Using Remote Data-Logging Techniques to Evaluate Transit System Interference

Jamey Hilleary
Director of M2M Products
Elecsys Corporation

Jerry Dewitt
Senior Cathodic Protection Specialist
Enbridge Pipelines Inc.

Len Krissa, P.Eng.
Engineering Specialist
Enbridge Pipelines Inc.

Keywords: Remote monitoring, data-logging, reverse current switch, DC transit system interference, CP, cathodic protection measurement, DC voltage, AC voltage, pipelines

Abstract

One of the challenges facing corrosion professionals is the co-location of pipelines with other sources of interference in congested urban and suburban right of ways. It is often difficult to determine the source(s) of interference currents so mitigative action can be made to restore sufficient cathodic protection on the affected pipeline. Evaluating the effects of electric transit systems can be a particularly difficult task when the interference is significant only in short intervals. Additionally, multiple data parameters including: AC and DC potentials, AC and DC current densities, and reverse current switch measurements should be gathered synchronously to build an accurate profile of the total interference being experienced. Data-logging at locations of high detrimental DC traction interference can be effectively used for evaluation however the time synchronization of the data events across multiple sites is not always accurate if the proper equipment is not employed.

Historically, the process of gathering and interpreting several parameters of data from multiple locations can be very time-consuming and costly. Web-based, remote access, data-logging systems have evolved to the point where multiple, time-stamped data measurements can now be acquired accurately and efficiently from multiple sites, and delivered to the user with insignificant (non-critical) data filtered out. Cathodic protection professionals now have technology available to streamline processes, which were previously impractical, making these large data sets usable and ultimately developing a clear picture of the interference from intermittent sources such as electrical transit systems.

This paper is a case study of the use of web-based monitoring systems with remote data-logging capability to acquire critical data and develop interference profiles on pipelines due to electric transit systems. The focus is on challenges of synchronizing time-based events across multiple sites, and correlating the data back to the intermittent activity producing the interference from the transit system.

An additional challenge is identifying sources of interference that are not associated with the transit system which may potentially distort the interference profile.

Introduction

The purpose of this paper is to explore the use of standard test point/critical bond remote monitoring equipment to measure the fluctuations in current levels at locations where a cathodically protected buried pipeline structure is bonded to an electric rail transit system through a reverse current switch. Locations where transit systems cross buried pipelines, or operate in very close proximity to the pipeline present a particular challenge for pipeline operators in regards to stray current interference. Significant current can be generated by electric transit systems. Significant fluctuations in interference DC potentials generated by the co-located transit system can occur, often associated with the passing train, but also at unpredictable intervals.

A reverse current switch can essentially be either a mechanical device or a diode-controlled bond between the pipeline and the transit system. This component enables the interference current to be returned to its source, thereby reducing the potential of safety hazard, damage to the pipeline and the cathodic protection system. PHMSA requires that the operational integrity of diodes and critical bonds installed on cathodically protected pipelines be verified six times per year. Reverse current switches fall into this category and as such are subject to this requirement.

Remote monitoring of the shunt at a reverse current switch can provide operational data necessary for fulfilling the compliance requirement. Monitoring additional parameters at the reverse current switch location can provide valuable information regarding the effect of the interference current on the overall cathodic protection at the interference location. Periodic current shunt measurements will provide adequate data to ensure the switch is functional and meets the minimum operational integrity verification for compliance purposes. However, since most of the interference generated by a transit system occurs as the train passes the current pickup point, data logging provides a more comprehensive view of the effect on the pipeline and the cathodic protection system. Using remote monitoring equipment with data-logging capabilities allows the operator to monitor the changes in the current profile, as well as measure in real time the effect this current has on other critical cathodic protection values, notably DC pipe to soil potentials.

This paper will look at data derived at several locations where remote monitoring systems are being used to measure current values and additional cathodic protection parameters at reverse current switch locations.

Equipment Used

Three reverse current switch sites were used for data compilation in this study. The sites selected were liquid transmission pipelines co-located with electric rail mass transit systems in two metropolitan areas in the US. At each location a reverse current switch had previously been installed to return interference current back to the rail system. Remote monitoring devices were installed in the junction box containing the switch. At the first location the monitor unit was connected to only measure the current shunt at 15 second intervals. At the other two locations the monitor equipment was connected to measure not only the current shunt, but to take DC pipe to soil potential measurements and AC and DC current density measurements as well. One of these sites recorded data at 4 hour intervals, and the other site recorded data at 1 minute intervals. An additional bond was also located at the same installation. Another monitor unit was installed to measure the bond current and DC pipe to soil potential for the bond. All of the monitors were equipped to log all measurements to the device memory, and the units were accessed periodically through the internet to download the stored measurements. The data points used for this study and shown in the graphs in this paper were derived from the stored measurements. When analyzing the data it was apparent the most pronounced correlation effect from the fluctuations observed in the current measurements occurred in the DC pipe to soil values. For this reason the analysis presented in this paper focuses on these two parameters.

Case Study

The first set of data shown in Figure 1 are measurements of current across a shunt in a reverse current switch installed at a crossing of a liquid products transmission pipeline and a metro electric passenger rail transit system. The measurement for the time period shown were taken at 15 second intervals over a three day period. Though the graph is very dense it clearly shows a pattern of high current values interspersed with levels of no activity. The inactivity time periods are from approximately 1:00 am to 5:00 am daily as the trains do not operate during this time period.

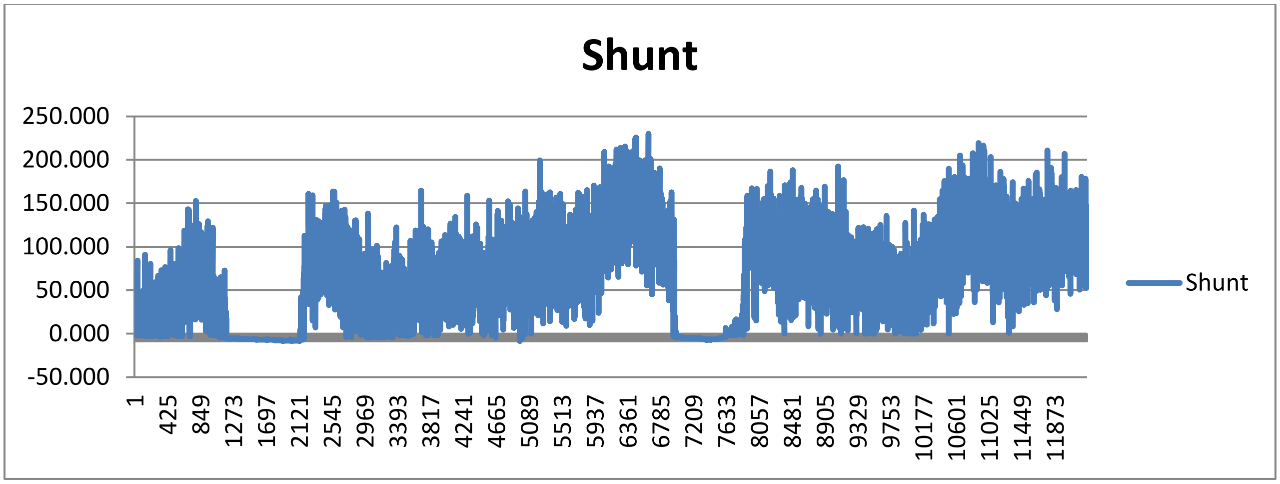

Figure 1 – Reverse current switch shunt measurements, 15 second intervals (DC amps vs. Event count)

Figure 2 is a smaller sample of data showing one hour of activity (5:00 pm to 6:00 pm). In this data sample the fluctuating data values measured are clearly seen.

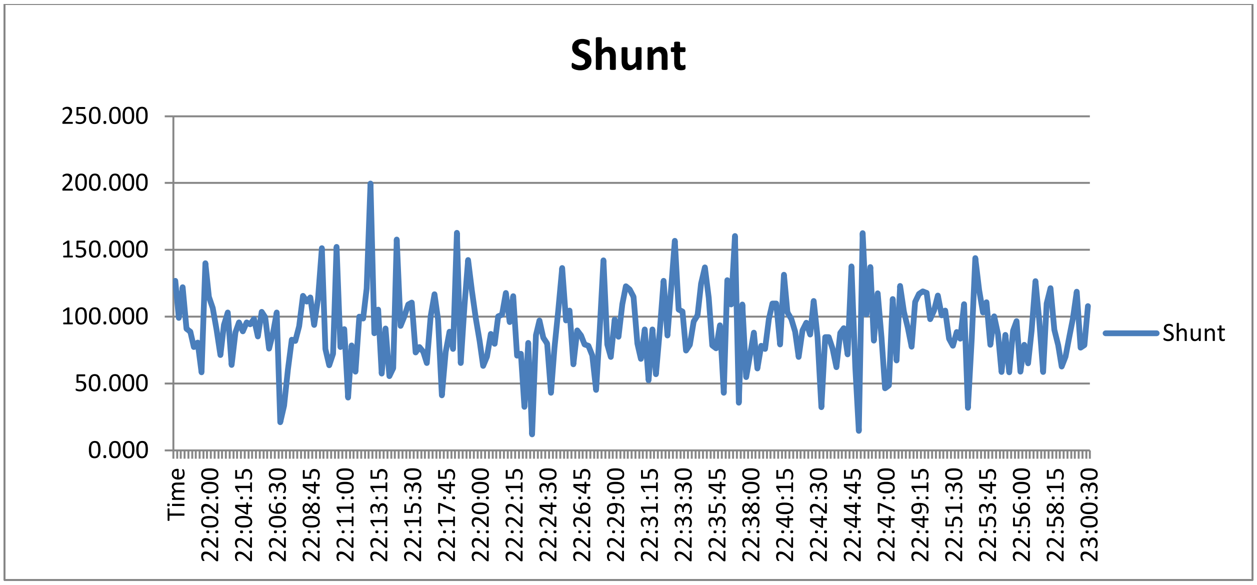

Figure 2 – Reverse current switch shunt measurements, 15 second intervals

Recording the shunt value provides the basic verification measurements required for compliance reporting, but this measurement alone provides no indication as to the effect that the interference current has on the pipeline and the cathodic protection system.

The second and third reverse current switch locations were installed on two separate liquid transmission pipelines co-located with an electric rail mass transit system. In the junction box at this location were two reverse current switches (one for each of the pipelines), and an additional bond (Figure 3).

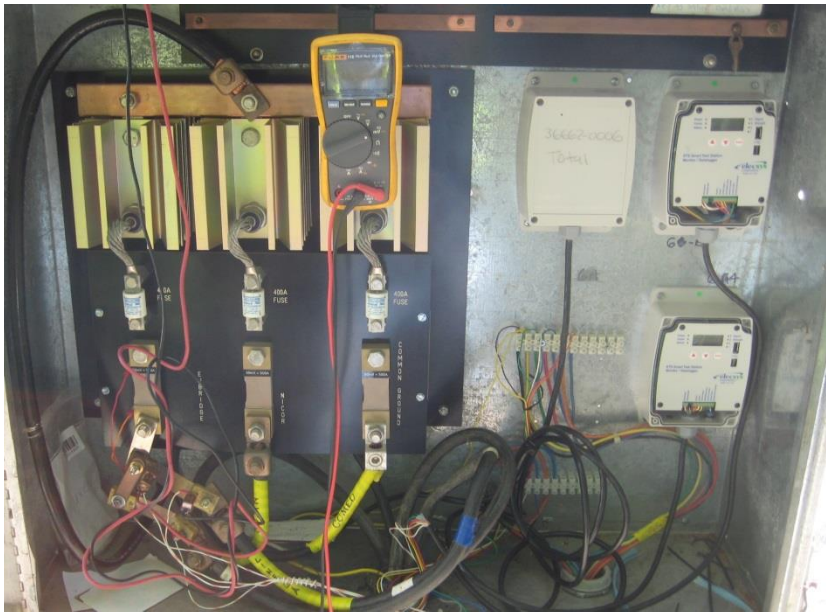

Figure 3 – Reverse current switch (2) and bond with 3 monitoring devices

The data displayed in Figure 4 and Figure 5 are measurements taken at the second reverse current switch location. These measurements were recorded at four hour intervals over several days. Figure 4 shows the current level measured across a shunt in the current switch enclosure, and Figure 5 displays corresponding pipe to soil measurements at the same location. A correlation between the current levels at the reverse current switch and the pipe to soil voltage potential measurements is evident.

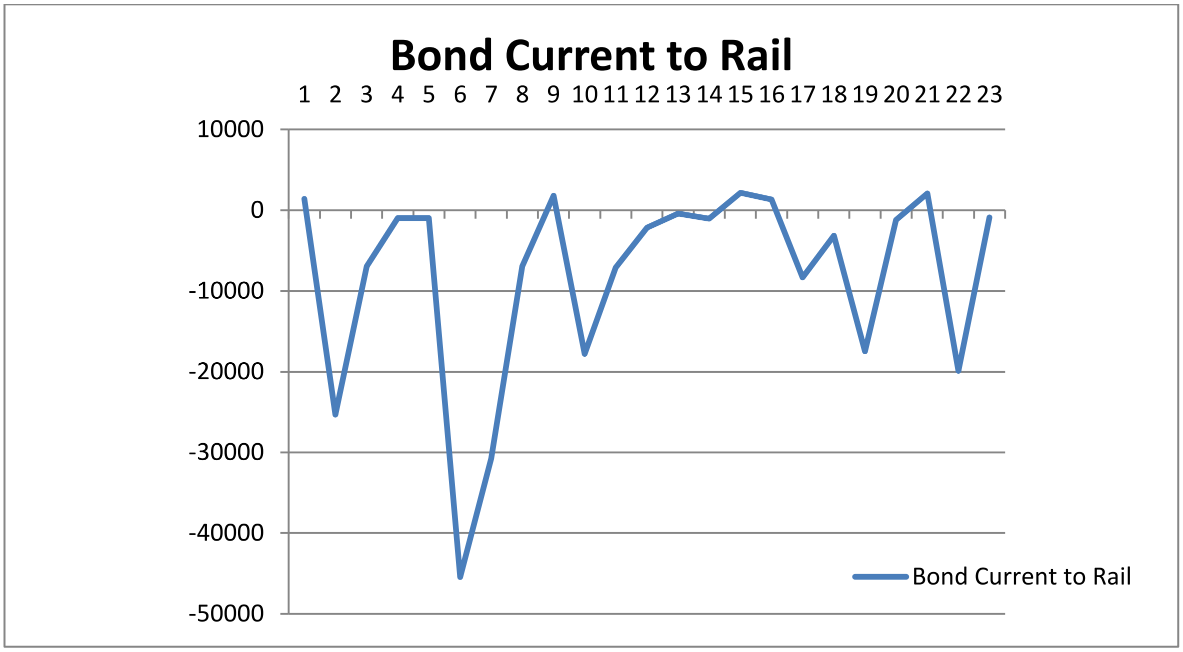

Figure 4 - Reverse current switch shunt measurements, 4 hour intervals (mA)

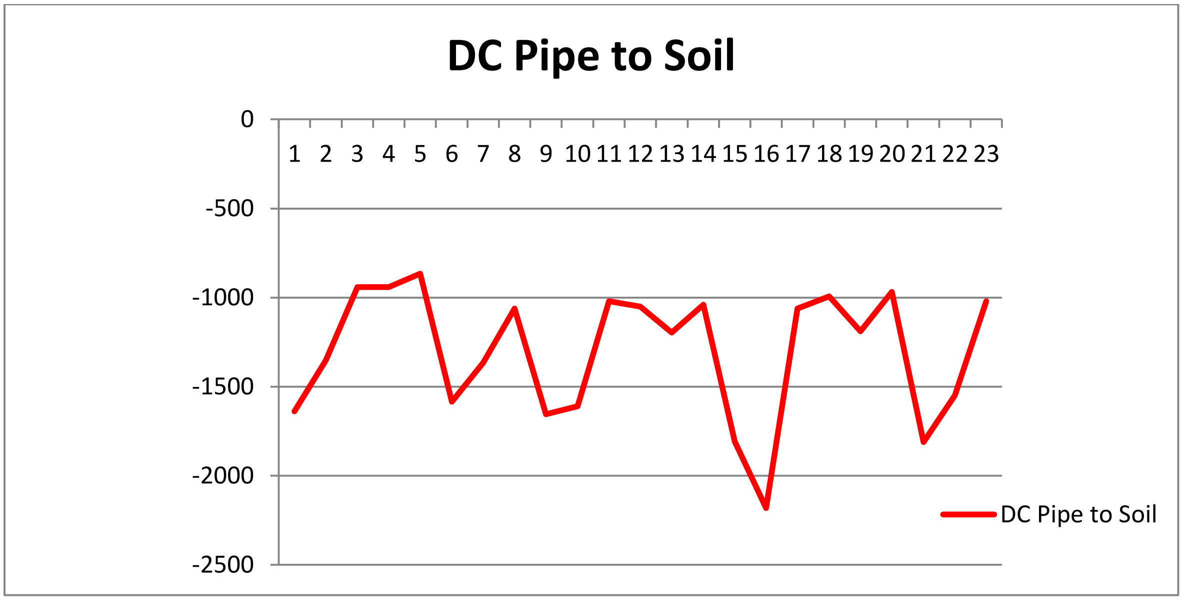

Figure 5 – Pipe to soil voltage potential (mV)

These comparative measurements indicate a direct relationship between the current level passing through the switch and the DC pipe to soil voltage potential measurement. Based on the data in the first set of measurements, it is easy to infer that a stronger correlation between the return current and the corresponding DC pipe to soil potential measurements would be seen with more granular data. Figure 6 and Figure 7 display the current level measurements and the DC pipe to soil measurements at one minute intervals. At this location the relationship between the current through the switch and the DC pipe to soil potential is evident. As the level of current through the switch increases, the pipe to soil potential value decreases (toward 0), by a proportionate amount.

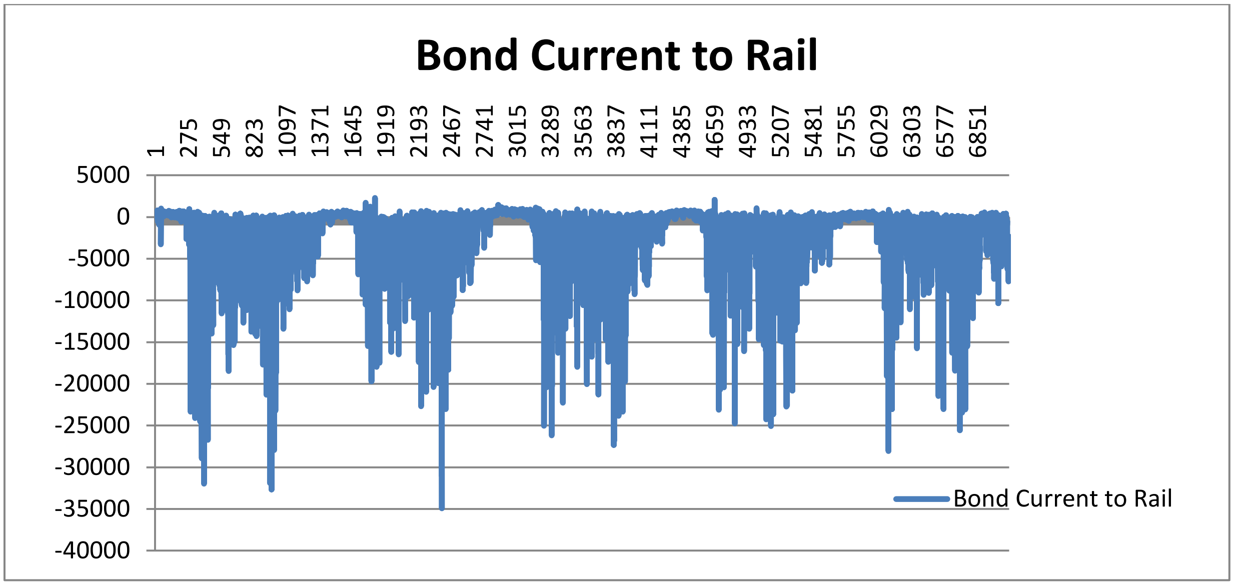

Figure 6 – Current level measurements at reverse current location, 1 min. intervals (mA)

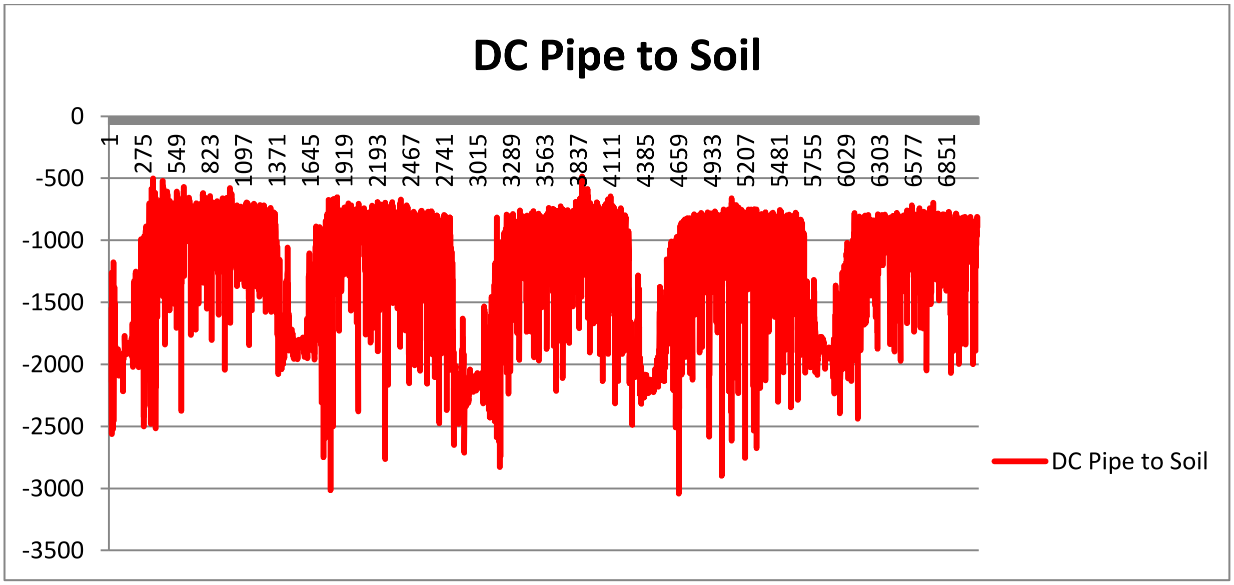

Figure 7 – Pipe to soil potential measurements at reverse current switch location, 1 min. intervals (mV)

Figure 8 and Figure 9 show a twelve hour portion of the same data displaying measurements over a time period from 6:00 pm to 6:00 am. Very apparent in this data is the dormant period when the trains are not operating.

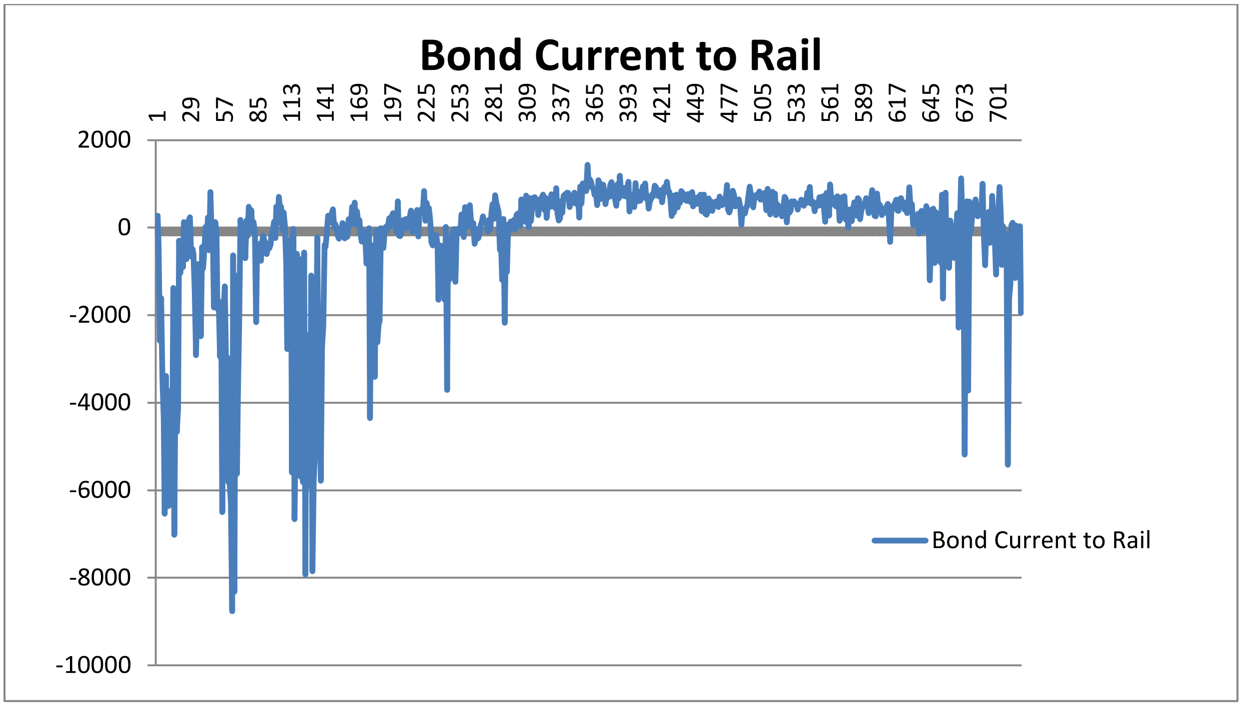

Figure 8 – Current level measurements at reverse current location, 1 min. intervals (mA)

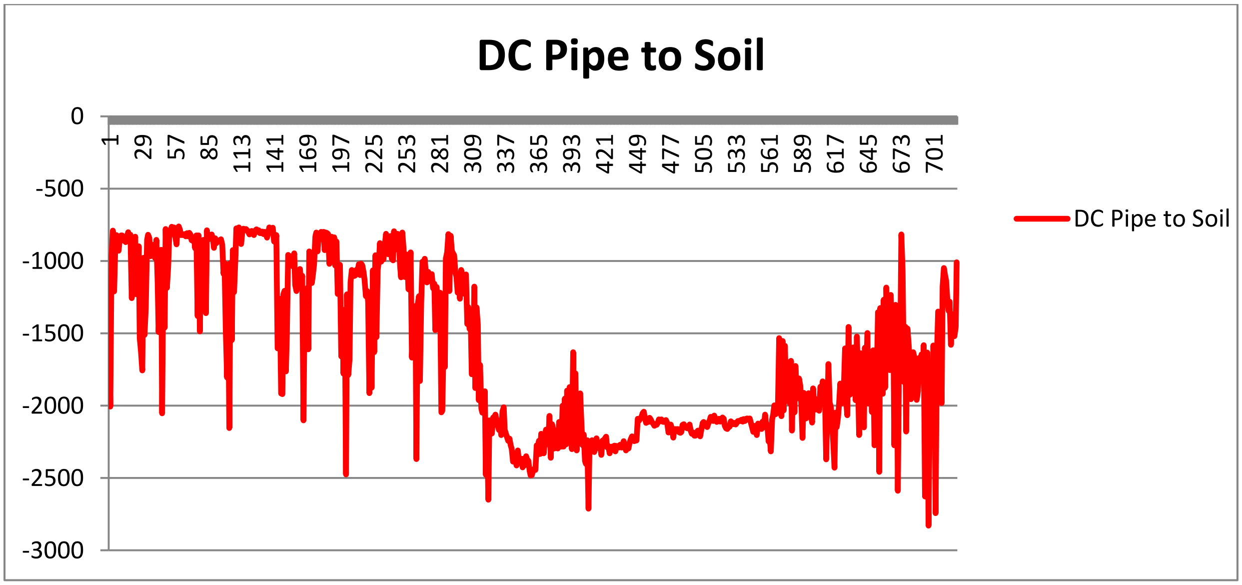

Figure 9 – Pipe to soil potential measurements at reverse current switch location, 1 min. intervals (mV)

Figure 10 below displays the bond current measurements overlaid with the DC pipe to soil potential measurements. The measurements displayed were recorded at 1 minute intervals between midnight and 2:00 am. This provides a very good view of the return current to DC potential relationship.

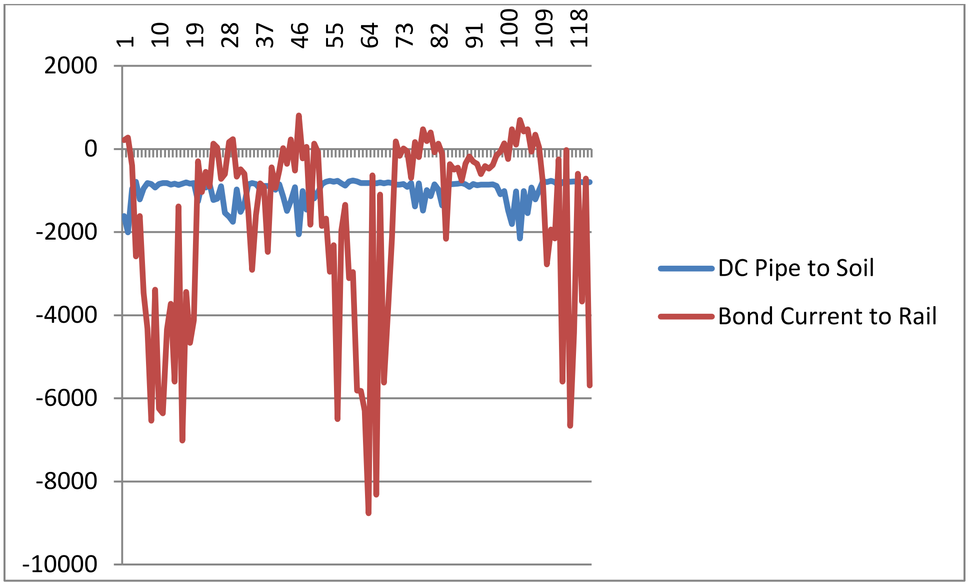

Figure 10 – Bond current (mA) and DC voltage potential (mV) overlaid on same scale

Summary

For compliance reporting purposes, it is essential to routinely measure the current across the shunt at reverse current switch installations. Very often data-loggers are used at these sites to capture the frequent and significant fluctuations in current levels associated with passing trains. Data-loggers provide a large amount of data to the user, but typically require site visits to retrieve the data. Additionally, the use of data-loggers can become cumbersome and expensive if recording data on several parameters. This case study demonstrates that currently available remote monitoring systems can be used very effectively for monitoring and compiling the data necessary to not only meet basic compliance requirements, but to produce detailed analysis of the effects of the periodic bursts of interference current encountered at electric mass transit crossings. Remote monitors provide flexibility and scalability to customize the data recording at any given site to the requirements of that site. This is an application of existing technology that should be considered where reverse current switches are in use.