The N2PK VNA

Brian Flynn GM8BJF

What is a VNA?

- Measures the transmission and reflection properties of a network.
- Technique has been around since the 1970s
- Instrumentation is expensive
- Normally beyond the scope of amateurs

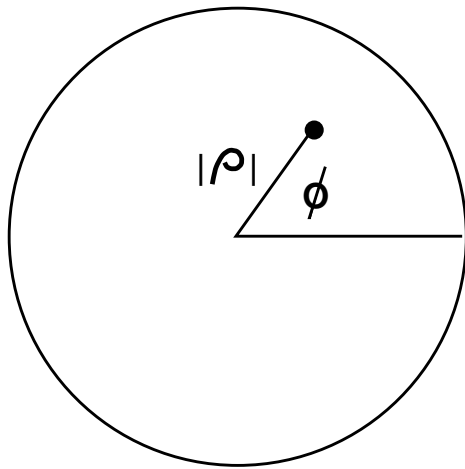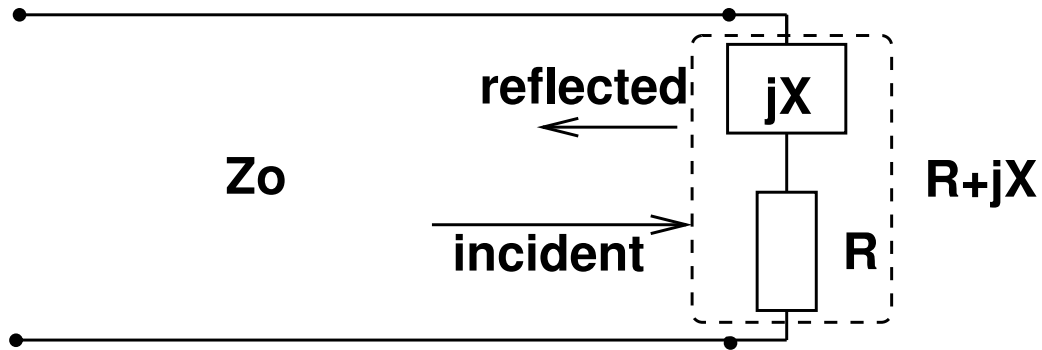# The H-P 8410 (History!)

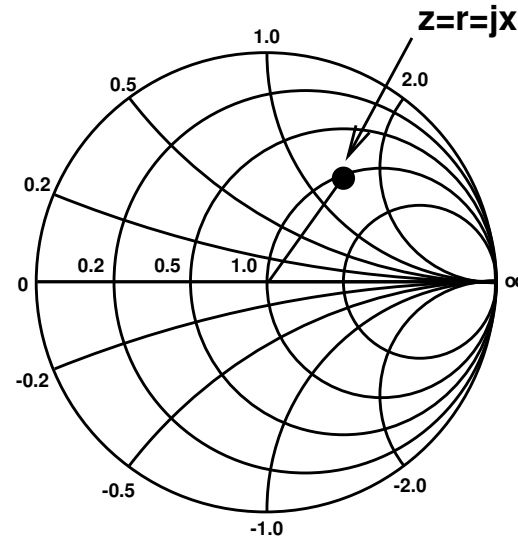# The H-P 8510 (Current)

The H-P 8573C (Current)

Why reflection and transmission?

- The reflection and transmission properties can completely describe a network.
- A "network" can be any device
- A load is a one port network
- Filters or amplifiers are two-port networks
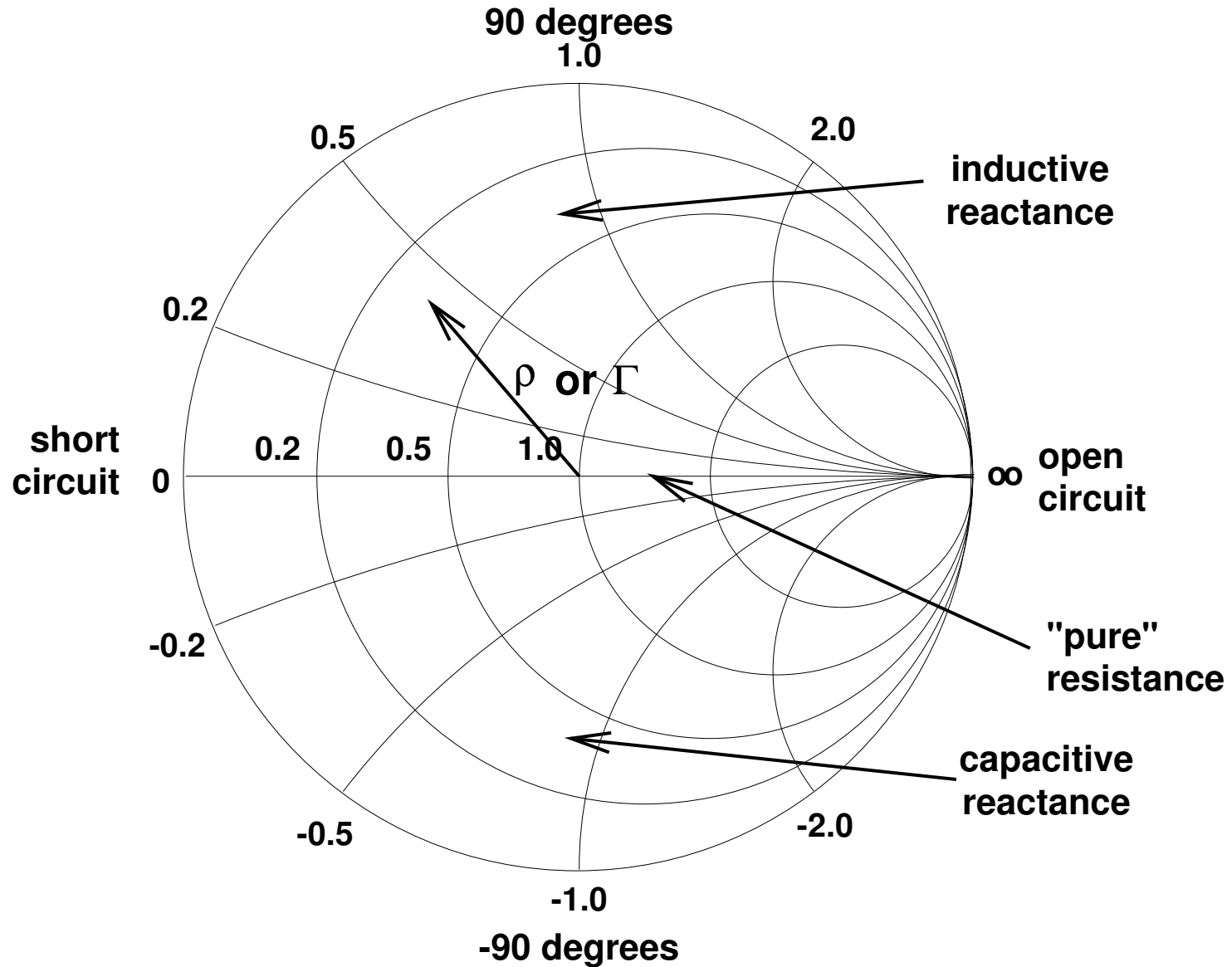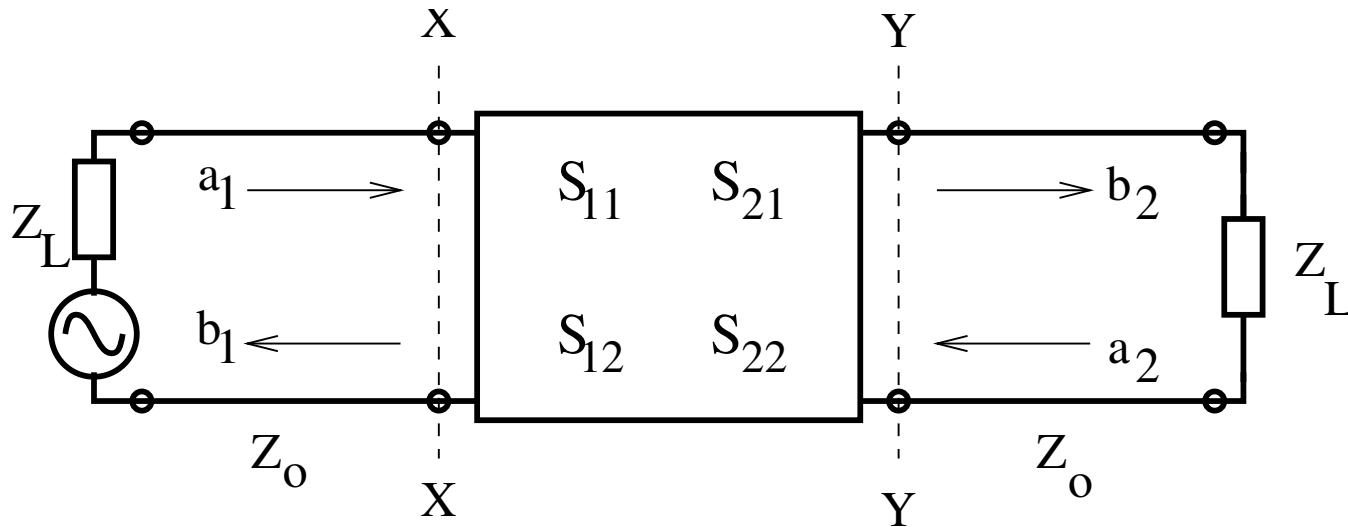- Directional couplers are 3 or 4 port devices

A one –port network

reflected

Zo

jX

incident

R+jX

R

$|\rho|$ ϕ

Reflecttion coefficient

z=r=jX

1.0

0.5

2.0

0.2

0.2   0.5   1.0

0

∞

-0.2

-0.5

-2.0

-1.0

Smith chart

The Smith Chart

90 degrees

1.0

0.5

2.0

**inductive
reactance**

0.2

ρ **or** Γ

**short
circuit**

0

0.2

0.5

1.0

∞ **open
circuit**

**"pure"
resistance**

-0.2

**capacitive
reactance**

-0.5

-2.0

-1.0

-90 degrees

A two-port network

- S11 is complex input reflection coefficient
- S22 is complex output reflection coefficient
- S21 is forward transmission coefficient (gain)
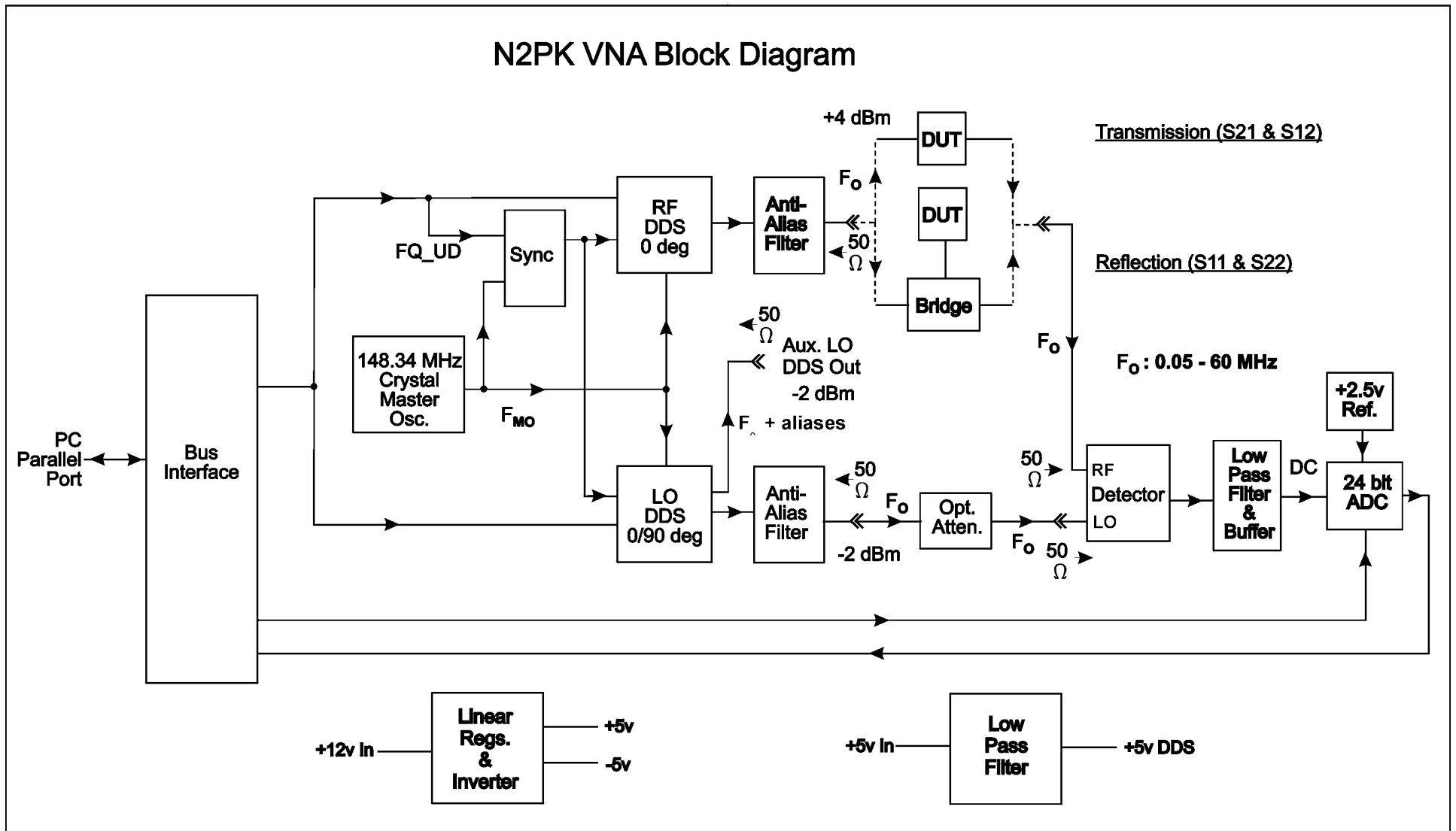- S12 is reverse transmission coefficient (isolation)

Black box representation of circuits

- Approach is very versatile
- A knowledge of 4 S-parameters completely characterises the network.
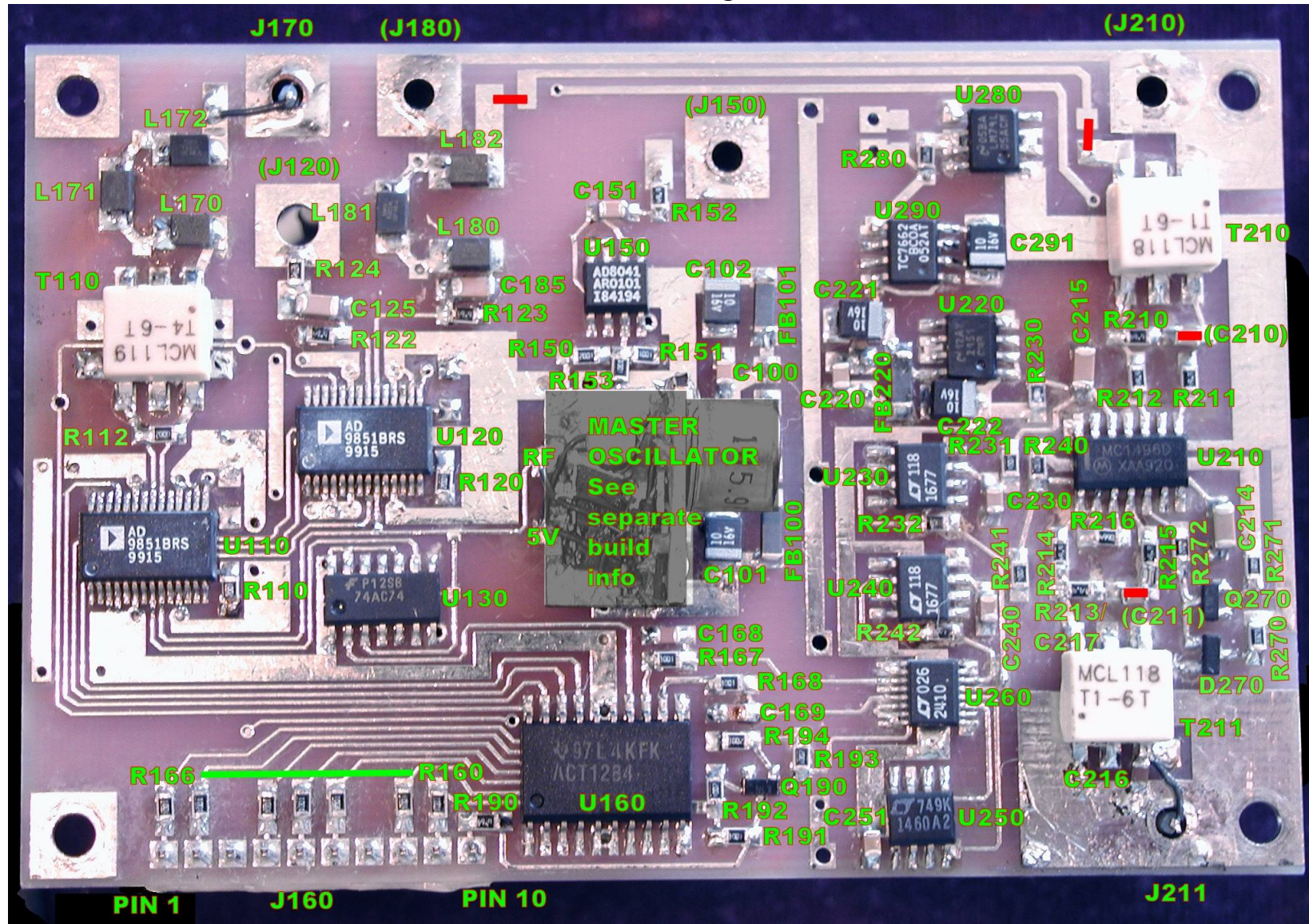- The VNA is the means of making these measurements.

The N2PK approach to VNA design

- Commercial instruments work with a superhet based architecture
- N2PK uses a direct conversion approach
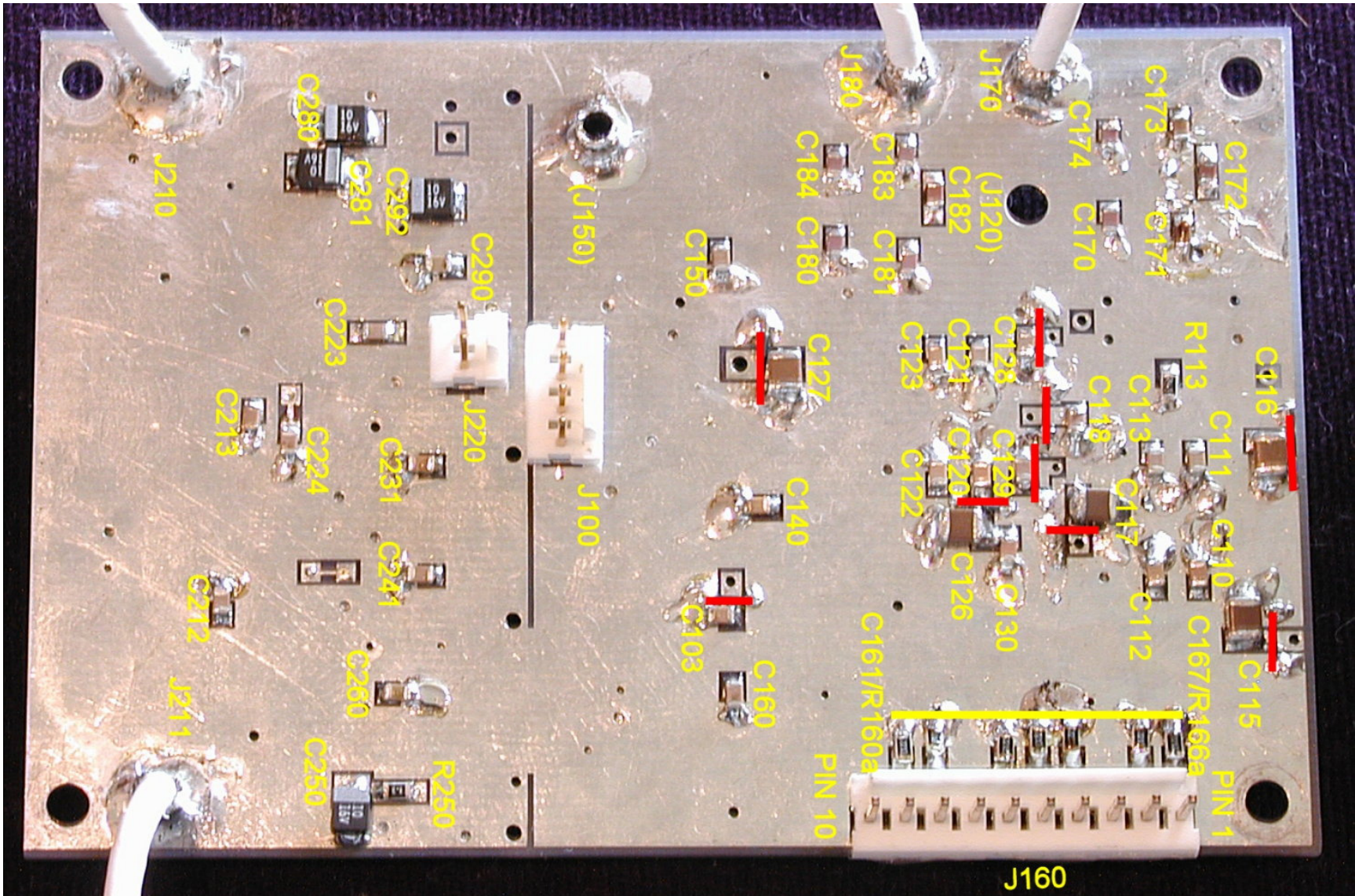- Depends on direct digital synthesis of test signals and accurate phase detection
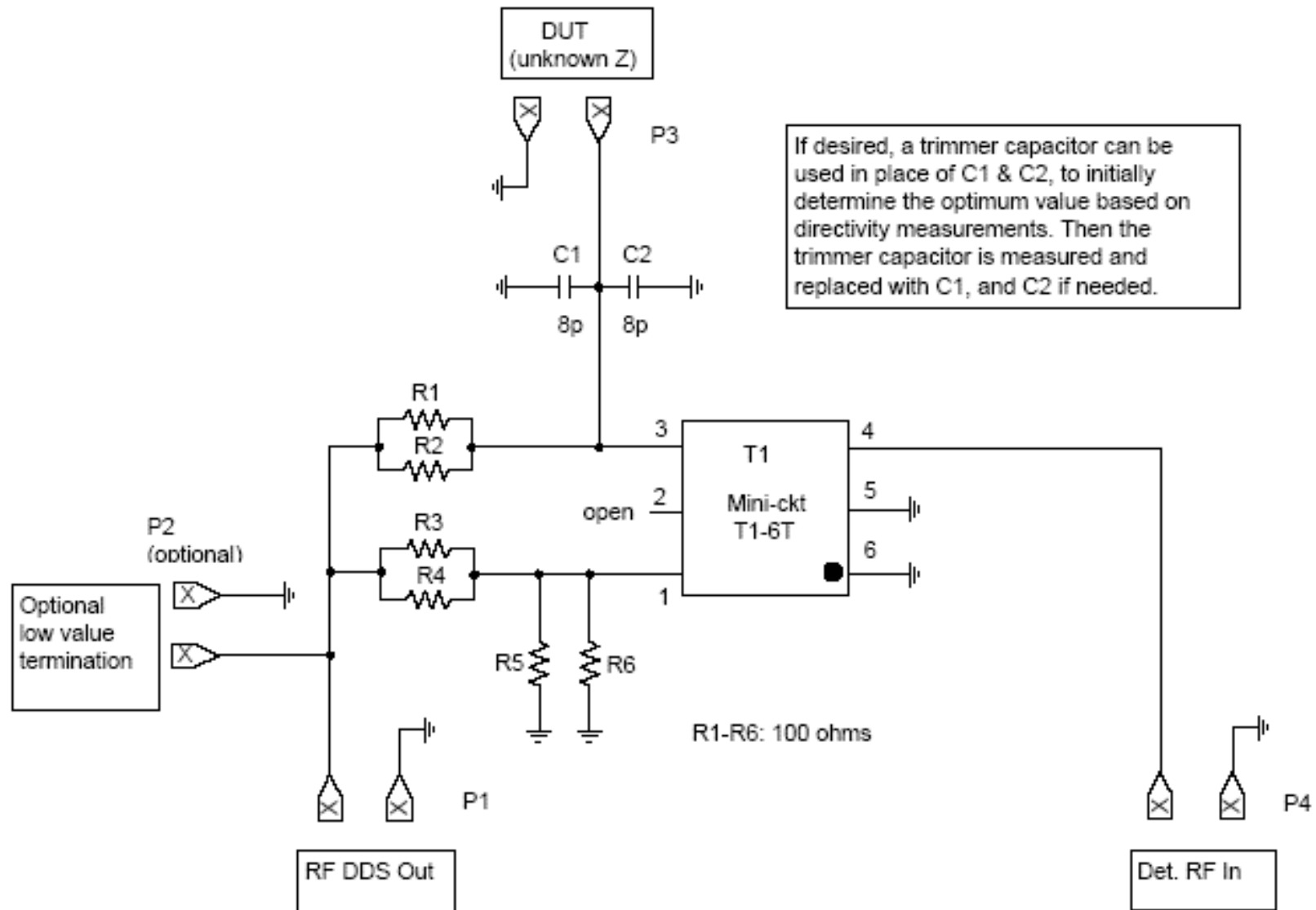
N2PK VNA Block diagram

PCB layout

Back view

The Reflection bridge

DUT
(unknown Z)

P3

If desired, a trimmer capacitor can be used in place of C1 & C2, to initially determine the optimum value based on directivity measurements. Then the trimmer capacitor is measured and replaced with C1, and C2 if needed.

C1   C2

8p   8p

R1
R2

3

T1

4

open   2

Mini-ckt
T1-6T

5

6

P2
(optional)

R3
R4

1

Optional
low value
termination

R5   R6

R1-R6: 100 ohms

P1

RF DDS Out

P4

Det. RF In

Calibration

- The accuracy of measurements depend on comparison with known standards.

- Open circuit

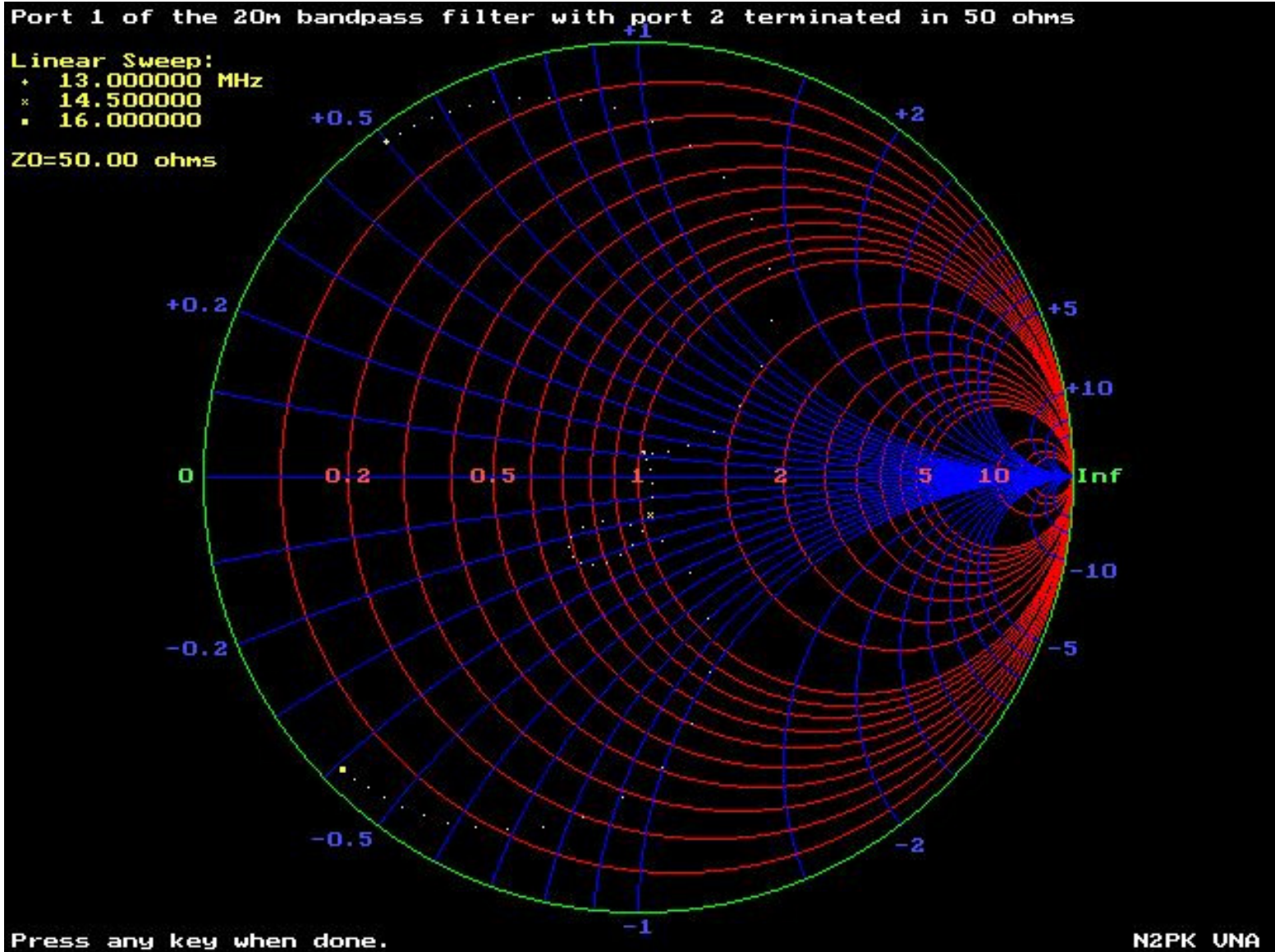- Short circuit

- 50 ohm load

- Through piece

Software

- A large part of the instrument's functionality is dependent on the software (which is freely downloadable).

- N2PK
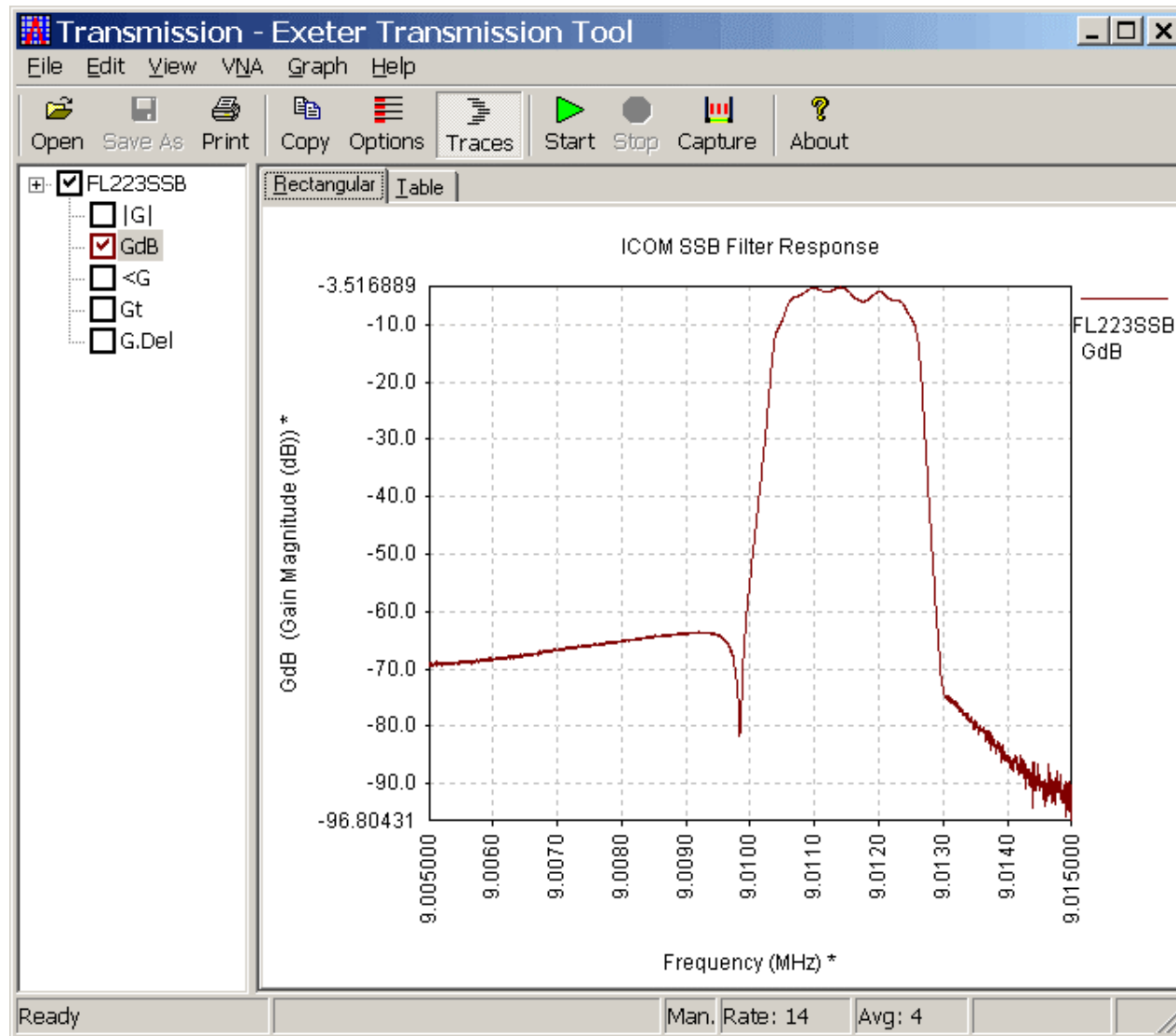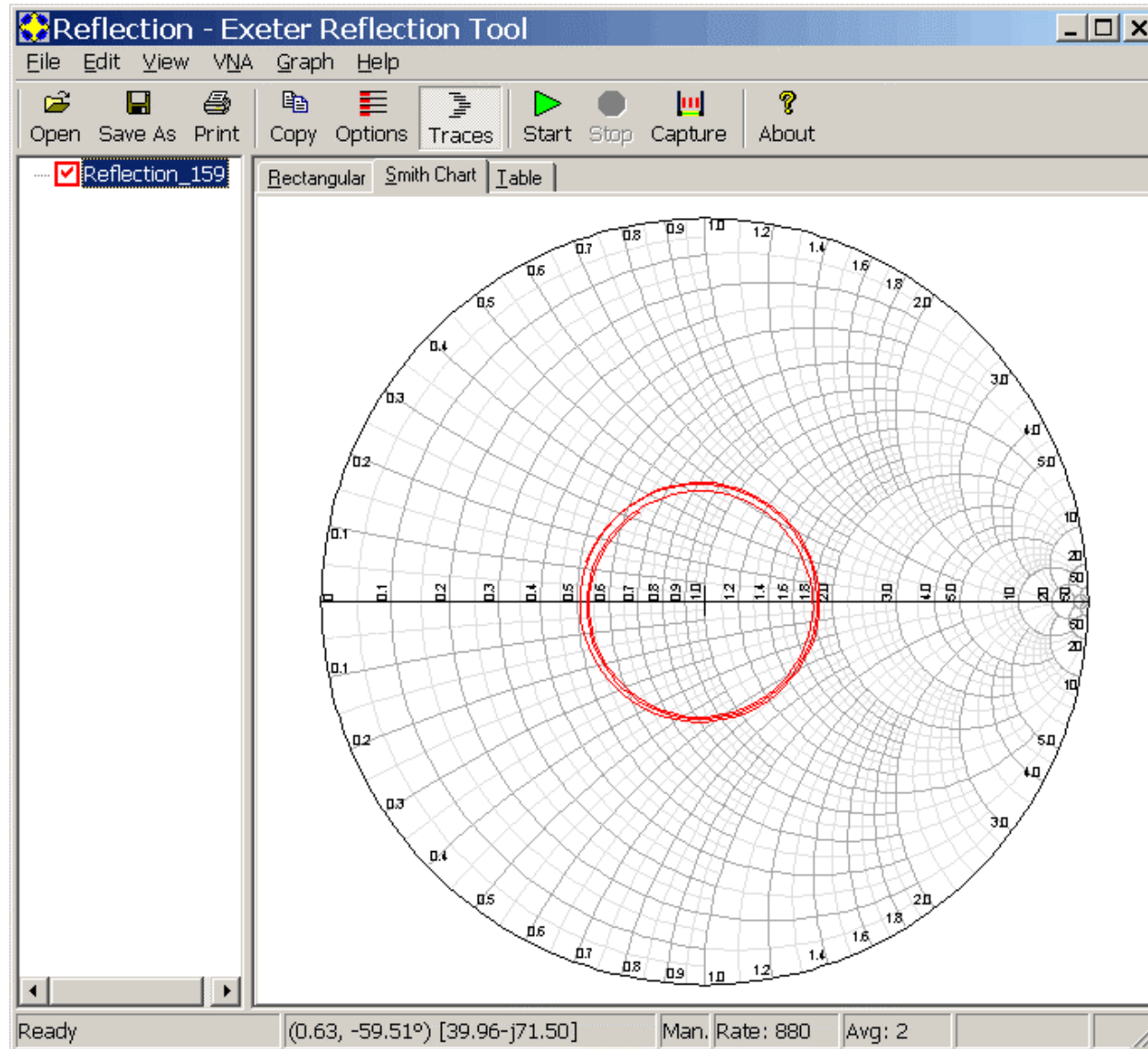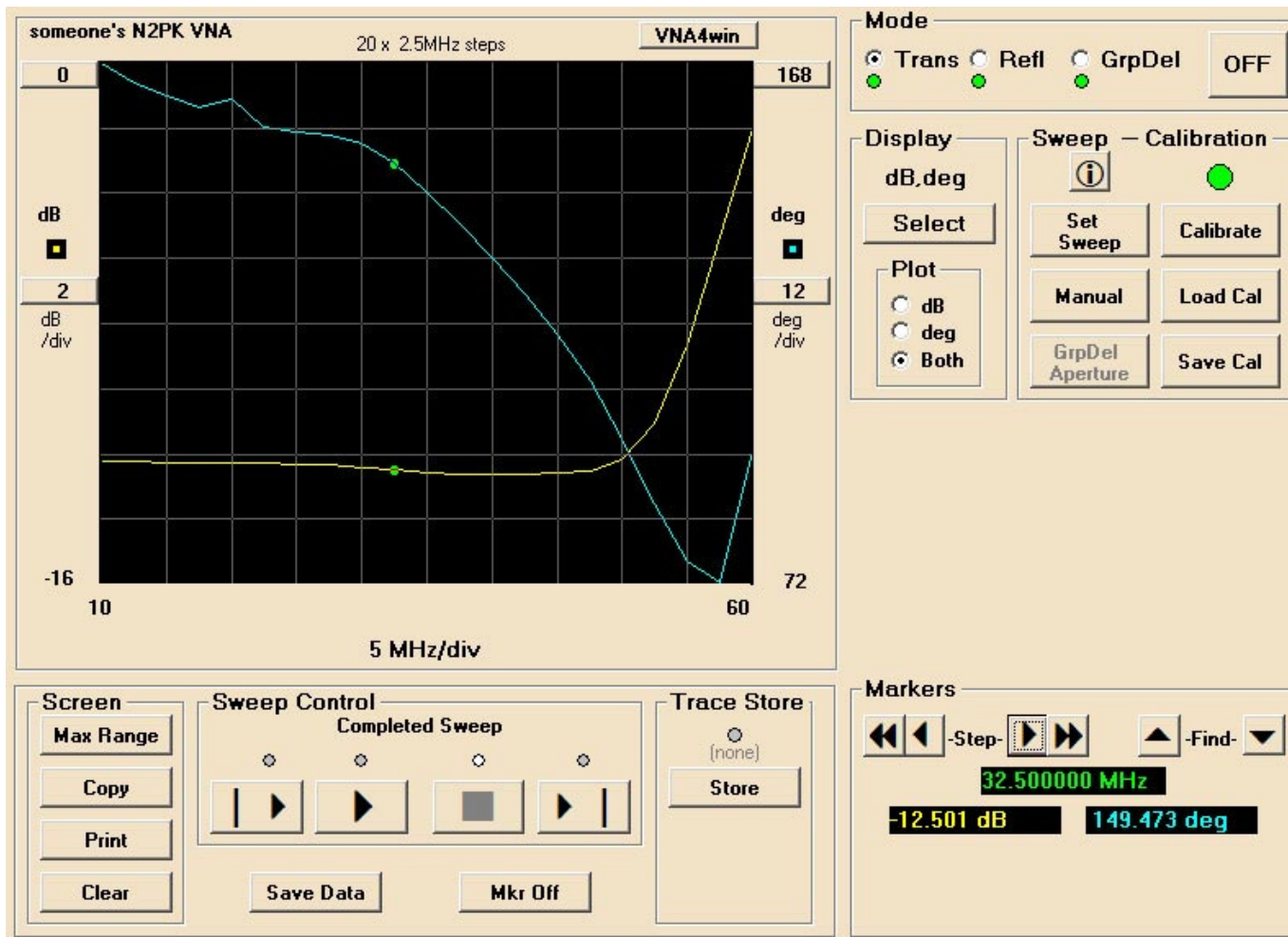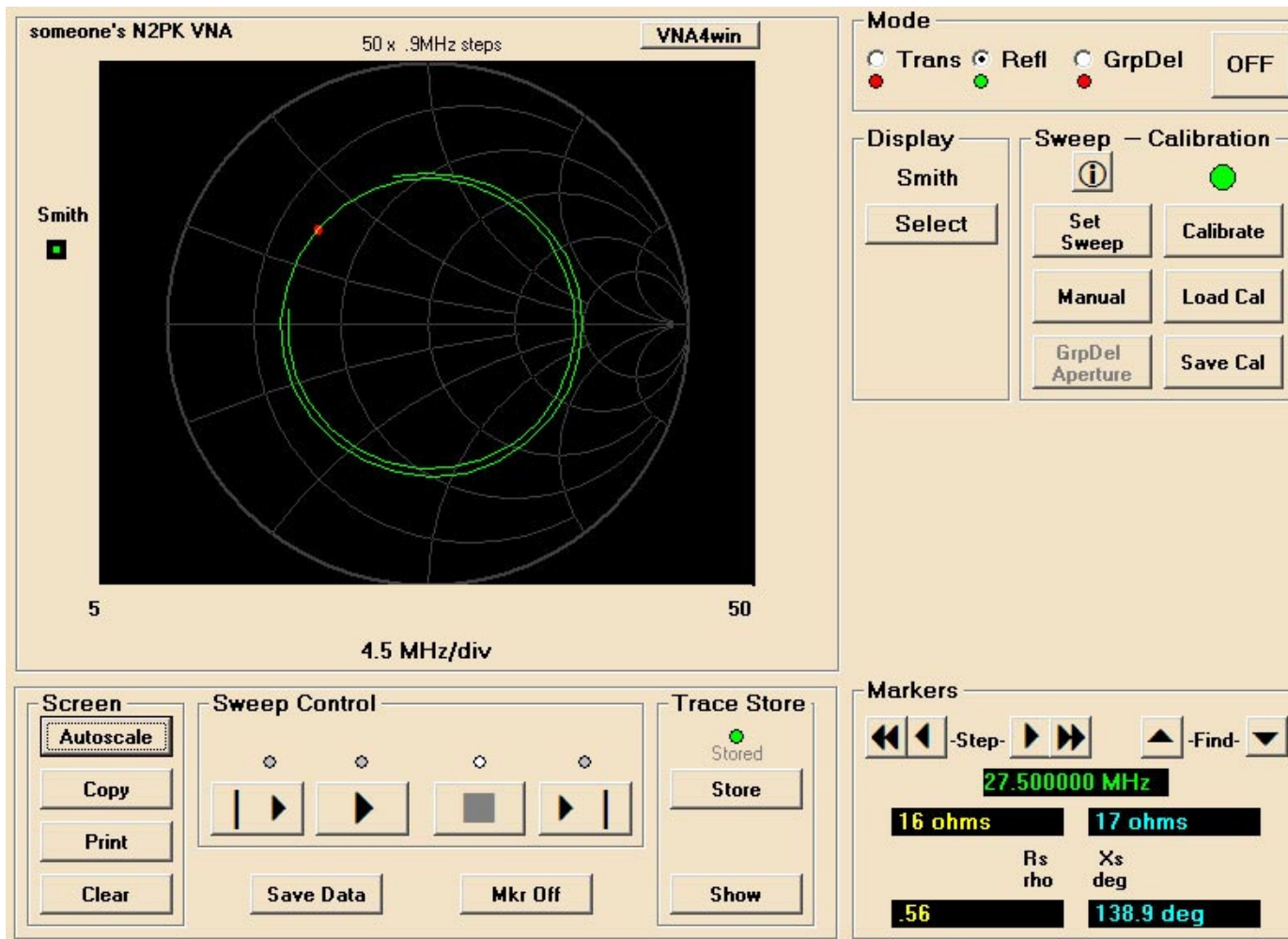- W3WWV – EXETER
- GM3SEK – VNA4WIN

N2PK
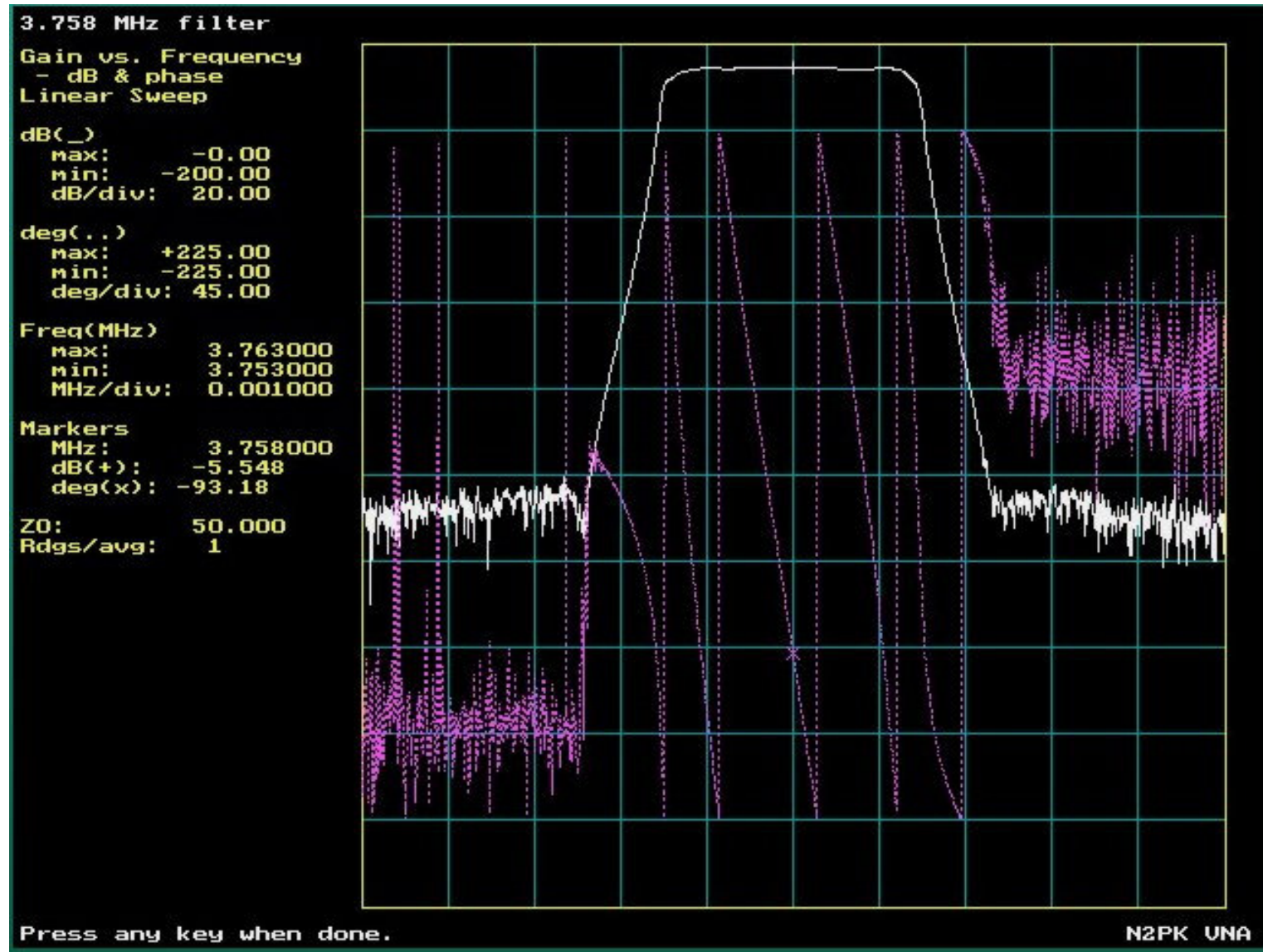
N2PK

Exeter

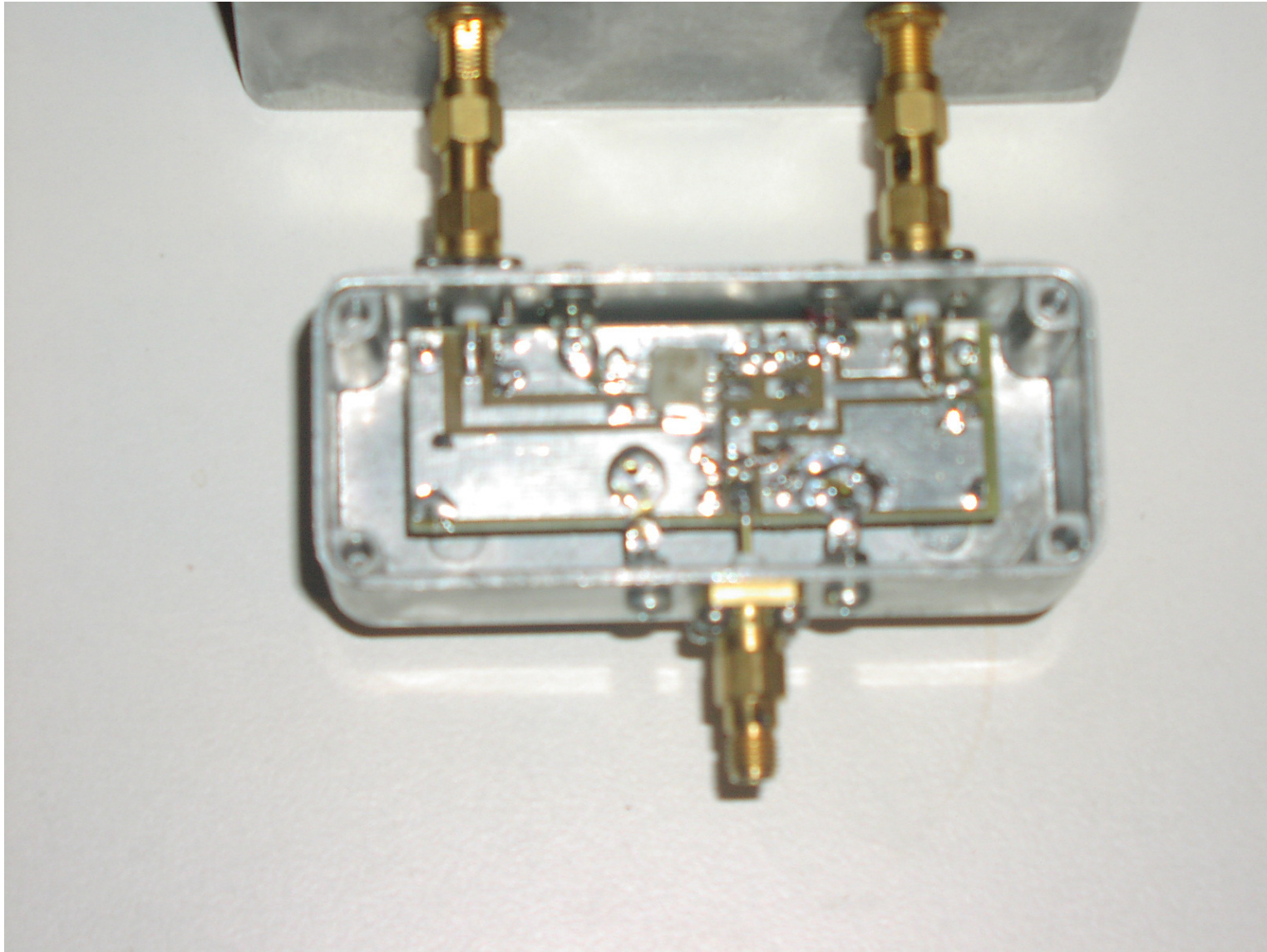# Exeter
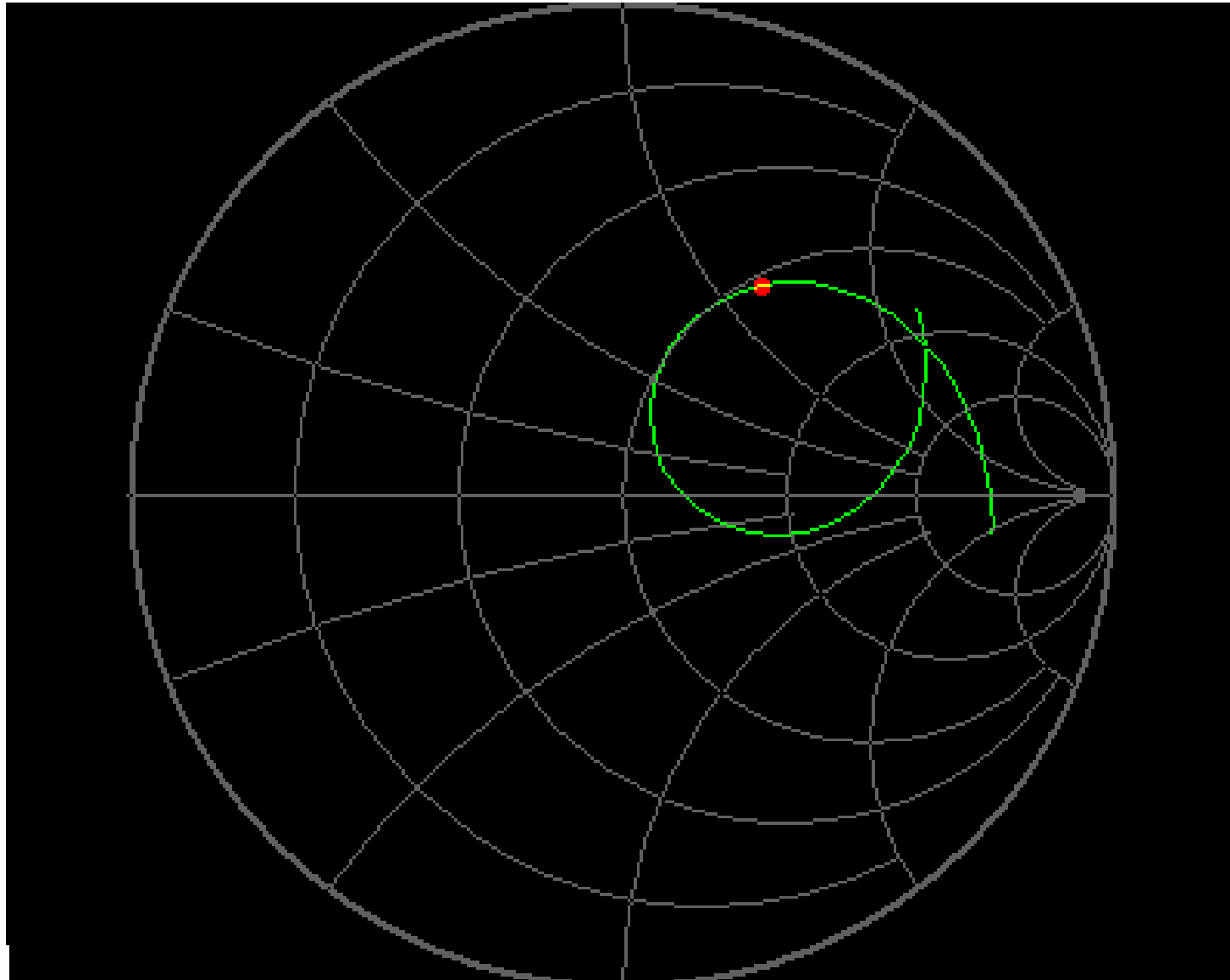
VNA4WIN

VNA4WIN

N2PK a la GM8BJF

The Reflection Bridge

The Calibration Standards

Plot of My 7MHz Dipole

A Live Demonstration.

Further Plans

. Convert to USB (Plug n' Pray)

Extend frequency range

Fast ADC conversion (allows real-time measurement)

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