

## ***Motor Management with Vibration Protection***

### **Introduction:**

Recent advances in motor management and accelerometer technology are providing a new means for motor protection utilizing dual outputs. Accelerometers are now available with loop power outputs (4-20 mA), and dynamic signal outputs (100 mV/g). Loop power outputs are compatible with most distributed process control systems and programmable logic controllers used for process management. The model #469 Motor Control Relay Manufactured by GE Multilin carries this process one step further by providing immediate trending and alarming at the motor & controller interface. These self contained motor management relays can provide process information on many motor variables such as speed, current, voltage, temperature, and now, with the introduction of the CTC Dual Output Loop Power Accelerometer, vibration protection without losing the ability to do dynamic signal (vibration) analysis.

The dynamic signal output is typical of existing vibration analysis technology used in the field today, and is compatible with existing diagnostic tools. The loop power output provides a peak or rms. value over a specified frequency band creating a proportional 4-20 mA signal that can be stored, trended, and alarmed. Changes in the loop power value will alert the control system or operations department of pending vibration problems with the motor or driven machine, and can be used to generate an alarm requiring further detailed analysis or immediate shutdown. Once alerted, the vibration analyst can use the dynamic output of the accelerometer (100mV/g) to measure, analyze, and determine root cause of the vibration problem. This integrated approach

between Motor Management and Vibration Analysis & Protection is combining the latest technologies for condition monitoring and reliability.

### **Using the Motor Management Relay as a Vibration Monitor:**

The 469 Motor Management Relay has 4 analog inputs, 4 to 20 mA, 0 to 20 mA, or 0 to 1 mA as selected. These inputs may be used to monitor sensors such as loop power accelerometers, tachometers, pressure transducers, or many others available with typical current outputs used in process applications. Analog inputs can be used for generating alarms to the control center, or tripping the motor and shutting down the machine prior to failure. The inputs are sampled every second, and the level of the analog input is also available over the serial communication port.

The relay is used to monitor the mechanical conditions of either the main machine, or any associated ancillary equipment, as part of the process. There might be occasions where a mechanical failure of the associated equipment implies the immediate removal from service of the main machine.

The 469 Motor Management Relay analog input settings contain two independent limits: one limit for alarm, and one limit for shutdown or trip. Both levels can be set in inches/second (velocity) or mils (displacement). In addition, a 4-20 mA output can be programmed to respond to the same signal provided by the vibration sensor, proportional to the vibration level, in case that the same signal is required for other purposes such as local indication.

Each analog input may be individually configured to represent a number of different measured parameters including the analog inputs. The minimum value programmed represents the 4 mA output, and the maximum value programmed represents the 20 mA output. If the maximum value is programmed lower than the minimum value, the output will function in reverse. All four of the outputs are updated once every second, but each parameter may be used only once.

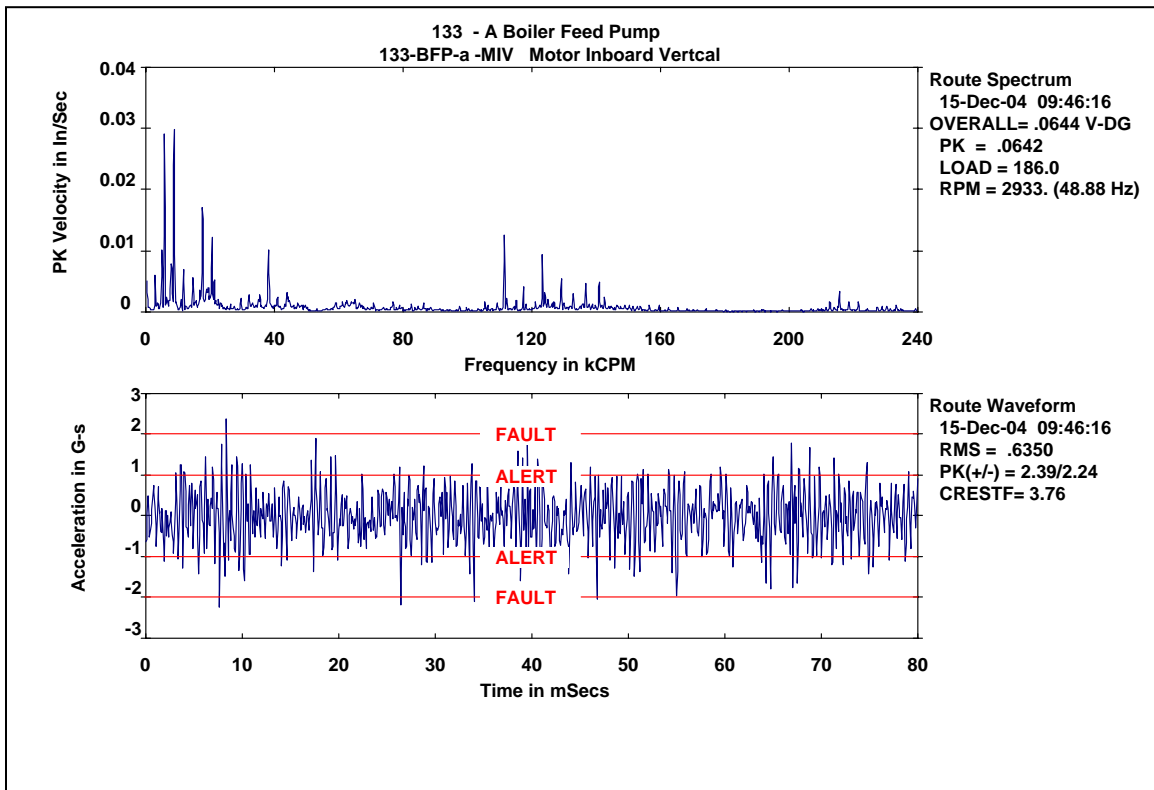
For example, the analog output parameter may be chosen as the “Analog Input 1” for a 4 to 20 mA output. If the minimum is set for “0 inches/second”, the analog output channel will output 4 mA when “Analog Input 1” is measuring 4 mA in response to a vibration sensor measuring a vibration velocity of 0 inches/second, 12 mA when it is 12 mA or a vibration of velocity of 0.5 inches/second, and 20 mA when it is 20 mA or a vibration velocity of 1.0 inches/second (based on 4 to 20 mA proportional to 0 to 1 inch/second). The 4 mA current will be present even when there is no vibration, thus demonstrating that the unit is functioning.

Two auxiliary contacts are also provided. These are dry contacts in the sense that they are isolated from the input power.

Time delay is available to prevent false tripping due to abnormal vibrations due to non-repetitive transient events. In addition to that, the Analog Inputs of the 469 Motor Management Relay can be set to ignore abnormal conditions during the starting sequence of the machine.

**Dual Output Loop Power Accelerometers for Vibration Protection & Analysis:**

Typical vibration analysis and condition monitoring utilizes the dynamic signal of an accelerometer to measure the vibration of a machine. These dynamic signals are displayed on data collectors or dynamic signal analyzers in the form of time waveforms or frequency spectrums (FFT). Trained technicians and engineers analyze the data and make diagnostic evaluations based on the measurement. A typical dynamic measurement is pictured in *Figure #1*.

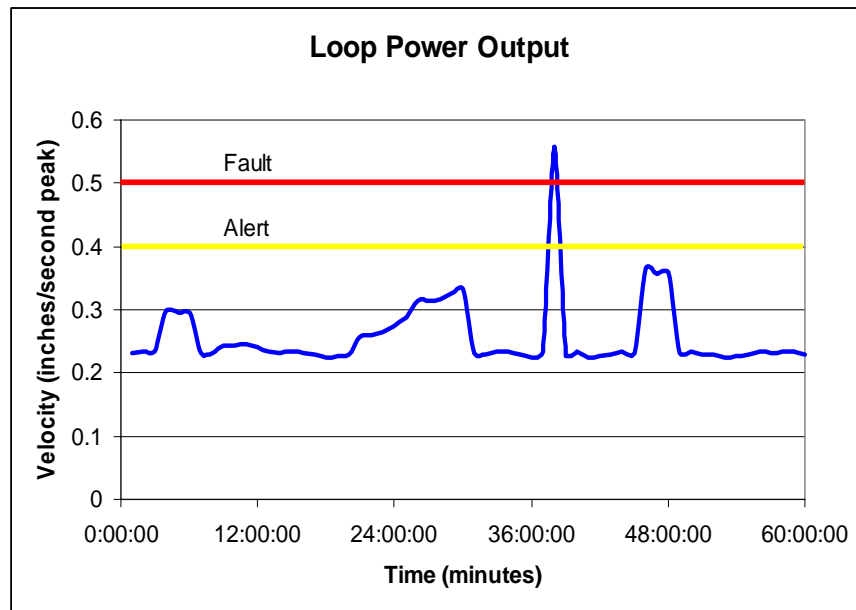


*Figure #1 – Dynamic Display of Frequency Spectrum and Time Waveform*

Although the dynamic measurement and analysis has stood the test of time in condition monitoring programs, it does require trained resources and routine data collection. Permanent monitoring systems are available for dynamic vibration measurement and analysis providing 24/7 protection, but they do require extensive

hardware/software installation, and technical resources to diagnose and interpret the data or generate proper alarm settings.

The Loop Power Accelerometer is relatively new to the process control industry for vibration protection. The 4 to 20 mA output is proportional to the overall vibration for a selected frequency band. These selected frequency bands follow ISO standards and are available in ranges of 3 to 2,500 Hz (180 to 150,000 cycles/minute) or 10 to 1000 Hz (600 to 60,000 cycles/minute). Acceleration and Velocity outputs can be expressed in units of “g’s” or “inches/second” or “mm/second” respectively with values expressed in rms. or peak. Standard Loop Power Accelerometers provide an overall vibration level indicating the general condition of the machine. However, they do not provide any capability for dynamic measurement and analysis to identify the source of the vibration disturbance. *Figure #2* is a typical trend from a loop power accelerometer providing overall vibration (velocity) measured over time (minutes).



*Figure #2 – Typical Trend for Loop Power Output*

Dual Output Loop Power Accelerometers provide the best of both worlds. One output provides 4 to 20 mA for process control, and one output provides dynamic vibration (100 mV/g or 100 mV/inch/second) for use with the traditional data collectors and dynamic signal analyzers. Leveraging the dual output capabilities of these sensors provides an easy method for process control and alarms that can be utilized at the shop floor level for protection, but still provides the capability for the trained technicians and engineers to analyze the source of the vibration. Both measurements are performed with one sensor, reducing the equipment and time required to get the measurement.

Vibration amplitudes for the Loop Power output are available in ranges of 0 to 0.5 inches/second, 0 to 1.0 inches/second, 0 to 2.0 inches/second, 0 to 10 mm/second, or 0 to 20 mm/second. Values are represented as “peak” or “rms.”

Vibration amplitudes for the Dynamic Output will have a range of +/- 50 g's.

### **Integrated System:**

*Figure #3* illustrates the integration of a Dual Output Loop Power Vibration Sensor with a 469 Motor Management Relay. Options for process control on the shop floor or control room are shown with diagnostic vibration analysis by trained technicians and engineers readily available at the switchbox interface. The gain in a process control function does not detract from the ability to do dynamic vibration measurements, data capture, or analysis using the typical vibration data collector found throughout industry today. The benefits are 24/7 monitoring to provide historical trending and actionable alarms to the shop floor.

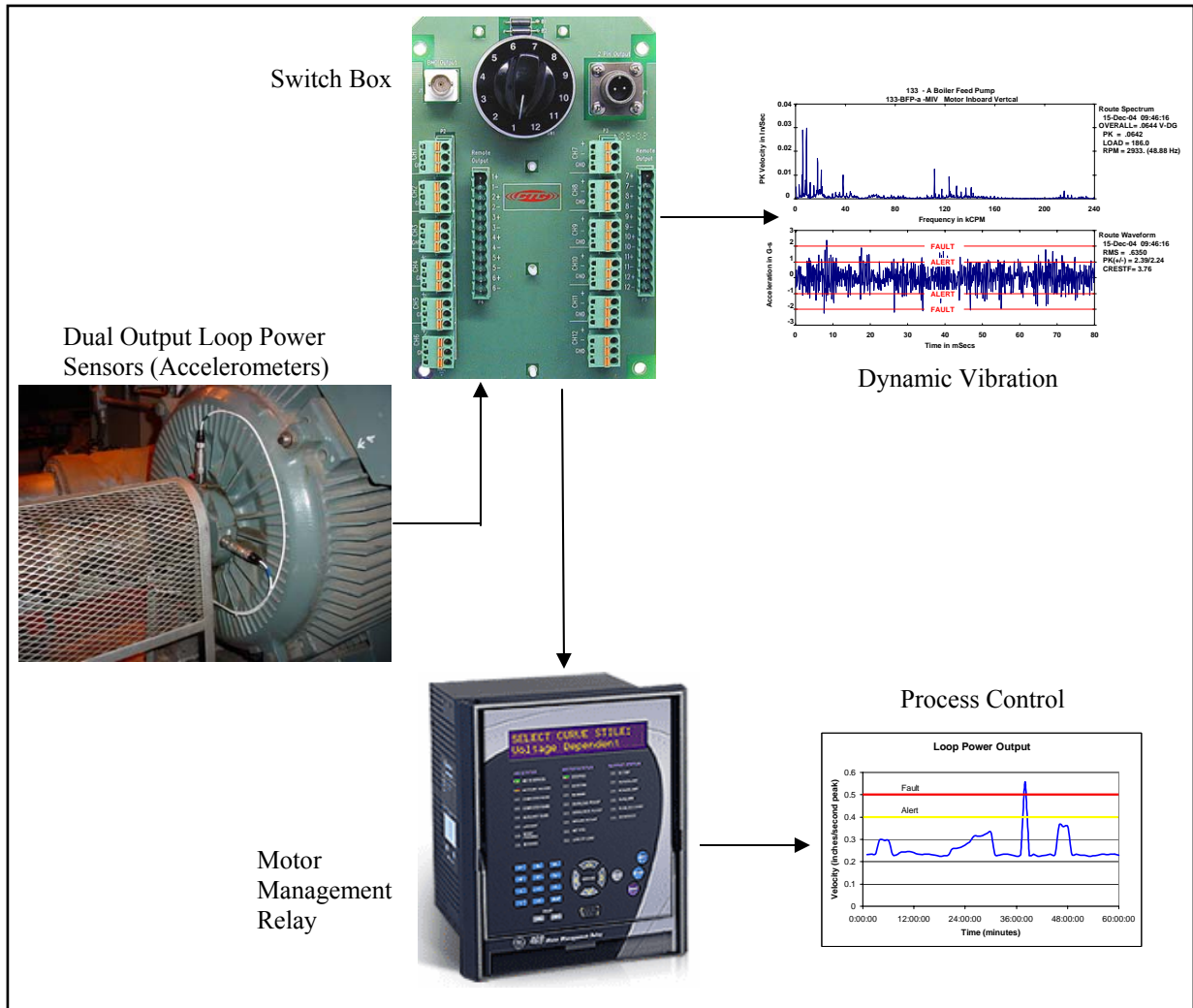
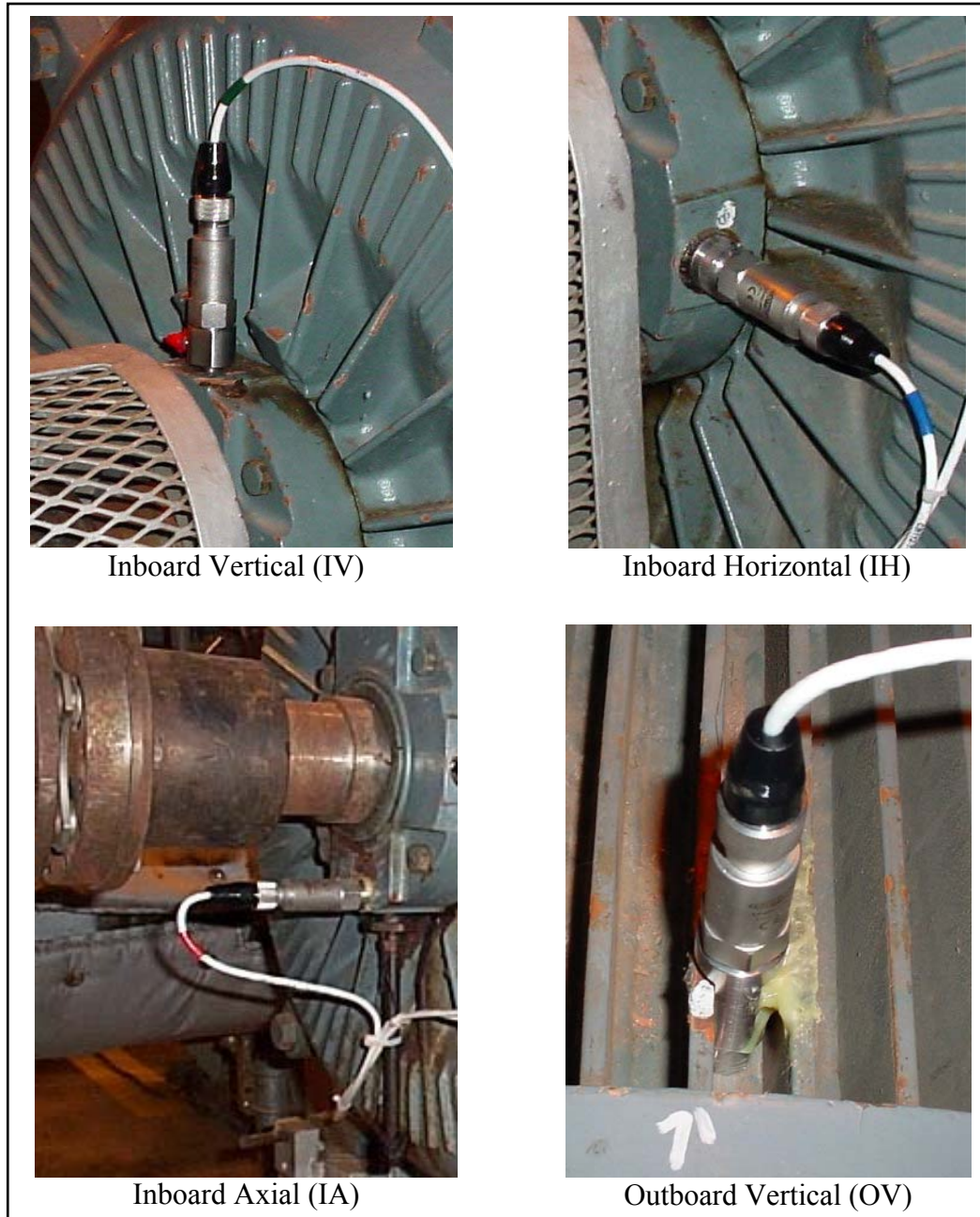


Figure #3 – Integrated System

**Boiler Feed Pump – Case History:**

Four CTC Dual Output Loop Power Sensors have been installed on a 600 HP Boiler Feed Pump Motor running at 2933 rpm. This variable speed motor drive has a GE Multilin 469 Motor Management Relay incorporated with the drive package. Three sensors were placed on the motor, on the inboard bearing casing, in the vertical, horizontal, and axial locations. The fourth sensor was placed on the outboard end of the

motor in the vertical location between cooling fins (fin mount). *Figure #4* identifies each sensor location and orientation on the motor.

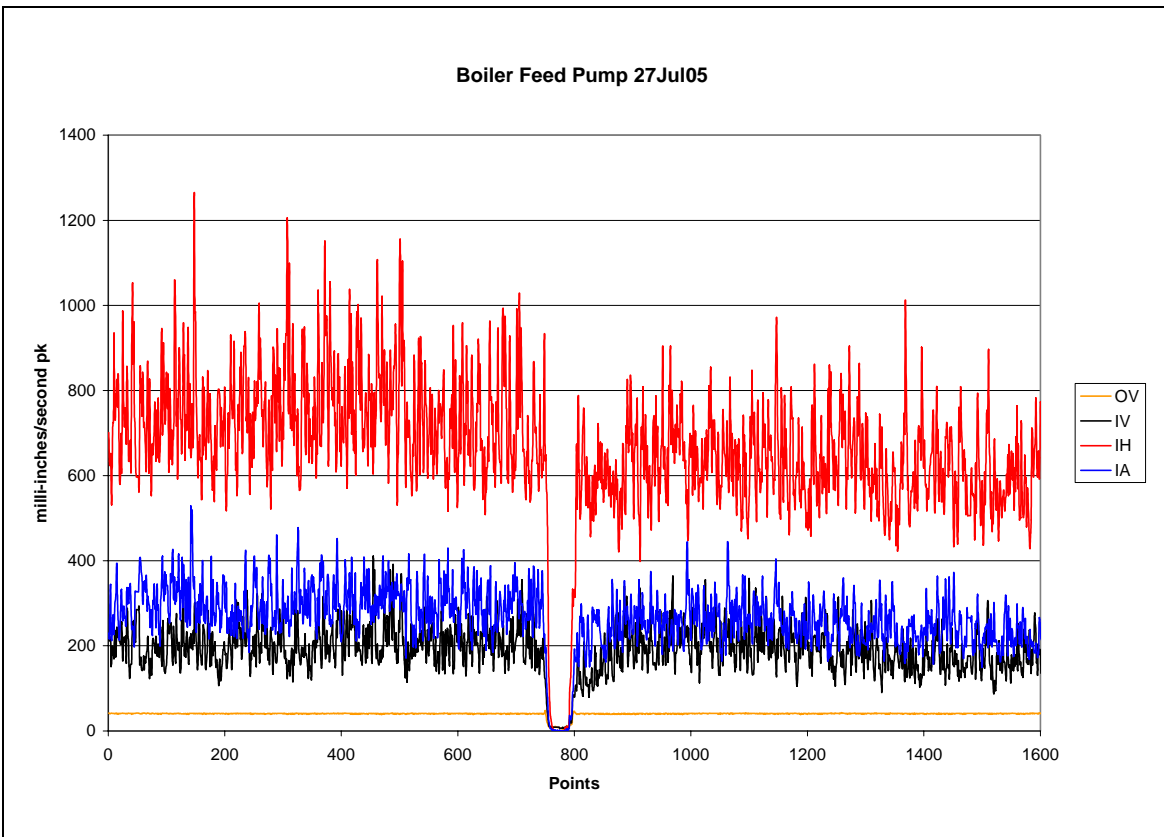


*Figure #4 – Sensor Mounting Locations*



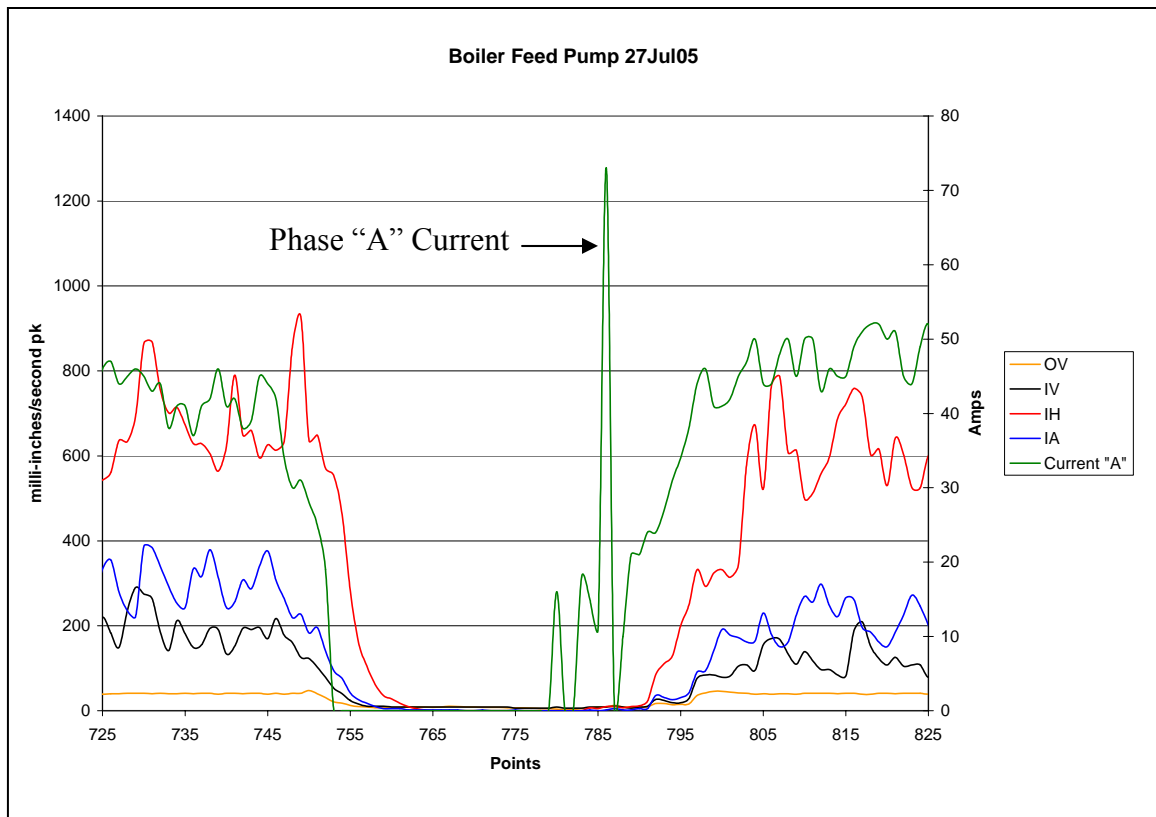
**Process Data:**

Data has been collected for process control using the 4-20 mA features of the GE Multilin 469 Motor Management Relay. Figure #5 is a trend chart representing 1,600 samples for July 27, 2005. The “X” scale represents approximately 27 minutes of data sampled once/second.



*Figure #5 – Trend of Loop Power Output*

It is easy to detect the transient that has occurred in the trend. All four of the vibration sensors have shifted to zero output and then recovered to the normal operating condition. The process data can be expanded around this transient, and is illustrated in Figure #6.

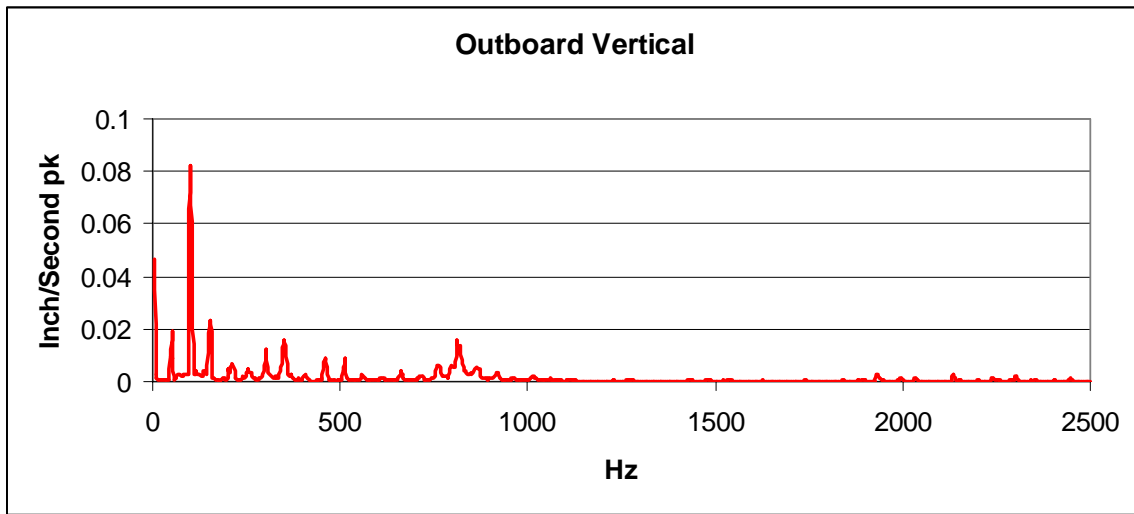


*Figure #6 – Expanded Trend of Loop Power Output around Transient*

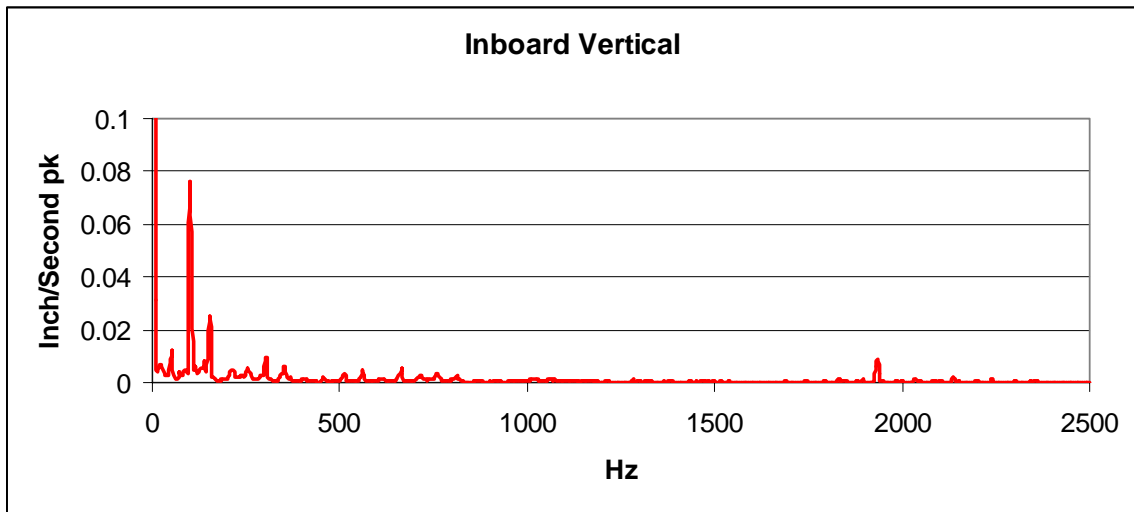
Since the data is in a “process” format, it provides an advantage for identifying those faults that only occur occasionally, and provides a method for investigation. The expansion of the data in Figure #6 allows the process technician or operations department to closely analyze the data and correlate this event to any others that may have happened at that same time. The phase “A” current was added to this expanded data. During investigation of this transient, it was learned that the operator had inadvertently stopped the pump and then immediately realized the mistake. The pump was quickly restarted, and the 41 second transient resulted. Note the current spike on restart!

**Dynamic Data:**

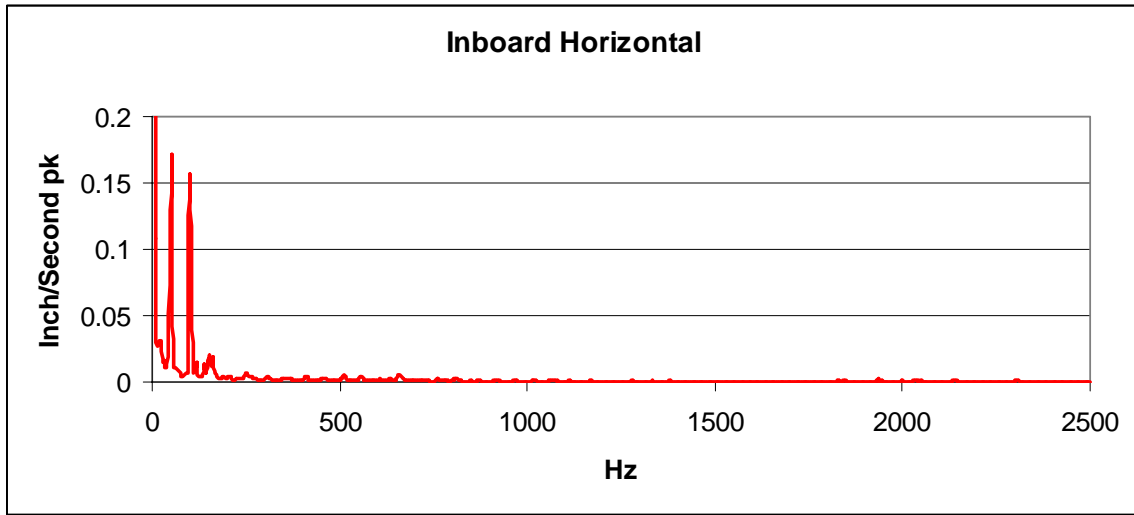
Not to be forgotten, the dynamic vibration data can also be measured and analyzed for the four dual output vibration sensors. This data will be typical of the vibration measurements made during normal “route” based data collection. Functionally the dual output sensors create a permanently mounted vibration sensor, and by utilizing the switchbox, allow the portable measurements as shown in Figures #7 - #10.



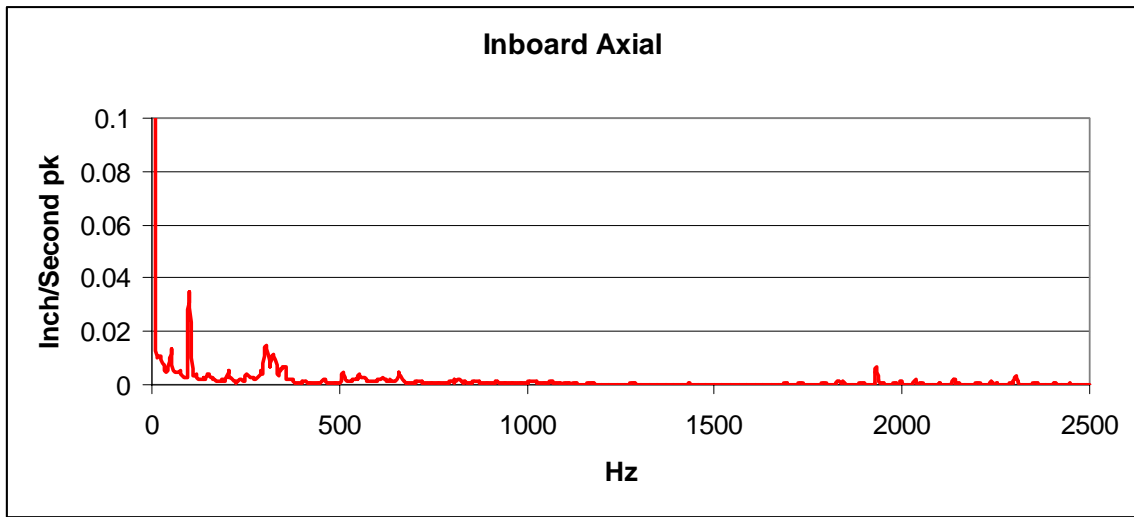
*Figure #7 – Outboard Vertical Vibration*



*Figure #8 – Inboard Vertical Vibration*



*Figure #9 – Inboard Horizontal Vibration*



*Figure #10 – Inboard Axial Vibration*

The FFT's of Figures #7 - #10 are typical of dynamic vibration that would have historically been collected periodically on a route based program. Utilizing the dual output sensors retains this feature with permanent accelerometers that also provide process alarms through the motor management relay.

**Summary:**

- The GE Multilin model 469 Motor Management Relay provides an excellent platform for utilizing 4-20 mA outputs in a process control environment.
- The CTC Dual Output Loop Power Accelerometer provides 4-20 mA outputs for process control in conjunction with 100 mV/g dynamic vibration outputs.
- Trending and alarming is available in typical process control formats for use by the operations and maintenance departments.
- Dynamic vibration measurement and analysis is available for the vibration team providing diagnostic support for process disturbances.
- Successful Process Control and Vibration Programs co-exist!

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