

Methods of testing characteristics of electrolytic condensers

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IN determining the worth of electrolytic condenser units there are four especially important factors to be considered. These four factors being, in the order of their importance, the capacity, the leakage, the resistance and the power factor.

All four of these factors can be accurately measured, but as a general rule such accurate determination requires the use of apparatus not always available and for that reason both the elaborate test methods suitable to the laboratory, as well as the more simplified

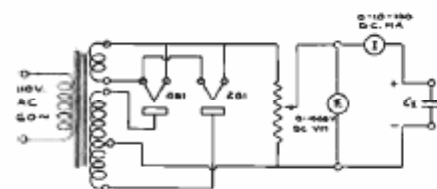


Fig. 2. Circuit for measuring current leakage of electrolytic condensers.

methods adaptable to economical production testing, will be described.

Capacity

The effective capacity of an electrolytic condenser is always slightly less than the electrostatic capacity due to the effect of the resistance of the electrolyte, this effect varying with frequency. For this reason and the fact that the anode or positive plate of the condenser must be maintained positive, with respect to the electrolyte, and further that there is always current leakage, ordinary capacity measurements are not suitable.

In all measurements of electrolytic condensers it is important to duplicate, as closely as possible, the conditions of operation in the actual circuit or filter networks in which these condenser units are used. For this reason it will be noted that all tests are shown as being made with a composite current consisting of the direct current with a superimposed alternating-current component.

One of the more commonly used methods of determining effective capacity is to pass an alternating current

through the condenser which is connected in series with a standard mica or paper dielectric condenser and from the measurement of this current calculate the capacity. Such a measurement, however, is not of sufficient accuracy except for production testing as only the impedance of the condenser is taken into consideration with no allowance for the resistance of the electrolyte.

A circuit is illustrated in Fig. 1 and in connection with same the following formula is used:

$$C_x = \frac{I}{2\pi f E}$$

C_x = Capacity (farads) of unit under test.

I = Alternating current (amperes).

E = Alternating current (volts).

In using this test method the application of the formula is simplified by maintaining the a-c. voltage E at a fixed value—say 100 volts. In this manner a chart can be easily worked out for quick capacity determination. The direct-current voltage value is not important so long as it exceeds the peak value of the alternating current, E .

If 50 volts is used at E , the d-c. voltage should exceed $E(2)^{1/2}$, in this case 50×1.414 or 70.7 volts, say 100 volts d-c.

Example: Capacity measurement of an electrolytic section, marked, say, 8 mfd. Upon connecting the unit to be measured in the test network we get the following readings: I —150 milliamperes. Applying this value to the formula we have:

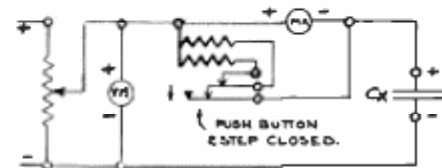


Fig. 3. Milliammeter shunt arrangement.

$$C_x = \frac{.150}{2 \times 3.1416 \times 60 \times 50} = \frac{.150}{18850} = .0000079 \text{ farads}$$

or $.0000079 \times 10^6 = 7.9 \text{ mfd.}$

Leakage Current

The average leakage current of electrolytic condensers varies with the type of condenser and type and conditions of operation. The leakage current is generally specified accordingly. In general, however, there are a few factors that hold rather constant under all conditions. When a condenser unit has been out of use for some time, there is an apparent deterioration of the anode film, or rather a lowering of the film resistance. This results in an increase in leakage current which, however, drops to normal upon the placing of the condenser in service.

Increase in temperature causes an increase in leakage current, therefore, the maximum operating temperature should be considered as 50 deg. Centigrade.

Fig. 2 shows a circuit recommended for the measurement of leakage current. This high voltage is terminated with a 100-watt, 50,000-ohm potentiometer. The voltmeter is connected across the variable voltage section and a milliammeter connected in series with the condenser under test. It is recommended that a standard 0 to 1 milliammeter be used and arranged with shunt resistances for additional ranges of 0 to 10 milliamperes and 0 to 100 milliamperes as in Fig. 3.

Normally both resistance units are in parallel to the meter and the scale 0-100 ma. Pushing in slightly disconnects one resistance unit and the scale be-

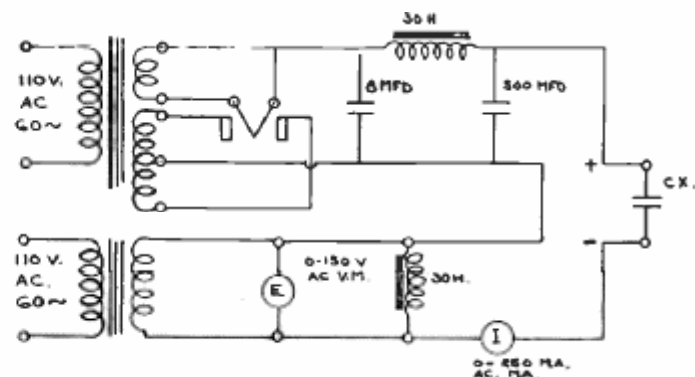


Fig. 1. Circuit for measuring capacity of electrolytic condensers.

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comes 0-10 ma., while pushing in hard disconnects both resistance units and the scale becomes 0-1 ma.

Resistance

The average resistance of an 8 mfd. condenser is approximately 8 ohms, although this varies with type of electrolyte, heat and frequency. The resistance is an important factor in the direct effectiveness of an electrolytic condenser for by-pass work in a filter network because a condenser's effectiveness is directly proportional to its impedance at any given frequency. In other words, the effectiveness of the condenser is proportional to the vector sum of the capacitive reactance and the resistance. The effectiveness then being equal to an equivalent pure electrostatic capacity which would give the same capacitive reactance as the total impedance referred to:

$$Z^2 = R^2 + X_c^2$$

This holds true only where the condenser is not used in a tuned circuit. In such a circuit the resistance becomes a vitally important factor. A quick and convenient method of measuring impedance is illustrated in the test set shown in Fig. 4. R is a standard decade resistance box, while C_x is the con-

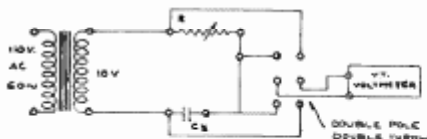


Fig. 4. Circuit for measuring impedance of electrolytic condensers.

denser under test. The procedure is to adjust R until the vacuum tube voltmeter reads the same when the double pole, double throw switch is in either position. When this condition exists the reading on the decade box is the impedance of the condenser.

For the accurate measurement of resistance it is necessary to use a capacity bridge and this is illustrated in a fundamental layout, Fig. 5. This bridge is an accurate means of not only measuring resistance, but capacity as well. In the use of the bridge the following relationship exists when the bridge is in balance.

$$\frac{R_2}{R_1} = \frac{C_x}{C_s}$$

R₂ and R₃ are standard decade resistance boxes, while R₁ is a variable resistance used to introduce resistance in series with a standard low power factor, paper or mica condenser C_s until a condition of balance exists in the bridge or when relationship

$$\frac{R_2}{R_1} = \frac{C_x}{C_s}$$

then R₂ will be of a value equal to the resistance of condenser C_x under test.

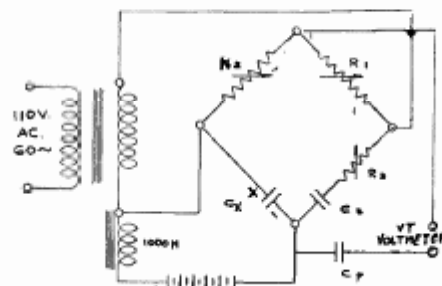


Fig. 5. Circuit for resistance measurement of electrolytic condensers.

In a like manner capacity measurements are made.

For more complete details of a bridge test network in which operating conditions of electrolytic condensers are duplicated there is included Fig. 6. Either 60 or 120 cycles may be used with little variation.

In all the diagrams where a vacuum tube voltmeter is indicated it is also possible to use an audio amplifier in connection with an output meter.

Should elaborate tests be desired with other frequencies than the 60 indicated then an audio oscillator may be substituted as the source of current.

Power Factor

The power factor can be ascertained from the other factors already discussed.

$$\text{Power factor} = \frac{R}{\sqrt{R^2 + (2\pi f c)^2}}$$

R = series resistance in ohms.
f = frequency.
c = capacity in farads.

In Fig. 7, an adaptation of the first method given to large production tests is seen. Here, a source, either generator or vacuum tube power pack is used. (It is difficult to state actual voltage on specifications for any test equipment inasmuch as condensers are manufactured in voltages ranging from 5 to 3,000 volts and capacities from 1/4 to many thousand microfarads, but in this instance we will consider testing condensers rated at 450 volts and 8 mfd.) 500 volts is impressed on the system. A register of 25,000 ohms is in series with each condenser. A small neon

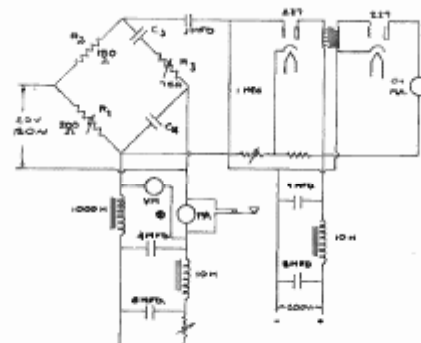


Fig. 6. Bridge method of measuring capacity, power factor and leakage.

lamp is attached across each resistor so that a condenser with high leakage can be spotted instantly. The lamp and resistor are also adjusted so that when the leakage falls below 4 milliamperes the drop across the resistor will be less than 100 volts, the lamp will go out and the leakage can then be read, by pressing a key, on the milliammeter in each circuit. The capacity section uses approximately 30 volts a-c. and is read by pressing a key.

As has been said, leakage and capacity specifications are individual requirements of the manufacturers, but with a normal production run of eight microfarad units rated at 450 volts, the condensers should be loaded on the rack, the circuits closed by means of

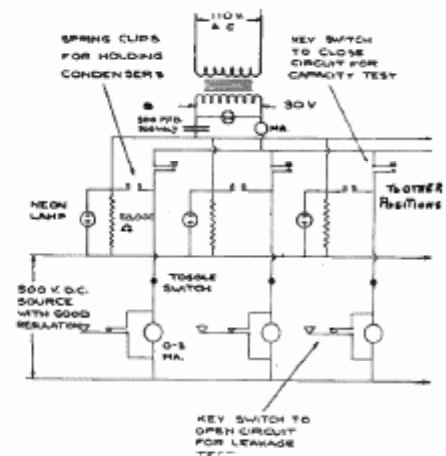


Fig. 7. Condenser test set for quantity test of condensers.

the toggle switches, and permitted to run five minutes before testing. At the end of this five minutes the leakage should not be over 2 milliamperes. This will also indicate that the condensers have 450 volts applied to them, as 2 milliamperes through the 25,000 ohm resistors would cause a drop of 50 volts. Any lower leakage would indicate that the condenser had come up to above its rated voltage.

This system for production has many advantages and particularly in the speed at which an operator may test. No definite time limit is necessary as the operator can judge the time by the speed with which the lights go out.

The capacity test may be calibrated either directly in microfarads or as a limit meter, depending upon the tolerance required by the manufacturers.

CONVENTIONS

April 7-9, at Pittsburgh, Pa.,
I. R. E.
May 23-26, at Chicago, Ill.,
R. M. A.