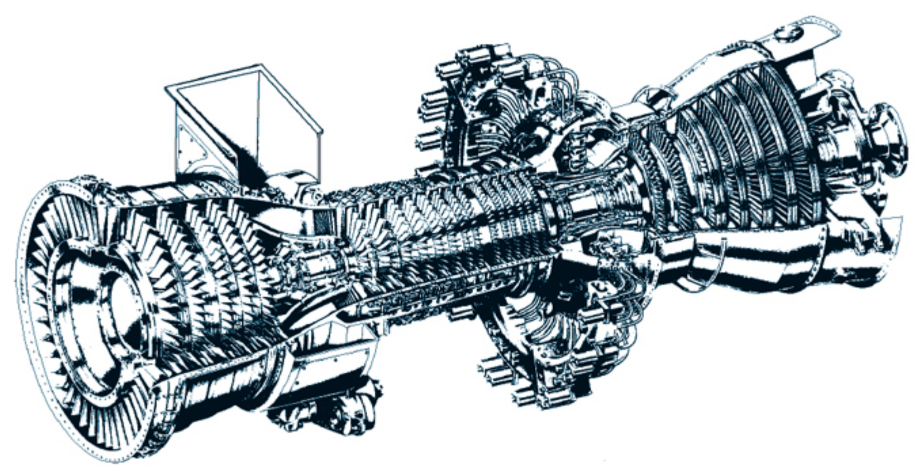
Protection and Condition Monitoring of the LM6000 Gas Turbine

By Chris James • SKF Reliability Systems



Overview

The LM6000 Gas Turbine

The LM6000 is a modern aeroderivative gas turbine from General Electric, and is used extensively for marine propulsion and power generation applications. It is a twin spool Gas Turbine Generator (GG) with a High Pressure (HP) spool and a Low Pressure (LP) spool.

Depending on the configuration, the load is directly coupled to either the cold end or the hot end of the Low Pressure spool, eliminating the need for a conventional power turbine.

The engine has a power output of approximately 50 MW, and a LM6000-DLE version was introduced to meet the demands for reduced NOx and CO emissions.

LM6000 Monitoring

The basic monitoring requirements for the LM6000 are defined by GE in the Installation Design Manual (IDM).

The LM6000 is commonly equipped with accelerometer sensors and a basic suite of analog vibration monitor instruments. However, as electrical products age, monitoring system reliability and obsolescence becomes an issue, and enhancement of the monitoring system, to modern digital technology, becomes a technical and economic necessity.

New Generation LM6000 Monitoring

SKF DYMAC and Vibro-Meter's new generation of sensors and monitoring systems provide a complete solution for the LM6000, for increased monitoring reliability and capability:

- ***High Temperature Accelerometers – Two (2) per engine***

  The proven vibration sensor of choice for gas turbines, the latest CA-series piezo-electric accelerometers offer increased reliability and improved immunity to transference vibration from the gas stream and structure.

DYMAC

Application Note

CM3083

- ***Dynamic Pressure Sensors – Two (2) per DLE Engine***

  Piezo-electric technology is employed in the CP-series sensor to provide a direct measurement of harmful pressure pulsations within the combustion chamber.

- ***Industrial accelerometers – Two (2) per Gearbox***

  When a reduction gearbox is required, for a 50 Hz power generation application for example, the use of accelerometers is recommended to capture the high frequency vibrations generated by gear wheels.

- ***Displacement Probes – Four (4) per Alternator***

  For journal bearing monitoring, the newest design CMSS-series "proximity" probes offer improved maintainability and reliability over earlier generations.

- ***Digital Monitoring System***

  The VM600 monitor system provides a compact and programmable solution. An single monitor card type, the MPC-4, is used for protection of the entire machine train, see Figure 1. Designed for gas turbine use, the MPC-4 permits the consolidation of vibration and combustion protection into a single monitoring system.

In particular, the programmability of the VM600 allows tracking of specific problems such as "Oil in Rotor", as well as improved vibration analysis and cross tracking of unbalance components.

NOTE: With Gearbox (50 Hz) – 4 x MPC-4.
NOTE: Without Gearbox (60 Hz) – 3 x MPC-4.

Figure 1. VM600 for LM6000 DLE with MPC-4 and CMC-16.

- ***Integrated Condition Monitoring***

  A single CMC-16 data acquisition interface, Figure 1, provides high performance monitoring, trending and analysis tools integrated in same rack system for increased reliability.

This application note will now discuss in detail the recommended installation for protection and condition monitoring of the LM6000, while remaining fully compliant to the needs of General Electric's IDM.

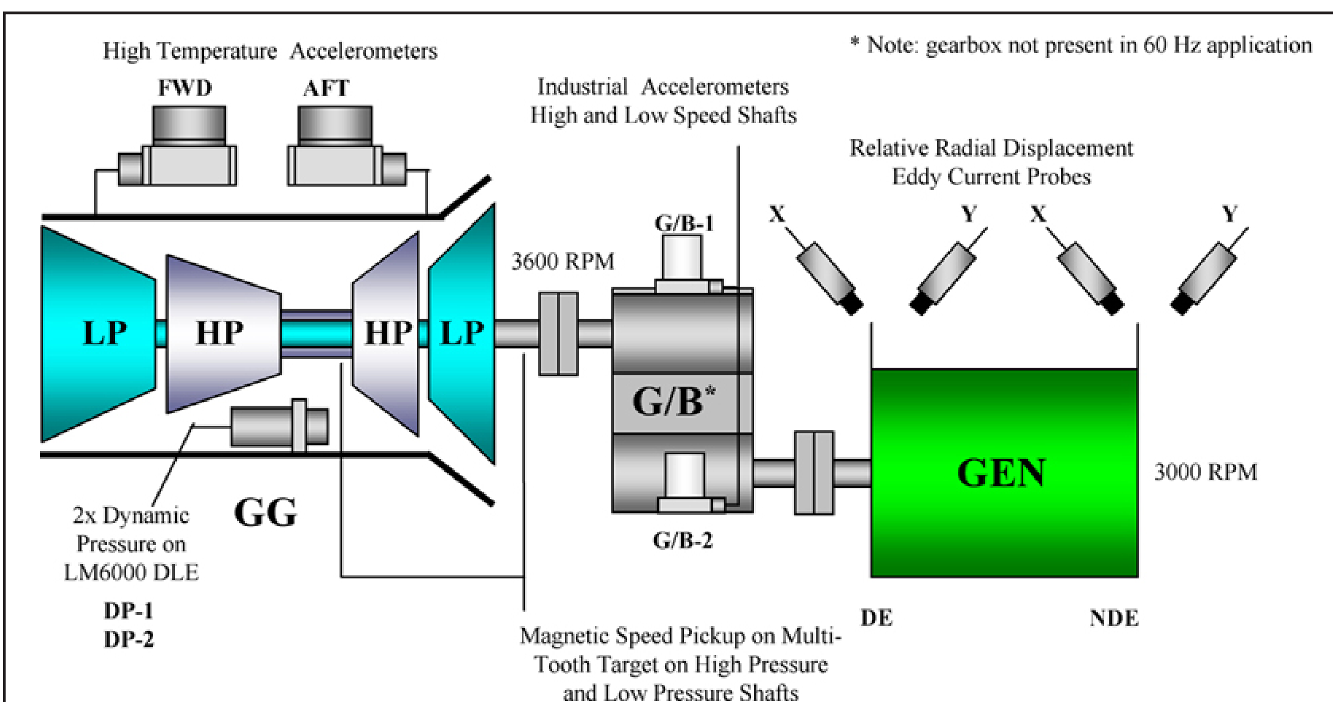


Figure 2. LM6000 Sensor Suite on a 50 Hz Generation Set.

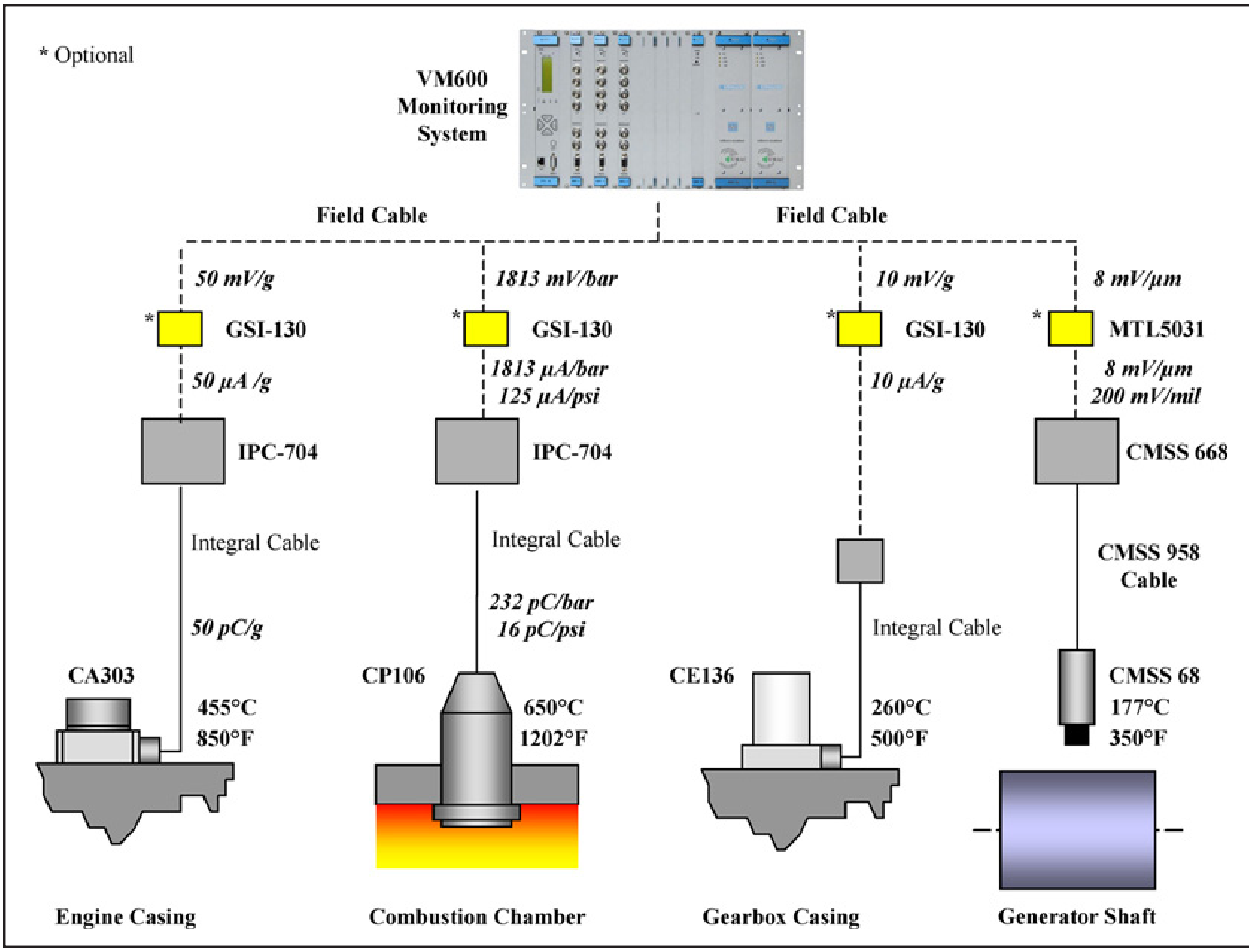


Figure 3. Sensor Measurement Chains (Non-Ex i Application).

Sensors – LM6000

Figure 2 illustrates the basic sensor suite for vibration monitoring of a 50 Hz LM6000 power generation train. Owing to variations in purchasing policy, the exact model and make of sensor installed by the OEM will have varied slightly over the years.

SKF DYMAC and Vibro-Meter would recommend its latest generation sensors for an instrumentation upgrade project, and these are listed in Figure 29. The diagram in Figure 3 illustrates the complete measurement component chain for a power generation application. Let us now consider each of these measurement chains in turn:

Engine Casing Vibration

The vibration of the Gas Turbine itself is measured with two piezo-electric accelerometers.

The high temperature requirement necessitates the use of an externally charge amplified accelerometer, the model CA303 from Vibro-Meter.

The unit has a linear frequency range from 5 Hz to 8 kHz. Made of high grade inconel stainless steel, the CA303 can operate within specification up to 455°C (850°F). An integral, mineral insulated, cable ensures good signal integrity for up to 2 meters (6 feet), to a locally mounted charge-amplifier, the IPC704.

The charge amplifier conditions the electrical charge output of the accelerometer to a current modulated signal of typically 50 µA/g.

In the application shown, galvanic separation is requested for electrical isolation, rather than prevention of explosive gas ignition. In this case, an optional model GSI-130 galvanic separator is used, with a Transfer Function of 1V/mA, providing a 50 mV/g output.

Dynamic Pressure

Reduction of emissions requires pre- mixed lean fuel/air mixture, which in turn can lead to flame instability and excessive dynamic pressures. The DLE version of the

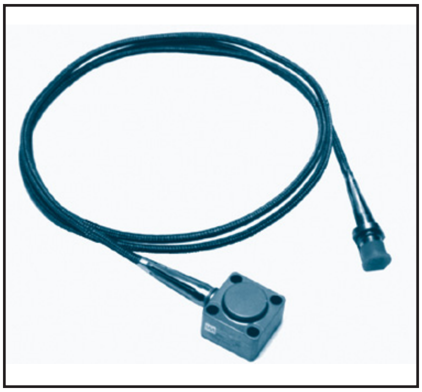


Figure 4. CA303 Accelerometer.

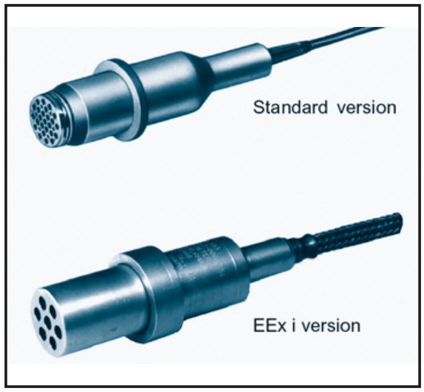


Figure 5. Dynamic Pressure Sensor.

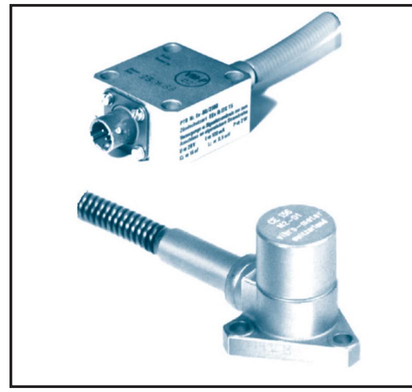


Figure 6. CE136 Accelerometer.

LM6000 uses two high temperature piezo-electric dynamic pressure sensors to measure "pressure pulsation" in the annular combustion chamber.

The consequences of excessive pulsations can be catastrophic, buckling of the combustion chamber and leaks reduce efficiency, and subsequent component failure can wreck the hot gas path components downstream. Hence the ability to measure, warn, and protect against these pressures is of vital importance.

The CP-series employs piezo-electric technology to provide a direct measurement of pressure within the high temperature environment of the combustion chamber itself. This offers a superior solution to indirect measurements utilizing industrial grade pressure sensors, which need to use bleed gas, or water-cooling assemblies.

The GE-approved models for mounting on the LM6000 is now the model CP106 from Vibro-Meter, and can withstand temperatures up to 650°C (1202°F). With a dynamic pressure signal, a current modulated output is once again preferred, owing to the low amplitude of the generated signals. This is converted to a mV/bar signal by the transfer function of the optional GSI-130 galvanic separator.

Gearbox Vibration

On an LM6000 package the temperature environment at the reduction gearbox (if present) is much less demanding than that at the gas generator (engine). Nevertheless, surface temperatures may still rise well above the 120°C (248°F) rating of general purpose industrial accelerometers.

The Vibro-Meter model CE136 offers a good compromise between high temperature capability, cost, and the frequency response (3 Hz to 7 kHz) needed to capture the high vibration frequencies generated by the teeth meshes within the gearbox.

The charge amplification electronics, rated to 100°C (212°F), of the CE136 are built into the local sensor cable assembly and hence mounted only a few metres away from the sensor itself. This minimizes degradation of the charge output and removes the need for a separate signal conditioner (required with the higher temperature models in the gas generator). Once again, a current modulated output signal is used, with conversion to mV/g at the separator.

Relative Shaft Vibration

The vibration of the driven component is usually measured by means of non-contacting sensors, known as "eddy current probes" or "proximity probes". These sensors provide a direct measurement of shaft radial displacement.

These are typically mounted through the bearing cap and targeted directly onto the shaft. The sensor system consists of a probe, cable and an oscillator/demodulator (known as a "driver" or "proximitor").

A suitable model is the CMSS 68 series from SKF DYMAC.

The probes have a linear frequency range from DC to 10 kHz. The RYTON™ tip material allows the probe to withstand temperatures up to 177°C (350°F), and

Figure 7. CMSS 68 Eddy Current Probe System

differential pressures to 414 Kpa (60 psi).

The voltage output of 8mV/mm is used owing to the relatively short cable run from the engine to the control package. This is passed through an optional MTL5031 galvanic separator at 1V/V transfer function.

Speed Sensors

Magnetic speed sensors would be provided by the OEM on both the High Pressure and Low Pressure shafts. The High Pressure and Low Pressure probes are targeted on 45 and 48 tooth wheels respectively.

Machine Protection – LM6000

A GE IDM compliant machine protection monitor system for the LM6000 is the VM600. The system uses a single MPC-4 universal, digital protection module. This module was specifically designed for gas turbine use, from transducer input, through signal conditioning and processing, to shutdown relay contact closure.

Figure 1 illustrates a system. The entire LM6000 driven train may be protected by three or four identical MPC-4 cards.

Optional redundant power supplies are employed for the highest integrity, and a CPU-M display unit also provides dual serial and/or Ethernet connections to a TCS/DCS/ PLC.

VM600 Monitor Sensor Inputs

Figure 8 shows a VM600 layout for the LM6000 configuration shown in Figure

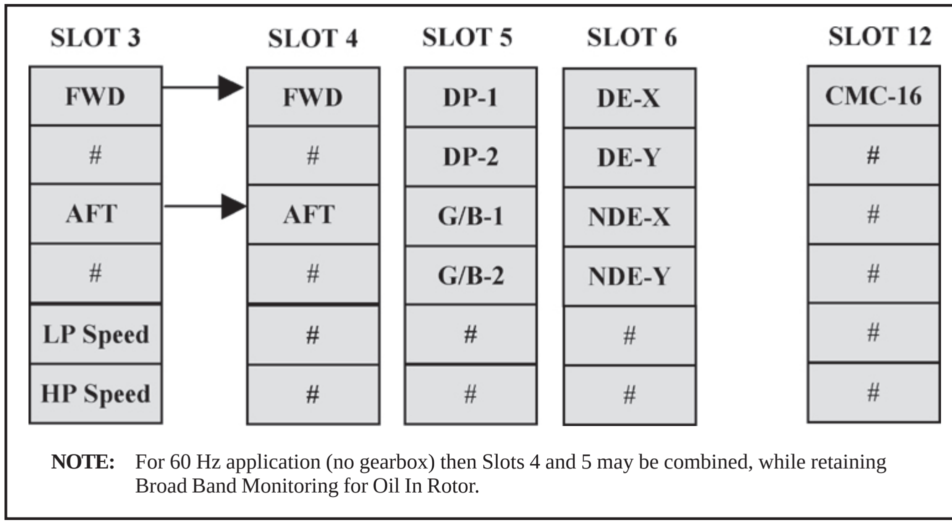


Figure 8. Channel Input Layout for LM6000 DLE with "Oil in Rotor" Modification and CMC-16.

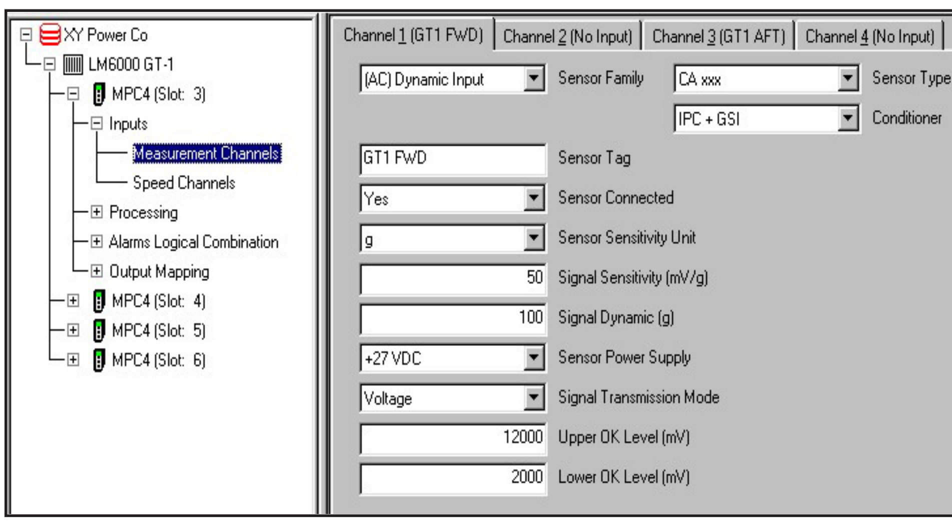


Figure 9. Channel Input Set-up, FWD and AFT Accelerometers.

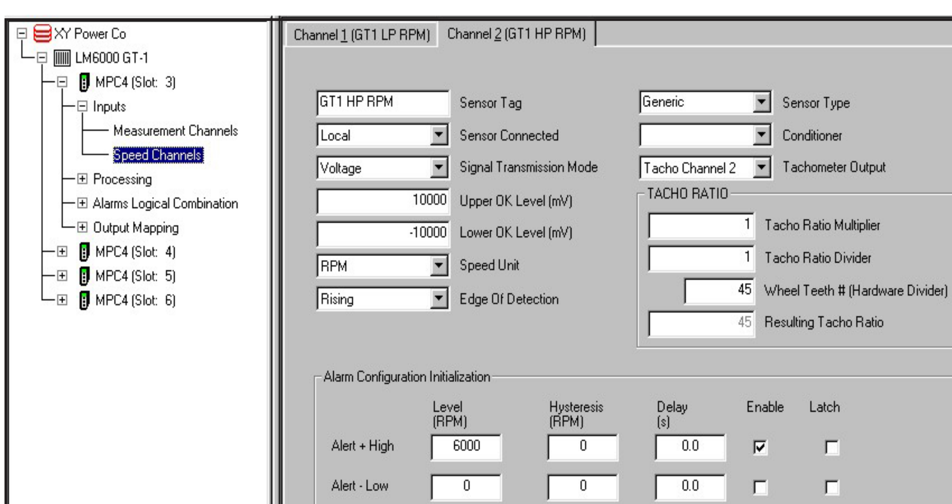


Figure 10. Channel Input Set-up, High Pressure Spool Speed.

2, with an additional MPC-4 card added for "Oil in Rotor" monitoring (see section "Slot 4 – "Oil in Rotor" for further explanation).

Slot 3 – "Cross Tracking" Monitor

The MPC-4 in Slot 3 supports of the engine FWD and AFT accelerometers, and their set-up is shown in Figure 9. The FWD accelerometer is terminated, powered and conditioned by Input Channel 1, the AFT accelerometer by Input Channel 3. The pickups for the Low Pressure and High Pressure spool speeds are supported by Speed Channels 1 and 2 respectively, and the High Pressure set up is shown in Figure 10.

Slot 4 – "Oil in Rotor" Monitor

"Oil in Rotor" is a condition where leakage of synthetic oil into the forward stages of the High Pressure Compressor can generate overflow of bearing lubricant, and other problems, which in turn can result in high vibration, overstressing and engine failure. The phenomenon was found to show up at sub-synchronous frequencies around 0.8X High Pressure speed, together with other acoustical components in the same range. After a number of "Oil in Rotor" incidents GE issued a Service Bulletin on the LM6000, recommending that a broad band filter be applied.

However, the flexibility of the MPC-4 is such that both the recommended Broad Band filter and a 0.8X tracking filter can be applied for protection against "Oil in Rotor" simultaneously.

This requires a dedicated

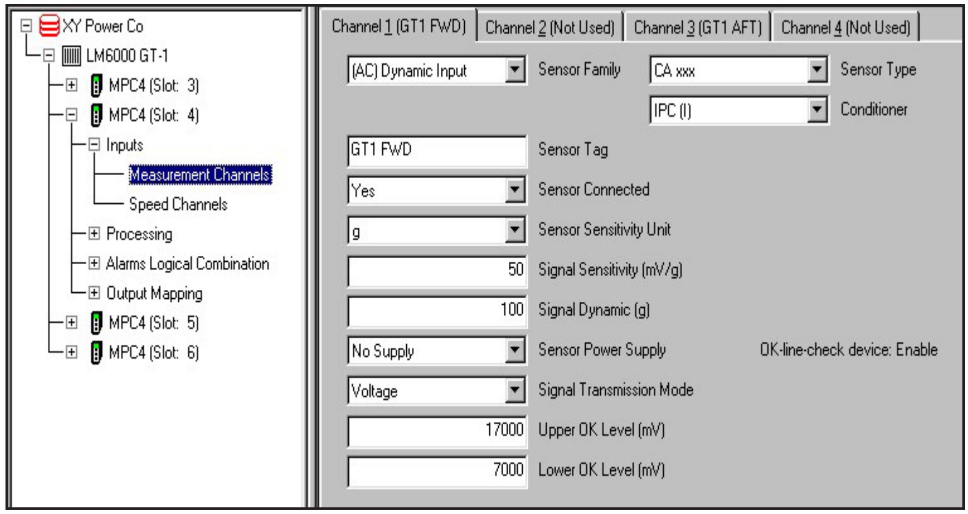


Figure 11. Channel Input Set-up, 0.8X High Pressure FWD and AFT.

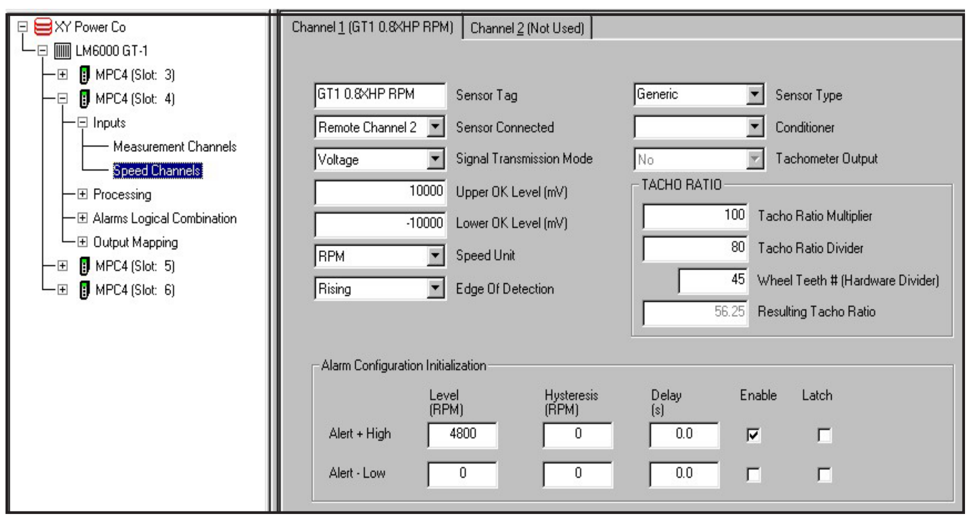


Figure 12. Channel Input Set-up, 0.8X High Pressure Spool Speed.

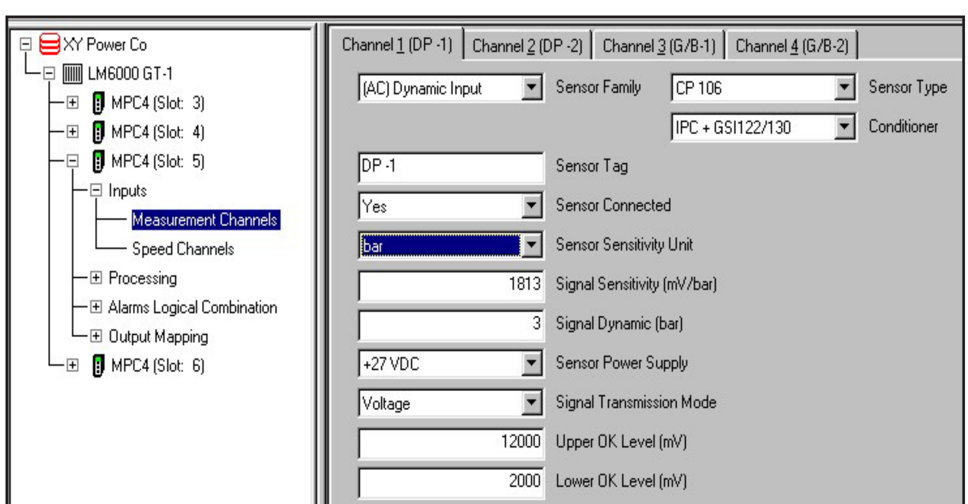


Figure 13. Dynamic Pressure Input Set-up.

MPC-4 card. The raw signal outputs of the sensors in Slot 3 are routed as inputs to Channels 1 and 3 on Slot 4. The set-up is shown in Figure 11, note it is identical to Figure 9 with the exception that sensor power is disabled.

The tracking of the 0.8X harmonic of High Pressure spool speed is achieved by producing a "dummy" High Pressure speed, shown by the Speed Channel set-up in Figure 12.

The "true" High Pressure spool speed from Slot 3 is assigned to the rear bus "Tacho Channel 2" in Figure 10. Figure 12 shows the set- up for Speed Channel 1 in Slot 4. The input is "Remote Channel 2" from the rear bus.

The "TACHO RATIO" fields are then used to provide a "dummy" speed signal at 0.8X "true" speed.

The Multiplier/Divider and Wheel Teeth fields are set to produce a "Resulting Tacho Ratio" of 56.25. This means that the real raw speed signal is divided by 56.25 teeth, instead of 45. That is, a High Pressure spool speed of 6000 RPM is seen by this MPC-4 as (6000 x 45)/56.25 = 4800 RPM. Hence any Narrow Band Processing (e.g. 1X) using this speed channel as a reference will in fact monitor 0.8X the true speed. In this way the VM600 can be configured to track any harmonic beyond the preset Narrow Band tracking harmonics of 1/3X, 1/2X, 1X, 2X, 3X and 4X.

Slot 5 – Dynamic Pressure and Gearbox

The MPC-4 in Slot 5 supports of the two Dynamic Pressure sensors used on a DLE variant, on Input Channels 1 and 2. This is illustrated in Figure 13.

Input Channels 3 and 4 support the gearbox accelerometers and are set-up in a similar manner to that in Figure 9.

Slot 6 – Generator Monitor

This final MPC-4 card is used to monitor the dual X-Y proximity probes used on the generator. Figure 14 shows a typical set-up.

If a phase reference probe ("keyphasor") is fitted, this would be supported by the speed channel on this card, with a "1/rev" field selected.

VM600 Signal Processing for Protection

The processing is defined by the GE IDM and is easily configured on an MPC-4 by the Microsoft Windows based MPS-1 configuration software. The processing used in each MPC-4 is illustrated by Figures 15 through 18.

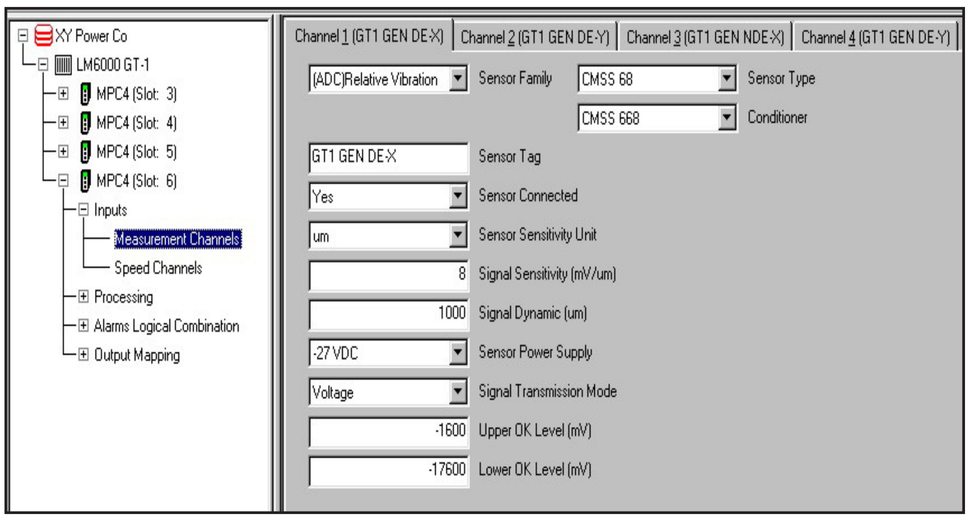


Figure 14. Radial Proximity Probe Set-up, Generator.

Point	Physical
1XLP FWD VEL	Channel 1 Output 1
Phase Not Used	Channel 1 Output 2
1XHP FWD VEL	Channel 2 Output 1
Phase Not Used	Channel 2 Output 2
1XLP AFT VEL	Channel 3 Output 1
Phase Not Used	Channel 3 Output 2
1XHP AFT VEL	Channel 4 Output 1
Phase Not Used	Channel 4 Output 2
-------	Channel 1 & 2 Output
-------	Channel 3 & 4 Output
GT1 LP RPM	Speed Channel 1
GT1 HP RPM	Speed Channel 2

Figure 15. Slot 3 Processing.

Point	Physical
BB FWD VEL	Channel 1 Output 1
BB FWD ACC	Channel 1 Output 2
0.8XHP FWD	Channel 2 Output 1
Phase Not Used	Channel 2 Output 2
BB AFT VEL	Channel 3 Output 1
BB AFT ACC	Channel 3 Output 2
0.8XHP AFT	Channel 4 Output 1
Phase Not Used	Channel 4 Output 2
-------	Channel 1 & 2 Output
-------	Channel 3 & 4 Output
GT1 0.8XHP RPM	Speed Channel 1
Not Used	Speed Channel 2

Figure 16. Slot 4 Processing.

Cross Track Monitoring

Figure 15 illustrates the processing for this primary monitoring requirement on an LM6000. A Narrow Band tracking function is programmed for the FWD signal against 1X Low Pressure speed on Processing Channel 1, and against 1X High Pressure speed on Processing Channel 2. The Output 1 of each signal is in RMS velocity (mm/sec or ips), the second output defaults to Phase Angle and is not used (no single pulse-per-revolution phase reference). The same is repeated on Channels 3 and 4 for the AFT signal.

Oil in Rotor Monitoring

Figures 16 and 19 illustrate the processing.

For both FWD and AFT signals, Processing Channels 1 and 3 perform Broad-Band Monitoring in the range 25–350 Hz.

This is to capture acoustic phenomena of interest outside the running speeds of the High Pressure and Low Pressure spools. Figure 20 illustrates the processing screen. The Output 1 of each signal is in RMS velocity (mm/sec or ips), the second Output 2 in RMS acceleration (g).

Processing Channels 2 and 4 are set to a Narrow Band Processing, references to the 0.8X speed signal, see Figure 21. The Output 1 of each signal is in RMS velocity (mm/sec), the second output defaults to Phase Angle and is again not used for lack of a phase reference.

Dynamic Pressure ("Pulsation") Monitoring

On the DLE variant, the Dynamic Pressure is set to monitor Broad Band pressure in the 10 Hz to 3 kHz range, Figure 22. The Output 1 of each signal is in RMS pressure (bar) , the second output is not used.

Gearbox Monitoring

The CE136 accelerometer are fitted to the input and output shafts of the gearbox, and set for Broad Band in a range typically from 10 Hz to 2 kHz. To best capture high frequency components, the Output 1 alone of each signal is in RMS acceleration (g).

Relative Vibration Monitoring

The generator is monitored for normal "X-Y" radial

Point	Physical
DP-1 BB	Channel 1 Output 1
Not Used	Channel 1 Output 2
DP-2 BB	Channel 2 Output 1
Not Used	Channel 2 Output 2
G/B-1 ACC	Channel 3 Output 1
Not Used	Channel 3 Output 2
G/B-2 ACC	Channel 4 Output 1
Not Used	Channel 4 Output 2
-------	Channel 1 & 2 Output
-------	Channel 3 & 4 Output
GT1 LP RPM	Speed Channel 1
GT1 GEN RPM	Speed Channel 2

Figure 17. Slot 5 Processing.

Point	Physical
GEN DE-X	Channel 1 Output 1
GEN DE-X GAP	Channel 1 Output 2
GEN DE-Y	Channel 2 Output 1
GEN DE-Y GAP	Channel 2 Output 2
GEN NDE-X	Channel 3 Output 1
GEN NDE-X GAP	Channel 3 Output 2
GEN NDE-Y	Channel 4 Output 1
GEN NDE-Y GAP	Channel 4 Output 2
GEN DE Smax	Channel 1 & 2 Output
GEN NDE Smax	Channel 3 & 4 Output
GEN Keyphasor	Speed Channel 1
Not Used	Speed Channel 2

Figure 18. Slot 6 Processing.

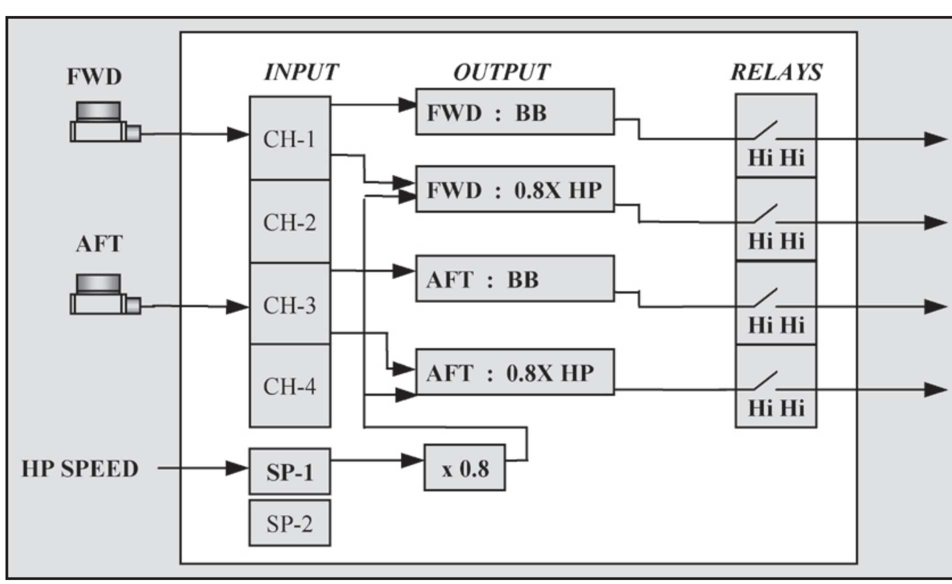


Figure 19. Oil in Rotor Processing, LM6000.

displacement on all four processing channels. The Output 1 of each signal is in Peak-to-Peak Displacement (µm or mils), the second output defaults to the gap (mm or mils or volts). If a keyphasor probe is present, then the Dual Channel processing functions can be used to provide an S_{max} value.

Alert and Danger (Shutdown) Levels

The IDM provides a guide to Alert and Danger levels. However, each installation will choose whether or not to implement a trip function, and will tailor Alert and Danger (shutdown) set-points for each unit. In an Oil in Rotor monitor scenario, the following are typical:

Broad Band Processing (25 Hz to 350 Hz band)

Alert: 50 mm/sec (2.0 ips) RMS

Danger: 75 mm/sec (3.0 ips) RMS

Narrow Band Processing (Order: 0.8X High Pressure)

Alert: 8 mm/sec (0.3 ips) RMS

Danger: 12 mm/sec (0.5 ips) RMS

Note the levels are much higher than that expected on other machines – this reflects the relatively flexible nature of aeroderivative gas turbine construction.

Shutdown Relay Output Logic

Machine shutdown based on any processed variable is actuated via a common or individual relay output, using

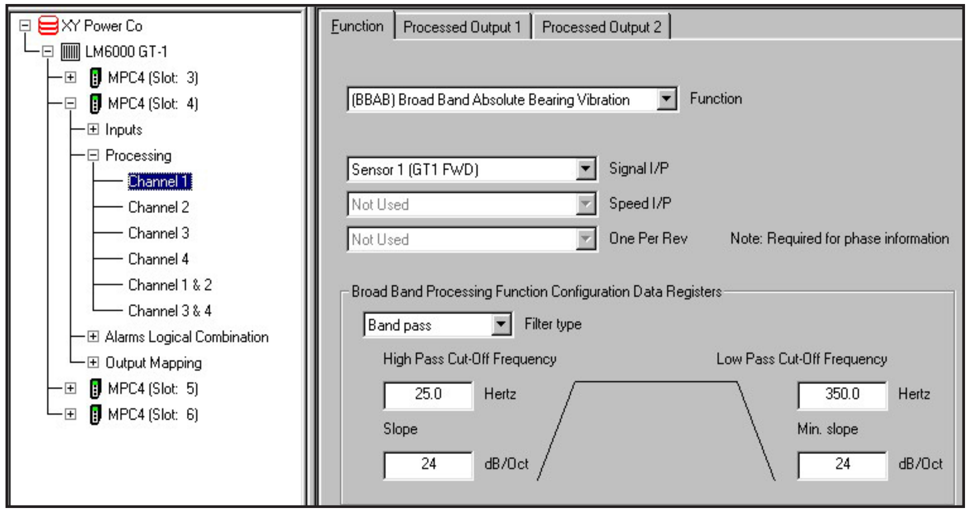


Figure 20. Broad Band Processing for "Oil in Rotor".

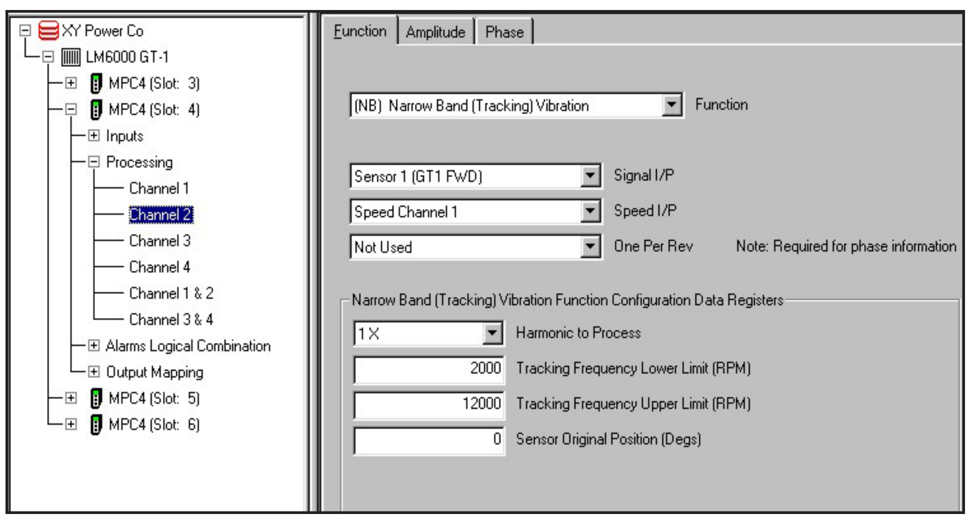


Figure 21. Narrow Band 0.8X Processing for "Oil in Rotor".

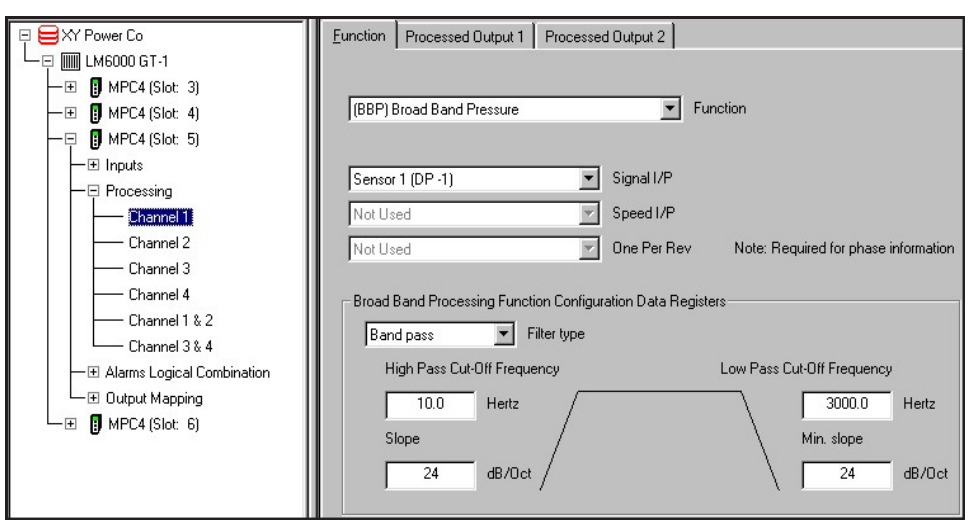


Figure 22. Broad Band Processing for Dynamic Pressure.

either the four relays situated on the IOC-4 card, or additional relays on a 16 channel RLC-16 relay card. The logic programming of the MPC-4, using "Basic" and "Advanced "functions, can lead to a large number of possible voting configurations.

The simple requirement of the "Oil in Rotor" monitor of Slot 4, Figure 19, is used here.

Each of the on-board IOC-4 relays is used to produce a Danger (Hi-Hi) contact closure. An additional RLC-16 card is used to provide contacts for Alert (Hi) alarms.

However, a common additional requirement of the control system is not to flag Alert or Danger signals unless the High Pressure speed is above 6000 RPM (4800 RPM for the 0.8X channel). This can be achieved by using the 'logical combination' features of the VM600, see Figures 23 to 26.

First step is to choose the AND function for "Basic Function 1" in Figure 23. Second step is in Figure 24, select the "Danger High" of Broad Band Velocity Output 1.1. Third step is to select the "Alert High" of Speed Channel 2 in Figure 25.

Final step is to assign the logical combination of "Basic Function 1" to the first IOC-4 relay in Figure 26. The end result is now that the first IOC relay in Slot 4 will only change state if the speed is above 6000 (4800) RPM AND the FWD Broad Band level is over 75 mm/sec.

This logic is then repeated on Channel 2, 3 and 4 for Basic Functions 2, 3, and 4 respectively.

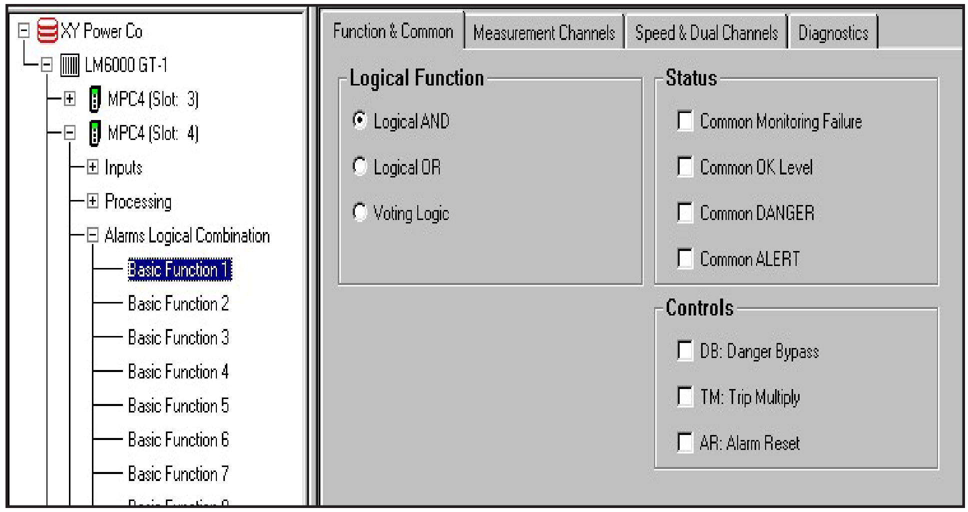


Figure 23. Oil in Rotor, Logical AND for Relay Output.

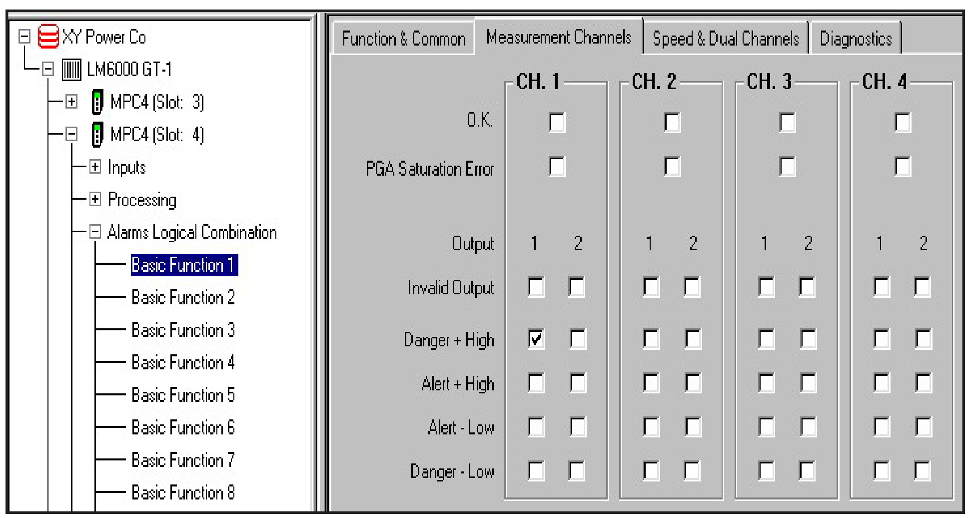


Figure 24. Oil in Rotor, Voting Logic, Danger, Channel 1 (Velocity mm/sec).

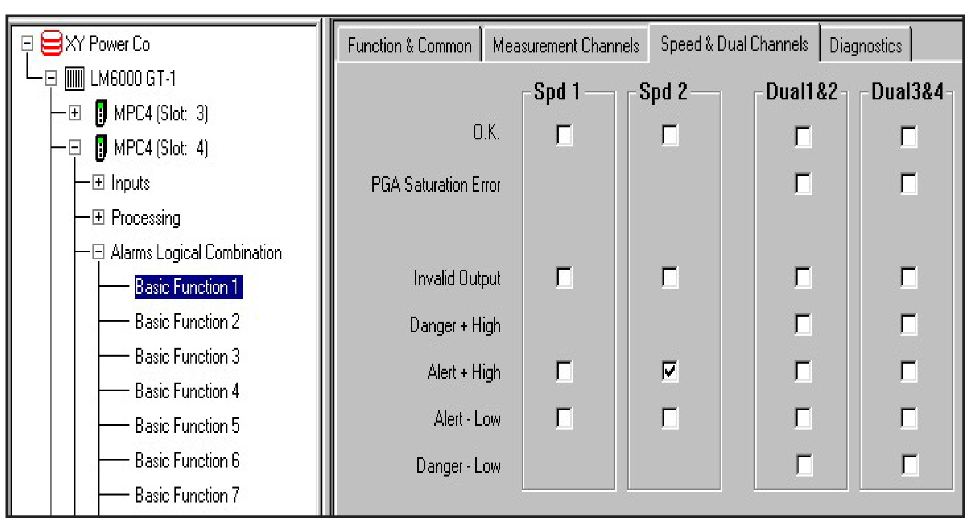


Figure 25. Oil in Rotor, Voting, Danger Channel 1 AND Speed Channel 2 Alert.

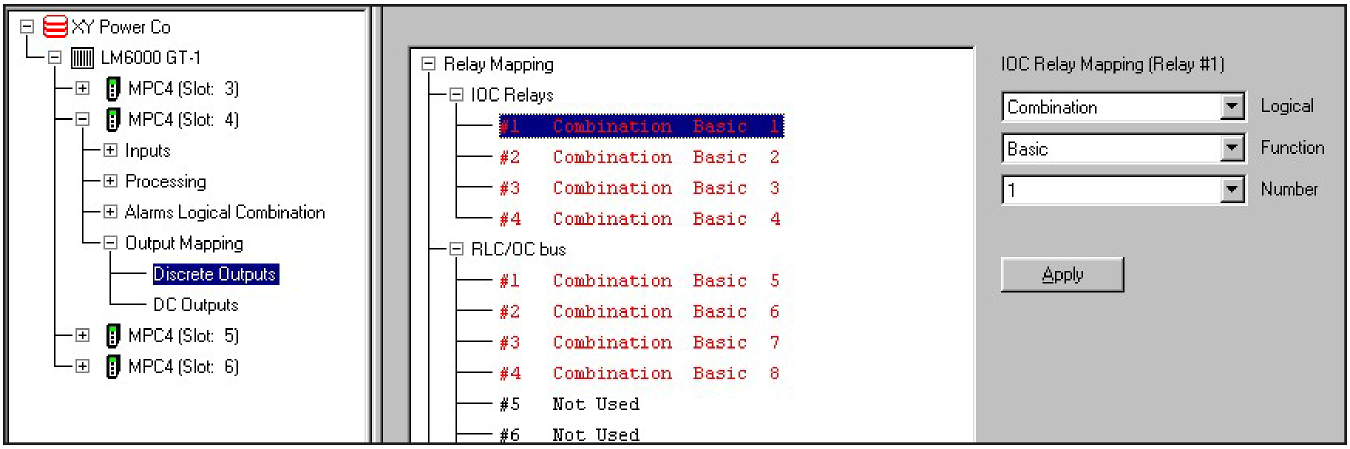


Figure 26. Oil in Rotor, Relay Output Mapping.

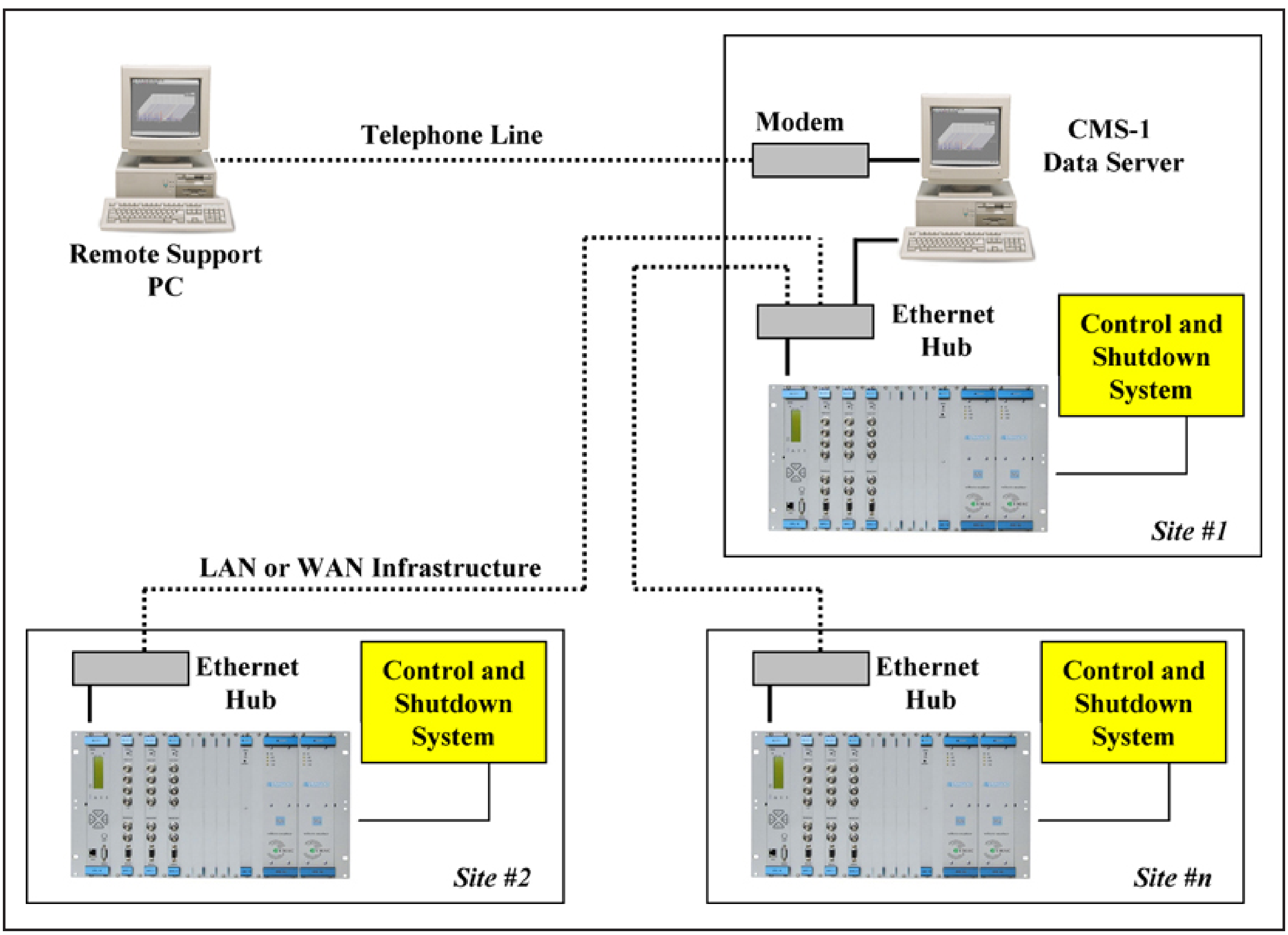


Figure 27. On-Line Condition Monitoring and Programming Network.

The Basic Functions 5, 6, 7 and 8 would be programmed in the same manner for alert levels, with the exception that the relays would be on the additional RLC-16 card as shown in Figure 26.

Machine Condition Monitoring – LM6000 Fleet

The VM600 permits addition of parallel data acquisition for condition monitoring in the same monitor chassis as that provided for protection - hence ensuring high system integrity without compromising the machine safeguarding function. Any number of 16-channel CMC-16 cards may be placed in any of the 12 available slots, see Figure 1.

Each channel can process and monitor up to 10 spectral bands. The philosophy of condition monitoring of these critical machines is Multi-Parameter Monitoring. That is, the same input signal is processed in different ways in parallel, in order to determine different characteristic vibration parameters. Each parameter may reveal something different about deteriorating engine condition over time.

The CMS-1 software, Figure 28, is particularly suited to monitoring multiple racks that could be only a few meters apart, or located at remote sites hundreds of kilometers away. The bandwidth typically available on an existing LAN or WAN is sufficient for operation of a centralized server computer, Figure 27.

During transient conditions, the FFT and bands would be monitored closely in order to identify phenomena including:

- High vibration amplitudes
- Combustion Chamber resonance
- External equipment stress/fretting
- Spool nX harmonics
- Bearing defect frequencies

During normal running conditions, the FFT and bands would be monitored periodically to watch for fluctuations in vibration levels, which can occur during low-, part-, or variable-load conditions.

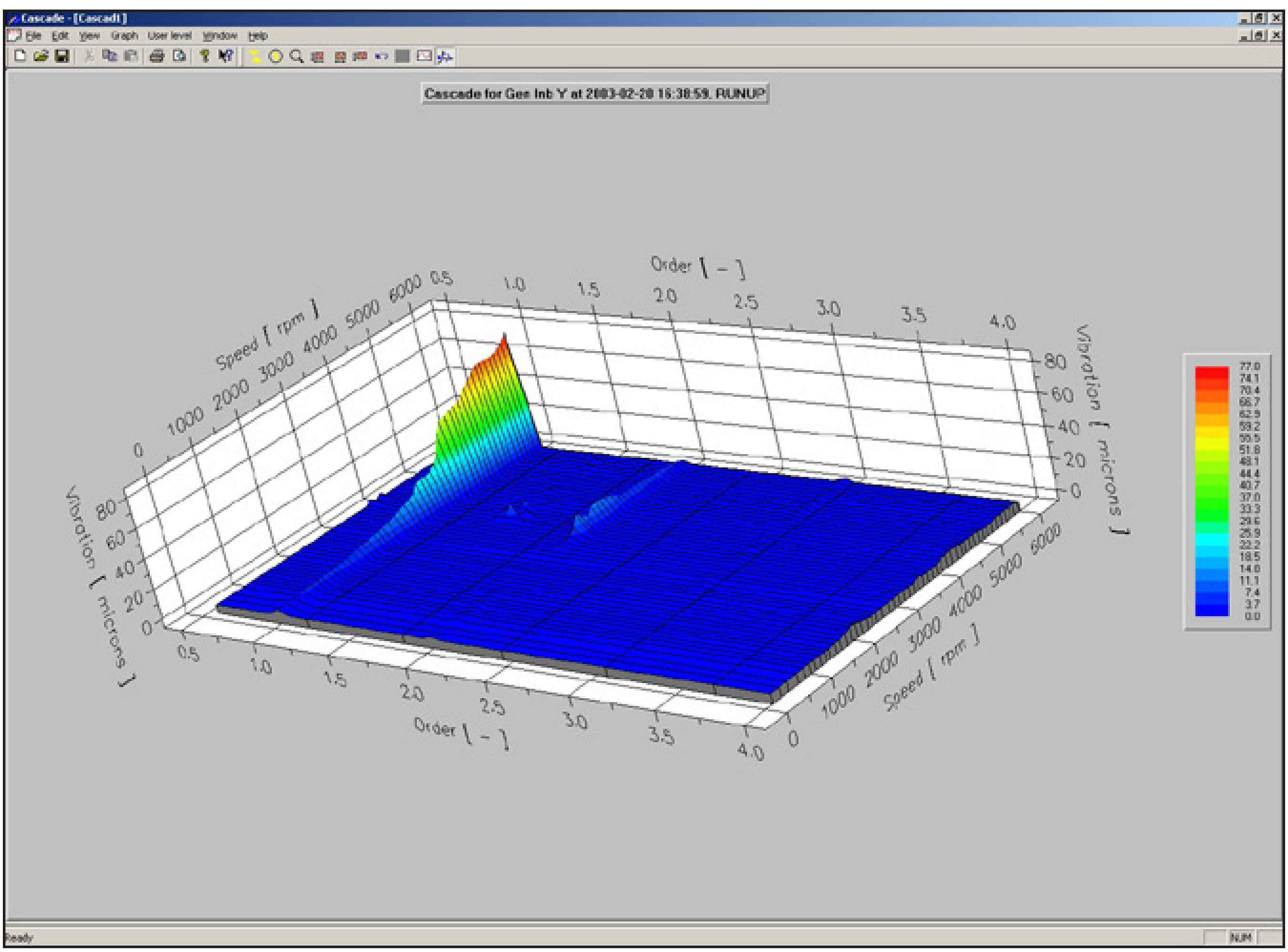


Figure 28. Transient FFT Plot, CMS-1 Software.

“Protection and Condition Monitoring of the LM6000 Gas Turbine”

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Item	Qty	Model	Product Number	Description
		SENSORS		**FWD and AFT Accelerometer Chain**
1	1	CA 303	144-303-000-311	FWD Accelerometer, -54°C to +455°C (+850°F), 50 pC/g, 1.22m (48") integral MI cable with stainless steel overbraid and M83723/89Y1020-7 connector
2	1	CA 303	144-303-000-221	AFT Accelerometer, -54°C to +455°C (+850°F), 50 pC/g, 2.06m (81") integral MI cable with stainless steel overbraid and M83723/89Y1020-6 connector
3	2	IPC 704	244-704-000-022	Symmetrical charge amplifier with configurable low-pass and high-pass filters, optional integrator. Voltage or current output.
4	2	GSI 130	244-130-000-204	Galvanic separation and power supply unit for piezoelectric measuring chain, 2-wire current transmission. 4kV input/output insulation, dynamic transfer 1 V/mA.
				Dynamic Pressure Sensor Chain (DLE Variant)
5	2	CP 106	143-106-000-011	-96°C to +650°C (-140°F to +1202°F), 232 pC/bar, 1.2 m MI cable with overbraid, M83723/89Y10207 connector, special GE flange.
6	2	IPC 704	244-704-000-022	Symmetrical charge amplifier with configurable low-pass and high-pass filters, optional integrator. Voltage or current output.
7	2	GSI 130	244-130-000-204	Galvanic separation and power supply unit for piezoelectric measuring chain, 2-wire current transmission. 4kV input/output insulation, dynamic transfer 1 V/mA.
				Gearbox Accelerometer Chain
8	2	CE 136	444-136-000-201	-54°C to +260°C, 10 µA/g, 3 m cable protected by BOA, MS 3112 bayonet-locked aluminium connector.
9	2	GSI 130	244-130-000-204	Galvanic separation and power supply unit for piezoelectric measuring chain, 2-wire current transmission. 4kV input/output insulation, dynamic transfer 1 V/mA.
				Generator Bearing Radial Vibration (X-Y) Chain
10	4	CMSS68	CMSS 68-000-00-12-10	Probe, 8mm, 3/8-24 Thread, 1.2" to 6.0" Case Length, 1m Cable.
11	4	CMSS958	CMSS 958-00-040	Extension Cable, 4.0m Length.
12	4	CMSS665	CMSS 668	Driver, 200mV/mil (8mV/µm), +/- 5%, 4140 Steel, 90mil (2.3 mm) Range, 5m System.
13	4	Barrier	MTL 5031	Galvanic Separation for 3-wire Eddy Current Probe System
		MONITOR HARDWARE AND SOFTWARE - PROTECTION		
14	1	ABE-040	204-040-100-012	Standard 19" Rack 6U high with VME backplane.
15	1	PLP-960	200-582-960-011	Backpanel with status relay, 2x switch and 2x IEC connectors + cables, dual AC mains input
16	2	RPS-6U	200-582-500-014	Power supply unit (max. 2 per rack). Mains input 90 to 264 VAC
17	1	CPU-M	200-595-033-111	CPU-M with front panel display, Single RS232/485 and Ethernet Configuration
18	1	IOC-N	200-566-000-HHh	I/O card for CPU-M with 2x RJ45 and 5x RJ11 connectors for single/redundant Ethernet
19	4	MPC-4	200-510-SSS-HHh	Machinery Protection Card, for 4 dynamic and 2 phase reference channels
20	4	IOC-4T	200-560-000-HHh	6 channel in- and output card for MPC with screw terminals. 4 x relays
21	1	RLC-16	200-570-000-HHh	Relay card with 16 relays with change over contacts
22	1	MPS-1	209-500-100-013	Software package for configuration of MPC-4. RS232 point to point connection or Ethernet network. Provides local and remote access. Microsoft Windows (98, NT, 2000, XP), English, French or German
23	5	Config	DMFS-CON	Customer Specific Configuration and Testing. Per card (MPC 4, AMC 8, RLC 16, CMC 16)
		MONITOR HARDWARE AND SOFTWARE - CONDITION MONITORING		
24	1	CMC-16	200-530-SSS-HHh	Condition Monitoring Card, for up to 16 dynamic / process channels, up to 4 which can be tacho / phase reference channels. Provides advanced FFT analysis, band extraction, processing and level checking (max. 12 per rack)
25	1	IOC-16T	200-565-000-HHh	16 channel in- and output card for CMC with screw terminals, and multidrop RS485 ports for serial networking. (1 required per CMC 16, max. 12 per rack).
26	1	CMS-1	209-500-600-SSs + Code	Condition Monitoring Software Package for Transient Vibration Analysis with CMC 16 Hardware. Microsoft Windows 98, NT, 2000 and XP Operating System. Sybase SQL Database Server Licence and 5 Concurrent User Client Display
27	1	Config	DMFS-CON	Customer Specific Configuration and Testing. Per card (MPC 4, AMC 8, RLC 16, CMC 16)

Figure 29. LM6000 Monitoring System Components.