IMPROVED DYNAMIC FILTERS FOR THE MAIN RING MAGNET POWER SUPPLY OF THE KEK 12 GeV PS

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Abstract

The dynamic filters of the KEK 12 GeV PS were improved in the voltage ripple detector, in the control system and in the power-up of the PWM and B-class amplifiers. As the results, the output of the low frequency voltage ripple ($\leq$ 300 Hz) could be reduced to less than - 25 db to the inputs in the B, Q_F and Q_D magnet power supply. These suggest for the current ripples to be a factor of 10^{-6} to flat top current 2,850 A during extraction.

Introduction

Dynamic filters have been operated in the MRMPS (main ring magnet power supplies) for the 12 GeV PS to reduce the current ripples. These ripples generate undesirable fluctuations in the circulating beam. During slow beam extraction, the ejected beam spill is modulated remarkably by the current ripples. These ripples have to be suppressed less than 10^{-5}.

The ripples come from the desired pulse voltage fed by phase control of 16 SCR rectifiers with 3 ϕ bridge connection as the MRMPS. Two 6 pulsed rectifiers make a 12 pulsed rectifier connected in cascade with 3 ϕ transformers of Y - Δ and Δ - Δ winding.

One group of the rectifiers working at flat top in B-MPS (magnet power supply) has the fundamental characteristic ripple of 300 Hz because of different phase control patterns between these 6 pulesed rectifiers, and the others of B and both Q_F and Q_D have the ripple of 600 Hz with the same pattern between the pair of 6 pulsed. As the uncharactristic ripples of 50 Hz, 100 Hz and harmonics are generated from jittering of ignition angle on the SCR and 3 ϕ unbalance in available ac line, passive filters were set up to reduce these ripples. The low pass filters have the cut-off frequency 55 Hz and the gradient - 12 db/oct with under-damping characteristics and the resonance filters have tuned frequency 100 Hz. The previous dynamic filters were designed for the residual ripples to be suppressed to the desired level in the entire pulse operation. But the filter could not compensate the low frequency ripples ($\leq$ 300 Hz).

Some improvements were carried out in the ripple detector, in the control system and in power-up of the PWM (pulse wide modulation) and B-class amplifiers connected in cascade through each reactor transformers.

Developed voltage ripple detector

Fig.1 shows a schematic diagram of the MRMPS included dynamic filter . The voltage pattern has frequency components less than 25 Hz and the ripple has higher than 50 Hz. In the previous, to separate the voltage pattern component and the ripple signal, the ripples were regarded as the difference between the pulsed voltage from a high impedance resistive voltage divider and a equalizer output. The equalizers had an approximate transfer characteristics of the MPS and the inputs were the voltage patterns from the control computer of the MPS.

But the first of error signals came from multi-grounding currents through the center of the dividers connected to the ground, the second from the mismatch between the MPS and the equalizer, the third from the phase difference between input and output signals of the voltage divider.

The developed voltage ripple detector given in Fig.2 consists of a low impedance resistive voltage divider, an equalizer and a high pass filter to improve these errors. The reactor transformer and the divider could reject the error signals, but the low frequency components of the voltage pattern still remained in the output. These components could be excluded by the simple CR equalizer and the high pass filter.

Amplifier system

The detected signals have been possible to control the dynamic filters by negative feed back loop. But the output power of the amplifiers had to increase up to reduce these ripples.

The powers are fed through the output reactor transformers by the PWM and B-class amplifier systems with appropriate phase compensations.

The PWM system with the carrier frequency of 40 KHz covers the ripple frequency range from 50 Hz to 1 KHz and has the same 22 water-cooled power amplifier modules with 4 high power switching transistors (selected from 2SC1471) per module. Two groups with the 9 modules serve to the B-MPS and two with the 2 modules to the Q_F - and Q_D - MPS through the same numbers of reactor transformer. The output power of the PWM increased up to about ten times larger than the previous by changing the power source from 110 V to 300 V.

The B-class amplifier covers the ripples from 50 Hz to 2 KHz and has the same 20 water-cooled power amplifier modules with 8 transistors (2SD465) connected in parallel.

Two groups with the 6 power amplifier modules serve to the B-MPS and each with the 4 modules to the Q_F and Q_D - MPS through the reactor transformers. The power-up of B-class amplifier was carried out at 4.5 times larger than the previous by changing the power source from 30 V to 48 V.

Experimental results

After these improvements, the current ripples have been estimated at a factor of 10^{-6} to flat top current 2,850 A. For example, Fig.3 (photo.) shows the output of the voltage ripple detector at input (top) and output (bottom) to the dynamic filter for the B-MPS on the flat top. Fig.4 gives a spectrum analysis of the same signals. The similar results have been obtaind in the Q_F and Q_D - MPS. The more detailed results will be described in some places before long.

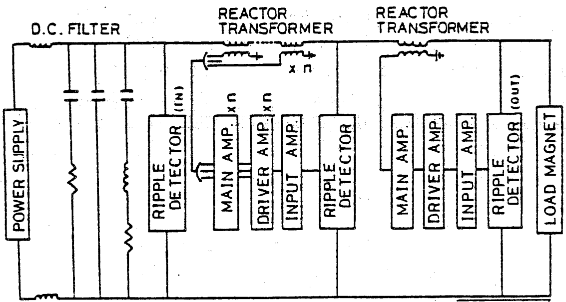

FIG.1 SCHEMATIC DIAGRAM OF THE DYNAMIC FILTERS

·	n
Bmag.1	9
Bmag.2	9
Q_F	2
Q_D	2

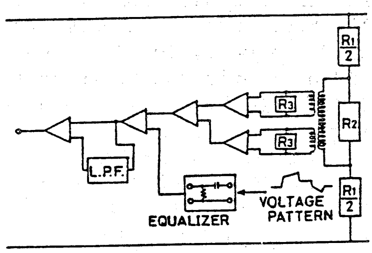

FIG.2 VOLTAGE RIPPLE DETECTOR

50 V/div

2 ms/div

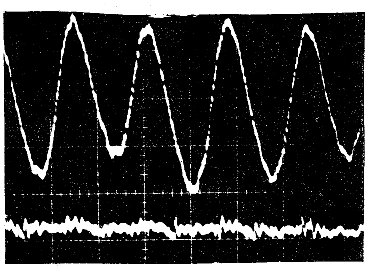

FIG.3 VOLTAGE RIPPLES OF THE INPUT AND OUTPUT

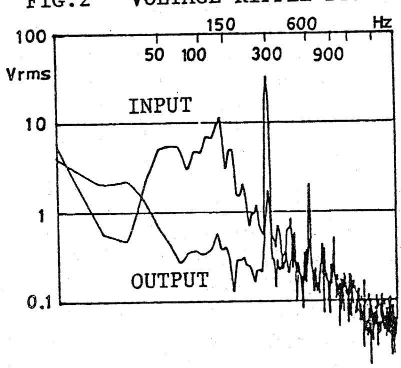

FIG.4 SPECTRUM ANALYSIS OF THE VOLTAGE RIPPLES