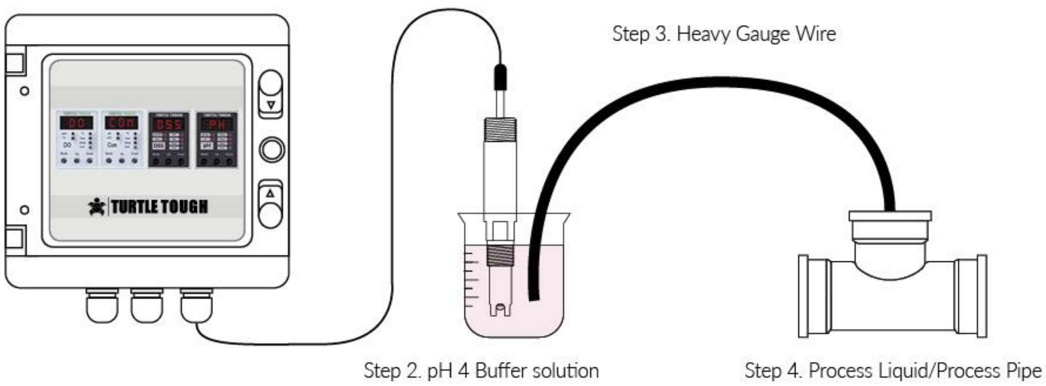
# Ground Loops & Electrical Interference

**Have you ever had problems with process controls and electrical instrumentation?**
**The source may be ground loops.**

A potentially detrimental loop is formed when two or more points in an electrical system normally at ground potential are connected by a conducting path such that either or both points are not at the same ground potential. Unwanted ground loops can cause inaccurate sensor readings by negatively affecting instrumentation signals.

Put simply, a ground loop exists when a circuit is connected to earth ground at two or more points. Because the potential of the earth varies from point to point, two or more connections to the ground cause currents to flow. If the current flows through a signal carrying wire, the result is a noisy, offset signal.

The classic symptom of a ground loop is a sensor that reads correctly in buffers but gives a reading grossly in error when placed in the process liquid. In a typical process measurement, the pH sensor is connected through the process liquid and piping to the earth ground. If the circuitry in the pH analyser becomes connected to a second earth ground, the current will flow through the reference electrode. A voltage proportional to the current and the electrode resistance develops across the reference electrode. Because the voltage is in series with the other cell voltages, the ground loop current causes the pH reading to be substantially different from the expected value. The currents created by ground loops are often unstable, so pH readings affected by ground loops are often noisy.




# Checking for a Ground Loop

If an instrumentation system starts acting strangely or erratically, make sure you eliminate all unintended ground connections. Or if your readings fluctuate when you touch a cable or move the sensor. These can occur when you – add or change a motor or agitator. Any electrical item that is worked on – may upset the balance and needs to be checked once more.

Use the following procedure to check for ground loops:

1. Remove the pH sensor from the process liquid.
2. Calibrate the sensor in buffers. Be sure there is no direct electrical connection between the container holding the buffer and the process liquid or piping.
3. Strip back the ends of a heavy gauge wire.
4. Connect one end of the wire to the process piping or, better, place it in the process liquid. Place the other end of the wire in the container with the buffer and sensor. The wire makes an electrical connection between the process and the sensor

If the pH reading changes or becomes noisy after making the connection, a ground loop exists. If no symptoms develop a ground loop probably does not exist.

# WARNING!

The presence of ground loops is not merely something that distorts the readings but rather something that also polarizes and **damages the sensor**. The polarization of the sensor can lead to erroneous readings even once removed from the ground loop condition. The polarization may dissipate in time to return to a more normal response although recalibration may be required because it has caused damage to the reference. In time the presence of a ground loop where the sensor is installed will **completely destroy** the responsiveness of the sensor and lead to premature failure. This situation when discovered requires immediate corrective action.

### Things to consider…

It is much easier to avoid ground loops during installation and project planning than to diagnose and resolve them in the field after installation.

1. Often not the same ground and often separated by distance
2. Not always just in the 4-20 mA loop
3. Consider non-isolated RS-485 of signal wires
4. Consider non-isolated power/output input power grounds
5. The ground potentials are NOT equal
6. RGND caused by multiple factors such as:
   a. Noise
   b. Resistance of ground path
   c. Poor initial power rail installations

# A Guide to Ground Loop Troubleshooting

As discussed, the classic symptom of a ground loop is a sensor that reads correctly in buffers but gives a reading grossly in error when placed in the process liquid. The currents created by ground loops are often unstable, so pH readings affected by ground loops are often noisy.

### Could it be a faulty sensor?

The simple answer to this is no. pH and ORP sensors are passive electrodes and as such they do not and cannot generate or store current. Any increase in the mV measured by a pH or ORP sensor must be coming from its environment. If a sensor is able to be calibrated and/or read correctly when placed in buffer solution then it is 100% working correctly. There is nothing that can be done to the sensor to correct for this situation, other than to remove the source of interference. Ground loops can effect many other sensor types, but pH and ORP are the most prone due to the small mV signals involved in their measurement, making the effect more pronounced. If you do have concerns about your sensors' health or response rate please see our sensor health and performance guidelines:

https://www.turtletoughsensors.com/support/troubleshooting/sensor-health-performance-guide.

## If you can't eliminate the conditions for ground loops, what's your next step?

You can use signal isolators. These devices break the galvanic path (DC continuity) between all grounds while allowing the analogue signal to continue throughout the loop. An isolator can also eliminate the electrical noise of AC continuity (common-mode voltage). There are a couple of ways to do this – but regardless of the isolation method you choose, an isolator must provide input, output, and power isolation. If you don't have this three-way isolation, then an additional ground loop can develop between the isolator's power supply and the process input and/or output signal.

## How do I fix this problem?

It is important to note that Turtle Tough cannot advise you on how to modify or rectify the problems you have occurring in your electrical system. It must be stressed that this is not some deficiency with our equipment, but rather, a problem within your electrical system. You must seek the assistance of experienced and qualified electrical personnel who are familiar with your systems and equipment to identify and resolve this problem. The following tips and guidelines serve only to help in a general nature for those unfamiliar with ground loops and provide you with a starting point for investigation. This is by no means a definitive list, and each installation will possess its own set of challenges.

Fundamental to any sensor installation is that ALL electrical equipment must be properly earthed and that sensors are installed in adequately earthed environments. As such it is recommended that pH/ORP sensors are installed in metallic fittings that can be properly grounded. pH and ORP sensors measure small incremental millivolts (ie there are just 59mV per pH unit), so any small amount of current, static or otherwise can cause large shifts to the sensors readings. In these instances, there is nothing wrong with the sensor; it can only see what it sees. Instead, the cause of the stray current must be eliminated. Stray currents are usually caused by improperly earthed or shielded equipment. They can occur on either the process side of the power/electrical side and they can even occur through the atmosphere as airborne interference. As such the pH/ORP sensor should be installed as far away as possible from high current carrying equipment such as pumps, motors, variable speed drives etc.

1. To rule out any interference from the non-process side (ie coming from power or signal input), isolate the sensor from these sources. It is recommended for digital sensors to use the HFC or Windows Interface. The HFC specifically powers the sensor by it's own 9 Volt battery power supply, completely isolating the sensor from your electrical installation.
2. If you do not have a HFC then you should proceed to:
   a) disconnect the outputs of the analyser

b) then power the analyser using a stand alone battery (this will completely isolate the analyser from your power and data acquisition device)

3. Where possible, make sure the sensor is installed on a metal immersion rod that is properly earthed (making sure everything is going to a common earth). This will provide a path for the stray electrons. If you have the sensor installed in poly-pipe or plastic fittings, you will need to find another adequate earthing method for the installation to divert stray current before it hits the sensor.
4. Make sure the pH sensor is not installed too close to an active sensor (ie DO, conductivity, level sensor etc)… these are active sensors and will generate current in close proximity to the tip (sensing element) of the sensor which will be detected by a passive sensor such as pH and ORP. They should be a minimum of 50cm apart, and more so if the vessel is not well earthed (ie like a plastic or rubber lined vessel).
5. In terms of locating the issue on the process side, if you can systematically switch off one device at a time (ie independently of one another) and note when the problem goes away you can isolate the piece of equipment that's causing the issue. For process side related issues this process of elimination is the quickest and most effective method at locating the source.
6. If the event is occurring intermittently, it is important that you study all data from your output devices. Make sure you enable data logging (either locally or via your PLC) so that can you see the event data. When reviewing your data, see if there is any time period where the reading returns to normal? Does this correlate with another piece of equipment being turned off. Conversely, identify time periods where the readings are abnormal and see if these correspond with any time something is being turned on? (ie like a pump, motor etc).
7. Primary suspects are large current devices and things like variable frequency and variable speed drives. If it's not poor/bad earth, often it's poor isolation of their power supplies, or insufficient shielding. Always make sure the sensor is not in close proximity to one of these devices (ie VSD etc).
8. Ground loops can also present from the 4-20mA output to the PLC. If the PLC has poor isolation you may see interference from other connected devices. If the system is already connected to PLC, temporarily disconnect it to rule out the output as being a source of the problem.
9. As a general rule, isolate, isolate, isolate. Where possible install both signal and power isolators.
10. Always ensure the analyser is properly earthed to the installation.

# Stopping Ground Loops in the future

To minimize the danger of introducing these loops into a complicated network, you should use a dedicated instrumentation system ground bus and connect grounds from the signal common, cabinet ground, and instrumentation AC power ground to it. The bus is tied to the earth via the building ground and plant ground grid. But, this can be much more complicated than it appears. For example, you will rarely have just one instrumentation loop. In fact, you could have hundreds or even thousands. Many are packaged together in vendor-supplied instrumentation system cabinets. Generally, these contain a DC signal common bus and a power supply common bus. The manufacturer normally ties these busses together within the cabinets at a master ground bus. The cabinet ground is a safety ground that protects equipment and personnel from accidental shock hazards. It also provides a direct drain line for any static charges or electromagnetic interference (EMI) that may affect the cabinets. This cabinet ground remains separate from the DC signal ground until it terminates at the master ground bus.

The AC service ground is a single-point ground termination of the system AC power. This ground connects to the neutral-to-ground bond at the main AC power isolation transformer. It also terminates at a single point on the plant ground grid (usually the grounding electrode).

**For clarifications, reach us on +61 3 9872 5055 or email us info@turtletoughsensors.com**