Environmental Potentials

Power Quality For The Digital Age

POWER LINE COMMUNICATION TECHNOLOGY IN THE MODERN FACILITY

AN ENVIRONMENTAL POTENTIALS WHITE PAPER

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Introduction

The modern facility has been revolutionized by advancements to electrical equipment. Most of the loads used in the modern facility are computer based loads such as PLC machines and motors controlled by VFD's. These sophisticated loads require power to operate and a communication channel to control the load's parameters. Traditionally, facilities would dedicate two separate lines, one for power and one for communication. This increased the infrastructure expenditure, the maintenance budget and electrical losses in the system.

Power line communications technology allows facilities to use low voltage power lines to transmit data. This means facilities do not need to run separate wire throughout the facility, greatly reducing costs and significantly improving the production process.

While power line communication technology significantly reduced infrastructure costs and electrical losses, the technology is susceptible to poor power quality. Noise generated inside the facility can interfere or completely disrupt communication data.

The Communication Highway

Theoretically, since both data and power are transmitted at much different frequencies, both should be able to use the same wire without the signals interfering. The communication channel is comprised of data in the form of bits (binary digits); the sinusoidal waveform consists of sinusoids along the waveform. To understand this, imagine a two lane highway. Assume the lanes are designed based on auto speed. Cars drive 80mph on the left, while trucks drive 50mph on the right.

As long as all cars and all trucks remain in the required lanes, there will not be collisions or congestion. However, if a truck moves to the left lane while maintaining its same speed of 50mph, it would cause congestion and/or collisions. In this example, left lane is the communication channel while the right lane is the power line channel. Cars are the data bits while the trucks are sinusoids. In order for this to function properly the frequencies on the power line and communication channel must remain at the intended frequency.

Capacitor Charging and Discharging Times

Examine this case at ConocoPhillips in Kuparuk, Alaska. ConocoPhillips uses a heat trace system to keep the oil warm as it flows through the Alaskan Pipeline. This facility has a 500kVA 480 Delta primary to 277/480 Wye secondary transformer. The heat trace system is distributed on the 277/480 (secondary side of the transformer) power line, while multiple Variable Frequency Drives (VFD's) are connected to the primary side of the transformer 480V. The 277/480 power lines are also responsible for transmitting the data channel at 47-51kHz. The measurement shown in figure 1 was taken at the receiver end of the communication channel after installing one EP filter.

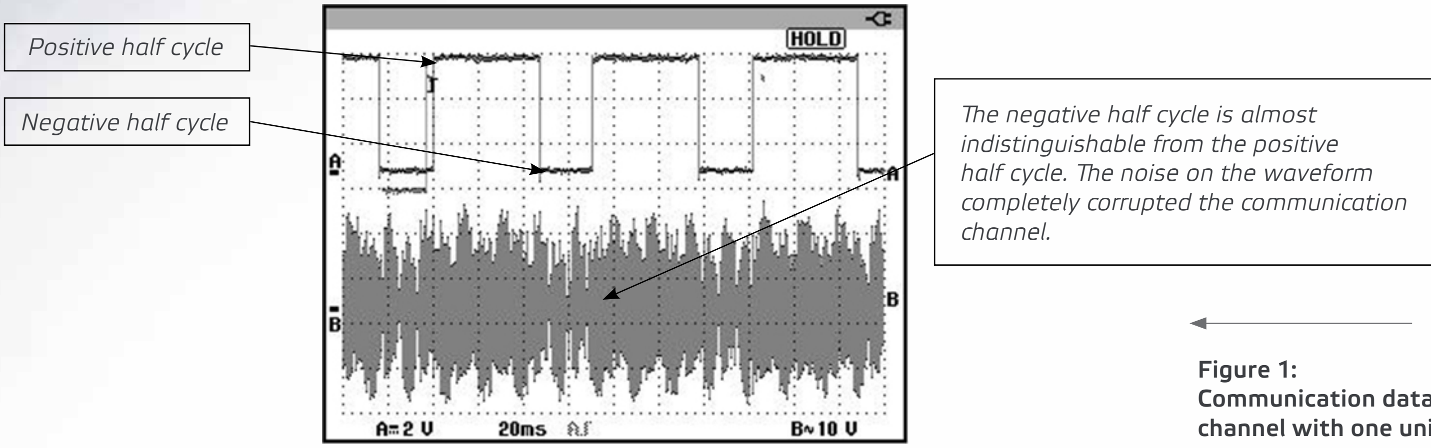


Figure 1: Communication data channel with one unit of EP installed

Figure 1 shows the data sent over the communication channel. Channel A is reference communication channel while the channel B is the actual data. The actual data is extremely corrupted and unusable.

In this facility, the VFD's on the primary side of the transformer are causing noise on the secondary side of the transformer. This noise interferes with the communication channel making the data unreadable. Electrical noise generated by the VFD increases the leakage inductance between the windings of the transformer. Leakage inductance increases hysteresis action of the windings, this distorts the sinusoidal nature of current. This means, VFD noise on the primary side of the transformer will deteriorate the non-sinusoidal nature of current on the secondary side of the transformer where the communication channel is powered.

A VFD is a non-linear load and capacitive in nature. A capacitor charges during the first half cycle of the sinusoidal waveform, and it discharges during the second half cycle of the waveform. The first and second half cycles of the sinusoidal waveform are identical. This means the capacitor should take the same amount of time to both charge and discharge. In reality, noise will cause capacitors to take more time discharging than charging.

Therefore, while the sinusoidal waveform is oscillating from first to second half cycles, the capacitor is taking longer to discharge. This transition between charging and discharging will create electrical noise at the points of intersection of half cycles.

The negative half cycle should be zero magnitude (OFF mode) since there is no data sent during this time. However, because the capacitor is still discharging during this 'OFF' mode of data, electrical noise is present. The line should be a horizontal line with Zero Magnitude just like the negative half cycle on the reference channel.

Figure 2: Communication data channel with fourth and fifth EP filters installed

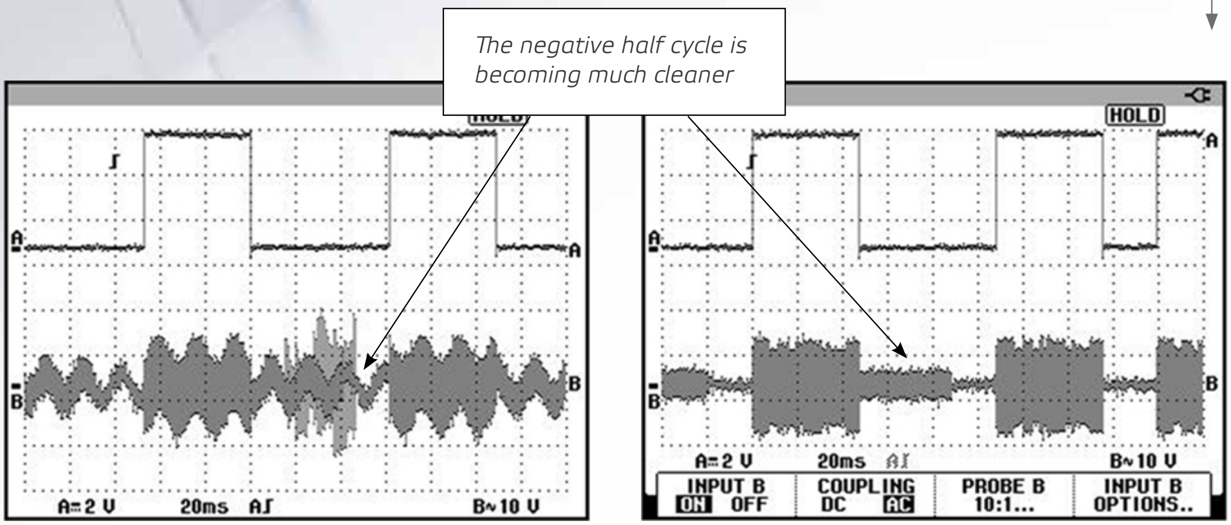
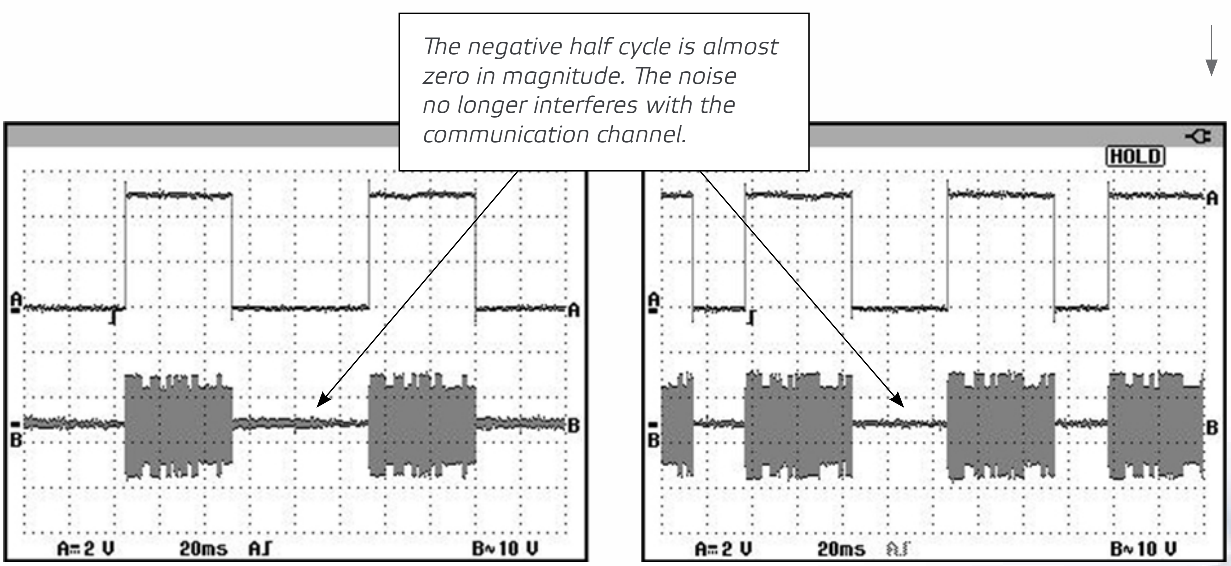


Figure 2 shows the high frequency content after installing additional EP filters. The positive and negative half cycles show significant noise reduction compared to Figure1. However the signal is still polluted with enough high frequency noise to interfere with the communication channel. The negative half cycle is beginning to smoothen but more filtration is still necessary.

The EP Solution

Figure 3: Communication data channel with 6 and 7 filters installed.



After installing one more unit, a total of six, the data signal on the communication channel B is much clearer compared to previous results. The electrical noise on the negative half cycle of the data signal is near zero magnitude. This means that the EP units are forcing the capacitor to charge and discharge in identical time intervals and this reduces the high frequency noise generated due to switching. Environmental Potentials' waveform correction technology corrects the sinusoidal nature of the waveform and removes the electrical noise present on the waveform at all half cycles. This reduces the discharging time of the capacitor, which in turn reduces the noise generated by the capacitor.

The results are clearly visible after installing seven EP filters. The data signal in communication channel B is free from high frequency noise and is in a readable format. The level of high frequency noise is not sufficient to interfere with the communication channel.

Conclusion

Power line communication technology has revolutionized the modern facility. It dramatically lowers infrastructure costs because it allows data and power to be transmitted over the same wire. Power is transmitted at 50/60 Hz while the communication channel is transmitted at 47-51kHz.

However, due to high frequency noise generated by non-linear loads such as VFD's, the data can become corrupted and information sent over the line is not useable.

ConocoPhillips uses a heat trace system to keep the oil pipelines warm. The heat trace system is distributed at 277/480V via hundreds of wires that also carry communication data on the voltage lines. The ConocoPhillips readings demonstrated severe corruption due to noise in the system. Communication channels are vital in the application of modern technology such as VFD's and PLC's. Load generated high frequency noise on the AC signal corrupted the data in the communication channel resulting in downtime and unusable data.

Environmental Potentials' waveform correction technology removed the high frequency noise responsible for interfering with data channel on the AC power line. This allowed the data in the communication channel to perform as designed. Environmental Potentials is the only manufacture to correct the sinusoidal nature of the waveform and eliminate noise from the electrical distribution system.

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