

IV COMMUNICATIONS AND RELATED PROJECTS

Staff Professor L B Arguimbau
Professor R M Fano
Dr S Goldman
Professor E A Guillemin
Professor Y W Lee
T P Cheatham, Jr
G E Duvall
W C Galloway
J Granlund
E R Kretzmer
D M Powers

A MODULATION STUDIES SPECTRUM UTILIZATION, EFFICIENCY OF POWER UTILIZATION, SIGNAL-TO-NOISE RATIOS

1 Pulse Modulation Studies

Staff E R Kretzmer

A new phase of this project has been started during the last quarterly period, the object being to determine the characteristics of certain types of pulse modulation with regard to interference. Attention will be focussed on common-channel interference between two pulse waves and on multipath interference. Because of its simplicity, pulse duration modulation (PDM) is being investigated first, to be followed later by a similar investigation of pulse position modulation (PPM), which is presumably of greater practical significance. It is expected that the results will also throw some light on the situation for other types of pulse modulation using pulses of constant amplitude and constant radio frequency. A search of the literature has uncovered relatively little work on the subject and indicates that further investigation seems justified.

Experimental work has started on common-channel interference. Two PDM transmitters and one PDM receiver, suitable for interference tests, have been built. Since the effect of many variables must be determined, numerous controls have been incorporated in the equipment. Among the variables are the carrier frequencies and the pulse repetition frequencies of the pulse waves generated by the two transmitters, the duty factors of the pulse waves, the limiting and clipping levels of the receiver, and the receiver bandwidth. Preliminary qualitative interference tests show an annoying beat between the two pulse repetition frequencies, this can be avoided by making the difference between the pulse repetition frequencies sub-audible, and there is then relatively little interference from the weaker of the two signals so long as it is below the receiver clipping level.

Some preliminary mathematical work on common-channel interference in PDM has also been started, this involves probability calculations and is rather complex unless simplifying assumptions are made about pulse shapes and other variables. It will be attempted to support and supplement experimental work with theoretical analyses whenever possible.

A special PPM detector has been devised on paper which is thought to reduce certain interference effects, it should decrease considerably the disturbance which results when some of the transmitted pulses fail to reach the detector.

2 Properties of Random Noise

Staff G E Duvall

Since the last progress report some preliminary observations have been made on temperature-limited noise in a diode. The results of these rough observations were entirely unreasonable in the light of the simple theory of temperature-limited noise. More careful investigation of the experimental conditions revealed that the plate resistance of the diode is small enough under the operating conditions to have a serious effect on the measurements.

It was also found that the minimum diode noise that could be detected was considerably greater than expected. This has led to a reconsideration of the theory of the measurement. Indications are that the ordinary definition of noise figure of an input circuit must be modified somewhat to obtain a quantity which has direct significance for this experiment. The basis for this modification is the difference in impedance between the experimental diode and the diode-connected WE708A used as a standard.

The notion of using a tunable frequency input circuit is being given up at least temporarily in favor of a fixed frequency circuit because of the difficulty of constructing a tunable amplifier that is stable over a wide band.

3 Noise Reduction and Range in Radar and Communication

Staff Dr Stanford Goldman

A theoretical analysis of the problem of noise reduction and range in radar and communication has been completed and the results will be issued as Technical Report No 32, "Some Fundamental Considerations Concerning Noise Reduction and Range in Radar and Communication." This material will also be presented at the National Electronics Conference in Chicago in November. The following is a summary of the report.

A general analysis based upon information theory and the mathematical theory of probability is used to investigate the fundamental principles involved in the transmission of signals, through a background of random noise. The first half of the paper is devoted to a development of the theoretical background of the problem. In the second half of the paper three general theorems governing the probability relations between signal and noise are proved and one is applied to investigate the effect of pulse length and repetition rate on radar range.

It is also shown how and why extra bandwidth can be used for noise reduction and it is pointed out that most noise improvement systems are based upon coherent repetition of the message information either in time or in the frequency spectrum. It is also pointed out why more powerful noise improvement systems should be possible.

The general mechanism of noise improvement thresholds is discussed and it is shown how they depend upon the establishment of a coherence standard. The reason for, and the limitation of, the apparent law that the maximum operating range of a communication system, for a given average power, is independent of the type of modulation used, is then explained.

The possibility of using extra bandwidth to reduce distortion is also pointed out. General ways in which improvements in range of radar and communication systems may be made are also discussed.

B STABILIZED OSCILLATOR PROBLEMS

Staff W C Galloway

A set of equipment has been constructed and assembled for measuring the distortion in the frequency-modulated output of a stabilized microwave oscillator. A great deal of time has been spent in adjusting the equipment and aligning the wideband discriminator of the receiver.

Preliminary measurements show that the open-circuit loop gain of the stabilizing system is approximately 200. This gain is sufficient for the measurements that are contemplated. Sixty-cycle noise in the system is low enough in magnitude so that no undue trouble is expected from this source.

The study will proceed with distortion measurements of the frequency-modulated output and comparison of these measurements with calculations.

C MULTIPATH TRANSMISSION

Staff Professor L B Argimbau
J Granlund

Since the last report a more careful study has been made of the operation of the experimental receiver. Various faults have been observed, in particular, the limiter action is inadequate and the discriminator balance condition is much too critical. Multipath distortion tests indicate that these defects increase the distortion by something like 6 db above the theoretical values. A receiver employing 10 stages of crystal limiting is being constructed to improve the operation.

D RESPONSE OF NETWORKS TO FREQUENCY TRANSIENTS

Staff Professor E A Guillemin
D M Powers

As a result of the difficulty of removing the envelope function from the expressions involved in the Superposition Integral when this integral is used in the determination of the response of electrical networks to frequency transients, attention was next turned and for the past three months directed, to a study of contour integration as a means of solving the problem.

The method of deforming paths of integration in the complex plane to pass over the saddle points of the function in such a way that the only important contributions to the integral are at the saddle points is known as the saddle-point method of integration. It is particularly appropriate for the case of functions involving exponentials, the case

at hand. If the paths across the saddle points are properly chosen the result appears in simple form. Contour integration has been used in the evaluation of inverse Laplace transforms proceeding from a complex function of frequency to the corresponding function in the time domain. The saddle-point method of integration is a powerful extension of this type of integration.

In the problem under study the starting point is a known function of time, for example an FM wave. This must be transformed to the frequency domain where it is multiplied by some network function. An inverse transformation to the time domain then yields the answer. However, the direct transforms of the functions under study are not known, and thus part of the problem is to discover them. The way this will be done is to treat time as a complex variable and to find the direct transformation by the method of saddle-point integration. This idea has been applied to known transform pairs with success, this yielding a novel way of obtaining such pairs.