STATUS OF THE 36 MHZ RF-SYSTEM FOR THE HIGH-CURRENT-INJECTOR AT GSI

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Abstract

Within the beam intensity upgrade program at GSI some significant changes of the rf equipment will take place. The replacement of the four Wideröe tanks means at the same time the elimination of the 27 MHz operating frequency at GSI. To supply the new 36 MHz structures, rf amplifiers with a peak power of about 2 MW are needed. These stages will be designed and built up in house. 200 kW amplifier stages were specified, ordered and delivered. They act as driver stages for the 2 MW final stages and as final stages for feeding smaller cavities, respectively. The frequency change, as well as the future operation with beam load implies the replacement of more than 60 % of the present UNILAC low level distribution and control.

1 INTRODUCTION

In 1999 the 1.4 MeV/u prestripper section will be replaced by the High Current Injector HSI with an accepted mass over charge ratio for heavy ions up to 65 and with beam currents up to 0.25 A/q (mA) [1]. A 36 MHz RFQ and two IH drift tube tanks will replace the four tank Wideröe section. Each of the three new cavities will be fed by 2 MW final amplifier stages designed at GSI (see fig.1). The duty factor is up to 2% at maximum rf level, the specified rf power fraction into the beam is ranging up to 40%. Though the RFQ will need only up to 500 kW input power it was decided to have three identical amplifier chains. Beam dynamical aspects, as well as the dimensions of the cavities caused the choice of the new frequency 36 MHz. Because of the future UNILAC time share operation with two 1.4 MeV/u – Injectors and with up to three ion sources running in parallel, it was necessary to change the master frequency from 27 MHz to 108 MHz, the Poststripper LINAC frequency. The new 36 MHz system includes the following structures : RFQ, Superlense, IH 1, IH 2, a rebuncher at the 1.4 MeV/u gas stripper section and a debuncher at the 11.4 MeV/u transfer line to the synchrotron SIS. The operating modes of the 36 MHz Injector LINAC are :

a) up to 20 Hz repetition rate with 1 ms flat top at maximum power and full beamload;
b) up to 50 Hz repetition rate with 6 ms flat top at 40% of maximum power without appreciable beamload;
c) replacement of single pulses out of the pulse train in case b) with short high current pulses like in case a) resulting in a mixed mode operation.

Additionally, a small rebuncher structure focusing to the input of the Alvarez 1 tank will be driven by an existing 200 kW amplifier [2], which has been modified from 27 to 36 MHz.

2 AMPLIFIERS 200 KW

The required driving power for the 2 MW stages, as mentioned before, is calculated to be up to 200 kW. Further two 36 MHz final stages in the power range from 120 kW to 150 kW are needed to supply the Superlense and a debuncher cavity in the injection line to the synchrotron SIS (see fig.1). Therefore it was decided to procure five identical stages. Within a call for tenders rf amplifiers including all these features have been specified. Details about the design philosophy can be found in Ref.[3].

The major design part as well as the construction was performed by Thomcast AG (Turgi, Switzerland) after the order was placed (see Fig. 3). These stages use a class A/B solid state amplifier with a maximum peak output power of about 2 kW as driver . For the layout of the following tube stages the current use of the Siemens tetrode RS1084CJ at GSI and the working mode of the 2 MW final stages have been taken into account. The 200 kW stage works in a grounded cathode circuit in a class A/B mode (quiescent current at 2 Amp). To reduce power dissipation between the rf pulses the operating point will be switched to class C during the intervals. The anode circuit is a capacitively shortened $\lambda/4$ resonator in strip line design, tuneable by a vacuum capacitor at the tube side. The input (grid) circuit is a tuneable Π-network loaded with a capacitivly coupled 50 Ω.

The stages are designed as an 'all including' system. It means that all electronic components are installed inside the rack system, including the power supplies for plate, grids and heater of the 200 kW stage. In three amplifiers the grid supplies for the 2 MW final stages are included. In addition the amplitude and phase control units, the analogue value measuring and tube protection units, the free programmable control (SPS), the computer interface and also the automatic tank tuning system are housed in these cabinets. The timing information for rf pulse width, pulse space and sampling time, transmitted via a GSI two-wire-bus, is decoded in a special timing interface. The identification of a high current pulse is also done within this system [4].

With regard to the pulsed beam operation of the UNILAC (max. 16 virtual accelerators and low duty factor in the high current mode) the analogue measurement unit had to be sampled. This allows to gate the measured values with the according beam pulse. For acceptable beam operation at unstable beam intensities, the frequency response of the amplitude and phase control loops had to be improved. For that reason a redesign of the existing control units of the Alvarez rf-transmitters was performed. Now the bandwidth of the amplitude control is set to f_{cutoff} = 500 kHz while the accuracy is up to ± 0.1%. The phase control unit attains a bandwidth of 1 MHz and an accuracy of ± 0.1 degree.

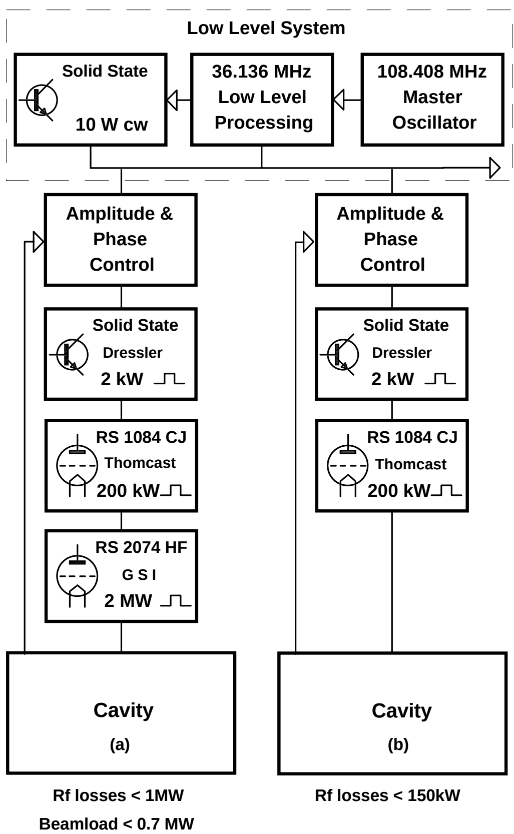

Fig. 1: Amplifier Chains of the New High Current Injector: (a) RFQ, IH1-DTL and IH2-DTL, (b) Superlense and Buncher

The delivery of the five stages to GSI started in December 97 and had been finished in July 98. Individual acceptance tests, including laboratory measurements, as well as electrical parameter tests (rf test with dummy load) and measurements of unwanted radiation leaks have been accomplished at the manufacturer. The observance of the very tight EN (European Harmonised) standards for electromagnetic compatibility and the IEC/VDE directives required an extension of the development time. Nevertheless this part of the project is terminated successfully with a delay of only three months. For tests of the RFQ tank and one 200 kW rf stage on resonant load, two of ten RFQ modules have been assembled to built a test cavity. They were powered by pulses of 90 - 100 kW peak at 1 ms / 20 Hz rep. rate and also by 20 kW at 6 ms / 50 Hz rep. rate. The results of the above mentioned RFQ tests showing excellent performance of the transmitter at 150 % of the nominal power level for the RFQ modules. Starting this test operation a parasitic oscillation at 190 MHz was observed at the plate circuit by switching the operating point to class A/B mode. This spurious mode could be eliminated by placing a frequency dependent attenuation circuit inside the anode circuit. An earlier detected oscillation at 280 MHz had already been eliminated at the manufacturer. At tests with the 2nd to the 5th stage at Thomcast AG by a pulsed grid voltage (-350 volts to 0 volts) with a resulting plate current up to 20 ampere, no parasitic effects could be seen. Tests were done with 50 Ω load, open and shortened amplifier output.

3 LOW LEVEL RF SYSTEM

The planned UNILAC upgrading requires also extended modifications within the low level rf equipment, including the master oscillator system and the low level rf distribution. The present system is driven by an oscillator frequency at 27 MHz. The frequency for the Poststripper section (108 MHz) is generated by quadruplicating the master oscillator frequency. This system will be replaced by a new 108 MHz master oscillator and a phase locked loop (PLL) synchronised slave oscillator at 36 MHz. Both low level systems are separately amplitude and phase controlled and can be supplied by different phase set values from the operating software. Thereby both 1.4 MeV/u UNILAC injector LINACs can be shifted in pulsed mode against the 11.4 MeV/u Poststripper LINAC. This feature is very important because the injectors can be operated in time share operation with different ions [5]. All input and output levels are normalised to +24 dBm (250 mW). Components like detectors, phase shifters, filters, oscillators, frequency dividers and amplifiers are designed and made in-house. Figure 2 shows the block diagram of the low level set-up and the rf-distribution.

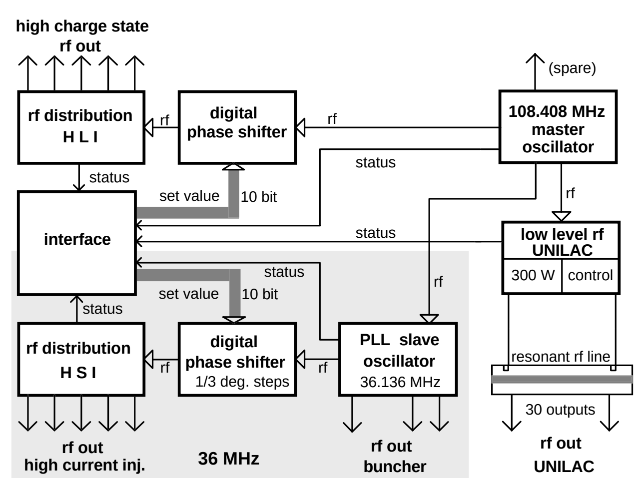

Fig. 2: Upgraded Low Level System

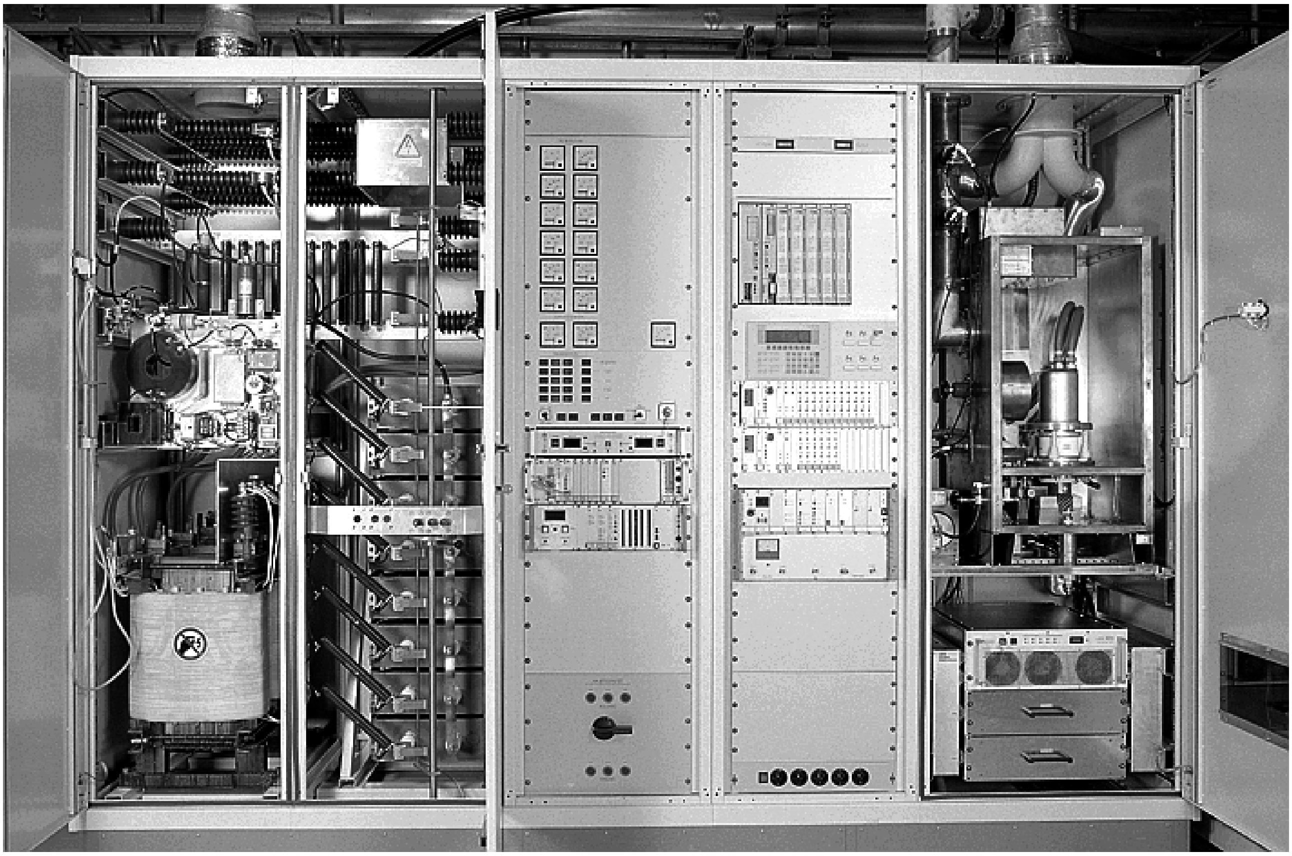

Fig. 3 : Front View of the 200 kW / 36 MHz Amplifier (by Thomcast AG) : the plate supply (two cabinets left); the local operation panel with computer interface and plunger control (3rd cabinet); Program controlled computer [Simatic] with the measuring device and amplitude & phase controls (4th cabinet); opened anode & grid circuit of the 200 kW stage with the 2 kW solid state amplifier (by Dressler) and the tube grid supplies below (right cabinet)

4 AMPLIFIERS 2 MW

The Siemens tube RS 2074 HF of the 2 MW final stages is the same tube as used at the final stages of the Poststripper LINAC (Alvarez 1 to 4). All the necessary calculations (partly performed with the Supercompact$^{\rightarrow}$ code) have been done for a 50 Ω load at the output of the amplifier. They were confirmed by cold measurements with a 1:1 model of the anode circuit using a dummy tube. The input circuit showed a good tunability. For a power range of 1:10 the load of different cathode currents at different power levels was simulated by variable resistors for this measurement. At present a prototype is under construction. The amplifier will be tested with rf on a dummy load early in autumn 1998. The construction of the three transmitters for the new injector should start by the end of this year. Commissioning of the RFQ and IH-Linacs with beam is scheduled for April to July 1999. A detailed report of the amplifier layout and the first results will be given elsewhere.

REFERENCES

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