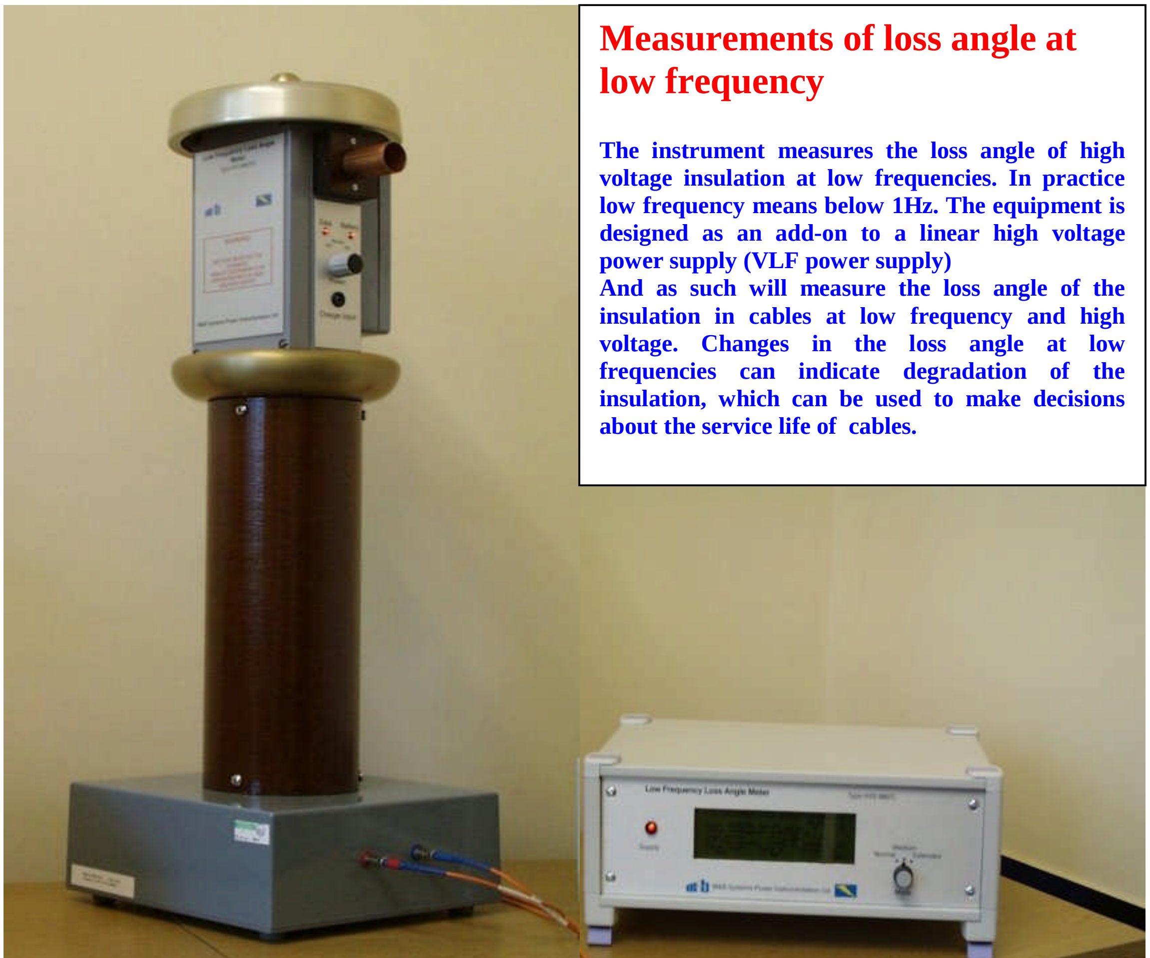
M&B Systems Power Test Equipment

Low Frequency Loss Angle Measuring Instrument

Measurements of loss angle at low frequency

The instrument measures the loss angle of high voltage insulation at low frequencies. In practice low frequency means below 1Hz. The equipment is designed as an add-on to a linear high voltage power supply (VLF power supply)
And as such will measure the loss angle of the insulation in cables at low frequency and high voltage. Changes in the loss angle at low frequencies can indicate degradation of the insulation, which can be used to make decisions about the service life of cables.



High Voltage Stack & Control Unit- the high voltage stack is operated from the control unit through fibre optic cables, providing total isolation from the high voltage circuit under test.

M&B Systems also manufacture a range of Partial Discharge equipment for both on-line and off-line testing of electrical plant .
For further information on these products and on VLF power supplies please contact our sales office

Advanced Technology for Industry

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Measurement of Loss Angle (tan δ) at low frequencies.

General

This Instrument measures the loss angle of high voltage insulation at low frequencies. In practice low frequency means below 0.2Hz for this device. It is designed as an add-on to a high voltage low frequency (VLF) power supply), and as such will measure the tan δ (loss angle) of the insulation in cables and capacitors at low frequency and high voltage.

The instrument is designed for use with high voltage cables, to measure the tan δ of the insulation. This can help with the diagnosis of the cable ageing. Changes in the tan δ at low frequencies can indicate degradation of the insulation, which can be used to make engineering decisions about the service life of the cables.

The instrument consists of two parts. A high voltage part must be connected to the high voltage system, and measures current and applied system voltage. The second part of the instrument is an analysis unit which shows the voltage, and current (in the high voltage circuit), and computes the tan δ (loss angle) of the cable or capacitor.

The high voltage unit is connected to the analysis unit using only two optical fibres. Full isolation of the voltage is thus maintained. The length of the fibres is not limited, although a 5m pair of fibres is supplied as standard.

As the voltage can be slowly changing, the anaylsis unit is provided with an indicator, which shows the applied voltage to the sample. A calculation of tan δ is carried out for each period, and displayed in real time at the end of each period. In the medium and extended modes (set on the front panel) the unit computes the tan δ from more than one cycle of data. In all modes, the unit bleeps when a new reading is available.

Measurement Circuit.

The measurement circuit is simple and easy to connect. The circuit diagram in Figure 1, shows the VLF power supply, connections to the high voltage unit, and the cable under test.

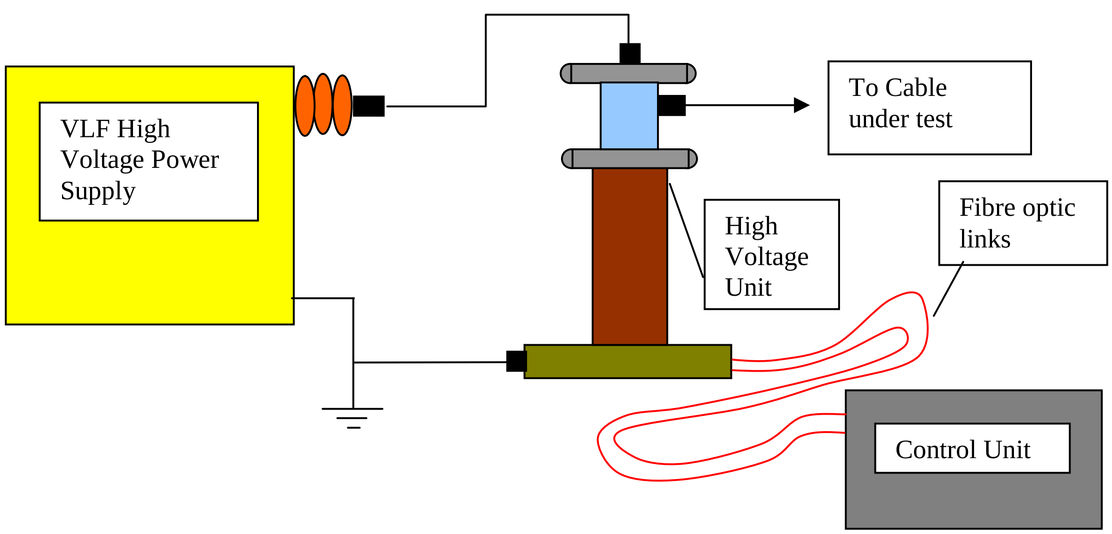

Figure 1 Circuit diagram of measurement of tan δ at low frequencies

Tan Delta measurements and Operation

The low frequency tan δ measurement is made on all the capacitance on the output side of the high voltage unit. Hence if a connecting cable is used to connect the VLF generator to the cable under test, the connecting cable will be a part of the cable under test. The effect of this cable can be corrected for in a calculation of the loss angle. However, if the loss angle and capacitance of the connecting cable is to be eliminated, the user may wish to place the high voltage unit next to the cable under test, with no connecting cable between the high voltage unit and the actual cable being tested.

The display of the analysis unit, shows the voltage and current measured in the high voltage circuit. It shows the values of the current and voltage at the end of each period. Where the periods are long, the display may not show the actual values of voltage and current until the end of the next period. At say 0.05Hz, this could be several minutes. These periods are still longer when medium or extended mode is selected. This is the reason for the unit to bleep, indicating a new reading is available.

The loss angle is also calculated at the end of each period, and the same applies to the updating of the display. Also bear in mind that following a change in frequency or magnitude setting, there will be a transient which whilst small, may still leave errors of a few percent due to this transient. Hence when making accurate measurements, make sure that a number of cycles have passed, and that the reading of tan δ is stable before using it as an accurate value. At switch on, and after mode change, '????' appears for a while on the display, showing answers are not yet valid.

The high voltage unit measures voltage using a resistor. This resistor also has a capacitance associated with it. Whilst this capacitance is small (typically 5 – 10 pFarads), it can change the loss angle measurements for higher frequencies. There will be an error due to this capacitance, but at frequencies of 0.1Hz and 0.05 Hz, this does not change the accuracy of the measurement. The losses and capacitances of external cables etc. can be compensated for using calculation, knowing the value of the capacitance and loss for each component to be included.

In the same way as small changes can be affected by the capacitance of the resistor, so to can any stray capacitance of the high voltage unit. To keep this to a minimum, do not allow any earthed metalwork to get close to the high voltage unit. If this becomes unavoidable, such as in confined spaces in a laboratory or van, then measure the effect of the stray capacitances, (i.e. measure loss angles of a 'standard' with and without the strays present) and remove the effect by calculation.

The current is measured by a shunt, which has a value of around 900ohms. This resistor can also have an effect on the measurement of loss angle near the resolution of the device. In most cases this resistor will represent a very small value of 'extra' loss. Most measurements can happily ignore this small effect. For example, it could introduce small errors at high frequencies with very lossless cables. Again this effect could simply be compensated for using calculation, by taking into account the effect of 900ohms in series with the cable under test. The high voltage unit measures current by using two resistor tappings to make more sensitive measurements still at high accuracy. This is automatic, and the range is indicated on the display. The value of the shunt resistor does not change with the changes in low and high sensitivity.

The analysis unit monitors the HV output of the VLF generator and learns the frequency by timing consecutive positive zero crossings. At least 1kV must be available for reliable operation, and it takes several complete cycles following start-up before full accuracy is obtained.

Features of the low frequency tan δ measurement

- Frequency range up to 0.2Hz
- In line measurement of current and voltage, so no changes to VLF power supply required.
- Automatic readout of frequency and loss angle
- Automatically adjusts to VLF generator frequency.
- Magnitude and frequency display

- Readout of high voltage and current in real time.
- Connection to HV measurement module is via fibre optics. Hence no high voltage safety hazards from the controller.
- Real time readout of loss angle
- Audible bleep when new reading is available
- The loss angle of high voltage insulation is measured by comparison of the phase between voltage and current waveforms at low frequency

Applications & Uses

- Cable manufacture for quality assurance
- Testing high voltage cables in service for degradation
- Replacement programmes for HV cable networks
- Research for high voltage cable investigations.
- Commission testing for new and repaired cables
- Can be used for high voltage insulation for condition monitoring with transformers, switchgear bushings etc.

Specification

VLF current Range	**0 – 50mA**
Frequency Range	**0.01Hz –0.2Hz**
Working Voltage	**1kV - 35kV rms**
Resolution of Tan δ.	**0.0005**
Accuracy	**<<2% + 0.005 zero error**
Display	**128 x 64 Backlit Liquid crystal**
Displayed data	**Loss angle in radians** **Frequency (Hz)** **System Voltage magnitude (kV rms)** **Current at HV (rms)** **Low battery indicator** **No data indicator**
Controls	**Averaging Mode 'Normal', 'Medium', 'Extended'**
Outputs	**Fibre optic communication to HV unit.** **Data RS 232 Interface output for use with Tan Delta software**
Power requirements	
Control box	**110 – 220V, 50/60Hz 70W (Supply voltage, operator selectable)**
High Voltage module	**Charging unit for battery (HV Unit)**

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