BEHAVIOURAL MODELLING OF MICROWAVE TRANSISTORS FOR WIDEBAND HIGH EFFICIENCY POWER AMPLIFIER DESIGN

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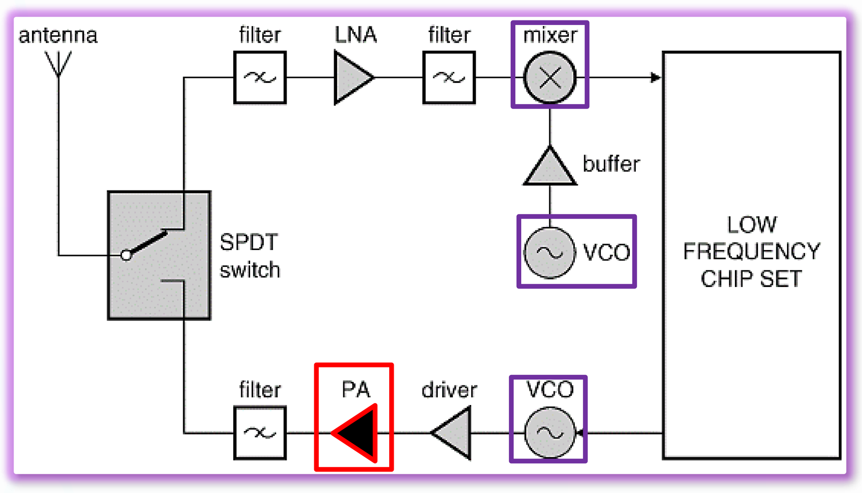
Motivation of the Work

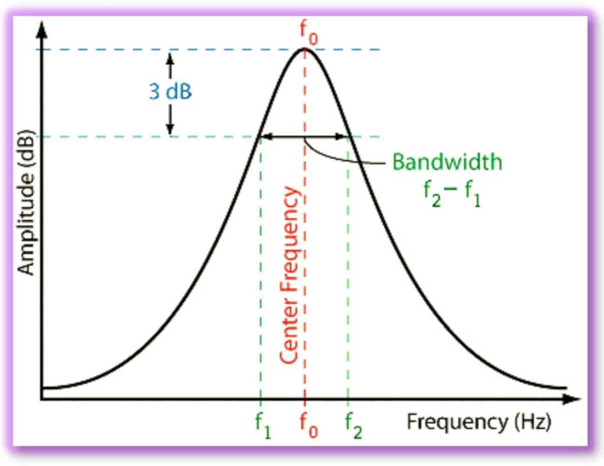
Power amplifier (PA) design for modern wireless communications systems is a complex process, since the **transceiver PA** module must accomplish strict specs in:



- Output Power
- Bandwidth
- Efficiency
- Linearity
- …

But accurate & efficient broadband PA design in this context, specially at C-band and beyond and under high PAPR signals, relies on the **quality of the nonlinear (NL) model**. Behavioral meas.-based NL models are a promising tool (like X-params [1],[2]), but they have limited bandwidth.

Thesis Objectives



1.- Bandwidth improvement of NL behavioural models for broadband PA design.

2.- Development of large-signal characterization tools for NL **model extraction and prototype validation.**

3.- Application in the design of high efficiency **broadband GaN PAs** for complex signals in C-band. Different PA architectures, dual-band, reconfigurable/concurrent, may also be considered.

Related Task:

- Setting-up a 25 W 20 GHz large-signal meas. system (**PNA-X** based) HW/SW with multi-harmonic load-pull.


UAV

Results & Discussions

1.- Extraction, implementation in the simulator and validation of the **Admittance behav. model** [3] for **HBTs**. URSI 2016 [4].

2.- New broadband Admittance **model** formulation. Validated with **GaN HEMTs & NVNA meas.** EuMIC 2016 [5].

3.- Challenge: transformation from LS A-B based NVNA meas. to LS I-V (admittance) based NVNA "meas" for model extraction.

→ Stay in Cardiff School of Engineering. Cardiff University, UK. 2 months.

Implementation of **new behav. model formulations** appropriate for **non-uniform data** grids.

Applied to intrinsic Cardiff & Admittance models: Advanced Cardiff and Admittance models.

1. Study and Matlab implementation of the Traditional Cardiff behav. model.

$$B_{p,h} = \sum_{i=0}^{W} M_{p,h.i}(|A_{1,1}|)|A_{2,1}|^{a_i} \angle A_{2,1}^{b_i} |A_{2,2}|^{c_i} \angle A_{2,2}^{d_i}$$

2. New formulations Cardiff behav. and Admittance models. Extraction at intrinsic plane.

AB domain: $B_{p,h} = \sum_{t=0}^{V} \sum_{i=0}^{W} K_{p,h.i,t} |A_{2,1}|^{a_i} \angle A_{2,1}^{b_i} |A_{2,2}|^{c_i} \angle A_{2,2}^{d_i} |A_{1,1}|^{e_{i,t}}$, $M_{p,h.i}(|A_{1,1}|) = \sum_{t=0}^{V} K_{p,h.i,t} |A_{1,1}|^{e_{i,t}}$

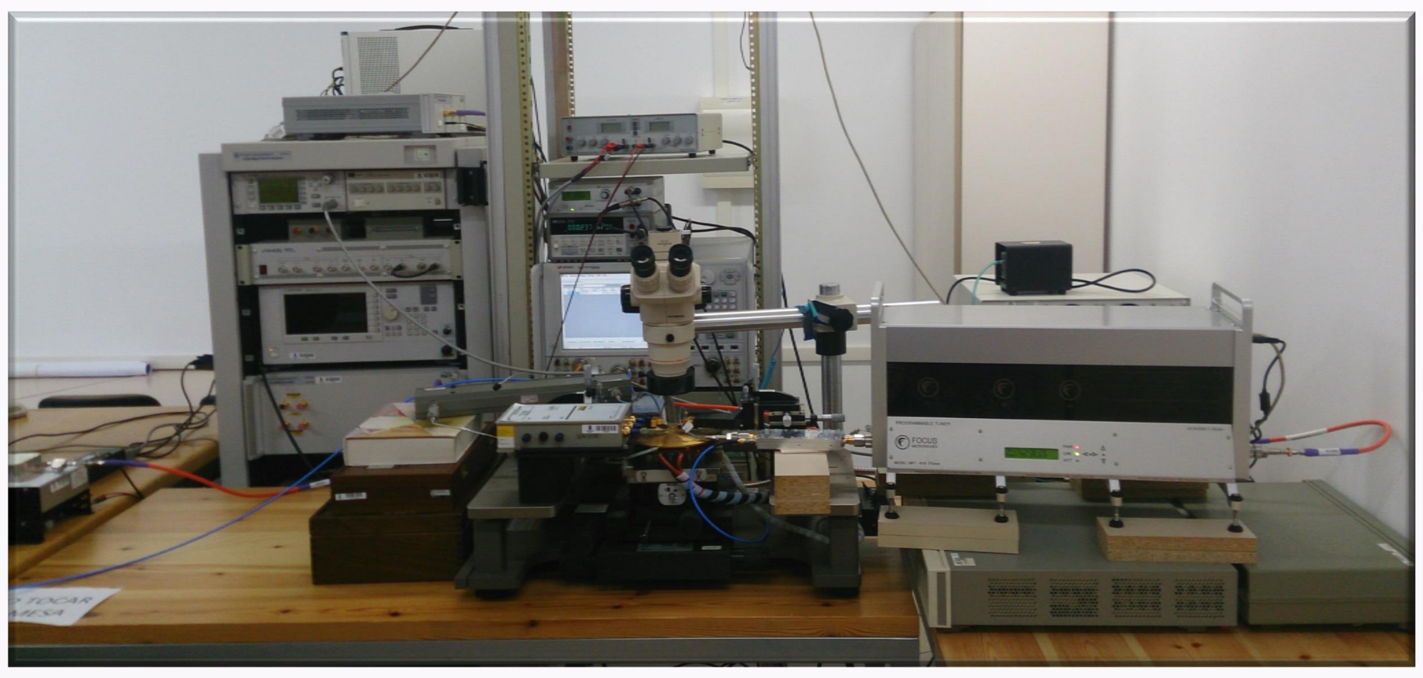
IV domain: $I_{p,h} = \sum_{t=0}^{V} \sum_{i=0}^{W} L_{p,h.i,t} |V_{2,1}|^{a_i} \angle V_{2,1}^{b_i} |V_{2,2}|^{c_i} \angle V_{2,2}^{d_i} |V_{1,1}|^{e_{i,t}}$, $N_{p,h.i}(|V_{1,1}|) = \sum_{t=0}^{V} L_{p,h.i,t} |V_{1,1}|^{e_{i,t}}$

3. Validation with **GaN HEMT & NVNA meas**, for different device sizes and fund. freqs. IEEE IMS 2017 [7].

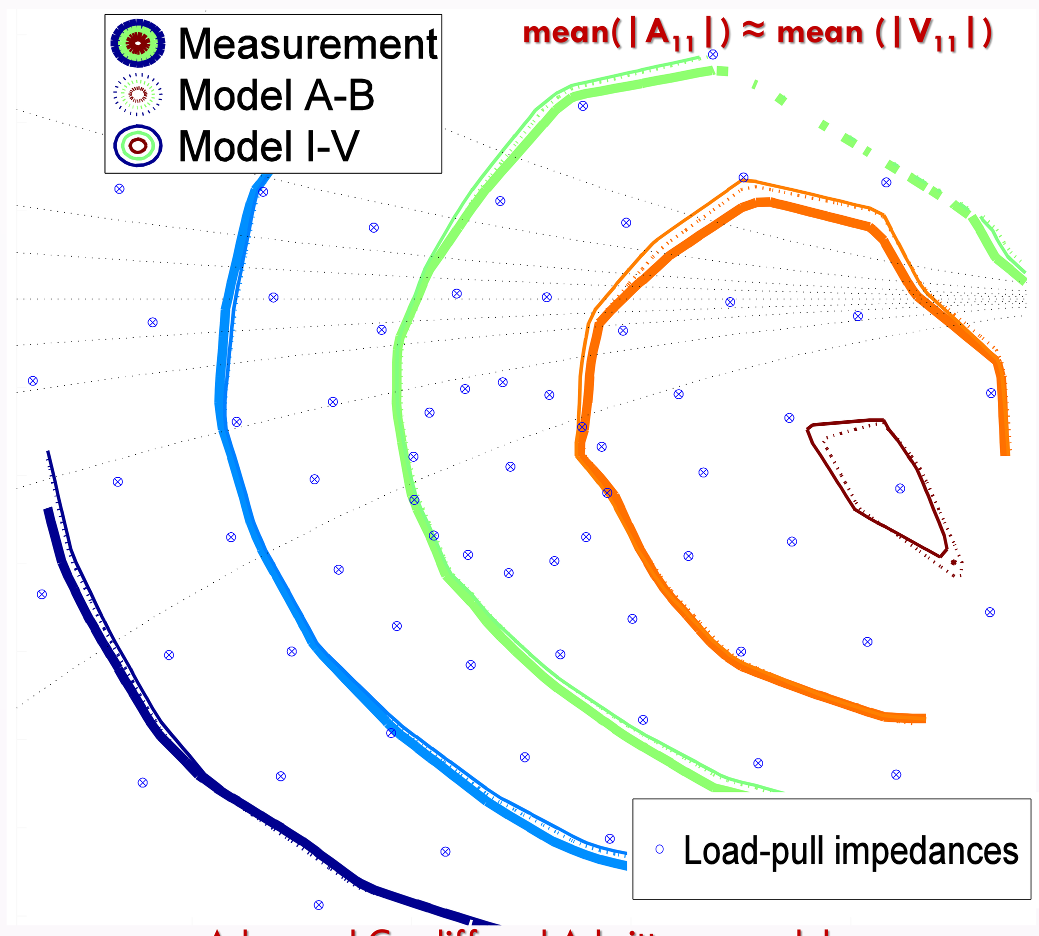
5.- Set-up and training of a new PNA-X load-pull configuration based on a **multi-harmonic tuner**, 20 GHz bandwidth (unique in Spain).

6.- GaN FET characterization with the new setup.


MPT FOCUS TUNER

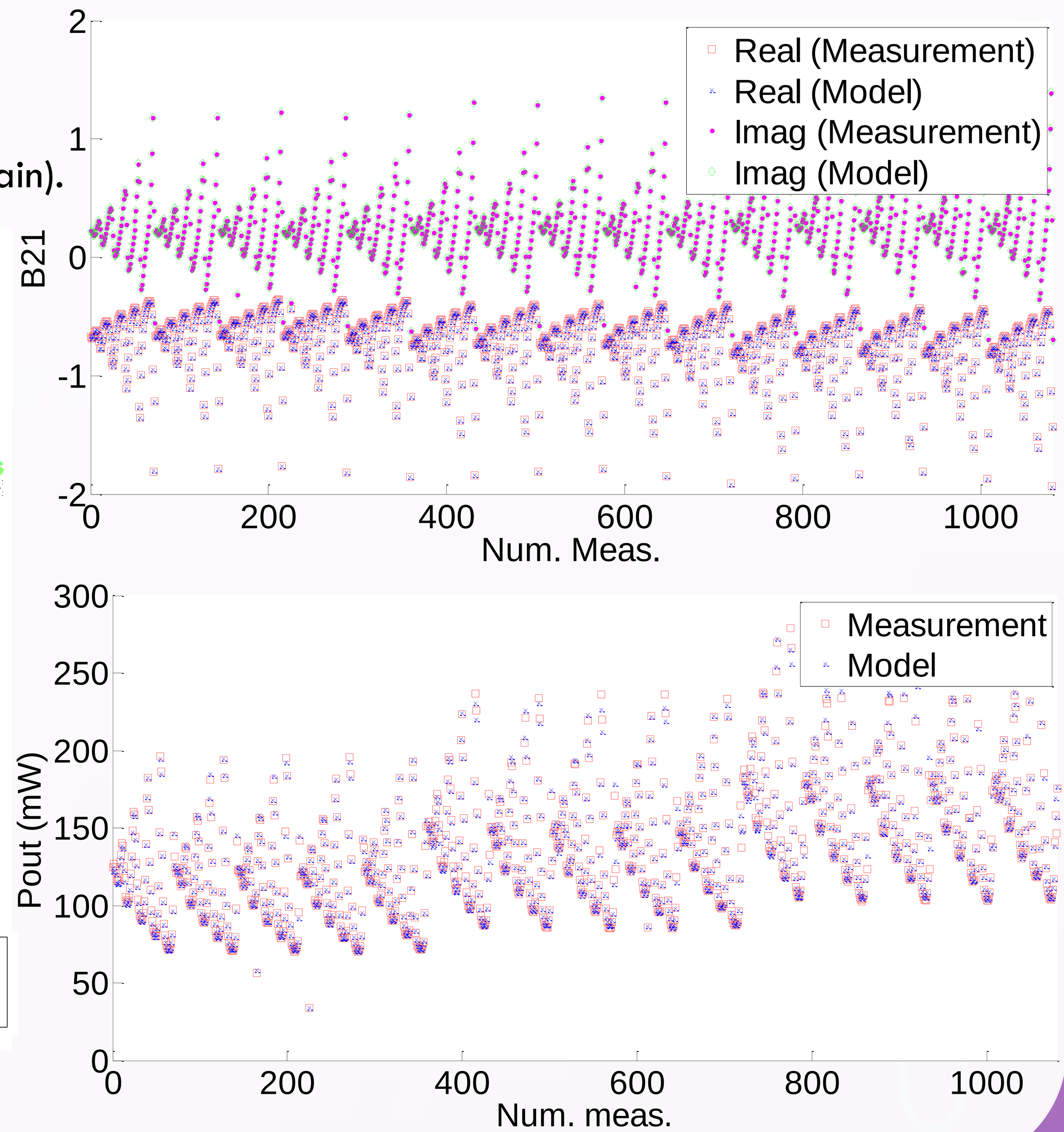


New meas. system PNA-X based set-up for 25W at Uvigo.
Bandwidth: 2-18GHz.
FOCUS MPT(Multi-Harmonic Tuner) for Load-Pull RF meas. at (f_0), $2f_0$ and $3f_0$.

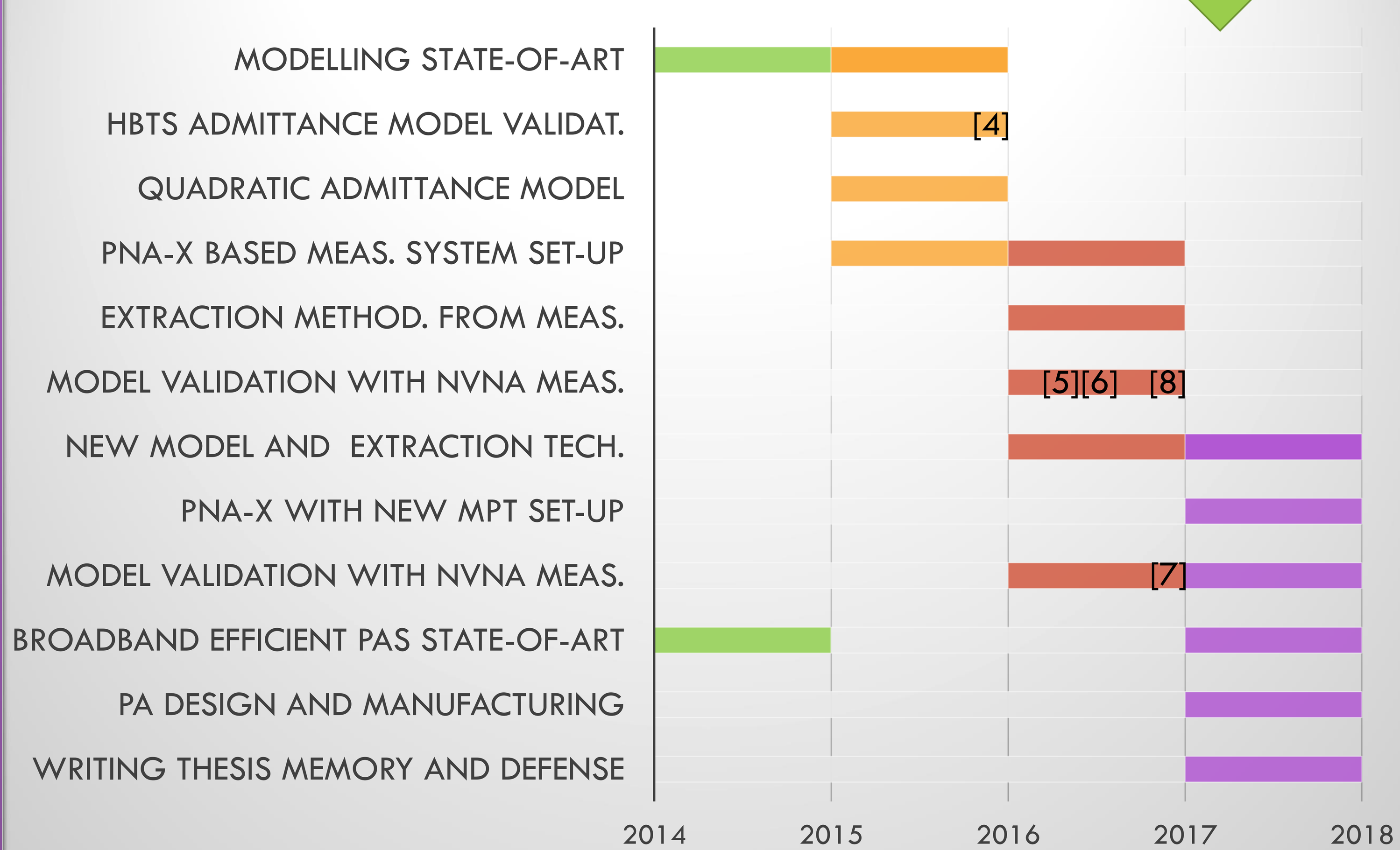


Advanced Cardiff and Admittance models.
Output power contours around Zopt with non-constant A_{11}.
GaN HEMT Wg=100um. f_0=8GHz. Output intrinsic plane

Validation of Advanced Cardiff model with non-constant A11.
GaN HEMT Wg=100um. f_0=4GHz. Output intrinsic plane.



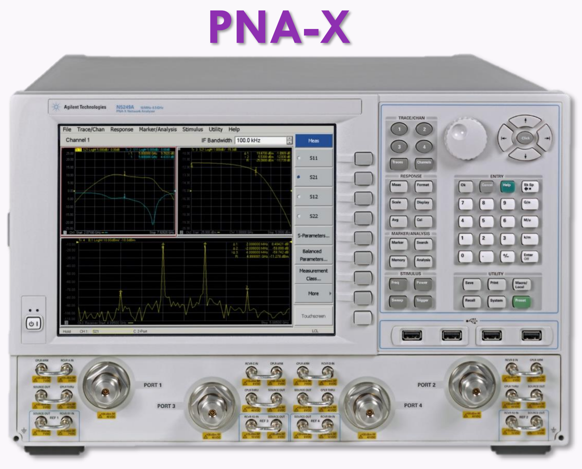
Research Plan



[X] => paper ref. as result of work done up to that point

Next Year Planning

PNA-X



1.- Models extraction & validation with new LS meas. system, new GaN samples.

2.- Design broadband GaN **PA prototypes using the admittance model.**

3.- PA prototypes manufacture (HMIC or MMIC) and validation.

4.- Writing the thesis memory and defense

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[2] **M. R. Moure**, "Diseño de software para la caracterización de dispositivos y circuitos no lineales de microondas mediante parámetros X," PFC, 2014.
[3] Koh et al., "Frequency scalable large signal transistor behavioral model based on admittance domain formulation", IMS, 2014
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[6] M. Fernández-Barciela, **M. R. Moure**, M. Casbon, A. Peláez Pérez, P.J. Tasker, "Exploiting behavioral modelling formulations for nonlinear analytical circuit design and improved frequency scalability. Bandwidth extension through the admittance domain", IEEE WAMICON, Abr. 2017.
[7] **M. R. Moure**, M. Casbon, M. Fernández-Barciela, P.J. Tasker, "Direct Extraction of an Admittance Domain Behavioral Model from Large-Signal Load-pull Measurements", IEEE MTT-S IMS, Jun. 2017.
[8] **M. R. Moure**, M. Casbon, M. Fernández-Barciela, P.J. Tasker, "Extensión del ancho de banda de modelos comportamentales en el dominio de admitancias", URSI, Sept. 2017. (Under review)

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