Electronic Design

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What is a Rugged Power Supply?

There's no agreed-upon definition for a "rugged" power supply. As a result, take care to check the mechanical, environmental, electrical, and long-life requirements early in the design phase.

Power supplies are used in a wide range of difficult and demanding environments. However, what makes a modern power supply "rugged" is subjective. For example, a power supply that's robust and rugged enough to withstand high altitudes may not have what it takes to tolerate marine environments. So, in the absence of a standard definition, how can you get the rugged power supply you need?

Whether your specification is a half-page document or 30 pages long, there are questions to ask and criteria to consider when it comes to rugged power design. Finding the right design and manufacturing partner can help, too.

Ultimately, engineers that want rugged power supplies need to define their requirements in four key areas:

1.Mechanical
2. Environmental
3. Electrical
4. Long life

The Mechanical Side of Rugged Power-Supply Design

In general, three key questions should be asked about a power supply's mechanical performance:

1. Will the unit be subjected to significant vibration or shock over its lifecycle?
2. Does the unit require a metal enclosure for protection against various hazards?
3. How will the power supply stay connected, or how will the unit physically plug in?

Rugged power supplies typically come in custom configurations as well as standard configurations like the Bear Power Supplies BP6 series. (Credit: Bear Power Supplies)

Vibration and Shock: Power supplies that face harsh vibrations or shock may need to be encapsulated in a material such as epoxy. After the liquid resin cures, the unit becomes brick-like. If your application requires a different type of encapsulant, urethane may be a suitable alternative.

In less severe applications, a staking adhesive instead of an encapsulant may be the right choice. Staking adhesives protect electronic components by minimizing vibrations and reducing pressure on leads. Typically, these adhesives are used with taller components, such as capacitors, transformers, or other passives and magnetics, in the power supply's printed-circuit-board assembly (PCBA).

Metal enclosures: Most power supplies are housed in metal or plastic en-

closures. Plastics are generally lighter and less expensive, but metal housings tend to have more robust impact-resistance, especially against objects with high terminal velocity. If you're designing a power-supply unit that must be bullet-proof, you may need a thick steel enclosure. If protection against large hail is what you need, a different type of metal in a different thickness may be the best fit.

Connectivity: Connectors are mechanical devices that are mated together so that electricity can flow from a source of electrical power to its destination. Connectors need to stay together, but there's always a risk that they could become unplugged in tough environments. For a rugged power supply, you may need connectors with twist-to-unlock features or other release mechanisms.

Rugged Power Supplies: A Product of Their Environment

Environmental considerations for rugged power supplies fall into several categories:

- Temperature
- Humidity
- Salt
- Contamination
- Altitude

Temperature: Many electronic components are designed for temperatures ranging from 0 to 70°C. Still, it's important to compare the temperature range on the spec sheet against your application's requirements. Thermal drift, a change in behavior caused by temperature changes, can affect component performance, especially in high-power applications.

In power supplies, the aluminum electrolytic capacitors that are used to store energy can lose their electrical properties in extreme cold. While aluminum electrolytic capacitors for colder temperatures are available, they generally provide less capacitance, which ultimately impacts the power-supply design. It's worth considering if, for example, you're designing a pole-mounted power supply that will turn on a camera in arctic conditions.

High temperatures can also lead to large variances in component performance. For instance, the oil-and-gas industry requires power supplies that can withstand temperatures of up to 150°C. In some cases, these units are used with printed circuit boards (PCBs) mounted on large drills. As the drills bore through rock at high speeds, friction is produced, and heat builds up that can cause problems for the power supply attached to them.

Humidity: High humidity can cause moisture to condense on a power supply's electronics. In turn, this could create electrically conductive pathways that lead to short circuits and corrosion. Sealed enclosures with proper ventilation can prevent moisture from entering a power supply, but your application might require the conformal coating of surface-mounted components instead.

Salt: In marine environments, corrosion may affect not just a power supply's internal components, but also its metal enclosure. If aluminum and another metal encounter salt water, galvanic corrosion could occur. For such rugged applications, irradiated aluminum can be used, but only if the entire unit passes salt spray testing.

Contamination: A wide range of contaminants can also impact power-supply performance. In many cases, airborne dust is the biggest problem. However, industrial environments may face different risks. In a machine shop, for instance, electrically conductive filings could cause an arc that damages the circuit board in a milling machine. If the power supply comes in close contact with animals, hair and fur that conduct electricity may also pose risks.

Altitude: The altitude can also affect the power supply's performance, particularly as it relates to cooling. Convection and forced-air cooling is less effective at higher altitudes due to the air being less dense. That's important if your product will be used in Denver, Colorado, for instance, or other mountainous locales. Similarly, the heatsinks employed in a commercial airplane or military aircraft will dissipate heat less effectively when the plane is flying instead of on the ground.

The Importance of Transients in Rugged Power Supplies

Rugged power electronics require a degree of protection against transients—sudden, short-duration changes in voltage or current at the input of the power supply. Appearing as spikes or dips on the power line, they can be caused by events like lighting strikes, which could lead to voltage surges. That's why lightning suppressors are installed on telephone poles and why more of these devices are found in places where storms often occur, rather than in desert climates.

Lightning strikes aren't the only cause of input transients, though. They can also be triggered by the fast switching of inductive loads such as electric motors or even sudden changes in power drawn from other devices connected to the same circuit.

Input transients: Most input transients are caused by lightning hitting a power-supply line. This can affect equipment inside of a building, but there's a greater risk when a power supply is mounted outside and, even worse, on outdoor metal poles. But these transients, which have very fast rise times and short durations, usually measured in microseconds or milliseconds, also typically occur when industrial loads are turned on and off rapidly. This is known as "ringing on the line."

Take, for instance, a worker that suddenly turns on an electric welder on a factory floor. It's on the same power line as a CNC machine that's equipped with programmable logic

controller (PLC). The current from the electric welder could introduce transient voltages to anything connected to the ground of this machine. Without adequate electrical isolation, the PLC could fail.

Load transients: Load transients are sudden, short-lived changes in the current drawn by a circuit. They cause a rapid increase or decrease in the load on a power supply, which may trigger a temporary fluctuation in output voltage. Some power supplies drive such large capacitive loads that it seems as though there's a short circuit whenever they turn on.

Loads can vary wildly, and there are situations where power is returned. That's a problem on factory floors, where heavy-duty electric motors and other industrial-grade systems are present. For example, a motor that drives a heat pump may require an average load of 50 W. But sometimes, additional power—up to 75 W—is required. There are also times when as much as 25 W is returned.

Electric motors can act as generators. The process, known as regeneration, occurs when the motor's kinetic energy is converted back into electrical energy.

While high-voltage transients have the potential to damage power transistors and diodes in the power supply, large current surges can cause malfunctions in the circuitry, requiring the use of protection mechanisms.

Longevity: What's the Lifespan of a Rugged Power Supply?

Most engineers want power-supply designs to stand the test of time—but how long do they really have to last? Typically, the type of application determines what's meant by "long life." For instance, many consumer products are only expected to last around five years. By contrast, medical devices and other equipment used in the healthcare industry are expected to last 10 or more years. Industrial products need to last even longer, typically 15-plus years.

The power supplies inside defense and aerospace electronics also have different definitions of "long life." Many military-grade power supplies must be rugged, but others may only have to last for the duration of a single, one-way mission. In contrast, the power supplies at the heart of automobiles and other transportation systems may have to last for several decades at a time. For instance, many of the electric relays that control train signaling have been in service for over 50 years.

The components that you select for power supplies also have their own lifespans. In a laptop, for example, a fan generally provides cooling. Over time, fans wear out and filters can become clogged. As for the aluminum electrolytic capacitors in power supplies, they seldom have an operating lifespan that lasts more than 15 years—even when the power supply unit is designed conservatively.

Defining "Rugged" for Power Supplies Depends on the Application

In the end, power-supply designers need to define "rugged" on their own terms. There isn't one commonly agreed-upon definition—the characteristics that make one unit rugged may not cut it in another case, or they could be disproportionate in a different application. But by choosing the right power-supply manufacturer and working with them on a tailor-made design, you can get the assistance you need to meet this challenge.

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