

GFL-1000

Ground-Fault Locator

GFL-SERIES



GFL-1000

Ground Fault Locator

User Manual

Version 1.5



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1. About the GFL-1000

1.1 Why do you need a Ground Fault Locator?

Before using the GFL-1000, it is necessary to understand why a ground fault locator is important.

With regards to DC power systems, power interruptions due to bad insulation or grounding can be very costly to repair. Fast localization and elimination of grounding faults in these systems are critical to industry professionals. These are also requirements of DIN VDE 0100-410 (VDE 0100-410): 2007-06 chapter 411.6.3.1 and IEC 60364-4-41 chapter 413.1.5.4. The GFL-1000 was developed to quickly detect, track, and locate grounding faults in DC systems, saving you time and money while increasing the reliability of your electrical equipment.

1.2 What is the GFL-1000?

Eagle Eye's GFL-1000 is a revolutionary product that locates ground faults and also has built-in capabilities for earth fault detection. It has been used widely in the locomotive, telecom, power, and utility industries. This patent protected unit is manufactured based on years of field experience in various DC systems. It specializes in dealing with current leakage in DC systems with high resistance below 1M Ω . Without turning off the DC system's power, it pinpoints faulty grounding where electrical lines have breakage and current lost to the ground. The GFL-1000 is integral part of any troubleshooting and maintenance program. Its compact and rugged design makes it easy to use in small places and harsh environments, while providing excellent durability.

1.3 Main Functions of the GFL-1000

The GFL-1000 utilizes signal strength, phase angle, and detection of leakage current direction to quickly pinpoint ground faults. It can accurately measure grounding resistance and distributing capacitance. The unit can select the right output frequency required for testing different distributing capacitance, making it adaptable for use in various DC systems.

Output voltage of the signal generator: 24V, 48V, 110V, 220V, 500V, and 1000V. This will meet the requirements for various electrical circuits of different voltage levels without interference to the circuit.

Output of the signal generator: 5mA and unlimited current (maximum 40mA). It is selected based on actual current, preventing incorrect operation of the circuit relay.

Output frequency of the signal generator: Standard 10Hz and optional 1.0Hz, 50Hz, 60Hz, and 325Hz, which are selectable based on differing DC systems.

1.3.2 Frequency Spectrum Analysis

The GFL-1000 effectively analyzes and detects the working signal and surrounding interference signals of the DC system. This helps to select the right output frequency for ground fault location and to avoid interferences by the surrounding signals.

1.3.3 Oscilloscope

The GFL-1000 oscilloscope function accurately checks the waveform of the target signal after band pass filter.

1.4 Features

- Patented technology that accurately pinpoints current leakage fault with a grounding resistance lower than 1MΩ.
- Innovative dual-clamp for the signal receiver; each clamp has two sizes of jaw opening for different conductors.
- Precisely measures current direction (positive or reversed), which indicates leaking current and helps to quickly locate the faulty grounding.
- Adjustable output frequency on the signal receiver effectively avoids interferences from the DC system itself.
- Signal receiver with adjustable sensitivity depending on the location of the circuit which helps to detect current leakage quickly.
- Digital signal processing technology for detecting grounding resistance and distributing capacitance.
- Built-in band pass filter to bypass different interference signals in the ambient environment.
- No disconnection of the electrical installation is necessary; ground fault detection can be carried out during operation.
- Frequency spectrum analysis will test the surrounding interference signal in the circuit. It helps select the right output frequency for the right DC system, which keeps is away from interfering frequencies.
- Signal generator with adjustable output voltage (24V-1000V) and output frequency (1-325Hz), suitable for different electronic equipment.
- Multiple ways to indicate ground fault; sensing current direction, phase angle difference and comparison of signal strength.
- More signal receivers and work simultaneously to narrow down the searching scope and find the fault quicker.
- Helps to determine the aging status of facilities which can lead to reduced maintenance and repair costs.

1.5 Typical Applications for the GFL-1000

The GFL-1000 is particularly useful in any industry in which the power supply for operating measurement, communication and control equipment is critical. Below are some examples of industries where the GFL-1000 can be highly effective:

- Railway: Signal, communication and locomotive electronic equipment in railways
- Communication: Electronic equipment with various voltage ranges experiencing faulty grounding
- Power Utility: DC systems with faulty grounding (e.g. switchgear in substations)
- Others: DC systems in aviation, metallurgy, automotive, household appliances, etc.

1.6 Technical Specifications

Output Voltage:	24, 48, 110, 220, 500, 1000 VDC
Output Frequency:	Selectable between 1, 10, 50, 60, 325 Hz
Output Current Limitation:	5 mA no limit (max: 40 mA)
Fault Location Sensitivity:	≤ 1 MΩ
Current Detect Sensitivity:	AC/DC Circuit: ≥ 0.5 mA
Quick Search Clamp:	55 mm (diameter), 60 mm (jaw opening)
Current Sensor:	φ8 and φ20
Jaw Opening:	60 mm (2.36 in)
Display:	Backlit Color LCD
Operating Environment:	Temperature: -5 – 40 °C (23 – 104 °F)
Power Requirements:	8.4 VDC Li-ion Battery
Dimensions:	360 x 260 x 135 mm (14.2 x 10.2 x 5.3 in)
Weight:	7 kg (15.4 lbs)

1.7 Composition of the GFL-1000

1.7.1 Package List

The GFL-1000 Kit includes the following:

Carrying Case & Signal Generator	
Signal Receiver	
Dual Current CT Clamps	
Voltage Test Leads	
Alligator Clip for Voltage Test Leads	
Power Adapter for Signal Generator	
Power Adapter for Signal Receiver	
Signal Receiver USB Cable	

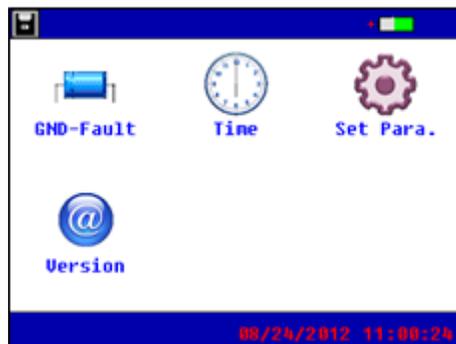
1.7.2 GFL-1000 Main Body

Below is a picture of the GFL-1000 kit with main components listed.



F.1.7.2.1

After turning the unit on using the On/Off switch, press any key on the keypad to continue. You will see the main menu as shown in the diagram below. Use the arrow keys to highlight the desired icon and press **ENT** to confirm your selection, press Esc at any time to go back. Functions and settings of the main body will be discussed in more detail later in this manual.



F. 1.7.2.2

1.7.3 Signal Receiver

Currently, all standard units come with a standard signal receiver and a pair of dual-range current detectors.

Signal Receiver Main Body:

Main body of the standard signal receiver:



F. 1.7.3

The standard signal receiver can be operated by touch screen, keypad or quick navigation keys located on the side of the unit. After turning on the unit, you will see the main functions including ground fault location, frequency spectrum analysis, oscilloscope and system settings, as shown in Fig. 1.7.3.3. These functions will be explained in more detail in the following section.



F. 1.7.3.1

Current Detector:

The main body of all signal receivers will be connected to a pair of dual-range current detectors as shown in Fig. 1.7.3.1. Eagle Eye’s innovatively designed dual-range current detectors come in two different sizes of jaw openings, 8mm and 20mm. Depending on the different sizes of wires or conductors, you could selectively clamp with either size jaw.

Also, with on pair of current detectors working at the same time in the circuit, the GFL-1000 possesses strong anti-interference capabilities. Therefore, it can check ground faults effectively even when the system is online.

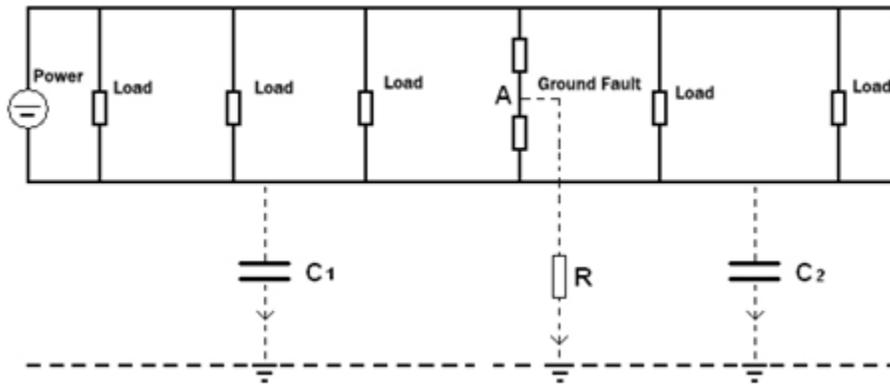
Each current detector has arrow indicators on both sides. The arrow indicator is used for current direction indication during ground fault location.

1.8 Basic Concepts

1.8.1 About Faulty Grounding

AC or DC power systems are generally insulated to the ground in railway electric works, power substations, telecom base stations, etc. There are also clear and strict rules for insulating resistance in different voltage levels of AC or DC power systems.

It is generally considered as the phenomenon of faulty “grounding” when the resistance of one point (or multiple points) to the ground becomes lower than the tolerance value. Take the following chart for example. Point A is the grounding point; R is the grounding resistance; and C1 and C2 indicate distributed capacitances before and after the malfunction point.



F. 1.8.1

When one point of circuit has unwanted grounding like this, protection equipment, signaling equipment, and automation equipment may operate incorrectly or stop running. Also, the fuse may burn out and thus cut off power supply for protection equipment, automation equipment, controlling circuit and the communication signaling system.

If the problem at any particular point goes unresolved for a long period of time, more points may develop the same problem. This may damage electronic circuits or equipment. Therefore, unwanted grounding of electronic circuits is a critical hidden danger that needs to be diagnosed quickly. Fast detection of ground faults is necessary to avoid having a small problem turning into a much larger one.

1.8.2 Wire Mix-connection

Sometimes two or more groups of power systems are working simultaneously, and normally they are insulated from each other. When insulating resistance between any two individual systems becomes lower than the required value at one or more points, it is called a “wire mix-connection”. Below is one example. Points A and B are malfunction points. R indicates the mix-connection resistance. C1 and C2 indicate the distributed capacitances.

Wire mix-connection is a common problem in the signaling system in railways. It’s also an indicator of other hidden hazards like faulty grounding.

1.8.3 Short Circuit

One power system generally functions with several loads working together at the same time. Normally when all loads are disconnected, power output current becomes 0 amps. However, when insulation values at one point or more are lower than the requirement but current flow still exists, it is called a “short circuit”. In this case, the positive bus bar is short circuited to the negative bus bar.

A short circuit will increase power consumption and may even burn up the power supply and cause other issues like faulty grounding.

1.8.4 Current Leakage

Circuits, which are normally insulated to the ground, can have current flow to the ground due to bad insulation or circuit distributing capacitance.

1.8.5 Tracing of Current Signal

When using the GFL-1000 to locate faulty grounding, the signal generator (main unit) will send a “current signal” in a certain frequency to the circuit. This current signal will flow in the circuit. With a signal receiver (connected with a current detector), we will trace the current signal at various points of the circuit. When performing a comprehensive test, such as for current direction, signal strength, and phase angle, the GFL-1000 can quickly locate the ground fault regardless of the cause of the problem.

2. Main Operation of the GFL-1000

2.1 General Procedures for Ground Fault Location

When performing ground fault location tests, follow the steps below:

1. Measurement preparation
 - a. Become familiar with the wiring diagram of the DC system, and determine which line has faulty grounding. It is very important to know the wiring structure of the wires connected in the DC system. This will help you quickly trace the ground fault effectively.
2. Properly connect the signal generator to the DC system
3. See the output signal in the signal generator, and set the signal mode as “Continue”. The signal generator will automatically test output voltage, current and grounding resistance.
4. Synchronize the output frequencies of the signal receiver and generator.
5. Proceed with “Reference setting” in the signal receiver ONLY IF the signal generator is transmitting the signal properly.
6. Use the GFL-1000 to pinpoint the faulty grounding one by one.
7. Take the necessary steps to correct the faulty grounding as per requirement.

The following section describes the operation of ground fault location in detail.

2.2 Operation Preparation

Before performing the onsite testing to find faulty grounding, please prepare by:

1. Making sure both the GFL-1000 signal generator and receiver are fully powered. The GFL-1000 main body can work with the power adaptor when connected to the AC power supply.
2. Getting familiar with onsite wiring for the target DC system. It will be very important and helpful to have the detailed wiring diagram on hand, which will indicate how each piece of equipment is connected in the whole DC system.
3. Wearing a helmet and insulation protected gloves, for safety purposes.
4. Judging which bus bar has faulty grounding:
 - a. DC circuit: Use a multimeter, and switch to DC voltage testing mode. Respectively test the voltage between the bus bar and the ground. Normally, both absolute values should be equal (around half of nominal voltage). If one of the voltage values is lower, that bus bar should have faulty grounding.
 - b. AD circuit: Switch the multimeter to AC voltage testing mode, and respectively test the voltage value between each power line (phase line and null line) and the ground. Normally, both absolute values should be the same. If one of the voltage values is lower, that line has faulty grounding.
5. Connecting testing leads on the signal generator and current detectors with the standard signal receiver.

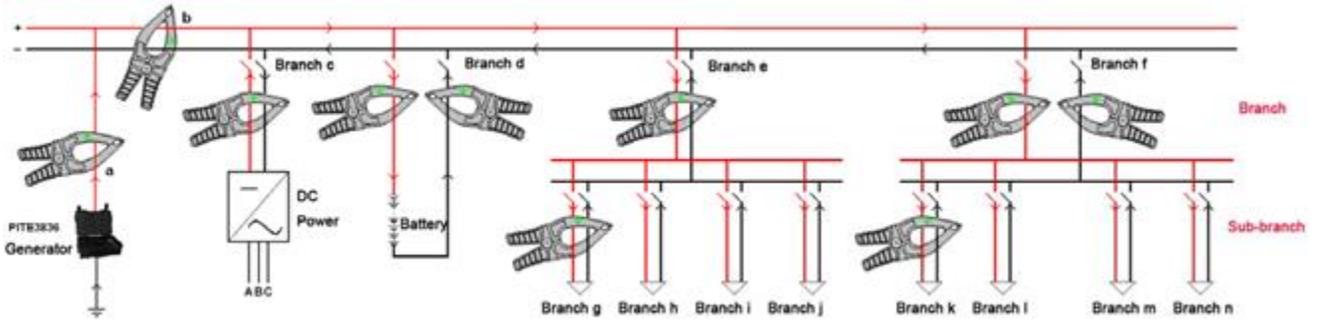
2.3 Wire Connection



F. 2.3.1

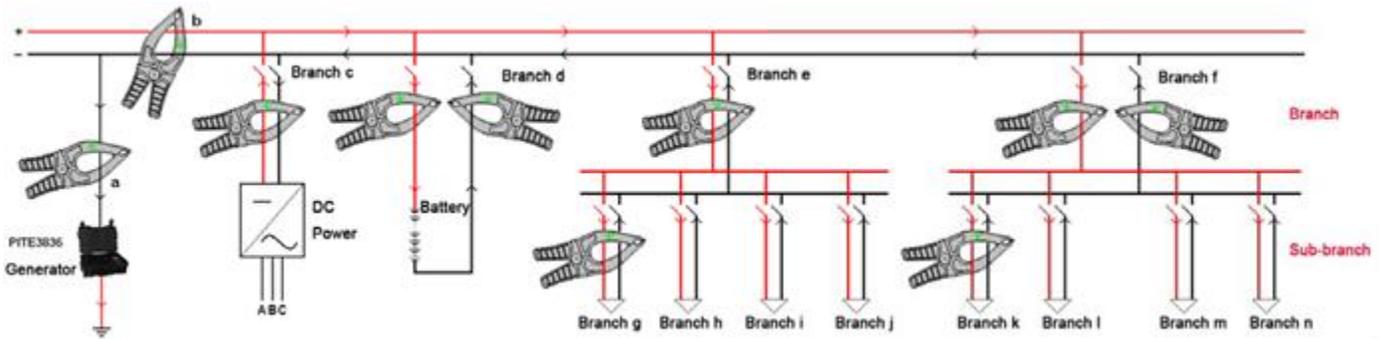
First, connect the testing leads with the GFL-1000 main body: red lead goes with the red socket and black lead goes with the black socket (Fig. 2.3.1). Make sure that these connections are not mixed up. Then, connect the other ends of the leads with alligator clips. After determining which bus bar has the ground fault, connect the red clip with that bus bar and the black clip with the ground, as shown below.

1. When the positive busbar has ground fault, connect the red test lead to the positive busbar and the black test lead to ground.



F. 2.3.2

2. When the negative bus bar has a ground fault, connect the black lead with the negative and red lead with the ground.



F. 2.3.3

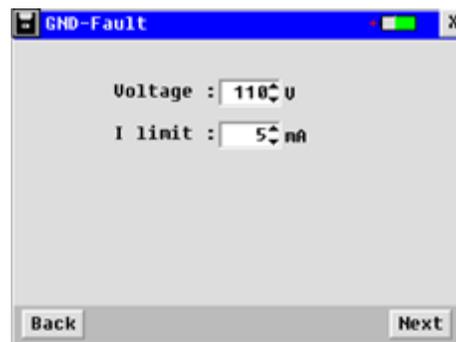
2.4 Setting the Generator Output Signal

2.4.1 Measurement of Circuit

After the signal generator is properly connected with the DC circuit, turn the unit ON. You will see the main screen as in Fig. 2.4.1. Use the arrow key to highlight “GND-fault”, and press **ENT** to select it. You will then be taken to the next screen for the output signal setting, as shown in Fig. 2.4.2.



F. 2.4.1



F. 2.4.2

You will now need to set the output voltage and output current. Their settings will be:

Output Voltage:

Optional between 24V, 48V, 110V, 220V, 500V, and 1000V. Select the voltage type based on the system you are testing. For example, if it is a DC 100V substation, then select 110V.

Output Current Limit:

Optional with “5mA” and “UL” (unlimited). When there is a limitation of output current, output current will be automatically adjusted (max: 5mA) based on the circuit.

When there is no limitation of output current, there is limitation of output power (max power: $5w = \text{output voltage} * \text{circuit current}$).

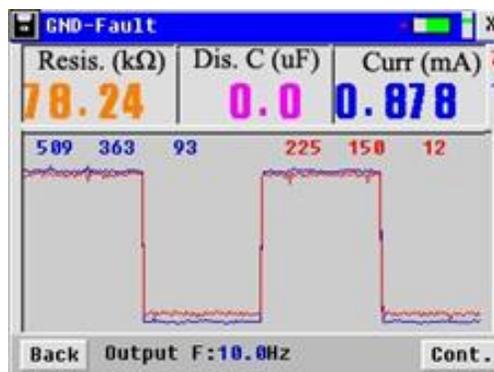
Warning:

To avoid unwanted operation of the relay in the DC system, select the current limit properly. In the signaling circuit of a railway station, more than 5mA of output current will cause unwanted operation of the relay. If there is no limitation for the output current in the DC system, you are advised to select “UL” (limited power) to maximize the signal.

Click “Next” to continue; the signal generator will have an initial measurement for grounding resistance, distributed capacitance, output current and waveform of the circuit before ground fault location (Fig. 2.4.3). Display of the waveform is in square wave. The waveform indicates output voltage (blue) and current (red) of the signal generator. Numbers (e.g. 509, 363, and 93 in Fig. 2.4.3) above the waveform indicate the maximal, average and minimal sampling values of voltage and current, respectively. Blue numbers are for voltage values, and red numbers are for current.

NOTE:

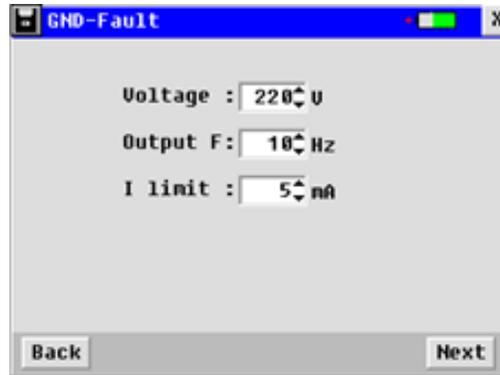
For the definition of distributed capacitance and its relationship with resistance and frequency, refer to **2.10.1 Distributed Capacitance**.



F. 2.4.3

2.4.2 Output Signal Adjustment

After the initial measurement for the DC circuit, press the **Cont.** button to continue. You will be taken to a screen like in Fig. 2.4.4 for output signal adjustment.



F. 2.4.4

Output voltage:

Based on the previous measurement, output voltage may automatically adjust in the following ways:

- If the previous output current limitation is set as "5mA", the default setting of output voltage on the screen (Fig. 2.4.4) will be automatically adjusted higher if the output signal is too low or adjusted lower if the output signal is too strong.
- If the previous output current limitation is set as "UL", the default setting of output voltage will be automatically adjusted lower if the output signal is too strong.

NOTE:

Automatic adjustment of the output voltage will help users get a proper voltage value to optimize the signal for ground fault location. At the same time, this safe measure will prevent the signal from being too strong and damaging the DC system. For a proper output signal, it can automatically skip to the next voltage level during ground fault location (like in Fig. 2.4.5).

Output Frequency:

Although the GFL-1000 supports different optional output frequencies, the default output frequency is set at 10Hz to make it simpler for users. Based on Eagle Eye's years conducting field testing, the 10Hz output frequency will fit most DC systems for quick location of ground faults. Generally, there is no need to change it.

- If you have a particular environment that requires a different output frequency, you can set it, as shown in Fig. 2.4.4. If your signal generator has a different output frequency, refer to **3.2.3.1 Frequency Synchronization** for setting instructions.

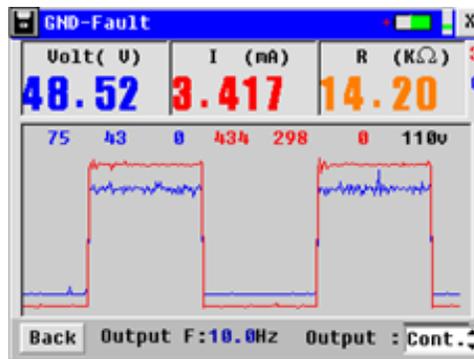
Output Current Limitation:

Change it to 5mA or UL, if necessary.

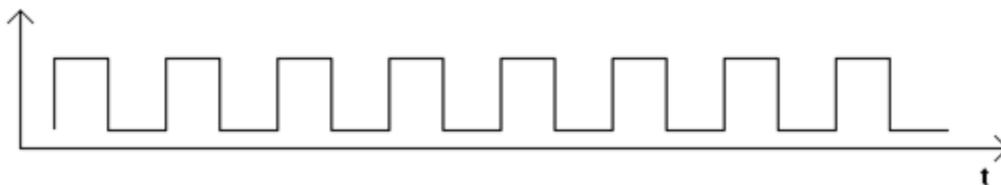
2.4.3 Output Signal to Circuit for Ground Fault Location

After the above adjustment, click **Next** to output the signal to the DC circuit. You will see the screen as shown in Fig. 2.4.5 with output voltage, current, grounding resistance and waveform. The default waveform is displayed as “Continued”. You can use the arrow key to change it to “Discontinue”, which will have a one-second interval. Variations of the display are illustrated in Fig. 2.4.6 and Fig. 2.4.7.

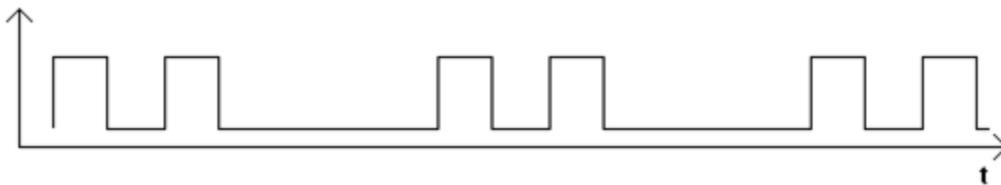
The voltage value (e.g.,110V in Fig. 2.4.5) on the right top of the waveform indicates the output voltage of the generator. As described previously, the output voltage may be automatically adjusted to a proper value for better signal and security of DC system.



F. 2.4.5



F. 2.4.6 Continued Waveform



F. 2.4.7 Discontinued Waveform

2.5 Setting of the Signal Receiver

2.5.1 Frequency Synchronization

This coordinates the frequencies of the signal generator and the receiver for precise location of fault. To help users simplify the operation in most DC systems, the frequency of all standard

GFL-1000 generators is set at 10Hz, and the signal receiver is synchronized with it before shipment of the product.

If your unit is defaulted to 10Hz frequency, skip this step and go to 2.5.2 below. If your signal generator has a different output frequency, refer to **3.2.3.1 Frequency Synchronization** for setting instructions.

2.5.2 Setting the Signal Receiver

After the signal receiver is properly connected with the current detector, turn on the receiver, and select “**GND-Locate**”. You will see the screen for the signal setting as below:

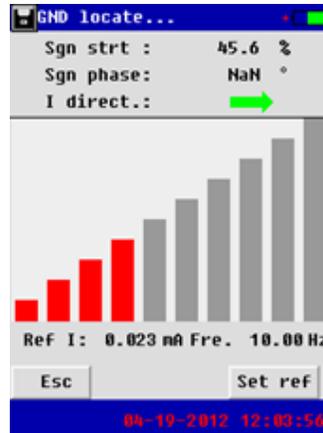


F. 2.5.2.1

After frequency synchronization, the receiving frequency of 10Hz is kept unchanged. Audio settings have options from 0 to 9. “0” means there is no audio indication during leakage signal searching. Other numbers mean that when the detected signal is higher than the setting value, the signal receiver will have audio indication in the form of a beep. For example, if the setting value is 4, when the detected signal is higher than 40%, the signal receiver will beep. A screenshot, like below in Fig. 2.5.2.2, indicates 40% signal strength.

Reference setting:

This is a very important step during ground fault location. After completing the initial settings for receiving frequency and audio, click **OK** to proceed to the screen as shown in Fig. 2.5.2.2.



F. 2.5.2.2

Clamp one of the two current detectors to a certain point on the circuit (named “reference point”) Click the reference setting button (Set ref) to set this pint as the reference point. So, at this point, we will have:

- Signal strength: 100%
- Phase angle: 0°
- Signal direction: → (positive direction)

After setting the reference point, move the current detector of the signal receiver in the circuit. At different points, there will be different indications for signal strength, phase angle and current direction. All of these indications can be compared with the reference pint to judge signal difference.

Example:

- Signal strength: 83%
- Phase angle: -153°
- Signal direction: --X→ (negative direction)

The above example means that the signal strength of this point is 83% of the reference point (17% weaker), the phase angle is 153° lag off, and the current direction is opposite.

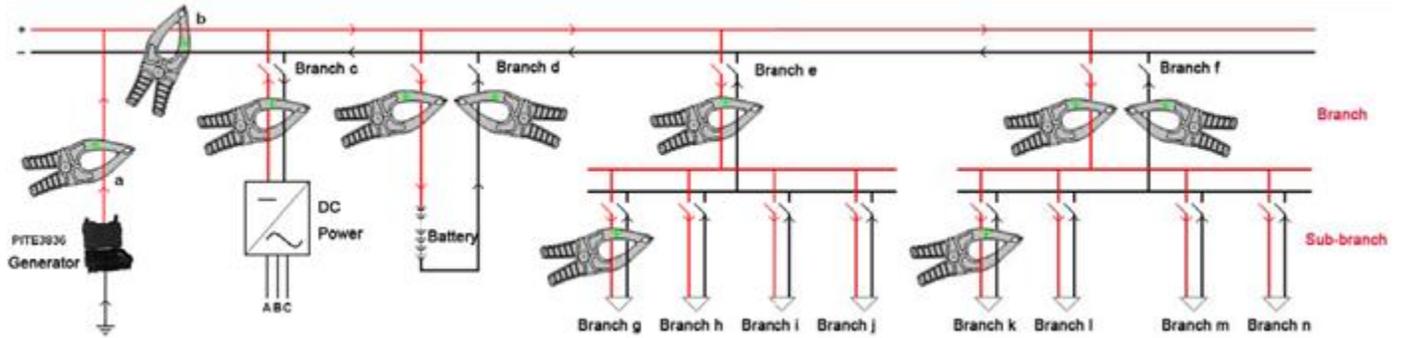
NOTE:

During ground fault location, the “reference point” could be set several times. Once you are sure that there is current flow at a certain point, you could set is as the “reference point” and proceed in the circuit. Then, compare the signal difference later with the previously referenced point.

Setting the reference point for the first time:

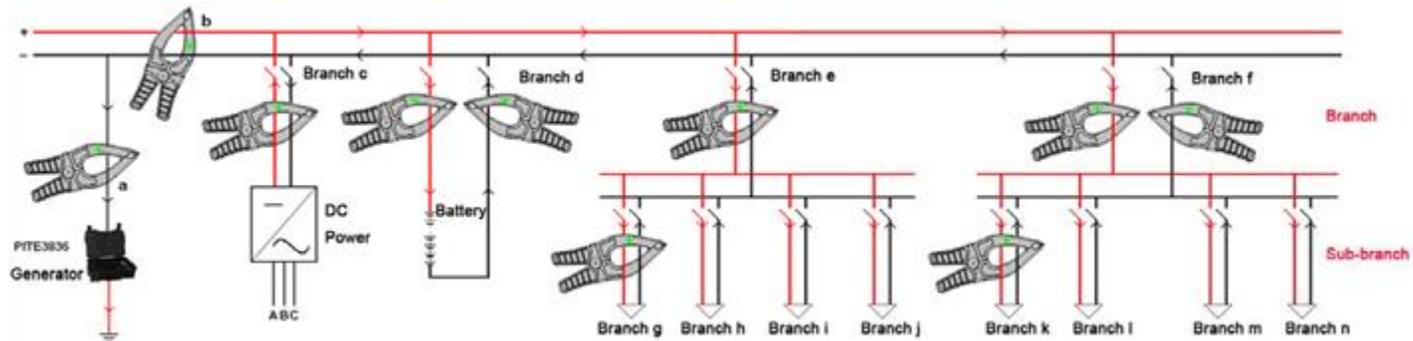
Important: After the signal generator is connected with the leakage circuit and it is transmitting the signal properly (see Fig. 2.4.5 for example), current signal will flow from the red testing lead to the DC circuit and finally back to the black testing lead. This is a return circuit. Refer to the wire connection diagram again. No matter how complicated the DC system is, the equivalent model could be exemplified as below:

1. When positive busbar has fault:



F. 2.5.2.3A

2. When negative busbar has fault:



F. 2.5.2.3A

In the above return circuit, the signal at the beginning (close to red socket on the signal generator) of the red testing lead is the strongest.

For the first reference setting, clamp either one of the two current detectors around the beginning of the red testing lead with the arrow (on the clamp) pointing to the direction of the current flow as in Fig. 2.5.2.4. Keep the current detector stable for a while, and then click the **Set ref** button on the signal receiver screen.

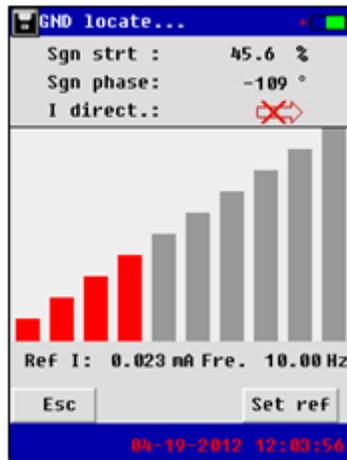


F. 2.5.2.4

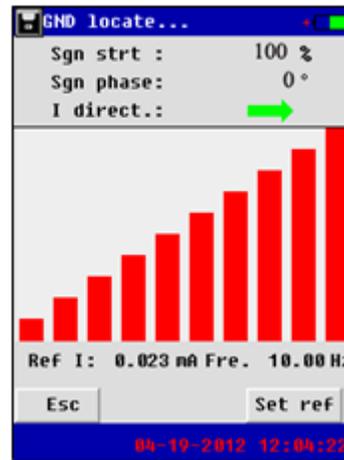
The signal strength of the reference will be set at 00%; the phase angle will be 0°; and current direction will be positive.

Below are examples before and after the reference setting. “Ref I” is the current value at the reference point. Before setting the reference, this value is displayed as 1.000mA.

Red columns on the screen indicate the percentage of signal strength. It will increase one level when the signal increases by 10%.



F. 2.5.2.6



F. 2.5.2.7

NOTE:

1. When using the indicating function of current detection, make sure to set signal as “Continue” in the signal generator.
2. Although you can set the reference at any time, make sure to clamp on the circuit that has current flow. This ensures that the reference setting is done under the condition when the signal generator is transmitting a signal properly. The screenshot in Fig. 2.4.5 is an example of when the signal generator is outputting signal properly.
3. If the reference setting is done when there is no current flow at all, the signal display after the reference setting is done will be misleading.

2.6 Locating a Ground Fault

After setting the reference point in the signal receiver, connect two current detectors with the DC circuit beginning from the output of the red testing lead on the signal generator, and search the signal at different points of the system. Following the direction indication on the signal receiver screen, you will quickly locate the faulty grounding. Make sure to keep the arrow marking (on the current detector) pointing to the same direction as the “reference setting”.

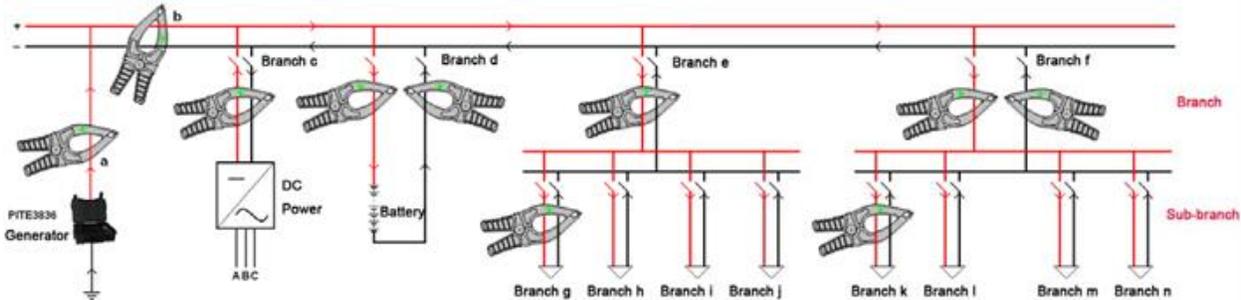
If the receiver indicates \rightarrow , then the grounding current is in the same direction with the arrow on the current detector. If it indicates $\leftarrow X \rightarrow$, then they are in the opposite direction. You need to go back and keep searching the signal with the help of the direction display.

Generally, if there are big changes in signal strength and phase angle before and after a certain point, we can determine that there is grounding current flow at this point or there is grounding fault there.

For a detailed illustration of ground fault location, refer to the below for the location theory and measurement tips.

Ground fault location with strong interference in the circuit:

High interference can be present in online DC circuits. In this situation, one clamp can be used to connect with faulty busbar and its corresponding busbar. Two clamps can be used with two busbars. Both types of connections have the same effect of cancelling the interference generated by the ripple current.



F. 2.6

2.6.1 Single Clamp Location

This is suitable when positive and negative bus bars are wired in parallel and very close to each other. In this case, you could use one of the two current detectors to clamp around the two bus bars at the same time no matter which bus bar has ground fault. When there is signal indication in the signal receiver, that means that there is ground fault in the circuit. Then you can continue searching the signal in the branches of this circuit until you pinpoint the fault.

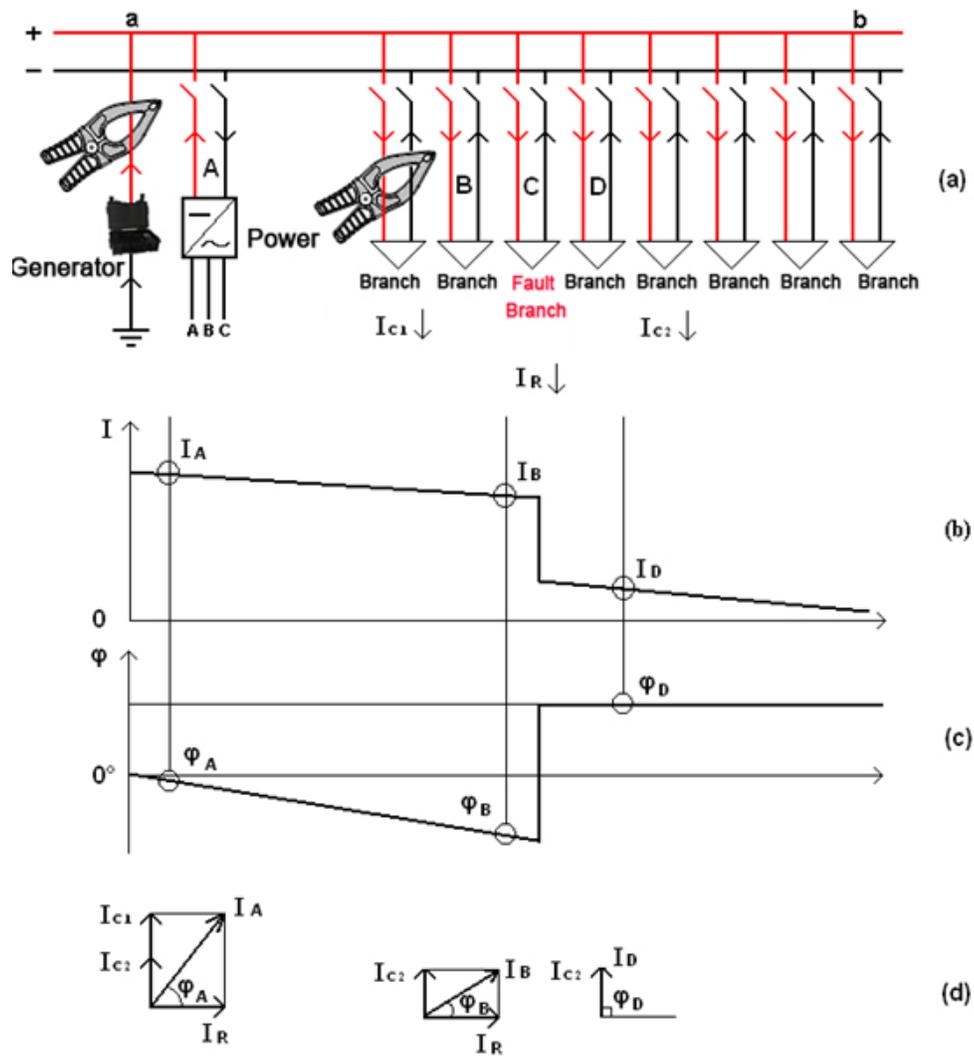
2.6.2 Dual-clamp Location

When the positive and negative bus bars are at a certain distance and one current detector cannot hold both at the same time, you can use a dual-clamp method to connect with both bus bars. Dual-clamp operation has the same effect of single clamp operation.

2.7 Theories of Ground Fault Detecting

Based on the characteristics of different DC ground faults, the GFL-1000 uses comprehensive methods to pinpoint the faults with the following **working rules**:

1. The signal generator injects a low-frequency current signal that is directionally sensitive to the DC system. This signal will outflow from the faulty grounding point.
2. The signal receiver will trace this current signal with the help of directional judgment. Direction of the current signal always goes to the faulty point.
3. When there are circuit branches, you will want to continue searching along the branch that has the stronger signal. For searching while the DC system is online, use the two current detectors together for anti-interference.
4. There will be large variations in strength and phase angle before and after the ground fault point.



F. 2.8

Suppose there is a ground fault on the positive busbar. As illustrated in F. 2.8, red test lead is connected with positive busbar and black lead with ground. Branch c has ground fault.

Signal generator will inject a voltage signal in the circuit. Due to the existence of distributed capacitance and grounding resistance, there will be current leakage. Current signal and phase changes will be like (b) and (c) in F. 2.8. There will be sudden changes before and after the point of fault. Phase angle will be lowest at the point of ground fault.

In the diagram, branch c has grounding resistance R . IR is the resistive current. $C1$ and $C2$ are distributed capacitance. I_{c1} and I_{c2} are capacitive current.

If a ground fault is detected at more than one point, locate the point of fault with the strongest signal and work down to all other faults.

2.8 Recommendations for Ground Fault Location

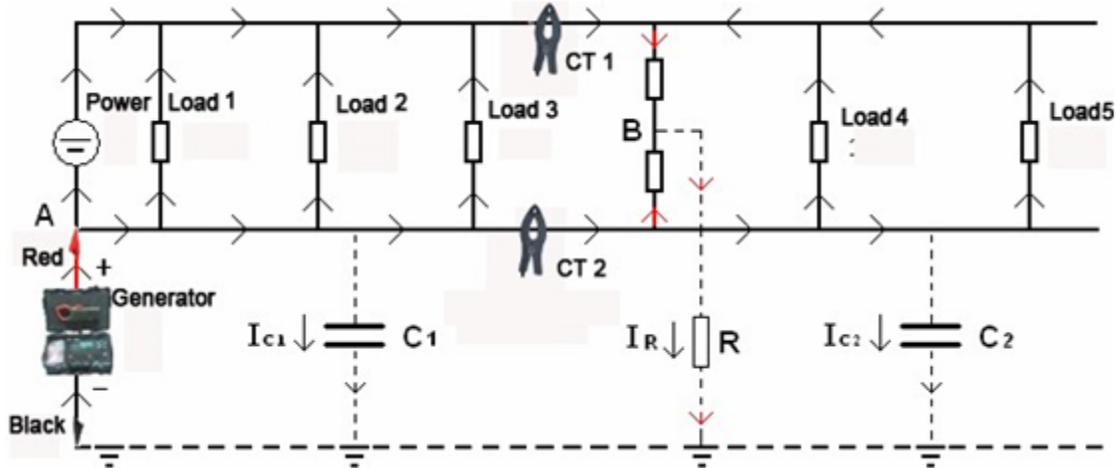
1) Gross Searching

Physically divide the DC system into several sections. For example, in a power substation, there are different cabinets (chargers, switchgears, control panels and so on) in the same DC system. Wiring could be complicated and most of the time different wires are tied together. In this case, you don't need to check wire by wire; you could check the inlet (or outlet) terminal of each cabinet to see the current strength, phase angle and direction.

Assume that Loads 1, 2, and 3 are Cases 1, 2, and 3 in the substation (Fig. 2.8.1). You will not need to check the bus bar all the way inside Case 1, Case 2 and so forth.

This way of gross searching will save time, and there is no need to take out all of the wires that have been tied together inside the cases. But when using this method, make sure that you are familiar with the wiring structure of the DC system, which will help you to find out the fault much faster.

This way of operation is also applicable to the quick signal receiver.



2) Multi-time Setting for the Reference Point

As described before, during ground fault location, the “reference point” can be set several times (every time the current direction is the same: positive in Green). Once you are sure that there is current flow at a certain point, you can set it as a “reference point” and proceed in the circuit. Then, compare the signal difference with the previous referenced point.

3) Use more than one signal receiver

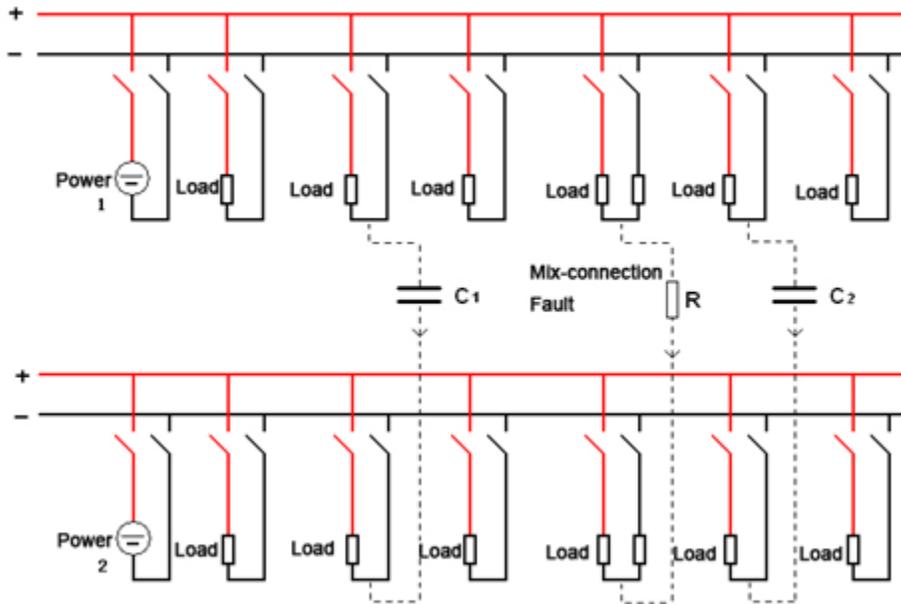
To save time, you can utilize multiple signal receivers and personnel to simultaneously check and narrow down the scope of signal searching. All GFL-1000 signal receivers (of the same frequency) may be used at the same time for ground fault location.

2.9 Locating Other Types of Fault

2.9.1 Wire Mix-connection

Locating a mix-connection fault is similar to locating a ground fault. The difference is that the signal generator injects the current signal in the two lines that are mix-connected (see Fig. 2.9.1 for wiring instructions). Trace the current signal with the signal receiver in the same manner as in the ground fault location as described before.

If both of the two lines are accidentally grounded, then they are mix-connected through the earth. In this case, check the ground fault of each line as described in **2.7 Theories of Ground Fault Detecting**.



F. 2.9.1.1

If there is a mix wire connection between DC and AC (single phase), try using 50Hz or 60Hz of AC signal to check for malfunction. No signal generator is needed. Use the signal receiver move along with the current flow. When there are visible differences in signal strength and phase angle before and after a certain point, then there is grounding malfunction at this point. Graphic wiring is as below:

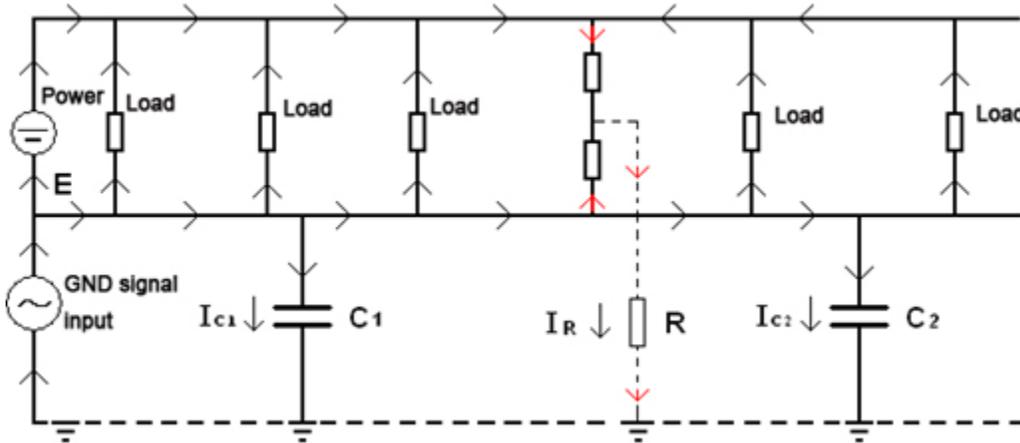
2.9.2 Short-circuit Fault Location

Short-circuit fault location is very similar to ground fault location. The signal generator will inject a signal into the circuit and you can use the signal receiver to trace the current signal.

2.10 Factors that may Affect Ground Fault Location

2.10.1 Distributed Capacitance

Distributed capacitance is a very common phenomenon. Generally, there is a large amount of distributed capacitance when a circuit line is long and the wiring structure in the electrical circuit is very complicated. Even if the circuit is insulated to the ground, there can be a return circuit when the signal generator injects current signal because of the presence of distributed capacitance. Fig. 2.10.1.1 shows one example. C1 and C2 represent distributed capacitance before and after a ground fault (R).



F 2.9.1.2

In ground fault location, grounding malfunction is due to resistance grounding malfunctions. We are not concerned with grounding caused by distributed capacitance, but we have to be aware of its existence and the effects it may have.

The relationship between resistance and distributed capacitance can be described as:

$$f = \frac{1}{2 \pi RC}$$

f = recommended grounding location (unit: Hz);

R: Grounding resistance (unit: Ω);

C: Distributed capacitance in the circuit (unit: f)

In the actual detection of a grounding malfunction, the circuit has grounding resistance and distributed capacitance. Distributed capacitance current and resistance current have a 90° difference for the phase angle. Current signal in the circuit is composed of distributed capacitance current and resistance current. Their flow directions are describes below:

Resistance current: Flows from the signal generator output terminal (red testing lead) to the DC circuit and finally out from the grounding point.

Distributed capacitance current: Flows from the signal generator output terminal (red testing lead) to the DC circuit and finally out of the earth from different points of the circuit in the direction of the distributed capacitance current.

2.10.3 Interference Signals Affecting Measurement

Most of the time, ground fault location needs to be carried out when the DC system is still active. The current signal of the DC circuit will affect the inspection of the ground fault,

especially when the frequency of the working signal is close to the output frequency of the signal generator.

Solutions offered by the GFL-1000:

1. By software and hardware filtering, the GFL-1000 will effectively get rid of the interference signal in the DC circuit.
2. Through frequency spectrum analysis, the GFL-1000 will analyze the surrounding signals of different frequencies. This will help users get the most suitable output frequency needed for ground fault detection. For a detailed introduction of analyzing function, refer to **3.2.1 Frequency Spectrum Analysis**. Output frequency of the generator is selectable amongst: 1.0Hz, 10Hz, 50Hz, 60Hz, and 325Hz.

2.10.3 Selection of Output Voltage for Location

For different electrical circuits, the output voltage of the signal generator can be selected amongst 24V, 110V, 220V, 500V, and 1000V based on the relevant nominal voltage of the circuit. Generally, you can select higher output voltage to amplify the grounding signal and make it easier for ground fault detection.

Sometimes when output voltage is too high while output current is high enough for fault location, the output voltage will automatically decrease (e.g., from 1000V to 500V) to keep the unit safe during measurement.

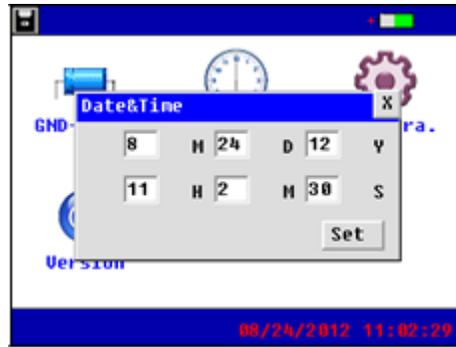
2.10.4 Selection of Output Current

If the circuit with a ground fault also has relay, current output that is too high may cause malfunction with regards to the relay operation. Therefore, proper selection of output current is important to avoid malfunction.

Based on the requirements of different circuits, the output current of the signal generator is selectable between 5mA and no limit.

3. Other Settings of the Generator and the Receiver**3.1 The Signal Generator Settings****3.1.1 Setting the Date & Time**

Select “**Time**” in the main menu; you will see the pop up screen as shown below. Use the arrow keys to change the date and time. Then, click **Set** to confirm the change.



F. 3.1.1

3.1.2 Parameter Setting

This is mainly used for calibrating the instrument. All units are well calibrated in Eagle Eye's lab before they are sent to our customers. Generally, you do not need to calibrate again. If accuracy errors are found and the unit needs to be calibrated, contact Eagle Eye to get a separate calibration manual.

3.1.3 Firmware Version

Select "Version" in the main menu; you will see the version information of the signal generator firmware as shown below. Eagle Eye continuously updates its software and firmware. To get the latest update, please call us toll free at 877-805-3377.

3.2 Functions and Settings of the Signal Receiver

3.2.1 Frequency Spectrum Analysis

Purpose: Analyzes surrounding signals and helps you to get the right output frequency for ground fault detection.

The standard signal receiver of the GFL-1000 has a frequency spectrum analyzing function to test surrounding frequencies. By testing different frequencies and their strength in the surrounding environment, it will be very helpful for users to avoid interference signals and select the right output frequency for ground fault location.

After the signal generator is connected with the DC system and it does not output any signal, connect the current detector with the standard signal receiver. Turn on the receiver, and you will see the main screen as shown in Fig. 3.2.1.1. Select "**Freq. Spect.**", and you will be taken to the next screen for frequency spectrum analysis.



F. 3.2.1.1



F. 3.2.1.2

Frequency spectrum resolution is selectable amongst 0.5Hz, 1Hz, 5Hz, 10Hz, and 25Hz. Different resolutions have different related fineness and maximal frequency. This will be reflected on the screen (Fig. 3.2.1.3) when the current detector is close to the tested circuit for signal analysis (Fig. 3.2.1.4).

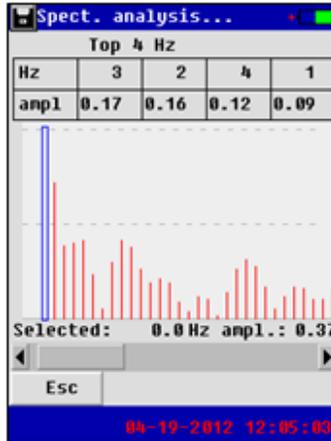
Below is their relationship:

Frequency Spectrum Resolution (Hz)	Frequency Spectrum Fineness (Hz)	Frequency Spectrum Analyzing Max Frequency (Hz)
0.5	0.5	50
1	1	100
5	5	500
10	10	1000
25	25	2500

A **programmable band pass filter** is built into the signal receiver to enhance the capability of anti-interference. For frequency spectrum analysis, the current detecting signal will not go through the band pass filter. Therefore, for surrounding frequencies analysis, the band pass filter should be shut off.

NOTE:

When the band pass filter is open, the current detecting signal will go through the band pass filter. In that case, the center frequency could be selectable amongst 10Hz, 50Hz, 60Hz, and 325Hz. Generally, the center frequency of the band pass filter is the same as that of the signal generator.



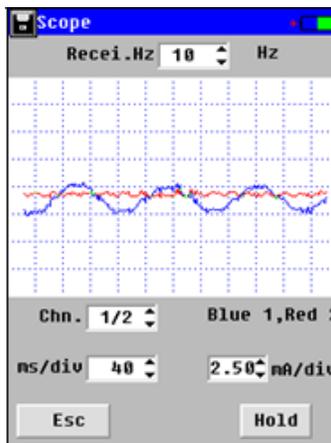
F. 3.2.1.3

After setting the frequency spectrum resolution and band pass filter, click **OK** and you will see the top four frequencies with different signal strengths in the ambient environment (Fig. 3.2.1.3). The higher the signal strength, the higher the interference will be to ground fault location.

3.2.2 Oscilloscope

To measure the waveform of a tested circuit:

Click **“Scope”** in the main menu; you will see the screen as shown below:



F. 3.2.2

Screen Introduction:

Frequency: means the receiver frequency. It is defaulted to 10Hz.

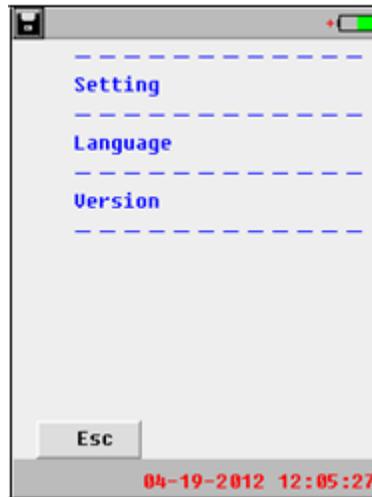
CH: Channel selection. Channel 1 in blue indicates the waveform after using the band pass filter. Channel 2 in red indicates the waveform not using the band pass filter. Selection options: Ch1, CH2 and Ch1/2.

ms/div: Indicates the time (ms) of each grid on the horizontal axle. It is selectable for different views.

mA/div: Indicates current value (mA) of each grid on the vertical axle. It is also selectable.

3.2.3 System Settings

Click “**System**” in the main menu; you will see the screen for the systems settings as shown below:



F. 3.2.3

3.2.3.1 Frequency synchronization

This is used to ensure that the receiving frequency of the signal receiver is identical with the output frequency from the signal receiver. All GFL-1000 units are defaulted to 10Hz output frequency and have been synchronized well before deliver to our customers.

If you have more optional frequencies in your signal generator, follow these steps:

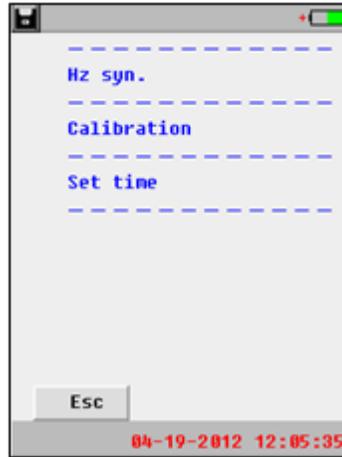
1. Preheat the signal generator and signal receiver for at least 20 minutes.
2. Connect the two signal testing leads with the signal generator, and connect the other two ends of the leads together (short connect).
3. Output voltage of the signal generator is set as 48V. DO NOT set it too high. Select the first output frequency, and go to the screen for signal generation (like Fig. 2.4.3 in **2.4 Setting the Generator Output Signal**).
4. Clamp the current detector of the signal receiver around the output terminal (red testing lead like in Fig. 3.2.3.1.1), and keep it still for a while.
- 5.
6. Go to **System--Setting--Hz syn** in the signal receiver. Select the same frequency as the output frequency of the signal generator, and click the **Hz syn** button, as shown in the screen shown below (Fig. 3.2.3.1.2 and Fig. 3.2.3.1.3). Frequency synchronization will be completed and saved within seconds.

Frequency synchronization must be done for all the four frequencies (10Hz, 50Hz, 60Hz, and 325Hz).

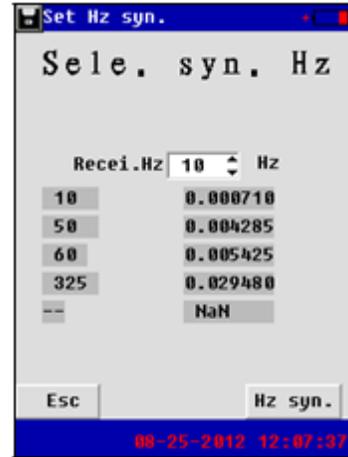
After setting the first frequency, do it in the same way for the other three.



F. 3.2.3.1.1



F. 3.2.3.1.2



F. 3.2.3.1.3

3.2.3.2 Signal Receiver Calibration

All units are properly calibrated in Eagle Eye’s lab before they are sent to our customers. Generally, there is no need to calibrate again. If accuracy errors are found or if calibration is needed, contact Eagle Eye to get a separate calibration manual.

3.2.3.3 Signal Receiver Time Setting

Go to **System—Setting—Set time** in the menu, and set the time with the touch screen or keypad as shown in the below screen, and click **OK** to save the changes.



3.2.3.4 Firmware version

Select “Version” in the main menu; you will see version information of the signal generator firmware as shown in the diagram below. Eagle Eye continuously updates its software and firmware. To get the latest update, please call us toll free at 877-805-3377.

4. Service & Maintenance

4.1 Self-Check

Before performing ground fault location with the GFL-1000, follow the steps below to do an initial check of the equipment:

1. To ensure that the signal generator and receiver will perform when you need them, charge them often and monitor the battery level as needed.
2. Check if the signal generator is normal:
Connect the two signal testing leads with the signal generator, and connect the other two ends of the leads together. Output voltage of the signal generator is set at 48V, and output current is set as "UL".

As it is short circuited in as a result of this type of connection, normally voltage and resistance will become 0. Current is around 6.5mA. If the output voltage is 24V and the output current is unlimited, normally voltage and resistance become 0. Current value is around 2.7mA.

For testing of voltage, resistance, and current, refer to **2.4 Setting the Generator Output Signal**.

NOTE: to ensure the security of the equipment, DO NOT output higher voltage for a short circuit.

3. Check if the signal receiver is normal:
When the signal generator is short-circuited, set the same receiving frequency in the receiver (10Hz), set the frequency synchronization and set the reference point.

Normally after frequency synchronization, phase angle and signal strength are pretty stable. After setting the reference, signal strength becomes 100%; phase angle is around 0°; and current direction will be →. If the current detector is clamped on the opposite direction, the phase angle will become around 180° and the direction will be reversed --X→.

4.2 Common Troubleshooting

Description	Causes	Solutions
Signal strength and phase angle in signal receiver periodically displays high or low.	Signal display of signal generator is set to “Discontinued” mode.	Change to “Continue” mode.
	Signal is too weak	Increase output voltage
	There might be similar frequencies nearby that interfere with signal	Use the frequency spectrum analyzing function of the signal receiver to test the surrounding signals and select the right output frequency.
	Opening jaw of the current detector is closed or obscured with dirt	Close the jaw of current detector, and clean the clamp jaw.
	The reference value is set when it does not clamp in the circuit that has current flow	Clamp the current detector in the circuit and make sure that the signal generator is transmitting signal properly, then set the reference point.
In the same point, signal receiver shows steady signal strength but phase angle is increased or decreased in certain rate.	<ol style="list-style-type: none"> 1. Frequency synchronization is not set in the signal receiver 2. Current detector is not kept stable during frequency synchronization. 	Perform “Frequency synchronization” with cu
Relay maloperation during ground fault location.	Red test lead is incorrectly connected with the busbar that has normal insulation	Connect red test lead to the correct busbar.
GFL-1000 operates for a short amount of time then the equipment powers off.	Unit not fully powered before operation	<ol style="list-style-type: none"> 1. Fully charge signal generator and receiver before using. 2. For long term operation, connect the AC power adapter to the signal generator.

4.3 Cleaning & Storage

4.3.1 Cleaning

Clean the GFL-1000 main unit and its accessories with a soft, damp cloth and a mild cleaner. Do not use abrasives, solvents, or alcohol, as they can deform or discolor the locator and the accessories. After cleaning the voltage testing clip with a software cloth, clean it again with water and wipe it. Do not damage the metal part of the clips in order to ensure its accurate performance during testing.

WARNING: For your own safety, make sure that the main unit and accessories are not working and are disconnected from the power supply before cleaning.

4.3.2 Storage

After using the GFL-1000, put the main unit and all its accessories into the carrying case, store the case in a ventilated area under proper temperature and humidity. Never expose the equipment and its accessories to water, high humidity, or dampness. If it is not use for some time, the Li-battery will discharge itself gradually. To keep the battery performing at its best, charge the battery periodically (e.g., once a month)

5. Contact

A black and grey graphic containing contact information. At the top, the slogan "Keeping an Eye on Your Critical Power!" is written in yellow. Below this is the Eagle Eye Power Solutions logo. To the right of the logo, the text "SALES & SUPPORT" is written in large, white, bold, sans-serif capital letters. Underneath, the contact details are listed: "call: 1-414-962-EEPS (3377)", "toll free: 1-877-805-EEPS (3377)", and "email: info@eepowersolutions.com". At the bottom of the graphic, the website address "www.eepowersolutions.com" is displayed in white, bold, sans-serif font.

Keeping an Eye on Your Critical Power!



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