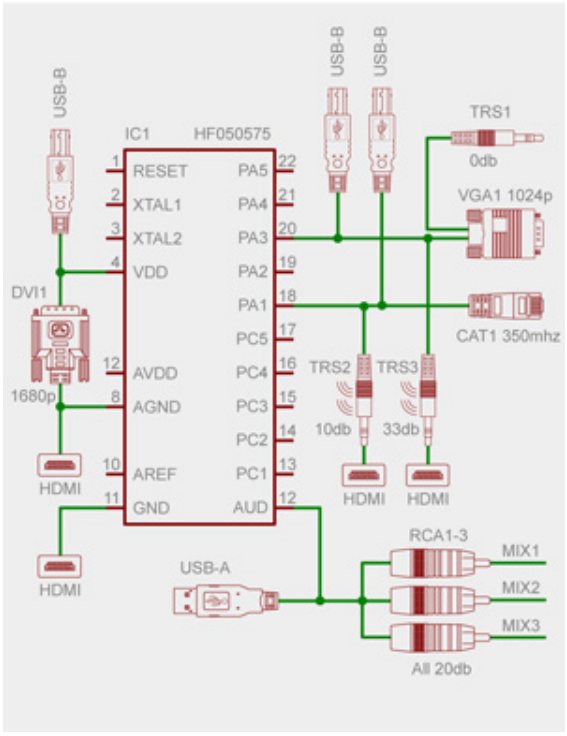
# Make The Right Connection






*You don't need a degree in electrical engineering or be able to read a schematic to make the right connection...*

With all the advances in technology, from the radio age to and beyond the information age, it is quite easy to lose one's bearings when it comes to audio, A/V, data and video interfaces, not to mention the cables that bridge their connections. This month, we will try to make some sense of this signal and connection-type frontier. While this may not be the most cutting-edge technical article topic, we feel that this subject is both important and potentially helpful to many of our customers.

Let us first define that by "interface" we are referring to an agreed upon specification that two or more devices use to communicate with one another. Whether the signal is for computer-to-modem communication or between an iPod and headphones, the fact is that both devices must be compatible with the same interface. For example, both USB 2.0 and FireWire 400 are data transfer signal types. However, these two interfaces are inherently different in the manner the zeros and ones are transferred and thus are incompatible with one another without a converter.

Secondly, we will be using the term "signal type" to encompass a class of interfaces related by their primary function. For example, both VGA (or the more current version SVGA) and DVI are both video signal types. Although the latter may transmit its video through a digital stream of bits, it is not considered in this article as a data signal type due to its primary function of transmitting video.

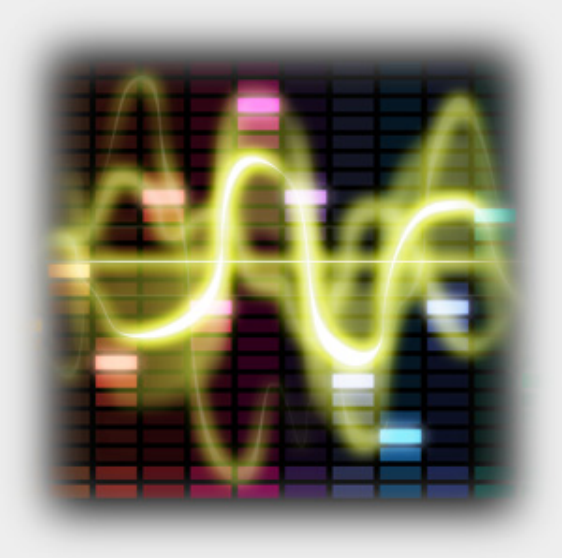
It is paramount that interfaces not be confused with the connectors they use. While some connectors may exclusively be used by one signal (e.g., HDMI), others such as RCA plugs are used by a handful of signal types for both audio and video. As such, terms like an "RCA cable" really have no meaning except to describe the connectors on each end. Instead, users should focus on the interface delivered through the cable and its signal type.

This article is broken down into four sections by signal type: Audio Signals, Audio/Video Signals, Data Signals and Video Signals. In each section, we provide a description of the interface including its history, a pictorial view of the connectors they use, any associated sub-interfaces, bandwidth/data rate information, maximum cable lengths and where the connectors are used. While we feel the tables below represent the majority of common signal types, it is by no means exhaustive and omits some classes such as power cables.

## Audio Signals

An audio signal is used as a representation of sound waves that can be stored, modified or transmitted. Of the four signal types in this article, audio signals are the oldest with electro-magnetically transmitted audio dating back to the late 19th century. Audio signals can take the form of

low-level voltages, magnetic particles, radio waves and even light pulses, with each having advantages and disadvantages. For example, low-level analog voltages can provide huge bandwidth but experience losses from EMI at distances. Optical audio signals on the other hand are inherently immune to EMI but suffer signal degradation with each bend in the cabling.



### Analog vs Digital Audio

In the past, all audio signals were analog and resulted from converting moving air (sound pressure) into positive and negative voltages through the use of a transducer. These signals worked well for recording on magnetic cassettes and records. Unfortunately, analog audio signals are easily corrupted by noise, EMI and other factors such as capacitance and resistance over distances. Additionally, analog audio signals are not instantly accessible and require large amounts of data for storage. Digital audio however does not suffer these setbacks as it can use error correction algorithms, is easily transmitted and can be compressed to require little storage space.

While digital audio has quickly gained ground since the public introduction of Compact Discs in the early 1980s, analog audio is still ever-present, since most audio signals start out analog via transducers in microphones or instrument pickups. Additionally, all audio signals must end as analog too, as a digital signal cannot drive an end device such as a speaker or headphones. These signal conversions between analog and digital and vice versa are made possible by devices called ADCs and DACs respectively.

[Digital Coaxial Audio (S/PDIF)]

| Description | Signal Type | Year Introduce |
|---|---|---|
| S/PDIF (Sony/Philips Digital Interconnect Format) was developed after the creation of the compact disc in order to keep signals transferred from CDs in the digital domain for as long as possible for the preservation of audio quality. This interface uses a 75 Ω shielded cable for signal transmission. An offshoot of this technology is TOSLINK fiber optic cables which transmits the same data through an LED optical light rather than controlled voltages. | Digital audio | Early 198 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| RCA (Phono) | None |  | 3.1 Mb/s | 100 feet | CD & DVI players, PCs, digit audio workstatic |

[Digital Optical Audio (TOSLINK)]

| Description | Signal Type | Year Introduc |
|---|---|---|
| TOSLINK ("TOShiba-LINK") is a digital optical transmission medium originally created by Toshiba in 1983 for connecting their CD players to receivers. Unlike other fiber, the 1 mm core of TOSLINK cables is typically constructed of inexpensive plastics such as Plexiglas. Like other fiber, TOSLINK cables are immune to interference making shielding unnecessary. Additionally, optical audio connections do not suffer from distortion or signal losses from resistance or capacitance unlike copper-based connections. | Digital audio | 1983 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| TOSLINK | None | | 125 Mb/s | 50-150 feet depending on cable bands and | HDTV, stereo systems Surroun |

| | | | | | |
|---|---|---|---|---|---|
| | |  | | transmission strength | Sound receiver |
| 3.5 mm Digital Optical (Mini TOSLINK) | None |  | 125 Mb/s | 50-150 feet depending on cable bands and transmission strength | Apple M computer |

[High-Level Analog Audio]

Description

Unlike low-level analog audio, this signal transmits high-current, low-voltage potentials from power amplifiers to speakers. Cabling for high-level signals should not be shielded due to signal losses from parasitic capacitance, as well as the potential for shorting between the conductor and its shield. High-level analog signals benefit from larger gauge wires to decrease cable resistance. However, there are practical limits to speaker wire thickness, as larger AWG wire has increased skin effect.

| Signal Type | Year Introduced |
|---|---|
| Analog Audio | Late 19th century |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| 1/4" TS | None |  | Varies | 120 feet for 12 AWG at 8 Ω | Guitar amplifie and speaker cabinets, audio patch panels, mixing boards |
| Banana | None |  | Varies | 120 feet for 12 AWG at 8 Ω | Home stereo/theater speaker cabine |
| Spade | None |  | Varies | 120 feet for 12 AWG at 8 Ω | Home stereo/theater speaker cabine |
| Speakon | None |  | Varies | 120 feet for 12 AWG at 8 Ω | Bass guitar amplifiers and speaker cabinets, pro audio amplifier and speaker cabinets |

[Low Level Analog Audio]

Description

Low-level analog audio signals are perhaps the most common audio signal even in the digital age. Although multiple digital transmission methods exist, small voltage-based signals are still required by microphones, headphones and small speakers. This transmission interface is somewhat delicate and needs a well-shielded cable to protect it from EMI which can show up as hiss, static or even captured radio broadcasts alongside the original audio signal.

| Signal Type | Year Introduced |
|---|---|
| Analog Audio | Late 19th century |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| | | | | Typically ≤ 100 feet before degradation | Electric guitars instruments, amplifiers, auc |

| | | | | | |
|---|---|---|---|---|---|
| 1/4" TS | Mono Audio |  | Varies | due to resistance and capacitance | patch panels and mixing boards |
| 3.5mm (1/8") TS | Mono Audio |  | Varies | Typically ≤ 100 feet before degradation due to resistance and capacitance | PC and camcorder microphones |
| RCA (Phono) | Mono Audio |  | Varies | Typically ≤ 100 feet before degradation due to resistance and capacitance | Subwoofer cables, mixing boards, reverb units, audio patch panels |
| XLR | Mono Audio |  | Varies | Typically ≤ 100 feet before degradation due to resistance and capacitance | Microphones, mixers, audio patch panels |
| 1/4" TRS | Stereo Audio |  | Varies | Typically ≤ 100 feet before degradation due to resistance and capacitance | Stereo instruments, audio patch panels, mixing boards |
| 3.5mm (1/8") TRS | Stereo Audio |  | Varies | Typically ≤ 100 feet before degradation due to resistance and capacitance | iPods, CD players, smart phones, mp3 players, nearly all handheld audio devices |
| RCA (Phono) | Stereo Audio |  | Varies | Typically ≤ 100 feet before degradation due to resistance and capacitance | DVD & CD players, TVs, nearly all audi equipment |

### Audio/Video Signals

Audio/video interfaces are a cable-based signal type that has become very popular within the last decade in consumer electronics. Driven by the public's hunger for larger, higher definition televisions and more complex surround-sound systems, digital technologies with high bandwidth and future scalability were needed.

### DisplayPort and HDMI

Coming quickly into its own in the mainstream market for display and sound interconnects is the audio/video cable. There are two primary contenders in this arena: the DisplayPort created by VESA (Video Electronics Standards Association) and the HDMI (High Definition Media Interface). The list of similarities between these two cables is quite long. For example, both cables offer multi-channel digital sound for 5.1-7.1 surround sound setup. They both are capable of delivering extremely high data transfer speeds, with HDMI claiming 10.2 Gb/s and Display Port claiming 17.2 Gb/s. Both cables can deliver stereoscopic 3D for your 3D Blu-ray or sporting events as well as providing digital copy protection. Although these specs seem very similar there are applications where one is better than the other. For instance for a

computer, the DisplayPort features a uniquely scalable bi-directional auxiliary channel. Thus, future implementations of the spec can be scaled upwards to support the signals of a monitor's embedded microphone, USB hub, webcam, etc.-over the same, single cable that carries your video signal. HDMI has also made its mark on digital cameras to transfer images via a HDMI/Mini HDMI cable to your TV, and just recently we have seen a flux of cell phones adopting the micro HDMI to stream content right from their phones onto a big screen. So while both are very similar they both serve distinct roles.

## DisplayPort

| Description | Signal Type | Year Introduc |
|---|---|---|
| DisplayPort is a connection that is primarily intended as a computer audio/video solution. It carries HD video resolutions up to 2560x1600 with 10-bit color along with optional surround sound audio. The PC industry is embracing DisplayPort technology as well because this single digital interface can connect both internal and external displays. DisplayPort can directly drive display panels eliminating certain control circuitry allowing for cheaper and slimmer displays. For more information on DisplayPort read our November 2009 technical article. | Digital Audio/Video | 2008 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| DisplayPort | None |  | 17.28 Gb/s Video, 24 bit @ 192 kHz Audio | 50 feet | Dell desktop compute PCs |
| Mini DisplayPort | None |  | 17.28 Gb/s Video, 24 bit @ 192 kHz Audio | 50 feet | Apple M compute and displays |

## HDMI

| Description | Signal Type | Year Introduce |
|---|---|---|
| HDMI (High-Definition Multimedia Interface) is the most popular digital audio/video interface on the market today. If you have bought a major consumer electronic device in the last few years, chances are, it has an HDMI port. HDMI supports uncompressed video including: standard, enhanced and high definition, HDCP, 8 channel audio and a CEC connection. Newer HDMI cables also support stereoscopic 3D technologies as well as incorporating a twisted-pair Ethernet cable for connecting devices to the Web. HDMI video signals are fully compatible with single-link DVI-D signals. | Digital Audio/Video | 2003 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| HDMI (Type A) | None |  | 4k x 2k video resolution, 10.2 Gb/s Video, 24 bit @ 192 kHz Audio | 28 AWG: 15 feet 24 AWG: 50 feet | Blu-ray players, HDTVs, PCs, laptops, cable boxes, direct TV boxes |
| Mini HDMI (Type C) | None |  | 4k x 2k video resolution, 10.2 Gb/s Video, 24 bit @ 192 kHz Audio | 28 AWG: 15 feet 24 AWG: 50 feet | Digital camcorde |

| | | | | | |
|---|---|---|---|---|---|
| Micro HDMI (Type C) | None |  | 4k x 2k video resolution, 10.2 Gb/s Video, 24 bit @ 192 kHz Audio | 28 AWG: 15 feet<br>24 AWG: 50 feet | Smart phones |

### Data Signals

Data signal types originated in the early 20th century with the use of teletypewriters which allowed data signals to be digitally encoded, transmitted and decoded over long distances. As the 20th century progressed and computers evolved from government- and research-only, building-sized monstrosities to office based equipment, digital data signals evolved too into two separate categories: signals for communication with peripheral equipment via parallel ports and serial ports and signals for communication with other computers via a network.

### Communication with Peripherals

Data communication between computers and peripherals has historically been through copper-based cabling but is increasingly becoming wireless through protocols such as Bluetooth, WiFi and Wireless USB. It is common for new cable types to be released with the introduction of new interface types as well as iterations of data types (e.g., USB 2.0 and 3.0). While the cycle of buying new equipment requiring buying new cables to connect it may never end, peripheral cables are usually inexpensive compared to network cabling.

### Communication over Networks

Unlike peripheral communication, network communication typically must rely on existing communication links whether they be older twisted pair copper-based, coaxial cables, newer fiber optics or even wireless transmission methods. As adding or modifying existing infrastructure is expensive, changes in data communications often involve changing the protocol for sending and receiving binary information rather than changing the hardware in between. Furthermore, network communication is unique is that the distances involved might nearly infinite but still attainable as in the case of computer to computer communication through the world wide web. In this article, we focused only on data communications via Ethernet signals as they are the most commonly used by consumers. Fiber optic data transmission was intentionally left off as the topic was covered in depth in last month's technical article which can be found here: Fiber Optics An Overview.

## Bi-Directional Parallel IEEE 1284

| Description | Signal Type | Year Introduc |
|---|---|---|
| IEEE 1284 is an interface designed as a low-cost replacement for SCSI and preceded the development of USB. IEEE 1284 enables bi-directional parallel communications (without the need for an expensive card) between computers and other peripherals such as printers, scanners and external hard disks. This interface remains in use in non-consumer legacy equipment such as plotter printers. | Parallel Data | 1994 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| DB25 | None |  | 4 MB/s | 32 feet | PCs |
| Centronics 36 (CN36) | None | | 4 MB/s | 32 feet | Printers scanner tape drives |

| | | | | | |
|---|---|---|---|---|---|
| Mini Centronics 36 (HPCN36) | None |  | 4 MB/s | 32 feet | Printers |

## Ethernet

| Description | Signal Type | Year Introduc |
|---|---|---|
| Unlike many other interfaces found in this article, Ethernet signals actually encompass a family of signals known as IEEE 802.3 for networking computers through a LAN. Ethernet signals are typically carried through twisted-pair copper-based Cat type cables within buildings which are supported by a fiber optic based backbone to and within a campus setting. The Ethernet protocol is among many other famous computer technologies developed at Xerox PARC [Factoid: Xerox PARC is responsible for developing: computer bitmap graphics, the laser printer and the GUI originally implemented in the first generation Apple Macintosh computers. Impressive resume indeed.]. | Data | 1972 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| RJ45 | Cat 5e |  | 100 MHz | 300 feet | Offices, homes, every P made since th mid 1990s. |
| RJ45 | Cat 6 |  | 250 MHz | 300 feet | Offices, homes, PCs. |

## FireWire IEEE 1394

| Description | Signal Type | Year Introduc |
|---|---|---|
| Developed by Apple Computer in the early 1990s, FireWire is a serial bus interface standard for high-speed communications and isochronous real-time data transfer. It can connect up to 63 peripherals in a tree chain topology as well as allow peer-to-peer communication between devices. FireWire is a competing technology with USB for data transfer to and from computers and peripherals. Although considered by many superior to USB due to higher speed and supporting multiple hosts per bus, FireWire has never garnered significant market share. Even today this interface remains specialized to Mac computers and digital camcorders. Although a new generation FireWire 3200 does exist, we are not aware of any products using this interface. The rise of USB 3.0 or Intel's Light Peak may prove to be FireWire's death knell. | Serial Data | 1995 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| FireWire 400 (4 pin) | FireWire 400 (IEEE 1394A) |  | 400 Mb/s | 15 feet | External hard drives |
| | | | | | External |

| | | | | | |
|---|---|---|---|---|---|
| FireWire 400 (6 pin) | FireWire 400 (IEEE 1394A) |  | 400 Mb/s | 15 feet | hard drives |
| FireWire 800 (9 pin) | FireWire 800 (IEEE 1394B) | | 800 Mb/s | 15 feet | New Apı Mac compute |

## MIDI

Description

MIDI (Musical Instrument Digital Interface), is an interface that allows electronic instruments such as keyboards, synthesizers, computers and even specialized stringed instruments to control, communicate and synchronize with one another. For example, one musical keyboard can be used as a controller for multiple banks of synthesizers and samplers. MIDI is notable in that it does not transmit any audio signal, it is up to the controlled instrument to output its own audio. Instead, MIDI transmits event data such as pitch, intensity, volume, vibrato and clock signals. MIDI has been the de facto interface for musical instruments since its inception in the early 1980s.

| Signal Type | Year Introduced |
|---|---|
| Serial Data | 1983 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| DIN5 | None |  | 3 kB/s | 50 feet | Musical keyboards digital aud workstatio some PC sound car |

## Serial RS-232

Description

RS-232 is the standard for serial binary single-ended data and control signals and is commonly used in computer serial ports. RS-232 is a legacy data interface that has been replaced by USB technology. However, like its faster sibling the parallel port, serial ports are still found on the multitudes of older PCs employed by businesses and entities worldwide.

| Signal Type | Year Introduc |
|---|---|
| Serial Data | 1962 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| DB9 | None |  | 115 kb/s | 50 feet | PCs, old joysticks modems printers |
| DB25 | None |  | 115 kb/s | 50 feet | PCs, old joysticks modems printers |

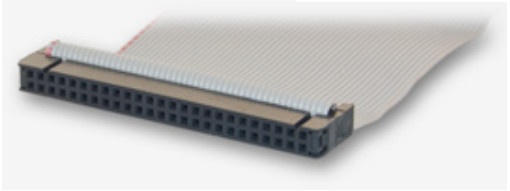
## SCSI

Description

SCSI is a data interface for connecting PCs to peripheral devices such as internal/external hard disks, internal/external optical drives and scanners. This interface along with its successors FireWire and SATA

| Signal Type | Year Introduc |
|---|---|
| Parallel | |

allow daisy chaining of devices. For SCSI, the maximum number of daisy chained devices is 16. As of 2010, SCSI is a legacy interface due to newer, faster protocols. Other factors that have led to SCSI's replacement are a limited BIOS support as well as unusually large number of different connectors and cables for one interface family.

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| Centronics 50 (CN50) | SCSI II (Fast SCSI) |  | 80 Mb/s | 75 feet | |
| HPDB68 External | SCSI III (Ultra-640) |  | 5.12 Gb/s | 40 feet | |
| IDC 50 | SCSI III (Ultra2) |  | 320 Mb/s | 75 feet | |
| HPDB68 Internal | SCSI III (Ultra-640) |  | 5.12 Gb/s | 40 feet | |

SATA (Serial Advanced Technology Attachment)

| Description | Signal Type | Year Introduc |
|---|---|---|
| SATA is a bus-based interface used to connect PCs to both internal and external storage devices like hard disks and optical drives. SATA has replaced PATA (also known as IDE or EIDE) within newer PCs as it is optimized for a faster system architectures. While PATA is limited to only 18 inch lengths, SATA cables allow for 33 inch maximum lengths. The smaller SATA cable with only 7 pins allows for better airflow within the congested confines of a PC case than its 40 connection predecessor. Additionally, SATA requires only 250 mV to operate as opposed to 5 V for PATA which is optimal for the latest generation of CPU cores which run on lower voltages than ever before. | Serial Data Transfer | 2003 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| eSATA | |  | 3 Gb/s | 6 feet | PCs, external hard dis |
| SATA | None |  | 3 Gb/s | 1.5 feet | PCs, internal hard dis |

USB

Description

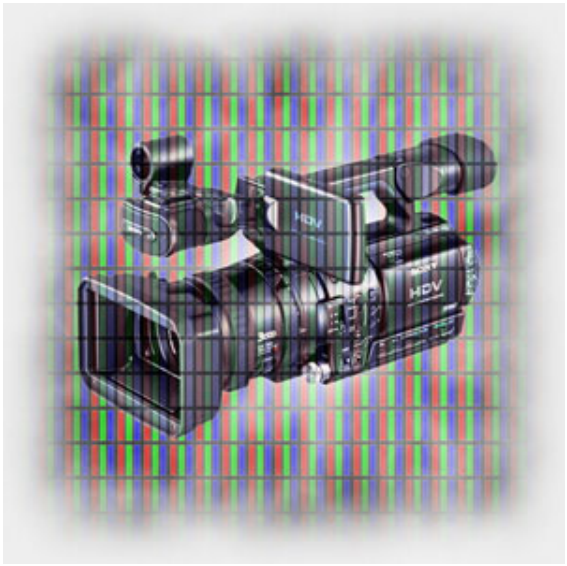
It's hard to believe but USB (Universal Serial Bus) 2.0, the ubiquitous peripheral interface for all things PC, is over ten years old. Since its inception in April 2000, USB 2.0 has been the connector for over 10 billion peripherals such as mice, keyboards, digital cameras, printers, external hard drives, etc. As impressive as these numbers are, USB has been in need of an update for some time now to keep up with increasingly sophisticated devices and their high data transfer demands. The newer version, USB 3.0, is just starting to populate devices as of 2010.

| Signal Type | Year Introduce |
|---|---|
| Serial Data Transfer | 1996 |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| USB Type A | USB 2.0 |  | 480 Mb/s | 15 feet | Nearly every PC since the late 199( |
| USB Type B | USB 2.0 |  | 480 Mb/s | 15 feet | External hard disk printers, scanners peripher |
| USB Micro B | USB 2.0 |  | 480 Mb/s | 15 feet | Digital cameras mobile phones, MP3 players |
| USB Mini B | USB 2.0 |  | 480 Mb/s | 15 feet | Digital cameras mobile phones |
| USB Mini B (4 pin) | |  | 480 Mb/s | 15 feet | Digital cameras |
| USB 3.0 Type A | USB 3.0 |  | 4 Gb/s | 10 feet | PCs |
| USB 3.0 Type B | USB 3.0 |  | 4 Gb/s | 10 feet | Printers, external hard disk |
| USB 3.0 Micro B | USB 3.0 | | 4 Gb/s | 10 feet | Smart |

phones

### Video Signals



Video signals are similar to audio signals in their means of transmission as well as historical progression from analog to digital. However, the information contained in video signals is far more complex. Video signals, whether analog or digital must contain information on frame rates, scanning, color depth and saturation, brightness, etc. As such, video as a whole requires greater bandwidth than audio signals. The cabling used to support different video types have reflected the resolution capacity of both the image-generating camera and the display type at the time. For example, advanced high resolution cables such as DVI would be useless with the adequate hardware to support them.

### Analog vs Video Redux

Just as in audio, video too made the transition to the digital realm in the 1980s. It was not until after the year 2000 however, that digital video in the United States was in widespread use with the rise of DVDs and digital cable television. Digital video is necessitated by HDCP and efficient transmission. However, modern analog video is not without its merits too. Most consumers are unaware just how high of resolution can be transmitted by the VGA video signal family with QSXGA rivalling even DVI for supported resolutions. Furthermore, analog video as a whole can be transmitted greater distances than their digital counterparts before signal degradation renders the picture useless.

[Component Video](#)

| Description | Signal Type | Year Introduc |
|---|---|---|
| Component video, otherwise known as YPBPR is a high quality analog video interface that superseded both composite and s-video signals. This signal type separates video into three components: Y that carries luma (brightness) and sync information; PB that carries the difference between blue and luma (B - Y) and PR that carries the difference between red and luma (R - Y). Interestingly, the green component of the RGB signal is not included due to redundancy; the green color information is easily derived from the luma, red and blue signals. | Analog Video | 1990s |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| RCA (Phono) | None |  | 1080i video resolution | Typically ≤ 100 feet | HDTVs, cable boxes, Blu-ray and DVI players |

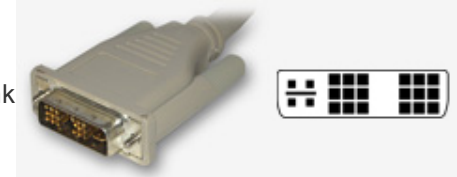
[Composite Video](#)

| Description | Signal Type | Year Introduce |
|---|---|---|
| Composite video signal is sent through a single carrier unlike its successors. This video interface derives its name from being the composite of three distinct signals with the abbreviations: Y, U and V. The Y carries the luminance (brightness) of the picture as well as synchronizing pulses [Factoid: The Y signal displayed alone would form a monochrome picture]. The U and V signals carry the color information: U is the color hue information and the V is the chrominance (saturation). | Analog Video | 1980s |

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| RCA (Phono) | None | | 480i video resolution | Typically ≤ 100 | TVs, DVI players, game |

| | | | | | |
|---|---|---|---|---|---|
| | |  | | feet | consoles VCRs, camcorde |

DVI

| Description | | | | Signal Type | Year Introduc |
|---|---|---|---|---|---|
| DVI (Digital Visual Interface) is a video interface designed to replace the older VGA analog family of interfaces. DVI is optimized for delivering high resolution images to larger LCD flat panel displays through its uncompressed digital data stream. DVI comes in three standard types: DVI-D (Digital), DVI-A (Analog) and DVI-I (Integrated digital and analog). DVI-D allows for forwards compatibility with HDMI video (but not audio since DVI is video only, not A/V). DVI-A allows for full backwards compatibility with the VGA family of signals (SVGA and below). DVI-I allows for compatibility with both HDMI and VGA. | | | | Digital Video | 1999 |
| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
| DVI-D Single Link | DVI-D Single Link |  | 3.96 Gb/s | 50 feet | HDTVs, PCs |
| DVI-D Dual Link | DVI-D Dual Link |  | 7.92 Gb/s | 50 feet | HDTVs, PCS |
| DVI-I Single Link | DVI-I Single Link |  | 3.96 Gb/s | 50 feet | PCs |
| DVI-I Dual Link | DVI-I Dual Link |  | 7.92 Gb/s | 50 feet | PCs, Ma Pros, Ma Minis |
| Mini DVI (DVI-I Single Link) | DVI-I Single Link |  | 3.96 Gb/s | 50 feet | Mac laptops |

S-Video

| Description | | | | Signal Type | Year Introduc |
|---|---|---|---|---|---|
| Introduced by JVC in 1987, S-video remained an unused video interface until the late 1990s when it became adopted by many big screen televisions and even a number of PC graphics cards. S-video is similar to composite video but splits the video into two synchronized signal and ground pairs: luminance (black and white information) and chrominance (color information). This amounts to a higher quality picture, especially in rendering sharp text, than possible with composite video and eliminates dot crawl. S-video has been superseded by the high quality analog component video which further separates the video signal into three | | | | Analog Video | 1987 |

component pairs.

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| Mini DIN 4 | None |  | 480i | 100 feet | TVs, DV players, projecto and gan console |

VGA

Description

| Signal Type | Year Introduc |
|---|---|
| Analog Video | 1987 |

VGA (Video Graphics Array) is used to reference a family of signals whose supported resolutions vary greatly from the first VGA (640 x 480 dpi) up to QSXGA (2560 x 2048 dpi). Most devices which are labeled as using VGA are actually designed for the SVGA (Super VGA) family of signals which allow for resolutions of up to 1080i. Although VGA signals have been superseded by both DVI and HDMI within the past five years, this signal technology still has a firm foothold in the PC and projector community.

| Connector Type | Sub-Interface | Connector Picture | Max Bandwidth or Data Rate | Max Cable Length | Found Where |
|---|---|---|---|---|---|
| HD15 | Many |  | Varies | Up to 100 feet | PCs, projecto HDTVs |

**Silly Questions You Were Afraid To Ask**

Q: I have a USB port in my car. Can I connect my laptop to it to access data or to charge it?

A: Unfortunately no. The USB Type A port in your car serves two purposes: to charge small devices like iPods and mobile phones and to allow the stereo to use mp3 files from flash drives. A laptop requires far more current to charge than a USB port can deliver.

Q: I have a USB hard drive but I want to connect it to my much faster FireWire connection on my computer. Where do I find a USB to FireWire cable at?

A: There are two things wrong with this idea: First, FireWire and USB are two entirely different protocols. USB can speak only when spoken to by the host while FireWire can freely communicate with any device on the network. Secondly, even if FireWire to USB was possible it would be as fast as your slowest link, which in this case is the USB device.

Q: I found a cable that has VGA on one end and Component RCA on the other but this does not work to connect my computer to my TV. Why?

A: This also comes down to the two different interface types. The computer outputs a RGB (SVGA) signal to decode video, while the TV is looking for a Y, Pb, Pr signal. Although they are essentially both red, green, blue, the TV looks to the luma/sync (Y) green RCA connection to provide the vertical and horizontal sync of the picture. The VGA connection uses pins 13 and 14 for this and thus cannot be directly mapped to component video without a conversion box.

**Terms and Definitions**


**Analog to Digital Converter (ADC):** An electronic device that converts an input analog voltage (or current) to a digital number proportional to the magnitude of the voltage or current.

**American Wire Gauge (AWG):** A standardized wire gauge system used since 1857 predominantly in the United States for the diameters of round, solid, nonferrous, electrically conducting wire.

**Consumer Electronics Control (CEC):** A one-wire bidirectional serial bus that allows users to command and control multiple CEC-enabled boxes with one remote control.

**Digital to Analog Converter (DAC):** An electronic device that converts a digital data (binary code) to an analog signal consisting of fluctuating current or voltage.

**Dot crawl:** A color analog video defect found in composite video signals consisting of checkerboard patterns appearing along vertical color transitions.

**Electro Magnetic Interference (EMI):** An electromagnetic disturbance that degrades or limits the effective performance of electronic or electrical equipment.

**Graphical User Interface (GUI):** A computer user interface item that allows users to interact with images rather than text commands.

**High-bandwidth Digital Content Protection (HDCP):** A digital copy protection protocol developed by Intel to prevent copying of digital audio and video content as it travels across DisplayPort, DVI and HDMI cables among others.

**Institute of Electrical and Electronics Engineers (IEEE):** An international organization for the advancement of technology that sets global standards in a broad range of industries, including: power and energy, information technology, telecommunications, nanotechnology and others.

**Line level:** The strength of an audio signal used to transmit analog sound between audio components such as CD and DVD players, TVs, audio amplifiers, and mixing consoles, and sometimes MP3 players.

**Local Area Network (LAN):** A computer network which covers a small area such as a home, office or small campus.

**Peripheral:** An electronic device such as a printer, scanner, digital camera, etc, that is attached to and usually dependent upon a host computer. Peripherals expand a computer's capabilities but are not considered part of its architecture.

**Ohm (Ω):** A resistance between two points of a conductor when a constant potential difference of 1 volt, applied to these points, produces in the conductor a current of 1 ampere.

**Red Green Blue (RGB) color model:** An additive color model where red, green, and blue light are added together to reproduce a broad spectrum of colors.

**Skin effect:** The tendency of an alternating current (AC) to flow near the surface of the conductor causing the effective resistance of the conductor to increase with frequency.

**Sound wave:** An oscillation of pressure transmitted through a solid, liquid, or gas, composed of frequencies within the range of hearing (12 Hz - 20 kHz) and of a level sufficiently strong to be heard, or the sensation stimulated in organs of hearing by such vibrations.