DUAL KLYSTRON MODULATOR*

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Abstract

The first phase of a 40 MeV upgrade at the Los Alamos Free-Electron Laser (FEL) experimental hall was completed during the summer of 1989. The second phase of this upgrade will be completed in November 1990. Because it was necessary to conserve facility space and expense, the concept of a dual klystron modulator was conceived. The novelty of this design is that a single switch tube and a single high voltage electronic circuit are used to simultaneously pulse two modulating-anode klystrons. In addition, this design configuration is amenable to extending the number of klystrons that are to be concurrently pulsed. In this short paper we report on this modulator design.

Introduction

A new 40 MeV high-brightness accelerator free-electron laser (HIBAF) facility is now nearing completion at the Los Alamos National Laboratory (LANL). The source for electrons is a laser driven photocathode injector.[1,2]. The RF power necessary for this accelerator is supplied by four 6.5 MW modulating-anode klystrons. Although some of the previous components from the old single klystron modulator were utilized, this dual-klystron modulator represents a new and novel design. Because the cost of building a new klystron gallery was prohibitive, a two-klystron per one-grided switch-tube system was developed. A photograph of this modulator is shown in Fig. 1. Lead glass windows were installed to facilitate high-voltage arc location. Note the symmetry in mechanical design. The modulator tanks are 130 in. long x 49 in. tall x 53 in wide and requires approximately 18 — 55 gallon barrels of insulating oil.

Modulator Design

Referring to Fig. 2, resistors R2 and R13 protect against modulating-anode to ground discharges as well as modulating-anode to cathode discharges. In addition the resistors limit the current flow to the modulating-anode during klystron pulse-on conditions. Resistors R5 and R6 protect against cathode to ground arcs and are necessitated by the duality of the modulator design. Resistors R1 and R14 provide initial protection during cathode to ground and cathode to modulating-anode arcs until the crowbar fires as well as dissipate any residual energy stored in the high-voltage coaxial cables after the crowbar has been fired.

The 1.4 kV secondary output of the klystron filament transformer is boosted via a voltage doubler circuit to 2.8 kV. This voltage provides the back bias necessary to keep the klystron dark current below acceptable levels. With a non-isolated collector klystron, this cw background current could not be measured directly but only inferred from the outgassing as measured by the vacuum-ion pump. With the increase in bias (up from 600 V) the vacuum ion pump measurement decreased an order of magnitude.

One common klystron filament transformer was used, i.e., one input, three secondary outputs–all on a common iron core. This design presents another difficulty; when one tube arcs, there is a large potential difference between the three collinearly wound secondaries. Miniature spark gaps (~2.5 kV) were placed across all transformer outputs, thereby minimizing these differences and protecting the transformer. The klystron filament transformer has been redesigned so that each secondary is physically separated from the other by insulating oil, i.e., non collinearly wound on a common core. This second generation dual filament transformer has been placed on order and will be used as a spare when needed.

The four klystrons are powered by one high voltage system. The system is comprised of a power supply, transformer, crowbar, capacitor bank, energy detector, and high voltage transport. Because physical space and reliability is a premium, the original 8 μF capacitor bank, made out of 40 kV capacitors, was augmented with 16 200 kV, 0.5 μF capacitors whose total volume is 112 in. long x 42 in. high x 26 in. wide. These capacitors were placed on a wooden table immediately adjacent to the original capacitor bank.

Conclusions

The HIBAF modulators have worked continuously since June 1989 without any problems. During klystron conditioning and once in a while throughout the year, the tubes have arced, but energy deposition was always mitigated and the klystrons have proven to be well protected.

References

1. P. G. O'Shea, et al. "Performance of the Los Alamos HIBAF Photoinjector Linac," these proceedings.
2. R. L. Sheffield, "Progress in Photoinjectors for Linacs," these proceedings.

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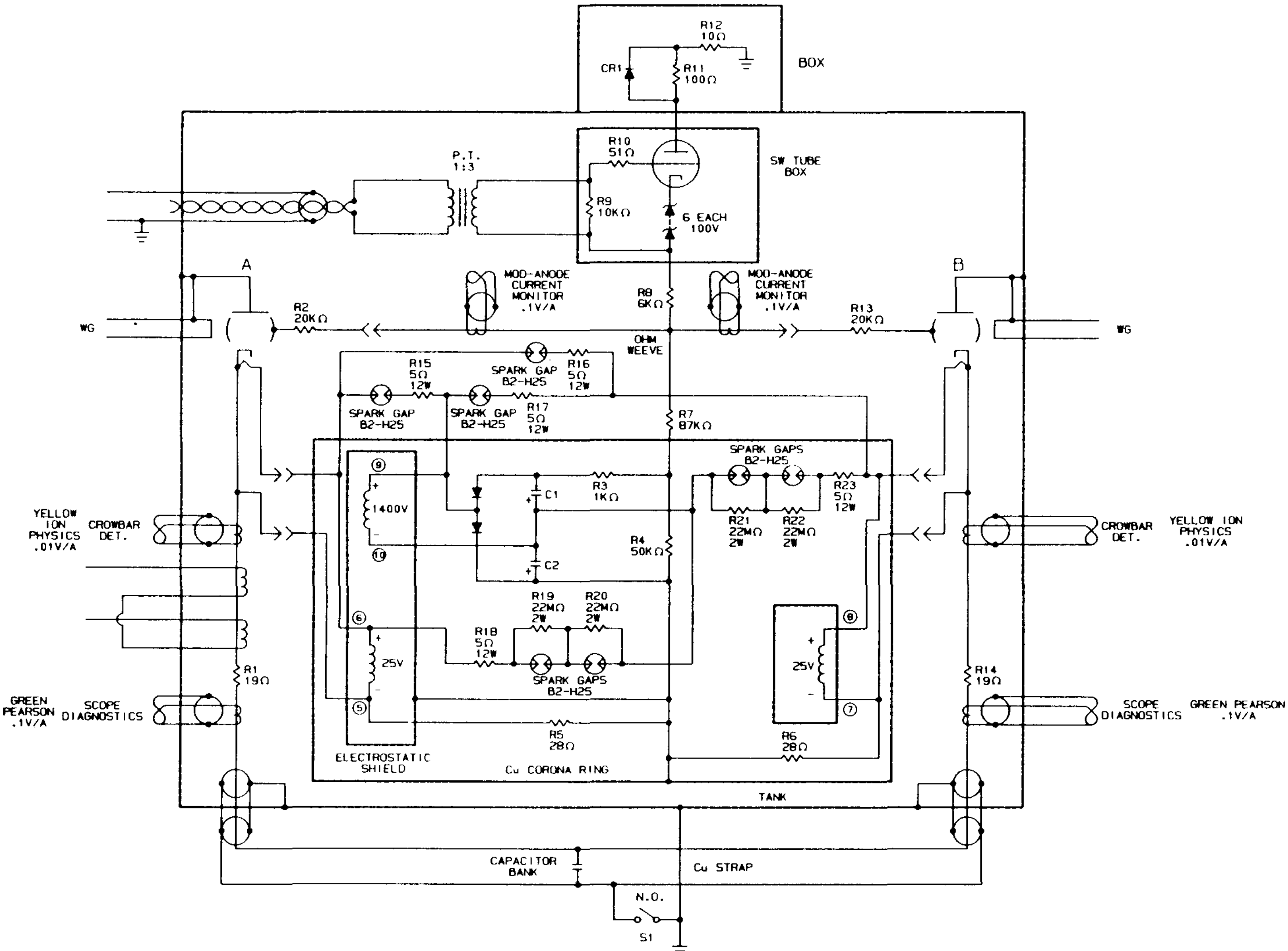

Fig. 2. Modulator schematic.

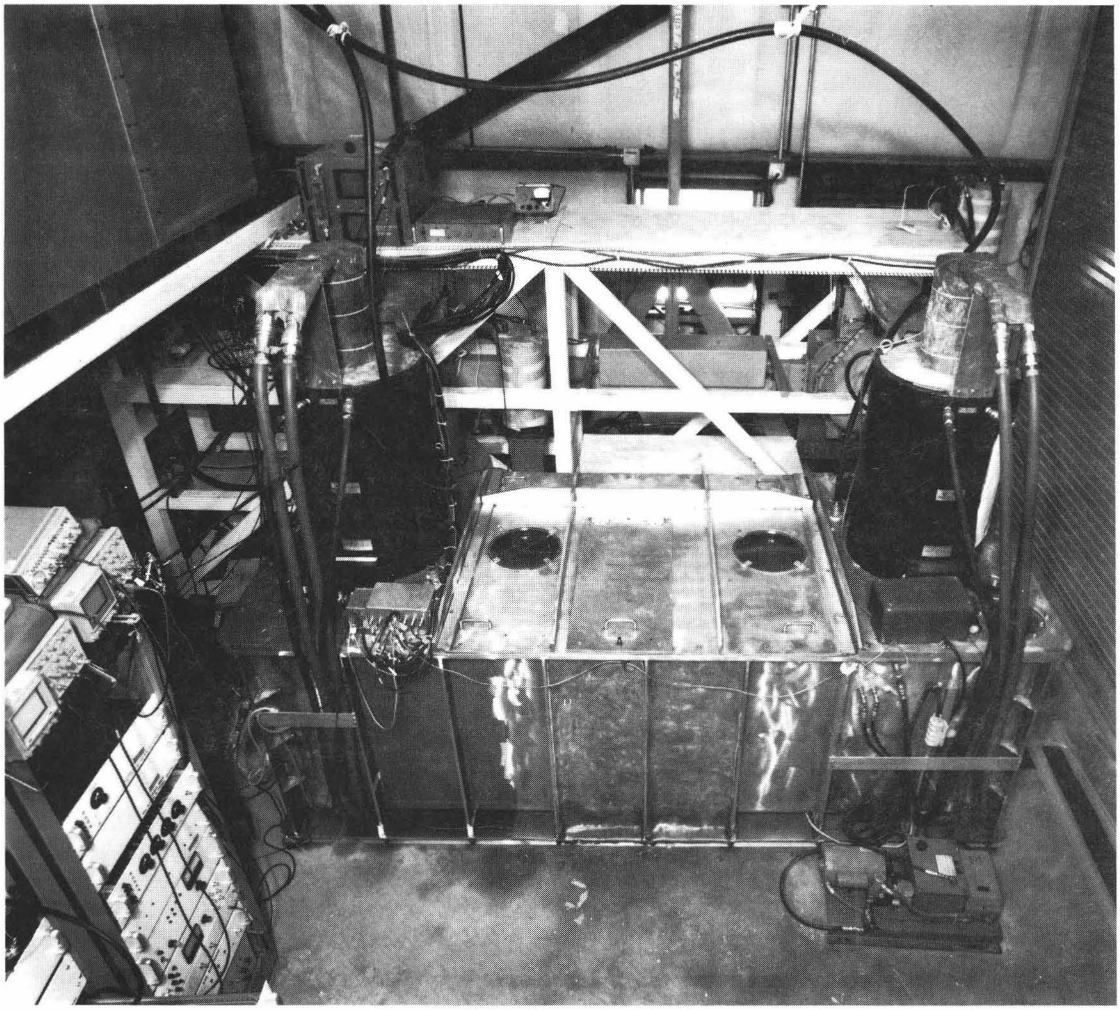

Fig. 1. Dual klystron modulator.