Specification
For
Structural Integrity Associates'
Transient Torsional Vibration Monitoring System
(**TTVMS**)

The **TTVMS** is an integration of a latest Pentium based PC and National Instruments' data acquisition and analysis hardware and software as shown in Figure 1. This combination provides a fast, dynamic, flexible data system which will support both the short term test demands for manual operation, and long term monitoring requirements for automatic acquisition, real time analysis and alarm capabilities. The system provides future expansion capabilities in number of channels, and additional monitoring and analysis functions.

Hardware

The **TTVMS** is a PC Pentium based high speed, digital data acquisition system running in the Microsoft Windows operating system. The system will accept up to 16 channels of analog, dynamic signals typically composed of torsional vibration, generator voltages and current, instantaneous generator output power, and spare channels adaptable for tie-ins with other plant process and vibration signals. The system provides relay outputs for warning and alarm indications. Table 1 provides detailed specifications.

The alarm status and sensor amplitude for each channel is displayed on the color monitor when in the **Monitor Mode**, with options to view time histories and frequency content real time of any two channels. In the **Test Mode**, any two of the thirty-two channels may be viewed real time. All data are viewed in engineering units.

The system may be triggered to record data automatically while in the **Monitor Mode** from any of the channels chosen for alarm. The channel alarm algorithm is based on a pre-set number of peaks from the signal exceeding the alarm set-point over a pre-set period of time. This algorithm eliminates false alarms due to short duration power transients.

The torsional channels are converted from frequency to a voltage proportional to torsional velocity, then fed into anti-aliasing filters prior to the analog/digital (a/d) conversion. The generator voltage, current and power signals from the CTs and PTs are anti-aliasing filtered, then fed into the a/d converters.

The thirty-two input channels are fed into the thirty-two channel analog-to-digital converter (ADC), where each channel is low passed (anti-alias) filtered, amplified and simultaneously digitized at rates up to 2,000 samples per second (sps) per channel. The ADC is a single card installed in the PCI bus of the PC motherboard.

The digitized data from the ADC is doubled buffered in the PC's memory (RAM), and recorded directly to disk in both the **Test** (manual controlled) and **Monitor** (automatic alarm trigger) **Mode**. The double buffer allows for simultaneous acquisition and data processing while maintaining continuous, seamless data acquisition and storage at the fastest data throughput rates of the ADC. Data is stored on disk in a binary format to minimize data storage capacity. Each file is time and date stamped and provided with a unique, updated file name.

Data can be permanently stored on a CD writer. The CD-ROM provides for easy and fast loading of software and upgrades, while the seventeen-inch SVGA monitor allows for easy viewing and high color resolution.

The data acquisition hardware is controlled by National Instruments' Labview graphical interface software, which provides "virtual instruments" to acquire, real time process, analyze and store high-speed digital data. The Labview software is a proven twelve-year-old technology, which is well integrated with National Instrument's hardware. The combination of National Instruments' Labview software and data acquisition hardware is used throughout the world to provide flexible, high speed, reliable monitoring and testing.

System Setup Controls

The **TTVMS** system is setup through a setup menu, where inputs are entered through simple mouse and keyboard strokes. In this menu, parameters, such as channel selection, channel identification, channel sensitivity (Engineering Volts per Units), amplifier gains, sample rate, filter settings, alarm set points and averaging times, are established. A time/date stamped System Setup data file is stored on disk with a unique identification name.

Continuous Monitor Operation Mode

In the **TTVMS Monitor Mode**, each alarm channel will be set up to provide two alarm states, **WARNING** and **ALARM,** for each of four user defined frequency bands. The frequency bands can be continuously set from narrow (1 Hertz) to broad (one-half the sample rate). Typically the bands are set for torsional monitoring from 0 to 50 Hertz to observe the lower sub-synchronous torsional modes, 50 to 100 Hertz to observe the super-synchronous modes, 100 to 150 Hertz for the highest torsional modes of interest, and a narrow band to cover a selected mode of interest.

For each alarm channel and each frequency band, two alarm state amplitude settings are user defined, **WARNING** and **ALARM**. An adjustable **WARNING/ALARM** algorithm is established based on number of peaks exceeding the set point per unit time in order to eliminate false alarms. If the set points are exceeded, the alarm level is triggered, resulting in a display indication and/or an output relay closure and/or an output logic signal sent for external alarm. The time and date for each alarm state excursion is maintained in the **Monitor Mode** session data file described below. For each alarm channel frequency band, a count of the number of signal peaks exceeding the alarm set point is maintained in a data file. These values can be used for fatigue calculations, if necessary.

Upon obtaining an **ALARM** state, all input channels are simultaneously recorded to disk for a user-defined period of time in a pre-trigger mode, as described in the **Transient Recording** section of this proposal.

An historical amplitude trend of the alarm channels will be maintained and will be displayed without interrupting the **Monitor Mode**. The trend displays the peak value for each frequency band as described above.

At the start of a **Monitor Mode** session, a new data file with a unique, automatically updated file identification is created with the initial **Monitor Mode** start time. Upon closing a **Monitor Mode** session, the data file is closed and all trending, peak counting, alarm level excursions (time/date), end of **Monitor Mode** session (time/date), and transient triggered file names are stored to disk under the file identification for this monitor session. Automatic file saves which will save the current **Monitor Mode** session status without ending the session will be made at the user defined intervals to protect data from power failures. An un-interruptible power supply is suggested.

Once daily, at a user chosen time, all input channels will be automatically acquired, similar to the **Transient Recording** for an **ALARM** excursion described above. The recording will provide a detailed view of the torsional vibration state at regular intervals.

All pertinent setup information, such as sample rate, engineering unit conversions, alarm set points, and frequency bands, are stored in a text file attached to each monitoring session.

Transient Recording (Test Mode)

The **Transient Recording** mode of operation is used for the automatic alarm triggering in the **Monitor Mode** and for manual operation during testing.

The **Transient Recording** mode allows for the manual and automatic initiation of the acquisition of data. Data may be acquired in a pre- or post-trigger mode. These modes allow for collecting data prior to or after the manual or automatic start-of-collection trigger with the pre- and post-delay user-defined between 0 and 50 % of the total data collection time. The pre-trigger mode uses the FIFO, circular data buffer concept to allow for capture of data prior to a trigger, and is useful in establishing the initial vibration conditions prior to a transient.
Data may be collected for 1 to 16 channels at over 2000 sps per channel with a pre-trigger data included in the data file and a mouse controlled switch to start/stop record. During transient recording any two channels may be monitored real time as time histories or frequency spectra. The data will be displayed in engineering units as a function of time and/or frequency. The graphs may be automatic or manually scaled.

Data Analysis

All data analysis with the **TTVMS** is performed with the flexible high speed Labview advanced analysis software. The software will allow for real time or off-line analysis of one or more channels selected by the user. The display graphs are automatically or manually scaled and provide zoom features to magnify selected portions of the graph. Multi-channel data is distinguished on the monitor by variation in line color and on hard copy by line variation. Multi-channel graphs will have line legends to distinguish the channels.

Graphs may be printed or spooled to disk for storage. All graphs are in engineering units. Analysis routines may be quickly called through the use of easily recognized icons.

Labview supports the following analysis for one to four selected channels:

a. time history
b. peak detection
c. root-mean-square (rms)
d. digital filter: low pass, high pass, band pass; 2 to 10 poles
e. frequency spectrum using the FFT with outputs in power, root-mean-square (rms), peak, power density, rms density
f. orbit plots (two selected channels only)

Table 1

Hardware Specification

Torsional Vibration Frequency-to-Voltage Converter

Type:	Frequency proportional to torsional velocity
Range:	+/-10 radians/second
Resolution:	+/-0.005 radians/second
Accuracy:	+/-0.005 %
Center Frequency Range:	variable 50 to 10000 Hertz
Demodulated Bandwidth:	variable 50 to 500 Hertz
Number of Channels:	7

Amplifier for Stator Current, Voltage and Power

Type:	Voltage Amplifier
Range:	+/-5 Volts
Resolution:	+/-0.00244 Volts
Gain:	0.5, 2, 1, 5, 10, 20, 50, 100
Bandwidth:	variable 50 to 500 Hertz
Number of Channels:	16

Low Pass Filter (Anti-Alias)

Channels:	16
Coupling:	AC or DC
Bandwidth:	Variable from 10 Hertz to 3000 Hertz
Roll off:	> 24 dB/octave
Linearity:	< 1 %
Phase:	Linear with frequency over the bandwidth

Computer System:

CPU:	Latest
Cache:	512 kB L2 Cache
RAM:	512 MB
CD ROM:	48x
Hard Drive:	> 20GB EIDE (x2)
Monitor:	17" SVGA, 0.28 dp
Backup:	CD – RW 8x
Operating System:	Microsoft Windows
Network Card:	Intergrated 3Com Etherlink 10/100

Table 1 (continued)

A/D Converter

Number of Channels:	16
Input Range:	± 50mV to ± 10V
Digitization:	16 Bit
Resolution:	± 1/32768 of input range
Accuracy:	± 0.0005%
Sample Rate:	Variable from 1 SPS to 3,000 SPS per channel
Sampling Mode:	Less than 0.00001 sec. for single channel
Data Transfer:	Continuous at all sample rates

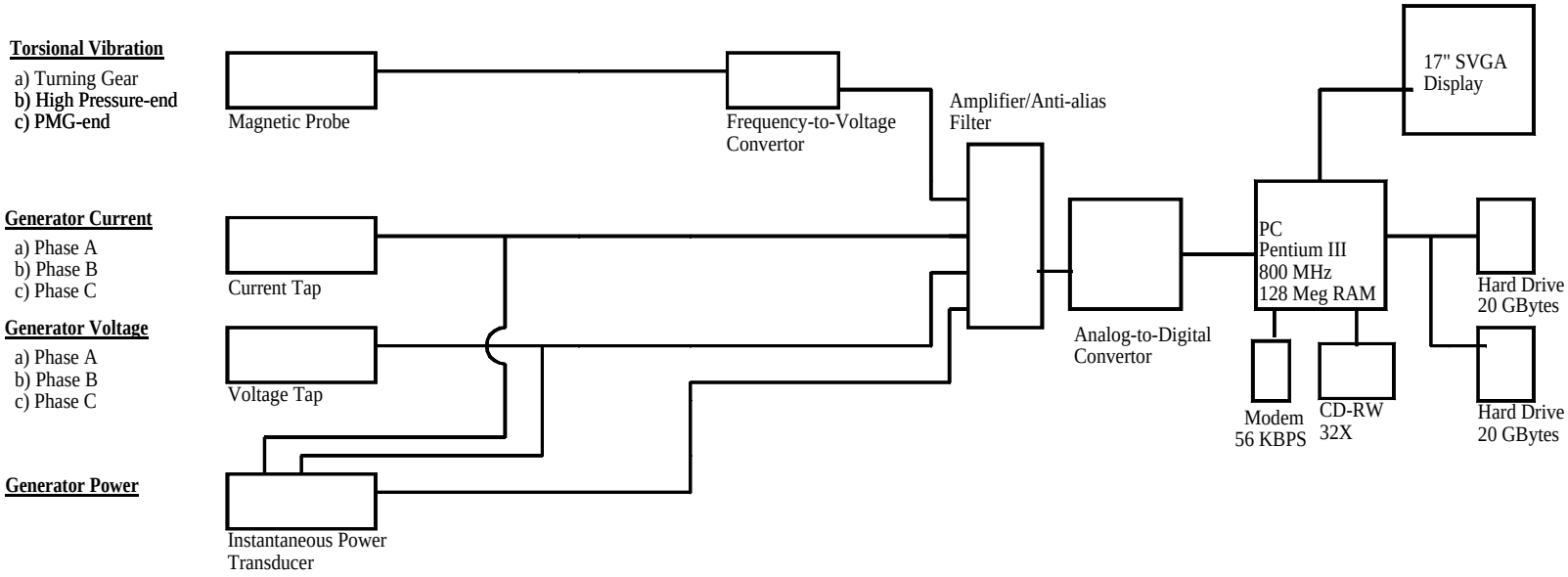

Figure 1. Transient Torsional Vibration Monitoring System