INTERFERING EFFECT OF NOISE ON SIGNALLING SYSTEMS

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ABSTRACT

Noise is a statistical phenomenon. It has a complex wave form. This wave form may undergo modifications in the process of the transmission of roise through a signalling system. The interfering effect of noise is always with specific reference to the type of signal that the system handles. Therefore, engineering evaluations of noise interference are more complex than the actual physical problem of noise.

Introduction

As ordinarily understood in physics, 'noise' represents sounds in which the energy is more or less uniformly distributed over a considerable frequency range without a definite pitch being present. Our concepts of radio noise began more or less on the same lines. However, because of its extreme importance to the problem of guided missiles and military communication systems generally, radio noise has been the subject of close study and investigations during the last two decades and, quite naturally, the definition of noise itself has undergone a significant change[1]. "Spurious signals which are undesired and often unrelated to the desired signal are always present in signalling systems and their components. Such spurious signals are called noise." Anything spurious either occurs at random or its magnitude or duration changes at random. Noise reduces the amount of useful information that can be transmitted with a specific signal power or adds spurious information which impairs the signal.

Types of noise

Scientifically, noise can be classified into two types only. The first is called fluctuation noise and the second, impulsive noise. Sometimes, there appears in electrical circuits or in nature, a large number of elementary disturbances which are not alike and which are not necessarily related to each other in any conceivably regular manner. It is ordinarily not possible to distinguish the elementary components from each other. The number of such components is extremely large and they show rapid and irregular variations. One gets the impression of some form of continuous process. This type of noise is called fluctuation noise. It can be subjected to Fourier analysis and it gives a continuous statistical frequency spectrum.

Noise that arises within a receiver itself is ordinarily fluctuation noise and its characteristics are well understood. In receivers, two types of noise are known to occur viz., Johnson noise and Shot noise. Johnson noise is caused by the fluctuation of charges or polarisable molecules in lossy materials. Thus, there can be Johnson noise in resistors, imperfect condensers and other components. Shot noise arises from the statistical variation of electrons emitted from cathodes or filaments of tubes. A reasonable theoretical evaluation of these noises have been made.[2—6].

The second type of noise is impulsive noise. The parameters associated with impulsive noise are magnitude, duration and recurrence frequency. In any evaluation of impulsive noise, these parameters have got to be first properly defined. Then, there is the wave form of the actual impulse itself. Ordinarily, all these parameters show statistical variations. Typical examples of impulsive noise are atmospheric noise during the period of peak activity of a thunderstorm and random sparking of elctrical equipment. The physical processes responsible for this type of noise are still not clearly understood. Therefore, rigorous mathematical analysis of such noise in simple terms presents an intriguing problem. A solution to the problem has been given by considering an idealized statistically valid representation of the impulse, its duration, recurrence frequency and wave form[7—10].

For improving the design of military equipment from the standpoint of reliability and secrecy, our understanding the characteristics of impulsive noise is more important. To-day, as aptly understood in the U.S.A. and U.S.S.R., we, electronic engineers, are in the age of guided missiles [11].

Noise Interference

Noise can arise within the signalling system in which case, it is easier to estimate it and allow for it. But, if it arises from sources external to the system either as natural noise or artificial noise created by the enemy, the problem of estimating it and allowing for it becomes more intricate. But, whatever the source, noise is, as indicated earlier, statistical in nature and has a complex wave form. The noise ultimately affects some electro-mechanical system like a loudspeaker, a relay etc. after passing through the different stages of the receiving system. This receiving system is designed for receiving a particular type of signal like speech, morse signals in different forms etc. Hence, the effect of the receiving system in modifying the wave form of noise depends upon the particular system. Therefore, the interfering effect of noise can only be considered with reference to a specific service. Further, the actual interfering effect depends on the final device employed to receive the signal like a relay, ear etc. Each one of these have their characteristics like time constants, the minimum or maximum time upto which the actual signal must last etc. Apart from time duration, even the limits of amplitude may be controlled by suitable circuits. It has to be remembered that, in assessing the interfering effect of noise, we are primarily concerned with the spurious signal that effects the final device for which the desired signal is meant and, this resultant spurious signal will always be different from the noise as it arises at the source.

Whether it be fluctuation noise or impulsive noise, even the parameters of noise that we need depend on the system and the signal it is meant to handle. Thus, we may require *rms* values, peak values, quasi-peak values or average values of amplitude. The Fourier components needed may be restricted to those lying in a certain narrow band.

Noise evaluations

In view of the complexities of the problem, operators in some communication services choose to experimentally determine the noise values etc. Thus, in a broadcasting organisation, noise is recorded on a recorder. It is not realized that the noise wave form as recorded on a recorder is different from what affects the ear.

The time constants of the recorder are different from those of the ear. What the ear misses may go to get recorded or vice versa. Similarly, the stage at which the noise is recorded becomes important. And so on. It follows that experimental determinations without the considerations detailed in the previous section may be of little use.

Sometimes, noise power at a certain stage is evaluated theoretically by using the Fourier transform of the auto-correlation function. This technique may ignore the time for which the averaging is to be done and, quite often certain effects of the signalling system. Even here, the stage at which this noise power is evaluated becomes important.

Noise being statistical in nature, it is obvious that data cannot be provided for 100 per cent of the time satisfactory operation or for success in 100 per cent of the cases. It is easy to provide data for 50 per cent reliability etc., and in some cases where the problem is well understood, for 90 per cent reliability.

It is thus obvious that an approach to the noise problem has got to be based on the considerations outlined in the previous sections. There is no escape from first making some reasonable theoretical approach on the lines indicated. This has to be followed by experimental work. Both theoretical and experimental work must go together, one assisting to improve the other.

The mathematical and physical complexities of the noise problem or the variations of equipment design can never be an excuse for the adoption of arbitrary methods of approach, experimental or theoretical, in noise evaluations. We are living in an age when engineering is a science and no longer a mere mechanical art.

References

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Discussion

Mr. S. Mitra (All India Radio) outlined the method of measurement of atmospheric noise employed in a study on progress in the All India Radio at Delhi, Nagpur and Gauhati. A statistical correlation between the subjective and objective measurements had been established on the data collected by the A.I.R.

Dr. B. N. Singh pointed out that considerable data had been collected during the last war on the protection factor that was necessary for various types of radio circuits and the results were not far wrong as borne out by actual trials.

Lt. Malhotra, I.N. wanted to know whether analysis on the noise characteristics of the signal had also been carried out for telegraph services. Not much information was available on this point.

Concluding remarks by the Chairman

The Chairman mentioned the various problems in which services in general were interested. They would like development of weapons as systems in which electronics played a very important role. Services, it was mentioned, would be interested if research organisations or groups in different parts of the country could pool their necessary information to step up the production of the electronic equipments needed by the services.

The Chairman emphasized the role of tropicalization of equipment in which services were vitally interested. He also pointed out that maintenance problems of weapons and equipments should be simplified so that ordinary soldier could tackle them after necessary training. There was a great necessity of developing raw materials needed for different types of components. With these introductory remarks called upon Mr. Ramamurti to present his paper on tropical testing of equipment.