Infrared Link, Universal Serial

New Interfaces for Data Acquisition & Test & Measurement

Connecting instruments to computers greatly extends the capability of measurement systems and has become commonplace. However, schemes for interfacing instruments with computers leave something to be desired. RS-232, for example, suffers from limited speed and poor standards. IEEE-488 has much better performance and is much more standardized, but it is relatively expensive. Other schemes are either highly specialized or improvised, resulting in high support costs.

The interfacing problem is not unique to test and measurement; it afflicts all sectors of the computer industry. Today there is a broad effort under way to provide better interfacing technology. These efforts have produced three new interface specs:

- The inexpensive Infrared Data Association (IrDA) wireless interface, useful for short-range, hassle-free (in principle), line-of-sight hookups.
- The low-cost and simple Universal Serial Bus (USB) interface, intended for keyboards, mice, and trackballs (at the low end of the range), as well as audio and telecommunications devices (at the high end of the range).
- The P1394 "FireWire" scheme for high-speed interconnect for use with mass storage, video, and multimedia devices.

None of these interfaces were designed specifically with data acquisition or test and measurement applications in mind, but their capabilities make them eminently suited for such applications, with each interface having unique capabilities.

Acronyms

UART	Universal Asynchronous Receiver/Transmitter
LAN	Local Area Network
CD-ROM	Compact Disk, Read Only Memory
LED	Light Emitting Diode
USB	Universal Serial Bus
ISDN	Integrated Services Digital Network
PBX	Private Branch Exchange
MPEG	Motion Picture Entertainment Group

INFRARED LINK*

The emerging standard for wireless infrared communications is that defined by the Infrared Data Association (IrDA), based on technology originally developed by Hewlett-Packard but now an open standard. It is formally known as IrDA — more informally as Infrared Link.

Infrared Link defines a line-of-sight communications system where the transmitter and receiver must be within a 30° viewing cone of each other. The link has a range of one meter at its lowest-power setting. The signaling scheme allows high-reliability transmission even in sunlight, though high-frequency fluorescent lighting can introduce noise.

The basic spec (IrDA 1.0) provides for a maximum of 115.2 kbps (kilobits per second) data rates; extensions to the original spec (IrDA 1.1) add data rates of 1.15 and 4 Mbps (megabits per second) — fast enough to support LAN or even a double-speed CD-ROM drive.

Infrared Link hardware is simple (at least for the 1.0 spec), consisting only of an encoder/decoder to allow interfacing to a UART, and an IR transducer consisting of a transmitter LED and a receiver photodiode.

Communications are necessarily half-duplex (meaning communications are on an I-talk-you-listen-you-talk-I-listen basis), because the output LED would saturate its accompanying input photodiode if they both operated at once.

Of course, the interface sends data in a serial format, with an IR pulse representing a "0" and no pulse representing a "1"; the scheme looks much like RS-232, with each frame consisting of 1 start bit, 8 data bits, and 1 stop bit.

** The term "infrared link" is informal and general in nature, and has no official standing as a name for the technology.*

Bus, and FireWire

New interfaces are already being applied to instrument technology.
This article examines the advantages and disadvantages of three new interfaces.

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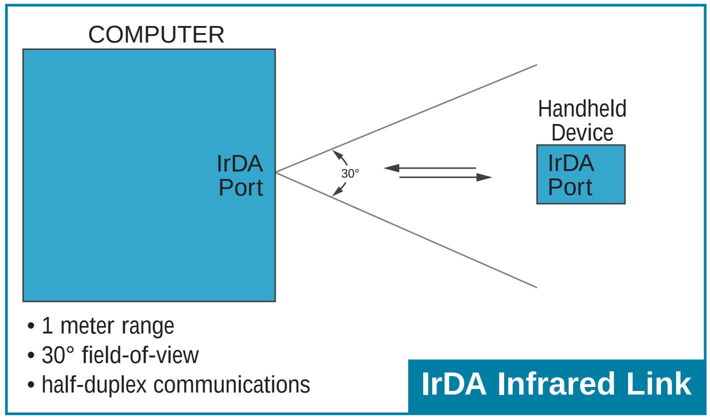
Two Infrared Link devices will establish communications through a protocol in which infrared activity is sensed at a 9.6 kbps data rate. The two devices then agree on what higher-speed data rate is appropriate and begin communications.

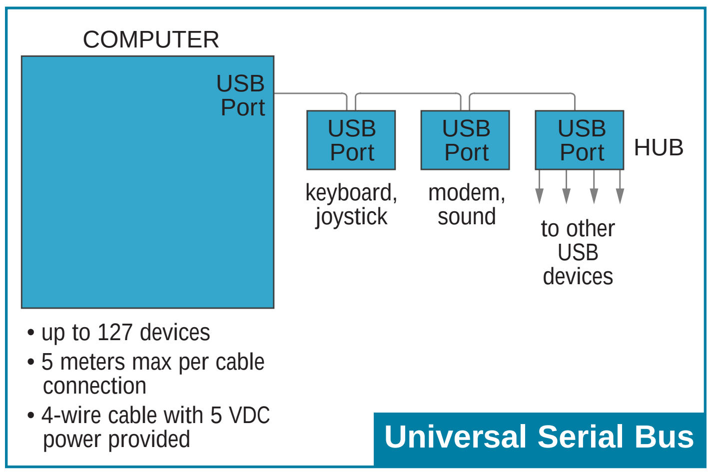
Infrared Link was originally promoted as a universal interface, but so far has not gained the critical mass needed to make it a feature most PC users care about. However, the cost is low, the standard is functional, and there is an obvious need for such a technology. Having such a standard available means that Infrared Link will find wide application in small portable devices such as watches, pagers, wireless telephones, and so on.



UNIVERSAL SERIAL BUS

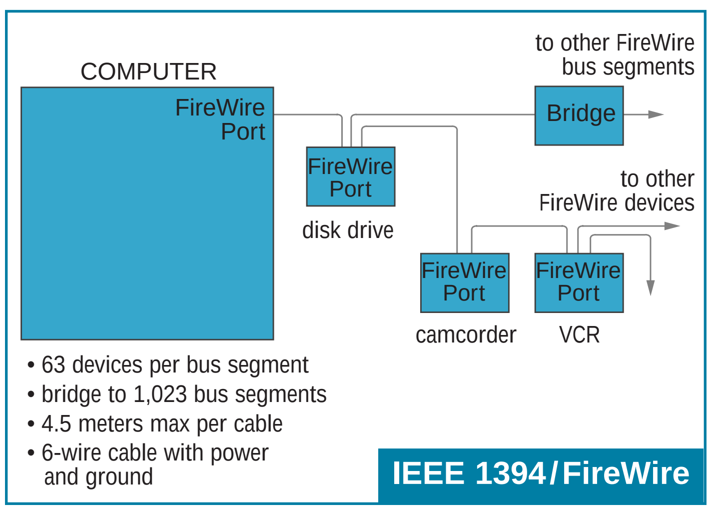
The PC plug & play initiative promoted by Microsoft has provoked extensive work in the computer industry towards standardization. One of the results of this work has been the development of the Universal Serial Bus, or USB.

USB is intended as a clean way to interface low-rate external devices to a PC through a serial bus that can be linked to up to 127 peripherals, providing data rates of up to 12 Mbps. The scheme is backed by Intel, Compaq, DEC, IBM, Microsoft and others, and is available as an open standard without royalty requirements.



The USB can be used to interface keyboards, mice, joysticks, printers, modems, sound systems, scanners, digital still cameras, CD-ROM drives, ISDN hookups, digital phone hookups, and PBX lines to a PC or workstation.

The USB architecture allows these peripheral devices to operate simultaneously. Peripherals can be "hot-plugged" — i.e., added or removed without rebooting the computer. The hardware is cheap, with a gate count of about 10,000 and with much of the control delegated to the host computer.



The connection scheme is a logical daisy chain, but can be connected as a daisy chain or a star (through a hub box), or any combination of the two. Each cable segment can be up to 5 meters in length. The cables have four wires, one pair for signal and one pair for power and ground. The connectors are keyed to prevent them from being plugged-in incorrectly.

In addition to the 12 Mbps data rate, USB supports a 1.5 Mbps data rate to avoid the need for cable shielding with low-cost, low-speed peripherals. The total bandwidth available is adequate to support from 6 to 12 human-input devices without bogging down the link.

5 VDC at 500 milliamps is available over the bus for low-power devices. Hubs can be self-powered, in which case they can distribute 500 milliamps to each of their connections, or unpowered (for instance, a keyboard acting as a hub), sharing 500 milliamps with all their connections. In either case, the hub performs signal regeneration.

Each hub contains control and status registers that the host uses for USB configuration. Using the status register, the host can, at initialization, determine the configuration of the USB and dynamically assign logical addresses to each peripheral. The host polls the USB periodically to see if peripherals have been added or removed, and reconfigures if necessary.

The USB runs under a polled master-slave protocol. In this scheme, the host communicates by first sending a 3-byte token that contains the destination address and the transaction type. For a write-data operation, this token is followed by 1 to 256 data bytes. A CRC checksum is used to ensure data integrity. The peripheral responds with an acknowledgement byte that can also be used to request retransmission, or to control the data flow.

The USB uses a so-called "isochronous" transmission scheme, in which each peripheral is guaranteed a time slot in the 1-millisecond host-scheduling frame. This limits the latency of signals to no more than 1 millisecond, essential for audio and telephone applications that cannot tolerate interruption.

Microsoft has been working with the USB Implementer's Forum to define a set of drivers that will support different classes of USB devices. For example, one class might handle mice, joysticks, pads, tablets and other input devices, while other classes would deal with communications, storage, or imaging devices. USB is now a common feature on new PCs and the hardware needed to support it is becoming readily available. It promises to be universal in the near future.

P1394 FIREWIRE

At the top of the speed spectrum is the P1394 FireWire specification, intended for mass storage, multimedia, and other high-speed applications. Its main driving force has been digital video for camcorders, VCRs, and the like, which require bandwidths of 221 Mbps, a rate far beyond the capability of current interfaces. Like Infrared Link and USB, it is a non-proprietary spec, backed by Apple, Hewlett-Packard, IBM, Microsoft, Sony, Texas Instruments, and others.

The FireWire system is mechanically quite simple. It is a serial interface system featuring a shielded 6-wire cable connection — with two wires for power and ground, and the other four wires as double (individually-shielded) twisted-pair signal lines, one for data and one for clock. Power can be from 8 to 40 VDC at up to 1.5 amps. Maximum cable length is 4.5 meters and it cannot be wired to form loops.

The connector system used was derived from that used on a popular Nintendo game machine. It is durable, inexpensive, and can be plugged in easily by "feel" even when the user can't see the socket. No terminator blocks are needed. Connections can be made in a daisy-chain or tree configuration, with up to 63 devices per "bus segment." Bridge boxes can be used to connect up to 1,023 bus segments to a single controller for a total of 64,449 devices in a system. FireWire supports 64-bit addresses, with six bits allocated to identify a device, 10 bits to identify bus segments, and the remaining 48 bits to address memory or I/O locations in a particular device.

Like USB, the system supports hot plugging which means that devices can be added or deleted without powering down the controller, and the system will automatically adjust itself. As with USB, device addresses are determined dynamically, and there is no need to set address switches.

Data rates supported include 100, 200, 400, and (soon) 800 Mbps. The system is "scalable" in that such different data rates can be mixed on the same bus. Expansions beyond 1 Gbps are being considered, but such extensions are unlikely to be compatible with the current specification and will probably be targeted at different markets.

FireWire supports both asynchronous and isochronous data transfer. In asynchronous mode, frames are sent to specific addresses and acknowledgements are returned. This is useful for short messages, such as control signals. Isochronous transmission blasts frames over the entire bus without addresses or acknowledgements at regular intervals (generally every 125 microseconds), providing "reserved bandwidth” of up to 80% of the FireWire capacity available for video and other multimedia streams.

Advanced features of FireWire include the ability to perform data transfers at high speed without direct controller intervention. The protocols also include commands to control camcorders and VCRs. There is no reason why FireWire has to have a computer in the loop, as it is a “peer-to-peer” system. In principle, it could be just as easily used to link a digital camcorder and a digital VCR, for example (though it appears that some parties involved in FireWire are soft-pedaling this particular claim).

Communications between audio and video devices imply common data and command specs, and so the International Electrical Committee (IEC) is devising, through the IEC SC100C subcommittee, a set of five such standards: one broadly applicable to all multimedia applications; three for digital VCR transmission (to accommodate standard definition, high definition, and standard definition/high compression video); and one to support MPEG compressed video data.

Converters will be available to link existing parallel and serial devices to FireWire. The SCSI-3 disk drive specification envisions using the new interface with SCSI protocols, and FireWire will also be linked into high-speed networking interfaces.

While FireWire devices are only now appearing, the lack of any other competing standard with its capability promises to make FireWire very common in the near future.

APPLICATIONS IN TEST & MEASUREMENT

The rise of these new interfaces should presently begin to replace traditional interfacing schemes in many test and measurement applications. RS-232 has long been a particular problem to deal with, with its loose standardization. IEEE-488, though quite robust and a good solution, has pretty much run out of steam for speed improvements and tends to be a high-cost solution with its hefty cables and connectors.

Once interfaces like USB and FireWire become standard equipment on PCs, buying an additional IEEE-488 interface will become an unnecessary expense. While RS-232 is normally built into a modern PC, it can only connect to a single device, while a USB or FireWire interface can connect to dozens. USB will also be available on portable computers, allowing easy development of portable test and measurement applications.

Most importantly, once PC plug & play technology gets the bugs worked out, the time-consuming and expensive process of trying to install and configure an interface and set up communications with an instrument should be much simpler. LAN/IEEE-488 interfaces have been available for some time. Experience has shown them to be much easier to configure than plug-in cards, and the new interfaces should be easier still to deal with.

Instrument technology tends to be more conservative than PC technology, so current interfacing schemes like IEEE-488 will persist for a long time. USB/IEEE-488 bridges are already available and should become commonplace in data acquisition and test and measurement applications. The new interfaces are already being applied to instrument technology.

Those interested in more details for these specs can find them on the World-Wide Web:

Universal Serial Bus Home Page:
http://www.usb.org/

Infrared Data Association:
http://www.irda.org/

1394 Trade Association:
http://firewire.org/

The Author

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