Accelerator Programme

A.1 : HV generator of the 750 keV DC accelerator achieved the target voltage

The Power Supplies Division of RRCAT has made the high voltage (HV) generator for the 750 keV DC Accelerator developed in Industrial and Medical Accelerators Section. The accelerator is being regularly operated at moderate power since 2002. Recently some upgradation work has been carried out on HV generator to increase its voltage and current. The DC accelerator will soon become operational at its full power and energy.

The schematic diagram of the high voltage generator and its control loop is shown below in Fig.A.1. A three-phase full wave controlled converter feeds the power to a fixed frequency sine wave inverter, which energizes the voltage multiplier at 40 kHz frequency through a centre-tap high voltage ferrite core transformer. The terminal voltage of the multiplier stack is controlled by controlling the output voltage of the converter in a feedback loop.

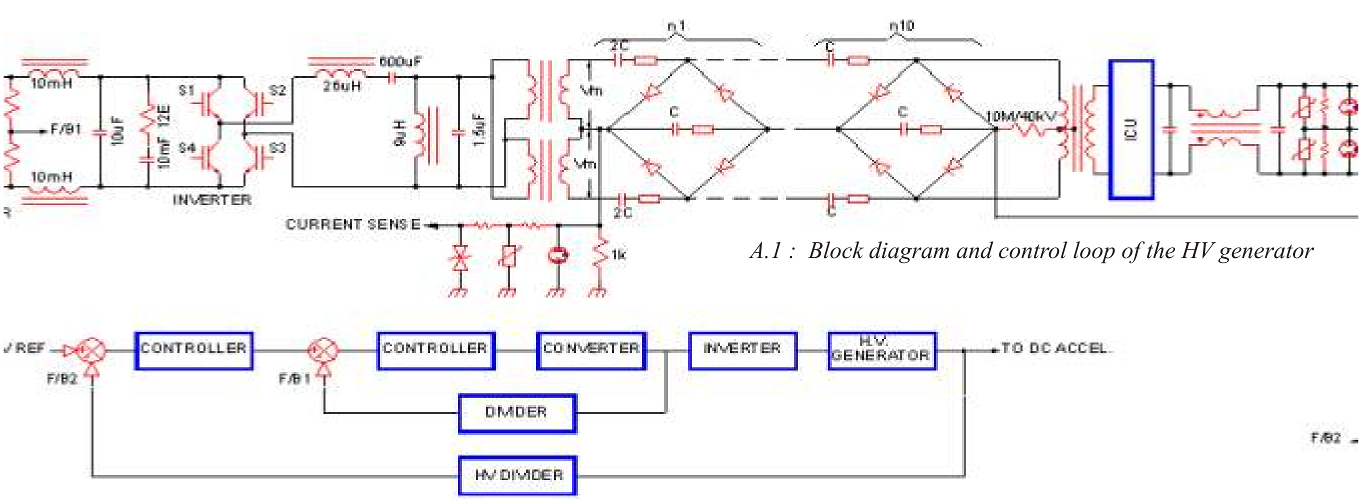
Initially the multiplier stack was designed using 15-stage symmetrical Cockcroft-Walton circuit with maximum stage voltage of 60 kV DC. A nonlinear buildup of voltage due to stray capacitances in the structure resulted in a voltage multiplication ratio of 11 against a theoretical value of 15 as compared with the 1st stage voltage. This implied that operating the 1st stage at its design value of 60 kV DC (with a safety margin of 33%), the multiplier stack would gennate a no load terminal voltage of 660 kV only. Hence the need was felt to modify the multiplier stack from the existing 15 stages to a10 stage circuit with operating stage voltage of 75 kV.

The multiplier stack has been redesigned with a maximum stage voltage of 90 kV DC keeping the same safety margin of 33% in the component ratings. Three capacitors of 10 nF/ 40 kV and 8 diodes of 15 kV PIV have been used in series to realize the multiplier components of 120 kV ratings. The decision to increase the stage voltage bestowed a demand of increased voltage ratings for the crucial components:

Name of the Component	Initial Voltage Ratings	New Voltage Ratings
High Voltage Transformer	30 - 0 - 30 kV AC Peak	45 - 0 - 45 kV AC Peak
High Voltage Bushings	30 kV AC Peak	45 kV AC Peak
Compensating Inductor	30 - 0 - 30 kV AC Peak	45 - 0 - 45 kV AC Peak
Filament Transformer	30 - 0 - 30 kV AC Peak	45 - 0 - 45 kV AC Peak
High Voltage Connector	30 kV AC Peak	45 kV AC Peak

Table : A.1.1

Apart from modification of the multiplier stack, major components described in Table A.1.1 were also redesigned, fabricated and tested individually for their required performances. With these components ready in hand, the high voltage generator was re-commissioned during the later part of the year 2006. As the effect of stray capacitance on voltage buildup cannot. be fully eliminated, it



A.1 : Block diagram and control loop of the HV generator became prominent this time too with reduced value of column capacitors. A study of voltage buildup pattern along the height of the multiplier stack revealed that seventh onward decks do not require voltage ratings more than 60 kV for the entire operating range of the accelerator. So a mix of 90 kV and 60 kV (3 capacitors and 2 capacitors in series) decks were assembled in a ratio of 7: 5 and finally a multiplication ratio of 9.5 was obtained with 12 such decks. Before reaching the target voltage in the high voltage generator, individual decks were tested for their rated voltages of 90 kV and 60 kV respectively.

The multiplier stack has been compensated and operated at 33 kHz for a terminal voltage of 760 kV for minimum no-load current from inverter. The 1st stage voltage in this condition was measured to be 80 kV DC. This shows that with a voltage multiplication ratio of 9.5 and permitted 1st stage voltage of 90 kV we can achieve a no load terminal voltage of 855 kV in the high voltage generator with SF_6 as an insulating medium. Furthermore the calculated voltage drop in the multiplier stack at 33 kHz is about 4 kV/ mA. This indicates that operation of the H V generator at full rated current of 25 mA will result a DC voltage drop of 100 kV and accelerating terminal voltage of 755 kV. Hence the rated power of the H V generator will be achieved. Also the load induced ripple at 25 mA comes out to 2 kVpp, which is well within the specified limit of 2%.

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A.2 : Large magneto-resistance in the Heusler alloy $Ni_{50}Mn_{34}In_{16}$.

The Heusler alloys are now well known as potential source of functional magnetic materials. They have a cubic $L2_1$ structure in the high temperature (T) austenite phase, and a general formula X_2YZ (with X = Cu, Ni, Pd, Y = Mn, Co, and Z = Al, In, Sn, Sb, etc.). They exhibit interesting physical phenomena of technological interest like ferromagnetic shape memory effect (FSME), large magneto-resistance (MR), and giant magnetocaloric effect. We, the MSMS of RRCAT, have been studying the Heusler alloys for quite some time for their functional properties. We have now established that the 'disorder influenced first order magnetostructural transitions' plays a crucial role in the phenomena mentioned above.

$Ni_{50}Mn_{34}In_{16}$, with the stoichiometry deliberately chosen as such, is a Heusler alloy of our current interest. The high T austenite phase of the material is paramagnetic (PM). With the lowering of T, it undergoes a PM to ferromagnetic (FM) transition at around 305K, and remains FM down to the lowest measured T (5K). But as T is lowered below 250K, the alloy also undergoes an austenite to martensite phase transition (i.e., martensitic transformation) .

As shown in Fig.A.2.1, the electrical resistivity (ρ) vs. T data exhibits a sharp jump around 250K and has a thermal hysteresis associated with this jump. The jump in ρ(T) is because of change in the crystal structure associated with the martensitic transformation. The thermal hysteresis suggests the first order nature of the transition. Away from this hysteretic region the temperature coefficient of ρ is positive, highlighting the metallic character of both martensite and austenite phases. The application of magnetic field has two effects: First, to decrease the value of ρ in both the phases. Second, to shift the characteristic temperatures of the martensitic transformation towards lower T. This second effect leads to a very large MR around the martensitic transformation. MR has been calculated using following standard definition:

$$MR\ (\%) = \frac{\rho(H) - \rho(0)}{\rho(0)} \times 100$$

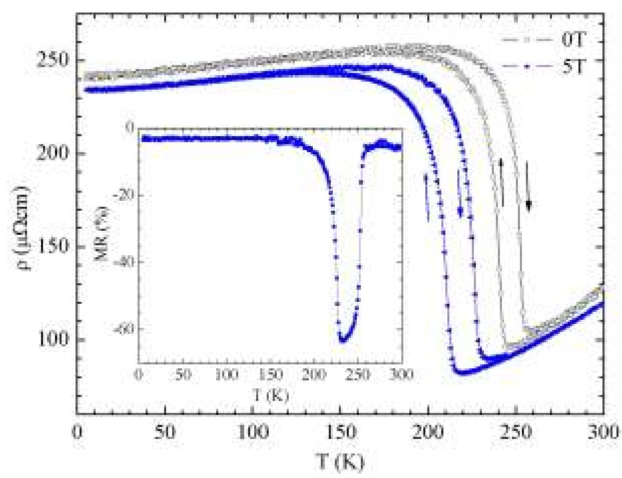

Fig.A.2.1 Temperature dependence of resistivity of $Ni_{50}Mn_{34}In_{16}$ alloy in 0 T and 5T magnetic fields. The arrows indicate changing temperature. Inset shows the corresponding magneto-resistance.