ANSALDO

DRIVE TRAIN FOR ELECTRIC VEHICLES

MANUAL FOR USE, INSTALLATION AND MAINTENANCE

30/60 [kW] ELECTRICAL DRIVE TRAIN

WITH “CAN-BUS INTERFACE” DESCRIPTION ATTACHMENT

ANSALDO

MANUAL FOR USE, INSTALLATION AND MAINTENANCE

ANSALDO electrical drive train for battery run vehicles consisting of:
three-phase induction motor, 30-60 kw rpm, fluid-cooled
IGBT inverter, fluid-cooled
Microprocessor control

1. GENERAL SAFETY WARNINGS

Installation, operating and maintenance of electrical drive apparatus can be potentially dangerous.
All precautions and measures must therefore be taken to prevent the occurrence of such dangerous situations.

Train drives and electrical motors are components with dangerous parts as they are live or have parts which move while operating.
Therefore: - incorrect use,
- removal of the protection,
- disconnection of protection devices,
- failure to perform inspections or maintenance,
may cause serious harm to persons

In particular, maintenance works must only be carried out by skilled personnel.
Skilled personnel must have the following qualifications:

- have specific technical expertise and experience
- be familiar with technical standards and applicable legislation
- be familiar with national and local general safety regulations
- be capable of recognising and avoiding all possible danger.

A list with some of the general rules to be followed is given here below, as an example but not limited to such:

- **Do not remove the mechanical protection on the converter and the motors before sectioning the batteries.**
- **Do not remove protection**
- **Always section the electrical supply (batteries) before working on converters or motor.**
- **Do not open the top of the converter box before sectioning the batteries.**

The manual for use and maintenance gives some of the symbols used to warn of any danger which could arise during the various operations.
The symbols, together with relative wording “Danger”, “Take Care” and “Warning” indicate the potential risk from not complying with the prescriptions which they are coupled up with.
The following table gives the meaning of the symbols:

	Warning that there is a risk of electric shock if this notice is ignored
	**DANGER** Warning that there is a serious risk of being hurt if this notice is ignored
	**TAKE CARE** Warning that there is a risk of damage to persons and/or objects if this notice is ignored
	**WARNING** Warning that there is a risk of damage to drive apparatus or vehicle if this notice is ignored

2. GENERAL

The ANSALDO drive train controls the speed of vehicles with battery run electric drives.
It can be used for a wide range of electrical and mixed vehicles, from city cars to vans, where its performance is suited to city service requirements.

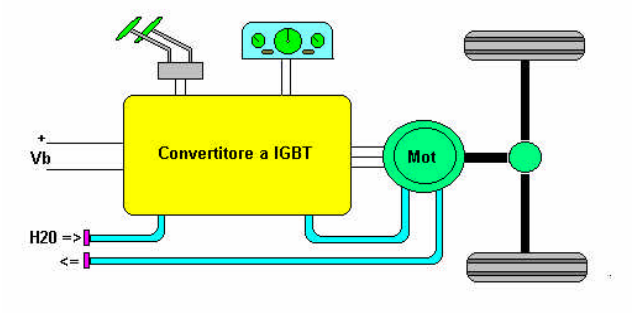
A general outline of the system is given in figure 1.

The train drive consists of an electrical three-phase induction motor controlled by a converter (IGBT inverter microprocessor controlled) and may be powered by any type of drive battery (Pb-acid, Pb-Gel, Ni-Cd, Ni-MH, Zn-air, etc.), gauging the control parameters beforehand.
Both the electric motor and the converter are fluid cooled; they are therefore enclosed and protected from the outside even with snow, rain, damp, saline fog, etc. A closed circuit system with water and glycol normally used for cars or vans is used for cooling.

The driver can control the drive train directly by using pedals (accelerator, brake), or else by using a special device if there is an electronic supervisor on board for controlling the vehicle.
Some of the electrical and mechanical variables may be measured when driving, and the relative information is sent to the dashboard to a display and/or device for controlling the vehicle, if provided.

A microprocessor unit regulates the drive train system.
The scalar technique used for controlling the electric motor was specially designed for electric vehicles. This makes it possible to start up the motor in a graduated way at once, at a high torque and limited current. The pedals respond quickly and there is good acceleration and excellent pick-up at high speed.
The four dials of the torque/speed diagram i.e. the functions of forward drive, forward drive brake, reverse drive, reverse drive brake, work with this controlled system.
Braking and hold on a down-grade are effected through battery energy regeneration.
Energy is regenerated both by releasing the accelerator and by pressing down the brake pedal when braking.
The adjustment system can be set to regenerate a current at a constant value in both cases, or else in proportion to the distance for pressing down the pedal.
The electrical brake function is disconnected when using batteries unable to accept return current.
Driving efficiency is first class, even where the charge is lower than the rated value.
This is particularly an advantage for battery run vehicles and is achieved by implementing an efficient algorithm for optimising the electric motor performance.
To guaranty maximum energy saving, the electric motor works with a weakened field when the vehicle stops in a queue, or at traffic lights, etc.

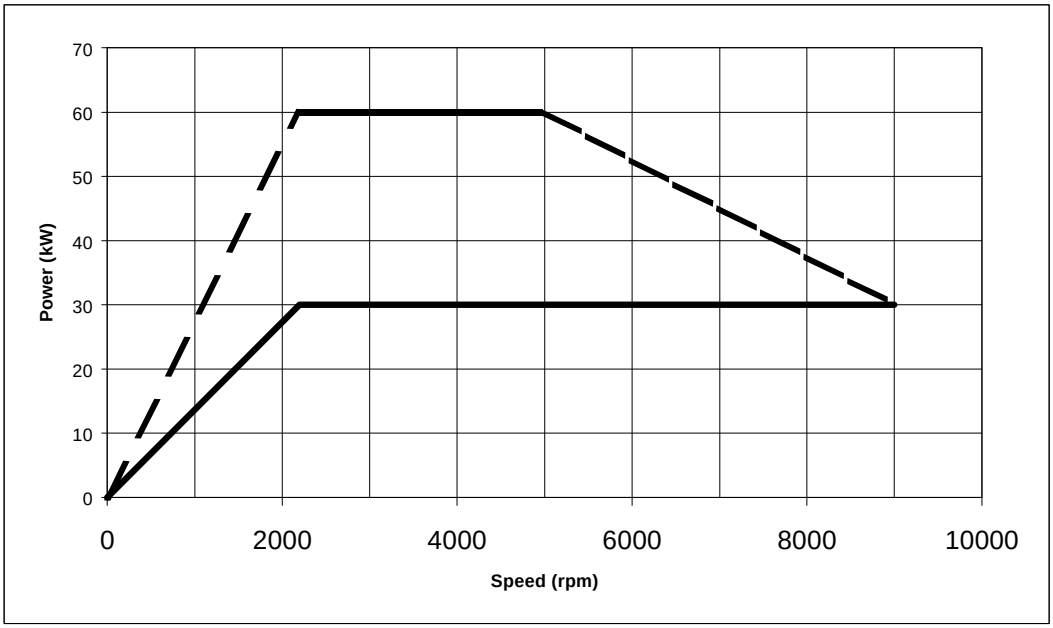
The “economy” function can also be used when the drive battery is empty, i.e. reducing the performance of the vehicle to increase autonomy.
The electric motor is a three-phase induction type, so that it is resistant and efficient and its performance conforms to specific application requirements.
The inverter is a PWM type; i.e. it generates a power supply consisting of a train of rectangular impulses with constant amplitude and variable width for each of the three phases of the electric motor.
The width of each voltage impulse is set to suppress the harmonics which are highly detrimental from an energetic point of view; the current to the motor is therefore practically sinusoidal, that is with a very low harmonic content. Together with a large capacity filter in the DC link, this prevents torque vibrations from being transmitted to the motor shaft so that rotation is regular and without vibration.

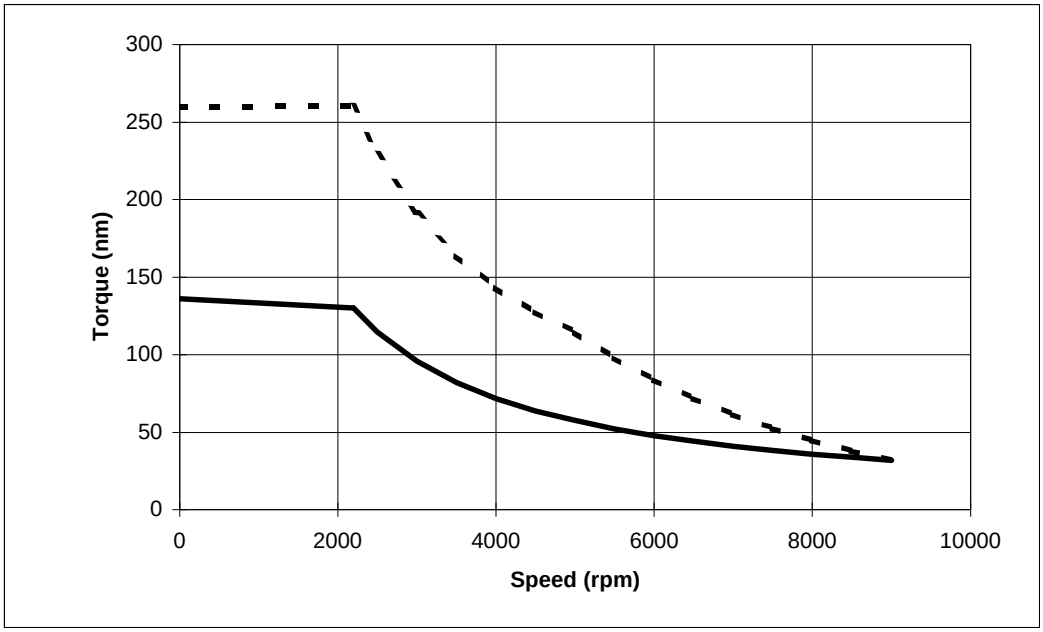


3. TECHNICAL SPECIFICATIONS

Type	AC drive
Power	30 kw rated – 60 kw peak
Rated battery voltage	260 ÷ 300 Volts
Working temperature	- 20 ÷ 65 °C
Shelf temperature	- 40 ÷ 65 °C
Cooling	water and glicol

The operating feature of this system is a constant torque up to a rotation speed of 2200 rpm.
It will work at constant power with decreasing torque over this speed up to the maximum speed of 9000 rpm.
The following figures show the working specifications.





Continuous line conversion denotes continuous duty. The dashed line denotes overload characteristic duty which can last for max 2 minutes.

Components of the drive train system for battery run vehicles.

- Three-phase, induction motor, 30-60 kw, 9000 rpm, fluid cooled.
- IGBT inverter, fluid cooled
- Microprocessor controlled

The following table gives the technical specifications of the components.

Component	**ELECTRICAL MOTOR**
Nameplate	**A2H 207 C44 G**
Tecnical specifications	
Type	induction
N. phases	3
N. Poles	4
Rated Torque	130 Nm
Max torque at 2300 rpm	260 Nm
Speed Range at constant torque	0 ÷ 2200 rpm
Speed Range at constant power	2200 ÷ 9000 rpm
Max speed (mechannical limit)	10000 rpm
Power continuous duty	30 kW
Power at 2' peak	60 kW
Insulation class	H
Safety class	IP 56
Size (L x Φ)	400 x 240 mm
Weight	80 kg

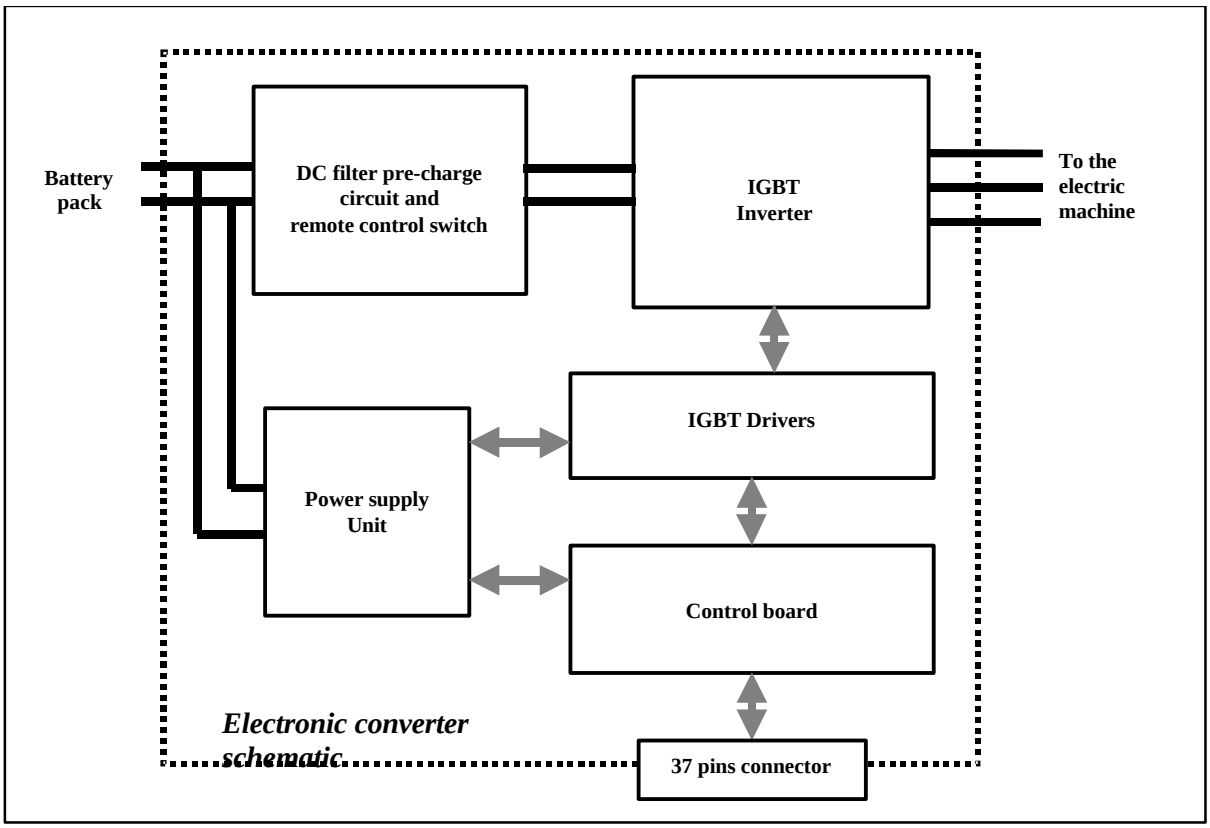
Component	**ELECTRONIC CONVERTER**
Nameplate	**I2H 130 HG 000**
Tecnical specifications	
Type	IGBT
Voltage Range	190 ÷ 380 V (1)
Max input current	280 A
Max AC Current	400 A
Modulation	PWM
Max frequency	400 Hz
Switching frequency	4 kHz
Control	Microprocessor
Safety class	IP 56
Size	410 x 340 x 138 mm (2)
Weight	14 kg

Note: (1) The 380 V limit is considered as the Absolute Maximum Rating

Note: (2) The above sizes include:

- IGBT inverter
- filter capacitors
- Power supply unit
- Control unit
- Plant auxiliaries
- Remote control switch (optional)

4. SYSTEM DESCRIPTION



4.1 Converter

The converter consists of the following main blocks:

- *pre-load system:* loads the filter capacitors onto the processor command at service start up (first turn of the key).

- r*emote control switch (optional):* connects the battery to the inverter when it is off, to feed all the electrical parts in the system; the battery is disconnected from the electrical system when it is on. It is closed by a command from the microprocessor to start service (second turn of the key), it is opened again with the command of end of service from the processor (key turned off), or else for safety protection in case of emergency.

- *IGBT inverter:* supplies the feed voltage to the electric motor

- r*esonant power supply unit:* supplies low voltage power to the entire converter. It takes energy directly from the drive battery for this function.

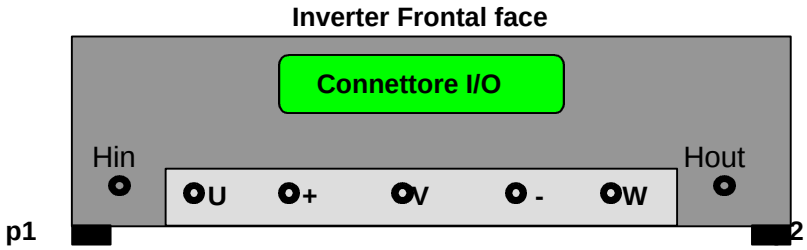
- p*ilot unit:* this is the interface unit between the control unit and the inverter. It verifies command signals coming from the control unit, pilots the IGBT gates and forwards information related to saturation voltage to control.

- c*ontrol unit:* this is the unit controlling the system. It implements the MCU (Motor Control Unit) and VMU (Vehicle Management Unit) functions.

- *sensors:* there are two Hall effect transducers inside the converter box, measuring the currents of the electric motor phases, one transducer measures the voltage in the DC link, a thermocouple conditioner measures the temperature of the motor winding and a heat sensor signals that the temperature threshold of the inverter dissipater has been exceeded.

The converter has the following input/output lines, all connected to the front part (see figure):

- 2 inputs marked with the symbols + and – for connection to the drive battery
- 3 outputs marked with the symbols U, V, W for connection to the electric motor
- 2 tubes for cooling fluid inlet/outlet, marked with the symbols H_{in} and H_{out} .
- 1 37 pin I/O connector: this is the interface for signals from/to the field (accelerator, brakes, forward/reverse drive, ignition, dashboard lights, supervisor, motor thermocouple, other I/O)
- A threaded hole, marked with M, for connecting to the vehicle unipotential system.



4.2 Motor

4.2.1 General

The A2H207C44G motor is a three-phase induction type with a squirrel cage rotor**.**
It is in the IP 56 safety class conforming with IEC 34-5 Directives and in the IM 3601 (IM B14) construction class conforming with the IEC 34 –7 edition.

4.2.2 Stator case

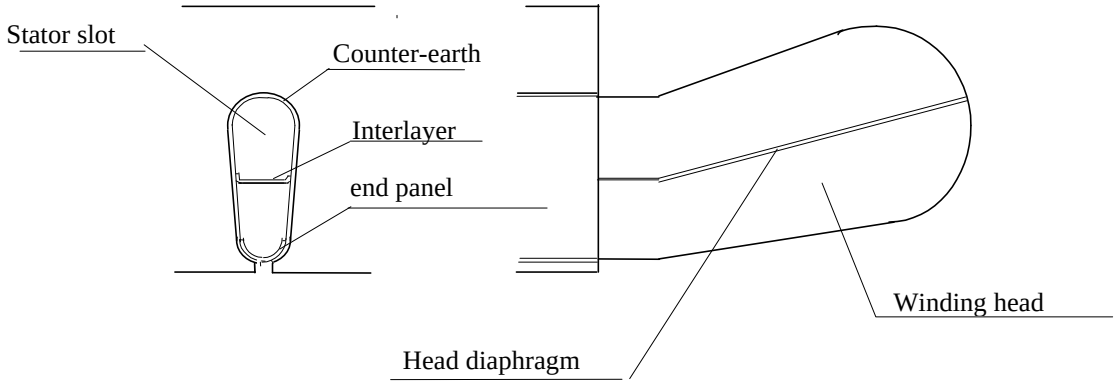
The casing is the outside shell of the motor made of highly resistant extruded aluminium alloy. As well as a structural function it also permits heat exchange with the cooling liquid. It is designed with two round surfaces, with appropriate ducts inside for conveying the cooling liquid**.**
The liquid centre line is ensured by shields and appropriate gaskets.
The above mentioned item makes it easy to gain access to the cooling liquid circulation chambers to make cleaning easier.

NB. The radiator output must be connected to the inverter, so that the cooling liquid passes throug the inverter before passing throug the motor.

The stator core is installed inside the casing, complete with windings.
The stator lamination core consists of thin walled (0,65 mm.) magnetic laminations. Longitudinal grooves have been made in the part of the laminations nearest to the air gap, called slots, distributed evenly around the air gap with the windings housed inside them.
The number of stator slots was chosen with the aim of optimising the electro-mechanical performance of the motor and reduce the torque vibrations which can occur when the inverter supplies power.The stator slots are half-open to make it easier to insert the winding.The laminations used are isolated one from the other. The insulation is in the order of hundreds of mm. to reduce loss from eddy currents.
The core stator laminations are made of steel sheeting bonded with a 4% silicon, characterised by a low amount of loss, (less than 1,7 W/kg measured at 1,0 Wb/m^2 with sinusoidal alternate voltage at 50 Hz) and after trimming they are treated with an oxidation process to reduce iron loss and improve the overall performance.
The production cycle includes shaping and punching the stator slots, the rotor slots, the shaft opening and extracting the two stator disks and rotor from the strip by using a “pitch” die installed on an automatic press.
The laminations are then piled up into packages and packed with a press to avoid vibrations and to reduce noise; aluminium tie rods are used to keep them in place.
The stator core is introduced into the casing after the latter has been heated up to achieve the right interference needed to prevent the core from rotating.

4.2.3 Statoric winding and insulation

The statoric winding is of the three-phase alternated current type, with coils made of enamelled copper wire installed into the stator slots**.**
Winding is normally made of copper (Cu) used for electrical goods, characterised by a grade of purity exceeding 99.9% after electrolytic refining, specific weight Ps = 8900 kg/m^3, resistivity at 20°C p = 0.0172 [*ohm^x mm^2 /m*].
The copper wire is pickled after drawing to increase ductility and helps to shape the winding.
The copper wire used for the stator winding is insulated by enamel made of modified polymeric resins in the 220°C. heat class.
The wire is made with double insulation.
Stator slots are isolated with sheets of “NOMEX”.
The figure shows the insulating parts of the stator winding and the materials used.



Component	Materials used
Enamelled wire	Poliestere imidico modificato
Counter-ground	Nomex ®
Diaphragm	Nomex ®
Interlayer	Nomex ®
Panel	Nomex ®

The wiring was finally treated to a vacuum impregnation process with heated polymerised resins in an autoclave as a further guarantee to insulation and to lock the copper wiring subjected to electro-dynamic stress.
The stator winding temperatures are controlled by a J type thermocouple installed inside.
A control unit placed on the control sends out a signal to warn the operator if the winding reaches dangerous temperatures.

4.2.4 Die-cast rotor and shaft

The rotor consists of a laminated core trimmed from the same magnetic lamination used for the stator core.
The rotor in short circuit is produced with a single cage with aluminium die-casting. This production technique is cost saving and results in an extremely compact cage resistant to the danger of the bars breaking because of electro-dynamic stress.
The rotor slots are on a longitudinal incline to dampen disturbances from harmonic fields appearing as eddy currents and noise.
The rotor lamination, complete with its die-cast cage, is parcelled under a press and fixed onto the shaft by interference.
The shaft is made of NiCr high tensile steel.
There are two kinds of shaft, depending on requirements:

- Normal cylindrical with key
- Spleaned shaft

4.2.5 Shield on opposite side to coupling

The shield opposite to the coupling is produced in shell-cast aluminium alloy and is fixed to the casing by highly resistant screws with encased hexagonal heads.
Three holes are made in it, protected by special cable gland unions used as the outlet of the feeder cables. These cables must be abutted to the U1, V1, W1 terminals installed on the inverter.
This is connected to the rotor shaft by the relative joint, which dampens torque vibrations.

4.2.6 Flanged shield coupling side

The flanged shield on the coupling side is produced in shell-cast aluminium alloy and is fixed to the casing by highly resistant screws with encased hexagonal heads.
Two openings have been made in the upper half for inlet and outlet of cooling liquid (water + glycol). The motor cooling system is perfectly symmetrical, so that it does not make any difference which opening is used to let in the cooling liquid.
Care must however be taken to ensure that the radiator outlet is connected to the inverter so that the cooling liquid passes through the latter first going on the motor afterwards.

4.2.7 Bearings

The motor has roller bearings lubricated with 6208-2Z-C3 type grease.
These bearings are pre-lubricated so they do not need any further lubrication for their entire working life.
Appropriate metallic sealing has been installed on the bearing to prevent lubrication from eventually leaking.
Nella versione con cuscinetto strumentato, all'interno del cuscinetto trova posto il sensore per il controllo della velocità (6208/VU1022). The instrumental version, sensors for controlling the speed are lodged inside the bearing.

4.2.8 Cooling system

The running motor is associated with power loss, which shows itself under the form of heat, to be removed by a suitable cooling system to keep the machine components within the tolerated temperatures.
The cooling system consists of a cavity used to convey the cooling liquid in contact with the internal wall of the casing to cool the stator core.The rotation of the rotor makes the air move around inside creating an even temperature of all the machine parts and preventing localized over-heating which could cause deterioration of the machine or some of its parts.
The cooling system (circuit + inverter) caracteristics are: reach = 10 l/min, pressure drop = 0,1 bar.

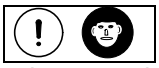
5. DELIVERY – HANDLING – STORAGE

5.1 Delivery

The converter and motor are delivered complete with all their parts and ready for installation after prescribed quality tests have been done during production and a final inspection to ensure that they conform to project specifications.
It is advisable to check the converter and motor upon delivery for any eventual damage which may have occurred during transportation.

Any damages must be notified immediately to the trucking company and to ANSALDO RICERCHE.

All the parts eventually protected by grease must be accurately cleaned after unloading the motor and removing the packing.
If the motor and converter are not used straight away, they must be stored in a covered, clean place without dampness and vibrations.
Any protection for the motor against rust must be left intact.



5.2 Handling

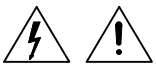
The motor is not supplied with eyebolts for lifting purposes. An eyebolt can be inserted into the openings for fastening either on the flange on the coupling side or on the shield on the opposite side, for handling purposes**.**
The motor can also be lifted with a suitable hoisting sling around the casing and fastened to the centre of it.
Care must be taken in this situation to prevent the motor from turning upside down.

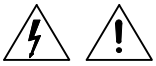
5.3 Storage

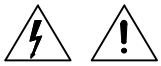
Several precautions have to be taken if the converter and motor are to be stored for a long time to prevent deterioration**.**
Converter and motor must be placed in a covered, clean and dry place.
The converter must be stored at a temperature of between – 40°C and 65°C and must not be exposed to direct sunlight.
As far as the motor is concerned, it is advisable to check the insulation of the windings at regular intervals. If a lower resistance value should be detected, it will be necessary to find the cause and resolve it.
The motor should stored in a place without a lot of vibration, which could damage the shaft and bearings.
The bearings are roller type lubricated with grease. They do not require any maintenance during storage.
It is advised to turn the shaft by hand a few times every month to prevent bearings and shaft deformation.

6. APPLICABLE NOTES

- Carefully follow the safety regulations here below under all circumstances:

1.  Do not remove the cover of the equipment while it is running

2.  Make sure the system is switched off and the drive battery sectioned before removing the cover of the equipment

3.  The capacitors must be disconnected at the end of service (key off). However, keep in mind that the dangerous voltage values remain on the capacitors for about another 8 minutes after the end of service. Furthermore, some parts with defects could still be live with a high voltage after 8 minutes. Carry out the following operations after removing the cover and before touching any part inside the converter:
   - measure the voltage with a voltmeter between the busbar points marked with symbols + (more) and – (less) making sure there is no voltage (see par. 10.2 point marked as 12 and 13).
   - measure the voltage with a voltmeter between the resonant feeder unit points marked with the symbols M2 and M3 making sure there is no voltage (see par. 10.2)

If in doubt, contact ANSALDO servicing dept.

4.  Do not add liquids, gas or corrosive substances to the converter.

5.  Do not use water or conductive liquids to put out fires burning near electronic parts.

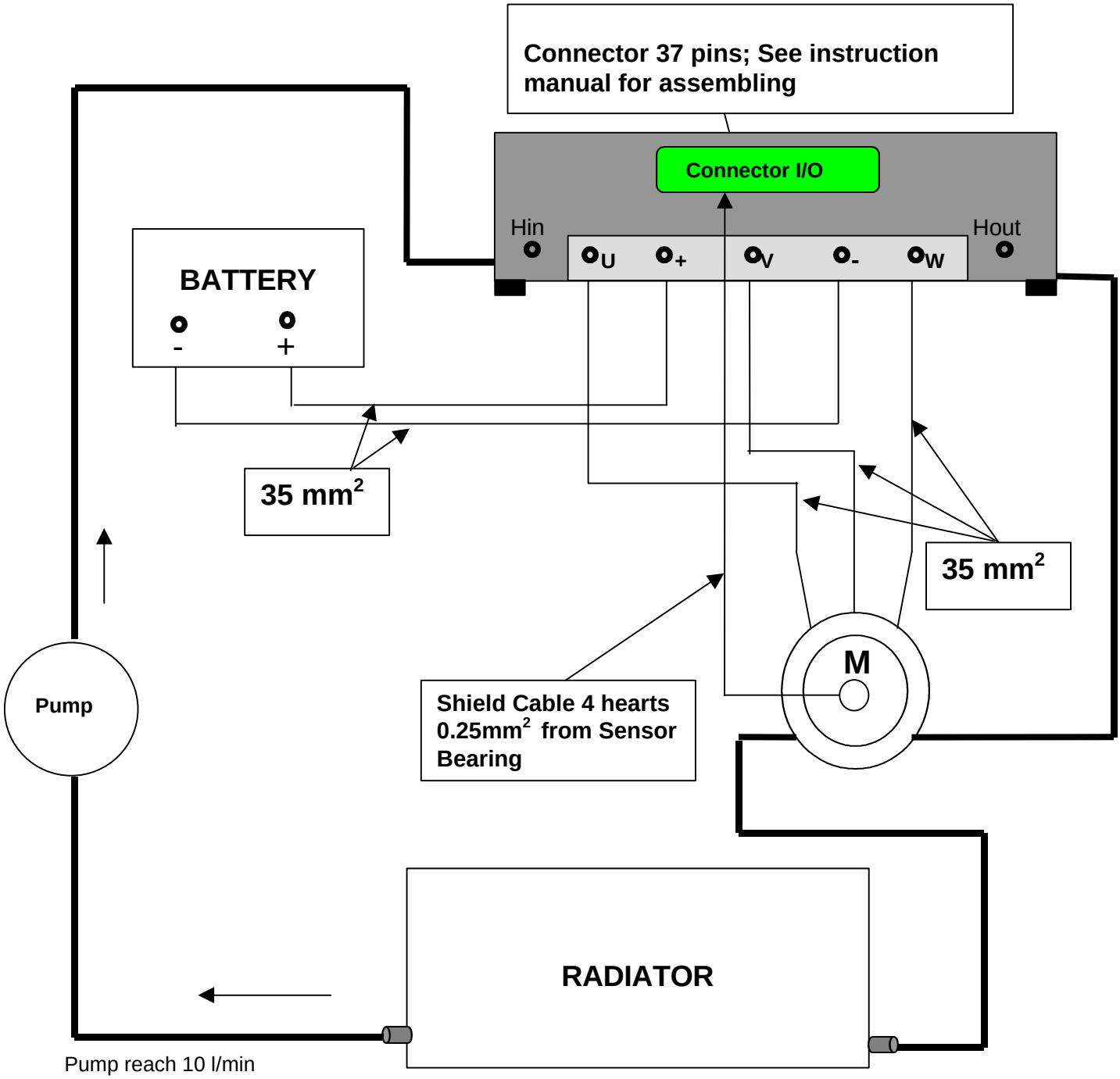
- It is advisable to contact ANSALDO servicing dept. for repairs. The end-user cannot repair any internal parts of the converter.

- Power factor correction capacitors must not be connected to the U, V, W inverter outlet terminals.

-  Do not introduce switches or meters between the inverter U, V, W outlets and the electric motor. Opening and closing movements of these switches could damage the converter.

7. INSTALLATION

7.1 Electric and hydraulic assembly outline motor + inverter + battery



Pump reach 10 l/min
Pressure drop only inverter + motor 0.1 bar;
Max disperse power (continuous duty) inverter + motor 4000 W

Connect the 2 terminals of the battery cables to the terminals in the box which are also marked with the symbols + and -, using the supplied nuts and bolts and a spanner (best tightening torque 3 Nm).
IMPORTANT: make sure that the battery cables are wired up correctly (+ with + and – with -) as a mistaken inversion will damage the converter.

7.2 Converter

Installation involves the following operations:

1. Prepare the signal cables from/to the field and connect them to the “mobile part” of the 37 pin I/O cable connector, the figure on page 18 shows the relative connection outline with detailed description. Use the wiring instructions given in the table on par. 7.3 for this purpose. Make sure they have been wired up correctly.

2. Fix the converter box to the chassis of the vehicle. The converter is equipped with 4 perforated feet (p1, p2, p3, p4), use siden blocks for fixing it.

3. Remove the cover from the terminal box situated on the front, unscrewing the screws.

4. Connect up a 35^2 mm M6 terminal to each of the free ends of the 3 motor cables.

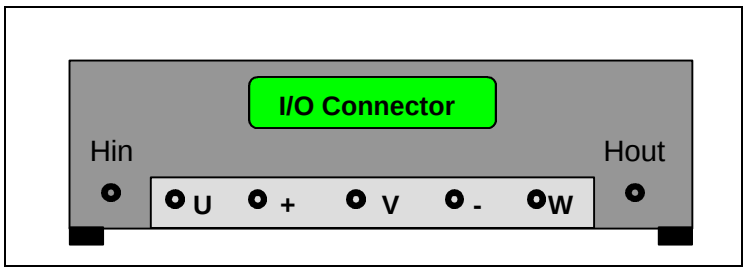
5. Place the cables of the three-phases U, V, W belonging to the electric motor into the terminal box of the converter box, threading them through the cable leads situated on the front part of the box and marked with the same symbols U, V, W.

6. Connect up the motor cable terminals to the terminals inside the box, which are also marked with the symbols U, V, and W, using the special screws.

7 Make sure the battery has been disconnected with the safety knife switch, then take the two battery cables marked with the symbols + and – coming from the knife switch outlet, check to see they are 35 $mm.^2$, measure between the two cables with a voltmeter to verify that there is no voltage.

8. Connect an M6 35 $mm.^2$ terminal to each of the free ends of the 2 battery cables.

9. Afterwards introduce the 2 battery cables into the terminal box, threading them through the cable lead located on the front of the box and marked with the symbols + and -.



CONVERTER FRONTAL FACE

10 Connect the 2 terminals of the battery cables to the terminals in the box which are also marked with the symbols + and -, using the supplied nuts and bolts and a spanner.
IMPORTANT: make sure that the battery cables are wired up correctly (+ with + and – with -) as a mistaken inversion will damage the converter.

11 Connect the 2 tubes, with inside diameter of 17 mm. conveying the cooling fluid, to the H_{in} and H_{out} unions. The fluid must enter at H_{in} and come at H_{out} so that the thermal sensor can take measurements correctly. It would also be better for the fluid to pass through the inverter first and then through the motor afterwards.

12. Connect threaded hole M to the equipotential system of the vehicle (usually the chassis) and put the cover back onto the converter fastening it down with the special screws.

13. Connect the I/O connector “mobile part” to the immobile part of the connector itself on the front part.

The drive train system is ready to be switched on if all the operations have been done correctly. The vehicle can be started up as soon as the safety knife switch has been disconnected (see point 7) and the ignition key has been turned, working the AV/IND command and the accelerator.

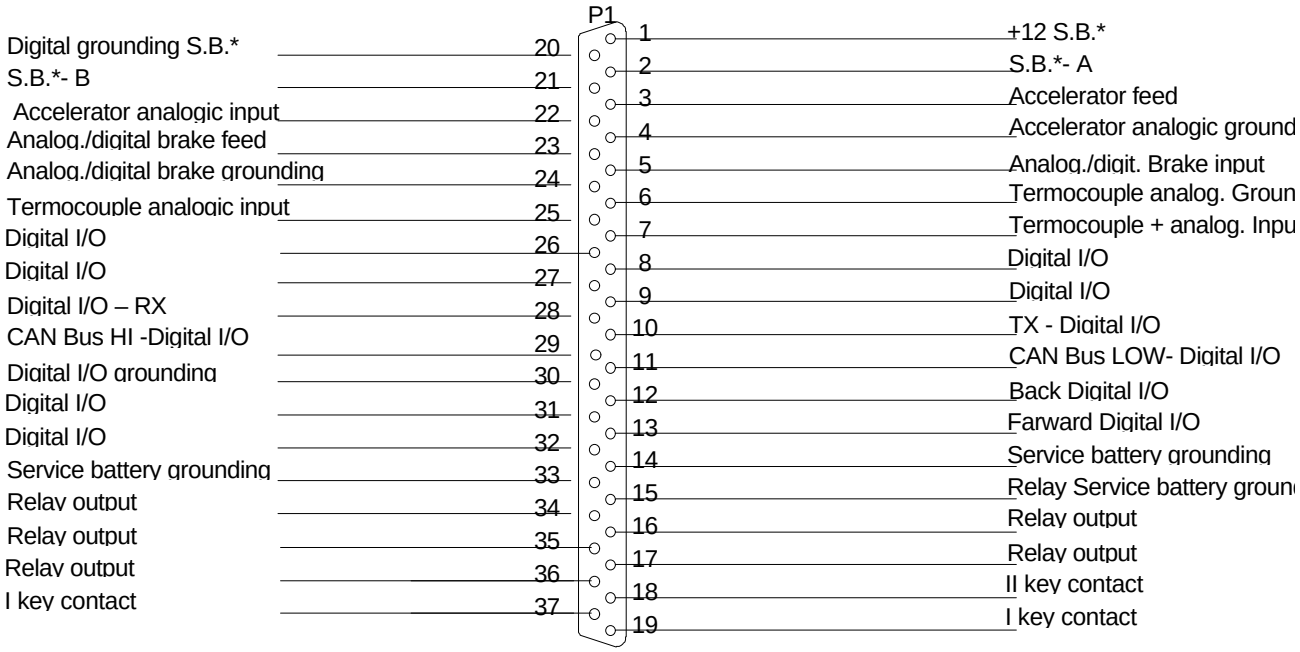
14. The converter can be equipped with standard can bus ISO 11898 version 2.0 B with message data as descripted in par. 11 or according with the SAE J 1939 protocol.

7.3 Instructions for the 37 pin connector wiring

PIN	Signal	From/to	Cable section	Notes
1	Sensor bearing supply (+ 12 V)	From control to sensor bearing	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
2	Encoder A channel	From encoder to control	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
3	Accelerator Potentiometer supply (+ 5 V)	From control to accelerator	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
4	Accelerator ground	From control to accelerator	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
5	Analog/digital brake input	From analogic central brake potentiometer unit or from the digital brake control switch	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
6	Thermocouple Motor ground	From the thermocouple inside the motor to control	Shielded: single section cable: 0,25 mm^2	Shielded cable for connecting to the vehicle chassis.
7	Thermocouple signal 1	From the thermocouple inside the motor to control	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
8	Piggy back 7	From control to field and vice versa (available)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
9	Piggy back 5	From control to field and vice versa (available)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
10	Piggy back 3	From control to field and vice versa (available)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
11	Piggy back 1	From control to field and vice versa (available)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
12	AV/IND – Forward/Reverse	From the gear selector to control	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.

13	Digital I/O 2	From control to field and vice versa (available)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
14	Service battery ground (12 or 24 V)	From pole – of the service battery to control	1 mm^2	Electrical cable
15	Service battery ground (12 or 24 V) for relay outlet	From pole – of the service battery to control	1 mm^2	Electrical cable
16	Outlet to relay 4	From control to field (stand-by)	0,25 mm^2	Electrical cable
17	Outlet to relay 2	From control to field (stand-by)	0,25 mm^2	Electrical cable
18	Second turn of key	From panel key unit to control	1 mm^2	Electrical cable
19	+ 12 V (0+24V) service battery	From + pole of the service battery to control	1 mm^2	Electrical cable
20	Sensor bearing ground	From control to sensor bearing	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
21	Channel B sensor bearing	From sensor bearing to control	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
22	accelerator potentiometer control unit (+ 5V)	From accelerator to control	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
23	Power supply analog / digital accelerator	From control to analog brake potentiometer or digital brake switch	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
24	Analog/digital brake ground	From analogic brake potentiometer or digital brake switch for control	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
25	Thermocouple signal 2	From thermocouple inside motor to control	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
26	Piggy back 8	From control for field and vice versa (stand-by)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
27	Piggy back 6	From control for field and vice versa (stand-by)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
28	Piggy back 4	From control for field and vice versa (stand-by)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
29	Piggy back 2	From control to field and vice versa (stand-by)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.

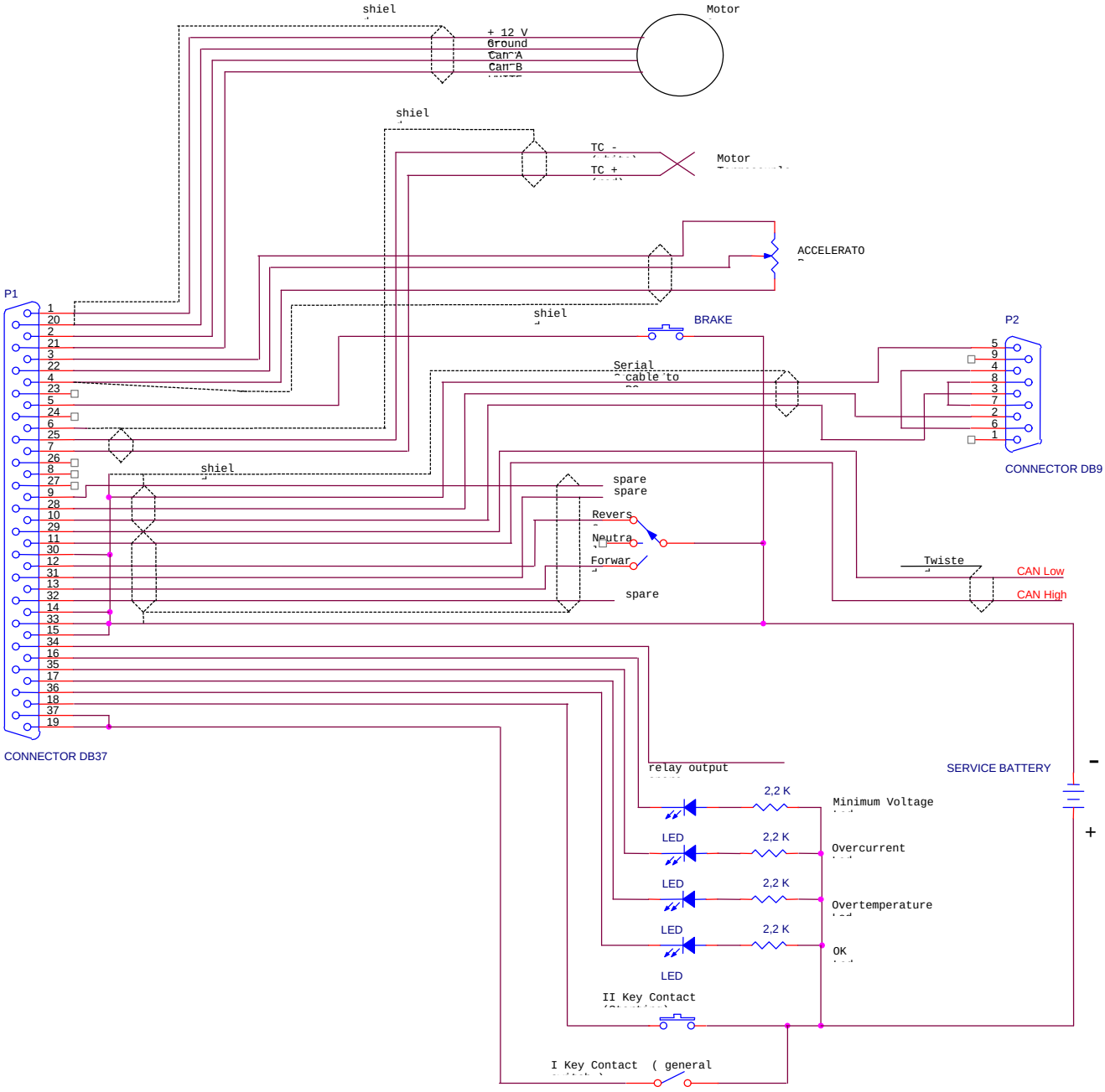
30	Digital I/O ground	From control to field and vice versa (stand-by)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
31	Digital I/O 3	From control to field and vice versa (stand-by)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
32	Digital I/O 1	From control to field and vice versa (stand-by)	Shielded: single section cable: 0,25 mm^2	Preferable to use the core of a shielded cable. Connect the cable screen to the vehicle chassis.
33	Service battery ground (12 or 24 V)	From – pole service battery to control	1 mm^2	Electrical cable
34	General protection (outlet to relay 5)	From control to dashboard	0,25 mm^2	Electrical cable
35	Outlet to relay 3	From control to field (stand-by)	0,25 mm^2	Electrical cable
36	Outlet to relay	From control to field (stand-by)	0,25 mm^2	Electrical cable
37	+ 12V (0 ÷ 24V) service battery	From + pole of service battery to control	1 mm^2	Electrical cable



CONNECTOR DB37

PIN OUT INVERTER CONNECTOR

*=Sensor Bearing.



INVERTER-VEHICLE'S CONNECTIONS OUTLINE

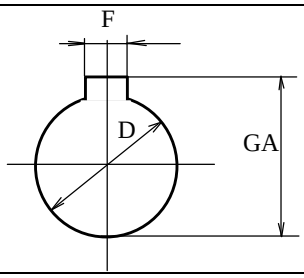
7.3 Motor

7.3.1 Installation and alignment

The motor is designed to be connected up directly to the reduction gear unit to make up a single unit, supported at the ends.
The reduction gear counter-flange must be flat, rigid and sufficiently resistant.
The motor can also be connected directly to the chassis and connected to the reduction gear using universal joints or flexible coupling.
The machine openings for fastening screws are located on the flanged shield on the coupling side.

7.3.2 Assembling and disassembling the drive train device

It is best to use a flexible coupling for connecting up the motor mechanically, to prevent eventual axial and radial thrusts on the bearings.
A coupled machine should not normally transmit torsion vibrations to the motor shaft.
Particular attention must be given to the alignment of the motor with direct coupling.
Eventual vibrations and irregular running are an indication of incorrect alignment. The alignment must be set more accurately if this happens.
The motor rotor has been dynamically balanced with half the key applied to the shaft projection.
The drive unit (half-joint) must also be accurately balanced before being keyed onto the shaft, with half the key in the corresponding slot to avoid vibrations whilst operating.
The drive unit must be heat assembled according to supplier's instructions.
The following tolerances for boring holes in the half-joint are used for more standard operations and normal coupling:

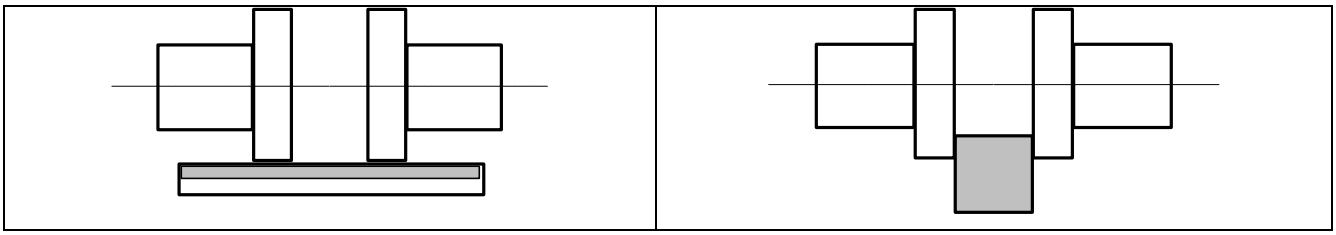


Tollerance	
D:	H7
F:	P9
GA:	+0.4 - +0.6 mm

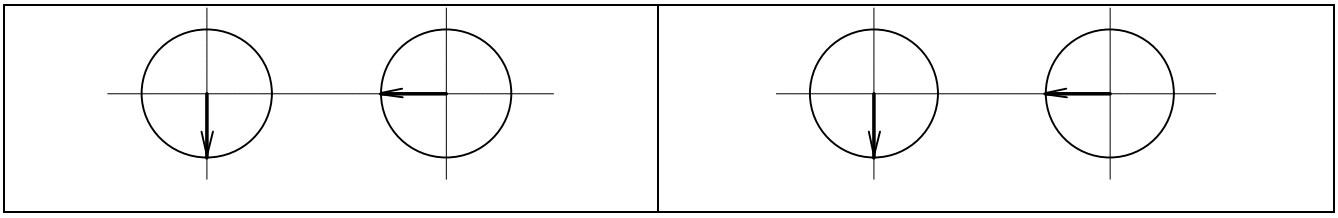
Do not use hammers or mallets for keying operations. Dismantle eventual non metallic parts, which could be damaged by the heat, before heating the half-joint.
The half-joint must also be dis-assembled after it has been heated up or heated by a flame or an electrical induction apparatus. It is best to use a special extractor.
Special equipment using pressurized oil for dismantling half-joints can be found on the market, which can be used without heating up the half-joint. The half-joints must be prepared before assembling them in this case.

7.3.3 Alignment

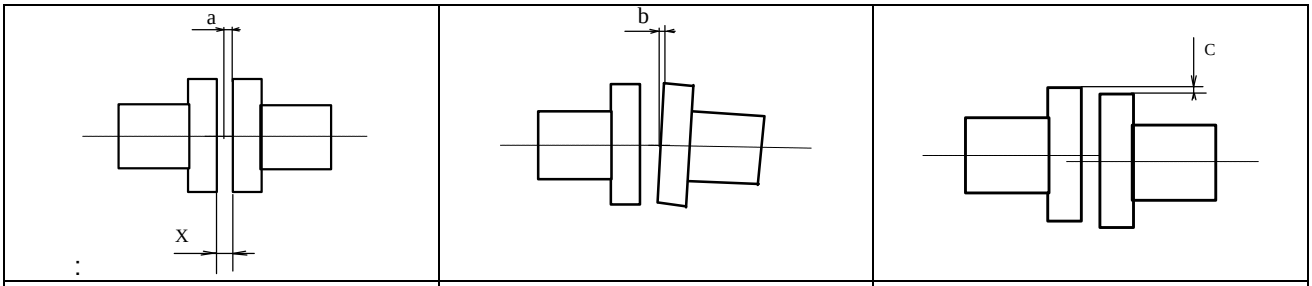
The motor must be properly aligned if it is connected up directly to the reduction gear.
Bad alignment causes vibrations, which could damage the bearings, supports and shaft.
A metallic ruler and thickness gauge must be used to obtain precise alignment or alternatively one or two comparators.
After assembling the two half-joints onto the coupled machine and onto the motor and after putting the two machines into position, leaving the gap between the two half-joints as indicated in the overall drawing, lightly screw up the screws fastening the flange and make a first rough alignment.
Lay the ruler on the two half-joints and measure the radial alignment.



Repeat the measurement at 90°, 180° and 270° angle after turning the two shafts together.

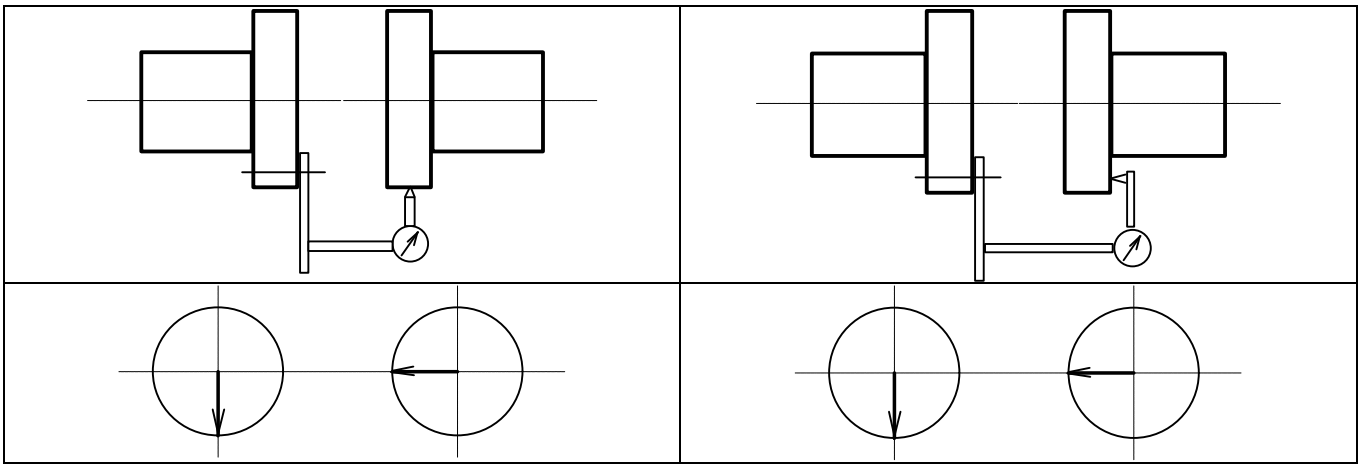


Introduce a wedge between the two faces of the half-joint and measure the distance of their centre line.
Repeat the measurement at 90°, 180° and 270° angle after turning the two shafts together.
The difference between the two measurements must be less than 0,05 mm.
Values here below indicate the maximum tolerated alignment errors:
(x = distance set for the type of half-joint used).



a = X/2 ± 5	b = ± 0.05	c = ± 0.05

Corrective measures must be taken if any errors in alignment are found exceeding tolerated values, using wedges introduced under the machine flange and with small movements sideways, if necessary.
Measurements must be repeated after screwing the bolts right down and reference pins can be applied between the machine and its supporting base if alignment is correct.
The alignment can be improved even further by using two comparators, each one attached to a half-joint to measure axial and radial oscillation in the various positions.



7.4 Commissioning

Control and watching of turn number must be guaratee that the maximum turn number doesn't be sourmonted. During and after assembling must be controlled:

- Cooling liquid must flow free.
- All fixed screws, mechanical and electric connectors must be lock out with the prescribed security elements.
- Must be present all of controllable parts of vosual control.

7.5 Operation

7.5.1 OPERATION WATCHING

Variation of normal operating (abnormal adsorbiment, high temperature, unusual vibrations, noises or smells, watching device intervention) is symptomatic of bed operating. In this case to avoid damages to persons or materials is timely put out immediately converter, doing controls and proceeding to maintenance.

8. MAINTENANCE.

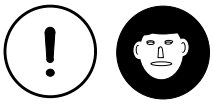
Motor and converter project and construction are realized to minimize the maintenance operations.
Per quanto riguarda la manutenzione straordinaria, ad opportuni intervalli temporali (indicativamente ogni 3-4 anni o 100.000 km,) è opportuno prevedere la sostituzione dei condensatori di filtro del DC link, degli IGBT e della batteria al litio residente sulla scheda di controllo al fine di garantire una maggiore affidabilità di funzionamento.
Even the motor doesn't need ordinary maintenace, because only part that wear are bearings, but they are projected to work all of life of the motor; they are prelubrificated and don't need lubrification all duty cicle.
During the daily duty be careful for anomaluos conditions of duty and protection operations.

8.1 Ordinary maintenance.

During normal duty do any inpection to verify the anomaly onset, and the need of maintenance. To guarantee a long duty cicle for the motor you must predispose a maintenance program, that considers real duty cicle and the motor installed displacement environmetal conditions.

WIRING BEFORE STARTING ANY MAINTENANCE WORKS

CONTROL THE SYSTEM AGAIN IN CONFORMITY WITH START-UP PROCEDURES BEFORE STARTING UP THE MOTOR UNIT



NON-COMPLIANCE WITH THESE PRECAUTIONS COULD CAUSE DAMAGE TO PERSONNEL

To do maintenace opertions on the converter or motor, is necessary to know that uncorrect use of the drive train cuse damage or die to personnel, and / or damages to materials.
During operations follow all warnings and informations writing on this chapter.

- Assembly and disassembly must do by skill personnel.
- Spare pieces must be authorize by the constructor.
- Absolutely rispect of maintenance intervals and the instructions of repair or substitution of parts.

For normal operation conditons advise that proceding to do next controls

Component	Required inspection or maintenance works	Interval
Cooling system	Check that there are no obstructions in the inlet and outlet cooling liquid tubes	3 months
Mechanical coupling	Make sure all the fastening bolts are tightened up properly	6 months
Wiring	Control all the electrical wiring	6 months
Windings	Control windings visually Clean windings Measure insulation resistance	12 months

IMPORTANT: Disconnect the drive battery before removing the cover of the electronic converter so that it is disconnected from the inverter. Remember that the capacitors still have dangerous voltage values for about another 8 minutes after the inverter has been switched off. Certain kinds of breakdowns could also cause high voltage to remain even after 8 minutes. Do the following operations after removing the cover of the converter and before touching any of the parts inside:

- measure the voltage with a voltmeter between the busbar points marked with symbols + (more) and – (less) making sure there is no voltage (see par. 10.2 point marked as 12 and 13) .
- measure the voltage with a voltmeter between the resonant feeder unit points marked with the symbols M2 and M3 making sure there is no voltage (see par. 10.2)

If in doubt, contact ANSALDO servicing dept.

The converter does not require ordinary maintenance works.

Precautions must be taken for eventual controls on insulation. If these tests are considered necessary contact ANSALDO Technical Dept. for the relative procedure.

Concerning special maintenance, the filter capacitors of the DC link, the IGBT and the lithium batteries housed in the control unit must be replaced at appropriate intervals (more or less every 3-4 years, varying according to how the converter is used). This operation could be risky, particularly when replacing the capacitors; FOR THIS REASON KEEP STRICTLY TO INSTRUCTIONS GIVEN AT THE BEGINNING OF THE PARAGRAPH. Before replacing, contact ANSALDO servicing dept., which will supply the spare parts or, alternatively, the list of components to be replaced.

WARNING
DISCONNECT ALL ELECTRICAL WIRING BEFORE STARTING ANY MAINTENANCE WORKS

CONTROL THE SYSTEM AGAIN IN CONFORMITY WITH START-UP PROCEDURES BEFORE STARTING UP THE MOTOR UNIT

NON-COMPLIANCE WITH THESE PRECAUTIONS COULD CAUSE DAMAGE TO PERSONNEL

8.1.1 Cooling system

It is advisable to control the cooling system periodically**.**

If the fluid inside the motor and/or converter does not flow freely, the hydraulic system must be cleaned with the following operations:

Motor:
1. remove tubes conveying the cooling fluid
2. blow in compressed air
   If the obstruction is still there, perform the following operations
3. disconnect the motor wiring connected to the inverter (the cover must be removed from the converter with this operation / follow the safety regulations)
4. remove the motor shields
5. clean the cooling jacket installed inside the casing

Converter:
1. remove tubes conveying the cooling fluid
2. blow in compressed air

In alternativa può essere inserito nel circuito di raffreddamento un liquido adatto per il disincrostamento dei radiatori. In tal caso è necessario attenersi alle prescrizioni allegate alla confezione del prodotto

8.2 Motor maintenance

A programme for maintenance and inspection planned and scrupulously carried out during the working life of the machine results in a highly reliable motor with low maintenance costs.
It is advisable to contact ARI for any repair works to the motor.

Durante il funzionamento normale del motore è tuttavia opportuno procedere ad alcune verifiche, pulizia del motore e eventuali sostituzione di cuscinetti.

WARNING
DISCONNECT ALL ELECTRICAL WIRING BEFORE STARTING ANY MAINTENANCE WORKS

CONTROL THE SYSTEM AGAIN IN CONFORMITY WITH START-UP PROCEDURES BEFORE STARTING UP THE MOTOR UNIT

NON-COMPLIANCE WITH THESE PRECAUTIONS COULD CAUSE DAMAGE TO PERSONNEL

8.2.3 INSULATION RESISTANCE MEASUREMENT

Insulation resistance tests are done to verify if the resistance of insulating material used and if the paint impregnation is sufficiently high for the motor to work in a satisfactory way.
A MegaOhmeter supplying a 500V voltage is used for the test and is connected to the windings and ground using a suitable test prod. The scale of the instrument is gauged directly in megaohm and shows the insulation resistance value.
The test is then repeated connecting a phase of the winding to a test prod of the instrument and the ground to the other test prod (naturally after switching on the winding wiring).
The insulation resistance measurement only gives the measurement for quality and not for quantity.
The insulation resistance value generally exceeds that of 100 Mohm with ease with new motors and under normal weather conditions.
With rewound motors or motors working in damp conditions, the minimum value of insulation resistance can be estimated to be around 20 Mohm at 15 ÷ 30°C.
If measurements are taken at temperatures exceeding 40°C, the resulting values must be taken to 40°C using the following formula:

$$R_{40} = K_t \times R_t$$

Where : R_{40} = *insulation resistance in Mohm at 40°C*
R_t = *insulation resistance at temperature t*
$K_t = 10^{((0.0301 \times t) - 1.2041))}$

Resistance doubles at approximately every 10°C of decreasing temperature.

WARNING

THE MACHINE MUST BE ARRESTED FOR SUFFICIENTLY LONG TO DISCHARGE ALL THE RESIDUAL VOLTAGE BEFORE MEASURING INSULATION RESISTANCE

CONNECT THE WINDINGS TO THE GROUND TEMPORARILY THROUGH THE CASING TO MAKE SURE THAT DISCHARGE HAS TAKEN PLACE

Even though the insulation system used for the machine windings ensures satisfactory results under tension, even at insulation resistance is 1/10 of those specified previously, it is good practice not to let the insulation resistance go below the recommended values.
The variation of insulation resistance for a period of time when applying the test voltage gives another indication of insulation conditions.

8.2.2 GENERAL CLEANING

When cleaning machines already assembled, it is recommended to remove all the accumulated dirt first of all by energetic suction.
Any grease must then be cleaned off using dry soft rags without fluff, or else a brush with soft bristles.
Use compressed air to remove eventual slag remaining after the above operations have been completed. During this operation be particularly careful not to let the jet of compressed air push the slag into some hidden corner where it will be difficult to extract it.
Use compressed air pressure below 2,5 bar.
A liquid solvent suitable for insulation material and which is not toxic or inflammable can be used if the dirt is too difficult to remove with a brush or with a dry rag. This solvent must be highly volatile and act as a good solvent for grease and oil but not for the resins in the insulation system.
Cleaning operations with liquid solvents must be done so that the solvent comes into contact with the windings for the shortest time possible.
Windings cleaned with solvents must be dried with a jet of hot air before being put under tension. The time needed for drying satisfactorily mainly depends on the environmental conditions, such as temperature and humidity.
Windings cleaned with solvents normally take two hours to dry at room temperature. The drying process can be accelerated (about 1 hour) by raising the temperature by about 15°C or, alternatively, using dry air under forced circulation.

***NOTE**: The insulation value (see point D4) is a useful indication for evaluating the humidity absorbed by the winding, but is not an indication of the condition of insulation where there are solvents.*
The winding must be completely free of solvent before measuring the insulation resistance to evaluate if it is dry enough to put under tension.
The winding can also be cleaned very carefully by skilled personnel with a weak solution of water and detergent, at a pressure below 2 bar and temperature below 90°C.
It is best to use a 1/60 volume solution of water and detergent with low electric conductivity to minimize the effect of detergent solution on the insulating resins protecting the winding.
If a plant for heating and distributing the solution under pressure is not available, the solution can be sprayed on with a spray gun, or else a tepid solution can be applied with soft rags without fluff.
Rinse the windings thoroughly with water and steam at low pressure after cleaning with detergent.

8.2.3 BEARING MAINTENANCE

- General

The motor bearings are both waterproof and self-lubricating. For this reason they do not need any further lubrication for their whole working life.

- Bearing disassembly

Bearings are one of the most important items for the successful performance of an electric motor. The highest quality bearings are installed on the motor and they are assembled accurately with skilled workmanship, in spite of this they sometimes have to be disassembled for maintenance work or replacement.
An extractor must be used to disassemble the bearings, after dismantling the shields.
Proceed with care to avoid nicking the ball tracks or rollers if the bearings are going to be used again.
It is however advisable to replace the bearings when the motor is being disassembled as it is often difficult to assess the satisfactory working condition of disassembled bearings, so it is generally not worth re-assembling the same bearings and running the risk of having to disassemble the motor to replace the damaged bearings.

- Bearing assembly

The housing must be carefully cleaned with a suitable solvent (e.g. petrol) before bearing reassembly, checking the housing for any frazes or damages. Care must be taken to avoid metallic dust deposits inside or around the bearings if emery cloth or a grinder has to be used to remove signs of scratches or other defects.
Smear a thin layer of grease on the surface of the pins and other parts indicated above, to protect them against corrosion.
Heat the bearing in an oil bath at 70 ÷ 80 °C, assemble it into its housing and keep it resting against the shoulder of the shaft until it has cooled down.

8.2.4 BALANCING

The motor is dynamically balanced with a whole key, and there is generally no need for any further balancing operations at site after assembly and alignment.
However the rotor balancing must be corrected if, after carefully checking that the alignment has been done properly in conformity to assembly instructions, the motor should vibrate abnormally.

8.2.5 MOTOR DISASSEMBLY

The following operations must be done to disassemble the motor and extract the rotor:
a) Check that the line is switched on
b) Disconnect the feed cables to the motor
c) Disconnect encoder and thermocouple connecting cables
d) Disconnect the motor from eventual reducer. *It is advisable to introduce suitable pins for reference, if not already installed, before disconnecting the counter-flange to help re-assembly)*
e) Disassemble the coupling unit
f) Remove the coupling key
g) Remove the screws fastening the shield on the opposite side to coupling
h) Remove the screws fastening the flanged shield on the coupling side
i) Gently lay the rotor onto the stator, free it from all supports and remove the shields.

The following operation must be done to disassemble bearings from the shaft:
a) Move the inside cover on the opposite side to coupling and the inside cover, coupling side, towards the inside of the shaft.
b) Extract the bearings with an extractor taking a hold on their inside ring.

NB Only disassemble bearings when they have to be replaced

8.2.6 MOTOR RE-ASSEMBLY

To assemble follow the same operations done for disassembly only the other way round.
Check alignment before starting up the motor again, even though the position of alignment is presumably the same as it was before disassembly.

8.2.7 SPARE PARTS

Spare parts list

Spare parts description	Nameplate	Quantity installed in each Motor
Bearing coupling side	6208 2Z - C3	1
Bearing opposite side to coupling	6208/VU 1022	1

- Ordering spare parts

A detailed description of the required component, the characteristics indicated on the motor rating plate and in particular the serial number of the motor must be given when ordering spare parts.
It is possible to identify all the spare parts from the type of motor stamped on the rating plate and the serial number.

- Storing spare parts

Spare parts must be stored in a clean, dry and ventilated place.
The spare parts should be checked periodically to verify their state of conservation.

8.3 CONVERTER MAINTENANCE

The converter usually do not need any works. In doubt, please contact ANSALDO services dept.

9. BREAKDOWN IDENTIFICATION

Any defects forming in the drive train are signalled by led and messages are sent to the supervisor through the serial port or the CAN bus.
If a defect should prevent the vehicle from moving, turn the ignition key to stop the vehicle and try to start it up again.
If the defect remains, this is probably because there is a permanent breakdown; it is better not to try any more otherwise the breakdown will be aggravated.

Possible causes for active safety protection are indicated in the table below:

Defect	Eventual causes
LED PROT lights up	Overcurrent on motor phases
	Desaturation
	Control Feed voltage out of range
	Inverter heat sensor
	Motor overheated
	Drive battery flat

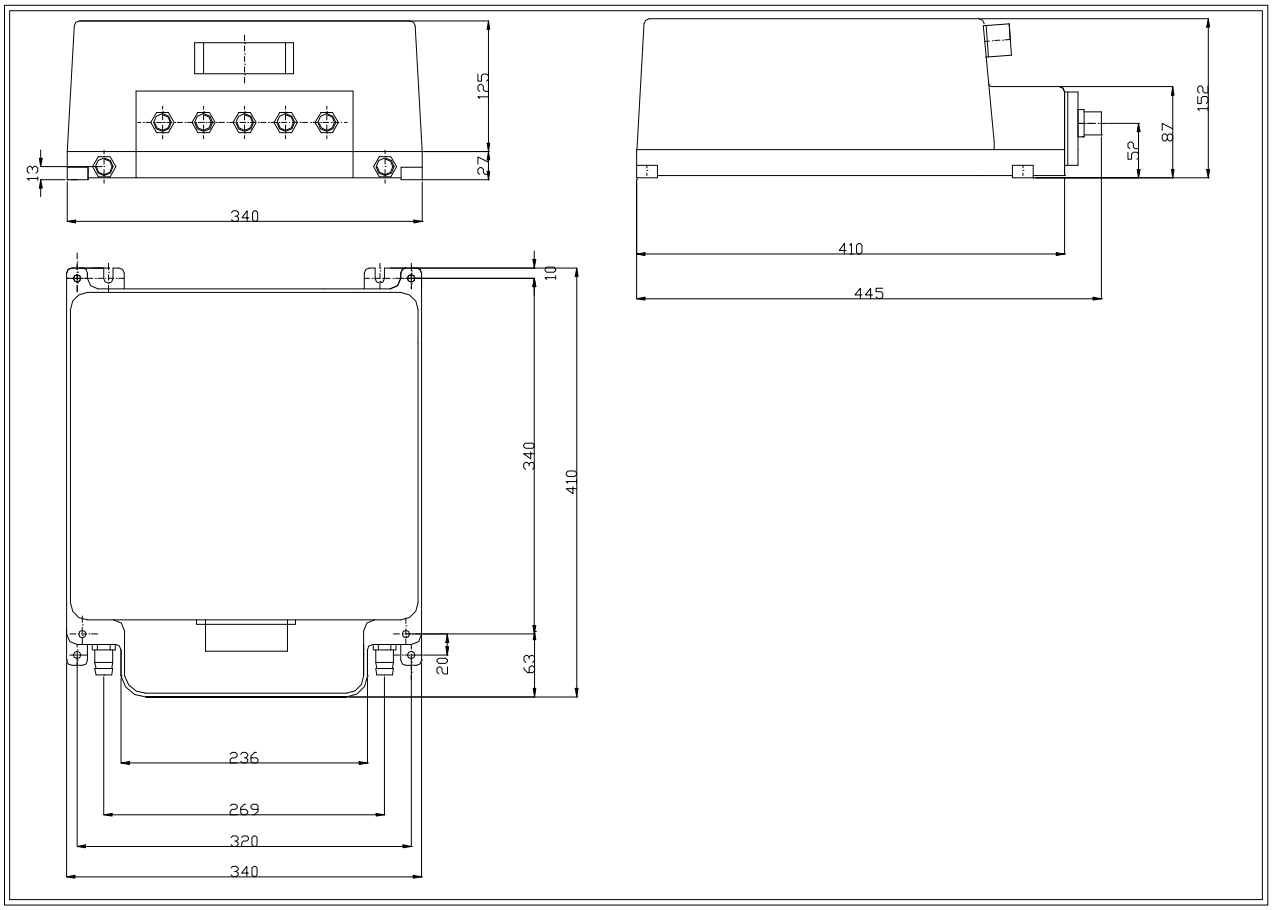
The following actions should be taken upon finding a defect, before notifying Ansaldo servicing dept.

Defect	Actions to be taken
LED PROT lights up	Switch off the drive train. Check that outside casing of the inverter and/or motor is not over 60°C. If so, wait until they have cooled down, then switch on again. If not, check to see if the drive battery no-load voltage exceeds 95 % of the nominal voltage and the services battery voltage is more than 11.5 V. If voltages are below these recharge the drive batteryor the services battery, otherwise try to start up the drive train again. Contact Ansaldo servicing dept. if the safety protection should become active again.

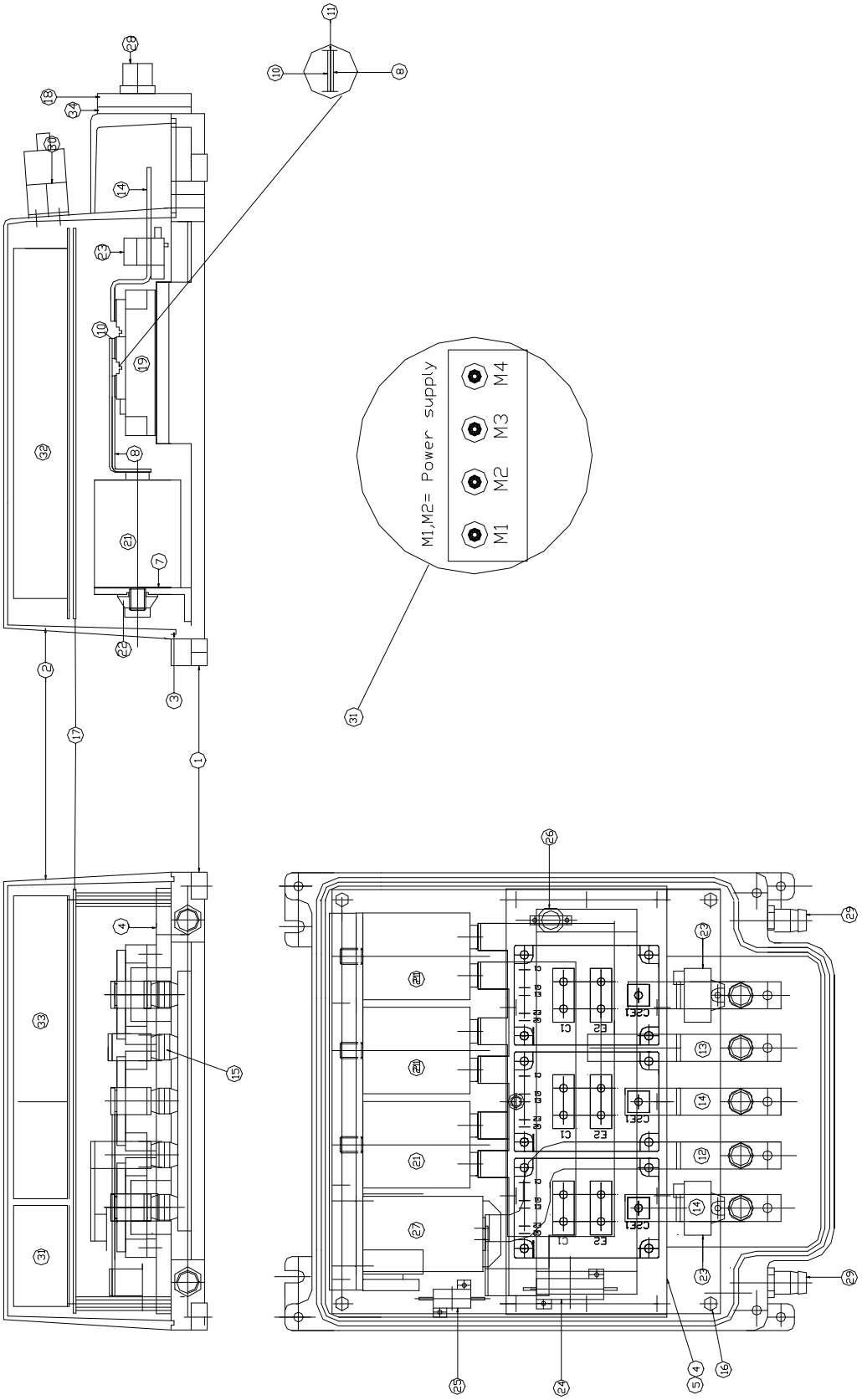
The LOW BATT led may also light up as well as the above leds, which does not signal a situation of alarm, at least at the beginning: in fact the vehicle can still move. But it must be remembered that the residual charge of the drive battery is below 20% so that the remaining autonomy is about 20 km for driving along a flat level or about 8 km climbing a hill with maximum gradient of 10%.

10. SIZES AND OVERALL DIMENSIONS

10.1 Dimensions of electronic converter



10.2 Electronic converter general



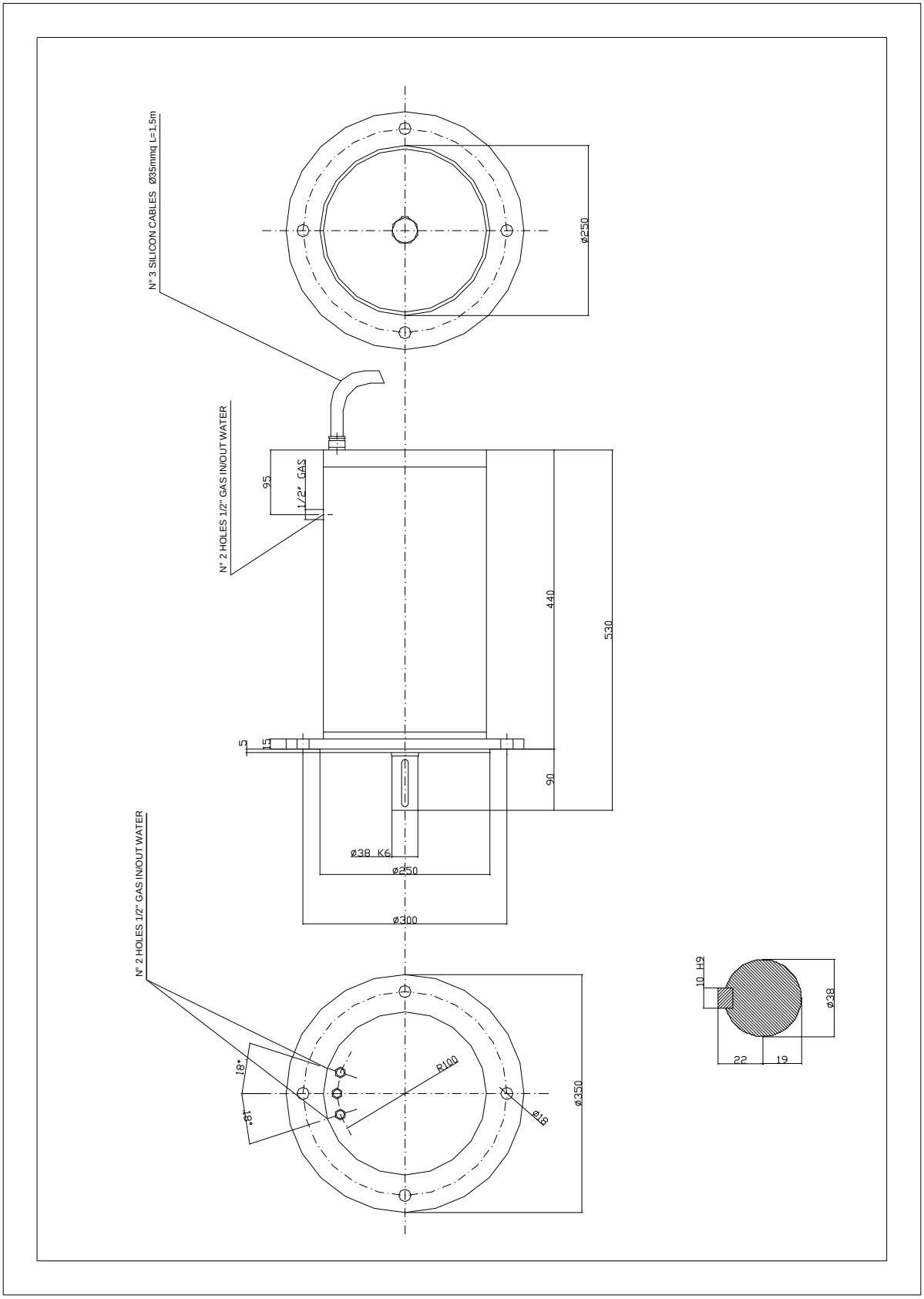
ANSALDO

ELECTRONIC CONVERTER LEGEND

P	OBJECT
1	CONVERTER BASE
2	LID GASKET
3	LID
4	IGBT SUPPORT PLATE
5	PLATE GASKET
6	CAPACITOR AND REMOTE CONTROL SWITCH SUPPORT
7	CAPACITOR INSULATING WASHER
8	CAPACITOR POSITIVE CONNECTOR
9	CAPACITOR AND REMOTE CONTROL SWITCH SUPPORTS
10	CAPACITOR NEGATIVE CONNECTOR
11	CAPACITOR BAR INSULATING
12	POSITICE CC INPUT
13	NEGATIVE CC INPUT
14	ALTERNATING OUTPUT
15	BAT INSULATORS
16	PRINTED CIRCUIT FIXED PLATE
17	PRINTED CIRCUIT PLATE
18	CABLE HOLDER PLATE
19	IGBT
20	IGBT RESISTANCE
21	CAPACITORS
22	CAPACITOR INSULATING NUT
23	TRANSDUCER
24	PRE CHARGE RESISTANCE
25	CAPACITOR DISCHARGE RESISTANCE
26	TERMIC SWITCH
27	REMOTE CONTROL SWITCH
28	CABLE-HOLDER
29	PUMP-HOLDER
30	CONTROL CONNECTOR
31	POWER SUPPLY UNIT CARD
32	DRIVE CARD
33	CONTROL CARD
34	OUTPUT PLATE GASKET

10.3 Electric motor dimensions

TYPE A2H



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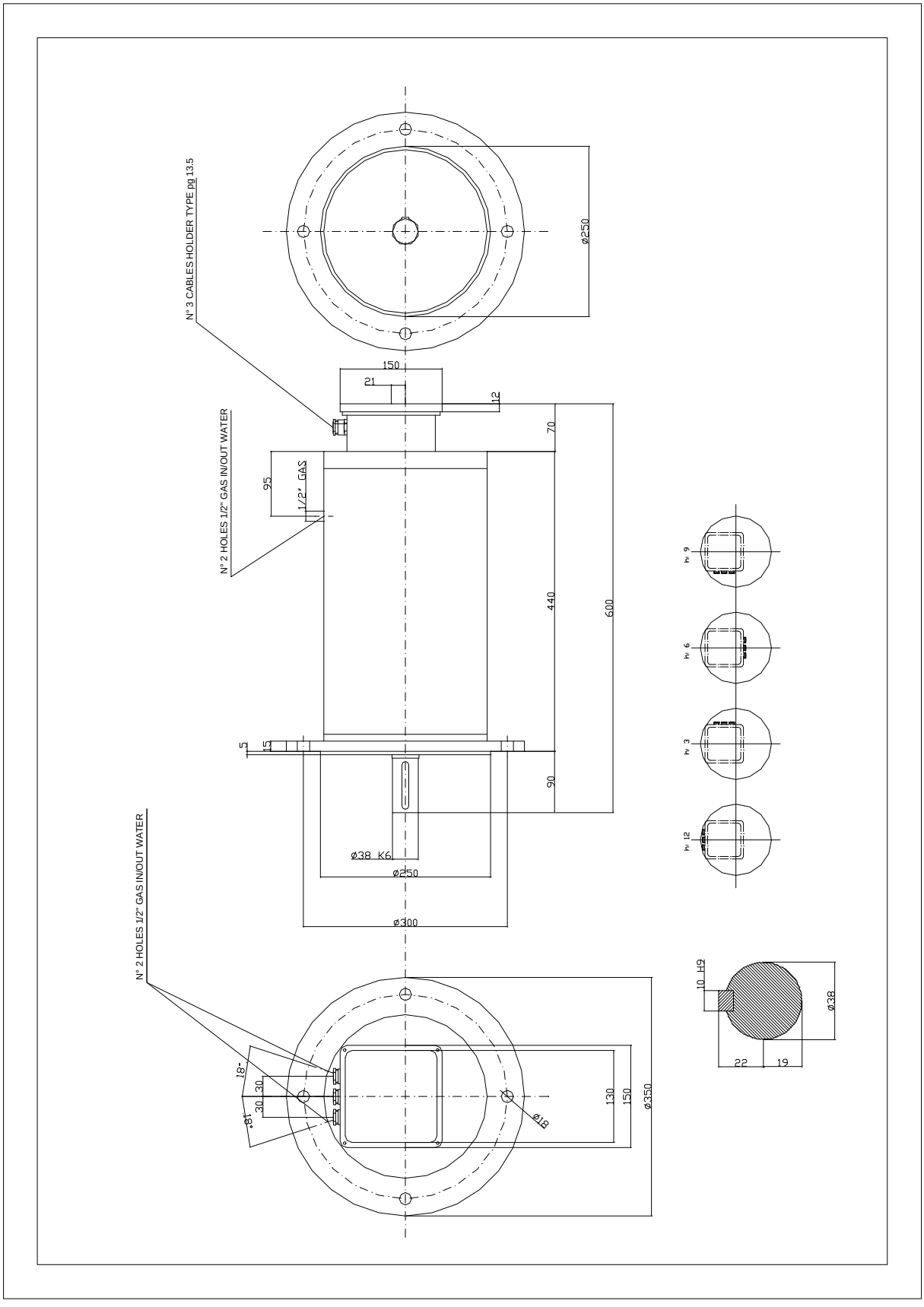
TYPE A3H



A. CAN BUS INTERFACE DESCRIPTION

A.1 Bus Interface

Communication Standard is the following:

Standard	ISO 11898
Baud Rate	500 Kbit/s (1)
CAN BUS	Specification 2.0 Part B Standard Frame (11 bits identifier) (2)
Bus terminator	To be placed externally (124 Ohm resistance on both bus sides)
Communication Period	100 ms (3)

(1) Other allowed transmission speed are 250 Kbit/s and 125Kbit/s
(2) Alternatively the Extended Frame (29 bits identifier) can also be used.
(3) Based on the bus occupation, related to other messages rate, it can be reduced to 10ms.

A.2 Data Frame Definition

Data type	Range	Lenght (Byte)	Description
Bitfield	-	1	Single bit have a value
Short Int	-128 .. +127	1	With sign
Unsigned Short Int	0 .. 255	1	Byte
Int	-32768.. +32767	2	Low Significant Byte first
Unsigned Int	0 .. 65535	2	Low Significant Byte first
LongInt	-2147483648.. +2147483647	4	Low Significant Byte first

A.3 Information available through CAN interface

Information available through CAN interface are packed as standard CAN messages and they are described in the following. Other sub-system can read such information and used them to monitor other's managed functional operations.

A.4 Temporisation

The time between the II Key contact and the transmission of the first message ("**start-up time**") is less than 1 second.
The "**transmission**" time (defined as the time between the signal acquisition and the reliability on the CAN-bus) is less than 10ms.

A.5 CAN messages Identifier

The ID messages (11 bits) definition method is based on the following rules:
- "priority" field free – set to 011 / 100 / 101
- R1 field set to a zero
- DP field set to zero
- PDU field free

PRIORITY			R1	DP	PDU					
11	10	9	8	7	6	5	4	3	2	1
X	**X**	**X**	**0**	**0**	**X**	**X**	**X**	**X**	**X**	**X**

For each field the choice must consider the other CAN messages on the BUS as to guarantee the singularity.

A.6 CAN Protocol

CAN MESSAGES Source:

VMU Powertrain System
SUPERVISOR Eletric Energy Management

Identifier (HEX)	Source	Description	Main Destination
401	VMU	Traction Information	SUPERVISOR
402	VMU	Traction Information	SUPERVISOR
504	SUPERVISOR	Battery Limit and performance request	VMU

The messages actually managed by Ansaldo equipment are reported in the following pages. An explanation about single byte meaning is reported for each message.

VMU Transmission Messages

Message	VMU1
ID	0100 0000 0001 = 401_H
Transmitter	VMU
Timing	100ms

This message communicates the DC-Link Battery Voltage measured by the traction inverter. Also the traction motor speed in term of rpm is communicate. In some applications, the battery current flow is also reported.

BYTE		7	6	5	4	3	2	1	0	BIT
	0	VBATT (low Byte)								
	1	VBATT (high Byte)								
	2	GMOT (low Byte)								
	3	GMOT (high Byte)								
	4	MOTOR-CURR (low Byte)								
	5	MOTOR-CURR (high Byte)								
	6				VSERV	SEQCNT				
	7									

IDENTIFIER	Res.	Unit	Range		Scaling		Explanation
			from	to	from	to	
VBATT	0.01	V	0	600	0	60000	Traction Battery Voltage (DC- Link)
GMOT	1	rpm	0	9000	0	9000	Traction motor speed
MOTOR-CURR	0.1	A	-300	300	-3000	3000	Battery traction inverter current flow.
VSERV	bit		0	1	0	1	Services Battery Voltage 0= 12 V – 1= 24 V
SEQCNT	4 bits						Message counter

The grey fullfill fields are not available in the current application.

VMU Transmission Messages

Message	VMU2
ID	0100 0000 0010 = 402_H
Trasmitter	VMU
Timing	100ms

This message sends some data useful to understand the traction inverter internal status.

BYTE		7	6	5	4	3	2	1	0	BIT
	0	T_MOT								
	1	PACC								
	2	REG_BRAK	KEY_ON		PREC_RUN	PREC_OK	MAIN_OK			
	2				PBRAKE	MODEACT		MODESEL		
	4	EINV								
	5	ETMOT								
	6	ETINV								
	7	EIMOT								

IDENTIFIER	Res.	Unit	Range		Scaling		Explanation
			from	to	from	to	
T_MOT	1	°C	-40	200	0	240	Motor coil head temperature
PACC	.3921	%	0	100	0	255	Accelerator Pedal Value (0 = Unpressed Pedal)
STATUS (*)							Vehicle Status (see succesive note) (1)
PBRAKE	bit						Brake Pedal (1 = Pressed Pedal)
MODEACT			0	3	0	3	Actuated Gear (2)
MODESEL			0	3	0	3	Requested Gear (2)
EINV							Inverter Fault (3)
ETMOT							Motor Temperature Fault (Over Threshold) (3)
ETINV							Inverter Temperature Fault (Over Threshold) (3)
EIMOT							Motor Current Fault (General Fault) (3)

(1) Vehicle Status

When the system is switched on the capacitors inside the inverter are precharged, during this phase PREC_RUN is set to 1. When the pre-charged capacitors reaches the battery voltage the main contactor is closed and PREC_OK = 1 => PREC_RUN = 0.
If the inverter works correctly (no protection active) MAIN_OK = 1.

(2) MODESEL – MODEACT :

MODESEL reports then gear state (1 = reverse, 2 = neutral, 3 = drive), as soon as the needed condition are respected the gear state is actuated and the actual one is reported in MODEACT. Note that the gear change is allowed only if the motor speed is inferior to 200 rpm.

(3) Error code legend

00h	No Error
01h	Open Circuit
02h	Short-circuit to GND
03h	Short-circuit to VBATT
04h	Open/Short-circuit to GND
05h	Open/Short-circuit to VBATT
06h	Max minimum value
07h	Max maximum value
08h	Constant value
09h	Not plausible value
0Ah	Timeout
0Bh	Generic Protection
0Fh	Case not managed

VMU Reception Message from SUPERVISOR

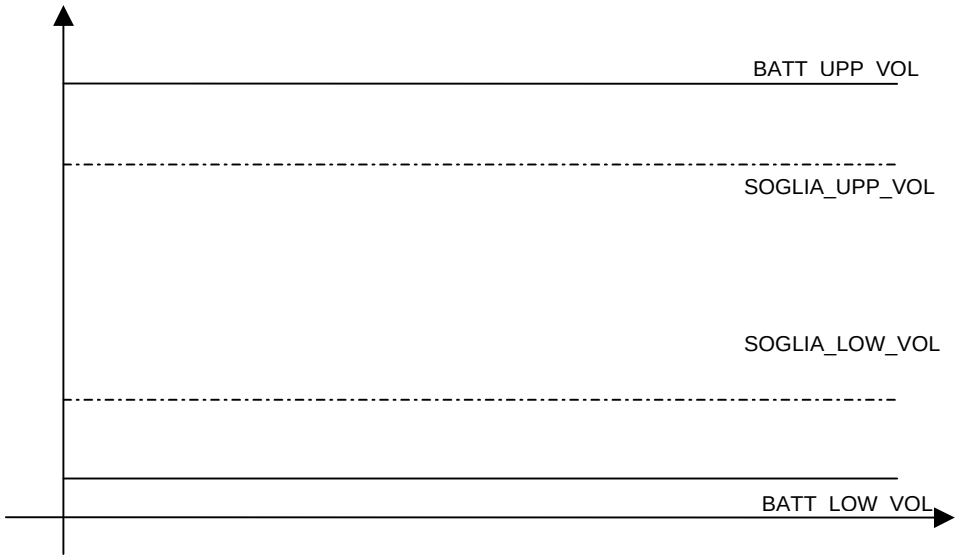
Message	SPV2
ID	0101 0000 0100 = 504_H
Trasmitter	SUPERVISOR
Timing	100ms

BYTE	7	6	5	4	3	2	1	0	BIT
0	BATT_UPP_VOL (low Byte)								
1	BATT_UPP_VOL (high Byte)								
2	BATT_LOW_VOL (low Byte)								
3	BATT_LOW_VOL (high Byte)								
4			INV_EMERG_SD	INV_LH	POWER_LH				
5									
6									
7									

IDENTIFIER	Res.	Unit	Range		Scaling		Explanation
			from	to	from	to	
BATT_UPP_VOL	0.1	V	0	600	0	6000	
BATT_LOW_VOL	0.1	V	0	600	0	6000	
INV_EMERG_SD	bit		0	1	0	1	1 = Emergency shutdown Inverter
INV_LH	bit		0	1	0	1	0 = Reduced Performance, 1 = Normal Condition
POWER_LH	4 bits		1	10	1	10	Reduced Performance Percentage

The grey fullfill fields are not available in the current application.

- The INV_EMERG_SD bit setting causes power inhibition keeping the inverter logic on. To start again, a key-off / key-on procedure must be done.
- The INV_LH signal set to zero causes an inverter power supply reduction;
- After setting the POWER_LH field, when the INV_LH signal is set the inverter decreases the motor mechanical torque using the POWER_LH as reduction percentage where the value 1 means a 10%, 2 =20%…10=100% power reduction
- The battery Voltage regulation strategy works using two additional voltage limits (SOGLIA_UPP_VOL and SOGLIA_LOW_VOL).



The SOGLIA_UPP_VOL and SOGLIA_LOW_VOL values are not sent by the Supervisor as they depend on the type of control implemented and they are calculated as a delta with respect to the Supervisor battery limit. Moreover these value depends also on internal characteristic of the inverter itself.