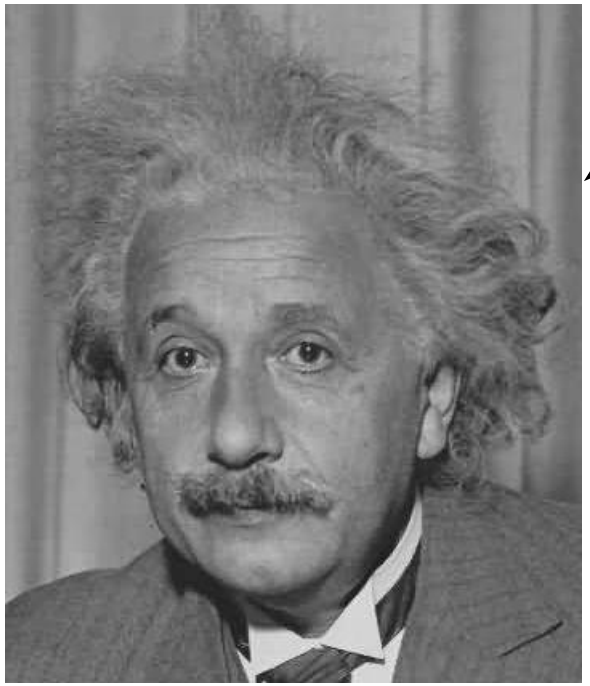
Avoiding common pitfalls when going beyond S-parameters.

A 5-minute intermezzo

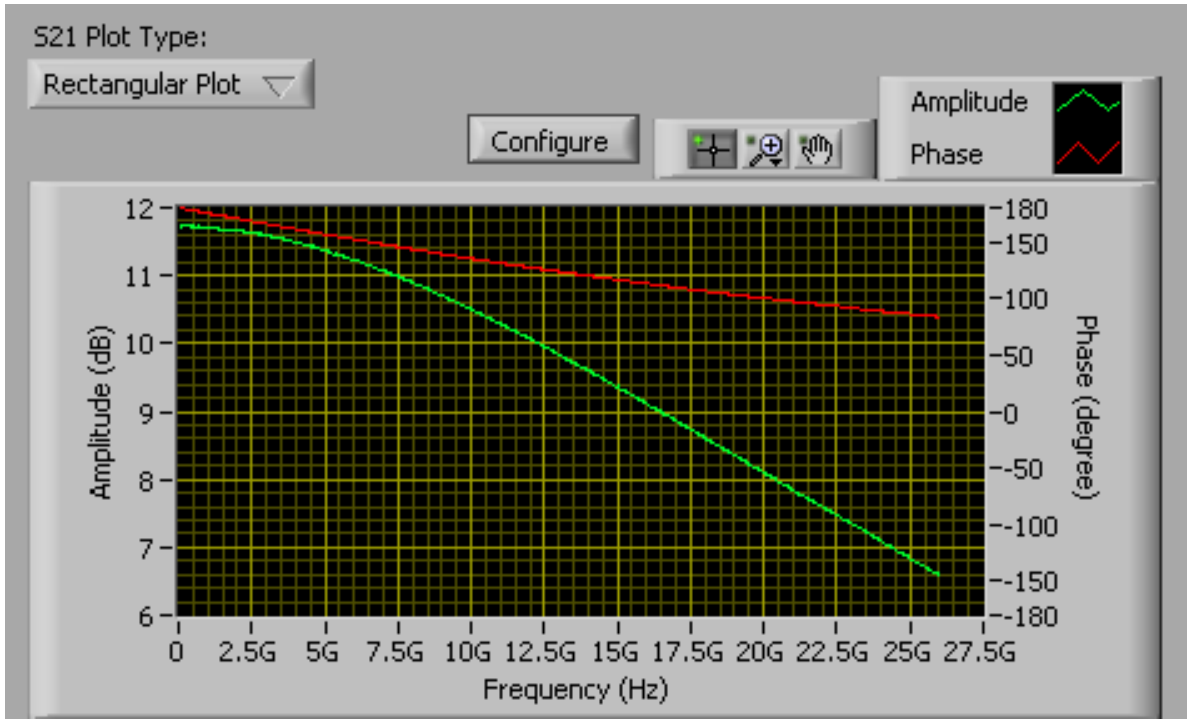
"Experts may leave the room."



S-par measurement #1

FET
$V_G = -0.8\ V$
$V_D = 2.0\ V$
$i_D = 22\ mA$

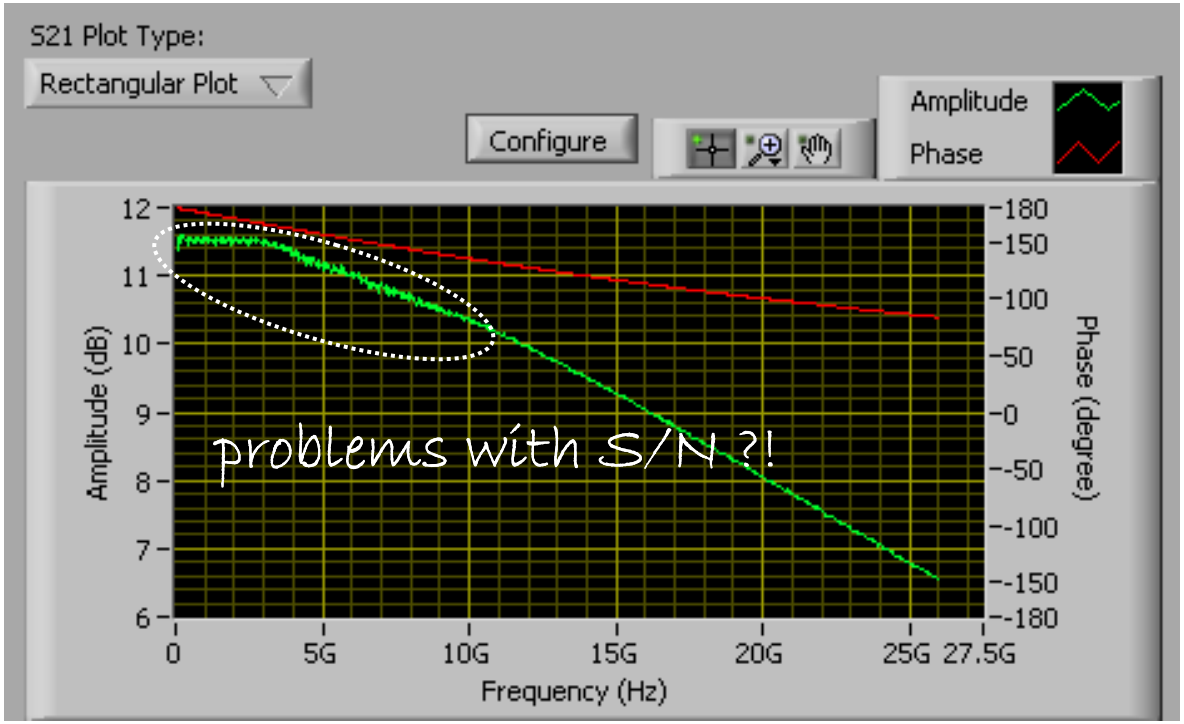
S_{21} source -20 dBm



50 MHz – 26 GHz (50 MHz spacing)

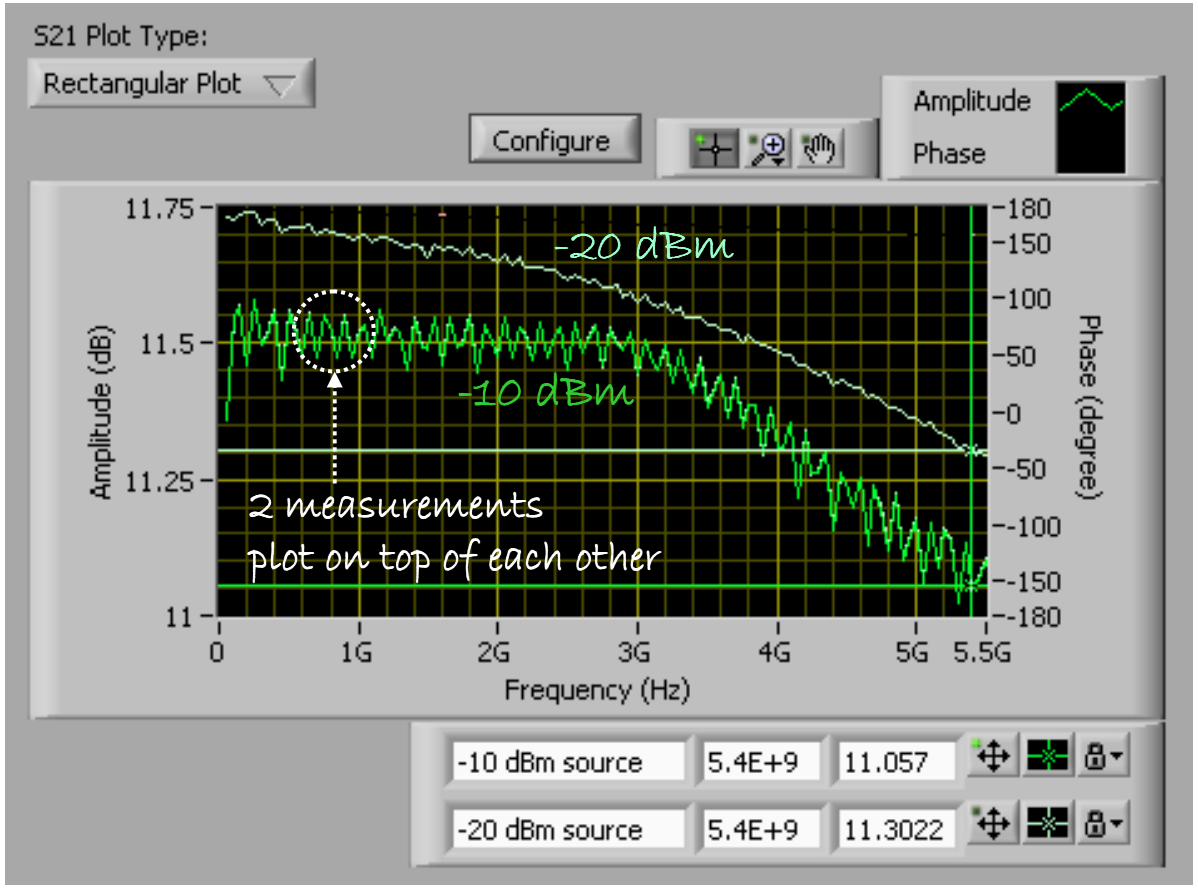
S-par measurement #2

S_{21} source -10 dBm



Zooming into difference

S_{21} source -10 vs -20 dBm



Lesson #1

Nonlinear behaviour
shows up in
S-parameter measurements
as
"deterministic noise".

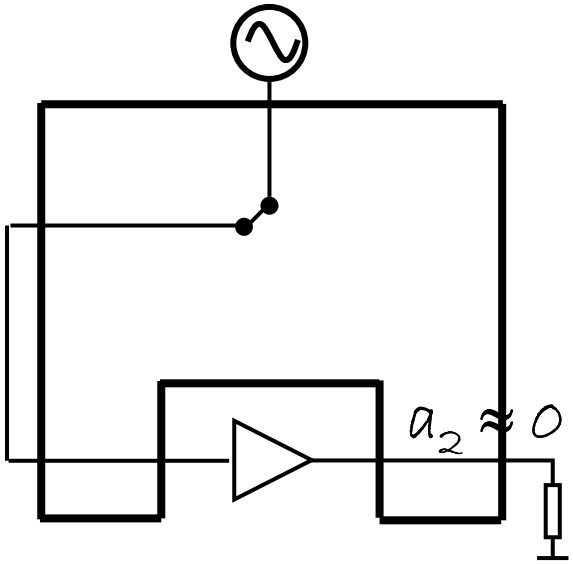
LSNA versus VNA mode

small - signal

LSNA

1.8 GHz – 10 harmonics

SOLT, PWM, HPR



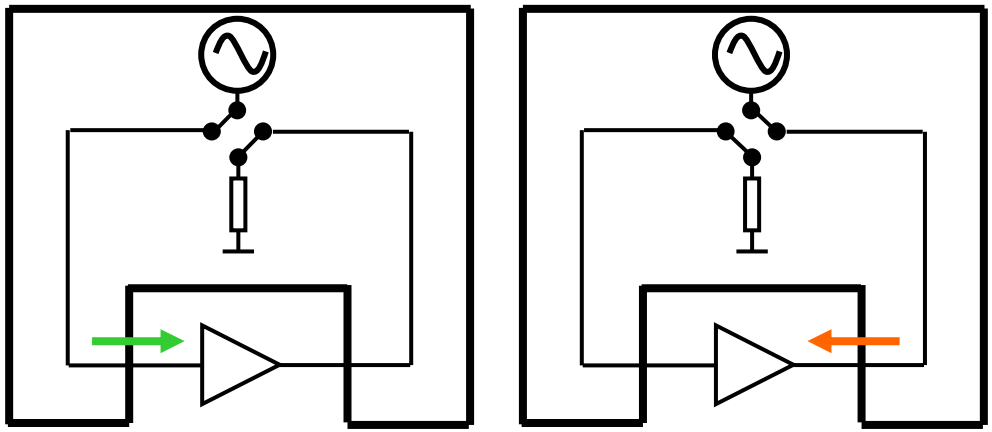
measure a_1, b_1, a_2, b_2 @ fund+harm

$S_{21} = b_2/a_1$ @ relevant freq

VNA

50 MHz – 26 GHz (50 MHz spacing)

SOLT



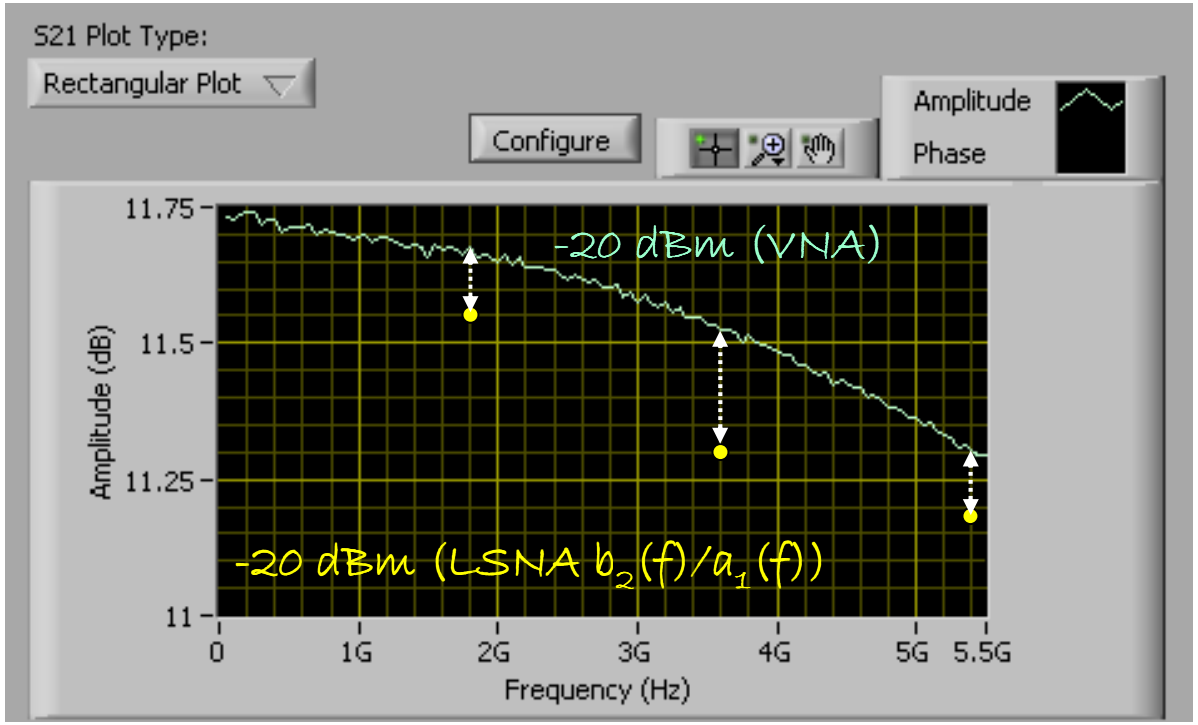
"forward" "reverse"

$$b_1 = S_{11}.a_1 + S_{12}.a_2$$
$$b_2 = S_{21}.a_1 + S_{22}.a_2$$

@ one freq

LSNA versus VNA mode

$b_2(f)/a_1(f)$ test set terminated in 50 Ohm

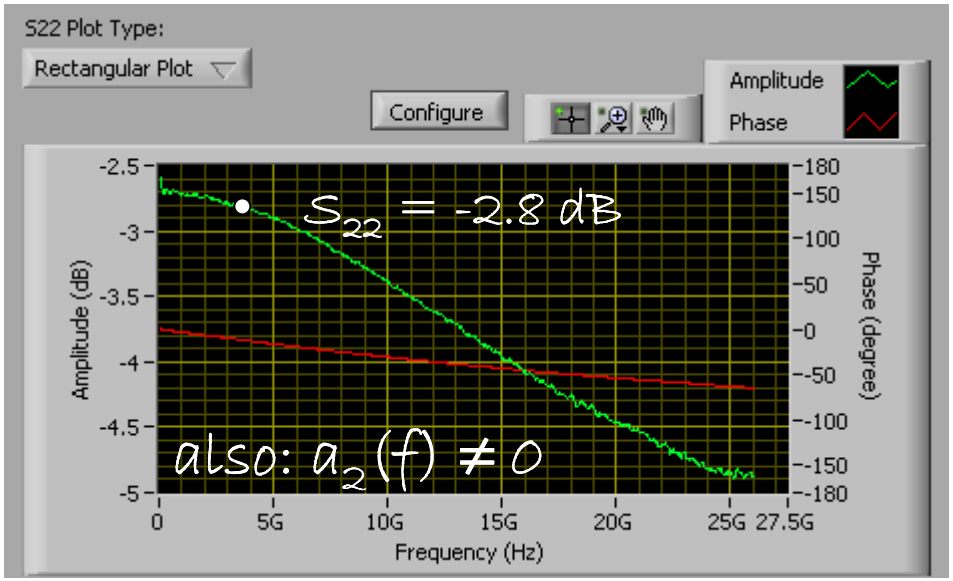


LSNA versus VNA mode

freq (GHz)	S_{21} (VNA) (dB) source -20 dBm	$b_2(f)/a_1(f)$ (LSNA) (dB) test set terminated in 50 Ohm source -20 dBm
1.8	11.68	11.55
3.6	11.53	11.30
5.4	11.30	11.18

0.23 dB discrepancy LSNA/VNA ?!

LSNA versus VNA mode



$$b_2(f) = S_{21}(f) \cdot a_1(f) + S_{22}(f) \cdot a_2(f)$$

LSNA VNA LSNA VNA LSNA

-9.029 dBm -9.030 dBm

Lesson #2

$$b_2(f) = S_{21}(f) \cdot a_1(f) + S_{22}(f) \cdot a_2(f)$$

$$b_2(f)/a_1(f) = S_{21}(f)$$

* if and only if *

$$a_2(f) = 0$$