VARIABLE MOTORS
ELECTRICAL COMPONENTS

DNV BUSINESS ASSURANCE

MANAGEMENT SYSTEM CERTIFICATE

Certificato No. / Certificate No. ***CERT-09505-2001-AQ-BOL-SINCERT***

Si attesta che / This is to certify that

SAI S.p.A.

Via Olanda, 51 - 41122 Modena (MO) - Italy

è conforme ai requisiti della norma per i sistemi di gestione:
has been found to conform to the management system standard:

UNI EN ISO 9001:2008 (ISO 9001:2008)

Questa Certificazione è valida per il seguente campo applicativo:
This Certificate is valid for the following product or service ranges:

Progettazione, produzione e assistenza di motori idraulici e motori a ruota
(Settore EA : 18)

Design, manufacture and servicing of hydraulic motors and drive units
(Sector EA : 18)

Data Prima Emissione/Initial Certification Date:

2001-11-15

Il Certificato è valido fino al:
This Certificate is valid until:

2016-11-15

L'audit è stato eseguito sotto la supervisione di/
The audit has been performed under the supervision of

Luca Catellani
Lead Auditor

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

SGQ N°003 A PRD N°003 B
SGA N°003 D SSI N°002 G
SCR N°004 F FSM N°001 I

Membro di MLA EA per gli schemi di accreditamento SGQ, SGA, PRD, PRS, ISP e LAB,di MLA IAF per gli schemi di accreditamento SGQ, SGA, SSI, FSM e PRD e di MRA ILAC per gli schemi di accreditamento LAB

Luogo e Data/Place and Date:

Vimercate (MB), 2014-10-09

Per l'Organismo di Certificazione:
For the Certification Body:

Zeno Beltrami
Management Representative

La validità del presente Certificato è subordinata al rispetto delle condizioni contenute nel Contratto di Certificazione.
Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.

VARIABLE MOTORS ELECTRICAL COMPONENTS

TECHNICAL CATALOGUE

INDEX

INTRODUCTION TO THE CATALOGUE AND USED SYMBOLS

This catalogue consists of:
A topic index;
An introduction page;
Texts and warnings divided into chapters, paragraphs and subsections.

SYMBOLS INDICATING DANGEROUS SITUATIONS OR VERY IMPORTANT INFORMATION.

...ING!
...tes risky situations for people, refers to accident prevention and suggests behavioral procedures.

NOTE!
...tes useful information for the consultation ... manual and the smooth operation of the ...ne.

GENERAL INFORMATION
Introduction
...carefully and keep this technical catalogue ...afe place. The information in it contained ...ssential to correctly operate with the product.
The manufacturer has designed the components in order to ensure safe usage conditions.

Purpose of the catalogue
This catalogue is aimed at presenting the products in it contained in order to help in the selection of the most suitable component for the ... application.
...ydraulic motors will not be held liable for ...amage, accident or inconvenience resulting from the failure to comply to the instructions given in this manual. SAI will also not be held liable for any modification, variation and/or installation of non-authorized accessories.

g of the catalogue
It is recommended to constantly keep this catalogue updated by adding amendments, updates or modifications made by the manufacturer. New pages will be sent in the event of minor changes and it will be up to the user to integrate them within the catalogue, replacing the existing ones in the related chapters or paragraphs. A revised copy of the catalogue will be sent to replace the existing version in the event of substantial changes to the components. In this case, the old version of the catalogue must be destroyed.

DISPLACEMENT VARIATION THEORY

In SAI motors, the displacement change is done by varying the stroke (2 x e) of the pistons, whilst keeping the bore and the number of "active" pistons unchanged. This makes it possible to change displacement in motion.
The "reaction time", or the time needed to change displacement, is specific for each application. SAI can supply motors with various reaction ti-

The variable displacement version allows the SAI motor to use any displacement between the minimum (which can be 0 cc/rev) and the maximum.
The piston retaining rings ensure the contact between the foot of the piston and the shaft in all working conditions.
SAI variable displacement motors are suitable for both mobile and industrial applications.
The variable displacement motor technology satisfies a wide operation range request. The same power can be utilized at maximum torque with low speed up to maximum speed with low/ me-

$$\text{Displacement} \quad \frac{d^2}{2} = \text{—} \times \pi$$

Where:
d = cylinders bore
nc = number of cylinders
e = eccentricity(= ½ stroke)

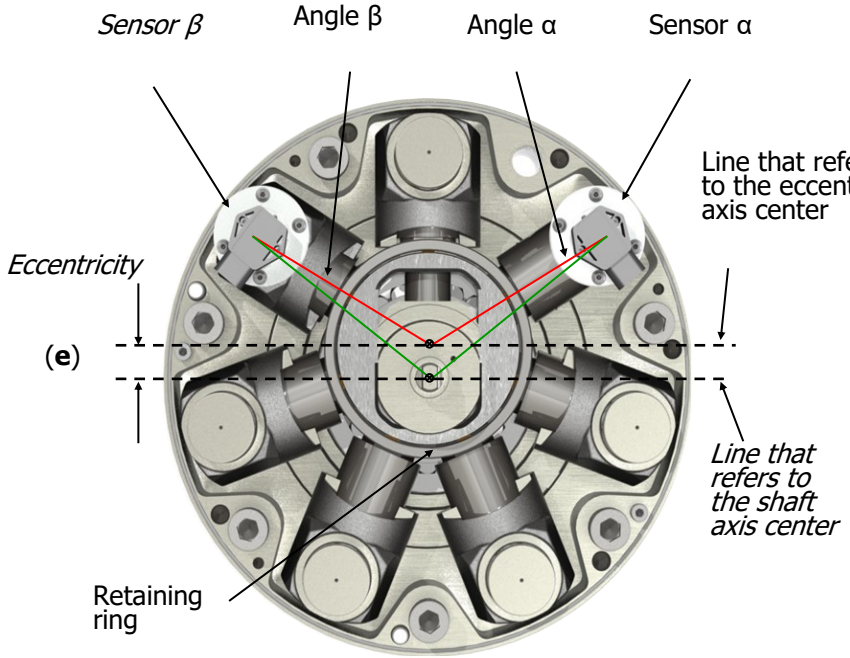


Fig.1: Symbols and nomenclature

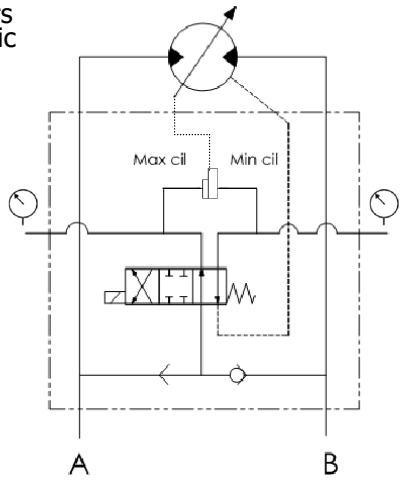


Fig.2: Hydraulic circuit

DISPLACEMENT VARIATION MECHANICAL COMPONENTS

The variation of displacement in a crankshaft design radial piston motor is achieved thanks to two controlled servo pistons (Fig. 3).
The design concept of SAI motors allows an extremely variable movement of the eccentric, thanks to which the motor can operate within a wide displacement range. The variable displacement motor is able to work and maintain a high efficiency level during the variation of the eccentric position, that corresponds to the displacement variation.
The versatility of this motor ensures the fulfillment of the speed and high torque requirements at the most different operating conditions.

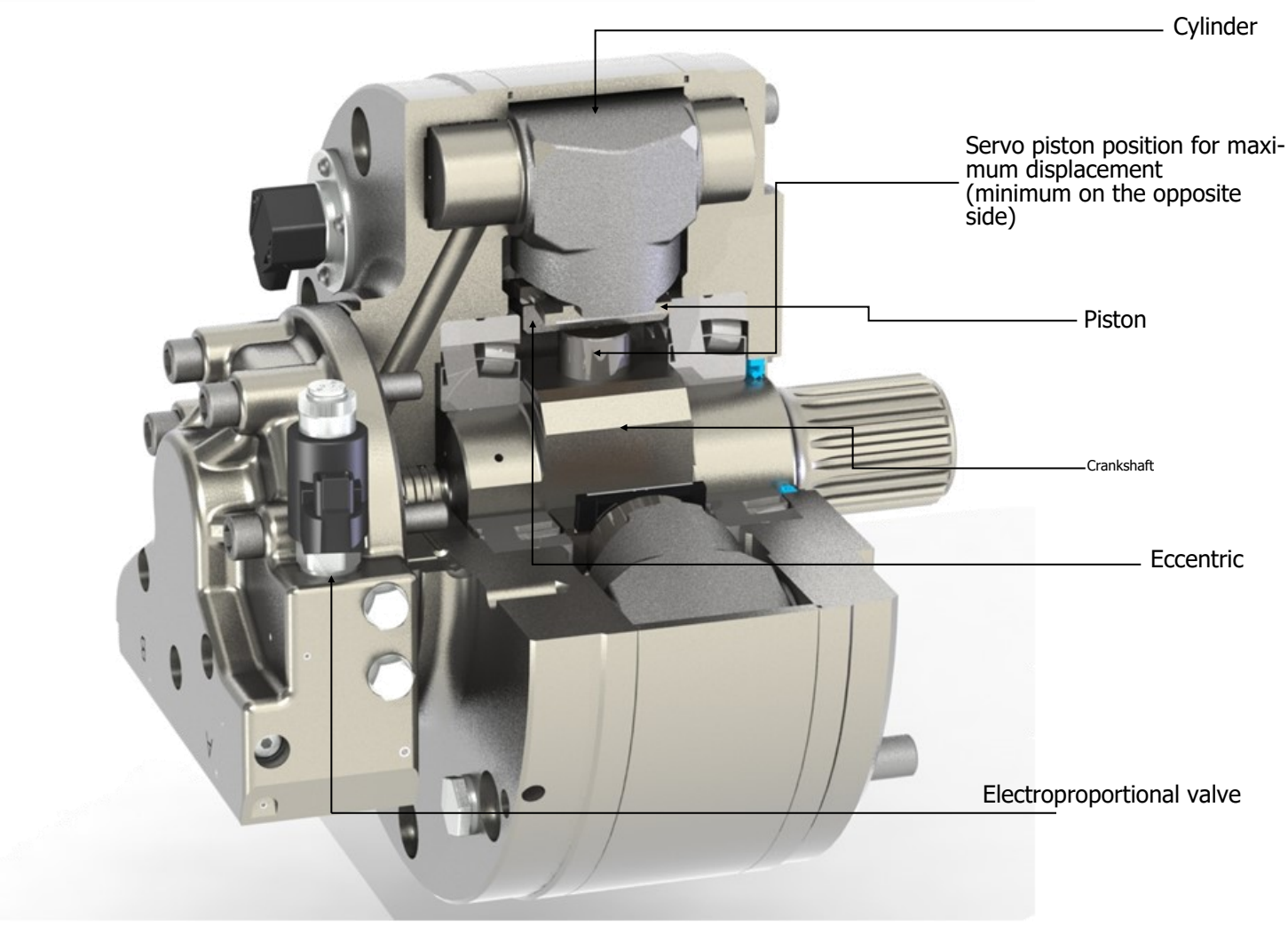


Fig.3: Sectional view

DISPLACEMENT VARIATION ELECTRONIC COMPONENTS

The command of displacement variation is managed by a controller which regulates the electro-proportional valve on the basis of a signal provided by the user through a potentiometer (4)(displacement request). The sensors on the motor send a feedback signal (actual displacement), thus realizing a closed loop control system.

Referring to the figure 4, the angular sensors Alpha and Beta (2), which are positioned on two cylinders, detect the cylinders' angular position with respect to the straight line that intersects the trunnions rotation axis with the shaft axis (see also the Alpha and Beta angles in Fig.1). This allows to determine the value of the eccentricity and consequently the value of the displacement, by using an implemented algorithm in the controller (3).

The process is developed with high acquisition frequency from the controller. This ensures the highest displacement control in all operating conditions.

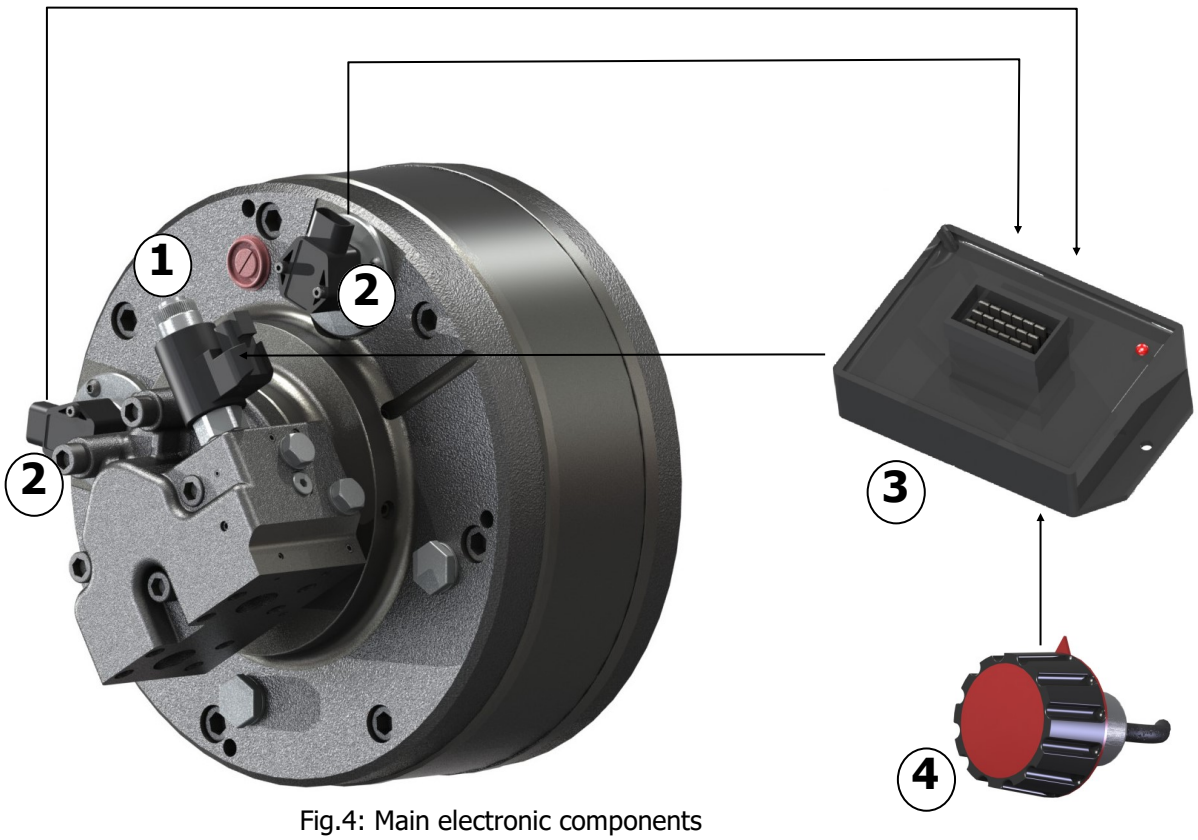


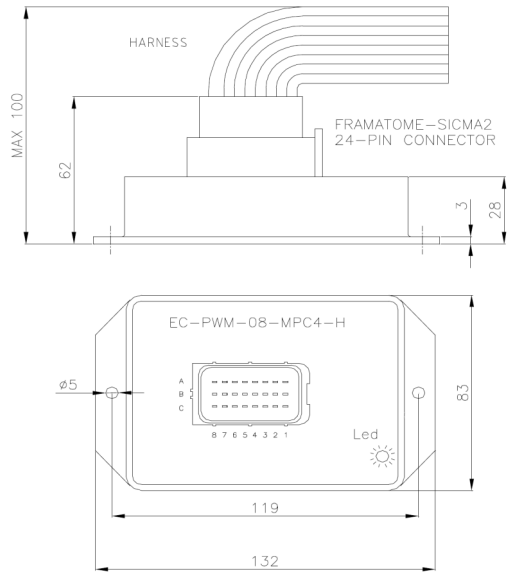
Fig.4: Main electronic components

CONTROLLER CHARACTERISTICS

The controller provides PWM current (Pulse Width Modulated) to the electro-proportional valve and processes the input signal from the potentiometer, PLC or other types of systems.
PWM currents are factory pre-set and cannot be adjusted.
(Any customization must be previously arranged with our Technical Department)

Features:
The current in the valve solenoid is independent from any charge in the coil resistance or in the supply voltage
The inherent superimposed dither frequency helps to overcome friction and static friction effects in the controlled device
The supply line is protected against reversed polarity and reserve load
The inputs are protected against short circuits through ground connection and against power-oversupply
The outputs are protected against short circuits, reversed polarity, over-current and over-temperature
The controller is completely insulated

Specifications:
Controller power supply : 12 o 24 V
Operating voltage: 9 - 30 Vdc
Maximum current consumption: 100 mA (no load applied)
Operating temperature: -40 / +100 °C
Degree of protection: IP67
Analogue inputs: 6 x 0 - 5V
Digital inputs: 2 x PNP (Active High)
Input impedance: 100 kOhm
Typical potentiometer control resistance: 1 - 10 kOhm
Resolution: 10 bits
PWM output channels: 4 x dual-coil electro-proportional valves
Output current range (PWM): 100 - 500 mA
PWM dither frequency: 75 - 250 Hz (factory pre-set, standard 100 Hz)
Each controller is set on its own motor (same serial number)



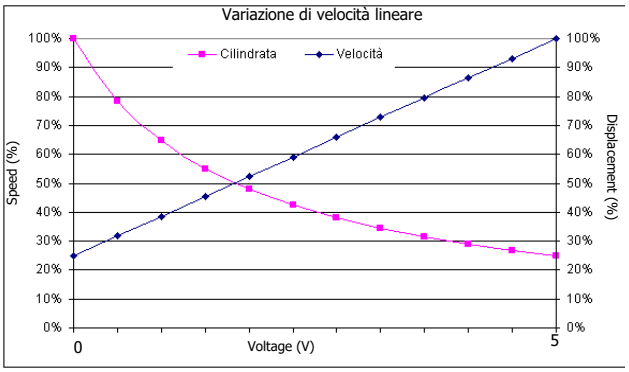
CONTROLLER SET UP

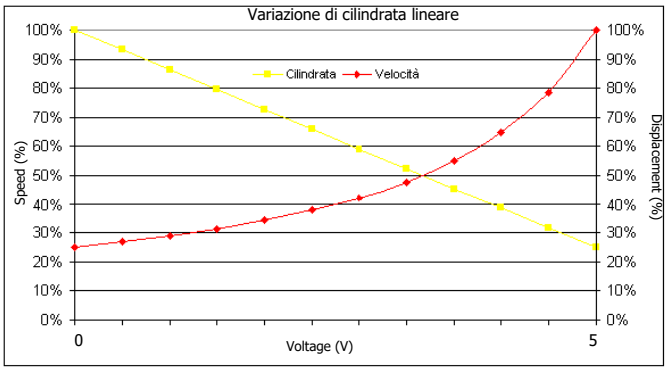
Linear speed variation mode

The linear variation of the input signal from the potentiometer corresponds to a speed linear variation when the input flow remains constant (non-linear displacement curve).

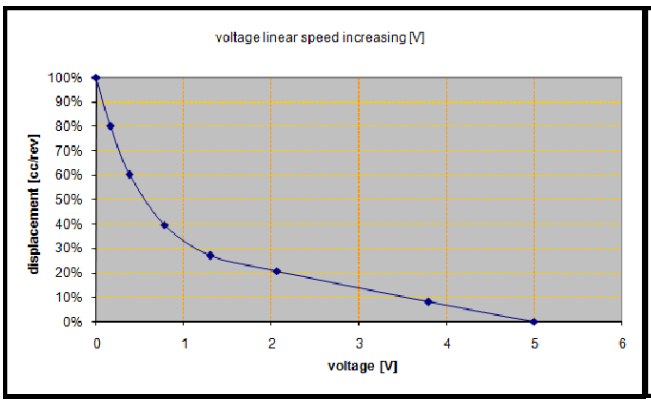
Linear displacement variation mode

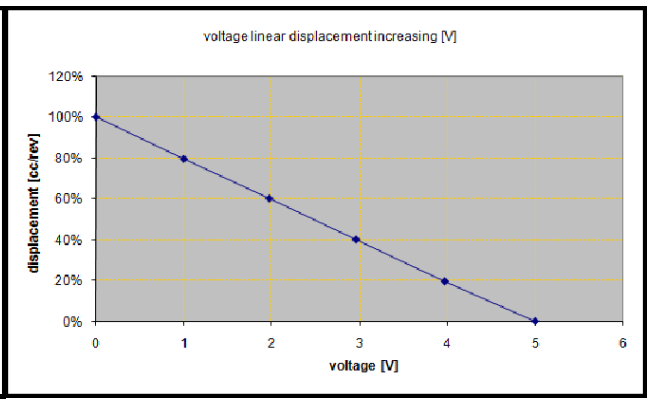
The linear variation of the input signal from the potentiometer corresponds to a linear variation of torque when the input pressure remains constant (linear displacement curve).





To drive multiple motors with one potentiometer it is possible to connect it with various controllers.
It is possible to connect several motors with a unique potentiometer. To this end, it is necessary that each motor's controller is connected to the same power supply.

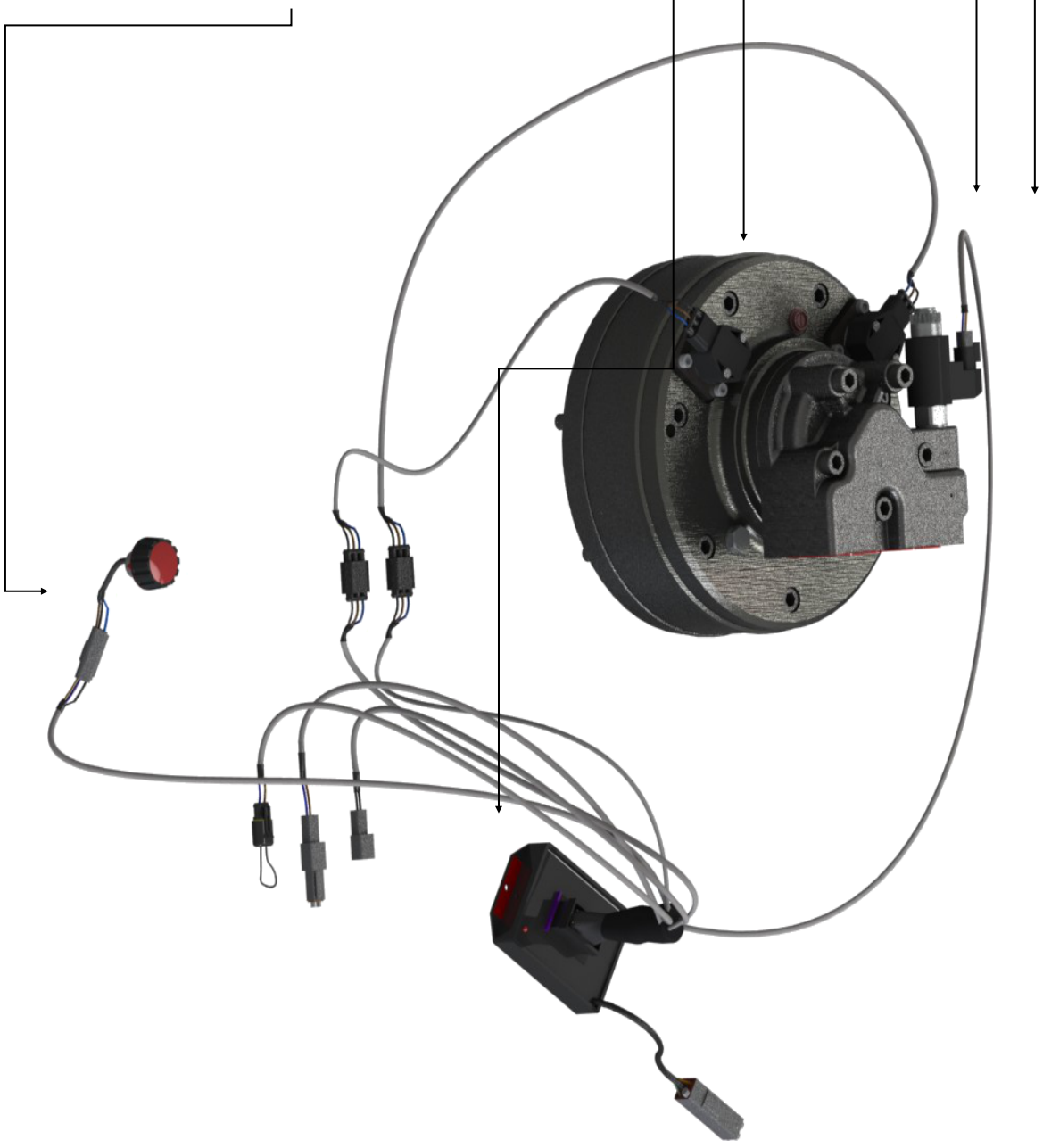




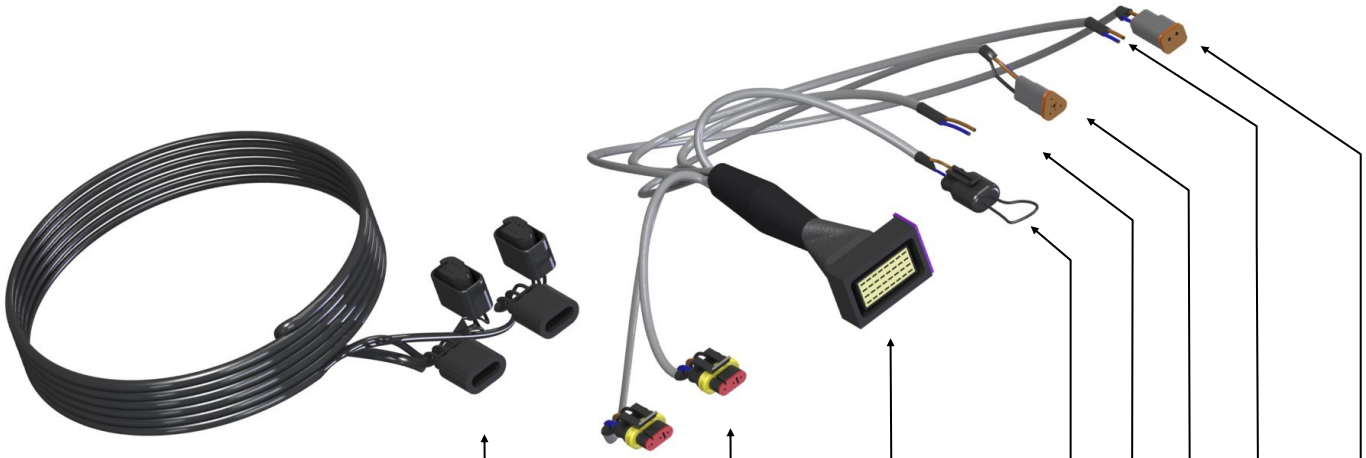
NOTE!
In case you want to control the displacement change with external signal (V) via systems different from the supplied potentiometer, refer anyway to the correlations indicated in the operating mode.

GENERAL CONNECTION

1. Electro proportional valve operated by controller
2. Sngle sensors to measure the angle of oscillation of the cylinders
3. Electronic control used to control the input signal from the potentiometer and from the sensors and control the valve
4. Potentiometer. It allows the user to select the displacement



CABLE CONNECTIONS



Angular sensors extensions

Angular sensors

Controller

Bridge

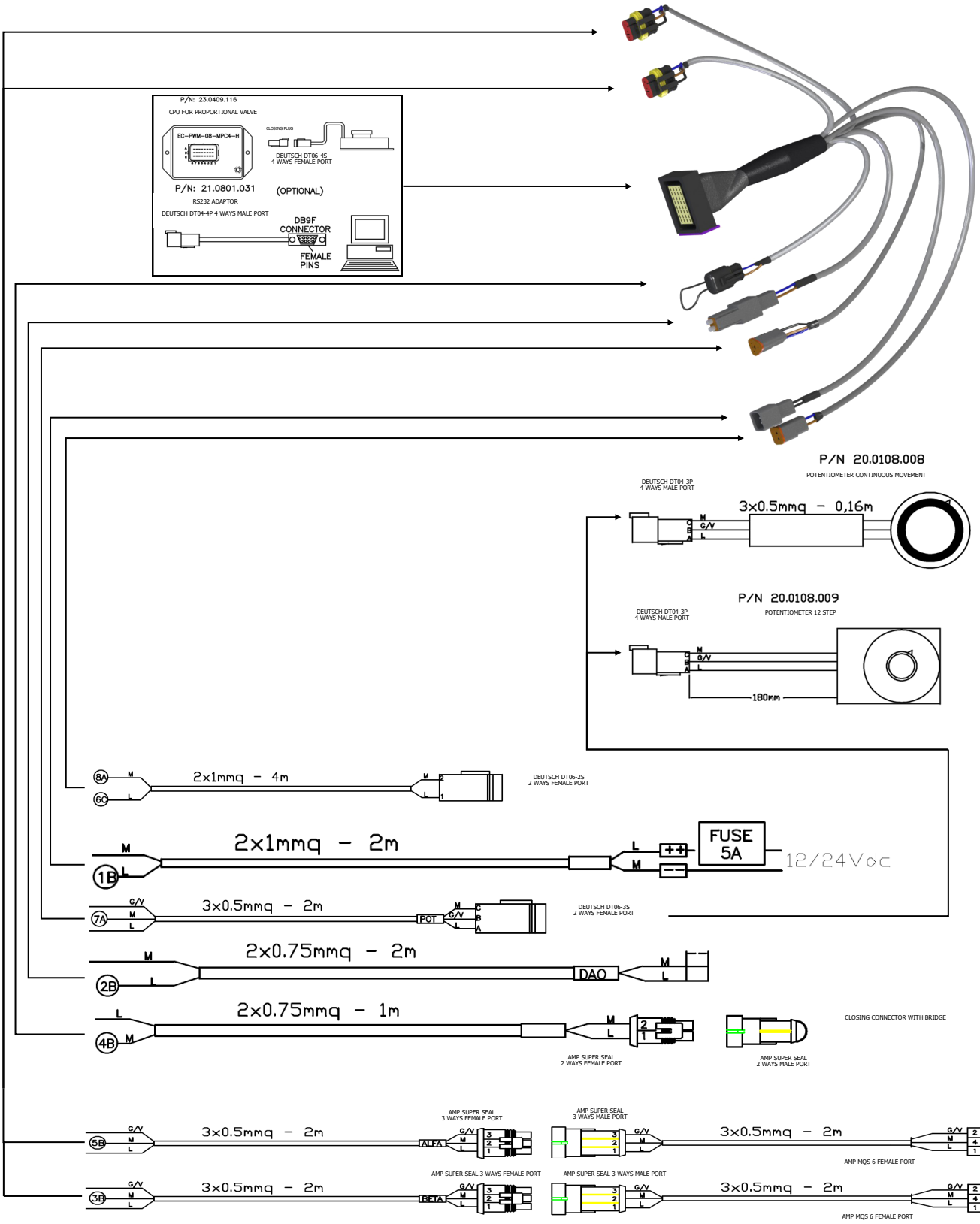
DAO 'uncovered'

Potentiometer

'Uncovered' power supply

Electro-proportional valve

CONNECTION CABLES CHARACTERISTICS



ELECTRONIC COMPONENTS - BV SERIES

0010060080 KIT CTRL-E 5C CB001-5-Z LIN.DISPL. standard
0010060082 KIT CTRL-E 5C CB001-5-Z LIN.SPEED on demand

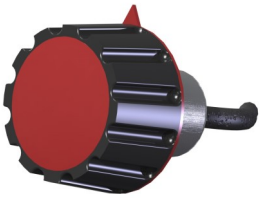
see pag.10

0010060018 Controller

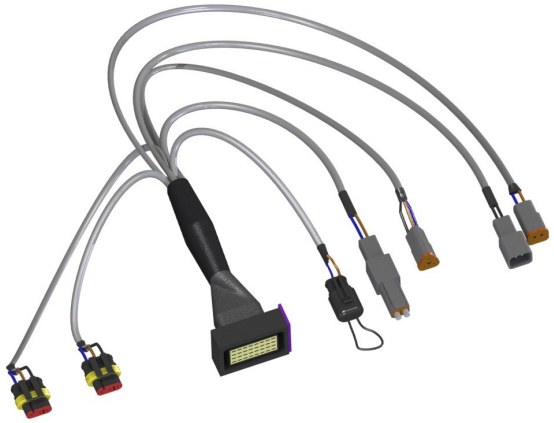
0010013004 Angular sensors

0010025509 Screw hexagonal head 8.8M4.30 UNI5739

0010060010 Potentiometer



010060069 Cables



ELECTRONIC COMPONENTS - TV SERIES

0010060081 KIT CTRL-E 7C CB001-7-Z LIN.DISPL. standard
0010060083 KIT CTRL-E 7C CB001-7-Z LIN.SPEED on demand

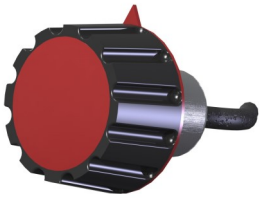
Vedi pag.10

0010060019 Controller

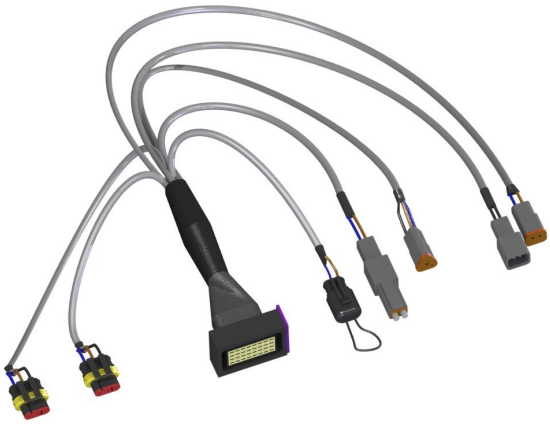
0010013004 Angular sensors

0010025509 Screw hexagonal head 8.8M4.30 UNI5739

0010060010 Potentiometer

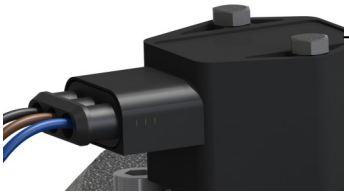


010060069 Cables

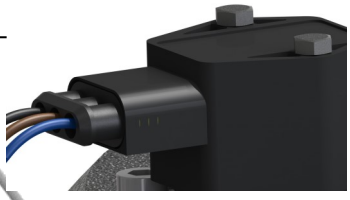


CONNECTIONS BV SERIES

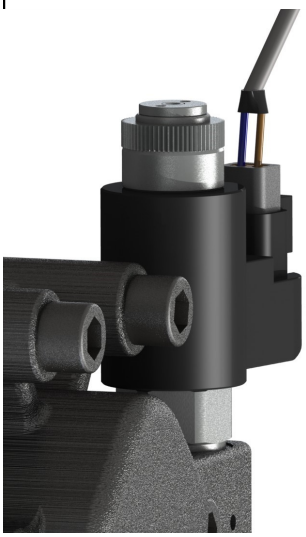
BETA
Angular sensor



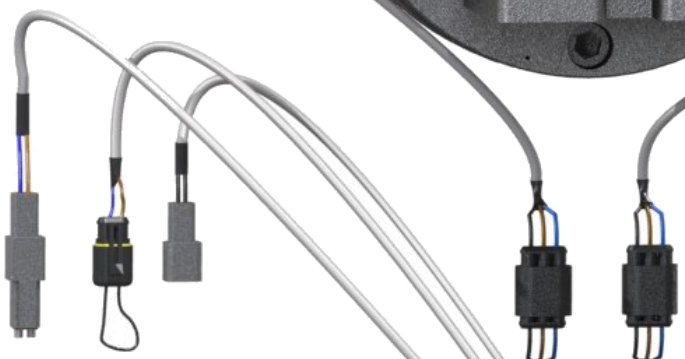
ALPHA
Angular sensor



Electro-proportional valve

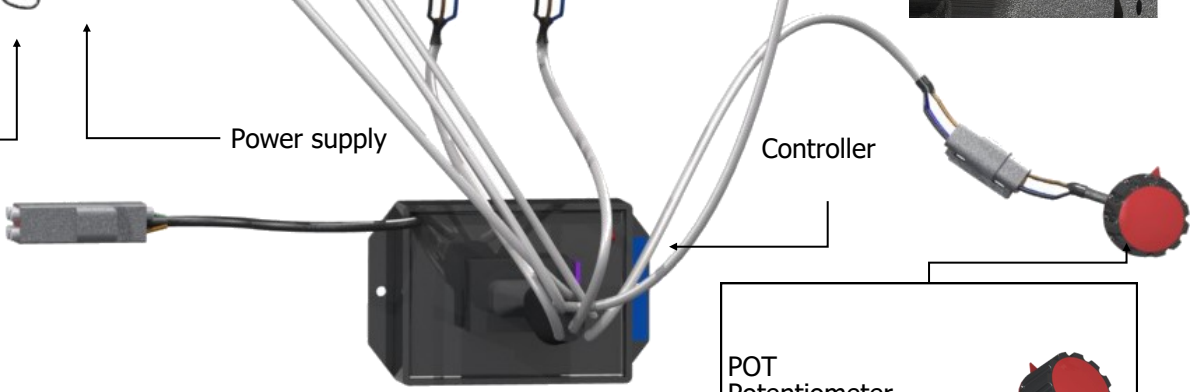


DAO
Displacement visualization

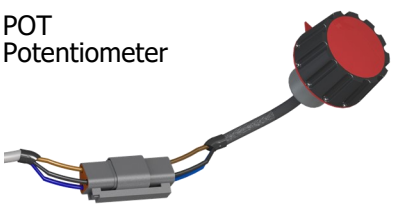


Power supply

Controller

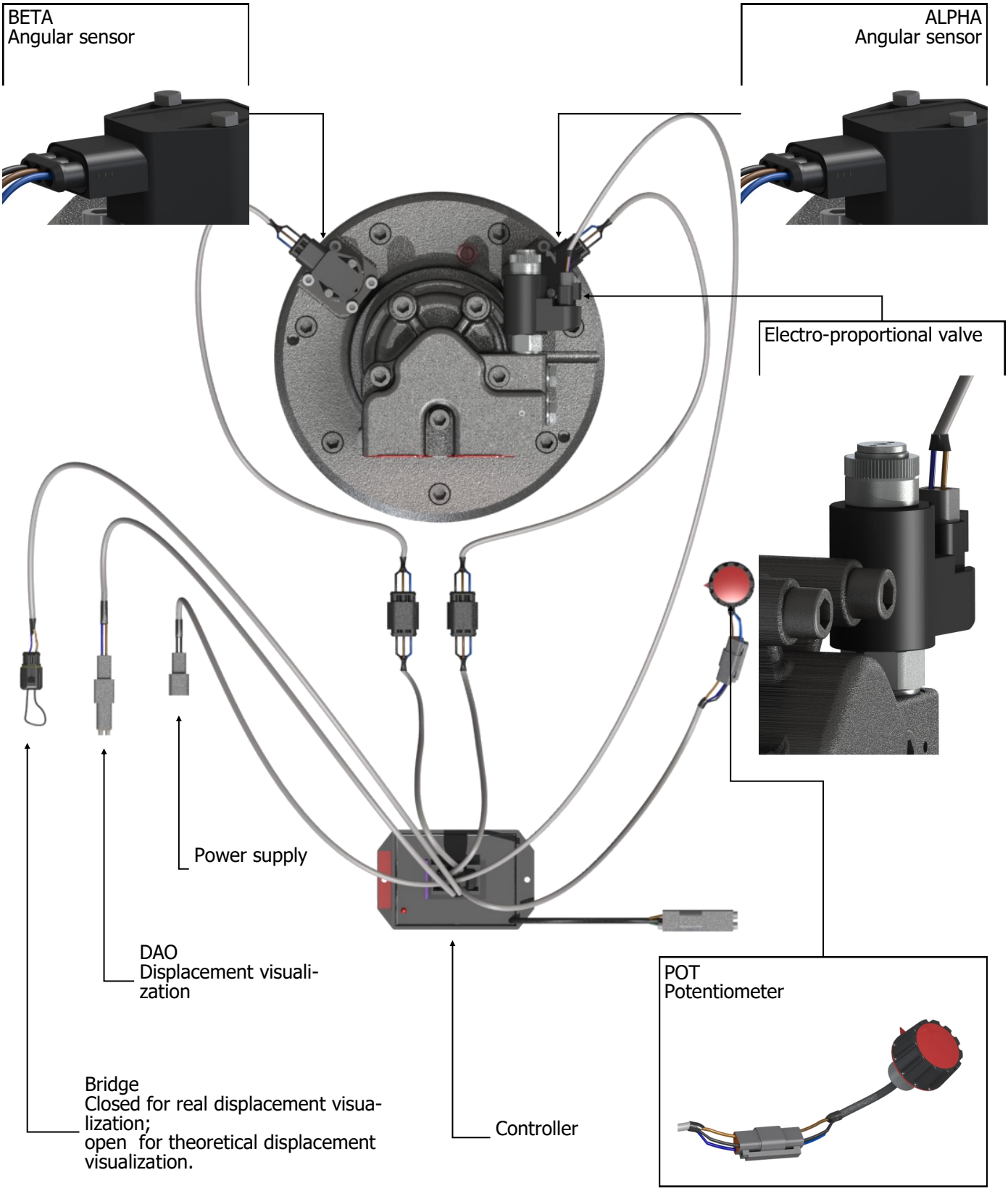


POT
Potentiometer

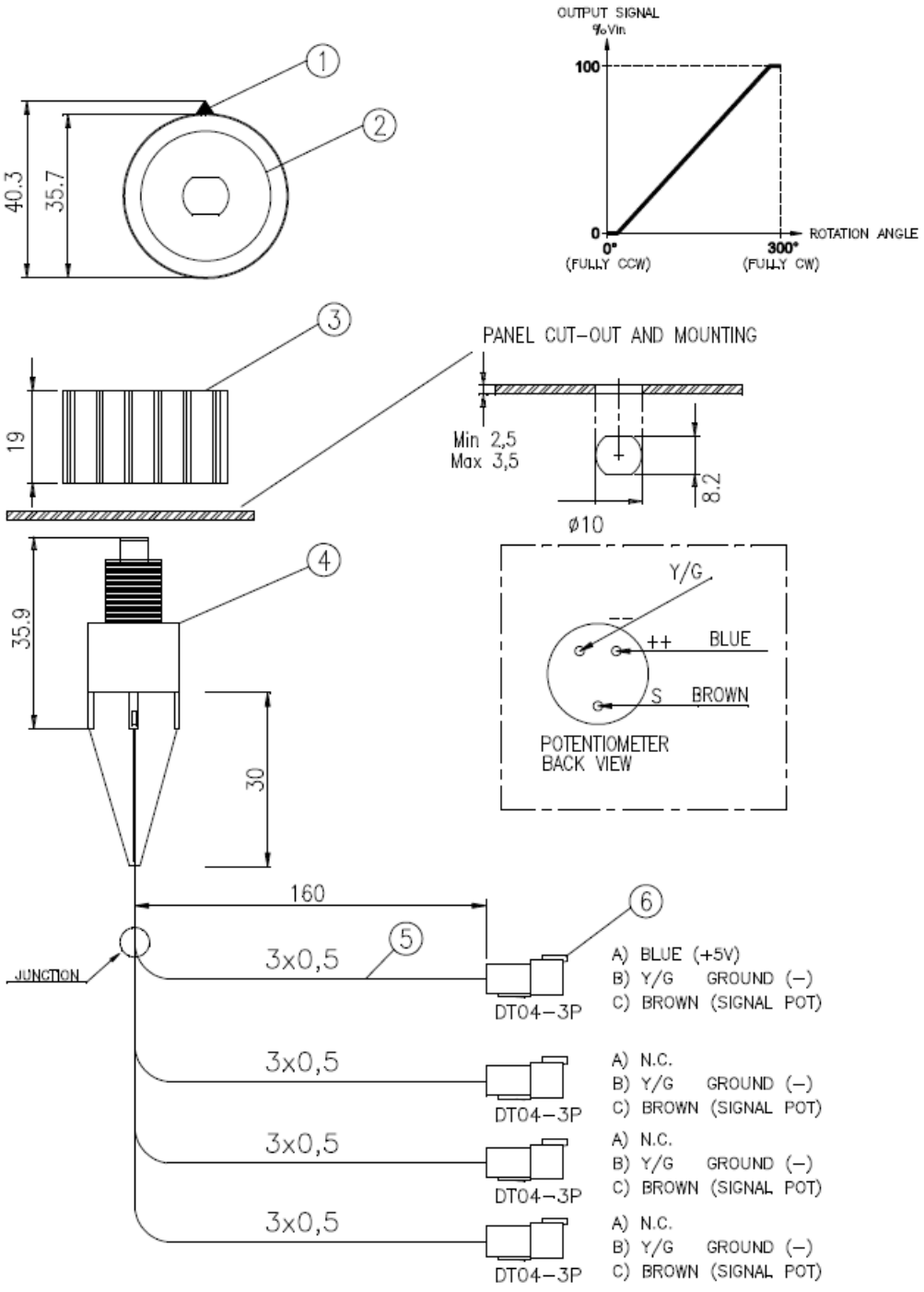


Bridge
Close for real displacement visualization; open for theoretical displacement visualization.

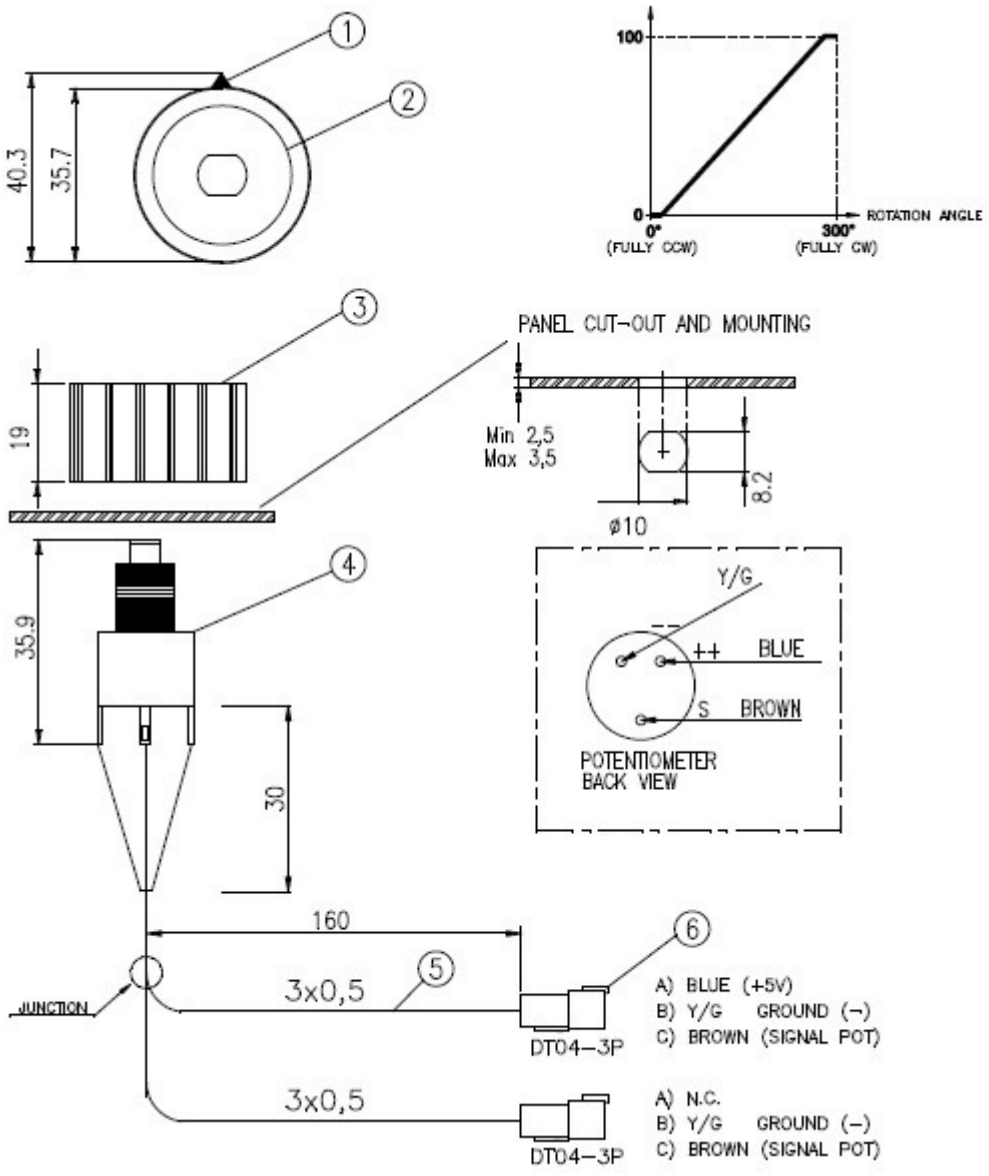
CONNECTIONS TV SERIES



CONNECTION OF A SINGLE POTENTIOMETER FOR THE CONTROL OF 4 MOTORS



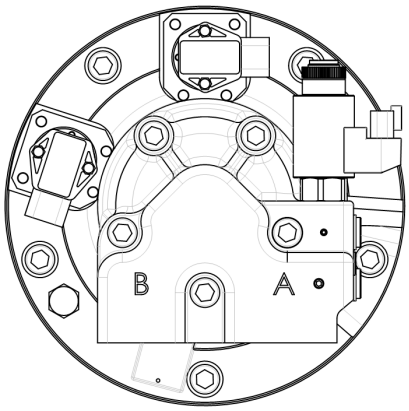
CONNECTION OF A SINGLE POTENTIOMETER FOR THE CONTROL OF 4 MOTORS



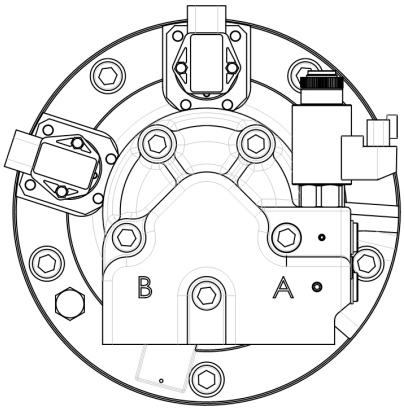
SENSOR POSITIONS

BV SERIES

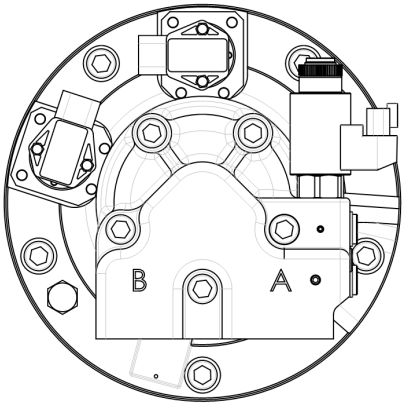
Position #1 (Standard)



Position #2

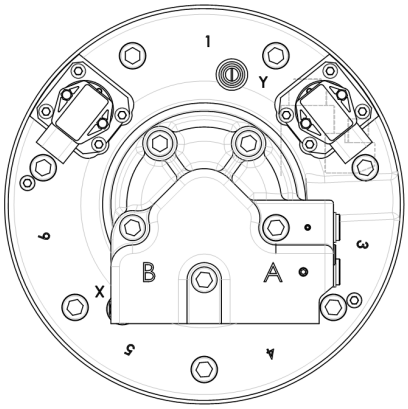


Position #3

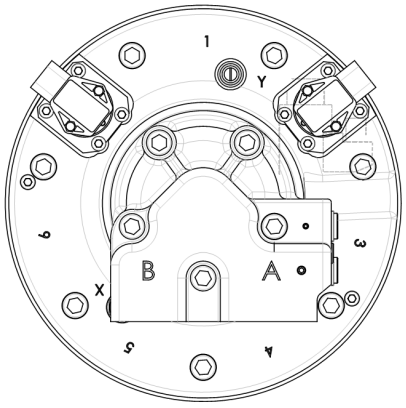


TV SERIES

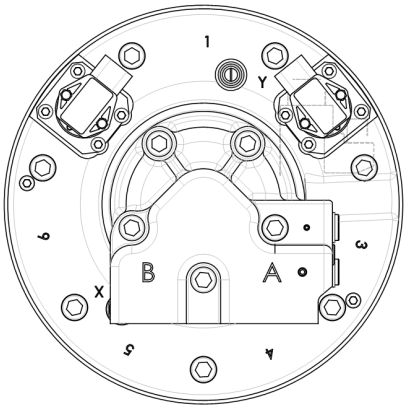
Position #1 (Standard)



Position #2

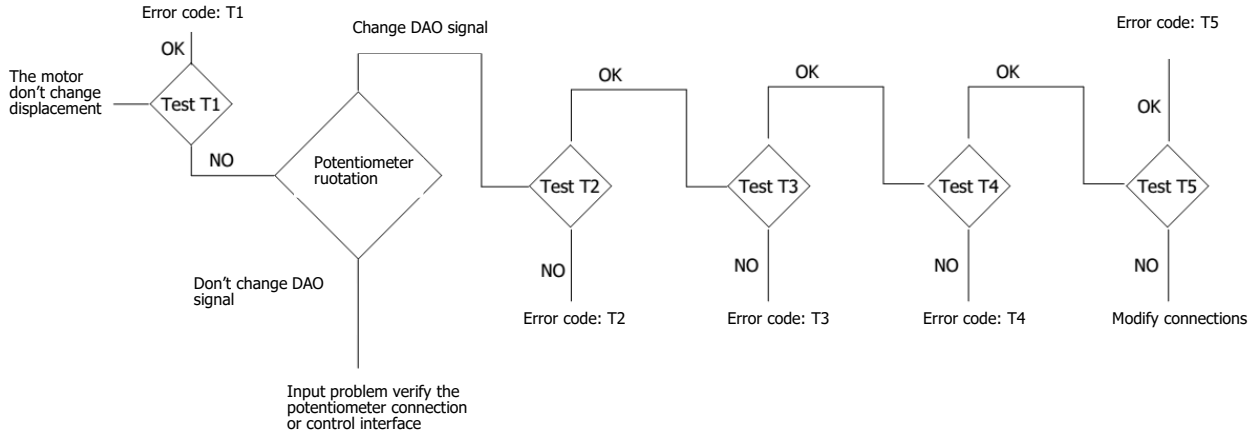


Position #3



NOTE!
The sensor positions #2 are not recommended because they are more subjected to shocks and accidental damages; tampering or damages to the sensors may cause incorrect operation of the motor.

PROBLEM-SOLVING



Before starting:

Tests have to be performed in low power conditions or with free shaft

If a high and continuous drainage flow is detected during the tests, stop the procedure and contact your SAI's reference sales engineer

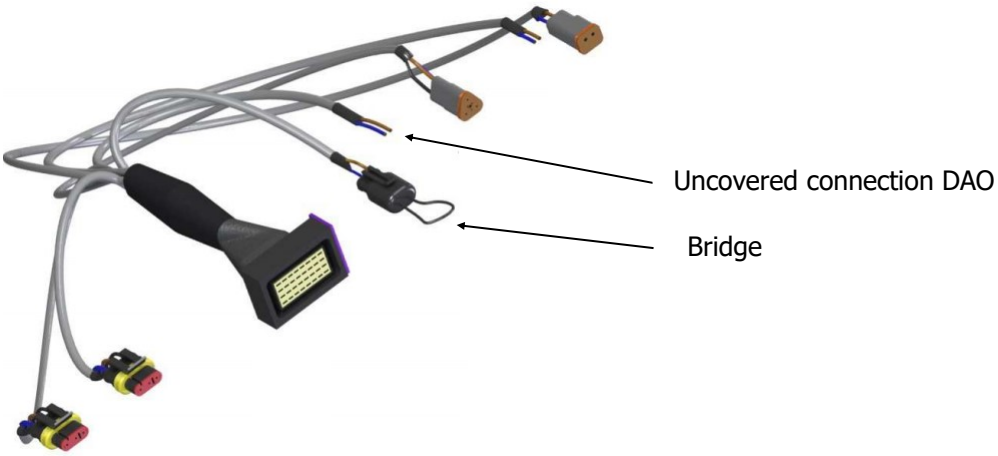
<u>T1 – DAO Test</u>

The DAO connection allows to check the two signals named DAO_{open} and DAO_{close}; both signals are between 0.5V (maximum displacement) and 4.5 V (minimum displacement).

DAO_{open} : signal detected with opened bridge
DAO_{close} : signal detected with closed bridge. Fluctuation of ±0.5V can be accepted.

DAO_{open} specifies the displacement that the control box (i.e. potentiometer) seeks, DAO_{close} specifies the displacement read by the angular sensors (i.e. real displacement).

The signals can be read with a tester connected to the DAO port; tester have to be set in the range of 0.5 V – 4.5 V or closest.

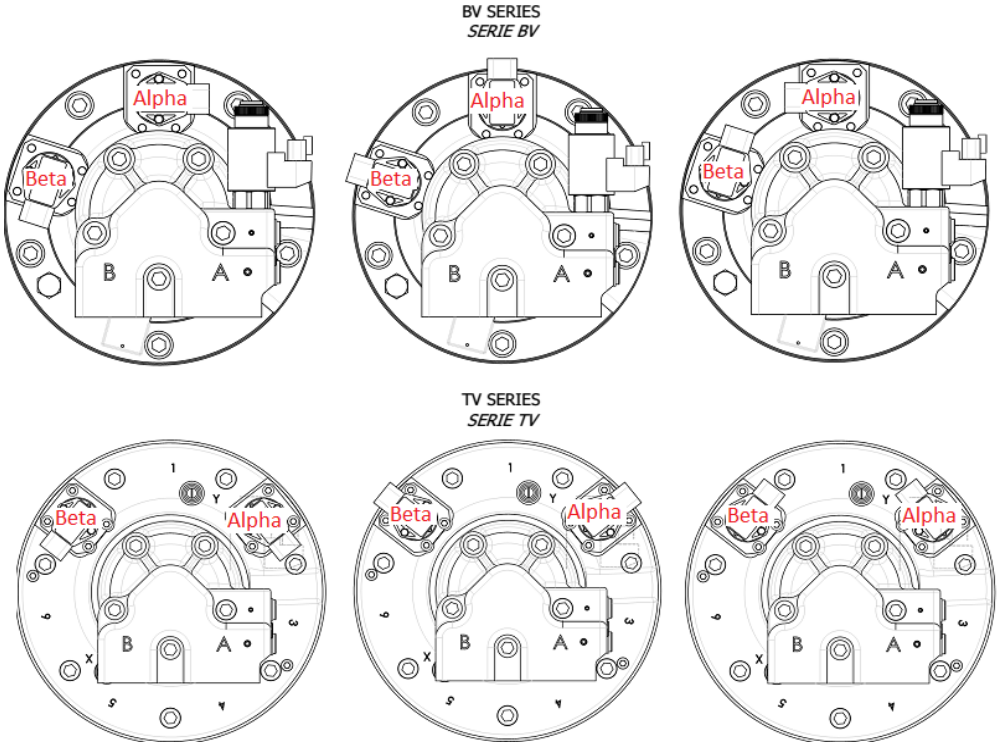


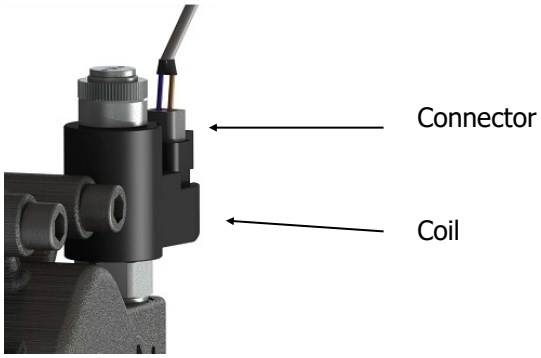
Tests

T1.1 - DAO_{open} and DAO_{close} signals have to be equivalent

T2 – Connections test

The Alpha and Beta sensors' connections to and the proportional valve's connections have to be checked in order to have a good motor functioning. Alpha and Beta sensors have to be installed properly on the motor cover and associated with the right cables; cables have to be securely connected to the control box.



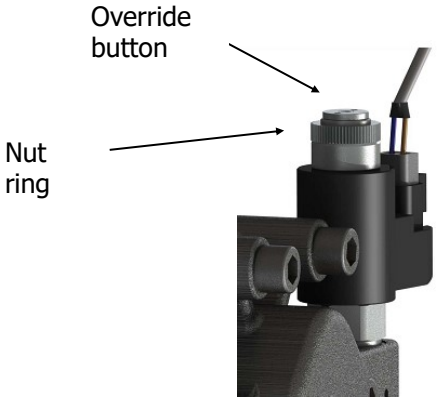


Tests

T2.1 – Alpha and Beta sensors must be securely assembled with the plastic connectors
T2.1 – Alpha and Beta sensors must be associated with the right cables (see label on the cables)
T2.3 – Alpha and Beta sensors' cables must securely assembled with the control box
T2.4 – The proportional valve's coil must be securely assembled with the plastic connector
T2.5 – The proportional valve's cable must securely assembled with the control box
T2.6 – Switch off the current; the motor should shift at maximum displacement.

T3 – Valve and coil test

The coil current feeding must be checked to guarantee a good motor functioning; T3 test allows to detect feeding's malfunction.



Tests

T3.1 – Move the potentiometer to the minimum position and verify that the proportional valve is feeded with current placing a tester between plastic connector and coil.

If a tester is not available, unscrew the nut ring and continue as follows

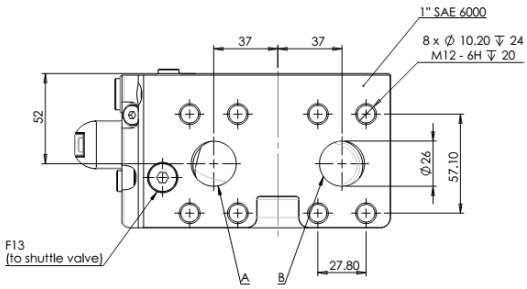
T3.1B – Move the potentiometer to the minimum position and try to lift the coil (without extracting it completely) from the valve; repeat with the potentiometer in maximum position. The opposition force of the coil should be less in the second case.

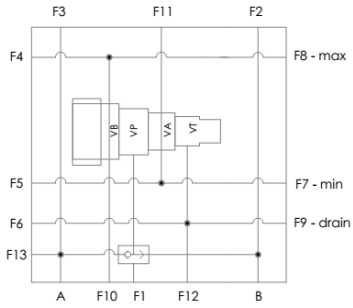
Restore the coil position and secure the nut ring (3-4 Nm)

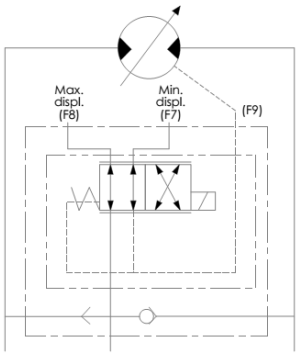
T3.2 – Push the override button placed in the top of the valve, motor should change the displacement. Release the button; the motor should shift to the previous displacement and the button should return to the previous position.

T4 – Distributor test

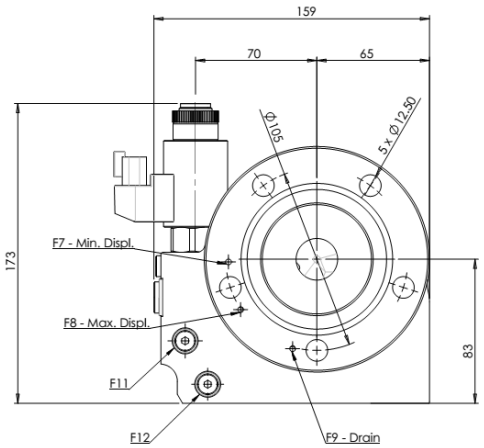
The T4 test detects malfunctions on the hydraulic connection between the distributor and the motor cover.

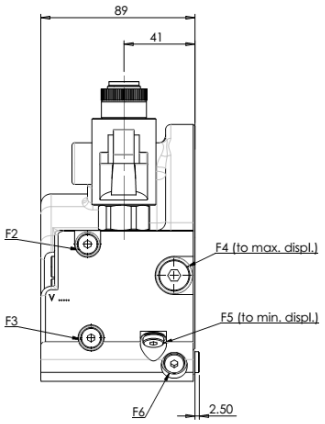


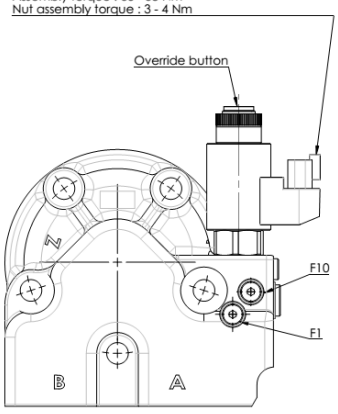


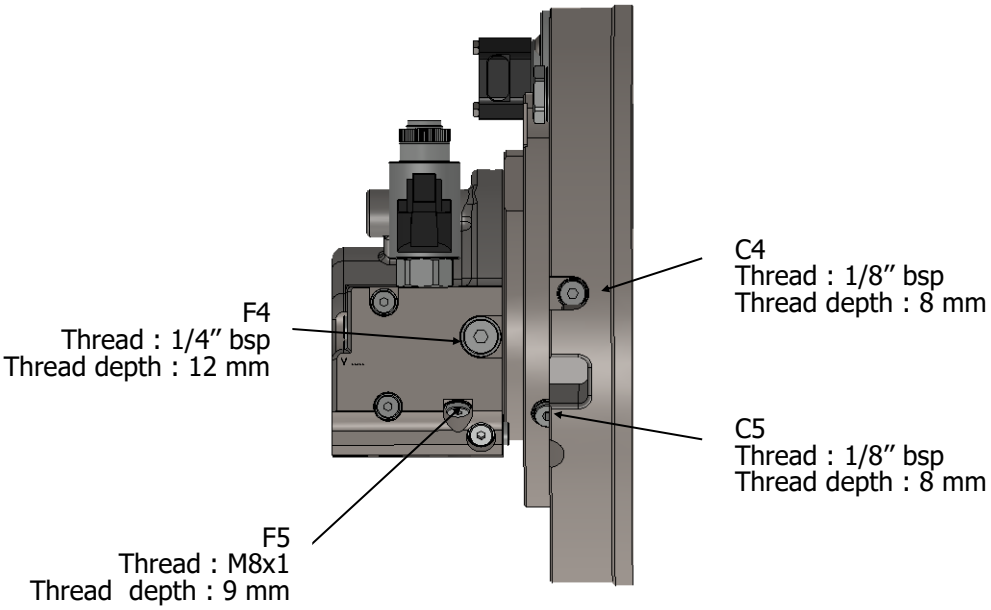


Electrical proportional valve for variable displacement
Nominal power : 20W
Voltage : 12V
Resistance at 20°C : 7.2 Ohm
Override : mechanical
Environment protection : IP67
Connection : DEUTSCH DT042P
Assembly torque : 35 - 38 Nm
Nut assembly torque : 3 - 4 Nm









Le prove necessitano un manometro collegabile a F4, F5, C4, C5

Tests

T4.1 – Unscrew F4 plug. Move the potentiometer to the minimum position and the manometer in F4. Manometer pressure should be equal to the input motor pressure. Screw the F4 plug.

T4.2 – Unscrew C4 plug. Move the potentiometer to the minimim position and the manometer in C4. Manometer pressure should be equal to the input motor pressure and equal to F4 pressure. Screw the C4 plug.

T4.3 – Unscrew F5 plug. Move the potentiometer to the minimim position and the manometer in F5. Manometer pressure should be equal to the case pressure. Screw the F5 plug.

T4.4 – Unscrew C5 plug. Move the potentiometer to the minimim position and the manometer in C5. Manometer pressure should be equal to the case pressure and equal to F5 pressure. Screw the C5 plug.

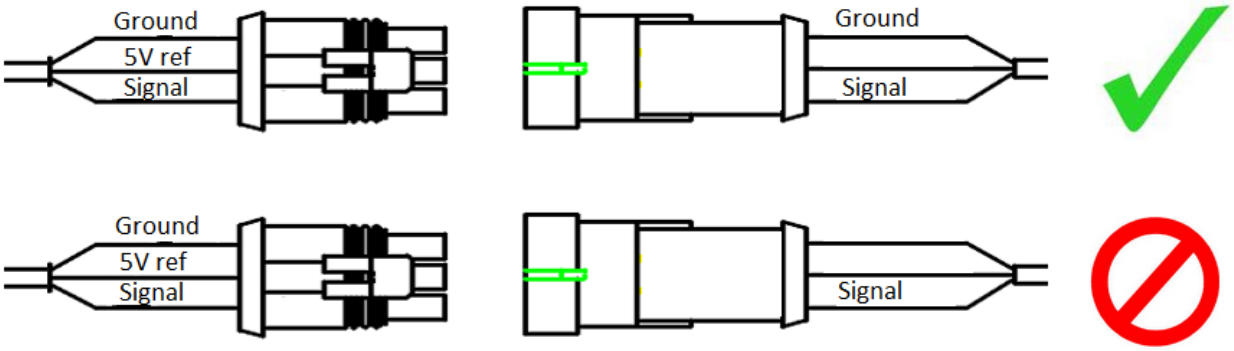
T4.5 – Unscrew F4 plug. Move the potentiometer to the maximum position and the manometer in F4. Manometer pressure should be equal to the case pressure. Screw the F4 plug.

T4T4.6 – Unscrew C4 plug. Move the potentiometer to the maximum position and the manometer in C4. Manometer pressure should be equal to the case pressure and equal to F4 pressure. Screw the C4 plug.

T4.7 – Unscrew F5 plug. Move the potentiometer to the minimum position and the manometer in F5. Manometer pressure should be equal to the input motor pressure. Screw the F5 plug.

T4.8 – Unscrew C5 plug. Move the potentiometer to the minimim position and the manometer in C5. Manometer pressure should be equal to the input motor pressure and equal to F5 pressure. Screw the C5 plug.

T5 – Ground test (only if cables have been extended or PLC instead of the potentiometer)
In case of cables' extension or substitution of potentiometer with PLC, reference ground must be the control box one.



In case of connections' extension, respect specifications written on the cables.

SENSOR ZERO ACQUISITION THROUGH ELECTRONIC UNIT

System correctly running LED is flashing in the following way in case all is ok (red LED is switched off for 250msec every 3 sec)

In case of problems LED flashes in the following way, showing code numbers

Alarm code 1	
Alarm code 2	
Alarm code 3	
….	….

Alarm code	Description
1	Zero acquisition: waiting phase in which sensor must be reconnect after electronic unit has been powered up with sensors disconnected
2	Zero acquisition: acquiring running
3	Zero acquisition: acquisition finished but potentiometer not in neutral, put potentiometer in neutral to re-enable unit
4	Alpha or beta sensor opened (signal less than 0.44V)
5	Alpha or beta sensor shorted to power supply (signal larger than 4.55V)
6	Driver alarm
8	Error acquisition Zero: both alpha and beta signals are over 4.5V or below 0.5V
9	Error acquisition Zero: both alpha and beta signals have span less than 1.33V (10°)
10	Error acquisition Zero: both alpha and beta zero are outside 2.5V ± 0.3V range
11	Error acquisition Zero: alpha signal is over 4.5V or below 0.5V
12	Error acquisition Zero: beta signal is over 4.5V or below 0.5V
13	Error acquisition Zero: alpha signal has span less than 1.33V (10°)
14	Error acquisition Zero: beta signal has span less than 1.33V (10°)
15	Error acquisition Zero: alpha signal zero is outside 2.5V ± 0.3V range
16	Error acquisition Zero: beta signal zero is outside 2.5V ± 0.3V range
20	Number of cylinder wrong

SENSOR ZERO ACQUISITION THROUGH ELECTRONIC UNIT

The new generation of control units, recognizable by the white band, are able to perform auto-zero and diagnostic errors. If it is necessary, proceed as follows:

1. Check and verify the motor is rotating
2. Switch off power supply
3. Disconnect both sensors
4. Put potentiometer in the position of maximum displacement (in case PLC or another electronic unit supplies the control signal, it should be put at the value corresponding to maximum displacement, i. e. 0 V)
5. Switch on power supply, electronic unit will have LED showing code 1: that corresponds to waiting phase before starting real acquisition phase
6. Quickly reconnect both sensors (before acquiring phase starts the is 30 sec of time)
7. After 60 sec, LED will show code 2: it means that electronic unit is acquiring alpha and beta values
8. At the end of acquiring phase (30 sec), LED will display system is correctly running code (switched on for 3 sec followed by a short with a short switch of and so on) or an error code depending on alpha and beta acquired value.

NOTES

NOTES

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