ACOUSTIC SURFACE WAVE SEQUENCE GENERATORS AND MATCHED FILTERS WITH ADJUSTABLE TAPS

D. A. Gandolfo, G. D. O'Clock, and C. L. Grasse
RCA Advanced Technology Laboratories, Van Nuys, CA 91409

Summary

A hybrid combination of an acoustic surface wave tapped delay line and semiconductor switching devices is used to generate bi-phase coded sequences and to serve as the matched filter for these sequences. The switches permit the phase of a tap to be changed by 180° so that complete code flexibility is achieved.

The usefulness of acoustic surface wave devices as sequence generators and matched filters for bi-phase codes has been widely recognized. In these devices each tap represents a digital bit and the polarity of the bit (i.e., "1" or "0") is determined by the phase of the tap which in turn is determined by the manner in which the tap is connected to the rf summing bus. Devices which generate and correlate a fixed sequence have been demonstrated in several laboratories; however, these fixed code devices have limited utility. In order for the surface wave correlators to realize the broad utility of which they are capable, means must be developed to achieve code flexibility, i.e., the ability to change the phase of a given tap by 180° in a controllable way. This paper describes our efforts toward that end.

We have developed code-flexible sequence generators and correlators such as the device pictured in Figure 1. This device is a composite consisting of an acoustic surface wave device and several diode switches mounted on a hybrid circuit board. The surface wave device is YZ $LiNbO_3$ with interdigital transducer/taps. It may be noted that some of the taps are hard-wired directly to the rf summing bus while others are connected to the summing bus through the diode switches. The hybrid circuit also incorporates diode bias connections. The operation of a single switchable tap is illustrated in Figure 2. TG (i.e., transmission gate) 1,2,3,4 are diode switches. With TG1,3 open and 2,4 closed the tap has a given polarity (e.g., digital "1"). With TG 2,4 open and 1, 3 closed the opposite polarity is obtained (digital "0").

In experiments with devices like that shown in Figure 1 we have observed controllable 180° phase shifts at given taps. The insets in Figure 1 show sequences generated by devices with switchable taps. The upper photo shows the sequence generated when three consecutive taps have the same polarity (....111....) while the lower photo shows the sequence when the polarity of the middle tap of the three is reversed (....101....). The phase shift between adjacent bits of opposite polarity is evident. It is also evident that there is very little difference in amplitude and distortion between those bits which are hard-wired directly to the summing bus and those which are connected through the diode switches.

A further series of experiments involved two devices similar to that pictured in Figure 1. One such device served as the generator of the bi-phase coded sequence while a second device served as the matched filter or correlator for this sequence. The results are summarized in Figure 3. Figure 3(a) shows the coded sequence generated by one of the devices while Figure 3(b) shows the correlation signal observed when the coded sequence is input to the correlator.

Several different semiconductor device types were considered for use as transmission gates and three of these were actually used successfully. These were discrete, beam-leaded PIN and Schottky barrier diodes and arrays of silicon-on sapphire diodes. Desireable characteristics include small foreward resistance, small capacitance and large reverse resistance. Since most systems envisioned require a large number of taps, availability in integrated arrays is also important and for this reason the SOS diodes are very attractive. The control logic circuitry required to store the desired codes and to impress the appropriate biases on the transmission gates may also be implemented in the SOS format so that integrated circuits containing both functions are possible.

We believe these results to be significant because they demonstrate the feasibility of acoustic surface wave correlators with code-flexibility. These devices should be useful in a wide variety of communications systems where they may offer significant advantages over purely digital matched filters.

The authors are grateful to R. Geshner, J. Mitchell, P. Schnitzler and D. Kleitman for device fabrication, and to E. Schmitt and J. Vollmer for program support.

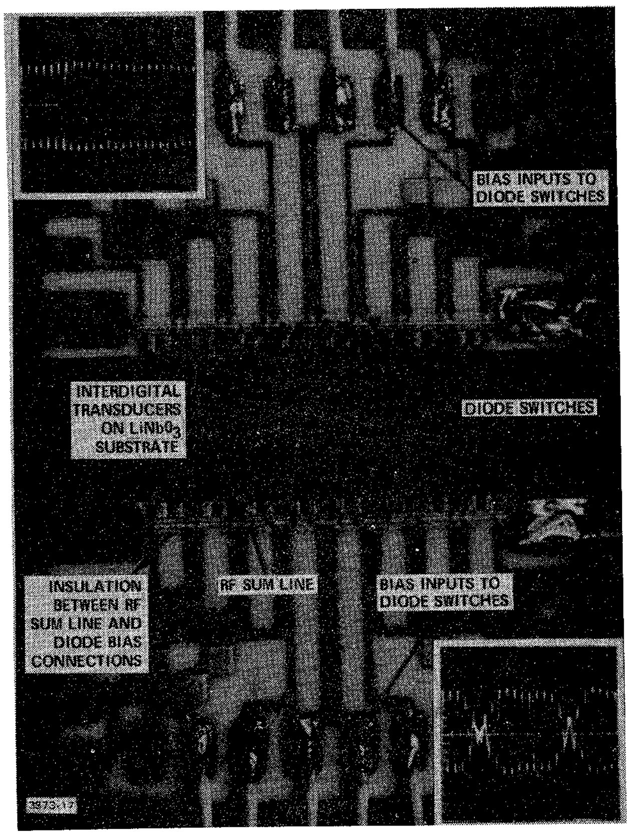

FIG.1 - Acoustic Sequence Generator with Adjustable Taps. Waveforms show (....111....) and, after phase reversal of one tap (....101....).

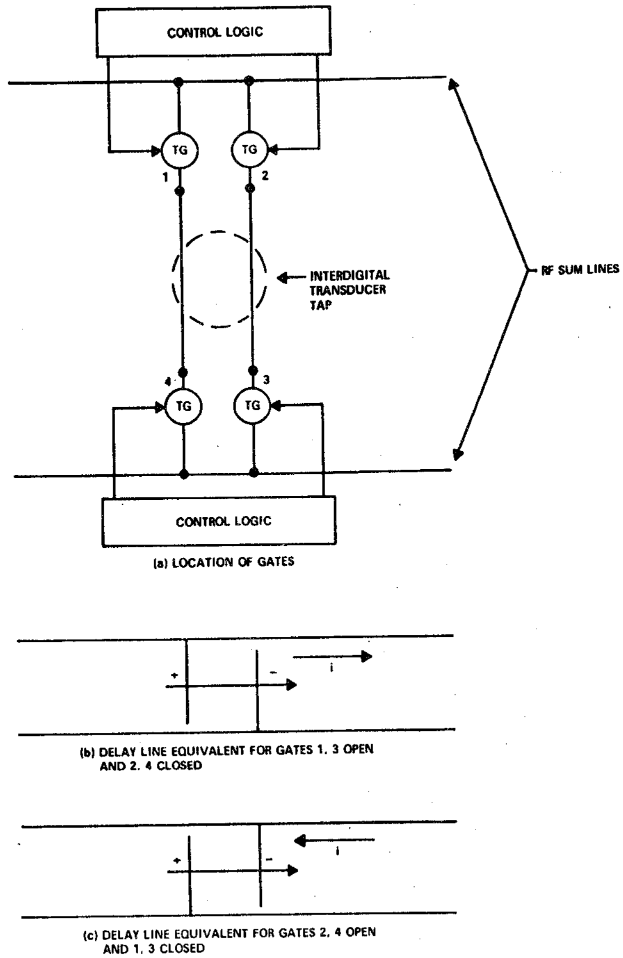

FIG. 2 - Operation of a Switchable Tap

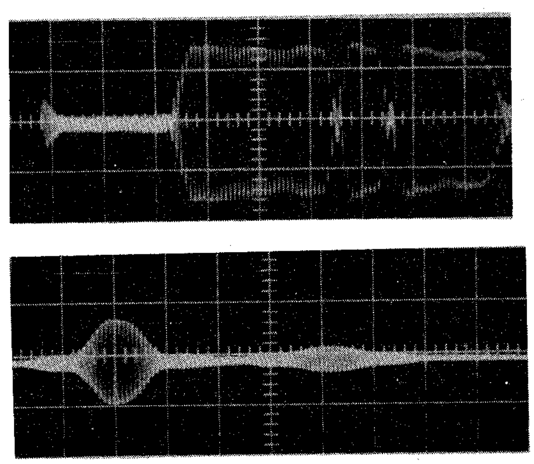

FIG. 3 - Coded Sequence (upper photograph) and Autocorrelation Function Obtained from Devices Similar to that in Figure 1.