POST ACCELERATOR BEAM PULSE LENGTH CHOPPER
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Summary
The CEA 130 MeV electron linac has a pulse length of 2.5 μsec. The 6.0 GeV synchrotron accepts only a 0.76 μsec pulse length to fill its circumference. To inject the entire 2.5 μsec pulse length results in unnecessary radiation damage to vacuum chambers and various portions of the transport system. It is desirable to inject only about 0.76 μsec of the pulse, and to select empirically that portion of the linac pulse that has the least energy spread. The unwanted portion of the pulse should be deposited on a suitably designed beam stopper. A magnet followed by a water-cooled collimator has been installed, which precisely chops the 130 MeV linac pulse. The system has been designated PAC for post acceleration chopper. The PAC system and our experience with it will be described.

Introduction
The electron beam from the 130 MeV varian linac has the following operating parameters: beam current 50 ma peak, 2.5 μsec long, and 60 pps repetition rate. About 60% of the beam passes through 2% energy defining slits. The beam is transported to the synchrotron, some 80 feet away, by three quadrupole triplets and two 52.5° bending magnets.

The synchrotron has an orbital frequency of 1.32 MHz and therefore a 0.76 μsec fill time. An injected pulse longer than this produces radiation damage downstream from the inflector.

Design
The PAC includes a fast ferrite pulsed magnet between two series-connected dc bias magnets. The dc magnets deflect the total beam pulse about 1° at the 1" diameter water-cooled collimator located about 16 feet downstream. The fast ferrite magnet deflects a portion of the linac pulse back to the beam centerline for injection into the synchrotron. The geometry of the system is shown in Fig. 1. The magnet system was designed to be outside of the 10-7 torr transport system vacuum. The aperture of the transport system was chosen as 7" minimum. A 0.125" wall thickness for a ceramic spool which is required for the ferrite magnet dictates that the magnet gaps be 1.25" minimum. The lengths of the magnets were chosen as 7" for the ferrite magnet and 4" for each of the dc magnets.

A conservative design was acheived by neglecting fringing and amper-turns dropped in the ferrite. The bending angle required (5.2 Mr) is determined by the distance to the water-cooled collimator (192") and the desired deflection (1°). For small angles and relativistic electrons the following equations are valid.

\[ \theta = \frac{1°}{192"} = \frac{(B \cdot L \text{ gauss-cm})(300)}{(K.E. \text{ ev.})} \text{ radians} \]  
\[ R = \frac{\theta \text{ rad} (K.E.)}{L \text{ cm} (300)} = 126 \text{ gauss} \]

for \( \theta = 5.2 \times 10^{-3} \text{ rad.}, K.E. = 130 \times 10^6 \text{ ev.}, \) and \( L = 17.78 \text{ cm.} \)

To provide a field of 126 gauss over a 3.18 cm gap (\( \psi = 1 \)) requires a (H,L) of about 400 amper-turns in the gap. The current required in a one turn winding to provide the above field is 318 amperes.

The pulser was designed to be a resistively charged distributed line pulser. The line includes two 50fL(RG-213/U) in parallel and of a length to provide the proper pulse length (0.76 μsec). The line is switched by a 7322 thyatron and the current produced flows through the pulsed magnet and a resistive non-inductive load (18.75Ω). The inductance of the pulsed ferrite magnet is about 0.3 μh and strays are estimated at 0.3 μh. The total resistance is the 25Ω of the line and the 18.75Ω of the load resistor. This gives an L/R time constant of 13.7 ns and a 90% rise time of 32 ns. The rise time to 90% is 40 ns. The peak line voltage is given by the product of I peak (318A) and the sum of \( V_C \) and \( R_L \) (43.75Ω) and is equal to 13.9 KB. A 0.057Ω/va Pearson current transformer monitors the peak current. A circuit schematic is shown in Fig. 2. A picture of the PAC in the beam run is shown in Fig. 3.

The water-cooled collimator is a 6" long cylinder of Hievomet with a 1" diameter hole. Water cooling is provided by
four turns of 1/4" O.D. copper tubing brazed to the collimator. The entire linac beam power (~1kW avg.) is delivered to this collimator if the PAC trigger is interrupted.

Results

When first installed, the PAC did chop the linac beam successfully, but due to mis-steering of the electron beam onto the ceramic spool, several small leaks developed. In subsequent assembly the ceramic was cracked due to mechanical stresses. An improved ceramic spool with bellows between the ceramic and the flanges eliminated the stress and a 3/4" diameter water-cooled collimator upstream from the PAC prevented mis-steering from damaging the ceramic. The system has been in use routinely for the past year using two different pulse lengths: one to produce a 0.76 μsec beam pulse for normal synchrotron injection and the other a 0.25 μsec beam pulse to fill only about 1/3 of the synchrotron for studies of multicycle injection in conjunction with the Bypass Beam Storage Project.

The beam current pulse, at an intensity monitor downstream from the water-cooled collimator, is shown in Fig. 4.

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References

