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BUILDING ON THE MULTIMEDIA PC ARCHITECTURE, TO PROVIDE NOISE & VIBRATION MEASUREMENT SYSTEMS, BASED ON VIRTUAL INSTRUMENTS.

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1. INTRODUCTION

This paper describes the concept of virtual instrumentation, and how measuring systems can be built up, using commonly available components from the personal computer world. In particular, the Microsoft Windows operating environment is examined, and its implications discussed, in relation to flexibility of measurement and reporting of noise & vibration results.

A new PC-based measuring system is presented, using a notebook PC format, where high qu· dedicated hardware is incorporated into a virtual instrument, whilst benefiting from the Win multimedia platform.

2. THE VIRTUAL INSTRUMENT

The concept of the virtual instrument (VI) is not new, but it is often misunderstood. In the early days of personal computing, the performance of the office computer was such that it was relegated to tasks little more demanding than routine office applications. Therefore, in the instrumentation world, dedicated instruments, developed and built for a specific task, performed the measurements, and the PC was used simply to present and store the data. As the digital signal processor slowly took over the measurement functions in the instrument, the speed required for the front end calculations still required specialised chips.

It is only recently that affordable computing power has become available, to allow a re-think of the way measuring instruments should be structured.

A virtual instrument can loosely be described as a combination of processing functions (often in hardware) brought together with software to create a specific instrument functionality. In other words, the instrument itself does not exist (hence the term 'virtual') per se, until the combination is actioned.

Often, the term VI is used to describe a traditional instrument, which is interfaced to a PC to provide a front panel display, and control panel. Although this is a step in the right direction, it still relegates the computer to an office function.

True VI architectures have been described [1][2] where basic building blocks are created in hardware, and the VIs such as analyzers, generators, voltmeters, etc. are built on the use and re-use of these elements, within a structured software program (Figure 1).

The first generation of this type of instrument required high computing power, and a powerful instrument bus, using VXI hardware, and workstation UNIX computers. The application of VXI virtual instruments is currently revolutionising the general ATE market, but in our small niche area of interest, sound & vibration measurements can now be performed using more generalised interfaces.

For example, the ISA bus inside AT PCs can be used for linking together hardware expansion cards, and the DOS software can provide both measurement and presentation capabilities.
An early example of such a system was the Aria concept [3], which is based on a high quality 16-bit expansion card, with dedicated DSP, and the software allowed measurements of environmental

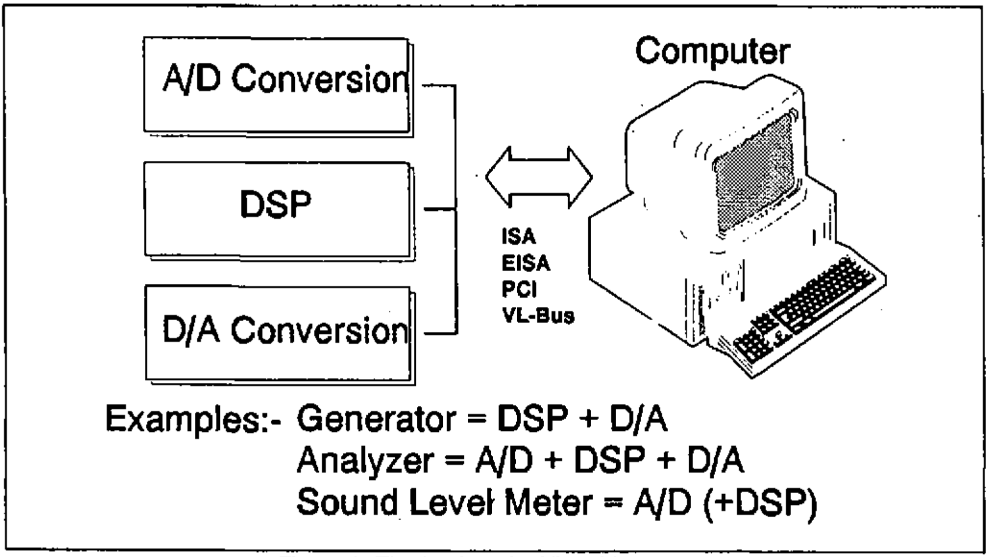

Figure 1: The basics of a Virtual Instrument

noise, building acoustics, sound intensity, frequency analysis and so on, simply by calling up a new program, which re-uses the same hardware. This hardware still retains some dedicated functionality as required by our field of application, such as powering for transducers, filtering, A/D conversion at satisfactory resolution and linearity, and triggering

Clearly the benefits of the virtual instrument approach are reduced redundancy of dedicated elements in the system, and flexible measurement functionality.

3. THE WINDOWS REVOLUTION

Early versions of the virtual instrument used specialised software, written, compiled and executed on basic operating system kernels such as DOS. This required each instrument to have a dedicated hardware driver to provide the interfacing of the expansion card, and a dedicated user interface, which generally reflected the preference of the programmer, or the measurement philosophy of the manufacturer. This resulted in front panel control of the VIs being reduced to a set of keystroke combinations, or function keys on the PC, to achieve a fast user interface, with little conformity between user interfaces from different manufacturers.

Although this is a commonplace problem with existing real instruments, the VI appeared daunting to the first time user, owing to the many possibilities of error introduced by the complexity of the computer user interface. DOS command line execution was often enough to put off the most experienced acoustician.

No-one can have failed to notice the advent of the graphical user interface (GUI), which initially appeared in the UNIX world, with the public domain X-Windows as an example. This is now the most popular interface for workstation computers. Instead of entering strange commands at the system prompt, users could now point at buttons or icons on the screen, using a pointing device, and execute programs by clicking on a mouse. In this way, software behaved like the front panels of instruments, where hard-wired buttons executed particular functions. The advantage of the software approach was that the front panel changed as the functionality of the software changed, a difficult task indeed for hardware.

In the PC world, the Microsoft Windows interface became dominant, and although Windows is not actually an operating system, but more an additional layer running on top of DOS, Microsoft laid down some strict rules governing programming in Windows. This ensures that there is a consistent 'look-and-feel' to software written for Windows, hence removing the proprietary feel to software from different manufacturers.

This can be illustrated simply by looking at the interfaces of the main competitive word processor packages under Windows, where the user will find File, Edit and Help menus in the same place, for example.

In addition, several mechanisms were created, which ensured that there was consistency in the way applications communicated with peripherals, and other software running in the same environment. This means that office applications such as spreadsheets and word-processors can share data such as tables and graphics, speeding up mundane office tasks.

This conformity also stretched to the way the PC acquires data from hardware peripherals, and this has meant that the basic architecture is in place for instrument applications. The office manifestation of this has been the use of multimedia (the combination of video, text and sound) for presentations and training. For instrumentation applications, it is now possible to shorten the distance between measurement and reporting, by using the same tools.

Whilst Windows was taking over the PC interface, the PC itself was gathering speed, and today's 486 or Pentium processors are now achieving performance levels many hundreds of times that of the humble IBM XT-class machines.

This has allowed a re-think of the use of PCs for instrument applications, and indeed, it is now possible to create flexible VIs using the Windows multimedia platform as a basis.

4. AN EXAMPLE OF A WINDOWS VI AND ITS ADVANTAGES

4.1 The Concerto Concept

To illustrate the state of the art in PC virtual instruments for noise & vibration measurement, the Concerto concept [4], from 01dB, is described and its advantages highlighted (Figure 2).

BUILDING ON MULTIMEDIA FOR MEASURING INSTRUMENTS

For acoustics measurements, certain criteria have to be met with regard to frequency response, linearity, dynamic range and filtering, before an instrument can be regarded seriously. Fortunately (or unfortunately for some) detailed standards, such as IEC651 and IEC804, exist which lay down minimum performance levels for measuring instruments.

In most cases, this requires dedicated hardware, produced in small runs, as befits the relative size of the market, with a correspondingly high price. Once the acoustic signal is digitized, however, relatively lower computing power is brought in to provide the 'life support system' for the instrument, and integrate the results into office software.

With Concerto, a dedicated unit has been developed, which houses powering for microphone preamplifiers, switchable gain, and C weighting before the two channel A/D conversion of the raw signal at 48kHz. Overload indication is also provided as required by instrument standards.

From this point on, further weighting is performed digitally, and parallel detectors calculate the Peak and equivalent continuous levels (Leq) using DSP, every 5 milliseconds.

This information is then transferred to software running on a notebook PC, which calculates all the other required parameters, such as F, S or I time weighted levels, longer term Leq, statistical levels (Ln) and displays these results as required.

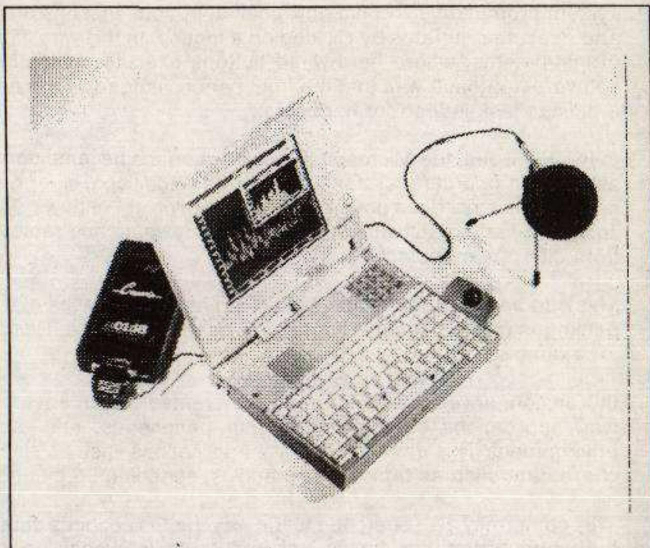

Figure 2: Concerto, showing the external data acquisition unit, connected to the notebook via a bi-directional parallel port

All control of the acquisition unit is performed by a front panel running under Windows on the notebook, and data is stored on the hard drive of the computer.

The data interface used is the standard bi-directional parallel port of the computer, with 16-bit capability, giving a tight link between hard- and software, with low power consumption. Alternatively, a PCMCIA interface can be used. Because of the capability of this interface, it is also possible to acquire raw sampled data from the external unit, and store the time history on the computer hard disk, much like a digital tape recorder. The format of these time histories is the standard Windows multimedia wave format (*.WAV), with extensions (permitted under the Microsoft 'standards') containing calibration information, peculiar to our acoustics field. Clearly well designed buffering of data is required to ensure integrated noise data is still acquired simultaneously.

The benefit of the multimedia approach is that these time records can be used for many functions. When running the environmental noise virtual instrument dBENV, for example, these records can be obtained as a function of a noise level exceedance, and tied in with the storage of noise data. The user can then play back the sounds later on, and identify the cause of the noise level increase. Additionally, digital frequency analysis algorithms can be used to calculate the spectrum of the records, after the event.

Because the format of the records is WAV compatible, they can be played back on regular multimedia hardware, available at mass market prices, although the data acquisition unit also contains a 16-bit D/A converter, which can be used for signal generation.

Additionally, the WAV files can be incorporated (embedded) in documents, which can then be distributed to others, to illustrate the measurement results. In principle, the recipient of a measurement report can simply click on an icon in the report, and the sound will be played back, as an illustration of the noise problem or whatever..

Similarly, data calculated in the measurement software, be it a table of Ln values, or a third octave spectrum, can swiftly be transferred to a word processor or spreadsheet, simply by using the Windows clipboard memory. No data reformatting is necessary, and intermediate files on disk need not be created. The VI itself becomes embedded in the office application.

Because the only dedicated part of the VI is the generic hardware, it is a simple matter to load new software on the computer, for building acoustics applications or narrow band FFT analysis.

The Concerto unit on its own has no instrument functionality, apart from the generic functions of input/output and DSP, therefore this illustrates the true VI concept, where IEC804 Type 1 functionality is achieved by the marriage of software to the hardware.

4.2 A Generalised Concept (Sonata)

The above architecture is based on current PC capabilities where the dominant processor is still the 486 and derivatives. As we move towards the Pentium, and even the P6 mooted for July 1995, clearly we will now have the power, at reasonable prices, to perform real-time processing on the computer itself.

Already it is possible to create a measurement system with this architecture, using simple A/D and D/A cards which are commercially available from computer stores. The market size ensures that costs are minimized, and 'Sound Cards' are now being offered with 16-bit SIGMA-DELTA conversion, ostensibly for office multimedia applications.

The performance of these cards in relation to the sound level meter standards will leave something to be desired in relation to selectable gain, linearity and availability of dedicated weighting networks, but a remarkably good measuring system can be achieved using this hardware. In fact, it could be argued that the instrument standards stifle the development of the VI, simply because they were written with traditional instrument architectures in mind.

With Pentium processors, it is also possible to calculate A-weighting on the input signal in real time, as well as performing all the Peak and Leq detection. The beauty of the system, apart from its price, is that it re-uses the same software modules as the Type 1 Concerto and Aria systems, the only difference being a new Windows multimedia system driver for the hardware.

For critical measurements, the established Aria hardware can be used (Aria being the first Type approved computer-based sound level meter), and this opens up possibilities for real-time frequency analysis and measurements of sound intensity, where the quality of hardware will remain of critical importance, particularly with respect to phase matching.

5. CONCLUSIONS

The concept of the virtual instrument has been discussed, along with the applications of personal computing to this architecture. A new instrument has been described, which uses the Windows multimedia platform as a basis for accurate Type-approved noise & vibration measurements, and some pointers provided for future developments in this area.

6. REFERENCES

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