Pulse PA32xxNL Sidewinder Reliability Demonstration Test Report

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Executive Summary

PA32XXNL APPLICA-TION

- Current Sensor in Smart Meter
- Measures 0 to 200 Amps
- Compliant with ANSI C12.1 over 20 year lifetime

TESTING

- Reliability Demonstration Test
- HASS using temperature and humidity for 100 days
- 70 production units tested, no failures.

RESULTS

- 6,090 years MTTF
- 99.7% Reliability after 20 years of 24/7 service with 90% confidence

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PA32XXNL SIDEWINDER™ - CURRENT SENSOR

Dynamic Range from 0.1 to 1000 Amps

Meets ANSI C12.20 Accuracy Class 0.2

Meets IEC 62053-22 class 0,2S

Phase error < 0.05 degree

Bandwidth 100KHz

Immune to external AC magnetic fields

Immune to DC current & magnetic field

Low temperature coefficient

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Reliability Defined

Reliability

- The ability of a component to meet its performance specifications over a period of time.
- The reliability of a component is measured as the probability of meeting its performance specifications for a given period of time (number between zero and one)

Measurement

- During the useful life of a component, failures occur randomly at a constant rate $=\lambda$ (lambda) $=1/MTTF$ (Mean Time to Failure)
- At a constant failure rate, the reliability as a function of time R(t) = e^(-t*λ) = e^(-t/MTTF)

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Demonstrating Reliability

HASS

- HASS – Highly Accelerated Stress Screening - requires the controlled application of elevated stress levels to accelerate aging and failure mechanisms to demonstrate reliability.
- A combination of high temperature and high humidity is typically used to generate the accelerated stress levels.

Reliability Demonstration

- The Sidewinder Reliability Demonstration Test (RDT) used the HASS described on the next page. No component failures occurred during the HASS.
- The reference for the calculation of the reliability is the United States, population weighted, annual average mean temperature of 13°C and relative humidity 67%.

Reliability Results

- Substituting these values into the Peck Model equation gives an acceleration factor, *Afpeck,* of 860
- The Chi Square statistic is used to calculate the MTTF of 6,090 years at 90% confidence.
- Because there were no failures, the linear exponential model R=e^(-t/MTTF) is used to calculate the reliability (R) of at least 99.7% at 90% confidence after 20 years of use.
- This means for a utility meter deployment of 1 million meters, less than 150 meter sensors would fail per year during each year of the 20 year lifetime of the meters.

Summary

- Based on the data obtained during the RDT the Sidewinder MTTF is at least 6,090 years with 90% confidence. After a mission time of 20 years with 24/7 service Sidewinder reliability is at least 99.7% with 90% confidence.
- The excessive, constant stress applied to the Sidewinder test samples throughout the RDT verify the design provides high reliability and is appropriate for use in mission critical end products where maximum uptime is a necessity.
- The failure mechanisms accelerated during this RDT include those considered most likely for a design such as Sidewinder and include insulation degradation, solder fatigue and interconnect degradation, among others. The end-user is advised to follow Pulse Engineering installation and design considerations when integrating Sidewinder into their end-product.

Appendix - HASS Parameters

HASS Temperature	+95°C
HASS Humidity	95%RH
Total Test Duration	85 days
Monitoring	The DC resistance of each sample was monitored and recorded during the screen to detect failures.

- **t(use)** = U.S. Annual Average Mean outdoor* temperature, population weighted, plus 5°C internal meter temperature rise Kelvin (13°C + 5°C + 273 = 291)
- **RH(use)** = U.S. Annual Average Mean outdoor* humidity, population weighted, 67%
- **Ea** = Activation energy = 0.70 selected for Sidewinder's dominant failure mechanism, insulation degradation
- The Peck temperature-humidity model describes the combined aging effects of elevated temperature and humidity

* Most U.S. Utility meters are located outdoors.

Appendix - HAAS Reliability Acceleration Model

Peck Model:

$$AF_{peck} = \left(\frac{RH_{alt}}{RH_{use}}\right)^m e^{\left[\frac{Ea}{k}\left(\frac{1}{t_{use}} - \frac{1}{t_{alt}}\right)\right]}$$

Where:

RH(HAAS) = Relative humidity during HAAS (95%)

RH(use) = Humidity during customer use (67%)

m = humidity power constant = 3.0

e = base of natural logarithms

Ea = Activation energy = 0.70

k = Boltzmann's constant (8.617 x 10-5 eV/K)

t(use)= temperature during customer use in Kelvin (18°C + 273 = 291)

t(HAAS) = temperature during HAAS in Kelvin (95°C + 273 = 368)

Standards:

- IEC 62059-31-1: Electrical meter equipment – Dependability – Accelerated Reliability Testing – elevated temperature and humidity (Annex C)

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Appendix - Reliability Calculation

Reliability Calculator

Number of test hours	t	2040
The number of DUT (devices under test)	n	70
Number of failure	r	0
The Chi-square distribution	X^2	4.605
Probability = 1-CL (90% Confidence Level)	α	0.1
Degrees of freedoms (use 2r+2 for low confidence limt where r is the number of failure)	DF	2
The test temperature (in Kevin)	T_2	368
The reference temperature, or the typical operating temperature (in Kevin)	T_1	291
Boltzmann's Constant	k	8.62E-05
Test environment relative humidity	RH2	95
Use environment relative humidity	RH1	67
Activation energy per molecule (ev)	Ea	0.7
The acceleration factor (Arrhenius Hallberg-Perk Model due to temp and humidity combination)	AF	981
	MTBF	60,841,541

hours 6,945 Years

$$A_f = \left(\frac{RH_t}{RH_u}\right)^3 e\left(\frac{Ea}{K}\left\{\frac{1}{T_u} - \frac{1}{T_t}\right\}\right)$$

RH_u = use environment relative humidity
RHt = test environment relative humidity

Reliability Calculation		
Time (yrs)	T	20
hours	T	175,200
Reliability		99.7%
Confidence		90.0%

R = Exp (-T/MTBF)

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