Commissioning and safety manual

CNL25IGD
CNL25IGDH

SIL2

Following of document	Date	Index
Initial version	03/04/19	00
minor change	18/10/19	01

LOREME 12, rue des Potiers d'Etain Actipole BORNY - B.P. 35014 - 57071 METZ
Téléphone 03.87.76.32.51 - Télécopie 03.87.76.32.52
Nous contacter: Commercial@Loreme.fr - Technique@Loreme.fr
Manuel téléchargeable sur: www.loreme.fr

writing : KR
verified : PH
Approved : SA

Table of content

LOREME 12, rue des Potiers d'Etain - 57071 Metz ☎ 03.87.76.32.51 - Fax 03.87.76.32.52 - Email: Commercial@Loreme.fr - Technique@Loreme.fr

1 Introduction

1.1 General information

This manual contains necessary informations for product integration to ensure the functional safety of related loops.
All the failure and the HFT of the module are specidied in the FMEA analysis

Other relevant documents:
- Technical datasheet CNL25igD
- UE conformity declaration CNL25igD (available in the EMC part of this manual)
- FMEA analysis AMDEC CNL25igD

The mentioned documents are available on www.loreme.fr

The assembly, installation, commissioning and maintenance can only be performed by trained personnel, qualified and have read and understood the instructions in this manual.

When it is not possible to correct the defects, the equipment must be decommissioned, precaution must be taken to protect against accidental use. Only the manufacturer can bring the product to be repaired.

Failure to follow advice given in this manual can cause a deterioration in security features, and damage to property, environment or people.

1.2 Functions and intended uses

The transmitter CNL25igD ensures the temperature measurement from a RTD, PT100 sensor or a thermocouple and provide on output an isolated 4-20mA analog current in two wires technology. With or without Hart protocol.

The devices are designed, manufactured and tested according to security rules.
They should be used only for the purposes described and in compliance with environmental conditions contained in the data sheet: http://www.loreme.fr/fichtech/CNL25IGD.pdf

1.3 Standards and Guidelines

The devices are evaluated according to the standards listed below:

• Functional safety according to IEC 61508, 2000 edition:
Standard for functional safety of electrical / electronic / programmable electronic relative to electronic safety.

The evaluation of the material was performed by "*failure modes and effects analysis"*
(IEC 60812 - Issue 2 - 2006)
to determine the device safe failure fraction (SFF)

The FMEA is based on (IEC 62380-2004) reliability data handbook. Universal model for reliability prediction of electronics components, PCBs and equipment and on manufacturer data.

1.4 Manufacturer information

LOREME SAS
12, rue des potiers d'étain 57071 Actipole Metz Borny
www.loreme.fr

Programmable, isolated temperature transmitter, 4..20mA loop powered, option SIL2 CNL25igD

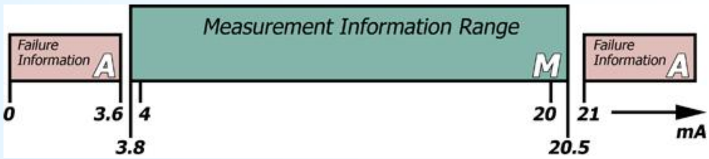
2 Safety function and safety state

2.1 Safety function

The safety function of the device is completed, as long as the outputs reproduce the input current (4 ... 20 mA) with a tolerance of + / -2%. The operating range of the output signal goes from 3.8 mA to 20.5 mA

2.2 Safety fallback position (according NAMUR NE 43)

The safety fallback state is defined by output current outside the range of 3.6 mA to 21mA.
• Either an output current <3.6 mA
• Either an output current> 21 mA



The application should always be configured to detect the current value out of range (<3.6 mA -> 21 mA) and considered "faulty ". Thus, in the FMEA study, this condition is considered as **not dangerous**.
The reaction time for all the safety functions is <200 ms.

WARNING! the burn out value is freely programmable, on CNL25igD, it is up to the installer to verify compatibility with process safety (factory burn out value is programmed at : 21 mA)

3 Safety Recommendation

3.1 Interfaces

The device has the following interfaces :

• safety interfaces : temperature input, analog output

• not safety interfaces : HART communication (diagnostic and configuration), serial link RS232 (device configuration)

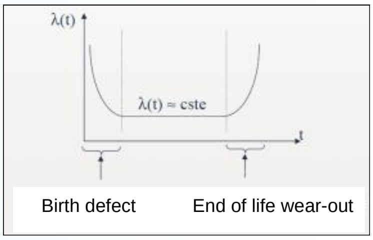
HART communication is not relevant for functional safety, loss of communication is considered as detected by the application, therefore, in the FMEA study, this condition is considered as not dangerous.

3.2 Configuration / Calibration

the device configuration is required to define the operating mode (sensor type, measurement range, burn out value) refer to the configuration handbook.
the calibration is only possible by return to factory, no changes should be made to the device.

3.3 Useful lifetime

Evolution of failure rate



Although a constant failure rate is assumed by the probabilistic estimation, that it applies only to the useful lifetime of components.
Beyond this lifetime, the probability of failure is increasing significantly with time.
The useful lifetime is very dependent components themselves and operating conditions such as temperature, particularly (Electrolytic capacitors are very sensitive to temperature).

This assumption of a constant failure rate is based on the bathtub curve, which shows the typical behavior of electronic components.
Therefore, the validity of this calculation is limited to the useful life of each component.
It is assumed that early failures are detected for a very high percentage during the burn in and the installation period, assuming a constant failure rate during the useful life remains valid.
according to IEC 61508-2, a useful lifetime based on the feedback, must be considered.
Experience has shown that the useful lifetime is between 15 and 20 years, and may be higher if there are no components with reduced lifetime in security function.
(Such as electrolytic capacitors, relays, flash memory, opto coupler)
and if the ambient temperature is well below 60 °C.

Note:

The useful lifetime corresponds to constant random failure rate of the device.
The effective lifetime may be higher.

User must ensure that the device is no longer necessary for the security before its disposal.

 LOREME 12, rue des Potiers d'Etain - 57071 Metz ☎ 03.87.76.32.51 - Fax 03.87.76.32.52 - Email: Commercial@Loreme.fr - Technique@Loreme.fr

Programmable, isolated temperature transmitter, 4..20mA loop powered, option SIL2 *CNL25igD*

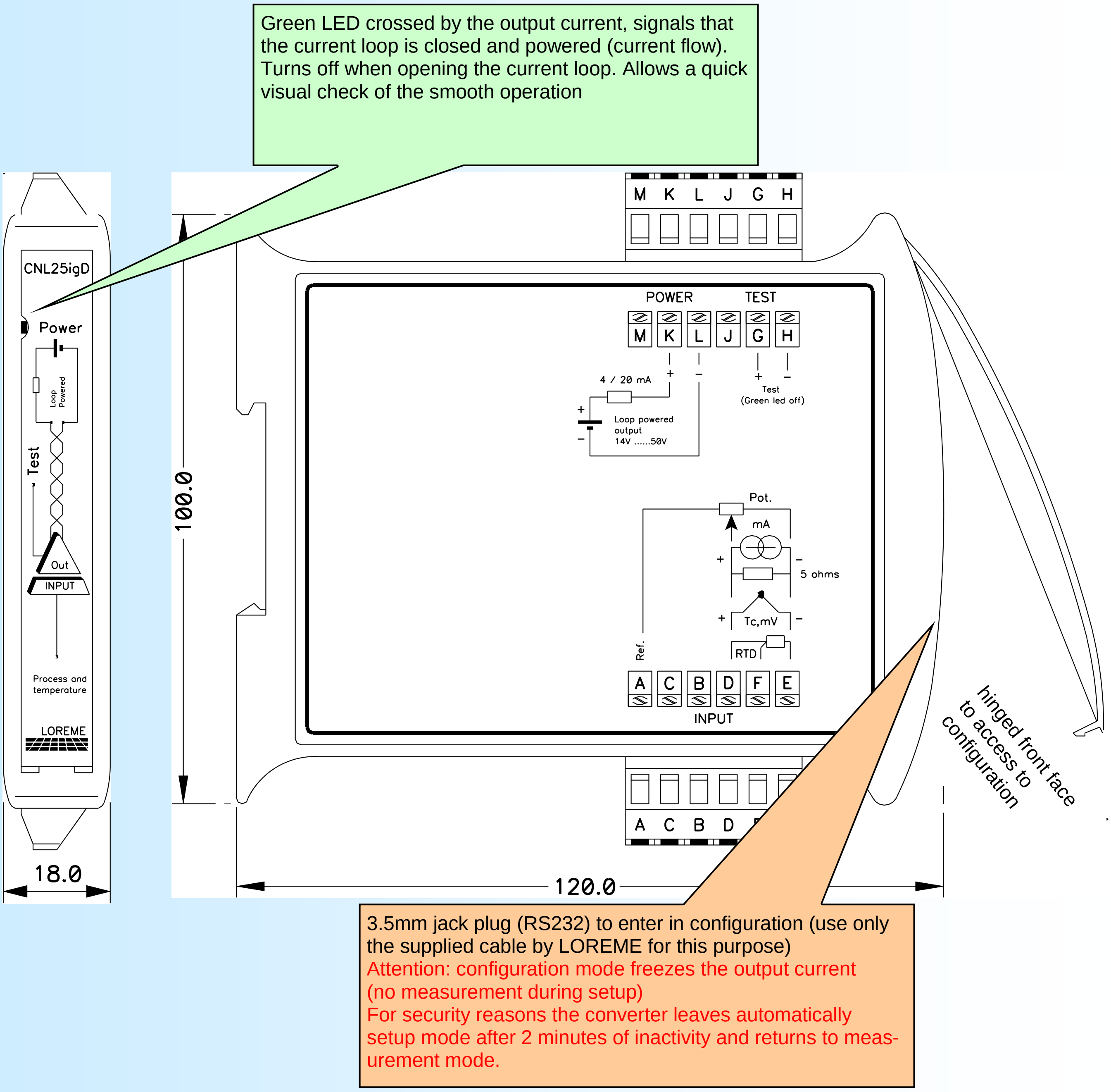
LOREME

4 Installation, commissioning and replacement

Operating capacity and current error reporting should be checked
during commissioning (validation) see section: "**commissioning and periodic proof**"
and at appropriate intervals recommended in paragraph: " **proof interval** "
Any device that does not satisfy the commissioning control must be replaced.

WARNING!
No user maintenance should be conducted, a defective device must be replaced by a new device of the same type. For a repair return or a recalibration, it is very important that all types of equipment failures are reported to allow the company to take corrective action to prevent systematic errors.

4.1 External description



4.2 Electrical connection and configuration

*** power supply and analog output :** terminal K+ and terminal L -
The device is protected against reverse polarity of power supply

*** Input** : two configurations are possible, PT100 and thermocouple
- Connection for Thermocouple input : Tc+ terminal D ; Tc- terminal E
- Connection for 3 wires RTD (PT100) input : white wire terminal E ; two red wire on terminal F and D

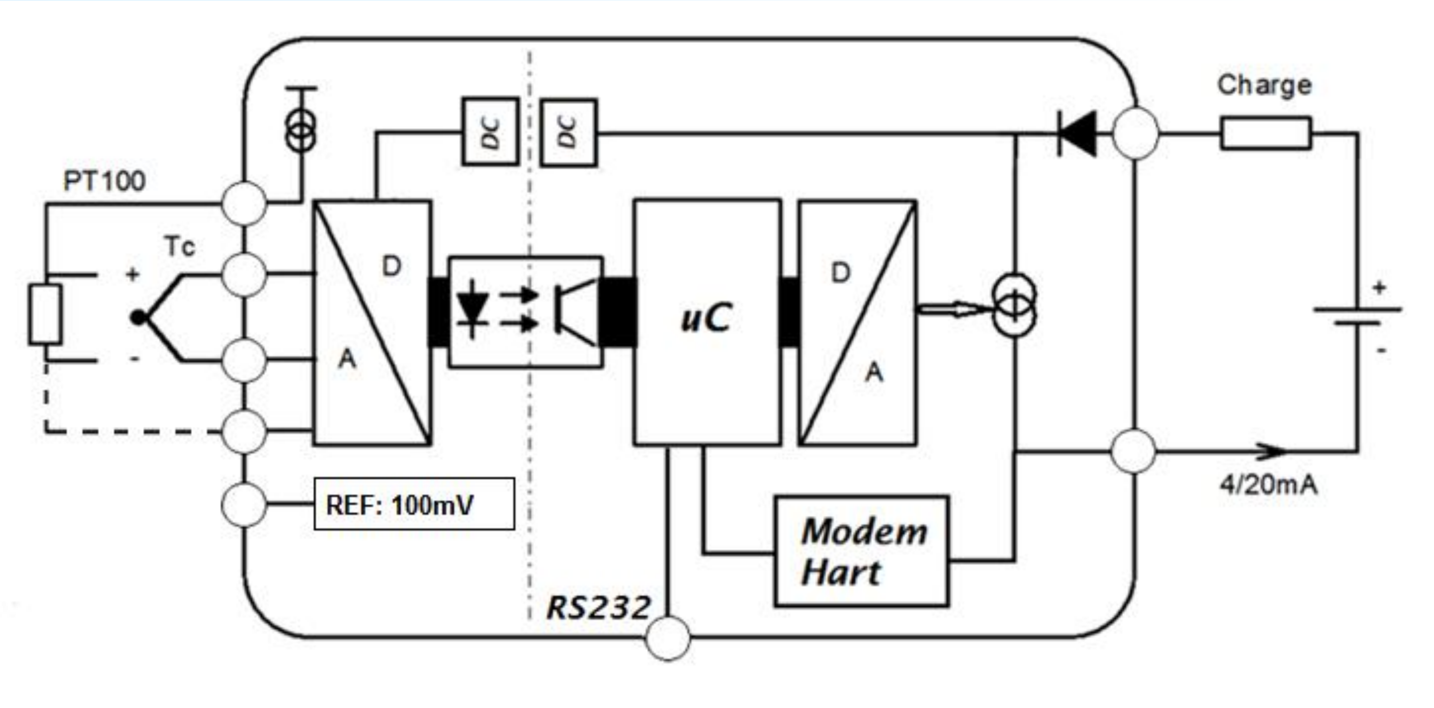
Notes:
- For remote thermocouple, make sure that the extension is made with compensation cable of the same type as the thermocouple, with respect to the cable polarity.
- For a remote Pt100 sensor, make sure the extension cable used has 3 conductors with same cross section to ensure the best line compensation.
- Ensure the proper choice of sensor type in the configuration.
- The temperature range programmed into the controller and the converter must be identical.
- The burn out value (Sensor break detection) of the analog output must be programmed <3.6mA at or> = to 21mA (21mA factory)

WARNING!

Do not exceed the specifications of the data sheet, to ensure safe operation of the analog output it is necessary to have:
- an auxiliary voltage supply range between 15 volts and 40 volts
- maximum load in the loop, calculated so that the residual voltage across the converter is 15V for a loop current of 21 mA.

Be careful, exceeding 4 ... 20mA loop load ,can prevent the output current to reach the burn out value
it may saturate in the measurement range , and place the system in a dangerous state.

4.3 Wiring



LOREME 12, rue des Potiers d'Etain - 57071 Metz ☎ 03.87.76.32.51 - Fax 03.87.76.32.52 - Email: Commercial@Loreme.fr - Technique@Loreme.fr

5 Commissioning and periodic proof

The periodic test procedure is defined by LOREME and must be followed by the end user to ensure and guarantee the SIL level over time.
Periodic testing should be performed following the procedure defined below and at the intervals defined under paragraph **" proof interval "**

5.1 control steps

Periodic proof allows detection of possible product internal failure and loop calibration.
environmental conditions and a minimum heating time of 5 minutes must be respected.

Transmitter test and complete output Loop control (*the system is unavailable during the test*)
1. If necessary, bypass the security system and / or take appropriate provision to ensure safety during the test.
2. Check the device aspect, no visible damage or pollution (oxidation).
3. Using a current simulation device (note 1), set the input current to high alarm value (≥ 21.0 mA).
3. Insert a milliammeter* in the output loop
4. Disconnect the sensor (Pt100 or thermocouple)
5. Verify that the output current goes into burn out value (<= 3.6mA or> = 21mA)
6. Connect a simulator* at the input of the converter (Pt100 or thermocouple) in place of the sensor
7. Simulate the appropriate temperature values across the converter (on 5 points : 0%, 25%, 50%, 75%, 100%)
   and check that the output current (4..8..12..16..20mA) is proportional to the input to + / -2% near
8. Disconnect the simulator and reconnect the sensor to the transmitter input
   (check that the output current is in the measurement range)
9. Remove milliammeter and close the output loop (green LED must light)
10. After testing, the results should be documented and archived.

Any device that does not satisfy the control needs to be replaced.

*note *: milliammeter, and the simulator must be calibrated on a regular basis for this test (depending on the state of the art and best practice)*

5.2 proof interval

According table 2 from CEI 61508-1 the PFDavg ,for systems operating in low demand mode,
must be between $\geq 10^{-3}$ and $<10^{-2}$ for SIL2 safety functions and between $\geq 10^{-4}$ and $<10^{-3}$ for SIL3 safety functions.

λ safe detected	λ dangerous detected	λ safe undetected	λ dangerous undetected = PFH	**SFF**
420 FIT	0 FIT	17 FIT	21 FIT	95.4%

Temperature conditions : 30°C

PFDavg **value depending proof interval**

T[Proof] **= 1 year**	**T**[Proof] **= 5 year**	**T**[Proof] **= 10 year**	**T**[Proof] **= 20 year**
PFDavg=$9.20E^{-05}$	**PFD**avg=$4.60E^{-04}$	**PFD**avg=$9.20E^{-04}$	**PFD**avg=$1.8E^{-03}$

approximation : PFDavg = λdangerous x T[Proof] /2 (error caused by approximation < 3%)

Fields marked in green means that the calculated values of PFDavg are within the limits allowed for SIL2

summary :

Probability of default: PFD = 9.20 E^{-5} x Tproof [years]

either for Tproof = 5 years, 50 % of safety instrumented function in SIL2 category

Remarks :

- Test intervals should be determined according to the PFDavg required .

- The SFF , PFDavg and PFH must be determined for the entire safety instrumented function (SIF)
ensuring that the " out of range current values" are detected at system level and they actually lead to the safety position.

Annex 1: EMC consideration

1) Introduction:

In order to satisfy its policy of Electromagnetic compatibility, based on the EU Directive 89/336/EC,
LOREME company takes into account the standards relative to this directive early in the design of each product.
All tests performed on devices designed to work in industrial environment, are compliant to EN 50081-2 and EN 50082-2 in order to establish the EMC compliance certificate.
The devices being in some typical configurations during the test,
it is impossible to guarantee results in all possible configurations.
To ensure optimum operation of each device ,it would be judicious to comply with several recommendations of use.

2) Recommendations:

2.1) General information:

- Comply with the mounting recommendations (mounting direction, devices spacing ...) specified in the datasheet.
- Follow the recommendations of use (temperature range, protection) specified in the datasheet.
- Avoid dust and excessive moisture, corrosive gases, sources of heat.
- Avoid disturbed environments and disruptive phenomena.
- If possible, group together the instrumentation devices in a zone separated from the power and relay circuits.
- Avoid close proximity with remote switches for high power, contactors, relays, SCR ,...
- Do not approach within two feet of a device with a walkie-talkie (5 W output power), because it creates a electromagnetic field with an intensity greater than 10 V / M for a distance of less than 50 cm.

2.2) Power supply:

- Observe the characteristics specified in the datasheet (Voltage and frequency tolerance).
- It is preferable that the power comes from a system with section switches equipped with fuses for instrumentation components, and the supply line is the most direct route possible from the section switch. Avoid using this power supply to control relays, contactors, solenoid valves, …
- If the power circuit is heavily disturbed by SCR switching , motor, inverter, ... it may be necessary to install an isolation transformer specifically for instrumentation and connecting the screen to ground.
- It is also important that the installation has a good grounding, and preferable that the voltage compared to neutral does not exceed 1V, and the ground resistance less than 6 ohms.
- If the installation is located near high frequency generators or arc welding, it is preferable to mount adequate power line filter.

2.3) Inputs / Outputs:

- In harsh conditions, it is advisable to use sheathed twisted cables whose ground braid will be grounded at on point.
- It is advisable to separate the input/output lines from the power supply lines in order to avoid the coupling phenomena.
- It is also advisable to minimize the lengths of data cables.

LOREME 12, rue des Potiers d'Etain - 57071 Metz ☎ 03.87.76.32.51 - Fax 03.87.76.32.52 - Email: Commercial@Loreme.fr - Technique@Loreme.fr

DECLARATION OF CONFORMITY

SIL2 — Safety Integrity Level — IEC 61508 / IEC 61511

REV1
Page 1/1

The LOREME society declare under its sole responsibility, that the following product :

Designation: **2 wires temperature transmitter**

Type: **CNL25igD**

Revision : 1 date : 16/06/2016

Can be used for functional safety applications up to SIL2 according to standard IEC61508-2: 2000 respecting the safety instructions specified in the safety manual .

The assessment of the safety critical and dangerous random errors lead to the following parameters :

device with type B components , Hardware fault tolerance HFT = 0
values for the converter only (worst case)

λ safe detected	**λ** dangerous detected	λ safe undetected	λ dangerous undetected = PFH	**SFF (1)**	**PFD**avg **T**[Proof] **= 1 year**	**PFH**
420 FIT$_{(2)}$	0 FIT$_{(2)}$	17 FIT$_{(2)}$	21 FIT$_{(2)}$	95.4%	9.20E^{-05}	2.1E^{-08} 1/h

(1) according to FMEA CNL25igD rev2 *established with "ALD MTBF calculator" : http://www.aldservice.com/*
(2) FIT = Failure rate (1/h)

The safety manual gives the failure probabilities of associated sensors (Pt100 and thermocouple) to allow the evaluation of a complete loop.

Metz : 16/06/16

Signed on behalf of LOREME ; M. Dominique Curulla

Temperature Transmitter CNL25igD rev2

FMEA Details

Context

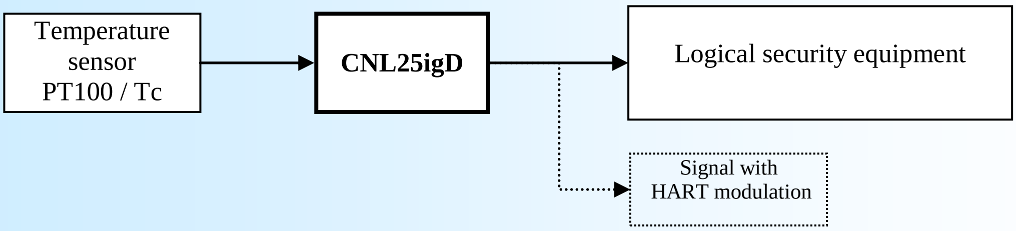
This document details the Failure Mode and Effects Analysis (FMEA) of CNL25igD component of society LOREME. Besides the characterization of the information necessary for safe operation (especially for availability calculations and constitution of stock of spare parts), this study can meet the requirements of IEC-61508 standard for identifying and quantifying dangerous failures of the component, allowing to interact with the design to avoid or reduce these risks.

Circumstances of the analysis

This study was conducted in order to verify the ability of the CNL25igD converter to be used in SIL2 applications.

Scope of analysis

The component concerned includes an electronics component assembly dedicated to the acquisition of input signals from temperature sensors in order to reconstitute an analog output signal (4 .. 20 mA) with or without HART communication. Typically, a converter is interfaced between a sensor and protection equipment, referred to as "logical security equipment"



Characterization of the component
The CNL25igD converter is a type « B » subsystem [CEI61508-2-§ 7.4.3.1.2] :
The components failure modes necessary for achieving the safety function are well defined.
The transmitter behavior in fault conditions is fully determined.
The converter has a feedback in many security applications.

Safe failure
[CEI61508-4-§3,6.8] Safe failure : Failure that has no potential to put the safety system in a dangerous state or unable to perform its function.
A safe failure is a failure that is not hazardous. Also known as secure failure.

SFF [CEI61508-2-§7.4.3.1.1-d] Safe failure fraction is the ratio of the sum of safe failure rate λS of a subsystem plus the dangerous detected failure rate λDD of the subsystem divided by to the total failure rate of the subsystem (total of safe failure λS plus dangerous failures λD).

$$SFF = \frac{\lambda_S + \lambda_{DD}}{\lambda_S + \lambda_D}$$

Dangerous Failure:
[CEI61508-4-§3,6.7] Failure which has the potential to put the safety instrumented system in a dangerous or fail−to−function state.

Functional Analysis

The transmitter consists of:
an input stage , analog digital converter
an isolation stage (ADC power and signal transmission)
a microcontroller (linearization, signal scaling and Hart communication)
an output stage (current amplifier)
and a modulator / demodulator for Hart signal

Definition of the feared event

For CNL25igD converter, the feared event (the dangerous failure, as defined in the previous section) is the emission of erroneous output current :
Either erroneous output current of more than 2% compared to the process demand.
Either an output current, blocked at a value such that it can not take a failsafe value :
output current locked in a range> 3.6 mA or <21mA.

Definition of the failsafe state

The failsafe state is defined by an output current out of the range of 3.6 mA….. 21mA.
Either an output current = <3.6 mA
Either an output current >= 21 mA
The burn out value of CNL25igD converter will necessarily be programmed for one of these values.
The application of the "logical Safety Equipment" program must absolutely be set to detect any current value out of range (=< 3,6 mA et >= 21 mA) and considered as "Invalids".
Therefore, in the FMEA study, this state is considered safe.

Study assumptions

The failure rate of the components are considered constant throughout the life of the system.
The evaluation of safety features of the module involves a number of assumptions:
Only the hardware aspect is covered. The aspect of dependability of the software is not discussed.
Only catalectic failures are taken into account : Frank failures, sudden and unpredictable.
Are not considered, the defects that may be due to:
- design errors,
- to defects in production batch,
- the environment (electrical interference, temperature cycling, vibration)
- human errors in operation or maintenance
(precautions are taken to avoid them: such as range value checks, consistency of Hardware ...)
only simple failures are handled. Solder defects, which are usually due to a lack of quality detectable after manufacturing by a specific burn-in, are not taken into account.
All specific aspects related to the power up phase are not covered.

Failure rate

Below the rate of basic component failures of CNL25igD converter
for a temperature around of the components of 30 ° C: (2 following pages)

Programmable, isolated temperature transmitter, 4..20mA loop powered, option SIL2 *CNL25igD*

LOREME

FMEA CNL25igD rev2

Etabli avec "ALD MTBF calculator" : http:// www.aldservice.com/

				selon IEC6-2380		répartition		λf = 1/MTBF				
								λfd		λfnd		
Count	RefDes	Pattern-Name	Value	λf (fit)	type	ratio	λf (fit)	λsd	λdd	λsnd	λdnd	effet
1	XC174	1206	0	0,02	co	100%	0,020	0,020				repli sortie > 21 mA
1	73	1206	1M 1% 50ppm	0,21	co	40%	0,084			0,084		drift sortie < 2%
					drift	60%	0,126			0,126		drift sortie < 2%
4	76	1206	1u X7R	0,21	co	30%	0,063			0,063		sans influence découplage vref
					cc	70%	0,147	0,147				repli sortie > 21 mA (vref=0)
	163	1206	1u X7R	0,21	co	30%	0,063			0,063		sans influence découplage modem hart
					cc	70%	0,147	0,147				plus de communication Hart
	XC169	1206	1u X7R	0,21	co	30%	0,063			0,063		plus de passe bas ligne
					cc	70%	0,147	0,147				plus de mesure de ligne (err < 2%)
	XC171	1206	1u X7R	0,21	co	30%	0,063			0,063		plus de passe bas entrée
					cc	70%	0,147				0,147	en tc non detecté / en pt rupture capteur
1	XC172	1206	2k5 1% 50ppm	0,02	co	40%	0,008				0,008	en tc non detecté / en pt rupture capteur
					drift	60%	0,012				0,012	dérive mesure (référence)
3	96	1206	2n2 NPO	0,07	co	10%	0,007			0,007		perte filtre reception Hart
					cc	70%	0,049	0,049				plus de communication Hart
					drift	20%	0,014			0,014		altération filtre Hart
	97	1206	2n2 NPO	0,07	co	10%	0,007	0,007				plus de communication Hart
					cc	70%	0,049	0,049				plus de communication Hart
					drift	20%	0,014			0,014		altération filtre Hart
	100	1206	2n2 NPO	0,07	co	10%	0,007			0,007		pas de filtre HF boucle 4..20 mA
					cc	70%	0,049	0,049				courant sortie > 21 mA (court circuit)
					drift	20%	0,014			0,014		sans influence
2	XC170	1206	5k 1% 50ppm	0,02	co	40%	0,008	0,008				repli sortie > 21 mA rupture capteur
					drift	60%	0,012			0,012		sans influence
	XC177	1206	5k 1% 50ppm	0,02	co	40%	0,008				0,008	mesure flottante
					drift	60%	0,012			0,012		sans influence
2	84	1206	7k5 1% 50ppm	0,02	co	40%	0,008	0,008				repli sortie < 3.6 mA
					drift	60%	0,012				0,012	dérive sortie
	XC166	1206	7k5 1% 50ppm	0,02	co	40%	0,008	0,008				rupture en PT / sans influence en tc
					drift	60%	0,012				0,012	dérive en pt / sans influence en tc
3	74	1206	10k 1% 50ppm	0,02	co	40%	0,008	0,008				repli sortie < 3.6 mA
					drift	60%	0,012				0,012	dérive sortie
	79	1206	10k 1% 50ppm	0,02	co	40%	0,008	0,008				plus de configuration RS232
					drift	60%	0,012			0,012		sans influence
	95	1206	10k 1% 50ppm	0,02	co	40%	0,008	0,008				plus de communication Hart
					drift	60%	0,012			0,012		sans influence
1	81	1206	10M 1% 100ppm	0,02	co	40%	0,008				0,008	plus de détection rupture tc
					drift	60%	0,012			0,012		sans influence
1	99	1206	23.7 1% 50ppm	0,02	co	40%	0,008	0,008				repli sortie < 3.6 mA
					drift	60%	0,012			0,012		dérive < 2%
1	83	1206	47u X7R	0,21	co	30%	0,063			0,063		plus de découplage uC
					cc	70%	0,147	0,147				repli sortie < 3.6 mA
2	67	1206	50k 1% 50ppm	0,02	co	40%	0,008	0,008				rupture capteur (ref à 0)
					drift	60%	0,012				0,012	dérive mesure (référence)
	78	1206	50k 1% 50ppm	0,02	co	40%	0,008	0,008				risque altération com RS232
					drift	60%	0,012			0,012		sans influence
4	77	1206	100n X7R	0,21	co	30%	0,063				0,063	ondulation courant de sortie
					cc	70%	0,147	0,147				repli sortie < 3.6 mA
	103	1206	100n X7R	0,21	co	30%	0,063			0,063		plus de decouplage AD
					cc	70%	0,147	0,147				rupture capteur AD plus alimenté
	105	1206	100n X7R	0,21	co	30%	0,063			0,063		plus de découplage XTR116
					cc	70%	0,147	0,147				courant sortie > 21 mA (court circuit)

LOREME 12, rue des Potiers d'Etain - 57071 Metz ☎ 03.87.76.32.51 - Fax 03.87.76.32.52 - Email: Commercial@Loreme.fr - Techni-

FMEA CNL25igD rev2

Count	RefDes	Pattern-Name	Value	selon IEC6-2380 λf (fit)	type	répartition ratio	λf (fit)	λf = 1/MTBF λfd λsd	 λdd	 λfnd λsnd	 λdnd	effet
	107	1206	100n X7R	0,21	co	30%	0,063	0,063				plus de découplage ref modem Hart, perte com
					cc	70%	0,147	0,147				plus de tension de ref modem Hart, perte com
2	98	1206	250k 1% 50ppm	0,02	co	40%	0,008	0,008				perte polarisation entrée modem hart, perte com
					drift	60%	0,012			0,012		sans influence
	106	1206	250k 1% 50ppm	0,02	co	40%	0,008	0,008				perte polarisation entrée modem hart, perte com
					drift	60%	0,012			0,012		sans influence
1	XC183	1206	500 1% 50ppm	0,02	co	40%	0,008	0,008				plus d'alimentation etage d'entrée rupture capteur
					drift	60%	0,012			0,012		sans influence
1	8	DC/DC 1W	LME1212S	286,00	co	50%	143,000	143,000				plus d'alimentation etage d'entrée rupture capteur
					cc	50%	143,000	143,000				plus d'alimentation etage d'entrée rupture capteur
1	13	LEDC-MSDUAL	LED	2,00	co	20%	0,400				0,400	risque dépassement charge en sortie
					cc	80%	1,600	1,600				plus d'alimentation etage d'entrée rupture capteur
1	2	MSOP10	LTC2402	37,00	out gnd	50%	18,500	18,500				rupture capteur plus de signal AD
					out vcc	50%	18,500	18,500				rupture capteur plus de signal AD
1	16	QFN20 0.65	DS8500	2,00	out gnd	50%	1,000	1,000				plus de communication Hart
					out vcc	50%	1,000	1,000				plus de communication Hart
1	1	QUARTZ HC49 CMS	3.6864 Mhz	5,00	cc	50%	2,500	2,500				plus de communication Hart
					co	50%	2,500	2,500				plus de communication Hart
1	6	SC70	TMP05	37,00	out gnd	33%	12,210	12,210				plus de t° de comensation
					out vcc	33%	12,210	12,210				plus de t° de comensation
						34%	12,580				12,580	dérive mesure erreur compensation
1	75	SO8	385 2v5	15,00	co	50%	7,500				7,500	dérive mesure alim AD non défini
					cc	50%	7,500	7,500				rupture capteur AD plus alimenté
1	18	SO8	ADuM1100A	12,00	out gnd	50%	6,000	6,000				rupture capteur plus de signal AD
					out vcc	50%	6,000	6,000				rupture capteur plus de signal AD
1	69	SO8	XTR116	19,00	out gnd	50%	9,500	9,500				repli sortie > 21 mA
					out vcc	50%	9,500	9,500				repli sortie < 3.6 mA
2	148	SOD8	4148	10,00	co	20%	2,000	2,000				repli sortie < 3.6 mA (ouverture boucle)
					cc	80%	8,000			8,000		sans influence, plus de protection inversion polarité
	149	SOD8	4148	10,00	co	20%	2,000	2,000				plus d'alimentation modem Hart, perte com
					cc	80%	8,000			8,000		tension modem Hart hors spécifications
1	5	SSOP28-0.65	16F886	20,00	outgnd	50%	10,000	10,000				repli sortie < 3.6 mA
					out vcc	50%	10,000	10,000				repli sortie > 21 mA
								420,029	0,000	16,827	20,774	
			somme fit :	457,63			457,63	(verif)		SFF=	95,46%	
			MTBF =	2 185 171	Hrs					DC=	91,78%	

Annexe 2 :
Using FMEA data and additional information about temperature sensors.

The CNL25igD converter connected to a temperature sensor in a temperature probe becomes an assembly. Therefore, when using the results of the FMEA in a SIL assessment, the failure rate of the sensors (Pt100 or thermocouple) must be taken into account for the calculation of the safety instrumented function (SIF)

Below are the summary of failure modes and frequencies for PT100 and thermocouples depending on the type of connection and the environment in which they are used.

Typical failure rates of thermocouples and PT100 with extension cable (remote sensor)

sensor type and process conditions	failure rate (FIT)
thermocouple in low stress environment	1000
thermocouple in high stress environment	20000
2 or 3 wires Pt100 in low stress environment	475
2 or 3 wires Pt100 in high stress environment	9500
4 wires Pt100 in low stress environment	500
4 wires Pt100 in high stress environment	10000

Typical failure rates of thermocouples and PT100 without extension cable (sensor with included transmitter)

sensor type and process conditions	failure rate (FIT)
thermocouple in low stress environment	100
thermocouple in high stress environment	2000
2 or 3 wires Pt100 in low stress environment	48
2 or 3 wires Pt100 in high stress environment	960
4 wires Pt100 in low stress environment	50
4 wires Pt100 in high stress environment	1000

Typical distribution of failure mode for thermocouples

Failure mode	With extension cable	Direct connection without extension
open circuit	90%	95%
short circuit	5%	4%
drift *	5%	1%

** the drift phenomenon of the thermocouples is essentially due to aging*

Typical distribution of failure mode for PT100

Failure mode	With extension cable	Direct connection without extension
open circuit	78%	79%
short circuit	2%	3%
drift	20%	18%

The failure rate distribution depends slightly of the type of pt100 connection (2,3,4 wires)

stress conditions are: strong vibrations on the process and or frequent temperature cycles, these events that cause substrate cracks and broken welds on the connecting cables.

LOREME 12, rue des Potiers d'Etain - 57071 Metz ☎ 03.87.76.32.51 - Fax 03.87.76.32.52 - Email: Commercial@Loreme.fr - Techni-

Appendix : term and definitions.

SIL stands for "Security Integrity Level", which is the level of integrity of security. The concept of SIL has been introduced in the IEC61508 standard and is incorporated in standards derived from IEC61508, such as the IEC61511 standard for safety instrumented systems (SIS) for processes and IEC62061 for safety systems with programmable electronics for machines.
When you want to make a security application, you have to start by assessing the risk (its dangerousness, its frequency of occurrence), which leads to defining the security requirements that we expect from the SIS. to say its SIL.
Ultimately, the SIL defines the level of reliability of the SIS. There are two ways to define the SIL, depending on whether the security system operates in low demand mode or if on the contrary it operates continuously or with high demand. There are 4 levels of SIL (rated SIL1 to SIL4) higher the SIL level, higher the availability of the security system.
For **Safety system operating in low demand mode**,
The failure measure is based on average Probability of dangerous Failure on Demand (PFD_{avg}) with a 10 years period.
The relationship between SIL level and PFDavg are following:
SIL 4 : PFDavg from 10^{-5} to 10^{-4}
SIL 3 : PFDavg from 10^{-4} to 10^{-3}
SIL 2 : PFDavg from 10^{-3} to 10^{-2}
SIL 1 : PFDavg from 10^{-2} to 10^{-1}
For **Safety system operating in high demand mode,**
The failure measure is based on average Frequency of Dangerous failure per hour. relationship between level and PFH are following:
SIL 4 : PFH from 10^{-9} to 10^{-8}
SIL 3 : PFH from 10^{-8} to 10^{-7}
SIL 2 : PFH from 10^{-7} to 10^{-6}
SIL 1 : PFH from 10^{-6} to 10^{-5}

SIL levels scale :

	Mode of operations		
SIL*	Low demand PFD**	High demand PFH***	Risk reduction factor
4	$\geq 10^{-5}$ to $<10^{-4}$	$\geq 10^{-9}$ to $<10^{-8}$	10 000 to 100 000
3	$\geq 10^{-4}$ to $<10^{-3}$	$\geq 10^{-8}$ to $<10^{-7}$	1 000 to 10 000
2	$\geq 10^{-3}$ to $<10^{-2}$	$\geq 10^{-7}$ to $<10^{-6}$	100 to 1 000
1	$\geq 10^{-2}$ to $<10^{-1}$	$\geq 10^{-6}$ to $<10^{-5}$	10 to 100

**** Safety integrity level***
***** Probability of Failure on low Demand***
****** Probability of a dangerous Failure per Hour***

Abbreviation	Description
HFT	Hardware Fault Tolerance, capability of a functional unit to continue the execution of the demanded function when faults or anomalies exist.
MTBF	Mean interval between two failures
MTTR	Mean interval between the occurrence of the failure in a device or system and its repair
PFD	Probability of a dangerous failure of a system on demand
PFDavg	Average of probability of dangerous failure of a system on demand
SIL	Safety Integrity Level, the international standard IEC 61508 defines four discrete safety integrity levels (SIL1 to SIL4). Each level corresponds to a specific probability range with respect to the failure of a safety function. The higher the integrity level of the safety-related system, the lower the likelihood of the demanded safety functions not occurring.
SFF	Safe Failure Fraction, the proportion of failures without the potential to put the safety-related system into a dangerous or impermissible functional state.
TProof	In accordance with IEC 61508-4, chapter 3.5.8, TProof is defined as the periodic testing to expose errors in a safety-related system.
XooY	Classification and description of the safety-related system with respect to redundancy and the selection procedure used. "Y" indicates how often the safety function is carried out (redundancy). "X" determines how many channels must work properly.
λsd and λsu	λsd Safe detected + λsu Safe undetected Safe failure (IEC 61508-4, chapter 3.6.8): A safe failure is present when the measuring system switches to the defined safe state or the fault signaling mode with out the process demanding it.
λdd and λdu	λdd Dangerous detected + λdu Dangerous undetected Unsafe failure (IEC 61508-4, chapter 3.6.7): Generally a dangerous failure occurs if the measuring system switches into a dangerous or functionally inoperable condition.
λdu	λdu Dangerous undetected. A dangerous undetected failure occurs if the measuring system doesn't switch into a define safe state, or into an alarm signaling mode on process demand.