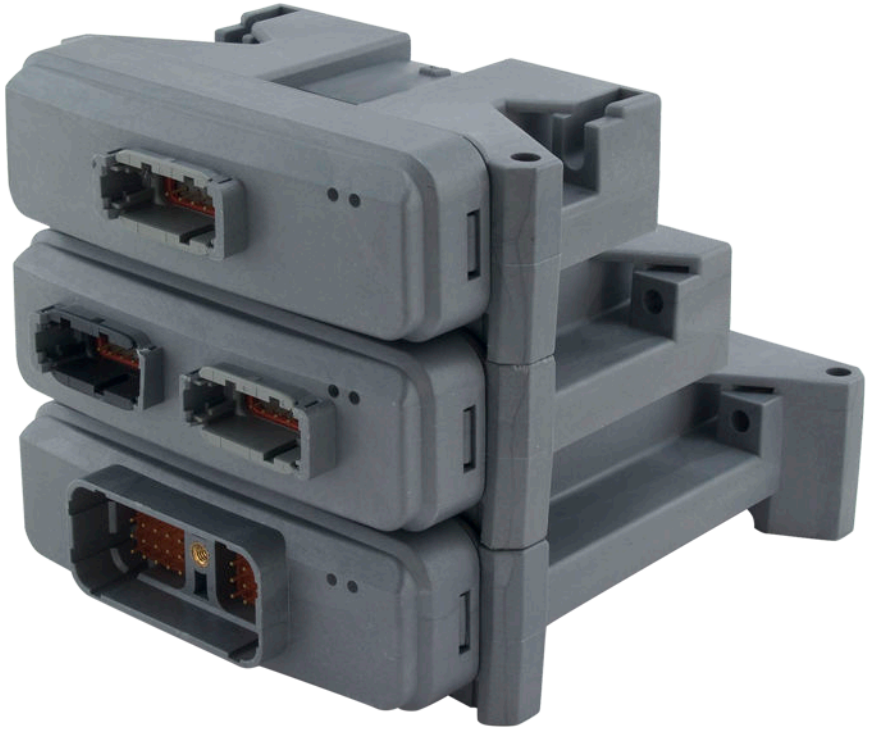
ENGINEERING
TOMORROW

Functional Safety

Reliability Data (MTTF)
for PLUS+1 Microcontrollers and I/O modules



Revision history

Table of revisions

Date	Changed	Rev
February 2020	Component and calculation summary chapter/topic MC050-010 added	0304
January 2020	Corrections made in Component and calculation summary	0303
December 2019	Component and calculation summary chapter/topic MC050-110 and MC050-118 replaced MC050-110; Added row to Device total table with MC050-118 information	0201
July 2016	First edition	0101

Contents

Overview

Reliability Data (MTTF)

Transfer of Mean Time to Failure (MTTF) data for the given product from Danfoss to the appropriate party.

This Mean Time to Failure (MTTF) data has been compiled by the Business Area engineering team responsible. These are professionals at Danfoss, who have the authority and technical knowledge to calculate the MTTF Data for this product based on the standards set in place by both the industry and/or Danfoss.

The purpose of this document is to assist in the transfer of MTTF data for the given product from Danfoss to the appropriate party in a way which will result in a clear understanding and documentation on how we derived it.

This MTTF data is provided to assist in calculating the overall MTTF of a complete or partially complete piece of machinery. Danfoss cannot be held responsible for the suitability of these calculated MTTF values for use in the calculation of the overall machinery MTTF values.

The MTTF values are based on a specific machine use, operating environment, and/or duty cycle as stated by the standards set in place by both the industry and/or Danfoss.

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Standards and references

Introduction

As of December 29, 2009, Machinery Directive 2006/42/EC is effective for all machinery *placed on the market in the European community*. This directive mandates that machinery manufacturers are responsible for performing and documenting a Hazard and Risk Assessment. Each identified risk must then be addressed to ensure risk reduction to an acceptable risk level.

The processes to guide the execution of these activities are defined in various harmonized standards such as:

- ISO 12100:2010 Safety of Machinery
  - General principles for design
  - Risk assessment and risk reduction
- ISO 13849 Safety of Machinery
  - Safety-related parts of control systems

Danfoss adds value by participating in the machine manufacturers process and providing the appropriate product information to enable the required probabilistic calculations.

Assumptions

The failure rate listed in this document is the result of a FMEDA analysis.

All failure rates were calculated using component data from MIL-HDBK-217F at 45°C, unless otherwise noted. All failure mode distributions were taken from IEC 62061:2005 Annex D.

For inputs, a failure included in $MTTF_d$ and PFH is categorized as a mismatch between expected and measured signal.

For logic and outputs, failure included in $MTTF_d$ and PFH is categorized as one that causes:

- Loss of high-side switch turn-off capability
- Uncommanded turn-on of high-side switch
- A mismatch between commanded and actual current (for proportional outputs only)

Analysis should be performed, taking into account if not all components fail dangerously.

Standards

IEC 61508:2006	PLUS+1® microcontroller hardware category - Type B device
IEC 62061:2005 Annex D	Failure modes and percentages
MIL-HDBK-217F	Reliability prediction of electronic equipment

Calculations

Probability does not consider CAN communication external issues.

Component and calculation summary

MC012-110 and IOX012-110

Inputs

Function (configuration)	MTTF (years)	$MTTF_d$ (years)
DIN/AIN/FREQIN (Digital)	4,827.50	6,595.80
DIN/AIN/FREQIN (Analog)	4,293.60	7,247.40
DIN/AIN/FREQIN (Frequency)	4,744.80	9,026.00
DIN/AIN/CANx SHIELD (Digital)	14,766.90	14,766.90
DIN/AIN/CANx SHIELD (Analog)	12,353.30	12,353.30

Common logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	195.90	220.10

Outputs

Function	MTTF (years)	$MTTF_d$ (years)
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

MTTF (years)	$MTTF_d$* (years)
129.10	144.90

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

MC024-110

Inputs

Function (configuration)	MTTF (years)	$MTTF_d$ (years)
DIN (Digital)	14,199.80	14,199.80
DIN/AIN/FREQIN (Digital)	4,827.50	6,595.80
DIN/AIN/FREQIN (Analog)	4,293.60	7,247.40
DIN/AIN/FREQIN (Frequency)	4,744.80	9,026.00
DIN/AIN/CANx SHIELD (Digital)	14,766.90	14,766.90
DIN/AIN/CANx SHIELD (Analog)	12,353.30	12,353.30
AIN/TEMP/RHEO (Digital)	8,165.50	8,165.50
AIN/TEMP/RHEO (Analog)	7,004.00	7,004.00
AIN/TEMP/RHEO (Rheostat)	4,406.50	4,406.50

Common logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	195.90	220.10

Component and calculation summary

Outputs

Function	MTTF (years)	$MTTF_d$ (years)
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

MTTF (years)	$MTTF_d$* (years)
91.30	100.90

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

MC024-120 and IOX024-120

Inputs

Function (Configuration)	MTTF (years)	$MTTF_d$ (years)
DIN (Digital)	14,199.80	14,199.80
DIN/AIN/FREQIN (Digital)	4,827.50	6,595.80
DIN/AIN/FREQIN (Analog)	4,293.60	7,247.40
DIN/AIN/FREQIN (Frequency)	4,744.80	9,026.00
DIN/AIN/CANx SHIELD (Digital)	14,766.90	14,766.90
DIN/AIN/CANx SHIELD (Analog)	12,353.30	12,353.30

Common logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	195.90	220.10

Outputs

Function	MTTF (years)	$MTTF_d$ (years)
PWMOUT/DOUT/PVGOUT	1.074.20	1.074.20

Device total

MTTF (years)	$MTTF_d$* (years)
75.50	80.10

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

MC024-130

Inputs

Function (Configuration)	MTTF (years)	$MTTF_d$ (years)
DIN (Digital)	14,199.80	14,199.80
DIN/AIN/FREQIN (Digital)	4,827.50	6,595.80
DIN/AIN/FREQIN (Analog)	4,293.60	7,247.40
DIN/AIN/FREQIN (Frequency)	4,744.80	9,026.00
DIN/AIN/CANx SHIELD (Digital)	14,766.90	14,766.90
DIN/AIN/CANx SHIELD (Analog)	12,353.30	12,353.30

Component and calculation summary

Common logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	180.90	201.40

Outputs

Function	MTTF (years)	$MTTF_d$ (years)
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

MTTF (years)	$MTTF_d$* (years)
74.00	78.30

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

MC050-010

Assumptions: Diagnostic coverage and $MTTF_d$ were not calculated

All failure rates were calculated using MIL-HDBK-217F at 45°C unless otherwise noted.

All failure mode distributions were taken from IEC 62061:2005.

For inputs, a failure included in $MTTF_d$ and PFH is categorized as a mismatch between expected and measured signal.

For logic and outputs, a failure included in $MTTF_d$ and PFH is categorized as any that causes:

1. loss of high-side switch turn-off capability, or
2. uncommanded turn-on of high-side switch, or
3. a mismatch between commanded and actual current (for proportional outputs only)

Inputs

Function (configuration)	Function (Configuration) [internal name]	MTTF (years)
DIN (Digital)	D4 (Digital)	14,598.5
DIN/AIN (Digital)	DA1 (Digital)	5,061.2
DIN/AIN (Analog)	DA1 (Analog)	4,577.1
DIN/AIN/CANx SHIELD (Digital)	DA3 (Digital)	11,630.8
DIN/AIN/CANx SHIELD (Analog)	DA3 (Analog)	10,079.6
DIN/AIN/CANx SHIELD (Digital)	DA3_B (Digital)	11,455.4
DIN/AIN/CANx SHIELD (Analog)	DA3_B (Analog)	8,898.8
DIN/AIN/FREQIN (Digital)	DAF1 (Digital)	6,509.7
DIN/AIN/FREQIN (Analog)	DAF1 (Analog)	6,069.7
DIN/AIN/FREQIN (Frequency)	DAF1 (Frequency)	10,057.9
DIN/AIN/ResIN (Digital)	DAR2 (Digital)	5,711.3
DIN/AIN/ResIN (Analog)	DAR2 (Analog)	4,913.5
DIN/AIN/ResIN (Rheostat)	DAR2 (Rheostat)	4,553.9

Component and calculation summary

Power and Logic

Function (configuration)	Function (Configuration) [internal name]	MTTF (years)
Power and logic	Power and Logic	146.4

Outputs

Function (Configuration)	Function (Configuration) [internal name]	MTTF (years)
PWMOUT	PWM1	1,199.7
PWMOUT/DOUT/PVGOUT	PWM2	1,069.7
DOUT	DOUT2	11,606.2

Device total

IEC 61508 Safe Failure Fraction [%]	ISO 13849 Diagnostic Coverage [%]	MTTF [years]
S	DD	50.3
DD	DU	
DU		
SFF*	DC**	
Failure Category DD = Dangerous Detected Failure DU = Dangerous Undetected Failure S = Safe Failure		

* SFF is the probablility of failing in a safe state.

** DC is the ratio of the rate of detected dangerous failures compared to the rate of all dangerous failures

MC050-110 and MC050-118

Inputs

Function (configuration)	MTTF (years)	$MTTF_d$ (years)
DIN (Digital)	14,199.80	14,199.80
DIN/AIN (Digital)	5,452.10	5,452.10
DIN/AIN (Analog)	4,882.60	4,882.60
DIN/AIN/FREQIN (Digital)	4,827.50	6,595.80
DIN/AIN/FREQIN (Analog)	4,293.60	7,247.40
DIN/AIN/FREQIN (Frequency)	4,744.80	9,026.00
DIN/AIN/CANx SHIELD (Digital)	14,766.90	14,766.90
DIN/AIN/CANx SHIELD (Analog)	12,353.30	12,353.30
AIN/TEMP/RHEO (Digital)	8,165.50	8,165.50
AIN/TEMP/RHEO (Analog)	7,004.00	7,004.00
AIN/TEMP/RHEO (Rheostat)	4,406.50	4,406.50

Common Logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	157.20	172.40

Component and calculation summary

Outputs

Function (Configuration)	MTTF (years)	$MTTF_d$ (years)
DOUT	8,218.40	8,218.40
DOUT/PVG PWR	4,717.30	4,717.30
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

Controller	MTTF (years)	$MTTF_d$* (years)
MC050-110	49.10	51.90
MC050-118	48.6	51.4

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

MC050-120

Inputs

Function (configuration)	MTTF (years)	$MTTF_d$ (years)
DIN (Digital)	14,199.80	14,199.80
DIN/AIN (Digital)	5,452.10	5,452.10
DIN/AIN (Analog)	4,882.60	4,882.60
DIN/AIN/FREQIN (Digital)	4,827.50	6,595.80
DIN/AIN/FREQIN (Analog)	4,293.60	7,247.40
DIN/AIN/FREQIN (Frequency)	4,744.80	9,026.00
DIN/AIN/CANx SHIELD (Digital)	14,766.90	14,766.90
DIN/AIN/CANx SHIELD (Analog)	12,353.30	12,353.30
AIN/TEMP/RHEO (Digital)	8,165.50	8,165.50
AIN/TEMP/RHEO (Analog)	7,004.00	7,004.00
AIN/TEMP/RHEO (Rheostat)	4,406.50	4,406.50

Common logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	159.30	174.90

Outputs

Function (Configuration)	MTTF (years)	$MTTF_d$ (years)
DOUT	8,218.40	8,218.40
DOUT/PVG PWR	4,717.30	4,717.30
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

MTTF (years)	$MTTF_d$* (years)
60.40	64.80

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

Component and calculation summary

MC050-155

Inputs

Function (configuration)	MTTF (years)	$MTTF_d$ (years)
DIN/AIN (Digital)	5,452.10	5,452.10
DIN/AIN (Analog)	4,882.60	4,882.60
DIN/AIN/FREQIN (Digital)	4,827.50	6,595.80
DIN/AIN/FREQIN (Analog)	4,293.60	7,247.40
DIN/AIN/FREQIN (Frequency)	4,744.80	9,026.00
DIN/AIN/CANx SHIELD (Digital)	14,766.90	14,766.90
DIN/AIN/CANx SHIELD (Analog)	12,353.30	12,353.30

Common logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	131.30	141.70

Outputs

Function (Configuration)	MTTF (years)	$MTTF_d$ (years)
DOUT	8,218.40	8,218.40
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

MTTF (years)	$MTTF_d$* (years)
59.80	63.40

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

OX012-110

Common logic

	MTTF (years)	$MTTF_d$ (years)
Power and logic	230.70	266.00

Outputs

Function (Configuration)	MTTF (years)	$MTTF_d$ (years)
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

MTTF (years)	$MTTF_d$* (years)
100.80	107.00

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

A risk assessment should be performed to define the right configuration of the Input/Output (I/O) module.

Component and calculation summary

The I/O modules can be configured to react in different ways to faulty conditions. For information about configuration of the I/Ot modules, please see *PLUS+1® Controller Family Technical Information*, **520L0719** and HWD documentation.

OX024-110

Common logic

	MTTF (years)	**$MTTF_d$ (years)**
Power and logic	225.60	259.20

Outputs

Function (Configuration)	**MTTF (years)**	**$MTTF_d$ (years)**
DOUT	8,218.40	8,218.40
DOUT/PVG PWR	4,717.30	4,717.30
PWMOUT/DOUT/PVGOUT	1,074.20	1,074.20

Device total

MTTF (years)	**$MTTF_d$* (years)**
68.30	71.00

* Assume worst-case scenario when all failures are determined to be *Dangerous* and the failure causes any change in device functionality.

A risk assessment should be performed to define the right configuration of the Input/Output (I/O) module.

The I/O modules can be configured to react in different ways to faulty conditions. For information about configuration of the I/Ot modules, please see *PLUS+1® Controller Family Technical Information*, **520L0719** and HWD documentation.

Terms and definitions

PFH and FIT

Failure rate per operational hour is also referred to as *lambda*.

PFH / lambda (Probability Failure Hour) = 1/MTTF (years) * 365 * 24

FIT (Failure In Time) = 1/MTTF (hours) * 10e-9

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