NEC Network and Sensor Systems,Ltd. Q/V-band Helix TWT for Future High Throughput Satellite Uplink Applications

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Abstract *NEC Network and Sensor Systems, Ltd. has developed a Q/V-band(47.2 - 51.4GHz) 250Wpeak 150Wcw TWT(Traveling-Wave-Tube). This was accomplished with attention to detail in the design of performance and reliability in support of future HTS(High Throughput Satellites) uplink application. This paper presents the summary of this development, which is based on NEC's vast experience, gained from the Ka-band 500W/550W TWTs, well as the space application TWTs.*

Keywords: Satellite Communications (SATCOM); Uplink; Q/V-band; High Power; Helix TWT; HTS; Reliability

INTRODUCTION

It's been a long time since the current generation of HTS using Ka-band was launched [1]. NEC Ka-band TWT products have supported these systems over many years with high reliability performance.

In the last 10 years, NEC has supported the HTS market with delivering over 3,000 units of Ka band TWTs; among this over 1,500 units were of the leading edge High Power 500W peak and 500W CW series. Fig. 1 describes the shipment heritages of NEC's Ka-band TWTs.

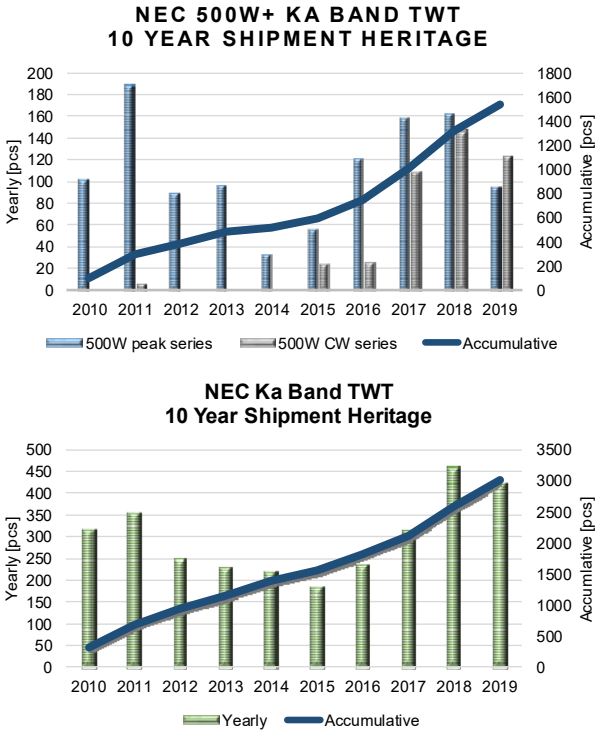

Figure 1. The shipment heritages of NEC's Ka-band TWTs

Recently, system integrators have been focusing on the next generation of HTS systems [2], [3]. These systems are planned to mainly use Q/V-band(47.2 - 51.4GHz) for uplink communication. To continue to support HTS systems, NEC Network and Sensor Systems, Ltd. has developed a Q/V-band(47.2 - 51.4GHz) 250Wpeak 150Wcw TWT.

DESIGN

NEC Network and Sensor Systems, Ltd has prioritized reliability as the one of the most important items for TWT product development. NEC's 500W peak and 500W CW Ka-band TWTs were developed with this criteria and result is a very reliable product [4], [5].

Furthermore, Q/V-band satellite communication is considered to be more susceptible to the effects of rain attenuation than Ka-band [6]. The Q/V-band satellite communication may need to use the Smart Gateway Management System (SGMS) techniques for mitigating the effects of rain attenuation. In this case, all gateways are assumed to be interconnected and shared resources [7], [8]. It's considered that the all gateways have to work reliably, including when they are part of a redundant system. Therefore, the Q/V-band development has to focus on not only RF characteristics but also continuous stable operation ("Reliability"). The Q/V-band TWT was designed based on NEC Ka-band 500W/550W TWTs and also added reliability verification processes utilized on NEC space TWTs.

Mecanical, Electrical: The part number of NEC's Q/V-band TWT is LD7375 shown in Fig. 2. TABLE 1 describes the typical operation parameter of LD7375.

Figure 2. NEC's Q/V-band TWT(LD7375)

Table 1. The typical operation parameter of LD7375

Parameters	Value
Frequency [GHz]	47.2 - 51.4
Cathode Voltage [kV]	17.5
Cathode Current – Typ. [mA]	180
Saturated Power(Psat) [W]	250 peak min.
Maximum CW power(Pmax) [W]	150
Gain at Small Signal – Typ. [dB]	49
Gain at Pmax – Typ. [dB]	42
Helix Current at Pmax [mA]	0.5
Collector	2-Stage
Waveguide Flange	WR-19
Weight – Typ. [kg]	4.3
Size (W×H×L) [mm]	70×70×400
Prime Power at Pmax [W]	700
Dissipated Power at DC [W]	480
Cooling	Conduction cooling
Ambient Temperature [°C]	-40 to 75

Reliability: The Arrhenius equation for accelerating the reliability verification was utilized, and applied to two types of test [9], [10]. The first is high temperature operating test. It was verified that the TWT has stable operation at least 5 years at extreme high ambient temperature condition(75°C). The second is thermal cycle operating tests. It was verified that the TWT has stable operation during thermal cycle testing (-20 to 80°C). The criteria for acceptance is ±0.3dB saturated output power, ±0.5dB gain at small signal, and ±0.5mA helix current.

TEST RESULTS

RF characteristics: It was confirmed the TWT produced 250Wpeak min saturated power; stable operation at maximum CW power, 150W, across the entire frequency band; plus 50W linear power(at -25dBc 3rd order intermodulation). Fig. 3 and Fig. 4 describes each test results.

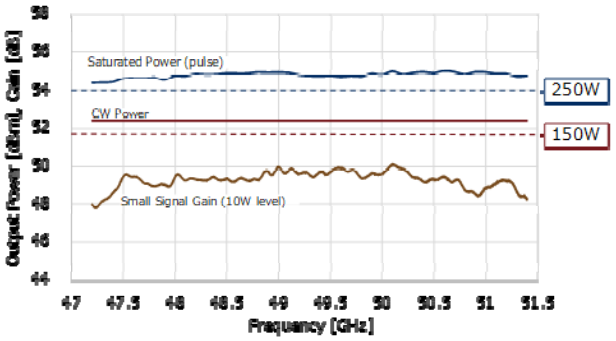

Figure 3. LD7375 measured saturated output power, maximum CW power and small signal gain

Reliability verification: Variation in performance of the TWT was verified in high temperature operating test; -0.10 to +0.02dB of saturated output power; -0.33 to +0.14dB of small signal gain; and -0.04 to +0.03mA of helix current. Fig. 5 describes the graphical result of this test.

Variation in performance of the TWT was verified in thermal cycle running test; Δ0.03dB of saturated output power; Δ0.01dB of gain at small signal; and Δ0.03mA of helix current.

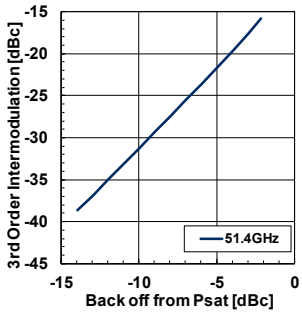

Figure 4. LD7375 measured 3rd order intermodulation

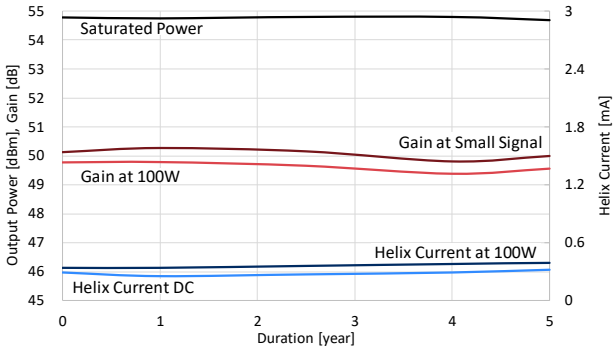

Figure 5. The test result of high temperature running test

As the result of the reliability verification, the TWT has enough reliability for operating stably at least 5years.

CONCLUSION

NEC Network and Sensor Systems, Ltd. has successfully and developed and deployed a Q/V-band(47.2 - 51.4GHz) 250Wpeak 150Wcw TWT, and verified its high reliability. More than 10 Q/V-band TWTs has been produced since the confirmation of the performance of the design. In support of the recent ITS frequency allocation, 47.2 - 51.4 GHz, NEC will proceed with the development of a more broad band Q/V-band(47.2 - 52.4GHz) TWT.

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