

# DC-DC Terminology

## APPLICATION NOTE

**ALTHOUGH THE CONCEPTS STATED ARE UNIVERSAL, THIS APPLICATION NOTE WAS WRITTEN SPECIFICALLY FOR INTERPOINT® PRODUCTS.**

### ABSOLUTE MAXIMUM

The maximum condition which the power converter can withstand without potentially damaging the device. Usually applied to input voltage, lead soldering temperature or case temperature.

### AGING

The change in the performance of a power supply over time. Typically considered with all other factors held constant but may be combined with other environmental factors such as radiation. Aging is accelerated by increased temperature.

### AMBIENT TEMPERATURE

The temperature in the medium around a component and is measured some distance from the device (usually 0.5 inches) to be considered uniform. Temperature ratings for converters are usually given for case temperatures ( $T_C$ ). The case temperature for an operating converter is ordinarily higher than the ambient temperature.

### AUDIO REJECTION

The attenuation in dB of an ac signal applied to the input of a converter as it propagates to the converter's output. The ac signal is swept over a defined frequency range and attenuated by the converter's control loop. Interpoint converters use feed-forward compensation which allows a significant attenuation of this ac signal in the audio range, typically around 40 dB.

### BALUN <sup>1, 3</sup>

An inductor used for impedance matching between a balanced line and an unbalanced line. The balun presents a high impedance to common mode signals and a low impedance to differential mode signals. A balun is sometimes used in series with the input lines of switching power converters to suppress common mode noise currents. The word balun is formed from the first three letters of balanced and the first two letters of unbalanced.

### BOOST CONVERTER – TOPOLOGY

The boost circuit is a commonly used building block in converter design where the output voltage is greater than the input voltage. A switch controls energy transfer from the input source, through the inductor, to the load. The boost topology also requires an output energy storage capacitor to support the load current during the inductor charging cycle.

### BUCK CONVERTER – TOPOLOGY

The buck circuit is another commonly used building block in converter designs. In its basic form, without a transformer, the output voltage is less than the input voltage. When the transistor is switched on, energy is transferred from the input source to the inductor and the output. When the switch is turned off, the inductor current ramps downward and the inductor energy is transferred to the output capacitor and the load. Since most applications severely limit the amount of pulsating current that can be drawn from the converter's input source, some form of low pass filter is generally inserted on the input side of the switch.

### CASE TEMPERATURE <sup>2</sup>

The temperature of a converter measured at its baseplate. Temperature ratings for converters are usually given for the case temperature ( $T_C$ ). The case temperature for an operating converter is ordinarily higher than the ambient temperature.

### COMMON

The common input or output terminal of a power supply. It carries the return current for the power terminals. Also referred to as "return".

### COMMON MODE NOISE <sup>1, 3</sup>

The component of noise which is common to both the dc input and input return or output and output return with respect to a common reference. The common reference is generally the converter's metal base.

### CONSTANT VOLTAGE POWER SUPPLY

A power supply that regulates its output voltage within specified limits independent of line, load and temperature changes.

### CONVERSION FREQUENCY

See nominal clock switching frequency.

### CROSS REGULATION

On multiple output power supplies, the change (usually measured in percentage) of the output voltage on one output while the load is varied on another output over specified conditions.

### CROWBAR

An overvoltage protection circuit which monitors the output voltage of a power supply and rapidly creates a low resistance path across the output when a predetermined voltage is exceeded. This is not used in Interpoint brand converters.

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### DC-DC CONVERTER

An electric circuit that changes its dc input voltage to a different dc output voltage which is then used to power a load. Usually the output is highly regulated within specified limits, while the input is free to vary. A dc-dc converter can have several outputs which may, or may not, be isolated from the input voltage.

### DERATING WITH CASE TEMPERATURE <sup>2</sup>

The specified reduction in output power/current as a function of case temperature above the maximum full load rated case temperature.

### DIELECTRIC BREAKDOWN VOLTAGE

The minimum ac or dc voltage which, when applied across an isolation barrier of a power converter, can breach the isolation barrier and cause a direct short circuit. Input to output and input/output to case are examples of isolation barriers. Exceeding a converter's dielectric breakdown voltage can permanently degrade performance and can be a safety issue.

### DIFFERENTIAL MODE NOISE <sup>1, 3</sup>

The component of noise measured from the dc output or input to its respective return. Also known as normal mode noise.

### DRIFT

The change in output voltage over a period of time with all other operating parameters held constant.

### DUTY CYCLE

The percentage of time the converter's main power switch stays on during a switching cycle. This would be the on-time of the power switch divided by one period of the clock cycle. This determines the volt-seconds that are applied across the main power transformer which determines the converter's output voltage. The term duty cycle is usually used in reference to the converter's PWM output which drives the switching power MOSFET.

### DYNAMIC LOAD REGULATION

The transient change of output voltage in response to a transient change in load current. Also known as "step load transient response".

### EFFICIENCY <sup>2</sup>

The ratio of output power to input power, expressed as a percentage.

### EMI (ELECTROMAGNETIC INTERFERENCE) <sup>1</sup>

Conducted or radiated noise which is emitted from switching electronic circuits.

### EPOXY POTTING

An inexpensive method of packaging which consists of coating the substrate with a conformal coating and then submerging it in a potting cup filled with epoxy. Epoxy-potted modules have excellent thermal capacity characteristics but are not as resistant to moisture or as tolerant of temperature cycles as other types of packaging.

### ESR (EQUIVALENT SERIES RESISTANCE)

The amount of resistance, in series with an ideal capacitor, required to exactly model a real capacitor. Capacitor ESR can vary significantly with temperature and frequency. ESR can also refer to the winding resistance of a coil used in an inductor.

### FARADAY SHIELD

An electrostatic shield between the input and output windings of a transformer. The shield reduces capacitive currents and output common mode noise by shorting capacitive currents to a fixed reference, usually the primary.

### FAULT MODE INPUT CURRENT

The input current of a dc-dc converter with the output terminals shorted.

### FLYBACK CONVERTER – TOPOLOGY

In the basic flyback converter when the switch is turned on, the current increases linearly in the transformer primary. When the switch turns off the decreasing flux in the transformer core causes a current to flow in the secondary, transferring energy to the output capacitor and the load. Since the transformer assumes the roles of both an energy storage device and a transformer, only one magnetic component is needed. The flyback may be considered a combination of the Buck and Boost topologies. See Buck and Boost topologies.

### FOLDBACK CURRENT LIMITING

A short circuit protection system which decreases the converter's output current as the overload increases, with the output current reaching a minimum at short circuit.

### FORWARD CONVERTER – TOPOLOGY

A switching dc-dc converter that uses a transformer to increase or decrease the output voltage and provide isolation for the load. When the switch is turned on energy is transferred to the secondary side. The transformer resets when the switch is turned off. On the secondary side the energy received is rectified and stored in the output capacitor and inductor and provides a steady dc voltage at the load.

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### GROUND LOOP <sup>1</sup>

An unwanted feedback voltage caused by two or more circuits sharing a common electrical ground or return line.

### HERMETIC SEAL

A sealing technique sometimes used for microcircuit packages to provide airtight and moisture resistant components. The highest quality hermetically sealed converters have final soldering or welding performed in a dry nitrogen environment and undergo leak testing. Hermetically sealed packaging increases a converter's reliability and extends its life. It also makes the converter less susceptible to internal arcing at high elevations.

### HI-POT TEST (HIGH POTENTIAL TEST)

A test performed by applying a high voltage between isolated test points in order to test the minimum specified isolation resistance of a power supply.

### HOLD-UP TIME

The length of time a power supply will maintain its output voltage within specifications after loss of its input power.

### IDLE CURRENT

See Standby Current.

### INHIBIT (CONVERTER FEATURE) <sup>4</sup>

A feature that allows the end user to turn a converter on or off without cycling the converter's input voltage. This allows converter to be turned on or off without losing the power bus that may be used to power other devices. With the converter inhibited the input current from the converter will be reduced to a very low level. All Interpoint converters have a primary side inhibit and some have both a primary side inhibit and a secondary side inhibit.

### INPUT LINE FILTER <sup>1</sup>

A low pass filter at the input of a switching converter which can attenuate input line noise fed into the converter or line ripple current generated by the switching converter. See also Pi Filter.

### INPUT/OUTPUT CAPACITANCE

The effective barrier capacitance from the input pins to the output pins of a dc-dc converter.

### INPUT RIPPLE CURRENT <sup>1</sup>

The magnitude of the ac current generated at the input of a dc-dc converter by the switching operation of the converter, measured in milliamps peak-to-peak or RMS. Input ripple current is usually measured at full load over a specified bandwidth with a specified source impedance. See also PARD.

### INPUT RIPPLE REJECTION (AUDIO REJECTION)

The attenuation, in dB, at the output of a converter in response to the injected ac input signal at a particular frequency or as a function of frequency.

### INPUT TRANSIENTS <sup>4</sup>

Temporary changes in the input voltage to a power converter which may, or may not, fall outside the minimum/ maximum input voltage range of the converter. Those which exceed the maximum may damage the converter.

### INPUT VOLTAGE RANGE

The input voltage range over which a dc-dc converter is guaranteed to operate continuously.

### INRUSH CURRENT <sup>6</sup>

The peak instantaneous currents drawn at the input of a converter. The instantaneous current can be due to the charging of the converter's input filter capacitors when input voltage is applied, and/or the instantaneous current due to the converter's output voltage rising and powering the load and charging output filter capacitors.

### INVERTER

A dc to ac power converter.

### ISOLATION

The electrical separation between the input, output and case of a power supply. Isolation is usually expressed in megohms at a specified voltage.

### ISOLATION VOLTAGE

The guaranteed maximum ac or dc voltage which can be applied from input to output of a power supply while the supply maintains the specified isolation resistance in megohms. Interpoint converters are specified with a dc voltage only.

### LEAKAGE CURRENT

The ac or dc current flowing from input to output and/or case of an isolated power supply at a specified voltage and frequency.

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### LINE REGULATION

The change in output voltage (expressed in millivolts or percentage of output voltage) as the input voltage is varied over its specified range. Line regulation is usually measured at full load.

### LINEAR REGULATOR - TOPOLOGY

A linear regulator is a circuit which reduces an input voltage to a lower regulated voltage without the use of switching. The absence of switching creates a clean output that typically will not need additional filtering. Some linear regulators include a short circuit protection circuit which senses the voltage across a current sampling resistor. When this voltage exceeds a preset level, the circuit reduces the base drive of the transistor and limits the output current. Linear regulators are used in dc-dc converters to regulate output voltages or to provide tight post-regulation. The drawback of using linear regulators is poor efficiency.

### LOAD REGULATION

The change in output voltage (expressed in millivolts or percentage of output voltage) as the load is varied from a specified minimum to full load. Load regulation is usually measured at nominal input voltage.

### LOW LINE DROPOUT VOLTAGE

The low input line voltage at which a converter's output voltage will drop out of regulation.

### MAGNETIC FEEDBACK

Magnetic feedback provides a way for the secondary side voltage loop to cross the primary / secondary boundary and provide feedback to the primary side PWM while still maintaining isolation. With magnetic feedback a transformer is used to send the signal from the secondary to the primary and still maintain primary / secondary isolation.

### MAXIMUM ALLOWABLE VOLTAGE BETWEEN PINS

Maximum safe voltage allowed between one pin referenced to another.

### MAXIMUM OUTPUT CURRENT

The maximum steady-state current a converter is guaranteed to supply while continuing to meet its full load electrical specifications.

### MTBF (MEAN TIME BETWEEN FAILURES)

The failure rate of a power supply, calculated using MIL-HDBK-217 for military or aerospace applications. MTBF calculations (expressed in hours) vary widely depending on assumptions made about the quality of components, assembly, number of interconnects, packaging methods, case temperature and operating environment. Interpoint calculations use MIL-HDBK-217 F, Notice 2.

### NOISE (ELECTRICAL) <sup>1, 3</sup>

The undesired or unintended high frequency voltage or current appearing at a converter's input or output and caused by the switching of power components internal to the converter during power conversion. Also see Common Mode Noise and Differential Mode Noise.

### NOMINAL CLOCK SWITCHING FREQUENCY <sup>5</sup>

In a switching power converter, the frequency at which the power switch chops the incoming dc voltage. The frequency is chosen to optimize efficiency and transformer size.

### OPTOCOUPLER FEEDBACK

This serves the same function as Magnetic feedback but the transformer is replaced with an optocoupler. The opto coupler maintains isolation while allowing a signal to pass from the secondary side voltage loop to primary side PWM.

### OUTPUT CURRENT LIMITING

An output protection feature in which the output current is limited to a predetermined maximum value under overload and/or short circuit conditions. This is typically specified as a percentage of the converter's maximum power with the percentage being greater than 100%.

### OUTPUT POWER

Output power is the product of output current and output voltage. At maximum output power the converter is guaranteed to be able to deliver power to the load while meeting the datasheet's full load specifications.

### OUTPUT TRIM

This is a function that allows the converter's output voltage to be adjusted. With some converters the voltage can be adjusted up or down. With other converters the voltage may only be able to adjust up. Do not exceed the maximum rated power when trimming the output voltage up. Do not exceed the maximum rated current when trimming the output voltage down. This feature is not available on all converters.

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### OUTPUT VOLTAGE

The nominal dc voltage at the output terminals of a dc-dc converter.

### OUTPUT VOLTAGE ADJUSTMENT

See Output Trim.

### OUTPUT VOLTAGE RIPPLE <sup>3</sup>

The magnitude of the ac voltage on the output of a converter, measured in millivolts peak-to-peak or millivolts RMS over a specified bandwidth. Usually measured at full load. Output ripple is usually defined and measured at the fundamental switching frequency of the converter as ac variations that result from power transfer during switching. See PARD and Noise.

### OUTPUT VOLTAGE TOLERANCE (TOTAL ERROR VOLTAGE)

The maximum deviation, in percentage of nominal, of the output voltage under all specified minimum or maximum conditions.

### OVERLOAD PROTECTION

An output protection feature which limits the output current of a power supply under overload conditions so that the power supply will not be damaged. See Short Circuit Protection.

### OVERSHOOT/UNDERSHOOT

The peak deviations above or below some steady state value. Overshoot/undershoot can occur during turn-on and turn-off of the converter or when there are perturbations on the line or load. See also Settling Time.

### OVERVOLTAGE PROTECTION

This typically references input voltage to a converter or output voltage of a converter. For input overvoltage protection, in order to protect the converter when a specified input voltage has been reached, the converter typically stops switching. For output overvoltage protection, in order to protect the converter and load when a specified output voltage has been reached, the converter typically stops switching. Interpoint converters typically do not have output overvoltage protection and often do not have input overvoltage protection.

### PERIODIC AND RANDOM DEVIATIONS (PARD)

The sum of all ripple and noise components measured over a specified bandwidth.

### PI FILTER <sup>1</sup>

A filter consisting of two parallel capacitors (line to line) and a connecting series inductance which is used at the input of a switching power supply to reduce ripple current, or at the output to reduce ripple voltage.

### POINT OF LOAD (POL)

A non-isolated dc-dc converter with high-efficiency. Designed to be placed close to the load to reduce output voltage drops and optimize transient performance.

### POST-REGULATION

Use of a linear regulator on the output of a switching power supply to improve output voltage regulation and to reduce ripple voltage.

### POWER DISSIPATION <sup>2</sup>

The total of all internal power losses defined as the difference between input power and output power.  $P_D = (P_{in} - P_{out})$ . Power dissipation is what creates the heat within a converter.

### POWER FOLDBACK

A power supply feature in which the input and output power are reduced under overload conditions.

### PRE-REGULATION

The regulation at the input side of a power supply, usually by a type of switching regulator or a linear regulator.

### PULSE WIDTH MODULATION (PWM)

This is the method a converter's PWM uses to regulate the converter's output voltage during changes in input line voltage or load. With pulse width modulation, the PWM duty cycle is varied to compensate for changes in input line voltage and load in order to maintain regulation of a converter's output voltage. A much less common method would be for the PWM to vary the converter's frequency in order to regulate the converter's output voltage.

### PUSH-PULL CONVERTER – TOPOLOGY

This topology is similar to a forward converter. The primary transformer is driven by a pair of transistors in a symmetrical circuit. These are switched on and off, alternately. Current is drawn from the line during both halves of the switching cycle. The secondary side receives power during both the "push" and the "pull" stages. It is full wave rectified before passing through the output inductor and capacitor to provide a steady dc voltage to the output load. Push-pull converters have lower input ripple current and are more efficient in higher power applications.



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### RADIATION TOLERANCE

The ability of a converter to meet its “post radiation specifications” after a specified radiation exposure. The accumulated exposure (total ionizing dose or TID) of radiation over time can cause degradation of some of the converter’s operating specifications but the converter should still meet its post radiation specifications if it has radiation guarantees. Since radiation occurs in a space environment, typically only space grade converters come with radiation guarantees. During a Single Event Effect (SEE) exposure, within the data sheet’s specifications, the SEE may temporarily cause a transient of the converter’s output voltage. The transient voltage may temporarily cause the converter’s output voltage to be out of specification, but after the SEE the converter’s output should return to regulation.

### REFERENCE VOLTAGE

A stable voltage, generally supplied by a voltage reference IC, which is used for comparison to control a regulated output voltage. A typical application would be a stable voltage (reference voltage) required at the positive input of the voltage error amplifier in the feedback circuitry.

### REGULATED/UNREGULATED

A power converter’s output voltage is said to be regulated if its value is constant within specified limits, regardless of input voltage and load variations. An unregulated output voltage varies in relation to changes in input voltage and load.

### REMOTE SENSING

A method of regulating a converter’s output voltage at the load by using sensing leads to compensate for voltage drops in traces to the load.

### RESOLUTION

For an adjustable power supply, the smallest change in output voltage which can be realized by the adjustment.

### RETURN

The common input or common output terminal of a power supply. It carries the return current for the terminals. Often referred to as “common.”

### REVERSE VOLTAGE PROTECTION

A feature which protects a power supply against damage from a reverse polarity voltage applied at the input or output terminals. Interpoint converters typically do not have reverse voltage protection.

### RIPPLE AND NOISE <sup>1, 3</sup>

Ripple is the direct result of power transfer/conditioning from the switching action of the power converter. It is the steady state ac variation at the switching frequency. Noise is a consequence of the periodic switching or fluctuations from internal—usually parasitic—element responses to internal or external stimuli. Noise is usually high-frequency and may be periodic or random. See also Input Ripple, PARD and Output Ripple.

### SETTLING TIME

The time required for a converter’s output to return to within its specified regulation range following a step change in line or load. See Overshoot/Undershoot.

### SHORT-CIRCUIT PROTECTION

A feature which, in order to prevent damage to the power supply, limits the output current of a power supply when the output power pins are shorted together.

### SHUNT REGULATION

A method of regulation in which the control device is in parallel with the load. This is primarily for low power circuitry. A Zener diode is an example of a shunt regulator.

### SOFT START

A feature which limits the start-up current of a switching power supply and causes the output voltage to rise gradually to its regulated value.

### SOLDER SEALING (SEAM SEALING)

A method of attaching a metal cover to a metal package base which uses a low temperature alloy to fuse the cover-to-base interface. Hermetically sealed converters are often solder sealed in a dry nitrogen atmosphere.

### SOURCE IMPEDANCE (INPUT IMPEDANCE) <sup>1</sup>

The impedance seen by a dc-dc converter at its input terminals when looking back to the dc source.

### SPLIT BOBBIN WINDING

A method of winding a magnetic in which the windings are wound side by side on a bobbin with a barrier between the two windings. This is typically done to create leakage inductance (DM inductance) in a CM choke. See Common Mode (CM) Noise and Differential Mode (DM) Noise.

### STANDBY CURRENT

The no-load or shutdown input current of a power supply.

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### START-UP DELAY (START-UP TIME)

The maximum time required for the output voltage of a power supply to reach a specified percentage of its final, steady-state value, following a release from inhibit condition.

### START-UP OVERSHOOT

The amount by which the converter's output voltage exceeds its nominal steady state value during the application of an input voltage or on release from inhibit.

### STEP LINE RESPONSE

The change in output voltage in response to a fast change of input voltage. The change of input voltage is typically from the lowest steady state operating value to the maximum steady state operating value within a specified time.

### STEP LOAD RESPONSE

See Dynamic Load Regulation.

### SWITCHING REGULATOR

A circuit which chops and rectifies a dc input voltage then uses a feedback control loop to regulate the output voltage of a power supply. The feedback loop controls the pulse width of the switching action and, with some topologies, the frequency.

### SYNCHRONIZATION <sup>5</sup>

A feature which allows the power supply's internal switching frequency to be synchronized with an external clock within specified limits.

### SYNCHRONOUS RECTIFICATION

A mechanism of output rectification in which two MOSFET switches, operating 180 degrees out of phase, replace the traditional output rectification diodes. In the case of a forward converter, one FET acts as a rectifier diode while the other FET acts as the catch diode (also known as the flywheel diode). The purpose of synchronous rectification is to reduce power losses and increase efficiency.

### TEMPERATURE COEFFICIENT (OF VOLTAGE)

The maximum percent change in nominal output voltage per degree centigrade change in case temperature over a specified temperature range.

### TEMPERATURE RANGE, OPERATING <sup>2</sup>

The temperature range within which a power supply can be operated while meeting specified performance characteristics. For Interpoint converters the operating temperature range is specified for case temperature rather than ambient temperature or a junction temperature.

### TEMPERATURE RANGE, STORAGE

The ambient temperature range within which a power supply can be stored with no subsequent degradation of its operating specifications.

### THERMAL IMPEDANCE <sup>2</sup>

Thermal resistance. The measure of opposition to heat flow for a particular material or materials (°C/W).

### THERMAL PROTECTION

A power supply safety feature which shuts the device down in the event of excess internal temperature. Interpoint converters do not implement this feature.

### THICK FILM HYBRID TECHNOLOGY

A method of microcircuit manufacture in which one or more integrated circuits are combined with discrete components and screen printed passive elements and interconnections to form a packaged module. Dc-dc converters made with thick film hybrid technology can be very small, have excellent thermal characteristics and are highly reliable.

### TRANSIENT PROTECTION <sup>4</sup>

This typically references the input voltage to a converter. With transient protection an excessive voltage can be applied to the input power pins of a converter for a specific time without damaging the converter. As an example a converter with a normal operating range of 16 to 40 volts dc could see a maximum of 80 volts for 50 ms without being damaged. For this example the input transient specification would be "80 V for 50 ms". During the input voltage transient an output voltage transient may also appear at the converter's output which may cause the converter output voltage to be momentarily out of specification. Some converters may stop switching while the input voltage is excessive in order to protect themselves while other converters maintain operation throughout the input transient voltage.

### TRANSIENT RECOVERY (TIME)

The time required for a converter's output to return to within a specified regulation range following a step change in line or load.

### TRANSIENT RESPONSE (VOLTAGE)

The peak change in the output voltage of a power supply following a step change in a load or line voltage.

### UNDERSHOOT/OVERSHOOT

See Overshoot/Undershoot.

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## APPLICATION NOTE

### VOLTAGE BALANCE

In a dual, opposite polarity power supply where the outputs share a common transformer and PWM, the difference in magnitude (in percentage) between the output voltages which are nominally equal at equal load.

### WARM-UP DRIFT

The change in output voltage of a power supply from turn-on until it reaches thermal equilibrium.

### References:

Notes in text refer to our Application Notes at [http://interpoint.com/resources/application\\_notes/](http://interpoint.com/resources/application_notes/)

1. EMI Conducted Interference
2. Thermal Management
3. Measurement and Filtering of Output Noise
4. Transient Suppression
5. Inhibit and Synchronization
6. Inrush Current

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