A.6: Development of 100 kV, 20 A, 1.6 ms, compact, all solid state long pulse converter modulator

A 100 kV, 20 A compact, all solid state long pulse converter modulator has been developed as a part of our ongoing program on advanced solid state modulator development. The specifications are summarized in Table A.6.1. The simplified schematic of the modulator is shown in Figure A.6.1. The modulator setup comprises two modules and both are connected in series to achieve 100 kV output. Both modules are exactly identical and generate 50 kV each.

Table A.6.1:Specifications of the modulator.

Output pulse	100 kV
Output current	20 A
Pulse width	1.6 ms
Output Power	2 MW
Rise time	70 µs
Fall time	65 µs
Droop	± 1 %
PRR capability	1-30 Hz

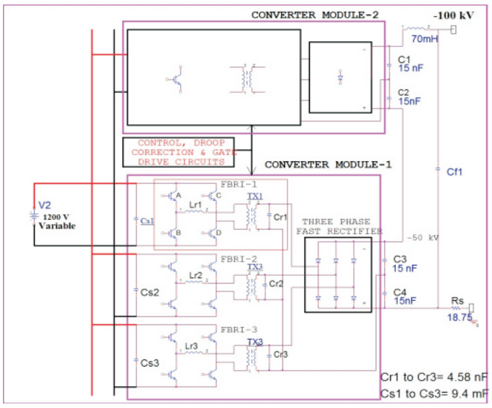

Fig. A.6.1: The simplified schematic of the 100 kV, 20 A, 1.6 ms modulator.

Each module consists of high frequency switched inverters (fs=20 kHz), high voltage high frequency transformer, fast six pulse rectifier. The primary phase shift controller, phase shifting circuits, droop correction circuits and low pass π - section filter are common to both modules. The full bridge inverter works on parallel loaded resonant (PLR) LC topology. PLR topology inherently offers high voltage gain depending on the quality factor (Q). This is advantageous in lowering the turns-ratio of the transformer. The non - idealities of the transformer are also effectively used as a part of the resonant circuit. The high voltage and high frequency transformer has been developed using iron based nanocrystallinecore material (VITROPREM 800 of Vacuumschmelze). The flux density is chosen as 0.6 T. Both primary and secondary are wound using litz wire. Secondary is wound on specially fabricated solid Teflon bobbin for high voltage insulation. Fast recovery epitaxial diodes are used in six pulse rectifier. Each arm is a series combination many diodes. A π - section low pass filter has been used to filter out 120 kHz ripple. All high voltage components are assembled in a steel stalk and immersed in transformer oil for insulation and cooling.

The 'phase shift control' method has been adopted for the primary inverter unit. The drive signals of unit-II and unit–III are phase shifted by 120° and 240°respectively, with respect to unit-I. The unique advantage of this scheme is to achieve overall ripple frequency (120 kHz) that is six times of the basic switching frequency (20 kHz). This increased ripple frequency helps in adopting lower filter component values. Lower filter values reduce the stored energy in the modulator. Low stored energy limits the energy deposition in the klystron during the event of klystron arcing. Pulse droop due to the limited stored energy in the input storage capacitor has been corrected using feed forward control method due to fixed droop pattern. A simple segmented droop correction scheme has been implemented using monoshots and operational amplifiers. With this technique, droop of ± 1 % has been achieved. Figure A.6.2 shows the view of the modulator set up and Figure A.6.3 shows the output wave form at 100 kV operation. Presently the modulator has been tested at low PRR and further tests are in progress.

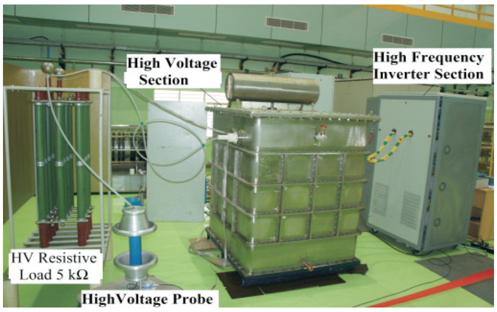

Fig. A.6.2: Photograph of the experimental setup.

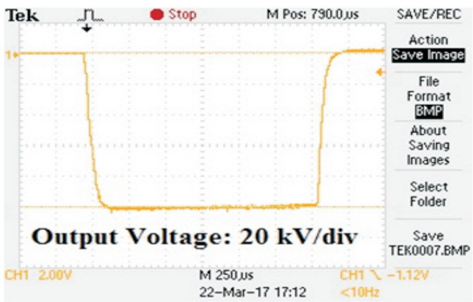

Fig. A.6.3: Modulator output voltage at 100 kV.

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