ScuDo

Scuola di Dottorato ~ Doctoral School

WHAT YOU ARE,TAKES YOU FAR

XXXIV Cycle

High Efficiency Power Amplifier for High Frequency Applications

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Research context and motivation

- Significant increase in the number of intelligent devices like mobile phones;
  - → Rapidly growing demands for communication data rates
    - → Need Wider signal channel
      - → Need Highly efficient and broadband operation of transmitters
- ✓ So, Broadband **Power amplifier** with high efficiency and high peak to average power ratio (PAPR) signal are deeply needed.
- The most challenging component in the transmitter that is affected by the PAPR is RF Power Amplifier
  - → Deliver the maximum output power for a given section of active device
- Final amplification stage before delivering power to the antenna
- Drive a load with high power
- ✓ From an energy standpoint: DC-RF converter controlled by the RF signal

○ Application of Power Amplifier:

Telecommunication, radar, electronic warfare, medical microwave imaging

Addressed research questions/problems

Main Factors in Power Amplifiers:

- ✓ Linearity
- ✓ Gain
- ✓ Efficiency
- ✓ Maximum power capability
- ✓ Impedance matching to the output device

Linearization Techniques:

- ❖ Polar Modulation
- ❖ Predistortion
- ❖ Feedforward
- ❖ Cartesian Feedback
- ❖ Outphasing

High Efficiency PAs:

- ❖ Class E PAs
- ❖ Class F PAs
- ❖ Class A PA with Harmonic Enhancement

High PAPR PAs:

- ❖ **Doherty Amplifier**
- ❖ Outphasing Amplifier (Chireix)
- ❖ Envelope Elimination and Restoration

Doherty Power Amplifier:

- ✓ Implement active load modulation technique
- ✓ Adopt a pair of active devices: carrier and peaking modulus
- ✓ Power combining network: by using impedance inverter network (IIN) to sum in phase the output signal of two devices
- ✓ OBO Efficient boosted by auxiliary operation

Pros:

- ✓ High efficiency at 6 dB OBO and High PAPR
- ✓ Capability to increase OBO to more than 6 dB

Cons:

- ✓ Difficult to maintain phase shifts of splitters for a wide bandwidth
- ✓ Design is complex to obtain optimum performance
- ✓ Bad Linearity Performance

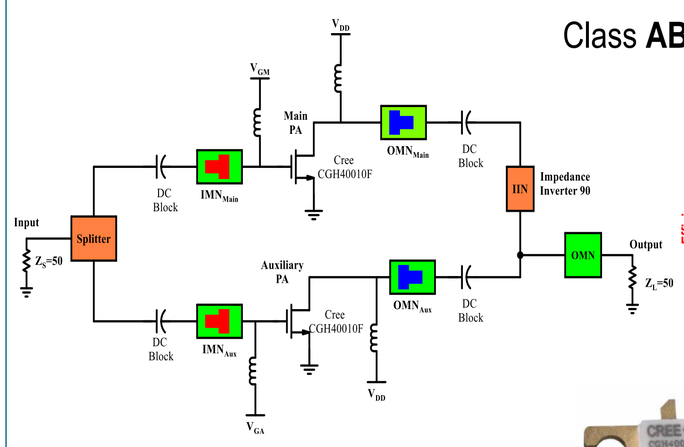
Submitted and published works

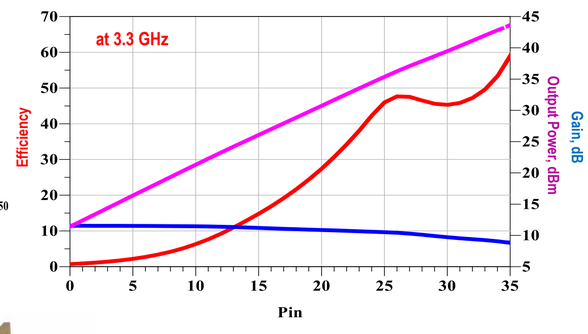
Novel contributions

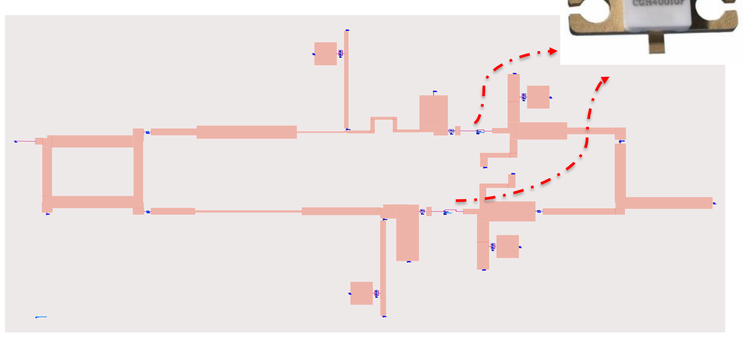
- ✓ High Efficiency and Wideband Hybrid **Doherty** Power Amplifier (3.1 -3.6 GHz)
- ✓ Based on 10W GaN HEMT active Device from Cree (CGH40010F)
- ✓ Covering most of mobile frequencies (LTE applications)
- ✓ Simple structure for OMN and IMN, appropriate reflection coefficient, High Broadband
- ✓ Simple Post Matching Network
- ✓ Using uneven hybrid 90° splitter
- ✓ Tested with a 16 QAM signal

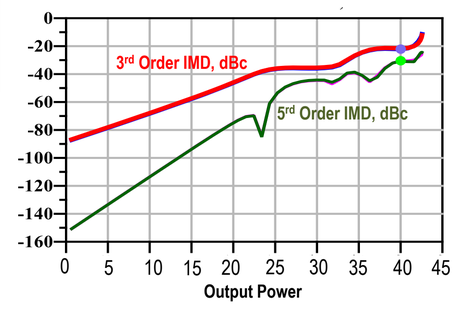
Adopted methodologies

Class **AB-C** Doherty Power Amplifier V_{DD}= 28V

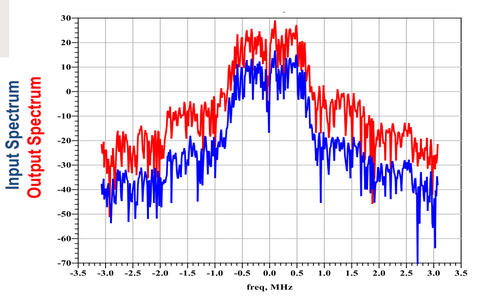








- ✓ Substrate: ABB20 Double-Sided Photoresist Board FR4,
- ✓ Thickness: 0.8 mm



Freq (GHz)	P_{sat}(dBm)	DE @ Sat(%)	DE @ 6 dB OBO(%)	Gain (dB)	ACPR	OBO
3.1 - 3.6	40 - 44.23	50- 68.22	40 -57.01	7 - 10	- 37	6

Future work

- ➢ Class AB-C Doherty Fabrication and Characterization at circuit and system level
- ➢ Linearization through digital Predistortion
- ➢ New Class F Doherty PA design
- ➢ Investigating input-output harmonic engineering
- ➢ Outphasing architecture
- ➢ Dual input Doherty PA

List of attended classes

- 01POHOQ – Radio Frequency Integrated Circuits (04/02/2019, 6)
- 01NNLOQ – High Speed Electron Devices (02/01/2019, 6)
- 01MMRRV – Advanced numerical techniques for the analysis and design of antennas (14/03/2019, 4)
- 01QRXIU – Multimedia communications: technological advances and social implications (27/06/2019, 4)
- 03QRHRV – Microelectronics for radiation detection II (03/06/2019, 4)
- 01QRRRV – Advanced iterative techniques for digital receivers (25/06/2019, 4)
- 01LEVRV – Power System Economics (10/05/2019, 3)
- 01PJMRV – IT Ethics (01/04/2019, 4)
- 02LWHRV – Communication (15/04/2019, 1)
- 01RISRV – Public speaking (17/04/2019, 1)
- 01SYBRV – Research integrity (23/04/2019, 1)
- 02RHORV – The new internet society: entering the black-box of digital innovations (23/04/2019, 1)

POLITECNICO DI TORINO

PhD program in

Electrical, Electronics and Communications Engineering