A BETTER WAVEGUIDE SHORT CIRCUIT

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Abstract

A new movable waveguide short circuit is presented which has better characteristics than designs presently in use. Comparison measurement data is shown on a variety of designs. Particular advantages of the new design are noted.

Introduction

When dealing with waveguide circuits we often think or speak of a waveguide short as a perfect reflector, creating the textbook field patterns at the end of a waveguide. In many applications, the fact that most real waveguide shorts do not fit this description is unimportant. In many cases the relative short position is more important than the actual position, and the influence of the short is desired some distance away. For the cases where it is important to accurately locate the short and characterize the local fields, the commercial shorts are unsatisfactory. The motivation for this new design came from such a situation where it was important to have a true "electric wall" for a short.

Discussion

The design concept is simple and is based upon a cam-action surface which translates an on-axis force into a lateral force. Rotation of a knurled nut on the back of a short pulls on the threaded shaft attached to the sliding upper half. As this sliding part is pulled back the cam forces it up and jams it tight in the waveguide, ensuring a good short circuit. Figure 1 shows two of these shorts, one assembled and one with the upper part removed. This design provides an excellent means of realizing a movable short circuit in waveguide. It is unique in that the short circuit face is very flat and acts essentially like a metal wall. It locks in position when desired yet can be easily moved to alternate positions. The effective electric position is a) coincident with the face of the short, and b) not frequency dependent.

The purpose of the design is to provide a good, multipurpose waveguide short circuit. The characteristics desirable in a waveguide short are listed for comparison in Table I. Six (6) other designs are compared to the new cam design. The cam design is the only

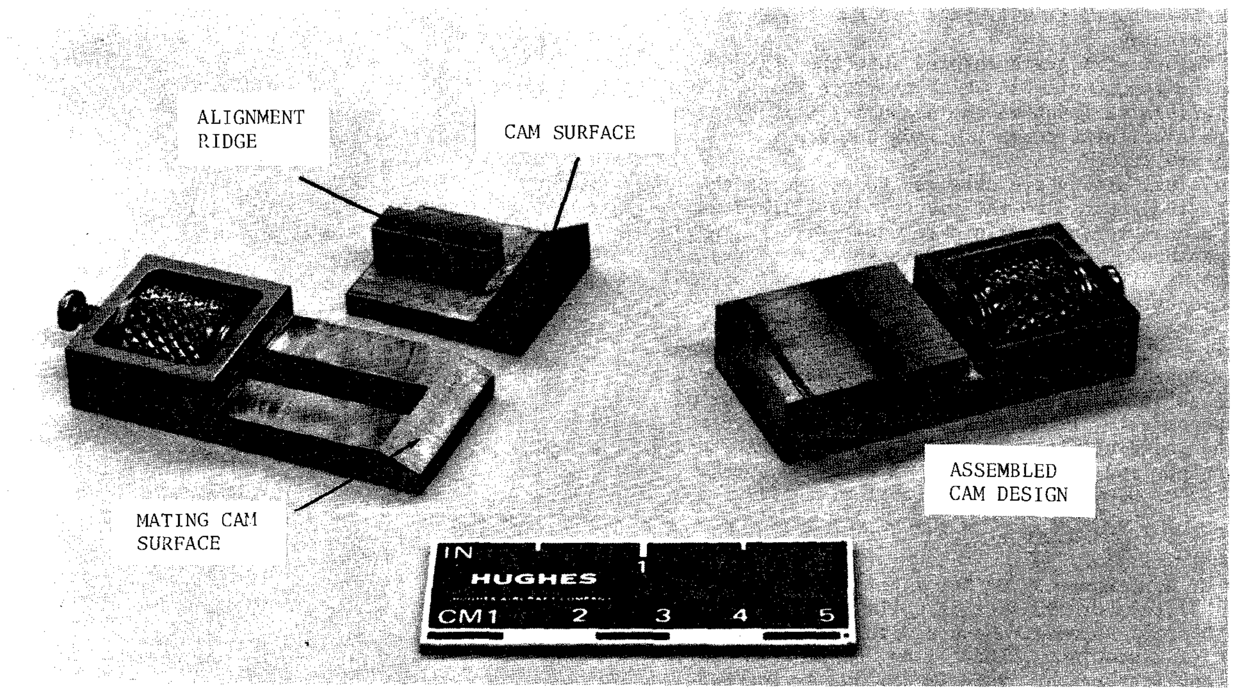

Figure 1. Assembled Cam Design is shown on the right. The left shows the cam surfaces and the alignment ridge. Rotating the knurled nut pulls the upper part back to create the spreading and subsequent jam action.

TABLE I

COMPARISON OF WAVEGUIDE SHORTS

	DESIRABLE CHARACTERISTICS	TYPES OF SHORTS: SHORTING (D) FLANGE	SPRING LOOP	SPRING FINGERS	NON-CONTACTING DUMBELL	NON-CONTACTING BLOCK	METAL BLOCK	CAM DESIGN
1.	HIGH REFLECTIVITY	√	√	√	√	(F)	(G)	√
2.	FREQUENCY INDEPENDENT (A)	√	(E)	15	15	40	(G)	√
3.	MOVABLE		√	√	√	√	√	√
4.	NON-DISTORTED LOCAL FIELDS	√					(G)	√
5.	ELECTRICAL PLANE (B) AT MECHANICAL END	√	37	217	17	21	(G)	√
6.	LOCATE INTERNALLY		√	√	√	√	√	√
7.	LOCKABLE (C)	√						√

(A) VALUES REPRESENT RATES OF ELECTRICAL PLANE SHIFT AT 10 GHz (MIL/GHz)
(B) VALUES REPRESENT OFFSET (MILS)
(C) WITHOUT ADDITIONAL PARTS
(D) PLATE ON END OF WAVEGUIDE
(E) VERY SLIGHT DEPENDENCE (SEE FIGURE 4)
(F) DEGRADES ABOVE 11.0 GHz
(G) INCONSISTENT - DEPENDING ON FIT

technique which has all of the desirable characteristics. Specifically it adds 1) frequency independence, 2) no field distortion, 3) coincident electrical and mechanical surfaces, and 4) lockability to the features of commercially available types such as the spring fingers. A number of prior designs, which essentially are represented by the four other movable short circuits (eliminating the metal block) shown in Table I, have been used for many years. Examples of non-contacting, loop, and spring fingers are shown in Figure 2 along with one of the cam designs. These others have, however, proved to have limited value in many applications which the cam design can handle. Of particular significance with the cam design is the ability to place the short extremely close ($<\lambda_g/4$) to an obstacle in a waveguide and get a true representation of an "electrical wall" at that point. This type positioning is needed in many waveguide components which use solid state devices. Electrical performance tests were run to compare this new design with others. Characteristics 1, 2 and 5 of Table I were measured. The reflectivity of the shorts is shown in Figure 3. Since the scale is considerably expanded the results represent excellent reflection by all units. Even so the cam design shows best and is similar in quality to the reference calibration standard. Figure 4 shows the phase measurement results for these same units. A true short would show as a constant 180 degrees over the frequency band. The calibration standard, the cam design and the shorting flange all fell within the $\pm$ 0.5 degrees indicated by the crossed area around 180 degrees. The other lines show a frequency dependence which can be interpreted as a short that changes position with frequency. The rate of change in mils/GHz is determined from the slope at 10 GHz and is shown in Table I.

Additional features of this type short are shown in Figure 5. On the left, an example of a 50 mil offset short is easily assembled for some special purpose. This cam design is used with our Automatic Network Analyzer where we need a special offset. The center shows how easily the short will mount securely in a surface as small as a 25 mil thick shim. The example on the right shows a reduced height (100 mils) shorc in a special adapter flange.

In all cases the step discontinuity in the face due to the positioning of the sliding parts is less than a couple mils, and is dependent upon the exact height of the waveguide. The step is zero when mounted in precision waveguide. The improvement of the cam design over previous types becomes even more important at millimeter frequencies where characterization, loss and physical size are more difficult to deal with.

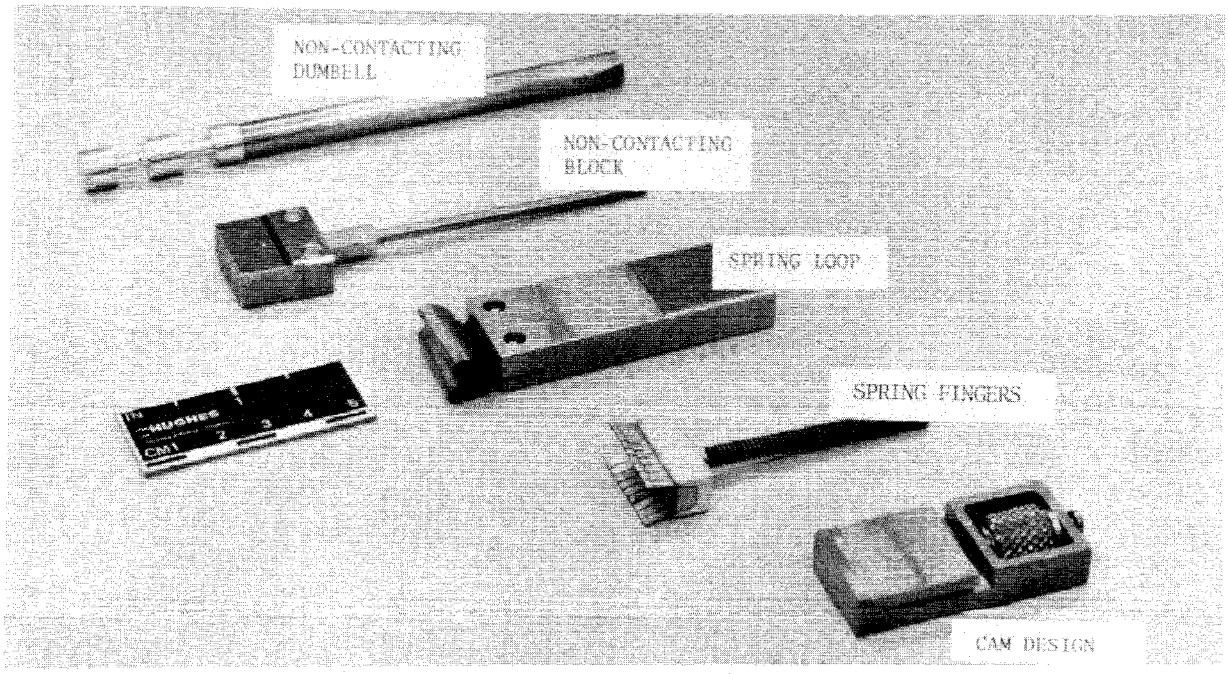

Figure 2. Displayed are the various types of waveguide shorts which were compared in the electrical tests.

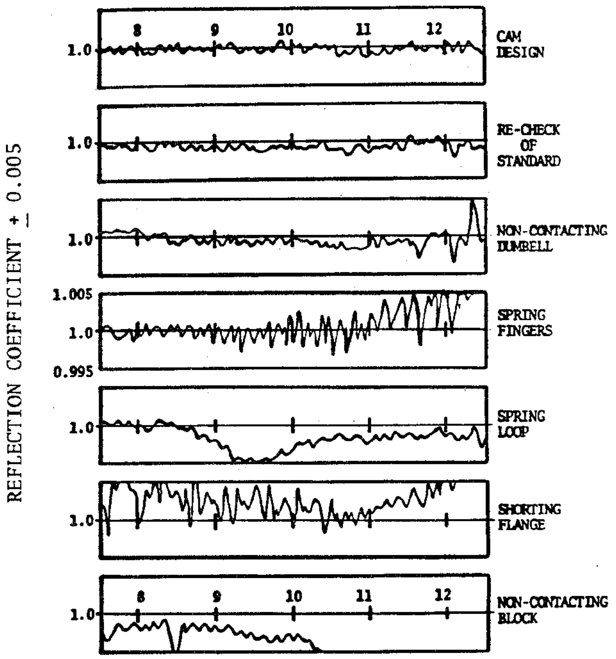

Figure 3. Reflectivity measurements for seven (7) waveguide shorting techniques. The cam design was best.

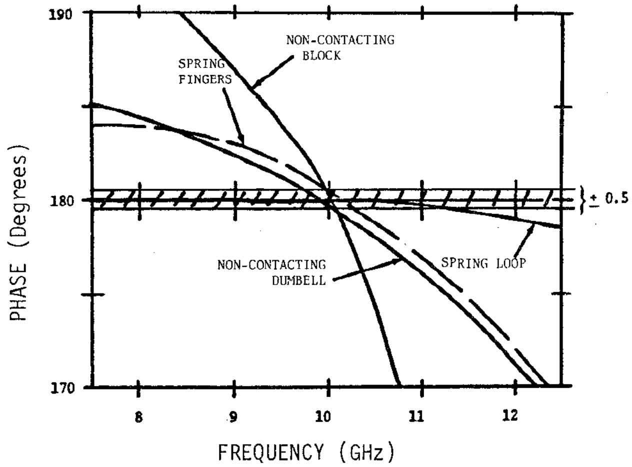

Figure 4. Phase measurement for seven (7) waveguide shorting techniques. The cam design, calibration standard and waveguide flange all fell within the ± 0.5 degree range.

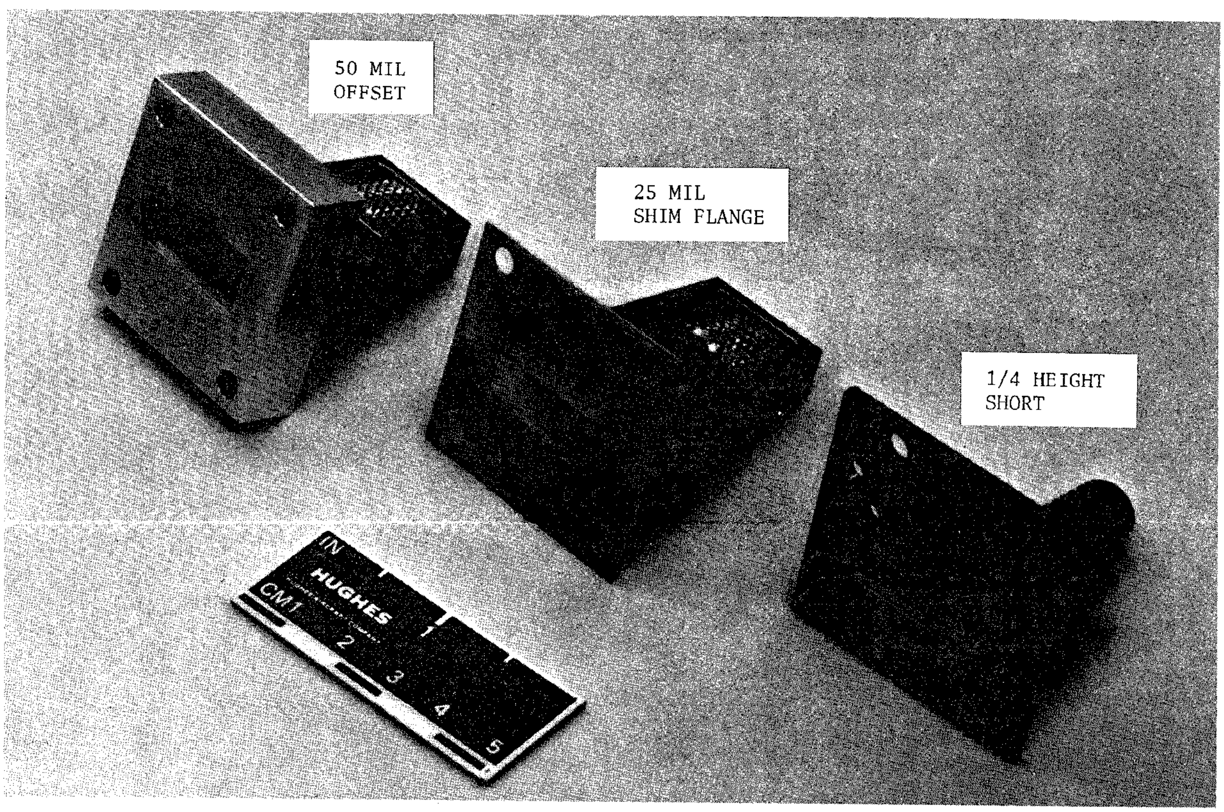

Figure 5. Additional features of the cam short which are not available with other designs.