NMDG
LEADING BEYOND S-PARAMETERS

ZVxPlus Application

PA Design

April 2009

Introduction

- The power amplifier
- Figures of merit
- Concept of load line
- Tuning in Practice: Source and load pull
- Classes of operations
- Conclusion

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The power amplifier

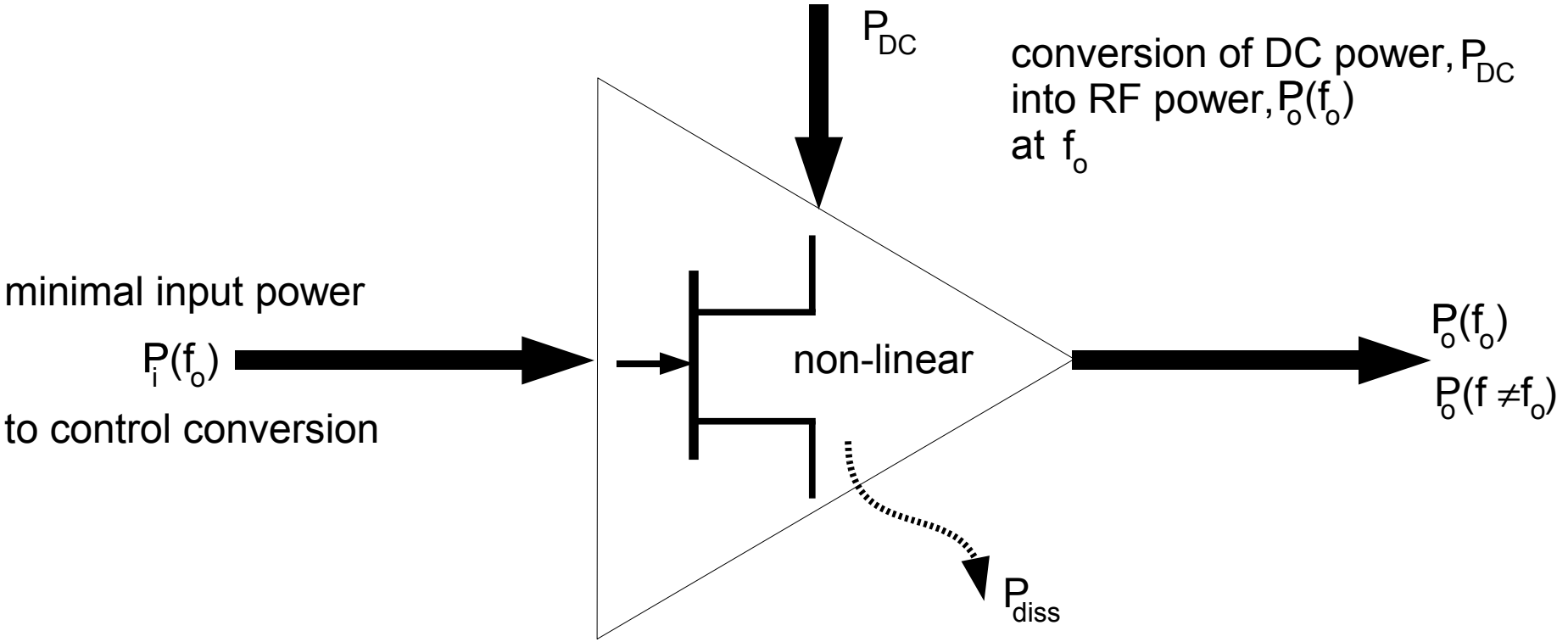

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Figure of merit

- Efficiency: quality factor for DC consumption

$$\eta = \frac{P_o(f_o)}{P_i(f_o)+P_{DC}}$$

- Power Added Efficiency (PAE): ratio between the RF power 'added' by the amplifier and the DC power required for this addition.

$$PAE = \frac{P_o - P_i}{P_{DC}}$$

linearity:
Class A: excellent
Class AB: between A and B
Class B: moderate
Class C: poor

η:
Class A: 50%
Class AB: between A and B
Class B: 78.5%
Class C: >78.5%

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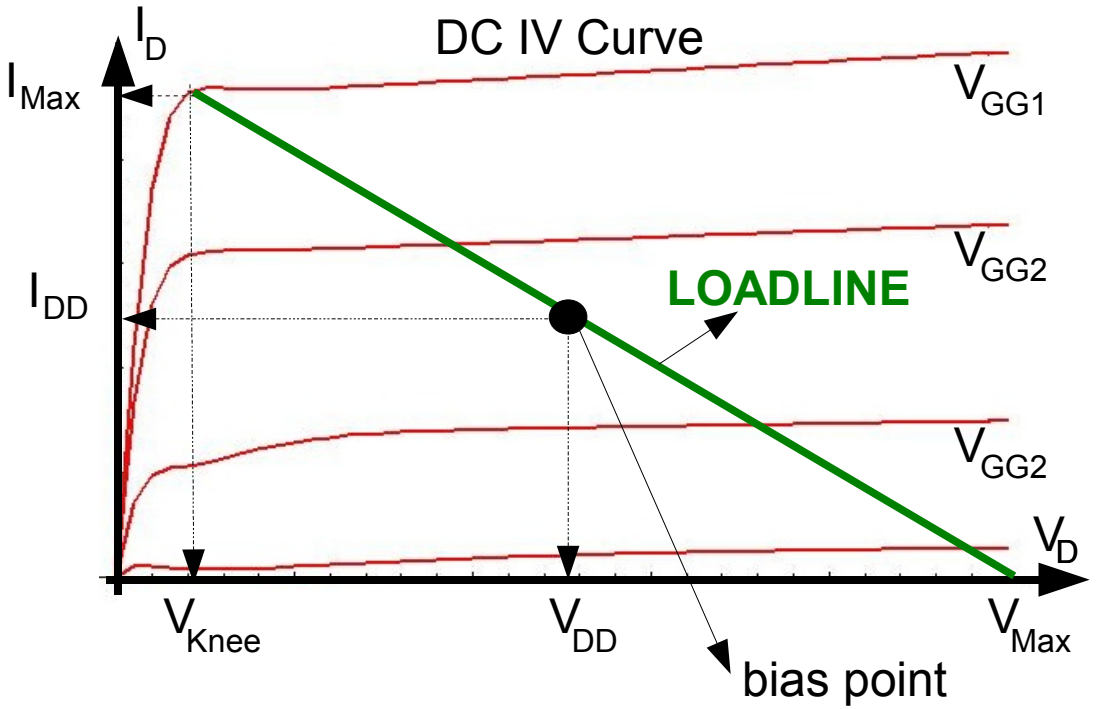
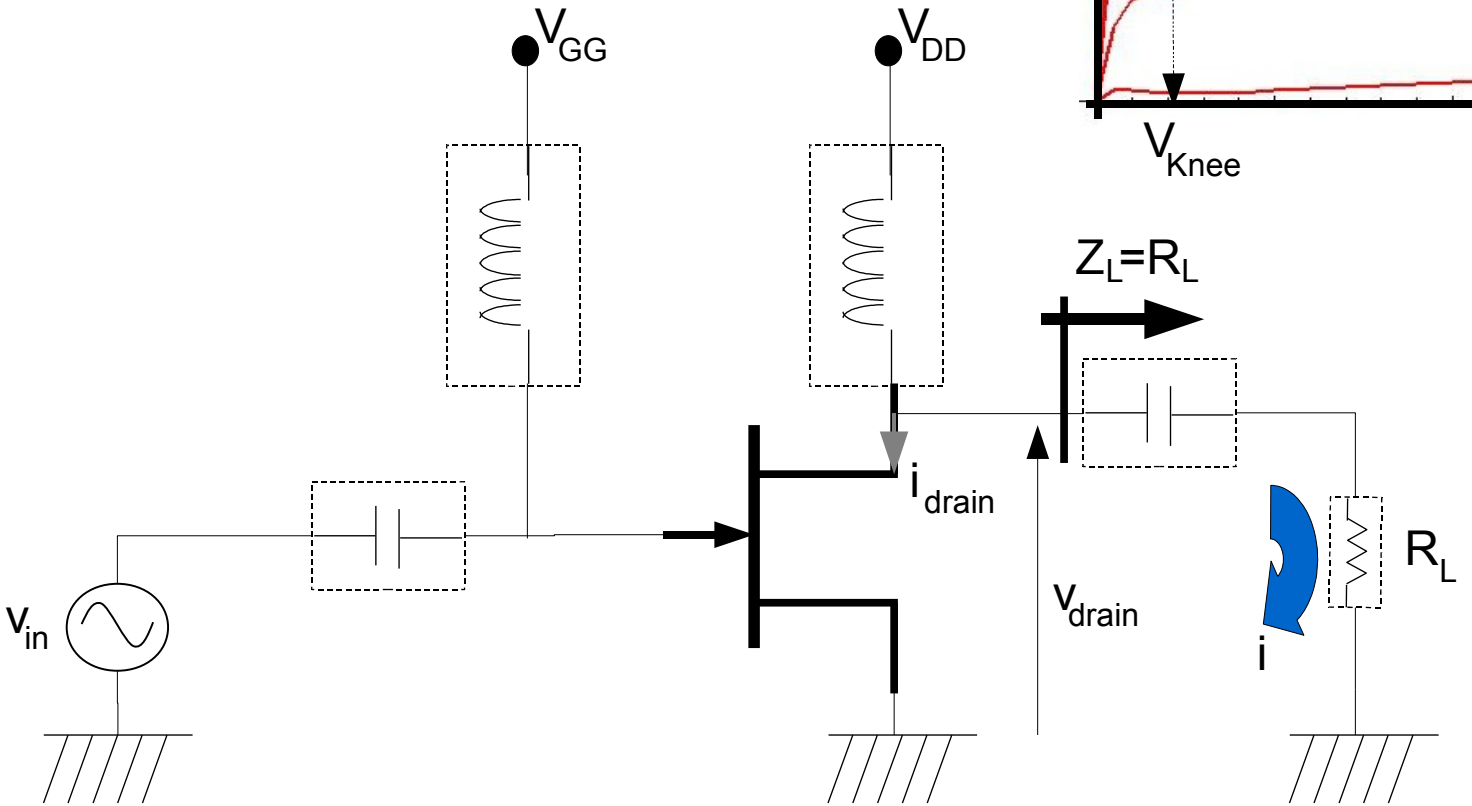
Concept of load line

$$R_L = \frac{V_{Max} - V_{Knee}}{I_{Max}}$$





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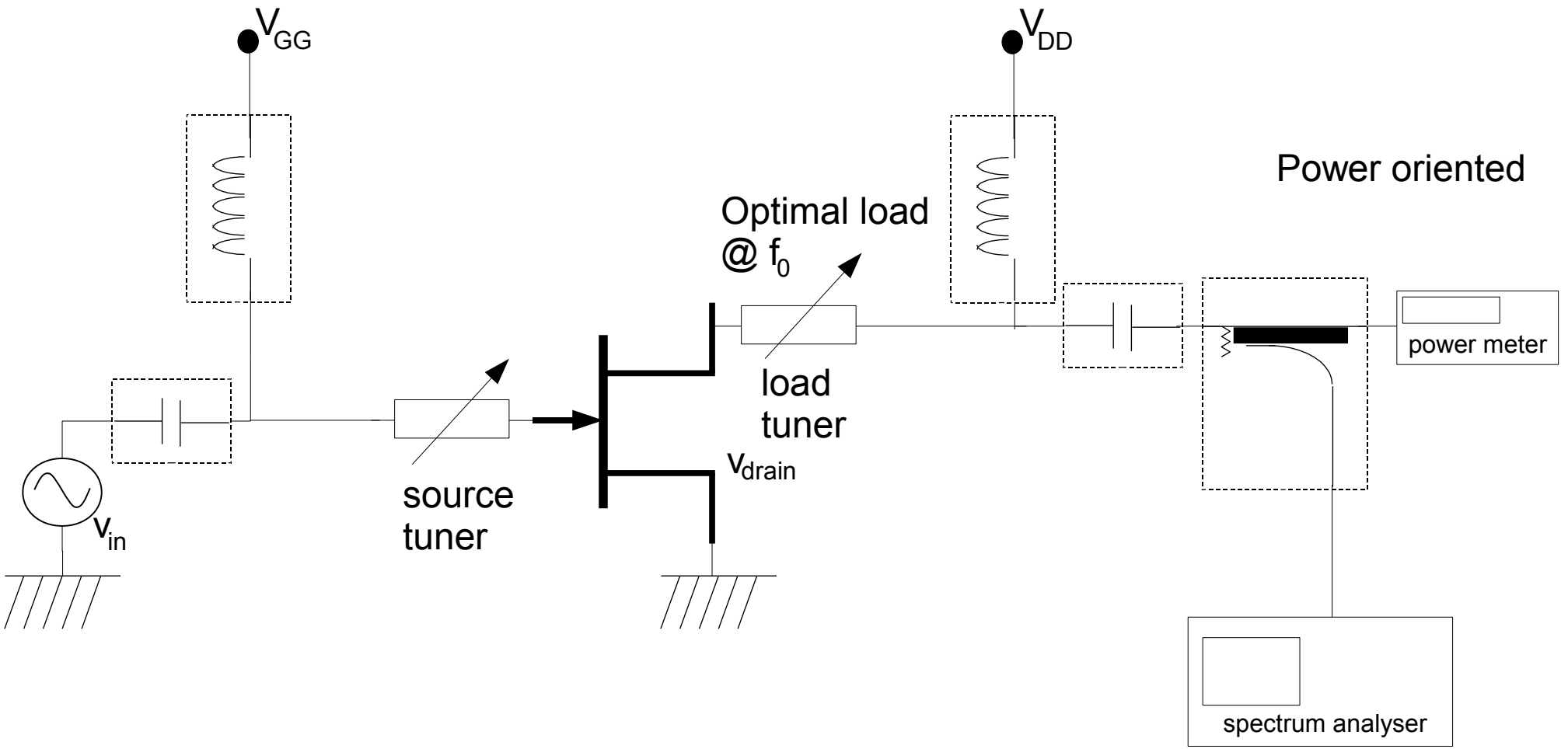
Classic Source / load pull



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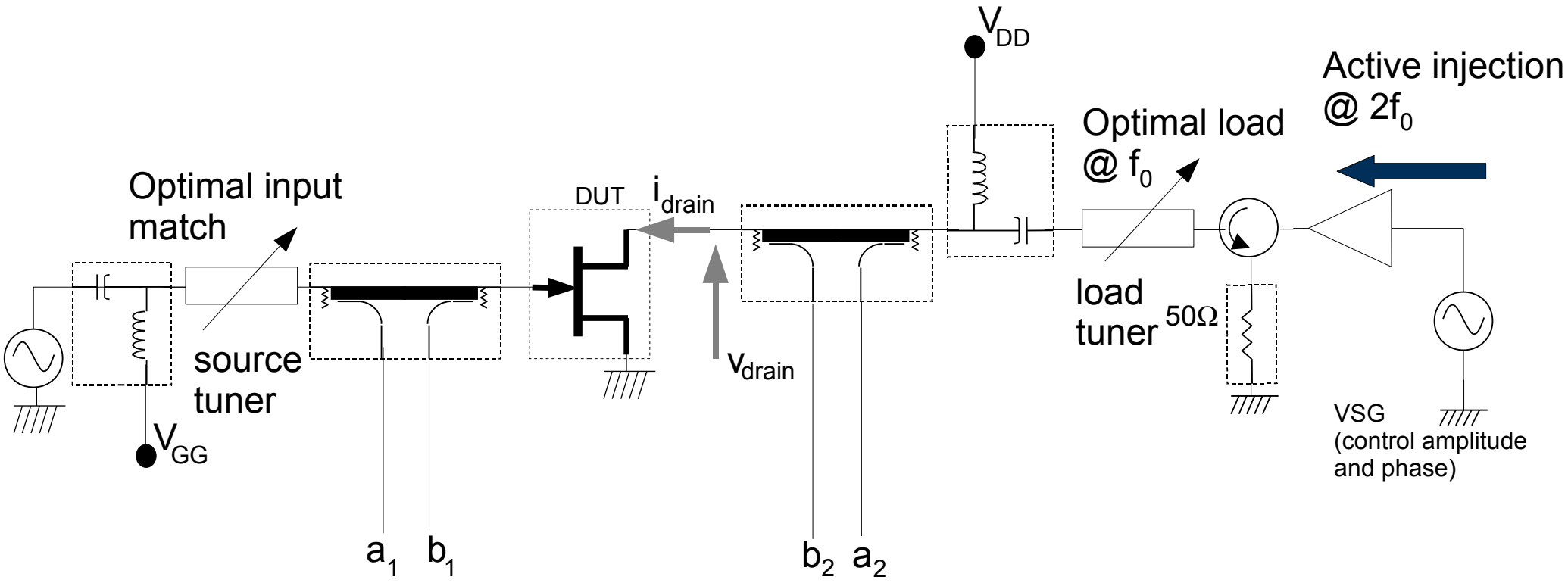
Source / load pull with the ZVxPlus



No power meter needed
No spectrum analyser needed

→ This can be done using the ZVxPlus and we get the waveforms for free

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Classes of operation

- Classes of operations
  - Class A
  - Class AB
  - Class B

  → Loadline?

  → Drain current and drain voltage waveforms?

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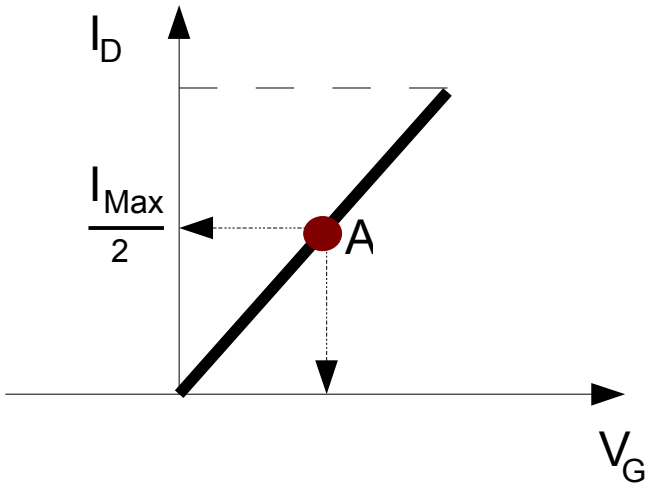
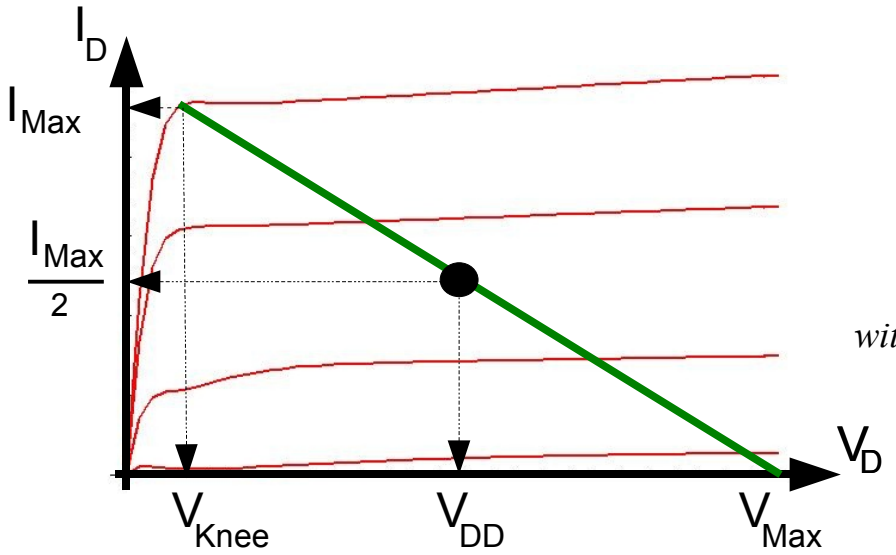
Classes of operation: Class A





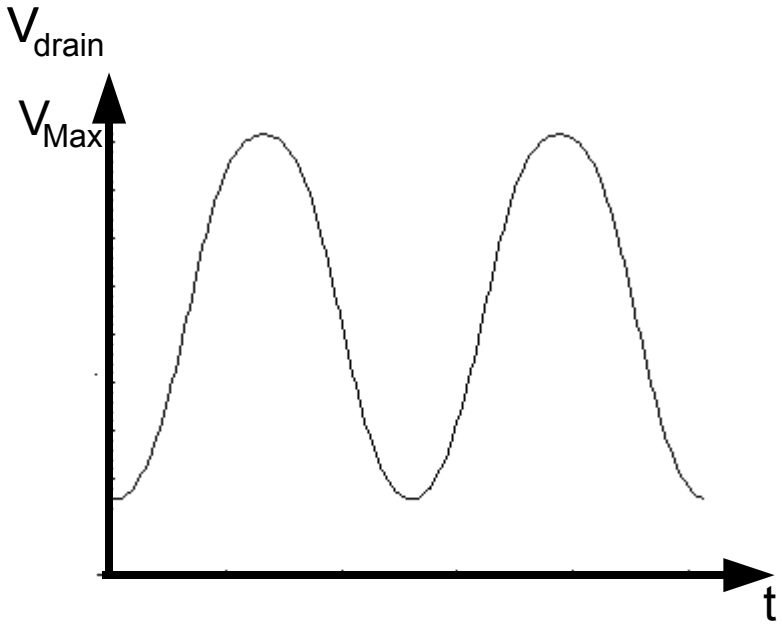
theoretical

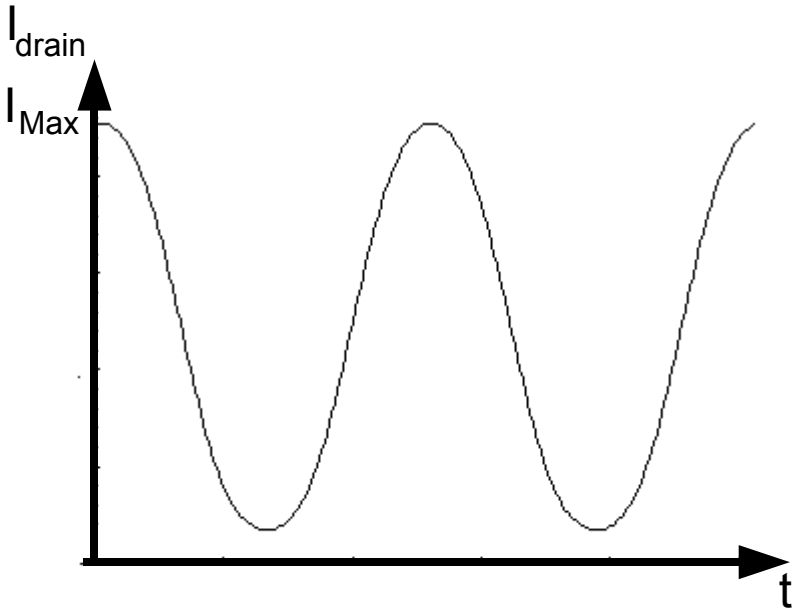
$\eta = 50\%$

if $V_{Knee} = 0\text{V}$

$$R_L = \frac{V_{DD}}{0.5\, I_{Max}}$$

$$\text{with } V_{DD} \approx \frac{V_{Max} - V_{Knee}}{2} + V_{Knee}$$





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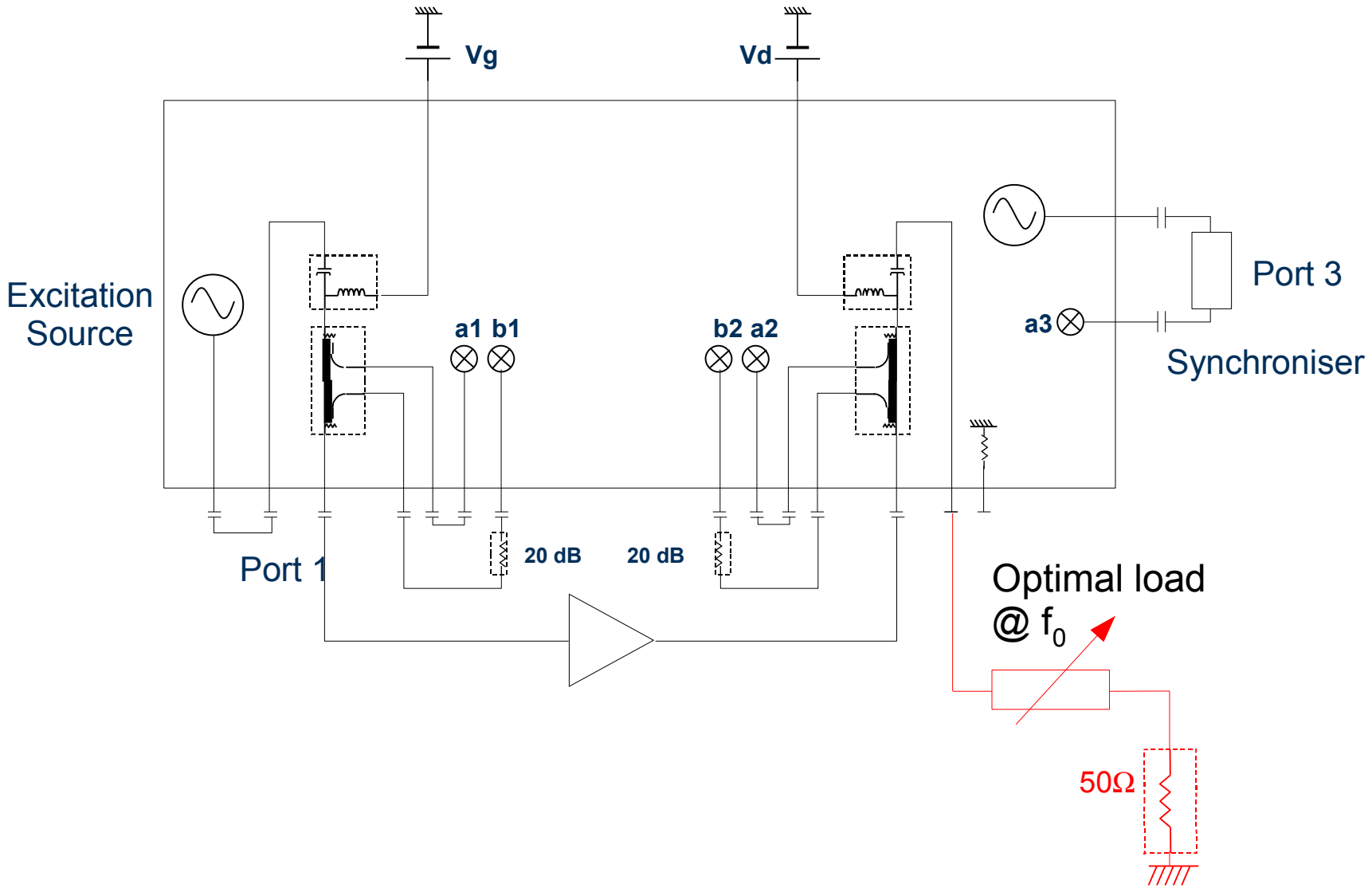
Fundamental load tuning



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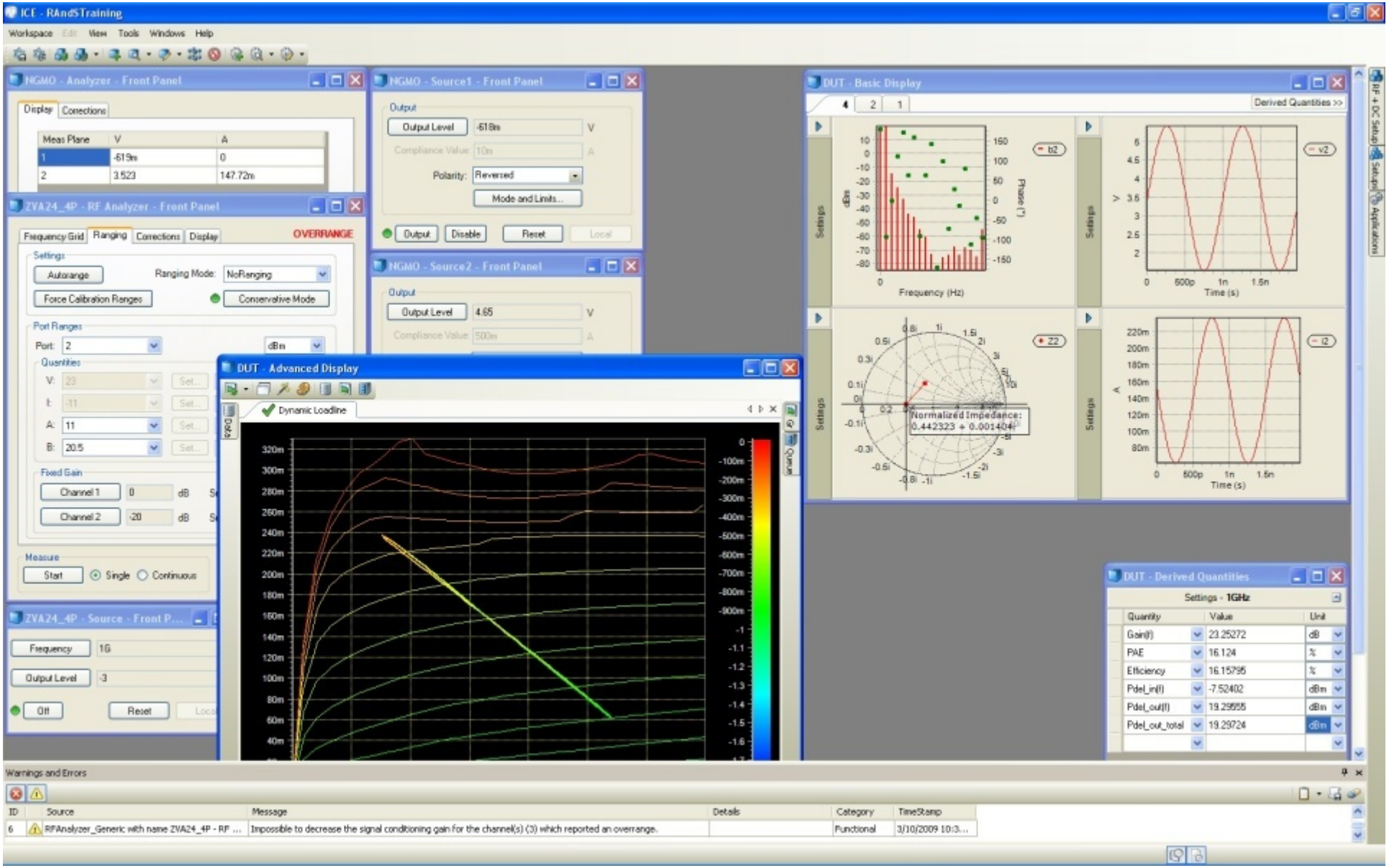
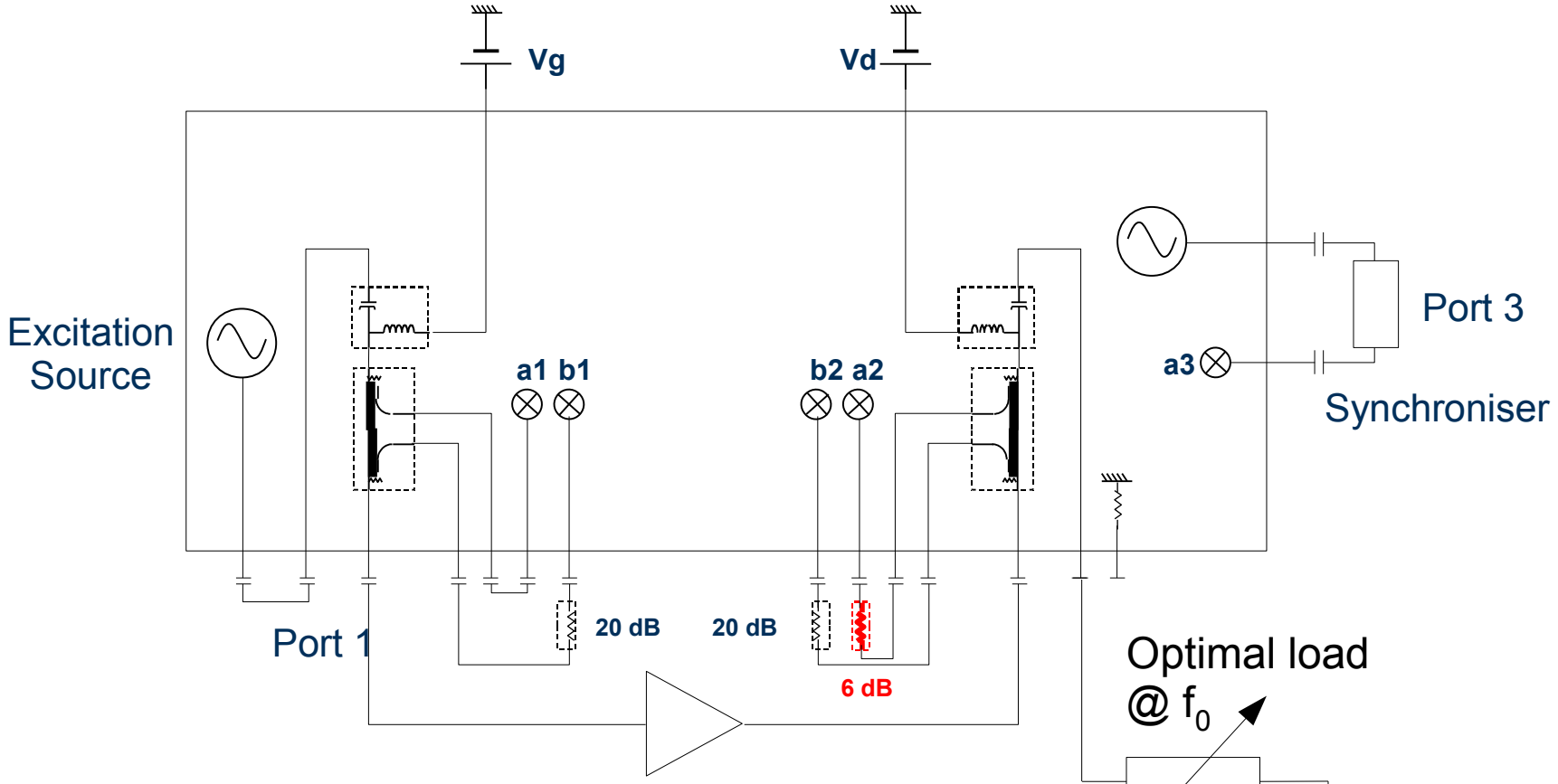
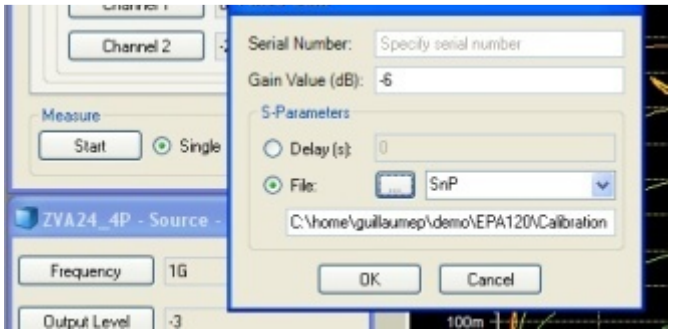
Class A in practice: Overrange



Overrange Solution

Adding a characterised 6dB attenuator in a2 channel on the fly!





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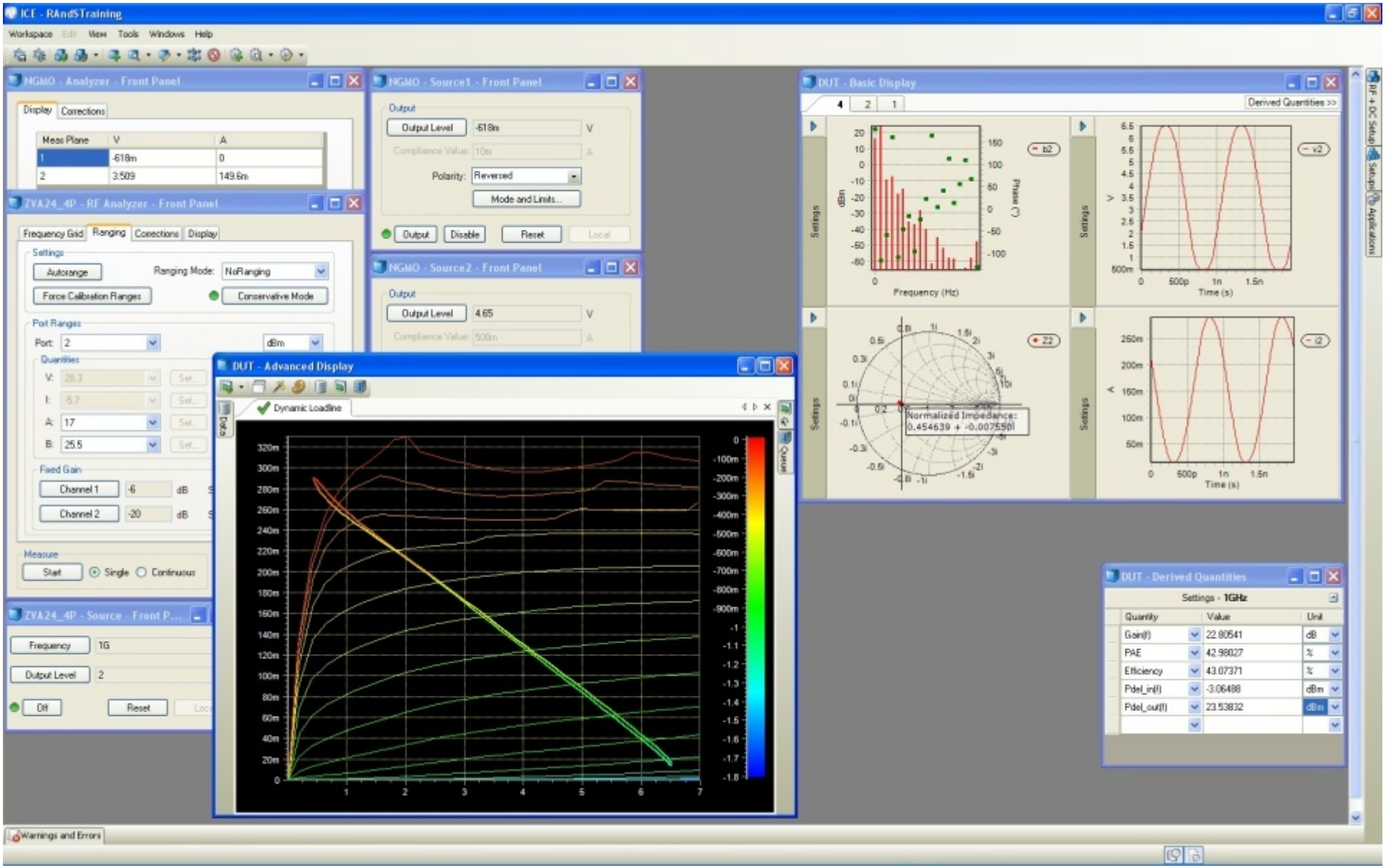
Class A in practice



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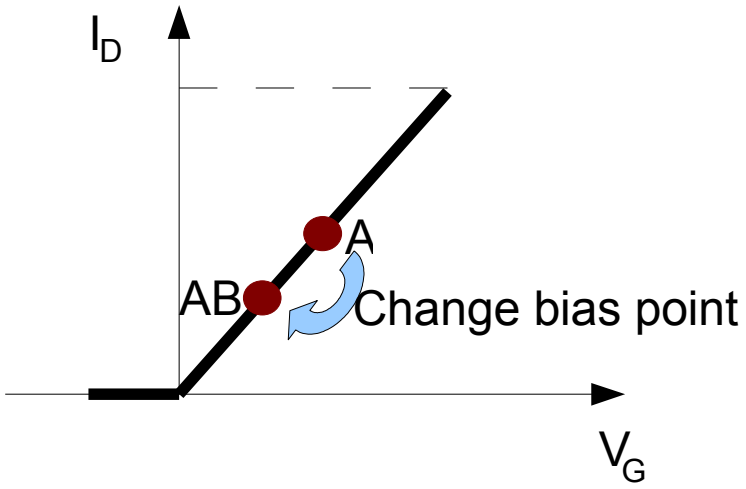
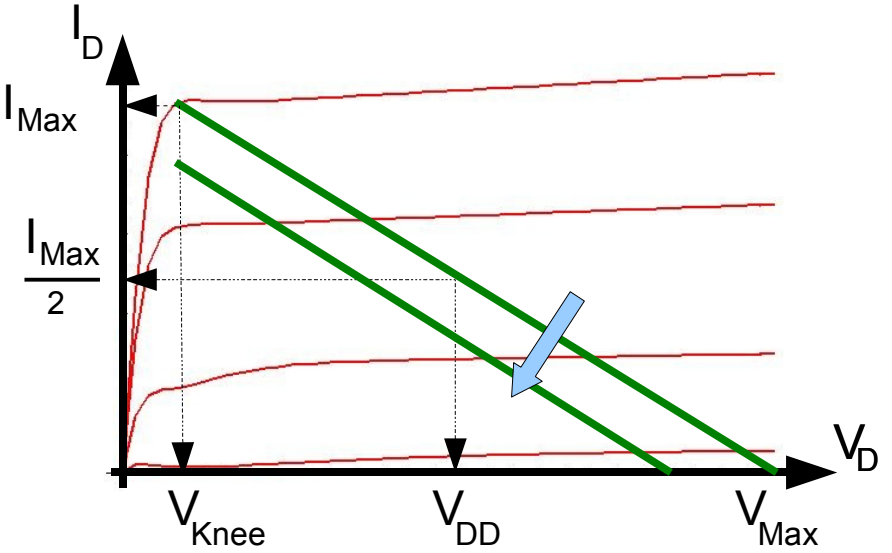
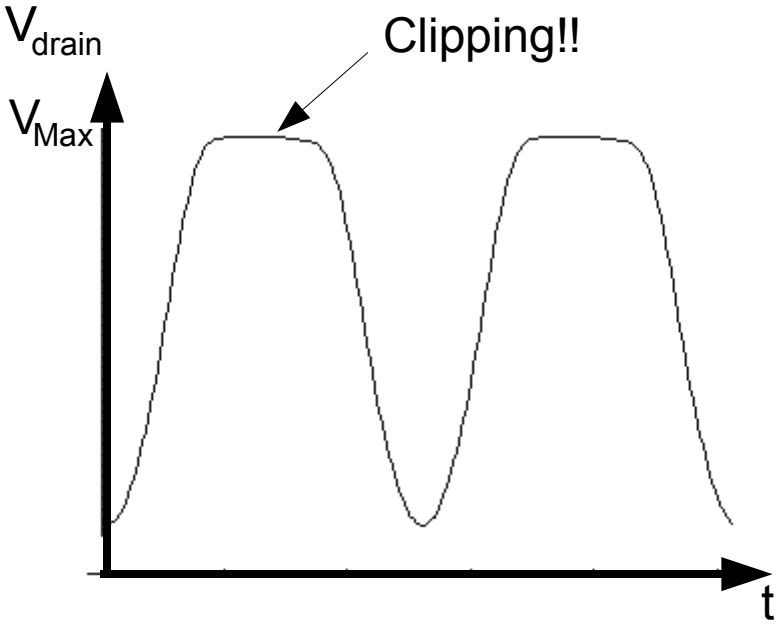
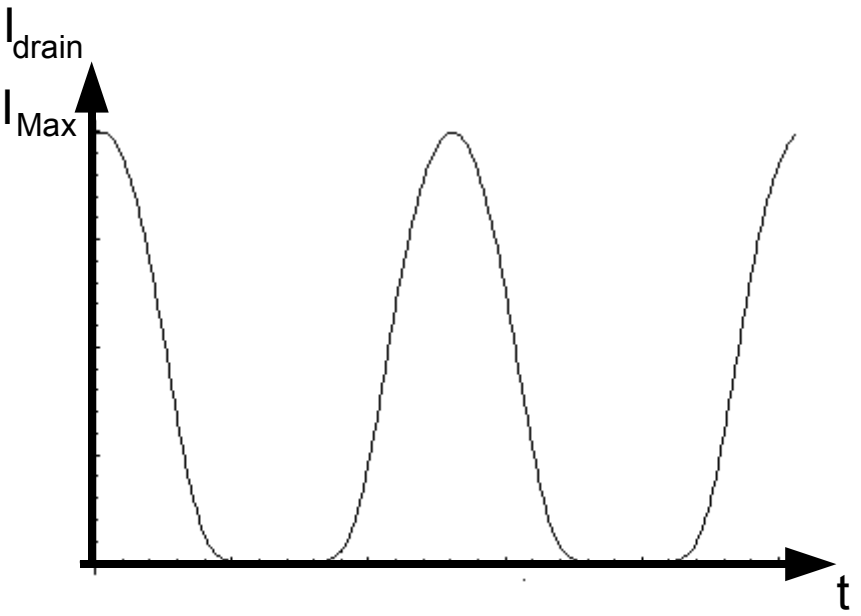
Classes of operation: From Class A to AB, the first step









The drain voltage contains harmonics → goal is a sine wave drain voltage

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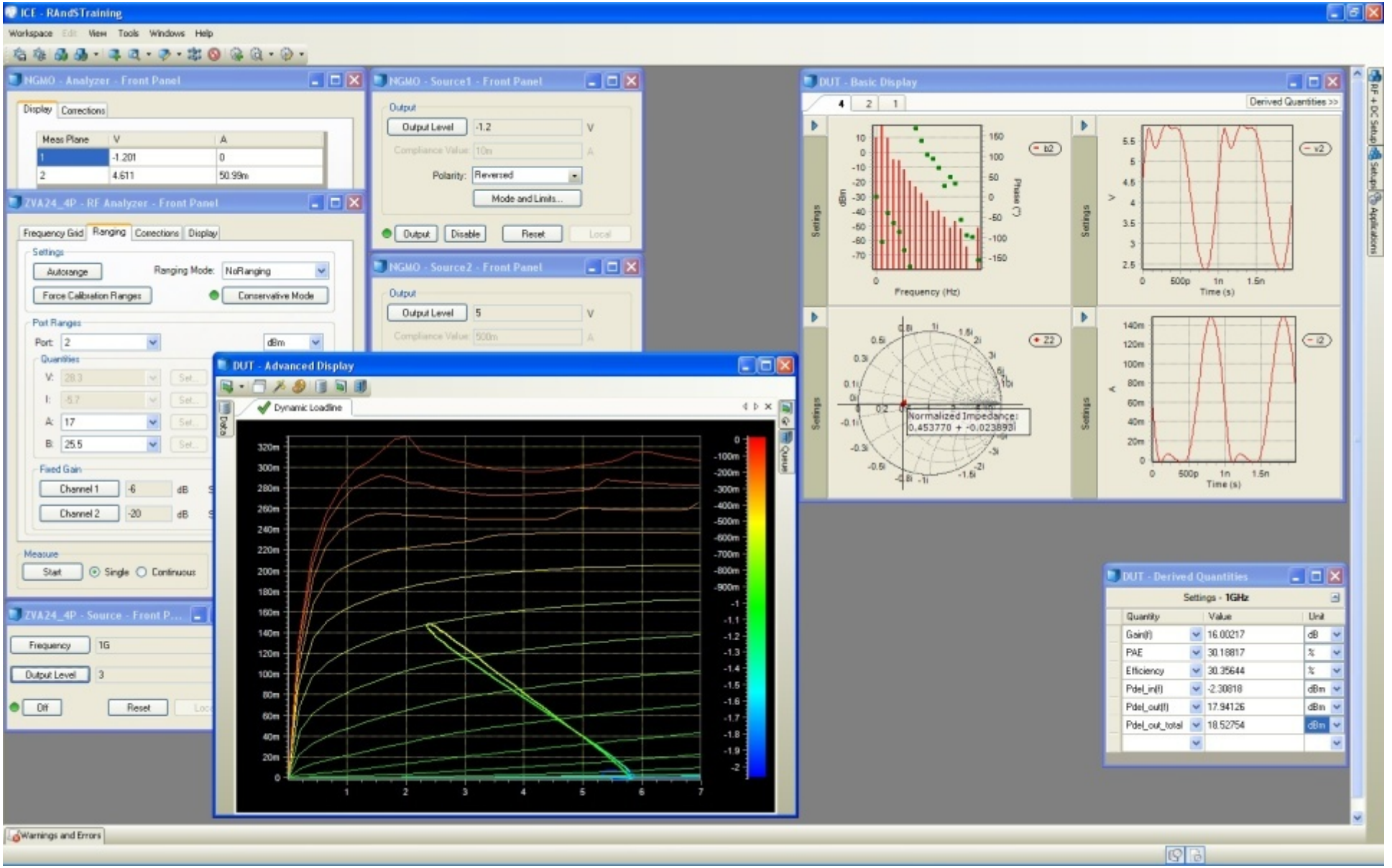
Class AB, first step in Practice



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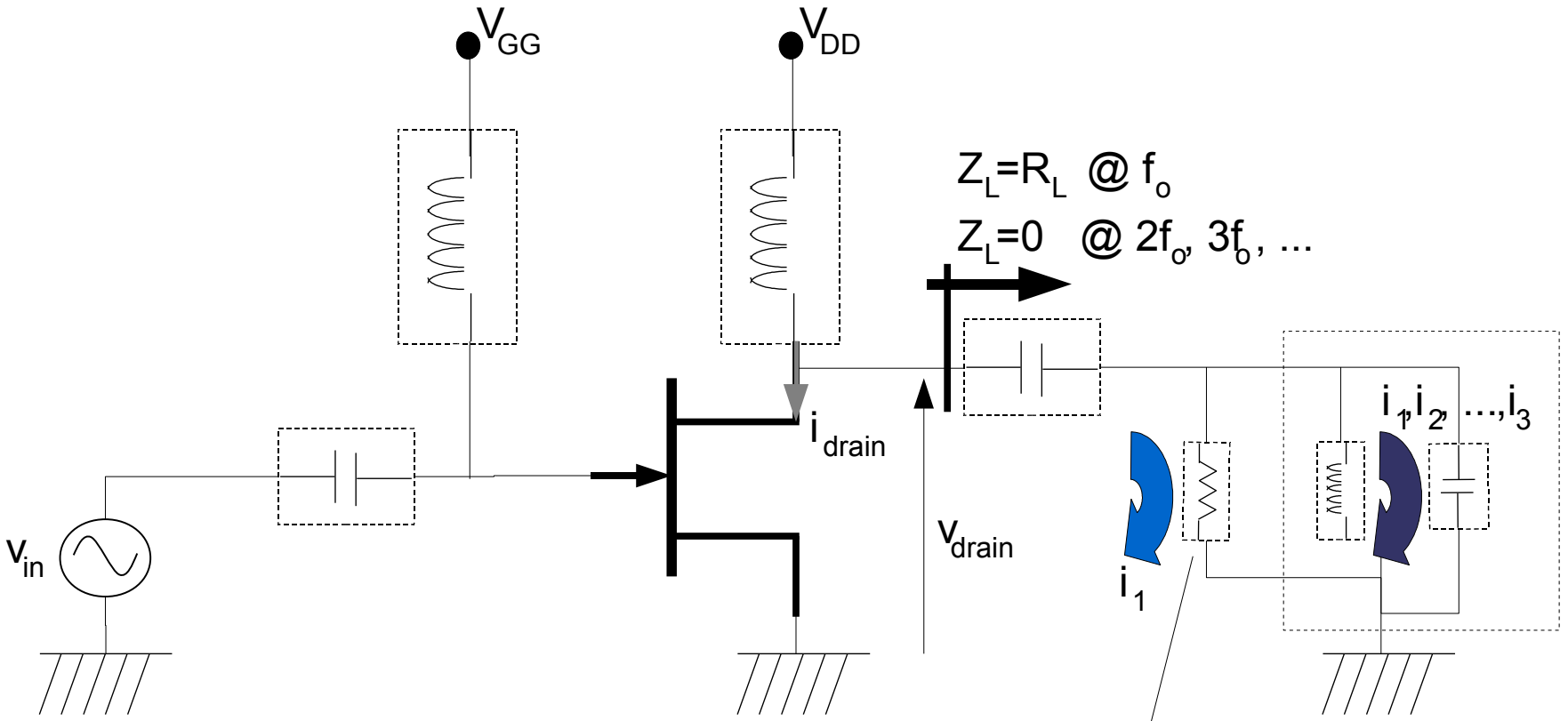
Harmonic output termination: tuned load



In case of :
- a perfect harmonic short
- maximum voltage swing of $2V_{DD}$
- no knee region

the optimum value of load resistance will be: $R_L = \frac{V_{DD}}{I_{@f_o}}$

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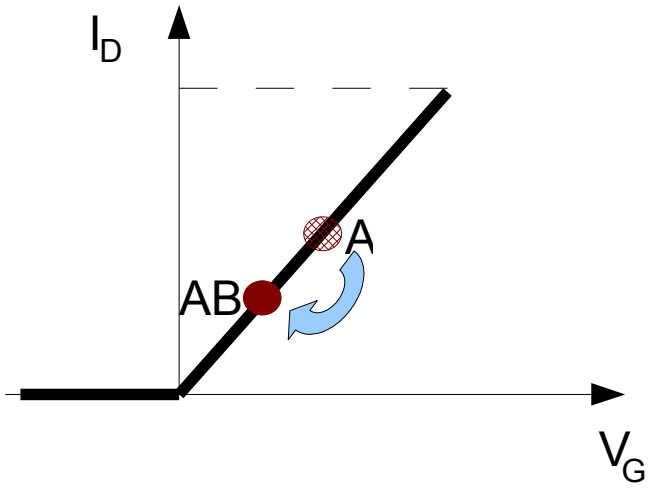
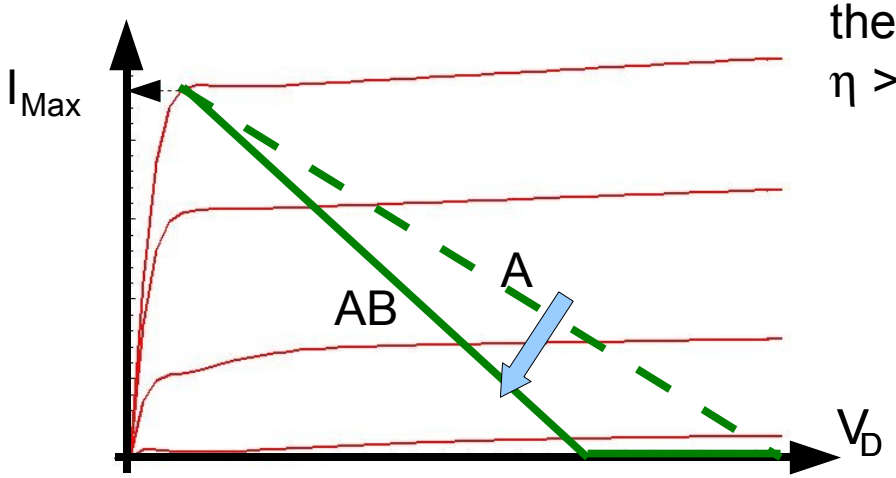
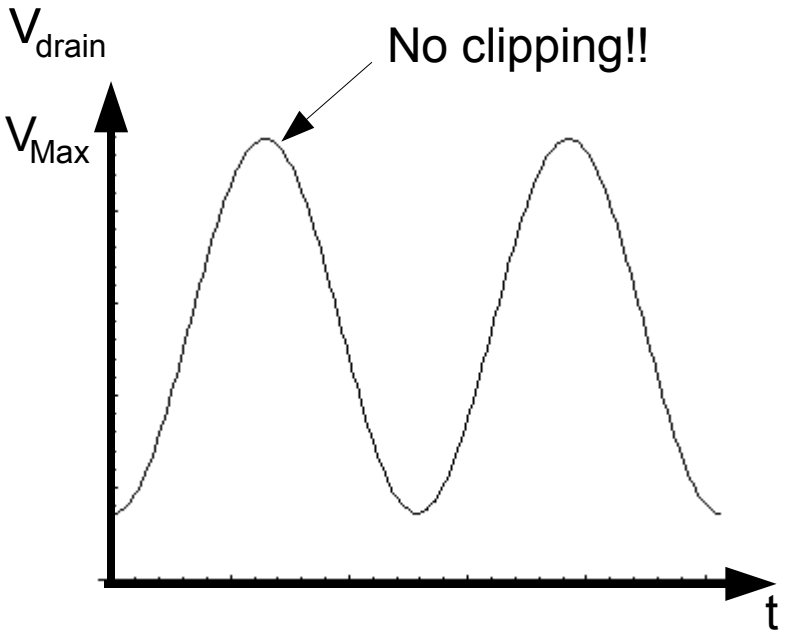
Classes of operation: Class AB

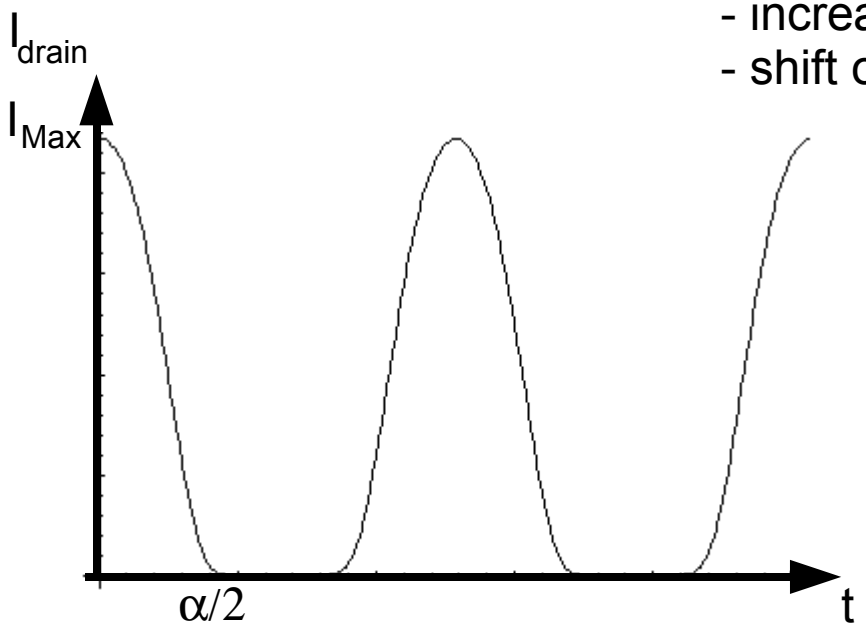




theoretical
η >50% and < 78.5%

due to:
- termination at harmonics
- increased input signal
- shift of V





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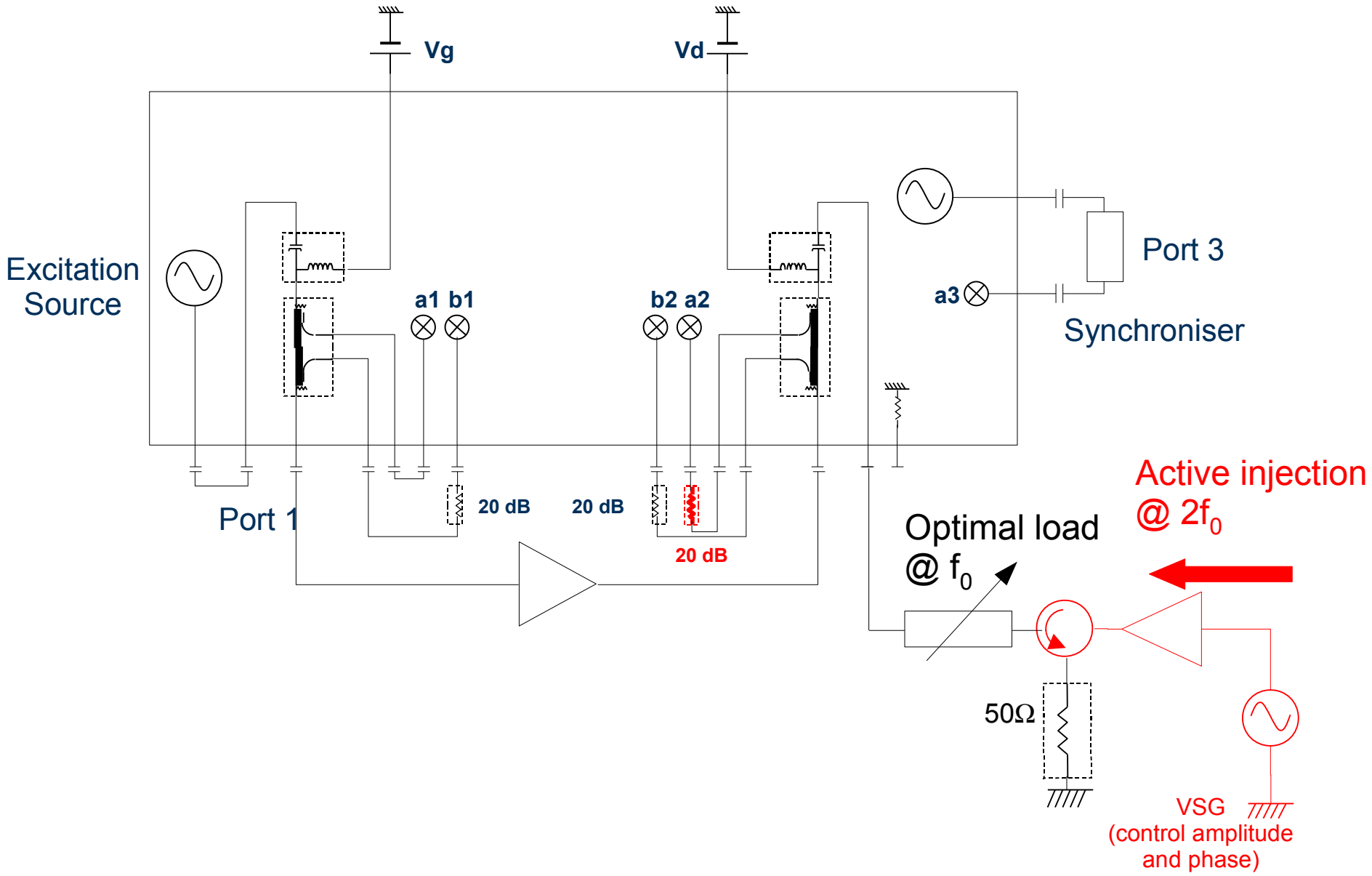
Harmonic active tuning



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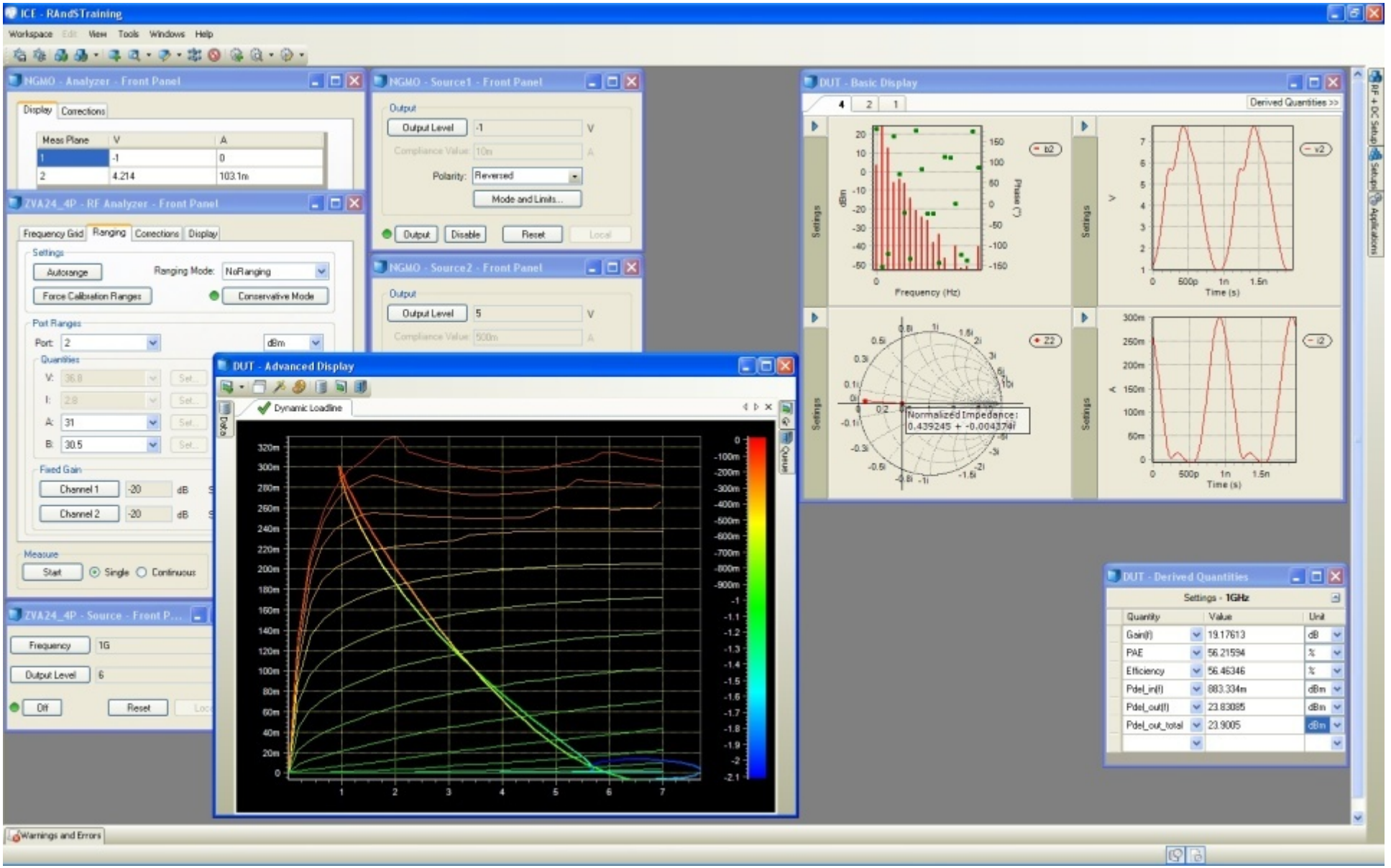
Class AB in practice



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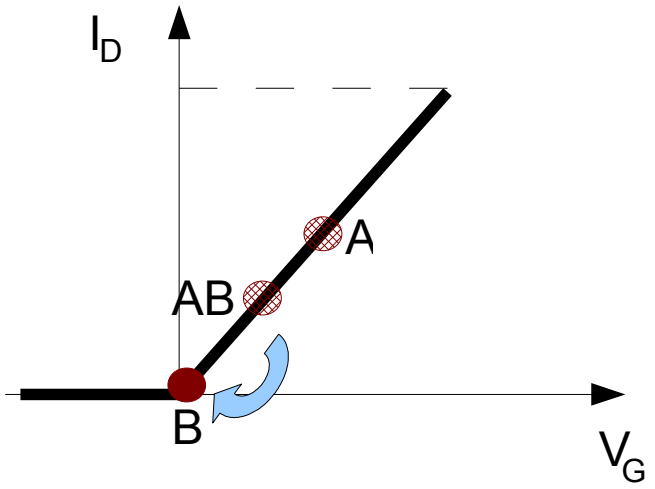
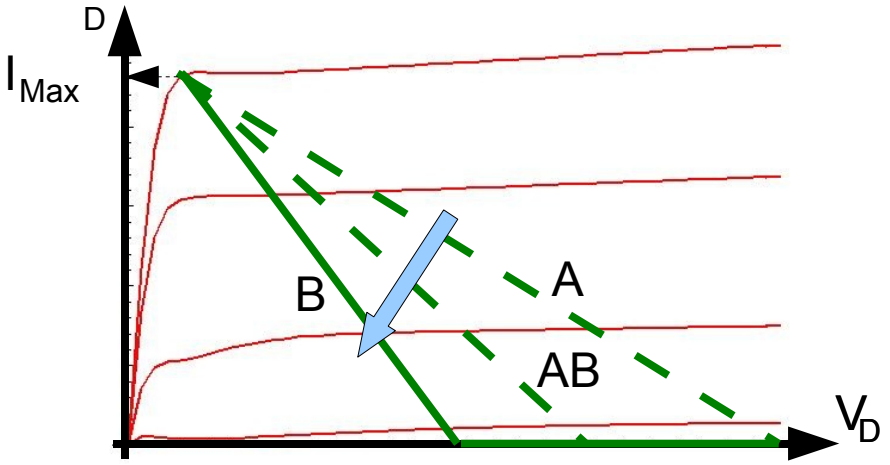
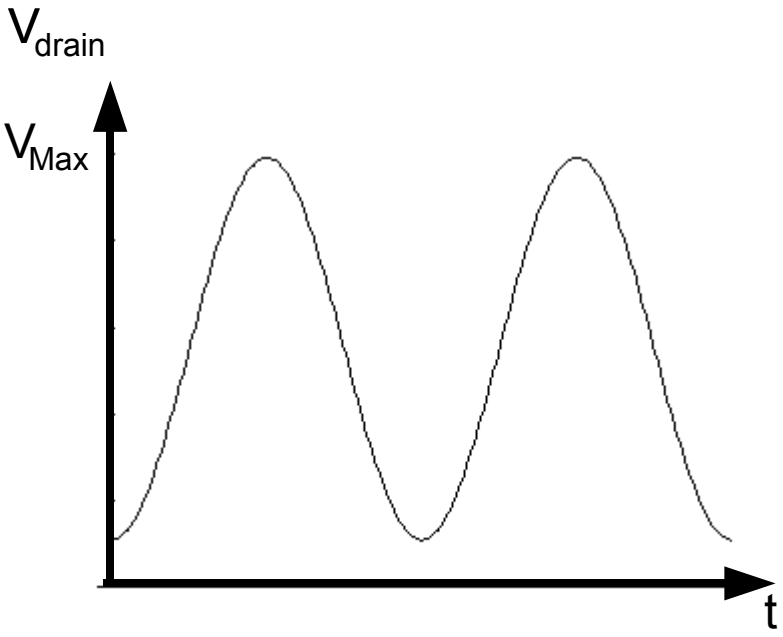
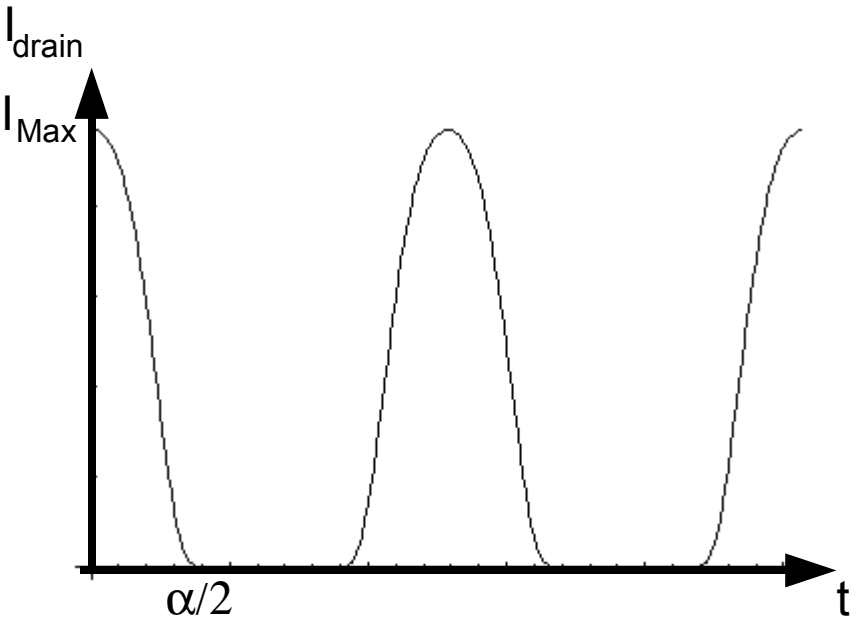
Classes of operation: Class B





theoretical
η=78.5%





Note: in case of a perfect short at all harmonics

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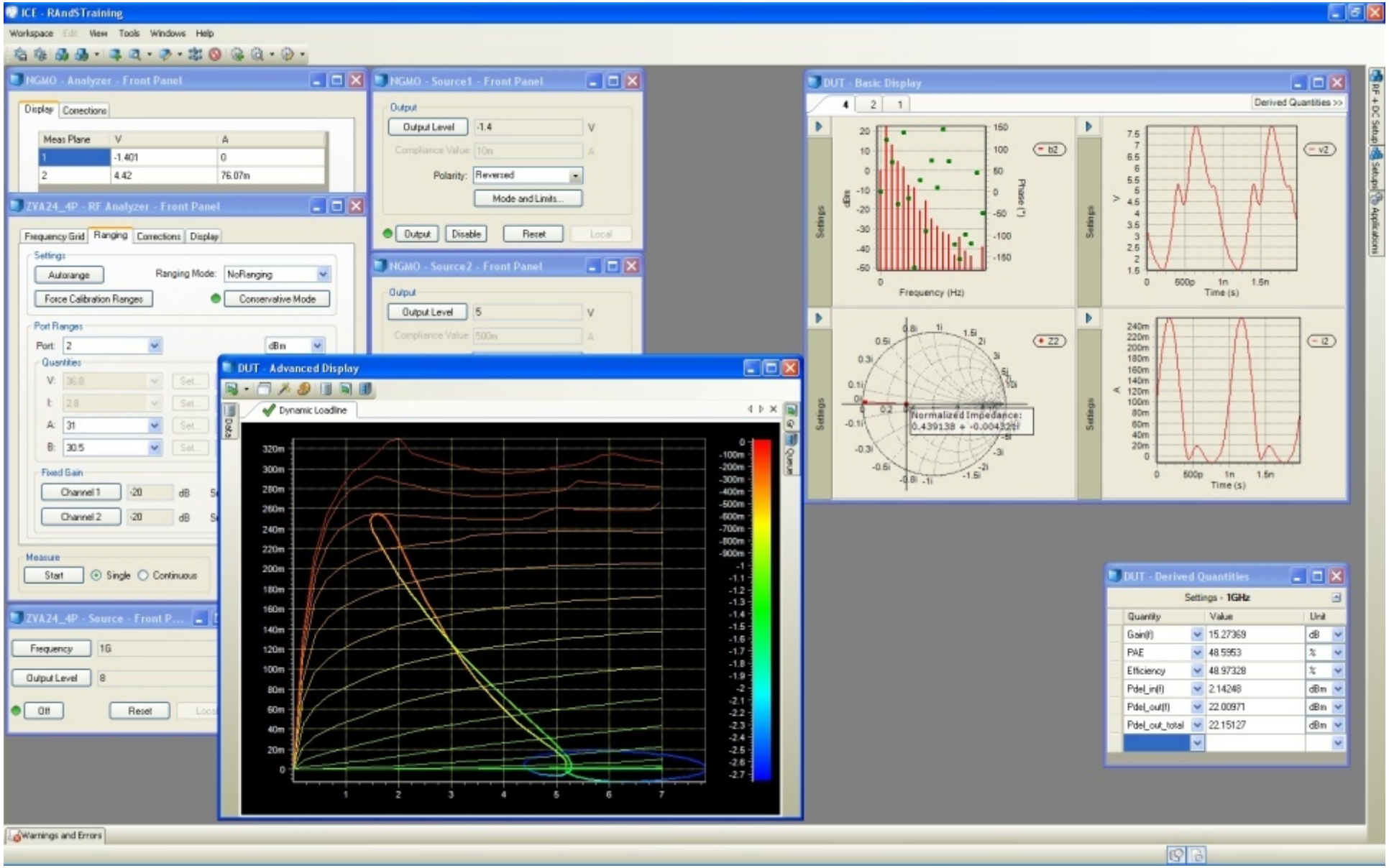
... to Class B



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Conclusion

- Fast Power Amplifier Design using ZVxPlus has been demonstrated.

- Using the ZVxPlus, a RF Design engineer can do **on the fly** a concrete application design, with one single tool. This tool gives all the information needed for the design.

It will surely open new domains and applications.

For more information info@nmdg.be

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