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Single Micro-Bunches from the Linac

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This note sketches the conceptual design of a simple beam chopper system to be used in conjunction with the RFQ that can provide single micro-bunches to Linac users. The bunching action of the RFQ is exploited to permit use of a high Q rf chopper to select single pulses from the 200 MHz fundamental frequency. Complete flexibility in choice of duty factor is provided by a d.c. coupled beam switch located before the RFQ. Use of the two devices, rf chopper and d.c. coupled beam switch, in combination can easily satisfy the two conflicting requirements of very fast rise time and very low duty factor that must be fulfilled for a single-bunch mode of operation.

The conflict between rise time and duty factor comes about because on one hand one needs fast beams to get short rise times, while on the other hand, fast beams are rigid and require high fields to deflect them. Consider a beam passing through a pair of deflection plates. Even if the voltage on the plates has arbitrarily fast rise time, the rise time on the beam is limited by the transit time through the plates. Shorter plates can decrease the transit time but require higher voltages and then the voltage rise time becomes the limiting effect.

One solution is the traveling wave deflector,[1,2] where a large number of short plates are fired in sequence to keep pace with the leading edge of the beam. Such devices are by nature complex, and costly to implement and maintain. For fast chopping a d.c. beam, the traveling wave deflector is the only option. For our situation, however, the bunching action of the RFQ implies that a separated function scheme where the rise time requirement is met by an rf device and the duty factor requirement is met by a d.c. coupled device is the preferred approach.

Figure 1 is a schematic diagram of the system components and illustrates the principle of operation.

The d.c. coupled beam switch is located before the RFQ and operates on the ~ 35 keV beam. A fast switch tube (or preferably a bipolar transistor circuit) switches ~ 1000 V on 10 cm long plates to give about 20 mrad of deflection for a duration of 100 ns. The transit time through the plates being only ~ 40 ns implies a rise time on the beam of at least 50 ns. The pulse that enters the RFQ would look like the triangle shown in the figure.

The RFQ would then accelerate and bunch this 100 ns pulse into 20 tight bunches of varying intensity. The center bunch would have the full intensity available from the source. Outside the ± 50 ns window there would be zero beam.

The sine wave chopper operating at 10 MHz has a 100 ns period and is phased to pass only the one bunch in the center of the pulse. The peak voltage required is determined by the writing speed necessary to insure that only one bunch enters the Linac. This requirement is eased greatly by the fact that the beam is already bunched. A window as large as 8 ns is acceptable (at least in this first order level of design, 5 ns may be a practical number), as shown in Figure 2. This implies a writing speed of ~ 20 mrad/4 ns, or a voltage on 10 cm long plates at 4 cm separation of only 12 kV. This is a modest voltage and could be achieved with less than 150 W of peak power.

A feature of this approach is the great flexibility in duty factor it provides. Since the pulse spacing is controlled by the d.c. coupled switch tube, pulse spacings from 50 ns (when the tube is not used) to any multiple of 50 ns are possible.

In conclusion, a system has been outlined which could provide single micro-pulse mode of operation from the Linac with a great deal of flexibility and could be implemented with a comparably modest investment of equipment and design manpower. A possible application of this facility is in sensitive studies work in the AGS where a single delta function beam pulse may be circulated to stimulate the response function of various diagnostic devices.

References

1. J.H. Anderson and D. Swann, NIM 30 (1964) 1-22.
2. J.S. Lunsford and R.A. Hardekopf, IEEE Trans. Nucl. Sci., NS-30 (1983) 2830.

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Figure 1.

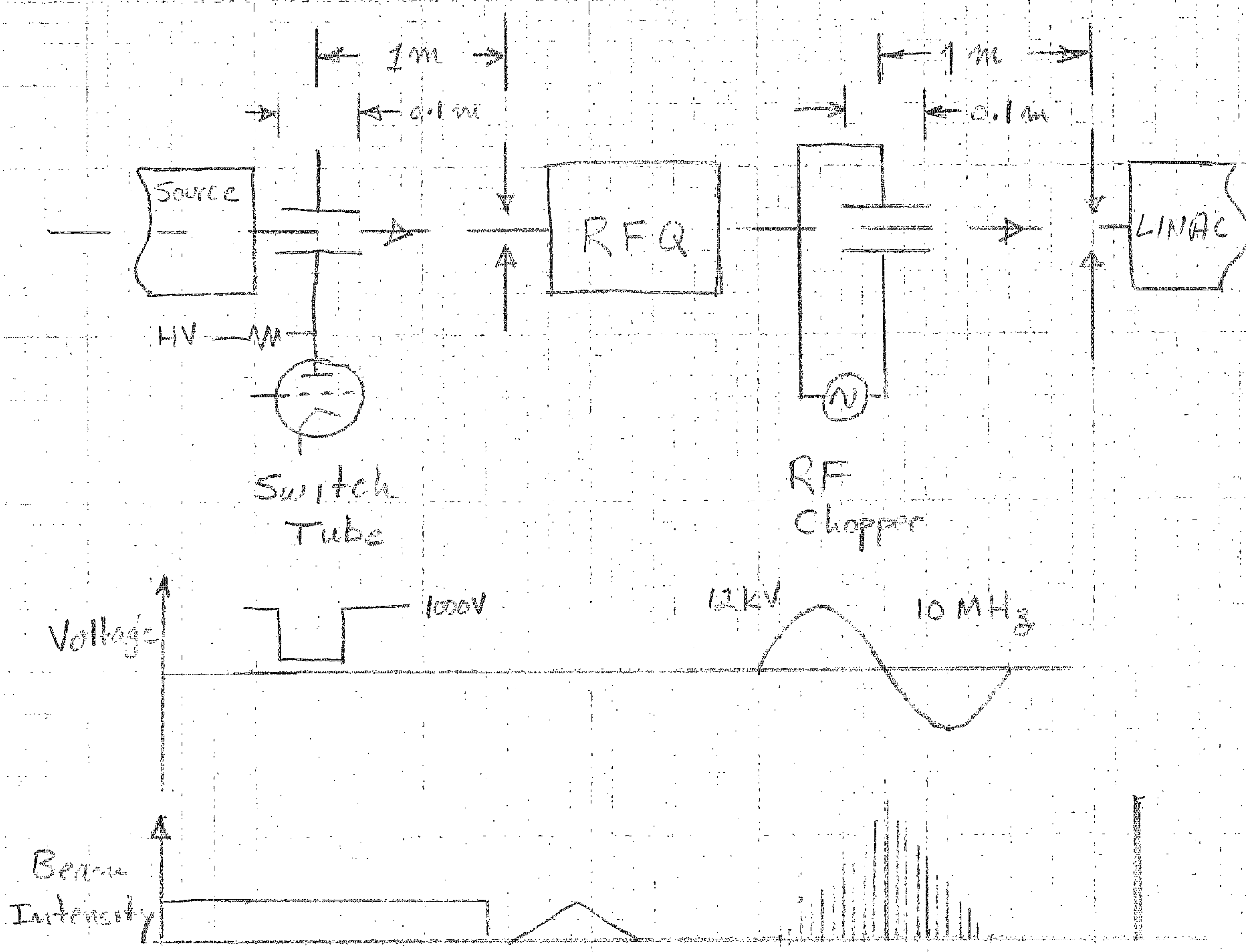

Figure 2.