Converging Technologies: Continuous and Periodic Vibration Monitoring

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Continuous machinery monitoring and periodic data collection, while sharing common objectives, have evolved from different directions. Continuous monitoring has normally been applied to more expensive, critical machines. Data collectors, on the other hand, have made periodic vibration data collection simpler and faster, while computer programs evaluate the large volumes of data to determine machine condition. Recently, however, periodic and on-line machine condition monitoring have started converging. Technology for both hardware and software are not only overlapping, but becoming quite similar. This evolution of hardware and software has also created the possibility of combining continuous and periodic monitoring efforts.

Until now, virtually every vibration data collector has been a special purpose computer. Each system has a set of assembler-type programs, designed to perform a limited set of tasks, and many systems require chip changes to upgrade programs. Some systems have downloadable software; however, most are in a language which is unique to a specific instrument.

As a result of this unique system design, many vibration data collectors do not have the ability to adapt to new user requirements or take full advantage of advances in technology. How often have you found that a recent instrument purchase is technically obsolete within a very short time, and there is no logical or economical upgrade path available? Sadly, that's been the price of advancing technology in the past. Fortunately, it may no longer be necessary to discard instruments or software to take advantage of advancing technology and the convergence of continuous and periodic data collection techniques.

An essential factor in the convergence of continuous and periodic functions is standardization. Small IBM compatible microprocessor boards are now available with significant functionality. The evolution in board designs for speed, accuracy, versatility and reliability are generally well ahead of special purpose designs. When computer manufacturers opened their architecture and standardized, they made it possible to create other hardware and software capabilities. This open architecture has also brought about significant price reductions. On the software side, the same has been true. Operating system standardization has been the catalyst for software advancement.

By adopting an IBM compatible structure, the design of a data collector/analyzer has a number of advantages. First, the design of the computer makes it unnecessary to use a hardware dependent programming language. Second, as computer upgrades and faster chips are introduced, they may be quickly and economically incorporated. Since these changes are, by design, compatible, no other hardware or software changes are required. For example, a user can easily upgrade a '286/287' CPU configuration to a '386/387' or '486' configuration. Software enhancements can be added to both hardware and software in modules. Additions are simply incorporated into the existing software and downloaded from a computer or external floppy drive. This may even include special purpose software such as word processing, CAD, or spreadsheets. This enables the user to write a report or make sketches on the data collector/analyzer.

Hardware standardization also allows the use of a hard disk. Small, low power, hard drives are available, capable of withstanding over 500 g's of shock load, and perform well in everyday industrial use. These hard drives provide a practical and cost-effective alternative to the expense and size limitations of solid state memories used in most data collectors. This enables the user to store considerably more data, programs, routes, etc., than with most portable data collectors (which are generally limited to less than 2 MB). Hard disks also have the advantage of being non-volatile. The use of a hard disk allows expansion of memory from 20 to 40 or even 180 MB. This feature is important if the data collector/analyzer is used for on-line monitoring over a long period of time.

The compatible PC structure and operating system standardization allow modular integration of related hardware and software. Portable multi-channel monitoring and analytical instruments can be networked with on-line PC stations which use permanently mounted transducers.

The software can share the same modular, standardized concept; including expert system analysis, data trending, modal, sound and statistical routines. More sophisticated analytical trending and statistical process control features can be easily added, and the modules of several systems can be integrated. This architecture also allows other DOS compatible programs to be directly used; and, since there is considerable DOS software available as public knowledge on all aspects of vibration, sound, modal analysis, and FFT's, this feature can be particularly important.

With an IBM compatible PC system design, large program libraries are available. Furthermore, the hardware components (screens, memory, keyboard, and expansion slots) are also PC compatible. This design allows the broadest and simplest component integration. Special purpose cards, such as the Analog and Digital cards, fit into the instrument, as one would fit them into a regular PC expansion slot. The same analog and digital cards can be inserted into a PC, permitting it to function as a multi-channel spectrum analyzer.

By configuring the design this way, the analog/digital (A/D) cards become multipurpose. Used in the data collector/analyzer, they may function as high powered cards with 16-bit resolution and built-in anti-aliasing protection for data collection as well as single- or multi-channel vibration analysis. Used in an expansion slot, these same cards turn a PC into a continuous on-line monitor, laboratory multi-channel spectrum analyzer, production line inspection station, or, via modem, a remote monitor.

Most data collectors use 12-bit A/D's. This limitation is rarely a problem, since most systems are used in hand-held applications which are inherently less accurate than 12-bits. A multi-channel design; however, typically collects data from 2, 3 or 4 channels, or a triaxial accelerometer with which all channels are simultaneously acquired. Even allowing for the time of connecting to a transducer mounting pad (it is recommended that threaded mounting pad **connections be used to enhance accuracy), data** collection with a triaxial accelerometer is still faster than a single channel system. It also ensures more precise orientation and repeatability of measurement axes. And, if 16-bit A/D's are used, they yield 96 dB dynamic range, compared to the 72 dB of 12-bit systems. This feature improves the signal to noise ratio and is readily apparent when integrating low frequency data.

Until now, many data collectors and real-time analyzers have been configured to work around memory and/or data storage limitations. Data collector memory limits the number of collection points, routes, and programs resident in the unit. Data points that should be collected in a horizontal, vertical and axial data collection scheme are omitted, simply to reduce the amount of data collected. The logic is that one or two axes of data collection will likely be adequate. This has resulted in a tradeoff between sufficient data for analysis and filling memory too quickly.

Using only overall data is a significant compromise compared to using narrowband data. The compromise is often made because overall readings take up less memory than narrowband. In fact, many data collectors acquire narrowband data only if the broadband values exceed a pre-established limit. Unfortunately, this approach can miss faults that are in the process of development, as well as subtle changes in machinery condition. This approach may also miss the objective of predictive maintenance: to track the evolution of a machinery problem.

For example, an overall or broadband vibration measurement may show little change in the early stages of bearing deterioration, gear mesh, or rotor bar or flow problems. Narrowband data with good resolution, on the other hand, can depict these problems almost from inception.

With the availability of hard drives, no compromise in data storage is necessary. Spectra in the horizontal, vertical and axial axes can be collected. Extra lines of resolution and multiple frequency ranges can be acquired with no concern for having to go back to the host PC to download. This data represents the six fundamental signatures required to properly assess any bearing condition. If shaft (proximity probe) data is also available, then it too is fundamental to the analysis of the test point and should be included. Complete data enhances the analyst's and/or expert software's ability to analyze the data. Therefore, because data is easily obtained and stored, it is safer and wiser to record all of the data initially and discard anything deemed unnecessary later.

Memory limitations have also limited the size and number of routes loaded onto a collector. The availability of hard disk memory thus makes it possible to have all routes loaded at once. In addition, all programs for analysis, data collection, balancing, expert systems, modal, sound, etc. can be resident in the instrument, and available at any time. This is especially helpful when there is no convenient access to another PC.

The IBM compatible structure allows a data collector/analyzer to be upgraded at a reasonable cost, while also providing enhancement features long after the system has been purchased. This has the advantage to the user of not requiring purchase of a new system each time new features are created. This is certainly true in using the data collector/analyzer for continuous monitoring. Limitations imposed by the solid state memory of most devices and machine language programs preclude the use of any continous or multiplexed applications. Continuous monitoring is simple for a data collector designed as an IBM PC compatible with 180 MB of data storage.

When using the multiplexer concept, monitoring is not continuous. However, by monitoring with a multiplexed system, the coverage or monitoring frequency per point is much greater than even a daily data collection route. And, there are other benefits, including data accuracy. Since the transducers are permanently mounted, there is no placement error and ID collection mistakes are virtually non-existent. Viewed in this context, it is understandable why a 16-bit A/D with 96 dB dynamic range can be quite important to provide data accuracy.

The modular concept of the hardware components also applies to the software. Many features of the instrument software carry over to the continuous-monitoring application and vice versa. The same high-level language functions can be used for both continuous monitoring and route data collection. Thus, the software modules for collection, trending, analysis, plotting, review, etc. can be perfected, utilized, and duplicated as required, whether used for route data collection, multiplexed data, or continuous monitoring systems.

Computer standardization over the past several years has had a significant impact on equipment manufacturers and users alike. Open architecture has provided an opportunity for substantial hardware and software advancement. The same results can be obtained if this standardization process is applied to vibration data collection, whether that be periodic, on-line or continuous monitoring. The beneficiary of this evolution will be the end user, who can spend more time collecting and analyzing data and less time worrying about whether or not his analytical equipment is about to become obsolete.

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The main beneficiary of standardization is the end user. By offering the newest IBM compatible configuration, the user has access to state-of-the-art, technology and older systems can be upgraded at a minimum cost. The hardware standardization also allows software standardization, including the operating system. And, software and operating system upgrades can be routinely installed to improve the system performance.

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