الورقة الثانية (٥)

Menoufia University
Faculty of Electronic Eng.
Department of electronics
and communications Eng.

3rd Year Elective Course (2)
Surface Acoustic Wave Devices
Final Exam., 3 / 1 / 2019
(Max. 70 Marks), Time: 3 hours

Answer the following questions:

1- 3- a- Draw and discuss the input/output equivalent circuit for a Surface Acoustic Wave (SAW) filter in the cross-field model at a center frequency f_o. (4Marks)

b- A SAW filter is fabricated on YZ- $LiNbO_3$. Its input and output IDTs have constant finger overlap. The input IDT has N_p = 50 finger pairs and apodization width W = 100 acoustic wavelengths at a center frequency f_o = 400 MHz. Consider that the capacitance/ finger pair/cm is C_o = 4.6 pf/cm. Determine the numerical values of the unperturbed radiation conductance G_a at f_o. (For YZ-$LiNbO_3$: v = 3488m/s and k^2 = 4.6 %). (10Marks)

2- a- Explain, with the aid of a block-diagram and equations, the overall transfer function of an ideal linear-phase response SAW filter (4Marks)

b- A SAW filter with nominal linear-phase response employs identical uniformly apodized IDTs in input and output stages. Each IDT has N=80 electrodes. Determine (i) the approximate 4-dB percentage fractional bandwidth of each IDT and (ii) their 3-dB fractional bandwidth; (iii) indicate whether or not the overall 4-dB filter bandwidth will be the same as in (i); and (vi) determine the approximate suppression level (in dB) of the first sidelobes of the filter. (10Marks)

3- a- Explain, with the aid of a sketch and equations, the calculation of IDT parameters. What is meant by damping an ultrasound transducer, and why is this necessary? What influence does damping have on the frequency response of the transducer? (6Marks)

b- A SAW is generated on the surface of a piezoelectric substrate by mean of an ac voltage applied to an IDT at f_o = 1GHz. Given that the velocity of propagation of the SAW on this material is v = 3488m/s, determine the acoustic wavelength. Compare the value of this wavelength with that of an electromagnetic wave propagating in free space at the same frequency. Determine the ratio between the SAW wavelength and the electromagnetic wavelength in this case. Comment on the obtained results. (8Marks)

4- a- Stat the four types of acoustic sensors. and draw an equivalent circuit model to describe the interaction between a SAW and charge carriers in a film overlay. (4Marks)

b- Deposition of a 100 nm-thick AL film on a $LiNbO_3$ SAW device causes sheet conductivity vary from $\sigma_s << v_0 c_s$ to $\sigma_s >> v_0 c_s$. (a) What acoustoelectric velocity and attenuation changes arise from this film? . (b) What is the maximum acoustoelectric attenuation (in dB) for a 100-MHz $LiNbO_3$ device with a path length of 100 λ?.(For $LiNbO_3$ k^2 = 4.8 %) . (10Marks)

5- a- Sketch an illustrative transceiver for a digital-cellular communications transceiver, such as for the GSM , and indicate the possible location of constituent SAW components. (4Marks)

b- What are SAW wireless label identification "tags", and what are they used for?. (4Marks)

c- A SAW convolver has a rated convolution efficiency h_c = - 46 dBm. If the signal input power P_s is 10 dBm (10 mW) and the reference power P_r is 20 dBm (100 mW), what is the correlated output power P_{out}?. If the output noise floor level in the previous SAW convolver is - 75 dBm, determine the output Signal-to-Noise (S/N) ratio. (6Marks)

Best wishes

Prof. Dr. Taha El-Sayed Taha