WHY ALL THIS NOISE ABOUT GROUNDING?
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When I was asked to speak before a group of architects and engineers about grounding, I puzzled over the problem of what to say given only one hour to talk. I decided that it would be best to discuss the historical reasons for grounding and then discuss the issues faced by electrical engineers. This is not a topic covered in universities as it is considered a trade topic. The engineer must gain his knowledge in the real world through trial and error and from information handed down by other engineers. Unfortunately there are no agreed upon answers and many different opinions exist among the various experts. Therefore I thought it best to discuss the reason why the subject is so poorly understood. This lack of understanding results in a great deal of wasted effort that goes unchallenged.

The word grounding means many things. In power engineering it means a connection to earth. In electronics it could mean a connection to a chassis. Grounding is a problem word along with the words shielding and isolation. There are many meanings to these words and the reader must be careful when these words appear in a text. The assumed meaning may not agree with the writer's definition that is seldom given.

In the early days of power distribution, earthing of one power conductor was found to be necessary to avoid lightning damage. A lightning strike on a power line is seeking a path to earth. This path should occur before the line enters a facility or there is a real safety problem. This path is the neutral-to-earth connection we see at all service entrances. With this earth connection the earth becomes a power conductor. Many conductors make contact with earth including building steel and most metal conduit. A person touching one of these conductors and a "hot" conductor will be shocked. This situation brought about the code requirements for protection against electric shock. Placing grounding conductors (equipment grounds) around power conductors provides this safety protection as well as fault protection. It was found early that power wiring could be the source of fires, personal injury and therefore lawsuits. The National Fire Protection Association established the National Electrical Code that we use today. This code and the standards it imposes are a given in any facility consuming power. These standards can be applied in many ways and some of these ways can impact the performance of electronic circuits. This is why the power installation needs to be a part of the facility design. It is always possible to design a facility that meets code requirements that will also meet a customer's needs. There are always a few problems that can only be solved by the proper design of the hardware.

In the early days of electronics it was found that connecting a chassis to earth tended to eliminate noise coupling into circuits. A "better earth" tended to reduce the noise. This practice was extended to entire facilities without a proper explanation of why it was necessary. Some of these earthing techniques are extensive and involve burying tons of copper into the earth. Many of these grounding or earthing ideas became standard practice and appeared as regulations in various military specifications. This also led to such descriptions as clean ground, signal ground, computer ground, signal ground etc.
The grounding requirements of the telephone industry, the military, and the computer manufacturers often do not agree. This leads to a great deal of confusion in the proper design of a new facility. This often means that grounding issues become political rather than a problem for engineers.

The coining of word pairs such as clean ground, isolated ground, and computer ground are an attempt to resolve issues that can not be treated by circuit theory. Unfortunately circuit theory fails in describing a power grid, a building, the earth as a conductor, transmission lines, radiation, lightning and ESD. Unfortunately these invented word pairs are not a part of electrical engineering and they imply solutions that often cannot be supported by engineering principles. The very word isolation implies security and circuit enhancement but these meanings have no place in engineering. Giving a title to a conductor does not change the way nature will treat the conductor. I always tell students that nature does not read labels or color codes and she never accepts our intent. She does things her way. Calling a conductor "quiet or clean" has no meaning. All conductor pairs accept signals going both directions regardless of the direction we assign. This is the only truth that works.

There is an explanation for all electrical phenomena and this is the physics of electricity. The way physics is taught it is a mathematical subject that solves only the very simplest of geometries. All electrical processes are understood but fitting numbers on practical problems is usually very difficult.. Circuit theory is a marvelous tool but it can not handle problems that stray from resistors, capacitors and inductors. The non-circuit world can only be understood using the electromagnetic field that underlies all –and I mean all-electrical activity.

The idea that a grounding rod disperses noise into the earth and that it disappears violates all known physical laws. Even in circuit theory the current must return somewhere and enter the world above. If earthing were a necessity then the electronics aboard an aircraft could not function.

The real electrical world involves fields that move energy or signals from one point to another. Our circuits work by containing and directing these fields by using specific conductor geometries. As an example, fields have a very difficult time entering or leaving a closed metal box. A shielded cable is an example of such a metal enclosure. A ground plane can not stop the propagation of a field but it can stop field penetration. In other words there are ways that fields can be confined, controlled and directed. These ideas are not considered by circuit theory. Grounded conductors are everywhere and they influence all fields that are in the area. In most cases these conductors are not a consideration in the circuits we draw. These conductors are a part of every facility and can not be discounted. Grounded conductors reflect field energy, they never absorb it.

I have felt strongly for some time that some changes in the education of engineers are needed. It led me to write a book titled “The Fields of Electronics” published by John Wiley. The book introduces electricity and electronics through the study of fields. The treatment avoids the mathematical approach taken in most physics courses. Circuit theory is brought in as a valuable tool but it is not the only tool however. This book allows the reader to see how conductor geometries can be used to limit field penetration and field generation to limit interference. When the conductor geometries are correct the equipment can function as a system without problems.

A facility can not be considered a circuit. It is a conductor geometry that modifies electromagnetic field behavior. For many reasons the fields that operate the hardware leave the confines of one circuit and cross couple into other circuits. Field energy follows power conductors and signal conductors and is modified and directed by all the conductors in a facility. Some of this coupling can be limited by proper hardware design. Cross coupling involving the power distribution system can be limited by how the power system is designed. The design considerations include locations of power entrances, use and location of distribution transformers, auxiliary and back-up power installations, location of isolation transformers, location of ground planes, lightning and surge protection. Location is critical to the control of electromagnetic fields. Each of these items must be grounded in order to function.

Location of hardware is just one parameter. The hardware must be correctly specified located and interconnected. Electricians need to be given specific instructions on these details. Once equipment is installed and in use it is very difficult to make changes. It is also very difficult to define tests that will measure the expected performance of a facility. The real test of performance is the operation of hardware after the facility is completed.

In review, the electrical design of a facility involves grounding simply because the earth is one of the conductors involved in cross coupling and in transporting interference. There are many power distribution techniques available to make it easier for users to operate equipment in an optimum manner. The electrical code is flexible enough that many different power arrangements are possible. It is the architect’s responsibility to recommend how the power distribution system should be installed. This may often be in conflict with the specifications as defined by the customer. Under no circumstances should the design violate any of National Electrical Code. Floating grounds or separate grounds are illegal and pose a real safety hazard.