

NAT USER GUIDE EXTENSION

for

Firmware Version 4

with

NACT-TO-SNA Hardware Upgrade Instructions

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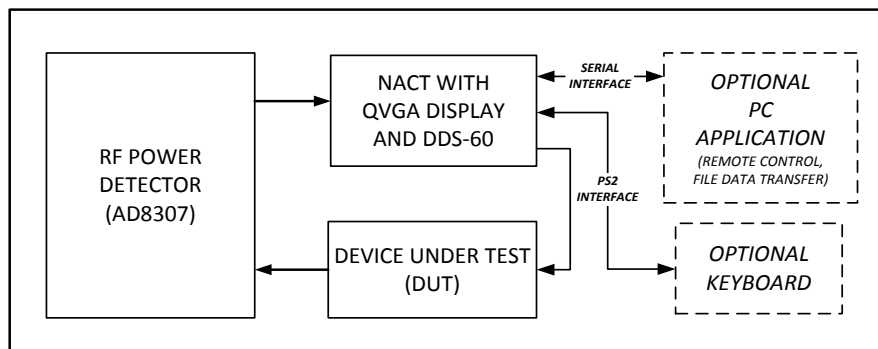
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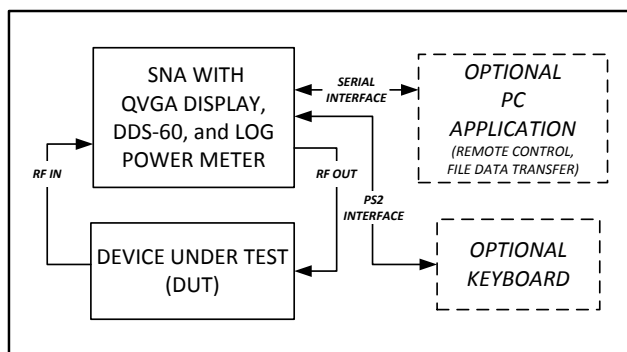
1 INTRODUCTION

Upgrade your NACT (Network Analyzer Controlling Terminal) to an SNA (Scalar Network Analyzer) and you will have all you need for a fully functional, Scalar Network Analyzer in a simple to use, hand-held tool. The NAT USER GUIDE EXTENSION FOR FIRMWARE VERSION 3 described how to upgrade your NAT to an NACT; this document describes what you need to do to convert your NACT to an SNA. In other words, how to go

from this:



to this:



This document also describes new features implemented in the Version 4 firmware.

2 NEW FEATURES AND ENHANCEMENTS

The V4 firmware includes the following new features and enhancements:

1. RF Power Meter mode (Scroll Lock-P) that displays current, average and peak power in both dBm and Watts.
2. Files can now be downloaded to the SD Card via the serial port enabling firmware updates without removing the SD Card.

3. Separators have been added to multi-plot log files to enable playback and re-plotting in DOS mode and to provide explicit data boundaries when exported to PC applications.
4. A new, more precise touch screen calibration procedure using nine points instead of the original three points.
5. The Command mode menu has been split into two pages (COMMAND MENU and EDIT MENU) to allow more entries while maintaining double line spacing to facilitate touch screen selection.

The following edit functions have been added:

1. The roll-off/bandwidth threshold was fixed at -3 dB and can now be edited and saved to EEPROM (Scroll Lock-R).
2. The power meter slope and intercept values can be entered and/or edited.
3. An optional, precision, 3V ADC reference voltage can be added with a simple hardware modification. The reference voltage level can be entered and/or edited.
4. The Power Meter calibration levels were set at 0 dBm and -20 dBm. The upper power level can be changed; the lower level remains 20 dB below the upper level.

A number of minor bug fixes and the following minor changes have also been included in the V4 firmware:

1. To avoid inadvertently resetting the EEPROM, the Reset EEPROM command has been made a keyboard-only command (Scroll Lock-~).
2. A warning message is displayed when the firmware cannot confirm the presence of an EEPROM.

3 OPTIONAL HARDWARE UPGRADES

Four optional hardware upgrades are described here and supported by the Version 4 firmware.

1. Add a daughter board containing the W5Z0I AD8307 RF Power Meter circuitry to the NAT PCBA assembly as described in Appendix A. This optional hardware upgrade converts a NACT to an SNA.
2. Add an independent power source for the RF Power Meter as described in Appendix B. This upgrade requires option 1.
3. Add a precision ADC voltage reference source as described in Appendix C. This upgrade may be installed with or without either of upgrades 1 and 2.

4. Add a calibrated signal source for calibrating the RF Power Meter as described in Appendix D. This upgrade may be installed with or without any of upgrades 1, 2, and 3.

Note that the PCBA modifications described here apply only to Revision A of the NAT PCB with the hardware modifications described in the NAT USER GUIDE EXTENSION FOR NAT FIRMWARE VERSION 3. Future PCB revisions will have all the hardware modifications in etch.

The hardware upgrades are virtually transparent to the firmware therefore both V3 and V4 firmware may be used with an SNA. Similarly, both the V3 and V4 firmware can be used with a NACT with external power meter. Note that some functions and features in the V4 firmware require the hardware upgrades. These functions and features will not work with an unmodified NACT configuration.

Appendix E contains a schematic of the SNA with all hardware options installed.

4 DDS-60 OUTPUT SETTING

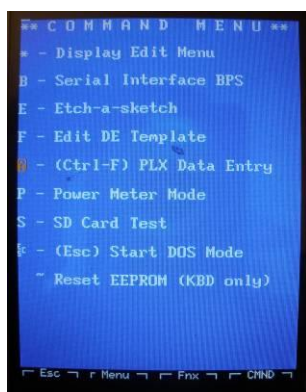
Even though the DDS-60 is not used when the firmware is in Power Meter mode, it is valuable for some calibration operations. It is convenient to have the DDS-60 output level set to 1 mW or 0.0 dBm. After the RF Power Meter has been calibrated, it can be used to do this with the SNA in Signal Generator mode and the RF OUT signal connected directly to the RF IN connector. Set the frequency to 1 MHz and adjust the DDS-60 output level to 0.0 dBm.



Note there is a new op mode setting for displaying the AD8307 output voltage level. When a question mark (?) is entered on the OP MODES line on page two of the PLX data entry form, the current voltage reading will be displayed in red characters directly below the dBm reading. When the RF IN signal level is at 0.0 dBm, the voltage should be approximately 2.1 volts.

Note also that it may be necessary to install the components for a 3 dB attenuator pad in the DDS-60 output to reduce the signal to a usable level.

5 RF POWER METER MODE



The Command mode menu has been changed to include the 'P' command which activates Power Meter mode. In this mode, the SNA reads the output power levels of the DUT. The DDS-60 will not generally be used in this mode except, possibly, to aid calibration. The DDS-60 is generally used in Signal Generator and PLX modes as described elsewhere.

Selecting Power Meter mode from the command menu activates the SNA power meter function and the power meter display. The display actually shows three meters. Each

meter displays a different type of power level measurement digitally in dBm and in Watts and as an analog display on a bar graph. The bar graph range in dBm is shown above the bar graph area at both ends of the bar graph. The 0.0 dBm point on the bar graph is shown with a vertical white line. For many settings, the maximum power level is shown in milliwatts below the end of the bar graph area.

On each meter, the Watt display will be scaled according to the power level just to keep the numbers reasonable. The power scales displayed are: Watts ("W"), milliwatts (mW), microwatts (uW), nanowatts (nW), and picowatts (pW).



5.1 POWER LEVEL MEASUREMENTS

The power level is sampled at a rate of about 200 times per second (every 5 ms) and used to generate three types of power measurements. The three power meters display the following power information:

UPPER METER: Ten-point running average of the current power reading updated after every 20 readings (about ten times per second).

MIDDLE METER: 200-point running average updated every reading.

LOWER METER: Highest power reading from the last 200 readings updated every 200 readings.

5.2 RANGE SHIFTING / SCALING

The standard range for the AD8307 log power amplifier/detector is from about -80 dBm to about +20 dBm which corresponds to a range from $1e-11$ (0.00000000001) Watts (10 pW) to 0.1 Watts (100 mW). The 100 dB range is fixed but it may be shifted by adding an

attenuator in series with the DUT. The button on the bottom of the power meter display shows the current attenuator value, if any. When an attenuator is used the bar graph range will be shifted accordingly.

For example, adding a -30 dB attenuator in series with the DUT will effectively change AD8307's range **to:** -50 dBm to +50 dBm. The range shift can be done with a calibrated, adjustable power source or a calibrated 0 dBm power source and an attenuator. Pressing Ctrl-G (or tapping the Gain button on the screen) tells the firmware that the current power reading is attenuated by the current power level reading.



In this example, the DDS-60 output (set to 1 mW or 0.0 dBm) and a -30 dBm attenuator are used to shift the power meter scale by 30 dBm. The first picture above shows the power meter with the DDS-60 output displayed. The second picture shows the effect of a -30 dBm attenuator in series with the DDS6-60 output. Pressing Ctrl-G or tapping the Gain button on the display will capture the current power level reading and adjust the power meter scales to reflect the effect of the attenuation. As the third picture shows, the attenuation level is now shown in the Gain button display area. The meter ranges now run from -50 dBm to +50 dBm and the 0.0 dBm line is centered in the meter. The power levels shown are now correct for the DDS-60 output. The fourth picture shows the meter readings with a +30 dBm (1 W) signal applied through the -30 dBm attenuator.

Pressing Ctrl-G (or touching the button area) when the gain is non-zero will clear the gain setting and will return the meter scales to run from -80 dBm to +20 dBm. The current gain setting is saved in the EEPROM and will be restored to the last value after cycling SNA power.

WARNING

When using an attenuator make sure it is rated to dissipate the power you will use. In the above example, a 50 dBm RF signal will require an attenuator that can dissipate 100 watts.

6 DOWNLOAD FILES (Ctrl-Z and Alt-Z)

Two new hot keys have been added to Terminal mode to allow files to be downloaded to the SD Card without removing the SD card from the SNA. The commands are:

- Ctrl-Z – Create a file on the SD card with the log file name and save all data received on the serial bus to that file. If a file of the same name exists in the current directory, declare an error and abort the download.
- Alt-Z – Delete a file on the SD card with the log file name (if any) and create a new file with the same name. Save all data received on the serial bus to that file.

After one of these commands is entered, the firmware will wait approximately three seconds for the data transfer to start. If the transfer does not start within this time, the download operation will be aborted and the file closed with zero size. Once the transfer is started it will proceed until there is a pause of over 0.5 seconds which will indicate the end of the file. At this point the download will be terminated and the file closed. The transfer may be terminated manually by pressing the Escape key. It will also be terminated in the event of a file system error.

The download file will contain the exact data set received from the time the download is started until it is terminated, nothing will be added or removed. The download data may be text, binary, or a combination of both. The primary intended use of these commands is to be able to transfer new firmware .HEX files to the SD card from a PC without having to remove the SD card from the SNA.

The file name will be the log file name previously entered/edited with the Scroll Lock L command. The file can have any name as long as it conforms to the standard DOS 8.3 file name format.

NOTE

Firmware update file name extensions must be “.HEX”. Also, if you choose to name the update file “APP.HEX” be sure to delete the file once the updated firmware has been loaded and the application started to avoid having to wait for the firmware to reload each time power is turned on.

Many terminal emulator programs include a file transfer function that can be used to transfer file data from a PC to the serial port. The TeraTerm emulator

<http://ttssh2.sourceforge.jp/index.html.en>

was used during the development of this feature. Note that a typical firmware update file contains close to 500 KB so make sure the terminal emulator can handle files of this size. With the serial interface baud rate set for 38400 bps, a file of this size will take slightly over two minutes to download.

Because of the overhead required to scroll the display, scrolling is turned off during the download. Instead, the received data will be displayed on one display line; each line received will overwrite the previously received line. After the transfer is complete, the display will be cleared.

7 LOGGING MULTI-PLOT DATA SETS

With previous firmware versions, multiple plot data was logged with no separator between plot data sets. Plot data sets needed to be separated/delineated manually after transferring the data to a PC application. Version 4 inserts a PLX ROW declaration between each plot data set declaring the number of data points in the previous data set. When a log file is played back for plotting, the firmware recognized these separators and plots the following data set as a new over-plot in a new color. This should produce the same plot that was generated when the data was sampled.

The example shown here is a multi-plot of the following:

1. 7 MHz LPF (white)
2. 7 MHz LPF with 10 dB attenuator on input (red)
3. DDS output with 10 dB attenuator (green)
4. DDS output with 20 dB attenuator (yellow)
5. DDS output with 30 dB attenuator (magenta)
6. DDS output with 40 dB attenuator (blue)
7. DDS output with 63 dB attenuator (white)
8. Open power meter input (about -84 dB, magenta)



Note that the green -3 dB markers and the data displayed at the top of the screen apply only to the first plot.

8 NINE-POINT TOUCH SCREEN CALIBRATION

The touch screen calibration process has been improved by going from a three-point algorithm to a nine-point algorithm. It has also been made easier to step through the calibration process. When power is turned on with a stylus touching the screen, the firmware completes only those initialization functions required to do the touch screen calibration and then indicates it is ready to continue by displaying “TAP EACH CROSS” across the top of the, otherwise blank, screen. This indicates that you can now raise the stylus and start the calibration process. When the stylus is raised, the first cross is displayed. As each cross is “tapped” the stylus position is recorded and the next cross is displayed. After all nine cross have been tapped the touch screen calibration constants are computed and a simplified etch-a-sketch screen is displayed. This screen can be used to test the accuracy of the calibration by drawing on the screen with the stylus. The firmware will

“write” white dots on the screen where it “believes” the stylus to be. If you are satisfied with the calibration, touch the green EXIT button to end the calibration process and start normal operation. If you are not satisfied with the calibration, touch the red REDO button to repeat the calibration process.



PENUP



8 CROSSES TAPPED



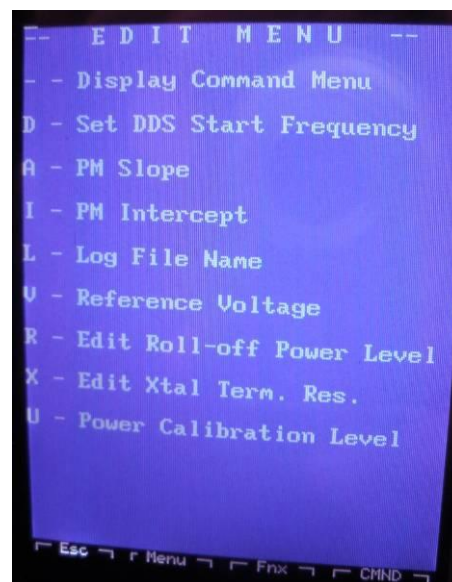
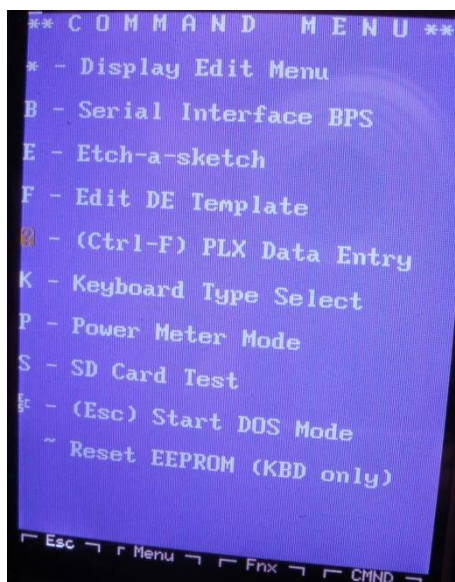
TAP NO. 9 DONE



ETCH-A-SKETCH

9 TWO-PAGE COMMAND MENU

The Command mode menu has been divided into two pages to allow additional items to be added while keeping the double-spacing to facilitate menu selections using the touch screen. The second page contains editing selections and is referred to as the “EDIT MENU”. When page one (“COMMAND MENU”) is displayed, entering an asterisk (“*”) will display the EDIT MENU. When the edit menu is displayed, entering a dash (“-”) will display the COMMAND MENU. Note that there is still only one menu containing the items on both pages. Only the display is affected by entering “*” or “-”. Items on the second page can be selected from the keyboard when the first page is displayed and items on the first page can be selected when the second page is displayed.



10 NEW EDIT FUNCTIONS

A number of new edit functions have been added. In all cases, the item being edited will be displayed on the top (command) line and the edit area of the blue text screen will be displayed with a black back ground. Initially the edit area will contain the current value of the item being edited. When a character is entered into the last editable character position of the edit field, a BEEP will be sounded and the cursor will not advance. Therefore, if another character is entered at this point, the new character will overwrite the last character and another BEEP will be sounded. Note that there is one character position beyond the last editable position in the edit field. This position is a place holder for the terminating (NULL) character required to mark the end of the character string.

The new edit functions are as follows:

10.1 POWER METER (PM) SLOPE

This floating point number is usually generated automatically when **Set Slope-Intercept** is selected in Signal Generator mode (hot key CTRL-S). This edit option allows you to manually enter the value. There are no range or sign checks.

10.2 POWER METER (PM) INTERCEPT

This negative integer is usually generated automatically when **Set Slope-Intercept** is selected in Signal Generator mode (hot key CTRL-S). This edit option allows you to manually enter the value. There are no range or sign checks.

10.3 ADC REFERENCE VOLTAGE

The original ADC reference voltage source was the Vcc for the dsPIC which is nominally 3.3V. The output level of the precision ADC reference voltage generator described in Appendix C is 3.00 Volts. Either of these voltage levels or another of your choosing may be used. This edit function is used to define the ADC reference voltage level to the firmware. The level must be specified as a whole number consisting of a single digit followed optionally by a decimal point and a one or two digit fraction. There are no format or range checks on the value entered.

10.4 ROLL-OFF POWER LEVEL

The standard plot function displays the power level point(s) on a plot where the power level is 3 dB less than the maximum value in the plot. Some devices (such as filters) may be specified in terms roll-off values other than 3 dB (e.g., 6 dB). This edit function can be used to change the roll-off threshold to something other than 3dB. The number is entered as a positive decimal value of one or two digits (0 to 99).

10.5 POWER (METER) CALIBRATION LEVEL

Previously the power meter calibration (slope-intercept) used two signal levels, zero dBm and -20 dBm. The calibrated signal source (PWRCAL) described in Appendix D generates a square wave. It turns out that some later generations of the AD8307 power meter IC do not respond properly to a square wave at power levels below around -20 dBm. For this reason, PWRCAL generates a signal level of +3 dBm and the -20 dB attenuator will reduce this level to -17 dBm which is high enough to avoid the AD8307 square wave response problem. If an external, sinusoidal signal source is used, most any two power levels within the AD8307's detector's range and separated by 20 dB can be used. Use this edit function to set the UPPER power level; the firmware assumes the lower power level will always be 20 dB below the upper power level.

11 MISCELLANEOUS MINOR CHANGES

In addition to the above functional changes, there have been a couple minor changes in the V4 firmware that affect the user interface.

11.1 EEPROM RESET COMMAND

The **Reset EEPROM** function completely resets the contents of the EEPROM to the default state and clears all PLX data forms. To avoid inadvertent resetting of the EEPROM when using the touch screen in Command mode, the **Reset EEPROM** command has been changed so that it may only be initiated from the keyboard; there is no way to specify it using the touch screen. It does appear on the COMMAND menu but touching it will do nothing.

11.2 EEPROM SENSING

The V4 firmware interrogates the EEPROM to determine if it is present and operating normally. If the firmware cannot determine that the EEPROM is present and operating it will display "NO EEPROM" in red at the top of the splash screen and, if doing a touch screen calibration, before the first touch screen calibration screen. Note that the EEPROM detection logic is very basic; it is not an EEPROM diagnostic test. A defective EEPROM may be detected by the firmware during initialization and not function properly.

11.3 UK KEYBOARD SUPPORT

There are two common English keyboards: US and UK. The differences are minor but can be a nuisance to you if you are not used to the keyboard layout. Earlier firmware versions only support the US keyboard. Firmware V4 gives you the option to specify and use either a US keyboard or a UK keyboard. The Command menu now includes a 'K' command which allows you to select the US (0) or the UK (1) keyboard. The default is the US keyboard. The keyboard type selection is saved in EEPROM so it will persist through power cycles.

When the UK keyboard is specified, the following substitutions are made with regard to the US keyboard:

1. The “ | \ ” key is moved to a key unique to the UK keyboard located between the left shift key and the ‘Z’ key.
2. The “ ` ~ ” key (to the left of the ‘ 1 ’ key) will generate ‘ | ’ if either ALT key is pressed.
3. The shifted ‘ 2 ’ key will generate ‘ ” ’ (double quote) instead of ‘ @ ’ as on the US keyboard.
4. The un-shifted key to the right of the “] } ” key will generate ‘ # ’ (pound sign) instead of ‘ \ ’ as on the US keyboard.
5. The shifted key to the right of the “] } ” key will generate ‘ ~ ’ (tilde) instead of ‘ | ’ as on the US keyboard.
6. The shifted single quote key will generate ‘ @ ’ (at sign) instead of a double quote as on the US keyboard.

Note that the shifted ‘ 4 ’ key will still generate a ‘ \$ ’ (dollar sign) instead of the ‘ £ ’ (pound sterling sign) and there is no provision for generating a ‘ € ’ (euro sign).

Note also that pressing the un-shifted “ ` ~ ” key (to the left of the ‘ 1 ’ key) on both the US and UK keyboards generate an ‘ è ’ (letter ‘ e ’ with a grave accent).

11.4 SPOOLED DATA CALIBRATION

The initial firmware releases (V1 & 2) spool data from the PHSNA controller as received (.CSV formatted text file) without applying the calibration data. When the spooled data is played back and plotted, it is calibrated using the current content of the calibration data buffer. This means that it is generally necessary to spool the calibration data as a separate file to be reloaded and entered into the calibration data buffer before playing back and plotting the real data. Similarly, when the un-calibrated data is entered into a PC application, some provision must be made for calibrating the data before further processing.

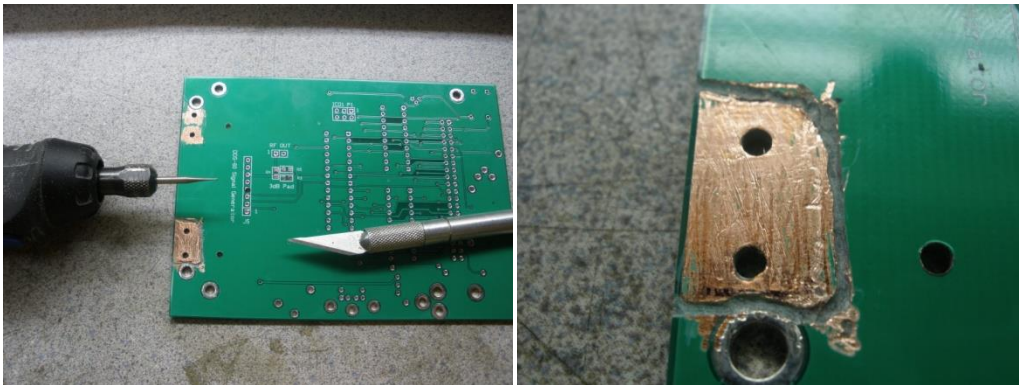
To be consistent, V3 firmware also spools un-calibrated data whether it is received from the PHSNA firmware or when generated without the PHSNA controller by analyzing the RF Power Meter output directly.

This is changed in Version 4. The data is calibrated before spooling using the then current content of the calibration data buffer. When the data is played back and plotted using the DOS commands PLOTP or PLOTV, the data is assumed to be calibrated and the current content of the calibration buffer is ignored. If the PHSNA firmware calibration is used, the SNA calibration data buffer should be cleared (ALT-C) before spooling the data.

APPENDIX A. NACT TO SNA CONVERSION

The RF Power Meter is based on a design by Wes Hayward (W7ZOI) and Bob Larkin (W7PUA) first published in the June 2001 edition of QST magazine. The RF Power Meter contains few components and can be added to the NACT PCBA using a number of construction methods such as “ugly”, “dead roach”, or “Manhattan”. A cleaner and easier method is to use an existing power meter PCB soldered or glued to the NACT PCB.

The RF Power Meter ground should be isolated and attached to the NACT ground plane at one place near the output connection. To do this, the RF IN BNC connector ground must be isolated from the NACT ground plane and attached to the RF Power Meter ground. This can be done by cutting the ground plane on the back side of the NACT PCB with either a small bur on a Dremel tool or an X-ACTO knife. This can be done before or after soldering the BNC connector in place.



Two RF Power Meter PCBs are available and shown here. The first is the PHSNA RF Power Meter III described on the PHSNA Yahoo Group web site:

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

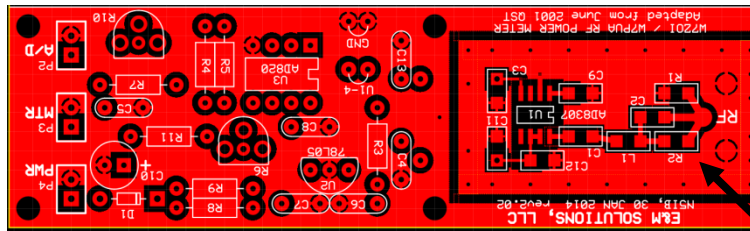
and sometimes available through Jim Giammanco (N5IB). The second is the K9IVB Power Meter implemented by Dick Faust (K9IVB). The K9IVB documentation is available at

http://www.k9ivb.net/RF_Power_Meter/files/RF%20Power%20Meter%20AD8307.pdf

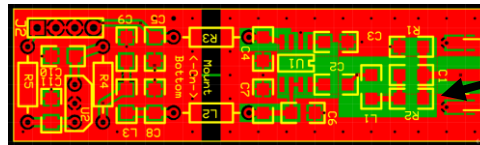
Dick has graciously made his PCBs available for purchase through OSH Park

(https://oshpark.com/shared_projects/qHCjVjbK).

PHSNA POWER METER III



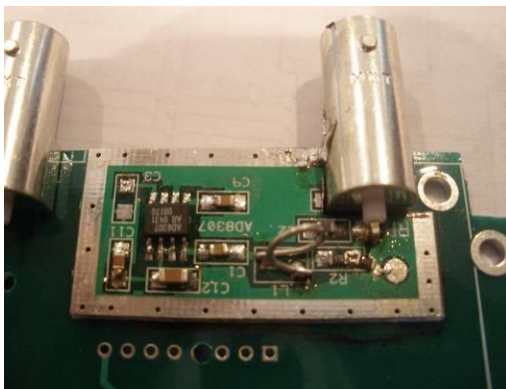
K9IVB POWER METER



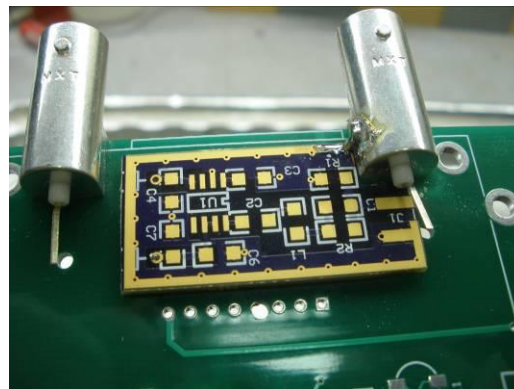
Isolated ground
plane areas

With either PCB, only the isolated ground plane area of the PCB is used. For the PHSNA version, the board must be cut on three sides around the outside of the tinned rectangle (with no solder mask). The K9IVB version need only be cut once across the board just outside the gold-plated rectangle. The resulting PCBs are essentially the same except for color and component reference designations.

The PM PCB is placed on top of the NACT PCB and must be notched to clear the RF IN BNC connector and the DDS-60 connector. In the case of the PHSNA PCB, we relocated R1 to share a pad with R2 since its pad was “nibbled away”.



PHSNA PM

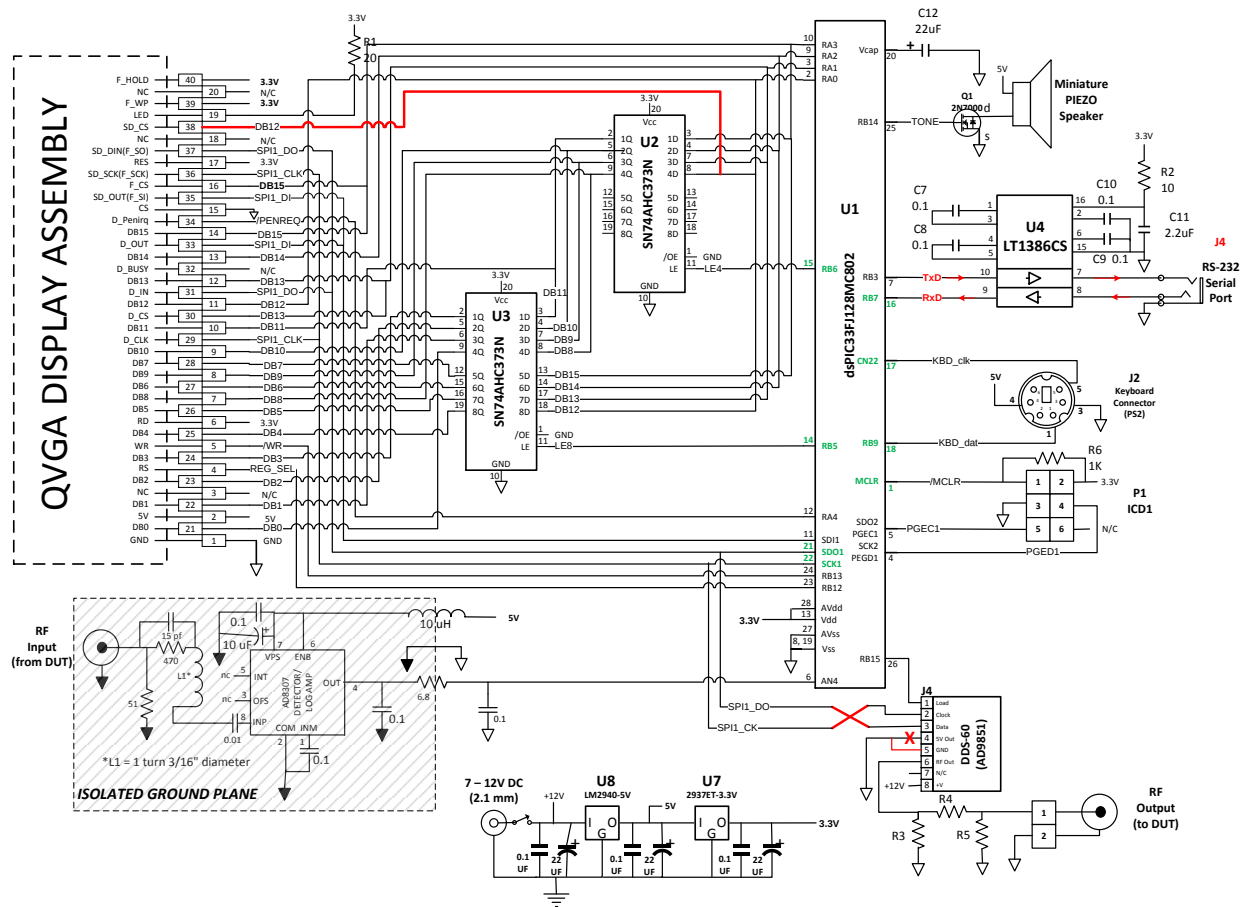


K9IVB PM

The ground connection to the isolated ground plane can be made direct to the rectangle surrounding the isolated ground plane from any convenient NACT ground such as the ground pin on the DDS-60 connector. The output is filtered using a pi CRC filter with the first 0.1 uF SMD capacitor mounted on the PM PCB and an axial lead, 68-ohm resistor used to connect to the ADC input pin on the dsPIC (U1-pin 6) and a second 0.1 uF capacitor.

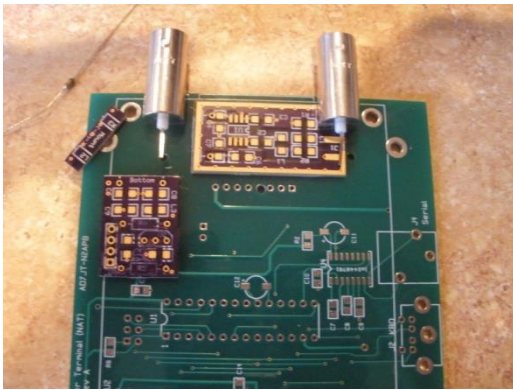
Power is supplied through a 10 uH RF choke from a 5V source near the power supply section of the NACT PCBA. Note it may be necessary to drill additional holes in the NACT PCB to route the output and power lines to the other side of the board.

Schematic:

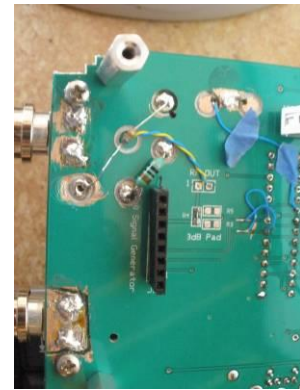


APPENDIX B. DEDICATED RF POWER METER **POWER SOURCE**

The RF Power Meter is a very sensitive circuit and it may be desirable to have its own, dedicated power regulator. This can be done with discrete components using any of a number of assembly methods. Another approach would be to use the regulator section from the power meter PCB. The following shows one way to implement this using the K9IVB power meter PCB.



Dissected PCB placement

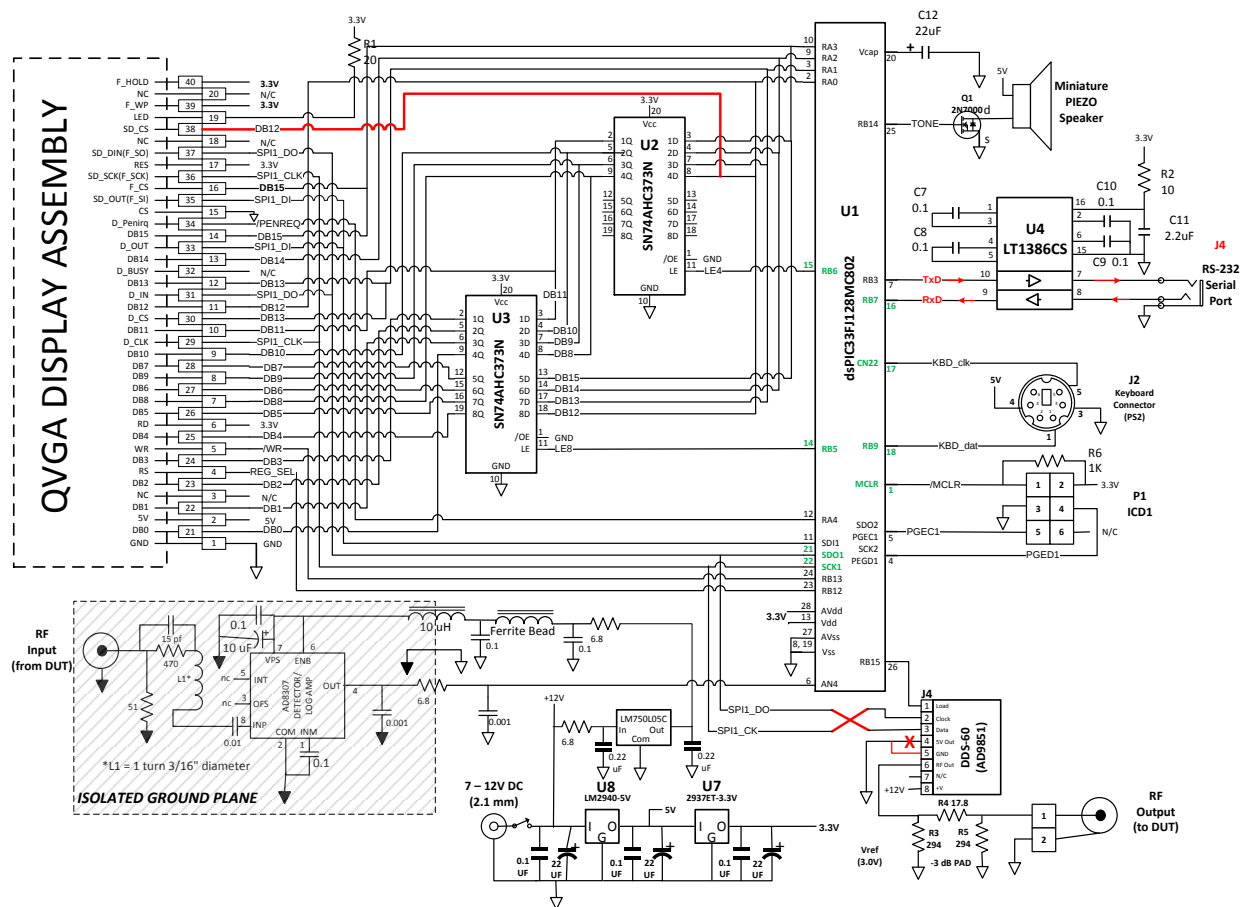


Completed assembly Power & output connections

Note that power regulator PCB was trimmed a little to reduce the footprint as much as possible. In this case, the isolated PM ground plane should be connected direct to the regulator PCB ground plane. The +12 V power for the regulator input can be taken from the power pin on the DDS-60 connector. Note that the output and power connections were made on the bottom of the PCB with isolating rings cut around the through-holes. This allowed the leads to be soldered on both ends and help hold the PCBs in place.

The example shown here uses the K9IVB RF Power Meter PCB, but a similar implementation could be made using the power regulator section of the PHSNA RF Power Meter. In this case, the end of the PCB also contains an output amplifier that is not needed here. This should allow you to trim the PCB enough to reduce the footprint so it will fit approximately in the same area as the K9IVB power regulator PCB.

Schematic:

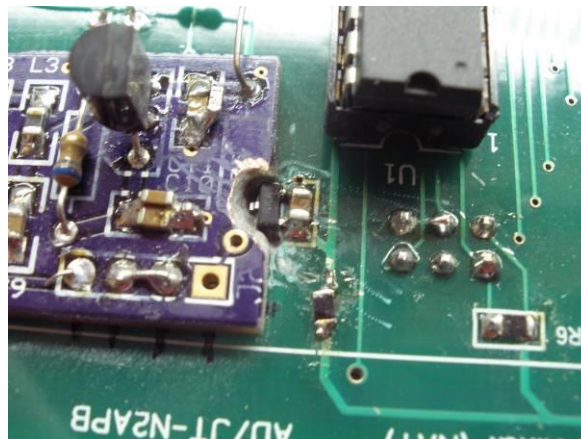
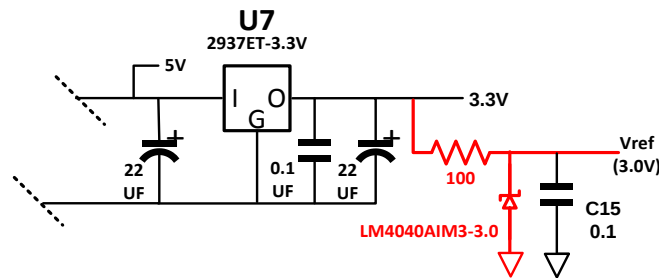


APPENDIX C. PRECISION ADC REFERENCE VOLTAGE.

The NACT uses the dsPIC Vcc (3.3V) as the ADC reference voltage. The analog to decimal conversion expresses the voltage on the ADC input pin as a fraction of the ADC reference voltage. The firmware does a 12-bit ADC conversion which returns an integer which is equal to $V * 4096 / V_{ref}$ where V is the ADC input voltage. This measurement is used to determine the power level reading of the RF Power Meter the accuracy of which is directly proportional to the accuracy and stability of Vref.

This modification provides a more accurate and more stable source for Vref. A precision, 3.00V voltage regulator is connected to the dsPIC Vref input with a 100 ohm dropping resistor from the 3.3V Vcc.

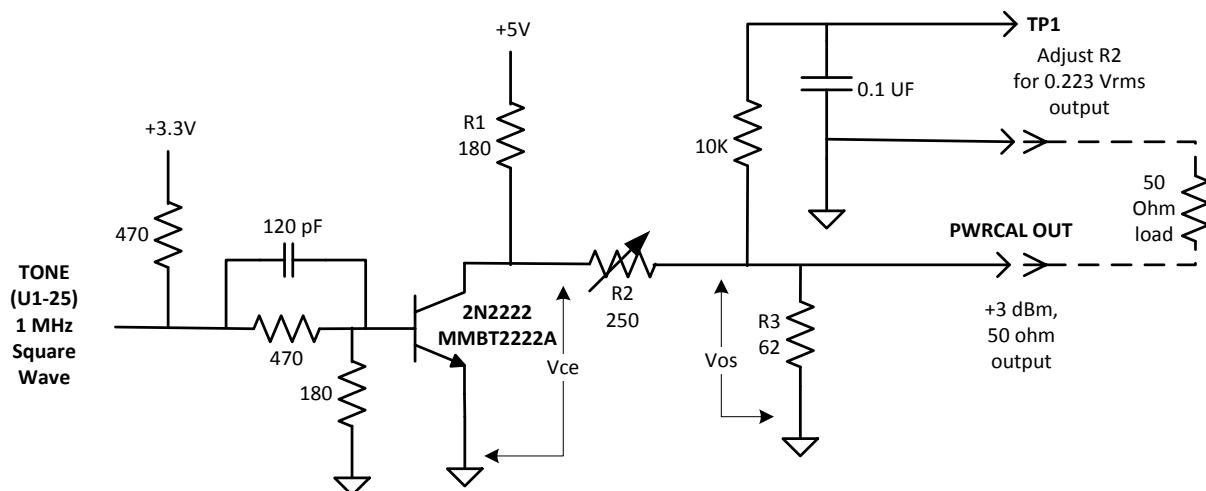
The ADC voltage regulator is added by soldering the LM4040AIM3-3.0 (SMT) across C15. The etch run from the positive pad of C15 to the 3.3V Vcc source is cut and the solder etch scraped off the etch run for about 1/8th inch above and below the etch cut. This etch cut is then bridged with a 100 ohm, SMT resistor. If the RS232 interface driver/receiver is used (U4), the etch run from C15 to R2 must be cut and a separate connection added between the 3.3V Vcc source and the positive connection to R2. This example shows it was necessary to cut a notch in the dedicated RF Power Meter power source PCB to give clearance for the voltage regulator. This would not be necessary if the PCB had been located a little further away from the C15 location.



APPENDIX D. CALIBRATED SIGNAL SOURCE (PWRCAL)

To properly calibrate the RF Power Meter a calibrated RF signal source is required. The signal source described here is based on the simple, square wave signal generator designed by Bob Kopski, K3NHI and published in the Jan/Feb 2004 issue of QEX and updated in the May/June 2010 QEX Tech Notes. The original design uses a CMOS crystal oscillator for the frequency source; this version (referred to as "PWRCAL") uses the dsPIC to generate a 1 MHz square wave.

The above references describe the concept and theory behind using a square wave to calibrate an RF power meter based on the AD8307 logarithmic amplifier in detail. This implementation uses the TONE output signal to drive a bipolar transistor amplifier to generate a 3.0 dBm square wave signal into a 50-ohm load such as the RF Power Meter. The TONE signal also drives a MOSFET amplifier driving the piezo speaker used to generate warning tones (BEEP). Since the speaker only responds to audio frequencies, the 1 MHz RF signal has no effect on it.

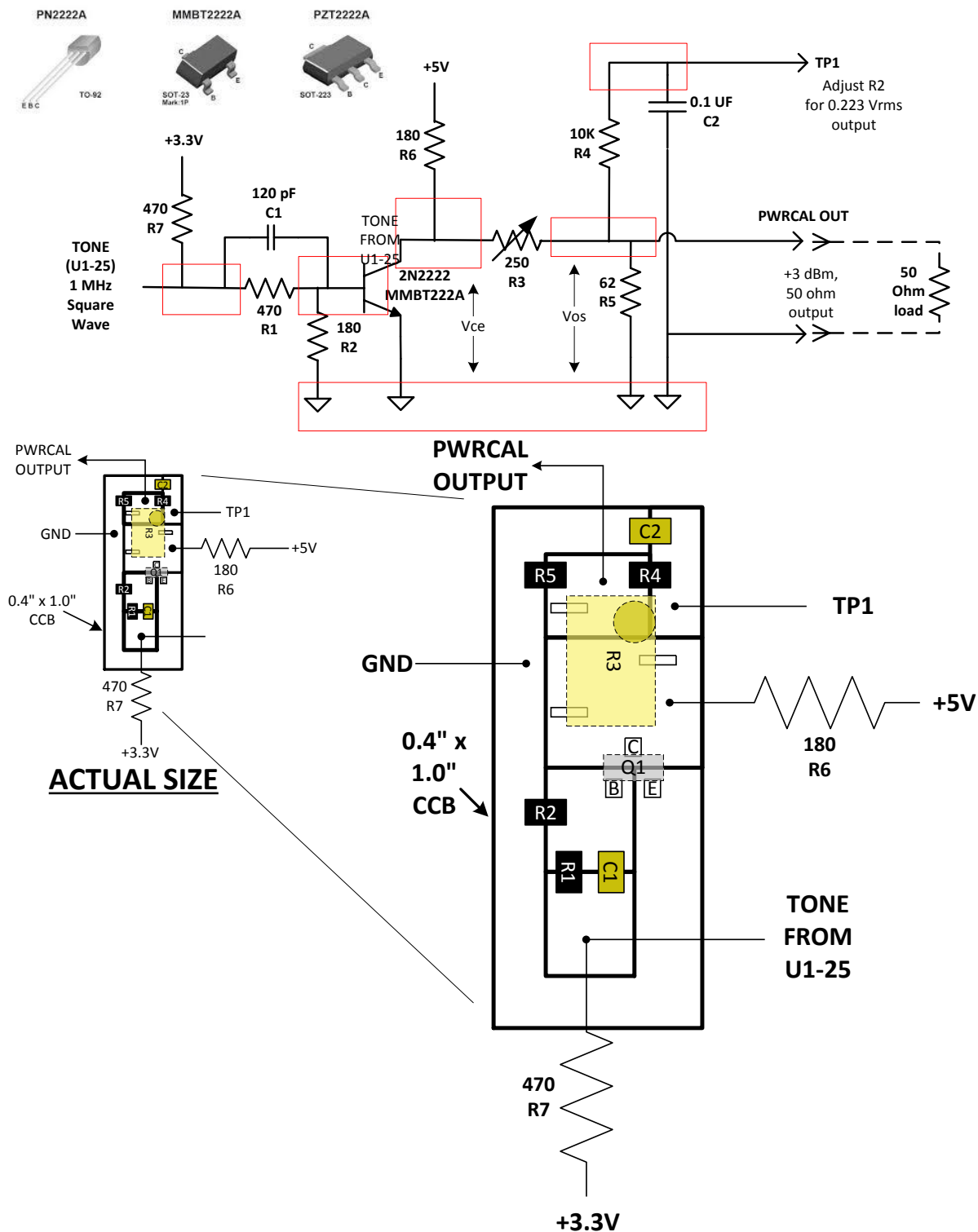


Referring to the PWRCAL schematic above, the output power level is set to 3 dBm by adjusting R2 so TP1 registers 223 mV plus the DC offset voltage (Vos) to ground on a digital volt meter (or DMM). The voltage at TP1 minus Vos is the RMS voltage of the output signal which, for a positive-going square wave, is one half of the peak-to-peak voltage at PWRCAL OUT. This value is also the RMS voltage for a 3 dBm RF power level and, according to the above references, is properly interpreted by an AD8307-based power meter. The offset voltage Vos is the result of the transistor collector-emitter voltage (Vce) reduced by the voltage divider formed by R2 and R3. With the component values shown and R3 properly adjusted for 3 dBm output, Vos will typically be about 20 mV. This offset voltage is only "seen" at TP1 since the input signal to the RF power meter is AC coupled.

The following shows one possible implementation of the PWRCAL circuit using a 0.4"x1" piece of copper clad. The simple circuit is "carved" in the top copper plating to accommodate

SMD components. The CCB is then adhered to the top side of the NAT PCB next to an added BNC connector just above the serial interface connector.

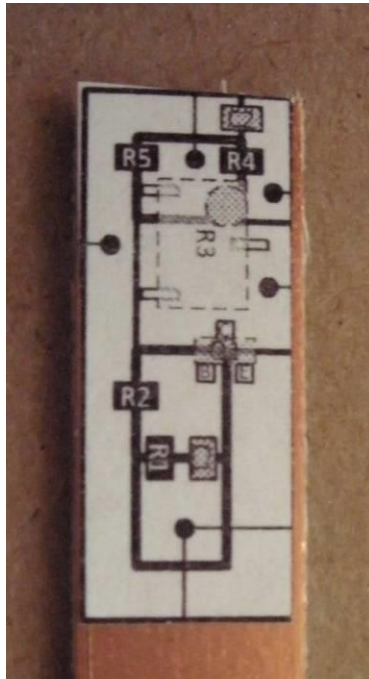
PWRCAL IMPLEMENTATION USING CCB (Carved Circuit Board) CONSTRUCTION



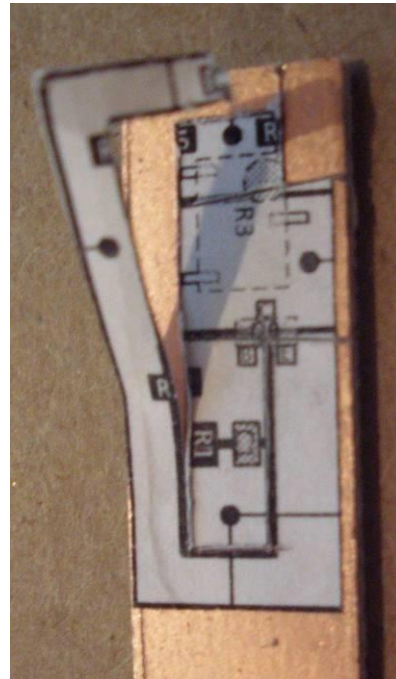
REF	QTY	DESCRIPTION	MOUSER P/N
C1	1	CAP 120 Pf CERAMIC SMD/SMT 25 V	77-VJ0805A121GXXPBC
C2	1	CAP 0.1 uF CERAMIC SMD/SMT100 V	77-VJ0805V104MXBPBC
R1	1	RES 470 OHM 1/8w 5% 0805 SMD	71-CRCW0805J-470-E3
R2	1	RES 180 OHM 1/8w 5% 0805 SMD	71-CRCW0805180RJNEA
R3	1	TRIM RES 250 OHM MULTI-TURN SMD	652-3269W-1-251GLF
R4	1	RES 10 K OHM 1/8w 5% 0805 SMD	71-CRCW0805J-10K-E3
R5	1	RES 62 OHM 1/8w 5% 0805 SMD	71-CRCW080562R0FKEA
Q1	1	TRANSISTOR MMBT2222A NPN SMD	863-MMBT2222ALT1G
R6	1	RES 150 OHM 1/8W AXIAL METAL FILM	71-RN55D-F-150
R7	1	RES 470 OHM 1/8W AXIAL METAL FILM	71-RN55C-F-150/R
J1	1	CONNECTOR BNC COAXIAL 50 OHM	538-73100-0105
CCB	1	COPPER CLAD PCB STOCK 0.4" x 1.0"	

CIRCUIT BOARD CARVING

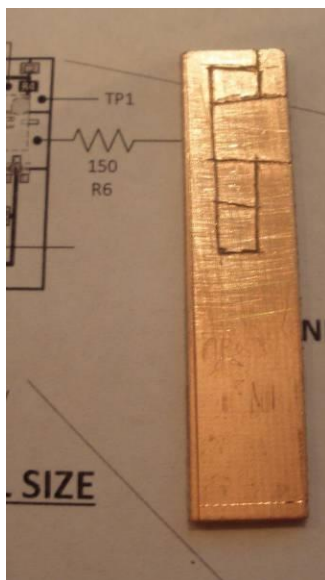
Use the Actual Size drawing as a pattern and attach it to a 0.4" wide piece of copper clad with spray adhesive. Cut the copper layer with an X-ACTO knife and remove the pattern. Solder the components to the board in the locations and orientations shown in the drawings. After assembly, cut the CCB to a length of one inch.



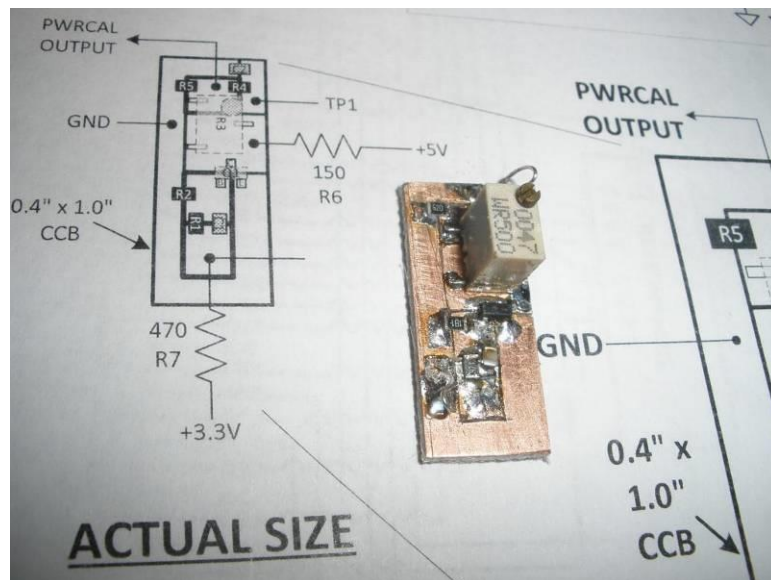
Ready to carve



Carved



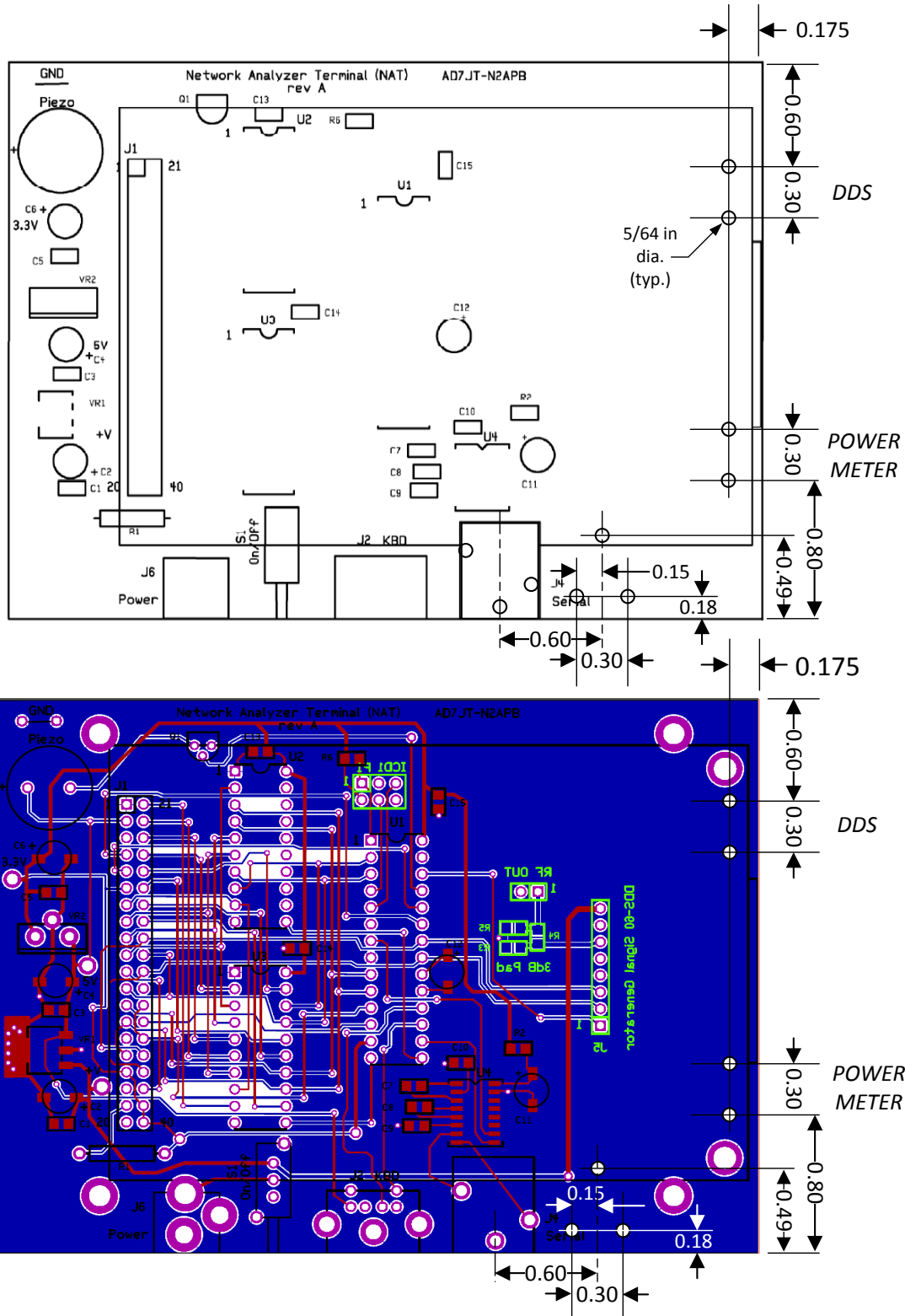
Ready for Assembly



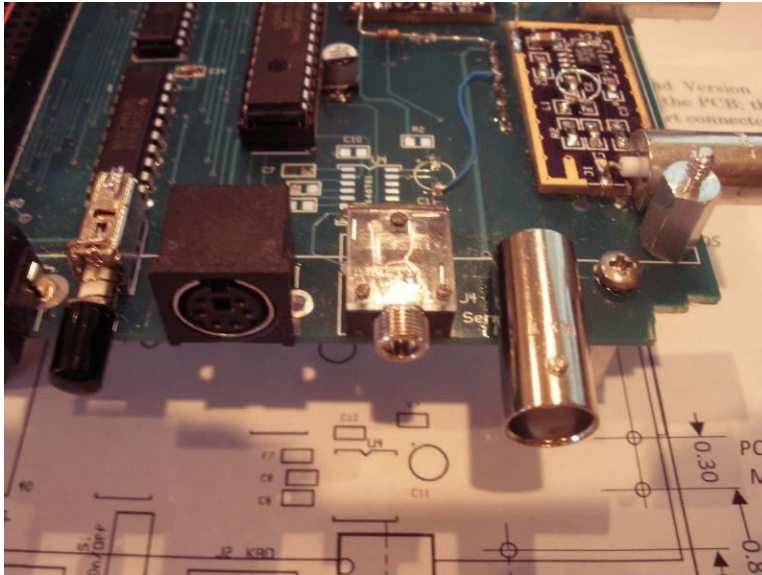
Assembled and Trimmed

HOLE PATTERN

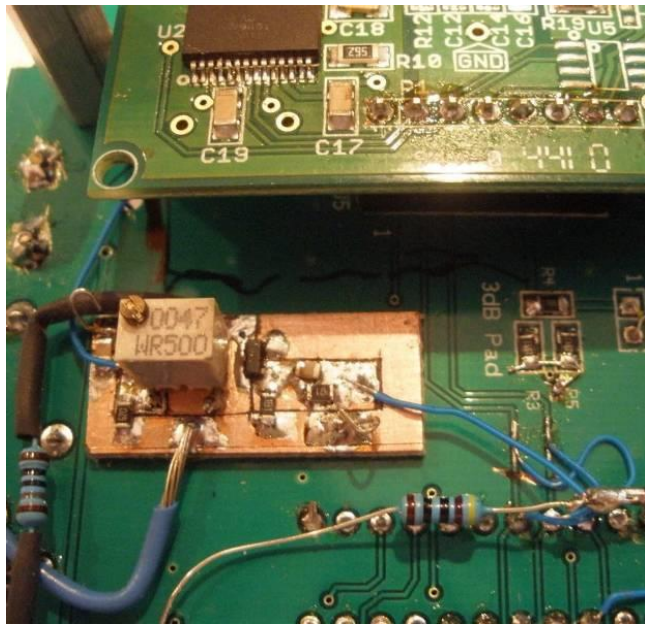
The following drawings show the hole patterns for both the Version 3 and Version 4 upgrades. The Version 3 upgrade adds the two BNC connectors at the top of the PCB; the Version4 upgrade adds the BNC at the side of the PCB just above the serial port connector.



COMPLETED V4 (PWRCAL) UPGRADE



TOP



BOTTOM

The CCA (Carved Circuit Assembly) is held in place with double-sided carpet tape. Position the CCA so that R3 is accessible with the DDS-60 installed. The test point (TP1) is the wire loop in the upper left corner of the CCA. The red wire (left picture, bottom left) is the 5V connection taken from the output pin of the 5V regulator (VR1). The input is the blue wire coming from the 470 ohm resistor (R7) and TONE (U1-pin 25). Don't forget the CCA ground connection (Blue stranded wire).

RF POWER METER CALIBRATION WITH PWRCAL

The following procedure will calibrate the RF Power Meter:

1. Connect PWRCAL OUT to RF IN with a short coax cable.
2. Attach a DMM between TP1 and ground.
3. Power on.
4. In terminal mode, adjust R3 so that the voltage at TP1 reads 20 mV. (Note, R3 is a multi-turn pot.)
5. In Command mode select 'U' to edit the upper calibration level and set it to 3 dBm.
6. Start PLX mode with op modes NAC (C), Signal generator (S), and PWRCAL (P) specified. The remainder of the PLX form will be ignored. This will turn off the DDS-60 and turn on the PWRCAL signal source.
7. Adjust R3 to measure 223 mV plus Vos (nominally 243 mV) at TP1 to set the output level to +3 dBm.
8. Press Escape to return to terminal mode and note the voltage level at TP1 (Vos). If it is different than 20 mV +/- 1 mV repeat steps 6 through 8 using the new value for Vos in step 7.
9. Press the Space bar a couple times to assure you are getting a reading.
10. Press Ctrl-S to capture the current reading.
11. Insert a 20 dB attenuator in the PWRCAL OUT to RF IN connection to lower RF IN to -17 dBm.
12. Press Enter to capture the -17 dBm reading.
13. Press the Space bar to confirm the -17.00 dBm reading (should be within one dBm).
14. Remove the 20 dB attenuator.
15. Press the Space bar to confirm the 0.00 dBm reading (should be within one dBm).
16. Press Escape to exit PLX mode and turn off the PWRCAL function.

Once the RF Power Meter is calibrated, it can be used to set the DDS-60 output level to 1.0 mW or 0.0 dBm:

1. Connect RF OUT to RF IN with a short coax cable.
2. Power on.
3. Start PLX mode with FREQ LO set to 1 MHz and op modes NAC (C) and Signal generator (S) specified.
4. Press 'A' to enable auto start mode. The display will be repeatedly updated about four times per second.

5. Adjust R8 on the DDS-60 to set the power reading to 0.00 dBm. If there are variations in the readings they should be less than 0.5 dBm and the level should be set so that the readings vary around 0.00 dBm.
6. Press Escape twice to exit PLX mode.

APPENDIX E. SCALAR NETWORK ANALYZER SCHEMATIC

