Radio Astronomy-Compliant Highly Efficient Power Amplifiers for Small Satellite Transmitters

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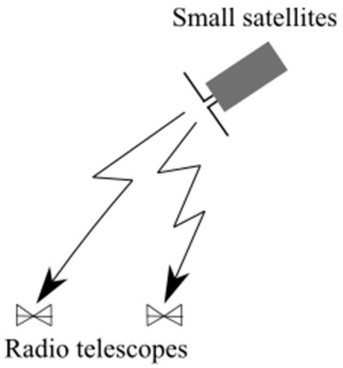
Overview

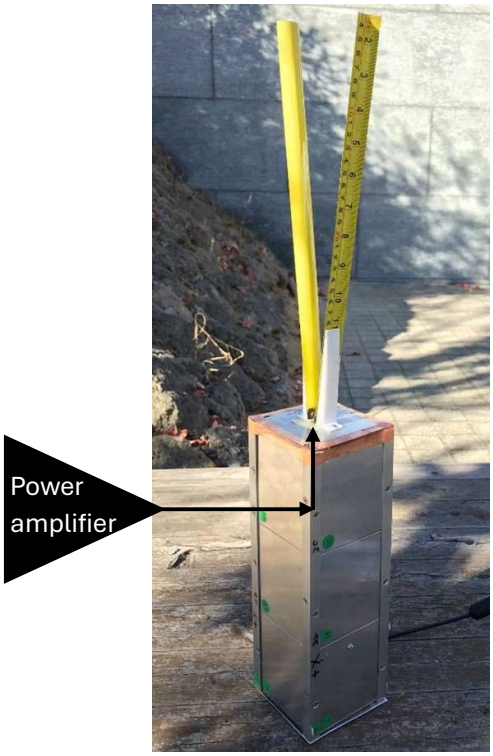
Controlling and suppressing the spurious emissions of small satellite transmitters in radio astronomy bands is essential to prevent debilitating levels of radio interference in the very near future (as close as the 2030s). Efforts by the International Telecommunication Union (ITU) have been made to protect radio astronomy from such spurious emissions through Recommendation ITU-R RA.1513 (2015). However, a concerning precedence has already been set by many current examples of small satellites that have been observed to exhibit unintended and out-of-band emissions that far exceed the limits set out by these regulations. Secondly, the radio astronomy community, in particular low frequency radio astronomers, are also concerned current regulations (if met) are inadequate to achieve their intended goal.



Controlling and suppressing spurious emissions to a sufficient degree to protect current and future low frequency radio astronomy telescope ventures is challenging. Firstly, determining the maximum acceptable level of spurious emissions requires detailed knowledge of the radio telescopes science use cases and its system specifications. Secondly, then achieving these stringent spurious emissions limits necessitates sufficient attenuation of noise and harmonics. For small satellites, high efficiency switch-mode power amplifiers are essential to enable most small satellite missions due to their low power budget. However, switch-mode amplifiers achieve high efficiency at the cost of introducing significant noise and harmonics at the output. As a direct consequence, implementing conventional filtering techniques to address spurious emissions requirements would result in a prohibitive reduction in transmitter efficiency for small satellite applications. Therefore, a new power amplifier design method to suppress spurious emissions in the radio astronomy band whilst retaining high efficiency operation is highly desirable. High efficiency power amplifier design with integrated targeted filtering of key frequency bands to meet the specific spurious emissions limits has the potential to directly address this need whilst at the same time maximizing efficiency.

Aims

To this end, there are two key project aims. The first being to define new spurious emissions limits that protect the science use cases of current and future low frequency radio telescopes, with a focus on the Murchison Widefield Array (MWA) and the Square Kilometre Array Low-Frequency (SKA-Low). Subsequently, the second aim of this project is to develop a new method to design highly efficient power amplifiers for small satellite transmitters that suppresses spurious emissions in radio astronomy bands and meets the new spurious emissions limits.



Objectives

The objectives of this project are:

1. To determine the telescope noise floor requirements to enable low frequency radio astronomy observations based on MWA and SKA-Low science use cases and system specification;
2. To use this noise floor requirement to define new low frequency radio astronomy spurious emissions limits for low Earth orbiting (LEO) satellites;
3. To explore new methods to design highly efficient power amplifiers for small satellite transmitters that satisfy the new low frequency radio astronomy spurious emissions limits;
4. And to develop a generalized design technique for generating such power amplifiers for small satellite transmitters that can be tailored to specific small satellite applications and transmitting frequencies.

Significance

This project is significant because it has the potential to present a solution that permits and facilitates the inevitable growth of small satellites, whilst at the same time enabling low

frequency radio astronomy using the MWA and SKA-Low. Specifically, this project has the potential to define new emissions limits for LEO small satellites that are compliant with radio astronomy. If enforced by a governing/regulating body such as the ITU, these emissions limits could successfully protect the science cases of current and future low frequency radio telescopes including the MWA and SKA-Low. This project also has the potential to provide the small satellite community with a practical design technique for highly efficient power amplifiers that meets the new emissions limits. The idea is that this design technique can be readily tailored to their specific application and transmitting frequency. Therefore, this project aims to benefit both small satellites and low frequency radio astronomy.