# Upgrade of a W-band Gyro-TWA for cloud radar application

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## Abstract

An existing W-band gyro-TWA is being upgraded to achieve an output power of 5 kW and a high pulse repetition rate of 2 kHz for cloud radar application. In this paper we report the latest results on the upgrade of the W-band gyro-TWA and its components. These components include input coupler, output window, corrugated output mode converter, pulsed power system and water-cooled beam dump.

## 1 Introduction

In the past gyrotron travelling wave amplifiers (gyro-TWA) and gyrotron backward wave oscillators (gyro-BWO) based on helically corrugated interaction regions (HCIR) have achieved unprecedented power-bandwidth performance [1,2]. An existing W-band gyro-TWA (Fig. 1) is being upgraded to achieve an output power of 5 kW with a 3 dB frequency bandwidth of 90-100 GHz and a saturated gain of 40 dB in the University of Strathclyde. For cloud radar application the output of the amplifier is also required to operate at a high pulse repetition frequency (PRF) of 2 kHz when the output microwave has a pulse duration of 380 ns (FWHM).

Fig. 1. A photograph of the W-band gyro-TWA experiment.

## 2 Principle

To increase the bandwidth of the amplifier a three-fold HCIR has been used. The resonant coupling of the $TE_{21}$ mode and the first spatial harmonic of the $TE_{11}$ mode in the HCIR gives rise to an "ideal" eigenwave for the amplifier. The eigenwave, which has an almost constant value of group velocity over a wide frequency band in the region of small axial wave numbers [3], can be readily matched by the dispersion line of an electron cyclotron mode or its harmonics allowing broadband microwave amplification to be achieved in a gyrotron travelling wave amplifier. The HCIR can also be designed to compress microwave pulses [4].

The large-orbit electron beam, generated from a cusp electron gun [5], is ideal for harmonic operation of gyro-devices as the mode selectivity nature of such a beam requires that the harmonic number is equal to the azimuthal index of a waveguide mode for effective beam wave coupling, which leads to a reduced possibility of parasitic oscillations.

## 3 Upgrades of components

Many components have been upgraded for operation at a PRF of 2 kHz and their microwave properties measured including: broadband input coupler [6, 7], corrugated quasi-optical mode converter [8], output window [9,10], pulsed power system and water-cooled beam dump.

The new output window (Fig. 2) was optimized through computer simulation, manufactured and measured to have a reflection of -27 dB which was a nearly 10 times improvement in comparison to the previous output window. The output window was mounted directly after a corrugated quasi-optical mode converter and the microwave properties, such as reflection coefficient, far-field output mode pattern and near-field electric contour plot were measured and found to be in excellent agreement with predictions from the numerical simulations. The contour plot was calculated to have a coupling ratio of 99.1% to the fundamental free space Gaussian mode.

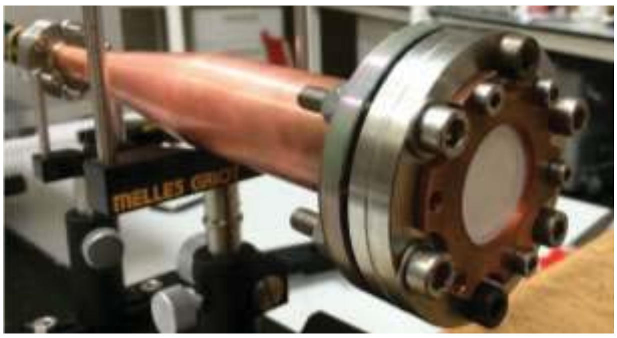

Fig. 2. A photograph of the upgraded W-band corrugated horn and output window.

The corrugated horn could be used to separate the output electromagnetic wave from the spent electron beam so that the energy of the spent electron beam could be recovered by a depressed collector system.

The upgraded input coupler (Fig. 3) was improved from its predecessor in three aspects. Its reflection was measured to be 2 dB better, its vacuum leak rate was improved 10 times to 10-9 mbar/s and it was mechanically more robust.

Fig. 3. A photograph of the upgraded input coupler of the W-band gyro-TWA.

A water-cooled beam dump to accommodate the higher average power associated with an increased PRF has been designed and optimised through thermal simulations and manufactured (Fig. 4).

Fig. 4 A photo of the water-cooled electron beam dump.

A new thyratron-based trigger and switching system capable of 2 kHz PRF was designed and manufactured and in conjunction with a double-Blumlein pulse forming network was used to provide the accelerating field for the electron beam. The electron accelerating potential was measured using a resistive voltage divider, while electron current, typically 1.5 A at operating temperature, was measured using a current probe. This beam current of 1.5 A was measured at the normal operating cathode temperature, although it could be varied by adjusting the heating power applied to the cathode. The output microwave radiation was detected by two crystal detectors situated inside screened boxes. The output power was calibrated using a known microwave source. The experimental results including the output powers and operating frequency bands were measured.

## 4 Conclusion

Latest upgrades of the W-band gyro-TWA including its main components such as input coupler, output window, corrugated output mode converter, water-cooled beam dump and the pulsed power system have been carried out. Significant performance enhancements were confirmed by measurements and are in excellent agreement with the results from numerical simulations.


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