tained with this circuit are shown in Fig. 5(b). It is seen that a very good match has been obtained for both the incident pulse and the first echo. (The entire matching network and transducer are now effectively lossless.) The fact that higher order echoes are not as small as the second echo is believed to be due to off-axis propagation effects.

The active matching networks used to demonstrate feasibility exhibited very narrow bandwidths. (This is the reason that the "ears" appear on some of the pulses in Figs. 4 and 5.) For example, the bandwidth over which the input VSWR is less than 2.0 is only 0.35 percent (the minimum VSWR within this band is less than 1.05). However, the circuit used was not designed for optimum bandwidth. It should be possible to design a broad-band matching network using standard techniques and assuming ideal, lossless circuit elements and transducers. The inductors would then be realized using ICC circuits and transducers having more than two ports, such as surface-wave transducers. In this case, the transducer is also important for maintaining low insertion loss. Thus, the triple-transit echo can virtually be eliminated without the need for large acoustic diffraction losses. These results open up the practical possibility of cascading such delay lines to form a tapped delay line configuration.

2) Lumped-circuit techniques can be used both for designing and realizing the matching networks. This results in a size for the matching network that is commensurate with the size of the delay line. Also, conveniently variable lumped elements are more easily realized than are variable distributed elements. Lumped-circuit techniques are probably suitable for frequencies well into S-band, especially if integrated-circuit techniques are used.

3) The technique of using a negative resistance to compensate for a positive series resistance in the transducer is also important for transducers having more than two ports, such as surface-wave transducers. In this case, the technique can be used to reduce the insertion loss even though a match at all ports cannot in general be obtained.

In some applications it may be necessary to trade off these advantages against a loss in dynamic range since the input power to the matching circuit is presently limited to less than one milliwatt. The limitation is not one of power dissipation, but rather of nonlinear cross modulation in the transistor. Also, the noise figures obtained with active matching circuits should be comparable to the noise figures that are obtained using the same transistors in an amplifier configuration.

ACKNOWLEDGMENT

The authors would like to thank D. K. Adams and L. Young for many stimulating and informative discussions, W. L. Cornelius and M. DiDomenico, Sr., for their excellent technical assistance in constructing the microwave delay line and transistor circuits, and W. A. Crofut and T. M. Reeder for their critical reading of the manuscript.

R. Y. C. Ho
A. J. Bahr
Stanford Research Inst.
Menlo Park, Calif. 94025

Analog Matched Filter Using Tapped Acoustic Surface Wave Delay Line

Abstract—VHF experiments are described employing 11- and 50-tap surface acoustic wave delay lines fabricated on crystalline quartz as analog matched filters. Excellent correlation characteristics were observed for a 63-bit maximal length biphase code.

Recent work has resulted in a thorough understanding of the electromagnetic-acoustic

Manuscript received June 18, 1969.

CORRESPONDENCE

The feasibility of using a multiple tapped surface wave delay line for analog matched filter applications (biphase correlator) has been investigated with excellent results. The response of the 11-tap line (with all 11 taps connected together) to an RF pulse of 200 ns (individual taps) has been experimentally determined to vary by 30 parts per million per °C over the temperature range 20 to 60°C.

The tapped surface wave delay line approach to analog matched filter implementation has considerable application potential. Examples include communications systems employing synchronous code detection, data demodulation, or variable data detection. Inherent advantages of this approach over digital matched filters are absence of Kirchhoff adder, invulnerability to CW interference, and operation at high speed with no dc power. Practical factors which will determine the utilization of the tapped surface wave delay line such as maximum frequency, maximum bit rates, maximum number of taps, cost, and reliability are under investigation.

ACKNOWLEDGMENT

The authors wish to thank J. H. Collins and B. L. Elvig for their contributions to this study.

S. T. COSTANZA
P. J. HAGON
L. A. MACNEVIN
Autonetics Division
North American
Rockwell Corp.
Anaheim, Calif. 92803

Dispersive Rayleigh Wave Delay Line Utilizing Gold on Lithium Niobate

Abstract—The dispersion characteristics have been obtained for a gold film overlay on lithium niobate into which Rayleigh waves around 100 MHz are injected. Phase and attenuation measurements are conducted continuously as the gold film is deposited under vacuum conditions. Linear increase of delay with frequency is observed for a gold thickness approximating 5000 Å.

Measurements at frequencies around 100 MHz on dispersive Rayleigh wave propagation are reported here for propagation on a piezoelectric, lithium niobate delay line that is coated with a layer of gold of thickness...