NM600 FSLP

Source- and Load-Pull
using your VNA
at its full power

- Fast, Simple and Low-Cost -

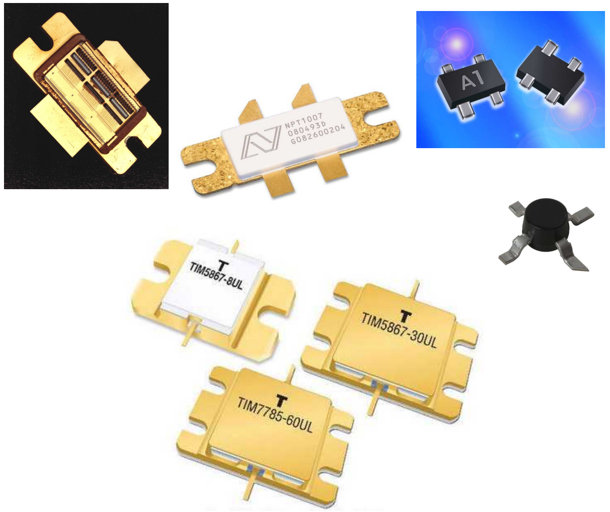
November 2010

Outline

- Target Markets and Requirements
- Key Benefits of NM600
- Problem description
- Fast Source- and Load-Pull Concepts
- Setup for NM600
- NM600 FSLP Application
- Examples of Source- and Load-pull
- Customization of NM600 for power applications
- Conclusion

Target Markets and Requirements

- Semiconductor Manufacturers
  - Low cost and fast characterization
  - Minimize the number of measurement setups
  - VNA is typically already being used



- Handsets
  - Cheap
  - Small
  - Talk forever without recharging
  - Speech, data, movies, conferencing etc...

- Base-stations
  - Low maintenance cost
  - More cells
  - Smaller units

<u>NM600</u>

- Needing to perform non-50 Ohm characterization
- Owning a vector network analyzer
- Not willing to invest in tuners

NM600: Key Benefits

- **Fast**
  - Electronic tuning
    - ~0.6s/point in Fast Mode (no control loop of independent variables)
    - ~1.4s/point in Control Loop Mode

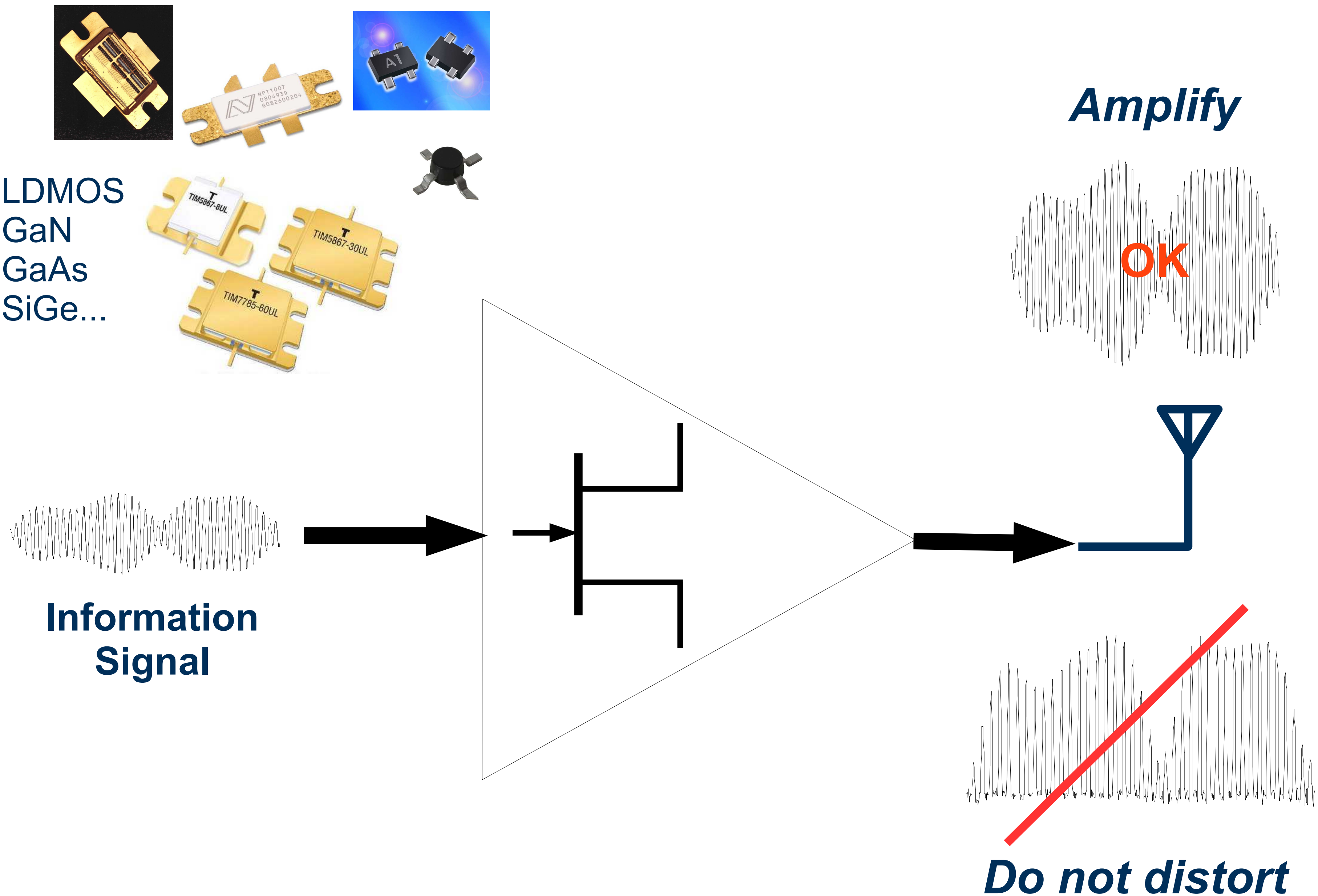
- **Simple and Accurate**
  - Standard network analyser connection to device under test (*)
  - Only VNA relative and power calibrations required

- **Low-cost**
  - No tuner required (passive techniques)
  - No expensive external sources required (active techniques)

- **Direct feedback**
  - Source and load impedances
  - Fundamental power and phase spectrum of input and output waves
  - Derived quantities such as input and output delivered power, PAE

(*) Circulator advised for source protection

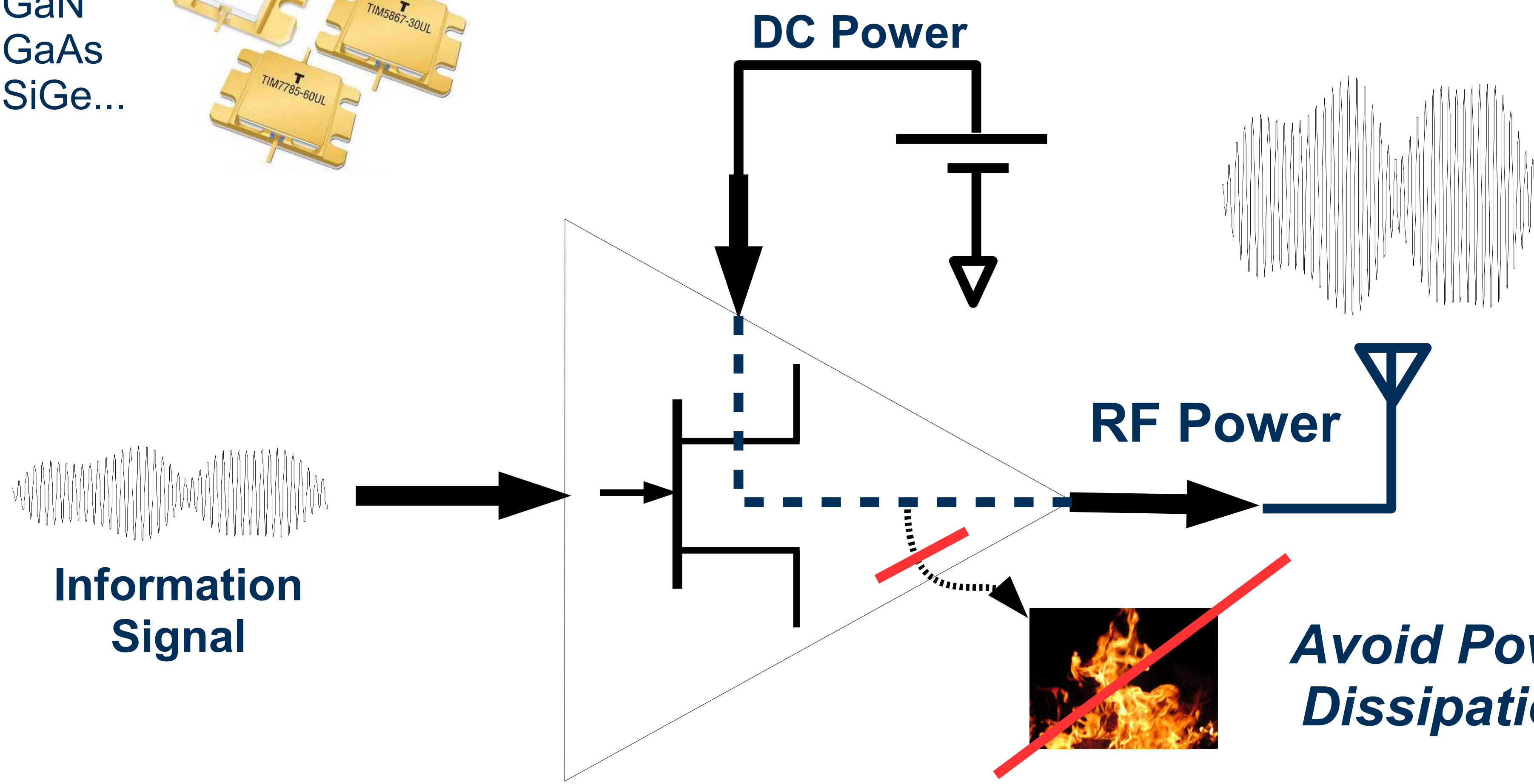
The Amplifier as essential Power Transformer



The Amplifier as essential Power Transformer

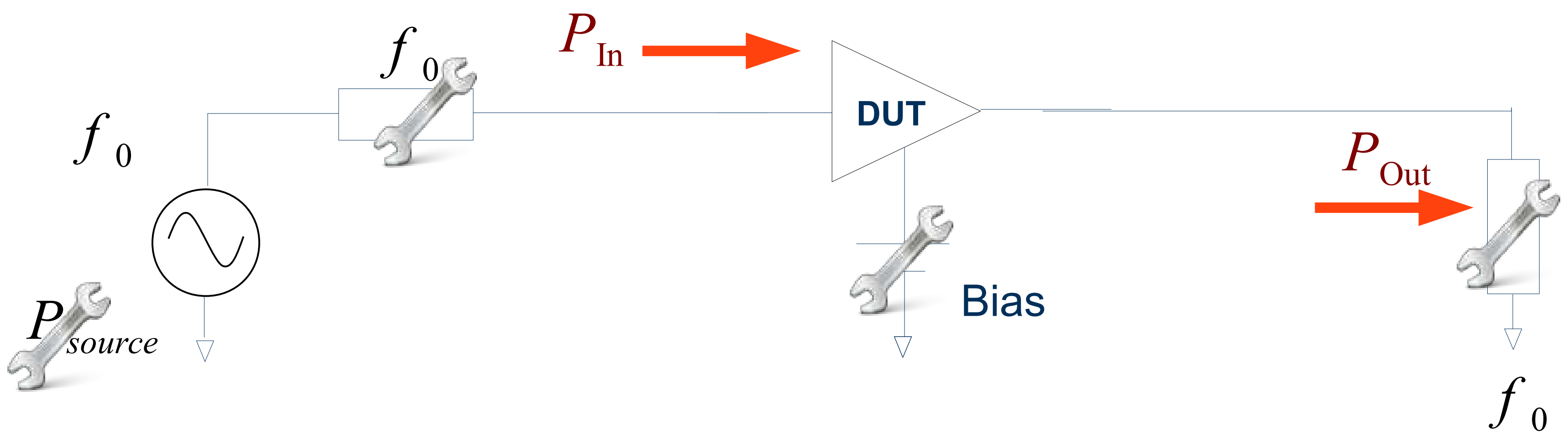
LDMOS
GaN
GaAs
SiGe...

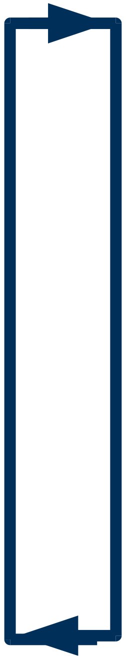
Convert DC Power into RF Power



Avoid Power Dissipation

Classic Technique: Fundamental Source and Loadpull



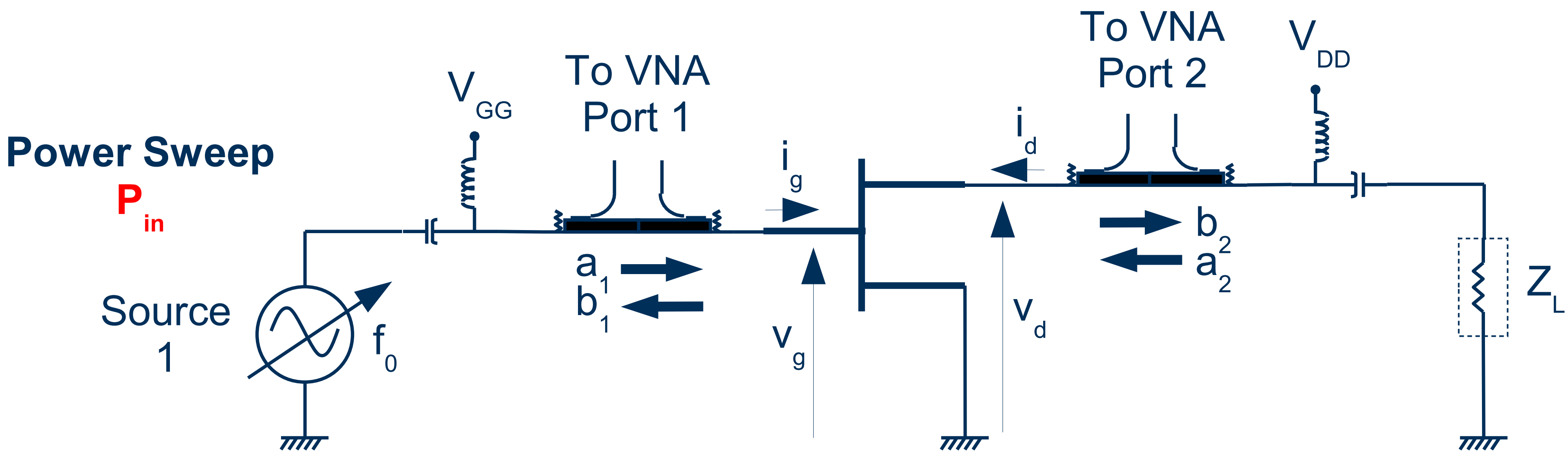


- Measure
  - Input and output DC and RF power
- For different values of
  - Input power
  - Bias
  - Load impedances
  - Source impedances
- Display and analyse collected data
- Until "some optimal" point is reached

What now?

- S-parameters
  - Small-signal characterisation
  - Only when no distortion
- 50 Ohm environment
  - Matching requires non-50 Ohm
- Harmonic and Intermod distortion
  - Only in 50 Ohm environment

Concept of Fast Source-Pull

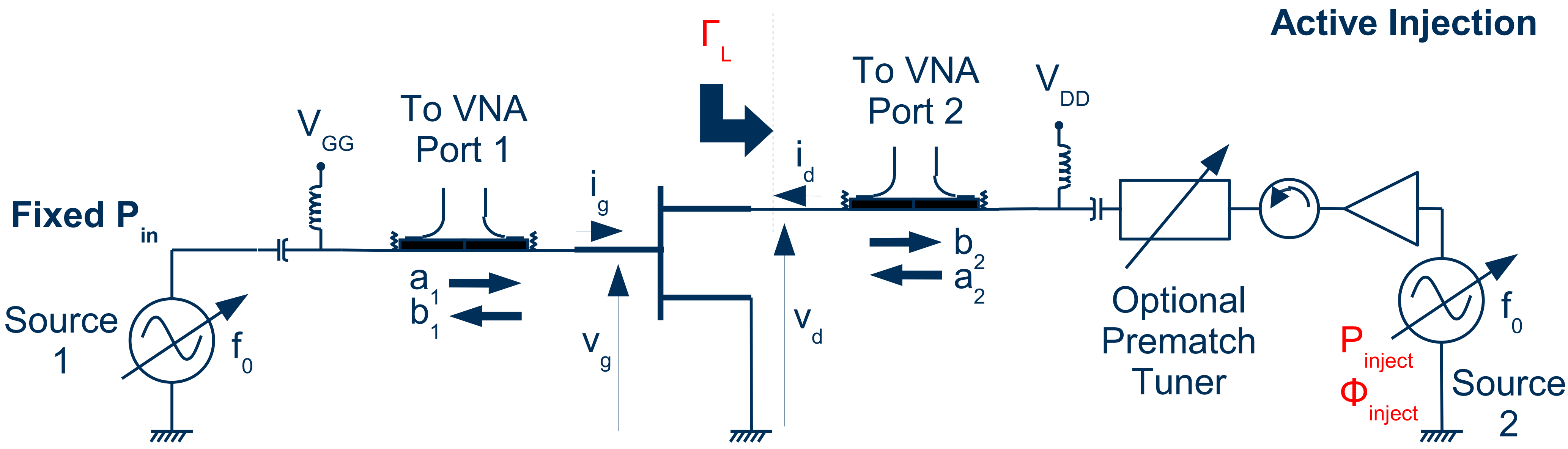


Measure $\forall P_{in}$ → v_g, i_g, v_d, i_d at DC
a_1, b_1, a_2, b_2 at f_0

Calculate mathematically $\forall P_{AV}$ and Z_{source} → P_{delin}, P_{delout}, PAE, ... at f_0

→ Source Pull Contours

Concept of Fast Load-Pull

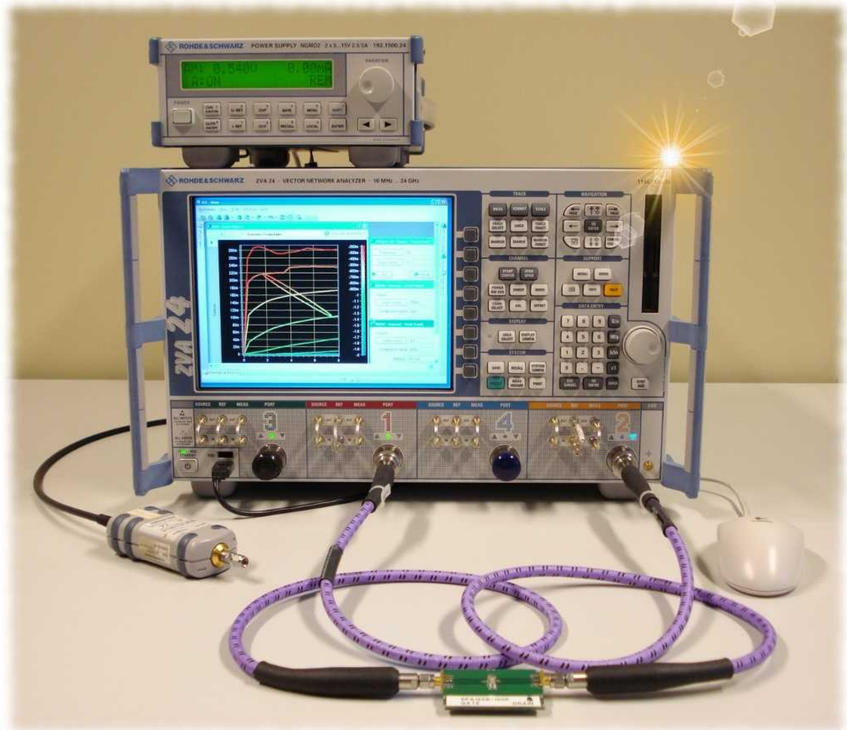


Adapting P_{inject} and Φ_{inject} for given P_{in} → Synthesize Γ_L

Measure → v_g, i_g, v_d, i_d at DC
a_1, b_1, a_2, b_2 at f_0

Calculate → P_{delin}, P_{delout}, PAE, ... at f_0

→ Load Pull Contours



2/4-port VNA

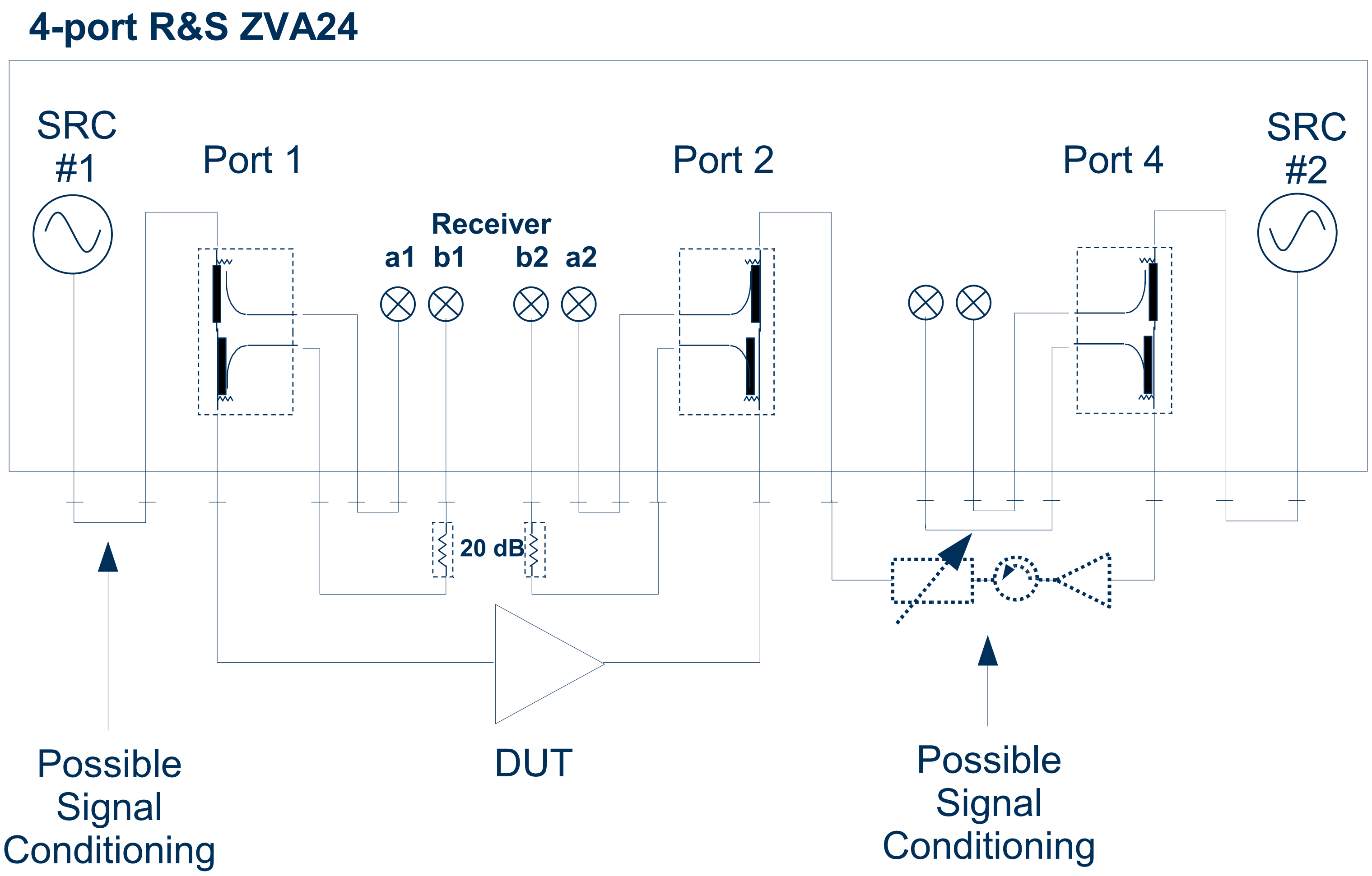
- direct gen. & rec. access
- Second internal source

+ Hardware (opt.)

- Circulator
- Amplifier
- Manual tuner

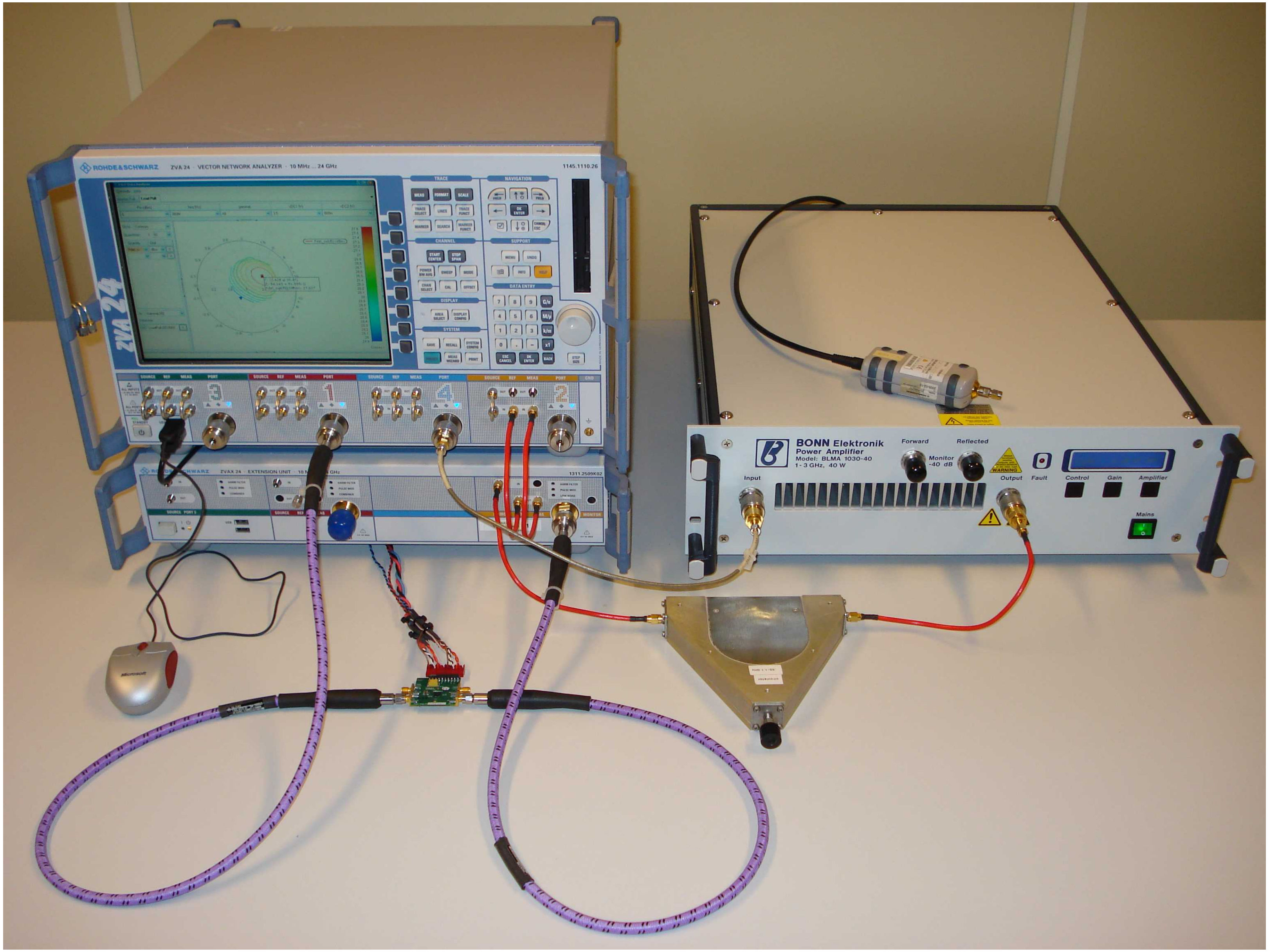
+ Software NM600 FSLP

NM600 Block Diagram on R&S ZVA24

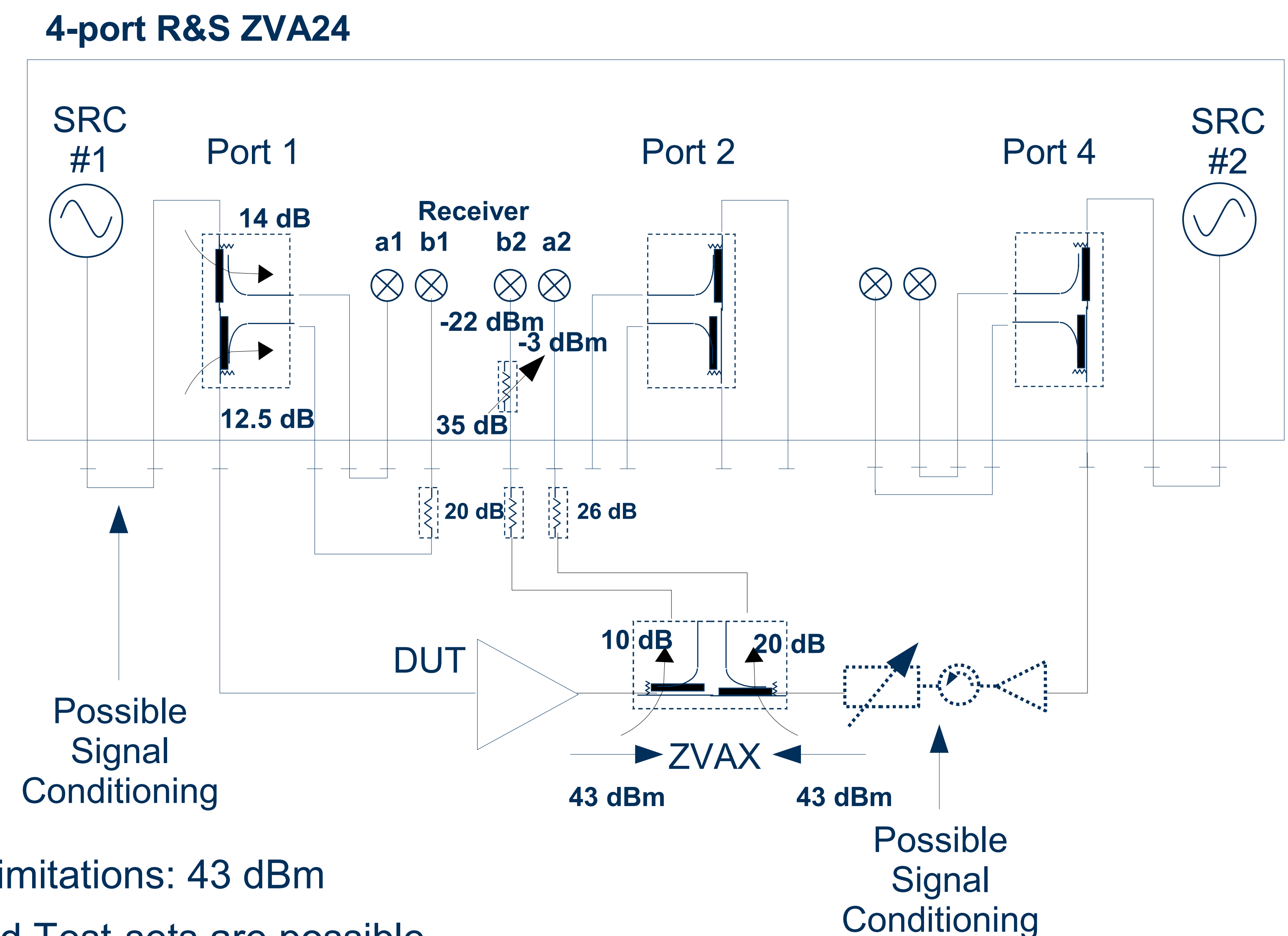


Test-Set Limitations: 27 dBm

NM600 Setup with ZVA and ZVAX



NM600 Block Diagram on R&S ZVA24



Test-Set Limitations: 43 dBm

Customized Test-sets are possible

NM600 FSLP Application

Multi-tab Displays
Source- or Load Pull Mode

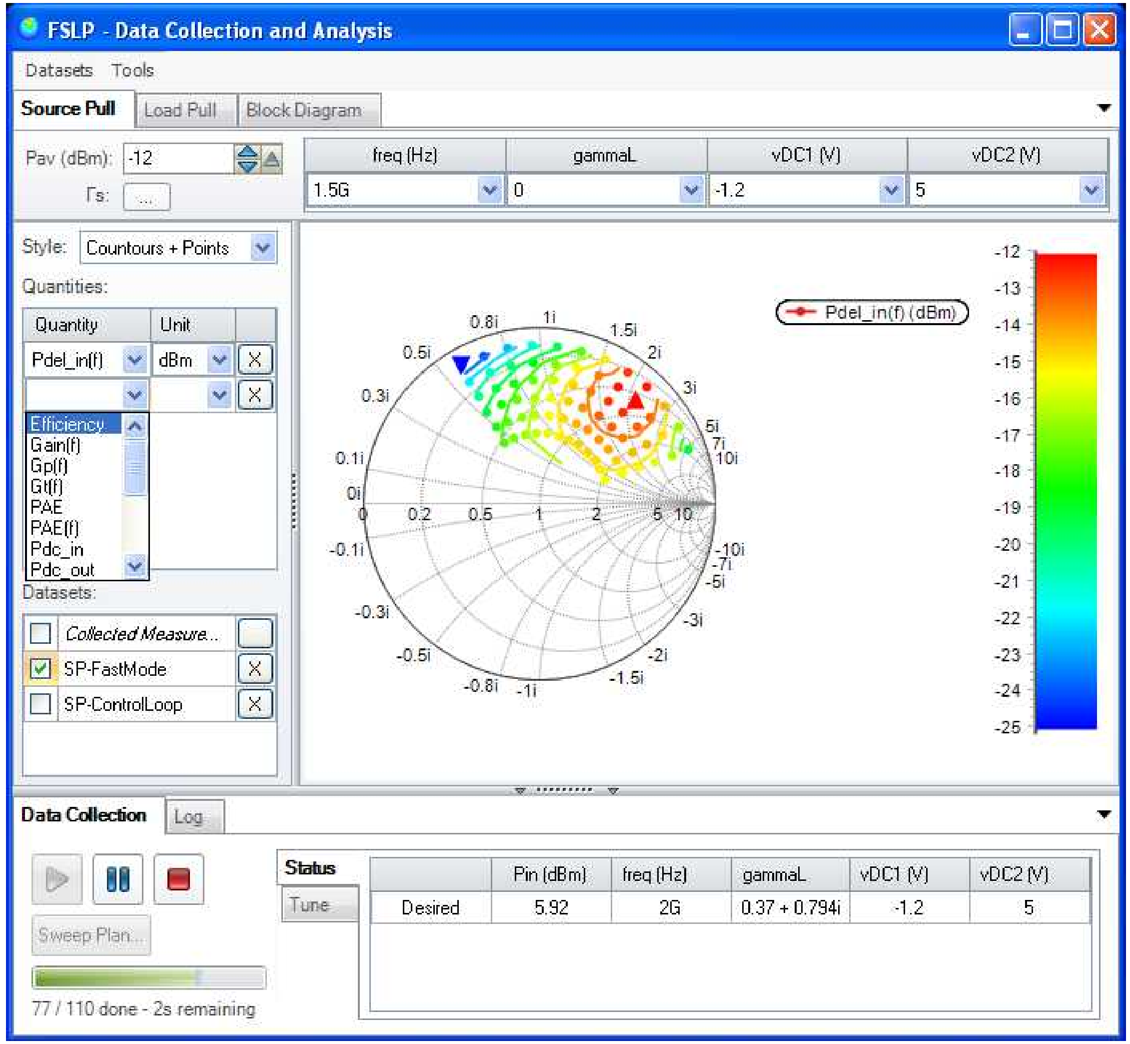
Selection of independent variables

Display Configuration

- **Style**
  - Points
  - Contours
  - Contours + Points
- **Derived Quantity:**
  - Selection of Qty & Unit
  - Multiple quantities at once

Selection of Datasets

- **Multiple datasets at once**
  - Union of indep. variables

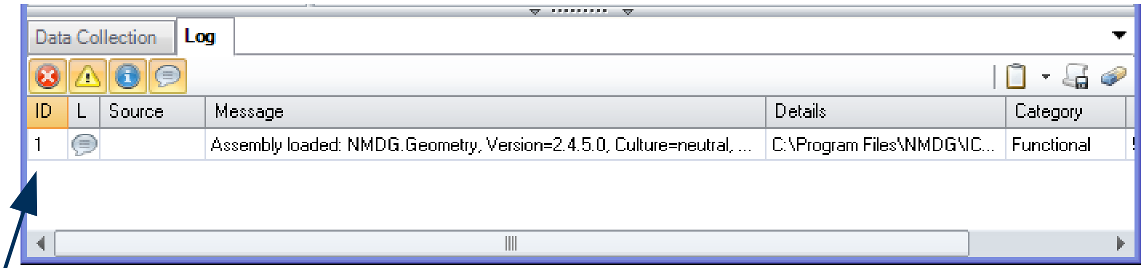


Off-line Display

Data Collection

NM600 FSLP Application – Data Collection

Log of messages
Verbose, Warning & Errors

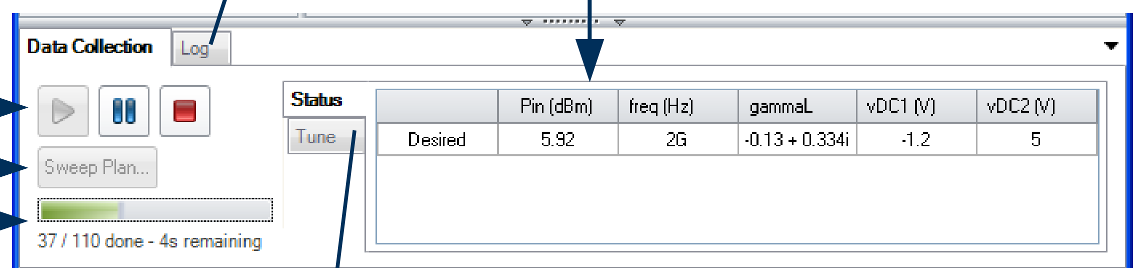


Live Status Monitor
Desired & realized sweep points

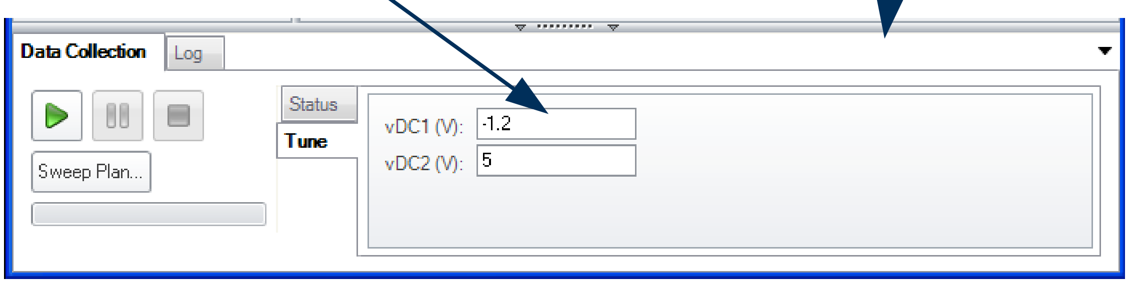
Sweep Start / Pause / Stop

Sweep Plan Configuration

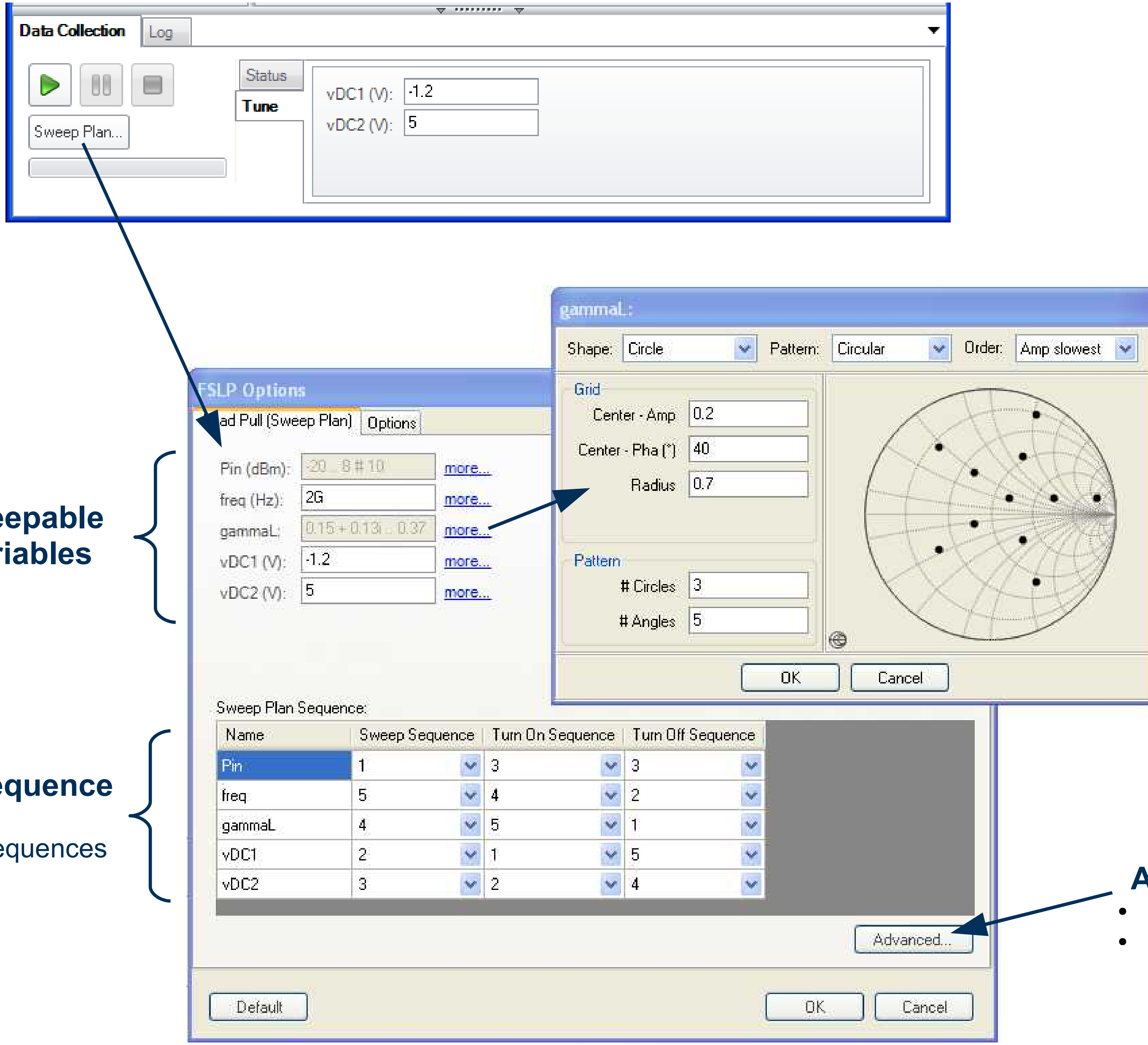
Progress Bar



Tune independent fixed variables
Change value & start automatically a new sweep



NM600 FSLP Application – Sweep Plan



Sweepable Variables

Γ_{Load} Sweep Configuration

Sweep Plan Sequence
- Sweep Order
- Turn On/Off Sequences

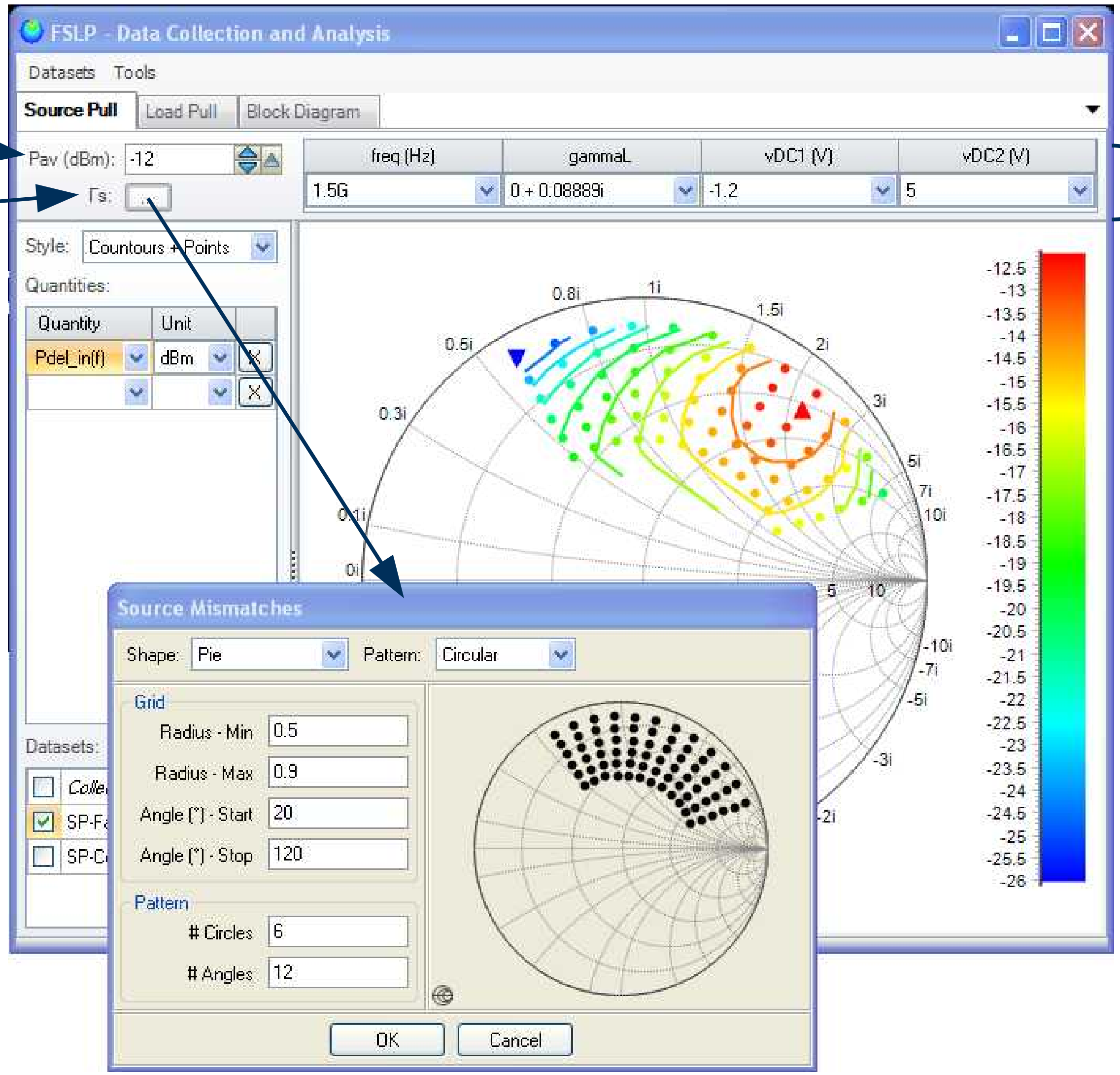
Advanced Settings
- Sweep Mode
- Control Loop Settings

NM600 FSLP Application – Source Pull Display

For a given Pav

For given Γ_s sets

Calculate mathematically



@ Selected
f_0, Γ_L, v_{DC1}, v_{DC2}

Display
Source Pull Contours

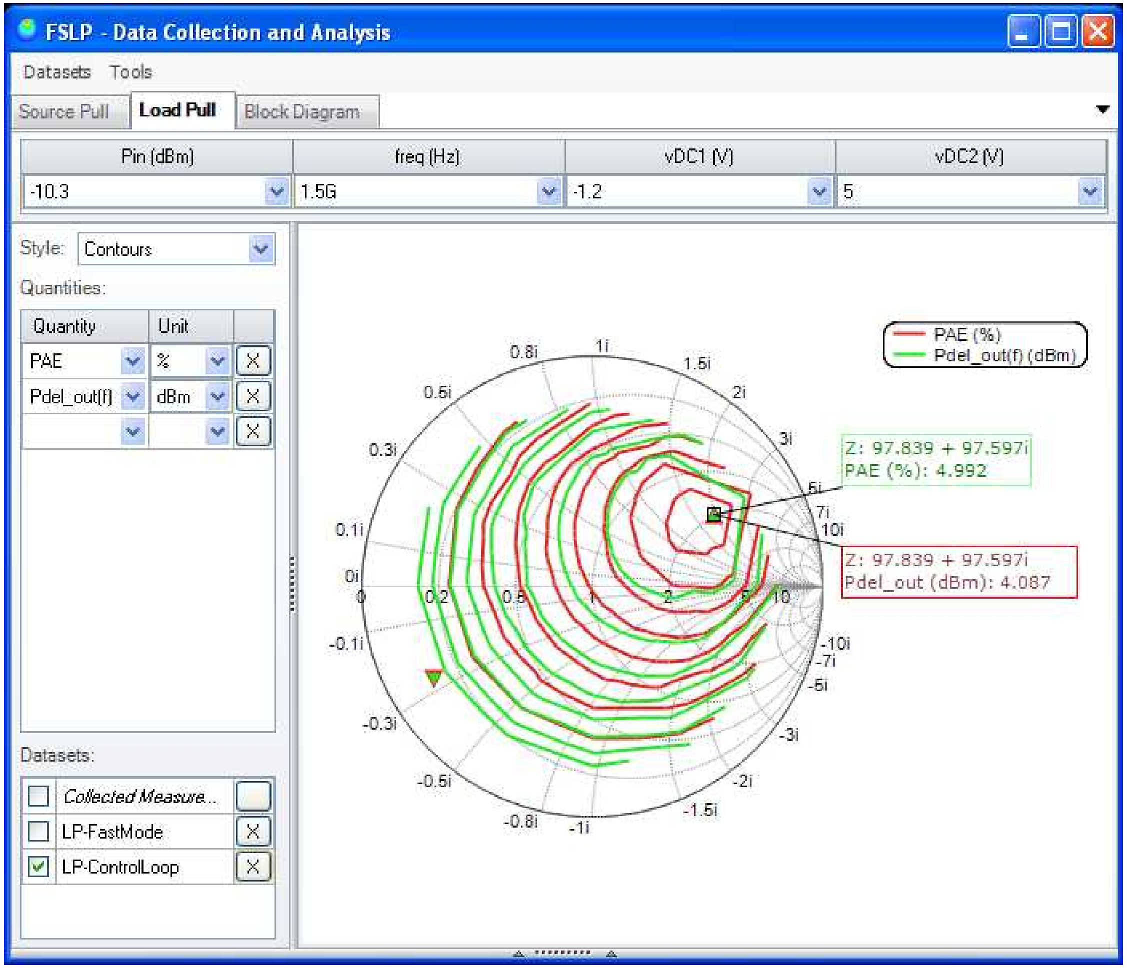
- **# Contour levels**
- **Min (▼) & Max (▲)**
- **Colour Scale to map values**

NMDG

NM600 FSLP Application – Load Pull Display

@ Selected
P_{in}, f_0, Γ_L, v_{DC1}, v_{DC2}

Calculate mathematically

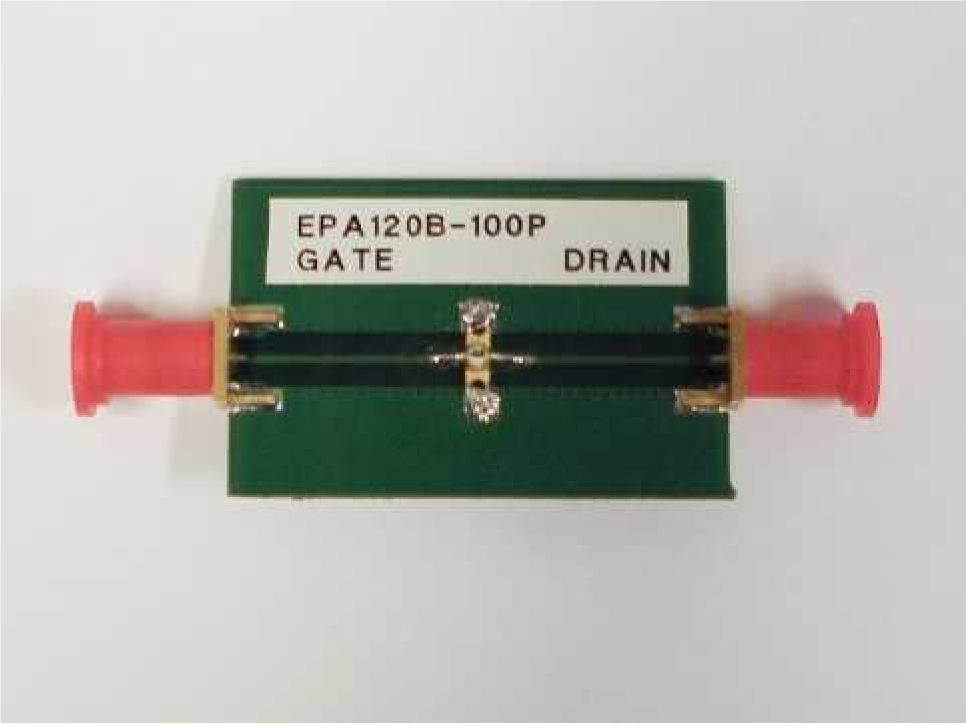


Display
Load Pull Contours

- **# Contour levels**
- **Min (▼) & Max (▲)**
- **One colour per derived qty**

<u>Example:</u> EPA120B-100P

- EPA120B-100P
  - high efficiency heterojunction power FET
  - power output: + 29.0dBm typ.
  - power gain: 11.5dB typ. @ 12 GHz



Source-Pull

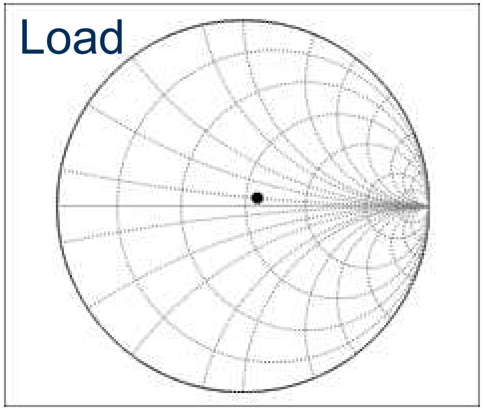
Measure for power sweep P_{in} = -20 to -5 dBm,

F_0 = 1.5GHz

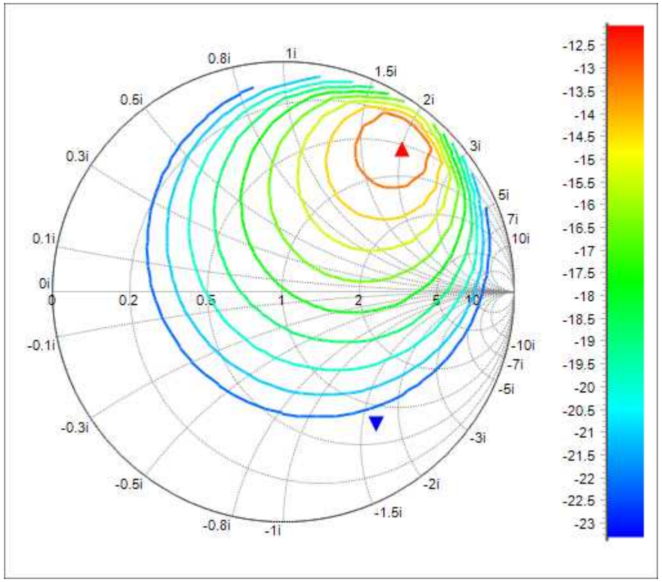
V_g = -1.2V, V_d = 5V

Class AB

Calculated for P_{av} = -12 dBm

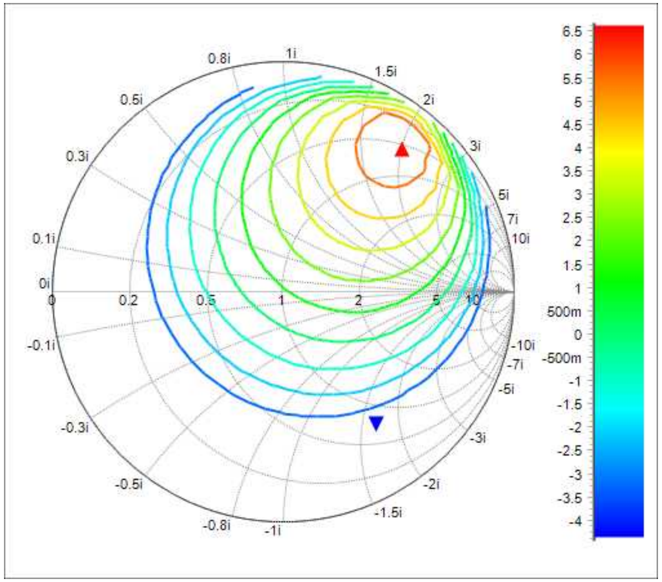


P_{delin}



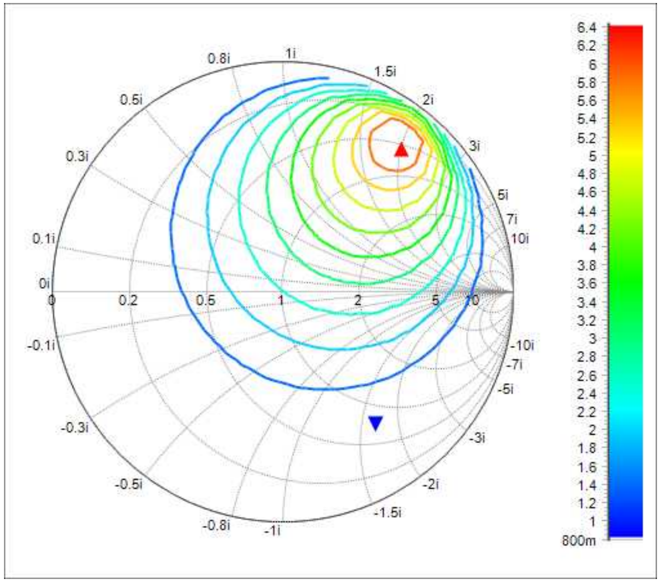
Min = -23.2 dBm
Max = -12.2 dBm
Δ = 1 dB

P_{delout}



Min = -4.6 dBm
Max = 6.6 dBm
Δ = 1 dB

PAE



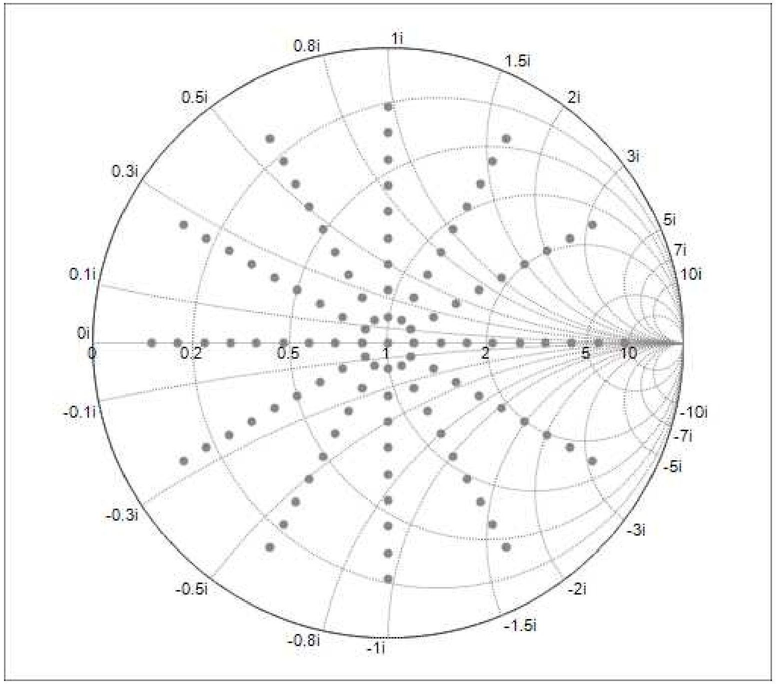
Min = 0.8 %
Max = 6.4 %
Δ = 0.4 %

Load-Pull

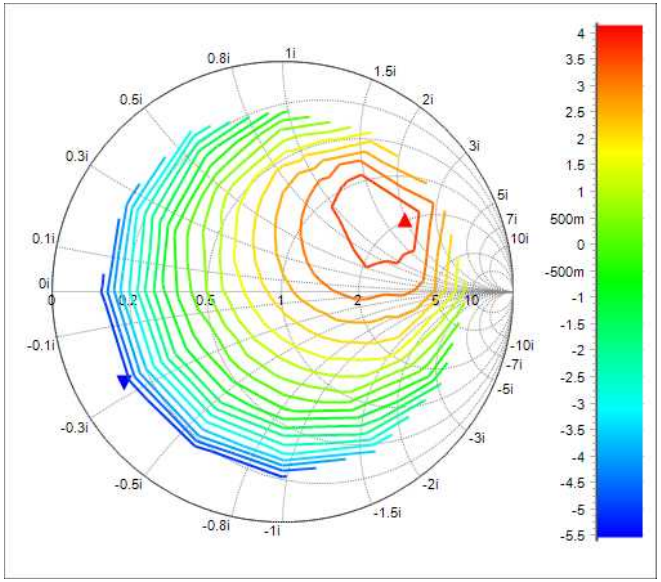
P_{in} = -10 dBm, F_0 = 1.5GHz

V_g = -1.2V, V_d = 5V

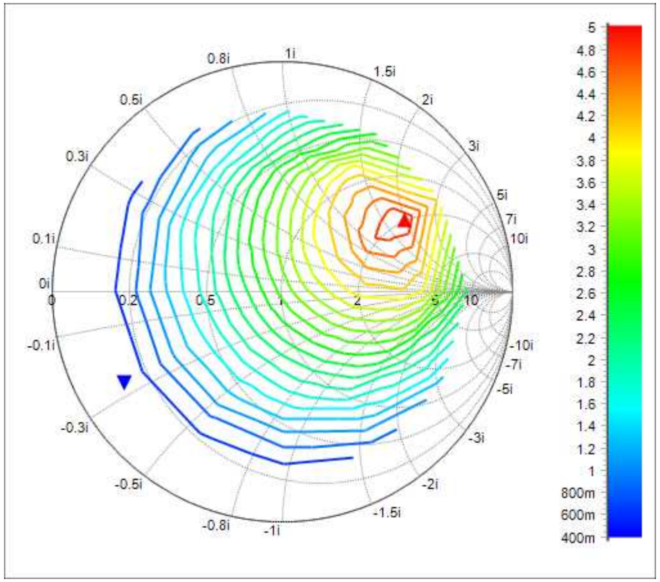
Class AB



Synthesized load impedances
with active injection

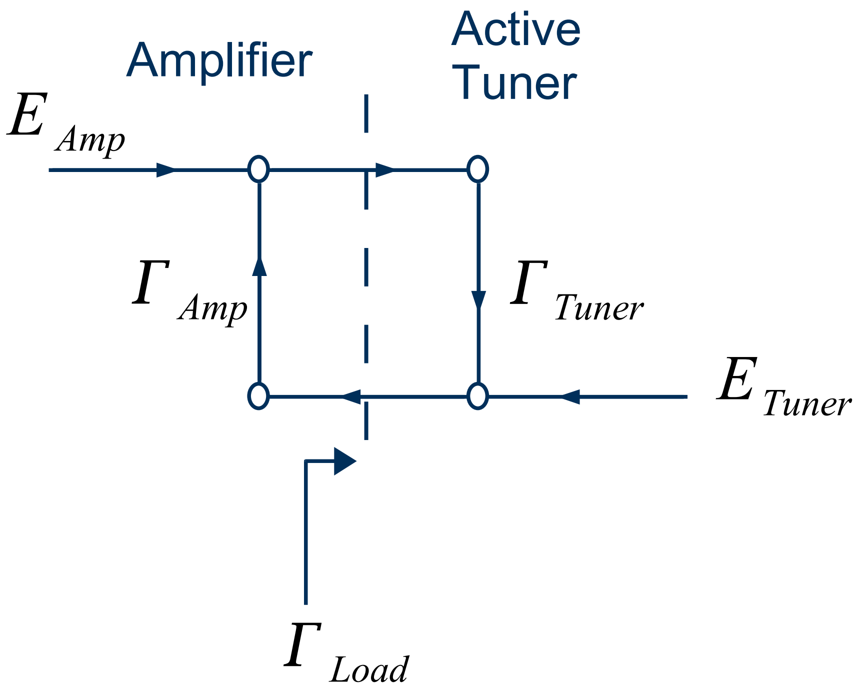


P_{delout}
Min = -5.5 dBm
Max = 4.1 dBm
Δ = 1 dB



PAE
Min = 0.4 %
Max = 5 %
Δ = 0.23 %

A Technical Note: Power Requirements for Active Injection



$$\Gamma_{Load} = \frac{E_{Tuner} + \Gamma_{Tuner} E_{Amp}}{E_{Amp} + \Gamma_{Amp} E_{Tuner}}$$

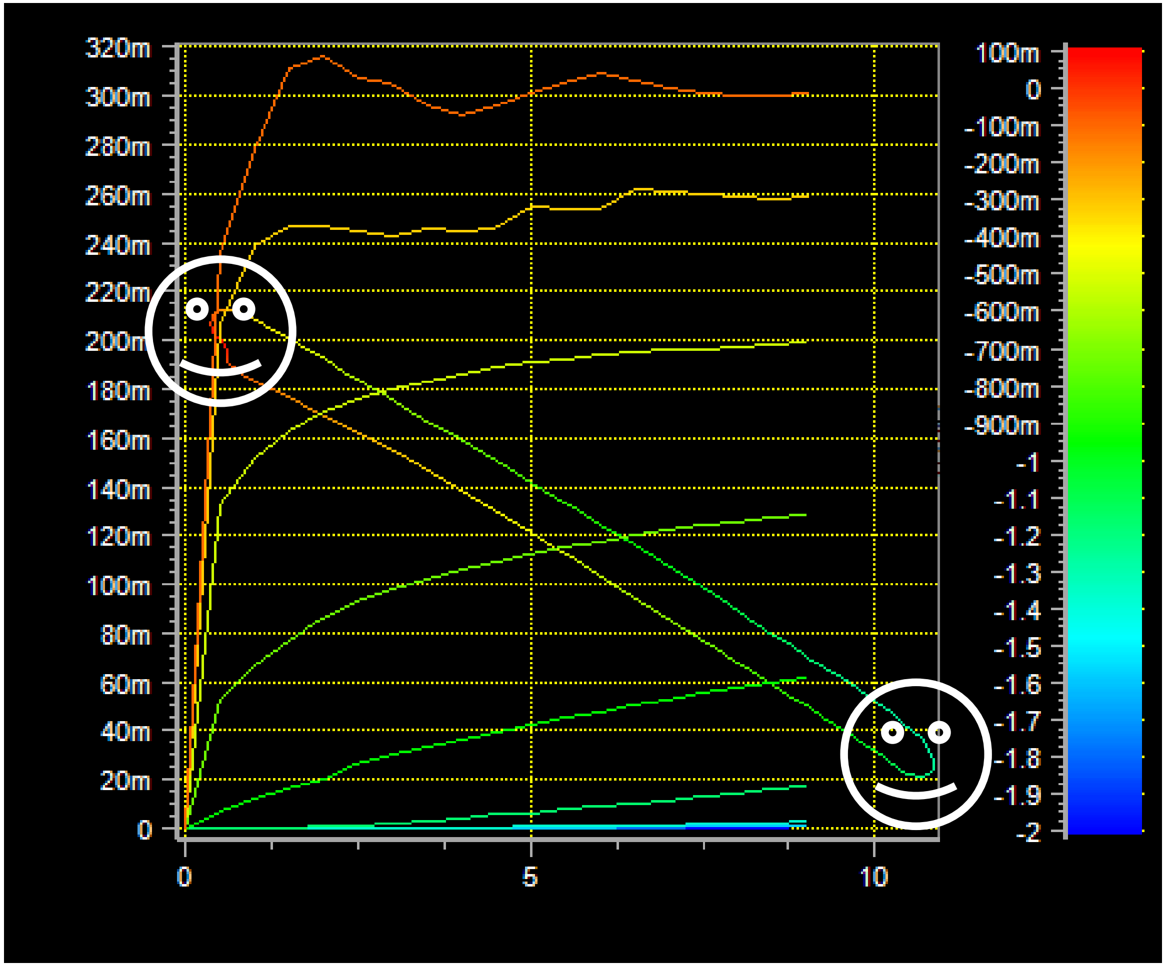
$$\left|\frac{E_{Tuner}}{E_{Amp}}\right| = \left|\frac{\Gamma_{Load} - \Gamma_{Tuner}}{1 - \Gamma_{Amp}\Gamma_{Load}}\right|$$

If perfect circulator: $\Gamma_{Tuner} = 0$

$$\Gamma_{Load} = \frac{E_{Tuner}}{E_{Amp} + \Gamma_{Amp} E_{Tuner}}$$

$$\left|\frac{E_{Tuner}}{E_{Amp}}\right| = \left|\frac{\Gamma_{Load}}{1 - \Gamma_{Amp}\Gamma_{Load}}\right| \quad \xrightarrow{\Gamma_{Load} = 1} \quad \left|\frac{E_{Tuner}}{E_{Amp}}\right| = \left|\frac{1}{1 - \Gamma_{Amp}}\right|$$

Getting more insight...



Dynamic Load line including Harmonics with the NM300 ZVxPlus

Conclusion

The NM600 FSLP Application enables fundamental Source and Load Pull using only a VNA

It is fast, simple, low-cost and accurate

For more information info@nmdg.be

www.nmdg.be

Want to try?

Contact us

at

icesupport@nmdg.be