A NEW ELECTRON GUN MODULATOR FOR THE ELETTRA LINAC

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Abstract

The ELETTRA Linac is equipped with a triode type electron source, capable to deliver up to 1 A beam current at 100 KeV electron energy. The first part of the Linac, named ELETTRA 100 MeV, is capable of delivering both relatively short electron pulses (2 ns for single bunch operation and 10÷300 ns for multibunch operation), suitable for storage ring injection, and with a much longer pulse train for FEL operation. Until now the switching between the two operating modes required hardware settings on the gun modulator electronics, resulting in time loss and limitation in flexibility.

A completely new integrated electron Gun Modulator has been developped which supports both operating modes. Hereafter the new design architecture and the results of preliminary tests are presented.

Introduction

The first part of the ELETTRA Linac, the 100 MeV pre-injector, has been preliminary tested [1,2] to verify its capability of producing an electron beam burst in order to drive the IR/FIR FEL under development at Sincrotrone Trieste [3,4,5].

A complete description of the Trieste pre-injector Linac can be found in [6], in table 1 the expected FEL beam parameters are listed.

Up to now, we have operated the machine in the FEL mode mainly at 30 MeV with a 5 µs macropulse at 10 Hz repetition rate.

Table 1
Expected beam parameters for FEL operation

Beam energy (MeV)	20 ÷ 75
Energy spread @ 75 MeV (%)	± 0.3
Macropulse repetition rate (Hz)	10
Macropulse length max. (µsec.)	10
Micropulse repetition rate (MHz)	20.8 ÷ 31.2
Micropulse length FWHM (psec.)	10
Charge per micropulse (nC)	0.4
Peak Current (A)	37.5
Normalized Emittance rms (mm mrad)	62.5

In a first stage, due to hardware constraints, we were also obliged to work at a fixed micropulse repetition rate of 25 MHz, while a notable limitation for the maxiumum achievable beam macropulse width, 5 µs instead of the 10 µs expected, was caused by the poor performances of the PFN (Pulse Forming Network), which only provides an useful pulse lenght for the klystron up to 6 µs.

Anyway, up to May '96, the major constraints to continue the machine operation and tests in FEL mode has been derived from the very long time required in switching the machine set up from Injection to FEL modes; in particular more than one hour was necessary to replace the Injection Gun Modulator with the FEL Gun Modulator, since a single unit supporting both operating modes was not available until that data.

Starting from the second half of '95 we have developped and assembled a new Gun Modulator Unit that can be operated both for the injection and for the FEL modes.

At the beginning of May '96 the beam test on the first prototype assembled on the Linac was started.

The New Gun Modulator Unit

The Trieste Gun is a standard thermionic Pierce triode, using a commercial planar cathode-grid unit, Thomson TH 306, with an emitting surface of 1.2 cm^2. The cathode-grid assembly is negatively HV referred with a low voltage grid bias for current interdiction.

In Fig.(1) the emitted currents as a function of the negative grid bias for two different anodic voltage settings (60 and 75 kV) are reported. Due to HV power supply limitation, we could not extend our measurements beyond 50 mA. The reported data have been collected on keeping the grid negatively biased at 30 V and superimposing a continuus adjustable positive pulse.

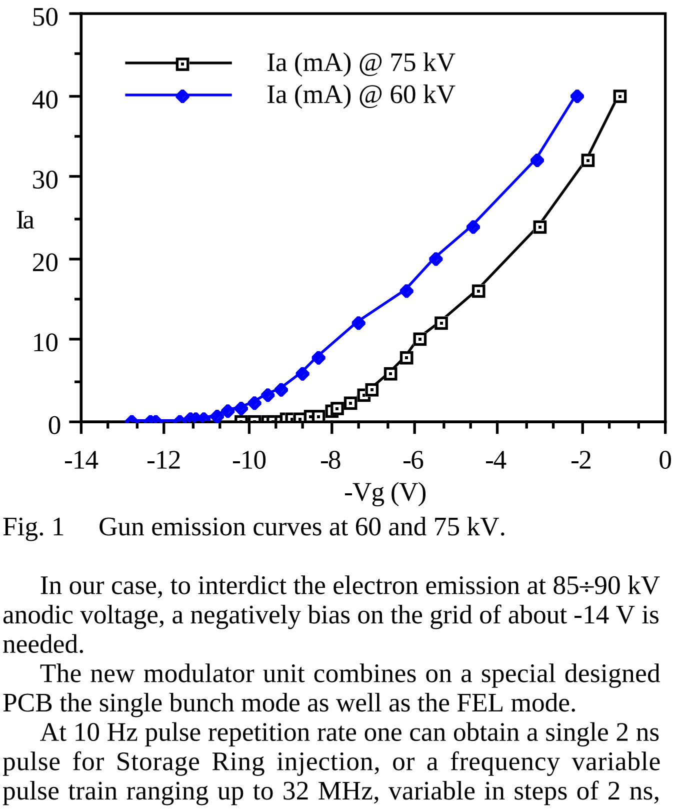

Fig. 1 Gun emission curves at 60 and 75 kV.

In our case, to interdict the electron emission at 85÷90 kV anodic voltage, a negatively bias on the grid of about -14 V is needed.

The new modulator unit combines on a special designed PCB the single bunch mode as well as the FEL mode.

At 10 Hz pulse repetition rate one can obtain a single 2 ns pulse for Storage Ring injection, or a frequency variable pulse train ranging up to 32 MHz, variable in steps of 2 ns, for FEL operation. In the second case the macropulse length can be continously adjusted up to 30 µs keeping the repetition rate fixed at 10 Hz.

In Fig. 2 a block diagram of the pulser (a) and the pulse time sequences (b) are reported.

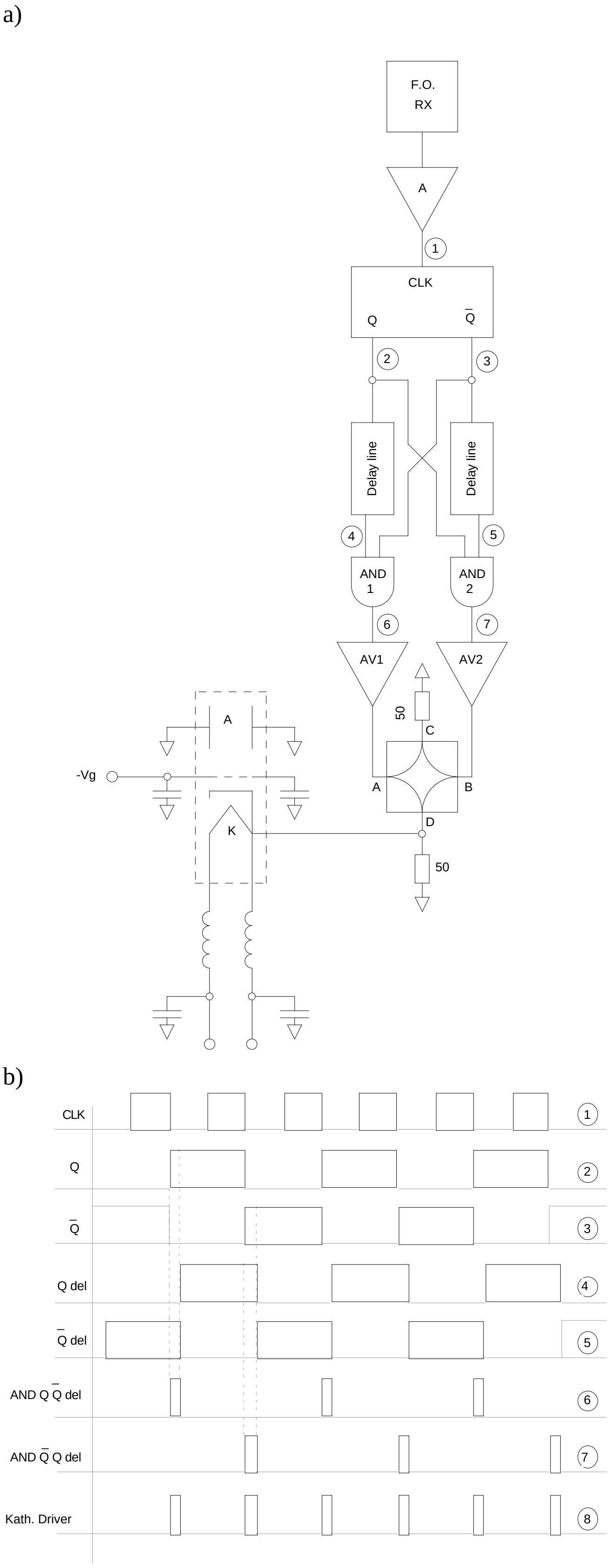

Fig. 2. a) Pulse time sequences.
b) Block diagram of the single bunch and FEL pulser.

A synchronized trigger (the main trigger) is sent via a fiber optic link to the clock of a flip-flop circuit; the two flip-flop exits are suitably delayed (5 nsec) and logically combined (AND1- AND2) to trigger the two main pulser circuits, AV1 and AV2; these make use of two 2N2369 transistors operating in avalanche mode.

The two transistors are alternately fired at half of the selected operating microbunch repetition rate and an hybrid circuit, recombines the two pulse trains to pilot the cathode of the gun.

The main trigger is synchronized with the 500 MHz frequency of the machine. The jitter between the two pulse trains before the pulsers AV1 and AV2 has been measured and found to be lower than ± 0.5 nsec. No remarkable jitter increase was observed from the avalanche pulsers or from transistor pairs which were differently matched.

The measured pulse to pulse amplitude stability seems to be acceptable (≤ 5%). Nevertheless, more work has to be performed and accurate measurements will be necessary to find the best operating conditions of the system.

In May '96 we have operated the machine with the new gun modulator in single bunch mode and in FEL mode with a micropulse repetition rate ranging from a few MHz up to 32 MHz. The macropulse beam current at the Linac exit has been measured to be higher than 100 mA.

In Table 2 the main beam parameters measured in May '96 compared with the previous measurements taken in '95 are reported.

Table 2
FEL mode linac beam characteristics:
comparison between the old and new gun modulator

	March '95	May '96
Beam Energy	30 MeV	30 MeV
Macropulse current	30 mA	≥ 100 mA
Horizontal emittance @ 30 MeV		
(p mm mrad)	3.38	4.22
Energy spread @ 30 MeV	≤ ± 0.6 %	≤ ± 0.51%

Conclusions

The preliminary tests performed on the first prototype of the new gun modulator has given encouraging results. Further improvements are now under consideration in order to increase the performance of the prototype.

We are considering the use of a wide band RF amplifier which should increase the peak current emitted from the gun. A new trigger scheme, with a 500 MHz programmable divider, is now under consideration in order to further reduce the pulse to pulse jitter and to improve the beam amplitude stability.

Aknowledgements

The authors are grateful to all the Linac technical staff for the continuous help received.

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