Doble PRIME: Aspects of Condition Monitoring

Expectations of Condition Monitoring

Condition monitoring is used to identify anomalous asset condition, measuring relevant parameters such as dissolved gas or PD levels. When applying condition monitoring, an expectation of what the data should look like is useful, both for setting individual parameter limits and for integrated diagnostics. This note has examples of data variations which could be seen as anomalous, but are just part of normal operation of a large generator transformer, monitored using Doble PRIME.

Partial Discharge

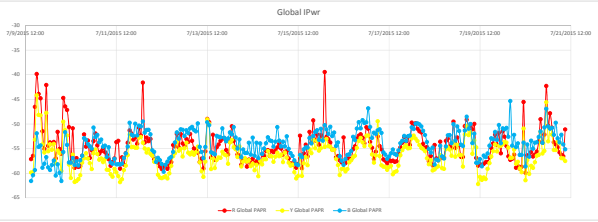
Partial Discharge is a sign of deteriorated or degraded insulation – electrical stress may lead to a breakdown or discharge, which may further reduce the effectiveness of the insulation. Early identification of PD may be performed through site surveys with a Doble PDS 100 or testing with a Doble PD Smart. Where PD is identified, monitoring may be used to provide information about progress of the PD.

PD Expectation

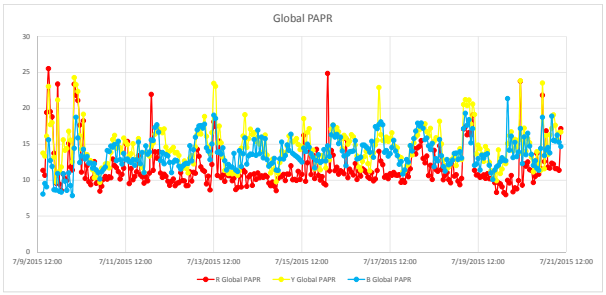
The expectation is that a PD source would be 'sustained', providing an elevated level of PD signal across a broad frequency range. The Doble PD Guard captures data across a user specifiable range between 50 MHz to 1 GHz, with a statistical analysis of the signal to generate the Integrated power of the signal (IPwr) and the Peak-to-Average-Power Ratio (PAPR) a PD signal of interest would be sustained, have a higher power than background noise and would have a significant PAPR, reflecting the broadband nature of the source.

PD Monitoring Results

The figure below shows IPwr over a 12 day period for each of the three phases of the GSU, monitored via the bushings using a HF CT.



The occasional spikes in the data are of a size which could reflect a PD source, but are not sustained – most likely relating to switching or other activity, on the system. The PAPR for the same period shows the signals are, indeed, of interest – a low PAPR may indicate a possible communications or electronics source.



The spikes in PAPR correspond to spikes in the IPwr, indicating a PD like source – but the occasional and random nature implies a non-PD source: switching, say.

Doble's PD Guard monitor derives IPwr and PAPR and applies advanced statistical analysis, in the form of an Alert State-machine (ASM). The ASM is highly configurable, with default values set for most PD monitoring situations on substations or generating plants; the ASM provides multilevel alerts based on state changes in the sources identified (see Doble application note on the ASM).

Online Bushing Monitoring

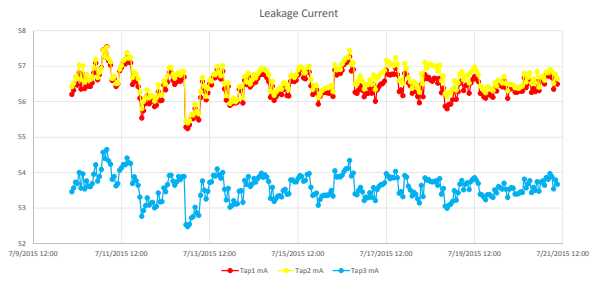
The simplest and most effective bushing monitoring is through measurement of the actual leakage current through the bushing tap, with the relative phase difference between the bushings in a set – as supplied by the Doble PRIME IDD.

Leakage Current

The leakage current in each bushing will depend on the system voltage and the bushing insulation; the system voltage will vary with time, responding to load changes and system configuration. Bushing insulation we expect to vary more slowly, and will rise if the insulation deteriorates.

Bushing Monitoring Results

The figure shows the leakage current in three bushings – clearly with some daily variation due to load/voltage fluctuations, but also with a significant difference between one phase and the other two.



Such variation could be a symptom of deteriorated insulation in two bushings – in this case, however, it is expected as the nameplate capacitance of one of the three bushings is different to the other two. There is no issue with any of the bushings shown here. The DoblePRIME IDD includes an Expert System analysis of data which identifies anomaly; the user may override default levels for alarms and alerts. (In the early days of bushing monitoring, Doble tried both a Schering Bridge approach, and also a 'sum of three currents' approach, but abandoned both for the more sensitive and meaningful leakage current measurement.)

Online DGA

Doble's Delphi DGA device provides a single value DGA measurement, either of Hydrogen alone, or of a composite of 4 key diagnostic gases (see app note).

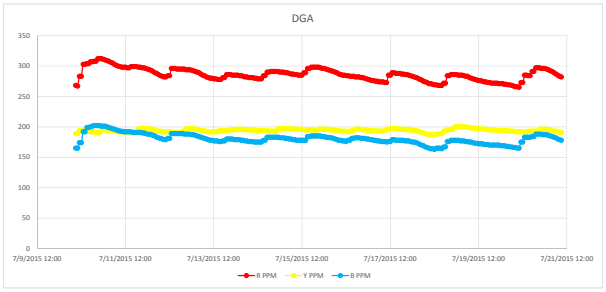
DGA Expectations

In this application, three Delphi Mini devices monitor composite gases on three single phase units. If the units were identical we would expect similar DGA levels, assuming they had a similar history and maintenance. It is common to set alarm limits for single value device DGA monitors at 20% and 40% above the 'current' level.

Doble PRIME Delphi DGA Monitoring Results

The data shown is for the three single phase units; one has gas levels 50% higher than the other two.

All three show daily variations due to load, but are relatively stable, not exceeding a variation of 20% to trigger an alarm.



Monitoring Analysis and Implications

A 2013 Doble Conference paper gives the case of a transmission transformer being switched out within 2 minutes of a high level alarm being issued by a Doble IDD1[1] - acting on an agreed and written plan: two transformers were saved through such actions. Condition Monitoring is more than just a box with lights on and needs to be applied with forethought and understanding. Integration of Doble PRIME data from monitoring modules provides an additional level of analysis – adding load and voltage data to give a more complete picture of asset condition.

The key is to have an understanding as to possible causes of parameter variation, and identify those which need further investigation or action.

Doble Expertise

More than any other company in the world, Doble experts have been dealing with issues in transformers and insulating fluids for over 80 years. Doble is always willing to help our customers with the equipment that we provide and interpretation of data from the Doble PRIME sensors.

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[1] "Condition Monitoring in the Real World", Ken Wyper *et al*, 80th International Conference of Doble Clients, 2013