Development of High-Power Pulses Traveling Wave Tubes at Thales

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ABSTRACT

Traveling Wave Tubes (TWTs) provide microwave amplification at high power, high efficiency and high reliability. Compared to other vacuum-electronic RF amplifiers, TWTs can also provide a relatively large bandwidth, and thus are in use in a large number of satellite-based applications ranging from L-Band to Q-Band. TWTs are also used as power amplifiers for Radar applications. In this case, the electron beam of the TWT is pulsed to provide a very high peak output power (up to several kW) while keeping the average thermal load of the TWT manageable.

Thales has a very extensive heritage in manufacturing both communication TWTs for satellite applications as well as Ka-Band pulsed TWTs for ground-based Radar applications. Recently, there has been great interest from the earth observation community in space-capable RF power amplifiers operating around 35.75GHz, with two examples being the 400W scatterometer of the ODYSEA mission [1] and the 1000W altimeter of the Sentinel 3-NG mission in the frame of the COPERNICUS program [2]. Thales is using its ground-based pulsed Ka-Band TWTs as a baseline to develop space-capable solutions to address these demands. This is aided by the strong industrialization of the baseline TWTs and the fact that almost all processes and materials used are already space-qualified.

The main differences in the requirements of the space TWT compared to the baseline TWT are the much-increased lifetime (~8 years) and necessary improvements in the efficiency. The lifetime is limited by the cathode, which has to provide a stable beam current over a much longer time, and the gun design with its combination of shadow grid and control grid. The efficiency is currently limited by the single-stage collector design. The lifetime requirements will be met with an updated gun design, and the efficiency will be improved by a multi-stage collector design and a revision of the delay line. The delay line is also adapted to provide the necessary output power at the operating frequency of 35.75GHz. The current state of the development and of the manufactured prototypes will be presented during the conference.

Apart from the activities in Ka-Band, there is also interest in a TWT operating in W-Band around 90GHz. Examples of applications are a spaceborne Radar TWT mainly for the observation of debris in LEO, and a broadband pre-amplifier in a ground-based Gyro-TWT, with an output power target of at least 100W. The development of these tubes at Thales has been put on hold in the early 2000s, and is now continued due to the renewed interest.

References

[1] E. Rodríguez, M. Bourassa, D. Chelton, T. Farrar, D. Long, D. Perkovic-Martin, and R. Samelson, “The Winds and Currents Mission Concept,” Frontiers in Marine Science., vol. 6, Jul. 2019.
[2] https://www.esa.int/Space_in_Member_States/Germany/Copernicus