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Multi-physics measurements under realistic load pull conditions

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Summary

We discuss the addition of multi-physics measurements to load pull measurement setups. In particular the use of thermoreflectance to obtain spatial and temporal temperature distributions of (RF) power devices, as well as the use of non obtrusive RF electric field scanning to obtain information about the voltages and currents inside a power device.

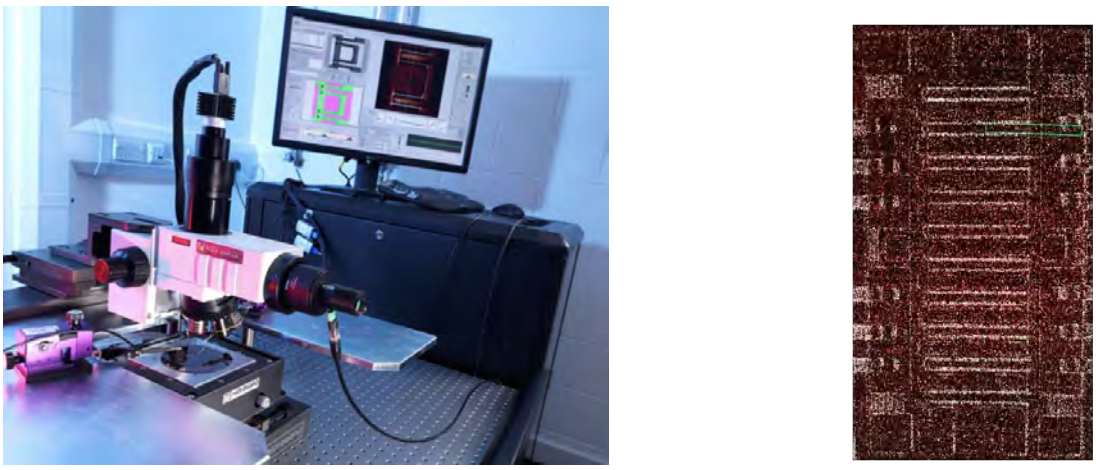
1 Introduction

Device characterization is key in the current telecommunications market, with mobile communication systems requiring increased data capacity, along with current progression towards higher frequencies, testing in real world conditions is paramount for devices to operate effectively when deployed [1]. Load pull measurements are an essential tool in power amplifier development, as it allows devices to be tested under realistic load conditions (non-50 Ω), as most RF devices are not perfectly matched, but optimized for linearity or efficiency [2].

Load pull is limited in that the device is often a 'black box' where the external properties of the device-under-test (DUT) are known, however the inside of the device is unknown [3]. Multi-physics measurements in tandem with load pull can be used to characterize a device further, obtaining knowledge of internal characteristics through multi-physics measurements. Thermoreflectance and electro-optic field probing can offer temperature and electromagnetic field maps across the DUT, which can be used in the design phase of RF systems to improve reliability, efficiency, and linearity [4].

2 Multi-physics measurements

Thermoreflectance is one multi-physics method that can allow improved device characterization. Thermoreflectance is a non-contact optical characterization technique that measures the surface reflectivity of the device, which varies with temperature. This in turn creates thermal maps of the DUT [5]. This mapping allows information on the DUTs spatial and temporal temperature distributions, which when used in the design phase can reduce hot spots or temperature gradients in specific locations of the device, improving performance and reliability [4].



(a) **(b)**

Figure 1. a) Photograph of the Microsanj NT220B thermoreflectance system at n3m-labs, University of Surrey [6]. b) Thermal measurement of Cree GaN HEMT, highest temperature is indicated by white.

Electric field scanning through electro-optic field probing is another such method for improved device characterization. Modern electro-optic probes are virtually transparent to electromagnetic waves at relevant frequencies, allowing them to unobtrusively measure RF electromagnetic fields [7, 8]. Measurement of electric fields at fixed locations over the DUT during load pull can give internal and external field maps of the DUT in use. These maps can be used to obtain information regarding the voltage and currents inside the DUT [9], whilst also helping with system design to reduce electromagnetic interference to other devices [10].

3 Experimental results

We show a partial demonstration of thermal imaging during load-pull in an emulation context [11]. Emulation load pull techniques allow for realistic non-50 Ω testing, reproducing the actual environment under which RF devices and components will be used. These techniques can predict device performance without need to realize a complete circuit or system. Thermal imaging on a GaN HEMT has been demonstrated, with the results showing temperature of the device under a highly reflective load termination (Fig. 1b). These measured performance characteristics are vital information to an RF device and circuit designer.

4 Conclusion

The need for improved RF device characterization through the addition of multi-physics measurements to load pull measurement setups have been discussed. The potential improvement of device performance through thermal maps produced using thermoreflectance has been illustrated. A preliminary experiment of load-pull in tandem with thermoreflectance on a GaN device has been presented.

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