

IMPROVED CONTROL SYSTEM OF THYRISTOR REACTIVE POWER COMPENSATOR  
FOR MAIN RING MAGNET POWER SUPPLY OF 12 GeV P.S.

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### 1. Introduction

On the routine operation of 12 GeV P.S., the voltage flicker from the magnet power supply (MPS) had been suppressed within  $\pm 1.5\%$  at 66 kV ac line by the thyristor controlled reactive power compensator (TQC)<sup>1)</sup>, except transient parts of pulsed voltage to the MR magnets. The maximum voltage spike (surge and sag) could be estimated at about  $\pm 2 \sim 4\%$  on the 66 kV line. The voltage spikes occur at the region just after the end of the flat top corresponding to the start of two-bridge-inverter-operation for the surge, and at the start of eight-bridge-inverter-operation for the sag, to release the stored energy in the bending magnets out to ac line. The spikes have not given any severe disturbance to the beam spill of the 12 GeV machine, but may be harmful to other machines constructed or planned inside site of the laboratory.

### 2. Improvement

Fig. 1 shows a block diagram of the whole improved system. The TQC consist of 16 MVar and 4 MVar bank with a rectifying transformer of  $\Delta$ - $\Delta$  winding and 4 MVar with Y- $\Delta$ - $\Delta$  winding. These 20 MVar lag powers are compensated at the fundamental 50 Hz by capacitors in eight banks of harmonic resonant filter.

In the previous, the TQC had been controlled independently by reactive current of the MPS through open-loop on the every single phase to secondary windings of the 16 MVar and 4 MVar bank. In the loop, the transfer function should be requested a comparable accuracy to a desired level to suppress the voltage fluctuation as a control error. The function could be hardly determined in exact, because the whole system compose of the MPS, TQC, harmonic filters and the power line correlating each other under swing of large active and reactive power.

Predominant error source should be due to the tracking errors on the pulsed operation of the MPS by transient characteristics of the reactive current detector, ignition dead-time of TQC thyristor, and coupled damping oscillations between large filter capacitors and source impedance of the line.

The improvements to the dead-time and the coupled oscillation would not be practical in cost performance. We have developed detectors on a voltage flicker ( $\Delta V$ ), interphase voltage unbalance ( $\Delta V$ ), and on a reactive power (Q), and have improved the control scheme essentially by both FF- and NFB-loops with these detectors. The FF-loops are controlled by the Q detector in the MPS and the forcing patterns processed from  $\Delta V$  signals. The NFB-loops are controlled by the  $\Delta V$  and  $\Delta V$  on the ac line.

### 3. Performance

The developed  $\Delta V$  detector has small transient to step input, fast and wide frequency response up to 300 Hz, and more exact detection less than 0.3%. The developed Q detector has reduced for the maximum sag to about 2/3 compared with the previous, as shown in photo. 1.

In the transient regions, the loads have different patterns to every single phase, because of the transient characteristics of the system and of different capacity and operation mode among the 16 MVar, 4 MVar TQC and MPS. But large parts of the transient flickers are steady-state components depended on the pulsed pattern of MPS. These fast components are suppressed into about 1/2 by FF-loop with a forcing pattern processed on a Z-80A micro-computer system. Photo. 2 gives typical flickers  $\Delta V$  on the vicinity of flat top with (top) and without (bottom) the forcing signal.

These results indicate for the voltage flicker including surge and sag to be suppressed within  $\pm 1.5\%$  at the 66 kV line.

Reference

- 1) M. Masuda et al.: IEEE Trans. on Nucl. Sci., NS-24 (1977), No.3, 1306.

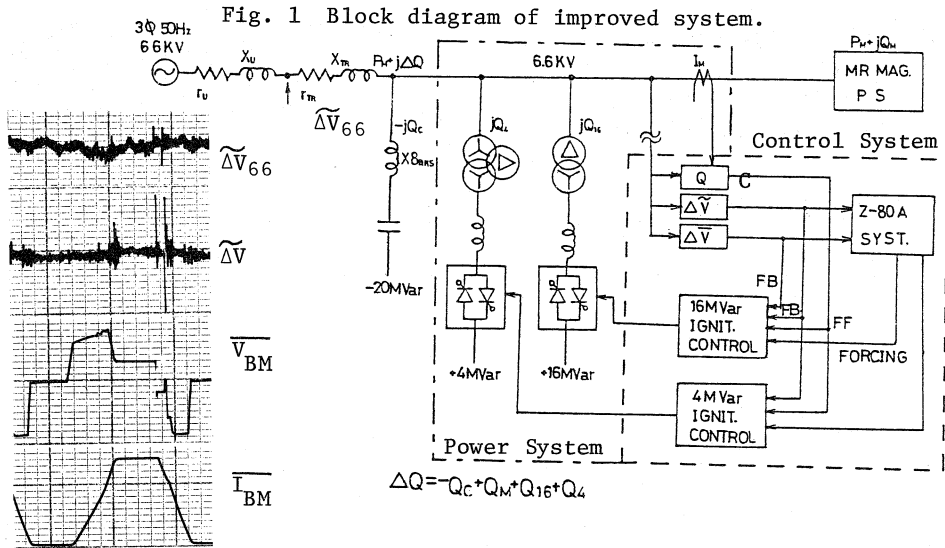


Fig. 2 Typical pulse forms.  
Photo. 1 The maximum surge and sag.

Photo. 2 Voltage flicker  $\Delta V$   
on vicinity of F. T..

