25/2019(i)

Proceedings of the VEDA-2019 Symposium

Investigation into Innovative Helix Slow Wave Structure for Performance Improvement

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***Abstract-* In this paper, authors have presented design of a simple, novel helix SWS (HSWS) for flat power and gain frequency response with improved electronic efficiency in the X-band. To control the dispersion of the structure, the helix is supported with two different types of dielectric supports, namely, T and rectangular shaped and as a consequence flat power and gain have been achieved.**

I. INTRODUCTION

Helix travelling wave tubes (HTWTs) are perhaps the most complex power amplifiers and have drawn attention if it is to be used for satellite communication due to high linearity, flat power and gain frequency response, high efficiency, high reliability, etc [1–4]. Performance of a TWT mainly depends on the interaction structure, and, hence, demand special design considerations. High power, wideband, high efficiency, etc, agility of space TWT needs innovative design with reduced size and weight. Suitably tailoring the design of interaction structure, namely, helix SWS, interaction efficiency can be improved and, hence overall efficiency of the TWT along with other electrical performances. Performance of the TWT can be improved if the helix SWS exhibits flat to negative dispersion [2]. However, achieving negative dispersion using isotropic inhomogeneous loading is difficult and can be realized by anisotropic inhomogeneous loading. Further, for narrow band TWT, anisotropic loading is not appreciated by the designer due to several constrains. In view of limitations of anisotropic loading, and to improve the performance of the TWT, multi-dispersion has been adopted and presented in this paper.

Moreover, it is common practice to tapper the helix pitch towards output to enhance efficiency [3], [4]. In this approach, presented in this paper, positive up-tapper has been used to enhance electronic efficiency. Also, positive up-tapper has another advantage to reduce the characteristic impedance of the interaction structure and become easy to model the coupling system.

Multi-dispersive SWS is more effective if one can model the SWS into three sections, rather than two sections. However, three section tube increases fabrication complexity. In view of this, a three section multi-dispersive structure has been modeled for performance improvement with flat power and gain frequency response.

The helix profile is depicted in fig 1. To control the dispersion two different types, namely, T shaped and rectangular shaped APBN helix supports have been used. The normalized helix pitches are Pitch 1 (P_1) = 1, Pitch 2 (P_2) = 1, Pitch 3 (P_3) = 1.04 , Pitch 4 (P_4) = 0.79, Pitch 5 (P_5) = 1 . The normalized lengths of different helix sub-sections are Length 1 (L_1) = 1 , Length 2 (L_2) = 0.43 , Length 3 (L_3) = 0.057 , Length 4 (L_4) =0.43, Length 5 (L_5) = 0.43, Length 6 (L_6) = 0.43, Length 7 (L_7) = 0.057, Length 8 (L_8) = 0.43, Length 9 (L_9) = 1.143, Length 10 (L_{10}) = 0.29, Length 11 (L_{11}) = 0.14, Length 12 (L_{12}) = 0.14.

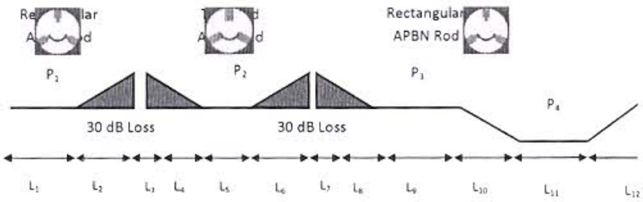

Fig 1. Schematic of HSWS profile. (Input and output section have T shape APBN supports rods placed symmetrically 120° apart, middle section has rectangular shape APBN supports rods placed symmetrically 120° apart).

II. RESULTS AND DISCUSSIONS

It can be observed from fig 2 that the HSWS exhibits almost linear profile in output power characteristics and the output power is around 265-275 watts in the entire operating band (10.8-12.0) GHz. The proposed HSWS have been designed using in house developed code SUNRAY 1D [5]. The large signal gain (LSG) of the structure is more than 57 dBm in the operating band. From figure 3 it can be observed that the

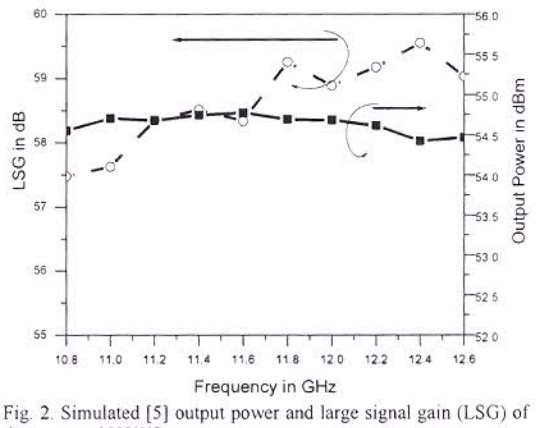

Fig. 2. Simulated [5] output power and large signal gain (LSG) of the proposed HSWS.

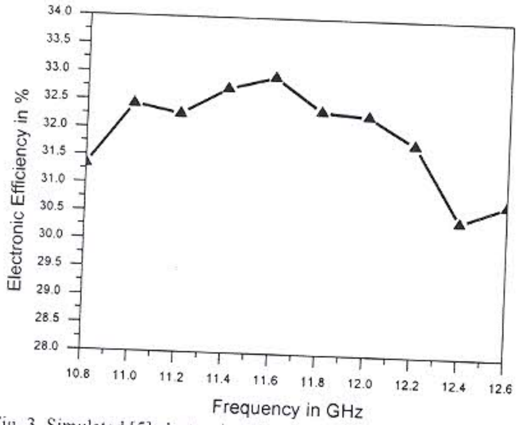

Fig. 3. Simulated [5] electronic efficiency of the proposed HSWS.

simulated [5] electronic efficiency is more than 30 % which indicates a significant increase in electronic efficiency in comparison with that of available in literature [1]-[4]. Therefore, the proposed HSWS is highly suitable for fixed satellite service and microwave power module applications.

Acknowledgment

Authors would like to thank Director, CSIR-CEERI for his support.

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