Application Report

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AM335x Reliability Considerations in PLC Applications

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ABSTRACT

Programmable Logic Controllers (PLC) are used as the main control in an automation system with high-reliability expectations and long life in harsh environments. Processors used in these applications require an assessment of performance verses expected power on hours to achieve the optimal performance for the application.

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1 Overview of PLC Applications

The programmable logic controller (PLC) is the main control system in an automation system that implements the proper sequencing and control of different I/O nodes. PLCs are typically benchmark in the number of I/O's in both size and through-put. Typically the PLC run-time on an embedded platform is managed over the Ethernet and is used in factory, building, mobile, and process and energy automation. In the past, many PLC systems utilized custom designed ASICs to obtain the system and environment requirements. Today, many manufacturers are looking for off-the-shelf processing solutions such as application processors or FPGAs with embedded cores.

This document describes some of the challenges in meeting the reliability and environmental requirements for types of logic controllers with commercially available processors.

2 PLC Critical Requirements

PLC applications generally require high reliability from both the hardware and software. The Soft Error Rate (SER) across all used device memory and logic must be low. Generally, the low SER failure rates are expected to be in the 130 to 240 FITs.

These applications are expected to have a long lifetime typically in the 100,000 power-on hours or 11.4 years of continuous use (24 hours/7 days per week) at a high operating temperature with little or no air flow. In some applications, the PLC life expectancy may exceed the 100,000 power-on hours.

In addition to the reliability expectations, PLC applications typically utilize low latency access to the I/O interfaces and processor through-put.

Low power is also a critical requirement as many of the PLC applications are designed to minimize space, which results in the use of a processor without a cooling fan or heat sink. Generally, PLC applications need low power and smaller footprints to achieve better overall efficiency.

3 Trade-Offs for Best Performance

Reliability is the probability of meeting specifications or requirements over time. This is often measured in FIT (Failure In Time). The FIT rate is the number of failures in 1,000,000,000 device operating hours and is a time dependent value. The reliability performance of a semiconductor device can be influenced by changes in material properties and application conditions.

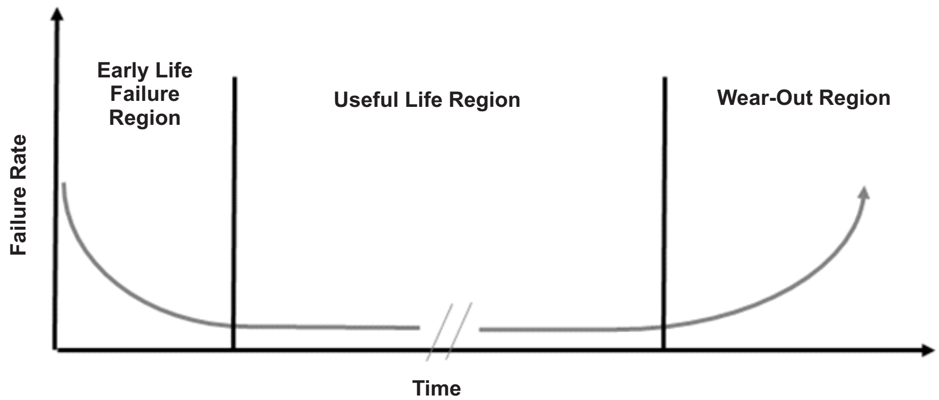

Figure 1. Reliability Curve

Application temperature, voltage and activity can have a large impact on the intrinsic or wear-out associated with the semiconductor device reliability performance. One of the most influential factors in effecting a products overall life expectancy is the operating junction temperature in the application. This is the temperature of the device silicon during operation. As the junction temperature increases, the overall product life expectancy will decrease. Voltage also has an impact in product performance over time. In much the same way as junction temperature, as the voltage increases, the product life will decrease. Finding the right balance in product performance verses reliability expectations is critical in optimizing the application goals.

The Texas Instruments AM335x products are designed to support an intrinsic reliability goal or wear-out rate of 50 FIT (MTBF = 2 e7 hours) for 100,000 power-on hours (POH), when used at a junction temperature of 105°C and nominal core voltage as defined by the device-specific data sheet.

Figure 2 demonstrates the effect of temperature and estimated FIT rate when operated at the defined junction temperatures for 100,000 power-on hours.

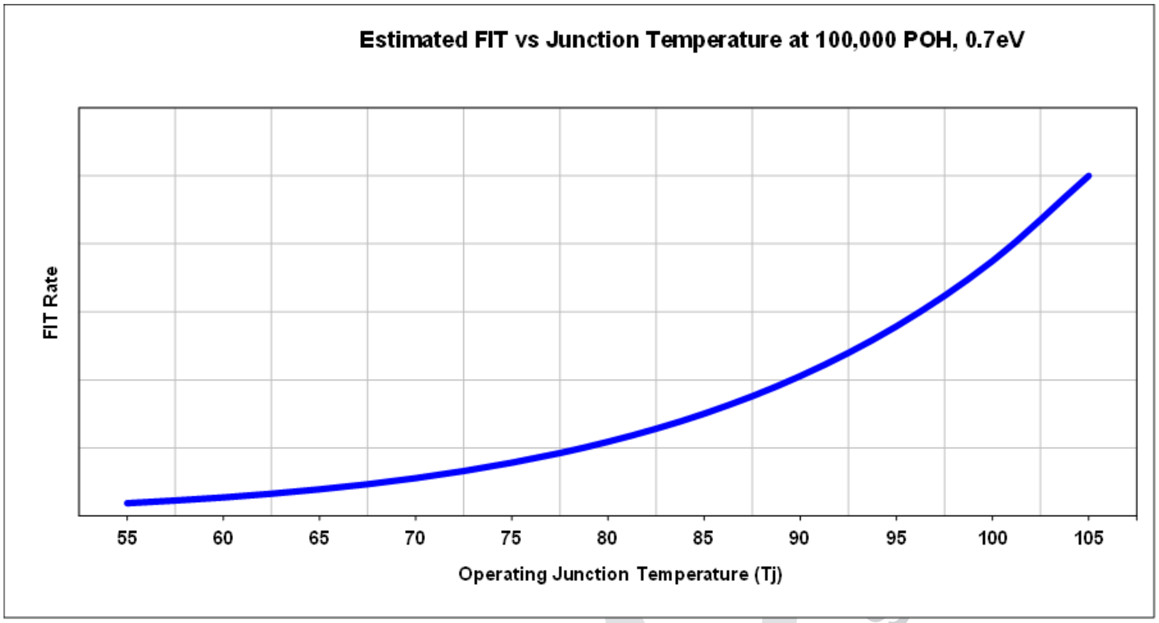

Figure 2. Chart 1

Many processors, such as the TI AM335x products, have multiple operating performance points which may be utilized depending on the application needs.

For example, the following operating performance points are from the April 2013 revision of the *Sitara™ AM335x ARM® Cortex™-A8 Microprocessors (MPUs) Data Manual* (SPRS717).

The power-on hours (POH) information in Table 1 is provided solely for your convenience and does not extend or modify the warranty provided under TI's standard terms and conditions for TI semiconductor products.

To avoid significant degradation, the device power-on hours (POH) must be limited to the following:

Table 1. Reliability Data

Operating Condition	Commercial		Industrial		Extended	
	Junction Temp (Tj)	Lifetime (POH) [(1)]	Junction Temp (Tj)	Lifetime (POH) [(1)]	Junction Temp (Tj)	Lifetime (POH) [(1)]
Nitro	0°C to 90°C	100K	-40°C to 90°C	100K	-40°C to 105°C	37K
Turbo	0°C to 90°C	100K	-40°C to 90°C	100K	-40°C to 105°C	80K
OPP120	0°C to 90°C	100K	-40°C to 90°C	100K	-40°C to 105°C	100K
OPP100	0°C to 90°C	100K	-40°C to 90°C	100K	-40°C to 105°C	100K
OPP50	0°C to 90°C	100K	-40°C to 90°C	100K	-40°C to 105°C	100K

(1) POH = Power-on hours when the device is fully functional.

NOTE: Logic functions and parameter values are not assured out of the range specified in the recommended operating conditions.

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In looking at the various operating conditions and assuming a target FIT rate of 10 FITs, Figure 3 would be the estimated reliability performance in power-on hours as it relates to the junction temperature. This model assumes constant operation at the specified junction temperature and power-on hours.

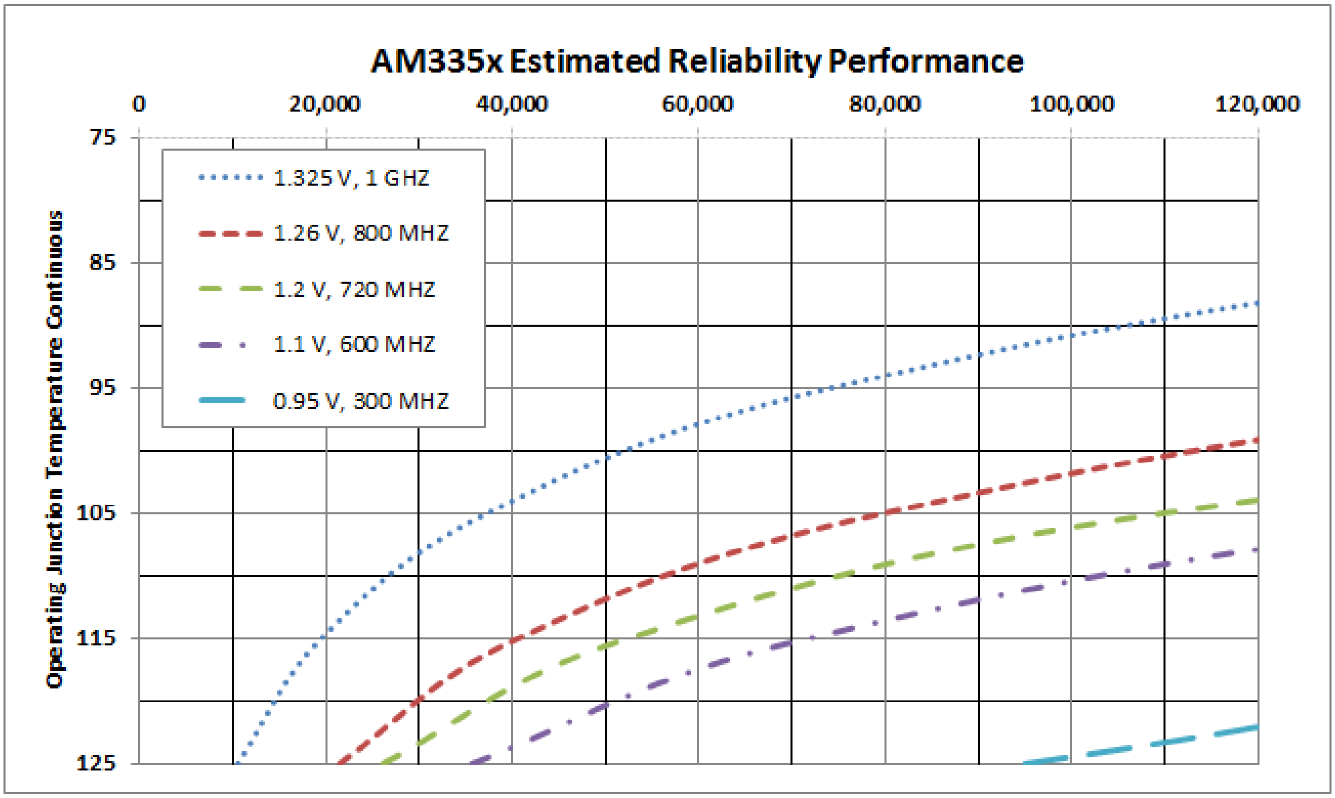

Figure 3. Chart 2

4 Summary

In conclusion, selecting the appropriate operating performance point to best meet the application needs for life expectancy targets and environmental conditions is critical in attaining the application goals. Trade-offs between frequency and junction temperature can greatly influence the product life expectancy.

5 Reference

- *Sitara™ AM335x ARM® Cortex™-A8 Microprocessors (MPUs) Data Manual* (SPRS717)

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