DEVELOPMENT OF POWER SUPPLY AND PROGRAMMER FOR SUPERCONDUCTING SOLENOID MAGNET

Rajesh Kumar, S.K.Suman, A.Mandal
Inter University Accelerator Centor, New Delhi-110067, India.

Abstract

A current and voltage regulated (0-100A / 0-10V) switch mode power supply and its programmer have been designed and developed, to power the super conducting solenoid magnets used as a transverse focusing devices inside the superconducting LINAC module, and other off-line superconducting magnet setups. The power supply and programmer are two independent units. The power supply is controlled by the programmer when it is used to power the superconducting magnet, but with other loads it can be used without the programmer. The programmer is designed as a special feed back loop element, which compensates the effect of large inductance and zero resistance of super conducting magnet to ensure oscillation free smooth operation. The programmer has special features like quench protection, magnet current ramp rate control and maximum limit settings of magnet current and voltage. The power supply alone (without programmer) can be used for other laboratory applications requiring regulated variable DC voltage and current source. These power supplies can be used in master-slave mode to get several kW of power. This set-up (supply and programmer) have both manual and computer control features.

1 KW (10 V/ 100 A) POWER SUPPLY

The power supply is an on-line switching supply operating at 60 kHz, which provides up to 1000 W of DC power over a range of 0-10V and 0-100A. Figure-1 shows the block diagram of the power supply. Regulation is done by a pulse width modulator. The power supply is 230 V_{AC} powered, which is directly rectified and converted to unregulated DC voltage (320V). A full bridge converter assembly converts the unregulated DC voltage to a high frequency pulse width modulated AC, which is fed to a high frequency step-down power transformer. The output of the high frequency step-down power transformer is rectified using schottky diodes and filtered using LC filter. Two feedback loops and two corresponding error amplifiers are used in automatic crossover configuration, one for controlling output voltage, the other for controlling output current working one at a time. By placing a diode AND gate after error amplifiers a sharp-knee crossover is achieved between current and voltage regulation modes. This arrangement makes a constant current/voltage power supply with an automatic crossover feature. Over voltage, over current and over temperature protections are incorporated to ensure the safety of the magnet and power supply. The power supply can also be controlled through a programming connector at the rear panel for remote current/voltage programming. Output voltage and current are displayed on the front panel.

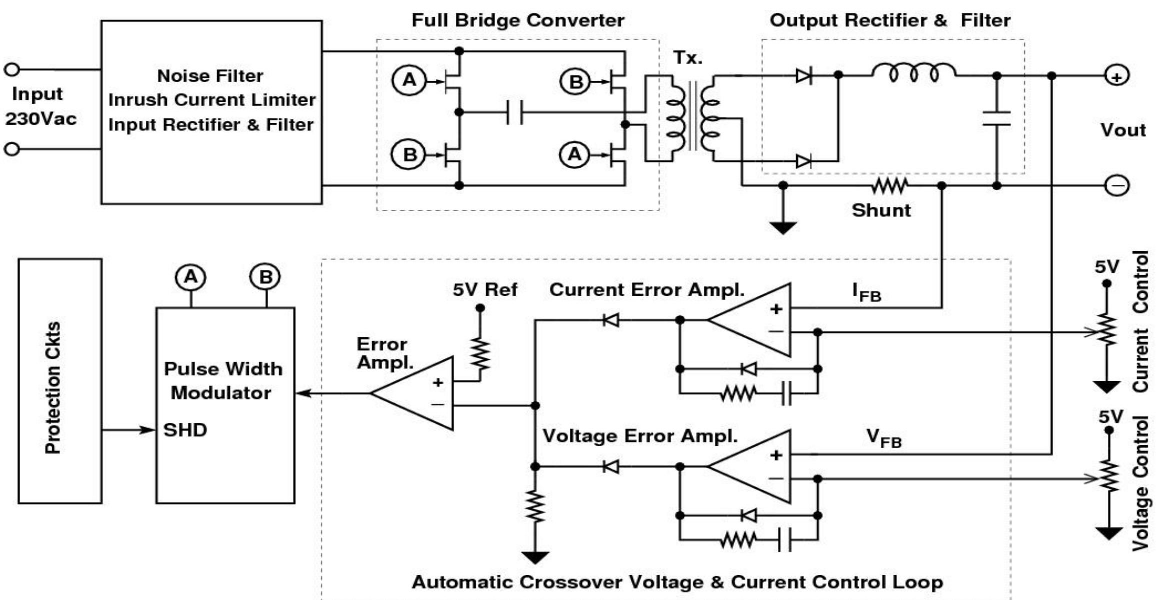

Figure 1: Block diagram of power supply.

SUPERCONDUCTING MAGNET POWER SUPPLY PROGRAMMER

The programmer controls the power supply by comparing the magnet current with the control signal (ramp out) and then producing the appropriate voltage control signal for power supply. The control signal modulates the output voltage of power supply in such a way that a constant di/dt as required by the input control signal can be achieved. Since the voltage across a superconducting coil is V=L*di/dt, one can also control the magnet current by appropriately controlling the voltage across the coil. The programmer provides either manual or computer controllable ramp of superconducting magnet current.

To generate any current function within the range of the magnet/power supply in the form of straight lines a programmable ramp (ramp out) is generated using an op-amp integrator. The ramp can be ramp up or down by selecting one of three ranges (0.1, 1 or 10 amperes per second) and fractional setting within each range is made by adjusting a ten turn potentiometer. The ramp can be paused in between to program it further. The ramp also can be limit by preset values of output current limit and output voltages limit potentiometers and can be terminated to zero in case of quench detection in the magnet. Further the ramp is compared with the magnet current, (an external shunt is used) the error signal (program out) is then fed to the voltage control input terminals of the supply to create the appropriate voltage across the magnet to achieve the desired output current function. This way the programmer acts as a feed back loop which controls the supply output voltage by sensing the power supply output current. The quench protection circuit provides indication of magnet quench and automatically ramps the magnet current to zero.

Specifications and features

- Ramp output : 0 to 5 VDC
- Charging rate ranges : 0.1, 1 and 10Amps/sec
- Current and voltage limit : 10 turn potentiometer
- Current direction control : Up/ Pause/ Down
- Quench protection
- Remote and local control

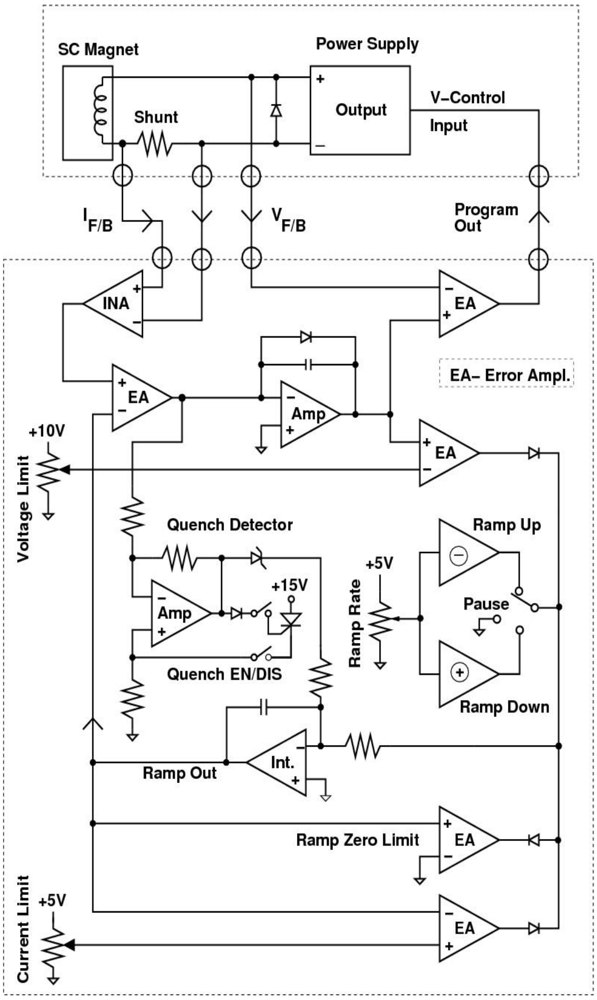

Figure 2: Block diagram of programmer.

CONCLUSIONS

The superconducting magnet power supply and programmer are successfully developed, fabricated inhouse and are in use with various superconducting solenoid magnets at IUAC. The long term stability of the power supply measured at full load is 0.025%. This development has helped us in lowering the operational costs, enabled easy and fast servicing and manpower training in this specialised field.