THE IMPLEMENTATION OF SURFACE ACOUSTIC WAVE DEVICES IN AVIONICS SYSTEMS

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The introduction of Surface Acoustic Wave Devices into military electronic systems has resulted in equipment which has improved performance characteristics and greater reliability. This paper presents a brief review of the techniques and materials utilized in the construction of SAW devices. SAW devices function as frequency control elements, pulse compression filters and correlators, nondispersive filters, nondispersive time delays, matched filters and correlators, and acousto-optic modulators. A compilation of various military systems incorporating SAW devices is included with commentary on selected implementations. Although SAW devices have been applied in over thirty Air Force systems, their use (quantities) is dwarfed by their widespread use in commercial TV. The production of SAW devices for avionics systems is very limited with production rates ranging from as low as ten per year to a few thousand per year.

One of the most fruitful applications of SAW technology to avionics systems is in the ECM area. Here the surface acoustic wave device offers a very cost effective, high performance means for achieving the filter functions required in a signal sorting receiver system which accomplishes its high probability of intercept role by converting signals across a broad rf band to a "base band" frequency and then through a second conversion into a bank of IF channel filters.

Such a channelized receiver offers a way to minimize measurement errors due to high probability of signal overlap which results from (1) the dense signal environment, (2) multi-beam-multifrequency radars, and (3) high duty cycle pulse-doppler emitters. Channelization with angle-of-arrival also permits rapid identification of emitters with combinations of frequency and PRF agility and good absolute frequency measurement accuracy. Absolute measurement accuracy in turn reduces processing time and complexity, i.e., low priority recurring signals can be identified and need not be continually sorted. The most significant part of such a receiver is the SAW capability tied closely to the receiver design.

Such a system is embodied in a SAW channelized receiver presently in design for the Air Force. The receiver is intended to measure frequency, amplitude, angle of arrival, time of arrival, and pulse width across a broad rf band. The receiver package is nominally 2.25 $ft.^3$ and will weigh approximately 150 pounds. Key to the development of this unit is the SAW filters contained in a 0.5 cubic foot IF unit. These filters are used primarily in the IF processor to multiplex a selected IF signal into 16 finer slots of 15 MHz bandwidth each as part of the frequency extraction process. There are over 300 of these devices in the IF processor. Each slot contains a 20.3 MHz $LiNbO_3$ SAW prelimiter filter and a 15.33 MHz quartz post limiter filter. The prelimiter filter is $LiNbO_3$ <u>to achieve the required bandwidth with reasonable insertion loss</u>. The post limiter filter is on quartz <u>to achieve good frequency stability</u> over the full temperature range. Specifications for the filters are shown as follows.

f_o 243.75 MHz and every 10.16 MHz to 406.25 MHz

$LiNbO_3$		Quartz	
BW_3	20.3 MHz	BW_3	10 MHz
BW_{20}	32 MHz	BW_7	15.23
BB_{25}	55 MHz		
		Loss	<20 dB
Time spurious	>55 dB	Time spurious	$\geq$25 dB
Freq.spurious	>55 dB	Freq.spurious	$\geq$25 dB
Temp.drift	$\leq$1.65 MHz	Side lobe impulse	>18 dB

Other functions in the receiver are accomplished with SAW devices such as simple delays and multiport switchable delay functions. These applications of SAW device technology present SAW technology in its best light, offer excellent performance advantages, and represent one of the highest volume military markets.

SAW devices are beginning to be employed in oscillators in place of quartz crystals. Improvement in vibration sensitivity by a factor of 5-10 is expected. Specific designs are being investigated for such missiles as WASP and AMRAAM. WASP is an anti-armor minimissile to be pod-mounted on such aircraft as the F-16. AMRAAM is a medium range air-to-air missile. Both represent potential high volume markets for SAW devices with estimates for production ranging as high as 300 missiles per month. In these applications, the SAW device is used as a frequency selective two-port feedback element to provide frequency stability. A number of designs have been demonstrated above 1.0 GHz; however, extending the application much above 2.0 GHz will be very difficult

The above detailed discussion represents the state-of-the-art of SAW applications. SAW acoustic wave devices are becoming more widely used in avionic systems. They will perform most of the band pass filter functions in the future over the 20 to 600 MHz portion of the spectrum. SAW devices will result in quartz crystal stability at frequencies as high as 1500 MHz. The technology of their construction has matured and little advancement is expected in this area. Computer Aided Design has become commonplace. Further refinement of these tools will reduce the cost of SAW devices and result in their wider utilization. Electronic countermeasures systems will find wide utilization of SAW devices and offer the potential for volume production. In general, SAW devices and their applicability are a well understood and indispensable facet of the avionics systems designers art.