Subject:
Re: CW Amplifier for 352 and 500MHz
From:
Jim Potter <jpotter@jpaw.com>
Date:
Mon, 02 Dec 2002 13:53:04 -0700
To:
Gough Christopher <christopher.gough@psi.ch>

Dear Mr. Gough,

Thank you for your interest in JP Accelerator Works' rf power products. We are currently have a conceptual design for a CW rf power system capable of 50 kW at 450 MHz. The final power amplifier based on parallel planar triode technology developed by JPAW. The design is based on a Russian tube, the GS-35A, which is rated at 2 kW dissipation with water cooling. We are in the process of evaluating this tube, which we believe is capable of 2 kW power output with >50% efficiency and at least 10 dB gain at 425 MHz and below. These tubes are currently in production and available at reasonable prices. There is also a considerable supply of the tubes at even lower prices that is available on the surplus market.

Our design uses a ring of n tubes in a radial array. The tube anodes are connected to a common inner conductor of a coaxial resonator that also serves as a water cooled heat sink. Two of these circuits, back-to-back, can be used in a push-pull configuration to double the power from a single amplifier. Each tube has a separate cathode resonator. The resonator has a low loaded Q so that the phase shift is identical in each circuit simply by setting all of the cathode tuners the same. Each tube is individually biased with a circuit that automatically adjusts the bias to keep all the cathode currents equal. This feature eliminates matching of tubes and insures that each is contributing equally to the output.

The intermediate power amplifier can either be individual solid state amplifiers or another parallel triode amplifier with a power splitter. The latter approach is considerably less expensive than the former.

All of our rf power systems feature computer control with a PC computer running LabVIEW. However, there are a number of ways to interface our system to a main control system, either directly through hardware or indirectly through software.

Your requirement for 80 kW is somewhat higher than our current design. At 352 MHz, we can increase the cavity diameter and the number of tubes in parallel to achieve slightly more power per amplifier. However, I think that it may be more practical to combine two 40 kW amplifiers. With our design this is easily accomplished. From the photo and drawing you can see that there is a coax line going through the cavity. This line has a gap in the outer conductor at the amplifier resonator. One end of the coax is the output, the other is a shorted stub that provides the series inductance for impedance matching. Note that the output can be either up or down by changing the location of the stub. The amplifier is effectively in series with the outer conductor. Two or more amplifiers can be combined by placing them one half wavelength (or multiples) apart, with one coupling stub. Thus, two 40 kW amplifiers can be combined to achieve 80 kW and four 50 kW amplifiers can be combined to obtain 200 kW. Alternatively, an external combiner could be used. The output coax can be EIA 3-1/8". 4-1/16". In either case the average power level will require water cooling of the center conductor. This is easily achieved since the inner conductor is at ground potential at the shorting stub end.

Your cost requirements may be approachable with the production of multiple units. With the Russian tubes and our cavity design, the most expensive part of the system is the dc power supply. For example 50 kW amplifier will require 100 KW of dc power, +4000 volts at 25 A. One interesting aspect is that the power supplies could be in 50 kW increments without parallel connections since each 25 kW of rf amplifier has an independent dc connection. I am currently looking at the price of 50 kW switching mode power supplies that meet VDE requirements. Perhaps you can recommend European power supply manufacturers to me. In order to approach your cost goal we need to find dc power that is available for $0.50/w or less. This may necessitate using a transformer-rectifier set instead of a switching type supply.

The attachment 12-tube.jpg is a photo of the FPA of a 12 tube amplifier, based on Eimac YU-141 tubes, that produces 240 kW of pulsed rf at 600 MHz. The pulse length is up to 100 usec and te duty factor is 1%. The attachment 24-tube.pdf is a simplified 3-D rendering of our conceptual design for a 50 kW CW amplifier at 450 MHz. The flanged coax is the output, the unflanged coax is the stub. (As mentioned above, these are interchangeable.) The two rings of tubes are shown with some of the cathode cavities removed. The tubes are operated with the grid grounded at the outer wall of the anode cavity. The scale for the drawing can be determined bu the 3-1/8" coax diameter. The photograph shows the coupling stub barely protruding from the top of the anode cavity. It is also EIA 3-1/8" coax. The photo also shows details missing from the 3-D rendering, such as the anode tuner, the output coupling adjustment, the cathode tuning adjustment, the rf input connectors (which have since been changed from SMA to TNC), the high voltage connector, the cooling water inlet and outlet and the support for the anode cavity inner conductor.

I would be pleased to answer any further questions you may have.

Regards,

Jim Potter

At 02:30 PM 11/29/2002 +0100, you wrote:

Dear Sir,

We have just completed this year's European synchrotron light source RF meeting in Villigen, Switzerland (http://psw100.psi.ch/www_sls_hn/workshops/esls/esls02.html).

An important topic of discussion was comparison of high-power klystrons with IOTs and semiconductors, in particular for use in new electron accelerators. By chance, I saw your web page with the note on it that you are developing CW triode amplifiers for UHF.

If the price is less than, say, 150kUSD, for a complete 80kW 352MHz CW amplifier, this would be very interesting. Also, the possibilities of combining, say, four such units to give 200kW is also interesting. Also, the possibilities for 500MHz CW.

Could you send some details and photos ?

Regards,
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