CORIOLIS MASS FLOW METERS

Signal processor

C-MASS 021

INSTRUCTION MANUAL

April 2011

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1. General

Coriolis mass flow meters consists of two main units

- -Sensor built in the pipeline
- -Electronic unit processing the signals of the sensor

Present Manual deals with the latter unit of the system. The task of the signal-processing unit is to control the vibration of the measuring tubes of mass flow sensor and processing the signals of the displacement and temperature detectors.

Most of the mass flow sensors operate at the resonance frequency of the measuring tube that makes possible the determination of the density of the measured media. Therefore it is possible to determine the volumetric flow rate. RTD built in the sensor gives the possibility of temperature measurement of the fluid. Summing, by applying mass flow metering systems user can measure the mass flow, density and temperature of the flowing fluid and thus we can calculate the volume, too.

Sensor unit can be connected through the Zener Barrier Unit (ZBU). In this case the system is explosion proof, with ex. protection mode according to standards EN 50014 and EN 50020. The protection mode of the system is:

[EEx ib] IIB, EEx ib IIB T3/T6

C-MASS-021 signal processors are built in wall-mounting box having IP65 protection. The electronic construction enables the user to process measured data by electrical outputs and by a direct link with a computer.

2. Installing the device

2.1 Location, wall mounting

To determine an appropriate location for the device you must consider the environmental requirements, cable distance, accessibility and visibility.

If **CORI-FORCE** mass flow sensor has been mounted in hazardous area than a **ZBU** (Zener-Barrier-Unit) has to be inserted between the **CORI-FORCE** sensor and **C-MASS-021** according to the connection diagram of the Fig. 2. **ZBU** has to be located on the border of hazardous and safe area at the safe side.
The devices (**C-MASS-021** and **ZBU**) can be mounted on a wall according to the Fig. 4, 5 and 6. Follow the steps bellow for the wall mounting process:

- Prepare the holes and screws for the fixation of the device(s) onto the wall.
- Demount the cover of the device.
- Fix the lower part of the device(s) onto the wall.
- Put the cover back.

2.2 Cabling

C-MASS-021 has two connecting sockets (Fig. 4):

- Sensor-socket
- User-socket

2.2.1 *Connection of sensor socket* (Fig. 1 and 2)

The possible cablings are the followings:

2.2.1.1 Connection of mass flow sensor located in normal area (Fig. 1)

If **CORI-FORCE** mass flow sensor has been mounted in normal (non hazardous) area then it can be connected directly to the **C-MASS-021** according to the connection diagram of Fig. 1. Use the original sensor cables supplied as accessory of measuring system mounted with appropriate connector plugs or cable fun. The normal length of sensor cable is 5 m. Other length (up to 300 m) can be requested in the order.

2.2.1.2 Connection of sensor located in hazardous area (Fig. 2)

If **CORI-FORCE** mass flow sensor has been mounted in hazardous area than **ZBU** (Zener Barrier Unit) has to be inserted between **CORI-FORCE** and **C-MASS-021** according to the connection diagram of Fig. 2. Use the original cables supplied as accessories of measuring system mounted with appropriate connector plugs or cable-fan. The length of the cables has to be predetermined in the order.

2.2.2 *Connection of User-socket* (Fig. 3)

It is recommended to connect a 7 wires cable into the user connector (Fig. 3.). The other end of this user cable should be generally connected into a cable distributor (junction box or cable terminal) depending on the devices to be connected (remote-counters, controllers, computers etc.)
IMPORTANT: negative side of the current and frequency output signals are identical with ground of the power supply (pins 4 and GND).

3. Using of C-MASS-021 signal processor

3.1 Items

The most important building units of the system are the Items of the signal processor's memory. Depending on the stored information the Items can be classed into the following groups:

- **Numerical Items** store the measured data, calculated data, constants for the calculation, limits and all other numerical parameters of the measuring process and output signals.
- **Pointer Items** store the Item-Number of an other Item for certain reasons (e.g. assignment of source of output signal, or counter)
- **State marker Items** store the actual state of a measuring process, or a system-parameter, or the effect of a command (e.g. error and warning byte, state of batching, zeroing, passwords, etc.)

The Items stored in the memory are listed in the chapter 7.4.

Consistent notation of the Items used in this Manual:

{XXX:**YYY**}

Where XXX Serial Number of the Item
YYY Name of the Item

Example: {029:**MfM**} (According to the chapter 4.7 this Item contains the maximum value of the mass flow)

3.2 Display

The display of C-MASS-021 is 122x32 dot resolution graphical LCD. The active area has been divided into three parts (Fig. 6):

1. Large row:

That data is displayed which has been selected by the operator with the pushbuttons (see chapter 5.1.2).

2. Bar graph

122 dot length bar graph for analog display. The length of the bar is proportional with mass flow. The length of bar is maximal when the measured mass flow is equal to the value of item {029:**MfM**}. This item should be programmed to the maximum flow of the sensor to be connected.

3. Editing row:

The first character of the editing row is the **Info-character**. It is reserved to display general information that are useful for the user should anything be displayed by the other parts of the display. At this position the following signals can appear in inverse background:

E	Any of the error signals are active
!	Any of the warning signals are active
b	Batch is in progress
z	Zero calibration is in progress

In case more signaling are simultaneously active, the signals appear in rotation, if neither of them is active, this character is empty.

The information appearing at the remaining part of this row can be the following:

A. Right after turn on the word **Initialization** is displayed signaling that the device restarted after power off. In few seconds that data is displayed of which Item-Number has been written into the item {170:**I10}**.
B. The name of one of the data groups (Menu). See Chapter 4
C. User can use this part of display for reading any of the measured, calculated or stored Item of the memory (see chapter. 3.3). The first 3 characters is the serial Number of Item **(`XXX`)**, then a separation-character **(:)**, after that the Name of Item **(`YYY`)**, than the value of Item **(`-1234,56`)** and the last 4 characters is the unit of Item if exists. Numeric data can be displayed with max. 6 digits, not displayed decimals are rounded. If the value contains more than 6 digits integer or is less than 10^{-5}, displaying changes to exponential form (i.e. 1.2E-07).
D. An operator command or question to be confirmed with **ENT** or cancelled with **ESC** before the activation of a user command. (E.g. **`Zero start?`**)

LED lamps:

At the right side of the display there are 3 LED of triple-color with functions bellow:

FLOW

Red: measuring error*****
Green: errorless state with low flow ({027**:%Mf}** < {028**:%M0**})
Fleshing green: Zero-calibration is in progress
Orange: errorless state with normal flow ({027**:%Mf}** > {028**:%M0**})

LIMIT

Red: one or more WAR signal are active*****
Green and Orange: are not used

BATCH

Red: Batch is in progress
Green and Orange: are not used

***** More detailed information at Submenu **Diagnostic**.

3.3 Keypad

There are 8 pushbuttons on the front panel of the device. The pushbuttons are effective only to the Editing row. The functions of the buttons are the followings:

► and ◄

- Turning the display over to the next or previous item,
- If the name of a menu is displayed, the next or previous menu can be displayed.

▲ and ▼

- Changing the units when a data is displayed that can have different units.
- Modifying a certain data (chapter 5.2.1),

DSP (DISPLAY)

- If the name of any of the menus is displayed, by pressing this push-button the first data of the menu is displayed.
- Selecting the position of the decimal point in data modification mode (chapter 5.2.1)

ESC (ESCAPE)

- Step back to menu display level.
- If a data is displayed, after pressing this push-button the name of the menu, in which the data is sorted, is displayed.
- If a name of a menu is displayed, after pressing this push-button we get to the start of the actual menu row
- Discard data modification in the data modification mode (chapter 5.2.1).

ENT (ENTER)

- Step into data modification mode,
- Validate (enter) the modified data.
- Activate the command in operator command mode.

MOD (MODIFY)

- Step into the operator command mode (at Batch, TOTAL and Calibration menu)
- Modifying of the other pushbutton's effects:

  MOD + ▲
  Data displayed in the Editing row will display in the Large row too. This data will stay in the Large row following the modification of the data in the Editing row or a power off.

  MOD + ►
  Shift the position of the decimal point to the right

  MOD + ◄
  Shift the position of the decimal point to the left

  MOD + DISP
  Insert a new Item into the Item-list of the actual Menu. Displays the Item-Number of the actually displayed Item and make possibility to edit a new Item-Number. Entering the new Item-Number the Editing row will display the new item.

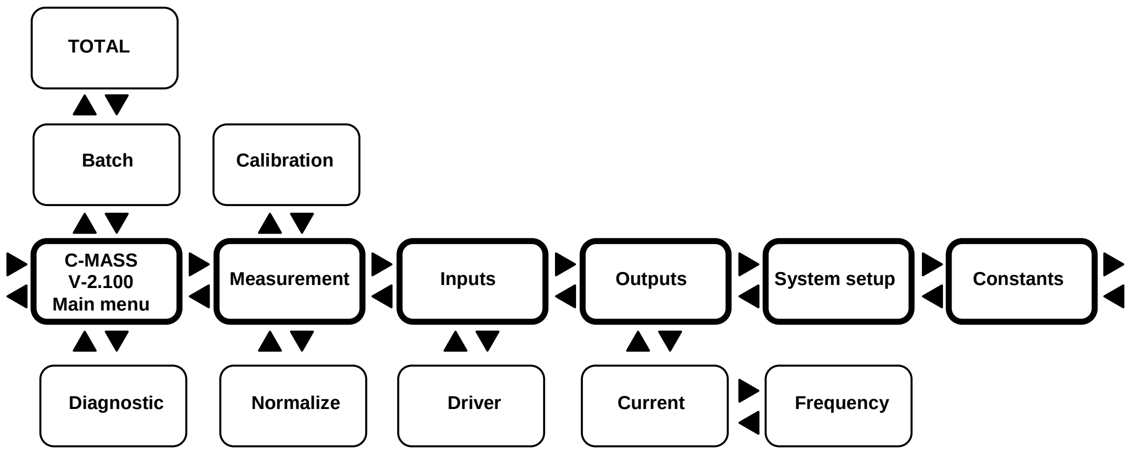
  MOD + ESC
  Delete the displayed Item from the Item-list of the actual Menu.

▼ + ▲

Set the value of item to zero in the data modification mode or set the string to spaces if the Item to be modified is a string type Item.

4. Menu system

The Items of **C-MASS-021** are organized in so-called menu system. It means that data are grouped for displaying and other functions. These main groups are called menus. The structure of the menu system is shown on figure bellow The main menu and the other menus are bold framed, the simple frame signals the sub-menus.



By pressing pushbutton **ESC** the name of the menu gets displayed. Displaying of the data inside the menus can be initiated by pressing pushbutton **DSP.** Data can be "paged" by ► or ◄ pushbuttons. At data having more than one units, changing of the unit displayed can be performed by pushbuttons ▲ or ▼.

4.1 Initialization

Initialization appears on the Editing row of the display only after turning on, or after **Software Reset** command by setting Item {013:**RST**}. It serves for signaling the probable power off. After pressing any pushbutton that data will appear which the Item {170:**I10**} has pointed.

4.2 Main menu

The name of the menu contains the name of the device and the version number of the operating software. In our case the name of the menu is C-MASS-V 2-100. This menu contains the totalized values. At entering into the menu the item bellow can be displayed according to the factory setting:

Data in the menu:

№:Name	Definition	Unit	Modification
030:**ΣM**	Total mass	kg	not possible
031:**ΣM1**	Total mass of fraction 1.	kg	not possible
032:**ΣV**	Total effective volume	m^3	not possible
033:**ΣVn**	Total normal volume	m^3	not possible
085:**ΣM2**	Total mass of fraction 2.	kg	not possible

The list of the items above can be modified according to he chapter 5.1.1.

4.2.1 Diagnostic submenu

C-MASS-021 signal processors perform two-level self-diagnostic tests:

- **Error-level Items** give information about the reliability of input signals. This kind of errors means that the system is not suitable for the correct working, so the measurement shell be stopped during the existence of this error. This error is displayed with E appearing at the Editing row in the **Info-character** of the display (chapter 3.2).
- **Warning-level Items** gives information about falling out of limits set by the user. This kind of errors means that the measuring results are out of the limits, but the system is working well. In case of C-MASS-021 this warning is displayed with ! appearing at the Editing row in the **Info-character** of the display (chapter 3.2).

Diagnostic submenu contains ten Diagnostic Items. Each of these Items contains a byte (eight bits). The processor decodes the bits to characters in the displayed form. Some of the characters refer to a measuring process or to the kind of deviation from the normal work. Capital character signals error (bit=1), small character means errorless state (bit=0), dot signals unused bit (bit=0).

The tables bellow explain in details the meaning of the bits of all Diagnostic bytes

Error Items

№:Name	Description				Unit	Modification
000:**Err**	**General error**		On the display:	F..DT..Y	–	not possible
			In the memory:	10011001		
	F	Fourier calculation error	**f**	errorless state		
	D	Density calculation error	**d**	errorless state		
	T	Temperature calculation error	**t**	errorless state		
	Y	Error in the memory	**y**	errorless state		
002:**ErF**	**Fourier calculation error**		On the display:	FR.A.TMD	–	not possible
			In the memory:	11010111		
	F	No input signal	**f**	errorless state		
	R	Tube-frequency is out of range	**r**	errorless state		
	A	Input signal is too low	**a**	errorless state		
	T	Duration of **D** or **M** error is too long	**t**	errorless state		
	M	Too big mass flow	**m**	errorless state		
	D	Too big changing in the mass flow	**d**	errorless state		
003:**ErD**	**Density calculation error**		On the display:	LH......	–	not possible
			In the memory:	11000000		
	L	De<0	**l**	errorless state		
	H	De>2500 g/lit	**h**	errorless state		
004:**ErT**	**Temperature calculation error**		On the display:	LH......	–	not possible
			In the memory:	11000000		
	L	T<-50 °C	**l**	errorless state		
	H	T>+250 °C	**h**	errorless state		
012:**ErY**	**Memory error**		On the display:	X.......	–	not possible
			In the memory:	10000000		
	X	Memory error	**x**	errorless state		

Warning Items

№:Name	Description				Unit	Modification
005:**War**	**General Warning**		On the display:	MDT....O	–	not possible
			In the memory:	11100001		
	M	Mass flow is out of limits	**m**	errorless state		
	D	Density is out of limits	**d**	errorless state		
	T	Temperature is out of limits	**t**	errorless state		
	O	Error in the memory	**o**	errorless state		
006:**WaD**	**Density (De) is out of limits**		On the display:	LH...F..	–	not possible
			In the memory:	11000100		
	L	De<DeL	**l**	errorless state		
	H	De>DeH	**h**	errorless state		
	F	Fraction calculation error	**f**	errorless state		
007:**WaT**	**Temperature (T) is out of limits**		On the display:	LH......	–	not possible
			In the memory:	11000000		
	L	T<TLo	**l**	errorless state		
	H	T>THi	**h**	errorless state		
008:**WaM**	**Mass flow (Mf) is out of limits**		On the display:	LH......	–	not possible
			In the memory:	11000000		
	L	Mf<MLo	**l**	errorless state		
	H	Mf>MHi	**h**	errorless state		
009:**WaO**	**Warning of output signals**		On the display:	SF....C.	–	not possible
			In the memory:	1100001		
	S	senseless message in the serial line	**l**	errorless state		
	F	Frequency output is unsuitable	**h**	errorless state		
	C	Current output is unsuitable	**c**	errorless state		

Any of digital outputs (**OC1** or **OC2**, see chapter 4.5) can be assigned to the Error signalization. This output gets low state when any bit of the Items {002:**ErF**} signals Error. In this case the mass flow calculation is stopped, so the measuring system doesn't work.

4.2.2 Batch submenu

The device is capable to perform batch control function, too. Batch can be determined by total volume or total mass. One of the digital outputs signal (**OC1** or **OC2)** can be programmed for batch control (chapter 4.5). The output signal (assigned to the Batch control) keep in LOW state during the whole batching that is until the set quantity of fluid {091:**XbM}** flows through the meter.
Te batching state is displayed with b in the **info-character** of Editing row (see chapter 3.2)

Data in the submenu:

№:Name	Description	Unit	Modification
091:**XbM**	Total value to be batched	-	free
092:**Xb**	Actual value already batched from **Batch-START**	kg or m^3	not possible
093:**XbI**	Counter to be assigned to the batch {030:**ΣM**},{031:**ΣM1**},{032:**ΣV**}, {033:**ΣVn**}, {085:**ΣM2**}	-	free

The list of the items above can be modified according to he chapter 5.1.1.

<u>Starting batch from pushbuttons</u>:

Get displayed menu **Batch**. After pressing **MOD** on the display **Batch START?** is displayed. After pressing **ENT** batch is started and on the display the menu **Batch** is displayed again.
Batching can be stopped before reaching the preset total batch value: press again **MOD** (on the display **Batch STOP?** appears) then press **ENT** for stop the batch. At reaching the value of **XbM** the signal processing unit automatically stops batching.

<u>Starting batch through serial line</u>:

Item {090:**bMo**} serves for this purpose. The item can have three states:

0 batch has been stopped (On the display: **NoBatch**)
1 batch start (On the display: **StartB**),
2 batching in progress (On the display: **BATCH**).

For starting batch set the Item {090:**bMo**} to 1. Batching can be stopped before reaching the preset total batch value by setting the Item {090:**bMo**} to 0. At reaching the value of XbM the signal processing unit automatically stops batching.

4.2.3 TOTAL (resettable counters) submenu

In this menu three independent resettable counters can be accessed. The three counters can be independently programmable. The user can choose the necessary source data, and the mode of totaling. By using these counters it is possible for instance in the case of bi-directional flow to summarize separately the forward and reverse flow, or in case of batch control the summing of released batches. Resetting of resettable counters can be performed by two ways, by pushbuttons, or by serial line.

Data in the submenu:

№:Name	Definition	Unit	Modification
041:**Σ1X**	Resettable counter 1.	kg or m^3	not possible
042:**Σ2X**	Resettable counter 2.	kg	not possible
043:**Σ3X**	Resettable counter 3.	kg	not possible
044:**Σ1I**	Counter to be assigned to the resettable counters **Memory** — **Display** **030** > **ΣM** **032** > **ΣV** **033** > **ΣVn** **092** > **Xb** **031** > **ΣM1** **085** > **ΣM2**	-	free
045:**Σ2I**		-	free
046:**Σ3I**		-	free
047:**Σ1s**	Type of increase of resettable counters: **Memory** — **Effect** — **Display** **1** — Only the **positive** increment is added — **PosInc** **2** — Only the **negative** increment is added — **NegInc** **3** — The **absolute** value of increment is added — **AbsInc**	-	free
048:**Σ2s**		-	free
049:**Σ3s**		-	free

№:Name	Definition	Unit	Modification
038:**Σ0F**	Counter reset with **MOD** pushbutton **Memory** – **Effect** – **Display** **0** – Clear is inhibited – **NoClear** **1** – Counter 1 is cleared – **Clr(1)** **2** – Counter 2 is cleared – **Clr(2)** **3** – Counter 1 and 2 are cleared – **Clr(12)** **4** – Counter 3 is cleared – **Clr(3)** **5** – Counter 1and 3 are cleared – **Clr(13)** **6** – Counter 2 and 3 are cleared – **Clr(23)** **7** – Counter 1, 2 and 3 are cleared – **Clr(123)**		free
039:**Σ0P**	Counter reset protection **Memory** – **Effect** – **Display** **0** – Reset can be performed anytime – **NoPsw** **1** – Reset is protected by password – **PSW**		free
040:**Σ00**	Counter reset command through serial line **Setting** – **Effect** **0** – No clear (state after setting any value bellow) **1** – Clear Σ1X **2** – Clear Σ2X **3** – Clear Σ3X **4** – Clear all counters (ΣM, ΣV, ΣVn, Σ1X, Σ2X, Σ3X)		free

The list of the items above can be modified according to he chapter 5.1.1.

The unit of the above table shows the unit of the data stored in the memory. In the display user can set other units bellow (chapter 3.3):

Σ1, Σ2, Σ3	g, kg, t.

Resetting by the **MOD** pushbutton:

At displaying the menu name (**TOTAL**) by pressing the pushbutton MOD the name of counters to be reset (determined by the setting of {038:**Σ0F**}) will appear following characters **Clear**.

E.g.: in case of **Σ0F** = 3 **Clear Σ1, Σ2** will appear on the display.

By pressing pushbutton **ENT** contents of the displayed counters are cleared. In case reset is inhibited, (**Σ0F** = 0) then **MOD** is ineffective.

Resetting counters through serial line:

Second method of resetting the counters is setting item {040:**Σ00**}.

At clearing all counters the "electronic seal-number" {152:**CNo**} is changed.

4.3 Measurement menu

The menu **Measurement** contains the momentary values of mass flowrate, volumetric flowrate, temperature and density. In this menu the limit values of some parameters can be set. When entering the menu, data **Mf** is displayed.

Data in the menu:

№:Name	Description	Unit	Modification*
020:**Mf**	Mass flow	kg/s	not possible
023:**MLo**	Mass flow low limit	kg/s	free
024:**MHi**	Mass flow high limit	kg/s	free
025:**Vf**	Actual volumetric flow	m^3/s	not possible
027:**%Mf**	Mass flow rate in percent of max flow {029:**MfM**}	%	not possible
029:**MfM**	Max flow	kg/s	not possible
051:**De**	Density	kg/m^3	not possible
052:**DLo**	Density low limit	kg/m^3	free
053:**DHi**	Density high limit	kg/m^3	free
130:**T**	Temperature	°C	not possible
131:**TLo**	Temperature low limit	°C	free
132:**THi**	Temperature high limit	°C	free

The list of the items above can be modified according to he chapter 5.1.1.

The unit of the above table shows the unit of the data stored in the memory. User can display the data in other units bellow (chapter 3.3):

Mf, MLo, MHi, MfM	g/s, kg/s, kg/h, t/h.
Vf	l/s, m^3/s, m^3/h.
De, DLo, DHi	kg/l, g/l

4.3.1 Calibration submenu

In this menu data measured at **zero flow** conditions can be found, they are used for determining the so-called „Zero" offset of the sensor.

Data in the menu:

№:Name	Definition	Unit	Modification
101:**zdt**	{105:**dt**} at zero flow condition	s	Psw
102:**zN**	Actual number of zero-measurements since zero start	[-]	not possible
103:**zNM**	Number of zero-measurements at automatic zero stop.	[-]	Psw
104:**zdM**	zero measurements acceptation limit	s	Psw
105:**dt**	Time shifting of input signals calculated by the Fourier analyze.	s	not possible

The unit of the above table shows the unit of the data stored in the memory. In case of C-MASS-021 user can display the data in other units bellow (see chapter 3.3):

zdt, zdM, dt s, ms, µs.

Zeroing process:

Warning! The zeroing process can be started only at perfect zero flow. When displayed flow (**Mf**) is continuously zero, then this state is not enough for starting the zeroing. It means only that the measured flow is lower than the preset low-flow-cut (**%M0)**. Display the flow rate {027:**%Mf**} as the low flow-cut has no effect to this item. Set the decimal point into the position **0.000%** in order to see the value with suitable resolution.
To provide a perfect zero flow preferably use perfectly closed valves at the inlet and outlet tubes of the sensor.
If the sensor is filled-up correctly and the flow is perfectly zero than the start of zeroing process is permitted.

Start and stop zeroing process:
Choose the **Calibration** menu (chapter 4.) then press **MOD**.
Confirm the displayed "**Zero START?**" with **ENT**. A small "**z**" will appear in the info-character of display, showing that the zero calibrating process is in progress and the menu name **Calibration** is displayed again. When "**z**" disappears then the zeroing process has finished. If instead of appearance of small "**z**" a message of "**Zcal disabled** !" appears on the display, than the device indicates too high flow, so start of zeroing is disabled. In this case check the zero flow setting (chapter 6.4.1) and start again the zeroing process.
Zeroing can be stopped without changing of item {101:**zdt**} before reaching the end of the zeroing process: press again **MOD** and confirm the displayed "**Zero STOP?**" with **ENT**.

Start and stop zeroing process through serial line:
The item {100:**zMo**} serves for this purpose. This item can have three states:

- 0 No zeroing (On the display: **NoZero**),
- 1 Zeroing start (On the display: **StartZ**),
- 2 Zeroing in progress (On the display: **ZeroCAL**).

For starting the zeroing **1**= StartZ state must be set. Zeroing can be stopped without changing of item {101:**zdt**} before reaching the end of the zeroing process by setting **0**=NoZero state. At reaching the end of zeroing process {100:**zMo**} will be set back automatically to **0**=NoZero state.

Duration of zeroing process:
The final result of zeroing process is the new value of {101:**zdt**}. It is calculated by averaging of the {105:**dt**} values measured during the zeroing process. Duration of zeroing process depends on the number of measurements {103:**zNM**}. Set this number higher (150-200) if the zero accuracy is critical (working in the low flow range). Set this number lower (50-100) if the zero-flow state can not hold in long time (gas bubbles originate, or the temperature changes quickly because of intensive heating or cooling effect etc.)

Warning!
During the Zero-calibration process avoid the mechanical shock and vibration of the sensor

4.3.2 Fraction submenu

The submenu Fraction can be applied for measurement of two component mediums. The submenu serves for calculating quantities of solvents and mixtures. The mass or volume proportion of the components are signed with %M1, %M2, %V1, %V2. The value of the proportion is always between 0 and 1. Constants necessary for fraction calculation (a1D ... c3D) must be determined considering this. The device displays these values in %. In case of display in % the values can be between 0 and 100 %

Calculation of solvent:

Calculation of mass percentage:

$$\% M1 = a1D + a2D * T + a3D * T^2 + \left(b1D + b2D * T + b3D * T^2\right) * De + \left(c1D + c2D * T + c3D * T^2\right) * De^2$$

Calculation of mass flow:

$$Mf1 = Mf * \% Mf1$$

Calculation of total normal state volume of fraction 1.

$$\sum Vn = \frac{\sum M1}{D1n}$$

where:

%M1	mass percentage of fraction 1.[-]
a1..c3	constants necessary for the calculation (must be calculated based on the table containing density vs. temperature of the solvent).
T	operating temperature [°C]
De	effective density [g/l]
Mf1	mass flow of fraction 1. [kg/s]
ΣVn	total normal state volume of fraction 1. [m3]

Calculation of mixture:

Volume percentage calculation:

$$\%V1 = \frac{De2 - De}{De2 - De1} \qquad \left(\%V2 = 1 - \%V1\right)$$

Calculation of mass percentage:

$$\% M1 = \frac{De1}{De} * \%V1 \qquad \left(\% M2 = 1 - \% M1\right)$$

Calculation of density:

$$Dei = Din * EXP\left[-\alpha\ i * dt * \left(1 + Dib * \alpha\ i * dt\right)\right]$$

$$\alpha\ i = \frac{Ki0 + Ki1 * Din}{Din^2} \qquad dt = T - TDn \qquad i = 1,\ 2$$

where:

%V1, %V2	volume percentage of fractions 1. and 2. [-]
%M1, %M2	mass percentage of fractions 1. and 2. [-]
De1, De2	effective densities of fractions 1. and 2. [g/l]
D1n, D2n	normal state densities of fractions 1. and 2. [g/l]
De	effective density of the mixture [g/l]
TDn	temperature for determining normal state density = 15 [°C]
α1, α2	thermal expansion factors for fraction 1. and 2. [1/°C]
K10, K11	Constants for calculating thermal expansion factor for fraction 1.
K20, K21	Constants for calculating thermal expansion factor for fraction 2.
D1b, D2b	Constants for calculating densities of fractions 1. and 2.

The selection of fraction calculation is performed by setting the value of item 060:12D.

1 = BRIX Serves for calculation of fraction of solutions. In this case the user must specify the constants necessary for the calculations based on the tables containing the density of the solution vs. mass percentage and temperature.

2 = Alcohol Calculation of water solution of ethyl alcohol. The program of the device contains the necessary constants. It calculates the hectoliter degree usual in spirit industry in the item ΣVn, too.

3 = NetOil Net oil computation in case of crude oil measurement. It can be used with the constants stored in the program for crude oils of normal state density between 771 - 981 [kg/m^3].

Base data of calculation in case of mixture:

T	measured effective temperature
De	measured effective density
D1n	normal state density of fraction 1. that can be determined by laboratory measurements.

4.4 Inputs menu

In this menu measured or calculated data related to the sensor are displayed.

Data in the menu:

№:Name	Description	Unit	Modification*
106:**Adt**	Filtered value of time shifting {105:**dt**}	s	not possible
170:**rT**	Measured resistance of Pt100 temperature sensor	Ω	not possible
050:**fRe**	Resonance frequency of measuring tubes	Hz	not possible

The unit of the above table shows the unit of the data stored in the memory. In case of C-MASS-021 user can display the data in other units bellow (see chapter 3.3):

Adt s, ms, µs.

4.4.1 Driver submenu

In this menu the vibration data of the measuring tubes are displayed:

№:Name	Description	Unit	Modification
112:**EfA**	Effective voltage of signal “A” vibration sensor	V	not possible
113:**EfD**	Effective voltage of driver coil	V	not possible
114:**DDA**	Amplification of vibration loop	[-]	not possible
115:**DA1**	Amplification of electronic stage	[-]	mPw
116:**DAP**	Driver P-factor	[-]	mPw
117:**DTI**	Driver I-factor	s	mPw
111:**E0A**	Base-value of “A” vibration sensor	V	mPw

4.5 Outputs menu

Two programmable outputs (OC1 and OC2) and one serial port are available (Fig. 3). The User can configure OC1 and OC2 by setting the items **OC1** and **OC2** according to the table bellow:

Data in the menu:

№:Name	Description	Unit	Modification
166:**OC1**	OC1 output signal selector **Setting** / **Selected output** / **Display** **0** Frequency output **FrqOut** **1** Batch control output **BATCH** **2** Error signalization output **ALARM** **3** Test point (for service purpose only) **TstHDT**	-	free
167:**OC2**	OC2 output signal selector **Setting** / **Configuration** / **Display** **0** Frequency output **FrqOut** **1** Batch control output **BATCH** **2** Error signalization output **ALARM** **3** Current output (4-20mA) **4-20mA**	-	free

If **OC2** has been set to 4-20mA current output, the jumper “**J**”. (Fig. 4 and 5) should be set into **ON** state. Jumper “**J**” should be set into **OFF** state in all other settings of **OC2**.

4.5.1 Frequency output submenu

The frequency output can be assigned to the output OC1 or OC2 by setting the Items {**166:OC1**} or {**167:OC2}** to “0” according to the Table 1.
The Items bellow determine the parameters of the frequency output signal:

Data in the menu:

№:Name	Definition	Unit	Modification
200:**Fq**	Actual value of frequency output	Hz	not possible
202:**FqM**	Max value of output frequency assigned to {204:**FvM**}	Hz	not possible
204:**fvM**	Max value of measured data determined by {205:**FqI**}		free
205:**FqI**	Measured data assigned to the frequency output **Setting** / **Assigned data** / **Display** **020** Mass flow **Mf** **025** Volume flow **Vf**	-	free

To determine pulse value of frequency output, divide the value of maximum flow with maximum frequency as in the following formulas:

$$\textbf{Pulse}-\textbf{value}(kg/pulse)=\frac{\textbf{FvM}(kg/s)}{\textbf{FqM}\,(Hz)}=\frac{\textbf{FvM}(kg/h)}{\textbf{FqM}\,(Hz)\cdot\textbf{3600}}$$

4.5.2 Current output submenu

The current output can be assigned only to **OC2** output by programming the Item {**167:OC2**} to 3.
The Items in the table bellow determines the parameters of the current output:

Data in the menu:

№:Name	Definition	Unit	Modification
210:**Cu**	Actual value of current output	mA	not possible
211:**Cuc**	Min value of output current assigned to {213:**Cuv**}	mA	not possible
212:**CuC**	Max value of output current assigned to {214:**CuV**}	mA	free
213:**Cuv**	Min value of data assigned to {211:**Cuc**}		free
214:**CuV**	Max value of data assigned to {212:**CuC**}		free
213:**CuI**	Measured data assigned to the current output **Setting** **Assigned data** **Display** **020** Mass flow **Mf** **025** Volume flow **Vf** **051** Density **De** **130** Temperature **T**	-	free

4.6 System setup menu

This menu contains general data of the signal processing unit and the sensor. These serve for identification of the signal processing unit on one hand, and are significant data relating serial communication. When entering the menu the serial number of C-MASS-021 {153:**NrE**} is displayed.

Data in the menu:

№:Name	Definition	Unit	Modification
153:**NrE**	Serial number of C-MASS-021 signal processor unit	-	Psw
154:**NrS**	Serial number of CORI-FORCE sensor	-	Psw
160:**COM**	Communication protocol selector	-	free
162:**Adr**	Communication address of C-MASS-021	-	free
163:**Bd**	Speed of communication	-	free
165:**RSx**	Selector for function of communication port	-	free
166:**OC1**	Output signal selector for OC1	-	free
167:**OC2**	Output signal selector for OC2	-	free
172:**DSM**	Selector for function of Bar-graph	-	free
245:**DIM**	Enable/disable the unit changing of the data	-	free

4.7 Constants menu

This menu contains all the constants that are needed for normal operation of the device. These data are related to the sensors connected to the inputs. When entering the menu the data FF is displayed.

Data in the menu:

№:Name	Definition	Unit	Modification*
015:**FF**	Calibration constant of the sensor	-	Psw
016:**FA**	Multiplying factor of calibration constant	-	Psw
017:**aT**	Cal. const. temperature coefficient	-	Psw
019:**TB**	Cal. const. reference temperature.	^{o}C	Psw
028:**%M0**	Low flow-cut in percent of max flow {029:**MfM**}	kg/s	Psw
029:**MfM**	Mass flow maximum of the sensor	kg/s	Psw
054:**DeA**	Density offset	kg/m^3	Psw
055:**DeB**	Density constant	-	Psw
056:**DeC**	Temperature coefficient of density measurement	-	Psw
057:**T0D**	Reference temperature of density constant	^{o}C	Psw
107:**Kdt**	Filter constant of mass flow measurement	-	Psw
138:**rTC**	Correction factor of Pt100 temperature sensor	-	Psw
152:**CNo**	Electronic seal number	-	not possible
159:**PSW**	Password for protection of data Effective only in case of **ON** state of K/3 switch (chapter 5.3)	-	free

5. Settings

5.1 Settings of the menu and display

5.1.1 Modification of displayed data inside a menu:

In case the grouping of data in a given menu is not satisfactory for the user, so display of any other data is desired or the display of a data seems to be useless, there is a possibility to build in, or cut out items into or from the menu. The procedure is as follows:

- If building an item into a menu is desired, look up the serial number of the item from chapter 7.4
- Step on the menu to be modified.
- Press push-button **DSP**. The first data of the menu is displayed.
- Press push-button **MOD** and keep it pressed. Press push-button **DSP** too. ITEM = XXX is displayed, where XXX is the item number of the displayed data before pressing **MOD/DISP** together. The third digit is flashing, signaling that its value can be modified. Each press of push-button ▲ increases, each press of push-button ▼ decreases the value of the number. Set the value of the last digit of serial number of the item to be inserted
- After pressing ◄ push-button the second digit starts to flash. Set the value of decimals, and after stepping left the value of hundreds.
- Press **ENT**. From now on the desired data will be displayed in this menu.
- If You want to discard displaying of an item from the menu, after stepping into the menu let that certain item be displayed. Press button **MOD** and keep it pressed. Press simultaneously the button **ESC**. The data vanishes from the display and further cannot be seen in this menu. Naturally the discarded item can be built in the menu again at any time by the method described before.

5.1.2 Modification of the displayed data in the Large-row of display

It is practical to choose data most important from technological point of view, for instance mass flow. The way of putting this data into the Large row is as follows:

- Let the desired data displayed in the Editing-row.
- Press pushbutton MOD and keep it pressed.
- Press pushbutton ▲ . From now on the selected data will be displayed in the Large row, continuously refreshed, independently of what is displayed in the Editing-row.
- In case You want to change selection, repeat the procedure above.

Data displayed in the Editing and Large row of the display will be changed by pressing **MOD** and ▼ pushbuttons simultaneously. Although the data altered to the Editing-row doesn't get built in the active menu of the Editing-row and will not be displayed afterwards in the given menu.

5.2 Settings of the data, data protection

The modification of data stored in the device, the modification of which is enabled, can be performed in two ways:

- By pushbuttons,
- Through serial communication line.

In this chapter we deal only with the first possibility, because APPENDIX-2 deals with serial communication. Only the data displayed can be modified by the pushbuttons. Data that can be displayed and modified in the menus can be sorted into three types:

- Numeric data
- Character type data.
- Selectable data.

5.2.1 Modification of numerical data

Data stored by the device that are not measured or calculated values can be modified in case the right value of the password is given (see below). The way of modification is the following:

- The data to be modified must be displayed.
- Press button **ENT**. If the modification of the data is enabled, the left first digit of the data begins to flash, indicating that the value can be modified.
- The value can be increased one by one by pressing ▲ button, decreased one by one by pressing ▼ button. After setting the desired value step to the next digit.

- Each pressing of ► button is one step right, pressing of button ◄ is one step left, thus any digit of the displayed data can be selected. The selected digit is flashing, signaling, that its value can be modified.
- For selecting the position of the decimal point press button **DSP**. The decimal point begins to flash. The position can be shifted right by ◄ button, left by ► button. When the decimal point is positioned, press again **DSP** button. That returns to mode of digit modification.
- It is also possible to modify the sign of the data. Positioned at the sign position, each pressing of either ▲ or ▼ button changes the sign.
- Data entry in exponential form: if the value to be entered is so large or so small value that its value cannot be entered in 6 digit fixed point form with satisfactory resolution, it is possible to enter it in exponential (normalized) form. After pressing **MOD** button in data entry mode, the value of the exponent appears on the last four position of the display. (for instance E-06). The value and sign of exponent can be modified the same way as the value of the mantissa.
- Modified data becomes valid and is overwritten in the memory of the device, if You press button **ENT** again.
- In case anything went wrong during modification and You want to re-set the old value, pressing button **ESC** brings the old value back. (naturally it is only true in case You haven't pressed the button **ENT** again).
- Either **ESC** or **ENT** button has been pressed after modification, the device steps out of data modification mode. For a new modification the procedure must be repeated from the start.

5.2.2 Modification of character-type data

The character type data stored in the device that can be modified are the following:

- Password (PSW)
- Serial number of the devices (NrE, NrS)

Modification of character type data is performed the same way as that of the numeric data with the exception that the digits can be not only numeric but the full narrow ASCII character set (small and capital letters without accent, and special characters). Setting here is also performed by character positions. Here we can use the possibility that while setting the value, we keep the ▲ or ▼ button continuously. This is regarded by the device as repeated pressing, and the value of the character changes with about 5 per second. This fastens setting. Nearing the desired character depress the button and after this set the desired value by stepping one by one.

5.2.3 Modification of selectable data

The device stores data that can be set or changed by the user during operation. Such data are for instance the designation of output data, serial communication speed, state of zero calibration, state of batch control.
Initiation of modification is similarly started by pressing button **ENT** but modification is possible not by characters. All of the characters of the item are displayed in inverse tone, we can page the possible variants by pressing ▲ or ▼ buttons. (for instance in case of Bd one by one 600, 1200, 2400, 4800, 9600 and again 600 is displayed). The selected data can be set by pressing **ENT**.

5.2.4 Data protection

The device stores all data in EEPROM, therefore data must be protected only against rewriting by chance or unauthorized by pushbuttons or through serial line.

<u>Data that cannot be modified:</u>
The measured or calculated data stored in the device cannot be modified.

<u>Data protected by PSW</u>
The right setting of password {159:**PSW**} enables the modification of all data except the data mentioned in clause above. After setting to a value different from the value of the password the so-called "**significant**" data become protected. The "**significant**" data have effect to the accuracy of the measured quantities. Such is the case for instance the changing the flow factor {015:**FF**}.
By changing a "**significant**" data the electrical seal has been "broken" in the same time, so the seal number {015:**FF**} is changed too.
The password protection can be enable and disable by setting of K/3 dipswitch (chapter 5.3)

<u>Data that can be modified without password</u>
All data except data that cannot be modified or are protected by password can be modified without password. These data have no effect to the accuracy of the measured quantities. Such is the case for instance the changing of the application mode of an output.

5.3 Hardware settings

Behind the cover (see Fig. 4.) there are a Dipswitch (K) and a Jumper (J)
Setting of Dipswitch “K” and Jumper “J”:

Contacts	ON	OFF
K/1	Not used	
K/2	Following the power-on the communication will be set automatically: {160:**COM**}→C-BIN {162:**Adr**}→1 {163:**Bd**}→1200	Following the power-on the communication will be set the same as before the power-off.
K/3	Password needed for changing the “**significant”** items while the {159:**PSW**} is set different from the enabling value (159)	Following of the power-on the item {159:**PSW**} will be set automatically on the enabling value (159).
K/4	“Zero-start” pushbutton disabled	“Zero-start” pushbutton enabled
J	4-20mA current signal has been connected to output **OC2**. Setting {197:**OC2**} → 3 is necessary	No current signal output. **OC2** can be configured to the other functions {197:**OC2**} → 0, 1, 2

5.4 Software settings

The basic of the software setting is the list of the Items stored in the memory of the device. A printed list of the factory setting has been attached into the package of each device. Default settings can be found in Chapter 7.4.
The constants of the measuring system can be read and write (set), but the measured or calculated data can be only read via serial line. The read and write commands structure can be found in chapter 7.

6. Starting of the metering system

6.1 Filling the sensor

Before starting the metering system the sensor has to be totally filled with fluid to be measured. In case of the liquid measurement air bubbles should be drive out from the sensor by using a flow rate around 50% of the max flow. During this “filling flow” the temperature of the sensor should be stabilize near the working temperature.
In case of the gas measurement the “filling flow” also necessary in order to stabilize the working pressure and temperature.

6.2 Applying power supply

Apply the supply voltage between the pins 1 and 4 of the User connector plug (Fig. 3).
Diagnostic lamps and **info-character** (Fig. 4, chapter 3.2) will sign the state of the measuring system. Follow the instruction of chapter 7. in case of error-indicating.

6.3 Configuration of output signals

Generally the manufacturer presets the output signals according to the ordering specification of user. The manufacturer setting is documented in the “Item-list” which is one of the most important documents of supply. Control these settings according to the chapter 4.5. Change the settings if necessary.

6.4 Zeroing the flow meter system

The first step of Starting-up should be the zeroing. The mass flow measuring system has a “living zero”. This means that it measures the zero flow too. During the zeroing process the metering system makes a self-calibration at zero flow conditions and store the necessary zero shifting for the perfect zero flow display and outputs.
Warning!
Zero calibration is obligatory in case of the first installation and after changing the location or fixation of the sensor. Follow the instructions bellow for the correct zero calibration:

6.4.1 Zero flow

Before starting the zero calibration the flow rate has to be set to a perfect zero. It is recommended to apply good quality valves connected directly to the inlet and outlet of the sensor. The leakage of these valves will result zero error. Avoid the elastic tubes or tanks between the sensor and the zeroing valves.

6.4.2 Starting of Zero-calibration process

See chapter 4.3.1
Warning!
During the Zero-calibration process avoid the mechanical shock and vibration of the sensor

7. Serial line communication

The standard RS232 or RS485/422 serial line communication port of C-MASS-021® provides the possibility of linking to a computer. The following chapter describes in details the format of the serial line communication, the structure of the message that C-MASS-021® can understand and the answering message sent back. Based on this the user can prepare the communication and data processing program for his own computer.
At the list of presettable data the underlined values are the valid values after cold start.

7.1 Settings of the serial line

600, 1200, 2400, 4800, 9600, 19200 bit/s (determined by item 163:Bd),
8 data bits,
No parity bit,
2 stop bits transmitted (but waits only for one).

7.2 Protocol of the serial communication

Depending on the state of item 160:COM appearing in the menu System setup different communication protocols can be used for reading or modifying the data of the device.

Presettable values of the item: 0 = C-BIN
1 = C-ASC
2 = M-ASC
3 = M-RTU

7.2.1 C-FLOW character protocol (C-ASC)

When the 160:COM selector is in C-ASC (1) state, the messages always start with colon (:) character and are finished by the character pair carriage return (CR) line feed (LF). First the character corresponding to bits 7..4 then the character corresponding to bits 3..0 are sent in the message.
The structure of the message bytes is the same as in case of C-BIN protocol with the difference that the byte 01H signaling the start of the message is left.
When 160:COM selector is in C-BIN (0) or C-ASC (1) state, the meaning of the message bytes is the same, therefore the description below refers for both cases.

7.2.2 C-FLOW communication protocol (C-BIN)

The device answers the received command only in case the value of Address byte is either 00, or is equal to the value of item 162:Adr and the value of checksum byte is equal to the value calculated from the message bytes.

Structure of the message in case of transmit or receive:

Start of message	**01H**	
Length of message	N (= **n+3**)	
Address	must match with item 162:Adr	1.
Type of message	Command, ERROR, or STATUS byte	2.
1. info byte		3.
2. info byte		4.
n. info byte		(n+2).
CSUM	checksum byte	**(n+3).**

The algorithm for calculating the checksum:
1a; CSUM := 0
1b; pointer to the length byte
2a; CSUM := CSUM + (pointed message byte)
2b; increase of message byte pointer
2c; in case there are more message bytes, repeat from 2a.
3 ; CSUM := 100H - (CSUM AND 0FFH)

7.2.3 Structure of the command sent to C-MASS-021®

Address:

Determines to which device the command is sent by the computer. The C-MASS-021® interprets the command only if the value of item 162:**Adr** is equal to this byte. If the value of this byte is = 00H, the device executes the command independently of the value of 162:**Adr**.

Type of message

56H - **"V"** asking software version of the device. No info byte.

44H - **"D"** reading definition of item.
Info byte = serial number of item.

52H - **"R"** reading the value of an item.
Info byte = serial number of the item.

57H - **"W"** data value modification.
1. Info byte = serial number of the item.
Further info bytes depending on type:
- bits: the bits in **1 byte**.
- byte: **1 byte** integer number
- selector: **1 byte**, the serial number of the selection
- character string: **10 byte**, the first byte is the code of the first character.
- floating point: **4 byte**, IEEE single precision (PASCAL single type) number, first is the LOW byte of the mantissa

49H - **"I"** restart of the device as it would be switched off and on.
Info bytes:
Cold character string means cold start at the same time.
Adr=1 character string means that at the time of initialization the value of item 162**:Adr becomes 01** .

7.2.4 Structure of the answer message given by C-MASS-021

Device address:

Always matching with value of item **Adr.**

Message type:

ERROR (00..1FH):

0 = errorless state
In this case the **ERROR** byte is followed by info bytes depending on the received command.
Their description can be read at the answering message starting with **STATUS** byte.
1 = undefined command
Info byte = received command code
2 = command refers to unused item
Info byte = item number
3 = value of the item cannot be modified
Info byte = item number
4 = length of the message is illegal
Info byte = received length byte
5 = must wait to access item
Info byte = item number
6 = item is not accessible
Info byte = item number

STATUS byte:

bit(7..4) = **0010***B*
bit(3) = 1, if any of bits of item 000:**Err** is 1
bit(2) = 1, while batching is in progress
bit(1) = 1, while zero calibration is in progress
bit(0) = **0**

STATUS byte is followed by info bytes depending on the received command.

"V" command: the identifier of the device
1. info byte: 00H
2 - 15. info byte: " **cMASS v6.97*x***"
x = version number of the device
16. info byte: 00H

"D" command: the definition of the item
1.info byte: number of the item

2.info byte: item type designator:

= 1 : one byte integer
= 2 : selector
= 3 : series of bits
= 4 : character string
= 5 : pointer
= 6 : remote data

(floating point types:)
= 100 : proportion, unit: [%]
= 101 : number of pulses, unit: [imp]
= 102 : time, unit: [s]
= 103 : volume, unit: [m^3]
= 104 : mass, unit: [kg]
= 105 : volumetric flow, unit: [m^3/s]
= 106 : mass flow, unit: [kg/s]
= 107 : frequency, unit: [Hz]
= 110 : no unit: [-]
= 111 : temperature, unit: [°C]
= 112 : (not used)
= 113 : density, unit: [g/l]
= 119 : voltage, unit: [V]
= 120 : angle, unit: [rad]
= 121 : resistance, unit: [Ω]
= 150 : relative, unit: [-]
= 151 : no unit .

3.info byte: bits signing the right for modification
if the value is 0, the item is read only

4,5,6.info byte: three characters identifier
The identifier appearing on the display with the difference that the info bytes contain underline (_) characters instead of space

From 7. info byte...
- In case the item type is selector (2) then from the 7. info byte the character string of pattern text give the meaning of each data. The patterns are separated by character "$" and at the end of the string is 00H byte.
  The 7. info byte contains the first character of the string dedicated to the 00 value of the item.
- in case of bit string (3) type item then the 7 - 14. info bytes contain the eight characters dedicated to the bits. 7th . info byte contains the character code dedicated to the most significant bit.
- in case of relative type (150) item then bytes 7., 8. points to the number of the item storing the 0 % and 100 % value of the item, in case of other type of floating point data these two bytes do not give information for the user.
- in case of other type items the answer given for the command "D" contains only six info bytes.

"R", or **"W"** command: the value of the item (VARIABLE) is:
1. Info byte = number of the item
Further info bytes depending on type:
- bit string: bits in 1 **byte**
- byte: **1 byte** integer number
- selector: **1 byte**, number of the selected unit
- character string: **10 byte**, first byte is the code of the first character.
- floating point: **4 byte**, IEEE single precision (PASCAL single type) first LOW byte of the mantissa.

For **"I"** command the device sends no answer but executes the command.

Structure of the MODBUS message

In the state of selector item 160**:COM M-ASC** (2), or **M-RTU** (3) the meaning of the message bytes is identical therefore the following description refers to both case.

The device answers the received command only in case the value of the *Address* byte matches the value of item 162:**Adr** and the control (LRC, or CRC) code matches the values calculated from the message bytes.

By the MODBUS protocol a register contains two bytes long data. The CMOS RAM area storing the data of C-MASS-021® can be considered as such a register block addressable by two bytes. The one byte (bit string, byte, selector, pointer) data cover a full register, that is they are appearing on both byte of the register at readout. The reason for it is that in case of data modification the data following each other should be handled separately. For reading the floating point (4 bytes) data two registers are necessary. String type data (length is 10 byte) are situated on 5 register area. At readout (and also at modification) care must be taken for that the handling of data covering more registers can be handled only by selecting all of the data between them.

Data of C-MASS-021® are accessible from the register address 0000.

R[0000*H*]	000:**Err** (repeated on two bytes)
R[0001*H*]	001:**ErD** (repeated on two bytes)
.	
R[0009*H*]	009:**WaO** (repeated on two bytes)
R[000A*H*]	013:**ErY** (repeated on two bytes)
R[000B*H*]	014:**MLi** (repeated on two bytes)
R[000C*H*]	015:**FF** SignExp, M22..16
R[000D*H*]	015:**FF** M15..08, M07..00
R[000E*H*]	016:**FA** SignExp, M22..16
R[000F*H*]	016:**FA** M15..08, M07..00

Relation of item numbers and MODBUS register addresses can be found in the table at the end of the manual, but also can be read out by using function *Register address readout.*

7.3 MODBUS character format (M-ASC)

In the **M-ASC** (2) state of selector item 160**:COM** the messages always start with colon (***:***) character and are finished by the character pair carriage return (***CR***) line feed (***LF***). First the character corresponding to bits 7..4 then the character corresponding to bits 3..0 are sent in the message.

Before the message terminating ***CR LF*** the one byte checksum byte appears, which, similarly to the message bytes contains two hexadecimal bytes.

Algorithm for calculating the LRC code:

1a; **LRC** := 0
1b; pointer to the first byte of the message
2a; **LRC** := **LRC** + (pointed message byte)
2b; increment of message byte pointer
2c; If there are more message bytes, repeat from point 2a
3 ; **LRC** := 100H - (**LRC** *AND* 0FFH)

7.3.1 MODBUS binary format (M-RTU)

In the **M-RTU** (3) state of selector item 160**:COM** the message bytes contain the message bytes contain the message binary without further coding.. At the end of the message, differing from the M-ASC protocol not a control sum (LRC) byte, but a two-byte CRC code can be found.
Algorithm for calculating CRC code:

1a; **CRC** := 0FFFFH
1b; pointer to the first message byte

2a; **CRC_low** := **CRC_low** *XOR* (pointed message byte)
2b; sh_Cntr := 8
3a; shifting CRC right one bit
3b; if the shifted out bit = 1, then:
CRC := **CRC** *XOR* 0A001H
3c; sh_Cntr := sh_Cntr -1
3c; if sh_Cntr > 0, repeat from 3a
4a; increment of message byte pointer
4b; In case there is are more message bytes, repeat from 2a

After the message bytes first the **CRC_low** byte is sent, the message is terminated by **CRC_high** byte.

7.3.2 Error signaling answers

In case of incorrect structure of the commands detailed later (in case the command is addressed to the device) one of the two following answers is sent back by the device.

Answer in case of unknown command

Device address	value of item Adr
Function code	80H + command Function code
Error code	01H

Answer in case of register address error

Device address	value of item Adr
Function code	80H + command Function code
Error code	02H

7.3.3 Function reading registers (03 Read Holding Registers)

Command:

Device address	Must match with item Adr
Function code	03H
Reg.addr. high byte Reg.addr. low byte	
Reg. no. high byte Reg. no. low byte	00H N

Answer in case of correct command:

Device address	value of item Adr
Function code	03H
number of following bytes	2 * N
1. Reg high byte 1. Reg low byte	data block 1.byte data block 2.byte
N. Reg high byte N. Reg low byte	data block (2*N-1). byte data block (2*N). byte

Number of registers readable in one turn (N) is max. 120. In case the specified register range does not start or end at data block limit, an error message is sent by the device.

Function Register modification (16 Preset Multiple Registers)

Command:

Device address	Must match with item Adr
Function code	10H
Reg.addr. high byte Reg.addr. low byte	
Reg. no. high byte Reg. no. low byte	00H N
number of following bytes	2 * N
1. Reg high byte 1. Reg low byte	data block 1.byte data block 2.byte
N. Reg high byte N. Reg low byte	data block (2*N-1). byte data block (2*N). byte

Answer in case of correct command:

Device address	value of item Adr
Function code	10H
Reg.addr. high byte Reg.addr. low byte	the one in the command the one in the command
Reg. no. high byte Reg. no. low byte	00H N

7.3.4 Device identification (17 Report Slave ID)

Command:

Device address	Must match with item Adr
Function code	11H

Answer in case of correct command:

Device address	a 162:Adr item value
Function code	11H
number of following bytes	n
identifier 1. character identifier 2. character identifier n. character	1. byte 2. byte n. byte

The identifying string sent in the answer for the function is identical with the string of the main menu, that is it contains the type and the software version number of the device. The function corresponds to the „**V**" command of protocol **C-BIN** (**C-ASC**).

7.3.5 Reading out register addr.

The relation between numbers of C-MASS-021® items and MODBUS register address is nonlinear, this function serves for reading the starting address of the register dedicated to an item. The answer for the command contains the byte defining the type of the item and the length of the item in bytes.

Command:

Device address	must match with item Adr
Function code	41H ('A')
Item no. high byte Item no. low byte	00H C-MASS-021 item number

Answer in case of correct command:

Device address	value of item Adr
Function code	41H ('A')
Reg.addr. high byte Reg.addr. low byte	
Item type	
number of item bytes	

7.3.6 Reading item definition

Command:

Device address	Must match with item Adr
Function code	44H ('D')
Item no. high byte Item no. low byte	00H number of item

Answer in case of correct command:

Device address	value of item Adr
Function code	44H ('D')
byte count	n
Item type	1. byte
Item modification right	2. byte
identifier 1. character identifier 2. character identifier 3. character	3. byte 4. byte 5. byte
= (7. info byte)	6. byte
= (last info byte)	n. byte

The function corresponds to command „**D**' of **C-BIN** (**C-ASC**) protocol, information described there contain the meaning of the bytes in the answer..

7.4 Description of IEEE Floating Point number

The arithmetic program of the device works by the single precision (byte) IEEE standard that stores floating point data in the following format:

1.BYTE:	M07	M06	M05	M04	M03	M02	M01	M00
2.BYTE:	M15	M14	M13	M12	M11	M10	M09	M08
3. BYTE:	E00	M22	M21	M20	M19	M18	M17	M16
4. BYTE:	SGN	E07	E06	E05	E04	E03	E02	E01

where:

SGN: Sign of mantissa (1 = -, 0 = +)
M00-07: Bits of byte0 of mantissa
M08-15: Bits of byte1 of mantissa
M16-22: Bits of byte2 of mantissa. M23 is always 1, therefore it is not stored. It means that the value of mantissa is always greater or equal to 1 and less than 2
E00-E07: Exponent bits.

Attention! The bit E00 is the most significant bit of the 3. byte. The value of exponent has 127DEC (&FH) offset. It means that if the exponent is 4 (2^2) we store it really as 127+4 = 131 DEC (83H) but not on one byte but the E00 is stored in the MSB of the 3. byte and the remaining on the low 7 bits of byte 4, shifted right with one. If the mantissa is negative, 128 (80H) must be added to this byte.

Examples:

Decimal	1.BYTE	2.BYTE	3.BYTE	4.BYTE
-1	00H	00H	80H	BFH
0	00H	00H	00H	00H
1	00H	00H	80H	3FH
2	00H	00H	00H	40H
4	00H	00H	80H	40H
10	00H	00H	20H	41H
100	00H	00H	C8H	42H

7.5 HART communication

C-MASS-021 is suitable for HART communication, when the user has requested this communication form in the order. In this case the measuring circuit is containing a MODBUS/HART converter, which can receive the MODMUS-RTU RS485 serial line output of C-MASS-021, and it converts this output to a standard 4-20 mA current output for HART communication. Type of MODBUS/HART converter: **NCS-MH105.**
Figure 7 show the mounting and mechanical sizes of this converter. Its connection with output of C-MASS-021 can be seen on the Figure 8.
The 4-20 mA HART output of the converter is passive, so it needs an external power supply (max. 30 VDC). As the GND of NCS and GND of C-MASS-021 are the same it is practical to use the same power supply for both devices.
The setting of HART output can be seen in the **Item-list** of the measuring system (see Ch. 7.6).

7.6 Data stored in the memory of devices

The list of the data stored in the memory of devices (so called **Item-list**) is the important accessories of the measuring system. This list is containing the factory setting of the memory, so the preservation of this list is very important. This list is the only source of the data recovery, when the memory of devices has been damaged.

8. FIGURES

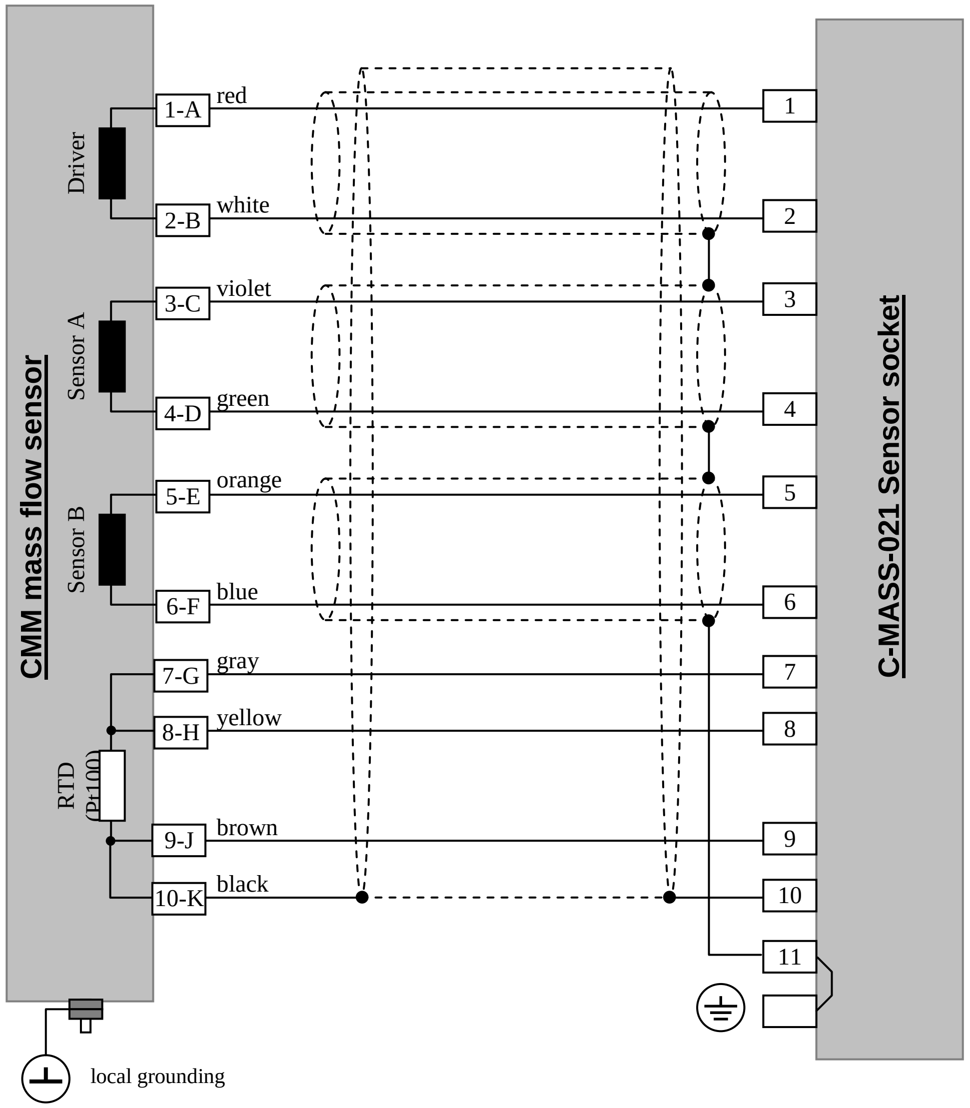


Figure 1. **Connection of Sensor-socket in normal (non hazardous) application**

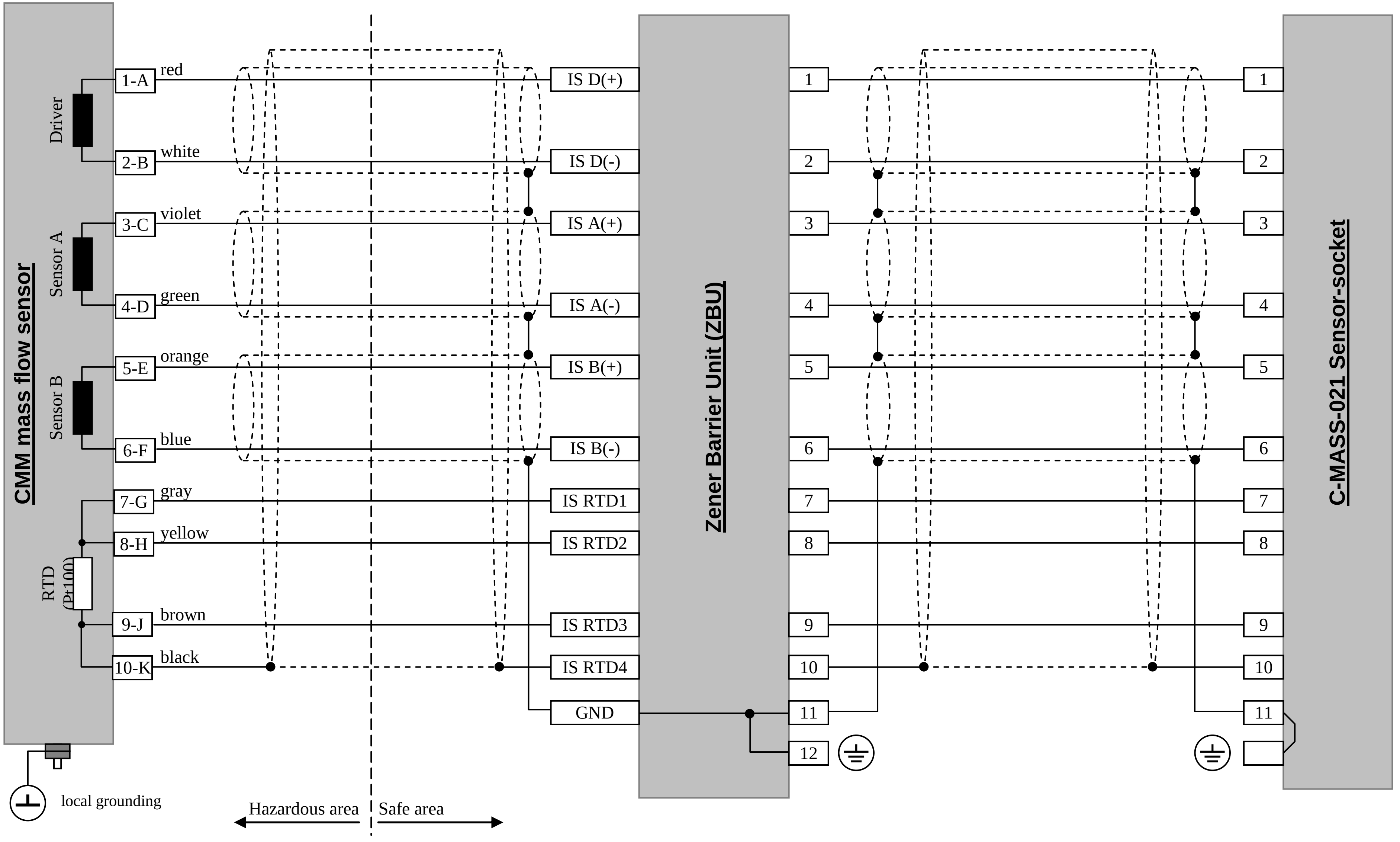


Figure 2. Connection of Sensor-socket in hazardous application

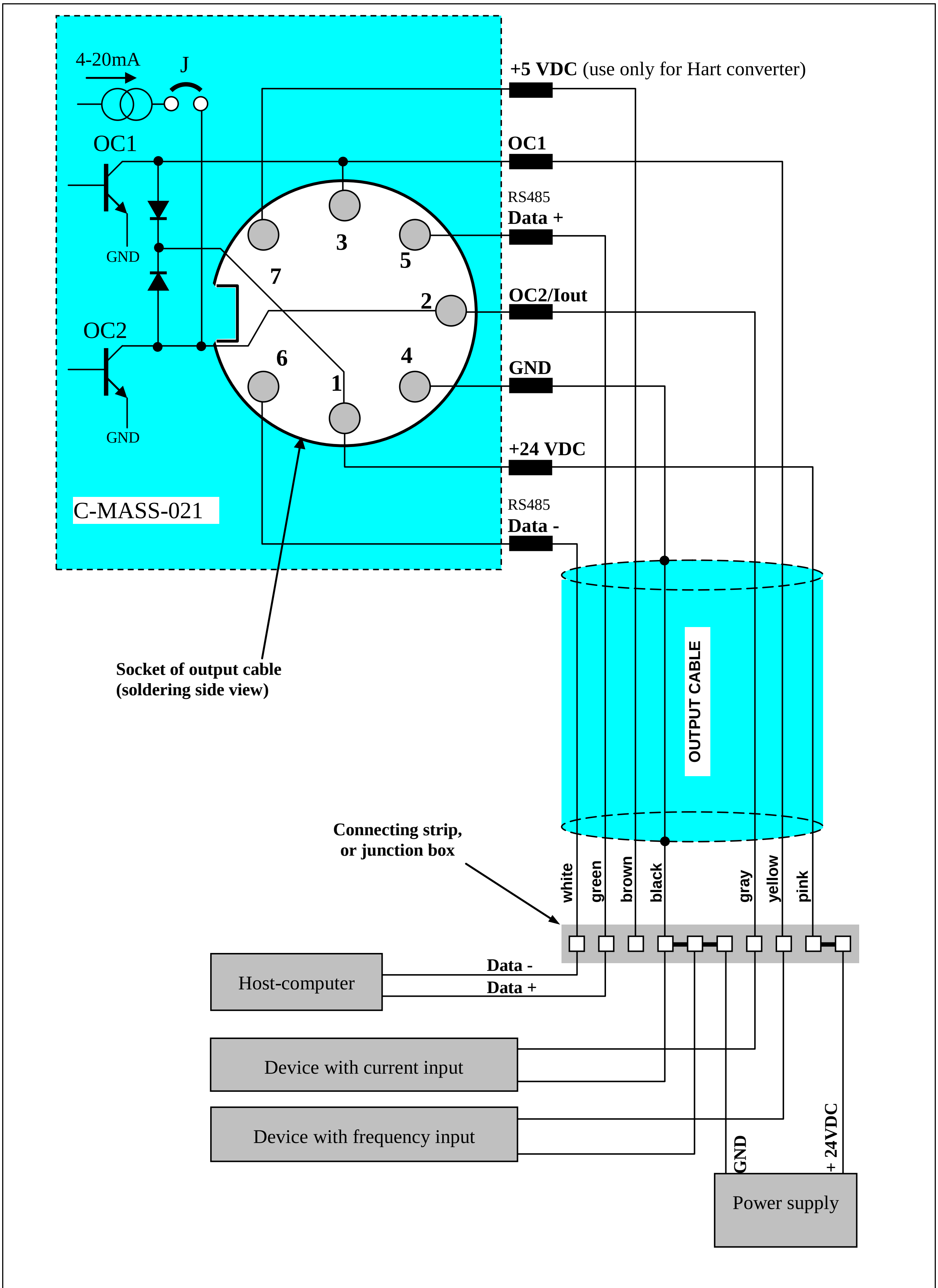
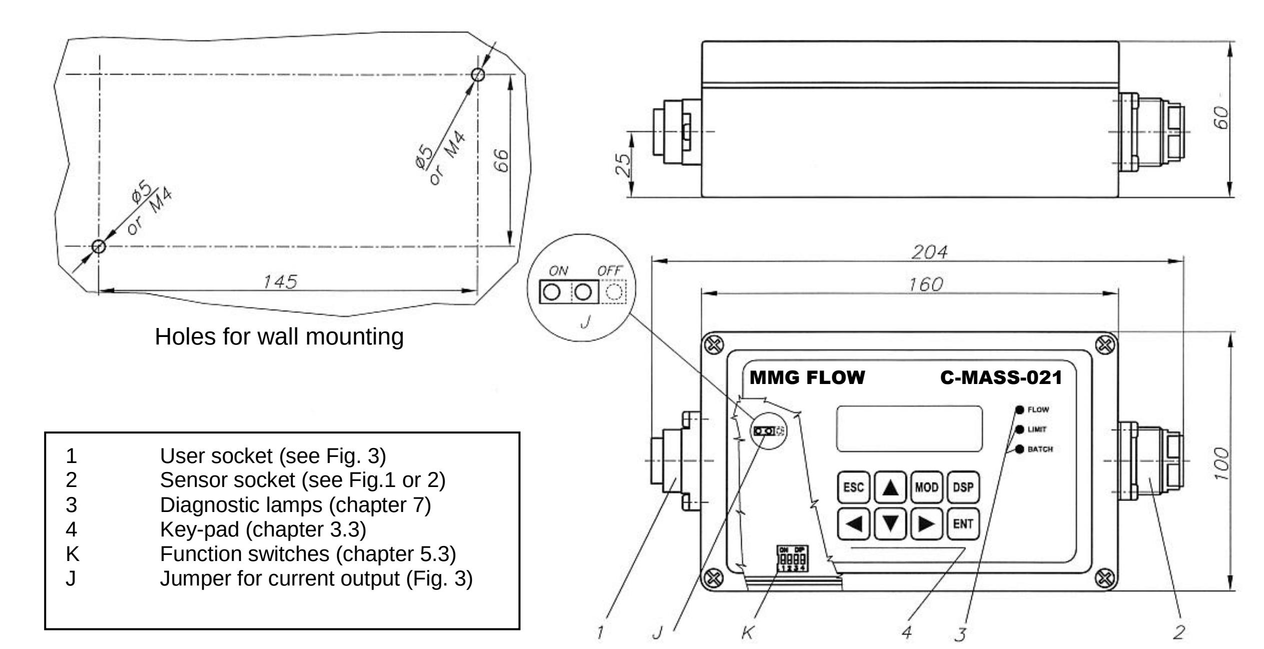


Figure 3. **Connection diagram of Outputs**



1	User socket (see Fig. 3)
2	Sensor socket (see Fig.1 or 2)
3	Diagnostic lamps (chapter 7)
4	Key-pad (chapter 3.3)
K	Function switches (chapter 5.3)
J	Jumper for current output (Fig. 3)

Figure 4. Mechanical sizes and hardware settings of C-MASS-021

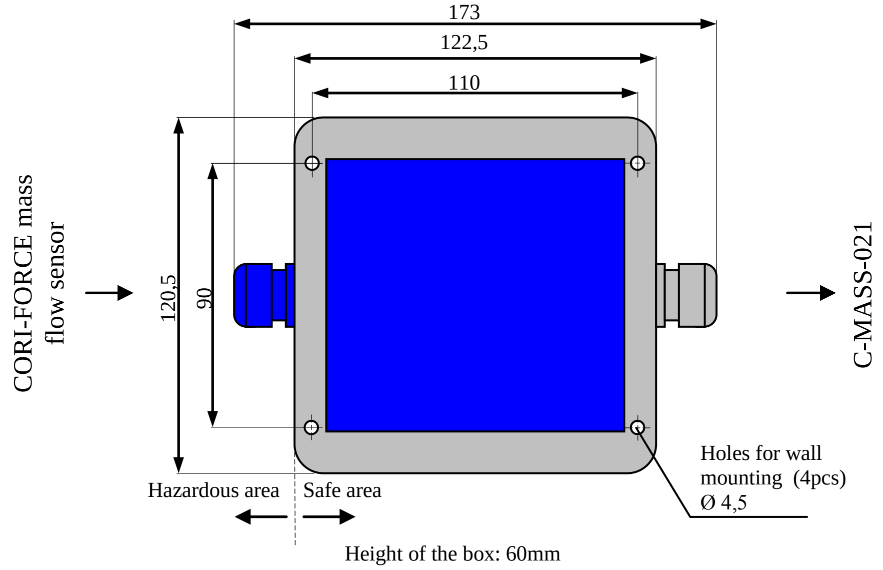


Figure 5. Mechanical sizes and connection of Zener Barrier Unit

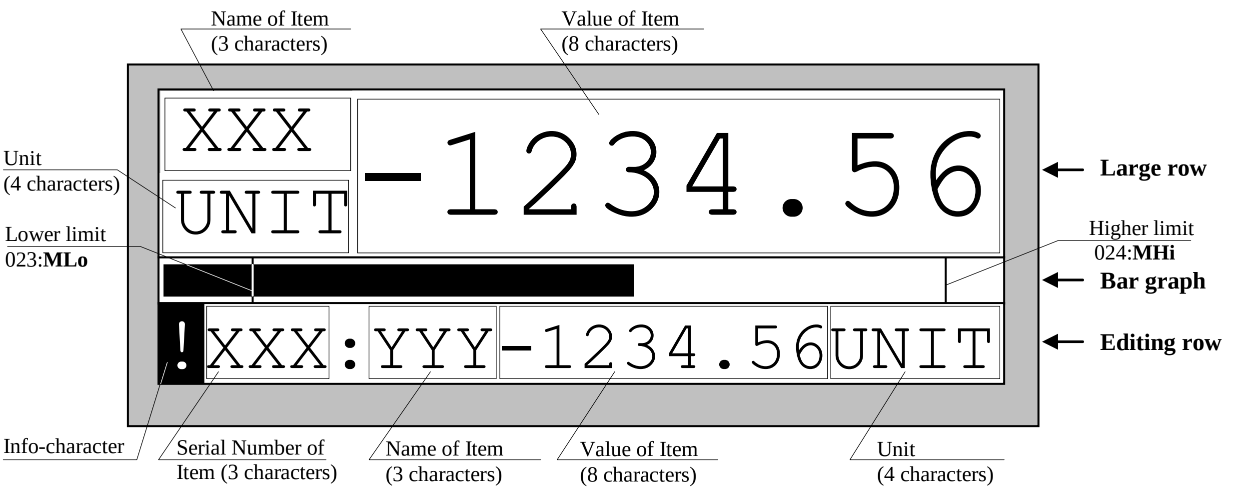


Figure 6. Structure of display

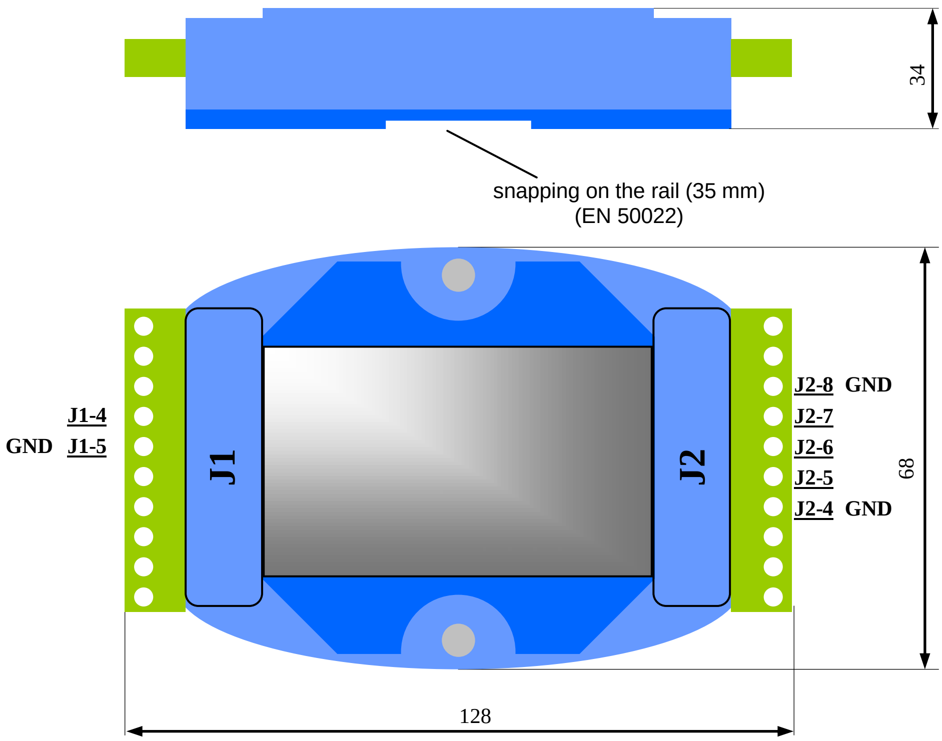


Figure 7. MODBUS / HART converter

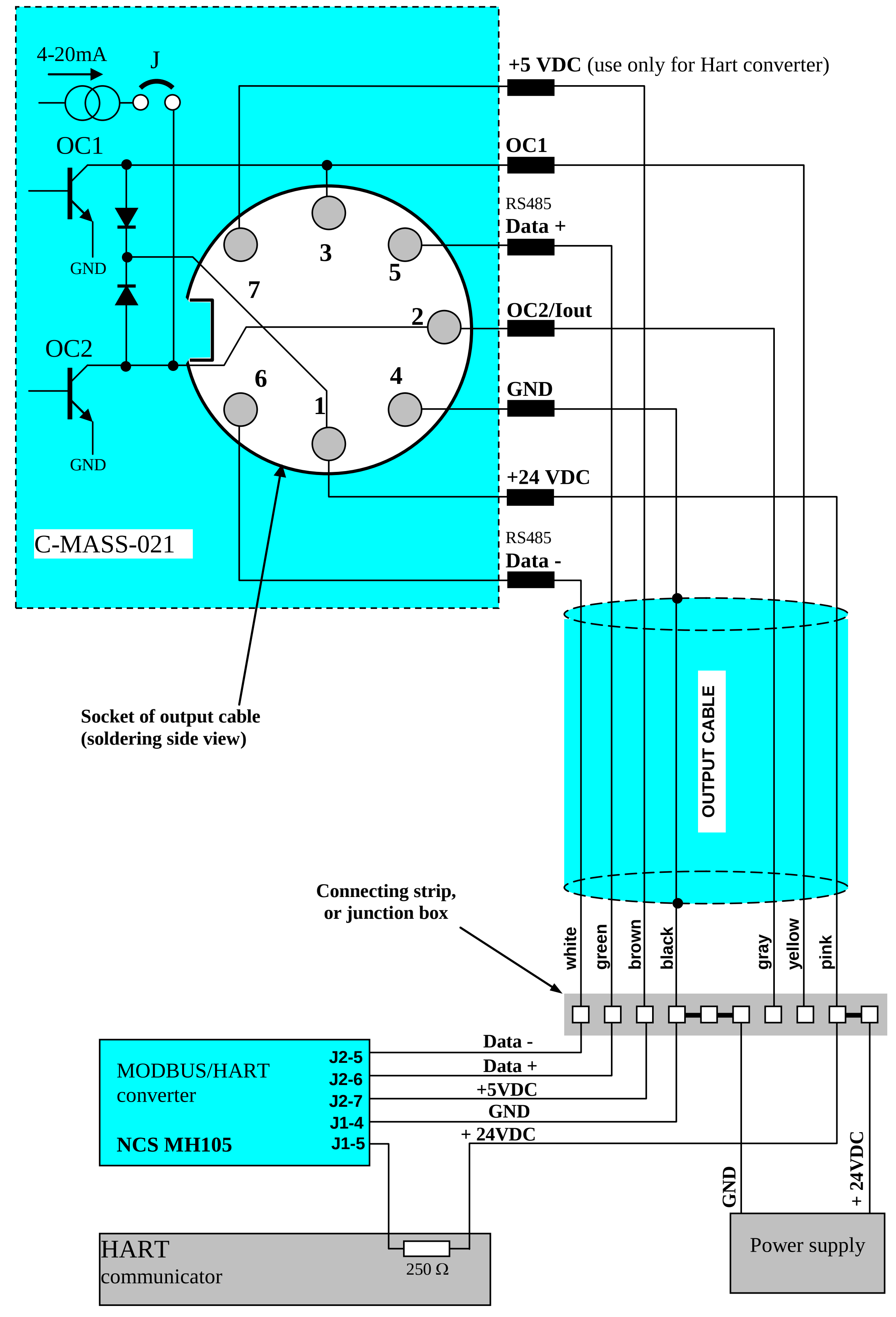


Figure 8. **Connection diagram of MODBUS / HART converter**