Medium Power High efficiency Ka Band

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ABSTRACT

Abstract:
The paper shows a new generation high efficiency Ka-band TWT especially for high data rate signals which demands high output back-off operation. This TWT, named TL 20075S, was not only designed for geostationary payloads but also for MEO orbits with electrical in orbit transfer (EOT). It is based on the well-known TL20073S Ka-band TWT. With this setup first time an average efficiency of 69% over 2.5GHz for saturation operation could be demonstrated. Simultaneously at 3 dB back-off operation with only half RF output power an average efficiency of more than 52% over 2.5 GHz could be achieved. In this paper the new feasibilities of this efficiency improvement will be discussed. It could be used either for increased number of output channels, for significantly reduced thermal payload layout or for new ideas to omit a linearizer before the TWT for cost improvements. All together this design will give a high flexibility to the customer in his payload layout, as well as a changeability of orbit operation with flexible output power and flexible back-off adjustments. A broadband performance of 2.5 GHz extendable to 2.9GHz will give new standard Ka-band product for a wide operation usage.

Keywords: 100W Ka; Wideband; Space TWT.

Introduction

The current Ka Band medium Power design has proven to be reliable and stable over time through the application in several satellite missions in the past. This design has been optimized in order to improve the RF performance in wideband and in the same step to improve the efficiency of the design in Saturation and in back off operation while keeping the same nonlinearities as the reference.
It has been shown to be capable to cover the frequency range of 17.3GHz - 22GHz with a minimum output power of 107W. The main performance data is shown in the following list.:

- Frequency Band: 17.7 GHz to 20.2 GHz
- Bandwidth: 2.5 GHz
- Output Power at Sat: 100 W amb BOL
- Non-linearity's: as heritage product TL20073S (100 W class)
- NOP: 3 dB OBO
- Output power Flex: 1 dB
- Efficiency at NOP: Specification goal 52%
- Operating conditions: incl. saturation and overdrive (up to 10 dB)

Design and Typical Figures

The main challenge was to improve the performance of the design significantly without changing the used Materials and processes in order to keep the long lasting in orbit heritage of the design. The characteristics of the 3 sub-assemblies (gun, line and collector) of the TL20075C TWT are described in the next paragraphs.All these parts use space proven manufacturing processes.

Gun

A stacked ceramic gun is used as on the existing Ka TWTs in order to keep the technological heritage. Some geometrical improvements in the inner electrode area have been made in order to improve the HV design.

The design allows to reach more than 15 years of life time (MM type cathode with limited cathode current density) with high reliability.
Beam Optics dimensions were unchanged and have already shown to optimize the beam parameters at this Frequency.

Line

The dimensions and the used materials of the delay line are the same as for the heritage Ka band TWTs. A periodic permanent magnet stack has been optimized in order to minimize the helix current considering the beam characteristics at the output of the gun.
Electrical efficiency has been optimized with high linearity characteristics. Instantaneous frequency bandwidth goes up to 2.5GHz.
Saturated RF gain is typically 53dB dB at saturation and around 60dB in small signal.
The RF output design, which has proven to be capable of handling the output powe has been left unchanged.

Collector

Together with the delayline the Collector allows to reach 69% overall efficiency min. in the desired frequency range from 17.7GHz-20.2GHz

Measurements

Fig 1 shows the typical performance data of this tube at saturation in the frequency range 17.7GHz-20.2GHz.

freq|GHz	17.7 GHz	18.2 GHz	18.7 GHz	19.2 GHz	19.7 GHz	20.2 GHz	--	
Ik|mA	66.02	66.02	66.02	66.02	66.02	66.02	66.02	
P2*|dBm	8.98	9.24	9.38	9.49	9.59	9.68		
P2|dBm	50.44	50.5	50.64	50.68	50.67	50.51		P2 av. [W]
P2|W	110.7	112.2	115.9	116.9	116.7	112.5		114.2
vp|dB	52.54	53.19	53.57	53.64	53.2	51.97		
Ih|mA	0.4	0.42	0.43	0.47	0.51	0.55	0.15	
Ig2|uA	13	12	13	15	17	18	2	Qdc av. [%]
Qdc|W	156.53	159.52	161.02	162.05	162.29	161.15	50.85	160.4
Qdiss|W	45.83	47.32	45.12	45.15	45.59	48.65	50.85	Eta av. [%]
ETA|%	70.7	70.3	72	72.1	71.9	69.8		71.1
ETA0|%	25.1	25.5	26.3	26.5	26.5	25.5		25.9
vpss|dB	59.52	60.21	60.51	60.51	59.86	58.52		Eta0 av. [%]

Fig 1: Typical characteristics for TL20075S at saturation

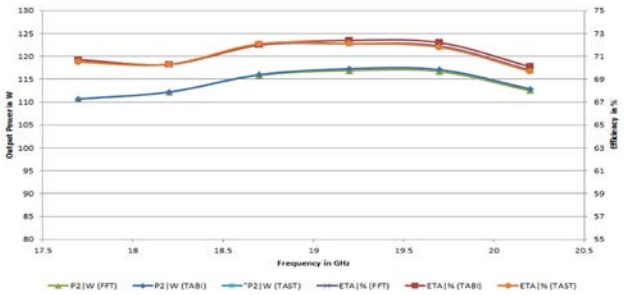

Fig 2: output power and efficiency for TL20075S at saturation

Fig 3 Summarizes the performance parameters in -3dB Back off operation.

freq|GHz	17.7 GHz	18.2 GHz	18.7 GHz	19.2 GHz	19.7 GHz	20.2 GHz	--	
Ik|mA	66.03	66.03	66.03	66.03	66.03	66.03	66.03	
P2*|dBm	5.97	6.22	6.35	6.44	6.53	6.65		
P2|dBm	47.43	47.48	47.61	47.63	47.61	47.48		P2 av. [W]
P2|W	55.34	55.98	57.68	57.94	57.68	55.98		56.8
vp|dB	58.32	59.05	59.39	59.46	58.91	57.7		
Ih|mA	0.25	0.25	0.25	0.25	0.26	0.26	0.16	
Ig2|uA	8	9	9	10	11	11	2	Qdc av. [%]
Qdc|W	106.46	107.89	108.38	108.41	107.74	106.6	50.96	107.6
Qdiss|W	51.12	51.91	50.7	50.47	50.06	50.62	50.96	Eta av. [%]
ETA|%	52	51.9	53.2	53.4	53.5	52.5		52.8
ETA0|%	12.6	12.7	13.1	13.2	13.1	12.7		12.9
vpss|dB	59.9	60.59	60.86	60.81	60.1	58.68		Eta0 av. [%]

Fig 3: Typical characteristics for TL20075S at –3dB back off operation.

The main performances have been demonstrated and reproduced on several EM and EQM tubes. The EQM tubes have seen a full level qualification testing and additionally a tube has been put into a extended temperature cycling with HV switching. have

Conclusion

The performance of the current medium power Ka band tube has been optimized in order to improve efficiency, efficiency in back off operation and wideband behavior of the tube. The optimisations have been done without changing the space qualified materials or processes used in the design. The performance and the reliability of the design have been validated on EQM and with additional testing.