Abstract

Metal-inserts (septums) placed in the E-plane of split block waveguide housing is a well known method for realizing low-cost and mass producible microwave filters. These filters offer low insertion loss and are suitable for high power applications, hence, are widely used in spacecraft applications. Various design aspects and approaches are available in literature for the design of E-plane filters. However, field computations required for predicting high power problems are not addressed adequately.

Power levels of microwave systems in satellites are continuously increasing due to the increase in number of simultaneous carriers. This is resulting in high power problems like multipactor. Multipactor is a resonant electron phenomenon that occurs in generic RF vacuum systems, which is a parasitic phenomenon that degrades system performance and can lead to loss of transponder or satellite. To reduce development time and cost for multipaction-free space hardware, risk has to be addressed at the design stage itself. Hence a lot of efforts are currently being put towards the accurate modeling and prediction of multipactor. In order to estimate the correct multipaction threshold for any structure, first it is required to find the electromagnetic field distribution and location of its maximum. Secondly, the secondary electron behavior and its trajectory in such high field region that leads to avalanche breakdown are to be computed.

In this thesis, a novel and very simple approach to calculate the maximum electric field strength in a waveguide E-plane metal insert filter, using a method based on modal expansion for both incident and scattered waves of interest is presented. This method not only considers finite thickness of the septum and higher-order mode interaction throughout the structure, but also fairly deals with types of geometries where the commonly used parallel plate model cannot be applied. Unlike in commercial EM simulators, in this approach, it is not required to model the structure for the given dimensions, analyze it and post process the results to calculate the maximum field strength and its location. Present results show uniformity in calculations as compared to the HFSS software and closely match with that of the measurement.

Based on the proposed approach, a generalized algorithm is developed to estimate fields inside any given waveguide structure with H-plane discontinuities. Conditions for occurrence of multipaction, governing equations and analysis by field based multipactor modeling procedure are discussed. Also, its prevention and suppression techniques are described.

A compact multipaction-free diplexer is designed for the Mars Orbiter Mission (MOM) spacecraft of Indian Space Research Organization (ISRO) launched during November, 2013. This is used in the S-band telemetry, tracking and commanding (TT&C) transponder, where it is required to handle 200 Watts in the telemetry path besides simultaneously maintaining an isolation of more than 145dBc to its tele-command path. This diplexer design, multipactor analysis and space qualification phases are presented which are aimed at meeting the primary specifications for multipaction, insertion loss, rejection, mass and size. The diplexer is successfully tested with 6dB margin power, with no evidence of multipaction. Deep space mission performance of the on-board diplexer is normal.

Keywords: **Metal insert filter, diplexer, multipactor, transponder, satellite, deep space mission.**