Conversion of Navy TDD-5 Transmitter to 40M Phone

The Rig – A Brief Description

I have owned a TDD-5 transmitter for about 7 years. I bought it from a person who converted it (by simply changing the crystal and tuning it as best he could) from the original 200 – 550 kHz range for it was designed to operate in, to the AM broadcast band – specifically 1460kHz. – I won't comment on why he did this! I decided to re-work the transmitter, keeping it outwardly original, but on frequencies for which we are authorized to transmit. I had hoped for an allocation in the 170 – 190kHz band – this was going to be my rig, but the FCC denied that allocation citing utility load management usage of that band.

The TDD-5, and the family of transmitters that are all nearly identical in design, were originally designed for longwave communications with aircraft. The original tube line-up is as follows:

Qty 2	807W	RF Power Amplifier
Qty 2	6L6G	Class AB1 Modulator
Qty 1	6V6GT	Triode-connected Class A Modulator Driver
Qty 1	6V6GT	Crystal Oscillator / RF Driver
Qty 1	83	Mercury Vapor HV Rectifier
Qty 1	5Y3GT	Bias Rectifier

The TDD-5 was originally designed to operate at a power level of 15 watts, although the manual indicates that 25 watts is typical. Looking at the transformer ratings, and the tubes used, it was clear that the transmitter was capable of more like 50 or 60 Watts. The modulation transformer is rated at 80Watts and the filament transformer was capable of 7 amps at 6.3V. As with most military radio gear of the era, it was designed with safety factors of 2:1 or greater; it was clear that lots of things could be done to this rig!

The Conversion

My first step was to retune the crystal oscillator / driver to 7.290 MHz – the AM calling frequency on the 40M band. The original inductors were supplied in 3 plug-in coils; one for 200 – 300kHz, a second for 300 – 425kHz, and a third for 425 – 550kHz. I found a section of B and W miniductor at a local hamfest that was ¾ inch in diameter and had enough turns to make 50 uHy which would resonate with about 60pF – just near the minimum that the original Oscillator Plate Tuning capacitor would allow. The output network was removed and replaced with a Pi-L configuration based on a coil I also found at a hamfest which had had a total inductance of 12uHz. I tapped it such that 7.2uHy was available on the Pi-side of the network and 2.6uHy was available on the L-portion of the network. The original plate loading caps, were removed and a single 400pF mica transmitting capacitor was installed as the loading capacitor. An operating Q of 12 was designed, and, although the original plate tuning cap could have been used, I replaced it with an identical model E.F. Johnson 50pF variable from my junk box, to which a small 25pF fixed vacuum (use what you have) was added in parallel. Resonance occurs with the variable capacitor meshed about 20%.

The next step was to increase the drive to the PA. To accomplish this, a second 30k / 5W resistor was placed in parallel with the original grids leak bias which is in series with the fixed –32V source. This reduced the operating grid bias from –135V to about –85V which was,. more inline with the specs for CCS usage of an 807. In addition, the plate dropping resistor for the 6V6 was changed from 15k to 6.8k, thus raising the plate and screen voltages, since the screen dropping resistor followed in the circuit. Finally, I replaced the 6V6 with a 6L6, which could handle the higher voltage better saving the 6V6 as a spare for the class A audio driver. The 807 grid current increased from 3mA to 6.8mA at resonance of the oscillator and PA plate. At the same time, I removed the strange PA plate circuit parasitic suppression circuit that was used: The original circuit had one plate tied directly to the output network, while the other plate had a 100 ohm resistor in series with it. I replaced the first 100 ohm resister with 22 ohms / 1W and added a second 22 ohm / 1W resistor in series with the other plate. The cathode circuit if the 807PA is grounded through 100 ohms via a control relay when the transmitter is keyed. That level of degeneration limited the carrier power level to about 42 watts. I decided to reduce this value to 33 ohms – plenty of degeneration for stability and modulation linearity, yet small enough to allow more than 50 watts of carrier power to be generated by the paralleled PA stage.

The power supply caps were replaced with new axle leaded Sprague / Vischay units under the chassis. The 4uFd / 600V caps in the 2 section, choke input filter of the high voltage supply were replaced with 20uF / 600V units. A 20uF / 600V capacitor was also added in parallel with the 4uF / 600V capacitor which acted as a secondary filter for the audio driver stage. The original power supply filter caps were left in place to retain the original appearance of the unit. The original rectifier circuit using a type-83 mercury vapor rectifier was retained.

The bias supply was also re-capped. The original caps were replaced with 50uF / 150V units, also from Sprague. In this case, the original tube-type bias rectifier was removed and a simple 1N4007 diode rectifier was installed using the tube socket as the tie point.

Since the goal was to get 50 watts out of the transmitter, the 6L6 modulators would need to deliver a bit more than 25 watts. While this was within spec, I had on-hand a pair of 6550’s, which have a higher plate dissipation rating. The pin-out is the same for both tubes, but the filament load of the 6550 is 1.6 Amp rather than the 0.9 Amp of the 6L6. Since the filament transformer had extra headroom, this was not a problem. Finally, a slight red color could be noticed on the inside edge of the 6550 plates. The bias network is designed such that it operates at –60V to cutoff the tubes until the transmitter is keyed. When that occurs, the keying relay, in series with a 22 ohm resistor, ground the bottom half of the bias supply. This decreases the bias to –24 volts. I raised the value of the series resister to 68 ohms and the operating bias rose to 32 volts, which was just enough to cool the plates of the modulator nicely while maintaining Class AB1 operation at the 25 watt power level. Finally, the modulation transformer itself was a multi-tap design. The original configuration was tapped for 3800 ohms PA plate impedance. This was re-configured for the new design value of 2700 ohms.

With all the changes made, then audio was checked for response and distortion. The first thing noticed was a roll-off that began at nearly 800 Hz. Replacing the cathode bypass capacitor in the 6V6 audio driver with a 100uF / 150V unit cured that.

Measured Audio Results

The audio response was now –1dB at 200Hz, referenced to 400Hz., +0.5dB at 1kHz, and +1dB at 5kHz. It was –6dB at 100 Hz, which I am still working to reduce rolloff. Finally, it was –3dB at just over 10kHz.

Measured distortion was exceptionally good for this type of transmitter; the transmitter performed as follows:

Mod	100Hz	400Hz	1kHz	2.5kHz	5kHz.	7.5kHz
25%	1.7%	0.9%	0.9%	1.1%	1.3%	1.4%
50%	1.9%	1.1%	1.0%	1.4%	1.6%	1.7%
75%	2.2%	1.3%	1.3%	1.7%	1.8%	1.9%
95%	2.8%	1.4%	1.5%	1.9%	2.1%	2.3%

It was clear that, other than the rolloff and distortion at 100Hz and below, the transmitter was operating quite nicely. It is unclear whether the low frequency distortion is due completely to saturation of the iron (the input transformer, the grid-coupling transformer, and the modulation transformer) or whether at least some of it is due to insufficient bypassing / regulation of the modulator screen voltage. This will be tackled in the future.

In my station, I use a variety of modified broadcast audio processing for speech compression and limiting. In the case of this rig, I intend to use a CRL MBL-100 HF processor which I was involved in the design of with Gary Clarkson, Vice-president of Circuit Research Labs, Inc., of Tempe, AZ. About 75 of these units were sold to Radio Free Europe and Radio Liberty in the late 1980's to increase coverage through high density audio processing. Radio Australia and others also purchased these units for the same purpose. Later, a special output filter that was 7.5kHz wide was developed for this processor so that it could be used at News / Talk AM / MW stations around the world. This unit is still being sold as the Amigo NewsTalk by CRL / Orban. I built a special ham radio filter for this unit – a 9th order elliptical lowpass filter with overshoot correction which cuts off at 2.8 kHz. I designed the filter specifically for AM phone use in the ham bands. The output filter compliments the input 5th order filter that removes voiced energy above 3.0kHz prior to compression and limiting. That processor will be visible in the pictures that follow.

During final configuration and tune-up prior to putting the rig on the air, I also determined that I wanted to keep the original 1 amp RF ammeter. Ohms Law teaches us that 1 amp into 50 ohms (I2*R) is 50 watts. The problem is that as the rig is modulated, additional power is developed. Remember that a 100% modulated AM transmitter operating at 50 watts of carrier, produces a 200 watt PEP output at the crest of modulation. Assuming a sinewave modulation term, 70.7 watts of average power will be delivered to the load; about 1.2 amps of RF line current – pegging the meter. There were several solutions to this: 1) Add a shunt resister across the meter to reduce it's sensitivity, 2) Replace the meter with a different movement, 3) Reduce the output power, or 4) Change the output impedance. I chose solution 4. A small toroidal transformer was wound to step a nominal 50 ohm antenna impedance up to 75 ohms. The Pi-L output network was modified slightly to match the 1350 ohm plate impedance to 75 Ohms, and the line current at carrier is now 0.82 amps, rising to about 1 amp under modulated conditions.

Final Testing and On-Air Results

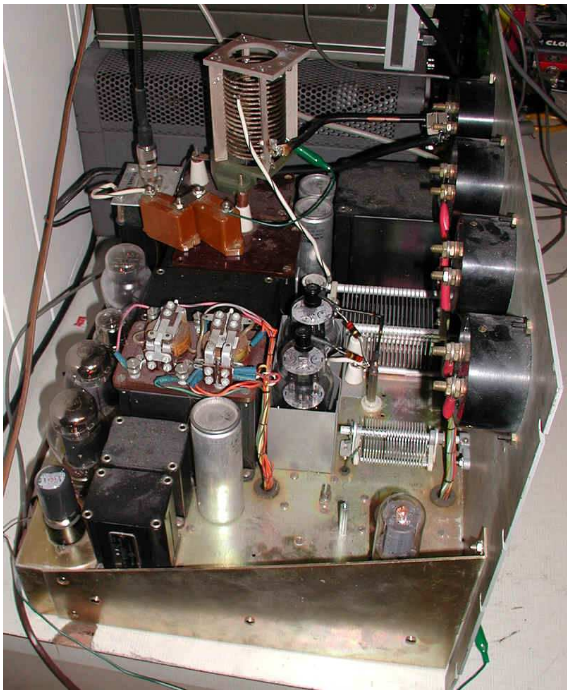
The unit was put on the air and reports from stations contacted proved the rig was working splendidly. The audio processing, while not as natural sounding as uncompressed speech, did increase the average audio level significantly. Nobody found the audio annoying or distorted in nature; the single critical comment was that it was a bit thin due to the low frequency roll-off in the transmitter itself. Since AM is a linear system, any additional modulation power directly and linearly impacts received signal to noise ratio. Unprocessed speech has a peak to average ratio of 12 – 20dB, depending upon the individual speaking. The modified MBL processor reduced my peak to average ratio to a mere 6.5dB – a gain of at least 6dB signal to noise in the field. Translated into power output, I would need to run a 200 watt carrier power transmitter (800 watts PEP), to get the same average SNR at the receiver as my 50 watt rig is currently producing with the audio processing unit.

The operating parameters were as follows:

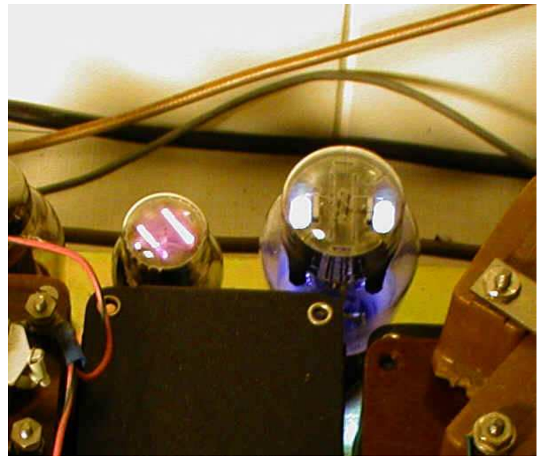
Plate Voltage:	465 volts
Plate Current:	160 mA
Plate Input Power:	74.4 watts
Output Power:	50.4 watts
Plate Efficiency:	68%
PA Grid Current:	6.8mA
RF Line Current:	0.82 Amps (75 Ohms)
2nd Harmonic:	-54dBc
3rd Harmonic:	-68dBc

The TDD-5 unit putting 50Watts of carrier into a dummy load antenna. Output RF ammeter indicates 0.82Amps due to the 75 ohm output impedance; the measurement point prior to the output torroid transformer (75 – 50 Ohms). The RF current read must be multiplied by 1.22 to get the actual RF line current into 50 ohms. The RF line current is actually 1 amp, thus 50 watts.

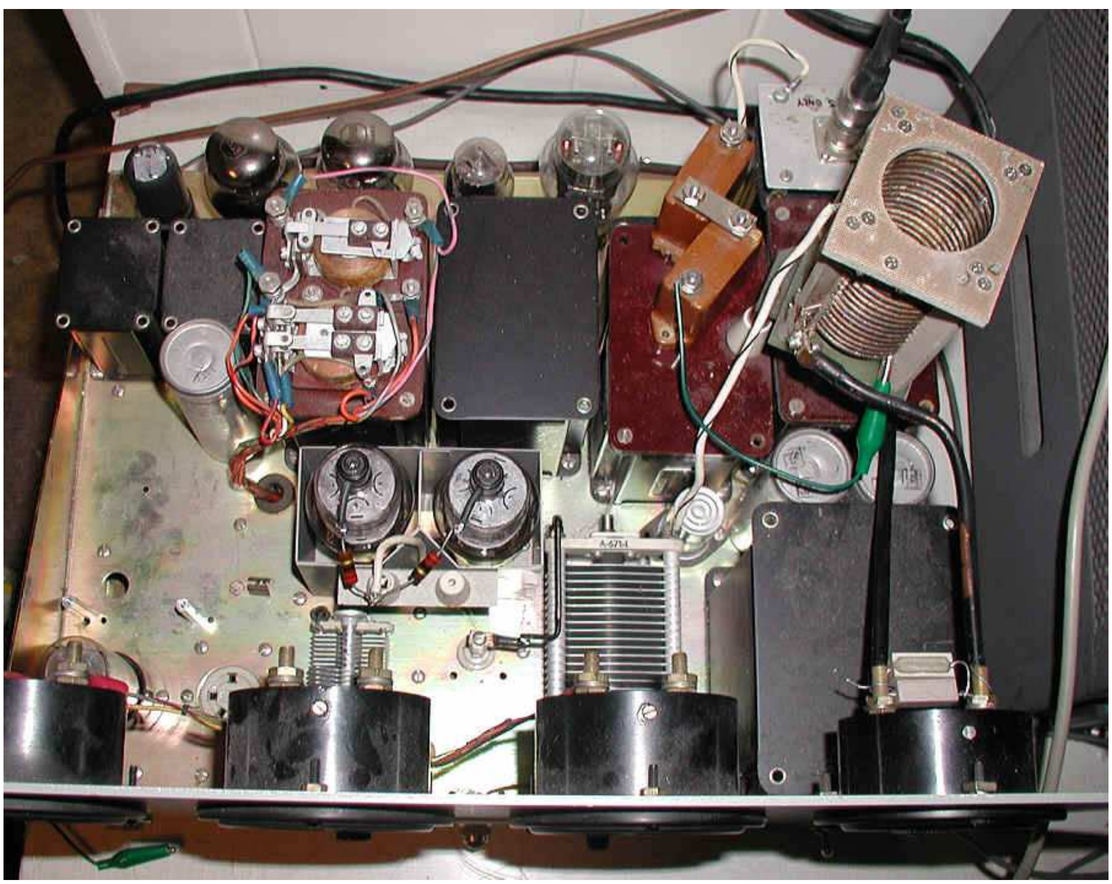
Here is a photograph of the meter panel with 100% sinusoidal modulation applied.



Side view of the transmitter with new
Output network at far end.



0D3 / VR150 voltage regulator and
Type 83 Mercury Vapor HV rectifier.



Top view: Along the back from left to right – 6V6 Audio Driver, pair 6550 modulators, VR150 / 0D3 Modulator screen regulator, 83 HV rectifier. Far left front – 6L6GT Crystal Oscillator / RF Driver, middle – pair of 807 RF power amplifiers. The output network has since been cleaned up; the coil is mounted horizontally and the fixed loading caps are also bolted directly to the chassis.

Name / ID plate on TX.

Sinewave 75% modulation through entire system, audio processing on top of scope.

Special 3.2 kHz audio output filter board in MBL audio processor unit.