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A NEW APPROACH TO INVESTIGATE LADDER-TYPE SAW FILTERS INCORPORATING PACKAGING EFFECTS

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Abstract. *Ladder-type surface acoustic wave (SAW) filter is a commonly used radio frequency (RF) filter in many communication systems. The circuit structure of a ladder-type filter consists of several one-port SAW resonators on a piezoelectric substrate arranged in series and parallel alternatively. The shape and dimension of bonding pads, the lengths of bonding wire, and the internal connection paths between one-port SAW resonators may present a significant influence on the performance of the filter. Hence, how to incorporate these effects into the early stage of the filter design is an important issue. In this paper, neural network was employed to extract the lumped element parameters of bonding pads and internal connections. As an example, an RF ladder-type SAW filter used in globe positioning system (GPS) was examined. The result showed a good agreement with measurement data as well as the data obtained by applying full electromagnetic wave simulator.*

Keywords: Ladder-type SAW filter, Neural network, Lumped element model

1. **Introduction.** Since the wavelength of surface acoustic wave is only 10^{-5} that of electromagnetic wave, SAW devices not only have the advantages of being compact, highly reproducible, and reliable, but also have the excellent band rejection over conventional lumped or distributive passive devices. Recently, as design and fabrication technologies improve, SAW devices have been widely applied in various modern communication and consumer electronic systems. Commercial SAW devices usually are fabricated on piezoelectric substrates, such as $LiTaO_3$, $LiNbO_3$, and quartz. In order to integrate SAW chip into circuit, specific packaging is required and the parasitic effects caused by wire bonding, bonding pad, and internal connection path are inevitable. Those effects, if not considered in advance, may seriously deteriorate the performance of the device, especially for RF SAW [1,2]. In previous studies, in order to incorporate those effects into the early stage of the SAW device design, full electromagnetic (EM) wave simulation is often employed. Although the capability of applying full EM wave to simulate packaging effects has been verified [3,4], full EM wave simulation, usually based on finite element or finite difference time domain, requires long simulation time and the drawing of three dimensional (3D) structures varies with package and internal arrangement pattern of the SAW device. In addition, for some users, the lumped circuit model is more convenient to be included in a circuit simulator if further simulation is required. Therefore, a new method that uses neural network to extract the lumped equivalent circuit models of the bonding pad and internal connection path was proposed in this paper. The validity of proposed method was verified on a ceramic SMD 3×3mm packaged RF SAW filter used in GPS system.