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COMPANY DEPT. SERVICES	MANAGEMENT EXECUTIVE	
ENGINEERING SECTION EXECUTIVE		
EXPORT MANAGER		

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INTRODUCTION

This equipment enables **manually controlled power steering and automatic centering.** Manually controlled steering may use either a tacho-generator or, in a later version, an inexpensive stepper motor fixed to the steering wheel. The automatic centering operation requires a potentiometer mechanically fixed on the MDU (Motor Drive Unit).

The MDU uses an inexpensive, robust and maintenance free three phases AC induction motor.

Also, **our patented system makes optional the adoption of an encoder** mounted on the steering motor shaft.

The on board CAN interface makes the communication exchange between our EPS and other controllers placed on the truck rapid and simple, so potentially extending the steering performance to steer equalization for traction speed, CAN management of a wire guidance application and so on.

Configuration options, steering adjustment, measurement functions, and toubleshooting operations are integrally supported by the ZAPI hand held controller equipped with Eprom release number CKULTRA ZP3.01 or later.

Improved safety and operation are provided **by having two microprocessor:** the first of them performs operations and a second one executes supervisor functions.

The microprocessors combined with the ZAPI hand held controller make servicing easy and direct, reducing adjustment and troubleshooting time. Increased steering motor performance and reduced noise levels are achieved by using MOSFET technology.

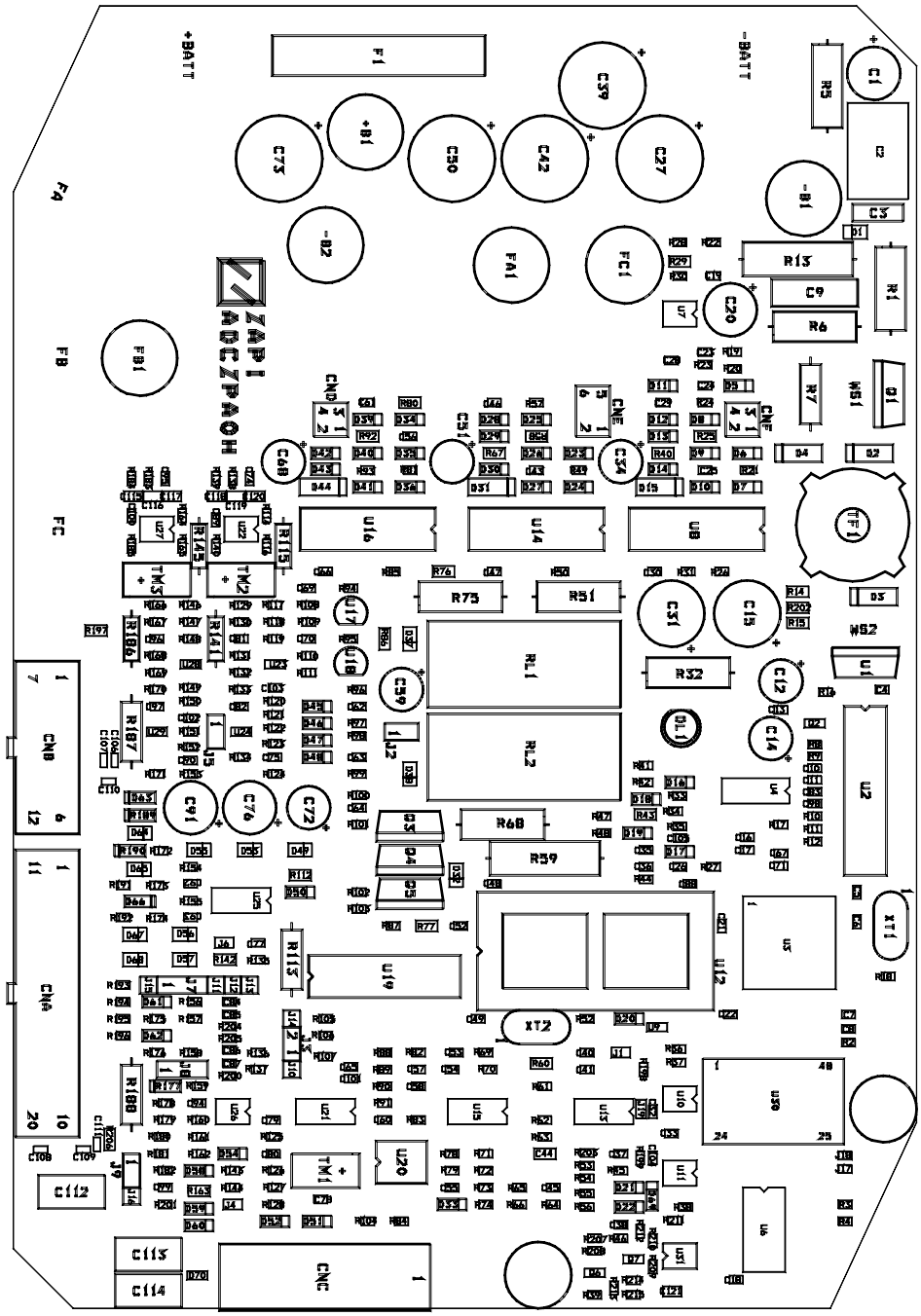
1 SYSTEM COMPONENTS

The EPS_AC equipment consists of the following parts:

1.1 STEERING SERVO MOTOR CONTROL UNIT

It consists of a control unit using the logic marked ADCZPA0H which operates the AC motor for both manual and automatic centering steering. There are three different control units available:

1) A 24/36Vbatt unit provides a maximum current of 70Amps.
2) A 48Vbatt unit provides a maximum current of 70Amps.
3) A 48/80Vbatt unit provides a maximum current of 50Amps.



1.2 STEER ANGLE POSITION POTENTIOMETER

To execute an automatic centering operation, a multiturn 5K potentiometer must be mounted directly on the end of the output shaft of the steering gear reduction box. This potentiometer measures the angle of the MDU directly. The full range of possible output is approximately 0÷5Vdc. This potentiometer also provides information for the steer angle indicator gauge mounted on the operator console.

1.3 OPERATOR CONSOLE

The control unit can support the following devices typically fixed on the operator console.

1) Key switch
2) Manual/automatic centering selection switch (AUTOSEL).
3) A status device (BUZZER).
4) A steer angle indicator gauge.

1.4 AC STEERING SERVO MOTOR

The steering system includes a three phase AC induction motor with a maximum rated power of:

1) 40A current rating (Imax=70A) if the battery voltage is 36Vdc or less. (about 1KW rated power motor at Vbatt=36V).
2) 30A current rating (Imax=70A) if the battery voltage is 48Vdc. (about 1KW rated power motor).
3) 22A current rating (Imax=50A) if the battery voltage is greater than 48Vdc. (about 1.2KW rated power motor at Vbatt=80V).

The gear box should be chosen so that the complete 180° MDU rotation takes 3 to 6 seconds at the maximum steer speed.

1.5 STEERING HANDLE

This is a multi-turn steering handle or wheel attacched to a command device. There are two option:

1) **tacho-generator.** This solution requires just a two wire connection. The recommended tacho-generator is AIRPAX Part N° 24Vdc - 9904 -120 - 16206.
2) **stepper motor.** This solution requires either a six wire connection or an optional three wire connection. The recommended stepper motor model is Minebea type code AA23KM-K227-T20V.

This last device requires a frictional linkage because there is no gear box.
Mounting the command device to eliminate axial or radial loading on the input shaft is important for reliable operation.
Note: the logic card for the tacho-generator and for the stepper motor applications are different. So a different order code must be specified.

1.6 MOTOR SHAFT ENCODER

This device is optional (not necessary). The Eps-Ac can receive an encoder (CNA #6, #16, #17 and #7) directly connected to the steering motor shaft. This is an option for a special application. E.g. fine steering speed control, safety improvement etc. A typical manual controlled steering with automatic centering does not require an encoder; it just requires a feedback pot.

2 ELECTRICAL SPECIFICATIONS

2.1 BATTERY VOLTAGE RANGE

Battery voltage input ranges for different releases of the control unit:

24/36	24-36 Vdc
48	48 Vdc
48/80	48-80 Vdc

2.2 STEER MOTOR CURRENT RANGE

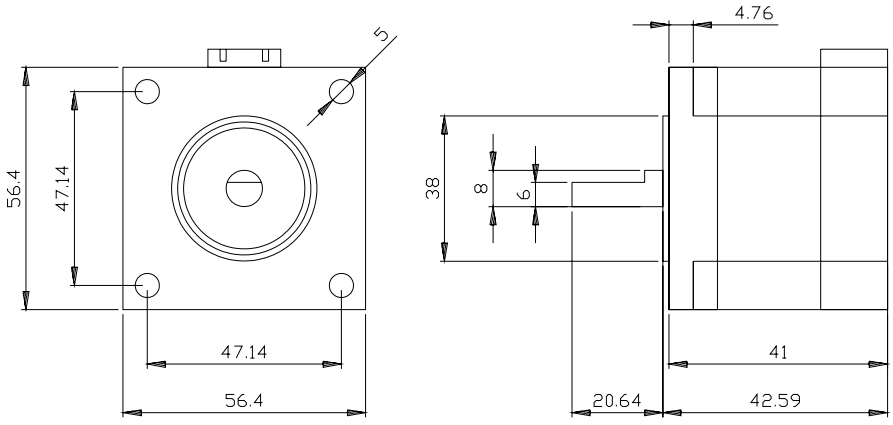
24/36	Imax ≤70Aac. Adjustable with the hand held controller (HARDWARE SETTING)
48	Imax ≤70Aac. Adjustable with the hand held controller (HARDWARE SETTING)
48/80	Imax ≤50Aac. Adjustable with the hand held controller (HARDWARE SETTING)

2.3 COMMAND DEVICE SPECIFICATIONS

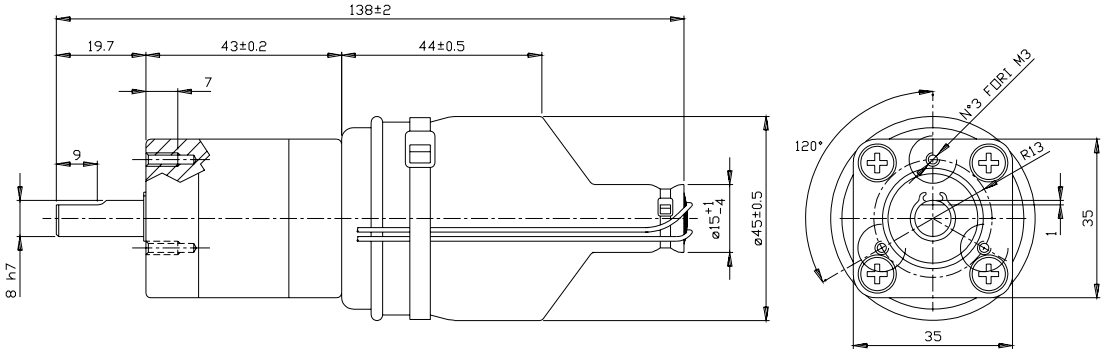
2.3.1 Tacho generator or stepper motor

We supply two command device solutions: Tacho-generator and Stepper motor.
Tacho-generator is to be AIRPAX 24VDC - part No. 9904-120-16206. Use of any other device may provide non-optimum performance.
Stepper motor is to be Minebea type code AA23KM-K227-T20V. Use of any other device may provide non-optimum performance.

Stepper motor - mechanical specification



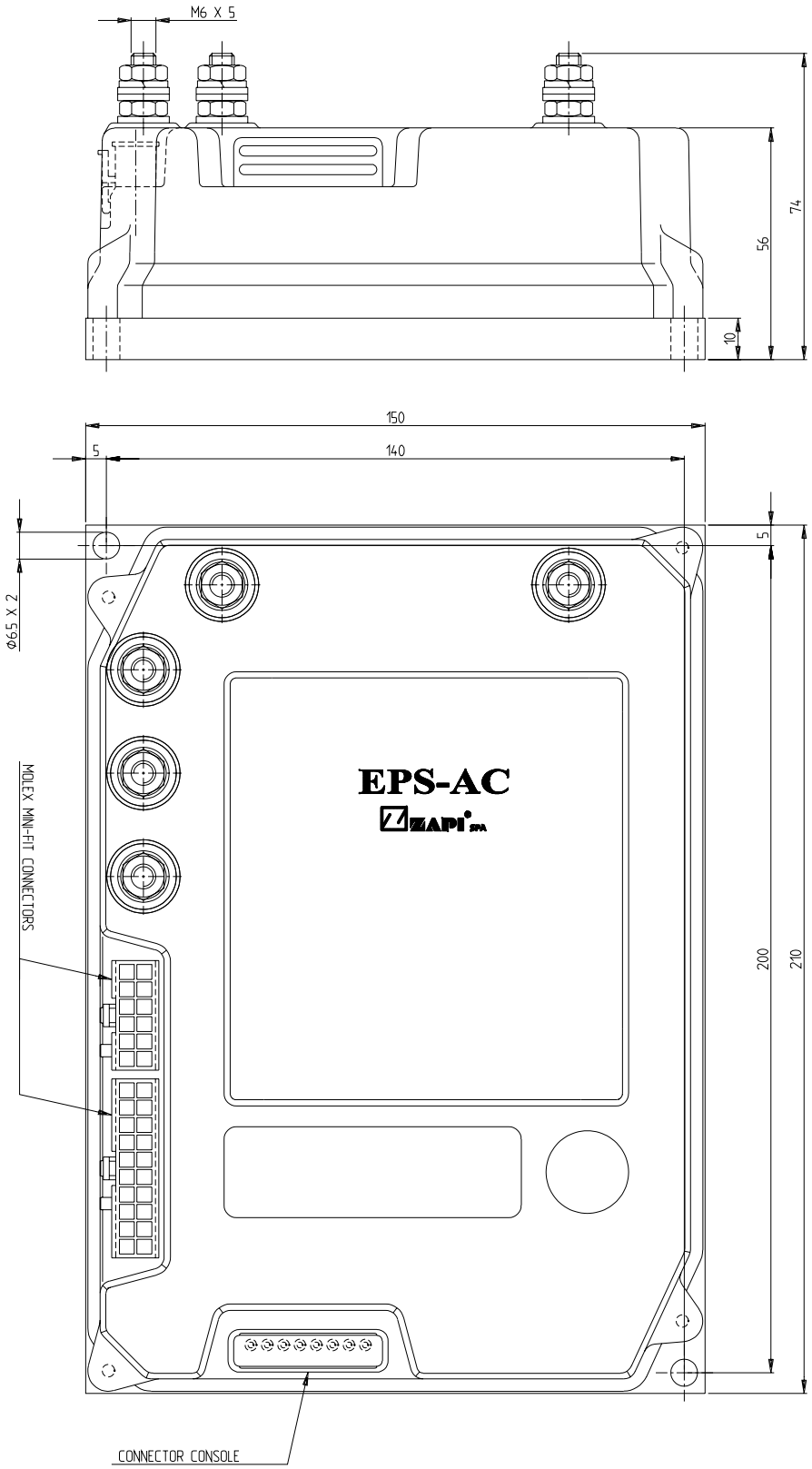
Tacho generator - mechanical specification



2.3.2 Automatic centering potentiometer

The potentiometer fixed on the steering gear box output shaft should be a 5K conductive plastic potentiometer. A multi-turn potentiometer is suggested to ensure negligible mechanical play.
The feedback angle potentiometer should rotate approximately ensure 80% of its total travel, corresponding to 180 degrees of steering angle. The greater the travel, the better the resolution and accuracy.

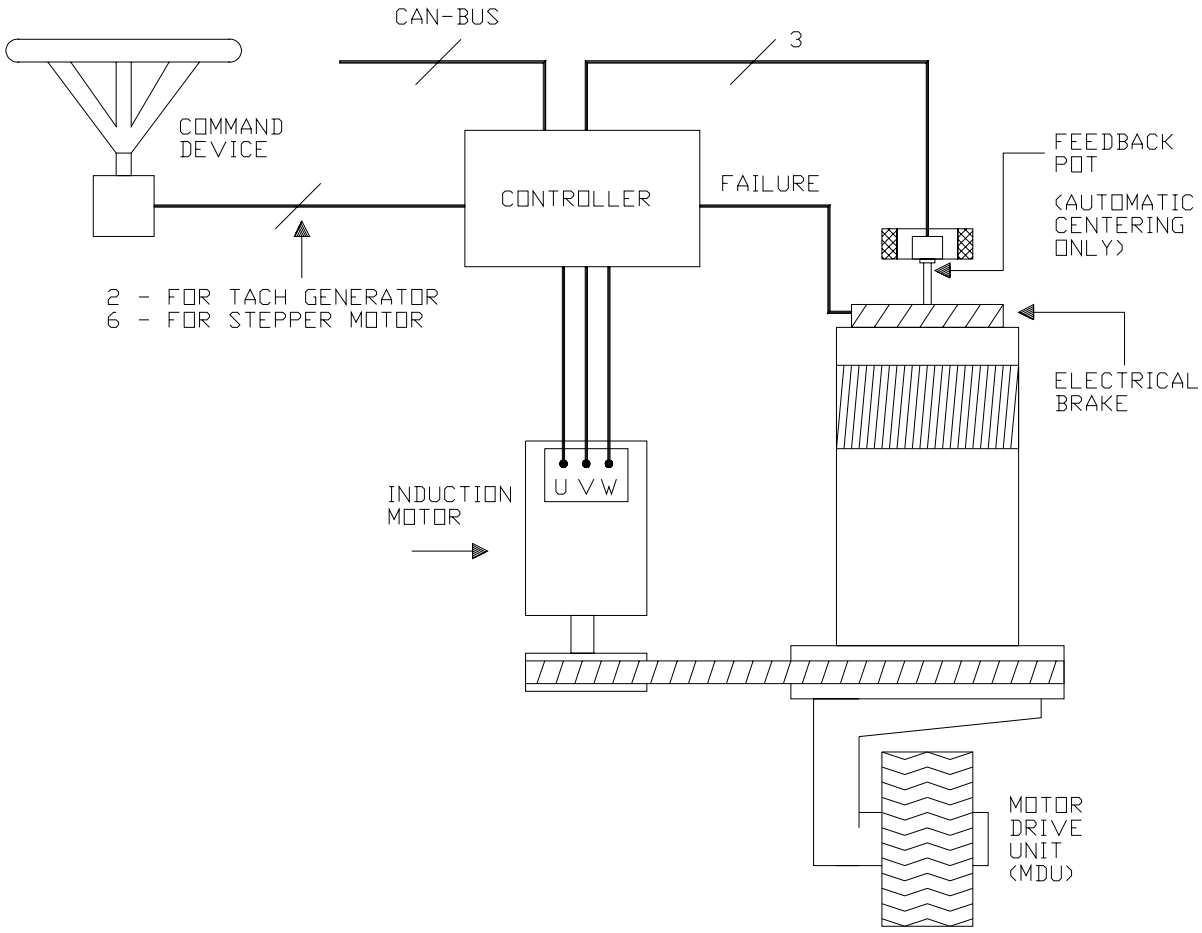
3 MECHANICAL SPECIFICATIONS



4 SYSTEM DESCRIPTION

4.1 MANUAL STEERING WITH TACHO-GENERATOR OR STEPPER MOTOR

This option uses a tacho-generator (or a stepper motor) attached to the steering wheel to convert the steering wheel rotation into an electrical signal. The control logic sets the steer servo-motor in motion at a speed that increases with the speed of the steering wheel. Steering sensitivity and maximum speed are adjustable by using the ZAPI hand held controller.



4.2 AUTOMATIC CENTERING

Through the AUTOSEL input request it is possible to turn the steering state from manual mode to automatic centering. The automatic centering request should be edge or level conditioned (see option AUT INP ACTIVE 10.7.7). As soon as an automatic centering request is recognized, the steering control will start to automatically rotate the MDU until it is straight ahead.

5 JUMPERS DESCRIPTION

Three are three jumpers it is possible to configure.

J7: This jumper selects the active level on the travel demand inputs. Travel demands are connected in the CNA #5 and CNA #15 positions. They are used in the automatic centering to restart steering always when the truck is moving. When J7 is closed between pins No. 1 and 2, travel demands are expected active low (fig. 5.1); when closed between pins No. 2 and 3, travel demands are expected active high (fig. 5.2).

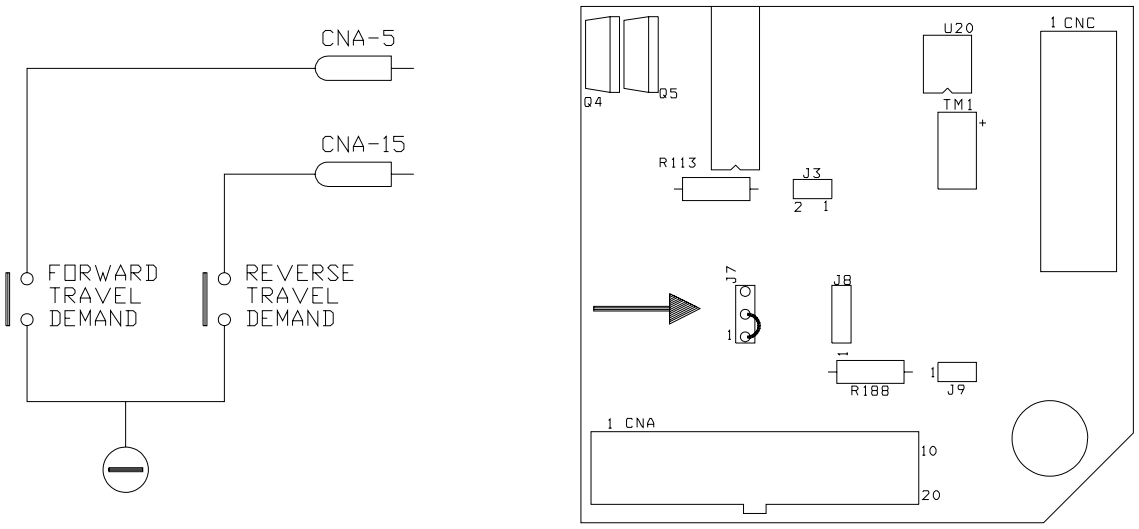


FIG. 5.1

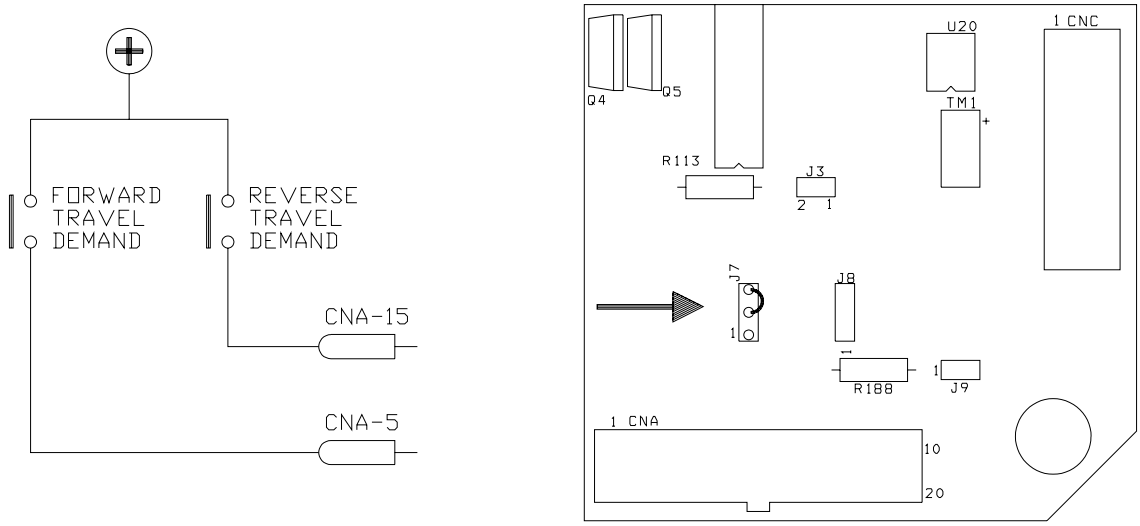
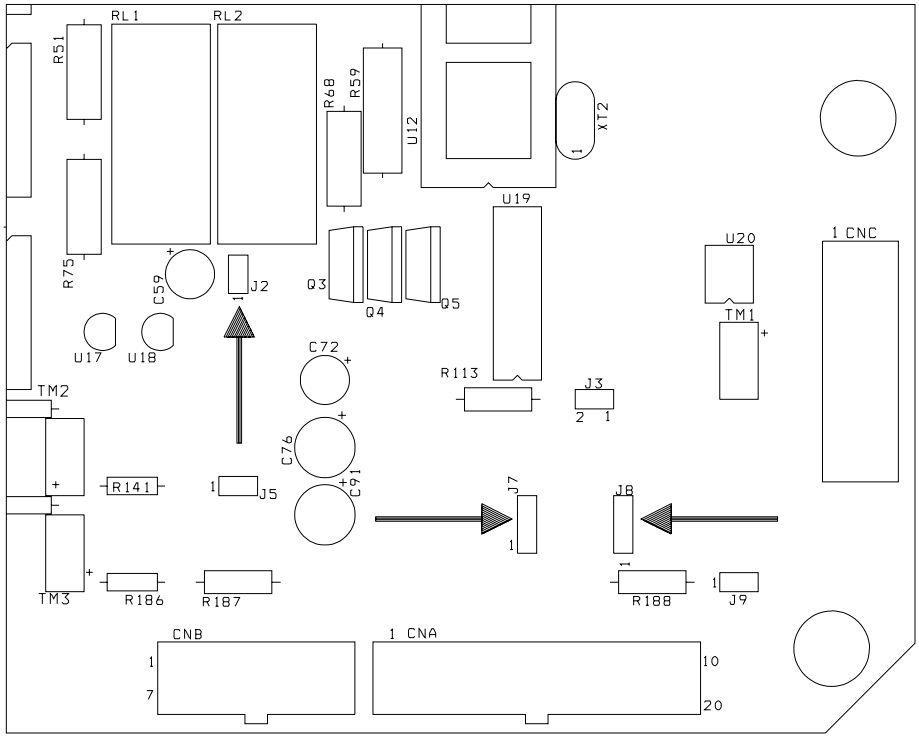


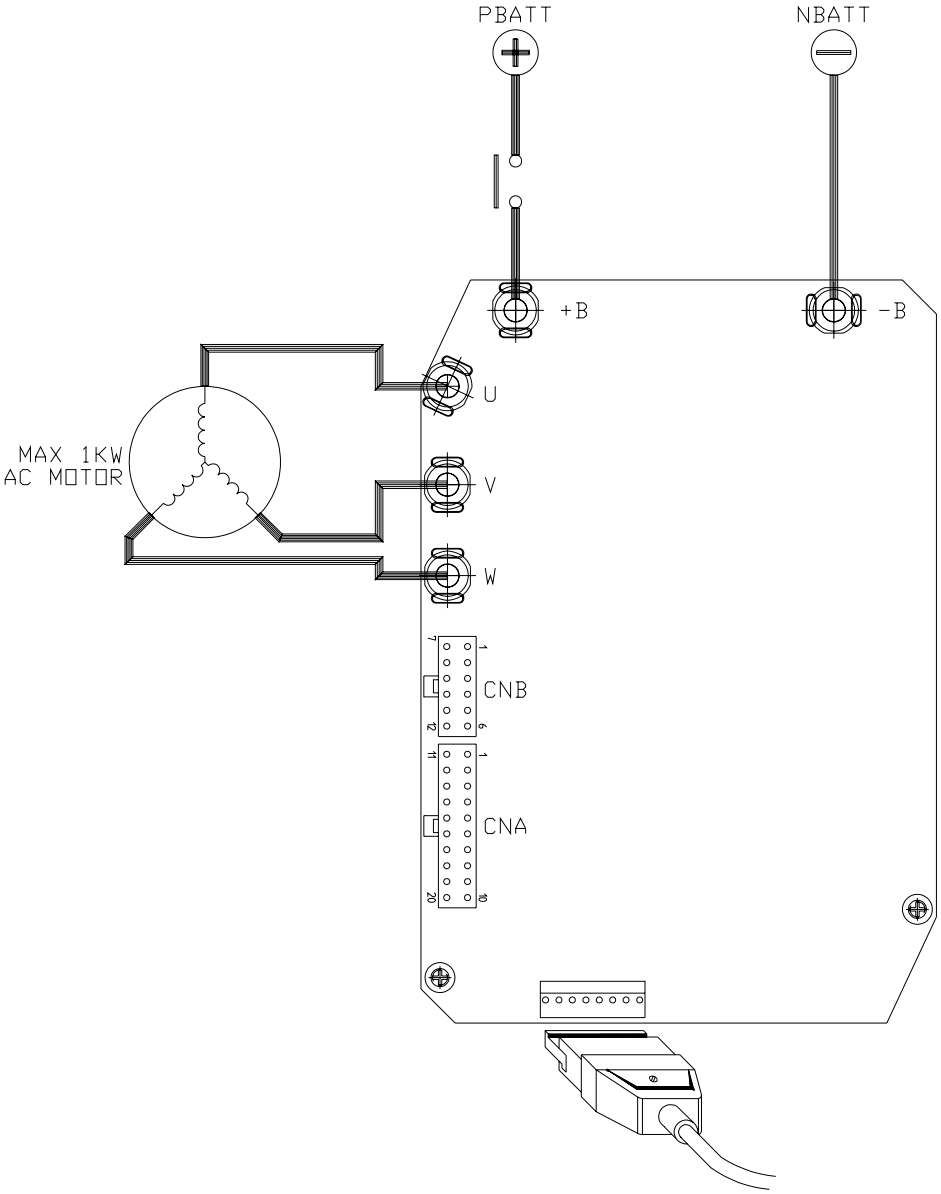
FIG. 5.2

J8: This jumper selects the optional encoder supply voltage. When J8 is closed between pins No. 1 and 2, the encoder supply is 16Vdc; when closed between pins No. 2 and 3, the encoder supply is 5Vdc.

J2: This is a two pin jumper. When closed the safety contact is internally grounded. When open the safety contact is floating and should be externally polarized (see 8.1).



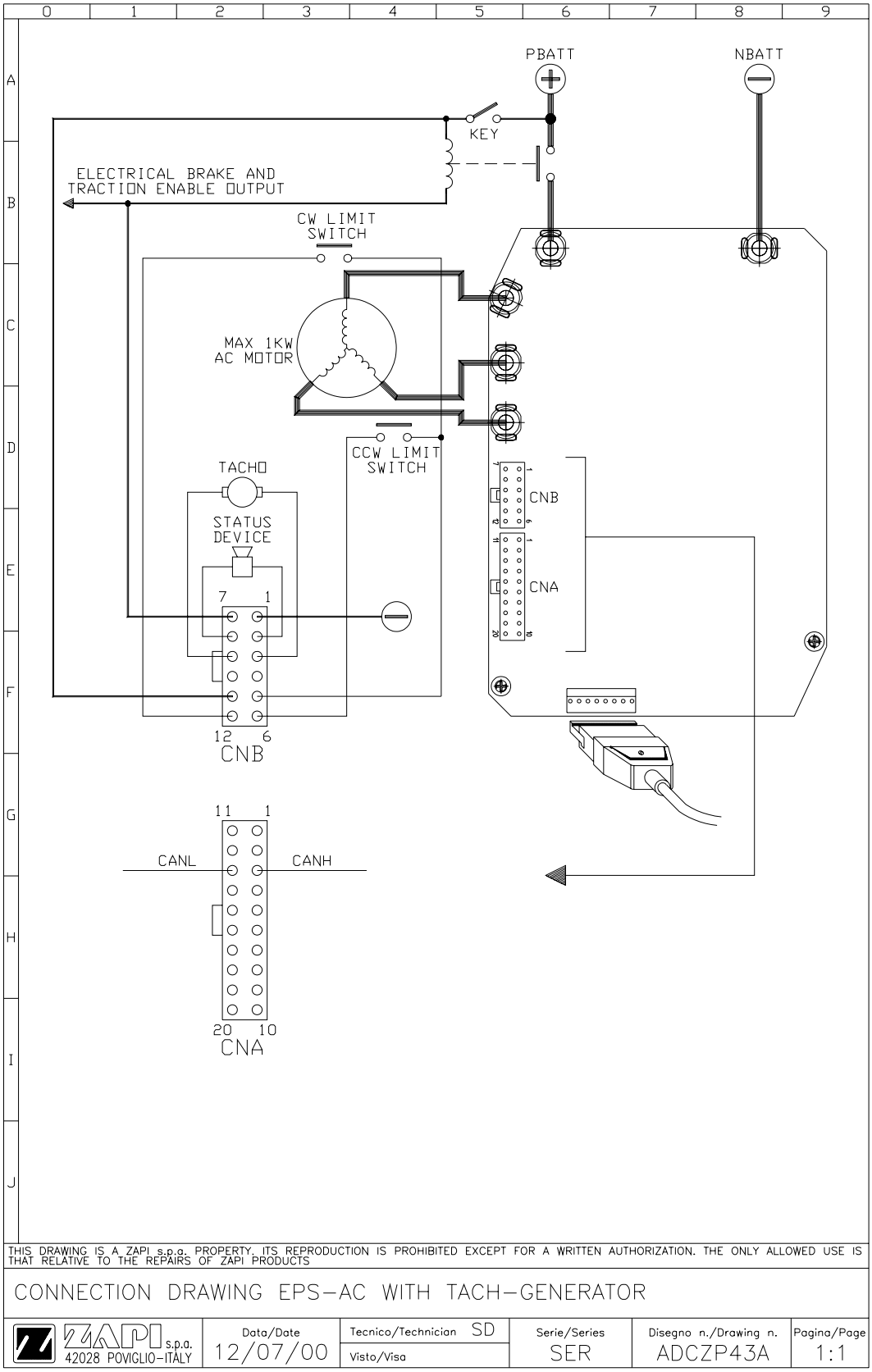
6 POWER CONNECTION DIAGRAM



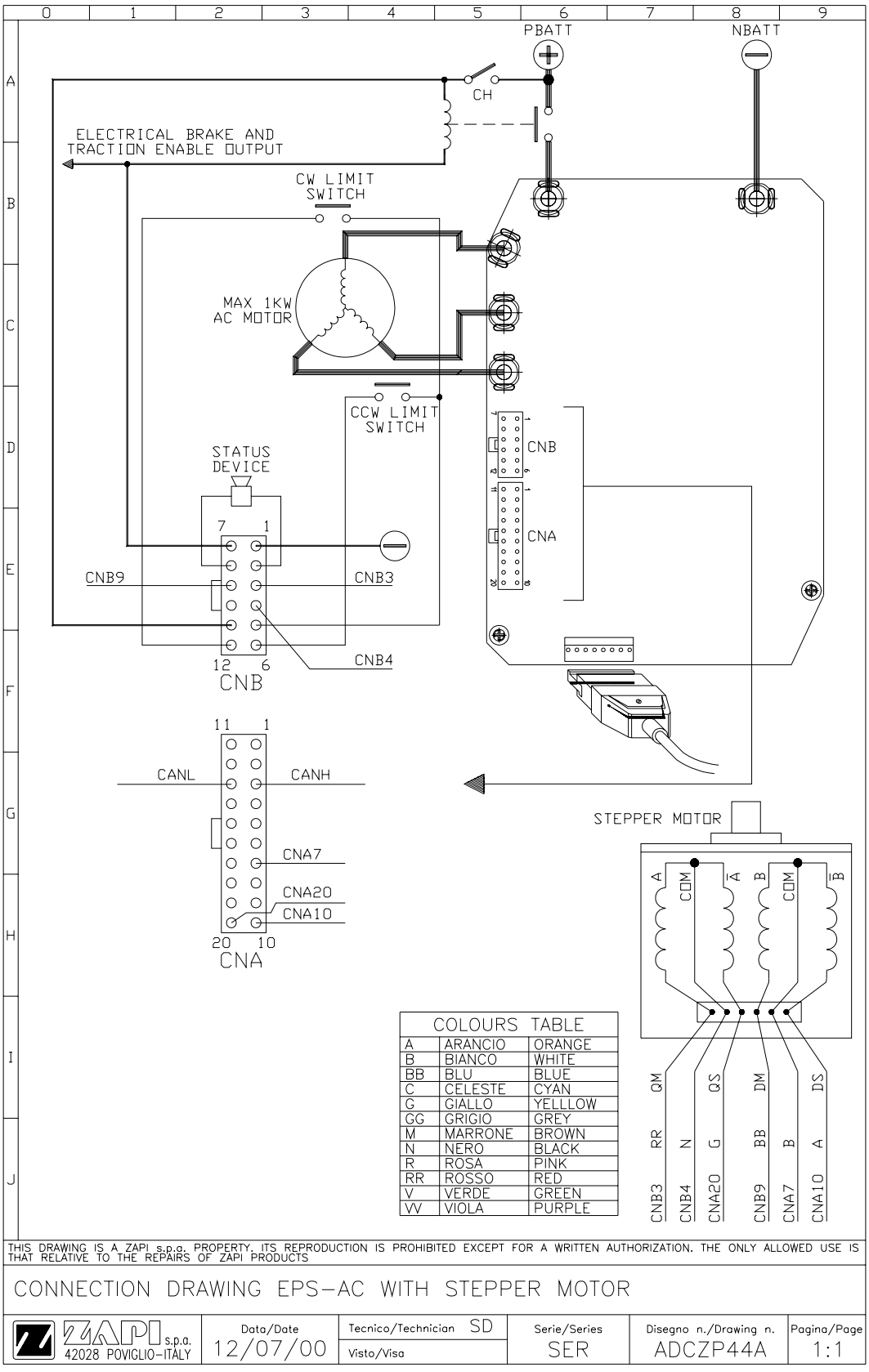
Note:
Reversing Battery positive and negative will damage the unit.

6.1 ELECTRICAL DRAWING

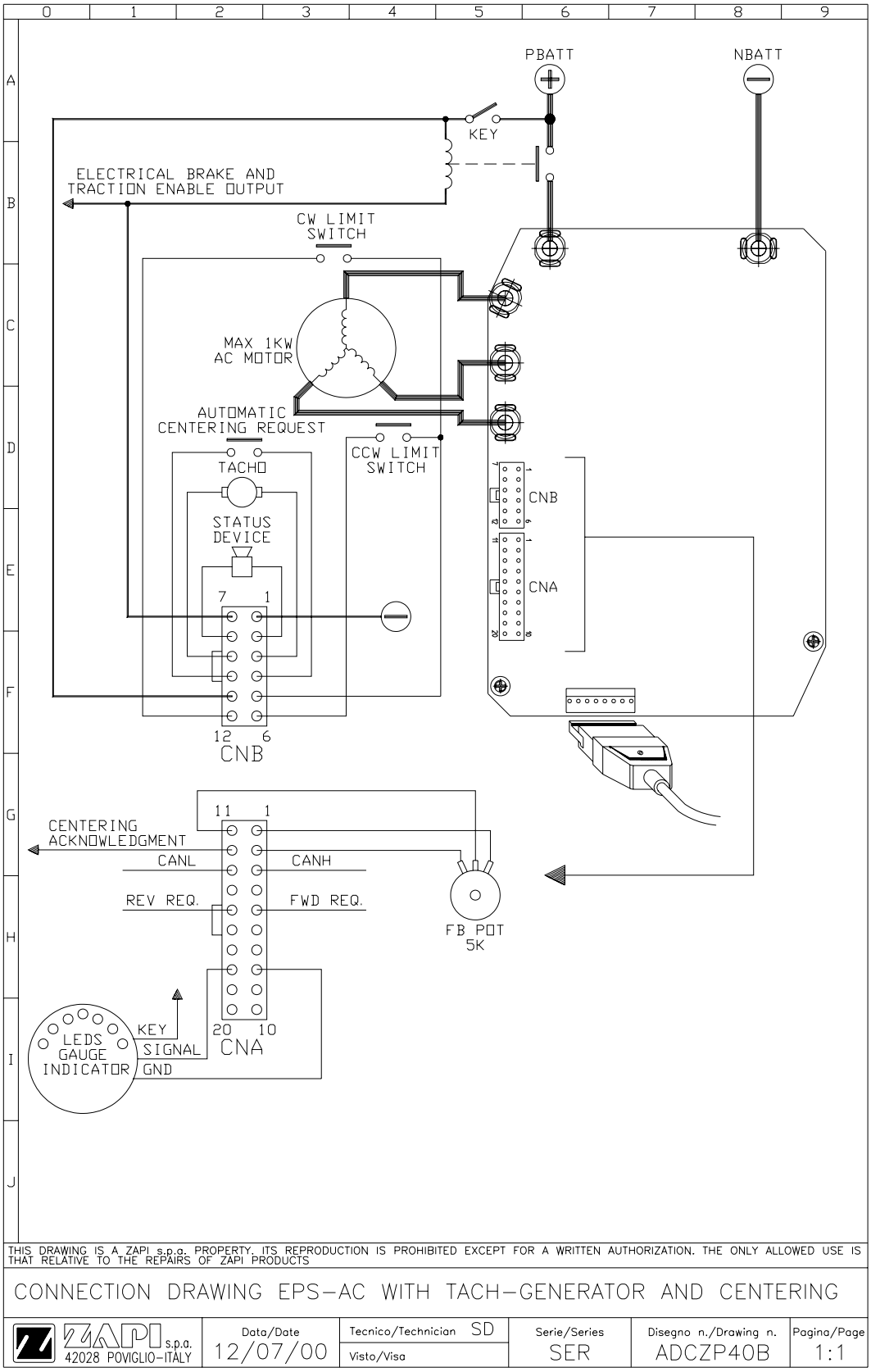
6.1.1 Tacho-generator steering



6.1.2 Stepper motor steering



6.1.3 Tacho-generator steering with automatic centering



CONNECTION DRAWING EPS–AC WITH TACH–GENERATOR AND CENTERING

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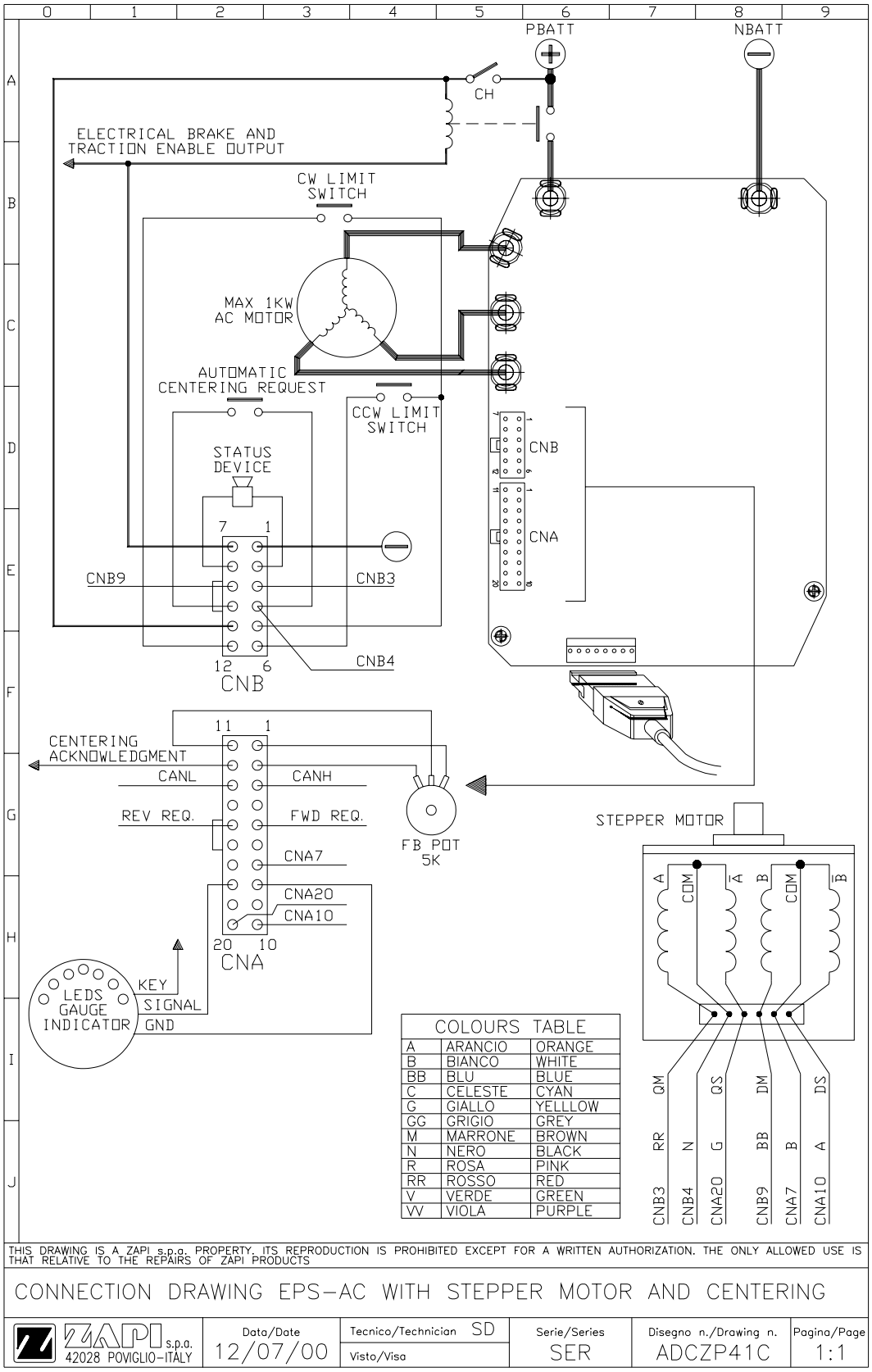
	12/07/00	Visto/Visa	SER	ADCZP40B	1:1

6.1.4 Stepper motor steering with automatic centering



CONNECTION DRAWING EPS–AC WITH STEPPER MOTOR AND CENTERING

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	12/07/00	Visto/Visa	SER	ADCZP41C	1:1

6.1.5 Interface description

a) The 5K steer angle feedback potentiometer should be rigidly mounted to the steering linkage with no play. The pot wiper is connected to Pin #11 of CNA connector. The ends of the pot are connected to Pins #1 and #2 of CNA connector. This feedback pot is necessary when either a direction gauge or the automatic centering operation is required.

b) Pin 5 on connector CNA is connected to the FWD (drive unit side) travel demand. Pin 15 on connector CNA is connected to REV (load wheels side) travel demand. Travel demands may be active high (plus battery) or low (minus battery). Specify the mode you want by configuring the Jumper J7 (see 5).
The travel demands are only required to maintain the steering control active after alignment when the truck is moving.

c) The status device is an optional extra (12Vdc max 40mA Buzzer or Lamp) supplying an audible or visible warning when a steering alarm occurs. It should be connected between connector CNB Pin #2 (16Vdc supply) and CNB Pin #8 (device driver collector).

d) The Eps-Ac provides an internal safety contact accessible through connector CNB pin #7 and CNB pin # 1. 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 #7 is connected to an equal or higher voltage than pin #1.**
For safety two cascaded safety switches are internally connected between pin # 7 and pin #1. The first is managed by the Main processor, the second is managed by the supervisor processor.
Note:
If the safety switch is connected in series with external switches (seat 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 the chain: see fig. 6.1.5.1).

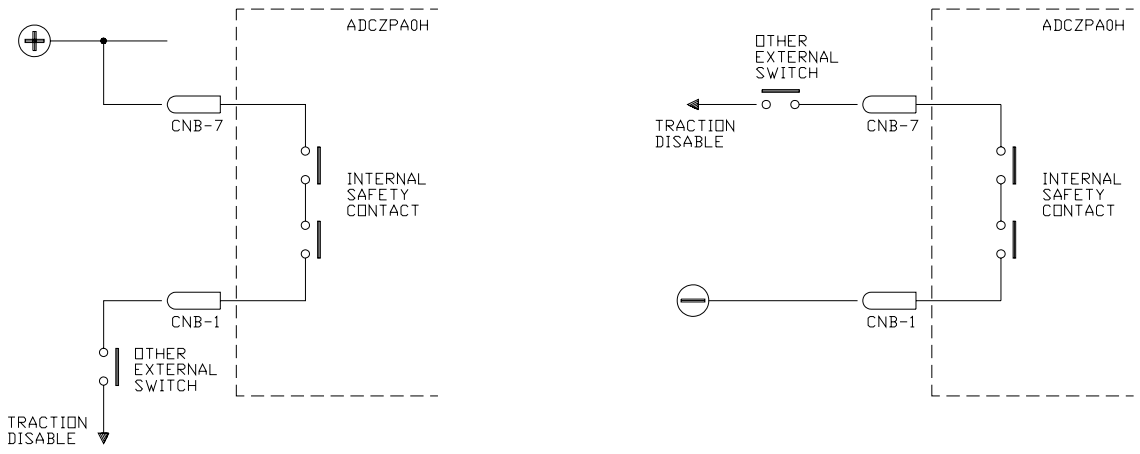


FIG. 6.1.5.1

e) The automatic centering request must have an NPN open collector output (see fig. 6.1.5.2). So it should assume the model of an open or closed switch with respect to GND. External pull-up is not required. The automatic centering request may be level or edge triggered depending on the AUT INP ACTIVE setting (see 10.7.7).
An edge is detected if the level before or after the edge remains for at least 30msec.

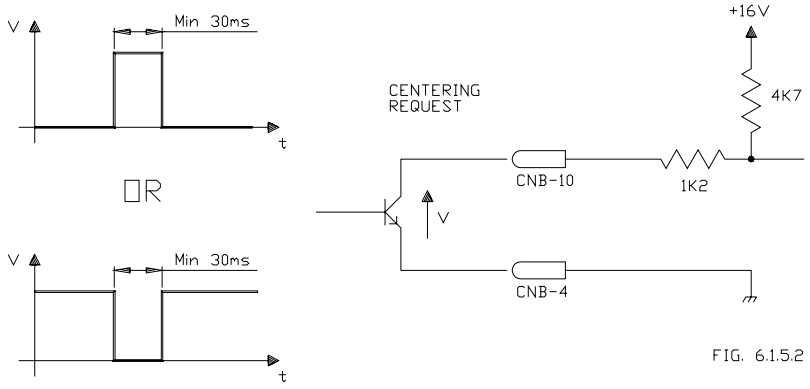


FIG. 6.1.5.2

f) Pin #18 of CNA connector provides 0 to 4.5Vdc output to control the steering angle indicator gauge Leds. Pin # 8 of CNA connector provides negative to the steering indicator.

g) Pin #12 of CNA connector (centering acknowledgment) provides a max 2Amps NPN open collector driver normally GND connected that opens when an automatic centering operation is finished.

h) The CAN connections are provided on the Pin #3 and Pin#4 CNA connector for the High reference and on Pin #13 and Pin #14 for the Low reference. They are two because our CAN should be externally loaded with a 120 ohms resistance to terminate the transmission line.

i) The Eps_ac provides an encoder interface. It was foreseen for special applications like accurate speed control or safety improvement. Normally it's not required. The encoder channels are connected on Pin #16 and Pin #17 of connector CNA. The encoder supply is provided through the Pin #6 of connector CNA (choose the supply you want through the jumper J8-see 5) and a Gnd reference on the Pin #7 of connector CNA (see fig. 6.1.5.3).

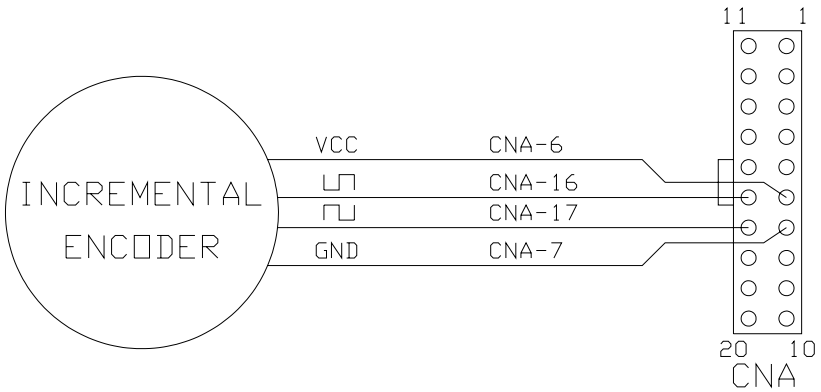


FIG. 6.1.5.3

7 ONE SHOT INSTALLATION PROCEDURE

This section of the manual describes the connection procedure for the tacho-generator, the potentiometer and the motor.

Step 1 - STEERING WHEEL (COMMAND) DEVICE CONNECTIONS

Connect the two wires from the tacho-generator (or the two stepper motor lines) so that clockwise rotation of the steering wheel produces an increasing (higher positive) command value. This may be measured in two ways. Using the ZAPI hand held controller see the TESTER MENU' (see 10.6.1). The second way, (valid only for a tacho-generator application) is to use a DC voltmeter on the +DT (Pin #9 of CNB connector) and the minus terminal on the battery.

Step 2 - STEERING ANGLE FEEDBACK POT. CONNECTION

a) The steer angle feedback pot. has 3 wires: two end wires and a wiper wire. If the truck has a not leading MDU (Motor Drive Unit - see figure 7.1)* connect the two end wires to Pin #1 and #2 of connector CNA so when the Drive Unit is turned Counter-Clockwise (Clockwise for a truck with a leading MDU) the value on the wiper is increasing. This value may be measured in two ways. Use the Zapi hand held controller through the TESTER MENU' (see 10.6.3). The second way is to use a DC voltmeter connected to the steering angle feedback pot. wiper and battery negative. The wiper should be connected to Pin # 11 of connector CNA.

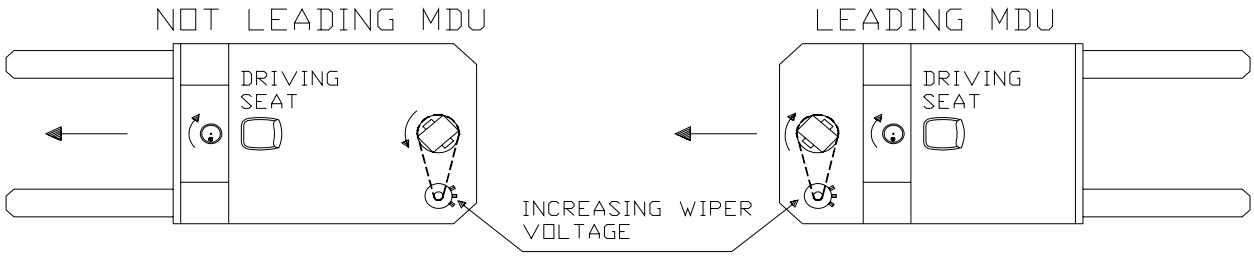


FIG. 7.1

* **Not leading MDU** : means the steering-traction wheel is opposite to the driving seat. When the steering handle is turned clockwise, the MDU turns counterclockwise.

Leading MDU : means the steering traction wheel is on the same side of the driving seat. When the steering handle is turned clockwise, the MDU turns clockwise too.

b) Physically adjust the steering angle feedback potentiometer so with the Drive Unit straight ahead, the wiper voltage is 2.5Vdc. The Zero Point for the steering angle feedback pot. can be adjusted using the ZAPI hand held controller. See the CONFIG MENU' (see. 10.8.1).

Step 3 - STEER MOTOR CONNECTIONS

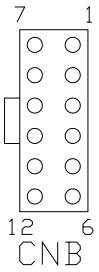
Connect the three steering motor wires so that a Clockwise steering wheel movement causes a Counter-Clockwise steer movement, for a not leading MDU truck, or a Clockwise steer movement, for a leading MDU truck. If this operation is carried out correctly, the truck will turn Clockwise when the steering wheel is moved Clockwise while the truck is travelling in frontal direction (with respect to the driving seat).

Step 4 - LIMIT SWITCHES CONNECTION

After completing Steps 1 - 3, check that the limit switch connected to Pin #12 of connector CNB stops steering in the handwheel clockwise direction. Then, check that the limit switch connected to Pin # 6 stops steering in the Counter_Clockwise direction.

8 DESCRIPTION OF CONNECTORS

8.1 CNB CONNECTOR

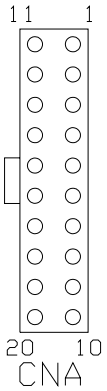


TAB.	B CONN. CODE
1	NK1
2	+16
3	DT-/DL
4	GND
5	GND
6	LLS
7	K1
8	BUZZ
9	DT+/QL
10	AUT
11	KEY
12	RLS

1	NK1	This is the second (lower potential) safety switch connection.The first connection is on Pin #7. If jumper J2 is closed, the Pin # 1 is ground referenced and NK1 is at ground (GND) potential. If jumper J2 is open, NK1 is floating. (It assumes an externally applied potential). NK1 must be connected to an equal or lower potential than K1 (Pin #7 of CNB).
2	+16	Output for internally provided +16Vdc stabilized supply. It may be used for the status device supply. The maximum rated output is 40mAmps. Warning: do not short circuit this pin because it is common with the Electric Power Steering card supply.
3	DT-/DL	For the tacho-generator application this is a tacho-generator connection. It is internally connected to battery negative (GND). For the stepper motor application this is a stepper motor line (called D line).
4	GND	This is internally connected to ground (battery minus) reference. It may be used for the GND reference of the Automatic Centering request switch and for the stepper motor GND connection.
5	GND	This is internally connected to ground (battery minus) reference. It may be used for the GND reference of the limit switches.
6	LLS	Left (CCW) Limit Switch. It's possible to stop steering in the direction that causes negative signal from the tacho-generator by closing the connection between LLS (Pin #6) and negative (GND Pin#5). Therefore, connection of a normally open switch between Pin #6 and Pin #5 acts as a Counter-Clockwise steering limit switch.

7	K1	This is the first (higher potential) safety switch connection.The second connection is on Pin #1. This normally open contact is closed by switching on the key. When the key switch is On, the contact opens in case of steering alarm. If Jumper J2 is closed, ground is provided on pin 7 whenever the key switch is on and there is no alarm. If jumper J2 is open, the safety contact between NK1 and K1 is floating and may be referenced either to the plus battery (connecting K1 to a plus battery voltage reference) or to the minus battery (connecting NK1 to a minus battery voltage reference).
8	BUZZ	This connection provides a ground line to switch on the status device (it could be a 12Vdc buzzer device). It can sink up to 40mAmps. This status device encodes steering alarm conditions.
9	DT+/QL	This is a tacho-generator connection or a stepper motor line (called Q line).
10	AUT	This is the automatic request input. It can be either an active level or edge detection depending by the AUTO INP ACTIVE setting (see 10.7.7). When the selected event happens an automatic centering request will immediately start. This input pin may be connected to: 1. An external ground through a switch. 2. An internal ground (Pin #4) through a switch. 3. An external open collector transistor (For example an output of a photocell circuit). To recognize an automatic request each level should remain for at least 30msec.
11	KEY	This is the key switch voltage input.
12	RLS	Right (CW) Limit Switch. It's possible to stop steering in the direction that causes positive signal from the tacho-generator by closing the connection between RLS (Pin #12) and negative (GND Pin#5). Therefore, connection of a normally open switch between Pin #12 and Pin #5 acts as a Clockwise steering limit switch.

8.2 CNA CONNECTOR



TAB.	A CONN. CODE
1	NPOT
2	PPOT
3	CANH
4	CANH
5	FWD
6	VCC
7	GND
8	GND
9	PPOC
10	QLS
11	CPOT
12	K3
13	CANL
14	CANL
15	REV
16	CHA
17	CHB
18	INDIC
19	PPOC2
20	DLS

1	NPOT	This is the lower voltage connection for the steer feedback potentiometer. It's internally connected to GND through a 470 Ohms resistance.
2	PPOT	This is the higher voltage connection for the steer feedback potentiometer. It's internally connected to a 5Vdc reference through a 470 Ohms resistance .
3	CANH	This is the high reference of the CAN interface.
4	CANH	Same of pin #3. Pin #3 and #4 are internally connected together.
5	FWD	A request to travel in the Drive Unit direction must provide a signal on this input, either at battery positive or battery negative. Either level may be selected configuring Jumper J2.
6	VCC	Optional encoder supply. When an encoder is used it may be supplied through this pin. The output voltage is selected through the jumper J8 (see. 5).
7	GND	This is internally connected to ground (battery minus) reference. It may be used for the GND reference of the optional encoder or for the stepper motor (manual command device).
8	GND	This is internally connected to ground (battery minus) reference. It may be used for the GND reference of the steer angle direction Led gauge.
9	PPOC	Not Used. This is the higher voltage connection for a handwheel set point potentiometer. **This steering option requires modifications on the logic card and cannot be carried out when a tacho-generator or a stepper motor card is chosen.** This pin is internally connected to a 5Vdc reference through a 470 Ohms resistance.

10	QLS	The stepper motor has four channels DL, QL, DLS, QLS. DL and QL are already assigned on the connector CNB. DLS and QLS are the stepper motor channels for the Supervisor microprocessor. This pin is the QLS input.
11	CPOT	This is the wiper connection for the steer feedback potentiometer.
12	K3	Pin # 12 of CNA connector provides a max 2Amps NPN open collector driver. GND is applied by switching on the key and GND is removed when an automatic centering operation is finished.
13	CANL	This is the low reference of the CAN interface.
14	CANL	Same of pin #13. Pin #13 and #14 are internally connected together.
15	REV	A request to travel in the Load Wheels direction must provide a signal on this input, either at battery positive or battery negative. Either level may be selected by configuring Jumper J2.
16	CHA	This is the first channel input for the optional encoder.
17	CHB	This is the second channel input for the optional encoder.
18	INDIC	Outputs a scaled and converted 0 to 4.5Vdc steer angle feedback potentiometer position for the steer angle indicator gauge LEDs. 0Vdc corresponds to the steer angle feedback pot voltage that was memorized using the ZAPI hand control for SET MAX FB POT. 4.5Vdc corresponds to the steer angle feedback pot voltage that was memorized using the ZAPI hand control for SET MIN FB POT . See 10.7.6 to reverse the turning direction displayed.
19	PPOC2	Not Used. This is the higher voltage connection for a second handwheel set point potentiometer. To improve the safety a second optional command pot is foreseen. While the first set point pot is Master microprocessor processed, this second set point pot is Supervisor microprocessor processed. The wiper of this second set point pot should be connected to the Pin #9 of CNB connector. The lower voltage end should be connected to the Pin #3 of CNB connector. **This steering option requires modifications on the logic card and cannot be used when a tacho-generator or a stepper motor card is chosen**. This pin is internally connected to a 5Vdc reference through a 470 Ohms resistance.
20	DLS	The stepper motor has four channels DL, QL, DLS, QLS. DL and QL are already assigned on the connector CNB. DLS and QLS are the stepper motor channels for the Supervisor microprocessor. DLS enters in this connection.

9 SETTING THE STEERING

Use the ZAPI hand set to adjust the manual steering settings.

9.1 TACHO-GENERATOR OR STEPPER MOTOR CONTROLLED STEERING

The following procedure should be used only after "One Shot Installation Procedure" in Section 7 is completed. Carry out the procedure in the following sequence.

1) Use the hand set to specify the steering is tacho-generator type using the SET MODEL setting (see 10.9).
2) Adjust SET BATTERY TYPE to the battery voltage in the truck using the hand set (see 10.8.6).
3) Regulate the maximum frequency to the motor rated frequency. Use the hand set adjustment SET SATURATION FREQ (see 10.8.7).
4) Regulate the SPEED LIMIT for steering on the hand set. Higher values cause the MDU to turn faster (see 10.4.1).
5) Adjust the slow steering responce using the SENSIBILITY setting on the hand set. A higher value causes faster responce (see 10.4.2).

Note:
Low settings of the SPEED LIMIT result in almost no steering responce when turning the steering wheel al low speed. To avoid this problem increase the SENSIBILITY setting.

9.2 AUTOMATIC CENTERING

1) For automatic centering operation it is necessary to adjust SET MODEL to level 1. When an automatic centering request on the input Pin #10 of CNB connector is recognized an automatic MDU alignment will start.
2) Adjust the steer angle centering precision using KP and POSITION ACCURACY parameters on the hand set. The first is for coarse regulation, the second is for fine regulation. Higher value of these parameters increase the precision, but make steering "busy" with dither.
3) Use the hand set SET STEER 0-POS (see 10.8.11) to adjust the steer angle feedback pot for straight steering MDU.The setting may be adjusted up and down in 5mV increments from the 2.5V default voltage. Test the results by driving the truck forward and reverse with a centered MDU. Watch for straight travel.
4) Use PURSUIT RAMP on the hand set to adjust the automatic centering speed (see 10.5.3).
5) Use DESENSIBILIZAT on the hand set to adjust the automatic centering speed closely the straight ahead MDU position (see 10.5.4).

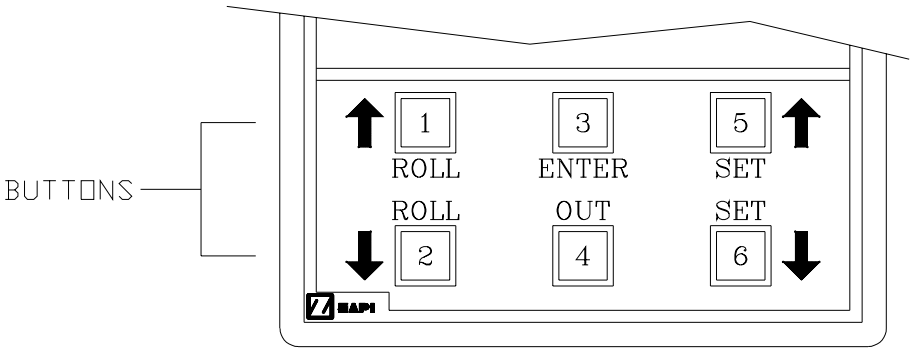
9.3 STEER ANGLE INDICATOR GAUGE

If a steer angle indicator gauge with Leds is applied then you will also need to perform the following steps for the gauge to respond correctly:

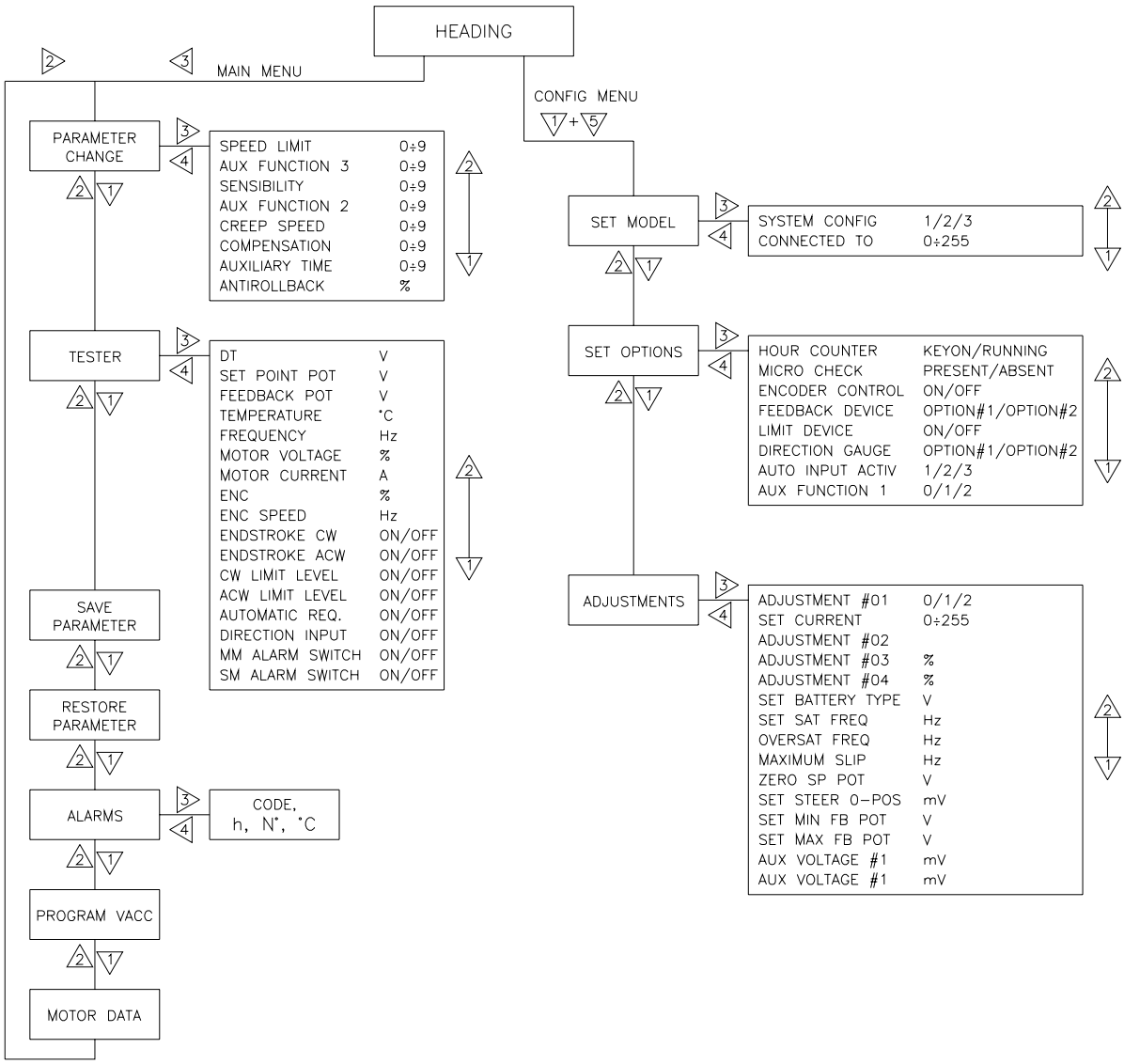
1) Use SET MIN FB POT on the hand set to memorize the steer angle feedback pot voltage for maximum Clockwise rotation of the Drive Unit (see 10.8.12).
2) Use SET MAX FB POT on the hand set to memorize the steer angle feedback pot voltage for maximum Counter-Clockwise rotation of the Drive Unit (see 10.8.13).
3) Use the hand set SET STEER 0-POS (see 10.8.11) to adjust the steer angle feedback pot for straight steering MDU.The setting may be adjusted up and down in 5mV increments from the 2.5V default voltage. Test the results by driving the truck forward and reverse with a centered MDU. Watch for straight travel.

10 ZAPI HAND SET DESCRIPTION

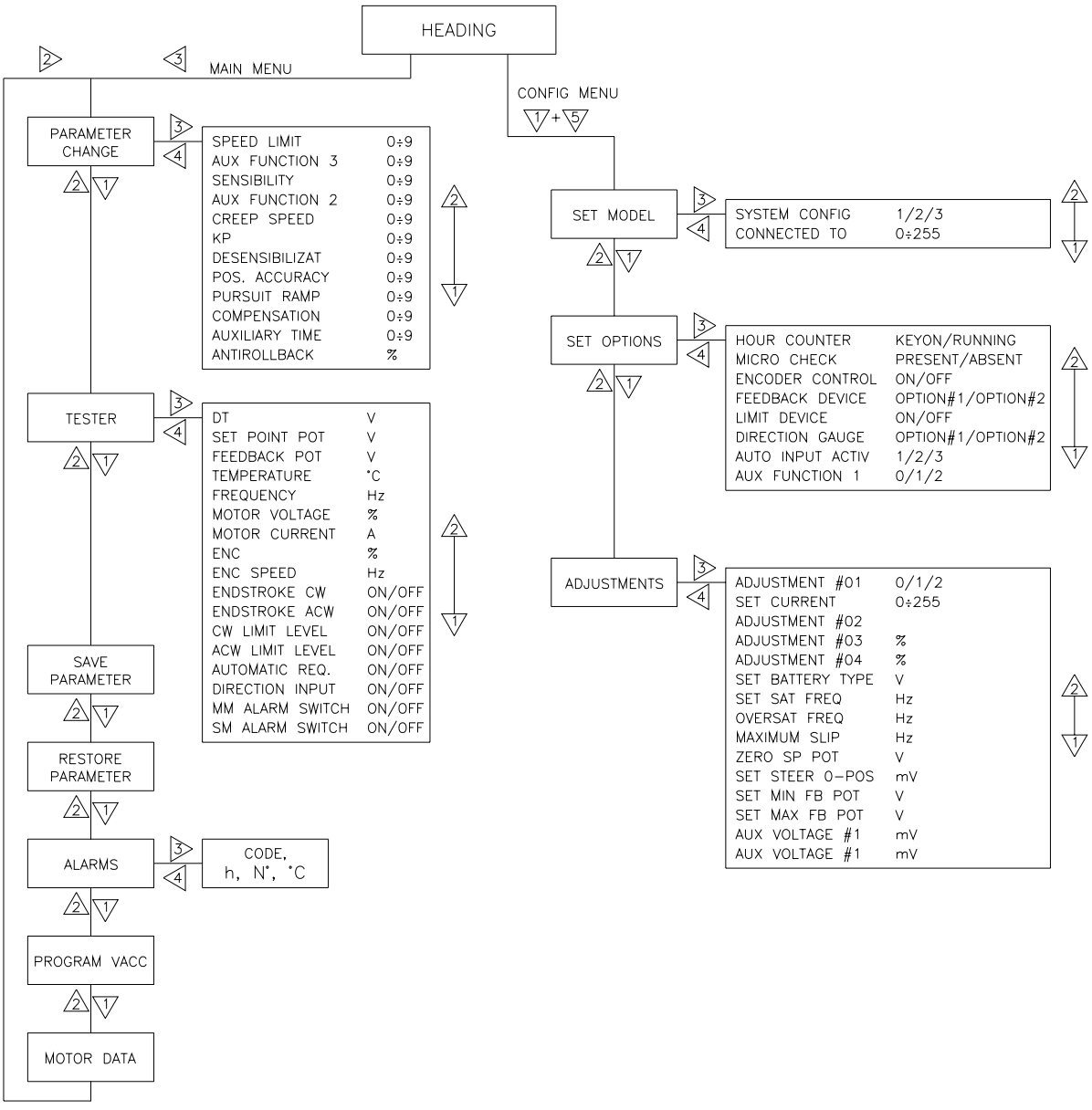
This section describes the ZAPI hand set functions. Numbers inside the triangles correspond to the same number on the hand set keyboard buttons shown in the figure below. The orientation of the triangle indicates the way to the next function.



10.1 MANUAL MODE STEERING OPTION - HAND SET FUNCTION MAP



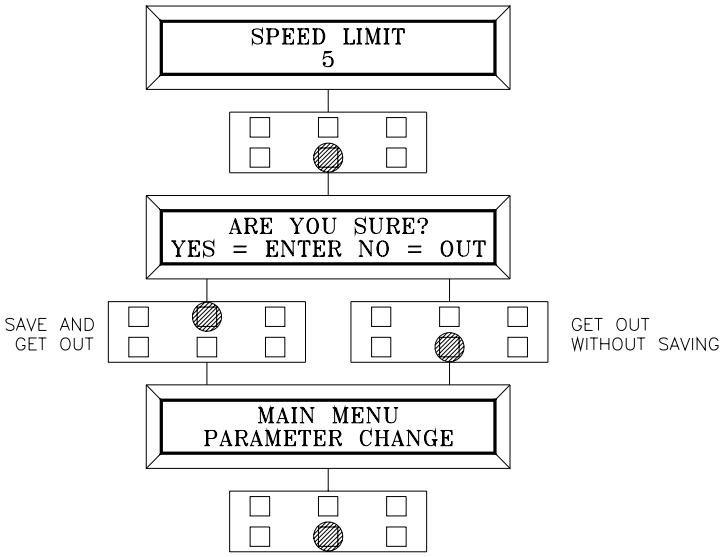
10.2 MANUAL MODE STEERING OPTION AND AUTOMATIC CENTERING - HAND SET FUNCTION MAP



10.3 MAIN MENU "PARAMETERS LIST"

The parameters are slightly different between tacho-generator, tacho-generator with automatic centering and pot steering option. (the stepper motor application has the same hand set map as the tacho-generator configuration)
After modifyng a parameter, memorize it with the hand set by pushing the "4" (OUT) button and the "3" (IN) button. Double pushing the OUT button exits without saving the modifications.

10.4 PARAMETERS IN SET MODEL 0 (TACHO-GENERATOR OR STEPPER MOTOR ONLY)



1) SPEED LIMIT

Regulates the MDU maximum turning speed.
- Level 0 is for slow turning.
- Level 9 is for fast turning.

Intermediate levels are for proportionally increasing speed settings. Maximum MDU speed has to be regulated after SET BATTERY TYPE is done (see JJ)

2) SENSIBILITY

It provides a non-linear relationship between MDU steering speed and tach-generator voltage when low. This parameter produces increasing steering sensitivity with small changes in steering input.
- Level 0 is for steering response that is less sensitive to small steering wheel movements.
- Level 9 is for steering response that is very sensitive to small steering wheel movements.

Intermediate levels are for proportionally increasing speed setting. This parameter does not influence the maximum MDU steering rate.

3) CREEP SPEED

Provides an increased torque for slow turning steering wheel. It's used to compensate the drop in V/f (flux) when the frequency applied to the motor is low.
- Level 0 is for no torque compensation
- Level 9 is for a very strong torque compensation

Intermediate levels are for proportionally increasing torque setting. This parameter is useful in two ways. First of all it guarantees a large torque for very slowly turned handwheel. Secondly this large torque allows it to neutralize the elastic tire effect when the handwheel is close to being released it.

4) COMPENSATION

Provides stator flux compensation. The ideal motor control provides constant flux value for each working frequency. While CREEP SPEED provides low frequency feedforward flux compensation effect, COMPENSATION produces a feedback flux compensation effect. This is a very important setting for an application without the shaft encoder be cause by turning compensation to a different value than zero gets the motor flux (and torque) indipendent from the battery voltage. So torque is guaranteed when the battery is low:
- Level 0 means no compensation but a flux degradation when current is too high
- Level 1 compensate the drop on power mosfets and cables
- Level 2 compensate the drop on power mosfets, cables and stator resistance
- Level 3 means no compensation.

This should normally be set to Level 2 as a strong compensation reduces the slip (difference between the speed and the frequency applied to the motor). An exception can be a smaller motor (small torque required) in which a strong flux (and a greater magnetization current) is not necessary (Level 0).

5) ANTIROLLBACK

Adjusts the stand still torque value with a released handwheel. This setting is a percentage of Imax. The stand still torque is used to neutralize the elastic tire effect which would move the MDU an angle back in the direction it was coming from. This parameter is specified as a percentage of the maximum current.

6) AUXILIARY TIME

Defines the time, after the handwheel is released, for which the stand still torque is applied.
- Level 0 is for no stand still torque
- Level 1 is for a short application of a stand still torque (about 6sec)
- Level 9 is for a long application of a stand still torque (about 90sec)

Intermediate levels are for proportionally increasing auxiliary time.

7) AUX FUNCTION 3

Through the Can comunication, the traction chopper supplies the truck speed information to the EPS-AC. The EPS-AC can reduce the steering motor speed as the truck speed increase. Aux function 3 make it possible to alter the amount of the max steering speed reduction with increasing truck speed.
- level 0 no effect
- level 9 maximum steering speed reduction

8) AUX FUNCTION 4

Has the same purpose as the previous parameter. The only difference is the aux function 4 varies the value of the steering speed when the hand-wheel is turning slowly.

10.5 PARAMETERS IN SET MODEL 1 (TACHO-GENERATOR OR STEPPER MOTOR AND AUTOMATIC CENTERING)

All the parameters in the section 10.3 are adopted also for the tacho-generator (or stepper motor) and automatic centering model. To this previous list here we have to add the following parameters:

1) KP

Used for the automatic centering set up. It modifies the static precision of the position control loop. To obtain precise centering increase the KP value. If overshoot becomes evident, try to lower the KP value.
- Level 0 is for less precise centering.
- Level 9 is for very precise steering (but "busy").

Intermediate levels are for proportionally increasing centering precision.

2) POS. ACCURACY

Used for automatic centering set up. It has the same KP function but it was introduced to increase the resolution of the static precision. To obtain precise centering increase the POS. ACCURACY value. If overshoot becomes evident, try to lower the POS. ACCURACY value.
- Level 0 is for less precise centering.
- Level 9 is for very precise centering (but "busy").

Intermediate levels are for proportionally increasing centering precision.

3) PURSUIT RAMP

Used for automatic centering set up. It decreases the amount of time it takes to complete an automatic centering operation.
- Level 0 is for an automatic centering carried out with a motor frequency of SAT.FREQ/5.
- Level 9 is for an automatic centering carried out with a motor frequency of SAT.FREQ.

Intermediate levels are for proportional frequency changes.

4) DESENSIBILIZAT

Used for automatic centering set up. It slows down the MDU in the region close to the straight ahead position.
- Level 0 is for a large slowing down quasi-centered MDU.
- Level 9 is for a no slowing down quasi-centered MDU.

Intermediate levels are for proportionally slowing down changes. The close to straight position slowing down should reduce the MDU overshoot in an automatic centering operation.

10.6 MAIN MENU: "TESTER" FUNCTIONS LIST

The TESTER functions list is common for applications with or without the automatic centering model. Each TESTER function provides the measurement, executed by the software, of the specified parameter. Descriptions of each TESTER function are given below.

1) DT

Provides the value of the tacho-generator (or stepper motor) input from the steering wheel with its sign in real time. The value is scaled for the CPU A/D converter (range 0±5Vdc). The value measured directly on the tacho-generator output is sometimes higher than measured on the hand set.

2) SET POINT POT

Not used. Pot steering only. It provides the steering handle command potentiometer voltage in real time (i.e. the voltage on the Pin #20 of CNA connector)(for two pots closed loop position control only).

3) FEEDBACK POT

Provides the MDU steer angle feedback potentiometer voltage in real time. A steer angle straight ahead corresponds to about 2.5Vdc.

4) TEMPERATURE

Provides in real time the control unit plate temperature in celsius degrees. An alarm occurs when the temperature is above 76 degrees Celsius.

5) FREQUENCY

Provides in real time the frequency applied to the steering motor with its sign.

6) MOTOR VOLTAGE

Provides in real time the voltage applied to the steering motor as a percentage of the battery voltage.

7) MOTOR CURRENT

Provides in real time the phase motor current (Rms).

8) ENC

Not used. It's for the optional encoder.

9) ENC SPEED

Not used. It's for the optional encoder. This reading (and the previous) was introduced to read the optional encoder speed and position. At present it's not managed.

10) ENDSTROKE CW

Provides in real time the active state (ON) or not of the Clockwise (Right) limit switch.

11) ENDSTROKE ACW

it provides in real time the active state (ON) or not of the Anti_Clockwise (Left) limit switch.

12) CW LIMIT LEVEL

Provides in real time the information that the steer angle feedback potentiometer has overcome the SET MAX FB POT value (see 10.8.13).

13) ACW LIMIT LEVEL

Provides in real time the information that the steer angle feedback potentiometer has overcome the SET MIN FB POT value (see 10.8.12).

14) AUTOMATIC REQ.

Provides in real time the steering state: manual or automatic. Note: this reading is not the AUTOSEL (Pin #10 of CNB connector) level but the steering state the SW is recognizing. This information coincides with the AUTOSEL input level when this input is level triggered.

15) DIRECTION INPUTS

Provides in real time the information of an active travel demand. It turns ON when either a FWD or a REV travel demand is present.

16) MM ALARM SWITCH

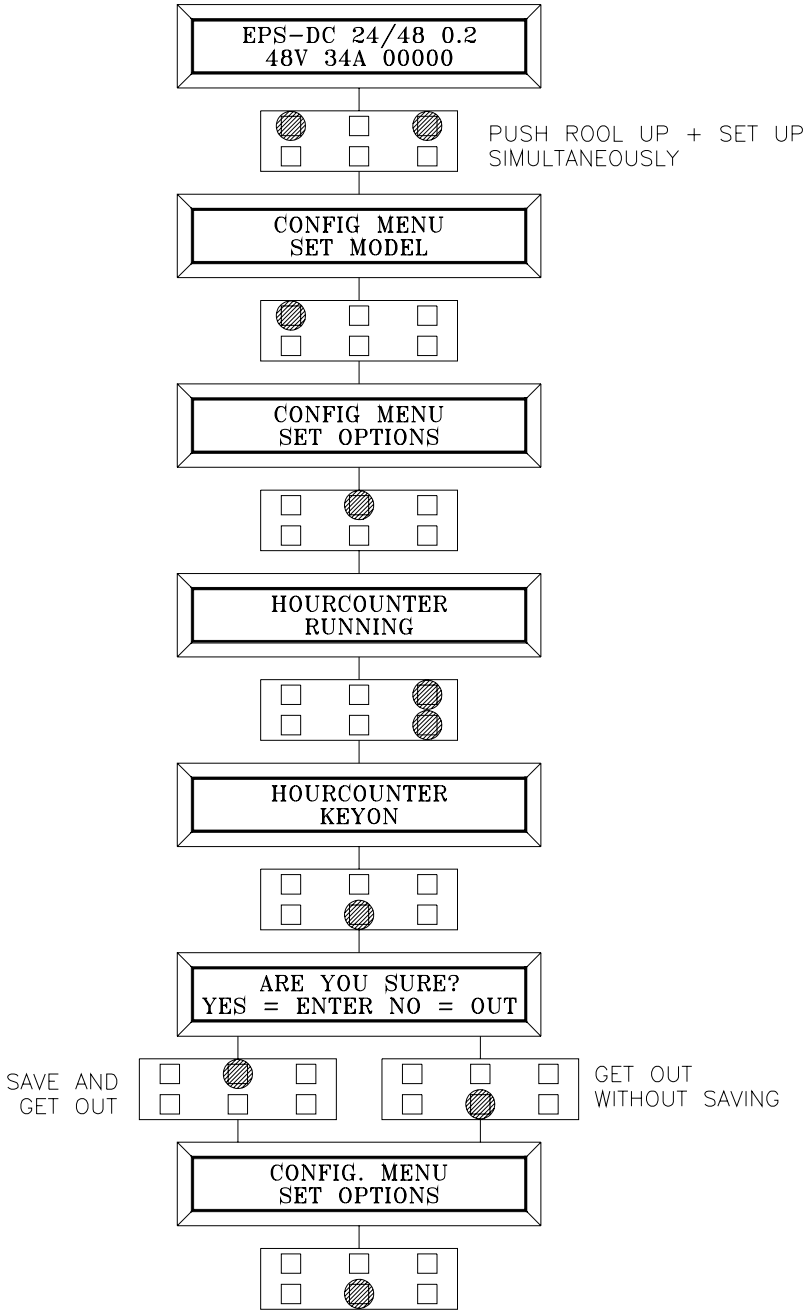
Provides in real time the state (closed or not) of the Master Microprocessor controlled safety switch.

17) SM ALARM SWITCH

Provides in real time the state (closed or not) of the Slave Microprocessor controlled safety switch.

10.7 CONFIG MENU: "SET OPTIONS" FUNCTIONS LIST

The SET OPTIONS functions list is used for all the steering options. These options modify the system configuration on user request. A description of each option follows in the list below.



1) HOUR COUNTER

There are two possible value options for what will appear in the root menu hand set display.
- RUNNING = Run time when the steering is enabled.
- KEYON = Time counted continously when the logic is supplied.

2) MICRO CHECK

This feature is to support the debugging activity option. It is used to inhibit the Supervisor microprocessor operation and allow the system to run with just the Main microprocessor support. **This operating mode does not allow the supervisor controlled safety switch to close. Therefore, traction is disabled.**
- NONE = Inhibit supervisor functions.
- PRESENT = Enable diagnostic interaction between Main and Supervisor microprocessors.

3) ENCODER CONTROL

Not used. This setting will turn the optional encoder control ON.

4) FEEDBACK DEVICE

Not used. The only feedback device expected is the steer angle feedback pot. This option (and the previous too) was to cater for an application using the FB encoder as a FB potentiometer replacement. This choice makes it possible to use the encoder also for the motor control: it could be a valid support to make steering control easier in a closed loop application (steering position control).

5) LIMIT DEVICE

When this option is set ON the steer angle feedback pot will be adopted instead of the limit switches. As soon as the feedback pot voltage overcomes either the SET MIN FB POT or the SET MAX FB POT adjustment, the steer will be disabled.

6) DIRECTION GAUGE

There are two options for trucks equipped with a steer angle direction gauge. This setting permits the indicated turning direction displayed on the gauge to be reversed.

7) AUTO INP ACTIVE

Sets the active logic level (or edge) for the automatic centering mode request (AUTOSEL).
- Level 0 = External automatic request is active High (i.e. the AUTOSEL switch is open)
- Level 1 = External automatic request is active Low (i.e. the AUTOSEL switch is closed)
- Level 2 = External automatic request is active on the rising edge of every odd number (i.e. the first rising edge is for automatic, the second returns to manual, the third is for automatic, etc.)
- Level 3 = External automatic request is active on the falling edge of every odd number (i.e. the first falling edge is for automatic, the second is return to manual, the third is for automatic, etc.)

8) AUX FUNCTION #1

Sets the steering mode after the feedback pot has reached the final position (it is for only the two pots steering and the automatic centering options).
- Level 0 = The steering motor is turned on when a travel demand is active.
- Level 1 = The steering motor is alternatively turned off (for 15sec.) and on (for 3sec.) disregarding the travel demand state.
- Level 2 = The steering motor is alternatively turned off (for 15sec.) and on (for 3sec.) but only when a travel demand is active.

The off state is counted starting from the expiration of the antirollback time. It duration depends on the AUXILIARY TIME setting. So, in reality, the off state duration is the sum of the AUXILIARY TIME and the fixed 15sec. delay.

10.8 CONFIG MENU: "ADJUSTMENTS" FUNCTIONS LIST

The ADJUSTMENT functions list is common for both tacho-generator and tacho-generator plus automatic centering model.

1) ADJUSTMENT #1

This adjustment supports the acquisition of the stator motor resistance and of the current amplifiers gain (factory adjusted). When Level=1 is set, a stator resistance acquisition procedure is enabled. The stator resistance is used for the flux compensation when the COMPENSATION parameter is Level=2 (see 10.4.4). When Level=2 is set both stator resistance and current gain amplifiers acquisition procedure is enabled. As soon as this adjustment is turned to a Level different from 0 a DATA ACQUISITION alarm will immediately occurs.

2) SET CURRENT

After the ADJUSTMENT #1 is changed from 0, the operator should connect a DC ammeter in series with the motor phase U or W. Next push the N° 5 (right side top) button on the hand set until the motor current is increased to a DC current level equal to the half Imax value. Then Roll back to ADJUSTMENT #1 and turn to 0 the selected level. Then execute a save operation pushing OUT and ENTER button. After switching the key off and on the SW will acquire the parameter (stator resistance or gains) you want.

Pay attention. The current amplifier gains are factory adjusted while the stator resistance must be adjusted by the user.

3) ADJUSTMENT #2

Provides the mOhms stator resistance value. It can be acquired (as above explained) or hand adjusted in 5mOhms step pushing the right side buttons. The stator resistance value is used for stator resistance drop compensation when COMPENSATION parameter is level 2. The motor resistance can be measured between two motor connections. This measured value can be replayed in the hand set "Adjustment #2" by rolling up or down the right side buttons.

4) ADJUSTMENT #3

Provides the first phase current gain: it can be acquired or hand adjusted pushing the right side buttons (factory adjusted).

5) ADJUSTMENT #4

Provides the second phase current gain: it can be acquired or hand adjusted pushing the right side buttons (factory adjusted).

6) SET BATTERY TYPE

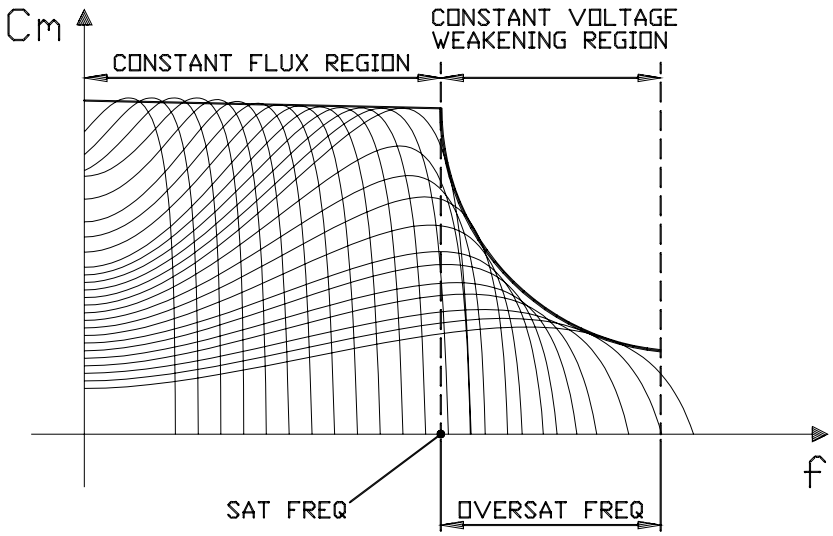
Specify the battery you have through this option. This setting is used for the flux compensation when the COMPENSATION parameter is set to Level 1 or 2. Note: it is important that the battery setting must be compatible with the Eps_ac version you have.

7) SET SAT FREQ

it specifies the limit frequency for the constant flux control law. There are two control regions. The first works with a constant V/f (flux) value from zero to saturation frequency. The second works with a constant voltage (Vbatt) for higher than saturation frequency values (weakening region) .

8) OVERSAT FREQ

The limit frequency for the constant voltage control law (degraded flux and torque) is set through this adjustment. It provides the increment over saturation frequency for the constant voltage region (weakening region).



In our open loop steer we suggest that you adjust oversat freq to level 1. A motor used as power steering infact does not need to work in the weakening region. We advise against oversat freq = 0 because with this setting the sinusoidal wave shape at the maximum frequency becomes a square wave increasing the noise.

9) MAXIMUM SLIP

Provides the maximum slip when an optional encoder control is adopted. It is used also to set the lowest limit to the frequency in a max current limit with a blocked rotor. (Typical value is 5Hz).

10) ZERO SP POT

Is only for a two pots steering application. It is used to capture the zero setting of the steer handle pot for manual mode steering.

11) SET STEER 0-POS

Is used to set the voltage the steer angle feedback pot wiper will assume at the end of an automatic centering operation. Adjust this setting by Entering SET STEER 0-POS. The default value is 2500.0 mV. You may roll the value up and down using the (5) and (6) keys in 5mV increments until the truck will move straight ahead after centering.

12) SET MIN FB POT

it is used to adjust the scaling of the counterclockwise 90 degrees rotation of the MDU for use with the LEDs steer angle indicator and to stop steering when this value is surpassed and LIMIT DEVICE setting is ON. Adjust this setting with guidance in manual mode (tacho or stepper motor controlled steering). Turn the handle-wheel counterclockwise until the maximum 90 degrees angle is obtained. With the SET MIN FB POT in the ZAPI hand set display, push the ENTER (3) button. The display changes to the present feedback pot value. Push the OUT (4) and the ENTER (3) button to save this new reading.

13) SET MAX FB POT

Is used to adjust the scaling of the clockwise 90 degrees rotation of the MDU for use with the LEDs steer angle indicator and to stop steering when this value is surpassed and LIMIT DEVICE setting is ON. Adjust this setting with guidance in manual mode (tacho or stepper motor controlled steering). Turn the handle-wheel clockwise until the maximum 90 degrees angle is optained. With the SET MAX FB POT in the ZAPI hand set display, push the ENTER (3) button. The display changes to the present feedback pot value. Push the OUT (4) and the ENTER (3) button to save this new reading.

14) AUX VOLTAGE #1

Is for the stepper motor application only. This voltage is auto acquired the first time the EPS-AC is switched on and corresponds to the voltage level in the D line (CNB-3) when the stepper motor is standing. Typical 2.5V.

15) AUX VOLTAGE #2

Is for the stepper motor application only. This voltage is auto acquired the first time the EPS-AC is switched on and corresponds to the voltage level in the Q line (CNB-9) when the stepper motor is standing. Typical 2.5V.

10.9 CONFIG MENU: "SET MODEL"

This adjustment selects the steering configuration. For a tacho-generator (or a stepper motor) controlled steering the only permissable settings are 0 and 1:
- Level 0: tacho-generator (or stepper motor) steering
- Level 1: tacho-generator (or stepper motor) steering plus automatic centering
- Level 2: two pots manual steering (logic modification required)
- Level 3: two pots manual steering plus automatic centering (logic modification required)

Note: a new SET MODEL value will be acquired only after the key is switched off.

10.10 MAXIMUM CURRENT ADJUSTMENT

With the hand set is possible to modify the maximum current setting. In order to modify it Enter the ALARM CONFIG MENU. Push at the same time the two right side buttons. This sequence will enter the hidden ZAPI MENU. Roll up and down (buttons 1 and 2) until the "HARDWARE SETTING" appears on the hand set display. Enter it and change with the right side buttons the maximum current setting. Save the new setting before exiting. Switch off and on the key to acquire the new setting. It is important that the new maximum current value is compatible with the Eps_ac version you have.

11 EPS-AC ALARM LIST

11.1 ANALYSIS OF ALARMS DISPLAYED ON CONSOLE

Here is the alarm list

11.1.1 One blink alarms

1) MICRO SLAVE KO

Cause: When no number is specified it means the Master Microprocessor (MM) has detected a status signal coming from the supervisor (SM) that dos't agree with the present comand values. In fact in real time MM and SM compare the command (tacho-generator, stepper motor, limit switches, automatic request) they are reading. When MM is reading a command value different from the one the SM is reading, this alarm occur.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

2) MICRO SLAVE #1

Cause: Means the SM has detected a lacking synchronisation pulse. MM generates a continuous a synchronisation pulse (every 16msec) to run an interrupt service routine reading the command on the SM. When this synchronisation pulse is missing for more than 100msec this alarm occur.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

3) MICRO SLAVE #2

Cause: Means the SM has detected the safety contacts closed prior to being commanded.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

4) MICRO SLAVE #3

Cause: Means the SM has detected an analog status signal coming from the MM -and replying the SP POT- frozen while the SP POT is changing. (Only for two pots steering).

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

5) MICRO SLAVE #4

Cause: means the SM has detected the motor turning direction is opposite to the present command. (Command and action disagree. Only for two pots steering and automatic centering).

Remedy: If the alarm occurs systematically, it is necessary a logic substition.

6) MICRO SLAVE #5

Cause: Means the SM has detected the motor is standing while the command is not at rest.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

7) MICRO SLAVE #6

Cause: Means the SM has detected the motor turning direction is opposite to the tacho command. (Command and action disagree. Only for a tacho or stepper motor controlled steering).

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

8) MICRO SLAVE #7

Cause: Means the SM has opened its safety contact but has not specified the reason on the local status bus. For example it occurs when the SM is absent or broken.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

9) KM CLOSED

Cause: It occurs when the MM has detected its safety contact closed prior to being commanded.

Remedy: The alarm can be due to a wrong installation. As figure 11.1.1.1 shows two cascaded safety switches are internally connected. They have three diagnostic points; low voltage, mid point and high voltage end that are read by software. When the switches are open, the three diagnostic points expect to be at different potential values thank to the resistances. If the outside interface connected on pin #1 and pin #7 of connector CNB gets one end equal to the midpoint, it looks like the switch is closed before it is driven and this unwanted alarm occurs. So we recommend the safety switch should be directly connected to the supply source (plus battery or minus battery) with no interposed switches.

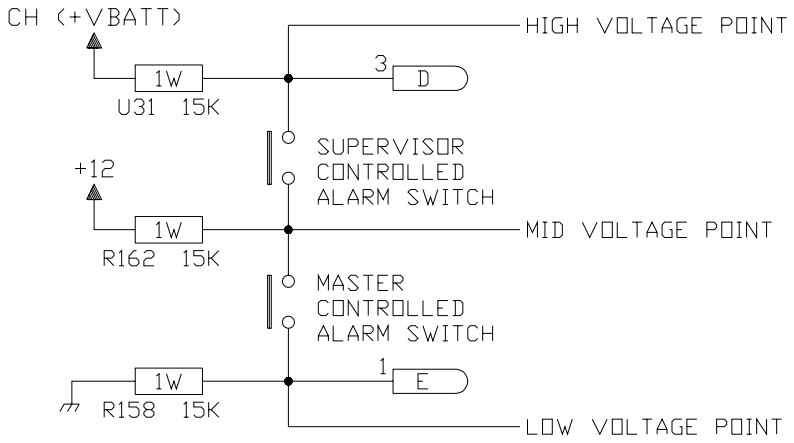


FIG. 11.1.1.1

If the alarm does not occur due to wrong wiring, it is necessary to substitute the logic. The failure could be in a mechanical relay defect or in a fault of the relay driver.

10) KS CLOSED

Cause: It occurs when the MM has detected the SM safety contact closed before it's commanded.

Remedy: The alarm can be due to a wrong installation. As figure 11.1.1.1 shows two cascaded safety switches are internally connected. They have three diagnostic points; low voltage, mid point and high voltage end that are read by software. When the switches are open, the three diagnostic points expect to be at different potential values thank to the resistances. If the outside interface connected on pin #1 and pin #7 of connector CNB gets one end equal to the midpoint, it looks like the switch is closed before it is driven and this unwanted alarm occurs. So we recommend the safety switch should be directly connected to the supply source (plus battery or minus battery) with no interposed switches.
If the alarm does not occur for the wrong wiring, it is necessary a logic substition. The failure could be in a mechanical relay defect or in a fault of the relay driver.

11) KM OPEN

Cause: It occurs when the MM has detected its safety contact open after being commanded.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic. The failure could be in a mechanical relay defect or in a fault of the relay driver.

12) KS OPEN

Cause: It occurs when the MM has detected the SM safety contact open after being commanded.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic. The failure could be in a mechanical relay defect or in a fault of the relay driver.

13) DATA ACQUISITION

Cause: This alarm only occurs when the operator turns to level 1 the "Adjustment #1"

Remedy: switching off and on the key will automatically remove the alarm.

11.1.2 Two blinks alarms

1) POWER FAILURE #1 o #2 o #3"

Cause: They occur when respectively phases U, V and W of the motor are broken. This alarm occurs when at least one of the phase currents is less than 6Aac while the applied frequency is different from zero.

Remedy: Verify the motor cables and motor windings continuity.

2) LOGIC FAILURE #1

Cause: It occurs when the real voltage between phase U and V is different fom the desired.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

3) LOGIC FAILURE #2

Cause: It occurs when the real voltage between phase U and W is different fom the desidered.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

4) HIGH CURRENT

Cause: It occurs when the output current amplifiers signal result higher than Imax level (not controllable) for more than about 1 sec.

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

5) MAIN CONT. OPEN

Cause: It occurs during init by Can-Bus synchronisation with traction module if main contactor doesn't close.

Remedy: Probable traction controller alarm.

6) KEY OFF

Cause: It's a warning that occurs if the Sicos module gives a key-off command via Can-Bus.

Remedy: This warning disappears if the Sicos module switches off the command.

7) CAN-BUS

Cause: It's a warning that occurs if the traction module is not connected or if there is some problems on the Can-Bus line.

Remedy: Check the Can-Bus lines. If you want the EPS-AC working without Can-Bus comunication turn to "Absent" the hardware setting "Can-Bus" with the hand set.
To do it enter in the alarm config menu. Push at in the same time the two right side buttons. This sequence will enter the hidden Zapi menu. Roll up and down (buttons 1 and 2) until the "Hardware setting " appears on the handset display. Enter it and roll with the left side button until the "Can-Bus" text appears. Turn it to "Absent" with the right side buttons.

11.1.3 Three blinks alarms

1) STEER SENSOR KO

Cause: It occurs when the tacho-generator is open or short circuited.

Remedy: Check the tacho-generator wires and measure the tacho-generator resistance (should be close to 22 Ohms). If the problem is not due to wiring, replace the tacho-generator.

2) D LINE SENSOR KO

Cause: It occurs when the stepper motor channel on the CNB pin #3 is open.

Remedy: Check the stepper motor wires and measure the stepper motor line D resistance (should be close to 30 Ohms between pin #3 CNB and GND). If the problem is not due to wiring, replace the stepper motor.

3) Q LINE SENSOR KO

Cause: It occurs when the stepper motor channel on CNB pin #9 is open.

Remedy: check the stepper motor wires and measure the stepper motor line Q resistance (should be close to 30 Ohms between pin #9 CNB and GND). If the problem is not due to wiring, replace the stepper motor

4) F.B OUT OF RANGE

Cause: It occurs when the angle steering feedback pot has a broken connection that means its wiper is higher than 4.7Vdc or smaller than 0.3Vdc.

Remedy: Check the steer angle feedback pot connections. If the problem is not due to wiring, replace feedback pot. Below is the feedback pot internal interface: when a connection is broken the pot wiper is stuck at 0Vdc o 5Vdc.

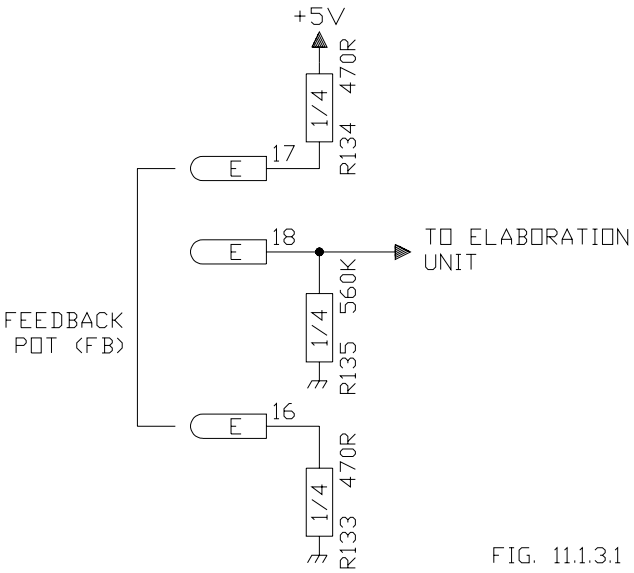


FIG. 11.1.3.1

5) SP OUT OF RANGE

Cause: For a two pots closed control loop only. This alarm is the same as the previous but for the command pot.

Remedy: Check the set point pots connections.

11.1.4 Four blinks alarms

1) EEPROM KO

Cause: It occurs due to a hardware or software defect of the non-volatile on-board memory parameters.

Remedy: Execute a CLEAR EEPROM operation. To do it Enter the ALARM CONFIG MENU. Push at the same time the two right side buttons. This sequence will enter the hidden ZAPI MENU. Roll up and down (buttons 1 and 2) until the "CLEAR EEPROM" appears on the hand set display. Push twice the Enter button. If the alarm occurs permanently, it is necessary to substitute the logic.

Note: each time the Eprom release is changed this alarm could occur. So we suggest doing a CLEAR EEPROM before changing the Eprom.

2) GAIN EEPROM KO

Cause: It occurs at startup if some reserved EEprom cells are damaged, or when substituting an old software (prior than 0.67) with a new one.

Remedy: It is necessary to modify the contents of EEprom address 0 x 63 and then to clear the EEprom. Ask for Zapi technicians support.

11.1.5 Five blinks alarms

1) HIGH TEMPERATURE

Cause: It occurs if the power base exceeds 76°C.

Remedy: Let the unit cool down. If the alarm occurs after, it is necessary to improve the unit's heat dissipation capability.

11.1.6 Six blinks alarms

1) STBY I HIGH

Cause: It occurs if the rest state current signals (measured on the phases U and W) are not in the window 2.5±0.3Vdc after switching on the key and 2.5±0.15Vdc when in the steady state. These voltage are measured between D46 and D45 anodes and gnd.

Remedy: The 2.5Vdc rest state values should be TM3 (for D46) and TM2 (for D45) factory adjusted. If the problem is not due to TM3 or TM2 settings, to try a logic substitution.

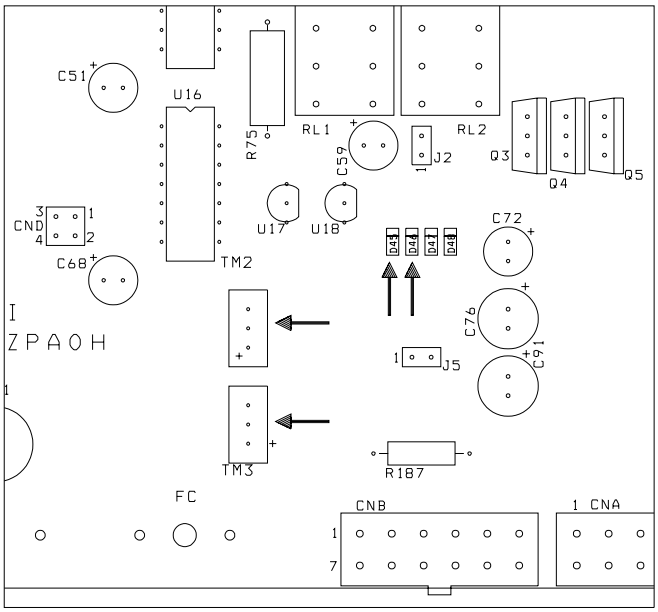


FIG. 11.1.6.1

2) VMN NOT OK

Cause: It occurs when in the initial rest state at least one of the phases of the motor voltage is high: that means the voltage between D47 and D48 anodes and gnd are not in the window 2.5±0.3Vdc (see Fig. 11.1.6.2).

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

3) LOGIC FAILURE #3

Cause: It occurs when in the rest state the Vv-Vu phase motor voltage is high: that means the voltage between D47 anode and gnd is not in the window (Vv-Vu)0±0.25Vdc (see Fig. 11.1.6.2).

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

4) LOGIC FAILURE #4

Cause: It occurs when in the rest state the Vu-Vw phase motor voltage is high: that means the voltage between D48 anode and gnd is not in the window (Vu-Vw)0±0.25Vdc (see Fig. 11.1.6.2).

Remedy: If the alarm occurs permanently, it is necessary to substitute the logic.

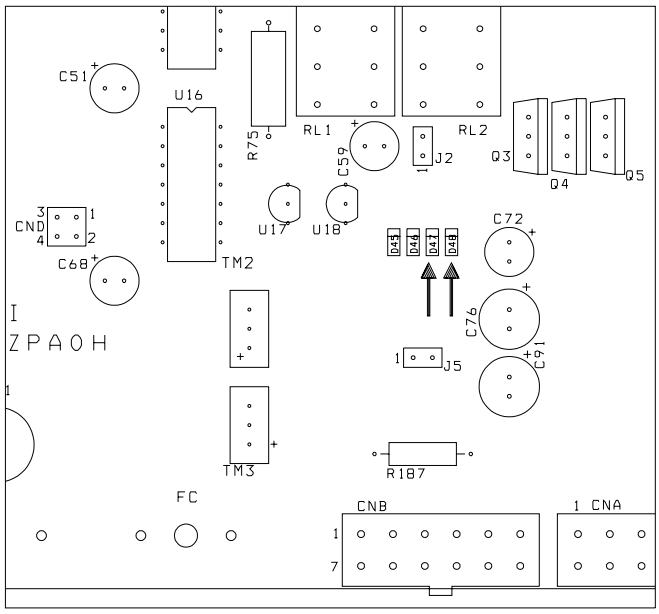


FIG. 11.1.6.2

12 SAFETY CONTROLS AND THEIR USE

12.1 SAFETY CONTROLS IN TACHO-GENERATOR AND AUTOMATIC CENTERING STEERING

The following malfunctioning conditions are tested on electrical manual steering:

1) Safety on motor wires broken.
2) Safety on failures of the steering wheel tacho-generator or stepper motor.
3) Safety on the presence of current when the steering motor is at rest.
4) Safety on the presence of phase voltage when the steering motor is at rest.
5) Safety on pot wires broken (for automatic centering operation).
6) Cross diagnosis between Master and Supervisor microcontroller.

All of these alarm conditions cause a relay to open that will remove the enabling drive. Here is a detailed look at them.

12.2 SAFETY ON MOTOR WIRES BROKEN

If the current on at least one of the motor phases is detected as less than 6Aac when the motor frequency is other than 0Hz an alarm will occur. The delay for alarm occuring decreases as the motor frequency increases. For a motor frequency higher than 50Hz this alarm will occur with a 100msec delay. If the steady state motor current is less than 6Aac this alarm could unwillingly occur.

12.3 SAFETY ON FAILURE OF THE STEERING TACHO-GENERATOR

The safety on tacho-generator failure detects the presence on the line of the tach-generator impedance (22 ohms resistance and 6 mH inductance). This is possible by using it as a load for an astable oscillator. It is therefore possible to detect defects due to disconnection and short circuiting the tacho-generator. The tacho-generator impedance is about 40 ohms. So when an impedance lower than 15 ohms and higher than 300 ohms is detected, an alarm occurs in less than 100msec.

12.3.1 Safety on failures of the steering stepper motor

The safety on stepper motor failures detects the presence of the stepper motor phases resistance (30 ohms). A biasing current is injected in both the D (CNB pin #3) and Q (CNB pin#9) lines for testing. When at least one of these currents is broken off an alarm occurs in less than 100msec.

12.4 SAFETY ON THE PRESENCE OF CURRENT WHEN THE STEERING MOTOR IS AT REST

The microprrocessor logic continuously tests the current amplifiers output at rest and if they are other than 2.5Vdc±0.15Vdc, causes an alarm. These voltage are measured between D46 and D45 anodes and gnd (see figure 11.1.6.1).

12.5 SAFETY ON THE PRESENCE OF PHASE VOLTAGE WHEN THE STEERING MOTOR IS AT REST

The microprrocessor logic continuously tests the phase voltage amplifiers output at rest and if they are other than 2.5Vdc±0.25Vdc, causes an alarm. These voltage are measured between D47 and D48 anodes and gnd (see Fig 11.1.6.2).

12.6 SAFETY ON POT WIRES BROKEN (FOR AUTOMATIC CENTERING OPERATION)

The safety on pot broken operates by looking for either higher than 4.7Vdc or less than 0.3Vdc on the wiper pin of the steer angle feedback pot. In fact, the 5K pot is connected with two resistances that confine its center point inside the two limits specified above if the pot is correctly connected (see Fig 11.1.3.1).

12.7 CROSS DIAGNOSIS BETWEEN MASTER AND SUPERVISOR MICROCONTROLLER

Each microcontroller independently reads the command input (tacho-generator or pot) and calculates a consequent controlling action. While the action generated by the Master becomes the executive, the supervisor's is just for a matching comparision. As each microcontroller receives both its own and the other microcontroller's value, if they are mismatched each microcontroller may open its own alarm switch.

13 PERIODIC MAINTENANCE

Periodical maintenance is reduced thanks to minimisation of wearing parts (no brushes, only one optional power contactor). So the periodic maintenance may be limited to the following checks. Perform every three months:

1) Check main remote control switch contact wear. Replace when contacts are worn.
2) Check mechanical movement of main remote control switch contactor. It must be free and not jammed.
3) Check power wiring going to the battery and steering motor. The terminal must be tight and firmly connected. The insulation must be sound.
4) In the prEN 1175-1 directive compliance, check the operation of the fault detection circuitry (see par. 13.1).

All work must be performed by qualified trained personnel. All replacement parts must be genuine OEM parts.

Any potential problem discovered by the service technician periodically checking the equipment that could lead to additional vehicle damage must be communicated to ZAPI technical staff or the technical sales network so that corrective action and an appropriate decision regarding continued operation of the equipment can be made.

If a user detects a steering problem, it is the user's responsibility to remove the truck from service, tag it, and notify a service technician for corrective action.

13.1 TESTING THE FAULT DETECTION CIRCUITRY

The material handling directive prEN 1175 requires periodic testing of the controller's fault detection circuitry to be checked in one of the following modes (choose your preferred):

1) Switch on the key and try to disconnect the tacho-generator (or the stepper motor channels). An alarm, stopping the traction should immediately occur.
2) Try to disconnect the steering motor. After switching on the key an alarm stopping the traction should immediately occur as soon as the tacho-generator or the stepper motor rotates.

IN THE EVENT OF TROUBLE WITH ELECTRICAL EQUIPMENT MAKING IT DANGEROUS TO USE THE VEHICLE, THE USER MUST NOT USE IT.

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