Transmitted Frequency Range for Telephone Message Circuits

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IN the Bell System the general objective which has been set up for the transmitted frequency range for new designs of telephone message circuits is a range having a width of 2,500 cycles, extending from about 250 cycles to about 2,750 cycles. In determining the frequency range of such a circuit, the cutoff points are taken as those at which the attenuation reaches a value 10 db greater than that at 1,000 cycles.

This frequency range for design is taken in general as applying to the overall transmission characteristic of the circuit between the terminal central offices of a connection. Where such offices are connected by a direct trunk this frequency range applies to the individual trunk. Where two or more trunks are used in tandem the frequency range of the overall connection will tend to be somewhat less than that of the component parts. For this reason then, to meet the specified range for an overall multi-switch connection, it will be necessary to have the frequency ranges of the trunks which are used as parts of built-up connections, somewhat greater than the specified range for the overall circuit.

In view of the relatively lower cost of toll switching trunks and other similar trunks from toll offices to local central offices, it is desirable that these terminal circuits have a broader frequency range than that specified above, so as to avoid their narrowing the range transmitted by the toll trunks with which they are connected.

It may be stated that the general purpose in working to the transmitted frequency range given above is that each individual trunk should have a frequency range at least as great as that specified and that the frequency ranges of those trunks which are frequently used as parts of built-up connections should be somewhat greater than the specified range.

In setting up the requirements for the various transmission characteristics of telephone message circuits, the aim is to arrive at the combination of requirements which will give the most economical telephone system for furnishing the desired grade of transmission service. Since the effects of many of the factors entering into the determination of this ideal are not susceptible to definite evaluation, the selection of a requirement such as that for the transmitted frequency range, is necessarily a matter of judgment, taking into account the various factors involved.

In Figure 1 are given the results of recent tests showing the effect upon articulation of varying the upper and lower cutoff frequencies of a circuit similar to the Master Reference System for Telephone Transmission. These results apply to the condition of no noise and the received volume at the optimum value. It will be noted from the curve for the variation of the upper cutoff frequency, that the rate

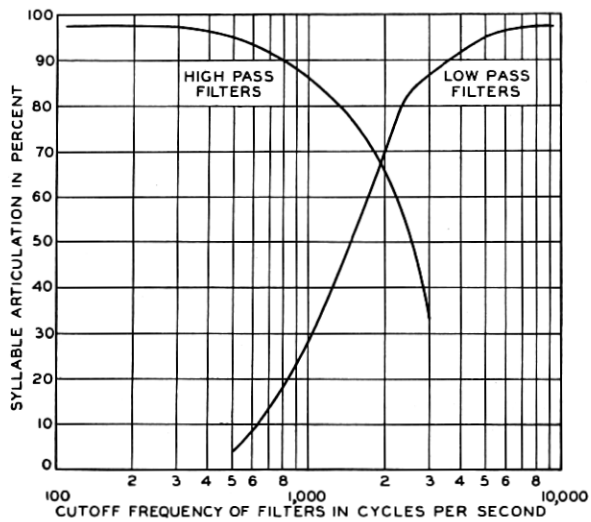
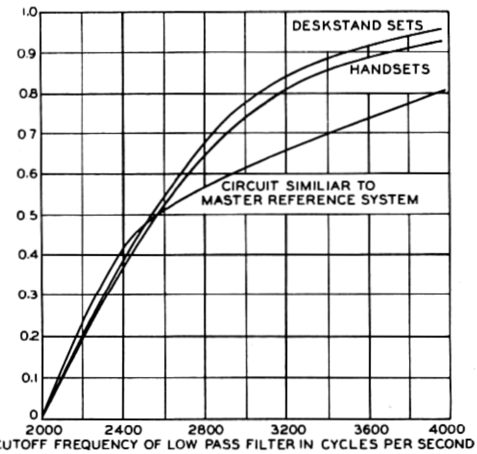


Fig. 1—Syllable articulation of circuit similar to master reference system at optimum received volume under quiet conditions.

of growth is relatively slower above 2,500 cycles than below, and that the total gain in going from this point to infinity is relatively small. Figure 2 shows on a somewhat different basis the upper part of this curve and also, for comparison, corresponding data for circuits having commercial terminal apparatus of the types used in the Bell System. The ordinates for these curves are the ratios of the increase in articulation in going from an upper cutoff frequency of 2,000 cycles to some higher point, to the total change in articulation in going from 2,000 cycles to infinity. For example, referring to the curve for the effect of upper cutoff frequency on articulation of the Master Reference System, it is seen that the articulation for the 2,000-cycle point is 70 per cent, for the 3,000-cycle point is 87 per cent and for infinity is 97 per cent. Increasing the cutoff from 2,000 to 3,000 cycles gives a growth in articulation which is 17/27, or .63, of the total increase in articulation which would be obtained in going to a cutoff of infinity. The values for the other curves of Figure 2 are obtained in a corresponding manner, it being appreciated that the articulation values with commercial instruments are lower than those for the Master Reference Circuit. This method of plotting the results has the advantage of showing the rate of growth of articulation for the three kinds of circuits on a comparable basis.



Ordinate is: $\dfrac{A_f - A_{2000}}{A_m - A_{2000}}$

Where A_f = the syllable articulation with a low pass filter of cutoff frequency f.

A_{2000} = the syllable articulation with the 2000 cycle low pass filter.

A_m = the syllable articulation obtained with no filters.

Fig. 2—Syllable articulation of telephone systems at optimum received volume under quiet conditions.

It is seen from the curves of Figure 2 that raising the upper frequency limit from 2,000 to 2,500 cycles gives about one-half of the total increase which would be obtained in going to an infinite cutoff and raising to 2,750 cycles gives for the commercial instruments about two-thirds of the increase in articulation which would be obtained in going to an infinite cutoff. These curves do not indicate any particular cutoff frequency as a stopping point for commercial circuits but it is considered that going as far as about 2,750 cycles is justified. While there is some articulation advantage in going further, observations of the number of repetitions occurring in conversations over circuits having different cutoff frequencies have indicated but little reduction in repetitions by going beyond about 2,750 cycles with commercial types of terminal sets.

For the lower end of the range, the lower cutoff frequency curve of Figure 1 shows little effect on articulation of cutoffs below 400 cycles.

The selection of the 250-cycle point for the specified frequency range is on the basis of maintaining reasonable naturalness.

It has been found that with present commercial station sets little is gained either in intelligibility or naturalness by extensions of the transmitted frequency range beyond the limits which have been set. This range, moreover, permits effective utilization, particularly from the standpoint of intelligibility, of the capabilities of much better station instruments even if this improved apparatus should approach the ideal in performance. With such terminal apparatus, major extensions beyond the upper frequency limits give improvements from the standpoint of naturalness largely as the result of better reproduction of the fricative consonants and of some of the incidental sounds which accompany speech. The extension necessary to effect a material improvement in this respect is a matter of a thousand cycles or more, rather than hundreds of cycles. It has been considered that such an extension for message circuits is not now justified.

Further in this connection, it must be borne in mind that an extension of the transmission range will in general increase the amount of noise on the circuit and magnify the crosstalk problem. For transmission systems such as carrier and radio where the noise may be assumed to be uniformly distributed over the sideband range, the added noise may be particularly important. Also a widening of the range increases the difficulties of securing proper impedance balances and of equalizing amplitude and phase distortion.

On the basis of these considerations, it has been decided that new designs of telephone message circuits for the Bell System should have an effective transmission band width of at least 2,500 cycles, extending from about 250 to 2,750 cycles. Furthermore, this band width will be made greater in those cases where this can be accomplished without material increase in costs.