OPERATIONAL EXPERIENCE OF THE PLS ELECTRIC POWER PLANT

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Abstract

The Pohang Light Source (PLS) is a 2.5 GeV third generation light source. To maintain power stability, the PLS power plant is directly connected to 154 kV national grid of Korea Electric Power Corporation (KEPCO). The 154 kV line has very good power stability of about 2%. The 154 kV is down converted to 22 kV and then to 6.6 kV. Monitoring systems are installed at 6.6 kV stage. 6.6 kV is further down converted to 208V, 380V, and 480V. Power failure directly affect the PLS beam operation. We observed sparse power failures during operation, which were mostly due to natural disasters such as forest fires, thunderstorms, etc. At 2.5 GeV operation, the PLS requires about 5.8 MVA supply. Total and peak power consumptions in 2003 were 33 MWH and 5.4 MW, respectively. Effect of AC voltage fluctuation has not observed on the MPS current, and thus also on the beam current.

ELECTRIC POWER DISTRIBUTION DIAGRAM

The Pohang Light Source (PLS) is a 2.5 GeV third generation light source in Korea. Fig. 1 shows the one-line diagram of the PLS electric power distribution. To maintain power stability, the PLS power is directly connected to 154 kV national grid of Korea Electric Power Corporation (KEPCO). The three phase 154 kV lines are connected to the main transformer (MTR in Fig. 1) via a gas insulated switch (GIS). The MTR is an outdoor transformer and steps down 154 kV to 22 kV. It has a maximum capacity of 50 MVA with a forced air condition. It has a built-in tap changer. The main transformer supplies electric power not only to the PLS, but also to the Pohang University of Science and Technology (POSTECH) campus. The PLS uses two 12.5 MVA step-down transformers (TR1, TR2 in Fig. 1). The transformers step down 22 kV to 6.6 kV. Gas circuit breakers (GCB) are used between the MTR and TR1&2 for protection. The TR1 mainly supplies power to the PLS Linac and SR. The TR2 covers others except the accelerator machine related areas. The sub connections of TR1 and TR2 are configured so that a bus-tie operation is possible during an emergency incident. Harmonic filter and power-factor compensator are installed at the 6.6 kV line. Details of the harmonic and power factor compensators are shown in Fig. 2. These systems are manually operating.

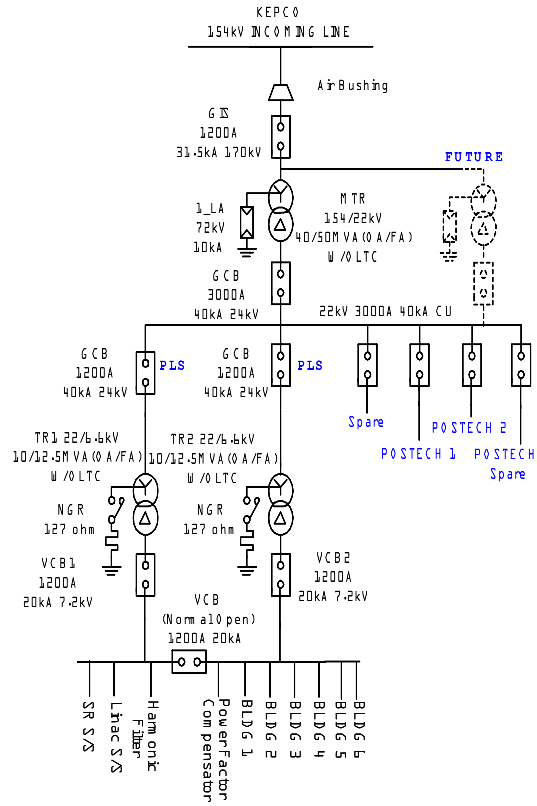

Figure 1: Single line diagram of the PLS AC power.

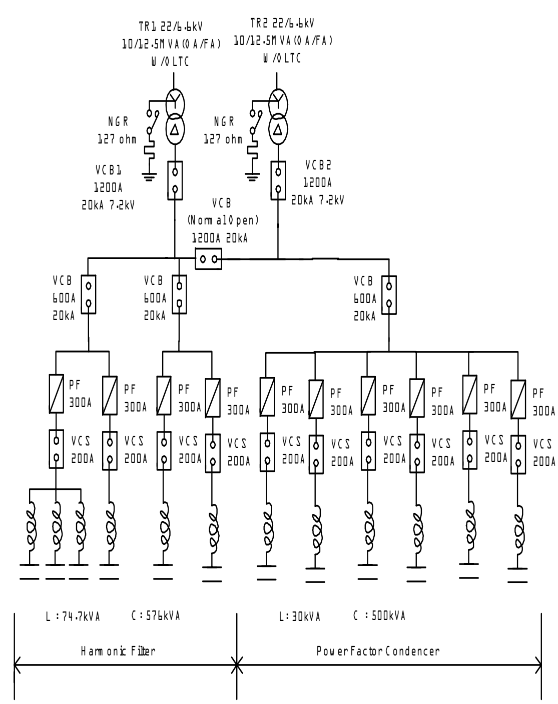

Figure 2: Phase modifying equipment network diagram

6.6 KV POWER MONITORING UTILITY

We continuously monitor voltage and current status of 6.6 kV lines. Typical voltage stability of KEPCO lines is better than 2 %. Fig. 3 shows a schematic diagram of the power monitoring utility. The monitored data are transferred to the control room via Ethernet. Fig. 4 shows a detected sample graph of a instantaneous phase-to-phase voltage sag. The top graph shows a voltage signal in short time scale, while the bottom shows a long time scale graph. The monitored data are used for tracking of power failures that cause beam dump. The power failure case shown in Fig. 4 actually resulted in beam dump. Table 1 shows the yearly accumulated power failure statistics. The main causes of power failure of KEPCO national power grid were due mostly to natural disasters such as forest fires, thunderstorms, etc. Power qualities such as total harmonic distortions (THD) are also measured periodically. Table 2 shows the THD measured at the transformers TR1 and TR2 at 2.5 GeV operation.

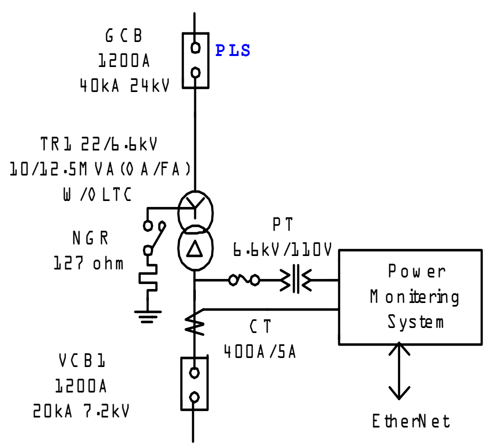

Figure 3: Power monitoring network diagram of 6.6 kV electric powers.

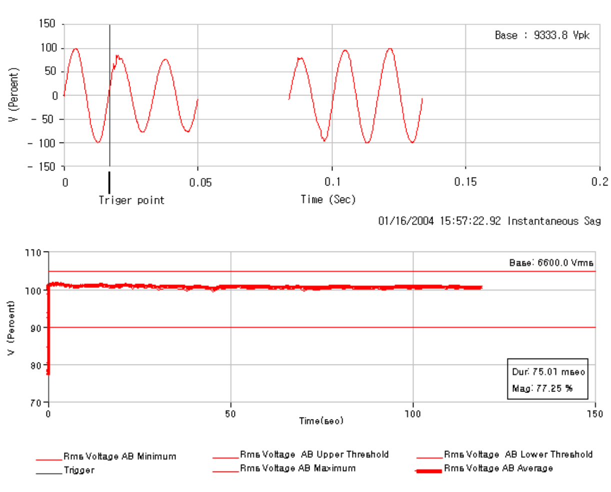

Figure 4: A sample graph captured at the instantaneous voltage sag.

Table 1 Yearly power failure statistics

Year	Number	Remark
1998	1	
1999	1	
2000	9	Forest fire (6), thunderbolt (2), etc (1)
2001	2	
2002	1	
2003	2	

Table 2: THD of TR1&2 (22 kV/ 6.6 kV Transformer)

	V harmonics (%)		I harmonics (%)	
Order	TR 1	TR 2	TR 1	TR 2
3-th	0.61	0.68	0.97	0.88
5-th	1.1	0.98	9.83	7.7
7-th	0.16	0.25	1.52	2.49
9-th	0.19	0.18	0.19	0.13
11-th	0.33	0.29	0.67	1.76
THD	1.058	1.704	10.71	9.144

POWER CONSUMPTION OF THE PLS

Table 3 shows yearly lists of the machine operation hour, total consumed power, and peak power of the PLS from 1998 to 2003. The total power heavily depends on the operation hour. In average, 5.84 kW is consumed for one hour operation of the PLS. As the operation hour has increased, the total power consumption has also increased. Total 32.3 MWH was consumed in 2003. The peak power usually appears during hot summer season that typically ranges from July to September in Korea. Considering the peak power consumption, the PLS needs about 5.8 MVA power utility supply. From 2003, the operation mode has been changed so that we could have one 8-week long shutdown during the summer season, instead of having two 4-week long shutdowns at winter and summer seasons. Table 4 lists monthly-consumed total power and peak power in 2003. Table 5 shows an example of electric power consumption per devices. Large portions of electric power is consumed by LCW utility, magnet power supplies (MPS), and storage ring RF, and linac modulators.

Table 3: PLS operation hours and power consumption.

Year	Operation Hour	Total P [MWH]	Peak Power	
			P [kW]	Month
1998	4773	26.034	5396	Oct.
1999	4812	28.486	5380	Sept.
2000	4774	28.718	5404	Sept.
2001	4995	29.659	5316	July
2002	5520	31.186	5476	July
2003	5357	32.286	5424	March

Table 4: Monthly total and peak power in 2003.

Month	Total P [MWH]	Peak Power [kW]
1	2105	4772
2	2395	4356
3	3617	4836
4	2949	5424
5	2427	4344
6	3361	5360
7	2469	3508
8	902	1972
9	2492	3960
10	3248	5100
11	3362	5064
12	2962	5000

Table 5: Power consumption at devices in 2.5 GeV

Item	Power (kW)	%
LCW, Cooler	1200	23.9
MPS	1030	20.5
RF	584	11.6
Modulator	510	10.2
Pump, Fan	402	8.01
SR Air conditioner, Light	360	7.17
Linac Air conditioner, Light, Pump	302	6.02
SR & Linac LAB	224	4.46
BLDG 1	200	3.99
BLDG 2	150	2.99
Inject	35	0.7
Linac control	13	0.26
BLDG 3	6	0.12
SR Control	2	0.04
Total	5018	100

EFFECT OF AC INPUT VOLTAGE FLUCTUATION ON MPS

Most sensitive device for the AC input voltage fluctuation is the storage ring MPS. If the MPS affects by the AC fluctuation, the stored beam will also fluctuate. Therefore, it is important to maintain the MPS output current stability requirement regardless of the AC input voltage fluctuation. Fig. 5 shows 4-hour measurement results of AC input voltage fluctuation, MPS current stability, and temperature change. The plots from the top in Fig. 5 are for Q5 MPS current, bending MPS current, MPS room temperature, and AC input voltage. During the measurement period, the Q5 MPS shows ±30ppm stability, while the bending MPS has ±15ppm. The MPS room temperature and the AC input voltage fluctuates 1.5°C and 2 %, respectively. From the plots, we could not see clear relations between current, room temperature, and AC input voltage fluctuations.

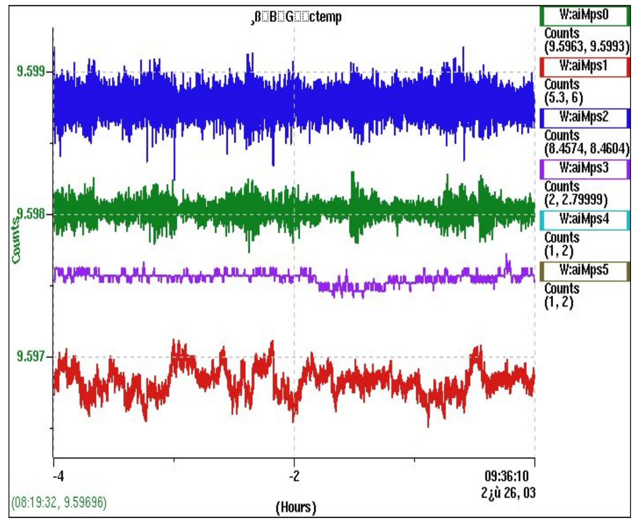

Figure 5: AC Voltage and MPS current stability

CONCLUSION

The PLS power is directly supplied from the 154 kV national power grid that is maintained by KEPCO. The 154 kV line has very good power stability of about 2%. The good power stability helps to operate the PLS in stable mode. We observed sparse power failures during operation, which were mostly due to natural disasters such as forest fires, thunderstorms, etc. At 2.5 GeV operation, the PLS requires about 5.8 MVA supply. Total and peak power consumption in 2003 were 33 MWH and 5.4 MW, respectively. During the PLS operation, most of power was consumed by LCW utility, MPS, storage ring RF, and linac modulators. Measurement results show that AC voltage fluctuation of 2% does not affect the MPS stability.