Novel configuration of a SAW-Dielectric antenna duplexer for Personal Digital Cellular (PDC) phone system with simultaneously transmit-receive packet mode scheme

Toshio Ishizaki[1], *Senior member*, Hiroyuki Nakamura[1], *Member*,

Katsuya Fujii[2] and Yukihiro Takeda[3]

1: Devices Development Center, Matsushita Electric Industrial Co., Ltd.

2: LCR Device Company, Matsushita Electronic Components Co., Ltd.

3: Matsushita Nitto Electric Co., ltd. (All with Panasonic)

Abstract — **A new antenna duplexer has been successfully developed. It is used for Personal Digital Cellular (PDC) handset with simultaneously transmit-receive packet mode scheme. The features of a SAW filter and a dielectric filter are cleverly utilized to create an Rx filter of the duplexer. An excellent attenuation performance and a small size are realized, which characteristics never any conventional filter can achieve. The newly developed filter is widely used in PDC handsets.**

I. INTRODUCTION

Simultaneously transmit-receive scheme for packet data communication has been recently introduced in Personal Digital Cellular (PDC) phone system in Japan to realize a high data-rate transmission. An antenna duplexer for the new digital cellular-phone handset corresponding to this system was developed successfully. In the handset, in addition to the voice mode, which performs transmission and reception as a conventional time division fashion, the capability for packet mode service becomes indispensable. A new antenna duplexer, which is not only a switch but also is able to simultaneously transmit and receive the signal with one antenna, becomes required. In this report, the filter of novel configuration of having combined with a SAW filter and a dielectric filter is proposed. The distinctive point of the duplexer is an elegant consideration for the features of the attenuation characteristics of a SAW filter and a dielectric filter. The novel configuration has been applied to the antenna duplexer for new PDC handsets. The attenuation characteristics, the reduction of insertion loss, and the miniaturization are discussed.

II. BACK GROUND

The structure of an antenna duplexer commonly used so far is shown in Fig. 1 [1], [2] (for example). The antenna duplexer comprises a transmitting filter and a receiving filter. It has the function to separate a transmitting signal and a receiving signal for one antenna. Regarding the characteristics, high attenuation in the attenuation band and low insertion loss in the

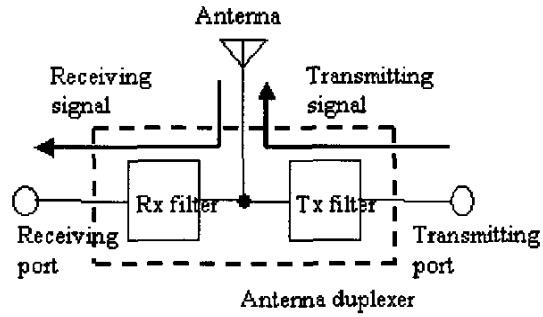


Fig.1 Block diagram of antenna duplexer

0-7803-7695-1/03/$17.00 © 2003 IEEE

pass band are required to keep good performance for transmission and reception. The improvement in receiving sensitivity of a cellular phone, the inter-modulation distortion durability and so on are considered. In order that, especially a receiving filter has to suppress the transmitting signal coming through the antenna circuit including an antenna switch circuit. The required amount of the attenuation has to be 55dB or more. The insertion loss has to be 2.0dB or less. The conventional technology might use dielectric filter for the receiving filter. However, in this case, the size of a three-pole dielectric filter is more than three times of 1.6mm x1.6mm x 7.0mm, which is a size for each resonator. Here, this size cannot be acceptable at all. On the other hand, a SAW filter alone cannot obtain such a severe performance. So far, the combination of both filters in one receiving filter has not been reported with such a complex topology as shown in Fig.4 later.

Here, Figure 2 shows whole antenna duplexer portion for new PDC system. The PDC system is adopting antenna switch diversity scheme. Thus a GaAs switch IC switches the antennas to get a diversity gain. The switch IC also switches transmitting-mode and receiving-mode. In this extent, the antenna switch circuit is the same as the conventional one.

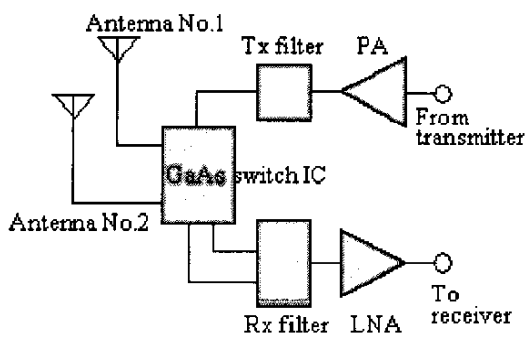


Fig.2 Block diagram of the whole antenna duplexer portion for new PDC handset

Due to the new function for packet mode communication, a Tx filter and an Rx filter are required to form a duplexer. The two filters are combined via the switch IC. The new PDC system has two frequency bands. One is for both packet-mode and voice-mode operation, which uses a simultaneous-transmit-receive and a TDMA fashion. We may call this band as the primary band here. The other is only for voice-mode operation, which uses the band as a TDMA fashion. We may call this band as the secondly band here. Fortunately, for Tx-side, the two bands are continuously adjacent. Thus one PA module and one Tx-filter of wide band are enough. On the other hand, for Rx-side, the two bands are a little bit separated. Therefore, the Rx filter, which has two input terminals (primary and secondly) for the respective bands, is required. The authors would like to emphasize the advantages of utilizing the features of this frequency allocation to develop the novel SAW-Dielectric Rx filter. The detail will be explained in the following section.

III. BASIC CONCEPT AND EXPERIMENTAL RESULTS

A novel combined structure of a SAW filter and a dielectric filter has been developed. This new structure was applied to the receiving filter at this time. The block diagram of the combination with a SAW filter and a dielectric filter is shown in Fig. 3. The characteristic improvement was tried by agreeing with the attenuation frequencies of the both filters. The features of this filter are as follows.

(1) Another adjacent receiving band (secondly band) is combined by another SAW filter, where the adjacent signal doesn't go through the dielectric filter

(2) The dielectric notch filter can provide low insertion loss for the receiving band and large attenuation for the transmission band, which is far from the receiving band (primary band)

(3) The dielectric filter can attenuate the high-power transmission signal, thus the power durability of the SAW filter is relaxed.

Figure 4 shows the structure of the receiving filter in detail. And Figure 5 shows the transmission performances of the primary SAW filter and the secondly SAW filter. From these figures, you can easily understand the features of this novel filter structure mentioned above.

The experimental transmission characteristics of (a) SAW filter alone, (b) dielectric filter, and (c) SAW-dielectric filter are shown in Fig. 6. From Fig. 6 (a), the SAW filter alone has loss of 1.6dB and attenuation of 35dB. By combining a SAW filter and a dielectric notch filter, the developed filter has loss of 1.8dB and attenuation of 60dB as shown in Fig. 6 (c). Compared with the conventional three-pole dielectric filter, 0.2dB loss reduction and 5dB higher attenuation were realized, simultaneously. The miniaturization by 20% from the conventional filter is achieved. A photograph of the receiving filter is shown in Fig. 6. The portion enclosed with the solid line in Fig. 6 is the mentioned receiving filter. The whole module also includes a 1.5GHz SAW Rx-filter, because this handset is a dual-band terminal for the 900MHz band and the 1.5GHz band.

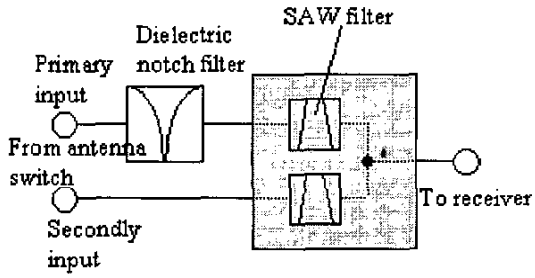


Fig.4 The structure of the receiving filter in detail

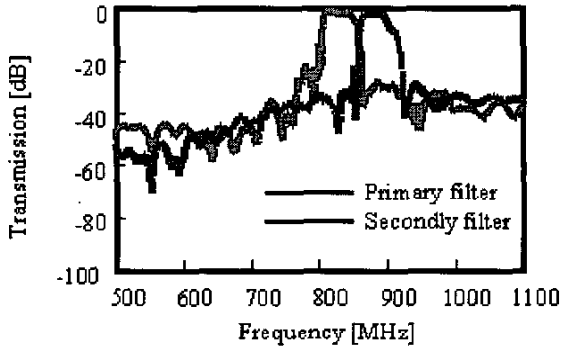


Fig.5 Transmission performances of two adjacent SAW filters

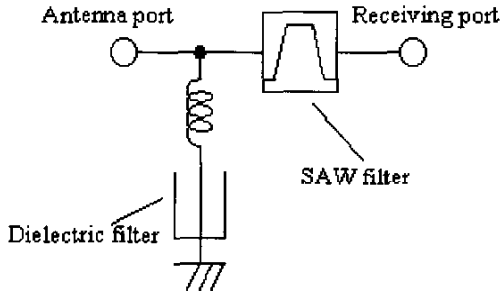
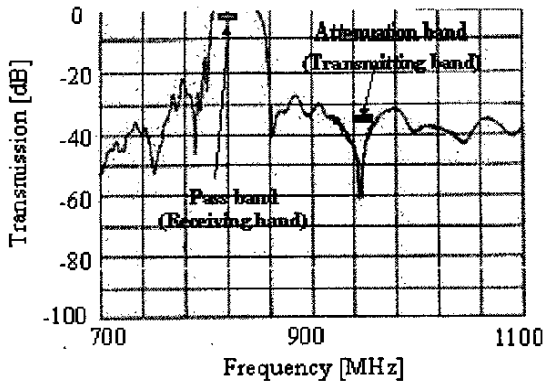
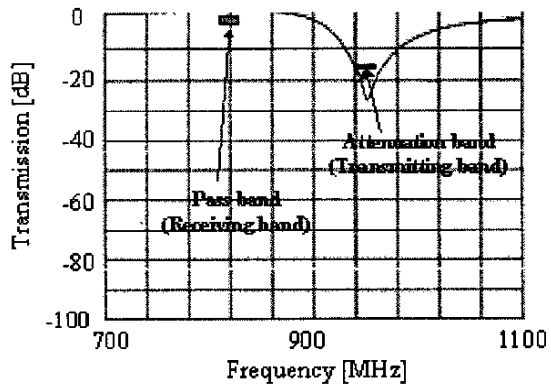


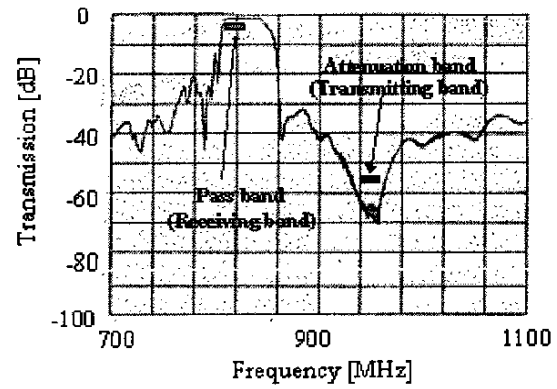
Fig.3 Block diagram of combination with SAW filter and dielectric filter



(a) SAW filter alone



(b) Dielectric notch filter



(c) SAW-Dielectric filter

Fig.5 Characteristics of the SAW-Dielectric filter
(a) SAW filter alone, (b) Dielectric notch filter,
(c) SAW-Dielectric filter

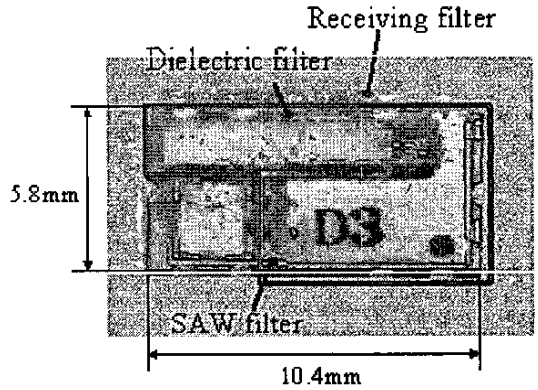


Fig.6 Photograph of newly developed Rx filter

IV. CONCLUSIONS

A novel SAW-dielectric antenna duplexer for packet mode digital cellular-phone has been successfully developed. The novel combination structure can obtain large attenuation and small insertion loss. The miniaturization was also realized simultaneously. The newly developed duplexer is widely used in PDC handsets. Of course, this new technology can be also applied to other systems using TDMA and simultaneous-transmit-receive scheme.

REFERENCES

[1] H. Matsumoto and T. Nishikawa, "Design of miniaturized dielectric duplexer with attenuation poles", IEICE Trans., vol.J76-C-I, No.5, pp.164-172, May, 1993. (In Japanese)

[2] R. Takayama, H. Nakanishi, T.Sakuragawa, T. Kawasaki and K. Nomura, "High power durable electrodes for GHz band SAW duplexers", 2000 IEEE Ultrasonic Symposium Digest, vol.1, pp.9-13, 2000.