A NEWLY DEVELOPED HIGH DIRECTIVITY X-BAND WAVEGUIDE DIRECTIONAL COUPLER

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Abstract

A new X-band waveguide directional coupler working at 11.9924 GHZ is designed. Four holes symmetrical to the structure are drilled along the central line of the narrow-wall, which is used to couple the electromagnetic power from the main-waveguide to the sub-waveguide. The final prototype has got a measurement result of 32.2 dB Directivity (-47.0 dB Coupling Degree) together with a very low VSWR (1.067) and Insertion Loss (-0.11 dB) at 11.9924 GHz. The vacuum performance is also qualified.

INSTRUCTION

Directional Coupler, which is one of the most widely used microwave components in many microwave systems, is used to distribute the power of the input microwave signal according to a needed ratio.

Unlikely used in microwave circuits or the radars, the directional couplers are mainly used for watching the power continuously or for chain protection together with other machines in the accelerator system[1][2].

A new X-band waveguide directional coupler working at 11.9924 GHZ is designed. Four holes symmetrical to the structure are drilled along the central line of the narrow-wall for coupling the electromagnetic power from the main-waveguide to the sub-waveguide. Two SMA joints are used to pick up the coupled power from the sub-waveguide.

STRUCTURE

The structure of the directional coupler is shown in Fig. 1. Four holes are drilled along the central line of the narrow-wall before welding the narrow-walls of the main and sub-waveguide together. The two ends of the main-waveguide are welded with flanges while two shorting walls are used at the two ends of the sub-waveguide, and two SMA joints are welded on the wide-wall of the sub-waveguide to pick up the microwave power out. The microwave power come in from the Input Port and about one over one hundred thousand of it is coupled to the sub-waveguide and picked out by the SMA joint finally.

SIMULATION RESULT

The simulation model of the directional coupler is shown in Fig. 2. The most important parameters of it are the distance between the coupling holes, the diameter of the coupling holes, the distance between the central point of the SMA joint and the shorting wall, the insertion depth of the SMA joint (Not shown in Fig. 2).

After the simulation and optimization in CST 2010, the designed directional coupler has got a Directivity of more than 31 dB within a bandwidth of 430 MHz (11.82~12.25 GHz) while maintaining a VSWR less than 1.04 as well as a variation of the Coupling Degree less than 0.4 dB (-48.5~ -48.9 dB) at the same time in simulation.

The frequency response of the Return Loss is shown in Fig. 3 while the frequency response of the Insertion Loss as well as the Directivity are shown in Fig. 4 and Fig. 5 respectively.

TEST RESULT

The prototype is shown in Fig. 6, and a satisfying test result has been achieved as shown in Table 1.

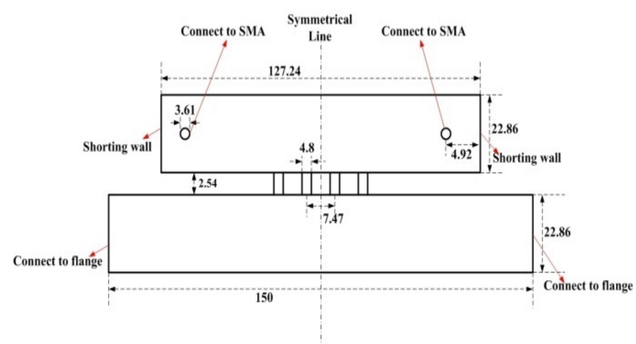

Figure 1: Structure of the X-band waveguide directional coupler (Looking down), Unit: mm.

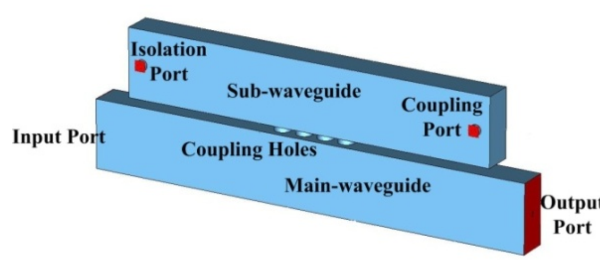

Figure 2: Simulation Model (3D).

The comparison between the test and simulation result is shown in Table 2. From this we can see that the test result is acceptable but worse than the simulation ones. Because the highly accurate fabrication requirement result in a large deviation from the simulation results even if there is only a very small fabrication error.

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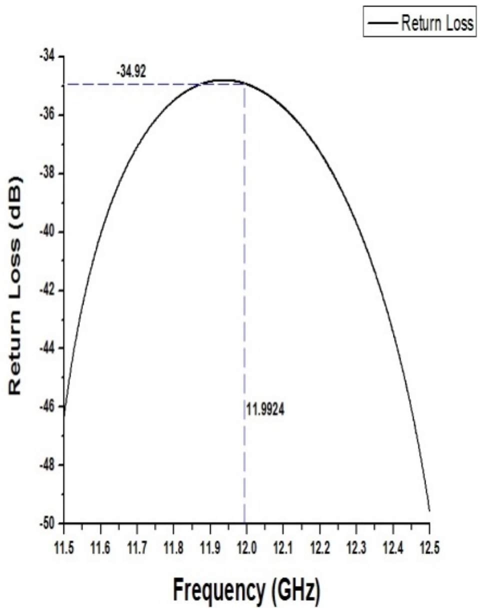

Figure 3: Frequency response of the Return loss.

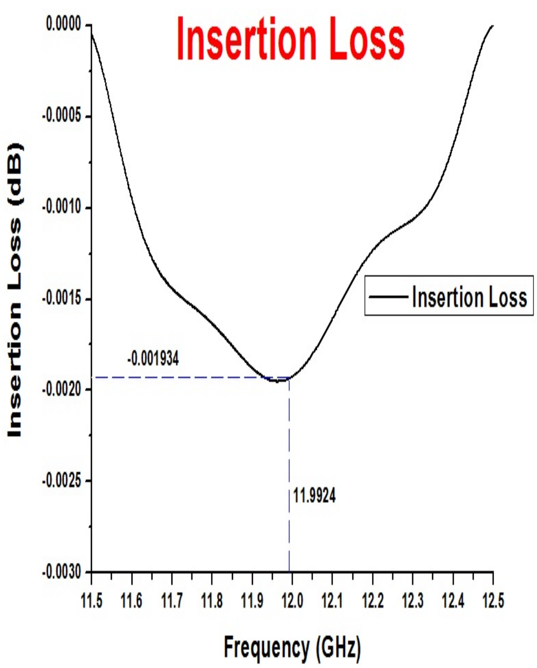

Figure 4: Frequency response of the Insertion Loss.

CONCLUSION

The X-band waveguide directional coupler designed here has got advantages of high directivity, small voltage standing wave ratio, small insertion loss, stable coupling degree, wide bandwidth, etc. However, even a very small fabrication error may cause a very large deviation between the test and simulation results because of the highly accurate fabrication requirement. So it is very important to control the fabrication error during the future processing.

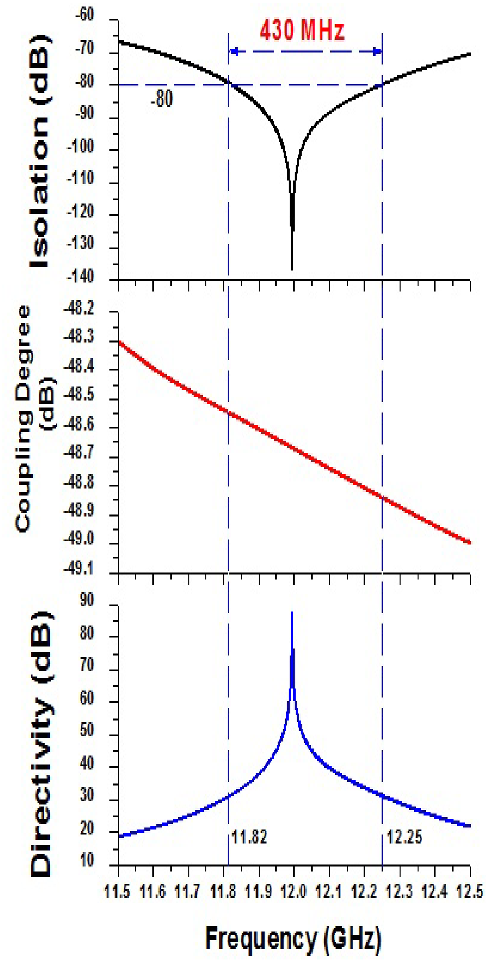

Figure 5: Frequency response of the Directivity, Coupling Degree and Isolation.

Table 1: Test result of the X-band directional coupler

	At 11.9924 GHz	**Within ±5 MHz**
Input port	Male port	/
VSWR	1.067	1.06 ~ 1.073
Insertion Loss (dB)	-0.11	/
Coupling Degree (dB)	-47.0	-46.9 ~ -47.2
Isolation (dB)	-79.2	-78.8 ~ -79.7
Directivity (dB)	32.2	More than 31.6

Figure 6: Prototype of the X-band waveguide directional coupler.

Table 2: Compare between the simulation and test results of the X-band directional coupler (at 11.9924 GHz)

	Simulation	Test
VSWR	1.037	1.067
Insertion Loss (dB)	-0.002	-0.11
Coupling Degree (dB)	-48.7	-47.0
Directivity (dB)	68.7	32.2

ACKNOWLEDGMENT

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