The Features of Forming the Magnetic Cycle of Yerevan Synchrotron

G.A.Martorossian, V.Ts.Nickogossian, K.A.Sadoyan
Yerevan Physics Institute, Armenia
V.P.Goncharenko, O.A.Gusev
D.V.Efremov's SRIEPA, Russia
V.Bothe
DESY, German

Abstract

The alternative schemes of Yerevan electron synchrotron power supply system, providing a forming of the magnetic field with long duration flat-top for accelerated beam slow extraction are investigated. The causes of appearance and methods of compensation of irregularity of flat-top area of field with duration of up to 20 ms and more are analyzed. The conditions of commutation of thyristor switches, shunting the magnet current circuit at the moment of plateau forming are considered.

One of the most important way to increase the efficiency of the Yerevan synchrotron is the formation of the extracted beams with minimum energy spread and sufficiently high duty factor.

In this report an alternative schemes of Yerevan electron synchrotron power supply system, providing a forming of the magnetic field with long duration flat-top for accelerated beam slow extraction are considered.

1.Flat-top formation by "cutting off" the a.c. component of the magnet supply

In this case [1], the flat-top is forming as follows. After reaching a required value of magnetic intensity the thyristor keys are turned on and shorting out the circuit of in-series connected capacitor banks and additional inductances. The experimental results prove, that this scheme has an essential disadvantage in spite of many obvious advantages. This disadvantage is connected with the real parameters of existing power supply system, which make practically impossible the forming of flat-top with duration of no more than 3 ms, since it is determined by the magnitude of additional inductance and voltage on a capacitor bank.

2. Flat-top forming by "addition" of a flat-top part to a magnet field maximum [2]

The circuit of magnetic field flat-top formation is shown in Fig.1. Thyristor Th1 makes the short, in consequence which the magnet current flat-top is forming. During this time capacitors discharged by damped oscillation via L and Th1. Thytistor Th2 is fired at maximum negative voltage of C and an inverse current starts to interrupt Th1 current. The resonant circuit transients to free frequency.

The process of flat-top formation is explained by the current and voltage diagrams given in Fig.2. The capacitors discharge at time t_3 and magnet current attains to maximum value. Th2- current is interrupting at time t_4 when magnet current becomes equal to inductance current. After this time the resonant circuit transients to frequency

$$\omega_0 = \frac{1}{\sqrt{L_e C}}$$

where L_e is resonant circuit equivalent inductance.

Voltage and current in Th1 are determined by

$$U_c(t) = - \frac{I \sin \omega_1 t}{\omega_1 C}$$

$$i_{Th1} = I (1 - \cos \omega_1 t)$$

where $\omega_1 = \sqrt{L C}$ is angular frequency of the resonant circuit.

It should be noted, that the remaining charge of C must be sufficiently high and therefore

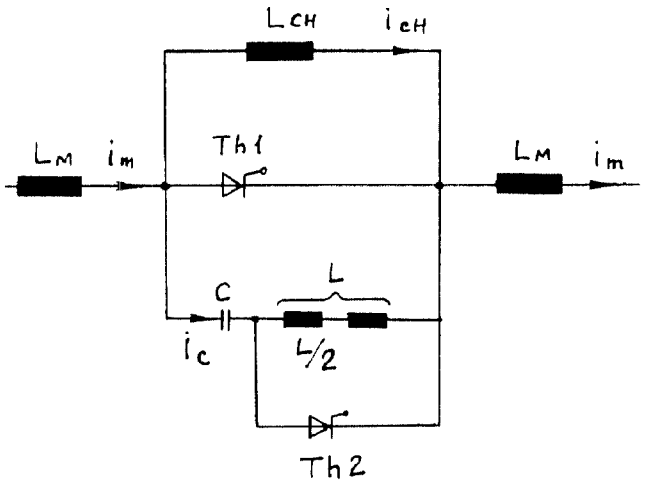

Fig 1.
Circuit diagram for short time flat-top
L_M - magnet inductance
L_{CH} - choke inductance
L - additional choke
Th1, Th2 - thyristor switches

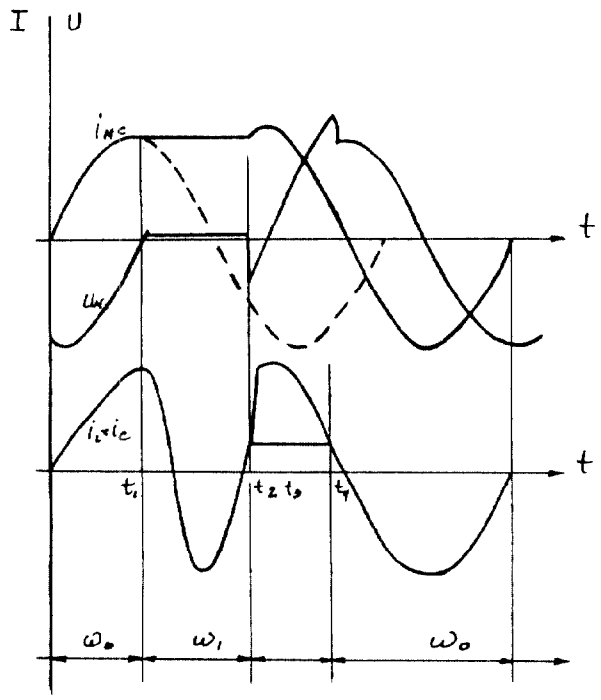

Fig.2
Parameters of the circuit shown in Fig.1.
u_M, i_M - voltage and current of magnet
$i_L = i_C$ - current of additional magnet

this method can only be used for short time flat-top [3]. The experimental results of of the Yerevan synchrotron magnetic field flat-top forming system operation for accelerated particles slow extraction, which is accomplished by above mentioned methods 1 and 2, are investigated in details in [2]. In considered methods of flat-top forming the thyristor keys are locked automatically. That is one of the main advantages of the schemes with "self commutation".

3. Flat-top forming by switching at $U'_C = 0$ and $I_{C\,max}$

Unlike the above considered schemes in this case has to be used "forced commutation" for interrupting the long-duration flat-top current, as it was proposed in [4].
The capacitors are short-circuited at their voltage zero-axis crossing, and the capacitor current, now at its maximum, commutates on the short circuit path. The magnet current is on its maximum at this time and the current in the chokes on its minimum. Without losses both currents would keep these values as dc for any period of time. In order to finish flat-top at the desired point the current has to be taken away from the short circuit path by forced commutation and guided again to the capacitors, and the alternating cycle begins with negative slope.
The circuit in Fig.3 shows a switching method like the proposal for the Cornell synchrotron as per [5]. In this case forced commutation is gained by an additional arrangement which is switched in series to the thyristor and which uses an isolating transformer. The short circuit will be started at the end of the accelerating phase and transition to flat-top. As the ignition of thyristors may be determined rather exactly synchronous (time lapses in the μs range), there are no disturbances to be expected in this critical phase. Short circuit of capacitors shall be individually in each group. A common short circuit can only take place via the auxiliary windings, for this method there exists a

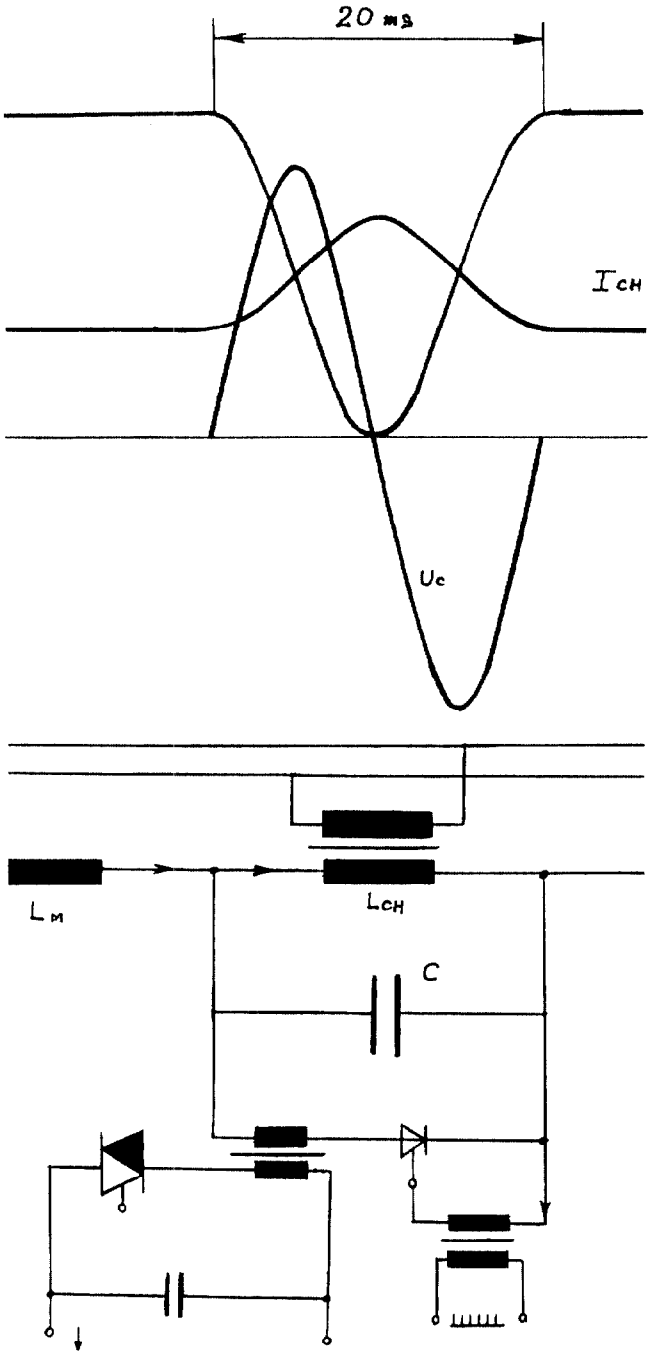

Fig.3
Circuit for forming long-time flat-top

$\frac{L_M}{L_{CH}} = \frac{1}{3}$

proposal by G.Hemmie [5], as per which a rectangular pulse is excited of the duration of flat-top and amplitude: maximum magnet current less minimum choke current via the choke auxiliary windings. Because of parallel circuit of the auxiliary windings the pulse to be produced has a current of N-times of this amplitude, if N is the number of groups. The large pulse power and the unsufficient cross section of the auxiliary windings will not allow this method.

This scheme is under development in Yerevan now, as one of the possible realization of the long-time flat-top forming.

References

[1] A.Ts.Amatuni et al., "The Prospects of Improvement and Development of Accelerator Installations at Yerevan Physics Institute", Proceedings of the European Particle Accelerator Conference, EPAC 88, Rome, 1988.

[2] V.A.Airapetian et al., "Yerevan Electron Synchrotron in the Mode of Formation of a Slow-Extraction Plateau", YPI-1265(51)-90

[3] W.Bothe, "Resonant Excitation of Synchrotron Magnets", DESY M-90-01, July 1990.

[4] W.Bothe, "Flat Top for Magnet Current of Yerevan Synchrotron", DESY MKK, Hamburg 16.11.87.

[5] PPAD 581 S of 9.2.1966, "Magnet Flat Topping Symposium Summary".