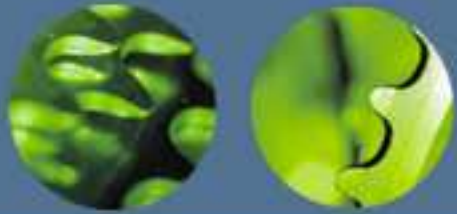# TAPR Vector Network Analyzer

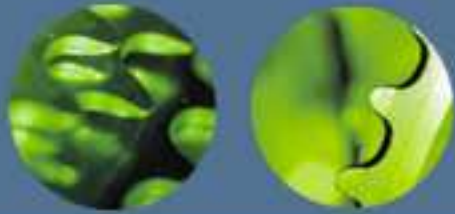**Project Update**
Tom McDermott, N5EG
September 24, 2005

VNA Project

- Open Source Vector Network Analyzer
- Low-cost, simple hardware
- Software released under GNU GPL
- Uses USB to interface to host
- Target software downloaded by host
- Target processor is Cypress EZUSB (8051 with additions)
  - Written in C with Keil tools.
- Host is Windows 98 – Windows XP
 - Written in Microsoft C++ .NET 1.1.
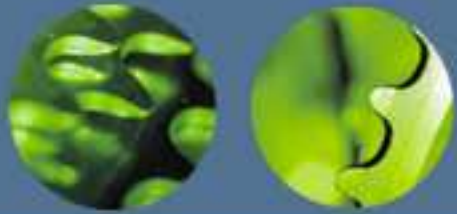
A Few VNA Applications

- S21
  - Filter transmittance
  - Attenuators (flatness, delay)
  - Power splitters
  - Baluns
  - Phasing networks
  - Crystals, resonances, impedances
  - Amplifier gain, delay
  - Cable electrical length, velocity factor

- S11
  - Antenna measurements
  - Complex load impedance
  - Power splitters, diplexers
 - Filter return loss
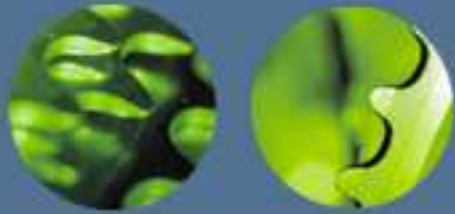 - Amplifier return loss
  - Cable impedance

Project Status

- Kit proved to be too difficult for TAPR – 8 fine lead pitch surface mount parts.
  - Steve Bible hand-assembled these on the 10 beta units.
  - Does not scale well for kits!
- TenTec is selling assembled & tested unit.
  - Including cables, attenuators, etc.
- Bare circuit boards will be available from TAPR.
  - Need to be an SMT expert to build it yourself
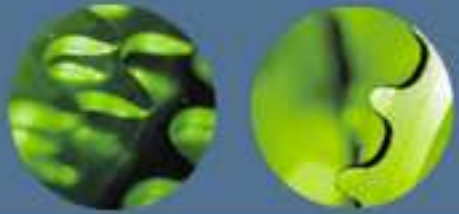- Software, parts list, schematic, etc. available at:
  ftp://ftp.tapr.org/pub/n5eg
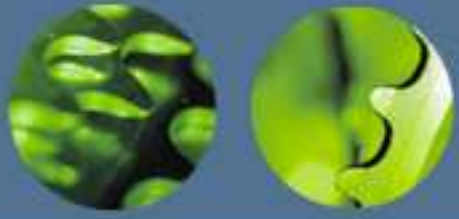
R3 Circuit Board - Integrated Preamplifier
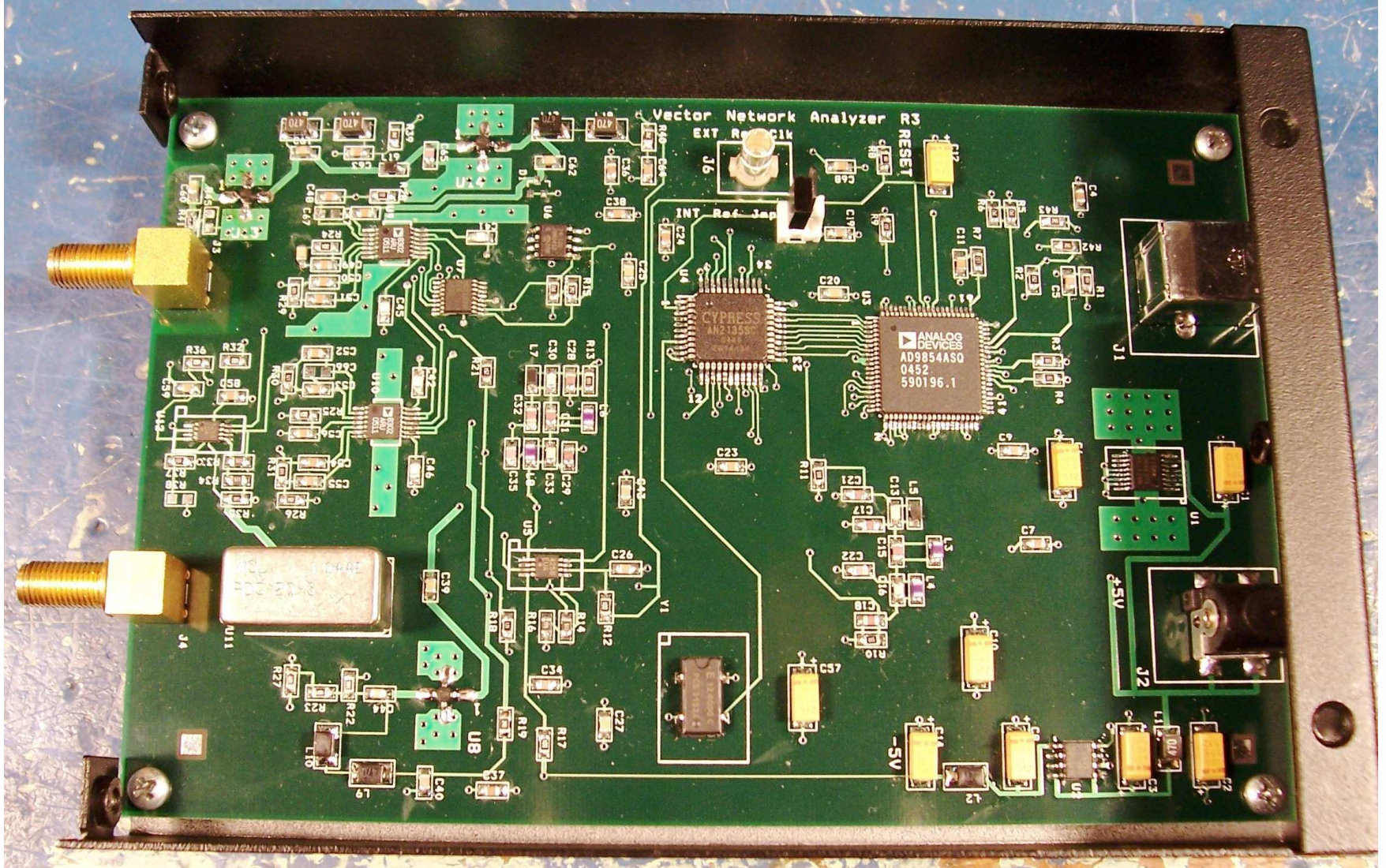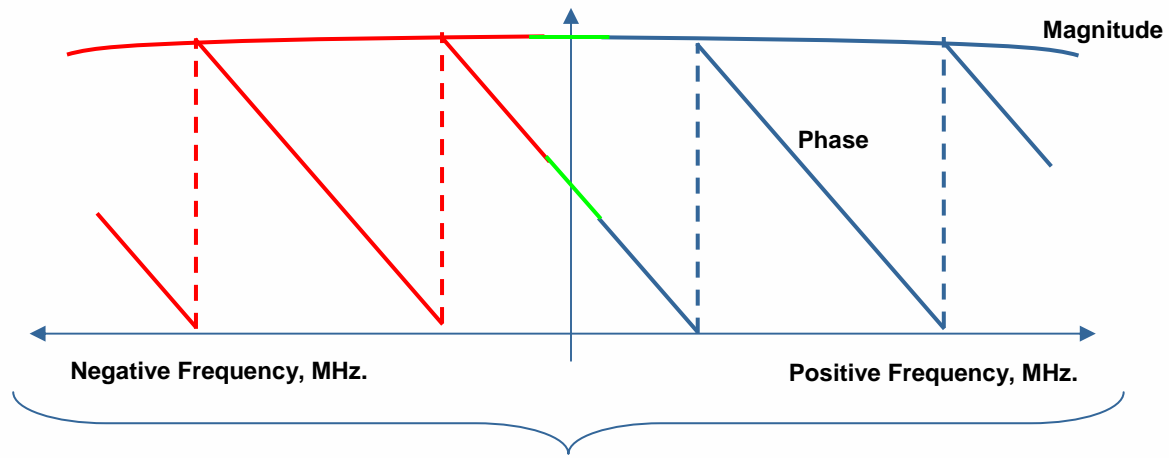
Software Enhancements Added

- Added Time Domain Reflectometer (TDR) display mode
  - Useful for:
    - Locating cable fault distance(s).
    - Determining Cable Velocity Factor (VF).
- TDR synthesized from S11 frequency sweep
  - Inverse Fast Fourier Transform of wideband reflection sweep.
  - Key issue is time *resolution*. Limited by the upper frequency of the VNA: 120 MHz.
  - 120 MHz → 8.25 nanoseconds.
  - Trick used to double resolution:
    - Extrapolate low and negative frequency data from sweep.
    - Doubles resolution → 4.125 nanoseconds.
  - Cable reflection doubles delay → 2.06 nanoseconds.
    - Velocity factor 0.66 converts to about 1.3 feet resolution.
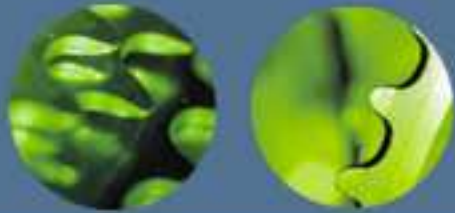   - Can visually interpolate between points of the IFFT for better than this.
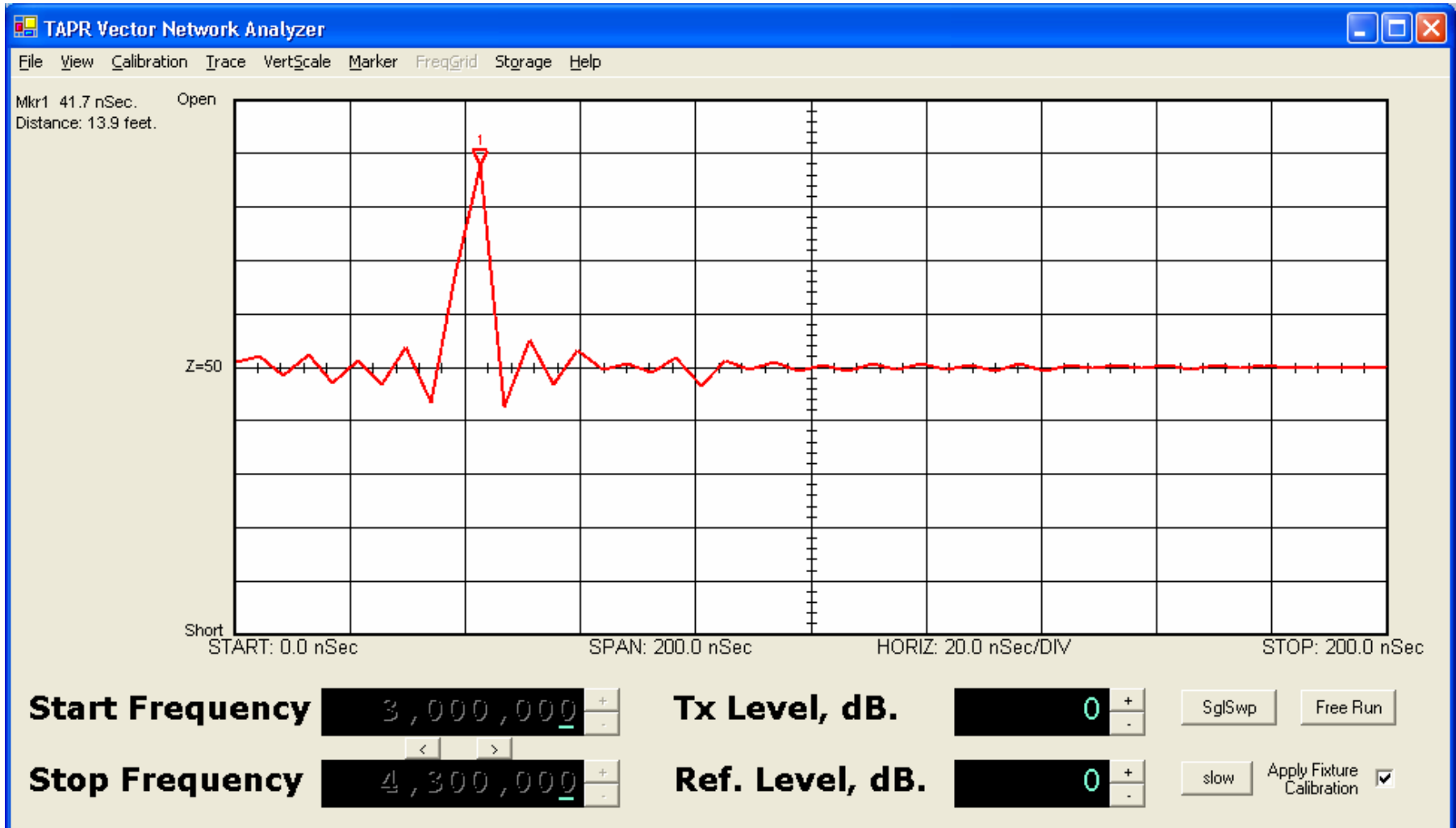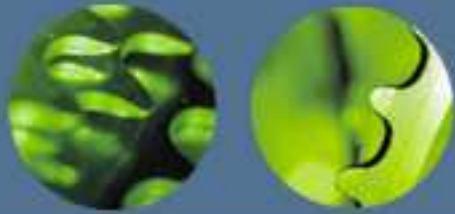
TDR resolution enhancement

Magnitude

Phase

Actual S11 Measurement of Cable

DC

Frequency, MHz.

Low frequency limit of VNA
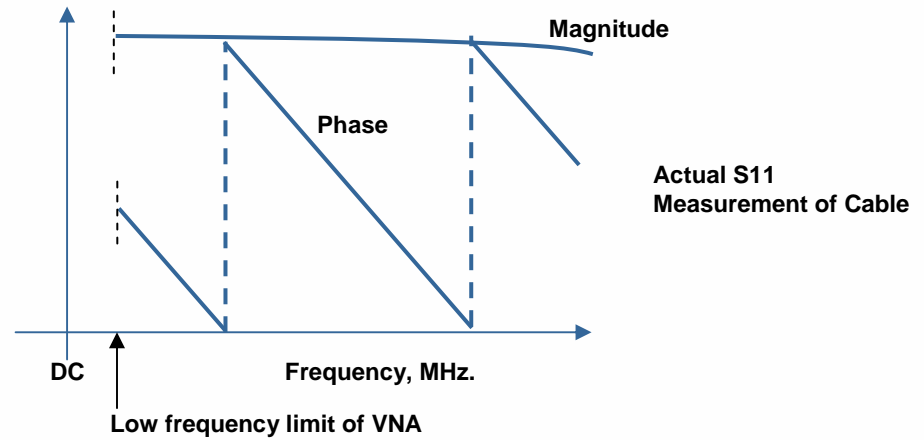
— Extrapolation
— Complex conjugate

Magnitude

Phase

Negative Frequency, MHz.

Positive Frequency, MHz.

Doubles effective frequency sweep range

TDR Screen

Interpolation
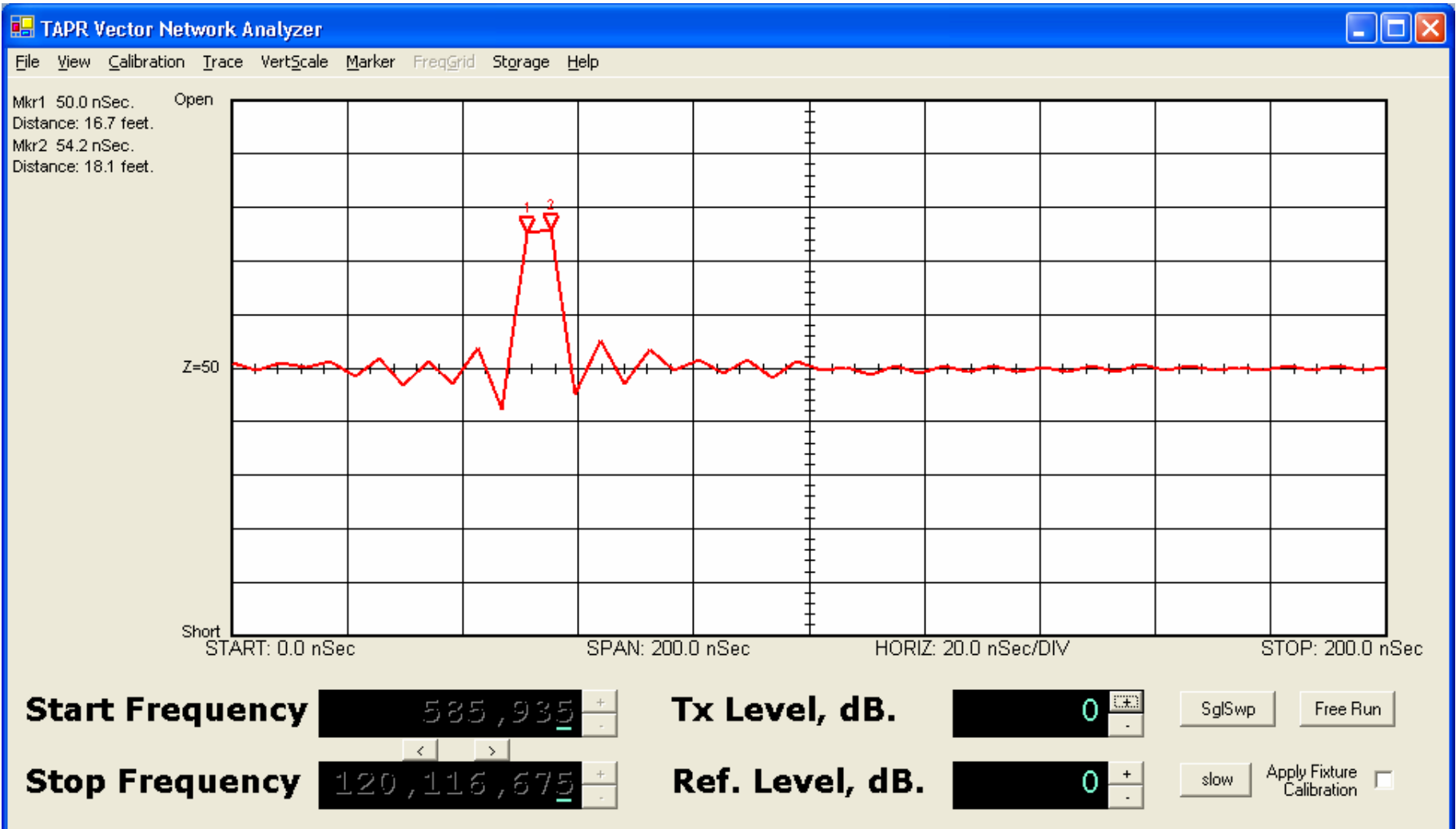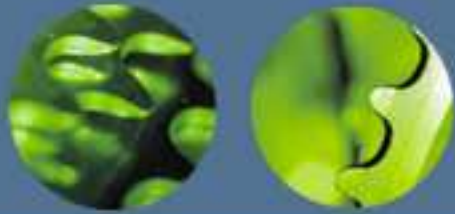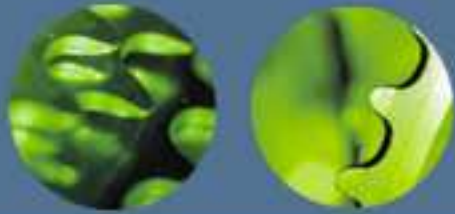
TDR Setup

- Sets start and stop time of display (zoom).

- Fixture Calibration determines the *reference plane*.

- Guess required for cable velocity factor.

- If distance to short or open is known then VF of the cable can be determined.
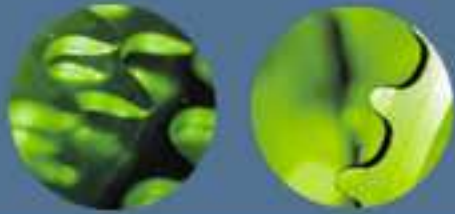
Signal Generator Application

- Existing hardware provides for reference clock to be strapped 'External'
- SIGGEN R1.0 application available on TAPR website
  - Different downloadable image than VNA – automatically handled.
  - Different host image than VNA – automatically handled.
  - Source code and binary windows installer available.
- Allows using:
  - GPS-derived external 10,000,000.000 Hz. reference clock,
  - or other external reference in the range of 5-75 MHz
- Provides Micro-hertz resolution and finer granularity amplitude setting.
- Contains analog phase-meter for comparing phase of external input to the synthesized frequency.
  - Useful for monitoring coarse behavior of test inputs compared to the synthesized reference.
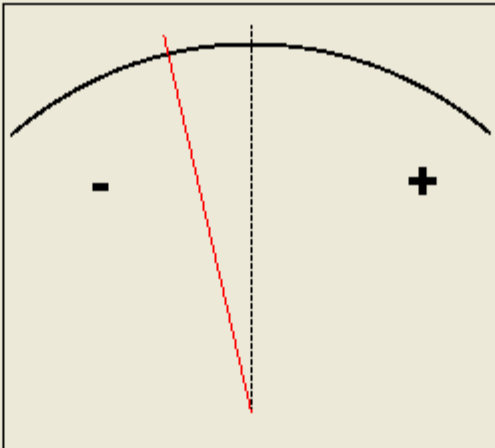
External Ref Clock
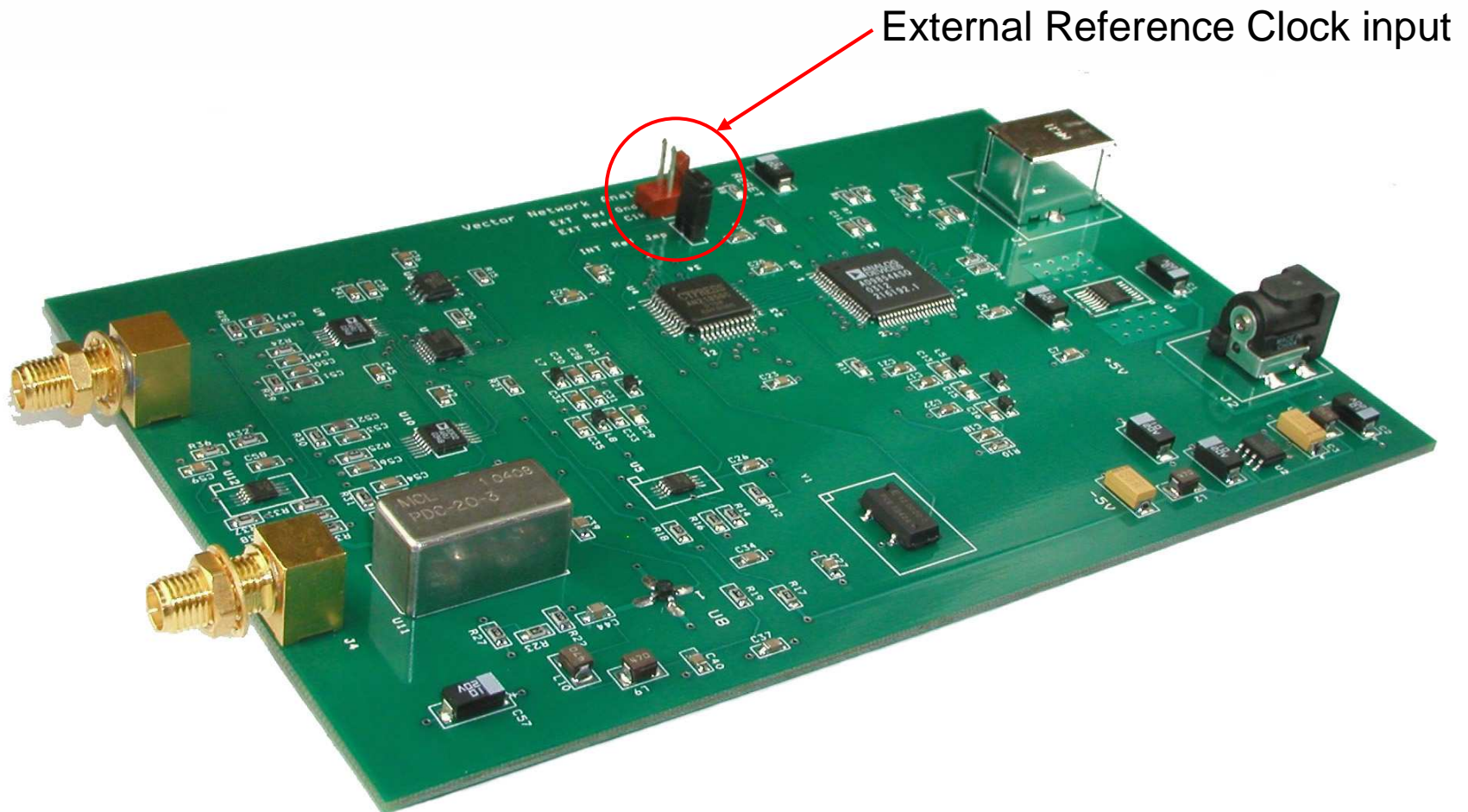
External Reference Clock input

Signal Generator

Resources

- Current parts list, build docs, schematic, updated source code, help files, Windows binary executable, *this presentation*

  ftp://ftp.tapr.org/pub/n5eg

- TenTec Website

  http://www.tentec.com

- TAPR Website

  http://www.tapr.org