CONTROL SYSTEM OF KEK COCKCROFT-WALTON GENERATOR

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A preinjector of the KEK proton synchrotron is an open Cockcroft-Walton (C-W) generator. A distinct beam loading appears in it, because beam pulses are accelerated not regularly but 9 pulses are delivered every 50 ms in 0.4 s followed by a rest of about 1.6 s. It is compensated by a forcing circuit in a new control system, which was made in 1977.

High voltage apparatus are set in the preinjector room, which is shielded with aluminum plates to protect many control circuit from noises caused by arcing. The C-W generator has an auxiliary capacitor column with a 500 kΩ resistor for filtering ripple voltage. A high voltage terminal is connected to the C-W generator with a damping resistor of 10 MΩ, which limits surge current from the C-W generator to avoid damage of selenium rectifiers when arcing occurs in an accelerating column.

Fig.1 shows a block diagram of the control system. It has two modes of operation: 1) the output voltage is divided and compared with a reference voltage. The difference between them is amplified and fed to a field current of a motor-generator of 350 Hz. The C-W generator is running normally in this negative feedback mode. 2) if the difference between them exceeds some limits, for example ±0.2 %, then the voltage is changed by 0.02 % every 1 s or 10 s. This mode of operation will be chosen when arcing occurs frequently in the accelerating column. A small discharge scarcely grows into a big arcing in this mode. When a new oxide cathode is put in a duoplasmatron ion source, then the C-W generator is operated in mode 2 until the accelerating column is well conditioned. It is possible to change from mode 1 to mode 2 and vice versa keeping an output voltage of 750 kV.

Since the beam pulse is as long as 15 μs, the negative feedback loop of mode 1 is not so fast. Thus beam loading in single beam pulse of 15 kV is reduced to ±1 kV by a bouncer circuit with a separate capacitor column. As the KEK synchrotron is a cascade machine, 9 beam pulses are delivered successively as mentioned above. It was found that a voltage drop of 2 kV occurs by beam loading between the first and the last of the 9 pulses. The negative feedback loop is insufficient to compensate the beam loading. Hence, the new control system is installed with a forcing circuit, which can raise the output voltage for 0.5 s by increasing the field current of the motor-generator. If the forcing is triggered 50 ms advanced from the first of the 9 beam pulses, the beam loading is compensated as shown in Fig.2.

The ripple voltage of the C-W generator is about 5.5 kV p-p at 750 kV. This must be mainly due to electrostatic coupling from the transfer capacitors, and it is reduced to 1 kV p-p by supplying suitable voltage of 350 Hz to the filter column.(Fig.3) As a momentum spectrum of the 20 MeV linac is not affected by ±0.5 % change of injection energy, the C-W generator accelerates ion beams of up to 800 mA with sufficient energy stability.

Table 1 Some parameters of KEK Cockcroft-Walton Generator

Output voltage and current	800 kV and 5 mA
Voltage stability	±0.1 % at 800 kV (for 24 hours)
AC frequency	350 Hz

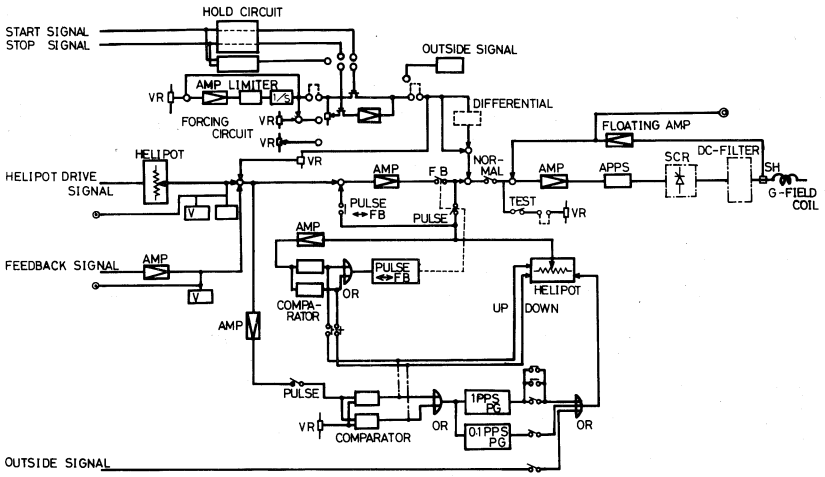

Fig.1 Block diagram of control circuit.

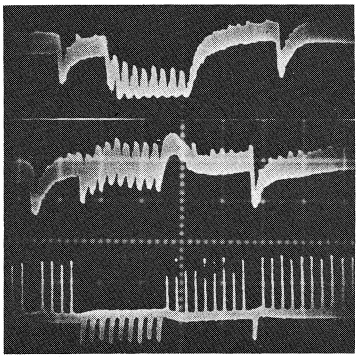

Fig.2 Output voltage fluctuations in 9 beam pulses operation with two extra pulses. Without forcing (upper) and with forcing (center). Horizontal: 0.2 s/div. Vertical: 1.5 KV/div. Rapid change of the voltage is detected by C-pickup (lower). Vertical: 10 KV/div.

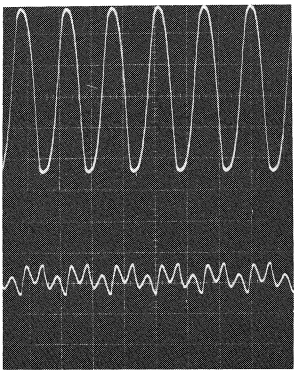

Fig.3 Ripple voltages at 750 KV. Without compensation (upper) and with compensation (lower). Horizontal: 2 ms/div. Vertical: 1 KV/div.