RF Book

R.F. Note #56

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The Parasitic Problem

Macmillans Modern Dictionary defines a parasite as one who lives at anothers expense. In Arkansas we have chiggers, and mite, which do this, and I don't like them! An amplifier, be it vacuum tube, transistor, klystron, magnetron or backward wave, is capable of being a negative resistance device that can self oscillate. Although these are inanimate objects, obeying the laws of physics, sometimes they seem sentient with a will of their own. but there is a basic underlying principle which they obey, as with sentient beings: they are lazy, and if a given way of behaving involves less work on their part than an alternate behavioral mode, they will always choose the mode that results in the least work on their part. This is Riedel's "Law of Parasitics"!

Brief prehistory of the problem

Prehistory is a story about what happened before yesterday! Prehistory means that the tale of the events is shrouded in possible untruths, lies, misconceptions, misinterpretations, and dreams. Man has a facile memory.

Nevertheless, we proceed as best we can. Fortunately we have a few RF Notes to substantiate some facts. RF Note #41 says that on February 4, 1979, the transmitter was tested for the first time, and at 20 KV B^+ and a dc current of 4 amps, there were no parasitic oscillations, and when this current was modulated over the range 9 to 32 MHz into a 75 ohm 50 KW waterload the transmitter behaved beautifully!

THERE WERE NO PARASITICS

All was well; we obeisced to heaven, thanked HIM and proceeded with tests 1,2,3, and 4, during which time the transmitter behaved perfectly. Note RF Notes # 42, 45 and 46. At the end of test 4 the transmitter stem short burned up and while I was in Arkansas fighting ticks it was decided that, due to a water spill, the tube should be pulled. During this procedure it was discovered that "crud" had intervened between the screen bypass condenser (90NF) and the aluminum 1/2" thick cathode grounding plane to which it was bolted. What is crud?

The crud was removed and the transmitter reassembled. Since then we have had parasitics! God, is all history like this?

In response to H. Blossers "feelings" that something was not only wrong in Denmark but at MSU as well, we installed a special monitor to detect the possible presence of VHF oscillations in the transmitter box. This monitor was a 1/4" diam. copper disk soldered to a BNC fitting on the anode box looking at the anode, so geometrized such as to produce 1 volt into a diode peak detector when the anode had 15KV at 30 MHz. The circuit configuration

associated with this monitor was chosen to make it a dv/dt monitor, and the peak detector was tested up to .9 GHz. After appropriate diode selection (germanium) it was determined that the monitor was good to within a factor of 2 to .9GHz, for voltages larger than .1V.

So we put this monitored voltage into S. Francis' first event detector set to fire at 2 volts. When it fired it lighted a resetable light and turned off the final screen power supply.

At the same time we installed the first of our amplitude override circuits, one that would limit the final screen current to 800 ma. This testing was done at 30 MHz at a 20 KW output power level.

Then we went down to 12 MHz and noted that the tube was neutralized and there was 180° $\Delta\phi$ between the driver anode and the final grid, and we were pleased with our recent modifications. But when we started pushing up towards 50 KW the parasitic monitor repeatedly shut us off. This shut off was accompanied by a large plate current surge (to 10 amps) and a screen overcurrent. The parasitic detector went to 8 volts.

From Chemistry we borrowed a spectrum analyzer good to 1GHz and quickly observed a line at 750 MHz. Then with a signal generator borrowed from Physics and a counter from EE we made some low level measurements and found a resonance in the screen flange at 750 MHz. We had previously noted that the parasitic produced a high voltage at the screen by connecting a NE2 neon bulb to it and noting that this lighted up when the parasitic appeared.

We therefore assembled a second screen bypass condenser and measured that it had a radial mode at 375 and 750 MHz, corresponding to $\lambda/2$ and λ modes. The Q was 100, the Q of Kapton and the shunt impedance was 1 ohm, corresponding to the calculated characteristic impedance of .005Ω, λ mode and Q of 100.

We endeavored to find resonances in the anode and grid circuits, but with confusing results. It is difficult to make measurements at 50 MHz! And I have very little experience in this frequency range. We found modes at least every 50 MHz between 400 and 900 MHz, but their significance eluded me.

So we tried a few things calculated to quench the parasitic. First, we installed $\lambda/2$ antenna absorbers. These were 7 1/2 inch long , 1 inch diam. rods with a 2" long 50Ω globar resistor mounted in their middle. Across the resistor we placed NE-2's. When the parasitic occurred the NE-2's glowed, showing that at least 100 volts appeared across the resistors. This meant that 400 watts was being dissipated in the globars at 750 MHz. With these two suppressors the signal from the dV/dt monitor was lowered by about 20% indicating that they were having a salubrious effect. Perhaps with enough of them the parasitic could be killed.

However, intuition predicted that most of the energy was inside the tube and outside it the best place to look for a handle on it was in the screen by-pass condenser. So we decided to crud

up the connection between the by-pass condenser and ground, that is, to introduce a lossy element there. Ideally one would like to introduce an element which would be preferentially lossy at high frequencies. Losses in conductors increase only as $\sqrt{F}$ but losses in sufficiently finely powdered iron or ferrite go as F.

We made a small toroid of 40 line iron filings with RTV as a binder and substantiated that up to 100 MHz was true. The Q at 100 MHz was 30. Given time we could measure the Q at 750 MHz, but there were faster ways of proceeding.

Another way of insuring high frequency dependent loss is to put a series RC to ground with a break frequency say at 300 MHz. But since we could test out the efficacy of this method without the C we tried several combinations of parallel globar resistors to ground from various places in the anode circuit. This gave virtually no effect. My conclusion was, therefore, that the tube was acting as a triode, with the screen being the anode.

The obvious place to damp the parasitic was at the screen. But because of the way in which the screen by-pass condenser is built there was no way to attach anything to the screen flange. So we designed a modification to the screen by-pass condenser that would permit damping it with resistors placed around its periphery.

However, this modification would take a few weeks to implement, so we tried other means. Four sets of 50Ω globars each in series with 10pf placed symetrically about the grid flange did some good. Eight did the trick. The damned parasitic was squashed! This was quickly verified by our being able now to deliver 60 KW into the water load at several frequencies in our range.

So the damned parasite can be licked--but what is our margin? Maybe he will reappear when least expected. I don't trust those guys. I would like to find two independent ways of clobbering him and then use them both. Therefore I propose that we build a modified screen by-pass condenser and, when installed, surround it with up to 24 series RC's. If by itself this kills the parasite, then we will add the RC's on the grid and thereafter, Allah agreeing, nevermore see the miserable bastard.

I apologize for my prolixity. Maybe, like Caesar, I should simply have said: "Veni, vidi, vici". After all, this is just a small battle in the midst of the larger war.

The Larger War

H.H. informs me that the test stand for TEST 5 will not be assembled before 3 weeks. I therefore assume that it may be assembled and vacuum tested by 1/2/81.

The modified screen by-pass condenser could conceivably be

ready for use by 12/15/79. If so I might conceivably come back to test it at that time. But it is winter, air travel is not reliable, and the approaching holiday season probably precludes effective use of my time.

Therefore, it seems that I should schedule myself to return after New Years. Meanwhile:

1) R. Gress will have 100% completed the synthesizer and it will be standing in a rack alongside our other test rack near the test stand.
2) The new 450KW final power supply will have been tested, received, installed and connected.
3) The DA2 power supply will have been rebuilt, debugged, installed and connected.
4) The modified screen by-pass condenser will have been assembled, impregnated and installed, with tapped holes existing in the ground plate.
5) The 300 ohm water cooled cermet resistor (housed in the 50 KW resistor ensemble from Dielectric Communications) will have been inserted properly into the anode box.
6) The second driver anode voltage monitor will have been installed.
7) All water circuits will have properly operating flow interlocks.
8) S. Francis will have operated the transmitter over the entire range, generated new sets of curves for everything, especially for harmonic problems.