COMMISSIONING OF THE CAMD LOUISIANA STATE UNIV. 200 MeV ELECTRON LINAC INJECTOR

P.LETELLIER, B.GREMONT, G.MEYRAND, D.TRONC
General Electric CGR MeV, Buc, France
D.WANG, R.JOHNSEN
Maxwell-Brobeck division, Richmond, California.

Abstract

This S-band electron linac injector is similar to the Oxford/IBM one. For a 100 nanos. pulse at 200 MeV it delivers 70 mA within an energy bandwith such that Δp/p = +/-1%, or 25 mA within Δp/p = +/- 0.25% (the beam emittance is then 0.4 π mm mrad to one σ). Pulse shapes agree with a simple modeling of the analysing slit effect. A 500 MHz subharmonic system insures that most of the accelerated charge lie within one to two microbunches over six (this distribution being repeated all along the 100 nanos. macropulse). A single bunch mode is also provided with help of a 2.5 nanos. gun.

1. INTRODUCTION

Louisiana State University (LSU) develops the Center for Advanced Microstructures and Devices (CAMD) in Baton Rouge. It will use a 1.2 GeV electron storage ring built by Maxwell Lab. Inc. The injector is a 200 MeV linac built by General Electric CGR MeV in France. Less than 15 meters full length, it injects electrons in single bunch or in multibunch modes.

2. LINAC DESCRIPTION

It is similar to the linac installed for IBM at Fishkill, NY. Its design and early results were given in /1-2/. The beam sees the following components:

(1) a PIERCE triode gun with a planar cathode. The grid is very near the cathode to operate at low voltage. Two amplifiers controls respectively 30 nanos. to 300 nanos. pulses and < 2.5 nanos. pulses. They are at the 50 kV cathode potential and linked to commands by optical fibers. Gun optics have been optimized to achieve smooth convergence with a minimum beam size well inside the RF field.

(2) a subharmonic chopper - prebuncher at 0.5 GHz close to a 4 MeV 3 GHz buncher. These elements are fed by < 4 kW and < 2 MW.

(3) two 6 meters TW sections in the 2π/3 mode give 100 MeV energy gain for 35 MW (37 MW at klystron window) each.

(4) focusing takes advantage of a careful study of the radial dynamics in presence of RF. Current monitors of two types (toroids plus associated amplifiers with overall bandwith to 100 MHz and resistive wall current monitors for bunched beams) are present at 100 MeV and 200 MeV.

3. ACCEPTANCE TESTS

The following tables summarize the acceptance test results:

TABLE 1: LONG PULSE TESTS

Test number	1 & 6	2	3
Energy [1] (MeV)	200	200	200
Pulse [2] (nanos.)	100	100	184
Repetition rate (Hz)	1 & 10	10	10
Duration (min.)	5	5	5
Current stability (%)	30	30	30
Δp/p (%)	±0.25	±1	±0.25
Current (mA) [3]	≥25	≥70	≥14
Microbunch percentage [4]	≥60	≥60	≥60
Emittance (π mm mrad) [5]	≤0.4		

[1] within +/- 2 MeV [2] FWHM length

[3] behind analysing slit with Faraday cup and current transformer

[4] in the central microbunch for any 2 nanos. interval

[5] measured in direct line to one σ by the parabola method, varying quadrupole strength (Q4) at the linac exit (9.27.1991).

TABLE 2: SHORT PULSE TESTS

Test number	4	5
Energy [1] (MeV)	200	200
Pulse [2] (nanos.)	2.5	2.5
Repetition rate (Hz)	10	10
Duration (min.)	5	5
Pulse-to-p. charge stability (%)	30	30
Δp/p (%)	$\pm$0.25	$\pm$1
Charge per pulse (picoC)	>50	>140

[1] within +/- 2 MeV [2] FWHM length

As final test, the beam was established for more than 7.5 hours. The conditions were: 200 +/- 2 MeV, 100 nanos., 10 Hz, Δp/p = +/- 1%. It was verified that the current reached 70 mA within 30 % stability. Beam was available except for 2 minutes. Only two trips were observed.

Figure 1 illustrates a typical long pulse operation with (upper part) 107 mA direct and (lower part) 79 mA analysed current pulses. Figure 2 illustrates a 150 mA short pulse operation in analysed current.

4. CURRENT BEHIND AN ENERGY ANALYSING SLIT

One see on figure 1 that the shape of the analysed current pulse vs. time is triangular (in contrast with the rectangular direct pulse). When selection occurs by a slit following a deviation by a magnet ("analysing slit"), this is a natural consequence of the beam loading combined to the instantaneous microbunch energy dispersion. A quantitative evaluation of these effects is required to specify characteristics for a linac. Our analysis can obviously be refined /3/:

Figure 3 shows (upper part) the energy and (lower part) the current vs. time. The triangle side Δ is the energy change due to progressive beam loading.The bandwith δ is the energy dispersion within a microbunch due to its phase extension. The bandwith ε is the slit energy acceptance.

One sees that the current increases to a flat-top and then decreases. Its shape could be refined with a bell-shaped energy dispersion within a microbunch instead of the rough rectangular model assumed here! Simple geometrical area calculations give the following formula for the ratio r of useful charge crossing the slit to total accelerated charge (beam supposedly optically perfect):

$$r = \frac{\varepsilon}{\max(\Delta \text{ or } \delta)} \quad \text{for } \varepsilon \leq /\Delta - \delta/$$

$$r = 1 - \frac{(\Delta + \delta - \varepsilon)^2}{4\,\delta\,\Delta} \quad \text{for } \varepsilon > /\Delta - \delta/$$

The evaluation of Δ and δ are made as follows:

$$\delta = \frac{\Delta\Phi^2}{8}$$

when a supposedly homogeneous microbunch of length $\Delta\phi$ radian is alternatively forward and backward the accelerating wave, tangent to the crest, to compensate the energy gains from section to section,

$$\Delta = \frac{q\,\omega\,L\omega}{2\,E}$$

for quasi-instantaneous (from the RF point of view) beam loading.
With $L\omega$ = 4000 Ω at $\omega = 2\ 10^{+10}$ (3 GHz) for E-coupled cells at 2π/3 mode, with E=16 MV/m: $\Delta = 0.002\ q_{\text{(nanoC.)}}$

For our linac, with ΔΦ = 25°, δ = 2.4% . With 100 mA accelerated (nominal energy equivalent) and for 180 nanos., Δ = 0.036. For ε = 0.02, r = 0.54.

REFERENCES

/1/ D.Tronc and al., "Electron Linac Design for light sources", EPAC, Rome, 1988, 487.
/2/ P.Letellier and al., "Commissioning of the 200 MeV Injector linac for the Oxford Instr. - IBM Synchrotron light source", 1989 PAC, Chicago, 1082.
/3/ D.Tronc, "Analyse des spectres en énergie et courants mesurés après déviation et traversée d'une fente...", CGR MeV report, 04.1989.

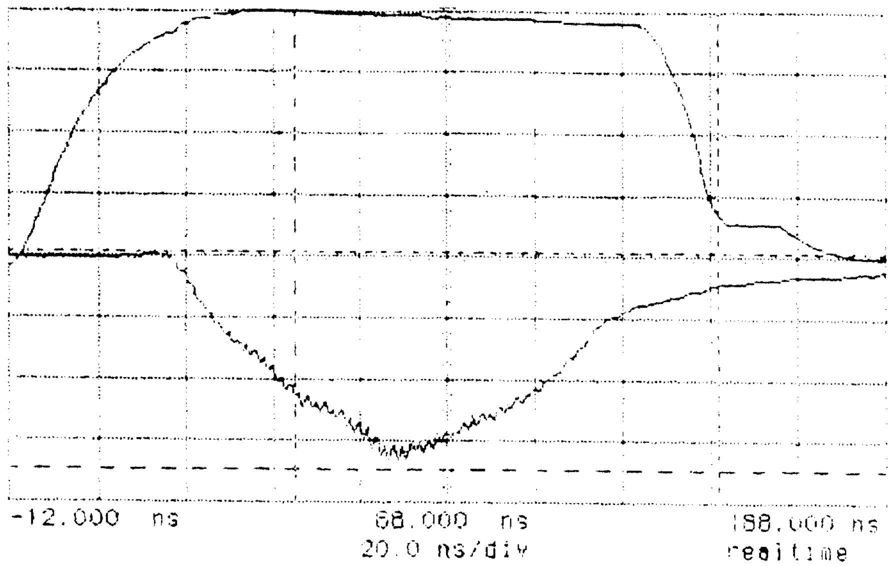

Figure 1. Long pulse

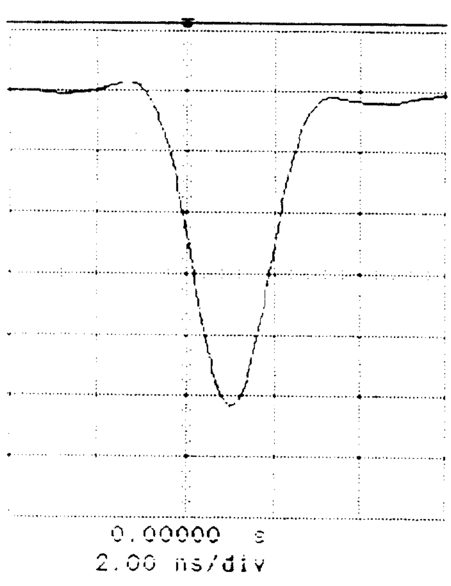

Figure 2. Short pulse

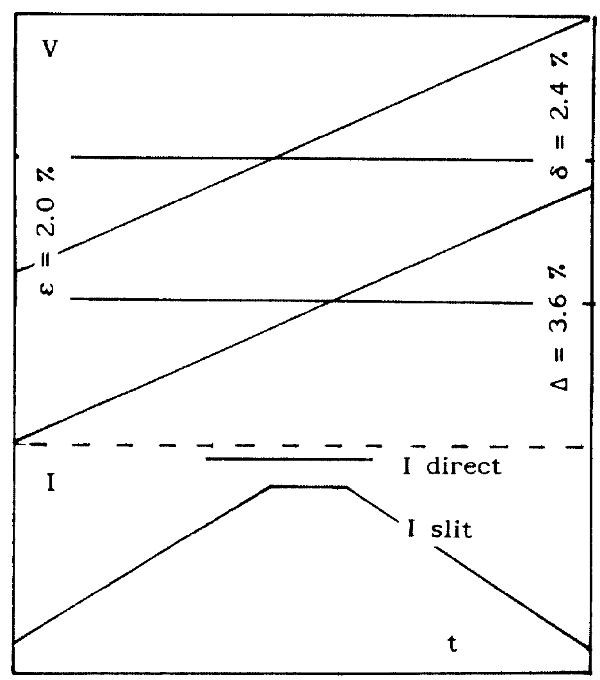

Figure 3. Current behind a slit