Video for Audio Engineers

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1.   Introduction

The purpose of this seminar is to give a practical introduction to the use of both analogue and digital video. It's not intended as an in-depth technical appraisal but more biased towards the practicalities of using video to enhance or augment audio. Its regrettable that all to often a video presentation is let down by poor quality sound, so perhaps with a professional audio engineer in charge, this situation can change.

Lets start at the beginning, with that I mean the most basic of analogue video signals you will encounter. My apologies if this appears very basic to some of you, but a brief resume of analogue video will help the migration to digital later.

2.   Composite Video

The most basic video signal is of course Composite Video; also know as CVBS (Composite Video Blanking Sync). It's normally a single unbalanced signal designed for a single point-to-point connection, rather like the original audio circuits used using impedance matching for reliability.
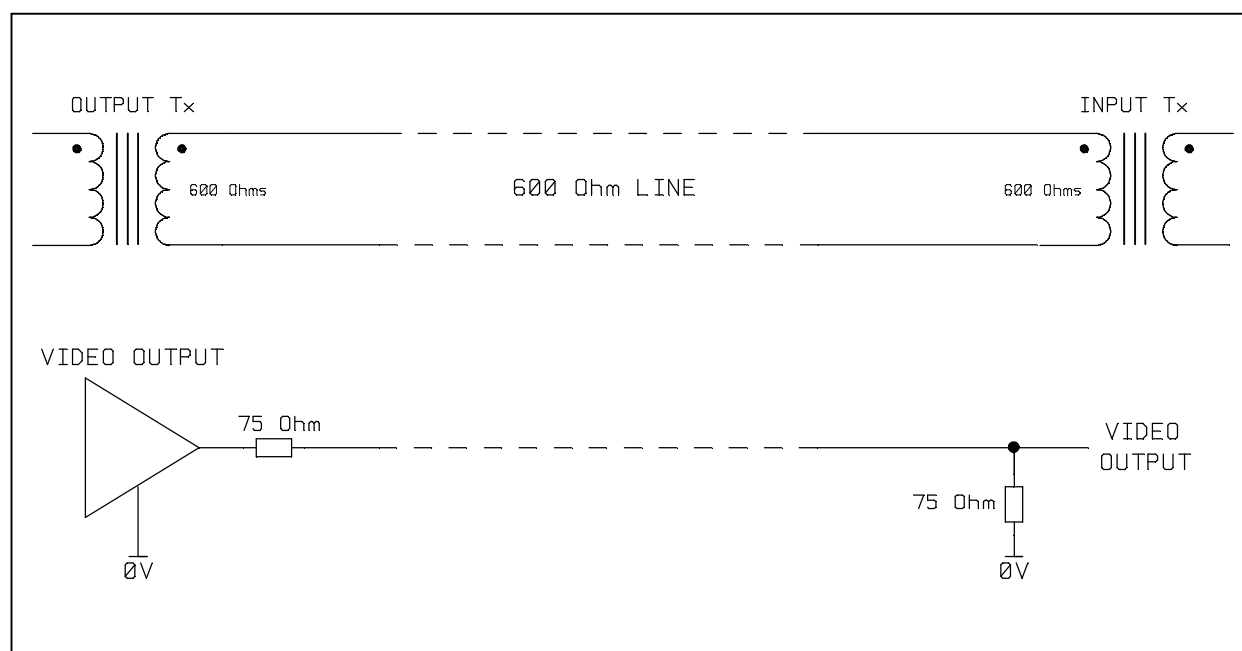
Other than being an unbalanced signal, not a lot different, except for the frequency. Whilst with audio we are typically dealing with a frequency range of 20Hz to 20KHz, more or less, with composite video the frequency is more in the order of 5.5MHz and creates a greater need for due diligence in connection and termination.

2.1 Correct termination

With all video signals it is important to have the correct termination at the receiver (usually a display of some type). Whilst with audio, a lack of correct termination results in a higher level than can usually be easily reduced; with video it is not as easy and can have undesirable results. Similarly you should not connect two receivers directly to one output.

| *NO Termination* | *Correct Termination* | *Double Termination* |

Traditionally composite video is carried by BNC connectors (BNC standing for Bayonet Neill-Concelman, after its inventers).
But as consumerism took its toll we have seen the wide adoption of what we know as the Phono connector (also known as RCA & Clinch) used for video, but in a cheery yellow to differentiate it from the audio

BNC SOCKET

BNC PLUG

**PHONO PLUG**

PHONO SOCKET

At least with the Phono connector its co-axial so there is some attempt to retain the signal and screening integrity.

There is another common connector used for composite video and that the SCART connector, I will come onto this shortly.

We haven't enough time to delve into the intricacies of the video waveform and significance of the characteristic impedance, but for those of you who want to know, have a look at the material contained in the references.

What we do need to know at this stage is that the signal level we can anticipate, or to be more pedantic, that we need is 1V p-p.
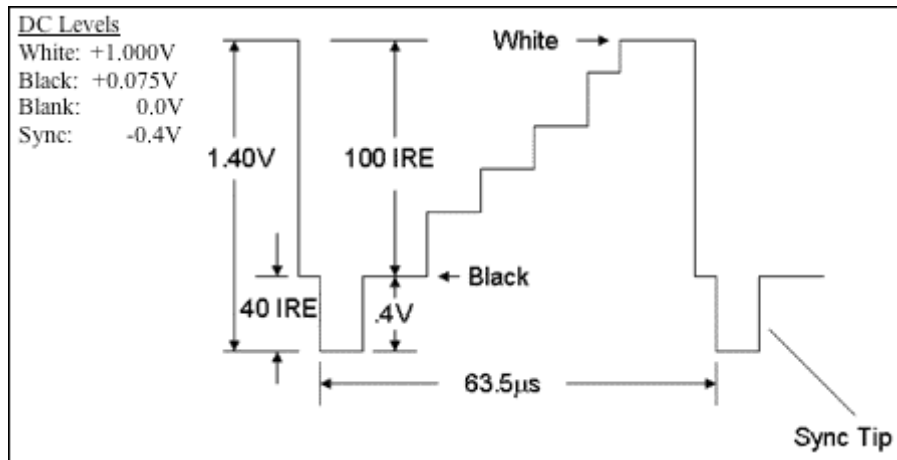

And the standard working impendence is 75 ohms.

If we look at a simple video transmission circuit:-
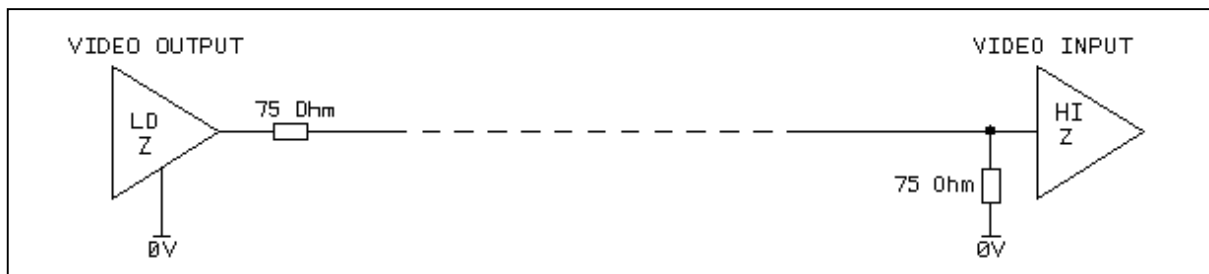
It should be obvious that to achieve a 1Vp-p at the destination, we need a 2V p-p signal to start with. This does though have an advantage if we want to split the signal. In its simplest form we need just two additional resistors to achieve a 3 way Video D/A provide the drive circuit is capable of the current required.
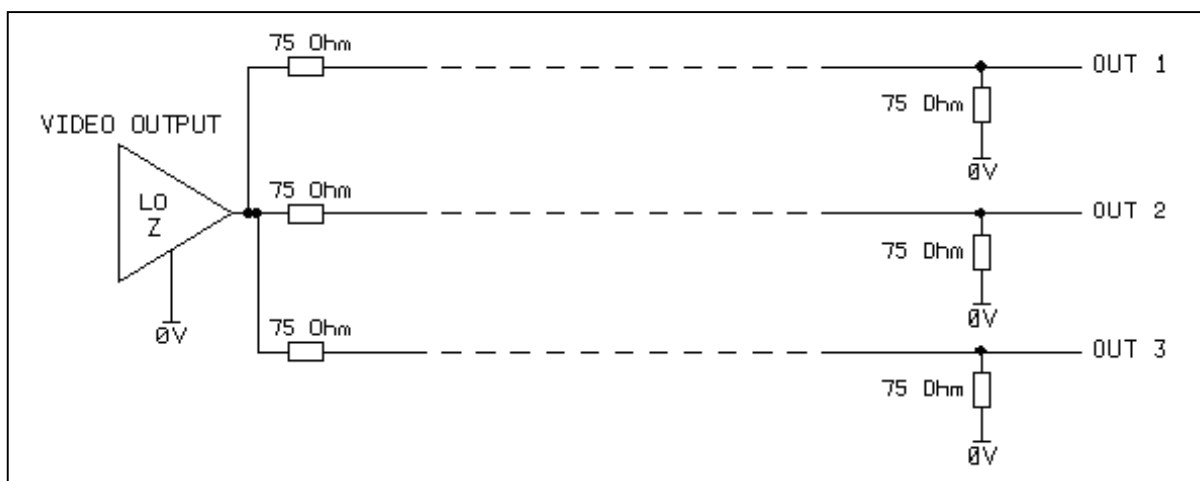
Please remember that this is a simplification and takes no account of DC offsets, colour correction and similar refinements.

3.   *S-Video*

With all the information of sync, picture and colour embedded into one signal there is a need for separate processing to extract the information. A better solution is to split the information into two signals, one carrying the picture information and sync and another carrying the colour information. So was born Separate Video, commonly referred to as S-Video and also known as Y/C. Here the rules regarding termination are the same as composite video, even though the signals levels between Y and C differ.
The most common connector is a 4 pin din plug although it's often preferred to use a breakout adapter to two BNC connectors for durability. Using separate cables with BNC's is also a good way of providing a quick and easy swap of Y and C if the 4 pin plug has been incorrectly wired (was it the plug or socket diagram I was looking at when I wired these 5 Connectors?)
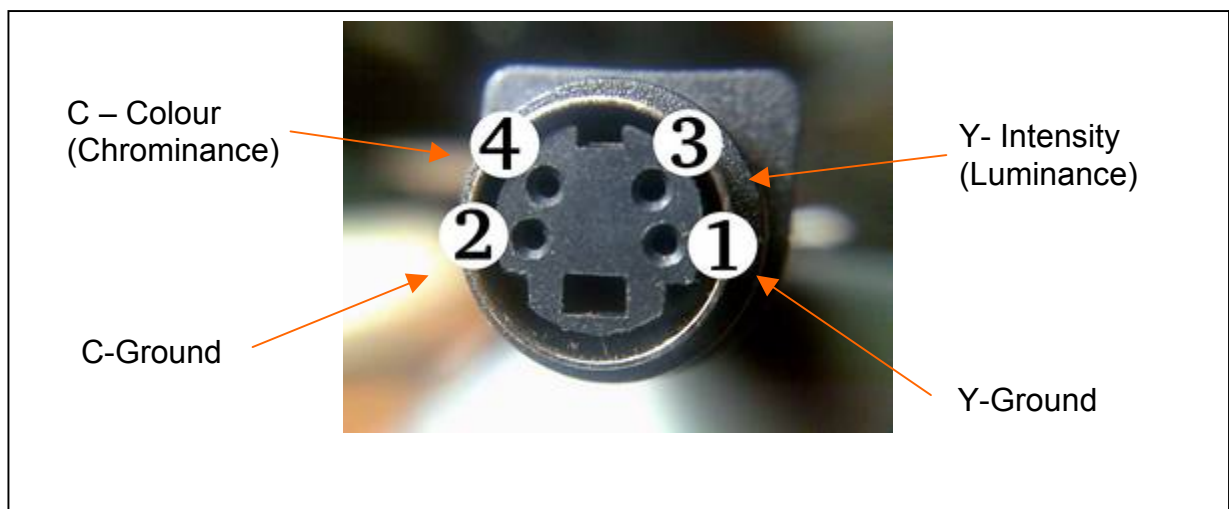
S-Video was introduced in the late 1980's in an attempt to offer high quality video recording as S-VHS. It lost popularity in the late 90's but having a resurgence in the 2000's when home cinema became popular and it provided a better quality image. It's now largely usurped by digital formats.

Before moving on it's worth saying that you can use the Y section on its own to provide a monochrome image. You can also convert from S-Video to Composite video using a simple passive circuits:-
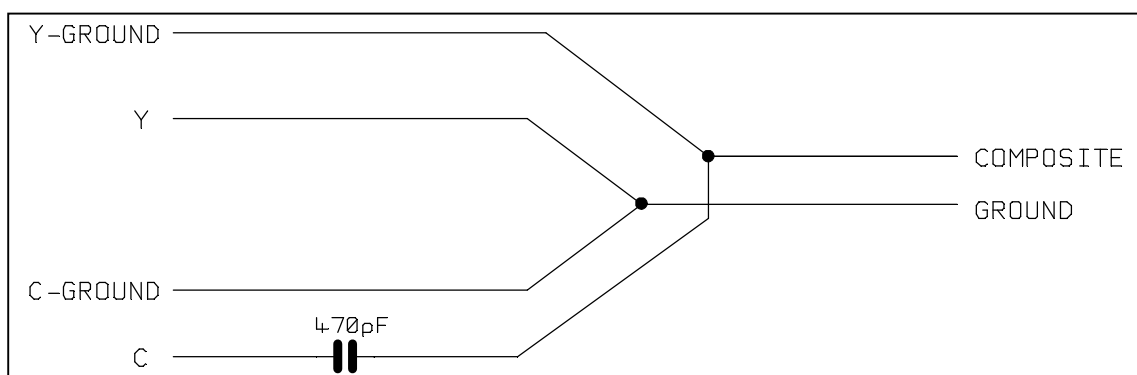
Whilst this can be used in the reverse form to split composite to Y/C, the resultant signal is of very poor quality so it is always best to use an active converter if this is required.

4.   RGB and Component

A three signal solution offers a higher quality of signal, after all we have three times the bandwidth available.

It's easy to confuse between RGB and component video often also referred to as YUV, but they are very different and incompatible formats. RGB is the simplest where the individual colours are carried by separate circuits. The sync is often added to the Green signal.
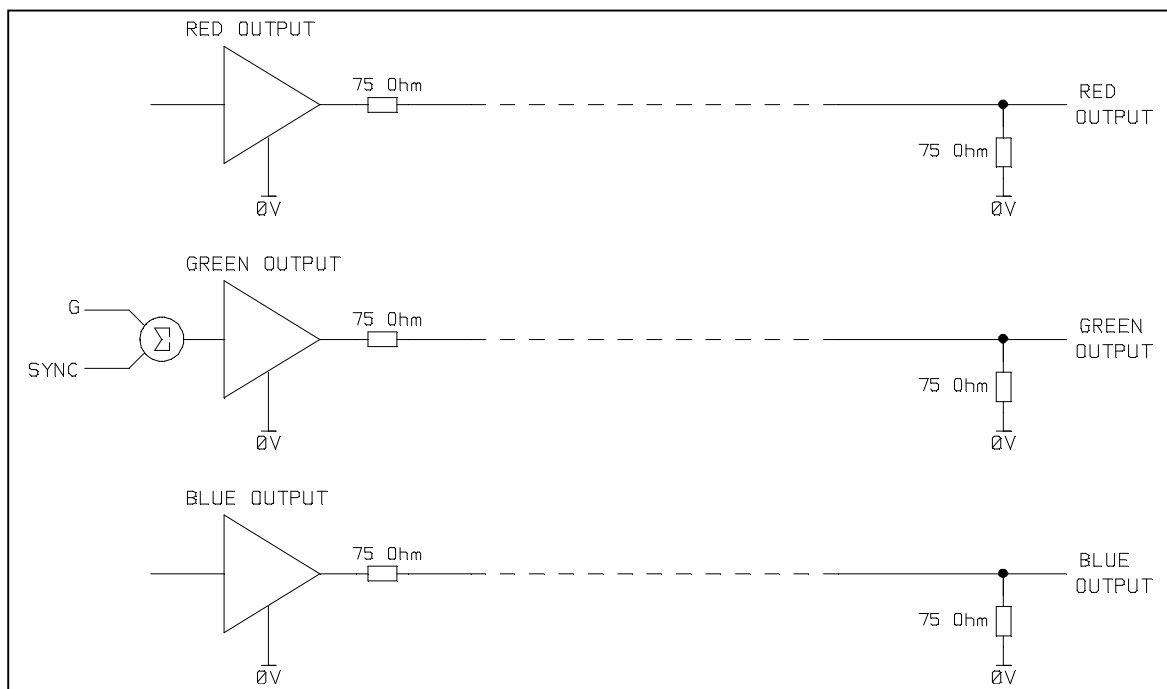
The problem with RGB is that it does use a lot of bandwidth; a better solution is to convert to component video.

Component video is a very different proposition, it consists of three components incorrectly refer to as YUV.

Y   Luminance indicating Brightness, Contrast and picture information

U   Normally labelled Pb, Cb or B-Y. This is first of the 'colour difference' signal and indicated how much blue is in the signal (B-Y).

V   Normally labelled Pr, Cr or R-Y. This is the second 'colour difference' signal and indicated how much red is in the signal (R-Y).

The colour difference signals are mathematically derived from the RGB signal. Green doesn't need to be transmitted, as the display knows how bright the image is from the

'Y' component, and since it knows how much Blue and Red there is, the rest must be Green.

With component video can reduce the required bandwidth by a factor or 3 to 2 over RGB allowing the scope for high definition video to be transmitted.
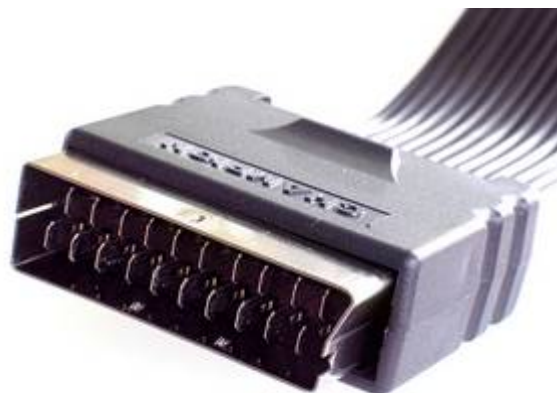
With component video the same rules regarding connecting, terminating and distribution apply as with composite video. From a connection aspect you can normally determine the format from the colour of the connectors provided, although they should be labelled. Whilst BNC's are preferable it is almost universal that Phono sockets are provide on source equipment and monitors. For projectors, component video can often be on the second VGA connector using a 15 pin D socket.
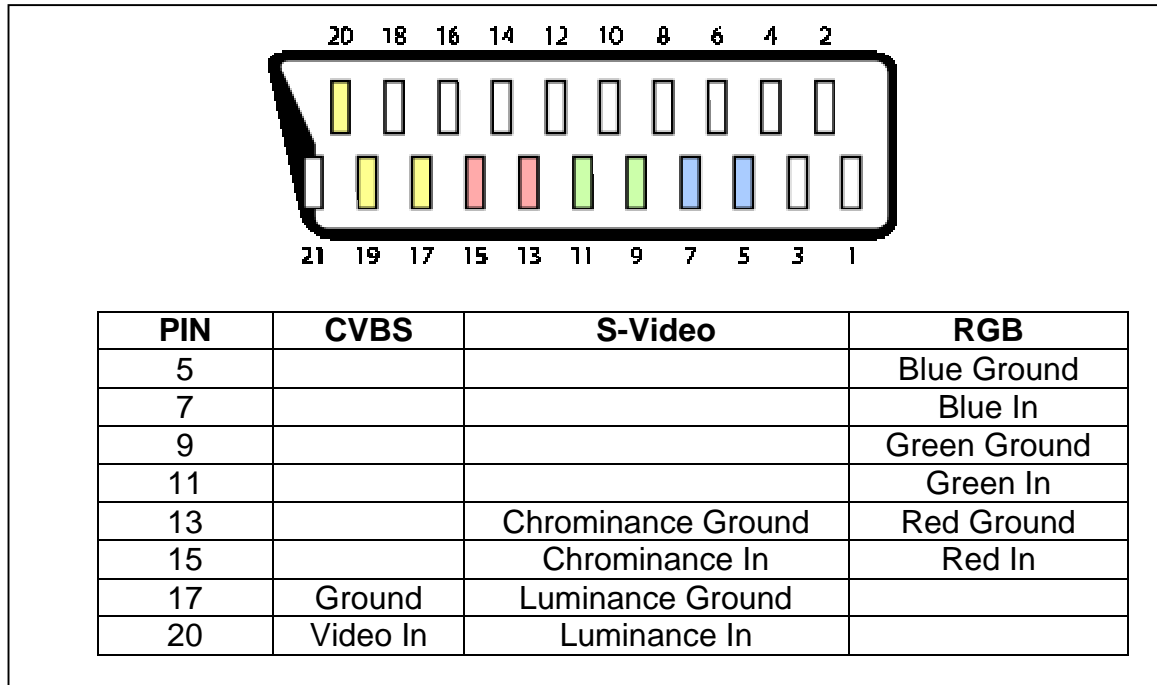

5.   SCART

This is probably a good point to have a brief look at the SCART connector common on TV sets, Video recorder and other analogue video equipment.

There are two types in common use, both identical in format but differing in use. One is intended for the connection to a display whilst the other if for an external decoder or additional player.

From a purely video aspect, the formal allows for;

PIN	CVBS	S-Video	RGB
5			Blue Ground
7			Blue In
9			Green Ground
11			Green In
13		Chrominance Ground	Red Ground
15		Chrominance In	Red In
17	Ground	Luminance Ground	
20	Video In	Luminance In	

Not all equipment with a SCART socket supports all these options so you do need to verify this before use if you need either S-Video or RGB.

Simple SCART to Composite and S-Video converters are available and almost exclusively use Phono sockets for Composite Video and audio and a 4 pin din socket for S-Video.

6. RGBHV

The final analogue format we will look at is RGBHV as used on computers under the guise of VGA, SVGA, XVGA and other variants.

There are three fundamental differences between RGB for computers and RGB for video. One is that we are looking at a significantly greater signal bandwidth from computers due to the higher resolutions. Typical resolutions are:-

For a 4:3 Display

Video	576 x 480 (interlaced)
VGA	640 x 480
SVGA	800 x 600
XVGA	1024 x 764

Secondly, whilst we use a 1V p-p signal for video, with then RGB of a PC signal the level is normally 0.7V p-p whilst the H&V are TTL level at approximately 5 volts.

Finally, the video when displayed on a monitor is normally an interlaced signal so you only get half the image in successive scans relying on the eyes persistence of vision to create a full image.

To achieve the higher bandwidth in addition to carrying the RGB information as three separate colours, separate horizontal and vertical syncs are used rather than the single blanking sync used for video.

RGBHV is most often presented as a 15pin high density D connector and even now when digital formats are prevalent, it's still the most common format. The strange choice of a HD15 is probably down to cost as it certainly breaks the rules regarding the handling of high frequency signals for video. At least it is pinned out to maintain the three video grounds separate from each other and also from the sync grounds.
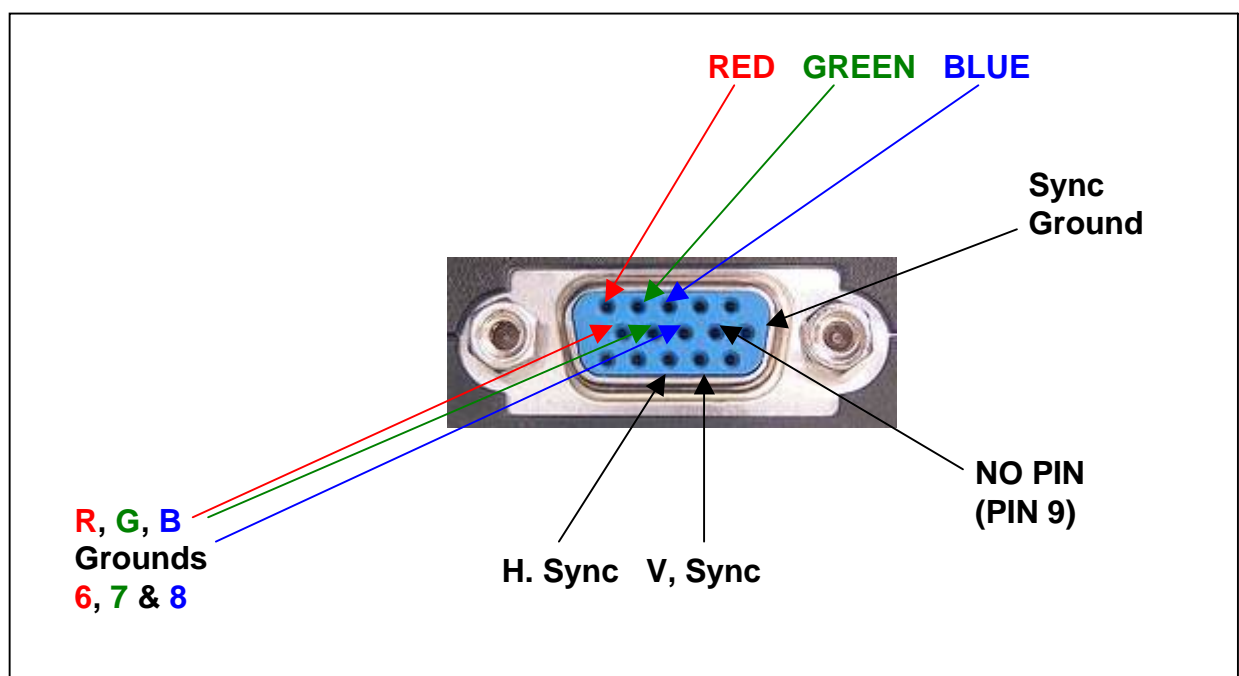
Note that on the above diagram pin 9 is missing. This is the official VGA pin out and whilst all the grounds are on the middle row, these should be kept separate, although they are linked on some equipment along with the 'unused' pin 9.

This can now cause a problem as some computers and monitors use pin 9 for ~ 5V DC from the graphics card, if the equipment grounds this pin it can cause the computer to shutdown or at worst case damage the computers power supply.

This is also a reason not to use the cable supplied with a monitor except for a direct connection, for in addition to the use of pin 9, often other internal pins are linked.

7.   *Distribution and Format Conversion*

Distribution of a RGBHV signal is by a combination of three analogue drives for RGB along with a TTL level distribution of H & V. The same rules regarding source impendence and termination apply.
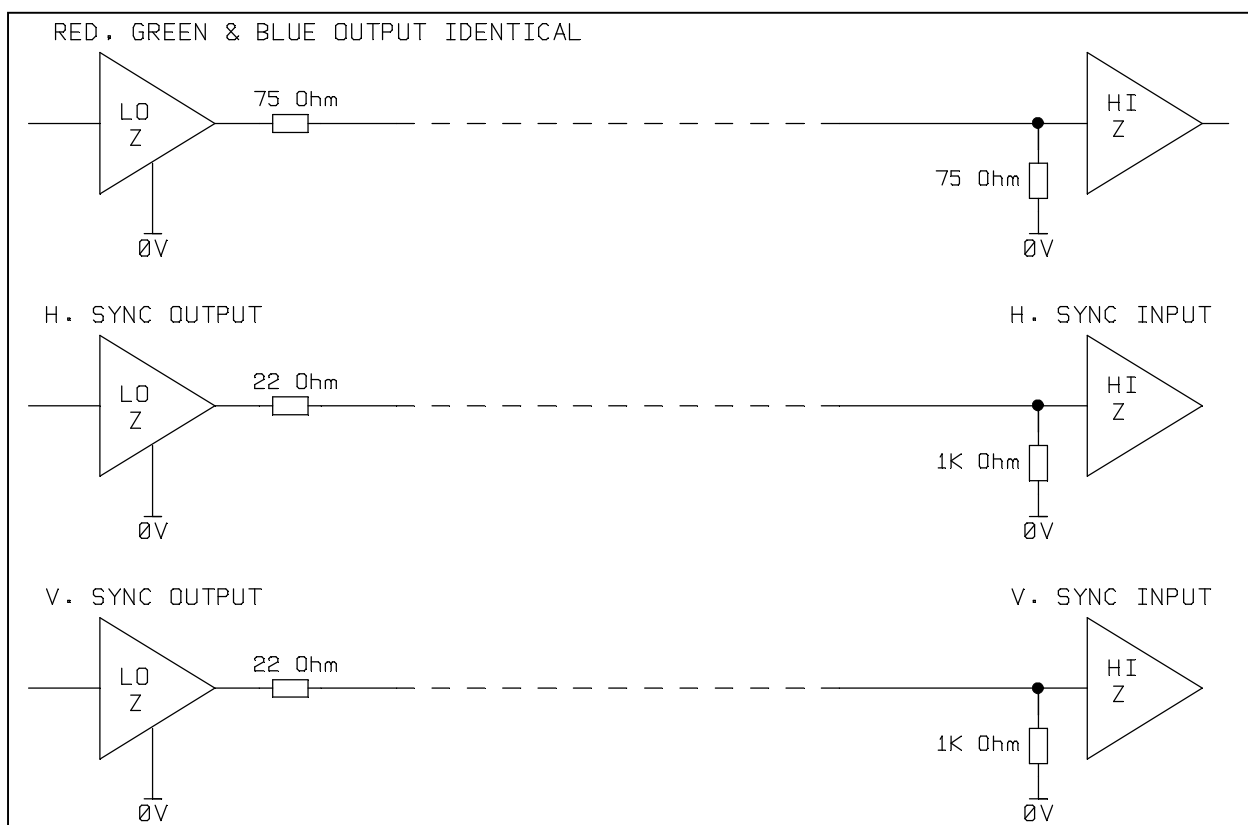
You can convert from Composite Video, S-Video and Component Video to VGA using an external scan rate converter that digitises the incoming signals and regenerates at the higher rate. This is what happens within LCD monitors supporting the various video input formats.

Its generally not worth a conversion the other way from RGBHV back to composite video as the resulting quality is very poor.

8. Cable Quality

As with audio, the quality of the cable used for interconnection can have an effect on the signal quality. For composite and component video the use of coax cable is the norm although you should consider carefully the use of the rather thin pre-made cables supplied with domestic equipment.

When you move onto VGA, in addition to the three video channels there are the two syncs and other signal conductors to consider. If we have a look at three typical cables.

Monitor Cable

Only suitable for the stated purpose and manufactured of flexibility. You can see that whilst there is an overall foil and braded screen the latter is very open mesh for flexibility. Also have a look at how thin the Video cores are. At least they each have a foil screen and drain cable.
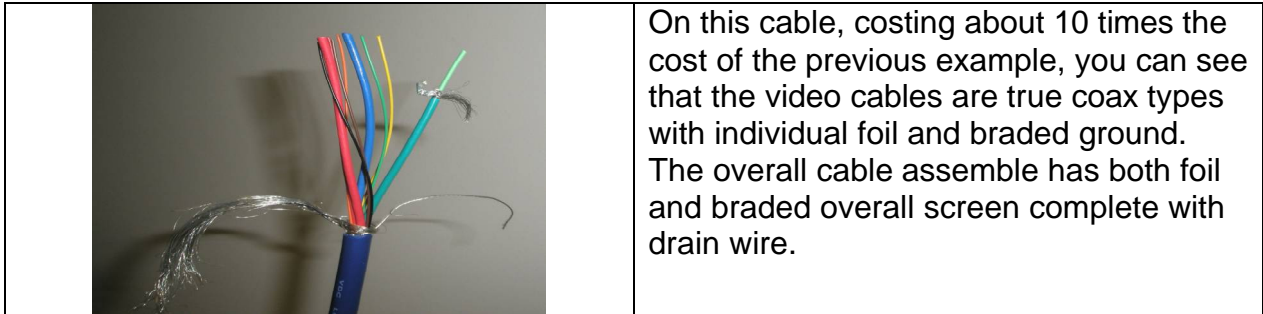
These are OK for their purpose, but that's all.

Low Cost pre-made cables

Whilst the use of pre-made VGA to VGA cable may appear attractive from a cost and convenience viewpoint, you get what you pay for. The three 'coax' video cores are not even that, just a centre core and around 6 strands of 'ground' laid by its side and in no way can maintain the 75 oh characteristic impendence. The whole assemble relies on the outer foil covering and loose woven braiding for screening.

Quality Pre-Made Cables

|	On this cable, costing about 10 times the cost of the previous example, you can see that the video cables are true coax types with individual foil and braded ground. The overall cable assemble has both foil and braded overall screen complete with drain wire.

The use of 5 core video coax cable terminated with BNC connectors is still widely used for high quality video installations.

Before moving onto digital formats I want to take a brief look at the distribution of video using Cat5 structural cable.

9.   *Cat 5 Distribution*

Twisted pair distribution of video is quite common in the security industry where long cables runs are required. Normally Baluns are used to change the characteristic impendence of the cable.
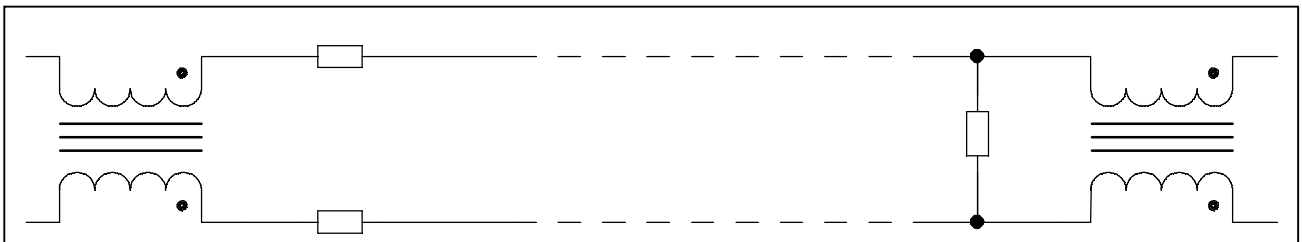

This technique can also be applied to RGBHV cables:-
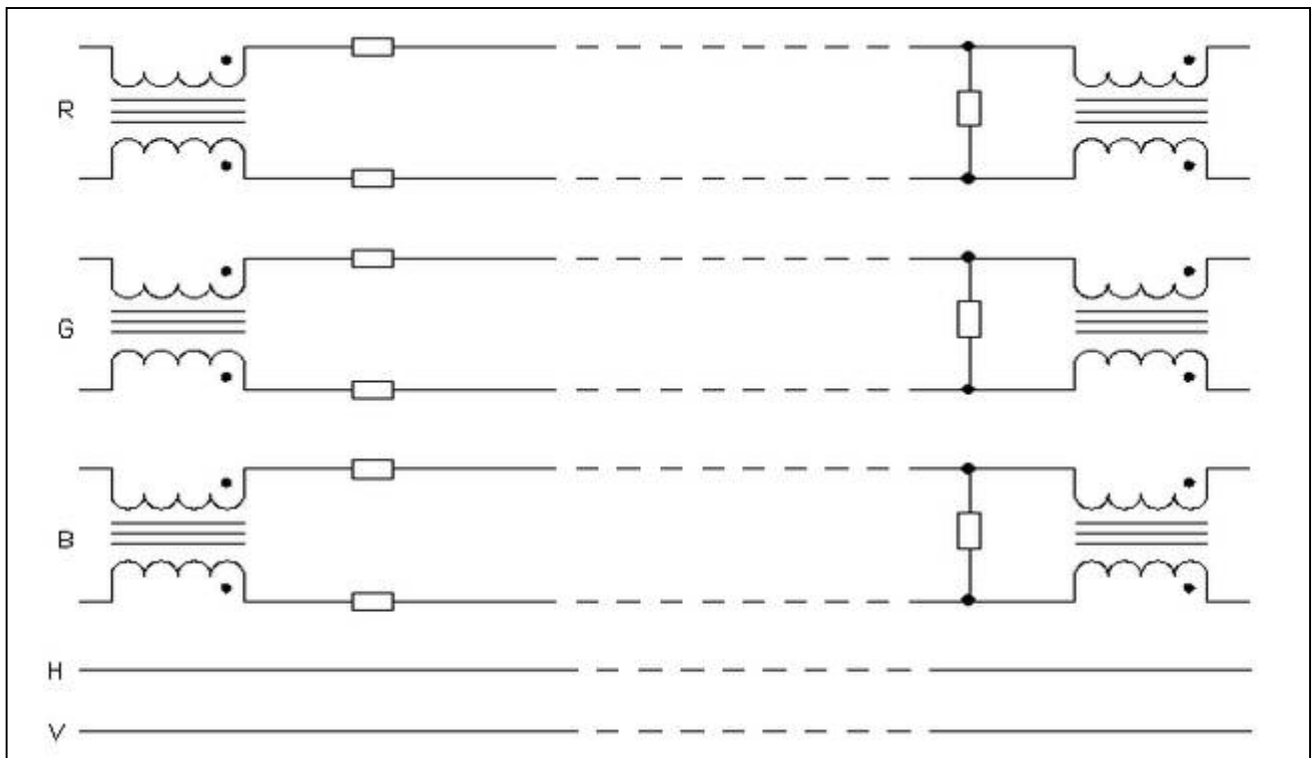
Being a passive circuit the loading upon the drive circuit is at least the same as a normal 75-ohm video load and possibly more when losses due to the impedance change and cable length are taken into account.

The other problem is that there is only one pair left for the two sync signals, leaving us short of the sync ground. Different ways of providing this are used ranging from sharing a ground with one of the colours to the use of shielded cat5 cable allowing the screen to be used for the sync.

Unless there is a requirement to use existing cables it's normally always best to install a dedicated RGBHV miniature coax cable rather that use a passive Cat5 approach.
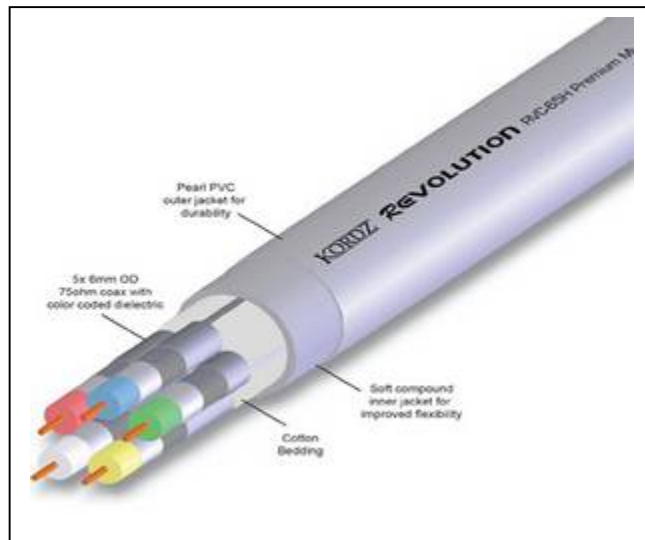
For longer runs that are greater than 30-50 meters it may be preferable to use an active Cat5 system. These tend to fall into two categories for analogue distribution.
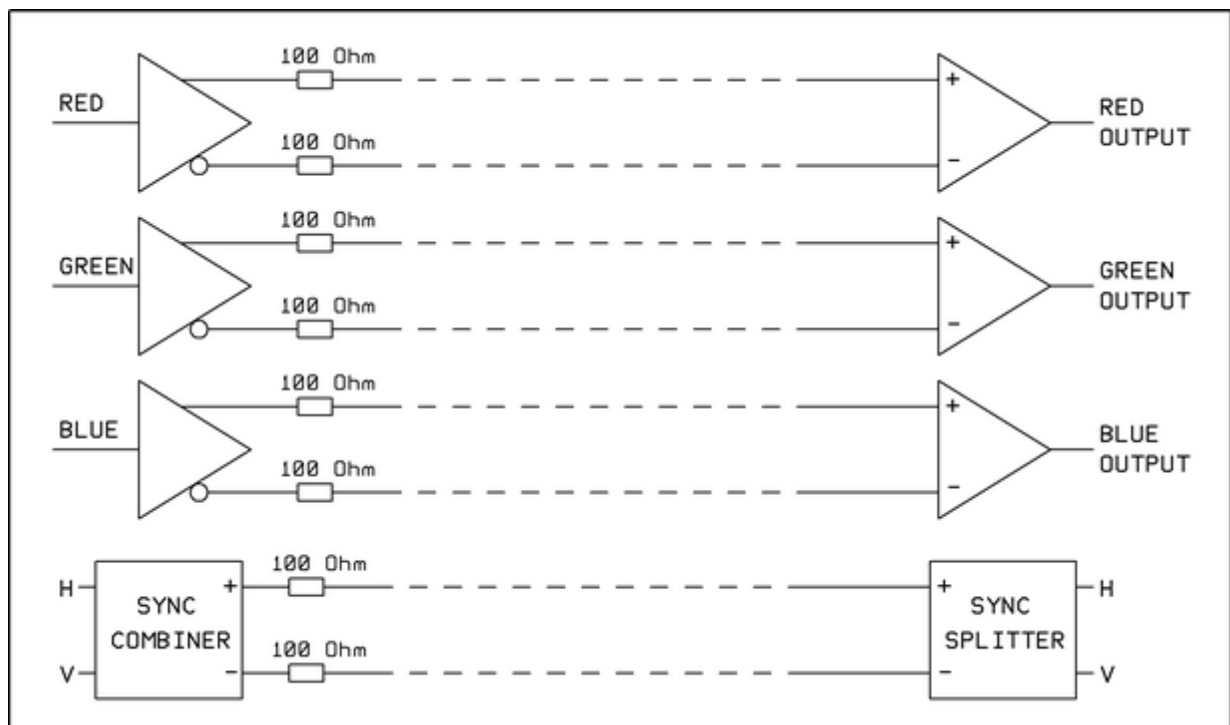
The RGB part of the distribution should look familiar, its just a standard balanced line transmitter and receiver, just optimised for 100 ohm cable. It does use all four pairs of the cable though.
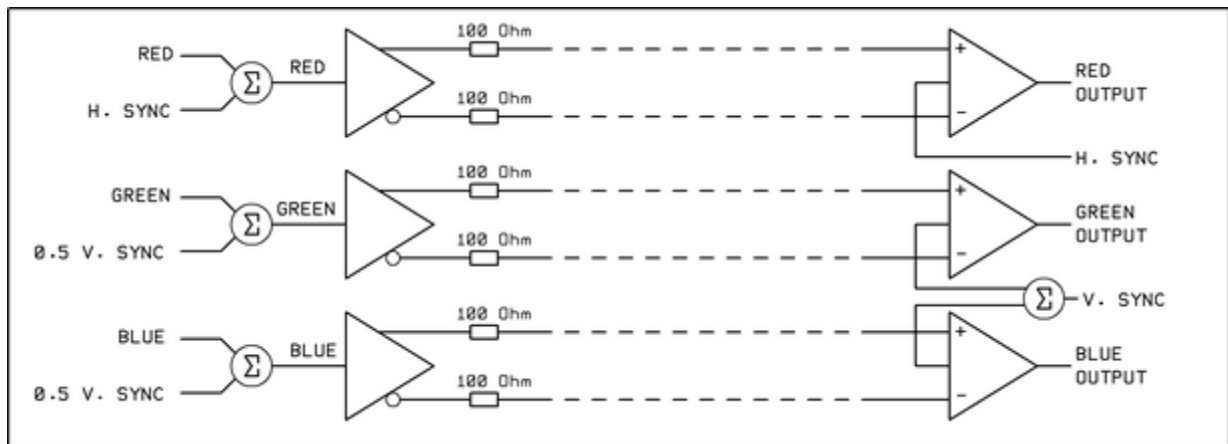
Here we are using the same principle as phantom power to share the syncs across the three colours introduced at the null point of the signal and recovered at the receiver. This leaves us a spare pair for power, audio, control or a combination of all three.

Of course the above are simplified circuits and included no allowance for cable compensation and adjustment in skew caused by differing path lengths of the RG and B cores due to the uneven twist of Cat5 cable.

	Pair Colour	Cm per turn	Turns per m
	Green	1.53	65.2
	Blue	1.54	64.8
	Orange	1.78	56.2
	Brown	1.94	51.7

Whist not obviously apparent, each core of a Cat 5 cable has a different twist ratio. This is designed to minimise cross talk with the digital signals the cable is intended for. When used for analogue VGA distribution, this can cause an obvious skew between colours.

A common question that arises is if it is best to use Cat5 distribution or conventional analogue distribution. Without doubt if going 100m or more then the active Cat5 solution is preferable as the received signal is locally buffered at the display. For shorted distances, unless the cable has been pre-installed, it's best to look at the economics of the situation and the relative costs for the cable, install & converters. Always remember that any format conversion will lead to a possible reduction in quality.

For a small room, say a school classroom its just a waste of time as the distance to short, but maybe for electronic signage in a shopping centre its would be worthwhile, particularly if you can get the IT contractor to install extra cabled for your use.

You do need to be very careful, as other than when using passive baulans, there is no standard format with different manufacturers achieving the transmission by different methods. It's also not uncommon to find two different cat5 products from the same manufacturer reluctant to work together.

And so to Digital.

10. Digital Formats

In general analogue and digital video formats are incompatible with each other. There is some confusion though arising from the dual use of the DVI connector, as we will see shortly.

Lets start a look at Digital Video with the nearest thing there is to Composite Video and that's SDI.


11.   SDI

Serial Digital Interface (SDI) is a family of video interface standardised for broadcast grade video. These are used for the transmission of uncompressed and unencrypted video signals via coax and fibre and are only available in professional video equipment being prohibited for use in consumer equipment due to licensing agreements.

As its very unlikely to encounter SDI outside a broadcast environment I wont go any further into it here.


12.   DVI

Introduced to provide very high visual quality images on digital display devices, the Digital Visual Interface (DVI) was developed to replace the VGA connector carrying uncompressed digital video to a display.

In its DVI-I format it carries both analogue VGA data with H&V syncs as well as a digital mode partially compatible with HDMI. This is unfortunately what leads to some confusion as some DVI devices support both analogue and digital modes whilst other will only be analogue OR digital. A simple check of what pins are available will normally confirm compatibility.
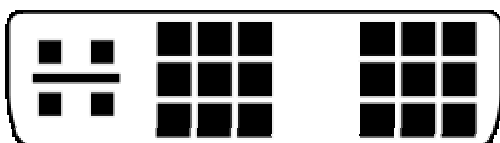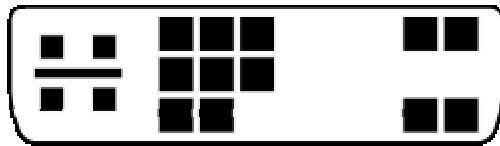

DVI-I

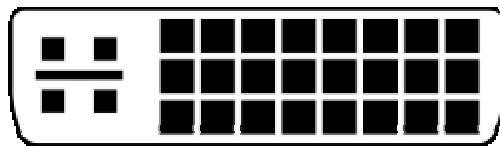Supports both Analogue and Digital formats
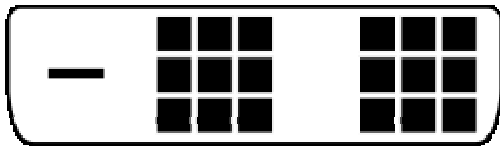
DVI-D

Supports digital format only.

DVI-A

Analogue format only. Very rare to encounter this.

DVI-I Dual Link

Similar to the DVI-I format but supports dual digital links for great resolution.

The analogue section is the same format as VGA and require handling the same.

The digital data format used is known as Transition Minimised Differential Signalling (TMDS). And is carried on four pairs of wires as balanced signals. Whilst these are Red, Green, Blue and Clock, they are more accurately defined as Channel 0, Channel 1, Channel 2 and Clock and bare no direct relationship with RGB and Sync as found on the analogue VGA connector although some timing is similar.

DVI is the only widespread video standard that includes analogue and digital transmissions in the same connector.

A question often asked is 'how far can I run a DVI cable?' the simple answer is that there is no maximum length included in the specification since it is dependent on bandwidth requirements of the image being transmitted.

In general, cable lengths up to 4.5m will work for displays at resolutions of 1,920 × 1,200. This resolution will work even up to 10m if appropriate cable is used. Cable lengths up to 15m can be used with displays at resolutions up to 1,280 × 1,024, and for longer distances, the use of a DVI booster is recommended.

Of course a lot of this depends upon the source and destination equipment. If you are using a domestic DVD player and domestic TV, these have been designed for sitting close to each other so the drive capabilities of the player will be minimal whilst the receiver probably uses minimum signal processing to recover the incoming signal.

A professional display will normally include re-clocking of the incoming signals along with automatic compensation for cable skew. If using domestic players, it's normally worth locating these within a couple of metres of a DVI switch and relying on this to buffer the signal.

In December 2010, Intel, AMD, and several computer and display manufacturers announced they would stop supporting DVI-I and VGA technologies and instead speed up adoption of DisplayPort and/or HDMI. They also stated: "*Legacy interfaces such as VGA and DVI have not kept pace, and newer standards such as DisplayPort and HDMI clearly provide the best connectivity options moving forward. In our opinion,*

DisplayPort 1.2 is the future interface for PC monitors, along with HDMI 1.4a for TV connectivity."

So the next logical digital format to look at would appear to be HDMI

13.   HDMI

HDMI (High-Definition Multimedia Interface) is a compact audio/video interface for transmitting uncompressed digital data. It is a digital alternative to consumer analogue standards, such as composite video, S-Video, SCART, component video, or VGA. HDMI connects digital audio/video sources (such as set-top boxes, DVD players, Blu-ray Disc players, camcorders, personal computers and AV receivers) to compatible digital audio devices, computer monitors, video projectors, and digital televisions.

As of 2010, there is a transition occurring for home TV monitors away from DVI towards HDMI as the common connector format. While DVI is functionally pin-compatible with HDMI, the DVI specification does not specifically support audio, while the HDMI specification does. It is not possible to "inject" a SPDIF digital audio signal directly into a DVI to HDMI adapter as the audio signal is transmitted along with the video information in a single TMDS data stream in HDMI.

Since its introduction in 2004 HDMI has evolved through from version 1.0 through to version 1.4 with each change increasing both the resolution and facilities.

Connectors

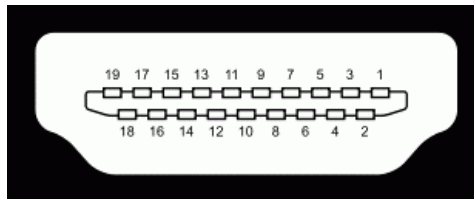Whilst there are four different HDMI connectors available, in most cases the type A, 19 pin variant is used.

HDMI Type A plug and Socket

Compatibility with DVI

HDMI is backward-compatible with single-link DVI-D or DVI-I, but not DVI-A. No signal conversion is required when an adapter is used, and consequently no loss in video quality occurs.

HDMI Connector & Signals

Type A (Female) HDMI

Pin 1	TMDS Data 2+ *	Pin 2	TMDS Data 2 Screen *
Pin 3	TMDS Data 2- *	Pin 4	TMDS Data 1+ *
Pin 5	TMDS Data 1 Screen *	Pin 6	TMDS Data 1- *
Pin 7	TMDS Data 0+ *	Pin 8	TMDS Data 0 Screen *
Pin 9	TMDS Data 0- *	Pin 10	TMDS Clock+ *
Pin 11	TMDS Clock Screen *	Pin 12	TMDS Clock- *
Pin 13	CEC	Pin 14	Reserved for future use
Pin 15	DDC Clock *	Pin 16	DDC Data *
Pin 17	Ground	Pin 18	+5V Power
Pin 19	Hot Plug Detect *		

* These signals are compatable with the DVI-D connector

Cable Lengths

Although no maximum length for a HDMI cable is specified, signal attenuation limits usable lengths in practice. With HDMI 1.3, the use of a 10m cable should cause no problems, even with domestic equipment. 20m should be no problem when using professional source and display equipment but of course you can also use active extenders.

HDMI extenders are a single device or pair of devices, powered with either an external power supply or with the 5V DC from the HDMI source. Several companies offer amplifiers, equalisers, and repeaters that can string several standard HDMI cables together. Active HDMI cables use electronics within the cable to boost the signal and allow for HDMI cables of up to 30 meters. HDMI extenders that are based on dual Category 5/Category 6 cable can extend HDMI to 250 meters, while HDMI extenders based on optical fibre can extend HDMI to 300 meters.

The HDMI Myth

Cable manufacturers would have you believe that you can only interconnect equipment using propriety pre-made HDMI cables, often at extortionate costs. Many even state that cable cores need to be matched to 0.1mm to work and use this as an excuse for not having rewireable plugs or sockets. This is simply not true.

HDMI 1.3 runs at a pixel rate of 340MHz (10.2 Gbits/s) and all the audio, video and control data are sent using the three TMDS channels along with a TMDS master clock. Being a parallel distribution system, with long cable lengths there is a possibility of data skew where all data does not arrive simultaneously at the receiver (sink in HDMI parlance). For this to be significant the difference between any two of the signals needs to be greater that half of one clock cycle as, in accordance with the HDMI specification, all data is latched on reception prior to further processing. Assuming a maximum error of ¼ of a cycle, as the maximum pixel rate is 340MHz that's 735µS, which equated to 147cm of copper cable.

So much for the 0.1mm tolerance, whilst not recommended you could theoretically have a 100cm difference without problems.
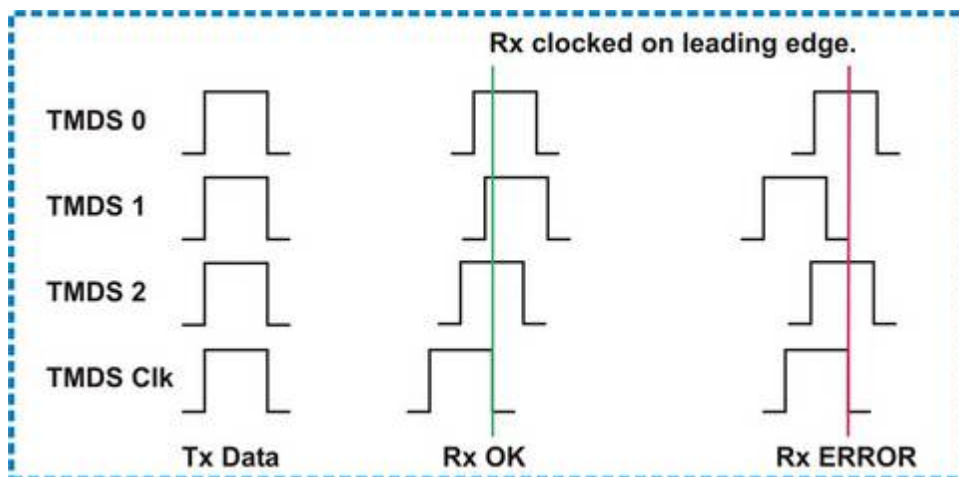
Of course the quality of the cable does have an effect, not so much on the above but the maximum distance you can send the signal before needing a repeater (to reclock the signals).

For the last 3 years there has been a rewireable HDMI connector available and this has been widely used for both repairing damaged cabled that have been permanently installed as well as allowing the use of bulk HDMI cable.
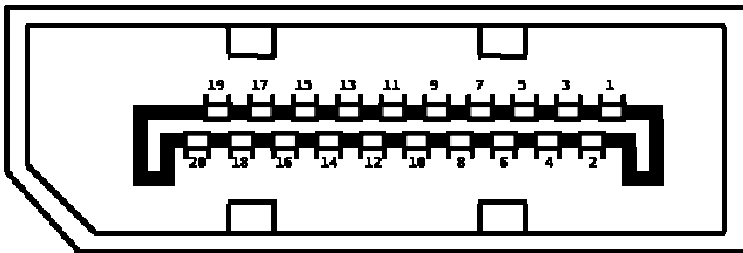
Terminated HDMI-ST connectors

14. DisplayPort

The final digital format we will look at is DisplayPort.

As mentioned earlier, several manufacturers are stopping the implementation of VGA and DVI in favour of DisplayPort.

The DisplayPort connector looks similar to HDMI, so why not use the HDMI?

Cynically you could say that it all comes down to cost. To use the HDMI logo and call the port HDMI required a yearly subscription to HDMI.ORG of $15,000.00. The DisplayPort is a VESA standard and royalty free. But this is not the only reason, as we shall see.

DisplayPort is a digital display interface standard that defines a digital audio/video interconnect, intended to be used primarily between a computer and its display, or a computer and a home-theatre system. It's designed to replace digital DVI and analogue VGA connectors. DisplayPort can provide the same functionality as HDMI but is not expected to replace HDMI in high-definition consumer electronics devices.

Unlike the DVI and HDMI standards, where differential pairs are fixed to transmitting RGB pixels and clock signal, the data transmission protocol in DisplayPort is based on micro data packets and can use variable number of data pairs, with the clock embedded in the data signal.

Both video and audio signals are optional. The video signal path supports 6 to 16 bits whilst the audio path supports up to 8 channels of 24 bit 192 kHz uncompressed PCM audio.

DisplayPort Logo

DisplayPort Connector & Signals
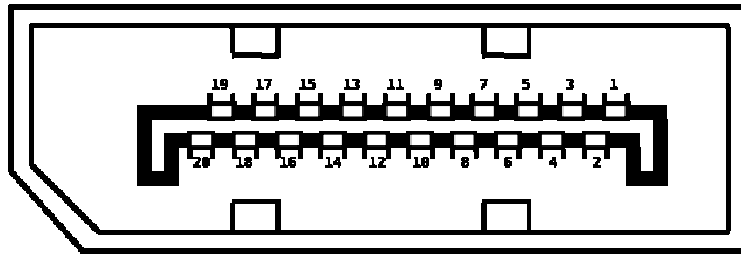
Pin 1	Lane 0 (+)	**Pin 2**	Ground
Pin 3	Lane 0 (-)	**Pin 4**	Lane 1 (+)
Pin 5	Ground	**Pin 6**	Lane 1 (-)
Pin 7	Lane 2 (+)	**Pin 8**	Ground
Pin 9	Lane 2 (-)	**Pin 10**	Lane 3 (+)
Pin 11	Ground	**Pin 12**	Lane 3 (-)
Pin 13	Config 1 *	**Pin 14**	Config 2 *
Pin 15	Aux channel (+)	**Pin 16**	Ground
Pin 17	Aux channel (-)	**Pin 18**	Hot Plug Detect
Pin 19	Return (for power)	**Pin 20**	Power for connector (3.3V @ 500mA)

* Pins 13 and 14 my either be connected directly to ground or connected to ground through a pulldown device.

The above is the pinout for a source-side connector. For the sink-side connector lanes 0-3 are reversed.

Compatibility with HDMI

Whilst the signals available on DisplayPort appear similar to HDMI, the major difference is that whilst HDMI (and DVI) operate at 5V, DisplayPort used 3.3V, so level translation is required.

There is a variation of called Dual-Mode DisplayPort that is capable of directly emitting single-link HDMI and DVI signals which uses the 4-lane main DisplayPort link and AUX channel link to transmit 3 TMDS signals plus a Clock signal and Display Data Channel data/clock from the chipset. Dual-mode compatible ports are marked with the DP++ logo

| Dual-mode pin mapping	
DisplayPort pins	**DVI 1.0/HDMI mode**
Main Link Lane 0	TMDS Channel 2
Main Link Lane 1	TMDS Channel 1
Main Link Lane 2	TMDS Channel 0
Main Link Lane 3	TMDS Clock
AUX CH+	DDC Clock
AUX CH-	DDC Data
DP_PWR	DP_PWR
Hot Plug Detect	Hot Plug Detect
Config 1	Cable Adaptor Detect
Config 2	CEC *(HDMI only)*

Cable Lengths

The maximum specified cable length is 15m although this is to cater for all formats. When used in HDMI or DVI compatible format, the restrictions are the same and extenders can be used.

Over the next year or so we will start to see dedicated extenders and routers appears along with connection panels and passive DisplayPort to DVI converters allowing the use of DisplayPort equipped computers with existing installations.

15. Routing and Distribution

Simple passive splitting of the TMDS digital signal in a similar way to VGA is not possible.

Analogue VGA is a voltage source. If we look again at the simplified analogue Distribution amplifier:-
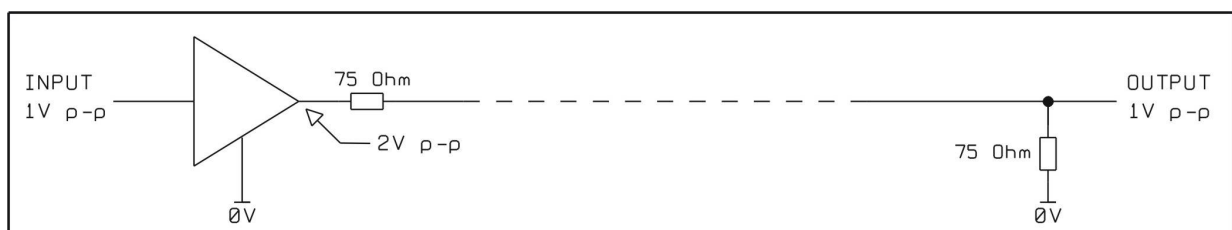
Her we are providing simple voltage amplification at the source to enable the signal to travel the distance to the destination. Splitting the voltage to multiple destinations only required additional resistors adding (as we saw earlier).

For TMDS signals it's a different matter as a TMDS signal is a current sink:-
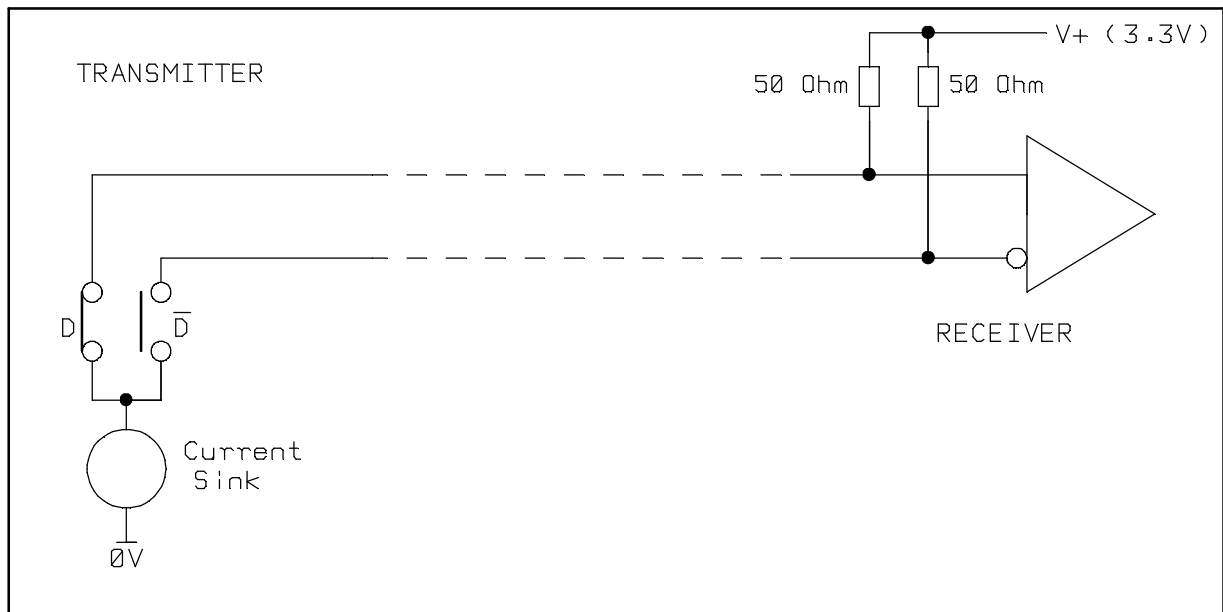
For a splitter it is necessary to have a receiver feeding multiple transmitters and most routers and D/A's employ active elements to regenerate the signals using separate active outputs. This way total compatibility is achievable as well as format & level conversion between DVI, HDMI and DisplayPort.

A practical consideration when installing line drivers for Analogue and Digital is that for an analogue signal the amplifier will always be at the transmitting end whist normally for a digital TMDS signal it will normally be at the receiver with long cable runs catered for by manipulating V+ at the receiver to maintain the correct current sink.

As the impedance between the two half's of the differential signal is 50 ohms, it lends itself to convenient Cat5 extenders when the transmitter end of the link is a simple connector change and the receiver is the active element.

16. Format Compatibility

As we can see from the earlier information, there is fortunately some compatibility between the digital format signals as there is between the different analogue format signals.

Between Digital and Analogue it's a different matter. Unfortunately you cannot simply use a cross wired cable to link Component video to HDMI or SCART to DVI without some intervening electronics. But format converters are available ranging from relative low cost up converts to complex scalars.

To give you an indication of the complexity, lets have a quick look at a typical VGA to HDMI converter.
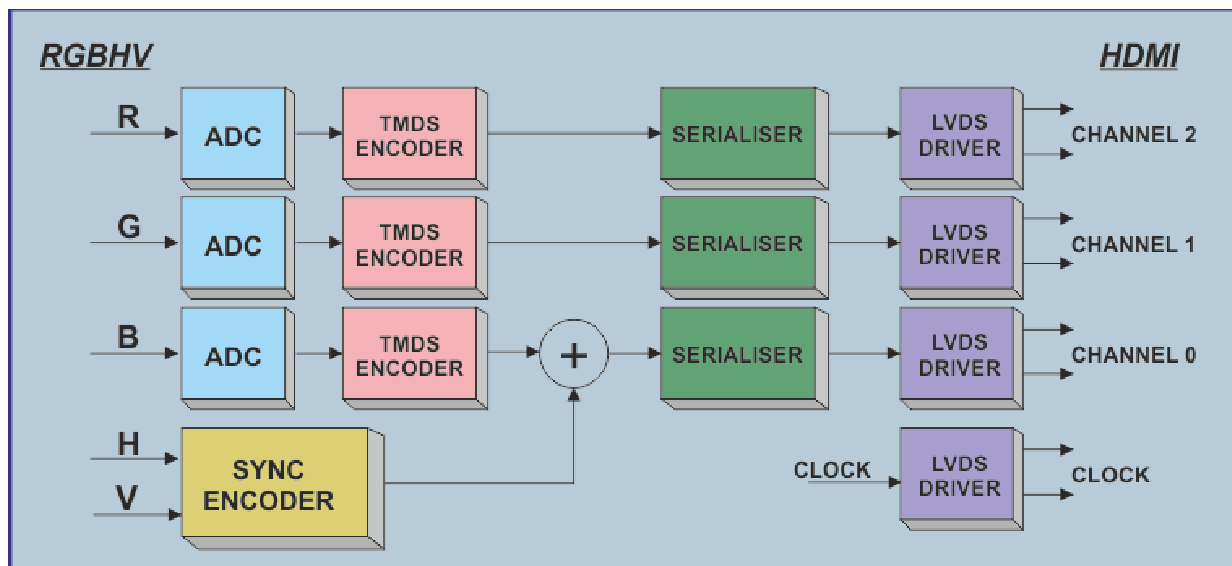
To convert VGA to HDMI we would first need to digitise each pixel for Red, Green and Blue with separate 8 bit ADC's. This would then need converting to 10 bits and TDMS encoding. The encoded bits are now serialised before being sent to the LDVS current drive.

Whilst a separate compatible TDMS sync would be required, the VGA's H&V syncs are inserted as part of the Channel 0 data stream.

17.   The Future

It's inevitable that analogue video connections will be phased out as new equipment appears and support for legacy formats diminishes. As we are always being told 'it's a digital future' and whilst, as audio engineers, we work in an analogue environment, at least for the bit that reaches the ears, we need to embrace digital technology for both audio and video. But if you understand the application of digital audio, digital video should be as easy for it is more forgiving due to our persistence of vision.

Further Information

Video Basics. Maxim Application note 734 available from;
http://pdfserv.maxim-ic.com/en/an/AN734.pdf

The full HDMI specification is available from http://www.hdmi.org

The full TDMS specification is available from http://www.ddwg.org/lib/dvi_10.pdf