Upgrade of the Front Ends of Storage Ring Vacuum System

Eighteen out of twenty four front ends are installed in the Taiwan Light Source (TLS) storage ring vacuum system. The front ends for the insertion devices include FE01(SWLS), FE05(EPU5.6), FE09(U5), FE17(W20), and FE21(U9). The front ends for the bending magnets include FE03, FE04, FE08, FE10, FE11, FE12, FE14, FE15, FE18, FE19, FE20, FE22, and FE24. As the front end vacuum system is directly connected to the storage ring, its vacuum should be of the same grade as the ultra-high vacuum (UHV) in the storage ring. The expected base pressure at the front end is below 3×10^{-10} Torr. Reliable operation of the front end system is the very important, since any malfunction would immediately interrupt the operation of the ring.

Problems of the front ends encountered over the last few years include: (1) pressure increase that back-filled the storage ring and thus reduced the beam lifetime, due to photon stimulated desorption (PSD) from the newly installed components; (2) melt-down of photon aperature because of insufficient water cooling; (3) water leak through the broken joint of the high heat load components due to improper welding; (4) malfunctioning fast-closing shutter damaged by irradiation from the intensive synchrotron light; (5) malfunctioning pneumatic-controlled components, such as solenoid valves, limit switches, among others; (6) null readings of the vacuum gauges because of the interference from the scattered photoelectrons; (7) status of the critical components not reliably monitored by the old interlock systems. The upgrade programs for the front ends have successfully solved these problems. In addition to trouble-shooting, the upgrade program for the front ends involved: (1) installing the photon beam position monitors (PBPM) in each front end to diagnose beam orbit; (2) replacing the unified independent interlock system in each front end, and (3) replacing high heat load components to adapt to the power at a maximum beam current of 500 mA to be in the near future, among other improvements. This article describes the efforts and progress made in maintaining and upgrading the front ends.

Fig. 1 presents the layout of the new front ends for (a) the Insertion Device (ID), and (b) the Bending Magnet (BM) sources. The aperture, part (a), constrains the synchrotron radiation (SR) photons to pass through the front end without irradiating the downstream components. The PBPM, part (b), located behind the aperture, is subjected only to a minimal heat load from the photons irradiation. The absorber, part (c), absorbs a total power of < 200 W by the BM-front ends, and < 3.2 kW by the ID-front ends, for TLS

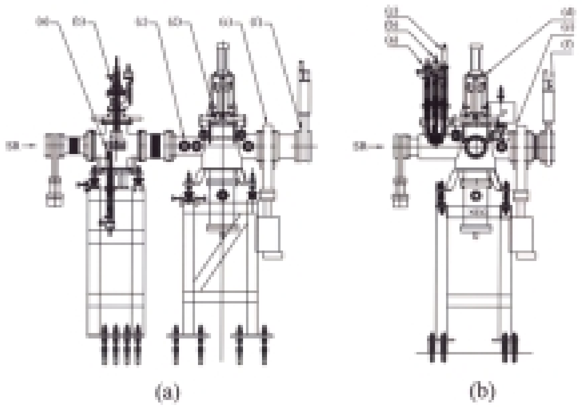

Fig. 1: Layout of front ends for (a) Insertion Device (ID), and (b) Bending Magnet (BM) sources at the TLS. The main components of the front ends are (a) aperture, (b) PBPM, (c) absorber, (d) safety shutter, (e) metal gate valve, and (f) fast-closing shutter.

operation at an electron beam current of 200 mA with 1.5 GeV beam energy. The front ends are mechanically fixed to the ground and the vibration is less than 0.2 μm.

All the components in the front ends are UHV-compatible and are cleaned by a standard process to ensure the quality of the UHV. Organic and plastic materials have been removed from the front ends. An extractor-type ionization gauge in each front end is installed to measure the vacuum pressure down to 10^{-12} Torr. A double-sided flange with 30 punched holes, 3 mm in diameter and 10 mm in depth, is installed in front of the ionization gauge to shield the gauge sensor from scattered light. The vacuum pump includes a 20 L/s sputtering ionization pump (IP) and a 500 L/s non-evaporable getter (NEG) pump to maintain the UHV. Fig. 2 shows the current base pressure of each front end. Over two-thirds of the front ends have pressures below 0.3 nTorr.

The utility system includes the water-cooling supply, the compressed air supply, and the electricity supply. The non-metal pipes and connectors of the cooling system and the compressed air system were replaced with parts made of stainless steel and copper, respectively. The pipes were connected by swagelok-joints. The entire manifold of the cooling and air systems was checked for leakages using a snooze leakage-detector when the pipes are filled with 10 kg/cm^2 He gas. Meters, are installed to display the flow rates of the water and the pressures of the air, are inspected every week. The strainers in the water system were cleaned as soon as the flow rate of the water dropped below a preset value. The front-end control racks consume little electric power. However, the grounding loop of the equipment will be re-wired as soon as the global grounding system of the machine is reconstructed.

The new interlock system for all the front ends has been constructed. It unifies all the front ends by using a simplified design of safety interlock logic and a friendly operating console for users. Fig. 3 shows a typical front panel of the front-end interlock system. Thirteen sets of new interlock systems have been installed so far. The new interlock system ensures that the front ends can operate in "interlock mode" at any time. The fail-safe rule is employed when the interlock system is powered off, such that neither valve nor shutter can be enabled unless electric power is supplied by the interlock system. The front panel displays the status of the vacuum pressure, the absorbers, the safety shutters, the gate valves, the fast closing shutter, the flow rate, the compressed air pressure, and other parameters. Three keys for controling the front end in three different modes, including safety-unlock, bypass, and operation, are accessible from the rear panel. The front panel of the beamline interlock system also displays the status of the front end, through a standard RS232 connection cable.

The two-blade vertical type photon beam position monitor (PBPM) has been developed for the insertion device. The two-blade type PBPM was installed in front ends 05 (EPU5.6) and 17 (W20). The prototypes of PBPMs of the four-blade and twelve-blade types were installed in front ends 09 (U5) and 05 (EPU5.6), respectively. The two-blade PBPM measures only the vertical position of the photons beam. The four-blade and twelve-blade PBPMs measure both the horizontal and the vertical positions of the photon beam. Additionally, a new version of the PBPM for bending magnet sources has been installed in front ends 03, 04, 10, 12, 15, 18, 20, 22, and 24. Fig. 4 shows a picture of the PBPM assembly for the BM source.

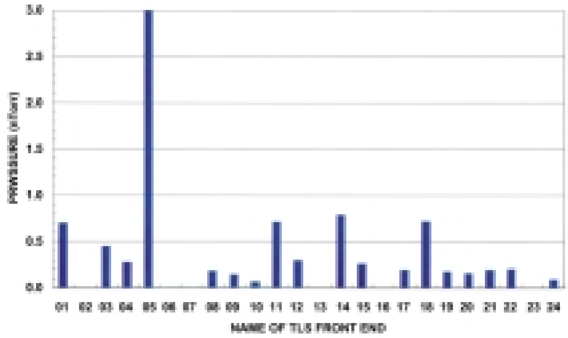

Fig. 2: Base pressures in TLS front ends.

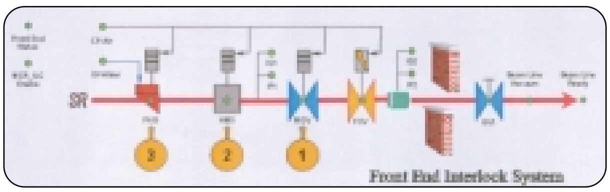

Fig. 3: Front panel of the front end interlock system.

Keithley™ picoammeters are used to record the blade current. The position in both vertical and horizontal directions is calibrated by driving the stepping motors of the PBPM through a personal computer (PC). A bias of +300 V is applied to the collector that surrounds the blades, to attract the scattered photoelectrons. The resolution of PBPM is better than 0.5 μm. Fig 5 shows the position of photon beam in various beamlines, as the gap of EPU5.6 is changed, which indicates that the electron orbit changes with the gap of EPU5.6.

The present design of the front ends works appropriately for the storage ring current of 200 mA and 1.5 GeV electron energy. Increasing the beam current to 500 mA in 2003 will increase the total power by a factor of 2.5, and therefore new absorbers are required to take higher heat load. The second vertical PBPM is being developed to monitor the vertical deflection angle of the photon beam, and certain chambers will be replaced for its installation.

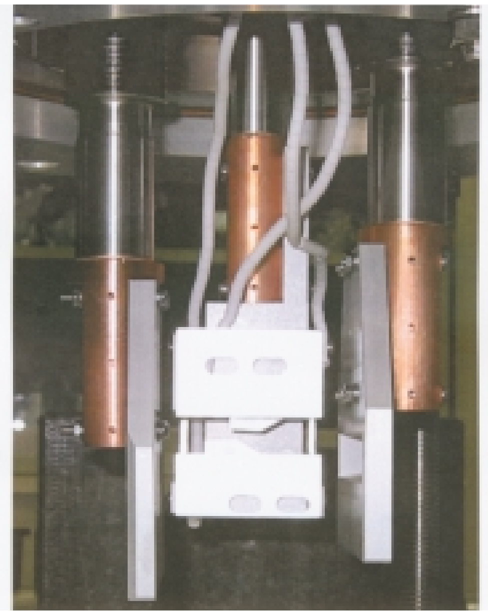

Fig. 4: Photograph of the PBPM assembly for the front end of BM source.

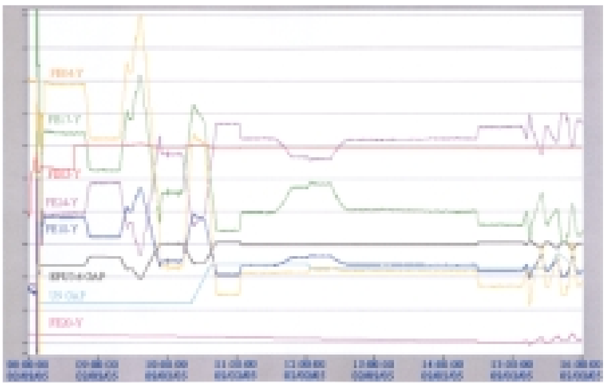

Fig. 5: Changes of the photon beam positions, monitored by some of the front-end PBPMs, as the gap of the EPU5.6 is changed.

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