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1.0 Introduction

1.1 Features and Functions: The analyzer breaks the size barrier for RF-analyzers by delivering user-friendly convenience, top-notch accuracy, and a vivid TFT multi-color display in an ultra-compact package. Although small in size, this unit is loaded with a great selection of *Single-Frequency* and *Swept-Frequency* VNA functions.

Use the **Single-Frequency** mode to view *Standing Wave Ratio* (*SWR), Resistance (R), Reactance (X), and Local Interference levels (S)* simultaneously on a high-resolution analog bar-graph display. Allows you to use your analyzer as a precision signal generator.

Use the **Scan-Frequency Mode** to graphically plot SWR, R, X, and Z. All four plots are captured as a sequence of sharply defined color graphs. Simply toggle through each screen for a complete visual analysis. There's also a tunable marker on each screen you can use to call up precise numerical values for SWR, R, X, and Z at any point along the plot.
The NS-60A has internal memory, so there's no need to worry about lost data -- if you turn your unit off, the last measurement will still be there when you turn it on again.

The analyzer is continuously tunable from 0.5 to 60 MHz with 100-Hz resolution and a wide range of tuning steps and scan widths for shaping your plots. The advanced DDS stimulus generator delivers rock-solid stability, smooth skip-free tuning, and a powerful +5 dBm test signal that overrides most strong local interference.

There's also a built-in *Field-Strength Indicator* to warn when high interference levels are present.

This unit long-running lithium-polymer power source is built right in. Simply connect to any available USB port on your computer or USB wall charger to recharge.

We strongly recommend reading through the manual before turning your analyzer on for the first time.

1.2 Technical Specifications

DDS RF-Stimulus Generator
- o Tuning Range: 0.5 - 60.0 MHz
- o Tuning Steps: 100Hz, 1kHz, 10kHz, 100kHz, 1MHz
- o Output Power: +5 dBm, ±1 dB typical
- o Frequency Stability: <5 ppm
- o Harmonic Suppression: -20 dB or better
- o Scan Width and Marker Steps: See Scan Mode

Single-Frequency Measurement Mode
- o VSWR Range: 1:1 to 9.9:1, analog bar and numerical readout
- o Load Resistance (R): 0-300 Ohms, analog bar and numerical readout
- o Load Reactance (X): 0-300 Ohms, analog bar and numerical readout
- o Impedance Magnitude (Z): 0-300 Ohms, numerical readout only
- o Interference Detector (S): full scale = 0 dBm, analog bar display.

Scan-Frequency Measurement Mode:
- o Widths: .3 MHz, .6 MHz, 1.2 MHz, 2.4 MHz, 6 MHz, 12 MHz, 24 MHz 48 MHz
- o Marker Steps: 1 kHz, 2 kHz, 4 kHz, 8 kHz, 20 kHz, 40 kHz, 80 kHz, 160 kHz
- o VSWR Plot Range: 1:1 to 9.9:1
- o Resistance Plot Range (R): 0-300 Ohms
- o Reactance Plot Range (X): 0-300 Ohms
- o Impedance Magnitude Plot Range (Z): 0-300 Ohms
- o Interference Detector: 5 bar style display, -30 to + 20 dBm range

Power Management
- o Power Source: Built-in 3.7-V, 1800-mAh Lithium Polymer battery
- o Charge Controller: Smart charger, LED charging-status indicator
- o Voltage Monitor: On-screen DVM, plus battery condition icon
- o Charger Source: Any USB port, analyzer accepts Micro-USB plug
- o Power Savers: Auto-off timer, manual Run/Stop RF-generator control

Interface
- o RF Connector: BNC,
- o Battery Charge Connector: Micro-USB
- o Screen: 2-inch high-output color TFT
- o Function Keys (4): Membrane, with on screen identifier
- o Tuning: Rotary encoder with press-in tuning-step selection
- o ID Tag: Programmable call letters or name, up to 8 characters.

Weight and Dimensions
- o Case: High-impact black molded
- o Size: 6.86 cm (W) x 8.9 cm (H) x 2.54 cm (D)
- o Weight: 0.144 kg

1.3 Layout and Controls
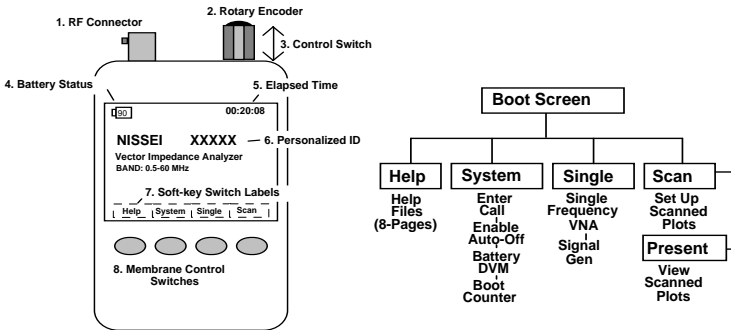
1. RF Connector: BNC-female.

2. Rotary Encoder: Tunes DDS frequency when setting up tests, positions marker when reviewing plot data, and scrolls for some system set-up functions.

3. Encoder Control Switch: Turns unit on and off, selects tuning steps, and scrolls through some setup menu choices. When used for power-off function, the *Boot Screen* must be displayed.

4. Battery Status: Indicates battery power remaining, warns when the battery is running low.

5. Elapsed Time: Displays running time for the current operating session.

**6. Personalized ID:** Displays owner's call letters or name .

7. Soft-Key Switch Labels: Displays the analyzer command-key assignments

8. Membrane Control Switches: Enters command instructions into the analyzer's processor.

2.0 Power Source and Initial Setup

2.1 Charging the Battery: The analyzer is powered by a 3.7-V 1800-mAH Lithium Polymer battery that comes pre-installed. To recharge, use a *micro-USB-to-standard-USB patch cable.*

> ***Be sure to charge the battery fully before turning on and operating your analyzer for the first time.***
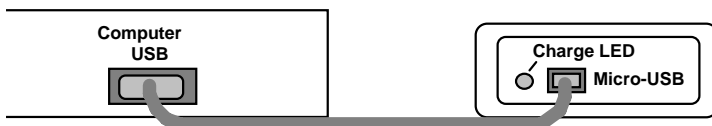
To monitor the charge cycle, check the status LED located to the left of the charging jack (LED not visible unless charging is in progress). *Red LED* signals normal charging, *Green LED* indicates when charging is complete, and *Flashing LED* warns of a charging fault (battery or power-source problem).

During the charge, a built-in smart-controller monitors battery condition and sets the best charge mode and rate. If the battery is depleted below 2.9 volts, the charger supplies a 50-ma trickle-charge until the 2.9-volt threshold is restored. It then increases to a 500-ma constant-current rate until the level reaches 4.2 volts. At that point, the controller switches into the constant voltage mode and tapers the charge down to shutoff.

> ***Important Charging Note:*** *Charge the battery before operating your analyzer for the first time, before storing, and at 2-3 month intervals while in storage.*

2.2 Processor Reset: For an unlikely event of a system crash, you can reset the processor by locating the small reset-switch access hole located on the left side of the case. To reset, insert the end of a paperclip or stiff wire into the hole and press gently.

2.3 Turning Analyzer On and Off:

Press the Rotary Encoder Knob switch "down" for 2-5 seconds to "power on"/ "power off " the machine.

Important Operating Note: The Boot Screen must be displayed in order to turn the analyzer off using the Rotary Encoder Switch.

2.4 Enter Call Sign or Name: You may personalize your analyzer by posting call letters or a name (up to eight characters) on the *Boot Screen*. To program these in, power up the analyzer and follow the procedure below:

➢ Press the switch labeled *System* to bring up the system menu.
➢ Press *Select* to toggle between *Auto-Off* and *Callsign*. Select *Callsign*.
➢ Press the *Encoder Knob* to toggle the curser to the start (or left) position.
➢ **Rotate** the *Encoder* to scroll in your first character
➢ **Press** the *Encoder* to move to the second character.
➢ Continue building the sequence until your call or name is entered.
➢ Press *Exit* to return to the Boot Screen and view your entry.

If you don't wish to enter a callsign, simply leave the field blank.

2.5 Auto-Off Function: This unit has an optional automatic-shutdown timer. Your data current remains in memory when the analyzer shuts down, so nothing will be lost. To activate (or to defeat) the *Auto-Off* function, use the following procedure:

➢ Press *System* to bring up the *System Menu.*
➢ Press *Select* to toggle between *Auto Off* and *Callsign*. Select *Auto Off*.
➢ Rotate *Encoder* clockwise to activate it, counterclockwise to deactivate it.
➢ Press *Exit* to return to the *Boot Screen*.

2.6 System Screen: The *System Screen* posts other information such as the name and revision of the current operating firmware, the text language, reactance mode, and a battery DVM. It also counts the number of times your analyzer has been booted since new (or since reset).

2.7 Help Menu:

The following procedure:

> ➢ Press the *Help* key to bring up the *Help-Contents* page
> ➢ Select a specific page using the *S-Prev* and *S-Next* keys, then press *Enter*
> ➢ Alternatively, press *Enter* then *Next* to scroll through all 8 pages sequentially
> ➢ Press *Top* to return to page 1 or *Exit* to escape back to the Boot Screen

2.8 Overload Precautions: Never connect your analyzer to a feeding or device a DC-bias voltage.
Never connect to a transceiver that could accidentally transmit into the analyzer, and always check the interference display when testing in high-RF areas.
Disconnect immediately if high pickup is indicated.

Important Protection Warning: Never connect a DC voltage or static-charged coaxial line to the analyzer.

3.0 DDS Frequency Entry

3.1 Tuning: The analyzer tunes continuously from 0.5 to 60 MHz with a choice of five tuning rates. All selection is done using the *Encoder* and *Encoder Switch*:

Rotary Encoder: Rotate the encoder knob to change frequency. Each encoder indent shifts frequency by one tuning increment. Use smaller increments for in-band tuning and larger increments for rapid shifts or band changes.

Encoder Switch: Depress the encoder switch to scroll through the five available tuning rates. They are: 100-Hz, 1-kHz, 10-kHz, 100-kHz, and 1-MHz. A highlighted placeholder appears below the analyzer's digital frequency display to designate the selected increment (see below).
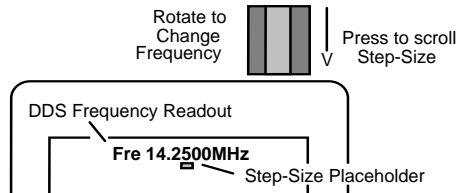
3.2 Rounding Off the Display: When you change the DDS step size (or increment), the new step will be added to -- or subtracted from -- the analyzer's *current frequency setting.* For example, if the current frequency is *3.920 MHz* and you select a *1-MHz* increment, rotating the encoder knob clockwise will advance the frequency from *3.920* to *4.920* > *5.920* > *6.920...etc.* in 1-MHz hops. As an alternative, you may choose to *round off* the existing frequency before entering a new larger increment. For example, you might tune from *3.920* up to *4.000 MHz* first, then switch to the *1-MHz* step. Now the analyzer will step from *4.000* to *5.000* > *6.000* > *7.000...etc.* Rounding off isn't mandatory, but some users find it helpful.

3.3 Practicing Entry: If DDS tuning is a new experience, we recommend spending a few minutes practicing step-size selection and frequency entry before heading out into the field to make antenna measurements. Most users develop a feel for DDS tuning quickly and enjoy its seamless mobility.

4.0 Single-Frequency Test Mode

4.1 Single-Frequency Screen Layout: In single-frequency mode, pressing the _Run/Stop_ key sends a steady CW carrier to the antenna under test. The analyzer's directional coupler then samples the incident (forward) and reflected (reverse) power values and sends this data to the processor for conversion into a visual display. The three top analog bars display approximate _SWR_, _Resistance_ (R) and _Reactance_ (X). More precise numerical values for SWR, R, X -- and also _Impedance Magnitude_ (Z) -- appear at the bottom of the screen (see below).

```
┌─────────────────────────────────────────────┐
│ ▢  Single   Fre 14.0000MHz      00:05:00      │
│  SWR        1.5        2.0   3.0  4.0          │
│ 1.0 ▮▮▮▮▮▮▮▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯ 9.9       │
│  Resistance       100        200              │
│ 0 ▮▮▮▮▮▮▮▮▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯ 300          │
│  Reactance        100        200              │
│ 0 ▮▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯ 300          │
│  S-Antenna         6      9    +10            │
│ 0 ▮▮▮▮▮▮▮▮▮▮▮▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯▯ +30          │
│                                               │
│  ┌────┐           ┌─┐           ┌─┐   ┌─┐     │
│  │SWR │ 1.52      │Z│ 75.1      │R│75.5│X│ 1.3│
│  └────┘           └─┘           └─┘   └─┘     │
│  ┌──────┐                           ┌────────┐│
│  │Return│  ──────    ──────         │Run/Stop││
│  └──────┘                           └────────┘│
└─────────────────────────────────────────────┘
```
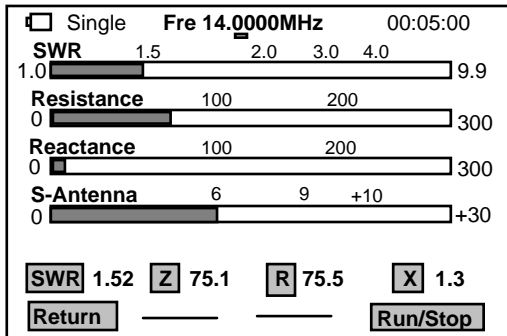
With the generator running, you may change frequency on the fly using the _Encoder_ while watching the display for key points of interest such as resonance ($X = 0$), minimum SWR, and the antenna's 2:1 bandwidth limits. You may also use the analog bars to provide continuous feedback when adjusting tunable circuits or matching networks. Pressing Run/Stop again toggles the generator off.

4.2 S-Antenna Bar: The S-Antenna bar warns when your antenna is being energized by powerful external signals from a nearby transmitter. It also indicates when the analyzer's DDS generator is running, but its primary function is to detect interference when the generator is stopped. A full-scale reading means power in excess of 0-dBm is being fed back into the analyzer from an external source. _In this event, disconnect the analyzer immediately to avoid damaging the coupler._ Although marked in S-units, the meter is not logarithmic, so any reading

exceeding S2 or S3 could potentially interfere and cause inaccurate readings.

Overload Warning: When testing, check the S-Antenna bar with the generator turned off to see if disruptive RF levels are being picked up by the antenna.

4.3 Single-Frequency Setup:
To enter the *Single Frequency* mode from the *Boot Screen*:
- ➢ Press the *Single* command key.
- ➢ Connect the test antenna to the analyzer and check the *S-Antenna* scale.
- ➢ Use the *Encoder* to select a step and tune to your first test frequency.
- ➢ Press the *Run/Stop* key to start the DDS stimulus generator running.
- ➢ *Tune* as needed to explore the antenna's measurements of interest.
- ➢ Press the *Run/Stop* key again to terminate the test run.

The *Run/Stop* function conserves battery power, allowing the analyzer to operate for extended periods without recharging.

4.4 DDS Signal Generator: The analyzer's test generator may also be used as a highly accurate RF signal generator for aligning receivers, tuning networks, or driving amplifier chains. Typical output power level is +5 dBm (±1 dB) with 20-dB or better harmonic suppression. Frequency resolution is 100 Hz from 0.5 to 60.0 MHz with <5 ppm error. Anytime the analyzer is in *Single-Frequency* mode and the Run/Stop key is activated, a test signal will be generated. Note that the +5 dBm power level may be too high for some sensitive preamplifier or mixer stages and could damage them. The use of a wide-range step attenuator is strongly recommended when using the analyzer for any alignment procedure.

Important Signal Generating Warning: Avoid overdriving sensitive circuitry with the analyzer's stimulus generator.

5.0 Scan-Frequency Mode

5.1 Scan Overview:

In *Scan-Set* mode, the DDS generator steps rapidly across a preset range of frequencies and samples reflected power at each stop.

The scan's *Center Frequency* and *Tuning Step* are entered the same way as they are for a single-frequency test.

Along with *Center Frequency*, you'll program in a *Scan Width*. *Scan Width* determines the span of frequencies covered during the test.

A choice of eight scan widths are available, ranging from 300 Hz to 48 MHz. Narrow scans are best for plotting low-frequency mono-band antennas while wider scans are more useful for broadband high-frequency antennas and multi-band arrays. Each scan is initiated manually and takes roughly 3-5 seconds to complete. When done, the analyzer switches from *Scan-Set* mode to *Present* mode.

In *Present* mode, four graphic plot files are available for viewing (wave.SWR, wave.Z, wave.R, and wave.X).

5.2 Screen Layout:

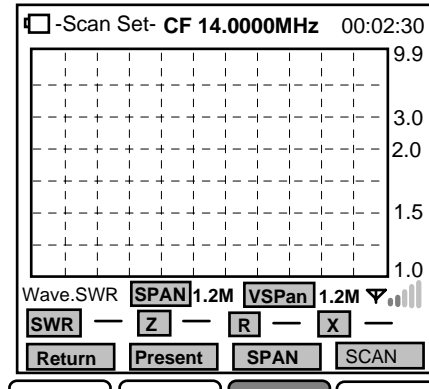From the *Boot Screen ,* press the <u>Scan</u> key. The screen is also shown in the figure shown below:

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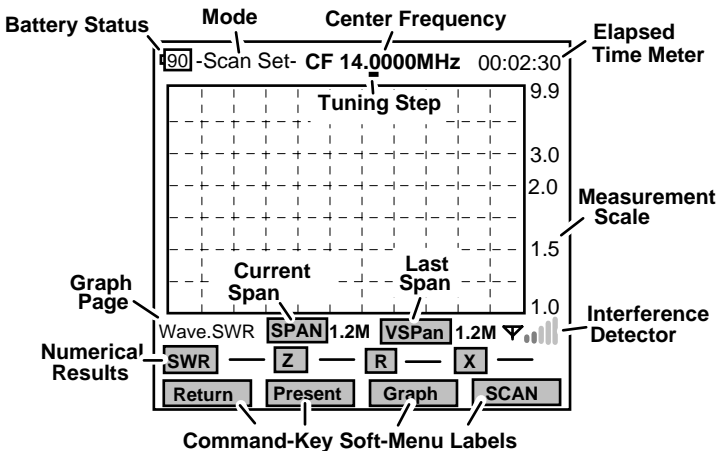
❖ **Top Line:** The analyzer's current operating mode (either *Scan-Set* or *Present*). *Scan-Set* is used for setting up and initiating scans, while *Present* is used to display results. In set-up mode, the frequency display shows center frequency (CF), and in presentation mode it shows the tunable-marker frequency (MK).

❖ **Grid:** This is the visual presentation area for plot files. Note the calibrated measurement scale that appears to the right of the grid.

❖ **First Line Under Screen:** The *Graph* page designator shows which plot is currently selected for display (SWR, Z, R, or X). The *SPAN* box next to it shows the currently entered *Scan-Width* (this value can be reset). V*SPan* shows the width used for the previous scan (can't be reset). The *Interference Detector* on the right side warns of strong interfering signals (see 5.3).

❖ **Middle Line Under Screen:** Displays numerical data for SWR, Z, R, and X in *Present* mode. These fields are normally blank in setup mode.

❖ **Bottom Line:** Shows soft-menu labels for command keys. Labels change for *Scan-Set* and *Present* modes -- see specific instructions in 5.5 and 5.6.

5.3 Interference Detector: The signal bars appearing in the lower right-hand corner of the screen warn of potential RF interference. Like the *S-Antenna* bar, they show deflection during scan runs, but the primary function is to warn of high interference levels with the DDS scanner is turned off. The scale is logarithmic with a range of -30 to +20-dBm (each bar indicates a 10-dB increment). When more than one bar is illuminated, interfering signals may be present.

When three or more bars are illuminated, disconnect the antenna line immediately to protect the analyzer's coupler.

Signal Overload Warning: *Before initiating scans, always check the interference meter for powerful external signals.*

5.4 Scan-Set Entry Procedures:

```
 -Scan Set- CF 14.0000MHz   00:02:30
                                              9.9


                                              3.0

                                              2.0


                                              1.5

                                              1.0
Wave.SWR  SPAN 1.2M  VSPan 1.2M ▼ ▪▁▃▅
  SWR  —   Z  —    R  —   X  —
  Return    Present    SPAN    SCAN
```

In *Scan-Set* mode, the four command keys are assigned the following functions:

[Return] Returns analyzer to the *Boot Screen*
[Present] Toggles the analyzer between *Scan-Set* and *Present* mode
**[Span]** Scrolls to select scan width. (0.3M ~ 48MHz)
[SCAN] Turns on DDS generator and initiates *Scan*
> ➢ To enter from the *Boot Screen*, press *Scan*.
> ➢ Choose *Tuning Step* using the *Encoder Switch*.
> ➢ Set your desired *Center Frequency* (CF) using the *Rotary Encoder*.
> ➢ Scroll with the *SPAN* key while watching the *SPAN* box to select a scan width.
> ➢ To initiate the scan, press the *SCAN* command key.

When you press *Scan,* the soft-menu label turns red while the scan is in progress. Allow it to finish -- when complete, the label turns back to green. Any previous scan data is overwritten by the new scan data and the analyzer switches automatically from *Scan-Set* to *Present* mode.

Note that the *Encoder* becomes assigned to the Marker (MK) function in *Present* mode.

5.5 Present Procedures:
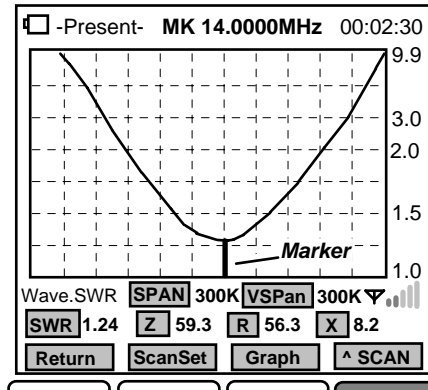
In *Present* mode, the four command keys are assigned the following functions:

[Return] Returns to the *Boot Screen.*
[Scan Set] Returns to *Scan-Set* so you may enter new setup information.
[Graph] Scrolls through graphic plots for SWR, Z, R, and X
[Scan] Initiates a re-scan using the current analyzer setup.

> ➢ To view SWR, Z, R, and X plots in sequence, scroll with the *Graph* key
> ➢ To check numerical data at any scan-stop on any plot, rotate *Encoder*
> ➢ To return to *Scan-Set* mode to enter a new setup, press *Scan Set**

*After reviewing your plots, you may wish to expand or compress them by using a wider or narrower scan width (*SCAN*), or you may wish to move them left or right on the screen by shifting and entering a new center frequency (CF).

5.6 Retrieving Data from Memory: The analyzer's previous scan data remains in memory, even when the analyzer is turned off. If you wish to recall it, do the following:

> ➢ From the *Boot Screen,* press *Scan*. The analyzer switches to *Scan-Set* mode.
> ➢ From Scan-Set, press *Present*. The analyzer switches to *Present* mode.

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The marker function will be activated and your numerical data will be recalled. To scroll through the screens, press *Graph*. Note that the trace for your first plot (SWR) will not actually appear on the screen until you cycle through Z, R, and X. If you wish to set up a new test, press *ScanSet* and re-enter the Scan-Set Mode. If you turn the analyzer off without initiating a new scan, your old data will continue to be retained in memory.

6.0 Measurement and Accuracy Limitations

6.1 General: The analyzer will serve as your eyes and ears when working with RF systems. However, all handheld analyzers share certain limitations, and being aware of them will help you to achieve more meaningful results.

6.2 Local Interference: Like most hand-held units, this analyzer uses a broadband directional coupler that is open to receiving signals across the entire radio spectrum. Most of the time, the unit's built in +5 dBm RF generator is powerful enough to overcome the lack of front-end selectivity and override stray pickup. However, a powerful transmitter located nearby could inject enough RF energy through the antenna under test to overload the directional coupler and disrupt readings. If this condition occurs, performance may become erratic and SWR readings may appear higher than they really are.

6.3 Coupler Loss and Directivity: Simple broadband couplers of the type used in the NS-60A may exhibit accuracy limitations,especially at the higher end of the analyzer's frequency range.Though the accuracy is enough for amateur radio applications.

6.4 Calibration Plane Error: The *Calibration Plane* is the point of reference where all measurements have the greatest accuracy (Gain Reference = 0dB and Phase Shift = 0 degrees). The calibration plane is fixed at the RF connector. Any time a transmission line is installed, it displaces the load from the calibration plane and introduces error.

For SWR readings, the error is mainly caused by loss in the cable. Generally, this condition isn't a problem because your radio and the analyzer both see the same reduction in SWR. However, if you're documenting antenna-SWR for design purposes, the analyzer should be connected directly to the feedpoint through a short pigtail to minimize error.

Calibration-plane error has far more significance for measuring impedance because of phase rotation in the cable.

In fact, impedance readings may swing dramatically, depending on the cable's electrical length and the severity of the load's mismatch referenced to 50 Ohms. For meaningful impedance data, always connect the analyzer directly to the DUT using the shortest cable possible.

6.5 Reactance Sign Ambiguity: Most handheld analyzers, including the NS-60A, lack the processing capability to directly calculate the reactance sign for complex impedance ($Z = Rs \pm j$).

7.0 In Case Of Difficulty:

Note that this unit has no user-adjustable alignment controls. Opening the analyzer case to perform unauthorized procedures could void your warranty. If unit fails to operate properly, please check the suggestions below:

- ➢ **Analyzer won't turn on:** Battery may be fully discharged. Plug in to charger, confirm red charge light comes on, and check unit again after a couple hours.

- ➢ **Analyzer functions or display acts erratically:** Reboot the processor (see Chapter 2.2 for reboot instructions).

- ➢ **All tests show very high or intermittently high SWR:** Check the condition of the analyzer's BNC jack plus, any adaptors you may be using to transition to the BNC jack, or condition of antenna connector and coax.

8.0 Quick Start and Review of Analyzer Functions:

❖ **Charging:** Accepts micro-USB plug on base of unit. Connect to USB port, charge until red LED turns green**. Charge fully before first use.**

❖ **Turn On/Off:** Press *Encoder Knob* down, wait for beep, and release. Turn off the same way. *Boot Screen* must be selected when turning off.
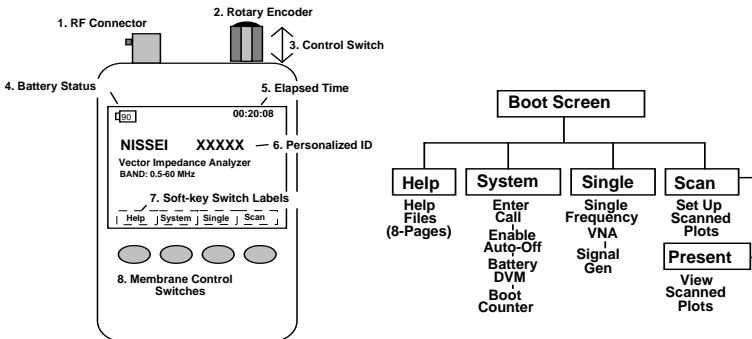
❖ **Commands from *Boot Screen*:** *Help* opens help index. *System* opens *System* page. *Single* opens *Single-Frequency* test functions. *Scan* opens *Scan-Frequency* set-up and presentation functions (see chart above).

❖ *Help Menu* **Commands:** *Exit* returns to Boot Screen. *S-Prev* scrolls to previous page, *S-next* scrolls to next page, *Enter* brings up highlighted page. Once a page is selected, keys can scroll pages without returning to index.

❖ *Frequency Control*: Press *Encoder Knob* to select tuning step (step size indicated by bar under frequency display). Rotate *Encoder Knob* to change frequency.

❖ *Single-Frequency* **Command Keys:** *Return* exits to *Boot Page*. *Run/Stop* starts and stops RF generator. *S-Antenna* scale warns of interference.

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❖ **Scan-Set Command Keys:** _Return_ exits to *Boot Page*. _Present_ toggles analyzer to *Present* mode (shows data from the last scan completed). _Span_ scrolls through available scan widths (see SPAN box for current selection). _Scan_ activates the RF-generator sweep. When scan complete, analyzer switches to *Presentation* mode automatically and activates tunable marker function (MK). Small bar-graph at lower right of screen warns of interference.

❖ **Present Command Keys:** _Return_ exits to *Boot Screen*. _ScanSet_ returns analyzer to *Scan-Set* mode to accept a new scan setup. _Graph_ scrolls through four "wave" plot files (*SWR*, Z, *R*, and *X*). See lower left side of the screen for the current *wave* file. *^Scan* repeats the scan with current setup entries. *Rotary Encoder* tunes marker (MK) across display to recover numerical data for SWR, Z, X, and R at any point along the plot.