SIEMENS

APACS+™

High Strength for Increased Reliability and Safety

The key to a control system's ability to provide high reliability and high safety is maintaining an inherently low failure rate. This document explains the relationship between reliability, safety, and failure rates. It also outlines how careful design and testing has enabled the APACS+ process automation system to achieve the most protection against failure of any process controller.

Stress/strength concepts

The foundation of high reliability and high safety is an inherently low failure rate. To achieve a low failure rate, a control system must provide "high strength." Strength is a system's ability to withstand the stresses that cause failures, such as heat, chemicals, and vibration. The concept of strength and its relationship to failure rates is as follows:

- When stress exceeds strength, a failure occurs.
- The lower the strength, the higher the failure rate.
- The higher the strength, the lower the failure rate.

The stress/strength concept is further explained in Figures 1 through 3.

Figure 1 illustrates the concept that a failure occurs when some stressor or combination of stressors exceeds the associated strength of the system. Stressors are represented by a curve showing the probability of a particular stress value. Strength is represented by another curve that shows the cumulative chances of any particular value in a collection of products. The chance of stress exceeding strength, thus resulting in a failure, is related to the "interference area" between the curves.

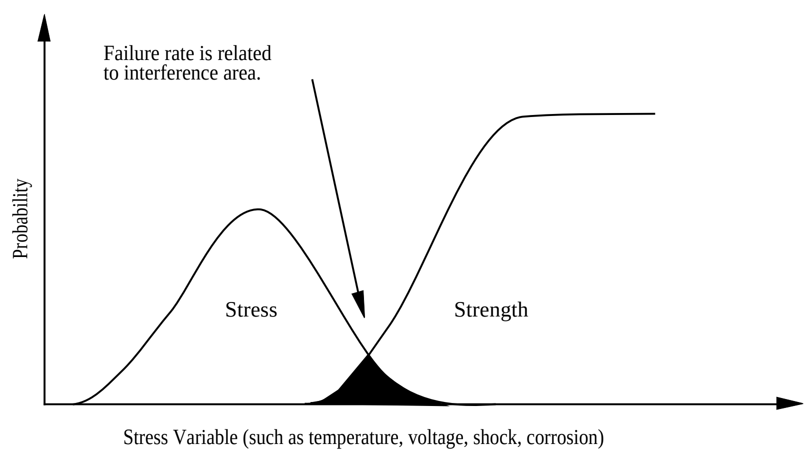

Figure 1 Stress/strength interference

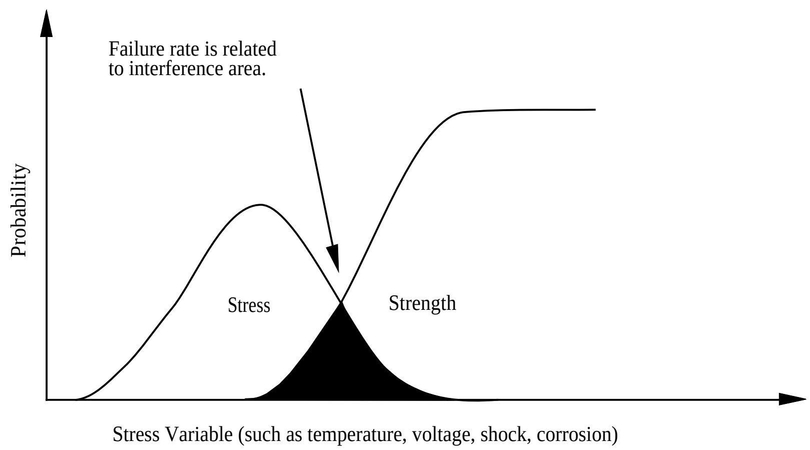

Figure 2 Lower strength, higher failure rate

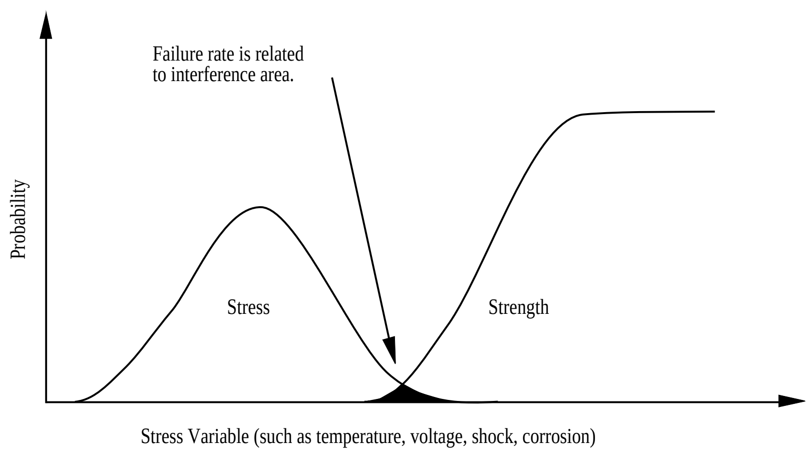

Figure 3 Higher strength, lower failure rate

When strength is lowered, the interference area increases and, in turn, the failure rate increases. As shown in Figure 2, this means a low strength product fails more frequently. Conversely, when strength increases, failure rates drop. Thus, as shown in Figure 3, a high strength product fails less frequently.

There are many kinds of stressors in an industrial environment. Environmental stresses include heat, humidity, chemicals, shock, vibration, electrical surge, electrostatic discharge, and radio waves. Operational stressors include incorrect commands from an operator, incorrect maintenance procedures, bad calibration, wrong software versions, and improper grounding.

Product strength against these stressors is initially determined by the design and manufacture of system components. Given certain specifications, the designer creates a product that will not fail under these conditions of stress. The manufacturing process ideally duplicates this ideal product without defect. In the real world, there are occasional defects; design errors and manufacturing errors can reduce strength. Unfortunately, strength is also reduced with time (wearout). Designers must account for this by adding a safety factor to product strength. The concept of high strength design is know as fault avoidance.

APACS+ fault avoidance

APACS+ achieves high reliability and safety in part by providing high strength against industrial stresses. This is accomplished via several different protection mechanisms that increase strength.

Heat

As shown in Figure 4, a cast aluminum housing covers each APACS+ module, and major heat-producing components are thermally shorted to this large heat sink. The thermal shorting block lowers the junction temperature of the main processor circuit.

Design testing verifies that internal component temperatures are not excessive. Case temperatures of the major heat dissipating elements are measured while operating at their maximum rating.

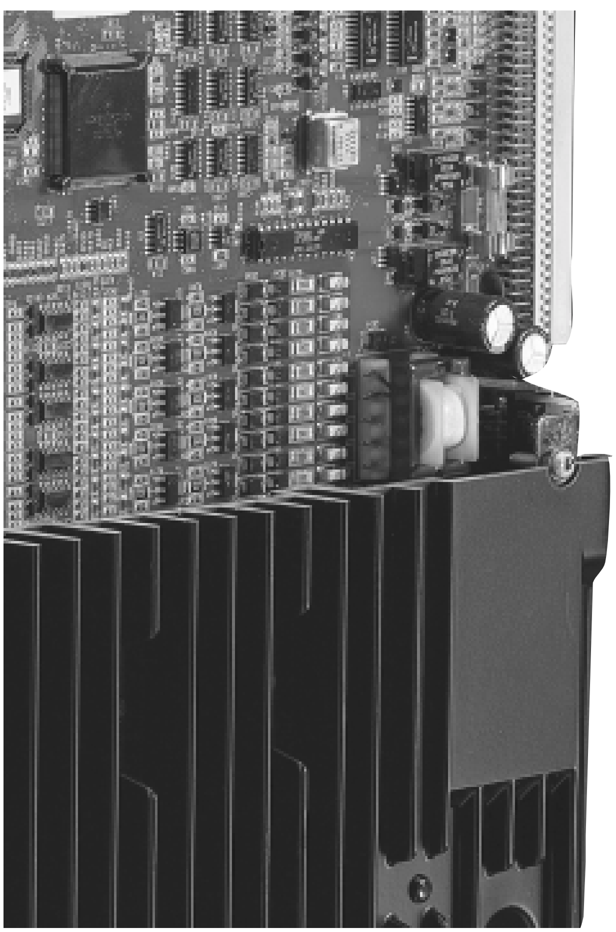

Figure 4 Module cutaway showing protection against heat

Because there must be a good safety margin between expected temperature and design strength, APACS+ modules are additionally tested by operating them in increasingly hot environments until failure. APACS+ modules have operated at well above 100°C.

Heat also reduces the lifetime of a product. Strength decreases over time at a rate proportional to temperature, a phenomena which is known as "wearout." To ensure APACS+ strength over its lifetime, wearout mechanisms in APACS+ components were identified and lifetime calculations were made.

Humidity and chemicals

Conformal coating of standard APACS+ electronic assemblies protects them against humidity and chemicals. Connectors include gold-plated contacts coated with a special "contact lubricant" to ensure gas-tight contact between connections.

APACS+ module packaging completely encloses the electronics assembly, diverting corrosive airflow away from the electronics and providing a second layer of protection. Type 12 (IP 55 equivalent) APACS+ enclosures provide further protection.

To ensure the effectiveness of these designs, APACS+ modules are tested in a chamber with corrosive chemicals beyond the ISA GX severity rating. Testing indicates that no failures due to corrosion are expected within a ten year lifetime.

Shock/vibration

APACS+ modules include secure screw-in mounting to an APACS+ module rack, and cable assemblies and connectors provide screw-in and clamp-type security. These positive latch mechanisms virtually eliminate disconnect failures due to mechanical shock and vibration. Testing by an independent laboratory to IEC, MIL, and ABS shock and vibration standards confirms these findings.

When a module is outside of its card cage, the rugged module enclosure prevents inadvertent mechanical damage to the module.

Electrical surge/discharge

APACS+ I/O circuitry is electrically isolated from system common. Both process I/O and power circuits include surge suppressors, protection resistors, and other "hardening" circuitry. To ensure the effectiveness of this additional circuitry, an independent laboratory tests them to ANSI/IEEE and IEC static discharge levels of over 15 kV and surge levels of 5 kV.

This testing covers stresses such as electrostatic discharge, radio frequency interference, repetitive fast electrical transients that can come from a switch contact bounce, and power line disturbances that accompany load switching and lightning strikes. Moreover, APACS+ meets IEC 801 and 1000-4 standards and the European Union's Electromagnetic Compatibility (EMC) Directive for electromagnetic emission and immunity, for products distributed in the European community.

Operational and maintenance errors

Many "foolproofing" features within APACS+ prevent inadvertent damage during operation and maintenance. For example:

- In non-hazardous locations, modules can be inserted and removed from a module rack without removing power
- Each module can be keyed so that modules can only be inserted into the correct module rack slot
- Cable connectors are keyed
- Setup jumpers have been eliminated
- Calibration is performed digitally
- A software security switch and password protection prevent unauthorized software changes, and software version information is stored in the non-volatile memory of all APACS+ modules
- Modules are designed with drip-proof housings

Table 1 APACS+ environmental specifications

Specification	Data	Reference standards
Ambient Temperature Range Operating Storage	 0 to 60°C, 0.5°C min -25 to 85°C, 17°C min	IEC 68-2-2 Test Bb IEC 68-2-14 Tests Na, Nb IEC 68-2-1 Tests Ab, Ad
Relative Humidity Operating Storage	 5 to 95%, non-condensing 0-100%, condensing	IEC 68-2-3 Test Ca IEC 68-2-30 Test Dd
Vibration	10-150 Hz 2 max	ABS 1995, Part 4 Section 11/23 Table 4/11/1 No. 12
Mechanical Shock Acceleration Duration	 15 Gs max 11 ms max	 IEC 68-26 Test Fc
Corrosives	Class G3, 10+ years	ANSI/ISA S71.04
Radiated Emission, E-Field	30 MHz - 230 MHz 30 dB (μ V/m) at 30 m	EN 55011
	230 MHz - 1000 MHz 37 dB (μ V/m) at 30 m	EN50081-2
Conducted Emission Power Lines	0.15 MHz - 0.5 MHz 79 dBm quasi-peak	EN 55011
	0.5 MHz - 30 MHz 73 dBm quasi-peak	EN50081-2
Immunity, Conducted Electromagnetic Field	150 KHz - 80 MHz, 10 V/m	IEC 801-6/IEC 1000-4-6
Immunity, Power Lines Surge	4 kV	IEC 801-5
	2 kV	ANSI/IEEE C62.41 (IEEE 587)
Immunity, Electrical Fast Transients	4 kV Power lines, 2 kV I/O	IEC 801-4/IEC 1000-4-4
	2.5 kV I/O	ANSI/IEEE C37.90 (Formerly IEEE 472)
Immunity, Radiated E-Field	10 V/m, 27 MHz - 1000 MHz 10 V/m, 80 MHz - 1000 MHz	IEC 801-3/IEC 1000-4-3
	2-abs: 2% span	SAMA PMC 33.1
Immunity, Electrostatic Discharge	8 kV contact, 15 kV air	IEC 801-2/IEC 1000-4-2

Every module may not be tested to the above standards. Contact a Siemens representative if more detailed information is required.

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For prompt, personal attention to your process automation needs, contact the Siemens location nearest you.

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