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Professional CCTV Manufacturer!

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What ground loops do to video lines?

As the source and destination of a video signal can be at differing ac or dc earth potentials, earth loop currents flow and cause longitudinal hum to be introduced into the video signal. Video hum is low frequency (50 or 60 Hz mains frequency or its harmonics) noise from the ground lines which has influenced the video signal, causing degradation of the displayed signal. Video hum is usually observed as bars rolling vertically through the video image, video hum may also cause video distortion or even tearing of the picture in severe cases. Video hum maybe a problem in any system where video sources and display devices are connected to different A/C power sources with varying grounding potentials.

Typically the humming can be seen as slowly vertically moving horizontal bars in normal TV video signals. The same kind of bars can be also seen in computer screen, but typically they are not as visible because bars are moving so fast that you see them as some strange flashing in screen.

The picture below is a real world example of the effects of a ground loop and what it causes a video picture received from the cable TV network:

And you can see that video signal has strong humming bars and other interference in it. Those have entered the cable TV signal because of ground loops in the system. Ground loops in the video systems can have following effects:

- Hum Bars: The mains frequency (50 Hz or 60 Hz) can cause stationary or moving horizontal humming bar to appear on the video signal (as shown on the picture above). If you have light dimmers nearby those humming bars can easily become quite severe and easily visible.
- RF Interference: Herring bone interference on video line is caused by a ground loop (that includes your coax shield) acting as an AM radio antenna. Any large loop of wire makes a good AM antenna. These antennas are especially adept at picking up AM broadcasts if most of the loop is vertical.
- Cross-Talk: Ground loops can cause one signal to interfere with another, because every cable should ideally return through the corresponding shield conductor, but there's an alternative path through the other shield conductor which causes undesirable voltage differences to nearby cables.

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Ground loop isolation in video lines

Ground Loop Isolator GB0001

Isolating video signal is more complicated than isolating audio or antenna signals, because the DC level of the video signal is important and video signals have very high frequency spectrum (normal composite video can have bandwidth from 50 Hz to 6 MHz).

Isolating video signal needs typically active technology which involves electro-optical isolation or differential amplifier with a floating ground on the input connector. Those both technologies are usable in real world situations. Differential input with floating ground works nicely for small ground potential differences and this approach is used in some professional video equipments (some video projectors I have seen have had differential inputs and option to disconnect input ground connection). Differential inputs are also used in applications where a video signal is transmitted through twisted pair wiring (some CCTV applications which use twisted pair interfacing equipments).

Electro-optical isolation works well in applications where complete electrical isolation is necessary. There are some this type of isolation devices on the market and some special video distribution amplifiers have this kind of option built in.

Ground loop elimination does not always ask for a complete isolation of the grounds. There are passive hum suppressor transformers which will very effectively remove the hum from the video signal (typically around 40 dB hum level reduction), but do not effect the video signal otherwise. Those special transformers act like a common mode coils, which stop the annoying ground loop currents on the shield of the coaxial cable, but provide a straight path for the signal inside the cable. This kind of devices is capable of passing the signals from DC to tens of MHz without problems. This type of hum suppression transformers has found their way to the professional video application (rental companies) and computer video applications (computer to video projector connections). The transformers of this type are usually called "hum bug transformers", "hum bucking transformers", "anti-hum video transformers" or "hum suppressor transformers". Generally term hum-bugger refers to any circuit (often a special coil) that introduces a small amount of voltage at power-line frequency into the video path to cancel unwanted ac hum.

There are also special wideband isolation transformers which can isolate video signals. A transformer which can nicely transfer the whole video frequency spectrum without much distortion is very hard to produce so there are not many of them on the market. Some of the isolation transformers are only designed for CCTV application, where more signal distortion is accepted than in broadcast industry.

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The choke (humbugging transformer) is primarily used in Broadcast TV because it passes the DC component of the signal. It is used in studio, and in remote ENG. The isolation transformer is primarily used in CCTV: security, manufacturing, avionics, display, etc.

Differential video amplifiers

Ground Loop Isolator GB0001

Differential amplifier approach uses an operational Amplifier. Operational Amplifiers only amplify the difference between the two input lines. This method eliminates common mode noise between the incoming signals by making A-B=C, as only the difference between A & B is amplified. Operational amplifiers are maintaining wide bandwidth signals throughout your system while eliminating ground loop problems that are caused by power and video. Differential video amplifier inputs are used in some video equipments (typically some video projectors) and video distribution amplifiers to fight against ground loop problems.

Differential video amplifiers have a limitation on their input voltage range which gives some limitations how much common mode signal those circuits can tolerate. If the ground potential difference is more than few volts, then operational amplifier based isolators don't work effectively. Too high voltage difference can cause problems from very distorted video signal to damaged differential video amplifier. If the voltage difference is a substantial proportion of the DC supply voltage of the amplifier, you will probably have trouble using an amplifier alone.

It is a good idea to measure the voltage difference before using differential video amplifiers to be sure not to damages them. Measuring can be done using a millimeters (check using both AC and DC ranges) or better using a scope earthed to the mains supply, and put the probe on the earth connection of the incoming video cable. If you many potential difference which are many volts, then you have quite probably something wrong in the grounding of the building and you should consult a qualified electrician to check and correct this potentially dangerous problem.

Good back porch black level clamp

Ground Loop Isolator GB0001

If the video signal input has well designed fast black level clamp circuitry that can also solve small common mode noise problems caused by ground loop. Back porch ground level clamp circuit adjusts the black level of the video circuits according the incoming video signal. If black level clamp circuit is active circuitry which samples the black level separately for every can lines the ground loop bars are quite effectively eliminated because the low frequency noise (50 Hz power or harmonics) is sampled at start of every scan line

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and suppressed then from the rest of the line. This works quite nicely with those low frequency humming bars, especially if combined with differential video inputs. Back porch black level clamp system does not help in fighting against higher frequency noise which might be injected to the video system through the ground loop.

Active video isolators

Ground Loop Isolator GB0001

Video Isolator passes a video signal from its input to its output with no electrical connection and is able to provide complete isolation, for the video signal, passing through it. Having the Video Isolator in the video signal path makes it possible to have Standard Safety earthing of all equipment with no associated earth loop problems. In the studio, feeds between different buildings are no longer a problem and it is no longer necessary to run technical earth to non critical locations such as viewing rooms.

Electro-optical isolators convert video signal voltage to blinking LED and other part of the circuit receives that light and converts it to back video signal voltage. This method guarantees very good isolation (complete galvanic isolation), but has typically bandwidth and linearity problems. Poor bandwidth will result in fuzzy images and poor linearity will result in an inability to produce the same gain for all signal levels (most noticeable in gray-scale patters).

Anti-hum video transformers

Ground Loop Isolator GB0001

Anti-hum video transformers are not real transformers, they are common mode chokes! Anti-hum transformers work as a series inductor offering series impedance to the circulating earth currents thus effectively reducing the current flowing in the loop which will reduce the voltage drops on the cable shields and equipment (that reduces hum). Those coils can reduce the currents on cable shield very effectively because they have very high impedance at 60 Hz and above and there presents high impedance to common mode signal differentials between the input and output. Earth loops typically have low resistance a quite the inductance will not have to be very huge to start to help. The coil itself will then have quite much voltage difference on the input and output grounds (the potential difference is now over the transformer instead of distributed to whole cable), but the common mode coil construction guarantees that this difference is not supped to the differential signal inside the cable. Since the signal and ground lead are coincident, the differential signal is unaffected.

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Hum reduction transformers or common mode coils are constructed with either 75 Ohm twisted pair (made of fine wire) or coaxial cable wrapped around a very high permeability core. Most basic hum isolation transformers are basically just coax cable wound on a toroid-type core. They work by mutual inductance. The coax cable is wound around a transformer core so that both the inner and shield of the cable become inductors. The tight coupling ensures that any voltage in the shield caused by variations in earth potential is transformed into the inner conductor.

The method is an ancient idea and can cope with very large ground loop signals, and has very large bandwidth with very little loss. This type of anti-humming transformer also provides DC continuity between the input and output leads which is a good thing. Transformer does not stop ground loop current flowing (the amount of current is lower because the added inductance) but the transformer reduces the current cancel the effect of ground loop current. Good one can reduce the ground loop effect up to 40-50 dB.

Hum isolation transformers are effective solutions for humming problems. The downside of them is that they are somehow bulky devices because of the large core needed to do the job. The boxes I have seen have been packed in metal case have weighted at least one kilogram. Hum isolation transformers are typically stand-alone passive boxes which are added to video system when problems are encountered.

Video isolation transformers

Ground Loop Isolator GB0001

There are special wideband isolation transformer which can isolate video signals, but not without problems. The design of a high bandwidth transformer which can go to very low frequencies is very hard. You have to always make some compromises on low and high frequency responses (highest components of composite video can be attenuated even few dB). All real isolation transformers have one serious drawback which can't be avoided: they can't pass the DC level through. So any system that relies on the video having any particular DC reference will not function properly. There are many video systems around which need particular DC reference level, but there are many which AC coupled are.

Some of the isolation transformers are only designed for CCTV other not so demanding applications application, where more signal distortion is accepted than in broadcast industry. So a video isolation transformer might be OK for a security camera installation if a complete isolation is needed, but I would not put it on any professional video studio system.

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FORESIGHT™ model: GB001 Ground Loop Isolator

The GB001 Ground Loop Isolator is a passive device which can reduce Ground Loop Interference with CCTV Video signals and can be easily installed in a new or add to existing systems. It's useful where a Video signal is transmitted via cable between points with difference ground potentials. Differences in ground potential are typically caused by unbalanced power line loads. It use to prevent video signal distortion caused by video ground loops, eliminates picture tearing, humming bars, cross talk and rolling, prevents power cables laid by others interfering with the CCTV system. It built in TVS (Transient Voltage Suppressors) for surge protection, built in Video BALUN, which perfect to work with DVR to immunity DVR interference, for extra interference rejection.

A) Video + Grounding contact or leak electricity to cause interference

Before

After

B) Video (+) contact other channel to cause interference (Diagonal Line)

Before

After

C) Unbalanced DVR interference or high frequency interference caused by nearby source

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Before

After

Download the specification **GB001 Ground Loop Isolator.pdf**

Note: If the interference caused by high frequency likes electromagnetic wave, high voltage electricity, wireless station ect. You may need High Frequency Interference Blocker CHB001.