Selection of Helix Tape Parameters for Ku-band 140W SL-TWT

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Abstract: *This paper presents the optimum selection of helix tape parameters for the design of Ku-band 140W short length TWT for space communication application. CST MWS code and in-house developed SUNRAY-3D codes have been used to design helical slow wave structure. In this model, helix is considered as perfectly conducting tape. The dependency of gain flatness and gain per unit length on tape thickness, tape width and helix pitch have been studied by maintaining the propagation constant(β) fixed at central frequency(i.e. 11.3GHz). Dependency of interaction impedance on helix tape width and tape thickness has also been studied.*

Keywords: Helix tape size; short-length TWT; MPM; Gain Flatness.

Introduction

Short-length TWT(SL-TWT) to be used in microwave power module(MPM). Short-length TWT has been designed to deliver 140W saturated power at 25dB gain over the operating frequency band i.e. (10.9-11.7GHz).The optimized beam voltage and beam current,5.9kV and 100mA respectively to 140W RF power,25dB gain and electronic efficiency >25%. The SWS parameters like helix radius, metal envelop radius, tape size, T-shape helix support(APBN) rods height and thickness have been optimized.

Design Approach

CST-MWS code has been used for computing propagation constant (β), interaction impedance(K) on axis of helix slow wave structure, phase velocity and group velocity of RF signal. The helix is made of tungsten tape and it is supported in the barrel assembly with three APBN T-shaped rods. The whole assembly is placed in perfectly conducting metal envelop and applied master slave boundary condition in the axial direction as shown in Figure 1. In-house developed SUNRAY-3D large-signal code has been used to optimize helix pitch and helix length profiles for desired RF performance over 10.9 to 11.7GHz with maximum saturated power and gain as shown in Figure 2. SWS is made in single-section with centre loss and positive taper.

SWS I single section has been designed based on three pitches(e.g. for maximum small signal gain, effective beam bunching and maximum electronic efficiency).Tape width(0.30mm) and tape thickness(0.150mm) to achieve 140W saturated output power at Saturated gain 25dB and more than 25%electronic efficiency. Further to improve the gain flatness and gain per unit length, in this design the dependency of tape thickness, tape width and helix pitches have been studied.

Initially, the pitch and propagation constant(rad/m) is computed by varied tape thickness ±0.05mm from the tape thickness 0.150mm as shown in Figure 3. In order to maintain the fixed propagation constant over the desired band width for different tape thickness ,pitches are varied as shown in Table 1.The study has been done at centre frequency 11.3GHz.It can be observed from Figure 4, if the tape thickness is reduced from 0.150mm to 0.100mm, the interaction impedance k1,k2,k3(Ω) is increased and reduced loading effect which improve flatness of gain and gain per unit length. Similarly, the tape width variation ±0.05mm from tape width 0.300mm has also been studied as shown in Figure 5. It can be observed that pitches are varied to maintain fixed propagation constant for different tape width in Table 2.As shown below in Figure 6, the phase velocity(Vp) of RF signal is increased with the positive variation of tape width and the interaction impedance has been studied at constant propagation constant(rad/m) for different tape width(mm).

Table 1. Pitch for same β at 11.3GHz vs. tape thickness

Tape thickness(mm)	P1(mm) β=1758.4	P2(mm) β=1660.3	P3(mm) β=1590.6
0.100	0.535	0.565	0.585
0.150	0.550	0.580	0.600
0.200	0.565	0.595	0.615

Table.2 Pitch for same β at 11.3GHz vs. tape width

Tapewidth(mm)	P1(mm) β =1590.6	P2(mm) β =1510.80	P3(mm) β =1434.89
0.250	0.601	0.636	0.664
0.300	0.600	0.630	0.660
0.350	0.5980	0.6299	0.6585

At different propagation,β(rad/m) kept helix pitches remain same, studied the effect of tapewidth(mm) and tapethickness(mm) on interaction impedence as shown in Figure 7 and Figure 8 respectively.

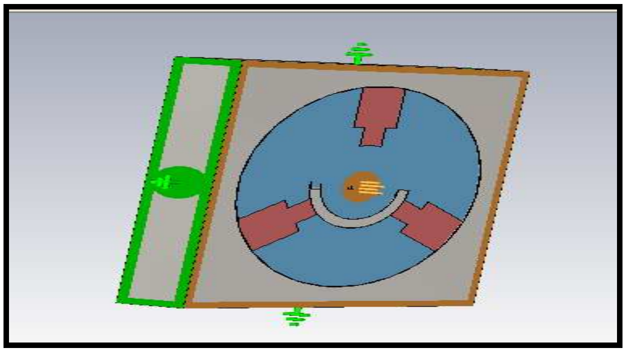

Figure 1. CST-MWS model of helix SWS

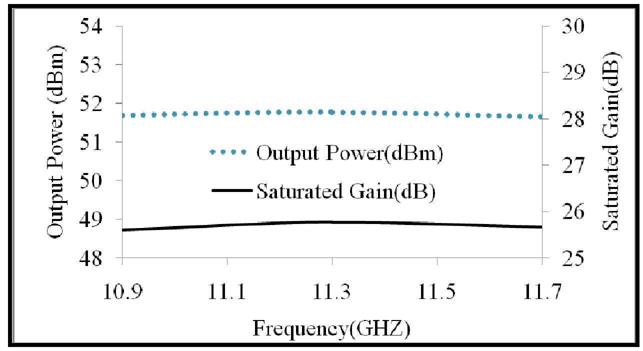

Figure 2. Power(dBm),Gain(dB) vs. Frequency(GHz)

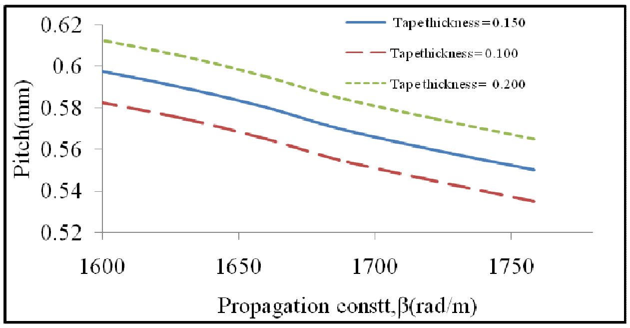

Figure 3. Pitch(mm) vs. β at different Tape thickness

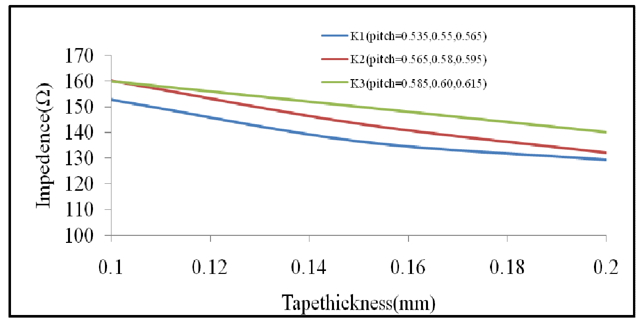

Figure 4. k(Ω) vs. Tape thickness(mm) at constant β

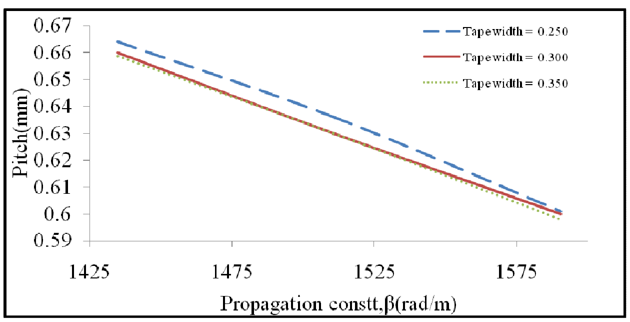

Figure 5. Pitch(mm) vs. β at different Tape width

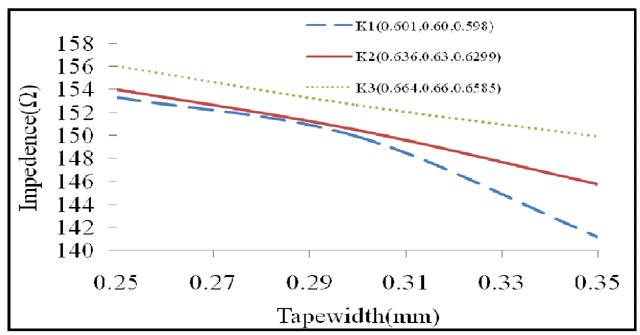

Figure 6. K(Ω) vs. Tape width(mm) at constant β

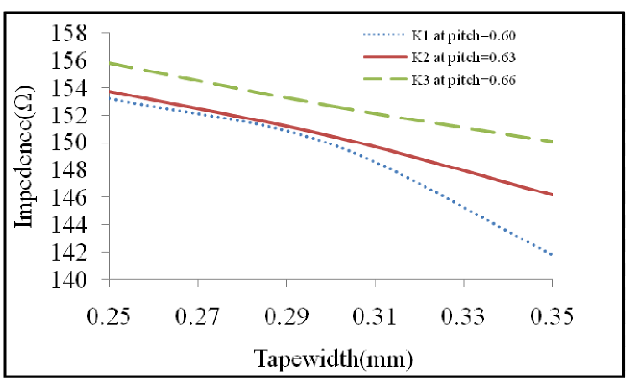

Figure 7. K(Ω) vs. Tape width(mm) at different β

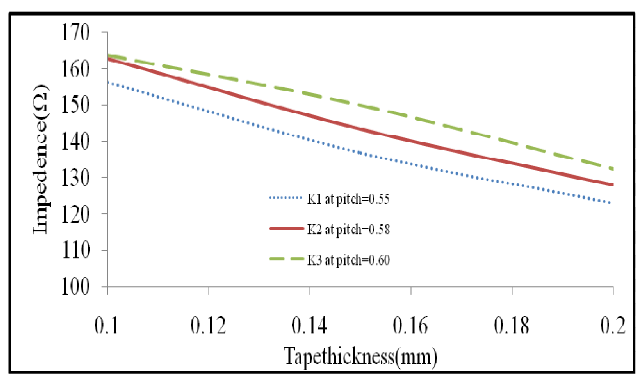

Figure 8. K(Ω) vs. Tape thickness(mm) at different β