NEC Network and Sensor Systems,Ltd. Development of the DBS band 1250W Peak, 750W CW, Helix TWT for Direct Broadcast Satellite Uplink

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Abstract *NEC Network and Sensor Systems, Ltd. has developed a DBS band 1250W peak 750W CW helix Traveling Wave Tube (TWT) for Direct Broadcast Satellite uplink. The TWT covers the full extended DBS band of 17.3 to 18.4GHz. The overall efficiency is greater than 30% at rated power. The measured data of electrical characteristics and the results of two reliability verification tests to ensure high reliability are shown in this paper.*

Keywords: DBS band; Helix; TWT; Reliability; Uplink

INTRODUCTION

The amount data content that is transmitted by Direct Broadcast Satellite systems is increasing, due to the increasing demand for higher resolution content like, 4K, 8K and next generation broadcasting high resolution video content. Therefore, high power and high reliability amplifiers for the uplinks will be necessary to satisfy the demand of content providers. To meet this increased demand, the TWT must achieve higher linear power while maintaining its high reliability.

NEC has developed the LD7369, 1250W peak power, 750W CW power, from 17.3GHz to 18.4GHz, high efficiency, conduction-cooled, helix TWT based on the LD7323, 750W CW TWT, conduction-cooled, helix TWT, developed in 2009.[1]

DESIGN

A. Mecanical, Electrical

LD7369 was designed as higher saturated power, with similar thermal dissipation and same footprint as LD7323. Fig.1 shows the appearance of LD7369. The parameters of LD7369 is shown in Table 1.

Regarding the RF circuit, helix pitch of LD7369 was optimized to increase output peak power. Regarding the collector, there are 2 improvements. First is the inner volume of collectors is increased 36% from LD7323 to improve overall efficiency. Second, The collector block material was changed from aluminum to copper for uniform distribution of collector thermal energy for further stable operation in high temperature condition.

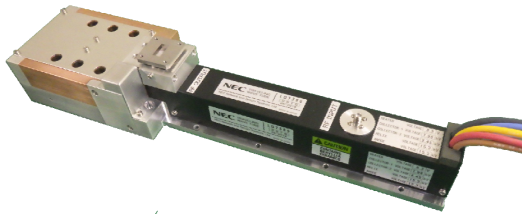

Figure 1. DBS-band 1250W peak 750W CW TWT (LD7369)

Table1 Parameters and measurement data of LD7369

Parameters	Value
Frequency[GHz]	17.3-18.4
Cathode Voltage[kV]	15.4
Cathode Current[mA]	450
Saturated Power(Psat)[W]	1342
Maximum CW power(Pmax)[W]	750
Gain at Small Signal [dB]	52
Gain at Pmax[dB]	51
Helix Current at Pmax[mA]	0.53
Prime power at Pmax[W]	2426
Thermal dissipation at zero RF[W]	1277
Collector	2-Stage
RF Input Connector	SMA Female
RF Output Connector	WR-62
Size(W x H x L)[mm]	96 x 71 x 410
Weight[kg]	4.3
Cooling	Conduction cooling
Ambient Temperature[degC]	-40 to 75

B. Reliability

The LD7369 was subjected to two reliability verification tests, each flowed down from space application TWT testing same as NEC's Ka band 500W/550W TWT. These verification were incorporated based on the Arrhenius equation for accelerating reliability verification[2,3,4]. The first one was high temperature operating test; which verified that the TWT operated stably at extreme high ambient temperature (90 degC) for at least 550hours (equivalent to 4 years in normal condition). The criteria for acceptance is +/-0.5dB of gain stability, +/- 0.5mA of helix current during this test.

The second one was high temperature turn on cycle tests. It was verified that the TWT had stable turn on at high ambient temperature condition (70 degC) at least 63 times (equivalent to 1000 times in normal condition). The criteria for acceptance is +/- 0.3dB saturated output power, +/- 0.5dB gain at small signal and +/- 0.5mA helix current.

TEST RESULTS

C. RF characteristics

It was confirmed the TWT produced 1342W(61.3dBm) saturated power; stable operation at maximum CW power, 750W, across the entire frequency band. Prime power at rated power is 2426W. Overall efficiency at rated power is 30.9%. Fig.2 shows the power transfer curve each frequency, Fig.3 shows small signal gain and rated power gain from 17.3GHz to 18.4GHz, Fig.4 shows 3rd order intermodulation at 17.85GHz.

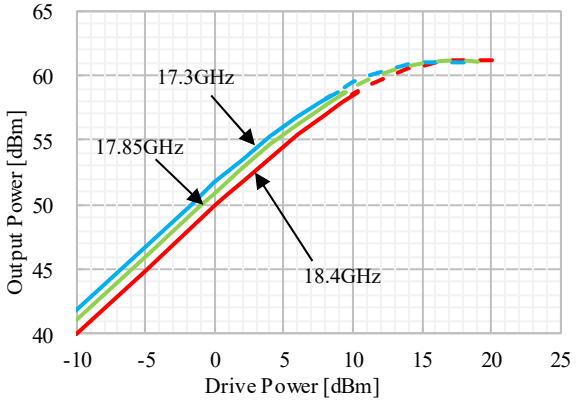

Figure 2. Power transfer curve

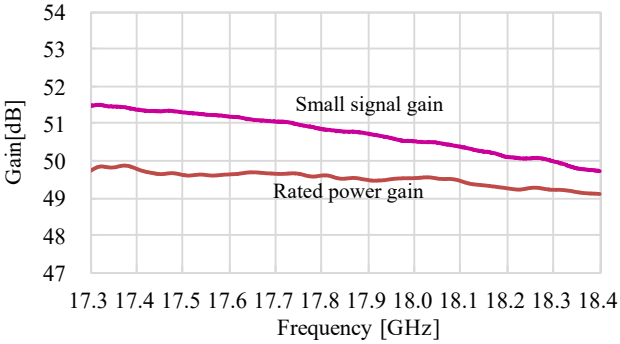

Figure 3. Frequency response

D. Reliability verification

Variation in performance of the TWT was verified in high temperature operating tests; 0.3dB of gain stability; 0.20mA of helix current variation. Fig.5 shows gain stability and helix current stability during high temperature operating test.

Differences before and after the test of the TWT was verified in high temperature turn on cycle test; 0.14dB of saturated output power; 0.07dB of small signal gain; 0.1mA of helix current.

It was verified that stable operation equivalent to 4 years and stable turn on equivalent to 1000 times of LD7369.

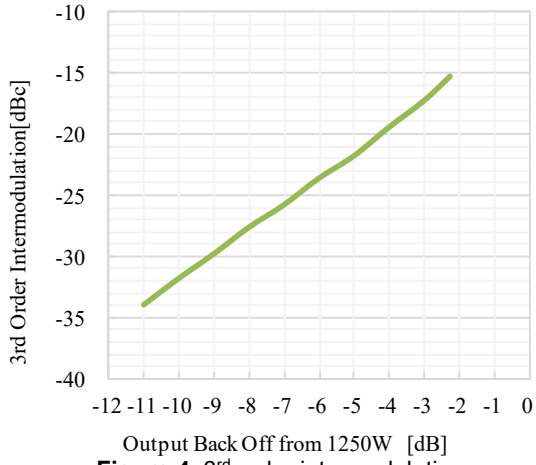

Figure 4. 3rd order intermodulation

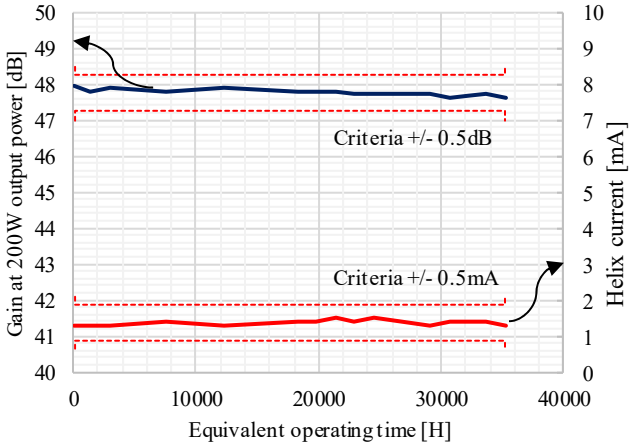

Figure 5. High temperature operating test

CONCLUSION

NEC has developed DBS band 1250W peak, 750W CW helix TWT and verified RF characteristics and its high reliability. NEC is planning higher CW power, higher saturated power TWT development as future prospects.

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