Homebrewing: NUE-PSK Digital Modem

A Build Report

By Mike KC2QPO / M0HSX

Two things seem to happen each year with near 100% certainty - my birthday and me loading the camping gear on my Hog and pointing it towards Oshkosh, Wisconsin, heading to the worlds largest airshow (http://airventure.org). Actually, both events happen pretty much at the same time.

Oshkosh is located on the shore of Lake Winnebago, to the West of one of the Great Lakes, Lake Michigan, here in N, W, K, AA country. The air-show is organized by the Experimental Aircraft Association (http://eaa.org).

There are over 10,000 aircraft, 535,000 visitors, daily air-shows and during the week-long event, OSH (airport identifier) is the busiest airport on the planet, averaging 1 takeoff/landing every 20 seconds (compare Heathrow at less than 1 per minute). It also holds the record for the largest number of aircraft in the air simultaneously since D-day. Airplanes range from open cockpit homebuilt airplanes over vintage, warbirds, current military to cutting edge experimental and unique commercial aircraft.

When I head to OSH I look forward to a week of airplanes, camping and Amateur Radio. This year my XYL Daniela (KC2YMW) produced a Yaesu FT-817ND and a Buddipole antenna for my birthday! This together with an LDG Z-817 QRP autotuner is exactly what the doctor prescribed for going motorcycle-camping mobile (well, perhaps plus a solar panel but that will have to wait).

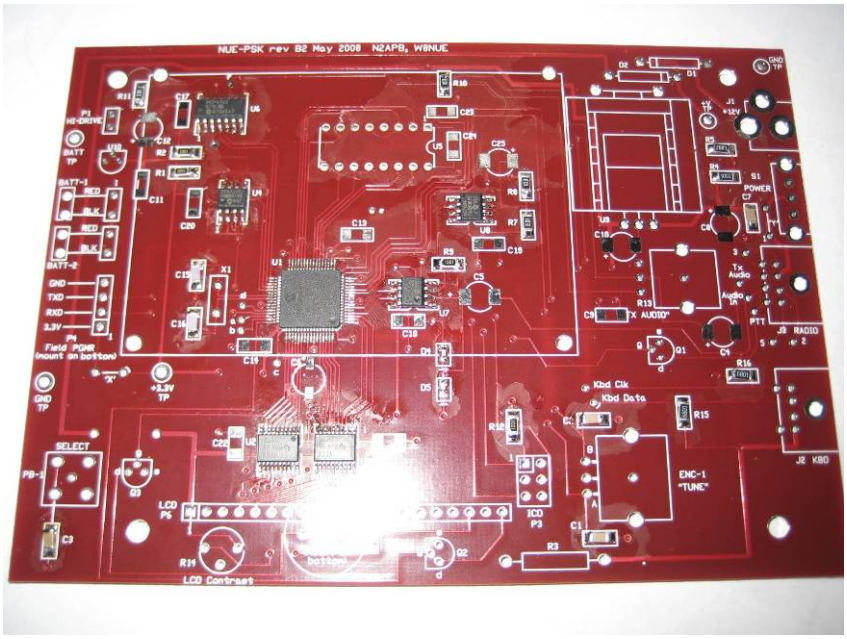
I enjoy operating the little rig in voice mode but my real interest is in digital HF communications. My favorite mode is Hellschreiber (Feldhellclub member FH1838) followed by Olivia and PSK-31. Operating for a week with only intermittent access to mains or car-battery power makes it difficult to use a laptop (did I mention that I also like to backpack my gear - sans laptop - up mountainsides?) So, I came across this nifty little modem designed by members of the American QRP club called NUE-PSK Digital Modem (the “thing”) (http://nue-psk.com) and for a nice QEX article (http://www.nue-psk.com/doc/NUE-PSK_(QEX_Mar-Apr_2008).pdf).

The “thing” is a standalone, no computer needed modem that hooks up to your radio and allows PSK-31, QPSK and RTTY operation (MT63 mode is in development). It weights less than 1lb and measures 7x4x1 inches.
The “thing” comes as free circuit diagram for home-brewers, a bare PCB, a solder-it yourself kit and as assembled & tested modem. I, for one, like soldering stuff so I ordered the do-it yourself kit for $148. It comes with EVERYTHING you need, all neatly labeled in separate plastic bags and an attractive, silkscreened metal case. I decided to order the USB Stick Flash memory option which enables logging of QSOs and field upgrades.

The “thing” uses two microcontrollers, a dsPIC33F PIC main controller and a keyboard controller. It has a nice, backlit display that shows the signal spectrum (for easy tuning) and the actual, decoded text received as well as the text buffer ready to send. It has programmable macros for calling CQ, storing names and “brag” text. It runs on two 9V batteries (or external 12V) and draws 60mA. I have an external miniature PS2 keyboard connected which makes typing a breeze.

Building it:

As mentioned, everything you need is in the bag except a soldering iron and a STEADY HAND. All components are of the surface mount kind and absolutely tiny! There are 2 diodes that measure less than 1 millimeter cathode to anode and to just see which side is which you need a magnifying glass! The surface tension of a (minuscule!) liquid blob of solder (like you would use to attach the darn diodes to the PCB) makes the SMT diodes do all kind of unnatural things, like swapping ends, floating on top or rotating one-end-up. But once you peek through a magnifying glass (set to maximum magnification - right at the border of blurring everything) you will realize with horror that the tweezers look like a D8 Cat (http://en.wikipedia.org/wiki/Caterpillar_D8) oscillating at 5Hz and trying to move your XYL’s most precious china vase. Let me just say that I used to solder for a living many moons ago and I was breaking out a sweat!

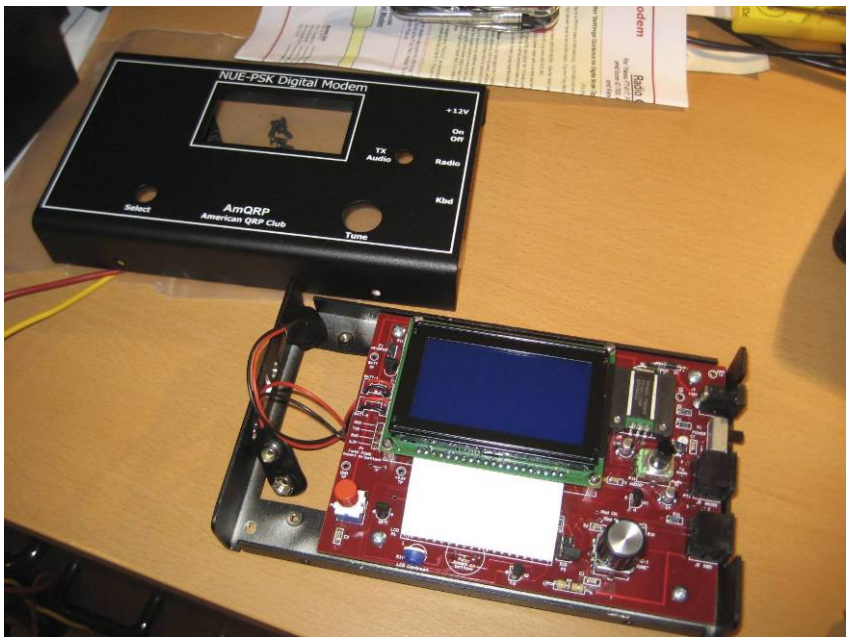


At the heart of this project is a highly-integrated dsPIC33F device. The processor is small yet it sports 64 legs! My guess is that the distance between each leg is about 2/10 of a millimeter. Whatever the distance exactly is doesn’t matter, but what matters is that it is less than the distance solder will happily travel no matter how careful you are with your soldering stick! The build manual is very good and very honest. It proclaims that soldering the PI C (without shorting pins!) is about 3/4 of the project build time and that unless you have rock-solid paws to just forget the

soldering iron (some people report good results by applying flux and baking the PCB/PIC in a kitchen oven).

The 128x64 pixel graphic LCD display is stacked on top of all the other components, connected with a short length of flexible, flat cable and held in place by metal stand-offs sandwiched between isolating washers. The finished PCB with components looks absolutely beautiful and you can see that while there is a little bit of space for future extensions (the project is still in active development), there is no wasted space here. It is just a nicely engineered PCB!

Interesting side note:
The spec says: Power requirements: 9-18V DC. Current at 12V is 60mA without backlight, 80mA with backlight. The current **decreases** as input voltage is **increased** - not what you would expect! Closer inspection shows that there is a conventional voltage regulator creating 3.3V and a switching-type voltage regulator for 5V that is supplied as a package - 3 pin SIP - but built with discrete SMT components and shrink wrapped. The switching power-supply is responsible for the current decrease with input voltage increase!



Turning it on:
It took me 3 or 4 long evenings to build the project - I have not yet added the Flash drive extension. It was an advanced yet thoroughly enjoyable project. On a Saturday afternoon, the moment of truth arrived. Will it power on or just quit amidst a puff of smoke? The build guide said something about “Smoke ‘em if you got ‘em!” I took my completely home-brewed (including winding the transformer) lab power-supply, set the max voltage to 18V (equivalent to the two 9V cells that will power the “thing”) and set the max current to 60mA (worse case of 1W - enough to fry most if not all components in this project!) I applied power for about 1 second and watched the Ampere-meter. 60mA! Voltmeter stayed at 18V. Well, was this 60mA because it wants 60mA or was it because it wants more current but the limiter is keeping it at 60mA? I quickly touched my lip to any exposed components, nothing felt warm and there was no smell of electronic-smoke! Since the voltage didn’t drop I assume the best and set the current limit to 70mA. Power up for a second, power down. 60mA. I took this as an indication that the board was not in self-destruct mode.

Power came up again and stayed on this time. I was looking for the boot-sequence on the display. Nothing! Just nothing. The screen was on, but no cursor or boot message. Perhaps the crystal is not oscillating and without a 10MHz clock agitating the microprocessor it most likely doesn't feel compelled to move beyond instruction #1. So I touched across the two pins of the crystal, hoping to change the parallel capacitance enough to get it going. Nothing!

I go over everything. No component feels hot. The PCB has 3 voltage probe points and they are all correct. I drag the build plan and the schematics out and go over every component again. Every capacitor, inductor and resistor is in its proper place. The magnifying glass helps to check that every pin of the ICs is cleanly soldered and none are shorted together.

After a long night I leave further debugging to the next day. On Sunday I go over the whole PCB and all components again. I unscrew the display to get at every component. Perhaps I was just too tired to see the short or the mistakenly swapped components. No, all looks fine. At about this time I wish I had bought the unit all assembled and tested! Silver lining: The producers of the kit

are all solid amateur radio folks and will help you debug your kit to the point where it will run no matter the time it takes.

As I try to think what I might have buggered up, it occurs to me that I never moved the pot that sets display contrast. Could it be that the contrast is way off and that is why I can't see anything on the display? I power the "thing" up and move the contrast pot. Oh! Look at that! There is a welcome message on the screen! It turns (no pun intended) out that the contrast pot is very sensitive and the setting that produces a readable display is very narrow - about 10 degrees of turn.

Voila! The "thing" works!

Operating:
Let's get on the air!
There is some adjustment of the Tx audio to do which is best done with a QRP wattmeter that I don't own, but setting my 817 to display the ALC meter proves quite accurate too. I fire up my 857D without an antenna and observe the 817 signal on the waterfall display of DigitalMaster (I usually either use HRD + DM on a PC or FIdigi on a Mac). The 817's signal is nice and clean with no splatter. I will be a good citizen on the airwaves.

The proof of the pudding is in the eating so I set up the 817ND, Z-817 autotuner and the Buddipole in my backyard (you would say garden) and get down to business. Incoming signals are easily tuned with the spectrum display and the capability to either tune the desired signal with the radio or in software in the "thing". Reports of the radiated signal are constantly positive especially when taking into consideration that I live in a high electronic-noise environment (too close to New York City - 40 miles across a stretch of ocean with all of the tall buildings clearly visible) and the 817 is only producing QRP signal levels. I end up running the 817 off my electric RC helicopter's 13.1V LiPo batteries, which it seems to like very much. That way I can keep it at 5W "full" power!

Everything I need to operate fits into a small bag and doesn't weigh much. The kit travels with me wherever I go. I am leaving on a business trip to Las Vegas on Monday and hope to climb some of the mountains there to be operating mountaintop portable!

72 and good DX!

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YouTube NUE-PSK Digital Modem Demonstrations
http://www.youtube.com/watch?v=QxiOAuIXSdw
http://www.youtube.com/watch?v=_0FRsTKkREg