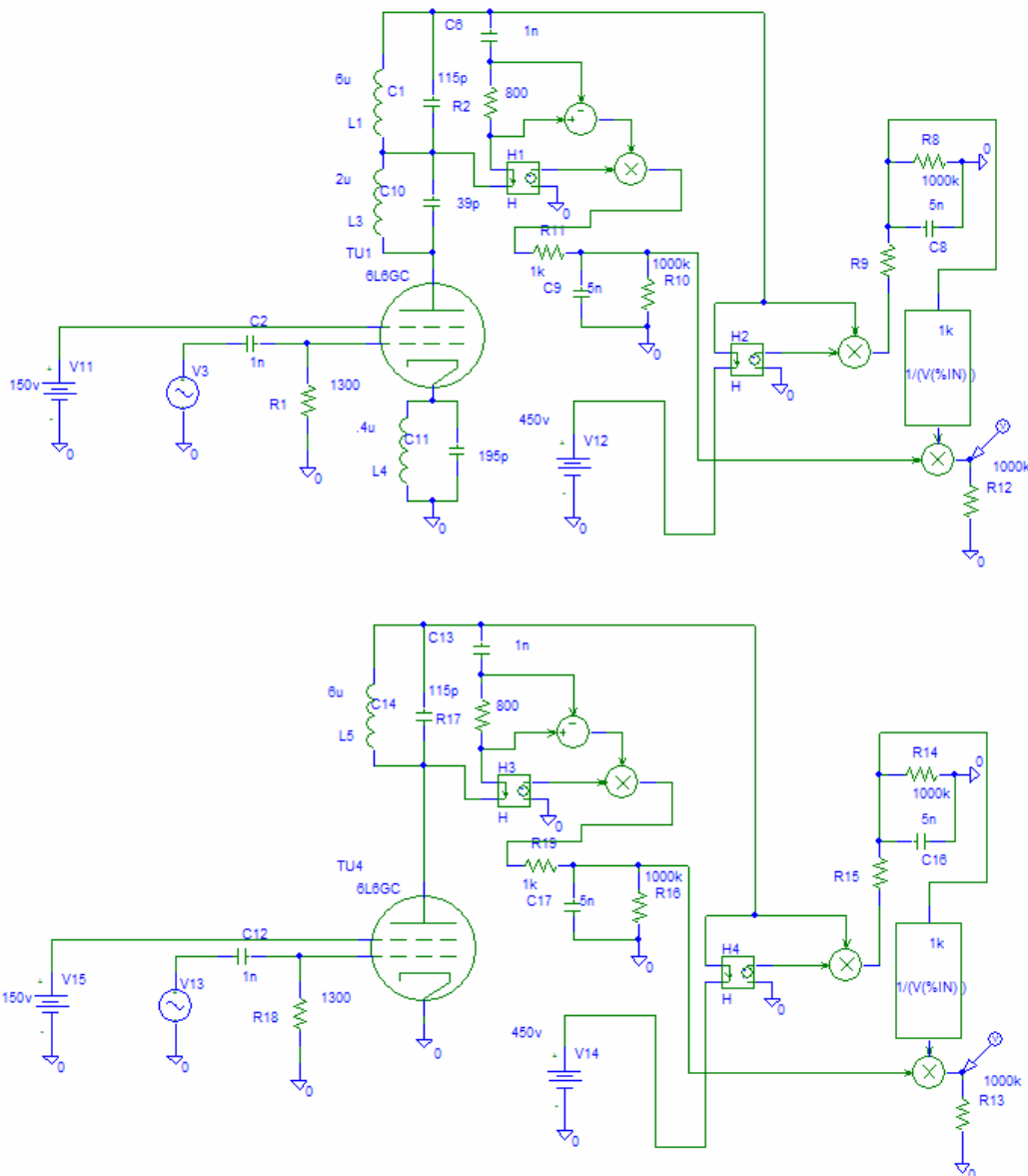


INCREASING THE EFFICIENCY OF TUBE CLASS C AMPLIFIERS “F - PI NETWORK”.

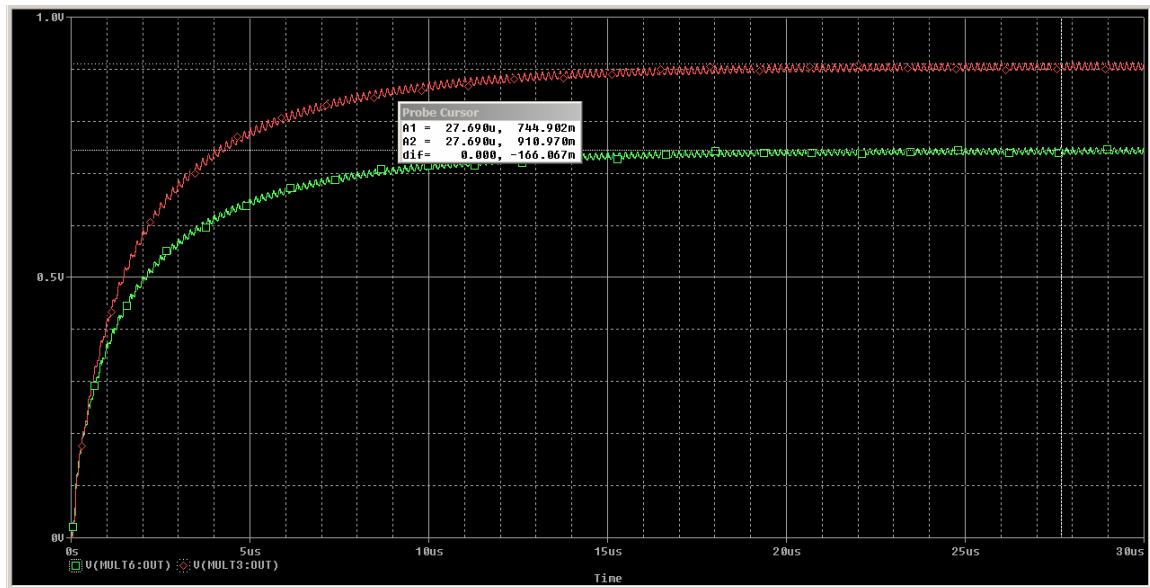
IN3IEX – Giorgio September 2011

Let's consider two slightly different class C amplifiers. The first one has a couple of parallel resonant circuits on the third harmonic at the cathode and the anode (18 MHz, being f out 6 MHz). The second one is without them. We perform SPICE simulations. ABM elements allow the calculation of the ratio between output Power and input Power.



In the next page the report of the efficiencies:

This is the efficiency as a function of setup time. Look at the asymptotic values.



The efficiency with 3rd harmonic circuits is 91.1%, without them it is 74.5%.
By adopting only the anode circuit it is 88.2%.
By adopting only the cathode circuit it is 80.5%.

The analysis confirms this 1960 RCA statement.

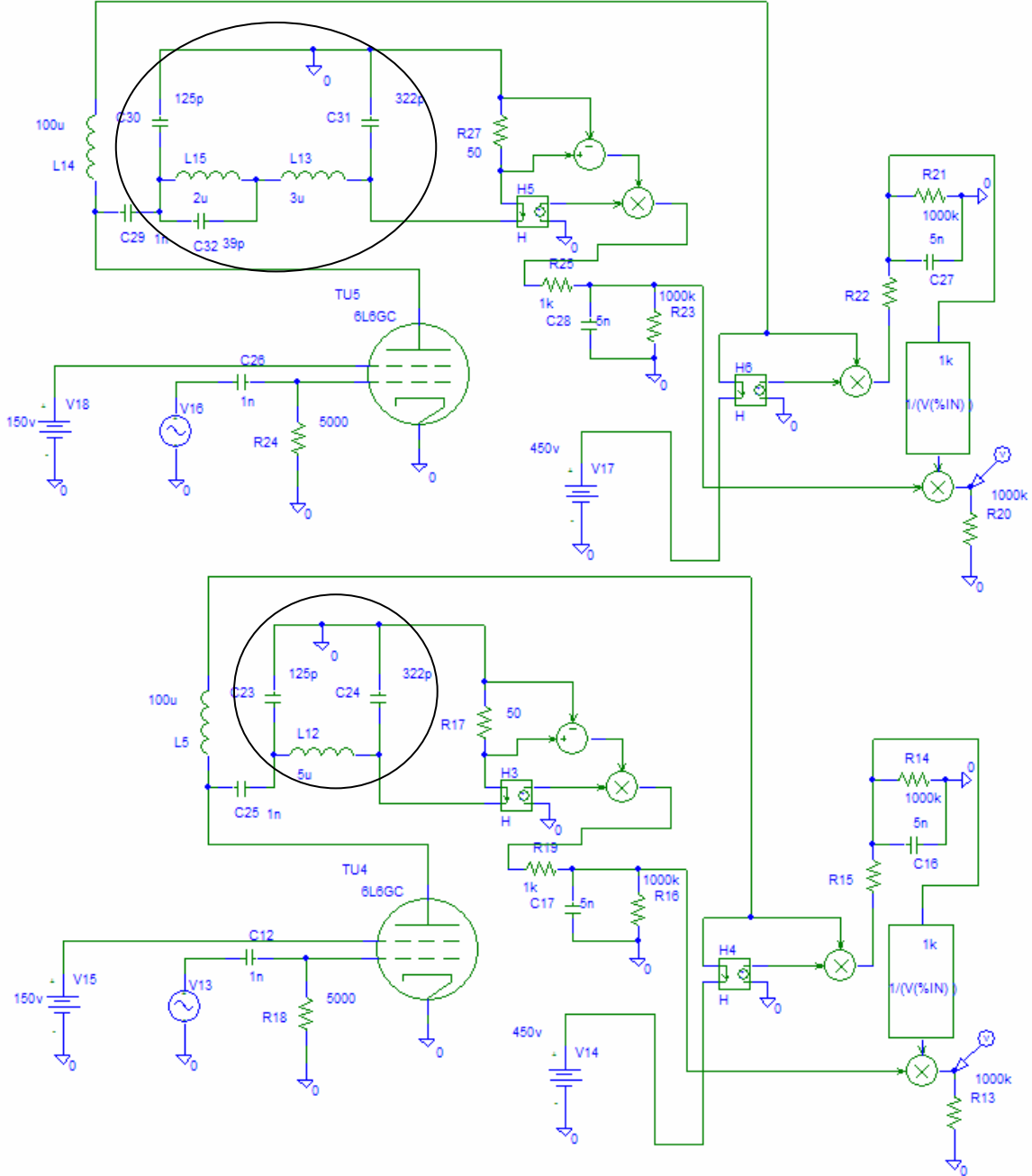
<http://nrctxas.org/articles/bta5t/>

NB: By reducing dissipation in the output tube the available power is remarkably increased. For instance a 6146 with 20W anode dissipation can provide 180W carrier. Without the two 3rd harmonic circuits, with 20W dissipation we get 60W carrier. Moreover 3rd harmonic circuits do reduce 3rd harmonic currents, and the output spectrum is cleaner. This form of harmonic control is known as class F.

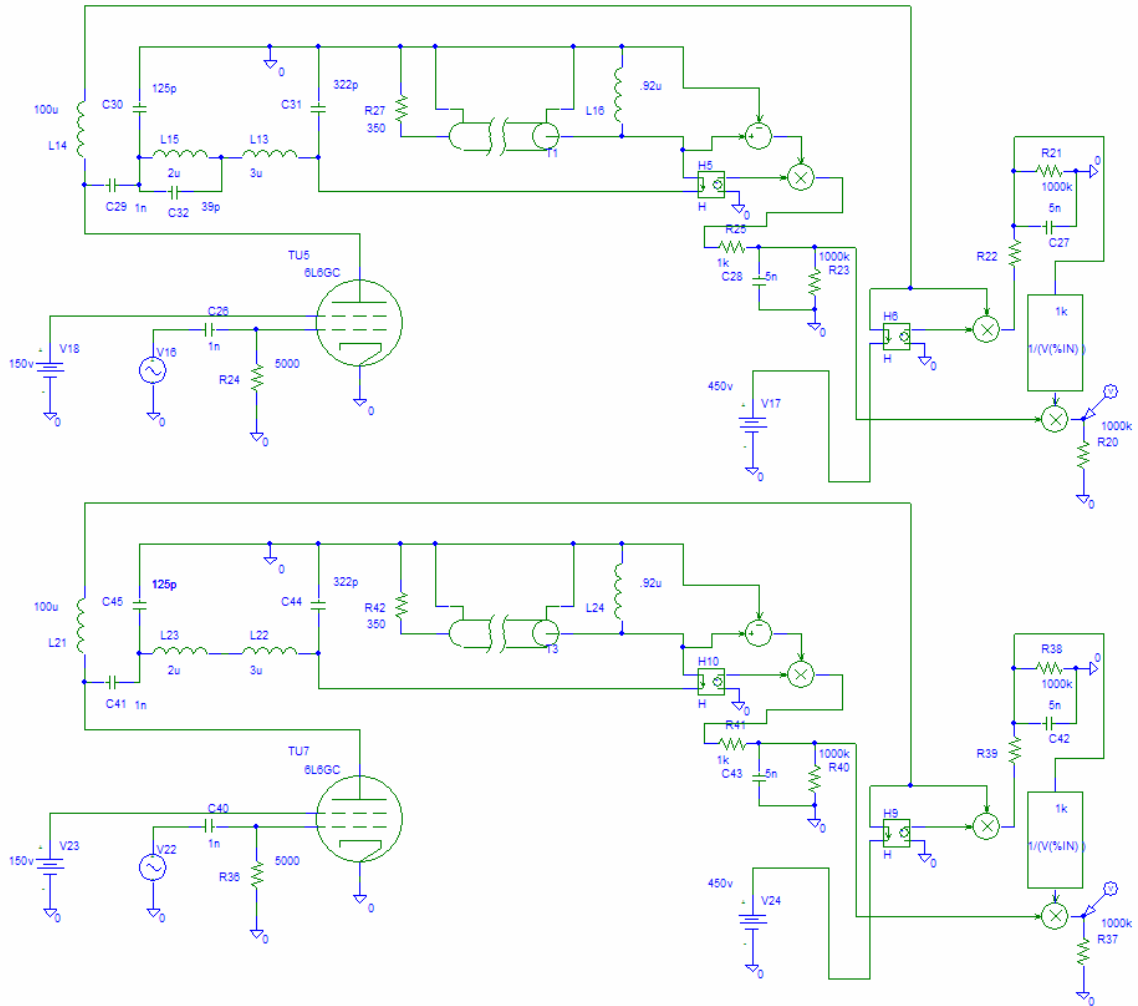
The “F - Pi NETWORK”

The 3rd harmonic anode circuit can be “integrated” in the Pi network of an existing tube amplifier. The aftermarket “modding” ability is the relevant point here.

Please note that in these examples the grid resistance is set to a more realistic 5 kohm, the bare/traditional class C amplifier has 77% efficiency in a circuit matched to 50 ohm as shown in the following figure. By simply adding a capacitor (variable capacitor in a real amplifier) connected to intermediate joints on the Pi inductor, the efficiency increases to 86%. I suggest ~1/3 of the coil. The “sub-resonator” resonates at the 3rd harmonic.



To estimate the efficiency of the amplifier connected to a real antenna we now adopt a load that exhibits $50-j0.2$ ohm at 6 MHz and $236+j47$ ohm at 18 MHz (3rd harmonic), the transmission line delay is 9.893 meters at the speed of light and the characteristic impedance is 71.61 ohm:



We obtain 78% efficiency with the usual Pi network, and 85.6% with the modified Pi network.

The modified Pi network keeps its functionality as expected; we also observe that the antenna itself can increase the efficiency of the class C amplifier if it presents high impedance at the 3rd harmonic. On the other hand a “collaborating” antenna is not so effective as the resonant circuit we are discussing because most of the 3rd harmonic current in the traditional Pi network circulates through the load capacitor (output capacitor) of the Pi network.

Send comments of your experience to fontana@science.unitn.it. I will keep this page updated.