CONFIGURATION OF A 30-MM-DIAMETER 94 KHZ ULTRASONIC LONGITUDINAL VIBRATION SYSTEM FOR PLASTIC WELDING

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Vibration and welding characteristics of a 30-mm- diameter 94 kHz ultrasonic plastic welding system are studied. The 94 kHz ultrasonic plastic welding system consists of a 30 mm-diameter bolt- clamped Langevin type piezo-ceramic (PZT) longitudinal transducer, a stepped horn (vibration velocity transform ratio N=3.0) with a supporting flange at a nodal position and a catenoidal horn (N=3.13) with a 8-mm-diameter welding tip. Total vibration transform ratio is 9.39. The vibration rod diameter of 30 mm is corresponding to 0.56 wavelength of longitudinal velocity that is larger than the conventional design criteria length that is under 1/4 wavelength to avoid radial resonance vibration. The 30-mm-diameter of PZT ring is corresponding to 0.95 wavelength that is less than 1 wavelength. The vibration system is made of high strength supper aluminum alloy (JISA7075B) to increase maximum vibration velocity. Radial vibration amplitude measured using a laser Doppler vibrometer around the welding tip is 1/50 of longitudinal vibration amplitude of the welding tip surface. The 94 kHz longitudinal vibration system is simple compared with the 90 kHz system that was made formally using six 15- mm-diameter bolt-clamped Langevin type (PZT) longitudinal transducers installed in a radial to longitudinal vibration direction converter. Maximum vibration velocity of the welding is 3.3 m/s (peak-to-zero value) and quality factor is about 1560. Welding characteristics of 1.0-mm-thick polyurethane sheet specimens using 94 kHz, 67 kHz, 40 kHz and 27 kHz welding systems with an 8- mm-diameter welding tip are compared. Required vibration velocity decreases as vibration frequency increases. Using the 94 kHz welding system, weld strength more than 580 N per one welded area of 8 mm diameter were obtained and the weld strength per welded area was 12 MPa. This vibration system is effective for the other various applications.

Session: 5G
SAW SIMULATION
Chair: V. Plessky
GVR Trade SA

5G-1  4:30 p.m.
A GENERALIZED P-MATRIX MODEL FOR SAW FILTERS
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The P-matrix model, which can be seen as a discrete version of the continuous COM-model, is a well established tool to analyze the electro-acoustic properties of IDTs and reflector gratings. It relates the outgoing surface waves and the electric current to the incoming surface waves and the electric voltage. If an acoustic track consists of several IDTs and reflectors, it can be described by cascading the P-matrices of its building blocks. However, this approach has its clear limitations. Let us consider, e.g. a DMS track: if a voltage is applied to one IDT it will generate electric charges not only on the fingers of this IDT but also on its neighboring fingers. These charges cause capacitive coupling between neighboring elements and change the electro-acoustic excitation and detection of forward and backward propagating surface waves. Both effects are ignored in the building block model. The resulting inaccuracies are most pronounced if short elements, such as in DMS tracks are used.

In this paper, I will present a generalization of the classical P-matrix model, which relates the outgoing surface waves and all electrical currents to the incoming surface waves and all voltages in a general acoustic track. This track might consist of an arbitrary number of IDTs and reflectors. To demonstrate the advantage of this model it will be compared to the simpler building block model and measurements for several typical filters.

5G-2 4:45 p.m.

APPLICATION OF B-SPLINE AND DUAL B-SPLINE WAVELETS TO THE ANALYSIS OF STATIC- AND DYNAMIC CHARGE DISTRIBUTIONS IN SAW- AND BAW DEVICES

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In previous works we have demonstrated the existence of Green’s-functions (GFs) induced wavelets for the analysis of electrostatic charge distributions in SAW- and BAW devices. We also have shown that it is generally not possible to construct GFs induced wavelets for piezoelectric problems. However, it turns out that it is always possible to construct a set of orthogonal basis functions which can be obtained from GFs, and which are integer translates of a single function. Our recent research efforts have been focused on using wavelets with finite support for efficient analysis of field distributions in acoustic devices. In this contribution we discuss the construction of B-splines, B-spline wavelets and dual B-spline wavelets defined on unit intervals. It turns out that these wavelets are best suited to the field problems in acoustic devices. Due to the finite-support assumption there exit boundary as well as interior scaling- and wavelet functions. Using suitable Vandermonde matrices we provide a simple recipe for the construction of these functions. For solving SAW- and BAW excitation and scattering problems, we employ the Method of Moments and use as basis- and testing functions first B-splines, then B-spline wavelets, and finally B-spline dual wavelets. We compare the associated numerical results in
terms of the accuracy, speed of computations, sparsity and the well-behavedness of the resulting impedance matrices. We consider linear as well as cubic B-spline implementations. In order to compress data, we investigate the effect of thresholding of the matrix elements on the results and convergence behavior. In the case of linear B-spline wavelets we consider basis functions in spaces $V_2$, $W_2$, $W_3$, and $W_4$, implying the involvement of 5 scaling- and 28 wavelet functions. In the case of cubic B-spline wavelets we consider basis functions in spaces $V_3$, $W_3$, and $W_4$, implying the involvement of 11 scaling- and 24 wavelet functions. We discuss an implementation in MATLAB. Several examples will demonstrate the application of this method to the static-, surface- and bulk acoustic wave interaction problems.

5G-3 5:00 p.m.

FULL WAVE SIMULATION OF SAW FILTER PACKAGE AND SAW PATTERN INSIDE PACKAGE
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With miniaturization of RF-SAW filter package, we should not only take the electromagnetic effects of package into consideration but also the electromagnetic effects of pattern on the SAW substrate. In this paper, the High Frequency Structure Simulator (HFSS) is employed to investigate the crosstalk effects on SAW substrate and mutual coupling effects between pattern on the SAW substrate and package. Special attention has been paid to model SAW filter pattern. We establish the package, bond wires, bumps and SAW filter in our simulation model. The simulation results are exported by using multiple-port S parameters. IDTs are replaced by internal ports in our approach. The exported S parameters are then combined with the responses of IDTs to obtain the final response. Thus we can predict the combined effects of package and crosstalk effects on the SAW substrate. It is found that an RF SAW filter device is sensitive to crosstalk between package and pads on the substrate. So the crosstalk effects must be taken into account in the design process. Our approach has been applied to two cases. One is SMD package 3mm x 3mm with ladder type SAW filter at 881 MHz and the other is Flip Chip package 2.5mm x 2.0mm with ladder type SAW filter at 1842.5 MHz. In both cases, ladder type SAW filter are combined with six different one-port resonators and each response of the one port resonators are measured on wafer. Measurement is also carried out to verify our results. Good agreements are obtained. Finally, some package effects, such as the change of bond wire length and bump numbers, are also discussed.
 APPROXIMATE ANALYSIS OF SAW LONGITUDINALLY-COUPLED RESONATOR (LCR) FILTERS
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The LCR filter, also called a Dual-Mode SAW(DMS) filter, is well established as a technique for realising bandpass filters with very low insertion loss and good stop-band suppression. Typically, this device has a three-transducer structure G-T-T-G (where T = transducer and G = grating). The outer transducers are connected together to give one electrical port, and the central transducer gives the second port. At RF frequencies (900 MHz and above), all components in the device usually have electrode pitches of approximately half the wavelength, because of the difficulty of fabricating narrower electrodes. Consequently, the transducers are strongly affected by electrode reflections, causing substantial complexity in the device behaviour. This paper presents a simplified approximate analysis making use of reciprocity and power conservation. It is shown that, when shorted, the central transducer behaves as a component that causes dispersion of the waves but does not reflect them. In consequence, the device behaves like a simple resonant cavity, but with cavity length dependent on frequency. From this point of view, a 2-pole device is a single cavity with two resonant modes, not a pair of cavities coupled together. For the filter passband, simple relations are obtained for the device Y-parameters in terms of the P-matrices of the SAW components, and the frequency response is readily calculated. The approximate analysis is verified by comparison with an accurate analysis using the COM method. The implications of the approximate analysis for device design are discussed.

 EVALUATION OF DISPERSION IN COM-PARAMETERS
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The so called COM parameters - reflection (RC), transduction (TC) and attenuation (AC) coefficients per IDT period, as well the phase parameter of radiation directionality (PPD) - play a key role in modeling of SAW and LSAW devices. As it is well known, in case of non-leaky (‘true’) SAW, all COM parameters, except the attenuation factor, can be evaluated from simple analysis of the stop-band width and positions corresponding to both short- and open-circuited infinite regular gratings (IRGs). However, this procedure is not applicable for transducers utilizing Leaky SAWs when the resonant mutual interaction of surface and bulk acoustic waves on a grating appears un-avoidably. As a result,
all COM-parameters acquire a dispersive nature (having frequency dependent values), and their dispersion portraits must be found to simulate the LSAW-device characteristics properly. A well-founded technique, based on the IRG and infinite IDT analysis only, is proposed here to develop an extraction procedure for the desired dispersion portraits. First, by using software, such as FEMSDA, the complex wave number, characterizing SAW (LSAW) propagation under a short-circuited IRG, may be found numerically. By comparing these results with the corresponding eigenvalues of relevant COM equations, it is possible to find RC- and AC-values at every frequency point of analysis. Substitution of the extracted values into appropriate COM expressions provides practically perfect restoration of the initial dispersion curves even at frequencies beyond upper side of the IRG stopband, confirming the validity of the extraction procedure. Then, the extracted RC- and AC-values are substituted into the COM-expressions for calculation of conductance and susceptance per period of infinite IDT. By relating the obtained results to the similar ones found numerically with help of, e.g., K.Y.Hashimoto’s SYNC program, it is possible to evaluate the needed dispersion portraits for TC- and PPD-values too. The parasitic radiation by IDT of the bulk acoustic wave modes is the only factor that complicates the last extraction step. The ways to overcome this difficulty is also discussed.

5G-6 5:45 p.m.

A POWERFUL NOVEL METHOD FOR THE SIMULATION OF WAVEGUIDING IN SAW DEVICES
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A new method to simulate waveguiding in SAW filters is presented and applied to mobile communication and consumer electronics filters. It is based on the P-matrix method and discretizes the filter into longitudinal and transversal sections. Diffraction effects are introduced by considering free waveguide propagation within the longitudinal sections.

This method is an extension of the pseudoinverse diffraction matrix method by Rooth et al. [1]. In contrast to the transmission matrix form of that scheme the presented method uses an intrinsically reciprocal 2D scattering matrix description. It can deal with general multi-channel planar waveguides and an arbitrary number of electrical connections of transducers.

This scheme has proved to predict 2D effects for a wide range of filter types reliably. This is exemplified for transverse-mode coupled resonator filters, recursive filters, as well as filters with apodized and fan-type IDTs built on quartz, lithium niobate, and lithium tantalate.

In order to better understand the filter behaviour visualizations of the wavefields are presented.


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