RADAR APPLICATIONS OF ACOUSTIC SURFACE WAVE DEVICES

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ABSTRACT

The concept of radar system cost reduction through the application of advanced technology is discussed. Emphasis is placed on the complex signal processing requirements of the Ballistic Missile Defense phased array radar and applications of surface wave devices which can simplify the system.

INTRODUCTION

Radar system design requires a multitude of tradeoffs which are directed toward a single goal; the development of a system which satisfies specified technical requirements at the lowest possible cost. While it may seem an oversimplification to state a cost objective as the ultimate criteria for successful system design, it is a fact that systems that are not cost effective will not mature in today's defense environment. By cost I do not mean just development and/or acquisition cost; but so-called life cycle cost which includes the former plus operation and maintenance costs over the anticipated life of the system.

Developers of advanced technology often prefer to view their efforts as providing new or enhanced capability rather than as means for reducing system cost. Sometimes this is true, but more often than not the real contribution of technology research and exploratory development is a simplification of the system to which it is applied with attendant cost reduction. The technologist should realize that the system designer is charged with a cost objective and will view with suspicion any new technology, however promising, until it is proven in a successful application.

Acoustic surface wave technology has reached the point in its development where it is a serious candidate for system applications. By this I mean that the performance of some devices has been successfully demonstrated to the satisfaction of the hardware system engineer so that he is confident that the virtues of the technology are real and he is aware of the limitations. The most striking example of a successful application is the dispersive network utilized in pulse compression where the surface wave device nicely fills the bandwidth gap between a few and several hundred megahertz. This successful application lends credibility to claims for more complex networks and provides the technologist with the system designer's support which is essential to continued development of any technology. Acoustic surface wave technology holds the promise of yielding devices which can simplify the complex signal processing subsystem of the modern radar. Nowhere is this need for simplification more pressing than in the Ballistic Missile Defense (BMD) phased array radar.

BMD PHASED ARRAY RADAR

The BMD radar is required to search, acquire, and track-to-intercept reentry vehicles which are imbedded in a dynamic clutter mass consisting of fragments, wakes, and penetration aids. All the designation and discrimination techniques which have optimized to the reentry vehicle characteristics must be employed to permit high-confidence intercept of the reentry vehicles outside of the defended area.

The BMD radar consists of a number of phased array faces with transmitter and receivers, a signal processor, and a data processor. The fundamental resources of this system are transmitter energy and data processor capacity. These resources must be utilized efficiently if a cost-effective system is to be realized. All the logic for performing the function of search, acquisition, bulk filtering, discrimination, and tracking resides in the data processor. Since even the largest data processing computer can be saturated easily by a radar of modest capability in the BMD environment, substantial signal processing on the radar side of the radar/computer interface is required to optimize the information going into the computer.

A practical BMD radar for terminal defense will require from twenty to thirty separate waveforms to permit all its functions to be accomplished. These waveforms may be categorized as follows:

Chirp Pulses	Several pulse widths to permit efficient transmitter energy utilization; several bandwidths for search, track, and discrimination.
Pulse Pairs	Several pulse widths, bandwidths, and spacings.
Pulse Bursts	Several bandwidths, pulse spacings, and pulse widths.

All waveforms require matched filters to correlate the chirp modulation permitting threshold detection. Additional processing is required for the doppler waveforms to reduce the total data volume and/or rate to a level acceptable by the computer.

SIGNAL PROCESSOR CONFIGURATIONS

Based upon these requirements, the signal processor designer could easily tabulate requirements for twenty types of dispensive filter as well as several tapped delay line pulse burst correlators. The overall complexity of such an analog processing subsystem would be dominated by the I.F. multiplexing required to select the proper sets of filters on a pulse-by-pulse basis.

Given a subsystem of this complexity, a natural alternative to the analog processor is a digital mechanization. Since signal processing is essentially a filtering operation, some form of a convolution process could be implemented digitally which could accommodate all the waveforms by simple changes in the filter coefficients and would additionally be amenable to waveform change through modification of the coefficient memories. The canonical configuration is illustrated in Figure 1. In this representation, the convolution process is implemented in a conventional form involving Fourier transforms. Other more specialized implementations are possible with an accompanying reduction in the amount of hardware and in operational flexibility. Such a digital processor could require 20 to 25 thousand medium complexity, integrated circuits and is therefore a substantial machine.

The primary difficulty with the digital processor is the exponentially increasing cost and complexity as a function of increasing signal bandwidth. All range processing of signals with 40 to 60 MHz bandwidth is within the state of the art.

My representation of the digital signal processor as a convolution processor permits a direct comparison with a recently demonstrated acoustic surface device: the surface wave convolver. If this device matures as has been postulated, it could perform the previously described signal processing task with a fraction of the hardware required for the digital system.

The magnitude of this potential hardware can be illustrated by observing the results already obtained with the surface wave device in a practical application. Figure 2 shows the wide bandwidth, All Range Processor (matched filter) developed by Lincoln Laboratory and installed on the ALCOR radar at the Kwajalein Missile Range. Approximately one-half of this equipment is being replaced by the acoustic surface wave Reflect Array Compressor also developed by Lincoln which is shown in Figure 3. Again, I must stress that the significant factor in this achievement is not size reductions, but is reduction in complexity which inevitably results in a savings in cost.

SUMMARY

The complex BMD radar must employ every signal processing trick to successfully perform its mission at a reasonable level of cost. Acoustic surface wave technology has already demonstrated its worth in applications such as pulse compression networks and transversal filters. Continued development of more sophisticated devices will hopefully yield equally impressive results leading to further radar system simplification and economies.

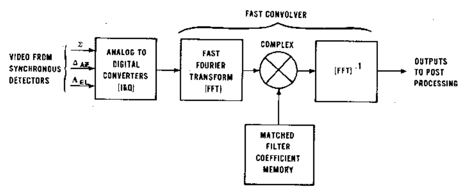

Figure 1 - A Radar Digital Signal Processor

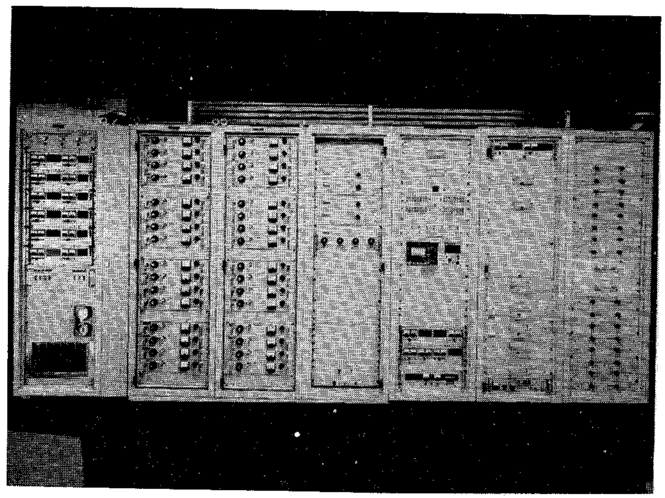

Figure 2 - ALCOR Wideband All Range Processor
Courtesy: MIT/Lincoln Laboratory

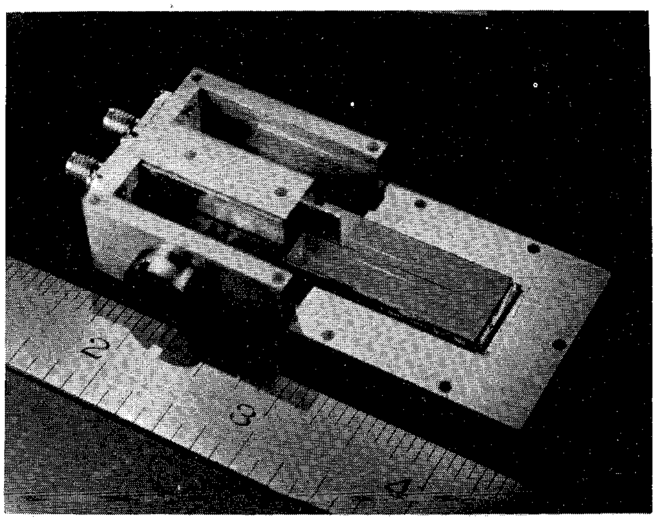

Figure 3 - Reflect Array Compressor (RAC)
Courtesy: MIT/Lincoln Laboratory