

EN



## Operation & Maintenance Manual

**NSV12N**  
**NSV12NI**  
**NSV16N**  
**NSV16NI**  
**NPV20ND**

**MCFE**  
**Hefbrugweg 77,**  
**1332 AM Almere,**  
**The Netherlands**

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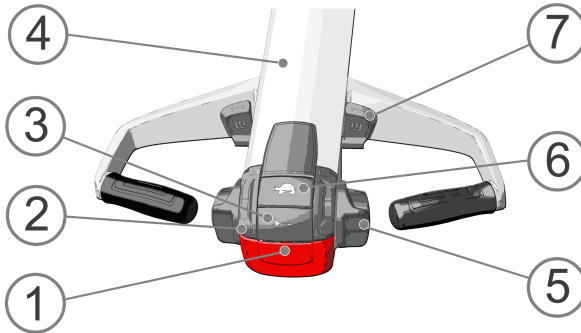
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## Tiller arm



### Safety button (1)

The safety button prevents you from getting squeezed between the truck and an obstacle.

When you push the safety button, the truck reverses its travelling direction and stops when the button is released, if the speed control is also released at the same time.

**NOTE** *Never use the safety button for normal driving. The safety button is disabled when driving on the platform.*

Check the operation of the safety button daily before you start working with the forklift truck.

### Push buttons for initial lifting and lowering (2)

- Standard for stackers with initial lifting and lowering
- Standard for double stackers

### Push buttons for single speed lifting and lowering (2)

- Standard for stackers without initial lifting and lowering

### Horn (3)

### Steering (4)

The tiller arm turns  $\pm 100$  degrees.

The truck may be equipped with an electronic steering system; see Section "Electronic steering system (optional)" in Chapter 5, Driving instructions.

### Accelerator (5)

The accelerator is used for controlling the driving speed and for braking. Handle the accelerator gently!

### Brake release / slow speed button (6)

Slow speed can be activated after the tiller arm has been tilted to the driving position (tiller arm in position 1, see the picture in Section Stopping the truck in Chapter 5, Driving Instructions). Slow speed will be de-activated after the tiller arm has been released to the up position or pressed down (tiller arm in position 2).

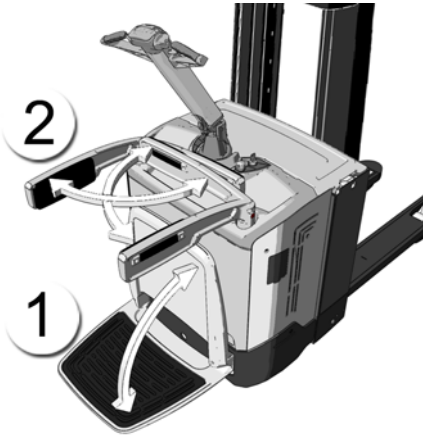
### Lever for stepless lifting and dual speed lowering (7)

- Standard for stackers with a lifting capacity of 1200 kg
- Standard for double stackers

**NOTE** *The maximum driving speed in riding mode is approximately 9 km/h. It is possible to drive the truck on the platform without unfolded side guards. In this case the maximum driving speed has been limited under 6 km/h.*

**NOTE** *The maximum lifting height has been limited to 1800 mm when driving the truck on the platform with the side guards unfolded. To lift above the limit, fold the side guards to the rest position.*

When you step off the platform, it will stay in the horizontal position. To return to pedestrian mode, fold the side guards to the rest position, lift the platform slightly and let the gas spring fold it up.



## Speed

Control the speed according to the situation. Take into consideration the load, visibility, and people in the working area and the working environment. Slow down at cross aisles and whenever the vision is obstructed. If the visibility is inadequate, use an assistant to help guide you.

Uncontrolled acceleration or braking, excessive speed at turning points, and fast and sudden turning may overturn the load and cause an accident. In all conditions, drive the truck at a speed that enables you to stop it safely.

## Stopping the truck

Brake the truck smoothly by turning the accelerator against the direction of travel (tiller arm in position 1). You should anticipate a situation when you must brake and decrease the speed well ahead.

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## 9. Service

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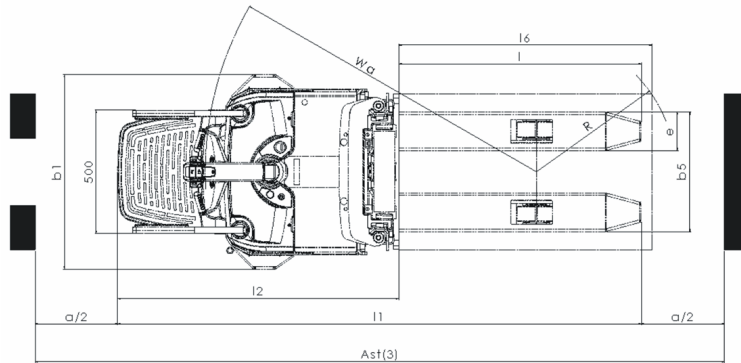
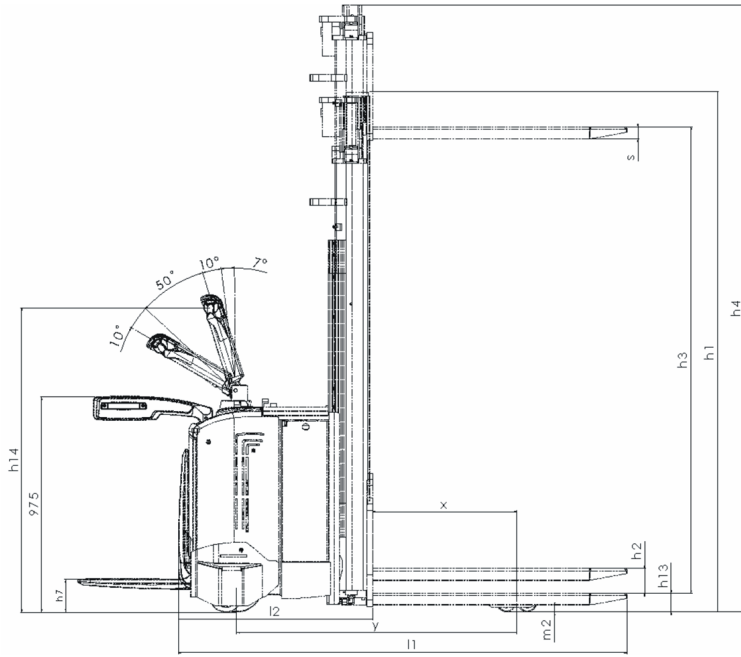
Only adequately trained people are allowed to carry out service operations. The terms of the warranty prescribe appropriate maintenance of the truck. All spare parts must be original ones.

It is recommended that you sign a maintenance agreement with the truck dealer, who can also supply spare parts. Only professional service ensures long-term, trouble-free truck operation. Service program monitoring becomes easier if you enter the service dates in a service logbook. Contact our service organisation or your truck dealer for qualified, authorised and efficient maintenance service.

### **Semi-annual inspection service (or 600 h)**

Check and, if necessary, adjust or repair:

- Connections of the drive motor and pump motor.
- Operation of the accelerator unit.
- Operation of the speed limiter.
- Operation of the microswitches or inductive sensors.
- Operation of the contactors and solenoids.
- Condition of the cables.
- Condition of the tiller arm gas spring.
- Function of the lift cylinders.
- Play of the fork carriage, and the slope of the forks and their condition.
- Air gap in the brake: 0.2 mm when new, maximum gap 0.55 mm.
- Brake pad thickness: 9.0 mm when new, minimum thickness 8.7 mm.
- Air gap in the brake cannot be modified.



Ast(3)



Mast must be lowered to free-lift area, and truck switched Off/On. If fault continues, check the functionality of the free-lift sensor.

**234            INPUT MISMATCH            (Alarm)            Stored**

Cause:

This is a safety related test. The micro processor has detected a mismatch between analogy and digital information.

This is an internal fault of the Combiac1 controller, so it must be replaced.

**235            HW FAULT VALVE            (Alarm)            Stored**

Cause:

The micro processor has detected that the controller is not able to stop hydraulic valve functions.

This is an internal fault of the Combiac1 controller, so it must be replaced.

**236            HARDWARE FAULT            (Alarm)            Stored**

Cause:

The microprocessor has detected that the controller is not able to stop the traction.

This is an internal fault of the Combiac1 controller, so it must be replaced.

**237            MASTER REDUCTION            (Warning)**

Cause:

This is information from traction controller side. There is some reduction active at the traction controller. Warning disappears when reduction is not active.

Connect handset to traction controller and check traction controller functionality.

<b>219</b>	<b>STEPPER MOTOR MISM (Alarm)</b>	<b>Stored</b>
	<p>Cause:  This alarm occurs if the frequency and the amplitude of the voltages from the stepper motor lines are mismatched in between the D and Q line of the stepper motor.</p> <p>It is necessary to replace the EPS controller.</p>	
<b>220</b>	<b>MOTOR LOCKED (Alarm)</b>	<b>Stored</b>
	<p>Cause:  This alarm occurs if the current in the steering motor stays close to the maximum current longer than 1 sec.</p> <p>Search for a mechanical problem locking the steering motor.</p>	
<b>222</b>	<b>FB POT LOCKED (Alarm)</b>	<b>Stored</b>
	<p>Cause:  This alarm occurs if the feedback hall sensor or potentiometer does not change (or changes to opposite direction) value even if it is commanded to change.</p> <p>a) Check that feedback sensor is not mechanically loosened.</p> <p>b) Check that connectors and cables of feedback sensor are in order.</p> <p>b) Verify that motor phases are not wrong way, cables are installed in correct places.</p>	
<b>223</b>	<b>JERKING FB POT (Alarm)</b>	<b>Stored</b>
	<p>Cause:  This alarm occurs if the feedback hall sensor or potentiometer voltage switching more than 0,3V in 16msec. This alarm is used to catch potentiometer discontinuities.</p> <p>Replace the feedback sensor.</p>	

NSVN, NPV20ND, Traction 24V  
 Controller: ZAPI CombiAC 350/350A  
 Software version: ad1m2b\_ro1.02  
 From Zapi serial number:

Rev. 8  
 Pvm. 10.9.2010

TRUCK TYPES							
	NSV12N, NSV12NI	NPV20ND	NPV20ND Fast Drive	NSV16N NSV16NI	Default	Adjustment Range	NOTE.
<b>MAIN MENU/ PARAMETER CHANGE:</b>							
ACCELER. DELAY	1,5	1,5	1,5	1,5	1,5	0,1-5	Acceleration ramp. 0,1 = fastest
RELEASE BRAKING	1,5	1,5	1,5	1,5	1,5	0,1-5	Release braking. 0,1 = strongest
TILLER BRAKING	0,5	0,5	0,5	0,5	0,5	0,1-5	Braking ramp when tillerl is released. 0,1 = strongest
INVERS. BRAKING	1,5	1,5	1,5	1,5	1,5	0,1-5	Inverse braking. 0,1 = strongest
DECEL. BRAKING	2,5	2,5	2,5	2,5	2,5	0,1-5	Deceleration ramp when speed is slowed down but not stopped. 0,1 = strongest
LOAD ACCEL DEL.	3	3	3	3	3	0,1-5	Acceleration ramp with maximum load. 0,1 = strongest
LOAD REL BRAKING	82 %	82 %	82 %	82 %	82 %	10-100%	Release braking with maximum load. 0,1 = strongest
LOAD TIL BRAKING	100 %	100 %	100 %	100 %	100 %	10-100%	Braking ramp with maximum load when tiller is released. 100 = strongest
LOAD INV. BRK.	70 %	70 %	70 %	70 %	70 %	10-100%	Inverse braking with maximum load. 0,1 = strongest
SPEED LIMIT BRK.	3,5	3,5	3,5	3,5	3,5	0,1-5	Deceleration ramp when speed reduction is activated. 0,1 = strongest
MAX SPEED FORW	100 %	100 %	100 %	100 %	100 %	0,1-5	Maximum speed forward without load. 100% = fastest
MAX SPEED BACK	100 %	100 %	100 %	100 %	100 %	0,1-5	Maximum speed backward without load. 100% = fastest
MAX SPEED FWD W	100 %	75 %	50 %	72 %	50 %	10-100%	Maximum walking speed forward. 100% = fastest. Note! Do not exceed marked values for safety reasons
MAX SPEED REV W	100 %	77 %	50 %	67 %	50 %	10-100%	Maximum walking speed backward. 100% = fastest. Note! Do not exceed marked values for safety reasons

## **CURRENT RMS**

This test provides the Root Mean Square value of the motor current. (RMS refers to the method of measuring current).

## **SLIP VALUE**

This test indicates the difference in turning speed between the rotating field and the motor shaft, expressed in the same units as the frequency.

## **ENCODER**

This test indicates the speed of the motor expressed in the same units as the frequency; the information originates from the encoder bearing that is mounted in the traction motor.

## **FREQUENCY**

This test indicates the frequency of the voltage and current that is supplied to the traction motor.

## **VOLTAGE BOOSTER**

The normal current limit might be set to such a low value that the motor does not start to turn. The voltage booster function provides a 10% boost to the maximum current to help to start the motor.

## **MOTOR VOLTAGE**

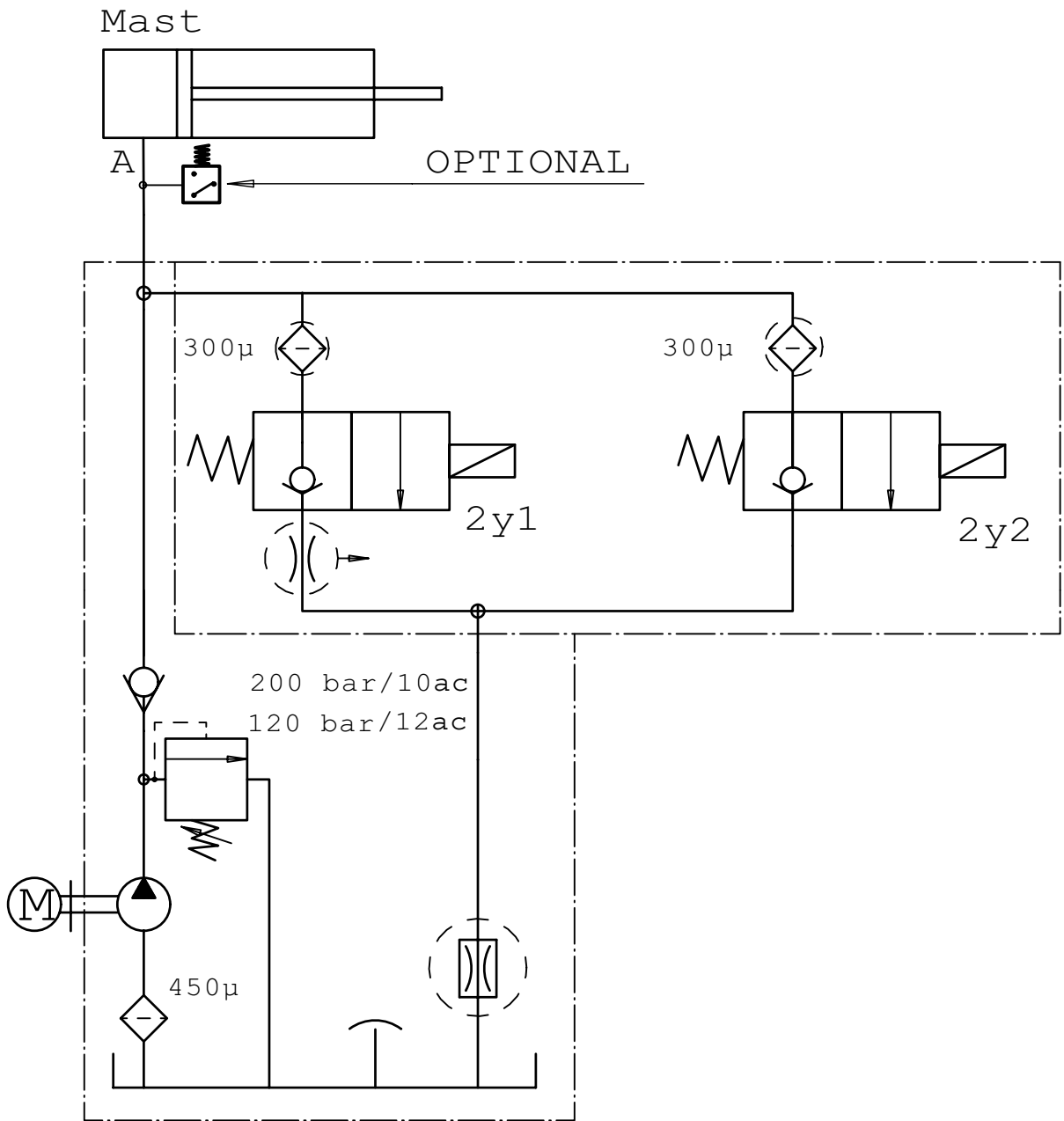
This test indicates the voltage supplied to the motor by the controller. It is expressed as a percentage of the full voltage (which depends on the battery voltage).

### **1.2 Pump motor controller (Combi Ac1) Mode:5**

Truck model specific information of the inputs and outputs are showed in the parameter list, at section "TESTER FUNCTIONS".

## **MOTOR CURRENT**

This test indicates the pump motor current.



2007-10-02

1:2



SFS-EN 22768-1

SFS-EN ISO 13920

SFS-EN-25817

**CAT** Lift Trucks

HYDRAULIC SCHEMA,  
TH67 1007  
NSP10N, NSP12N, NSV12N

TH67 1007



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*User Manual*

# COMBI AC1



### 4.1.3 Fuses

- Use a 6.3-10A Fuse for protection of the auxiliary circuits.
- For protection of the power unit, use a 400A fuse in the Battery Positive connection. For special applications or requirements these values can be reduced.
- For Safety reasons, we recommend the use of protected fuses in order to prevent the spread of fused particles should the fuse blow.

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## 4.2 Installation of the hardware

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***Before doing any operation, ensure that the battery is disconnected and when all the installation is completed start the machine with the drive wheels raised from the floor to ensure that any installation error do not compromise safety.***

***After operation, even with the Key Switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend that the battery is disconnected, and a short circuit is made between Battery Positive and Battery Negative power terminals of the chopper using a Resistor between 10 Ohm and 100 Ohm. Minimum 5 Watts.***

---

### 4.2.1 Positioning and cooling of the controller

**CONTROLLER WITH BASE PLATE:** Install the controller with the base-plate on a flat metallic surface that is clean and unpainted; suggested characteristics are: planarity 0.05 mm and rugosity 1.6  $\mu\text{m}$

- Apply a light layer of thermo-conductive grease between the two surfaces to permit better heat dissipation.
- The heat generated by the power block must be dissipated. For this to be possible, the compartment must be ventilated and the heat sink materials ample.
- The heat sink material and system should be sized on the performance requirement of the machine. Abnormal ambient air temperatures should be considered. In situations where either ventilation is poor, or heat exchange is difficult, forced air ventilation should be used.
- The thermal energy dissipated by the power block module varies and is dependent on the current drawn and the duty cycle.

**CONTROLLER WITH FINNED HEATSINK:** Sometimes the base plate installation cannot be adopted. Due to positioning problems or to the lack of a thick enough truck frame, it is necessary to adopt a finned dissipation combined with one or more fans.

- The air flux should hit the fins directly, to maximize the cooling effect.
- In addition to fans, also air ducting systems can be used to maintain low the temperature of the controller.
- It is necessary to ensure that cold air is taken from outside the controller compartment and hot air is easily pushed away from the controller compartment.
- It is mandatory to avoid that the cooling air is recirculated inside the controller compartment.

- 3) **ELECTROSTATIC IMMUNITY.** Three ways can be followed to prevent damages from ESD:
- A) **PREVENTION:** when handling ESD-sensitive electronic parts, ensure the operator is grounded; test grounding devices on a daily basis for correct functioning; this precaution is particularly important during controller handling in the storing and installation phase.
  - B) **ISOLATION:** use anti-static containers when transferring ESD-sensitive material.
  - C) **GROUNDING:** when a complete isolation cannot be achieved, a good grounding can divert the discharge current trough a “safe” path; the frame of a truck can works like a “local earth ground”, absorbing excess charge. **So it is strongly suggested to connect to truck frame all the parts of the truck which can be touched by the operator, who is most of the time the source of ESD.**

---

## 4.5 Various suggestions

- Never combine SCR low frequency choppers with COMBI AC1 modules. The filter capacitors contained in the COMBI AC1 module would change the SCR chopper operation and subject to excessive workload. If it is necessary to use two or more control units, like the chopper should both be of the Zapimos family.
- During battery recharge, the COMBI AC-1 must be completely disconnected from the battery. Beside changing the charging current seen by the battery charger, the module can be damaged by higher than normal voltages supplied via the charger.

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## 8 ONE SHOT INSTALLATION PROCEDURE

This section of the manual describes the basic connection procedure.

To move, the truck needs a minimum I/O outfit that it is mandatory: this minimum outfit is listed in the Steps from 1 to 8 below.

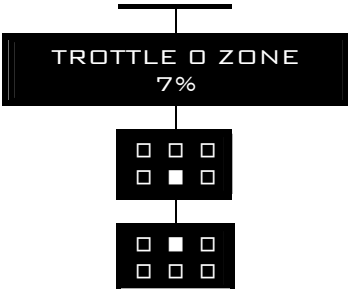
- Step1** Connect a potentiometer in the range 0.5 to 10Kohms, to modify the wished speed, between CNA#23, CNA#24, CNA#26 [AmpSaab connector]
- Step2** Connect two travel demand switches. The FWD travel demand must be connected between a battery (key) voltage and CNA#18 in AmpSaab Connector [CNA#32 in AmpSeal Connector]. The REV travel demand must be connected between a battery (key) voltage and CNA#19 in AmpSaab [CAN#31 in AmpSeal]. Only one of them can be active at the same time. They become active when connected to a key.
- Step3** Connect a tiller (or seat) switch enabling/disabling the truck motion between CNA#7 in AmpSaab [CNA#1 in AmpSeal] and a key voltage. It becomes active, enabling the motion, when closed to a key voltage.
- Step4** Connect the encoder in the motor shaft between CNA#9=VDD, CNA#10=GND, CNA#8=CHA, CNA#22=CHB in AmpSaab [CNA#25=VDD, CNA#5=GND, CNA#14=CHA, CNA#13=CHB in AmpSeal connector] . The VDD voltage may be 12V or 5V depending on a jumper inside the controller.
- Step5** Connect the plus battery voltage through a key switch at the KEY input CNA#13 [CNA#10 in AmpSeal]. This is the input for the controller supply.
- Step6** Connect the Main Contactor Coil to CNA#13 and CNA#17 in AmpSaab connector (respectively CNA#10 and CNA#12 in AmpSeal connector). The contactor must connect the battery positive to the +BATT power terminal of the COMBI AC1.
- Step7** Connect the motors and the minus battery to the corresponding power terminals of the COMBI AC1.
- Step8** Connect the Electromechanical Brake between CNA#30 and CNA#31 in the AmpSaab connector [respectively CNA#2 and CNA#4 in the AmpSeal connector]; when the tiller switch opens, the electromechanical brake gets de-energized braking the truck.

The Steps from 1 to 8 describe the installation operations that is mandatory to do in order your truck moves. Obviously the COMBI AC1 may execute a wider set of optional services as:

- 1) to handle some speed reductions requests
- 2) to handle a analog sensor inside the motor
- 3) to handle a proportional braking
- 4) to handle a proportional forks lowering valve
- 5) to handle a pump motor by a chopper.
- 6) to handle a belly switch and an Inching operative mode.
- 7) to handle a proportional input for the forks lifting/lowering.
- 8) to handle a number of on/off E-valves.

You must fill your I/O outfit with your optional functions. The optional functions are shown in the connecting drawing and described in detail inside this manual.

The index may help you.



- 11) Press OUT
- 12) Press ENTER to confirm
- 13) Repeat the same from 5 to 12 points for the other adjustments

- 1) **SET BATTERY TYPE**  
Selects the nominal battery voltage.
- 2) **ADJUST BATTERY**  
Fine adjustment of the battery voltage measured by the controller.
- 3) **THROTTLE 0 ZONE**  
Establishes a deadband in the accelerator input curve.
- 4) **THROTTLE X POINT**  
This parameter, together with the THROTTLE Y POINT, changes the characteristic of the accelerator input curve : when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point per cent of the Maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slopes.
- 5) **THROTTLE Y POINT**  
This parameter, together with the THROTTLE X POINT, changes the characteristic of the accelerator input curve (see also paragraph 13.5): when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point per cent of the Maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope.
- 6) **BAT. MIN ADJ.**  
Adjust the lower level of the battery charge table (Level 0 to 9).
- 7) **BAT. MAX ADJ.**  
Adjust the upper level of the battery charge table (Level 0 to 9).
- 8) **LOAD HM FROM MDI**  
When set On, the HourMeter of the Controller is transferred and recorded on the HourMeter of the Standard MDI (connected on the Serial Link).
- 9) **CHECK UP DONE**  
Turn it On when the required Maintenance service has been executed to cancel the CHECK UP NEEDED warning.
- 10) **CHECK UP TYPE**  
It specifies the handling of the CHECK UP NEEDED warning:

**10) MIN EVP**

0 to 100. This parameter determines the minimum voltage applied on the EVP when the position of the potentiometer is at the minimum. This parameter is not effective if the EVP is programmed like a On/Off valve.

**11) MAX EVP**

0 to 100. This parameter determines the maximum voltage applied on the EVP when the position of the potentiometer is at the maximum. If the EVP is programmed like a On/Off valve this parameter determines the fixed voltage applied on the electrovalve coil.

**12) EVP OPEN DELAY**

In seconds. It defines the opening ramp of the evp electrovalve when related output is set as Analog (refer to Set Option menu).

**13) EVP CLOSE DELAY**

In seconds. It defines the closing ramp of the evp electrovalve when related output is set as Analog (refer to Set Option menu).

**14) EV1 OPEN DELAY**

In seconds. It defines the opening ramp of the evp1 electrovalve, when related output is set as Analog (refer to Set Option menu).

**15) EV1 CLOSE DELAY**

In seconds. It defines the closing ramp of the evp1 electrovalve, when related output is set as Analog (refer to Set Option menu).

PARAMETER	UNIT	PROGRAMMED LEVEL									
		0	1	2	3	4	5	6	7	8	9
PUMP IMAX	%	From 50% to 100% of IMAX, resolution of 5%									
PUMP ACC. DELAY	Sec.	From 0 to 10 sec., resolution of 0.1									
PUMP DEC. DELAY	Sec.	From 0 to 10 sec., resolution of 0.1									
SPEED LIMIT	%	From 0% to 100%, resolution of 1%									
CREEP SPEED	%	From 0% to 100%, resolution of 1%									
COMPENSATION	%	From 0% to 100%, resolution of 1%									
HYD SPEED FINE	%	From 0% to 100%, resolution of 1%									
HYDRO COMPENSATION	%	From 0% to 100%, resolution of 1%									
CUTBACK SPEED	%	From 0% to 100%, resolution of 1%									
MIN EVP	%	From 0% to 100%, resolution of 0.1%									
MAX EVP	%	From 0% to 100%, resolution of 0.1%									
EVP OPEN DELAY	Sec.	From 0 to 25.5 sec., resolution of 0.1									
EVP CLOSE DELAY	Sec.	From 0 to 25.5 sec., resolution of 0.1									
EV1 OPEN DELAY	Sec.	From 0 to 25.5 sec., resolution of 0.1									
EV1 CLOSE DELAY	Sec.	From 0 to 25.5 sec., resolution of 0.1									

The Battery Charge detection follows this algorithm:

- 1) Battery voltages is read when the Battery current is zero, that is when the output power stage is not driven.
- 2)  $V_{batt}$  is the mean of the least samples measured by the microcontroller converter (the samples are took on key input).
- 3)  $V_{batt}$  is compared with a threshold value (function of the actual charge percentage) in a table and with comparison is found a new charge percentage.
- 4) Thresholds value can be changed with parameters Bat. Max. Adj. and Bat. Min. Adj.
- 5) After key on battery charge can be only increased if the battery charge computed after key on is greater than the last value stored in Eeprom the battery charge value is updated otherwise the Battery charge is not updated.

---

## 11.5 Analysis and troubleshooting of Master warnings

1) "PUMP WARNING"

Cause:

The slave has a warning.

Troubleshooting:

Connect to the slave with the hand set console and check the warning.

2) "SLIP PROFILE"

Cause:

There is an error on the choice of the parameters of the slip profile.

Troubleshooting:

Check in the hardware setting menu the value of those parameters.

3) "FORW+BACK"

Cause:

This alarm occurs when both the travel demands (Fwd and Bwd) are active at the same time.

Troubleshooting:

Check the wiring of the Fwd and Rev travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting). Check the microswitches for failures.

A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the controller.

4) "INCORRECT START"

Cause:

This is a warning for an incorrect starting sequence.

Troubleshooting:

The possible reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting):

A) A travel demand active at key on

B) Presence man sensor active at key on

Check the wirings. Check the microswitches. It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the controller.

5) "VACC NOT OK"

Cause:

The test is made at key-on and after 20sec that both the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading in the TESTER menu' is 1,0V higher than PROGRAM VACC min acquisition when the accelerator is released.

Troubleshooting:

Check the mechanical calibration and the functionality of the potentiometer.

6) "HIGH TEMPERATURE"

Cause:

This alarm occurs when the temperature of the base plate is higher than 85°. Then the maximum current decreases proportionally with the temperature increases from 85° up to 105°. At 105° the Current is limited to 0 Amps.

14) "EEP WARNING"

Cause:

Eeprom checksum failed

Troubleshooting:

Try to execute a CLEAR EEPROM operation (refer to Console manual).

Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters.

15) "LIFT + LOWER"

Cause:

This alarm occurs when both forks movement requests(Lift + Lower) are active at the same time.

Troubleshooting:

Check the wiring of the Lift and lower inputs (use the readings in the TESTER to facilitate the troubleshooting). Check the microswitches for failures.

A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the controller.

16) "EEPROM KO"

Cause:

It's due to a HW or SW defect of the non-volatile embedded memory supporting the controller parameters. This alarm does not inhibit the machine operations, but the truck will work with the default values.

Troubleshooting:

Try to execute a CLEAR EEPROM operation (refer to Console manual).

Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters.

17) "PUMP MOTOR TEMPERATURE"

Cause:

This warning occurs when the temperature sensor is opened (if digital) or has overtaken the threshold of 150° (if analog).

Troubleshooting:

Check the thermal sensor inside the motor (use the MOTOR TEMPERATURE reading in the TESTER menu); check the sensor ohmic value and the sensor wiring. If the sensor is OK, improve the air cooling of the motor. If the warning is present when the motor is cool, then the problem is inside the controller.

18) "HIGH TEMPERATURE"

Cause:

This alarm occurs when the temperature of the power section plate is higher than 75°. Then the maximum current decreases proportionally with the temperature increases from 85° up to 105°. At 105° the Current is limited to 0 Amps.

Troubleshooting:

Improve the air cooling of the controller. If the alarm is signaled when the controller is cold, the possible reasons are a thermal sensor failure or a failure in the logic card. In this case, it is necessary to replace the controller.

# 2 SPECIFICATION

## 2.1 Technical specifications

Steering controller for AC asynchronous 3-phase motors  
Digital Control using Two Microprocessors  
Can-Bus interface  
Both microprocessors Can Bus connected  
Encoder Interface  
Stepper Motor or Twin Pot Interface  
Analog Feedback pot interface (1024 steps resolution)  
Analog KTY84-130 thermal sensor input  
Analog input with 1024 steps resolution (one input)  
Analog input with 4096 steps resolution (one input)  
Two digital inputs  
Double Safety Relay inside  
Operating frequency: ..... 8 kHz with center aligned PWM  
External temperature range: ..... -30 °C ÷ 40 °C  
Maximum inverter temperature: ..... 75 °C  
Environment protection: ..... IP54

## 2.2 Block diagram

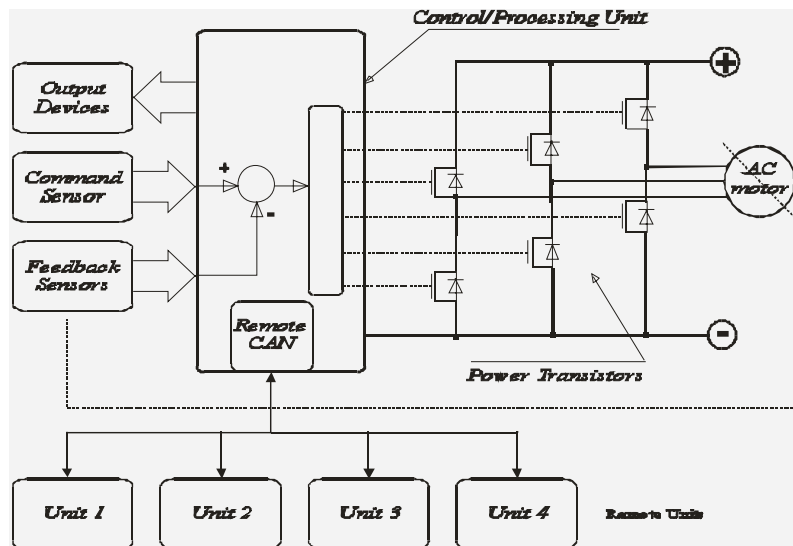


Figure 2-1

## 2.3 Electrical specifications

Battery Voltage: ..... 24 V-36 V  
Maximum current (24 V-36 V): ..... 50 A (RMS) for 2'  
Logic Supply current: ..... max 200 mA @ 24 V

## 4.5.2 Encoder in the motor shaft and one (two) toggle switch(es)

It consists of (see Figure 4-5):

- 1) Straight ahead toggle switch on the input CNA#3 and GND.
- 2) 90 degrees toggle switch on the input CNA#2 and GND.
- 3) Feedback encoder on the steering motor shaft.

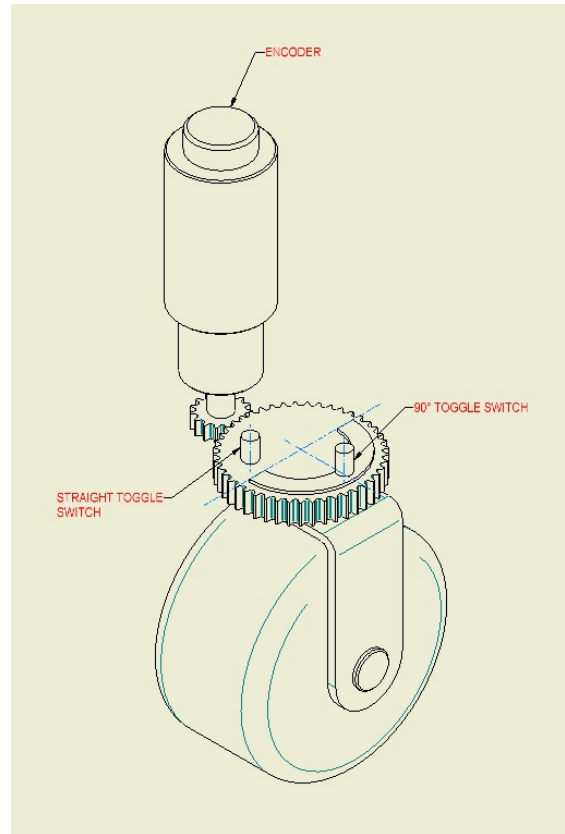


Figure 4-5

### 4.5.2.1 Straight ahead toggle switch

The straight ahead toggle switch must be of NPN type (i.e. it must connect a minus battery to CNA#3).

A possible arrangement for the straight-ahead switch (proximity switch) is shown in Figure 4-6 below. The proximity switch is connected to the truck frame; the Iron plate rotates together with the steered wheel.

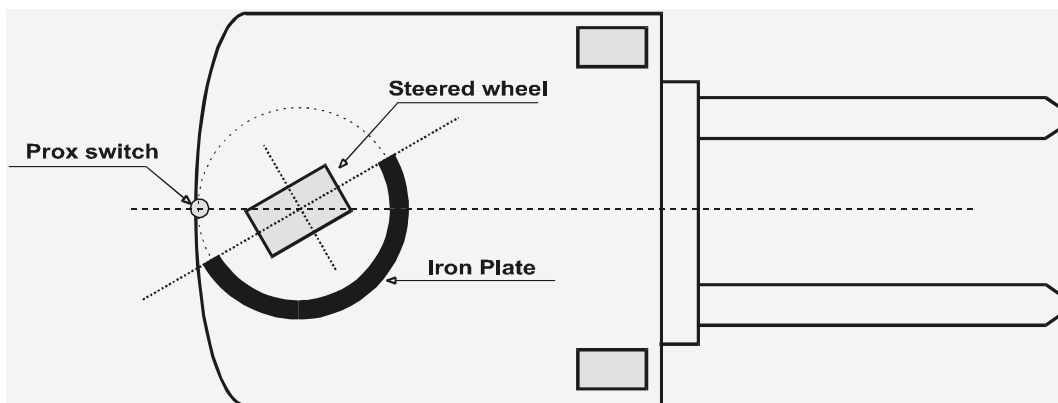


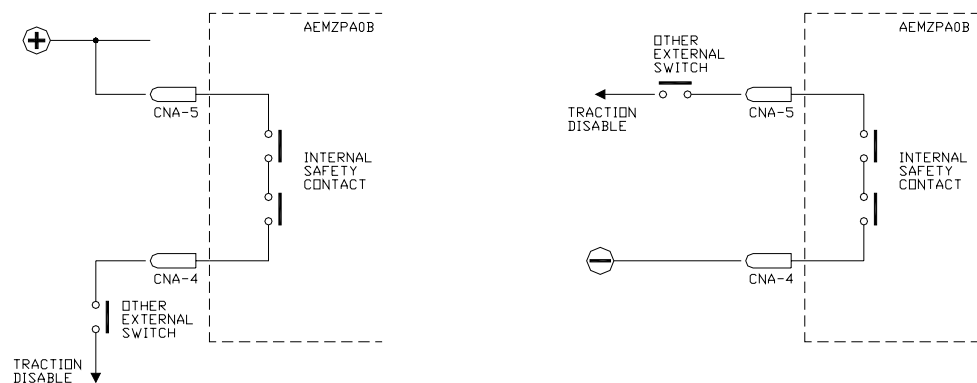
Figure 4-6

## 7.6 Safety contacts

The Eps-ac0 provides an internal safety contact accessible through connector pins CNA#5 and CNA#4. It should be used to stop the traction and to enable an electromechanical brake when a steering alarm occurs. This safety contact is closed when the key switch is turned on. The contact opens where there is a steering alarm. This safety contact is floating, that means it's possible to connect it either to the plus battery or to the minus battery. **Ensure that the pin #5 is connected to an equal or higher voltage than pin #4.** For safety two cascaded switches are internally connected between CNA#5 and CNA#4. The Main microprocessor manages the first contact; the Supervisor microprocessor manages the second contact.



**Note:** If the safety switch is connected in series with external switches (dead-man switch, tiller switch or similar) it's recommended that the steering safety switch should be directly connected to the supply source (plus battery or minus battery) with no interposed switches (it should be the first in the chain: see Figure below).



## 7.7 Motor thermal sensor connections

Eps-ac0 handles a motor thermal sensor: it should be KTY184-130 type. Through this sensor, the eps-ac0 measures the motor temperature: when DIAG MOTOR TEMP is set ON, and the motor temperature overtakes 150 degrees, an alarm occurs. Input CNB#3 is configured with an aboard 1K Pull-up resistor suited to receive the analog thermal sensor between this input and a negative (CNA#13).

- 1) Use shielded cable for the connections of the potentiometers (especially for the SP POT). The shielded cable reduces the noise in the wiper voltage. Connect the shield to a GND pin of the eps-ac0 connectors.
- 2) Use the FB ENC instead of the FB POT as feedback sensor. The Encoder has not noise. When the Encoder is stopped in a position, the Encoder counting is absolutely constant.
- 3) Reduce the gain of the Closed Loop. It means KP and POS. ACCURACY parameters must be decreased. When the gain reduces, the modification of the position error due to noise, are less amplified giving less dither; but less accuracy is got in the final pursuing at the wished position.

- Step1** Connect the AC motor phases in such a way the phase references U, V, W on the steering motor correspond to the terminals references (U, V, W) on the eps-ac0.
- Step2** In the SET MODEL menu set the SYSTEM CONFIG setting to LEVEL 0 to steer in open loop with a stepper motor in manual mode. Turn off and on the key in order the setting is acquired.
- Step3** Set the FEEDBACK DEVICE to OPTION #4 to specify your feedback solution is the encoder with one or two toggle switches. Switch off the key after the change.
- Step4** Turn the special adjustment DEBUG OUTPUT to Level 11 to inhibit the alarm POSITION ERROR and recycle the key.
- Step4** Set option ENCODER CONTROL to OFF.
- Step5** Connect the encoder. The encoder supply is between CNB#4 (5 Vdc) and CNA#11 (GND): the two channels are CNB#8 (CHA) and CNB#7 (CHB).
- Step6** Verify the reading ENC SPEED in the tester menu is consistent with the reading FREQUENCY in the tester menu. Consistent means that ENC SPEED and FREQUENCY must have the same sign and a close value. If ENC SPEED has a wrong sign, swap CHA (CNB#8 with CHB (CNB#7). If ENC SPEED is not close to FREQUENCY, the encoder resolution is wrong and a different SW is needed (see 12.4.7.12 and 12.4.7.8).
- Step7** If the motor runs well without glitches, it is possible to stays with ENCODER CONTROL to OFF; otherwise, turn ENCODER CONTROL to ON.
- Step8** Verify the steered wheel rotates in the correct direction according to the hand wheel. If it isn't, swap DL (CNA#9) with QL (CNA#8).
- Step9** Set the LIMIT DEVICE option to OFF to avoid the maximum angle limitations.
- Step10** Detect the encoder counting corresponding to a steered wheel revolution. To do that, turn the steered wheel some revolutions in CW direction and read the ENC COUNT AT 360 in the tester menu. At every falling edge of the CNA#3 toggle switch (SW1), this reading is updated. It corresponds to the encoder counting for a complete revolution of the steered wheel. ENC COUNT AT 360 shows real time the encoder counting between two consecutive falling edges on the straight ahead toggle switch. The reading is scaled in the range 0 to  $\pm 5$  V.  
 5 V corresponds to an encoder counting of  $2^{15}$  events.  
 -5 V corresponds to an encoder counting of  $-2^{15}$  events.  
 To be sure the shown value is correct, turn the steered wheel some revolutions in the opposite direction. I expect the reading ENC COUNT AT 360 gets the same value but with opposite sign.
- Step11** Enter and save the adjustment SET ENC AT 360. The absolute value in the reading ENC COUNT AT 360 will be recorded on SET ENC AT 360.
- Step12** Recycle the key and turn the steered wheel to get the WHEEL ANGLE reading in the tester menu close to 0 degrees.
- Step13** Check the orientation of the steered wheel in the position having WHEEL ANGLE close to 0. If the steered wheel has not the wished orientation change AUX FUNCTION 11. If AUX FUNCTION 11 is set to Level 5, it is necessary to change to Level 4 or vice versa. If AUX FUNCTION 11 is set to Level 2, it is necessary to change to Level 3 or vice versa.
- Step14** Recycle the key. Now, when WHEEL ANGLE is null, the steered wheel must be oriented in the wished direction.
- Step15** Turn the steered wheel to have the reading WHEEL ANGLE close to +45 degrees (first sector). Read the ENDSTROKE CW and ENDSTROKE ACW in the tester menu. Set AUX FUNCTION 11 to the proper level as specified below:  
 ENDSTROKE CW=OFF and ENDSTROKE ACW=OFF: Level 2

---

## 12.4 Function configuration

The functions list change with the settings SYSTEM CONFIG and FEEDBACK DEVICE (see 12.4.3.1 and 12.4.1.3). In particular, we will distinguish between the configuration with stepper motor against the one with RTC in the hand wheel: besides we distinguish between the configuration with the encoder plus toggle switches against the one with the encoder plus potentiometer as feedback sensor. In the next we refer to a complete list that is the union of the settings in the above configurations. When the setting refers to only one configuration, it will be specified in the description.

- functions. With this choice, the automatic functions are inhibited (the AUTC function isn't possible).
- LEVEL 5: **Single pot with feedback sensor.** This is a closed loop configuration. The single pot supplies the commanded position for the steered wheel. The feedback sensor is mandatory to close the loop with the commanded position. This choice is just for testing a prototype before to gather a twin pot; we strongly advice against using this configuration for the field production. The FEEDBACK DEVICE option (see 12.4.1.3) specifies which kind of feedback sensor is adopted.
  - LEVEL 6: **Via CAN demanded speed without feedback sensor.** This is an open loop configuration. A remote unit provides the wished steering motor speed via CAN Bus. As the feedback sensor is not strictly necessary in open loop mode, it is possible to work without feedback sensor at all. In spite of that, when the maximum angle limitation via feedback sensors is enabled (option LIMIT DEVICE to ON when FEEDBACK DEVICE is OPTION #1-2-3; 1<sup>ST</sup> ANGLE COARSE and 2<sup>ND</sup> ANGLE COARSE less than level 9 when FEEDBACK DEVICE is OPTION #4), the feedback sensor is expected to perform the secondary functions of maximum angle limitation, detection of the locked motor and to perform the alignment at the rest position. When these conditions are met, the FEEDBACK DEVICE option (see 12.4.1.3) specifies which kind of feedback sensor is adopted for the secondary functions. With this choice, the automatic functions are inhibited (the AUTC function isn't possible).

In the above list, the configurations with the command via CAN Bus may be developed only if the communication protocol between eps-ac0 and remote unit is known.

## 2) AUTO REQ TYPE

Level 0 to 9. This setting specifies the type of the automatic request. The standard version foresees no automatic function so this setting is ineffective. The only exception is the configuration FEEDBACK DEVICE to OPTION #4 (encoder and toggle switches). Then the automatic centering is regulated with the option AUTOCENTERING (see 12.4.1.5). AUT REQ TYPE will be handled time to time according the automatic function customer's specification.

## 3) CONNECTED TO

It assumes a number between 0 to 255. This setting is used to (virtually) connect the hand-set to a remote unit CAN Bus connected. With the hand-set connected to the eps-ac0 it is possible to communicate with a remote Zapi unit. Every Zapi unit has its own identification number (e.g. eps-ac0 is 6; traction controller is 2; pump controller is 1). By setting CONNECTED TO to 2, the hand set will be virtually connected to the traction controller.

## 4) MODEL TYPE

It assumes a number between 0 to 3. This setting is used to specify which one local elaboration unit must be virtually connected to the hand-set. In fact eps-ac0 has two uCs aboard. When MODEL TYPE is set to 0, the hand set is communicating with the main uC; when MODEL TYPE is set to 1, the hand set is communicating with the slave uC.

- LEVEL 1-9 Zapi reserved.
- LEVEL 10: Enables the NO LOAD CURRENT test (see 12.4.2.10). Roll from level 10 to level 15 and save the new setting to exit this testing condition.
- LEVEL 11: Disables the alarms FB SENS LOCKED, MOTOR LOCKED and POSITION ERROR (the latest only for FB ENC & Toggle Switches configuration) till a new DEBUG OUTPUT hand setting.
- LEVEL 12: The SET POINT POT of the Tester menu is connected at the high resolution AD input (it is in the range 0 to 5Vdc when the command potentiometer (CPOC1) is close to ZERO SP POT).
- LEVEL 13: Reading SET POINT POT in the tester menu is connected to the 2nd wiper of the twin (command) pot (CPOC2 on CNA#8).
- LEVEL 14: Disables the alarms FB POT LOCKED, MOTOR LOCKED and POSITION ERROR (the latest only for FB ENC & TOGGLE SWs configuration). It switches automatically to the default Level 15 recycling the key.
- LEVEL 15: Default value (no special functions activated).

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