The HP 8753C Vector Network Analyser (VNA)

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Background

- Norman Stewart GM1CNH recently donated the Society an HP 8753C VNA.
- I have become the custodian of the instrument.
- Covers the frequency range 300 kHz to 6GHz

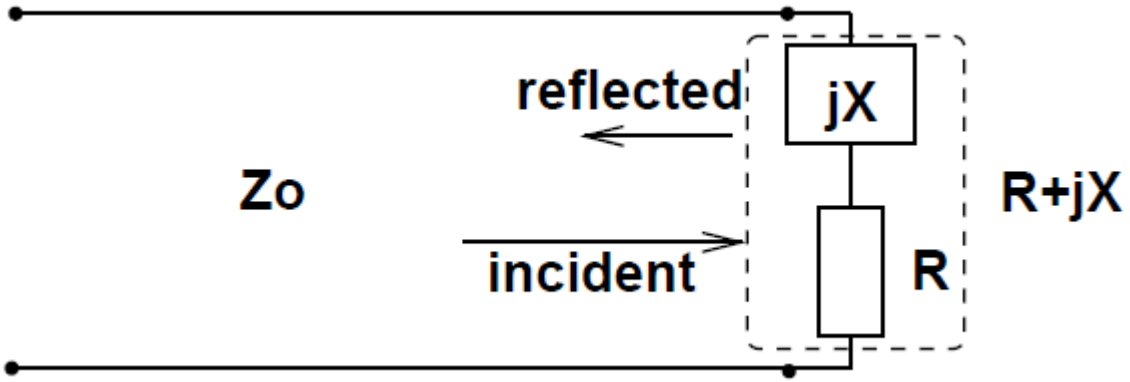
An HP 8753C

What is a VNA ?

- An instrument to measure the reflection and transmission co-efficients of both one and two-port networks.
- Generally coaxial instruments (as opposed to waveguide) so they operate over wide bandwidth.
- Until recently only within the reach of R&D labs. Now coming into the hands of amateurs.

What is a reflection co-efficient?

- Any load on the end of a transmission line will in general reflect some of a signal incident on it.

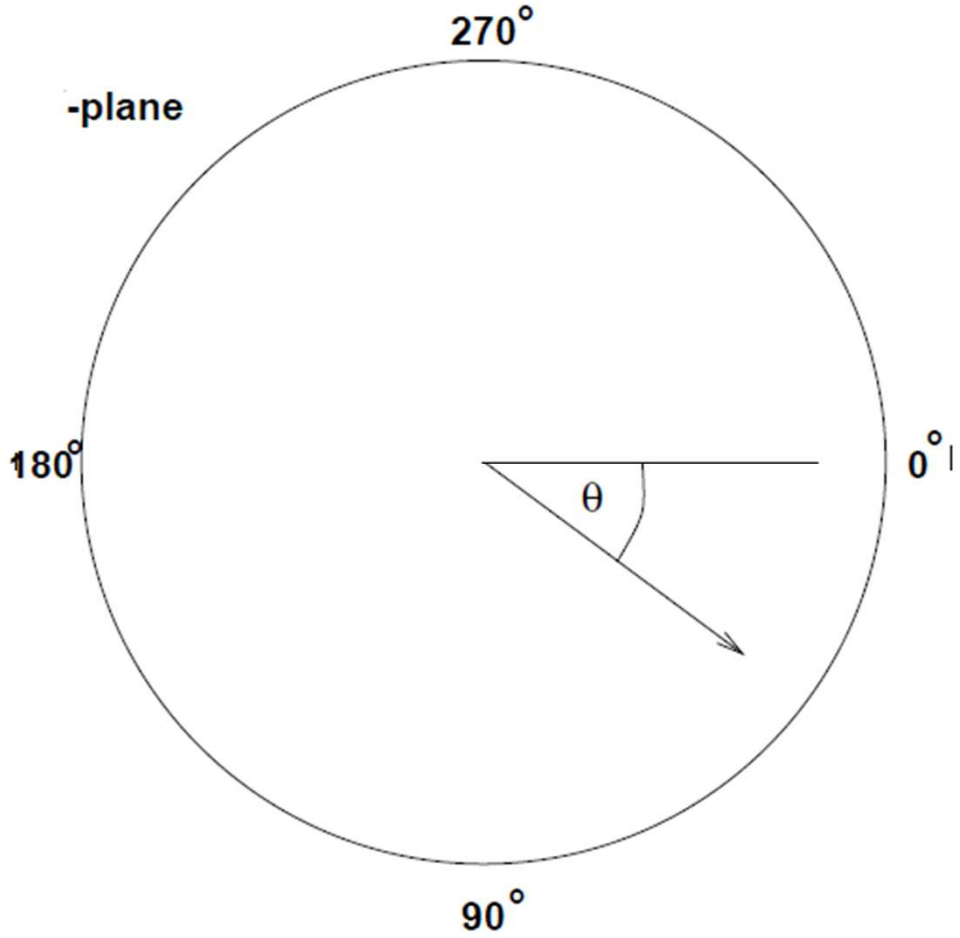


Reflection Co-efficient

- Usually use the Greek symbol rho ρ
- ρ has two parts: (1) a magnitude and (2) a phase shift.
- The magnitude part is simply the fraction of the voltage wave that is reflected.
- The phase angle is the phase shift produced in the reflection process. Loads in general will have a reactive (capacitive or inductive) component.

Reflection Coefficient Polar Graph (or Reflection Coefficient Plane)

ρ -plane



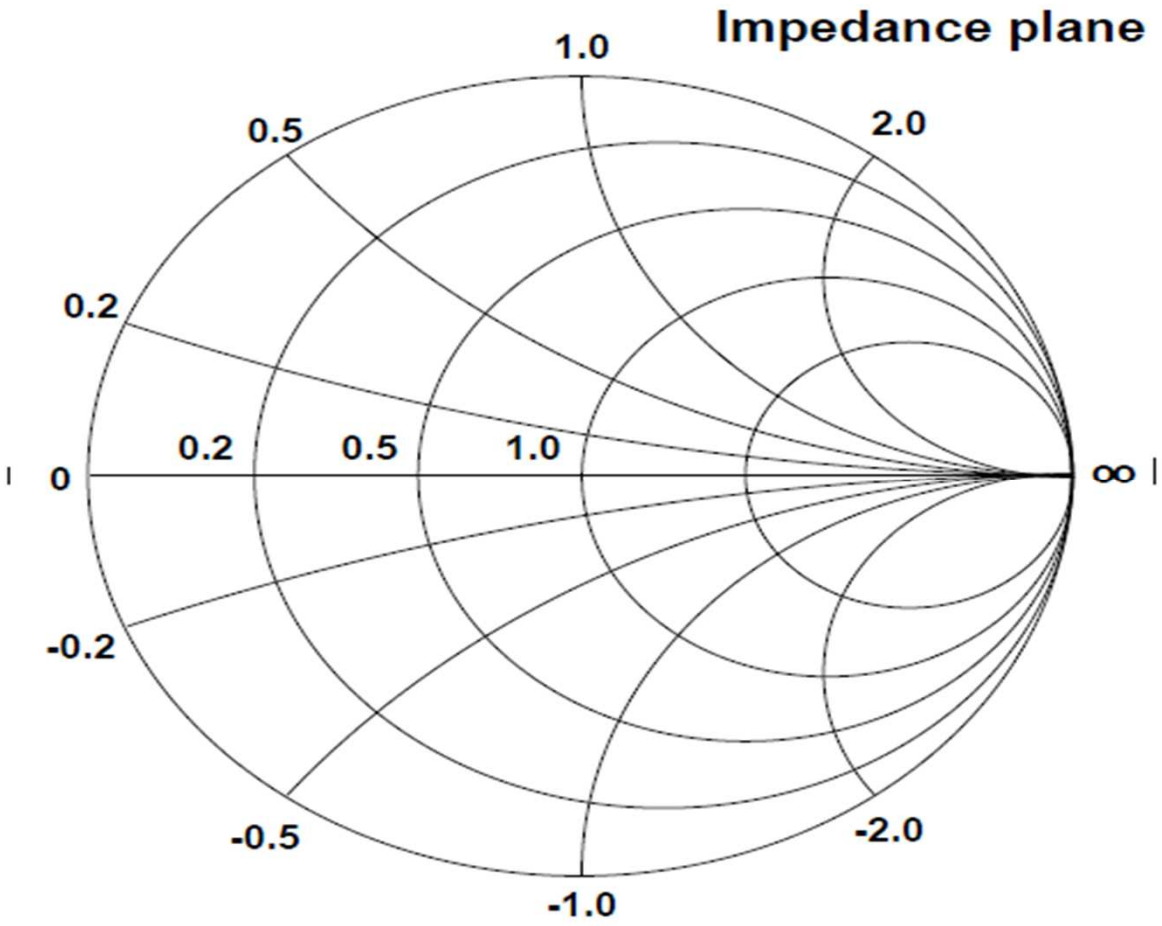
Reflection Coefficient and Impedance.

- For every value of load impedance there will be a unique of reflection coefficient so for every value of load it is possible to compute the reflection coefficient by means of the equation:

$$Z_{in} = Z_o \frac{1+\rho}{1-\rho}$$

- Clearly this is tedious at ρ is complex.

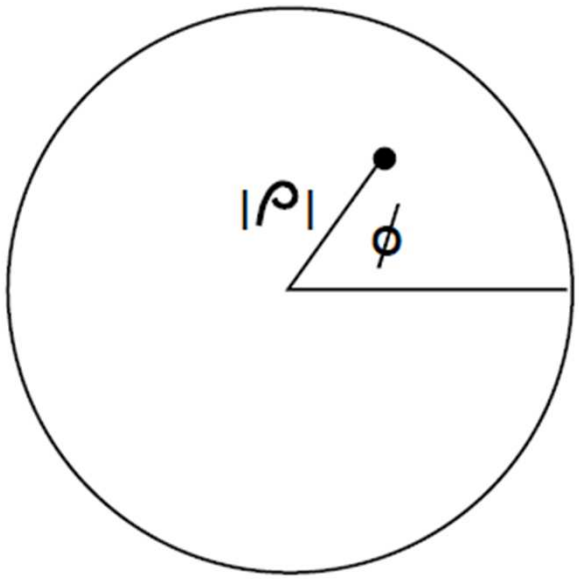
The Smith Chart



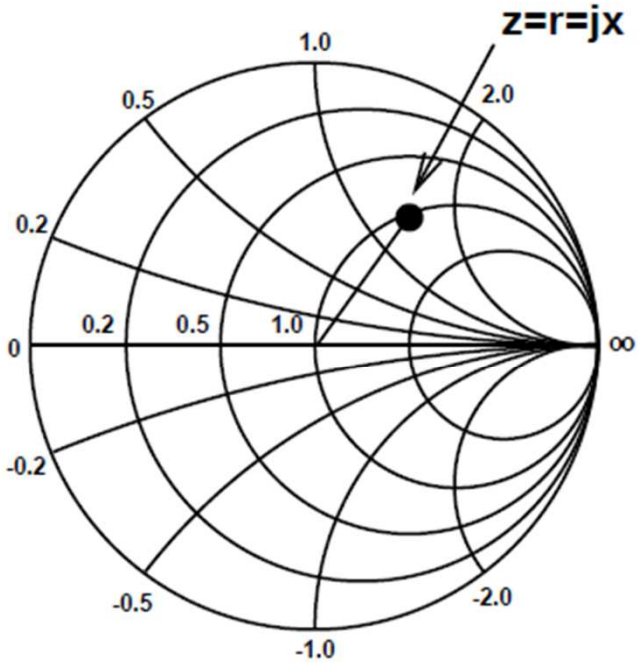
The Smith Chart

- At its simplest the Smith chart is simply a nomograph for converting from reflection coefficient to impedance.
- It can be thought of as an overlay of impedance contours on the reflection coefficient plane.
- The chart is widely used as a means of visualising the impedance of a load.

The Smith Chart

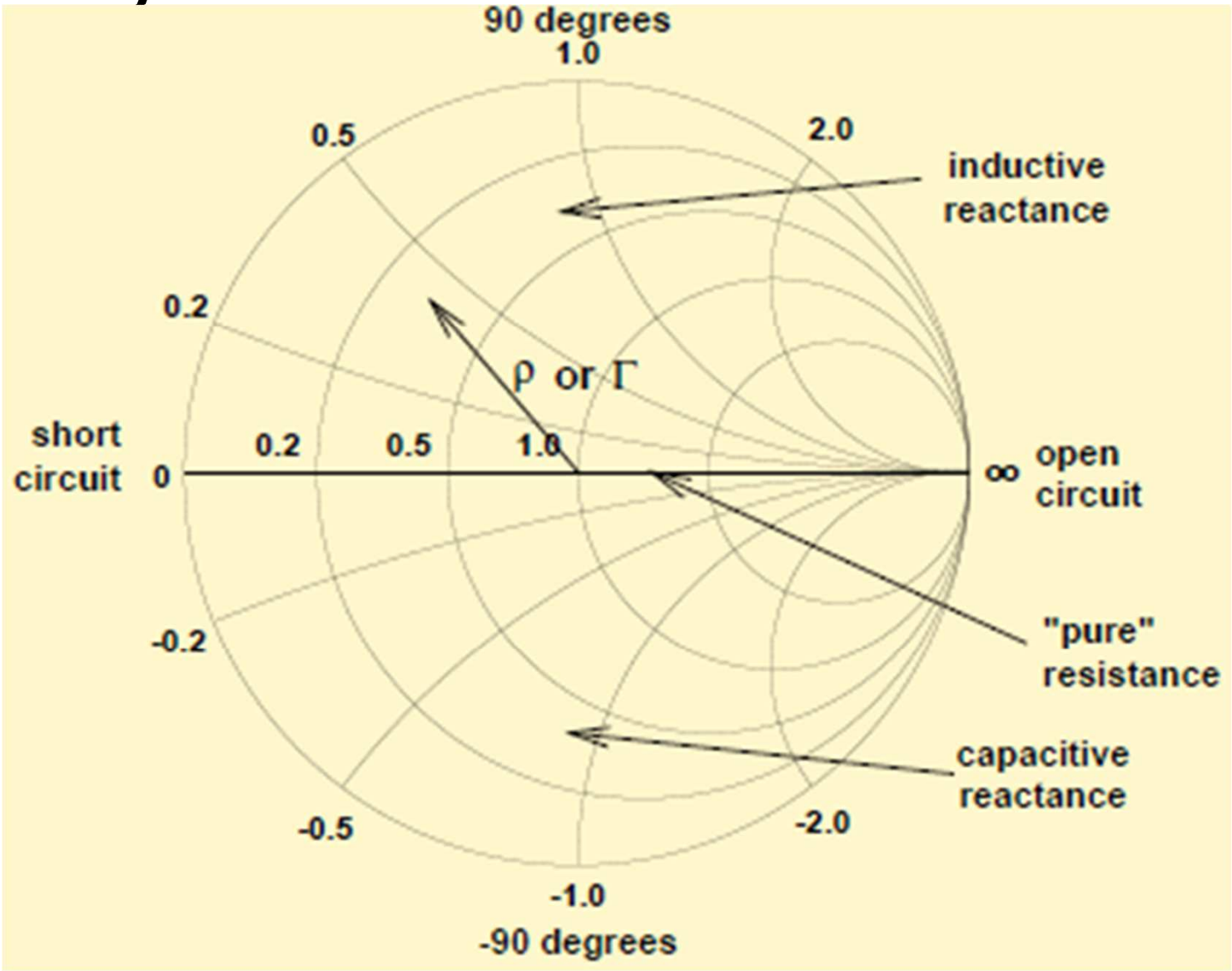


Reflecttion coefficient



Smith chart

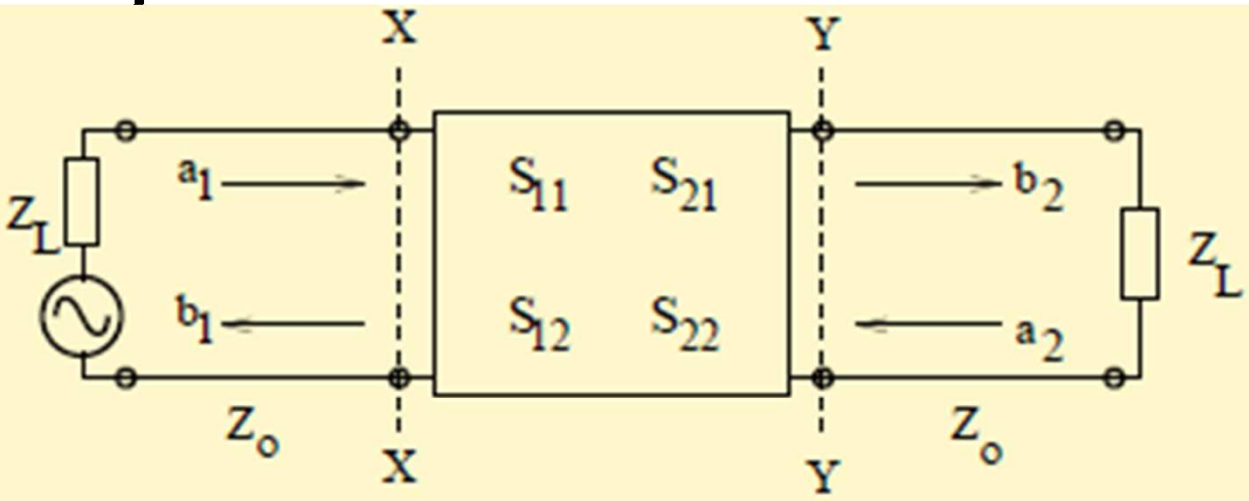
Key Points on the Smith Chart



Scattering (S) Parameters

- The VNA measures these for you
- But what are they ??

S-parameters Definition.

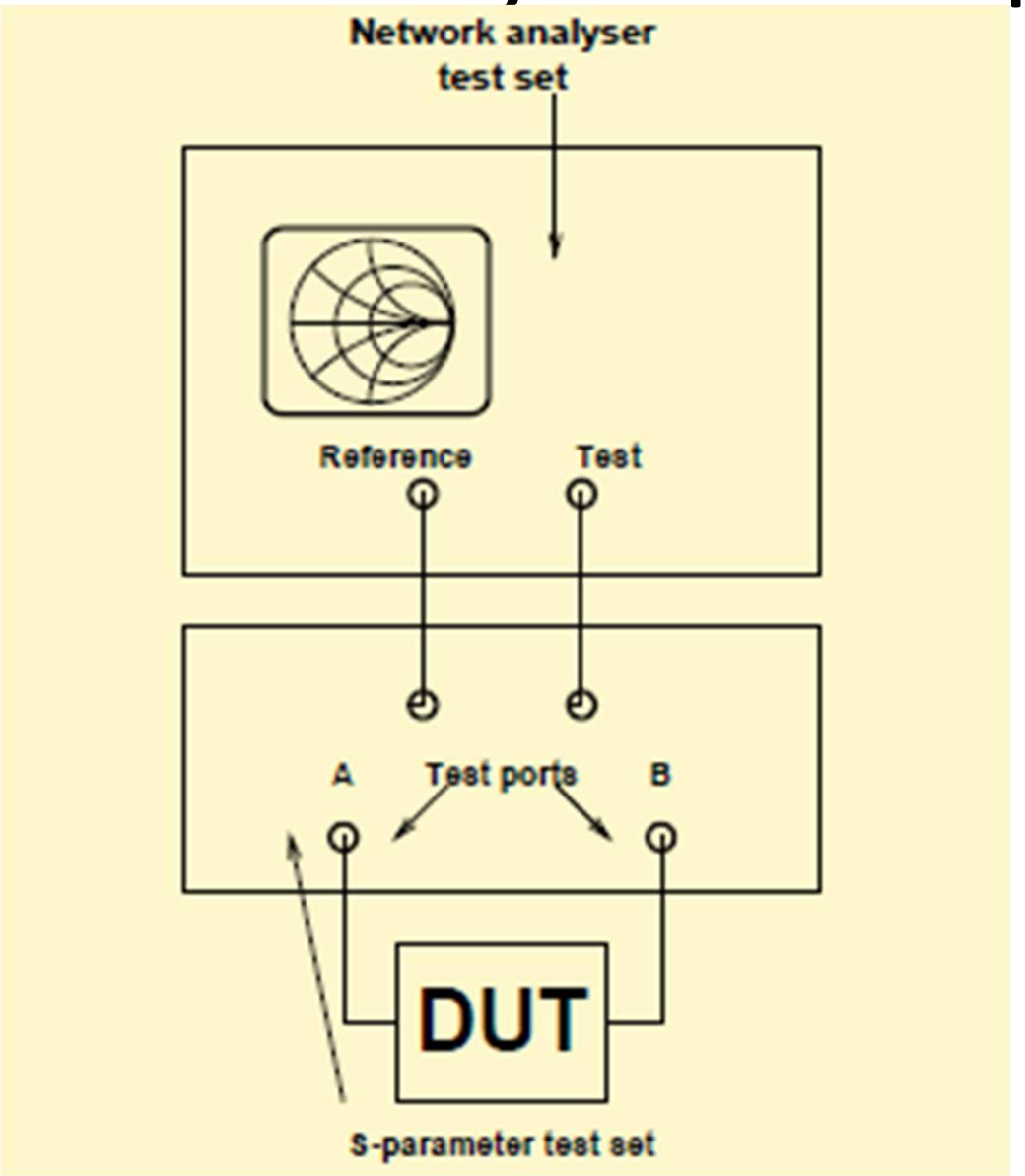


The S-parameter matrix is defined by

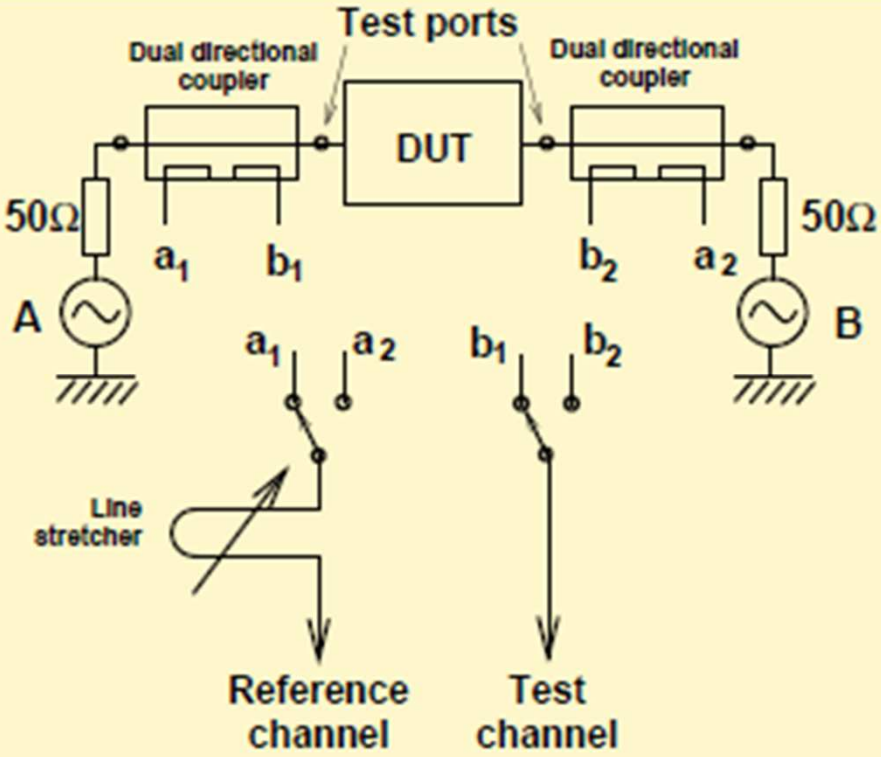
$$b_1 = S_{11}a_1 + S_{12}a_2$$
$$b_2 = S_{21}a_1 + S_{22}a_2$$

S_{11} - input reflection coefficient
S_{22} - output reflection coefficient
S_{21} - forward transmission coefficient (gain)
S_{12} - reverse transmission coefficient (isolation)

Network Analyser Concept.

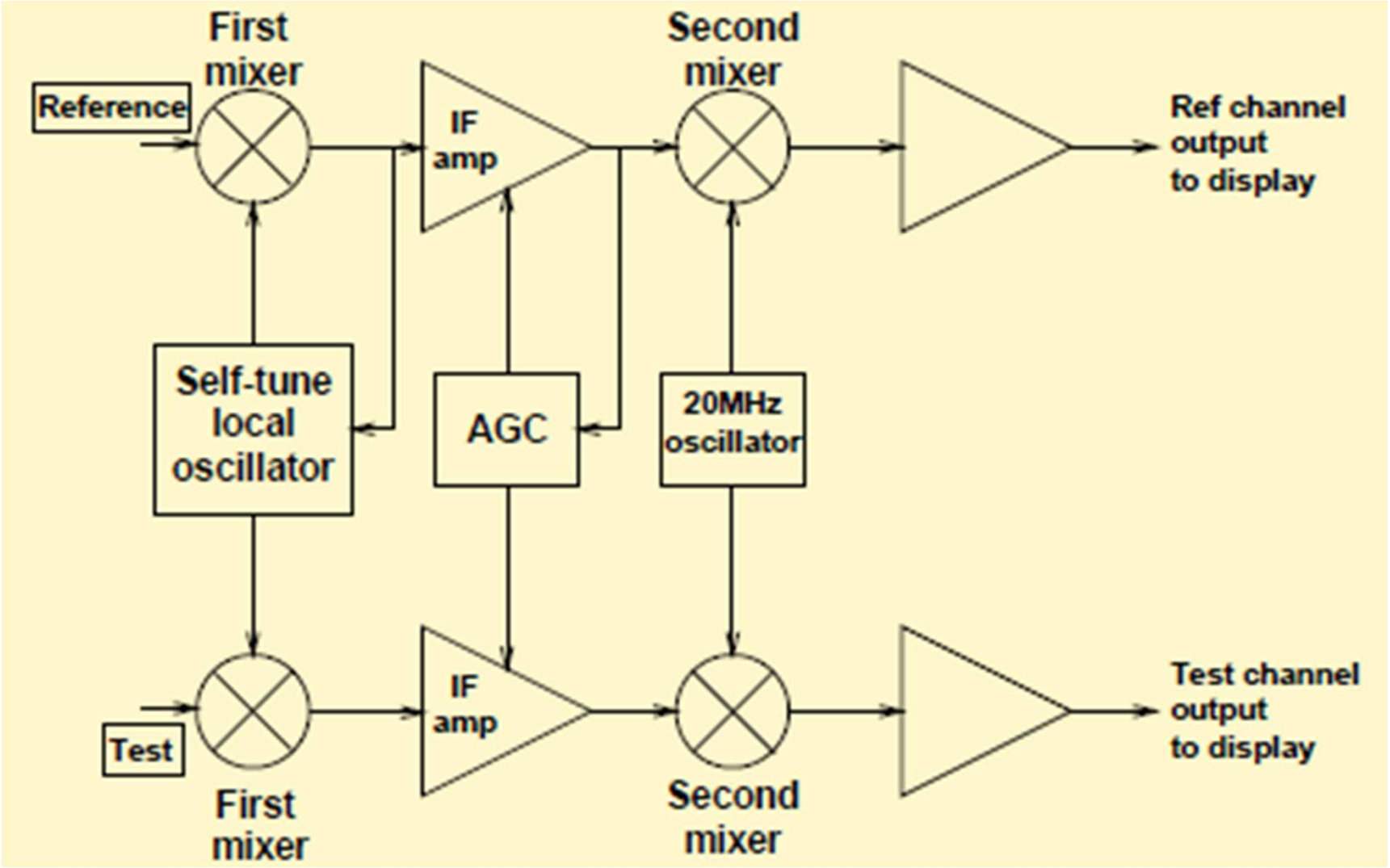


Network Analyser Operation.



Switch settings for S-parameter test set			
Reference channel		Test channel	RF source
S_{11}	a_1	b_1	A
S_{21}	a_1	b_2	A
S_{12}	a_2	b_1	B
S_{22}	a_2	b_2	B

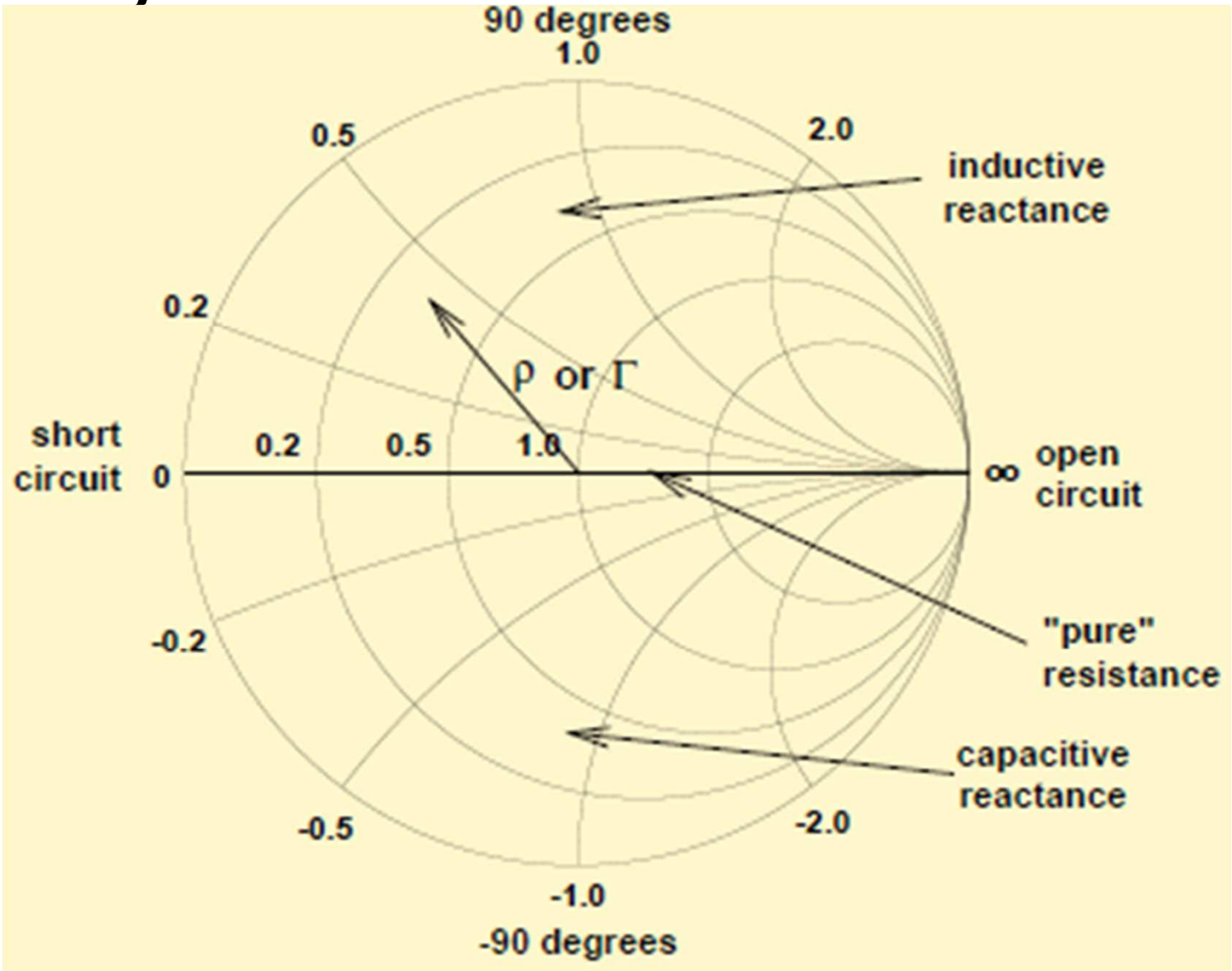
Phase and Amplitude Detection



Calibration

- Calibrated with known standards of reflection.
- Short, open and load.
- Known points of reflection plane.
- Must know the (phase) reference plane.

Key Points on the Smith Chart



Demonstration

- Any testing wanted ???