

# 16. LIQUID DIODE

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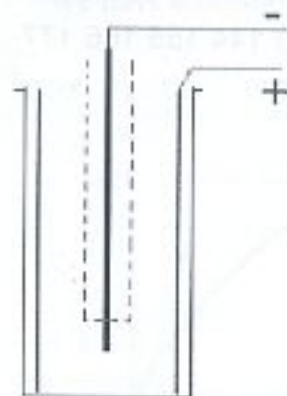
School № 42 named after I.N. Vekua

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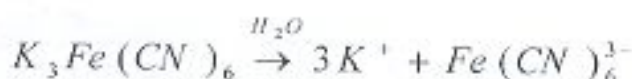
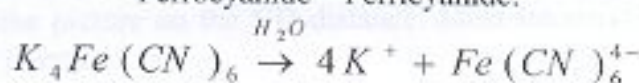


At first I want to talk about our diode, it's geometry, and chemical contents. We propose such diode (fig. 1) : vessel with two electrodes put in: one with a big surface square (macroelectrode) and another with a small surface (microelectrode). In the vessel is poured tricky electrolyte which is a mixture of two another electrolytes, they can be: Ferrocyanide – ferricyanide , Kaliumiodum – iodum.

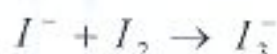
Fig. 1.

Chemical processes running in the electrolyte:

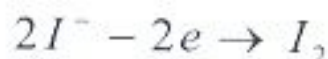
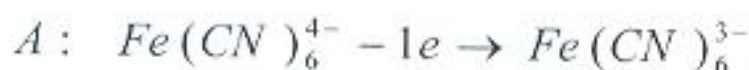
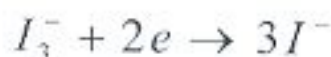
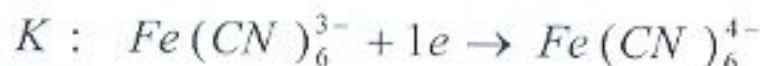
Ferrocyanide – Ferricyanide:



Kaliumiodum - Iodum



When we put voltage on electrodes these processes on the cathode(K) and anode(A) begin:



Now I'll try to explain why this system poses diode properties. To do this let's understand that voltage drop on the diode consists of voltage drop on microelectrode, macroelectrode and in electrolyte medium. It's easy to talk about electrode voltage drop (resistance) proportionality. It's reverse proportional to surface square and to the concentration of electrolyte which comes into reaction with the electrode. Now let's observe two situations: first, when microelectrode is plus sign and when microelectrode is minus sign.

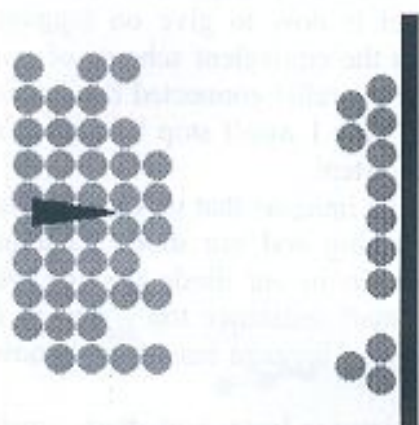


Fig. 2.

Now in second case (fig. 3) on the macro electrode we have small voltage drop but on the microelectrode with the small surface square we have very small concentration of electrolyte, and voltage drop is very big. The system has bad conductivity now.

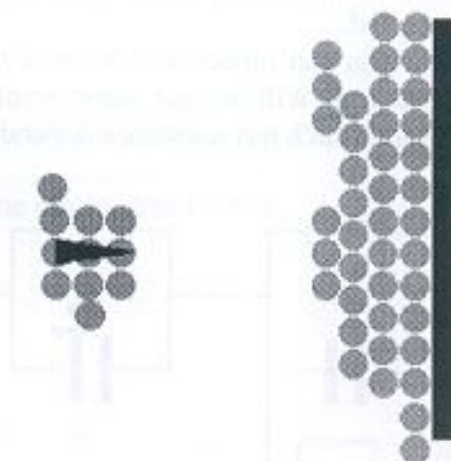


Fig. 3.

Two following schemes we used to take diode's voltamperic characteristics and frequency characteristics:

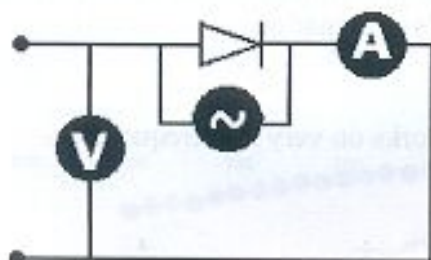


Fig. 4. One diode testing circuit.

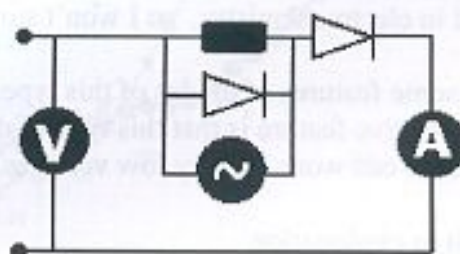


Fig. 5. Two-diode system testing circuit.

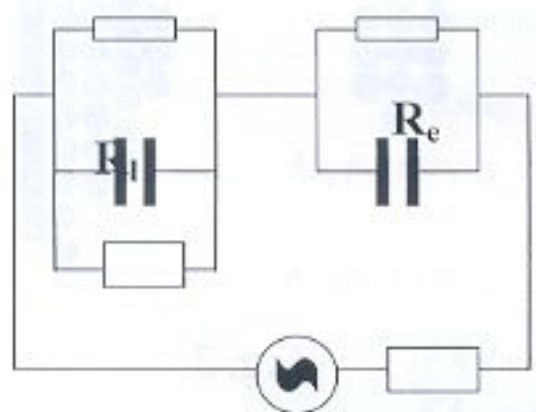


You can see that we used also circuit where are two electrochemical diodes used with resistance. Role of this scheme is to extend frequency characteristics of our diode. So whole system constructed from two diodes and resistance we will call diode.

In many electrochemical systems there is such a phenomenon like reverse current, and our system can operate in such a way too (when we give on electrodes alternative current), and one of purposes we use this scheme is to suppress this current. Our resistance is luggage resistance which can be – so commonly in radiotechnicks are called headphones, speakers, devices on which we take modified signal. And our target is now to give on luggage resistance cut in diode-like style signal. Here on the fig. 6 is the equivalent scheme of our two-diode system. You can see that we replaced each diode by parallel connected condenser and resistance, on explanation why we replaced diode in this way I won't stop because it's easy to understand it. Now I'll go to explanation of two-diode system.

As I said the main purpose is to suppress reverse current. Let's imagine that reverse current appeared - what happens? This current is effectively alternating and our diode contains condenser which has small resistance for alternating current, so in our diode we get two resistance parallel connected and this connection produces small resistance too – and as a result the main part of the current will go through the diode, our luggage resistance is now protected.

But you can object now what if we connect to luggage resistance instead of diode small resistance? Will we get same result? No, it's because we need nonlinear elements in our scheme which has resistance dependent on voltage.



Now let's estimate order of resistance and capacity of diode. So, taking experimental results: Voltages on one diode and resistor  $R_e$  on the two different frequencies, we can get system of  $N$  equations with  $N$  variables and find values for  $R$  and  $C$  order:

$$R \sim 100k\Omega$$

$$C \sim 0.1\mu F \quad \text{Fig. 6.}$$

So, I want to clarify one moment in this problem – why this diode poses capacity. This capacity appears because of existence of double electron layer near the electrodes. This layer is explained in electrochemistry, so I won't stop on it's explanation.

Now about some features of diodes of this type.

One of the positive feature is that this type of diode works on very low frequencies.

Also this diode can work on very low voltages.

But...

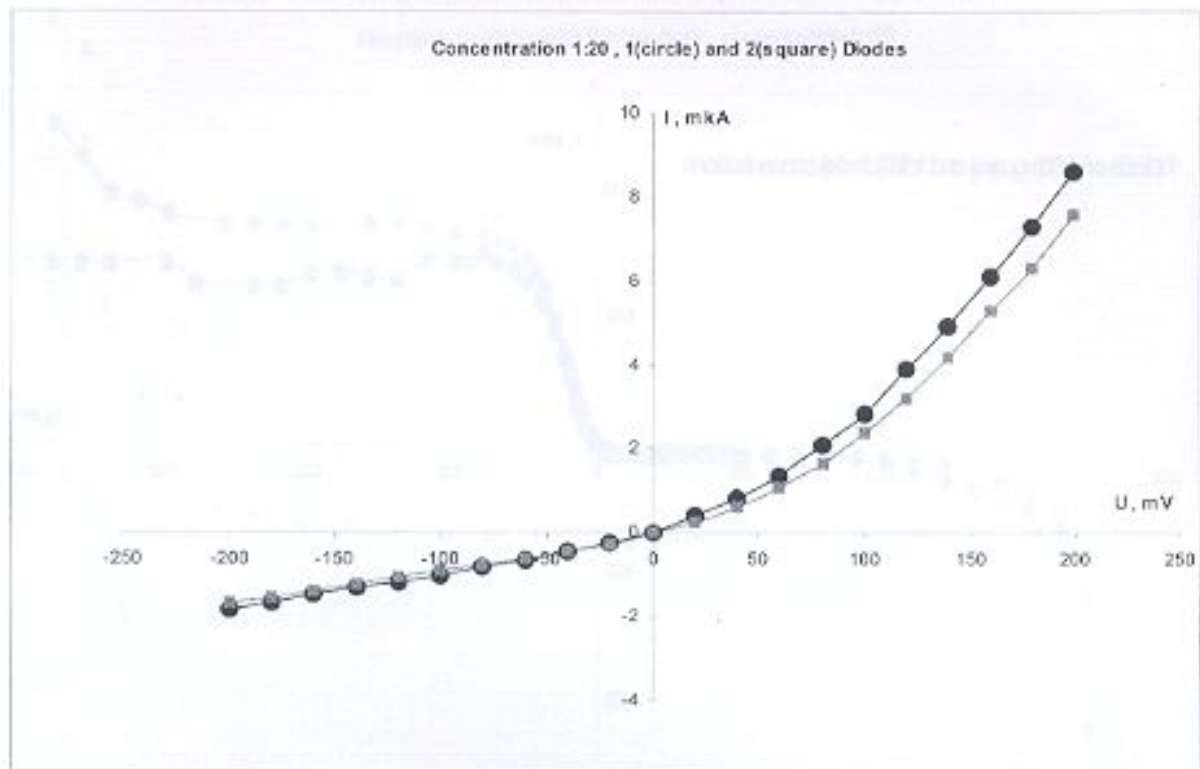
It's difficult in exploitation.

It's very sensitive to external electric field, shaking.

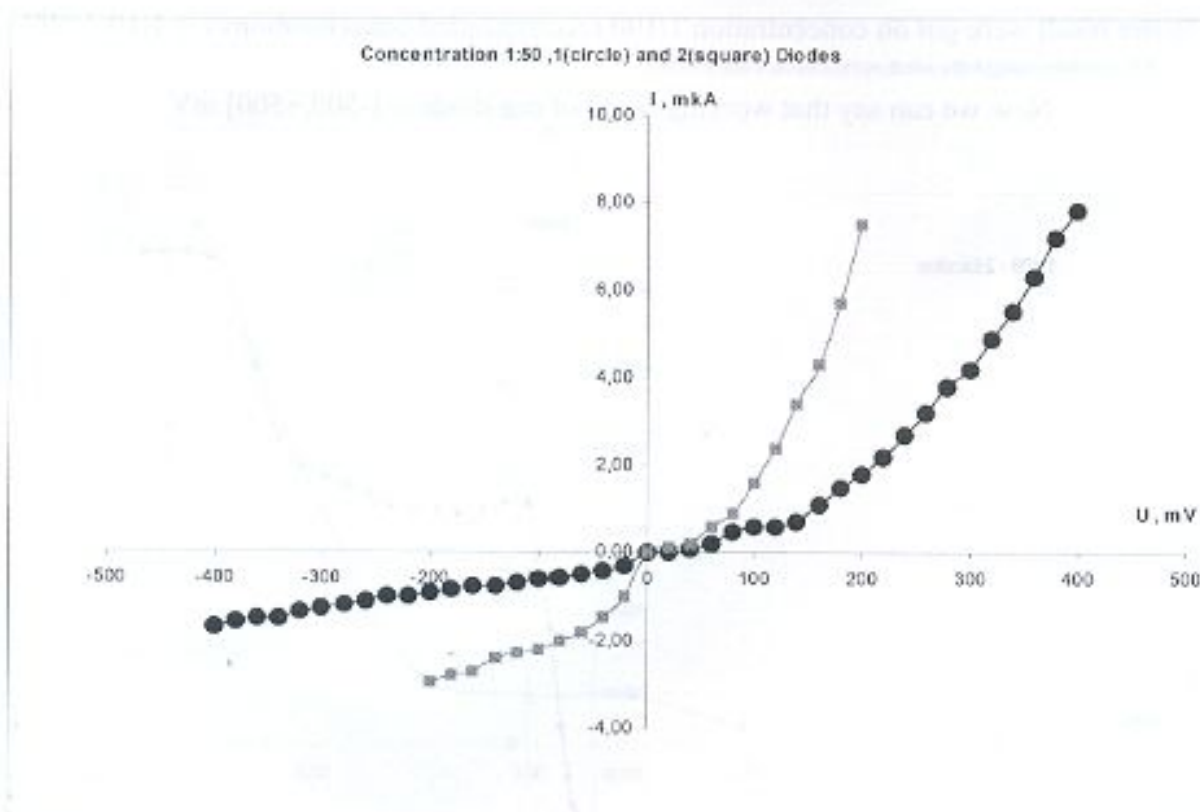
And it can't work on high frequencies (higher then  $\sim 20kHz$ ).

Now when well prepared in theory let's go directly to experimental data.

Following two graphs made for stainless steel electrodes:

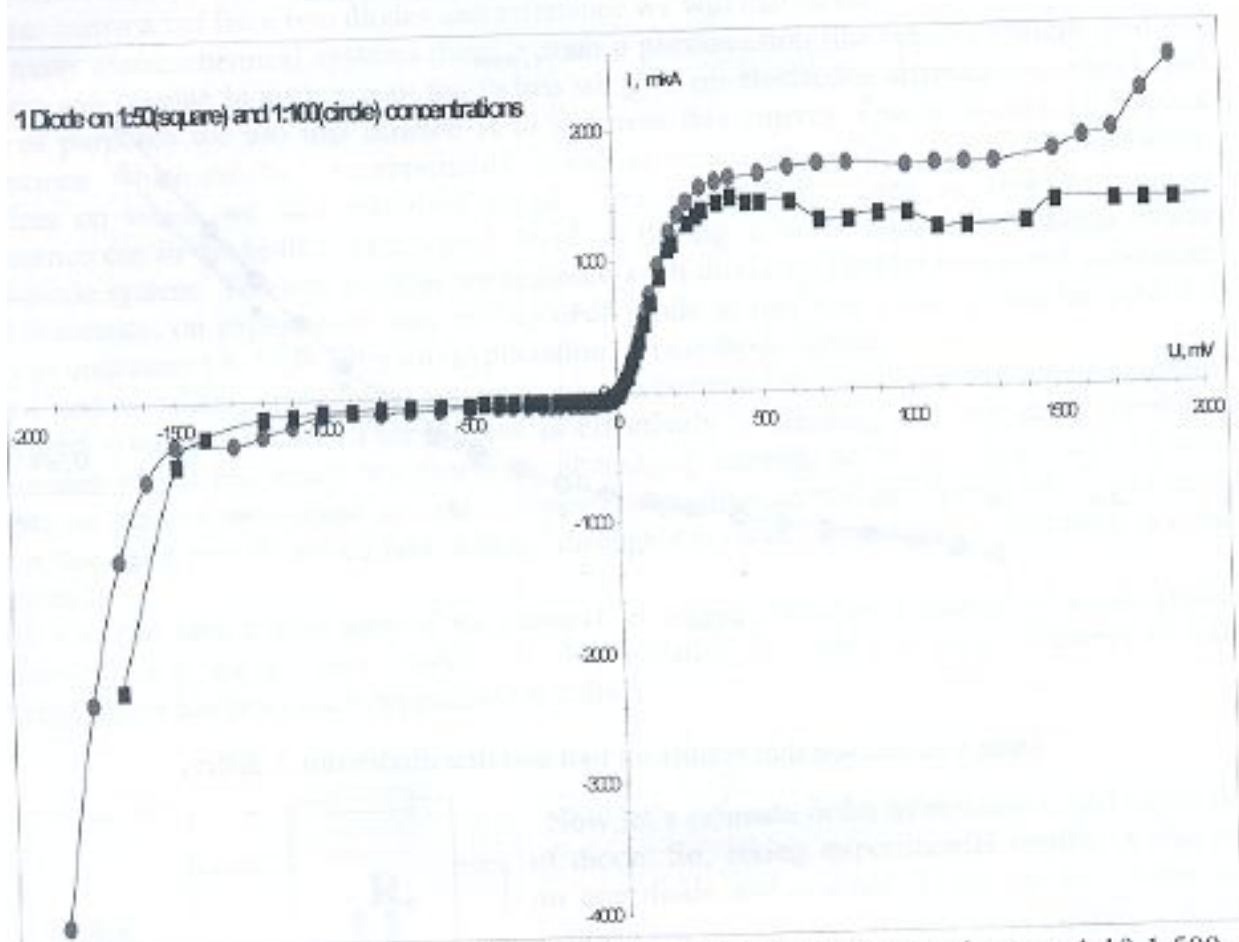


Here you can see that results on two and one diodes don't differ.



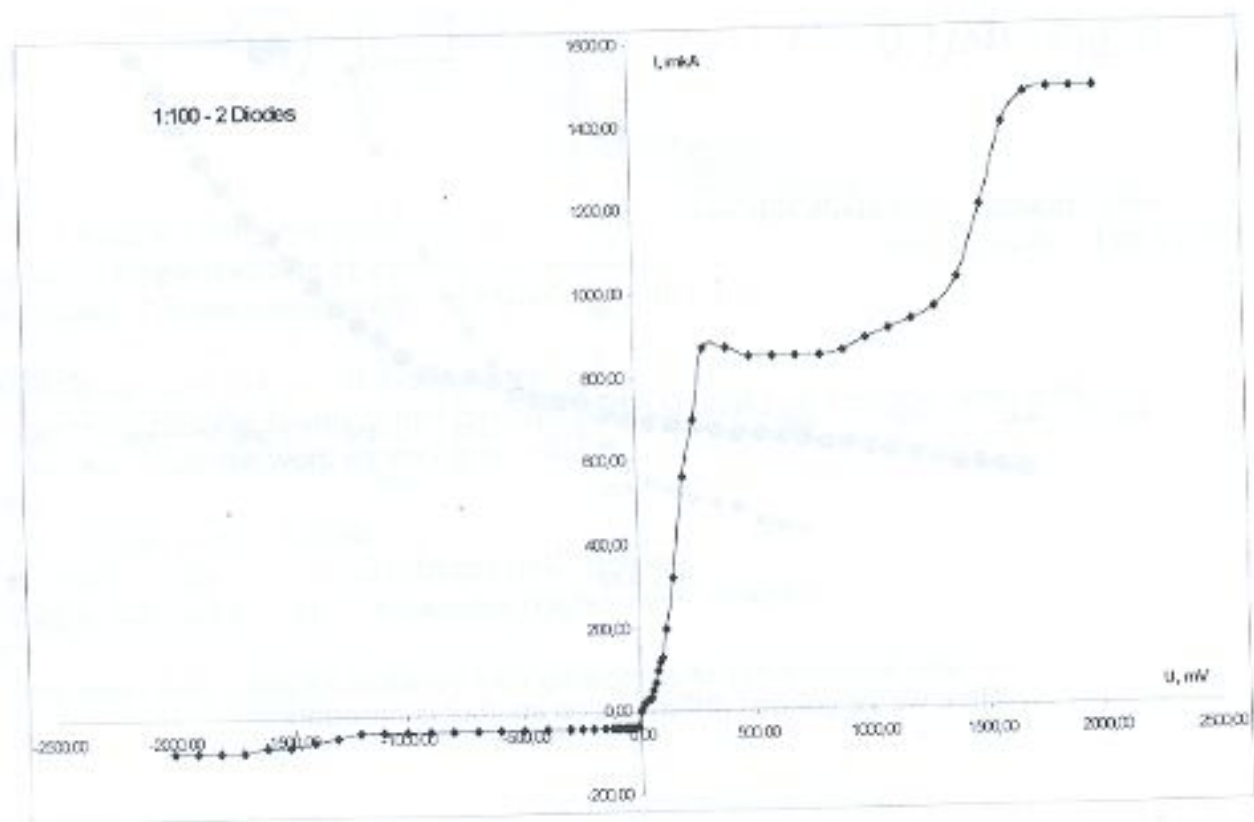
Here we've got real difference on another concentration.

Another data – we used platinum electrodes and got better results.



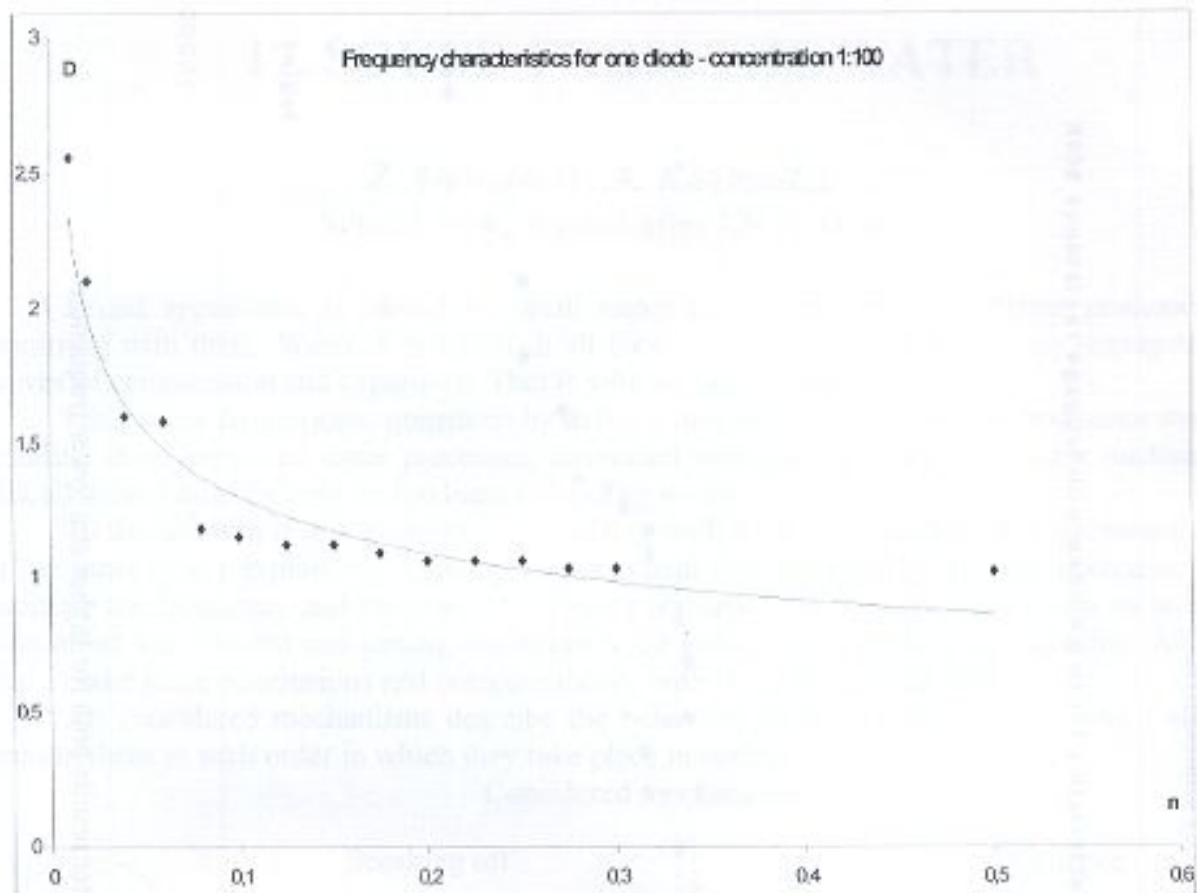
Better result were got on concentration 1:100, recommended concentrations are 1:10-1:500

Now we can say that working range of our diode is  $[-500, +500]$  mV

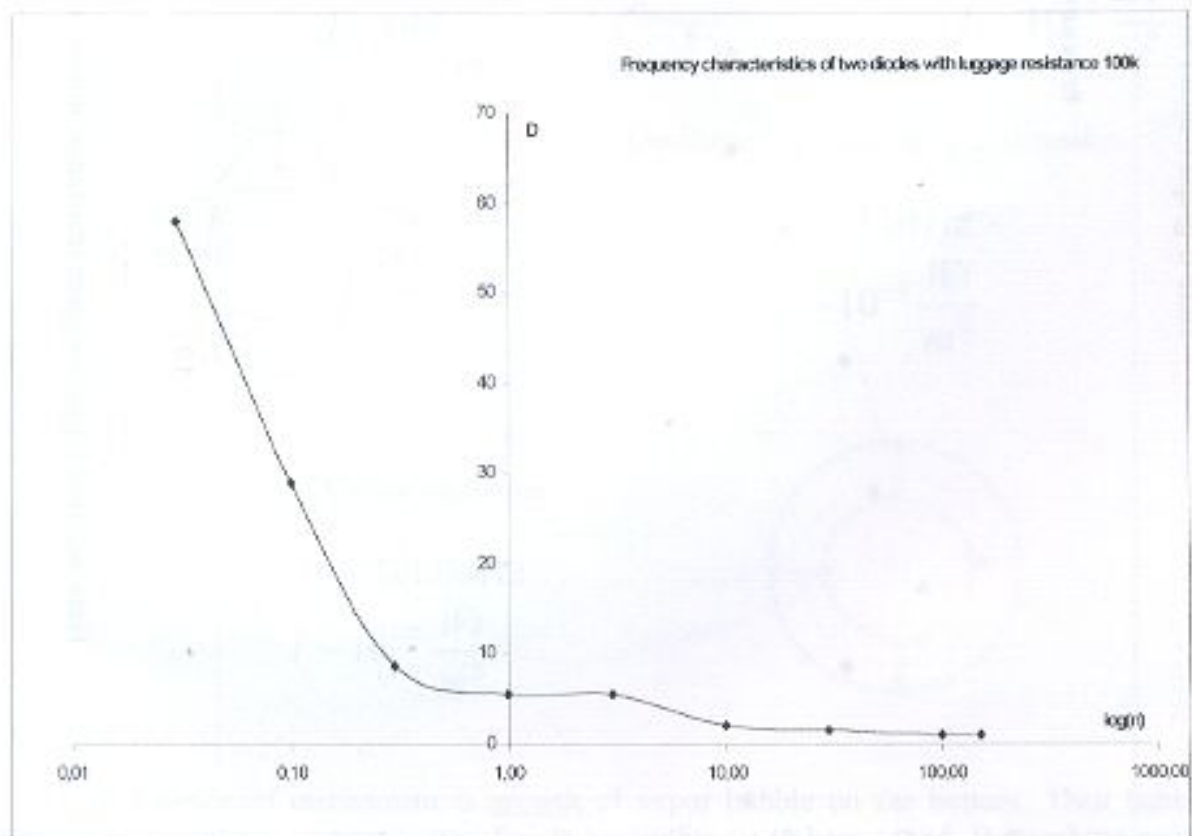




Here are frequency characteristics.



This graph shows us that our diode it self is bad on freq. Higher then 0.1Hz



Here we can see now how big extension we've got using two-diode system. But here luggage resistance is the same order like diode resistance so, on higher frequencies there is no diode effect.

Here is graph which shows us frequency characteristics for

Frequency characteristics for two diodes with luggage resistance 560K

