Data Center High Voltage DC

- High Voltage DC has existed in the Data Center for some time
- HVDC is common on the battery bus for high end UPS.
- APP touch safe 600V connectors are used in many of these applications
High Voltage DC Battery

APP Powerpole connector
APC HVDC battery module

APP connector for APC HVDC extended run battery packs
Requirements for 400 DC connectors

- 600V UL rating
  - UL class for connectors <150V, <300V, <600V, <1000V
- Touch safe connector for hazardous voltage
  - Meeting IP20 and UL 1977, 10.2 in unmated condition
- UL rated first mate-last break grounding circuit
  - For 10 awg, 750A 4 sec
- Other considerations
  - Hot swapping
    - Contacts handle load
    - Enabling circuit
  - Latching or locking
  - Keying capability for different amperage levels
  - Size compatibility with IEC 320 inlets
APP Connector

- 600 VDC rated
- Touch safe power circuits
- UL 10A and 30A ground contacts
- Hot plug capable
  - UL rated 30A @110V
  - Estimate 8A @ 400V
- Prototype 1 to 4 cir signal insert for enabling and/or data
- Positive latch
- Keying capability
- Size compatible with 16A IEC 320
  - Prototype for 10A IEC 320 inlet size
- Future options – over molded plug
- Multi-source
One-piece Powerpole Pak
IEC320-C14 Compatible
Anderson Power Products

- The largest manufacturer of DC power connectors.
- Global ISO 9000 certified manufacturing and logistics
  - Sterling MA USA
  - Fermoy Ireland
  - Hong Kong PRC
  - Songgang (SZ) PRC
- UL and TUV certified client test facility

Sterling USA Warehouse and Administration

Songgang (SZ) PRC Manufacturing
Contacts/Connectors and Other Hardware Panel:

July 12, 2007
400VDC DISTRIBUTION SYSTEM
Topics to be addressed:

- Nominal voltage rating of connectors
- Wiring configuration for cord/plugs and connectors
- Receptacle & Plug Physical Design Considerations
- Branch circuit control options
Standards

• What standards exist today for DC connectors?
  – Swedish TC 23
  – IEC Standards
  – IEEE – NEMA – NFPA(NEC) – UL
  – Others?

• Examples from other industries?
  – TELCO
  – Transit
  – Electric Vehicles
  – Military
  – Alternative Energy (Solar – Fuel Cell – Etc..)
  – DC Link in AC UPS

• Proposed Standard = International

• Standardization Process for DC Connectors?
Voltage Rating

- Nominal voltage rating of connectors
  - 600vDC
  - 500vDC
  - 400vDC
  - ???
Wiring Configuration

• Wiring configuration for cord/plugs and connectors
  – Plus, Minus, Ground and Enable
  – Impedance Issues?
  – Cord Rating and Construction
Receptacle & Plug Design

• Receptacle & Plug Physical Design Considerations
  – Base on existing standards for AC connectors - Or develop new configuration that is DC specific
  – Impedance Issues
  – Insertion & Withdrawal Force
  – Contact Metallurgy & Mechanics
  – Contact Resistance / Reliability
  – Contact Wear & Arc Resistance
  – Physical Retention / Locking Receptacle?
Branch Circuit Control

• Branch circuit control options
  – Build in controls to verify system is off before plug or unplug action can occur
  – What is the real arcing hazard exposure?
PowerPak configurations for 400 VDC

30 amp Receptacle
Sun Micro

10 Amp Receptacle
Intel

30 amp Plug w/latch
Sun Micro

10 Amp Plug w/latch
Intel

Red spacer location will be replaced by future 4 circuit signal module
EXAMPLES
EXAMPLES
Standard B225 Amp System to 600 Volts

Also B160 or 160 Amp Systems

2, 3 or 4 pole with/without Isolated ground

2.375 in.
4.187 in.

Power Feed
Housing Section
Support Hardware
End Cap
End Piece
Tee
Coupler
Elbow
Installation Tool
Plug-In Units

Accessories - Closure Strip, Wt. Hook, etc
BUSWAY IS RATED AT 200Amps AT 600V DC

**STARLINE TRACK BUSWAY**

Track Busway housing section consists of an extruded aluminum shell with "spring-pressure" type copper channel busbars contained in a full length PVC insulator mounted on one side on the interior wall. The aluminum extrusion acts as a 100% ground path meeting UL 857 Standard and complies with applicable paragraphs of Section 250 of the NEC. Each housing has an open access slot over its entire length for the insertion of turn-n-lock plug-in units. Housing configurations include 2, 3 and 4 pole varieties with 600 Volt maximum rating. Each housing section has male stabs protruding at one end which fit into the channels of the adjoining section. Installation tool is used to force the stabs into the busbar channels for a solid "spring-loaded" electrical connection.

**MATERIAL:** Extruded Aluminum 6005-T5 unpainted

**RATINGS:** 100% Ground Path

**LENGTH:** 225 Amp, 600 Volt

**INSULATION:** PVC

**VOLTAGE DROP:** distributed load

Single Phase 40ft (.8PF)

---

**HOUSING SECTIONS**

- BLUE (C)
- RED (B)
- ISO GRD.
- BLACK(A)
- WHITE(N)

Spring pressure

"Spring-pressure" channel busbar

Tool Force

Housing sections are joined by inserting male end into open female end so that stabs are parallel to female slots. Installation tool is then rotated to force stabs into slots.
NEW BUSWAY IS RATED AT 400Amps AT 600V DC
DC RATED BUSWAY PLUG FOR HVDC POWER DROP
15 Interlocked socket-outlets
Socket-outlets interlocked with a switch shall be constructed in such a way that a plug cannot be inserted into or completely withdrawn from the socket-outlet while the socket-contacts are live, and the socket-contacts of the socket-outlet cannot be made live until a plug is almost completely in engagement.

_Compliance is checked by inspection and by manual test._

NOTE Other test requirements are specified in IEC 60884-2-6.

Propose to change by:

15 Interlocked socket-outlets
This clause of SS-IEC 60884-1 is applicable.

Draft new text for UC (universal) and DC interlocked socket-outlets for SS 428 08 34

Socket-outlets for UC and DC might be designed for 16 A current maximum.

Plugs for loads for UC and DC rated for up to 2,5 A can be connected and disconnected without interlocking. Plugs for 2,5 A are rated for UC and DC without interlocking mechanical or electronic functions.

For loads higher than 2,5 A, the standard UC and DC plug can be used if it is equipped with a mechanical or electronic interlocking switch function with or without connection to the outlets cover. The function shall be designed in such a way that a plug cannot be inserted into or completely withdrawn from the socket-outlet while the plug-contacts can carry current, i.e. the plug-contacts shall be switched off from the load or high-ohmic during these procedures.
For other dimensions and specifications see standard sheet III.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
Two-pole socket-outlet with side earthing-contacts
for power supply of DC equipment

For other dimensions and specifications see standard sheet III.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
DC Two-pole plug with side earthing-contacts for power supply of AC/DC equipment

For other dimensions and specifications see standard sheet IV.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
**DRAFT**

**STANDARD SHEET IV c**

<table>
<thead>
<tr>
<th>2,5A/400V DC</th>
<th>Two-pole plug with side earthing-contacts for power supply of DC equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>without interlock</td>
<td>Two-pole plug with side earthing-contacts for power supply of DC equipment</td>
</tr>
<tr>
<td>10A/400V DC</td>
<td>with interlock</td>
</tr>
</tbody>
</table>

For other dimensions and specifications see standard sheet IV.

The sketches are not intended to govern design except as regards the dimensions shown.

Dimensions in mm.
STANDARD SHEET V b

<table>
<thead>
<tr>
<th>16A/250V AC</th>
<th>Two-pole socket-outlet with pin-type earthing-contact for power supply of AC/DC equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>10A/250V DC</td>
<td></td>
</tr>
</tbody>
</table>

For other dimensions and specifications see standard sheet V.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
Two-pole socket-outlet with pin-type earthing-contact for power supply of DC equipment

For other dimensions and specifications see standard sheet V.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
**STANDARD SHEET VI b**

<table>
<thead>
<tr>
<th>16A/250V AC</th>
<th>2,5A/400V DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>10A/400V DC</td>
<td></td>
</tr>
</tbody>
</table>

Two-pole plug with pin-type earthing-contact for power supply of AC/DC equipment

For other dimensions and specifications see standard sheet VI.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
Two-pole plug with pin-type earthing-contact for power supply of DC equipment

<table>
<thead>
<tr>
<th>2.5A/400V DC</th>
<th>10A/400V DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>without interlock</td>
<td>whit interlock</td>
</tr>
</tbody>
</table>

Dimensions in mm.

For other dimensions and specifications see standard sheet VI.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
### STANDARD SHEET VII b

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16A/250V AC</td>
<td>Two-pole plug with dual earthing-contacts for power supply of AC/DC equipment</td>
</tr>
<tr>
<td>2.5A/400V DC without</td>
<td></td>
</tr>
<tr>
<td>interlock</td>
<td></td>
</tr>
<tr>
<td>16A/250V AC</td>
<td></td>
</tr>
<tr>
<td>10A/400V DC with</td>
<td></td>
</tr>
<tr>
<td>interlock</td>
<td></td>
</tr>
</tbody>
</table>

**Dimensions**

- 12 ± 0.1 mm
- 0.5 ± 0.1 mm
- 3.7 mm (MIN)
- 4.5 ± 0.06 mm

For other dimensions and specifications see standard sheet VII. The sketches are not intended to govern design except as regards the dimensions shown. Dimensions in mm.
Two-pole plug with dual earthing-contacts for power supply of DC equipment

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5A/400V DC</td>
<td>without interlock</td>
</tr>
<tr>
<td>10A/400V DC</td>
<td>with interlock</td>
</tr>
</tbody>
</table>

For other dimensions and specifications see standard sheet VII. The sketches are not intended to govern design except as regards the dimensions shown. Dimensions in mm.
DC Plugs and Socket-outlets
Swedish draft proposal

Göran Persson,
2005-08-29
DC Plugs and Socket-outlets

For other dimensions and specifications see standard sheet IV.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.

2.5A / 400 V DC Two-pole socket-outlet with side earthing-contacts
for power supply of AC/DC equipment

For other dimensions and specifications see standard sheet IV.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
DC Plugs and Socket-outs

For other dimensions and specifications see standard sheet IV.
The sketches are not intended to govern design except as regards the dimensions shown.
Dimensions in mm.
DC Plugs and Socket-outlets

- **IEC 60 884-1 Plugs and socket-outlets for household and similar purposes + national standards**

- **Examples of additions and changes necessary when adding DC**
  - 1. **Scope**
    - Add: This standard does also apply to AC/DC and DC plugs and socket-outlets. The rated current is limited to 2.5 A for plugs and socket-outlets without interlock.

  - 6. **Rating**
    - Add a new row in table 1
      | Type    | Rated voltage V DC | Rated current A DC |
      |---------|--------------------|--------------------|
      | 2 P plug| 400                | 2.5                |

  - 8.1 **Marking**
    - Add.
      - Socket-outlets according to standard sheet III b shall be marked AC/DC
      - Socket-outlets according to standard sheet III c shall be marked DC
      - Plugs according to standard sheet IV b shall be marked AC/DC
      - Plugs according to standard sheet IV c shall be marked DC

  - 8.2
    - Add the symbol for direct current
DC Plugs and Socket-outlets

- IEC 60 884-1 Plugs and socket-outlets for household and similar purposes + national standards.

- Examples of additions and changes necessary when adding DC
  - 8.3 – 8.4
    - Add: The marking according to the addition in clause 8.1 shall be placed so that it is readable also after the plug inserted in the socket outlet.
  - 9.
    - Add relevant gauges.
  - 9.101
    - Add at the end of the requirement: standard sheet III b, III c, IV b and IV c.
  - 15. Interlocked socket-outlets
    - Socket-outlets for AC and DC might be designed for 16 A current maximum.
    - Plugs for loads for AC and DC rated for up to 2,5 A can be connected and disconnected without interlocking. Plugs for 2,5 A are rated for AC and DC without interlocking mechanical or electronic functions.
    - For loads higher than 2,5 A, the standard AC and DC plug can be used if it is equipped with a mechanical or electronic interlocking switch function with or without connection to the outlets cover. The function shall be designed in such a way that a plug cannot be inserted into or completely withdrawn from the socket-outlet while the plug-contacts can carry current, i.e. the plug-contacts shall be switched off from the load or high-ohmic during these procedures.
DC Plugs and Socket-outlets

- IEC 60 884-1 Plugs and socket-outlets for household and similar purposes + national standards
- Examples of additions and changes necessary when adding DC
  - 20. Breaking capacity
  - 21 Normal operation