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MATHEMATICAL MODEL TO ESTIMATE THE VENESAT-1 TRANSPONDERS ANODE VOLTAGE
EVOLUTION IN ORBIT OPERATION**Abstract**

The transponders as the core of the communications satellites payload are involved in different tests processes, whose objective is ensuring their best performance and optimal evolution during the operation time. In consequence, various tests are performed over the transponders in the stage of manufacturing and also in the phase of Assembly and Integration Test (AIT). Equally, In Orbit Test (IOT) phase, when the satellite is positioned in the final operation orbit. After the aforementioned processes, the transponders evolution and ageing from the Begin of Life (BOL) until the End of Life (EOL) in orbit must be estimated in order to define the most suitable strategies to manage the communications payload during the useful life. In this regard, considering the VENESAT-1 transponders designed mainly with Travelling Wave Tube Amplifiers (TWTAs), technology that adopts the Anode Voltage Variation configuration from the Begin of Life (BOL) until the End of Life (EOL) to compensates the Cathode degradation; since it is a thermionic device with a high rate of ageing due to its physical properties affected for the high temperatures to which operates in the transponders. Phenomena that impact significantly the TWTAs useful life reducing their reliability in orbit, the transponders Anode Voltage Evolution Trend from the BOL until the EOL in orbit becomes in a critical parameter that requires be analyzed and modeling using scientific methodologies, helpful to estimate the transponders evolution. Therefore, in this paper is presented a novel Mathematical Model to Estimate the VENESAT-1 Transponders Anode Voltage Evolution in Orbit Operation based on the statistical treatment and modeling of the Anode Voltage data obtained from: AIT phase, IOT phase and the Anode Telemetry data downloaded from the VENESAT-1 Transponders in orbit operation. Nevertheless, statistical techniques such as: Statistical Treatment of Discrete and Continuous Variables, Arithmetic Mean, Standard Deviation, Karl Pearson's Correlation Coefficient, Dispersion Estimation for Discrete and Continuous Variables, Normal Distribution as well as Interpolation Methods, are used to carry out the transponders telemetry statistical treatment with the aim to formulate the Mathematical Model and predicts the VENESAT-1 transponders evolution in orbit. As result, is demonstrated in experimental way that the telemetry statistical treatment of the VENESAT-1 transponders is a reliable methodology to estimate the Anode Voltage Evolution Trend and Transponders ageing. Similarly, it is a proper method to manage the VENESAT-1 payload through its useful life in orbit.

Key words: Transponders, Anode Voltage Evolution, BOL-EOL, Mathematical Model, Telemetry Statistical Treatment