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VAIC Analog Input/Output

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Functional Description

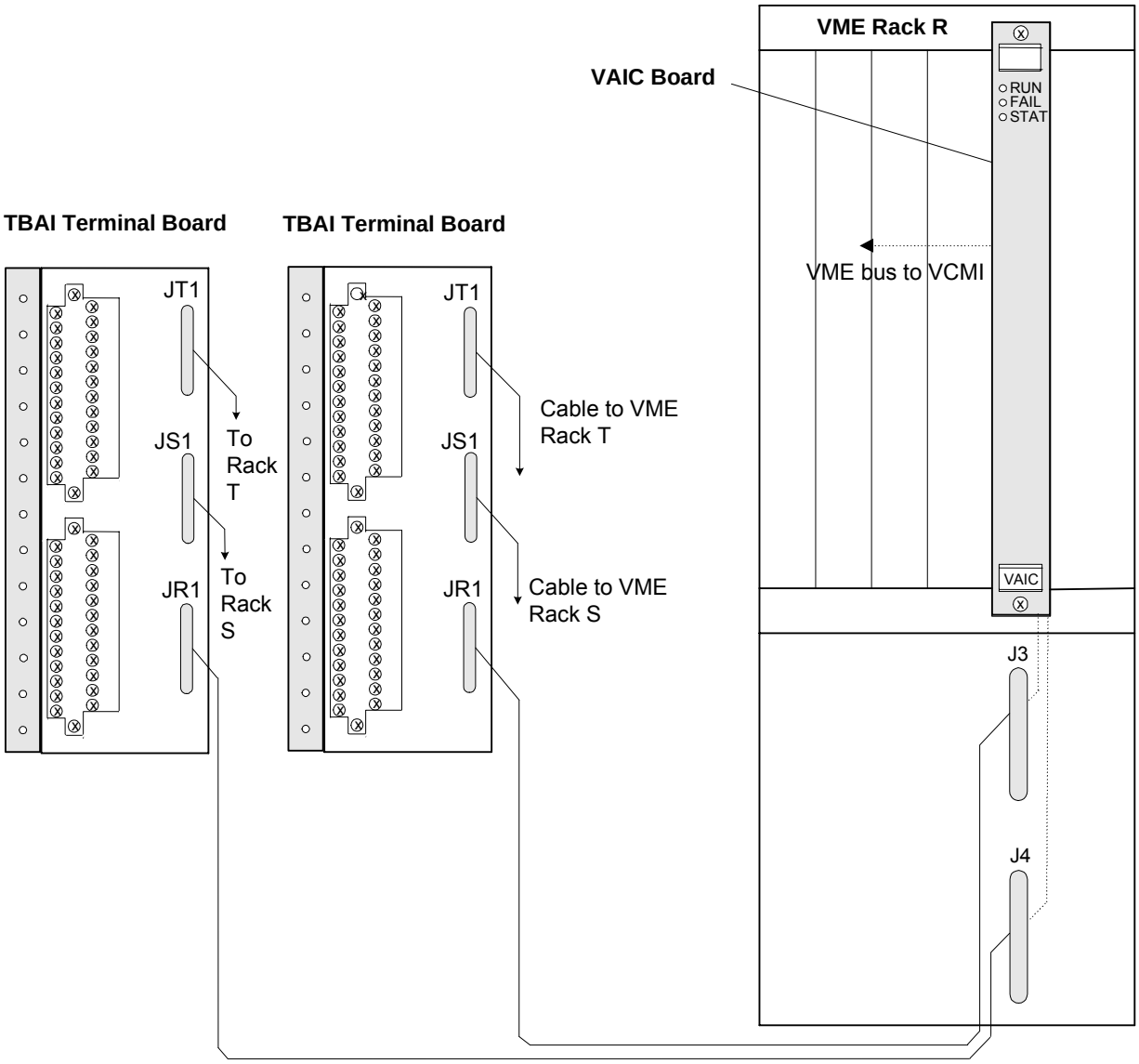
The Analog Input/Output (VAIC) board accepts 20 analog inputs and controls 4 analog outputs. Each terminal board accepts 10 inputs and 2 outputs. Cables connect the terminal board to the VME rack where the VAIC processor board is located. VAIC converts the inputs to digital values and transfers them over the VME backplane to the VCMI board, and then to the controller. For outputs, the VAIC converts digital values to analog currents and drives these through the terminal board into the customer circuit.

VAIC supports both simplex and triple modular redundant (TMR) applications. When used in a TMR configuration, input signals on the terminal board are fanned out to three VME board racks R, S, and T, each containing a VAIC. Output signals are driven with a proprietary circuit that creates the desired current using all three VAICs. In the event of a hardware failure, the bad VAIC is removed from the output and the remaining two boards continue to produce the correct current. When used in a simplex configuration, the terminal board provides input signals to a single VAIC, which provides all of the current for outputs.

Compatibility

There are two generations of the VAIC board with corresponding terminal boards. The original VAIC includes all versions prior to and including VAICH1C. VAICH1B is included in this generation. When driving 20 mA outputs these boards support up to 500 Ω load resistance at the end of 1000 ft of #18 wire. This generation of board requires terminal board TBAIH1B or earlier for proper operation. They also work properly with all revisions of DTAI terminal boards.

The newest VAICH1D and any subsequent releases are designed to support higher load resistance for 20 mA outputs drive voltage: up to 18 V is available at the terminal board screw terminals. This permits operation into loads of 800 Ω with 1000 ft of #18 wire with margin. This generation of the board requires TBAIH1C or later, or any revision of STAI.



VAIC, Analog Input Terminal Boards, and Cabling (TMR System)

Installation

➢ **To install the V-type board**

1 Power down the VME processor rack

2 Slide in the board and push the top and bottom levers in with your hands to seat its edge connectors

3 Tighten the captive screws at the top and bottom of the front panel

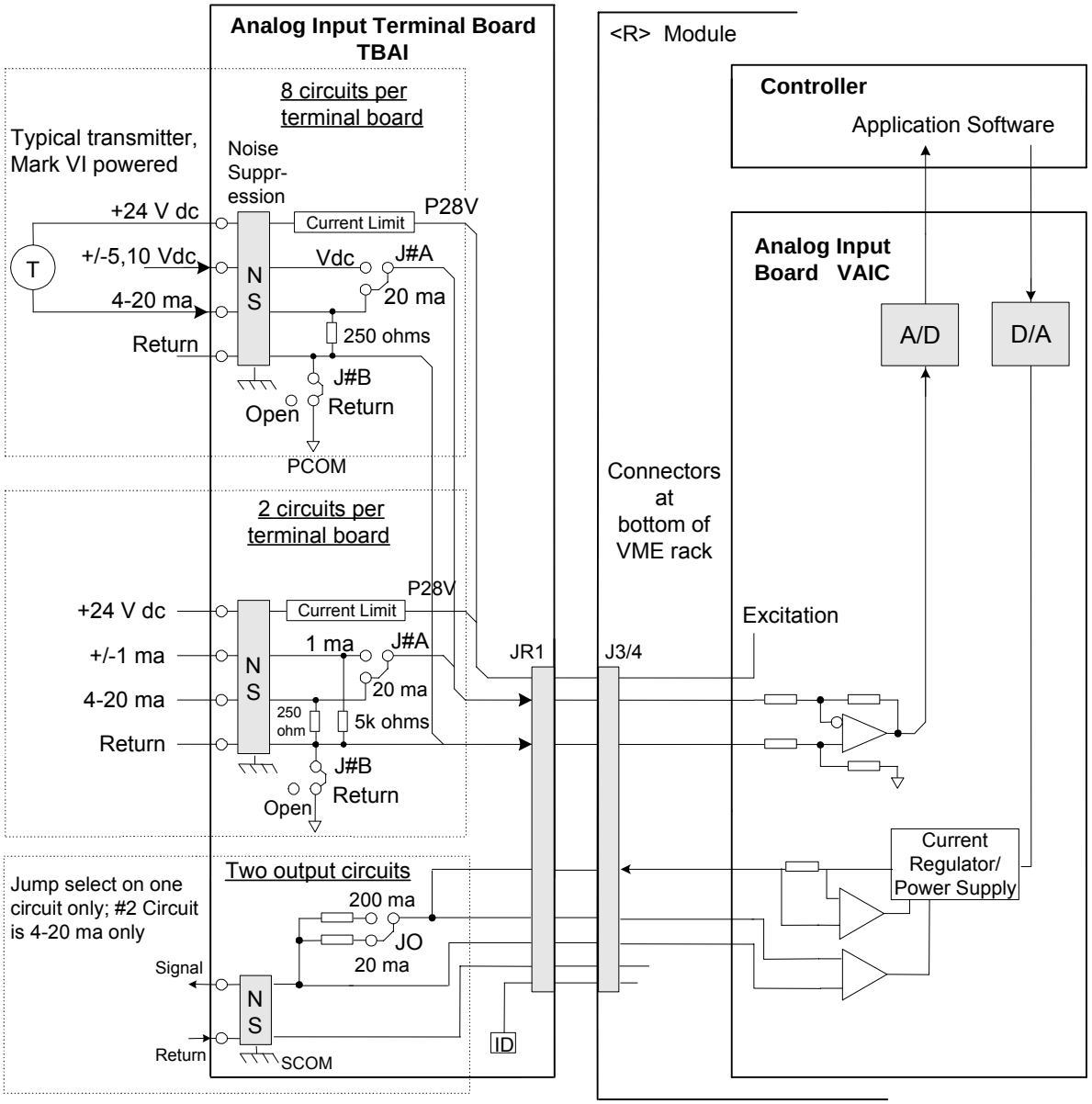
Note Cable connections to the terminal boards are made at the J3 and J4 connectors on the lower portion of the VME rack. These are latching type connectors to secure the cables. Power up the VME rack and check the diagnostic lights at the top of the front panel. For details, refer to the section on diagnostics in this document.

Operation

The VAIC board accepts 20 analog inputs, controls 4 analog outputs, and contains signal conditioning, an analog MUX, A/D converter, and D/A converter. The type of analog input, either voltage, 4-20 mA, or ±1 mA, is selected by jumpers on the terminal board. Two of the four analog output circuits are 4-20 mA and the other two can be configured for 4-20 mA or 0-200 mA. Inputs and outputs have noise suppression circuitry to protect against surge and high frequency noise.

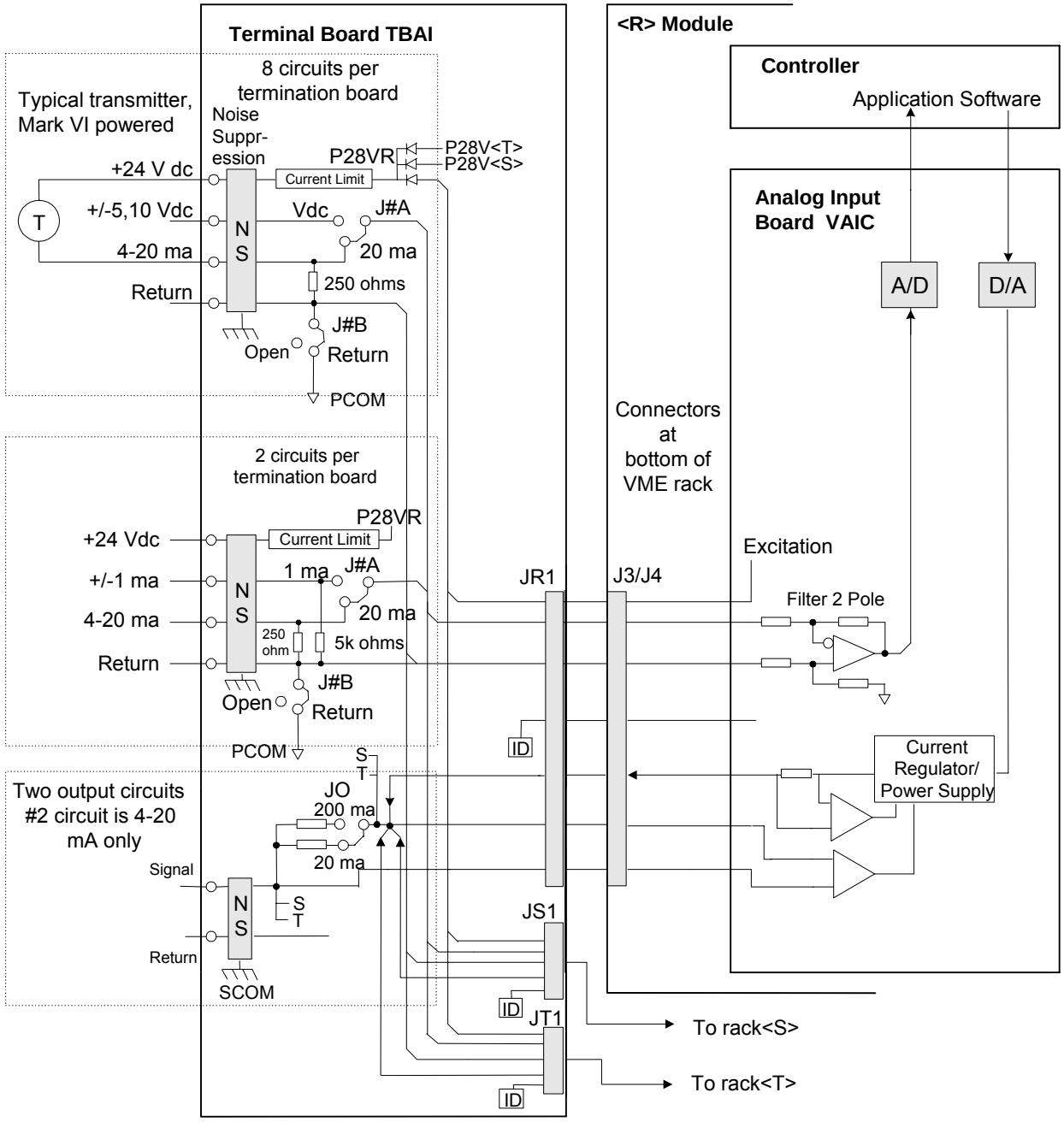
The following table displays the analog I/O capacity of VAIC, using two TBAI terminal boards.

Quantity	Analog Input Types	Quantity	Analog Output Types
16	±10 V dc, or ±5 V dc, or 4-20 mA	2	0-20 mA or 0-200 mA
4	4-20 mA, or ± 1 mA	2	0-20 mA



VAIC and Analog Input Terminal Board, Simplex System

In a TMR system, analog inputs fan out to the three control racks from JR1, JS1, and JT1. The 24 V dc power to the transducers comes from all three VME racks and is diode OR selected on the terminal board. Each analog current output is fed by currents from all three VAICs. The actual output current is measured with a series resistor, which feeds a voltage back to each VAIC. The resulting output is the voted middle value (median) of the three currents. The following figure shows VAIC in a TMR arrangement.



VAIC and Analog Input Terminal Board, TMR System

Note With the noise suppression and filtering, the input ac common mode rejection (CMR) is 60 dB, and the dc CMR is 80 dB.

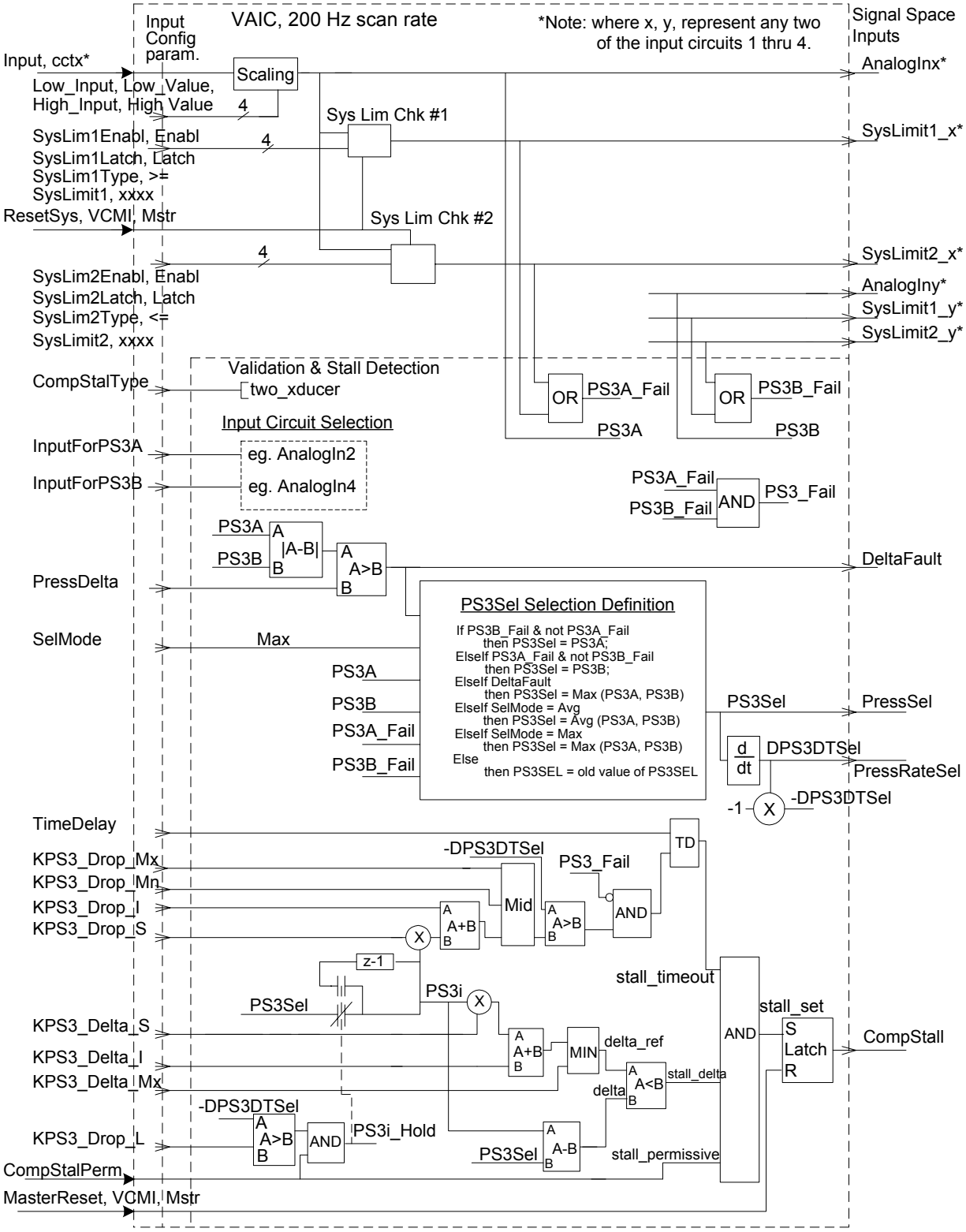
Transmitters/transducers can be powered by the 24 V dc source in the control system, or can be powered independently. Diagnostics monitor each output and a suicide relay disconnects the corresponding output if a fault cannot be cleared by a command from the processor. Hardware filters on the terminal board suppress high frequency noise. Additional software filters on VAIC provide configurable low pass filtering.

Compressor Stall Detection

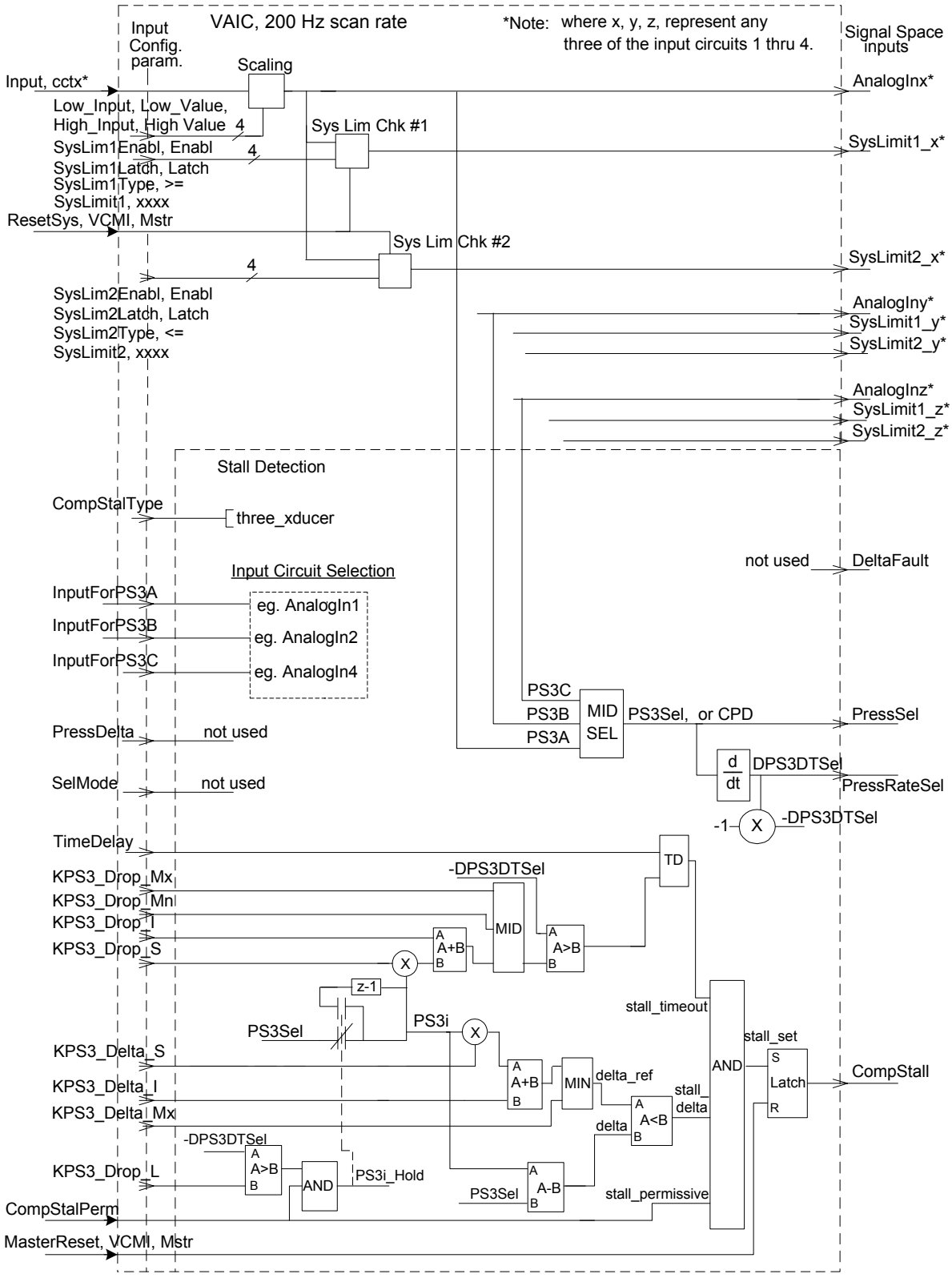
VAIC firmware includes gas turbine compressor stall detection, executed at 200 Hz. Two stall algorithms can be selected. Both use the first four analog inputs, scanned at 200 Hz. One algorithm is for small LM gas turbines and uses two pressure transducers (refer to the figure, *Small (LM) Gas Turbine Compressor Stall Detection Algorithm*). The other algorithm is for heavy-duty gas turbines and uses three pressure transducers (refer to the figure, *Heavy Duty Gas Turbine Compressor Stall Detection Algorithm*).

Real-time inputs are separated from the configured parameters for clarity. The parameter CompStalType selects the type of algorithm required, either two transducers or three. PS3 is the compressor discharge pressure. A drop in this pressure (PS3 drop) indicates possible compressor stall. The algorithm also calculates the rate of change of discharge pressure, dPS3dt, and compares these values with configured stall parameters (KPS3 constants).

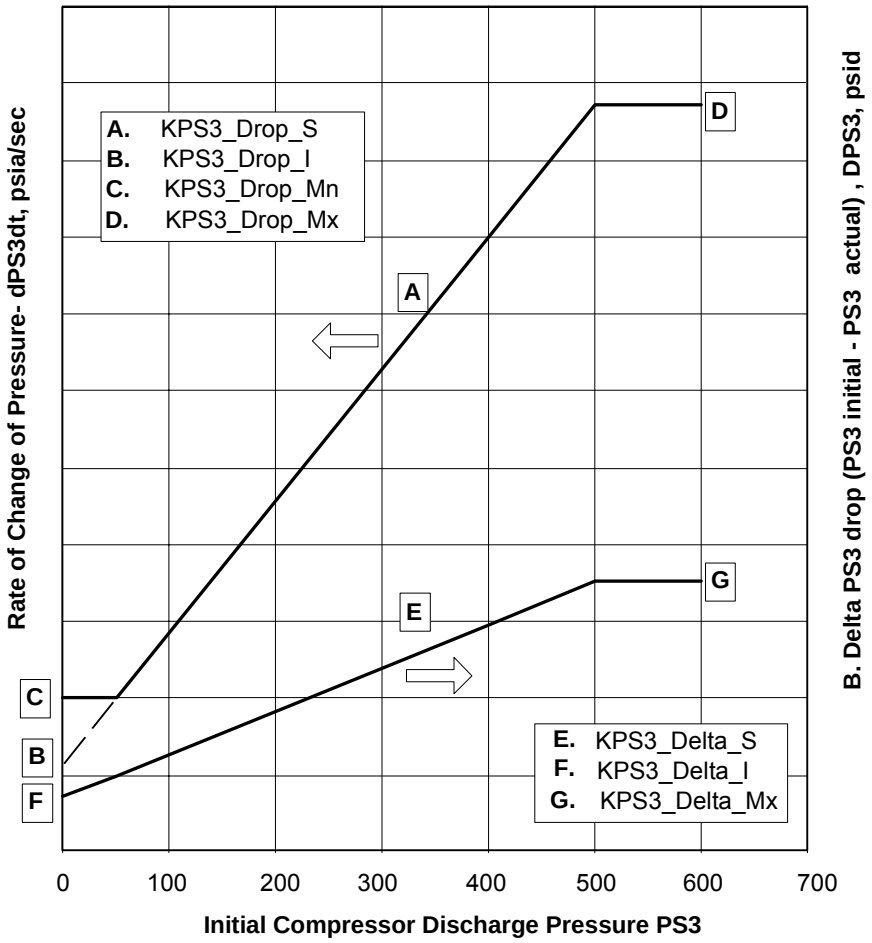
The compressor stall trip is initiated by VAIC, which sends the signal to the controller where it is used to initiate a shutdown. The shutdown signal can be used to set all the fuel shut-off valves (FSOV) through any relay output.



Small (LM) Gas Turbine Compressor Stall Detection Algorithm



Heavy Duty Gas Turbine Compressor Stall Detection Algorithm



Configurable Compressor Stall Detection Parameters

The variables used by the stall detection algorithm are defined as follows:

Variable	Variable Description
PS3	Compressor discharge pressure
PS3I	Initial PS3
KPS3_Drop_S	Slope of line for PS3I versus dPS3dt
KPS3_Drop_I	Intercept of line for PS3I versus dPS3dt
KPS3_Drop_Mn	Minimum value for PS3I versus dPS3dt
KPS3_Drop_Mx	Maximum value for PS3I versus dPS3dt
KPS3_Delta_S	Slope of line for PS3I versus Delta PS3 drop
KPS3_Delta_I	Intercept of line for PS3I versus Delta PS3 drop
KPS3_Delta_Mx	Maximum value for PS3I versus Delta PS3 drop

Specifications

Item	Specification
Number of channels	24 channels per VAIC board (20 AI, 4 AO) with two terminal boards
Input span	4-20 mA, ±1 mA, ±5 V dc, ±10 V dc
Input Impedance	250 Ω at 4-20 mA 5,000 Ω at 1 mA 500,00 Ω at voltage input
Input converter resolution	16-bit A/D converter with 14-bit resolution
Scan time	Normal scan 10 ms (100 Hz)
	Inputs 1 through 4 available for scan at 200 Hz
Measurement accuracy	Better than 0.1% full scale
Noise suppression on inputs	The first 10 circuits (J3) have a hardware filter with single pole down break at 500 rad/sec
	The second 10 circuits (J4) have a hardware filter with a two pole down break at 72 and 500 rad/sec
	A software filter, using a two pole low pass filter, is configurable for 0, .75, 1.5 Hz, 3 Hz, 6 Hz, 12 Hz
Common mode rejection	Ac CMR 60 dB @ 60 Hz, with up to ±5 V common mode voltage
	Dc CMR 80 dB with -5 to +7 peak volt common mode voltage
Common mode voltage range	±5 V (±2 V CMR for the ±10 V inputs)
Output converter	12-bit D/A converter with 0.5% accuracy
Output load	500 Ω for 4-20 mA output – board revisions prior to and including VAICH1C (requires TBAIH1B or DTAI)
	800 Ω for 4-20 mA output, board revisions VAICH1D and later (requires TBAIH1C or STAI)
	50 Ω for 200 mA output
Power consumption	Less than 31 MW
Compressor stall detection	Detection and relay operation within 30 ms
Fault detection	Analog input out of limits
	Monitor D/A outputs, output currents, and total current
	Monitor suicide relay and 20/200 mA scaling relays
	Compare input signals with the voted value and check difference against the TMR limit
	Failed I/O chip
Physical	
Temperature	0 to 60°C (32 to 140 °F)
Size	26.04 cm high x 1.99 cm wide x 18.73 cm deep (10.26 in x 0.782 in x 7.375 in)

Diagnostics

Three LEDs at the top of the VAIC front panel provide status information. The normal RUN condition is a flashing green, and FAIL is a solid red. The third LED displays STATUS and is normally off, but displays a steady orange if a diagnostic alarm condition exists in the board. Diagnostic checks include the following:

- Each analog input has hardware limit checking based on preset (non-configurable) high and low levels set near the ends of the operating range. If this limit is exceeded a logic signal is set and the input is no longer scanned. If any one of the input's hardware limits is set, it creates a composite diagnostic alarm, L3DIAG_VAIC, which refers to the entire board. 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.
- Each input has system limit checking based on configurable high and low levels. These limits can be used to generate alarms, and can be configured for enable/disable, and as latching/non-latching. RESET_SYS resets the out of limits.
- In TMR systems, if one signal varies from the voted value (median value) by more than a predetermined limit, that signal is identified and a fault is created. This can provide early indication of a problem developing in one channel.
- Monitor D/A outputs, output currents, total current, suicide relays and 20/200 mA scaling relays; these are checked for reasonability and can create a fault.
- TBAI has its own ID device that is interrogated by VAIC. The board ID is coded into a read-only chip containing the terminal board serial number, board type, revision number, and the JR, JS, JT connector location. When the chip is read by the I/O processor and a mismatch is encountered, a hardware incompatibility fault is created.

Configuration

Parameter	Description	Choices
Configuration		
System limits	Enable or disable system limits	Enable, disable
Output voting	Select type of output voting	Simplex, simplex TMR
Min_ MA_Input	Select minimum current for healthy 4-20 mA input	0 to 21 mA
Max_ MA_Input	Select maximum current for healthy 4-20 mA input	0 to 21 mA
CompStalType	Select compressor stall algorithm (# of transducers)	0, 2, or 3
InputForPS3A	Select analog input circuit for PS3A	Analog in 1, 2, 3, or 4
InputForPS3B	Select analog input circuit for PS3B	Analog in 1, 2, 3, or 4
InputForPS3C	Select analog input circuit for PS3C	Analog in 1, 2, 3, or 4
SelMode	Select mode for excessive difference pressure	Maximum, average
PressDelta	Excessive difference pressure threshold	5 to 500
TimeDelay	Time delay on stall detection, in milliseconds	10 to 40
KPS3_Drop_Min	Minimum pressure rate	10 to 2000
KPS3_Drop_I	Pressure rate intercept	10 to 100
KPS3_Drop_S	Pressure rate slope	0.05 to 10
KPS3_Delta_S	Pressure delta slope	0.05 to 10
KPS3_Delta_I	Pressure delta intercept	10 to 100
KPS3_Delta_Mx	Pressure delta maximum	10 to 100
KPS3_Drop_L	Threshold pressure rate	10 to 2000
KPS3_Drop_Mx	Max pressure rate	10 to 2000
J3:IS200TBAIH1A	Terminal board connected to VAIC through J3	Connected, not connected
AnalogIn1	First of 10 analog inputs - board point	Point edit (input FLOAT)
Input type	Current or voltage input type	Unused, 4-20 mA, ± 5 V, ± 10 V
Low_Input	Value of current at the low end of scale	-10 to +20
Low_Value	Value of input in engineering units at low end of scale	-3.4082e + 038 to 3.4028e + 038
High_Input	Value of current at the high end of scale	-10 to +20
High_Value	Value of input in engineering units at high end of scale	-3.4082e + 038 to 3.4028e + 038
Input _Filter	Bandwidth of input signal filter	Unused, 0.75, 1.5 Hz, 3 Hz, 6 Hz, 12 Hz
TMR_Diff_Limit	Difference limit for voted inputs in % of high-low values	0 to 100
Sys_Lim_1_Enable	Input fault check	Enable, disable
Sys_Lim_1_Latch	Input fault latch	Latch, unlatch
Sys_Lim_1_Type	Input fault type	Greater than or equal
		Less than or equal
Sys_Lim_1	Input limit in engineering units	-3.4082e + 038 to 3.4028e + 038
Sys_Lim_2_Enable	Input fault check	Enable, disable
Sys_Lim_2_Latch	Input fault latch	Latch, unlatch
Sys_Lim_2_Type	Input fault type	Greater than or equal
		Less than or equal
Sys_Lim_2	Input limit in engineering units	-3.4082e + 038 to 3.4028e + 038
AnalogOut1	First of two analog outputs - board point	Point edit (output FLOAT)
Output_MA	Type of output current	Unused, 0-20 mA, 0-200 mA
Low_MA	Output mA at low value	0 to 200 mA
Low_Value	Output in engineering units at low mA	-3.4082e + 038 to 3.4028e + 038
High_MA	Output mA at high value	0 to 200 mA
High_Value	Output value in engineering units at high mA	-3.4082e + 038 to 3.4028e + 038

Parameter	Description	Choices
TMR Suicide	Suicide for faulty output current, TMR only	Enable, disable
Diff Limit	Current difference for suicide, TMR only	0 to 200 mA
D/A Err Limit	Difference between D/A reference and output, in % for suicide, TMR only	0 to 100 %
J4:IS200TBAIH1A	Terminal board connected to VAIC via J4	Connected, not connected
AnalogIn11	First of 10 analog inputs - board point	Point edit (input FLOAT)
AnalogOut3	First of two analog outputs - board point	Point edit (output FLOAT)

Board Points (Signals)	Description - Point Edit (Enter Signal Connection)	Direction	Type
L3DIAG_VAIC1	Board diagnostic	Input	BIT
L3DIAG_VAIC2	Board diagnostic	Input	BIT
L3DIAG_VAIC3	Board diagnostic	Input	BIT
SysLimit1_1	System limit 1	Input	BIT
:	:	Input	BIT
SysLimit1_20	System limit 1	Input	BIT
SysLimit2_1	System limit 2	Input	BIT
:	:	Input	BIT
SysLimit2_20	System limit 2	Input	BIT
OutSuicide1	Status of suicide relay for output 1	Input	BIT
:	:	Input	BIT
OutSuicide4	Status of suicide relay for output 4	Input	BIT
DeltaFault	Excessive difference pressure	Input	BIT
CompStall	Compressor stall	Input	BIT
:	:	Input	FLOAT
Out4MA	Feedback, total output current, mA	Input	FLOAT
CompPressSel	Selected compressor press, by stall Algor.	Input	FLOAT
PressRate Sel	Selected compressor press rate, by stall Algor.	Input	FLOAT
CompStallPerm	Compressor stall permissive	Output	BIT

Alarms

Fault	Fault Description	Possible Cause
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
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 connectors 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
32-65	Analog input [ ] unhealthy	Excitation to transducer, bad transducer, open or short-circuit
66-69	Output [ ] individual current too high relative to total current. An individual current is N mA more than half the total current, where N is the configurable TMR_Diff Limit	Board failure
70-73	Output [ ] total current varies from reference current. Total current is N mA different than the reference current, where N is the configurable TMR_Diff Limit	Board failure or open circuit
74-77	Output [ ] reference current error. The difference between the output reference and the input feedback of the output reference is greater than the configured DA_Err Limit measured in percent	Board failure (D/A converter)
78-81	Output [ ] individual current unhealthy. Simplex mode only alarm if current out of bounds	Board failure
82-85	Output [ ] suicide relay non-functional. The shutdown relay is not responding to commands	Board failure (relay or driver)
86-89	Output [ ] 20/200 mA selection non-functional. feedback from the relay indicates incorrect 20/200 mA relay selection (not berg jumper selection)	Configured output type does not match the jumper selection, or VAIC board failure (relay)
90-93	Output [ ] 20/20 mA suicide active. One output of the three has suicided, the other two boards have picked up current	Board failure
94	J3 terminal board and configuration incompatible	
95	J4 terminal board and configuration incompatible	
128-223	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
224-249	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