POWER SUPPLY FOR THE KEK PROTON SYNCHROTRON

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The method and problems of power supply for the pulsed magnet is disucssed for example of the KEK proton synchrotron.

The general characteristic of the inductive load for the pulsed magnet are write down in an itemized form. That is,

(1) method of power supply
    1) Fly wheel
    2) Capacitor
    3) Direct powering from utility line
(2) Problem to utility line
    1) Flicker
    2) AC harmonics
(3) Problem to load
    1) Accuracy
    2) DC harmonics
(4) Thyristor rectifier
    1) Ripple of DC current
    2) Power factor

The power supply of KEK proton synchrotron, designed as following in the consideration above problem, which is also explained in relation to the problem with connecting line.

The Power Supply of KEK Proton Synchrotron

Twelve phase thristor rectifier	Flicker
Converter-inverter operation	AC harmonics
AC filter	Accuracy
TQC (Thyristor Q Control)	DC harmonics
DC filter	Ripple
Computer control	Power factor
Dynamic filter	

Generally, the problems of ripple, harmonic currents and reactive power are strongly correlated to the phase angle of firing thyristors. That is, with small phase angle, which is fired at injection time to yield lower voltage and smaller magnet current, the thyristor will generate a large amount of harmonic currents at AC side, ripples at DC side and reactive power.

AC harmonics are degraded by AC filters and the reactive power is compensated by TQC. DC passive filters and a sensitive dynamic filters suppress the ripple contents lower than 10^{-5} of the magnet current.

As for the converter-inverter operation of the thyristor rectifier, two rectifiers are connected in series and operated with each phase angle. When the low voltage operation is desired,

one rectifier is operated in convertor mode with large phase angle and the other rectifier is operated in inverter mode with large nagative phase angle, so total reactive power and ripple are small.

In order to gain the current stavility, which is $\sim 10^{-5}$, and the tracking error of the quadrupole magnet aginst to the Bending magnet, which must be lower than 0.3 %, the power supply is controlled by H-350 computer. The basic point of computer control is the combination between the double feedback loop and feed-forward control. That is consisted of the real time AVR feedback loop, the 10 msec sampling ACR feedback loop and the calculated voltage pattern for feed-forward control.

As for the future plan power supply for pulsed magnet, the SCES (superconducting coil energy strage) is most desired. There are amount of merits, that is, no flicker, no AC harmonics, and low electric cost, because only average active power is drawn from utility line.

Reference

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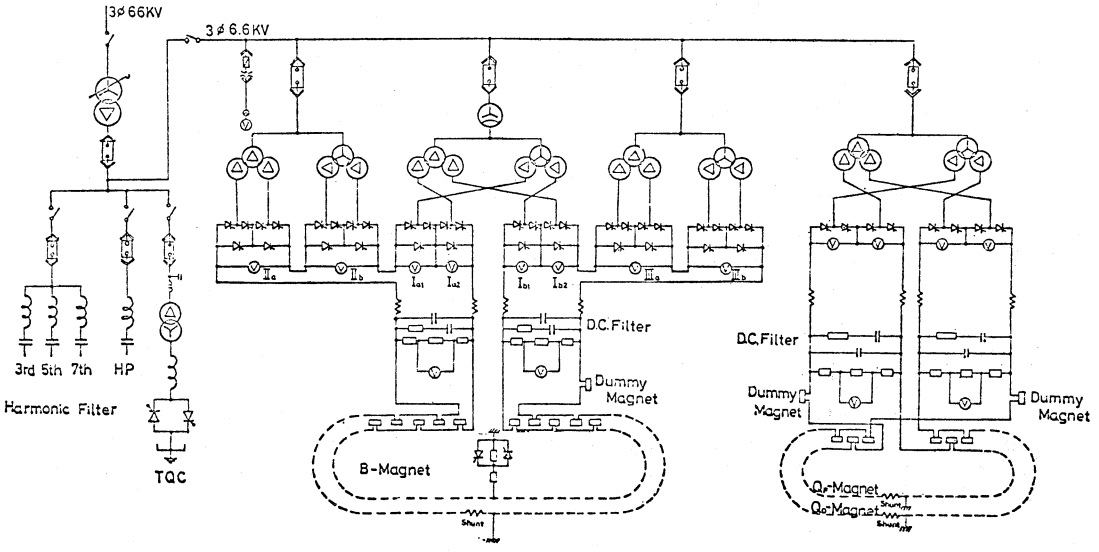

Skelton Diagram of the Power Supply for the KEK Proton Synchrotron