# Low-Noise Receivers: Microwave Maser Development

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*Low-pass microwave filters have been built and tested in the laboratory and are now ready for installation in the 14.3- to 16.3-GHz traveling wave maser presently being used on the 64-m antenna at Goldstone Deep Space Communications Complex. These filters, when placed in the input and output lines of the traveling wave maser, will prevent possible calibration errors caused by traveling wave maser gain changes resulting from pump frequency radiation into the signal waveguides. These filters are matched at the signal frequency of the traveling wave maser, have low insertion loss, and will operate at 4.5 K. Therefore, no significant degradation in system performance results.*

## I. Introduction

Two low-pass filters with pump frequency rejection have been completed and tested in the laboratory. They are ready for installation in the 14.3- to 16.3-GHz traveling wave maser (Ref. 1) presently installed on the 64-m antenna at Goldstone Deep Space Communications Complex. Differences in traveling wave maser (TWM) gain of as much as 0.5 dB have been recorded and are a function of impedance changes at the pump frequencies as seen at the input of the TWM. Calibration errors can occur due to changes in gain caused by pump frequency radiation into the signal waveguides. These gain changes will be substantially reduced by the use of low-pass filters that are placed in the signal frequency waveguide to coaxial line transitions which operate at 4.5 K. The small physical size of the filter permits it to be located within the existing transition.

## II. Filter Description

The filter is of a coaxial type with eleven semi-lumped elements. The design data for this type of filter were obtained from Ref. 2 and have been used successfully in the construction of a pair of low-pass filters that have been incorporated into the X-band TWM system (Ref. 3). The X-band filter, with a 12-GHz cutoff, has a rejection at the pump frequencies (18.4 to 19.6 and 22.6 to 24.8 GHz) of over 30 dB and a reflection coefficient at the signal frequency (7700 to 8800 MHz) of better than −21 dB. Because of these favorable rejection and match characteristics, a scaling factor of ⅔ was used to obtain an 18-GHz cutoff for use with the Ku-band TWM.

A removable metal centering sleeve was used to establish adequate concentricity of the filter elements to the outer conductor. It was found that the reduced clearance between the capacitive elements and the outer conductor in the scaled-down filter required a higher degree of concentricity to obtain a satisfactory match. To solve this problem a Teflon dielectric centering sleeve (Fig. 1) was incorporated. The element diameters were reduced to compensate for the difference in dielectric constant, and a Teflon sleeve was made to fit tightly over five of the six capacitive elements.

In building this filter, as with the X-band filter, the match was optimized by cut-and-try methods. The final tuning for best match at the TWM signal frequency (14.3 to 16.3 GMz) is done by adjusting the length of the two 2-56 screws holding the coupling loop to the transition body (Fig. 2). The filter section is located in the transition body between the coupling loop and the center contact of the SMA connector, a space previously occupied by a straight section of coaxial center conductor. Since the transition body, coupling loop, and SMA connector fitting are identical to those now installed in the Ku-band TWM, the transition/filter assembly has the same outside appearance and dimensions and is directly interchangeable with the present transition. Implementation of these filters will require no modification of the traveling wave maser/closed cycle refrigerator (TWM/CCR) system.

## III. Filter Performance

These filters are designed to have low insertion loss at the Ku-band signal frequency and have an 18-GHz cutoff. Rejection at the pump frequencies (25.4 to 27.4 and 35.4 to 39.3 GHz) is more than 20 dB.

Loss and match measurements have been made on both filters in the laboratory and, on the basis of these measurements, the filter with the best reflection coefficient has been chosen for use in the TWM input line. The reflection coefficient at the signal frequency of this filter is better than −20 dB across the entire TWM tuning range (Fig. 3). The reflection coefficient of the filter chosen for the output line has been recorded at better than −15 dB across the same frequency range. The installation of the filters is not expected to degrade the match of the TWM.

While "identical" parts were used in both assemblies, small machining differences account for the considerable difference in the characteristics of the two filters.

The insertion loss at the signal frequency of the filter chosen for the TWM input is less than 0.2 dB at room temperature. These transition/filter assemblies, when installed, will be bolted directly to the 4.5 K station of the CCR. Operation at this temperature will decrease the noise contribution caused by the insertion loss of the filter to less than 0.2 K.

# References


1. Clauss, R. C., and Quinn, R. B., "Low Noise Receivers: Microwave Maser Development," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Volume V, pp. 102–108, Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1971.

2. Matthaei, G. L., Young, L., and Jones, E.M.T., *Microwave Filters, Impedance-Matching Networks, and Coupling Structures,* McGraw-Hill Book Company, Inc., New York, 1964, pp. 102, 365–380.

3. Clauss, R., Wiebe, E., and Quinn, R., "Low Noise Receivers; Microwave Maser Development," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Volume XI, pp. 71–80, Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1971

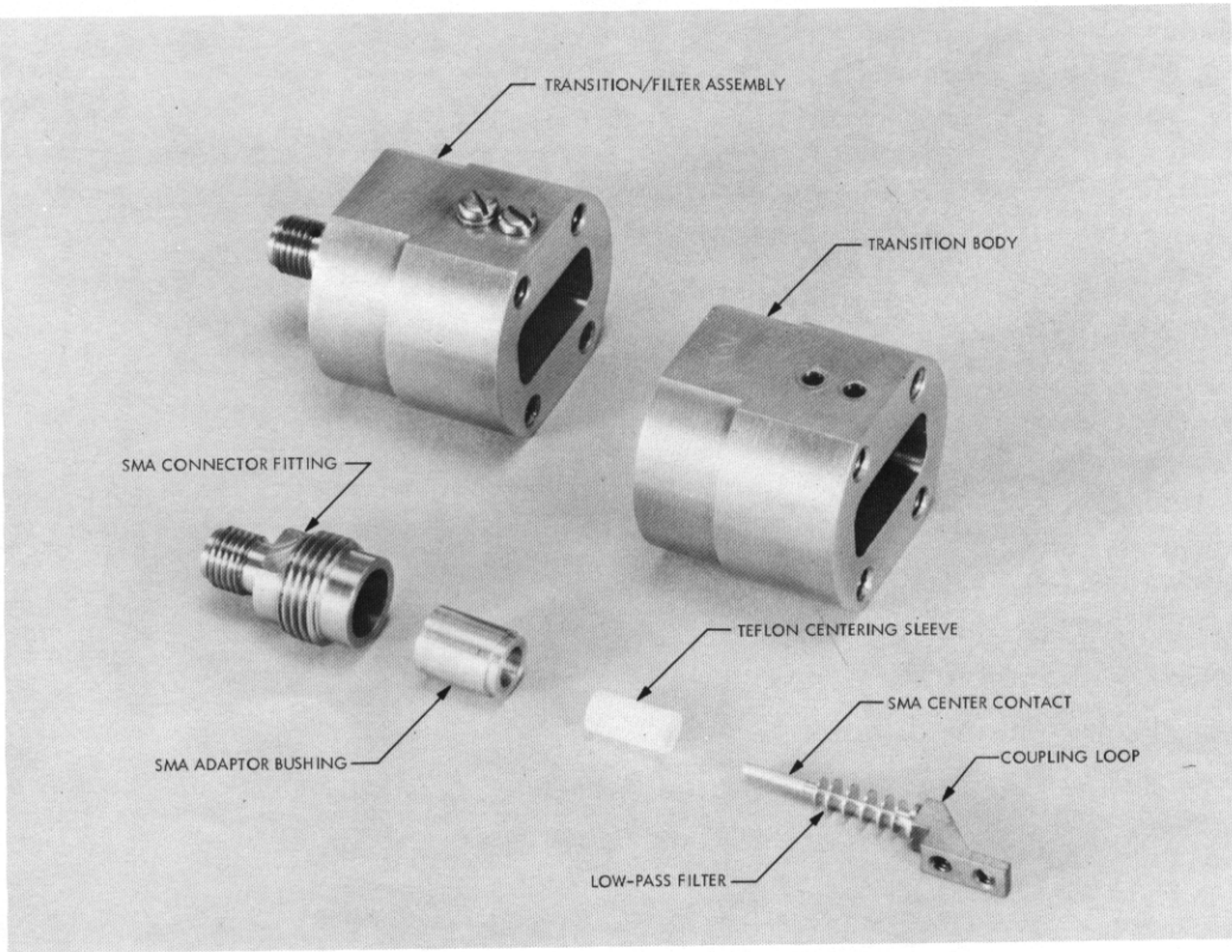


**Fig. 1. Photo of transition/filter parts and assembly**

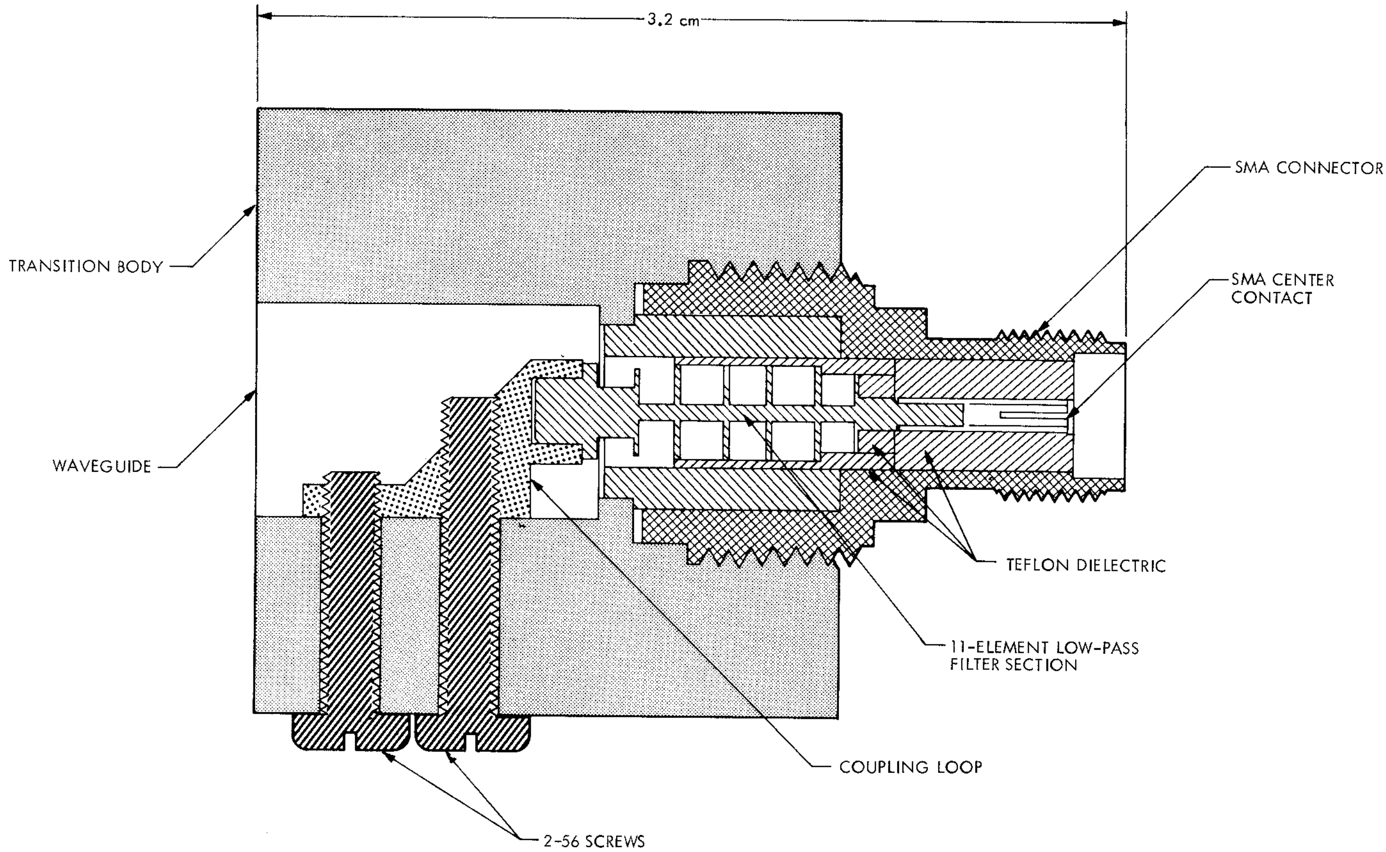


**Fig. 2. Section view of transition/filter assembly**

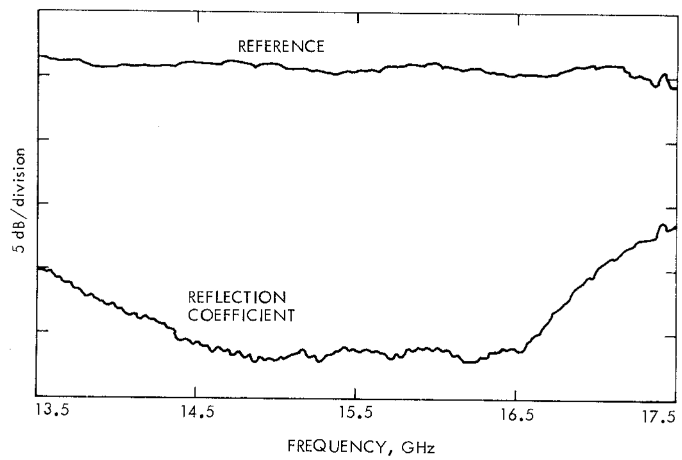


**Fig. 3. Match diagram (input filter)**