

Circuit Grounds and Grounding Practices

Introduction

This attempts to explain and clarify the difference between term “Ground” or ”Earth Ground” when speaking of Electrical Circuits.

There is also an attempt to explain the difference between the term “Ground” and “Common”. Specifically the term Ground originally referred to a current return path through Earth Ground. Unfortunately, it has become to be loosely used to represent any type of current return path to the energy source, regardless of whether it is at actual **Earth Ground**.

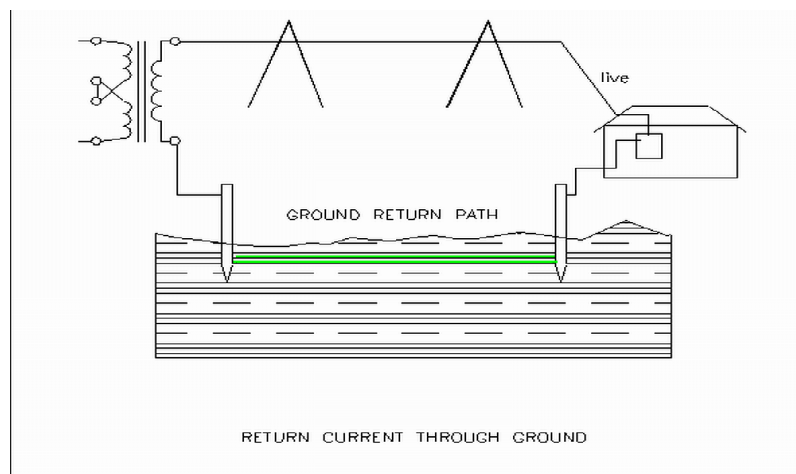
Why “Earth” Ground.

An Early Concept was Earth consisted of one homogenous mass that was electrically neutral, i.e. an equal number of negative and positive charges are distributed throughout the earth at any given time.

Being electrically neutral, earth is considered to be at zero potential at any location and establishes a convenient reference frame for voltage measurements.

Noting that voltmeters read only the difference in potential between two points, absolute measurements can be made, by using Earth as a reference

A true earth ground as defined by the National Electrical Code, both in USA and Canada, physically consists of a conductive pipe or rod driven into the earth to a minimum of 8 feet.



The fig shows this concept, where the earth is used as the conductive current return path to the lowest potential point of the generating station or distribution transformer.

It can be seen that a ‘live’ conductor is ‘neutralised’ by connecting to earth ground which happens

to be at the same potential we are.

So what is served by grounding electrical equipment?

Primarily it is a safety issue. Secondary is an electrical noise issue which will be covered later.

As already mentioned the Earth is considered a large spherical conductor, so anyone or anything in contact with this is considered electrically 'neutral'.

So how does this implement safety?

The answer is to prevent a potential difference between any leakage current and the surface you are standing on, if a 'live' conductor would come in contact with a machine or equipment frame and the equipment was not at ground potential, an Electric shock could be the result.

An Illustration of a Typical Power Supply Grounding Error.

As previously pointed out, the ground symbol, in many cases, has been taken as a generic symbol in electronic circuit diagrams to represent the current return path, even though no physical earth ground is used.

The accepted symbols, but not always adhered to is the Signal Common, Chassis Common, and Earth Ground as shown in fig 2.

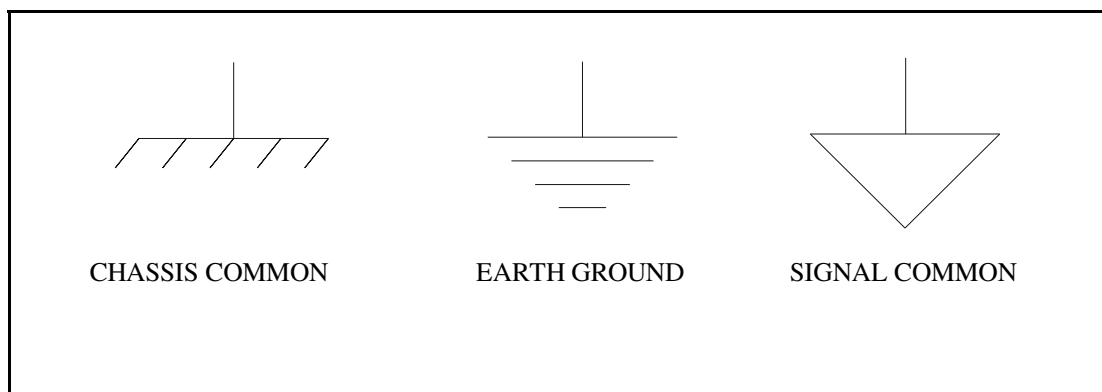


fig 2:

Earth Ground Symbol

The Earth Ground symbol represents a current return path through the earth to the low potential (voltage) side of an energy source. Frequently however, it is used in electronic schematic drawings

to indicate a current return such as a wire or conductor.

This can cause some confusion to the novice in electronics when using instruments having an earth ground terminal. As an example, Figure 3 shows the front panel of a typical power supply. The supply is represented as a variable voltage battery. Note that three terminals are shown: a positive, a negative, and a ground terminal. The ground terminal of the supply is tied to the case of the instrument, which in turn is wired to a true earth ground such as a water pipe.

Let's look at the load connection in Figure 3. Using the positive terminal of the battery and the ground terminal does not complete a current return path to the energy source (battery), so no current will flow from the source, i.e. Figure 3 A Common Power Supply Grounding Error

The positive and negative terminals must be used to have a return path exist.

Use of the ground terminal will be discussed in a following section.

Many circuits require both positive and negative voltages. A power supply must be used to provide each polarity. The supply for positive voltage will have the negative terminal as a return, and the negative supply will have the positive terminal as the return. These two terminals are connected together, forming a common return path for load current. Figure 4 shows the proper connections for these supplies to provide positive and negative voltages.

Figure 4 Power Supply Configuration for Dual Polarity Voltages

Although it may be shown as a ground in the circuit diagram, the connection between the negative and positive terminals of the supplies results in a common, or floating, return. If students feel that they must faithfully adhere to the circuit diagram, the floating common may be connected to the earth ground terminal of the supply. Generally, it will neither help nor hinder circuit performance.

Some Examples of Current Return Path Symbols.

A current return path to an energy source is not necessarily, and frequently isn't, earth ground. It can be a simple wire or a metal chassis or enclosure on which the circuit is mounted. Because the return is the point of lowest potential for all these cases, it is a convenient reference for circuit voltage measurements.

Figures 5a, 5b, and 5c illustrate the symbols commonly used to represent

the power supply common (a direct wire connection to the negative supply terminal) or floating return, the chassis ground, and earth ground returns, respectively. When more than one ground is required, the schematic circuit diagram will generally define the meaning of each symbol."Image5.gif"

Shock Hazard Protection Using Earth Ground

In instances where high voltages are required and chassis grounds or metal frames are used as return paths, hazardous conditions can be created if earth grounds are neglected. When the load circuit uses a metal enclosure as a chassis ground, resistive leakage or "sneak" paths can exist which result in high voltages between the enclosure and earth ground. (Leakage is any unsuspected, unwanted resistive path between two points.) If, inadvertently, a earth-grounded object, such as a water pipe, and the enclosure are simultaneously touched, a serious shock will result. Such a condition is illustrated in Figure 6.

In Figure 7, the earth ground is connected to the load enclosure, placing the water pipe and the enclosure at the same potential, eliminating the shock hazard. Similar hazardous conditions can develop in the installation of household appliances. This is the reason that electrical codes require that appliance frames such as washers and dryers be connected to earth ground.

Grounding Considerations

The most common noise problem encountered in large scale electronic systems stems from a lack of good grounding practice. Grounding is a major concern to practicing design and systems engineers. An extensive body of literature has been published on these subjects. While it is beyond the scope of this note to go into great depth, we will mention some basic practices to avoid grounding problems in your circuits.

If several points are used for ground connections, differences in potential between the points can cause troublesome "ground loops" which will cause errors in voltage readings. This is illustrated in Figure 8, where two separated chassis grounds are used. V_g represents a voltage existing between signal ground and the load ground. If voltage measurements are made between the load ground and the input signal, V_s , an erroneous voltage, $(V_s + V_g)$ will be indicated.

common sign that a ground loop(s) exists, or that a ground is missing, is the presence of induced power line (60 Hz) noise in the circuit.

Finding and eliminating troublesome ground loops in complex electronic systems can be a difficult and frustrating task; it requires an expertise gained largely through experience. This is why grounding, in many cases, is referred to as a "black magic art".

Basic Grounding Practice and Equi-Potential Bonding

a/ Circuit Grounding

The ideal "single point ground" concept insures that no ground loops are created. As the name implies, all circuit grounds are returned to a common point. This concept is shown in Figure 9.

"Image9.gif"

While this approach looks good on paper, it is usually not practical. Even the simplest circuits can have 10 or more grounds, and connecting them at a common point becomes a physical challenge. The next best thing is a ground bus.

Bus bars are available or can be constructed to serve as an adequate substitute for single point ground. The bus bar is simply a heavy wire or copper bar of low resistance which can carry the maximum sum total of the load current back to the power supply. The bus can be extended along the length of the circuitry so that convenient connections can be made at various points. The use of a ground bus is shown in Figure 10.

Image10.gif"

Grounding Practice for Protoboards

Most protoboards provide 2 or 3 lines of connected terminals extending along the length of the board. One of these continuous strips should be dedicated as a circuit ground bus. All circuit grounds should be tied directly to this bus. A word of caution - with use, terminal contacts on the board can spread apart to the extent that intermittent contact may be made with an inserted wire. This could appear as noise in the circuit. Care should be taken that a good contact is made to the ground bus.

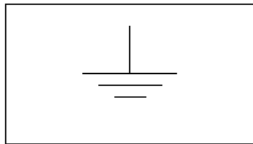


Figure 1 The Symbol for Earth Ground

Analog/Digital Grounds

In general, analog and digital grounds should be kept separated and connected together only at one single point.

Differing Philosophes When it comes to Grounding.

There are basically two schools of thought when it comes to mating different systems, or parts of a system as to whether to attempt total isolation or bond all commons together and make them common to Earth Ground.

In some cases, isolation may unavoidable as in say, a SCR controller where the low control part of the system can be at a high potential with respect to earth ground.

Never use the Earth Ground as a conductor, even when the common or neutral of a supply is at earth ground.

Various Examples of Current return path Symbols.

Various Methods to Prevent Noise in Industrial Sytems.

Reverse EMF Diode Rectifier, DC device.

Resistor-capacitor snubber, AC device

Zero cross over AC SSR

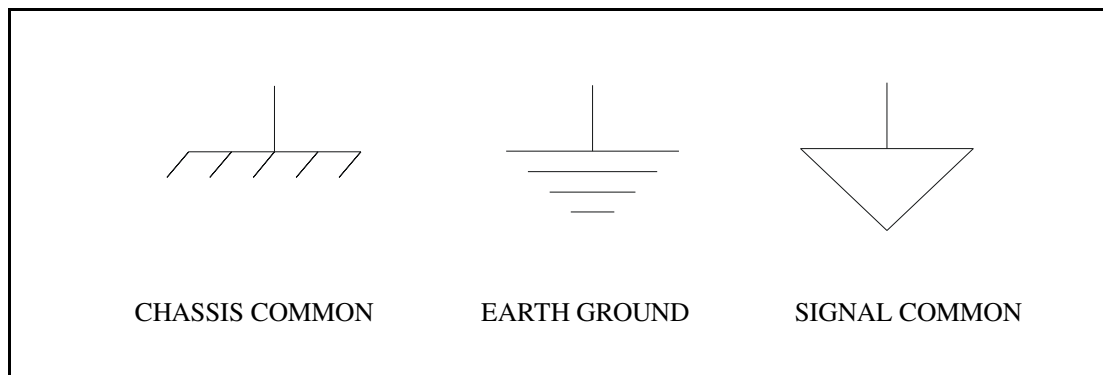


Fig 5

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