

This glossary is presented to help our readers of this catalog understand the terms that are used to describe Kepco Power Supplies and Digital Programmers. The definitions should be understood in this context and are not intended to be generally applicable.

Amplifier - A circuit or element that provides gain.

Amplifier, Comparison - A d-c amplifier which compares one output quantity to a stable reference, and amplifies the difference to create corrective drive to the power supply's power-control elements to effect stabilization.

Amplifier, d-c - A direct coupled amplifier that can provide gain for zero-frequency signals.

Amplifier, Differential - An amplifier which has available both an inverting and noninverting input and which amplifies the difference between the two inputs.

Amplifier, Inverting - An amplifier whose output is 180° out of phase with its input. Such an amplifier can be used with degenerative feedback for stabilization purposes.

Amplifier, Noninverting - An amplifier whose output is in phase with its input.

Amplifier, Operational - A d-c amplifier whose gain is sufficiently large that its characteristics and behavior are substantially determined by its input and feedback elements. Operational amplifiers are widely used for signal processing and computational work.

Automatic Crossover - The characteristic of a power supply that switches its operating mode automatically as a function of load or setting from the stabilization of voltage to the stabilization of current. The term is reserved for units having substantially equal stabilization for both voltage and current, not for voltage-limited current stabilizers or current-limited voltage stabilizers. See Figure 1. See Crossover Point.

Bipolar - Having two poles, polarities, or directions.

Bipolar Power Supply (2-Quadrant) - A power supply fitted with polarity reversing relays that enable the voltage polarity to be changed. See Figure 2.

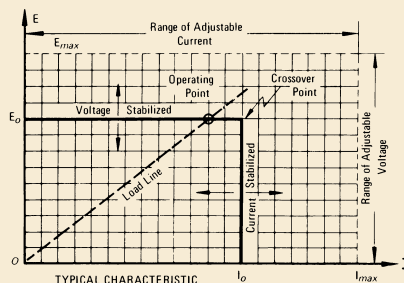


FIGURE 1
Automatic voltage/current crossover

Bipolar Power Supply (4-Quadrant) - A power supply able to linearly pass through zero to produce outputs of either positive or negative polarity and able to function in all four quadrants of the orthogonal voltage-current area as either source or sink. See Figure 3.

Bounding - The process of providing a boundary or limit to various output quantities. Fuses, circuit breakers and current limiters, as well as overvoltage crowbars, spark gaps and voltage limiters, are all examples of bounding circuits.

Carry Through Time - Refers to the time interval between loss of source power and the generation of an indicator. This represents the time for which such source power loss is invisible. The interval is usually defined in terms of fractions of a cycle (half cycle or full cycle at the source frequency).

CC/VL - Constant Current, Voltage Limit. See Current Stabilization.

CE Mark - A designation by the European community to signify compliance with applicable EMC and safety directives.

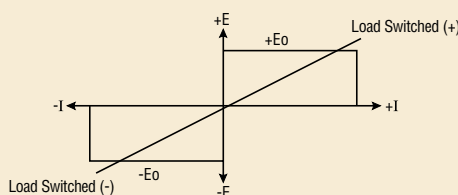


FIGURE 2
Two quadrant operation results when relays are used to provide polarity reversal

Common-Mode Output - That electrical output supplied to an impedance connected between the terminals of the ungrounded output of a power supply, amplifier, or line-operated device, and the ground point to which the source power is returned. Normal isolation makes the impedance of the common-mode output relatively high so that it may be expressed as a common-mode current.

Common Point - With respect to operationally programmable power supplies one output/sense terminal is designated "common," to which load, reference, and external programming signal all return.

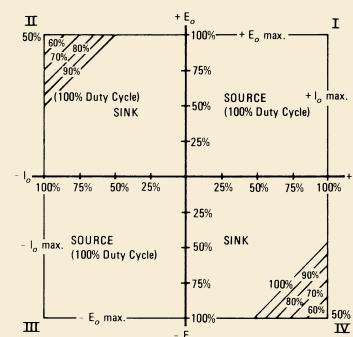


FIGURE 3
Output source-sink plot for a bipolar power supply showing the Safe Operating Area (SOA)

Complementary Tracking - A system of interconnection of two voltage stabilizers by which one voltage (the slave) tracks the other (the master). By placing the two outputs in series opposing, a pair of complementary (+ and -) voltages are created.


Compliance Voltage - A term sometimes applied to the load voltage of a current stabilizer. The compliance voltage range is that range of voltage for which a current stabilizer can comply with the requirements of a load resistance. The corresponding term "compliance current", for voltage stabilizers, is not generally used.

Constant Current - As a prefix to the phrase power supply, the term describes a current stabilizer. See *Current Stabilization*.

Constant Voltage - As a prefix to the phrase power supply, the term describes a voltage stabilizer. See *Voltage Stabilization*.

Cooling - The process of removing heat, which in a power supply is generated by transformation, rectification, filtering, and the stabilization process that converts unwanted electrical energy to heat energy. Cooling means include convection and radiation, both "natural" and blower-aided, conduction to an external heat sink, and liquid cooling medium circulation.

Crossover Point - That point on the operating locus of a voltage/current automatic crossover power supply formed by the intersection of the voltage-stabilized and current-stabilized output lines. The resistance value (E/I) defined by this intersection is the *matching impedance* for the power supply, which will draw the maximum output power.

CSA - Canadian Standards Association. In Canada, a body that issues standards and specifications prepared by various voluntary committees of government and industry. CSA harmonizes its standards with those of UL in the USA and VDE and TÜV in Germany to implement the recommendations of the IEC, International Electrotechnical Commission. Most Kepco switch mode power supplies have been examined and are certified by this agency. Presently, Underwriters Lab (UL) is authorized to provide both UL and CSA certification. A new symbol,  is in use.

Current Limiting - A bounding circuit designed to prevent overload of a voltage stabilizer in which, for load resistances smaller than the crossover resistance, the current is limited to a preset value, while the output voltage diminishes in proportion to the load's resistance. See *Figure 4*.

Current Stabilization - A process of stabilizing an output current so that the effect of various influence quantities is minimized. A current stabilized power supply contains means for controlling or setting the current, and will produce the load voltage (compliance voltage) required by the product of the set current and the load's resistance.

CV/CC - Constant Voltage, Constant Current. See *Automatic Crossover*.

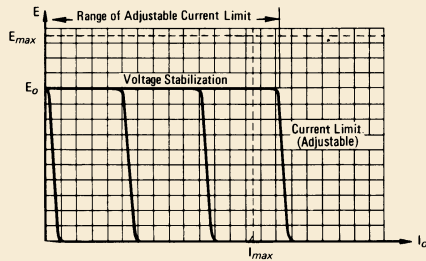


FIGURE 4
Plot of typical current limiting circuit

CV/CL - Constant Voltage, Current Limit. See *Current Limiting*.

Effect, Coefficient - The maximum change of a stabilized output quantity per unit change of any one influence quantity, all other influence quantities maintained constant.

Effect, Combined - The maximum change of a stabilized output quantity produced by the concurrent change in two or more of the following influences: load, source voltage, source frequency, temperature. The *combined* effect excludes the time and settling effects.

Effects, Individual -

Load Effect - The change in stabilized output produced by the specified change in the output load. See *Figure 5*.

Source (Voltage) Effect - The change in stabilized output produced by a specified primary source voltage change.

Temperature Effect - The change in stabilized output produced by a specified change in the environmental temperature. (This effect is usually reported as a coefficient % per °C).

Time Effect - Unprogrammed output deviation; when observed in the frequency range d-c to 20Hz, it is classified as "drift"; in the 20Hz to 10MHz range, it is classified as "ripple" and "noise". Over a specified time period, usually an 8-hour day, drift is the residual output deviation that cannot be accounted for by a specific influence quantity. Unless specified separately, drift is understood to include the settling effects which follow a major change in an influence quantity affecting dissipation - except that drift does not include the turn-on transient settling effect; warm-up. NOTE: Drift cannot be extrapolated to longer time periods by simple multiplication. The expression of a maximum drift amplitude for an 8-hour period does not imply that direction at the same rate over a longer term. (See *Noise*.)

Transient Effect - A transient effect follows a step change in any influence quantity, consisting of a temporary excursion in the stabilized output quantity decaying to the effect band within the recovery time.

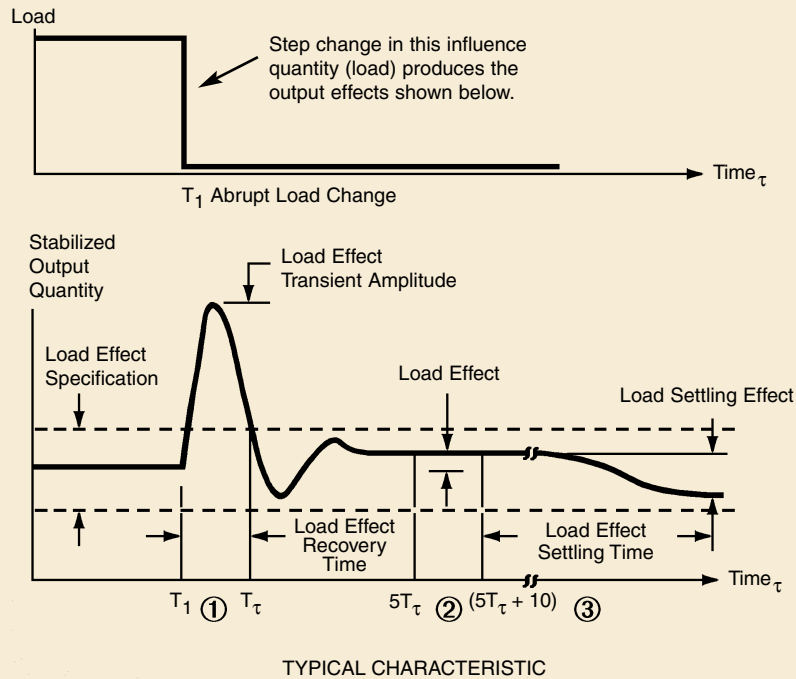


FIGURE 5
Load Effect Time Behavior

Three time-separable output effects that follow on abrupt load change
① Load Effect Transient ② Load Effect ③ Load Effect Settling

Effect, Interactive - A change in one stabilized output quantity produced by a specified change in another output quantity or its load.

Effect, Output - Typically, there are three time-separable responses to a step change in any influence quantity: the transient effect, output effect, and the settling effect. The output effect is considered to follow the transient effect by a time equal to five times the transient effect's recovery time plus 10 seconds. See Figure 5.

Effect, Settling - The temperature effect coefficient multiplied by the change in equilibrium temperature. Unless specified separately, the settling effects are understood to be included in either the individual effect or the drift specification.

EMC - Electromagnetic compatibility. A group of requirements covering susceptibility, emissions and conducted electromagnetic energy

EMI, Conducted - Electromagnetic Interference reflected back into the source power connection by the action of switching circuits or other abrupt actions within a circuit connected to the source. The amount of noise that may be reflected is regulated by various agencies, the FCC, VDE, CISPR etc. Filters to reduce the noise to accepted limits are commonly included in switch-mode power supplies. The limits are tailored for expected applications, with higher conducted EMI permitted for industrial applications (Class A) than for home or office applications (Class B). See EMC.

EMI, Radiated - Consisting of broad band radio frequencies and narrow band emissions, the radiated noise generated by the action of a switching regulator is limited by standards set by various agencies such as FCC, VDE, CISPR etc. It is controlled by shielding. See EMC.

Fast Programming - The operation of a power supply with reduced filtering and high frequency discrimination so as to allow it to be programmed at faster than normal rates. A power supply in fast programming mode is typically sensitive to load reactance and should be used with essentially resistive loads.

Fault Tolerant - A system configuration to ensure the integrity of operation in the event of a single point failure. For power supplies, the requirement is usually to ensure the maintenance of system power despite the loss of any single power module. The usual technique is to provide redundant power modules on an N+1 basis, with sufficient isolation that the failure of any one power module does not cause system failure. Additional systems redundancy may require multiple source power inputs.

Feedback - The process of returning a part of the output of a system to its input. Negative feedback (out-of-phase return) is used to effect the corrective action that is basic to the process of stabilization.

Ferroresonance - The principle used in a simple open-loop (nonfeedback), voltage-stabilizing power supply. The process consists of allowing a portion of a special 2-loop transformer's iron to be driven to saturation in a capacitor resonated "tank." Output is derived from the saturated part of the transformer so that its amplitude level is determined by core geometry and is relatively independent of the exciting source amplitude.

Flag Signal - An alarm signal generated by a power supply, indicating an abnormal situation.

Flyback Converter - A circuit used for low power a-c to d-c switching type power supplies. It is economical since the function of choke and transformer are combined in a single component. See Figure 6.

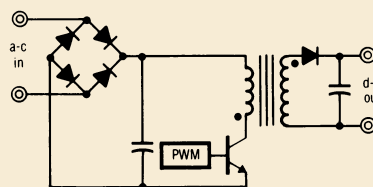


FIGURE 6
Flyback system

Forced Current Sharing - When voltage stabilizers are paralleled, they will self-arrange their operation so that only one unit controls the voltage. The other units in the parallel group are forced to either shut off or go into current limit mode. This produces a natural unbalance in the way they share the load current. To restore a balance, circuits are employed to force paralleled voltage stabilizers to share the load current. With parallel operation used for redundancy and N+1 combinations, the concept of forced current sharing is increasing in importance.

Forward Converter - A circuit used in high powered a-c to d-c switching type power supplies. Current flows in the output filter during both the on and off cycles, returning through a catch or flywheel diode. A separate choke is used to sustain the current during the off part of the cycle. See Figure 7.

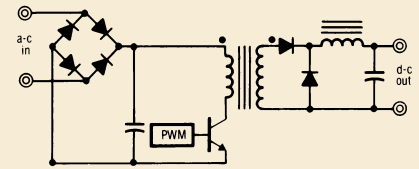


FIGURE 7
Forward converter

Frequency Response - The band of frequencies over which a control signal can effectively modulate the output. The usual frequency limits are taken to be the frequency points where the output response has diminished to 0.707 of the datum level.

Gain, Closed Loop - The gain measured after feedback is applied, designated "G" in the operational diagrams.

GPIOB - General Purpose Interface Bus. The IEEE 488 bus. The latest edition is IEEE 488.2, supporting SCPI.

Heat Rise - The temperature increase caused by self-heating or absorption.

Heat Sink - A device designed to aid the transfer of heat by conduction, convection or radiation.

Hold Up Time - Refers to the time interval between detection of source power loss and the loss of a power supply's output stabilization.

Hot Swap - A phrase indicating the ability to insert and extract an electronic module from a larger assembly while it is powered (hot). In power supplies, it is used to describe a design which allows live power supplies to be attached to and removed from a powered set of rails without causing disturbance to the operation of the load.

IEC - International Electrotechnical Commission. A standards writing body headquartered in Geneva which produces safety recommendations that are incorporated by the various national standards organizations. Currently, power supplies are governed by IEC 60950 which has been widely adopted by national bodies.



Influence Quantities - Those items which have an effect on a stabilized output quantity. The list includes, but is not limited to:

- source voltage
- source frequency
- load
- temperature
- time
- control

Isolation Voltage - The amount by which the output terminals of a stabilizer may be operated off ground (chassis). See *Common-Mode Output*.

Lag Network - Resistance capacitance combinations placed in an amplifier circuit to control the gain rolloff with increasing frequency. Lag networks are used to tailor the phase margin of a feedback loop for stability. The main effect of a lag network is the reduction of gain at high frequencies.

Large Signal Frequency Response - The frequency at which the closed loop gain (fully loaded output) reaches 3% harmonic distortion.

Lead Network - Resistance capacitance combinations placed in an amplifier circuit to control the phase shift versus frequency. Lead networks are used to tailor the phase margin of a feedback loop for stability. The main effect of a lead network is the reduction of phase lag at low frequencies.

Linearity - With respect to the control function, the correspondence between successive incremental changes in the control quantity and the consequent incremental changes in the controlled output quantity.

Linearity Error - Applied to digitally programmed power supplies it is the absolute deviation between the analog output and the digital input signals at any point of the output range.

Load - For a voltage stabilizer, the load is its current (load current); for a current stabilizer, the load is the voltage (compliance voltage). The loading means, the resistance or dissipator, is a sink.

LVD - Low Voltage Directive. Safety standards promulgated by the European community as one of the requirements for the CE mark. Presently the applicable LVD for instrumentation power supplies is EN61010. For component (modular) power supplies it is EN60950.

MTBF - An acronym standing for Mean Time Before Failure. It is a rough gauge of reliability as it is computed by summing the reciprocal of the individual probabilities of failure associated with components under specified levels of stress. Kepco uses the MIL handbook 217 in its latest revision to compute MTBF.

N+1 - A system configuration by which power supplies are wired in parallel, with isolation (OR-ing) diodes, and sized so that the total system power can be supported by N modules. If there are N+1 modules, then one module may fail without interrupting operations of the system. A variant will allow X modules to fail by paralleling N+X modules in the system.

Noise - One of the time effects, usually lumped together with ripple in assessing the unprogrammed output deviation. Noise is the aperiodic random component while ripple is the periodic component harmonically related to the source frequency. Generally, "noise" is distinguished from "signal" by its unwanted, unappreciated character.

Null Junction - (also *Summing Point*) - the inverting input terminal of the comparison amplifier to which reference and feedback are referred. With respect to common - or a non-inverting input, the null junction supports a virtual ground because of the voltage gain of the amplifier.

Offset Current - The net current flowing into or out of a closed-loop comparison amplifier's null junction. Normally zero (or nullable), its variations (ΔI_{iO}) are tabulated for the major influences.

Offset Voltage - The residual voltage across the input terminals of a closed-loop comparison amplifier's input terminals. Normally zero (or nullable), the variations (ΔE_{iO}) are tabulated for the major influences).

Operational Power Supply - A power supply with sufficient open-loop gain, and provision for offset nulling such that its behavior is analogous to an operational amplifier. See *Figure 8*.

Output Impedance - The impedance that a power supply appears to present to its output terminals, and thus to its load's impedance. For a voltage stabilizer, this impedance is small, equal at d-c to the load effect ratio, $\Delta E_o / \Delta I_o$, increasing with the increasing load modulation frequency until the impedance is asymptotic to a characteristic series inductance. For a current stabilizer, this impedance is large, equal at d-c to the load effect ratio, E_o / I_o , decreasing with increasing load modulation frequency until the impedance is asymptotic to a characteristic shunt capacitance.

OVP - Over Voltage Protection. A sensing circuit that prevents a power supply's voltage from exceeding a preset limit. This limit can be fixed or programmable or may track the voltage setting of variable power supplies. For linear (series pass) power supplies, the action of the OVP is usually to short the output to discharge the energy stored in its capacitors. Sometimes this is called a "crowbar." For switch mode power supplies, the usual action of the OVP is to stop the transfer of energy by inhibiting the switch.

PARD - An acronym comprised of Periodic And Random Deviations. Recommended by the IEC as the specification term for "ripple and noise." Not used by Kepco.

Pass Element - The active circuit element (commonly a transistor, MOSFET or vacuum tube) which forms the output power stage of a power supply.

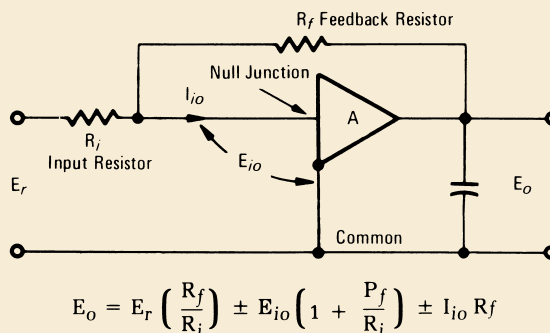


FIGURE 8
The ideal amplifier with offset voltage E_{iO} and offset current, I_{iO} depicted



PFC - Acronym for Power Factor Correction. Better defined, however, as a technique for harmonic reduction in a power supply's source current. Off line rectifiers, un-corrected, draw large peaks of current from the source (mains) near the peak of the input sinusoid. The flattening, caused by the non-zero source impedance of the utility mains, causes harmonic distortion. Power Factor Correction may be of two types: Passive correction uses a choke input filter with the choke sized so that the rectifiers conduct continuously (critical choke value). Active correction uses a separate converter in front of the rectifier having the effect of causing conduction to occur over nearly the whole mains cycle. This produces near sinusoidal source current reducing harmonic generation and improving source power utilization. See Figure 9a and 9b.

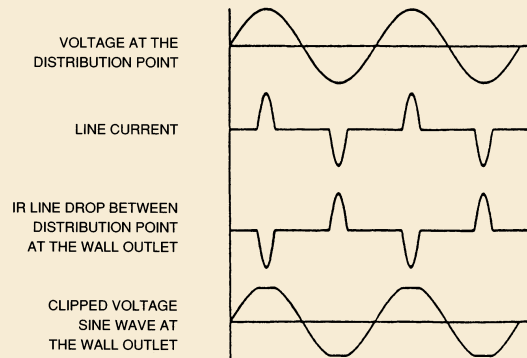


FIGURE 9a
Power Factor Correction

Phase Margin - The amount of phase shift subtracted from 180° found in a feedback system at the frequency for which its gain reaches unity. The margin from 180° represents a measure of dynamic stability.

Power Factor - The ratio of real to reactive power. In sinusoidal circuits, it is the measure of the fraction of current in phase with the voltage and contributing to the average power.

Programming - The control of a power supply's stabilized output quantity in accordance with a program of values usually by a remotely located, variable control quantity.

Programming Speed - A measure of a power supply's ability to respond to a varying command to change its output setting from one level to another. Can be measured in terms of programming time constant and a slewing rate.

Recovery Time - The time required by a transient overshoot in a stabilized output quantity to decay to within specified limits (usually within the individual effect band of the influence quantity whose step change initiated the transient).

Recuperation - The process of recovering energy and passing it back to the a-c mains. Used in Kepco's BOP High Power models to avoid dissipative losses while sinking.

Redundancy Power Systems - A configuration which combines fault tolerance, with fault detection, isolation and hot swap capability to improve overall system reliability.

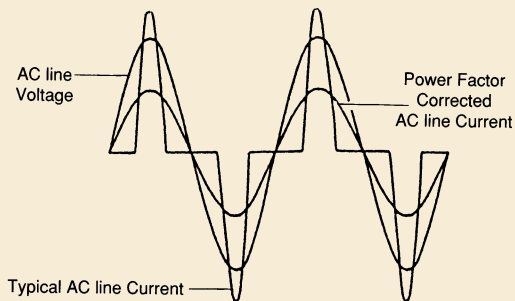


FIGURE 9b
Power Factor Correction

Reference - A known, stable quantity to which an output quantity can be referred - via a comparison amplifier for the purpose of stabilizing that output quantity.

Regulation - The process of exercising control over an output quantity. A regulator devoted to stabilization, the maintenance of a constant output in the face of adverse influence quantities, has its degree of stabilization measured in terms of the effect individual influence quantities exercise on the output. See *Effects, Individual*.

Remote Error Sensing - The means by which a power supply senses the potential at a remote point (usually the load) for the purpose of stabilizing that voltage. Remote error sensing is accomplished by a 4-wire connection to the load, in which one pair of wires is reserved for the voltage-sensing role and carry no load-related current.

Response Time - The response time for a transient disturbance with an exponential decay is the time corresponding to a single time constant. Response time is thus distinguished from recovery time for which the decay is timed to a specific error limit.

Resolution - The smallest level capable of being reliably changed. The resolution of a digital programmer is the number of bits used in the instruction. The resolution of an analog control is a function of the number of turns available and the fineness of the material used to produce the variable control signal.

Ripple - See *Noise*.

RS 232 - A serial communications protocol that is supported by the COM ports of many personal computers.

SCPI - A control language for instruments: Standard Commands for Programmable Instruments. The SCPI command set conforms to all of the common commands declared mandatory by IEEE 488.2 and is implemented in many Kepco power supplies.

Single Address, Multiple Instrument Bus - A serial communications protocol used to distribute communications to a number of instruments on a "daisy chain" basis. It is capable of relatively long distances (300 m) and supports many instruments (27 Kepco power supplies).

Slewing Rate - The maximum rate of change that a power supply output can respond to when controlled (programmed) by an overdriving or forcing control quantity.

Slow Programming - The operation of a power supply with internal filtering to discriminate against high frequencies. The programming of such a power supply is characterized by a relatively narrow band-width and slow response to program inputs. Slow or conventionally filtered power supplies are generally independent of load reactance.

Soft Start - A system for controlling the rate of turn-on so as to reduce the surge current that a starting power supply can impose on the source mains. See Figure 10.

Stabilization - The function of a regulator devoted to maintaining a constant output quantity.

Step Change - An abrupt and sustained change in one of the influence or control quantities. When employed as a test means to observe transient behavior, a step change shall be complete in less than one-tenth the transient's response time.

Summing Point - (See Null Junction.)

Temperature, Ambient - The environmental temperature which exists unmodified by the operation of dissipative apparatus.

Temperature, Operating - The environmental temperature that prevails when the power supply is operating, reflecting, therefore, the effect a dissipative power supply has on its own environment. Measured at the air intake or - for convection-cooled supplies - below the equipment. Also, the operating temperature range is the range of temperatures through which specified operation can be obtained.

TÜV - Technische Überwachungs-Verein (Rhineland). A laboratory licensed by the German government to test products to international standards. Most Kepco switch-mode power supplies have been examined and are approved by this agency.

UL - Underwriters Laboratory. A laboratory established in the United States to test electrical apparatus mainly for fire safety. In recent years, UL has written standards that are (nearly) harmonized with the equivalent IEC standard. UL examines power supplies for recognition as a "listed component." Most Kepco switch mode power supplies have been so examined and listed.

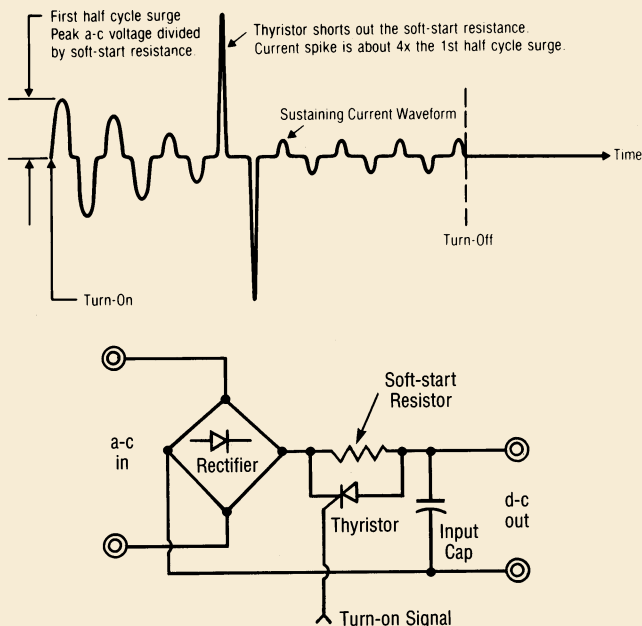


FIGURE 10
a-c input current vs. time and soft start circuit

Under Voltage Protection - A circuit to detect and react to a prolonged output voltage that is below a threshold value. It is principally used to protect against prolonged short circuit faults.

Unipolar - Having but one pole, polarity or direction. Applied to power supplies, it means a single polarity output that operates in a single quadrant and therefore, has a d-c component. Unipolar power supplies equipped with polarity changing relays have the appearance of operating in two quadrants.

Universal Input - See Wide Range Input.

VDE - Verbund Deutscher Elektrotechniker. A Laboratory licensed by the German government to test products to international standards. Some Kepco power supplies have been examined and are approved by this agency.

VISA - Virtual Instrumentation Software Architecture. A protocol that enables communication between hardware such as a power supply and the programming languages used for "soft panels" under such programs as National Instrument's LabView and LabWindows.

Voltage Limiting - A bounding circuit designed to prevent overload of a current stabilizer. For load resistance larger than the crossover resistance, the voltage is limited to a preset value, while the output current diminishes in proportion to the load's resistance.

Voltage Stabilization - The process of stabilizing an output voltage so that the effects of various influence quantities are minimized. A voltage-stabilized power supply contains means for controlling or setting the voltage and will produce the load current required by the ratio of the set voltage to the load's resistance.

VXI - VME eXtension for Instruments. A standard for test and measurement instruments that seeks to reduce the size of the instruments and the complexity of their interconnect by standardizing the size and shape, placing the functions on plug-in cards.

Wide Range Input - Refers to a power supply's ability to accept a-c mains voltage through a wide range of voltage (typ: 85-264V a-c) without manual selection. This may be accomplished in a variety of ways. In low powered models, it is achieved by simply sizing the components appropriately and requiring the regulator's control range to accommodate the voltages. In higher power models that use PFC, power factor correction, the preregulator that causes the input current to conduct over the whole of the mains cycle also accommodates the range of a-c input voltage. Also called "Universal Input".

