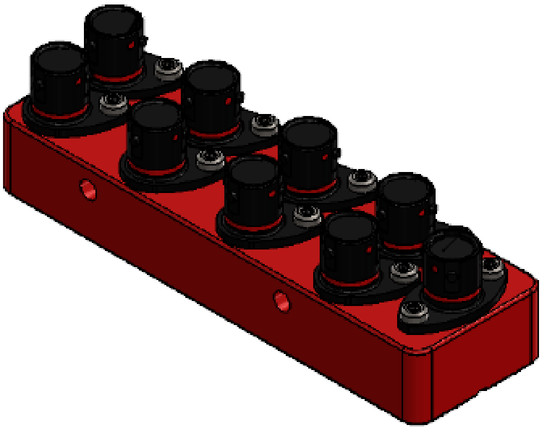
# A-CAN-DG-V4-1 User Guide



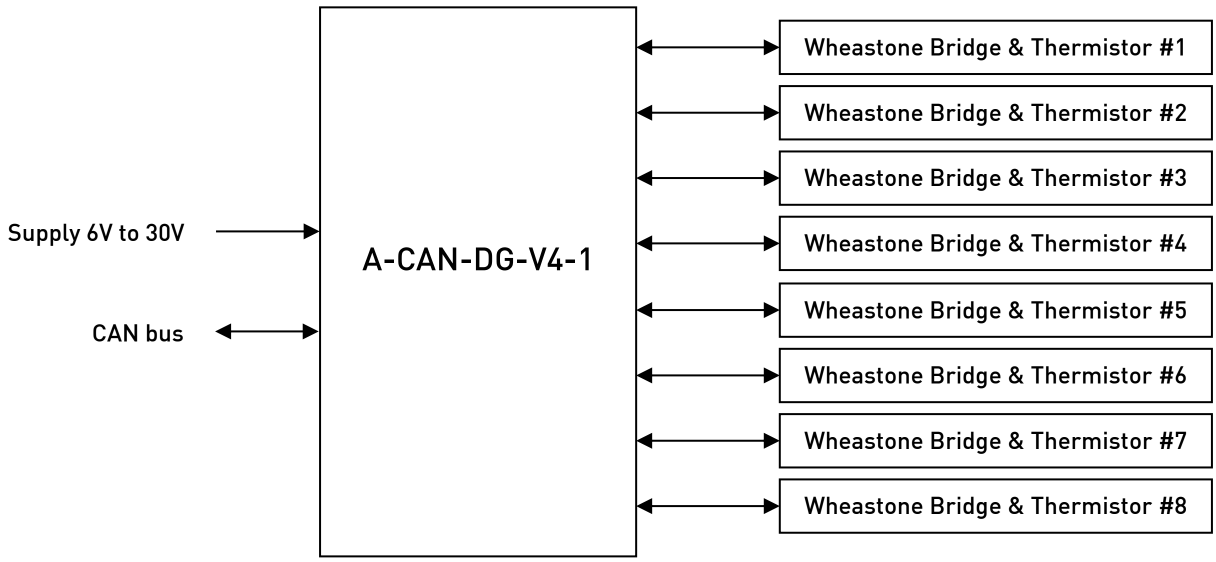
## Summary

# 1. Introduction

The A-CAN-DG-V4-1 is an 8 channel analog to CAN converter. The analog stage is specifically designed to fit Wheastone bridge systems using strain gauges. Based on this, this product can handle effort, torque and pressure instrumentation.

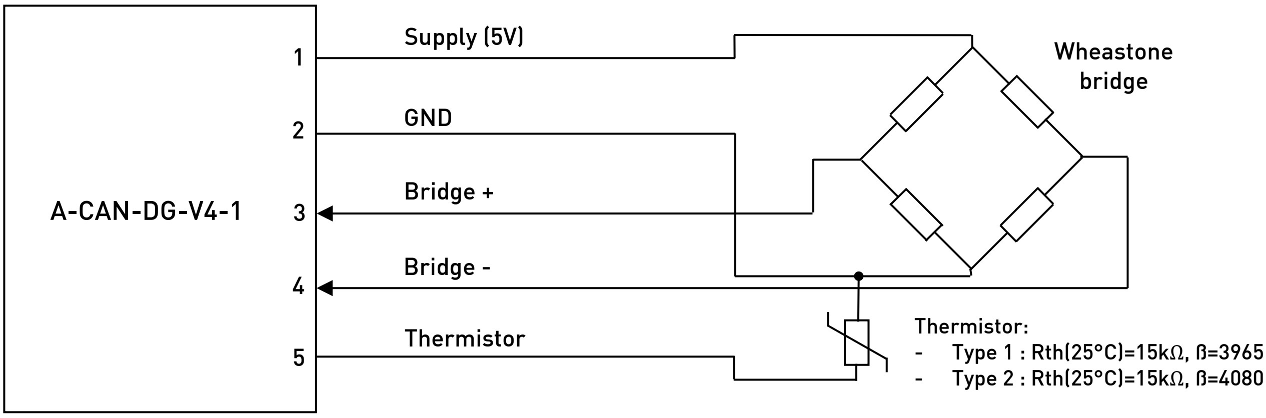
The A-CAN-DG-V4-1 also includes temperature measurement input for thermal effect compensation (offset and sensitivity drift).

# 2. Architecture



# 3. Analog interface

For each channel, the A-CAN-DG-V4-1 is interfaced with the sensor through a 5 wires connector:




## *3.1 Wheastone bridge requirements*

The output current per channel is limited to 45mA. This implies that the Wheastone bridge impedance must be more than 110Ω. The signal lines must be isolated from any other conductive part with at least 100MΩ under 50V.

*Note:*

- *The offset and sensitivity tuning can be done on software side, so there is no need for hardware compensation regarding this.*
- *The software enables to perform thermal compensation for offset and sensitivity, so there is no need for any balco, nickel, manganin wires nor any other hardware compensation.*
- *The analog acquisition stage is quite accurate, high resolution, and range configurable, so there is no need to balance the bridge in most applications.*

## *3.2 Thermistors requirement*

The A-CAN-DG-V4-1 includes a temperature calculation algorithm based on a NTC thermistor. This calculation is used for 2 purposes:

- The temperature data is sent on CAN bus directly converted in Celsius degrees to provide application temperature.
- The temperature calculation gives a linear information to the internal thermal compensation mechanisms. As the same thermistor will be used for calibration and use, only linearity and repeatability features are needed for this purpose.

### 3.2.1 Thermistor selection

The algorithm for temperature calculation includes 2 thermistor types that are user configurable:

- Type 1: Rth(25°C)=15kΩ, β=3965. Texense advises to use the following reference: Vishay NTCS0402E3153FHT (0402 SMD package).
- Type 2: Rth(25°C)=15kΩ, β=4080. Texense advises to use the following reference: AVX ND03N00153J— (through hole package).

*Note: the system can only handle one algorithm at a time for all the thermistors. So you have to use the same type for all the 8 channels, you cannot mix the types.*

### 3.2.2 Thermistor wiring

There is no formal requirements regarding wiring. But please be aware that:

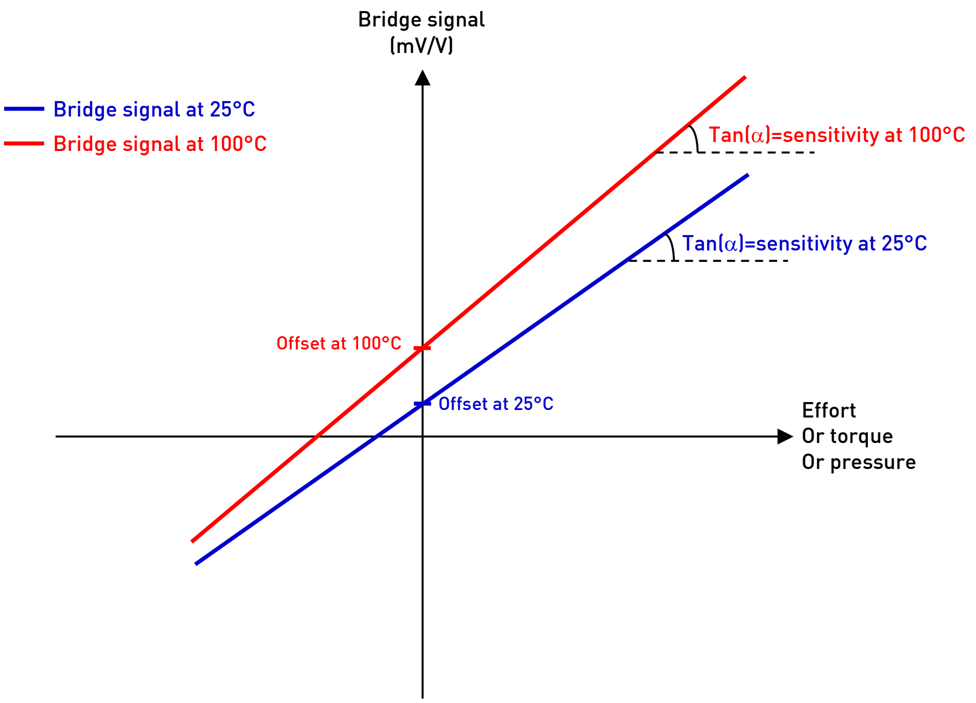
- Good conductivity wires will provide better signal accuracy.
- In case of long cable, it is advised to use a shielded cable between the bridge and the A-CAN-DG-V4-1 to reduce EMC susceptibility.
- The thermistor has to be placed as closed as possible to the Wheastone bridge for proper compensation.

# 4. Bridge signal sampling features

- sampling rate : 500Hz
- analogic input anti-aliasing filter cut-off frequency: 209Hz
- CAN output frequency: configurable from 1Hz to 250Hz (numerical filter : average of 1 to 250 samples)

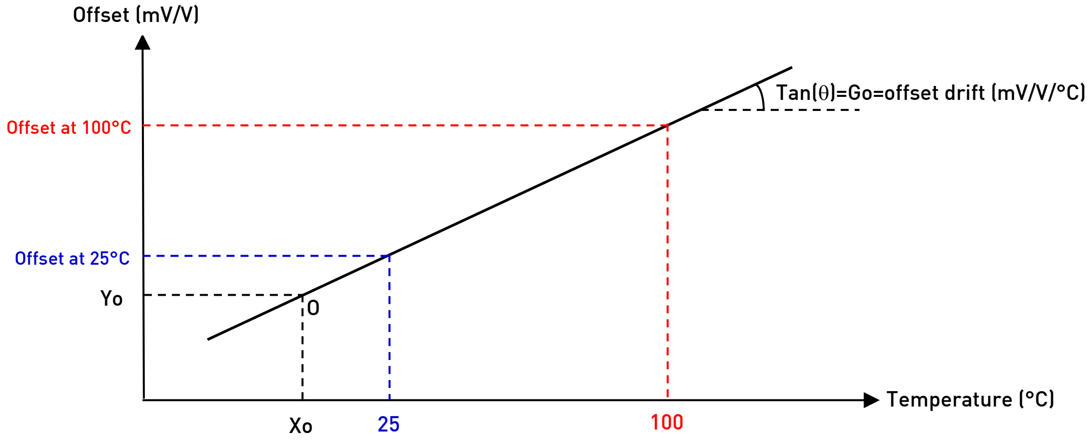
# 5. Software compensations

The software is able to manage the offset and sensitivity errors and their thermal drift. For each term, we suppose that the drift is linear with temperature. Texense's experience in strain gauges shows that thermal linearity errors are not significant regarding expected effort accuracy in most applications. Here is an example of signal response according to the model:



## 5.1 Offset compensation

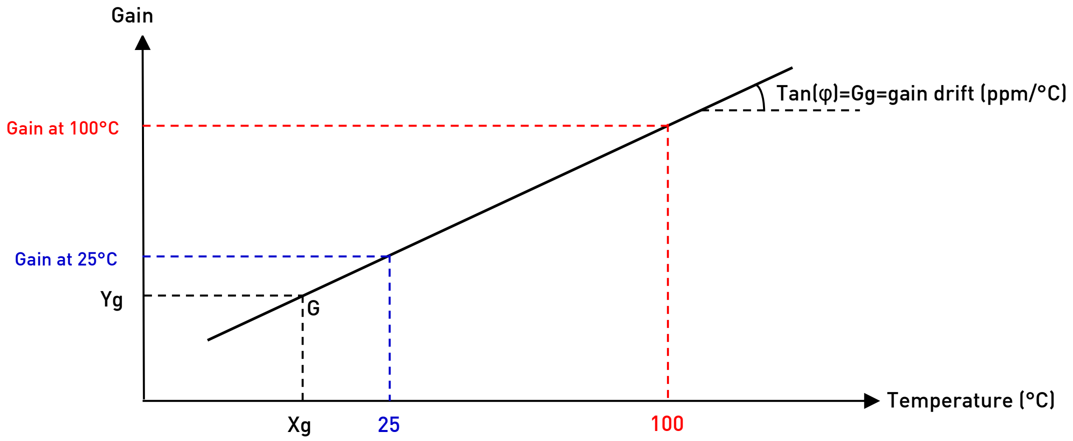
The model supposes that the offset drift is linear. Based on this hypothesis, defining an O point on the curve and the drift (slope) fully defines the offset compensation to apply.




The values {Xo; Yo; Go} fully define the gain compensation curve. Please refer to chapter 7.2.4.3 to know how to configure the offset settings.

## 5.2 Gain compensation

For the gain, the mechanism is the same than for the offset.




The values {Xg; Yg; Gg} fully define the gain compensation curve. Please refer to chapter 7.2.4.3 to know how to configure the gain settings.

## 6. CAN communication

CAN bus can run according to Bosch's CAN 2.0A or 2.0B specification. All the CAN features are configurable by the user (CAN type, baudrate, emission frequency, CAN IDs, 120 ohms termination). Please refer to A-CAN-DG-V4-1 datasheet to have more details regarding all parameters. Please refer to chapter "User configuration" to see how to change the parameters.

## 7. User configuration

The user can configure multiple parameters of the A-CAN-DG-V4-1 thanks to 2 ways:

- By CAN interface.
- By "One Wire" interface.

### *7.1 CAN interface*

This interface enables to modify all CAN parameters:

- CAN type
- Baudrate
- Data output frequency
- CAN IDs
- 120 ohms termination resistor.

This interface uses the "Texense CAN protocol". To use this protocol, you have 2 ways:

- You can use our tAST® hardware tool combined with our Android software TexCApp.
- You can implement the Texense CAN protocol by your own. In this case, please refer to our document "Texense CAN protocol".

### *7.2 "One wire" interface*

This interface enables to modify all CAN parameters described in previous chapter + all calibration parameters (offset compensation, gain compensation...).

#### 7.2.1 Hardware and Software requirements

The requirements to use the "One Wire" interface are:

- The hardware accessory "USB-Connect-1W-3V". Please contact Texense for more information about this tool.
- A COM port terminal software (Teraterm, Hyperterminal...).
- A computer with Windows OS.

#### 7.2.2 Computer installation

To configure the system according to your application, you must first connect it to a Windows computer. To do so:

- Install the driver of our "USB-Connect-1W-3V".
- Connect our "USB-Connect-1W-3V". Please refer to the datasheet for pinout and wiring information.
- Open a COM port terminal software (for example: Teraterm) :
  - Select the COM port number according to your computer peripheral manager.
  - Configure the COM port to 115200bps, 8 data bits, no parity, 1 stop bit, no flux control.
  - Configure the terminal to VT100 mode, reception LF, emission CR.
  - Open the port.
- Power on the product.

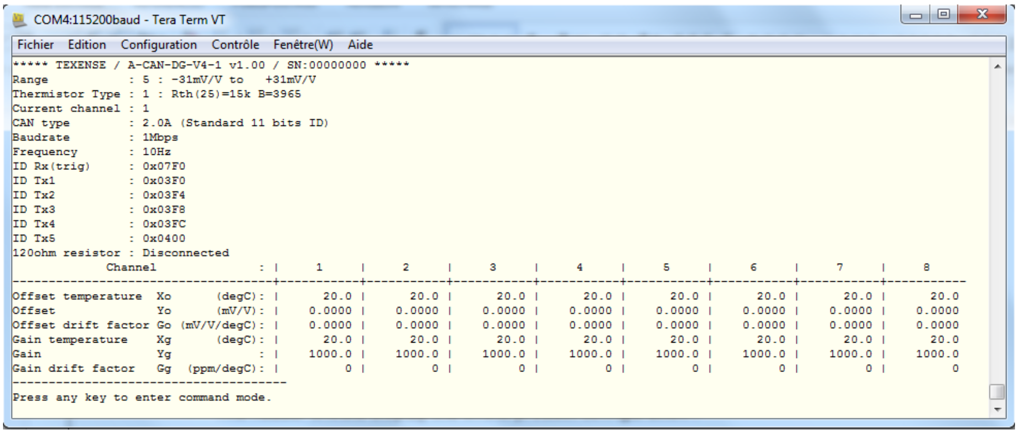
### 7.2.3 General user interface overview

The user interface can display 3 different panels:

- Configuration panel
- Command list panel
- View panel

#### 7.2.3.1 Configuration panel

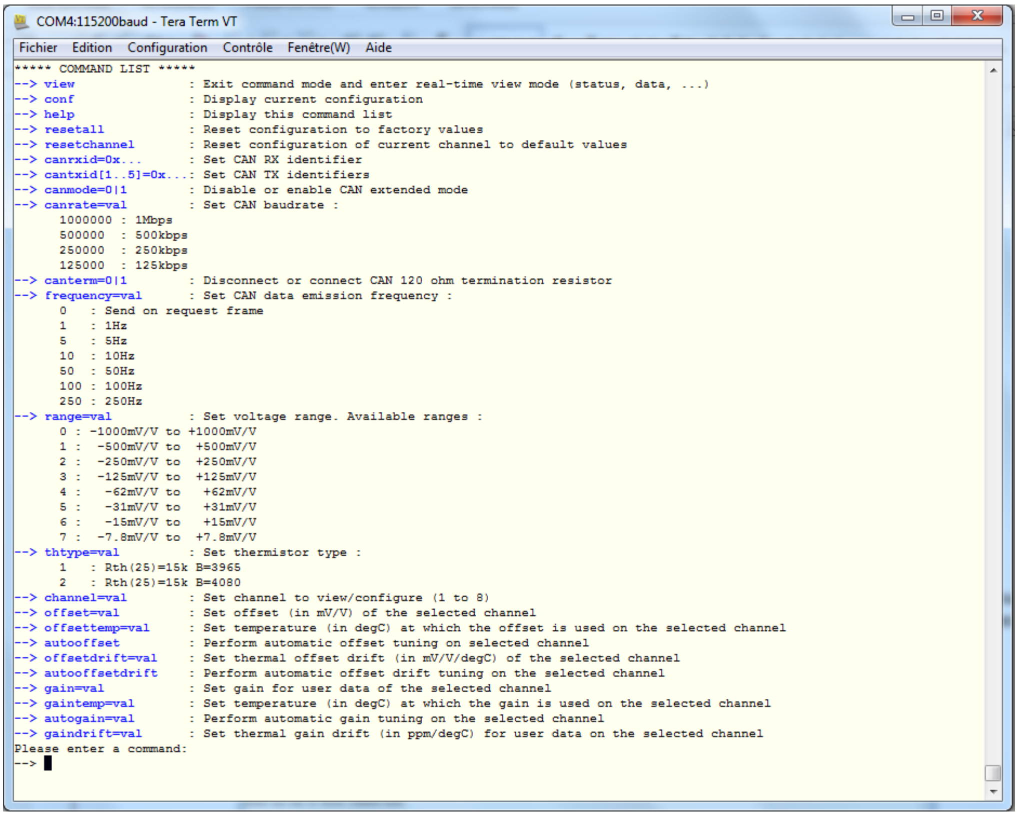
At startup or by taping the "conf" command, the configuration panel appears. It display the whole product configuration:



```
COM4:115200baud - Tera Term VT
Fichier  Edition  Configuration  Contrôle  Fenêtre(W)  Aide
***** TEXENSE / A-CAN-DG-V4-1 v1.00 / SN:00000000 *****
Range           : 5 : -31mV/V to   +31mV/V
Thermistor Type : 1 : Rth(25)=15k B=3965
Current channel : 1
CAN type        : 2.0A (Standard 11 bits ID)
Baudrate        : 1Mbps
Frequency       : 10Hz
ID Rx(trig)     : 0x07F0
ID Tx1          : 0x03F0
ID Tx2          : 0x03F4
ID Tx3          : 0x03F8
ID Tx4          : 0x03FC
ID Tx5          : 0x0400
120ohm resistor : Disconnected
             Channel               : |    1     |    2     |    3     |    4     |    5     |    6     |    7     |    8
-----------------------------------+----------+----------+----------+----------+----------+----------+----------+----------
Offset temperature  Xo      (degC) : |     20.0 |     20.0 |     20.0 |     20.0 |     20.0 |     20.0 |     20.0 |     20.0
Offset              Yo      (mV/V) : |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000
Offset drift factor Go (mV/V/degC) : |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000 |   0.0000
Gain temperature    Xg      (degC) : |     20.0 |     20.0 |     20.0 |     20.0 |     20.0 |     20.0 |     20.0 |     20.0
Gain                Yg             : |   1000.0 |   1000.0 |   1000.0 |   1000.0 |   1000.0 |   1000.0 |   1000.0 |   1000.0
Gain drift factor   Gg   (ppm/degC): |        0 |        0 |        0 |        0 |        0 |        0 |        0 |        0
-------------------------------------
Press any key to enter command mode.
```

#### 7.2.3.2 Command list panel

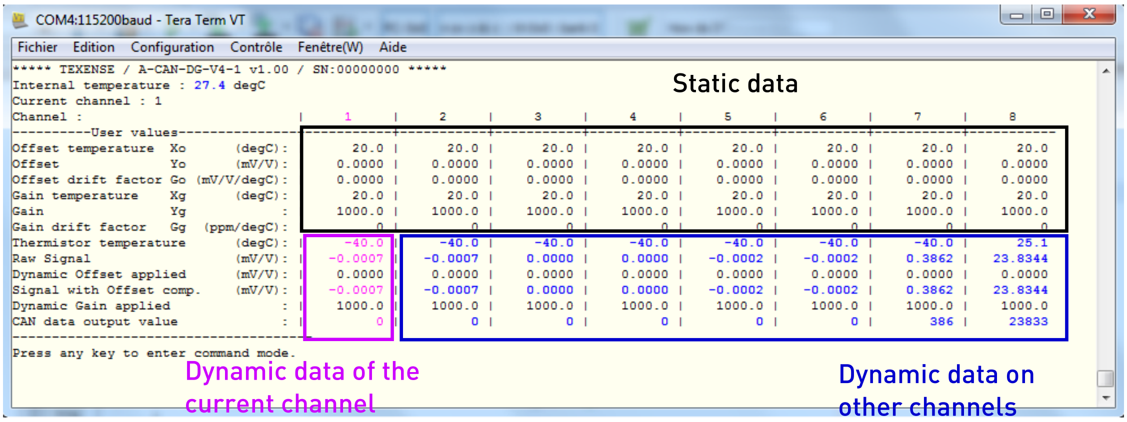
If you tape one character or the "help" command, you will see the command list:



```
COM4:115200baud - Tera Term VT
Fichier  Edition  Configuration  Contrôle  Fenêtre(W)  Aide
***** COMMAND LIST *****
--> view                : Exit command mode and enter real-time view mode (status, data, ...)
--> conf                : Display current configuration
--> help                : Display this command list
--> resetall            : Reset configuration to factory values
--> resetchannel        : Reset configuration of current channel to default values
--> canrxid=0x...       : Set CAN RX identifier
--> cantxid[1..5]=0x...: Set CAN TX identifiers
--> canmode=0|1         : Disable or enable CAN extended mode
--> canrate=val         : Set CAN baudrate :
      1000000 : 1Mbps
      500000  : 500kbps
      250000  : 250kbps
      125000  : 125kbps
--> canterm=0|1         : Disconnect or connect CAN 120 ohm termination resistor
--> frequency=val       : Set CAN data emission frequency :
      0   : Send on request frame
      1   : 1Hz
      5   : 5Hz
      10  : 10Hz
      50  : 50Hz
      100 : 100Hz
      250 : 250Hz
--> range=val           : Set voltage range. Available ranges :
      0 : -1000mV/V to +1000mV/V
      1 :  -500mV/V to  +500mV/V
      2 :  -250mV/V to  +250mV/V
      3 :  -125mV/V to  +125mV/V
      4 :   -62mV/V to   +62mV/V
      5 :   -31mV/V to   +31mV/V
      6 :   -15mV/V to   +15mV/V
      7 :  -7.8mV/V to  +7.8mV/V
--> thtype=val          : Set thermistor type :
      1   : Rth(25)=15k B=3965
      2   : Rth(25)=15k B=4080
--> channel=val         : Set channel to view/configure (1 to 8)
--> offset=val          : Set offset (in mV/V) of the selected channel
--> offsettemp=val      : Set temperature (in degC) at which the offset is used on the selected channel
--> autooffset          : Perform automatic offset tuning on selected channel
--> offsetdrift=val     : Set thermal offset drift (in mV/V/degC) of the selected channel
--> autooffsetdrift     : Perform automatic offset drift tuning on the selected channel
--> gain=val            : Set gain for user data of the selected channel
--> gaintemp=val        : Set temperature (in degC) at which the gain is used on the selected channel
--> autogain=val        : Perform automatic gain tuning on the selected channel
--> gaindrift=val       : Set thermal gain drift (in ppm/degC) for user data on the selected channel
Please enter a command:
-->
```

### 7.2.3.3 View panel

Taping the “view” command will display the real-time data so that you can see your changes effects:




*Note : In view mode, the CAN data output frequency is set to 1Hz in order to have the best filtering features for display and calibration. The frequency automatically goes back to its configured value when leaving this mode.*

### 7.2.4 Calibration procedure

#### 7.2.4.1 Range selection

First of all, you must select the range in the choice list from ±7.8mV/V to ±1000mV/V. The default range is ±31mV/V. As data is sampled with high resolution (20bits), this default setting works with most applications and leave a good security margin in case of important unbalance of the bridge.

Example command to set the ±7.8mV/V range: `range=7`.

*Note:*

- *You must take care of the unbalance when selecting the range. It can be more significant than the signal itself.*
- *You can only use one range for all the 8 channels so you have to set the range according to the channel who has the most important signal.*

#### 7.2.4.2 Thermistor type selection

Please refer to chapter 3.2 for hardware information about thermistors.

Example command to set the type 1: `thtype=1`.

*Note: This setting is applied to all the 8 channels.*

#### 7.2.4.3 Offset and gain tuning

All the calibration parameters defined in chapter "Software compensations" (Xo, Yo, Go, Xg, Yg, Gg) can be set manually by taping commands. A faster and easier procedure also exists using semi-automatic functionalities. For each channel tuning, you must first select the channel before taping any other commands.

Example command to set the first channel as configuration channel: `channel=1`.

For better understanding, we will consider an example with the following bridge behaviour:

| Effort | Raw signal (mV/V) | |
|---|---|---|
| N | At 25,1°C | At 100,6°C |
| -50 | -1,2300 | -2,7157 |
| 0 | -0,2300 | -1,7400 |
| 50 | 0,7700 | -0,7643 |

### 7.2.4.3.1 Manual procedure

#### 7.2.4.3.1.1 "Xo" and "Yo" tuning (offset)

Put your system at a stabilised temperature (25.1°C in this example) and release the effort (or torque or pressure) to measure on your system. Use the view panel to see the signal value.

The raw signal gives you the Yo value. For example, if you read a raw signal of -0.2300 mV/V, you must tape the following command: `offset=0.2300`. This will set Yo to 0.2300.

Then you must save the temperature at which you have done the Yo tuning. To do this, tape the following command: `offsettemp=25.1`. This will set Xo to 25.1°C.

After tuning Xo and Yo, you must have the field "Signal with Offset comp." null or almost null:

```
Channel :                                |     1     |
----------User values--------------------+-----------+
Offset temperature  Xo       (degC) :    |    25.1   |
Offset              Yo       (mV/V) :    |  0.2300   |
Offset drift factor Go  (mV/V/degC) :    |  0.0000   |
Gain temperature    Xg       (degC) :    |    20.0   |
Gain                Yg              :    |  1000.0   |
Gain drift factor   Gg   (ppm/degC) :    |       0   |
Thermistor temperature       (degC) :    |    25.1   |
Raw Signal                   (mV/V) :    | -0.2300   |
Dynamic Offset applied       (mV/V) :    |  0.2300   |
Signal with Offset comp.     (mV/V) :    |  0.0000   |
Dynamic Gain applied                :    |  1000.0   |
CAN data output value               :    |       0   |
```

#### 7.2.4.3.1.2 "Xg" and "Yg" tuning (gain)

After tuning the offset, leave your system at the same temperature and apply the max effort (50N in this example).

```
Channel :                                |     1
----------User values--------------------+-----------
Offset temperature  Xo       (degC) :    |    25.1
Offset              Yo       (mV/V) :    |  0.2300
Offset drift factor Go  (mV/V/degC) :    |  0.0000
Gain temperature    Xg       (degC) :    |    20.0
Gain                Yg              :    |  1000.0
Gain drift factor   Gg   (ppm/degC) :    |       0
Thermistor temperature       (degC) :    |    25.1
Raw Signal                   (mV/V) :    |  0.7700
Dynamic Offset applied       (mV/V) :    |  0.2300
Signal with Offset comp.     (mV/V) :    |  0.9999
Dynamic Gain applied                :    |  1000.0
CAN data output value               :    |     999
```

The default gain is 1000, so the CAN data output value is 999. The CAN data output value is a 16bit signed integer value from -32768 to +32767. To have the output into your effort unit, you must tune the gain to have a good resolution and no overflow.

In this example, setting the gain to 5002 will provide a range from -5000 to +5000 and the unit will be hundredths of Newton.

Taping command `gain=5002` will set Yg to 5002. Then you must also save the temperature at which you have done the Yg tuning. To do this, tape the following command: `gaintemp=25.1`. This will set Xg to 25.1°C.

```
Channel :                                |     1
----------User values--------------------+-----------
Offset temperature  Xo       (degC) :    |    25.1
Offset              Yo       (mV/V) :    |  0.2300
Offset drift factor Go  (mV/V/degC) :    |  0.0000
Gain temperature    Xg       (degC) :    |    25.1
Gain                Yg              :    |  5002.0
Gain drift factor   Gg   (ppm/degC) :    |       0
Thermistor temperature       (degC) :    |    25.1
Raw Signal                   (mV/V) :    |  0.7699
Dynamic Offset applied       (mV/V) :    |  0.2300
Signal with Offset comp.     (mV/V) :    |  0.9998
Dynamic Gain applied                :    |  5002.0
CAN data output value               :    |    5000
```

##### 7.2.4.3.1.3 "Go" tuning (offset drift)

Put the system to another temperature and wait stabilization (100.6°C in this example). Release the effort and read the raw signal value. In this example, we read -1.7400mV/V:

```
Channel :                                |      1
----------User values--------------+-----------
Offset temperature  Xo       (degC): |     25.1
Offset              Yo       (mV/V): |   0.2300
Offset drift factor Go (mV/V/degC): |   0.0000
Gain temperature    Xg       (degC): |     25.1
Gain                Yg             : |   5002.0
Gain drift factor   Gg  (ppm/degC): |        0
Thermistor temperature       (degC): |    100.6
Raw Signal                   (mV/V): |  -1.7400
Dynamic Offset applied       (mV/V): |   0.2300
Signal with Offset comp.     (mV/V): |  -1.5100
Dynamic Gain applied               : |   5002.0
CAN data output value              : |    -7551
```

The offset drift to apply is:

$$G_O = -\frac{(Signal_{at\,T2} - Signal_{at\,T1})}{(T_2 - T_1)} = -\frac{(-1.7400-(-0.2300))}{(100.6-25.1)} = 0.02 \text{ mV/V/°C}$$

So tape the command **offsetdrift=0.02**.

```
Channel :                                |      1
----------User values--------------+-----------
Offset temperature  Xo       (degC): |     25.1
Offset              Yo       (mV/V): |   0.2300
Offset drift factor Go (mV/V/degC): |   0.0199
Gain temperature    Xg       (degC): |     25.1
Gain                Yg             : |   5002.0
Gain drift factor   Gg  (ppm/degC): |        0
Thermistor temperature       (degC): |    100.6
Raw Signal                   (mV/V): |  -1.7400
Dynamic Offset applied       (mV/V): |   1.7395
Signal with Offset comp.     (mV/V): |  -0.0024
Dynamic Gain applied               : |   5002.0
CAN data output value              : |       -2
```

##### 7.2.4.3.1.4 "Gz" tuning (gain drift)

When at the highest temperature, apply the max effort (50N in this example). Then find the gain drift value that gives you back the expected 5000 value. **gaindrift=-330** works well in this example :

```
Channel :                                |      1
----------User values--------------+-----------
Offset temperature  Xo       (degC): |     25.1
Offset              Yo       (mV/V): |   0.2300
Offset drift factor Go (mV/V/degC): |   0.0199
Gain temperature    Xg       (degC): |     25.1
Gain                Yg             : |   5002.0
Gain drift factor   Gg  (ppm/degC): |     -330
Thermistor temperature       (degC): |    100.6
Raw Signal                   (mV/V): |  -0.7144
Dynamic Offset applied       (mV/V): |   1.7395
Signal with Offset comp.     (mV/V): |   1.0251
Dynamic Gain applied               : |   4877.3
CAN data output value              : |     5000
```

### *7.2.4.3.2 Semi-automatic procedure*

The A-CAN-DG-V4-1 includes shortcut functionalities that enables to tune the parameters without doing calculation. The parameter calculation is performed on software side.

#### 7.2.4.3.2.1 "Xo" and "Yo" tuning (offset)

Put your system at a stabilised temperature (25.1°C in this example) and release the effort (or torque or pressure) to measure on your system.

Simply tape the command: `autooffset`. This will set Yo. It will also set Xo (temperature at which Yo is calculated).

#### 7.2.4.3.2.2 "Xg" and "Yg" tuning (gain)

After tuning the offset, leave your system at the same temperature and apply the max effort (50N in this example). The CAN data output value is a 16bit signed integer value from -32768 to +32767. In this example we want to have 5000 as output value for 50N applied.

Tape the command `autogain=5000`. This will set Yg. It will also set Xg (temperature at which Yg is calculated).

#### 7.2.4.3.2.3 "Go" tuning (offset drift)

Release the effort. Put the system to another temperature and wait stabilization. It is recommended to use an important temperature difference (at least 40°C).

Tape the command `autooffsetdrift`. This will set Go.

#### 7.2.4.3.2.4 "Gz" tuning (gain drift)

Using our experience and if you don't want to practically calibrate the gain drift, using the following values will provide quite good results (only valuable for Constantan strain gauges):

| | Gain drift to apply | |
|---|---|---|
| Material on which the strain gauge is glued | % / °C | ppm / °C |
| Steel (default) | -0,033 | -330 |
| Titanium | -0,050 | -500 |
| Aluminum | -0,059 | -590 |
| *No compensation* | *0* | *0* |

The current example is steel. So we simply tape the command `gaindrift=-330.`

In case this table doesn't fit your need, please refer to manual procedure 7.2.4.3.1.4.