FLUKE®

GFL-1500

Solar Ground Fault Locator

Users Manual

BC
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Introduction

The GFL-1500 (the Product) is a solar ground fault locator. The Product consists of a transmitter (the Transmitter), a receiver (the Receiver), a signal tracing clamp (the Clamp), a set of test leads with alligator clips, and MC4 test leads. The Product detects and locates ground faults, locates open circuits, and maps circuit paths in an energized or de-energized photovoltaic system.

The Transmitter generates a high frequency signal in a system and uses electrical measurements to identify a ground fault. The Receiver or the Clamp detects the signal to locate the fault.

The Product works on systems with voltages up to 1500 V dc/600 V ac.

How to Contact Fluke Corporation

Fluke Corporation operates worldwide. For local contact information, go to our website: www.fluke.com.

To register your product, or to view, print, or download the latest manual or manual supplement, go to our website.

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Safety Information

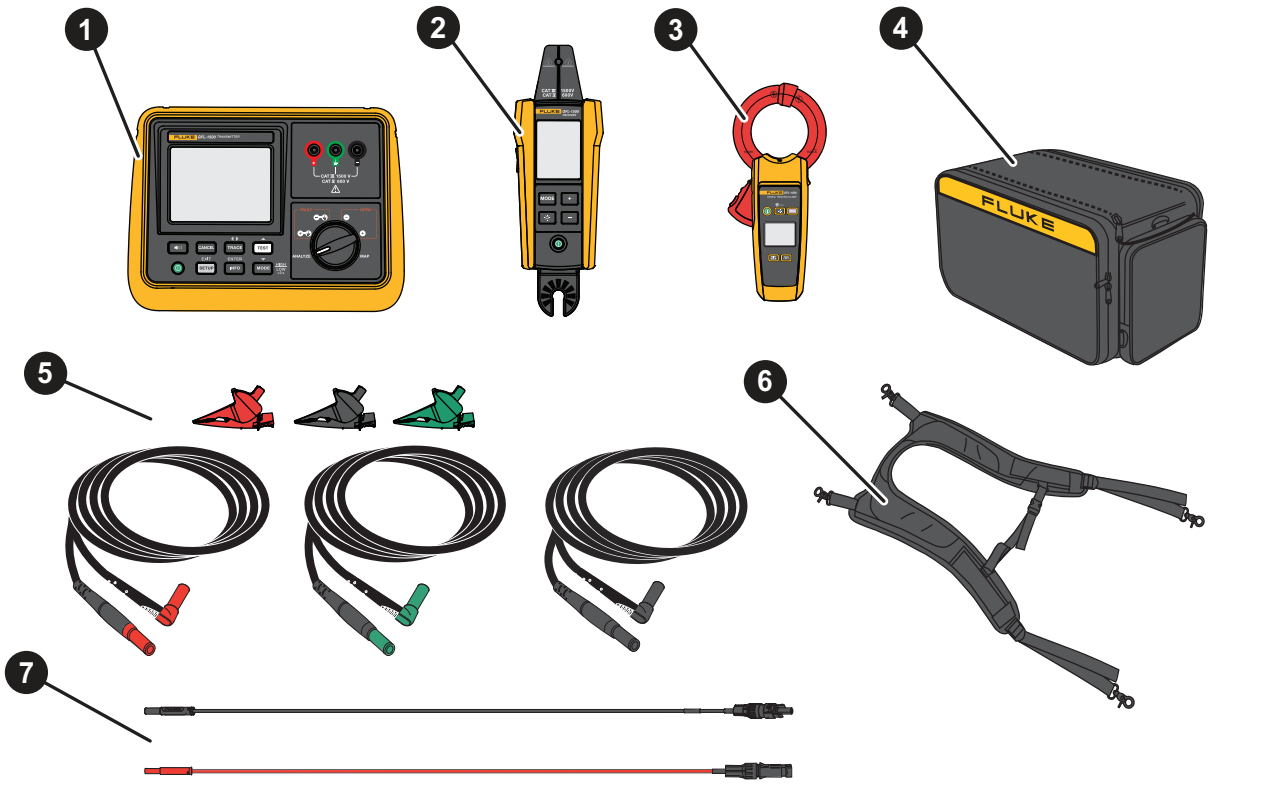
General Safety Information is in the printed Safety Information document that ships with the Product and at www.fluke.com. More specific safety information is listed where applicable.

A **Warning** identifies hazardous conditions and procedures that are dangerous to the user. A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.

The Product

Table 1 shows the items that ship with the Product. For replacement part numbers, see *Replacement Parts*.

Table 1. Product



Item	Description	Item	Description
1	The Transmitter	5	Test leads and alligator clips
2	The Receiver	6	Strap
3	The Clamp	7	MC4 test leads
4	Case	--	Batteries

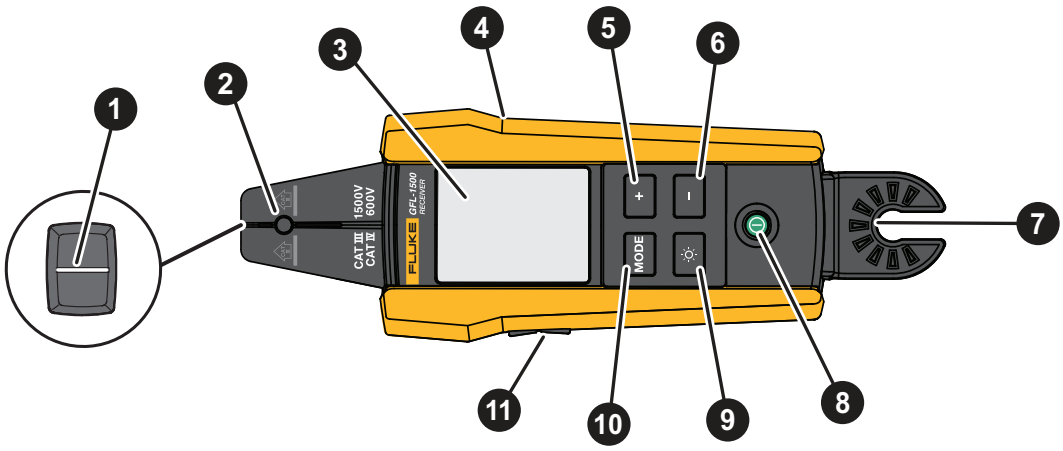
The Receiver

Use the Receiver with the Transmitter to directly detect a signal in a wire.

Features of the Receiver

Table 2 shows the features of the Receiver.

Table 2. Features of the Receiver



Item	Function
1	Align the line on top of the tip sensor with a wire or fuse to detect a signal. See *Tip Sensor and Open Modes*.
2	The LED indicator lights up when the Receiver detects a signal. The frequency of the flash is proportional to the strength of the signal.
3	The display shows the settings, test functions, and results. See *Receiver Display*.
4	Tactile barrier. **⚠⚠Warning** **Hold the Receiver behind the tactile barrier.**
5	Push + to increase the level of sensitivity the Receiver uses to detect a signal.
6	Push − to decrease the level of sensitivity the Receiver uses to detect a signal.

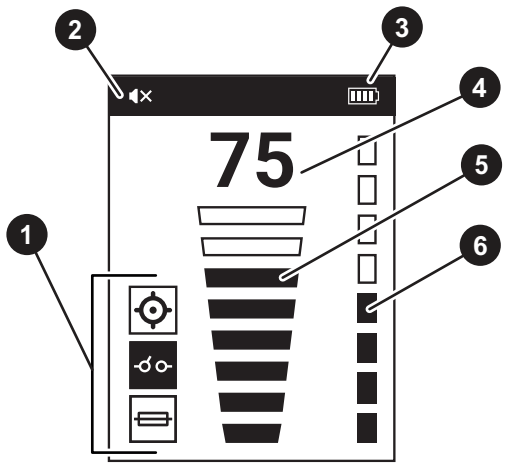
Table 2. Features of the Receiver (cont.)

Item	Function
7	Point to attach a hot stick. The hot stick is sold separately.
8	Push ⏻ to turn on and off the Receiver
9	Push ☼ to adjust the brightness of the display.
10	Push MODE to select a mode. See Table 4.
11	Adjusts the level of the volume the Product emits.

Receiver Display

Table 3 shows the items on the display of the Receiver.

Table 3. Receiver Display



Item	Function
1	Trace mode indicator. The icon with the black background shows the selected mode.
2	Volume level indicator.
3	Battery level indicator.
4	The strength of the signal as a number from 00 to 99.
5	The strength of the signal in number of bars.
6	The sensitivity level (1 to 8) of the Receiver.

Use the Receiver

The Receiver can directly detect a signal in a wire.

Note

The Receiver cannot detect a signal on a section of a wire that is underground.

To use the Receiver:

1. Connect the Transmitter. See *Trace a Fault Overview*, *Find a Break in a Wire*, and *Map a System*.
2. Turn on the Receiver.

   Note

   Keep the Receiver >1 m (3 ft) from the Transmitter and test leads to minimize signal interference.
3. If needed, adjust the brightness of the display and the volume.
4. Push MODE to select a mode. Table 4 lists the Receiver trace modes and describes the applications for each mode.
5. To trace another wire in a different mode, push MODE to select a new mode to use.

Table 4. Receiver Modes

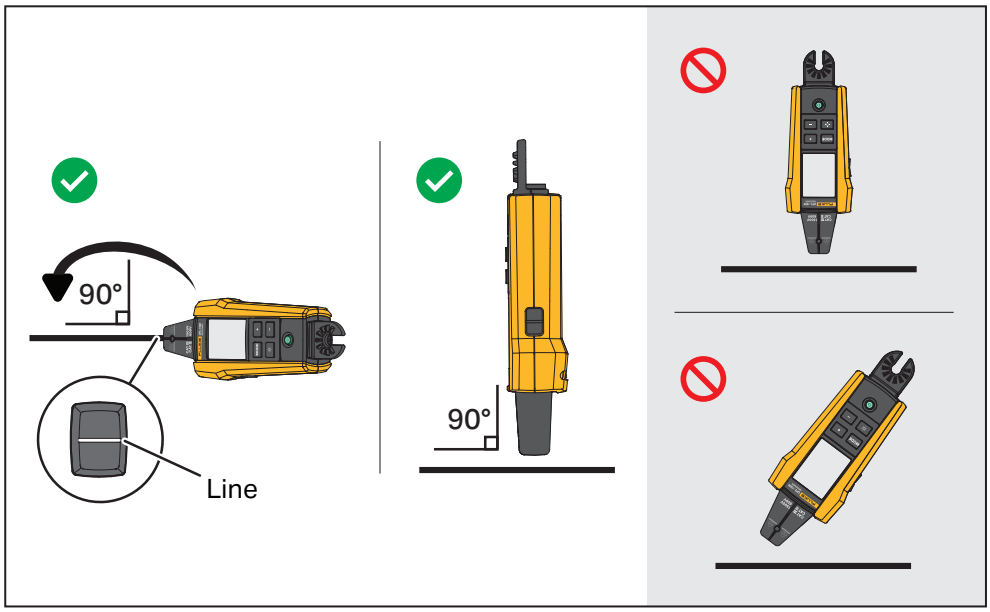
Mode	Description
Tip sensor	Use with the **FAULT** functions on the Transmitter to locate a ground fault in an isolated string or in an open parallel circuit. See *Tip Sensor and Open Modes*. Use with the **MAP** function on the Transmitter to confirm the string layout of a PV system. The PV system must not contain a ground fault or broken wire. See *Tip Sensor and Open Modes*.
Open	Use with the **OPEN** function on the Transmitter to trace a signal in an isolated string or circuit to locate a break in a wire.
Breaker	Use with the Transmitter to identify which fuse or breaker connects to the Transmitter. See *Receiver Breaker Mode*. Use with the **FAULT** or **MAP** functions.

Tip Sensor and Open Modes

To use tip sensor or open modes:

1. Scan a target area with the tip sensor to find the strongest signal level.
2. To find the strongest signal level on a wire, align the Receiver perpendicular to the wire with the line on the top of the tip sensor parallel to the wire. See Figure 1.
3. To verify the direction of the wire, periodically rotate the Receiver 90 degrees from side to side while the tip sensor remains perpendicular to the wire.

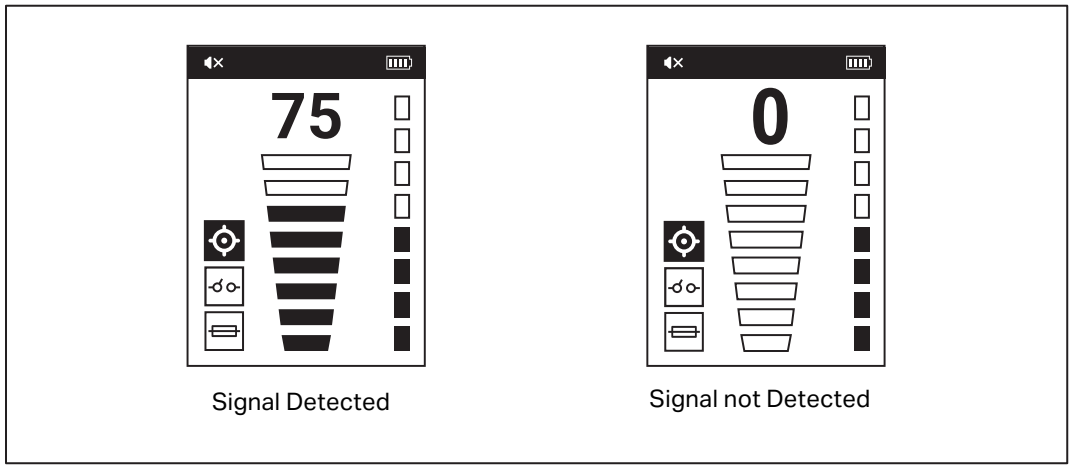
Figure 1. Receiver Tip Sensor and Open Mode Alignment



4. Periodically adjust the sensitivity to keep the signal strength near 75 %.

   The signal strength indicator on the display changes. See Figure 2.
5. If the signal is too strong to precisely locate the wire, decrease the sensitivity on the Receiver or use **LOW** mode on the Transmitter.

Figure 2. Receiver Tip Sensor and Open Mode Signal Strength



Receiver Breaker Mode

Breaker mode automatically adjusts the sensitivity of the Receiver. The Receiver stores in memory the strongest signal detected. As a result, the Receiver identifies one correct breaker or fuse.

To use breaker mode:

1. Align the Receiver perpendicular to the breaker. The line on the top of the tip sensor aligns parallel to the breakers. See Figure 3.

   Note

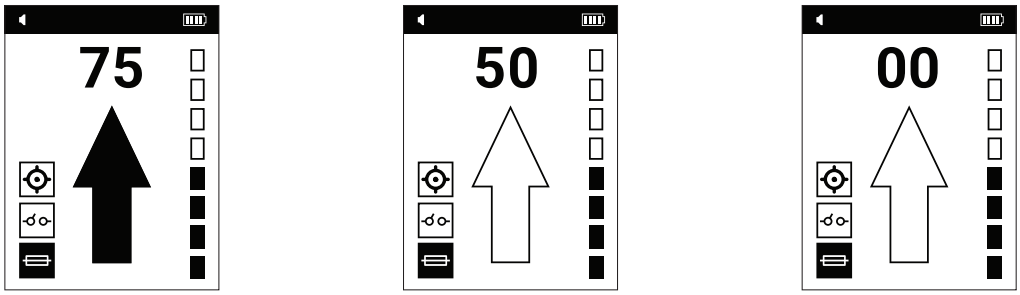
   Different breaker or fuse designs, height, or internal contact structure may affect the precision of breaker or fuse identification. For best results, remove the breaker or fuse panel cover, and do the scan on the wires instead of the breakers or fuses.

Figure 3. Receiver Breaker Mode Alignment

2. Scan each breaker or fuse multiple times until the arrow on the display shows solid for only one breaker or fuse. For best results, scan at the output of the breaker or fuse. The order you scan the breakers or fuses does not matter.

   The signal strength indicator on the display changes. See Figure 4. For a breaker mode application, see Figure 5.

Figure 4. Receiver Breaker Signal Strength

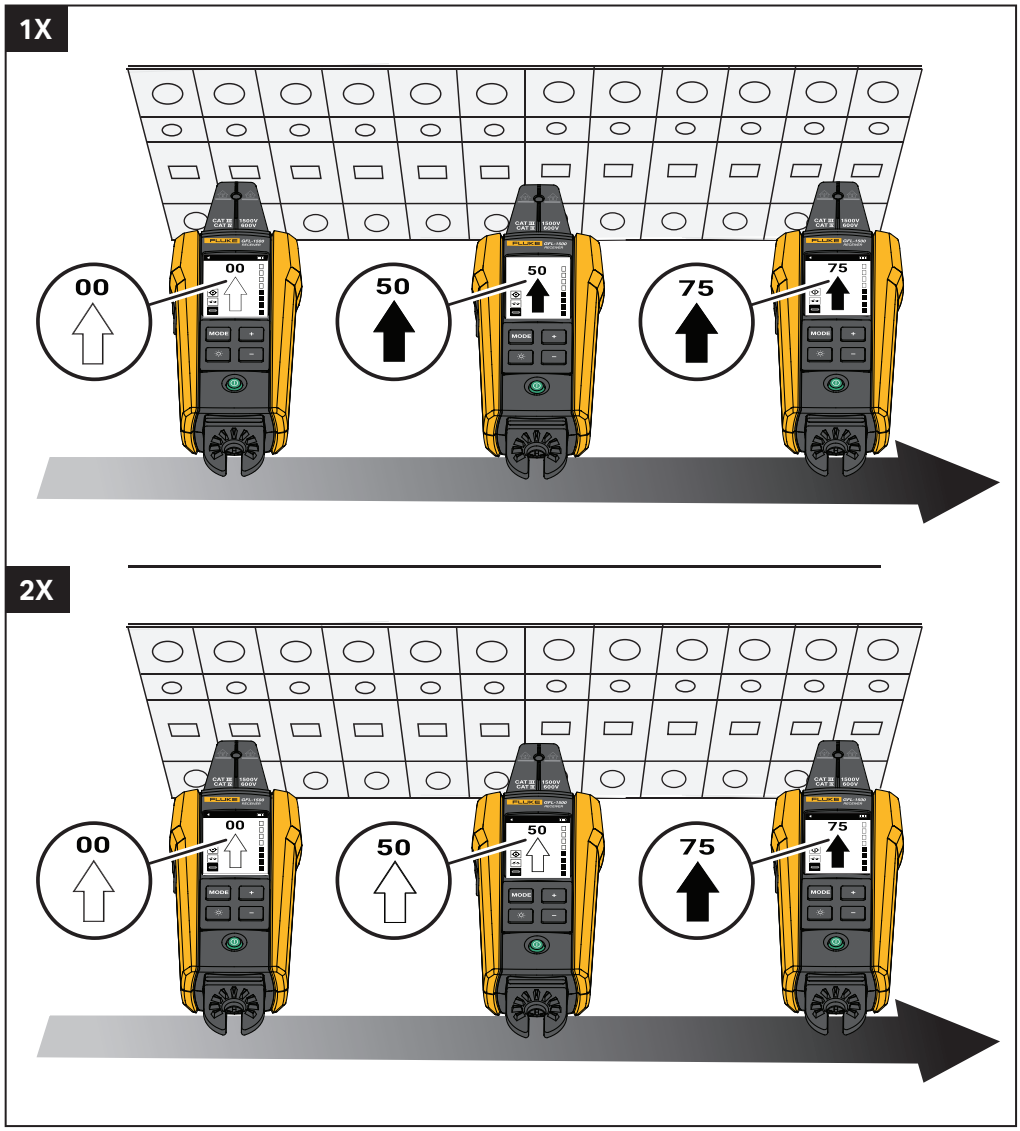


Strongest Signal Detected

Signal Detected

Signal not Detected

Figure 5. Receiver Breaker Mode Application



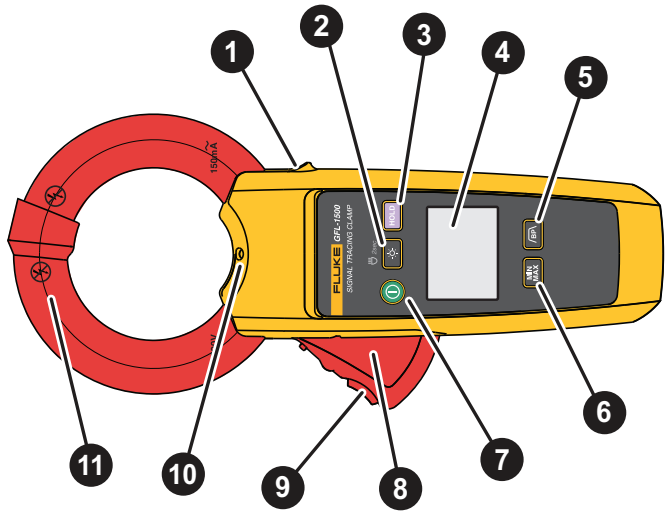
The Clamp

The Clamp can detect a signal in wires enclosed in the jaw. Use the Clamp when you do not make a disconnection in the system.

Features of the Clamp

Table 5 shows the features of the Clamp.

Table 5. Features of the Clamp



Item	Function
❶	Tactile Barrier. **⚠⚠Warning** **Hold the Clamp behind the tactile barrier.**
❷	Push ☼ to turn on and off the backlight of the display. Push and hold ☼ for 2 seconds to turn on and off the spotlight (❿).
❸	Push HOLD to retain the results and show **HOLD** on the display. Push HOLD again to clear the results and remove **HOLD** from the display.
❹	The display shows the measured value, unit, function, and battery level. See *Clamp Display*.

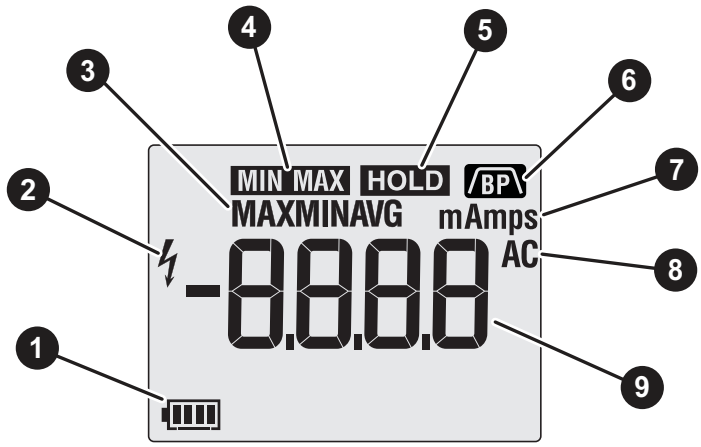
Table 5. Features of the Clamp (cont.)

Item	Function
5	Push BP to activate the band pass filter to filter out leakage capacitive paths for more reliable results. Filters to only use 30 Hz to 70 Hz. For the band pass (BP) filter to work, the Transmitter must be in **HIGH** or **LOW** array mode and the hazardous voltage indicator (⚡) must show on the display. See *Transmitter Modes*.
6	Push MIN MAX: 1x to show the minimum measurement on the display. 2x to show the maximum measurement on the display. 3x to show the average measurement on the display. See Table 6.
7	Push ⏻ to turn on and off the Clamp.
8	Jaw trigger. Use with the jaw unlock button (9) to unlock and open the jaw (11).
9	The jaw unlock button. Use with the jaw trigger (8) to unlock and open the jaw (11).
10	With the spotlight enabled, illuminates the jaw area of the Clamp to increase visibility.
11	The jaw.

Clamp Display

Table 6 shows the items on the display of the Clamp.

Table 6. Clamp Display



Item	Function
1	Battery level indicator.
2	Hazardous voltage indicator.
3	**MAX**, **MIN**, or **AVG** shows based on the number of times you push MIN MAX on the Clamp. See Table 5.
4	Shows with MIN MAX enabled. See Table 5.
5	Shows with HOLD enabled. See Table 5.
6	Shows with BP enabled. See Table 5.
7	Unit of measure
8	Shows the measurement is in AC.
9	The measured value.

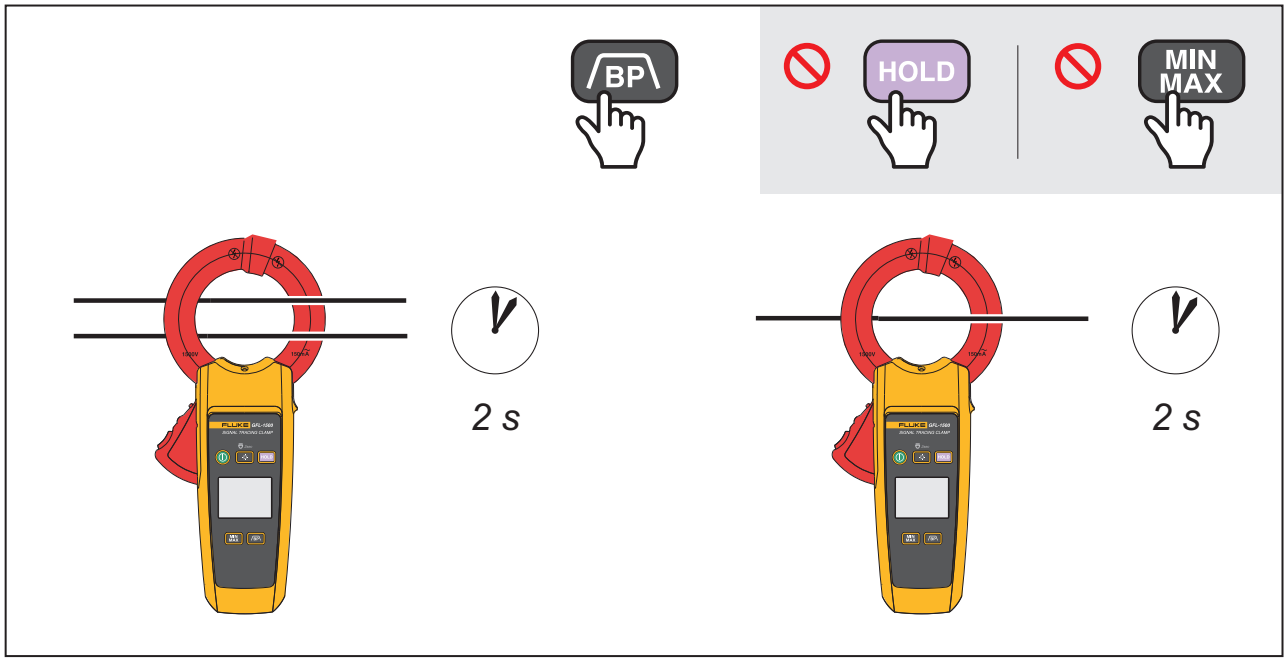
Use the Clamp

Use the Clamp with the Transmitter to trace a ground fault or to map a system.

To use the Clamp:

1. Connect the Transmitter. See *Trace a Fault Overview* and *Map a System*.
2. Correctly align the insulated wires in the Clamp. See Figure 6.
3. Turn on the Clamp. Do not push HOLD or MIN MAX.
4. If the Transmitter is in array mode, push BP. See *Transmitter Modes*..
5. If the Transmitter is in unit mode, do not push BP. See *Transmitter Modes*.
6. Hold the Clamp still for 2 seconds for the measurement to stabilize.

Figure 6. Clamp Alignment



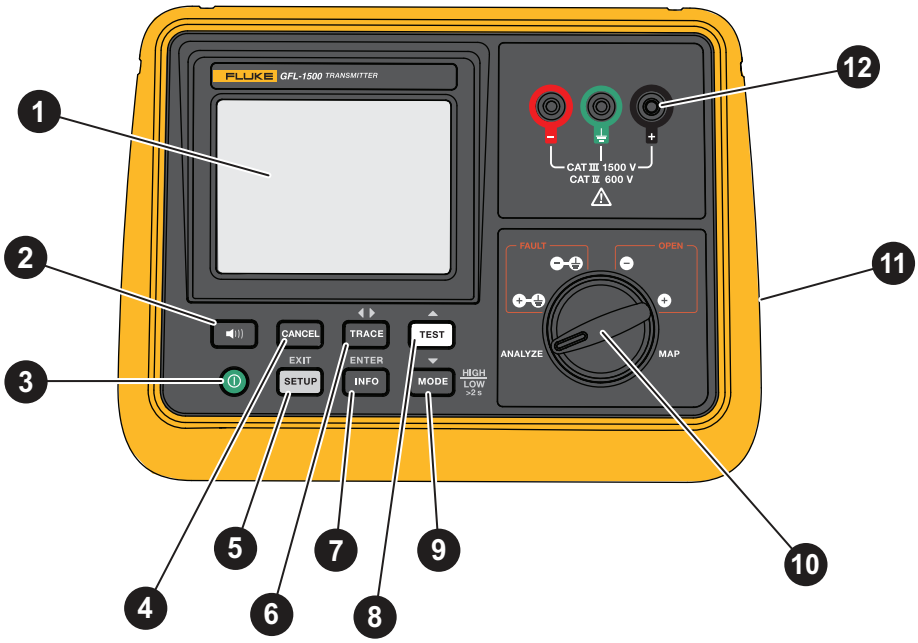
The Transmitter

The Transmitter generates a signal on an energized or de-energized circuit.

Features of the Transmitter

Table 7 shows the features of the Transmitter.

Table 7. Features of the Transmitter



Item	Function
1	The display shows menu selections and test results. See *Transmitter Display*, .
2	Push to adjust the volume.
3	Push to turn on and off the Product.
4	Push **CANCEL** to cancel an action.
5	Push **SETUP** once to open the setup menu and activate the secondary functions of the buttons as marked above the buttons. Push **SETUP** again to exit the setup menu. See *Transmitter Setup Menu*.

Table 7. Features of the Transmitter

Item	Function
❻	With **FAULT**, **OPEN**, or **MAP** selected on the rotary knob, push **TRACE** to start a trace signal.
❼	With **ANALYZE** selected on the rotary knob, push **INFO** to toggle between the ANALYZE results screen and the ANALYZE modules screen.
❽	With **ANALYZE** selected on the rotary knob, push **TEST** to analyze the system. See *Analyze a System*.
❾	With **FAULT**, **OPEN**, or **MAP** selected on the rotary knob, push **MODE** to select the mode: array, unit, or auto. Push and hold **MODE** for 2 seconds to toggle between **HIGH** and **LOW** amplitude mode. **LOW** mode is only available in unit mode with **OPEN** selected on the rotary knob. See *Transmitter Modes*.
❿	Use the rotary knob to select the type of test to do. See *Rotary Knob Functions*.
⓫	The battery compartment is on the back.
⓬	Input jacks for the test leads.

Transmitter Display

When you turn on the Transmitter for the first time, the screens show in English. To change the language selection, see *Transmitter Setup Menu*.

The users manual shows English screens in examples and translates the explanations as appropriate in tables or text.

Note

Text that shows in English on the buttons and the rotary knob functions shows in English in the user interface (UI) on the display.

Transmitter Setup Menu

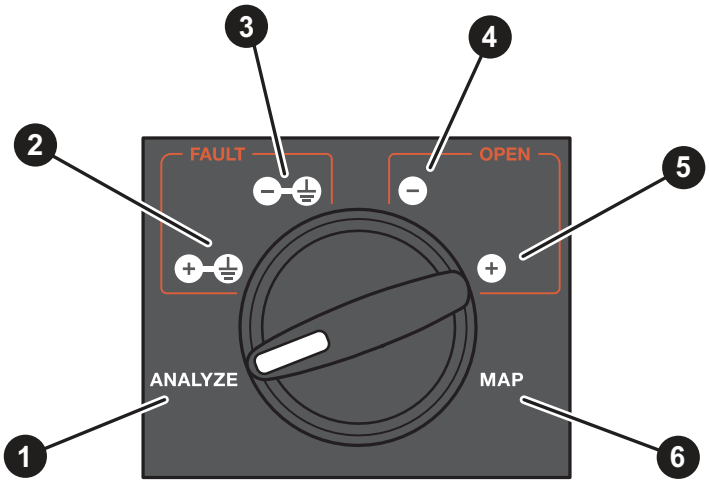
To change the brightness level of the display:

1. Push **SETUP** to open the setup menu and activate the secondary functions above the other keys.
2. Push **TEST** (up arrow) or **MODE** (down arrow) to highlight a menu item, and push **INFO** (**ENTER**) to select the item.
3. Use the secondary functions to make adjustments.
   a. To change the brightness of the display, push **TEST** (up arrow) or **MODE** (down arrow) to select a brightness level.
   b. To change the language selection, push **TEST** (up arrow) or **MODE** (down arrow) to highlight a language.
   c. To update the firmware, use TruTest™ Software available on our website. See *Update Firmware*.
   d. To change a module number, push **TRACE** (right and left arrow) to toggle between the ones and tens columns and **TEST** (up arrow) or **MODE** (down arrow) to change a value).
4. Push **INFO** (**ENTER**) to return to the setup menu.
5. With all changes set, push **SETUP** (**EXIT**) to exit the setup menu and deactivate the secondary functions.

Rotary Knob Functions

Table 8 shows the functions on the rotary knob of the Transmitter.

Table 8. Rotary Knob Functions



Item	Function
❶	In **ANALYZE** function, the Transmitter: • Measures voltage to ground. • Estimates fault resistance. • Can estimate the number of modules to the fault in a string. • Monitors hazardous voltage between the positive, negative, and ground terminals. See *Analyze a System*.
❷	In **FAULT** ⊕⏚ function, the Transmitter: • Generates a signal that flows from positive to a ground fault. • Monitors hazardous voltage between the positive and ground terminals. See Figure 7.

Table 8. Rotary Knob Functions (cont.)

Item	Function
❸	In **FAULT** ⊖⏚ function, the Transmitter: • Generates a signal that flows from negative to a ground fault. • Monitors hazardous voltage between the negative and ground terminals. See Figure 7.
❹	In **OPEN** ⊖ function, the Transmitter: • Generates a signal that flows from the negative terminal on the Transmitter to a break in an isolated circuit. • Monitors hazardous voltage between the negative and ground terminals. See Figure 8.
❺	In **OPEN** ⊕ function, the Transmitter: • Generates a signal that flows from the positive terminal on the Transmitter to a break in an isolated circuit. • Monitors hazardous voltage between the positive and ground terminals. See Figure 8.
❻	In **MAP** function, the Transmitter: • Generates a signal that flows from the positive terminal to the negative terminal of the Transmitter through an isolated circuit. • Monitors hazardous voltage between the positive and negative terminals. See Figure 9.

Figure 7. FAULT Signal Flow

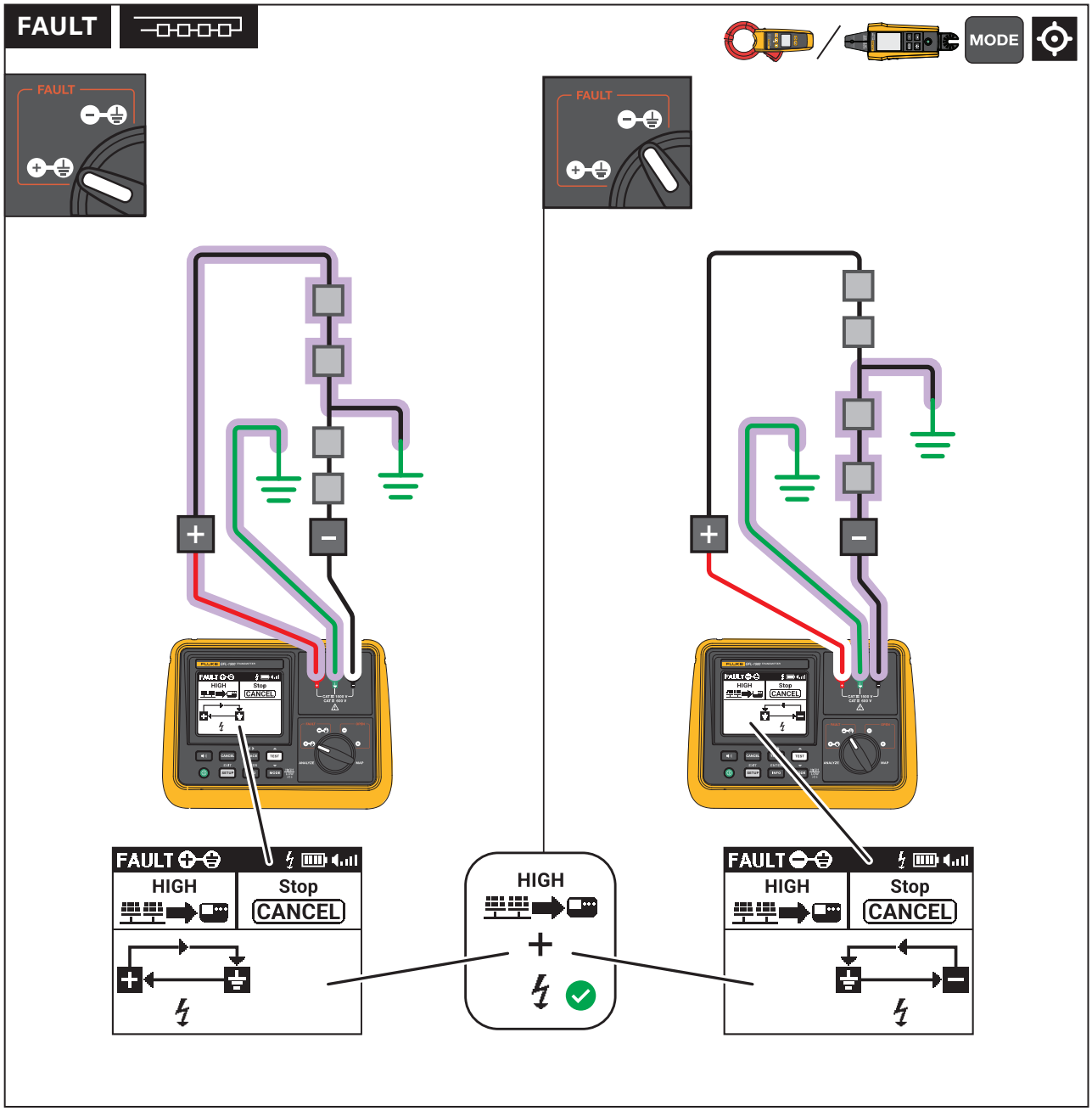


Figure 8. OPEN Signal Flow

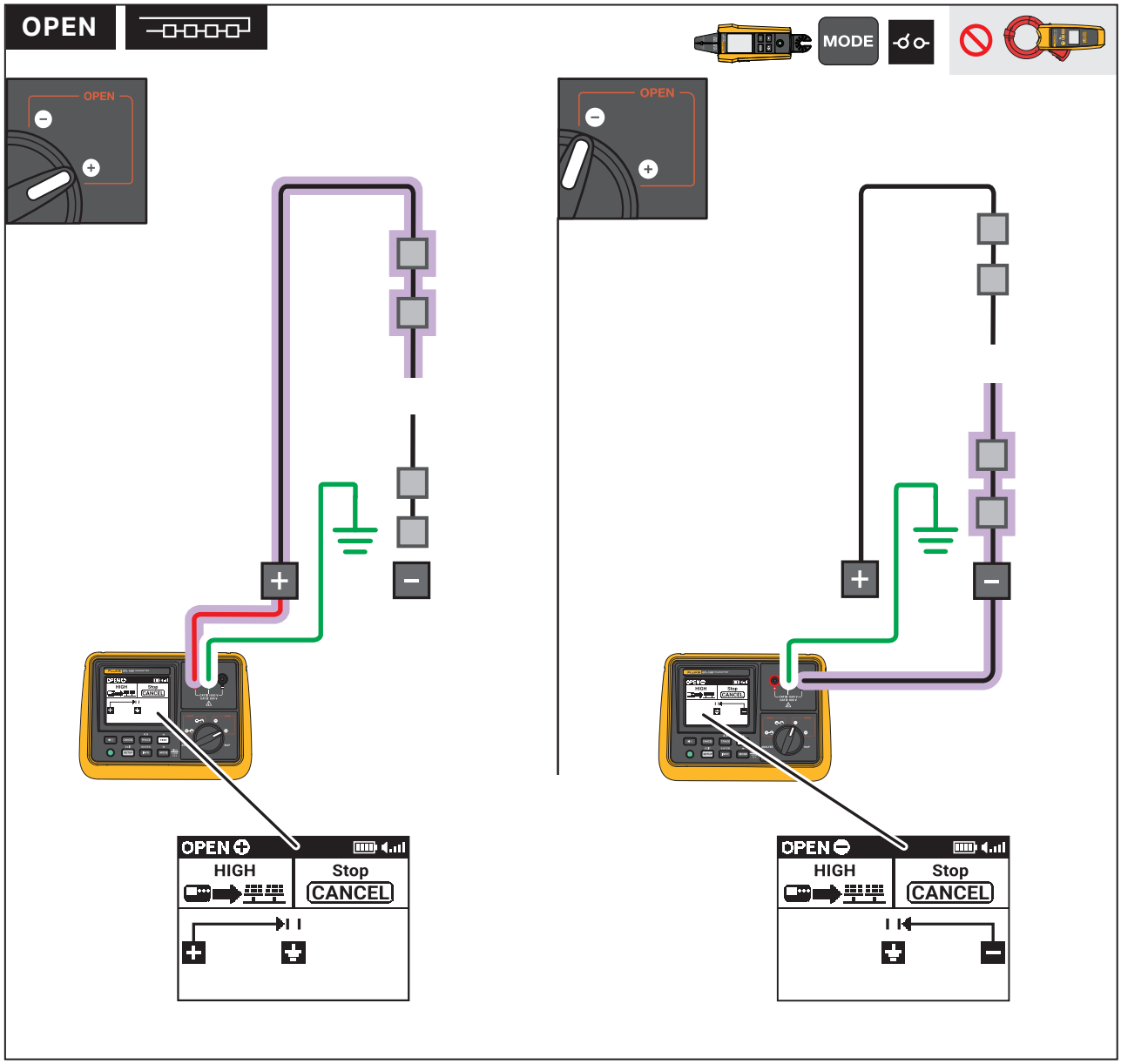
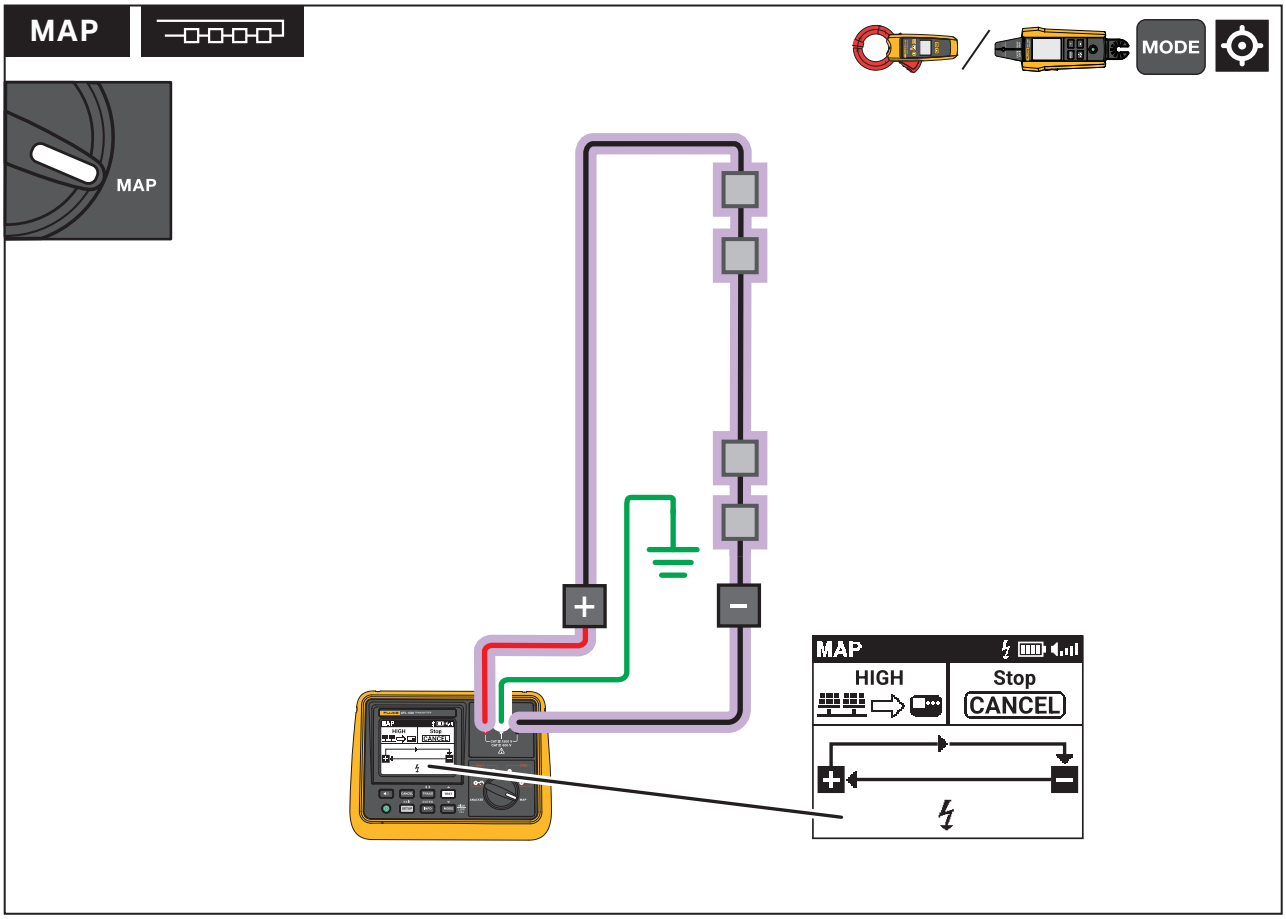


Figure 9. MAP Signal Flow



Analyze a System

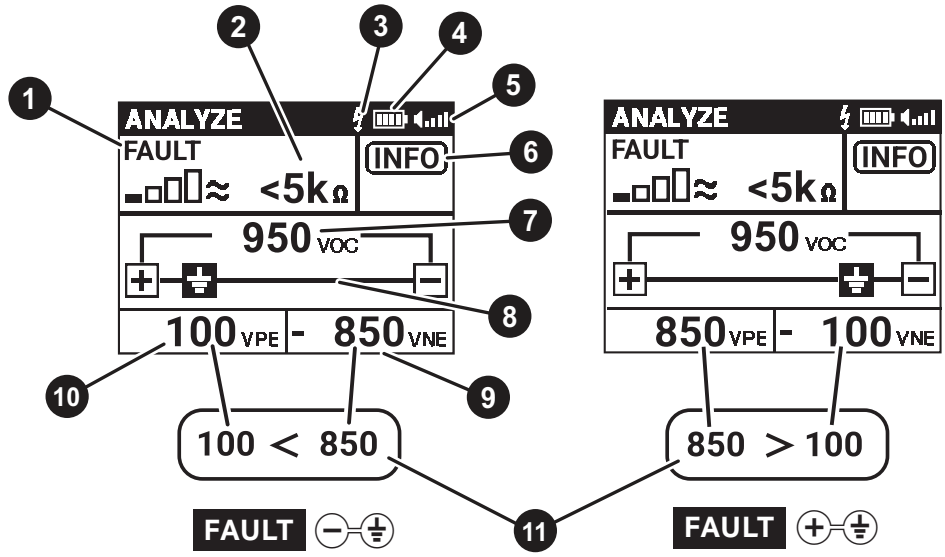
The **ANALYZE** function provides key diagnostic measurements such as estimated fault resistance and voltage to ground.

To analyze a system:

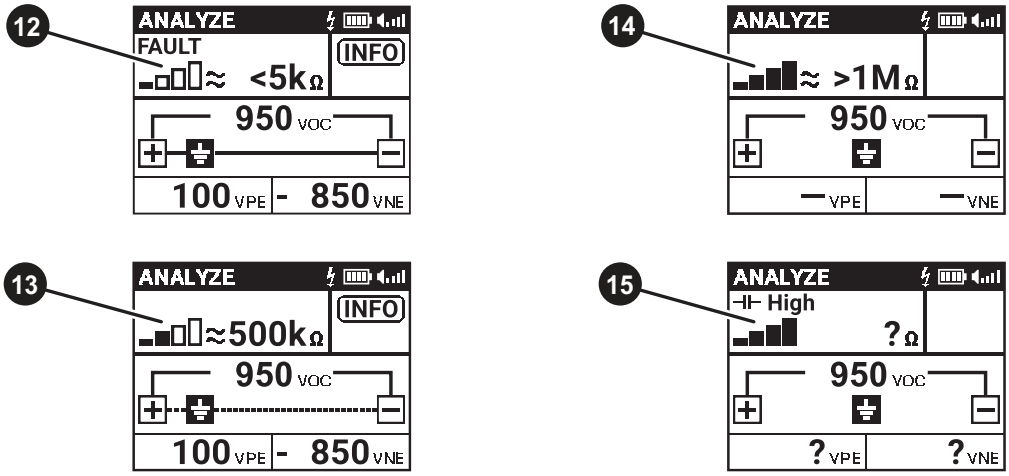
1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Select the workflow that most closely matches the System to trace. See *System Workflows*.
3. Connect the Transmitter correctly based on the workflow of the type of system to trace. See *System Workflows*.
4. On the Transmitter:
   a. Push ⏻.
   b. Turn the rotary knob to **ANALYZE**.
   c. Push **TEST**.

The **ANALYZE** results screen shows. See Table 9. The results do not save in the Transmitter. When the rotary knob turns to another function, do another test to see the results screen again.

Table 9. ANALYZE Results Screens



Possible results screens



Item	Function
❶	**FAULT** shows when the Transmitter detects a traceable hard ground fault, which is defined as the ground fault resistance approximation (❷) is ≈ <10 kΩ.
❷	Ground fault resistance approximation. The greater the resistance the more difficult it is to trace a fault.

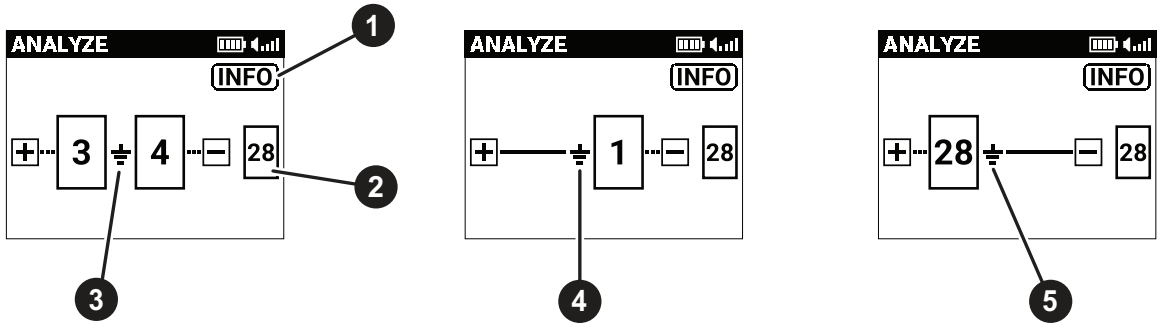
Table 9. ANALYZE Results Screens (cont.)

Item	Function
❸	Hazardous voltage (>30 V) indicator. When hazardous voltage is detected, ϟ shows.
❹	Battery level indicator.
❺	Volume level indicator.
❻	Push **INFO** to toggle between the **ANALYZE** results screen and the ANALYZE modules screen. See Table 10.
❼	VOC: Voltage open circuit (positive to negative).
❽	A solid line indicates a traceable hard ground fault. A dashed line indicates a fault with a high resistance that may be difficult to trace. No line shows when the ground fault resistance approximation (❷) is ≈ >500 kΩ or the Transmitter cannot determine if a fault is present.
❾	Voltage negative to earth (ground).
❿	Voltage positive to earth (ground).
⓫	For all system workflows except for a single-fused combiner box or string inverter, if the absolute value of: • VPE > VNE, use **FAULT** ⊕⏚ to trace a fault. • VNE > VPE, use **FAULT** ⊖⏚ to trace a fault. For a single-fused combiner box or string inverter system, see *Single-Fused Combiner box or String Inverter Workflow*.
⓬	Traceable hard fault detected. See *Trace a Fault Overview*.
⓭	High resistance fault detected. Can be traceable. If difficult to trace, reduce the fault resistance. See *Troubleshoot a Workflow*.

Table 9. ANALYZE Results Screens (cont.)

Item	Function
14	No fault detected. There is no fault to trace.
15	High resistance and capacitance detected. No hard fault detected. A fault is unlikely, but there can be an intermittent or high resistance fault. Do not trace. Trace results may be inconsistent.

Table 10. ANALYZE Modules Screens

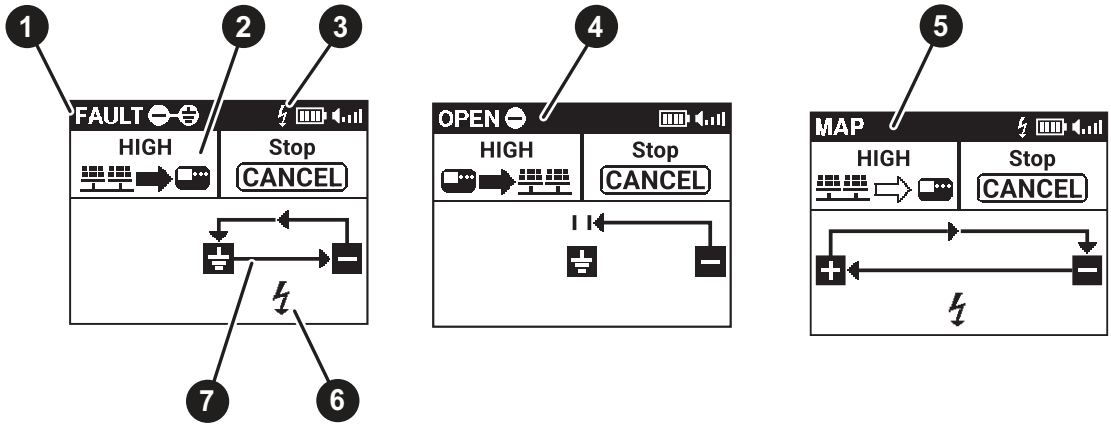


Item	Function
1	Push **INFO** to toggle between the ANALYZE modules screen and the ANALYZE results screen.
2	Total number of modules in the series string entered in the setup menu. If the number of modules do not show, push **SETUP** to enter the number of modules. See *Transmitter Setup Menu*.
3	The approximate location of the fault in relation to the number of modules. In this example, the fault is approximately between modules 3 and 4 in the string with the fault.
4	The fault is in the system before the first module in the string.
5	The fault is in the system after the last module in the string.

FAULT, OPEN, and MAP Screens

Table 11 show the information on the **FAULT**, **OPEN**, and **MAP** screens.

Table 11. FAULT, OPEN, and MAP screens



Item	Function
❶	Name of the function selected on the rotary knob. In this example, the **FAULT** ⊖⏚ function is selected on the rotary knob.
❷	Selected mode. See *Transmitter Modes*.
❸	Hazardous voltage (>30 V) indicator. When hazardous voltage is detected, ϟ shows here and on the active terminals (❻). Can show on all screens.
❹	The **OPEN** ⊖ function is selected on the rotary knob.
❺	The **MAP** function is selected on the rotary knob.
❻	The hazardous voltage indicator (ϟ) on the active terminals. Can show on **FAULT**, **OPEN**, and **MAP** screens. When ϟ shows on a FAULT screen, use **HIGH** array mode to trace a fault. See *Transmitter Modes*.
❼	The active terminals and the signal path. Can show on **FAULT**, **OPEN**, and **MAP** screens.

Transmitter Modes

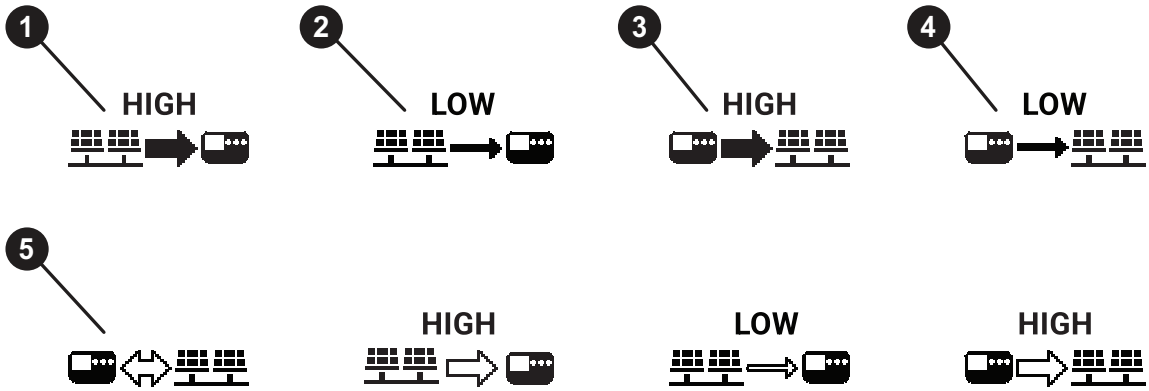
The Transmitter has different modes that may make it easier to detect a signal. Table 8 shows the modes of the Transmitter.

The Transmitter emits different tones for array and unit modes to indicate something changed in the system.

If you hear the tone change:

1. Check the connections and the array.
2. If you are in array mode, change to unit mode.
3. If you are in unit mode, change to array mode.

Table 12. Transmitter Modes



Item	Description
❶	**HIGH** array mode. The array mode generates a high-amplitude signal by sourcing the voltage from the array. When to use: • When hazardous voltage (>30 V) is detected on the active terminals and ϟ shows on the display. See ❻ in Table 11. • This is the default mode for the **FAULT** functions. • Can be used with the **MAP** function.

Table 12. Transmitter Modes (cont.)

Item	Description
❷	**LOW** array mode. The array mode generates a low-amplitude signal by sourcing the voltage from the array. When to use: • When hazardous voltage (>30 V) is detected on the active terminals and ϟ shows on the display. See ❻ in Table 11. • Use with the **FAULT** functions when: ○ The **ANALYZE** results indicate the presence of a fault in the system, but the signal is unstable. ○ The amplitude of the signal is too high for the Receiver to distinguish the changes in the signal. • May be used with the **MAP** function.
❸	**HIGH** unit mode. Unit mode generates a high-amplitude signal by injecting a voltage from the Transmitter. When to use: • This is the default mode for the **OPEN** function. • Use with the **FAULT** functions when the **ANALYZE** results indicate the presence of a fault in the system, but the hazardous voltage symbol does not show on the **FAULT** screen. • May be used with the **MAP** function.

Table 12. Transmitter Modes (cont.)

Item	Description
❹	**LOW** unit mode. Unit mode generates a low-amplitude signal by injecting a voltage from the Transmitter. When to use: • This is only available for the **OPEN** function. • The amplitude of the signal is too high for the Receiver to distinguish the changes in the signal.
❺	Auto mode. The double arrows show as the Transmitter determines which mode to select. Auto mode selects: • Array mode when the Transmitter detects a voltage ≥25 V. • Unit mode when the Transmitter detects a voltage <25 V. This is only recommended for use with the **MAP** function. Auto mode may not be effective in systems with high capacitance.

Ground Fault Overview

For the Product to detect and locate a fault in a system:

- The fault must be active in the system.
- You must be able to identify any parallel branches in the system.
- You must know which system workflow most closely matches the system to trace and how to trace a fault on the system. See *System Workflows*.
- You must isolate the dc system from ground. See *Isolate the DC System from Ground*.

Trace a Fault Overview

To locate a ground fault:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Select the system workflow that most closely matches the system of the fault to trace. See *System Workflows*.
3. Connect the Transmitter based on the workflow of the type of system to trace. See *System Workflows*.
4. Use the **ANALYZE** function to detect a ground fault. See *Analyze a System*.
5. Select the correct **FAULT** function to use to trace the fault. See Table 9.
6. Select the correct mode on the Transmitter. See *Transmitter Modes*.
7. Verify which terminals are active. See *Verify the Active Terminals*.
8. Use the Receiver or the Clamp to (see *System Workflows*):
   a. Identify the branch that contains the fault.
   b. Locate the fault on the branch that contains the fault.

      The signal stops at the point of the fault.

Isolate the DC System from Ground

The positive and negative wires of the dc system must be isolated from ground to locate a fault.

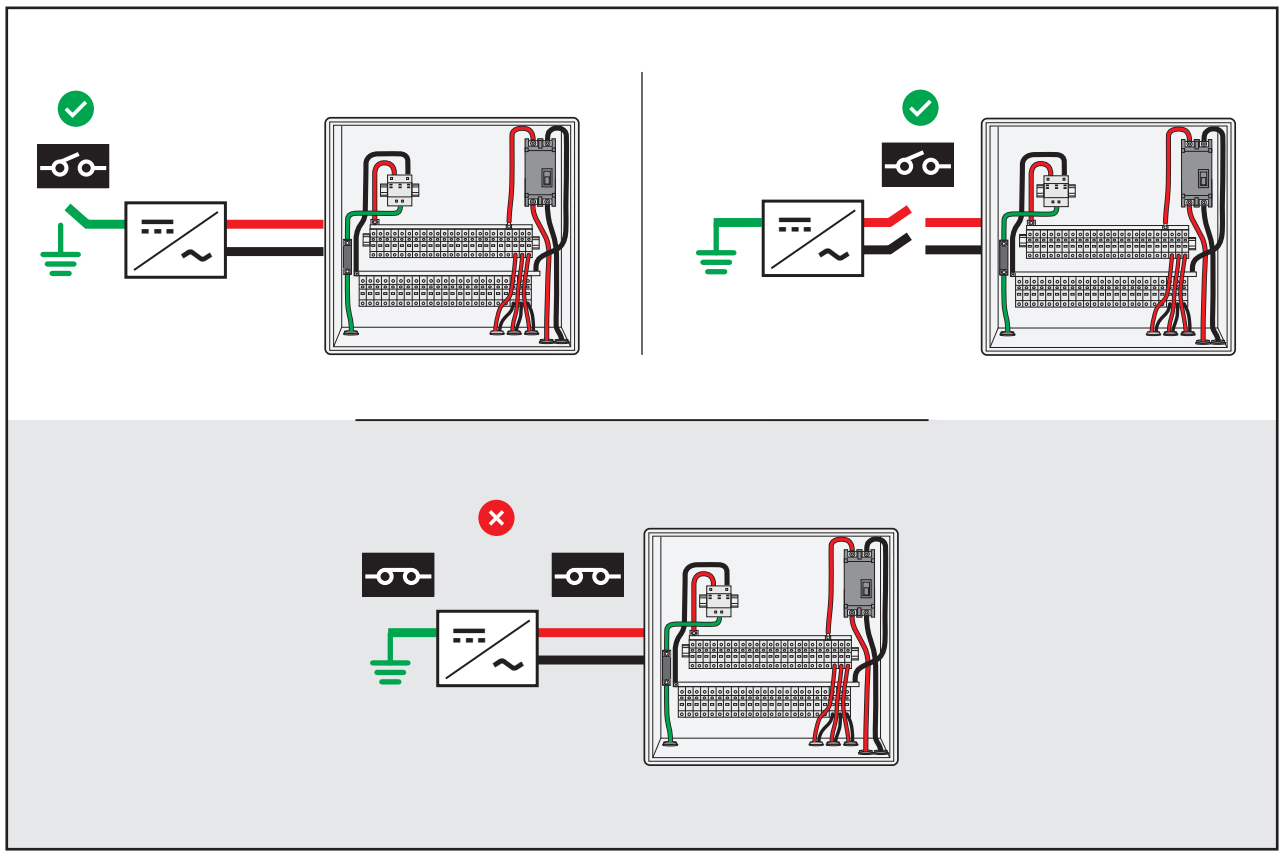
To isolate the System from ground (See Figure 10):

- Turn off the inverter and confirm the ground fault protection device (GFPD) is on an open circuit.

  Or,
- Disconnect the positive and negative conductors to the inverter from the sub-array.
  - Open the load break disconnect (LBD).

    Or,
  - Remove the positive and negative conductors from their terminals.

Figure 10. Isolate the System from Ground



Verify the Active Terminals

Verify the active terminals before you trace a fault and each time you move the Transmitter or adjust the connections.

To verify which terminals are active:

1. Use the Clamp or the Receiver on the test leads near the terminals of the Transmitter. See Figure 11.
2. Push **TRACE** on the Transmitter.

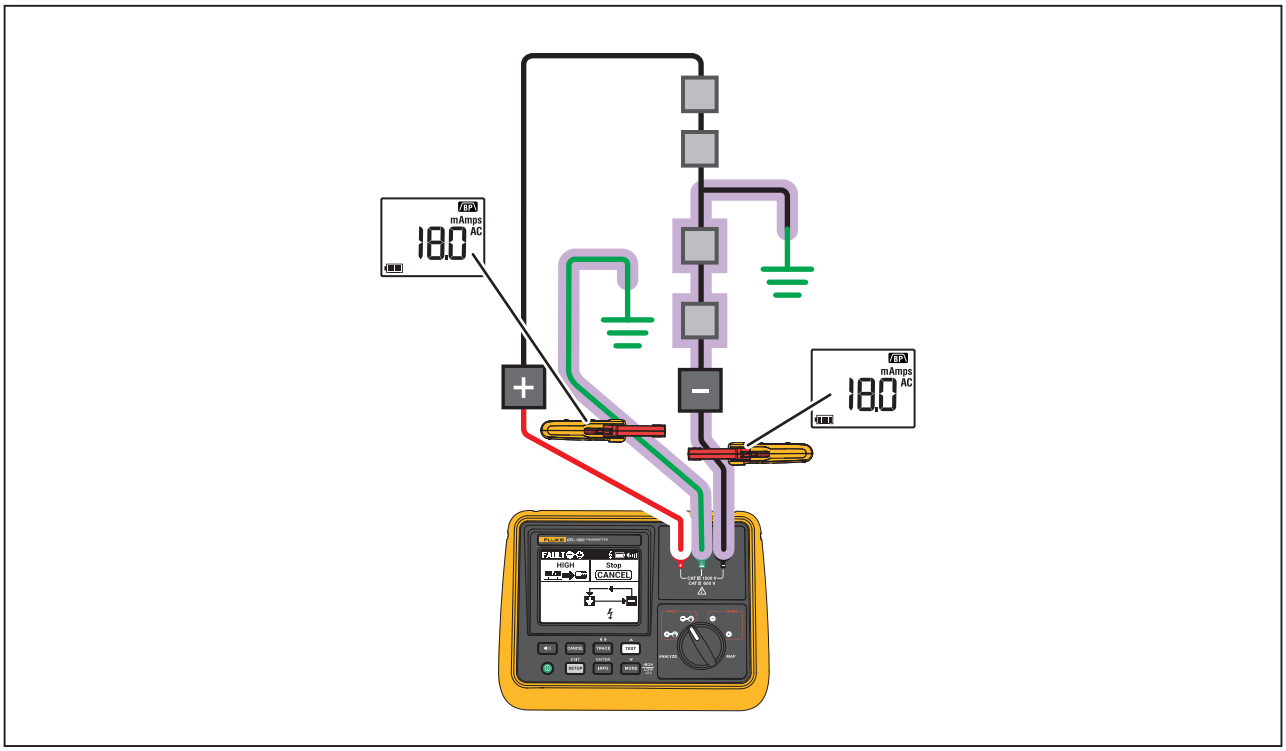
   In this example, the Transmitter generates a signal from negative to ground. No signal is detected on the positive terminal.

3. Use the Clamp or the Receiver to verify the Transmitter sends the signal on the active terminals.

   For the most reliable results, use the Clamp with the band pass (BP) filter activated to filter out leakage capacitive paths. For the band pass (BP) filter to work, the Transmitter must be in **HIGH** or **LOW** array mode and the hazardous voltage indicator (⚡) must show on the display.

4. If the results do not show as expected, see *Troubleshoot a Workflow*.

Figure 11. Verify the Active Terminals



System Workflows

Use the type of system workflow and the suspected issue to determine how to locate a fault.

In workflows, unless otherwise stated:

- Set the fault function on the rotary dial to:
  - **FAULT** ⊕⏚ if the absolute value of VPE > VNE.
  - **FAULT** ⊖⏚ if the absolute value of VNE > VPE.
- For transmitter mode:
  - If the hazardous voltage indicator (ϟ) shows on the display, use **HIGH** or **LOW** array mode. See ❻ in Table 11 and ❶ and ❷ in Table 12.
  - If the hazardous voltage indicator (ϟ) does not show on the display, use **HIGH** unit mode. See ❻ in Table 11 and ❸ in Table 12.
- You can use the Clamp or the Receiver to trace a fault.
- For the most reliable results, use the Clamp with the band pass (/BP\) filter activated to filter out leakage capacitive paths. For the band pass (/BP\) filter to work, the Transmitter must be in **HIGH** or **LOW** array mode and the hazardous voltage indicator (ϟ) must show on the display.

Isolated String Workflow

Applies to: Applies to all systems on which a single string can be isolated. On a system with parallel branches, you must be able to isolate a string.

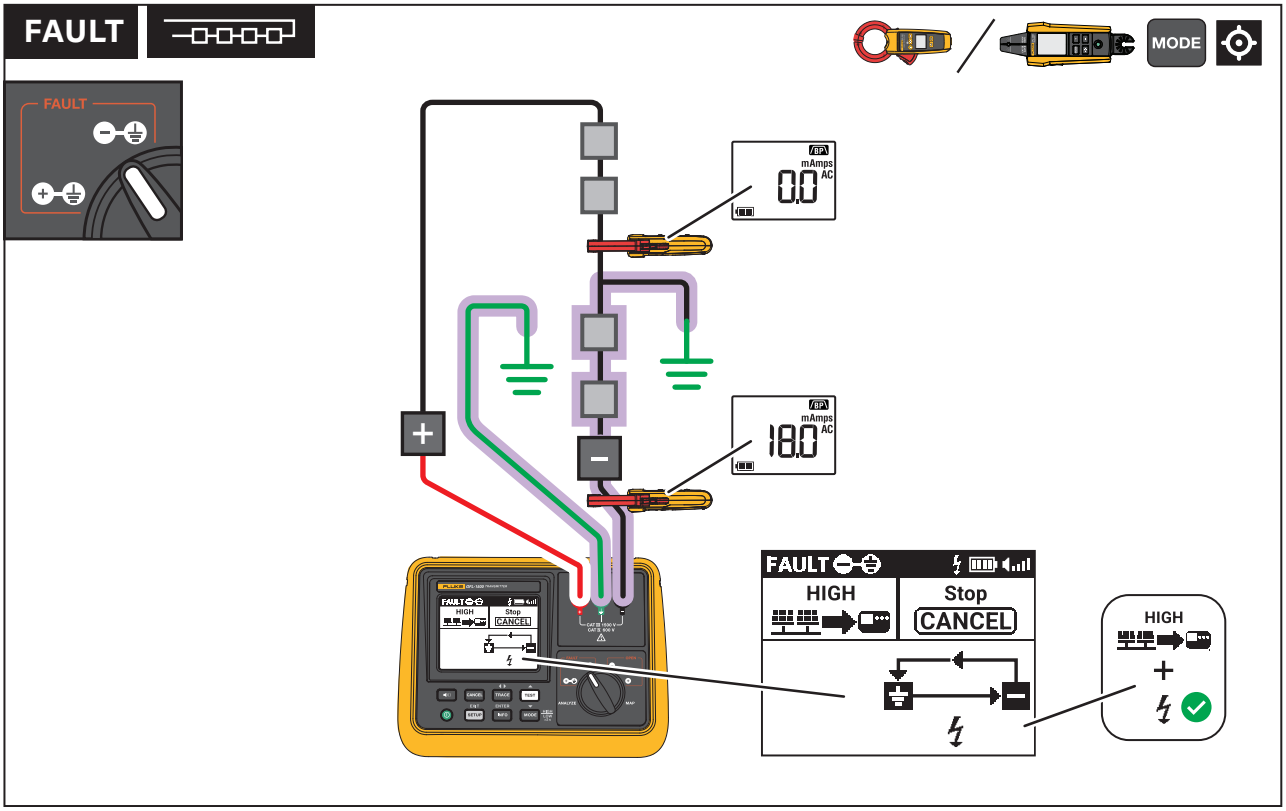
Issue: A possible fault on a single string.

Goal: Trace an isolated string to locate a fault.

To trace a fault on an isolated string:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Directly connect the Transmitter to the isolated string. See Figure 12.

Figure 12. Isolated String Direct Connection



3. Use the **ANALYZE** function to detect a ground fault. See *Analyze a System*.
4. Select the correct **FAULT** function to use to trace the fault. See ⓫ in Table 9.
5. Select the correct mode on the Transmitter. See *Transmitter Modes*.
6. Verify the active terminals. See *Verify the Active Terminals*.
7. Use the Clamp or the Receiver to follow the signal from the active terminal to the fault. See Figure 12.

   In this example, trace from the negative terminal to the fault.

Underground Faults

Note

The Receiver and the Clamp are unable to identify the exact fault location in an underground section.

Ground faults often occur on underground conductors. A ground fault can occur on the positive or negative end of a string of solar modules where the strings connect in parallel at an inverter, combiner box, or trunk bus system.

Measure immediately before and after the underground section to determine if the fault is underground.

If you detect the signal on the circuit before the underground section but do not detect the signal after the underground section, the fault is located in the underground section.

Double-Fused Combiner box or String Inverter Workflow

Applies to: Combiner boxes or string inverters with parallel branches bused together that have easy disconnects (fuses) on positive and negative buses.

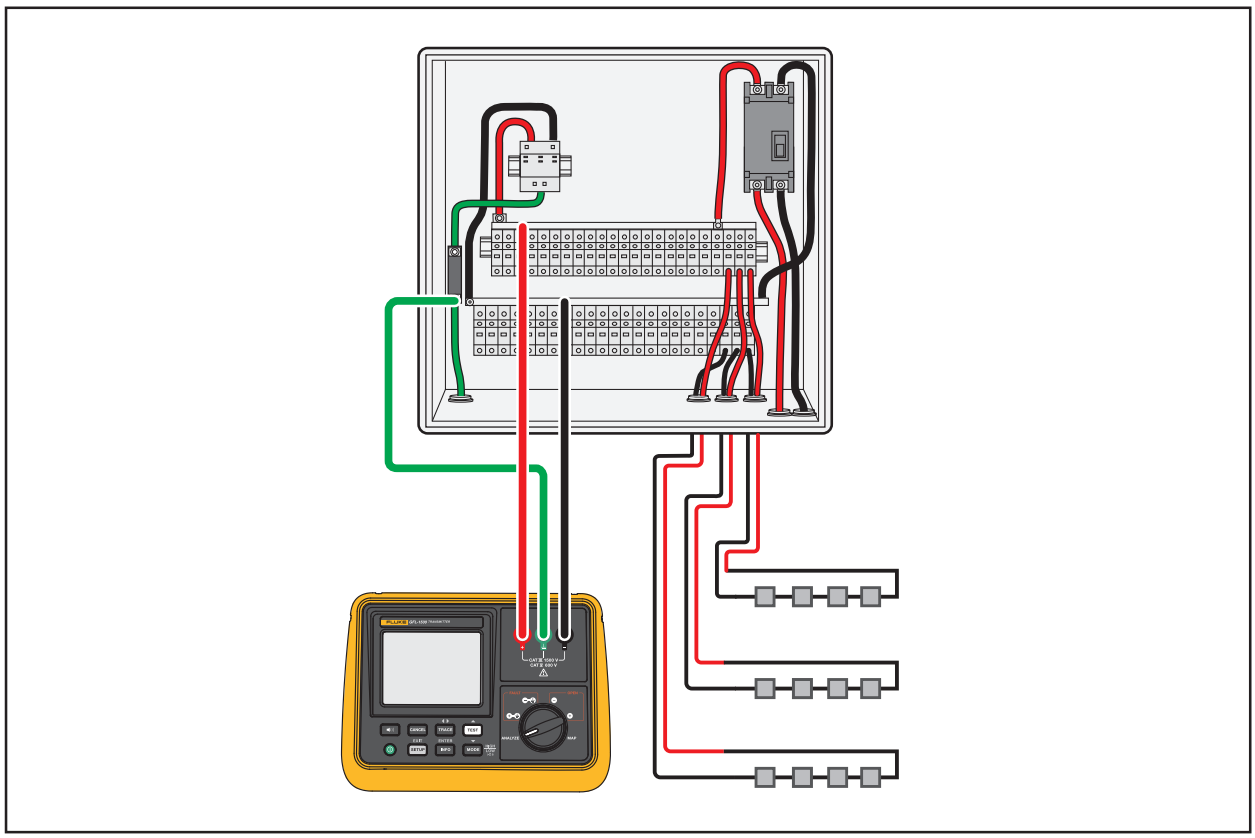
Issue: A possible fault in the system.

Goal: Start at the combiner box or string inverter. Then, identify a faulted branch, and locate the fault on the branch.

To locate a fault in a double-fused combiner box or string inverter:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Connect the Transmitter to a double-fused combiner box. See Figure 13.

Figure 13. Double-Fused Combiner Box Connection

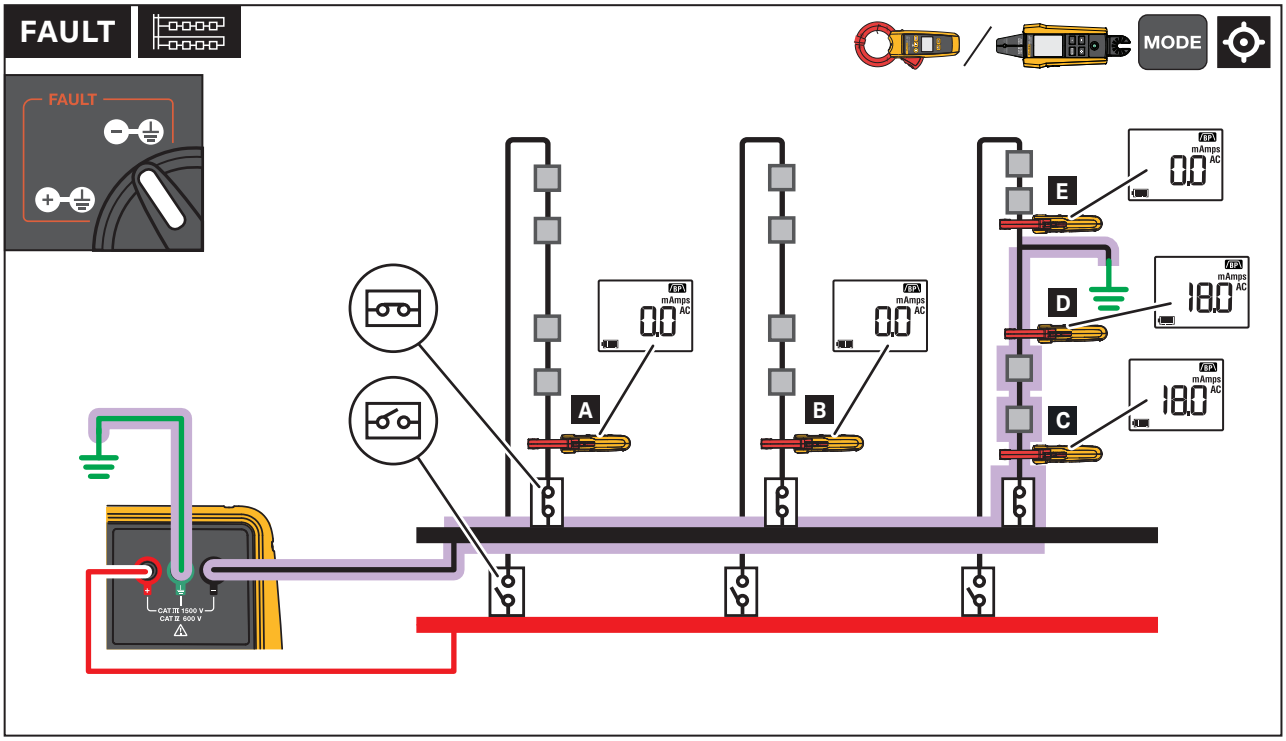


3. Use the **ANALYZE** function to detect a ground fault. See *Analyze a System*.
4. Select the correct **FAULT** function to use to trace the fault. See ⓫ in Table 9.
5. Select the correct mode on the Transmitter. See *Transmitter Modes*.
6. Identify the branch that contains the fault.
   a. Disconnect the parallel branches on the side the signal does not transmit on. This breaks parallel loops and focuses the signal on the branch with the fault. See Figure 14.
   b. In this example, the Transmitter generates a signal from negative to ground.
   c. Verify the active terminals. See *Verify the Active Terminals*.
   d. Use the Clamp or the Receiver to locate the branch with the fault. See steps A, B, and C in Figure 14.

7. Locate the fault on the branch that contains the fault.
   a. Keep the same disconnections on one side of all parallel branches.
   b. Use the Clamp or the Receiver to follow the signal from the active terminal to the fault. See steps C, D, and E in Figure 14.

      In this example, trace from the negative terminal to the fault.

Figure 14. Trace Open-Fused Workflow



Single-Fused Combiner box or String Inverter Workflow

Applies to: Combiner boxes or string inverters with parallel branches bused together that have easy disconnects (fuses) on only one bus. Note, most single-fused combiner boxes have fuses on the positive side.

Issue: A possible fault in the system.

Goal: Start at the combiner box or string inverter. Then, identify a faulted branch, and locate the fault on the branch.

You can trace a fault with all the fuses closed or with one or more fuses open. Both have good uses. See *Single-Fused Combiner box or String Inverter: Closed-Fused Workflow* and *Single-Fused Combiner box or String Inverter: Open-Fused Workflow*. For best results, use a closed-fused workflow.

Single-Fused Combiner box or String Inverter: Closed-Fused Workflow

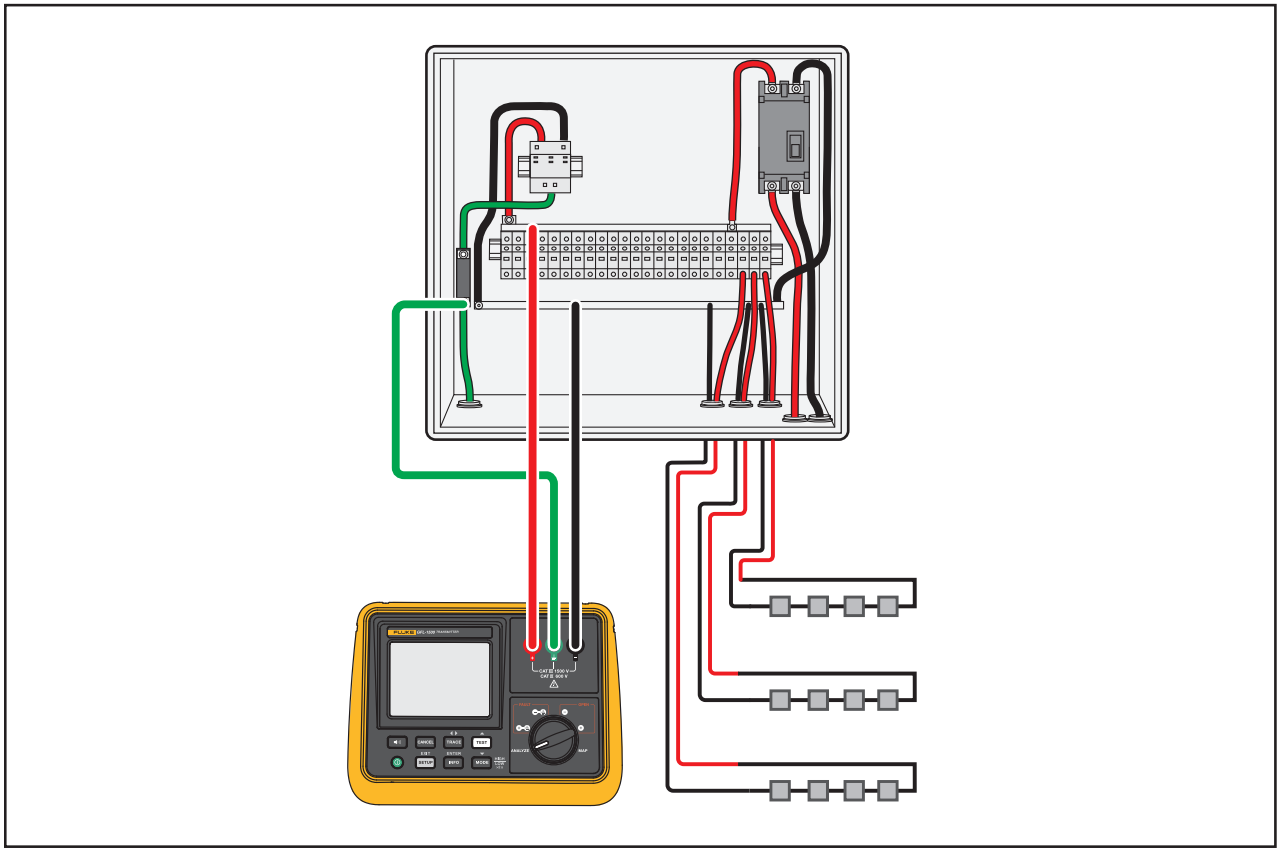
In a closed-fused workflow:

- You can use the Clamp with the band pass (BP) filter activated to filter out leakage capacitive paths.
- You may need to move the Transmitter and connect it only to the branch that contains the fault.

To locate a fault in a single-fused combiner box or string inverter in a closed-fused workflow:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Connect the Transmitter to a single-fused combiner box. See Figure 15.

Figure 15. Single-Fused Combiner Box Connection

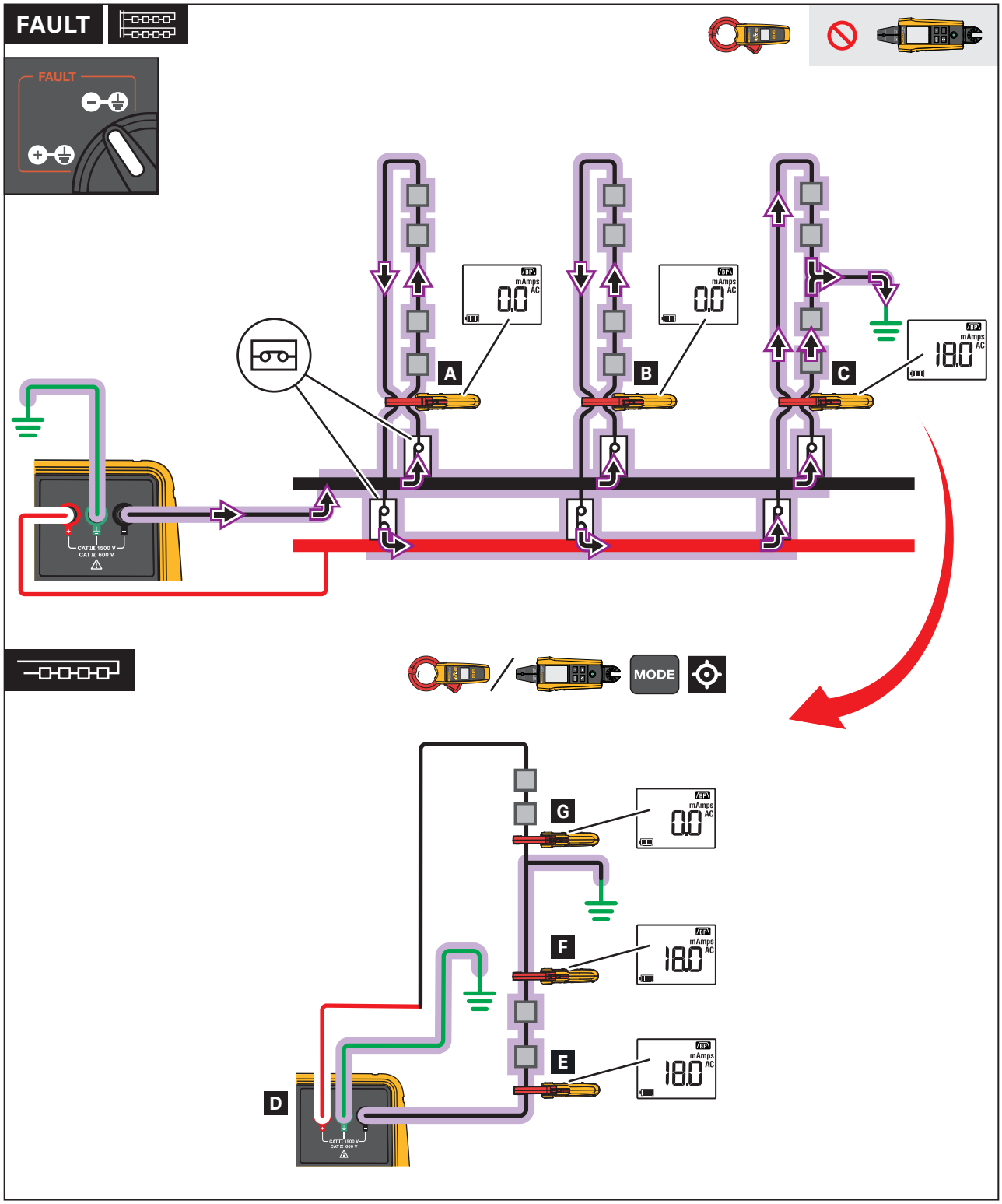


3. Use the **ANALYZE** function to detect a ground fault. See *Analyze a System*.
4. Select the correct **FAULT** function to use to trace the fault. See ⓫ in Table 9.
5. Select the correct mode on the Transmitter. See *Transmitter Modes*.
6. Verify the active terminals. See *Verify the Active Terminals*.
7. Identify the branch that contains the fault.

   Place the Clamp around the positive and negative wires in a branch to confirm which branches are balanced (0 mA) and do not have a fault.

   A branch that contains a fault is unbalanced and has the highest reading. See steps A, B, and C in Figure 16
8. Locate the fault on the branch that contains the fault.
   a. Move the Transmitter and connect it only to the branch that contains the fault. See step D in Figure 16.
   b. Verify the active terminals. See *Verify the Active Terminals*.
   c. Use the Clamp or the Receiver to follow the signal from the active terminal to the fault. See steps E, F, and G in Figure 16 or steps C, D, and E in Figure 14.

Figure 16. Trace a Closed-Fused Worflow



Single-Fused Combiner box or String Inverter: Open-Fused Workflow

In an open-fused workflow:

- You can use the Receiver or the Clamp.
- You might not be able to use the Clamp with the band pass (/BP) filter activated to filter out leakage capacitive paths.

To locate a fault in a single-fused combiner box or string inverter in an open-fused workflow:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Connect the Transmitter to a single-fused combiner box. See Figure 15.
3. Use the **ANALYZE** function to detect a ground fault. See *Analyze a System*.
4. Select the correct **FAULT** function to use to trace the fault. See 11 in Table 9.
5. Select the correct mode on the Transmitter. See *Transmitter Modes*.
6. Identify the branch that contains the fault.
    a. Disconnect the parallel branches on the side the signal does not transmit on. This breaks parallel loops and focuses the signal on the branch with the fault. See Figure 14.

       In this example, the Transmitter generates a signal from negative to ground.
    b. Verify the active terminals. See *Verify the Active Terminals*.
    c. Use the Clamp or the Receiver to locate the branch with the fault. See steps A, B, and C in Figure 14.
7. Locate the fault on the branch that contains the fault.
    a. Keep the same disconnections on one side of all parallel branches.
    b. Use the Clamp or the Receiver to follow the signal from the active terminal to the fault. See steps C, D, and E in Figure 14.

Central Inverter with Branched Combiner Boxes Workflow

Applies to: A central inverter or combiner box with multiple upstream combiner boxes. Parallel branches in each combiner are bused together.

Issue: A possible fault in an array, but the fault is not yet isolated to a single combiner box.

Goal: Start at a central inverter or combiner box with multiple upstream combiner boxes, and locate the combiner box with the fault. Then, identify the faulted branch, and locate the fault on the branch.

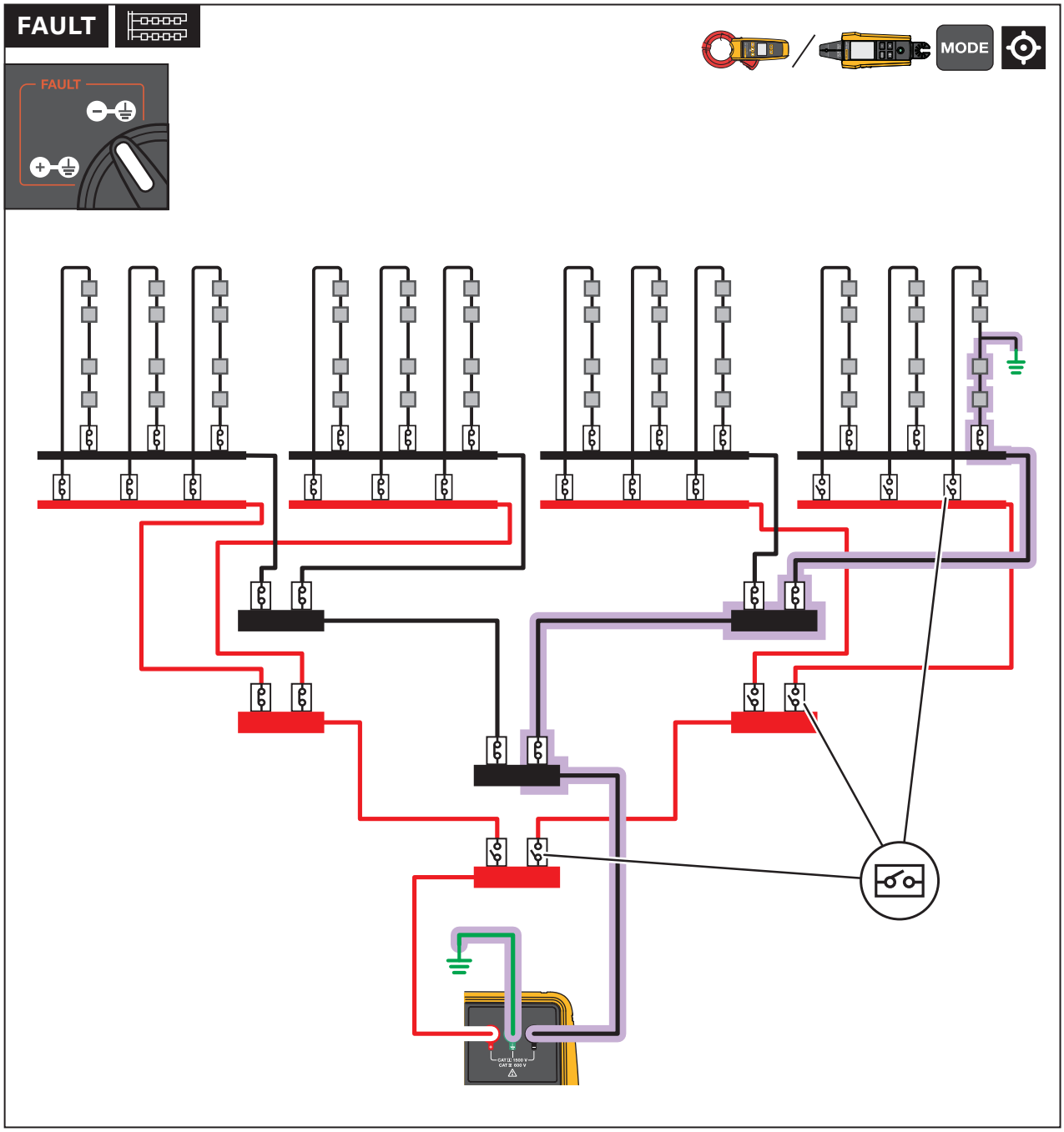
To locate a fault in a central inverter with branch combiner boxes:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Connect the Transmitter to the positive and negative dc buses of the central inverter or furthest downstream combiner box with a suspected fault. Connect the Transmitter ground to an available ground point in the system. See Figure 17.

   Note

   The fault may be between combiner boxes or further upstream in the solar array.

Figure 17. Trace an Upstream Fault



3. If the combiner boxes are double-fused, follow the rest of the instructions in *Double-Fused Combiner box or String Inverter Workflow* for each upstream combiner box until you locate the fault.
4. If the combiner boxes are single-fused, follow the rest of the instructions in *Single-Fused Combiner box or String Inverter Workflow* for each upstream combiner box until you locate the fault.

Note

If you use the Single-Fused Combiner box or String Inverter: Open-Fused Workflow or Double-Fused Combiner box or String Inverter Workflow, you must open fuses on the same side at each combiner box level until you locate the fault.

Trunk Bus Workflow

Applies to: Trunk bus. Accessible quick connects for the positive and negative of individual branches.

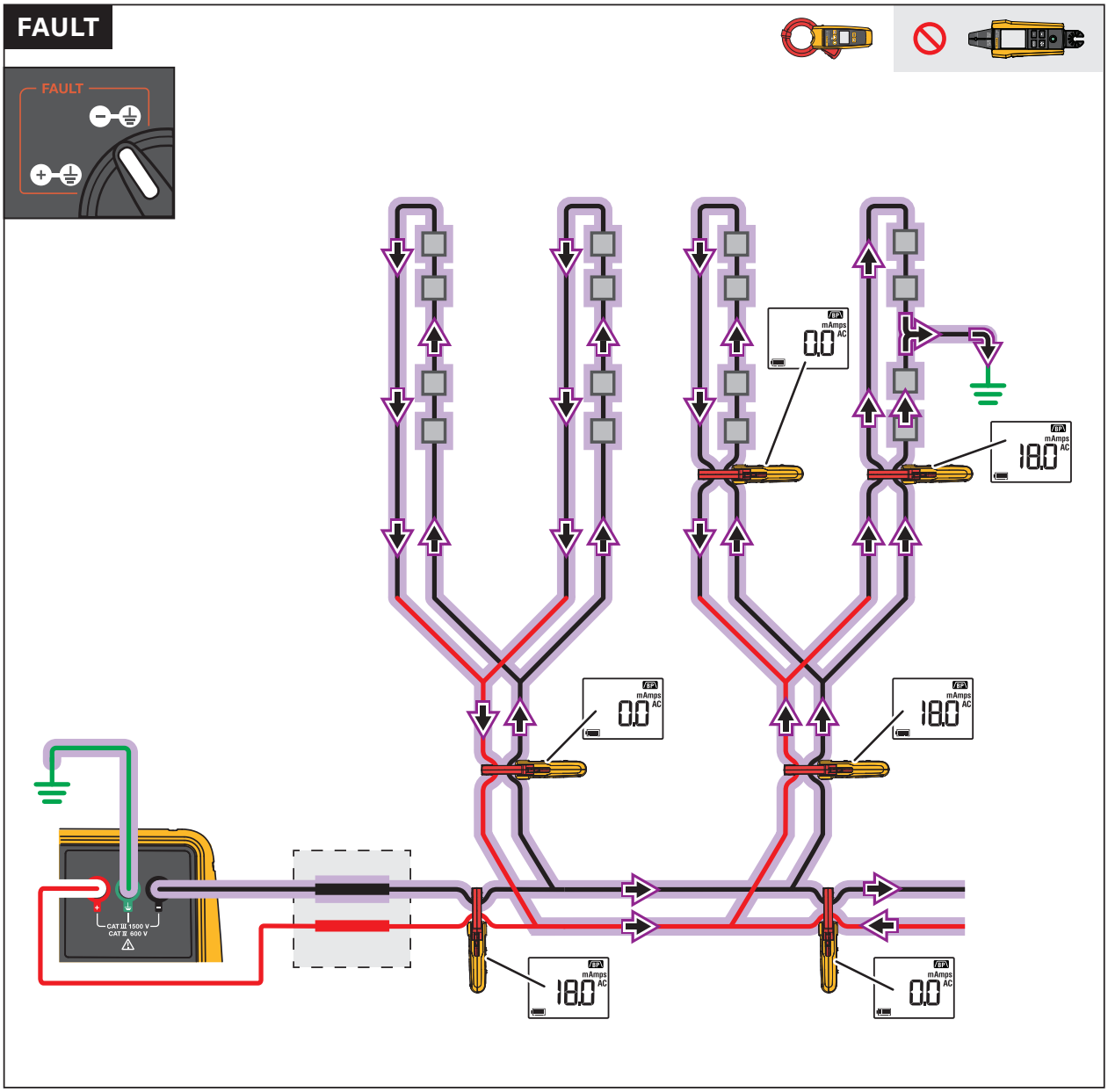
Issue: A possible fault is in the array.

Goal: Start at a load break disconnect (LBD). Then, identify a faulted branch, and locate the fault on the branch.

To locate a fault in a trunk bus system:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Connect the Transmitter to the positive and negative buses of the load break disconnect (LBD) with a possible fault, and connect the Transmitter ground to an available ground point in the system. See Figure 18.

Figure 18. Trace a Trunk Bus System



3. Use the **ANALYZE** function to detect a ground fault. See *Analyze a System*.
4. Select the correct **FAULT** function to use to trace the fault. See ⓫ in Table 9.
5. Select the correct mode on the Transmitter. See *Transmitter Modes*.
6. Verify the active terminals. See *Verify the Active Terminals*.
7. Identify the branch that contains the fault.
   a. Place the Clamp around the positive and negative wires in a branch to confirm which branches are balanced (0 mA) and do not have a fault.

      A branch that contains a fault is unbalanced and has the highest reading. See steps A, B, and C in Figure 18

   b. Repeat at each branch that splits from the trunk until you locate the branch that contains the fault.
8. Locate the fault on the branch that contains the fault.
   a. Move the Transmitter and connect it only to the branch that contains the fault. See step D in Figure 16.
   b. Verify the active terminals. See *Verify the Active Terminals*.
   c. Use the Clamp or the Receiver to follow the signal from the active terminal to the fault. See steps E, F, and G in Figure 16 or steps C, D, and E in Figure 14.

Combiner Box or String Inverter with External Connectors Workflow

Applies to: A combiner box or string inverter that uses external connectors to interface with strings.

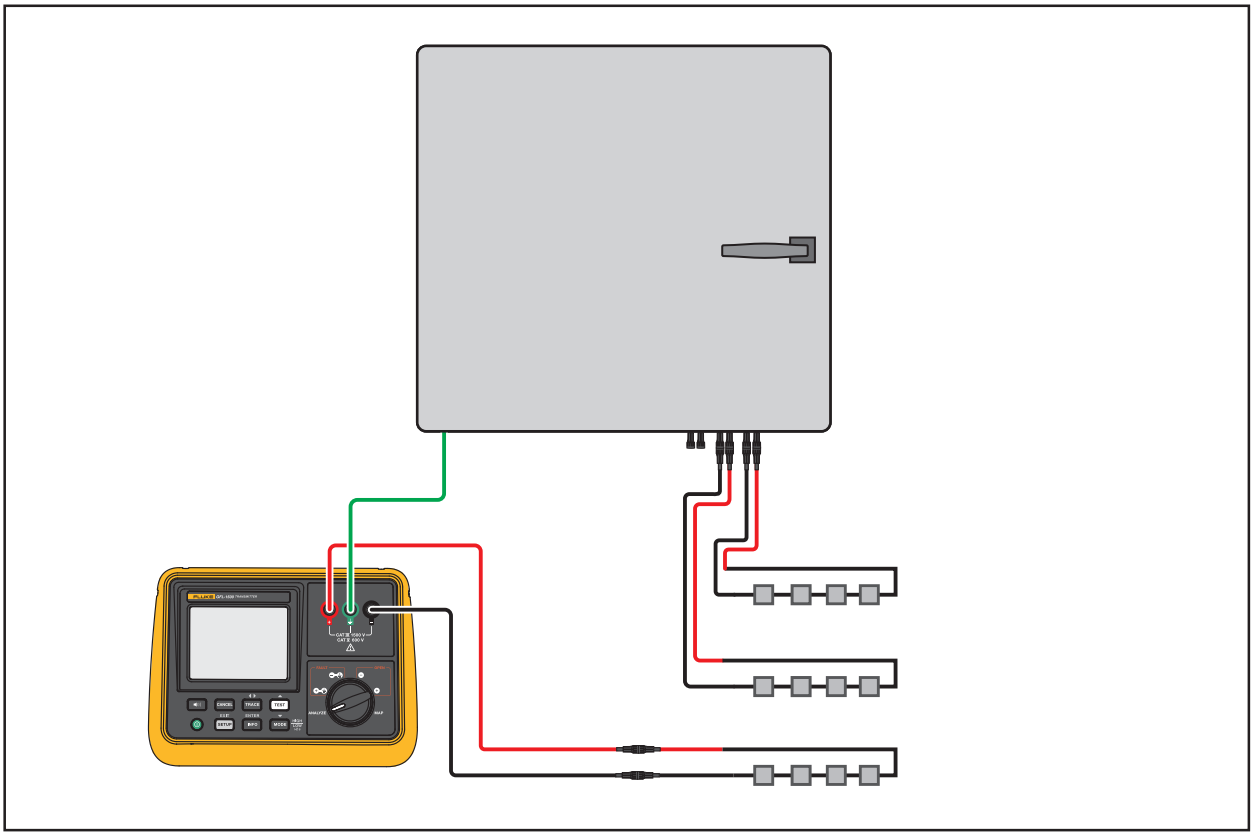
Issue: A possible ground fault in the system.

Goal: Start at a closed combiner box or string inverter. Then, identify a faulted branch, and locate the fault on the branch.

To locate a fault at a combiner box or string inverter that uses external connectors:

1. Isolate the dc system from ground. See *Isolate the DC System from Ground*.
2. Disconnect and analyze one string. See Figure 19.
    a. Disconnect the positive and negative sides of one string from the external connectors.
    b. Connect the Transmitter to the isolated string using the MC4 test leads.
    c. Use the **ANALYZE** function to determine if there is a fault on the isolated string. See *Isolated String Workflow*.
    d. If the **ANALYZE** function indicates there is a fault on the isolated string, use the correct **FAULT** function to trace the fault. See *Isolated String Workflow*.
    e. If the **ANALYZE** function does not indicate there is a fault on the isolated string, continue to the next step.

Figure 19. External Connection to an Isolated String



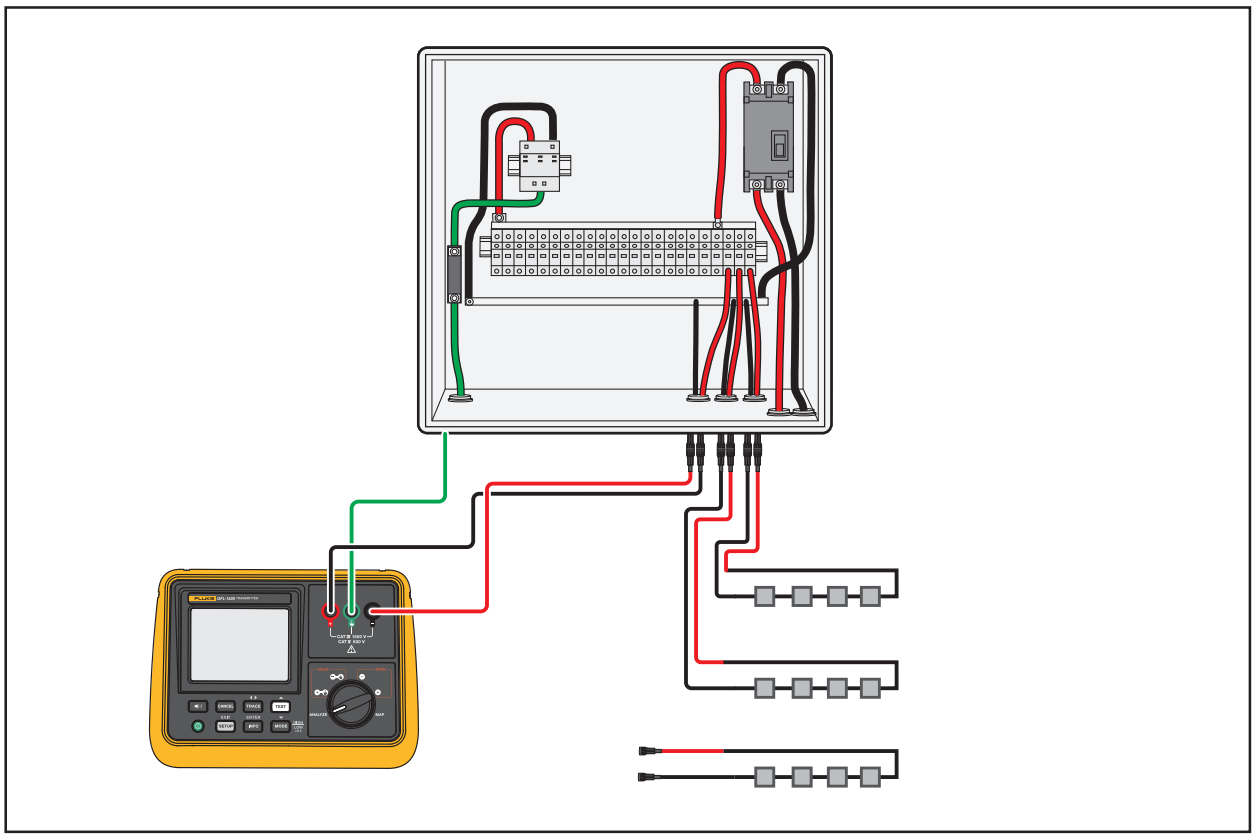
3. Use the available external connectors where the isolated string was previously connected to connect the Transmitter to the dc bus. See *External Connections to a DC Bus*.
   a. Use an MC4 test lead to connect the Transmitter positive terminal to the positive external connector.
   b. Use an MC4 test lead to connect the negative terminal on the Transmitter to the negative external connector.

Note

The color of the MC4 test leads might not match the color of the terminals on the Transmitter.

The Transmitter is coupled to strings on the same dc bus as the external connectors. To remove strings from the bus, open the external connectors instead of the fuses.

Figure 20. External Connections to a DC Bus



4. Use the **ANALYZE** function to determine if there is a fault on the strings connected to the dc bus. See *Analyze a System*.

   If you connect the test leads with incorrect polarity, an error message shows on the display. To correct the error:

   a. Disconnect the positive and negative test leads from the Transmitter.

   b. Connect the test leads again with the correct polarity.

   c. Push **TEST**.

5. If the **ANALYZE** function indicates there is a fault on the on the strings connected to the dc bus, use the correct **FAULT** function to trace the fault. See 11 in Table 9.

6. Select the correct mode on the Transmitter. See *Transmitter Modes*.

7. Verify the active terminals. See *Verify the Active Terminals*.

8. Identify the branch that contains the fault.

   Place the Clamp around the positive and negative wires in a branch to confirm which branches are balanced (0 mA) and do not have a fault.

   A branch that contains a fault is unbalanced and has the highest reading. See steps A, B, and C in Figure 16

9. Locate the fault on the branch that contains the fault.

   a. Move the Transmitter and connect only to the branch that contains the fault. See step D in Figure 16.

      Or,

      Disconnect wires from the external connectors to disconnect all the parallel branches on the side the signal does not transmit on. See Figure 14. This breaks parallel loops and focuses the signal on the branch with the fault.

   b. Verify the active terminals. See *Verify the Active Terminals*.

   c. Use the Clamp or the Receiver to follow the signal from the active terminal to the fault. See steps E, F, and G in Figure 16 or steps C, D, and E in Figure 14.

Troubleshoot a Workflow

First, verify:

- The dc system is isolated from ground. See *Isolate the DC System from Ground*.
- The test leads are connected securely to the Transmitter.
- The Transmitter is connected to the positive, negative, and ground in the system.
- The Transmitter beeps and the active terminals and the signal path shows on the display. See *FAULT, OPEN, and MAP Screens*.
- The correct transmitter mode is set on the Transmitter.
  - If the hazardous voltage indicator (ϟ) shows on the display, use **HIGH** or **LOW** array mode. See ❻ in Table 11 and ❶ and ❷ in Table 12.
  - If the hazardous voltage indicator (ϟ) does not show on the display, use **HIGH** unit mode. See ❻ in Table 11 and ❸ in Table 12.
- On systems with parallel branches:
  - One side of all branches are disconnected.
  - You moved the Transmitter to connect to an isolated string.

    Or,
  - You use the Clamp around branch conductor pairs to identify a fault.

Other possible issues:

The **ANALZYE** results indicate the presence of a fault, but you cannot detect a signal in the system. Cause: You may have a high resistance fault.

- Use **LOW** array mode. Less current may provide a more stable signal.
- Attempt to reactivate the fault in one or more ways.
  - Spray the array with water to lower the fault resistance.
  - Jiggle wires where poor insulation is suspected.
  - Adjust the tracker system if you suspect wires are pinched at a certain position.

  ANALYZE the system again to see if the estimated fault resistance is lower than before. Then trace the fault.

The signal does not lead to the fault. Signal or imbalance is observed in multiple branches
Cause: You may have leakage from capacitance in the system.

- Do not use the Receiver.
- Use the Clamp with the band pass (BP) filter activated to filter out leakage capacitive paths. For the band pass (BP) filter to work, the Transmitter must be in **HIGH** or **LOW** array mode and the hazardous voltage indicator (⚡) must show on the display.
- Verify the Transmitter beeps and the active terminals and signal path show on the display. See *FAULT, OPEN, and MAP Screens*.

Find a Break in a Wire

The Receiver may be used with the Transmitter to locate a break on an isolated string.

To locate a break in a wire:

1. Move the Transmitter and connect only to the branch that contains the break. See Figure 21.
   a. Connect to only two terminals: ground and either positive or negative.
   b. Leave the unused terminal open and disconnected from any parallel branches.

   Or,
2. Connect the Transmitter to a bus with parallel branches. See Figure 22.
   a. Connect to only two terminals: ground and either positive or negative.
   b. On the side of the terminal that is connected to the circuit, disconnect all the parallel branches in the bus that do not have the break.
3. Then, select the correct **OPEN** function to match the connected terminals. The active terminal should be on the same side as the disconnection on parallel branches.

   In these examples, the Transmitter generates a signal from negative to the break in the wire. The parallel disconnections are on the negative side.
4. Push **TRACE** on the Transmitter.
5. Use the Receiver in open mode to follow the signal from the active terminal to the break in the wire. See Figure 22.

   In this example, trace from the negative terminal to the break in the circuit.

Figure 21. Locate a Break with a Direct Connection

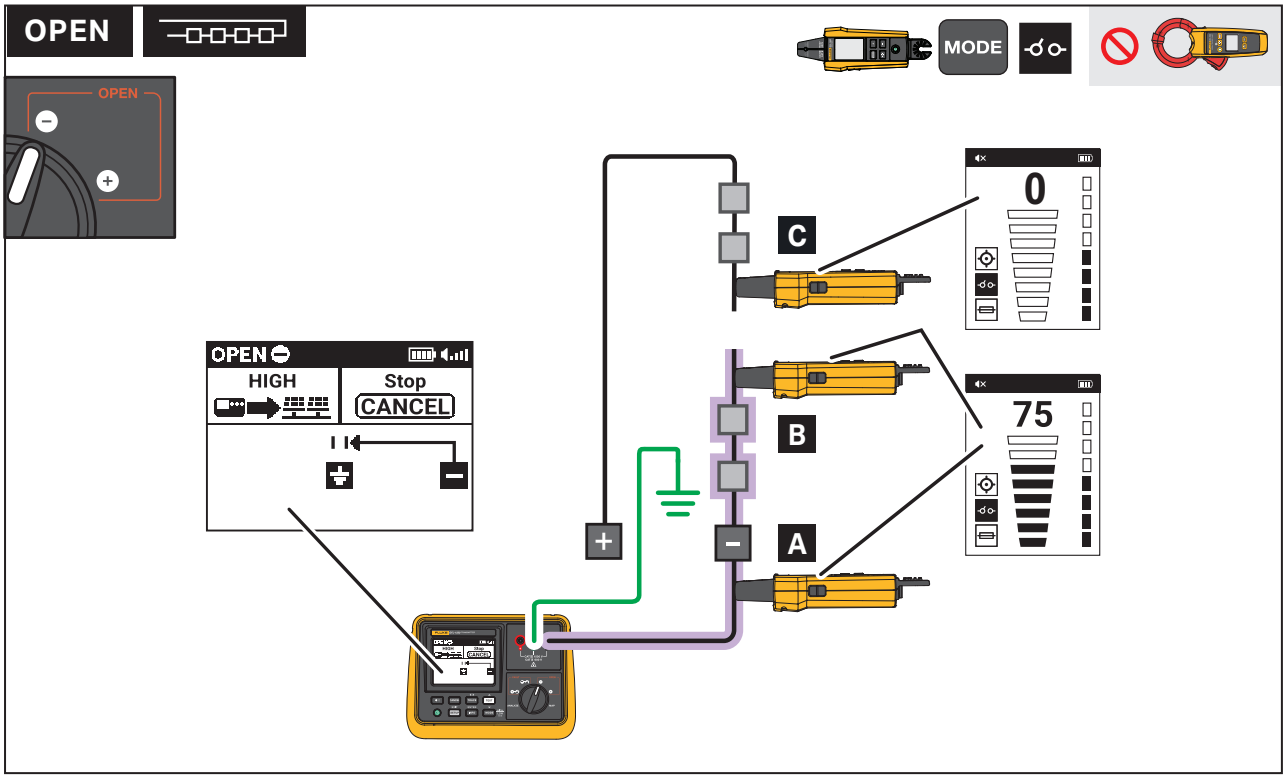
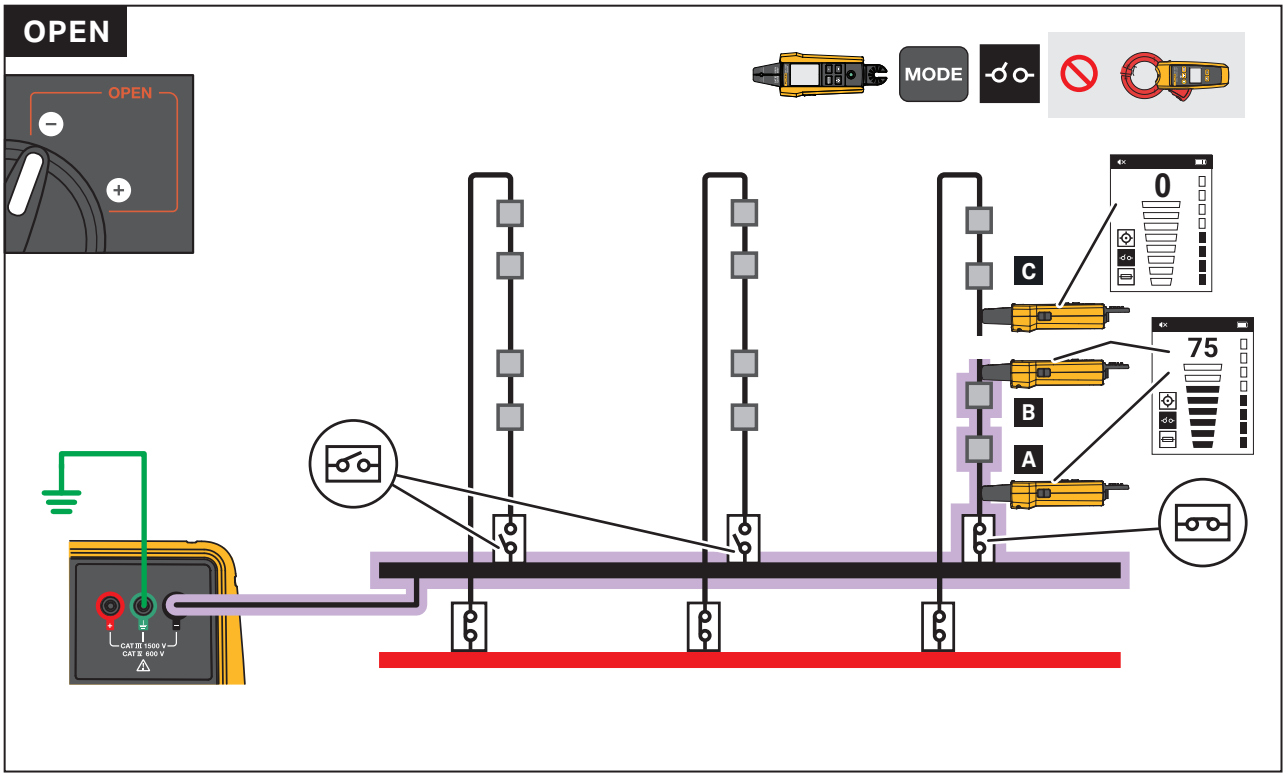


Figure 22. Locate a Break with Open Fuses



Map a System

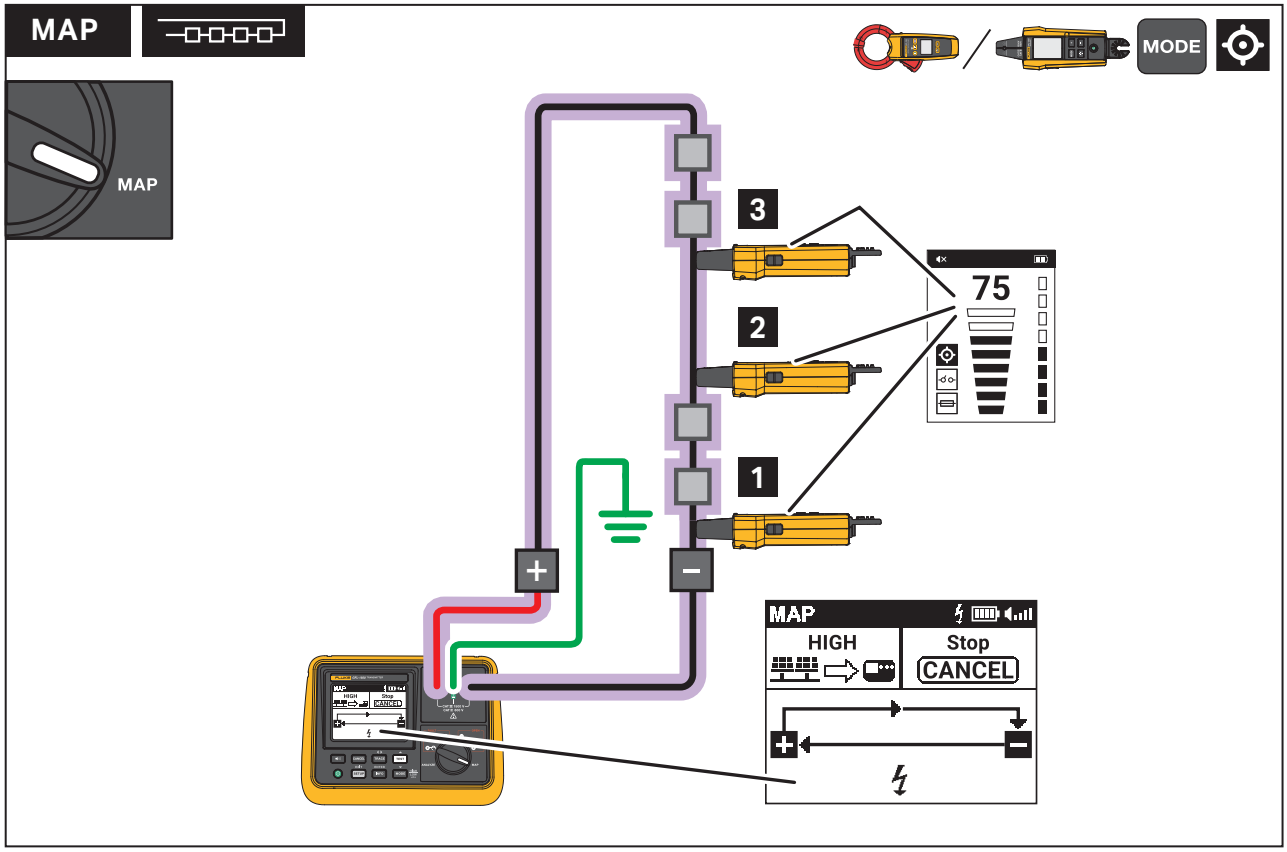
The Clamp or the Receiver may be used with the Transmitter to map a system.

To map a system:

1. Connect the Transmitter to the system. See Figure 23.
2. Select the **MAP** function, push **TRACE**, and use the Receiver or the Clamp to follow the signal to map the system.

   Figure 23 shows how to map an isolated string in a system.

Figure 23. Map an Isolated String

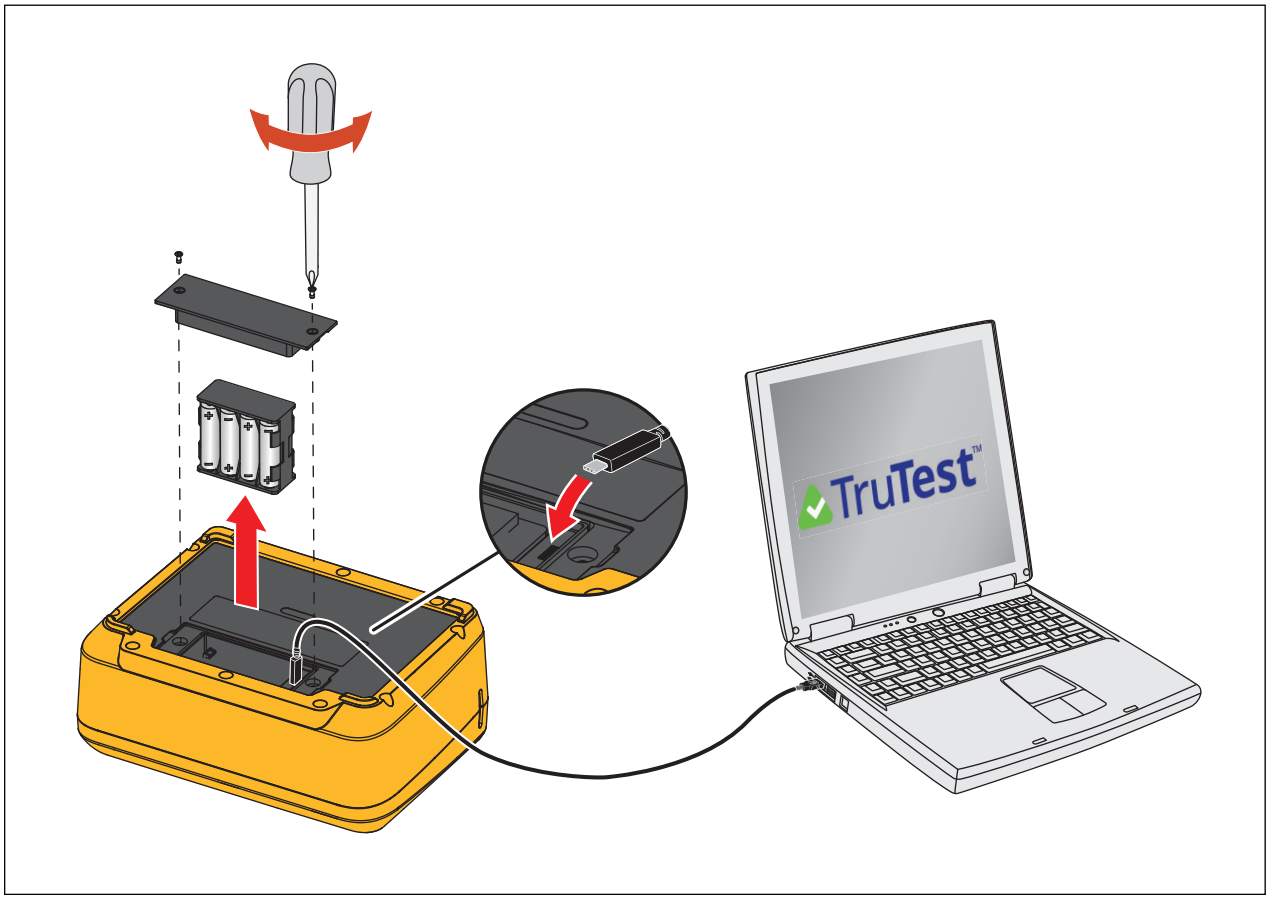


Update Firmware

To update the firmware of the Transmitter.

1. Disconnect the test leads from the Transmitter.
2. Open the battery door.
3. Remove the battery pack.
4. Connect a USB-C cord to the USB port in the Transmitter. The USB cord is not sold with the Product.
5. Connect the other end of the USB cable to a PC.
6. Go to our website and download TruTest™ software.
7. Follow the instructions in the TruTest software to update the firmware.

Figure 24. Update Firmware



Replacement Parts

Table 13 is a list of the replacement parts. To order parts, see *How to Contact Fluke Corporation*.

Table 13. Replacement Parts

Item	PN
FLK-GFL-1500 Receiver	6050955
FLK-GFL-1500 Clamp	6047762
Test Lead Set Black/Red	5590592
Alligator Clips Set	6078023
Test Leads Straight Angle Set Red/Green/Blue	6078010
TLPV-UTool, Solar Connector Unlock	5591306
Batteries (2AA IEC LR6 Alkaline)	376756

Maintenance

The Product requires little maintenance.

⚠⚠ Warning

To prevent possible electrical shock, fire, or personal injury:

- **Remove all probes, test leads, and accessories before the battery door is opened.**
- **Batteries contain hazardous chemicals that can cause burns or explode. If exposure to chemicals occurs, clean with water and get medical aid.**
- **Be sure that the battery polarity is correct to prevent battery leakage.**
- **Do not operate the Product with covers removed or the case open. Hazardous voltage exposure is possible.**
- **Have an approved technician repair the Product.**
- **Repair the Product before use if the battery leaks. Battery leakage may create a shock hazard or damage the Product.**

- **Remove the batteries if the Product is not used for an extended period of time, or if stored in temperatures above 50 °C. If the batteries are not removed, battery leakage may result.**
- **The battery door must be closed and locked before you operate the Product.**
- **Do not put battery cells and battery packs near heat or fire. Do not put in sunlight.**

Clean the Product

Periodically wipe the case with a damp cloth and mild detergent. Do not use abrasives or solvents. Dirt or moisture in the terminals can affect readings.

Product Disposal

Dispose of the Product in a professional and environmentally sound manner:

- Delete personal data on the Product before disposal.
- Remove batteries that are not integrated into the electrical system before disposal and dispose of batteries separately.
- If this Product has an integral battery, put the entire Product in the electrical waste.

Battery Replacement

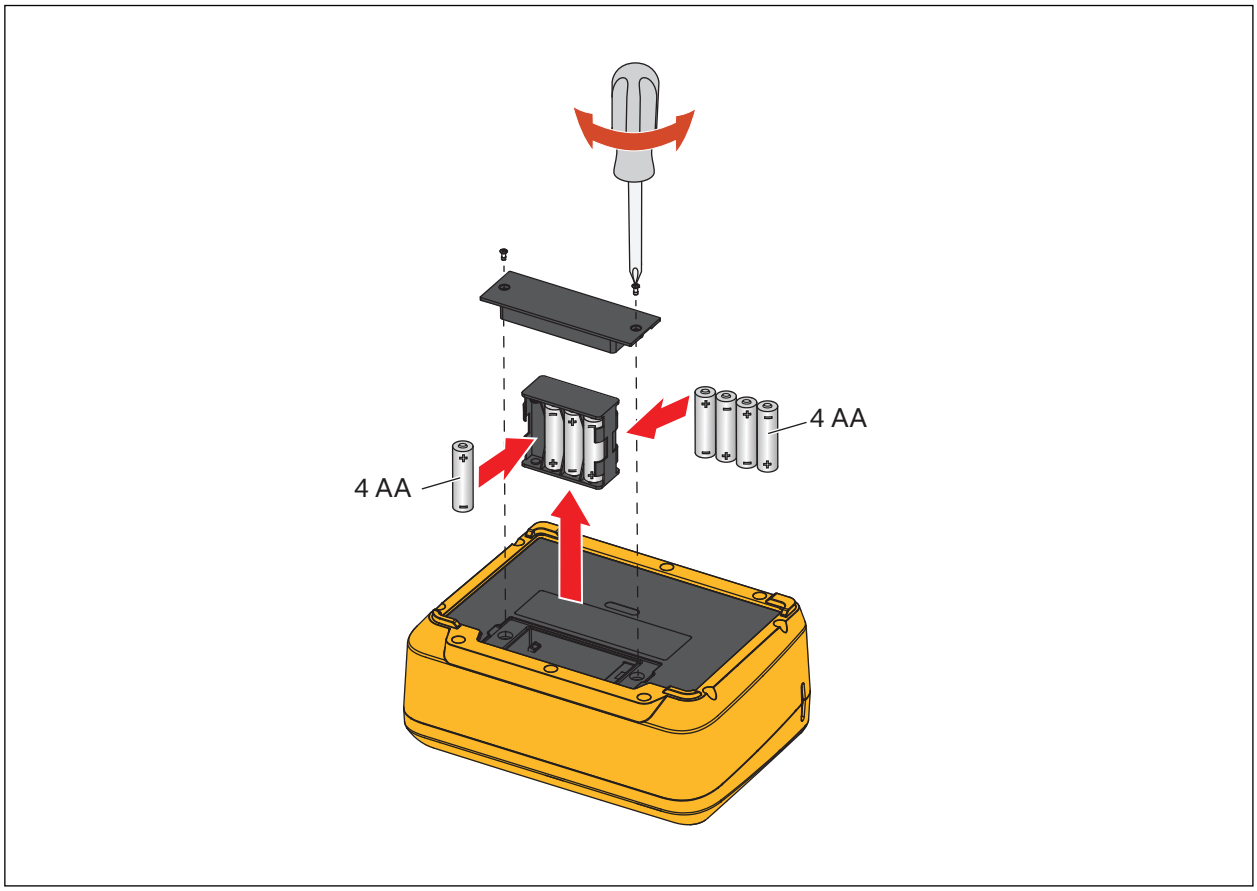
Alkaline batteries ship with the Product, but do not come installed in the Product. If desired, use NiMH rechargeable batteries in the Product. To charge NiMH batteries, remove the batteries from the Product.

To install or replace the batteries in the Product, turn off and disconnect the Product from the system and install new batteries with the correct polarity.

Transmitter Battery Replacement

Figure 25 shows how to replace the batteries in the Transmitter.

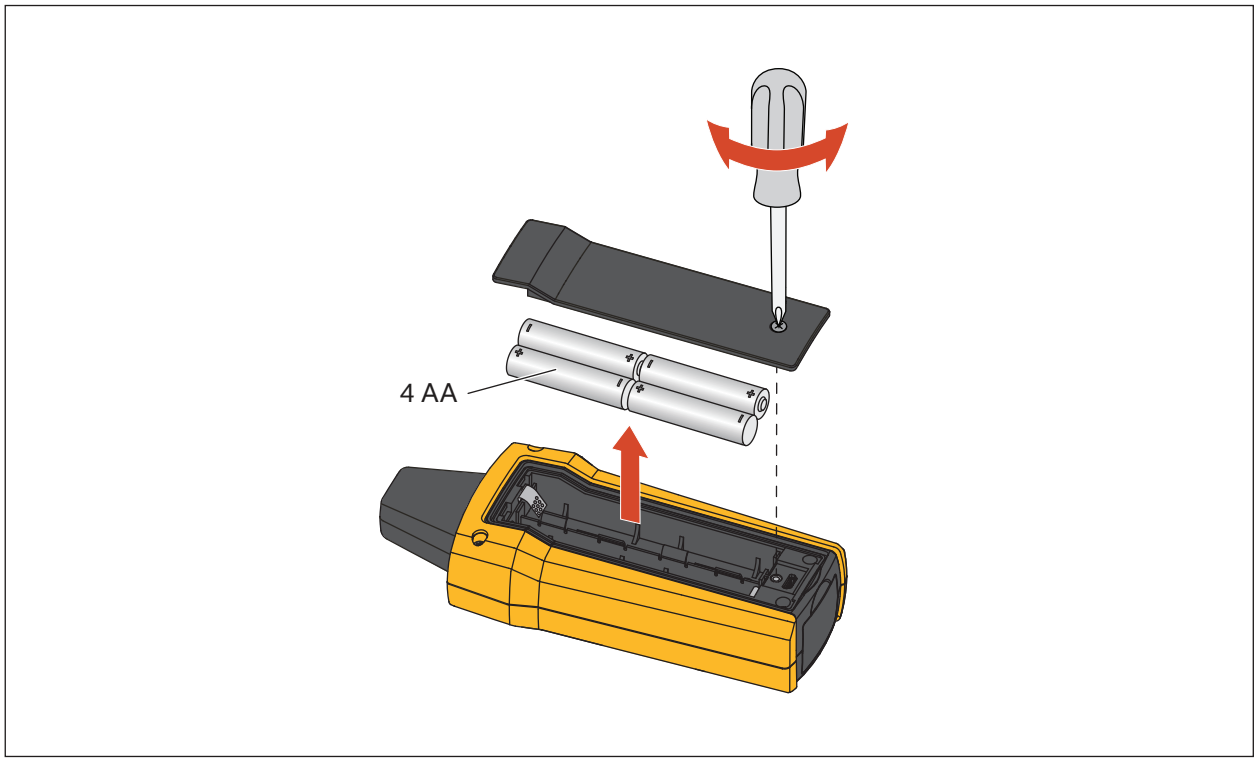
Figure 25. Transmitter Battery Replacement



Receiver Battery Replacement

Figure 26 shows how to replace the batteries in the Receiver.

Figure 26. Receiver Battery Replacement



Clamp Battery Replacement

Figure 27 shows how to replace the batteries in the Receiver.

Figure 27. Clamp Battery Replacement