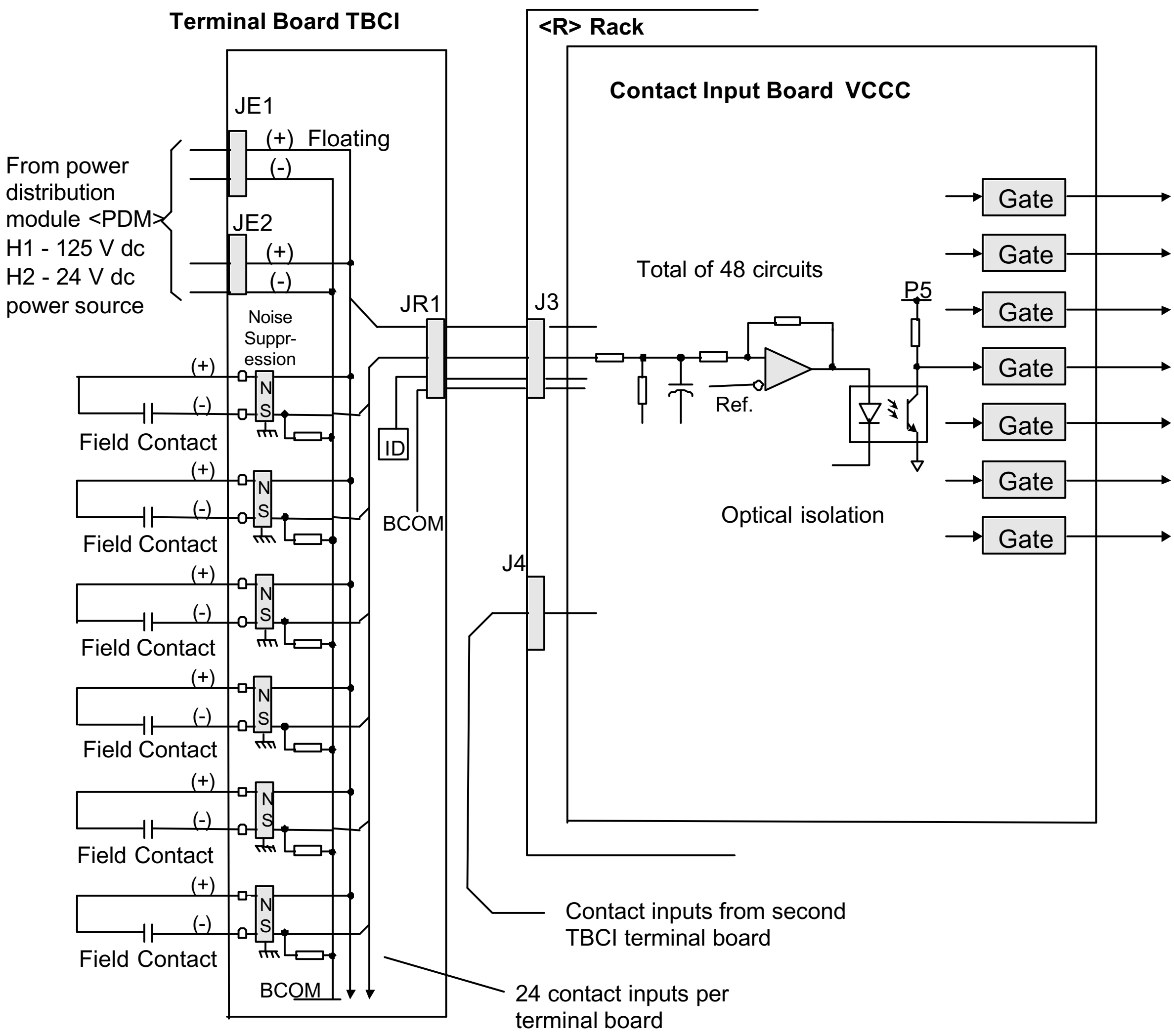


TBCI Terminal Board Wiring

Operation

The VCCC passes the input voltages through optical isolators and transfers the signals over the VME backplane to the VCMI. The VCMI then sends them to the controller. The contact input processing is shown in the following figure.

The TBCIH1 dry contact inputs are powered from a floating 125 V dc (100 − 145 V dc) supply from the turbine control. Power converters convert the 115/230 V ac and/or 125 V dc power sources to a redundant, internal 125 V dc bus to power the electronics. The 125 V dc bus is current limited in the Power Distribution Module prior to feeding each contact input. The TBCIH2 dry contact inputs are powered from a floating 24 V dc (18.5 – 32 V dc) supply.

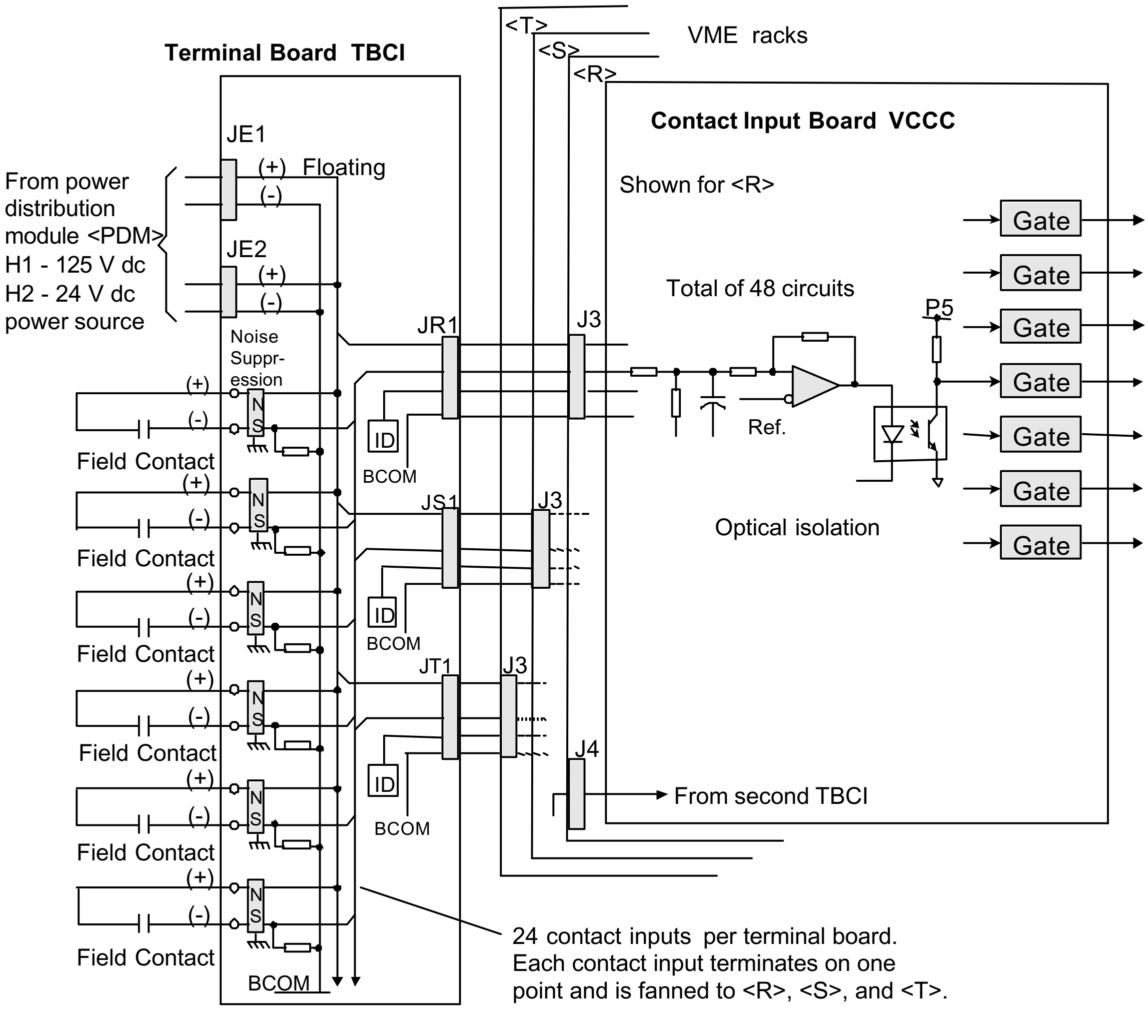


Simplex Contact Input Processing

A pair of termination points is provided for each input with one point (screw) providing the positive dc source and the second point providing the return (input) to the board. The current loading is 2.5 mA per point for 21 of the inputs on each terminal board, and the other three have a 10 mA load to support interface with remote solid-state output electronics.

Each input is optically isolated and sampled at frame rate for control functions, and at 1ms for SOE reporting. A 4 ms hardware filter is used, and noise rejection is 60 V rms at 125 V dc excitation. Contact input circuitry is designed for NEMA Class G creepage and clearance.

For TMR applications contact input voltages are fanned out to three VME board racks R, S, and T via plugs JR1, JS1, and JT1. The signals are processed by the three VCCCs and the results voted by the VCMI board in each controller rack.



TMR Contact Input Processing

Specifications

High speed scanning and recording at 1 ms rate is available for inputs monitoring important turbine variables. The sequence of events recorder reports all contact openings and closures with a time resolution of 1 ms. Contact chatter and pulse widths down to 6 ms are reported.

Filters reduce high frequency noise and suppress surge on each input near the point of signal exit. Noise and contact bounce is filtered with a 4 ms filter. Ac voltage rejection (50/60 Hz) is 60 V rms with 125 V dc excitation.

VCCC Specifications

Item	Specification
Number of channels	48 dry contact voltage input channels (24 per terminal board)
Excitation voltage	H1 - Nominal 125 V dc, floating, ranging from 100 to 145 V dc H2 – Nominal 24 V dc, floating, ranging from 18.5 to 32 V dc
Input current	H1 for 125 V dc applications: First 21 circuits draw 2.5 mA (50 kohms) Last three circuits draw 10 mA (12.5 kohms) H2 for 24 V dc applications: First 21 circuits draw 2.5 mA (10 kohms) Last three circuits draw 9.9 mA (2.42 kohms)
Isolation	Optical isolation to 1500 volts on all inputs
Input filter	Hardware filter, 4 ms
Ac voltage rejection	60 V rms @ 50/60 Hz at 125 V dc excitation
Frame rate	System dependent scan rate for control purposes 1,000 Hz scan rate for SOE monitoring
Power consumption	20.6 watts on the terminal board N/A watts in the VCCC board
Fault detection	Loss of contact input excitation voltage Non-responding contact input in test mode Unplugged cable

Diagnostics

If any one of the 48 inputs goes unhealthy, a composite diagnostic alarm, L3DIAG_VCCC occurs. Details of the individual diagnostics are available from the toolbox. The diagnostic signals can be individually latched, and then reset with the RESET_DIA signal if they go healthy

Three LEDs at the top of the VCCC front panel provide status information. The normal RUN condition is a flashing green, FAIL is a solid red. The third LED is normally off but shows a steady orange if a diagnostic alarm condition exists in the board

The dry (isolated) external contacts are monitored, and also the excitation voltage. If the excitation drops to below 40% of the nominal voltage, a diagnostic alarm is set and latched

Each terminal board connector has its own ID device which is interrogated by the I/O board. The board ID is coded into a read-only chip containing the board serial number, board type, revision number, and the JR1/JS1/JT1 connector location. Refer to GEH-6421D, Vol. I *Mark VI System Guide*, Chapter 8, *Troubleshooting and Diagnostics*

Configuration

Like all I/O boards, the VCCC is configured using the toolbox. This software usually runs on a data-highway connected CIMPLICITY station or workstation. The following table defines configuration choices and defaults. Refer to GEH-6403, *Control System Toolbox for Configuring the Mark VI Turbine Controller*.

Typical VCCC (Contact Input) Configuration

Parameter	Description	Choices
Configuration		
System Limits	Enable all system limit checking	Enable, disable
J3A:IS200TBCIH1A	Terminal board connected to VCCC from J3	Connected, not connected
Contact01	First contact of 24 on first terminal board - board point	Point edit (input BIT)
Contact input	Select contact input	Used, unused
Signal invert	Inversion makes signal true if contact open	Normal, invert
Sequence of events	Select input for sequence of events scanning	Enable, disable
Signal filter	Contact input filter in milliseconds	0, 10, 20, 50
J4A:IS200TBCIH1A	Terminal board connected to VCCC from J4	Connected, not connected
Contact01	First contact of 24 on second terminal board - board point	Point edit (input BIT)

Board Points Signals	Description-Enter Signal Connection Name	Direction Type
L3DIAG_VCCC1	Board diagnostic	Input BIT
L3DIAG_VCCC2	Board diagnostic	Input BIT
L3DIAG_VCCC3	Board diagnostic (For relay output points, see TRLY)	Input BIT

TICI Isolated Digital Input Board

The Isolated Digital Input terminal board (TICI) is an input board which works with VCCC (but **not** VCRC) in a similar way to TBCI. TICI provides voltage detection circuits to detect a range of voltages across relay contacts, fuses, and switches.

The TICI is similar to the TBCI, except for the following items:

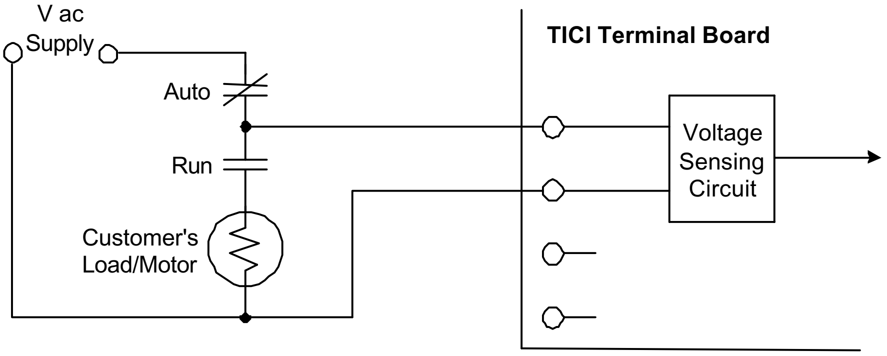
TICI input voltage ranges are:

- 70 – 145 V dc, nominal 125 V dc, with a detection threshold of 39 to 61 V dc
- 200 – 250 V dc, nominal 250 V dc, with a detection threshold of 39 to 61 V dc
- 90 – 132 V rms, nominal 115 V rms, 47-63 Hz, with a detection threshold of 35 to 76 V ac
- 190 – 264 V rms, nominal 230 V rms, 47-63 Hz, with a detection threshold of 35 to 76 V ac

Input hardware filtering is provided using time delays of 15 ms, nominal:

- For dc applications the time delay is 15 ± 8 ms
- For ac applications the time delay is 15 ± 13 ms

In addition to hardware filters, the contact input state is software filtered using configurable time delays, selected from 0, 10, 20, 50, and 100 ms. For ac inputs, a filter of at least 10 ms is recommended.



TICI Sensing Available Control Voltage Across Device

The following restrictions should be noted regarding creepage and clearance on the 230 V rms application:

- For NEMA requirements: 230 V single-phase
- For CE Mark: 230 V single or 3-phase

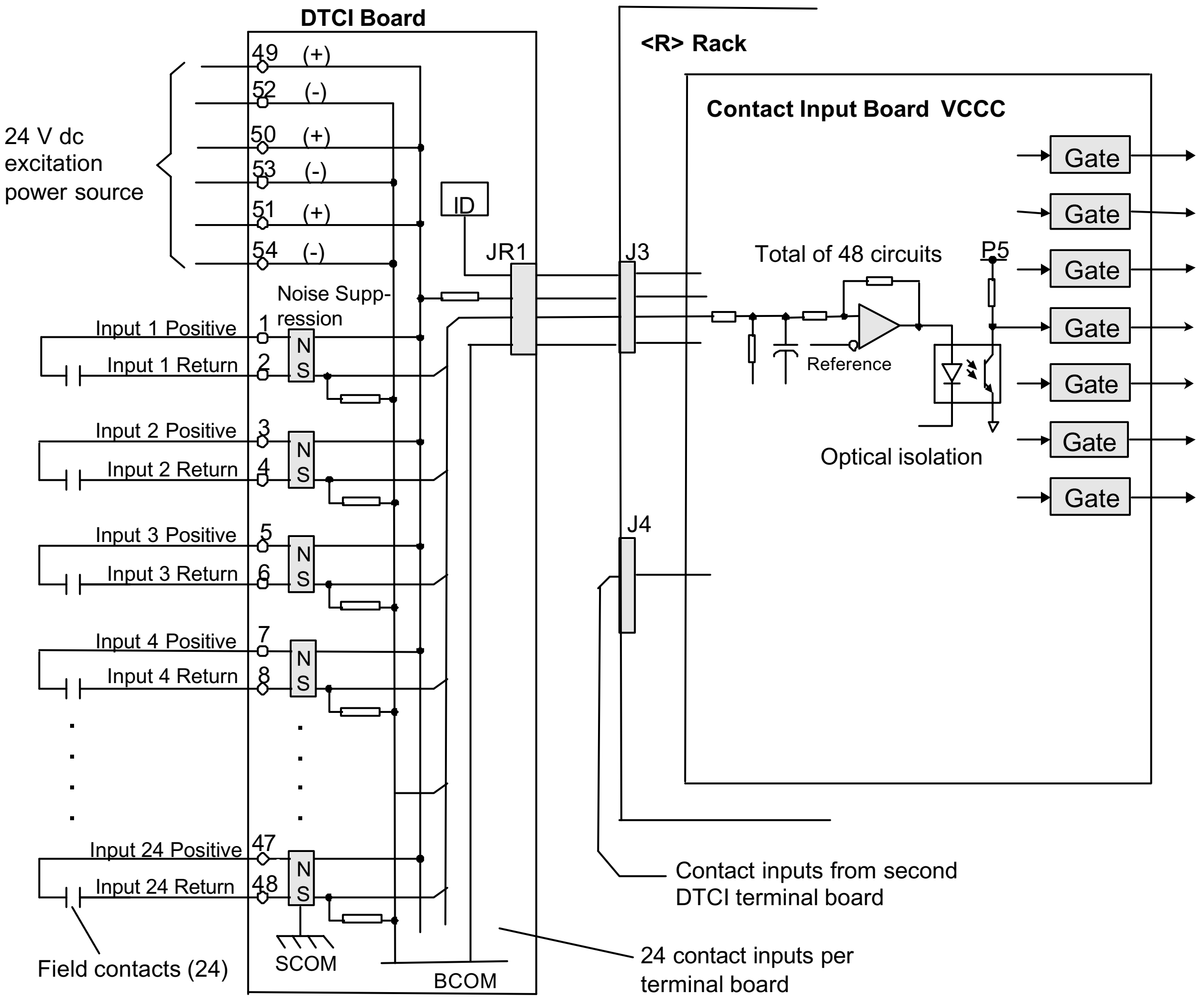
Refer to the section *Contact Inputs TBCI* for information on monitoring dry (isolated) contact inputs, and on the VCCC board.

DTCI Simplex Contact Input Terminal Board

VCRC is a single-width board and is preferred to VCCC.

The DTCI board is a compact contact input terminal board, designed for DIN-rail mounting. The DTCI board has 24 contact inputs with a nominal excitation of 24 V dc, and connects to the VCCC (VCRC) processor board with a single 37-pin cable. The terminal boards can be stacked vertically on a DIN-rail to conserve cabinet space. Two DTCI boards can be connected to the VCRC for a total of 48 contact inputs. Only a Simplex version of this board is available.

The function and on-board signal conditioning are the same as those on TBCI, except they are scaled for 24 V dc. High density Euro-Block type terminal blocks are permanently mounted to the board with two screw connections for the ground connection (SCOM). The input excitation range is 18 to 32 V dc, and the threshold voltage is 50% of the excitation voltage. The ac voltage rejection is 12 V rms. Contact inputs take 2.5 mA nominal current on the first 21 circuits, and 10 mA on circuits 22 through 24.

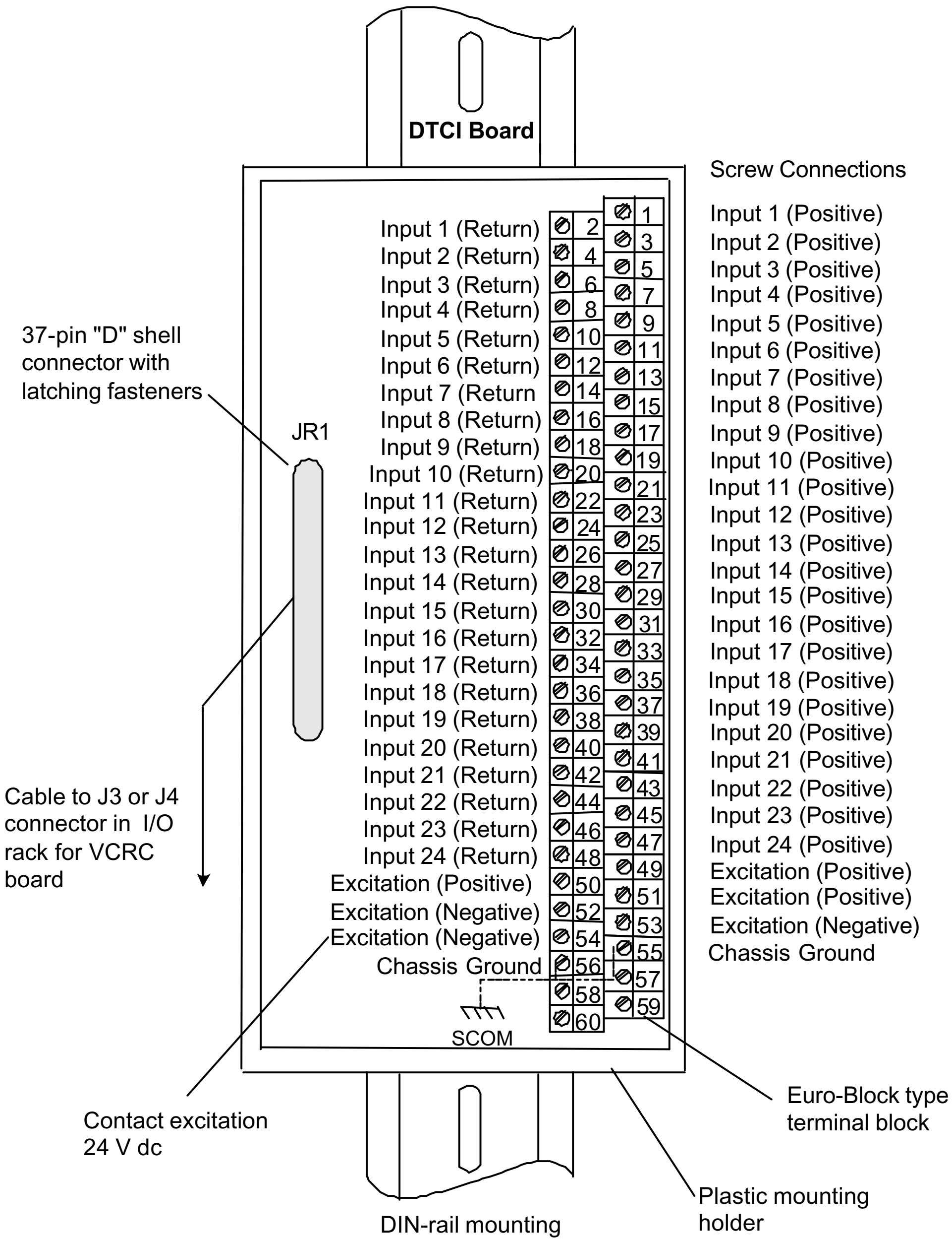


DTCI Board

Installation

There is no shield termination strip with this design.

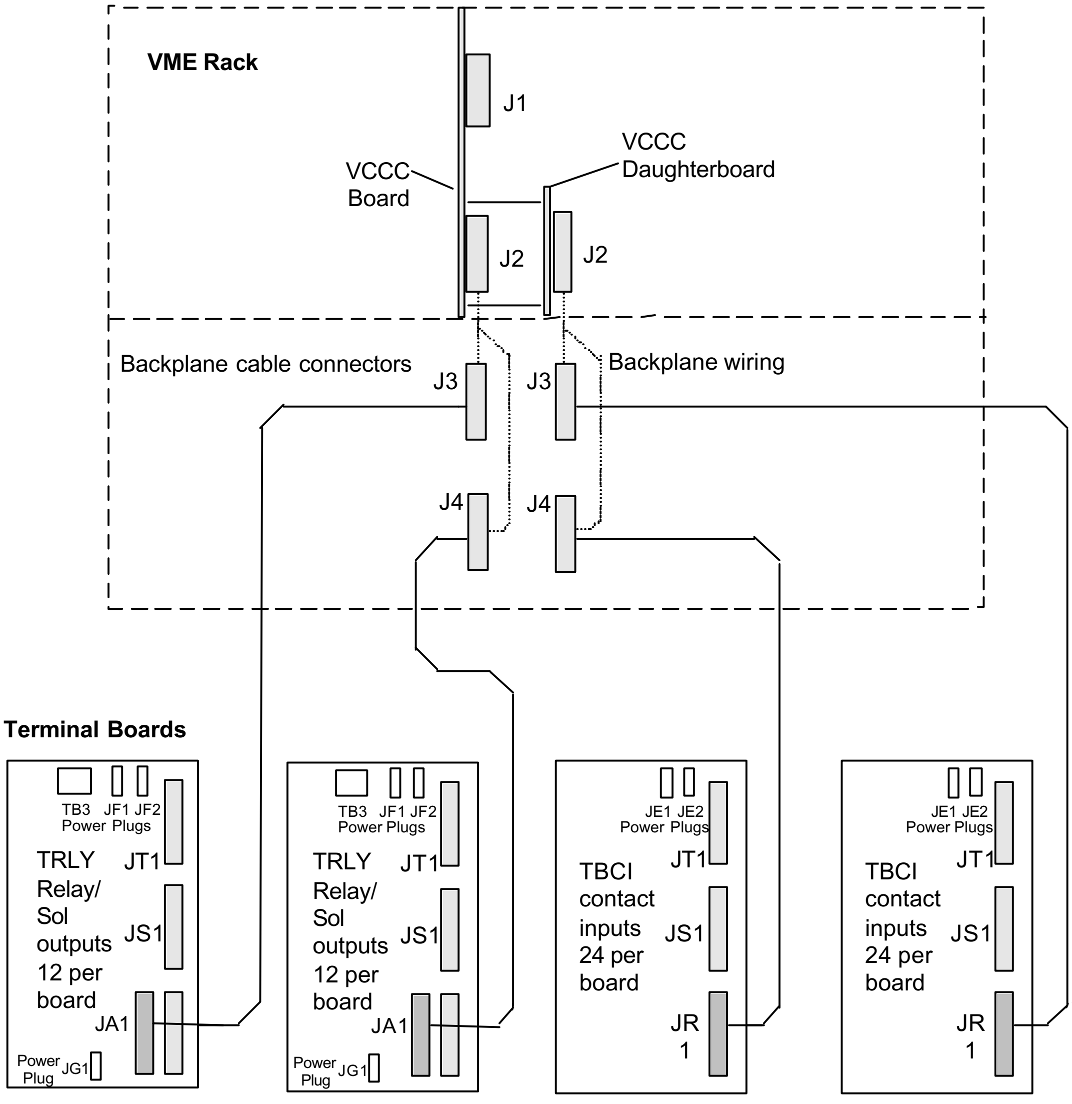
The DTCI board slides into a plastic holder, which mounts on the DIN-rail. The contact inputs are wired directly to the terminal block. The Euro-Block type terminal block has 60 terminals and is permanently mounted on the terminal board. Typically #18 AWG wires are used. There are two screws for the SCOM (ground) connection, which should be as short a distance as possible, and six screws for the 24 V dc excitation power.



DTCI Wiring and Cabling VCCC Relay Output Board

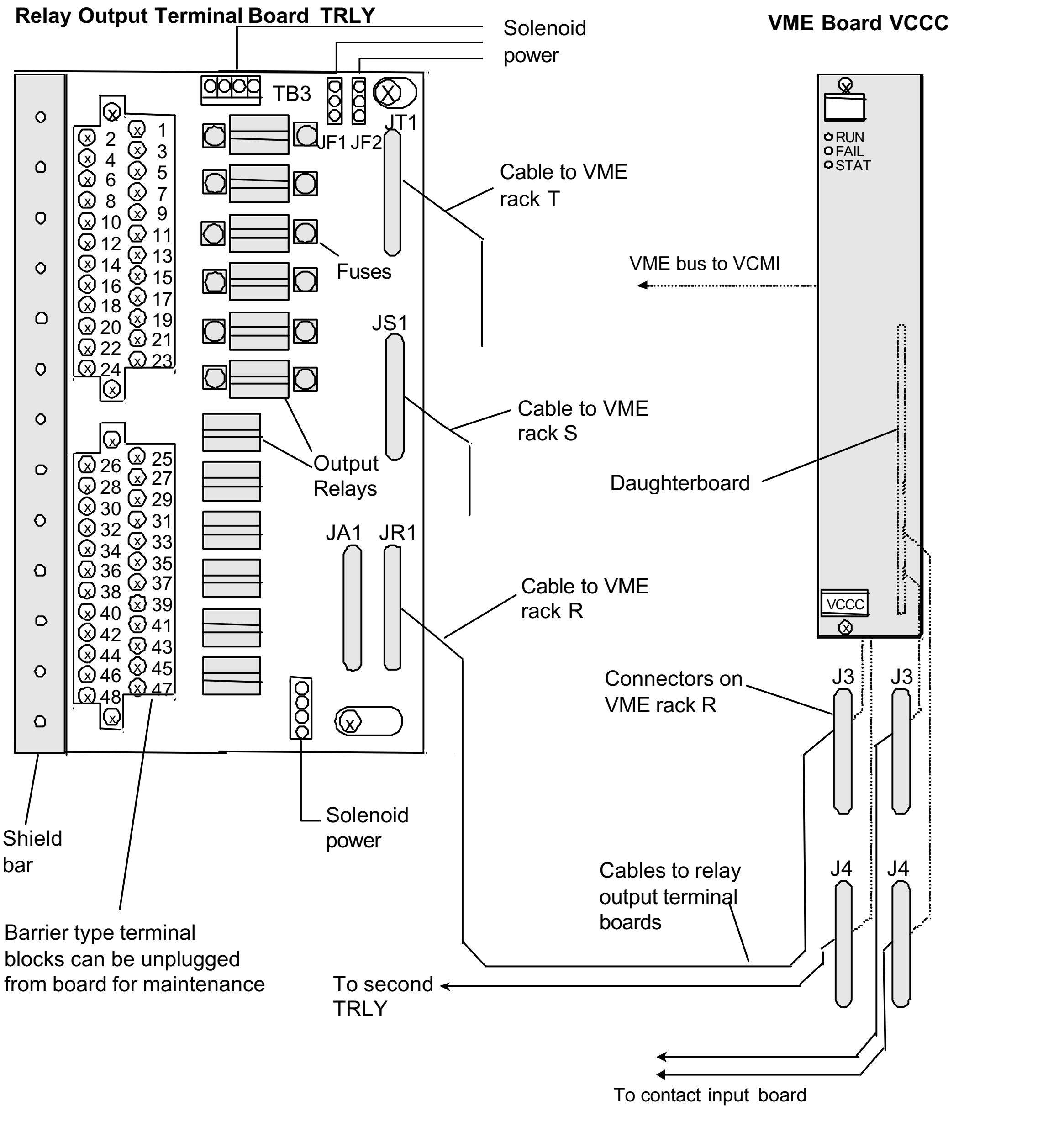
VCRC is a single slot version of VCCC with the same functionality (except driving TICI) and relay output cables plug into J3 and J4.

The Contact Input/Relay Output Board (VCCC), with its associated daughterboard, controls 24 relay/solenoid outputs. VCCC is a double-width module and connects to two sets of J3/J4 plugs via the VME backplane. The main board controls 12 relays through the Relay Output Terminal board (TRLY). Two TRLY boards are required for a total of 24 relays.



Simplex Cabling for Contact Inputs and Relay Outputs

TRLY holds twelve plug-in magnetic relays. A second board is required for output relays 13-24. Cables with molded fittings connect the terminal board to the VME rack where the VCCC processor board is located. Plug JA1 connects to J3/4 on Simplex systems, and plugs JR1, JS1, and JT1 are used for TMR systems.



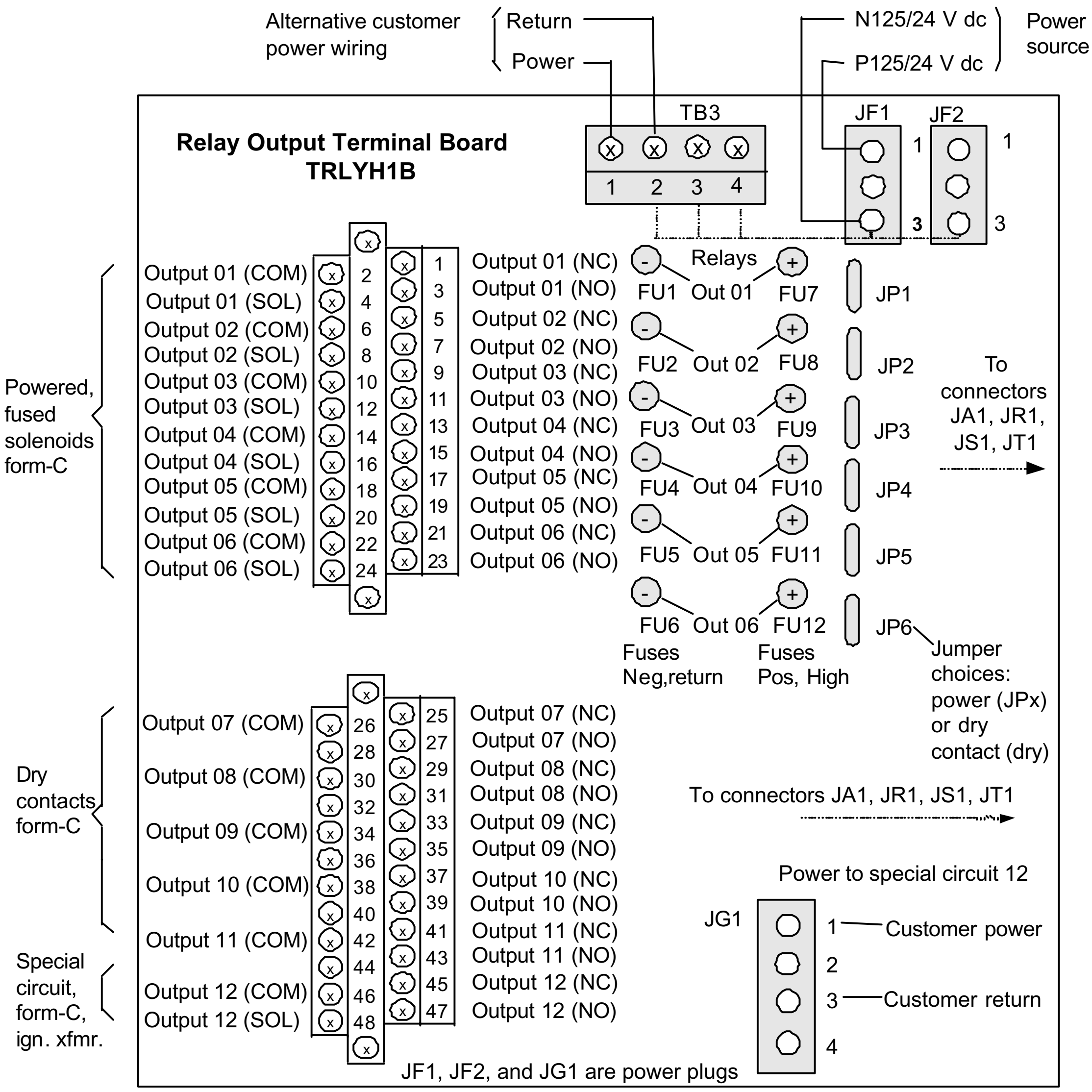
Relay Output Terminal board, I/O Board, and Cabling

Installation

The customer's 12 relay outputs are wired directly to two I/O terminal blocks mounted on the terminal board as shown in the figure below. Each block is held down with two screws and has 24 terminals accepting up to #12 AWG wires.

These jumpers are for isolation of the monitor circuit when used on isolated contact applications.

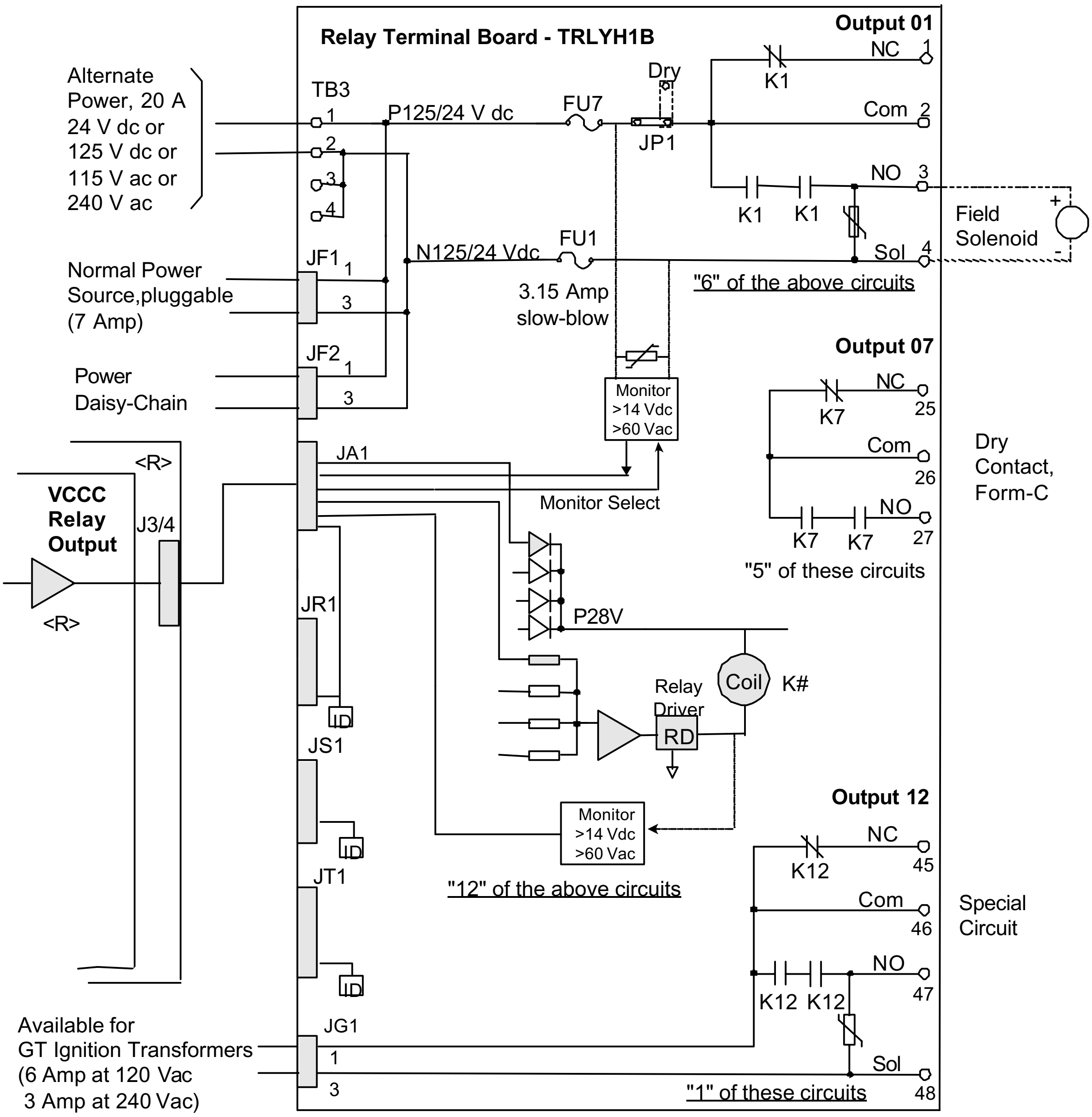
A shield termination strip attached to chassis ground is located immediately to the left of each terminal block. Solenoid power for outputs 1–6 is plugged to JF1 normally. JF2 can be used to daisy-chain power to other TRLYs. Alternatively customer power may be wired directly into TB3 when power is not plugged into JF1/JF2. JG1 provides power to customer's special solenoid, Output 12. Jumpers JP1–JP6 are removed in the factory and shipped in a plastic bag. Reinstall the appropriate jumper if power to a field solenoid is required. The fuses should also be removed for this application to ensure that suppression leakage is removed from the power bus.



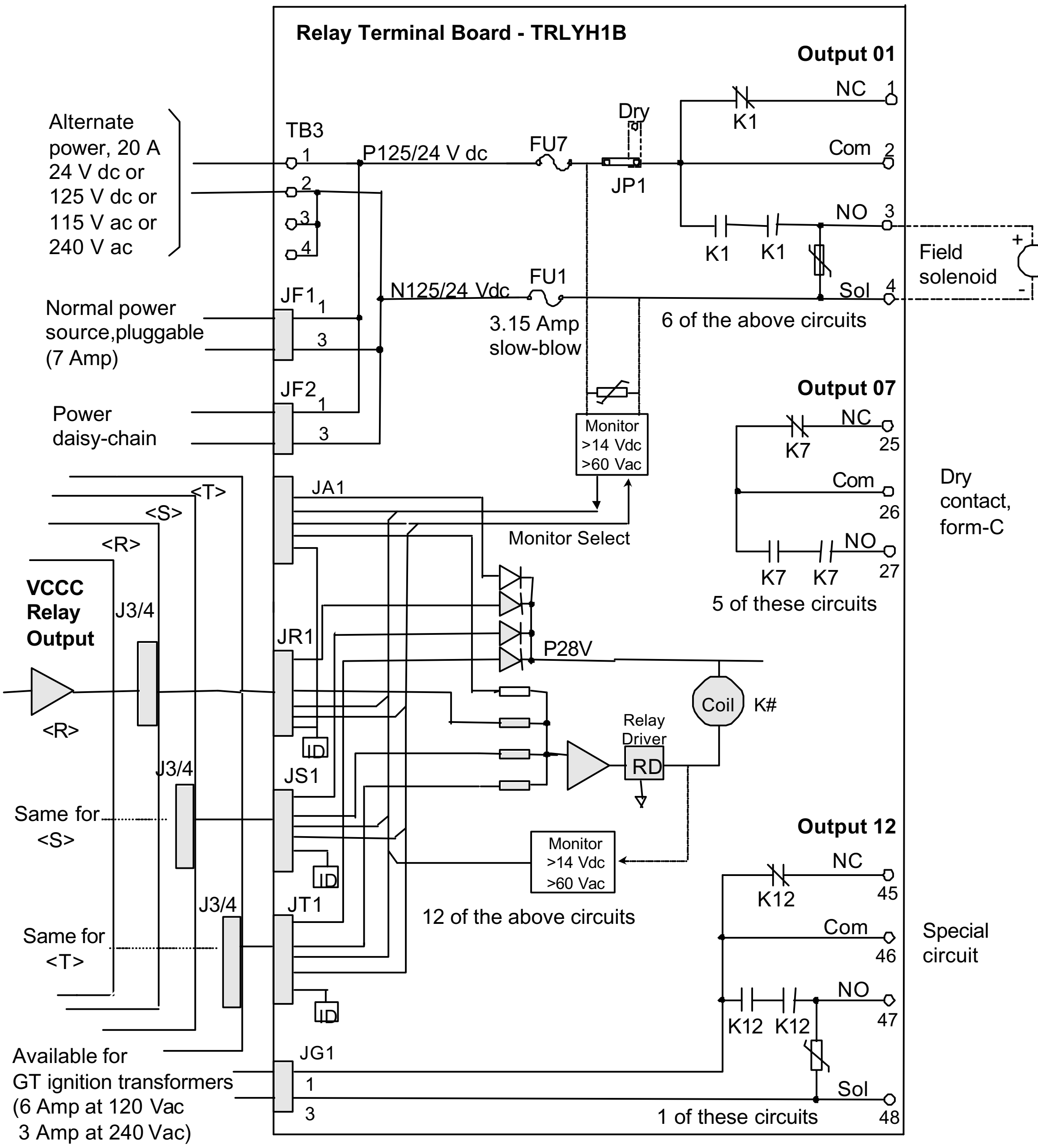
TRLY Terminal Board Wiring

Operation

For simplexoperation, cables carry control signals plus monitor feedback voltages between VCCC to TRLY through JA1. Relay drivers, fuses, and jumpers are mounted on the relay board. The first six relay circuits can be jumpers configured for either dry, Form-C contact outputs, or to drive external solenoids. A standard 125 V dc or 115 V ac source, or an optional 24 V dc source, with on-board suppression can be provided for solenoid power. This comes in on JF1 (or TB) as shown in the figure below. The next five relays (7 – 11) are unpowered isolated Form-C contacts. Output 12 is an isolated Form-C contact, used for ignition transformers, for example.



For TMR applications, relay control signals are fanned into TRLY from the three VME board racks R, S, and T through plugs JR1, JS1, and JT1. These signals are voted and the result controls the corresponding relay driver. Power for the relay coils comes in from all three racks and is diode shared.



TMR Relay Output Board

Specifications

Relays are driven at the frame rate and have a 3.0 Amp rating. The rated contact to contact voltage is 500 V ac for one minute and the rated coil to contact voltage is 1,500 V ac for one minute. The typical time to operate is 10 ms.

The relay outputs have failsafe features so that when a cable is unplugged, the inputs vote to de-energize the corresponding relays. Similarly, if communication with the associated VME board is lost, the relays de-energize.

VCCC Relay Output Specifications

Item	Specification
Number of relay channels on one TRLY board	12 relays: 6 relays with optional solenoid driver voltages 5 relays with dry contacts only 1 relay with 7 Amp rating VCCC total is 24 relays on two TRLY boards
Rated voltage on relays	a: Nominal 125 V dc or 24 V dc b: Nominal 120 V ac or 240 V ac
Max load current	a: 0.6 Amp for 125 V dc operation b: 3.0 Amp for 24 V dc operation; c: 3.0 Amp for 120/240 V ac, 50/60 Hz operation
Max response time on	25 ms typical
Max response time off	25 ms typical
Contact material	Silver cad-oxide
Contact life	Electrical operations: 100,000 Mechanical operations: 10,000,000
Fault detection	Loss of relay solenoid excitation current or coil current disagreement with command. Unplugged cable or loss of communication with VME board. Relays deenergize if communication with associated VME board is lost.

Diagnostics

Three LEDs at the top of the VCCC front panel provide status information. The normal RUN condition is a flashing green, FAIL is a solid red. The third LED is normally off but shows a steady orange if a diagnostic alarm condition exists in the board.

Each of the three terminal board connectors have their own ID device which is interrogated by the I/O board. The board ID is coded into a read-only chip containing the board serial number, board type, revision number, and the JR1/JS1/JT1 connector location.

The output of each relay (coil current) is monitored and checked against the command at the frame rate. If there is no agreement for two consecutive checks, an alarm is latched. The solenoid excitation voltage is monitored downstream of the fuses and an alarm is latched if it falls below 12 V ac/dc.

If any one of the 12 outputs goes unhealthy a composite diagnostic alarm, L3DIAG_VCCC occurs. Details of the individual diagnostics are available from the toolbox. The diagnostic signals can be individually latched, and then reset with the RESET_DIA signal if they go healthy.

Configuration

Like all I/O boards, the VCCC module is configured using the toolbox. This software usually runs on a data-highway connected CIMPLICITY station or workstation. The following table summarizes the configuration choices and defaults. Refer to GEH-6403, *Control System Toolbox for Configuring the Mark VI Turbine Controller*.

Typical VCCC Relay Configuration

Parameter		Description	Choices
Configuration			
	System Limits	Select system limits	Enable, disable
J3:IC200TRLYH1B		Terminal board 1 connected to VCCC via J3	Connected, not connected
	Relay01	First relay output (from first set of 12 relays) - Board point	Point edit (output BIT)
	Relay output	Select relay output	Used, unused
	FuseDiag	Enable fuse diagnostic	Enable, disable
	Relay01Fdbk	Relay 01 contact voltage (first set of 12 relays) - Board point	Point edit (input BIT)
	Contact input	Configurable item: slot#	Used, unused
	Signal invert	Inversion makes signal true if contact is open	Normal, invert
	Signal filter	Contact Input filter in milliseconds	0, 10, 20, 50
J4:IC200TRLYH1B		Terminal board 2 connected to VCCC through J4	Connected, not connected
	Relay01	Relay output 1 (second set of 12 relays) - Board point	Point edit (output BIT)
	Relay01Fdbk	Relay 1 Contact Voltage (second set of 12 relays) - Board point	Point edit (input BIT)

Board Points Signals		Description- Enter Signal Connection Name	Direction Type
1*	L3DIAG_VCCC	Board diagnostic	Input BIT
2	L3DIAG_VCCC	Board diagnostic	Input BIT
3	L3DIAG_VCCC	Board diagnostic	Input BIT

*For VCCC contact input points, see TBCI section.

TRLYH1C Relay Outputs with Voltage Sensing

Relay contact voltage detection is available with the optional TRLYH1C relay terminal board. TRLYH1C is driven by VCCC (or VCRC) in the same way as TRLY, and has the same 12 output relays. Voltage sensing is done with 18 small voltage monitor boards as shown in figure below. Individual voltage monitors can be isolated by removing a jumper.

TRLYH1C is the same as the standard TRLY board except for the following:

- Six jumpers for converting the solenoid outputs to dry contact type are removed. These jumpers were associated with the fuse monitoring.
- Input relay coil monitoring is removed from the 12 relays.
- Relay contact voltage monitoring is added to the 12 relays. Individual monitoring circuits have voltage suppression, and can be isolated by removing their associated jumper.
- High frequency snubbers are installed across the NO and Sol terminals on the six solenoid driver circuits and on the special circuit, output 12.

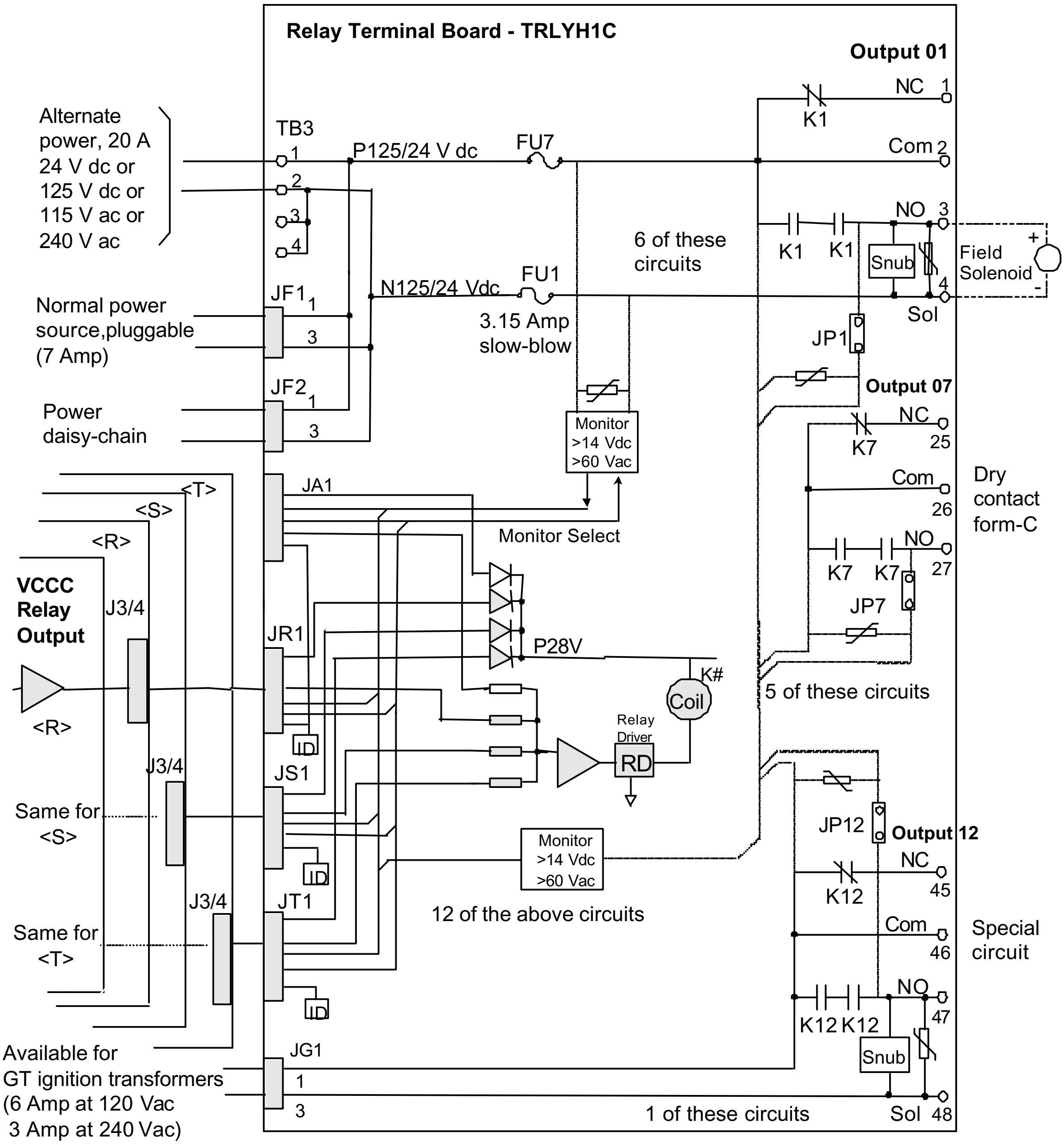
The contact voltage ranges for the monitors are as follows:

- 16-32 V dc, nominal 24 V dc
- 70-145 V dc, nominal 125 V dc
- 90-132 V rms, nominal 115 V rms, 47-63 Hz
- 190-264 V rms, nominal 230 V rms, 47-63 Hz

The threshold voltage ranges for the monitors are as follows:

- 24 V dc applications: 10 to 16 V dc
- 125 V dc applications: 40 to 65 V dc
- 115/230 V ac applications: 45 to 72 V ac

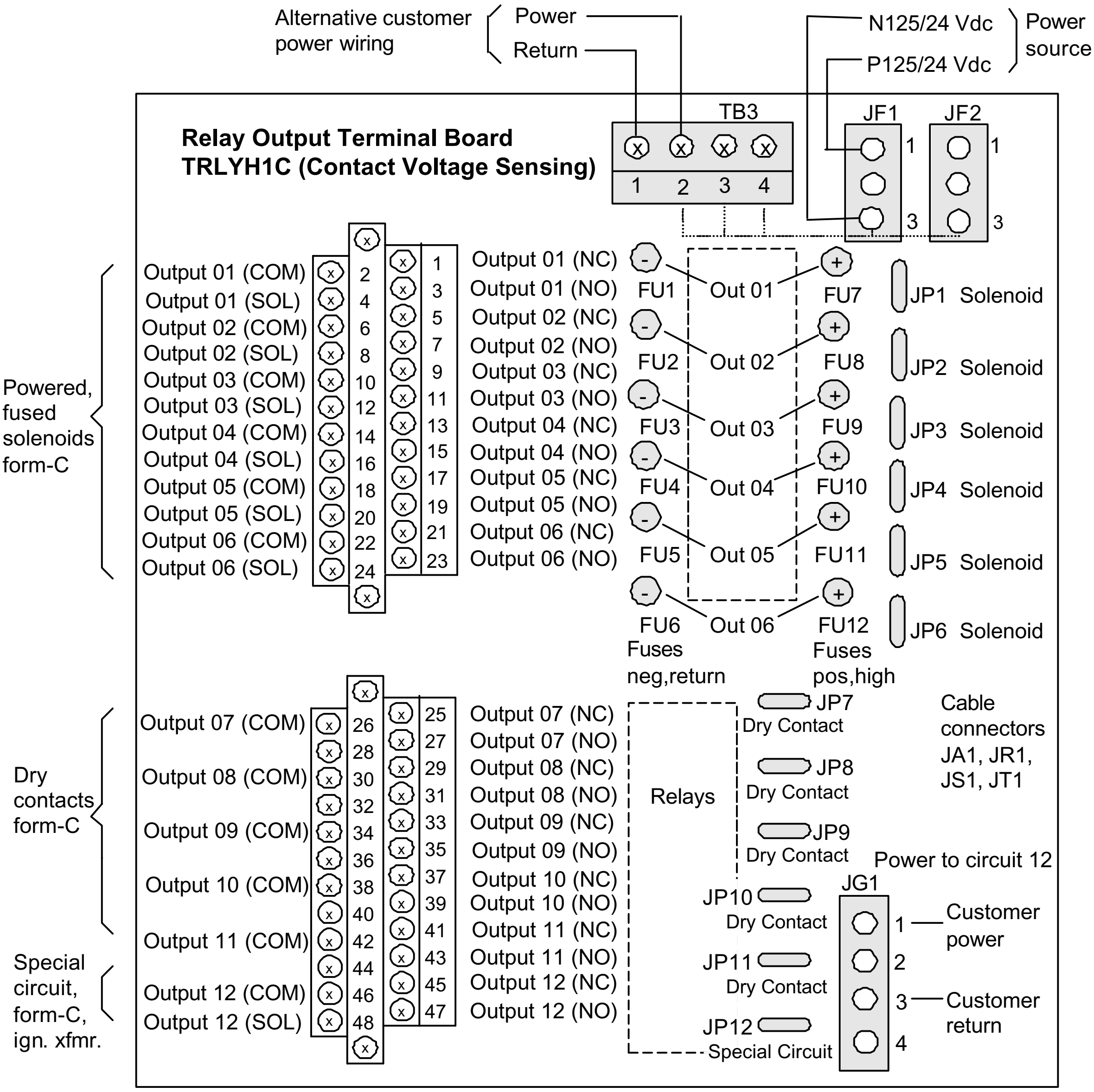
The contact input state is software filtered using time delays.



Relay Output Board with Contact Voltage Sensing

Installation

TRLYH1C wiring is the same as for TRLY, but the jumpers are different. It is not possible to jumper convert the solenoid driver circuits to isolated output contacts, but the two fuses can be removed for this purpose. Twelve jumpers are available to isolate the contact voltage monitors. The default is jumper in place, and isolation is by removing the jumper.



TRLYH1D Relay Outputs with Solenoid Integrity Sensing

The TRLYH1D board with solenoid integrity sensing provides six powered relay outputs for controlling 24 V dc, 110 V dc, or 125 V dc solenoids. For 24 V dc solenoids, the solenoid monitoring function can accommodate solenoids with nominal resistance of 17 to 53 ohms. A BAD 24 V SOLENOID alarm is annunciated if this resistance is outside of a 10 to 150 ohm band. For 110/125 V dc solenoids, the solenoid monitoring function can accommodate solenoids with nominal resistance of 300 to 1100 ohms. A BAD 110/125V SOLENOID alarm is annunciated if its resistance is outside of a 167 to 2500 ohm band. There are two normally open (NO) relay contacts for each solenoid. Solenoid current flows through 3.15 Amp, time delay fuses, which have a short circuit rating of 35 Amps.

Each solenoid fuse pair is monitored downstream of the fuses and gives a latched alarm when the fuse output is less than 16 V dc (± 4 V dc). The TRLYH1D board is controlled by either the VCCC daughterboard or the VCRC (both mounted in the VME rack).

The TRLYH1D is similar to the TRLYH1B board with the following differences:

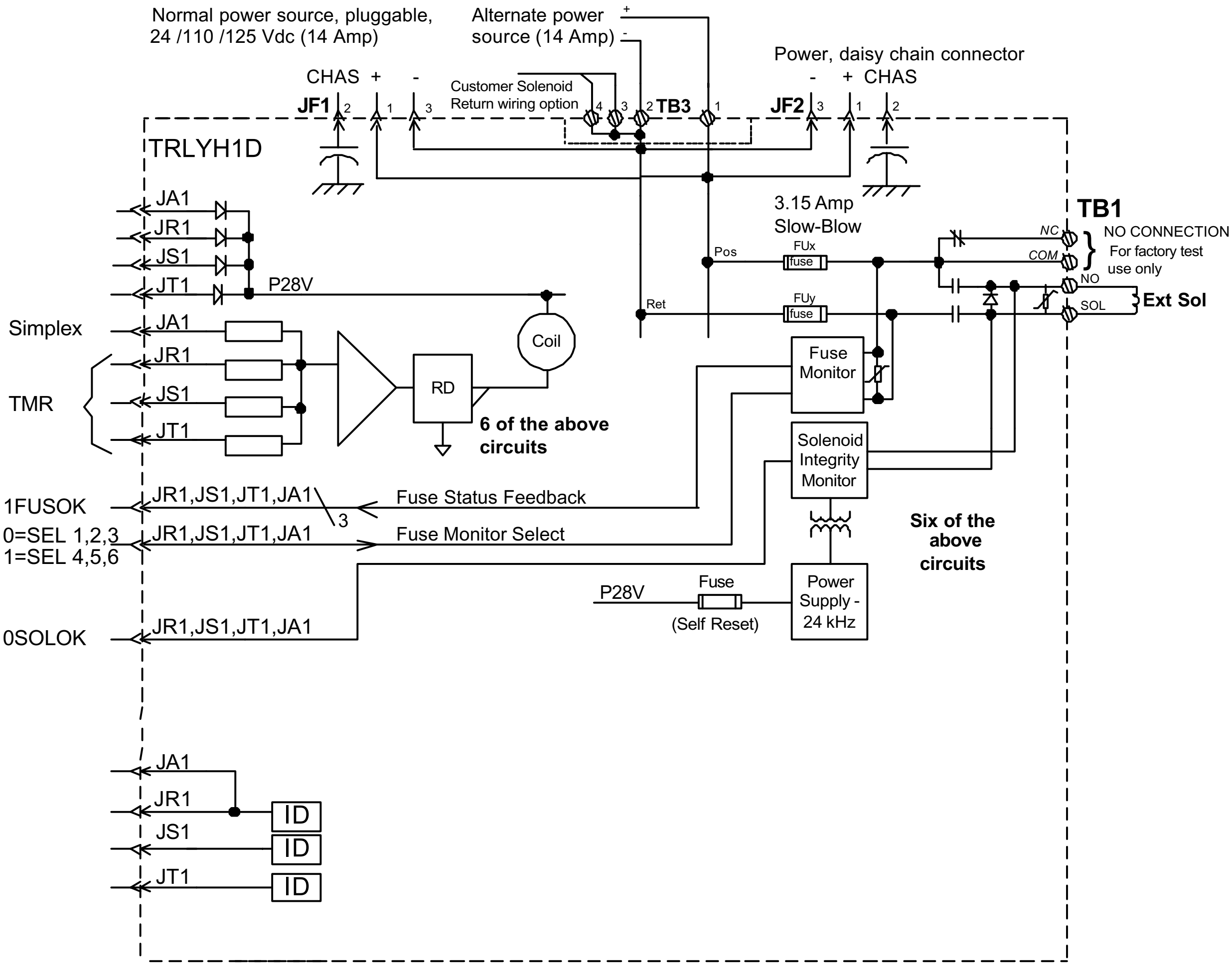
- Only six relays configured as solenoid drivers
- Designed for 24 /110/ 125 V dc applications only
- Solenoid relay circuits have a normally open (NO) contact in the return side as well as the source side.
- No relay coil monitoring
- Cannot be configured for externally powered dry contact use
- Provides solenoid integrity monitoring
- No special use relay for driving an ignition transformer
- Not backward compatible with either the TRLYH_B or TRLYH_C.

Diagnostics

Diagnostic alarm signals and one alarm reset signal are provided. When each solenoid is de-energized, the resistance is monitored for abnormal values. If a bad solenoid is detected two consecutive times, the VCCC or VCRC board will set a latched alarm, one per relay. The solenoid detection signal has a 1.3 second delay because the solenoid contacts must be open for at least 1.3 seconds to get a valid reading.

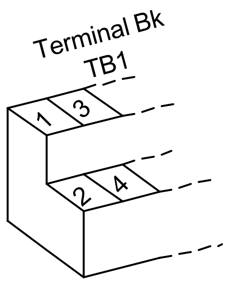
Diagnostic messages are posted for each relay output as follows:

- Solenoid #x has an electrical open or short circuit
- Solenoid #x has no voltage source, check fusing

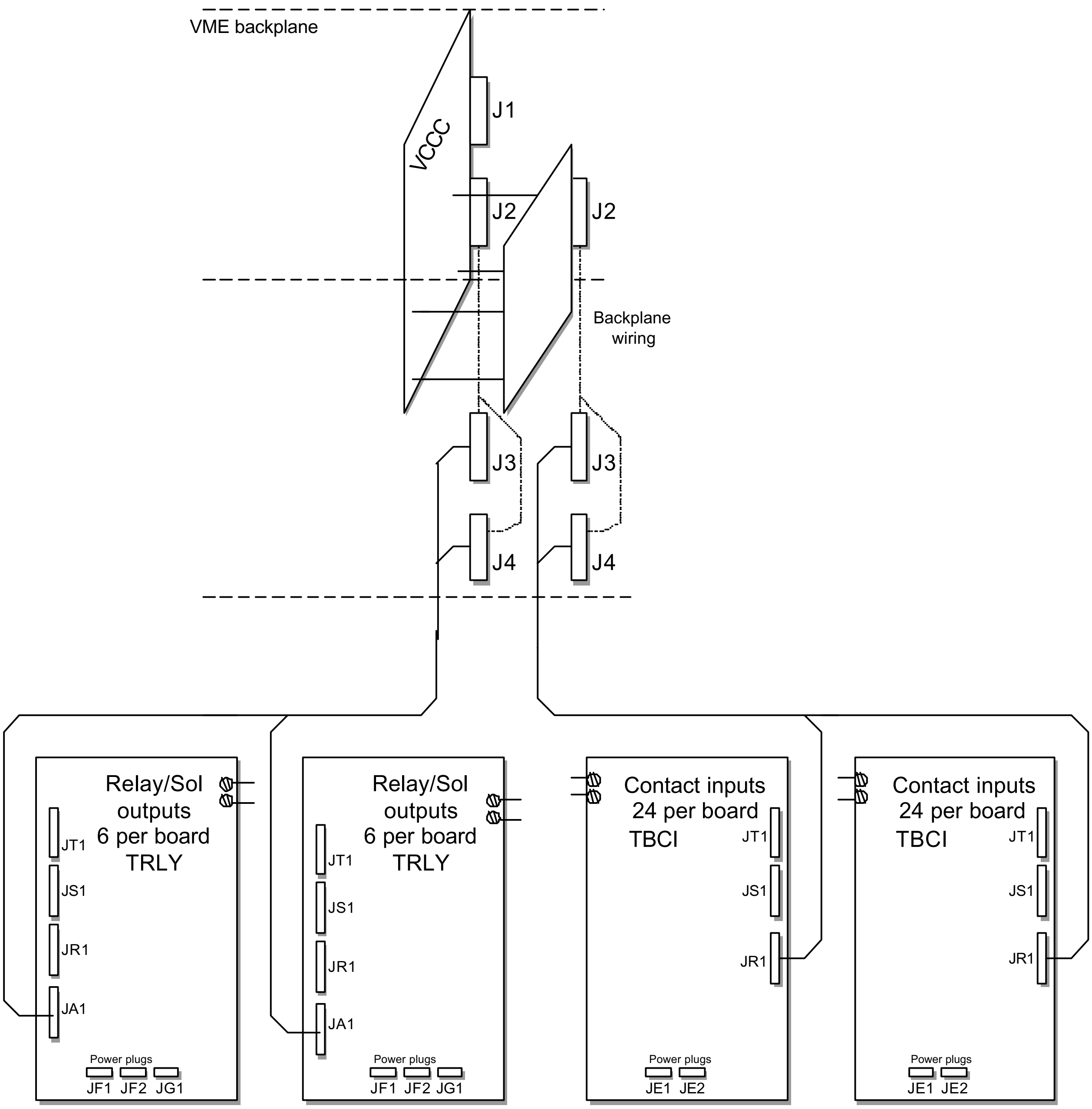


Assignments:

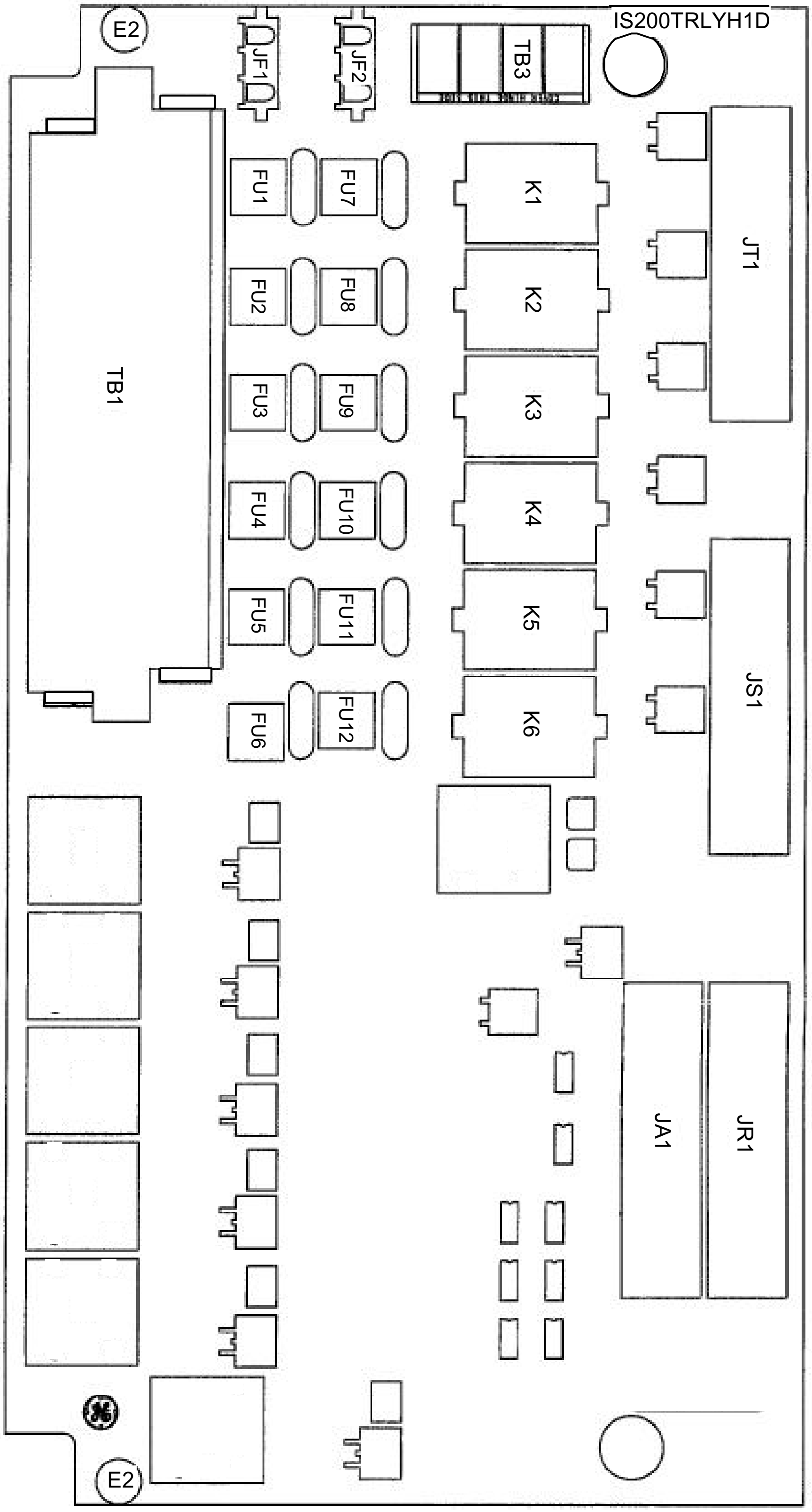
CKT	NC	COM	NO	SOL	FUx/y
#01	01	02	03	04	FU7/1
#02	05	06	07	08	FU8/2
#03	09	10	11	12	FU9/3
#04	13	14	15	16	FU10/4
#05	17	18	19	20	FU11/5
#06	21	22	23	24	FU12/6



TRLYH1D Block Diagram



TRLYH1D Connections to VCCC Board (Simplex)



TRLYH1D Component Layout

TRLYH1D Connector and Replaceable Component Descriptions

Connector	Description
JA1	37-Pin D-connector receptacle to VME rack for Simplex control*
JR1	37-Pin D-connector receptacle to VME rack "R" for 1/3 of TMR control*
JS1	37-Pin D-connector receptacle to VME rack "S" for 1/3 of TMR control*
JT1	37-Pin D-connector receptacle to VME rack "T" for 1/3 of TMR control*
JF1	Solenoid power input, 3-position receptacle contact vertical header; use with twisted wire harness; 14 A dc maximum Pin 1 - Positive Pin 2 - Negative (return) Pin 3 - Connect to chassis
JF2	Solenoid power daisy-chain, 3-position receptacle contact vertical header; use with twisted wire harness; 14 A dc maximum Pin 1 - Positive Pin 2 - Negative (return) Pin 3 - Alternate chassis connect
TB1	Solenoid or form-C contact connector; maximum rating 300 V, 10 A
TB3	Alternate power input connector; maximum rating 300 V, 14 A Pin 1 - Positive Pin 2 - Negative (return) Pin 3 - Customer solenoid return wiring (optional) Pin 4 - Customer solenoid return wiring (optional)
FU1 – FU12 Solenoid Fuses	5 x 20 mm, 3.15 A, 250 V slow-blow, GE P/N: 259A9266P16 Mfr. P/N: Bussmann GDC-3.15
K1 – K6 Relays	Dual form-C with dust cover, 24 V dc 0.9 watt coil 24 V dc, 10 A resistive 125 V dc, 0.5 A resistive GE P/N: 44A770196-001 Mfr. P/N: Cornell Dublier CDR402CQQSN-24D

* Designed to connect with GE Cable P/N 323A5750PX where X is the bale length in feet.

I/O Board Alarms

Diagnostic alarms for any I/O board can be displayed and reset form the toolbox. For troubleshooting and general diagnostic alarm information refer to GEG-6421 Volume I, Chapter 8.

I/O Board Diagnostic Alarms

Board	Fault	Fault Description	Possible Cause
VCCC	**1**	SOE Overrun. Sequence of Events data overrun	Communication problem on IONet
	2	Flash Memory CRC Failure	Board firmware programming error (board will not go online)
	3	CRC failure override is Active	Board firmware programming error (board is allowed to go online)
	16	System Limit Checking is Disabled. System limit checking has been disabled	System checking was disabled by configuration
	17	Board ID Failure	Failed ID chip on the VME I/O board
	18	J3 ID Failure	Failed ID chip on connector J3, or cable problem
	19	J4 ID Failure	Failed ID chip on connector J4, or cable problem
	20	J5 ID Failure	Failed ID chip on connector J5, or cable problem
	21	J6 ID Failure	Failed ID chip on connector J6, or cable problem
	22	J33/J3A ID Failure	Failed ID chip on connector J33 or J3A, or cable problem
	23	J44/J4A ID Failure	Failed ID chip on connector J44 or J4A, or cable problem
	24	Firmware/Hardware Incompatibility. The firmware on this board cannot handle the terminal board it is connected to	Invalid terminal board connected to VME I/O board. Check the connections and call the factory.
	30	ConfigCompatCode mismatch; Firmware: #; Tre: # The configuration compatibility code that the firmware is expecting is different than what is in the tre file for this board	A tre file has been installed that is incompatible with the firmware on the I/O board. Either the tre file or firmware must change. Contact the factory.
	31	IOCompatCode mismatch; Firmware: #; Tre: # The I/O compatibility code that the firmware is expecting is different than what is in the tre file for this board	A tre file has been installed that is incompatible with the firmware on the I/O board. Either the tre file or firmware must change. Contact the factory.
	33-56/ 65-88	TBCI J33/J3A/J44/J4A Contact Input # Not Responding to Test Mode. A single contact or group of contacts could not be forced high or low during VCCC self-check	Normally a VCCC problem, or the battery reference voltage is missing to the TBCI terminal board, or a bad cable.
	129-140/ 145-156	TRLY J3/J4 Relay Output Coil # Does Not Match Requested State. A relay coil monitor shows that current is flowing or not flowing in the relay coil, so the relay is not responding to VCCC commands	The relay terminal board may not exist, or there may be a problem with this relay, or, if TMR, one VCCC may have been out-voted by the other two VCCC boards.

161-172/ 177-188	TRLY J3/J4 Relay Driver # Does Not Match Requested State. The relay is not responding to VCCC commands	The relay terminal board may not exist and the relay is still configured as used, or there may be a problem with this relay driver.
97-102/ 113-118	TRLY J3/J4 Fuse # Blown. The fuse monitor requires the jumpers to be set and to drive a load, or it will not respond correctly	The relay terminal board may not exist, or the jumpers are not set and there is no load, or the fuse is blown.
240/241	TBCI J3/J4 Excitation Voltage Not Valid, TBCI J33/J3A/J44/J4A Contact Inputs Not Valid. The VCCC monitors the excitation on all TBCI and DTCI boards, and the contact input requires this voltage to operate properly	The contact input terminal board may not exist, or the contact excitation may not be on, or be unplugged, or the excitation may be below the 125 V level.
256-415	Logic Signal Voting Mismatch. The identified signal from this board disagrees with the voted value	A problem with the input. This could be the device, the wire to the terminal board, the terminal board, or the cable.

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Board Specification

VCRC Contact Input/ Relay Output Board

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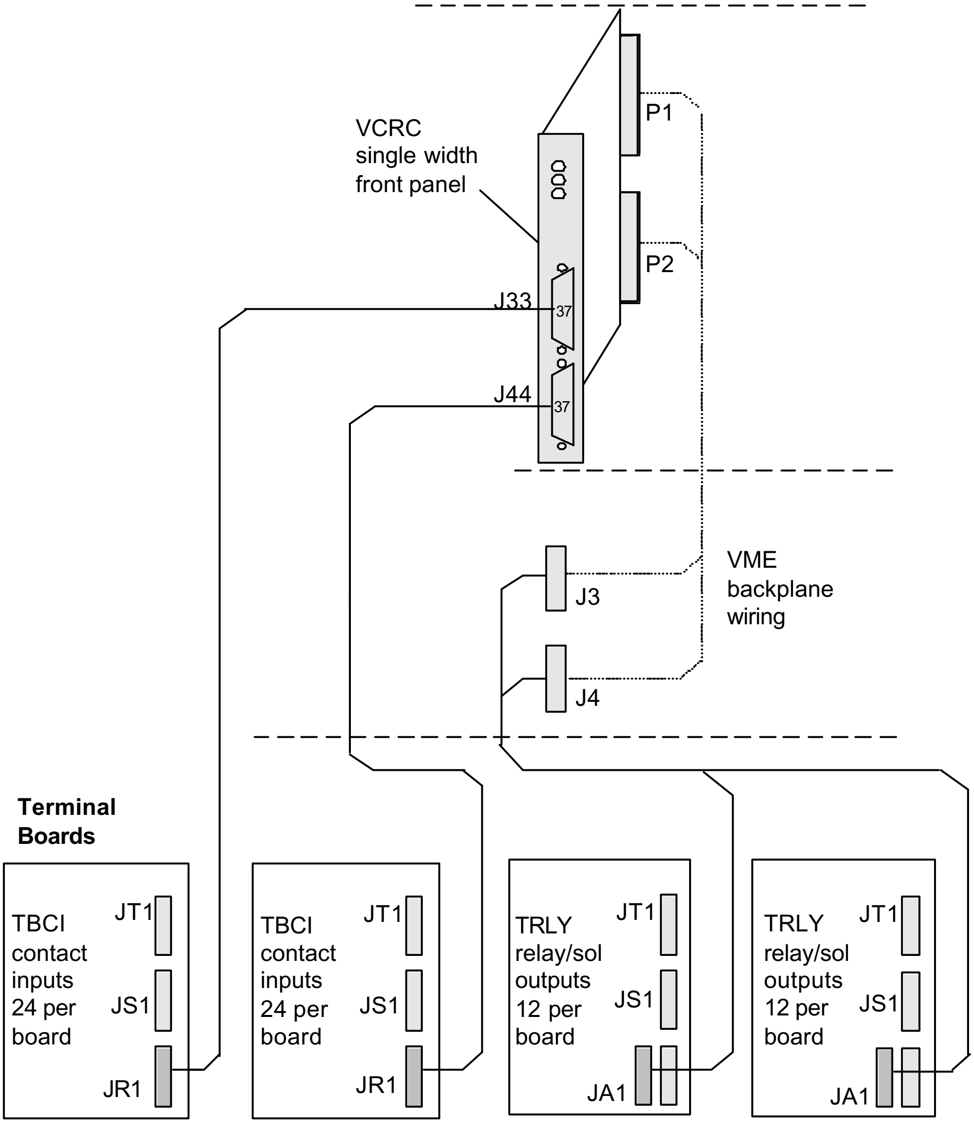
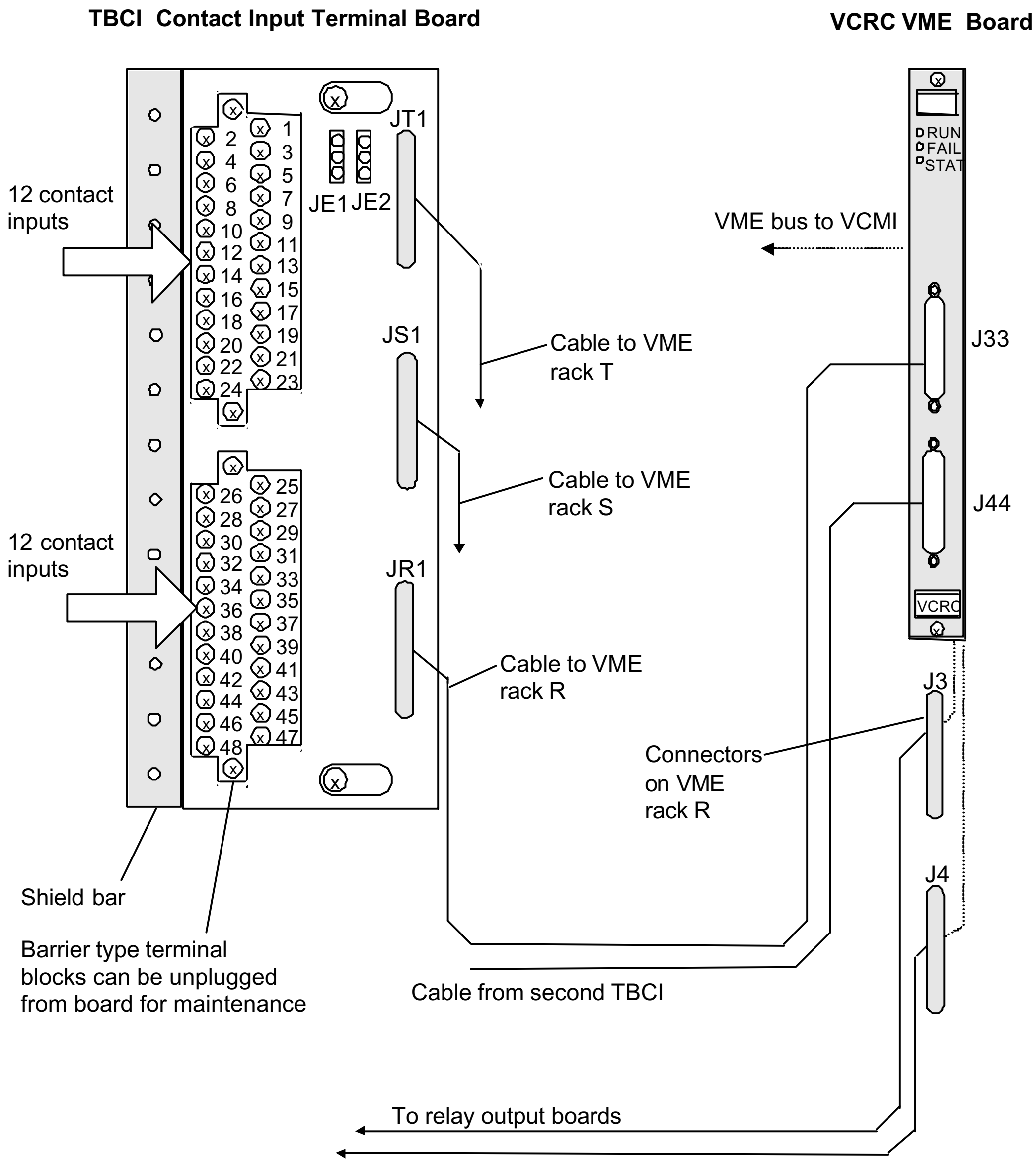
Section	Page

Functional Description

The VCRC board has the same functionality as the VCCC board but takes only one VME slot and the daughterboard is not required. Two front panel connectors, J33 and K44, accept the contract inputs from the TBCI boards. Relay outputs on TRLY use the J3 and J$ ports on the VME rack. VCRC does not support the TICI contact voltage sensing board. The firmware, configuration, and specifications are the same as for the VCCC board.



VCRC with Boards and Cabling to Contact Inputs and Relay Outputs



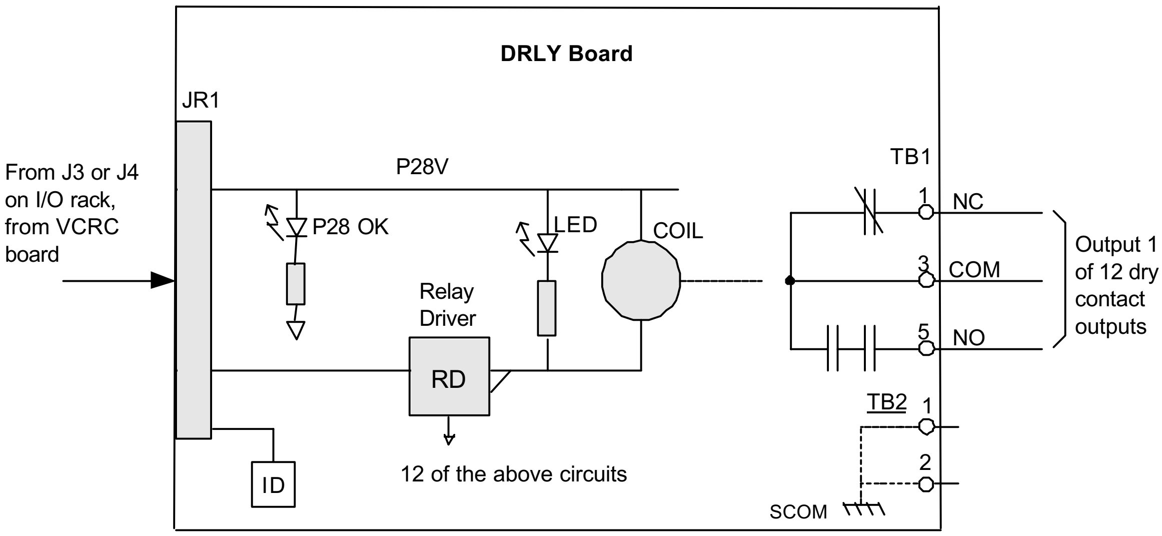
VCRC with Contact Input Board and Cabling

DRLY Simplex Relay Output Terminal Boards

There are two versions of the DRLY terminal board, H1A and H1B. The H1A has higher-powered relay contacts that H1B.

VCRC is a single-width board and is preferred to the VCCC.

The DRLY board is a compact relay output terminal board designed for wall mounting (not DIN-rail mounting). The board has 12 output relays, each with one form-C contact, and connects to the VCRC processor board with a single 73-pin cable. The 37-pin cable is identical to those used on the larger TRLY terminal board. Two DRLY boards can be connected to the VCRC for a total of 24 contact outputs. Only a simplex version of this board is available. Solenoid source power is not included, and there is one set of dry contacts per relay, (there are two NO contacts in series). The relay outputs meet NEMA Class B 300 V creepage and clearance. Unlike TRLY, there is no on-board suppression, and no relay state monitoring.



Wall Mounted DRLY Board

Specifications

The following tables define the output ratings for the DRLY board. The H1A is designed for general purpose use and has ratings covering most applications, whereas the H1B relay is sealed and has smaller contacts for Class 1 Div. 2 applications. An onboard ID chip identifies the board to the VCRC for system diagnostic purposes.

DRLYH1A Output

Application	Conditions	Output Specification
Environment	0 – 65 C ambient	General purpose
General requirements	Safety, electrical, environmental, packaging	See GEH-6421D, Vol. I *Mark VI System Guide* Chapter 4, *Codes and Standards*
28 V dc	Resistive load	10 A
	Inductive load without suppression	2 A, L/R = 7 ms
125 V dc	Resistive load	0.5 A
	Inductive load without suppression	0.2 A, L/R = 7 ms
	Inductive load, MOV suppression across load, 2 contacts used in series on the same relay	0.65 A, L/R = 150 ms
120 V ac	Resistive load	10 A
	Inductive load without suppression	2 A, 10 A inrush, PF = 0.4
	Motor load	1/3 Hp
240 V ac	Resistive load	3 A
	Inductive load without suppression	2 A, 10 A inrush, PF = 0.4
	Motor load	1/2 Hp
Response Time	Operate Release	15 ms typical 10 ms typical

DRLYH1B Output Specifications

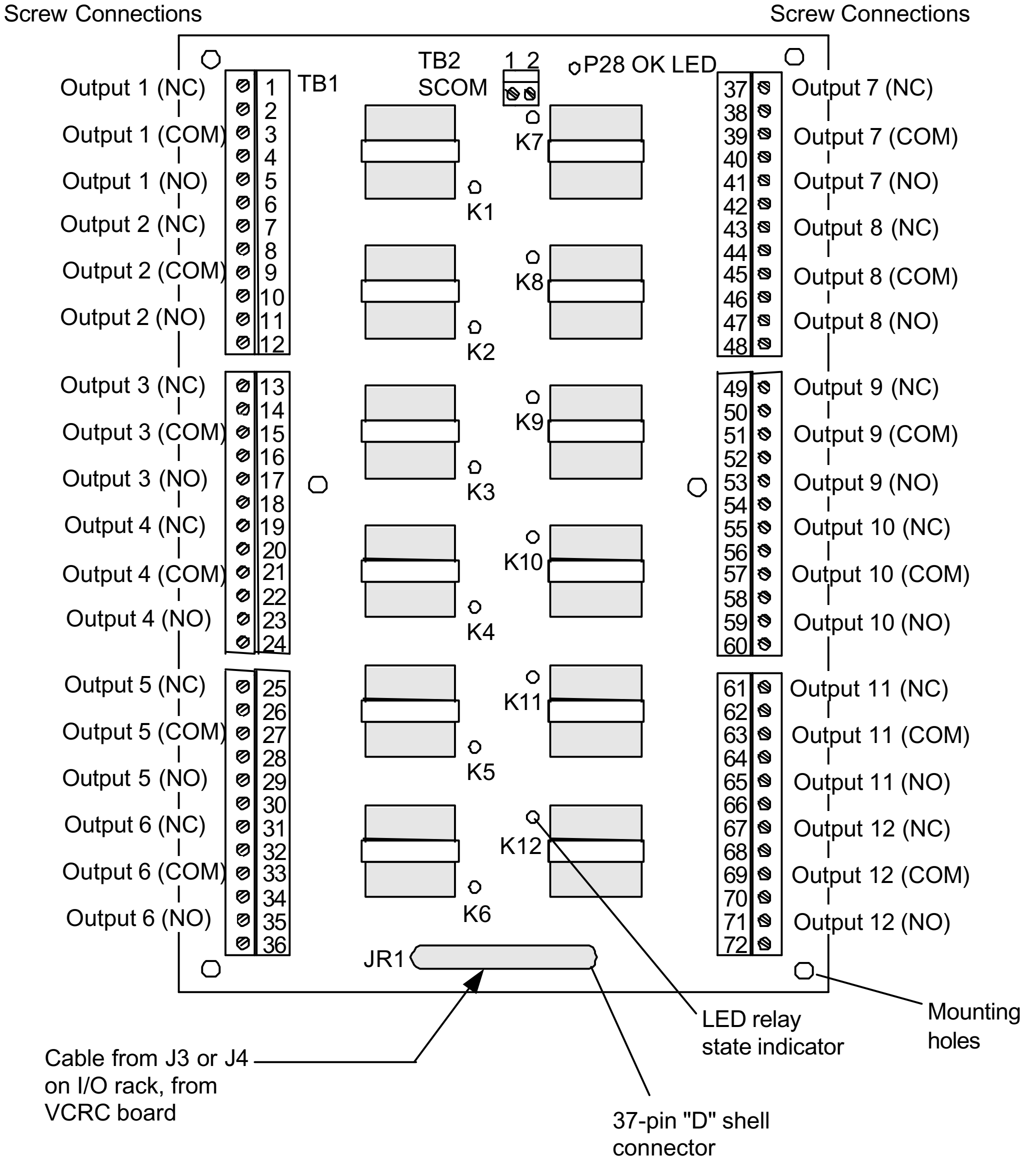
Application	Conditions	Output Specification
Environment	0 – 65 C ambient	Class 1, Div. 2
General requirements	Safety, electrical, environmental, packaging	See GEH-6421C, Vol. I *Mark VI System Guide* Chapter 4, *Codes and Standards*
28 V dc	Resistive load	2 A
125 V dc	Resistive load	0.5 A
120 V ac	Resistive load	1 A
240 V ac	Resistive load	0.5 A
Maximum switching voltage	Dc, resistive load Ac, resistive load	220 V dc 250 V rms
Maximum operating current	Dc, resistive load Ac, resistive load	2 A dc 2 A rms
Maximum switching capacity	Dc, resistive load Ac, resistive load	60 watts 125 VA
Response time	Operate Release	3 ms typical 2 ms typical

Installation

There is no shield termination strip with this design.

The DRLY board is supposrted on a metal plate, which can be wall mounted with four screws. The 12 relay outputs are wired directly to the odd-numbered screws on the terminal blocks. The high density Euro-Block type terminal blocks can be plugged into the numbered receptacles on the board. There are two separate screws on TB2 for the SCOM (chassis ground) connection, which should be as short a distance as possible.

DRLY Board



DRLY Wiring and Cabling

I/O Board Alarms

Diagnostic alarms for any I/O board can be displayed and reset from the toolbox. For troubleshooting and general diagnostic alarm information refer to GEG-6421 Volume I, Chapter 8.

For I/O Board Alarms refer to GEI-100557.

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Board Specification

VSVO Servo Board

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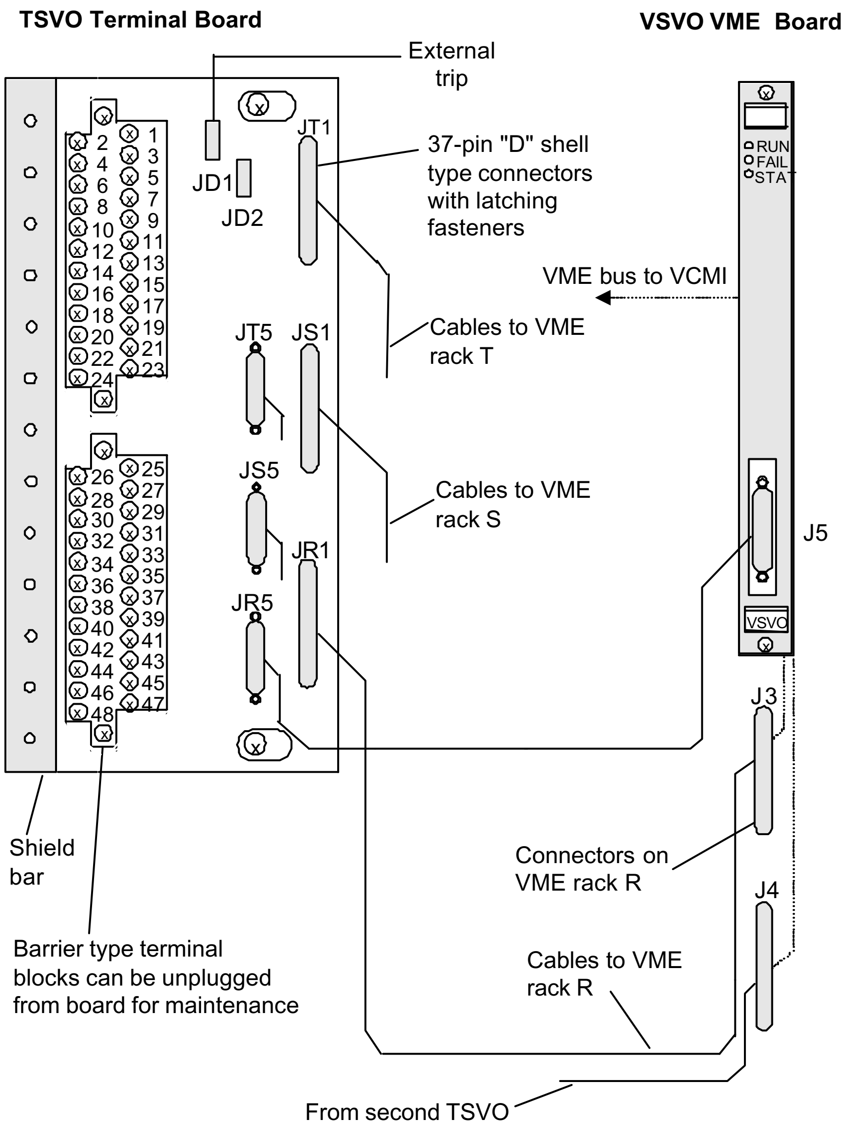
Functional Description

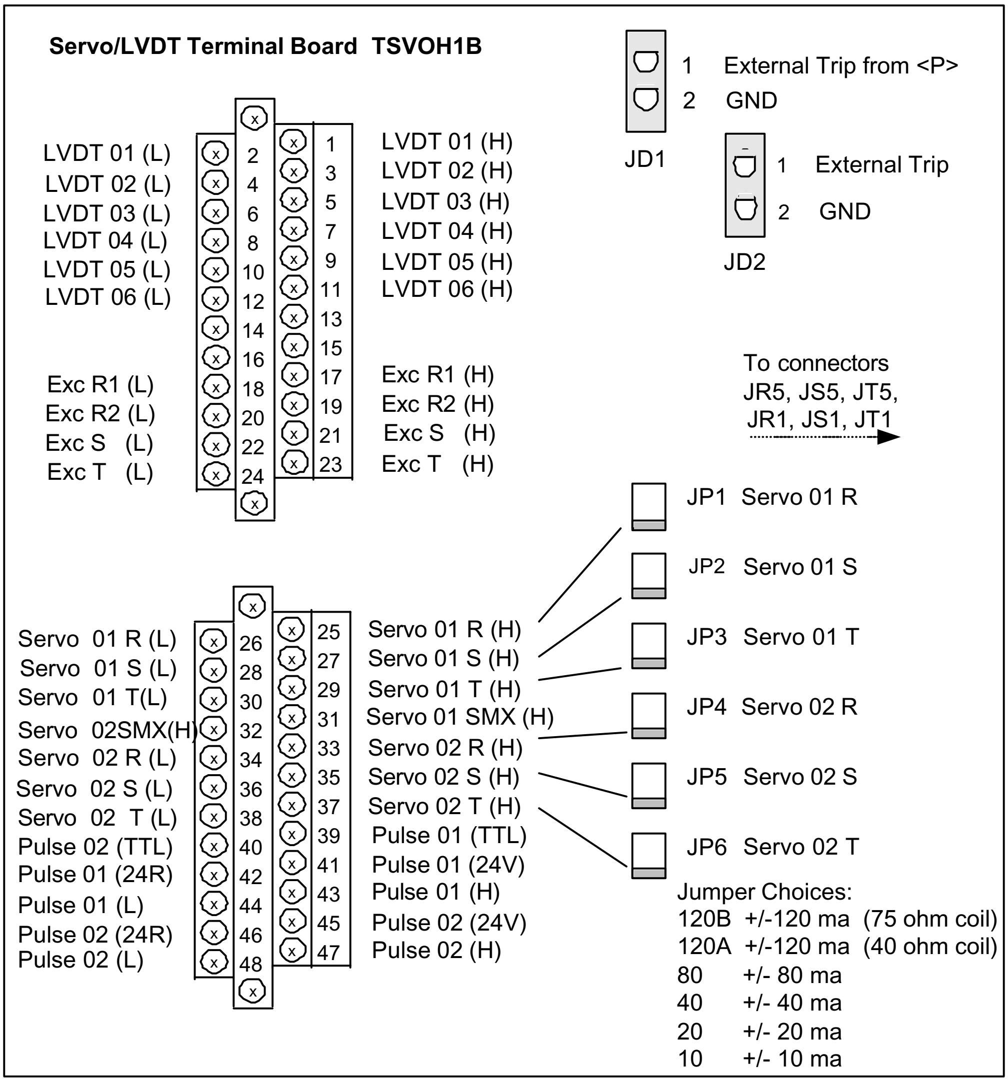
The Servo Board (VSVO) controls four electrohydraulic servo valves that actuate the steam/fuel valves. These four channels are divided between two TSVO terminal boards. Valve position is measured with linear variable differential transformers (LVDT). Three cables to VSVO use the J5 plug on the front on the board and the J3/4 connectors on the VME rack. TSVO provides Simplex signals via the JR1 connector, and fans out TMR signals to the JR, LS, and JT connectors. Plugs JD1 or JD2 are for external trip from the protection module.



Servo/LVDT Terminal Board, Processor Board, and Cabling

Installation

Sensors and servo valves are wired directly to two I/O terminal blocks mounted on the terminal board. Each block is held down with two screws and has 24 terminals accepting up to #12 AWG shield termination strip attached to chassis ground is located immediately to the left of each terminal block. External trip wiring is plugged into either JD1 or JD2. The screw connection and position choices for the servo current jumpers.



Up to two #12 AWG wires per point with 300 V insulation

Terminal blocks can be unplugged from terminal board for maintenance

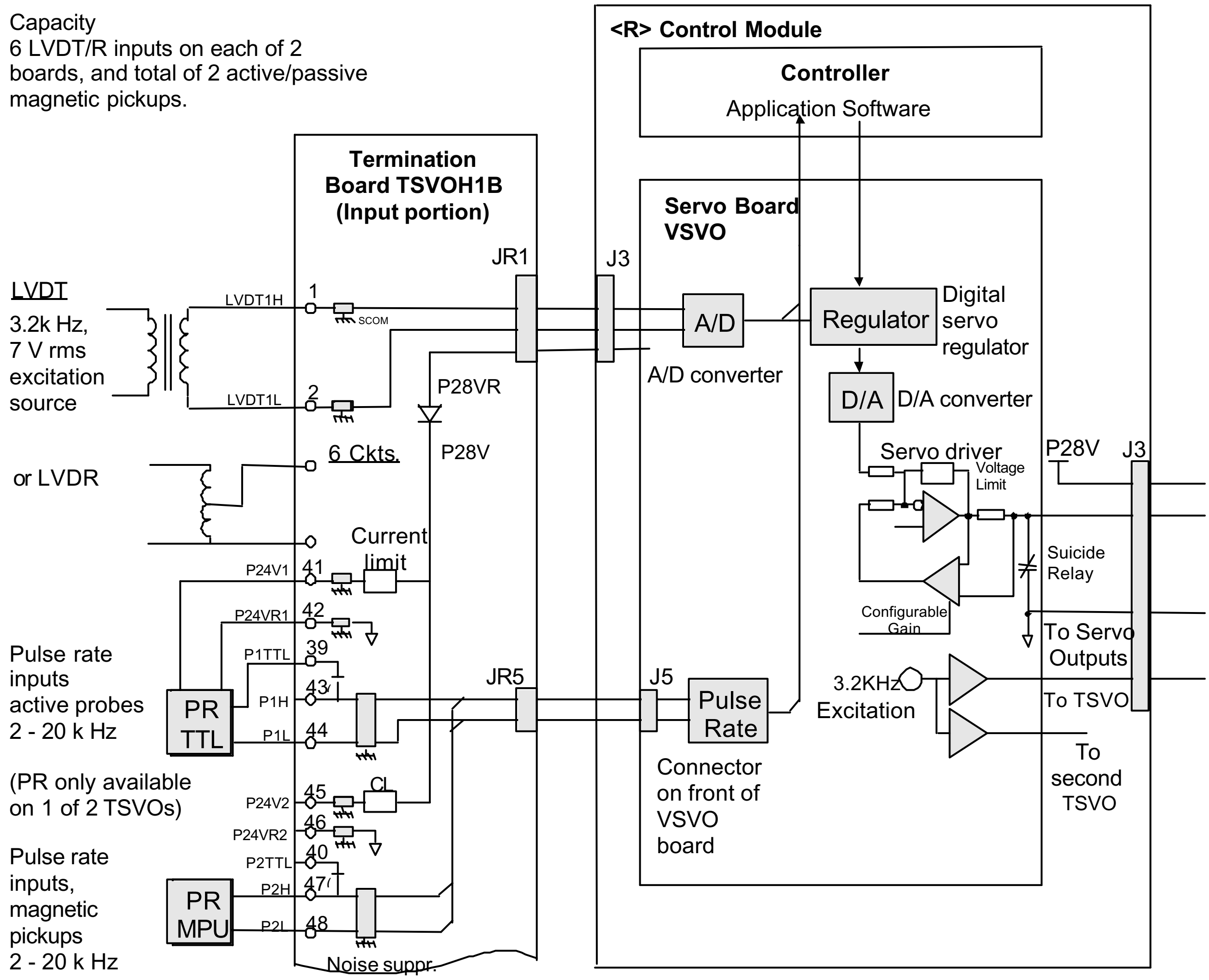
Servo/ LVDT Terminal Board Wiring

Operation

Refer to the figures for inputs and outputs.

The servo board provides four channels consisting of bi-directional servo current outputs, LVDT position feedback, LVDT excitation and pulse rate flows inputs. The TSVO provides excitation for, and accepts inputs from , up to six LVDT valve position inputs. There is a choice of one, two three, or four LDTs for each servo control loop. If three inputs are used they are available for gas turbine flow measuring applications, and these signals come through TSVO and go directly to the VSVO board front at J5.

Each servo output is equipped with an individual suicide relay under firmware control that shorts the VSVO output signal to signal common when de-energized, and recovers to nominal limits after a manual reset command is issued. Diagnostics monitor the output status of each servo voltage, current and suicide relay.

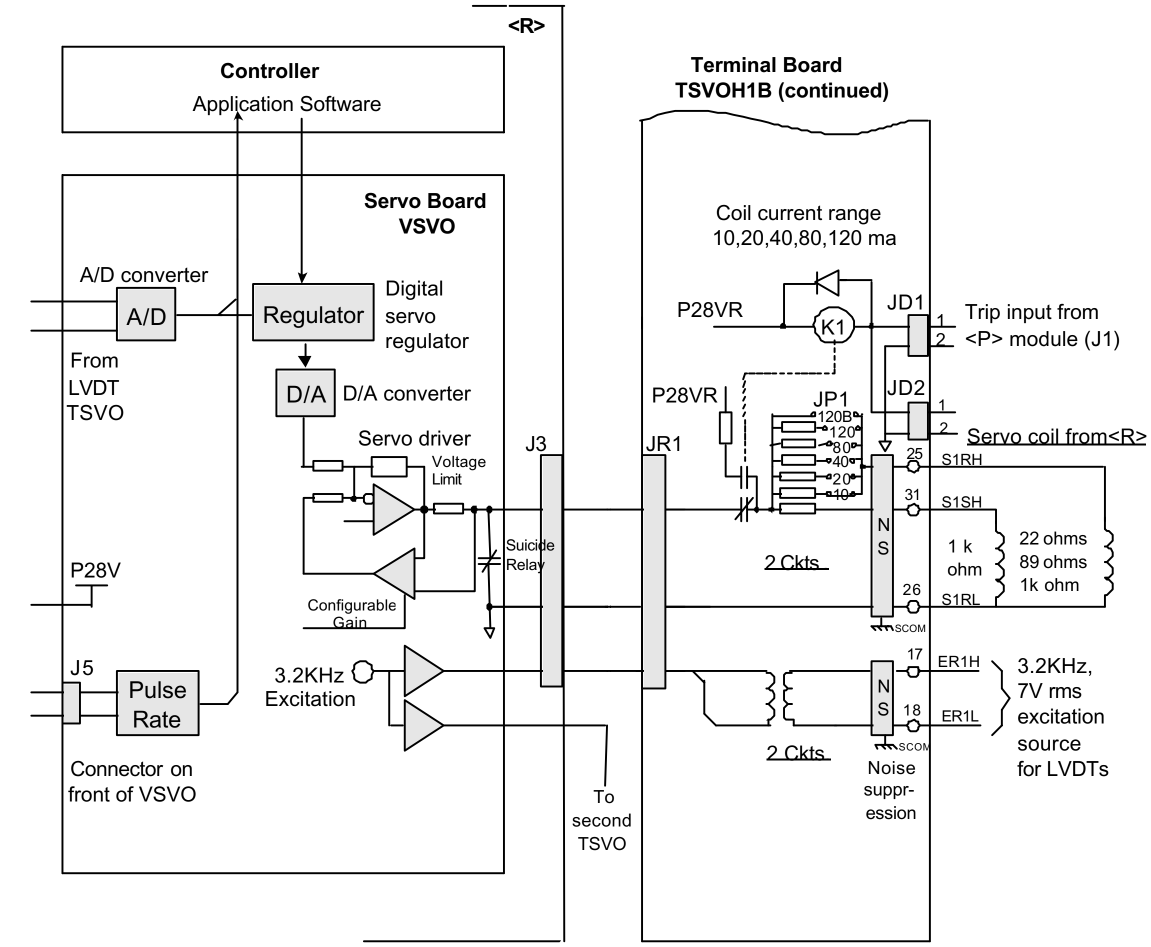


LVDT and Pulse Rate Inputs, Simplex

Each of the servo output channels can drive either one or two-coil servos in Simplex applications, or two or three-coil servos in TMR applications. The two-coil TMR applications are for 200# oil gear systems where each of two control modules drive one coil each. And the third module has to servo interface. Servo cable lengths up to 300 meters (984 feet) are supported with a maximum two-way cable resistance of 15 ohms. Sine there are many types of servo coils, a variety of bi-directional current sources are jumper selectable.

The primary and emergency overspeed systems will trip the hydraulic solenoids independent of this circuit.

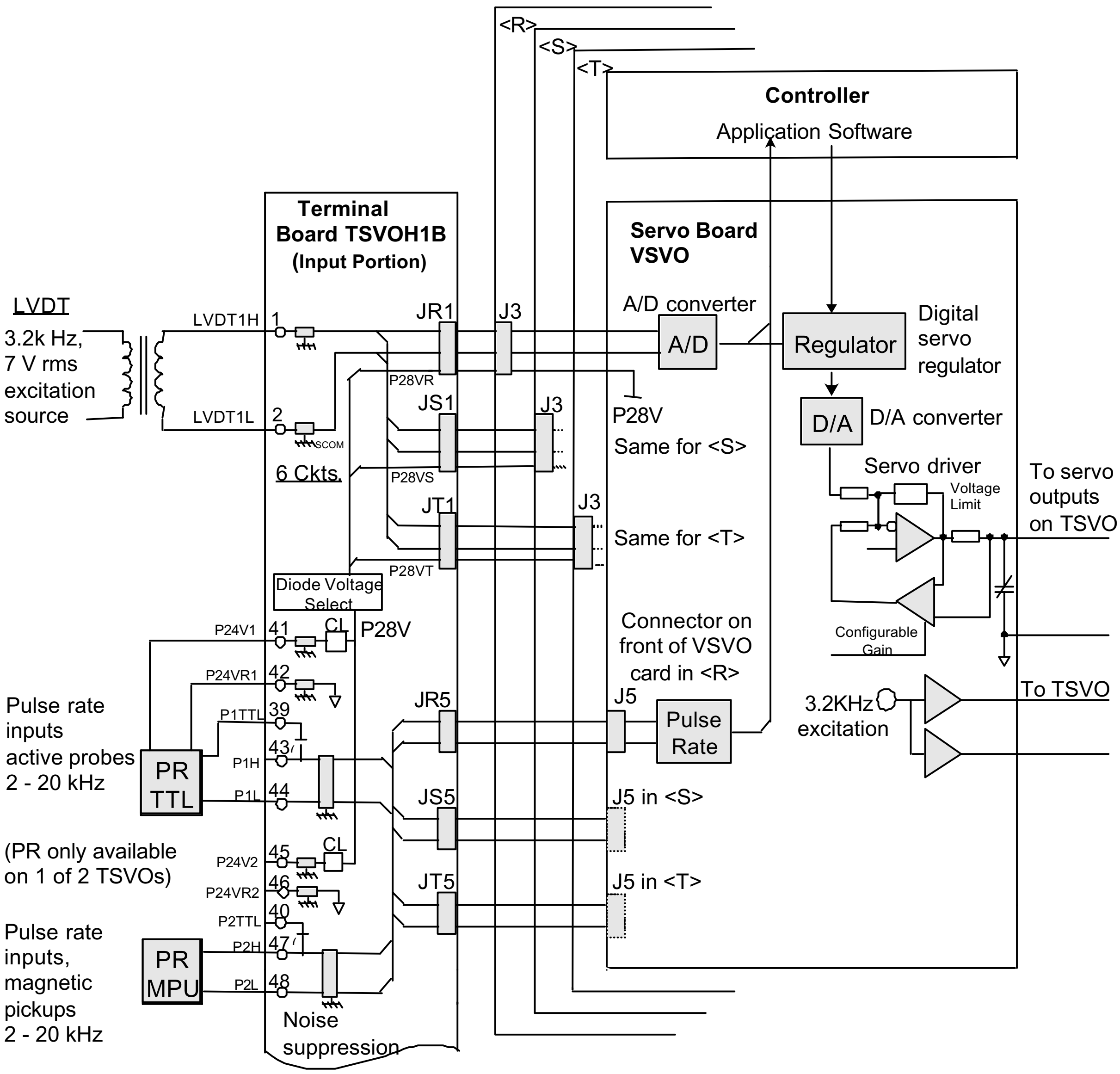
Another trip override relay K1 is provided on each terminal board which is driven from the <P> Protection Module. If an emergency overspeed condition is detected in the Protection Module, the K1 relay will energize and disconnect the VSVO servo output from the terminal block and apply a bias to drive the control valve closed. This is only used on Simplex applications to protect against the servo amplifier failing high, and is functional only with respect to the servo coils driven from <R>.



Servo Coil and LVDT Outputs, Simplex (continued) LVDT Outputs, Simplex (continued)

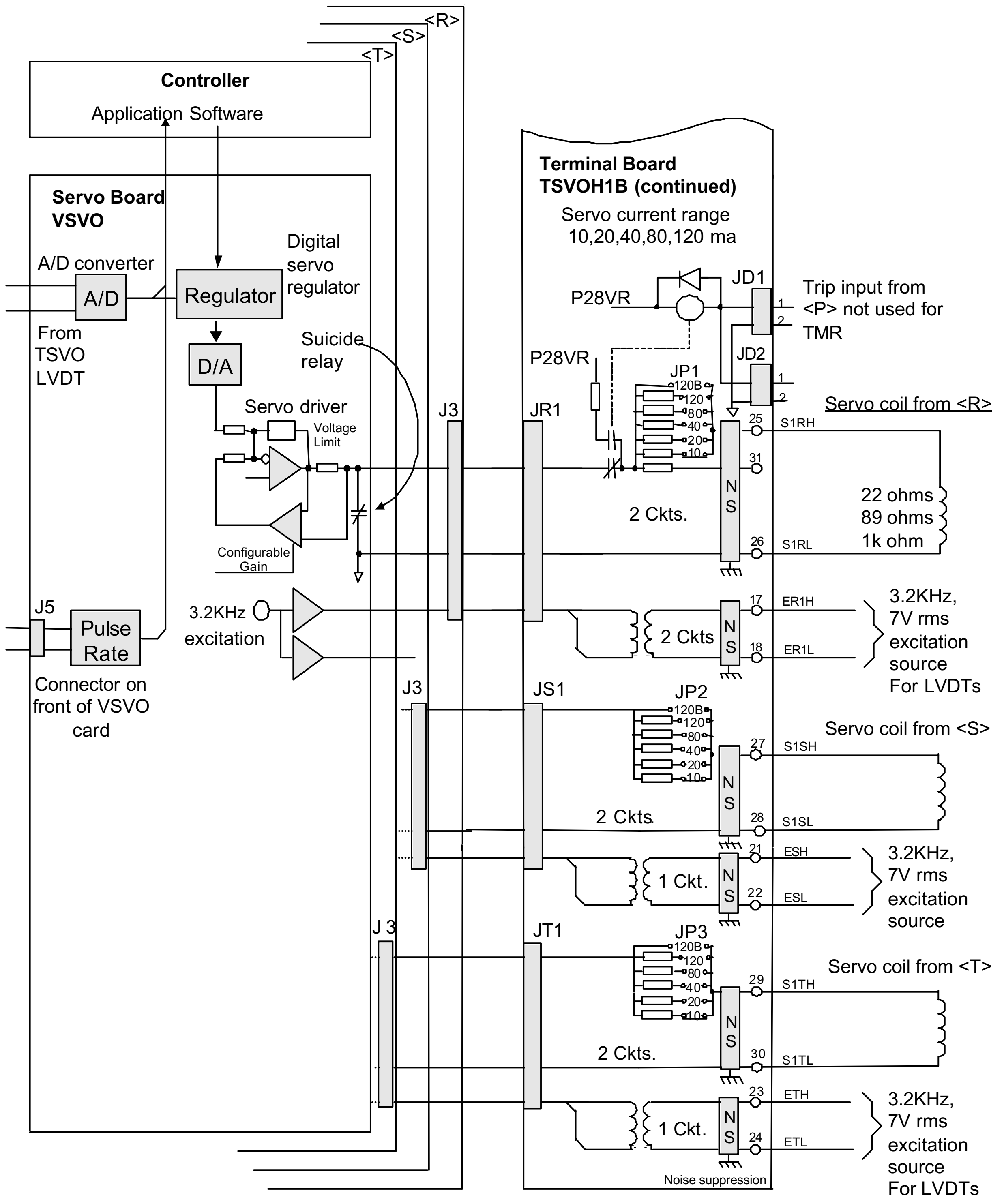
Only two pulse rate probes on one TSVO are used.

In TMR Applications, the LVDT signals on TSVO fan out to three racks through JR1, JS1, and JT1. Thee connectors also bring power into TSVO where the three voltages are diode high-selected and current limited to supply 24 V dc to the pulse rate active probes.



LVDT and Pulse Rate Inputs, TMR

For TMR systems, each servo channel has connections to three output coils with a range of current ratings up to 120 mA selected by jumper.



Servo Coil Outputs and LVDT Excitation, TMR

Servo Coil Ratings

Coil Type	Nominal Current	Coil Resistance (Ohms)	Internal Resistance (Ohms)	Application
1	± 10 mA	1,000	180	Simplex and TMR
2	± 20 mA	125	442	Simplex
3	± 40 mA	62	195	Simplex
4	± 40 mA	89	195	TMR
5	± 80 mA	22	115	TMR
6	± 120 mA (A)	40	46	Simplex
7	± 120 mA (B)	75	10	TMR

The total resistance would be equivalent to the standard setting.

The following table defines the standard servo coil resistance and their associated internal resistance, selectable with the terminal board jumpers shown in the figure above. In addition to these standard servo coils, it is possible to drive non-standard coils by using a non-standard jumper setting. For example, an 80 mA, 125-ohm coil could be driven by using a jumper setting 120B.

The excitation source is isolated from signal common (floating) and is capable of operation at common mode voltages up to 35 V dc, or 35 V rms, 50/60 Hz.

Control valve position is sensed with either a four wire LVDT or a three-wire linear variable differential reluctance (LVDR). Redundancy implementations for the feedback devices is determined by the application software to allow the maximum flexibility. LVDT/Rs can be mounted up to 300 meters (984 feet) from the turbine control with a maximum two-way cable resistance of 15 ohms.

Two LVDT/R excitation sources are located on each terminal board for Simplex applications and another two for TMR applications. Excitation voltage is 7 V rms and the frequency is 3.2 kHz with a total harmonic distortion of less than 1% when loaded.

The software limit check is adjustable in the field.

A typical LVDT/R has an output of 0.7 V rms as the zero stroke position of the valve stem, and an output of 3.5 V rms at the designed maximum stoke position (some applications have these reversed). The LVDT/R input is converted to dc and conditioned with a low pass filter. Diagnostics perform a high/low (hardware) limit check on the input signal and a high/low system (software) limit check.

Two pulse rate inputs are cabled to a single J5 connector on the VSVO board front. This is a dedicated connection to minimize noise sensitivity on the pulse rate inputs.

Inputs support both passive magnetic pickups and active pulse rate transducers (TTL type) interchangeably without configuration. Normally, these inputs are not used on steam turbine applications, but are usually for liquid fuel flow measurement, and monitoring flow divider feedback in gas turbine applications. Pulse rate inputs can be located up to 300 meters (984) from the turbine control cabinet; this assumes shielded-pair cable is used with typically 70 nF single ended or 35 nF differential capacitance and 15 ohms resistance.

The maximum short circuit current is approximately 100 mA with a maximum power output of 1 watt.

A frequency range of 2 to 30 kHz can be monitored at a normal sampling rate of either 10 or 20 ms. Magnetic pickups typically have an output resistance of 200 ohms and an inductance of 85 mH excluding cable characteristics. The transducer is a high impedance source, generating energy levels insufficient to cause a spark.

Specifications

Specifications

Item	Specification
Number of inputs (per TSVO)	6 LVDT windings 2 pulse rate signals (total of 2 per VSVO) External trip signal
Number of outputs (per TSVO)	2 servo valves (total of 4 per VSVO board) 4 excitation sources for LVDTs 2 excitation sources for pulse rate transducers
Internal sample rate	200 Hz
Power supply voltage	Nominal 24 V dc
LVDT accuracy	1 % with 14-bit resolution
LVDT input filter	Low pass filter with 3 down breaks at 50 rad/sec ±15%
LVDT common mode rejection	CMR is 1 V, 60 dB at 50/60 Hz
LVDT excitation output	Frequency of 3.2 +/- 0.2 kHz Voltage of 7.00 +/- 0.14 V rms
Pulse rate accuracy	0.05% of reading with 16-bit resolution at 50 Hz frame rate Noise of acceleration measurement is less than ± 50 Hz/sec for a 10,000 Hz signal being read at 10 ms
Pulse rate input	Minimum signal for proper measurement at 2 Hz is 33 mVpk, and at 12 kHz is 827 mVpk.
Magnetic PR pickup signal	Generates 150 V p-p into 60 K ohms
Active PR Pickup Signal	Generates 5 to 27 V p-p into 60 K ohms
Servo valve output accuracy	2% with 12-bit resolution Dither amplitude and frequency adjustable
Fault detection	Suicide servo outputs initiated by: Servo current out of limits or not responding Regulator feedback signal out of limits

Diagnostics

Three LEDs at the top of the VSVO front panel status information. The normal RUN condition is a flashing green, and FAIL is solid red. The third LED is normally off but displays a steady orange if an alarm condition exists on the board

Servo diagnostics cover items such as out of range LVDT voltage, servo suicide, servo current open circuit, and short circuit. If any one of the signals goes unhealthy a composite diagnostic alarm, L#DIAG_VSVO occurs. If the associated regulator has two sensors, the bad sensor is removed from the feedback calculation and the good sensor is used. Details of the individual diagnostics are available from the toolbox. The diagnostic signals can be individually latched, and reset with the RESET_DIA signal if they go healthy

Connectors Jr1, JS1, JT1 on the terminal board have their own ID device that is interrogated by the I/O board. The ID device is a read-only chip coded with the terminal board serial number, board type, revision number, and the plug location.

Configuration

The VSVO module is configured using the toolbox. This software usually runs on a data-highway connected CIMPLICITY station or workstation. The following table defines the configuration choices and defaults. For details refer to GEH-6403, *Control System Toolbox for Configuring the Mark VI Turbine Controller*.

Typical VSVO Configuration

Parameter	Description	Choices
Configuration		
System Limits	Select system limits	Enable, disable
Regulator 1	LVDT/R calibration	Online LVDT calibration, yes/no
RegType	Algorithm used in the regulator	Unused 1_PulseRate 2_PlsRateMAX 1_LVPosition 2_LV_PosMIN 2_LV_PosMID 2_LvpilotCyl 4_LVp/cylMAX 4_LV_LM 2_LV_posMAX
RegGain	Position loop gain in (%current/%position)	−100 to 100
RegNullBias	Null bias in % current, balances servo spring force	−100 to 100
DitherAmpl	Dither in % current (minimizes hysteresis)	Dither amp: 0 to 10
Monitor 1		
Monitor type	Monitor algorithm	Unused 1_Lvposition 2_LVposMIN 2_LVposMAX 3_LVposMID 1_LvposRatio 2_LVposRatio
J3:IS200TSVOH1A	Terminal board 1 connected to VSVO through J3	Connected, not connected
Servo Output1	Measured output current in percent – Board point	Point edit (input FLOAT)
Reg Number	Identify regulator number	Unused, Reg1, Reg2, Reg3, Reg4
Servo_MA_Out	Select current output for coil windings	10, 20, 40, 80, 120 mA
EnableCurSuic	Select Suicide function based on current	Enable, disable
Curr_Suicide	Percent current error to initiate suicide	0 to 100% (output current error)
EnablFbkSuic	Select Suicide function based on feedback	Enable, disable
Fdbk_Suicide	Percent position error to initiate suicide	0 to 100% (actuator position error)
Servo Output2	Measured output current in percent - Board point	Point edit (input FLOAT)
J4:IS200TSVOH1A	Terminal Board 2 connected to VSVO via J4	Connected, not connected
Servo Output3	Servo current output wired to valve - Board point	Point edit (input FLOAT)
Servo Output4	Servo current output wired to valve - Board point	Point edit (input FLOAT)
J5:IS00TSVOH1A	Pulse Rate inputs cabled to J5 connector	Connected, not connected

FlowRate1	Pulse rate input selected - Board point	Point edit (input FLOAT)
PRType	Select speed or flow type signal	Unused, speed, or flow
PRScale	Convert Hz to engineering units	0 to 1,000
SysLim1Enabl	Select system limit	Enable, disable
SysLim1Latch	Select whether alarm will latch	Latch, not latch
SysLim1Type	Select type of alarm initiation	>= or <=
SysLimit	Select alarm level in GPM or RPM	0 to 12,000
SystemLim2	Same as above	Same as above
TMR_DiffLimt	Difference limit off voted pulse inputs (EU)	0 to 12,000
FlowRate2	Pulse rate input selected - Board point (as above)	Point edit (input FLOAT)

Board Points Signals	**Description - Point Edit (Enter Signal Connection)**	**Direction**	**Type**
L3DIAG_VSVO1	Board diagnostic	Input	BIT
L3DIAG_VSVO2	Board diagnostic	Input	BIT
L3DIAG_VSVO3	Board diagnostic	Input	BIT
SysLim1PR1	Process alarm	Input	BIT
SysLim2PR1	Process alarm	Input	BIT
SysLim1PR2	Process alarm	Input	BIT
SysLim2PR2	Process alarm	Input	BIT
Reg1Suicide	Reg1 suicide relay status	Input	BIT
:	:	Input	BIT
Reg4Suicide	Reg4 suicide relay status	Input	BIT
Reg1_PosAFlt	Reg1, LM machine only, position A failure	Input	BIT
:	:	Input	BIT
Reg4_PosAFlt	Reg4, LM machine only, position A failure	Input	BIT
Reg1_PosBFlt	Reg1, LM machine only, position B failure	Input	BIT
:	:	Input	BIT
Reg4_PosBFlt	Reg4, LM machine only, position B failure	Input	BIT
Reg1_PosDif1	Reg1, LM machine only, position Diff failure	Input	BIT
:	:	Input	BIT
Reg4_PosDif1	Reg4, LM machine only, position diff failure	Input	BIT
Reg1_PosDif2	Reg1, LM machine only, position diff failure	Input	BIT
:	:	Input	BIT
Reg4_PosDif2	Reg4, LM machine only, position diff failure	Input	BIT
RegCalMode	Regulator under calibration	Input	BIT
Reg1_Fdbk	Regulator 1 feedback	Input	FLOAT
:	:	Input	FLOAT
Reg4_Fdbk	Regulator 4 feedback	Input	FLOAT
PilotFdbk1	Pilot/Cyl	Input	FLOAT

:	:	Input	FLOAT
PilotFdbk4	Pilot/Cyl	Input	FLOAT
Reg1_Error	Null bias error Input	Input	FLOAT
:	:	Input	FLOAT
Reg4_Error	Null bias error Input	Input	FLOAT
Accel1	GPM/sec	Input	FLOAT
Accel2	GPM/sec	Input	FLOAT
Mon1	Position monitor	Input	FLOAT
:	:	Input	FLOAT
Mon12	Position monitor	Input	FLOAT
CalibEnab1	Enable calibration reg 1	Output	BIT
:	:	Output	BIT
CalibEnab4	Enable calibration reg 4	Output	BIT
SuicideForce1	Force suicide reg 1	Output	BIT
:	:	Output	BIT
SuicideForce4	Force suicide reg 4	Output	BIT
PossDiffEnab1	Position difference enable reg 1, LM only	Output	BIT
:	:	Output	BIT
PossDiffEnab4	Position difference enable reg 4, LM only	Output	BIT
Reg1_Ref	Reg 1 position ref	Output	FLOAT
:	:	Output	FLOAT
Reg4_Ref	Reg 4 position ref	Output	FLOAT
Reg1-GainMod	Reg 1 gain modifier	Output	FLOAT
:	:	Output	FLOAT
Reg4-GainMod	Reg 4 gain modifier	Output	FLOAT
Reg1_NullCor	Reg 1 null bias correction	Output	FLOAT
:	:	Output	FLOAT
Reg4_NullCor	Reg 4 null bias correction	Output	FLOAT
Internal Variables	Internal variables to service the auto-calibration display, not configurable		

DSVO–Simplex DIN-rail Mounted Servo Terminal Board

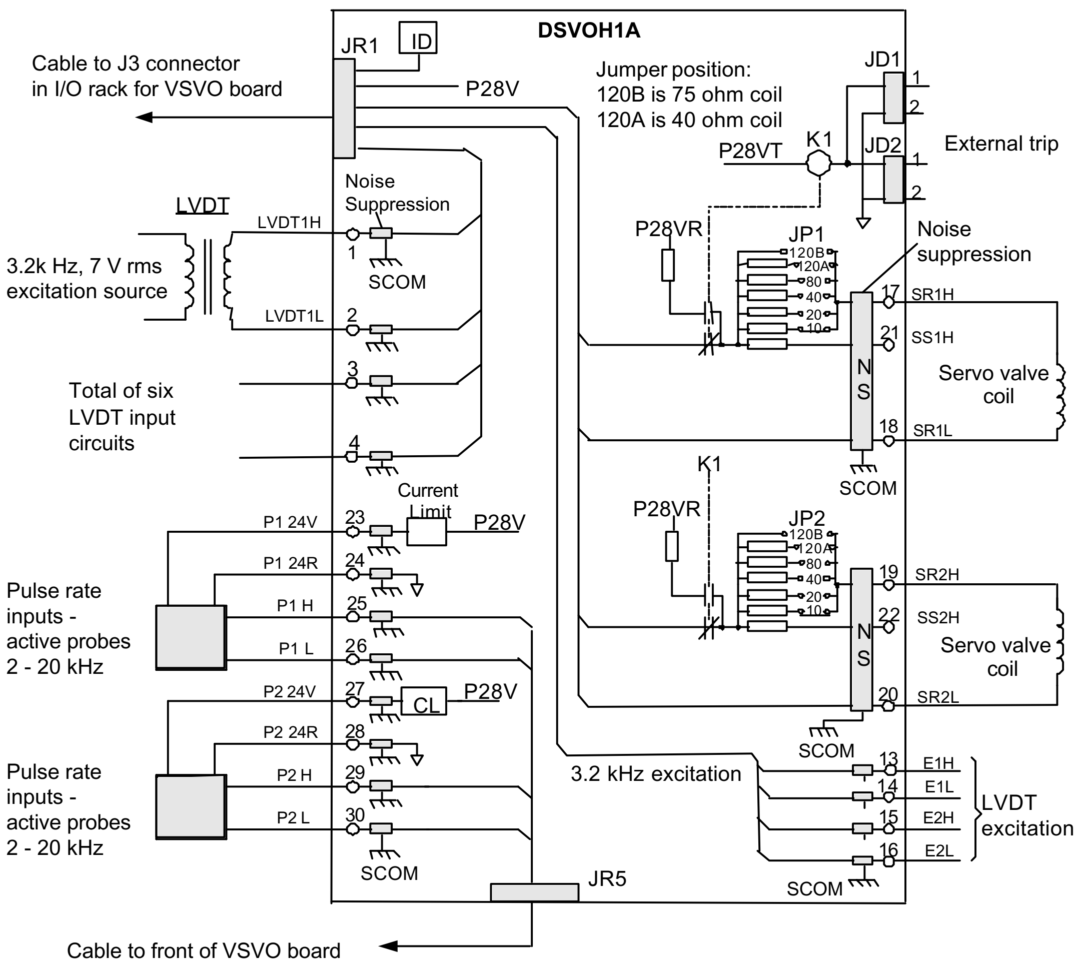
The DSVO board is a compact servo terminal board, designed for DIN_rail mounting. This board has two servo outputs, I/O for six LVDT position sensors, and two active pulse rate inputs for flow measurement (refer to the diagrams). Servo coil currents ranging from 10 to 120 mA can be jumper selected. DSVO connects to the VSVO processor board with a 37-pin cable, which are identical to those used on the larger TSVO board. The terminal boards can be stacked vertically on the DIN-rail to conserve cabinet space. Two DSVO boards can be connected to the VSVO, if required. Only the Simplex version of this board is available

The on-board functions and high frequency decoupling to ground are the same as those on the TSVO. High density Euro-Block type terminal blocks are permanently mounted to the board with six screws for the ground connection (SCOM). Each of the two connectors, JR1 and J5, connect to signals from on-board ID chips which identify the board to the VSVO for system diagnostic purposes.

There are versions of the DSVO, H1B and H2B. The H1B is a direct replacement for the previous H1A design. The H2B is certified by UL as Class 1 Division 2.

The differences between the H1B and H1B versions of DSVO are as follows:

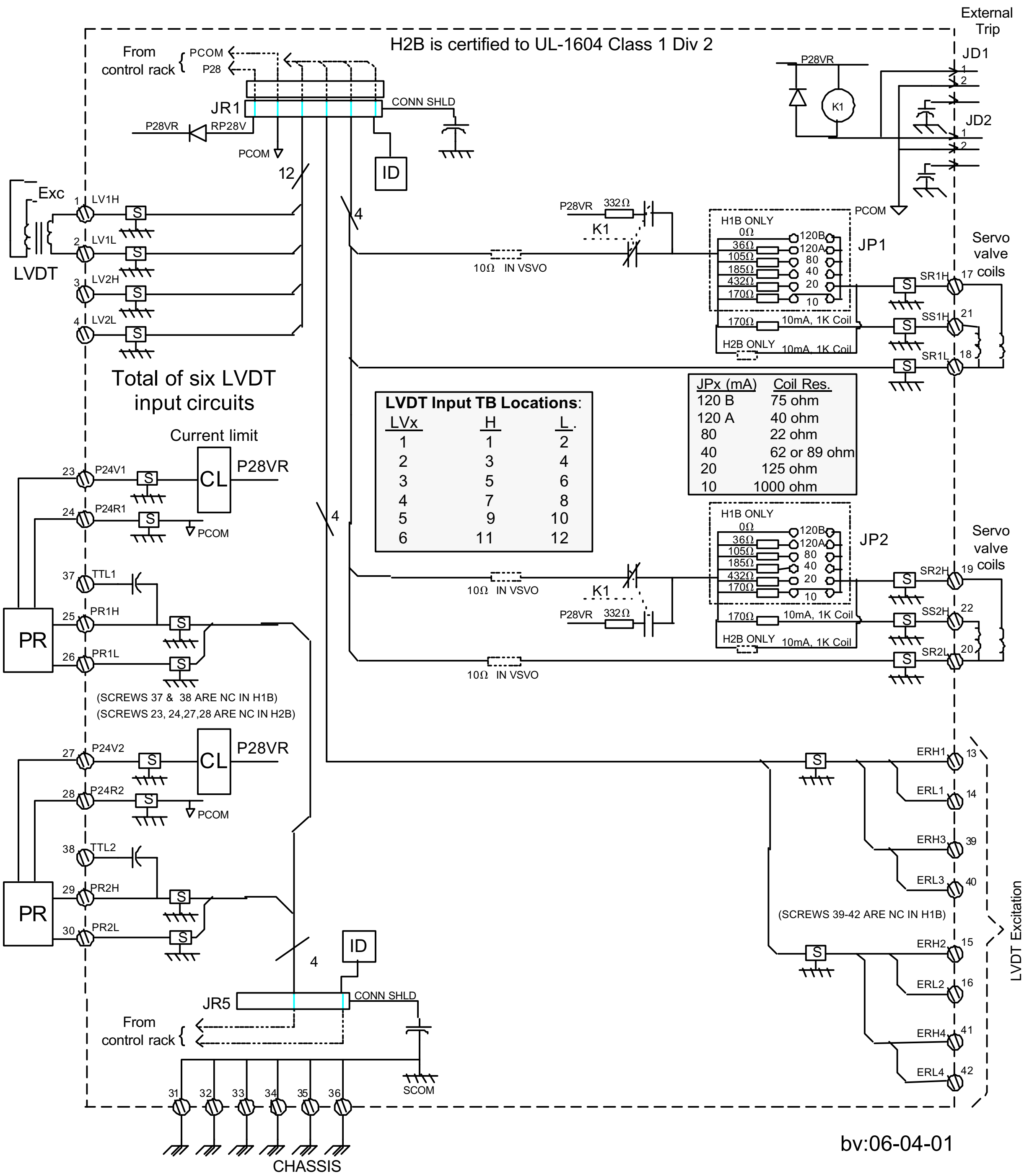
Function	**H1B**	**H2B**
Class 1, Div. 2 certification	No	Yes
Servo valves accommodated	75, 40, 22, 62, 89, 125, 1k ohms	1k ohms (10 mA)
LVDT excitation outputs	Qty. = 2, 120 mA each	Qty. = 4, 60 mA each
Excitation for pulse rate probes	Qty. = 2, 24 V dc, 100 mA each	No
Additional pulse rate inputs for TTL signals	No	Qty. = 2



DSVOH1A Board

Mark VI Servo Valve Terminal Board IS200DSVOH1B, H2B

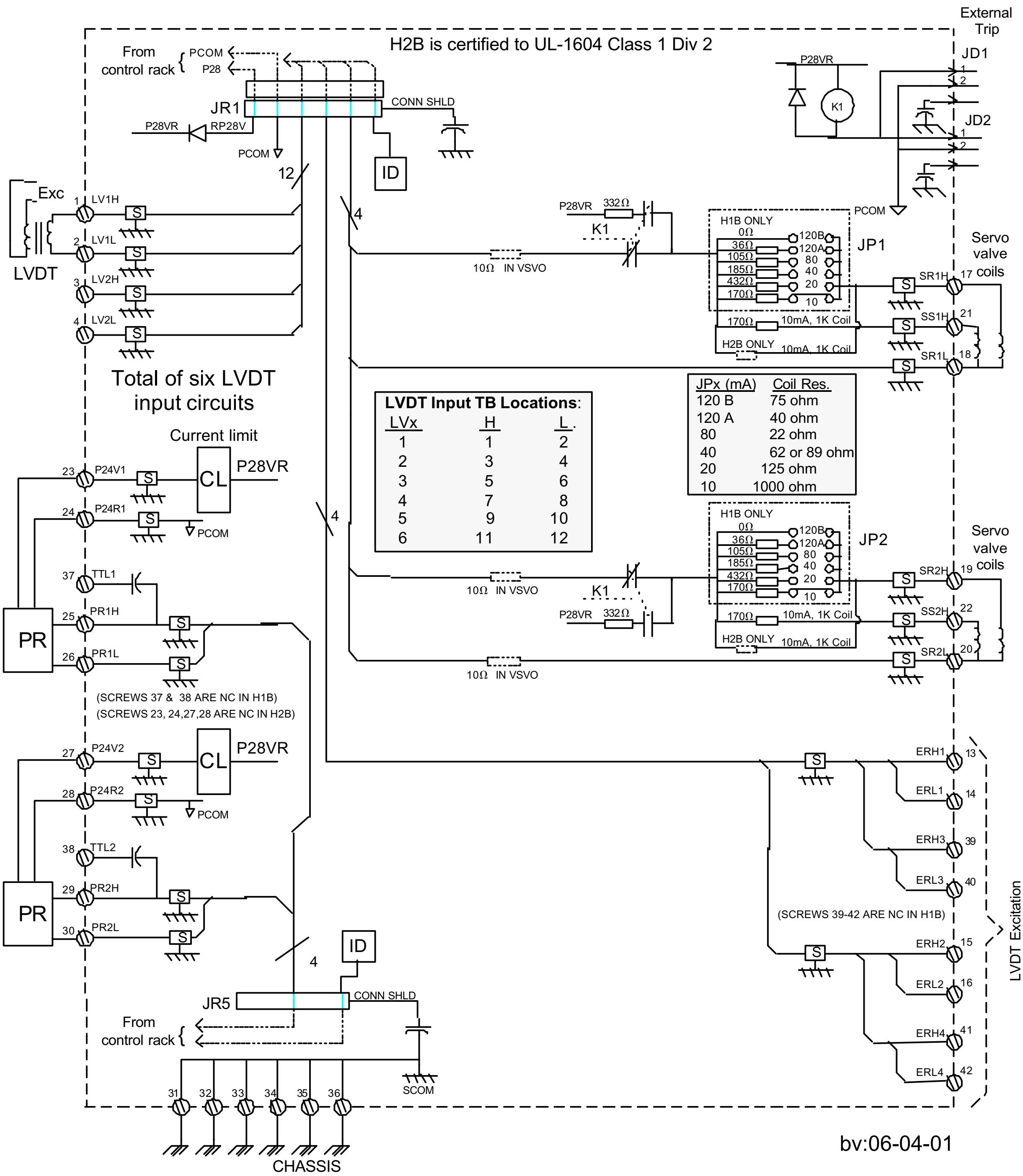
(IS200DSVOH1B Replaces IS200DSVOH1A)



DSVOH1B, H2B Board (Part 1 of 2)

Mark VI Servo Valve Terminal Board IS200DSVOH1B, H2B

(IS200DSVOH1B Replaces IS200DSVOH1A)

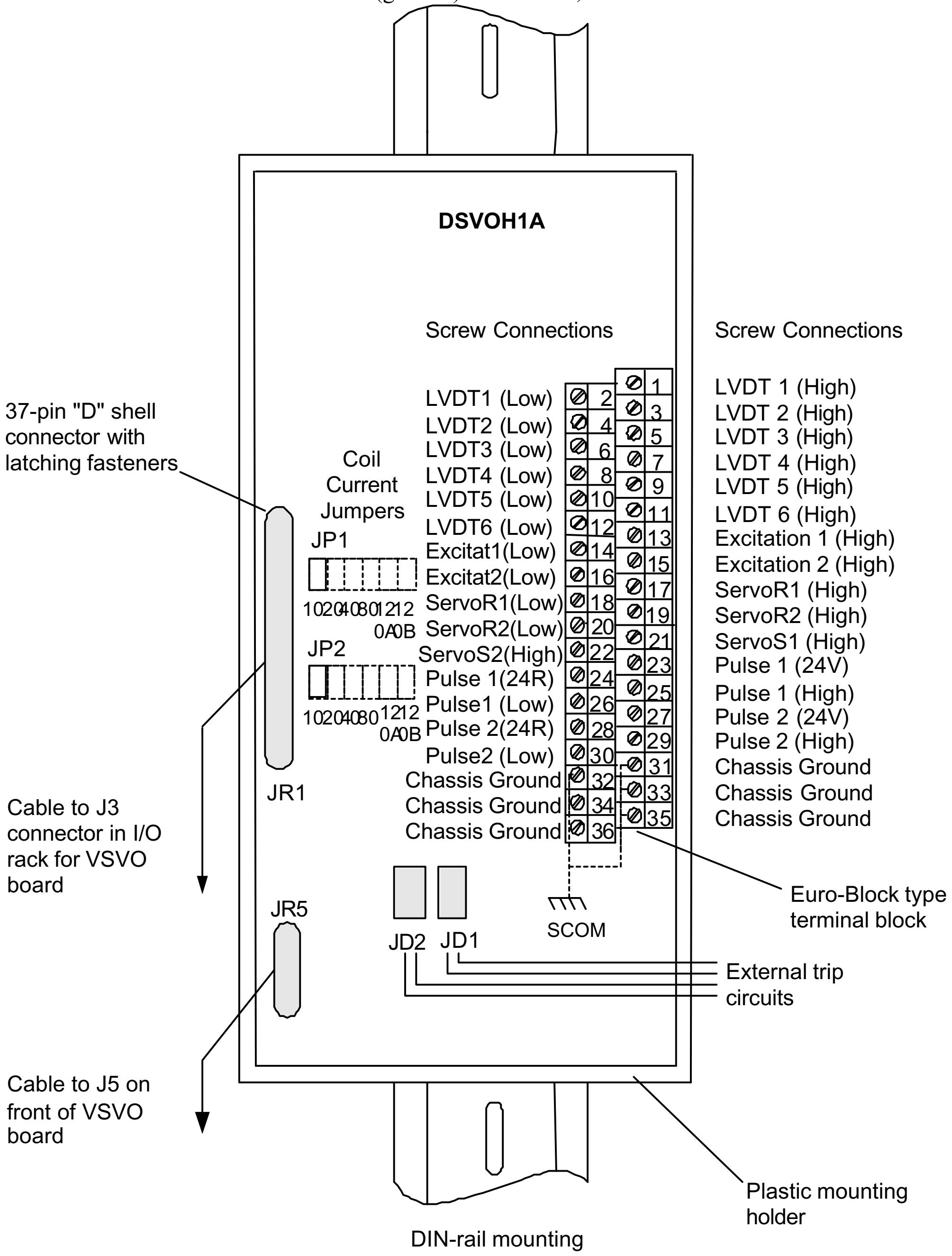


DSVOH1B, H2B board (Part 2 of 2)

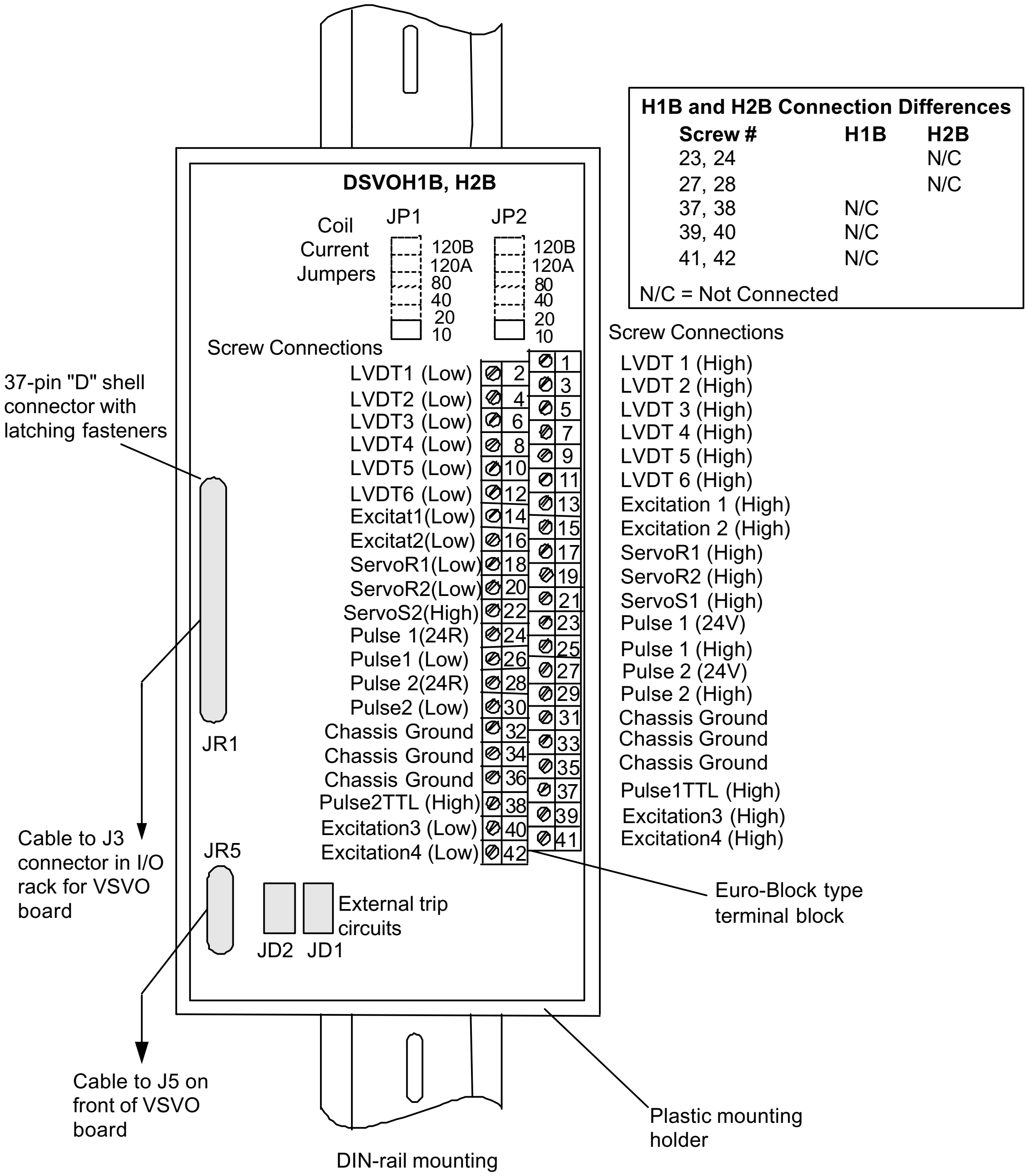
Installation

There is no shield termination strip with this design.

The DSVO board slides into a plastic holder, which mounts on the DIN-rail. The servo I/O are wired directly to the Euro-Block type terminal block as shown in the following figures. This has 36 terminals (DSVOH1A) or 42 terminals (DSVOH1B, H2B); typically #18 AWG shielded twisted pair wiring is used. There are six screws for SCOM (ground) connection, which should be as short as distance as possible.



DSVIH1A Wiring and Cabling



H1B and H2B Connection Differences

Screw #	H1B	H2B
23, 24		N/C
27, 28		N/C
37, 38	N/C	
39, 40	N/C	
41, 42	N/C	

N/C = Not Connected

DSVOH1B, H2B Wiring and Cabling

I/O Board Alarms

Diagnostic alarms for any I/O board can be displayed and reset from the toolbox. For troubleshooting and general diagnostic alarm information refer to GEH-6421 Volume I, Chapter 8.

I/O Board Diagnostic Alarms

Board	Fault	Fault Description	Possible Cause
VSVO	**2**	Flash Memory CRC Failure	Board firmware programming error (board will not go online)
	3	CRC failure override is Active	Board firmware programming error (board is allowed to go online)
	16	System Limit Checking is Disabled	System checking was disabled by configuration.
	17	Board ID Failure	Failed ID chip on the VME I/O board
	18	J3 ID Failure	Failed ID chip on connector J3, or cable problem
	19	J4 ID Failure	Failed ID chip on connector J4, or cable problem
	20	J5 ID Failure	Failed ID chip on connector J5, or cable problem
	21	J6 ID Failure	Failed ID chip on connector J6, or cable problem
	22	J3A ID Failure	Failed ID chip on connector J3A, or cable problem
	23	J4A ID Failure	Failed ID chip on connector J4A, or cable problem
	24	Firmware/Hardware Incompatibility	Invalid terminal board connected to VME I/O board
	30	ConfigCompatCode mismatch; Firmware: #; Tre: # The configuration compatibility code that the firmware is expecting is different than what is in the tre file for this board	A tre file has been installed that is incompatible with the firmware on the I/O board. Either the tre file or firmware must change. Contact the factory.
	31	IOCompatCode mismatch; Firmware: #; Tre: # The I/O compatibility code that the firmware is expecting is different than what is in the tre file for this board	A tre file has been installed that is incompatible with the firmware on the I/O board. Either the tre file or firmware must change. Contact the factory.
	33-44	LVDT # RMS Voltage Out of Limits. Minimum and maximum LVDT limits are configured	The LVDT may need recalibration.
	45	Calibration Mode Enabled	The VSVO was put into calibration mode.
	46	VSVO Board Not Online, Servos Suicided. The servo is suicided because the VSVO is not on-line	The controller (R, S, T) or IONet is down, or there is a configuration problem with the system preventing the VCMI from bringing the board on line.

47-51	Servo Current # Disagrees with Reference, Suicided. The servo current error (reference - feedback) is greater than the configured current suicide margin	A cable/wiring open circuit, or board problem.
52-56	Servo Current # Short Circuit. This is not currently used	NA
57-61	Servo Current # Open Circuit. The servo voltage is greater than 5V and the measured current is less than 10%	A cable/wiring open circuit, or board problem.
62-66	Servo Position # Feedback Out of Range, Suicided. Regulator number # position feedback is out of range, causing the servo to suicide	LVDT or board problem
67-71	Configuration Message Error for Regulator Number #. There is a problem with the VSVO configuration and the servo will not operate properly	The LVDT minimum and maximum voltages are equal or reversed, or an invalid LVDT, regulator, or servo number is specified.
72	Onboard Calibration Voltage Range Fault. The A/D calibration voltages read from the FPGA are out of limits, and the VSVO will use default values instead	A problem with the Field Programmable Gate Array (FPGA) on the board
73-75	LVDT Excitation # Voltage out of range	There is a problem with the LVDT excitation source on the VSVO board.
77	Servo output assignment mismatch. Regulator types 8 & 9 use two servo outputs each. They have to be consecutive pairs, and they have to be configured as the same range	Fix the regulator configurations.
128-191	Logic Signal # Voting mismatch. The identified signal from this board disagrees with the voted value	A problem with the input. This could be the device, the wire to the terminal board, the terminal board, or the cable.
224-259	Input Signal # Voting mismatch, Local #, Voted #. The specified input signal varies from the voted value of the signal by more than the TMR Diff Limit	A problem with the input. This could be the device, the wire to the terminal board, the terminal board, or the cable.

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