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Application Note:

Station cables of a length greater than 100 feet.

When a site requires a station cable to be placed or is already in place that originates at the High Voltage Interface (HVI) (Isolation or Protection) but extends a distance equal to or greater than 100 feet, extraordinary measures need to be taken.

First, Station Cables of 100 to maybe 200 feet in Length:

1. IEEE 487 will tell you to utilize a cable with a metallic shield.
2. Regardless of station cable length beyond 100 feet, the design for this cable should be of a construction grade, and for that matter be capable of being direct buried and it should contain a moisture barrier compound to prevent moisture migration into the core of the cable.
3. Next, there needs to be a metallic conduit to route this cable in and a #2/0 AWG bonding conductor to be routed along with the cable and for that matter it should be in the conduit if possible.
4. In addition you will need a station protector rated for primary usage at each end of this cable (UL 497 listed for primary usage).
5. These items (the cable shield, conduit, #2/0 AWG conductor, and station protector(s)) are all bonded together at each end and connected to the grid ground at each ones respective end.

This is identified in 487 for distances of 100 feet and greater.

It is important to note: The fault produced earth return current causes the grid to elevate in potential relative to remote earth. It may not be clear that the fault-produced elevation of the grid does not appear as an even voltage level across the total grid. In fact, some areas of the grid may be at a level of potential that is twice the potential of another area. This of course imparts differing potentials on the equipment being utilized at these locations. The end result is potential differences between the two ends on any communication circuit connecting these two grid areas together.

Therefore the intent of this cabling/conduit arrangement is to equalize the two ends of the circuit so that any potential differences that appear at the two cable ends within and/or on the grid will have a minimum impact on the circuit traveling this long distance. These potential differences result in circulating currents within the cable pair(s). These circulating currents can ultimately cause equipment failure due to the common mode of this energy (conductor to conductor within the pair) and its action on the individual circuit components.

For a Graphic Representation see Figure #1.

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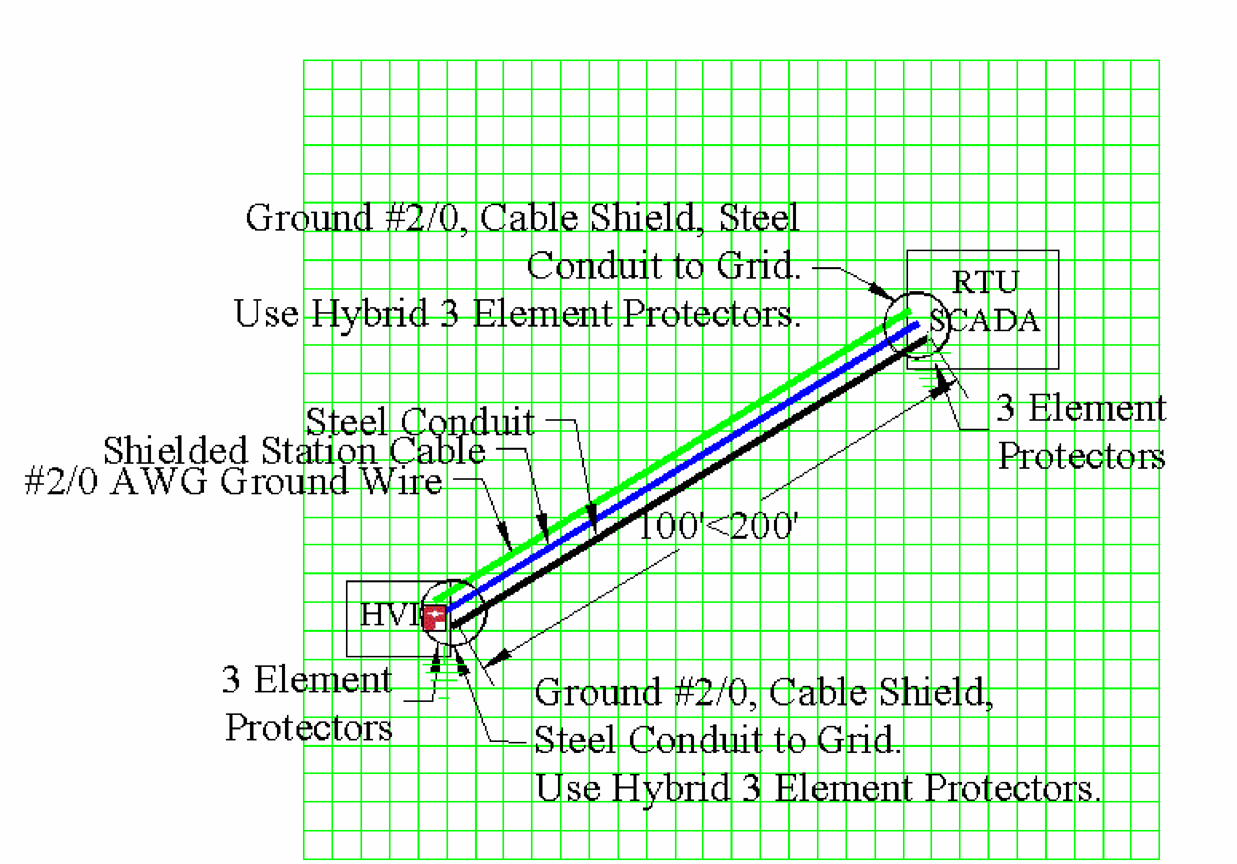

Figure 1
Greater than 100 feet but perhaps less than 200 feet from the HVI to the End Equipment

Implementation of this design establishes a wiring and equipment configuration for reliable communication.

Second, Station Cables of 200 or more feet in Length:

However, when you go beyond 200 feet then these same grid potential differences are in all probability even greater and may cause equipment problems anyway. This of course implies that the previously mentioned cable, (again, this cable should really be of construction grade, preferably contain a moisture barrier compound), conduit, protector block, and bond wire are all utilized.

It is important to note: The exact distance that creates this situation is not a hard and fast footage amount. The grid design of the substation is a major factor in determining at what distance this issue would need to be addressed. So a grid design of even spaced cross

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connecting ground wires would impart a somewhat equalizing environment to the faulting energy, whereas a grid of say only 2 bonding conductors between two cross connecting grids at a distance from each other would present a larger potential between the two areas on the grid than the former listed grid design. This would impart a larger differing potential across the communication cable if the fault was returning to one of the grid sections (say where the transformer is connected) than the other grid section.
For a Graphic Representation see Figure 2.

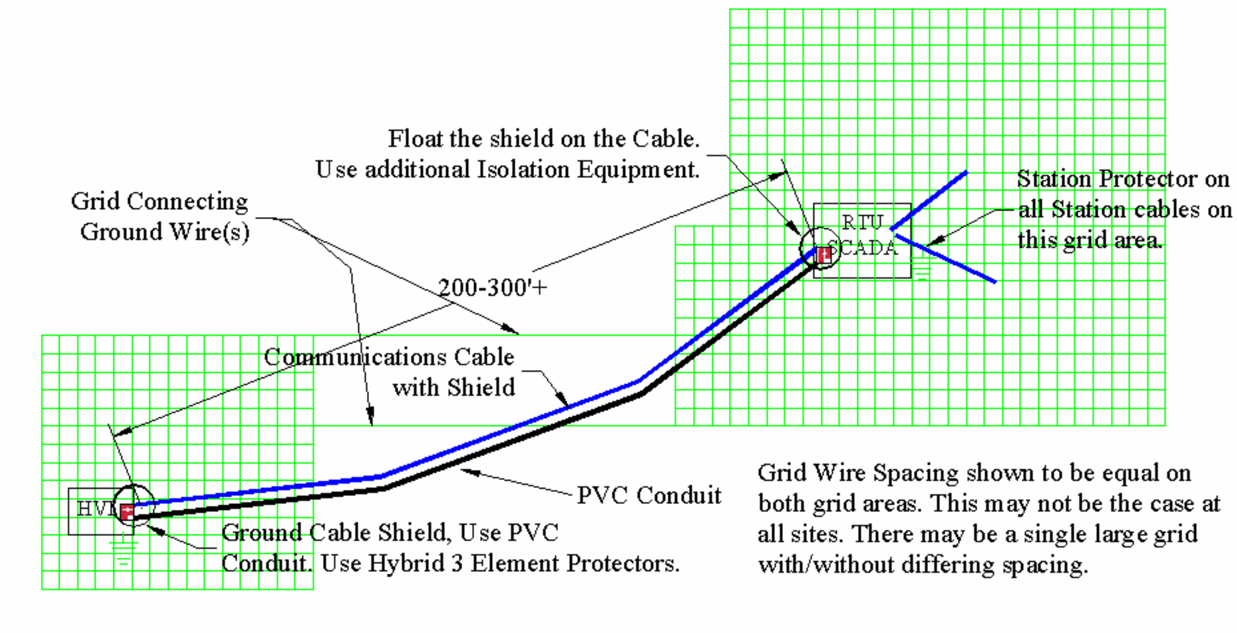

Figure 2
Greater than 200 feet from HVI to End Equipment

So if for example you have a very large grid and this station cable is going to be say 400, -600, -800, -1000 feet or longer, then other protection equipment and procedures should be utilized.

Why won't the 487 listed methods be sufficient when this cable run is considerable longer than 100 or 200 feet?

1. The #2/0 ground wire is not going to be much help, due to its extreme length and the electrical environment being stressed. The grid design with perhaps only two bonding conductors between the individual grid areas allows the two grids to achieve their own potential relatively independent from the other.

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2. Due to this extreme distance across the grid, the fault created voltage potential difference impressed upon the communication circuits will be present even if the grid area is of a design of large equally spaced grid conductors.
3. The cable should still have a shield because that allows for some harmonic shielding to take place. But again the length of the run and the cable shield resistance reduces the potential difference it can mitigate.
4. The station protectors will operate thereby introducing energy onto the cable pairs rather than removing it. Whereas the lesser energy involved with the 200 foot maximum distance exposure is controlled and allows both ends of the cable to assume the same level of potential.

So at what station cable length determines that the end to end distance is too great for the 487 procedure to be adequate? The actual ground grid design now enters the picture. If the grid system is composed of a very straight forward rectangular configuration with grid wires running at an even spacing through out the grid, then the cable distance can be greater because there will be less potential difference across the grid. However, if the site is composed of multiple grids connected together utilizing only one or two tie grid wires, then during a GPR event, the potential difference across the grid will be greater than an equalized even grid structure. In that case the distance will be considerably shorter, therefore recommending additional isolation equipment at the far end of the station cable.

So what to do:

1. Isolate the circuit(s) (originating at a CO or other feeding site) at the primary entrance (HVI) serving the substation or site utilizing an isolation card.
2. Install an additional isolation unit at the far end of the station cable.
3. Ground the station cable shield at the primary HVI location, but float it from ground at the far end (2nd HVI Location) where the second isolation unit is installed on the circuit.
4. Make sure that there is not a station protector installed on the feeding or primary HVI side of the second isolator unit at the far end.
5. However, a station protector installed on the cable pairs on the station side of the second isolator unit is a big plus in controlling energy on the station side of the second isolation unit.

Or

Another solution for this problem would be to consider a fiber system that would originate at the primary HVI location and terminate at the far end of the circuit. This of course would require an all dielectric fiber cable. And yes this fiber cable could be placed in a metallic conduit, although PVC would be greatly preferred, as long as the conduit is not connected (Bonded) to the same ground connection as the HVI, the Copper Fiber Junction (CFJ) (near the HVI end of the fiber

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cable) or the Optical Equipment Interface (OEI) (located at the far end of the fiber cable) (These terms are identified in IEEE standard 1590-2009). The conduit should not be bonded to the grid at both ends as the conduit would bring the differing potential right to the HVI thereby negating the use of a fiber system to isolate the circuits. Therefore the use of PVC conduit eliminates any conduit bonding to the grid. Placement of the CFJ should be at or immediately adjacent to the primary HVI location. Placement of the OEI should be at the far end of the circuit (across the grid) immediately adjacent to the equipment the circuit is connecting to. The (CFJ & OEI) are basically equipment locations that consist of the copper to fiber (CFJ) & fiber to copper (OEI) conversion equipment.

Summation:
So as you can see, there are significant problems when a station cable run is extended across the grid. But as you can also see, there are solutions that significantly reduce the impact from the energies involved.

Richard Knight