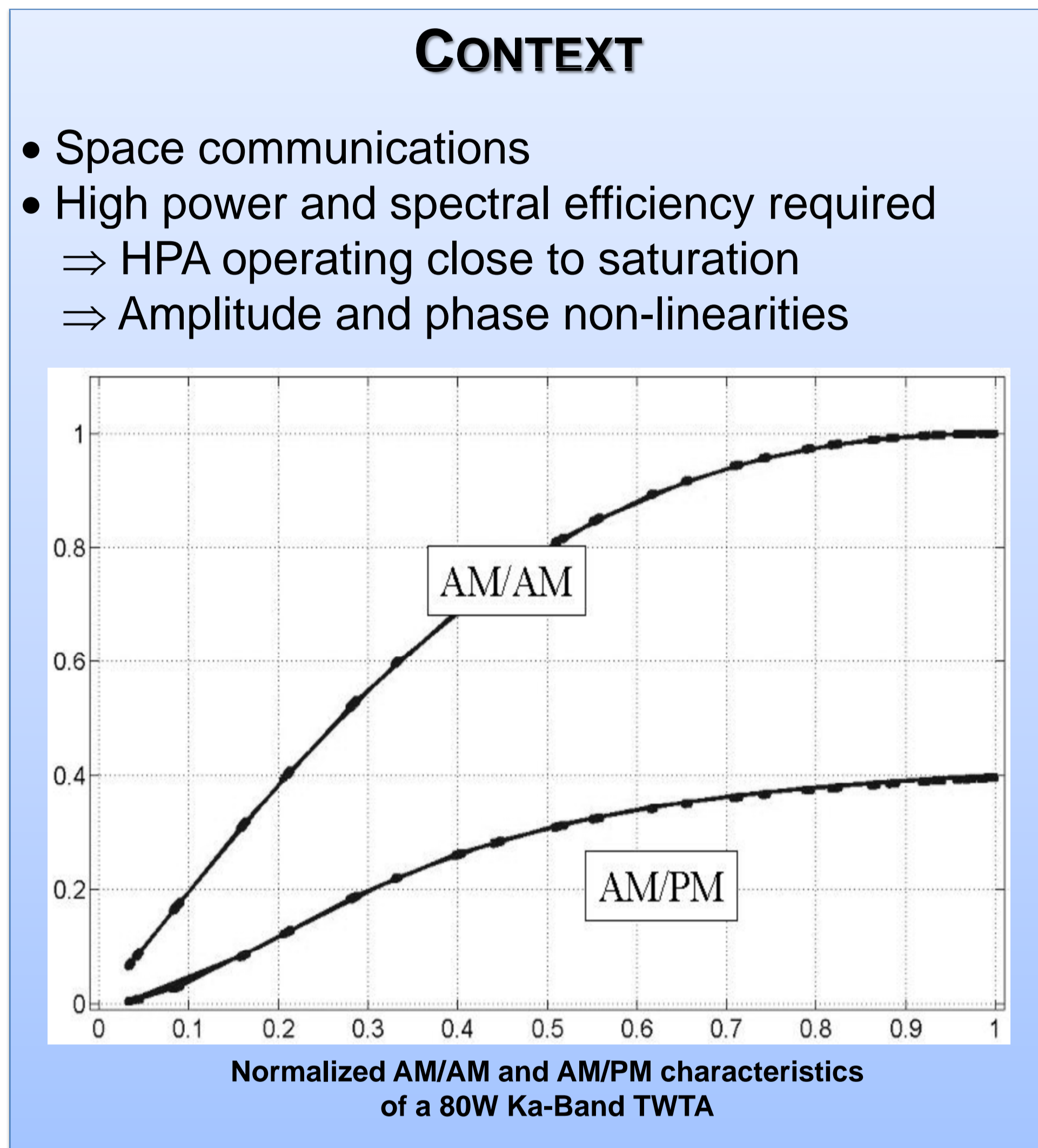


# Predistortion System Implementation Based On Analog Neural Networks For Linearizing High Power Amplifiers Transfer Characteristics



Blaise MULLIEZ<sup>1,2,3,4</sup>, Emmanuel MOUTAYE<sup>1,2,3</sup>, Hélène TAP<sup>1,2</sup>, Laurent GATET<sup>3</sup>, Francis GIZARD<sup>3</sup>

<sup>1</sup> CNRS-LAAS, 2, rue Camichel, F-31071 Toulouse Cedex 7, France  
<sup>2</sup> Univ. de Toulouse, INP, F-31400 Toulouse, France  
<sup>3</sup> CNES, 18, avenue Edouard Belin, F-31401 Toulouse Cedex 9, France  
<sup>4</sup> DGA/DS-MRIS, 7, rue des Mathurins, F-92221 Bagneux, France



### MODELING AND LINEARIZATION OF HPA

- Saleh model to approximate HPA transfer characteristics

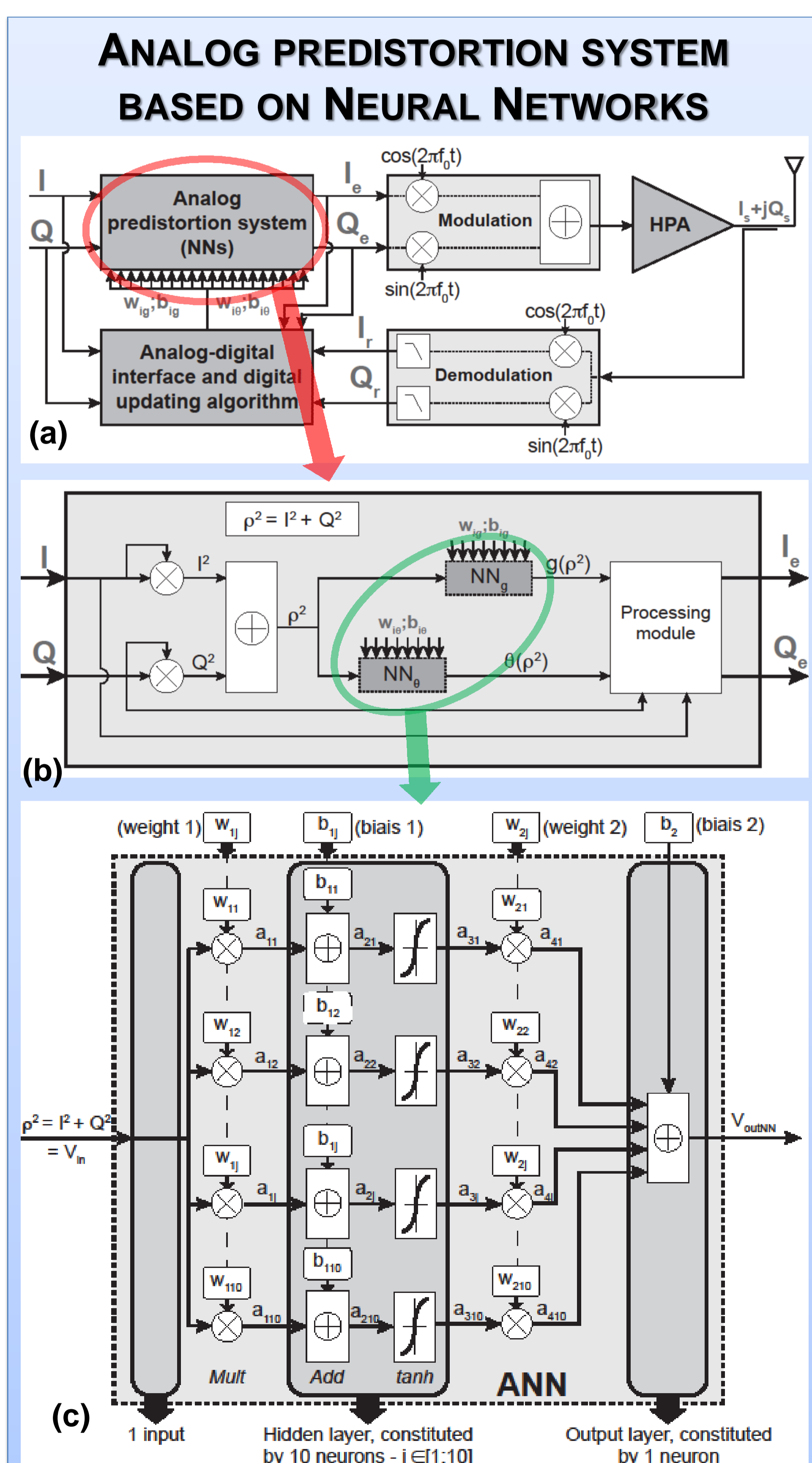
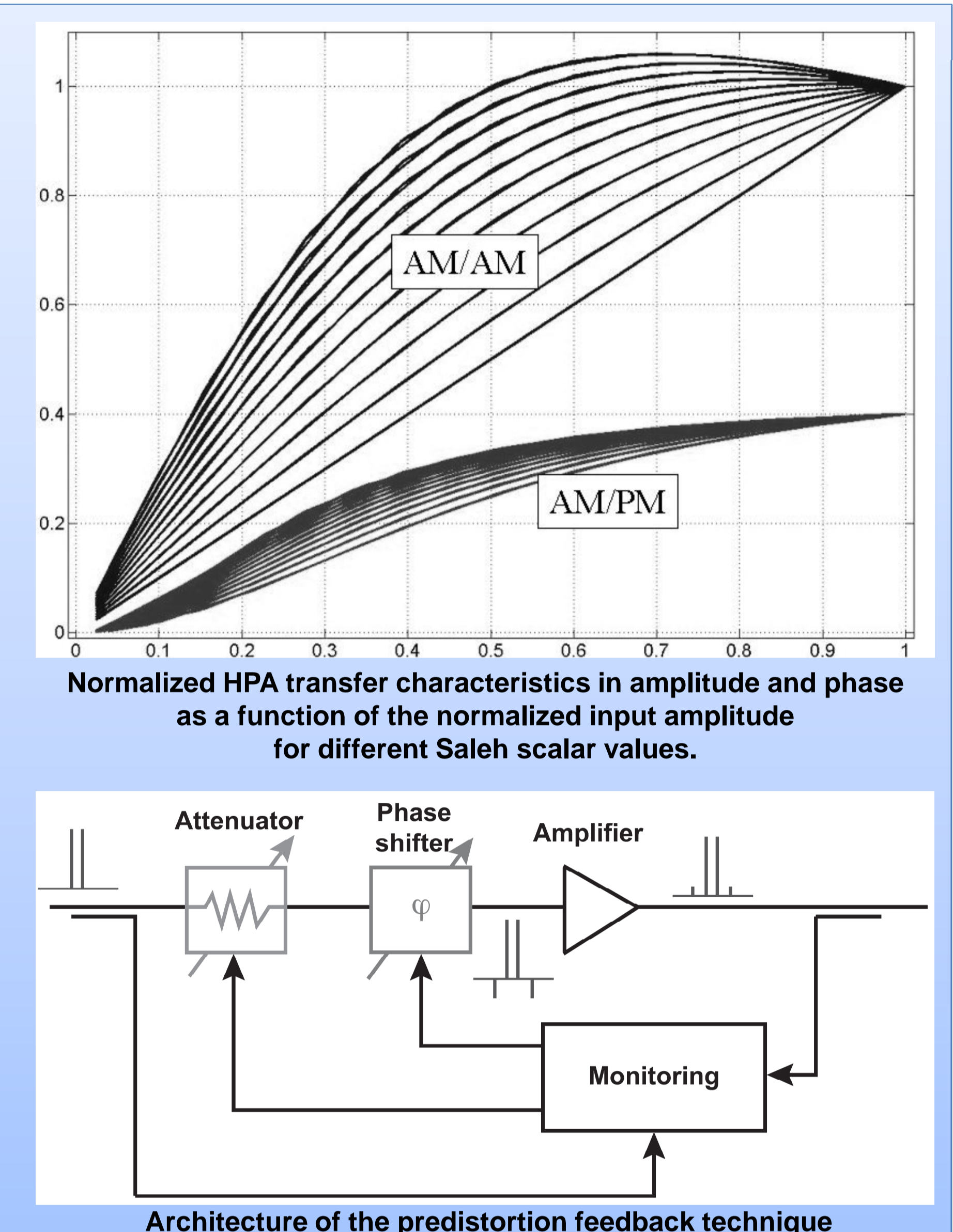
$$A_{HPA}(\rho) = \frac{\alpha_1}{1 + \beta_1 \cdot \rho^2}$$

$$\phi_{HPA}(\rho) = \frac{\alpha_2 \cdot \rho^2}{1 + \beta_2 \cdot \rho^2}$$

$\alpha_1, \alpha_2, \beta_1, \beta_2$ : Saleh parameters

- Simple to use
- Fits well the HPA characteristics at first order
- Adaptive through scalar parameters' modification

- Linearization by feedback predistortion technique

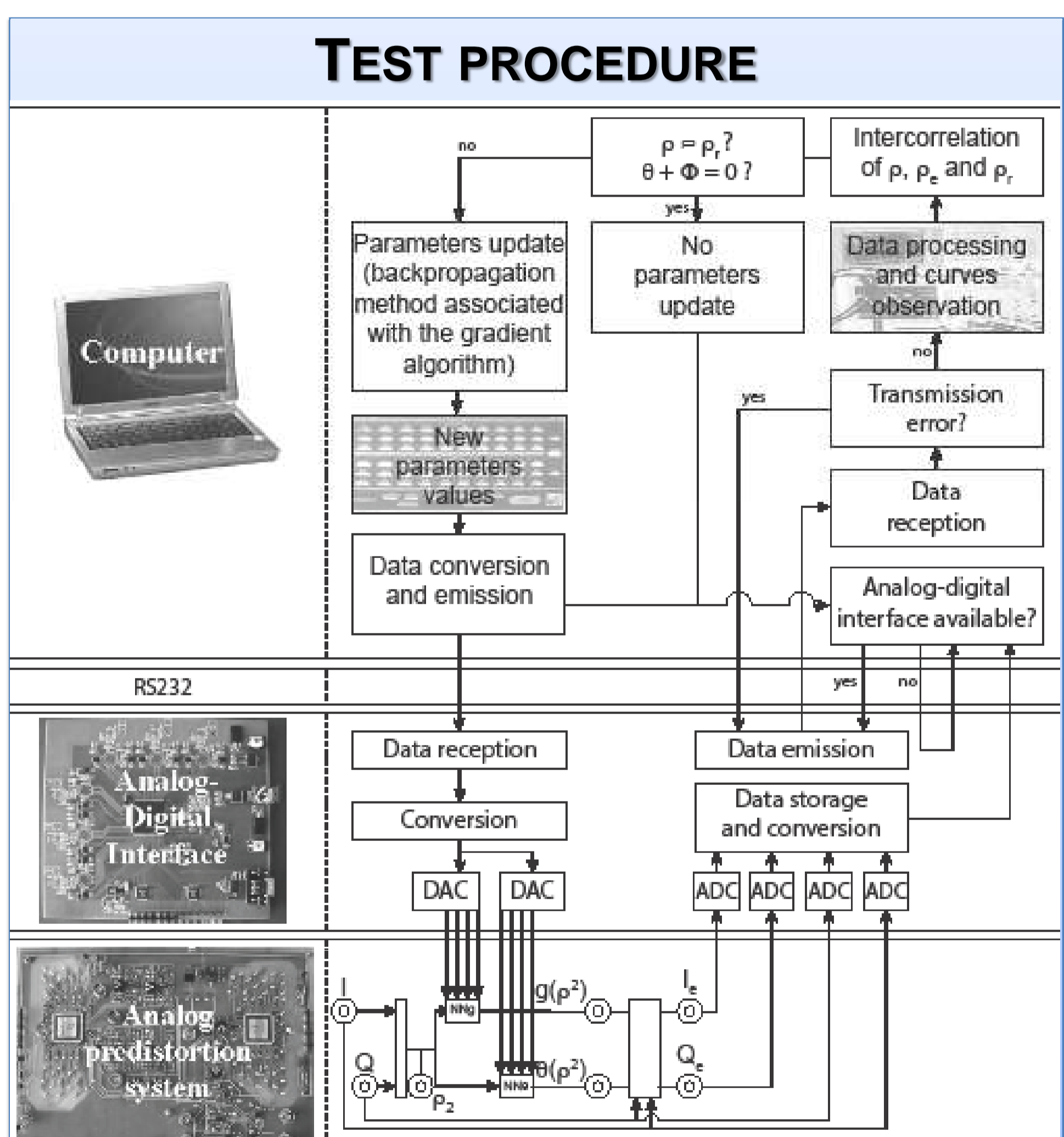


### REALIZATION

- Predistortion circuit:
  - CMOS 0.6μm ASIC
- Analog-digital interface:
  - FPGA
  - 62 DACs
  - 6 ADCs
- Processing and control unit:
  - NI LabWindows™/ CVI software

Neural Network circuit for the analog predistortion system

Analog-digital interface | System testbench

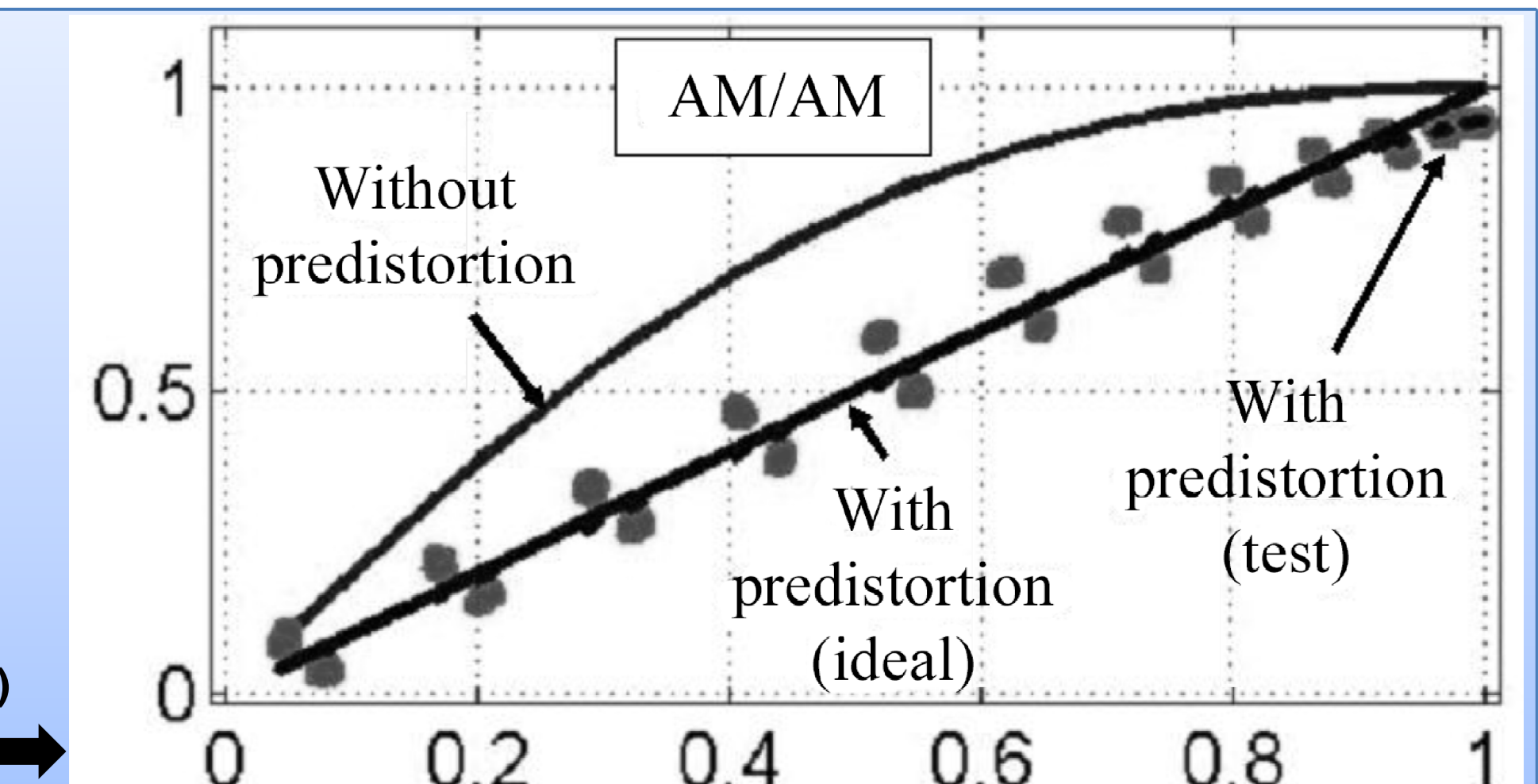


### RESULTS

- System able to correct both AM/AM and AM/PM non-linearities:
  - SER > 30 dB
  - Amplitude mean relative error < 5%
  - Phase mean relative error < 5%

Experimental AM/AM curves as a function of the input amplitude (normalized)

- without predistortion (solid curve)
- with predistortion (solid straight: ideal; dots: experimental points)



$$I_e \cong I \cdot g(\rho^2) \cdot \left(1 - \frac{\theta(\rho^2)}{2}\right) - Q \cdot g(\rho^2) \theta(\rho^2)$$

$$Q_e \cong Q \cdot g(\rho^2) \cdot \left(1 - \frac{\theta(\rho^2)}{2}\right) - I \cdot g(\rho^2) \theta(\rho^2)$$

### CONCLUSION AND PERSPECTIVES

- System able to linearize different HPA transfer characteristics approximated with the Saleh model
- Validation of the concept of analog predistortion based on Neural Networks
- Future improvements:
  - Taking into account memory effects
  - Real-time auto-adaptive system
  - Complete integration in SiP