The most valuable feature offered by IBM compatible Personal Computer (PC) since its introduction is an "Open architecture". This feature allowed the designers to configure plug-in boards which could be installed right into the PC for realisation of advanced but cost effective computer based instrumentation systems. However, the plug-in boards had to conform to the "bus architecture" stipulated by the PC manufacturers. In earlier PCs, Industry Standard Architecture (abbreviated as ISA) bus was provided on the PC motherboard for interfacing application specific hardware with the host computer. However, with the increase in CPU speed and increasing demands from users of PC based instrumentation, limitations of ISA bus became a serious bottleneck. After a series of upgradations and innovations, the Peripheral Component Interconnect bus (popularly known as PCI bus) has been introduced. It enables extremely high speed data transfer between the plug in boards and the host memory, and also provides many other useful features. PCI bus has now gained wide acceptance and it is expected to remain an accepted standard for at least a few more years to come. The PCI-SIG (PCI Special Interest Group) has given very careful considerations to requirements such as data width, throughput rate, processor independence, plug and play facility, scope for expansion and others before proposing the PCI bus standard.

Some of the major advantages offered by PCI bus are:

1. Extremely high-speed data transfer: 32-bit wide data transfer @ 33 MHz gives a maximum throughput of 132 Mega bytes per second. Data transfer @ 66 MHz with 64 bit wide data is now being offered.

2. Plug and play facility: This circumvents the need for an explicit ‘address’ for a plug in board. A PCI board inserted in any PCI slot is automatically detected and the required I/O and memory resources are allotted by the system. Thus, there is no risk of clash of resources.

3. New approach: It moves peripherals off the I/O bus and places them closer to the system processor bus, thereby providing faster data transfer between the processor and peripherals.

4. Processor independence: The PCI local bus fulfills the need for a local bus standard that is not directly dependent on the speed and structure of the processor bus, and that is both reliable and expandable. It is for the first time in PC industry that a common bus, independent of microprocessor and manufacturer, has been adopted.

5. Full multi-master capability: This allows any PCI master to communicate directly with other PCI master/slave.

6. Parity on both data and address lines: This allows implementation of robust system.

7. Support for both 5V and 3.3 V operated logic.

8. Forward and backward compatibility between 66 MHz and 33 MHz PCI.
Development of PCI Bus Compatible Cards

In order to meet the need of very high speed PC based instrumentation systems, Electronics Division has planned to develop a variety of PCI compatible boards as a part of IX\textsuperscript{th} five-year Plan proposal. Ultrasonic Instrumentation Section of Electronics Division has successfully developed PCI bus based cards suitable for

1. Acquisition of fast repetitive and non-repetitive electrical signals at sampling rates of 100 Million Samples Per Second (MSPS).

2. Capturing video images for further processing/analysis.

Technical specifications, hardware features and potential applications of these boards have been outlined in this article.

1. Dual Channel 100 MSPS Transient/Repetitive Waveform Digitizer

Capture and analysis of fast electrical signals (repetitive or non-repetitive types) is necessary in various scientific and industrial applications. Analog storage oscilloscopes (based on storage CRTs, scan converter tubes or CCDs) have been the initial instruments used in such requirements. Today, with the availability of high speed ADCs (with sampling speeds ranging from 50 to 1000 MSPS), direct digitization followed by storage and analysis is a far superior approach. It may be noted that in PC based digitizers, the data transfer rate between the digitizer (card) and the host memory also becomes a major consideration because the on board memory (i.e., the record length) is always limited. The PCI bus based Digitizer Board developed at Ultrasonic Instrumentation Section allows simultaneous capture of two electrical signals (repetitive or non-repetitive) at a highest sampling rate of 100 MSPS on each channel. Features such as pre and post trigger, programmable gain and offset, selectable sampling rate and others, offer flexibility and permit optimal data acquisition. The control and display software for this digitizer card has been developed under Lab Windows (cvi) platform. A highly noteworthy feature of this board is its ability to display the acquired signal waveforms along with their amplitude spectra (computed using FFT technique) in near real time. Thus the board serves both as an oscilloscope as well as a spectrum analyzer.
Fig. 1 Functional block diagram of PCI bus based dual channel 100 MS/s waveform digitizer.
SALIENT TECHNICAL FEATURES

Data Acquisition

Digitizer Section
Sampling rate: 100, 50, 25, 12.5, 6.25, 3.125, 1.56 MSPS and 781 KSPS
(User selectable)
Resolution: 8 bits
Record length: 64 K samples/channel

Analog Input
Input voltage:
Channel A: ± 100 mV to ± 5 V in standard 1, 2, 5 sequence
Channel B: ± 100 mV and ± 1 V
3dB BW: 50 MHz (each channel)

Trigger Features

Source:
External: TTL compatible - level triggering
Internal: User selectable threshold over the entire input range

Mode:
Pre or post trigger delay: 0 to full record length (user programmable)

Acquisition Modes

Continuous: Suitable for acquisition of periodic/repetitive signals
Single shot: Suitable for acquisition of transient signals
Multiple acq.: Suitable for statistical analysis of triggered events
Envelope: Suitable for analysis of jitter in signals
Averaging: Running average up to 256 waveforms for SNR improvement

Display

Screen: User selectable display windows for
Ch.A only, Ch.B only, Ch.A & B, Ch.A & FFT, Ch.B & FFT, Ch.A & B with respective FFTs.
Size: Single slot full length: 32 bit PCI board 13.33" x 4.75"

Software Support

Windows 95 based software package has been developed for data acquisition and display. The monitor screen features a familiar 'oscilloscope like' panel for parameter selection and information display in Time & Frequency domains. Suitable 'soft knobs' are provided for selection of parameters in an on-line manner. Cursors have been provided to enable measurement of signal amplitude and time/frequency related measurements.
Fig. 2 Component side of PCI bus based dual channel 100 MS/s waveform digitizer.

Fig. 3 Simultaneous display of acquired test signal in time and frequency domains. (Top trace shows ultrasonic A-scan of test block and bottom trace shows corresponding frequency spectrum.)
Applications

This board is particularly suitable for PC based acquisition and analysis of electrical signals which have fast rise/fall times or those which are non-repetitive in nature. Some application areas where the advanced features of this board can be exploited are:

- Ultrasonic characterization of internal defects in materials.
- Resonance ionization mass spectrometry.
- Laser wavelength studies.
- Laser induced fluorescence studies.
- Laser plasma investigations.
- High-pressure impact studies.
2. PCI Bus Based Video Image Capture Card

Importance of Video Image Capture (also referred to as frame grabber) cards is very well established in scientific and industrial applications. In conjunction with video cameras (monochrome or colour) and relevant Image Processing / Analysis software, frame grabber boards have found enormous use in numerous applications. With frame grabber boards based on the ISA bus, the data transfer rates are too slow to permit direct usage of PC RAM for the purpose of image data storage. Consequently, on-board memory is needed. Further, the type, speed and size of the on-board image memory impose design constraints. This also increases the hardware complexity and cost. PCI bus enables direct transfer of digital data from image digitizer to PC RAM resource. Consequently, PCI bus based image capture cards provide higher speed and performance at a significantly lower cost. Ultra Instrumentation Section over last few years has successfully developed a variety of cards for video image capture and processing. The latest development is a PCI bus based card that permits acquisition of video images (colour as well as monochrome) in PAL / NTSC / S-Video compatible signal format.

Technical specifications and salient features of the card are as follows:

- Image display directly on SVGA monitor (no separate video monitor necessary).
- Image resolution: Max. 768 x 576 pixels (PAL) & 640 x 480 (NTSC).
- Image size scalable down to icon.
- User selectable Region Of Interest (ROI).
- Auto NTSC/PAL format detection.
- Selection of video input from either three composite or two composite and one S-video sources.
- On-line image enhancement (by manipulation of brightness, contrast, saturation and hue).
- Image storage in standard BMP format (24 bits for colour & 8 bits for monochrome).
- Intensity profile plots corresponding to (overlay) horizontal and vertical cursors.
- Capture of image sequence.
- Compact size: 122 mm x 80 mm.

Applications

The PCI bus based video image capture card is a low cost solution for PC based video image processing or analysis. Hardware features make this card suitable in a wide variety of fields such as Video Microscopy, Laser beam studies, Radio Fluoroscopy, Medical Imaging, Image Archiving, etc. PCI bus compatibility makes it suitable for web based monitoring applications.

Conclusion

PCI is the latest and widely accepted bus standard for personal computers. Its features such as processor independence, extremely high throughput rate and plug & play facility are ideally suited for development of high performance, PC based instrumentation systems. Electronics Division, BARC, has developed PCI compatible boards for (i) High-speed data acquisition and display, and (ii) Capture and processing of monochrome/colour video images in PAL, NTSC or S-video format. These boards are highly suitable for a variety of scientific and industrial applications. Attempts are underway to further improve the performance features of these boards.