REVIEW AND ANALYSE OF GROUND FAULT CIRCUIT INTERUPTER

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Abstract - *As manufacturers find more applications for adjustable speed drives in household appliances, ground fault circuit interrupter compatibility becomes crucial. As compared to industrial applications, the GFCI thresholds for residential applications are much lower. The experimental frequency response of a commonly-used GFCI breaker is compared to the common-mode current of a commercially available. Thus the input filter needs to be changed to reduce capacitance to earth.It describes the functional principles of Ground Fault Circuit Interupter and relates their performance to effects of electric current on the human body. In this, the history, research and testing, installation practices, fire protection aspects, types, manufacturers and costs of are included*

KEYWORDS: Adjustable speed drive, ground fault circuit interrupter, electromagnetic compatibility.

1. INTRODUCTION

A second challenge is ground fault circuit interrupter (GFCI) compatibility. While permanently installed HVAC systems do not require GFCI protection, hot tubs and spas do require GFCIs for personnel safety, as do cord-connected appliances used in wet location. The US standard for GFCI breakersonly specifies performance at 60 Hz. A typical breaker, will respond to ground current at other frequencies in some undefined manner. Thus the, experimental determination of GFCI frequency response is discussed.In Experimental determination of the ground current in a typical ASD is discussed and compared to the GFCI. Finally, a mitigation method is described. It is to ensure that the ASD does not inadvertently trip the GFCI. Previously, GFCI breakers have concern is ground currents at frequencies related to either the input rectifier (harmonics of the line frequency, 60 Hz) or the output bridge (harmonics of the pulse width modulation (PWM) frequency, 10 kHz). Although GFCI compatibility is related to the issues that occur in ground fault detection of high-resistance ground systems, the problems in a residential application are distinct.

2. GFCI

A **ground fault circuit interrupter** is a type of circuit breaker which shuts off electric power when it senses an imbalance between the outgoing and incoming current. The main purpose is to protect people from an electric shock caused when some of the current travels through a person's body due to an electrical fault such as a short circuit, insulation failure, or equipment malfunction. Standard circuit breakers shut off power when the current is too high, like 10, 15, or 20 amps, but a mere 0.030 amps through a body can cause paralysis of skeletal muscles and stop the human heart. The GFCI breaks the circuit when it detects an imbalance of only 0.005 amps. A circuit breaker protects the house wires and receptacles from overheating and possible fire. It protects people and is often found in bathrooms or kitchens where electrical devices are used and people's bare flesh may be in contact with the floor or metal which provide an alternate path for current to travel in the case of an electrical fault.A GFCI can also prevent fires from short circuits and other electrical faults that don't involve humans such as a low current short where the current never reaches the trigger point for a circuit breaker.

3. HOW DOES A GFCI WORK?

GFCI are devices that protect against injury, shock and electrocution hazards. A GFCI will trip in a fraction of a second at currents well below those that are considered dangerous. GFCls have contributed to a reduction in the number of deaths due to electric shock. A GFCI is NOT a substitute for a fuse or circuit breaker as these devices are still required to protect equipment and property from overloads or short circuits that can result in fire or other damage. A GFCI has a test button that should be pressed prior to using the equipment. This test button checks the functionality and proves it is in perfect working condition because it creates the imbalance that proves it's working. GFCI do not require a ground to work. Notice the sensing coil senses the imbalance between neutral and the conductor(s). Always remember the GFCI is to be used at the power source because you want the cord going from the piece of equipment to the power source protected. It would be a shame using a GFCI on the equipment side only to leave the cord leading to the power source was unprotected and compromised. Cords tend to be the ones that are compromised and are found to be the leader in the cause of electrical faults.

a. Must trip between 4 to 5mA for personnel protection.
b. Trip time shall be less than 25ms.
c. Must have open neutral protection.
d. Must withstand overload current 5 times its rated current.

4. WHERE SHOULD WE BE USING GFCI?

GFCI are used for personnel protection with all types of equipment that need ground fault protection; fans, welders, lights, air compressors, filters, pump, heaters just to name a few. Some ground fault protection equipment allows the flexibility to select and lock in a trip level thus customizing each application for that specific type of equipment to maximize protection while avoiding unwanted (nuisance) tripping. With certain equipment, like air compressors for example, a 6mA trip level cannot be achieved and a higher trip level must be used to avoid nuisance tripping during operation.

a) Compressors
b) Industrial Fans Pressure Washers
c) Tile/Concrete Cutters Arc Welders
d) Conveyers Hoists
e) Assembly and Test Equipment
f) Pumps
g) Motor and lighting loads
h) Escalator/Elevators
i) Maintenance Equipment, etc.

Receptacle Type GFCI should not be field installed on extension cords. Doing this violates the listing of the Receptacle Type GFCI and mostly likely the enclosure the receptacle is placed in. Another issue to consider is that Receptacle type GFCI do not provide open neutral protection.

5. Functional Description of GFCIs

The functional description of a typical GFCI. As long as the current flowing in the black wire equals the current flowing in the white wire, the voltage in the secondary winding of the differential transformer is zero. If current above the trip value of the GFCI flows to groundthus the solid state electronic circuitry causes the interrupter solenoid to disconnect the circuit. Energy to operate GFCIs is supplied by the building branch circuits.

6. Functional Characteristics

The functional characteristics of Group 1, Class A, GFCIs (see Section 8) are described in this report. The principle difference between Class A and Class B GFCIs is the higher trip value (20 mA) permitted for Class B. A Group 1, Class A GFCI has a trip value of 5 mA or less. A GFCI does not limit the current to ground to 5 mA or some other value, but opens the circuit whenever its trip value is exceeded. The upper value of line-to-ground current that a person will experience on ordinary 120 or 240 V branch circuits is approximately 240 mA assuming that his resistance is 500 ohms (See section 2.3). A person would probably feel the shock of this current before the GFCI opened the circuit. However, a GFCI is designed to trip fast enough (about 25 milliseconds or less at 240 mA) to prevent electrocution. See plot of a GFCI characteristics (trip time versus fault current) in Figure 3. UL requires that a Class A GFCI be capable of interrupting the electric circuit to the load when the fault current to ground is within the range of 5 to 264 mA in accordance with the following relationship: [1]'=(7)where T is in seconds and / is the fault current to ground in milliamperes. Figure 3 shows a plot of this equation which can be compared with the curves showing the electrocution threshold for adults, the let-go threshold and maximum expected body currents on ordinary branch circuits. Analysis of available6data (on animals and adult humans) by Underwriters'Laboratories indicated that protection against electrocution for man, including a 2-year old child should be provided if all combinations of body current and duration are below the plot of the above equation [12]. GFCIs will not function to protect the circuit against line-to-line overloads. A fuse or circuit breaker is required for this purpose. On most branch circuits, however, a fuse or circuit breaker will not open a circuit until current exceeds 15 or 20 A, which, of course, is far above maximum expected currents through the body.

7. GFCI Regulatory Provisions

Required use of GFCIs by regulatory authorities isincreasing. Generally, provisions, requiring the installation of GFCIs are first incorporated in the National Electrical Code [2] before becoming part ofState, local or other regulations.

8. National Electrical Code

The trend toward increased use of GFCIs is illustrated by comparing GFCI requirements in the last three editions (1968, 1971 and 1975) of the National Electrical Code (NEC) [14, 15, 2].

The NEC is developed under procedures of the National Fire Protection Association and the American National Standards Institute and is a voluntary standard as published. However, because of adoption, (sometimes with revisions) by State and local authorities, the installation of electrical equipment in buildings throughout the U.S.A. is generally in accordance with the NEC. The 1968 edition of the NEC [14] was the first edition to mention GFCIs. It recommended that attachment plug receptacles in the area adjacent to swimming pools be installed on a circuit protected by a ground fault circuit interrupter. The 1971 Edition of the NEC [15] required that receptacles located between 10 and 15 feet from the inside wall of a swimming pool be protected by a GFCI. It prohibited outdoor receptacles closer than ten feet from a pool. The 1971 edition permitted the use of GFCIs as one means of protecting against fault conditions involving underwater lighting fixtures which might result in electrical shock hazards. Also, the 1971 NEC edition required that all electrical equipment used with storable swimming pools be supplied with circuits protected by GFCIs. The use of GFCIs in boatyards and marinas on receptacles used to provide shore power for boats was suggested.Quite widespread use of GFCIs was required by the 1971 NEC on dates subsequent to the effective date of the Code. In residential occupancies all 120V, single phase, 15 and 20 A receptacle outlets installed outdoors on or after January 1, 1973 were required to have approved GFCI protection for personnel. Such protection could be provided on branch circuits or on feeders supplying applicable branch circuits. The use of GFCIs was suggested for other circuits, in other locations and in other occupancies. All 15 and 20 ampere receptacle outlets on single phase circuits for construction sites were required to have GFCI protection for personnel on or after January 1,1974.For residential occupancies, (including mobile homes and mobile home parks) in addition to receptacle outlets on outdoor circuits, the 1975 NEC [2] requires that 120 V, single phase, 15- and 20-A receptacle outlets in bathrooms have GFCI protection for personnel. For construction sites, GFCI protections required except when receptacle outlets on permanent wiring are used or when power is supplied by 5 kW or smaller portable generators meeting certain requirements.Branch circuits supplying under-water lighting fixtures in swimming pools which operate at more than 15 V are required by the 1975 NEC to have GFCI protection. Also, GFCI protection is required on branch circuits supplying fountain equipment operating at more than 15 V. In general, other 1975 NEC requirements pertaining to swimming pool GFCI protection are similar to those in the 1971 NEC. However, the 1971 NEC suggested use of GFCIs in boatyards and marinas was eliminated from the 1975 Code. "Leakage currents inherent in boats" was the apparent reason for this reversal in the trend to recommend and require greater use of GFCIs each time the NEC is up-dated.

9. Occupational Safety and Health Administration

The Occupational Safety and Health Administration (OSHA) of the US Department of Labour is responsible for issuing and enforcing regulations concerning the safety of workers in places of employment. On July 1, 1974 OSHA, pending reconsideration of the requirement, postponed enforcement of the National Electrical Code provision requiring GFCIs on all 15 and 20 ampere receptacle outlets on single phase circuitsfor construction sites.

10. Other Authorities

In building and construction many authoritiesissue regulations, specifications or other requirements. For example the Oak Ridge National Laboratory requires GFCIs on outdoor receptacles within 15 feet of the inside walls of reactor pools. To determine requirements pertaining to the use of GFCIs, the authority having jurisdiction should beconsulted.

CONCLUSION AND FUTURE SCOPE

Ground fault circuit interrupters are designed to open electric circuits prior to the time a normal adult or child would receive energy sufficient for electrocution; a person would, however, ordinarily feel the shock. There is increasing use of GFCIs in this country because of increasing requirements in Codes and other rules issued by enforcing authorities. There was wide use of GFCIs in some foreign countries prior to their extensive use in the USA. 4. The effectiveness of GFCIs has been demonstrated by tests on dogs. Principal controversies concerning GFCIs involve nuisance tripping, reliability over an extended period of time and the application of GFCIs to older buildings. Because of leakage currents encountered in wire and other electrical equipment in various locations and applications, there are controversies concerning the feasibility of GFCIs. The practical problems of leakage current appears to be the principal technical parameter which needs investigation for the use of GFCIs in older buildings.

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