



**PHC STUDIO**  
**IEC 61131-3**  
**programming**  
**of the CED400W**  
**USER MANUAL**



## **WARNING**

The User is required to properly verify and test that the Software is correctly working within the specific scope of its application and under the actual configuration of the operating system in use. The Software will perform in substantial conformance with the documentation supplied with the Software when used with the indicated hardware and operating system configuration.

The User is required to verify the accuracy of the installation of the libraries on the control units programmed with the Software and the reliability of their operating system. The manufacturer and/or the distributor is not liable for: (i) the incorrect installation of the libraries on the control units, as well as (ii) an installation which is not conforming with the requirements of the control units, and (iii) any other deviations from the recommended use of the Software and of the operating system, including but not limited to virus, third parties installations, and any other modifications affecting the correct and recommended use of the Software.

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### **Additional information**

This catalogue shows the product in the standard configurations.  
Please contact our Sales Dpt. for more detailed information or special requests.

### **WARNING!**

All specifications of this catalogue refer to the standard product at this date.  
Walvoil, oriented to a continuous improvement, reserves the right to discontinue, modify or revise the specifications, without notice.

**WALVOIL IS NOT RESPONSIBLE FOR ANY DAMAGE CAUSED BY AN  
INCORRECT USE OF THE PRODUCT.**

2<sup>nd</sup> edition May 2021

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## 1. Document Overview

This document is the manual for the system integrator, with the programming guidelines for the CED400W control unit.

The manual gives to the system integrator all the hardware and software information useful to write the custom software, implementing the functionality requested by the application.

High attention is dedicated to the software construction, that has to be robust and safe, not forgetting the simplicity and the easy maintenance.

The PHC STUDIO Integrated Development Environment supports all the five programming languages defined by the IEC 61131-3 standard. The software libraries available for this tool are described in the document.



PHC STUDIO splash screen image

Refer to the PHC STUDIO Integrated Development Environment, code DCDWIDE001 (English), to understand how the tool workspace is organized, and discover all the potentialities of the tool.

### 1.1 Copyright

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### 1.2 History releases of the document

Date	Argument	New release
2015 September	Complete User Manual	V15.01 (first release)

History releases of the document

### 1.3 Warning highlights

A couple of warning highlights, WARNING and NOTICE, are used to put in evidence programming suggestions, the non-safe programming, the improper usage, or the non-correct installation of the control unit CED400W.

Please, pay extreme attention to these warning highlights.

#### **WARNING**

**Cautions have to be taken to avoid death or serious injuries to the operators or the people that operate in the machine working area.**

**Damage of the control unit CED400W parts may be expected also.**

#### **NOTICE**

**For the proper usage of the control unit CED400W the suggestion has to be taken into consideration.**

Warning highlights

## 2. Safety instructions

### 2.1 System integrator knowledge requirements

This document is intended for people with proven knowledge in programming and controlling technology.

These people must be properly trained and already have matured experience in-field.

In the applications they are going to serve, they have to be able to see and calculate risks to avoid hazards, that may be caused during the operation or the maintenance of a product.

### 2.2 Set-up behaviors of the controller

This document contains instructions about the correct and safe programming and handling of the control unit CED400W. Read this document to understand which are the proper installation and operating conditions for the control unit CED400W.

Adhere to the safety instructions, use all the safety features and redundancy options available by the control unit CED400X, to improve the system safety and reduce the risk of unwanted movements and non-safe actuations on the machine.

## 3. Hardware description

A detailed hardware description is provided for the control unit CED400W.

All the I/O interface ports are described through a schematic block diagram, whose main electrical characteristics are put in evidence to understand which are the maximum performances obtainable through the hardware.

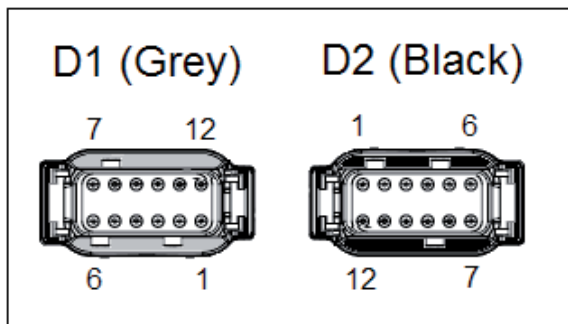
The diagnostic capabilities of these blocks and the installation precautions to be observed are discussed also.

### 3.1 Connectors

The interface to the CED400W is provided through two main connectors

- D1 connector (Grey) for the input signals,
- D2 connector (Black) for the output signals.

See below the pin numbering of these two connectors (system integrator view).



*CED400W, D1 and D2 connectors (system integrator view)*

Refer to the catalogue D1WWEE01E for more detailed information about connectors part numbers and mating parts.

### 3.2 Hardware configuration

A few pins on the interface connectors of the control unit CED400W can have multiple functionalities.

The pin functionality is defined through its hardware configuration.

The hardware configuration is not modifiable through the application software.

Four standard hardware are available for the control unit CED400W.

The system integrator has to select the hardware able to manage the signals in the application, depending by their type and number.

part number	CED application software	CAN		analog input			digital input	digital output		sensor supply
		port	120R	Type F (0,5 ÷ 4,5V)	Type F (0 ÷ VK)	Temp.	0/VK	HSD	LSD	5V
183337025	PHC400F	0	0	4	4	0	4	8	4	0
183337033	FAN DRIVE	1	0	0	0	4	6	4	2	1
183337037	PHC400C	1	0	4	4	0	2	8	4	0
183337046	PHC401C	1	0	4	4	0	1	8	4	1

*CED400W default hardware configurations*

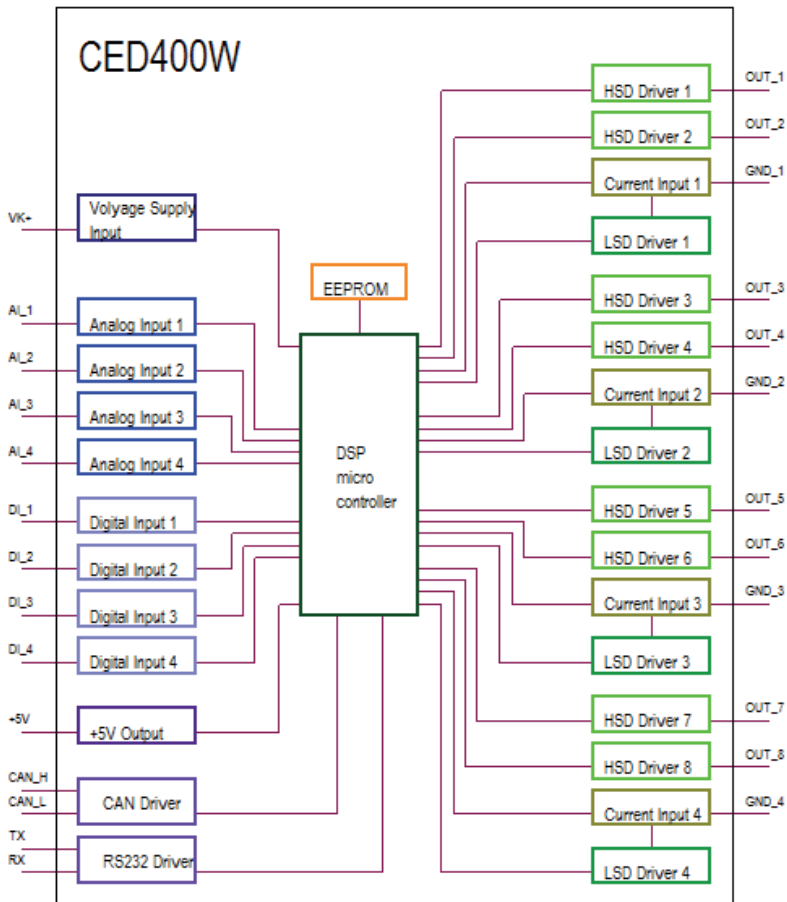
See in the next page the complete list of the hardware with the connectors pin-out functionality in details.

183337025				183337033				183337037				183337046			
D1 connector		D2 connector		D1 connector		D2 connector		D1 connector		D2 connector		D1 connector		D2 connector	
pin	function	pin	function	pin	function	pin	function	pin	function	pin	function	pin	function	pin	function
1	VK+	1	OUT_8	1	VK+	1	-	1	VK+	1	OUT_8	1	VK+	1	OUT_8
2	AI_4	2	OUT_2	2	AI_4	2	OUT_2	2	AI_4	2	OUT_2	2	AI_4	2	OUT_2
3	AI_3	3	OUT_4	3	AI_3	3	OUT_4	3	AI_3	3	OUT_4	3	AI_3	3	OUT_4
4	DI_1	4	OUT_3	4	DI_1	4	OUT_3	4	DI_1	4	OUT_3	4	5V_EXT1	4	OUT_3
5	RX	5	OUT_6	5	RX	5	DI_3	5	RX	5	OUT_6	5	RX	5	OUT_6
6	DI_3	6	OUT_5	6	CAN_L	6	DI_4	6	CAN_L	6	OUT_5	6	CAN_L	6	OUT_5
7	DI_4	7	GND_3	7	CAN_H	7	DI_6	7	CAN_H	7	GND_3	7	CAN_H	7	GND_3
8	TX	8	GND_2	8	TX	8	GND_2	8	TX	8	GND_2	8	TX	8	GND_2
9	DI_2	9	GND_1	9	DI_2	9	GND_1	9	DI_2	9	GND_1	9	DI_2	9	GND_1
10	AI_1	10	GND_4	10	AI_1	10	DI_5	10	AI_1	10	GND_4	10	AI_1	10	GND_4
11	AI_2	11	OUT_1	11	AI_2	11	OUT_1	11	AI_2	11	OUT_1	11	AI_2	11	OUT_1
12	VB-	12	OUT_7	12	VB-	12	5V_EXT	12	VB-	12	OUT_7	12	VB-	12	OUT_7

CED400W default hardware configurations, connectors pin-out and functionality

### 3.3 Block Diagram

The control unit CED400W can be schematized into a simple block diagram to let the system integrator understand which are the main peripherals available and their number

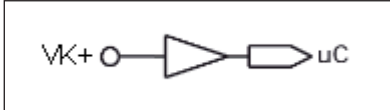


CED400W, complete block diagram for the hardware configuration

## 3.4 INPUT\_ANALOG Driver (Voltage Supply)

This INPUT\_ANALOG Driver provides the voltage value of the power supply source VK+.

In the picture below, the INPUT\_ANALOG Driver is schematized.



*INPUT\_ANALOG Driver for the Voltage Supply measure, simplified schema*

The power supply input VK+ is connected to the microcontroller  $\mu\text{C}$  through an hardware amplifier made of a pull-down resistor and a built-in protection circuit.

The measured value

- is useful for the Power Supply voltage monitoring, as general information,
- is useful to prevent system malfunctioning at low battery supply voltages,
- is useful for the ratiometric joystick value calculus,
- is not affected by the protection circuitries of the Power Supply hardware.

### NOTICE

- 1. The application software must handle the input value measured on the input pin VK+ to properly manage any input signal fault condition.**

### WARNING

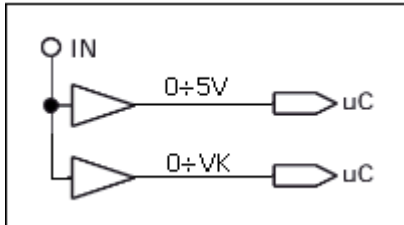
- 1. Do not connect any inductive load in parallel on the input pin VK+ (load connected between VK+ and GND). This may cause an irreversible damage of the input channel hardware. (example of inductive load : electro-hydraulic coil, relay coil, clacson coil).**
- 2. Provide an external 7.5A fuse on the power line VK+ to not exceed the maximum load of the power input pin VK+.**



## 3.5 INPUT\_ANALOG Driver

Each INPUT\_ANALOG Driver provides the voltage value of the signal IN on the correspondent input pin.

In the picture below, the generic INPUT\_ANALOG Driver is schematized.



*INPUT\_ANALOG Driver, simplified schema*

For the generic Analog Input channel

- Two separate hardware circuits work in parallel on the input signal connected to the input pin IN
  - o circuit for the input signal range of 0÷5V,
  - o circuit for the input signal range of 0÷VK,
  - o dynamics 5ms for both the circuits.
- The input pin IN is connected to the microcontroller µC through an hardware amplifier, made of
  - o pull-down resistor,
  - o built-in protection circuit (overvoltage).

### NOTICE

1. **The application software must select the proper input circuit depending by the input signal range and properly manage any input signal fault condition.**
2. **Thanks to the pull-down resistor, if no signal is connected to the input pin IN, the µC will measure 0V.**
3. **Thanks to the built-in protection circuit, any overvoltage on the input pin IN is limited into the range defined by the hardware circuitry, 5V or VK, preventing any damage of the µC. During an overvoltage saturation the µC will measure 5V or VK.**

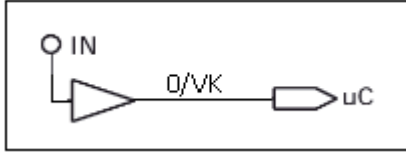
### WARNING

1. **Do not connect any inductive load in parallel on the input pin IN (load connected between IN and GND).  
This may cause an irreversible damage of the input channel hardware.  
(example of inductive load : electro-hydraulic coil, relay coil, clacson coil).**

## 3.6 INPUT\_DIGITAL Driver

Each INPUT\_DIGITAL Driver provides the logical level (0 or VK) of the signal on the correspondent input pin IN.

In the picture below, the generic INPUT\_DIGITAL Driver is schematized.



*INPUT\_DIGITAL Driver, simplified schema*

For the generic Digital Input channel,

- One hardware circuit
  - o input signal range of 0÷VK,
  - o dynamics 5ms.
- The input pin IN is connected to the microcontroller  $\mu\text{C}$  through an hardware amplifier, made of
  - o NPN interface with a pull-down resistor,
  - o built-in protection circuit.

### NOTICE

1. Thanks to the NPN interface and the pull-down resistor, if no signal is connected to the input pin IN, the  $\mu\text{C}$  will trigger the logical level 0 (OFF).
2. Thanks to the built-in protection circuit, any overvoltage on the input pin IN is limited into the range defined by the hardware circuitry, preventing any damage of the  $\mu\text{C}$ . During an overvoltage saturation the  $\mu\text{C}$  will trigger the logical level 1 (ON).

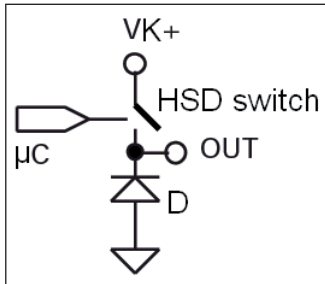
### WARNING

1. Do not connect any inductive load in parallel on the input pin IN (load connected between IN and GND).  
This may cause an irreversible damage of the input channel hardware.  
(example of inductive load : electro-hydraulic coil, relay coil, clacson coil).

## 3.7 HSD\_CHANNEL Driver

The HSD\_CHANNEL Driver drives current on the correspondent output pin OUT. The current flow direction is from VK+ to OUT.

In the picture below, the generic HSD\_CHANNEL Driver is schematized.



*HSD\_CHANNEL Driver, simplified schema*

A few protection features are available

- Under the microcontroller  $\mu\text{C}$  control, the VK+ line of each HSD Switch is connected to the VK through a common series enable switch HSD\_ENABLE.
- Under the microcontroller  $\mu\text{C}$  control, the power line VK+ is connected to OUT through the HSD switch.
- The HSD switch protection diode D is integrated in the hardware. It protects the HSD switch itself against the inductive load switch-off action.
- The HSD switch is protected against short circuits to GND of the OUT pin. An automatic thermal shut-down of the switch is executed when the fault event is detected.
- A built-in hardware+software diagnostic is provided. This diagnostic is always implemented and running. The microcontroller  $\mu\text{C}$  turns OFF the HSD switch, avoiding any hardware damage.

### NOTICE

1. **Even if the hardware is "self-protected", the application software must handle the built-in diagnostic to properly manage the output port fault conditions.**

### WARNING

1. **Do not interrupt the connection between the output pin OUT and the inductive load through an additional external series switch. The internal protection diode D will have no effect against the voltage spikes produced by the inductive load switch-off. This may cause an irreversible damage of all the electronic devices in the system, CED400W included. (example of inductive load : electro-hydraulic coil, relay coil, clacson coil).**
2. **Do not drive loads greater than 2A to not exceed the maximum output load capability of the pin.**

## 3.8 LSD\_CHANNEL Driver

Each LSD\_CHANNEL Driver channel enables the current feedback control on the correspondent output pin IN. The current flow direction is from IN to the control unit internal ground connection GND.

Two main features

- Performances

Through the measure of the load current, it's possible to compensate the current itself against the

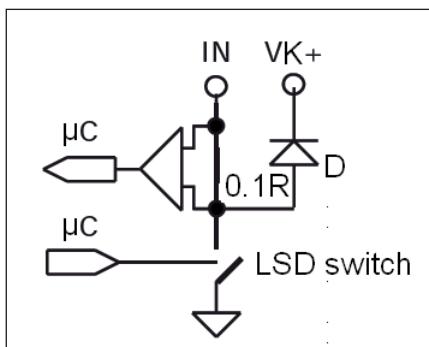
- o load resistance variations (temperature),
- o supply voltage fluctuations (VK+).

- Safety

The LSD\_CHANNEL Driver implements redundancy on the output current control.

The current to the load can be interrupted not only through the HSD\_CHANNEL Driver, it can be interrupted through the LSD\_CHANNEL Driver also.

In the picture below, the generic LSD\_CHANNEL Driver is schematized.



LSD\_CHANNEL Driver, simplified schema

A few protection features are available

- Under the microcontroller  $\mu\text{C}$  control, the input line IN is connected to GND through the LSD switch.
- The LSD switch protection diode D is integrated in the hardware. It protects the LSD switch against the inductive load switch-off action.
- The LSD switch is protected against short circuits to VK+ of the IN pin. This fault causes a current overload on both the current measurement resistor 0.1R and on the LSD switch itself.
- A built-in hardware+software diagnostic is provided. This diagnostic is always implemented and running. The microcontroller  $\mu\text{C}$  turns OFF the LSD switch, avoiding any hardware damage.

### NOTICE

1. Even if the hardware is "self-protected", the application software must handle the built-in diagnostic to properly manage the output port fault conditions.

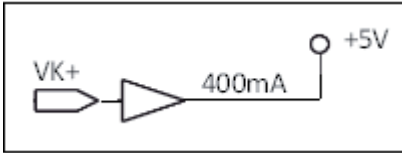
### WARNING

1. Do not interrupt the connection between the output pin OUT and the inductive load through an additional external series switch. The internal protection diode D will have no effect against the voltage spikes produced by the inductive load switch-off. This may cause an irreversible damage of all the electronic devices in the system, CED400W included. (example of inductive load : electro-hydraulic coil, relay coil, clacson coil).
2. Do not drive loads greater than 2A to not exceed the maximum output load capability of the pin.

## 3.9 +5V Output

The +5V Output channel provides a stabilized 5V output for sensors and/or joysticks supply.

In the picture below, the +5V Output channel is schematized.



+5V Output, simplified schema

A few protection features are available

- The output is protected against short-circuits to GND and VK+.
- The maximum load capability is 400mA, resistive load.

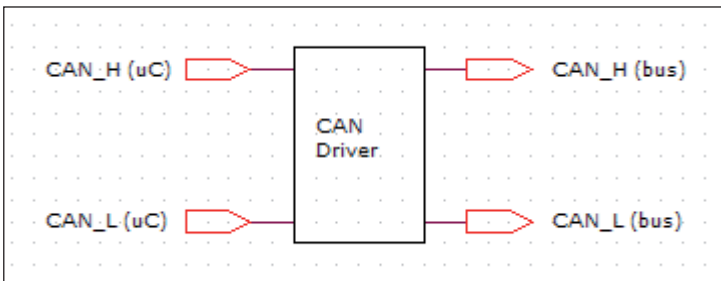
### WARNING

- Do not connect any inductive load in parallel on the output (load connected between +5V and GND). This may cause an irreversible damage of the output channel hardware. (example of inductive load : electro-hydraulic coil, relay coil, clacson coil).**

## 3.10 Can Driver

There is one CAN Driver port.

In the picture below, the CAN Driver port is schematized.



CAN Driver, simplified schema

The 120Ω termination resistor is not provided on the bus side (bus).

## 3.11 EEPROM memory

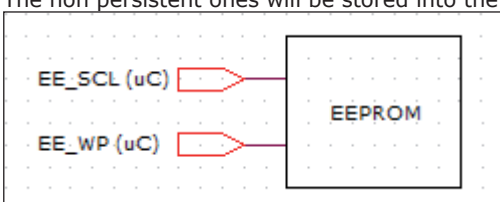
There is one external EEPROM memory.

In the picture below, the EEPROM memory hardware/access is schematized.

The EEPROM size is 1K byte.

Here will be stored the persistent working parameters of the application.

The non persistent ones will be stored into the microcontroller μC RAM memory.

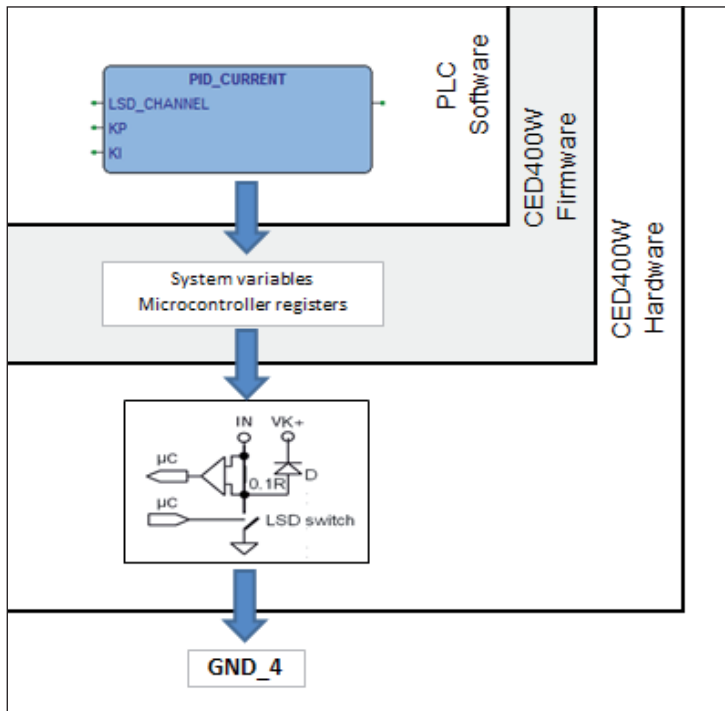


EEPROM, simplified schema

## 4. Software description

Through the PHC STUDIO the system integrator writes the PLC software, correspondent to the desired application functionality, combining the input signals to properly control the outputs of the CED400W electronic control unit. The PLC software, based on the IEC61131-3 standard programming languages, is the highest software layer of the project. It works with the software functions available to control the I/O hardware of the CED400W electronic control unit : CED400W firmware. The CED400W firmware is the lowest software layer, not accessible by the system integrator.

A simple schema of these different layers is represented in the picture below.



PLC software layers : LSD\_CHANNEL control on GND\_4, through the PID\_CURRENT function

### 4.1 PLC Software

#### 4.1.1 Hardware Drivers

##### 4.1.1.1 Input

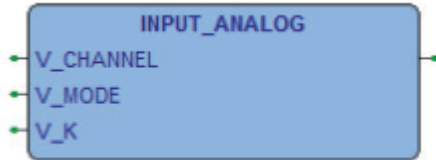
## 4.1.1.1.1 INPUT\_ANALOG

Name: INPUT\_ANALOG

Unit type: FUNCTION (F)

Library: CED400W.lib

Symbol:



INPUT\_ANALOG function symbol

Description:

The INPUT\_ANALOG function provides the analogue voltage value of the signal on the selected input channel V\_CHANNEL. The measure is standardized through a list of conversion modes V\_MODE. The conversion mode can also be custom-defined, the input range is specified by the V\_K input parameter.

Input parameters:

**V\_CHANNEL:** input channel on the control unit D1 connector,

Input	Type	Dec	Hex	Label	Description
V_CHANNEL	BYTE	4	04	AI_1_5V	Input channel 1, 0÷5V hardware
		8	08	AI_1_5K	Input channel 1, 0÷VK hardware
		5	05	AI_2_5V	Input channel 2, 0÷5V hardware
		9	09	AI_2_VK	Input channel 2, 0÷VK hardware
		6	06	AI_3_5V	Input channel 3, 0÷5V hardware
		10	0A	AI_3_VK	Input channel 3, 0÷VK hardware
		7	07	AI_4_5V	Input channel 4, 0÷5V hardware
		11	0B	AI_4_VK	Input channel 4, 0÷VK hardware
		4	04	T_1	Input channel 1, 0÷120°C hardware
		5	05	T_2	Input channel 2, 0÷120°C hardware
		6	06	T_3	Input channel 3, 0÷120°C hardware
		7	07	T_4	Input channel 4, 0÷120°C hardware
		15	0F	VJ	Input channel, 5V external supply
		2	02	VK	Power supply channel, 0÷32V hardware

INPUT\_ANALOG function: V\_CHANNEL description

**V\_MODE**: conversion and representation of the measure of the input signal,

Input	Type	Dec	Hex	Label	Description	Full Scale	Label
V_MODE	BYTE	0	00	OFF	OFF	-	-
		1	01	ADC	Uncalibrated raw (ADC 12bit)	0÷32767	12bit
		2	02	VOLT_5V	Referred to 5000mV	0÷5000	mV
		3	03	VOLT_VK	Referred to 32000mV	0÷32000	mV
		4	04	RATIO_VK	Ratiometric, referred to VK	0÷1000	‰
		5	05	RATIO_VJ	Ratiometric, referred to VJ	0÷1000	‰
		6	06	RATIO_5V	Ratiometric, referred to 5V	0÷1000	‰
		10	0A	K_CONVERSION	Custom conversion range	-	-

*INPUT\_ANALOG function: V\_MODE description*

**V\_K**: custom conversion (full scale)

This input parameter is significant only if K\_CONVERSION is selected in V\_MODE.

Input	Type	Dec	Hex	Label	Description
V_K	UINT	4950	1356	K_05V	Output from 0 to 5000 mV
		9900	26AC	K_10V	Output from 0 to 10000 mV
		32560	7F30	K_32V	Output from 0 to 32000 mV
		3000	0BB8	K_03V	Output from 0 to 3000 mV

*INPUT\_ANALOG function: V\_K description*

*Output parameters:*

**(function output)**: error byte, representing the status of the control.

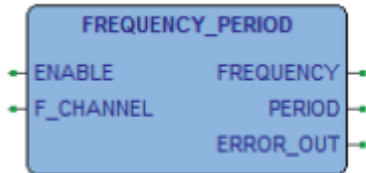
Output	Type	Dec	Hex	Label	Description
(function output)	UINT	-	-	(none)	Output value according to V_MODE

*INPUT\_ANALOG function: Output description (OUT)*



## 4.1.1.1.2 FREQUENCY\_PERIOD

**Name:** FREQUENCY\_PERIOD  
**Unit type:** FUNCTION BLOCK (FB)  
**Library:** CED400W.lib  
**Symbol:**



*FREQUENCY\_PERIOD function symbol*

### Description:

The FREQUENCY\_PERIOD function measures the period duration of the signal on the selected channel F\_CHANNEL. The period is measured in ms, the input range is 0.2÷33.3ms. The period is measured between two successive rising edges of the input signal.

The frequency of the input signal is then calculated. The frequency is expressed in Hz, the input range is 30÷5000Hz.

### Input parameters:

**ENABLE:** enable of the period time measure of the input signal

Input	Type	Dec	Hex	Label	Description
ENABLE	BOOL	-	-	F_EN_YES	TRUE: measurement enabled
		-	-	F_EN_NO	FALSE: measurement not enabled

*FREQUENCY\_PERIOD function: ENABLE description*

**F\_CHANNEL:** frequency input channel on the control unit D1 connector

Input	Type	Dec	Hex	Label	Description
F_CHANNEL	BYTE	0	00	F_DI_1	Frequency channel 1, 30÷5000Hz hardware
		1	01	F_DI_2	Frequency channel 2, 30÷5000Hz hardware

*FREQUENCY\_PERIOD function : F\_CHANNEL description*

Output parameters:

**FREQUENCY:** frequency of the input signal.

The measure is expressed in Hz, into the range 30÷5000Hz.

Output	Type	Dec	Hex	Label	Description
FREQUENCY	UINT	-	-	(none)	Frequency of the input signal in (Hz)

*FREQUENCY\_PERIOD function : FREQUENCY description*

**PERIOD:** period of the input signal.

The measure is expressed in ms, into the range 0.2÷33.3ms.

Output	Type	Dec	Hex	Label	Description
PERIOD	UINT	-	-	(none)	Period of the input signal in (ms)

*FREQUENCY\_PERIOD function : PERIOD description*

**ERROR\_OUT:** diagnosis of the status of the conversion.

Input	Type	Dec	Hex	Label	Description
ERROR_OUT	BYTE	0	00	ERR_NO	No Error
		1	01	ERR_FREQ_CH	Bit 0: Error F_CHANNEL (not correct)
		2	02	ERR_FREQ_H	Bit 2: Error frequency TOO HIGH
		4	04	ERR_FREQ_L	Bit 3: Error frequency TOO LOW

*FREQUENCY\_PERIOD function : ERROR\_OUT description*

## 4.1.1.2 Output

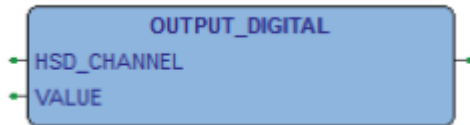
### 4.1.1.2.1 OUTPUT\_DIGITAL

Name: OUTPUT\_DIGITAL

Unit type: FUNCTION (F)

Library: CED400W.lib

Symbol:



*OUTPUT\_DIGITAL function symbol*

Description:

The OUTPUT\_DIGITAL function, through the input parameter VALUE, turns ON or OFF the selected HSD\_CHANNEL. When the channel is turned ON, inside the control unit, the VK line is connected to the output through the HSD circuitry.

Input parameters:

**HSD\_CHANNEL:** HSD output channel

The HSD\_ENABLE is a 'master switch' that enables all the HSD\_CHANNEL (via hardware).

This HSD\_ENABLE has to be turned-ON to work with the HSD\_CHANNELS

Input	Type	Dec	Hex	Label	Description
HSD_CHANNEL	BYTE	0	00	OUT_1	HSD channel 1
		1	01	OUT_2	HSD channel 2
		2	02	OUT_3	HSD channel 3
		3	03	OUT_4	HSD channel 4
		4	04	OUT_5	HSD channel 5
		5	05	OUT_6	HSD channel 6
		6	06	OUT_7	HSD channel 7
		7	07	OUT_8	HSD channel 8
		8	08	HSD_ENABLE	HSD channels enable

*OUTPUT\_DIGITAL function: HSD\_CHANNEL description*

**VALUE:** turn-ON or turn-OFF commands for the HSD\_CHANNEL

Input	Type	Dec	Hex	Label	Description
VALUE	BOOL	-	-	(TRUE)	HSD turn-ON
		-	-	(FALSE)	HSD turn-OFF (floating state)

*OUTPUT\_DIGITAL function: VALUE description*

Output parameters:

**(function output):** error byte, representing the status of the control.

Output	Type	Dec	Hex	Label	Description
(function output)	BYTE	0	00	ERR_NO	No Error
		1	01	ERR_HSD_CH	Bit 0: Error HSD_CHANNEL (not correct)

*OUTPUT\_DIGITAL function: function output (ERROR) description*

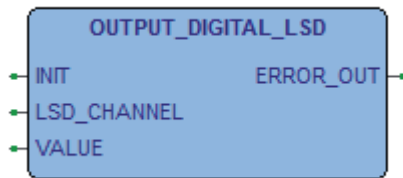
## 4.1.1.2.2 OUTPUT\_DIGITAL\_LSD

Name: OUTPUT\_DIGITAL\_LSD

Unit type: FUNCTION BLOCK (FB)

Library: CED400W.lib

Symbol:



OUTPUT\_DIGITAL function symbol

Description:

The OUTPUT\_DIGITAL\_LSD function, through the input parameter VALUE, turns ON or OFF the selected LSD\_CHANNEL. When the channel is turned ON, inside the control unit, the GND line is connected to the output through the LSD circuitry.

Input parameters:

**INIT:** initializes the function block.

The value of this input parameter has to be active (TRUE) at the first main cycle of the application software, then reset (FALSE) at the successive cycle, then maintained reset (FALSE).

Input	Type	Dec	Hex	Label	Description
INIT	BOOL	-	-	(TRUE)	The function block is initialised
		-	-	(FALSE)	The function block is not initialised

OUTPUT\_DIGITAL\_LSD function: INIT description

**LSD\_CHANNEL:** LSD (output) channel.

Input	Type	Dec	Hex	Label	Description
LSD_CHANNEL	BYTE	0	00	GND_1	LSD channel 1, with current control
		1	01	GND_2	LSD channel 2, with current control
		2	02	GND_3	LSD channel 3, with current control
		3	03	GND_4	LSD channel 4, with current control

OUTPUT\_DIGITAL\_LSD: LSD\_CHANNEL description

**VALUE:** turn-ON or turn-OFF commands for the LSD\_CHANNEL

Input	Type	Dec	Hex	Label	Description
VALUE	BOOL	-	-	(TRUE)	HSD turn-ON
		-	-	(FALSE)	HSD turn-OFF (floating state)

OUTPUT\_DIGITAL function: VALUE description

Output parameters:

**ERROR\_OUT:** error byte, representing the status of the control.

Input	Type	Dec	Hex	Label	Description
ERROR_OUT	BYTE	0	00	ERR_NO	No Error
		1	01	ERR_LSD_CH	Bit 0: Error LSD_CHANNEL (not correct)

OUTPUT\_DIGITAL\_LSD function: ERROR\_OUT description

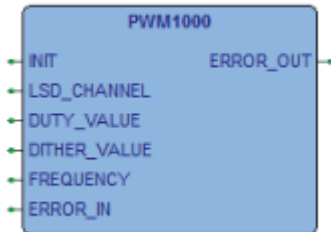
### 4.1.1.2.3 PWM1000

Name: PWM1000

Unit type: FUNCTION BLOCK (FB)

Library: CED400W.lib

Symbol:



PWM100 function symbol

Description:

The PWM1000 function configures the PWM driver and the DITHER control for the selected LSD\_CHANNEL. The PWM carrier is the real physical control of the LSD\_CHANNEL hardware. The DITHER modulation is an over imposed frequency control on the PWM carrier.

Each LSD\_CHANNEL can be configured with its own and independent set of parameters.

The function output is an error information ERROR\_OUT, representing the status of the control.

Input parameters:

**INIT:** initializes the function block.

The value of this input parameter has to be active (TRUE) at the first main cycle of the application software, then reset (FALSE) at the successive cycle, then maintained reset (FALSE).

Input	Type	Dec	Hex	Label	Description
INIT	BOOL	-	-	(TRUE)	The function block is initialised
		-	-	(FALSE)	The function block is not initialised

PWM1000 function : INIT description

**LSD\_CHANNEL:** LSD (output) channel.

Input	Type	Dec	Hex	Label	Description
LSD_CHANNEL	BYTE	0	00	GND_1	LSD channel 1, with current control
		1	01	GND_2	LSD channel 2, with current control
		2	02	GND_3	LSD channel 3, with current control
		3	03	GND_4	LSD channel 4, with current control

PWM1000 function : LSD\_CHANNEL description

**DUTY\_VALUE:** duty-cycle of the PWM carrier.

The resolution of the duty-cycle DUTY\_VALUE of the PWM carrier is 1000.

The frequency of the PWM carrier is fixed @20KHz (not modifiable by the application software)

Input	Type	Dec	Hex	Label	Description
DUTY_VALUE	UINT	0	0000	(none)	0 ‰ (NULL) duty-cycle of the PWM carrier
		1	0001	(none)	1 ‰ duty-cycle of the PWM carrier
		-	-	(none)	-
		1000	03E8	(none)	1000 ‰ (FULL) duty-cycle of the PWM carrier

PWM1000 function : DUTY\_VALUE description

**DITHER\_VALUE:** additional part of duty-cycle of the PWM carrier

A built-in control verifies that

- $DUTY\_VALUE + DITHER\_VALUE < 1000 \text{ ‰} \Rightarrow$  limited at 1000 ‰,
- $DUTY\_VALUE - DITHER\_VALUE > 0 \text{ ‰} \Rightarrow$  limited at 0 ‰

Input	Type	Dec	Hex	Label	Description
DITHER_VALUE	UINT	0	0000	(none)	0 ‰ additional duty-cycle
		1	0001	(none)	1 ‰ additional duty-cycle
		-	-	-	-
		1000	03E8	(none)	1000 ‰ additional duty-cycle

PWM1000 function: DITHER\_VALUE description

**FREQUENCY:** frequency of the DITHER modulation.

A typical value for FREQUENCY is 100Hz.

A built-in control verifies that

- $FREQUENCY < 0\text{Hz} \Rightarrow$  limited at 0Hz,
- $FREQUENCY > 300\text{Hz} \Rightarrow$  limited at 300Hz.

Input	Type	Dec	Hex	Label	Description
FREQUENCY	UINT	0	0000	(none)	DITHER frequency 0Hz
		1	0001	(none)	DITHER frequency 1Hz
		-	-	-	-
		300	012C	(none)	DITHER frequency 300Hz

PWM1000 function: FREQUENCY description

**ERROR\_IN:** external 'enable' of the function.

If the input value is NOT NULL the function is turned-OFF and the DUTY\_VALUE is overwritten by 0.

Input	Type	Dec	Hex	Label	Description
ERROR_IN	BYTE	0	00	ERR_NO	No error, the function block is enabled
		1	01	(none)	The function block is not enabled.
		-	-	-	
		255	FF	(none)	

PWM1000 function: ERROR\_IN description

Output parameters:

**ERROR\_OUT:** error information, representing the status of the function.

Output	Type	Dec	Hex	Label	Description
ERROR_OUT	BYTE	0	00	ERR_NO	No Error
		1	01	ERR_LSD_SCC	Bit 0: LSD_CHANNEL short circuit
		2	02	(none)	Bit 1: (not used)
		4	04	(none)	Bit 2: (not used)
		8	08	(none)	Bit 3: (not used)
		16	10	ERR_LSD_PWM	Bit 4: LSD_CHANNEL already used in PWM1000
		32	20	ERR_LSD_OSC	Bit 5
		64	40	(none)	Bit 6: LSD_CHANNEL already used in OUT_SECTION_CURRENT_CONTROL
128	80	ERR_LSD_CH	Bit 7		

PWM1000 function: ERROR\_OUT description

## Output description:

The following diagram is a short description of the function control.

The light-blue dot line is the effect of the duty-cycle DUTY\_VALUE (only) on the PWM carrier and the DITHER control (no any DITHER\_VALUE is applied). The 'triangular' ripple on the output (light-blue dot line) is practically 'flat', no vibration is added to the load (typically an electro-hydraulic reducing valve).

Applying the DITHER\_VALUE to the duty-cycle DUTY\_VALUE, it's possible to generate on the output line a 'triangular' DITHER, at the frequency FREQUENCY, with a ripple of amplitude AMPLITUDE.

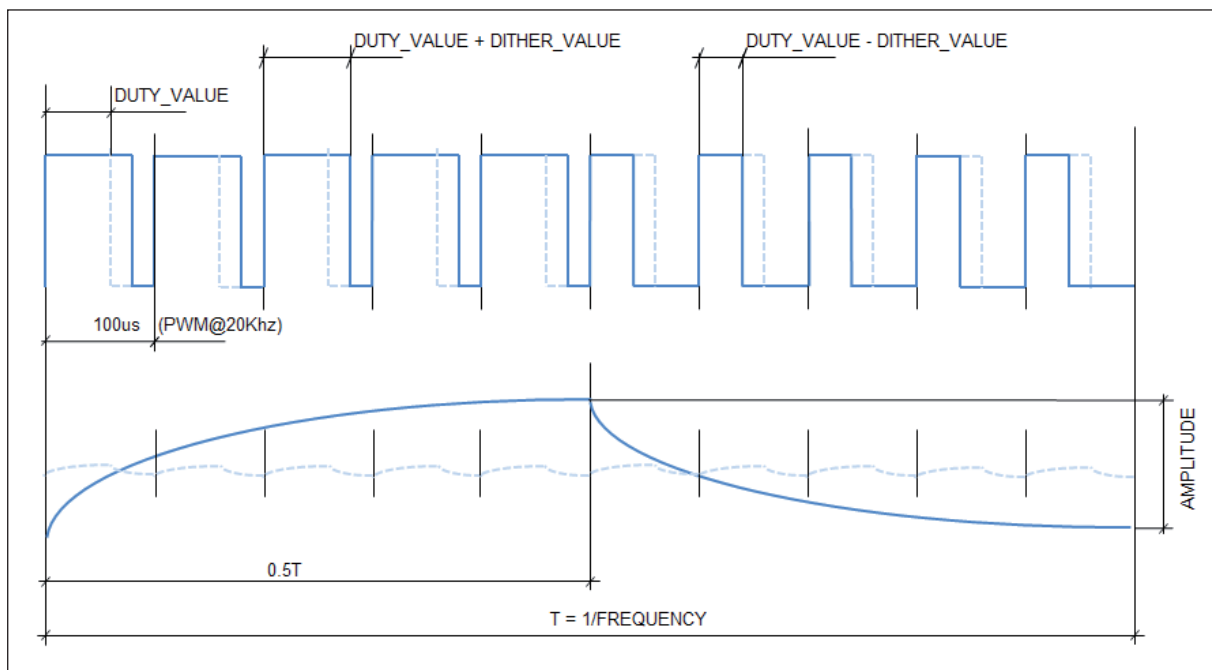
This DITHER\_VALUE is added to the DUTY\_VALUE in the first half part of the period T.

This DITHER\_VALUE is subtracted to the DUTY\_VALUE in the second half part of the period T.

This will introduce a vibration on the load, increasing the performances of the control.

The AMPLITUDE is non controllable by the function, it is load dependent.

The period T is defined as  $T = 1/\text{FREQUENCY}$  (see FREQUENCY).



PWM1000 function: function diagram

## NOTICE

### 1. The PWM1000 function is the basic driver of the LSD\_CHANNEL.

The PWM carrier with the DITHER modulation can be intended as an 'open-loop' control of the output. No compensation of the current driven to the load is implemented by the function.

The system integrator has to add this control if requested by the application :

- call the OUTPUT\_CURRENT function to measure the current on the LSD\_CHANNEL,
- call the PID\_CURRENT function to implement the current compensation control.

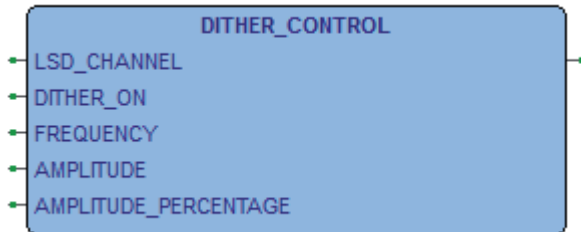
## 4.1.1.2.4 DITHER\_CONTROL

Name: DITHER\_CONTROL

Unit type: FUNCTION (F)

Library: CED400W.lib

Symbol:



*DITHER\_CONTROL function symbol*

Description:

The DITHER\_CONTROL function configures the DITHER control for the selected LSD\_CHANNEL.

The DITHER control has to be enabled through DITHER\_ON.

The FREQUENCY, the AMPLITUDE and the AMPLITUDE\_PERCENTAGE can be defined to characterize the DITHER control.

It is possible to set different DITHER parameters for each LSD\_CHANNEL.

The function output is an error byte, representing the status of the control.

Input parameters:

**LSD\_CHANNEL:** LSD (output) channel.

Input	Type	Dec	Hex	Label	Description
LSD_CHANNEL	BYTE	0	00	GND_1	LSD channel 1, with current control
		1	01	GND_2	LSD channel 2, with current control
		2	02	GND_3	LSD channel 3, with current control
		3	03	GND_4	LSD channel 4, with current control

*DITHER\_CONTROL function: LSD\_CHANNEL description*

**DITHER\_ON:** DITHER control enable.

Input	Type	Dec	Hex	Label	Description
DITHER_ON	BYTE	0	00	DITHER_OFF	DITHER disabled
		1	01	DITHER_ON	DITHER enabled

*DITHER\_CONTROL function: DITHER\_ON description*

**FREQUENCY:** frequency value of the DITHER control, normally called 'low frequency PWM'.

The range of permissible values is 50÷300 Hz.

Input	Type	Dec	Hex	Label	Description
FREQUENCY	UINT	50	0032	(none)	DITHER frequency 50Hz
		51	0033	(none)	DITHER frequency 51Hz
		-	-	-	-
		300	012C	(none)	DITHER frequency 300Hz

*DITHER\_CONTROL function: FREQUENCY description*



**AMPLITUDE:** amplitude value of the DITHER control.

The range of permissible values is 0÷500 mA.

The parameter is active only if AMPLITUDE\_PERCENTAGE = 0 %.

The amplitude is constant for all the values of CURRENT\_SETPOINT.

(see OUT\_SECTION\_CURRENT\_CONTROL function)

Input	Type	Dec	Hex	Label	Description
AMPLITUDE	UINT	0	0000	(none)	AMPLITUDE ripple 0mA
		1	0001	(none)	AMPLITUDE ripple 1mA
		-	-	-	-
		500	01F4	(none)	AMPLITUDE ripple 500mA

*DITHER\_CONTROL function: AMPLITUDE description*

**AMPLITUDE\_PERCENTAGE:** amplitude value of the DITHER control.

The range of permissible values is 0÷90 %.

The amplitude is a percentage of the value of CURRENT\_SETPOINT.

(see OUT\_SECTION\_CURRENT\_CONTROL function)

This means that its absolute value is greater at the values of CURRENT\_SETPOINT

Input	Type	Dec	Hex	Label	Description
AMPLITUDE_PERCENTAGE	BYTE	0	00	(none)	0% of CURRENT_SETPOINT
		1	01	(none)	1% of CURRENT_SETPOINT
		-	-	-	-
		90	5A	(none)	90% of CURRENT_SETPOINT

*DITHER\_CONTROL function: AMPLITUDE\_PERCENTAGE description*

Output parameters:

**(function output):** error byte, representing the status of the control.

Output	Type	Dec	Hex	Label	Description
(function output)	BYTE	0	00	(none)	No Error
		1	01	(none)	Bit 0: Error wrong LSD_CHANNEL
		2	02	(none)	Bit 1: FREQUENCY out of range
		4	04	-	Bit 2: AMPLITUDE out of range
		8	08	(none)	Bit 3: AMPLITUDE_PERCENTAGE out of range

*DITHER\_CONTROL function: function output (ERROR) description*

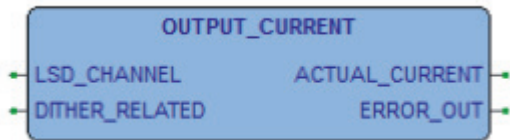
## 4.1.1.2.5 OUTPUT\_CURRENT

Name: OUTPUT\_CURRENT

Unit type: FUNCTION BLOCK (FB)

Library: CED400W.lib

Symbol:



OUTPUT\_CURRENT function symbol

Description:

The OUTPUT\_CURRENT function measures the current driven through the selected LSD channel. The measure is executed in the time period specified by the input parameter DITHER\_RELATED. A few error events can be detected by the function, and specified in the output parameter ERROR\_OUT.

Input parameters:

**LSD\_CHANNEL:** LSD (output) channel.

Input	Type	Dec	Hex	Label	Description
LSD_CHANNEL	BYTE	0	00	GND_1	LSD channel 1, with current control
		1	01	GND_2	LSD channel 2, with current control
		2	02	GND_3	LSD channel 3, with current control
		3	03	GND_4	LSD channel 4, with current control

OUTPUT\_CURRENT function : LSD\_CHANNEL description

**DITHER\_RELATED:** defines the period time to be considered for the current measure. The current measured is the average value in that period.

Input	Type	Dec	Hex	Label	Description
DITHER_RELATED	BOOL	-	-	(TRUE)	One DITHER period
		-	-	(FALSE)	One PWM period

DITHER\_CONTROL function: DITHER\_ON description

Output parameters:

**ACTUAL\_CURRENT:** measure of the current on the selected LSD channel

Input	Type	Dec	Hex	Label	Description
ACTUAL_CURRENT	UINT	-	-	(none)	Output current expressed in mA

OUTPUT\_CURRENT function : ACTUAL\_CURRENT description

**ERROR\_OUT:** diagnosis of the status of the measure, a few errors can be detected

Output	Type	Dec	Hex	Label	Description
ERROR_OUT	BYTE	0	00	ERR_NO	No Error
		1	01	ERR_LSD_CH	Bit 0: Error LSD_CHANNEL (not correct)

OUTPUT\_CURRENT function: ERROR\_OUT description

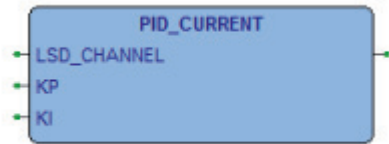
## 4.1.1.2.6 PID\_CURRENT

Name: PID\_CURRENT

Unit type: FUNCTION (F)

Library: CED400W.lib

Symbol:



*PID\_CURRENT function symbol*

Description:

The PID\_CURRENT function configures the PID control applied to the current driven through the selected LSD\_CHANNEL. The gains KP and KI of the proportional and integral corrections of the PID control can be set as desired. For each LSD\_CHANNEL the KP and KI parameters are already set to default values, the best ones for most of the applications. The function has not to be called in the application software if different values have not to be set. The function works only in conjunction with OUT\_SECTION\_CURRENT\_CONTROL that executes the current control on the same LSD\_CHANNEL.

The function output is an error byte, representing the status of the control.

Input parameters:

**LSD\_CHANNEL:** LSD (output) channel.

Input	Type	Dec	Hex	Label	Description
LSD_CHANNEL	BYTE	0	00	GND_1	LSD channel 1, with current control
		1	01	GND_2	LSD channel 2, with current control
		2	02	GND_3	LSD channel 3, with current control
		3	03	GND_4	LSD channel 4, with current control

*PID\_CURRENT function : LSD\_CHANNEL description*

**KP:** gain of the proportional correction of the PID control

The default value is set at KP=25

Input	Type	Dec	Hex	Label	Description
KP	UINT	0	00	(none)	Null proportional correction
		1	01	(none)	-
		-	-	-	-
		25	19	(none)	Suggested gain for the proportional correction
		-	-	-	-
		100	64	(none)	Maximum proportional correction

*PID\_CURRENT function : KP description*

**KI:** gain of the integral correction of the PID control

The default value is set at KI=50.

Input	Type	Dec	Hex	Label	Description
KI	UINT	0	00	(none)	Null integral correction
		1	01	(none)	-
		-	-	-	-
		50	32	(none)	Suggested gain for the integral correction
		100	64	(none)	Maximum integral correction

*PID\_CURRENT function: KI description*

Output parameters:

**(function output):** error byte, representing the status of the control.

Output	Type	Dec	Hex	Label	Description
(function output)	BYTE	0	00	ERR_NO	No Error
		1	01	ERR_LSD_CH	Bit 0: Error LSD_CHANNEL (not correct)
		2	02	ERR_KP_H	Bit 1: Error KP too High (>100)
		4	04	ERR_KI_H	Bit 2: Error KI too High (>100)

*PID\_CURRENT function : function output (ERROR) description*

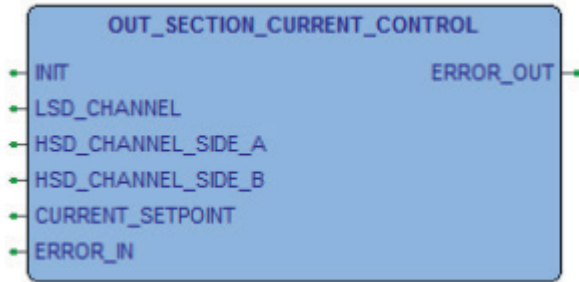
## 4.1.1.2.7 OUT\_SECTION\_CURRENT\_CONTROL

Name: OUT\_SECTION\_CURRENT\_CONTROL

Unit type: FUNCTION BLOCK (FB)

Library: CED400W.lib

Symbol:



OUT\_SECTION\_CURRENT\_CONTROL function symbol

Description:

The OUT\_SECTION\_CURRENT\_CONTROL function controls through the two outputs HSD\_CHANNEL\_SIDE\_A and HSD\_CHANNELS\_SIDE\_B the two electro-hydraulic valves (typical loads) of a complete working section on an hydraulic directional valve.

For the current control, the LSD\_CHANNEL is the common feedback line of the two HSD\_CHANNELS.

The CURRENT\_SETPOINT is the current value desired on the output, expressed in mA and with sign.

The current on the output is compensated against load and power supply voltage fluctuations

The ERROR\_IN is used to turn-OFF the output lines, both the two HSDs and the common LSD.

The INIT input parameter is used to initialize the hardware structure, checking if there is any incongruence on the HSDs and LSD selection.

Input parameters:

**INIT:** initializes the function block.

The value of this input parameter has to be active (TRUE) at the first main cycle of the application software, then reset (FALSE) at the successive cycle, then maintained reset (FALSE).

Input	Type	Dec	Hex	Label	Description
INIT	BOOL	-	-	(TRUE)	The function block is initialised
		-	-	(FALSE)	The function block is not initialised

OUT\_SECTION\_CURRENT\_CONTROL function : INIT description

**LSD\_CHANNEL:** LSD (output) channel.

Input	Type	Dec	Hex	Label	Description
LSD_CHANNEL	BYTE	0	00	GND_1	LSD channel 1, with current control
		1	01	GND_2	LSD channel 2, with current control
		2	02	GND_3	LSD channel 3, with current control
		3	03	GND_4	LSD channel 4, with current control

OUT\_SECTION\_CURRENT\_CONTROL function : LSD\_CHANNEL description

**HSD\_CHANNEL\_SIDE\_A:** HSD (output) channel for the load A control.

Input	Type	Dec	Hex	Label	Description
HSD_CHANNEL_SIDE_A	BYTE	0	00	OUT_1	HSD channel 1
		1	01	OUT_2	HSD channel 2
		2	02	OUT_3	HSD channel 3
		3	03	OUT_4	HSD channel 4
		4	04	OUT_5	HSD channel 5
		5	05	OUT_6	HSD channel 6
		6	06	OUT_7	HSD channel 7
		7	07	OUT_8	HSD channel 8
		8	08	HSD_ENABLE	HSD channels enable

*OUT\_SECTION\_CURRENT\_CONTROL function: HSD\_CHANNEL\_SIDE\_A description*

**HSD\_CHANNEL\_SIDE\_B:** HSD (output) channel for the load B control

Input	Type	Dec	Hex	Label	Description
HSD_CHANNEL_SIDE_B	BYTE	0	00	OUT_1	HSD channel 1
		1	01	OUT_2	HSD channel 2
		2	02	OUT_3	HSD channel 3
		3	03	OUT_4	HSD channel 4
		4	04	OUT_5	HSD channel 5
		5	05	OUT_6	HSD channel 6
		6	06	OUT_7	HSD channel 7
		7	07	OUT_8	HSD channel 8
		8	08	HSD_ENABLE	HSD channels enable

*OUT\_SECTION\_CURRENT\_CONTROL function: HSD\_CHANNEL\_SIDE\_B description*

**CURRENT\_SETPOINT:** desired current value to be driven to the output.

The input value is expressed in mA, and with sign.

The absolute value represents the desired amount of mA to be driven through the outputs.

The maximum absolute value is 2000mA, in respect of the load capability of the connector D2 pins.

The sign selects the HSD channel, a negative value will drive the HSD\_CHANNEL\_SIDE\_A, a positive value will drive the HSD\_CHANNEL\_SIDE\_B.

Input	Type	Dec	Hex	Label	Description
CURRENT_SETPOINT	INT	-2000	F830	(none)	Output current 2000mA, driven to Side A.
		-	-	-	-
		-1	FFFF	(none)	Output current 1mA, driven to Side A.
		0	0000	(none)	NULL output current 0mA
		1	0001	(none)	Output current 1mA, driven to Side B.
		-	-	-	-
		2000	07D0	(none)	Output current 2000mA, driven to Side B.

*OUT\_SECTION\_CURRENT\_CONTROL function: CURRENT\_SETPOINT description*

**ERROR\_IN:** external 'enable' of the function.

If the input value is NOT NULL the function is turned-OFF, the CURRENT\_SETPOINT is overwritten by 0.

Input	Type	Dec	Hex	Label	Description
ERROR_IN	BYTE	-	-	(NULL)	The current on the output is driven normally
		-	-	(NOT NULL)	The current on the output is forced to 0mA

*OUT\_SECTION\_CURRENT\_CONTROL function: ERROR\_IN description*

Output parameters:

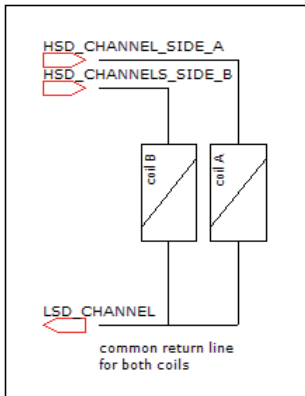
**ERROR\_OUT**: error information, representing the status of the function.

Output	Type	Dec	Hex	Label	Description
ERROR_OUT	BYTE	0	00	ERR_NO	No Error
		1	01	ERR_LSD_SCC	Bit 0: LSD_CHANNEL short circuit
		2	02	(none)	Bit 1: (not used)
		4	04	(none)	Bit 2: (not used)
		8	08	(none)	Bit 3: (not used)
		16	10	ERR_LSD_PWM	Bit 4: LSD_CHANNEL already used in PWM1000
		32	20	ERR_LSD_OSC	Bit 5: LSD_CHANNEL already used in OUT_SECTION_CURRENT_CONTROL
		64	40	(none)	Bit 6: Wrong HSD_CHANNEL (A or B)
		128	80	ERR_LSD_CH	Bit 7: Wrong LSD_CHANNEL

*OUT\_SECTION\_CURRENT\_CONTROL function : ERROR\_OUT description*

Output description:

The current control is on the low side channel LSD\_CHANNEL. Because only one coil is driven at the same time just one current common return line is used for the two coils.



*OUT\_SECTION\_CURRENT\_CONTROL function : typical connection for the two coils of the section*

## NOTICE

- The OUT\_SECTION\_CURRENT\_CONTROL function is the basic compensates the current drive on the output against the load impedance and the power supply voltage VK fluctuations. This means that the function measures the current and corrects the control to drive exactly the desired current.**

## 4.1.2 Utility Functions

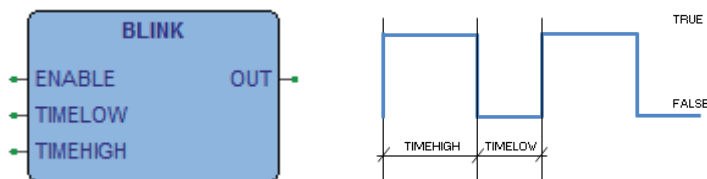
### 4.1.2.1 BLINK

Name: BLINK

Unit type: FUNCTION BLOCK (FB)

Library: Utility.lib

Symbol:



*BLINK function symbol and functionality*

Description:

The BLINK function generates a square wave pulsating signal on OUT. The TIMELOW and TIMEHIGH input values define respectively the low and the high period times of the square wave. An ENABLE input has to be triggered to activate the function.

Input parameters:

**ENABLE:** function enable.

ENABLE is type BOOL.

An ENABLE input has to be triggered TRUE to start the pulse generation, and maintained TRUE to continue the operations. When the ENABLE input is reset to FALSE the blinking is stopped and the OUT level will not change, maintaining the last level reached.

**TIMELOW:** time period of the low level (FALSE) of the signal on OUT.

TIMELOW is type TIME.

**TIMEHIGH:** time period of the high level (TRUE) of the signal on OUT.

TIMEHIGH is type TIME



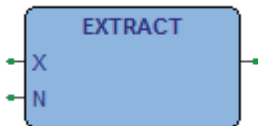
## 4.1.2.2 EXTRACT

Name: EXTRACT

Unit type: FUNCTION (F)

Library: Utility.lib

Symbol:



*EXTRACT function symbol*

Description:

The EXTRACT function returns TRUE if the Nth bit of X is 1, otherwise FALSE.

X is type DWORD, the LSB is bit 0.

N is type BYTE.

EXTRACT is type BOOL.

Example:

X = 81d (1010001b) , N = 4d, then EXTRACT = TRUE

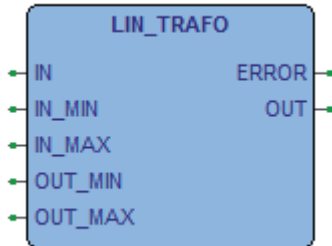
## 4.1.2.3 LIN\_TRAFO

Name: LIN\_TRAFO

Unit type: FUNCTION BLOCK (FB)

Library: Utility.lib

Symbol:



LIN\_TRAFO function symbol

Description:

The LIN\_TRAFO function transforms the input value IN, which lies in a value range defined by a lower value IN\_MIN and an upper limit value IN\_MAX, to a corresponding value OUT which lies in another range also defined by its lower OUT\_MIN and upper OUT\_MAX limit values.

The LIN\_TRAFO function executes the following conversion

$$OUT = [(IN - IN\_MIN) / (IN\_MAX - IN\_MIN)] \times (OUT\_MAX - OUT\_MIN) + OUT\_MIN$$

The function output is an error information ERROR, representing the status of the control.

Input parameters:

Input	Type	Dec	Hex	Label	Description
IN		-	-	(none)	Input value
IN_MIN		-	-	(none)	Input value range, lower limit
IN_MAX	REAL	-	-	(none)	Input value range, upper limit
OUT_MIN		-	-	(none)	Output value range, lower limit
OUT_MAX		-	-	(none)	Output value range, upper limit

LIN\_TRAFO function: input parameters description

Output parameters:

Output	Type	Dec	Hex	Label	Description
OUT	REAL	-	-	(none)	$OUT = [(IN - IN\_MIN) / (IN\_MAX - IN\_MIN)] \times (OUT\_MAX - OUT\_MIN) + OUT\_MIN$

*LIN\_TRAFO function : OUT parameter description*

Output	Type	Dec	Hex	Label	Description
ERROR	BOOL	-	-	(TRUE)	If $IN\_MIN = IN\_MAX$ , or $IN$ is outside its values range

*OUTPUT\_CURRENT function: ERROR\_OUT description*

Example:

The following example can represent the typical conversion of a joystick input signal  $IN$  (expressed in V), into a desired output current setpoint  $OUT$  (expressed in mA).

- $IN = 5d$ ,  $IN\_MIN = 0d$ ,  $IN\_MAX = 10d$ ,  $OUT\_MIN = 200d$ ,  $OUT\_MAX = 400d$ , then  $OUT = 300d$  (linear)

The following examples show how the function manages the input values conflicts.

- $IN < IN\_MIN$ , then  $OUT = 0$  (error detection).
- $IN > IN\_MAX$ , then  $OUT = 0$  (error detection).
- $IN\_MIN \geq IN\_MAX$ , then  $OUT = 0$  (error detection).

## 4.1.2.4 LIN\_TRAFO\_SAT

Name: LIN\_TRAFO\_SAT

Unit type: FUNCTION BLOCK (FB)

Library: Utility.lib

Symbol:



*LIN\_TRAFO\_SAT function symbol*

Description:

The LIN\_TRAFO\_SAT function transforms the input value IN, which lies in a value range defined by a lower value IN\_MIN and an upper limit value IN\_MAX, to a corresponding value OUT which lies in another range also defined by its lower OUT\_MIN and upper OUT\_MAX limit values.

The LIN\_TRAFO\_SAT function executes the following conversion  
$$OUT = [(IN - IN\_MIN) / (IN\_MAX - IN\_MIN)] \times (OUT\_MAX - OUT\_MIN) + OUT\_MIN$$

If the input value IN exceeds the input values range, IN is limited into the range (IN\_MIN or IN\_MAX), and the output value OUT is saturated (OUT\_MIN or OUT\_MAX).

The function does not output any error information.

Input parameters:

Input	Type	Dec	Hex	Label	Description
IN		-	-	(none)	Input value
IN_MIN		-	-	(none)	Input value range, lower limit
IN_MAX	REAL	-	-	(none)	Input value range, upper limit
OUT_MIN		-	-	(none)	Output value range, lower limit
OUT_MAX		-	-	(none)	Output value range, upper limit

*LIN\_TRAFO\_SAT function: input parameters description*

Output parameters:

Output	Type	Dec	Hex	Label	Description
(function output)	REAL	-	-	(none)	$OUT = [(IN - IN\_MIN) / (IN\_MAX - IN\_MIN)] \times (OUT\_MAX - OUT\_MIN) + OUT\_MIN$

*LIN\_TRAFO\_SAT function : function output parameter description*

Example:

The following examples can represent the usual conversion of a joystick input signal IN (expressed in V), into a desired output current setpoint OUT (expressed in mA).

- IN=5d, IN\_MIN=0d, IN\_MAX=10d, OUT\_MIN=200d, OUT\_MAX=400d, then OUT=300d (linear).
- IN=-4d, IN\_MIN=0d, IN\_MAX=10d, OUT\_MIN=200d, OUT\_MAX=400d, then OUT=200d (low saturation).
- IN=11d, IN\_MIN=0d, IN\_MAX=10d, OUT\_MIN=200d, OUT\_MAX=400d, then OUT=400d (high saturation).

The following examples show how the function manages the input values conflicts.

- IN\_MIN >= IN\_MAX, then OUT=OUT\_MIN (error correction).

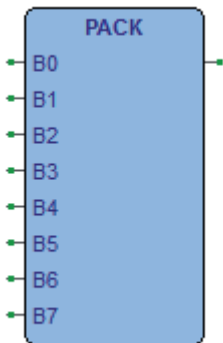
## 4.1.2.5 PACK

Name: PACK

Unit type: FUNCTION (F)

Library: Utility.lib

Symbol:



*PACK function symbol*

Description:

The PACK function delivers back as a BYTE the eight input bits B0, B1, ..., B7, BOOL type. The UNPACK function is closely related to this function.

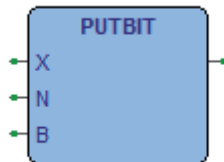
## 4.1.2.6 PUTBIT

Name: PUTBIT

Unit type: FUNCTION (F)

Library: Utility.lib

Symbol:



*PUTBIT function symbol*

Description:

The PUTBIT function puts the input value B, in the Nth position of the input value X. X is DWORD type (bit0 is the LSB), N is BYTE type, B is BOOL type.

Example:

X = 38d (100110b) , N = 4d, then, B = TRUE, PUTBIT = 54d (110110b)

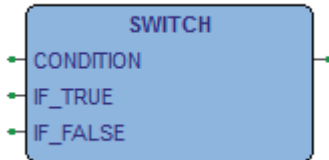
## 4.1.2.7 SWITCH

Name: SWITCH

Unit type: FUNCTION (F)

Library: Utility.lib

Symbol:



*SWITCH function symbol*

Description:

If the input variable CONDITION is TRUE, the input variable IF\_TRUE is connected to the output. Otherwise the input variable IF\_FALSE is connected to the output. CONDITION is type BOOL, IF\_TRUE and IF\_FALSE can be any type of variable.

Example:

CONDITION = FALSE, IF\_TRUE = 10d, IF\_FALSE = -4d, then SWITCH = -4d.



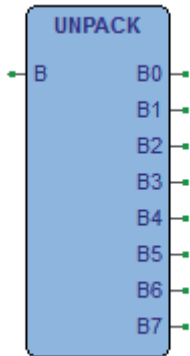
## 4.1.2.8 UNPACK

Name: UNPACK

Unit type: FUNCTION (F)

Library: Utility.lib

Symbol:



*UNPACK function symbol*

Description:

The UNPACK function converts the input B, BYTE type, into eight output variables B0, B1, ..., B7, BOOL type.

The PACK function is closely related to this function.



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