60kV, 10Amp DC Power Supply multiple input control and monitoring provision for the operation of various high power RF generation systems.

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Abstract A 60 kV, 10 A DC power supply is used for testing of high power RF and microwave tubes e.g. Klystron, Gyrotron. Two 500 kW, 3.7 GHz klystrons, and one 82.6 GHz Gyrotron are located in SST1 Hall whereas 200 kW; 28 GHz Gyrotron is located in Aditya Hall. The same power supply is required to operate, control and monitor various systems at different locations with easy change over from one system to other as per experimental requirements.

An off line, control change over system, is designed to accomplish the above requirements, with control panels installed at desired different locations. The input (0 to 11 kV) A.C. voltage to power supply is given from a motorized voltage variation system (VVS). The control panels provide indication of A.C. input voltage to power supply from 11 kV potential transformers of VVS. In addition, the control panel is provided with 11 kV circuit breaker status indication and control i.e. Emergency OFF switch. The control panels are designed and developed indigenously which are successfully installed and are in continuous use for the safe and easy operation of different high power rf systems from the same DC power supply.

The paper presents the design of the controls, monitoring and indications. Safety aspects of the system are also highlighted.
1. Introduction of HVDC PS & 11kV AC voltage variation system:
There are two power supplies each capable of delivering 600 kW continuous power or 2.4MW for 3 seconds ‘ON’ and 120 seconds ‘OFF’ duty cycle. Two power supplies, here after referred as PS-1 and PS-2, are designed to operate separately or in series to give a maximum of 120 kVdc output voltage. PS-2 is designed to operate at the higher end of voltage (i.e. 60 to120kV) and so, is bigger in size. Otherwise, the power supplies are identical in all respects. PS-1 is presently being used for powering of ICRH final stage based on Tetrode and PS-2 is being used for the powering of Klystrons (LHCD) and Gyrotron (ECRH).

11kV AC voltage variation system:
A continuously variable output DC voltage needs a 0 to 11kV input to the power supply. The 11kV input to the power supply is made ON-LOAD variable, using this remotely operated voltage variation system. The variation of input voltage from 0 to 11kV varies the DC output voltage from 0 to–60 kV. The 0 to 11kV output of this system are connected to the input of both power supplies. The regulator comprises of three separate units namely, step-down transformer, regulator and buck-boost transformer. The step-down transformer is fed from an 11kV oil circuit breaker, which has over current and earth fault protections. The secondary of the transformer feeds the regulator coils directly and also through the brushes connected to the buck boost transformer. The regulator has four parallel paths for each phase and hence 12 coils. On each coil 2 sets of brushes are mounted in diametrically opposite directions. They are connected to a chain mechanism, which is motorized. The chain mechanism is so designed that the two sets of brushes move in opposite directions i.e. if one set moves upward, the other set move downwards. The brushes are connected to the current balancing coils. The output from the current balancing coils is connected to the 12 primary windings of the buck boost transformer. The Buck-boost transformer output is connected to the load, which needs 0 – 11kV input.

A potential transformer for output voltage measurement is also provided. Initially when the brushes are positioned as shown in the drawing, the output voltage is zero. In this configuration, the system is in maximum buck condition. When voltage is increased, the lower end brushes move upward and upper end brushes move downward, progressively decreasing the buck voltage. When both the brush gears cross at the middle the buck voltage is close to zero. Further raise causes boosting of voltage, until they reach the other end of the coil. At this position, the output voltage of the system is 11kV. The block diagram is indicated in fig.1

2. Requirement:
GPS1 and GPS2 output is used at various locations. Their input 11kV circuit breaker is located in SST1 utility building. Refer Fig.1 they switch ON / OFF 11 kV voltage regulator.
The control panels located at user areas currently display variable output of the regulator only. At the time of switching ON the regulator is kept at minimum position hence the operator has no idea regarding the status of the input 11kV. To avoid this confusion it is required to indicate the status of breaker as well as actual voltage at the input of the regulator.

![Circuit Breaker: 3ph, 11kV, Oil Circuit Breaker
Unit A: Step down transformer 11000V/1160V
Unit B: Voltage regulator 0-1160V O/p
Unit C: 0-1160V/0-11kV](#)

**Fig.1**

**3. Previous Status:**
We had a provision to indicate 11kv Regulator o/p at different location (SST1 Hall, ECRH room and RF lab ground floor). But we have no arrangement to indicate the status of 11kV input in these control boxes.
4. Present status

The scheme is designed according to availability of control cables. The two nos. of 1160V/110V transformers are procured and installed in two different regulators front end doors as mentioned in figure 3. The transformers output are brought to control boxes as mentioned in figure No.2. These cables are wired with selective switch to 11kV meters. The 110V AC relays are used to indicate the Circuit Breaker status. The potential free contacts of relays are brought to indication lamps. The regulator panel inbuilt indication lamps are used for Circuit breaker ON/OFF status. The Emergency OFF facility is provided by wiring with the regulator buchloz protection. The each control box are checked OFF line and then kept for OFF load testing. The circuit breaker indication, voltage monitoring and emergency OFF facilities checked and found Ok. These facilities are used established and put in operation.
5. The list of material is used:

| Material Required                                      | Quantity |
|--------------------------------------------------------|----------|
| 3Ph 1160/110volt, 200VA Dd0 transformer                | 02       |
| Voltage selection switch                               | 04+01    |
| 110 @11kv AC voltmeter                                 | 04+01    |
| Control Boxes                                          | 04+01    |

6. Conclusion:
By doing this the Unit-A input i.e.11kV monitoring and indication, 11kV Emergency OFF facilities are available at each control boxes of High voltage power supply by economic way & safe. These facilities are established and working in running condition.