

Backfeeding Ground Fault Circuit Breakers

Introduction

The increasing number of photovoltaic (PV) system installations has prompted many questions regarding whether or not circuit breakers with ground fault protection can be backfed. This document will answer this question regarding not only PV applications but any application where it may be desirable to backfeed a circuit breaker incorporating ground fault protection.

What is Backfeeding?

The source of power is typically connected to the ON end of a circuit breaker and the load to the OFF end. There are applications where this connection needs to be reversed, i.e. the power source connected to the OFF end and the load connected to the ON end. This is called backfeeding or reverse connecting.

Can Standard Circuit Breakers be Backfed?

The UL 489 standard for molded case circuit breakers requires that, "...if a circuit breaker is not marked "line" and "load", one sample of each set tested, or one additional sample, shall be connected with the line and load connections reversed during the overload, endurance, and interrupting tests." Additionally, the standard requires that, "Circuit breakers shall be marked "line" and "load" unless the construction and the test results are acceptable with the line and load connections reversed." These requirements have been in UL 489 since the first edition was published in the 1940s.

This means that circuit breakers are suitable for reverse connection unless they are marked "line" and "load".

Can Circuit Breakers with Ground Fault Protection be Backfed?

The answer to this question depends on how the ground fault protection function is powered. The electronic circuitry used to provide the ground fault protection may be line powered or fault powered.

Miniature Circuit Breakers (MCBs) of the type typically used in residential and "lighting panelboard" applications may provide ground fault protection for personnel, in which case the circuit breaker is called a Ground-Fault Circuit Interrupter (GFCI, Figure 1). GFCIs have a nominal 5 mA ground fault trip level.

MCBs are also available with Ground-Fault Protection of Equipment (GFPE), often with a nominal 30 mA trip level, for protection of heating cables and other applications. Because of the low ground fault trip level of these circuit breakers, their electronic circuitry must be line-powered.

These circuit breakers are distinctive in that they have a white “pigtail” wire intended for connection to the neutral bar in the panelboard in which they are installed. This pigtail wire not only completes the branch circuit (the neutral wire must be connected to the circuit breaker rather than to the neutral bar), but also completes the power supply circuit for the electronic ground fault detection circuitry.

Backfeeding (reverse connecting) these circuit breakers will result in damaging the trip solenoid, rendering the ground fault trip function inoperative. For this reason the terminals on these circuit breakers are marked “line” and “load”.

The GFPE function in larger molded case, insulated case, and low voltage power circuit breakers, with a typical nominal ground fault pick-up range between 200 and 1200 A, is fault-powered (see Figure 2). This means that the current transformers within the circuit breaker intended to measure the amount of current flowing in the circuit also supply power to the electronic circuitry. The electronic trip circuit in these circuit breakers cannot be damaged due to backfeeding, therefore, these circuit breakers are not marked “line” and “load”.

(It should be noted that there are other reasons why a circuit breaker may be marked “line” and “load”. Don't assume that just because a circuit breaker has a higher level of GFPE and does not have a line power connection for the electronic protection circuitry that it will not be marked “line” and “load”.)

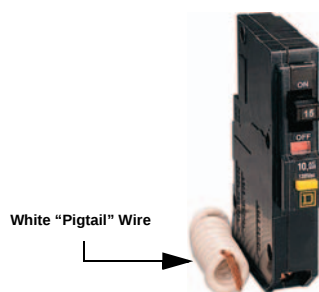


Figure 1: Circuit Breaker with Line-Powered GFCI Protection



Figure 2: Circuit Breaker with Fault-Powered GFPE

Photovoltaic Applications

Questions regarding PV applications stem from a requirement in Section 690.64(B)(3) of the 2008 National Electrical Code (NEC) and Section 705.12(D)(3) of the 2011 NEC which states:

(3) Ground-Fault Protection. The interconnection point shall be on the line side of all ground-fault protection equipment.

Exception: Connection shall be permitted to be made to the load side of ground-fault protection, provided that there is ground-fault protection for equipment from all ground-fault current sources. Ground-fault protection devices used with supplies connected to the load-side terminals shall be identified and listed as suitable for backfeeding.

The wording of the exception may introduce confusion as it states that the ground fault protection device “shall be identified...for backfeeding” which implies a specific marking on a GFPE equipped circuit breaker, while in actuality it is the absence of “line” and “load” markings on a circuit breaker that indicates that it is suitable for backfeeding.

The Fine Print Note in Section 690.64(B)(5) of the 2008 NEC and 705.12(D)(5) of the 2011 NEC clarifies the situation, stating that:

(5) Suitable for Backfeed. Circuit breakers, if backfed, shall be suitable for such operation.

FPN: Circuit breakers that are marked “Line” and “Load” have been evaluated only in the direction marked. Circuit breakers without “Line” and “Load” have been evaluated in both directions.

Summary

In summary, circuit breakers with ground fault protection that is line powered, such as those with a pigtail connection, are not suitable for backfeeding. The terminals on these circuit breakers are clearly marked “line” and “load”. This includes Square D™ QO™ and Homeline™ circuit breakers with GFCI (5 mA) and QO and Homeline circuit breakers with low level GFPE (30 mA) protection.

Circuit breakers with ground fault protection that is fault powered, such as larger molded case, insulated case and low voltage power circuit breakers, may be suitable for backfeeding. If they are, their terminals will not be marked “line” and “load”. All Square D PowerPact™ and Masterpact™ circuit breakers with Micrologic™ electronic trip units are suitable for backfeeding.

Square D add-on ground-fault modules for PowerPact H- and J-frame molded case circuit breakers are also suitable for backfeeding.

Square D add-on earth-leakage modules for PowerPact H- and J-frame molded case circuit breakers are not suitable for backfeeding as they are line-powered devices. The OFF end terminals on these modules are marked “load”.

The following table summarizes which Square D circuit breakers and add-on modules providing ground fault protection can and cannot be backfed.

Circuit Breaker	Type of Ground Fault Protection	Line/Load Markings	May be Backfed
HOM-EPD	GFPE	Yes	No
HOM-GFI	GFCI	Yes	No
LE/LX	GFPE	No	Yes
Masterpact NT	GFPE	No	Yes
Masterpact NW	GFPE	No	Yes
PowerPact D-frame	GFPE	No	Yes
PowerPact H-frame add-on earth leakage module	GFPE	See Note	No
PowerPact H-frame add-on ground fault module	GFPE	No	Yes
PowerPact H-frame with factory-sealed electronic trip units	GFPE	No	Yes
PowerPact H-frame with field-interchangeable electronic trip units	GFCI	Yes	No
PowerPact J-frame add-on earth leakage module	GFPE	See Note	No
PowerPact J-frame add-on ground fault module	GFPE	No	Yes
PowerPact J-frame with factory-sealed electronic trip units	GFPE	No	Yes
PowerPact J-frame with field-interchangeable electronic trip units	GFCI	Yes	No
PowerPact L-frame with factory-sealed electronic trip units	GFPE	No	Yes
PowerPact L-frame with field-interchangeable electronic trip units	GFCI	Yes	No
PowerPact P-frame	GFPE	No	Yes
PowerPact R-frame	GFPE	No	Yes
QO-EPD	GFPE	Yes	No
QO-GFI	GFCI	Yes	No

NOTE: Circuit breakers are not marked "line/load". Add-on modules are marked "load" on the end with the lugs. (Modules may only be connected to the OFF end of circuit breakers.)

For More Information

For more information see the following references:

UL 489 7.1.1.18 and 9.1.1.13.
2008 NEC 690.64(B)
2011 NEC 690.64, 705.12(D)(3) and 705.12(D)(5)

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