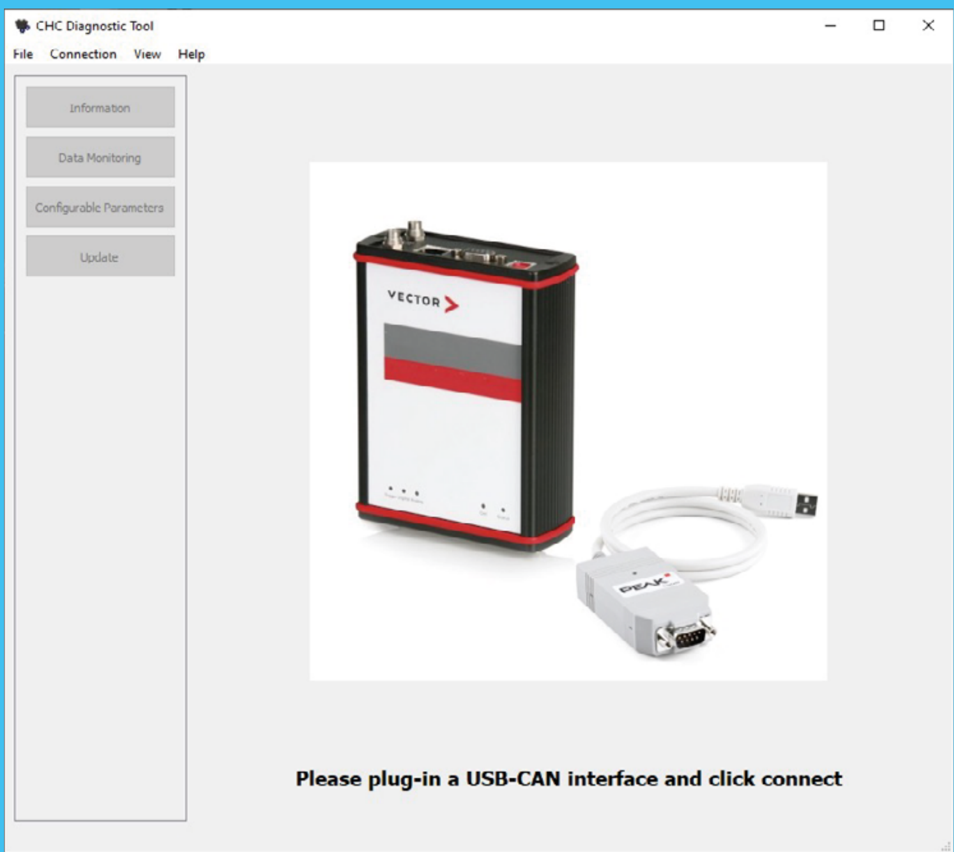
A Bosch Company

Instruction manual

CHC-DT applied on Base SW



RE 18324-43/2023-06-16, EN

The data specified within only serves to describe the product. No statements concerning a certain condition or suitability for a certain application can be derived from our information. The information given does not release the user from the obligation of own judgment and verification. It must be remembered that our products are subject to a natural process of wear and aging.

The cover shows an example application. The product delivered may differ from the image on the cover.

Contents

1 Introduction

The purpose of the following manual is to explain the operation of the software “SW_CHC_BASE” created ad hoc for the CHC 12-1/20 control unit.
Starting from an overview explanation to describe in more details the functioning and the safety behaviour of the software treated.

– What “Base software” is? –
SW_CHC_BASE is a software created to define a default customer usable software. It has 3 different input types to drive all the 12 CHC output ports. The default one use CAN communication messages. The second one uses the analog inputs in a linear way. The third one uses the analog inputs in a parametric way.
It can use CAN communication to send and receive messages from other control units. Using different logical procedure is possible to define safety features on analog input communication, on CAN communication and during output drive.
EEPROM was used to define default parameters. These parameters could change the behaviour of the software.

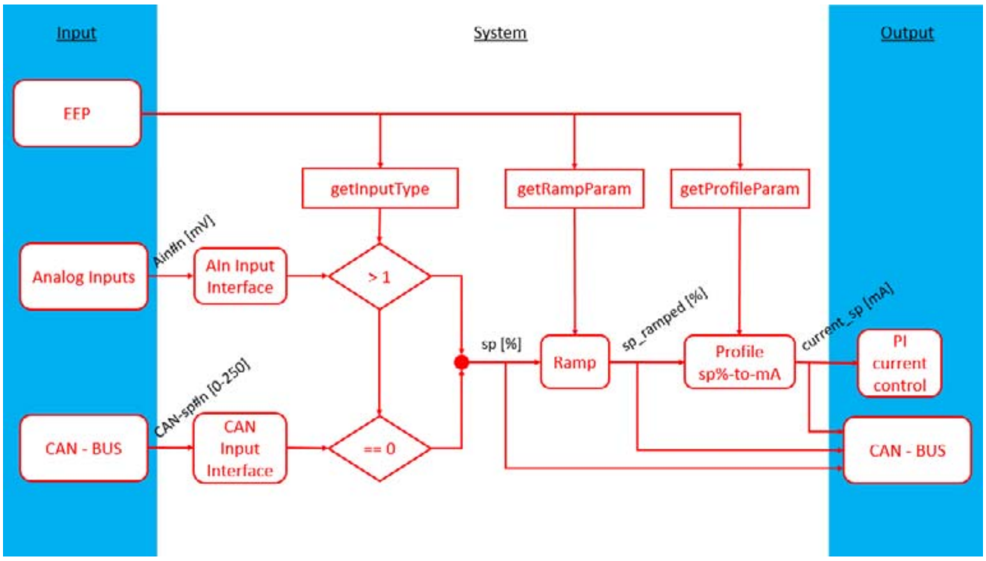


Figure 1-1 Software general block scheme

In the figure 1-1 are visible the three different areas of the software. From input, passing through logic system, concluding to the output state.
CHC Base software can read as an input:
• Analog input, for example pressure sensors or flow sensors.
• Input message from CAN with certain name ID.
• Configurable parameters from EEPROM.
From a certain input Set Point a standard ramp with profile are configured for the outputs drive.
With PI current control is possible to define a current closed loop to correctly drive the desired output.
With the PI current control is also possible, changing the voltage to the coil, to keep the current sent to the coil constant at each temperature variation of the same.
CHC sends also debug and status CAN message to allow user to know the system state during application run.
In the next chapters the focus will be on the Diagnostic Tool and how form it is possible to change EEPROM parameters whose are necessary for software functioning.

2 Diagnostic Tool

2.1 Installation details and requirements

- CHC Diagnostic Tool doesn’t require installation. User must unzip the archive and shall run the file named “CHC-DT.exe”
- The User must not move the “CHC-DT.exe” file outside the containing folder
- CHC Diagnostic Tool software makes use of Peak or Vector CAN-to-USB Interfaces to provide CAN connectivity; therefore, the User shall install the drivers of the intended CAN Interface before making use of the CHC Diagnostic Tool.

2.2 Interface Description

Once the User successfully installed the CAN Interface driver and unzipped the archive than it is possible to launch the .exe file contained in the folder that shall have the content shown in the following image.

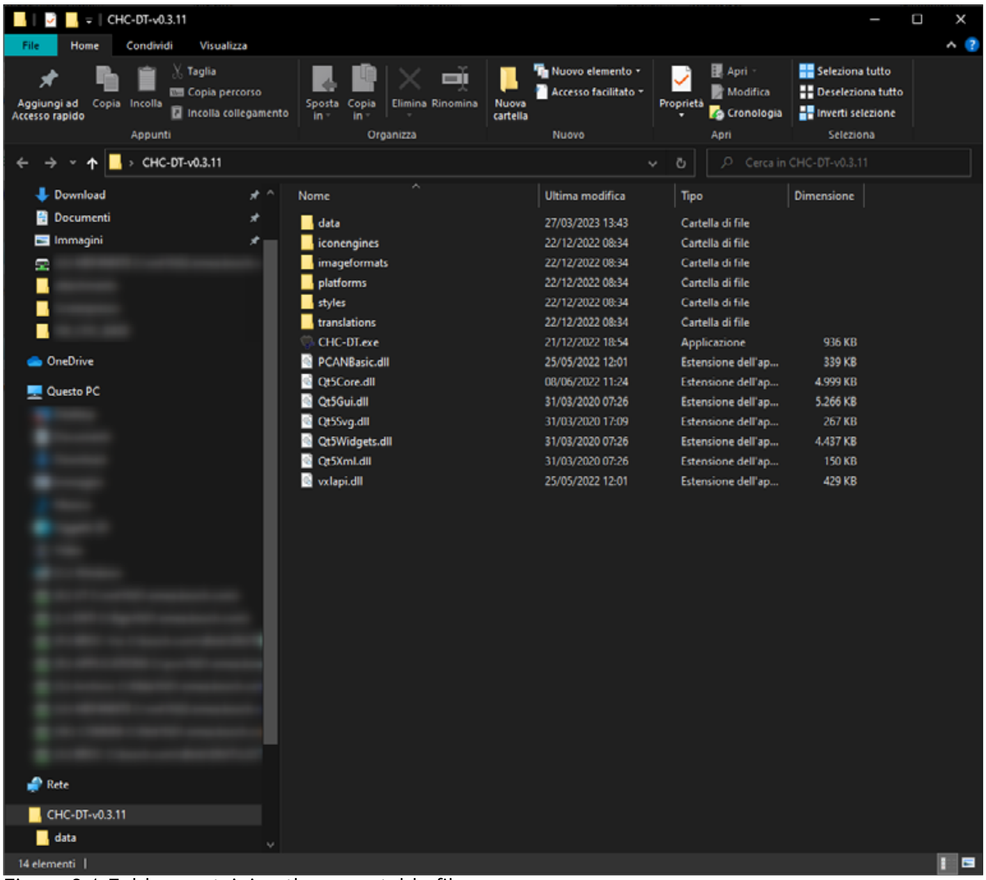


Figure 2 1 Folder containing the executable file

2.3 GUI

The following figure represents the opening screen of the CHC-DT. It has the following features:

- File: not used
- Connection: set up connection parameters, start and stop connection.
- View: toggle the view of the CAN Log and App Log.
- Help: additional information.

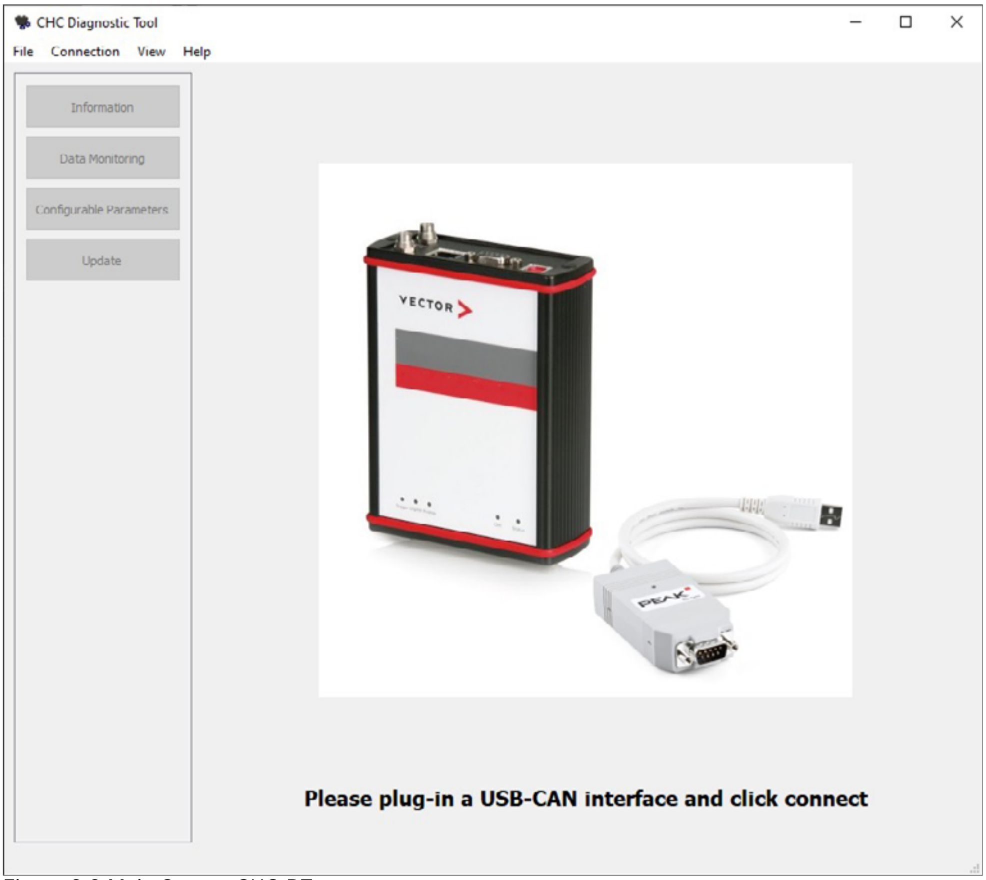


Figure 2 2 Main Screen CHC DT

N.B. the User is highly encouraged to toggle the “Show App Log View” from the “View” menu.

2.4 Connection

Once the User installs the drivers of the USB-CAN interface and plugs the interface in the USB port of the PC it’s possible for the DT to take the rights on such interface and open the CAN communication channel.

The sequence of operations that the User must perform are the following:

- Set up the CAN settings by means of the “CAN Settings” option selectable through the “Connection” menu, when clicking on such option the Dialog box shown in Figure 2-3 here below (example using Peak interface and baudrate of 250kbps)
- Start the connection by means of the “Connect” option in the “Connection” menu.

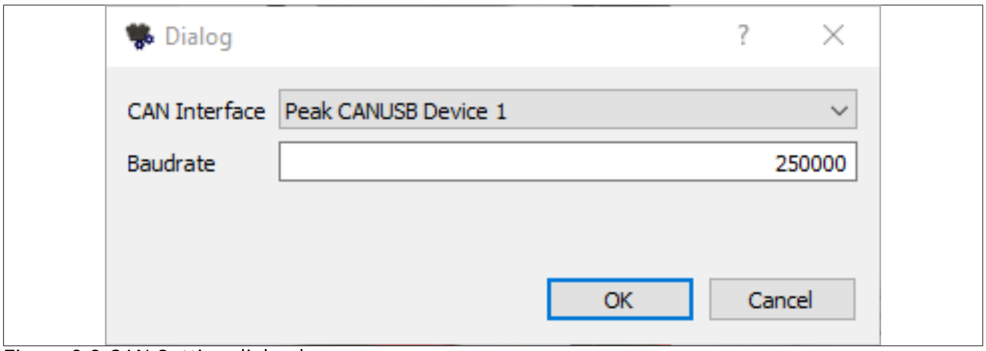


Figure 2 3 CAN Setting dialog box

Once connected the buttons on the left on the GUI shall be enabled (User shall be able to press them)

N.B. if the User enabled the App Log view then it’s possible to assess if the connection operation has been performed successfully and get troubleshooting information if not.

2.5 Firmware Update

Once Connected the User may use the Update feature of the CHC-DT to flash a new firmware version on the CHC. This operation shall be done by left clicking on the Update Button on the left side of the GUI.
The User shall select the proper hex file to be updated to the CHC by means of the browse functionality.
Once everything is set in place it’s possible to start flashing the board by clicking on the Update button right below the progress bar.

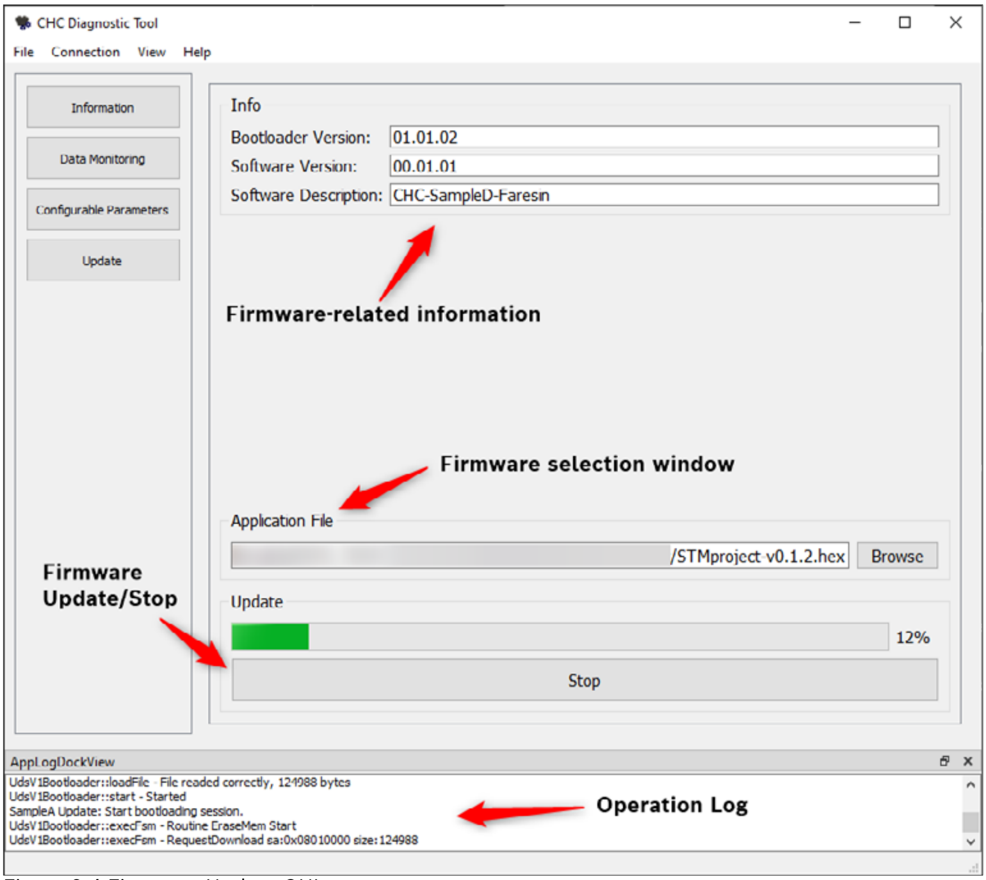


Figure 2 4 Firmware Update GUI

N.B. CHC must not be switched off during update operation
N.B. DT must not be closed during update operation
N.B. During the Update the DT and the CHC will exchange information on CAN frames having IDs 0x650 and 0x651 therefore these IDs must not be used by other ECUs
N.B. Update operation of the CHC shall be carried out in safety condition i.e., when the machinery is not in a condition in which it can harm people or things in the surroundings

2.6 Configurable Parameters

Configurable parameters are written and read by the Diagnostic tool by means of UDS protocol over CAN communication between CHC and Diagnostic tool.
These parameters are stored in the non-volatile memory of the CHC (EEP memory) and can be changed only by means of the Diagnostic Tool; more specifically the user that shall read/write EEP parameters from/to the CHC shall use the “Configurable Parameters” menu in the Diagnostic tool.

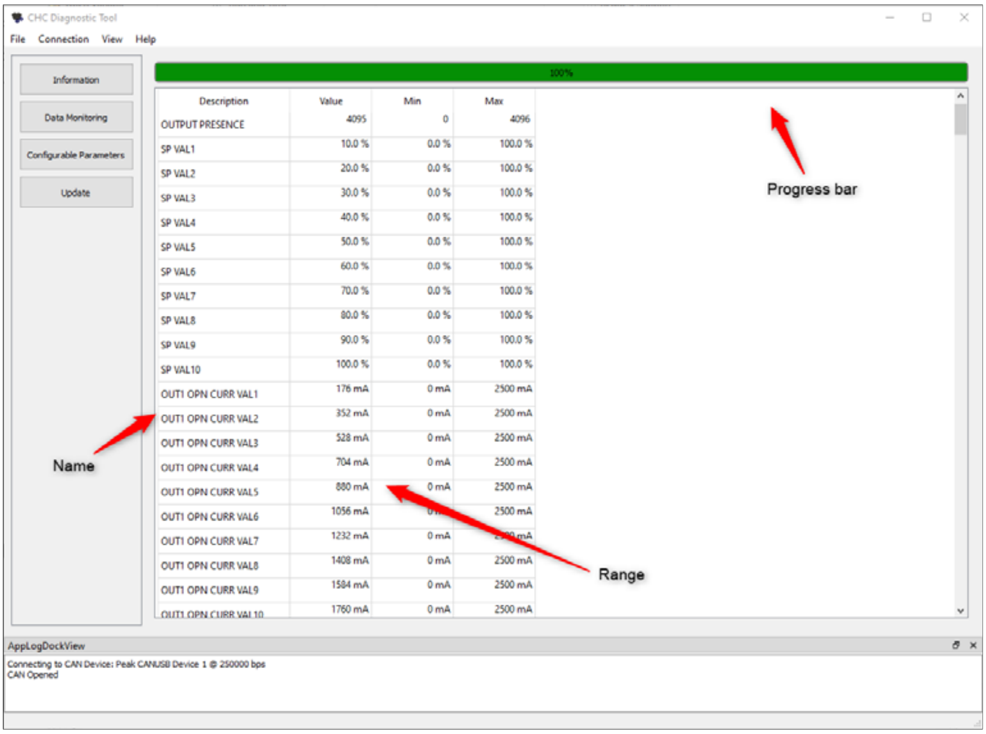


Figure 2 5 Configurable parameter GUI

Parameter	Use in the application
"OUTPUT PRESENCE"	User can define which Output ports will be enabled and covered by diagnostics. Value from 0 to 4096, user must use decimal value, which correspond to binary code (each Output port is a binary unit). i.e., if user want use Output ports "Out1" and "Out2" the binary code must be "0000 0000 0011", which correspond to decimal "3"→ "OUTPUT PRESENCE" = 3
"SP VAL1 ... SP VAL10"	User can define "10 points" Set point values. At each Set point correspond a current value, then used in PI control loop. Set point values inserted in these parameters will be used for all the 12 Output ports. Default values: - SP VAL1 = 10,0 % - SP VAL2 = 20,0 % - SP VAL3 = 30,0 % - SP VAL4 = 40,0 % - SP VAL5 = 50,0 % - SP VAL6 = 60,0 % - SP VAL7 = 70,0 % - SP VAL8 = 80,0 % - SP VAL9 = 90,0 % - SP VAL10 = 100,0 %
"OUT#1-12 OPN CURR VAL1 ... OUT#1-12 OPN CURR VAL10"	User can define 10 Output current "opening" values. Each current value has the correspondent Set point value, then used in PI control loop. Default values: - OUT#1-12 OPN CURR VAL1 = 176 mA - OUT#1-12 OPN CURR VAL2 = 352 mA - OUT#1-12 OPN CURR VAL3 = 528 mA - OUT#1-12 OPN CURR VAL4 = 704 mA - OUT#1-12 OPN CURR VAL5 = 880 mA - OUT#1-12 OPN CURR VAL6 = 1056 mA - OUT#1-12 OPN CURR VAL7 = 1232 mA - OUT#1-12 OPN CURR VAL8 = 1408 mA - OUT#1-12 OPN CURR VAL9 = 1584 mA - OUT#1-12 OPN CURR VAL10 = 1760 mA Above current values are defined for KBVS/KSVS 12V valves uses, for other valves see "No default valves use" part.
"OUT#1-12 CLS CURR VAL1 ... OUT#1-12 CLS CURR VAL10"	User can define 10 Output current "closing" values. Each current value has the correspondent Set point value, then used in PI control loop. Default values: - OUT#1-12 CLS CURR VAL1 = 176 mA - OUT#1-12 CLS CURR VAL2 = 352 mA - OUT#1-12 CLS CURR VAL3 = 528 mA - OUT#1-12 CLS CURR VAL4 = 704 mA - OUT#1-12 CLS CURR VAL5 = 880 mA - OUT#1-12 CLS CURR VAL6 = 1056 mA - OUT#1-12 CLS CURR VAL7 = 1232 mA - OUT#1-12 CLS CURR VAL8 = 1408 mA - OUT#1-12 CLS CURR VAL9 = 1584 mA - OUT#1-12 CLS CURR VAL10 = 1760 mA Above current values are defined for KBVS/KSVS 12V valves uses, for other valves see "No default valves use" part.
"DEBUG MSG"	User can define which debug message see. Allowable values from 0 to 12. - 0, no debug message on CAN - From 1 to 12, from Out1 to Out12 debug messages
"OUT#1-12 OPEN TIME"	User can define the ramp "opening" time for each Output port. Values are defined in ms.

Parameter	Use in the application
“OUT#1-12 CLOSE TIME”	User can define the ramp “closing” time for each Output port. Values are defined in ms.
“CLEAR EEP”	User can rewrite default parameters in EEPROM. When the value of this parameter is different than 2021, the default table will be rewrite in EEPROM. CHC needs “reboot” to write default parameters in EEPROM.
“AIN VMIN”	User can define the min value for Analog input reading (for linear analog input condition). Values are defined in mV. AIN VMIN is the same for all the Analog inputs.
“AIN VMAX”	User can define the max value for Analog input reading (Linear analog input condition). Values are defined in mV. AIN VMAX is the same for all the Analog inputs.
“VP MIN”	User can define the percentage of the analog input value, with respect to the supply voltage, at which the driving of a given “low Output” ends. Default value: 25% of the power supply. (Ratiometric analog input condition).
“VP REST”	User can define the percentage of the analog input value, with respect to the supply voltage, at which correspond no Output drive. Default value: 50% of the power supply. (Ratiometric analog input condition).
“VP MAX”	User can define the percentage of the analog input value, with respect to the supply voltage, at which the driving of a given “high Output” ends. Default value: 75% of the power supply. (Ratiometric analog input condition).
“VP DEADZONE”	User can define the percentage of the analog input value, with respect to the supply voltage, which is the dead zone value. Use of VP DEADZONE: - Added to VP MAX → from VP MAX to VP MAX + VP DEADZONE max drive to the “high Output”. - Subtracted from VP MIN → from VP MIN to VP MIN - VP DEADZONE max drive to the “low Output”. - Added and subtracted to VP REST → from VP REST to VP REST + VP DEADZONE no Output drive. From VP REST to VP REST - VP DEADZONE no Output drive. Default value: 3% of the power supply. (Ratiometric analog input condition).
“INPUT TYPE”	User can define which “input type condition” will use. - 0, CAN Input condition (default condition). - 1, Linear Analog Input condition - 2, Ratiometric Analog Input condition
“INPUT PRESENCE”	User can define which Analog input will be enabled and covered by diagnostics. Value from 0 to 4096, user must use decimal value, which correspond to binary code (each Analog input is a binary unit). i.e., if user want use Analog input “Ain1” and “Ain2” the binary code must be “0000 0000 0011”, which correspond to decimal “3”→ “INPUT PRESENCE” = 3
“KP_#1-12”	User can define the “proportional” and the “integral” component of the PI control loop.
“KI_#1-12”	Each Output can have its KP and KI parameters.
“ID CHC”	User can define a certain ID number for each CHC.
“AIN_VIEW”	User can set the view of the Analog input readings. If AIN_VIEW = 1, Analog input readings are reported on CAN messages.

To modify the parameters, the user shall left click the parameter to be modified, edit the value, and then left click on another spot on the screen. This operation triggers an exchange of data between the DT and the CHC, if the operation has been performed successfully the user shall see the parameter value updated in the table of the GUI.

In the case in which the operation has failed the used should see the parameter value highlighted with a color yellow and the progress bar gets colored of red.

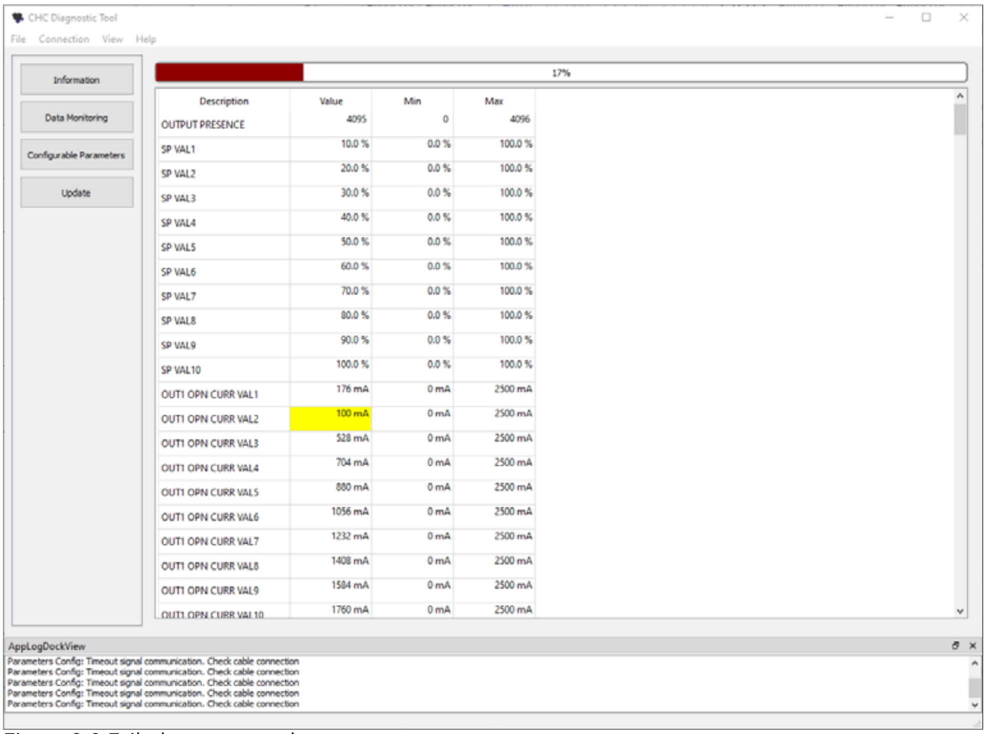


Figure 2 6 Failed parameter change

In addition, a line of the log should highlight what went wrong.

To reset the DT, once the fault has been restored (bad connection, CHC switched off, ...) the used shall disconnect the DT and reconnect it.

Caution must be taken in modifying such parameters as they directly influence the speed of the arm in lowering operations and the performances of the electronic load compensation.

Generally, these parameters should not be modified once the valve has been received since they have already been tuned properly by our production process. Only skilled personnel shall modify these parameters.

2.7 Data Monitoring

Data Monitoring allow to see in real time the behavior of some system parameters. The data on this section cannot be changed as in the “Configurable Parameters” section. Is possible only to filter certain data you want to view.

In this section are sown:

• State and instantaneous values of Analog inputs.

Diagnosis

	Code	Parameter	Value
1	AIN1_VALUE	Analog Input 1 Value	0 mV
2	AIN1_STATUS	Analog Input 1 Status	2

• Voltage supply to the board.

Diagnosis

	Code	Parameter	Value
13	BATTERY_VALUE	Battery Voltage	12516 mV

• Safety switch voltage.

Diagnosis

	Code	Parameter	Value
14	HSD_VALUE	Safety Switch Voltage	11970 mV

• Board temperature.

Diagnosis

	Code	Parameter	Value
15	BOARDTEMP_VALUE	Board Temperature	29 °C

• State and instantaneous values of Output ports.

Diagnosis

	Code	Parameter	Value
32	OUT1_CURRFB	Output 1 Current Feedback	0 mA
33	OUT1_STATUS	Output 1 Status	0
56	OUT1_SETPOINT	Output 1 Setpoint	0 %

3 CHC Base software

3.1 Input

As mentioned before, the SW can handle three different types of input. It is not possible to drive all these inputs at the same time so an EEPROM parameter is set to define which of these must be used.
This parameter is called “Input type”, it can assume 0, 1 or 2 as value:
• Case “Input type = 0” → CAN Input condition.
• Case “Input type = 1” → Linear Analog Input condition.
• Case “Input type = 2” → Ratiometric Analog Input condition.
The Input Voltage range of the analog inputs is set to 0-32 V.
Below the CAN messages which report the value of the voltage in Analog inputs in mV.
These messages are visible setting parameters “AIN_VIEW” equal to 1.

ID	**0xB3**	**ext.**					
Freq.	**100ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFSET**	**Function**	**Comments**
0	0	8	8	0-255	-	Input voltage LSB	AIN#1 LSB Input voltage in mV
1	8	15	8	0-255	-	Input voltage MSB	AIN#1 MSB Input voltage in mV
2	16	23	8	0-255	-	Input voltage LSB	AIN#2 LSB Input voltage in mV
3	24	31	8	0-255	-	Input voltage MSB	AIN#2 MSB Input voltage in mV
4	32	39	8	0-255	-	Input voltage LSB	AIN#3 LSB Input voltage in mV
5	40	47	8	0-255	-	Input voltage MSB	AIN#3 MSB Input voltage in mV
6	48	55	8	-	-	n.a.	-
7	56	63	8	-	-	n.a.	-

ID	**0xB4**	**ext.**					
Freq.	**100ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFSET**	**Function**	**Comments**
0	0	8	8	0-255	-	Input voltage LSB	AIN#4 LSB Input voltage in mV
1	8	15	8	0-255	-	Input voltage MSB	AIN#4 MSB Input voltage in mV
2	16	23	8	0-255	-	Input voltage LSB	AIN#5 LSB Input voltage in mV
3	24	31	8	0-255	-	Input voltage MSB	AIN#5 MSB Input voltage in mV
4	32	39	8	0-255	-	Input voltage LSB	AIN#6 LSB Input voltage in mV
5	40	47	8	0-255	-	Input voltage MSB	AIN#6 MSB Input voltage in mV
6	48	55	8	-	-	n.a.	-
7	56	63	8	-	-	n.a.	-

Another important parameter to use the Analog inputs is the “INPUT PRESENCE”. As explained before, this EEPROM parameter can manage which Analog inputs use and on which the diagnosis is made.

3.1.1 Can Input condition

Can input condition is the default one (“Input type = 0”), the condition which the user will find on default use of the software.
Below, the block scheme of the Can input condition.

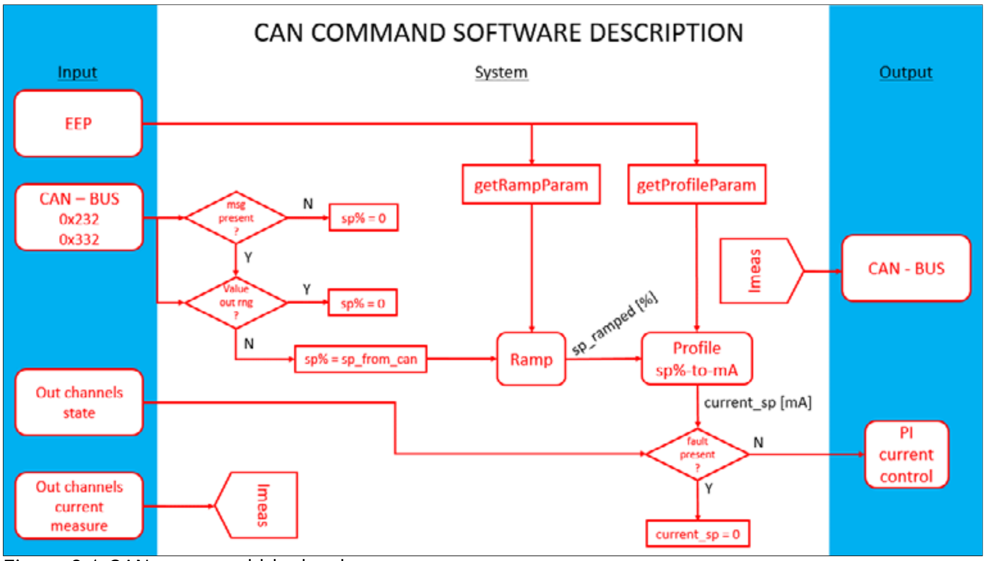


Figure 3-1 CAN command block scheme

“System section” and “Output section” will be explained in the next chapter
Two CAN messages are involved to drive the outputs, next how they are composed

ID	**0x232**			**ext.**			
Cycle Time	**100ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFFSET**	**Function**	**Comments**
0	0	7	8	0-250	-	B1 setpoint 0.4% max current/digit	OUT#1 setpoint
1	8	15	8	0-250	-	B2 setpoint 0.4% max current/digit	OUT#2 setpoint
2	16	23	8	0-250	-	B3 setpoint 0.4% max current/digit	OUT#3 setpoint
3	24	31	8	0-250	-	B4 setpoint 0.4% max current/digit	OUT#4 setpoint
4	32	39	8	0-250	-	B5 setpoint 0.4% max current/digit	OUT#5 setpoint
5	40	47	8	0-250	-	B6 setpoint 0.4% max current/digit	OUT#6 setpoint
6	48	55	8	-	-	n.a.	-
7	56	63	8	-	-	n.a.	-

ID	0x332			ext.			
Cycle Time	**100ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFFSET**	**Function**	**Comments**
0	0	7	8	0-250	-	B7 setpoint 0.4% max current/digit	OUT#7 setpoint
1	8	15	8	0-250	-	B8 setpoint 0.4% max current/digit	OUT#8 setpoint
2	16	23	8	0-250	-	B9 setpoint 0.4% max current/digit	OUT#9 setpoint
3	24	31	8	0-250	-	B10 setpoint 0.4% max current/digit	OUT#10 setpoint
4	32	39	8	0-250	-	B11 setpoint 0.4% max current/digit	OUT#11 setpoint
5	40	47	8	0-250	-	B12 setpoint 0.4% max current/digit	OUT#12 setpoint
6	48	55	8	-	-	n.a.	-
7	56	63	8	-	-	n.a.	-

Set point range from CAN message must be from 0 to 250 (in hex 0-FA). Then the software will scale the value inserted from 0 to 1000 (sp% from 0% to 100,0%).
These values correspond to a certain current value driven to the output (settable with EEPROM parameters, configurable parameters section in DT)
If Set point higher than 250, alarm appears. (See diagnostic chapter)
If at least one of the two command messages is not present, alarm appears. (See diagnostic chapter)
On boot up, all the command byte of the messages must be set to zero.
If, on boot up, at least one sent command byte is set at a value higher than 0, software gives an alarm, and it doesn’t drive the desired output. (See diagnostic chapter).
If command message transmission is stopped, set point then must be set to zero to drive the desired output. (See diagnostic chapter).

3.1.2 Linear Analog input condition

In this input condition all the six analog input ports could be used to drive the odd outputs. The value of current to the outputs is strictly related to the voltage applied on the analog inputs.

Input voltage and Output current range values are settable from certain EEPROM parameters.

Linear analog input condition block scheme below:

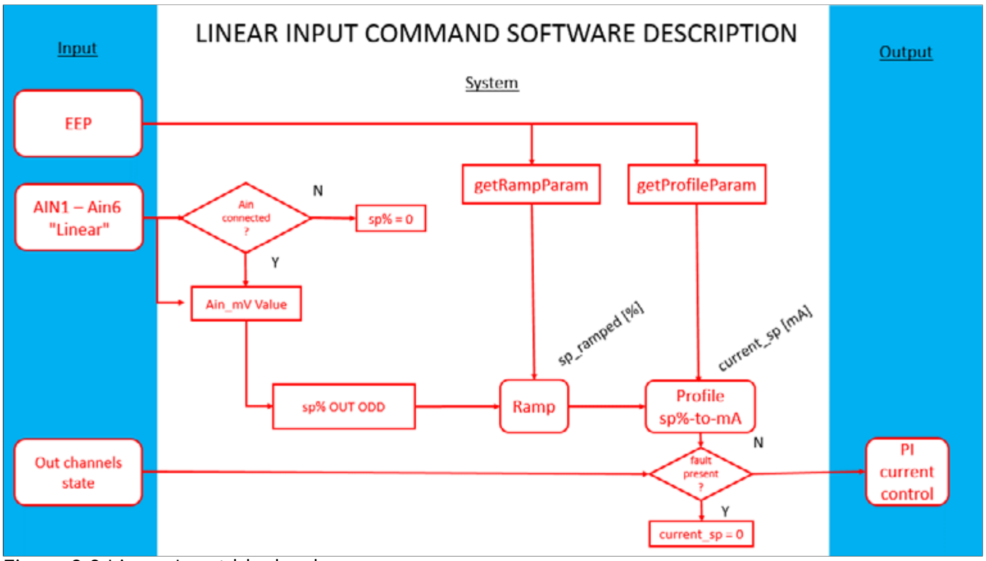


Figure 3-2 Linear Input block scheme

"System section" and "Output section" will be explained in the next chapter.

With EEPROM parameters AIN VMIN and AIN VMAX is possible to set a certain input voltage range, which will be converted to an internal Setpoint from 0 to 1000. Then the desired Output ports will be driven with a current value proportional to the internal Setpoint.

Below the Input voltage vs Setpoint characteristic.

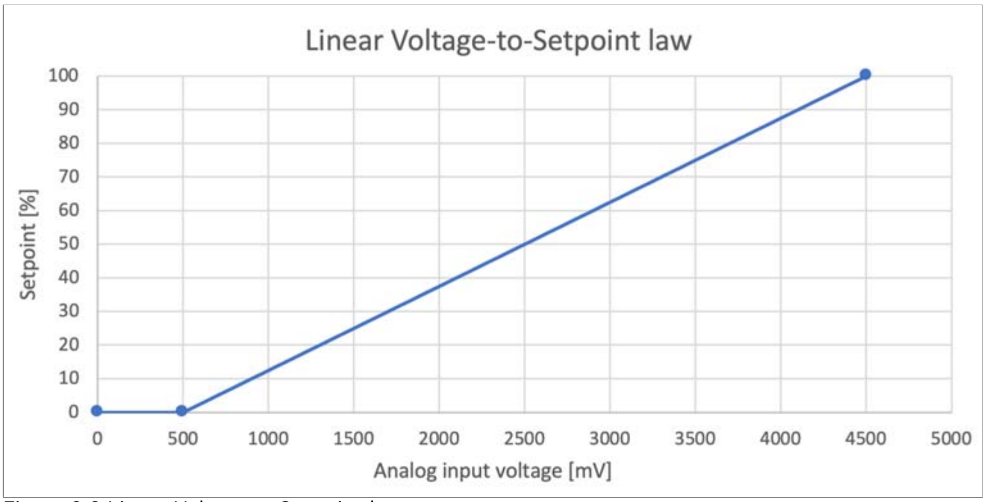


Figure 3-3 Linear Voltage-to-Setpoint law

Then the table of Input/Output pairs:

Analog input	Output
Ain1	Out1
Ain2	Out3
Ain3	Out5
Ain4	Out7
Ain5	Out9
Ain6	Out11

See diagnostic chapter for all the diagnostic procedures performed on this feature.

3.1.3 Ratiometric Analog Input condition

During this condition all Input ports and Output ports are used. One single Analog input can drive two different Outputs.
Ratiometric analog input condition block scheme below:

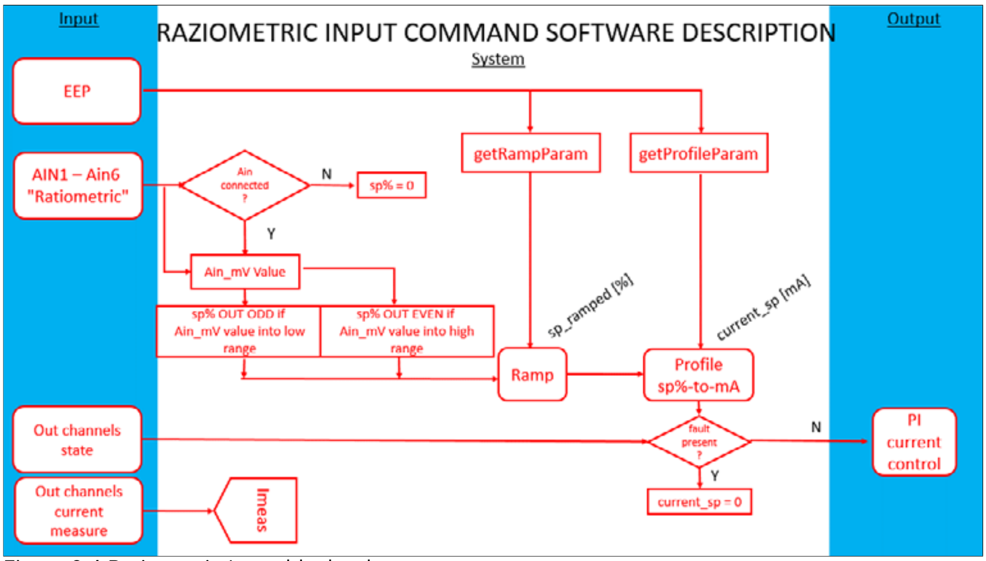


Figure 3-4 Ratiometric Input block scheme

"System section" and "Output section" will be explained in the next chapter.
In this operating condition, Analog input voltage will be compared with the supply voltage.
From the Analog input voltage, as in the other input types, will be calculated a Setpoint from 0 to 1000. In Ratiometric input condition, Setpoint is in relation with the supply voltage.
Below, the correlation between them, in the case of Ain 1.

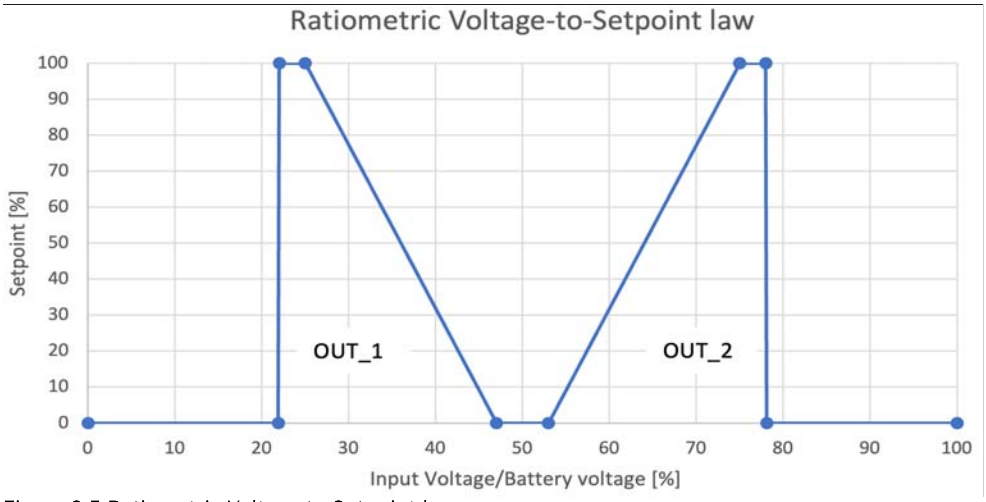


Figure 3-5 Ratiometric Voltage-to-Setpoint law

From one Analog input two Output ports will be piloted.
Following the operating states.

- **Steady state condition** → Analog input voltage value from 47% to 53% with respect the supply voltage value, the two output ports aren't enabled
- **OUT_A linear enable** → Analog input voltage value from 47% to 25% with respect the supply voltage value, only the "A" output port is enabled, the output current follows the Setpoint behaviour.

- **OUT_A max value** → Analog input voltage value from 25% to 22% with respect the supply voltage value, only the “A” output port is enabled, the output current keeps its maximum value.
- **Low value** → Analog input voltage value from 22% to 0% with respect the supply voltage value, the two output ports aren’t enabled.
- OUT_B linear enable → Analog input voltage value from 53% to 75% with respect the supply voltage value, only the “B” output port is enabled, the output current follows the Setpoint behaviour.
- **OUT_B max value** → Analog input voltage value from 75% to 78% with respect the supply voltage value, only the “B” output port is enabled, the output current keeps its maximum value.
- **High value** → Analog input voltage value from 78% to 100% with respect the supply voltage value, the two output ports aren’t enabled.

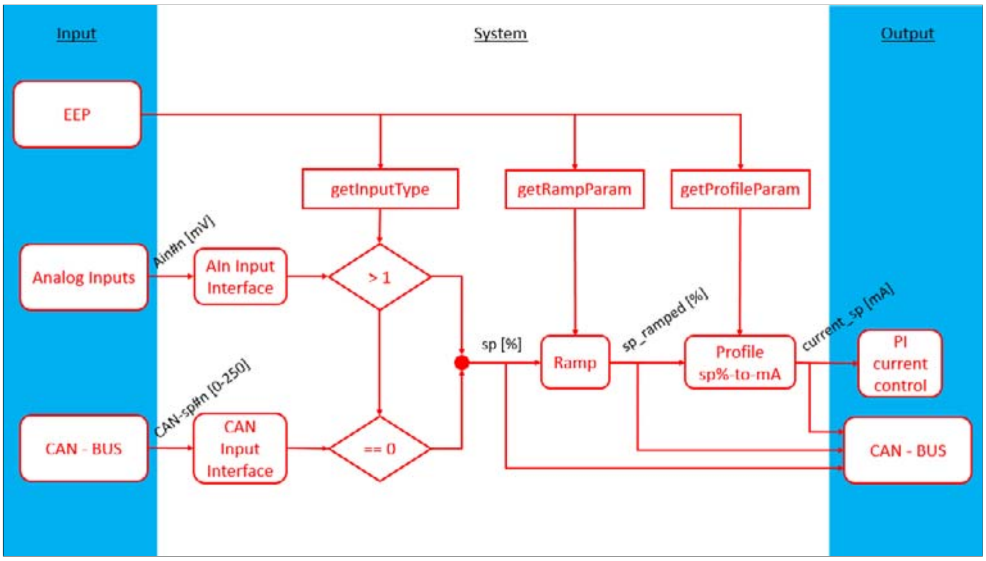
Percentage range values reported above are the default values. Since are EPP parameters customer can modify them in a suitable way for his uses.
As in Linear Analog input condition, the input Set Point correspond to a certain current value driven to the output.
Below are reported the Input/Output ports pair decided for this type of input condition.

Analog input	Output
Ain1	Out1
	Out2
Ain2	Out3
	Out4
Ain3	Out5
	Out6
Ain4	Out7
	Out8
Ain5	Out9
	Out10
Ain6	Out11
	Out12

See diagnostic chapter for all the diagnostic procedures performed on this feature.

3.2 Logic

In this section the system logic behaviour will be explained in more details.



From input types an initial Setpoint is created, as sad before the initial Setpoint could be:
• From 0 to 250 (CAN input condition).
• From Input Analog voltage (Linear Analog input condition and Ratiometric Analog input condition)
These two Setpoint types are transformed into 0-1000 Setpoint range from the logic. After, with “Ramp” and “Profile sp%-to-mA”, the calculated Setpoint will follow a certain behaviour to the output ports.
“OUT#1-12 OPEN TIME” and “OUT#1-12 CLOSE TIME” parameters are used to define the Setpoint ramp time for each Output port.
Ramped Setpoint will follow a profile. This profile is created with:
• “SP VAL1 ... SP VAL10”, which they are corresponding to “10 input Setpoint” points
• “OUT#1-12 OPN CURR VAL1 ... OUT#1-12 OPN CURR VAL10” and “OUT#1-12 CLS CURR VAL1 ... OUT#1-12 CLS CURR VAL10”, which they correspond to the output current at certain Setpoint value, for open and close condition respectively.
From the “Profile sp%-to-mA” a current Setpoint is calculated, this will go to the Output ports to drive the connected valves.

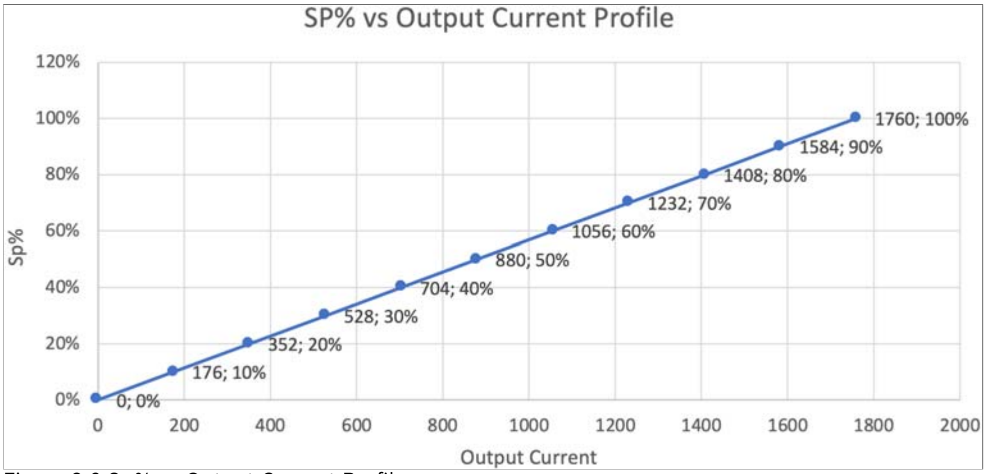


Figure 3-6 Sp% vs Output Current Profile

In the graph above the Sp% vs Output Current Profile is graphically explained, the values are referred to the default one inserted for the KBVS/KSVS 12V valves use.

3.3 Output

In this section the software outputs will be explained.
With the Current Setpoint, internally calculated, software can drive 12 PWM output ports.
The maximum current value the CHC can drive per Output port is 2.4 A.
The maximum sum of the currents the CHC can drive to the Output ports at the same time is 10 A.
Below the CAN messages which explain the current value driven to the Output ports.

ID	**0xB1**	**ext.**					
Cycle Time	**100ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFFSET**	**Function**	**Comments**
0	0	7	8	0-255	-	current output/10	OUT#1 current output
1	8	15	8	0-255	-	current output/10	OUT#2 current output
2	16	23	8	0-255	-	current output/10	OUT#3 current output
3	24	31	8	0-255	-	current output/10	OUT#4 current output
4	32	39	8	0-255	-	current output/10	OUT#5 current output
5	40	47	8	0-255	-	current output/10	OUT#6 current output
6	48	55	8	-	-	n.a.	-
7	56	63	8	-	-	n.a.	-

ID	**0xB2**	**ext.**					
Cycle Time	**100ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFSET**	**Function**	**Comments**
0	0	7	8	0-255	-	current output/10	OUT#7 current output
1	8	15	8	0-255	-	current output/10	OUT#8 current output
2	16	23	8	0-255	-	current output/10	OUT#9 current output
3	24	31	8	0-255	-	current output/10	OUT#10 current output
4	32	39	8	0-255	-	current output/10	OUT#11 current output
5	40	47	8	0-255	-	current output/10	OUT#12 current output
6	48	55	8	-	-	n.a.	-
7	56	63	8	-	-	n.a.	-

A PI current control loop is implemented in the software. With EEPROM parameters KI and KP is possible to define the current control loop behaviour, the time response, and the stability of the desired output current.
Defining the Setpoint values and the OPN/CLS currents associated them is possible to define the current target which the PI current control loop must reach.
PI current control loop allows to keep constant the current driven to the valve constant, changing the duty cycle when the resistance changes.

3.4 Diagnosis

In this section the Software diagnostic operations will be explained.
Diagnostic analysis is done on the three input types and during the Output ports drive.
Below the used CAN message to define the diagnosis state of the system.

ID	**0xB5**	**ext.**					
Freq.	**500ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFSET**	**Function**	**Comments**
0	0	0	1	-	-	CAN ERROR	error occurred upon CAN communication
0	1	1	1	-	-	CAN OUT RNG WARNING	CAN setpoint out of range
0	2	2	1	-	-	CAN INCORRECT START	CAN setpoint must return to 0 before operating the output
0	3	3	1	-	-	LIN ANALOG INPUT INCORRECT START	Analog input incorrect start on linear mode input
0	4	4	1	-	-	RATIOMETRIC INPUT INC START	Incorrect start on ratiometric mode input
1	8	9	2	0 - 3	-	OUT#1 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
1	10	11	2	0 - 3	-	OUT#2 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
1	12	13	2	0 - 3	-	OUT#3 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
1	14	15	2	0 - 3	-	OUT#4 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
2	16	17	2	0 - 3	-	OUT#5 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
2	18	19	2	0 - 3	-	OUT#6 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
2	20	21	2	0 - 3	-	OUT#7 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
2	22	23	2	0 - 3	-	OUT#8 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm

ID	**0xB5**	**ext.**					
Freq.	**500ms**						
DLC	**8**						
Byte	**Start Bit**	**Stop Bit**	**Length (bit)**	**Values**	**OFSET**	**Function**	**Comments**
3	24	25	2	0 - 3	-	OUT#9 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
3	26	27	2	0 - 3	-	OUT#10 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
3	28	29	2	0 - 3	-	OUT#11 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
3	30	31	2	0 - 3	-	OUT#12 state	00 - no alarm; 01 - coil open alarm; 10 - drv short alarm; 11 - coil shorted alarm
4	32	33	2	0 - 2	-	AIN#1 state	00 - Analog input not used; 01 - Analog input OK; 10 - Analog input connection NOT OK
4	34	35	2	0 - 2	-	AIN#2 state	'00 - Analog input not used; 01 - Analog input OK; 10 - Analog input connection NOT OK
4	36	37	2	0 - 2	-	AIN#3 state	'00 - Analog input not used; 01 - Analog input OK; 10 - Analog input connection NOT OK
4	38	39	2	0 - 2	-	AIN#4 state	'00 - Analog input not used; 01 - Analog input OK; 10 - Analog input connection NOT OK
5	40	41	2	0 - 2	-	AIN#5 state	'00 - Analog input not used; 01 - Analog input OK; 10 - Analog input connection NOT OK
5	42	43	2	0 - 2	-	AIN#6 state	'00 - Analog input not used; 01 - Analog input OK; 10 - Analog input connection NOT OK
5	44	47	4	-	-	n.a.	-
6	48	55	8	-	-	Safety Level	safety state
7	56	63	8	-	-	Reset Cause	reset cause

3.4.1 CAN ERROR

Occurs when both or only one of the CAN Command messages (0x232 and 0x332) aren’t present.

3.4.2 CAN OUT RNG WARNING

Occurs when Setpoint from CAN exceed the max allowable limit. If CAN Setpoint = FF (max is FA=250), error occurs. Error returns to low value only if Setpoint returns to zero.

3.4.3 CAN INCORRECT START

Occurs when CAN Command messages are sent with an initial Setpoint value different than zero.

3.4.4 LIN ANALOG INPUT INCORRECT START

Occurs when initial Linear Analog input voltage is different than zero.

3.4.5 RATIOMETRIC INPUT INC START

Occurs when initial Ratiometric Analog input voltage is different than Steady state condition voltage.

3.4.6 OUT#1-12 state

Gives the state of the Output ports.
Initial diagnosis: At start up SW drive low Setpoint value to the Output ports to find open circuit or short circuit on them.
Runtime diagnosis: During normal functioning SW can find open circuit or short circuit on the Output ports.
When fault occurs, Setpoint must be zero to redrive the desired output.

3.4.7 AIN#1-6 state

Gives the state of the Analog Input ports.
Analog input Setpoint voltage must be zero (Linear Analog input) and steady state (Ratiometric Analog input) when Analog Input will be reconnected after disconnection.

3.5 No default valves use

In this section will explained as user can use the CHC Base SW also with valves different than the default one, the KBVS/KSVS 12V valve.
In default situation the "OUT#1-12 OPN CURR VAL" and the "CLS#1-12 OPN CURR VAL" EEPROM Parameters are defined for KBVS/KSVS 12V valves.
In the case the user would use different types of valves he must define, using datasheet values, the new desired Current values associated to the input SP%.
For example, using KBVS/KSVS 24V valves, "OUT#1-12 OPN CURR VAL10" or "OUT#1-12 CLS CURR VAL10", should be equal to the maxim datasheet Current the valve could support, in this case 800 mA.
The other Current values associated to SP%, if the user follow the default linear behavior, should be equally spaced of a quantity equal to 10% of the max Current (800 mA).

4 Foss licenses

Two Open-Source Files are included into the software: BDS-3-Class and Apache-2.0.
These files are used without any modification.
There are the user licenses.

1.1 BDS-3-Class

BSD-3-Clause (University of California-Specific)
Copyright [various years] The Regents of the University of California. All rights reserved.
Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the follow-ing disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of the University nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE REGENTS AND CONTRIBUTORS ‘’AS IS’’ AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

1.2 Apache-2.0

Apache License Version 2.0, January 2004
http://www.apache.org/licenses/
TERMS AND CONDITIONS FOR USE, REPRODUCTION, AND DISTRIBUTION
1. Definitions.
“License” shall mean the terms and conditions for use, reproduction, and distribution as defined by Sections 1 through 9 of this documents.
“Licensor” shall mean the copyright owner or entity authorized by the copyright owner that is granting the License.
“Legal Entity” shall mean the union of the acting entity and all other entities that control, are controlled by, or are under common control with that entity. For the purposes of this definition, “control” means (i) the power, direct or indirect, to cause the direction or management of such entity, whether by contract or otherwise, or (ii) ownership of fifty percent (50%) or more of the outstanding shares, or (iii) beneficial ownership of such entity.
“You” (or “Your”) shall mean an individual or Legal Entity exercising permissions granted by this License.
“Source” form shall mean the preferred form for making modifications, including but not limited to software source code, documentation source, and configuration files.

“Object” form shall mean any form resulting from mechanical transformation or translation of a Source form, including but not limited to compiled object code, generated documentation, and conversions to other media types.
“Work” shall mean the work of authorship, whether in Source or Object form, made available under the License, as indicated by a copyright notice that is included in or attached to the work (an example is provided in the Appendix below).
“Derivative Works” shall mean any work, whether in Source or Object form, that is based on (or derived from) the Work and for which the editorial revisions, annotations, elaborations, or other modifications represent, as a whole, an original work of authorship. For the purposes of this License, Derivative Works shall not include works that remain separable from, or merely link (or bind by name) to the interfaces of, the Work and Deriva-tive Works thereof.
“Contribution” shall mean any work of authorship, including the original version of the Work and any modifi-cations or additions to that Work or Derivative Works thereof, that is intentionally submitted to Licensor for inclusion in the Work by the copyright owner or by an individual or Legal Entity authorized to submit on behalf of the copyright owner. For the purposes of this definition, “submitted” means any form of electronic, verbal, or written communication sent to the Licensor or its representatives, including but not limited to communica-tion on electronic mailing lists, source code control systems, and issue tracking systems that are managed by, or on behalf of, the Licensor for the purpose of discussing and improving the Work, but excluding communica-tion that is conspicuously marked or otherwise designated in writing by the copyright owner as “Not a Contri-bution.”
“Contributor” shall mean Licensor and any individual or Legal Entity on behalf of whom a Contribution has been received by Licensor and subsequently incorporated within the Work.
2. Grant of Copyright License.
Subject to the terms and conditions of this License, each Contributor hereby grants to You a perpetual, world-wide, non-exclusive, no-charge, royalty-free, irrevocable copyright license to reproduce, prepare Derivative Works of, publicly display, publicly perform, sublicense, and distribute the Work and such Derivative Works in Source or Object form.
3. Grant of Patent License.
Subject to the terms and conditions of this License, each Contributor hereby grants to You a perpetual, world-wide, non-exclusive, no-charge, royalty-free, irrevocable (except as stated in this section) patent license to make, have made, use, offer to sell, sell, import, and otherwise transfer the Work, where such license applies only to those patent claims licensable by such Contributor that are necessarily infringed by their Contribu-tion(s) alone or by combination of their Contribution(s) with the Work to which such Contribution(s) was sub-mitted. If You institute patent litigation against any entity (including a cross-claim or counterclaim in a lawsuit) alleging that the Work or a Contribution incorporated within the Work constitutes direct or contributory pa-tent infringement, then any patent licenses granted to You under this License for that Work shall terminate as of the date such litigation is filed.
4. Redistribution.
You may reproduce and distribute copies of the Work or Derivative Works thereof in any medium, with or without modifications, and in Source or Object form, provided that You meet the following conditions:
1. You must give any other recipients of the Work or Derivative Works a copy of this License; and
2. You must cause any modified files to carry prominent notices stating that You changed the files; and

3. You must retain, in the Source form of any Derivative Works that You distribute, all copyright, patent, trade-mark, and attribution notices from the Source form of the Work, excluding those notices that do not pertain to any part of the Derivative Works; and
4. If the Work includes a "NOTICE" text file as part of its distribution, then any Derivative Works that You dis-tribute must include a readable copy of the attribution notices contained within such NOTICE file, excluding those notices that do not pertain to any part of the Derivative Works, in at least one of the following places: within a NOTICE text file distributed as part of the Derivative Works; within the Source form or documentation, if provided along with the Derivative Works; or, within a display generated by the Derivative Works, if and wherever such third-party notices normally appear. The contents of the NOTICE file are for informational pur-poses only and do not modify the License. You may add Your own attribution notices within Derivative Works that You distribute, alongside or as an addendum to the NOTICE text from the Work, provided that such addi-tional attribution notices cannot be construed as modifying the License.

   You may add Your own copyright statement to Your modifications and may provide additional or different license terms and conditions for use, reproduction, or distribution of Your modifications, or for any such De-rivative Works as a whole, provided Your use, reproduction, and distribution of the Work otherwise complies with the conditions stated in this License.

5. Submission of Contributions.
Unless You explicitly state otherwise, any Contribution intentionally submitted for inclusion in the Work by You to the Licensor shall be under the terms and conditions of this License, without any additional terms or conditions. Notwithstanding the above, nothing herein shall supersede or modify the terms of any separate license agreement you may have executed with Licensor regarding such Contributions.

6. Trademarks.
This License does not grant permission to use the trade names, trademarks, service marks, or product names of the Licensor, except as required for reasonable and customary use in describing the origin of the Work and reproducing the content of the NOTICE file.

7. Disclaimer of Warranty.
Unless required by applicable law or agreed to in writing, Licensor provides the Work (and each Contributor provides its Contributions) on an "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, ei-ther express or implied, including, without limitation, any warranties or conditions of TITLE, NON-INFRINGEMENT, MERCHANTABILITY, or FITNESS FOR A PARTICULAR PURPOSE. You are solely responsible for determining the appropriateness of using or redistributing the Work and assume any risks associated with Your exercise of permissions under this License.

8. Limitation of Liability.
In no event and under no legal theory, whether in tort (including negligence), contract, or otherwise, unless required by applicable law (such as deliberate and grossly negligent acts) or agreed to in writing, shall any Contributor be liable to You for damages, including any direct, indirect, special, incidental, or consequential damages of any character arising as a result of this License or out of the use or inability to use the Work (in-cluding but not limited to damages for loss of goodwill, work stoppage, computer failure or malfunction, or any and all other commercial damages or losses), even if such Contributor has been advised of the possibility of such damages.

9. Accepting Warranty or Additional Liability.
While redistributing the Work or Derivative Works thereof, You may choose to offer, and charge a fee for, ac-ceptance of support, warranty, indemnity, or other liability obligations and/or rights consistent with this Li-cense. However, in accepting such obligations, You may act only on Your own behalf and on Your sole respon-sibility, not on behalf of any other Contributor, and only if You agree to indemnify, defend, and hold each Con-tributor harmless for any liability incurred by, or claims asserted against, such Contributor by reason of your accepting any such warranty or additional liability.
END OF TERMS AND CONDITIONS
APPENDIX: How to apply the Apache License to your work.
To apply the Apache License to your work, attach the following boilerplate notice, with the fields enclosed by brackets "[]" replaced with your own identifying information. (Don't include the brackets!) The text should be enclosed in the appropriate comment syntax for the file format. We also recommend that a file or class name and description of purpose be included on the same "printed page" as the copyright notice for easier identifi-cation within third-party archives.
Licensed under the Apache License, Version 2.0 (the "License"); you may not use this file except in compliance with the License.
You may obtain a copy of the License at http://www.apache.org/licenses/LICENSE-2.0
Unless required by applicable law or agreed to in writing, software distributed under the License is distributed on an "AS IS" BASIS,
WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
See the License for the specific language governing permissions and limitations under the License.

Bosch Rexroth Oil Control S.p.A.
Via Leonardo da Vinci 5
P.O. Box no. 5
41015 Nonantola – Modena, Italy
Tel. +39 059 887 611
Fax +39 059 547 848
compact-hydraulics-pib@boschrexroth.com
www.boschrexroth.com/compacthydraulics

Your local contact person can be found at:
https://addresses.boschrexroth.com

Subject to change
RE 18324-43/2023-06-16