A Generic Pick-Up Horn for High Power Thermal Vacuum Test of X, Ku, and Ka band Satellite Payloads

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Abstract: This paper presents development results of a generic pick-up horn (GPUH) for high power thermal vacuum (TVAC) test of satellite communications payloads. The GPUH is an improved method than the PUH that was presented earlier [1]. It has much wider bandwidth of more than three octaves covering X-band, Ku-band, and Ka-band, can handle more power than the PUH, has better return loss, and is insensitive to polarization. Design and measured results of the GPUH are given here and are also discussed in an earlier publication [2].

GPUH Design and Measured Results: High power TVAC tests are conducted in order to ensure the integrity of the payload and spacecraft in vacuum and with high power. The purpose of the HPTVAC tests is two-fold, firstly to validate the thermal performance of the spacecraft in vacuum with all downlink channels powered-up, and secondly to validate the payload performance of all transponder channels. Based on the successful high power TVAC test of two satellite payloads using the PUH, a generic PUH has been developed jointly by Lockheed Martin and Custom Microwave Inc. The objectives of the GPUH are (a) much wider bandwidth capability, (b) insensitive to polarization so that it can be used for vertical, horizontal, left hand circular, and right hand circular polarizations, and (c) larger electrical size so that it could be used for all satellite horns that are employed as feeds for both single reflectors and Gregorian reflectors that produce contoured beams through surface shaping of the reflector(s). The geometry of the GPUH is shown in Figure 1. The GPUH is much larger than the PUH and has a square opening of about 7 in. by 7 in. One of the design modifications made for the GPUH is that the thin metallic walls (exposed in PUH) are covered with small loads in order to improve the return loss and also make it less sensitive to polarization and alignment. All the four slots have identical size of 6.6 in. X 1.575 in and are loaded with ceramic loads. The number of vent holes is increased from 8 to 32 for better venting in vacuum. The 8 thermo-couples (2 per slotted region) are used to monitor temperature during the HPTVAC test of the spacecraft. The RF leakage is also improved due to larger size of the GPUH and due to addition of absorber walls on the four detachable plates that are attached to the aperture of the GPUH and surrounding the flight horn. The geometry of the GPUH is optimized by analyzing the return loss and RF leakage response of the GPUH with the flight horn by using the microwave wizard software by MiCIAN. The spacing between the two units is optimized analytically and the computed power distribution among the modes and slots is given in Table 1. Each of the four slots is over-moded in order to make the GPUH less sensitive to polarization and to increase the power handling capability. The power in the central two slots is about

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46% each and the edge slots have about 3.3% of the input power each. The modes in the slotted region are TE10, TE30, TE11, and TM11. The measured return loss of the combined geometry of the GPUH and flight horn is shown in Figure 2 and is better than 25 dB over the band when the polarizations are aligned and is better than 21 dB when the polarizations are completely mis-aligned by 90 degrees. The return loss has improved by about 5 dB for the GPUH relative to the PUH. This is due to the addition of the smaller loads covering the metallic walls that minimized the reflected signal going back into the flight horn. Measured RF leakage is better than -55 dBc with the detachable plates. The thermal profile of the GPUH monitored at various RF power levels through the thermo-couples in the thermal vacuum chamber is shown in Figure 3. The LN2/GN2 coolant is used to transfer the heat outside the chamber during high power test. The maximum temperature of 148 deg. C and minimum temperature of – 110 deg. C are well within the allowable limits of the GPUH loads and the bonding film. The GPUH has been tested with a Ka-band horn and the return loss response is shown in Figure 4. The return loss is better than 18 dB over the Ka-band transmit frequencies. Figure 5 shows measured return loss of the GPUH with an X-band horn and is better than 20 dB over the 7.0 GHz to 10 GHz band. The GPUH has been successfully used for high power TVAC test of a Ku-band commercial satellite payload. The GPUH is shown to have very wide bandwidth from 7.0 GHz to 21.0 GHz (3:1 bandwidth ratio) and can be used with return loss of better than 20 dB for flight horns with arbitrary polarization (VP, HP, LHCP, or RHCP). The RF leakage is very low and is better than –55 dBc.

Summary and Conclusions: A novel method for high power thermal vacuum test of satellite payloads using the generic pick-up horns has been presented. It is shown that the complete payload performance including the flight horn can be measured in the TVAC chamber for all antennas simultaneously without breaking vacuum and with good return loss and minimum RF leakage. The GPUH has very large bandwidth from 7.0 GHz to 21.0 GHz and can be used with feed horns illuminating a single reflector or dual-reflector antenna system for high power TVAC test of the X-band, Ku-band, or Ka-band satellite. The GPUH design is insensitive to polarization and can be used to test any linearly polarized or circularly polarized antenna system. Lockheed Martin has two patents pending on the PUH and GPUH technologies [3, 4].

References:

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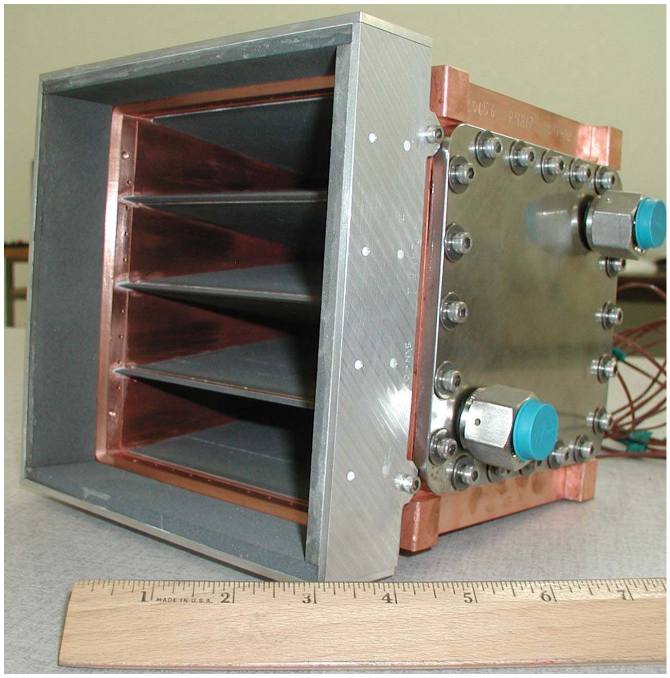

Figure 1: Geometry of the GPUH

PUH	Percent TE1	Percent TE3	Percent TE1	Percent TM1	Percent Power Slo
1	1.5	0.0	1.5	0.0	3.2
2	37.1	5.6	0.3	3.0	46.1
3	37.1	5.6	0.3	3.0	46.1
4	1.5	0.0	1.5	0.0	3.2
Tota	77.4	11.3	3.8	6.0	98.7

Table 1: Computed Power Distribution of the GPUH

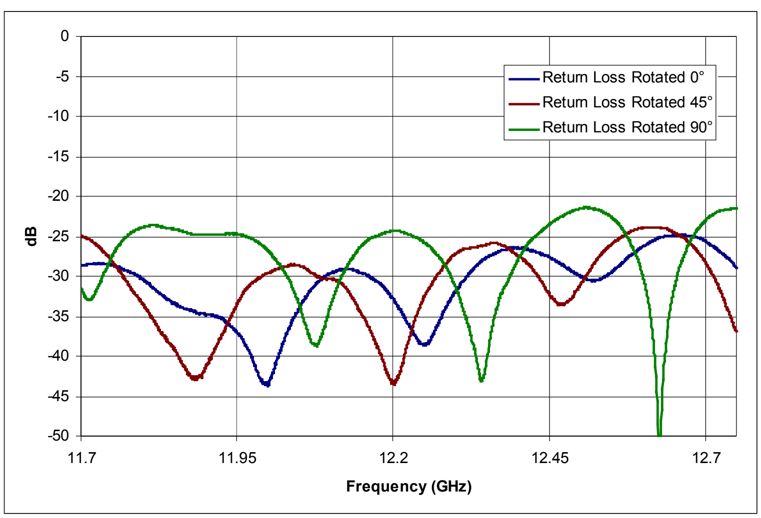

Figure 2: Return Loss of the GPUH with a Ku-band Flight Horn

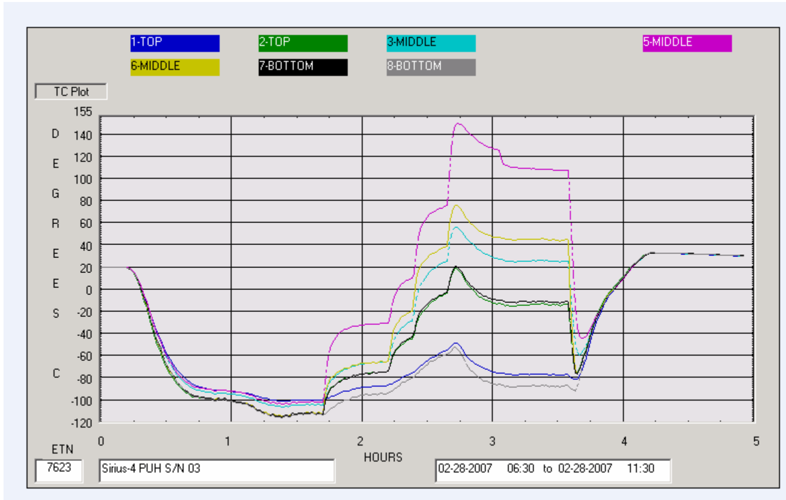

Figure 3: Thermal plot of the GPUH during HPTVAC tests

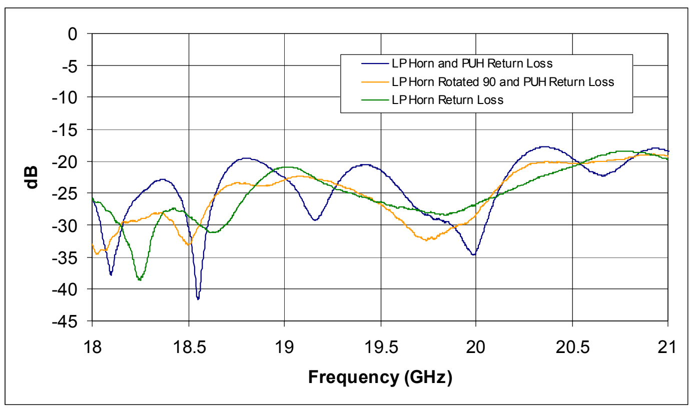

Figure 4: Measured return of the GPUH at Ka-band frequencies for two polarization orientations (VP to VP and VP to HP)

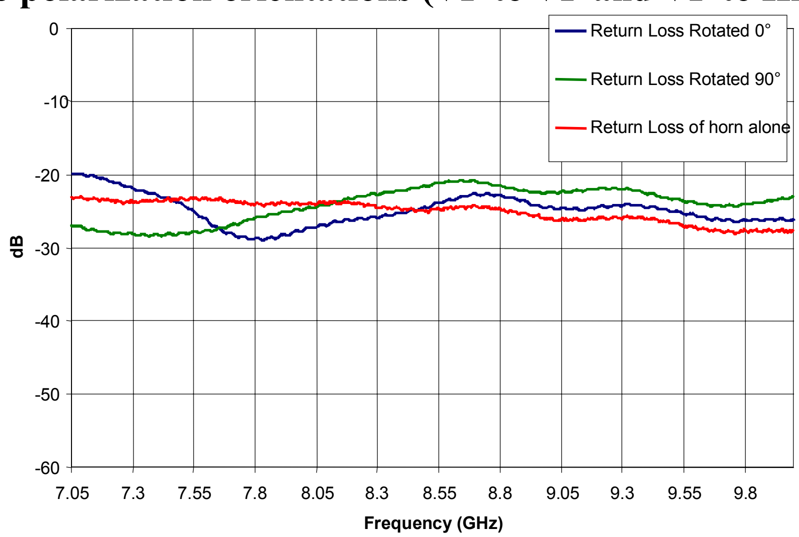

Figure 5: Measured return of the GPUH at X-band frequencies for two polarization orientations (VP to VP and VP to HP)