

## **Pbar Note #691**

### **ARF1 Power Amplifier Repair**

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Power amplifier schematic 8000-EC-119585 and system block diagram 8000-ED-119600 will be helpful in understanding the system.

The amplifier is a grounded grid triode tube pair connected in a push-pull manner. As with most all tubes, there is an input and output circuit. The input circuit consists of a coaxial coil made to offer 50-Ohm impedance at 52.8Mhz. This is a broadband circuit (beyond 40 to 60 MHz.). It is DC isolated from ground, (RF grounded thru two 1000pf capacitors) and the filament and bias voltage is applied at the RF grounded end of the coil. The input RF drive signal is developed across the parallel combination of this coil and the tube input characteristics. The bias is applied to the floating filament supply (10V 100A) and clamped approximately at 80Volts thru a stack of forward biased power diodes. (DWG 8000-EB-119592 Located, AP50 rack B55R02). A keep-alive forward biasing voltage is supplied from a Kikusui power supply (located B55R02). The entire amount of DC tube current will go thru these diodes.

The RF drive source is supplied from a single ended grounded grid triode amplifier DWG 8000-EC-119605. Since we require a push-pull drive signal, a 180-degree power splitter is used. This is a Fermilab built device (DWG 8000-EB-119604). The circuitry is within an oil-filled container located at the front center of the power amplifier. Shunt variable capacitors and special length input (aprox.5ns) and output (1ns) cables are used for tuning.

Note:

Generally, it is wise to transfer the power splitter and tuning capacitors when replacing the RF deck (this greatly reduces phase alignment time after installation).

The output circuitry consists of the coupling loop and cavity. Little can be adjusted with this stage except perhaps the depth the loop may go into the cavity. It is critical that this does not change. Quarter inch spacers, which were used for adjusting the amplifier (thus loop depth) are now screwed to the amplifier base and should not be removed.

The coupling loop can be viewed as a center tapped transformer where the high voltage is applied to its center (RF grounded with bypass capacitors at this point) and its ends connected to the tube anodes. This completes the push-pull output circuitry. The combined RF is transformer coupled into the cavity.

Safety and operating interlocks are incorporated into the system. Such as tube filament cooling fans. Should a failure occur, the affected airflow switch and/or a klixon switch, inhibits the filament and anode power supplies. Note: The anode p/s is

common to all ARF1 systems and a special bypass switch on the interlock chassis (DWG 8000-ED-266055, B55R01 & B55R03) is used so one can still drive the good cavity alone, if needed. Since the tubes have water-cooled anodes, it is important to monitor and interlock the LCW flow also. We use redundant turbine flow pickups for this purpose (two in series). They are traditionally troublesome and often fail from debris in the system. The anode and filament power are also inhibited. The circuitry for this is in a NIM crate in rack B55R09 (DWG 8000-ED-266298). Its trip level is set for 6GPM. Each tube filament current is held constant with a regulated power supply (Lamda model LT-820). The Fan, Filament, Bias control chassis (DWG 8000-ED-119591) is part of the interlock system with a short warm up delay and sensitive to a current tolerance of 2%. Should a fault develop at this point, the HV will be inhibited and the operator should reset the detected faults once the filament current is within the set operating window. This may not be obvious since there is a tube warm up period of five minutes before the interlock chassis enables the anode voltage. It is easy to assume a serious problem, when only a reset will cure the symptom.

The typical repair job only requires replacing the two YC166 water-cooled tubes. The key to much of the process, is to use good mechanical sense, however some points should be paid extra attention:

- 1) Always make sure the depth of the coupling loop remains unchanged (ceramic posts measured at 8.5 inches from the amplifier inside top to the posts end).
- 2) When finished, always pressure test with 100 to 120 psi. LCW when checking the plumbing connections (compression fittings, hose barb and hose this is now peek and copper lines).

The procedure:

Access the coupling loop assembly by turning the amplifier upside down on the fixture that it is transported on, or other convenient device to provide a good work platform. (This requires two people, as it is cumbersome to maneuver).

Remove the copper-coupling loop (the thing with fins).

- 1) Two screws w/locknuts that connect the HV to Loop center.
- 2) Eight screws which connect the loop to the split cylinder spacers.
- 3) Six screws holding each split spacer, although asymmetric, always make note of its position with respect to the plumbing.
- 4) Disconnect the tube water fittings.
- 5) Loosen the four stainless steel clamps on the post clamp assembly, (recommend loosening the two outside screws before the clamping screw. Leave the center screw tight). Also loosen the three screws that hold the tube firmly in its socket.

Note:

The ceramic posts can easily break by over tightening or misalignment. (Spare ceramic and G7 posts are available in the RF Cavity parts cabinet at AP50).

These posts can change the coupling loop depth. DO NOT CHANGE ITS POSITION!

- 6) Remove the clamp assembly by pulling straight up and gently nudging as necessary.
- 7) Remove the tube and check for radioactivity and discard (if OK) in recyclable can (No hazardous materials are inside the tube).

Note about the YC166 tube:

The replacements come from the factory with 45degree flair fittings. We do not use them. They are cut off using a mini tubing cutter and a small copper extension is soldered in its place to mate with the compression-fitting elbow.

- 8) Install new tube and its collar ring. The collar is put on the top of the tube to provide a firm surface for the three screws in the clamp assembly to push against. This will keep the tube snugly in its socket when in its operating position (anode facing down).
- 9) Reverse the above steps.
- 10) Leak check with 100 to 120 lb LCW. Look carefully! Even at unlikely spots.

Note about the internal LCW hose DC block connection:

Recently, we have had major failures with the “orange hose” DC block water connections. As a result, we modified this connection by using a plastic (called PEEK) to replace the hose. It is 5 inch long and machined at the ends to use Parker compression fittings. This is a perfect choice of material, as it is radiation resistant, reasonably flexible and electrically ideal for our application.

All the amplifiers (3) will be modified as failures occur.

See pictures below for identifying various components of the ARF1 Power Amplifier.



RF power splitter located on top front of the amplifier.



Overview of the ARF1 power amplifier on its' work stand.



Coupling loop.



Notice the split spacers used to access the water connections at the tube. Also the three screws on the clamp assembly used to push against the tube collar ring to keep it snug when in its operating position.



Wide view.



Close view of the modified water connections. Much better than the hose type DC block. Also note the ceramic (this case picture) standoff set to 8.5 inches. Careful!



Wide view of amplifier. Notice the  $\frac{1}{4}$  inch spacers screwed onto the frame. No touch!