A.4: New switch-mode power converters for TL-2 steering coils in Indus

A large number of power converters, energizing various magnets in different parts of Indus Accelerator Complex (IAC), are operational in round-the-clock mode. Some of these power converters were developed, installed and commissioned nearly 25 years ago. Many components in these power converters were reaching the end of useful life, leading to increase in the operational difficulties. Further, compatible spares were also not readily available, posing difficulty in their maintenance. Therefore, in order to improve the overall reliability of these power converters, it was decided to upgrade these power converters in a phased manner with technologically superior alternatives (Ref: RRCAT Newsletter, Vol. 24, Issue 1; Vol. 25, Issue 1; Vol. 28, Issue 2; Vol. 32, Issue 1). This report gives details of the recent upgradation of power converters for steering coils in Transport Line – 2 (TL-2) in IAC. Upgradation of power converters in a working facility poses additional challenges to retrofit the converters in existing location and space, maintaining compatibility to other interfacing systems, maintaining calibration, etc., for smooth changeover without affecting the operation of the accelerator facility.

In all, 11 power converters are used to energize steering coils in TL-2. These converters are rated for 6 A / 36 V with output current stability of ±1000 ppm, and are equipped with polarity reversal switches at the output. The new power converters are based on a switch-mode power converter design standardized on 6U card for low-power (up to ~ 300 W), which were first deployed in IAC for Transport Line – 1 (TL-1) magnets (RRCAT Newsletter, Vol. 25, Issue 1) and later refined for Infra-red Free Electron Laser (IRFEL) beamline magnets (RRCAT Newsletter, Vol. 28, Issue 1). It is worthwhile to mention that these power converters in TL-1 and IRFEL have not reported any major issue since their installation. In the present version of these power converters, a few more enhancements have been made, while designing for their application in proposed injector linac (Alok Singh et al., Proc. of InPAC 2018).

The earlier versions used customized two-terminal type shunt, made from Zeranin strip. To improve module-to-module repeatability in calibration and to facilitate large-scale fabrication in industry, a commercially available precision four-terminal shunt is used. Further, two shunts are used for independent sensing of output current for feedback and measurement. To further improve output-current stability, an on-board oven is used to maintain constant ambient temperature for the front-end electronics. An on-board, relay-based polarity reversal scheme is incorporated to facilitate reversal of load voltage and current polarity. The output filter configuration is modified by placing the filter inductors in both positive and negative lines in differential configuration, to combine differential as well as some amount of common-mode filtering. In the earlier versions, in-situ diagnosis and monitoring was not easy, when the boards were plugged inside the 6U sub-rack. To facilitate this, separate connector is provided on the front-side in this new version for monitoring of various critical signals.

In order to reduce the complexity in the circuit and associated wiring, and also to retain the accuracy of remote reference signal, the new converter operates only in remote mode. An interfacing connector is provided for the remote mode operation. A small simulator card can be easily plugged to this connector for occasional testing of the power converter in local mode. Further, a constant-voltage mode is also incorporated in the control loop to limit the output voltage if the converters operate in the open-load condition.

Fig. A.4.1: A photograph showing newly installed power converters for steering coils in TL-2. The inset shows one power converter card.

The power converters are installed and commissioned (Figure A.4.1), for regular operation in round-the-clock mode in IAC.

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