Manual for the N3ZI DDS2
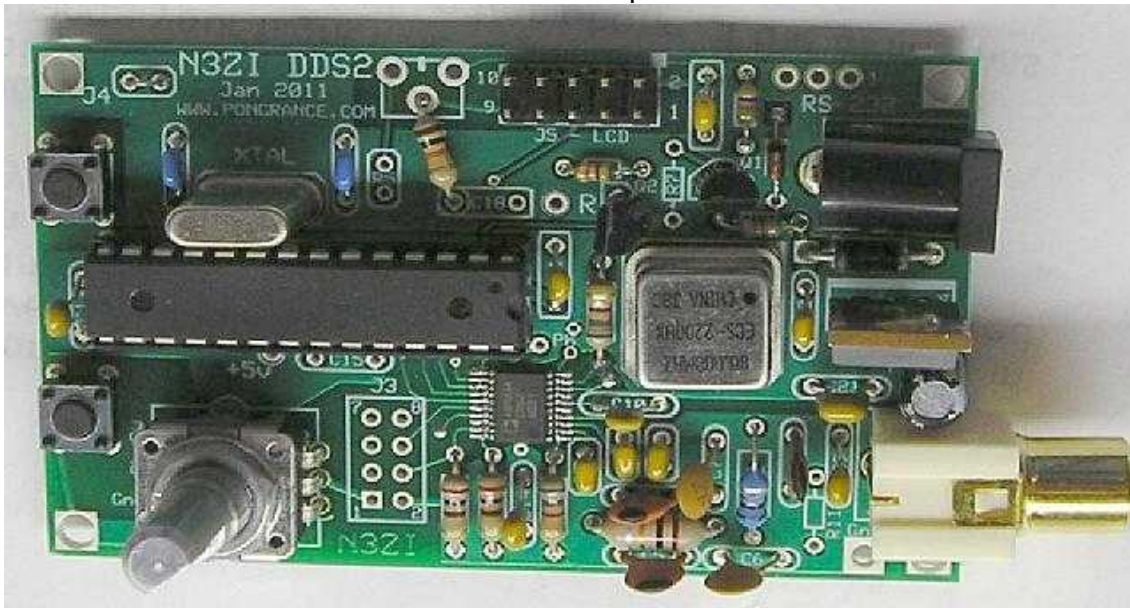## WWW.PONGRANCE.COM
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Assembly

Verify that you have all the correct parts for your kit by checking the parts against the packing list included with your kit. Many of the parts are static sensitive, and you should use industry standard techniques for proper handling of all parts. Be careful unpacking the DDS chip. It's a tad fragile, I usually pack it in with the PCB. It's in a small piece of antistatic rail tube or foam. It's best not to take it out of that until you are ready to solder it. The above photo should only be used as a general guide. Parts shipped with your kit may be of a different color or size, and not all the items shown in the photo are included in all kits.

Start by soldering in the power supply components. D1, U4, C19, C20, C21, you can use a power connector in J2, or just solder your power wires directly to the PCB. Double check the polarity on D1, C19, and the orientation of U2. Apply 12VDC power and check to see if 5VDC is present at U2 pin 7. If this is ok, solder down the DDS chip. It's the tiny 20 pin chip AD9834. It will be easier to solder it down if the rest of the board is nearly empty. The best method I have found for this chip is the use a 15~30 watt soldering iron, with a fine tip. Carefully align the chip in the right location. Make note of the direction.   Pin 1 goes in the lower right. Pin1 on the chip has a dot indent in the plastic package. I normally use scotch tape to temporarily hold the chip in place while I'm soldering it. Under no circumstances should you glue the chip to the PCB. Carefully align the chip to make sure it's centered, both left/right and up/down then hold the chip down with a piece of tape leaving one side of the chip exposed. Solder down one of the exposed corner pins. Remove the tape, re-align the chip, and solder the opposite corner. Then solder all the remaining pins, use plenty of solder and don't worry about solder bridging. After you are

done use solder wick to remove excess solder and any solder bridges. (Flux will help the solder wick.) If the solder wick becomes frozen (soldered) to the board, don't rip it off, heat it up with your iron and pull it up carefully.   Inspect it carefully by eye under a magnifying glass. Clean it with flux remover, and make sure there is no debris under the chip or elsewhere. Use a DVM or continuity tester all the connections are made by testing right as the lead exits the package, then on the PCB at the appropriate point. Also make sure there are no pin to pin shorts and no shorts to power or ground. Note than pins 4 and 5 will show as shorted because they are both connected to +5v. And pins 7, 10, 12, and 18 are hardwired to ground, so all should show continuity to ground. Pin to pin solder shorts are fairly common, frequently they appear OK visually, but show up sorted on the continuity check. Just lay some wick down apply heat, and you should wick up the excess solder causing the short. I that doesn't work, you can try running the blade of an exacto knife between the leads to clear out any short.

Bill of Materials

Designator	Part	Qty	Description / Appearance
U2	Micro ATMEGA168	1	28 Pin Dip
U2	Socket	1	28Pin DIP socket
U1	DDS Chip AD9834	1	Tiny 20 pin TSSOP
PCB	Circuit Board	1	N3ZI DDS
XTAL	13.44 MHz XTAL	1	Marked ECXR3392
U3	Oscillator	1	Metal can 80MHz
J5 LCD	LCD	1	KTM-S1201
C1,C2,C3	Bypass Capacitor	3	See packing list
C9, C10, C11, C12, C13, C14, C20, C21	Bypass Capacitor	8	See Packing list
C15, C18	Not Used	0	
C5, C16, C17	27pF Capacitor	3	Blue 27
C19	Electrolytic Cap	1	Black Radial
C8	68pF Capacitor	1	Brown 68
C6	47pF Capacitor	1	Brown 47
C4	10pF Capacitor	1	Orange 10
C7	4.7pF Capacitor	1	Brown 4.7
L1,L2	1.0uH Inductor	2	Brown, Black, Gold
U4	Volt Reg	1	7805
D1	Diode	1	Black epoxy
D2	Signal Diode	1	Glass
Q1,Q2	NPN Transistor	2	To-92 2N2222
R1, R10	6.8K Resistor	2	Blue, Grey, Red
R2,R4	47K Resistor	2	Yellow, Purple, Orange
R3	4.7K Resistor	1	Yellow, Purple, Red
R5	See Text	0	For Character LCD's
R6/opt	See Text	0	For Character LCD's
R6	10K Resistor	1	Brown, Black, Orange
R7, R11	Not used	0	
R8, R9	200 Ohm	2	Red, Black Brown
R-ENC	Encoder	1	
SW1,SW2	Push button Switch	2	
J4	Shorting Jumper	0	Jumper
J1	RCA Jack	1	

(Note: the appearance color and value of some parts change from time to time with differences from various suppliers. You should receive a packing list with your kit, which should have a current description for the parts in your kit, and it supersedes this list.)

Next install the 3 capacitors next to the DDS chip, C1, C2, C3 be careful with these to avoid any solder shots, and trim the leads neatly.   Solder in the rest of the components. Kits normally include a socket for the micro. The XTAL can be mounted standing up, or laying down, though it hangs over the edge a little bit when paying down. Solder in the remaining components.

R6 installation: R5/R6 set the LCD voltage. When using the Standard LCD display R5 is not used, and a fixed 10K resistor is used instead of the trimmer for R6. When installing the 10K resistor solder one end in the middle hole for the R6 trimpot, and the other end (ground) in the left hole for C18 (C18 is not used) See photo on page 1.   If you choose to use a different LCD, use a 1K resistor for R5, and a 1K trim pot for R6. There are a few LCD's that don't need an adjustment, just ground the center pin of R6. And a few that require a negative voltage, you're on your own with that. See my latest LCD info here: http://www.pongrance.com/dds-lcd.html Even if you are going to use a different LCD I recommend that you initially build the kit with the Serial LCD module supplied, then change it out later once every thing is working ok.

A number of components can be installed on the front or the back of the PCB. Which you use will depend on how you plan on mounting the DDS. The Switches, the rotary encoder, the LCD connection, the RCA jack, all can be mounted on the back if you like. All function the same regardless of the side they are mounted on except the LCD connection (see below.) Note that you may have to cut the plastic nubs off of the RCA connector to get it to fit properly, or the pins can be bent such that the nubs hang off the end of the PCB.

The push-buttons are simple SPST switches, and you can remotely mount another switch in parallel if you like. You could use a single SPDT switch to replace both SPDT switches. One that is momentary with a center off position is a very slick setup. If you received the optical encoder in lieu of the PCB mounted encoder, please refer to the section below for connecting the optical encoder.

Power connector: The PCB is laid out to accept a 2.1mm power connector, but it isn't really needed. This is a 2.1 mm coaxial power connector, +12v inside, ground outside. These connectors usually have 3 pins, there is no PCB hole for the side pin, just break it off.   If you don't have a power connector, just solder your power wires directly into the PCB holes. You may notice that there is a rather fine PCB trace on the back of the board running from the power connector to D1. This is for the case when someone (usually me) accidentally shorts the 5v power on the board to ground. With any luck this trace will at as a fuse and open up before any components get damaged. You can then fix it by soldering a jumper wire to make the connection.

If you are using the standard cable kit with the standard serial LCD, then mount a 10 Pin header to the front of the DDS PCB, and to the back of the LCD module. Mark one side of the cable with a red mark. Plug the connectors on so that the red mark is closest to pin 1. Pin 1 is marked on the DDS PCB. Pin 1 on the LCD module is closest to the 3 gold plated holes in a triangle pattern on the LCD module.

Shown below is the wiring connections to the LCD. If you are using the supplied serial LCD module, and don't have the cable kit just use hookup wire. You can see from the chart that connections are straight through if you mount the LCD module and DDS PCB back to back. An engineering drawing of the LCD module is on my web site here: http://www.pongrance.com/SLCD-data-notes.pdf

If you are using a different LCD wire it carefully. It is very easy to get the odd and even pin rows mixed up. If you use a header on the front of the DDS PCB, the odd and even pins will be interchanged in the cable. This is not a problem unless you forget to account for this when you connect the other end of your cable to the LCD. Be careful, and double check all connections before applying power.

PCB Pin Number	Standard LCD Connection		HD44780 LCD Connection	
1	Vcc	1	Vcc	2
2	Gnd	2	Gnd	1,5,7,8, 9,10
3	SCK	3	E	6
4	SI	4	DB4	11
5	C/D	5	RS	4
6	Reset	6	DB5	12
7	/BUSY	7	N/C	
8	/CS	8	DB6	13
9	Vlcd	9	Vlcd	3
10	GND	10	DB7	14
J4	Shorted		Open	

Output filer: This DDS uses a D/A converter to generate the sine wave output. This D/A converter is clocked at 80Mhz. The theoretical maximum output frequency is 40Mhz, this is refereed to the nyquist rate. All D/A converters have an image output above the nyquist frequency. (If you go to wikipedia, and search for nyquist you will find a nice article describing the theory) So if you generate a 39Mhz signal, which is 1 Mhz below the nyquist frequency, there will be a mirror image exactly 1 MHz above the nyquist rate, at 41Mhz. If you generate a signal at 25Mhz the mirror will be at 55Mhz. Normally an output filter is used to filter out this signal. The output filter included in your kit, will allow operation up to 34MHz, with about 40db of attenuation of the 46MHz mirror.

Jumpers: You need to install a shorting jumper at J4 to tell the micro that the serial LCD is being used. Omit the jumper if any other display is used. You can either use J4 on the PCB, or put a jumper from pin 10 to ground on your LCD module.

Operation

Memories: There are a total of 12 memories, each holds a Frequency and an IF. In many cases all the IF's will be set the same. Memories 0 though 9 and standard memories but are tunable. That is if you turn the dial while at that memory the frequency will change. When you switch to the next memory, the last used frequency will be saved for the prior memory location.

The other two memories, are VFO A and B. These are different in that a separate control line (PB5) selects between the two. You can program a different IF in for VFO A and B, but I doubt you will want to. You can set any or all IF's to 0.00.

With the standard serial LCD a single character on the left side of the display indicates the memory number (0 to 9) or A, b for the VFO's With the character based 44780 LCD's the display will be slightly different.

Dial speedup. The default frequency increment is usually 1, 5, 10 or 25Hz per tick. As you turn the dial continuously, the tuning rate will start to increase. When acceleration starts a "F" will appear on the display. If you continue to turn the dial, the rate will continue to accelerate up to a maximum of 100KHz per tick. If you stop turning the dial for a few seconds the rate will return to the default rate and the "F" will disappear from the display. Many parameters associated with tuning can be changed using the rs232 port, including default tune step and trigger points for acceleration. Refer to rs232 manual for details.

Setting IF's If's offset can be set in 3 different ways. You can use the serial port (refer to the serial port manual)   You can set the current IF using the push switch, see the **"IF SET"** in the **"Function Switch Operation"** section below, that's the preferred method. There is also a special IF set mode similar to the method used in my older DDS. To enter this mode, remove power, hold either SW1 or SW2 and apply power. It will then come up in a mode, which will allow you to set the IF's. "IF" will be indicated on the LCD display.   The DDS will output the IF frequency in this mode, which can be used to zero beat with your BFO if applicable. Then when complete, toggle through all memories, to make sure they are all ok, then remove power. This method may erase the operating frequency in memory, so it's best to set the IF's before anything else.

Additive IF: This VFO supports 3 different IF modes. The simplest is the additive, and example of this is the one used on the BITX20. The IF is 11MHz and the VFO tunes 4.0 to 4.35, resulting in an operating frequency of 14.0 to 14.35. For this type of operation enter the IF as a positive number, and enter the operating frequency as a positive number. It will compute the proper VFO frequency to generate. Note that this type of radio can never operate below the IF.

Subtractive IF: With subtractive IF schemes, there are two options for the VFO, high side, and low side VFO injection. For example, many 40m QRP radios have a 11MHz IF, with a VFO ranging from 4.0 to 3.7MHz. Tuning is backwards, so the higher the VFO the lower the operating frequency. To program you DDS VFO to work this way, enter the IF frequency as a negative number, i.e. –11.000.0 in this case, and also enter your operating frequency as a negative number, to indicate low side injection. i.e –7.000.0, the DDS

micro-controller will computer the proper VFO frequency to use, 4.000.0 in this case. Note that if you are using the serial port, you can turn on the debug mode, and it will display the IF, VFO, and operating frequency every time. Note that most radios will also work with high side injection without modification. For example you can charge the operating frequency to +7.000.0 and you will be on the same frequency, but with high side VFO at 18MHz. Usually when you do this, the opposite sideband is selected.

Dial Direction: The dial direction may be reversed because of the use of negative IF's and/or high vs. low VFO injection. The dial direction can be reversed by changing the sign of parameter 9, (tick_div) via the serial port. 0.02 or –0.02 are values to try for this parameters. If your encoder is remotely mounted, you can also interchange the A & B connections to reverse direction.

Expanding your radio's coverage: In the case mentioned above, the BITX20 with an 11MHz additive IF scheme, you can get this radio to receive 10MHz WWV, with a 1MHz or 21Mhz VFO. To get your DDS to do this, make the IF negative, i.e -11.000.0 and the operating frequency to +10 or –10 MHz. If you use low side, which results in a 1MHz VFO you will also receive the image on 12MHz.   You could also cover the 30M amateur band. It's interesting to do this with the receiver, but you should never try to transmit unless you have redesigned the filters for the new band. In most cases receive sensitivity will be substantially lesser, but it will frequently work for WWV or other strong signals.

Output: The output signal is not amplified, and the level is approx. 250mV peak to peak which works well with SA612 or similar mixers. Output impedance is 200 ohms. It does not need to be matched, but the output filter is flatter if the output is matched. With vintage radios, or other applications, you may need a separate buffer amplifier.

Calibration: It is normally not necessary to calibrate your DDS-VFO. The 80MHz reference oscillator is specified at 100ppm accuracy, but they are normally much more accurate than this.   Calibration is done in software, it is an extremely fine adjustment, much finer than the fundamental step size. The oscillation frequency of the 80Mhz timebase will not change, but the mathematics will be adjusted. 64 bit math is used in computing operating frequency to be certain, that no error would be introduced by rounding. A change of +0.20 in this parameter is approx. a 10 Hz change of operating frequency at 20MHz. Keep in mind that it is a multiplicative correction factor, so a 10Hz change at 20MHz, will result in a 5Hz change at 10MHz. The calibration factor can be set via the serial port, or using one of the push switch modes, see below.

Function Switch operation: The function switch can be either a push switch on the encoder, or a separate push button switch. This switch brings up special parameter setting modes for RIT, Tuning Step, Calibration, IF, and EEPROM format. Press and hold the switch, then press one of the up/down buttons you will toggle through the 5 different parameters that can be set. The first is RIT mode, is indicated on the left 2 digits as dF (for delta F) Tuning speed is shown as "SP", Calibration is shown as "CA", IF set is shown as "IF", EEPROM Format is "EF". On the other LCD types they are a single character R,S,C,I,E.   Simply release the switch when you get to the one you want. Each of these settings is described below

> **RIT Adjust (dF):** Use the tuning knob to adjust the Rit offset. If the Rit control line is low, then the output frequency of the DDS will move accordingly. When you are finished, simply stop tuning for a while and it will return to normal.
>
> **Tuning Step (SP):** Use the dial to set the tuning step. As above simply stop turning the knob when you get to the value you want, and it will return to normal after a few seconds. 25 or 50Hz works well for SSB, 5 or 10Hz works well for CW. Do not set to anything greater than 10,000Hz.
>
> **Calibration (CA):** This adjustment if very fine. You will be making an adjustment to the main calibration factor, and only the delta will be displayed. First, in normal operation, set the DDS output to a reference frequency, such as 10.000.000MHz. Use the push switch to get into the calibration mode, then use the dial to zero beat the DDS signal to your reference, be it WWV or some other source. The adjustment is extremely fine. Once you are satisfied, stop tuning and after a few seconds the value will be saved, and the master calibration factor will be adjusted.   When setting it via the knob only the change from the current setting is displayed, so it always starts out at 0.000 and changes are cumulative.
>
> **IF SET (IF):** The current IF is set by turning the dial. If you want to change the IF for a different memory, you need to return to the normal operating mode, then change the memory number, and then change the IF again.
>
> **EEPROM format (EF):** This function causes the EEPROM to be loaded with factory default values. You will loose any IF's or frequencies you have set in, and any parameters you may have changed. Turn the encoder until you get to a reading of 73 on the LCD. Stop turning and wait, it will take a few seconds to initialize the EEPROM, and then the LCD should display a flashing message. At this point, remove power and re-apply power to reboot. The DDS will now start up with fresh factory default parameters. All the IF's are set to 0.0, and the memories are set to a MHZ value equal to their memory number (ie memory 5 is set to 5.000.000) If you set the LCD to anything other than 73, nothing will happen and the reformat will be canceled. (If you are using a 3rd party LCD, rather than "EF" you will just see "E", and the dial will change the Rit Digits, which you will set to 0.073)

Other Encoder Connections

The standard kit includes a mechanical encoder that mounts to the PCB, with an integrated push switch (5 pins). If you chose the optical encoder, it mounts off the board, and the pushbutton switch is separate as shown in the photo below.

The Optical Encoder has 4 pins on the back, labeled: + A B -

- Connect Encoder pin "+" to +5v on the PCB (Red wire in above photo)
- Connect Encoder pins A, B to the holes marked A.B on the PCB photo below.(Green and yellow wires in the above photo) Note: Reversing these will reverse tuning dial direction
- Connect the encoder pin labeled "-" to ground.(Black wire in the above photo)
- Connect the pushbutton switch pins to the holes makes PB-SW and GND in the photo below (Black white twisted pair in above photo)
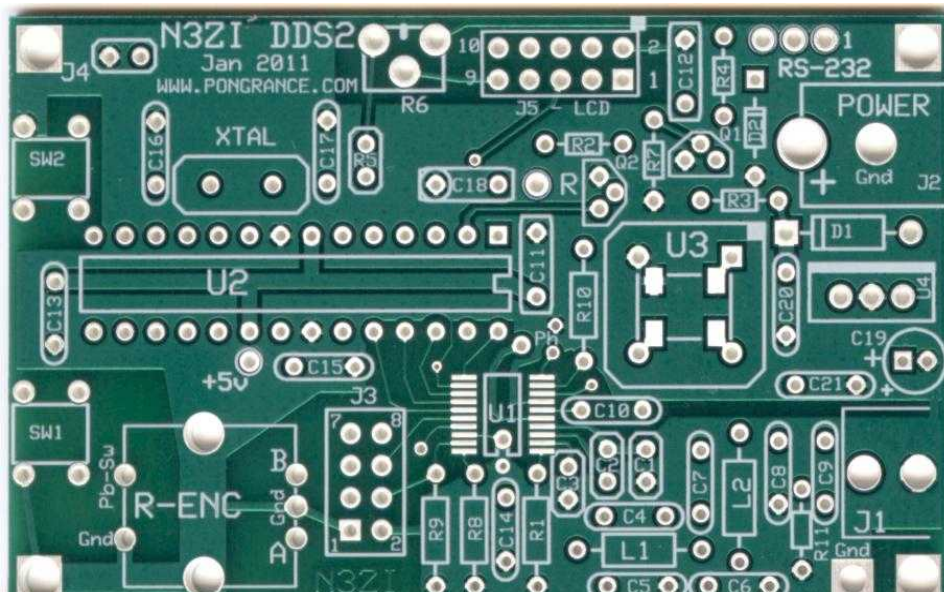
You will need to connect the serial port and change some parameters in the micro. (No programming is required) The "DDS 2 RS-232 interface Spec" is located on my web site here: http://www.pongrance.com/manuals.html

- Change parameter #4 to 0.001 (Step size)
- Change parameter #5 to 0.003 (3 for 128pulse, 1 for 256)
- Change parameter #6 to 0.200 (Loop delay)
- Change parameter #7 to 1.100 (Acceleration)
- Change parameter #8 to 0.000 (Debounce)
- Change parameter #9 to 0.001 (Tick Divider)

If you ordered one of the kits that includes the optical encoder, then these changes may have already been made to your micro.

Some kits may include a PCB mounted encoder with only 3 pins. This type does not have an integral push switch. With this encoder, you will have to add an external pushbutton switch, wired as shown above. No parameter changes are needed with this encoder.

Aux Connector

There is a 8 pin connector in the lower center of the board. Carefully note the pin numbering, in may or may not match up with other connectors. Pin number are on the front silk screen and back copper.

Pin #	Name	Type	Function
1	Gnd (D)	Ground	Digital Ground
2	Gnd(A)	Ground	Analog Ground
3	PB5	Digital Input	A/B VFO select, grounded selects VFO A, open or high selects VFO B You can connect this to a switch, or relay, but any voltage over 5v, or negative, will likely damage the microprocessor. Use an opto isolator to connect to anything that may have a high voltage. Only 200uA will flow when PB5 is grounded.
4	Aux-A	Analog Output	Secondary DDS RF output, un-filtered.
5	PC0	Digital Output	Band output, high if operating frequency is below limit in EEPROM
6	D - out	Digital Output	Not used
7	RITa	Digital Input	LOW causes LCD to display Freq w/ Rit (Normally tie pin 7 and 8 together)
8	RITb	Digital Input	LOW Causes RF output to shift in frequency by Rit offset (Normally tie pin 7 and 8 together)

Rit wiring: PIns 7 and 8 control the Rit. Pin8 causes to DDS to actually shift to the Rit frequency. Pin 7 causes the LCD to display that frequency. Normally you would tie these together. But you could keep them separate and it would give you the ability to look at the Rit frequency is without actually changing the frequency.   When you are adjusting the Rit by using the tuning knob (see above) the output of the DDS will only reflect this frequency if the Rit is turned on, i.e Line 7 above is low.

Rit is an offset to the main frequency. So for example if the Rit is set to 1.000KHz, and the main frequency is set at 7050.000, when you lower the rit control line (Pin 8) the frequency will shift to 7051.000 and if you also low control line #7, the LCD will display that new frequency. If you then change the main frequency, to, for example, 10,110.00, then lower the rit control line the output frequency will move up to 10,111.00. You do not have to set the rit offset again after you change the main frequency. The Rit can be set to pretty much anything, positive or negative.

The rit frequency shift is fast an phase continuous, there are no glitches, and it could be used for FSK (Rtty)

There are two other test points that might be of interest. 1) One is Labeled "Ph" located between U1, U2 and U3 On the back there is a thin trace connecting it to ground. This controls a phase shift for the DDS chip. If you cut this grounding trace then a 5v logic signal will select between normal and phase shifted output. The default phase shift is 180 degrees, which would allow you to transmit BPSK31 directly. This parameter is #10, and can be set via the serial port to other interesting values, e.g. 90 degrees. 2) Another is Labeled "+5v" located between the Renc and U2 which outputs a 10Gb/s stream equal to the square root of the time of day in Chinese. (I just want to see if anyone actually reads the manual.)

Changing Text on 16x2 Alpha-Numeric Displays

If you use a 16x2 or larger Alpha-Numeric display it is possible to change the text in certain areas, to display your callsign or something else.

To do this you will need to connect the RS-232 port. The "DDS 2 RS-232 interface Spec" is located on my web site here: http://www.pongrance.com/manuals.html
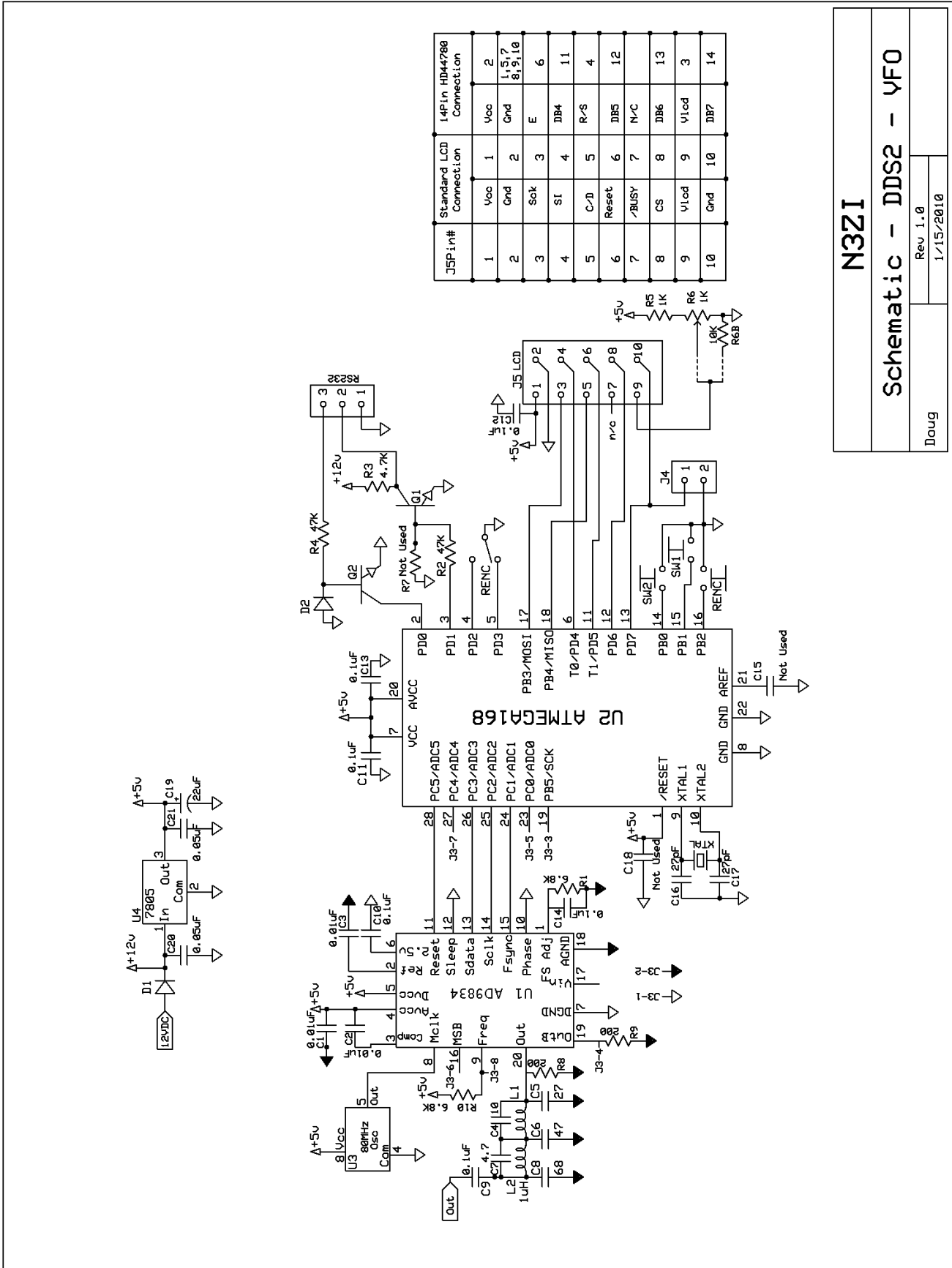

There are 4 Ascii characters on the end of the first line, there are saved in EEPROM location 20(2.000)

There are 8 Ascii characters on the end of the second line, the first 4 are in EEPROM location 21, the last 4 are in location 22. I do recommend that the first character be a space.

In the above example, **N3ZI** is in location 20, **space space WA** is in location 21, and **3JBN** is in location 22

The editor for EEPROM is based on 32 bit BCD coding, so you have to manually pack your 4 Ascii characters into a 32 bit word, then enter it in BCD. This is a tad confusing. For example "N3ZI" ends up being 1,230,648.142 I have a excel spreadsheet that will do this for you on my website manuals page: http://www.pongrance.com/manuals.html look for "DDS Text converter tool"

You cannot add or change text to the standard serial display (KTM-S1201) or and 8x2 or 16x1 Alpha-Numeric displays.

N3ZI

Schematic - DDS2 - VFO

		Rev 1.0
Doug		1/15/2010

J5Pin#	Standard LCD Connection		14Pin HD44780 Connection	
1	Vcc	1	Vcc	2
2	Gnd	2	Gnd	1,5,7 8,9,10
3	Sck	3	E	6
4	SI	4	DB4	11
5	C/D	5	R/S	4
6	Reset	6	DB5	12
7	/BUSY	7	N/C	
8	CS	8	DB6	13
9	Vlcd	9	Vlcd	3
10	Gnd	10	DB7	14