LNA, PA Testing

- LNA Test Plan
  - Measurements
  - Things to Remember
  - Lab: Develop LNA 3rd Harmonic Test
- PA Test Plan
  - Measurements
  - Things to Remember
  - Lab: Develop ACPR test for NADC

Mixer Test

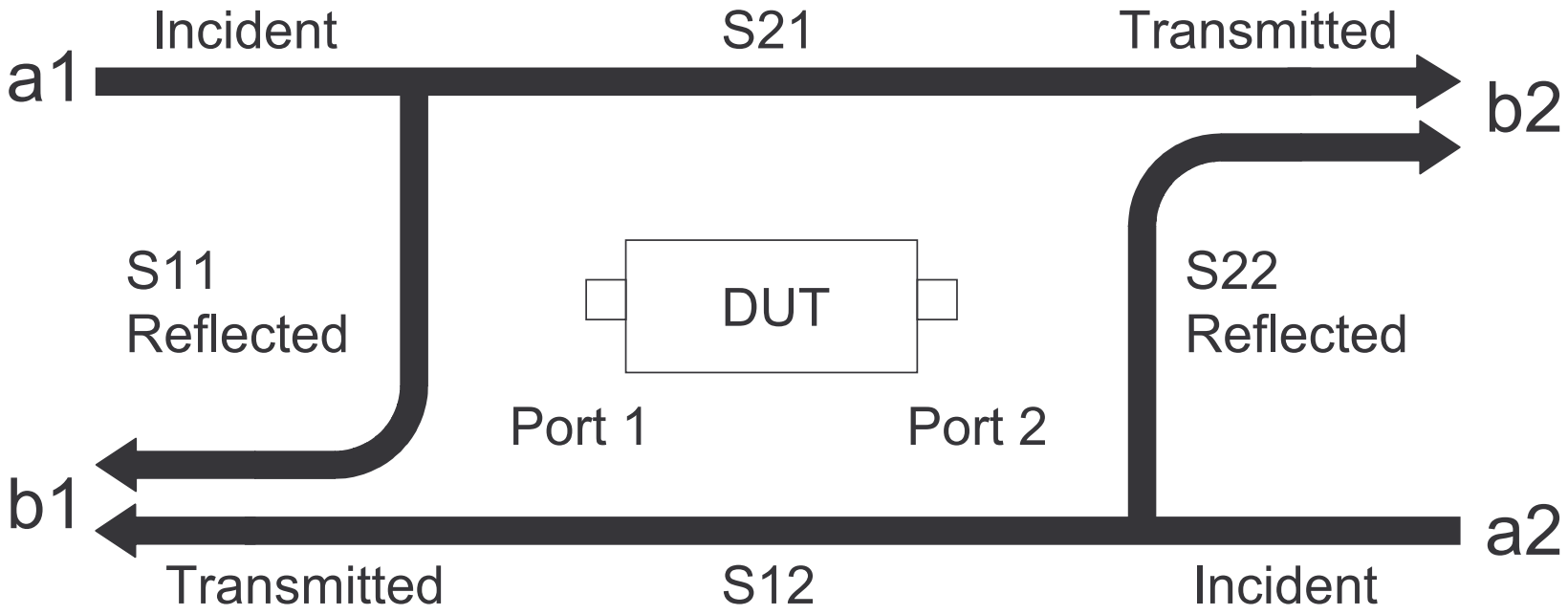
- Mixer Test Plan
  - Measurements
  - Things to Remember
  - Lab: Develop Image Rejection Test

LNA Test Plan
Measurement Notes

S-Parameters

- Forward
- Bi-Directional
- S11 Only

Definition



$$b_1 = S_{11}\, a_1 + S_{12}\, a_2$$

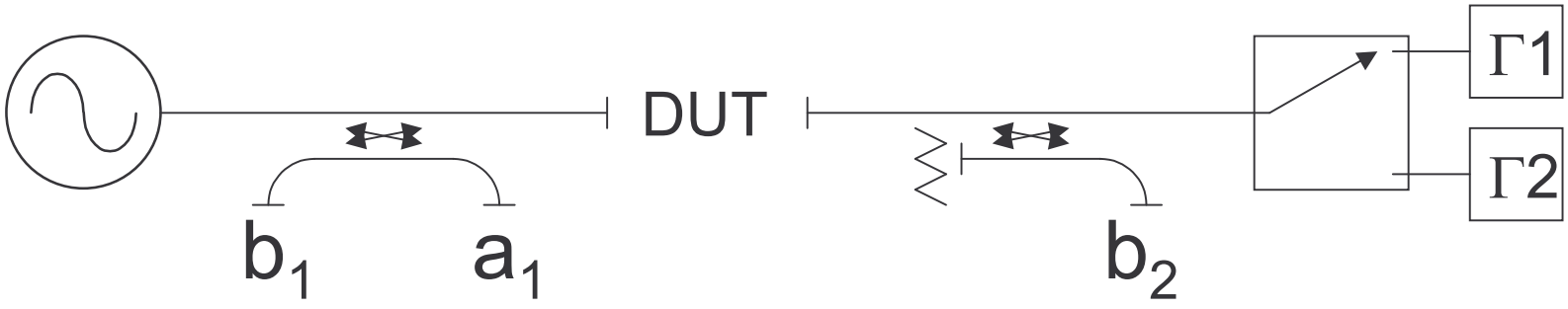
$$b_2 = S_{21}\, a_1 + S_{22}\, a_2$$

Forward or Unidirectional

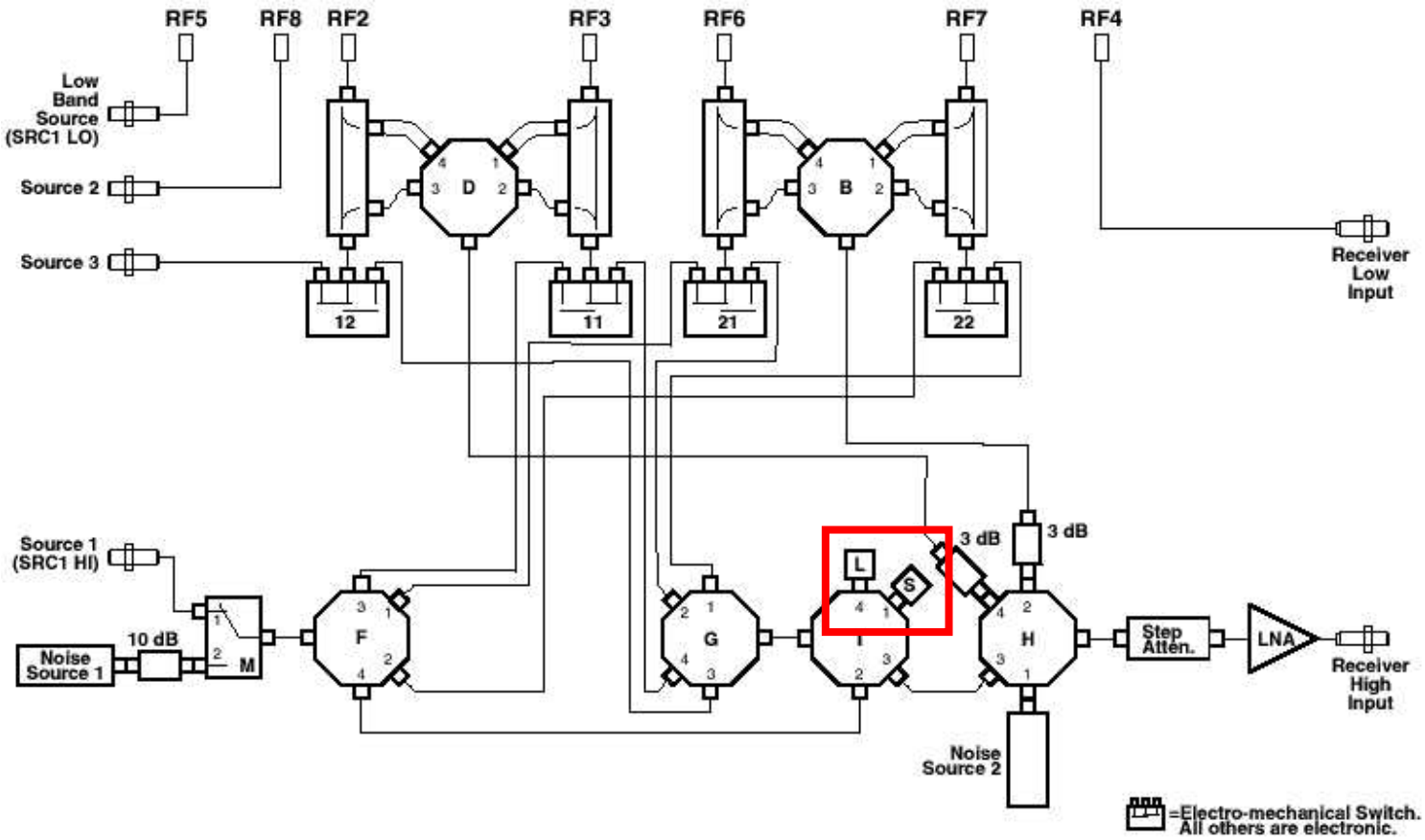
- Fastest method
- 6 Vector Measurements
- No Source Switching
- Allows "Hot" S_{22}
- Default RI Method

Forward Method

- Measure a_1, b_1 and b_2 terminated with known Γ_1 and again with known Γ_2.
- Equations infer a_2, and therefore s_{22}



Forward Method

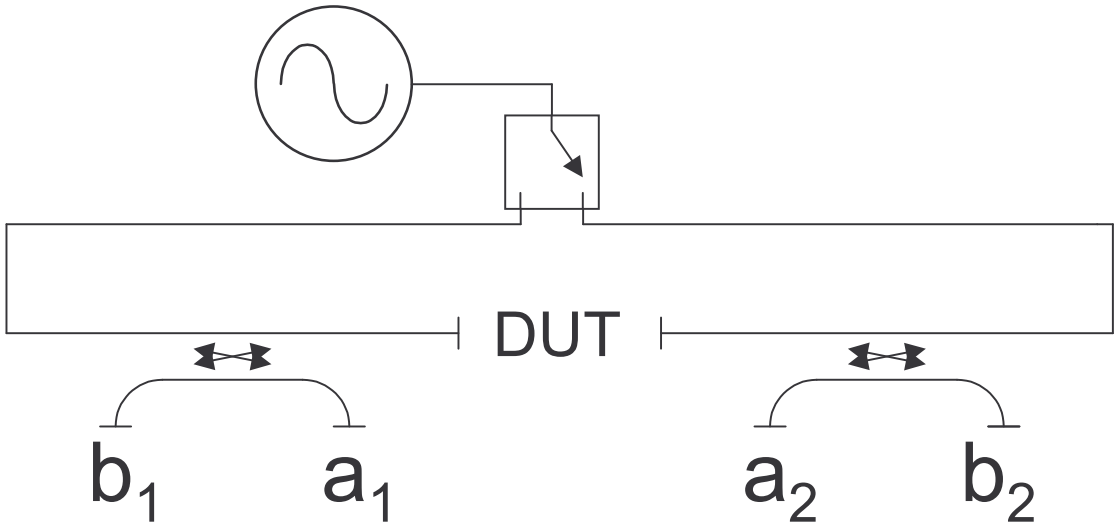


Conventional or Bi-directional

- VNA Method
- 8 Measurements Required
- Slower
- Most Accurate
- Switch Source to Output Side
- No Hot S_{22}

Conventional Method

- Measure a_1, b_1, a_2 and b_2 ; Stimulated forward and reverse



Unidirectional or Bi-directional

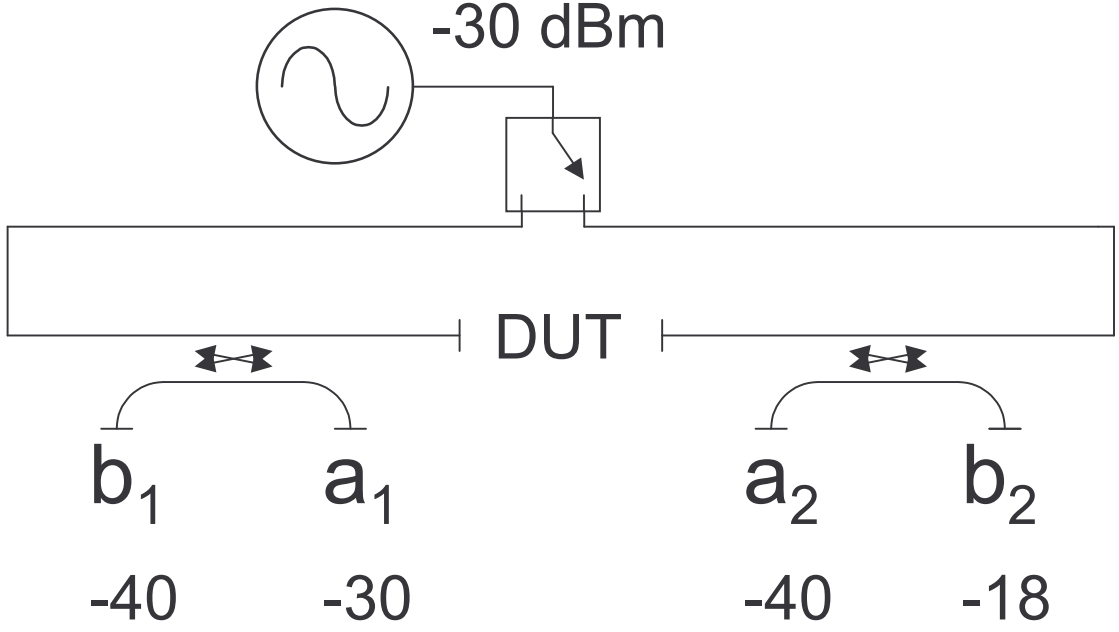
- Use Unidirectional for:
  - Speed
  - Hot S_{22}
- Use Bi-directional for:
  - $S_{22,}$ S_{12} accuracy

High Dynamic Range Devices

- Wave variation > 30 dB (approx.)
- Waves are a1, a2, b1, b2

Typical Device; LNA

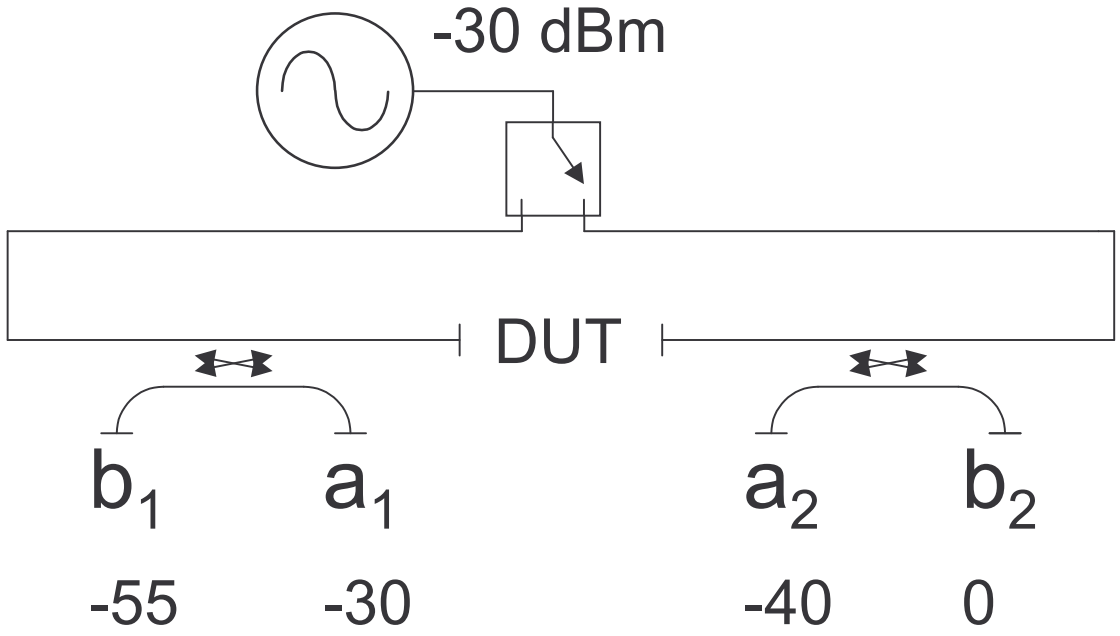
- S21 12 dB
- S11 10 dB
- S12 15 dB
- S22 10 dB



Total Variation 22 dB

High Dynamic Range Device; PA

- S21 30 dB
- S11 10 dB
- S12 25 dB
- S22 10 dB



Total Variation 55 dB

Example HD Devices

- Multi-stage amplifier
- PA
- Limiter
- Filter
- Log Amplifier
- GPS Amplifier

Tester Methods; VNA

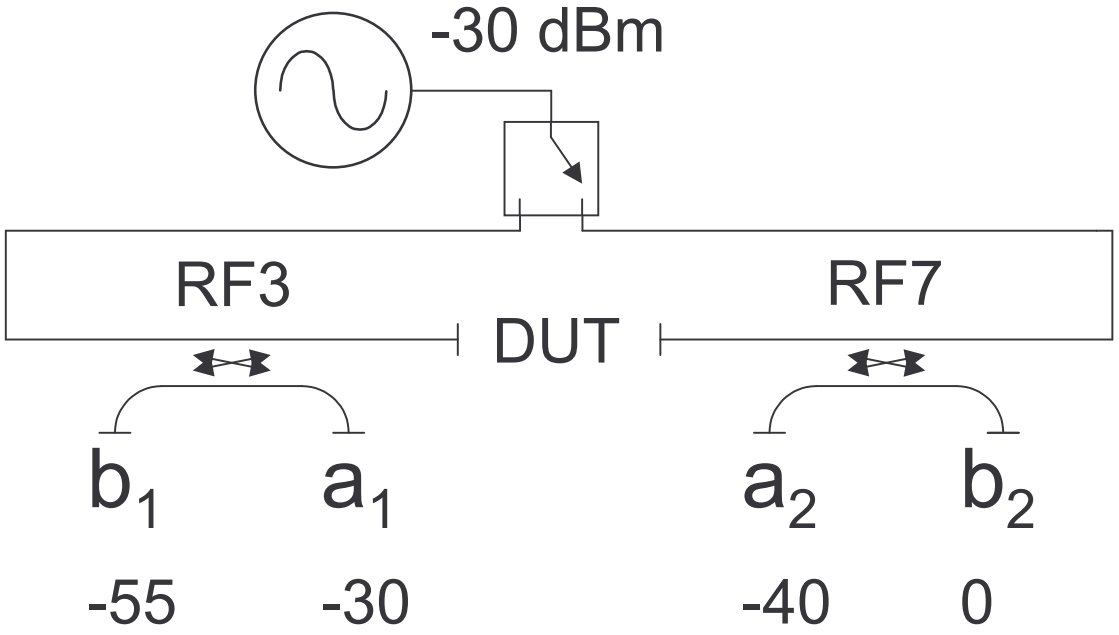
- Measures all four waves
- Same Conditions
  - IF Gain
  - Receive Attenuation
- All waves are used to calculate each S-parameter
- Low dynamic range parameters will be influenced by non-optimized ones

HDD Strategy

- Group according to power variation
- Separate S21 from S12
- Reduce to relevant waves; i.e. S11 only
  - Valid for high dynamic range device
  - If s12 is small; output will not influence input

High Dynamic Range Device; PA

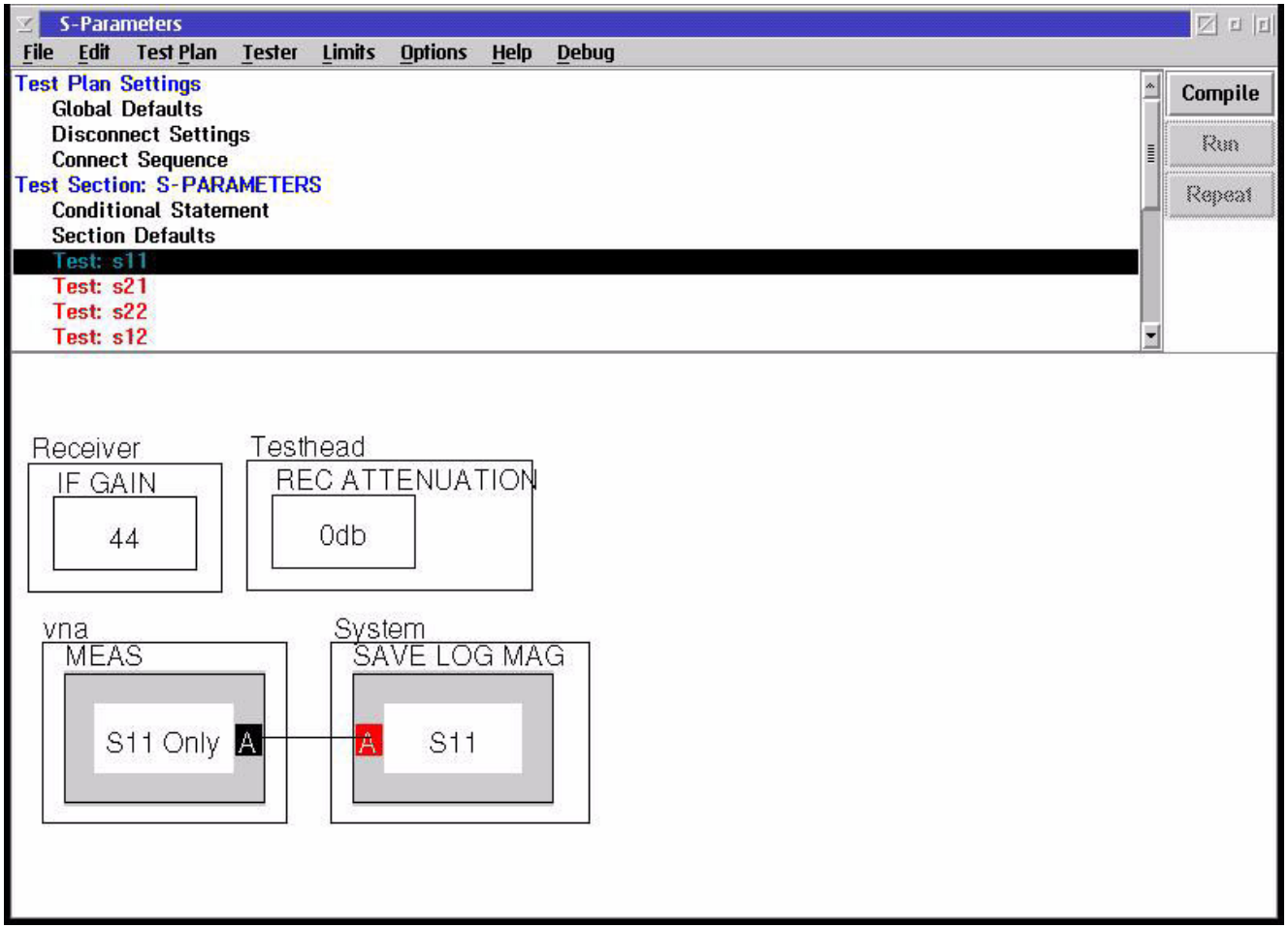
- S21 30 dB
- S11 10 dB
- S12 25 dB
- S22 10 dB



Total Variation 55 dB

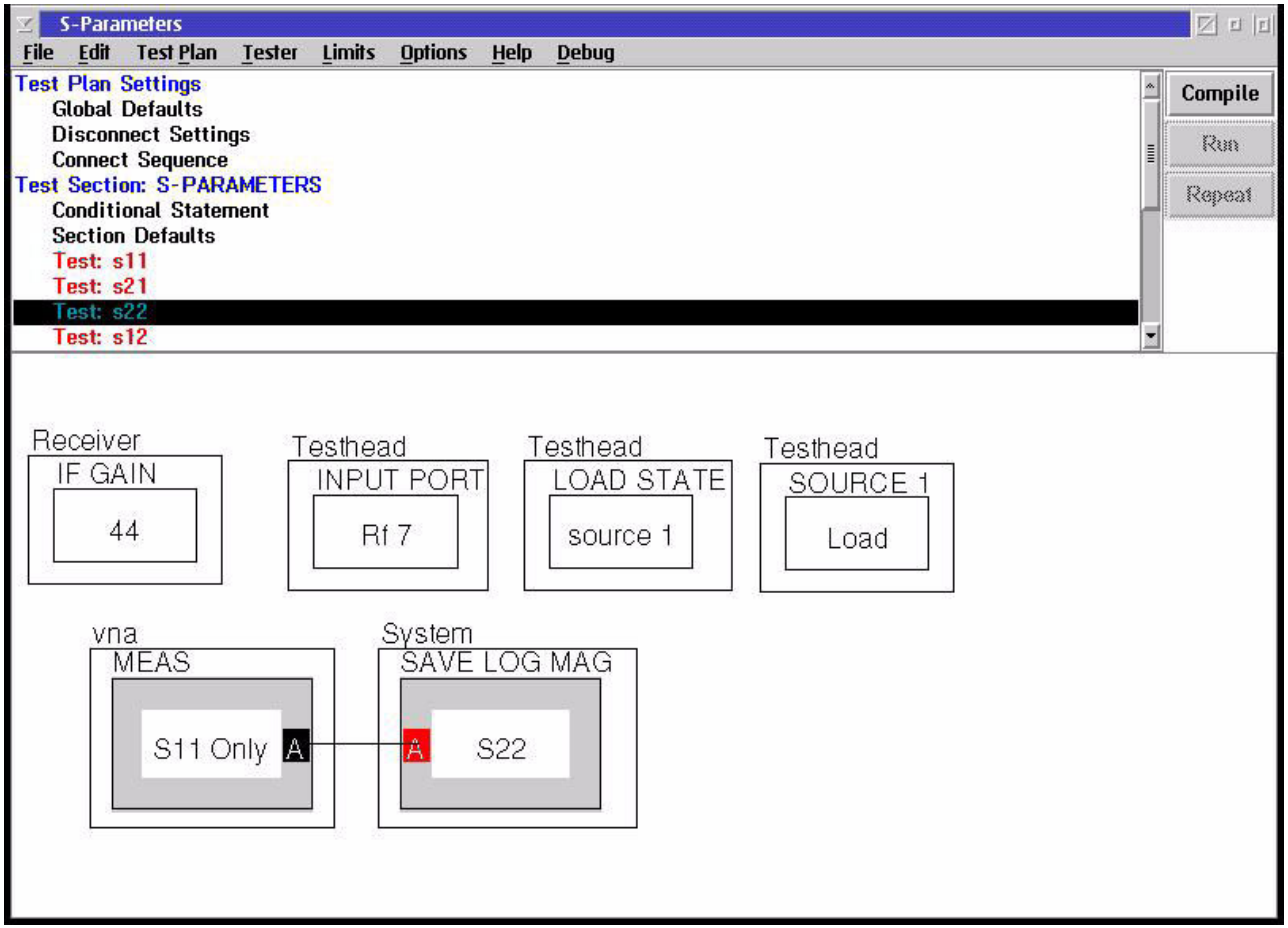
S11

- S11 Only

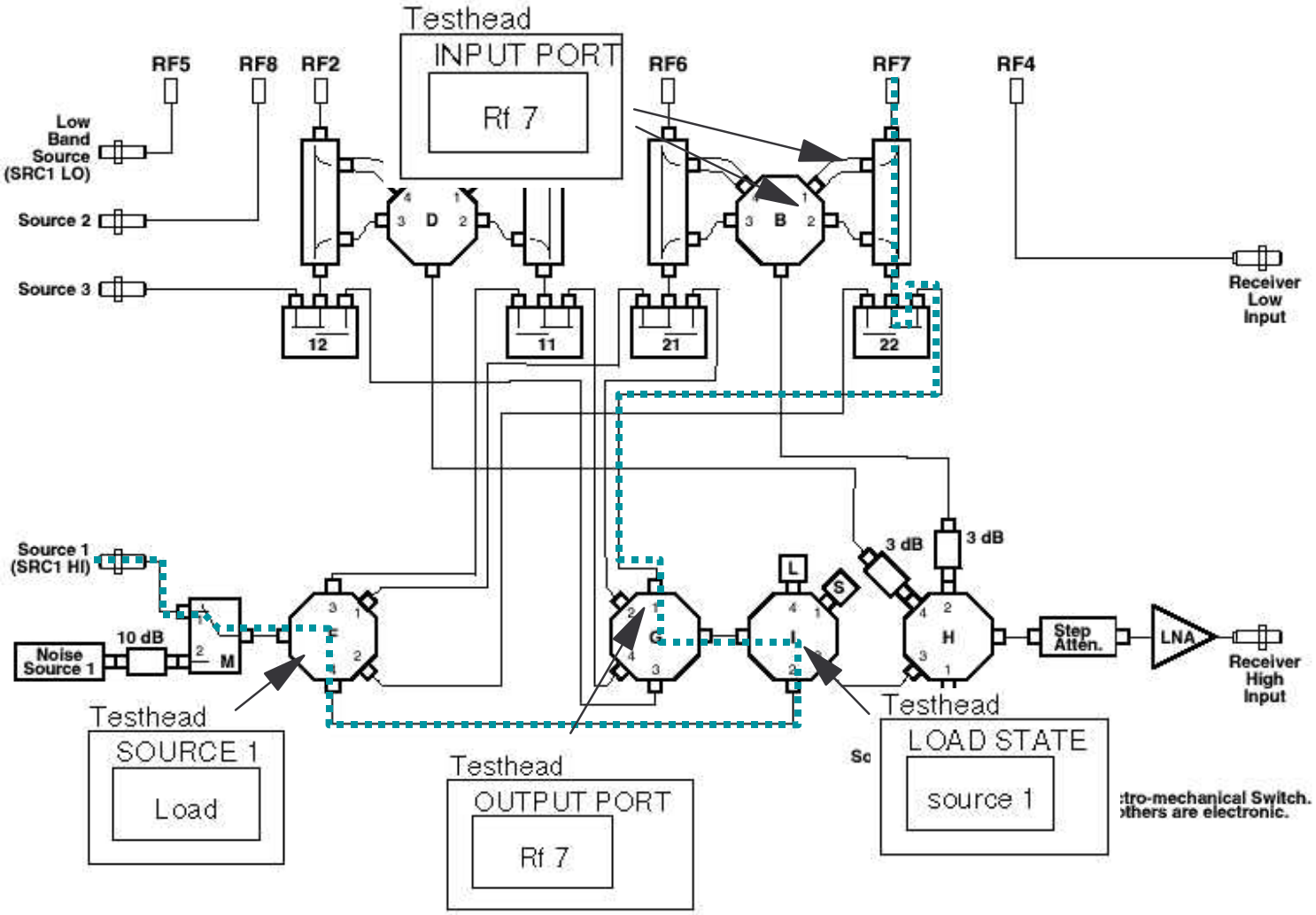

S-Parameters
File Edit Test Plan Tester Limits Options Help Debug
Test Plan Settings
Global Defaults
Disconnect Settings
Connect Sequence
Test Section: S-PARAMETERS
Conditional Statement
Section Defaults
Test: s11
Test: s21
Test: s22
Test: s12
Compile
Run
Repeat
Receiver
IF GAIN
44
Testhead
REC ATTENUATION
0db
vna
MEAS
S11 Only
A
System
SAVE LOG MAG
A
S11

S22

- Back Door

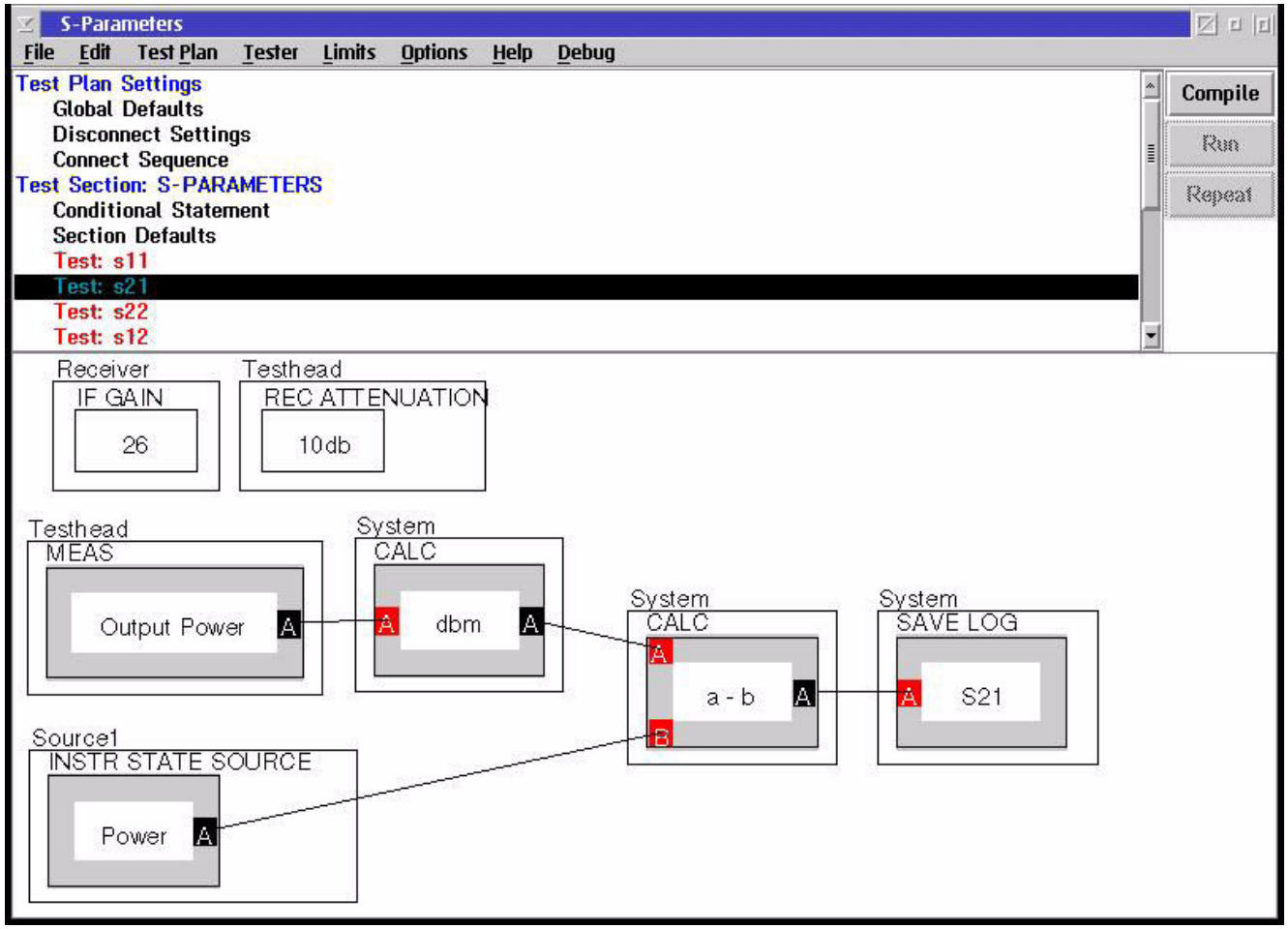


Back Door Path



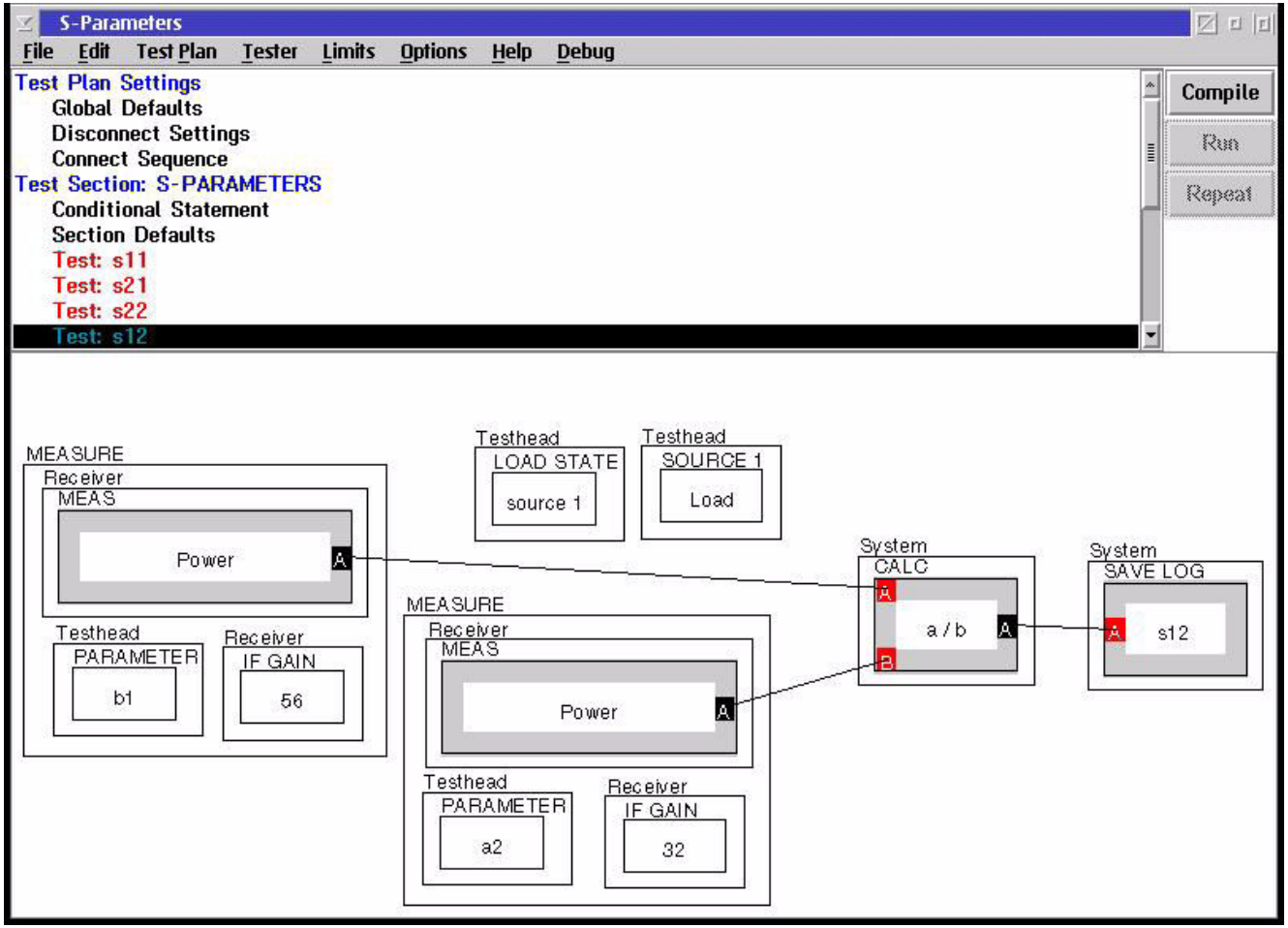
S21

- Only Meas Pout
- Vector Correct for output match



S12

- b1, a2
- back door

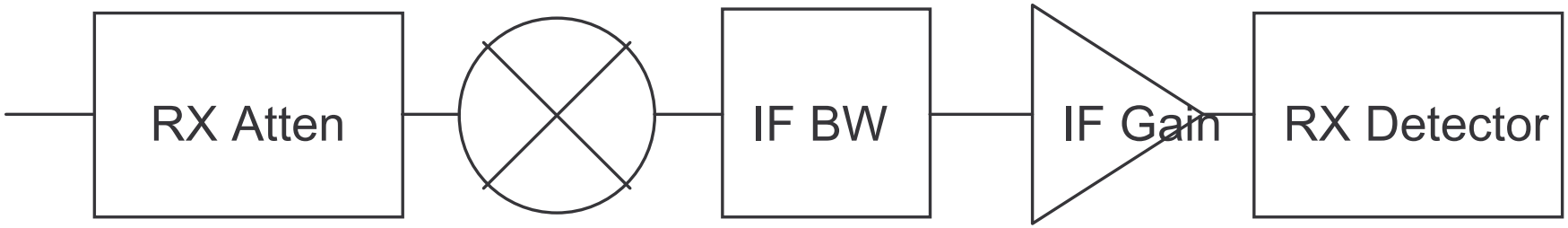


System Gain Adjustment

- Receive Attenuation
- IF Gain
- Signal Dependent
  - Single tone
  - Multi tone
- Measurement Repeatability

Simplified Diagram

- Receive Attenuator
- Mixer
- IF Filter
- IF Amplifier
- Receiver Detector



System Sensitivities

- RI 7100A Receiver Mixer
  Saturate (Compression)
  Generate Intermodulation Distortion

- Receiver Detector
  Compression
  "Fold-over"

Single Tone Measurements

- RF Power, S-Parameters, Noise Figure
- Objectives
  - Maximize Power to Receiver
  - Maximize Power to Mixer
  - Set Appropriate IF Gain

Single Tone Method

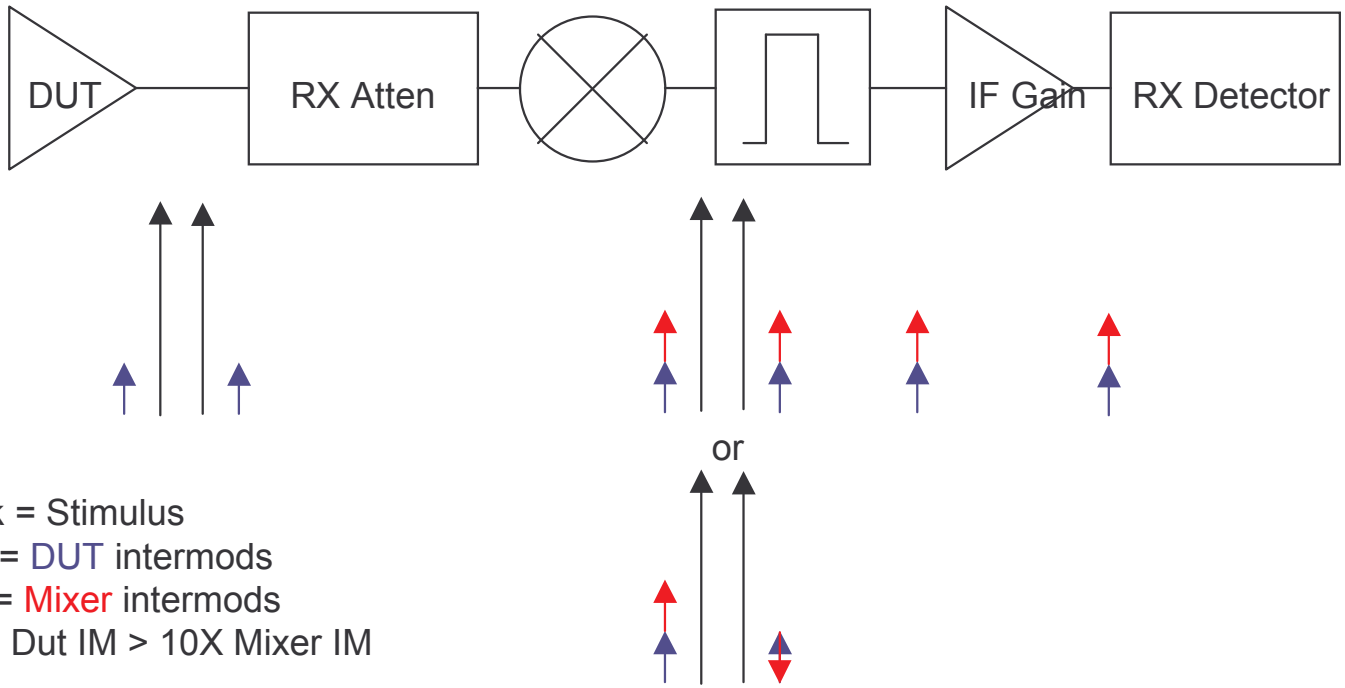
- Set IF Gain to 20 dB or Lower
- Reduce Rx Atten Until Error Message
- Backoff One Rx Atten Setting
- Increase IF Gain Until Error Message
- Backoff One IF Gain Setting

Multi-Tone Measurements

- IM3/5/7 and ACPR
- Measure Device not Tester's Mixer
- Operate in the Mixer's Linear Range
- The Mixer Can Add to or Subtract from the Measurement

Mixer Intermods

- Receive Attenuator Controls Mixer IM Performance and System Noise Floor



Multi-Tone Method

- Measuring Main Tone(s)
  - Not Sensitive to Mixer IMs
  - Use Method for Single Tone
- Measuring IM & ACPR Tones
  - Sensitive to Mixer's IM performance
  - IF Gain usually at or near Maximum (Minimize noise floor)
  - Verify with Spectrum Analyzer (SA)
  - Be careful of SA's intermods!

Measure IM Tone

- Set IF Gain 50/55; Receive Atten 20 dB
- Measure C/I
- Verify with Spectrum Analyzer
  - Go to break point
  - Set Receive input to Aux out
  - Measure C/I
- If Different, Increase RF Attenuator
- Repeat

IM Considerations

- Verify High and Low IM Tones
- Use Highest Linear Power DUT Condition
- Typically 20 dB Rx Atten, 55 dB IF Gain
- Too Much Rx Atten Raises Noise Floor

LNA Test Plan Lab: Develop 3rd Harmonic Test

- RF Input Level = -5 dBm
- RF Input Frequency = 960 MHz
- 3rd Harmonic Spec. Approx. -35 dBc
- Device Gain Approx. +10 dB
- Calc 3rd Harmonic in dBc
- Extra Credit:
  Find 3rd Harmonic at +5 dBm Out

LNA Test Plan Measurement Results

'LNA_class_example_revC' Statistics (Limits: None)

View Inspect Help

	Mean	Std. Dev.	%SD	Min	Max
Igc	-93.046e-9	3.1238e-9	3.3573	-98.540e-9	-86.596e-9
IDD	41.649e-3	20.929e-6	50.251e-3	41.602e-3	41.692e-3
Gain	11.598	17.256e-3	148.78e-3	11.556	11.642
S11	-17.993	78.813e-3	438.01e-3	-18.126	-17.836
S22_rev_path	-12.699	35.531e-3	279.79e-3	-12.780	-12.642
Gain_sweep@Frq:925.0	11.598	17.256e-3	148.78e-3	11.556	11.642
Gain_sweep@Frq:942.5	11.528	14.648e-3	127.06e-3	11.497	11.559
Gain_sweep@Frq:960.0	11.545	12.846e-3	111.27e-3	11.513	11.568
Gain_flatness	72.447e-3	22.371e-3	30.879	26.911e-3	127.23e-3
Target_gain	10.812	16.841e-3	155.75e-3	10.776	10.852
NF	4.9934	94.232e-3	1.8871	4.7280	5.1111
Gain_vs_power@Pwr:-10.0	11.700	13.838e-3	118.27e-3	11.679	11.724
Gain_vs_power@Pwr:-8.0	11.659	14.985e-3	128.53e-3	11.632	11.685
Gain_vs_power@Pwr:-6.0	11.528	16.130e-3	139.92e-3	11.508	11.558
Gain_vs_power@Pwr:-4.0	11.371	13.093e-3	115.14e-3	11.346	11.392
Gain_vs_power@Pwr:-2.0	11.003	13.649e-3	124.04e-3	10.979	11.036
Gain_vs_power@Pwr:0.0	10.292	13.276e-3	128.99e-3	10.263	10.316
P1dB	9.3487	27.106e-3	289.95e-3	9.2988	9.4005
Pi1dB	-1.4638	34.321e-3	2.3447	-1.5426	-1.3992
OIP3	23.674	241.68e-3	1.0209	23.139	24.244
IIP3	12.121	241.28e-3	1.9906	11.554	12.664
pout_search@Pwr:-10.0	1.5544	13.655e-3	878.47e-3	1.5230	1.5783
pout_search@Pwr:-8.0	3.5223	13.811e-3	392.10e-3	3.4965	3.5460
pout_search@Pwr:-6.0	5.3906	16.722e-3	310.20e-3	5.3652	5.4218
pout_search@Pwr:-4.0	7.2330	15.070e-3	208.35e-3	7.2015	7.2673
pout_search@Pwr:-2.0	8.9052	15.307e-3	171.89e-3	8.8800	8.9322
pout_search@Pwr:0.0	10.240	15.065e-3	147.12e-3	10.210	10.263
pin_hm3	-6.4181	17.037e-3	265.46e-3	-6.4497	-6.3908
3rd Harm	-42.564	114.69e-3	269.46e-3	-42.781	-42.422
3rd Harmonic (dBc)	-32.564	114.69e-3	352.20e-3	-32.781	-32.422