4.3: THE DESIGN OF BRANCH-GUIDE COUPLERS, WITH APPLICATIONS TO THE SUPPRESSION OF SPURIOUS FREQUENCIES*

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This investigation was the result of a program to suppress the harmonic frequency output from high-power transmitters without causing undue reflection of the attenuated frequencies. The attenuation is produced by a rejection filter (which took the form of a waveguide, lowpass, "waffle-iron" filter). To protect the transmitter, a "harmonic pad" is placed between it and the rejection filter to absorb most of the power in the reflected harmonics (in this case, up to the tenth harmonic), while introducing negligible insertion loss in the transmitter fundamental band.

A 0-db branch-guide coupler was selected to provide the "harmonic pad"; this choice was predicated on the fact that the coupling from the main guide to the branch-guides decreases rapidly with frequency, and

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the feeling that the straight-line geometry of the input guide would cause most of the spurious frequencies to end up in the load. If there should be undue reflection, then the branch guides offered the possibility of building in suitable chokes or filters, to improve the attenuation or decrease the reflection.

To achieve a larger bandwidth of low VSWR and low insertion loss than is possible with a periodic structure [1], a design procedure was developed based on a quarter-wave transformer prototype circuit [2], and a special chart resembling a Smith chart was developed to facilitate this design procedure. In addition, a digital computer program was used to check the performance of any coupler by analysis, before committing any design or design changes to the shop.

It was decided to make the 0-db coupler by cascading three 6-db couplers. Each 6-db coupler had five branches, but as the adjacent branches of the cascaded couplers were to be merged, the 0-db coupler would consist of thirteen branches. An S-band model of the 6-db coupler was first constructed. This is shown in Figure 1. Its computed and measured performance is shown in Figure 2.

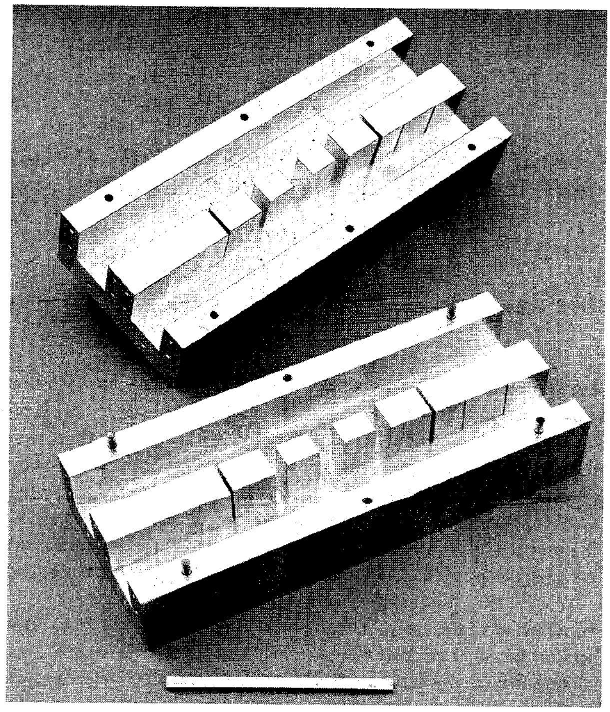

Fig. 1. Exploded view of S-band 6-db branch-guide coupler.

The 0-db coupler was then constructed in L-band, and is shown in Figure 3. Its computed and measured VSWR and insertion loss is shown in Figure 4. The measured performance of this coupler may be summarized as follows:

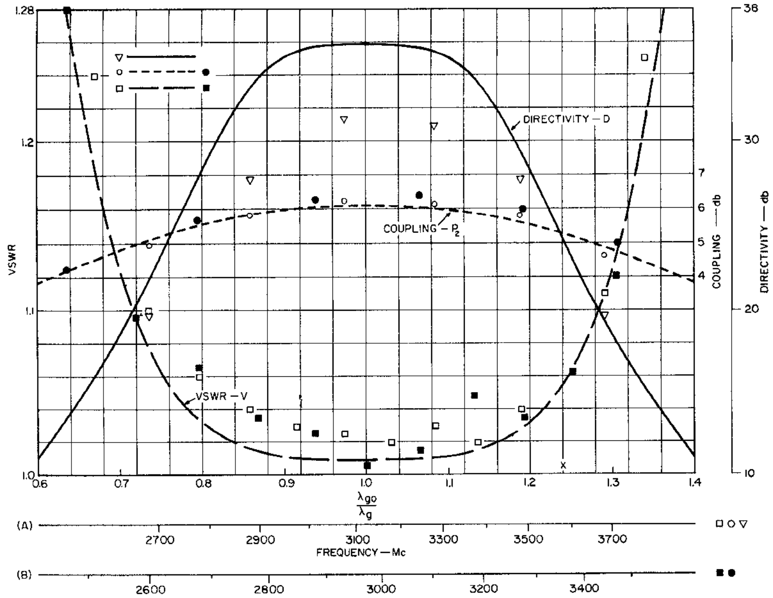

Fig. 2. Measured and computed performance of 6-db coupler (lines are computed; points are measured). (A) Original design; (B) After increasing guide lengths.

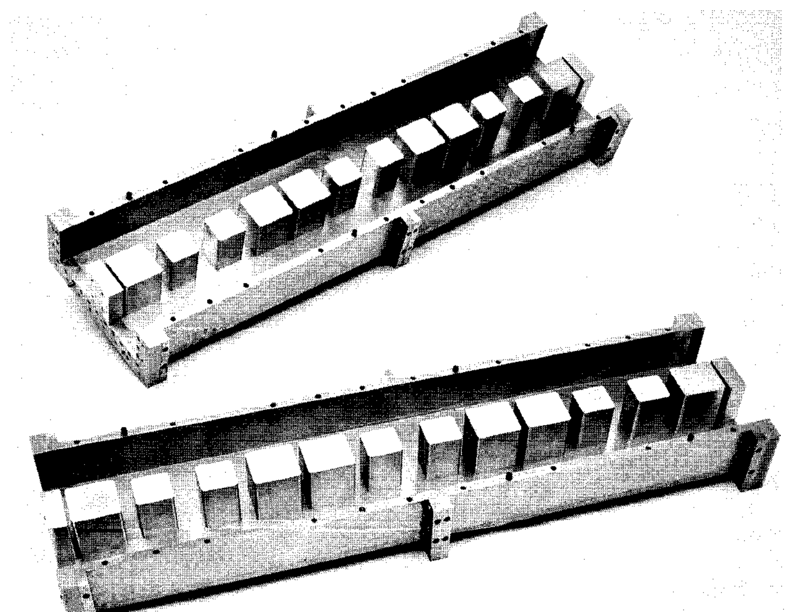

Fig. 3. Exploded view of L-band 0-db branch-guide coupler.

VSWR	<	1.07
Insertion Loss (Coupling)	<	0.05 db
Directivity	>	20 db
In-Line Coupling	>	20 db

over the 20 per cent frequency band 1300 ±130 megacycles. (This corresponds to a reciprocal-guide-wavelength bandwidth of about 40 per cent.)

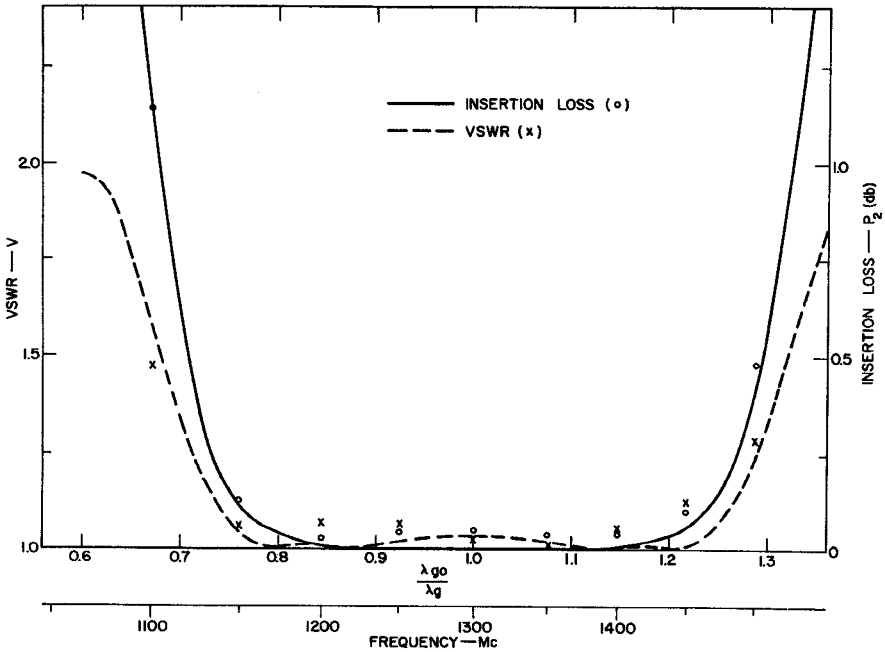

Fig. 4. Measured and computed performance (insertion loss and VSWR) of 0-db coupler (lines are computed; points are measured).

This 0-db coupler gave adequate attenuation and VSWR at all harmonic frequencies in the TE_{10} mode, except for the second harmonic band where the coupling reached a peak of - 1-1/2 db near 2600 megacycles; this would result in a high VSWR at that frequency when a rejection filter acting as a short circuit at this frequency is placed at the output. To improve the second harmonic VSWR, chokes were cut into the blocks making up the branches, as shown in Figure 5. The branch impedances were reduced to compensate for the reactances introduced by the chokes in the fundamental passband. This had the desired effect of raising the attenuation in the second harmonic band. A further improvement resulting in lower VSWRs at other harmonic frequencies also, was achieved with the arrangement of Figure 6, splitting the 0-db coupler into two 3-db couplers and using cut-off waveguides to separate the fundamental from the harmonic bands. With this arrangement the

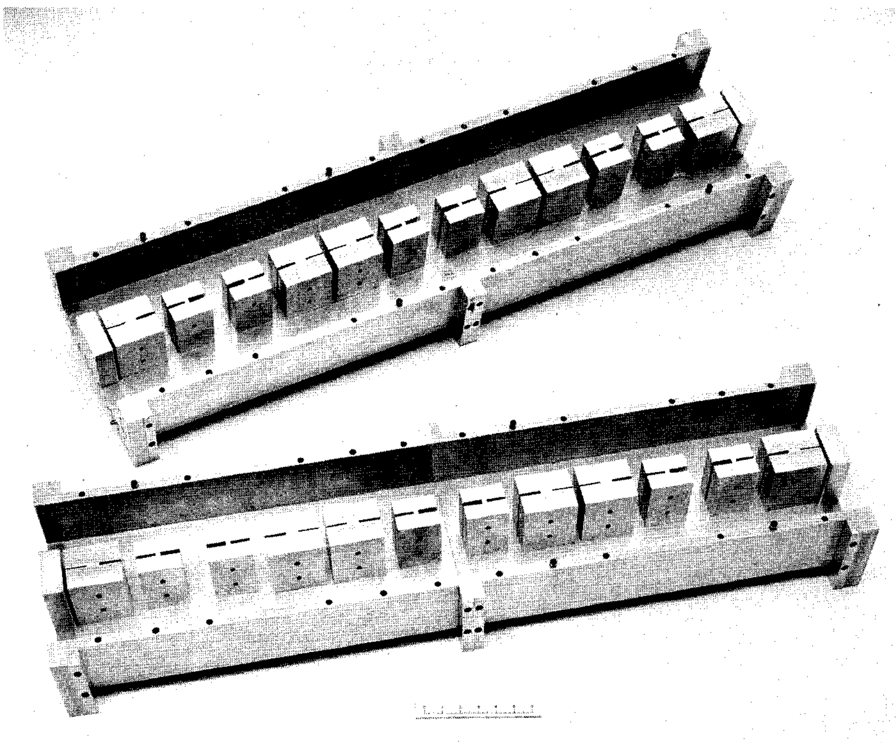

Fig. 5. Exploded view of L-band 0-db branch-guide coupler with second-harmonic chokes.

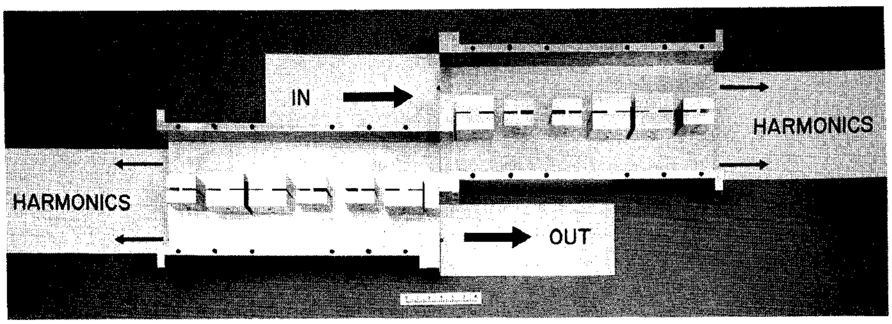

Fig. 6. Arrangement of two 3-db couplers to suppress harmonic frequencies.

VSWR in the TE_{10} mode of all frequencies in the harmonic bands of 1250-1350 megacycles was measured, from the second to the eleventh harmonic, and was found to be better than 2 to 1.

The coupler was tested at high power. No arcing could be observed up to the peak power available, which was 5.1 megawatts of peak power. The tests were made in air at atmospheric pressure.

1. John Reed, "The Multiple Branch Waveguide Coupler," Trans. IRE MTT-6, 398-403 (1958).

2. Leo Young, "The Quarter-Wave Transformer Prototype Circuit," Trans. IRE MTT-8, 483-489 (1960).

3. Leo Young, "Branch Guide Directional Couplers," Proc. NEC 12, 723-732 (1956). (In Table I, under 5-Branch Coupler, the term PKH contained in the expression for Y should be PKH^2.)