

COMMUNICATION SCIENCES
AND
ENGINEERING

XXI. STATISTICAL COMMUNICATION THEORY*

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RESEARCH OBJECTIVES AND SUMMARY OF RESEARCH

1. Digital Signal-Processing Techniques

The use of digital computers as tools to process real-time signals is becoming commonplace. Many interesting problems remain to be solved, however. For example, given the equations that define a process, how are the resources of the computational processor organized (or for that matter, what resources are required in a machine) to accomplish the process in some optimum (say, for example, minimum time; or in some time T with minimum resources) manner. Also of interest, particularly in processing signals like radar returns, is the design of filters with both short impulse response characteristics and sharp cutoff characteristics in their frequency responses. One class of filters satisfying a part of these requirements is the nonrecursive filter. (Such a filter has only zeros in its system function and, therefore, has a number of samples in its impulse response equal to the number of zeros in the filter.) Another class of filters showing promise for these applications is a time-variant filter used in conjunction with and to initialize a recursive filter.

Still another example is the work being done on the transformation of signals. Here, transforms similar to the Discrete Fourier Transform are being studied. The objective is to determine the properties of these transforms and also to determine whether "fast" versions (in the sense that the Cooley-Tukey algorithm is a "fast" computational technique for performing the discrete Fourier transform) exist.

J. D. Bruce

2. Random Processes in Electronic Switching Circuits

Switching-time randomness, or jitter, which occurs when a regenerative electronic switching circuit (such as a Schmidt trigger or tunnel diode switch) is driven by a slowly rising signal, can be a fundamental limitation in many important applications, such as in sampling systems, trigger and comparator circuits, and pulsewidth modulators. We have been investigating the mechanisms whereby this jitter is related to the more fundamental shot, thermal, and $1/f$ noise processes that occur in a given switching circuit.

Considerable progress has been made during the past year. A small-signal method of analysis was found¹ which should relate the statistics of the switching-time jitter to the power density spectrum of noise in the circuit for an arbitrary switching circuit. When the method was applied to the tunnel diode switch, the predicted statistics agreed completely with results previously obtained² by other methods of analysis. During the

*This work was supported principally by the Joint Services Electronics Programs (U. S. Army, U. S. Navy, and U. S. Air Force) under Contract DA 28-043-AMC-02536(E), and in part by the National Aeronautics and Space Administration (Grant NGL 22-009-304).

coming year this method will be used to investigate jitter in two-transistor regenerative switches, such as the Schmidt trigger and the flip-flop. In another investigation just completed, the statistics of the first zero-passage time of a class of noise signals superposed on a ramp were empirically obtained by means of a computer simulation.³ The statistics of the first-passage time were discovered to be related in a very simple manner to the noise spectrum and to the ramp slope. This simple result has motivated the present research toward solving this long-elusive problem from a theoretical point of view. Solution of this problem should provide considerable insight into the over-all switching jitter problem.

D. E. Nelsen

References

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3. D. K. Campbell, "The First Zero Passage Time Statistics of a Ramp Plus Noise," S. M. Thesis, Department of Electrical Engineering, M. I. T., September 1968.