help desk

DMX Isolation | By Wayne Howell

"The crew chief concluded that the Earth stake was not working well and asked the crew to urinate over it. It did actually work, although the first crew member had an eye-watering moment as he completed the circuit!"

In the next two *Help Desk* articles I plan to look at the subjects of Isolation and Protection. Just in case you are concerned, this is neither the subject of President Trump's next book, nor a discussion on Brexit! Regular topics on our Help Desk at Artistic include why control circuits fail, and good engineering practice to ensure they don't. This month, we'll look at the oft misunderstood concept of electrical isolation in control circuits. Let's start by looking at DMX. Within the context of this discussion, installation faults can generally occur via electrical damage or 'common mode' failure; the latter being the focus of this article . . .

COMMON MODE FAILURE

The 'common mode voltage' is a voltage offset that is common to both data connections in the DMX cable. It is measured relative to a reference level called the 'signal common'. When the DMX signal travels from transmitter to receiver, the reference level is not always as constant as we would like. This, in turn, causes variations in the common mode voltage (CMV), which is bad news for the drivers (the chips that electrically connect to the cable). Low cost drivers will generally accept a common mode voltage in the range -7V to +12VDC before problems occur - i.e. common mode failure.

But why would the signal common vary in the first place? In order to understand that, we need to take a brief look at how power distribution works . . .

POWER DISTRIBUTION

Most countries use a three-wire system for (single phase) mains power. The names vary from country to country, but Live, Neutral and Earth are widely understood. Live 'sends' the power, Neutral 'returns' the power and Earth is for safety. Depending upon both a country's electrical code, the age of the power installation and the location, the Neutral and Earth connections may be bonded together at the sub-station or also at the installation. Indeed, a system called PME (Protective Multiple Earth) which is widely used in the UK, combines Neutral and Earth conductors and connects to planet Earth at multiple points.

So, depending on the electrical installation, the Earth pin on your chosen power outlet may be:

- Connected only to a local 'planet Earth' bond. This is called a TT power network.
- Connected to a local Earth conductor which is bonded to planet Earth at the sub-station.
- Connected to the local combined Neutral and Earth conductor which is bonded to planet Earth both locally and at the sub-station.

In fact, there are many more variants, but I have simplified for the purposes of this article.

In a TT power network, the real problem is planet Earth:- it's not an awfully good conductor. Depending upon the conductivity of the planet - 'the Earth' - there may be a noticeable resistance between Earth at two points (for example, the lighting console and the dimmer rack). The same is true of power networks with a metal Earth connection, as they can be very long and possibly old or corroded.

THE PHYSICS

The resistance of the Earth connection increases with distance. Ohm's law (V = IR) tells us that for a given resistance, an increase in current will increase the voltage. It also says that for a given current, the voltage will increase with resistance. We conclude that there are two scenarios that can lead to a voltage offset between our various Earth points: current and distance.

THE REAL WORLD

- 'Current surge' tends to be most relevant to the touring industry. Very large currents flow at the push of a flash button. This surge can lead to a voltage spike between the Earth conductors at the different points. If non-isolated DMX512 equipment is connected to those points, the surge travels into the equipment and through the DMX cable common.

On stage, the current surges can be so large that even a small resistance between two distribution racks can lead to common voltages at either end of a DMX512 cable that interconnects equipment from a different power source.

This is particularly true at festival sites with generator-based power. Large touring power generators need a solid bond of their Earth conductor to planet Earth. Without this, the imbalances between live phases which are inevitable in a concert situation will force the Earth voltage to follow the Neutral. Untamed, this situation will destroy electronics. The bond to planet Earth is connected to a metal stake which is driven into the ground. The effectiveness of the Earth Spike will of course depend on the local geology.

I am reminded of a story from my touring days back in the '80s. We were setting up a festival on the Isle of Wight and suffering from a lot of flickering lights. The problem was caused by the local geology being chalk: not a great conductor. The crew chief concluded that the Earth stake was not working well and asked the crew to urinate over it. It did actually work, although the first crew member had an eye-watering moment as he completed the circuit!

- 'Distance' tends to surface more frequently in architectural installations. The DMX512 control signals can span an entire site that may be fed by different sub-stations with differing Earth voltages. In the worst-case scenario, a DMX512 system without any isolation could

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inadvertently short together the Earths of multiple sub-stations - causing a massive and damaging flow of current through the equipment and cable.

Whether caused by current surge or distance between Earth points, the result is the same: damaged drivers.

ISOLATION IS THE SOLUTION

DMX512 is one of the few control protocols that does not mandate isolation, and isolation is the one thing that can protect against this type of problem. DALI, MIDI, Ethernet all mandate isolation and, if installed correctly, do not suffer from this problem.

Isolation simply means that there is no electrical connection between the transmitter and the receiver. In turn, this ensures that the transmitter and receiver electrical commons are not connected together, and so differing Earth voltages will not cause Common Mode voltage failure.

Isolation can be achieved by one of two methods: optical and transformer. The former converts the electrical signal to light and then back to electrical. The light is used to provide electrical isolation. This topology is called optical isolation or opto-isolation and is widely used for DALI, MIDI and DMX512.

The latter method uses a transformer so the electrical signal is converted to a magnetic field and then back to electrical. This is used in Ethernet systems.

The last evolution of the DMX512 standard: DMX512-A went a long way to improving the situation, but due to inter-manufacturer rivalry fell short of mandating one system of isolation. This means that it is perfectly valid to manufacture products with no isolation, isolated inputs or isolated outputs. The recommended scheme is to have products with isolated inputs and use transmitters and splitters with 'ground referenced' outputs. This scenario gives the maximum benefit for the lowest cost.

For those wishing to read more on the correct use and debugging of DMX512, PLASA has published a *Recommended Practice* by Adam Bennette.

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