DLINE JOURNALS

Electronic Devices

Print ISSN: 2278 – 6422
Online ISSN: 2278 – 6430

ED 2024; 13(2)
https://doi.org/10.6025/ed/2024/13/2/45-48

Determining the Suitability of Capacitor Models with Frequency Range Control

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ABSTRACT

This paper examines the capacitance properties of capacitors operating under alternating current up to 200 KHz, utilizing an LCR meter from the firm "R @ SH" (Germany, Munich). Considering the dielectric material's frequency-dependent behavior, predictions regarding the alteration in the dielectric constant at elevated frequencies were calculated. The analysis led to a determination regarding the suitability of different capacitor models for the specified frequency range.

Keywords: LCR - meter, AC Electrical Capacity, Dielectric Constant, Loss Tangent

Received: 16 May 2024
Revised: 3 July 2024
Accepted: 22 July 2024

1. Introduction

The properties of capacitors and, in particular, the frequency dependences of their capacitance are determined by the dielectric class located between the capacitor plates. According to the type of these patterns, capacitors are distinguished: · with fast types of polarization (electronic and ionic) - group 1; · with relaxation types of polarization (electronic-relaxation, ion-relaxation and dipole-relaxation) - group 2; · with structural (volumetric) polarization, the properties of which are determined by the composition and quantity of ingredients - group 3; with spontaneous polarization - group 4. The nature of the frequency dependencies of the capacitance is determined by the types of polarization inherent in the dielectric. In this work, an attempt is made to study the frequency dependence of some capacitors experimentally. Based on this, conclusions were drawn about the contribution of different types of polarization to the capacitance.

Experiment

The experiment was carried out using an immittance meter (LCR meter) Rohde & Schwarz HM8118 (Figure 1). The Basic instrument error is 0.05%. The measurements used a Kelvin cable (Figure 2) and a four-pin test adapter for surface-mount components (SMD).

Figure 1. Appearance of the LCR meter HM8118 from Rohde & Schwarz

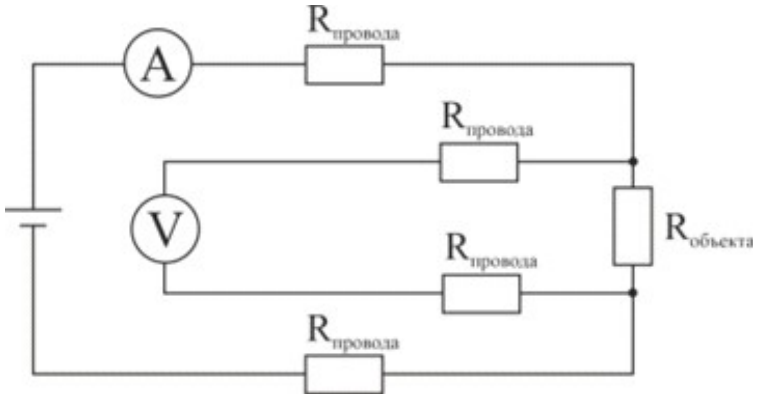

Figure 2. Four-wire Kelvin measurement circuit

The frequency range of measurements is from 20 Hz to 200 kHz.

The following capacitors participated in the experiment: MBGP-2 series of capacitors with an operating voltage of 200V and an accuracy of 10% 20%, a CBB 22 type capacitor with a nominal value of 175 J and an operating voltage of 400V, capacitors of the MKR 104K type with an operating voltage of 275V, capacitors of the MPP 474 J type , 400 V.

Discussion of the Results Obtained

In our measurements, the current frequency varied from 20 Hz to 200 kHz. The following data were obtained (Table 1) and represented as a graph in Figure 3.

KON-2 capacitor paper is used as a dielectric in metal-paper capacitors intended for operation in direct or pulsating current circuits. To isolate the electrically conductive particles in the paper from the capacitor plates, the paper is coated on one or both sides with a layer of ethyl cellulose varnish about 1 micron thick. The dielectric of MBGP capacitors for operating voltages of 160 and 200 V is single-layered from capacitor paper 8 microns thick. The capacitor plates are metal layers with a thickness of about a hundredths of a micron, applied to one side of the paper over a layer of varnish. The coatings are deposited onto the paper using a special metallization machine in an airtight chamber where metals melt and evaporate due to electrical heating. To facilitate their evaporation and to reduce the oxidizing effect of air oxygen on them, an atmospheric solid vacuum is created inside the machine chamber. A paper belt moving inside the machine passes over a crucible with molten tin and then a crucible with molten zinc.

Vkhz	CnF , 474 J	CnF , MKP 104 K	C µ F , CBB22
10	454	92	1.7 0
20	456	92	1.7 3
40	465	92.5	1.76
60	480	93	1.89
80	503	94	2.17
100	535	95	2.73
120	581	96.5	4
150	693	99	10
180	901	102	
200	1000	105.5	

Table 1. Frequency Variation and Response

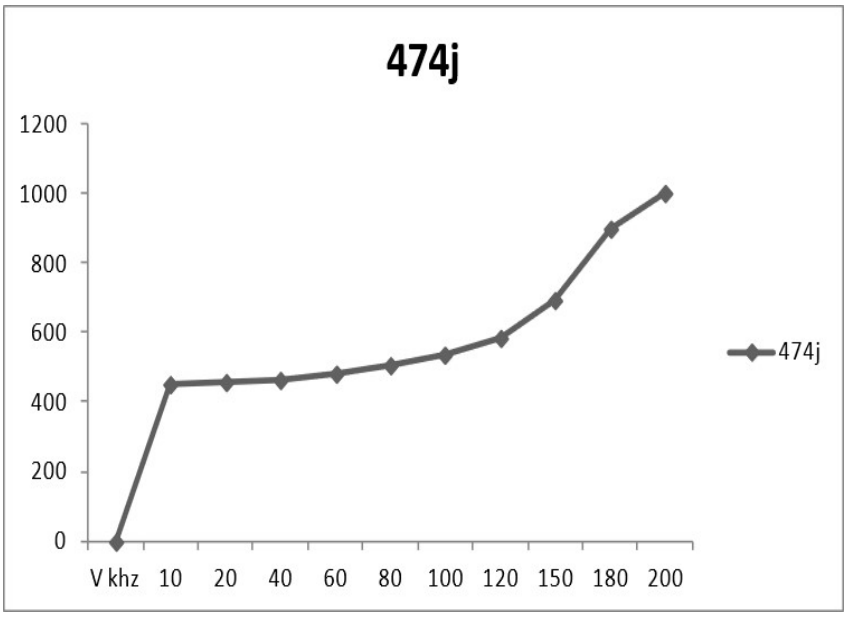

Figure 3. Frequency response Vs Capacitance

Metal vapours, coming into contact with the varnished surface of the paper, instantly cool and harden. As a result, a very thin (monomolecular) layer of tin is deposited on one side of the paper, which adheres tightly to the surface of the paper, and on top of it is a slightly thicker layer of zinc, which has fairly good electrical conductivity. Aluminum is also used for metallization of capacitor paper. The capacitors of the MBGP series detect a minimum at a frequency of about 6 KHz, which indicates a change in the types of polarization as shown in figure 4.

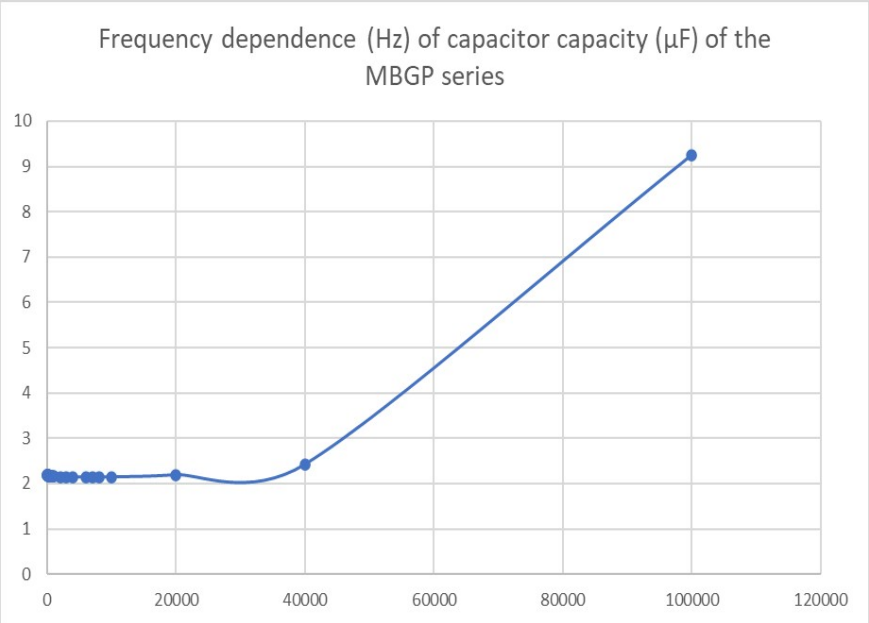

Figure 4. Frequency Vs Capacitor capacity

Conclusion

In this range of measured frequencies of alternating current (10 Hz - 200 KHz, 1.5 V), the intercontact capacitance of the MBGP series capacitors, measured using the Kelvin circuit, has a pronounced minimum in the region from 2 KHz to 6 KHz. In this frequency range, the types of polarization change. To accurately determine the type of polarization, an attempt was made to calculate the contributions for multi-component capacitors with structural (volume) polarization (such as MBGP capacitors). The calculation led to several extrema corresponding to certain components of the combined dielectric. In the general case, structural polarization that occurs at the interfaces between media (capacitors with paper-film insulation) results in a certain minimum in frequency dependence.

The work was carried out within the framework of a subproject of the Jizzakh Polytechnic Institute under a World Bank grant from the Academic Innovation Fund of the Ministry of Higher Education and Science of the Republic of Uzbekistan, project ID 128516.

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