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A NEW PARTIAL DISCHARGE MEASURING SYSTEM CALIBRATOR

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Abstract: A new PD (partial discharge) measuring system calibrator is described. The device, battery operated, may be used either grounded or in a floating position, and generates securely mains-synchronized impulses by capacitive coupling.

It allows the determination of the scale factor k and resolution time T_r in PD measuring systems, and it fulfils the requirements of International Standard IEC 60270.

PD measuring instruments have mains-synchronized sweeps. Hence, in order to have stationary calibration impulses in the PD measuring instrument , the calibrator must generate mains-synchronized impulses. Usually, PD calibrators synchronize to mains frequency by a photodiode. In case of insufficient pick-up of power frequency light, these calibrators automatically select an internal quartz oscillator. When the internal oscillator is on, there is usually a slight difference between the oscillator frequency (fixed) and the mains frequency (variable), and consequently the impulses generated by the internal oscillator are not stationary in the PD measuring instrument (detector screen).

This new calibrator avoids that problem because it generates securely mains-synchronized impulses by capacitive coupling, making unnecessary an internal quartz oscillator.

Key words : PD (partial discharges), calibrator, synchronization, resolution time

1. INTRODUCTION

The calibration of a PD measuring instrument allows to determine the scale factor k. In order to state the discharge magnitude in pC, the instrument reading must be multiplied by the said scale factor.

The accuracy of PD measurements depends on the accuracy of the calibrators. International Standard IEC 60270 recommends that the first performance test on a calibrator, for which approval is sought, should be traceable to national standards [1].

In order to check the PD measuring system characteristics (scale factor k and resolution time T_r) a PD calibrator is required. The resolution time determination constitutes a type test of PD measuring systems, according to International Standard IEC 60270. The impulse resolution time T_r is the shortest time interval between two consecutive impulses of very short duration, of same shape, polarity and discharge magnitude, for which the peak value of the resulting response will change by not more than 10 % of that for a single impulse.

The resolution time is an indication of the measuring system's ability to resolve successive PD events.

2. DESCRIPTION AND OPERATION OF THE NEW CALIBRATOR

Fig. 1 shows the circuit of the new calibrator. One can see that the upper half and the lower half of the circuit are almost identical. We shall name the two halves upper circuit and lower circuit.

Let us consider the lower circuit. Once the calibrator is energized, the charging voltage on capacitor C_1 rises exponentially up to the value fixed beforehand by potentiometer P. When the mercury wetted reed relay I closes, there is a step voltage on C_1. The amplitude of this voltage is the final charging voltage of C_1 , that is to say the direct voltage measured at the output of P. Each time the relay I closes, C_1 discharges through R_2 , falling abruptly the capacitor voltage to 0 V (step voltage wave). The capacitor charging time constant R_1C_1 is many times higher than the capacitor discharging time constant R_2C_1 .

Furthermore, each time the relay closes, the generated step wave is applied to the series circuit formed by R_4 , the output capacitor C_2 and the external circuit, giving rise to an impulse which may be recorded in a PD detector.

Commercial PD measuring instruments have mains-synchronized sweeps. Hence, in order to have stationary calibration impulses in the PD measuring instrument, the calibrator must generate mains-synchronized impulses.

Let us see how 50 Hz voltages applied to the excitation coils L are generated. By observing the lower circuit, for example, one can see a field effect transistor T. Its gate is internally connected to an input connector of the calibrator. A thin insulated cable is externally connected to this connector. This cable is tightly wound (60 turns at least), around a two wire cable (cross section 2x1.5 mm^2) connected to a 220 V/50 Hz wall outlet.

One end of the coiled thin cable is left free, and one end of the two wire cable is left at open circuit. Fig. 2 shows the connections of both cables. Between the coiled cable and the two wire cable there is a stray capacitor. This capacitor is in series with the high input impedance of the field effect transistor T [2].

When the two wire cable is plugged into the wall outlet, the transistor's gate is excited by capacitive coupling,

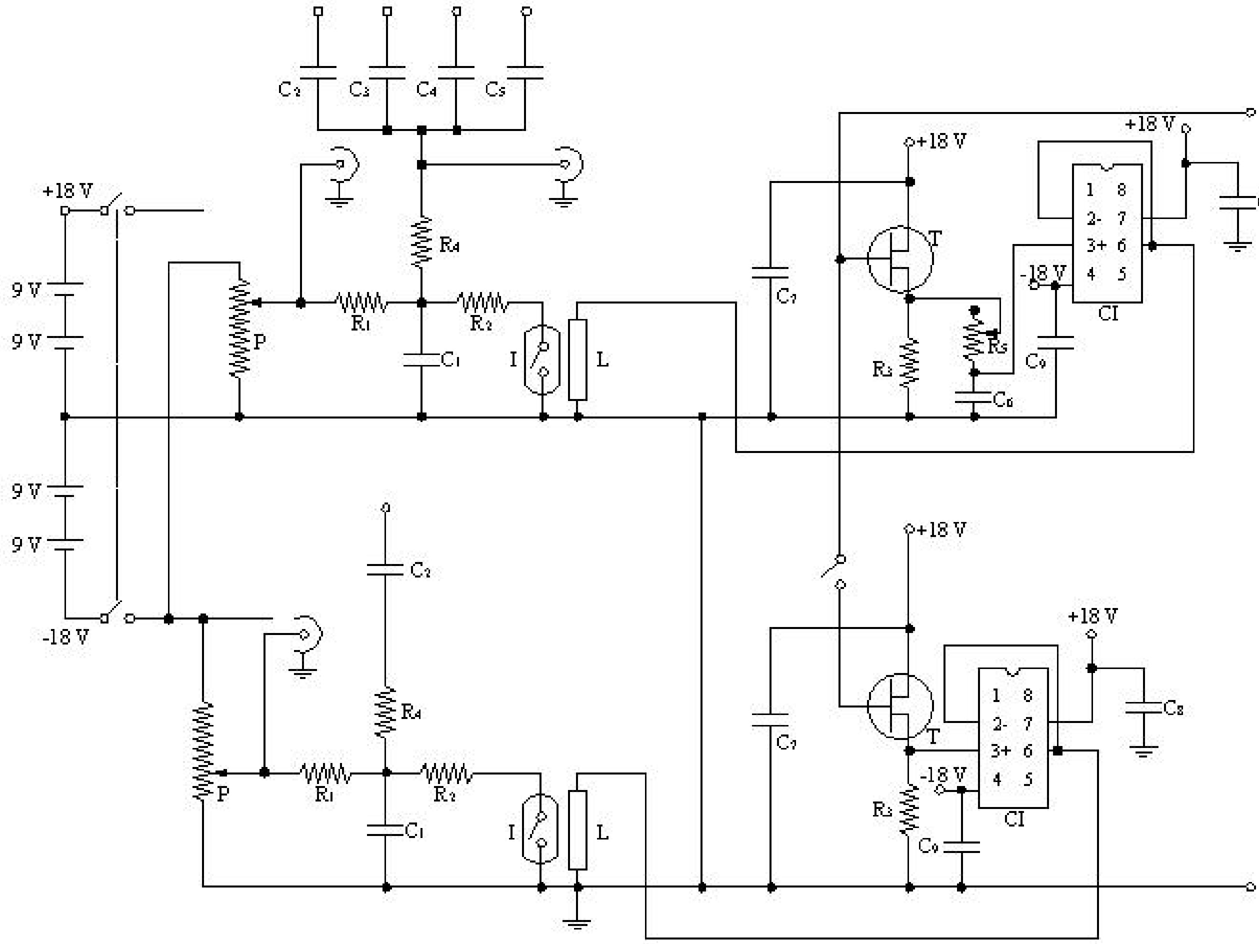

Fig. 1 . Circuit of calibrator

and on R_3 there is a 50 Hz voltage drop (see Fig. 1). This voltage is applied to the non inverting input of CI, which is operating as a voltage follower. The output voltage of CI is finally applied to the excitation coil L of relay I.

The upper circuit works on the same way as the lower one, but there are 2 differences between them.

Firstly, in place of one output capacitor, in the upper circuit there are four output capacitors, identified as C_2, C_3, C_4 and C_5 . These capacitors are named calibration injection capacitors (calibration capacitors) and their capacitances are 10, 25, 50 and 100 pF respectively.

The output voltage of one of these series capacitors is normally injected in a PD detection circuit, in order to realize the calibration of the measuring instrument (determination of the scale factor k).

When determining the resolution time T_r of a PD measuring system, two voltages are applied to this system : the output voltage of upper capacitor C_2 and the output voltage of lower capacitor C_2 .

The other difference between upper and lower circuits is the presence of a phase shifting branch, in the upper circuit, formed by a variable resistor R_5 in series with capacitor C_6 . By means of this phase shifting branch, the voltages applied to the upper relay coil and to the lower relay coil are not in phase. Hence, the relays' closing times are different. This time difference may be continuously varied with the help of variable resistor R_5 .

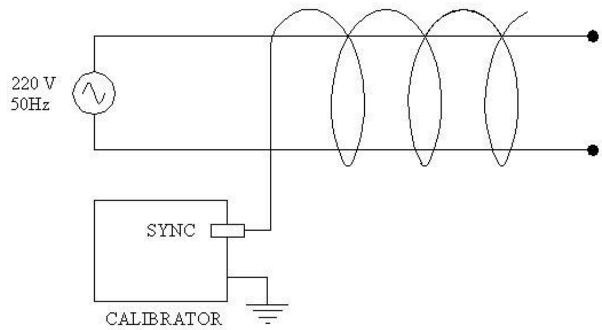

Fig. 2 . Diagram for synchronization of impulses

3. DETERMINATION OF THE IMPULSE RESOLUTION TIME

As it was said before, a PD calibrator must allow the determination of scale factor k and resolution time Tr of impulses recorded in a PD measuring instrument. The determination of Tr requires the use of an auxiliary oscilloscope.

The calibrator must be connected to the PD measuring system under test. According to International Standard IEC 60270, a PD measuring system can be divided into a coupling device, a transmission system and a measuring instrument. Generally, the coupling device is a coupling quadripole, the transmission system is a coaxial cable, and the measuring instrument is an oscilloscope. Consequently, the output terminals of both capacitors C_2 must be connected to the coupling quadripole input. This connection must be made by employing two short cables.

An auxiliary coaxial cable is connected between the oscilloscope input under test and one of the auxiliary oscilloscope channels (see Fig. 3).

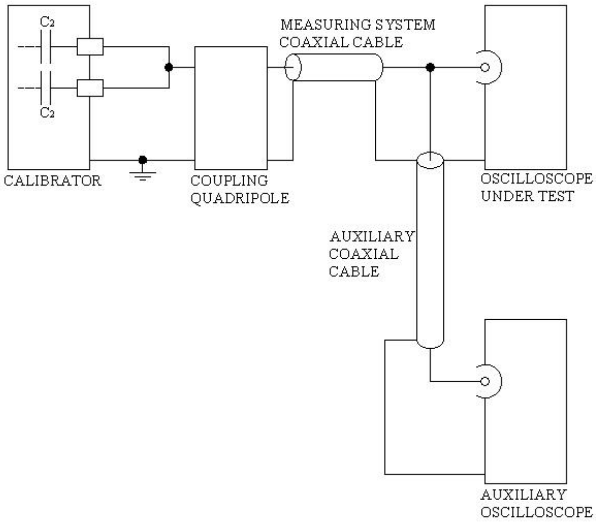

Fig. 3 . Diagram for determination of impulse resolution time

On the other hand, each potentiometer output voltage is fixed at 5 V, by measuring this voltage in another channel of the auxiliary oscilloscope.

When the calibrator thus adjusted is connected to the quadripole, two impulses appear on the oscilloscope screen under test and on the auxiliary oscilloscope screen. If necessary, the potentiometers P are operated so that both impulses have exactly the same height in the auxiliary oscilloscope.

According to the theory, the discharge magnitude of each impulse equals the step voltage amplitude (5 V) times the output capacitance C_2 (10 pF).Hence, the discharge magnitude of each impulse is 50 pC.

The impulse generated by the lower circuit is fixed, whereas the impulse generated by the upper circuit can be moved in both oscilloscope screens with the aid of variable resistor R_5 .

Initially, both impulses must be present with the maximum separation between them. Under this circumstance, the impulse amplitude recorded in the auxiliary oscilloscope is the initial amplitude.

As follows, the moving impulse is approximated to the fixed one, until the moment in which the amplitude recorded in the auxiliary oscilloscope screen is 10 % higher than the initial amplitude. Under this circumstance, the time between both impulses is measured in the auxiliary oscilloscope. This is the resolution time T_r looked for.

4 . RESULTS

In order to determine the scale factor k in a PD measuring system calibration, one of the four calibration output terminals is suitably selected. By means of a short cable, the selected terminal is connected to the HV terminal of the test object, and the calibration impulse is injected without applying the high voltage (see Fig. 4).

This calibrator may be used either grounded or in a floating position. The floating position happens when PD are measured in a test object not straightly grounded (see Fig. 5).

The measured rise time of the step voltage wave is

40 ns. According to International Standard IEC 60270, this time must be less than 60 ns.

The calibrator is powered by means of four 9 V rechargeable batteries.

The amplitude of the step voltage wave may be varied continuously between 0 and – 18 V.

The discharge magnitude of calibration impulses may be suitably selected between 5 pC (0,5 V x 10 pF =

= 5 pC) and 1,500 pC (15 V x 100 pF = 1,500 pC) .

The error of the rated values of discharge magnitude is less than 5 %.

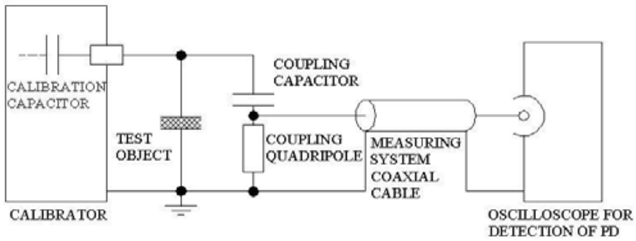

Fig. 4 Diagram for determination of scale factor k (grounded calibrator)

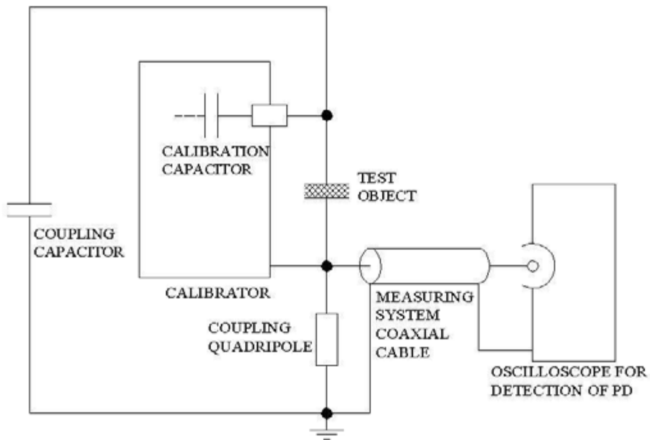

Fig. 5 Diagram for determination of scale factor k (floating calibrator)

5 . DISCUSSION

Existent PD calibrators synchronize to mains frequency by a photodiode. In case of insufficient pick-up of power frequency light, these calibrators automatically select an internal quartz oscillator. When the internal oscillator is on, there is usually a slight difference between the oscillator frequency (fixed) and the mains frequency (variable), and consequently the impulses generated by the internal oscillator are not stationary in the detector screen.

This new calibrator avoids that problem because it generates mains-synchronized impulses by capacitive coupling, making unnecessary the existence of an internal quartz oscillator.

6. CONCLUSION

The proposed calibrator constitutes a new alternative. An important feature of this calibrator is the use of a capacitive coupling for the secure synchronization of the generated impulses.

7. ACKNOWLEDGEMENT

The author wishes to thank Mr. Claudio Recchia , who constructed the PD calibrator.

8. REFERENCES

[1] International Standard IEC 60270, pp. 43, 2000.

[2] M. A. Pecorelli, “ Miniature partial discharge calibrator synchronized by capacitive coupling “, IEEE Transactions on Electrical Insulation, Vol. 27, pp. 181-183, 1992.