VVIB Vibration Monitor Board

VVIB Vibration Monitor

Functional Description

The Vibration Monitor (VVIB) board processes vibration probe signals from the TVIB or DVIB terminal board. Up to 14 probes connect directly to the terminal board. Two TVIB can be cabled to the VVIB processor board. VVIB digitizes the various vibration signals, and sends them over the VME bus to the controller. The Mark* VI system uses Bently Nevada* probes for shaft vibration monitoring. The following vibration probes are compatible:

- Proximity
- Velocity
- Acceleration
- Seismic
- Phase

Note If desired, a Bently Nevada 3500 monitoring system can be connected to the terminal board.

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

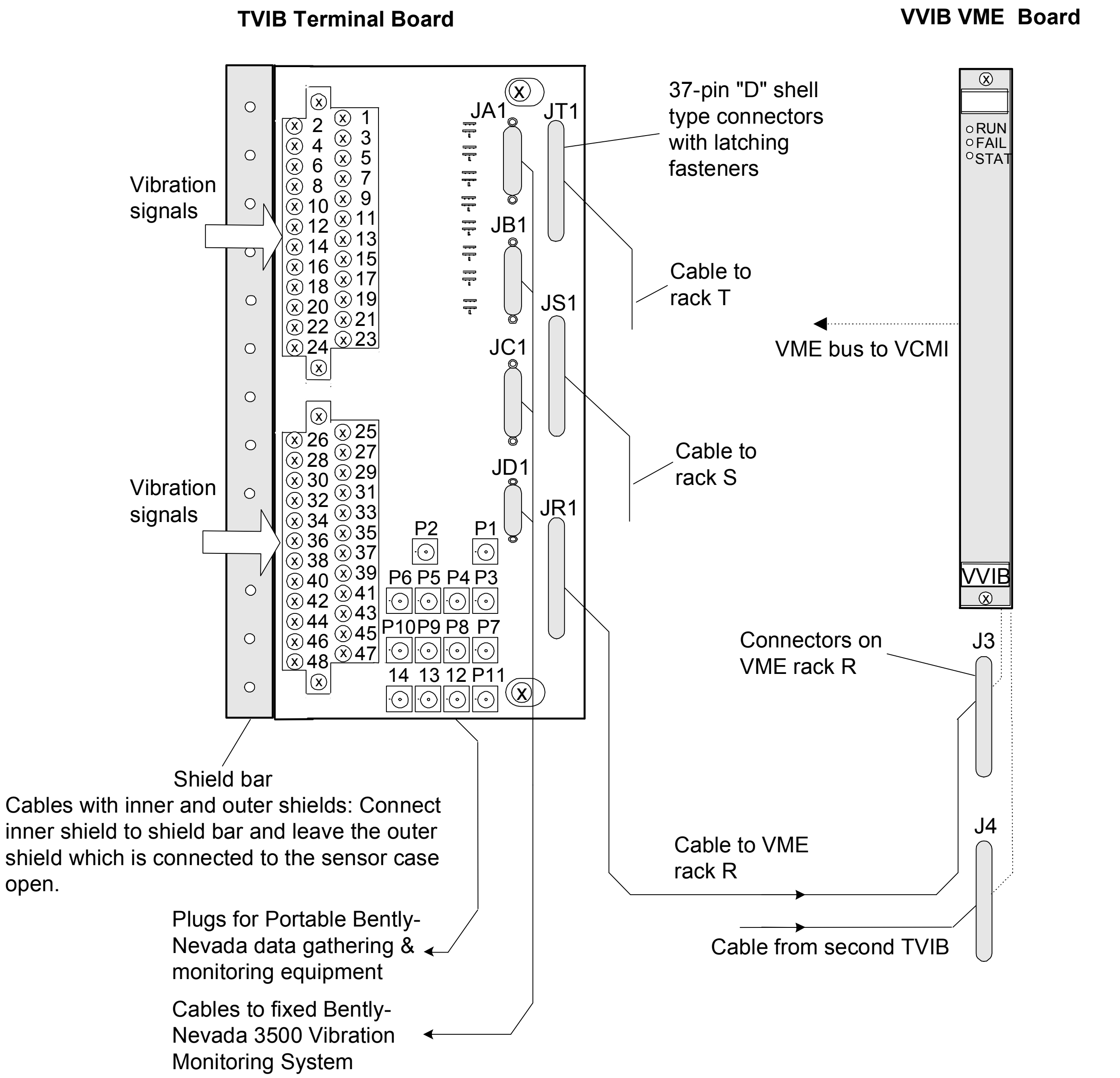
Vibration: Proximity probes monitor the peak-to-peak radial displacement of the shaft (the shaft motion in the journal bearing) in two radial directions. This system uses non-contacting probes and Proximitors®, and detects alarms, trips, and faults.

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 detects thrust bearing wear alarms, trips, and faults.

Differential Expansion: This application uses non-contacting probe(s) and Proximitor(s) and detects alarms, trips, and faults 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.

There are two types of TVIB terminal boards, H1A and H2A. The H2A type board has BNC connectors allowing portable vibration data gathering equipment to be plugged in for predictive maintenance purposes. Both types have connectors so that Bently Nevada vibration monitoring equipment can be permanently cabled to the terminal board to measure and analyze turbine vibration.



Vibration Processor Board, Terminal Board, and Cabling

Installation

➢ **To install the V-type board**

1 Power down the VME processor rack

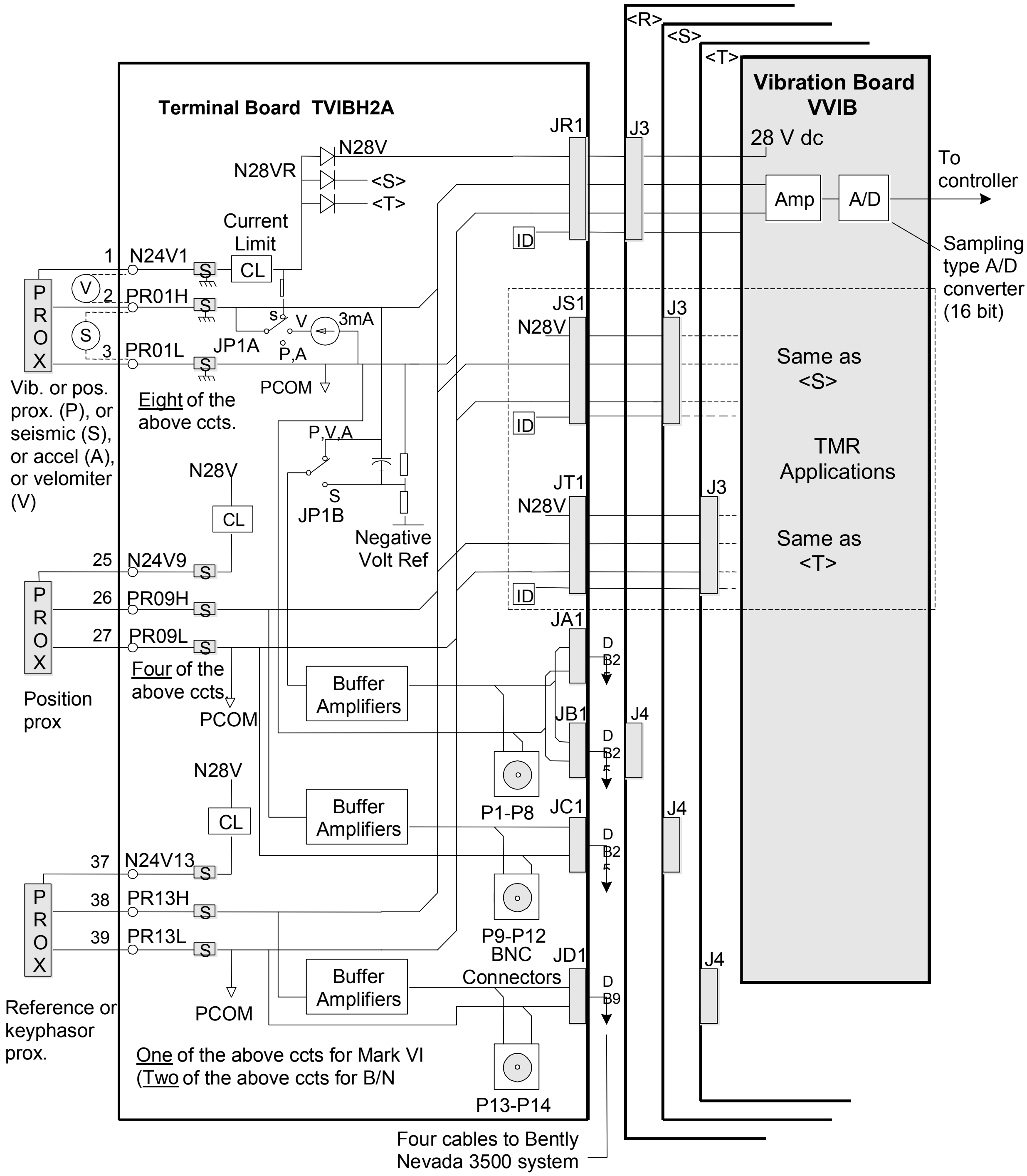
2 Slide in the board and push the top and bottom levers in with your hands to seat its edge connectors

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 terminal board 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.



VVIB Processor, Vibration Probes, and Bently Nevada Interface, TMR system

VVIB supplies -28 V dc to the terminal 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 speeds up to 4600 samples per second 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 engineering units (EU) (peak-to-peak) displacement for Proximitors inputs, EU (pk) for velocity inputs from accelerometers, integrated outputs, seismics, and Velomitors.

Vibration Monitoring Firmware

The Vibration Monitoring on the VVIB in partitioned in the following manner:

Channels 1 – 3:

Channels 1 through 3 can be used for position information from Proximitors, wideband vibration information from Proximitors, accelerometers with integrated outputs, Velomitors, and Seismics. 1X and 2X information can be derived from Proximitors viewing axial vibration information when a Keyphasor® probe is used. Tracking filters are normally used in LM applications with accelerometers.

Gapx_Vibx Vibration Filtering section runs the low-pass filter for the gap calculation, the wideband vibration filter, and the maximum / minimum detect for the peak-to-peak calculation at a 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels. The Gap Scaling and Limit Check runs at the frame rate. This function converts the gap value from volts to the desired EU. The system limit check provides two detection limits and Boolean outputs for the status. The Vpp, Filter and Limit Check block runs every 160 ms. The peak-to-peak calculation is based on the Vfmax and Vfmin values of the Gapx_Vibx Wideband Vibration Filtering section. The wideband peak-to-peak signal is filtered and then scaled to EU.

Note Vibx is expressed in EU (pk) for the configuration parameter, VibTypes: accelerometers with integrated outputs, seismics, and Velomitors. Vibx is expressed in EU(pk – pk) for Proximitors.

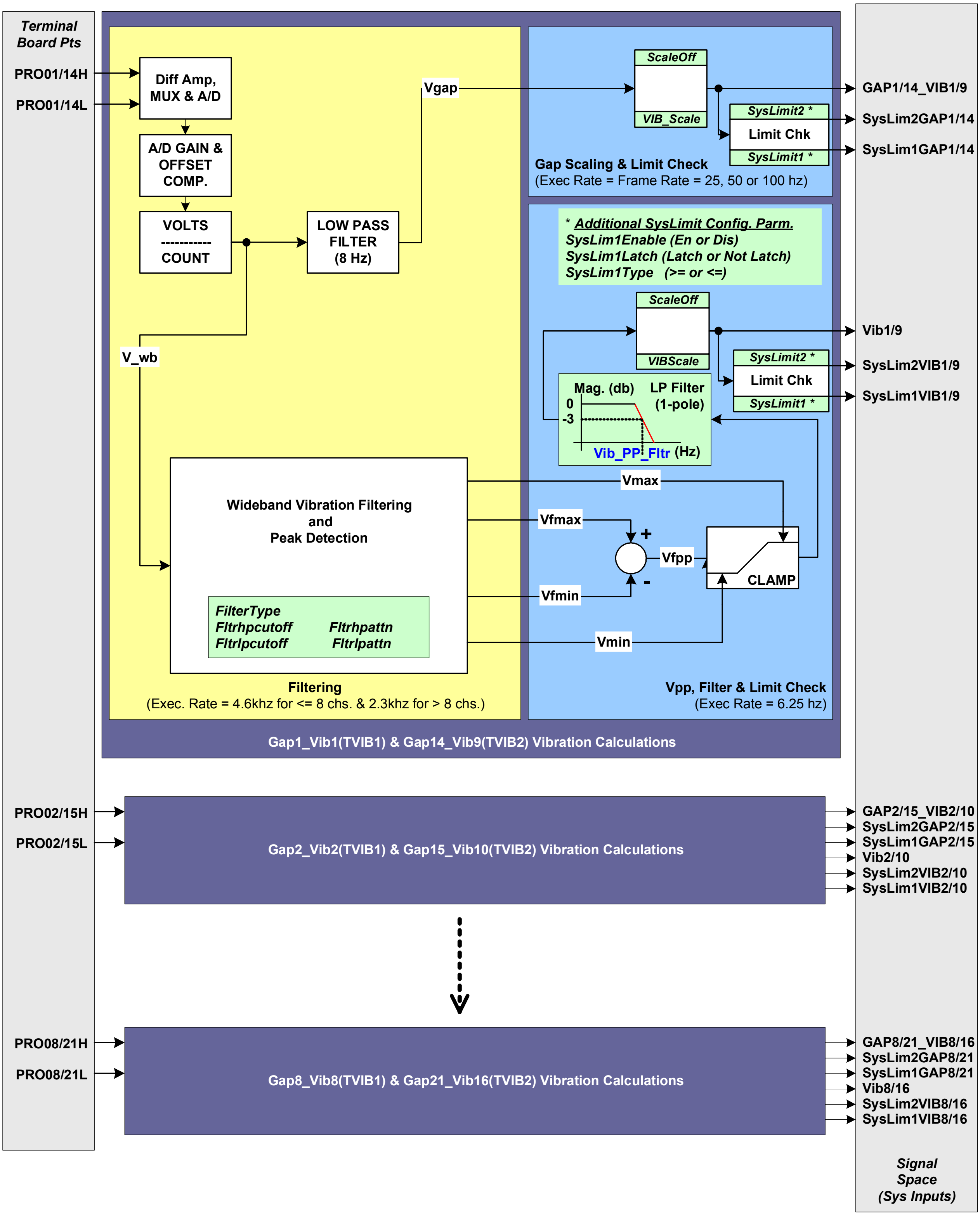
The re-scaled wideband signal is the input for the limit check function. The limit check provides the Booleans, SysLim1VIBx, and SysLim2VIBx for the limit check status.

Three tracking filters are provided to calculate the peak vibration for the LM applications when accelerometers are used. The tracking filters provide the vibration that occurs at the rotor speeds defined by the System outputs, LM_RPM_A, LM_RPM_B, and/or LM_RPM_C. LMVib1A is the vibration detected on channel 1 based on the rotor speed, LM_RPM_A. LMVib1B is the vibration detected on channel 1 based on rotor speed, LM_RPM_B. LMVib1C is based on LM_RPM_C.

The 1X and 2X filters provide the peak-to-peak vibration vector relative to the Keyphasor input from channel 13. VIB1X1 is the peak-to-peak magnitude of the vibration from channel 1 relative to the rpm based on the Keyphasor input. Vib1xPH1 is the phase angle in degrees of the vibration vector from channel 1 relative to the Keyphasor input. VIB2X1 is the peak-to-peak magnitude of the vibration from channel 1 relative to twice the Keyphasor rpm. Vib2xPH1 is the phase angle in degrees of the 2X vibration vector from channel 1.

Channels 4 – 8:

Channels 4 through 8 can be used for position information from Proximitors, wideband vibration information from Proximitors, Velomitors, and Seismics. 1X and 2X information can be derived from Proximitors viewing axial vibration information when a Keyphasor probe is used. Channels 4 through 8 are identical to channels 1 through 3 with the exception of the Tracking filters. Channels 4-8 do not include the Tracking filters.



Channels 9 – 12:

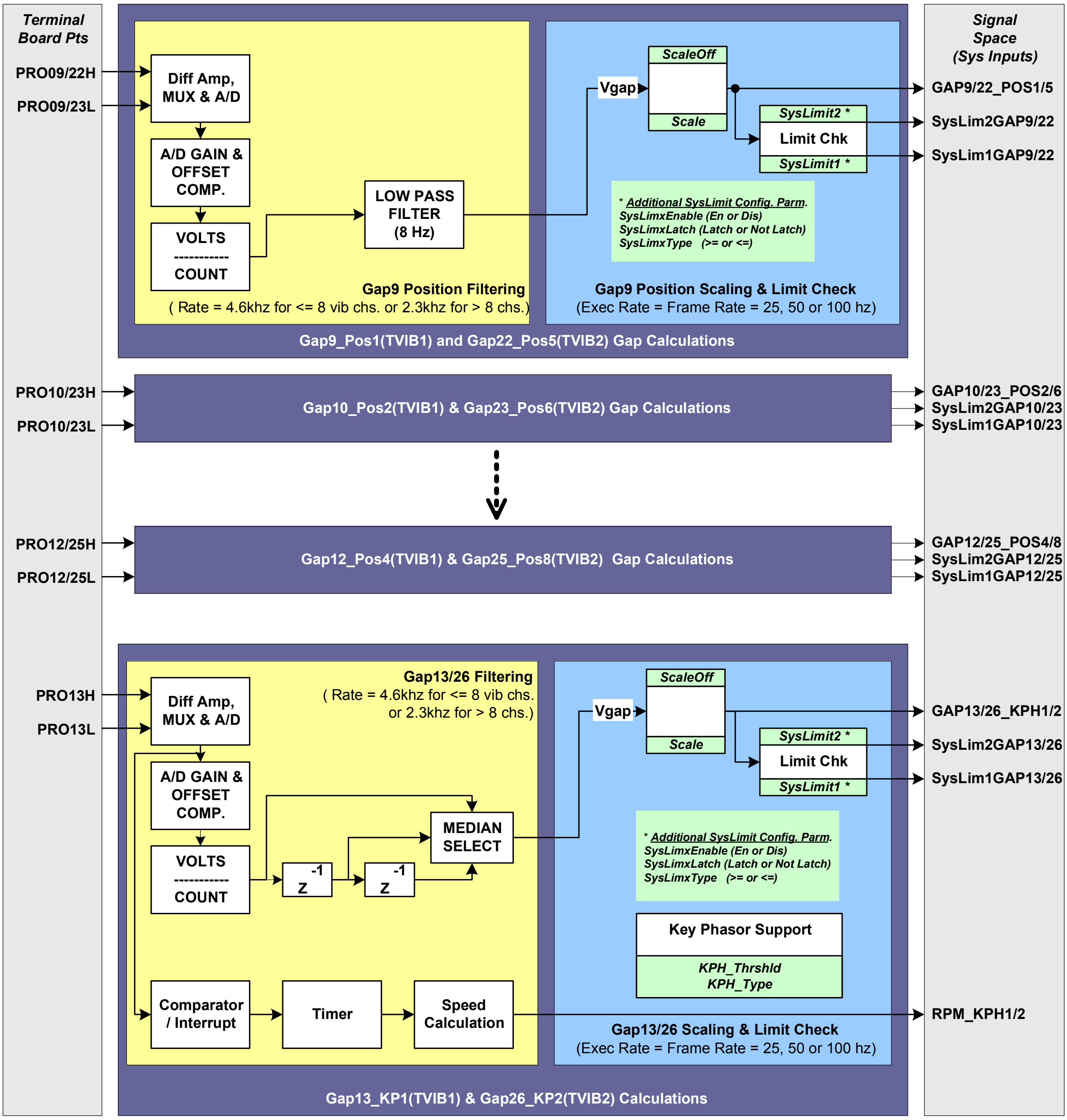
Channels 9 – 12 are used for position information only. The Gapx_Pos_Filtering runs at 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels. This section provides an 8 Hz low pass filter for the gap calculation. Gapx_Pos Scaling and Limit Check runs every frame. This function rescales the gap value from volts to EU based on the configuration. The System Limit Check can be used set a Boolean at minimum and/or maximum limit values configured by the user.

Channnel 13:

Channel 13 supports position feedback and Keyphasor feedback. The Key_Phasor Filtering is executed 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels. The Filtering function performs a median select filter for the gap signal.

A hardware comparator circuit with a software controlled hysteresis limit is used to detect the leading edge of the slot or pedestal gap transition. The Keyphasor timing pulse is fed into an FPGA with counters that determine the time between Keyphasor pulses and the firmware uses this information to calculate the rotor speed in rpm. At very low speeds the hardware Keyphasor comparator is not usable and the runtime application code determines speed by counting pulses detected through the system input, GAP13_KPH1.

The Gap13 KP Scaling and Limit Check runs every frame. The gap scaling and System Limit Check performs the same way it does for channels 1 through 12.



Terminal Board Pts
PRO09/22H
PRO09/23L
Diff Amp, MUX & A/D
A/D GAIN & OFFSET COMP.
VOLTS ----------- COUNT
LOW PASS FILTER (8 Hz)
Gap9 Position Filtering
(Rate = 4.6khz for <= 8 vib chs. or 2.3khz for > 8 chs.)
Vgap
ScaleOff
Scale
SysLimit2 *
Limit Chk
SysLimit1 *
* Additional SysLimit Config. Parm.
SysLimxEnable (En or Dis)
SysLimxLatch (Latch or Not Latch)
SysLimxType (>= or <=)
Gap9 Position Scaling & Limit Check
(Exec Rate = Frame Rate = 25, 50 or 100 hz)
Gap9_Pos1(TVIB1) and Gap22_Pos5(TVIB2) Gap Calculations
Signal Space (Sys Inputs)
GAP9/22_POS1/5
SysLim2GAP9/22
SysLim1GAP9/22
PRO10/23H
PRO10/23L
Gap10_Pos2(TVIB1) & Gap23_Pos6(TVIB2) Gap Calculations
GAP10/23_POS2/6
SysLim2GAP10/23
SysLim1GAP10/23
PRO12/25H
PRO12/25L
Gap12_Pos4(TVIB1) & Gap25_Pos8(TVIB2) Gap Calculations
GAP12/25_POS4/8
SysLim2GAP12/25
SysLim1GAP12/25
PRO13H
PRO13L
Diff Amp, MUX & A/D
A/D GAIN & OFFSET COMP.
VOLTS ----------- COUNT
Gap13/26 Filtering
(Rate = 4.6khz for <= 8 vib chs. or 2.3khz for > 8 chs.)
MEDIAN SELECT
z -1
z -1
Comparator / Interrupt
Timer
Speed Calculation
Vgap
ScaleOff
Scale
SysLimit2 *
Limit Chk
SysLimit1 *
* Additional SysLimit Config. Parm.
SysLimxEnable (En or Dis)
SysLimxLatch (Latch or Not Latch)
SysLimxType (>= or <=)
Key Phasor Support
KPH_Thrshld
KPH_Type
Gap13/26 Scaling & Limit Check
(Exec Rate = Frame Rate = 25, 50 or 100 hz)
Gap13_KP1(TVIB1) & Gap26_KP2(TVIB2) Calculations
GAP13/26_KPH1/2
SysLim2GAP13/26
SysLim1GAP13/26
RPM_KPH1/2

Wideband Vibration Filtering

The Wideband_Vibration Filtering function is executed at 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels. The vibration input for this function comes from the FPGA that controls the A/D and multipler circuit. The gap or position filter is a 2-pole low pass filter with a cutoff frequency set at 8 Hz. The output of the gap filter is expressed in volts and provides the input the Gap Scaling and Limit Check function.

The wideband vibration information can be shaped or conditioned based on the configuration parameter, FilterType. FilterTypes equal to Low-pass, Band-pass or High-pass are used for the Seismic and Velomitor sensor types. FilterType = None is used by all the other sensor types. The Low-Pass filter can be configured for 2, 4, 6 or 8 pole attenuation behavior through the parameter, Filtrlpattn. The 3 db cutoff frequency, Filtrlocutoff is also adjustable. The High-pass filter can also be configured for 2, 4, 6 and 8 pole to sharpen the attenuation characteristics of the filter through the parameter, Filtrhpattn. The cutoff frequency, Filtrhpcutoff is adjustable in configuration.

The wideband filtered vibration output, Vfout goes through a minimum/maximum peak detect function. The capture window for the minimum/maximum detect is 160 milliseconds wide for Keyphasor based speeds greater than 12 rpm. The objective is to capture at least 2 cycles of vibration information to get an accurate peak-to-peak calculation.

The wideband unfiltered vibration output, goes through a second minimum/maximum peak detect function. The outputs, Vmax and Vmin, are used to clamp the filtered vibration output peak-to-peaks.

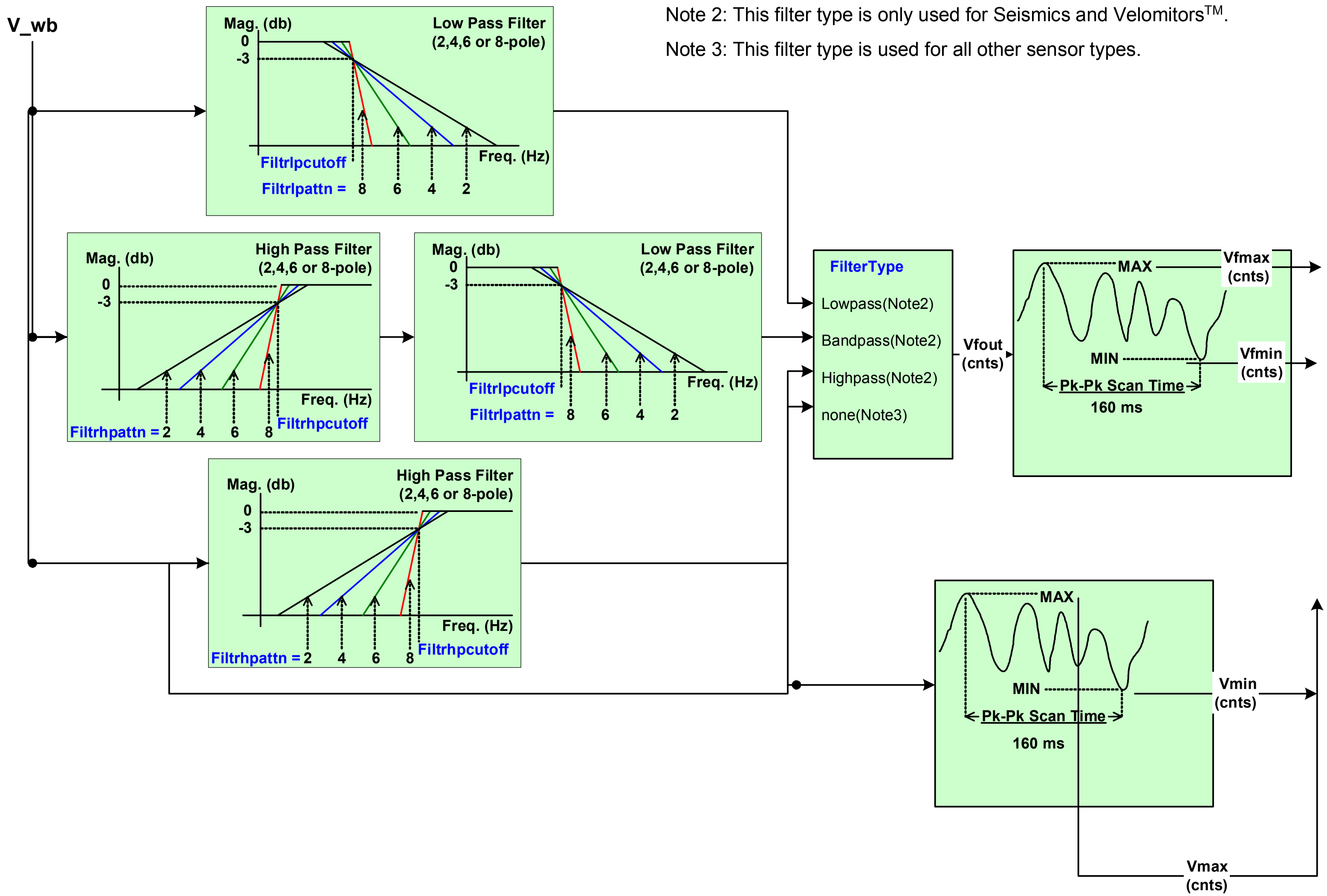
Wideband Vibration Filtering and Peak Detection

Exec. Rate = 4600 / 2300 Hz

Note 1: Text in **BLUE** are PVIB configuration parameters.

Note 2: This filter type is only used for Seismics and Velomitors™.

Note 3: This filter type is used for all other sensor types.



Vpp Filter and Limit Check

The Vpp, Filter and Limit Check operates on channels 1 through 8 for TVIB1 and channels 14 through 21 for TVIB2. The execution rate for the function is 6.25 Hz. The Vpp, Filter, and Limit Check inputs are the following:

- Vfmax – filtered maximum peak vibration
- Vfmin – filtered minimum peak vibration
- Vmin – unfiltered min peak vibration
- Vmax – unfiltered max peak vibration

The system inputs or Vpp, Filter, and Limit Check outputs are:

VIBx - the wideband vibration in EU where the units for EU are in peak for the configuration parameter, VibType = Seismic, Velomitor or Accelerometer and the EU units are peak-to-peak for VibType = Proximitor

SysLim1VIBx – the System Limit #1 Boolean (Boolean is True if VIBx is in the limit 1)

SysLim2VIBx – the System Limit #2 Boolean (Boolean is True if VIBx is in the limit 2)

The system output used is the System Limit Reset Boolean. If Reset is True, a latched System Limit Boolean is cleared.

The filtered peak-to-peak wideband vibration signal, Vfpp = Vfmax – Vfmin. Vfpp is then clamped based on the unfiltered peak-to-peak wideband value. The clamp prevents outputs from the Infinite Impulse Response (IIR-based) filter designs used for the high-pass and low-pass filters to exceed the original input values. The clamped wideband vibration signal, Vpp passes through a single-pole low-pass filter with an adjustable cutoff frequency, VIB_PP_Fltr.

The Vpp, Filter, and Limit Check scaling block converts the clamped and filtered wideband peak-to-peak vibration from volts to EU or Volts peak (Vp) depending on the configuration parameter VibType.

- VibType – determines the A/D conversion value, AD_CONV in units of volts / counts and the default value for the sensor offset and the final EU units being expressed in peak or peak-to-peak.
- VIBScale – gain factor expressed in volts peak / EU (peak) irregardless to the VibType setting.
- ScaleOffset – offset value in EU (peak).

The Vpp, Filter and Limit Check provides two System Limit blocks. The following configuration parameters control the behavior of the System Limit block:

- SysLimxEnabl – the System Limit (x=1 or 2) Enable is set True to select the use of the block.
- SysLimxType – the System Limit (x=1 or 2) Type selects whether the limit check does a “>=” check or a “<=” check.
- SysLimitx – System Limit (x=1 or 2) is the limit value used in the “>=” or “<=” check.
- SysLimxLatch – System Limit (x=1 or 2) Latch determines whether the Boolean status flag is latched or unlatched. If the Boolean status flag is latched the flag will remain True even if the limit value is no longer exceeded.

The system input or System Limit Boolean status flag is SysLimxVIBy where x is the System Limit block number (1 or 2) and y is the VVIB channel input number (1 – 8 for TVIB1 and 14 – 21 for TVIB2).

Gap Scaling and Limit Check

The Gap Scaling and Limit Check operates on channels 1 through 8 for TVIB1 and channels 14 through 21 for TVIB2. The execution rate for the function is 25, 50, or 100 Hz. The rate of execution is based on the frame rate selected for IONet. The system inputs or Gap Scaling and Limit Check outputs are:

Gapx_VIBx – the position or gap value in EU for Proximitors and bias voltage in Vdc for accelerometers with integrated outputs, seismics, and Velomitors

SysLim1GAPx – the System Limit #1 Boolean; (Boolean is True if GAPx_VIBx is in the limit 1)

SysLim2GAPx – the System Limit #2 Boolean. (Boolean is True if GAP_VIBx is in the limit 2)

The system output used is the System Limit Reset Boolean. If Reset is True, a latched System Limit Boolean is cleared.

The Gap Scaling and Limit Check scaling block converts the 8 Hz filtered output gap signal from volts to EU or Volts peak (Vp) depending on the configuration parameter VibType. The scaling is determined by the following configuration parameters:

- VIB_Scale – gain factor expressed in volts peak / EU (peak) irregardless to the VibType setting.
- ScaleOffset – offset value in EU (peak)

The Gap Scaling and Limit Check provides two System Limit blocks. The following configuration parameters control the behavior of the System Limit block:

- SysLimxEnabl – the System Limit (x=1 or 2) Enable is set True to select the use of the block.
- SysLimxType – the System Limit (x=1 or 2) Type selects whether the limit check does a “>=” check or a “<=” check.
- SysLimitx – System Limit (x=1 or 2) is the limit value used in the “>=” or “<=” check.
- SysLimxLatch – System Limit (x=1 or 2) Latch determines whether the Boolean status flag is latched or unlatched. If the Boolean status flag is latched the flag will remain True even if the limit value is no longer exceeded.

The system input or System Limit Boolean status flag is SysLimxGAPy where x is the System Limit block number (1 or 2) and y is the VVIB channel input number (1 – 8 for TVIB1 and 14 – 21 for TVIB2).

Gapx_POSy Gap Calculations

The Gapx_POSy Gap Calculations is comprised of the Gapx Position Filtering and the Gapx_Pos Scaling and Limit Check where x is the VVIB channel number 9 through 12 for TVIB1 and 22 through 25 for TVIB2 and y is the position number 1 – 4 for TVIB1 and 5 – 8 for TVIB2. The Gapx_POSy Gap Calculation's outputs are:

Gapx_POSy – the position or gap value in EU for Proximitors

SysLim1GAPx – the System Limit #1 Boolean (Boolean is True if GAPx_POSy is in the limit 1)

SysLim2GAPx – the System Limit #2 Boolean (Boolean is True if GAP_POSy is in the limit 2)

The system output used is the System Limit Reset Boolean. If Reset is True, a latched System Limit Boolean is cleared.

The Gapx_Position Filtering is executed at 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels. The position input for this function comes from an FPGA that controls the multiplexed A/Ds. The A/D value is compensated for A/D gain and offset errors and converted to volts. A median select filter is then applied.

The Gapx_Position Scaling and Limit Check scaling block converts the filtered gap signal from volts to EU or Volts peak (Vp) depending on the configuration parameter VibType. The configuration parameters are:

- Scale – gain factor expressed in volts peak / EU (peak)
- ScaleOffset – offset value in EU (peak)

The Gapx_Position Scaling and Limit Check provides two System Limit blocks. The following configuration parameters control the behavior of the System Limit block:

- SysLimxEnabl – the System Limit (x=1 or 2) Enable is set True to select the use of the block.
- SysLimxType – the System Limit (x=1 or 2) Type selects whether the limit check does a ">=" check or a "<=" check.
- SysLimitx – System Limit (x=1 or 2) is the limit value used in the ">=" or "<=" check.
- SysLimxLatch – System Limit (x=1 or 2) Latch determines whether the Boolean status flag is latched or unlatched. If the Boolean status flag is latched the flag will remain True even if the limit value is no longer exceeded.

The system input or System Limit Boolean status flag is SysLimxGAPy where x is the System Limit block number (1 or 2) and y is the VVIB channel input number (9 – 12 for TVIB1 and 22 – 25 for TVIB2).

Gap13/26_KPH1/2 Calculations

The Gap13/26_KPH12 Calculations is comprised of the Gap13/26 Filtering and the Gap13/26_KP Scaling and Limit Check. The Gap13/26_KPH1/2 Calculation system inputs are:

GAP13_KPH1 – the position or gap value in EU for the Keyphasor Proximitor for TVIB1

GAP26_KPH2 – the position or gap value in EU for the Keyphasor Proximitor for TVIB2

SysLim1GAP13 – the System Limit #1 Boolean for TVIB1 (Boolean is True if GAP13_KPH1 is in the limit 1)

SysLim2GAP13 – the System Limit #2 Boolean for TVIB1 (Boolean is True if GAP13_KPH1 is in the limit 2)

SysLim1GAP26 – the System Limit #1 Boolean for TVIB2 (Boolean is True if GAP26_KPH2 is in the limit 1)

SysLim2GAP26 – the System Limit #2 Boolean for TVIB2 (Boolean is True if GAP26_KPH2 is in the limit 2)

The Gap13_KPH1 system outputs are:

SysLimReset – the System Limit Reset Boolean (If Reset is True, a latched System Limit Boolean is cleared)

LM_RPMx – rotor shaft speed in rpm from different stages of the turbine (x = A, B or C)

The Gap 13/26 Filtering is executed at 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels. The input for this function comes from a multiplexed A/D controlled by an FPGA. The Gap 13/26 Filtering uses the median select function to calculate the filtered gap. The median select filter uses the present value (n), the previous (n-1), and the value 2 samples back (n-2) to perform a median select on. The output is expressed in volts and passes to the Gap13/26 Scaling and Limit Check.

The Gap13/26 Scaling and Limit Check scaling block converts the filtered gap signal from volts to EU. The Gap13/26 runs at the frame rate of either 25, 50 or 100 Hz. The gap conversion is based on the following configuration parameters:

- Scale – gain factor expressed in volts peak / EU (peak)
- ScaleOffset – offset value in EU (peak)

The Gap13/26 Scaling & Limit Check provides two System Limit blocks. The following configuration parameters control the behavior of the System Limit block:

- SysLimxEnabl – the System Limit (x=1 or 2) Enable is set True to select the use of the block.
- SysLimxType – the System Limit (x=1 or 2) Type selects whether the limit check does a “>=” check or a “<=” check.
- SysLimitx – System Limit (x=1 or 2) is the limit value used in the “>=” or “<=” check.
- SysLimxLatch – System Limit (x=1 or 2) Latch determines whether the Boolean status flag is latched or unlatched. If the Boolean status flag is latched the flag will remain True even if the limit value is no longer exceeded.

The system input or System Limit Boolean status flag is SysLimxGAP13 for TVIB1 and SysLimxGAP26 for TVIB2 where x is the System Limit block number (1 or 2).

1X and 2X Calculations based on Keyphasor Input

The 1X and 2X Calculations based on a Keyphasor input provides a peak-to-peak vibration component (magnitude and phase) at both the Keyphasor frequency and twice the frequency. The calculations are comprised of two sections:

- Modulator and Filter
- Magnitude and Phase Calculation

The system inputs from the 1X & 2X calculations are:

- Vib1Xy – the peak-to-peak magnitude of the vibration phasor that is rotating at the Keyphasor frequency
- Vib1xPHy – the phase angle between the Keyphasor input and the ViB1Xy vibration phasor
- Vib2Xy – the peak-to-peak magnitude of the vibration phasor that is rotating at the twice the Keyphasor frequency
- Vib1xPHy – the phase angle between the Keyphasor input and the Vib2Xy vibration phasor, and where y is the VVIB channel number, 1 through 8 for TVIB1 and 14 through 21 for TVIB2

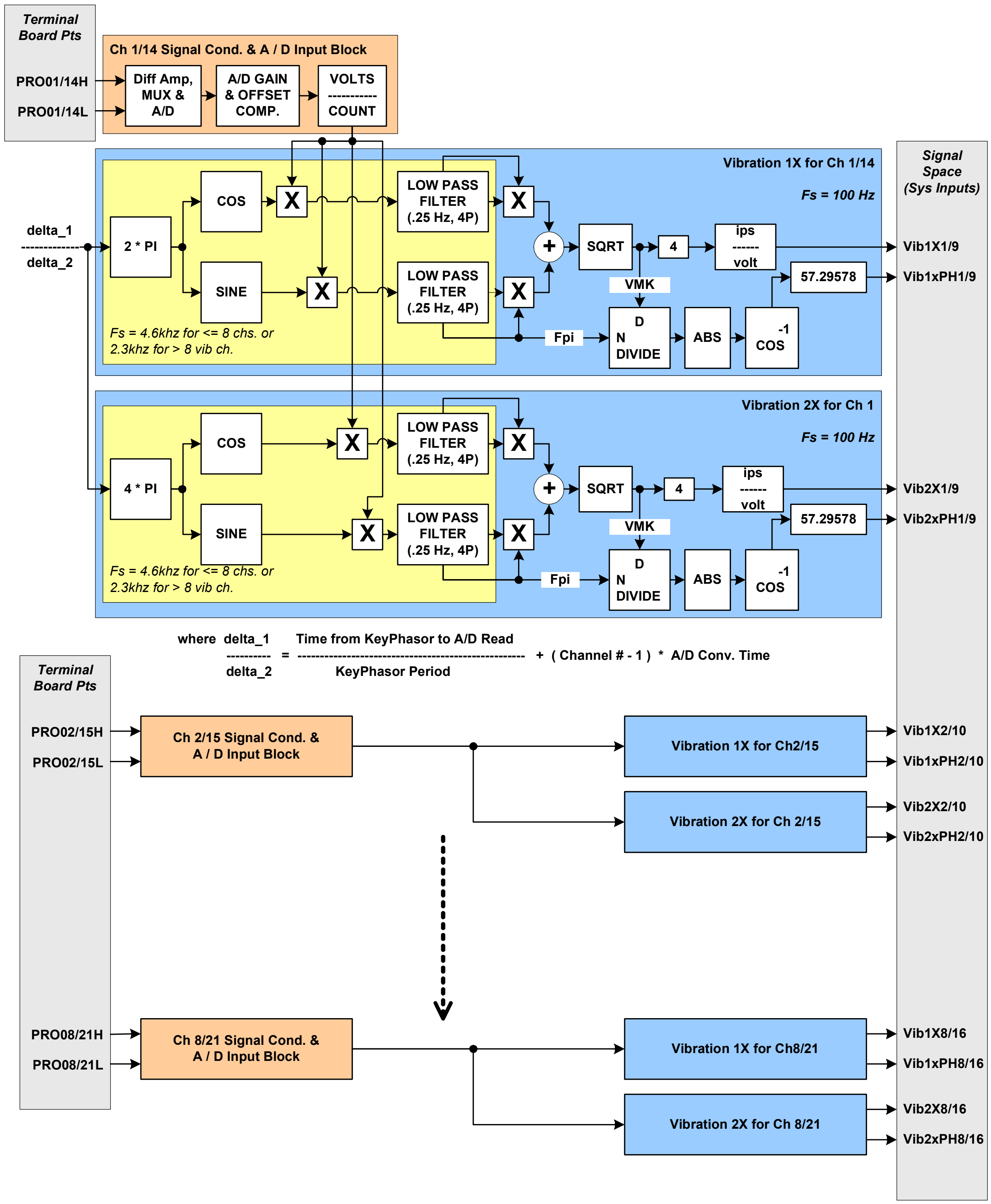
The Modulator and Filter for both the 1X and 2X calculations are executed at 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels. The 1X modulator has two inputs: delta_1/delta_2 and the vibration channel input. The delta_1/ delta_2 is the point in the key_phasor cycle where the vibration channel input was sampled. The range for delta_1/delta_2 is from 0 to 1. Delta_1/delta_2 is converted to radians and is the index into a cosine and sine lookup table. The result from the cosine and sine lookup table is modulated with the vibration channel input. The modulated signal is filtered through a 4-pole low pass filter with a cutoff frequency of 0.25 Hz. The filter output provides the dc value of the de-modulated components: the real and imaginary phasors of the vibration component that is rotating at 1X speed.

The Vibration 1X function uses the real and imaginary vibration components based on the Keyphasor frequency as the inputs to the RMS calculator. The square root of the sum of the squares of the real and imaginary vibration components times the scaling block results in the peak-to-peak magnitude of the 1X vibration phasor, Vib1Xy rotating at the Keyphasor frequency. The phase, Vib1xPHy, is the arccosine of the absolute value of Fpi / (VMK).

The Vibration 2X function is the same calculation except the input delta_1/delta_2 is multiplied by 4 * PI instead of 2 * PI. The results are a peak-to-peak magnitude of the 2X vibration phasor, Vib2Xy, rotating at twice the Keyphasor frequency and a phase of Vib2xPHy.

The scaling block converts the VMK * 4 signal to EU. The scaling is based the following configuration parameters:

- Scale – gain factor expressed in volts peak / EU (peak)
- ScaleOffset – offset value in EU (peak)


Terminal Board Pts
PRO01/14H
PRO01/14L
Ch 1/14 Signal Cond. & A / D Input Block
Diff Amp, MUX & A/D
A/D GAIN & OFFSET COMP.
VOLTS ----------- COUNT
Signal Space (Sys Inputs)
Vibration 1X for Ch 1/14
Fs = 100 Hz
delta_1 -------------- delta_2
2 * PI
COS
SINE
X
LOW PASS FILTER (.25 Hz, 4P)
SQRT
4
ips ------ volt
VMK
57.29578
Fpi
D N DIVIDE
ABS
-1 COS
Fs = 4.6khz for <= 8 chs. or 2.3khz for > 8 vib ch.
Vib1X1/9
Vib1xPH1/9
Vibration 2X for Ch 1
4 * PI
Vib2X1/9
Vib2xPH1/9
where delta_1 ---------- delta_2 = Time from KeyPhasor to A/D Read -- KeyPhasor Period + (Channel # - 1) * A/D Conv. Time
PRO02/15H
PRO02/15L
Ch 2/15 Signal Cond. & A / D Input Block
Vibration 1X for Ch2/15
Vibration 2X for Ch 2/15
Vib1X2/10
Vib1xPH2/10
Vib2X2/10
Vib2xPH2/10
PRO08/21H
PRO08/21L
Ch 8/21 Signal Cond. & A / D Input Block
Vibration 1X for Ch8/21
Vibration 2X for Ch 8/21
Vib1X8/16
Vib1xPH8/16
Vib2X8/16
Vib2xPH8/16

Tracking Filters based on LM_RPM_A/B and C

The Tracking Filters based on LM_RPM_A/B and C provide the peak vibration component (magnitude only) at the frequencies: LM_RPM_A, LM_RPM_B, and LM_RPM_C. The Tracking filters require both Modulation & filter stage executing at 4.6 kHz rate and 2.3 kHz rate if input channels 14 through 21 are configured as vibration channels and the Magnitude calculation.

The system inputs from the Tracking filters are:

- LMVibxA – the peak magnitude of the vibration component rotating at LM_RPM_A speed
- LMVibxB – the peak magnitude of the vibration component rotating at LM_RPM_B speed
- LMVibxC – the peak magnitude of the vibration component rotating at LM_RPM_C speed
- SysLim1ACCx – the System Limit Boolean status of Limit1 where x = 1 through 9
- SysLim2ACCx – the System Limit Boolean status of Limit2 where x = 1 through 9

The Modulator and Low-pass filter for the LMVibxA, LMVibxB, and LMVibxC tracking filters are executed at 4.6 kHz rate. The low-pass filter is identical for all tracking filters. The filter is a 5-pole low-pass filter with a cutoff frequency equal to 2.5 Hz. The LMVibxA filter inputs are the modulated signals cos(2pi/60Fs * LM_RPM_A) * Vibration Input and sin(2pi/60Fs * LM_RPM_A) * Vibration Input. The filtered output of the modulated vibration input with the sine is the de-modulated imaginary component of the channel vibration based on the rotor shaft speed, LM_RPM_A and the filtered output of the modulated vibration input with the cosine is the de-modulated real component of the channel vibration based on the rotor shaft speed, LM_RPM_A.

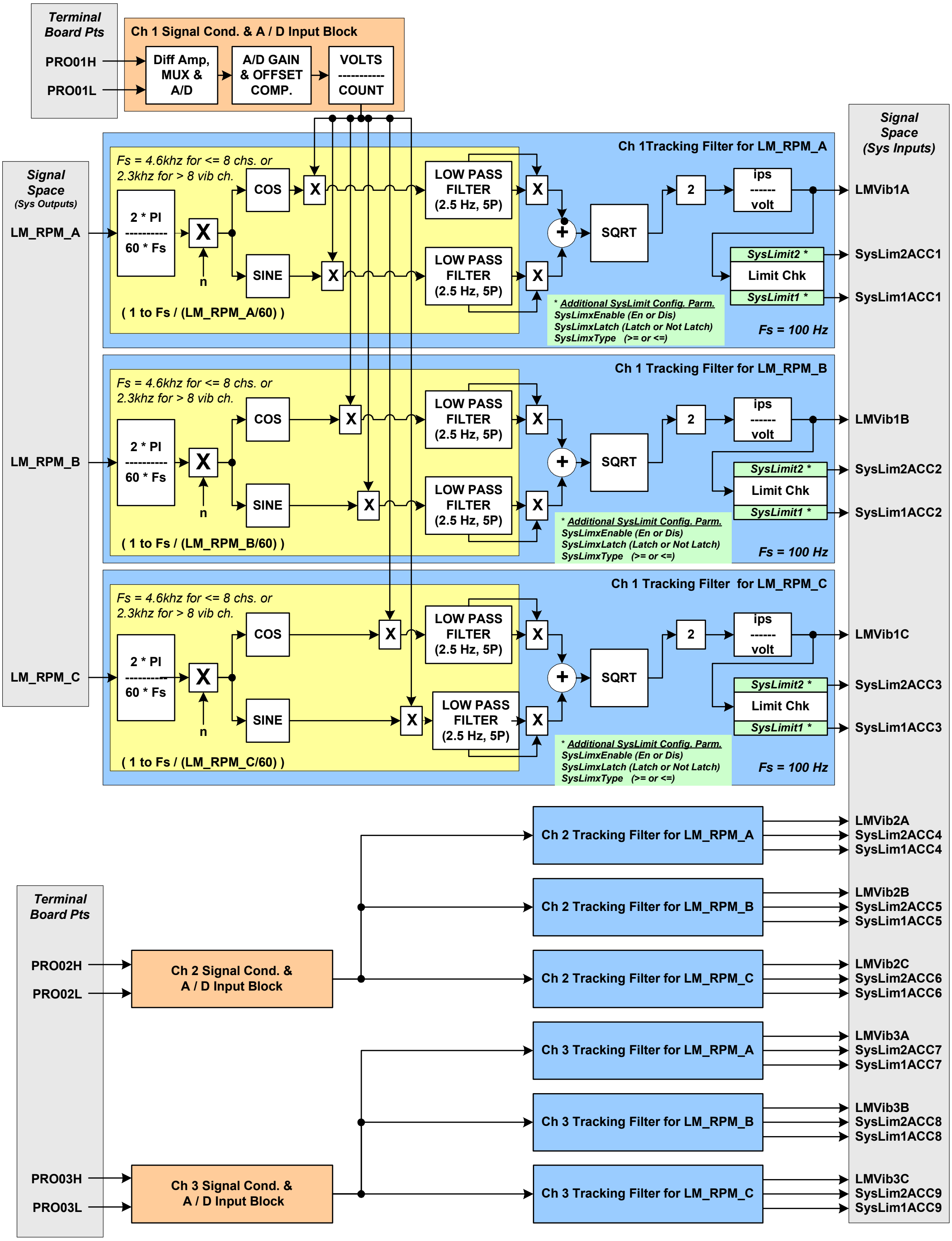
The LMVibxB and LMVibxC tracking filters perform the same task as the LMVibxA filter, except the de-modulated real and imaginary components of the vibration input are based on the rotor speeds: LM_RPM_B and LM_RPM_C.

The scaling block converts the VMx where x = A, B, or C magnitude to EU. The scaling is based on the following configuration parameters:

- Scale – gain factor expressed in volts peak / EU (peak)
- ScaleOffset – offset value in EU (peak)

The Tracking Filter provides two System Limit blocks. The following configuration parameters control the behavior of the System Limit block:

- SysLimxEnabl – the System Limit (x=1 or 2) Enable is set True to select the use of the block.
- SysLimxType – the System Limit (x=1 or 2) Type selects whether the limit check does a “>=” check or a “<=” check.
- SysLimitx – System Limit (x=1 or 2) is the limit value used in the “>=” or “<=” check.
- SysLimxLatch – System Limit (x=1 or 2) Latch determines whether the Boolean status flag is latched or unlatched. If the Boolean status flag is latched the flag will remain True even if the limit value is no longer exceeded.



Terminal Board Pts
PRO01H
PRO01L
Ch 1 Signal Cond. & A / D Input Block
Diff Amp, MUX & A/D
A/D GAIN & OFFSET COMP.
VOLTS ---------- COUNT
Signal Space (Sys Outputs)
LM_RPM_A
LM_RPM_B
LM_RPM_C
Ch 1Tracking Filter for LM_RPM_A
Fs = 4.6khz for <= 8 chs. or 2.3khz for > 8 vib ch.
2 * PI ---------- 60 * Fs
COS
SINE
LOW PASS FILTER (2.5 Hz, 5P)
SQRT
ips ------ volt
SysLimit2 *
Limit Chk
SysLimit1 *
(1 to Fs / (LM_RPM_A/60))
* Additional SysLimit Config. Parm.
SysLimxEnable (En or Dis)
SysLimxLatch (Latch or Not Latch)
SysLimxType (>= or <=)
Fs = 100 Hz
Ch 1 Tracking Filter for LM_RPM_B
(1 to Fs / (LM_RPM_B/60))
Ch 1 Tracking Filter for LM_RPM_C
(1 to Fs / (LM_RPM_C/60))
Signal Space (Sys Inputs)
LMVib1A
SysLim2ACC1
SysLim1ACC1
LMVib1B
SysLim2ACC2
SysLim1ACC2
LMVib1C
SysLim2ACC3
SysLim1ACC3
Ch 2 Tracking Filter for LM_RPM_A
Ch 2 Tracking Filter for LM_RPM_B
Ch 2 Tracking Filter for LM_RPM_C
Ch 3 Tracking Filter for LM_RPM_A
Ch 3 Tracking Filter for LM_RPM_B
Ch 3 Tracking Filter for LM_RPM_C
LMVib2A
SysLim2ACC4
SysLim1ACC4
LMVib2B
SysLim2ACC5
SysLim1ACC5
LMVib2C
SysLim2ACC6
SysLim1ACC6
LMVib3A
SysLim2ACC7
SysLim1ACC7
LMVib3B
SysLim2ACC8
SysLim1ACC8
LMVib3C
SysLim2ACC9
SysLim1ACC9
PRO02H
PRO02L
Ch 2 Signal Cond. & A / D Input Block
PRO03H
PRO03L
Ch 3 Signal Cond. & A / D Input Block

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	0 to 4.5 V pp	±0 .030 V pp	5 to 200 Hz
	Displacement	0 to 4.5 V pp	±0 .150 V pp	200 to 500 Hz
Seismic	Velocity	0 to 2.25 V p	Max [2% reading, ±0.008 Vp]	5 to 200 Hz
	Velocity	0 to 2.25 V p	Max [5% reading, ±0.008 Vp]	200 to 500 Hz
Velomitor	Velocity	0 to 2.25 V p	Max [2% reading, ±0.008 Vp]	5 to 200 Hz
	Velocity	0 to 2.25 V p	Max [5% reading, ±0.008 Vp]	200 to 500 Hz
Accelerometer	Velocity (track filter)	0 to 2.25 V p	±0.015 Vp	10 to 233 Hz
Position	Position	-.5 to -20 V dc	±0.2 V dc	Air gap (average)
Phase	Degrees	0 to 360 degrees	±2 degrees	Up to 14,000 rpm
	(1X vibration component with respect to key slot)			
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 occurs if either of an X or Y probe pair exceeds its limits. In addition, the application software prevents 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

Note The Mark VI system 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 retaining the real-time data access to the Bently Nevada system for static and dynamic vibration monitoring.

Note The Mark VI system 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 kΩ internal impedance, and can drive loads up to 1500 Ω configuration.

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

Parameter	Description	Choices
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

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
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
34	TVIB J3 Analog Input (channel #) Out of Limits	Possible open circuit, customer cable short or sensor failure
35	TVIB J4 Analog Input (channel #) Out of Limits	Possible open circuit, customer cable short or sensor failure
65-77/ 81-93	TVIB/DVIB 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/DVIB 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.