A Harmonic Multiplying Gyrotron Traveling Wave Amplifier at Ka Band Developed in IECAS

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The works related to harmonic multiplying gyrotron traveling wave amplifier were ever reported by us in IRMMW2006 and IVEC2007, which showed that there were some contradictions between output power and band-width.[1, 2] In [1], the output frequency bandwidth of more 500 MHz can be reached at output pulse power of only 10.07~12.88kW. In [2], output pulse power can be increased to 25kW with very narrow bandwidth. Because of using harmonic multiplying, the resonant circuit is usually used to increase the coupling between fundamental and harmonic. However, it will decrease operating bandwidth. In this article, a new method is utilized for enhacing output power and improving bandwidth.

The interaction circuit of the harmonic multiplying gyrotron travel wave amplifier discussed here includes the TE_{01} mode fundamental interaction zone, a drift section, the TE_{02} mode second harmonic interaction zone, the conversion and insulation zone for the TE_{02} and TE_{03}, and the TE_{03} mode second harmonic interaction zone. The Input coupler is designed using Ansoft's HFSS to operate in the TE_{01} mode at Ku band with a traveling wave version of the rectangular to coaxial chamber to circular beam tunnel geometry [3, 4]. The design for it has obtained the band-pass response at a not larger than 2 of VSWR in the range of operating frequency when the combination of the input coupler, the TE_{01} mode fundamental interaction zone and the drift section are considered as a RF interaction structure. After the drift section, the TE_{02} mode filter operating in second harmonic is used to increase beam-wave interaction intensity and widen bindwidth. The simulation results without the beam shows that the transmission coefficient is larger than -0.5dB when the reflection coefficient is less than -15dB in the frequency range of 32.9-33.4GHz. But the transmission coefficient descends slowly outside above frequency range, which means that the beam wave interaction intensity may not be very strong. So the TE_{03} mode filter is added in order to futher ehance the beam wave interaction. The simulation results show that the frequency response characteristics of the mode filter without the beam, which is similar to that of the TE_{02} mode except the insertion loss is a little larger. A mode converter is placed between the two mode filters for converting the TE_{02} mode into the TE_{03} mode.

The tube based on the above mentioned design has been manufactured and measured. The results show that the maximum peak power of larger than 62kW can be reached at beam voltage of 68 kV, beam current of 15A and 0.1% duty cycle with -3dB bandwidth of larger than 250MHz with the TE_{03} mode output. Although parasitical oscillation from competing mode without obvious output power was ever observed when RF signal was not input, RF driving signal can efficiently suppress the mode competition and keep the stability of the operating mode in the range of the operating frequencies. However, when the operating frequency is higher than 16.7GHz, no steady amplification can be reached because of mode competitions. Further improvement for the tube is under way.

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