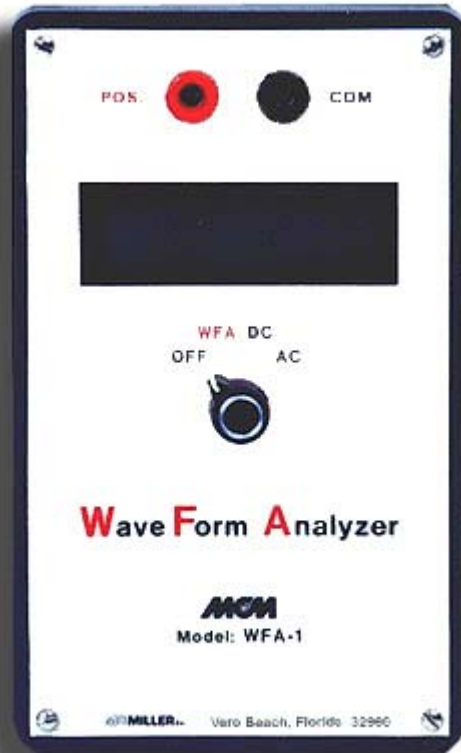


# WaveForm Analyzer

## User Guide



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# WaveForm Analyzer User Guide

## Introduction

The WaveForm Analyzer (WFA) is a portable handheld autoarranging voltmeter designed specifically for cathodic protection monitoring. When the WFA is used in conjunction with Pulse Generators installed in impressed current rectifiers, both ON and OFF (soil and pipe IR drop free) readings are made.

The WFA has three (3) modes of operation:

1. **WFA Mode:** used to measure both ON and OFF pipe-to-soil potentials.
2. **DC Mode:** The WFA functions as a standard autoarranging DC voltmeter.
3. **AC Mode:** The WFA functions as an autoarranging AC voltmeter.

## WaveForm Analyzer/Pulse Generator System

The WFA is a microprocessor based handheld voltmeter which uses a complex computer algorithm to measure the ON and OFF (IR drop free) pipe-to-soil (P/S) potentials in impressed current cathodic protection systems. In order for the WFA to accurately calculate the OFF potential, a Pulse Generator (PG) must be installed in each rectifier or current source affecting the location where the P/S measurement is being made.

The PG interrupts the output of the rectifier in which it is installed on a precise timing cycle. This interruption generates the precisely timed zero current pulse which is required by the WFA to accurately calculate the OFF potential. PGs are low cost and are designed to be permanently installed in the rectifiers. PGs cannot be synchronized. They are installed in the rectifier and are turned on and left operating permanently.

The WFA uses a complex algorithm or set of computer instructions to calculate the ON and OFF P/S potential. The algorithm consists of the following types:

- The WFA captures a digital picture of the P/S potential waveform by recording thousands of voltage readings on the waveform.
- Digital signal processing techniques are then used to filter out any induced AC or 60-cycle noise in the waveform.
- The ON potential readings are calculated.
- The IR drop contribution from the six (6) PGs having the greatest influence on the reading is determined by analyzing the zero current pulses from the PGs.



## WaveForm Analyzer User Guide

- Once the total IR drop contribution is known, the OFF potential reading is calculated by subtracting the IR drop from the ON value.

**Note:** The WFA algorithm includes the IR drop contribution from the six (6) rectifiers (or up to six) having the largest IR drop. To date, in extensive field-testing conducted on numerous cross-country pipelines, tank farms, and industrial facilities, no location has been found where more than five (5) rectifiers were influencing the reading.

### Using the WaveForm Analyzer

A WFA operating mode is selected by turning the rotary switch on the front of the unit from the OFF position to either the WFA, DC, or AC position as needed. When the WFA is first turned on, it will briefly display the following message while it performs an internal self-test:

SYSTEM TEST ...

If all WFA modules check out properly, then the following message is displayed for approximately one (1) second:

ALL SYSTEMS OK ...

In normal operation, the WFA will begin operation in the selected mode after the "All Systems OK-" message has displayed.

During the system test, alarm messages will display if any faults or potential problems are detected during the operation of the WFA. These messages include the following:

LOW BATTERY

This message indicates that the battery within the WFA should be replaced. When this alarm is first displayed, there is approximately one (1) hour of operating life remaining. Note: "Operating Life is defined as the time remaining when the WFA is on and displaying readings. See the section titled "Care and Maintenance" for instructions on how to change the WFA battery.



## WaveForm Analyzer User Guide

There are three (3) other possible alarm messages.  
They are:

RAM FAULT

EPROM FAULT

A/D FAULT

These messages indicate that there is a problem with a specific part of the WFA hardware and was detected during the unit's self-test. If any of these messages display, the WFA will need to be returned to MCM for service.

If the mode selector switch has not been moved for approximately five (5) minutes, the WFA will automatically turn itself off in order to conserve battery power and life. When this happens, the display will go blank. In order to turn the unit back on, you will need to turn the mode selector switch to the OFF position and then select the desired mode.

### WFA Mode

The WFA mode is used to take both ON and OFF P/S potential readings. The algorithm used by the WFA requires that a digitized copy of a four (4) second segment of the P/S potential waveform be stored in the WFA memory before the ON and OFF potential readings may be calculated.

When the WFA mode is entered, the unit first collects or digitizes the four (4) second waveform and then it collects and displays the ON and OFF potential readings. After the first four (4) seconds of data have been used to calculate the ON and OFF potential, the WFA digitizes the waveform for an additional second. It then discards the oldest second's worth of data and recalculates the ON and OFF potential. This cycle continues until a different mode is selected or until sufficient time has elapsed for the WFA to turn itself off. A sample WFA mode display is shown below:

```
WFA ON  1.234V
      OFF 1.000V
```



## WaveForm Analyzer User Guide

In the WFA mode, both the ON and OFF potentials are displayed. The IR drop component can be calculated by subtracting the OFF potential value from the ON potential Value. Note: The WFA mode will display the correct OFF value only if the reference electrode is connected to the RED or POS input terminal and the structure is connected to the BLACK or COM input terminal. If the polarities are reversed (i.e. reference cell connected to BLACK or COM terminal and structure to RED or POS terminal) the correct OFF value will not be displayed.

The ranges, resolution and accuracy in the WFA mode is:

RANGE	RESOLUTION	ON Accuracy	OFF Accuracy
0 – 2.5V	.001V	± .001V	± .003V
2.5V – 25V	.01V	± .02V	± .03V
25V – 250V	.1V	± .2V	± .3V

### DC Mode

In the DC mode, the WFA functions as an autoarranging DC voltmeter. A typical DC mode display might be:

DC +1.234V

The polarity of the reading is always shown either by a plus (+) or a minus (-) sign. The reading is always displayed in volts.

The resolution accuracy for each range is:

RANGE	RESOLUTION	Accuracy
0 – 2.5V	.001V	± .001V
2.5V – 25V	.01V	± .02V
25V – 250V	.1V	± .2V

### AC Mode

In the AC mode, the WFA functions as an autoarranging AC voltmeter. A typical AC mode display might be:

AC +1.234V



## WaveForm Analyzer User Guide

The reading is always displayed in volts. The resolution and accuracy for each range is:

RANGE	RESOLUTION	Accuracy
0 – 2.5V	.001V	± .001V
2.5V – 25V	.01V	± .02V
25V – 250V	.1V	± .2V

### Care and Maintenance

#### ❖ General

- The WFA has been designed to operate reliably and accurately in the corrosion field-testing environment. Other than replacing the battery, and occasionally cleaning the case with a clean damp cloth, no other special care or maintenance is required.
- While the WFA case is rain and splash proof, it is NOT designed to be submerged. The WFA is designed to withstand the normal bumps, knocks and drops of every day field use. As with all electronic instruments, the WFA may be damaged by sharp or severe impacts.

#### ❖ Charging the Battery

- Replacing the WFA battery is a simple and straightforward task. The four (4) steps in changing the WFA battery are:
  1. Loosen the four (4) screws in the front corners of the WFA until the back cover can be removed. These screws are permanently mounted on the front cover of the WFA so you will not loose them from the cover.
  2. Separate the front and back covers. While holding the front cover, remove the battery from the cut out in the printed circuit board where it is installed. Disconnect the old battery from the battery cable.
  3. Plug a new nine (9) volt Lithium battery onto the battery cable and insert the battery into the cutout within the printed circuit board.



## WaveForm Analyzer User Guide

4. Attach the back cover to the WFA front cover, by tightening the four (4) screws in the corners of the front cover of the WFA.

- While any standard nine (9) volt alkaline battery may be used in the WFA, MCM recommends that you use a Lithium battery. This readily available battery will provide approximately 50% more life than a nine (9) volt alkaline battery.

### ❖ Calibration

- M. C. Miller Co., Inc. certifies that this MCM instrument meets or exceeds all published specifications and has been calibrated using standards whose accuracy is traceable to the National Institute of Standards and Technology (NIST) within the limitations of the institute's calibration services, or have been derived from accepted values or natural physical contents, or have been derived by ratio or self calibration techniques.

Under normal use, this MCM instrument should be calibrated annually to insure the accuracy of its readings. Only the qualified technicians at M. C. Miller Co., Inc. should do this annual calibration. Contact MCM for annual calibration service information at: [sales@mcmiller.com](mailto:sales@mcmiller.com).

### ❖ Troubleshooting

A number of possible WFA problems and suggested corrections are listed below.

#### ➤ **The WFA Will Not Turn On**

- If the WFA does not turn on when the rotary switch is moved from the OFF position to the WFA, DC, or AC position, then the battery has likely been discharged. Follow the section above regarding battery replacement.
- If the WFA will not turn on after a battery replacement, the WFA must be returned to MCM for repair.



## WaveForm Analyzer User Guide

- **The LCD Display Turns Black**
  - When the Liquid Crystal Display (LCD) in the WFA is exposed to direct sunlight for extended periods of time, each dot within the display may turn black. If this happens, remove the display from direct sunlight. After several minutes, the display should return to normal (blank). This situation does not harm the display. It is a normal characteristic of Liquid Crystal Displays.
  
- **Questionable OFF Reading in the WFA Mode**
  - If the OFF reading or IR drop value in the WFA mode is questionable, first check to make sure the proper polarity connections was made. The reference cell is always connected to the RED or POS input and the structure is always connected to the BLACK or COM input when recording P/S potentials in the WFA mode. Reversing the reference cell and the structure connections will result in incorrect readings.
  - If you have not taken IR drop free or OFF potential readings on your line before, you will likely find some areas with OFF potentials higher than you expected and other areas with OFF potentials lower than expected.
  
- **Low Battery Message**
  - The WFA checks the voltages of the internal battery each time the WFA is turned on and each time it is switched to another mode.
  - If the battery has been discharged below the 6.85-volt cutoff level, then the “Low Battery” message will display.
  - When the low battery message first displays, the WFA has approximately one (1) hour of operational life remaining. The battery should be replaced as soon as possible after the first “Low Battery” message displays.
  
- **The WFA Display Goes Blank**
  - The WFA automatically turns itself off if the mode selector switch has not been moved over the previous five (5) minutes. This feature extends the battery life.
  - To restart the WFA, turn the rotary mode selector switch to the OFF position and then back to the desired mode selection. The WFA will now operate properly.





# WaveForm Analyzer User Guide

## Specifications

- ⇒ **WFA Mode:** Displays the ON and OFF (IR drop removed) Potentials
  - Three Voltage Ranges
    - 0 – 2.5 Volts
    - 0 – 25 Volts
    - 0 – 250 Volts
  - Requires Pulse Generators to be installed on all rectifies that are influencing readings.
- ⇒ **DC Mode:** Autoarranging DC Voltmeter
  - Three Voltage Ranges
    - 0 – 2.5 Volts
    - 0 – 25 Volts
    - 0 – 250 Volts
- ⇒ **AC Mode:** Autoarranging AC Voltmeter
  - Three Voltage Ranges
    - 0 – 2.5 Volts
    - 0 – 25 Volts
    - 0 – 250 Volts
- ⇒ **Input Resistance:** 10 Megohm – All Ranges
- ⇒ **Battery:** Nine (9) Volt Lithium)
- ⇒ **Size:** 6 1/8" x 3 5/8" x 1 3/4"
- ⇒ **Weight:** 14 oz. (approximately)