

Frequency Analysis Provides Insight During Close Interval Surveys

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ABSTRACT

When performing a close interval survey (CIS), good practice has the surveyor using an oscilloscope to obtain a waveform reading. The main purpose of obtaining a waveform is to establish that correctly timed interruption is taking place. However, further analysis in the field or at the office can provide more insight into the rectifier operation and other electronic sources affecting the pipe. Examining frequency analysis using the Fast Fourier Transform (FFT) algorithm provides insights about the frequency of interference. Graphing the FFT results against time can confirm proper interruption in noisy circumstances where simple visual analysis fails.

Keywords: close interval survey, waveform, waveform analysis, Fast Fourier Transform, harmonics

INTRODUCTION

Close Interval Surveys (CIS) are frequently performed on pipelines to measure the pipe to soil potential. While the instrument is connected to the pipe it is possible to obtain additional types of readings that can be analyzed to provide further information. Many modern electronic instruments are capable of functioning as oscilloscopes in addition to obtaining synchronized CIS readings. The information captured by the oscilloscope function provides a waveform for further analysis. The waveform is captured as a raw, unfiltered signal with at least 2000 data points per second for the duration of the interruption cycle or longer.

WAVEFORMS IN THE FIELD

The introduction of computerized data loggers with graphical screens in the 1990's has allowed field surveyors to obtain, store and visualize waveforms in the field. While initially limited in display resolution and difficult to use, portable tablet and computer technology has expanded the potential to use waveforms. Modern survey instruments also record the waveform with ephemeral information such as the date, time and location taken. This allows the data to be recorded accurately for later comparison with internal and external data. However, a lack of

knowledge and understanding of the usefulness of observing and storing waveforms has led to this tool being under-utilized on most surveys.

Synchronization

In the field, a visual analysis of the graphed waveform can be made to determine interrupter synchronization. The typical presentation of interruption is a section of the waveform that is noticeably different than the rest, often electro-positive. If there is any capacitance or inductance from the coating of the pipe, this is also seen on the graphed waveform. This information can be used to adjust the timing of the CIS readings to eliminate the effects of the capacitance or inductance. Confirming synchronization and reading timing are the most common uses of waveforms in the field [1].

Alternating Current

Waveforms can also be used to analyze the amount of AC in the area as they capture the raw signal, both DC and AC components. When the waveform is taken and stored at a test point, further analysis may be performed to calculate the magnitude of AC influence on the structure. If the reading is taken some distance away from the test point, the trailing wire may pick up an unknown amount of induced AC from the area, influencing the waveform and rendering any calculations inaccurate. This is why AC CIS surveys are not technically possible [2].

The waveform can be analyzed to confirm the presence or absence of AC voltage, although it does not indicate the source or method of coupling. The voltage gradient peak to peak (V_{p-p}) can be obtained from the waveform, then the voltage root mean squared (V_{rms}) calculated in Equation 1 [3].

$$V_{rms} = \frac{V_{p-p}}{2.83} \quad (1)$$

This provides the magnitude of any AC voltage on the pipe. The magnitude of AC voltage is also used to assess safety, with voltages above 15 V_{rms} considered to be potentially hazardous and may require investigation and/or mitigation for safety [4] [5]. Further information on other safety considerations and mitigation can be found in NACE Standard SP0177 [5].

While the presence of AC voltage indicates that AC corrosion is possible, voltage alone is not sufficient to analyze the risk. AC corrosion probability is based on the current density, not voltage potential [6].

FFT ANALYSIS

Further analysis of the waveform can be done using a technique known as a Fast Fourier Transformation (FFT). FFT is used to calculate the frequency domain of a time-based or space-based signal. It is an algorithm to compute a discrete Fourier transform utilizing a matrix [7]. The FFT algorithm converts a complex signal into the various frequencies that make up the signal [8]. FFT is commonly used in audio and radio transmission applications. To date it has rarely been applied to the corrosion industry.

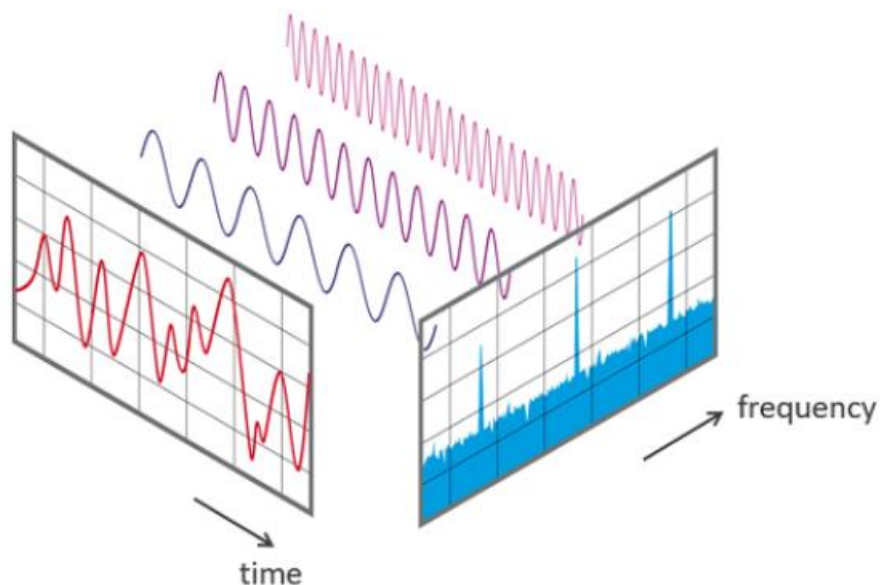


Figure 1 - View of a signal in the time and frequency domain [8]

Utilizing FFT provides more information on any additional signals detected. Frequently, a strong, or fundamental signal will have additional related signals known as 'harmonics'. By dividing the fundamental frequency into an even number of segments, the related harmonics can be found. For example, if the fundamental frequency is 60 Hz, then the harmonics are 120 Hz, 180 Hz, 240 Hz, etc. There may be signals other than those related to the native AC frequency. The most common additional source on CIS surveys is the use of a pipe locator.

Some analysis has been done to investigate the harmonics of AC interference on pipelines. This prior work has found that the third harmonic is commonly detected, likely due to the three-phase orientation of high voltage AC transmission lines [9].

APPLYING FFT TO SURVEY DATA

The following examples obtained in the field during interrupted CIS surveys with the Cath-Tech Hexcorder¹ were analyzed using simple charting and FFT analysis. By creating a 3D graph of changes to the frequency and magnitude over time, the interruption cycle can be confirmed. A software package named SigView² from SignalLab was utilized to generate the graphs and FFT analysis.

¹ Trade name

² Trade name