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RF Book

RF Note #~~50~~ 51

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TEST 4

Test 4 was ready to commence on 7/9/79. After TEST 3 the coupler was removed and it was discovered that the top spacing alumina insulator was broken and coated with copper. Obviously there had been persistent glow discharges between this insulator and the vacuum insulator three feet down where the air transmission line transition occurs.

The insulator was replaced with a new one, and everything reassembled. But the vacuum was not good and the rate of rise was bad. So the bolts providing force on the stem insulator seals were tightened, resulting in some improvement, and the lower stem outer conductors were lowered to permit insertion of wires in the spinning flange. The vacuum and rate of rise were now tolerable.

While this was going on, an anode supply voltage monitor was built and installed in the final B^+ power supply. Also, discriminators looking at the transmission line bias current and the vacuum guage, calculated to turn off the rf in case either of these two quantities exceeded adjustable limits, were installed. The limits were: vacuum, 3×10^{-5} mm and bias current, 2 ma.

As a reminder, we also had the following things that could cut off the rf: sparking at five places along the transmission line, sparking at the dee stem fingers, sparking at the stem insulators, and sparking observed by a newly installed monitor looking at the dee coupling capacitor.

This wasn't enough. When we tried to thump on without success we lowered the frequency and got on, but we had vicious sparks in the transmitter box. In the process of installing the network connecting the transmission line bias supply to the transmission line, the transmitter box spark monitor had been removed. This should have been immediately relocated, but wasn't. The consequence was that the transmitter output coupling capacitor was damaged.

After modifying the geometry to increase distances, our newly arrived 300 pf 10KV vacuum condenser was installed and on 7/12/79 we started thumping away again. Everything worked fine at 60 K.V., except the vacuum wasn't good. By 4:30 p.m. we hit 80 K.V. and then MSU electricians turned our power off so that we could go and play a game of golf.

On the third hole, in consultation with D. Lawton, M. Fowler and J. Ottarson we considered the problem of excessive sparking at the dee coupler, and by the ninth hole had arrived at an agreed upon solution. The reason we were able to do this was that we had a lot of time waiting for each other to make bad shots.

On Friday the thirteenth, an ominous day, we recommenced. The vacuum was a problem, and we readjusted the limit to 4×10^{-5}T. As we approached 90KV, half the time we kicked off due to vacuum and the other to coupler sparks. As predicted in a previous rf note, sometimes the transmission line spark gaps also fired. By noon we were approaching 100 KV and by 2 p.m. it was a common thing.

But there were problems. On turn-on the power supply would sag by 30% and at turn-off would surge by 40%, exactly the opposite of what would be desirable. This power supply performance is almost intolerable. To be able to live with it at all we had to set the load voltage at 20 KV and the over voltage relay at maximum. Under these conditions we had 14 KV at turn on and 28KV at turn off and thus were jeopardising our transmitter tube. The anode rf voltage at 100KV on the dees was 12.5 KV, thus we were left with an E min. of only 1.5 KV resulting in excessive screen current.

About 2 PM the vacuum suddenly got better and for the remainder of the run was at 1.2×10^{-5} and was unaffected by rf. Strange, but welcome. For the next two hours the percentage of time spent at 100 KV increased. Stable CW operation at 80 KV was possible, and 50% duty factor at 90 KV was achieved.

Then, about 4 p.m. we observed sparking in the anode box immediately followed by a crowbar. On inspection it was discovered that the transmitter stem fingers were destroyed. So TEST 4 thus was terminated.

Conclusions to be drawn from TEST 4 results

The coupler was pulled for inspection. It looked good, but under a 20 power microscope myriads of sparking induced craters could be observed, mostly within a discolored circle about 3 mm in diameter halfway between the tip of the hemisphere and the end of the cylindrical portion of the prong. This substantiated our belief that most, if not all, of the sparking was between the coupler and dee.

A panel on the upper stem was removed so that the fingers could be inspected. No visible damage was discernible, so we conclude that the fingers can work at this current density (70 amps/inch (cm)). So we learned two things from TEST 4:

1. The finger design, if executed properly, can work o.k.
2. The 3/8" coupler spacing is too small for reliable operation at 100 KV.

Here we are presuming that the failure of the transmitter stem fingers was due to faulty mechanical assembly. The transmitter stem current is only 1/8th of the dee stem current so that if the dee stem fingers survive, the transmitter stem fingers should also. There exists a small possibility that the transmitter suddenly, because of the large plate voltage with the resultant increase in Gm. broke into a very high frequency parasitic self oscillation with a consequent 10 fold increase in finger current. Next time, unless overruled by God or some other higher authority I am going to refuse to subject the transmitter to dc voltages exceeding 20 KV.

New Coupler Design

D. Lawton has a drawing for a new coupler design eminently compatible with existing hardware. In this design the upper insulator is thrown out, the present vacuum insulator is moved to the position previously occupied by the upper insulator. This gets rid of the vacuum problem that we previously had in the 4 foot section between the two insulators.

In addition the cup is increased from 1 ½" to 2" inner diameter and the inner conductor to 3/4", thus leaving us with 5/8" spacing, coupler to dee. This is 5/3 larger than the present 3/8" spacing and should be adequate, providing it is properly centered.

Suggested Program in Preparation for TEST 5

1. Mechanical

   Disassemble the dees and stems and modify to permit reassembly with the new geometry necessary to use the "C" seals, which are due by Aug. 15. It would be desirable to have the stems and panels of the dees and transmitters silver plated, time perimitting. In any case, fix the transmitter stem. Build the new coupler. Mount the vacuum guage nearer to the dees.

2. Hydraulics

   Measure water flow to all circuits and install flow switches in each circuit. Install a differential pressure switch across the hydraulic circuit.

3. Controls

   Modify the control interlockery so that when the control panel switches are set to "DEE" the above mentioned switches are included in the interlock chain that prevents turn on of the final B+ supply. For consideration by the controls engineer, the final interlockery will include the feature that all position follow POTS must be where they are commanded to be before rf can be turned on.

4. RF

It is proposed that S. Francis and W. Nurenburger work cooperatively together on the following projects:

A. Install optical monitor in anode box and connect to first event trip ckt.
B. Get first event trip circuit indicators working properly.
C. Design and build DA2 fast trip circuits as specified in RF Note #49.
D. Have a duplicate of the transmitter anode rf voltage monitor built. This is to be connected to a high pass filter with 60 db attenuation below 100 MHz. This output will be peak detected and go to a discriminator and first event detector RF "OFF" trip circuit labelled "PARASITIC". The peak detector needs to be checked out over the range .1 to 2 GHz.

5. Other

W. Harder should design and build the DA2 filter and screen circuits as per RF note #49 and install them in a suitable box(relay rack?) and interconnect with the DA2 supply.

W. Johnson should take responsibility for testing the 150 KW water load. If it tests out satisfactorily, D. Lawton should build two more.

J. Riedel and W. Harder will do what is necessary to make the final power supply behave. This will involve using the 50MeV transmitter tubes as a shunt voltage regulator. Pas de probleme.