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The 300 Volt Point

By Richard Knight
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The importance of the 300 Volt Point:
This white paper is written to address this issue and to identify in detail the functions of the 300 Volt point.

IEEE Standard 487-2007 and/or 1590-2009 are used to determine the correct and proper methodology for deploying a copper or fiber based communication system into an electrical environment that is subject to GPR. These practices call for the placement of the Dedicated cable to start at the 300 volt point and the CFJ equipment for a fiber system should also be at the edge of the Zone of Influence (ZOI), which is more commonly known as the 300 Volt point. This position is taken because of several reasons outlined in this document, the most important of which is safety. Circuit and equipment reliability issues are associated with a placement location but these problems are eliminated when the Dedicated cable originates or the CFJ is positioned at the 300 Volt point.

This white paper documents the significance of following IEEE Standard 487-2007 and/or 1590-2009 when deploying copper or fiber optic equipment into a site subject to GPR. In addition, the copper cable feeding a Copper Fiber Junction (CFJ) fiber equipment installation should be deployed using IEEE Standard 487-2007. These two standards work jointly when using a copper to the substation or to a copper/fiber to the sub protection system.

The 300 Volt Point, What is it, Where is it, What happens there, and Why do I need it?

300 Volt Point or its' correct name is the '300 Volt Peak Asymmetrical Point'

What is it?
Explanation or Definition:
This is a location on the earth's surface where the resultant voltage from a GPR of a site subjected to a fault or condition from whence a GPR relative to remote earth is reduced to a level of 300 Volts Peak Asymmetrical.

This is also usually considered to be the outer edge or zone for the ZOI. The definition of the Zone of Influence (ZOI) follows.

Following is a direct quote of the definition from IEEE 367-1996 for the term ZOI.

"3.20 zone of influence (ZOI): An area around a ground electrode bounded by points of specified equal potential resulting from the voltage drop through the earth between the ground electrode and remote earth."

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Where is it?
The Edge of the ZOI and the 300 Volt Peak Asymmetrical point are general assumed to be one and the same.

The 300 Volt point for an installation is defined by the electrical parameters of the substation. This is the point where the Ground Potential Rise of the site is reduced to 300 Volts or less. This is usually a new or existing cable closure. This is a calculated location. The values utilized in this calculation are provided by the line to ground fault data along with other information regarding the substation in question.

What happens there?

Cable Splicing:
The 300 Volt point is usually a new or existing cable closure.

There will be a minimum of two cables in the closure at this point. The cable that originates at the Central Office will be called the general use cable. The cable that originates in this closure and routes into the substation switch room or equivalent will be called the Dedicated cable. Any other cables located in this closure will be referred to as other cable(s).

Splicing of the general use cable pairs to the dedicated cable pairs in this closure MUST follow the following rules:

1. All pairs spliced from the general use cable to the dedicated cable **MUST NOT** be spliced using modular connectors. These pairs **MUST** be spliced using single conductor splice connectors. This is an electrical dielectric strength item.
2. All pairs spliced from the general use cable to other cable(s) can be spliced using any normal splicing method.
3. All cable shields **SHOULD** be bonded together at this point.
4. Grounding of the splice closure is a **CRITICAL** safety item. This ground will be used to dissipate any energy from the cable pair protectors, if utilized, and the cable shields. Please refer to the section on grounding the 300 Volt point closure.

Cable Shields:
They will all be bonded together at this location. However, they should not be bonded to a MGN ground at this location.

Cable Grounding:
Protective Grounding - 300 Volt Point:
Grounding of the 300 Volt Point closure can be accomplished utilizing a ground rod driven within or very near (within a 6' radius of) the closure. Attach a #6 AWG bare copper wire to this ground rod and route it to this same cable closure. Attach this ground wire to the cable closure bond bar. All cables within this closure are to be bonded to this cable bond bar, thereby effectively grounding them to a local ground.
Under NO circumstances can there be a bond wire to any power system multi grounded neutral conductor or other power system apparatus at this closure.

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The local ground for this closure should be a low impedance ground. The value should be at or below 25 Ω's
This may require a special grounding scheme to insure an effective low impedance to ground connection of the cable shields, remote ground cable pair, or other protective or circuit equipment.

Cable Pair Protectors (if utilized):
The protectors used should be of a balanced three element gas tube design.
These units, if utilized, are provided to protect against conductor to conductor voltage imbalance on the Central Office side of the isolation equipment. Imbalances may be present as a result of induction effects and or other energy sources during a power system fault.

Remote Drainage Location (RDL):
This is usually a location where the GPR in the earth is at or lower than 300 Peak Asymmetrical volts. It is at this location where special equipment and/or procedures are deployed to insure a safe and effective Dedicated and/or general use cable installation.

The 300 Volt peak asymmetrical point value was selected as the Remote Drainage Location (RDL) or the last grounding point of the general use/dedicated cable splice point. This location/voltage level was chosen due to the operating voltage point of station protectors in common use on metallic telephone plants. This point is expected to be a safe place to stand on the earth and touch the cable pairs barehanded because it equals the maximum possible voltage level in the cable at any location in the network prior to protector operation.

This location is not always defined in a project or on outside plant cable records unless there is a need for one. This means that the design of the High Voltage Protection scheme may require a RDL for proper equipment operation or circuit function.
If a RDL is developed then special equipment and/or wiring methods are enacted.

Fuse Link:
The placement of a fuse link may occur here.
This is a cable of two gauges smaller than the Dedicated cable pairs. It is used as the name implies as a fuse. It works in conjunction with the station protectors when they are installed either at this location or just in the Central Office end.

Mutual Drainage Reactor(s):
The placement of a Mutual Drainage Reactor(s) (MDR) may occur here.
These are used to drain energy off of certain data type circuits. They help prevent excess energy causing equipment damage or circuit interruptions.

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Why do I need it?

The 300 Volt Peak Asymmetrical point is necessary and here are the reasons why:

1. **Potential Difference**
   During a power fault, or GPR event, the electrical potential between the local substation earth, where one is standing, is elevated to very hazardous levels relative to any conductive components, including cable pairs, that are floating at the Central Office (CO) ground potential.

2. **Earth Contact Between Personnel and Cable Pairs**
   Actual contact between personnel and cable pairs will present a hazard to the individual contacting those cable pairs if the GPR value impressed onto the earth at the location is at a level higher than 300 Volts.

3. **Potential Difference of Ground Contact of Telephone Equipment and Cable Pairs**
   If the metallic cable shield is connected to ground within the ZOI, the GPR potential at that grounding location will be fed into the cable shield. This will effectively extend the ZOI even further out due to the conductive aspect of the cable shield. IEEE Standards 487-2007 and 1590-2009 recommend avoiding this practice. The last grounding point of the cable shield should be well outside the ZOI if not just at the 300 Volt point.

4. **Special Safety and/or Protective Equipment Required**
   If copper extends into the ZOI beyond the 300 Volt point and interfaces to the electronic equipment via a CFJ device, the craftsman will be exposed to a grounding "step and touch" potential greater than the design limit for the cable environment of 300 Volts. If an installation is done in this manner, craftsmen involved will be exposed to the potential difference between the earth, locally grounded objects, and the cable pairs and will risk getting injured. Isolation mats and rubber gloves are required when handling the cable pairs and cable shield. A 20,000 Volt insulation value is recommended as a minimum. But placing the Electronics at the 300 volt point solves that issue.

5. **Dielectric Pad**
   The use of a dielectric pad, adjacent to an equipment enclosure, adds additional issues to consider. What keeps the pad clean? Is someone going to use a pressure washer to clean the surface and dry the pad every time? Even if the pad is placed on top of gravel, there will still be a resistive connection to the earth. Over time, wind, dust, rain and other weather related events will degrade this dielectric earth contact to a point where energy could be transferred. By placing the CFJ equipment at the 300 Volt point these issues are reduced to a safe contact level.

6. **Protector Operation**
   If a protector is installed on the cable pairs within the ZOI, a direct connection of the GPR energy will be connected to the cable pairs via the ground connection for the protector. This energy will then be drained off at the CO or the next closest cable pair protector. If voltage levels exceed the operating point of the protector anywhere in the network, that protector will operate and then drain

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that energy to the protector ground thereby removing it from the circuit. This will occur whether the protector is at the CO or at a remote location in the network.
Placement of a protector within the ZOI or at a level higher than the 300 Volt point is **DEFINITELY NOT RECOMMENDED.**

7. **Extending a Fiber Cable**
   If a fiber cable is placed between the CFJ and the Optical Equipment Interface (OEI) equipment, it can be extended so that the origination point is at the 300 Volt point and the terminating end is on the grid. This will eliminate any concern over equipment placement and possible contact between the equipment and cable with the energized earth.

8. **Different environments skew the Zone of Influence (300 Volt Point)**
   Due to the existing infrastructure in some environments, the 300 Volt point may not be easily or accurately determined and can actually skew the location of the ZOI. Considerable thought has been given to the entire infrastructure and determining the acceptance of going a few feet from the site and terminating the copper to fiber interface at that location. This brings up the issue of establishing what the infrastructure is, and how to apply that knowledge to a real-world design of the installation. This skew could place the 300 Volt point further away from the GPR site.

   There are many items that affect the actual 300 Volt point location, which are both above and below the earth's surface. IEEE Standard 1590-2009 identifies the CFJ's location to be at or closer to the Central Office than the 300 Volt point location

9. **Personnel Expertise**
   In utilities, the level of technical expertise among personnel is constantly changing. Therefore, the employees may not have the knowledge or the means to conduct an appropriate study to determine what aspects of the infrastructure that should be involved in determining the effective ZOI. This might result in an almost impossible task to accurately identify and evaluate all of the infrastructure items that could be involved. The cost of doing this far outweighs the cost of extending the fiber cable to cover the distance between the 300 Volt point and the site subjected to GPR.

10. **Earth Surface**
    A key element when determining the 300 Volt point is the fact that the earth is not made up of homogenous material. The higher value of the known resistivity of the local terrain should be used when calculating the 300 Volt point. Determining the location of the 300 Volt point using a more conservative value would result in it being further from the GPR location, which would be the safer procedure to follow. This would apply to personnel first and equipment last.

11. **Additional Grounding**
    If the 300 Volt point is chosen for the deployment of the CFJ, no additional grounding or specific ground ring is required.

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Conclusion

Hazardous voltages can appear suddenly as a result of power faults or lightning strikes. Conductive objects (metal, damp saline soils, etc.…) can become energized or carry a harmful potential that, if not properly protected, can cause serious injury. Safety of personnel can be achieved through education, proper facility design, and approved and tested insulated safety equipment. Personnel should use approved and tested rubber gloves and/or insulating blankets when working within the ZOI on the cable(s), equipment and high voltage interface (HVI) equipment.

Touch potential is the difference between the voltage gradient that one is standing on and the voltage gradient of the object one is touching. A significant difference in touch potential can be hazardous. Step potential is the difference in voltage gradients between a person's two feet, when making a nominal step of 30" spacing.

It is imperative to establish the proper protection scheme when dealing with telecommunication circuits and at any location where high voltage equipment is co-located with these circuits. The safest and most cost effective protection will always utilize High Voltage Isolation designs against GPR. Protection against both high voltage contact and GPR is the best precaution against equipment failures and human injury.

Deployment of the CFJ at the 300 Volt point, which follows nationally recognized protection schemes with approved methodology and equipment, eliminates any GPR related problems that the CFJ would be exposed to if located within the ZOI.

Reliable communications require a properly protected telecommunications network. Isolation is the best means of protection against the effects of a Ground Potential Rise (GPR). Whether you are an electric service provider, power utility, rural electric cooperative or telecommunications provider, you are subject to a hostile electric environment. An unprotected or improperly protected network is unsafe and exposes equipment to service interruptions, outages or damages.

Each year, electrical damage from GPR has an estimated cost in the millions of dollars. Safety is of the utmost concern and protecting the lives of those involved is essential, which is why manufacturers design their lines of Fiber and Copper isolation equipment around industry standards. IEEE Standard 487-2007 applies to Copper based installations on a site and IEEE Standard 1590-2009 applies to Fiber Optic based installations on a site.

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