

PULSE PA32XXNL SIDEWINDER RELIABILITY DEMONSTRATION TEST REPORT

Executive Summary

PA32XXNL APPLICATION

- 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



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



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 = λ (lambda) = $1/\text{MTTF}$ (Mean Time to Failure)
- At a constant failure rate, the reliability as a function of time $R(t) = e^{-t\lambda} = e^{-t/\text{MTTF}}$

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, A_{peck} , 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

- **t (use)** = U. S. Annual Average Mean outdoor* temperature, population weighted, plus 5°C internal meter temperature rise Kelvin ($13^{\circ}\text{C} + 5^{\circ}\text{C} + 273 = 291$)
- **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

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.

* 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 = 30

e = base of natural logarithms

Ea = Activation energy = 0.70

k = Boltzmann's constant ($8.617 \times 10^{-5} \text{eV/K}$)

t(use) = temperature during customer use in Kelvin ($18^{\circ}\text{C} + 273 = 291$)

t(HAAS) = temperature during HAAS in Kelvin ($95^{\circ}\text{C} + 273 = 368$)

Standards:

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

Reliability Calculator

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

RH_U = use environment relative humidity
 RH_t = test environment relative humidity

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 limit 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
Reliability Calculation					
Time (yrs)	T	20			
hours	T	175,200			
Reliability		99.7%			R = Exp (-T/MTBF)
Confidence		90.0%			

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