Warning! Improperly designed tetrode amplifier ahead!

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This article is written to dispel some of the misconceptions and misunderstandings about some of the tetrode based linear amplifiers, which are currently available on the amateur market. Firstly, the use of swamped (resistive) input networks is most likely the most dangerous of the design shortcomings. This is done purely as a cost-cutting measure by the builder, but comes at a great cost to the end user in many cases. You will not find this type of input network in any tetrode amplifier designed for commercial/military services, and here are the reasons why:

(1) A swamped input does not attenuate harmonics or out-of-band IMD in any way.

(2) A parasitic oscillation in the output network can and will pass through the swamped input circuit directly into the exciter's PA section or front-end, causing severe damage. (This has been documented in several cases)

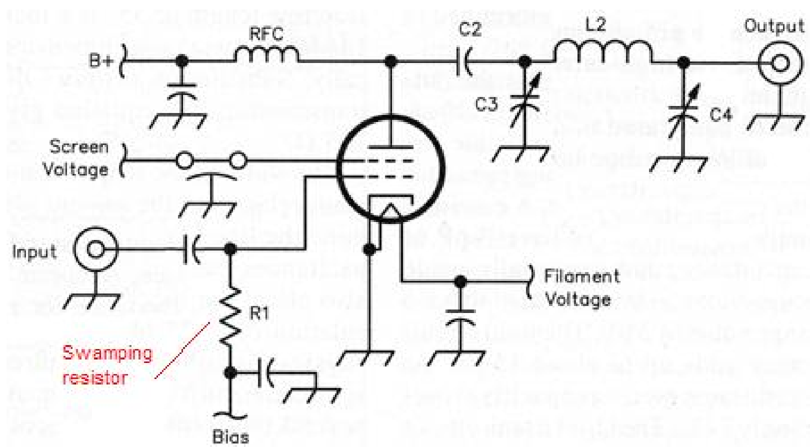
A parasitic oscillation in a tetrode amplifier with a swamped input network is often not noticeable. This differs markedly from a parasitic in a grounded-grid triode amp; these tend to be loud and destructive, but rarely damage the exciter, mainly due to the fact that most triode amps use tuned input networks, which drastically attenuate the VHF/UHF energy of which a parasitic is primarily composed. A parasitic in the aforementioned tetrode amp seldom makes any noise, since the energy is usually contained in the grid signal path of which the exciter forms part. Damage to the exciter can range from a blown-out front-end, to destruction of the PA, LPF, ATU, etc. Depending on when the parasitic occurs, the exciter can be damaged while in RX or TX state with damage to the associated circuits, but not necessarily to those related to the opposite state. Often the tetrode amplifier itself is not damaged, because the VHF/UHF energy is entirely absorbed by the exciter. The user might notice a sudden jump in plate and grid currents, and the amp returns to normal operation, but the exciter sustains damage. Another possible scenario is when the amplifier it first powered up a parasitic takes place un-noticed by the user, and the exciter is damaged. Many times the user does not realize that the amplifier was the actual cause of the exciter damage, and blames the exciter for the failure, when the real blame should be placed on the poor tetrode amplifier design.

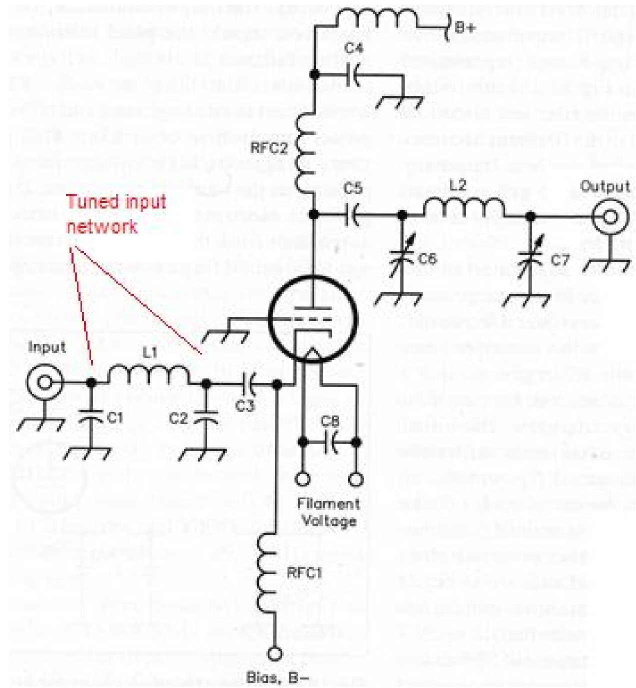
You may well be asking yourself at this point: “I have one of those amps; how can I prevent such damage to my exciter?” Here is what can be done; Place a simple TVI-type low-pass filter between the exciter and the amplifier input. If the filter has at least 5 poles and a cutoff frequency (-3 or -6 dB point) of 30-50MHz, with at least 70dB of attenuation, it should do the trick.

From the author’s perspective, the best (and safest) solution is still the well-proven grounded-grid triode amplifier with band-switched, tuned input networks. These amplifiers are available new and second-hand, from a variety of manufacturers and at many different power-output (and price) levels. The enterprising and technically savvy Ham can even build his own; there are many design articles in the amateur radio literature, and also on the Internet. Don’t let the cheap cost of tetrode tubes (mostly from Russia and China) be an expensive mistake when it takes out parts of your exciter, due to a poorly designed amplifier circuit.

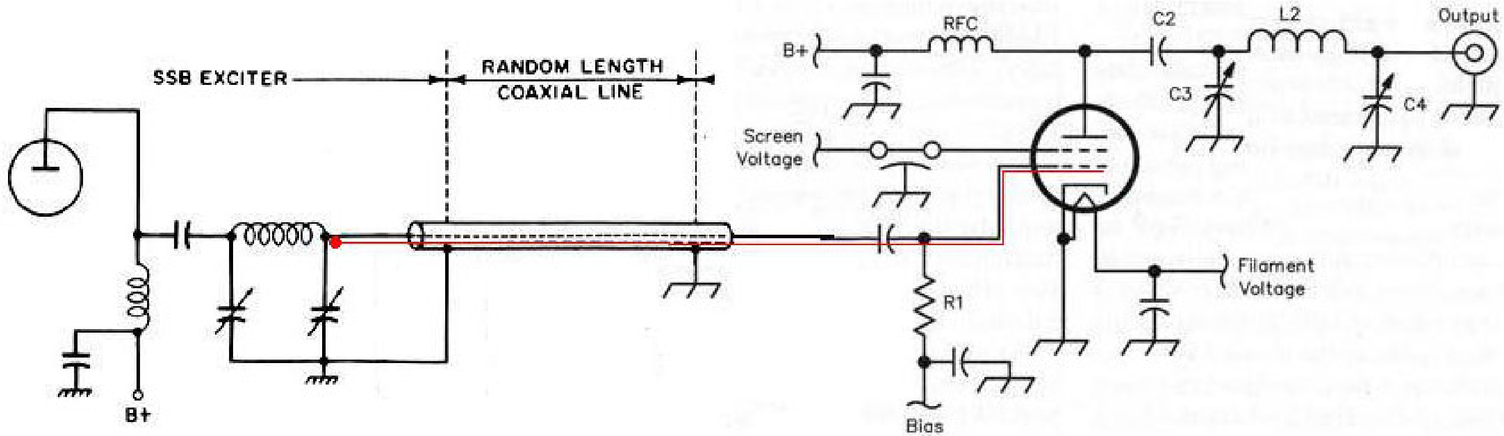
Below, are representative circuits showing the swamped input tetrode amplifier on the left, and a grounded-grid triode amp with tuned input network on the right.

Cheap tetrodes, perhaps not, the damage they can cause might be very expensive.





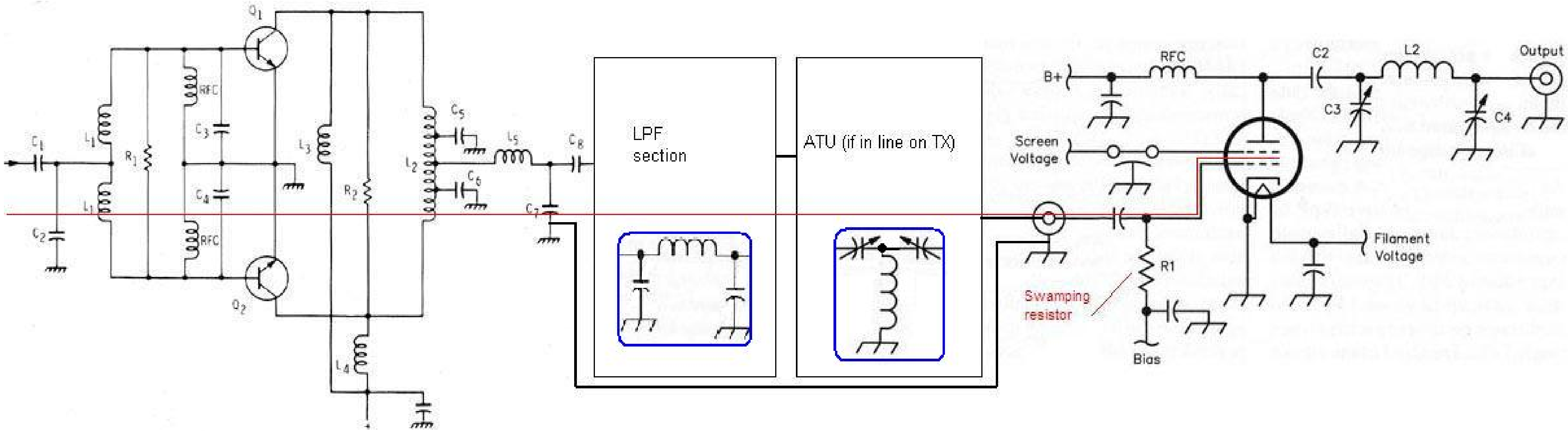
"Why are solid-state exciters vulnerable to parasitic oscillations with a swamped input tetrode amplifier, and not my old tube PA exciter? "
A tube-type exciter PA has a tuned output network that acts as an input network when connected to an amplifier that does not have a tuned input network. Below is a representative schematic of such a station configuration.



The red line on the schematic represents the energy path of a VHF parasitic when the system is in TX mode. The VHF energy encounters a high RF impedance in the tuned output network of the exciter and is effectively stopped. One reason why these older SSB exciters did not suffer from RX front-end damage very often from such a parasitic is that they tend to have much more robust devices in the front-end, and the T/R change over times are much slower, and the parasitic event has dissipated long before the exciter has returned to RX mode, and the PA does not suffer damage. Having more robust devices in the RF front-end is not necessarily better, because these devices had lower gains and higher noise and IMD levels than those of devices used today. The older devices tended to be vastly over sized, drawing much more power than the devices used today as well.

The tuned networks of tube-type PAs are very narrowly tuned due to the high working Q, and are therefore sharply tuned within a given band, they resist firmly, RF above or below this narrowly tuned range, and pass all RF that primarily falls within the tuned range. This is why the tube-type PA can withstand such a parasitic event that can be generated by the swamped input tetrode amplifier.

Below is a representative schematic of a system with a fully solid-state SSB exciter with ATU and a tetrode amplifier with swamped input.



The red line in this schematic represents the VHF parasitic energy path. Since the solid-state PA section is a broad-band network it presents a low RF impedance to VHF energy and the parasitic is free to pass through many parts of the circuit and do damage. Common forms of damage are: shorted capacitors, arced relay contacts, burned resistors, and dead semiconductors. The system above is shown in TX mode. If the system were shown in RX mode the likely damage would be in the RF front-end of the exciter to the active devices and coupling capacitors.

If the ATU is actively in the TX signal path when a parasitic event takes place, it will likely be the first section to get damaged. If the ATU is off-line, the LPF is the next section to likely sustain damage. Once the LPF is damaged, the SWR presented to the PA can likely cause the PA to be damaged since many exciters do not have an SWR detector between the PA and the LPF sections, the SWR detectors are usually located between the LPF section and the ATU.

Again, the safe way to use these types of tetrode amplifiers is to place a low-pass/TVI type filter in the coax line between the exciter and the amplifier. Often a low-pass filter is placed at the output of the final amplifier, to reduce TVI, and the input of the amp is often overlooked., this is one more reason to add a filter here.

One of the reasons why we are seeing more of this type of damage is due to the rising popularity of the cheap Russian and Chinese tetrode tubes and the amplifiers designed only for the amateur service that use them, and less use of the hybrid tube PA exciter.