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Evaluation of Commercial GaN HEMTs for Pulsed Power Applications

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Introduction

The present study investigates the behaviour and performance of commercially available GaN HEMTs when used for the amplification of pulsed waveforms. GaN technology is not as well understood and established as its GaAs counterpart and a number of studies have reported potential problems, namely:

- Current reduction due to surface states & buffer traps
- Virtual gate formation
- Gate and drain lag transients
- Non-linearities in the source resistance

These effects could potentially be exacerbated by operating the device in pulsed mode and the experiments conducted aimed to study such phenomena and assess the suitability of commercial GaN HEMTs to pulsed RF applications such as radar.

The frequency at which the study was conducted was 3.5 GHz.

Test Setup

MATLAB was used to control the instruments through GPIB and LAN interfaces and also for data acquisition and processing. The pulsed RF was generated by a purpose-built interface board which safely turned the transistor fully on and fully off to ensure that full transients would be undergone by the device.

Results

In this section we present the changes in pulse power, rise times and fall times at different input powers as the PRF is increased. Transients on output waveforms are also presented and analysed.

The pulse power was found to remain largely constant across the PRF range. This would suggest that there is no current reduction due to trapping effects or self-heat ing at the power levels used.

At input powers higher than 22dBm, corresponding to output powers greater than 36dBm, the fall time was seen to increase significantly in an exponential fashion as can be seen in the graph. In the time domain this was seen to be due to an additional transient on the pulse falling edge at transistor turn-off.

At higher power levels the rise time does not change significantly. The fall time however suffers a considerable increase due to the presence of an exponential decay on the falling edge. This demonstrates that the device output capacitance plays a much more significant role when operating near the 1dB compression point of the amplifier.

Conclusions

In this study the suitability of commercially available GaN samples to pulsed operation has been demonstrated. The devices presented a consistent and reproducible performance at specific power levels across a broad range of Pulse Repetition Frequencies (PRFs). These devices could find application in S-band radars which utilise much lower PRFs than those analysed in this study.

The reason for pushing the devices to higher PRFs was to analyse the response that their structure would have to repetition frequencies which are used at higher RF frequencies. Seeing that higher frequency devices will maintain some commonalities with their lower frequency counterparts, this gives some degree of confidence that future devices could be utilised for pulsed RF applications which operate in higher frequency bands. Further investigations are needed to gain a better understanding of the effects that operating the devices near their compression point will have on the pulse shape.

Future Work

Future work will focus on repeating the experiments presented in this paper at much higher input levels and with devices with higher power ratings. Bare die HEMTs will also be subjected to similar tests at frequencies ranging from 6 to 10 GHz.

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