UPGRADING OF THE LNLS INJECTION SYSTEM

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Abstract

The energy of the injection linac and transport line into the LNLS synchrotron storage ring will be increased to 170 MeV by doubling the microwave power of the linac.

The new system will operate with 4 klystrons, delivering 25 MW pulses into each one of 4 accelerating SLAC-type structures. This paper describes the design and construction and tests of 2 new klystron modulators, microwave drive system, waveguides, as well as the upgrading of the power supplies for the linac and transport line magnets.

1 INTRODUCTION

At present, the injection system into the LNLS storage ring is made up of a 120 MeV linac followed by a short transport line [1]. Accumulation of current is done at low injection energy followed by ramping up to 1.37 GeV. This corresponds to almost a twelve-fold dynamic range. The combination of relatively low energy accumulation and large energy ramping limits the high energy current to around 50 mA. To increase the accumulated current at low energy as well as the ramping efficiency, a higher energy linac would be required. Consequently, it was decided to upgrade the injection energy by increasing the microwave power in the linac. By doubling the number of klystrons it would be possible to attain 170 MeV at the output of the linac, which according to the available ramping data, will suffice to overcome the most critical range of energies.

2 THE LINAC

The present linac, which has been in operation since the beginning of 1996, comprises 4 SLAC-type accelerating structures. Each structure is fed with 12 MW, 3 μs-long microwave pulses produced from two split-output 25 MW klystrons. The waveguide system has a short section with pressurized SF6, as required by the klystron manufacturer, separated by ceramic windows from the vacuum waveguide stretches. An extra ceramic window is located at the input coupler of each accelerating structure to avoid leakage of SF6 into the accelerators in case of a breakdown in the first window. Figure 1 shows a top and side view of the linac klystron number 1. The waveguide that goes into the first structure has a 26 dB coupler to derive power for the prebuncher. The second waveguide is provided with a high power phase shifter used to adjust the electron's energy gain. The second klystron and waveguide arrangements are similar to the first one except for the absence of the coupler.

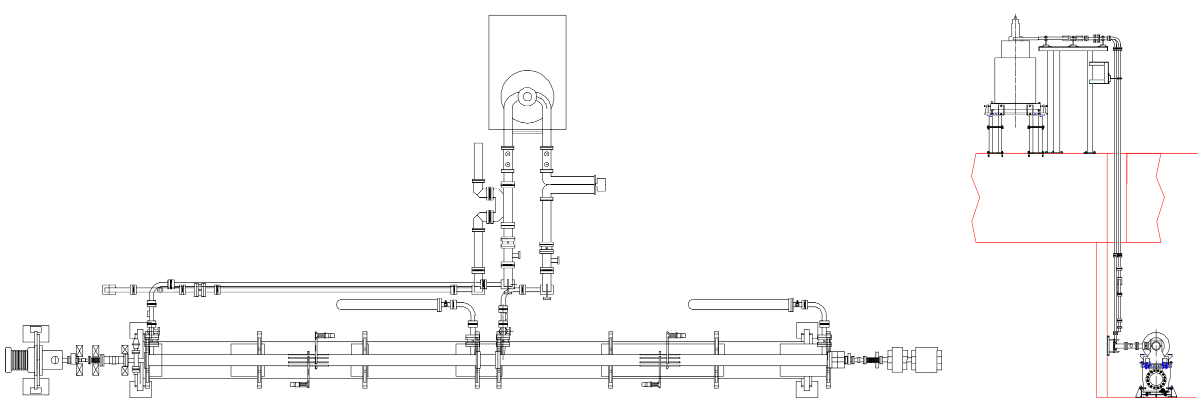

Figure 1: top and side view of the present linac waveguide system for the first and second accelerating structures.

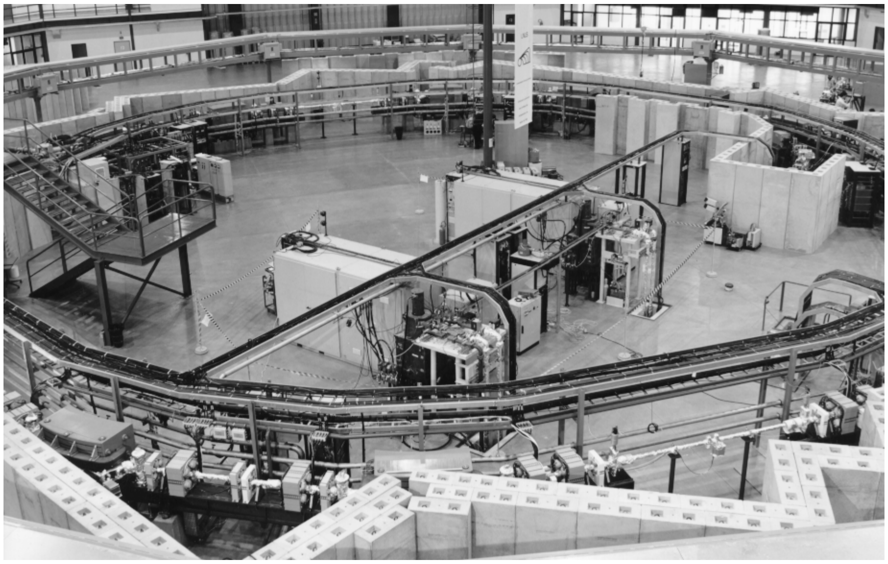

Figure 2: linac modulators and klystrons shown on the central part of the storage ring hall.

Figure 2 shows the distribution of linac equipment on the inside area of the storage ring. The linac is mounted in an underground tunnel below the inner part of the storage ring. At the storage ring floor level, occupying 1/3 of the available space, are the 2 high-power klystron modulators and the medium-power klystron and modulator. The new klystrons and modulators will be placed on the free space to the right.

3 THE UPGRADING

One way to increase the linac energy would be to enlarge the microwave power delivered to the accelerating structures. This could be done by adding 2 more 22 MW Klystrons, the corresponding high and medium power drivers and a new waveguide system. Since the linac does not have a buncher, the efficiency of the first structure is low and its energy gain is about 17 MeV, much smaller than the corresponding gain in the other three structures, which is about 34 MeV each. Thus, with 22 MW pulses, the expected energy increase will be more than 40% with the electron's energy reaching 170 MeV at the linac output. Measurements performed during ramping of the stored current show that 170 MeV is a safe starting point to increase accumulation and ramping efficiency to the desired values [2].

Figure 3 shows the new arrangement of the microwave system that distributes the power into the first and second accelerating structures. As can be seen, the output of the existing Thomson TV 2015B6 klystrons is combined in a 3 dB hybrid and delivered into the first structure, while a new ITT 8568 klystron, is used for the second structure. Similar arrangements are used for the third and fourth accelerating structures. The high power phase shifters, which are used at present to adjust the microwave phase between the 1-2 and 3-4 structures, will be used now to maximize the output power in the hybrid ports. The combining hybrids have been machined and brazed in house and are constructed and tested to operate in high vacuum. A ceramic window separates the SF6 region from the vacuum waveguide. The hybrid forth port is terminated with a full-power water load which requires SF6 and again is separated with a ceramic window.

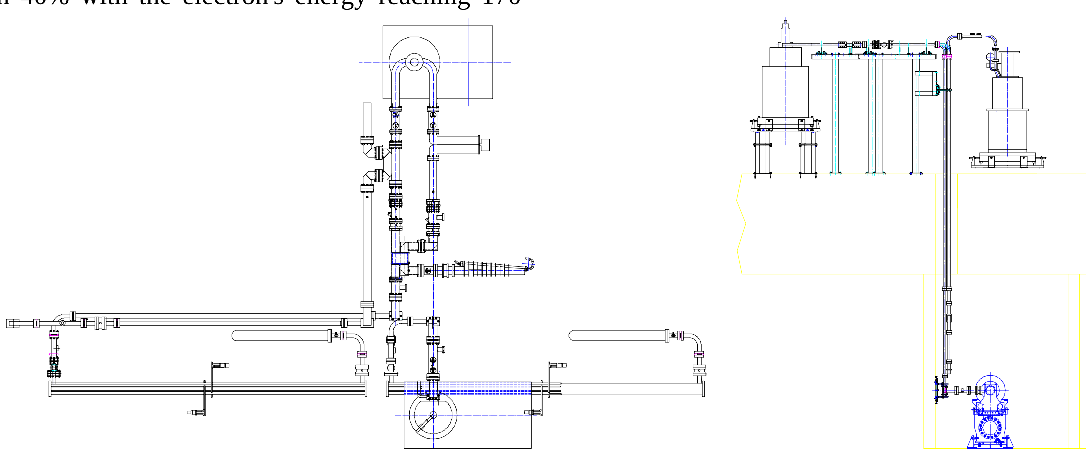

Figure 3: top and side view of the new arrangement of klystrons for the first and second accelerating structures.

Two new modulators will be added to the existing ones. Each one includes a pulse-forming network (PFN) comprising 24 HV capacitors which produces 3 µs-long pulses. The two existing HV power supplies, used with the present modulators, will be adequate to charge the 2 additional PFN, since the pulsing rate is very small. The pulsing rate is determined by the damping time of synchrotron oscillations (~ 6 s) and is typically about 0.6 Hz at 120 MeV injection energy, although it may go up to 7 Hz for waveguide conditioning. The PFN charging voltage stability has proven to be a critical parameter to keep the linac energy variations below 0.2 %, as required for low energy accumulation. Initially, the PFN voltage will be regulated using a standard d'Quing circuit. Later on, a regulated current source will be used to charge the PFN to full voltage. This should improve the stability of the klystron output power as well as avoid several other disadvantages of the resonant charging method such as: discharge of the PFN before triggering of the thyratron and mains current surges during the charging of the HV capacitor filter.

Special consideration has been given to the medium power microwave system. In order to drive the high-power klystrons, 250 W are needed for the Thomson klystrons, and 150 W for the ITT ones. A system of medium-power drivers is used to drive the high-power klystrons. These drivers use a series of 2 high-frequency EIMAC triodes model 8847, which can easily deliver 500 W of regulated peak power at the output.

4 CONCLUSIONS

A program to increase the linac injector energy has been initiated. This includes doubling the microwave power by including two more high-power klystrons. Two new pulse-forming networks and auxiliary equipment, providing 3 µs-long pulses, have been built and tested. The waveguide system, adequate for the new power system, is ready. This involved machining, brazing and testing 28 pieces including straight sections, curves, 3 dB hybrids, power monitors, arc detectors and vacuum flanges. The new medium-power microwave system, based on pulsed high frequency triodes is in the construction stage. The installation of the upgraded linac is planned to start in the second semester of 1997, during the next scheduled shutdown of the LNLS machine.

REFERENCES

[1] A. R. Rodrigues et al. “LNLS Commissioning and Operation”. In these proceedings.
[2] A. R. Rodrigues et al. “Ramping Efficiency Studies in the LNLS Synchrotron Light Source”. In these proceedings.