

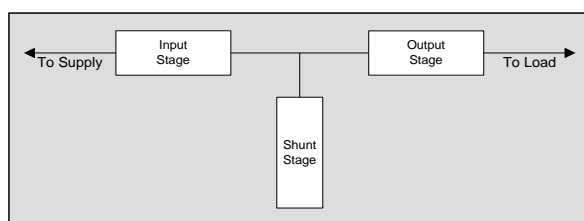
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APPLICATION NOTE

## Theory of Operation - Low Pass Harmonic Filters (Type LPF)

### Three Stage Filter

Type LPF harmonic filters combine three stages of filtering to achieve wide band attenuation of the harmonic frequencies normally associated with 6-pulse power converters. Two stages of the filter offer series impedance to the flow of harmonics, while the other (shunt) stage diverts harmonics away from the power source. This low pass filter, applied in series with the input terminals of the power converter, permits the fundamental frequency current to flow easily through the filter with very low losses, but is very effective at minimizing the flow of harmonic currents.



### Output stage

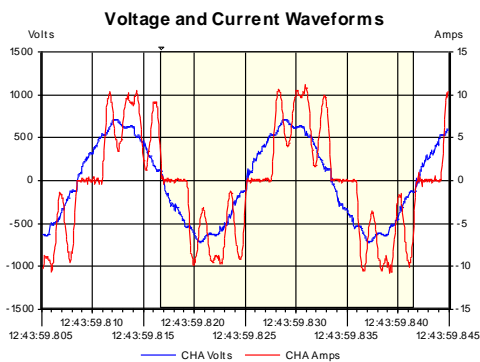
This stage is the first line of defense against harmonics and utilizes an optimum value of series impedance to reduce the magnitude of individual harmonic currents that are produced by a six pulse converter load, and also detunes the shunt stage to prevent a resonance conditions between the shunt stage and the load, and to minimize the peak current at the load terminals. During normal operation there will be a voltage drop across this stage, which increases as load current increases. The maximum voltage drop at the load terminals is maintained within 5% of the input voltage at full load operating conditions. The waveform, as measured in this stage, looks very similar to that which is measured at the input terminals for a 6-pulse rectifier with line reactor of approximately five percent impedance.



*Typical current through LPF output stage*

### Shunt Stage

This stage provides an alternative source for the residual harmonics so that they do not need to be supplied by the power source nor flow on the facility power system. This stage is carefully tuned to achieve maximum attenuation of load harmonics without causing resonance problems. During normal operation, this stage will have a highly distorted current waveform which demonstrates the significant amount of harmonic that it is being diverted away from the power source. The shunt stage capacitance, combined with the total input circuit reactance, will boost the voltage at this point. Voltage rise is regulated to a maximum of about 5% at no load operating conditions.



### Input Stage

The input stage of the Low Pass Harmonic Filter provides series impedance which further attenuates harmonics and also detunes the shunt stage, relative to the facility power system, so it does not attract harmonics from other non-linear loads which are fed from a common power source. The current measured at this point is fully filtered and very closely resembles a sine wave as shown to the right. The typical total harmonic current distortion, measured at the input to the filter, is normally 5% THD-I or less at full load and may increase slightly as the load current is reduced. The current distortion at this point can also be affected by source impedance, system voltage distortion and voltage unbalance. Current distortion here will typically be lower for systems which have higher source impedance, higher for systems with background voltage distortion, and higher for systems that have unbalanced line voltages. Although the low pass filter can reduce current harmonic distortion, caused by its load, to 5% or less, any line voltage distortion on the supply will approximately add algebraically to this value.

