AN-09
Why do power supplies take time to warm up?

Power supplies typically have a warm up period, after which stability specifications are then applicable. From a functionality standpoint, a unit will work the moment after it's turned on. But if your application requires a very stable output, allowing the power supply to warm up and reach "thermal equilibrium" will eliminate the warm up drift, which is detailed as follows:

Control and regulation of the power supply is accomplished by sampling the actual high voltage output through the use of a high voltage feedback divider. This divider network is comprised of a number of series connected high impedance, high voltage resistors. One end of the divider is connected to the power supply's high voltage output; while the other end is terminated to ground through a scaling resistor creating a low voltage signal that is proportional to the high voltage output being measured. Typically a 0-10Vdc feedback signal is created, which corresponds to 0-100% of the power supply's output voltage.

The feedback divider string is sensitive to temperature variations. This is called the "temperature coefficient" (TC) and it is usually specified in parts per million per degree C. A typical temperature coefficient spec might be 150ppm/°C. For this case the resistor impedance value will change by the ratio of (150/1,000,000) = 0.00015, or 0.015% for each degree C of temperature change the feedback divider sees. Let's look at a real life power supply example:

SL50P300   TC= 100ppm/°C   (100/1,000,000) = 0.0001 or 0.01%
(0.01%) (50kV)= 5 volts

So for each degree C change the feedback divider sees, the proportional change in the power supplies output voltage shall be ≤5 volts.

If a power supply has been sitting unused for a long period of time we can assume the components inside the supply are at the ambient room temperature. For the purpose of illustration let's say the room temperature is 22°C (about 71.5°F) and we will assume the room temperature remains constant for the duration of our test.

The power supply is turned on and set to operate at maximum voltage and current. There are two basic effects that occur:

1) The feedback divider begins to create its own self heating effect due the I²R losses of the feedback current flowing through the feedback resistors.

2) There are other components in power supply that also generate heat, and this begins to raise the temperature inside the power supply itself, which in turn raises the temperature of the feedback divider string.

After an amply long period of time, the power supply reaches a new thermal equilibrium. For the sake of this example let's say the temperature of the feedback divider string is now 28°C (about 82.5°F), a change of 6°C.

We know that the feedback divider is specified to change ≤0.01% (or ≤5 volts) for each degree C change in our example. So the overall change we would expect would be: (5 volts/°C) (6°C) = ≤30 volts

Overall this is a small percentage compared to the magnitude of the maximum output voltage, but in some critical applications it could be significant.

What about the time period it takes for this change to occur? Well that's mostly influenced by the actual physical design of the power supply itself. The thermal mass content of the unit, the internal heat transfer characteristics, air flow in and out of the enclosure, and the design of multiplier in particular will greatly influence the thermal time constants involved.