WIDE-BAND SAW FILTERS BASED ON SLANTED AND FAN-SHAPED IDT

Igor S. Mitrofanov

State University of Aerospace Instrumentation
B. Morskaja 67, 190000 , St. Petersburg , Russia
e-mail:mitrofanov_igor@mail.ru

Abstract

The wide-band SAW filters are widely used in electronics products and equipment as key devices of pulse-compression radars and wide-band communication systems. Also , it well known the linear phase SAW filters utilizing as delay line , Fourier processors for frequency-domain and cepstral analysis and adapted filters.

The slanted and fan-shaped Interdigital Transdusers (IDT) are the most attractive for wide-band SAW filters because the multiple reflections and conversion in bulk waves are low in both cases. Moreover, the fan-shaped IDT provides the collimation of acoustic beam in piezoelectric materials with strong electromechanical coupling such as lithium niobate.

This paper presents the results of design of wide-band SAW filters based on slanted and fan-shaped IDT. The linear and non-linear IDT, including hyperbolic fingers for fan-shaped IDT, have been investigated. The possibility of achievement of 100% relative bandwidth is experimentally shown. The features of application of reflective arrays with slanted and fan-shaped IDT are given.

1.Introduction

With the progress market for wide-band communication systems, much attention has been given to the use SAW filters using slanted and fan-shaped IDT. The application of such IDT obtains to minimize degradation of signal and insertion loss in comparison with usual wide-band IDT.

In 1983, Lewis (Ref.1) proposed the use of slanted IDT for filters with low loss. In a later experimental study of the slanted IDT , Saw and Campbell (Ref.2) presented the design of filter with bandwidth up to 10% and insertion loss 4.9dB.

The fan-shaped IDT were used Campbell *et al*. in (Refs3-5) for wide-band filters with bandwidth more 50%. In these works the collimation of acoustic beam in anisotropic piezomaterials has been discovered. For example, for lithium niobate (YZ-cut), this feature is retained up to ±7° of slanting angle of fingers IDT.

Desirable levels for parameters of modern wide-band filters are:
-bandwidth more 30%;
-phase error less 1°;
-sidelobe level for compressing signal more 30dB.

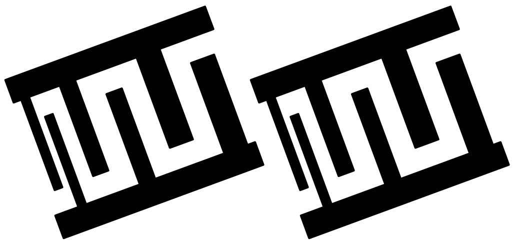
In practice, however, some design trade-offs between bandwidth, delay time and insertion loss.

This paper presents the theoretical and experimental results of study such filters.

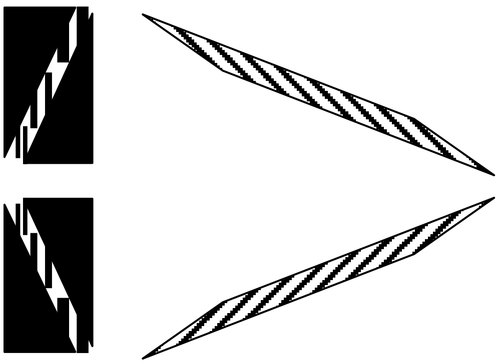
2.Device modeling

2.1. Slanted IDT

The layout of filters with slanted IDT are showed in Fig.1



a)



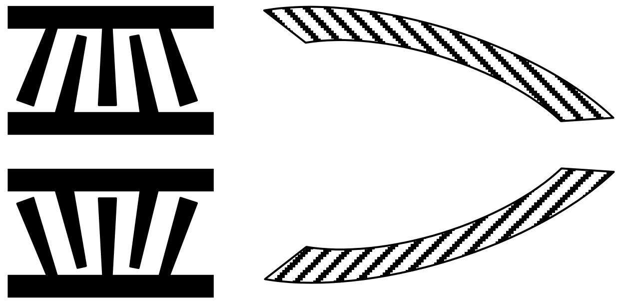
b)

Fig.1 The layout of filters with slanted IDT
a-non-dispersive filter;
b-dispersive filter with reflective array.

The detailed design of such filters had been described in (Refs 6,7). The calculation of topology Fig.1a is based on well developed theory of determination active and reactive parts of the input and output transducer impedances. The model , in which the IDT and reflective arrays were divided on the channels ,were used for structures Fig.1b.

2.2. Fan-shaped IDT

The layout of filters with fan-shaped IDT and reflective array are showed in Fig.2



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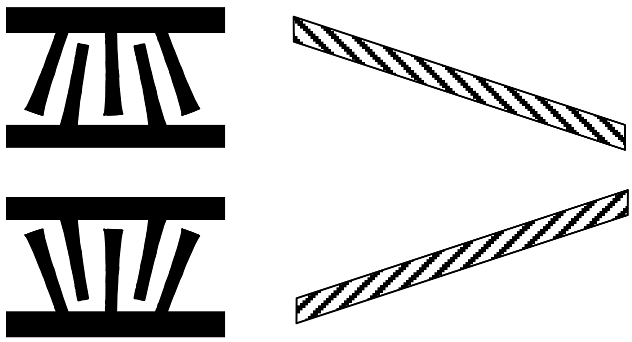

b)

Fig.2 The layout of filters with fan-shaped IDT and reflective array
a-linear finger;
b-hyperbolic finger.

The detailed design of such filters had been described in (Ref.8). Every continuos electrodes is expanded into finite series of uniformly distributed unary point sources , positioned at the center line of electrode. The results of calculations have been showed, that the amplitude distribution of acoustic field in the transducer aperture can be approximately described with the function *sinX/X*. The anisotropy of piezomaterial is taken into account.

3.Experimental results

3.1. Slanted IDT

The parameters of experimental filters are showed in the Table 1.

3.2. Fan-shaped IDT

The parameters of experimental filters are showed in the Table 2.

When the filters were being designed, two factors affecting frequency parameters were taken in account.

The first one is connected with SAW velocity in the substrate under the IDT metallized electrodes. This changing is determined from the relation $K/2=-\Delta V/V$, where K – is piezoelectric coupling coefficient in the substrate material. For lithium niobate (YZ-cut), ΔV=42m/s. Velosity decreasing results in the down shift of IDT operating band , which in its, turn affects the condition of synchronism in the IDT and reflective array. That increases insertion losses (6-10dB) and distorts frequency modulation law in the pulse. In order to eliminate this effect, this velocity changing is to be taken into account during the design of the fan-shaped IDT layout.

Another factor affecting the frequency parameters is connected with SAW diffraction by fingers edge .As the completed evaluations show, the shape of the amplitude distribution of acoustic field at the aperture edges differ from the function *sinX/X*. When the frequency of the input signal approaches the frequencies correspondent to the IDT edges, the field maximum stops moving in the aperture quickly decreasing in value. As the both pulse fronts are determined by reflective arrays edges, their durations increases. Therefore, during the design of the device layout, the IDT aperture is increased by 10-15% in respect to the operating aperture.

4.Conclusion

The wide-band SAW filters using slanted and fan-shaped IDT have been presented. The developed filters with relative bandwidth 100% and acceptable level of the amplitude and phase were being manufactured. The most interesting using of the elaborated filters is the dispersive receivers, spectrum analyzers and radars.

References

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Table 1. The main parameters of experimental filters with slanted IDT.

Model	Center frequency, MHz	Bandwidth, MHz (%)	Delay, mks	Insertion loss, dB	Type
SDL-1	160	100 (62,5)	3,2	28	Non-dispersive
SDL-2	300	200 (67)	0.8	25	Dispersive IDT
SDL-3	85	30 (35)	50	40	Dispersive with RAC
SDL-4	140	40 (28,5)	70	45	Dispersive with RAC

Table 2. The main parameters of experimental filters with fan-shaped IDT.

Model	Center frequency, MHz	Bandwidth, MHz (%)	Delay, mks	Insertion loss, dB	Type
FDL-1	125	47 (37,6)	16	35	Linear fingers RAC
FDL-2	50	23 (46)	20	40	Linear fingers RAC
FDL-3	105	60 (57)	6	40	Hyperbolic fingers RAC
FDL-4	105	105 (100)	10	52	Hyperbolic fingers RAC