Reliability White Paper

POWERLOK Rack PDUs

Prepared by mtechnology

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Gateview Technologies retained mtechnology, Inc. (MTech) to evaluate the reliability and risk of load loss of the PowerLOK Rack PDU (Power Distribution Unit).

Method of Analysis

MTech compared the architecture and construction methods of PowerLOK to a rack PDU currently produced by a leading competitor. MTech calculated the reliability and risks of both products using fault trees. Our work was compliant with current IEEE recommended practices[1,2] and component failure rates.[3]

The definition of failure used for this evaluation is the loss of electrical continuity to any receptacle connection. A fault tree for this failure was constructed. As there are no redundant paths in either product, the fault trees are quite similar.

Findings

Based on the fault analysis, PowerLOK PDUs will experience about 1/3 as many PDU failures or, put another way, is about 3X less likely to fail compared to a PDU using the competing product design and construction. The additional Push-on connectors, insulation displacement connectors, and riveted bus bars in the competing product introduce opportunities for failure that are not present in the PowerLOK PDU. MTech identified 8 potential failure points in the PowerLOK and calculated a probability of failure of 1.3E-4 per year (0.013% per year). The competing product had 11 potential component failure points and a probability of failure of 3.7E-4 per year (0.037% per year).

PowerLOK incorporates several design features and manufacturing methods that increase the reliability of the product. These include:

- Elimination of Insulation Displacement Connectors (IDC) and rivets
- Each connection is both crimped and soldered to printed circuit boards for C13 and C19 connectors replace Faston connectors to riveted bus bars in the competing product.

Both crimp and solder for each connection is a method used by NASA to maximize reliability. Eliminating the IDC connections eliminates the possibility of overheating and failure. As shown in Table 1, just crimped connections are about 4 times more likely to fail in a given period of time than soldered connections. Each riveted connection removed increases the system reliability by 0.07% and each connector has 2 rivets.

[1] IEEE 3006.7 – 2013, 3006.7-2013 - IEEE Recommended Practice for Determining the Reliability of 7x24 Continuous Power Systems in Industrial and Commercial Facilities

[2] 3006.8-2018 - IEEE Recommended Practice for Analyzing Reliability Data for Equipment Used in Industrial and Commercial Power Systems

[3] MIL-HDBK-217F

The PowerLOK product has relatively equal distribution of failures among the component sub-assemblies. This is typical of products engineered for high reliability. The competitor product concentrates ~70% of all failures in three C13 groups.

Monitoring System Reliability

Gateview Technology also performed a reliability analysis of its Monitoring system utilizing a Mean Time Between Failure (MTBF) method. After the analysis we focused on two components that have the lowest MTBF. These two components are the touch-screen display and the AC/DC Converter. We also reviewed the following components: Arm Cortex, SPI serial flash memory, integrated 3port managed switch, IC power monitor.

Based on display with backlight at a lower percentage full lighting and with the display having a sleep mode when not prompted by the user, the life of the display is maximized. The actual MTBF calculation for the backlight at 20% intensity is 175,000 operating hours or 20 years at 25C. This is the minimum operating hours as the analysis assumes the display is never in a sleep state.

The AC/DC converter was analyzed based on actual return failure data and the manufacturer's datasheet. The analysis of the AC/DC converter based on the manufacturer's datasheet has a MTBF of 2271×10^3 at 25C.

The PowerLok monitoring module has a minimum MTBF of about 20 years which is by far longer than the typical retrofit plan used by most large datacenters of about 7 to 10 years.

Reliability Summary

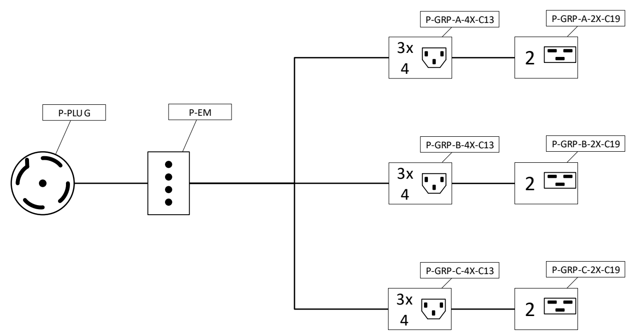
PowerLOK achieves higher reliability than exemplar competing products by eliminating part count, failure prone components, and using robotic soldering from input to output. The probability of a competing PDU failure is 3 times that of the PowerLOK PDU.

While UPS, batteries, standby generators, and redundant utility feeds are purchased and configured with the intention of providing maximum reliability and availability, PDUs are also an integral part of the electrical distribution system. The large number of PDUs in a data center results in many opportunities for failure. By improving reliability, availability, risk, and the frequency of installation errors, the PowerLOK PDUs provide better performance of critical loads while lowering the time and costs data center operators incur for installation and repairs of failures.

Table 1: Failure Rates and Sources

Component	Failure rate per hour	Probability of failure in 1 year	Source
Crimp	2.60E-10	2.28E-6	MIL-HDBK-217F, 17.1, π_Q = 1.0, π_E = 1.0 (IDC connector failure rate is the same as crimped connection)
Solder	6.90E-11	6.04E-7	MIL-HDBK-217F, 17.1, π_Q = 1.0, π_E = 1.0
Plated-through hole (PTH)	4.10E-11	3.59E-7	MIL-HDBK-217F, 16.1, π_C = 1.0, π_Q = 1.0, π_E = 1.0
Rivet	8.00E-08	7.01E-4	NSWC-11, 23.12.2
Power pin	8.27E-10	7.24E-6	MIL-HDBK-217F, 15.1, T = 45 °, insert material B, π_K = 1.0, π_P = 1.0, π_E = 1.0
Faston	1.09E-9	9.52E-6	1x crimp + 1x power pin
IDC/faston	1.65E-9	1.45E-5	2x power pin
Quad C13	9.90E-10	8.67E-6	9x solder + 9x pth
PowerLOK EM	1.70E-9	1.49E-5	4x crimp + 6x solder + 6x pth
PowerLOK dual C19	1.10E-9	9.64E-6	10x solder + 10x pth
Plug	1.30E-9	1.14E-5	5x crimp
Hex C13, Type 1	4.45E-9	3.89E-5	2x IDC/faston + 1x faston + 2x dual rivet failure
Hex C13, Type 2	5.01E-9	4.39E-5	3x faston + 2x dual rivet failure
Competitor EM	2.60E-9	2.28E-5	10x crimp
Competitor dual C19	3.12E-9	2.73E-5	6x crimp

Figure 1: PowerLOK PDU



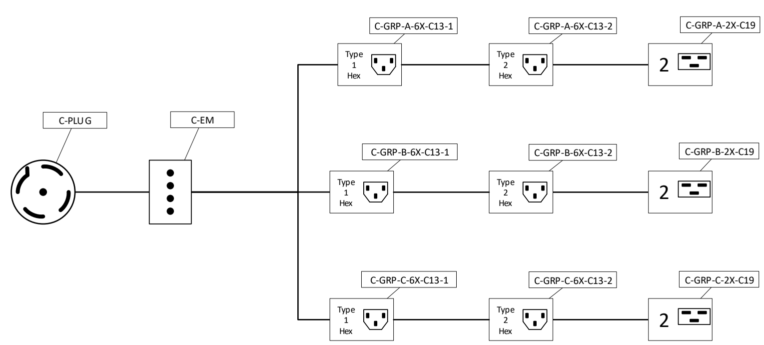
<u>Failure Rate Assumptions</u>

1) Plugs and entrance modules have higher failure rates than IEC 320 modules because of hand assembly
 a) plug, 1.30 * 10^{-9} per hour
 b) EM, 1.70 * 10^{-9} per hour

2) IEC 320 groups failure rates from MIL-HDBK-217F, 16.1 (PCBs w/ PTHs, π_Q = 1, π_C = 1.0, π_E = 1.0) & 17.1 (Reflow soldered connections, π_Q = 1, π_E = 1.0)

 a) 3x quad C13: 2.97 * 10^{-9} per hour
 b) 2x C19: 1.10 * 10^{-9} per hour

Figure 2: Competitor PDU



<u>Failure Rate Assumptions</u>

1) Plug's failure rate is the same as for PowerLOK PDU. MIL-HDBK-217F, 17.1 (π_Q = 1.0, π_E = 1.0) crimp failure rate (x5 = 1.3 * 10^{-9} per hour)

2) Competitor entrance module has 6 additional faston connections. Failure rate = 2.69 * 10^{-9} per hour

3) Insulation displacement connector failure rate is the same as 2x power pin. MIL-HDBK-217F, 15.1 (T = 45 °C, insert material B, π_K = 1.0, π_P = 1.0, π_E = 1.0), 8.27 * 10^{-10} per hour

4) IEC 320 groups failure rates from MIL-HDBK-217F, (Crimp connections, 17.1, π_Q = 1.0, π_E = 1.0; power pin, 15.1, T = 45 °C, insert material B, π_K = 1.0, π_P = 1.0, π_E = 1.0) & "Handbook of Reliability Prediction Procedures for Mechanical Equipment", Naval Surface Warfare Center (NWSC-11), 23.12.2, Rivet Failure Rate
 a) Hex C13, Type 1: 4.45 * 10^{-9} per hour
 b) Hex C13, Type 2: 5.01 * 10^{-9} per hour
 c)2x C19: 3.12 * 10^{-9} per hour