POWER SYSTEM OPERATION AT THE CAMBRIDGE ELECTRON ACCELERATOR

William S. C. Henry, Electrical Engineer
M.I.T - Harvard University
Cambridge Electron Accelerator
Harvard University
Cambridge, Massachusetts

Summary. The laboratory requires a large amount of electric power to produce the high energy particles and perform the physics research. This makes it important to operate the power system with maximum efficiency and economy. This paper discusses the problems and actions taken to accomplish these objectives.

The Cambridge Electron Accelerator, as a basic research laboratory, uses a large amount of electric power for the production of high energy particles and for the fulfillment of experimentation.

Electric power used by the laboratory is channeled to essentially three load demands. These load demands are classified by use as machine power, experimental power and laboratory facilities.

Machine power per se is that electric energy used to produce the high energy particles. For this requirement, power is used by the necessary interrelated machine components which include the linear accelerator, pulse power supply system, D.C. bias system, R.F. system, vacuum system and a variety of equipment used for beam control.

Experimental power is that electric energy used to power experimental beam magnet transport systems and experimentalist's equipment, such as the largest experimental load to date, a 40-inch liquid hydrogen bubble chamber magnet.

Laboratory facilities is a broad classification which overlaps both machine and experimental power requirements. Electric power for this classification includes energy for power tools, lighting, pump and fan motors, cryogenics equipment, cooling systems and varied minor requirements in the laboratory building, machine shop, power building and experimental hall areas.

Operations have involved a variety of load combinations; however, the past experience has been such that most of the laboratory energy taken was used for machine power and experimental power requirements in the form of D.C.

The D.C. Power for these large users is produced by ignition and saturable reactor controlled solid-state rectifier units. These rectifier units operate as phase shift devices with low power factor as loads. Machine load power factor varies from .5 at 4 Bev particle energy, to .8 at 6 Bev particle energy. Experimental power rectifier units operate with .4 P.F. at 25% output up to .7 P.F. at rated output.

The supply of power is contracted with the Cambridge Electric Light Company based on demand and energy use. The laboratory power taking is firm demand limited during weekday daylight hours and incoming supply cable limited during off hours, week ends and holidays. Supply of power above the contract firm demand limit up to cable capacity is supplied on an interruptible basis.

To improve power system operation by offsetting the combined effect of low power factor demand limitations, an ever increasing need for electric energy and power cost economics, a power factor improvement program has been put into effect. This program is being accomplished by connecting static capacitor banks at strategic locations on the power system.

The P.F. correction banks are sized to match load circuit reactive and permit switching without undesirable voltage disturbances. Another factor which influenced size and electrical location of P.F. capacitor banks was the need to utilize maximum transformer capacities.

Application of the static capacitors to a rectifier load creates a circuit tuned to a frequency close to the predominant harmonic generated by the rectifer (the fifth). This problem has been minimized by building into the P.F. capacitor unit involved, a series detuning reactor. These reactors have been sized to detune at this fifth harmonic generated by the rectifiers. Reactor size was also selected to minimize, as much as possible, the loss of effective KVAR's by the capacitors.

The P.F. correction program has significantly improved power system operation by reducing power costs and allowing increased energy taking without reaching demand limits. At present, approximately 30% of the total program has been in operation. This portion has been sufficient for our load requirements thus far. To date, a power cost saving of 15% of the working investment has been realized in six months time.

If our electric power use increases as anticipated, it is estimated that the P.F.

improvement program will compensate for the investment in two years.

Estimates of future power requirements for the CEA indicate that it will be necessary to operate the electrical system at maximum power factor. With this operating condition, we will achieve maximum efficiency for load demands from a limited supply and greatest economy for energy used.

References:

1 - CEA-100, The Cambridge Electron Accelerator, A Comprehensive Account.

2 - AIEE Tech Paper #53-24, Capacitors in Power Systems With Rectifier Loads, by A. Schmidt.

3 - AIEE Tech Paper #58-220, Power Factor of Rectifiers by A. Schmidt.

4 - AIEE Tech Paper #49-252, Report on Operation and Maintenance of Shunt Capacitors. Committee Report.

5 - AIEE Tech Paper #49-254, Connection Arrangements and Protective Practices for Shunt Capacitor Banks. Committee Report.

6 - Transmission & Distribution - Westinghouse Book.