Myths and Truths about On-Line PD Monitoring Instruments

One instrument for all applications

This note answers the question 'Can a 10 MHz instrument for on-line PD monitoring be used on any equipment, with any type of PD sensors, and any method of noise separation?'

INTRODUCTION

An instrument provider has been circulating an advertisement alleging 'no need for a different instrument for each application' to promote its products for on-line Partial Discharge monitoring with any type of PD sensors (including capacitive couplers, RTDs, Stator Slot Couplers, etc.) and any method of separation (including time-of-flight, pulse shape, etc.). According to the data available for its PD monitoring portable instrument, 'the frequency band is 0.5 to 10 MHz' (available from its own website and from a Russian manufacturer website). This note explains some terms such as time-of-flight, differential configuration, directional configuration, and Stator Slot Couplers, and why a 10 MHz instrument is inappropriate for some of the claimed applications.

DEFINITIONS

Time-of-flight

This technique is based on the comparison of the arrival time of a single pulse at two sensors. Basically two configurations are used: differential and directional.

Differential configuration (Figure 1)

In a differential configuration the installation is calibrated in such a way that a noise pulse will be detected at a pair of PD sensors at the same time. PD originating near one sensor (C1 or C2) will arrive a significant time later at the other sensor. The differential configuration is employed in large hydro generators that have enough room to install PD sensors along the circuit ring bus.

Directional configuration (Figure 2)

For machines with a small bore (< 2 m) diameter such as motors and turbo generators, a PD sensor pair is located outside of the machine along the output bus, in a directional configuration. It is called a directional configuration because pulses coming from beyond the bus segment between the PD sensor pair, arrive first to one sensor and a delayed time after, arrive to the second sensor. The PD sensor closest to the machine is named M and the PD sensor further down the system is named S. Pulses coming from beyond M are classified as PD; otherwise, pulses are classified as noise (pulses from beyond S, and pulses between the pair of PD sensors).

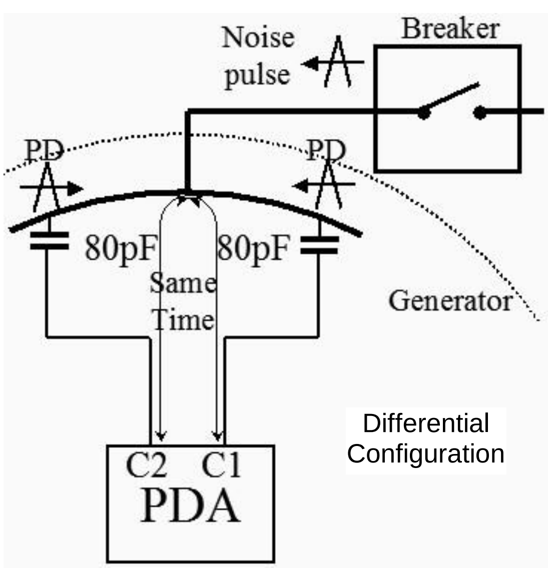


Figure 1

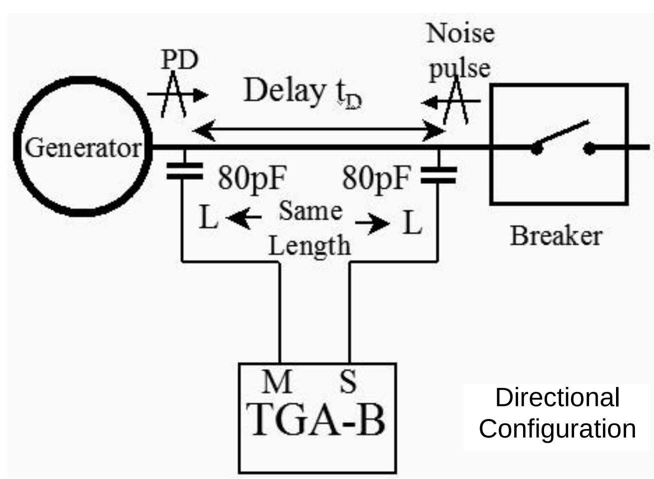


Figure 2

NOISE SEPARATION AND BANDWIDTH

10 MHz instrument for differential configuration (Hydros)
The time resolution of the instrument depends on its frequency bandwidth (Figure 3). Thus, for a bandwidth of 10 MHz the time resolution is longer than 30 ns, and therefore the distance resolution is longer than 9 m (speed * time = distance, 0.3*30=9, considering speed of light of 0.3 m/ns). The Figure 4 shows the circuit ring bus of a hydro generator with the distance D between parallels along that bus. In most hydro generators the distance D is less than 9 m. An instrument with bandwidth of 10 MHz would required a distance D longer than 9 m, so for most hydro generators such 10 MHz instrument would classify PD pulses as noise, which makes such instrument inappropriate for this application. In contrast the frequency bandwidth of the PDA-IV instrument from Iris Power allows safe distances along the bus as short as 2 m (i.e. 6 ns), which is advantageous for differential configuration in most hydro generators, so that PD pulses are correctly assigned as coming from the corresponding parallel circuit and pulses from outside the machine are labelled as noise pulses.

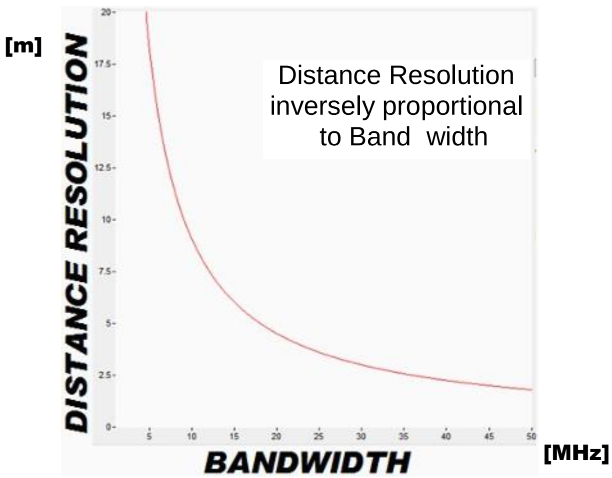


Figure 3

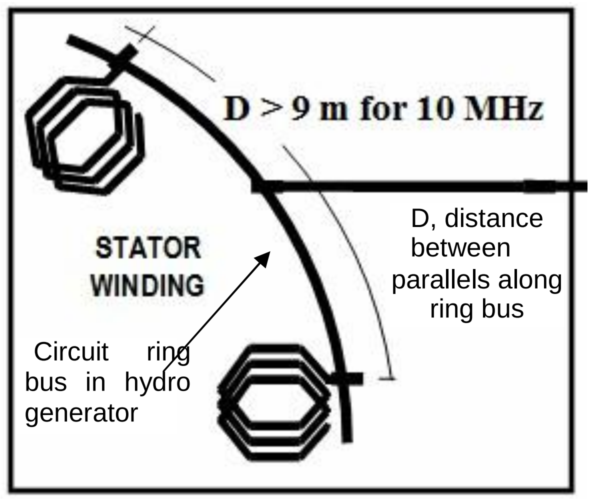
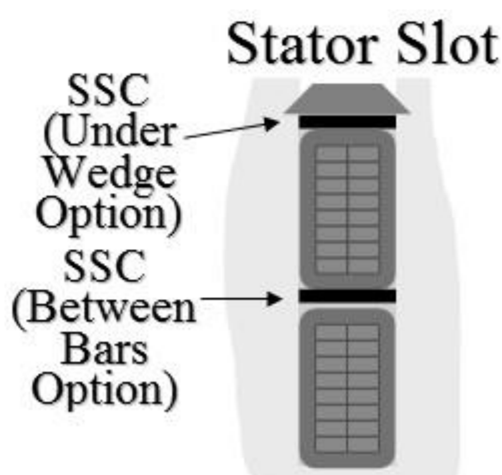


Figure 4

10 MHz instrument for directional configuration
As mentioned above, due to the long distance resolution, a 10 MHz instrument would wrongly classify as PD, noise pulses between the pair of PD sensors up to a distance of almost 5 m from M (PD sensor closest to the machine in Figure 2).

10 MHz instrument and Stator Slot Coupler
The time resolution is even more critical in the case of the Stator Slot Coupler (SSC). The SSC is a two port directional electromagnetic coupler that is installed in slots of large turbo generators, either under the wedges, or between the two bars in the slot (Figure 5). Noise is separated from PD based on the width of the detected pulse. Extensive, independent research shows that PD pulses have a width shorter than 6 ns when detected by an SSC. A 10 MHz instrument could not detect any difference in pulse width, since any pulse shorter than 30 ns would result in the same signal. Thus noise would be classified as PD, resulting in false indications of the stator winding insulation condition.



SCCs Installed in Stator Slots of Turbo-Generator

Figure 5

OTHER CONSIDERATIONS

! The applications of RTDs as PD sensors and the consequent subjective interpretation even by an experienced expert is discussed in the peer reviewed paper ‘Investigations into the use of temperature detectors as stator winding partial discharge detectors' available in the Conference Record of the 2006 IEEE International Symposium on Electrical Insulation. A response paper by proponents of RTDs as PD detector was strongly criticized as unscientific by every discusser at the 2007 IEEE EIC.

- As listed in the IEEE 1434-2000 Guide, there are multiples methods to detect PD activity, even cheap methods such as ozone detection. However the goal of on-line PD monitoring is not just to detect PD or PD like signals for itself. In the case of rotating machines, the on-line PD monitoring should be a tool to reliably and objectively assess the condition of stator windings for predictive maintenance with a low risk of false indications. This is the reason why Iris Power offers the right instruments for each type of application (PDA-IV -differential configuration- for large hydro generators, TGA-B -directional configuration- for turbo generators and motors, and TGA-S -with SSCs- for large turbo generators), specifically designed to be used by non-experts.
- The low frequency bandwidth is an old technology that was originally intended for off-line applications. Iris Power even offers the capability of low frequency testing (instruments with dual frequency option) for that purpose, in compliance with IEC 60034-27. However, for on-line PD monitoring where the noise becomes an important obstacle to overcome, the high frequency bandwidth is required to get high signal to noise ratios. This subject has been discussed in several peer reviewed papers such as 'Importance of Bandwidth in PD Measurement' available in the IEEE Transactions on Dielectrics and Electrical Insulation Vol. 7 No. 1, February 2000.
- Both the sensors and instruments from Iris Power have been successfully used for many years in thousands of machines. This has been documented in papers written by users and independent consultants such as the paper 'Partial Discharge -A Valuable Stator Winding Evaluation Tool' published in the Conference Record of the 2006 IEEE International Symposium on Electrical Insulation.

CONCLUSION

Stating that a low frequency instrument for on-line PD monitoring is suitable for any equipment, with any type of PD sensors, and any method of noise separation is trying to show the impossible as possible.

Reviewed by G. Stone, January 2009