SURFACE ACOUSTIC WAVE (SAW) CONTROLLED OSCILLATORS

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Opening Statement for Panel Discussion

The surface acoustic wave (SAW) controlled oscillator consists of a narrow band SAW delay line or resonator used as a feedback element, an amplifier with sufficient gain to overcome the insertion loss of the SAW device, and a means to couple out part of the signal. The SAW oscillator is related to the quartz crystal oscillator in that the stabilizing element is provided by the long delay time of an acoustic device. The surface wave device is also generally fabricated on quartz because of the inherent stability of this material. However, the planar technology of SAW devices allows fabrication of devices with operating frequencies up to the range of 1 to 2 GHz. Also, great flexibility is available in SAW design because either a resonator or delay line may be used. Delay line type oscillators are particularly useful for applications where frequency modulation is required since a tuning range of up to 1 percent can be achieved. In general, SAW controlled oscillators are small, simple, and rugged devices operating in the frequency range of 50 MHz to above 1 GHz.

The frequency stability of SAW controlled oscillators has been investigated in three general areas: short-term stability (FM noise), temperature dependence, and long-term stability (aging). FM noise levels have been measured experimentally and have been found to be in good agreement with theoretical values. For an oscillator using a 310 MHz resonator with an unloaded Q of 15,000, the single sideband FM noise power level in a 1 Hz bandwidth is -135 dBc at 1 KHz, -160 dBc at 10 KHz, and -170 dBc at 100 KHz. For a 2 μsec delay line at 401 MHz, the noise levels are -115 dBc at 1 KHz, -140 dBc at 10 KHz, and -160 dBc at 100 KHz.

The temperature dependence of two oscillators made with two different SAW materials is shown in Fig. 1. ST-cut quartz is the most commonly used material for SAW oscillators and has a parabolic temperature dependence. The SiO_2/YZ $LiTaO_2$ structure is a YZ $LiTaO_2$ plate with a sputtered layer of SiO_2. This material exhibits a significantly smaller temperature dependence but requires a more complex fabrication procedure and also has a large aging rate.

The long-term drift, or aging, of SAW oscillators has been under study for a relatively short time, but it has become obvious that packaging and processing are important parameters. Figure 2 shows the long-term drift of five, 400 MHz, ST-cut quartz oscillators processed in several different ways. Generally the cleanest and most hermetic packaging provides the lowest aging as indicated by curve 5. Preaging at elevated temperatures is also useful as illustrated by curve 4. It is very likely that long-term stability will improve as better packaging and processing techniques are developed. The observed drift for the SiO_2/$LiTaO_3$ structure is -15 to -20 ppm per year.

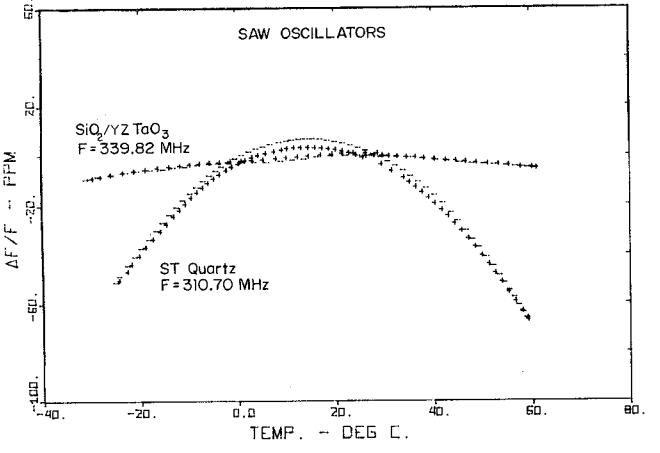

Figure 1. Temperature dependence of an SiO_2/$LiTaO_3$ Oscillator Compared to an ST-Quartz Oscillator.

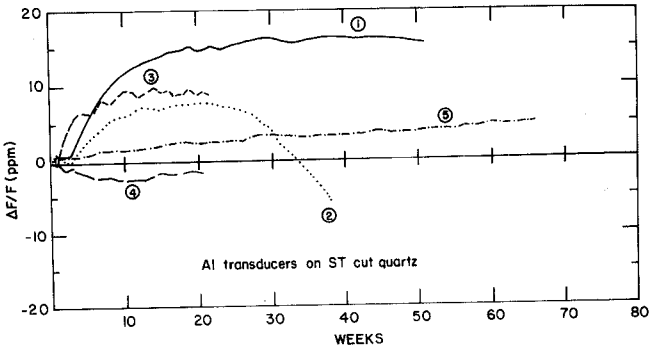

Figure 2. Aging of 400 MHz SAW Oscillators Made on ST-Cut Quartz.