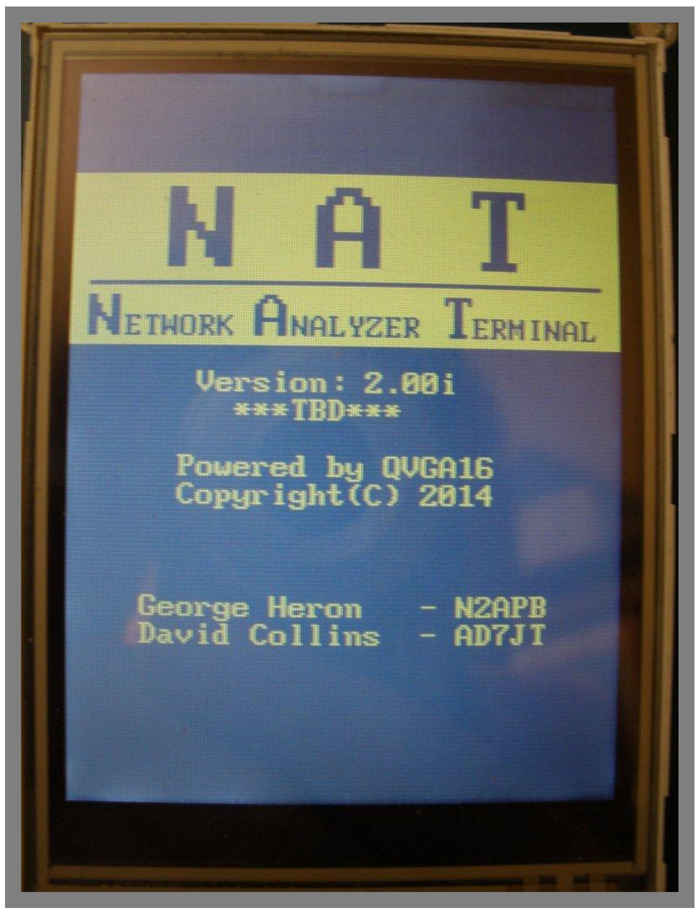
NETWORK ANALYZER TERMINAL

(NAT)

User Guide

Firmware Version 2.00



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1 GENERAL INFORMATION

Test instruments, radios and bench accessories for the electronics experimenter these days are increasingly using the PC to augment the instrument's control, data processing and display capabilities. Whether for remote operation, remote display or post processing, the PC offers much computational power via the serial port connection to the instrument.

However this extension of the instrument's capabilities comes at a price, considering the size of the PC, the complexity of making the serial connections work, and the updating and configuration of the PC application being used for the enhanced capabilities.

Enter the Network Analyzer Terminal … We designed the NAT to serve as a convenient, small, inexpensive and dedicated "terminal and controller" for instruments offering serial port expansion capabilities. The cost of bright, multi-color, and moderate-resolution VGA displays has come down in recent years to enable a small form-factor device such as the NAT to be developed. Further, the display's touch-sensitive surface will allow the developer to use "soft keys", thus eliminating the need for mechanical pushbuttons and other controls. Lastly, adding a jack to accept low-cost, industry standard, mini keyboards allows the terminal to be "bidirectional" for the operator to conveniently enter textual information, numeric calibration data or whatever specific input the instrument requires.

The small size of the NAT pc board (approx 3" x 4" x ¾") enables users to add it to the front panel of the enclosure that houses the instrument itself (e.g., the PHSNA Simple Scalar Network Analyzer), or even into a small, dedicated enclosure for use as a handheld accessory that is tethered to the target instrument via the serial cable.

The NAT platform incorporates the use of an SD Card to provide massive spooling of the instrument's incoming data stream, thus enabling at-speed operation of the instrument, long multi-point scanning capability, and convenient/extensible data storage. The user can also use the SD Card for transfer of instrument data to other platforms. Further, the SD Card offers a convenient way to upgrade the NAT firmware in the field … just load the latest NAT firmware release or an entirely different application onto the card and then command the NAT to reflash itself using that file!

While initially designed as an optional accessory for the PHSNA instrument, other applications of the Network Analyzer Terminal are planned for follow-on releases, including use as serial port terminals for the Micro908 Antenna Analyst and for the SDR Cube Transceiver, as well as CAT terminals for popular rigs from Yaesu, Icom, Kenwood and Elecraft. And with plug-in options, the NAT can easily become an attractive standalone VFO, power meter and display/control head for other commonly used equipment in Amateur Radio.

With the Network Analyzer Terminal, the capabilities of many bench instruments and accessories are instantaneously expanded, and many interesting new applications are made possible!"

Please direct any and all questions, comments, suggestions, critiques, etc to the authors:

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2 INTRODUCTION

First we need to get the disclosure out of the way.

```
****************************************************************************
***    THIS FIRMWARE IS PROVIDED IN AN "AS IS" CONDITION. NO WARRANTIES,   ***
***    WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING, BUT NOT LIMITED   ***
***    TO, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A         ***
***    PARTICULAR PURPOSE APPLY TO THIS SOFTWARE. THE AUTHOR(S) SHALL      ***
***    NOT, IN ANY CIRCUMSTANCES, BE LIABLE FOR SPECIAL, INCIDENTAL OR     ***
***    CONSEQUENTIAL DAMAGES, FOR ANY REASON WHATSOEVER.                   ***
****************************************************************************
```

At this time, the NAT firmware is not open source. It currently consists of nearly 16,000 lines of (mostly C) code organized into 34 source code files. It is based on a collection of general firmware modules developed to support a 3.2-inch QVGA (quarter VGA) 16-bit color display module that includes the display, display controller, EEPROM, resistive touch screen, touch screen controller, and SD card interface connector on a single PCB assembly. (Note: the touch screen is not supported in this initial firmware version; its support is currently planned for version 2.)

This document describes the Network Analyzer Terminal (NAT) functions and operating procedures provided by the firmware version and revision level identified on the cover page. The primary intent of the NAT is to provide a convenient alternative to the PC in a Simple Scalar Network Analyzer (SSNA) system. As the name implies, an SSNA is a tool for analyzing the frequency response characteristics of hardware networks such as filters and amplifiers. The NAT firmware has been developed to support and enhance a particular SSNA implementation referred to as the "Poor Ham's Scalar Network Analyzer" (PHSNA) and a topic of the Yahoo group found on-line at:

https://groups.yahoo.com/neo/groups/PHSNA/info

The NAT firmware is highly dependent on the current PHSNA firmware implementation (V3.02). Throughout this document, operation of the PHSNA implementation using a PC is often described as a lead-in to describing system operation using the NAT.

2.1 NAT VERSION 1 FIRMWARE RELEASE

The initial firmware release implemented the basic NAT functionality including Terminal mode and PLX mode. Utilities for SD card file management were provided in the form of DOS-like commands. A Command mode was also implemented to allow customization and control of basic functions like serial channel baud rate and editing PLX parameters. Version 1.01 was released consisting primarily of minor bug fixes and changes to simplify some setup operations.

2.2 NAT VERSION 2 FIRMWARE RELEASE

Firmware version 2 activated the touch screen functionality (Section 12) and introduced context menus and a numeric pad for touch-screen data entry. Also introduced was a Signal Generator mode (Section 11) giving the user manual control of the DDS output frequency. The calibration algorithm was changed to not require the data scan and the calibration scan to cover the exact same data points. When the number of points is different, the firmware will interpolate to find the best (closest) calibration value for the frequency.

The plot routine was changed to use a different color (up to 9) for each overlaid plot. Changes were also made to improve performance to the point where the version 2 firmware can run the serial interface at baud rates up to 38,400 bps. The number of baud rate selections was changed from seven to ten by adding 1200, 2400, and 4800 bps. Changed PLX mode so when the CLEAR DATA directive is received, the display buffer is also reset to avoid any scrolling when the data transfer starts.

This release also includes a number of minor bug fixes and a few changes in response to user requests. A detailed list of all the changes can be found in the release notes listed in Appendix D.

Major NAT Features

- Handheld graphic terminal for display and control of SSNA
- 3.2 inch, 240 x 320, 16-bit color graphic LCD display w/touch panel
- User-friendly operator interface
- Field upgradable firmware
- Serial port connection to SSNA (RS-232 or digital UART 3.3V)
- Keyboard input for control of SSNA menu system
- 32KB EEPROM for persistent storage of settings and options
- 14 Macros (in EEPROM) for storing operating parameters
- PLX-DAQ (Excel) mode for test automation and PHSNA compatibility
- Compatible with standard and enhanced PHSNA firmware versions
- Simplified calibration (no curve fitting required)
- Measurement & Plot Capabilities (v1.0):
    - *Testing and evaluating filters*
    - *Measuring crystal parameters*
    - *Return Loss Measurement*
    - *VSWR and antenna tuning*
    - *Continuous/repeated operation options*
- SD Card mass storage up to 1 GB provides:
    - *FAT16 file system compatibility*
    - *Subdirectory support for easy file management*
    - *Data spooling and playback*
    - *Calibration data storage and reloading*
    - *Direct data exchange with Windows and Linux apps*
    - *Easy and efficient firmware upgrades*
    - *DOS–like commands to manage and playback data files*

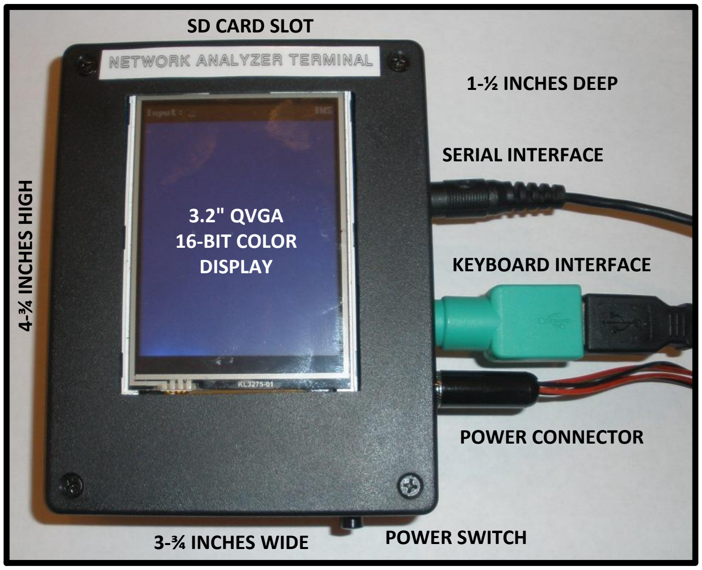
General NAT Specifications

- PCB: *4.47" x 3.31"*
- Enclosure: *4.82" x 3.77" x 1.39"*
- Data rates: *1.2 to 19.2 kbaud*
- Power: *9-18V DC @ 120ma (typ)*
- Weight: *7 oz (approx)*

Additional information including technical details, ordering, online documentation, schematic, etc. are located here: http://www.midnightdesignsolutions.com/nat

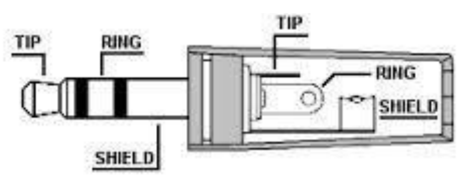
3 GENERAL DESCRIPTION

The standard NAT is housed in a plastic case. Four screws hold the top cover in place. Inside, four screws hold the electronic assembly in place. The display assembly plugs into the main board with a 40-pin connector and is attached to the main board with four mounting screws. The following figure shows the NAT interface connectors and approximate case dimensions.



The following paragraphs describe the various NAT connectors:

- The serial interface connector is a standard 3.5 mm, stereo audio jack with the NAT's receive (Rx) data line connected to the tip terminal and the NAT's send (Tx) data line connected to the ring terminal. An assembly option is provided to allow the serial interface levels to be either RS232 (default) or 3.3V, positive, logic levels. The standard PHNSA firmware operates the serial interface at 9600 bits per second and there are no provisions for flow control.



- The keyboard interface is a standard PS2 keyboard interface. The NAT firmware assumes a standard U.S. keyboard layout. The above photograph shows a USB to PS2 converter being used to interface a common USB interfaced keyboard. USB to PS2 converters are available from many sources such as:

  http://www.frys.com/product/3470833?site=sr:SEARCH:MAIN_RSLT_PG

- The power connector is a standard 5.5x2.1 mm male center pin jack. Matching plugs are available from many sources. The NAT power requirements are 6.5 – 14 VDC at TBD Amps, center pin positive. The current draw includes current used by the keyboard which depends on the model keyboard used.

- The power switch is a push-on/push-off switch. The above picture is of a prototype NAT, production models will have the power switch moved to the side of the case adjacent to the power connector.

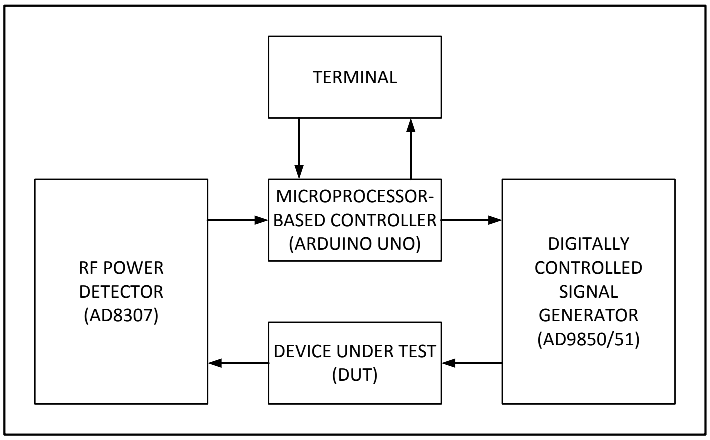
- The SD Card slot at the top o the case accepts a standard size SD Card or a micro SD Card in a full-sized adapter.

The NAT firmware includes an implementation of an abbreviated FAT16 file system using an SD card for the mass storage device. The implemented file system will only work with SD card capacities up to 1 GB formatted with the standard 512 byte sector size. The SD card must be formatted before using it in the NAT; the NAT is not able to format an SD card. In addition to the basic file system, the firmware includes a small number of DOS-like commands that can be used for simple file maintenance functions.

The mass storage is used by the NAT to spool and playback data generated by the SSNA during operation. Data is generally stored in standard Comma-Separated-Value (.csv) format so the SD card can be used to load SSNA data onto a PC for archiving and further analysis and evaluation by spread sheet or other graphic analysis programs running on the PC. The SD card is also used to update the NAT firmware.

4 SIMPLE SCALAR NETWORK ANALYZER (SSNA) ARCHITECTURE

The following block diagram illustrates the basic architecture of an SSNA system:



The devices identified in parentheses are the devices used in the PHSNA implementation. The remainder of this document assumes the PHSNA implementation. Other implementations may use other devices and still be compatible with the NAT.

The controller used in the PHSNA implementation is an Arduino UNO, hereafter referred to simply as the "UNO", (http://arduino.cc/en/Main/ArduinoBoardUno) which is essentially an Atmel ATMEGA329P eight-bit microcontroller with a USB controller added for programming and communication with a PC. System interfacing is facilitated by a number of inter PCBA interface connectors which expose UNO I/O ports for connection to a variety of other system components. The PHSNA implementation consists of custom PCBAs designed to interface with the UNO interface connectors and specialized firmware to control and monitor the PHSNA system.

The PHSNA firmware running in the UNO (hereafter referred to simply as the "PHSNA firmware" or the "PHSNA") directs the signal generator to generate a sine wave signal at a specified frequency. The sine wave is applied to the input of the device under test (DUT). The power level of the output of the DUT is measured by the RF power detector the output of which is an analog voltage level sent to an analog-to-digital converter (ADC) input of the UNO. This digitized voltage level is a function of the signal generator output and the frequency response of the DUT. The power detector output is logarithmic and is generally expressed in dB relative to the signal generator output or in dBm. The AD8307 output is calibrated in dBm and is extremely accurate (+/- 1 dBm from DC to 500 MHz). The AD9850/51 output level is not generally linear with respect to frequency and, therefore, it will be necessary to calibrate the PHSNA across the frequency range of interest if accurate dBm readings are required.

The interface between the UNO and the terminal is a simple, 2-wire, serial interface operating at 9600 bits per second with 8-bits per character, no parity, and one stop bit (8-n-1). The UNO's USB interface is generally used to interface a PC running a terminal emulator program or custom software with special USB drivers that emulate a serial interface at that end. The UNO's USB interface controller emulates a serial interface at the UNO end. The USB interface is not used (except, possibly, to load the PHSNA firmware) when the PC is replaced by the NAT. The serial interface lines must connect to the UNO's Rx and Tx pins which are available on pins 0 and 1 of the UNO's interface connectors. Note that the USB interface controller also uses the UNO's Rx and Tx pins so it is not possible to use the USB interface when the NAT is attached.

All communications are encoded in ASCII. The terminal supplies operating parameters such as frequency range and frequency increment. The PHSNA firmware directs the signal generator to sequentially output a series of discrete frequency signals and records the DUT power output for each. The digitized power outputs are returned to the terminal for displaying directly as raw data and/or for displaying in a graphical format. Spooled data may also be input to a graphical analysis program for more detailed analysis.

5 PHSNA OPERATING MODES

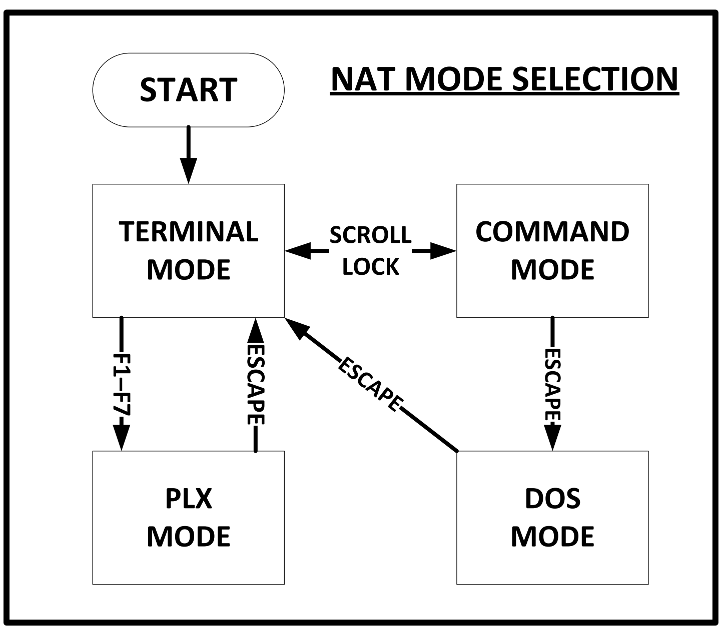
The terminal in the above block diagram can be a PC running a terminal emulator program (Terminal mode) or a spreadsheet program (such as Excel) with a special macro (or VB add-on) that allows the PHSNA firmware to access specific cells in the spreadsheet (PLX mode). The NAT can operate in both of these modes plus two additional modes used to setup operating parameters (Command mode) and manage spooled files (DOS mode). The remainder of this document assumes the PHSNA terminal is the NAT.

5.1 NAT START UP AND BEEP

When the NAT is first turned on, it displays a splash screen for a few seconds. A screen shot of the splash screen is shown on the first page of this document. It identifies the product and the version and revision level of the installed firmware. During the initial startup sequence, the hardware is initialized and the keyboard is reset (the keyboard LEDs will flash briefly). At the completion of the initialization sequence, the NAT will sound an audible indicator (BEEP) and begin normal operation. During normal operation, the NAT will sound BEEPs to alert the operator to abnormal conditions such as entering an invalid key stroke. A BEEP will also be sounded to alert the operator of the initiation and/or completion of some normal operations.

5.2 NAT MODE SELECTION

The NAT firmware always starts in Terminal mode. In Terminal mode, data entered by the operator is transmitted to the PHSNA via the serial interface. There are a number of hot-key sequences to do special functions while in Terminal mode. Pressing and releasing the Scroll Lock key switches the NAT to Command mode. In Command mode, keyed data is processed by a command processor in the NAT firmware. The serial interface is ignored. Pressing Esc in Command mode will switch to DOS mode. In DOS mode, keyed commands are executed to perform file management functions on the SD card files. Pressing one of the function keys F1 through F7 while in Terminal mode will switch to PLX mode. In PLX mode, pressing the Esc key will return to terminal mode. There are a couple hot keys available in Terminal, PLX, and DOS modes for capturing and clearing calibration data.

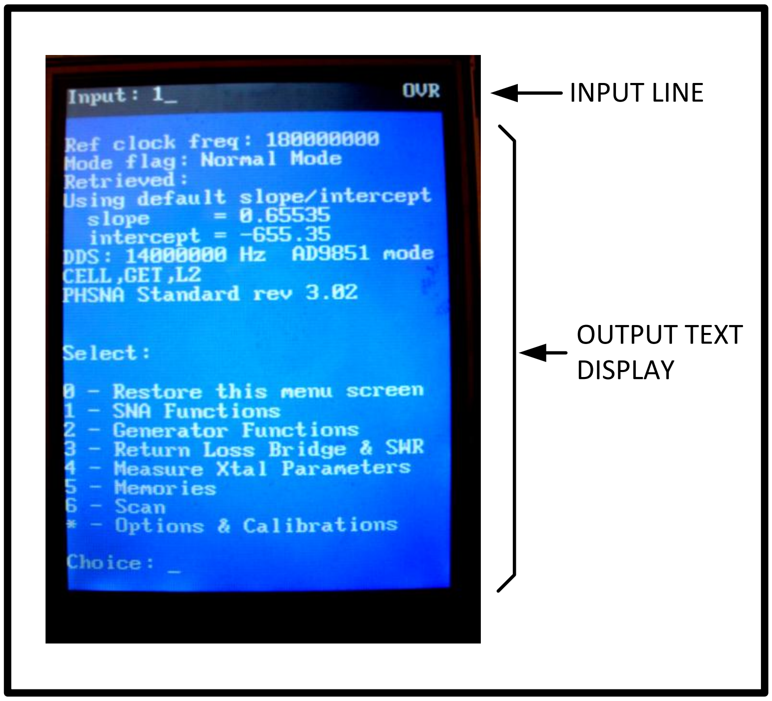


6 TERMINAL MODE

In Terminal mode, the PHSNA firmware generates menus from which the operator makes selections and inputs parameters to direct PHSNA operation. All PHSNA output data is displayed on the text portion of the NAT display. The standard PHSNA firmware will work with the NAT; however, the NAT's limited line length (30 characters) will not properly display some text lines. The PHSNA firmware is easily modified to reformat output to display neatly on the NAT display. All display shots of PHSNA firmware output used in this document have been generated with a modified copy of the PHSNA firmware Version 3.02. The modified version also has a few other changes and bug fixes that simplify operation and improve performance. These modifications are described elsewhere.

6.1 MENU INTERACTION

The following is a screen shot of the modified PHSNA firmware V3.02 start menu displayed on the NAT:



The top line is the Input line. Anything keyed by the operator will appear here. Full editing capabilities are provided on this line. The cursor can be positioned using the left and right arrow keys. Pressing the Insert key toggles between overstrike (OVR) and insert (INS) modes as indicated at the end of the input line. The backspace key deletes the character to the left of the cursor (if any) and shifts all following characters one position to the left. The Del (delete) key deletes the character at the cursor position and shifts all following characters one position to the left. When Enter is pressed, all input is sent to the PHSNA followed by a Carriage Return (CR or 0x0d). In some cases, the PHSNA firmware does not expect the CR so if the user holds down an Alt key while pressing the Enter key, the keyed data will be sent to the PHSNA without the following CR. The modified PHSNA firmware will accept single character entries with or without the trailing CR. Pressing the Home key will clear any entered characters and position the cursor at the start of the input line.

The lower portion of the display (with a blue background) is the output text display area. All text received from the PHSNA firmware is displayed here. The display area consists of 25 lines of 30 characters each. When the display area is cleared, received text is displayed starting at the first character position of the first row. When the end of line 25 is reached, the display is scrolled up one line and following text is displayed starting at the first character position of the last line. The operator may clear the output text display area by holding the Alt key down while pressing the Home key. This clears the display area and returns the cursor (the received data entry point) to the first column of the first line. Characters are rendered using an 8-pixel wide by 12-pixel high character font.

The menu items and responses are determined by the PHSNA firmware and will not be covered in detail in this document. See PHSNA documentation for details. When manually initiating a frequency sweep using the PHSNA menus, it is possible to plot the data on the NAT display screen and/or spool the data to a file on the SD card.

6.2 RECORDING DATA IN TERMINAL MODE

One of the prime functions of the NAT is to record data generated by the PHSNA system. The NAT does not automatically record data in Terminal mode; the operator must manually initiate and stop the recording operation. Data recording is turned on and off by the operator keying the hot key sequence sCtrl-R (for "Record") to start and Alt-R to stop. The NAT firmware does, however, validate the format of the data records and will ignore any that do not meet the validation criteria. With the current PHSNA firmware, this eliminates the possibility of unwanted information interfering with the recording of data.

```
4000000, -6.9, 839
4050000, -6.6, 842
4100000, -6.6, 842
4150000, -6.6, 842
4200000, -6.6, 842
4250000, -6.6, 842
4300000, -6.6, 842
4350000, -6.6, 842
4400000, -6.7, 841
4450000, -6.7, 841
4500000, -6.7, 841
4550000, -6.7, 841
4600000, -6.7, 841
4650000, -6.7, 841
4700000, -6.7, 841
4750000, -6.7, 841

  - - - - - - - -

27150000, -51.2, 357
27200000, -51.2, 357
27250000, -51.2, 357
27300000, -51.2, 357
27350000, -51.2, 357
27400000, -51.2, 357
27450000, -51.2, 356
27500000, -51.2, 356
27550000, -51.2, 356
27600000, -51.2, 356
27650000, -51.2, 356
27700000, -51.2, 356
27750000, -51.2, 356
27800000, -51.2, 356
27850000, -51.2, 356
27900000, -51.3, 355
27950000, -51.3, 355
28000000, -51.4, 354
```

The expected data format is a series of data points representing the frequency response of the DUT. The listing on the left shows the start and end of a sample data stream. Each data point consists of two or more fields, separated by commas and terminated with a CARRIAGE RETURN (CR = 0x0d). CR-LINE FEED character pairs (0x0d-0x0a) are used in some systems (e.g., Windows) to mark the end of a line in text files. The NAT also accepts this sequence as a valid end of line. Blank lines (two or more consecutive CR characters) are ignored. The first character following the end of line character(s) must a numeric digit. This field is assumed to be a frequency so it must be an unsigned, positive number. One decimal point is allowed. There are no limits on how many numeric digits precede and follow the decimal point other than the minimum and maximum values allowed for a double-precision floating-point number. The value is translated on the fly to double precision floating point. The numeric value is terminated by the first non-digit character. Any following characters are ignored until the comma separator is detected indicating the start of the second field. This allows comments or unit definitions to be included in the data field.

The second data field is assumed to be the power level detected at the output of the DUT when the frequency in the first data field was applied to the DUT input. Leading spaces (0x20) are allowed in this field and will be ignored. This field is assumed to be an ASCII representation of a signed, floating-point number. The value may be prefixed with either a minus sign ('-'), a plus sign ('+'), or neither. Unsigned values are assumed to be positive. One decimal point is allowed. There are no limits on how many numeric digits precede and follow the decimal point other than the minimum and maximum values allowed for a double-precision floating-point number. This field is evaluated on the fly and the resulting floating-point value is recorded in a RAM buffer in the NAT.

Only the power levels (second data field) are recorded. Starting frequency is read from the first field of the first data record (4,000,000 Hz in this case). The frequency step is calculated by subtracting the starting frequency from the frequency in the second data record (50,000 Hz in this case). From then on, the frequency information is ignored. The number of data records received (481 in this case) is used to determine the ending frequency (needed for plotting). The NAT data buffer can hold up to 960 data points. Only the first 960 data points will be retained in the buffer. After the sweep, the operator must again press Ctrl-R to disable further recording. The data is retained in the buffer until overwritten by another data recording operation.

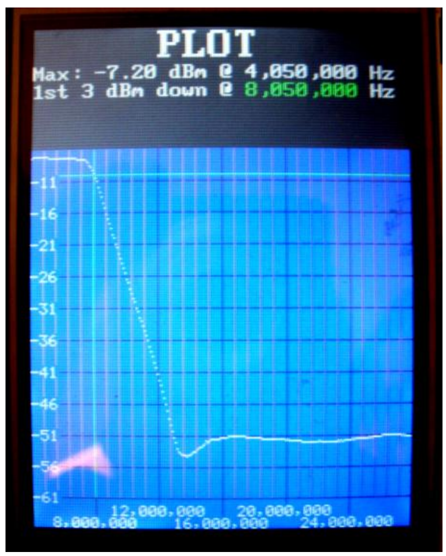
As stated above, all PHSNA output is displayed on the NAT screen in Terminal mode. Normally, when the text area is full, each new line of text causes the display to scroll up one line. When **recording** data in Terminal mode, display scrolling is disabled as soon as the NAT firmware recognizes it is receiving data. When data is received with data recording **not** enabled, scrolling is not disabled. Scrolling the 750 character display is very time consuming and the NAT firmware may not be able to keep up with the data flow. If this happens, the receive buffer may overflow causing blocks of data to not be displayed and displayed data to not be formatted properly.

6.3 SPOOLING DATA IN TERMINAL MODE

When data recording is enabled in Terminal mode, all data records will be spooled to a file (the "log file") on the SD card if such a file is specified and a file having the same name does not already exist in the current directory or sub-directory. The NAT firmware will not overwrite an existing file; it must first be deleted by the operator using the DOS DEL(ete) command (described later). Data is spooled exactly as received from the PHSNA firmware. All data received will be spooled, even if the internal data buffer is full. Note that the data file is opened when recording is first enabled (Ctrl-R) and closed when recording mode is terminated (Alt-R). Spool data is buffered by the NAT firmware in blocks of 512 bytes and recorded to the SD card file only when the buffer is full or when the file is closed. For this reason it is important for the operator to terminate record mode at the end of the sweep to assure all data gets written to the SD card and the file control data on the SD card is properly updated. Spooled data may be transferred to a PC for further analysis and processing. It may also be played back and plotted on the NAT.

6.4 PLOTTING DATA IN TERMINAL MODE

When a sweep is completed, the operator may initiate a plot of the data in the NAT's data buffer using the frequency data captured at the start of the data transfer. Only the data in the buffer will be plotted. The data is plotted when the operator presses the hotkey sequence Ctrl-P.



The plot is rendered in a 240x240 pixel area with a blue background. Major grid lines are rendered in black, minor grid lines (vertical only) are rendered in gray. The major and minor grid line positions in the plot area are the same for all plots; the scales are changed according to the ranges included in the data. Before plotting, the data is analyzed to determine minimum and maximum values for each axis. The ranges are then analyzed to compute label values for the major grid lines. The data is analyzed to determine the type of plot. Five plot types are recognized:

- Low-Pass-Filter (LPF)
- High-Pass-Filter (HPF)
- Notch Filter
- Band-Pass Filter
- Free-Form

A “free-form” plot is one that does not fit into any of the other categories which usually means the difference between the high and low readings is less than 4 dBm. Note that the plot type may be unknowable if the sweep frequency range is too narrow to cover significant response areas.

Depending on the plot type, no, one, or two -3 dBm points may be calculated and shown on the plot as the intersection of two green lines. The above example is a LPF so there is only one -3 dBm point. The frequency of this point is displayed at the top of the chart along with the maximum value and the frequency at which it was detected. A plot from an HPF filter would also have one -3 dBm point; band-pass and notch filters have two. Free-form plots have none. Neither do notch and band-pass plots when the end level of the plot is not within a 6 dBm band centered on the start level.

6.5 SWEEP CALIBRATION

As stated earlier, the power detector in the PHSNA system is very accurate but the signal generator output level may vary significantly as a function of frequency. The PHSNA may have adjustments for both the signal generator output and the RF power detector gain/attenuation to compensate for basic differences but these procedures can be tedious and time consuming and may only be valid for one set of sweep parameters. The NAT provides a simple way to calibrate the PHSNA system for a given set of sweep parameters. In addition to the basic data buffer, the NAT includes a second buffer for calibration constants. During a sweep, each data value is entered into the data buffer minus the value contained in the corresponding entry in the calibration constant buffer. Since the values are logarithmic, this is the equivalent of multiplying the data value by a scaling factor.

To load the calibration buffer, simply replace the DUT with a direct connection between the signal generator output and the RF power meter input. The connection should be a low-loss, frequency independent short such as a short piece of 50 ohm coax cable. Make sure the calibration buffer is cleared (Alt-C) before starting the sweep. With the direct connection in place, run the sweep using the parameters to be used with the DUT and plot it. The result will indicate the miss-match between the signal generator and the RF power meter. After the sweep has been recorded, pressing the hot key sequence Ctrl-C will load the calibration constant buffer with the contents of the data buffer. All future sweep data will be loaded into the data buffer minus the value stored in the calibration constant buffer. The following figure illustrates the process:

RAW
CALIBRATION SWEEP

CALIBRATED
CALIBRATION SWEEP

CALIBRATED
LPF SWEEP

These sweeps were done with the development test PHSNA used to sweep the 40M LPF shown earlier. The first display shows the raw results of the sweep with a two-foot length of coax cable replacing the DUT. This plot shows that, without calibration, it would appear that the DUT has less than 1.5 to over 3 dBm of insertion loss across the frequency range. With this plot on the screen, pressing Ctrl-C loaded the data into the calibration constant buffer. The sweep was then repeated with the coax cable still in place giving the second plot which adds the “calibrated calibration sweep” to the plot. Note that we now have a

0 dBm line. The third plot was made by rerunning the sweep on the 40M LPF. Note that we now have about 0 dBm loss at the start of the sweep instead of the loss we had without calibration. Note also that the loss at higher frequencies is only about 45 dBm instead of the 51 dBm shown on the un-calibrated plot.

The calibration constant buffer is maintained in RAM and is cleared to all zeroes each time the NAT is powered up. It may also be cleared manually with the hot key sequence Alt-C. Several sets of calibration constants can be saved to SD card files associated with different sweep parameters. The set associated with the current sweep parameters can be used to setup the calibration constant buffer to avoid having to rerun the calibration sweep every time the sweep parameters are changed.

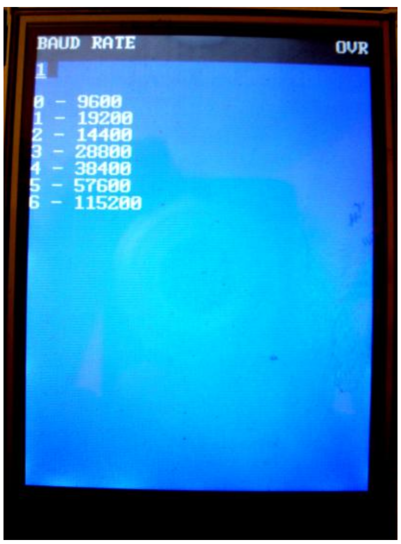
7 COMMAND MODE

Command mode is entered by pressing and releasing the Scroll Lock key. The Scroll Lock LED on the keyboard will remain on as long as the NAT is in Command mode. A menu will be displayed showing the available commands. In Command mode all keyed data is passed to a command processor and not to the serial interface. The serial interface is ignored and all displayed text is generated by the command processor. All commands are initiated by pressing a single key (or key combination). Command mode will be terminated and the NAT returned to monitor mode at the end of a single command execution. The currently available commands are as follows:

- B – Select serial port baud rate
- F1-7 & Alt-F1-7 – PLX data entry
- F – Edit data entry format template
- L – Edit log file name
- X – Edit crystal fixture termination resistance
- ~ – Invalidate EEPROM content
- Esc – Switch to DOS mode

All information entered in Command mode is stored in an EEPROM. This preserves the data between power cycles and avoids the need to reenter parameters and data each time the NAT is restarted.

7.1 B – SELECT SERIAL PORT BAUD RATE



The standard PHSNA firmware sets the serial port baud rate to 9600 bps. In some instances this can excessively limit PHSNA system performance. The NAT defaults to 9600 bps but allows the user to select higher data rates. Command code “B” displays a number representing the current setting and list of baud rate selections. When the user makes a selection and presses Enter, the selection is stored in the EEPROM and the serial interface is reinitialized to the selected baud rate. Each time the NAT is restarted, the baud rate selection is read from EEPROM and the serial interface set to the corresponding baud rate.

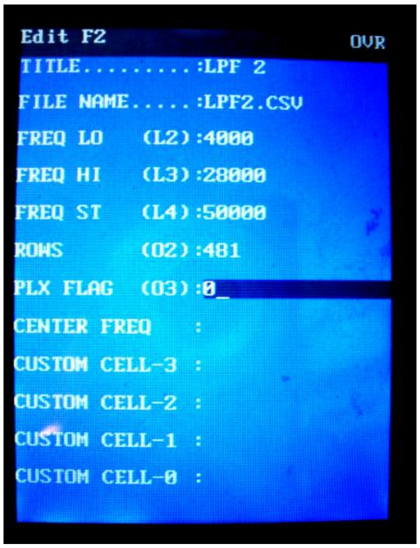
Note: It may be necessary to restart the NAT and/or the UNO after changing the serial port baud rate.

7.2 F1 to F7, ALT-F1 to ALT-F7 – PLX DATA ENTRY

PLX mode is entered from Terminal mode by pressing one of the function keys F1 through F7 or Alt-F1 through Alt-F7. Each of the fourteen function keys has associated with it a set of parameters used in PLX mode to simulate the PLX-DAQ spreadsheet macro and to specify some NAT operating parameters. These parameters are entered by the NAT operator pressing the associated function key while in Command mode. This brings up a data entry screen template with the current values for the sweep parameters filled in. Once entered, the parameters are stored in EEPROM so they persist through power cycles.

The edit screen, shown here, is based on a data entry (DE) template that defines a number of values to be used by the NAT in PLX mode. The top (command) line indicates which set of parameters is being edited (F2 in this case) and whether the edit mode is overstrike (OVR) or insert (INS). Pressing and releasing the Insert key will toggle between OVR and INS edit modes.

The portion of the display with a blue background shows the parameters and their names, double-spaced. Each variable is limited to 15 characters, maximum; spaces are not allowed except in the TITLE. The parameter field in the currently active data entry line is shown with a black background (PLX FLAG in this case). The up and down arrows move the active data entry line up and down. The left and right arrow keys move the cursor in the active parameter field. Data is saved exactly as entered, there are no validation checks made. Once the parameters have been entered/edited, pressing the Enter key stores them in EEPROM. Pressing the Esc key will exit data entry mode without saving any changes to the data.



Cell numbers in parentheses define the default cell number in the spreadsheet the NAT is emulating. The PHSNA firmware can access these cells to read the current value or change the value associated with the corresponding cell number. The default cell numbers can be overridden by entering an equal sign ('=') following the value for that cell. Typing a cell number after the equal sign will override the default cell number. Leaving the area blank after an equal sign will disable the default cell number and make the "cell" inaccessible to the PHSNA firmware.

Any parameter with a cell number assigned to it will be used to answer PHSNA firmware requests to access the assigned cell number (CELL,GET and CELL,SET Control Directives). The standard DE template shown here is what is required to interface with the current PHSNA standard and modified firmware. The lines labeled "FREQ LO" through "PLX FLAG" are accessed with the default cell numbers shown. The lines labeled CUSTOM CELL-3 through -0 are provided to meet future and/or custom requirements.

The data entry template (also stored in EEPROM) defines the name of the associated parameter and the spreadsheet cell number (if any) assigned to that parameter. The user may edit the DE template as described in the next section of this document but there are some restrictions. The following paragraphs describe the purpose of each parameter line in the DE template and the restrictions on editing it.

1. TITLE………: This is the title the NAT will use for any plot made from a sweep using these parameters. This field is generally only used by the NAT and for this specific purpose. The name of this variable cannot be changed or edited by the user. It could, however be made available to the PHSNA firmware using an equal sign to define a spreadsheet cell number.
2. FILE NAME…..: This is the name of the data spooling file. When a spool file name is not specified, the data will not be spooled, only plotted. If a file with the same name exists in the currently active directory, the data will not be spooled; the NAT will not overwrite an existing file. The user must either change the specified file name or delete the existing file to spool new data. The name of this variable cannot be changed or edited by the user. It could, however be made available to the PHSNA firmware using an equal sign to define a spreadsheet cell number.

The next four parameters totally define the frequency sweep and must be made available to the PHSNA firmware. The default cell numbers shown are those used by the standard and modified PHSNA firmware to access these parameters. The NAT uses these parameters to scale and generate plots. These values are obviously dependant on each other such that a sweep can be totally defined by any three of the four parameters. To simplify data entry, when any three of the four parameters are entered, the NAT firmware will compute and enter the fourth parameter. It will only do this when one, and only one, of the four parameter fields is blank (not zero and no spaces). The currently active parameter field can be blanked by pressing the Home key.

3. FREQ LO (L2): This is the start frequency for the sweep in KHz calculated to three decimal places. It is accessed by the PHSNA firmware at the start of each frequency sweep. The PHSNA firmware uses the spreadsheet cell number shown.

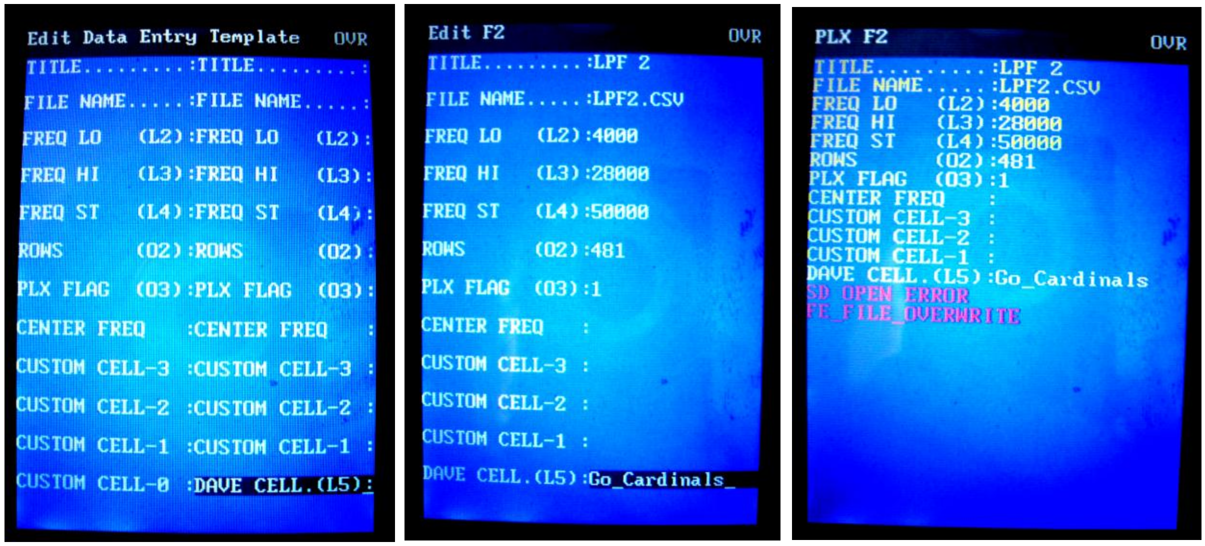
4. FREQ HI (L3): This is the end frequency for the sweep in KHz calculated to three decimal places. It is accessed by the PHSNA firmware at the start of each frequency sweep. The PHSNA firmware uses the spreadsheet cell number shown.
5. FREQ ST (L4): This is the frequency increment in Hz calculated to two decimal places added to the frequency for each point in the sweep. The PHSNA firmware starts a sweep using FREQ LO and sequentially adds FREQ ST until the frequency is greater than FREQ HI.
6. ROWS (O2): Each data point in a sweep is represented by a data row containing the frequency and the DUT's power output at that frequency. At the end of a sweep, the PHSNA firmware returns the number of rows in the sweep as an integer to this spreadsheet cell number. The NAT does not use the value returned (it already knows the answer) but it does use the "CELL,SET,O2,rrr" Command Directive as an indicator that the sweep is finished and the data set is complete. The NAT uses this as a command to plot the data.
7. PLX FLAG (03): This parameter, when set to "100" directs the PHSNA firmware to terminate PLX mode and change to menu mode. Any value other than "100" leaves the PHSNA firmware in PLX mode. When this value is set to "1", the modified PHSNA firmware will use a shortened version of the DATA Directive to transfer data to the NAT. This performance enhancement is described in more detail in the ADDITIONAL NAT FEATURES section of this document.
8. CENTER FREQ : This parameter is provided as a convenience to the NAT operator, it is only used by the NAT firmware during data entry. When FREQ ST and ROWS have been entered, when a value is entered in CENTER FREQ, the NAT firmware will calculate and enter values for FREQ LO and FREQ HI. If there are values in either or both of these locations, they will be overwritten.

Note that the NAT firmware retrieves parameters from the list by their position in the list; it does not use either the titles nor the assigned cell numbers. The PHSNA only uses the assigned cell numbers to access a parameter. For this reason it is important that the parameters used by the NAT firmware remain in the above positions in the list. Their titles can be changed and their assigned cell numbers can be changed but their position in the list cannot be changed. Similarly, it is important that the assigned cell numbers match those in the master spread sheet which are the cell numbers the PHSNA firmware uses to address the parameters.

7.3 F – EDIT DATA ENTRY FORMAT TEMPLATE

Editing the data entry format template is essentially the same as editing the parameters in the data entry form. When initiated, the data entry screen is displayed but, in this case, the variables listed on the right half of the display will be the labels on the left side of the display. With the exception of the first two labels, the labels can be edited as described above. When the Enter key is pressed, the new template is saved in EEPROM and all future parameter data entry displays will display the edited template labels on the left half of the display. In PLX mode, the edited default cell numbers (if any) will be used.

If the EEPROM has not been initialized (validation code not found in first two locations) or the area reserved for the first label in the template does not start with a valid, non-space ASCII character, the template in EEPROM will not be used. Instead, the default template (shown above) will be used. This means that editing a space code into the first character position of the first label will revert back to the default template.



TEMPLATE EDIT PARAMETER EDIT PLX START UP

The above example illustrates template editing. In the first display, CUSTOM CELL-0 has been renamed "DAVE CELL" with a default cell number assignment of "L5". After saving the new template, the F2 parameter set is edited to enter "Go_Cardinals" as the DAVE CELL parameter. After closing this edit screen, F2 is pressed to start PLX mode (described later) using the F2 PLX parameter set. The PHSNA firmware can now reference DAVE CELL by issuing a CELL,GET,L5" Control Directive. When the NAT receives this Control Directive it will return the character string "Go_Cardinals" to the PHSNA firmware via the serial interface.

Note the file error message in the last display. The first line, "FE_OPEN_ERROR" means the NAT could not open the named file ("LPF2.CSV") in write mode. The seconds lines gives more detail; FE_FILE_OVERWRITE" means the file already exists and the NAT will not overwrite an existing file. If not stopped by the operator, the PLX operation will continue without spooling the data. The operator has three options to proceed with spooling.

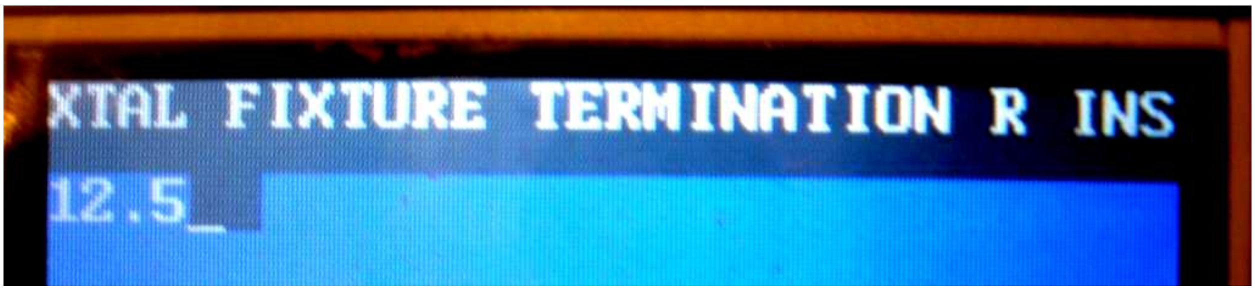
1. Edit the parameter set to change the file name to one that does not exist in the current directory (e.g., "LPF2A.CSV").
2. Use the DOS command "DEL LPF2.CSV" to delete the existing file.
3. Use the DOS CD command to change the default directory to a subdirectory that does not contain a file with this name.

7.4 L – EDIT LOG FILE NAME

The log file is used in menu mode to spool data received from the PHSNA. Since there is no parameter list to guide menu mode operation, the specified log file is used for all data transfers. The log file name, however, can be edited to spool data from different sweep parameters in different files. When L is pressed in Command mode, the Log File Edit screen is displayed containing the current log file name with the cursor positioned after the last character in the name. All editing modes and functions are available. Pressing Enter saves the edited log file name to EEPROM and closes the edit screen.

7.5 X – EDIT CRYSTAL FIXTURE TERMINATION RESISTANCE

This parameter is used as both a flag and a parameter value. When greater than one, it is assumed that all band pass filter plots are made using a quartz crystal as the DUT and additional information is added to the plot display. The parameter is the termination resistance of the fixture used to hold the crystal under test. The most common values for the termination resistance are 12.5 and 50 ohms. The edit function allows entries from 0.0 to 999.9 ohms; five characters maximum, one decimal place allowed. Pressing Enter saves the edited crystal fixture termination resistance to EEPROM and closes the edit screen.



7.6 ~ – INVALIDATE EEPROM CONTENT

It is sometimes useful or even necessary to completely clear or invalidate the data stored in the EEPROM. Examples of when this may be the case include the following:

- A firmware update changed the EEPROM address assignments
- A project has been completed and the new project requires mostly new EEPROM data
- The EEPROM has been replaced.

Entering this command will change the EEPROM validation codes in the first two locations and write zeroes to the portion of the EEPROM used by the NAT firmware (currently 64 pages of 64 bytes each for a total of 4,096 EEPROM locations).

7.7 ESC – SWITCH TO DOS MODE

Pressing the Esc key in Command mode switches to DOS mode. DOS mode is entered as if a DIR command had been entered. Pressing the Esc key while in DOS mode returns to Terminal mode.

8 DOS MODE

Pressing the Esc key while in Command mode switches the NAT to DOS mode. The name "DOS" was chosen because the available commands are similar to and were modeled after the old Microsoft DOS commands. They are provided primarily to enable the operator to access and maintain data files generated by SSNA sweeps. The file format is standard FAT16 so the SD card files may also be accessed and manipulated by most any MS DOS/Windows or compatible systems (even including many digital cameras). The FAT16 file system limits the NAT to SD cards of 1GB capacity or less. The card must be formatted on another system (or a camera); the NAT cannot perform a format function. The format must be a basic FAT16 format with only one partition. SD Cards with special formatting, such as multiple device emulation or built-in hubs, will probably not work with the NAT.

The following DOS commands are currently implemented in the NAT firmware:

DIR .... Displays the contents of the first sector of the current directory.

CD <Directory Name>.. Change Directory. Subdirectories are supported.

DEL <File Name> .... Deletes the specified file from the current directory.

DUMP .... Displays physical sectors in a combined hex and ASCII format.

DUMP <File Name> .... Displays file data in the dump format.

TYPE <File Name> ..... Displays the contents of the specified file as text.

PLOT <File Name> ...... Plots the Power data in the named file.

PLOTP <File Name> ... Plots the Power data in the named file.

PLOTV <File Name> ... Plots the VSWR data in the named file.

SDLD <File Name> ..... Reload the NAT Firmware from the named file.

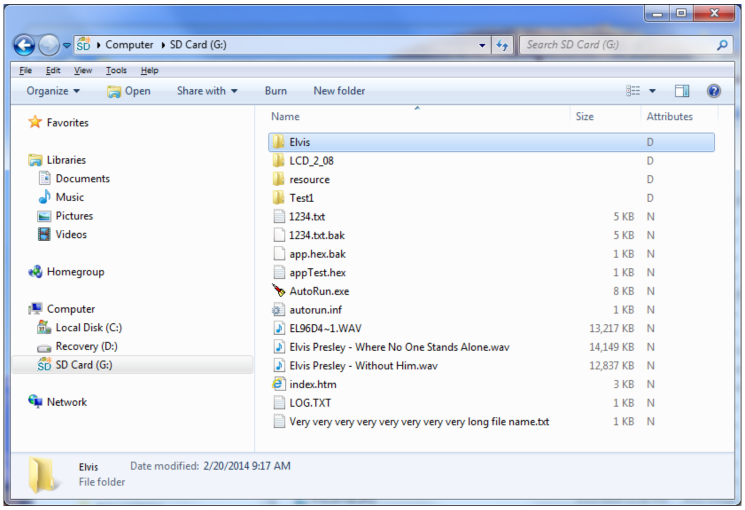
? .... Show a menu of available DOS commands

When DOS mode is first entered, the command line starts with the standard DOS prompt "\>" indicating the current directory is the root directory. When accessing subdirectories, the prompt is enlarged to show the complete path. There is no limit on the level of subdirectories; however, the command line is limited to 30 characters and will not allow entering more than this limit including the size of the prompt.

If a file system error is encountered during the execution of a command, a one or two-line error message will be displayed in red letters. In most cases, when a command is successfully executed, it will remain on the command line until a key is pressed. Then the command line will be cleared and the new keystrokes entered.

8.1 DIR – DISPLAY DIRECTORY

File names are limited to the original DOS format of 8-characters plus an optional 3-character file name extension (often referred to as the "8 point 3 format"). The names of files created on the NAT are forced to all caps. The NAT handles longer file names and mixed-case file names indirectly. This is best understood by looking at an SD card DIR display on a windows system and on the NAT.



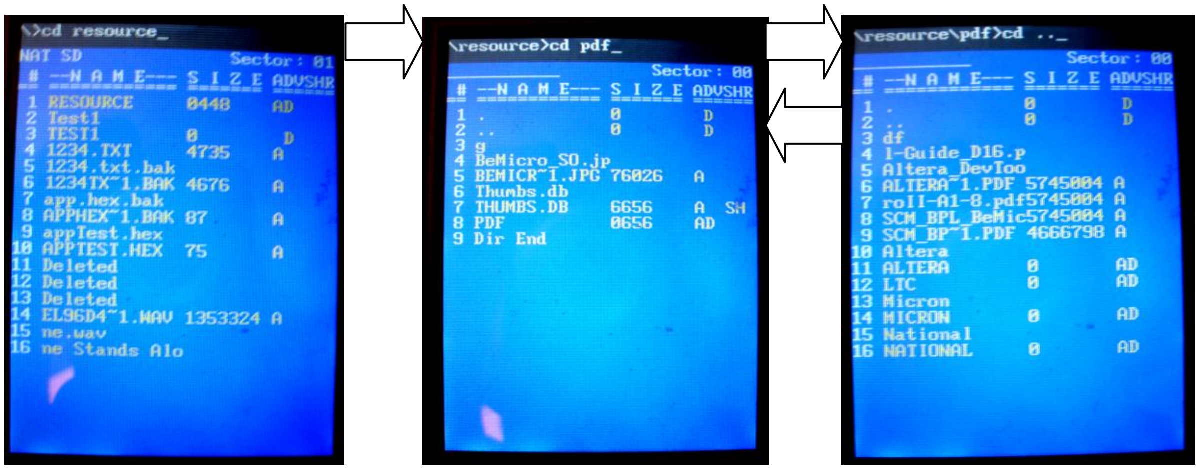
The PC displays a sorted list of directory and file names along with some file characteristics. The NAT display is simpler. It shows a list of all the directory entries (16 maximum) in only one sector of the directory along with some file characteristics (sizes and attributes). The FAT file system handles long file names by using extra directory entries to hold the names, 13 characters to an entry. This method is also used to handle mixed case and extended ASCII characters. These file name entries use two-bytes (16-bits) per character which is why a 32-byte directory entry is limited to 13, 2-byte characters. The other 6 bytes are used to hold additional information about the file name. The PC file system uses an algorithm to generate a standard 8.3 file name from longer and mixed case file names. The generated name is used in a standard directory entry which is the one the file system uses to access the file. The directory entries holding the long or mixed case file name characters are only used to translate the real name to the generated one. The extra directory entries are located just in front of the "real" directory entry, in reverse order. For example, consider the file named "Elvis Presley – Without Him.wav" in the above directory examples. The Windows system lists the complete file name on one line and it is accessed by clicking it in the explorer display. The NAT lists the long name in directory entries 4, 3, and 2 and the generated file name ("ELVISP~1.WAV" in directory entry 5 which is the "real" entry for this file. In the NAT, this file is accessed by entering the generated name.

In the DIR display, the volume name is shown in the upper left corner of the display and the directory sector number in the upper right corner. Pressing the right arrow key will move to the next sector in the directory; the left arrow will move to the previous sector. The last line of the last sector is marked "Dir End" to indicate the end of the current directory.

The DIR display also shows the size of the file and the file attributes. The size is the actual file size; it may occupy more space on the SD card because storage is allocated in clusters of 512-byte sectors. A cluster is typically 32 sectors. The only attribute of interest to the NAT is the 'D" or directory entry which identifies that entry as a subdirectory, not a file. The PC shows 'N' for no attributes, the NAT just shows nothing.

8.2 CD – CHANGE DIRECTORY

The NAT file system supports subdirectories to any level. The only limitation is the 30-character command line length. The following displays illustrate the CD command:



In the first display the operator has navigated to the second sector (001) in the root directory and entered a "CD resources" command. The second display comes up when Enter is pressed. Note the prompt has been expanded to show the current directory ("\resource>"). The operator now enters "CD pdf" and when Enter is pressed, the third display comes up. Note the subdirectory listings all start with directory entries named "." (dot) and ".." (dot-dot). These "names" represent the current and parent directories. The (CD ..) command in the third display will change back to the previous display when enter is pressed.

The command prompt includes the total path to the currently active directory. When a sub-directory name is entered in a CD command without additional path information, the sub-directory must be in the currently active directory or a "FILE NOT FOUND" file error will be displayed. The complete directory name is constructed by concatenating the path part of the command line prompt with the keyed directory name. The keyed directory name can contain additional path information. For example, in the above CD displays, the command "cd resource/pdf" entered in the first display will go directly to the third display. Similarly, the command "cd \" will always return to the root directory. Note that the NAT will accept either '\' or '/' as the name delimiter in a path specification. Also, note that commands can be entered in either upper case or lower case letters but will always be forced to upper case.

DOS commands will only look for a specified file in the currently active directory. If necessary, the CD command must be used to navigate to the directory containing the file before the command is entered. The active directory is retained and will remain the active directory even after exiting and returning to DOS mode as long as the NAT is not reset (power cycled). The CD command must be used to change the currently active directory.

8.3 DEL – DELETE FILE

This command deletes the named file in the current directory and frees the storage spaced for reuse. The directory entries for deleted files are identified as "Deleted" in the DIR display (see previous examples). When a new file is created, the NAT searches the directory from the beginning looking for either an entry for a deleted file or the first unused entry in the directory. The unused entries are always at the end of the directory and identified by "Dir End" in the DIR display. This is a little different than the way a PC does it. The PC always uses an unused entry to create a new file unless there are none. This is why there may be a number of deleted entries in a directory if the SD card has been used in a PC. If the proliferation of deleted files becomes annoying, the only cure is to save the files to a PC then reformat the SD card and restore the files to it.

8.4 DUMP – DISPLAY DATA IN HEX AND ASCII

The DUMP command is mainly provided to trouble shoot problems with file data and will probably rarely, if ever, be used by the average user. The following is a brief description of the command.

There are two DUMP command formats. One specifies a file name, the other does not. Without a file name specification the DUMP command displays data from physical sectors. The first one shown is sector 0 on the SD card. Only 64 bytes at a time are shown. The up and down arrows move one 8-byte row up or down; the Page up and Page down move one full sector (64 rows) up and down the sector data. Left and right arrows move one screen (8 rows) up and down. The operator can also key in a sector's LBA (Large Block Address). The display is eight double-lines of eight characters. The first half of the double line displays the bytes' hex values. The second half of the double line displays the bytes' ASCII character if one has been assigned and it is in the NAT's font table. Note that the NAT has some unique fonts to represent things like Function keys and they will probably show up in dumps of binary data files.

When a file name is specified, the named file is opened and the sector data from that file are displayed in the dump format. The arrow keys provide the same navigation as described above but only within sectors in the named file.

8.5 TYPE – DISPLAY TEXT

The TYPE command displays text files in blocks of 18 lines. The display is scrolled up and another 18 lines of text every time either Enter, Space, or the Right Arrow key is pressed. Pressing the Esc key ends the command. This DOS command can be useful to validate recorded data and data formats as well as for reading text files.

8.6 PLOT(P) – PLOT POWER DATA FROM A FILE

The PLOT command action is similar to the plotting done in Terminal mode described above except the data comes from an SD card file and not from the serial interface. The "P" at the end of the command is optional; PLOT and PLOTP are the same commands. When a PLOT command is entered, the data read from the file is displayed as it was in Terminal mode. Scrolling is turned off when the actual plot data is read. Instead, the last line of the display is repeatedly updated with the plot data. At the end of the file, the data is plotted as described above. Once plotted, the plot remains on the screen until a key is pressed other than Ctrl-C (which loads the calibration constant buffer from the data buffer) and Alt-C (which clears the calibration constant buffer).

This command can be particularly useful to restore calibration constants without having to redo the calibration sweep each time. The file can be generated once for a given set of scan parameters and then loaded every time those scan parameters are used. A different file name can be used for each set of scan parameters. It may be helpful to use the same file name as one of the plot data files with a different name extension such as ".CAL" instead of ".CSV".

8.7 PLOTV– PLOT VSWR DATA FROM A FILE

This command is the same as the PLOT(P) command with a plot of the VSWR added to the reflected power loss plot. Plotting data from a Return Loss Bridge is described later in this document.

8.8 SDLD – RELOAD NAT FIRMWARE FROM SD CARD FILE

The NAT firmware may be updated from a file in the root directory of the SD card. The SDLD command must include the name of a file located in the root director of the SD card. If the named file cannot be opened, the command posts an error and terminates execution. The actual load requirements and operation details are covered in a later section of this document (see **LOADING NAT FIRMWARE UPDATES**).

8.9 ? – SHOW A MENU OF AVAILABLE DOS COMMANDS

The next DOS command may be entered while the menu is displayed. Each line in the menu includes a brief description of the command. The menu will be displayed until another command is entered.

9 PLX (EXCEL) MODE

In this mode, the PHSNA firmware "thinks" it interrogates specific cells in an Excel spread sheet running a freely available macro developed and distributed by Parallax Corporation. Information about installing and using the macro are posted on the PHSNA Yahoo group web site. The macro can be downloaded from the following web address:

http://parallax.com/search?search_api_views_fulltext=PLX-DAQ+

Before describing the NAT operation in PLX mode, it will help to first understand the PHSNA system operation when interfaced to a PC. The following section briefly describes the PLX mode concepts using that configuration and the PC executing Excel with the Parallax macro installed. The next section describes PLX operation with the NAT replacing the PC.

9.1 PLX MODE OPERATION WITH THE PLX-DAQ SPREADSHEET MACRO

The macro has been named "PLX-DAQ" which stands for "Parallax Data Acquisition tool" thus the PHSNA firmware operating in this mode is designated "PLX mode". When running, the macro accepts command directives from an external device (such as the PHSNA controller) to gain access to cells in the spread sheet and to do some simple functions. The complete description of the PLX-DAQ Control Directives can be found on the Parallax web site. The PHSNA firmware does not use all of the Control Directives and only those used by the PHSNA firmware are implemented in the NAT firmware. The following Control Directives are used and implemented:

- DATA
- LABEL
- CLEARDATA
- MSG
- CELL,GET
- CELL,SET

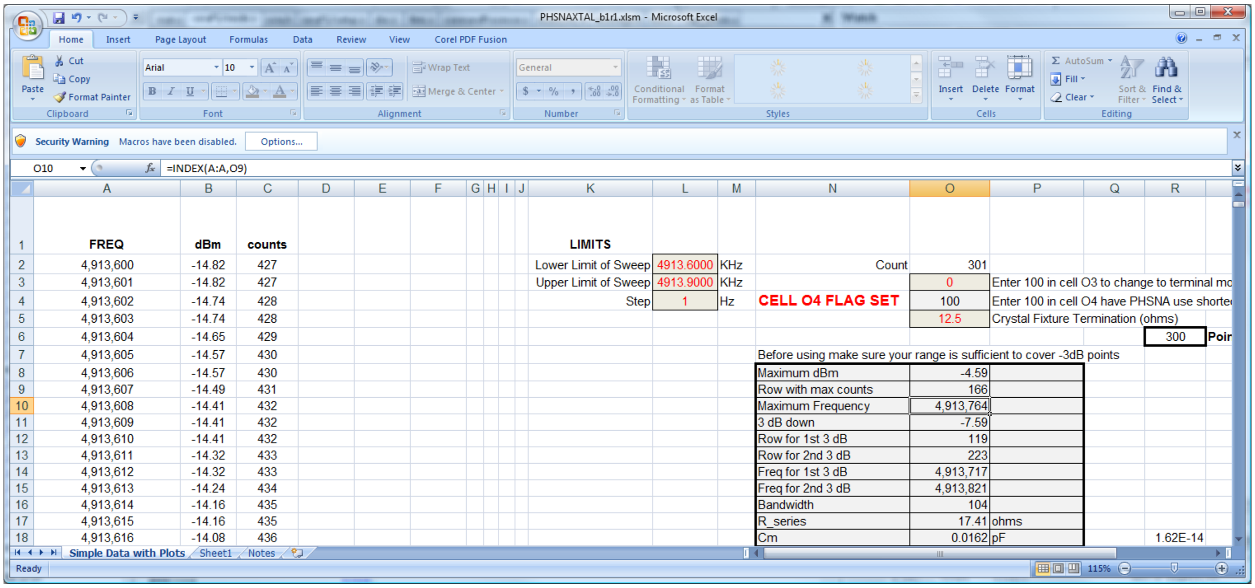
The following Control Directives are not used by the PHSNA firmware and not implemented in the NAT firmware at this time:

- RESETTIMER
- ROW,GET
- ROW,SET
- DOWNLOAD,GET
- STORED,GET
- USER1,GET
- USER2,GET
- DOWNLOAD,SET
- STORED,SET
- USER1,SET
- USER2,SET
- DOWNLOAD,LABEL
- STORED.LABEL
- USER1,LABEL
- USER2,LABEL

All but the first three of the unimplemented Control Directives have to do with accessing and manipulating checkboxes on the spreadsheet.

To run a sweep, the UNO's USB interface is used to emulate a serial interface. The connection can be checked out in menu mode using a terminal emulator program. To run in PLX mode, Excel must be loaded with a spreadsheet using the PLX-DAQ macro and containing the sweep parameters entered into specific cells in the spreadsheet. The sweep operation is then initiated by resetting the UNO.

A sample spread sheet has been created to use with the standard PHSNA firmware. This spreadsheet contains specific operating parameters in specific cells and displays received data in the first few columns of the spreadsheet. The following is a screen shot of a portion of the standard spread sheet presented here to help understand how the PHSNA firmware works with the macro:



	A	B	C	K	L	M	N	O	P	R
1	FREQ	dBm	counts	LIMITS						
2	4,913,600	-14.82	427	Lower Limit of Sweep	4913.6000	KHz	Count	301		
3	4,913,601	-14.82	427	Upper Limit of Sweep	4913.9000	KHz		0	Enter 100 in cell O3 to change to terminal mo	
4	4,913,602	-14.74	428	Step	1	Hz	CELL O4 FLAG SET	100	Enter 100 in cell O4 have PHSNA use shorte	
5	4,913,603	-14.74	428					12.5	Crystal Fixture Termination (ohms)	
6	4,913,604	-14.65	429							300 Poi
7	4,913,605	-14.57	430				Before using make sure your range is sufficient to cover -3dB points			
8	4,913,606	-14.57	430				Maximum dBm	-4.59		
9	4,913,607	-14.49	431				Row with max counts	166		
10	4,913,608	-14.41	432				Maximum Frequency	4,913,764		
11	4,913,609	-14.41	432				3 dB down	-7.59		
12	4,913,610	-14.41	432				Row for 1st 3 dB	119		
13	4,913,611	-14.32	433				Row for 2nd 3 dB	223		
14	4,913,612	-14.32	433				Freq for 1st 3 dB	4,913,717		
15	4,913,613	-14.24	434				Freq for 2nd 3 dB	4,913,821		
16	4,913,614	-14.16	435				Bandwidth	104		
17	4,913,615	-14.16	435				R_series	17.41	ohms	
18	4,913,616	-14.08	436				Cm	0.0162	pF	1.62E-14

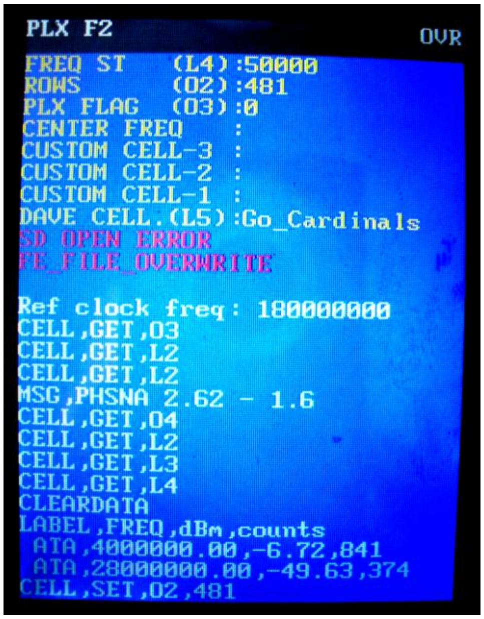
The contents of cells L2, L3, and L4 define the frequency sweep to be carried out by the PHSNA. When the PHSNA firmware is reset, it tries to access cell L2 ("CELL,GET,L2" Control Directive). If successful, the firmware switches to PLX mode and reads the rest of the information needed to define the frequency sweep operation. As each frequency is generated, the PHSNA firmware reads the power meter output, converts it to dBm and transmits it to the macro (DATA Control Directive). The data is stored sequentially in the first few columns of the spread sheet starting at row 2. Each data row contains the frequency in column one and the power level in column two. (Note that the standard PHSNA firmware also includes the raw output from the ADC which the NAT does not use.) The Parallax macro will accept up to 26 columns of data corresponding to spreadsheet columns A through Z but the PHSNA firmware only generates the first three columns.

After the data has been inserted in the spread sheet the operator may use standard Excel operations to analyze and plot the data from the sweep. It may also be exported as a .csv file for analysis by other PC applications. The standard spread sheet also includes a few computations for basic analysis (contained in the large block of cells with the grey background). The entire sequence is run each time the UNO is reset.

9.2 PLX MODE OPERATION WITH THE NAT

The NAT emulates the PLX-DAQ macro using one of fourteen sweep parameter sets previously entered using the data entry display described above. The NAT is put in PLX mode by pressing one of the function keys F1 through F7 or Alt-F1 through Alt-F7. The NAT displays the PLX parameters in yellow and examines the second parameter ("FILE NAME"). If this parameter is empty, the NAT displays a message stating "NO FILE NAME SPECIFIED". All information and error messages will be displayed with a red font color. If a file name is specified, the NAT checks to see if a file with the same name already exists in the currently active directory. If one does, the NAT displays an "SD OPEN ERROR" message followed by an "FE_FILE_OVERWRITE" error detail message. If there is no SD card inserted in the NAT, an "SD_MOUNT_ERROR will be declared. A number of other errors may be declared if the NAT encounters file system errors trying to mount the SD card or open the named file. The error messages should be self explanatory.

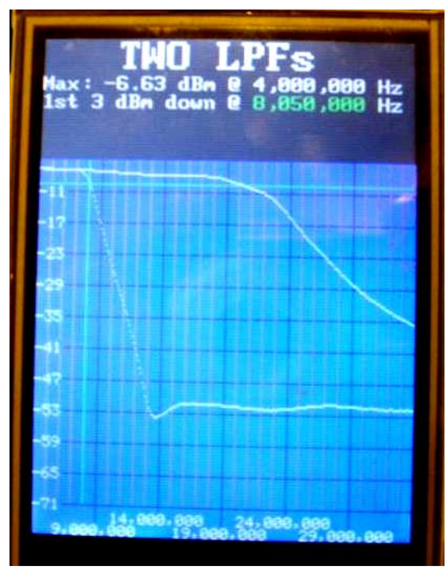
The NAT will continue in PLX mode whether or not it was able to successfully mount the SD card and open the specified file in write mode. It simply waits for the PHSNA firmware to send it Control Directives. The NAT will respond to those Control directives it can and will ignore those it cannot respond to. The PHSNA firmware includes a time-out mechanism to avoid hanging while waiting for a response that will never come. During PLX operation, all command and data directives received from the PHSNA firmwae are displayed by the NAT. Responses generated by the NAT are not displayed.



This screen shot shows the NAT display just after receiving all the data points. When the UNO is reset, the PHSNA firmware first tries to read cell O3 with a "CELL,GET,O3" command directive. If it gets a response in a reasonable period of time, it assumes the spreadsheet macro is active. Cell O3 is a flag and if equal to "100", the PHSNA firmware will abort and switch to menu mode. If O3 is not equal to "100", the PHSNA firmware will read L2 twice to confirm the macro is active then send a Message directive containing the current PHSNA firmware version and revision level. It will then read the sweep parameters and issue a command directive to clear the data buffer ("CLEARDATA"). It then outputs a LABEL command directive which directs the macro to set the labels (column headings) for the first three columns in row one of the spreadsheet. The NAT ignores the LABEL command directive. The PHSNA firmware then starts the sweep.

Each three-part data point (row) is returned in a DATA directive. The NAT displays the DATA directives but turns off scrolling after the first one is displayed so the last line on the display is repeatedly updated until a non-DATA directive is received. The PHSNA firmware ends the data transmission with a "CELL,SET,O2,nnn" command directive where nnn is the number of data points sent. The NAT firmware does not use the value in this command directive but recognizes it as an indicator that all the data has been sent. This data set contained 481 data points.

After receiving the CELL,SET,O2,nnn command directive, the NAT will plot the data as was done in Menu mode. The NAT remains in PLX mode and will continue to respond to command directives received from the PHSNA firmware. The PHSNA firmware will repeat the process every time it is reset and restarted. The NAT, however only initializes the plot when the first data set is plotted. Each successive data set will be added to the same plot. Each pass uses the same vertical and horizontal scales. This plot shows a (sloppy) 20-Meter LPF plotted with a 40-Meter LPF. Note, the heading and green lines only apply to the first plot.



The NAT remains in PLX mode until the operator presses the Escape key which returns the NAT to Terminal mode. The PHSNA firmware will remain in PLX mode until one of three things happens. If it starts a PLX sequence and reads "100" from the contents of cell O2, it will return to menu mode. If the UNO is reset and the NAT is in Terminal mode, the PHSNA firmware will repeatedly try to access cell L2 (starting frequency). If it gets no response and times out 30 times, it will temporarily go into menu mode and send the top menu to the NAT. Normally a flag is set in an EEPROM in the UNO when the PHSNA firmware is in PLX mode. This causes the PHSNA firmware to always start in PLX mode each time it is reset. After the 30 time-outs, the PHSNA firmware goes into menu mode but does not change the PLX flag setting in the EEPROM. Once in menu mode, the operator can use menu options to reset the EEPROM flag so the PHSNA firmware will start in menu mode.

The third way to direct the PHSNA firmware requires the modified PHSNA firmware. Pressing Esc on the keyboard at the end of a plot will clear the plot and return the NAT to Terminal mode. The PHSNA firmware, however, will remain in PLX mode. Pressing the Esc key a second time will send the Esc code to the PHSNA firmware causing it to terminate PLX mode and switch to menu mode. When this happens, the PHSNA firmware will send the normal menu mode start up sequence which includes the top-level menu.

10 ADDITIONAL NAT FEATURES

There a number of additional features in the NAT firmware that is activated by editing parameters retained in the EEPROM or by editing parameters in a PLX parameter set. This list is expected to grow with future firmware releases. Note that some of these features require changes to the PHSNA firmware; the required changes will be described with the feature. The list of additional NAT features currently contains the following:

- Operating Mode Control
- Crystal Characterization
- VSWR and Return Loss Measurements
- Improved Performance

These features are controlled, in part, by a second page of parameters associated with the Function keys. When editing a parameter set (Scroll-lock > Fn or Alt-Fn) the user can switch between pages using the PgUp and PgDn keys. There are currently three active and two reserved entries on the second parameter page. The names of these entries are fixed in the firmware; their template cannot be edited like the first page's template. Also, these entries cannot be assigned spreadsheet cell numbers and cannot be accessed by the PHSNA firmware. When done editing a parameter page, pressing Enter, PgDn or PgUp will save only that page. Each of the two pages in the parameter set must be saved separately after editing.

10.1 OPERATING MODE CONTROL

One of the parameters on the second page defines the settings for flags that control certain operating modes. The parameter's title is "MA OR PV S ...:". Each letter group is associated with an operating mode; the first letter in a pair is the default setting. Off is the default setting for a single-letter group (e.g., 'S'). Letters can be entered in any order in either upper or lower case. Letters not in the list are ignored and if both letters in a multi-letter group are entered, the last one on the line will be used.

The lower half of the display contains a legend to help the operator remember the significance of the etter codes. The default option letter is followed by an asterisk. The defaults do not need to be entered but it is recommended that they be entered to better display the operating mode settings.

The following paragraphs describe the operating modes and the significance of the associated letters:

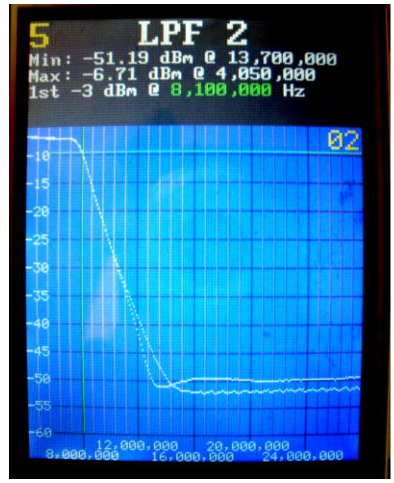
10.1.1 Sweep Initiation: M(annual) or A(utomatic)

Using the standard PHSNA firmware requires the operator to reset the UNO to initiate each sweep in PLX mode. The modified firmware will accept two commands from the NAT after a sweep, while in PLX mode. The first (Esc or 0x1b) will terminate the PHSNA PLX mode and switch to menu mode. The second (Space or 0x20) will initiate another PLX sweep operation. The action is virtually the same as pressing the reset button on the UNO. Any key pressed after a sweep is complete and the data plotted on the NAT, will be sent to the PHSNA firmware. Repeatedly pressing the space bar will repeat the sweep. Other than the Escape key, all other key codes will be ignored by the modified PHSNA firmware. This is manual mode and is the default (M) operating mode.

When an 'A' is included in the character string, the NAT will issue space codes at constant intervals as defined by the parameter labeled "AUTO DELAY(ms):" This value specifies the number of milliseconds the NAT will wait after a data set has been plotted before commanding the PHSNA firmware to start another sweep. When this value is not specified or is zero, the NAT will command another sweep immediately at the end of each plot. Once initiated, "auto mode" will continue until the operator presses

Escape to terminate PLX mode in both the NAT and the PHSNA firmware. The delay can be set to any value up to 32,767 milliseconds.

10.1.2 Repeating Plots: R(einitialize) or O(verplot)



This operating mode setting determines whether multiple plots will be overlaid (O) or plotted on a new (reinitialized) plot screen (R). The first character position in the title line provides an activity indicator. As the data is being captured by the NAT, each digit is displayed in this position on the title line. When all the data has been received and plotted, the activity indicator will be erased and a beep sounded.

The second indicator is two digits in the upper right corner of the plot area. This indicator will show how many data sets have been plotted and is only displayed when plots are being overlaid (O), not when the plot is reinitialized for each data set (R).

The first plot trace is rendered in white. If there are over plots, each one is rendered in one of eight colors. The color sequence is as follows: white, red, orange, yellow, green, violet, gray, and black. The color sequence repeats with each eight plots. The plot number in the upper right corner is rendered in the same color as the last plot. If the plot screen is reinitialized for each plot, the plot number will not be displayed and all plot traces will be rendered in white.

10.1.3 VSWR Plotting: P(ower only) or with V(SWR)

When using a Return Loss Bridge (RLB) the power detector output reflects the amount of return loss for the DUT over the frequency spectrum. Assuming the sweep goes across the DUT's resonant frequency, the plot will look something like a notch filter plot with the low point occurring at resonance. This information can be used to calculate the Voltage Standing Wave Ratio (VSWR) for the DUT. When operating mode "V" is selected, the NAT will add a plot of the VSWR to the power plot, adding a separate scale along the right-hand margin. The scale and the VSWR plot are rendered in green. Return loss and VSWR calculations are discussed in more detail in a following section of this document.

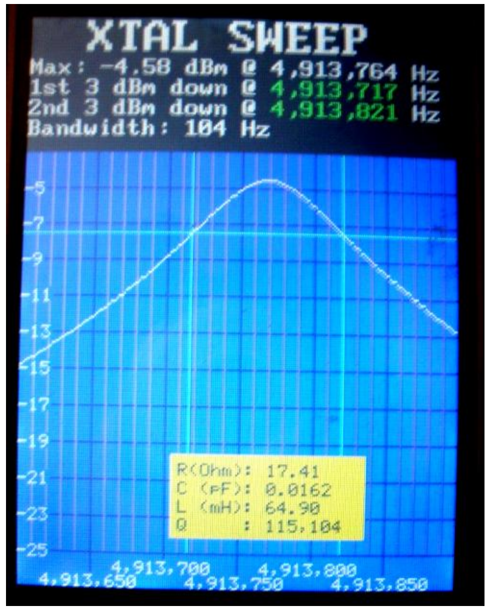
10.1.4 Manual Control S(ignal generator) operating mode

The Signal Generator operating mode gives the user manual control over the DDS output frequency. The operator specifies the frequency range and can vary the frequency in steps ranging from 1 Hz to 100 MHz. Power level readings can be made on command or automatically with or without a specified delay between readings. This feature requires the modified PHSNA firmware to be fully functional but will work in a limited manner with the standard PHSNA firmware. Manual operation in Signal Generator mode is discussed in more detail in a following section of this document.

10.2 CRYSTAL CHARACTERIZATION

When designing crystal filters it is important to characterize the crystals and select crystals that match as close as possible. One set of parameters used to grade and sort crystals are the motional parameters Rm, Lm, and Cm. These are the equivalent series resistance, inductance, and capacitance. The quality factor (Q) is also an important parameter used in grading crystals. When a sweep is done on a crystal it is generally held in a special test fixture which presents a well-defined termination resistance to the RF power source. The termination resistance is used to compute the motional parameters. Since it is fixed for a given test fixture, the NAT operator can enter and edit the value as described earlier and store it in the EEPROM.

A sweep on a quartz crystal results in a plot of type band pass (which is what we are looking for in a crystal filter). When the test fixture termination resistance read from EEPROM is greater than one and the NAT recognizes a band pass plot, the three motional parameters and the quality factor are computed and displayed in a window in the lower center of the plot. These values are not displayed on any other plot type. Setting the crystal fixture termination resistance to zero inhibits the display of these values.



When characterizing crystals, it is a good idea to first calibrate the test fixture. This can be done as described earlier but, in this case, plug something into the crystal socket to short the two pins. This will result in a plot of the fixture's insertion loss across the frequency range of interest plus any miss-match between the signal generator and the power detector. Once the shorted-fixture plot is displayed, keying Ctrl-C will save the data in the calibration constant buffer. The buffered calibration constants will be subtracted from the data points on all future sweeps. Until the calibration constant buffer is cleared (Alt-C or power cycle).

Crystals are generally tested in batches, one crystal after another. To help maximize the efficiency of this operation, the NAT can spool only the crystal parameters, not the sweep data, along with a serial number that can be used to identify which crystal goes with which parameter set. The data from each sweep is plotted without reinitializing the plot display. The data from each sweep will be plotted on top of the preceding plots. The spooled file data format is as follows:

```
ID,Fs,BW, R(Ohm),C (pF),L (mH),Q
X1,4913764,104,17.41,0.0162,64.90,115104
X2,4913768,108,17.32,0.0153,65.73,115085
X3, . . . . . . . .
```

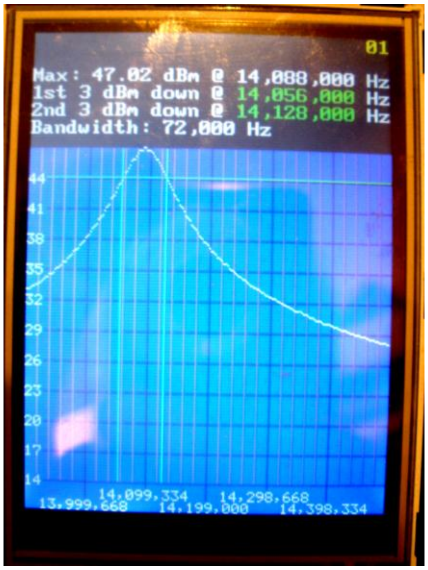
Each line ends with a CR character (0x0d). The first line is just a heading line to show the placement of the parameters in each line. It could be used as a heading row on a spreadsheet or just ignored. The frequency shown (Fs) is the frequency at which the power detector registered maximum power out. This is the series resonance frequency of the crystal. The third column, BW, is the bandwidth measured at the -3 dBm points.

Each line after the heading starts with the crystal ID for that data point. The prefix is derived from the second page parameter labeled "XTAL PREFIX". If the prefix is not defined, the sweep data will be processed normally; the sweep data will be spooled (assuming a new spool file is specified), not the crystal parameters. When the XTAL PREFIX is defined the crystal parameters will be spooled, not the sweep data.

The serial number is appended to the XTAL PREFIX and spooled as the first field of each data line. The serial number is reset to zero when the NAT first enters PLX mode and is incremented by one after each plot but before spooling the data. This means the first data line will always have a serial number of 1. As each data set is added to the plot, the crystal parameter window is updated to reflect the parameters for the current plot. Note that if the plots are overlaid, the serial number will be the value displayed at the end of the title line at the top of the plot display. In this case, the final plot will give the user a feel for the variation in resonant frequency, maximum power out, and bandwidth for the batch of crystals. The green lines showing the -3 dBm points are generated when the plot display is first initialized so they only apply to the first crystal in the batch.

10.3 VSWR AND RETURN LOSS MEASUREMENTS

Return loss measurements are used to test and evaluate DUTs that exhibit resonance such as antennas. When making the measurements, the DUT is the Return Loss Bridge (RLB) with the resonating device connected to it. The PHSNA injects RF into the RLB and the resonating device and sends any reflected power to the power detector. The output of the power detector is a measure of the power reflected and, therefore, lost in the system.

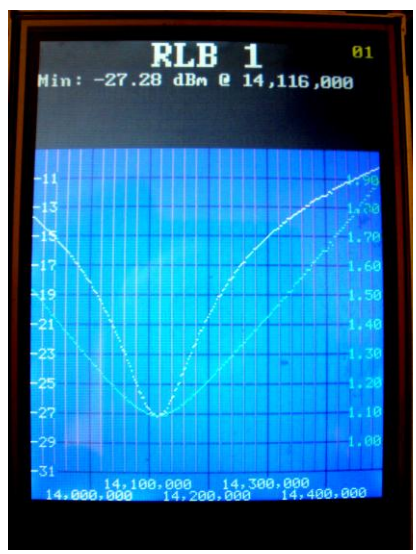


The standard PHSNA firmware has a special menu selection for using a Return Loss Bridge and computing VSWR across the frequency sweep. Since this is a menu selection, these functions are not available in PLX mode. When a sweep is done, the PHSNA firmware generates a data point for each frequency in the sweep. The data format is a little different than the one generated for a "normal" sweep in that it includes some additional information. The column headings returned are:

`kHz, RL, SWR, rho`

kHz	is the frequency in KHz
RL	is the return loss expressed in dBm (a positive number)
SWR	is the standing wave ratio
rho	is related to added line loss caused by increasing SWR

In Terminal mode, the NAT will only use the frequency and the Return Loss to generate a plot. Since the Return Loss value is expressed as a positive number, it peaks at resonance and the plot will look similar to a band pass filter plot. The NAT ignores the SWR and rho data but all four values will be spooled if requested.



The NAT can process RLB data in PLX mode and will calculate and plot (RLB 1) the VSWR when operating mode "V" is specified (see the above discussion of operating mode control). In this case, the Return Loss will be plotted as a negative value and the plot will be similar to a notch filter plot. The NAT firmware computes the VSWR from the Return Loss data and plots it in green with a separate scale on the right edge of the plot area. The same major, horizontal grid lines are used for both scales, only the values rendered are different to reflect the scale of the associated plot. Rho is not calculated or plotted. It can be calculated using the following formula:

$$Rho = (SWR - 1) / (SWR + 1).$$

Note that the two plots shown here were made with the same antenna attached to the RLB; the top one (made by standard PHSNA firmware) was not properly calibrated. The second plot was calibrated which accounts for the approximate 18 dBm difference in the return loss numbers. Calibration with the NAT is done by simply making and plotting a sweep with nothing attached to the RLB. With the plot displayed, keying Ctrl-C will capture the data in the calibration buffer. The sweep data can also be saved to a file for later reloading without having to make a special calibration sweep. If all you want is to locate the resonant frequency, calibration is not necessary. If you want accurate SWR values, calibration is mandatory.

10.4 IMPROVED PERFORMANCE

The performance of the PHSNA system is largely dependent on the serial bus data rate. The performance of the signal generator (step time) and the power detector (lock time) are really insignificant compared to the time required to access sweep parameters and return data points. A typical 480 point sweep will take nearly 17 seconds to complete. Normally, this may not be a problem but if the operating mode is set to Automatic Start and the operator is attempting to use the PHSNA to tune (or tweak) a circuit, a 17 second delay between plots can be very frustrating.

To help speed up the operation, the modified firmware contains some changes to significantly enhance performance. These changes reduce the 480 point, 17 second sweep delay to about 2.55 seconds. The PHSNA firmware modifications are primarily in the PLX_SWEEP.ino source file where the modifications were made to facilitate the NAT being able to initiate a sweep without having to reset the UNO.

The repeat loop was shortened so that the PHSNA firmware retains the sweep parameters and reuses them each time it is directed to repeat a sweep. This saves a fair amount of time by eliminating the “spreadsheet” accesses and some timing and response delays.

The second change was the introduction of a second, shorter DATA Directive. The unmodified PHSNA firmware typically generates a 27- or 28-character DATA Directive. The NAT typically only uses six of these characters (the dBm power readings). A sample, standard DATA Directive looks like this:

```
DATA,27600000.00,-51.23,356
```

This same information in the modified firmware looks like this:

d-51.23

Both forms are terminated with a carriage return character (CR or 0x0d).

To direct the modified PHSNA firmware to use the shorter DATA Directive, set the PLX FLAG (O3) to 1. The PHSNA firmware retrieves this cell and, if set to 100, will end PLX mode and switch to menu mode. If set to any other value, the PHSNA firmware stays in PLX mode. The modified firmware does the same with one addition. If the PLX FLAG is set to 1, the new, shorter DATA Directive will be used. . The modified firmware will use the standard, longer DATA directive format if any value other than 1 is received. The NAT firmware is prepared to accept and use either DATA Directive format.

These changes got the sweep time down to about 4.4 seconds, a 75% reduction. Then a modification was done to the PHSNA_standard_rev_3r02 source file to speed up the serial interface data rate. Doubling the data rate to 19,200 bits per second reduced the sweep time to about 2.55 seconds (about an 85% overall time reduction). This was done with a 15-foot serial interface cable and no particular attention paid to grounding or shielding. Under these same conditions, intermittent errors were encountered at 38,400 bits per second. No doubt, equipping both the UNO and NAT serial interfaces with RS232 driver/receiver pairs would enable much higher serial interface data rates and, therefore, significantly shorter sweep times. The NAT user can select one of several data rates using the “B” command. The PHSNA firmware is easily modified by entering the desired baud rate in the Serial.begin(baud rate) instruction at the start of the setup() code section.

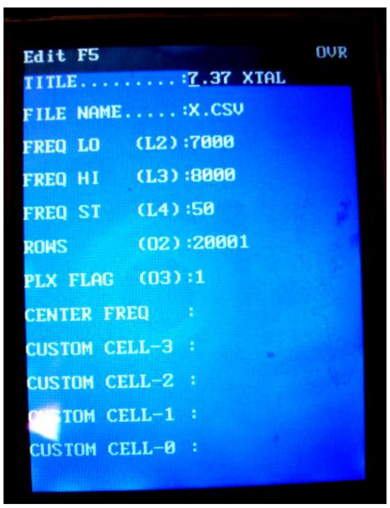
10.5 EXTENDED SWEEP

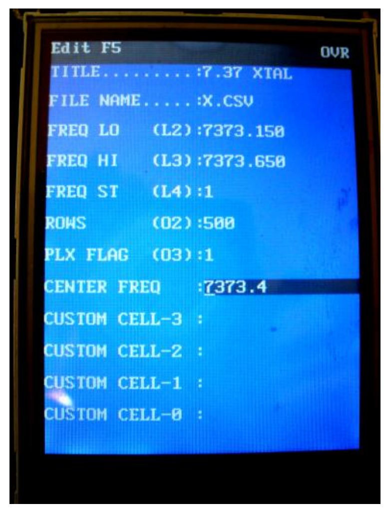
As stated earlier, the NAT has a 960-point buffer to hold data and a second 960-point buffer to hold calibration constants. The buffer size limits the amount of data that can be included in a plot. The plot area is 240 pixels wide therefore; there are four buffer positions for each pixel. This does not improve the plot resolution. If the buffer is full, only every fourth data point will be plotted. It does, however, improve the resolution (accuracy) of the minimum, maximum, -3 dBm, and bandwidth values displayed above the plot.

Even though the number of points that can be plotted is limited, there is no limit to the number of points in the sweep. When the sweep consists of more points than locations in the buffers, only the first 960 data points will be buffered and plotted. When there are a very large number of data points in the sweep this can be very boring plot and is generally classified as “FREEFORM”. The unbuffered data points are not ignored; all data points in the sweep are used to locate the maximum and minimum values which will be displayed above the boring plot. This information can be very time saving when trying to determine the resonant frequency of a crystal or a radiator (antenna).

As an example, consider a crystal of unknown source marked as 7.37 MHz. As you recall, crystal response curves tend to be very narrow band pass plots and are generally taken with 1Hz step sizes. Taking a sweep with the 7.37 MHz crystal using 500 steps on 1 Hz centered on 7,370 KHz plots nearly as a straight line. The real resonant frequency is significantly more than 250 Hz from 7,370 KHz. The resonance point could be found by taking repeated sweeps at various center frequencies until a plot gave an indication of where the peak is. This process can be very time consuming.

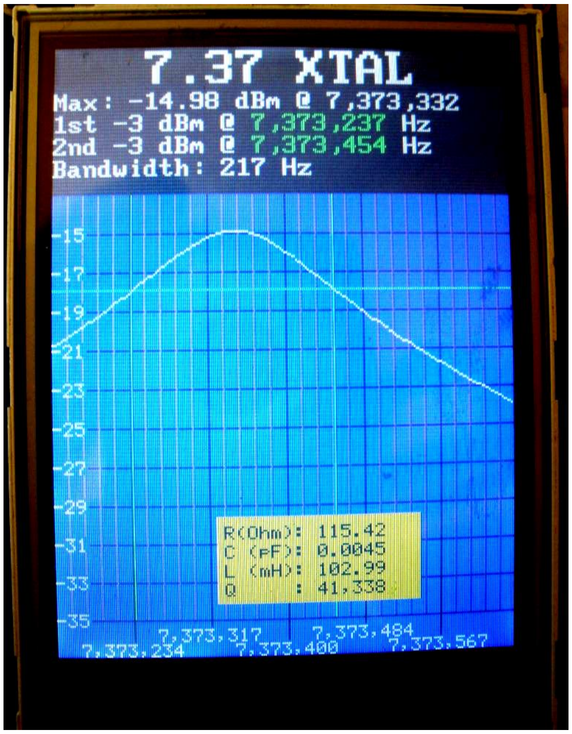
A better approach would be to take a broad sweep using a slightly larger step size and let the NAT find the peak. The band pass of most crystals is quite narrow (100 to 250 Hz) so the step size should be small enough to hit the band pass region of the peak. The example used here is a sweep from 7.0MHz to 8.0MHz using a FREQ ST of 50 Hz. The NAT calculated this sweep will generate 20,001 data rows (slightly more than the NAT's buffer capacity). The data entry screen for the setup is the first picture below. Note that the PLX FLAG is set to "1" directing the modified PHSNA firmware to use the shortened data directive format. This sweep took about 95 seconds. The second picture is the resulting plot of the data. Very boring, nearly a straight line across the -52 dBm level. The Max of -15.17 dBm, however, occurred at a frequency of 7,343.4 MHz. That is 3,400 Hz from our original starting point based on the markings on the crystal. The third picture shows the data entry screen after changing ROWS to 500 and FREQ ST to 1 Hz and setting CENTER FREQ to 7373.4 KHz.

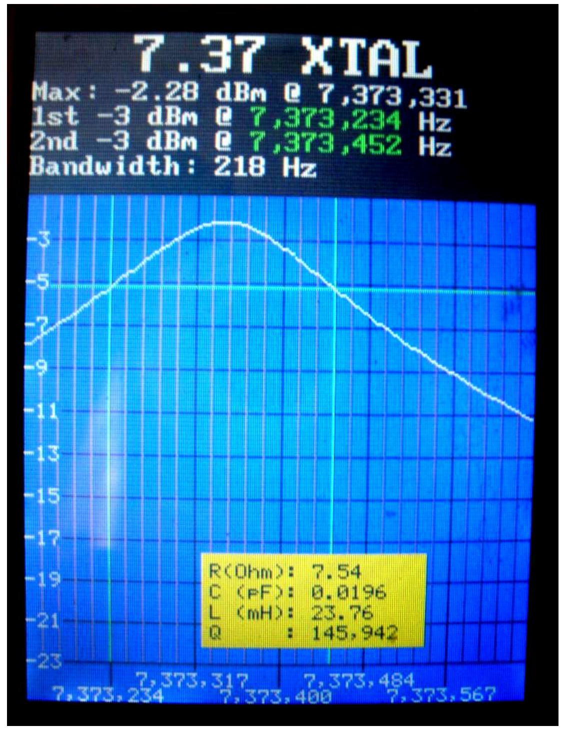


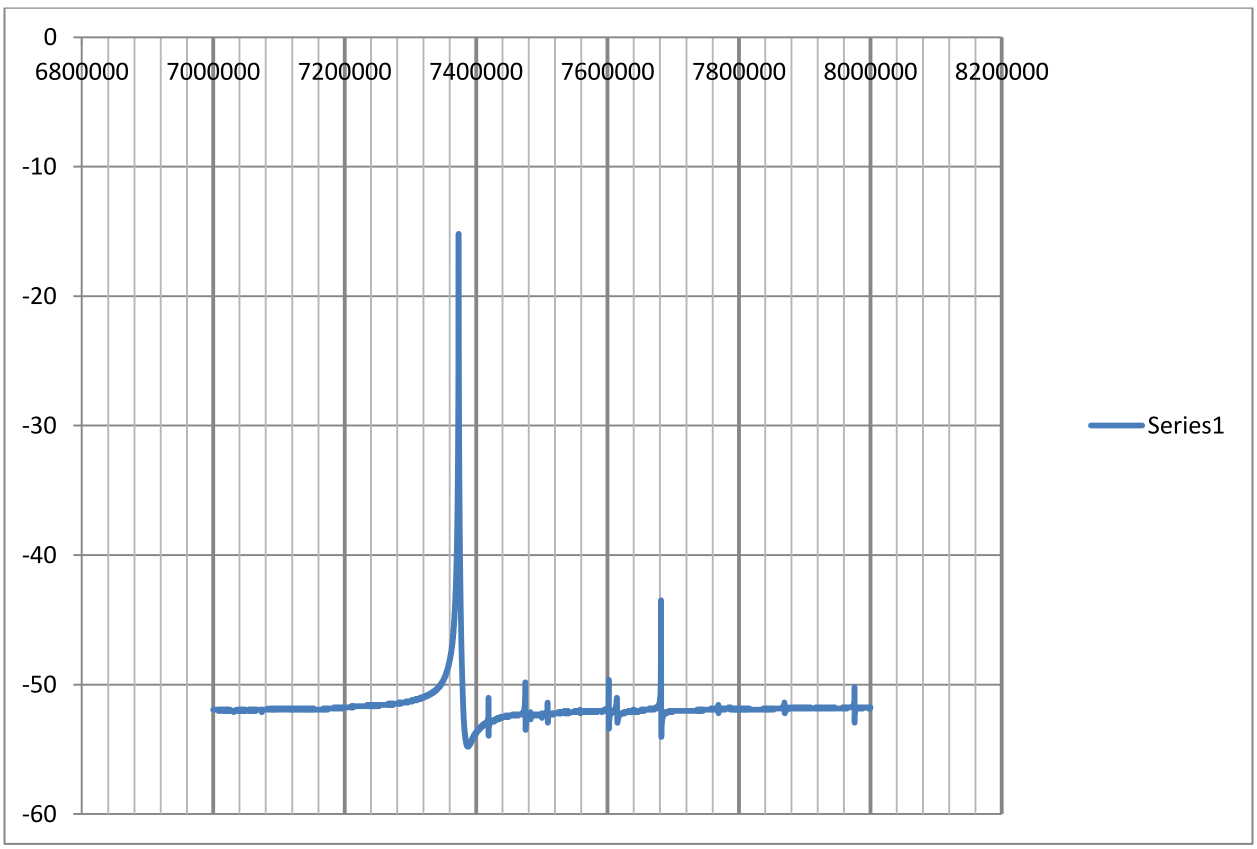


This time the plot (below) is much more interesting. With 1 Hz resolution, the peak now is located at 7,373,332 Hz, just 68 Hz below where the peak was located with 50 Hz resolution. Note that the above plots and the first one below were made without calibrating the test fixture. The second one below was made after calibrating the test fixture. Note the big difference calibration made to the parameters in the yellow box. The resonant frequency, however, is only two Hz lower and that shift is probably due more to effects of temperature changes than calibration.

The final figure in this section is a plot of the entire 20,001-point data set done on an Excel spread sheet. This plot and the accompanying data set could also be used to locate the crystal's approximate resonant frequency by using the plot to get close and then manually scanning the data points in the vicinity. Using the NAT to do the work is much more efficient. The plot does illustrate how narrow the resonance peak is and indicates how hard it may be to find using the "guess and try" technique.

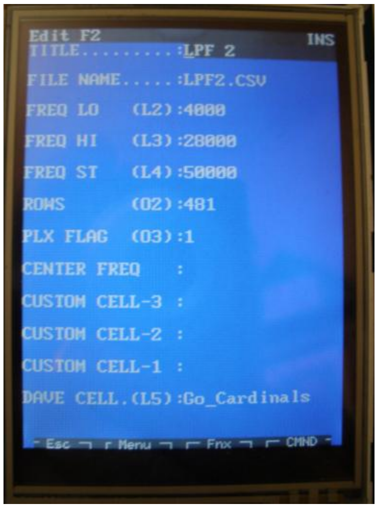

7.37 XTAL
Max: -14.98 dBm @ 7,373,332
1st -3 dBm @ 7,373,237 Hz
2nd -3 dBm @ 7,373,454 Hz
Bandwidth: 217 Hz
R(Ohm): 115.42
C (pF): 0.0045
L (mH): 102.99
Q : 41,338
7,373,234
7,373,317
7,373,400
7,373,484
7,373,567


7.37 XTAL
Max: -2.28 dBm @ 7,373,331
1st -3 dBm @ 7,373,234 Hz
2nd -3 dBm @ 7,373,452 Hz
Bandwidth: 218 Hz
R(Ohm): 7.54
C (pF): 0.0196
L (mH): 23.76
Q : 145,942
7,373,234
7,373,317
7,373,400
7,373,484
7,373,567

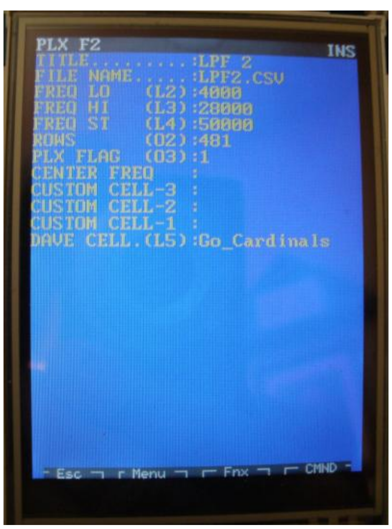

0
-10
-20
-30
-40
-50
-60
6800000
7000000
7200000
7400000
7600000
7800000
8000000
8200000
Series1

11 MANUAL CONTROL SIGNAL GENERATOR OPERATION

Signal Generator operating mode (SG op mode) is set up using the standard PLX data entry screens. The sweep parameters on page one are entered as they would be for a full sweep of the frequency range in PLX mode. Here we will use a 40M LPF as an example to better explain SG op mode. Here are the two data entry pages and a full sweep of the frequency range:



The first DE page shows the sweep will be from 4 MHz to 28 MHz with a frequency step of 50 KHz. This will result in 481 data points. The PLX FLAG is set to 1 which specifies the shortened DATA directive format. The plot shows the (un-calibrated) output power level across the frequency range and identifies the minimum, maximum, and -3 dBm point. The sweep was made with the SG op mode turned off ("MOP" not "MOPS" as shown above. When the SB op mode is enabled the operator goes through the same steps as when starting a PLX sweep operation but, this time, there will be no sweep and no plot of the data. Instead, the following screen will come up:



The first screen just shows the parameters from the data entry screen that the SG operating mode will be using. This screen will be displayed for about one second and then the second screen will be displayed. This is the SG op mode control screen.

The top three lines come directly from the first data entry page. The Freq LO and Freq HI fields define the allowed frequency range. Any attempt to go lower than Freq LO will cause a BEEP and the frequency will be set to Freq LO. Similarly, any attempt to go above Freq HI will cause a BEEP and the frequency will be set to Freq HI. The next line is the DUT power output level. It will be set to "0.00" until the first reading. Since we are in manual operating mode, readings will only be taken when the operator presses the space bar on the keyboard. The second screen shows the result of the first reading.

The last line is the current frequency setting. At the start of each sweep, the PHSNA firmware reads three values from the simulated spread sheet: FREQ LO, FREQ HI, and FREQ ST. It then starts a normal PLX sweep. It first sets the DDS to FREQ LO and returns the power reading to the NAT. It then increments the DDS frequency by FREQ ST and compares the result with FREQ HI. If the new DDS frequency is greater than FREQ HI, the PHSNA firmware terminates the sweep. To hold the sweep to a single value, the NAT firmware sets FREQ HI to equal FREQ LO and, as long as FREQ ST is a positive, non-zero value, the sweep will only return one data point. The returned value is displayed on the fourth line of the display.

The yellow bars above and below a digit on the current frequency display identify the digit that can be incremented and decremented by the operator. The location of the digit is determined by the value in the data entry screen for FREQ ST. The real frequency step value is generated by rounding FREQ ST down to the next full power of ten. In this case FREQ ST is 50,000 Hz so the initial frequency step will be 10,000 Hz placing the yellow bars over the 4th digit from the right.

The specified digit will be incremented by pressing the up arrow or the plus ('+') key (shift is not necessary). The digit will be decremented by pressing the down arrow or the minus ('-') key (shift ignored). Incrementing a digit through 9 will cause a carry into the next higher digit position. Decrementing a digit through 0 will generate a borrow from the next higher digit position. Incrementing the frequency to a value outside of the specified range is not allowed.

The digit selection can be changed using the left and right arrow keys. The range is from one Hz (10.0E0) through 100 MHz (10.0E8). There is no limit on setting the frequency step but, if set too high, it may not be usable depending on the frequency range specified. Hot keys may be used to set the frequency to Freq LO (Home) and Freq HI (End).

The calibration data buffer is used in SG op mode. When the SG frequency is within the range used to load the calibration data buffer, the frequency will be used to find the calibration value closest to the current SG frequency. When the SG frequency is below the range used to load the calibration data buffer, the first calibration value in the buffer will be used. When the SG frequency is above the range used to load the calibration data buffer, the last calibration value in the buffer will be used.

SG op mode is terminated by pressing the Esc key. Nothing is logged or spooled in SG op mode. The final frequency or frequency step are not saved. They will be set to the values in the data entry form the next time it is used. Note that the NAT in SG op mode may be used as a VFO or local oscillator; just ignore the power level readings. When used as a VFO, you can set the frequency range to the legal range for the band you are operating in and the NAT will make sure you don't QSY outside of the band during the heat of the contest or while fighting your way through a pile-up in order to bag that rare DX station.

12 TOUCH SCREEN OPERATION

The touch screen functions are implemented in Version 2 of the NAT firmware. The touch screen allows nearly all of the NAT operations to be performed without a keyboard attached. Some preliminary setup operations may require the keyboard to be used to enter alpha text such as plot titles and file names. An on-screen numeric pad allows the user to enter and edit numeric data. Plot titles and file names can also be edited to add and edit numeric suffixes and prefixes to titles and names.

Touch screen support enables operator input through button presses and selections from menus. While it may be possible to use the touch screen with finger presses, due to the small size of the screen and the closeness of the objects displayed, touch screen operation will be much easier if a stylus is used. But first a warning about stylus use:

WARNING

The touch surface is plastic, not glass, and can be permanently damaged by using an improper stylus. Never use a sharp metal or hard plastic stylus. A wooden stylus is recommended, however, a metal or plastic stylus can be used as long as the tip is blunt and polished.

HINT

A wooden golf tee makes an excellent stylus.

This section describes the general methods to operate the NAT with the touch screen. The operations performed are described elsewhere in this document. The touch screen "tools" include buttons and two types of menus. First, however, we need to define the terms we will be using to describe these tools. Then we will cover touch screen calibration and how to use the various touch screen tools the NAT firmware provides.

12.1 TOUCH SCREEN GLOSSERY

Here is a brief list of touch screen terms and their meaning as used herein:

- Touch Screen – A transparent membrane covering the surface of the display designed so that the position of a **single** touch can be determined by the NAT firmware.
- Stylus – A pointing device used to improve resolution and accuracy of a touch over that possible with a finger.
- Pen – Another name for a stylus (**NOT A WRITING IMPLENT**).
- Pen down – The pen is touching the touch screen so that the firmware can accurately locate its position on the display.
- Pen up – The pen is not touching the touch screen and the firmware cannot accurately locate its position.
- Tap – Momentarily touching the screen (pen down followed by pen up).
- Button – A (generally marked) display area where a tap will cause an action such as displaying a menu or changing operating modes.
- Menu – A displayed list of options that can be selected by tapping one option list row. Many NAT menu selections can also be made from the keyboard.
- Static menu – A fixed menu, the listed options are determined by the NAT firmware and will be the same every time the menu is displayed.
- Context menu – A menu that pertains to the current operating mode. Context menus generally initiate/perform keyboard hot key functions.
- Dynamic menu – A menu with options that are not determined or defined by the NAT. For example, a menu generated by the PHSNA firmware and displayed on the NAT screen is a "dynamic menu". So is the listing generated by the DOS DIR command.

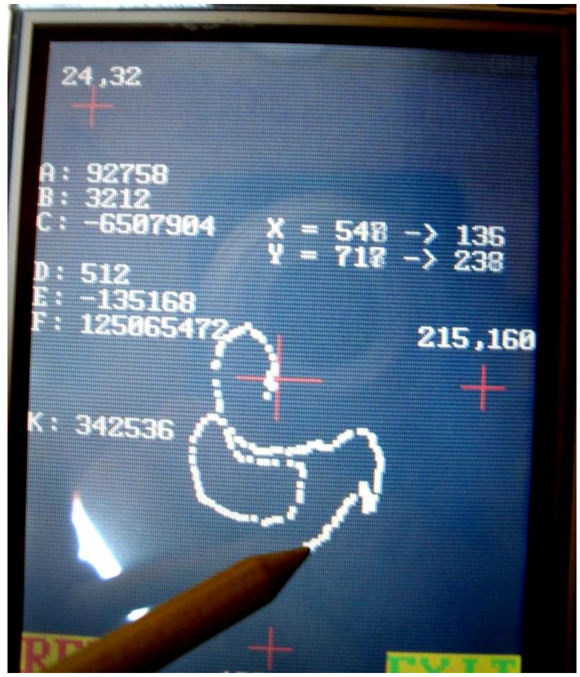
12.2 TOUCH SCREEN CALIBRATION

The touch screen membrane is actually two layers of resistive film that are shorted together at the touch point. The touch screen controller measures the resistance between the four edges of the touch screen and provides two values **related** to the touch position. The characteristics of touch screens can and do vary significantly from unit to unit. They can also be affected by temperature and by age. For these reasons, it is necessary to calibrate touch screens individually. This calibration process should be repeated if the accuracy of locating the touch point degrades. The NAT firmware provides a simple and quick way to calibrate the touch screen and to verify its accuracy.

Calibration is performed by the user touching three points on the display that are "known" to the firmware. The relative readings provided by these three touches are used to solve six simultaneous equations to provide a set of six calibration parameters. These parameters are stored in the EEPROM. From then on, every time a pen position is read, these values are used to generate the exact coordinates of the pixel at the touch location.

The calibration sequence is started by touching (pen down) the screen when the NAT powers up. The screen will clear and look white or off-white. When the pen is removed (pen up), the first calibration screen is displayed. This screen has three crosses on it at known locations and instructions to "PRESS HERE ONCE" with an arrow pointing to the first cross. The user places the pen (pen down), as accurately as possible, on the center of the first cross and then raises it (pen up). Note that the position readings are taken continuously while pen down and the last reading will be captured at pen up. The instructions then move to the second cross, and then the third.

After the third point is entered, the display changes to an "etch-a-sketch" like screen where the calibration can be verified. Note that the parameters have not yet been saved; they will only be saved after exiting the etch-a-sketch screen. This screen displays the original three crosses and their actual locations, the six calibration values, a fourth cross in the absolute center of the display (x, y = 120, 160) and two buttons labeled "EXIT" and "REDO". At pen down, the x, y coordinates of the touch will also be displayed. (The first coordinate number is the raw number received from the touch screen controller; the second number is the calibrated position.) The firmware also paints a 3x3 pixel rectangle under where it calculates the pen to be. Moving the pen will draw a 3-pixel wide line on the screen. Touching the center of the crosses should result in displaying the coordinates of the cross center (within a few pixels in either direction). If you are satisfied with the calibration, tap EXIT and the calibration constants will be saved in EEPROM for future use. If you are not satisfied with the calibration, tap REDO and the first calibration screen will reappear. If the calibration is so far off you cannot activate the buttons, turn NAT power off for a few seconds and repower it with pen down to restart the calibration process. (Note that buttons operate at pen up so you must press and release to activate a button.)



12.3 PERMINENT BUTTONS

After exiting calibration, the splash screen will be displayed for a few seconds and then the NAT firmware will start normal operation in Terminal mode. As long as the firmware is running, regardless of the mode, there will be four buttons at the bottom of the screen. The touch screen actually extends more than 10 pixel rows below the display area and this area is utilized by the four permanent buttons. A button is activated by touching anywhere in the area marked on the display and within about 1/8 inch below the display area. The standard functions for these buttons are as follows:

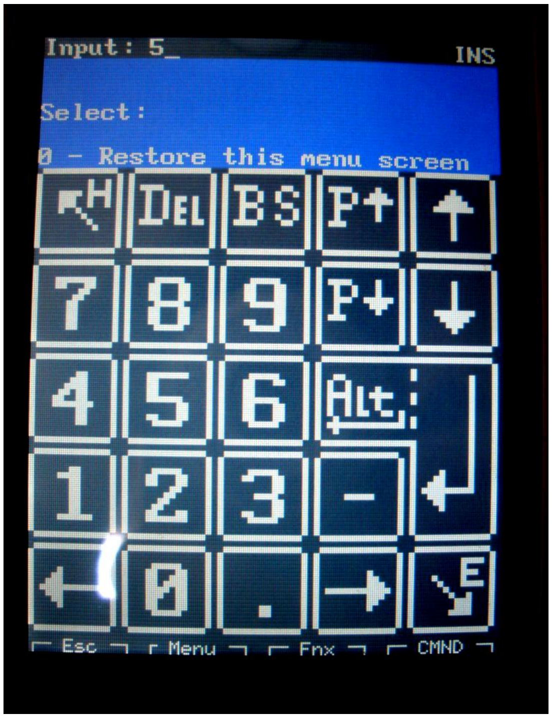
- **Esc** – Same as the Esc key on the keyboard. It generally terminates an in process operation or changes the NAT firmware mode.
- **Menu** – Brings up a context menu listing the hot key functions available to the current context. Context menus will be described in the appropriate subsections.
- **Fnx** – Brings up a dynamic menu listing the 14 function keys associated with 14 sets of PLX parameters. The menu is dynamic in that it also lists the title parameter to help the user identify the parameter set. The use of this menu depends on the context and will be described later.
- **CMND** – Same function as the Scroll Lock key on the keyboard.

There is also a semi-permanent, unmarked button in the upper right corner of the display. Tapping this area is the same as pressing and releasing the Ins key on the keyboard and will toggle between insert and overwrite edit entry modes The button is only active when either “OVR” or “INS” is displayed.

12.4 NUMERIC PAD

To facilitate touch screen data entry, the NAT firmware includes a 24-key numeric keypad (the "num pad"). The num pad may be brought up in any mode except PLX mode by tapping on the data entry/command line. In Terminal mode, the edit line is always the input line. In Command mode data entry the edit line is the line being edited in the data entry form. The num pad may be closed by tapping anywhere outside the num pad and the input line areas. Certain keys will also close the num pad. The num pad display is an overlay so when the num pad is closed, the previous (underlying) display is restored.

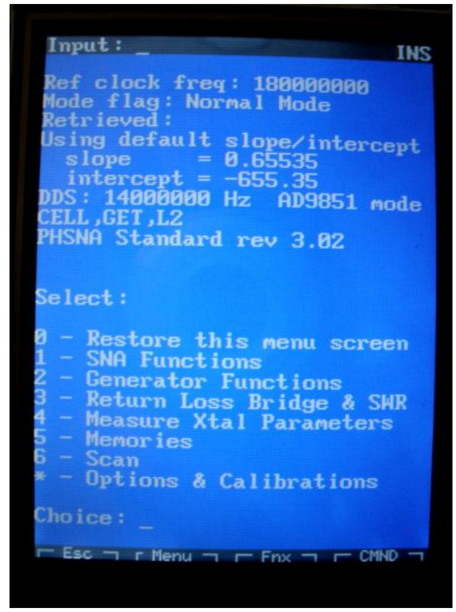
The num pad contains the ten decimal digits ('0' – '9'), the decimal point, and a minus sign for entering numeric data. It also includes the delete (Del) and backspace (BS) keys and the four arrow keys for cursor positioning. The keys with the up and down arrows and a "P" are Page Up and Page Dn. The key in the upper left corner is the Home key; the one in the lower right corner is the End key. Two forms of Enter are provided. The double-high key is the standard Enter key which will send the input with a following CR (0x0D) character. The key labeled "Alt" will send the input with no following CR character. Both of these keys will also close the num pad and restore the previous display. The num pad may also be closed by touching the display anywhere between the num pad and the top line.

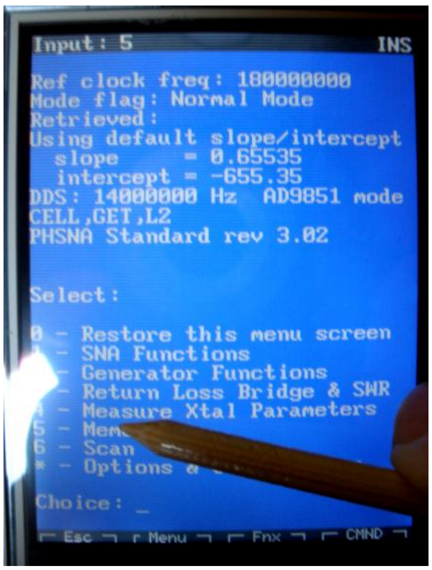


Two forms of the num pad are used. The first (shown on the left) is used when the edit line is the input line. In that case the entered characters are displayed on the edit line. The second form is used when the num pad may cover the edit line as when filling in values on the data entry screen. In this case the num pad has its own edit line just above the top row of keys. The display shows the entire line as it appears in the data entry form.

12.5 TERMINAL MODE

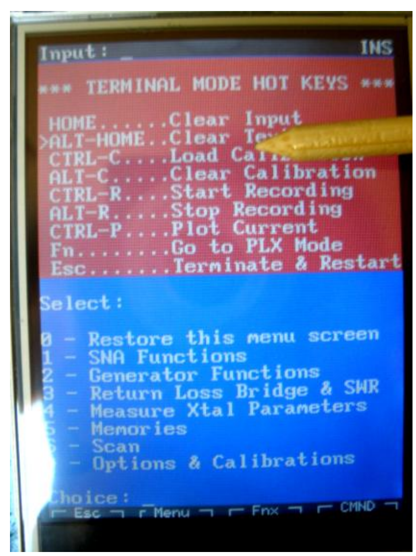
In Terminal mode, the entire text area is a dynamic menu. Tapping any line (pen down) will send the first letter of that line to the PHSNA firmware as a response. As an example, consider this screen showing the PHSNA firmware output after a reset. (Note that in the modified PHSNA firmware the menus and other prompts have been modified to have the expected response in the first column of the line. The original firmware will work but there may be instances where the proper response cannot be made with the touch screen.) This approach allows the NAT firmware to respond properly to menus and prompts generated by the PHSNA firmware without regard for their placement on the display and without the NAT firmware having to be aware of the significance of the menu item or prompt.





To facilitate item selection (and to compensate for some misalignment due to less-than-perfect touch screen calibration), at pen down, the response character will be displayed on the input line. In this example, the pen is down on the fifth line in the menu and a “5” is displayed on the input line. Moving the pen up and down the display will change the input line display to match whatever line the pen is on. The current value is captured at pen up and sent to the PHSNA firmware as a response.

Since seven of the items in this menu expect numeric responses, the num pad could also be used to make the selection. In this case and since the PHSNA firmware expects a single character response, you would key the number followed by the Alt-Enter key instead of the Enter key. The modified PHSNA firmware will accept either response, the unmodified versions may not.

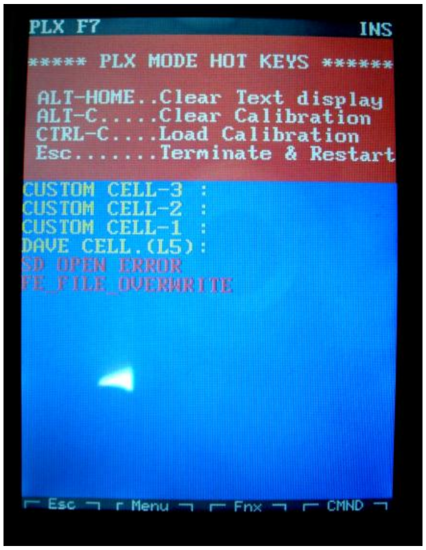


In Terminal mode, tapping the Menu button (bottom line, second from left) brings up the Terminal mode context menu. Context menus are always displayed with a red background. This menu essentially lists the Terminal mode hot keys. Markers will be displayed in the first (‘>’) and last (‘<’) columns of the line on pen down. The markers will follow the pen up and down the list. On pen up, the context menu is closed and the selected function is performed just as if the associated keyboard hot key were pressed. If the markers are not showing on pen up, the context menu is closed but no other action is taken.

The context menu may also be opened from the keyboard with the hot key sequence CTRL-M. The keyboard may be used to enter the hot key which will result in the closing of the context menu and the associated function performed. In this way, the context menu can serve as a help window when using the keyboard.

12.6 PLX MODE

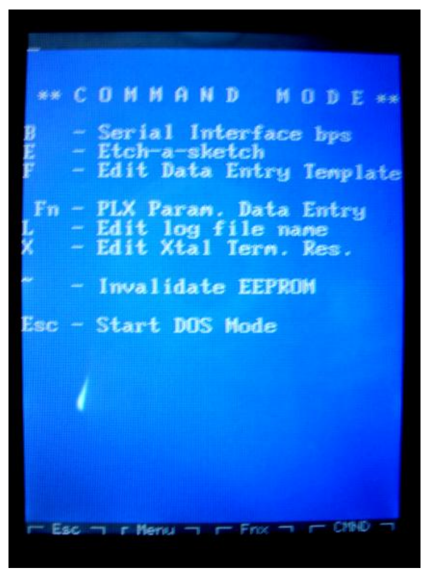
Tapping the Fnx button (bottom row, second from the right) while in Terminal mode will bring up the Function Key select menu. The first half of each line defines the associated function key. The last half of each line displays the content of the first item in the parameter list associated with the function key. This parameter is the plot title and will help the operator select the correct PLX parameter set. This menu may also be activated with the hot key sequence CTRL-F.



This menu acts like a context menu in that the markers in the first and last columns will follow the pen up and down. At pen up, the current line number is captured, the menu is closed, and the NAT switches to PLX mode using the parameter set associated with the selection. When the markers are not on one of the 14 menu lines, nothing will be input. In this case, pen up will do nothing. The menu can be closed without making a selection by tapping the Esc button.

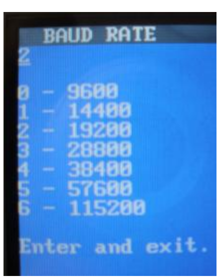
Tapping the Menu button will bring up the PLX mode context menu. This menu works just like the Terminal mode context menu. Since the user does not input data in PLX mode, the num pad cannot be activated in PLX mode.

12.7 COMMAND MODE



Pressing and releasing the Scroll Lock key or tapping the CMND button will switch the NAT to Command mode. The Command mode hot key list is actually a static menu and selections can be made by tapping a line or entering the leading character on the keyboard. The PLX parameter data entry screen cannot be accessed through the menu; it can be accessed by tapping the Fnx button. There is no context menu for this screen and pressing the Menu key will exit Command mode and return to Terminal mode.

12.7.1 SERIAL INTERFACE BPS



Selecting this item brings up the BAUD RATE edit screen which is also a static menu. After the selection is made, tapping the Enter and Exit line will save the selection to EEPROM and return the NAT to Terminal mode.

RECOMMENDATION

Always cycle NAT power after changing the baud rate.

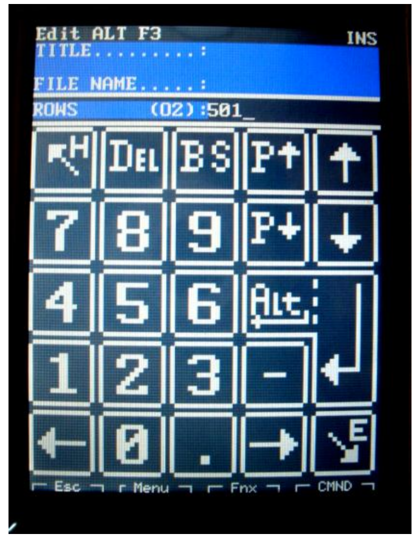
12.7.2 ETCH-A-SKETCH

This is a simple tool to check touch screen calibration. It is similar to the calibration confirmation screen described under TOUCH SCREEN CALIBRATION. To allow checking of the out-of-bounds area, the four permanent buttons at the bottom of the display are disabled. Without a keyboard, it will be necessary to cycle NAT power to end ETCH-A-SKETCH.

12.7.3 EDITING LOG FILE NAME AND XTAL TERMINATION RESISTANCE

The num pad can be used to enter and edit numerical data in these two edit screens.

12.7.4 DATA ENTRY



Selecting the F menu item will bring up the data entry template edit screen. Due to the lack of alpha characters on the touch screen, this item will find little use. Use the keyboard to edit the data entry template.

To edit one of the PLX parameter sets, tap the Fnx button while in Command mode to bring up the Function Key select menu. Select the desired parameter set by tapping its line on the menu. The markers will be shown in the first and last columns as long as the pen is down; the selection will be made when the pen goes up. After the selection, the standard data entry form is displayed. Tapping a line on the left side of the form will select that field. Tapping a line on the right side of the form will select that field and bring up the num pad.

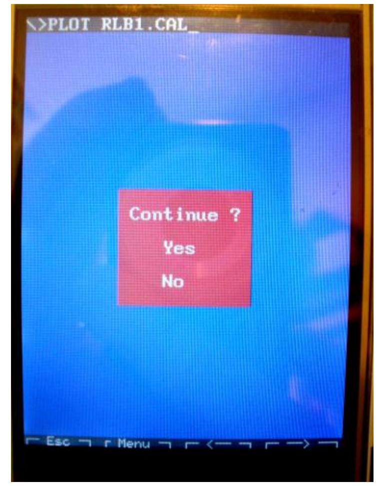
With the num pad displayed, tapping the up or down arrow will close the num pad and select the adjacent line above or below the current line. Tapping Enter will save the edited data set to EEPROM, close the num pad, and switch the NAT back to Terminal mode. All num pad keys are active in data entry mode.

Note that during data entry the num pad has its own data display. The line appears directly above the num pad keys and is an exact copy of the field being edited. This is done to make the edit line visible with the num pad display covering most of the data entry screen. The data is actually being edited in the main buffer. The num pad display is only an image of that data. In this example, “501” has been entered in the ROWS field.

12.8 DOS MODE

Enter DOS mode by tapping the Esc button while in Command mode. This puts the current DOS prompt on the command line and displays the contents of the first sector in the current directory. Two of the permanent four buttons at the bottom of the display change meaning in DOS mode. When DOS mode is exited, the original permanent buttons are restored. The Fnx and the CMND buttons have no use in DOS mode so they are changed to left and right arrows, respectively. They are used to navigate through data on the SD card. Each time on of these buttons is tapped, the DIR display changes to the next or previous directory sector (if any). If there is not a next or previous sector in the current directory, the NAT firmware will BEEP and the current sector remains displayed. The current sector number in the current directory is displayed in the upper right corner of the DIR display (starting with sector zero). Note that the DIR command is the only one that can display the previous sector. The other DOS commands that display file data can only move forward.

To execute a DOS command, first select a file (or directory) from the DIR display. This will bring up the DOS mode command context menu. Use this menu to select a DOS command on the previously selected file. When the command does not require a file, select any file or none by tapping outside the menu item list or on a blank line in the list.



After a command is selected the confirmation menu is displayed. The complete command to be executed is displayed on the command line. Select “Yes” to continue and execute the command; select “No” to abort and exit without executing the command. Here we have selected to execute the PLOT command on the file named “RLB1.CAL”.

Note that there are no ways to clear and load the calibration buffer using the touch screen in DOS mode. The data buffer can be loaded in DOS mode from a file on the SD Card. Once this is done, the data remains in the buffer until it is reloaded in any mode. To load the calibration buffer from the data buffer, return to Terminal mode and use the Terminal mode context menu to clear and/or load the calibration buffer. If a keyboard is attached to the NAT, it can be used to clear (Alt-C) and/or load (Ctrl-C) the calibration buffer while remaining in DOS mode.

12.9 MANUAL CONTROL SIGNAL GENERATOR OPERATING MODE

All of the hot-key functions described for SG op mode can be done with the touch screen. From the top, touching the display line for Freq LO will set the frequency to that value (Home). Touching the display line for Freq HI will set the frequency to that value. Touching the green plus (‘+’) or the red minus (‘-‘) areas will increment or decrement the selected digit in the frequency display. Touching any digit position in the frequency display will move the yellow bars to that digit position and change the frequency step accordingly. The buttons at the bottom of the remain active with the exception of the Fnx button. However, only the Esc button may be of use. The others may give unexpected and surprising results.

13 UPDATING NAT FIRMWARE

An SD Card (SDC) boot loader is installed in the NAT controller's upper program memory. The boot loader will load firmware updates from Files located in the root directory of the SDC. The boot loader is documented in detail in another document which includes the technical details a developer would need to write or modify applications to use the boot loader. The following paragraphs describe how to use the boot loader to load NAT firmware updates.

The boot loader protects itself and will not allow a program to overwrite it. All standard NAT firmware releases will contain the boot loader in addition to the NAT firmware; both in a single HEX file. When the HEX file is loaded by the boot loader, it will not overwrite itself; the boot loader portion of the Hex file will be ignored. If the boot loader becomes corrupted and the user has access to a dsPIC programmer, it may be used to load the HEX file which will do a total load of the NAT firmware and the boot loader. After a total load, the boot loader will be restored and can be used to load future firmware updates.

When firmware is loaded, the boot loader saves the starting (reset) address of the new firmware load and replaces it in the reset start vector with its own starting address. Each time the NAT is reset, the NAT firmware starts in the boot loader. The boot loader first attempts to mount the SDC. If the mount is successful, the boot loader attempts to open a file named "APP.HEX". If the file open is successful, the boot loader loads the new firmware. If either the mount or the file open operations fail, the boot loader transfers control to the previously loaded firmware at the starting address saved when that firmware was loaded. This is the normal, NAT firmware start-up sequence. If any method other than the boot loader (such as using the Microchip In-Circuit Programmer interface) is used to load NAT firmware, the boot loader will probably not be preserved and will have to be reloaded.

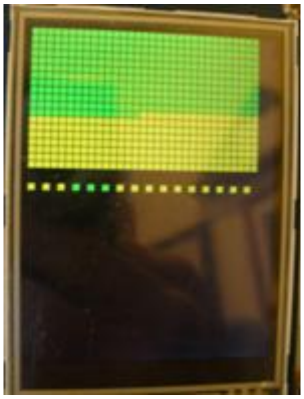
The boot loader will normally be started by the currently loaded application. Using an APP.HEX file to boot load the firmware is intended to be used only when the currently loaded firmware cannot start the boot loader either because the capability was not programmed into the application or the firmware has been corrupted. Instead, the boot loader will generally be started from the NAT firmware using the DOS command SDLD as described earlier. In this case, the file to be loaded must be in the SD Card root directory but may have any file name with one to eight characters, all caps, and must have a "HEX" file name extension. The recommended file naming format for NAT firmware boot load files is:

"NAT_v_rr.HEX"

Where "v" is the version number and "rr" is the two-digit revision number. For example, the recommended file name for the current version is "NAT_1_01.HEX".

Before transferring control to the boot loader, the NAT firmware will verify the named file does exist in the root directory by mounting the SD card and opening the named file in read mode. If either of these operations fails, the firmware will BEEP and will not transfer control to the SDC boot loader leaving control with the current application.

The file to be loaded must be a properly formatted, Intel HEX file and must be located in the SDC root directory. The file is the standard load file exported by the Microchip compiler (actually, the linker). No modifications or preprocessing are required. To avoid the preprocessing needed by many other loaders, the boot loader is a multi-pass loader which reads the complete file several times. The repeated reading is required because there is no guarantee that the object code in the HEX file will be sorted by address, in fact, it usually is not sorted. Each pass assembles a block of code to be loaded in consecutive program memory locations. The Intel HEX file format is well documented and widely used for firmware object code. The file format includes a check sum for each line which the boot loader does check. A typical boot load operation can take one to two minutes to complete.



The boot load progress is shown on the NAT display as several rows of small, colored squares. Each square represents the processing of one line (64 words) of program memory data. Each row of the display represents one block of four pages for a total of 32 squares per row. Lines that do not contain new program data are represented by yellow squares. Lines containing new program data will be represented by green squares. Lines containing new data but one or more checksum errors was detected will be represented by red squares.

If the boot load is terminated (by removing the SDC or turning off power) before any green squares are displayed, the current application is still viable. In this case, the SDC can be removed and power cycled to restart the last loaded application. If one or more green squares have been displayed, the old application may have been corrupted and cannot be restarted without completing a successful load. Note that in either case, cycling power on the microcontroller will restart the boot loader. If the microcontroller is restarted with the SDC removed, it will try to restart the last loaded application. If an SDC is present, it will try to do a firmware load from a file in the root directory named “APP.HEX”.

NOTICE

When an APP.HEX file us used to boot load the NAT firmware, it should be removed from the SDC to avoid having to wait for a boot load operation each time the NAT is turned on. This can be done by either removing / replacing the SD card or by deleting the APP.HEX file using the DOS command “DEL APP.HEX”.

APPENDIX A. HOT KEY SUMMARY

EDITING, All Modes

Home................Clears editable text area and moves cursor to the first editable position.

End ....Moves cursor to the first position past the end of the text in the edit field.

Backspace ....Deletes the character to the left of the cursor position and moves all following characters one position to the left.

Delete...............Deletes the character at the cursor position and moves all following characters one position to the left.

Insert ....Toggles between Insert and Overwrite entry modes.

Left Arrow ....Moves the cursor one position to the left.

Right Arrow.....Moves the cursor one position to the right.

TERMINAL MODE

Alt-Home ....Clears the output text display and moves the text entry point to the first character position.

Alt-C ....Clears the calibration constant buffer.

Ctrl-C..............Loads the calibration constant buffer with the current contents of the plot data buffer.

Ctrl-F ....Display Function Key select menu.

Ctrl-M ....Display Terminal mode context menu.

Ctrl-R..............Open spool file and start recording.

Alt-R ....Stop recording and close spool file.

Ctrl-P ....Plots the current contents of the plot data buffer if loaded.

F1-7, Alt-F1-7..Switch to PLX mode using parameter set associated with the hot key pressed.

Esc ....Terminate an in process operation and reinitialize Terminal mode. Will close an open file, if any, and post any pending error messages.

PLX MODE

Alt-Home ....Clears the output text display and moves the text entry point to the first character position.

Alt-C ....Clears the calibration constant buffer.

Ctrl-C..............Loads the calibration constant buffer with the current contents of the plot data buffer.

Ctrl-M ....Display PLX mode context menu.

Esc ....Terminate PLX mode in the NAT and the PHSNA firmware and return to Terminal mode. If receiving data in automatic operation mode, the termination will wait until the end of the current sweep unless Esc is pressed a second time.

COMMAND MODE

Ctrl-F ....Display Function Key select menu.

Esc ....Switch to DOS mode.

DOS MODE

Esc .... Switch to Terminal mode.

Alt-C .... Clears the calibration constant buffer.

Ctrl-C............... Loads the calibration constant buffer with the current contents of the plot data buffer.

SIGNAL GENERATOR OP MODE

Home................ Set the operating frequency to Freq LO.

End .... Set the operating frequency to Freq HI.

Left Arrow .... Increase frequency step one decade (x10).

Right Arrow..... Decrease frequency step one decade (/10).

Plus (‘+’)
Equal (‘=’)
Up Arrow......... Increment frequency by the current frequency step.

Minus (‘-‘)
Underline (‘_’)
Down Arrow .... Decrement frequency by the current frequency step.

Space................ Initiate another data sample.

Esc .... Terminate PLX mode in the NAT and the PHSNA firmware and return to Terminal mode. If receiving data in automatic operation mode, the termination will wait until the end of the current sweep unless Esc is pressed a second time.

APPENDIX B. NAT COMMAND SUMMARY

COMMAND MODE COMMANDS

B..Select serial port baud rate

F1-7 & Alt-F1-7 ....PLX data entry

F ....Edit data entry format template

L ....Edit log file name

X ....Edit crystal fixture termination resistance

~ ....Invalidate EEPROM content

Esc .... Switch to DOS mode

DOS MODE COMMANDS

DIR ....Displays the contents of the first sector of the current directory.

CD <Directory Name>....... Change Directory. Subdirectories are supported.

DEL <File Name> ....Deletes the specified file from the current directory.

DUMP ....Displays physical sectors in a combined hex and ASCII format.

DUMP <File Name> ....Displays file data in the dump format.

TYPE <File Name> ....Displays the contents of the specified file as text.

PLOT <File Name> ....Plots the Power data in the named file.

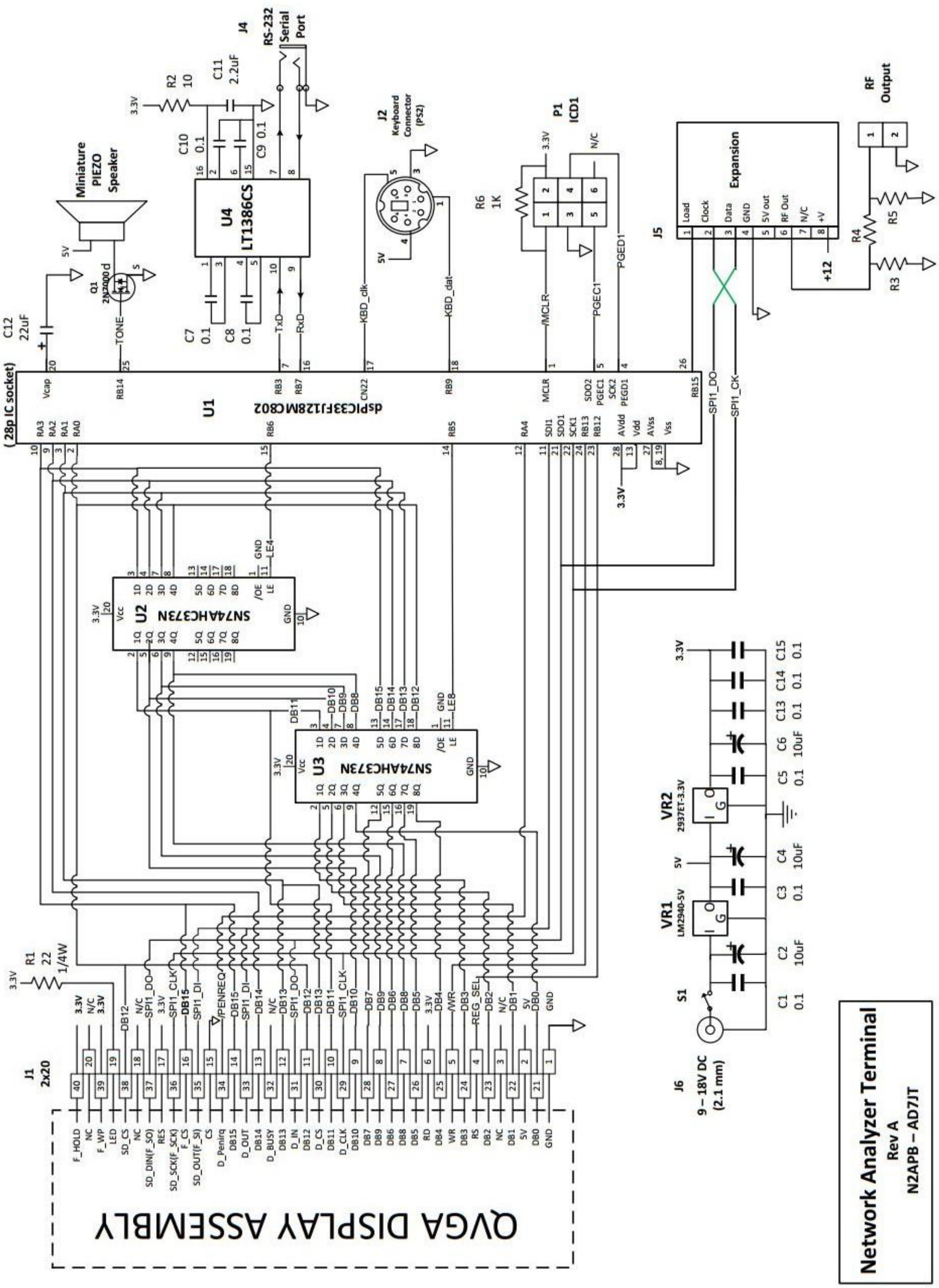
PLOTP <File Name> ....Plots the Power data in the named file.

PLOTV <File Name> ....Plots the VSWR data in the named file.

SDLD <File Name> ....Reload the NAT Firmware from the named file.

? ....Show a menu of available DOS commands

APPENDIX C. NAT (rev A) SCHEMATIC



APPENDIX D. FIRMWARE RELEASE NOTES

*** .. Version 01.00 - 01 April 2014**

*.... 1. Deleted commented code blocks and reduced global count
*.... 2. Retain volume name when CDing to subdirectories.
*.... 3. Implemented writing to sub directories
*.... 4. implemented RLB and XTAL plotting
*.... 5. Moved plot count to upper right corner of plot area.
*.... 6. Modified the SDLD DOS command to start the SD Boot Loader
*.... by executing a reset command.
*

*** .. Version 01.01 - 18 April 2014**

*.... 1. Changed plot to always do -3dB calc for band pass plots
*.... 2. BUG FIX - change to avoid overwriting the min/max line on plot header.
*.... 3. BUG FIX - clear plxDataRow at start of each DATA directive processing.
*.... 4. Added routine to calculate FREQ_LO, FREQ_HI, FREQ_ST, or ROWS
*.... when other three are entered.
*.... 5. Converted one of the custom cells to "CENTER FREQ" and added
*.... FREQ HI and FREQ LO calculations when CENTER FREQ is changed.
*.... 6. BUG FIX - Limited plot step count to buffer size to avoid address errors.
*.... 7. BUG FIX - Limited calibration adjust to max buffer size to avoid
*.... address errors. Last calibration constant used beyond buffer limit.
*.... 8. Modified DATA directive processing to capture minimum and maximum
*.... data points over whole scan even beyond the buffer capacity.
*.... 9. BUG FIX - Limited plotting to buffer capacity when data set is bigger.
*.... 10. Added min and max info on FREEFORM plots, even when min or max beyond
*.... buffer capacity.
*.... 11. Added read check and retry to FAT writes.
*.... 12. BUG FIX - Corrected fdeleteM to properly release all clusters assigned
*.... to the file being deleted (was just deleting the first one).
*.... 13. BUG FIX - Removed space count limitation in TB backspace (CW remnant).
*.... 14. BUG FIX - Made sure whole upper area was cleared after an error at end
*.... of plotting to get rid of plot title remnants.

APPENDIX D. FIRMWARE RELEASE NOTES (cont.)

*** .. Version 02.00**

*.... 1. Added touch screen support
*.... 2. Added menus for function key select, Terminal mode hot keys, and PLX
*.... mode hot keys.
*.... 3. Modified Command menu for touch screen use.
*.... 4. Added numeric pad for touch screen data entry and terminal input.
*.... 5. Added DOS context menu.
*.... 6. BUG FIX - Plotting in DOS mode now calibrates the data before testing
*.... for min and max. Doing it after caused plot data heading to be different
*.... than the plotted data.
*.... 7. File name in command line in DOS mode and plot titles will be red when the
*.... calibration buffer is not loaded and in white when the calibration buffer
*.... is loaded.
*.... 8. Over plots will be different colors : white, red, orange, yellow, green,
*.... violet, gray, black (mod 8).
*.... 9. Increased plot dot size from 1x1 to 2x2 pixels to thicken lines.
*.... 10. Changed plot algorithm to make a single Y step when data called for a
*.... Y step of 2. This does some smoothing and eliminates some apparent breaks
*.... in near-horizontal plots.
*.... 11. BUG FIX - Changed input processing order to eliminate extra characters
*.... being inserted when Alt-Enter pressed.
*.... 12. BUG FIX - Corrected x offset introduced for #9 to avoid x = -1 which
*.... displayed pixel at end of line (x = 0 - 1 => xmax = 219).
*.... 13. BUG FIX - Correctly set TRISBbit.TRISB7 (RxD) for input (1) to disconnect
*.... port output pin driver from Rx which was overloading the line driver.
*.... 14. BUG FIX - Changed EEPROM invalid code from 0xffff to 0x0000 to avoid
*.... EEPROM initialize from assuming there was no EEPROM.
*.... 15. Added tbReinit(&tb1) to PLX clear data directive to eliminate the possibility
*.... of scrolling during first data transfer sequence. Also disabled BEEP after 1st.
*.... 16. BUG FIX - The keypad decimal point translation was backwards; shifted was Delete,
*.... un-shifted was '.'. Also made arrow keys work properly with Num Lock on.
*.... 17. BUG FIX - editInsEnable was getting reset by Home function thus disabling INS in
*.... edit mode.
*.... 18. USER REQUEST - Added 1200, 2400, and 4800 bps to the baud rate menu.
*.... 19. USER REQUEST - Added BEEP at end of recording session.
*.... 20. USER REQUEST - Changed ERROR color from RED to ORANGE to show up better on BLUE
*.... 21. Added Signal Generator mode.
*.... 22. Changed calibration to interpolate so that the calibration scan does not have
*.... to exactly match the DUT scan.