

Design Considerations for Power Supplies in High-Altitude Applications

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Topics Covered

Altitude Environments in Power Applications

Effects of Altitude on Power Electronics

Regulatory impacts

Fanless power supply implementation

Applications where altitude is a Consideration: High-Reliability, Harsh-Environment Electronics

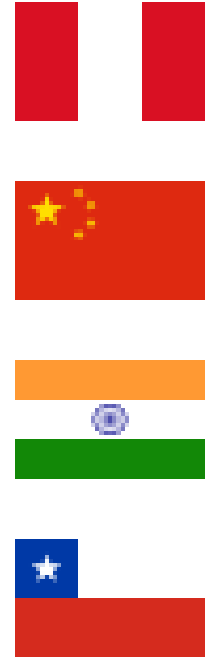
- ” Aircraft applications (rotary and fixed wing aircraft) – cabin entertainment, medical transport passenger seat power plugs, airborne instrumentation
- ” Drones, surveillance balloons, ROVs, surveillance aircraft, mapping aircraft
- ” Broadcast towers, repeaters, transmitters, radar – weather and others



Applications Where Altitude is a Consideration: Medical

” Global medical applications in geographic areas with high-altitude operation – Peru, China (GB 4943.1-2011), India, Chile and more

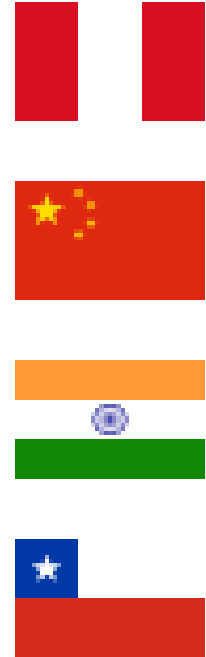
- ” clinical diagnostic equipment
- ” medical lasers
- ” dialysis equipment
- ” radiological imaging
- ” surgical robotics
- ” clinical chemistry



Applications where altitude is a consideration: Industrial

” Global industrial applications in geographic areas with high-altitude operation – Peru, China (GB 4943.1-2011), India, Chile and more

- ” test and measurement
- ” industrial machines
- ” automation equipment
- ” Printing
- ” Telecommunications
- ” Audio equipment



Why is Altitude a Factor? What Effects are Present?

- ∅ As altitude is increased, the air is less dense – cooling capacity of the air is decreased as altitude increases making heat removal via air less effective

Why is Altitude a Factor? What Effects are Present?

- ∅ Paschen's Law :
 - ∅ Dielectric properties of the air change with altitude.
 - ∅ The creepage and clearance of the power supply has to take this into account.
 - ∅ At Higher altitude air is not as good an insulator – until you reach a vacuum

Why is Altitude a Factor? What Effects are Present?

- ∅ To maintain safety ratings for an approved medical and or industrial power supply the creepage and clearance must be taken into consideration

Why is Altitude a Factor? What Effects are Present?

- Ø Paschen's curve describes electric discharge voltage as a function of atmospheric pressure and wiring/electrode separation (defining the minimum voltage for breakdown in air to be 327V.) Voltages, steady-state or repeated transients higher than 327V are referred as high voltages

Why is Altitude a Factor? What Effects are Present?

- Ø Power supplies routinely have 240 VAC, 380 VDC plus internally, as well as high frequency high-voltage AC energy

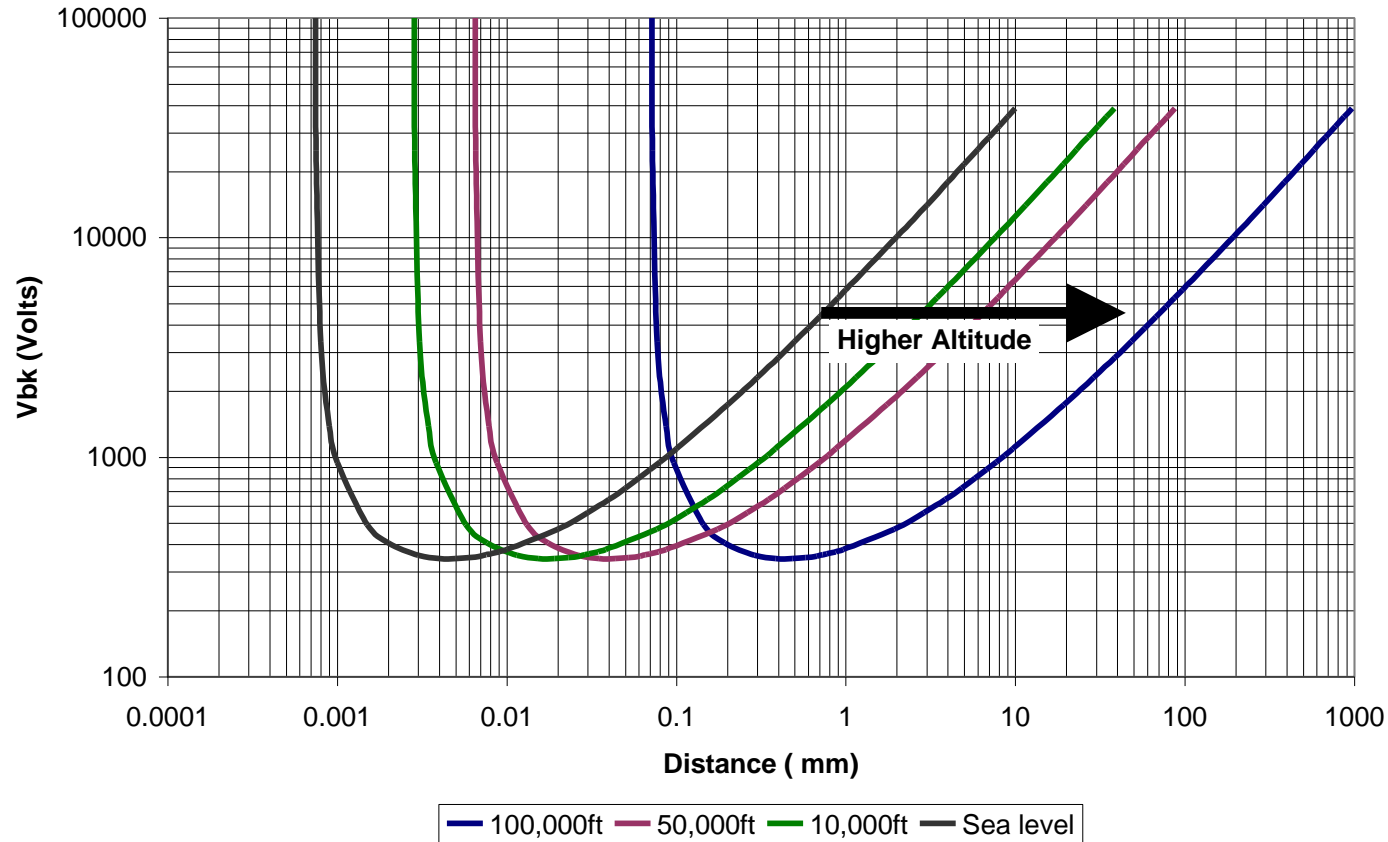
Why is Altitude a Factor? What Effects are Present?

- ∅ Thus: considerations for breakdown and processing high voltage must be considered for use in the end application

Why is Altitude a Factor? What Effects are Present?

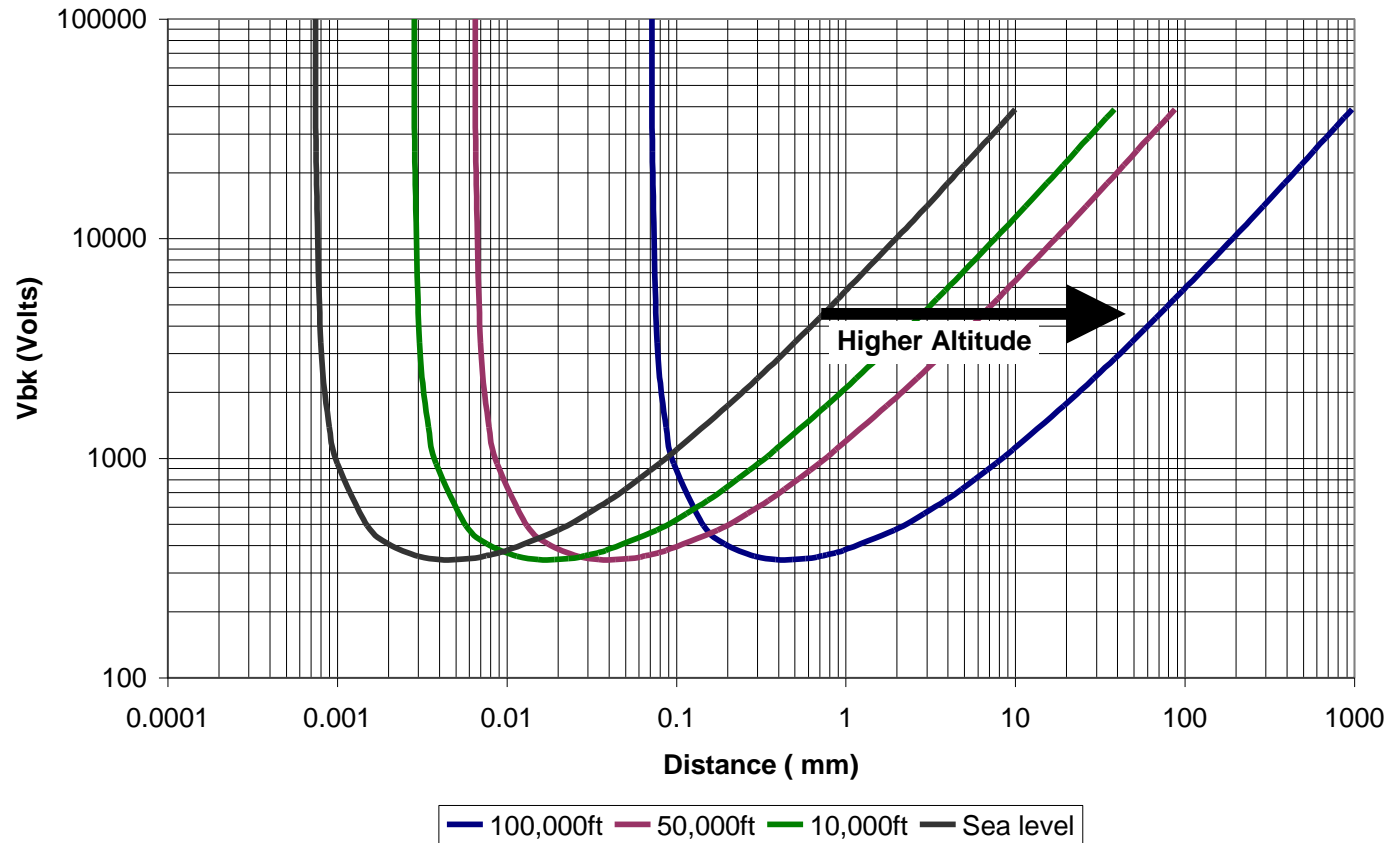
- Ø Air at high altitude is less dense than air at sea level, reducing its convective capability and overall heat transfer capacity. Therefore, all electronics that rely on natural or forced convection to dissipate heat will experience greater air and component temperature rises for the same amount of power at high altitudes
- Ø THERMAL Derating above 2000 M = 1 degree C per 305m (1000 ft)

Paschen Curves



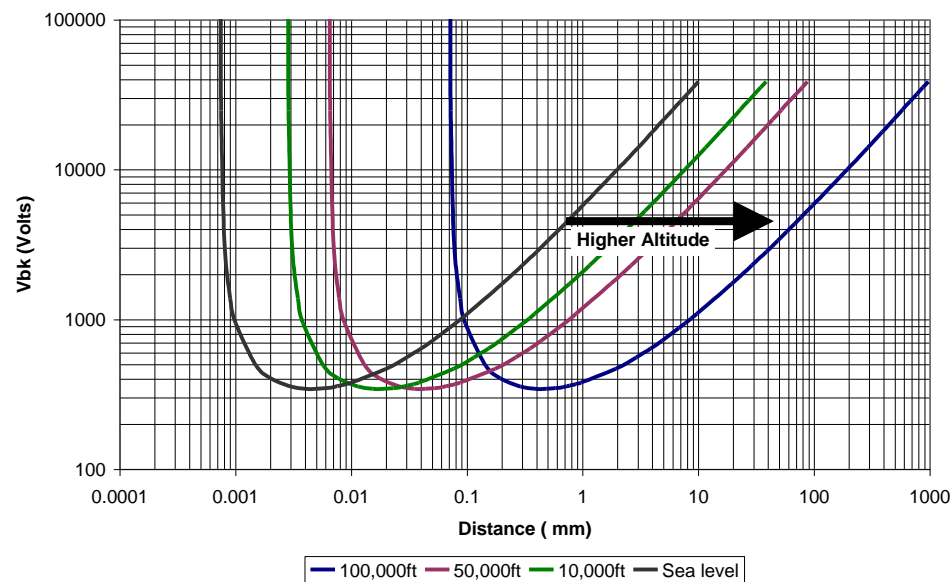
Paschen curves illustrate the dependency of breakdown voltage on distance between conductors and altitude.

Paschen Curves



Variation in breakdown voltages is approximately proportional to pressure and inversely proportional to temperature

Paschen Curves



Example: For a 1cm gap between conductors

The breakdown voltage for this spacing will be:

” 30kVdc at sea level

” 1.2kV at 50000ft

” 300V at 150,000ft

Creepage and Clearance Defined

- ∅ Clearance is the shortest distance through air between two conductors, and is the path where damage is caused by short-duration maximum peak voltage
- ∅ Creepage is the shortest distance between two conductive parts along the surface of any insulating material common to both parts. The breakdown of the creepage distance is a slow phenomenon based upon dc, or RMS voltage
- ∅ Clearance relates to flashover – creepage relates to tracking
- ∅ These separations must be increased at higher altitudes

Creepage and Clearance Defined

- ∅ Clearance relates to flashover
- ∅ Creepage relates to tracking
- ∅ These separations must be increased at higher altitudes

Creepage and Clearance

- ” The creepage and clearance distances required to meet medical and industrial specifications at sea level must be increased to meet safety specifications and prevent breakdown at altitude
- ” As altitude increases, greater distances are needed

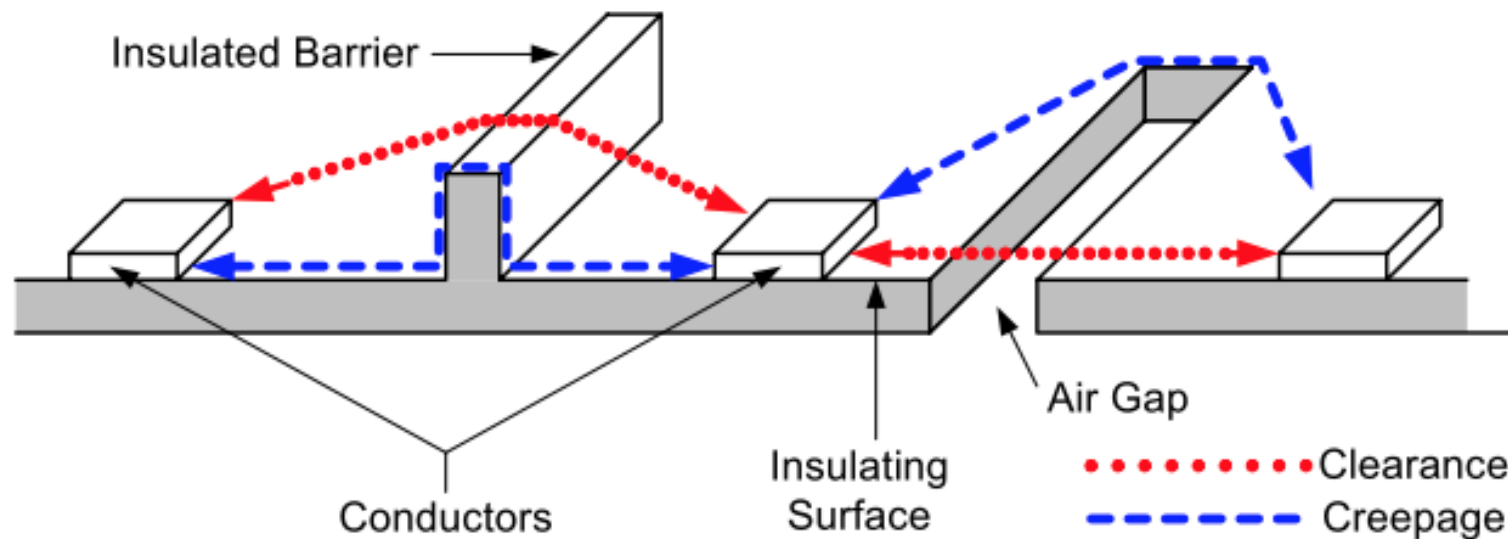


Fig. 5. Definitions of Creepage and Clearance.

Specifications for Power Supplies

- ∅ What does an altitude specification mean?
- ∅ *Does it simply mean the power supply will work at X altitude?*
- ∅ The correct key specification answers the question:
“Does it meet the desired regulatory requirements for creepage and clearance with margin at the altitude specification (i.e. 60601)?”
- ∅ Does it still meet the safety requirements of a medical – industrial power supply at that altitude?

Design Methodologies

- Ø For equipment manufactured or sold in China, the standard GB 4943.1-2011 assumes your unit must be suitable for use at altitudes up to 5000 m.
- Ø This will require clearance limit 1.48 times of IEC/UL 60950-1 – unless your device is marked as suitable for use only up to 2000 m. In that case, it has to be so marked.
- Ø IPC-2221B requirements (guidelines for PCG Layout) are typically used with a multiplier as a design guide

Design Temperature Deratings at Altitude

IF you need a fan it's worse



temperature rise multipliers for high altitudes			
Altitude	Multiplier		
m(ft)	Fan-Cooled (General)	Fan-Cooled (High Power)	Naturally Cooled
0	1	1	1
1,500 (5,000)	1.2	1.16	1.1
3,000 (10,000)	1.45	1.35	1.21
4,500 (15,000)	1.77	1.58	1.33
6,000 (20,000)	2.18	1.86	1.48

Regulatory Impacts

- Ø GB 4943.1-2011
- Ø 60601 for medical – with multiplier
- Ø 60950 going to 62368-1 with multiplier
- Ø For equipment manufactured or sold in China, the standard GB 4943.1-2011 assumes your unit must be suitable for use at altitudes up to 5000 m. This will require clearance limit 1.48 times of IEC/UL 60950-1 unless your device marked as suitable for use only up to 2000 m

IPC-2221B Requirements are typically used with a multiplier usually 1.48 X

Implementation

- Ø New modular power supply has been designed to exceed regulatory safety requirements at 5000 M for creepage and clearance.
- Ø But it does not just WORK there - it also meets medical and industrial standards with margin at 5000M altitude
- Ø altitudes with higher flexibility and freedom and higher reliability



Implementation

- ∅ The new product is fanless. By having no fan, the thermal derating needed at altitude is less – giving more freedom to the system designer and requiring less over specification. This will also save the designer money
- ∅ Extra efficiency means it does not dissipate the heat in the first place, so heat removal is easier. It can work at greater altitudes to increase reliability

Benefits for System Designer

- Ø Reduced derating gives higher flexibility and more freedom
- Ø Less over specification of the power supply
- Ø Cost savings



Thank You

Ø Questions?

