Dissertation Paper On The Subject Of Grounding Methodologies:
A Comparison
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October, 2007
(Illustrations and photos are high resolution files
And may be copied and zoomed for examination)

OPENING:

Change is not necessary or relevant for all things. Change is the evolution of an idea that has been developed and has reached a point where some form of need, requirement, growth or progress mandates that new ideas be considered. It is this consideration that promotes change.

Grounding, a term widely used and mis-used for the last hundred years. Before the era of wire based conduction of electricity, Benjamin Franklin tried very hard to incinerate himself by flying a kite in an electrical storm to prove or disprove wild theories about the phenom of lightning. Ben's conductor was a wet string to which he had tied a fabled metal lock key. It was his hope that he would be able to change the theories about lightning and make a practical judgments about what he learned.

Grounding, here we go again. Grounding, Earthing, by any other name, the conduction of electrons, or static potential, to Earth or a commonality of potential amongst objects commonly at the potential charge of the surrounding earth. Grounding is a term that can be construed to connotate a Noun, Verb or Adjective. Like many words in the English language it can have many meanings and be grossly abused. Grounding is a practice, a convention, and an art form.

It is the intent of this paper to introduce the concept of the Distributed Single Point Ground. This is an adaptation of the widely accepted Single Point Ground theories being promoted by a number of manufacturers of electronic equipment. In the concept of Single Point Grounding, there is only one point that is tied to earth and from this point, all sources of power, control, signal sourcing and of course, Grounding emanate. While it has become common practice to unify the single point ground within an apparatus, this practice has not been properly extended to the installation of complex associations of these apparatus within a given site. While the Single point Ground is an appropriate and safe way to control fault energy within an apparatus, the Distributed Single Point Ground is required due to the complexity of most electrical, industrial and transmitter sites.

Convention:

We have done "it" this way for decades, made few significant changes, killed low numbers of people, and have had "some" success with the way we do "it", Why change now? This obviously applies to every thing in every day life.

Conversely: (per grounding)

We have seen many changes in the global grounding scenario as evidenced by the multitude of educational grounding primer documents and de-facto standards that claim there is enough data, if not history, to recommend changes in this time honored methodology. (A supposition) Practices are also held tightly to the convention of the writer of a particular document.

Grounding Is A Religion:

Though a provocative statement, this is a stereotypically accurate statement.

The art, science and craft of Grounding has been around for such a long time and there are so many beliefs, facts and myths, that it can be allowed that no singular methodology is wholly correct. In today's modern world, the problem of Patent Infringement and other legalities drives these numerous fallacies. It is impossible for any one company to create a methodology that would be totally correct without stepping on another companies Patents or (copy) rights. If this is not complicated enough, simple pride and misunderstanding accounts for the rest of the out right fabrications and distortions of the truth..

In grounding, conventional thought also has to be understood that every situation is different. Certainly there are similarities, but the small esoteric differences in every facility mandate that an open mind must be maintained in the design and application of which ever convention is used. In this paper, I refer to numerous large and venerable Corporations that have been involved in the Two-Way-Radio, and Broadcasting businesses.

These corporations are regarded as knowledgeable and should under any circumstances be held above reproach in their teachings, as these teachings are developed supposedly in the vein of protecting the end user from harm. In truth, these teachings are developed to protect the corporation from harm and inadvertently protect us, the users of the equipment though the aforementioned limitations of acceptable broad thought apply. Corporations protect themselves at our expense and are driven by liability and the ramifications of exposure and indemnification. Among these venerable corporations, documents from Motorola, Telos, Polyphasor, and Nautel are offered up for evaluation. While there are literally hundreds of published works, selected topics will be used to illustrate the numerous considerations required here. These works are selected to promote a combative comparison amongst the documents, and not to initially promote a theory or point. It should be noted that these referenced works completely and totally contradict each other. To make matters more confusing, the works of Polyphasor, typically authored by Mr. Roger Block, contradict each other from document to document. It is the intent of this paper to show the extreme diversity of the Religion of Grounding and to make some sense of it in proper applications.

Grounding Is A Lot Of Subjects Under One Header:

Grounding as a descriptive activity, regardless of the method, and the assumption that the purveyor has no axe to grind, and selflessly promotes the intention to protect equipment and personnel from damage due to lightning strike, or other electrical fault. These strikes may be either direct conduction, or impressed in the form of near field, static, or EMP (ElectroMotive Pulse, a magnetic impression wave)

We will use some generic terms. These terms will include but not be limited to, Strike, Pulse, EMP, Voltage, and Current. What is the idea? The goal is to avoid the "Strike".

Secondarily, the goal is to minimize the strike and in a tertiary thought, to control the strike and any potential for damage. These are three simple goals. We shall develop the thoughts in sequence.

Avoid The Strike:

Among the fallacies, the tallest thing does not get struck every time, the smallest things can be struck as many times as the largest thing. Laying down in a field during a storm may not prove to be safer than standing up. There are many half truths and loads of out right lies. To avoid the strike, it is accepted that the ground charge potential in respect to the cloud charge must be bled off so that the difference of potential no longer exists. If there is no longer a difference of potential, there can be no strike. The huge debate is exactly how is this accomplished. The Patent infringement suites abound here. It is accepted that a sharp object will dissipate a charge and a rounded object will gather a charge until (in either case) a sudden discharge event occurs. Leaving Patent law out of the equation, these two theories have been proven in physics by everyone from Nicola Tesla to your high school teacher. No matter how you do it, get rid of the difference of potential.

Minimize The Strike:

If at first you don't succeed, try again. So dissipating the charge did not do the trick. The argument is that by trying to dissipate the charge, you actually caused a strike on your own site. This is partially true. By attempting to bleed off the difference of potential, you inadvertently created a step leader which is the pre-cursor to the actual strike. With nothing ventured there is nothing gained. The idea is to bleed off the charge so that the strike will not happen. If the charge is building at a rate faster than you bleed it off, the strike will likely occur, however, it is widely accepted that if you have been bleeding off the charge, the impending strike will contain substantially less energy than if you had not bled off any charge. You have therefore minimized the strike to the best scenario. If you are going to get hit, get hit with the least energy possible.

Control The Damage:

Ah, the crux of the goal. At first the goal of total strike avoidance is attempted. Failing this, the impending strike is minimized and what you get hit with is theoretically less than what you would have gotten hit with had you not given the streaming of surplus charge ions a chance to harmlessly equalize the difference of potential. The strike hits, It seems like the big one but in truth it is just a remnant of the big one. Where does it go?

Where do you want it to go? How do you get it to go there? What is required to do this? The questions grow and the answers as given in the referenced documents contradict each other. Again points taken in turn.

It is fairly fruitless to debate the cloud to ground or ground to cloud theories of positive or negative streaming and the direction of the actual strike. Point of fact is that hundreds of kilovolts and tens of thousands of Amperes is looking for a place to go.
The safe bet is that you do not want it anywhere in the building and it should just dissipate into the ground somewhere else.

Diligent reading of the offered documents will lead you astray and in the application of the thousands of pages tips and hints you will often wind up causing yourself significant damage instead of avoiding it.

Mis-application and cross application of conflicting conventions is very dangerous. The typical grounding system is designed for a taunting low resistance with little thought as to the inductances involved.

We will learn that low resistance and low inductance coupled with straegically placed higher resistances and high inductances are our friend.

In order to avoid being your own worst enemy, the idea is to harmlessly divert the strike energy in to the earth, not running it around the plant in circles where it will cause problems to equipment, personnel, or structures. The most egregious fallacy is that the steel used in your building or in your foundations makes a good ground. This steel may make a barely suitable substitute for a Faraday Cage but never a ground. When energized as a conductive part of the intended grounding system, (sometimes referred to as Ufer ((yoofer)), tremendous damage due to sudden expansion of metals from generated steam has been seen to shatter solid concrete and destroy foundations along with other critical building components like columns and beams. This fracturing allows water and salts intrusion which further promotes and accelerates deterioration. The possibility of electrocution from energized building steel is a tremendous problem, as is fire from arcing. These objects of steel should be tied to the grounding system and isolated from your electronics, but in such a fashion as to drain their charges and minimize the chance for the electrocution of equipment and personnel. This clearly dictates that the use of these steel components as conductors in the grounding system is wrong if not dangerous. The strike energy needs to go in to the earth and be dissipated downward. There is the key word. It is Downward.

Downward Dissipation:

Vegetation, animals and people are killed every year by both lightning and downed power lines. They die due to simple electrocution. While it is established by theory that many people die from the hysteria that an electrical shock imposes thusly causing their own heart attack, the act of electrocution is real and can not be disputed. Documentation is offered that when in near proximity of a downed power line or caught in an impending lightning strike, you should stand perfectly still with your feet close together. This is because energy is being dissipated in to the earth and as it radiates horizontally,

outwardly from the point of contact, these voltage field gradients may be sufficient to breach your footwear (provided you are not lying down as some ancient lore suggests) and these gradients enter your body via the legs and impose a sufficient difference of potential via voltage and current to cause electrocution. It has been supposed that you should shuffle your feet one inch at a time, never breaking contact with the ground, to leave the affected area, hop with both feet together or hop on one foot until safely out of reach of the voltage gradients. Variations of these theories are commonly taught to electric utility personnel. Other than electrocuting vegetables and creatures, this horizontal gradient of electricity from a nearby strike is unfortunately also picked up by the grounding systems of buildings that are in the way of the emanating waves.

Remembering that the key word is Downward, the un-tamed strike energy radiates both downward and outward (spherically) from a surface point strike or energization. Patent infringement is not the only problem in the scenario. As well meaning as it may be, the National Electrical Code causes some problems here also. Generically, the code requires that all metal objects related to the electrical system be tied together. This causes much flag waiving by designers of grounding systems.

The over zealous bonding of every metallic thing to every other metallic thing causes damage in the worst way. It is impossible to sufficiently bond objects together so as to eliminate the action of circulating currents during a strike event. It is these circulating currents that cause the primary damage.

While it is convenient to assume or think that the electrical supply of a device can be sufficiently insulated from its metallic case (Hi potting tests) the fact is that flash over's do occur but these are unavoidable when the aforementioned difference of potential exists in a sufficient quantity to breach any insulative medium. This aspect of damage will be ignored as irrelevant to this discussion. The goal is the control the strike and where the damaging energy goes. It is accepted that the single point, or star ground is effective. If all objects emanate from a central point of reference, instilling a strike charge on the quantity, (ignoring the possibility of power supply internal breach) will elevate the potential of all objects of the quantity for the duration of the energy impression and upon dissipation of that energy, all objects within the entity will return to a normal potential. The theory is that a single point grounding system has no circulating path. With no circulating path, there is no current flow. With no circulating path, there may exist a difference of potential but is it accepted that the simple existence of a difference of potential may only cause normally conductive and non conductive objects to physically move, and/or also stream ions in an attempt to equalize their charge with their surroundings (VanDeGraff) When shuffling across a carpet in a dry environment, you build a static charge. This charge builds and dissipates by itself. You are totally unaware of the charge until you touch the door knob.

While the works of Polyphasor are contradictive, the works of Motorola in the R56 manual (while a very good publication) (among others) poorly apply many conflicting conventions in a singular manual. The correct applicative approach is to take the conventions from each work, and condense them in to a cohesive theory which is properly applied for each specific scenario..

The Design:

As each site is different, so each site is the same. For the purpose of this paper, it is assumed that there is a source of entry for the strike energy. It is assumed that there is a shelter of some type and there is equipment contained within the shelter along with random personnel. Ben Franklin would have enjoyed being able to use a 1549 foot tall lightning rod for his experiments. Assuming the worst, the lightning rod is adjacent to the shelter. This distance is typically under 100 feet. A properly designed dissipative array is purposed to direct the strike energy developed from the tower "Downward" in to the earth, and away from the shelter horizontally and vertically. Proper design of the grounding applications of the various electrical and radio related conductors descending from the tower also assist the strike in a controlled way on the downward and directively outward path. Stray energies will radiate horizontally through the earth toward the shelter. This energy and the remaining energy on the conductors attack the shelter. The National Electrical Code contributes to the damage by mandating that all electrical devices be contiguous. There is no definition of what contiguous means other than to be connected by conductive means. This is a good loop hole that we will exploit to our advantage. Effective strike control is to effectively control the strike. This means putting the energy where you want it and not where you don't. In this paper, new theories of directivity are introduced while complying with the NEC, and keeping the integrity of the equipment and the safety of personnel as priorities.

In figures 1 and 2, it is seen that the subject sites of WEAT FM and WKTK FM are shown in graphic representation of an electrical circuit equivalent in 3 dimensions. Apologies for the limitations of the drafting program. In these representations, resistive and inductive components are considered. Any capacitive features would be considered to be a part of the insulative barrier against the break down of the difference of potential are not a part of the discussion.

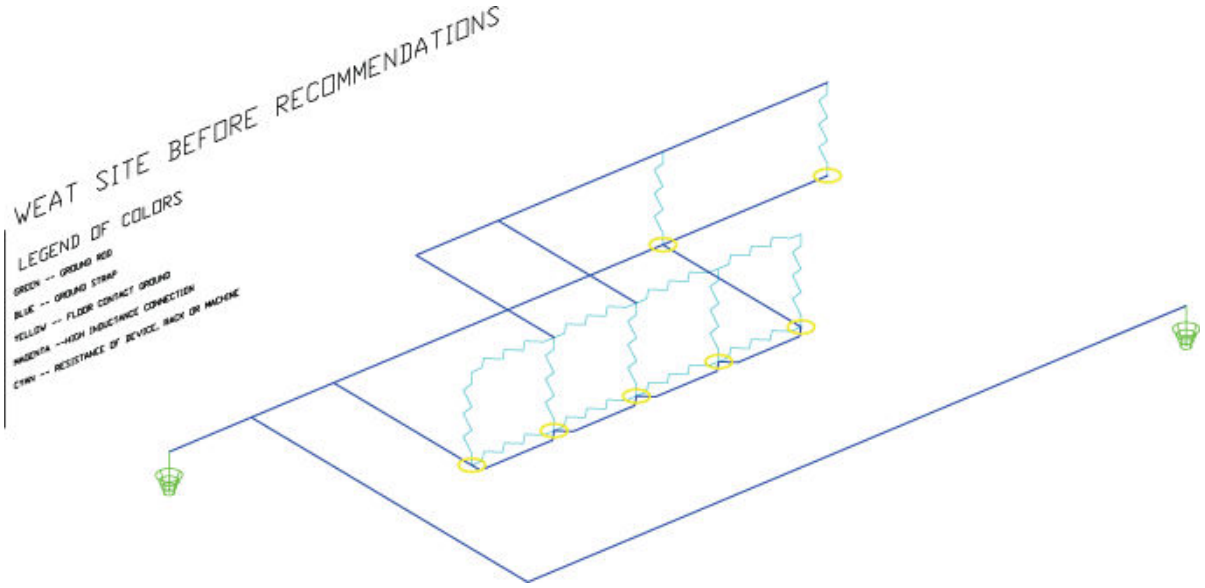


Figure 1

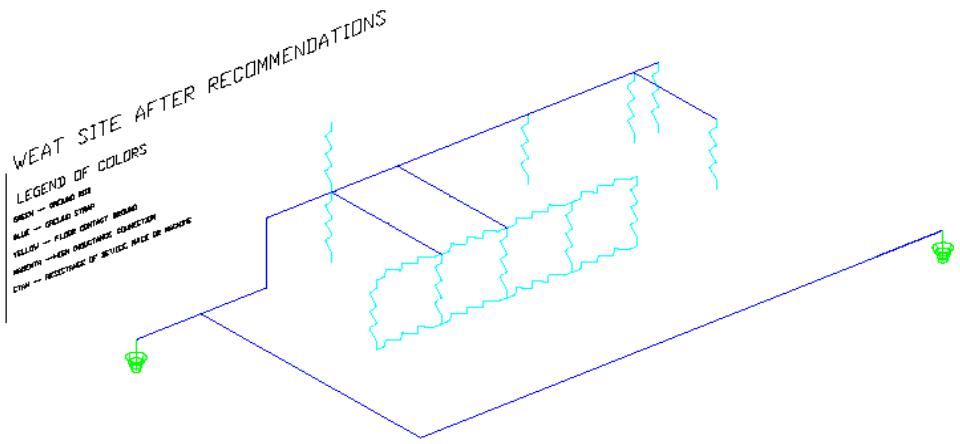


Figure 2

Figures 3 and 4 show the same sites after modifications were made or proposed. All figures and drawings in this paper suggest changes that may be proposed and may not as of yet been implemented. One can see that the elimination of circulating paths has largely been accomplished. It is un-avoidable to eliminate all paths due to requirements in the conduit and wiring systems but attention to detail is made.

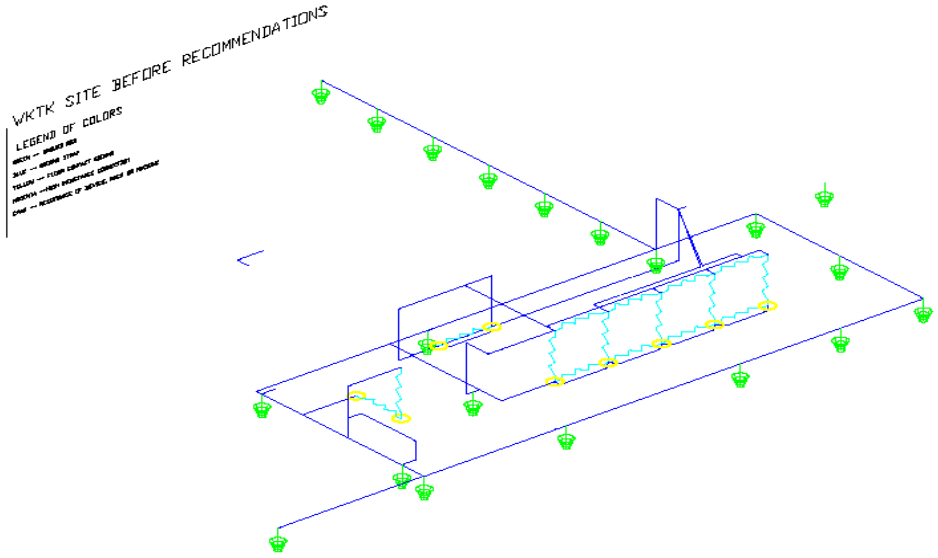


Figure 3

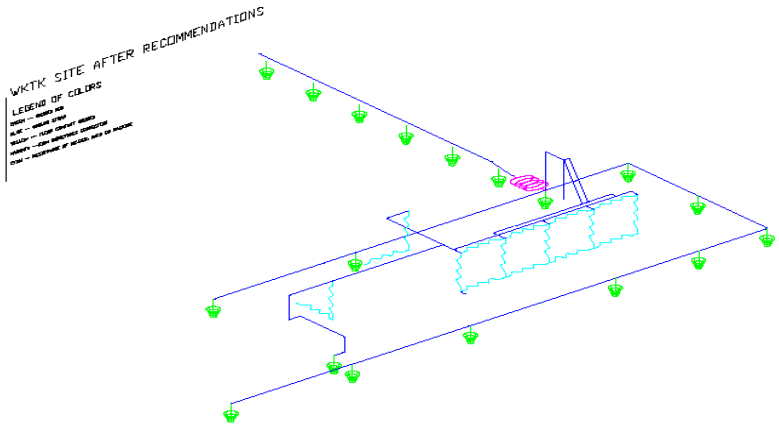


figure 4

The Theory:

Remove the circulating current paths and everything in the room stands up with a potential rise and once dissipated milliseconds later, it all sits back down un-touched. Without circulating paths, there is no current flow. Ohm and Kirchoff would be proud. With no I/R losses there is no voltage drop. With no voltage drop, there is no dissipation of current. With no dissipation, there is no heating, arcing or burning. Figure 5 shows arc flare of components subjected to current flow in a circulating loop. Figure 6 shows simple breach the insulative barrier due to arc over. Because we are dealing with two energy sources. Two methods of control must be considered. AC Mains and Strike potential.

Figure 5

Figure 6

AC Mains:

It is essential to control energy impressed on to the AC Mains regardless of the source. There are many devices that can contribute to peak voltage limiting of the Mains and they will be largely ignored. Suffice to say that regardless of the spike source, limiting of the spike voltage is essential to minimizing the damage to the equipment in the shelter. Figure 6 is referred to again. The two basic types of Mains surge arresting are series inserted devices and parallel devices.

The series devices are substantially more effective at spike control in the use of inductors, and as they often also contain a method of sine wave tracking which minimizes the spike to a low RMS average value, as opposed to peak value, regardless of the position or location on the sine wave. Parallel devices usually only clamp the spike voltages to a prescribed value regardless of the location (time, and angle) on the sine wave. Assuming that the spike energy is controlled by either keeping it out of the plant and/or clamping if it is generated by an errant machine in the plant, this topic is easily dealt with. Surge arresting is typically accomplished via devices situated across the line to neutral, line to ground and neutral to ground. (assuming the arrestor is not located in direct proximity to the first means of disconnect that has the neutral grounding bolt inserted.

Strike Potential:

The tough one. The strike needs to be diverted. Entry of the strike energy into the shelter must be avoided. The AC Mains protective system can assist with this imparted energy but only if it is impressed on to the Mains conductors, or attempts to breach the conductors insulative value if entry is achieved on the grounded or neutral conductors side of the shelter devices. The entry of strike energy in to a shelter system through the grounding system and devices in mechanical contact with the floor that causes another significant source of damage is called the Reverse Burst. This is the crux of the requirement to insulate devices from the floor in the shelter. The rest of the diversion is left up to effective fire walling of the energy at a machine location.

Enter the Single Point or Star ground. In a physical plant the size of any transmitter facility, whether simple cellular or broadcast, the idea of a true single point is almost not possible. The modification of design called the Distributed Single Point System is introduced. This theory involves the creation of single point entities unto themselves, acting upon and by themselves and minimizing electrical contact (conduction) to the other members of the quantity. Figure 7 shows a design for a grounding system for the WKTK site. In this design four entities are created.

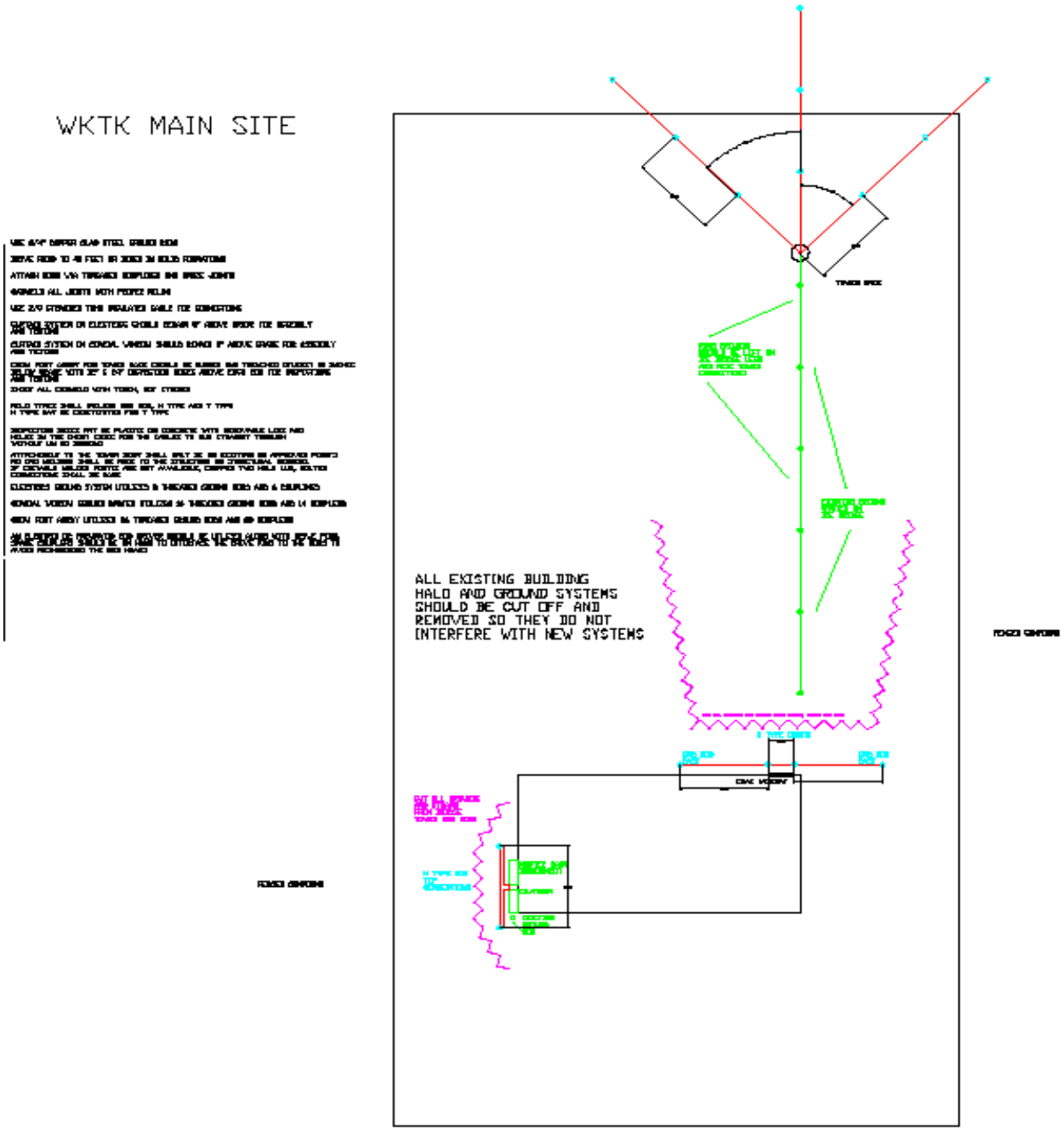


Figure 7

Grounding Entities:

Tower Entity:

The Tower, AC Mains, Cable Portal, and the Shelter are the Entities. It can be seen that in the tower entity, a dissipative array that is called the Crow Foot is applied to promote the "throwing" of the charge away from the shelter. This is accomplished by installing this geometry of the array outwardly, away from the shelter and downwardly via 40 foot driven rods. (physical design selected for local conditions) The mechanical assembly of the array will be ignored. It is important to accept that the energy from a lightning strike on to untreated soil imparts energy that is a half spheroid in shape. Energy will radiate as essentially well downward as well as circumferentially outward. (excepting for gradient moisture changes which cause a cardioid emanation downwardly) Strike energy imparted in to a single ground rod of sufficient length and construction, changes the geometry of the imparted energy in to an ellipsoidal or conical expression with minimal horizontal radiation.

The energy will prefer to travel on the metallic conductor rather than radiate outwardly in to unknown soils. This Tower array Single Point entity exists singularly. To maintain compliance with the NEC, this array is allowed to be contiguously connected to the shelter, only, via the descending cables from the tower. While these cables are also treated as a part of the tower entity in strike management, there is some remaining energy transmitted via these conductors.

It is the intent of this hap-hazard (casual) conduction in to the structure that is secondarily addressed. The geometry of departure of the conductors that go toward the shelter determine the amount of energy imparted. A simple 90 degree bend offers some change of impedance to the strike energy. Creating a dip in the conductors in excess of 90 degrees, if not a full circle, offers substantially more inductance. This is especially effective when the conductors are appropriately grounded and bonded to the Tower ground entity (not the structure itself as is a common mistake) to bleed the charge off of the lateral run. Where possible, one or two turns in a rigid loop formation offers the greatest rise in the inductive path value and creates the highest impedance to this energy which can be bled off to the tower ground before heading for the shelter.

Cable Portal Entity:

The cable portal can be a major source of energy imparted to the shelter. This portal entity is controlled by the proper application of various devices and methodologies such as grounding straps and surge arresting coaxial devices (which will be ignored) to the cables entering the shelter. Energy from these cables may be arrested and controlled by the driven array curtain as shown in figure 7 if properly applied. The grounding entity of figure 7 is in compliance with the NEC in the requirement of a contiguous connection if only via the cable conductors. Herein lies one of the keys. Figures 3 and 4 insinuate that the connection of the tower and portal arrays are indeed contiguous but they are highly inductive. It is this high inductance value and low curtain array resistance that creates a substantial barrier to strike energy. This in effect creates a RF shunt network.

It should not be debated that unlike a standard Fall of Potential grounding system test which measures the effectiveness of non R.F. wave fronts, high inductance values pose significant impedance figures to any imparted strike energy due to the high rise time (high frequency) emulation of the strike. The tower entity is inductively separated from the portal entity via this high inductance. This high inductance is insured by the cutting of the traditional convention of the connected ground strap to the tower system and the portal/shelter entities. See figure 8.

figure 8

Mains Entity:

The Mains entity incorporates a similar curtain array as does the portal. This driven array bonds the AC Mains to earth thusly enhancing the NEC requirement of a driven stabilizing ground conductor. It should be understood that the driven ground conductor at the base of the supply pole or ground mounted transformer is placed to protect the Power Company assets and stabilize their device. The Mains array only has contiguous connectivity to the Power company via a relatively small conductor which is very high in impedance and inductance above 60 Hertz. This is fortunate since the Power Company grounding conductor is tied to another lightning rod that is many miles long. The Mains entity also has contiguous connectivity with the shelter electrical distribution system via a much lower inductive conductor due to the multiplicative paths of grounds, neutrals, and the Neutral bonding screw. (bolt, on larger systems)

Sufficiently sized neutral conductors, and the augmentation of segregated grounding conductors in both insulative dedicated conductors (green) and the related metallic conduit systems, augment this low impedance. Not wishing to make any claim that the NEC is designed to damage systems in the shelter, the attention paid to conductor size, bonding and conduit layout and assembly during site design or re-work are very assistive in to the Distributed Star Point construction within any shelter.

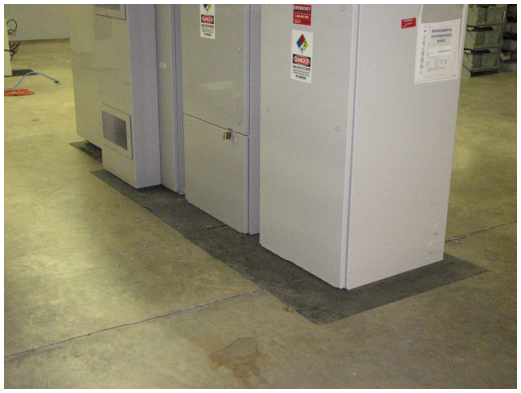
Shelter Systems Entity:

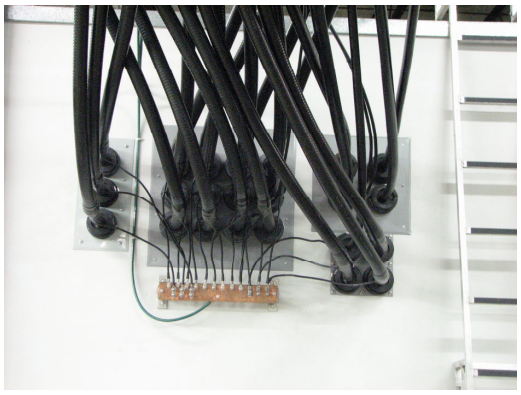
After the Tower entity, the Portal entity, and the Mains entity, the Shelter entity Single Point design is the most corrupted. While attempting to maintain the Single Point design inside the shelter, corruptions and the occasional crossed connection can not be avoided. Installation of inter device conduits and control circuits often inadvertently corrupt the Single Point design and can not be avoided. These corruptions can be minimized on a best effort basis by more careful design of the conduit systems and subsequent bonding of these systems. (See figures 9 through 13) The shelter system has long suffered from conforming to the antique convention of running the tower ground bonding straps from the tower entity invasively inward to the floor of the shelter. This strap usually also picks up the building steel, floor reinforcing bar systems, and the bases of all metallic machinery in the shelter and then heads for the AC Mains system. This strap system creates a dynamic circulating current loop for not only AC Mains stray voltages and currents, but distribution of strike potentials from both direct conduction and antenna like inductive pick up of EMP magnetic waves. It is exactly the installation of this strap system on the BOTTOM of each metallic device that causes the Fuse Effect.

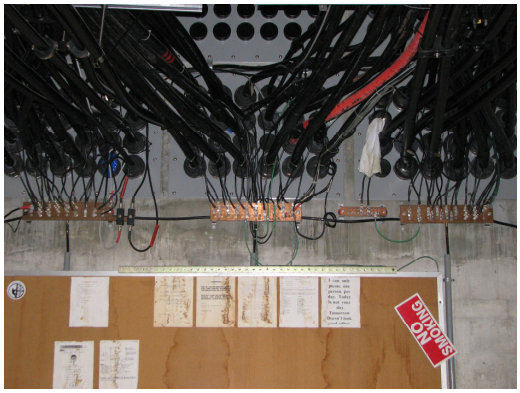
When strike energy is imparted in to the shelter, this circulating current flows in an inductively induced fly wheeling manner throughout the shelter one or more times before dissipating. This flow of current treats the fall of potential across the top to bottom of a metallic device as a Fuse. Sufficient impartation of energy in this fall of potential turns everything in the rack in to a fuse and the result is seen in figure 5. An exception must be mentioned which involves methods of integrity for AM Radio Stations regarding the connectivity of the transmitter, Antenna Phasing Equipment and the Antenna array's themselves. The incorporation of the large strap system has been considered a key component to the proper installation of these systems however It is maintained by debatable theory that treating the bonding strap with a substantial curtain array at the entrance to the shelter will assist in the control of imparted energy to the Shelter. The writer maintains that this straps entry in to the building is unnecessary and may be inductively segregated or eliminated as prescribed in this paper while still maintaining the R.F. integrity of the system.

Again, the goal is to eliminate circulating paths. The removal of the strap system from the bottoms of the shelter devices is key and critical. As seen in figures 9 through 13, this installation method utilizes not only the top of device connectivity convention but also insulates metallic devices from the floor. Figures 9 through 13 show applications of this insulative and device based Single Point technique.

Figures 9-a Through 13 Follow







Implementation:

Once the design is accepted, the construction or modification of a site should commence. Testing of the various conductor paths to be removed or observed, may be done by a the use of a Volt-Ohm meter, or by measuring the effect of inserting of a small isolated power supply with an ammeter, (low voltage AC or DC) or a ground resistance clamp measurement system, (see figure 15) along with visual inspection. A three point fall testing set is depicted in figure 16. Ohm meters are subject to errant readings due to small stray circulating currents in the Shelter Entity. This can be confirmed by the careful removal of one end of a grounding conductor and noting that a voltage exists on this now free wire. This is likely indicative of another potential (no pun intended) problem in the plant. Small isolated 2 ampere power supplies or AC voltage sources with an ammeter may be used with a Variac to determine the resistivity of a conductive path where stray currents or voltages may exist either due to leakage or induction. Clamp on meters may be well suited for measuring, tracking and routine maintenance of rods by recording the stray currents and resistance of a given single ended entity such as a rod in an inspection well once or twice per year.

Figure 15

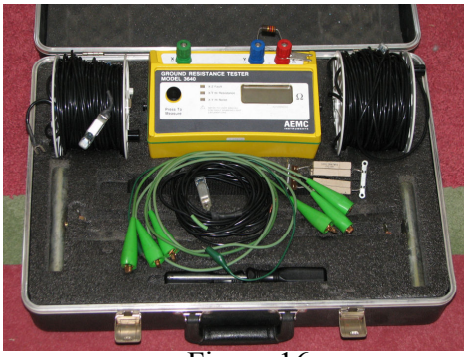


Figure 16

Once conductors have been identified as either removable or repairable, it is the goal of a conductor to have a very low resistance amongst itself within the entity in which it exists and to have a low resistance toward the grounding array to which it belongs. It is the further goal to create either deliberately or accidentally a high inductive coupled impedance value between the entities in order to comply with the requirements of the electrical code. Examples of highly inductive couplers could include the outer conductors of RF related cables or the shields of signal cables between one entity and another. Where these casual conductors do not exist, a coil of wire of an appropriate gauge may be created and contained within a steel enclosure of sufficient size with a removable cover to hold and protect it. This coil of wire will allow reasonable amounts of lower frequency currents to pass when needed during a 60 Hertz fault so that the distributed aspect of the large foot print grounding system may come in to assistive play but the tightly affixed coils of wire will present a very high inductance/impedance to a high frequency strike whether direct conduction or EMP. This coil of wire can also be used as a gauge of effectiveness after a known strike to see if the coil has blown open or burned in any way, or if the method of securing the coil such as nylon tie wraps has been damaged. The integrity of the system is totally dependant on the methods of connection whether bolted, clamped or preferably exothermic. The integrity of each entity is dependant on it's ability to stand alone in it's function and to not affect, or rely on, the entities adjacent to it.

Inspection:

In the design of the various entities of the grounding system, it is important to be able to inspect, log and repeat testing and verification of the effectiveness of the design along with certain components. The use of large deep plastic valve boxes or inspection boxes at the location of each driven rod is very important. At regular intervals, use of a device such as the clamp on ground component tester may be utilized to verify the continued resistivity of a driven or planted rod system. This device is simply clamped around a singled ended entity such as a ground rod or a wire singularly leading to a ground rod. This resistive value should be logged an maintained for future use and testing. Upon finding that a particular rod may have "glassified", from the observance of an elevated resistivity, corrective replacement action may be taken. Glassification is the turning in to a glass like material, the earth surrounding a driven ground rod by imparting extreme heat in proximity to the rod. Glassification of a ground rod renders it void as a conductor of strike energy and may raise the resistive value by a magnitude of several hundred times the initial driven value. Contact with a glassified rod during a strike condition may be fatal as it does not flow current to minimize voltages in I/R losses.

Maintenance:

In this paper we have seen various points of view leading to a new cohesive thought of designing, constructing, repairing and managing a ground system. In this care and feeding we see that it is possible for even the best design to fail at some point either through the application of overwhelming energy or in the performance of it's duty.

Like any electrical or mechanical system it is important that a maintenance and inspection program be designed for the various entities in the facility which is unique to that facility. Hopefully it is this electrical and visual inspection regimen that will surface any deficiencies before they become issues during the next strike event. It is often noted that simple decay will deteriorate any grounding system however it is usually the damage that is developed in the performance of it's duty that brings most of the damage to light. Hopefully this damage is the sacrificial anode so to speak of the system and that the integrity of the apparatus and personnel at the site were spared.

Conclusion:

It is not as important what you tend to believe or what is fact or fiction. The proof of the matter is that certain techniques work and others are simply ineffective or downright dangerous to materiel or personnel. As mentioned earlier, as each site is different, each site is the same. The commonalities of installations are the backbone of most system designs. It is the small esoteric differences that require us to apply the element of not only common sense but practicality in the effective design of grounding and electrical systems. Proper application of the various conventions to each identifiable entity in a physical plant is critical to the longevity and trouble free aspects of survival. Simply because we as a group have done "it" a certain way for ever, is not a good reason to continue to do this type of thing especially if there is conclusive proof if not reasonable conjecture that there is a better or safer way. Effective application of the numerous grounding conventions needs to avoid the pitfalls of Patent infringement or legalities and rights indemnification. Bold steps need to be taken to create a more unified and appropriate convention that allows the designers and ultimate users the assuredness that a system was specifically and appropriately designed for them and favors none other than them. Lightning suppression is about control. The best way to control the bull in the china shop is to keep him out all together. Mega Joules of energy will go pretty much where it wants to but with a little creative help, it can be harmlessly diverted.

End of Text

FIGURES LIST:

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