LOW-LOSS SURFACE-ACOUSTIC-WAVE (SAW) RING FILTERS WITHOUT MATCHING ELEMENTS

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Several methods are in use for the creation of low-insertion-loss SAW filters. A traditional way of reducing insertion losses is through the use of various constructions of unidirectional counter-stub converters (CSC); this technique encounters numerous difficulties. The principal difficulty resides in the fact that the complexity of the spherical construction and topology of such CSC substantially reduces flexibility in the development of SAW filters and the guarantee of their ultimate electrical parameters (see [1]). In this connection the utilization of a ring construction consisting of input and output bidirectional CSC situated in parallel acoustic channels, plus two multistrip reflecting gratings which ensure transmission of the SAW between these channels (see [2]; Fig. 1) is promising. In such a construction, it is fairly simple to implement the stipulated selectivity and the low losses, since the amplitude-frequency response (AFR) of the filter is determined by multiplication of the AFR of the grating and the AFR of the input and output CSC in this case, while the low insertion losses are determined by the reflection coefficient of the grating and are ensured by the choice of its construction. In addition, the creation of filters with self-matching (see [3]) is possible in ring constructions. When the relationship $N = 1.5/k^2$, where k is the electromechanical coupling coefficient, is used to select the number of electrode pairs N in the input and output CSC in a manner which is optimal for the given cut of the piezoelectric, the impedances of the filter become resistive in the passband due to compensation of the static capacity of the CSC by the radiation reactance of the acoustic wave. As a result, the matching of the filter to the loads is ensured without external elements. Under these conditions, the relative passband of the filter is determined by the construction of the reflecting grating and is proportional to k^2 of the piezoelectric substrate.

In the present work we present the results of an experimental investigation of ring filters for effluent SAW based on rotated $LiNbO_3$ Y-cuts - YX/41° and YX/49° - which have values of k^2 equal to 18% and 16%, respectively (see [4,5]). The losses due to the propagation of the effluent SAW (and therefore the insertion losses in the filters also) depend substantially, as we know, on the distance between the CSC, the degree of metallization of the space between them, and on the construction of the reflecting grating. The latter feature must be taken into account in developing ring filters. It has been demonstrated in [5] that for a shorted reflecting grating the cut YX/49° has lower propagation losses, while for an open-circuited grating the cut YX/41° has lower losses.

A reflecting grating (Fig. 1) having three electrodes corresponding to λ (λ is the length of the effluent SAW at the center frequency of the filter), which ensures a 4-5% relative passband for a length consisting of 60 electrodes (see [6]), was used in the construction of the filters. As has already been noted, the AFR of the filter is determined by multiplication of the AFR of the gratings and the AFR of the input and output CSC; therefore, taking account of the graph of the AFR of the gratings based on the YX/49° cut of $LiNbO_3$ (see [6]), it is not difficult to show that in order to ensure a relative passband of the filter which is close to the band of the reflecting gratings and a guaranteed attenuation in the blocking band of no less than 40 dB for a rectangularity coefficient close to 3, it is sufficient to construct the input and output CSC so that they are weighted in accordance with the Fejer window function. The relative width of the spectral response of the window function at the 3 dB level must be no smaller than the bandwidth of the reflecting gratings. In this case, as calculations show, it follows that notwithstanding the dissection of the AFR in the transitional zone a maximally smooth AFR is achieved for the filter in a passband of 4-5%.

In Fig. 2 (curves 1, 2) the AFR of a ring filter based on the YX/41° cut of $LiNbO_3$ is shown in a wideband and passband, respectively (the AFR of the filter based on the YX/49° cut of $LiNbO_3$ is not shown in order not to encumber the figure, since it has the same shape and differs only in its center frequency and its level of insertion

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