



Ground Fault Circuit Interrupters

An Online Continuing Education Course for Engineers

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Ground Fault Circuit Interrupters

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Introduction

The physical nature of electricity is to seek the shortest path to ground. If a person makes contact with an energized conductor he may become a ready path for the current to flow to ground risking an electric shock or death from electrocution. In a residential environment the most likely cause of being shocked or electrocuted comes from an internal short in an appliance such as an electric drill, or from a damaged wire on an appliance or extension cord. The degree of current flowing through the person is dependent on the conditions at the point of contact. If the person is standing on a wet or damp floor in bare feet, the risk is much greater than if the person is wearing rubber soled shoes. Leaning against a metal appliance (e.g. washing machine) or contacting a metal pipe also increases the risk of electrocution. Of course, wearing rubber soled shoes and not contacting a metal appliance does not guarantee a shock or electrocution will not occur.

It only takes an amazing small amount of electric current to kill a person. Exposure to currents as low of 100 milliamps (ma) for only two seconds can cause death. Larger currents can cause death in much shorter times and currents as low as 10ma may temporarily paralyze muscles preventing the person from being able to release the appliance or source of the electric shock. The low currents and short times cannot be emphasized enough. It takes very little current for a very short time to kill someone. Consider someone using an electric hedge trimmer and he accidentally cuts the extension cord with the trim. The electricity has to go somewhere. If the trimmer has a metal case and he is standing on the ground, there's a very high risk that his body will form a short circuit—the path of least resistance for the current to flow through—creating a very strong likelihood that he will feel an electric shock or risk electrocution.

A *ground fault circuit interrupter* (GFCI) is an electronic device that can operate quickly to prevent electric shocks from electrical shorts. During normal operation of an electrical appliance, the current flowing through the conductors into a GFCI generally equals the flow of current returning from the appliance to the GFCI. However, if a “short” occurs in the appliance, or the cord, an imbalance is created between the current going to the device from the GFCI and the current returning to the GFCI. A GFCI is a device that can detect this imbalance in current flow, and, once the imbalance is detected, the GFCI opens the circuit so that no electricity can flow through the circuit, preventing electric shock or electrocution.

A professor of electrical engineering at the University of California, Charles Daiziel, invented the modern ground fault circuit interrupter in 1961. A form of “imbalance detectors” were in use prior to this time in special applications such as mining operations, however, the device designed by Daiziel became the basis for residential GFCI’s. Daiziel estimated the electrical shock hazards to humans and developed a safe current-time envelope for ventricular fibrillation and

used this information to design his GFCI. Daiziel's GFCI used a transistorized circuit to provide quick detection and tripping times for current imbalances.

Early GFCI's were integrated into circuit breakers. These first generation units suffered from many false trips due to the poor alternating current characteristics of 120 volt insulations, especially in circuits having longer cable lengths. So much current leaked along the length of the conductors' insulation that the breaker might trip with the slightest increase of current imbalance. Later the circuitry was added to duplex electrical outlets and has become the ubiquitous GFCI in residential applications. Today, GFCI's are found in panel mounted circuit breakers, outlets, and in-line in the cord of some high risk devices such as hair dryers.

National Electrical Code requires GFCI devices intended to protect people to interrupt the circuit if the leakage current exceeds a range of 4-6 mA of current (the trip setting is typically 5 mA.) GFCI devices which protect equipment (not people) are allowed to trip as high as 30 mA of current.

Ground Fault Circuit Interrupters are known by other names around the world. A few of the common names, where this name may be used, is shown below,

<u>Name</u>	<u>Description</u>	<u>Location</u>
GFCI	Ground Fault Circuit Interrupter	North America
RCD	Residual Current Device	Europe/Australia
RCCB	Residual Current Circuit Breaker	Europe
RCBO	Residual Current Circuit Breaker with overcurrent protection	Europe
ELCB	Earth Leakage Circuit Breaker	Asia

In the first chapter we will look at the theory of operation of GFCI's. In chapter two, we look at the specifications and characteristics of the different types of GFCI's. Chapter three covers code requirements, installation, and operational issues associated with GFCI's.

Theory of Operation

GFCI's operate by measuring the current balance between two conductors using a differential current transformer. The device will open its contacts when it detects a difference in current between the live conductor and the neutral conductor. The supply and return currents must sum to zero; otherwise, there is a leakage of current to somewhere else such as to earth/ground, or to another circuit, etc. This process is known as a residual current detection.

Residual current detection is complementary to ground fault protection. Residual current detection does not provide ground fault protection.

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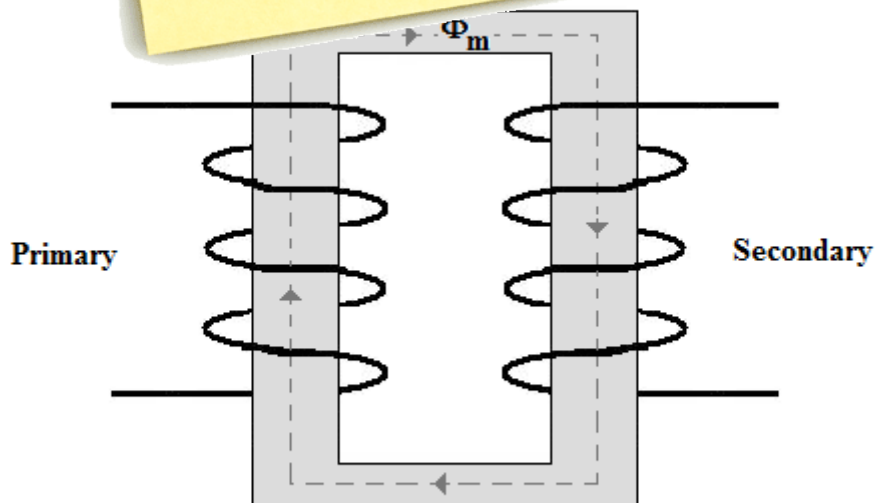


Figure 1