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RF Notes #41

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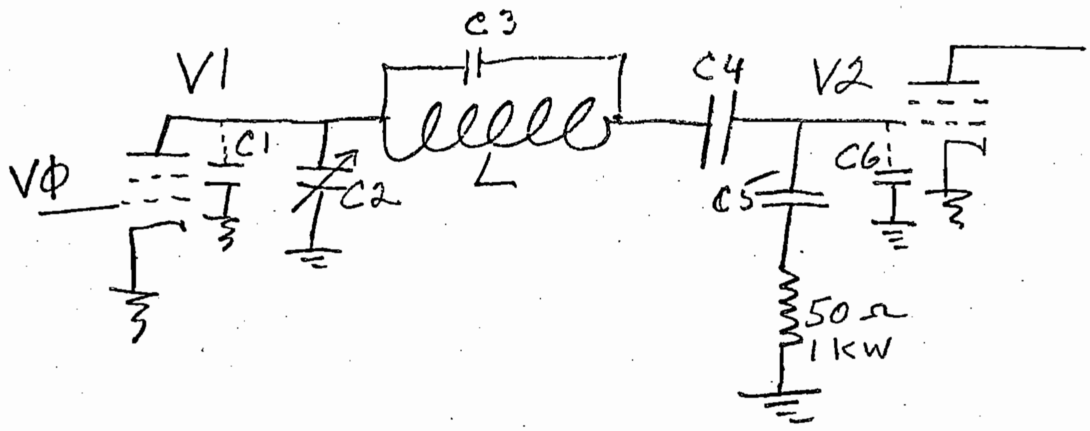
Driver Circuit Problems

Below is a diagram of the driver ckt.



C1 = driver anode capacities = ∿48 pf
C2 = vacuum variable = ∿50 pf
L ≙ the variable inductor which resonates the ckt
C4 = blocker = 2800 pf
C5 = " = "
C6 = final grid cap≃ 500 pf.
C3 = distributed cap across L, which we calculate to be about 5 pf.

Now at a sufficiently high frequency (60 mHz) the Q of this ckt is >15 and V2 = -V1/5, which is what we designed for, and we thought very little about what happened at 9 mHz. However, measurements showed that at 9 mHz the phase of V2 with respect to V1 was not 180^o, but 180- 45.

So we wrote a little computer program and calculated everything, and sure enough the phase of V2-V1 was 135^o, and also the voltage ratio V2/V1 was 1/7 instead of 1/5, the ratio of C6 to C1. The circuit Q was 2.5.

So, whereas we previously were contemplating using the phase difference of $\phi_o - \phi_2 = 0$ as the criterion for adjusting L, it is now obvious that we must monitor V1 directly and use the criterion $\phi_1 = -\phi_o$. So we install a V1 monitor! The phase of V1-Vφ varies in the normal manner as the frequency is scanned over the regime of the universal resonance curve, but the phase difference between V2 and V1 remains a constant 135.

The consequence of this is that, for the fast electronic phase shifter servo system to work properly, a programmed delay (up to 45^o) will have to be inserted in the low devel signal to the driver amplifier for each frequency setting. Thus another black box has to be invented.

Now this is an historical document. The above analysis was done about 2/6/79. Besides the problem of this phase difference mentioned above, there was a problem near 20 mHz where the driver wanted to (and did) become a self excited oscillator at an unknown frequency, for when it decided to self excite various overcurrents kicked it off. Hoping to solve the problem we did three things. First we ordered a different tube socket which, with a solderable alteration to the tube should reduce the feedback capacity. The results of this won't be apparent for a month (until the socket arrives). Next, we cut the unused 3 top turns off the grid tuning inductor, and third, we added clips so that we could install the just received 1000 Ω 50 watt globar resistors across the three top adjacent turns of the grid tuning coil.

Well, things were better behaved than before; in fact, everything about the driver works as expected over the frequency range 9 to 18 and 22 to 32 mHz. But, unfortunately, in fact exasperatingly, at or near 20 mHz the damned driver wants to self excite at that frequency. This is not quite the same as a parasitic, but still intolerable.

On 2/13/79 the cause was found: the inductance of the .1 μf condenser which was added to the driver screen socket capacity resonated the screen ckt at 20 mHz, thus neither capacitor was effective. So with the usual expertise and efficacy of Don Lawton and crew we quickly made a few modifications. We installed a shield between the anode and the screen grid of the drivers and installed 6 - .01 μf capacitors, each in series with 10 Ω to ground from the screen connector. And turned on!

It was quickly found that this "fix" was not adequate. The damned driver still wanted to self excite when the drive was sufficiently high. Well, we won't belabour the reasoning that went on; it is sufficient to report the "fixes" and their consequence.

First it became obvious that thetube sockets built in screen bypass capacity of 1500 pf was stupidly insufficient and that trying to add discreet capacitors in parallel could only result in resonances (cancellation of bypass efficiency) at some frequency without our range. So we cut out the built in capacitor and installed 6- .01 μf mucon capacitors to ground each in series with 1.5 ohms. This solved all problems. The beedback capacity was now less than .1 pf, neutralization was unnecessary, and the driver purred like a kitten over the entire frequency range. Thus, we feel now that all driver problems are solved, and that we can use the two parallel 4C W 2000 A tubes as originally designed. But this has yet to be proved.

Final Amplifier Tests

On two days we performed hi level amplifier tests into the 50 KW dummy water load, and took voluminous data on knob settings, currents, voltages, etc. Everything was well behaved.

Then, suddenly, on 2/19/79 the water load disintegrated catastrophically. We blew it up! Good. Except we had not completed our data taking. Even so, it is believed that the transmitter is in good shape and will perform satisfactorialy over the entire range. We will install a new water load resistor and complete the tests during the next two weeks.

Anomalous Position Servo Behavior

With the addition of velocity feedback to the position servoes they seemed perfectly behaved. But under a microscope (using the newly received 6 channel recorder) it was discovered that the position of the stem short oscillated between two adjacent wires of the follow pot resulting in a motion of $\pm$ 3 x 10^{-3} inches. This had been predicted by P. Marchand and I now understand it. To solve this problem (maybe it is not a problem, as the fingers probably don't even move) we will replace the follow pots with infinite resolution cermet pots, and, in addition, as will be later discussed, freeze the position in other ways, once we have arrived there. As pointed out in a previous note, $\pm$ 1/4" is a satisfactorily accurate setting of the deestem shorts.

The Dee Stem Motor Drive

We have a design for the "Phase and Position Servoes for Hydraulic Motors." We were just about to have printed circuit cards made because some expedition is required in that we will need 3 of these for the upcoming dee-stem tests (1 month from now) and 1 dual slave position servoe. However we suddenly realize that some more things should be added, and to make sure we are proceeding correctly, it seems desirable to present the overall plan.

The reason for the changes is to:

A. Show the plan for freezing the stem short positions when high power rf is on,
B. To indicate and provide a signal to the controls that the short has gotten to where it is supposed to go, and
C. To clamp the servo amp at zero output.

The sequence of events would be as follows: On the station control panels we add two lights and a switch between the "low level ON" switch and the "RF ON HIGH" switch. Top light lit means it is ok to lock the stem positions, bottom light means they are locked, toggle switch has 2 positions, down means locked (hydraulic fluid to motors valved off), UP means unlocked. An interlock prevents high RF from coming on unless the stem shorts are frozen. Later on the computer can handle all this, but for now, until we gain some operating experience this method will provide safety yet flexibility. Circuit diagrams for the "Phase and Position servoes for hydraulics" and for "Slave Position servoes are shown on diagrams number 5REJ, 3L-E/1 and 5REJ3L-E/2

Driver Tests on 2/22/79

The driver was run over the full range using the two driver tubes in parallel with the new "fix" on the screens. Everything is well behaved, as with one tube, but now we can deliver 450 rf peak volts to the final grid with the tubes running well within their ratings, and with drive requirements of less than 40 volts. This should be sufficient drive power to get 200 KW out of the final.