VVIB Vibration/Position Board

Board Specification

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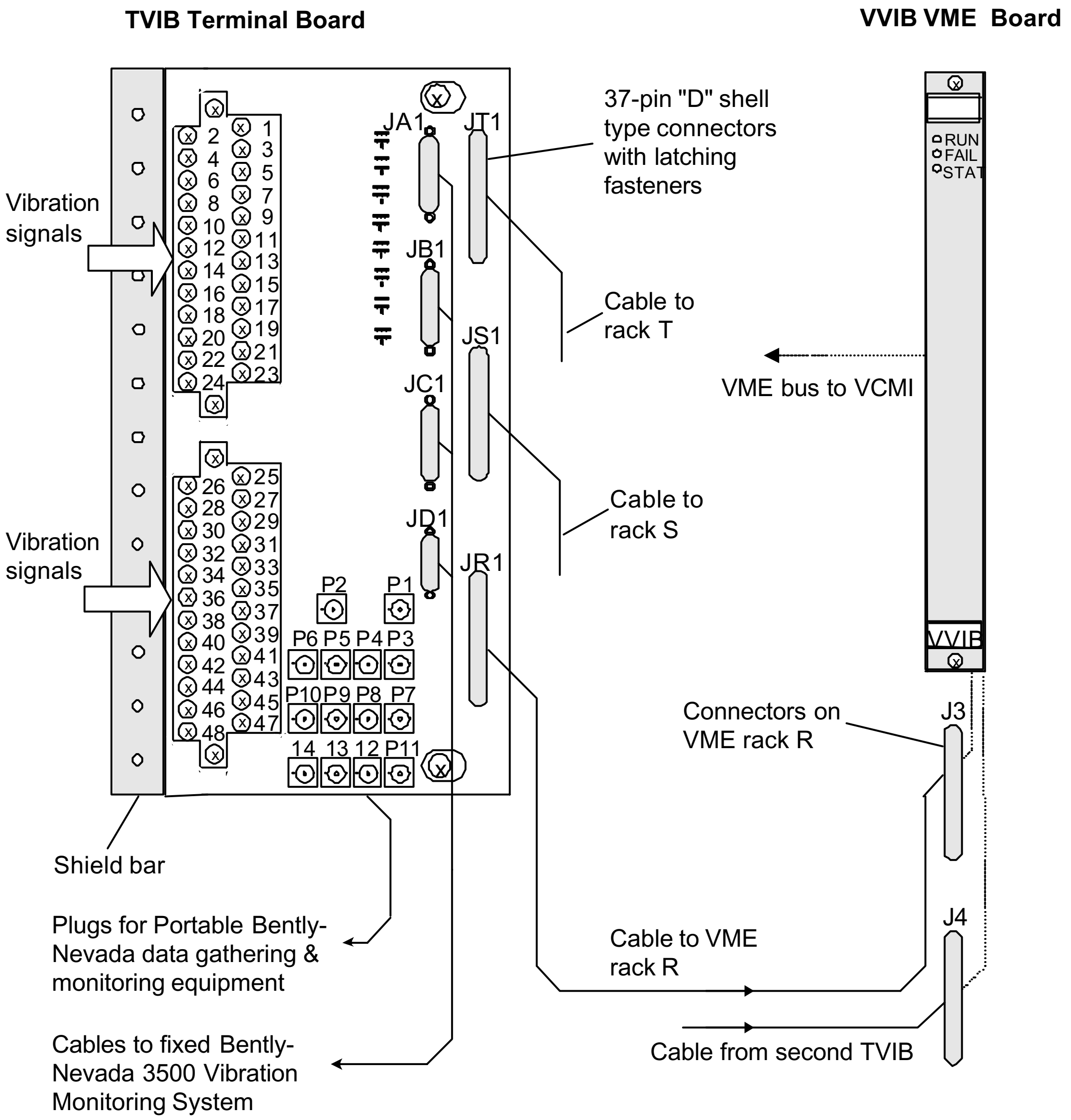
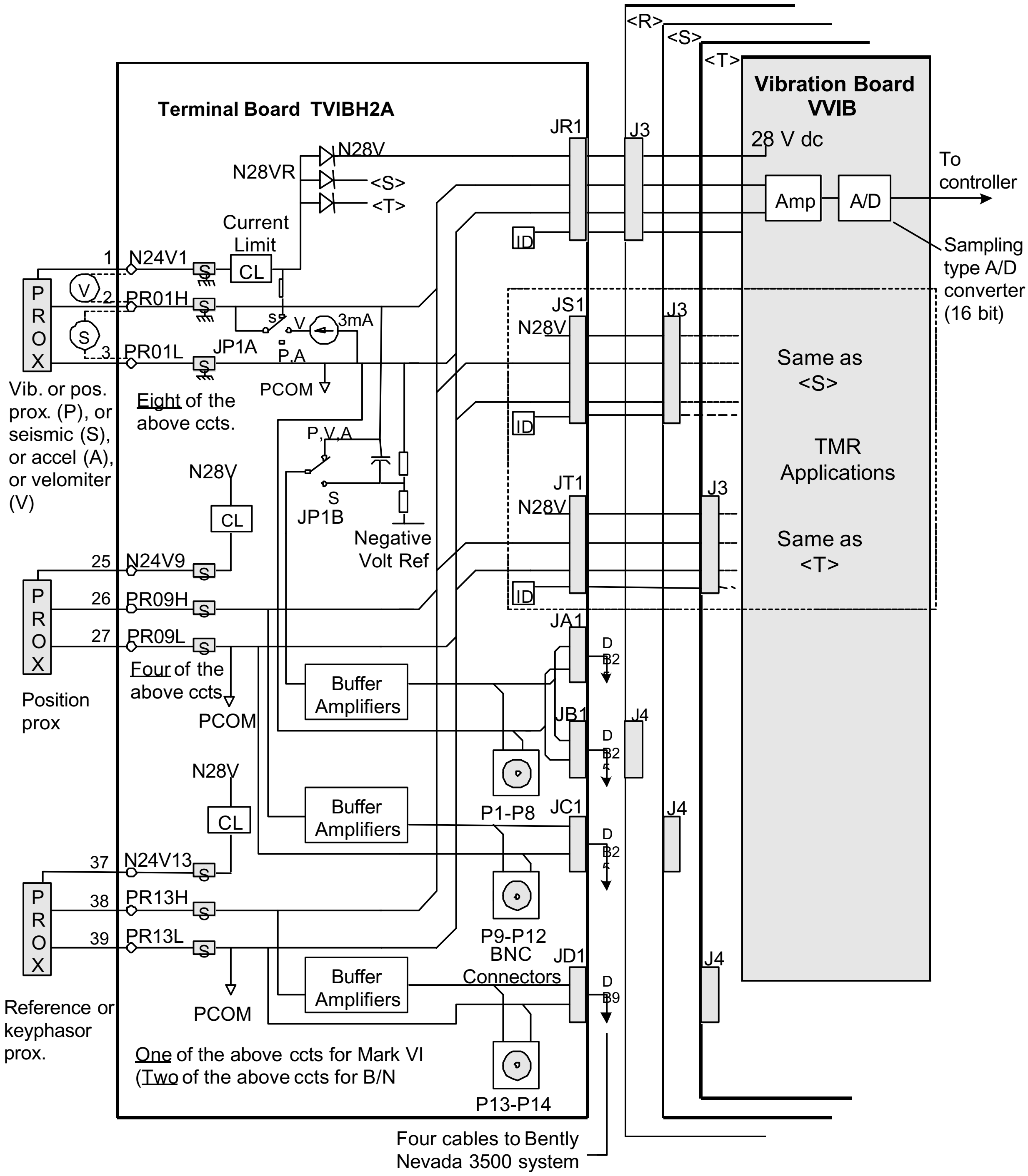
Functional Description

If desired a Bently Nevada 3500 monitoring system can be cabled into the terminal board to permanently monitor turbine vibration.

The Mark VI system uses Bently Nevada probes for shaft vibration monitoring. Up to 14 probes connect directly to the TVIB terminal board, two of which can be cabled to the VVIB board. The signals are processed by the VVIB board, and the digitized displacement and velocity signals are sent over the VME bus to the controller. Also the type 2 terminal board (H2A) has BNC connectors allowing portable vibration data gathering equipment to be plugged in for predictive maintenance purposes.



Vibration Terminal Board, Processor Board, and Cabling

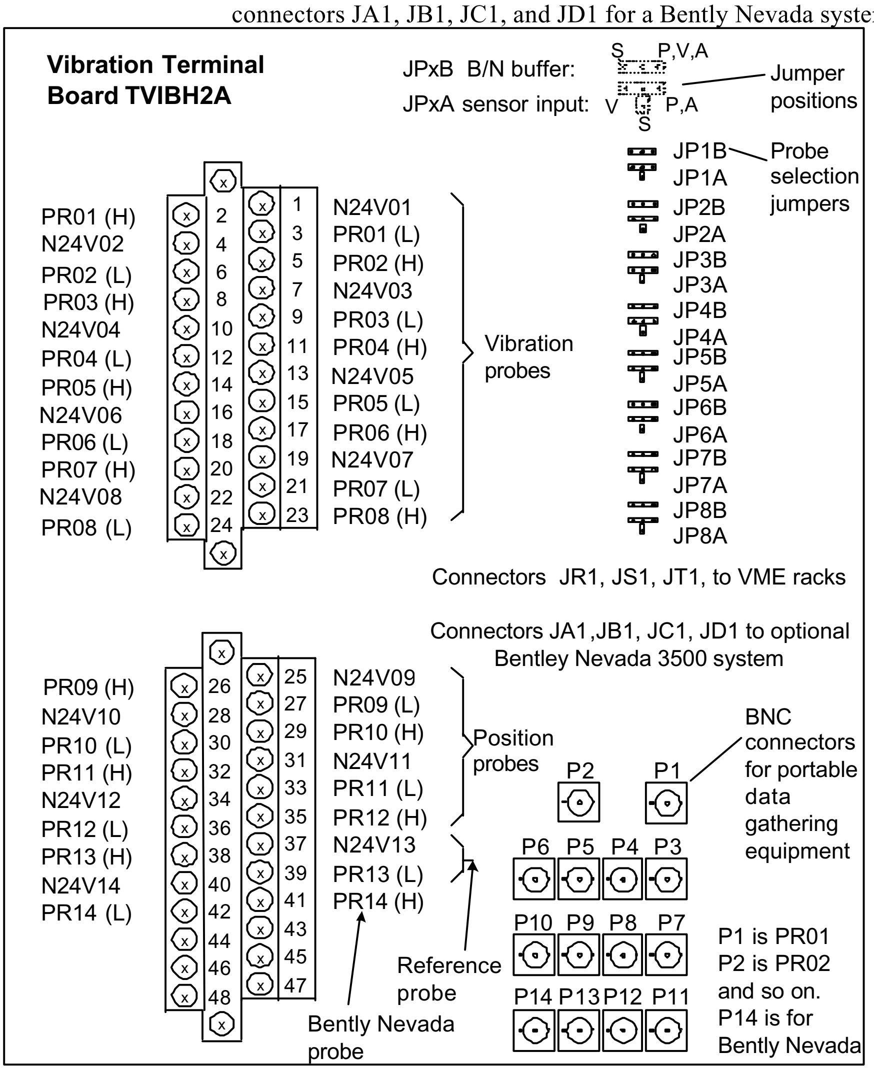


TVIB Board, Vibration Probes, and Bently Nevada Interface

Installation

There are no permanent cable connections to BNCs P1 through P14.

Fourteen vibration probes are wired to the two terminal blocks, three wires per probe. Jumpers JP1 through JP8 select the type of the first eight probes. Use of connectors JA1, JB1, JC1, and JD1 for a Bently Nevada system is optional.



Ckt	Sensor	Connector Pin Assignments Conn	Comm	Sign	Shld	Px, BNC Connector
01	Vib 1	JA1	2	3	4	P1
02	Vib 2	JA1	6	7	8	P2
03	Vib 3	JA1	10	11	12	P3
04	Vib 4	JA1	24	23	22	P4
05	Vib 5	JB1	2	3	4	P5
06	Vib 6	JB1	6	7	8	P6
07	Vib 7	JB1	10	11	12	P7
08	Vib 8	JB1	24	23	22	P8
09	Pos 1	JC1	2	3	4	P9
10	Pos 2	JC1	6	7	8	P10
11	Pos 3	JC1	10	11	12	P11
12	Pos 4	JC1	24	23	22	P12
13	Ref probe	JD1	3	1	2	P13
14	B/N only	JD1	9	5	4	P14

Jumper JPXA:
S = Seismic
V = Velomitor
P = Proximitor
A = Accelerometer

Jumper JPXB:
S = Seismic
V = Velomitor
P = Proximitor
A = Accelerometer

Terminal Board TVIB Wiring

Operation

TVIB supports Proximitor, Seismic, Accelerometer, and Velomitor probes of the type supplied by Bently Nevada. Power for the vibration probes comes from the VVIB boards, in either Simplex or TMR mode. The probe signals return to VVIB where they are A/D converted and sent over the VME bus to the controller. Vibration, eccentricity, and axial position alarms and trip logic are generated in the controller.

A –28 V dc source is supplied to the terminal board from the VME board for Proximitor power. In TMR systems, a diode high-select circuit selects the highest –28 V dc bus for redundancy. Regulators provide individual excitation sources, –23 to –26 V dc, short circuit protected. Probe inputs are sampled at high speed over discrete time periods. The maximum and minimum values are accumulated, the difference is taken (max-min) for vibration, and the results are filtered. The resulting peak to peak voltage is scaled to yield mils (peak to peak) displacement, or velocity.

Features

Vibration Functions

Vibration probe inputs are normally used for four protective functions in turbine applications as follows:

Vibration: Proximity probes monitor the peak-to-peak radial displacement of the shaft (the shaft motion in the journal bearing) in two radial directions. This system uses non-contacting probes and proximitors, and results in alarm, trip, and fault detection.

Rotor Axial Position: A probe is mounted in a bracket assembly off the thrust bearing casing to observe the motion of the thrust collar on the turbine rotor. This system uses non-contacting probes and Proximitors, and results in thrust bearing wear alarm, trip, and fault detection.

Differential Expansion: This application uses non-contacting probe(s) and proximitor(s) and results in alarm, trip, and fault detection for excessive expansion differential between the rotor and the turbine casing.

Rotor Eccentricity: A probe is mounted adjacent to the shaft to continuously sense the surface and update the turbine control. The calculation of eccentricity is made once per revolution while the turbine is on turning gear. Alarm and fault indications are provided.

Probes

The eight vibration inputs on each terminal board can be applied as either proximitor, accelerometer, seismic (velocity), or velomitor inputs. Jumpers on the terminal board are used to assign a specific vibration sensor type to each input point with the seismic type assigned to point (S), the velomitor type assigned to point (V), and the proximitor and accelerometer types sharing point (P/A). A proximitor reads a shaft keyway to generate a once per revolution keyPhasor input for phase angle reference.

Specifications

VIB Specifications

Item	Specification			
Number of Channels	TVIB: 13 probes: 8 vibration, 4 position, 1 keyPhasor VVIB: 26 probes with two TVIB boards			
Vibration	**Measurement**	**Range**	**Accuracy**	**Frequency**
Proximity	Displacement 5 to 200 Hz	0 to 4.5 V pp	±0 .030 V pp	
	Displacement 200 to 500 Hz	0 to 4.5 V pp	±0 .150 V pp	
Seismic	Velocity	0 to 2.25 V p 5 to 200 Hz	Max [2% reading, ±0.008 Vp]	
	Velocity	0 to 2.25 V p 200 to 500 Hz	Max [5% reading, ±0.008 Vp]	
Velomitor	Velocity	0 to 2.25 V p 5 to 200 Hz	Max [2% reading, ±0.008 Vp]	
	Velocity	0 to 2.25 V p 200 to 500 Hz	Max [5% reading, ±0.008 Vp]	
Accelerometer	Velocity (track filter) 10 to 233 Hz	0 to 2.25 V p	±0 .015 Vp	
Position	Position	–.5 to –20 V dc Air gap (average)	±0.2 V dc	
Phase	Degrees (1X vibration component with respect to key slot)	0 to 360 degrees Up to 14,000 rpm	±2 degrees	
Probe power	–24 V dc from the –28 V dc bus; each probe supply is current limited 12 mA load per transducer			
Probe signal sampling	16-bit A/D converter with 14-bit resolution on the VVIB Sampling rate is 4,600 samples per second in fast scan mode (4,000 to 17,500 rpm) Sampling rate is 2,586 samples per second for nine or more probes (less than 4,000 rpm) All inputs are simultaneously sampled in time windows of 160 ms			
Rated RPM	If greater than 4,000 rpm, can use eight vibration channels, (others can be prox/position) If less than 4,000 rpm, can use 16 vibration channels, and other probes			
Buffered outputs	Amplitude accuracy is 0.1% for signal to Bently Nevada 3500 vibration analysis system			

Diagnostics

Diagnostics perform a high/low (hardware) limit check on the input signal and a high/low system (software) limit check. The software limit check is adjustable in the field.

A probe fault, alarm, or trip condition will occur if either of an X or Y probe pair exceeds its limits. In addition, the application software will inhibit a vibration trip (the ac component) if a probe fault is detected based on the dc component.

Position inputs for thrust wear protection, differential expansion, and eccentricity are monitored similar to the vibration inputs except only the dc component is used for a position indication. A 16-bit sampling type A/D converter is used with 14-bit resolution and overall circuit accuracy of 1% of full scale.

Vibration Monitoring and Analysis

Mark VI provides vibration protection and displays the basic vibration parameters.

Each input is actively isolated and the signals made available through four plugs for direct cabling to a Bently Nevada 3500 monitor. This configuration provides the maximum reliability by having a direct interface from the proximitors to the turbine control for trip protection and still retain the real-time data access to the Bently Nevada system for static and dynamic vibration monitoring. Note that the Mark VI displays the total vibration, the 1X vibration component and the 1X vibration phase angle, but it is not intended as a vibration analysis system.

Fourteen BNC connectors on TVIB provide buffered signals available to portable data gathering equipment for predictive maintenance purposes. Buffered outputs have unity gain, 10 K ohm internal impedance, and can drive loads up to 1500 oh Configuration.

VVIB Configuration

Parameter	Description	Choices
Configuration		
System limits	Enable system limits	Enable, disable
Vib_PP_Fltr	First order filter time constant (sec)	0.01 to 2
LMVib1A	Vib, 1X component, for LM_RPM_A, input #1 - board point	Point edit (input FLOAT)
SysLim1Enable	Enable system limit 1 fault check	Enable, disable
SysLim1Latch	Latch system limit 1 fault	Latch, not latch
SysLim1Type	system limit 1 check type	>= or <=
SysLimit1	System Limit 1 - Vibration in mils (Prox) or Inch/sec (seismic, accel)	–100 to +100
SysLim2Enable	Enable system limit 2 (same configuration as above)	Enable, disable
TMR_DiffLimt	Difference limit for voted TMR inputs in volts or mils	–100 to +100
LMVib1B	Vib, 1X component, for LM_RPM_B, #1 - board point	Point edit (input FLOAT)
LMVib1C	Vib, 1X component, for LM_RPM_C, #1 - board point	Point edit (input FLOAT)
LMVib2A	Vib, 1X component, for LM_RPM_A, #2 - board point	Point edit (input FLOAT)
LMVib2B	Vib, 1X component, for LM_RPM_B, #2 - board point	Point edit (input FLOAT)
LMVib2C	Vib, 1X component, for LM_RPM_C, #2 - board point	Point edit (input FLOAT)
LMVib3A	Vib, 1X component, for LM_RPM_A, #3 - board point	Point edit (input FLOAT)
LMVib3B	Vib, 1X component, for LM_RPM_B, #3 - board point	Point edit (input FLOAT)
LMVib3C	Vib, 1X component, for LM_RPM_C, #3 - board point	Point edit (input FLOAT)
J3:IS200TVIBH1A	Vibration terminal board, first of two	Connected, not connected
GAP1_VIB1	Average air gap (for Prox) or dc volts (for others) - board point	Point edit (input FLOAT)
VIB_Type	Type of vibration probe	Unused, PosProx, VibProx, VibProx-KPH1, VibProx-KPH2, VibLMAccel, VibVelomitor, KeyPhasor
VIB_Scale	Volts/mil or volts/ips	0 to 2
ScaleOff	Scale offset for prox position only, in mils	0 to 90
SysLim1Enable	Enable system limit 1	Enable, disable
SysLim1Latch	Latch the alarm	Latch, not latch
SysLim1Type	System limit 1 check type	>= or <=
SysLimit1	System limit 1 – GAP in negative volts (for vel) or positive mils (prox)	–100 to +100

SysLim2Enabl	Enable system limit 2 (same configuration as above)	Enable, disable
TMR_DiffLimt	Difference limit for voted TMR inputs in volts or mils	–100 to +100
Vib1	Vibration, displacement (pk-pk) or velocity (pk) - board point	Point edit (input FLOAT)
SysLim1Enable	System limits configured as above	Enable, disable
GAP2_VIB2	Second vibration probe of 8 - board point	Point edit (input FLOAT)
Vib2	Vibration, displacement (pk-pk) or velocity (pk) - board point	Point edit (input FLOAT)
GAP9_POS1	First position probe of 4 - board point	Point edit (input FLOAT)
GAP13_KPH1	KeyPhasor probe air gap - board point	Point edit (input FLOAT)
J4:IS200TVIBH1A	Second vibration terminal board	Connected, not connected
GAP14_VIB9	First Vibration Probe of 8 - board point	Point edit (input FLOAT)
Vib9	Vibration, displacement (pk-pk) or velocity (pk) - board point	Point edit (input FLOAT)
GAP22_POS5	First position probe of 4 - board point	Point edit (input FLOAT)
GAP26_KPH2	KeyPhasor probe air gap - board point	Point edit (input FLOAT)

Board Points Signals	Description - Point Edit (Enter Signal Connection)	Direction	Type
L3DIAG_VVIB1	Board diagnostic	Input	BIT
L3DIAG_VVIB2	Board diagnostic	Input	BIT
L3DIAG_VVIB3	Board diagnostic	Input	BIT
SysLim1GAP1	Gap signal limit	Input	BIT
:	:	Input	BIT
SysLim1GAP26	Gap signal limit	Input	BIT
SysLim2GAP1	Gap signal limit	Input	BIT
:	:	Input	BIT
SysLim2GAP26	Gap signal limit	Input	BIT
SysLim1VIB1	Vibration signal limit	Input	BIT
:	:	Input	BIT
SysLim1VIB16	Vibration signal limit	Input	BIT
SysLim1ACC1	Acceleration signal limit	Input	BIT
:	:	Input	BIT
SysLim1ACC9	Acceleration signal limit	Input	BIT
SysLim2VIB1	Vibration signal limit	Input	BIT
:	:	Input	BIT
SysLim2VIB16	Vibration signal limit	Input	BIT
SysLim2ACC1	Acceleration signal limit	Input	BIT
:	:	Input	BIT
SysLim2ACC9	Acceleration signal limit	Input	BIT
RPM_KPH1	Speed RPM, of KP #1	Input	FLOAT

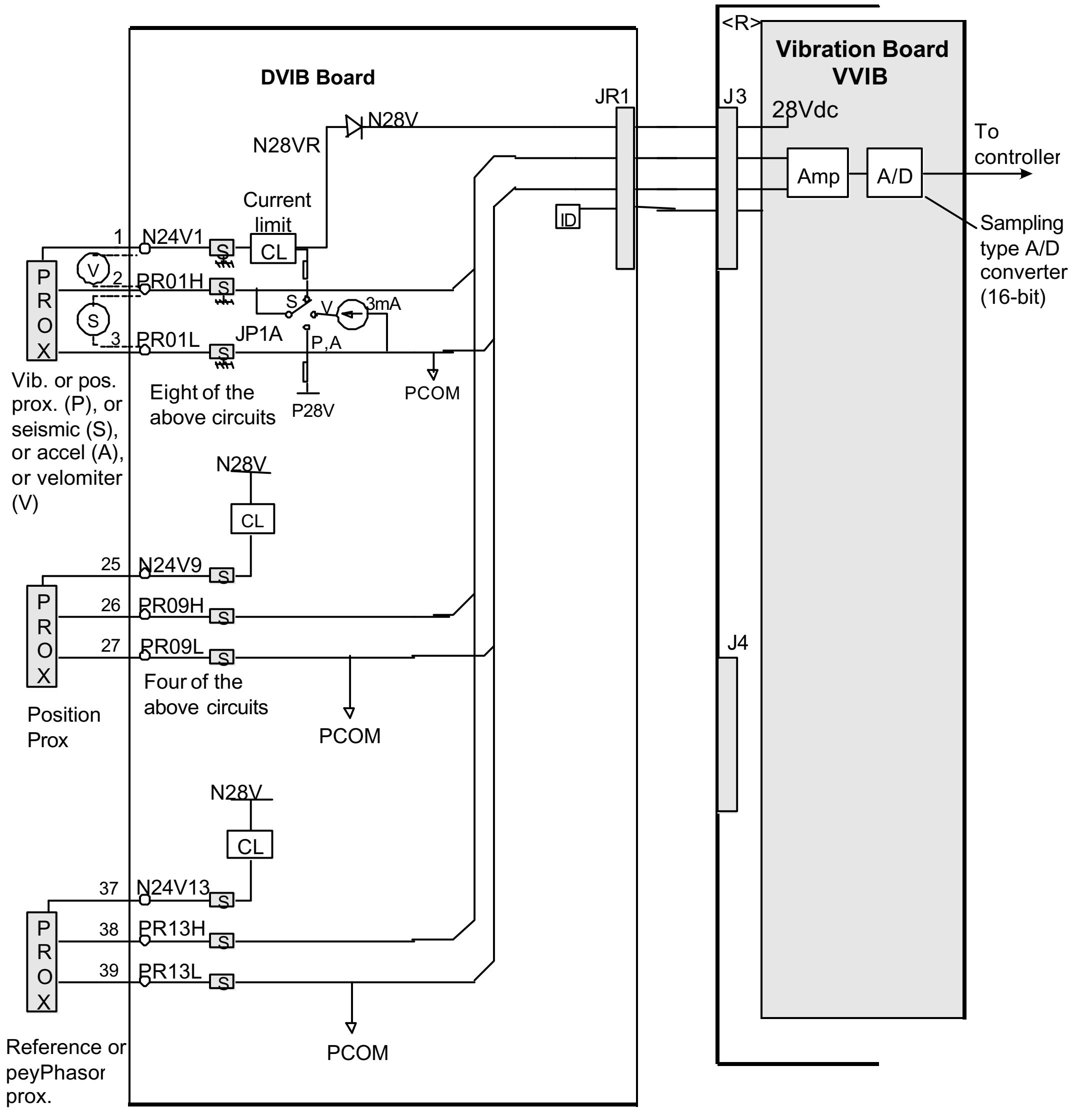
RPM_KPH2	Speed RPM, of KP #2	Input	FLOAT
Vib1X1	Vibration, 1X component only, displacement	Input	FLOAT
:	:	Input	FLOAT
Vib1X16	Vibration, 1X component only, displacement	Input	FLOAT
Vib1XPH1	Angle of 1X component to KP	Input	FLOAT
:	:	Input	FLOAT
Vib1XPH16	Angle of 1X component to KP	Input	FLOAT
LM_RPM_A	--------	Output	FLOAT
LM_RPM_B	--------	Output	FLOAT
LM_RPM_C	--------	Output	FLOAT

DVIB Vibration Terminal Board

Only the simplex version is available.

The DVIB board is a compact vibration terminal board, designed for DIN-rail mounting. (Designed to meet UL 1604 specification for operation in a 65 °C class 1, division 2 environment.) The board accepts eight vibration, four position, and one keyphasor input. It connects to the VVIB processor board with a 37-pin cable. These cables are identical to those used on the larger TVIB terminal board. VVIB accommodates two DVIB boards.

High-frequency decoupling to ground on all signals is the same as on TVIB. High density Euro-Block type terminal blocks are permanently mounted to the board with two screws for the ground connection (SCOM). An on-board ID chip identifies the board to VVIB for system diagnostic purposes.



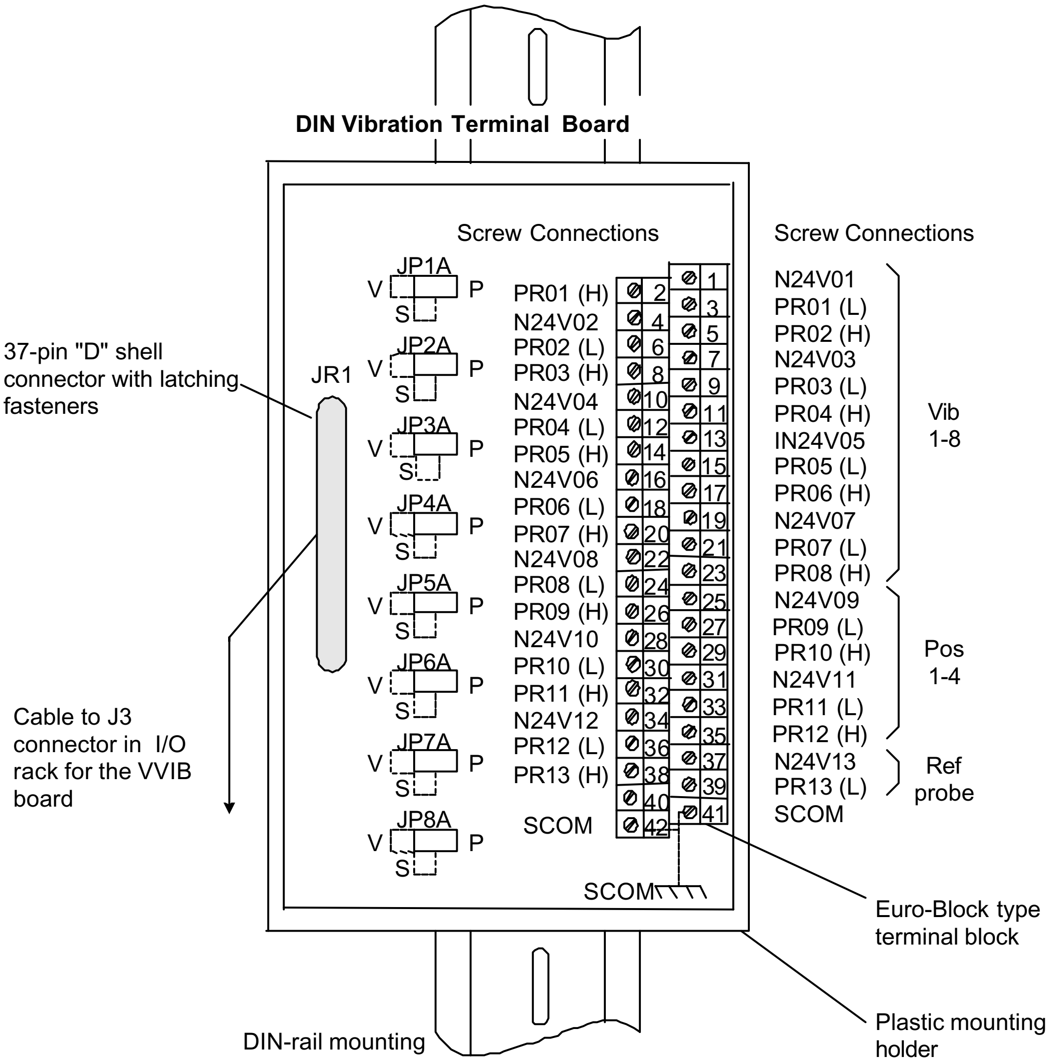
DVIB Board
N28V
N28VR
JR1
J3
<R>
Vibration Board
VVIB
28Vdc
To
controller
Amp
A/D
Sampling
type A/D
converter
(16-bit)
Current
limit
CL
ID
1
N24V1
2
PR01H
3
PR01L
S
V
3mA
JP1A
P,A
P28V
PCOM
PROX
Vib. or pos.
prox. (P), or
seismic (S),
or accel (A),
or velomiter
(V)
Eight of the
above circuits
25
N24V9
26
PR09H
27
PR09L
Four of the
above circuits
J4
Position
Prox
37
N24V13
38
PR13H
39
PR13L
Reference or
peyPhasor
prox.

DVIB Board

Installation

There is no shield terminal strip with this design.

The DVIB board slides into a plastic holder, which mounts on the DIN-rail. The vibration probes are wired directly to the terminal block which has 42 terminals. Typically #18 AWG shielded twisted triplet wiring is used. There are two screws for the SCOM (ground) connection, which should be as short a distance as possible.



DVIB 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
VVIB	**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.
	32	VVIB A/D Converter 1 Calibration Outside of Spec. VVIB monitors the Calibration Levels on the 2 A/D. If any one of the calibration voltages is not within 1% of its expected value, this alarm is set	The hardware failed (if so replace the board) or there is a voltage supply problem
	33	VVIB A/D Converter 2 Calibration Outside of Spec. VVIB monitors the Calibration Levels on the 2 A/D. If any one of the calibration voltages is not within 1% of its expected value, this alarm is set	The hardware failed (if so replace the board) or there is a voltage supply problem

65-77/ 81-93	TVIB J3/J4 Analog Input # out of limits. VVIB monitors the Signal Levels from the 2 A/D. If any one of the voltages is above the max value, this diagnostic is set	The TVIB board(s) may not exist but the sensor is specified as used, or the sensor may be bad, or the wire fell off, or the device is miswired.
128-287	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.
288-404	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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GE Industrial Systems

Board Specification

VGEN Generator Board

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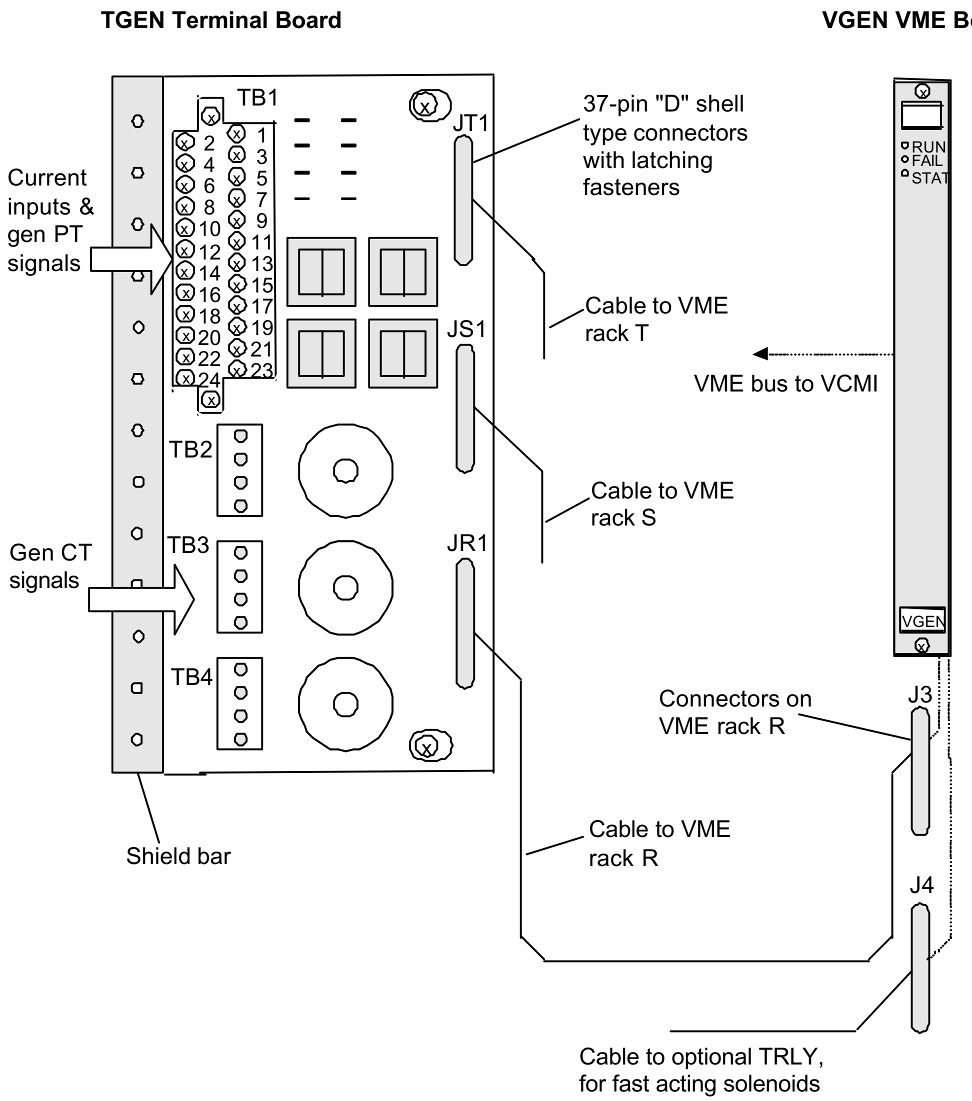
Section	*Page*

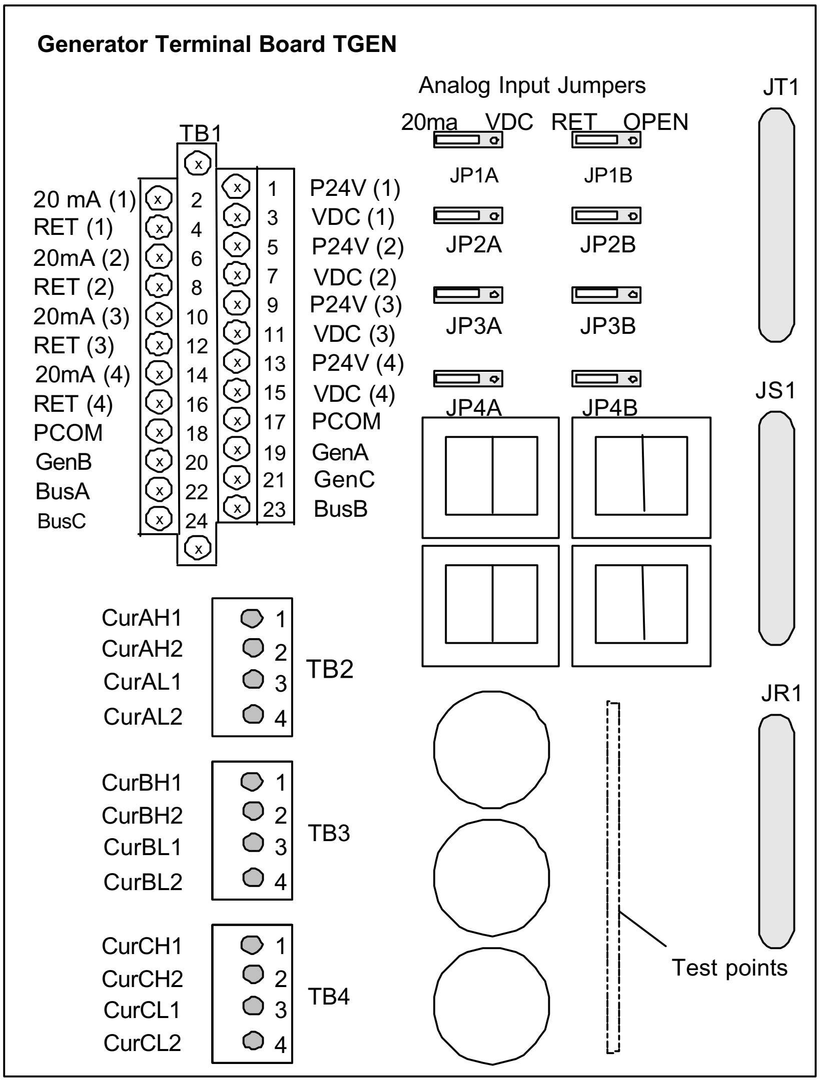
Functional Description

The generator board VGEN and its terminal board TGEN monitor the generator three-phase voltage and currents, and calculate three-phase power and power factor. For large steam turbine applications, VGEN provides the power load unbalance (PLU) and early valve actuation (EVA) functions, using fast acting solenoids located on the TRLY terminal board.



Installation

The analog current and PT inputs are wired to terminal block 1. The CTs are wired to special terminal blocks TB2 , 3, and 4, which cannot be unplugged. This protects against an open CT circuit. Jumpers J1A, B set the desired input current or voltage on analog inputs 1 through 4.



Terminal block 1 can be unplugged from terminal board for maintenance. TB2, TB3, TB4 are not pluggable.

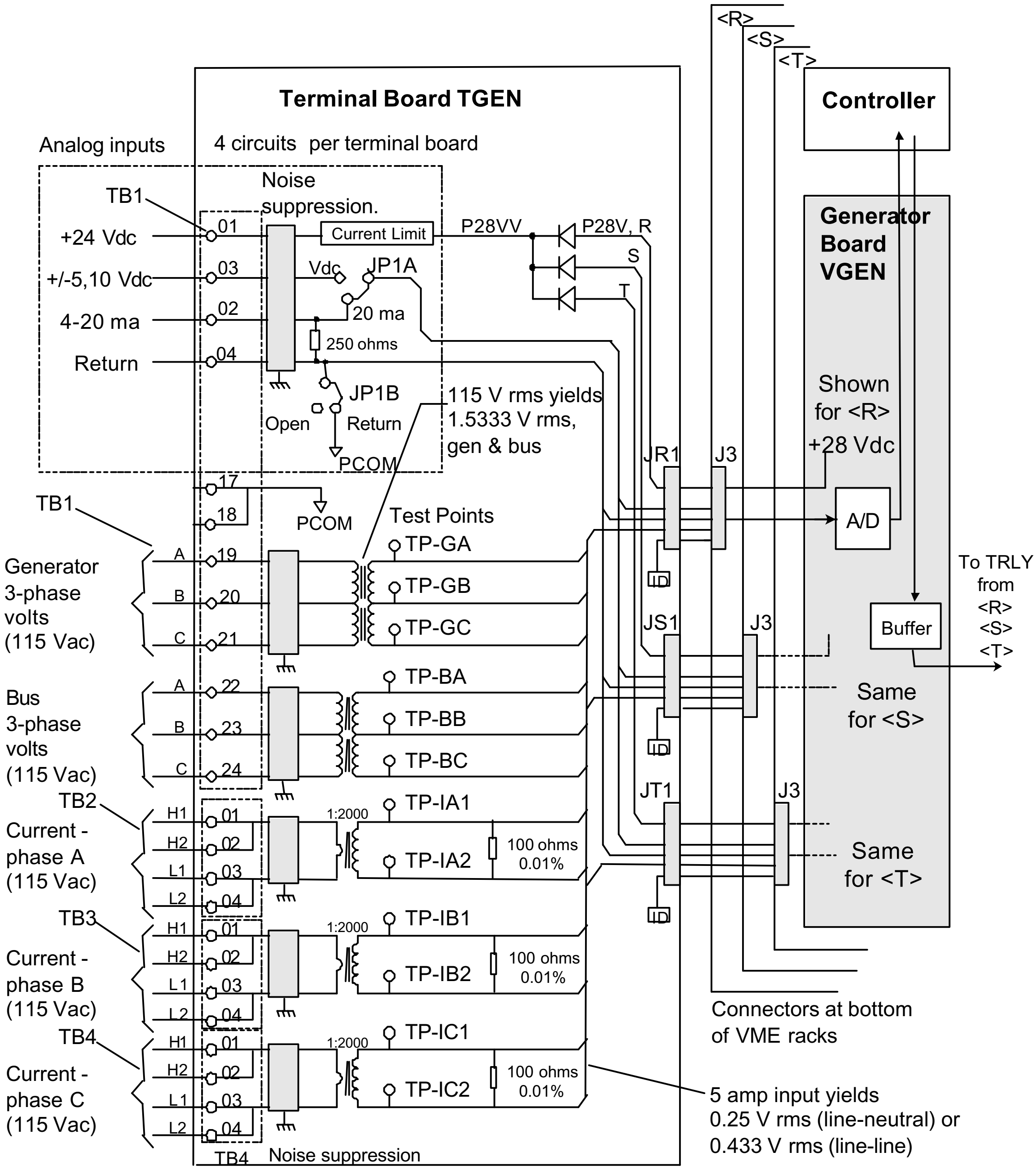
Terminal Board TGEN and Wiring

Operation

VGEN monitors two, 3-phase potential transformer (PT) inputs, and three, one-phase current transformer (CT) inputs. On TGEN there are four analog inputs which can be configured for 4-20 mA or ±5, ±10 V dc.

Test Points on the generator and bus voltages and currents are for checking the phase of the input signals. Signal conversion and calculations of power, power factor and frequency take place on the VGEN board.

Note TGEN may be used with on VGEN board (simplex) or three VGEN boards (TMR).



TGEN Board Showing Potential and Current Transformer Inputs

VGEN monitors generator 3-phase power, and supplies the power load unbalance (PLU) and early valve actuation (EVA) functions for large steam turbines.

The generator and bus PT inputs are three-wire, open delta, voltage measurements that are used to calculate all three line-to-line voltages. They are not used for automatic synchronizing which requires two separate single-phase PT inputs. Each PT input is nominally 115 V rms, and the PTs are magnetically isolated.

Test points are provided for all PT and CT inputs to verify the phase in the field.

Three single-phase CT inputs are provided with a normal current range of 0 to 5 A continous. The Cts are magnetically isolated on TGEN. Terminations for the CTs are non-pluggable terminal blocks with captive lugs accepting are up to #10 AWG wires. The following parameters are calculated from these inputs:

- Total Mwatts
- Total Mvars
- Total MVA
- Power factor
- Bus frequency (5 to 66 Hz)

High frequency and 50/60 Hz noise is reduced with an analog hardware filter.

The four analog inputs can accept 4-20 mA inputs or ± 5, ± 10 V dc inputs. A +24 V dc source is available for all four circuits with individual current limits for each circuit. The 4-20 mA transducer can be connected to use the +24 V dc source from the turbine control or as a self-powered source. A jumper is located on the terminal board to select between current and voltage inputs for each circuit.

Specifications

VGEN Specifications

Item	Specification
Inputs to TGEN and VGEN	2 three-phase generator and bus PTs 3 one-phase generator CTs 4 analog inputs (4–20 mA, ± 5, ± 10 V dc)
Outputs from VGEN via TRLY	12 relay outputs (for large steam turbines)
Generator and bus voltages	Nominal 115 V rms with range of interest of 10 to 120% Nominal frequency 50/60 Hz with range of interest 25 to 66 Hz Magnetic isolation to 1,500 V rms and loading less than 3 VA Input measurement resolution is 0.1% Input accuracy is 0.5% of rated V rms from 45 to 66 Hz Input accuracy is 1.0% of rated V rms from 25 to 45 Hz Input loading less than 3 VA per circuit
Generator current inputs	Normal current range is 0 to 5 A with overange to 10 A Nominal frequency 50/60 Hz with range of interest 45 to 66 Hz Magnetic isolation to 1,500 V rms Input accuracy 0.5% of full scale (5A) with resolution of 0.1% FS Input burden less than 0.5 ohms per circuit
Analog inputs	Current inputs: 4–20 mA Voltage inputs: ± 5 V dc or ± 10 V dc Transducers can be up to 300 m (984 ft) from the control cabinet with a two-way cable resistance of 15 ohms. Input burden resistor on TGEN is 250 ohms. Jumper selection of single ended or self powered inputs Jumper selection of voltage or current inputs Analog Input Filter: Breaks at 72 and 500 radians/sec Ac common mode rejection (CMR) 60 dB Dc common mode rejection (CMR) 80 dB
Conversion accuracy	Sampling type 16-bit A/D converter, 14 bit resolution Accuracy 0.1% overall
Frame rate	100 Hz
Calculated values	Total MWatts and MVars have an accuracy of 1% FS, and 0.5% for totalizing. Total MVA and power factor have an accuracy of 1% full scale. Bus frequency (5 to 66 Hz) has an accuracy of ± 0.1%.

Diagnostics

Diagnostics perform a high/low (hardware) limit check on the input signal and a high/low system (software) limit check. The software limit check is adjustable in the field. Open wire detection is provided for voltage inputs, and relay drivers and coil currents are monitored.

Connectors JR1, JS1, and JT1, on the terminal board have their own ID device which 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 plug location.

Configuration

Typical VGEN Configuration

Parameter	Description	Choices
Configuration		
PLU_Enab	Enable PLU function	Enable, disable
PLU_Del_Enab	Enable PLU delay	Enable, disable
MechPwrInput	Mech. power through TMR (first 3 MA ccts), dual xducer (Max), single xducer, or signal space	TMR_1 thru 3, dual 1 and 2, SMX_1, SMX_2, signal space
PLU_Rate	Select PLU threshold rate	ME, LO, HI
PLU_Unbal	PLU Unbalance threshold %	20 to 80
PLU_Delay	PLU delay, secs	0 to 10
Press Ratg	Reheat press equiv. to 100% mechanical power	50 to 600
Current Ratg	Generator current equivalent to 100% electrical power	1,000 to 60,000
EVA_Enab	Enable EVA function	Enable, disable
EVA_ExtEnab	Enable external EVA function	Enable, disable
EVA_Rate	Select EVA threshold rate	LO, ME, HI
EVA_Unbal	EVA unbalance threshold %	20 to 80
EVA_Delay	EVA drop out time, seconds	0 to 10
MW_Ratg	Generator MW equivalent to 100 % electrical power	10 to 1,500
IVT_Enab	Enable IVT function	Enable, disable
Min_MA_Input	Minimum MA for healthy 4-20 mA input	0 to 21
MAx_MA_Input	Maximum MA for healthy 4-20 mA input	0 to 21
SystemFreq	System frequency in Hz	50 or 60
J3:IS200TGENH1A		Connected, Not Connected
AnalogIn1	First analog input (of four) - board point	Point edit (input FLOAT)
Input type	Type of analog input	Unused, 4–20 ma, ± 5 V, ± 10 V
Low input	Input MA at low value	–10 to 20
Low value	Input value in engineering units at low MA (configuration inputs the same as for TBAI)	–3.4028e+038 to 3.4028e+038
System limits	Standard System Limits (see TBAI configuration)	
GenPT_Vab_KV	Generator potential transformer input "ab", (first of 3) - board point	Point edit (input FLOAT)
PT_Input	PT input in KV rms for PT_output	1 to 1,000

PT_Output	PT output in V rms for PT_Input-typically 115	60 to 150
Phase Shift	Compensating phase shift, applied to PT signals	Zero, plus 30, plus 60, minus 30, minus 60
System limits	Standard system limits (similar to analog Inputs)	
BusPT_Vab_KV	Bus potential transformer input "ab", (first of three) configuration similar to GenPT - board point	Point edit (input FLOAT)
GenCT_A	Generator current transformer A (first of three) - board point	Point edit (input FLOAT)
CT_Input	CT input in amperes rms for rated CT_Output	100 to 50,000
CT_Output	Rated CT output in amperes rms, typically 5	1 to 5
System Limits	Standard system limits (similar to genPT)	
J4:IS200TRLYH1A		Connected, not connected
Relay01_Tst	Fast acting solenoid #1 test, first of 12 relays - board point	Point edit (output BIT)
Relay Output	FAS valve type	Unused, CV, tst only, CV EVA
RelayDropTime	Relay dropout time	0 to 5

Board Points Signals	Description – Point Edit (Enter Signal Name)	Direction	Type
L3DIAG_VGEN1	Board diagnostic	Input	BIT
L3DIAG_VGEN2	Board diagnostic	Input	BIT
L3DIAG_VGEN3	Board diagnostic	Input	BIT
SysLim1Anal1	System limit 1 exceeded on analog cct #1	Input	BIT
:	:	Input	BIT
SysLim1Anal4	System limit 1 exceeded on Analog cct #4	Input	BIT
SysLim2Anal1	System limit 2 exceeded on Analog cct #1	Input	BIT
:	:	Input	BIT
SysLim2Anal4	System limit 2 exceeded on analog cct #4	Input	BIT
SysL1GenPTab	System limit 1 exceeded on gen PT, Vab	Input	BIT
SysL1GenPTbc	System limit 1 exceeded on gen PT, Vbc	Input	BIT
SysL1GenPTca	System limit 1 exceeded on gen PT, Vca	Input	BIT
SysL1BusPTab	System limit 1 exceeded on bus PT, Vab	Input	BIT
SysL1BusPTbc	System limit 1 exceeded on bus PT, Vbc	Input	BIT
SysL1BusPTca	System limit 1 exceeded on bus PT, Vca	Input	BIT
SysL2GenPTab	System limit 2 exceeded on gen PT, Vab	Input	BIT
SysL2GenPTbc	System limit 2 exceeded on gen PT, Vbc	Input	BIT
SysL2GenPTca	System limit 2 exceeded on gen PT, Vca	Input	BIT
SysL2BusPTab	System limit 2 exceeded on bus PT, Vab	Input	BIT
SysL2BusPTbc	System limit 2 exceeded on bus PT, Vbc	Input	BIT
SysL2BusPTca	System limit 2 exceeded on bus PT, Vca	Input	BIT
SysL1GenCTa	System limit 1 exceeded on gen CT, phase A	Input	BIT
SysL1GenCTb	System limit 1 exceeded on gen CT, phase B	Input	BIT

SysL1GenCTc	System limit 1 exceeded on gen CT, phase C	Input	BIT
SysL2GenCTa	System limit 2 exceeded on gen CT, phase A	Input	BIT
SysL2GenCTb	System limit 2 exceeded on gen CT, phase B	Input	BIT
SysL2GenCTc	System limit 2 exceeded on gen CT, phase C	Input	BIT
Relay01_Fdbk	Status of relay 01	Input	BIT
:	:	Input	BIT
Relay12_Fdbk	Status of relay 12	Input	BIT
L10PLU_EVT	Power load unbalance event	Input	BIT
L10EVA_EVA	Early valve actuation event	Input	BIT
GenMW	Generator MWatts	Input	FLOAT
GenMVAR	Generator MVars	Input	FLOAT
GenMVA	Generator MVA	Input	FLOAT
GenPF	Generator power factor, 0/1/0	Input	FLOAT
BusFreq	Bus frequency, Hz	Input	FLOAT
PLU_Tst	Power load unbalance test	Output	BIT
EVA_Tst	Early valve actuation test	Output	BIT
IV_Trgr	Intercept valve trigger command	Output	BIT
EVA_ExtCmd	Early valve actuation external command	Output	BIT
EVA_ExtPrm	Early valve actuation external permissive	Output	BIT
TN_Hz	PLL center frequency, Hz	Output	FLOAT
MechPower	Mechanical power, percent, when configured through signal space	Output	FLOAT
AnalogIn1	Analog input 1	Input	FLOAT
:	:	Input	FLOAT
AnalogIn4	Analog input 4	Input	FLOAT
GenPT_Vab_KV	Kilovolts rms	Input	FLOAT
GenPT_Vbc_KV	Kilovolts rms	Input	FLOAT
GenPT_Vca_KV	Kilovolts rms	Input	FLOAT
BusPT_Vab_KV	Kilovolts rms	Input	FLOAT
BusPT_Vbc_KV	Kilovolts rms	Input	FLOAT
BusPT_Vca_KV	Kilovolts rms	Input	FLOAT
GenCT_A	Generator Amperes RMS, phase A	Input	FLOAT
GenCT_B	Generator amperes rms, phase B, same configuration as phase A	Input	FLOAT
GenCT_C	Generator amperes rms, phase C, same configuration as phase A	Input	FLOAT
Relay01_Tst	Fast acting solenoid #1 test	Output	BIT
:	:	Output	BIT
Relay12_Tst	Fast acting solenoid #12 test	Output	BIT

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.

I/O Board Diagnostic Alarms

Board	Fault	Fault Description	Possible Cause
VGEN	**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.
	32-43	Relay Driver # does not Match Requested State. There is a mismatch between the relay driver command and the state of the output to the relay as sensed by VGEN	The relay terminal board may not exist and the relay is configured a used, or there may be a faulty relay driver circuit or drive sensors on VGEN.
	44-55	Relay Output Coil # does not Match Requested State. There is a mismatch between the relay driver command and the state of the current sensed on the relay coil on the relay terminal board	Relay is defective, or the connector cable J4 to the relay terminal board J1 is disconnected, or the relay terminal board does not exist.

56-59	Analog Input # Unhealthy. Analog Input 4–20 mA ## has exceeded the A/D converter's limits	Analog input is too large, TGEN jumper (JP1, JP3, JP5, JP7) is in the wrong position, signal conditioning circuit on TGEN is defective, multiplexer or A/D converter circuit on VGEN is defective.
60-65	Fuse # and/or # Blown. The fuse monitor requires the jumpers to be set and to drive a load, or it will not respond correctly	One or both of the listed fuses is blown, or there is a loss of power on TB3, or the terminal board does not exist, or the jumpers are not set.
66-69	Analog 4–20 mA Auto Calibration Faulty. One of the analog 4–20 mA auto calibration signals has failed. Auto calibration or 4-20 mA inputs are invalid	3 Volt or 9 Volt precision reference or null reference on VGEN is defective, or multiplexer or A/D converter circuit on VGEN is defective.
70-73	PT Auto Calibration Faulty. One of the PT auto calibration signals has gone bad. Auto calibration of PT input signals is invalid, PT inputs are invalid	Precision reference voltage or null reference is defective on VGEN, or multiplexer or A/D converter circuit on VGEN is defective.
74-79	CT Auto Calibration Faulty. One of the CT auto calibration signals has gone bad. Auto calibration of CT input signals is invalid, CT inputs are invalid	Precision reference voltage or null reference is defective on VGEN, or multiplexer or A/D converter circuit on VGEN is defective.
96-223	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.
224-241	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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Board Specification

VPYR Pyrometer Board

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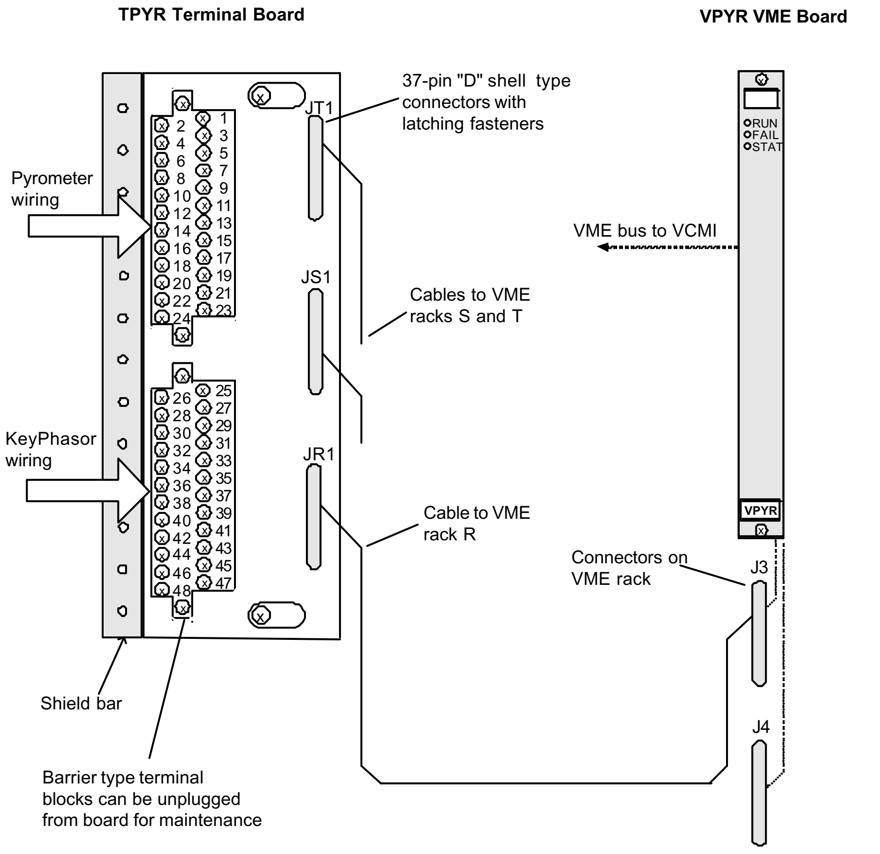
Section	***Page***

Functional Description

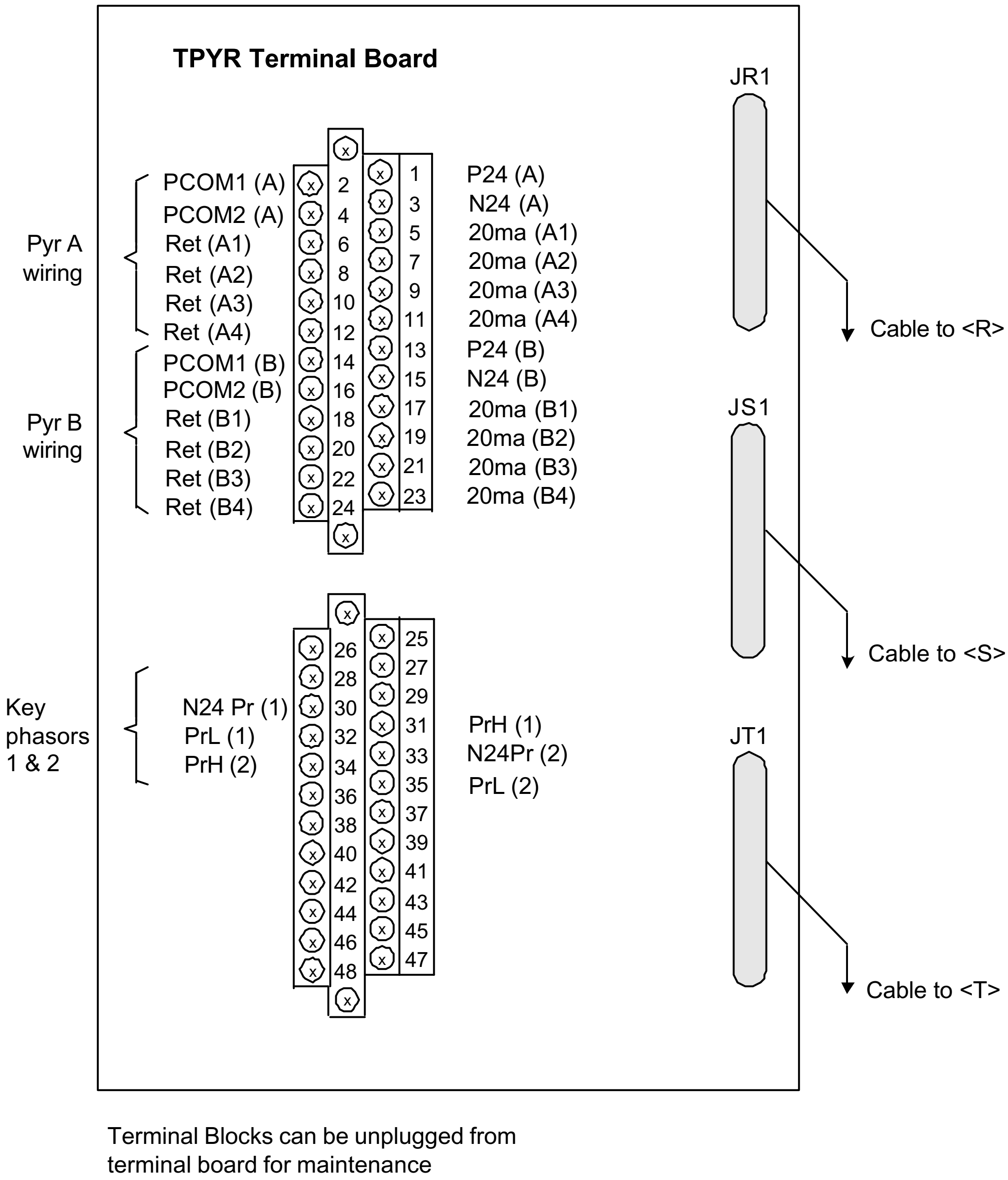
The Optical Pyrometer Board (VPYR) provides a dynamic temperature profile of the rotating turbine blades, and computes temperature conditions that can lead to a trip. The Pyrometer terminal board (TPYR) is wired to two infrared TBTMS thermometers, known as pyrometers, and to two keyPhasor proximitor probes for shaft reference. Dedicated analog to digital converters on VPYR provide sampling rates up to 200,000 samples per second for burst data from two of the temperature channels. Fast temperature data is made available for display and offline evaluation. The terminal board has simplex and TMR capability as shown in the following figure.



Pyrometer Terminal Board, Processor, and Cabling

Installation

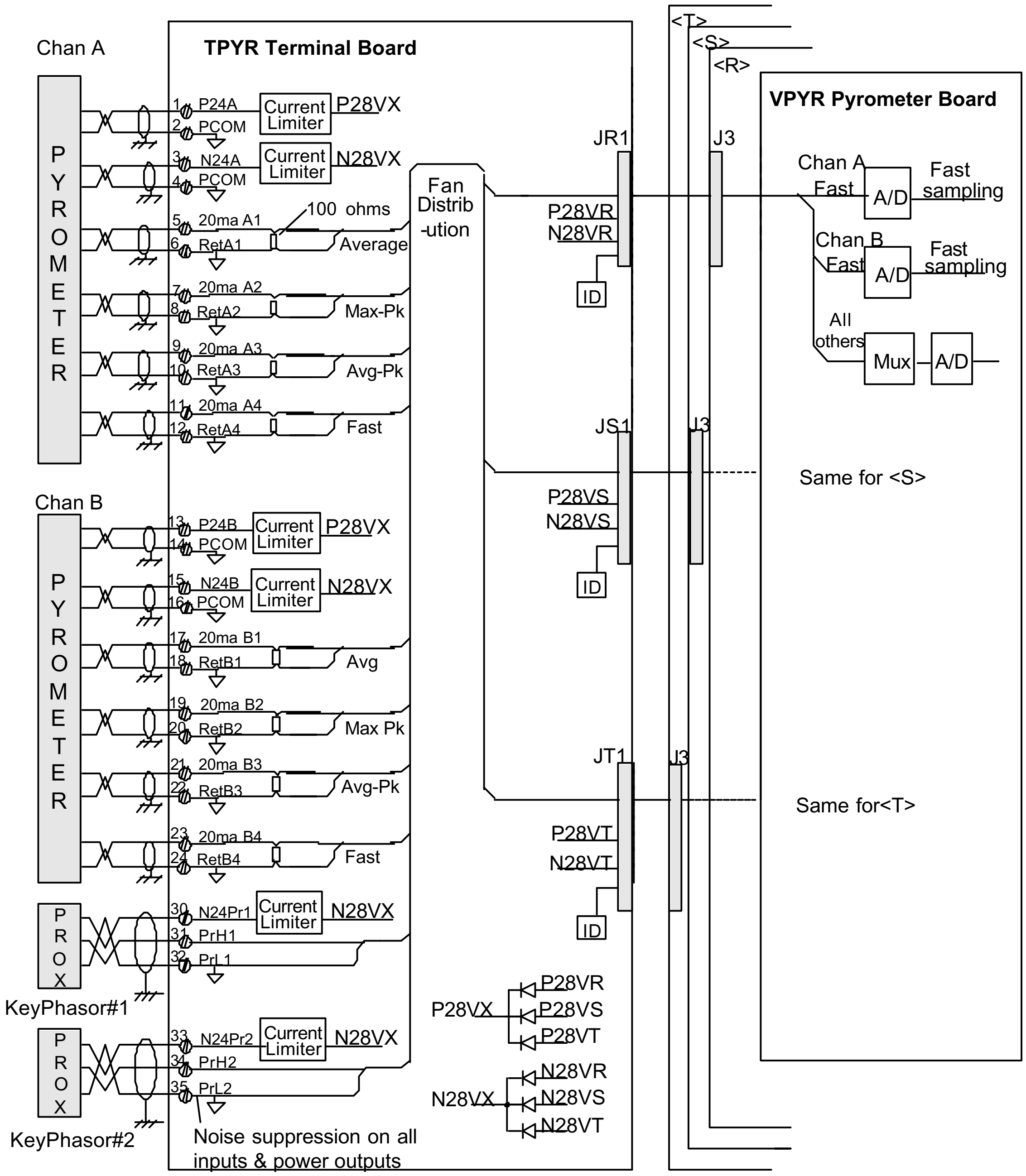
The two optical pyrometers are wired to the first terminal block on TPYR, and the two KeyPhasor probes are wired to the second terminal block. Power comes in through the JR1, JS1, and JT1 connectors. There are no jumpers as on the TVIB board.



Terminal Board TPYR and Wiring

Operation

Analog signals from the terminal board are cabled to the VPYR processor board where signal sampling and conversion take place. VPYR calculates the temperature profiles and runs turbine protection algorithms using both pyrometer signals. If a trip is indicated and the signals are validated, VPYR issues the trip signal.



TPYR Terminal Board and Processor BoardFeatures

Optical Pyrometer Measurements

Two infrared pyrometers dynamically measure the temperature profile of the rotating turbine blades. Each pyrometer is powered by a +24 V dc and a –24 V dc source on the terminal board, diode selected from voltages supplied by the three VPYR boards. Four 4–20 mA signals are returned from each pyrometer, representing the following blade measurements:

- The average temperature
- The maximum peak temperature
- The average peak temperature
- A fast dynamic profile, with 30 kHz bandpass, providing the full signature.

Each 4–20 mA input generates a voltage across a resistor which is sent to the VPYR board where it is multiplexed and converted. A dedicated A/D converter is used to sample the fast input (#4) at up to 200,000 samples per second. VPYR can be configured for different numbers of turbine buckets, with up to 30 temperature samples per bucket.

KeyPhasor Inputs

Two keyPhasors are used for shaft position reference, one as a backup. These keyPhasor probes and associated circuitry are identical to those used with TVIB/VVIB. They sense a shaft keyway or pedestal to provide a time stamp.

Turbine Protection Algorithm

Fast burst data is used for the protection algorithms. One peak temperature per bucket is isolated and the highest for that revolution is selected. The delta temperature compared to the previous revolution is calculated (the rate of change) and compared to a calculated value which uses configurable parameters. Three of these are computed using different parameters. Similarly a distance variable is computed by taking the difference between the revolution peak and a peak taken y samples ago, where y is configurable. This delta is also compared to a configurable value. Finally the three rate signals and one distance signal are logically combined with permissives and the other channel trip condition to produce the trip signal.

Specifications

VPYR Board Specifications

Item	Specification
Number of inputs	2 pyrometers, each with 4 analog 4–20 mA current signals
(TPYR and VPYR)	2 keyPhasor probes, each with –0.5 to –20 V dc inputs
Current inputs from pyrometers	4-20 mA across a 100 ohm resistor Common mode rejection: Dc up to ± 5 V dc, CMRR of 80 dB Ac up to ± 5 Volt peak, CMRR of 60 dB Measurement accuracy of ± 0.1 % full scale, 14-bit resolution Bandwidth of 0 to 100 Hz on 6 slow inputs using multiplexed A/D converter Bandwidth of 0 to 30,000 Hz on two fast inputs using dedicated A/D converters, sampling at 200,000 per sec.
KeyPhasor inputs	Input voltage range of –0.5 to –20 V dc Common mode rejection: CMR of 5 V, CMRR of 50 dB at 50/60 Hz Accuracy 2 % of full scale (0.2 V dc) Dc level detection typically 0.2 V/mil sensitivity Speed measurement 2 to 5,610 RPM with accuracy of 0.1 % of reading
Device excitation	Pyrometers have individual power supplies, current limited: P24V source is diode selected, +22 to +30 V dc, 0.175 A N24V source is diode selected, -22 to -30 V dc, 0.175 A
Measurement parameters	Rated RPM up to 5,100 RPM Number of buckets per stage, up to 92 Number of samples per bucket, up to 30 Fast inputs sampled in bursts covering three revolutions, at twice per second.

Diagnostics

VPYR provides system limit checking on the keyPhasor gap signals. The two pyrometer inputs are compared against configuration limits to determine if they are tracking, and the fast data is compared with other inputs to check validity.

Connectors JR1, JS1, and JT1, on the terminal board have their own ID device, which 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

Like all I/O boards, VPYR 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. For details refer to GEH-6403, *Control System Toolbox for Configuring the Mark VI Turbine Controller*.

Typical VPYR Configuration

Module Parameter	Description	Choices
Calibration		
System limits	Enables or disables all system limit checking	Enable, disable
Min_MA_Input	Minimum MA for healthy 4−20 mA input	0 to 21
Max_MA_Input	Maximum MA for healthy 4−20 mA input	0 to 21
RPMrated	Rated turbine RPM	0 to 10,000
BuckSamples	Minimum samples per bucket at 110 percent speed	10 to 30
BuckOffset_A	Offset from key to the first bucket, % bucket, pyrometer A	0 to 100
BuckSpan_A	Percent of bucket to include in protection algorithm, pyrometer A	0 to 100
BuckNumb_A	Number of buckets, pyrometer A	30 to 92
SetptR1_A	Setpoint, rate 1, pyrometer A	0 to 30
SetptR1B_A	Setpoint, rate 1, bias, average temp, pyrometer A	−1 to 1
SetptR2_A	Setpoint, rate 2, pyrometer A	0 to 30
SetptR2B_A	Setpoint, rate 2,bias, average temp, pyrometer A	−1 to 1
SetptR3_A	Setpoint, rate 3, pyrometer A	0 to 30
SetptR3B_A	Setpoint, rate 3, bias, average temp, pyrometer A	−1 to 1
SetptD_A	Setpoint distance, pyrometer A	0 to 30
SetptDB_A	Setpoint distance bias, average temp, pyrometer A	−1 to 1
SetptDDepth_A	Setpoint, depth of the distance measurement, pyrometer A	0 to 30
Rate2Enab_A	Enable, temperature rate 2, pyrometer A	Enable, disable
Rate3Enab_A	Enable, temperature rate 3, pyrometer A	Enable, disable
DistEnab_A	Enable temperature rate 3, pyrometer A Same configuration for channel B pyrometer	Enable, disable
J3:IS200TPYRH1A	Terminal board 1 connected to VPYR through J3	Connected, not connected
SlowAvg_A	Slow, average temperature, pyrometer A - board point	Point edit (input FLOAT)
Input use	Is this point used?	Used, unused
Low_Input	Input MA at low value	0 to 21

Low_Value	Input value in engineering units at low MA	–3.4e+038 to 3.4e+038
High_Input	Input MA at high value	0 to 21
High_Value	Input value in engineering units at high MA	–3.4e+038 to 3.4e+038
TMR_Diff	Difference limit for voted TMR inputs in % of (high value/low value)	0 to 100
SlowMXPk_A	Slow, maximum peak temperature, pyrometer A (configuration similar to above) - board point	Point edit (input FLOAT)
SlowAvgPk_A	Slow, average peak temp, pyrometer A - board point	Point edit (input FLOAT)
FastAvg_A	Fast, average temp, pyrometer A - board point	Point edit (input FLOAT)
SlowAvg_B	Slow, Average Temperature, Pyr B - board point	Point Edit (Input FLOAT)
SlowMXPk_B	Slow, Max Peak Temperature, Pyr B - board point	Point Edit (Input FLOAT)
SlowAvgPk_B	Slow, average peak temperature, Pyr B - board pt.	Point Edit (Input FLOAT)
FastAvg_B	Fast, average temperature, Pyr B - board point	Point Edit (Input FLOAT)
GAP_KPH1	Air Gap, keyPhasor #1 - board point	Point Edit (Input FLOAT)
VIB-Type	Configurable item	Used, Not used
VIB_Scale	Volts/mil	0 to 2
KPH_Thrshld	Voltage difference from gap voltage where Keyphasor Trigger	1 to 5
KPH_Type	Type of Pulse Generator	Slot, Pedestal
SysLim	System Limits 1 and 2, and TMR same as above	Standard Choices
GAP_KPH2	Air Gap, keyPhasor #2, config. Same as above - board point	Point Edit (Input FLOAT)

Board Points (Signals)	**Description – Point Edit (Enter Signal Name)**	**Direction**	**Type**
L3DIAG_VPYR1	Board diagnostic	Input	BIT
L3DIAG_VPYR2	Board diagnostic	Input	BIT
L3DIAG_VPYR3	Board diagnostic	Input	BIT
TripPyrA	Bucket temperature rate trip, pyrometer A	Input	BIT
TripPyrB	Bucket temperature rate trip, pyrometer B	Input	BIT
KeyPh1Act	Keyphasor 1 Active	Input	BIT
KeyPh2Act	Keyphasor 2 Active	Input	BIT
SysLim1KP1	System Limit	Input	BIT
SysLim2KP1	System Limit	Input	BIT
SysLim1KP2	System Limit	Input	BIT
SysLim2KP2	System Limit	Input	BIT
FastMxMxPk_A	Fast, Max of the Max Peaks Temp, Pyr A	Input	FLOAT
FastAgMxPk_A	Fast, Average of the Max Peaks Temp, Pyr A	Input	FLOAT
FastMnMnPk_A	Fast, Min of the Min Peaks Temp, Pyr A	Input	FLOAT
FastAgMnPk_A	Fast, Average of the Min Peaks, Pyr A	Input	FLOAT
FastMxMxPk_B	Fast, Max of the Max Peaks Temp, Pyr B	Input	FLOAT

FastAgMxPk_B	Fast, Average of the Max Peaks Temp, Pyr B	Input	FLOAT
FastMnMnPk_B	Fast, Min of the Min Peaks Temp, Pyr B	Input	FLOAT
FastAgMnPk_B	Fast, Average of the Min Peaks, Pyr B	Input	FLOAT
RPM_KPH1	RPM Keyphasor #1	Input	FLOAT
RPM_KPH2	RPM Keyphasor #2	Input	FLOAT
TripBuckIx_A	Index of the first Bucket causing trip, Pyr A	Input	FLOAT
TripBuckNb_A	Number of Buckets causing trip, Pyr A	Input	FLOAT
TripBuckIx_B	Index of the first Bucket causing trip, Pyr B	Input	FLOAT
TripBuckNb_B	Number of Buckets causing trip, Pyr B	Input	FLOAT
LogTrigger	When true, records freeze, two before, one after	Output	BIT
TurbRPM	Turbine Speed in RPM	Output	FLOAT
SlowAvg_A	Slow, Average Temperature, Pyr A	Input	FLOAT
SlowMXPk_A	Slow, Max Peak Temperature, Pyr A (configuration similar to above)	Input	FLOAT
SlowAvgPk_A	Slow, Average Peak Temperature, Pyr A	Input	FLOAT
FastAvg_A	Fast, Average Temperature, Pyr A	Input	FLOAT
SlowAvg_B	Slow, Average Temperature, Pyr B	Input	FLOAT
SlowMXPk_B	Slow, Max Peak Temperature, Pyr B	Input	FLOAT
SlowAvgPk_B	Slow, Average Peak Temperature, Pyr B	Input	FLOAT
FastAvg_B	Fast, Average Temperature, Pyr B	Input	FLOAT
GAP_KPH1	Air Gap, Keyphasor #1	Input	FLOAT
GAP_KPH1	Air Gap, Keyphasor #1	Input	FLOAT

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.

I/O Board Diagnostic Alarms

Board	Fault	Fault Description	Possible Cause
VPYR	**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.
	32&38	Milliamp input associated with the slow average temperature is unhealthy. Pyro## SLOW AVG TEMP unhealthy	Specified pyrometer's average output is faulty, or VPYR or TPYR is faulty.
	33&39	Pyro## Slow Max Pk Temp unhealthy. Milliamp input associated with the slow maximum peak temperature is unhealthy	Specified pyrometer's maximum output is faulty, or VPYR or TPYR is faulty.

34&40	Pyro## Slow Average Peak Temp. Milliamp input associated with the slow average peak temperature is unhealthy	Specified pyrometer's peak output is faulty, or VPYR or TPYR is faulty.
35&41	Pyro##Fast Temp Unhealthy. Milliamp input associated with the fast temperature is unhealthy	Specified pyrometer's fast output is faulty, or VPYR or TPYR is faulty.
36&42	Pyro## Fast Cal Reference out of limits. The fast calibration reference is out of limits	VPYR is faulty
37&43	Pyro## Fast Cal Null out of limits. The fast calibration null is out of limits	VPYR is faulty
44	Slow Cal Reference out of limits. The slow calibration reference is out of limits	VPYR is faulty
45	Slow Cal Null out of limits. The slow calibration null is out of limits	VPYR is faulty
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.
224-247	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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