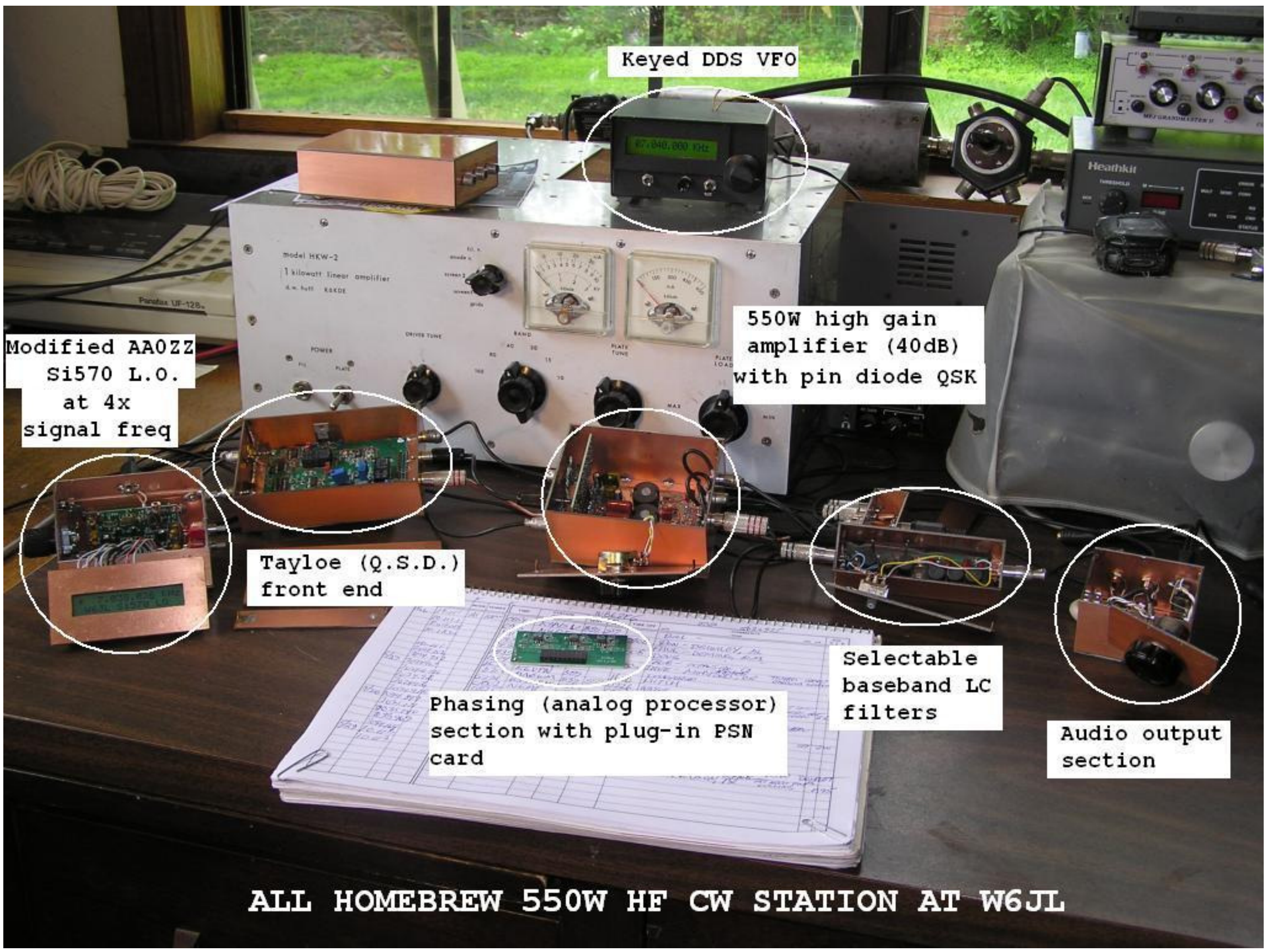
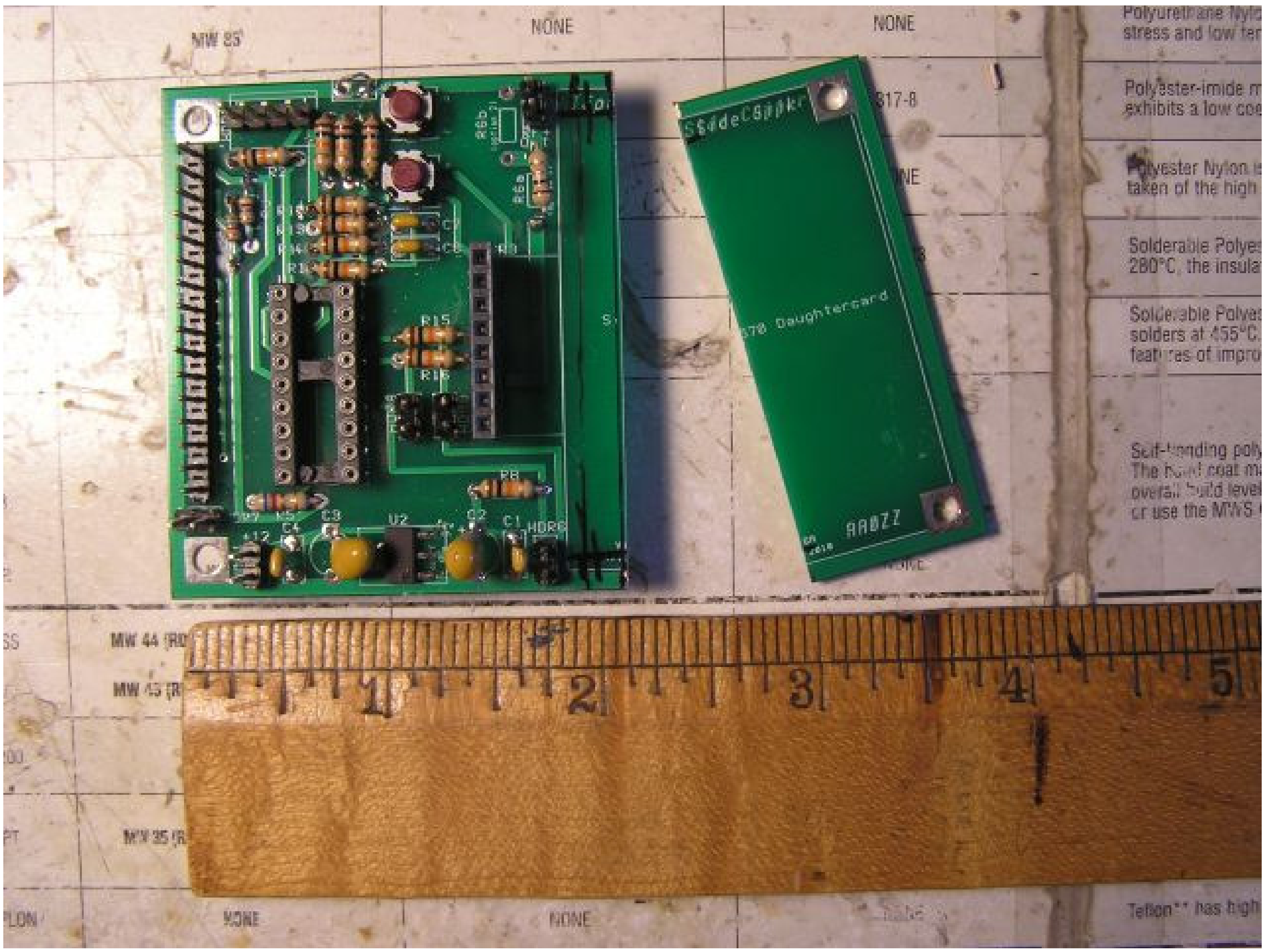
HOMEBREW QSK CW STATION AT W6JL
USING PHASING RECEIVER WITH "TAYLOE" FRONT END
AND AA0ZZ Si570 VFO AS LOCAL OSCILLATOR.

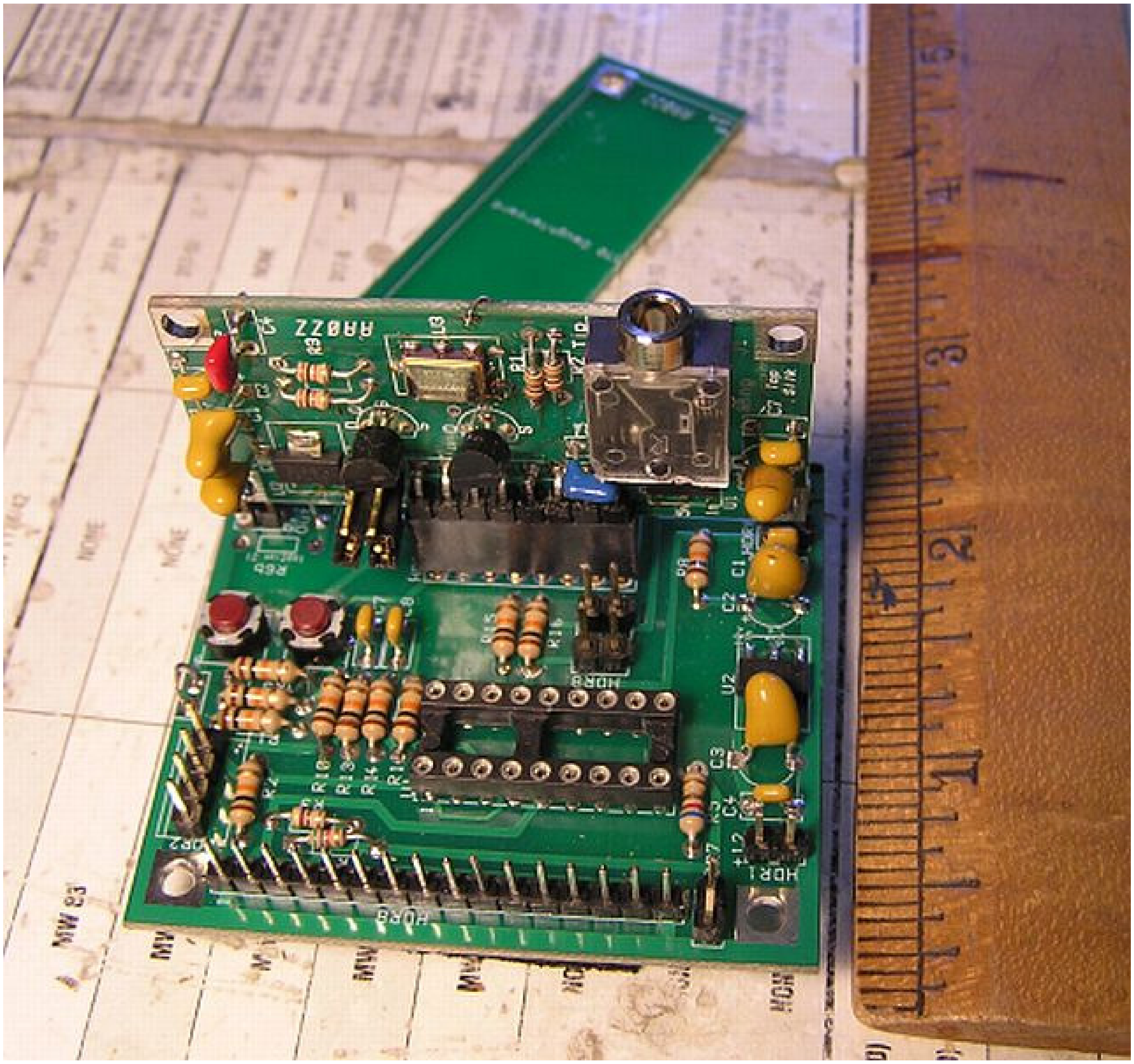
14 July 2011
Updated 4 August 2011
Updated 17 August 2011
Updated 20 August 2011

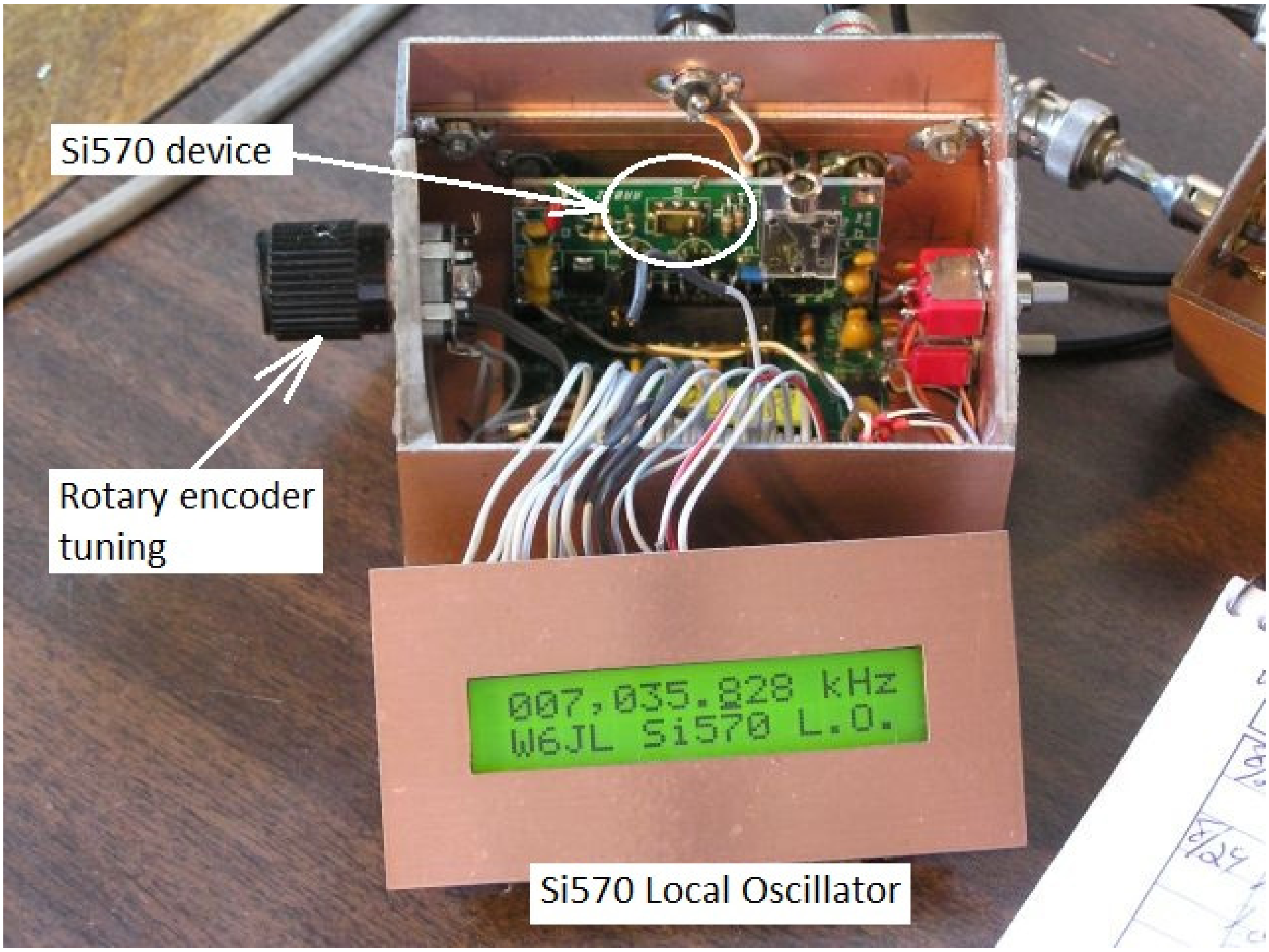


Homebrew station at W6JL. 550W output, using a keyed AD9850 DDS VFO. HB amplifier is one I built in 1972 and has 40 dB of power gain (10,000). (Homebrew rigs last forever :o)). The all band phasing receiver uses a double-balanced version of the Tayloe (also known as a Quadrature Sampling Detector, Q.S.D.) front end. The receiver is contained in the boxes shown. The Tayloe replaces the lossy dual ring balanced mixers, quadrature high level L.O's; power splitter, LC diplexers, and post mixer attenuators used in previous phasing receiver designs. This receiver's MDS is less than -142dBm, using no RF gain whatsoever. This is an equivalent noise figure of under 7 dB. Like most phasing receivers, it has beautiful audio. The receiver has 4 controls, all falling where my hands naturally lie on the operating desk. This is why the receiver is spread out. I don't care for tiny (especially vertical) front knobs and buttons; I find them uncomfortable to use. As usual, if you want things *your* way, you build it! The receiver has plug-in phase shift networks to enable experimenting with different types of phasing networks. PC boards are homebrew single-side etched with copper ground plane back side, with etched side tin-plated.

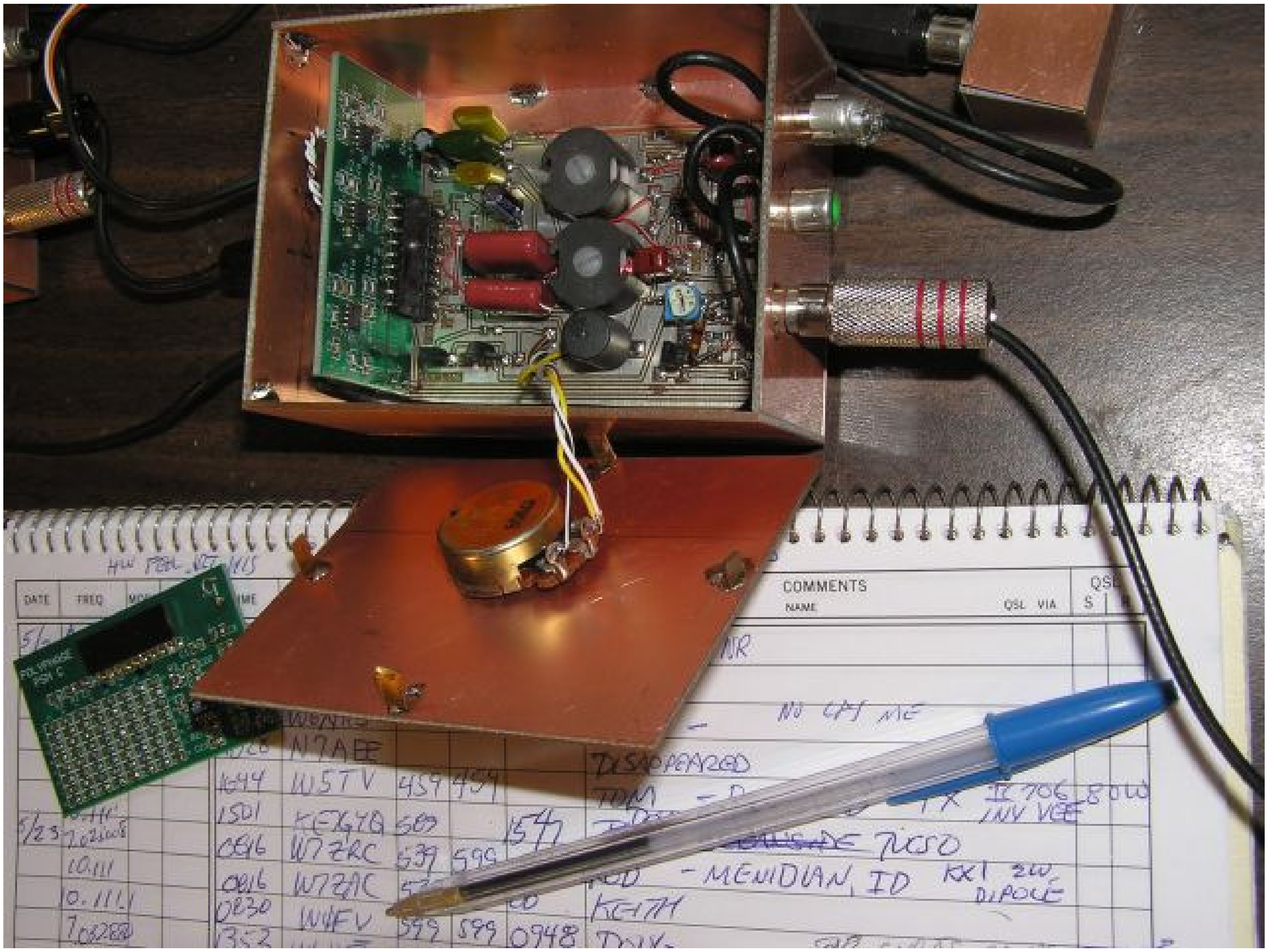


Cut off top of AA0ZZ Si570 control board so as to mount Si570 daughter-card vertical instead of horizontal, to save space.

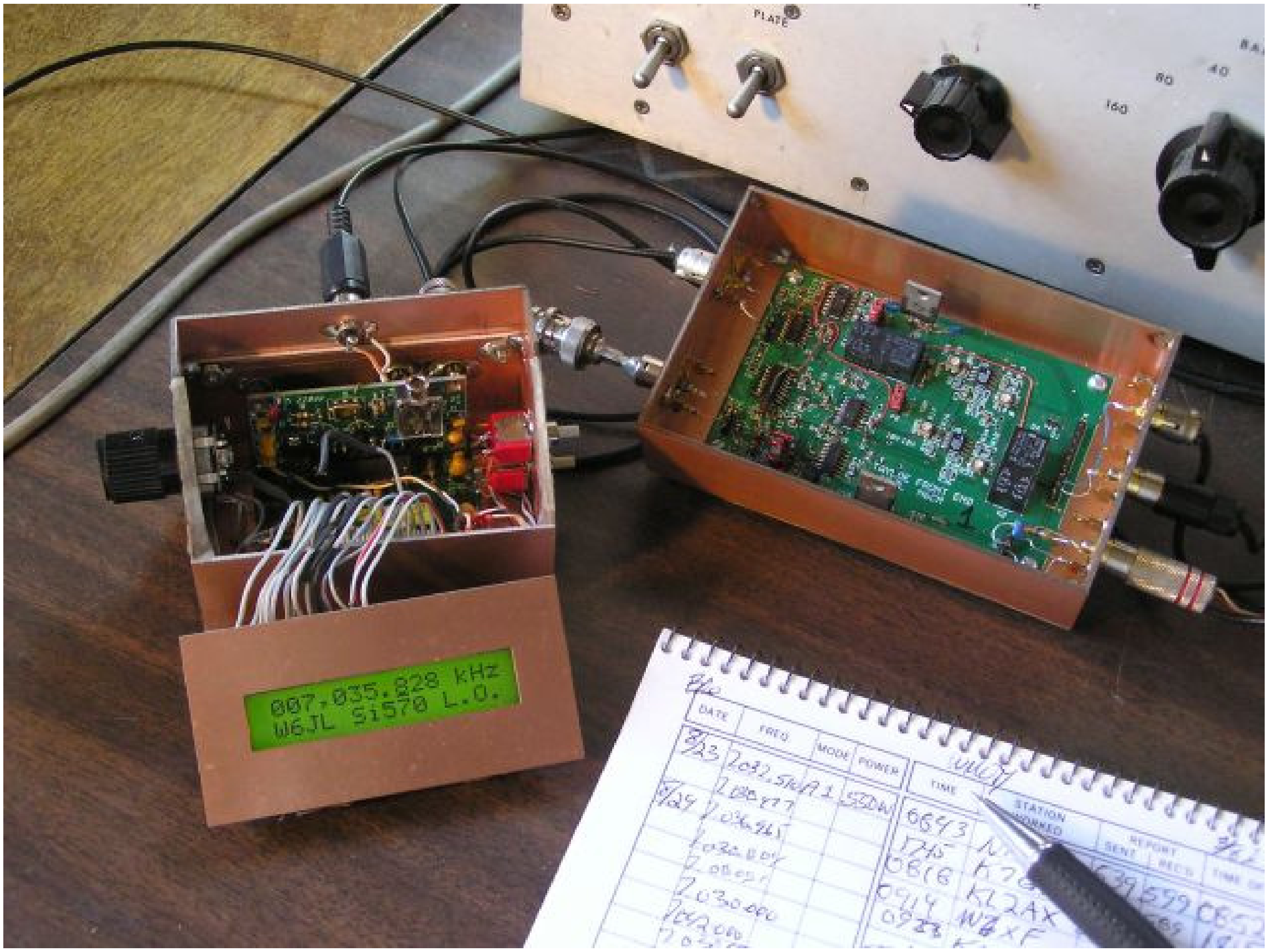

AA0ZZ
HDR8
HDR1
U2



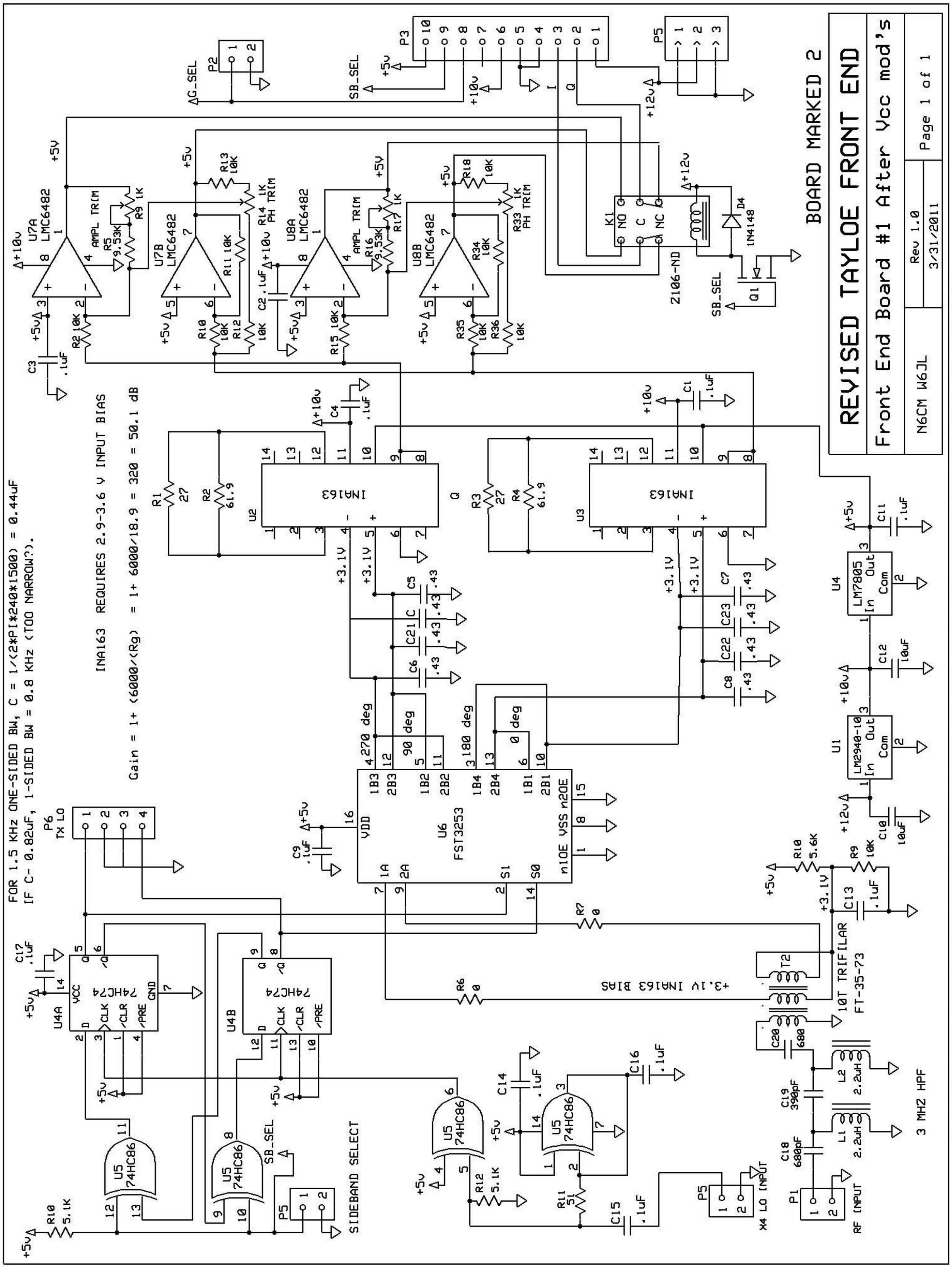
Si570 L.O. interior. This is built from Craig, AA0ZZ's Si570 VFO board, see http://cbjohn.com/aa0zz/index.html and http://www.kangaus.com/si570_project.htm. I cut off the back end of Craig's board, making it a two-piece board, so as to enable fitting in this homebrew enclosure. I also modified Craig's PIC16F88 source code slightly, to put my callsign on the LCD and format the frequency readout to my liking. The Si570 has much lower spurs and phase noise than a DDS, and a much higher maximum frequency, making it ideal for a double-balanced Tayloe receiver using an L.O. Running at 4X the signal frequency. Copper-clad boxes are easy and inexpensive to build of most any size and shape, and make excellent RF shielded enclosures. Placing the rotary encoder tuning on the left side makes it easier to tune in actual use, than being on the front panel. When you homebrew, you have complete control over the electronic features and physical arrangement of your rig. You do not have to settle for what some other designer thought was best for you, in *your* rig.



Receiver phasing and amplifier section. Uses plug-in phasing networks to facilitate experimenting with various phase shift networks. A 6-pole all-pass and a 8-pole polyphase network have Been built, using 0.1% tolerance hand matched components. The main board is homebrewed and tin-plated. The pot sets the level of the key-down signal as heard in the receiver, using the PIN diode QSK system.

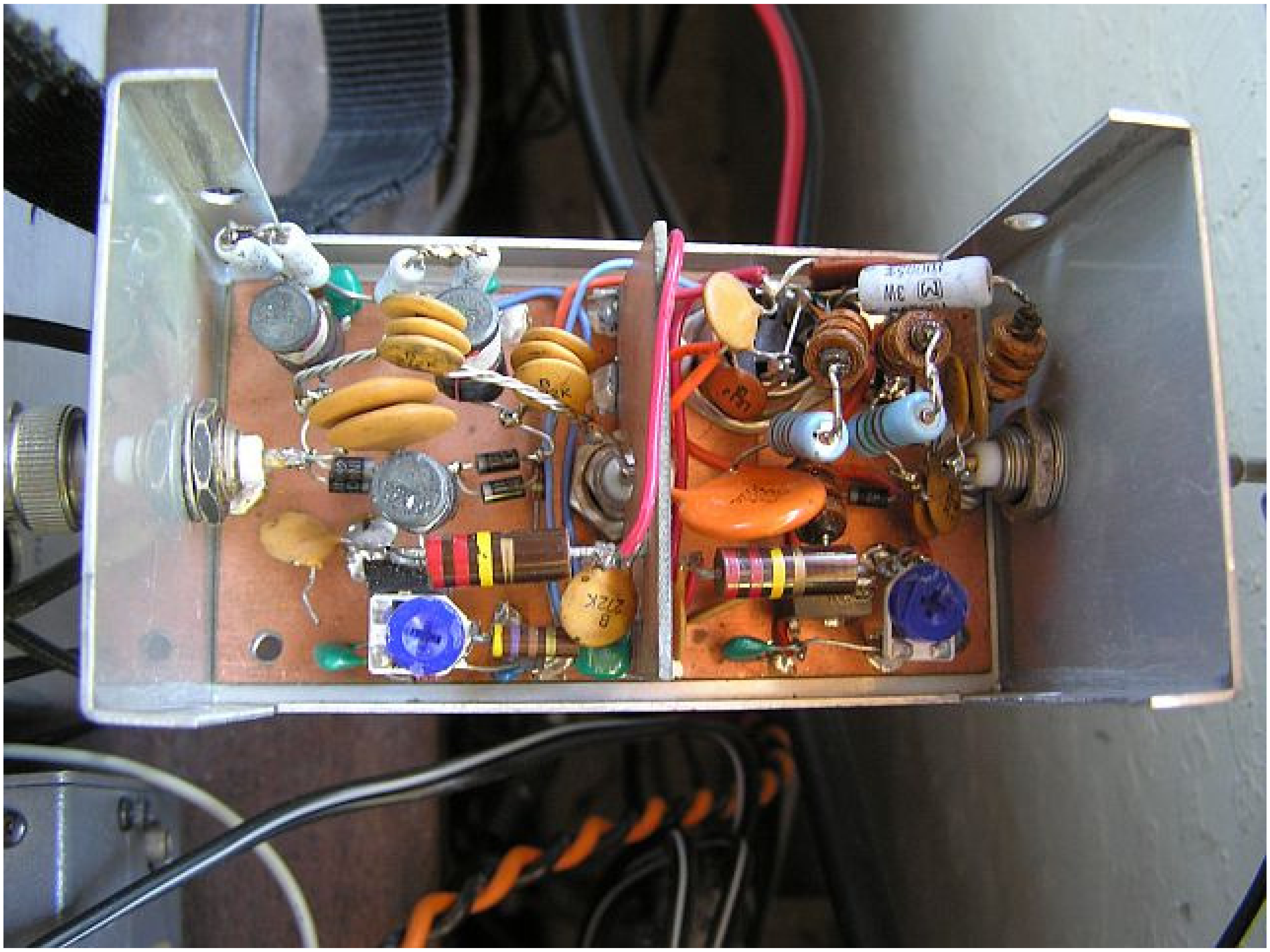


Closer view of Si570 L.O. (left) and double-balanced Tayloe front end (right), for receiver. The Tayloe, or Quadrature Sampling Detector (Q.S.D.), is a simple but elegant (I would even say amazing) circuit popularized by Dan Tayloe, N7VE. It has revolutionized the building of homebrew phasing receivers for both hardware defined (HDR, like this one), and software defined (SDR) architectures. For a descriptive paper by Dan Tayloe on how this circuit works, see: http://www.norcalqrp.org/files/Tayloe_mixer_x3a.pdf

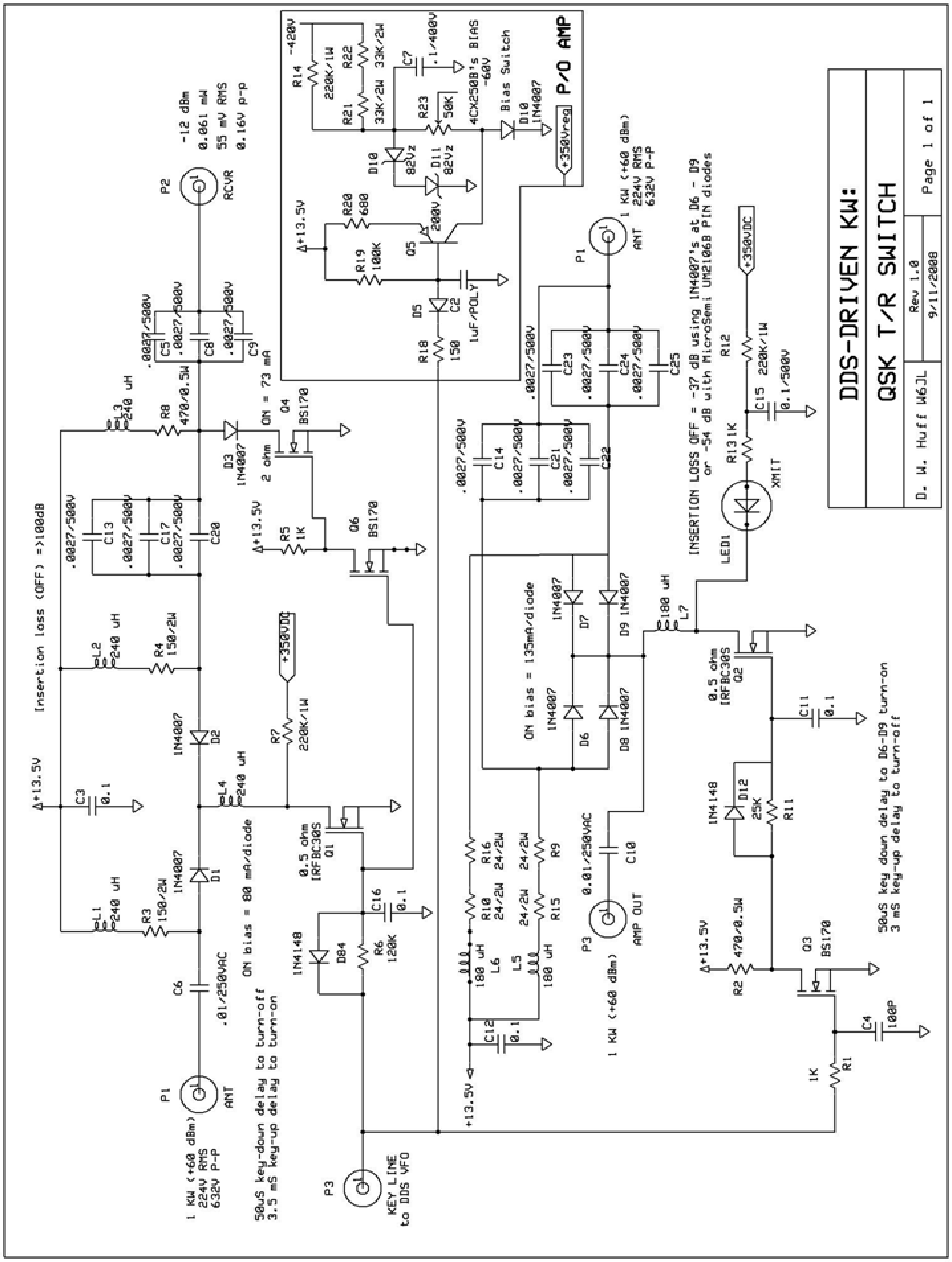


Schematic of double-balanced Tayloe (aka Q.S.D.) front end.

AD9850 DDS VFO/exciter for XMTR. The VFO output is keyed and shaped and drives the 40 dB gain HB amp. Just 50mW of drive from the DDS VFO gives 550W out on the HF bands. I built this VFO ten years ago from an article by Curtis, WB2V, in July 1997 QEX. For several years, Analog Devices provided free samples of DDS devices to any homebrewer who requested them online. This resulted in many getting their feet wet with DDS (including me) which makes it so easy now to build a VFO. It eliminates dial drives, variable capacitors, inductors, band calibrations, and bandswitching. Plus, it has DC to 30 MHz coverage, (useful even as a clean sine wave audio source), and no drift. Homebrew has never been easier (or cheaper!) than it is today.



PIN diode QSK antenna T/R switch, mounted on rear of amplifier. Here again, ugly-style on bare copper-clad serves just fine. The four 1N4007 rectifier diodes used as PINs are visible at left center. Attenuation looking back into the input of the always-connected receiver is over 100dB when the key is down. Note ancient carbon resistors from my junk box. Some of the inductors were salvaged from junked computer power supplies. Cost to build: $0 out of pocket; the best kind of project :o). This switch easily handles 600W and has been in daily use for several years, with thousands of accumulated hours. Oh, and brand new 1N4007 diodes are 10 cents each.



PIN T/R switch. The inspiration for using high voltage rectifiers as RF PIN diodes came from a 1995 Wes Hayward (W7ZOI) QEX article.

UPDATE - 8/4/2011

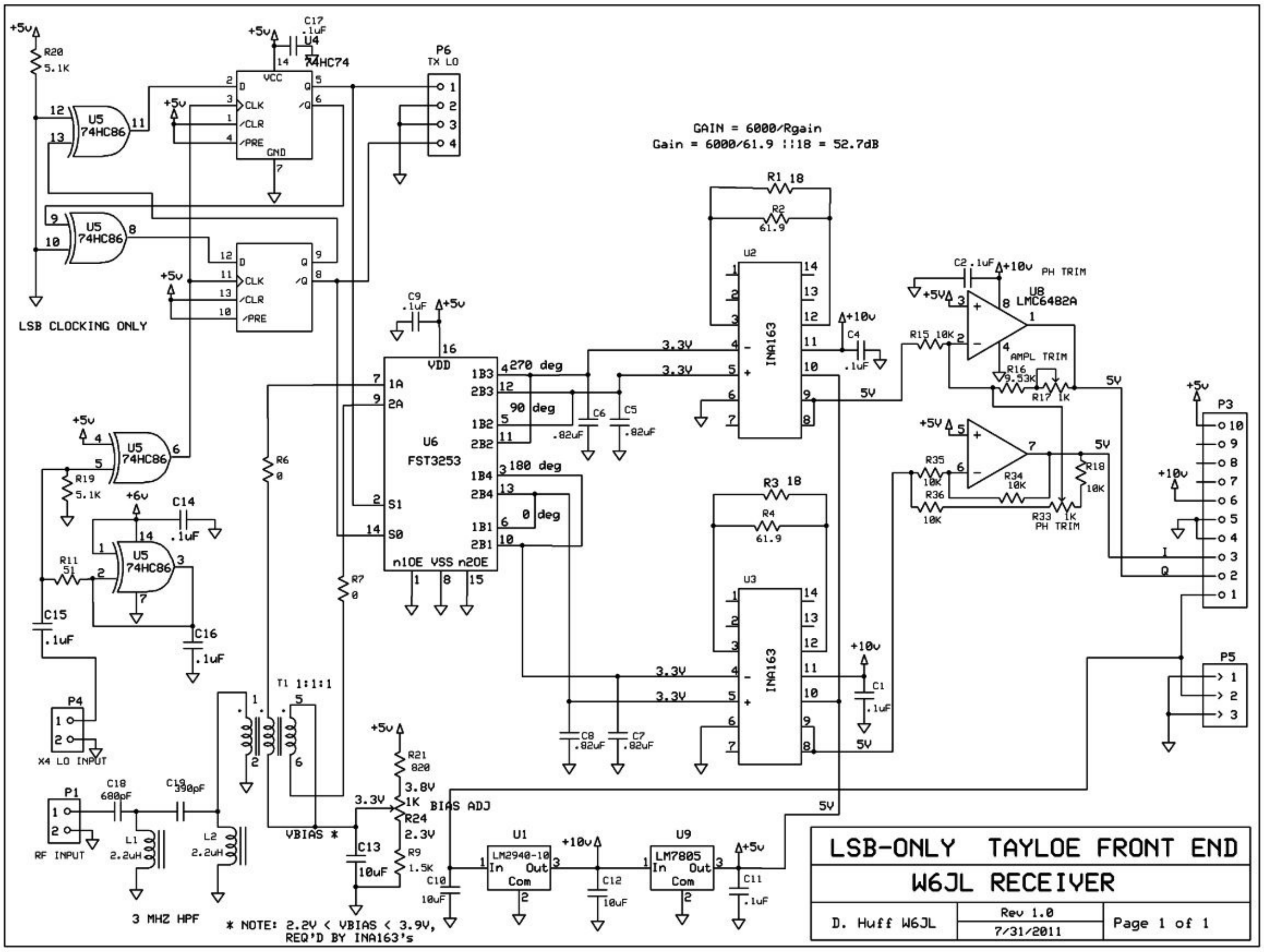
Since my entire station consists of only HB equipment, including the PC boards, with the exception of the PC board for the Tayloe (which was made by ExpressPCB, at zero incremental cost, since Bob N6CM tacked it onto another existing board order's image), I decided I wanted exclusively my own PC boards. To that end I built entirely new Audio Processor and Filter and Audio boards, eliminating the former modified R2PRO entirely. But the Tayloe remained, so I laid out yet another Tayloe and loaded it with only the parts required for a LSB-only receiver. No need for selectable sidebands when one is a CW-only op, right? This strips a bunch of parts out of the Tayloe front end, including sideband selection relays, output summing amps, USB amplitude and phase 15T pots, etc. Things keep getting simpler! However I thought of this simplification after I had made the bare board. So I just did not load the unnecessary major parts. See pix below of board. A thing of beauty it ain't; I made it single-sided (solid copper on back side for GP) so there are plenty of jumper wires. That notwithstanding, it works beautifully, and hears -142 dBm with 3 dB S+N/N ratio. Yet another illustration that cosmetics is unrelated to performance (let's hear it again for Ugly Construction :o)).

This is my third working Tayloe. What does a guy do with three hot Tayloe front ends? Hmm, maybe I could make the LO multiple output and then can simultaneously listen to three frequencies anywhere in the HF range. The receiver is broadband, remember.

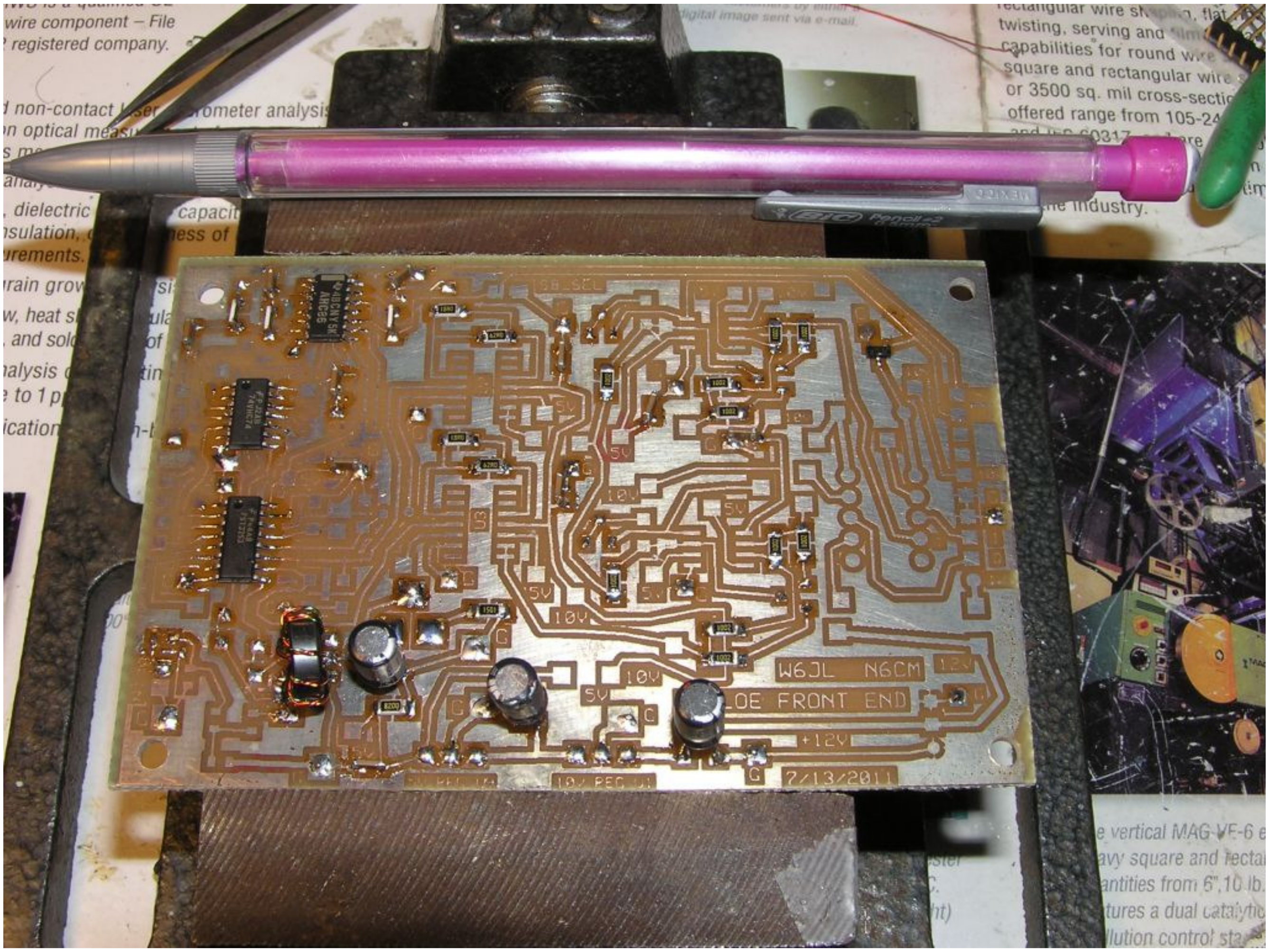
So, now the station is 100% homebrew (except for the components.. hmmm…).

Later,

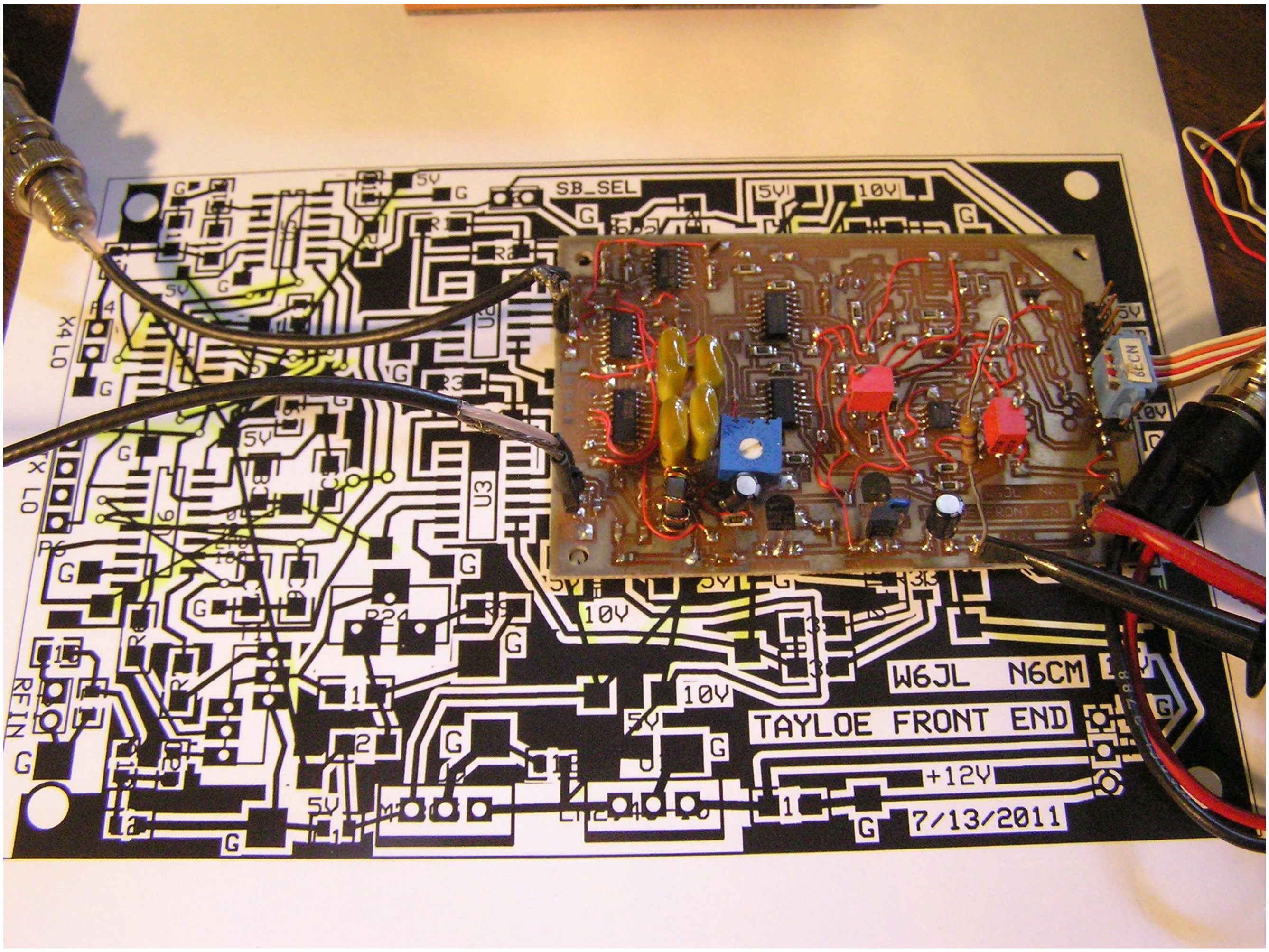
Don



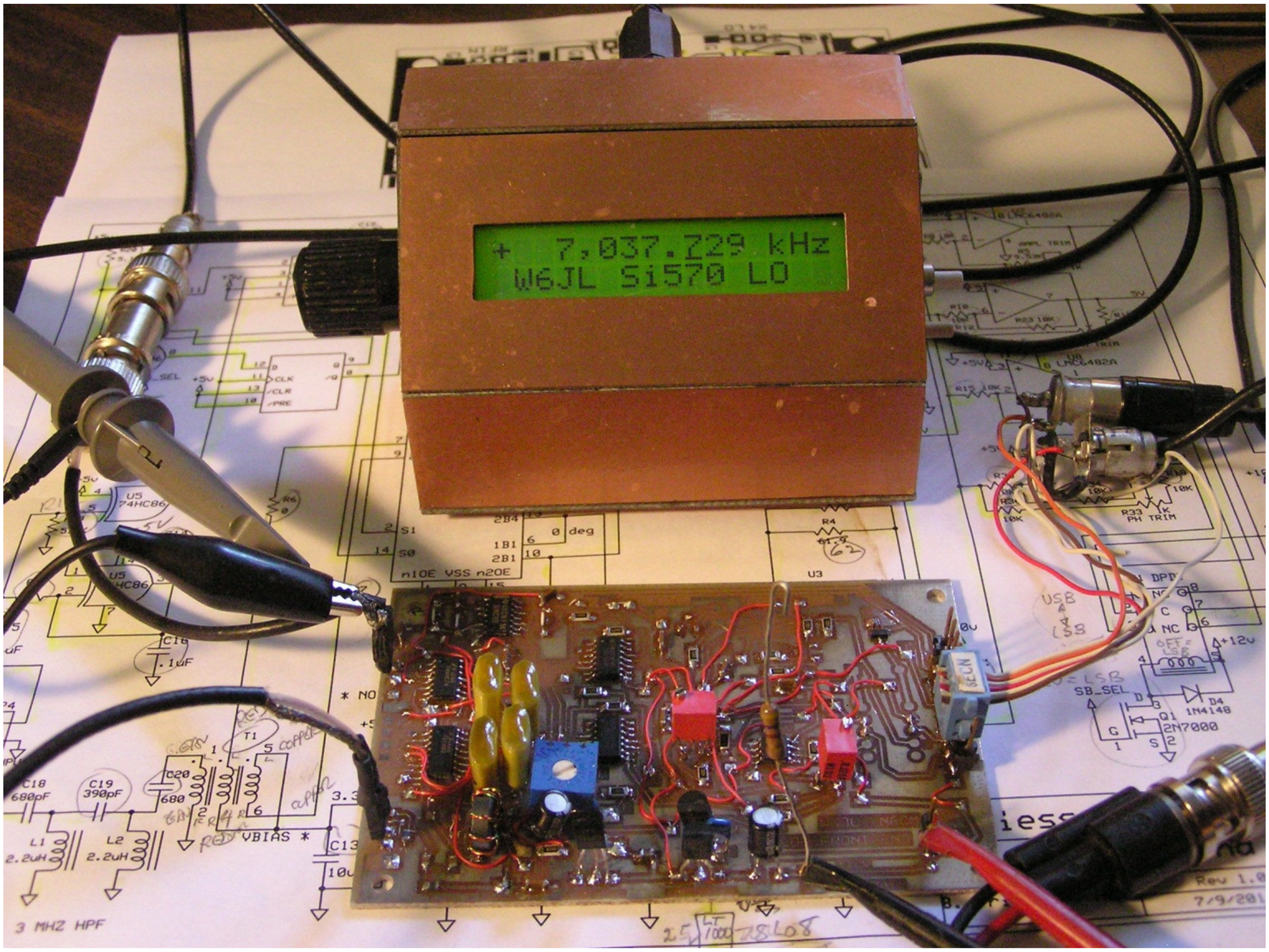
This is the one-sideband-only Tayloe mixer.



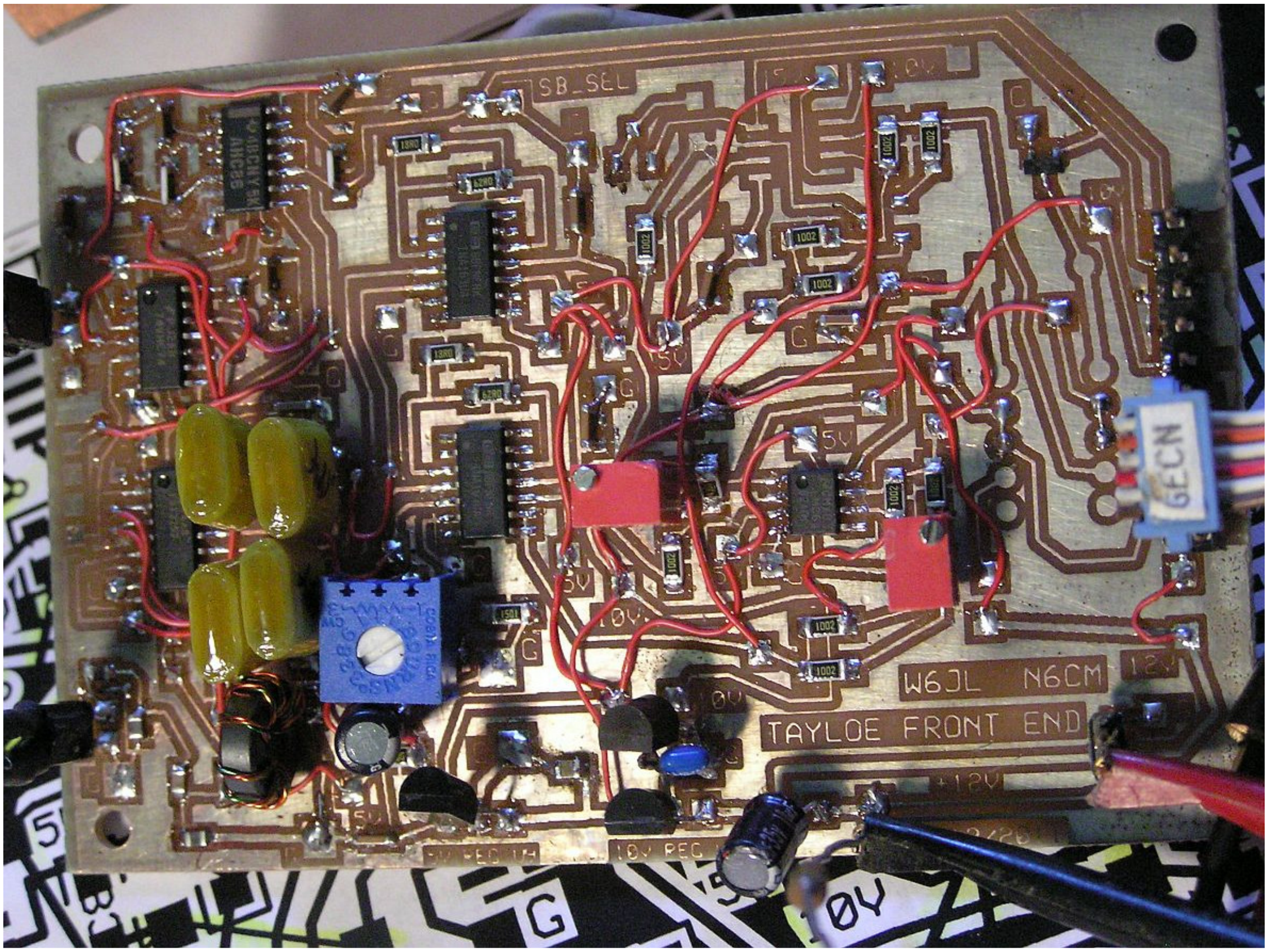
Starting to load homebrew board. I tin plate my HB boards with a simple immersion tin plating solution I found somewhere years ago.



Working board, on copy of PC mask. Blue pot sets bias on input, which the INA163's seem to want to be about 3.3V for lowest noise.



I was amazed that the RF input phase inversion transformer wiring polarities came out right the first time! You can see my scribbling on the schematic to hopefully verify in my mind beforehand that the phasing would be correct. It was.

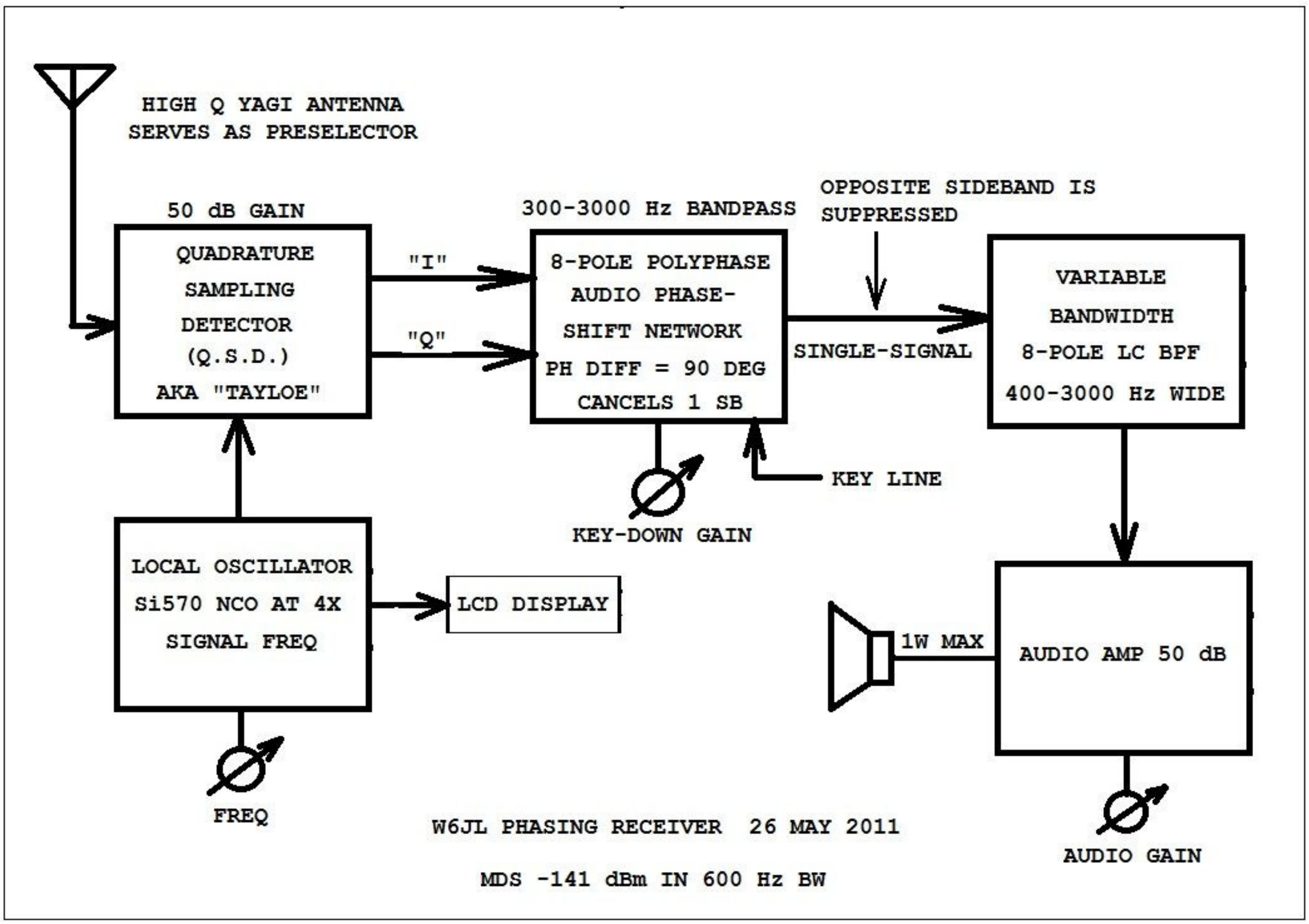


Working board. Four green caps are the sampling caps, matched as closely as I could out of a collection of 25 caps. They are .15uF. That gives a much wider Tayloe corner frequency than I normally use, but I had these caps on hand. The much smaller ceramics are made of Barium Titanate, which is an excellent audio transducer. Using metalized film caps eliminates the microphonic sensitivity I've noticed with ceramics. With 115 dB of gain following the Tayloe sampler, it only takes nanovolts of microphonics and you will hear it. The blue pot sets the bias on the input to the Tayloe, which is also the bias at its output, connected to the INA163 instrumentation amps. I discovered that the noise from these amps seems to have a minimum when they are biased at about 3.0-3.3V, instead of 2.5V, which is the center of the MUX Vcc of 5V. So I have a pot to play around with this bias. The MUX works fine with 3.3V of DC bias on the analog lines.
 I use larger square pads and designate them as Ground. These are drilled through to the copper back side and connected with a soldered-in piece of wire-wrap wire. All components are surface mounted, including through-hole components, as you can see. This minimizes drilling on the board.

New - 8/17/2011

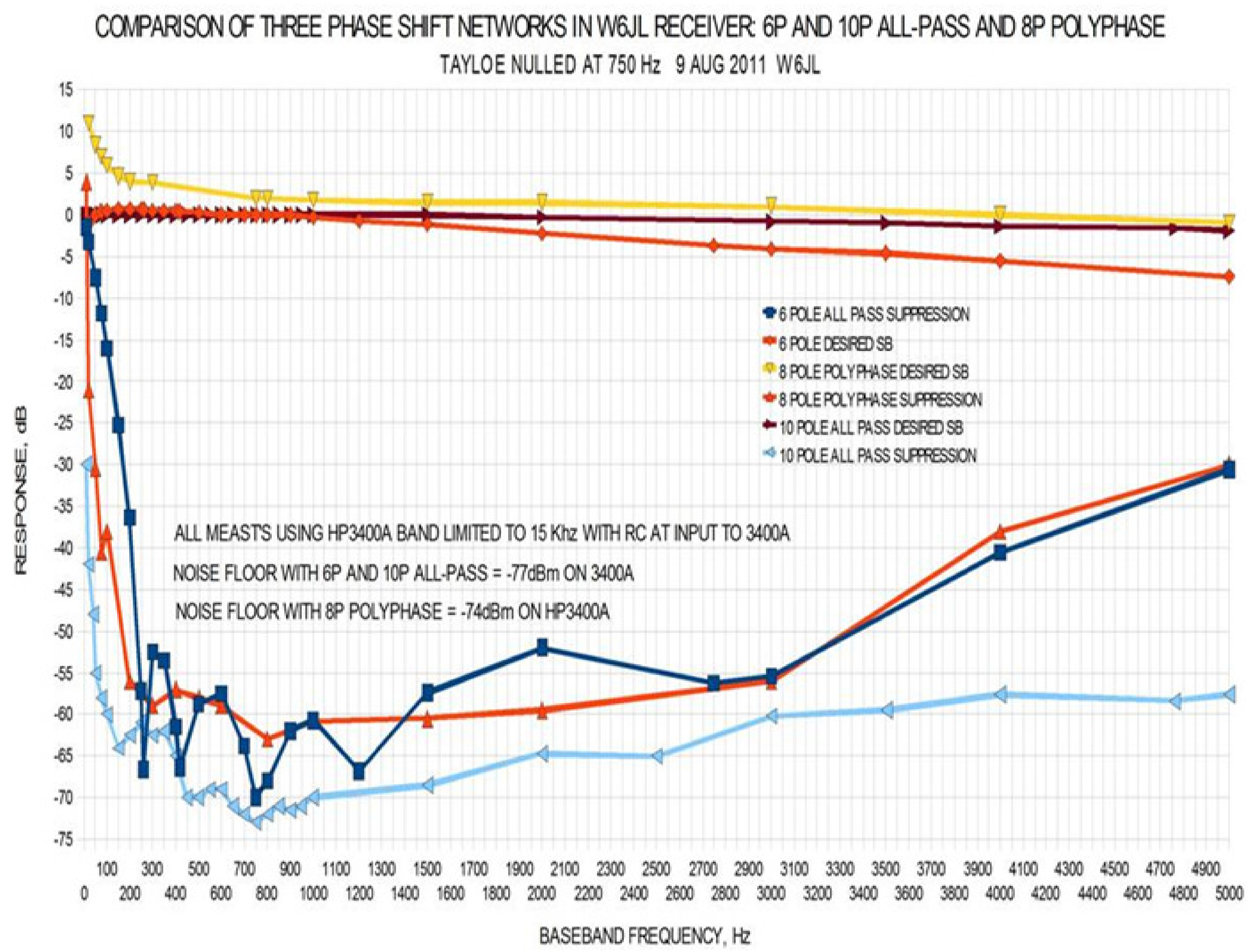
This is an update of my phasing receiver with modified AA0ZZ Si570 L.O.; and showing the latest Q.S.D. (aka Tayloe) front end, along with 10-pole all-pass phase shift network achieving 70 dB of opposite sideband suppression.

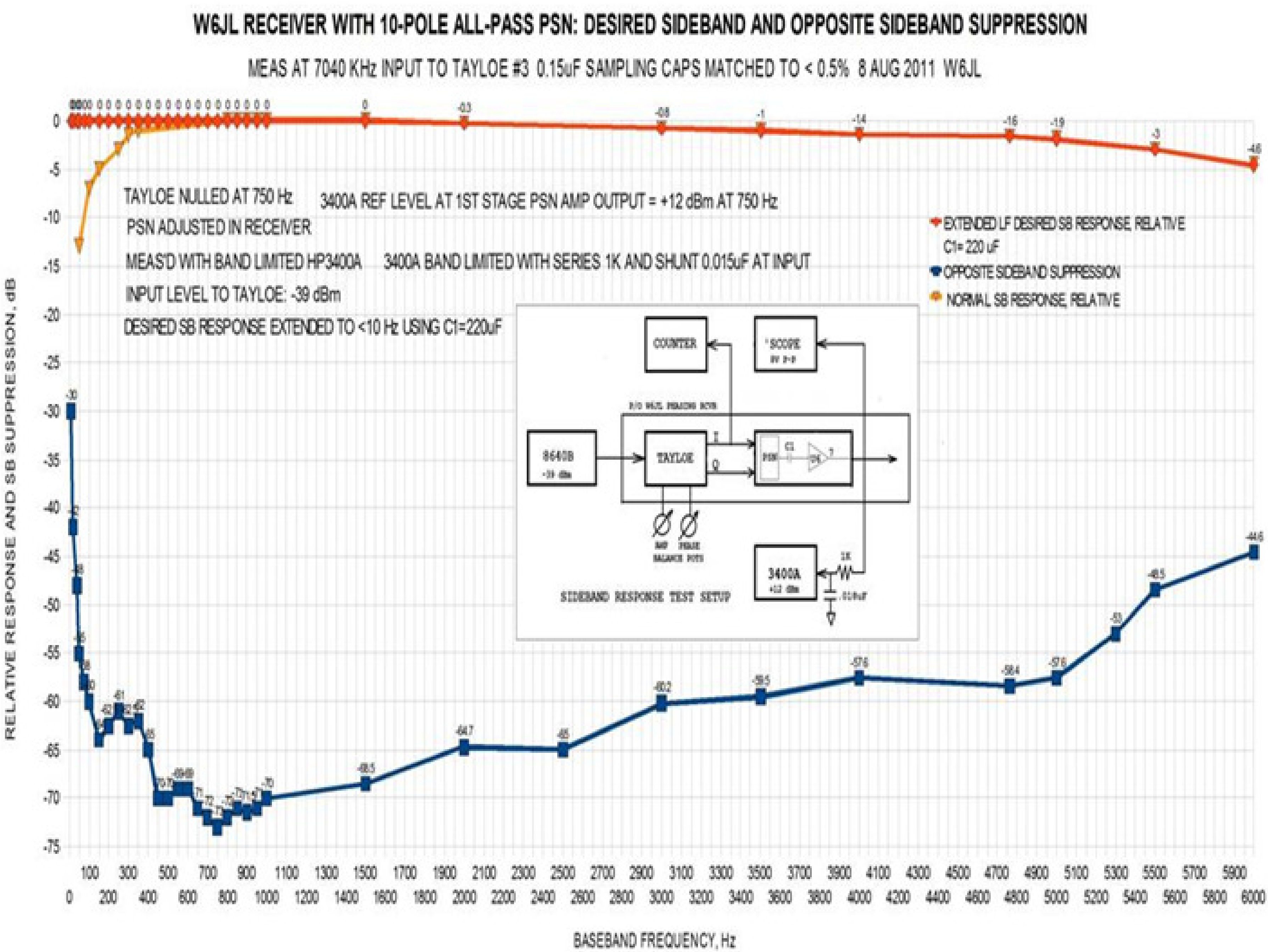
To say that I enjoy using this sweet receiver on the air every day is an understatement. Fun stuff!
73, Don, W6JL August 17, 2011.



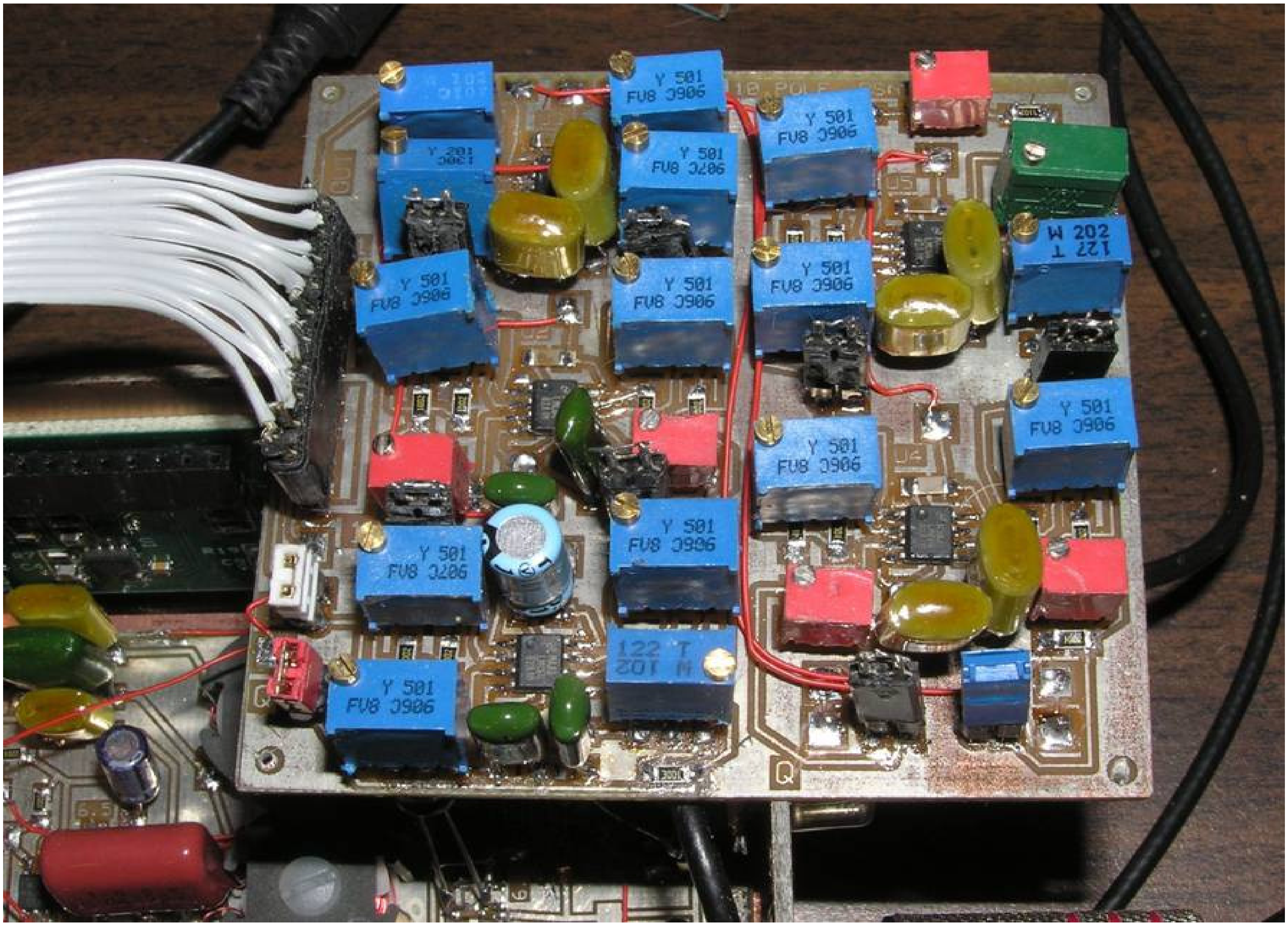
W6JL Phasing Receiver simplified block diagram.

My third Tayloe (Q.S.D.) front end for W6JL Receiver, built on a homebrew PC board. Parts deleted are for selectable sideband, which are not needed for CW-only ops like myself. This further simplifies an already simple front end.

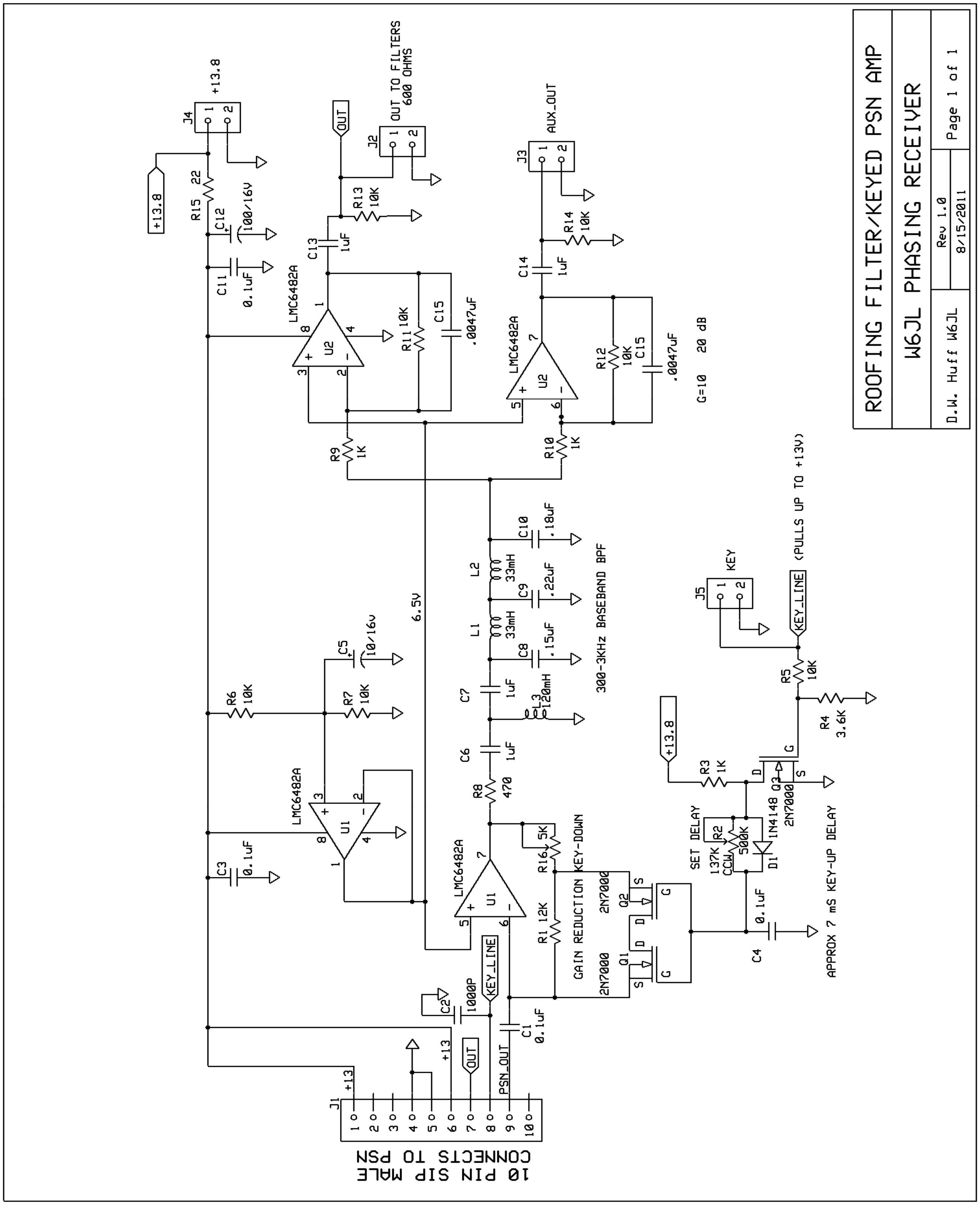

COMPARISON OF THREE PHASE SHIFT NETWORKS IN W6JL RECEIVER: 6P AND 10P ALL-PASS AND 8P POLYPHASE
TAYLOE NULLED AT 750 Hz 9 AUG 2011 W6JL
6 POLE ALL PASS SUPPRESSION
6 POLE DESIRED SB
8 POLE POLYPHASE DESIRED SB
8 POLE POLYPHASE SUPPRESSION
10 POLE ALL PASS DESIRED SB
10 POLE ALL PASS SUPPRESSION
ALL MEASTS USING HP3400A BAND LIMITED TO 15 Khz WITH RC AT INPUT TO 3400A
NOISE FLOOR WITH 6P AND 10P ALL-PASS = -77dBm ON 3400A
NOISE FLOOR WITH 8P POLYPHASE = -74dBm ON HP3400A
RESPONSE, dB
BASEBAND FREQUENCY, Hz


W6JL RECEIVER WITH 10-POLE ALL-PASS PSN: DESIRED SIDEBAND AND OPPOSITE SIDEBAND SUPPRESSION
MEAS AT 7040 KHz INPUT TO TAYLOE #3 0.15uF SAMPLING CAPS MATCHED TO < 0.5% 8 AUG 2011 W6JL
TAYLOE NULLED AT 750 Hz
3400A REF LEVEL AT 1ST STAGE PSN AMP OUTPUT = +12 dBm AT 750 Hz
PSN ADJUSTED IN RECEIVER
MEAS'D WITH BAND LIMITED HP3400A
3400A BAND LIMITED WITH SERIES 1K AND SHUNT 0.015uF AT INPUT
INPUT LEVEL TO TAYLOE: -39 dBm
DESIRED SB RESPONSE EXTENDED TO <10 Hz USING C1=220uF
EXTENDED LF DESIRED SB RESPONSE, RELATIVE C1= 220 uF
OPPOSITE SIDEBAND SUPPRESSION
NORMAL SB RESPONSE, RELATIVE
COUNTER
SCOPE
8640B
TAYLOE
PSN
C1
3400A
SIDEBAND RESPONSE TEST SETUP
RELATIVE RESPONSE AND SB SUPPRESSION, dB
BASEBAND FREQUENCY, Hz

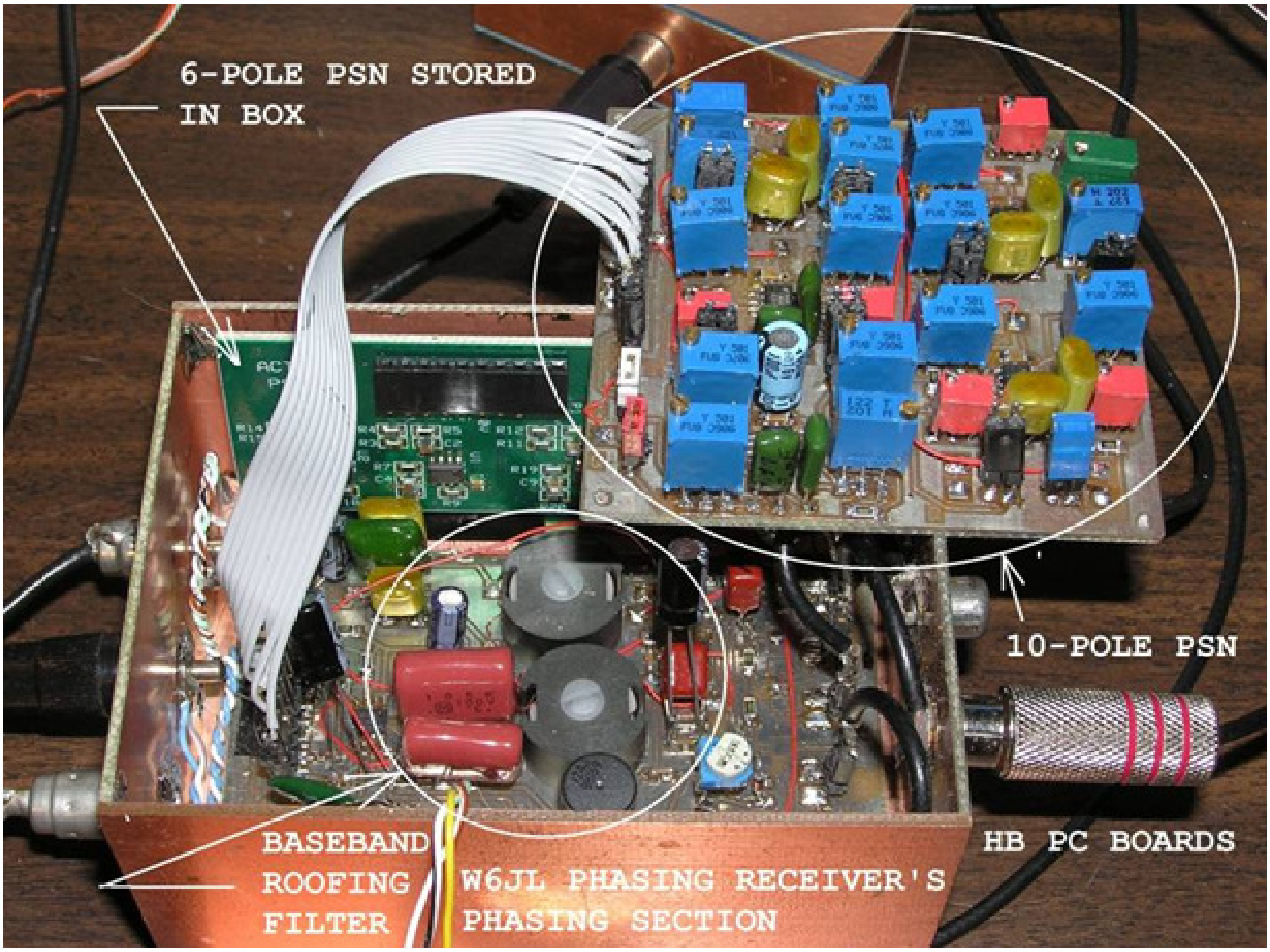
Above: Opposite and desired sideband response plots of phasing networks tested in the W6JL Receiver. Adjustable 10-pole all-pass network has excellent performance, especially over the CW passband of the receiver where it has roughly 70 dB of opposite sideband suppression.



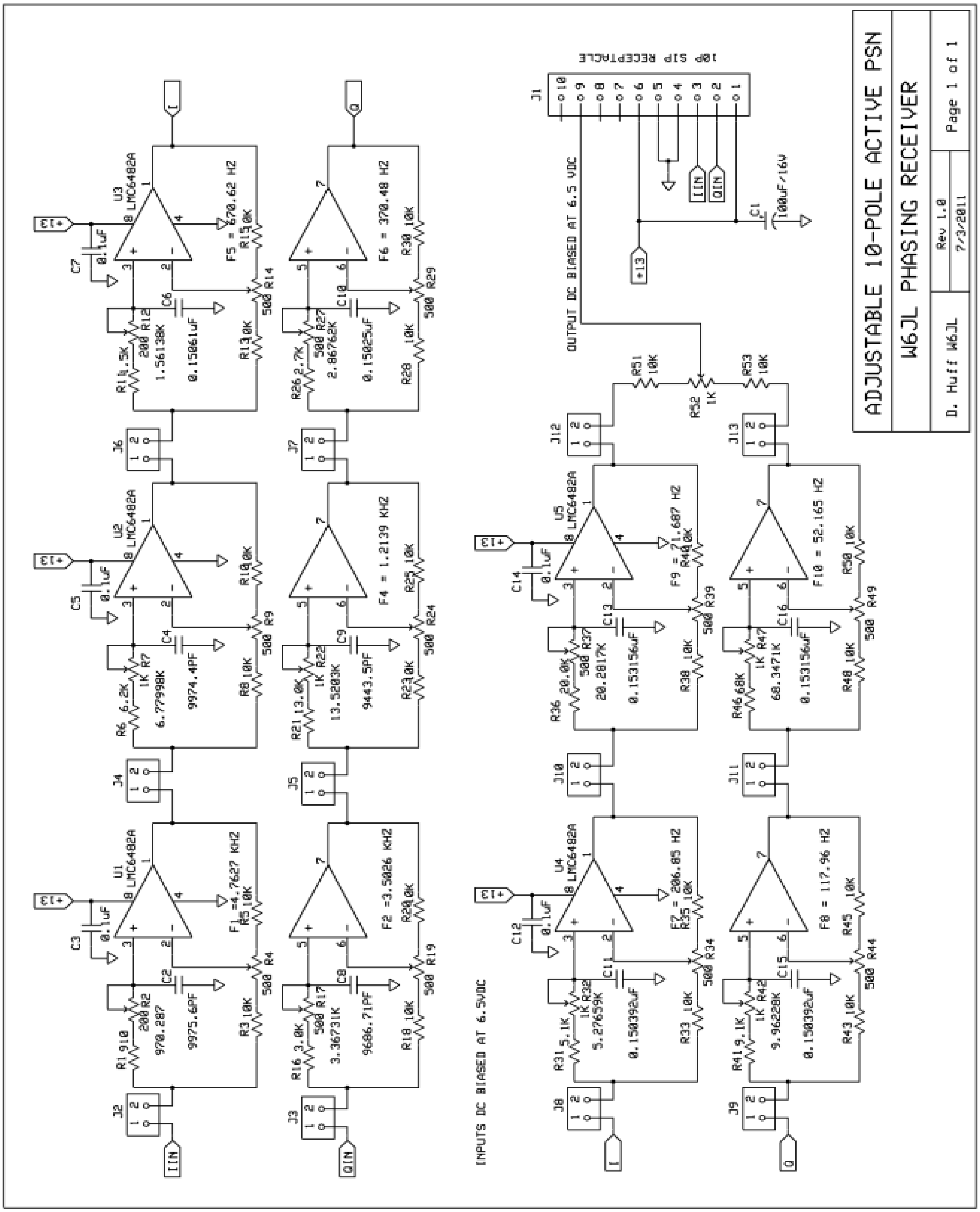
10-pole adjustable all-pass phasing network on HB PC board.



W6JL Receiver phasing section schematic, with baseband roofing filter and QSK gain reduction.



W6JL receiver with phasing section module and 10-pole adjustable all-pass PSN attached on HB PC boards.



10-Pole all-pass adjustable phase shift network schematic.

W6JL Receiver's Phasing Section, with three plug-in phasing boards.

============= UPDATE 2011-08-20 ==
Craig,

I got to thinking yesterday (again!), and below see the same data, plotted another way, to illustrate the remarkable capability of phasing receivers to handle sigs down very close to zero beat, and have the other side be wayy down. With superhets we use frequency-selective filters to suppress the opposite sideband in the i.f. and also to partially suppress the carrier. To have a very sharp cutoff requires complex crystal filters, or else DSP, but DSP then requires low noise wide dynamic range A/D's, etc. But a phasing receiver can have its phase reverse very quickly, not subject to the limitations of frequency selective I.F. filters. And it does so in a "noise free" manner. Below see plot of my phasing receiver with the 10-pole PSN installed. Kinda cool, eh? And the receiver is so simple: No I.F.; no crystal filters, no RF stages, very sensitive, inherently broadband, and beautiful audio…