

Functional Safety

# Reliability Data (MTTF) for XM100



**Revision history***Table of revisions*

Date	Changed	Rev
January 2021	First Edition	0101

**Contents**

**Overview**

Reliability Data (MTTF/MTTFd)..... 4

**Standards and references**

Introduction.....5  
Assumptions.....5  
Standards.....5  
Calculations..... 5

**XM100 Component and calculation summary**

**Terms and definitions**

PFH and FIT..... 7

## Overview

### Reliability Data (MTTF/MTTFd)

#### General

The Mean Time to Failure (MTTF) and Mean Time to dangerous Failure (MTTFd) data included in this document was compiled by Danfoss engineering and experts with the technical expertise to determine the MTTF/MTTFd data for the product based on the standards set in place by the industry.

The purpose of this document is to assist in the transfer of MTTF and MTTFd data for the product from Danfoss to the appropriate party in a way which will result in a clear understanding of the product reliability information. MTTF and MTTFd information is provided to assist in calculating the overall MTTF/MTTFd of a complete or partially complete piece of machinery. MTTFd information may be required for functions where a failure can lead to a dangerous situation. The different methods used to calculate MTTFd values for specific functions are shown in .

---

If the related product/subsystem is not explicitly mentioned to be a Safety Product, it is developed according to common quality principles (ISO 9001). Therefore, the can only be used as standard part within a Safety Function.

---

#### Disclaimer

Danfoss cannot be held responsible for the suitability of these calculated MTTF/MTTFd values for use in the calculation of the overall machinery MTTF/MTTFd values.

The MTTF/MTTFd values for the transmissions are based on a specific machine use, specific functions, operating environment, and/or duty cycle as stated by the standards set in place by the industry and/or Danfoss. This communication along with any attached Danfoss drawings, sketches, or data is transmitted in confidence. No information stated in this document or any attachments or supplements may be reproduced or disclosed in whole or in part without written permission of Danfoss. Further, neither these documents nor any attachments are a warranty of any sort by Danfoss or a guarantee of machine suitability for its intended purpose. It remains the responsibility of the machine manufacturer to ensure overall machine functionality and overall machine safety.

## 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<sub>d</sub> and PFH is categorized as a mismatch between expected and measured signal.

For logic and outputs, failure included in MTTF<sub>d</sub> 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

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

### Calculations

---

Probability does not consider CAN communication external issues.

---

## XM100 Component and calculation summary

### Per Function Data

Function (Configuration)	Function (Configuration) [internal name]	MTTF [years]	MTTFd [years]*	ISO 13849 Diagnostic Coverage [%]
DIN/AIN/FreqIN/ResIN/CrntN (Digital)	DAFRC3 (Digital)	4,560.2	4,560.2	18%
DIN/AIN/FreqIN/ResIN/CrntN (Analog)	DAFRC3 (Analog)	4,303.8	4,303.8	17%
DIN/AIN/FreqIN/ResIN/CrntN (Frequency)	DAFRC3 (Frequency)	4,347.5	4,418.7	17%
DIN/AIN/FreqIN/ResIN/CrntN (Rheostat)	DAFRC3 (Rheostat)	3,994.1	3,999.2	16%
DIN/AIN/FreqIN/ResIN/CrntN (Current)	DAFRC3 (Current)	3,808.9	3,816.8	15%
DIN/AIN/CANx SHIELD (Analog)	DA3 (Analog)	14,519.7	14,519.7	5%
DIN/AIN/CANx SHIELD (Digital)	DA3 (Digital)	17,972.4	17,972.4	6%
DIN (Digital)	D2 (Digital)	18,850.1	18,850.1	0%
GNSS	GNSS	118.1	118.8	92%
<b>Power and Logic</b>				
Power and Logic	Power and Logic	29.6	30.5	97%
<b>Output</b>				
DOUT	DOUT14	1,231.9	3,083.7	45%
Sensor PWR	5V_SNSR3	8,380.6	9,548.0	74%
Audio	Audio	9,178.3	11,780.9	90%
#N/A	0	2,860.2	2,860.2	97%
#N/A	0	8,554.5	9,638.9	47%
#N/A	0	1,646.9	1,665.9	96%

\* Assume worst case scenario where all failures are determined to be "Dangerous if the failure causes any change in device functionality"

### Device Total

IEC 61508 Safe Failure Fraction [%]		ISO 13849 Diagnostic Coverage [%]		MTTF [years]	MTTF*[years]
S <sup>1</sup>	1.13E-07	DD <sup>2</sup>	4.66E-06	22.4	22.9
DD <sup>2</sup>	4.66E-06	DU <sup>3</sup>	3.31E-07		
DU <sup>3</sup>	3.31E-07	DC <sup>††</sup>	93.37		
SFF <sup>‡</sup>	93.52				

\* Assume worst case scenario where all failures are determined to be "Dangerous if the failure causes any change in device functionality"

<sup>1</sup> Safe Failure

<sup>2</sup> Dangerous Detected Failure

<sup>3</sup> Dangerous Undetected Failure

<sup>††</sup> DC is the ratio of the rate of detected dangerous failures compared to the rate of all dangerous failures

<sup>‡</sup> SFF is the probability of failing in a safe state

## Terms and definitions

### PFH and FIT

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

**PFH / lambda (Probability Failure Hour)** =  $1/\text{MTTF (years)} * 365 * 24$

**FIT (Failure In Time)** =  $1/\text{MTTF (hours)} * 10\text{e-}9$

**Products we offer:**

- Cartridge valves
- DCV directional control valves
- Electric converters
- Electric machines
- Electric motors
- Gear motors
- Gear pumps
- Hydraulic integrated circuits (HICs)
- Hydrostatic motors
- Hydrostatic pumps
- Orbital motors
- PLUS+1® controllers
- PLUS+1® displays
- PLUS+1® joysticks and pedals
- PLUS+1® operator interfaces
- PLUS+1® sensors
- PLUS+1® software
- PLUS+1® software services, support and training
- Position controls and sensors
- PVG proportional valves
- Steering components and systems
- Telematics

**Danfoss Power Solutions** is a global manufacturer and supplier of high-quality hydraulic and electric components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market as well as the marine sector. Building on our extensive applications expertise, we work closely with you to ensure exceptional performance for a broad range of applications. We help you and other customers around the world speed up system development, reduce costs and bring vehicles and vessels to market faster.

Danfoss Power Solutions – your strongest partner in mobile hydraulics and mobile electrification.

**Go to [www.danfoss.com](http://www.danfoss.com) for further product information.**

We offer you expert worldwide support for ensuring the best possible solutions for outstanding performance. And with an extensive network of Global Service Partners, we also provide you with comprehensive global service for all of our components.

Local address:

**Hydro-Gear**

[www.hydro-gear.com](http://www.hydro-gear.com)

**Daikin-Sauer-Danfoss**

[www.daikin-sauer-danfoss.com](http://www.daikin-sauer-danfoss.com)

**Danfoss  
Power Solutions (US) Company**  
2800 East 13th Street  
Ames, IA 50010, USA  
Phone: +1 515 239 6000

**Danfoss  
Power Solutions GmbH & Co. OHG**  
Krokamp 35  
D-24539 Neumünster, Germany  
Phone: +49 4321 871 0

**Danfoss  
Power Solutions ApS**  
Nordborgvej 81  
DK-6430 Nordborg, Denmark  
Phone: +45 7488 2222

**Danfoss  
Power Solutions Trading  
(Shanghai) Co., Ltd.**  
Building #22, No. 1000 Jin Hai Rd  
Jin Qiao, Pudong New District  
Shanghai, China 201206  
Phone: +86 21 2080 6201

Danfoss can accept no responsibility for possible errors in catalogues, brochures and other printed material. Danfoss reserves the right to alter its products without notice. This also applies to products already on order provided that such alterations can be made without subsequent changes being necessary in specifications already agreed. All trademarks in this material are property of the respective companies. Danfoss and the Danfoss logotype are trademarks of Danfoss A/S. All rights reserved.