



Compact Dual Band Dual Circularly Polarized User-cum-Gateway Feed Chain for Multiple Beam Antennas at K/Ka Bands

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Abstract

This paper describes the design of a compact dual band dual circularly polarized feed chain for satellite communication antennas at K/Ka bands. The proposed feed chain caters to User-cum-Hub bands (Transmit: 17.7-20.7GHz & Receive: 27.5-30.5GHz) with a transverse envelope of 40mm*20mm which is suitable for multiple beam antennas having small feed-feed spacing due to smaller beam size. The chain consists of a dual band septum polarizer with high bandwidth of individual bands and transmit/receive diplexer for frequency separation. The comparative R.F performance of two configurations based on circular and square septum polariser is elucidated. The analysis of the feed chain components was carried out using two different techniques namely 2D-FEM/MM and FEM through commercially available softwares Mician and HFSS respectively and there is a close match in the results. The high performance circularly polarized feed chain was optimized in an integrated manner for Axial ratio < 1dB .

1. Introduction

SATCOM applications benefitting several business enterprises and societal needs in India demand high-throughput and a large capacity payload. Multiple Beam Antennas (MBA) with spot beam and frequency reuse technology have been proven to be most suitable candidate for these applications. MBA at Ka band are frequently utilized due to various advantages viz. availability of large spectrum, small terminal size etc. Contemporary MBA support both Transmit/Receive capabilities within a single reflector either by reflector shaping or beam equalization using multimodal feeds. The beams are typically circularly polarized so that alignment of mobile user terminal may become less critical. These high gain beams are very small in size (0.3-0.6°) which poses a challenge on feeder networks to have small transverse envelope. Moreover, the allocated bands for transmit and receive operation are widely separated (55% band separation). The two possible architectures for

dual band dual circular polarization operation are discussed in [1]. In first architecture, orthomode transducer (OMT)-cum-septa dual band polarizer may be implemented which operates in both the bands and diplexers may be utilized to separate transmit/receive band signals. In another architecture, dual-polarization diplexer is implemented followed by single band combiners/polarizers/OMT. The former approach is utilized in [3] in which feed chain includes broadband ridge based polarizer followed by reduced height turnstile based orthomode transducer and diplexers. The topology may lead to a higher insertion loss due to ridge guide and reduced height OMT despite achieving excellent RF performance. Another configuration with the same architecture is discussed in [4] but with reduced bandwidth in transmit/receive bands, which may be suitable for user beam feed chain. The topology for latter approach [2] in spite of achieving excellent RF performance leads to a bulky and heavy configuration and it becomes difficult to fit in an envelope of 50mm at Ka band as desired by typical multiple beam antennas. Moreover, the assembly of power splitter section becomes critical and minor change in electrical length of the combining arms leads to spikes in insertion loss of the chain. Present work is based on first architecture in which a dual band septum polarizer is followed by transmit/receive diplexers. The transverse envelope of the cavity is planar & compact and suitable for small feed-feed spacing. Due to CP operation, the feed chain may be aligned at any angle with respect to feed axis and a compact lattice may lead to smaller feed-feed spacing.

2. Feed Chain Design and Predicted Results

The user-cum-gateway feed chain is physically a 5-port device catering both transmit (17.7-20.7GHz) and receive (27.5-30.5GHz) functions in dual circular polarization. The common port is a circular guide, which is connected to radiating horn feed. The other end of circular guide is connected to septum polarizer which is followed by transitions and diplexers. The rectangular interfaces of

diplexers are WR51 and WR34 for transmit and receive bands respectively. The feed chain with circular polarizer RF model is shown in fig. 1.

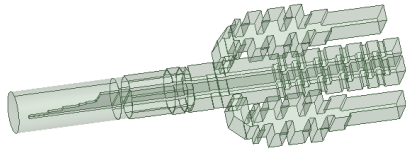


Fig. 1. 4-Port K/Ka CP feed chain with circular polarizer

2.1 Septum polarizer and transformer

The prime advantage of septum polarizer is that it simultaneously achieves both the operations of linear to Circular polarization conversion and polarization separation in a compact geometry. Moreover, it is capable of handling high power due to absence of small gaps around the high E-field region. The two possible configurations of septum polarizers are circular guide and square guide polarizer. The initial design of both the configurations is performed as given in [5] by uniformly increasing the width of steps in equal proportion and choosing the length of each step in a decreasing manner such that impedance at center frequency is matched with input guide.

Semi-octagonal transformer is chosen for circular to rectangular transition as the transformer provides good match over a wide bandwidth with compact geometry due to similar field pattern as that of circular and rectangular guide fundamental mode. Moreover, they are relatively immune to higher order mode excitation [6].

The predicted results of axial ratio and return loss, pol-pol isolation & higher order mode excitation for square guide septum polarizer are presented in Fig. 2-3.

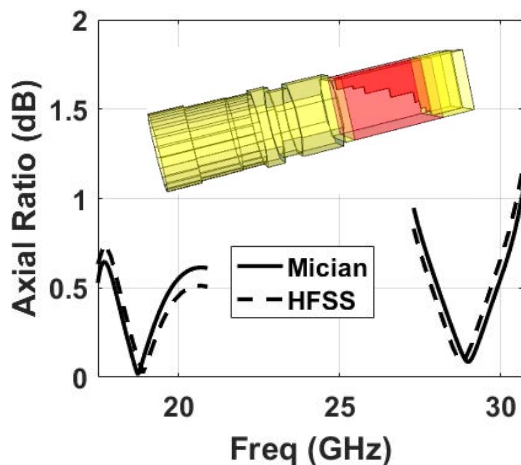


Fig. 2. Axial ratio performance of square guide polarizer

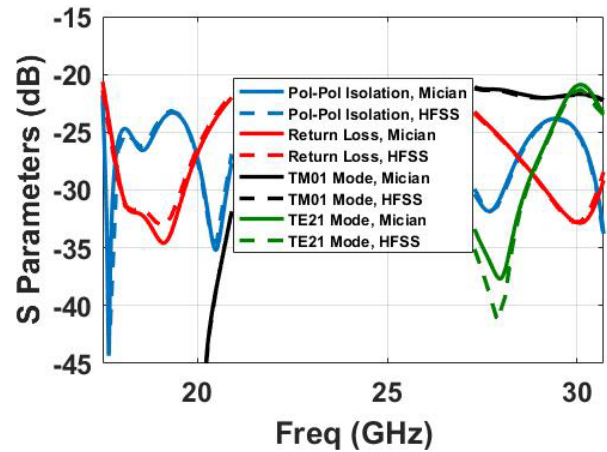


Fig. 3. Return loss, pol-pol isolation and higher order mode excitation of square guide polarizer

2.2 Diplexer

Waveguide diplexer consists of a low pass corrugated filter, a band pass filter and an E-plane Tee junction to combine the filters. E-plane Tee junction was chosen because it can be manufactured by splitting the broad wall of the filter, which allows minimum current disturbance. Achieved performance of optimized diplexer is shown in fig. 4. As PIM was a concern, no tuning screws were used. Multipaction analysis was performed by calculating the maximum threshold voltage across the minimum gap size from susceptibility zone chart of ESA over the operating power with 2 channels, 120W each with N^2P_i rule and comparing the same with voltage computed from FEM based solver HFSS for minimum gap (2.24mm). The margin computed was better than 8dB so a rigorous Multipaction test may be avoided. The diplexer can be easily manufactured with milling technique.



Fig. 4. Diplexer return loss and isolation performance

3. Conclusion

A compact dual band feed chain for user-cum-hub beam is designed with two different configurations of dual band septum polariser with nearly 55 % band separation. The square waveguide polarizer based feed chain is found to be superior to the circular wave guide polarizer with better control over Axial Ratio and Higher Order Mode over widely separated bands . The feed chain is planar in nature and can be easily integrated in a compact manner. The feed chain achieves good RF performance over the complete bands of operation with the Axial Ratio <1 dB.

Microwave Theory and Techniques, pp. 2247-2451, Vol. 59, No. 10, Oct. 2011.

4. Acknowledgements

The authors sincerely thank Sh. Dipak Das, Director, Space Applications Centre (SAC), Indian Space Research Organization (ISRO), India for encouragement to carry out the work. The authors also wish to thank engineers of Satellite Communication Antenna Division, Antenna Systems Group, SAC for their much needed support.

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