Tues. P.M., Rm 355A

NOISE AND BANDWIDTH LIMITATIONS WITH TRANSISTORIZED ANTENNAS

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In recent discussions many arguments have been brought forward against and in favor of transistorized antennas. We have now measurements with 40 transistorized antennas at about 30 frequencies. This enables us to give an outlook of the possibilities and limitations of these antennas.

1. Noise

The sensitivity of a receiving antenna is determined by its noise behavior. According to IRE-standards we can express the noise temperature T_S of a receiving system with transistorized antenna by

$$T_S = T_A + T_T + T_R/G \quad ,$$

where T_A is the noise temperature of the antenna due to external noise, T_R the noise temperature of the receiver, T_T the noise temperature of the transistor and G the power gain of the transistor. For optimum performance T_S should be as low as possible. For a passive antenna without transistor we get $T_T = 0$ and $G = 1$. So T_S is given by the sum of T_A and T_R. Since T_A cannot be influenced, the lowest value of T_S is given by the lowest achievable value of T_R, which for good receivers is about 1000°K. For a transistorized antenna we get $G \gg 1$ and T_R/G becomes very small, so that T_S is approximately given by the sum of T_A and T_T.

For some appropriate transistors we investigated the noise temperature T_T experimentally and theoretically and found it to be extremely dependent on the internal impedance of the signal source, feeding the transistor. This internal impedance has an optimum value, which depends on the transistor and on the frequency. By inserting a transistor at a gap in an antenna, where the antenna impedance is equal to this optimum value, we get noise temperatures T_T as low as 120°K and the improvement in the system noise temperature T_S compared with T_S of a passive antenna is obvious. On the basis of this theory we have designed many low noise antennas at various frequencies and found our experimental results in full agreement with theory. Since for a given frequency the minimum value of T_T is only dependent on the transistor, a further improvement of T_T will only be possible with new types of transistors.

2. Bandwidth

In the following only electrically short antennas will be considered. Hence their bandwidth is determined by the frequency dependence of the impedance. If we consider a passive transmitting antenna, we find that it has a natural bandwidth, which depends only on its physical dimensions. In general, this natural bandwidth is not achieved with passive antennas, since the networks necessary for matching the antenna impedance to a cable or to the internal impedance of a signal generator reduce the effective bandwidth. With transistorized transmitting antennas it is possible to get optimum match between antenna and transistor without special matching networks by inserting the transistor at a proper gap in the antenna. Thus the full natural bandwidth of the antenna can be exploited. A further increase in bandwidth can be obtained by reducing the transistor efficiency.

With a transistorized receiving antenna the bandwidth is about the natural bandwidth, if the antenna is designed for minimum noise temperature T_T. There are many cases, however, where T_T is allowed to have much larger values than the possible minimum, e. g. if the external noise temperature T_A is high. This is especially true for frequencies below 200 MHz. Then the bandwidth of a transistorized receiving antenna can be considerably larger than the natural bandwidth. On this basis we have designed antennas for the HF and VHF-band with very broad bandwidths by introducing a feedback.

For many applications broadband antennas are not required because of the large bandwidth of the signal spectrum, but because of the large operating frequency range. For this case we have constructed transistorized transmitting and receiving antennas, which can be electronically tuned. Some of these antennas are provided with automatic self tuning.

Pictures and measured data of existing antennas will be shown.

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