# SMART HEATER REQUIREMENTS

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# 1  Operation Requirements

Req  1.1 The device shall sense the temperature of an user's cabin.

Req  1.2 The device shall be able to measure temperatures from -40°C to 60°C.

Req  1.3 The device shall have a maximum error of ±3°C.

Req 1.4 The temperature sensor shall give feedback to the device.

Req 1.5 Temperature sensor feedback shall be used by the device to perform a control action that enables a fan to maintain a temperature regardless of perturbation within tolerance established by requirement 1.3.

Req 1.6 The device shall send a message with the actual temperature of the device.

Req 1.7 Vibration or audio sensor shall be used by the device to send a message to prevent a failure in the fan.

# 2  Systems requirements:

## 2.1 Mechanical

### 2.1.1   Wiring

Req  2.1.1.1 The device shall have all its electrical connections electrically isolated.

Req  2.1.1.2 The device AWG should not be lower than AWG 18.

## 2.2 Hardware

### 2.2.1   Protection and Diagnostics

Req  2.2.1.1  The device shall be able to detect the following failure conditions:

| **Fault Mode Indicator Name (FMI):** |
| --- |
| Data Valid but Above Normal Operational Range |

| | |
|---|---|
| | Data Valid but Below Normal Operational Range |
| | Data Erratic, Intermittent or Incorrect |
| | Voltage Above Normal, or Shorted to High Source |
| | Voltage Below Normal, or Shorted to Low Source |
| | Current Below Normal or Open Circuit |
| | Current Above Normal or Grounded Circuit |

Req 2.2.1.5  The device shall stop operation when any failure condition is triggered.

## 2.2.2    Pinout and Wiring

Req  2.2.2.1 The device shall have a DB9 connector.

Req  2.2.2.2 The connector pinout shall be defined as follows.

| PINOUT | Color |
|---|---|
| +12V | Red |
| CAN+ | Yellow |
| CAN- | Green |
| GND | Black |

Req  2.2.2.3 The device shall use a dedicated pin for short circuit detection.

Req  2.2.2.4 The device shall use a dedicated pin for high impedance state detection.

Req  2.2.2.5 The device shall use a dedicated pin for variable measurement.

Req  2.2.2.6 The device shall have a 1.5 meters harness with wires specifications given by Req 2.2.2.1 so it can be connected to its 4-pin socket and to another similar 4-pin socket.

## 2.2.3    Hot End

Req  2.2.3.1 The system shall have a "hot end" device to regulate its heat based on the desired set point with the error defined in Req.1.3

## 2.2.4    Display

Req 2.2.3.1 The system shall have a digital display to send the desired set point and see the actual temperature.

# 2.3 Software

## 2.3.1 Communications

Req 2.3.1.1 The device shall transmit its information only when it receives a request from another device.

Req 2.3.1.2 When a failure is detected, measurement data transmitted shall be 0xFF.

Req 2.3.1.2 PGN and SPN for this device shall be 65262 and 110 respectively

Req 2.3.1.3 When a DTC is triggered the device shall send SPN and FMI in message data as established by J1939 protocol.

| PGN 61495 Temperature Heater Setpoint | |
|---|---|
| Parameter Group Number | 61490 (0x00F037) |
| Data length | 8 bytes |
| Default priority | 1 |
| Suggested Rep. Rate | 20ms |
| Destination Address: | |
| DPQ | 0 (0x00) |
| PDU Format | 240 (0xF0) |
| PDU specific | 55 (0x37) |
| PDU Type | PDU 2 |
| Transmission repetition rate | 20ms |
| Variable length | No |
| | |

| Byte(s) | Bit(s) | SPN | SPN Description |
|---|---|---|---|

| 1 | 1 - 8 | 5825 | Measured Temperature |
|---|-------|------|----------------------|

## SPN5825 – Measured temperature

| | |
|---|---|
| **Parameter size** | 8 bits |
| **Parameter use** | Parameter & Diagnostics SPN |
| **Parameter measure type** | Temperature |
| **Resolution** | 1 °C/bit |
| **Range offset** | -40 |
| **Range limit** | 60 |
| **Data range** | 0 to 100 °C |

## PGN65263 – Cabin Temperature - ET1

| | |
|---|---|
| **Parameter Group Number** | 65263 (0x00FEEF) |
| **Data length** | 8 |
| **Default priority** | 6 |
| **Suggested Rep. Rate** | 1000 msec |
| **Destination Address:** | |
| **DPQ** | 0 (0x00) |
| **PDU Format** | 254 (0xFE) |
| **PDU specific** | 239 (0xEF) |
| **PDU Type** | PDU 2 |
| **Transmission repetition rate** | 1000 |
| **Variable length** | No |

| Byte(s) | Bit(s) | SPN ID | SPN Description |
|---------|--------|--------|----------------|
| 1 | 8-1 | 110 | Engine Coolant Temperature |
| 2 | 8-1 | 174 | Engine Fuel Temperature |
| 3-4 | 16-1 | 175 | Engine Oil Temperature |
| 5-6 | 16-1 | 176 | Engine Turbocharger Oil Temperature |
| 7 | 8-1 | 52 | Engine Intercooler Temperature |
| 8 | 8-1 | 1134 | Cabin Internal Temperature |

| SPN110 – Cabin Air Temperature (Internal) | |
|-------------------------------------------|--|
| Parameter size | 8 bits |
| Parameter use | Parameter & Diagnostics SPN |
| Parameter measure type | Temperature |
| Resolution | 1 deg C/bit |
| Range offset | -40 deg C |
| Range limit | 60 deg C |
| Data range | 0 to 100 deg C |

Req  2.3.1.4 When a failure is detected, measurement data received shall be a predictive maintenance value to log or 0xFFFF if no predictive maintenance is involved.

Req  2.3.1.5 When a failure is detected, the device shall send a DM1 DTC message with respective SPN and FMI according to J1939.

| PGN65226  DM1 Active Diagnostic Trouble Codes | |
|-----------------------------------------------|--|
| Parameter Group Number | 65226 (0x00FECA) |
| Data length | 6-1782 bytes |

| | |
|---|---|
| **Default priority** | 6 |
| **Suggested Rep. Rate** | 1000ms |
| **Destination Address:** | |
| **DPQ** | 0 (0x00) |
| **PDU Format** | 254 (0xFE) |
| **PDU specific** | 202 (0xCA) |
| **PDU Type** | PDU 2 |
| **Variable length** | No |

## 2.3.2 Software Architecture

Req 2.3.2.1 The device shall have a minimum resolution of 1°C/bit in temperature measurement.

Req 2.3.2.2 The device shall receive and transmit its data over a CAN network using J1939 protocol.

## 2.3.3 Software Functionality

Req 2.3.3.1 The temperature read shall be filtered with a rolling average filter of 16 coefficients.

Req 2.3.3.2 The actuator shall implement a verification means to allow open circuit detection through *software fuse*.

Req 2.3.3.3 The software fuse shall be implemented in a task that runs each 10ms.

Req 2.3.3.4 The softfuse shall calculate the maximum timeout, for the fuse based on the Measured Current by linear interpolation method through the table *Relative Current Flow Percent to Software Fuse Timeout Table.*

Req 2.3.3.5 The *Relative Current Flow Percent to Software Fuse Timeout Table* is the timeout value corresponding to the relative current flowing with reference to the rated current for the selected driver circuit in Ampere.

Req 2.3.3.6 It is required to blow the fuse immediately if the relative current flow exceeds maximum percent.

Req 2.3.3.7 The component shall continuously accumulate lapsed time, *AccumulatedLapsedTimePercent*, in terms of percentage of calculated Maximum

Software Fuse Timeout, Timeout as per requirement Calculating Maximum Software Fuse Timeout if all of the following conditions are fulfilled:

- Measured Current is greater than OR equal to Output Circuit Driver Rated Current **AND**
- Timeout is not equal to zero **AND**
- *AccumulatedLapsedTimePercent* is not greater than or equal to 100%

The software fuse is considered as a damage accumulator and after x amount of damage, the fuse needs to blow. There should be a higher "damage" factor for larger currents. As an example, consider the current is high for a time period just below the timeout, then the current falls to a point where it still takes a large amount of time to blow the fuse. In this case, the accumulated damage was almost enough to already cause the software fuse to "blow", so even a short amount of time at the lower current (still greater than the rated) should cause the fuse to blow. Hence, in this requirement a percent of time lapsed with respect to corresponding timeout value is accumulated to account for damage factor.

Req  2.3.3.8 The component shall set the AccumulatedLapsedTimePercent to 100% if the timeout calculated is equal to zero. The library component shall set the AccumulatedLapsedTimePercent to 0% if the Measured Current is less than the Driver Rated Current

Req  2.3.3.9 The component shall set Software Fuse Blown Flag to TRUE if the AccumulatedLapsedTimePercent is equal to 100% and false if it is equal to 0%

## 2.3.4    Software Diagnostics

Req  2.3.4.1 Activating sensor above Operational Range faul
The device shall report the "Data Valid but Above Normal Operational" if the filtered temperature is above or equal to 60 degrees Celsius For at least 7 seconds.

Req  2.3.4.2 Deactivating sensor above Operational Range fault
The device shall stop reporting the "Data Valid but Above Normal Operational" if the filtered temperature is below 50 degrees Celsius

Req  2.3.4.3 Activating sensor bellow Operational Range fault
The device shall report the "Data Valid but Below Normal Operational Range" if the filtered temperature is below 0 degrees Celsius.

Req  2.3.4.5 Deactivating sensor bellow Operational Range fault
The device shall stop reporting the "Data Valid but Below Normal Operational Range" if the filtered temperature is above 0 degrees Celsius.

Req  2.3.4.6 Activating sensor erratic operation fault
The device shall report the "Data Erratic, Intermittent or Incorrect" if any of the following is true:
- the read temperature is below -40 degrees Celsius
- The read temperature is above 60 degrees Celsius

Req  2.3.4.7 Deactivating sensor erratic operation fault

The device shall stop reporting the "Data Erratic, Intermittent or Incorrect" if the read temperature is above -40 and below 60 degrees Celsius.

Req  2.3.4.8 Activating sensor Shorted to High Source
The device shall report the "Voltage Above Normal, or Shorted to High Source" if the source voltage feedback is above *EOLMaxThreshold* for CircFltTiOutEol.

Req  2.3.4.9 Deactivating sensor Shorted to High Source
The device shall stop reporting the "Voltage Above Normal, or Shorted to High Source" if the source voltage feedback is above *EOLMaxThreshold*.

Req  2.3.4.10 Activating sensor Shorted to Low Source
The device shall report the "Voltage Below Normal, or Shorted to Low Source"  if the source voltage feedback is below *EOLMinThreshold* for CircFltTiOutEol.

Req  2.3.4.11 Deactivating sensor Shorted to Low Source
The device shall stop reporting the "Voltage Below Normal, or Shorted to Low Source"  if the source voltage feedback is above *EOLMinThreshold*.

Req  2.3.4.12 Activating sensor Open Circuit Fault
The device shall report the "Current Below Normal or Open Circuit"  if the source voltage feedback is above *EOLMinThreshold*, And the current is less than OpenCirclThdEol.

Req  2.3.4.13 Deactivating sensor Open Circuit Fault
The device shall stop reporting the "Current Below Normal or Open Circuit"  if the source voltage feedback is above *EOLMinThreshold*, And the current is more or equal to OpenCirclThdEol.

Req  2.3.4.14 Activating sensor overload Fault
The device shall report the "overload or Grounded Circuit"  if *a software fuse detected* is blown.