

## **An introduction to Instant-Off potentials, IR Error, and basic CP theory.**

**Corrosion Instruments 12/05/18**

### **The background**

Cathodic Protection 101

Electrons flow from anode to structure

Electrons flow to coating defects to protect the structure.

Ions are released at coating defects and travel through the earth (electrolyte)

Over time the structure becomes polarized

Think of polarization as a charge stored in the structure, and separate to the current flowing through the structure.

A good analogy would be pouring water into a tank with holes in it.

The level would increase until the rate of water leaking is equal to the rate of pour

Now in this analogy, the rate of pour is your applied CP current, and the level at equilibrium is the polarization.

Measuring this level (or polarization) is a great means of gauging the effectiveness of the CP system.

Unfortunately when we try to measure the voltage at a test post, the presence of the aforementioned ions traveling through the earth provide a great deal of error we call this "IR error" as it is proportional to the quantity of ions flowing and the soil resistance. What can we do about this error? We stop the CP Current! If we make  $I$  (current) = 0 then  $I \times R$  also equals zero.

Unfortunately the instant we stop pouring water into our tank, the level will decline. The rate of decline can be extremely fast initially though as the level goes down, there are fewer leaks below water level and the rate of decline reduces.

So what do we do? Simple, we measure the polarization the instant that we "turn the CP current off" we call this an Instant-Off measurement.

We "turn the current off" by using precisely timed relays called interrupters, if we have multiple sacrificial anodes or impressed current systems protection a section of structure, then we need to synchronise all of the interrupters, typically, interrupters use the GPS clock system for precise synchronization.

Due to several factors like non-perfect switching and timing delays, a good Instant-Off measurement doesn't happen at exactly the instant that we interrupt but more like an "instant after" we interrupt, say 50mS, after we interrupt the CP Current.

In practice, we typically see a small bend, or even a little kick in a voltage plot which lets us know that we have now no IR error, typically this occurs between 10ms and 150ms after the interrupt and depends on the structure, the CP system and the interruption hardware. Immediately after this Instant-Off instant, the structure will typically depolarize at a rate that depends on several factors such as the coating condition and soil conductivity

## The Problem

Traditionally, Instant-Off potentials have been measured with a Digital Multi-Meter DMM. However a DMM has two major flaws which render it insufficient to measure accurate instant off potentials, these are:

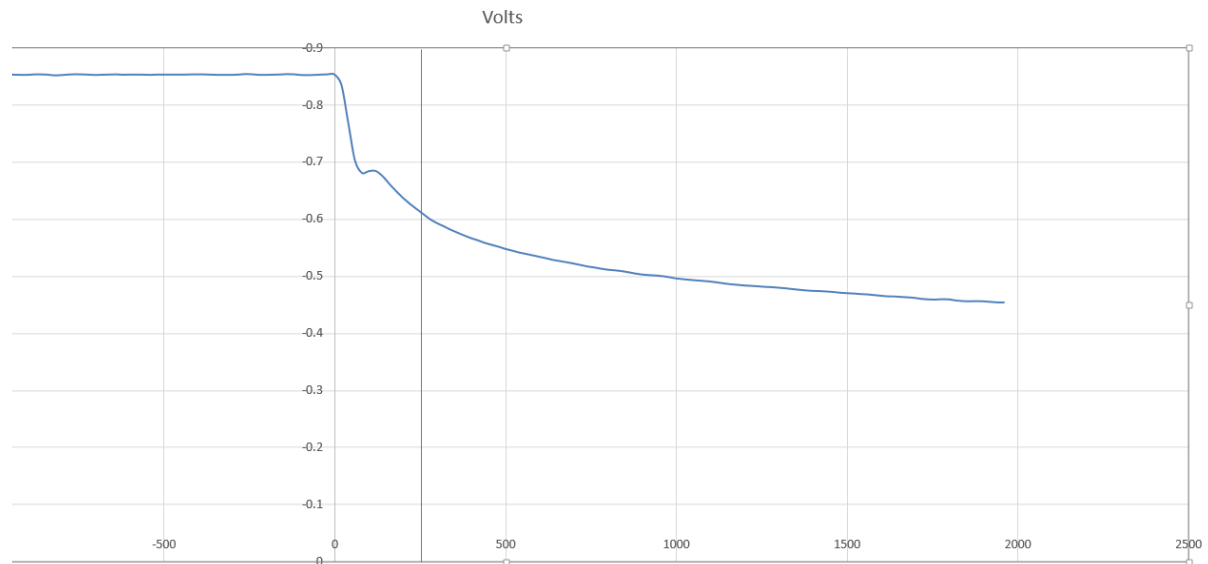
**Screen refresh rate** – your DMM refreshes its screen at a rate of somewhere between once every 200ms and once every 500ms, most common is once every 250ms.

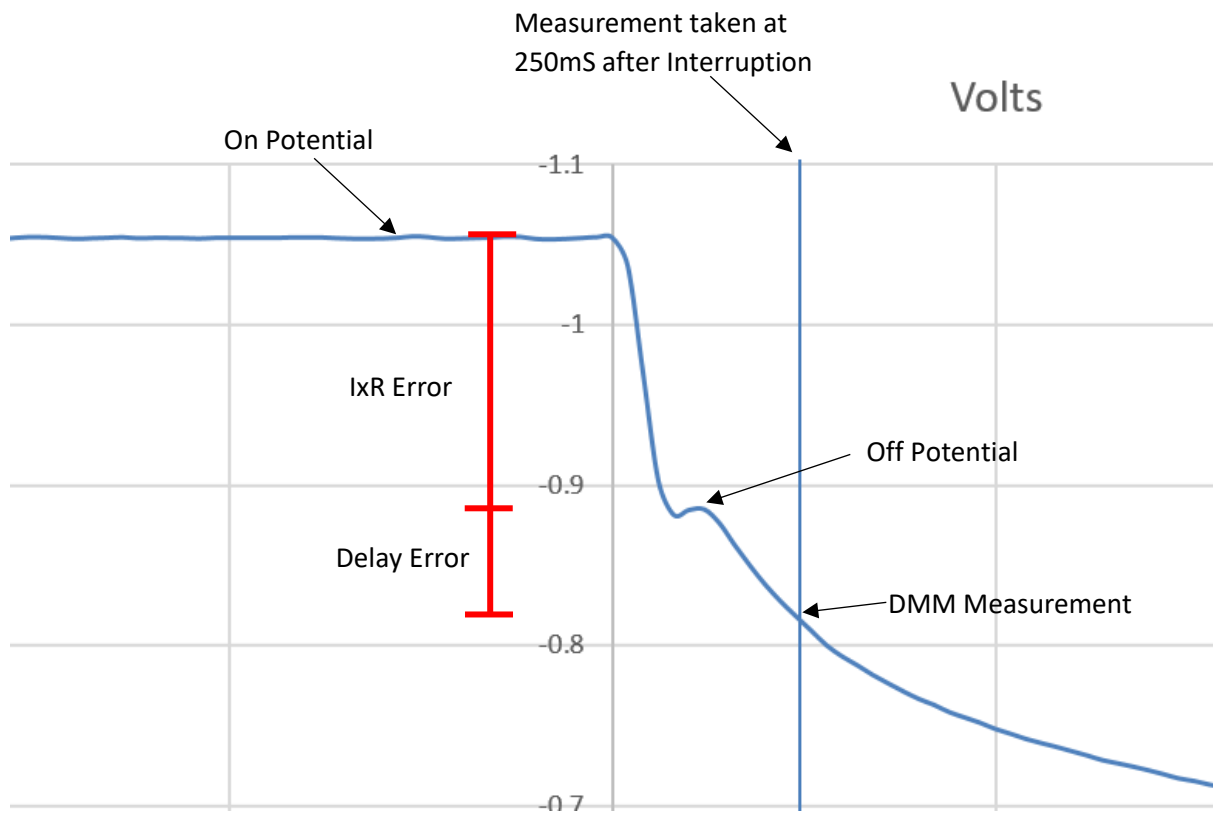
Let's look at the data below.

After 100ms we see the Instant-Off event.

This is followed by a steep depolarization.

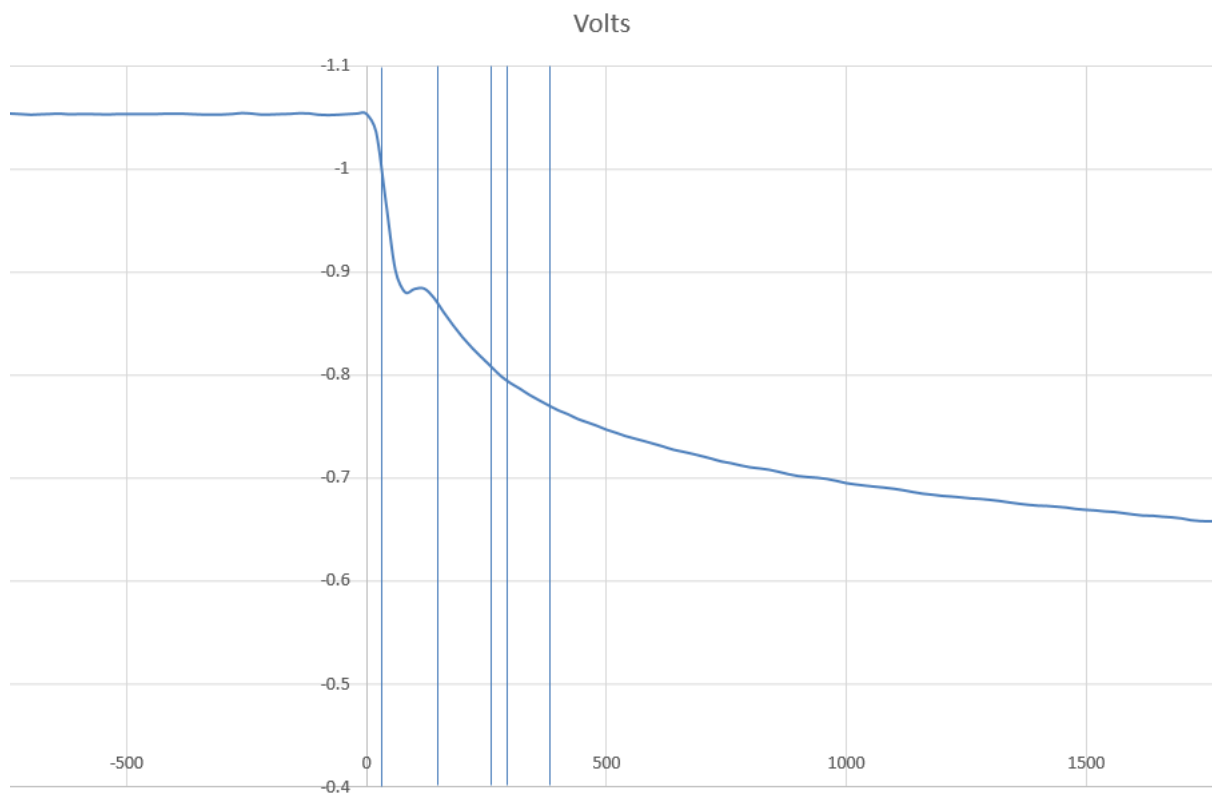
250ms is marked on the plot in this instance the difference between the instant off and the value measured by DMM is 76mV. We can see there will almost always be an error caused by a delay in measurement, we will call this the Delay Error





**No Synchronisation** – Not only is there a delay but because the DMM is not time synchronized to any reference, the delay is unpredictable and unmeasurable. For example below are 5 instances of recording using a DMM.

	time	measurement	dT	dV
Instant-off	100	-884	0	0
Reading 1	260	-809	160	75
Reading 2	40	-970	-60	-86
Reading 3	380	-771	280	113
Reading 4	140	-876	40	8
Reading 5	300	-793	200	91



You can see that the measured off potentials range from -571mV to -770mV that's a range of 200mV and this is very typical for measurement of Instant-Offs on a pipeline. The error could be much greater on an old pipeline with many coating defects.

### The answer

In order to remove the delay error, we need to either synchronise the measurement with the interrupter or look for the bend or kick in the graph.

What if we could do both?

The CP-Pro does exactly this, additionally it displays a curve of the structure potential during the interruption which allows a technician can review to quickly determine the Instant-Off potential.