Another Simple Quick-Build AM Transmitter for 40m

WO1U October 2018

Background (Why?)

The reasons for this build:

1. To prove a couple of needed revisions to the previous design. It is not intended to be 'the greatest transmitter ever built' or necessarily better than other approaches. It is just one of many purpose built designs to evaluate a particular parameter.

2. The design features I intended to prove out with this are: A) an even lower cost, "bag of hammers" simple modulator <u>for use with an external stereo power amp</u>; and B) a very simple to build and low cost Class D RF stage, hand-built on a small piece of blank 0.062" thick double-sided FR4.

3. This is an update of a design I did in 2012, in which I used a **ridiculously** over-sized transformer in the modulator, and used an H-Bridge VMCD RF deck on 75m. I built this one to test the merits of using a $36.00 300VA toroid power transformer as a modulator instead of that monstrous 1KVA behemoth transformer. In addition to being cheap, small (only 4.5" across) and wide bandwidth, the transformer's 300VA rating has proven to be adequate for a legal limit transmitter even though this build is about ~125W carrier. Considering the old rule of thumb for high level AM modulation, audio power rating needed (RMS_CW is the typical denomination) is about ½ the carrier CW power. With a 375W carrier, a modulation transformer would need to be rated just under 200W. Since transformers are rated in terms of continuous power, 300VA should be more than adequate. It certainly is for this PW 125W rig.

Interestingly, two forum commenters that read the 2012 article were critical of using transformer coupled modulation vs. their preferred PWM series modulation. Both those two commenters are apparently in the business of selling PWM modulators. For the record, PWM is not "the only way forward". It might actually be by many measures, better than what is presented here and in the previous article, but not by cost, simplicity, and time to build. Critics seem to have missed a couple glaring mistakes with the 2012 article, and I have corrected those here and in this build.

This one uses a simpler, more reliable RF Deck, a much smaller, much cheaper modulation transformer, and it corrects a couple of downright stupid things I did in the previous design, corrections such as adding a diode in the modulation coupling to the RF Deck, and including *SOME* modulation filtering (No more "Slop Bucket Eliminator" Mode).

What is this thing exactly?

It is basically a box containing a Vdd power supply, a high level Vdd modulator, an RF Power Amp, a low pass harmonic filter and a T/R bypass relay. Operating it requires an external audio amplifier, and a

5-10W ham transceiver to be used as an external carrier exciter and AM receiver. The idea is to connect a rig like the Elecraft KX3, and a 75W or more external audio amplifier, plug it all into 120Vac and transmit reasonably high quality AM on 40m. It is bypassed in receive mode and connected like a linear amplifier in transmit. The exciter is used in ‘tune mode’ to generate a drive carrier. I built it up in the same 19” 3U housing I built in 2012, using the same T/R switch, but I used a different power supply (isolated this time), a smaller modulation transformer, additional base-band filtering, different RF deck, added a minimal but effective over-modulation indicator, and an off-the-shelf LPF.

What’s so great about it?

Nothing really, except that: 1) It works reliably and efficiently. 2) It’s easy and quick to build. 3) It’s cheap. 4) It’s flexible and can use any available external audio gear and RF deck you have laying around. 5) It is capable of very high quality TX audio if good audio gear is used.

Ok, so how does it work?

The schematic and pictures below and the following blurb describes it in detail.

The modulation transformer (Xfmr 1 in the schematic) is the heart of this transmitter and the whole reason for doing it. It is an Antek model 3236 available for $36.00 here http://www.antekinc.com/an-3236-300va-36v-transformer/ It weighs 7 lbs and is 4-1/2” in diameter. Rated at 300VA it is capable of supplying enough audio to modulate a legal limit RF Deck. I intend to scale up the RF Deck to prove this out in another version (presently under construction). I use a Crown XLS1000 audio amp in bridge mode connected to J2. The mic I use with it is an AKG P120 studio mic and the preamp is a dBx-286 broadcast voice processor. The dBx provides 48V phantom power for the mic, enough gain to drive the Crown amp, compression, 2 band EQ and a soft-transition noise gate. IMO a perfect setup for AM speech processing.

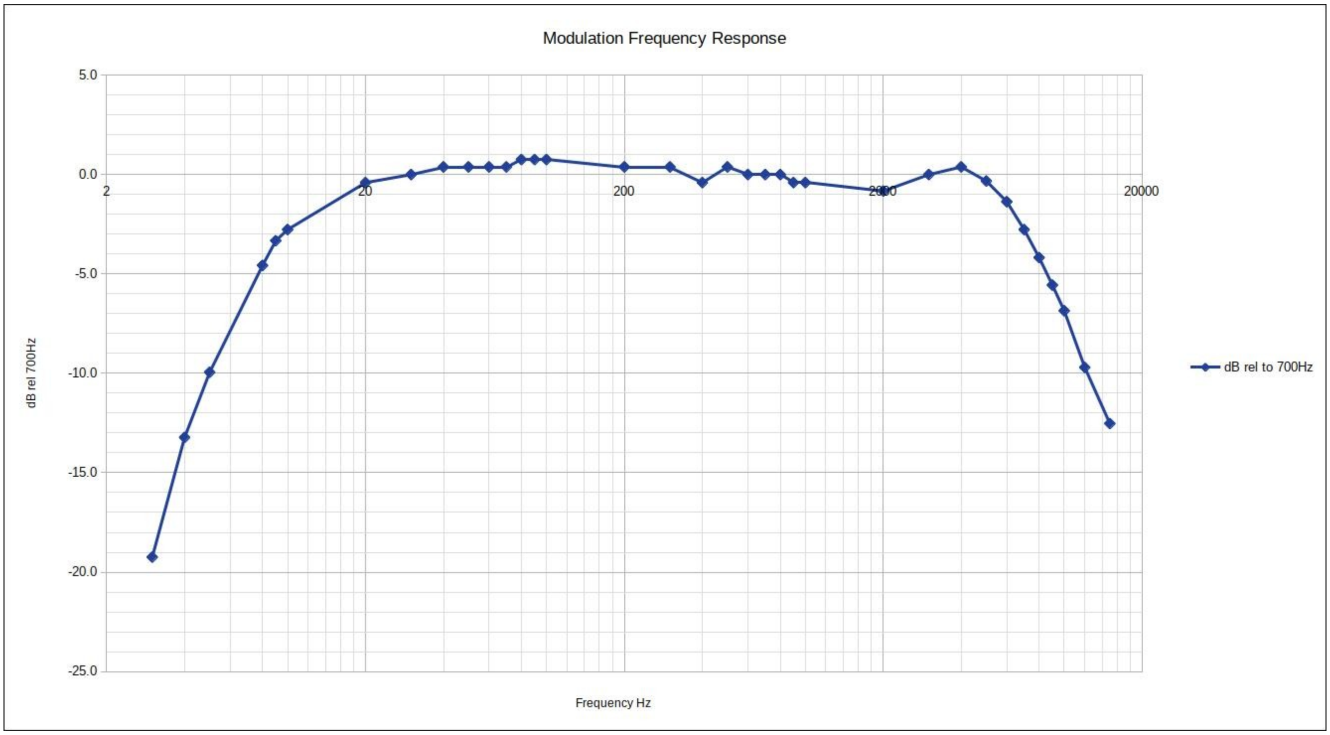
Audio Filtering:

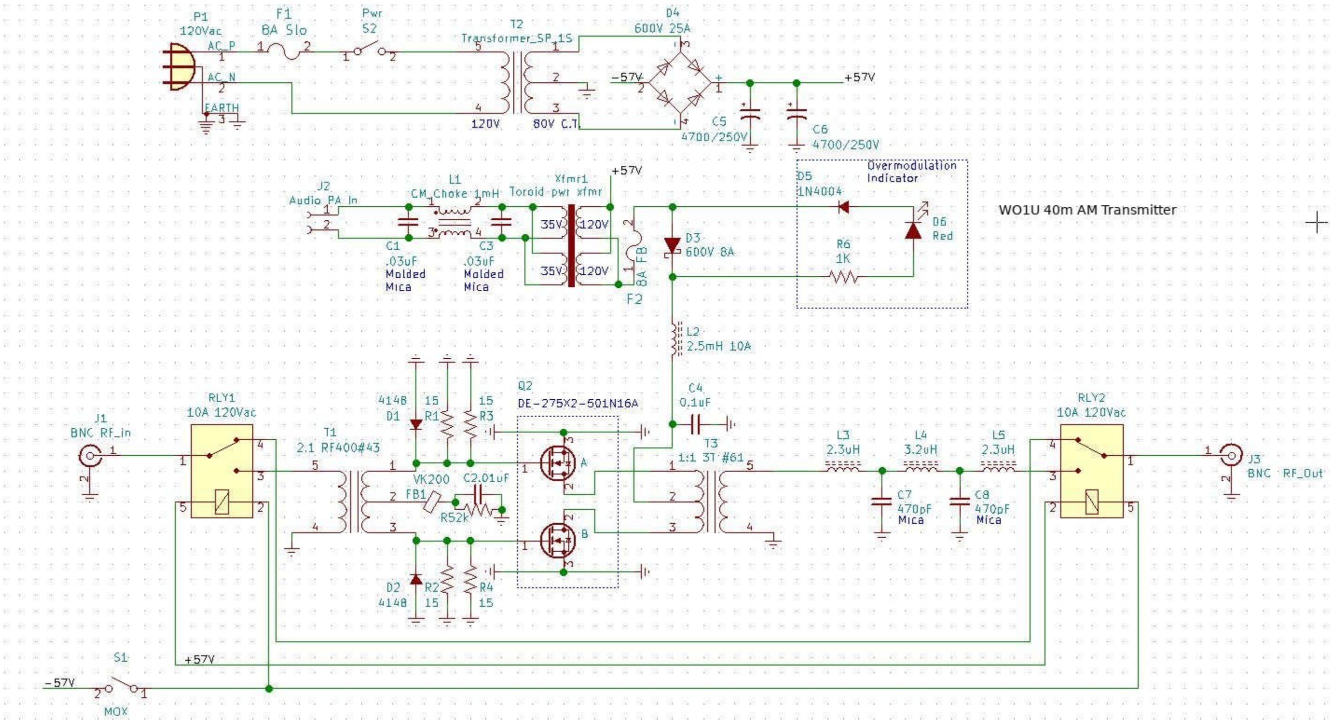
Audio power goes through a common mode choke filter wound on an FT225-77 ferrite toroid with #14 AWG solid. Inductance is approximately 1mH each winding. Windings are opposite direction to attenuate common mode and differential mode RF ingress and egress to and from the box. The corner frequency is set to 15kHz to further reduce the 375kHz switching noise from the Crown amp, also to keep 7MHz RF from getting out and beating up the filter in the Crown. The filter also softens the pulse edge that occurs when the carrier is cut and the drop in current to the RF deck propagates to the audio amp through the modulation transformer.

Modulation is fed to the RF deck through an 8A Schottky diode, D3. When modulation exceeds 100%, e.g. the audio signal tries to swing negative, D3 prevents the RF output device body diodes from going into conduction. This was the reason for the issue I had mistaken for core saturation in the 2012 article. A red LED is connected across D3 such that when the Vdd line goes negative, it flashes indicating over-modulation. An additional low pass filter in L2 and C4 keep the modulated signal from getting too wide, having a -3dB corner frequency just under 7kHz.

The frequency response of the Vdd as measured at the top of C4 is shown below.

The 3dB points, relative to the 700Hz value are 9Hz on the low end and 7kHz on the high end. The response at 700Hz seemed to be the flattest mid-band point and was chosen as the reference for the response curve. This response is very reasonable for avoiding “yellowy sounding audio” indeed! Not bad for a $36 modulator. Ok $50 with the filters. Still, PWM would be hard pressed to compete with the cost and simplicity of this, at this performance level. And the switch-mode spurs are **much** lower.





Schematic

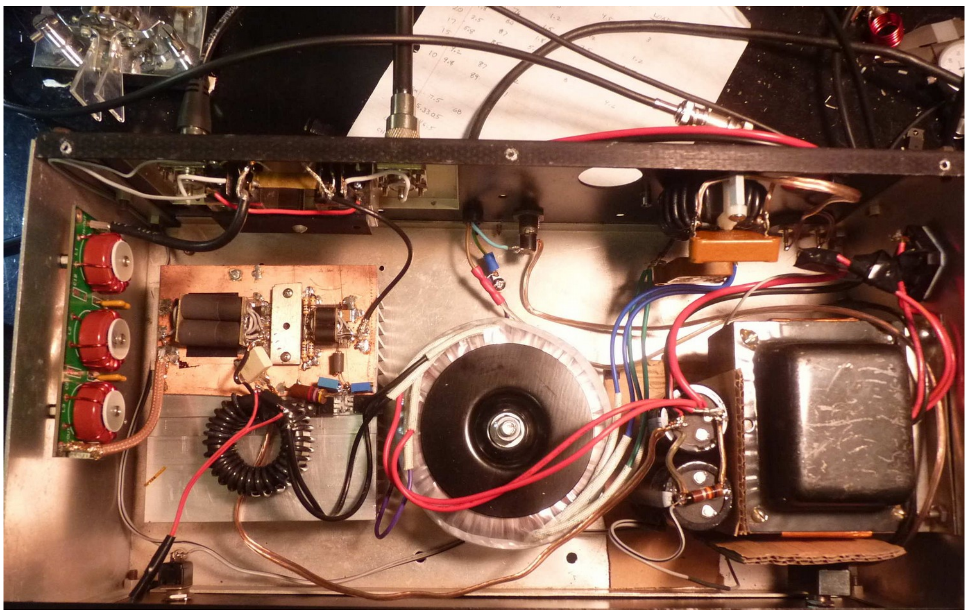
The power supply is a straightforward full-wave center tap type connected for bipolar output. The +57V Vdd is very well filtered. The -57V rail is only used for the relay coils so it has no filtering.

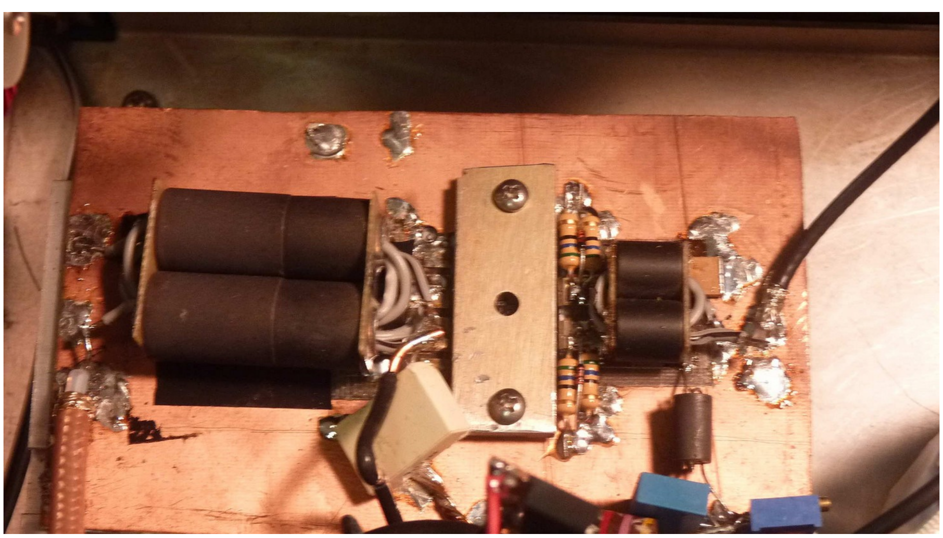
The amplifier is a very straightforward solid state Voltage Mode Class-D stage, based on the DE275X2-501N16A. The two-transistor device is $33 each at 1 piece and has a total dissipation rating of 1180W. https://www.digikey.com/product-detail/en/ixys-rf/275X2-501N16A-00/275X2-501N16A-00-ND/6805172 It does not require an insulator at the heat-sink which is very nice. Also unlike common RF power transistors, it uses no beryllium oxide which can be quite toxic. T1 steps 50 ohms down to 12.5 ohms to drive the gates. These FETs are essentially the same die as used in the 2012 amp transistors except they are in an RF friendly package, which reduces the stray package inductance and extends the usable frequency range. Diodes D1 and D2 are specific to non-linear amps and improve the peak gate drive voltage per watt of input. R5, 2k ohms provides the zero bias reference point. These gates can temporarily withstand +/- 30V without damage and +/- 20V continuously. With a 4:1 input transformer (2:1 turns ratio) this equates to surviving hitting it with 70W by accident or driving it continuously with 30W. No need though, they saturate very nicely with 5W drive thanks to D1 and D2. The output transformer is of typical construction with #61 ferrite. There are many of these available cheap surplus recovered from illegal CB amplifier manufacturers that were shut down by the FCC. Mix #61 ferrite is not ideal for the lower bands but with 3 turns there is adequate inductance for 40m and up and the saturation flux density of #61 is better than #43 material in this size. The brass tubes in the primary are not used. Anyone building this amplifier for lower bands should use #43 or #77 ferrite transformers. The windings are actually 1:4 with 1-1/2 turns on the drain side per device and 3 turns on the antenna side. The schematic says 1:1 which is incorrect and I'm too lazy to fix it.

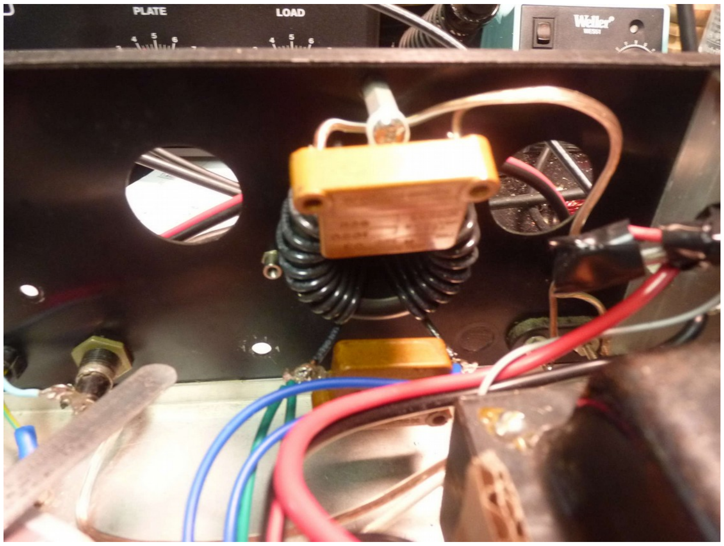
The LPF is an off-the-shelf unit from Communication-Concepts Inc. http://www.communication-concepts.com/fl1-40/ Harmonics are -50dBc.

Performance is nothing spectacular in terms of output power. In a linear amp built with this device I have hit 500W PEP output, so 125W carrier is just about right for AM. The amp stays stone cold but the LPF gets a little warm after long winded buzzardly transmissions. This transmitter’s bigger brother (under construction) will have a much more robust low pass filter constructed with T200-6 coils and molded mica transmitting capacitors.

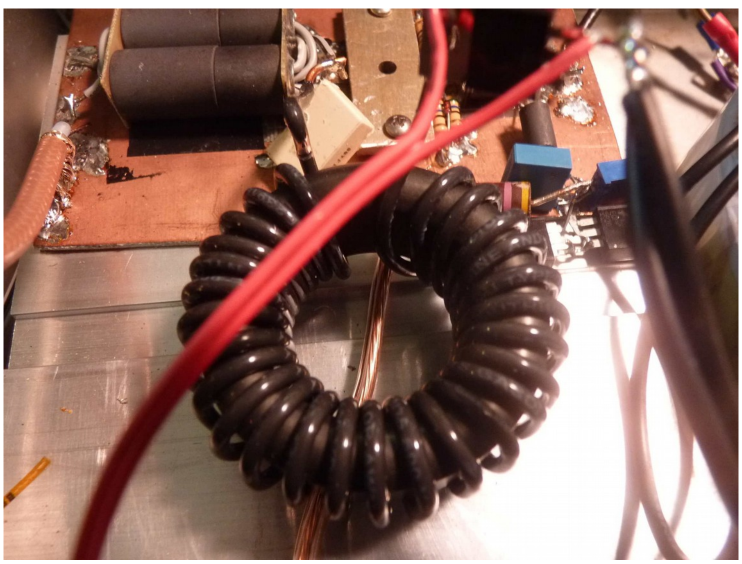
Here are some pictures of the construction (yep it’s ugly, but hey it does work!)







Common Mode Filter


Modulation Filter