RF. Book

R.F. Note 63

April 28, 1980
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K500 RF Status as of 4/28/80

We have logged about 50 hours of running at 100 kV with a sparking rate of less than 1 per hour. Thus, we have demonstrated that it is possible to build a workable rf system for the K=500 cyclotron, now that the two major hurdles have been crossed: the 5/8" gap is o.k. at 100 kV, and our fingers have not burned up.

Presently we are using fixed position shorts (F=30.7 Mhz). The lower inner stem short has a rubber band around the fingers to increase the force pushing the fingers to the stem. The upper inner short employs the door spring clamp. Both panel shorts use rubber backed bumpers to push on the fingers. All finger surfaces are silver plated.

It is incontrovertible that 80 kW must be supplied to the resonator to achieve 100 kW! The operating conditions are: Anode PS, 17kV at 8 amps=136 kW, Anode dissipation from water ΔT= 52 kW, delivered power as measured by the directional coupled=80 kW, unaccounted for = 4 kW (2kW in transmitter). So the efficiency is 60%. Measureing some flows and ΔT's at the resonator we conclude:

upper stem :	22.5 kW
lower stem	18 kW
upper short	2.1 kW
lower short	2.0 kW
upper dee	1 kW
lower dee	3 kW
Σ	48.6 kW

adding 25% for the outer conductors gives 60 kW leaving 20 kW unaccounted for.

Q Measurements

We used three independent ways of measuring the Q. Method #1 involved modulating the amplitude to find the break frequency. This was 6 kHz resulting in a Q=2800. Method #2 was to suddenly cut off teh rf and measure the decay time constant. This was 28 μs resulting in a Q of 2700. The third method was the F/ΔF method and this gave a figure of 3150. We believe the latter, because this results in requiring 80 kW to acheive 100 kV.

RF note #17 and MSUDS report the calculated Q=5400, Rs = 9.6×10^4, F_B = 3 kHz, τ= 50μs and the power required = 52 kW. The program was reviewed and it was discovered that the power due to horizontal currents in the lines were neglected. Mainly, this means the short power and the power consumed by the plate on the bottom of the insulator. These powers calculate to be: 3 kW for each carriage,

3 kW for each insulator, adding to 12 kW, bringing the calculated power to 64 kW. Thus our measured power is 16 kW, or 25% more than the calculated value. The major clue as to where this power is going is the disparity between the measured power in the stems. The lower stem power agrees precisely with the calculated value, the upper stem power is 25% more.

Bad as these results are, even if we can't improve the Q, we can live with this resonator. It is trivial to readjust the transmitter - dee voltage ratio such that the transmitter would run at 20 kV and 6.8 amps from the power supply, so that our power supply is adequate, and the transmitter is still loafing. Of more concern is the rf leakage. On installing a filter box in the anode B+ lead we eliminate most of the bothersome rf leakage, especially all the harmonic leakage. But the resonator leak is fundamental. We measure two volts where the panel corners meet the mating surface, due to no connection being made there. We will have to solve this problem. Another source of leakage is where the 10 inch pipes connect to the aluminum plate of the dee housing via a "c" seal. Perhaps the "c" seal makes a good vacuum joint but leaves a poor rf connection due to the force on the "c" seal not being able to penetrate the aluminum oxide. If so, we needn't worry about it since this problem won't exist in the final structures.

Another vexing problem is that both fine tuners have vacuum leaks which come and go depending on how much duct seal is packed around them and how often we try to exercise them. It is recommended that the design be modified so that, like the coupler, the fine tuner bellows can be readily accessable without having to dismantle the whole structure.

Transmitter

The transmitter performs well. At 30 Mhz the 10 kW water load is not necessary and it is presently disconnected. Biasing the transmission line facilitates multipactoring breakthrough, but is not necessary. Presently it is selfbiased, the dee coupler acting as a very good rectifier. On one occasion S. Francis found that we could rectify 10 kW at 14 amps into 50 Ω. So now we simply have a 50 μa voltage metering circuit there and note that at Vdee = 100 kV we have between +2 and +5 kV on the line.

We recently received two new 4CW100000E tubes from Eimac which may have been damaged in shipment. Eimac informs us that the normal test to determine damage is to high pot them at 60 kV and they should draw less than 1 ma. Both tubes, as well as our spare, passed this test, so I predict that they are o.k.

Plans

J. Ottarson is almost complete with the details for the moving shorts, and the shop is diligently producing machined parts. We should have our new finalized carriages ready by 6/11/80. By that

date we should have a thin (.1 mil) silver plating on the panels and can commence TEST 6 which, I hope, will be the last test. Before then we will also have solved the fine tuner leak problems. Whether the new drive for the push rods will be installed by 6/1/80 is a moot question. Let us hope so. Same with the bang bang hydraulic drive for the coupler. Let us hope that we will have a finally tested complete design for the resonators by 7/1/80, so that we can all go to Mexico or Rio and have a good vacation.

This coming week we will install and test the new screen bypass condenser in the transmitter. No doubt it will work fine and we can then make 3 more. There are three further modifications to be made to the transmitter before it is in its final version:

1. The chain drive mechanism and motor are to be replaced. This is all designed but has low priority. Still, I hope that it will exist by 7/1/80.
2. I am willing to forego the plating of the transmitter stem and panels, but I feel very strongly that the transmitter should have a duplicate of the short carriage of the dees.
3. We need to install a fine tuner in the transmitter. The parts will not arrive until 6/15/80. We should have a design done by then and by 7/1/80 can test this.

Other

The rebuilt DA2 should be ready by 8/1/80. The second and third transmitters should be completed by this same time. The Transrex 450 kW anode supply should be received and tested by 9/1/80.

During the week of 4/28/80→5/2/80 we will endeavor to close the loop on the fine tuners; but because of the vacuum leak problems this might not result in success. If we have to, we will go down to air and solve this problem, or find out why we can't. This endeavor will prove out the synthesizer up-down circuit and mixers and phase detectors that W. Gress has produced.

Then J. Riedel must come up with the specifications for the controls, and then W. Johnson will implement them. This could all happen by 9/1/80. All in all, it seems like, if we have three dees+ liners + stems built by 10/1/80, the rf system will be ready to power them, God willing.