SOME INVESTIGATIONS ON RESONANTLY LOADED INTERDIGITAL TRANSDUCERS IN SURFACE ACOUSTIC WAVE DEVICES

by

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CERTIFICATE

This is to certify that the thesis entitled "Some investigations on Resonantly Loaded Inter-digital Transducers in Surface Accustic Wave Devices" being submitted by Jagannath Prasad Agrawal to the Department of Electrical Engineering, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by him under our supervision and guidance and in our opinion it has reached the standard fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted to any other Institution for the award of any Degree or Diploma.

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ABSTRACT

The solid state planar technology has seen many strides in the past few decades. The emphasis had been on miniaturization of circuits required for signal processing. The need grew faster with the growth of computers and satellite communication. Piezoelectric crystals have been used since long in crystal controlled, single frequency oscillators using the bulk waves.

The acoustic waves have very low propagation velocities. This makes the electro-acoustic transducers very small and attractive for integration with electronic circuits. In 1965, an efficient method of launching/detecting the surface acoustic waves (SAWs) on piezoelectric crystals was invented. As a result the surface acoustic wave devices are now emerging as important components in signal processing systems.

Most of the SAW devices require a single mask planar technology well established in integrated circuits. Devices in the frequency range of 10 MHz to about 2 GHz are available that provide large time delay, good bandpass filter responses, matched filtering, real time convolution etc.

The interdigital transducer (IDT) is the heart of most SAW devices. In the present thesis, a resonantly loaded IDT (RLIDT) as a track changer of SAWs in bandpass filters is

described. A new scheme utilising the voltgage trasfer function between the RLIDT and the launcher IDTs is proposed. This scheme is shown to have useful properties such as near zero dB voltage attenuation within the passband which is almost flat with very small ripples (0.4 to 0.5 dB) and has good roll off with moderate sidelobe levels.

The voltage across the RLIDT is tapped by a high input impedence, low noise amplifier. This makes the filter scheme suitable for use in the front end of a receiver.

The above scheme also provides flexibility of obtaining a desired response. For example, x/sin x response, useful in digital communications, can be synthesized.

An RLIDT based SAW filter has been demonstrated on a low piezoelectric coupling substrate like quartz. A close-in sidelobes of about -50 dB with ultimate stop bond rejection of 70 dB is obtained without using apodization. The size of the substrate required for this filter is at least two times smaller than that is required, using conventional techniques, for a comparable performance.

The use of an RLIDT as a reflector of SAW has been investigated. It is predicted and experimentally verified that an IDT undergoing self resonance acts as a good reflector of SAWs without the need of any external inductor. The effective loss conductance in the self resonant IDT selected for the demonstration, has been deduced from the measurement of IDT impedence. This resulted in an estimate of 0.96 for the reflection coefficient of the IDT. As against this, the measured reflection coefficient varied from 0.93 to 0.95 in different samples. The difference has been attributed to the beam steering.

The unique feature demonstrated of a self resonant IDT as a reflector, is the possibility of electrically altering its reflection/transmission properties after the device has been packaged. Preliminary results on cavity resonators formed by two such self resonant IDTs are presented.

A new and simple technique of fabricating crossovers required in multiphase unidirectional IDTs is proposed. This process requires normal photolithography with three masks and two levels of metallization. The insulation needed under the cross-overs is obtained by using positive photoresist AZ 1350 as the insulator. The performance of the crossovers has been evaluated by studying the unidirectional radiation of a hybrid junction IDT fabricated by this technique. A directivity of bett r than 20 dB in the entire 3 dB passband has been obtained indicating that the quality of the crossovers is acceptable for the fabrication of multiphase unidirectional IDTs.

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