Power Supply Features

Abstract: The object of this paper is to provide the reader with an insight to the features that are provided on a power supply and the value that these features provide. Any system designer intending to use a power supply in their application should be aware of the features that are provided on many standard designs. They should also be aware of the convenience that comes with choosing the right off-the-shelf option instead of trying to come up with their own solutions.

1.0 Introduction:

Features can be broken up into several distinct categories.

- Protective
- Enhancement of Overall Performance
- Physical
- Application Specific
- Environmental
- Extra's - Killer Features

2.0 Protective

A protective feature can be described as one that will either protect the power supply or the application is will be designed into in the event of an abnormal destructive condition arising.

Some examples of this would be…

- Overvoltage Protection
- Thermal Shutdown
- Short Circuit Protection
- Current limit.
- Current Overload.

2.1 Overvoltage Protection:

Overvoltage protection is essentially a standard feature on modern power converters. It serves to protect the load circuitry from excessive voltage levels in the event of a catastrophic failure in the power converter.

On low power converters, the simplest overvoltage implementation is a zener diode clamp on the output which, when its voltage level is exceeded, will conduct enough current to activate the converter's overcurrent protection circuitry. A more common and sophisticated approach is to have a separate voltage detector monitoring the output voltage and set to activate at the desired overvoltage value. This detector then shuts down the converter through the control circuitry. This shutdown can be either latching or non-latching.

2.2 Thermal Shutdown:

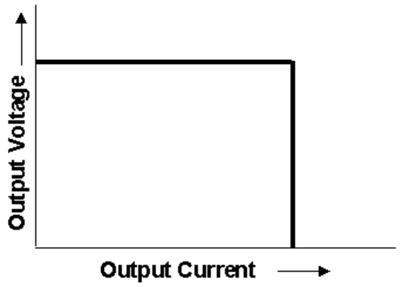
Thermal shutdown is by where the unit will monitor the ambient temperature of its surroundings and in the event of this rising to a dangerous level will shut itself down as a safety precaution. This usually involves the thermal sensing of a given device and using the increase in temperature of this device to trigger the shutdown. One such method is to use a thermistor. Here thermal protection is invoked via a PTC resistor. The PTC is positioned so in the event of insufficient airflow or a fault condition then the change in its resistance will activate a switch and disable the pulse width modulator. This will have the effect of pulling the Vref to zero. The unit will remain in this condition until the case temperature of the PTC reduces and its resistance drops off.

2.3 Short Circuit Protection:

Short circuit protection is a feature by where the output current of a power supply under short circuit is limited to protect the power supply. Again, the key is how does the design implement this, and how does the unit recover after the short circuit is removed. Below are several ways of implementing current limit.

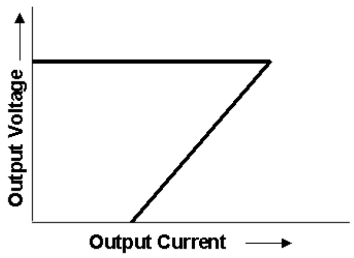
2.4 Current Limit:

Current limit is by where a protection circuit will limit the maximum output current that a convertor can supply. There are several ways of implementing this as described by the plots below.



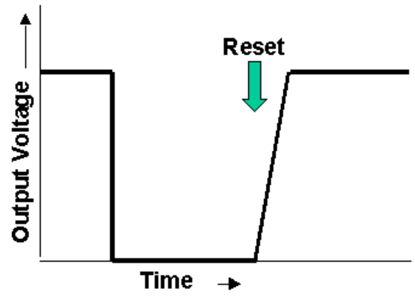
Continuous

Continuous (also known as Brickwall) is where the output voltage goes to zero when the current trip point is reached. When the output overload is reached the unit will automatically recover.



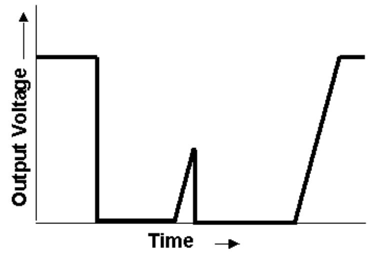
Foldback

Foldback is a variation of the continuous approach. Once current limit is reached the convertor becomes a constant current supply. The value of current is a function of the degree of overload.



Latching

Latching overcurrent protection is by where the output voltage is pulled to zero but will not automatically recover until the system has been reset. This approach will not automatically recover but will wait for a system intervention.



Auto Retry

Auto retry is by where the unit will enter a hiccup-up mode. This is by where the unit will turn itself off and enter a wait mode. After a certain time, the unit will attempt to start itself up again, but will be unable to do so until the fault condition has been removed.

From a safety point of view, there is no preferred method in the above. However, system designers should be aware of what technique is incorporated into the design in order to make the best decision about what they need for their application.

2.5 Current Overload:

Here we have the condition by where the unit is exceeding its current driving capability, but not sufficient to cause the current limit circuitry to trigger. (Current limit is normally set to shut the unit off at about 125% of its rated current.) If the unit stays in this condition for long periods there is a danger that catastrophic damage being caused to the unit. At best we will reduce the mean time between failure and with it its expected lifetime of operation.

3.0 Enhancement of overall performance.

- Line Regulation
- Load regulation
- Output Setpoint Accuracy
- Ripple and Noise
- Undervoltage Lockout

3.1 Line regulation:

Most power sources for electronic equipment are regulated. Regulation can either be voltage or current regulation, i.e. the power supply can be designed to either supply a constant voltage or a constant current. Line regulation can be defined as the variation in output voltage as the line voltage changes from a min to max at a fixed load. Most power supplies will have a range of input voltage with which we use as the minimum and maximum input voltages when measuring line regulation. It is usually specified as a percentage deviation from the output setpoint.

3.2 Load regulation:

Load regulation can be defined as the variation in output voltage as the load changes from a min to max at a fixed input voltage.

In many applications the load current will vary more than the temperature or input voltage, so will consequently have a greater effect on the output voltage than will the other variables. The load regulation is specified either as a percentage of output voltage or as a specific voltage deviation.

3.3 Output Setpoint Accuracy:

Max percentage deviation of output voltage from specified nominal value. Specified at nom Vin, full load. The set point is a range of output voltage within which the converter is guaranteed to operate for a specific set of conditions.

Naturally we would expect the output setpoint to vary as the environment in which it is being operated changes accordingly. By this we mean a change in ambient temperature, a change in line voltage and also a change in loading conditions. This is why setpoint accuracy is normally stated with the conditions also specified.

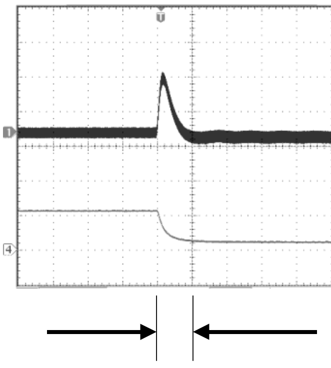
3.4 Ripple and Noise:

Switching regulators generate noise during their operation due to the non-linear nature of the voltage and current waveforms, and some of this noise appears on the output voltage terminals. There are two distinct components to the output noise, a "low" frequency component referred to as ripple, and a higher frequency component that is simply called noise.

3.5 Undervoltage Lockout:

A protection system by where the convertor is deliberately shut down if the input voltage drops below a pre-defined level. Some hysteresis is usually present to prevent the convertor oscillating on and off. UVLO is usually needed with battery systems where the voltage decreases gradually with time rather than snaps on and off quickly.

Transient Response.

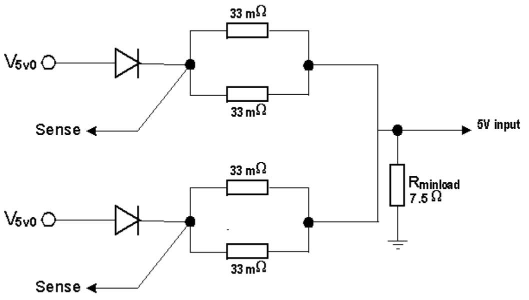


Transient response can be used to determine product stability from the transient response (to a good approximation).

Stability analysis determines whether the power converter will operate without oscillation or other abnormal characteristics over the complete range of line voltage, load currents and dynamic loading. Historically, it has been expensive and difficult to do the proper system-level stability analysis because of the need for specialised software and analysis skills. However, transient response allows us to view the stability of the system by use of just an oscilloscope.

3.6 Remote sensing:

This will automatically adjust the output voltage level to provide the desired voltage level if there is a voltage drop between the output pins unit (source) and the required location in the application (destination).



Consider the above set-up. We have two power supplies used in a redundant array. Only one power supply will be on at any given time, and we use O-ring diodes to decouple the two power supplies. Because of this there is a drop in voltage across the diode of approx. 0.5 Volts. By sensing the voltage at the destination, the converter can automatically increase its output voltage to accommodate for this drop in voltage. The application now has the 5 volts necessary for operation.

3.7 Current Sharing.

Parallel connection of converters can be used to increase the load capability in a system. A system designer may need to decouple the power supplies using Or-ing diodes or series inductors on the output.

4.0 Environmental:

This is a reflection on how the unit reacts with the environment it is intended to be operational in. It is both an indication on how it is affected by and how it effects its surrounds.

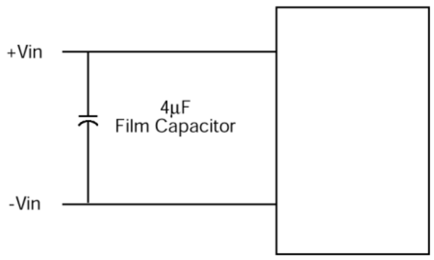
There are many national and international standards in the areas of safety, EMC/EMI, powerline interface and manufacturing quality.

- Conducted Emissions
- Conducted Immunity
- Radiated Emissions
- Radiated Immunity
- Electro-static Discharge
- Surge & Burst

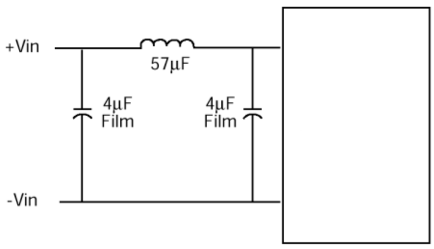
EMC refers to the *capability* of electrical or electronic equipment or system to function satisfactorily in its corresponding electromagnetic environment without *unduly affecting* this environment, which also includes other installations.

Electromagnetic waves consist of both E (electric) fields and H (magnetic) fields, which oscillate at right angles to each other. The wave impedance is determined by the ratio of the electric field to the magnetic field. High impedance waves are produced by Electric fields, which occur in systems operating with high voltage and low current. Conversely, Magnetic fields occur in systems with a low voltage and high current producing low impedance. Most commercial electronic equipment are a source of EMI emissions. These emissions are either, internal (affects the source), external (affects devices other than the source), or both. Most of these sources primarily produce E field emissions. Most conductive materials have low impedance and therefore reflect most of the E field waves.

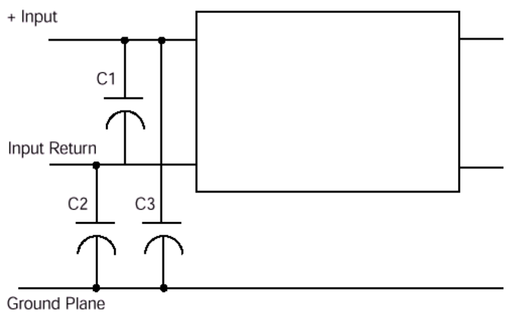
4.1 Conducted Emissions:



Convertor X, needs one external component to meet Class B.



Convertor Y, need three external components to meet Class



Convertor Z, needs three external components and a ground plane to meet Class B.

Here we have an example of three types of power convertors that must each attain to Class B emissions in their application. We can compare the necessary external filter that is required for each of the units to meet this limit.

A designer should be aware of this before the part is designed into the system. We can see that even though option 3 may have initially appeared to be the most cost effective, when you take into consideration the extra filter cost, increased parts count in the final system, and time to test the design it can be seen that it may not possibly be the most cost effective solution.

4.2 Radiated Emissions:

Electronic equipment producing electromagnetic radiation must be isolated to prevent it from degrading the performance of surrounding equipment. Such devices must meet FCC, EC, VDE, and other organisational standards on electronic emissions and susceptibility.

4.3 Radiated Immunity:

Adverse effects caused by electromagnetic radiation are termed EMI or electromagnetic interference. Electronic equipment sensitive to this radiation must be shielded from external EMI sources in order to ensure proper performance.

4.4 Surge & Burst:

This test is designed to simulate the effect of induced currents from a near-miss lightning strike on overhead power and telephone cables. This type of test is normally only carried out on AC/DC convertors.

5.0 Extra's - Killer Features:

Extra's are often what can separate one product from all other manufacturers. It is often what can be the deciding factor in choosing one vendor over another.

An increase in the efficiency of a unit will have many positive effects on a unit.

- Increased operating temperature range
- Increased Reliability
- Smaller size
- Energy saving
- Reduced power dissipation
- Reduced the size of heatsinks
- Components run cooler so less forced air cooling for open frame units
- Less input current => Less input ripple => Smaller filters

5.1 Trimmable Output Voltage

This feature on a power supply allows the user to trim the output setpoint of a power supply using either an external resistor or an analogue voltage. This can be useful for system designers who are designing systems whose voltage needs are either slightly different from the standard output ranges, or have dropped due to new technologies.

It may not be necessary to look for another design, and go through the qualification process again . but continue with the existing power supply and simply change one resistor.

5.2 Trimmable UVLO Set-Point

This is the same principal as the output trim range but allows the user to set what voltage the unit turns on at.

6.0 In summary:

We saw how products fit in to the operation of power distribution. System designers to get more on-board solutions and reduce their time to market for complex designs. Features give our products the competitive edge and add value when a designer can make use of them.

Features may initially seem to be more expensive. But the costs need to be measured against the following…

- Reduced part count.
- More reliability and increased MTBF
- Less testing for System Designers if off-the-shelf solutions are used.
- Total cost ownership (TCO) may be less than with a discrete solution

About Advanced Energy

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

AE's power solutions enable customer innovation in complex semiconductor and industrial thin film plasma manufacturing processes, demanding high and low voltage applications, and temperature-critical thermal processes.

With deep applications know-how and responsive service and support across the globe, AE builds collaborative partnerships to meet rapid technological developments, propel growth for its customers and power the future of technology.

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