

The Electro-Voice logo is written in a stylized, italicized font. It is positioned on a black rectangular background that is part of a larger graphic design consisting of overlapping colored squares (yellow, grey, and brown) and illustrations of various microphone types.

MICROPHONE FACTS

OR THE OPERATING ENGINEER

ELECTRO-VOICE, INC. • BUCHANAN, MICHIGAN • PHONE OXBOW 5-6831

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INFORMATION FROM ELECTRO-VOICE'S MICROPHONE LABS

From time to time you will hear from E-V Engineers on various audio subjects. For this letter, I was able to tear my right-hand-man away from development projects long enough to do some writing.

Robert C. Ramsey, our chief engineer for BC, TV and Recording Equipment, has prepared the following information in response to numerous queries on:

MICROPHONE LOADING

Usually, the letters that we receive are concerned with the performance of our microphones in specific applications; for example, the effect of cable capacity on high-frequency response. Because it is difficult to answer this type of question in a letter, it was decided to include a general discussion of microphone loading in this issue of MICROPHONE FACTS.

A microphone without a connected load will still have an output voltage across its terminals. This is the unloaded or open-circuit voltage output. It is this voltage the manufacturer refers to when output level and frequency response is specified.

In most applications, these open-circuit specifications accurately describe the microphone performance since the microphone is usually unloaded. In a typical audio console, the microphone is connected to a transformer that raises the microphone impedance (50 ohm, 150 ohm, 250 ohm) to approximately 50,000 ohms. The secondary of the transformer is connected to an open grid, which is virtually an open circuit; hence the microphone is not loaded.

In some applications, broadcast microphones are connected to impedances equal to the impedance of the microphone. When this occurs, the microphone is loaded and the performance of the microphone differs from that of the open circuit condition. One example of microphone loading is low-level mixing at the input of the console. In this type of installation, the microphone is connected to an impedance very nearly equal to that of the microphone, resulting in a load on the microphone. Another example is in transistor amplifiers, which are usually designed with an impedance match between the microphone and input stage.

To sum up: broadcast microphones are typically used unloaded and manufacturers specifications accurately describe the performance. However, in certain applications, broadcast microphones are used loaded and, when this occurs, the performance of the microphone changes. It is this change in performance that makes the subject of microphone loading important to both the manufacturer and user.

The simplest condition of loading is one where both the microphone impedance and load impedance are the same at all frequencies. This condition occurs when a microphone with essentially a constant impedance is connected to a purely resistive load. The impedance of a Model 655C, rated at 50 ohms, is shown in Figure 1. When this microphone is connected to a 50-ohm resistor, the voltage output changes, as shown in Figure 2. This change can be accurately described as simply a change in level. No change in frequency response is evident as the output has dropped by the same amount at all frequencies. Microphones with essentially constant impedance curves, which would include the E-V Models 655C, 654, 635, 646 and 649A, suffer only a loss in level when connected to a resistive load. This loss is significant only to the designer of the input circuit to be used with the microphone and is of little importance to the user.

One type of loading that is important to the user is the type where the load impedance varies with frequency and results in a change in frequency response of the microphone. An example of a load of this type is the capacitance of a standard microphone cable connecting the microphone to the input equipment. This capacitance has an impedance that decreases with increasing frequency. For long cable runs this impedance can be low enough in the range of 10 to 20 kc to affect the microphone output. The amount that the high frequencies are attenuated depends on the impedance of the microphone and the length of cable used. Chart 1 shows the cable lengths at various impedances that cause a 1-db loss at 10 kc. These cable lengths are the maximum lengths that can be used without introducing noticeable loss in high frequency response.

Another loading condition that is important to the user is that in which the microphones have an impedance that varies with frequency. Mass controlled bidirectional and cardioid microphones generally have impedance curves as in Figure 3. When microphones of this type are connected to a resistive load both a loss in level and a change in frequency response occurs, as shown in Figure 4. The significant change is the reduction in bass response. The reduction shown in Figure 4 is typical. This amount of change would not be heard as a severe degradation in bass, but rather as a coloring of the sound quality. Whether this coloring of the sound is good or bad is a question we have no room to discuss here; rather, it is sufficient to state that bidirectional and cardioid microphones will generally have reduced bass response when connected to a resistive load equal to its impedance.

As the information in this letter indicates, loading broadcast microphones normally will not result in any severe degradation of sound quality. In most applications broadcast microphones are used open-circuited, and loading simply does not exist. With care, cable capacity need not be a problem. Bidirectional and cardioid microphones should be used open-circuited, or with the knowledge that some bass attenuation may be present.

CHART I

Thus far, the normal conditions of microphone loading have been discussed. It has been assumed that the microphone impedance falls within the design limits of the input equipment. In broadcast work the input equipment is rated at 50, 150, or 250 ohms. Broadcast microphones also are rated at 50, 150, or 250 ohms. Obviously many combinations of microphone and input impedance are possible. Under certain extreme conditions of impedance mismatch, the input transformer can act as a load on the microphone.

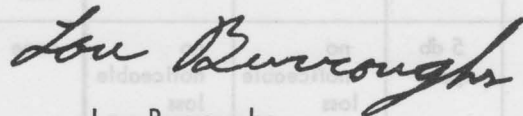
Chart II shows the effect on frequency response and level of each of the possible combinations of microphone impedance and rated input impedance. In preparing the chart it has been assumed that the input transformer is well designed. An examination of this chart shows that, ignoring level variations, the only combination that causes a noticeable change in microphone performance is a 250 ohm microphone used with a 50 ohm input.

Because of space, we can not fully cover special problems of loading, such as would occur with the use of electrical filters. However, as an aid in solving special problems of this type, a general solution of the problem of loading a microphone has been included as an appendix.

- - Robert C. Ramsey

CHART II

Bob's paper is just the beginning. In future issues, there will be more of these "meaty" discussions from our labs. Because "MICROPHONE FACTS" is published specifically for you, it would be a big help to know what information you would like to have. We will be happy to write on any phase of the microphone subject. Just drop us a line and we'll do our best to help you.



Lou Burroughs
Vice President
Broadcast & Recording Equipment

pt
attached

CHART I

Microphone Impedance (ohms)	Cable Length (feet) Causing 1 db Loss at 10 kc
50	920
150	310
250	190

CHART II

RATED AMPLIFIER INPUT IMPEDANCE

Microphone Impedance In Ohms	50-ohm input impedance			150-ohm input impedance			250-ohm input impedance		
	effect on level	effect on 100 response	effect on 10,000 response	effect on level	effect on 100 response	effect on 10,000 response	effect on level	effect on 100 response	effect on 10,000 response
50	none	none	none	5 db loss	none	none	7 db loss	none	none
150	5 db gain	no noticeable loss	no noticeable loss	none	none	none	2 db loss	none	none
250	7 db gain	noticeable loss	noticeable loss	2 db gain	no noticeable loss	no noticeable loss	none	none	none

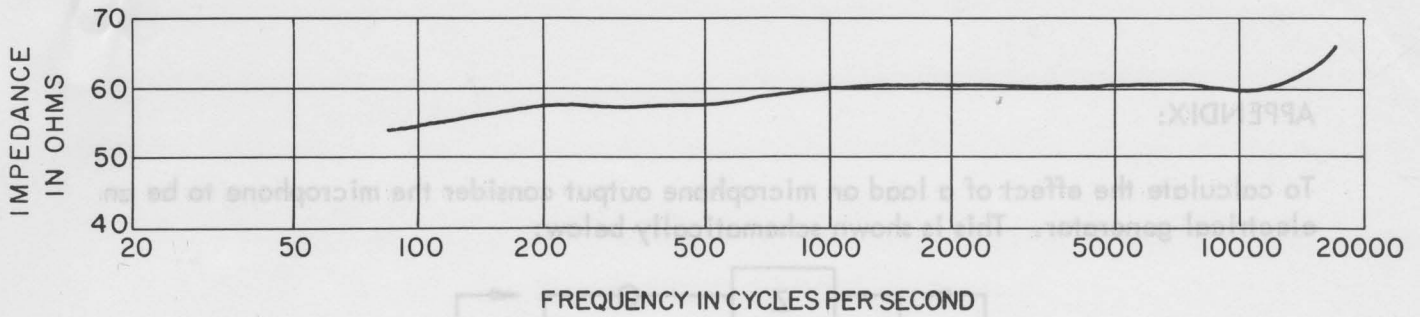


FIGURE 1 - IMPEDANCE OF 655C

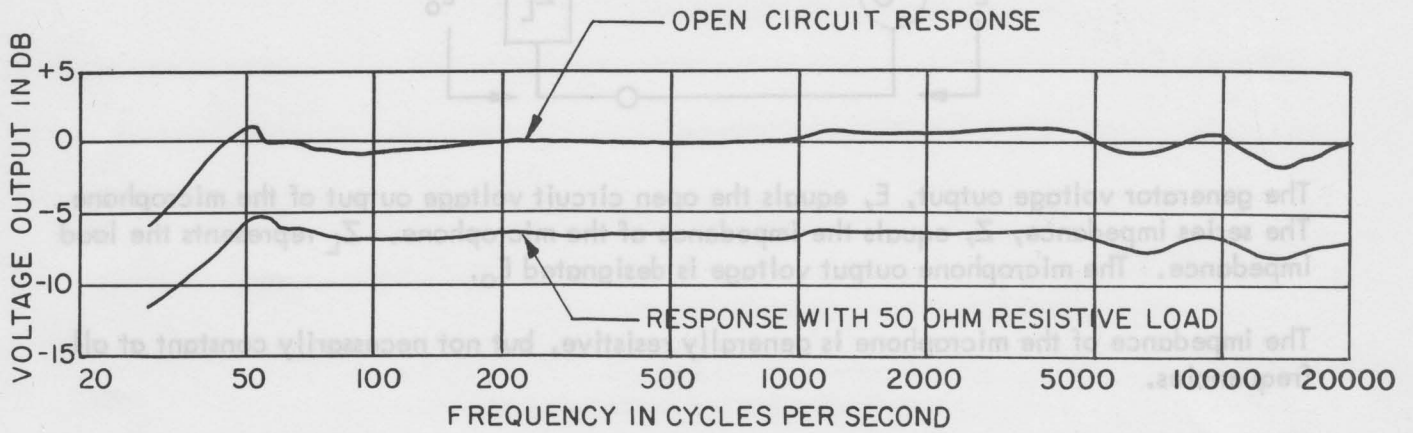


FIGURE 2 - RESPONSE OF 655C

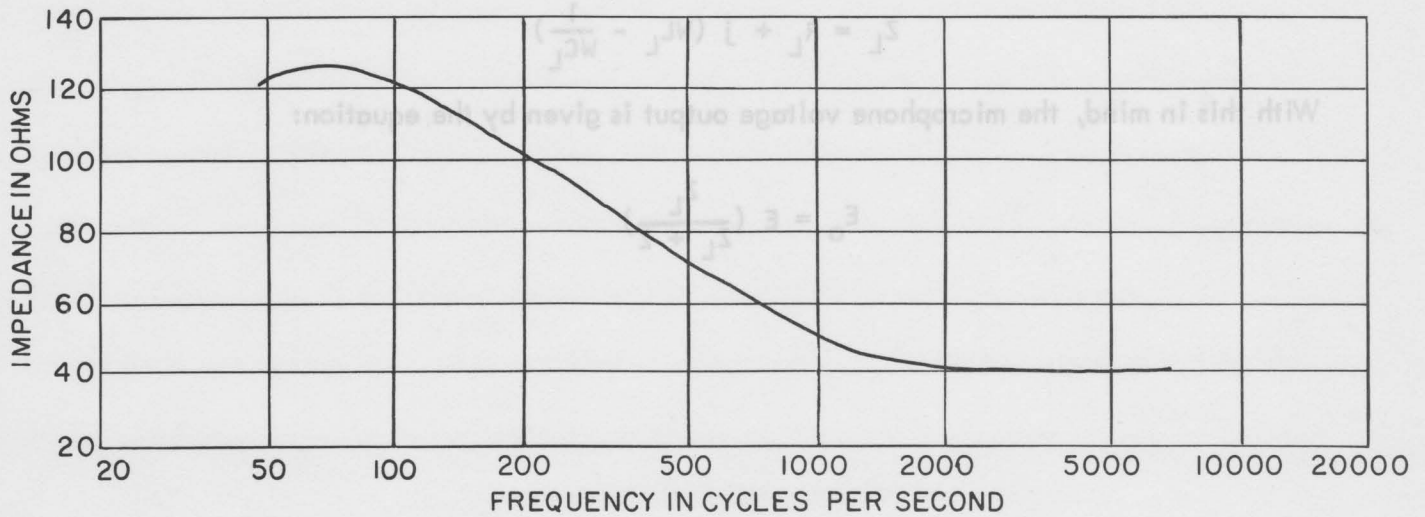


FIGURE 3

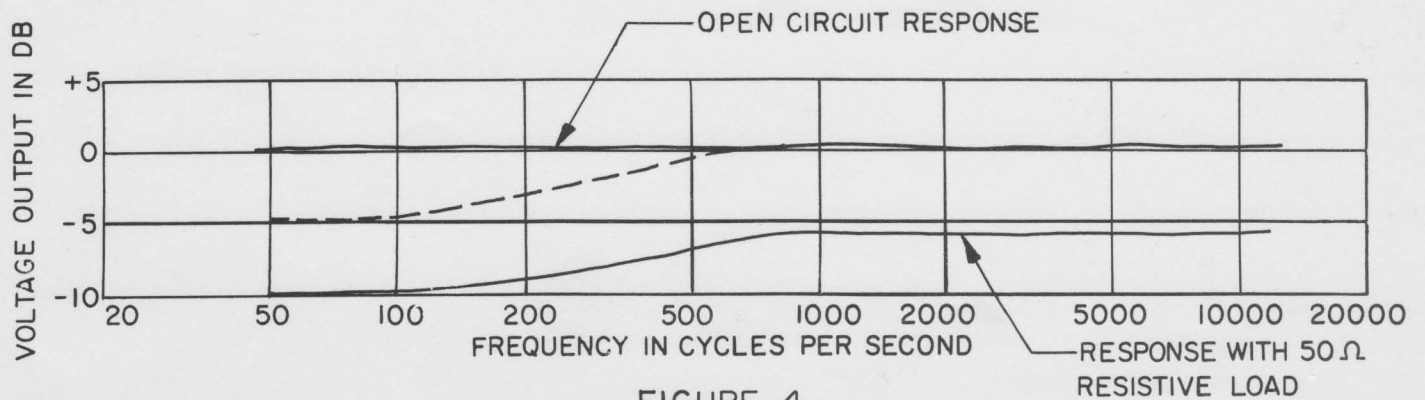
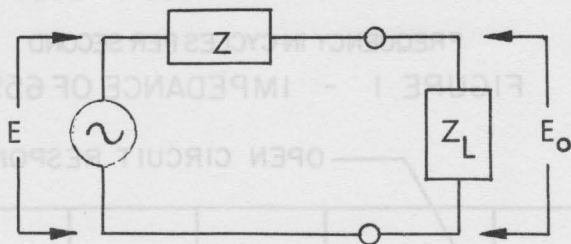


FIGURE 4

APPENDIX:

To calculate the effect of a load on microphone output consider the microphone to be an electrical generator. This is shown schematically below:



The generator voltage output, E , equals the open circuit voltage output of the microphone. The series impedance, Z , equals the impedance of the microphone. Z_L represents the load impedance. The microphone output voltage is designated E_o .

The impedance of the microphone is generally resistive, but not necessarily constant at all frequencies.

The load impedance can be a resistor, capacitor or inductor or a combination and in the general case:

$$Z_L = R_L + j \left(\omega L_L - \frac{1}{\omega C_L} \right)$$

With this in mind, the microphone voltage output is given by the equation:

$$E_o = E \left(\frac{Z_L}{Z_L + Z} \right)$$