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A REVIEW OF SURFACE ACOUSTIC WAVE DEVICES AND THEIR CURRENT APPLICATIONS

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Millions of SAW bandpass filters are produced each year for TV IF application. Recently SAW resonators for oscillators at 680 MHz and other frequencies in CATV set-top convertors have reached volumes of tens of thousands per month. New applications for filters, resonators, and coded devices in security and identification systems are nearing high-volume production. Military applications have increased steadily over the last decade with some production programs requiring thousands of SAW components per year. Clearly, in recent years the use of SAW filters has increased dramatically. This paper reviews the present state-of-the-art performance of production SAW devices and their commercial and military applications.

One of the earliest uses of SAW devices was in pulse compression and expansion filters in radar systems. For example, compressor and expander filter pairs are used in the E-2C aircraft. Reflective Array Correlator (RAC) techniques have increased the performance range in these applications to more than 100 usec of dispersion while bandwidths of some delay line devices currently in production approach 500 MHz.

By far the most common uses of SAW filters in military applications, however, are the IF bandpass filters where insertion loss is easily made up with amplifiers. The classic advantages of SAW technology that are responsible for these widespread uses include size, reliability, and linear phase. Examples include a family of 70 MHz IF filters for military satellite receivers. Twenty-two bandpass filters of different bandwidths and shapes are used in one receiver. The design flexibility of SAW filters is uniquely demonstrated by one class of these filter passband characteristics. These "signal shaping filters" have a dip in the passband that flattens the sin(x)/x shape of the received signal's frequency spectrum. Thousands of these and other military bandpass filters are produced each year. In many cases, these components are assembled into subsystems for receivers, synthesizers, and processors.

Comparable volumes are produced as well for commercial applications. Bandpass filters at 44 MHz with 5 MHz bandwidth and 1.25:1 shape factor are used by most CATV modulator manufacturers. Also, wideband 70 MHz filters are employed for TV satellite receivers where bandwidths from 20 MHz to 40 MHz are needed. Low group delay ripple is critical in this application and $\pm$ 5 to $\pm$ 10 nsec ripple is typical in these filters. Other commercial applications for bandpass filters and SAW resonators in CATV, mobile communications, and data modems are developing worldwide.

SAW low-loss bandpass filters deserve special attention since insertion loss and triple transit characteristics are the major disadvantages of conventional SAW techniques. Recently, the use of low-loss filters has begun to increase in military applications where lower loss, greater dynamic range, or reduced power consumption outweighs the higher cost of these filters and in commercial applications where large volumes permit more economical production. Low-loss filters have been developed with 2-10 dB of loss, depending on other parameters, at frequencies from 70 MHz to 900 MHz. Front-end filters for receivers and stand-alone filters to protect against adjacent channel interference for CATV are two noteworthy examples.

SAW resonators represent another area of SAW technology that is experiencing significant acceptance into production programs. Resonator applications range from the high volume CATV oscillator mentioned earlier to narrowband multi-pole IF and front-end filters produced for military applications. Two, four, six, and eight pole filters have been used.

Other current SAW applications are covered. Emphasis is placed on products that are commercially available in reasonable quantities from U.S. SAW companies.