IEC 62604-2

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INTERNATIONAL STANDARD

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Surface acoustic wave (SAW) and bulk acoustic wave (BAW) duplexers of assessed quality – Part 2: Guidelines for the use

Duplexeurs à ondes acoustiques de surface (OAS) et à ondes acoustiques de volume (OAV) sous assurance de la qualité – Partie 2: Lignes directrices d'utilisation

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FOREWORD

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International Standard IEC 62604-2 has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection.

NOTE In this standard, SAW and BAW duplexers are treated simultaneously because both duplexers are used in the same manner especially in mobile phones and have same requirements of characteristics, test method and so on.

The text of this standard is based on the following documents:

FDIS	Report on voting
49/974/FDIS	49/985A/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 62604 series under the general title: *Surface acoustic wave (SAW) and bulk acoustic wave (BAW) duplexers of assessed quality,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,
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SURFACE ACOUSTIC WAVE (SAW) AND BULK ACOUSTIC WAVE (BAW) DUPLEXERS OF ASSESSED QUALITY –

Part 2: Guidelines for the use

1 Scope

This part of IEC 62604 concerns the duplexers, which can separate receiving signal from transmitting signal and are key components for two-way radio communications. They are generally used in mobile phones using CDMA systems such as N-CDMA, W-CDMA / Universal Mobile Telecommunication System (UMTS). So far, dielectric duplexers have been mainly used. However, recently SAW duplexers, which are utilized surface acoustic wave (SAW), are becoming popular and replacing the dielectric duplexers year by year in recent mobile phones, because of their advantage of small size, light weight and good electrical performances. In addition to SAW duplexers, BAW duplexers, which are utilized bulk acoustic wave (BAW), are also becoming in the spotlight and popular because of their higher *Q* property and better performances especially in PCS band.

It is neither the aim of these guidelines to explain theory, nor to attempt to cover all the eventualities which may arise in practical circumstances. These guidelines draw attention to some of the more fundamental questions, which should be considered by the user before he places an order for SAW and BAW duplexers for a new application. Such a procedure will be the user's insurance against unsatisfactory performance. Because SAW and BAW duplexers have very similar performance for the usage, it is useful and convenient for users that both duplexers are described in one standard.

Standard specifications, such as those of IEC of which these guidelines form a part, and national specifications or detail specifications issued by manufacturers, will define the available combinations of centre frequency, pass bandwidth and insertion attenuation for each of transmitting and receiving filters and isolation level between transmitting and receiving ports, etc. These specifications are compiled to include a wide range of SAW and BAW duplexers with standardized performances. It cannot be over-emphasized that the user should, wherever possible, select his duplexers from these specifications, when available, even if it may lead to making small modifications to his circuit to enable the use of standard duplexers. This applies particularly to the selection of the normal frequency.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60862-1:2003, *Surface acoustic wave (SAW) filters of assessed quality – Part 1: Generic specification*

IEC 60862-2:2002, *Surface acoustic wave (SAW) filters of assessed quality – Part 2: Guide to the use*

IEC 61019-2:2005, *Surface acoustic wave (SAW) resonators – Part 2: Guide to the use*

3 Technical considerations

It is of prime interest to a user that the duplexer characteristics should satisfy particular specifications. The selection of the front-end circuits in mobile phones and SAW and BAW duplexers to meet such specifications should be a matter of agreement between the user and the manufacturer.

Duplexer characteristics are usually expressed in terms of centre frequency, pass bandwidth and insertion attenuation for each of transmitting and receiving filter parts in the duplexer and isolation level between transmitting and receiving ports. Since the SAW and BAW duplexer is used in RF front-end of the mobile phones, lower insertion attenuation, higher isolation/rejection level, stronger power durability and smaller/thinner package dimension are strictly required.

4 Fundamentals of SAW and BAW duplexers

4.1 Basic function

Duplexers are necessary for mobile phones to simultaneously receive and transmit signal. Duplexers are 3-port devices which consist of Antenna port, Transmitter port (TX port) and Receiver port (RX port) shown in Figure 1. It has three basic functions. First one is to transmit transmitting signal from TX port to Antenna port. Second one is to transmit receiving signal from Antenna port to RX port. Last one is to prevent from leaking transmitting signal from TX port to RX port. The transmitting frequency and the receiving frequency are determined corresponding to each mobile phone system. For example, Table 1 shows typical allocated frequency bands for UMTS.

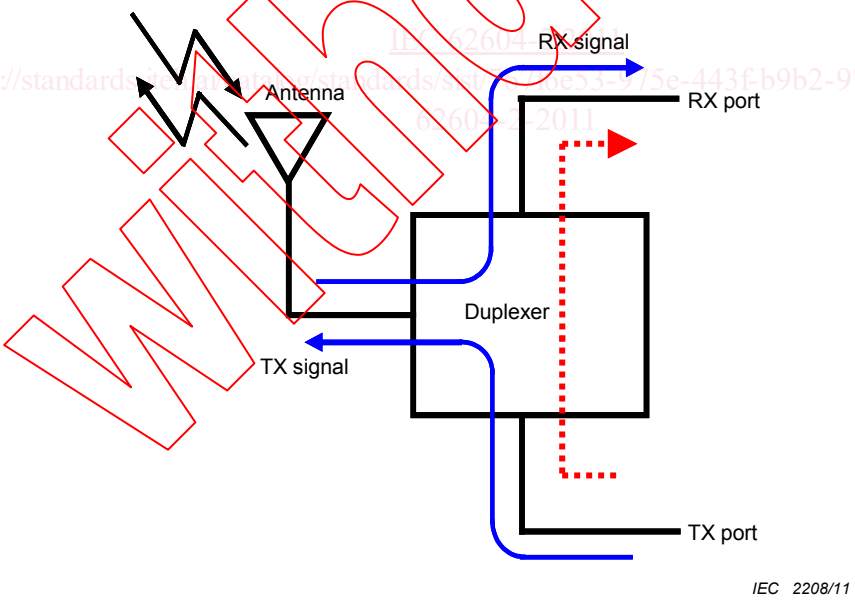


Figure 1 – Basic duplexer configuration

Table 1 – Frequency allocation of typical UMTS bands

Band	Transmitting frequency (MHz)	Receiving frequency (MHz)
I	1 920-1 980	2 110-2 170
II	1 850-1 910	1 930-1 990
III	1 710-1 785	1 805-1 880
IV	1 710-1 755	2 110-2 155
V	824-849	869-894
VIII	880-915	925-960

4.1.1 TX filter response (Filter response from TX port to antenna port)

Figure 2 shows frequency characteristics example of the TX filter. The required frequency characteristics are low insertion attenuation in transmitting frequency band (f_T), high insertion attenuation in receiving frequency band (f_R) and good impedance matching.

4.1.2 RX filter response (Filter response from antenna port to RX port)

Figure 3 shows frequency characteristics example of the RX filter. The required frequency characteristics are low insertion attenuation in receiving band (f_R) and high insertion attenuation in transmitting frequency band (f_T).

4.1.3 Isolation (Isolation from TX port to RX port)

Figure 4 shows isolation characteristics example. One of the important functions for the duplexers is isolation characteristics which show the frequency dependence of the leakage power from the TX port to the RX port.

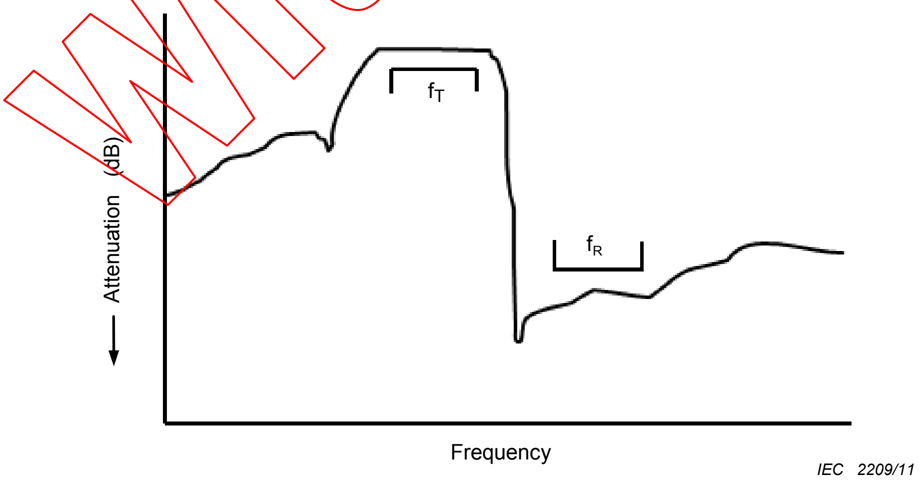


Figure 2 – Basic TX filter response example of SAW and BAW duplexers

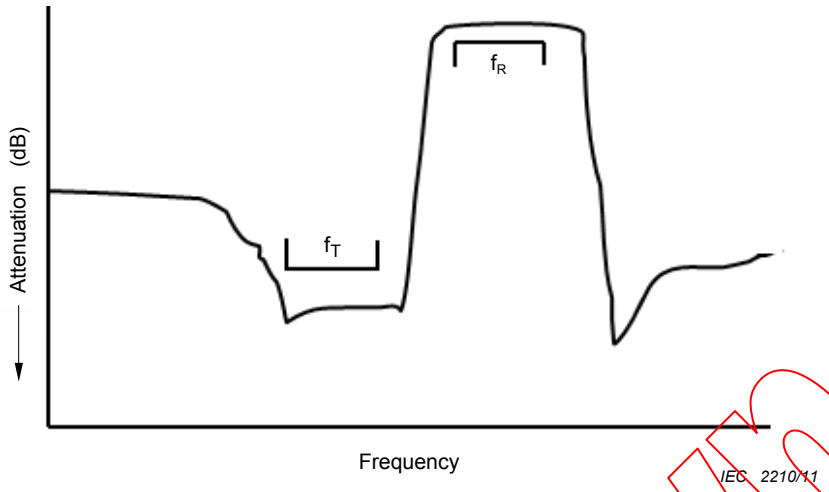


Figure 3 – Basic RX filter response example of SAW and BAW duplexers

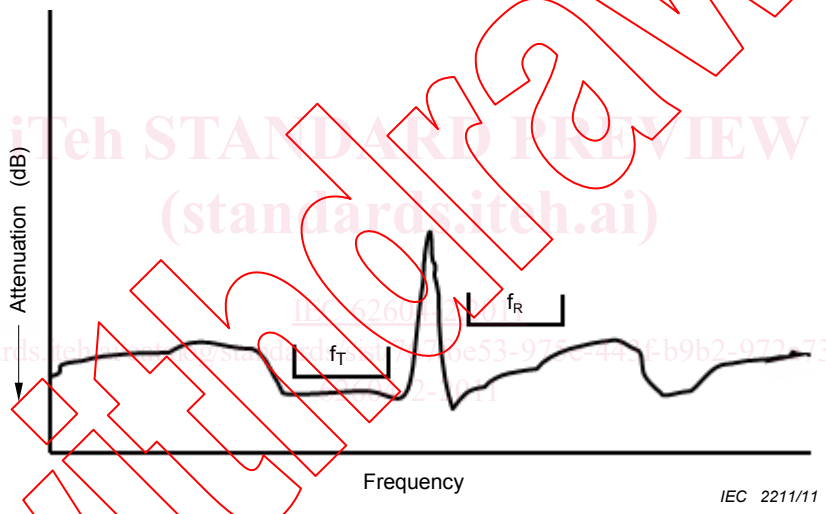


Figure 4 – Basic isolation response example of SAW and BAW duplexers

4.2 Basic structure

Duplexers are 3-port devices/modules, which enable to transmit and receive signals simultaneously through a common antenna. A basic structure of duplexers is shown in Figure 5. SAW and BAW duplexers consist of a transmitting (TX) part and a receiving (RX) part. These two parts, which may add a phase shifter, are connected to antenna port. The phase shifter is utilized to prevent the interaction between the filters. In the Figure 5, Z_t and Z_r correspond to the impedance of TX and RX part at the antenna port side, whereas Z_o is the impedance of antenna port. The following conditions must be fulfilled to achieve the duplexer functions.

$Z_o \cong Z_t << Z_r$ in the TX pass-band

$Z_o \cong Z_r << Z_t$ in the RX pass-band

DMS (Double Mode SAW) type SAW filters which are also known as longitudinally coupled resonator filters[1)], ladder type SAW[2)] and BAW filters and other type of SAW filters such as

1) See IEC 60862-2:2002, 6.3.

2) See IEC 60862-2:2002, 6.2.

interdigitated interdigital transducer (IIDT)[3] can be adopted as TX and RX filters. High power durability is required in the TX filters.

4.3 Principle of operation

In the TX pass-band, the impedance of the TX part in the antenna port side (Z_t) is almost the same as that of antenna(Z_o), while that of the RX part (Z_r) is much higher, which means that at the antenna port, the RX part has large reflection coefficient in this band.

$Z_o \cong Z_t << Z_r$ in the TX pass-band

On the other hand, in the RX pass-band, the impedance of the RX part at the antenna port side (Z_r) is almost the same as that of antenna (Z_o), while that of the TX part (Z_t) is much higher. This also means the TX part has large reflection coefficient in this band.

$Z_o \cong Z_r << Z_t$ in the RX pass-band

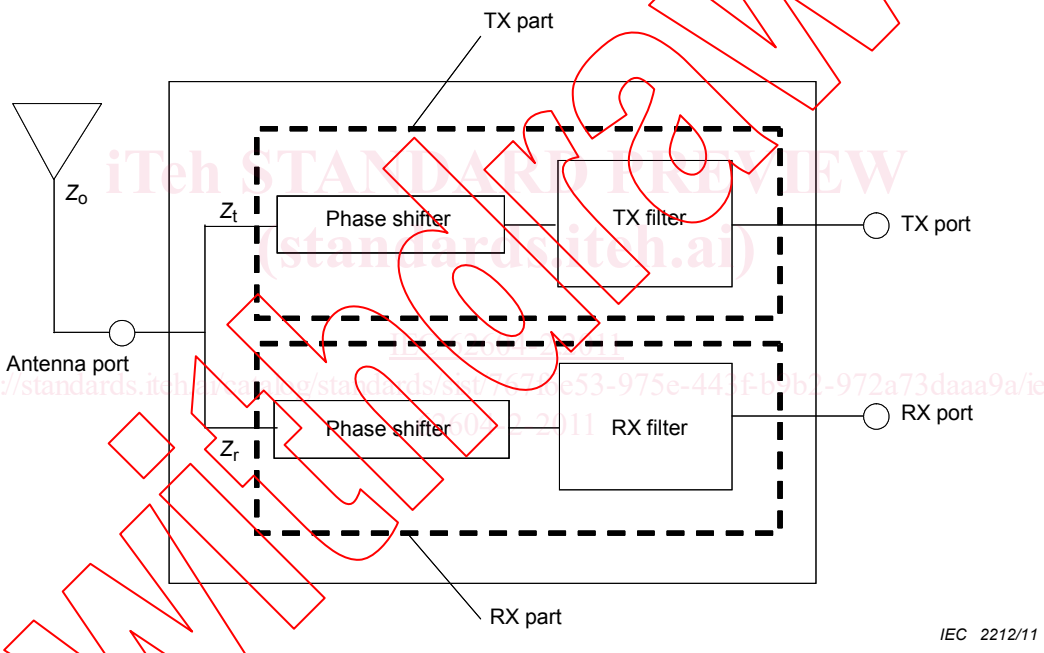
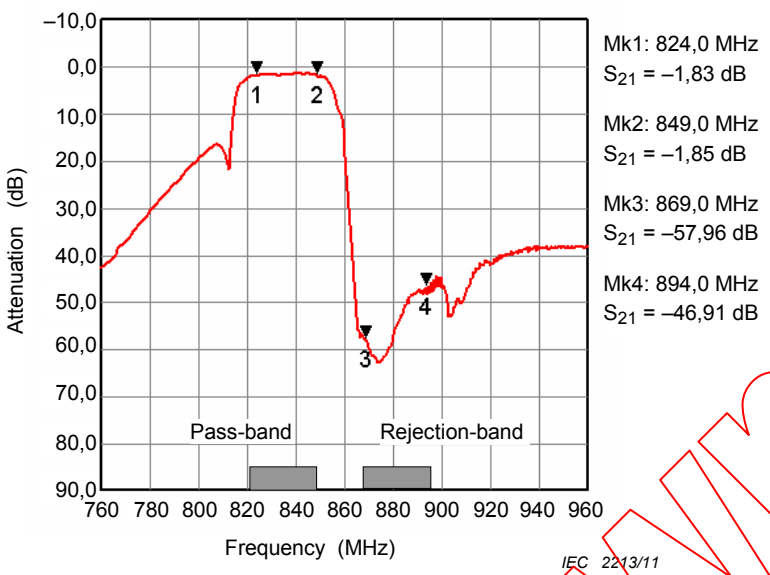


Figure 5 – The block diagram of duplexer

The transmitter signal applied to the TX port passes through the TX filter and then flows to the Antenna port, not the RX filter. The received signal from Antenna port doesn't flow to the TX filter, but to the RX filter. As a result, the TX part and the RX part can share the common antenna port. In the following explanation, the impedance of the antenna (Z_o) is assumed to be 50 Ω. The S_{11} curve of TX part at the antenna port side must satisfy the demanded condition indicated in Figure 6. The impedance of its pass-band must be around 50 Ω. In the rejection band, the impedance must be sufficiently larger than 50 Ω. In the actual duplexer, the S_{11} trace in the Smith chart of the TX filter is rotated to its optimum state by a phase shifter, as shown in Figure 7. On the other hand, the frequency characteristics of S_{21} remain the same as that of without phase shifter. Figure 8 shows the S_{21} frequency characteristics and S_{11} demanded condition of RX part.

3) See IEC 60862-2:2002, 6.4.



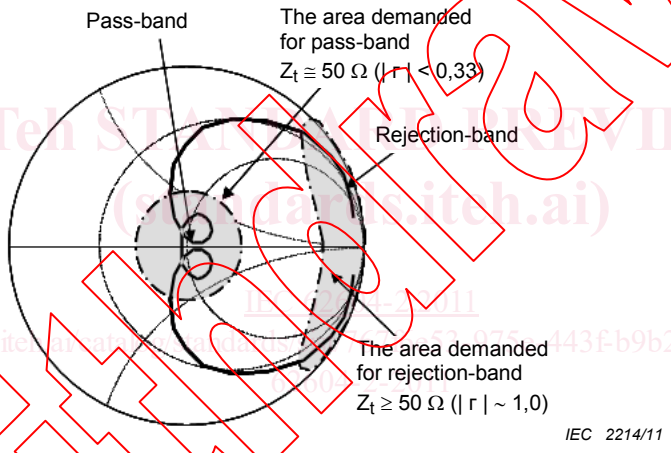


Figure 6 – Demanded condition of TX part for duplexers

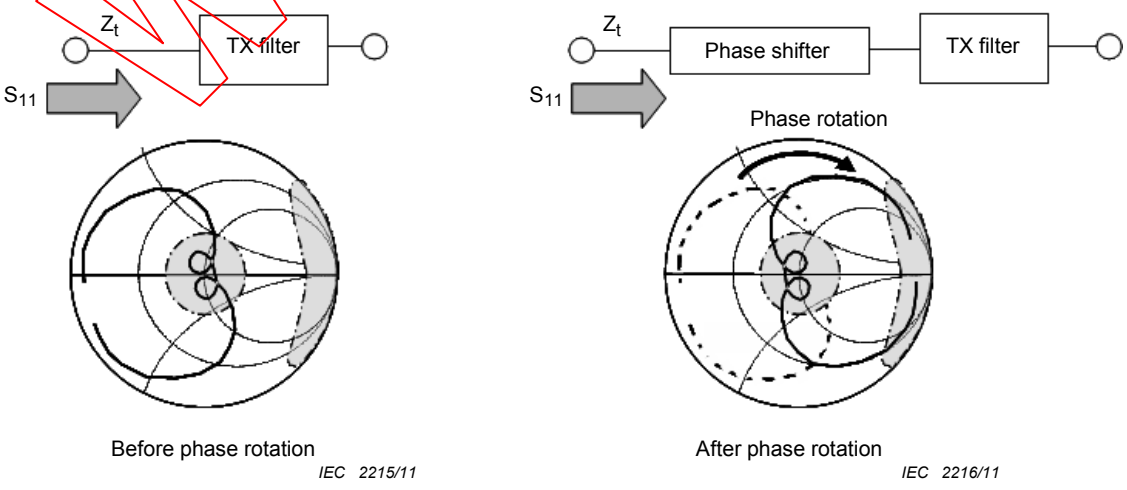
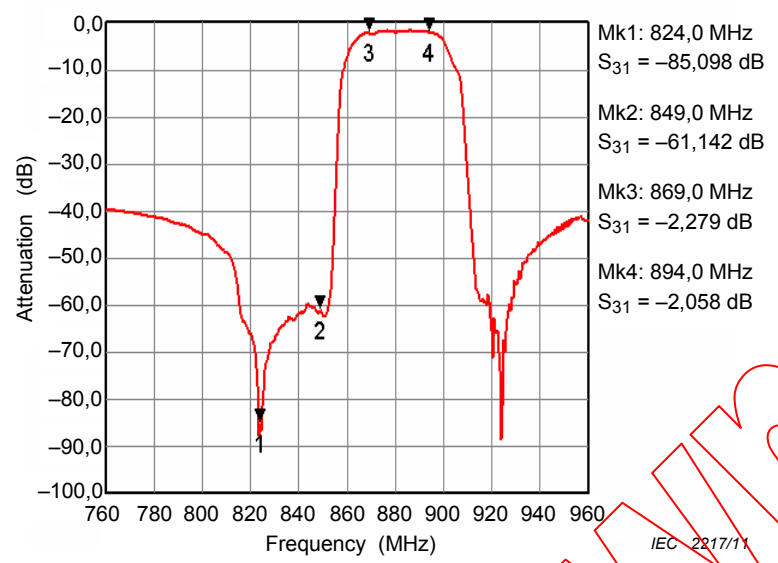


Figure 7 – Phase rotation in TX part



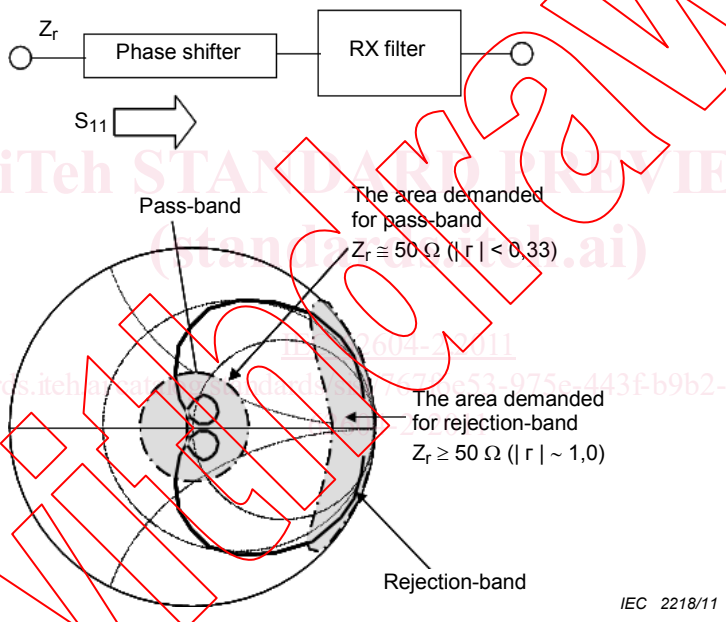


Figure 8 – Demanded condition of RX part for duplexers

5 SAW and BAW duplexer characteristics

5.1 General conditions for SAW and BAW duplexers

TX filter, RX filter and phase shifter, which compose SAW and BAW duplexer as shown in 4.2, are described in this section. Duplexer assemble configuration is also explained here.

– **TX filter**

The TX filter of the duplexers needs high power durability against the transmitting signal. To ensure the durability against high power such as one watt or so, ladder filter or lattice filter is used for the TX filter because of their higher power durability among several types of SAW and BAW filters. SAW filters are described in 6.2 of IEC 60862-2:2002.

Besides of low insertion attenuation in TX band (f_T) and high insertion attenuation in RX band (f_R) described in 4.1, high attenuation in the second harmonic ($2f_T$) and the third harmonic ($3f_T$) is also important. The attenuation in spurious frequency (f_{SP}) suppresses