db broadcast sound

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• Telephone lines are used for a great many purposes besides normal phone conversations. Program audio is fed over the lines by broadcasters, background music services, as well as special information and marketing information networks for feed to f.m., SCA subcarriers, etc. Many other data signals, such as computer, teleprinter, and telemetry data use telephone lines. Our concern in this article is the use of local lines for sending audio around town rather than some inter-city network arrangements. If you have not had the experience of using telephone lines for audio in the past and are now faced with the prospect, the information given may help you to understand better the problems involved.

BASIC PARAMETERS

When connecting *any* two audio units together by wire circuits, short or long, such as a speaker to an amplifier or a microphone to a pre-amplifier, the two interfacing units must have their electrical characteristics matched properly or the units will either not perform properly or not at all. These characteristics must match even if there is no interconnecting wiring and the terminals are directly tied together. The important characteristics are the impedances of the sending and the receiving units, balanced and unbalanced circuit isolation, and the signal levels.

IMPEDANCES

All audio units are designed around their input/output impedances so that units can be matched up. The impedance matching (or mismatching) affects the units' operations and signal levels, as well as the bandpass achieved, so every effort should be made to match these properly.

Impedance is a value that contains both a resistive element and a reactive element. The resistive element will cause equal loss to all signals in the bandpass, while the reactive component is frequency-dependent and will cause loss according to frequency. This reactive component may be either inductive or capacitive or it may be cancelled out (zero reactance) with only the resistive element remaining.

Inductive reactance is directly proportional to frequency, that is, its value increases as the frequency increases. In audio work, the inductive reactance is usually not a problem unless large chokes, transformers, tape hands or similar inductive devices are concerned. But, except for transformers, these are usually not involved in the input/output impedances.

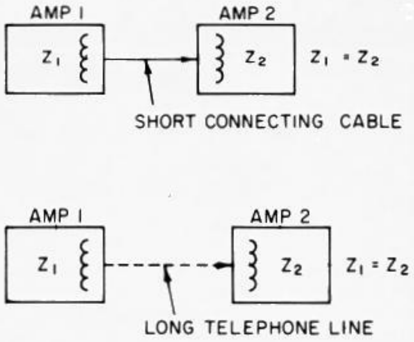

Figure 1. The two audio units must be matched, regardless of the length of line between them, or they won't work properly.

Capacitive reactance, on the other hand, is inversely proportional to frequency; as the frequency increases, the reactance value decreases. This reactive component will cause the most problems in audio work, whether it is designed in series or parallel with the circuit. When in shunt across the circuit, it effectively bypasses the upper audio frequencies before they can reach the load. If it is in series with the circuit, it will discriminate against the *low* audio frequencies.

INTERCONNECTION

When the two units are connected together by short-length circuits in the studio or the building, the interconnecting wiring should not affect the two units. When this is done carefully, except for a few critical circuits, such wiring is mostly not significant to the operation of the two units.

But when we wish to place our audio units across town from each other, the characteristics of the very long interconnecting lines do become very significant and call for more serious treatment. Our basic requirements of the two audio units remain the same, but now the distributed resistance and reactance of the line add up and affect our match considerably.

LINE CHARACTERISTICS

The circuit leased from the Telephone Company will be a balanced, unloaded cable pair. Each wire in this

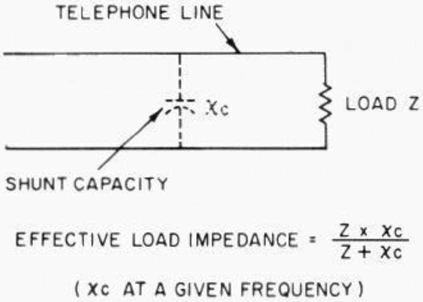

Figure 2. The shunt capacitive reactance is in parallel with the load impedance.

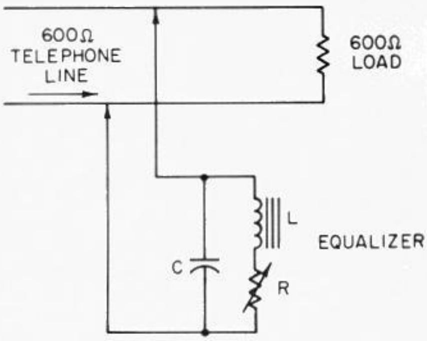

Figure 3. A simple passive equalizer that is a parallel resonant circuit. More sophisticated equalizers are available.

pair will be of very small diameter, usually of 26 gauge. Because of the small diameter of the wire, resistance can be high and will become more significant as the length increases. How much total resistance of the circuit there is depends upon the length of the circuit and the particular type of wire used, but this can typically range from 200 ohms to 500 ohms for one mile of cable length. That resistance will cause a considerable loss to the signal as it passes through the cable.

The same pair of wires will also have an approximately 0.083 μF shunt capacity across them in each mile of cable, adding directly as the cable length is increased. For example, three miles of cable will have a total of 0.249 μF shunt capacity. It doesn't take much calculation to realize what this will do to the higher audio frequencies.

Actual losses due to the resistive and reactive components in the line will be approximately 2.9 dB at 1 kHz, and the losses increase rapidly at the upper frequencies.

EQUALIZATION

Remember that we must still match our two audio units, but now we have a significant amount of resistance and capacitance between them. Unless we can reduce the effect of these components, our audio units won't work properly and signal transfer will suffer in both signal level and response. The counteraction of these line characteristics is called *equalization*. Equalization can be done by the one who orders the circuit, or an equalized circuit can be ordered from the Telephone Company. Naturally, an equalized circuit will cost more than a non-equalized circuit, the price depending on the grade (according to bandpass) ordered.

LOADING

A simple form of loading which the Telephone Company does on their regular voice circuits produces enough equalization to make a reasonably good voice channel. Loading coils are added in series with the circuit at approximately one mile intervals. The actual distance between the coils and the coil value depends upon the particular circuit, but a typical value is 6 mHy. The coils' inductances neutralize part of the line capacity but also increase the normal 600 ohm line impedance to approx. 1,000 ohms. The net result is a bandpass from approximately 300 Hz to about 3200 Hz. Above this figure, the response drops off very steeply. Although this form of equalization makes a reasonably good voice circuit, the line cannot be further equalized to improve the bandpass. The loading coils must be removed when a wider bandpass is required, and a different form of equalization performed.

LOWER THE IMPEDANCE

When the circuit is very long, the first step is to reduce the impedance of the two audio units. That is, if they are normally set for 600 ohm impedance, change the transformer taps to 150 ohms. This process in itself will cause some signal loss, but it will make equalization easier. Since the line capacity is across the load impedance, it will have less effect across 150 ohms than across 600 ohms. For example, a cable three miles in length will have approximately 0.25 μF shunt capacitance. This will have a reactive value of about 650 ohms at 1 kHz, 125 ohms at 5 kHz, and only 70 ohms at 10 kHz. At each of these frequencies, the load impedance will be a parallel combination of the capacitive reactance and the load im-

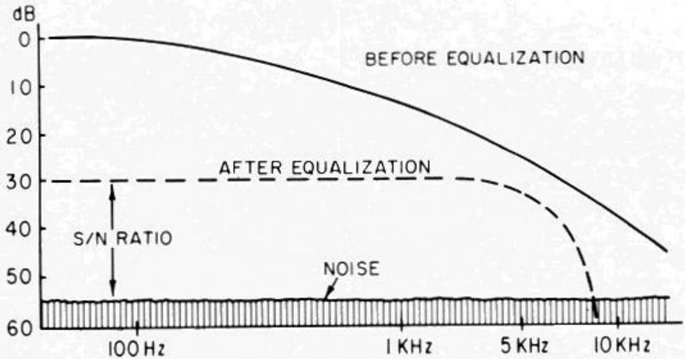

Figure 5. When there is too much equalization, the s/n ratio will suffer.

The two circuits must be identical in amplitude response and phase, or separation will be lost between channels. So, equalize very carefully and make each curve identical. But this won't be easy. Phase is basically line length and there isn't much you can do about that, so consider using one of the electronic phase adjusters, such as the Garron phase enhancer.

SUMMARY

Audio units connected together must be matched or they will not perform properly, and this is so whether they are next to each other or across town from each other. The long telephone line does have distributed capacity and resistance that will make the matching more difficult, or impossible, so its effect must be reduced by equalization. But equalization introduces losses and should not be overdone, since these losses will cause the signal/noise ratio to suffer. If stereo is to be fed over a pair of circuits, match them up very carefully and identically. ■

pedance. If these values are in parallel with 150 ohms, there will be less effect than if they are across 600 ohms.

BASIC EQUALIZER

The basic equalizer introduces a complementary curve to the loss curve of the line. In effect, it lowers the low audio frequency response down to the value of the high frequency response at the limit of the bandpass desired. The simple passive equalizer is made up of an inductance, capacitance and switchable resistors. This unit, when combined with the line capacity, will create a resonant peak to occur somewhere in the upper audio range. By resonating with the capacity, that partially cancels some of the capacity of the line. The lower skirt of the resonance curve is broadbanded by the use of the switchable resistors which lower the resonant circuit's Q.

LOSSES

Equalization will cause considerable signal loss in the circuit; these losses vary with the circuit itself and the bandpass desired. The wider the bandpass, the greater the losses, so keep this in mind and only equalize the bandpass necessary for the program requirements. For example, a circuit intended only for voice signals does not need a circuit with a 15 kHz bandpass. Although the losses must be made up, there is a limit that can be fed into the head end of the line. This is +8 dB at maximum. More than that will cause cross-talk into other circuits and the Telephone Company frowns on that. The higher the circuit losses are, the worse the signal/noise ratio becomes.

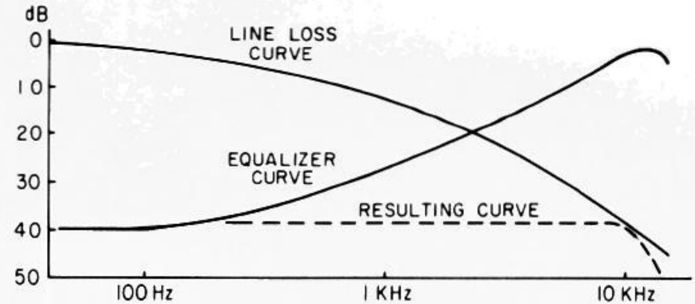

Figure 4. The equalizer curve is adjusted so that it is complementary to the line-loss curve.

NOISE

Telco measures noise differently than we do. They use a noise reference value and figure above this reference, which is set at 90 dB below 1 mW (600 ohm circuit). If the circuit (to them) has a noise figure of 50 dB, this means 50 dB *above* the reference. To us, this is 40 dB *down* from program reference of zero dB, or, if we are sending at +8, the noise level is down —48 dB.

STEREO

When stereo signals will be sent over a pair of lines, the circuits call for more critical consideration. For example, a musical program from an auditorium may be sent back to a recording studio and later receive air play on an f.m. station with its matrix arrangement, or anywhere that the program may be summed for mono use.