Laboratory Assignment: Surface Acoustic Wave Devices

ECE 6361: Microwave Design Lab

Objective

This laboratory assignment will explore the properties and frequency response of Surface Acoustic Wave (SAW) devices used for filters, sensors, and RFID. (75 points)

Preparation

Before coming to the laboratory to perform this assignment, the students should prepare the following:

- Be familiar with measurement and data capture of complex s-parameters with the network analyzer
- Study surface acoustic wave (SAW) devices for RF filters, sensors, and RFID

Picture of encapsulated SAW device.

Write-Up

The students performing this laboratory must submit their documented procedures and analysis in a *concise* laboratory write-up. All group member names must appear on the front page. The write-up will be graded on

- Completeness and Technical Correctness
- Technical Writing and Readability
- Conciseness

Be sure to include plots of data and copies of any analysis code written for data processing,. Be sure to address each analysis question in the procedure.

Procedure

In this procedure, the student team uses the network analyzer to measure the complex s_{11} parameters of SAW devices at different frequency scales.

1. Obtain the four SAW devices, which are sealed in small acrylic boxes and kept inside one of the wooden calibration kit boxes. The four SAW devices are labeled 1 through 4. You will not use device 2 in this lab. NOTE: Take extreme

care when connecting a cable to the device; over-tightening will break the connector from the housing.

2. Calibrate Network Analyzer (1 port). Set the frequency scale from 1 MHz to 800 MHz.
3. Connect SAW devices 1, 3, and 4 to the VNA. Measure and record the magnitude of s_{11}.
4. Measure the s_{11} response and find the dip where return loss is maximized (minimum reflection level). This shows the band over which the transducer converts RF power into acoustic waves within the device substrate. The center of that band can be labeled f_0, or the resonant frequency. Calculate this for each SAW device, if observed.
5. In lieu of using a microscope to get a better view of the SAW device, an enlarged picture of the interdigitated transducer for device 4 is shown in Appendix A. Given that the total length of this structure (including an extra finger space at the end) is 400 microns, count the number of interdigitated finger pairs and determine the width of a pair, including a trailing space. Note that all fingers and spaces are the same width.
6. With the resonant frequency and finger pair width known, estimate the propagation speed on the Lithium Niobate substrate. (Hint: The SAW device was designed so that the wavelength is equal to the width of 1 pair of interdigitated fingers)
7. Zoom into the s_{11} plot of each of the three devices and order the devices by the approximate the bandwidth for each device (the width of the dip in the frequency response). Rank-order the devices from highest-to-lowest bandwidth.
8. If Np is equal to the number of fingers on one side of the device, and the bandwidth is equal to f_0 / Np, estimate the bandwidth of Device 4. What relationship do you notice between the width of the interdigitated fingers and the bandwidth of the SAW devices?
9. Measure and record the complex (amplitude and phase) of s_{11} data for each device. Using Matlab or any other desired software, take an inverse Fourier transform (e.g. IFFT) to convert the section of the frequency domain capture into the time-domain.
10. Plot your result and mark the time domain output and observe any significant echoes in the response. Be sure to plot and label your graph as a function of time. Mark each major peak on the graph with the corresponding round-trip distance traveled to and from the inter-digitated transducer using the velocity that you calculated for the SAW medium.

Acknowlegment

This laboratory experiment was designed by Daniel Smith, Colin Purdue, and Dr. Ryan Westafer.

Appendix

Computer-Aided Design (CAD) mask used for SAW device 4 interdigitated transducer

Total length = 400 microns