

Substation Monitoring System

UHF Partial Discharge Monitoring

Siemens Transmission and Distribution Ltd

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System Description

Introduction

The UHF PDM System is the third generation, spanning 20 years, of monitoring systems developed for GIS partial discharge monitoring. It utilises well proven technology used from the former systems but the data acquisition system has been modified to conform to the one-platform approach as used for GDM and CBM systems. The IEC requirement for High Voltage on-site testing using partial discharge monitoring can be met by this system where an on-line system is required. A portable PDM system can also be applied - see the Dialoc System in Appendix1.

The system is modular and designed to facilitate measurements using internal or external UHF sensors. In order to simplify the signal cabling, a Node Unit Cubicle containing the monitoring equipment is located in the GIS switchgear hall where the signals for each CB bay can be concentrated. This wall mount Node Unit Cubicle also allows for a very simple communications connection to transmit all of the bay data along a single fibre cable.

The UHF transducer head provides the signal input to the specially designed signal conditioning modules and comprises:-

UHF Sensor [Internal or External type] with UHF Cable [typically 5m, to 10m]
UHF Signal Filtering and Optical Processor

The optical signal conditioning modules provide the data input to the data acquisition system. The Node unit has been developed to process data for 27 UHF inputs [i.e. 9 conditioning modules for 9 three-phase sets of sensors for 275kV to 800kV GIS] Typically this allows one Node unit to concentrate and process data for three circuit breaker bays

The Node Units are connected via fibre optic communications cable to a central PDM control cubicle where an HMI is available to provide access to the data and where alarm data is automatically generated. Multiple Node Units can be connected to the central CBM Control Cubicle to provide adequate coverage for every size of GIS substation.

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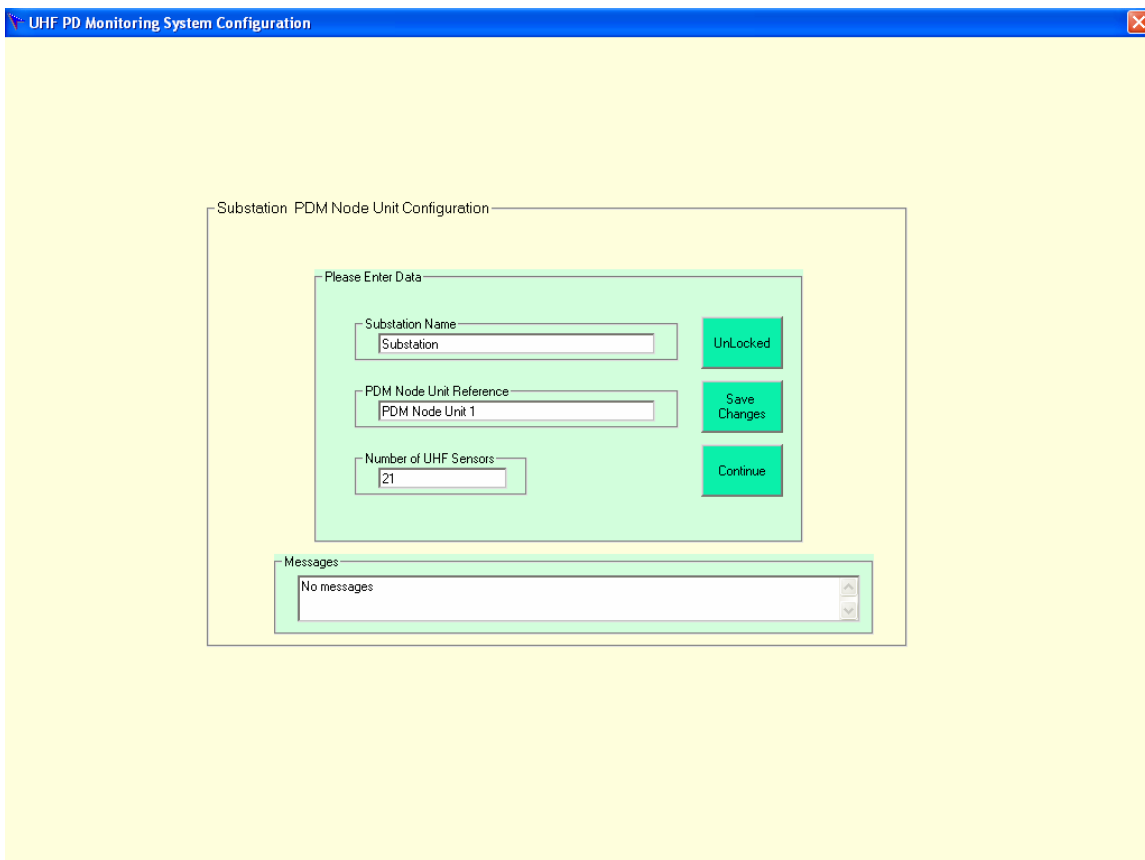
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Node Unit Configuration

The PDM Node Unit is modular in design and can house up to 9 UHF Optical transducer interface modules. Each module contains 3 optical input channels, and an optical output control channel. This allows 9 sets of three-phase UHF transducers to be monitored giving a maximum of 27 UHF optical transducers per node. Processing at the node is carried out using an integrated measurement system built on industrial PC technology. Access to the measurement system to configure the node is provided by an Ethernet connection.

Each Node Unit is configured independently via software installed on the Node Unit's industrial PC. The software has been designed so that even the very largest of systems can be configured very quickly and easily. The first defining parameter of the Node is the number of UHF transducers that the Node is required to monitor for a particular installation. Figure 1 below provides an illustration of this.



The screenshot shows a software window titled "UHF PD Monitoring System Configuration". Inside, there is a dialog box titled "Substation PDM Node Unit Configuration". The dialog box contains a "Please Enter Data" section with three input fields: "Substation Name" (containing "Substation"), "PDM Node Unit Reference" (containing "PDM Node Unit 1"), and "Number of UHF Sensors" (containing "21"). To the right of these fields are three buttons: "UnLocked", "Save Changes", and "Continue". Below the input fields is a "Messages" section with a text area containing "No messages".

Figure 1 – Substation PDM Node Unit Configuration

The name of the substation is entered along with the Node Unit number which identifies the particular Node to the central GDM Control Cubicle. The number of UHF transducers connected to the Node Unit (maximum 27) is also entered.

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On entering these details and saving the changes, the software will automatically provide access to a second interface screen which is used to configure the individual channels. Figure 2 below provides an illustration of this.

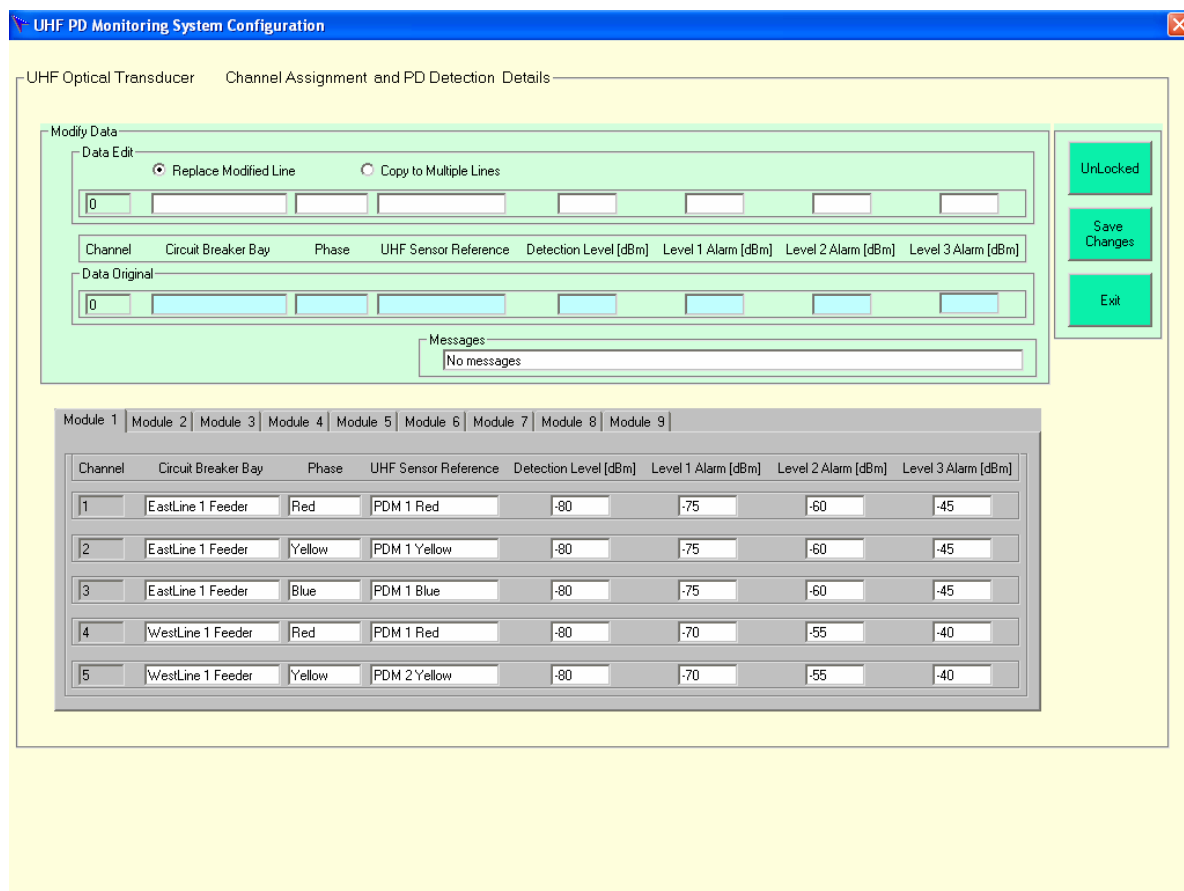


Figure 2 – Channel Assignment and PDM Sensor Details

From Figure 2, it can be seen that the channels are assigned to PDM sensors on a module by module basis. The number of modules activated to allow data to be input is determined by the screen shown in Figure 1. Since many of the PDM sensors have identical parameters in terms of CB Bay reference, Detection [Sensitivity] Level and alarm levels, the software allows the user to copy the settings to multiple lines to aid the configuration process. The following parameters are assigned to each channel:

- Circuit Breaker Bay.
- Phase.
- PDM Sensor Reference.
- Detection Level.
- 1st Stage Alarm Level
- 2nd Stage Alarm Level
- 3rd Stage Alarm Level

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Once the Node Units channels have been configured, and the settings saved, the main Node Unit monitoring screen will be displayed. This can be seen overleaf in Figure 3.

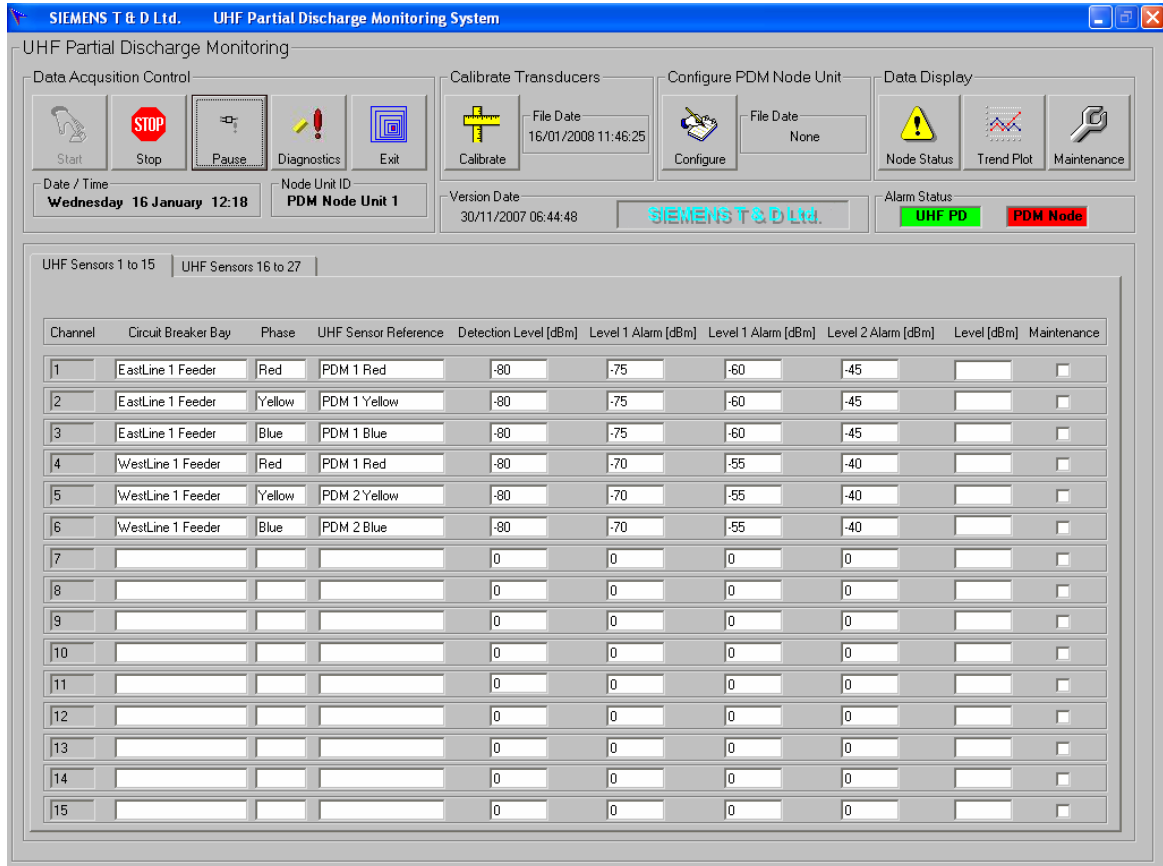


Figure 3 – Main Node Unit Monitoring Screen

Calibration

The main Node Unit monitoring screen displays the settings from all 27 transducer inputs, divided into three tabs. The readings are displayed in dBm values. On selecting the Start button, real time Peak PD Levels will be displayed for each of the sensors. Prior to performing this action however, the channels are required to be calibrated. Although all of the channels are identical in terms of components, the components will inevitably have slightly different values (within their quoted tolerance window) which need to be normalised across the channels.

Figure 4 overleaf provides an illustration of the Calibration screen. Calibration is carried out with the transducer disconnected from the Node Unit inputs. In most situations this will be the default situation since the Node Unit will be configured in the factory in the absence of the actual installed sensors themselves. If calibration is to be carried out in service with the transducer already connected then the

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transducer input terminal links within the Node Unit will need to be opened (see Drawings section for terminal link identification).

The channels are calibrated on a module by module basis (maximum of 9 modules per Node Unit and 3 channels per module). Each module is selected by clicking on the appropriate tab.

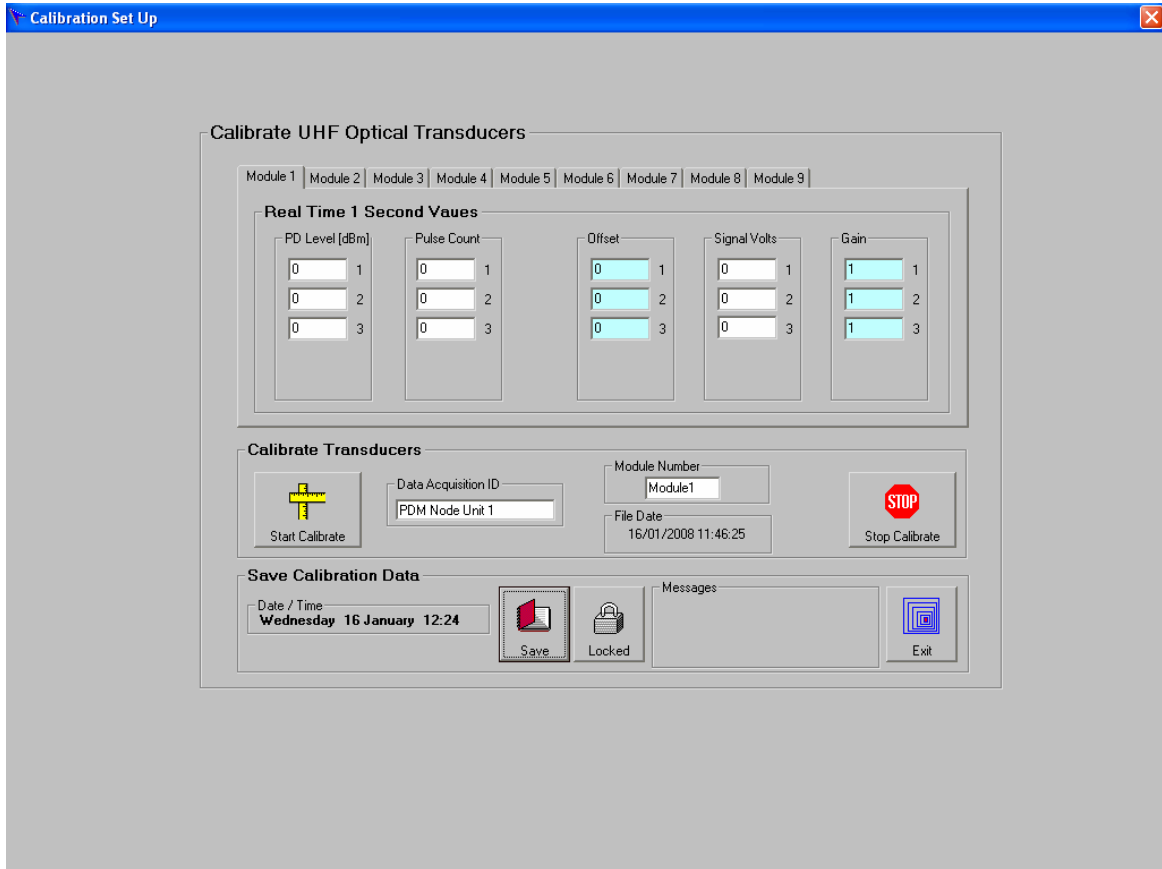


Figure 4 – Calibration Screen

By selecting the “Start Calibrate” button the real-time signal volts at the input to the data acquisition card for the 3 channels shown will be displayed. This is effectively the offset value which is required to be made zero. For each channel input the negative value of the signal volts into the “Offset” box for each channel. All channels should then read zero i.e. base setting of -80dBm.

Connect the -50dBm calibrator or use the internal -50dBm Self test calibrator to each of the three inputs in turn. Note the dBm value for each channel. In the “Gain” box insert the value determined by the following equation:

$$1-(\text{Measured Value}/-50)$$

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All channels should then read -50dBm. Calibration is then completed for that module. Select the remaining modules in turn within the Node Unit and repeat the procedure to calibrate the respective input channels.

When completed press the “Stop Calibrate” button and “Save” the settings. The values will remain stored until the next calibration procedure is carried out. By selecting “Stop Calibrate” followed by “Exit”, the user will be returned to the main Node Unit monitoring screen as shown in Figure 3.

Data Collection

Once calibration has been completed and the transducers connected to the input channels, the “Start” button will initialise data collection from all of the transducers connected to the Node Unit. Readings every second are acquired from every transducer connected to the Node Unit. The readings are displayed as real-time values in their respective position on the main Node Unit monitoring screen. If any of the alarm criteria is met for any of the channels then that particular channel will be highlighted in red for clarity.

Should any areas of the substation be undergoing maintenance or any channels of the PD system being tested or maintained, then the maintenance box for that particular zone can be checked if required. Any noise or test pulses etc that occur within the maintenance period can then go unrecorded (if required – see Maintenance section) for as long as the maintenance box is checked.

All data will be saved on the hard drive of the Node Unit. To provide a backup of this data, periodically, the PDM Control Cubicle will poll the Node Units and transfer any new data to its hard drive. This data will then be backed up to an external hard drive located within the PDM Control Cubicle. The data is therefore stored on three separate media devices which will minimise any risk of loss of data.

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Diagnostics

Should a Node Unit be in a hardware alarm condition at the GDM Control Cubicle, the nature of the alarm can be identified by selecting the “Diagnostics” button on the main Node Unit monitoring screen. Figure 5 overleaf provides an illustration of the Diagnostics screen. The hardware item that is in alarm will be indicted by a red light. The alarms are generated by the following criteria:

- +12Vdc Supply (Modules 1-5) out of limits.
-
- +12Vdc Supply (Modules 6-9) out of limits.
-
- -12Vdc Supply (Modules 1-9) out of limits.

- +48 Vdc Supply out of limits

- Node temperature transducer fail.

- Ambient temperature transducer fail.

- UHF Optical transducer fail (1-27 individually identified).

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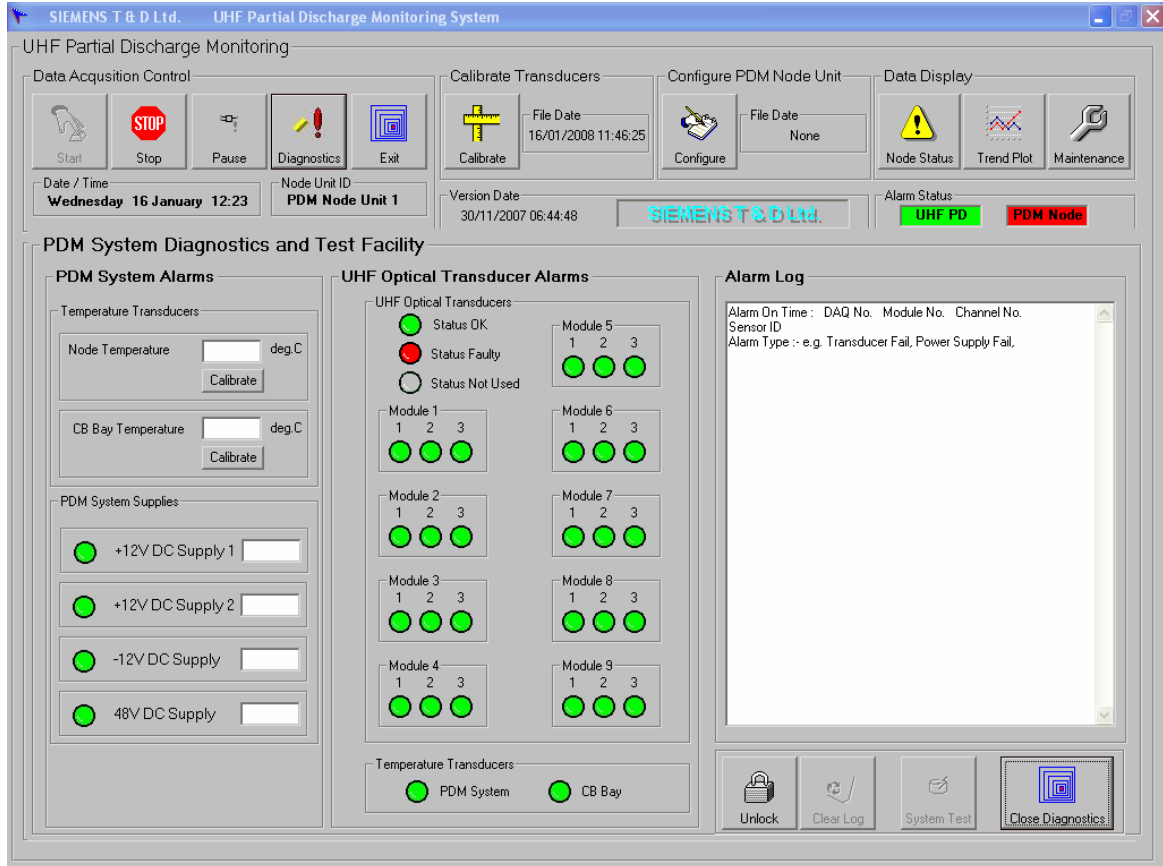


Figure 5 – Diagnostics Screen

Failure of one of the power supplies to the input modules will produce an alarm condition for both the relevant power supply and all of the UHF optical transducer inputs connected to the affected modules since they will be inactive and unable to gather data.

All alarms are recorded in the Alarm log which can be viewed from this screen. The alarms are listed in chronological order.

By selecting “Close Diagnostics” the user will be returned to the main Node Unit monitoring screen.

PDM Summary – UHF Sensor Status

By selecting “Node Status” from the main Node Unit monitoring screen the current status for each UHF sensor can be viewed. Figure 6 overleaf provides an illustration of the UHF Sensor Status screen.

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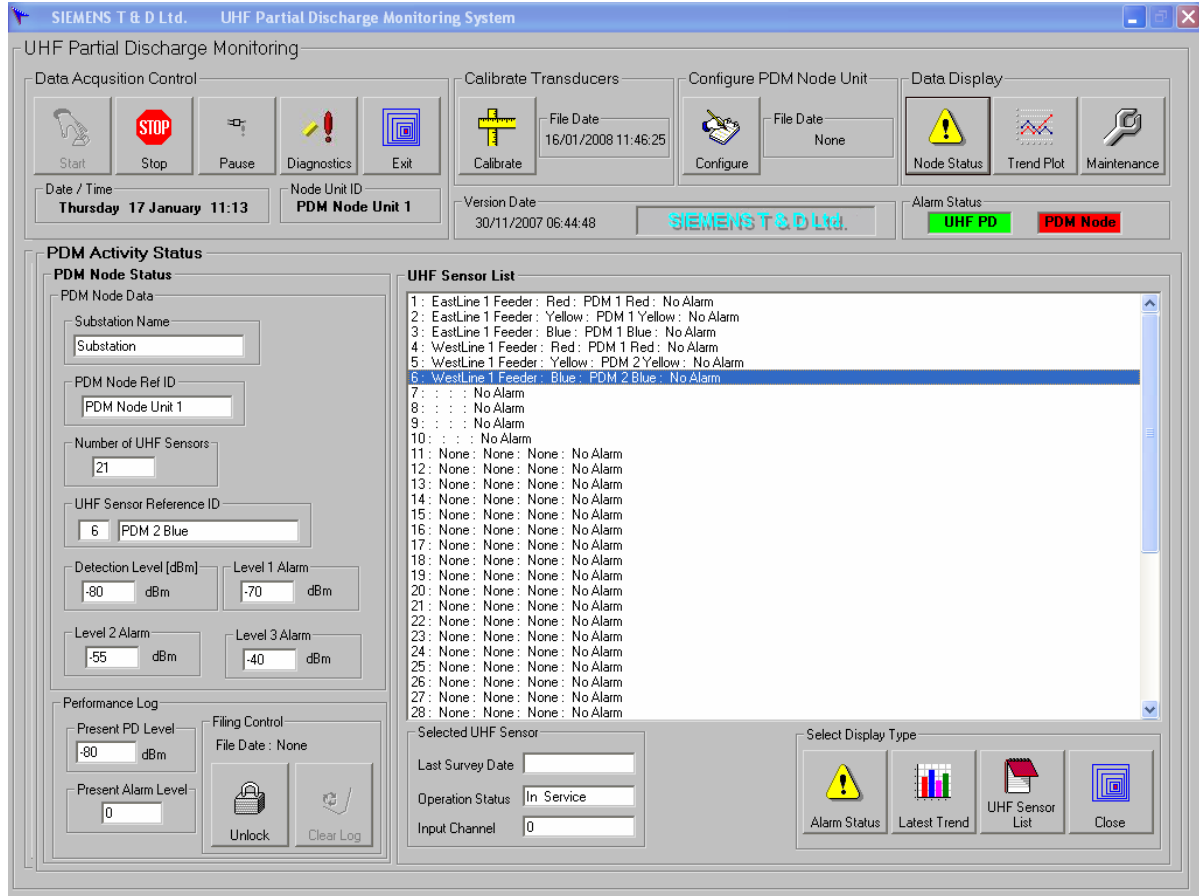


Figure 6 – Zone Status Screen

By selecting a UHF Sensor from the UHF Sensor list, the following information will be displayed:

- **Detection Level (dBm):** Displays the nominal detection level in dBm that the PDM system will acknowledge as a signal. If the environment has background noise above this level then the detection level can be increased to avoid noise detection.
- **Level 1 Alarm (dBm):** Displays the level value of the 1st stage alarm level.
- **Level 2 Alarm (dBm):** Displays the density value of the 2nd stage alarm level.
- **Level 3 Alarm (dBm):** Displays the density value of the 3rd stage alarm level.
- **Present PD Level (dBm):** Displays the current signal level being detected.
- **Present Alarm Level:** Displays the current alarm level for the signal being detected in dBm.

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Trending

By selecting “Trend Plots” from the main Node Unit monitoring screen the trending of the PDM data can be viewed. Figure 7 provides an illustration of the Trend Plots screen.

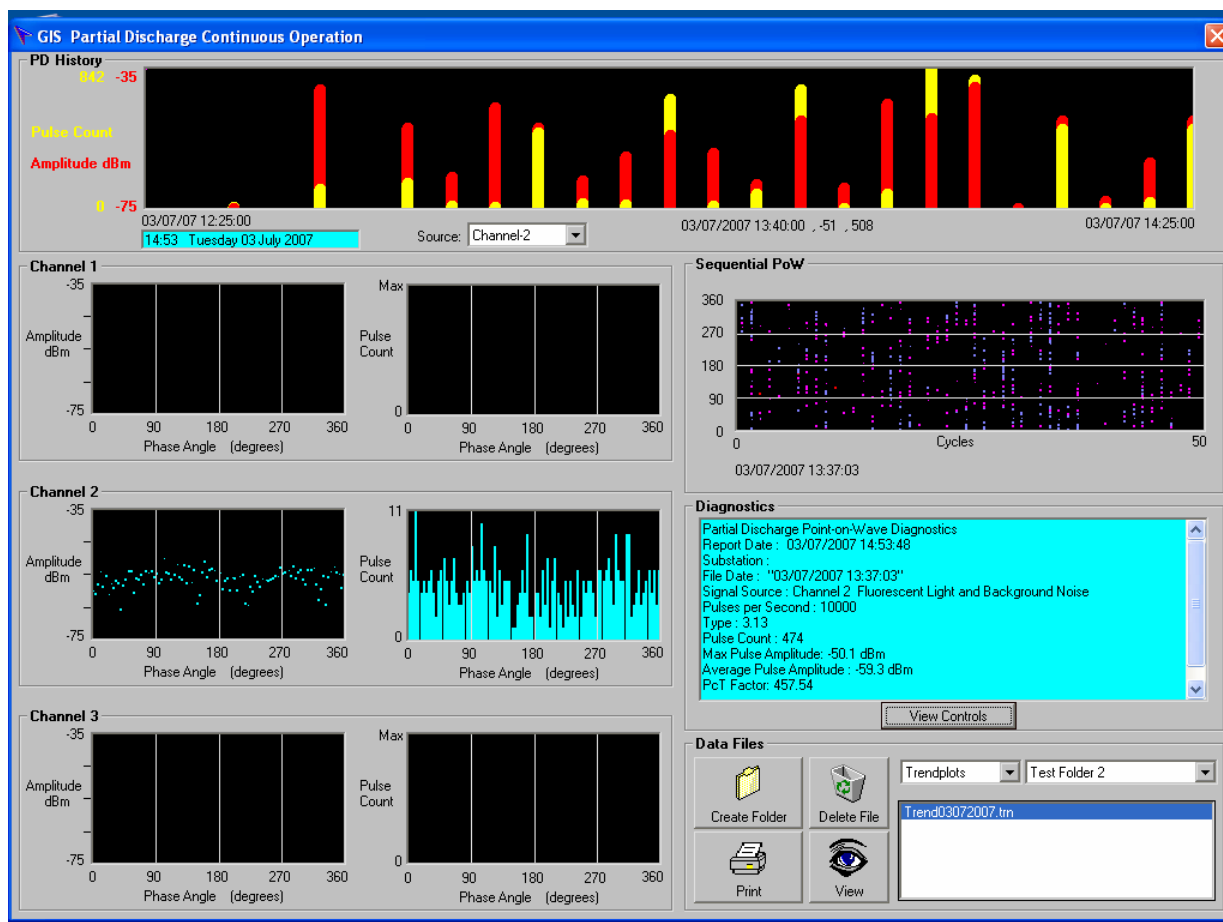


Figure 7 – Trendplots Screen

The trends can be viewed over 24 hours, 1 week and 1 month as required.

By selecting PD activity point on the Trendplot, the PD diagnostic data can be displayed as amplitude, pulse counts in relation the point-on-wave [POW] of power frequency voltage. Also a sequential POW display shows the PD behaviour over 50 cycles of power frequency voltage

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Data Archiving and Displays

The data is archived in monthly files and can be used as a database for diagnostic information. The archived data can be viewed, as show in Figure 8, using a range of data visualisations and can be copied for reports directly into Microsoft Word files.

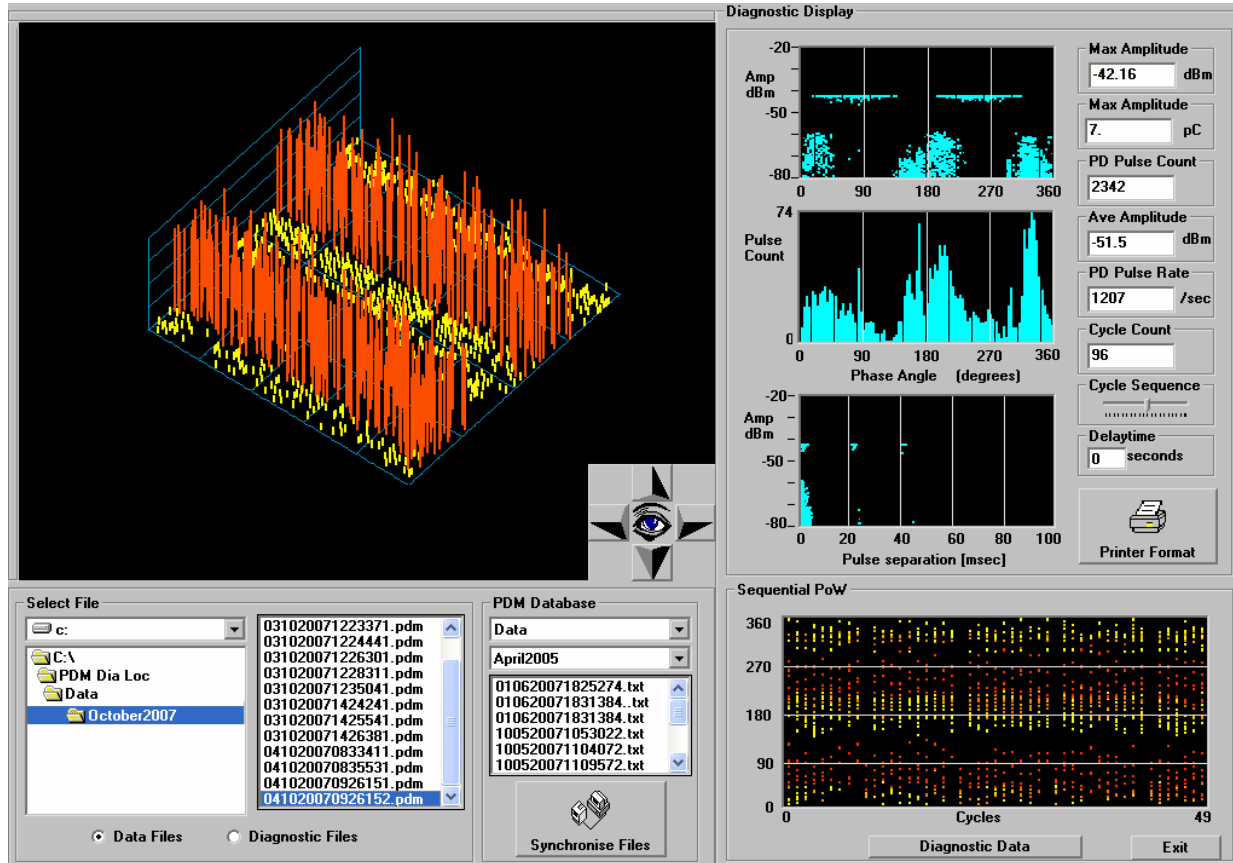


Figure 8 – Archived Data Screen

Remote Access

Remote access to the PDM Control Cubicle is very much dependent on the infrastructure available at the substation. The most common form of access is via a modem but it is possible to also use a Local or Wide Area Network to gain access to the data.

The remote access options are explored with each individual customer to define the best possible solution to implement in each case.

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