Review on Surface Acoustic Wave (SAW) Filters

Anjali Patel[1] Anil K. Sisodia[2]
[1,2]Department of Communication System Engineering
[1,2]L. J. Institute of Engineering and Technology, Gujarat Technological University, Ahmedabad, Gujarat

Abstract— the uses of RF devices have been increasing day by day. Filters are one of the most important device in communication channel. Now a days, SAW devices are most commonly used in many systems due to their linear phase response. The survey has been done for Saw filters based on different techniques to achieve advanced functionality, This paper presents the literature survey on SAW filters having different structures to improve parameters such as narrowband operation, sharp cutoff, less insertion loss, wide band operation etc.
Key words: Wave (SAW) Filters, SAW

I. INTRODUCTION

In recent time most of the communication systems are digital, This requires linear phase(constant group delay) for better performance . SAW filters are inherently lnear phase hence suitable for digital communication.SAW filters have the advantage of good performance compare to other filters in terms of frequency as it can be realize on high frequency and as it does not contain any components like inductors and capacitors which get affected by temperature so the parameters will never get affected by temperature.

For the RF SAW filter three kinds of IDT(Inter-digital Transducer) design method have been proposed. Those are an IIDT(Inter-digital inter-digital Transducer) design, A ladder type SAW filter & double mode SAW design

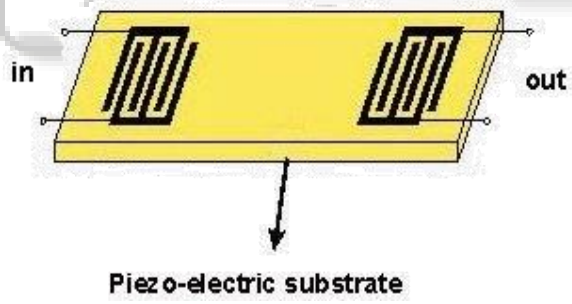

Fig. 1: Simple design of SAW filter

It is an electromechanical device. A Surface Acoustic Wave (SAW) filter is a filter whereby the electrical input signal is converted to a acoustic wave by so-called inter-digital transducers (IDTs) on a piezoelectric substrate . IDTs consist of interleaved metal electrodes which are used to launch and receive the wave so electrical signal is converted to acoustic wave and again to electrical wave at output side. In the early stage until 1992 IIDT type SAW filter is mainly used for RF filter. This structure had the insertion loss limit at3-4 Db level and it required the external matching ciruit. To overcome this problem in the ear of 1992 Ladder type SAW filter and DMS SAW filter are reported. Both filter design utilize SAW resonators which are suitable for low loss characteristics and their designs are resemble with BAW(Bulk Acoustic Wave) filters. The DMS filter utilizes two identical resonant modes acoustically coupled in the longitudinal direction. Two types of one port SAW resonator, the series arm resonator and parallel arm resonator which has slightly different resonant resonant frequency are coupled with each other by ladder type network.

II. LITERATURE SURVEY

M. Ei hakiki, J-A Damy, H. hartmann [1] had designed leaky waves based fan shaped filters,63% of bandwidth is achieved by using fan shaped structure They have designed the structure that comprised of first (FT1) and second(FT2) transducers are are arranged within the same longitudinal surface. A shielding structure is arranged between two transducers comprising fully metallic area.

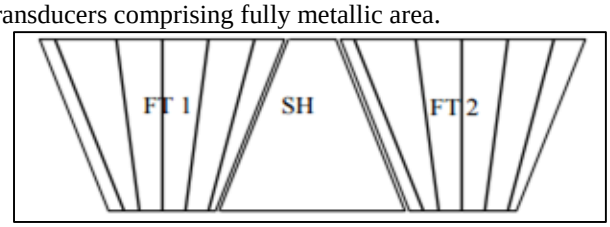

Fig. 2: FAN shaped structure with shielding surface[1]

Also they have adapted a structure in which instead of shielding surface non reflective finger gratings are used to minimize propagation losses due to leaky waves.

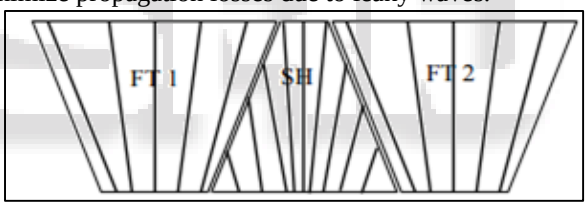

Fig. 3: Fan shaped structure comprising non reflective finger grating[2]

By applying fan shaped structure on LiNbO3 insertion loss of 12.7 dB have been achieved and by using LiTao3 as material they have designed filter at 219 MHz with relative bandwidth of 9% and streepness of 1.5%..

Xiaoming Lu,Koen mounthan,Yeo Tai Soon[2] had designed a SAW filter consisting SAW resonator network and parallel coupled lines.

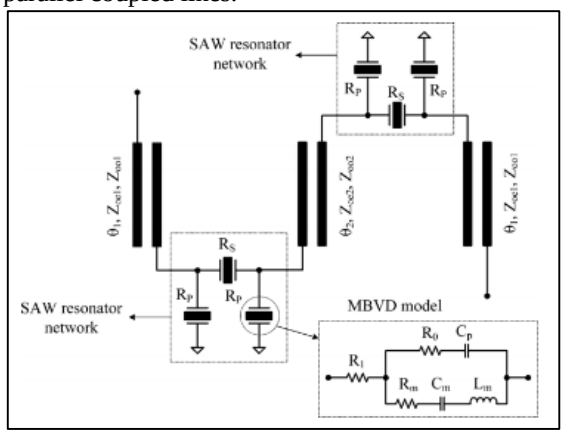

Fig. 4: proposed circuits for the wideband BPFs with SAW filter-like selectivity[2]

By using proposed method filter was designed at 2GHz having the bandwidth of 10% and 17%.

S. A. Doberstein[3] In proposed paper they have used fan shaped structure having one input IDT and two output IDT

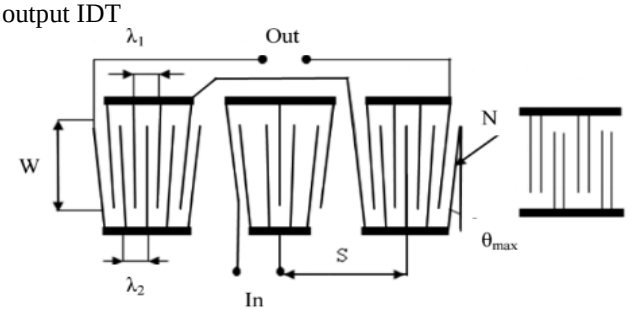

Fig. 5: FAN shaped structure with three IDTs[3]

The filter was designed on 128° Y-X LiNbO3.The simulation were done using delta function model in CST. By using this design insertion loss can be decreased. The 255 & 305 MHz samples of the SAW filters have shown 3-dB bandwidth of 30-61 MHz, insertion loss of 5.5-7.5 dB, The samples were housed in the 5×5×1.35 mm

Doberstein Sergei[4] had designed a DMS filter with narrowed pass band and improved selectivity on 42° Y-X LiTaO3. Filter was designed with two IDTs. Narrowed passband was achieved by choosing definite gap length between input and output IDTs

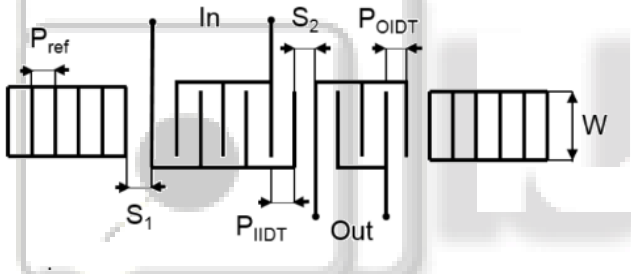

Fig. 6: Balanced two IDT DMS filter[4]

The filter was designed on 300 MHz frequency. . It provides the insertion loss of 3 dB .Bandwidth of 1.5 MHz, stop band attenuation of 70 dB at ±12 MHz offsets from a center frequency. The filter was housed in the 9.1×7.1×2 mm SMD package.

Jia hong sun; yuan-hai yu[5] **yu** had developed this filter using phononic crystal structure. Phononic crystals are artificial composites made of two or more elastic material. The existence of band gap is one of the important property of PnCs. Acoustic waves within the frequency range cannot propagate in PnCs. They have used SiO2/LiNbO3 layered structure used as reflective gratings for SAW.

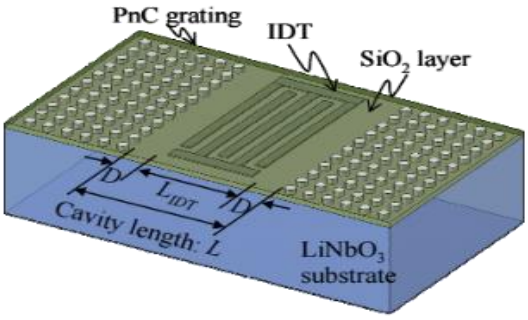

Fig. 7: A PnC resonant cavity for SAWs

Filter was designed on 947MHz frequency and narrowed pass band was achieved.

III. Recent Technologies to Achieve Advanced Functionality

1) Narrow pass band can be achieved by choosing definite gap length between input and output IDTs.
2) Insertion loss can be decreased by using weighting withdrawal technique.
3) Leaky wave FAN shaped structure can be used to achieve wide band operation
4) Selectivity can be achieved by using series connection of output IDTs in the parallel acoustic tracks of the filter.

IV. Conclusion

A Literature survey on Surface Acoustic Wave filter is presented in this paper which finds great application in the field of digital communication. After studying various research paper it is concluded that by choosing proper piezoelectric material and appropriate finger length and distance between fingers in IDT we can achieve the advance functionality.

References

[1] M. Ei hakiki, J-A Damy, H. hartmann. "Very large bandwidth IF SAW filters using leaky waves on LiNbO3 and LiTaO3", IEEE conference on international ultrasonics symposium,DOI:10.1109/ULTSYM.2011.03272011.
[2] Xiaoming Lu; Koen Mouthaan; Yeo Tat Soon,"Wideband Bandpass Filters With SAW-Filter-Like Selectivity Using Chip SAW Resonators", IEEE Transactions on microwave theory and techniques,vol:62,issue:1DOI:10.1109/TMTT.2013.2292041,2014
[3] S. A. Doberstein," Balanced wide band fan-shaped three-tranducer SAW filters with reduced insertion loss and improved frequency response," IEEE conference on international ultrasonics symposium,DOI:10.1109/ULTSYM.2014.0505,2014
[4] Doberstein Sergei," Balanced low-loss 2-IDT double mode SAW filter with narrowed passband and improved selectivity" Joint Conference of the IEEE conference on International Frequency control Symposium & the European Frequency and Time Forum,2015
[5] jia-hong sun,Yuan-hai yu, "A SAW filter using Sio2/LiNbO3 layered structure phononic crystals", IEEE conference on International Frequency control Symposium ,DOI:10.1109/FCS.2016.7546802,2016
[6] K. Misu; K. Murai ; K. Yamagata; K. Yoshida," An m-derived ladder high pass SAW filter," IEEE ultrasonics symposium,pp.397-400,2003.
[7] Sergei Doberstein," Switchable low-loss SAW filter banks with MEMS switches," IEEE conference on international ultrasonic s symposium,2010
[8] S. A. Doberstein, "Wide-band balanced low-loss SAW ring filters with impedance conversion," proceedings of IEEE conference on international ultrasonics symposium,DOI:10.1109/ULTSYM.2012.0447,2012.

[9] S.A.Doberstein,"2-IDT double-mode SAW filters with decreased insertion loss and advanced functionalities" 011 Joint Conference of the IEEE conference on International Frequency Control and the European Frequency and Time Forum (FCS) Proceedings,2011
[10] Takaya wada; Takashi ogami; Atushi horita "A new tunable SAW filter circuit for reconfigurable RF" IEEE conference on MTT-S International Microwave Symposium (IMS),2016
[11] M.Ueda; O.Kawaci; K.Hashimoto; O.Ikata; Y.Satoh,"Low loss ladder type SAW filter in the range of 300 to 400 MHz" proceedings of IEEE conference on international ultrasonic s symposium,DOI:10.1109/ULTSYM.1994.4015681994
[12] Hideki Hirano; Tetsuo Samoto; Tetsuya Kimura; Masahiro Inaba," Bandwidth-tunable SAW filter based on wafer-level transfer-integration of BaSrTiO3 film for wireless LAN system using TV white space" IEEE conference on International Ultrasonics Symposium,2014
[13] M,S,Saad;A,zaki;T,E,Taha;"Designofweightedtransducer SAW filter for RF wireless sapplications" IEEE International Conference on Electronics, Circuits, and Systems ,2015
[14] Tsung-Chieh Lee; Andrew Guyette; Eric J. Naglich; Dimitrios Peroulis," Coupling-matrix-based SAW filter design" IEEE MTT-S International Microwave Symposium,2014
[15] R,E,Chang; S,Malocha,"Wide band tapered SAW filter with improved Shape factor and phase response"proceedings of IEEE conference on Ultrasonics symposium,2013
[16] XiaomingLu; JefferyGalipeau; KoenMouthaan; EmmanuelleHenryBriot; "reconfigurable multiband SAW filter for LTE application" IEEE topical conference on Biomedical Wireless Technologies, Networks, and Sensing System ,2013

