

# Rectangular Waveguide to Coax Transition Design

Learn how to find the optimum dimensions for a waveguide to coax transition using an empirical approach that relies on a set of impedance measurements and a few calculations.

Paul Wade, W1GHZ

A question I am frequently asked is, "Why do the antenna dimensions in the *W1GHZ Microwave Antenna Book — Online* not include the probe dimensions (for the transition from waveguide to coaxial transmission line)?"<sup>1</sup> The answer is that the transition is part of the transmission line, not the antenna, and does not directly affect the performance of an antenna. The transition may be right at the antenna, seemingly part of it, or at the other end of a run of waveguide transmission line, many meters away.

The transition is an important part of most microwave systems, however, since solid-state components are usually constructed on microstrip transmission lines and interconnected with coax, while microwave antennas normally use waveguide techniques.

A typical transition consists of a coaxial connector on the broad side of a rectangular waveguide with the center conductor extended as a probe into the waveguide, with one end of the guide ending in a short circuit, like Figure 1. Since the structure is well-known, *designs* may be too ambitious a term, but the correct dimensions are far from obvious and are difficult to calculate. A number of sets of dimensions have been published, but there is little agreement between them, so it is difficult to tell which are right. Also, many of the published transitions are part of an antenna, so the dimensions may have been chosen to compensate for a poorly matched antenna impedance.

Therefore, I chose an empirical approach: making a comprehensive set of measurements from which the optimum dimensions may be reached. I had previously used this technique

<sup>1</sup>Notes appear on page 16.

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to determine probe dimensions for circular waveguide made from copper water pipe.<sup>2</sup> It is easier to determine the dimensions for rectangular waveguide, since commercial guide and components are readily available from surplus sources.

Characteristics of a transition are best viewed by measuring the complex impedance (magnitude and phase) in the waveguide, using a waveguide slotted line. Figure 2 shows a typical X-band slotted line — the precision impedance measurement instrument of a few years ago, and, for waveguide, still more accurate than most network analyzer measurements. Since all professional microwave work today uses automatic network analyzers and computers, and few remember how to use a slotted line, slotted lines are almost given away today. I have paid as little as \$2 for one at a hamfest.

To find the optimum dimensions for a transition, I needed to make measurements over a range of transition dimensions, so an adjust-

able transition was desirable. The probe dimensions are readily varied by unscrewing the coax connector and trimming the probe, but the distance to the shorted end of the waveguide, or backshort, must also be varied. I machined a sliding plug to fit inside the guide, with alternating quarter-wave sections of high and low impedance to form an electrical short circuit, so that the performance of the short does not depend on intimate contact with the waveguide walls. Figure 3 is a photograph of adjustable transitions for two common sizes of X-band waveguide, WR-90 and WR-75, as well as one for circular waveguide.

## Measurement Technique

The first measurement is with a short circuit (flat metal plate) closing the end of the slotted line. The short provides a clear standing-wave pattern with sharp nulls at half-wavelength intervals, so we can measure the guide wavelength, and make any adjustments to the slotted line measuring probe.

The next measurement is of the sliding tran-

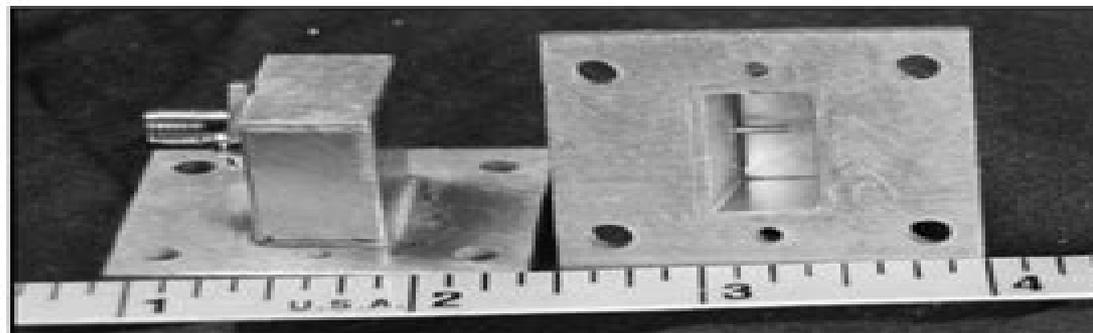


Figure 1 — WR-75 waveguide to coax transition for 10 GHz.

# Rectangular Wave To Coax Transition Design

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**EPAC96, Fifth European Particle Accelerator Conference** ,1996 **QEX.** ,2006 *On-Wafer Calibration*

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