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Detailed Test and Qualification of S-band WR-340 Waveguide Full Height to Quarter Height Transitions for Satellite Testing Applications

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Abstract: *The paper presents the detailed test and qualification of S-band WR-340 Waveguide full height to quarter height transition for usage in satellite testing applications. The transition specifications achieved by theroitical calculations and the High frequency structure simulator software (HFSS) simulations have close match. This technical paper presents the work carried out for realization of such waveguide transitions used for Satellite testing applications. The Aluminium (AL6061) material is used for fabrication of the transition. The detailed test procedures and test results of the WR-340 waveguide transition developed in-house are been presented in the paper.*

Keywords*:* High Frequency Structure Simulator(HFSS), Transition, Waveguide, Radio Frequency, Scattering parameters, Thermal-vacuum testing,Vector network analyzer (VNA)

I. INTRODUCTION

Waveguide is a structure which guides electromagnetic waves or microwaves along their paths through internal reflections. It consists of hollow or dielectric material with particular dimenstion allowing certain frequencies of electromagnetic waves within its boundaries. Waveguides are widely used in microwave and millimeter wave systems. Waveguides are low loss compared to coaxial cables at microwave frequencies and hence their power handling capacity is more which makes them suitable dor high power communication systems. The cutoff frequency of waveguide is the lowest frequency that can be propagated through it and it depends on the dimension of a waveguide. In a rectangular waveguide, the dominant mode of propagation is TE_{10} and for this mode, the height of waveguide doesn't affect the operational frequency but the power handling capacity reduces proportionally. S-Band waveguide in general, is bulkier in size and weight and hence, a decision of usage of quarter height waveguides at S-band will be taken cautiously whenever it is required.

As the technology advances, the RF power levels in S-band satellite transponders are increasing and with increase in power level there is a requirement in usage of waveguides as the transmission media. To reduce the overall mass of the satellites, these S-band waveguides onboard the satellites could be quarter height along with some full height waveguides. This raises the requirement of WR-340 waveguide transition from quarter height to full height and vice versa. An image of S-band WR-340 waveguide full height to quarter height transition is shown in Figure-1.

The main features of a waveguide transition are the following:

- Low insertion loss
- Good return loss
- Wider bandwidth
- Matched dimensions
- High power handling capacity

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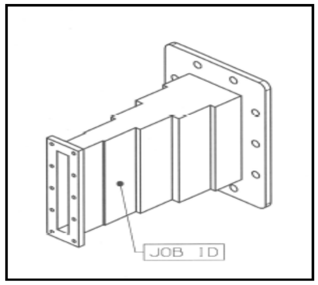

Figure 1: S-band WR-340 Waveguide full height to quarter height transition

The target specifications of the indigeneously developed WR-340 waveguide transition[1,2] are shown in Table 1.

Table 1: Target Specification

SN	Parameters	Specified values
1	Opearting Frequency	2.06 GHz
2	Bandwidth	1 GHz
3	Insertion Loss	$\leq$ 0.2 dB
4	Return Loss (at the input and output)	$\geq$ 15dB over the bandwidth
5	Maximum Power Handling	1 Kilo Watt RF CW Power
6	Opearing Temperature Range	-20 Degree C to 100 Degree C
7	Dimensions	Full height to Quarter Height

II. PHYSICAL DIMENSIONS OF THE WR-340 WAVEGUIDE FULL HEIGHT TO QUARTER HEIGHT TRANSITION

Using HFSS simulations, the physical dimensions of the different sections of the WR-340 Waveguide full height to quarter height transition are shown in Figure-2(a). Figure-2(b) shows the photograph of the waveguide transition realized in-house.

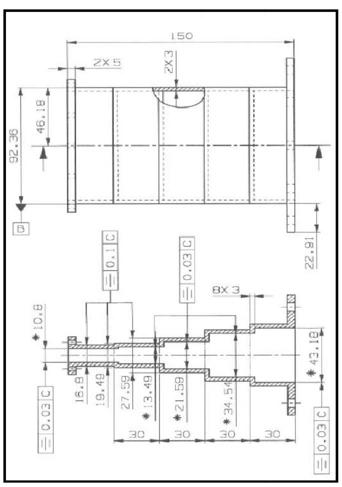

Fig. 2(a): Physical dimensions of Realised WR-340 Waveguide full height to quarter height transition

Fig. 2(b): Image of Realised WR-340 Waveguide full height to quarter height transition

III. TEST AND EVALUATION OF THE WR-340 WAVEGUIDE FULL HEIGHT TO QUARTER HEIGHT TRANSITION

The detailed test flow for the WR-340 waveguide full height to quarter height transition is shown in section 3.1. On the other hand, the test plan details and the test result details are shown in section 3.2.

3.1 WR-340 Waveguide Full Height to Quarter Height Transition: The Test Flow Graph

After fabrication of Waveguide transition detailed test and qualification is carried out. A flow chart is shown in Figure-3 describing the sequence of tests carried out.

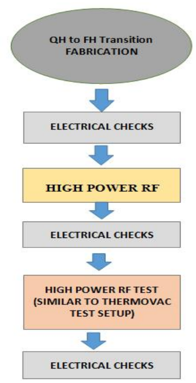

Fig. 3: Test flow graph of test and qualification

After carrying out high power RF test in ambient conditions, waveguide transition is tested in the thermovaccum chamber with the setup shown in Figure 4&5. Pressure window is used to isolate vacuum and ambient conditions allowing RF transmission.

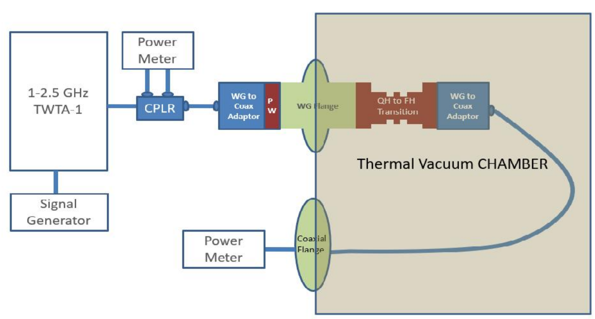

Fig. 4: Test Setup for TVAC Qualification of waveguide transition

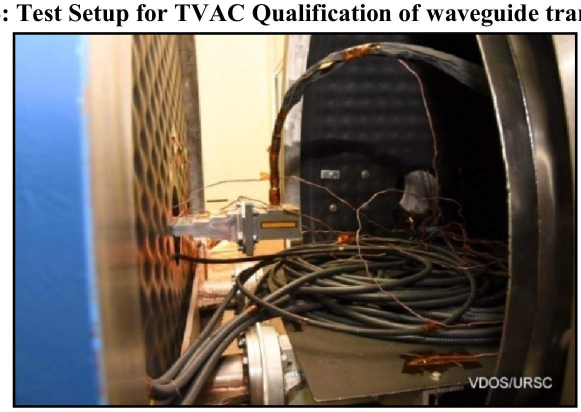

Figure 5: Waveguide Transiiton inside Chamber during TVAC Qualification

3.2 Detailed Test Results

The following tests were carried out for all the ten numbers of indigeneously developed Waveguide transition:

1. Initial Electrical checks
2. High power RF test at Ambient Conditions

3. High power RF test at Thermal Vacuum Conditions
4. Final Electrical checks

3.2.1 WR-340 Waveguide Transition's Initial Electrical Checks

As initial electrical checks (also called passive checks), the plots of the S-parameters (namely, S_{11}, S_{12}, S_{21} and S_{22})[3,4] of a pair of WR-340 Waveguide transitions (when connected back to back with their quarter height sections joining together) were measured on Vector Network Analyzer(VNA). In order to measure the S-parameters of each transition on VNA[8], the selected pair of waveguide transitions were connected with a pair of WR-340 waveguide to coaxial adaptors and the entire assembly was connected to both the ports of the VNA as shown in Figure-4. Hence, to compute the insertion loss due to waveguide transition alone, one has to subtract the insertion loss of the waveguide to coaxial adaptor-pair from the measured S-parameter (S_{12} or S_{21}) values of the entire assembly. The S-parameter plots on VNA showing insertrion loss and return loss variations over the operating frequency range for the *waveguide to coaxial adaptor pair* alone are shown in Figures 6. On the other hand, the S-parameter plots on VNA showing insertrion loss and return loss variation over the same frequency band for the waveguide transition pair along with the waveguide to coaxial adaptor-pair are shown in Figure 7.

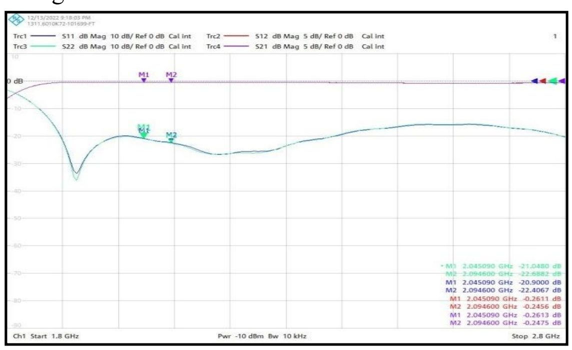

Fig. 6 : S-parameter plots of WR-340 waveguide to coaxial adaptor-pair assembly

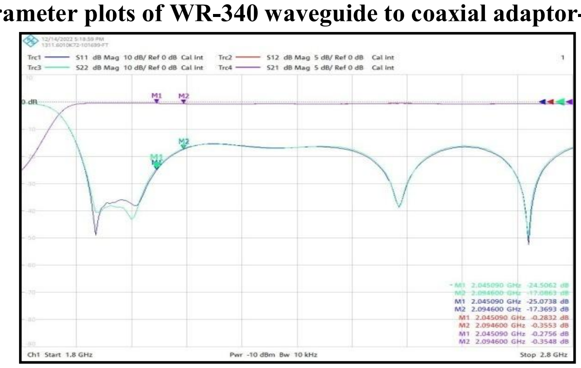

Fig. 7: S-parameter plots of WR-340 waveguide transition pair along with waveguide to coaxial adaptor-pair assembly

3.2.2 WR-340 Waveguide Transition's High power RF test at Ambient Conditions

High power RF testing is carried out for waveguide transition by making the test setup shown in figure. Each pair of waveguide transition is subjected to 400 Watt high power level for about 6 Hours in ambient conditions. In the test setup shown in Figure 8, instruments like Amplifier, Power meter, signal generator, waveguide coupler, waveguide load are used. A 20 dB coupler and power meter are used for monitoring the power level. A thermal logger is used for monitoring the temperatures. Travelling wave tube amplifier(TWTA) is used for genertating High-power RF signals. Waveguide Load is used to terminate the high-power RF signals. External cooling is provided to reduce the

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temperatures at higher power levels. Using these instruments and waveguide components, high power RF testing is carried out in ambient conditions and the detailed test results are tabulated in Table 3.

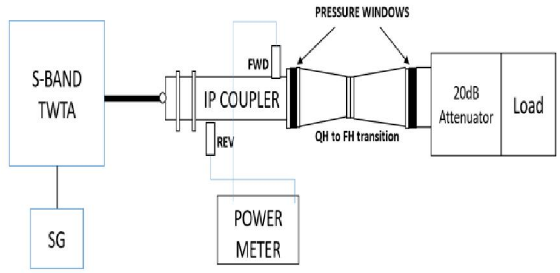

Fig. 8: High power RF test setup in ambient condition for testing WR-340 Waveguide transition

Table 3: High Power RF test results in Ambient Condition

Duration	TWTA Power in Watt		Temperature Sensor(DegC)
	Forward	Reverse	QH to FH Transition
15 min	100	0	20.8
15 min	200	0	22.8
15 min	320	4	24.9
6 Hrs	401	8	29.1

3.2.3 Waveguide Transition's High power RF Test at ThermoVacuum Conditions

Transitions are used to convert Quarter height interface to Full Height interface in the vacuum and ambient conditions. Hence these transitions have to tested in Vacuum conditions as part of qualification using pressure windows[5,6] and waveguide loads[7]. The test profile for the Thermal vacuum condtions is shown in the figure below

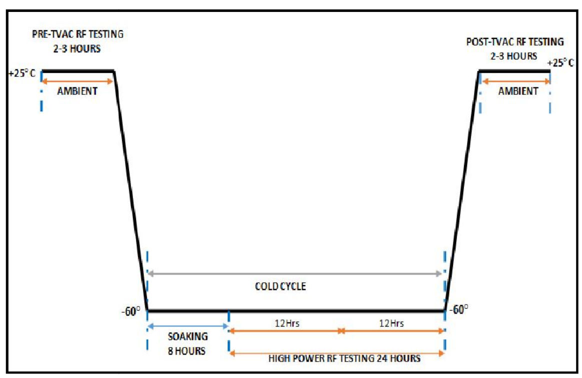

Fig. 9: Thermal-vacuum test profile for waveguide transition qualification

High power RF testing in Thermovacuum chamber is carried out using the setup shown in figure 16. Here RF testing testing is done at Ambient and cold cycles by varying the temperature from -60 Deg C to +25 Deg C. Similar measurement instruments that are used in high power testing in ambient condtions are taken for this testing. Using these instruments and waveguide components high power RF testing is carried out in vacuum conditions at power level of 200 Watt for the duration provided in the Thermovacuum profile. The detailed test results are tabulated below. Due to increase in power level there is an increase in temperature, which reflects in changes in material properties and inturn the reflected power is varied.

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Table 4: High power RF Test results during Cold cycle

Test Phase	Input Power Meter in dBm		Output Power Meter in dBm	Temperature Sensor in Deg C
	Forward	Reverse		QH to FH transition
Pre-TVAC	46.52	32.13	40.37	25.88
Pre-TVAC	51.27	38.69	44.96	26.38
Pre-TVAC	55.18	43.12	48.52	30.66
Hot Soak	46.56	33.39	40.15	38.6
Hot Soak	51.32	38.70	44.88	40.7
Hot Soak	48.64	35.66	42.29	43.5
Cold Soak	52.08	39.58	46.11	-10.65
Cold Soak	52.16	40.53	46.51	-2
Vacuum Ambient	52.03	40.38	46.31	26.36
Post TVAC	55.24	43.1	48.56	30.2

3.2.4 WR-340 Waveguide Transition's final electrical checks

After completion of all the tests, final electrical checks are carried out and the performance is evaluated. The final S-paramter plots are in close match with the initial electrical check test results. Final test results of the pair of WR-340 waveguide transition (when connected back to back with their quarter height sections joining together) are presented in Figure-10.

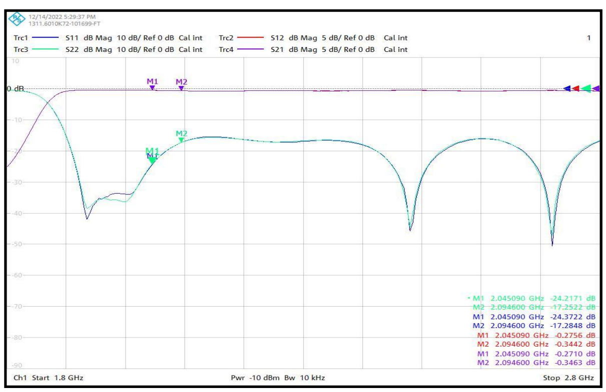

Fig. 10: Final S-parameter plots of WR-340 waveguide transition pair along with waveguide to coaxial adaptor-pair assembly

3.2.5 Comparison of Results: Simulation vs Achieved

Table-5 shows the close match of simulation test results and achieved test results

Table-5: Comparison of Results

Parameter	HFSS Simulation	Achieved Test Result
Operating Frequency	2.06 GHz	2.06 GHz
Bandwidth	1 GHz	1 GHz
Insertion loss	0.1dB	0.1dB
Return Loss	20 dB	17 dB

V. CONCLUSION

Waveguide Transition have been tested and are being used for satellite testing applications. Post fabricaton of waveguide transition, detailed test and qualification is carried out. Simulation results and Theoritical Results have close match. This Developmental work has resulted in large savings in FE and in accomplishing realisation of high power high frequency waveguide transitions within short turn around time.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

REFERENCES

[1]. George L. Matthaei, L.Young and E.M.T.Jone, **"**Microwave Filters, Impedance-Matching Networks, And Coupling Structures"**,** McGraw-Hill, New York, 1964.
[2]. Nathan Marcuvitz, "Waveguide Handbook", NewYork:McGrow Hill, 1951.
[3]. "Analysis of S-parameters for RF Coaxial Cables at Different Environmental Conditions" published in International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) Volume 2 Issue 1, September 2022.
[4]. D. M. Pozar, "Microwave Engineering", John Wiley & Sons, 4th edition, 2011.
[5]. "Design and Development of High Power Rectangular Ka-band WR-51 Waveguide Pressure window for Satellite Testing Applications" published in International Journal of Science and Research (IJSR) Volume 11 Issue 3, March 2022.
[6]. "Realization of Alumina based Pressure Window at Microwave Frequencies" published in 2022 IEEE International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE).
[7]. "Indigenous Development of High-Power Ku- Band WR-75 Load using Silicone Adhesive Material" published in Journal of Spacecraft Technology Vol.34, No.1, Jan-June 2023

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