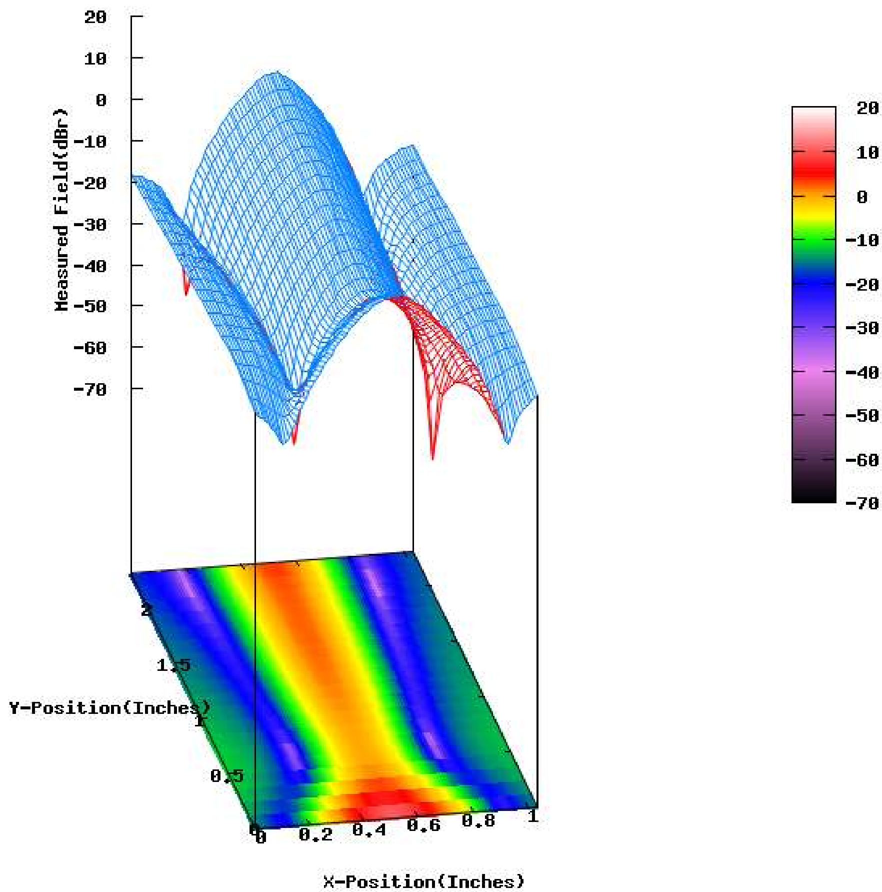
TEST EVOLUTION CORP



NFSA Probe User's Manual

DOC0056

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102 South Street, Hopkinton, MA, 01748, USA.

Test Evolution Corporation
LIMITED WARRANTY

Hardware Limited Warranty

WARRANTY

Test Evolution Corp. (TEV) believes in the quality of its products. Accordingly, TEV provides the following limited, non-transferable warranties for the benefit of the original end-use purchaser of the TEV NFSA Probe. TEV warrants that the NFSA Probe hardware shall be free from defects in material and workmanship for one (1) year from the date of purchase.

TEV warrants that the CD containing the TEV software shall be free from defects in material and workmanship for one (1) year from the date of purchase. TEV further warrants that the software will perform in substantial conformance with the system specifications of the TEV NFSA Probe at the time of purchase and for the period of one (1) year thereafter.

The above warranties are in lieu of all other warranties, express or implied, including all warranties of merchantability and/or fitness for a particular purpose. TEV's liability under these warranties, including any damages sustained by the customer through malfunction or failure of the TEV software, shall not exceed the amount of the purchase price of the TEV NFSA Probe, regardless of the extent of any such damage, including any special, consequential, or incidental damages of any kind.

These warranties shall only apply to products in ordinary use. TEV shall have no obligation under these warranties with respect to damage caused by accident, transportation, neglect, misuse, unauthorized alterations or repair, improper installation, or operating conditions. Products purchased in the United States are to be returned to TEV at its factory, transportation prepaid. Products purchased outside the United States are to be returned to the source of purchase for Warranty repair.

Written notice of, and an explanation of the circumstances of, any defect believed to be covered by this agreement shall be provided promptly to TEV by the customer following discovery of the defect. In satisfaction of its warranty liability, TEV agrees to take reasonable and prompt action to correct the defect, either by repair or replacement, at its option.

Software Limited Warranty & License Agreement

WARRANTY

TEV Instruments believes in the quality of its products. Accordingly, TEV provides the following limited, non-transferable warranties for the benefit of the original end-use purchaser of the TEV NFSA Probe software.

TEV warrants that the media containing the TEV NFSA Probe software shall be free from defects in material and workmanship for one (1) year from the date of purchase. TEV further warrants that the TEV NFSA Probe software will perform

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LICENSE AGREEMENT
TEV hereby grants the customer a non-transferable, non-exclusive license to use the TEV NFSA Probe software. The license is perpetual as long as the customer abides by the terms and conditions of this agreement.
The TEV software may be used only with one particular TEV NFSA Probe and may not be used with any other TEV instruments, without the written permission of TEV. The customer shall not, without the specific written consent of TEV copy in whole or in part, the TEV software for any purpose, except to make one copy for backup purposes.
The customer shall not remove or obscure any copyright notice or notices included on or as part of the TEV software.
The customer shall not recompile, decompile, disassemble or modify the TEV software in any way, nor produce any derivative work thereof.

Contacting Test Evolution

To obtain information about service, accessories and other products, contact:

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NFSA Users Manual

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Patent Information

The NFSA system and its technology are protected under US patent number 7,496,466.

Introduction

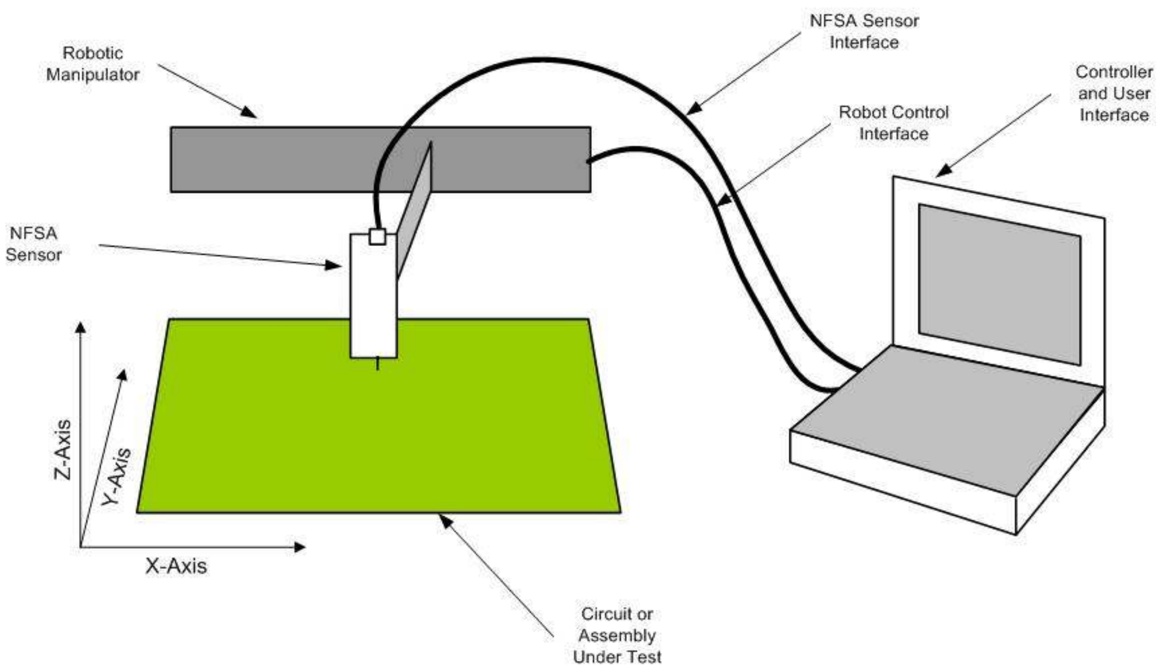
The Near Field Signature Analysis (NFSA) system is a non-contact diagnostic tool designed to determine the location of faults in high frequency electronic circuits. It combines robotic positioning with sensitive field measurement and graphical comparative software. Use of this tool is similar to manual signal tracing techniques in that the software automatically guides a sensor along the RF signal path of a circuit and checks for deviations from normal operation.

Theory of Operation

The NFSA system relies on the fact that all electric circuits with time varying or changing current flows radiate an electromagnetic field into the space surrounding those currents. The magnitude and spatial distribution characteristics of these fields vary significantly as a function of circuit geometry, the physical and material characteristics of the immediate volume around the circuit (including both metallic and dielectric structures), the magnitude of the currents themselves and the magnitudes and phase of any other current flows in the vicinity. The fields are also directly influenced by the frequency (or wavelength) of the alternating currents. Transient and complex time varying waveforms contain a multitude of frequencies each independently contributing to the characteristics of the field.

Nearly all circuit assemblies are mass-produced using modern process technology. By design, all geometric, material, component and electrical characteristics are held to be within tight tolerances from unit to unit of like types to insure a consistent product. In fact, rigorous final testing prior to shipment of electronic assemblies using Automated Test Equipment is a generally accepted practice with the goal of guaranteeing repeatable performance. The electromagnetic fields generated by circuits of like unit types would, therefore, be as consistent as the tolerances of the various circuit characteristics given identical environmental and operating conditions. This can be referred to as an electromagnetic field *signature*.

Once units get to the field they may become damaged or age or in other ways experience a degradation of performance at times to the extent that they no longer meet the manufacturers published specification. These units are re-tested and a diagnosis of the problems is performed with the intent to repair the unit. Key to this notion is the identification of individual components or circuit elements that are damaged, non-operational or marginal in some way.



NFSA System

This is where RF circuits differ from DC or digital circuits. Direct measurement of signal amplitudes is often hampered by the perturbation of the circuit when a probe is put into direct contact with the circuit. Non-contact methods of signal measurement would minimally perturb those circuits. Manual methods of non-contact measurement of signal levels are constrained by two factors. The first is positioning repeatability. Small deviations in distance from the active circuit can mean large deviations in measurements. It requires much skill and experience on the part of a technician to get an interpretable reading under such circumstances. Secondly, any remote measuring instrument such as a spectrum analyzer or power meter would require a lengthy cable and some sort of probe. To measure small deviations in the near field at typically low signal levels means a very small antenna, a very sensitive receiver and a very close proximity to the circuit under test. The cable and probe in the manual method actually comprise a large antenna thus defeating the purpose of the measurement.

When using the NFSA, the software records a set of measurements at particular frequencies and precise coordinates of a known good assembly. That data set is then referenced as a baseline for future measurements of unknown assemblies of the same type. Each point (known as a Virtual Test Point or VTP™) is compared in magnitude between the unknown and the baseline at precisely the same place. When those comparisons exceed a limit value in dB, a failure or anomaly is noted by the software.

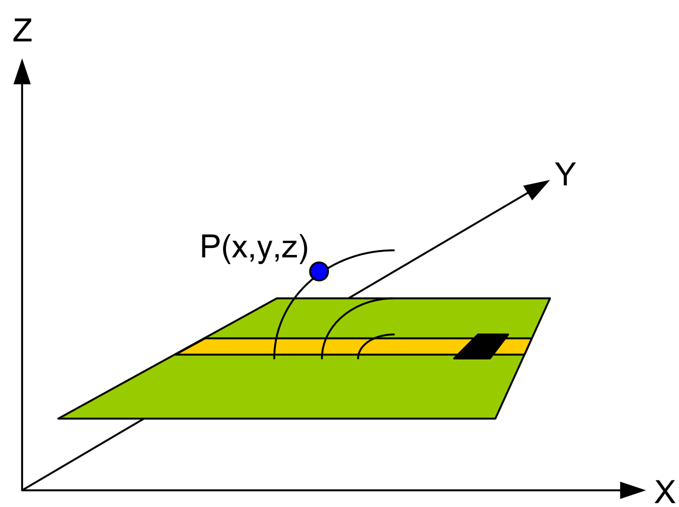
If one looks at a typical RF signal chain, one usually finds a linear progression in signal processing functions (amplification, attenuation, filtering, switching, splitting etc.). As the signal passes through each stage, it's magnitude and therefore it's field strength change. The NFSA system automatically follows the path of the signal and verifies that those changes are within a specified tolerance.

When signals at VTPs as represented by their fields do fall outside limits, then a strong clue is given as to where a failure has occurred. If, for example, a signal is ok at the input VTP of an amplifier and the output VTP is failing, then the amplifier (or its biasing) would be suspect. The same would apply to most other RF signal processing components.

Virtual Test Points

An experienced repair engineer would know where to probe along the signal path to look for problems. In DC and digital circuits its common for test points to be designed into the circuit to aide this process. That's very rare in the RF design world due to the negative impact on circuit performance by adding any extraneous loading. One can see though, that with non-contact measurements, one has an infinite number of test points available. That's lead to the notion of the Virtual Test Point (or VTP™) as mentioned before.

VTPs can be placed as close or as far as one would want to the surface of the assembly or its components. The robotics can step over tall components or place the probe within housing cavities. When we refer to VTPs we're actually referring to where in Cartesian space we're placing the NFSA probe tip (and also what frequency we're tuning the sensor to).

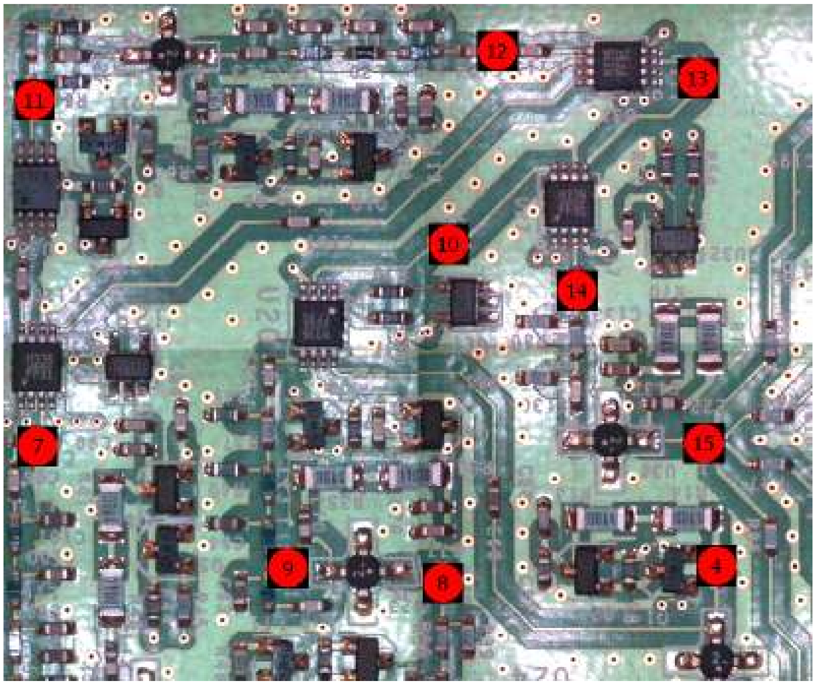


VTP Concept

There are no firm or hard rules regarding the placement of VTPs but there are some guidelines. One can place as many or as few as one likes. One can place VTPs anywhere the probe can reach.

VTP Placement

Generally, place VTPs at the inputs and outputs of signal processing components or sub-circuits. The signal processing component is there for a reason. Most likely there should be a change between input and output. Make sure that change is normal. If it isn't then the problem has been located.



Typical placement of VTPs

Divide and Conquer

Most RF circuits have separate paths or branches that contain sub-circuits. Check the inputs and the outputs of each path separately. If there is an anomaly with a particular path output then there is a problem within that path.

1. <u>Separate RF from DC or Digital Problems</u>. Signals that disappear or appear when they're not supposed to can be caused not only by an RF component but sometimes by an improperly functioning digital control line or a failed bias line. Once an RF failure is encountered, take out the DVM or scope and check the control and bias lines.
2. <u>VTP Heights and Distances</u>. In general, the measured level diminishes as the probe moves away from the emanating circuit. This doesn't always apply, especially if the entire circuit operates at one frequency. In these cases, the VTP

will want to be as close as possible to respective inputs and outputs. Not so close that it touches but a good place to start is 1-2mm. Make a test measurement, then move the probe around (up and down and side to side) to see how sensitive it is. Fields in general dissipate quickly from their source but do not disappear. So do not be surprised when the difference between a close VTP and a farther away VTP is only 10-20dB. That's typical but in no way detracts from the probes ability to see changes due to circuit problems at that close VTP.

Sweet Spots

It usually becomes apparent when setting up a new VTP that there is an area around a point of interest that gives good spatial discrimination and good signal to noise ratio. Good signal to noise ratio is visually seen on the spectral display by having at least one or two divisions separating the peak from the noise floor.

Low Signal Levels

In receiver circuits, signals at the front end can be very low. To test these circuits with NFSA one needs to get the signal level where the probe can measure it. While the probe is quite sensitive, the coupling between the circuit and the probe is quite low depending on the proximity. The closer the probe to the circuit the higher the measured level. One approach for dealing with this is to increase the level being input to the chain (within the limits of input compression). If a front end is normally tested for sensitivity at -110dBm input, but it can operate at -50dBm, use -50dBm when planning the VTP. Remember, the NFSA is not qualifying the sensitivity, it's following the circuit to discriminate anomalies indicative of component failure. Another tool to use is that the NFSA has both averaging and Resolution Bandwidth adjustments that make dealing with low levels more repeatable.

High Signal Levels

In transmitter circuits, an amplifier driver chain typically builds up the level to excite a final output amplifier. Those early lower power stages can be probed as usual. That final amplifier, however, may produce power at such levels that VTPs too close will experience overloading. Backing off the proximity generally will solve this problem along with keeping the probe input range at a high enough level. Note that because the probe is 5 cm away from the final stage, it will still discriminate whether that stage is functioning correctly or not. In some cases, with high power amplifiers, the probe maximum input ratings (+20dBm at 4mm) can be exceeded and the probe will be damaged. As with any transmitter caution must be observed. This is no different than using other measuring devices around transmitters. Please follow normal precautions both for the protection of the probe as well as for personal safety.

Low Frequencies

The probe is specified to a lower operating limit of 30MHz. As one would expect, the spatial resolution of the measurement degrades with lower frequencies necessitating ever more proximate measurements. What is less known is that the probe can actually be tuned down to 10MHz. The trick here is to get the probe as close as possible to the circuit. Since the actual physical antenna is a pogo pin designed to handle gentle unintentional vertical contact with the unit under test at times, it can actually touch down on low frequency circuits for intentional measurements at low frequencies (<50MHz). Where is this useful? When making measurements of clock oscillators of divider outputs in PLL's. Take care when doing this if the circuit is a crystal oscillator or high-Q circuit. Obviously the loading incurred when applying this method can completely detune a circuit. However, the buffered output of an XTAL oscillator is a great test point to touch down on. Try it non-contact first – it may be acceptable.

Signals that don't belong: Spurious

Most of the discussion to this point has been around signals that are different in magnitude from what they should be. Note that one can look for signals that are there but shouldn't be. Set up a VTP at a suspected point of spurious oscillation, isolation or leakage and measure the noise floor. Set a limit above that by some amount. If a signal appears it will trigger a limits failure indicative of a fault at that location. In these situations it's more difficult to say definitively that a particular component failed since spurious are often caused by a combination of feedback mechanisms and paths. On the other hand, this technique can help identify broken ground connections, cold solder joints, un-torqued screws, bad connectors or shielding.

Garbage In – Garbage Out

The most important thing to keep in mind is that this is a diagnostic tool. Its ability to resolve failures lies in the time spent up front placing VTPs in strategic locations. If the VTPs are placed without some level of fore-thought and understanding of the circuit, the results will be sub-standard. Although they'll likely be better than if the tool weren't used at all, the results will be more difficult to interpret. A logical approach to the circuit under test will yield easy to locate failures. Additional VTPs can be added if desired as more information is gathered while testing many units.

VTP Measurement Parameters

Each VTP has settings that need to be modified based on RF signal being sensed at each VTP. The goal is to obtain a good RF spectrum measurement at each VTP as shown below. For ease of use it is best to only have 1 range (measurement setup) for each VTP. To make measure different frequencies at the same XY coordinate it is best to have multiple VTPs at the same XY coordinate each with 1 measurement setup specifying the different measurement frequency.

Bandwidth

This is the bandwidth of the measurement. Possible options:

2.4KHz, 1.2 KHz, 600 Hz, and 300 Hz

This determines the number of digitizer samples and the FFT Bin spacing of the measurement.

Frequency

This is the expect frequency of the RF signal being sensed.

Level

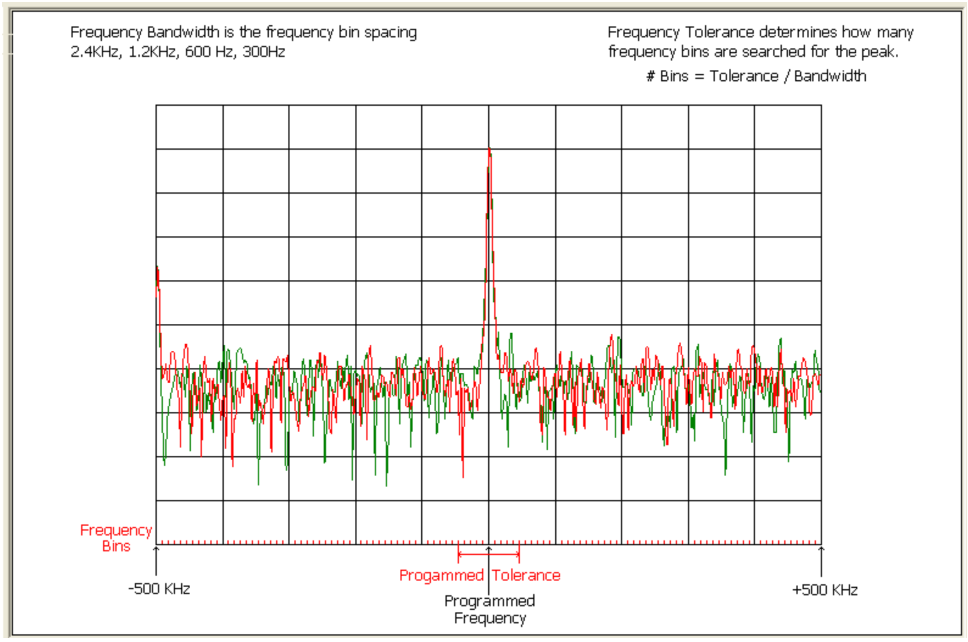
This is the expect power level of RF signal being sensed in dBr. This is a dB level relative to a calibrated signal being sense at a point 5mm above a strip line.

Averages

This specifies the number of measurements average to obtain the result.

Frequency Tolerance

This specifies the amount of frequency bins around the expected frequency to search for the signal (rounded to the nearest frequency bin). The number of bins searched is Frequency Tolerance / Bandwidth. See diagram below.



Measurement Waveform

The waveform displayed above is a captured waveform from the NFSA Workstation. The software will search in the bins around the programmed expected frequency bin for the signal to measure. The number of bins searched is determined by the Frequency Tolerance programmed and the Bandwidth programmed for the measurement. The total number of Bins in the display is determined by the Bandwidth. The waveform displayed is always 1MHz (+/- 500KHz) around the expected frequency.

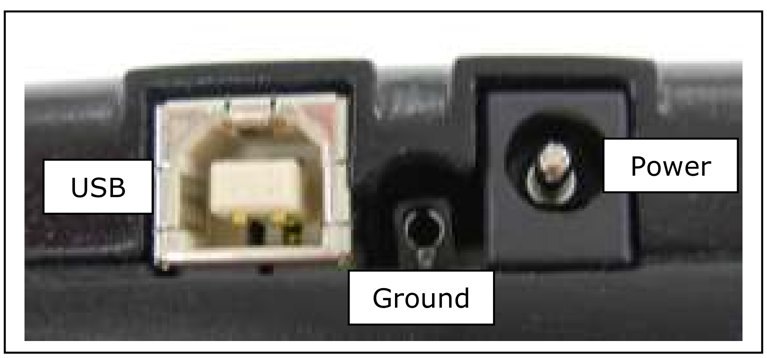
Bins Searched = Frequency Tolerance / Bandwidth

NFSA Probe

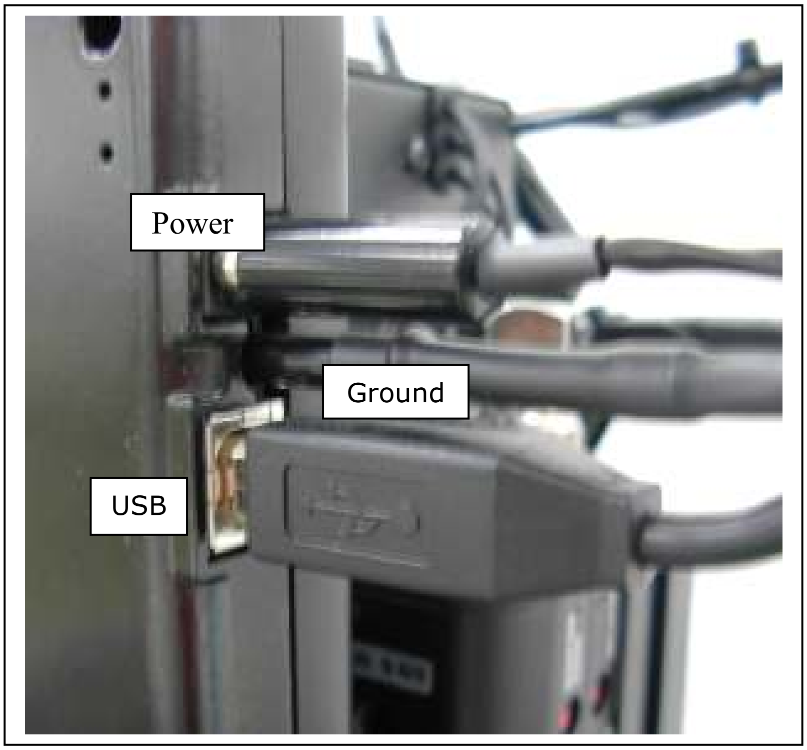
The NFSA Probe is mounted on the Huntron Access prober and is connected to the USB, power and ground of the prober.

TEV NFSA Probe

NFSA Probe Connections



TEV NFSA Probe Connectors



TEV NFSA Probe Connected to Prober

NFSA Probe Antenna

The NFSA Probe Antenna is a spring-mounted pogo pin attached to an SMA connector. If an antenna is broken it may simply be unthreaded and a new one threaded in place. Once mounted the offset for XYZ should be measured and the device recalibrated. Please note that the SMA connector should be hand-tightened and NEVER put on with tools. Over-tightening will result in damage to the instrument.

TEV NFSA Probe Antennae

NFSA Probe LEDs

The NFSA Probe has two status LEDs. The upper LED is the USB status and should be blinking. The lower LED is power status and should be on solid.

Mounting NFSA Probe

The NFSA Probe is mounted to the Huntron Prober with 3 screws. The NFSA is mounted on the Z stage of the prober.

Huntron Z-Stage Mount for TEV Probe

TEV NFSA Mounted on Huntron Prober

Specifications

Physical Characteristics	
Weight	0.63lb
Size	4.25"x9.25"x1.5"
Connectors	USB 2.0, B-Type Connector 500mA
	2.5mm ID, 6.5mm OD, CUI PJ-102B
	TipJack Connector, Emerson 105-1103-001
Antenna	TEV CON0077 Coaxial Probe Antenna

Non-Contact RF Mode
Four Bandwidth Ranges: 300Hz, 600Hz, 1200Hz and 2400Hz

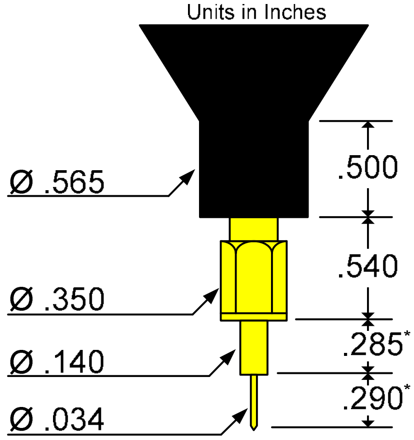
Sensitivity @ 2mm Offset Range		
Frequency Range	Repeatability Using 300Hz Bandwith	Input Power Range
30MHz to 300MHz	±1.5dBr	-30 to 0dBr
300MHz to 3.0Ghz	±0.5dBr	-30 to 0dBr
300MHz to 3.0GHz	±1.0dBr	-60 to -30dBr

Contact Mode

Sensitivity in Contact Mode (>100kΩ DC Input Impedance)		
Frequency Range	Resolution	Input Range(Typ.)
DC	16 Bits	±20V
1kHz-5MHz	16 Bits	±10V
5MHz-100Mhz	±1.5dBr	-60 to 0dBr

Power

11.5V-20V Input Range, Currents Measured at 12.0V	
RF Non-Contact	600mA
RF Contact	450mA
DC Contact	500mA



*Standard antenna dimensions, customized solutions are available