

DISCHARGE ACTIVITY DETECTION IN ACOUSTIC BAND IN STRONG ELECTRIC FIELD

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ABSTRACT

This paper is oriented in the area of analysis of acoustic noise obtained from service of power engineering devices with very strong electromagnetic field. In this case not only operator but also measurement devices need protection. For this purpose optical insulated amplifier with frequency range up to 2 MHz was developed. We analyse acoustic signal from acoustic sensor in audible band from 1 kHz to 20 kHz. The acoustic signal transmitted from object is unique for specific conditions. Exploitation of audible band for PD phenomenon detection is difficult in outdoor bias level but with appropriate filtering it is possible this disadvantage eliminate. Advantage of this method consist in simple results prepare.

KEYWORDS

acoustic noise, ambient disturbance, coupling, optic insulation, overvoltage

1. INTRODUCTION

Measurements in the area of high voltage technique realised in service conditions or laboratory measurements are often realized using measuring accuracy technique. Performance of experiments with measuring accuracy technique is dangerous in term of damage input circuits by overvoltages.

Electric equipments are affected by external electromagnetic environment. Prepatie penetrate from source – lightning electromagnetic pulse (LEMP), nuclear electromagnetic pulse (NEMP), electrostatic discharge (ESD), switching electromagnetic pulse (SEMP) to equipment – victim. Overvoltages penetrate to measurement technique by coupling which are either needed for proper operation of electric equipment (e.g. mains supply) or directly exist in environment where measurement technique operate with chance to reduce its influence. There exist galvanic coupling, inductive coupling, capacitive coupling and electromagnetic coupling. Overvoltages affect circuits or electric equipments from:

- radiation of electromagnetic field,
- power supply,
- z information network or data network,
- grounding.

Therefore overvoltage protection of input circuits of electric equipments on all input and output is needed. Required protection level of electri equipments can by achieved by proper coordination of overvoltage protection. Insulation coordination resides on reducing of overvoltages using protective facilities – overvoltage protection.

When insulation of specimen break down full test voltage can damage input circuits during experiments also. The voltage range of input circuits are normally used in the low voltage range but not for high voltage range.

Nowadays it is possible protect inputs of measuring accuracy technique by fast overvoltage protection that ensure low protective level in very short time. However in the case of more inputs of measuring accuracy technique this solution may be economic ineffective. Moreover frequency characteristic of connected protective device must be considered. Measuring accuracy technique galvanically bounded from specimen under high voltage is optimal. There exist galvanic isolation by separate winding transformer which is from the power supply simple. Measuring accuracy technique has more ground levels and for that reason full galvanic isolation of power supply as well as input circuits is the best. Galvanic isolation of specimen must be frequency independent. Optical coupling meet these requirements.

2. CLASSIFICATION AND ANALYSIS OF DISCHARGE PHENOMENA IN NON-HOMOGENEOUS FIELD

Discharge processes are classified according to duration on temporary and steady. Steady discharges are divided into independent and non-independent. Sort criterion result from the condition which lead to generation and sustain of discharge path. Category of independent discharges include: silent discharge, corona discharge, spark discharge and arc discharge. Non-independent discharges require the source of charge carrier or source of energy for ionization of atoms.

Corona discharge exists surround electrodes with small curve radius which create non-homogeneous electric field in discharge path. Corona discharge existing only on one electrode we call unipolar. Corona discharge create by specific voltage which is called corona inception level. Under corona inception level exist only non-independent silent discharge in consequence of secondary discharging processes e.g. space, ultraviolet radiation. If voltage on the electrodes is higher then corona inception level plasma enlarges to opposite electrode and breakdown of discharge path occur. Corona discharge changes to spark discharge or arc discharge. Under DC voltage positive or negative corona discharge is created. Under AC voltage AC corona discharge is created which properties are dependend to time.

On the interface solid-gas material creeping discharge in non-homogeneous electric field is developed. This discharge act on the surface of insulation between electrodes. For these processes the best representation is Toepler model. Creeping discharges are undesirable because these discharges quickly degrades insulation and shutdown high voltage devices from operation. The advantage is that we have possibilities to eliminate for example by using different surface layers especially semiconducting layers.

Sparc discharge is temporary form of electric discharge in gas. This discharge manifest in the form of shined chanel which has high temperature and high level of thermal ionization.

3. MEASUREMENT IN NON-HOMOGENEOUS HV FIELD

Most of measurement method originate from the following discharge activity phenomena:

- electromagnetic,
- optic,
- acoustic.

Technical insulation materials which are used in the area of high voltage technique are realised from the solid, liquid and gas combination e.g. liquid-solid, gas-liquid, eventually gas-solid. On the interfaces of particular materials under specific condition surface discharges occurs which produce noise. In the praxis following types of interfaces exists:

- homogeneous electric field with explicitly tangential action of field on interface,
- homogeneous electric field rectangular affect on interface of two insulant,
- non-homogeneous electric field with tangential action of field and small normal part,

- non-homogeneous electric field with tangential action with strong normal part.

For the operation the most dangerous is case (d). This case we applied for measurement and acoustic signal analysis. On the figure 1 is block diagram of scheme and applied electrode arrangement on figure. 2. Electrode arrangement applied in our experiment represent interfaces between solid and gas material. In the measurement according to Toepler different types of electrodes were applied, see figure 3. Electrodes A and B have cylindric design and were in contact with dielectric, electrode C has point shape with curve radius of 0,5 mm. Electrodes D–F are created from needles and their mutual distance (case E and F) is 5 mm.

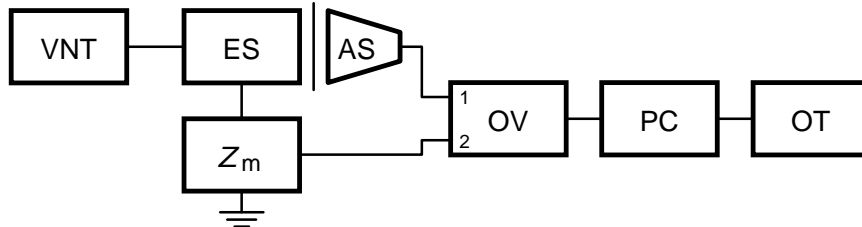


Fig. 1 Block diagram of scheme

VNT – hv transformer, ES – electrode system, AS – acoustic sensor, Z_m – impedance, OV – 2-channel amplifier with optic isolation, PC – personal computer, OT – separate winding transformer

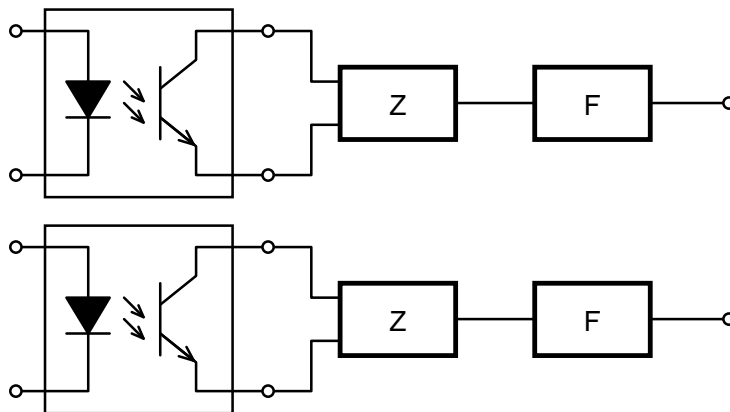


Fig. 2 Block diagram of amplifier with optic isolation: Z – amplifier, F – filter

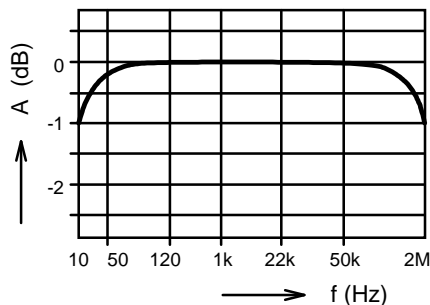


Fig. 3 Frequency characteristic

AC voltage on the electrode system was applied with variable amplitude from 5 kV to 50 kV. Distance between acoustic sensor and electrode system was 30 cm. The signal from acoustic sensor was recorded on data medium and postprocessed. For measurement of discharge activity device with optic isolation of inputs was

developed. Different sensor (optic, acoustic, electromagnetic etc.) can be connected to the device so we are able to observe discharges by another physical phenomenon. Also earphone can be connected to device and so directly qualitative evaluation of discharge activity is possible. On figure 2 the block of device is shown and its frequency characteristic on figure 4. Although frequency range of acoustic sensor is from 20 Hz to 20 kHz the device is developed with frequency range up to 1 MHz eventually with 1 dB drop up to 2 MHz. Device is constructed with two channels in order to compare in real time acoustic and electric response from discharge activity. In case of need device can be constructed with arbitrary inputs and compare more signals. The device has filter for attenuation signals with low frequency.

4. CONCLUSIONS

Acoustic noise is from environmental point of view very dangerous for service operator. Acoustic noise generated from discharge activity is present in full acoustic range as we can see on figure 4. For evaluation of measured acoustic signal frequency analysis with FFT was applied. The amplitude of signal is relatively equally distributed over acoustic band. However, contains several extremes which vary in accordance with the shape of electrode, its distance from grounded electrode and amplitude of applied voltage. Measured characteristics are nearly directly proportional with applied voltage.

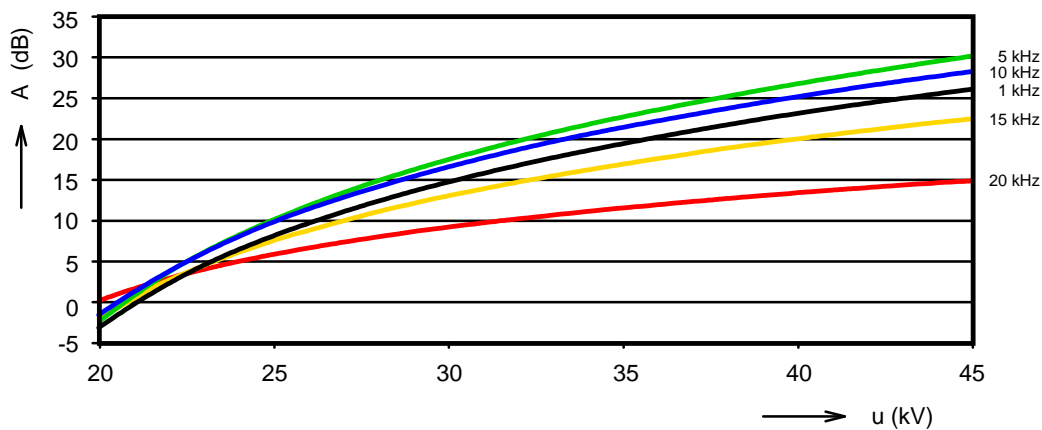


Fig. 4 Increase in amplitudes of particular frequencies for given voltages

On the figure 4 comparison of amplitude growth for frequencies 1 kHz, 5 kHz, 10 kHz, 15 kHz and 20 kHz and electrode system according figure 2B with electrode E and distance of 2 cm from grounded electrode is shown. On figures we can see that frequencies 5 kHz and 10 kHz dominate. 1 kHz frequency was compared with another frequencies because represent ambient acoustic noise. Similar characteristics with other electrode systems and appropriate distances were measured.

Measurement of discharge activity in acoustic band is strongly affected with acoustic background of surrounding environment and therefore its practical application is delimited on objects with low ambient acoustic noise. Advantage of this method consist in simplicity of quantitative as well as ability of immediate qualitative evaluation. In environments with strong noise it is better to orient on measurement of signals in ultrasonic band.

Constructed device is suitable for measurement in strong electromagnetic field for safe isolated coupling between sensor devices and measuring computer. In next period by evaluation of measured data we will pay attention to influence of electrode shape, electrode configuration, frequency spectra of signal, amplitude of applied voltage, kind of insulation.

5. REFERENCES

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