Low Power Measurements of TE_{10}-TE_{01} Mode Converters and TE_{01} TWC Windows

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Abstract

The results of computer simulation and "cold" measurements of three types of X-band compact TE_{10}-TE_{01} mode converters are presented. Two types of "Travelling Wave in Ceramics Windows" were manufactured and measured on the basis of these converters.

Introduction

TE_{01}-type waves are in the focus of attention of designers of a high power X-band RF devices. Due to minimum losses, such waves allow to design, using long circular waveguides, highly efficient RF pulse compression devices [1,2]. While manufacturing RF windows, it is advisable to get rid of any electrical field on the waveguide walls, which reduces the requirements to the metal-ceramics contact and hence enhances the electrical durability. To use TE_{01} waves, TE_{01}-TE_{10} converters are needed. The converters should be compact in size and simple in fabrication. These properties can be found in the "Flower-Petal" converter [3]. Ref. [4] represents the results of simulation of some other compact converters with the reduced maximum surface electrical field strength. The results are in regard with the "cold" measurements of converters and TE_{01} TWC windows manufactured on the basis of these converters.

Operation Principle of Converters

Converters #1,#2 are presented in Fig. 1 and Figs. 2,3, respectively. The base element of the two converters is an extended diaphragm with four sector-shaped' holes that are one-mode waveguides. The diameter of the circular waveguide is chosen so that for TE_{14} it is boundless. If in the four sectors-shaped waveguides the wave amplitudes and phases coincide, then evidently the wave propagating in the circular waveguide is purely TE_{01}.

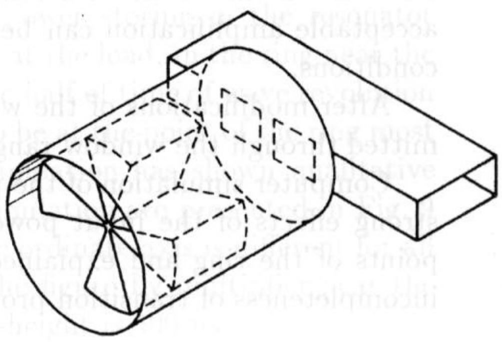

Fig. 1: Scheme of converter #1.

As follows from the symmetry conditions, the sector-shaped waveguides are excited with equal amplitudes and phases if they are appropriately orientated to the incoming wave with the even number of azimuth variations. In converter #1, the required wave is excited by two holes in the narrow wall of the rectangular waveguide that are half wave-length distance from each other.

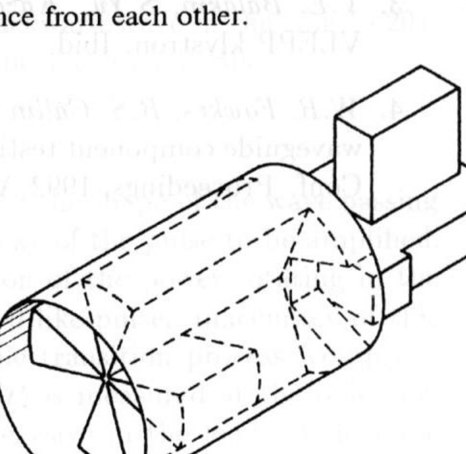

Fig. 2: Scheme of converter #2.

In converter #2, the given wave is generated by the TE_{20} wave propagating in the rectangular waveguide, which, in turn, is generated in the E-bend of the waveguide.

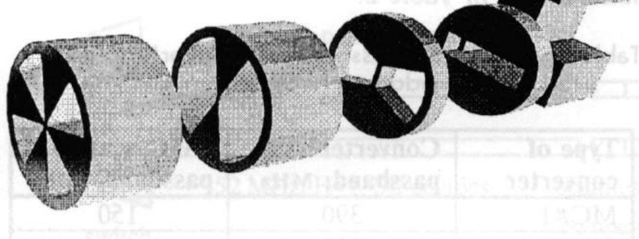

Fig. 3: Converter #2.

Converter #3. The operation principle of the converter is clear from Fig. 4. The circular waveguide is circumvented by the E-plane bend with a rectangular cross-section. The circular and rectangular waveguides are coupled through the slots. Five coupling slots are spaced azimuthally in the circular waveguide, and at the wave-length distance in the surrounding rectangular waveguide.

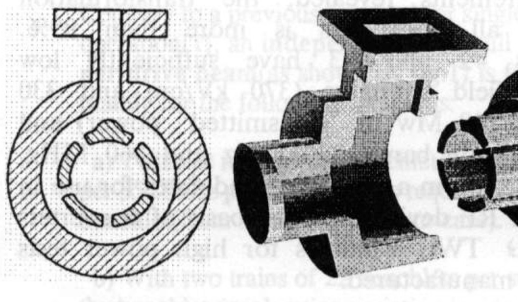

Fig. 4: Converter #3.

The rectangular waveguide is fed by the T-junction with the matching element. Since the distance between any two slots is equal to the wavelength, one should expect the equality of the field amplitudes and phases. Then the wave excited in the circular waveguide is purely TE_{01} wave. The plunger in the circular waveguide serves for fine tuning of SWR.

Field Strength Calculations

The field strengths were calculated for converters #1, #2 and #3. For comparison, same calculations were done for the SLAC "Flower-Petal" converter. The HFSS program was applied to simulate the process. For all these cases, the rounding radius for sharp edges was chosen to be 1 mm. The results of the calculations for transmitted power 100 Mw are summarized in Table 1.

Table 1. Maximum surface electrical field strength at 100 MW transmitted power

Type of converter	Surface field strength
Flower-Petal	740 kV/cm
MC#1	680 kV/cm
MC#2	370 kV/cm
MC#3	330 kV/cm

Experimental Results

The samples of converters #1, #2, and #3 were manufactured and tested. The purity of TE_{01} -- TE_{01} mode conversion was measured with a rotating probe. As the estimations showed, for all converters the TE_{01} mode purity is better than 99%. On the basis of converters #1 and #3, TWC windows were manufactured.

Converter #1. Fig. 5 shows the graph of the SWR of converter #1 with the matched load and SWR of TE_{01} TWC window that was manufactured on the basis of converters #1. At the SWR level equal to 1.21, the bandwidth of the converter is 390 MHz, and the window band is 150 MHz.

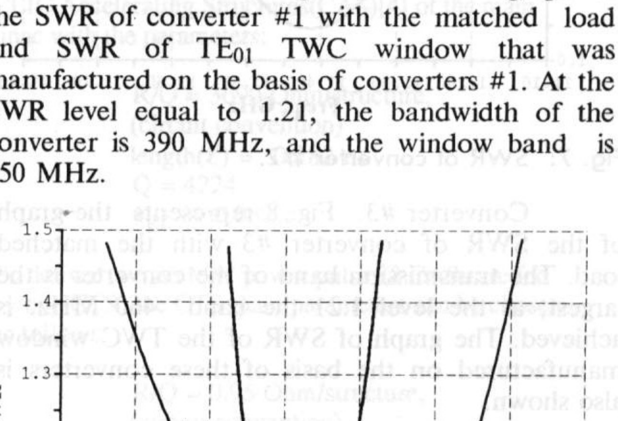

Fig. 5: SWR's of converter #1 and TWC window on its basis.

Fig. 6 shows the graphs of SWR of two converters #1 coupled through the circular waveguide. The curves correspond to different angular positions of the converters with respect to each other.

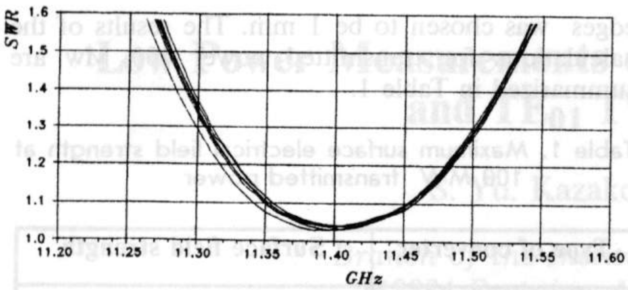

Fig. 6: SWR of two converters #1 coupled through a circular waveguide.

Converter #2. Fig. 7 displays the SWR of the converter # 2. At SWR equal to 1.21, the transmission band of the converter with the matched load is 270 MHz.

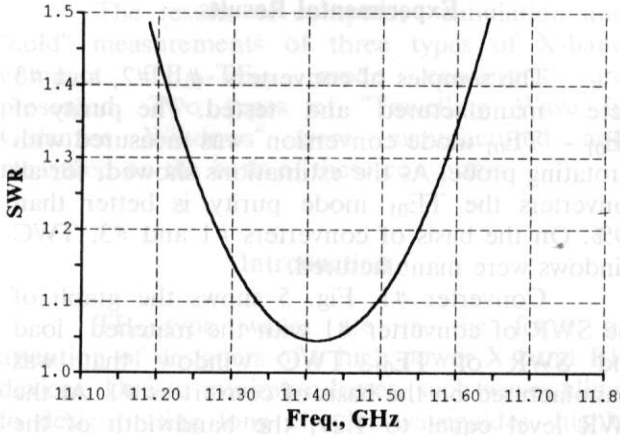

Fig. 7: SWR of converter #2.

Converter #3. Fig. 8 represents the graph of the SWR of converter #3 with the matched load. The transmission band of the converter is the largest; at the level 1.21 the band 460 MHz. is achieved. The graph of SWR of the TWC window manufactured on the basis of these converters is also shown.

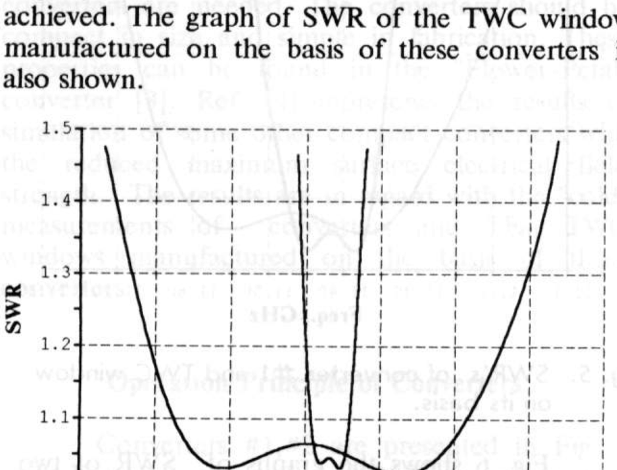

Fig. 8: SWR's of converter #3 and TWC window on its basis.

In the TWC regime, this window was matched by shifting the plungers of the converters. This is not the best way because the large resonance volume is formed. It explains the relatively narrow window passband.

The results of measurements are summarized in Table 2.

Table 2. Measured passband of converters and TWC windows

Type of converter	Converter passband, MHz	TWC window passband, MHz
MC#1	390	150
MC#2	270	20
MC#3	460	65

Conclusions

3 types of TE_{10}-TE_{01} compact converters have been calculated, and cold models for three such types have been manufactured. Cold measurements have been carried out for TE_{01} TWC windows on the basis of the given converters. As measurements revealed, the transformation purity in all converters is more than 99%. Converters #2 and #3 have sufficiently low maximum field strengths (370 kV/cm and 330 kV/cm for 100 Mw of transmitted power) and the transmission bands 270 MHz and 460 MHz, which makes them a plausible candidates for use in high power RF devices. On the basis of converters #1 and #3 TWC windows for high power tests have been manufactured.

References

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