1. Introduction –

The Electrostatic Precipitator (ESP) power supplies which are in use today operate at a fixed frequency of 50 Hz. In recent years various power supply designs using frequencies in the >10,000 Hz range have been used for ESP's with the goal of improving ESP field efficiencies. The difference in performance is almost completely due to the low ripple voltage delivered by such power supplies. Ador's high frequency power supply can be operated in a range of 200 Hz to 1000 Hz. At the preferred frequency of 400 Hz the Ador system can achieve ripple reduction to negligible value while avoiding the complexity and reliability problems of higher frequency power supplies.
This control system provides the significant advantages of higher frequencies while permitting the use of existing transformer-rectifiers and existing interconnecting wiring. The control system can be housed in existing TR controls cabinets. If desired, this new control system may be fed from existing single phase supply or from 3 phase supply if available. The use of frequencies between 200 and 1000 Hz permits the reliability that is associated with conventional TR's.
These abilities provide a host of advantages to precipitator operation and maintenance. The lower frequency of operation allows improved ESP power at a lower cost and with easier installation than higher frequency supplies.

2. Background –

The use of higher frequency Switch Mode Power Supplies (SMPS) for Electrostatic Precipitators has gained acceptance as a means of performance improvement. Even as the early high failure rates of such power supplies has improved. High cost and decreased reliability continue to accompany present units running at 10,000 cycles/sec (Hz) and above. In addition conversion to 10,000+ Hz systems require scrapping of existing controls, TR's and power connections, as well as requiring the routing of 3 phase power to the ESP rooftop. In addition, maintenance of such high frequency systems require significant training of plant maintenance personnel and/or additional maintenance expense due to lack of supplier documentation and availability of spare parts.
In order to offer a more practical and reliable approach to SMPS application, Ador provides a solution in the form of High-frequency power supply. This supply is capable of operation from 200 Hz to 1000 Hz, and in most instances permits the use of existing 50 Hz transformer - rectifiers. The improved performance is especially relevant to sparking fields that are current suppressed. With such a field, using a 400 Hz supply can easily affect a 15% increase in KV and an increase of ESP field power in excess of 25%.

3. Description of High Frequency Power Supplies –

A single phase or three phase AC main power source is fed into a rectifier and filter combination to create a relatively smooth DC power source. A three phase set-up is shown in Figure 1 (see next page). The use of an alternate single-phase supply requires additional components for filtering, yet is still viable within existing cabinets. This DC source is then fed into an IGBT full wave bridge circuit where it is converted into a high frequency AC waveform. The use of lower frequencies permits the use of the existing TR with the existing internal rectifiers and feedback signals. The value of the existing CLR for the conversion needs to be checked for possible modification. Typically lower CLR values are needed.

See Fig. 1 on next page.

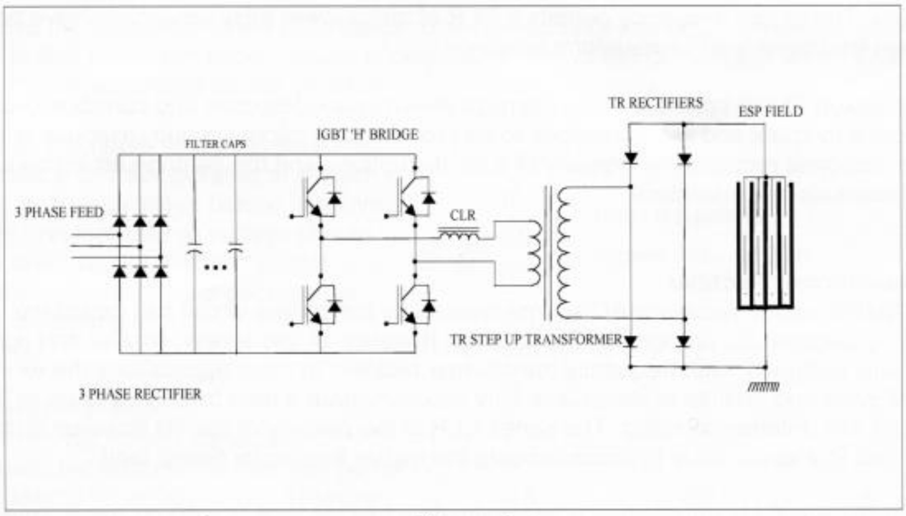


Figure 1

4. Retrofit to existing systems –

The High Frequency system can be retrofitted to a precipitator electrical field through the use of existing control cabinets and existing TR's. The installation involves mainly the removal of the 50 Hz SCR assembly and replacement with the new High Freq control module.
The High freq module is assembled on a MS plate that occupies roughly the same space as an existing SCR module. Mounted on a common heat sink are the rectifiers, the filter assembly, IGBT Modules, and IGBT Gate drivers. The IGBT firing freq is programmable from 100Hz up to 1000 Hz. Feedback control uses existing mA and kV feedback for voltage, Current and spark/arc Control. The higher frequency allows a CLR of much lower value to achieve protective current limiting as well as waveform shaping.
The Ador controller uses interrupt driven spark detection and control allowing response to spark and arc disruptions to be processed in micro-second response time. Such rapid response reduces the intensity of such disruptions and the damage arcing can do to ESP internals and insulators.

5. Transformer Rectifier –

The High frequency AC source created by the control circuit can feed into an existing electrostatic precipitator Transformer Rectifier or into a new, smaller and lighter specially designed, high frequency transformer rectifier. In most applications the existing transformer and rectifier system can easily accommodate a source frequency of up to 1000 Hz without and detrimental effect. The series CLR in the primary of the TR however must be changed to a lower value to accommodate the higher frequency power input.
Generally, a 400 Hz transformer is approximately half the size of a 50 Hz transformer. The 400 Hz transformer-rectifier system is smaller than a 50 Hz unit, but the size reduction will not be nearly as much as can be realized by the 10 kHz + systems.

6. Advantages of Switching (High freq) Power Supplies –

- **Higher power levels**

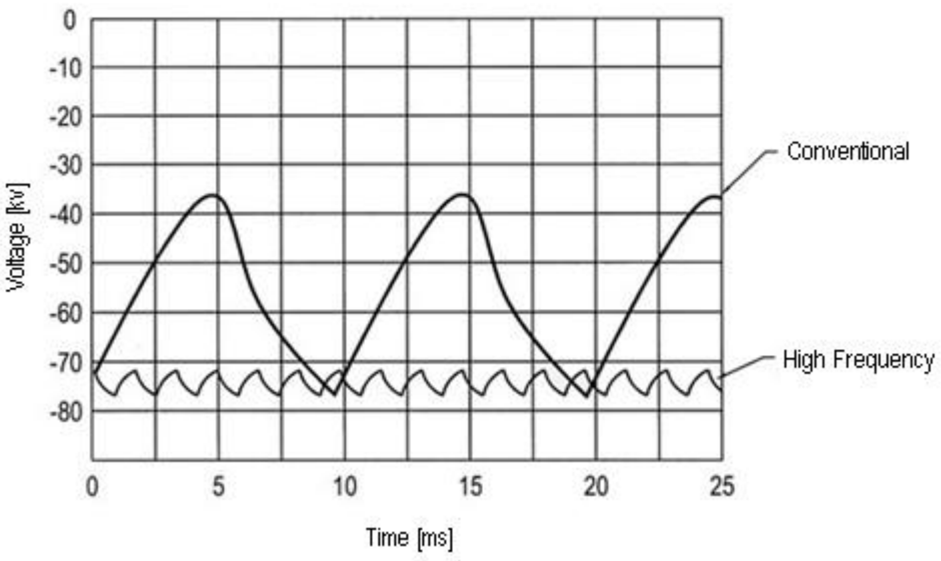
The efficiency of an ESP field is closely related to the level of average power that can be delivered to the field. The power level that can be delivered to an ESP field, however, is almost always limited by the spark-over voltage that the field can withstand. Sparking and arcing typically occur at the peak of the KV waveform. The KV ripple, as well the ratio of the peak voltage to the average voltage is reduced through the use of higher switching frequencies. A 400 Hz signal would tend to reduce the value of such ripple. Due to the steep nature of an ESP V-I curve; a relatively small increase in KV could result in a significant increase in current.

- **Faster spark control**

Unlike SCRs that depend upon the natural zero crossing of the 50 Hz feed signal to turn off, IGBT control allows instantaneous (micro-second) turn off. This ability provides the means for drastically reducing the energy delivered to the ESP during sparking and thus should reduce internal component erosion and insulator tracking.

7. Higher Collection Efficiency –

Because the frequency of the DC voltage to the precipitator has been increased from 50 Hz to 400 Hz, the ripple voltage is only 5% to 10% of the DC voltage level. With 50 Hertz the ripple voltage can be 35-40%.



Because the ripple voltage is less, the precipitator can be operated at a much higher average voltage before flashover occurs. An increase in voltage should result in an increase in precipitator collection efficiency, and decrease in outlet emissions.

8. Energy Savings –

The response time of a typical SCR controlled transformer rectifier can be no faster than 10milliseconds. However, at the higher frequency operating level of Ador controller, the response time can be as quick as 100 microseconds, an order of magnitude quicker.

This quicker response time allows the control to reduce the short circuit inrush current created by arcing in the precipitator. Short circuits created by arcs simply send current to ground and waste power. By reducing these arcs, power is conserved.

9. High Power Factor –

The Three Phase input permits a better power factor as well as better load balance.