OPERATION OF INVERTER DC POWER SUPPLY FOR KLYSTRON

Y. Shoji, LASTI, Himeji Institute of Technology, NewSUBARU/SPring-8, 678-1205 Japan

Abstract

A new crowbarless power supply for a klystron was installed at NewSUBARU and has been operated since 1998. A high-power switching inverter unit eliminated the need for an unstable crowbar circuit. There has been no problem of the inverter system.

We have had two failures, which disabled the beam commissioning. One was a trouble of a small DC power supply unit. The other was an over heating of a harmonic filter of primary AC line. Both of them could be avoided if the troubled elements had good margin for safety.

1 INTRODUCTION

NewSUBARU [1] is 1.5GeV synchrotron radiation ring in the SPring-8 site. LASTI (Laboratory of Advanced Science and Technology for Industry) of Himeji Institute of Technology is in charge of the operation collaborating with SPring-8.

The storage ring has one RF cavity powered by a 180kW/500MHz klystron. A -45kV DC power supply with inverters is used to operate it [2]. The ratings of the power supply are listed in Table I. A conventional power supply for a klystron uses a crowbar circuit that suddenly quenches a klystron arc and results in a discharge of stored energy. However the crowbar circuit has false-firing problems caused by electric noise. The new power supply has high-power switching inverter units, which eliminate the need for an unstable crowbar circuit.

Table 1: Ratings of the crowbarless power supply.

Maximum current	9A
Voltage control range	-22.5 ~ -45kV
AC line frequency	60Hz
Inverter frequency	21.3kHz
Voltage ripple	±0.2% at 1~10kHz
Klystron	Toshiba E3774 frequency : 500MHz rf power : 180kW

The commissioning of the ring started in September 1998. Since then there has been no failure comes from the inverter system. However we have had two failures, which disabled the operation for some days. One was a trouble of a small DC power supply unit. The other was an over heating of a harmonic filter of primary AC line. These failures will be presented in the section 3 and 4.

2 CHARACTERISTICS OF THE CROWBARLESS POWER SUPPLY

Fig.1 shows the configuration of the crowbarless power supply. The transformer Tr1 steps down the AC voltage from 6.6kV to 440V, which is suitable for inverters consist of IGBTs. The Tr1 has star connection and ring connection and it leads to 12-phase rectification by the rectifier Rec1. After the conversion the DC voltage is inverted to AC 21.3kHz. The AC voltage is stepped up by the transformer Tr2 and is full wave rectified by Rec2. Then the main frequency component of the ripple is 42.6kHz. Finally, the DC voltage ripple is reduced by the capacitance C2. The switching frequency (21.3kHz) is high enough to prevent a resonance with a synchrotron oscillation, which is lower than 6kHz in NewSUBARU.

High voltage units, which consist of Tr2, Rec2 and so on, are connected in parallel, not in series. Even if one of the high-voltage units had a problem, the parallel connection enables us to continue an operation by using other high-voltage units.

When the klystron faults the IGBTs are turned off in 4μs. The estimated inflow energy into the klystron when it faults is as small as 0.2Joule because C2 is only 0.01μF. This value is so small that the crowbar circuit is not required.

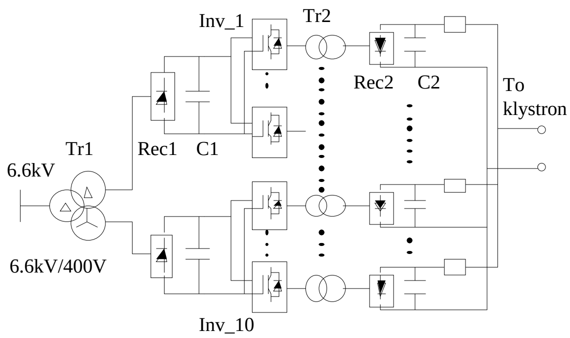

Figure 1: Configuration of a crowbarless power supply.

3 THE FAILURE OF SMALL DC PS

The small DC power supply (±15V, 0.3A, Fig.2) was broken. It was used to control 15 DCCTs and switching relays. The trouble happened because it did not have enough power for them. The selection of small DC power supply unit was wrong.

The trouble happened at Friday night and we could start the beam commissioning at Tuesday noon. We spend our time to check all DCCTs and other elements. They were so tightly packed in a body in order to made it compact, that we had to remove many elements to reach to and check DCCTs. In this case maintainability was sacrificed for the compactness.

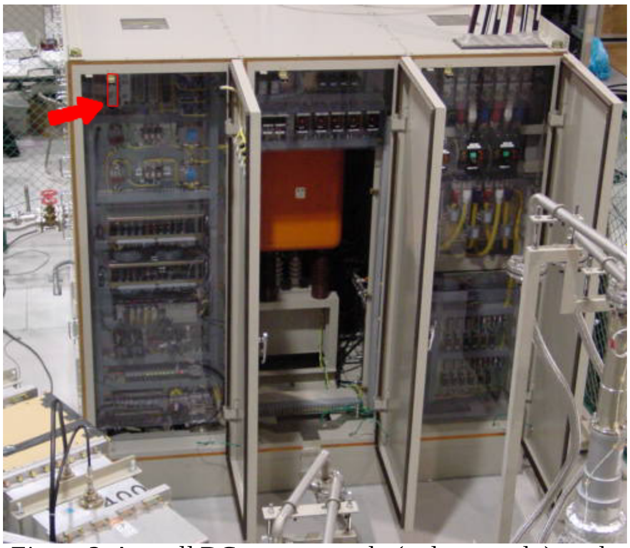

Figure 2: A small DC power supply (red rectangle) made the failure. The DCCTs are set at the bottom behind the foreseen plates for the circuits. The melted resistors are set at the top behind the foreseen plates.

4 THE FAILURE OF A FILTER

After the operation of 2 years it was found that resistors of a harmonic filter (Fig.3) for the primary 60Hz line melted (Fig.4). The ratings of the resistor and the conditions in the normal operation were listed in Table II. They were used in the condition closed to their ratings, above the recommended temperature for a long and continuous use. However there could be the other reason because their damage was terrible. One possibility was that they were resonant with 11th harmonic component of the primary line (660Hz), because the resonant frequency of the filter capacitance (627µF/phase) combined with the transformer Tr1 (109µH/phase) was 609Hz. However we could not reproduce that overheating condition. We are not sure about this point.

5 REFERENCES

[1] Y. Hashimoto, *et al.*, "Present status of the synchrotron radiation facility NewSUBARU", PAC01, Chicago, June 2001.

[2] Y. Shoji, *et al.*, "Operation of crowbarless power supply for klystron at NewSUBARU", PAC01, Chicago, June 2001.

Table II: Ratings and the operating condition of the resistors.

	temperature	power
in operation (measured)	>260 ^{o}C	1.1kW (primary 914W + commutation 180W)
rating	350 ^{o}C	1.2kW
recommended	250 ^{o}C	
oxidized	>500 ^{o}C	
melt	>1100 ^{o}C	

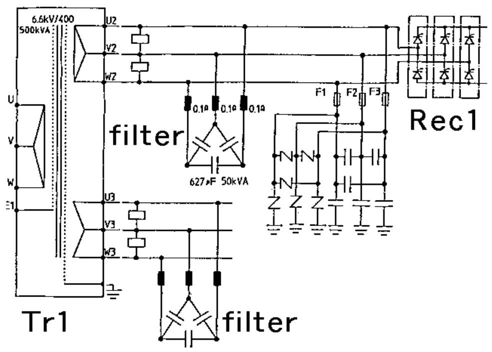

Fig.3 Overheated filter. The black rectangles are the melted resistors.

Fig.4: Damaged (melted) resistor array of the filter