

## Programmable DC Power Supplies

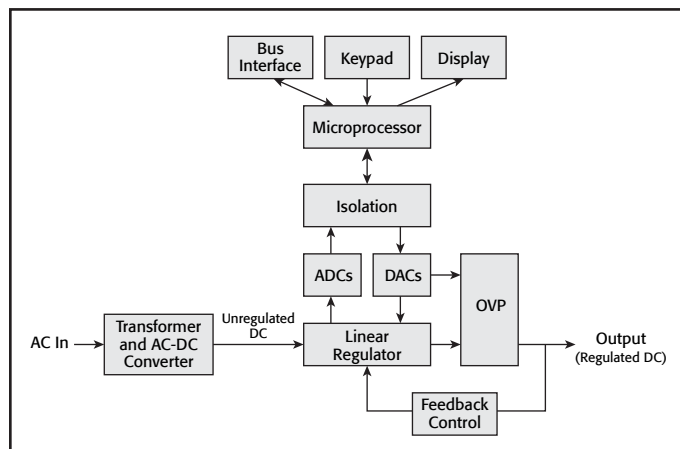
DC power supplies provide a regulated DC output to power a component, a module, or a device. A power supply must deliver voltage and current that is stable and precise, with minimal noise to any type of load: resistive, inductive, low impedance, high impedance, steady-state, or variable. How well the power supply fulfills this mission and where it reaches its limits are defined in its specifications.

Power supplies have two main settings, the output voltage and the current limit. How they are set in combination with the load determines how the power supply will operate.

Most DC power supplies have two modes of operation. In Constant Voltage (CV) mode, the power supply controls the output voltage based on the user settings. In Constant Current (CC) mode, the power supply regulates the current. Whether the power supply is in CV or CC mode depends on both the user settings and the resistance of the load.

- CV mode is the typical operating state of a power supply. It controls voltage. The output voltage is constant and is determined by the user's voltage setting. The output current is determined by the impedance of the load.
- CC mode is typically considered a safety mode, but can be used in other ways. In CC mode, the output current is constant and is determined by the user's current limit setting. The voltage is determined by the impedance of the load. If the power supply is in CV mode and its current exceeds the user's current limit setting, then the power supply will automatically switch to CC mode. The power supply can also revert back to CV mode if the load current falls below the current limit setting.

The most important parameters for any application are the maximum voltage, maximum current, and maximum power that the power supply can generate. It is essential to ensure that the power supply can deliver the power at the required voltage and current levels. These three parameters are the first specifications that must be investigated.



**Figure 1. Simplified block diagram of a programmable linear power supply showing the digital and analog control circuit blocks**

## Accuracy and Resolution

Historically, the DC power supply user turned potentiometers to set output voltage or current. Today, microprocessors receive input from the user interface or from a remote interface. A digital-to-analog converter (DAC) takes the digital setting and translates this into an analog value, which is used as the reference for the analog regulator. The setting resolution and accuracy values are determined by the quality of this conversion and regulation process.

Voltage and current settings (sometimes called limits or programmed values) each have resolution and accuracy specifications associated with them. The resolution of these settings determines the minimum increment in which the output can be adjusted, and the accuracy describes the extent to which the value of the output matches international standards. In addition to output settings, there are measurement or readback specifications that are independent of the output specifications.

Most DC power supplies provide built-in measurement circuits for measuring both voltage and current. These circuits measure the voltage and current being delivered by the power supply output. Since the circuits read the voltage and current that is fed back into the power supply, the measurements produced by the circuits are often called readback values. Most professional power supplies incorporate circuits that use analog-to-digital converters, and for these internal instruments the specifications are similar to those of a digital multimeter. The power supply displays measured values on its front panel and can also transmit them over its remote interface, if it is equipped with one.

## Setting Accuracy

Setting accuracy determines how close the regulated parameter is to its theoretical value as defined by an international standard. Output uncertainty in a power supply is largely due to error terms in the DAC, including quantization error. Setting accuracy is tested by measuring the regulated variable with a traceable, precision measurement system connected to the output of the power supply. Setting accuracy is given as:

$$\pm(\% \text{ of setting} + \text{offset})$$

For example, consider a power supply with a voltage setting accuracy specification of  $\pm(0.03\% + 3\text{mV})$ . When it is set to deliver 5V, the uncertainty in the output value is  $(5\text{V})(0.0003 + 3\text{mV})$ , or 4.5mV. Current setting accuracy is specified and calculated similarly.

## Setting Resolution and Programming Resolution

Setting resolution is the smallest change in voltage or current settings that can be selected on the power supply. This parameter is sometimes called programming resolution if operating over an interface bus such as GPIB.

## Readback Accuracy and Resolution

Readback accuracy is sometimes called meter accuracy. It determines how close the internally measured values are to the theoretical value of the output voltage (after setting accuracy is applied). Like a digital multimeter, this is tested using a traceable reference standard. Readback accuracy is expressed as:

$$\pm(\% \text{ of measured value} + \text{offset})$$

Readback resolution is the smallest change in internally measured output voltage or current that a power supply can discern.