MOOG

DBS

User's Manual

DBS - USER'S MANUAL

Rev.	Date	Description	Updated Pages
0	Jan/96	Initial Release	
1	26/Feb/96	Add Section #6 (Block Diagram); correct resolver connections; correct miscellaneous errors	1, 3, 4, 6, 8, 10, 13, 14, 15, 16, 17, 18, 21, 29, 42, 66, 67, 68, 69, 70, 76, 77, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92
2	15/Mar/96	Add Section #7; add Fig. 1.2 (Component Identification); update defaults for demagnetization parameters; add Fig. 3.1 (acceleration/deceleration); update IT table; correct miscellaneous errors	1, 5, 6, 16, 21, 29, 31, 32, 36, 42, 48, 49, 50, 53, 54, 93, 94, 95
3	2/May/96	Correct resolver wiring; update fuse rating; add pinouts of RS232/RS485 converter; update OC, OV and VO commands; complete Fig.3.2 (Bus Bar 460V); correct miscellaneous errors	7, 8, 9, 10, 27, 28, 29, 46, 47, 64, 69
4	Jan/97	Revised edition	All
5	22/Apr/97	Update standards with EN 61800-3, EMC product standard; add EMC filter for DBS with 24V; delete par.n° from commands; correct miscellaneous errors	I-3, 4, 7, 9, 10; II-3, 4, 9, 11, 12, 15, 16, 18; III-6, 8 to 44; IV-19; V-1, 2, 3, 4, 6
6	25/Jun/97	Add note about DBS special version compatible with condensing atmospheres; update recovery resistor for DBS 15/42; update range of OV command; correct miscellaneous errors	I-3, 4; II-1, 13, 14, 15, 16; III-6, 22, 25, 26
7	10/June/98	Exchange Section V (EMC) with Section III (Commands); update the control card; add default values for keypad setup; update parameters settings for IT protection and for the adjustment of T/S curve; add Fig.4.17 (Runaway); add Par.2.13 (Sizing of PS); add Par.2.14 (Dissipation); correct miscellaneous errors	I-1, 2, 3, 4, 7, 8; II-3, 4, 5, 8, 9, 10, 11, 15, 18, 19, 20, 21, 22, 23, 24, 26; III (ex-V)-1, 3, 7, 8; IV-5, 17, 20; V (ex-III)-5, 6, 14, 18, 19, 27, 28, 29, 30, 32, 33, 34, 38; VI-10; VII-1 to 6
8	19/May/00	Add UL markings; add DBS 100/240, W120/240, 180/320; add rating plate; add new connectors; correct miscellaneous errors	I-1 to 16; II-1, 2, 4 to 32; III-1 to 4, 6, 7; IV-1; V-18, 27; VI-1, 7
9	22/Nov/00	Change Logo; correct miscellaneous errors	I-3, 4, 11; II-4, 10, 21; III-1, 2, 7
10	6/July/01	Update UL markings; correct miscellaneous errors	I-1 to 16; II-2, 4, 11, 12; IV-10
A	3/Oct/01	Add CE requirements; correct miscellaneous errors	I-1 to 16; II-2, 4, 12, 13, 14, 17, 19; III-3, 7

Accident Protection

The safety instructions provided in this Manual are included to prevent injury to personnel (WARNINGS) or damage to equipment (CAUTIONS).
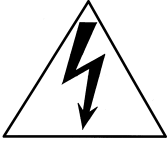
WARNING: High Voltage. Bus Bar's can have voltage ≥810Vdc even after switching off (capacitive voltage).
Discharge Time approx. 6 Minutes.

WARNING: High Voltage. The recovery resistor is connected to the Bus Bar's and can have voltage ≥810Vdc.

WARNING: do not touch recovery resistor during operation to avoid scalds.

CAUTION: make sure that the correct input voltage, 400V or 460V, has been set

CAUTION: it is recommended to disconnect the drive and the EMC filters to carry out the AC Voltage Tests of EN 60204-1 (1997), par.19.4, in order to not damage the Y-type capacitors between phases and ground. Moreover the DC voltage dielectric test required by EN 50178 (1997), product family standard, has been carried out in factory as a routine test. The DC Insulation Resistance Tests of EN 60204-1 (1997), par.19.3, may be carried out without disconnecting the drive and the EMC filters.

CAUTION: when required for an emergency stop, opening U2-V2-W2 pins and closing motor phases to resistors, must be preceded by disabling the axis. The delay time must be at least 30 ms.

CAUTION: in case of repetitive switching on and off, wait 1 minute between off and on.

CAUTION: the cooling circuit of DBS W120/240 must be kept clean. Cooling media must not contain particles that may deposit causing obstruction to cooling circuit. We recommend to check periodically cooling flow.

CAUTION: do not exceed the tightening torque of the table (but see proper data sheets for the tightening torque of input capacitors and power modules and see Section 2 of this Manual for the tightening torque of terminal blocks)

Screw Thread	Tightening torque	
	[Nm]	[lb in]
M3	1.00	8.85
M4	3.00	26.55
M5	6.00	53.10
M6	8.00	70.80
M8	20.0	177.0

EC DECLARATION OF CONFORMITY

The undersigned, representing the following manufacturer

Moog Italiana S.r.l., Electric Division
Via Avosso 94, Casella (Genova), ITALY

herewith declares that the products

Complete Drive Modules series: BRD-4S, DBC III, DBS, DS2000, PDBS Basic Drive Modules series: BRM-4S, DBM 03, DBM 033, DBM 04, Feeding sections series: ADR, BRM-P1, BRM-P2, DBM 03-PS, DBM 033-PS, DBM 04-PS Motor groups series: FAE F/ K/ N/ T/ W, FAS F/ K/ N/ T/ W, FC

are in conformity with the provisions of the following EC directives
(including all applicable amendments)

ref. n°	title
73/23/EEC	Low Voltage Directive
89/336/EEC	EMC Directive

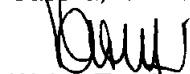**and that the following harmonized standards, or parts thereof, have been applied**

nr	issue	title	parts
EN 60034-1	1998	Rotating electrical machines. Part 1: Rating and performance	
EN 60034-6	1993	Rotating electrical machines. Part 6: IC Code	
EN 60034-7	1993	Rotating electrical machines. Part 7: IM code	
CEI EN 60204-1	1993	Safety of Machinery. Electrical Equipment of machines. Part 1: General requirements	par. 6.2.3, 20.3, 20.4
EN 60529	1991	IP code	
CEI EN 61800-3	1996	Adjustable speed electrical power drive systems. Part 3: EMC product standard including specific test methods	par. 4, 5.3.2, 6.3.2
EN 61800-3 /A11	2000	Amendment A11	

Other references or information required by the applicable EC directives:
The conformity of products is subjected to the installation of filters and to the procedures
included in the proper "Installation Manual". The user has the primary EMC responsibility in
following the recommendations of the manufacturer.

Last two digits of the year in which the CE marking was affixed: 97

Casella, 2/Nov/2000

Walter Tettamanti
GENERAL MANAGER

DEC_SALE.DOC - MOD.176/PMA/4/96

CE Requirements

- **Cautionary Marking.** See previous page.

- **Protection against electric shock**. Electronic Equipment intended for installation in closed electrical operating areas kept locked. The lock shall be only opened by authorized person and the access only allowed to skilled persons whilst energized. Where the equipment requires manual intervention, 412.2.1 of HD 384.4.41 S2 shall be consulted.

- **Fixed connection for protection**. The equipment may have a continuous leakage current of more than a.c. 3.5 mA or d.c. 10 mA in normal use and a fixed ground connection is required for protection.

- **RCD**. A d.c. component can occur in the fault current in the event of a fault connection to earth. Only a residual-current-operated protective device (RCD) of Type B is allowed. When the protection in installations with regard to indirect contact is achieved by means of an RCD, their appropriate function/combination shall be verified.

- **Climatic Conditions.** Equipment intended to operate within its performance specification over the range of Class 3K3, as defined in table 1 of EN 60721-3-1, EN 60721-3-2, EN 60721-3-3, EN 60721-3-4, partly modified.

- **Pollution Degree 2 Installation** - The equipment shall be placed in a pollution degree 2 environment, where normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation is to be expected, when the electronic equipment is out of operation.

- **EMC Requirements.** The installer of the equipment is responsible for ensuring compliance with the EMC standards that apply where the equipment is to be used. Product conformity is subjected to filters installation and to recommended procedures, as from Section 3 of this Manual.

- **Second Environment (EMC)**. Equipment intended to be connected to an industrial low-voltage power supply network, or public network which does not supply buildings used for domestic purposes (second environment, according to EMC Standards).
It is not intended to be used on a low-voltage public network which supplies domestic premises (first environment). Radio frequency interference is expected if used on such a network.

- **Recovery Resistor Cable.** Shielding of the recovery resistor cable, provided in kit for test purposes, is recommended for ensuring compliance with the EMC standards.
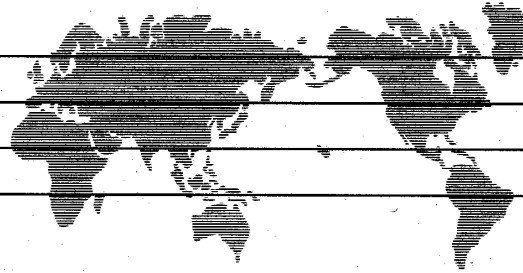
Agrate Brianza, May 30th, 2001

Spett.le
MOOG Italiana S.r.l.
Electric Division
Via Avosso, 94
I - 16015 Casella (Genova) - Italy
Attn.: Mr. Daniele Rolla

Subject : **Listed – Industrial Control Equipment, Open Type Power Conversion Equipment
Brushless Motor Servo-Drives : "DBS Series"**

Ref. : **File E194181 Vol. 1, Sec. 2 - Project 01ME07523 - Report Revision**

NOTICE OF AUTHORIZATION TO APPLY THE UL LISTING MARK
AND UL LISTING MARK FOR CANADA

This letter is sent on behalf of Underwriters Laboratories Inc. pursuant to the Corporate Services Agreement between Underwriters Laboratories Inc. and UL International Italia Srl.

We find that the product is eligible for Listing and Follow-Up Service.

This letter temporarily supplements the UL Follow-Up Services Inspection Procedure and serves as authorization to apply the UL Listing Mark and Listing Mark For Canada to the above product(s).

To provide the manufacturer with the intended authorization to use the UL Listing Mark and Listing Mark For Canada you, the Applicant, must send a copy of this Notice to each manufacturing location covered by the UL Follow-Up Service Procedure, File E194181, Vol. 1, Sec. 2.

This authorization is effective only for 90 days from the date of this Notice. Records covering your product(s) are now being prepared and will be sent to you in the near future.

Products produced which bear the UL Listing Mark and Listing Mark for Canada shall be identical to those, which were evaluated by UL and are found to comply with UL's requirements. If changes in construction are discovered, authorization to use the UL Listing Mark and Listing Mark For Canada may be withdrawn and the products that bear the UL Mark may have to be revised (in the field or at the manufacturer's facility) to bring them into compliance with UL's requirements.

Within Canada, there are federal and local statutes and regulations, such as the Consumer Packaging and Labeling Act, requiring the use of bilingual product markings on products intended for the Canadian market. It is the responsibility of the manufacturer (or distributor) to comply with this law. The UL Follow-Up Service Procedures will only include the English version of the marking.

If we can be of assistance, please do not hesitate to contact the undersigned.

Very truly yours,

REVIEWED BY:

Giuseppe Redaelli
Engineering Services
UL International Italia Srl

Kevin Connelly
Engineering Services
UL International Germany GmbH

A subsidiary of **Underwriters Laboratories Inc. and** **Demko A/S**

UL Requirements

- These Brushless Servo-Drives shall be assembled with the guidelines specified in this Manual. Only the configurations with the components tested and described in the UL Report, file E194181, Vol.1, Sec.2, Issue date 06-09-00 and following Revisions can bear the Listing Mark.

- These drives shall be used within their ratings, as specified in the marking of the equipment.

- **Cautionary Marking.** See Accident Protection page.

- **Surrounding Air Temperature** - *"Maximum Surrounding Air Temperature 40°C".* In the final installation considerations shall be given for the need of repeating Temperature test if the unit is mounted with a different Surrounding Air conditions.

- **Pollution degree 2 Installation** - The drive must be placed in a pollution degree 2 Environment.

- **Environmental designation** - *"Open Type Equipment"*.

- **Short Circuit Ratings**.

  1. DBS 3/9, 6/15, 15/42, 25/70, 35/90, 50/140: *"Equipment suitable for use on a circuit capable of delivering not more than 5000 rms Symmetrical Amperes, 460 V ac +10% maximum"*
  2. DBS 60/180, 100/240, W120/240, 180/320: *"Equipment suitable for use on a circuit capable of delivering not more than 10000 rms Symmetrical Amperes, 460 V ac +10% maximum"*

- **Branch Circuit Protection**. The Branch Circuit Protection for Short Circuit shall be provided in the end-use applications by external R/C Fuses (JFHR2), manufactured by Bussmann Div Cooper (UK) Ltd, Semiconductor fuse type, rated 660 Vac, 200 kA A.I.C., Mod.No. as follows:

  1. DBS 3/9, 6/15, 8/22, 15/42: Mod.No. 50 FE, rated 50 Amps
  2. DBS 25/70, 35/90: Mod.No. 100 FE, rated 100 Amps
  3. DBS 50/140, 60/180: Mod.No. 160 FEE, rated 160 Amps
  4. DBS 100/240: Mod.No. 280 FM, rated 280 Amps
  5. DBS W120/240: Mod.No. 315 FM, rated 315 Amps
  6. DBS 180/320: Mod.No. 500 FMM, rated 500 Amps

- **Overspeed Protection**. The Power Conversion Equipment is incorporating an Overspeed Protection. See MV command in Section 5 of this Manual.

- **Overvoltage Control**. In the equipment the Overvoltage is controlled by a Transient Suppressive device, with 1500 V Clamping Voltage and min 120 J (10x1000 us or 2 ms) Energy Handling Capability. See also "Bus not normal" protection in Section 4 of this Manual.

- **Overload Protection**. The equipment does not incorporate internal overload protection for the motor load. The drive is intended to be used with motors that must have integral thermal protection through a PTC. The overtemperature fault of the drive will trip when the PTC reaches 1.2 kΩ. See J4 connector in Section 2 of this Manual for wiring.

- **Over-Current Protection**. The drive is provided with a current limiting circuitry. See IL and IT commands in Section 5 of this Manual.

- **Wiring**. Wiring shall be made by stranded and/or solid, copper (Cu), 60/75°C (140/167°F) conductor only, and, for terminal blocks, the tightening torque values specified in Section 2 of this Manual shall be applied. These requirements do not pertain to control circuit terminals.

- **Wiring of Recovery Resistor**. The Dynamic Brake Unit Recovery Resistor, when external, shall have the connection wiring made with R/C (AVLV2) or insulated with R/C (YDPU2) or R/C (UZCW2) in the end-use installation.

TABLE OF CONTENTS

SECTION 1 - DESCRIPTION

1.1 Description

DBS servodrives are identified as very high performance converters thanks to a multiprocessor architecture which maximizes the advantages of digital technology: PI regulator for different motors (brushless and induction with both resolver feedback or sensorless), diagnostics, software set up, low speed PC/PLC serial communication, CAN BUS speed reference management. It is a very wide product range (motors up to 75 kW can be fed) with the capabilities to meet any "servo" requirement in conjunction with our FAS, FC and FASY resolver equipped servomotors. DBS is a single axis servodrive with analog (±10V) or digital (CAN OPEN according to CIA DS-402) speed reference.

1.2 General Features

- built-in power supply
- digital speed loop
- sinusoidal current waveform
- SMD technology with boards automatically assembled and tested
- automatic resolver to digital (R/D) resolution switching (from 16 to 10 bit) to achieve high motion accuracy in the whole speed range (from 0 to 10000 rpm)
- 10 kHz switching frequency up to size 50/140 included, 5 kHz for the other sizes
- ambient temperature 0 to +40°C
- storage temperature -25 to +55°C
- maximum case depth 370 mm
- programmable gains of the speed and current loops
- programmable digital filters (see Application Note GB-4522)
- built-in fans with internal power supply
- built-in soft start electronic circuit
- intelligent IGBT (IPM) power bridge
- constant motor torque in the whole speed range thanks to dedicated software algorithm

1.3 Options

- software programmable (from 64 to 16384 pulses per electrical revolution).simulated encoder with marker pulse
- A/D 14 bit converter on the speed reference as alternative to the standard 12 bit version
- 4 arc/min R/D converter resolution
- installation and set up keypad
- PC communication package: see par.2.8.2.1
- 24 Vdc auxiliary power supply voltage
- notch filter software (see Application Note GB-4522)
- high dynamic (HD) special software (see Application Note GB-4526)
- protection for pollution degree 3 or 4 environment (conductive dust or condensation)
- accessible DC-Bus from outside (for energy exchange among drives)

1.4 Dimensions

Fig. 1.1 (dimensions in mm) shows the dimensions and the drilling jig of the drive. Leave a clear space of at least 50 cm (19.7 in) over and under the system for air circulation.

FIG. 1.1   DBS 3/9 to 60/180 - Dimensions and Drilling Jig (Drill For M5 Screws)
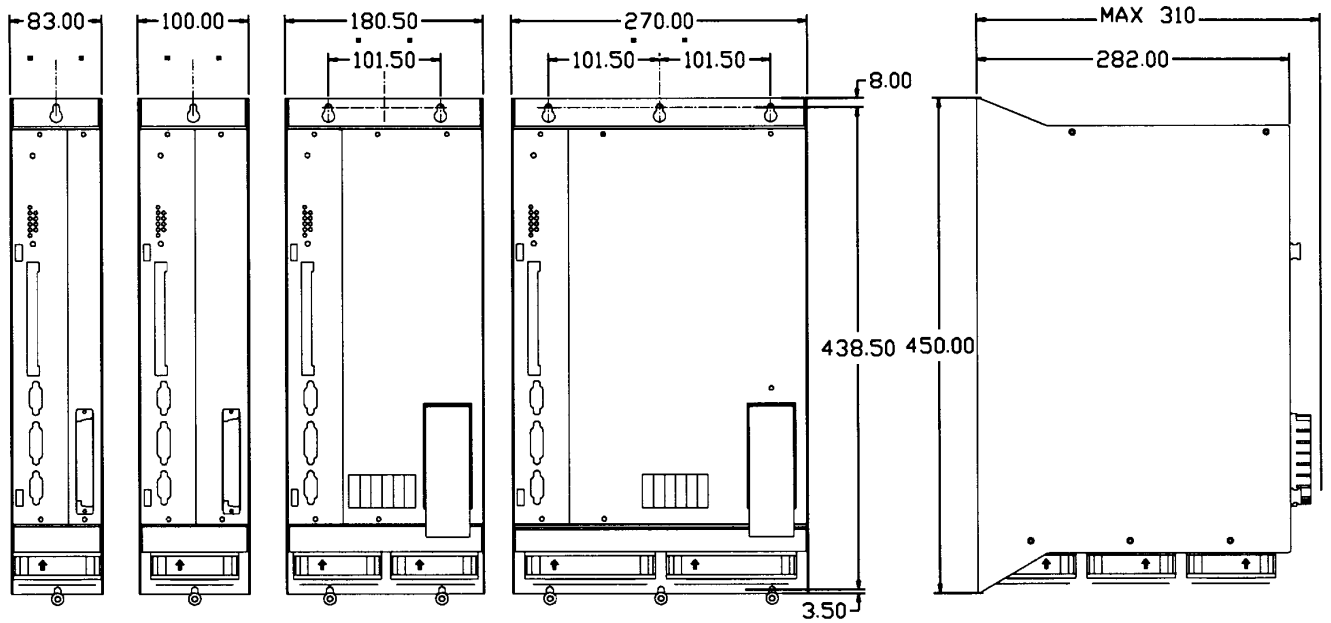
DBS 3/9	DBS 15/42	DBS 25/70	DBS 50/140
DBS 6/15		DBS 35/90	DBS 60/180
DBS 8/22			

FIG. 1.2   DBS 100/240 - Dimensions and Drilling Jig (Drill For M5 Screws)
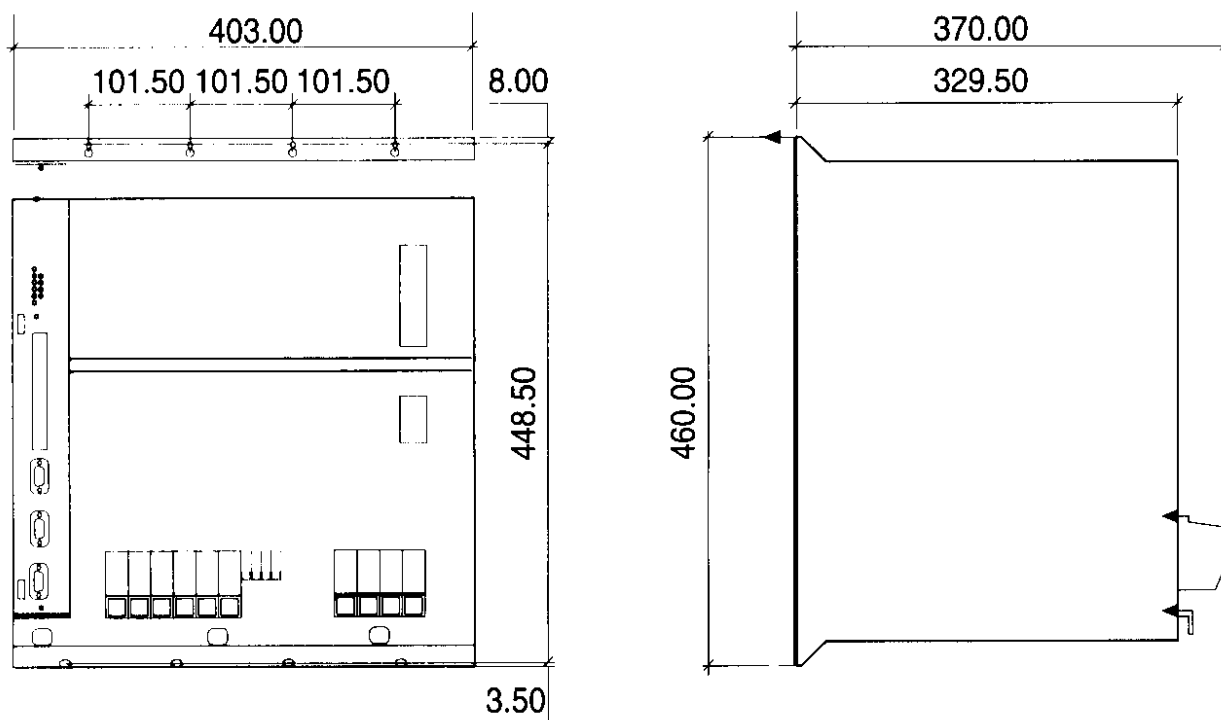
FIG. 1.3   DBS 180/320 - Dimensions and Drilling Jig (Drill For M5 Screws)
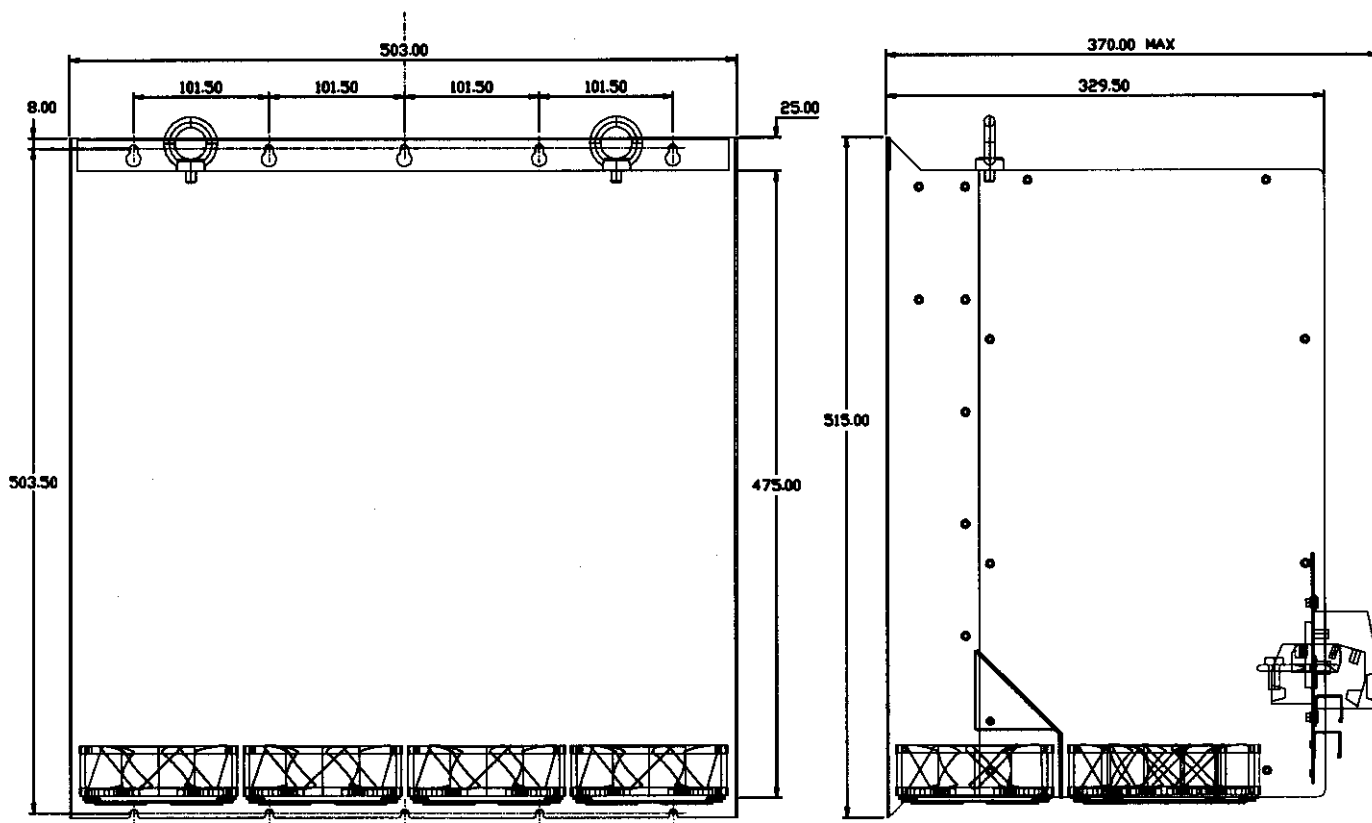
FIG. 1.4A DBS W120/240 - Dimensions and Drilling Jig (Drill For M5 Screws)

WATER IN
2.5 l/min at 20°C
or 3.5 l/min at
25°C

WATER OUT
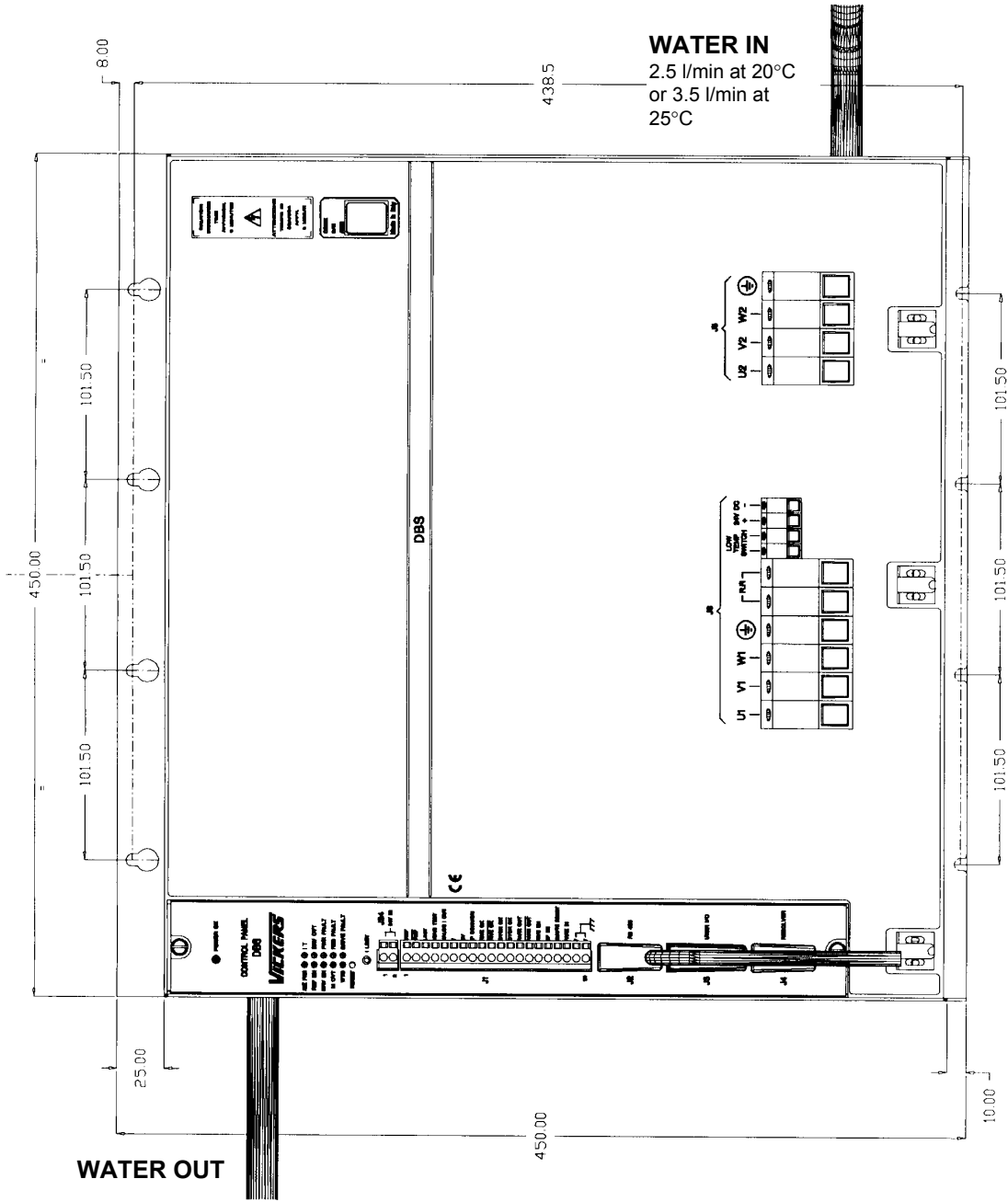
FIG. 1.4B DBS W120/240 - Water Ports
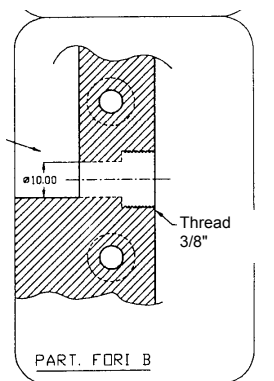
Thread 3/8"

ø10.00

PART. FORI B

CAUTION: *the cooling circuit must be kept clean. Cooling media must not contain particles that may deposit causing obstruction to cooling circuit. We recommend to check periodically cooling flow.the cooling circuit must be kept clean.*

FIG.1.5 DBS W120/240 - Component Identification
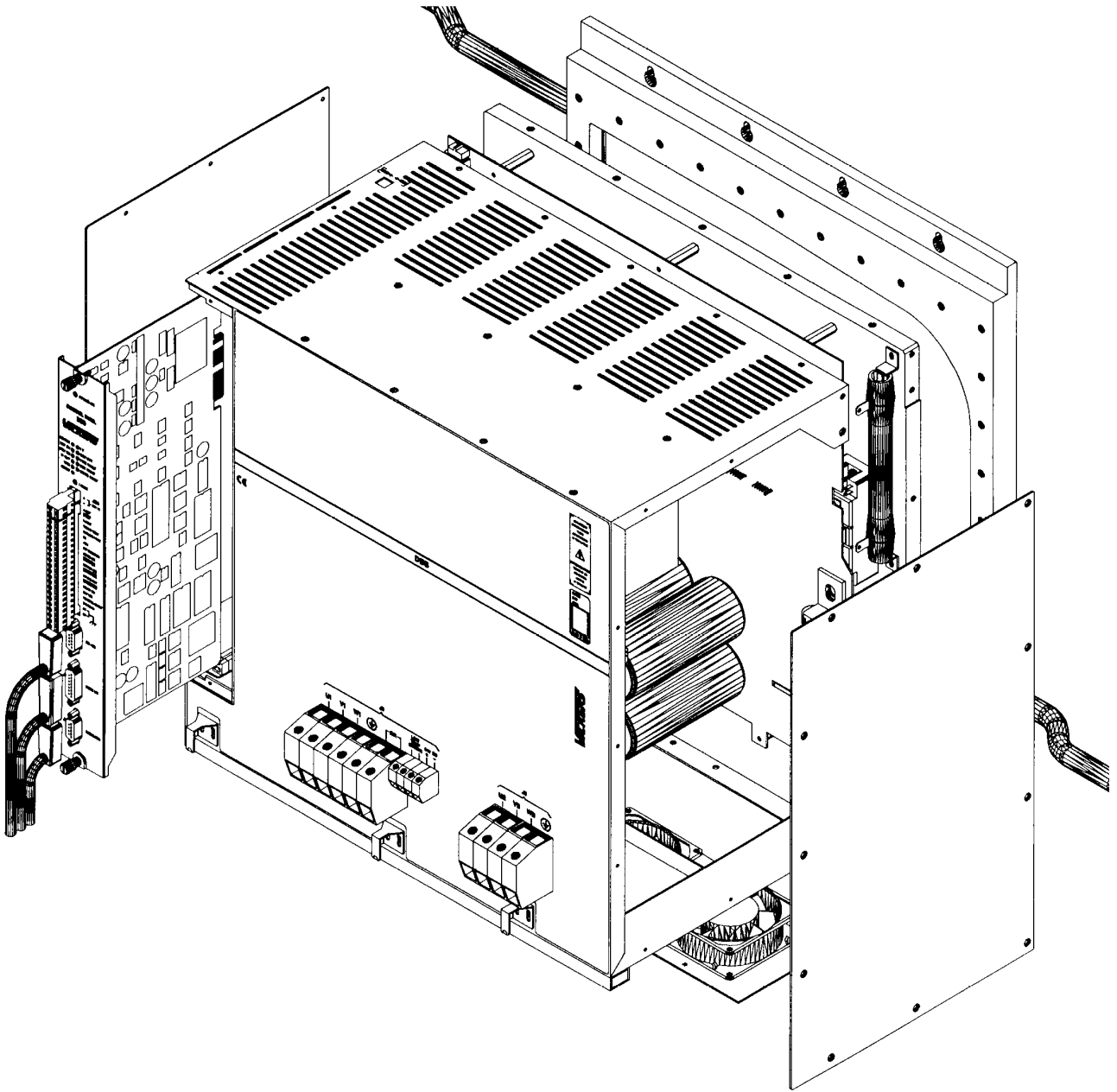
1.5 Technical Data

Nominal input voltage	400 or 460 Vac ±10%, 50/60 Hz, selectable via switch
Three-phase output voltage	325 V (with 400 Vac) or 375 V (with 460 Vac)
Switching frequency	10 kHz
Operating temperature	0 to +40°C (exceeding Class 3K3)
Relative humidity	5% to 85% (no condensation, no formation of ice)
Air pressure	86 kPa to 106 kPa
Storage temperature	-25 to +55°C (Class 1K4)
Transportation temperature	-25 to +70°C (Class 2K3)
Immunity to vibration	Class V.H.2 according to HD 413.3 S1 (1987)

DBS W120/240 (Water Cooled)

Min water flow rate	2.5 l/min @ 20°C or 3.5 l/min @ 25°C
Max water pressure	10^5 Pa (1 bar)

Model	Output Current			Weight
	Nominal	Max		
	Arms	Arms	Apeak	(kg)
DBS - 3/9	3	6.5	9	10
DBS - 6/15	6	10.5	15	10
DBS - 8/22	8	15.5	22	10
DBS - 15/42	15	30	42	12
DBS - 25/70	25	50	70	13
DBS - 35/90	35	64	90	14
DBS - 50/140	50	100	140	22
DBS - 60/180*	60	127	180	23
DBS - 100/240*	100	170	240	46
DBS - W120/240*	120	170	240	50
DBS - 180/320*	180	226	320	56

* = 5 kHz switching frequency

1.6 Interfaces

1.6.1 Analog
- speed reference differential input 0 ±10V
- peak current limit
- tacho signal
- resolver signal
- output current signal

1.6.2 Digital
- full-duplex RS485 serial link
- simulated encoder output (optional)
- CAN-OPEN (optional)

1.6.3 On/Off (opto isolated)
 - drive OK
- motor OK
- drive enable
- motor enable

FIG.1.6 DBS Common Panel

○ POWER OK

AUX PWR ○ ○ I T
REF EN ○ ○ DRV OVT
DRV EN ○ ○ PWR FAULT
M OVT ○ ○ RES FAULT
WTD ○ ○ DRIVE FAULT
RESET ○

○ I LIMIT

J24

1 ○ +
2 ○ − 24V IN

1 ○ △ REF
○ $\overline{\triangle REF}$
○ I LIMIT
○ TACHO TEST
○ ANALOG I OUT
○ 0V
○ +15V
○ INP COMMON
○ DRIVE OK
J1 ○ $\overline{DRIVE\ OK}$
○ MOTOR OK
○ $\overline{MOTOR\ OK}$
○ SPARE OUT
○ $\overline{SPARE\ OUT}$
○ DRIVE EN
○ REF EN
○ REMOTE RESET
○ SPARE IN
○ 0V
20 ○ 0V

J2 RS 485

J3 USER I/O

J4 RESOLVER
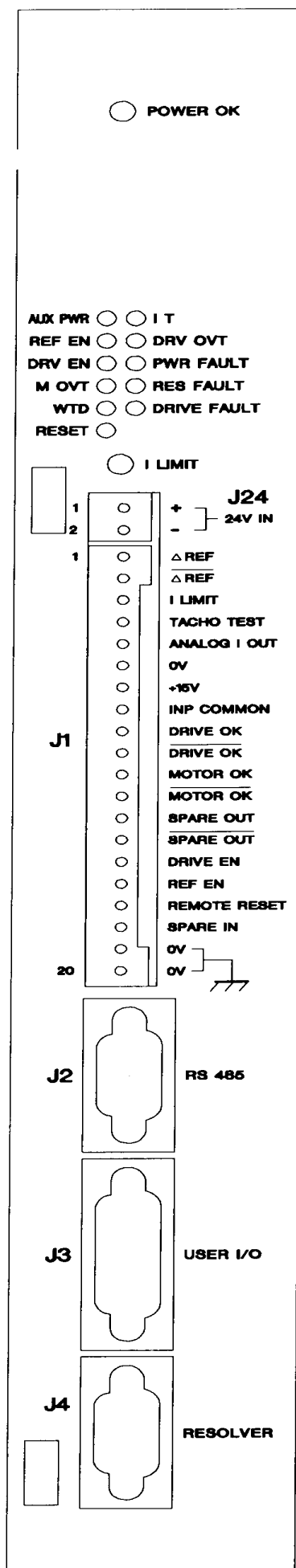
1.7 System Grounding

FIG. 1.7 EMC/Equipotential Bonding
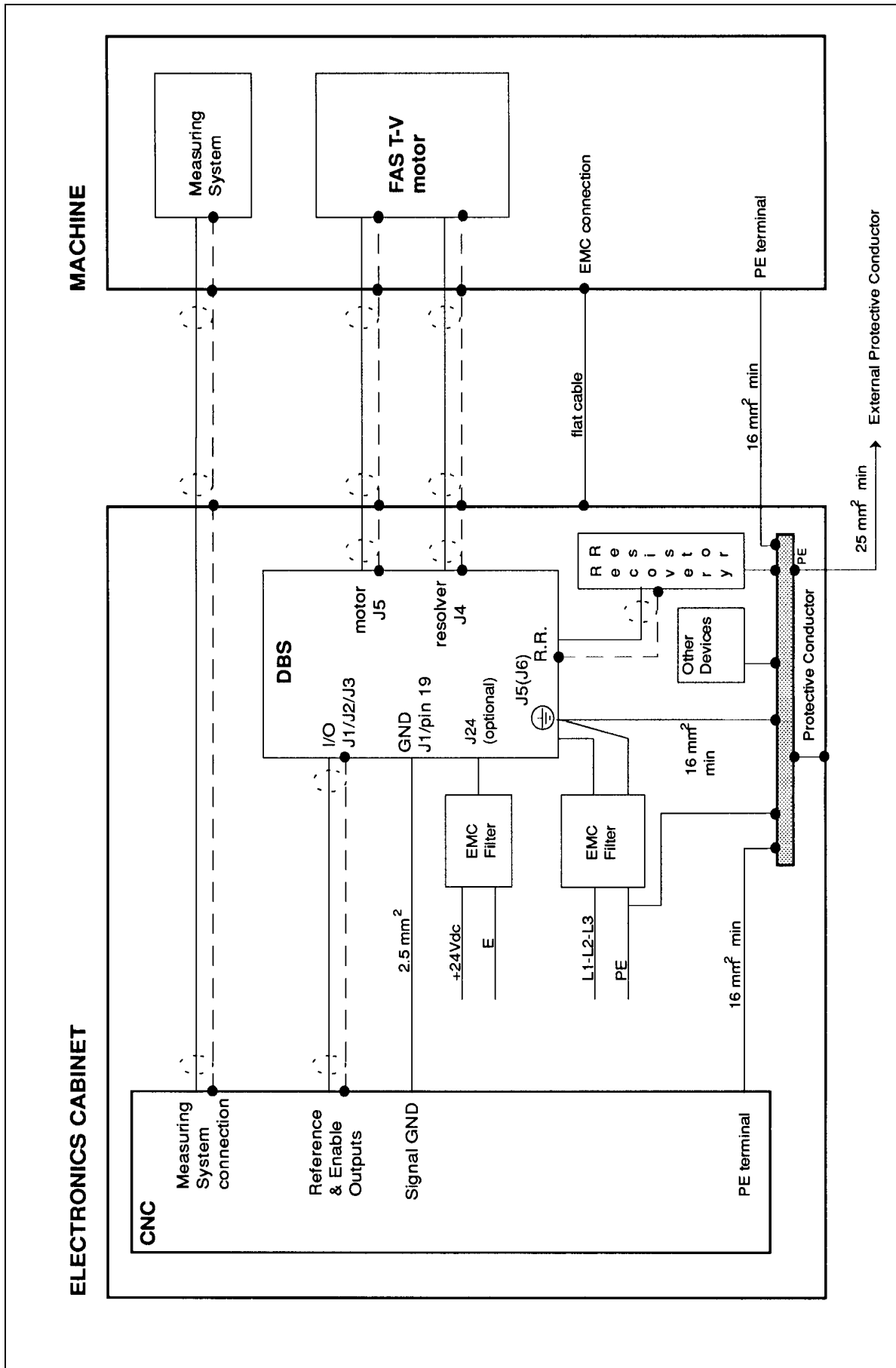
1.8 Rating Plate

The following informations are supplied on the rating plate of DBS.

CODE:	CNxxxxxx	model code
S/N:	AASSNNNNYY	serial number, where AA=year, SS=week, NNNN=progressive number, YY=option code (00=standard, 02=resolver interface)
Vin:	xxx V	nominal three phase input voltage
3-phase 50/60 Hz		
Iin:	xxx A_{rms}	nominal rms input current
Iout nom:	xxx A_{rms}	nominal rms output current
Iout max:	xxx A	peak output current

$C_1C_2C_3-C_4$ C_1=pulses per electrical revolution (C=64, D=128, E=256, F=512, G=1024, H=2048, I=4096, L=8192, M=16384)
C_2=motor poles (A=2, B=4, C=6, D=8, E=10, F=12)
C_3=resolver poles (A=2, B=4, C=6, D=8, E=10, F=12)
C_4 =marker width (A=1, B=1/2, C=1/4, D=no marker)

1.9 Dynamic Brake Unit Rating Plate

The following informations are supplied on the Dynamic Brake Unit rating plate, according to UL508C. The Max Peak Current is the maximum current compatible with the recovery IGBT, the Max Duty Cycle is the duty cycle tested according to UL508C.

DYNAMIC BRAKE UNIT		
	Recovery Resistor	
Model Code	Max Peak Current	Max Duty Cycle
DBS 3/9 to 8/22	13.4 A	2.0 %
DBS 15/42	15.9 A	1.5 %
DBS 25/70, 35/90	62.5 A	1.6 %
DBS 50/140, 60/180	91.4 A	2.9 %
DBS 100/240, W120/240, 180/320	192 A	2.1 %

SECTION 2 - INSTALLATION

CAUTION: make sure that the correct input voltage has been set on the top panel

Fig.2.1 400/460V Setting

SWITCH
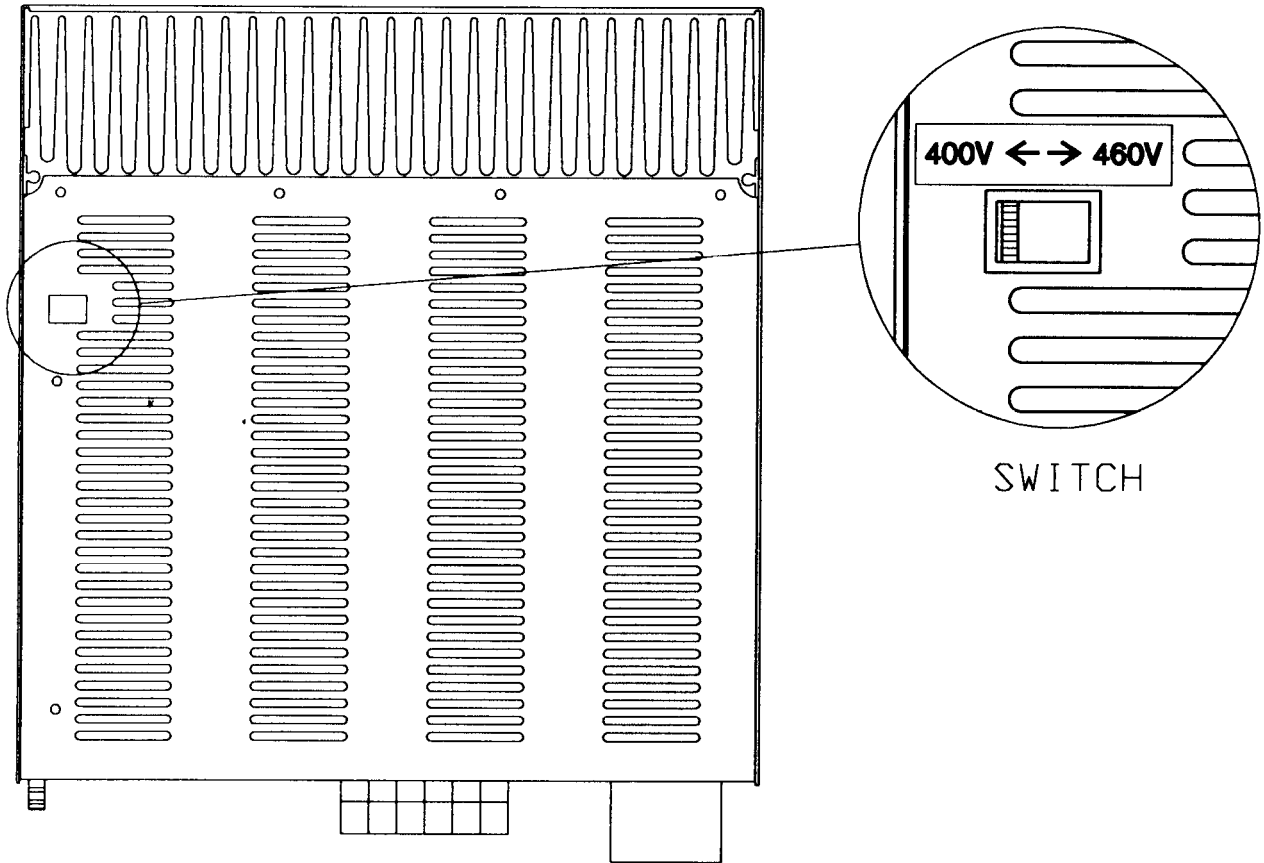
CAUTION: make sure that the correct wiring for DBS 3/9, 6/15, 8/22, 15/42 has been set for recovery resistance on J5 connector:
- check the jumper between P1 and P2 to use the internal recovery resistor (standard braking)
or
- disconnect the jumper and connect an external recovery resistance to RR pins (hard braking)

FIG.2.2 P1/P2 Jumper

* = jumper, factory setting
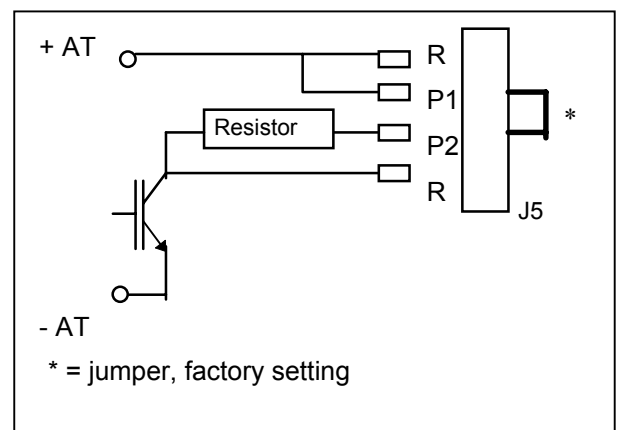
2.1 Fuses

2.1.1 Internal Fuses

DBS drive has the following fuses on the bus bars:

- DBS 3/9, DBS 6/15, DBS 8/22:   50A ultrafast (cod. AM6408)

2.1.2 External fuses

CAUTION : equipment suitable for use on a circuit capable of delivering not more than the Short Circuit rating, 460V +10% maximum, when protected by semiconductor type fuses, manufactured by Bussmann Div.Cooper (UK) Ltd, according to UL508C (1998). See the following table.

	DBS Model						
	3/9 to 15/42	**25/70, 35/90**	**50/140**	**60/180**	**100/240**	**W120/240**	**180/320**
Short Circuit Rating	5000 rms symmetrical Amps			10000 rms symmetrical Amps			
Input power line fuse	Type 50-FE (50A/660Vac)	Type 100-FEE (100A/660Vac)	Type 160-FEE (160A/660Vac)		Type 280-FM (280A/660Vac)	Type 315-FM (315A/660Vac)	Type 500-FMM (500A/660Vac)

2.2 Soft Start

The soft start is included in the circuit. The soft start resistors are short-circuited after 250ms.

2.3 Fans

CAUTION: a free circulation must be guaranteed for the air flow.

2.3.1 DBS 3/9 to 60/180 - Fans

The ventilation is provided by fans mounted under the modules. The input power is provided by the drive.

2.3.2 DBS 100/240, 180/320 - Fans

The ventilation is provided by three 24 Vdc fans for DBS 100/240 and five 24 Vdc fans for DBS 180/320, mounted under the modules. They must be powered by the user. Total power rating is 33 W for DBS 100/240 and 55 W for DBS 180/320.

2.3.3 DBS W120/240 - Fans

The card ventilation is provided by one fan mounted under the drive.
The other four fans under the drive are anti-condensation devices and must be powered by the user, via 24 Vdc, 12 W inputs on J6 connector, 5 minutes before start-up. After start-up these fans can be powered off.

CAUTION: the anti-condensation fans of the DBS W120/240 must be powered on 5 min. before start up

2.4 Led's

Tab. 2.1 - Module - Led's

Name	Function
Red LED DRIVE FAULT	generic fault: the fault can correspond, according to the type, to a LED on the front end; if other red LED's are not on, out of the considered one, it is necessary to interrogate the drive via serial link to know the fault reason (see FA command)
Red LED WTD	Watch dog - signal; microprocessor circuit faults; this LED is on during reset
Red LED RES FAULT	Resolver fault - signal; resolver fault, sin /cos signals interrupted, short circuit between signals or 10kHz carrier abnormal
Red LED M OVT	Motor overtemperature
Red LED DRV OVT	Module overtemperature
Red LED PWR FAULT	Intelligent Power Module fault
Green LED REF.EN	Reference enable
Green LED DRV EN	Axis enable (see also ON command)
Red LED IT	IT protection (*)
Green LED AUX PWR	Auxiliary power OK

(*) when the IT LED becomes blinking, it indicates the activation of the IT protection; when the IT LED becomes steady illuminated, it indicates the activation of an internal protection. In this case please ask the Service Centers.

2.5 Potentiometer/Button

Tab. 2.2 - Potentiometer/Button

I LIMIT POTENTIOMETER	Peak current control. A full CCW rotation will set the current to zero. A full CW rotation will set the current to 100%.
RESET BUTTON	Digital control card reinitialization and reset of protections

2.6 Wiring

2.6.1 Sizing of Wires

It is recommended to use Cu, stranded and/or solid wires, 60/75°C (140/167°F), UL approved, per the following table.
Note that this sizing of wires is referred to new (UL) version of connectors.

Tab. 2.3A - Sizing of Wires

	DBS Model						Notes
	3/9 to 8/22	15/42	25/70 35/90	50/140 60/180	100/240 W120/240	180/320	
Line Power wiring (No.of wires x AWG)	4 x 14 AWG	4 x 10 AWG	4 x 8 AWG	4 x 4 AWG	4 x 1/0 AWG	4 x 4/0 AWG	
Motor Power wiring (No.of wires x AWG)	4 x 14 AWG	4 x 10 AWG	4 x 8 AWG	4 x 4 AWG	4 x 1/0 AWG	4 x 4/0 AWG	shielded
Recovery Resistor wiring (No.of wires x AWG)	2 x 14 AWG	2 x 10 AWG	2 x 8 AWG	2 x 8 AWG	2 x 8 AWG	2 x 2 AWG	shielded
Optional Dc-Bus (+/-AT) wiring (No.of wires x AWG)	2 x 14 AWG	2 x 10 AWG	2 x 8 AWG	2 x 4 AWG	2 x 1/0 AWG	2 x 2 AWG	shielded
Optional +24V Power Supply wiring (No.of wires x AWG)	2 x 14 AWG						shielded
Resolver wiring (No.of wires x AWG)	4 x 2 x 22 AWG						with 4 pair, each pair twisted and individually shielded with an independent overall shield

Tab. 2.3B - AWG/mm^2 Conversion Table

AWG	22	20	18	16	14	12	10	8	6	4	3	2	1	1/0	4/0
mm^2	0.3	0.5	0.8	1.3	2.1	3.3	5.3	8.4	13	21	27	34	42	54	107

Tab. 2.3C - Tightening torque of Terminal Blocks

	HDFK 4	HDFK 10	HDFK 16	HDFK 25	HDFK 50	HDFK 95
lb in	5-7	13.2-16	18	35	75	133-177
Nm	0.6-0.8	1.5-1.8	2	4	8	15-20

Tab. 2.3D - Wire stripping length for Terminal Blocks

	HDFK 4	HDFK 10	HDFK 16	HDFK 25	HDFK 50	HDFK 95
in	0.35	0.43	0.63	0.75	0.95	1.1
mm	9	11	16	19	24	27

2.6.2 I/O Wiring

All the signal cables must be separated from power cables by a distance ≥30 cm.
See Section 3 for shielding procedures according to EMC Directive.

REMARKs:
- *DRIVE OK (J7 connector): it is suggested to connect the isolated output " DRIVE OK " to a remote control switch so that, if a fault occurs, the power supply is disconnected to avoid system damages.*
- *SIMULATED ENCODER SIGNALS (J7 connector):*
  - in specially noisy environments it is suggested to connect a 220 ÷ 680 Ω resistor between A and $\overline{A}$, B and $\overline{B}$, C and $\overline{C}$ at the receiver input.
  - for lengths in excess of 5 m (16 ft.) the cable must have 3 pairs, each pair twisted.

FIG. 2.3 - SPEED REFERENCE WIRING
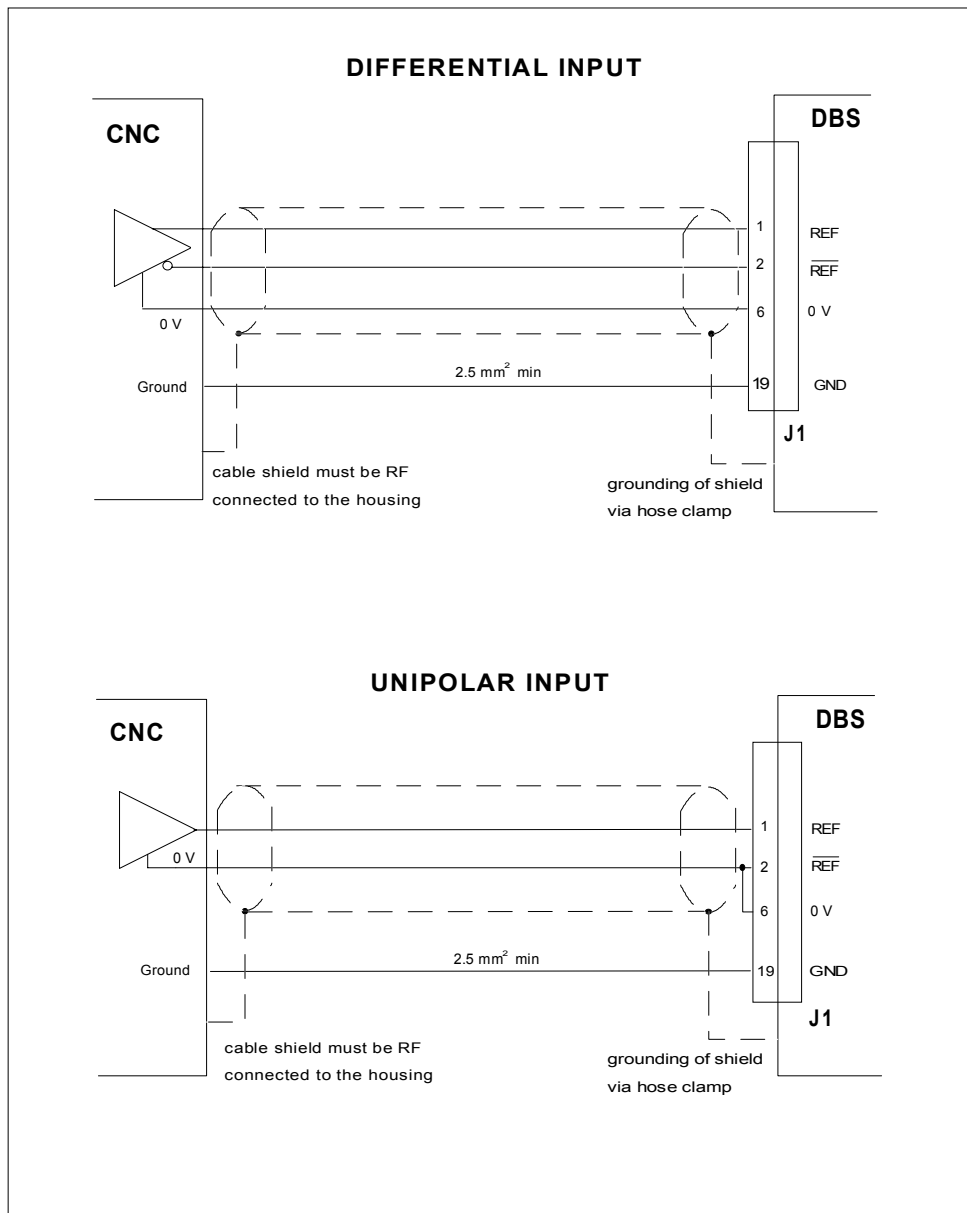
Tab. 2.4 - J1 Connector - I/O Commands And Signals

Panel side: male, type Wago 231-450 (code AK5953)
Wiring side: female, type Wago 231-120/026-000 (code AK4960)

Pos.	Name	
1	REF	Differential non-inverting analog input for the speed reference signal (or torque ref. signal, see TC command), max range ±10V (see MR command). See Fig. 2.3
2	$\overline{\text{REF}}$	Differential inverting analog input for the speed reference signal (or torque ref. signal, see TC command), max range ±10V (see MR command). See Fig. 2.3
3	ILIMIT	Analog input I limit (0 to +10V)
4	TACH0 TEST	Tachometer analog output. Full scale ±10V for ±MV.
5	ANALOG OUT	Analog output for the Iout information, which is the absolute value of the current reference measured on the speed loop output, range ±10V for ± 100% peak current..
6	0V	Analog 0V
7	+15V	+15Vdc output (Imax = 30mA)
8	INP COMMON	Common optoisolated 0V
9	DRIVE OK	Collector of Drive OK optoisolator
10	$\overline{\text{DRIVE OK}}$	Emitter of Drive OK optoisolator
11	MOTOR OK	Collector of Motor OK optoisolator
12	$\overline{\text{MOTOR OK}}$	Emitter of Motor OK optoisolator
13	SPARE OUT	n.c.
14	SPARE OUT	n.c.
15	DRIVE EN	Drive enable optoisolated input, referred to common 0V(J1-8). See Fig. 2.4
16	REF EN	Reference enable: optoisolated input for the confirmation of the reference to the axis (REF EN not active means no speed reference or zero torque), referred to common 0V(J1-8)
17	REMOTE RESET	Remote reset: optoisolated input for logic section reset, equivalent to push button on the front panel, referred to common 0V (J1-8). The width of the pulse must be ≥ 200 ms
18	SPARE IN	Spare optoisolated input referred to common 0V(J1-8). When OFF (0V) the first parameter set will be selected, when ON (+15V) the second parameter set will be selected.
19	0V	Ground. It must be connected to CNC ground with 2.5 mm^2 wire as short as possible.
20	0V	Digital 0V

Fig. 2.4 - Input/Output Wiring

CNC

+ 24V Power Supply
+24V
0V

DBS

+24V
0V
Drive Enable
Ref. Enable

Drive OK
Motor OK

8	Optoisolated input common
15	Drive Enable
16	Reference Enable
9	Drive OK
10	Optoisolated Output
11	Motor OK
12	Optoisolated Output

cable shield must be RF
connected to the housing

grounding of shield
via hose clamp

J1

+ 24V POWER SUPPLY

DBS

6	0V Common
7	+15V dc output
8	Optoisolated input common
15	Drive Enable
16	Reference Enable

J1

**+ 15V INTERNAL SUPPLY
(for drive test)**

Tab. 2.5 - J2 Connector - Sub-D 9 pos. - RS485 Port Signal
Panel side: female
Wiring side: male with conductive shell

Pos.	
1	+ Rx (RS485 serial link)
2	N.C.
3	+ Tx (RS485 serial link)
4	N.C.
5	+ 5Vdc output referred to digital 0V
6	- Rx (RS485 serial link)
7	Digital 0V
8	- Tx (RS485 serial link)
9	N.C.

Tab. 2.6 - J3 Connector - Sub-D 15 Pos. - Simulated Encoder Outputs
Panel side: female
Wiring side: male with conductive shell

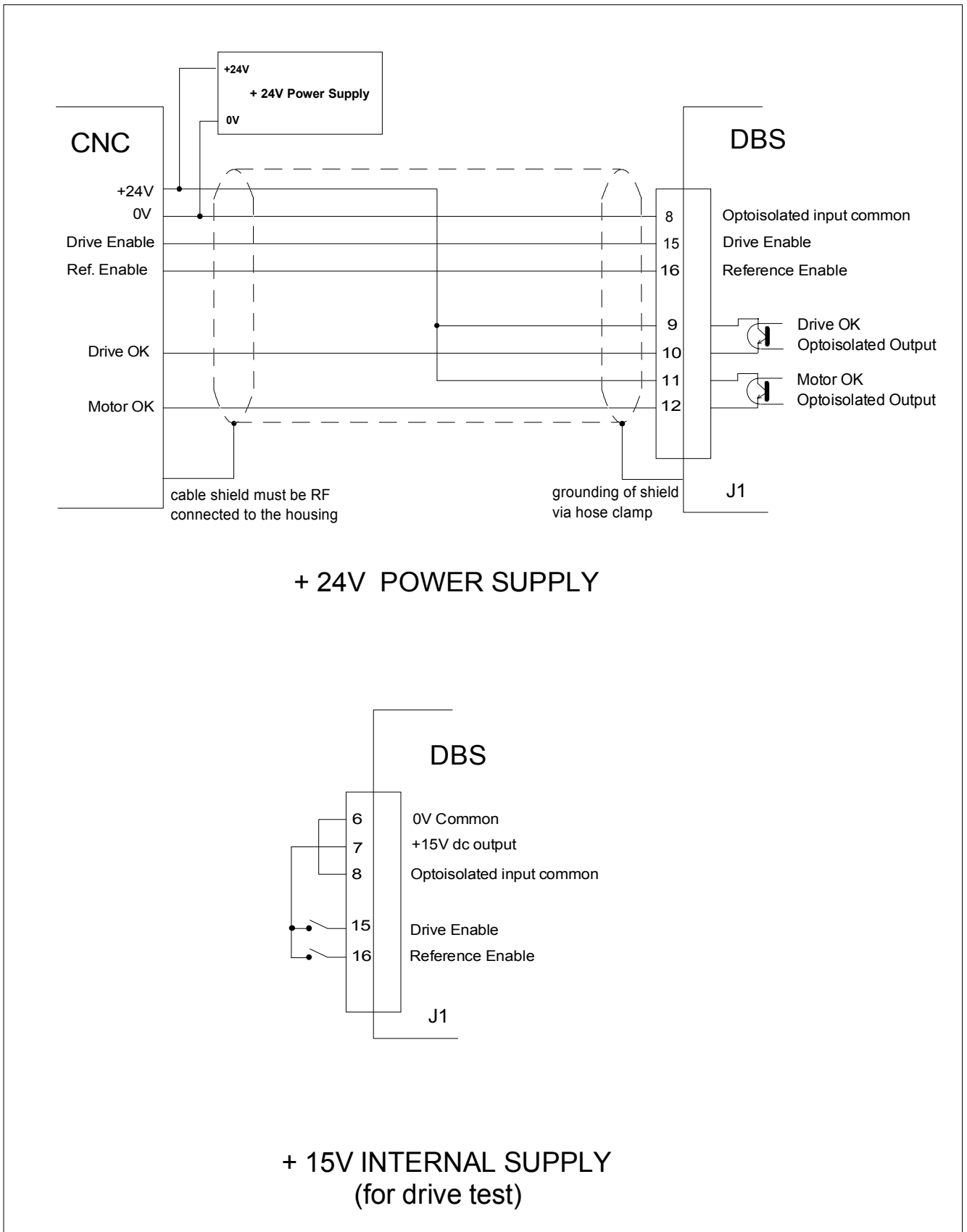| Pos.	Name	
1	SPARE IN	n.c.
2	$\overline{B}$	encoder output: inverted phase B
3	A	encoder output: phase A
4	C	encoder output: phase C
5	-15	- 15Vdc output (I max = 30mA)
6	+15	+15Vdc output (I max = 30mA)
7	SPARE IN	n.c.
8	OUT SPARE	n.c.
9	B	encoder output: phase B
10	$\overline{A}$	encoder output: inverted phase A -
11	$\overline{C}$	encoder output: inverted phase C -
12	SPARE IN	n.c.
13	TP1	n.c.
14	TP2	n.c.
15		Digital 0V

Tab. 2.7 - J24 Connector - +24V (Optional)

Panel side: male, type Wago 231-432 (code AK5959)
Wiring side: female, type Wago 231-102/026-000 (code AK4967)

Pos.	Name	
1	+24 IN	Inputs for 24 Vdc ($\pm$4V) to retain auxiliary logic supply
2	- 24 IN	voltage in case of main supply failure (Iload=1.3A; Istdby=0.13A)

Tab. 2.8 - Input/Output Characteristics

OPTOISOLATED INPUTS Drive enable Reference enable Remote reset Spare In	z in =1.2 kΩ I nom = 10 mA (8 to 20 mA) Vmin = 15Vdc (15 to 25V)
OPTOISOLATED OUTPUTS Drive OK Motor OK	z out = 390 Ω I nom = 10 mA (8 to 20 mA) Vnom = 15Vdc (8.5 to 25V)
Analog tacho output	z out = 100 Ω I max = 5 mA Full scale: $\pm$ 10V for $\pm$ MV
Velocity differential Reference Signals	z in > 20 kΩ Full scale = see MR command Vmax = 12V
Simulated Encoder differential output signals	z out = 100 Ω Full scale = 7V (RS422/RS485 compatible)

2.6.3 Resolver Wiring

Fig. 2.5 - Resolver Wiring
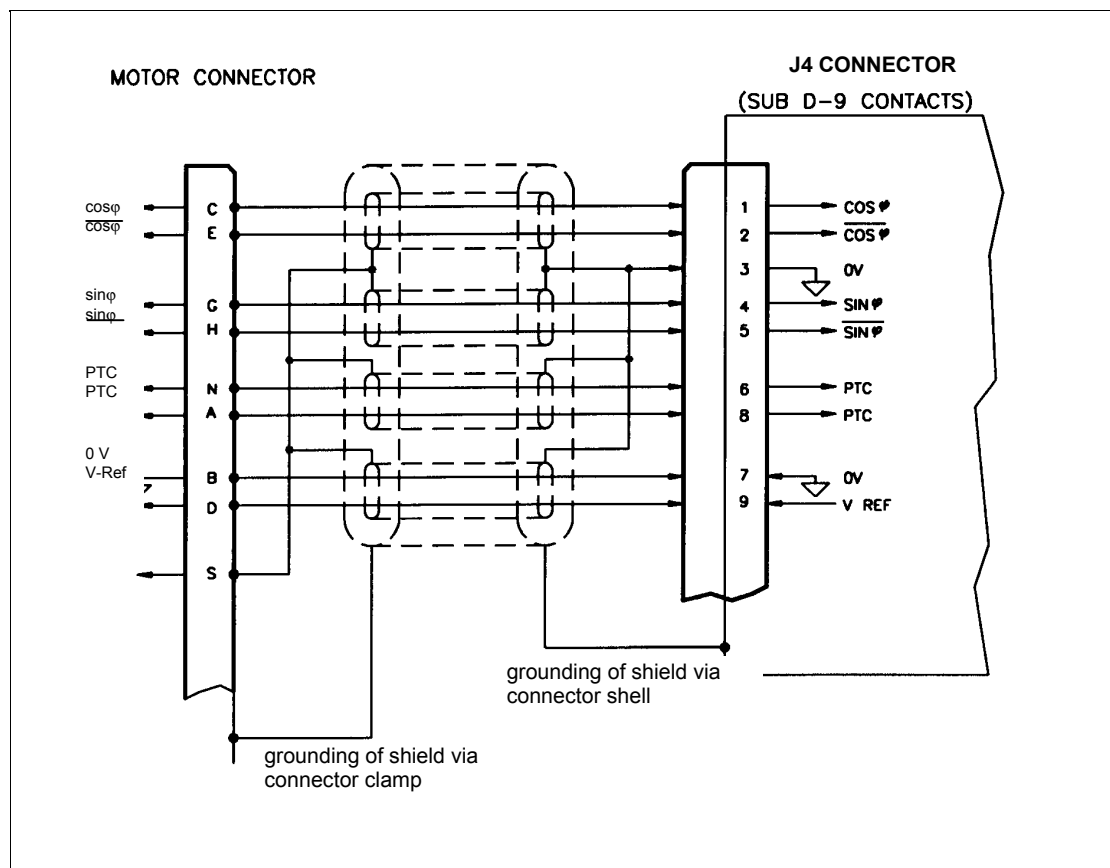
RESOLVER CONNECTOR, MOTOR SIDE		
Signal Type	FAS T/ FAS K	FAS N
	Pos.	Pos.
cosφ	C	1
$\overline{\cos\varphi}$	E	2
V-Ref	D	10
0V	B	7
PTC	N	8
PTC	A	9
sinφ	G	11
$\overline{\sin\varphi}$	H	12
shield	S	3

Each DBS must be connected to the resolver via the J4 connector. Figure 2.5 shows the wiring lay-out of the resolver with differential output. We recommend to use 4 pair cables, each pair twisted and individually shielded with an independent overall shield (85% min coverage)

22 AWG (0.38 mm^2) wire with low capacitance (max 100 pF/m) can be used. We suggest to use ground connections as shown in Fig. 2.5.

Cable length should not exceed 30 m (100 ft.). It is recommended that the signal cable and power cable be separated, if possible, through the use of independent duct (conduit) or by a distance of 12 inches (30 cm).

Tab. 2.9 - J4 Connector - Sub-D 9 pos. - Resolver
Panel side: female
Wiring side: male with conductive shell

Pos.	Name	
1	cos	Differential cos signal non-inverted input
2	$\overline{cos}$	Differential cos signal inverted input
3	Shield	Internally connected to 0V common
4	sin	Differential sin signal non-inverted input
5	$\overline{sin}$	Differential sin signal inverted input
6	PTC	Motor PTC input
7	0V	0V common. Special for 10kHz carrier
8	PTC	Motor PTC input
9	V ref	20 Vpp/ 10kHz sinusoidal output signal for supplying primary resolver winding (carrier)

2.6.4 Power Wiring

External recovery resistor cable (if applicable) and motor phases cable must be shielded to comply with EMC Directive. Power supply input cable (not shielded) must be connected to the input filter (see Sect.3). See par.2.6.1 for sizing of wires.
It is recommended to use motor phases wiring with low capacitance (max 500 pF/m).

CAUTION: *do not parallel power connection cables to achieve requested section: this will increase the capacitance value at levels that may irreversibly damage the drive. If the value of capacitance of motor and cables, seen from drive output, exceeds 30 nF it is necessary to verify with Moog technicians the need of an adequate choke in series.*

Fig. 2.6 - Motor Phases Wiring
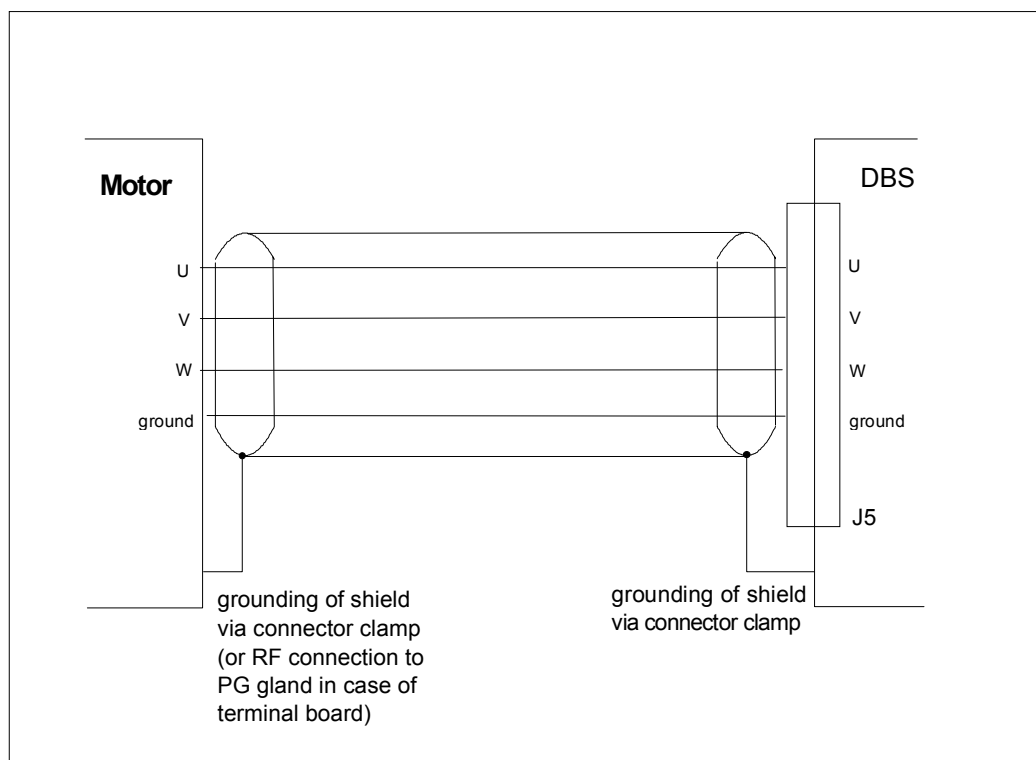
CAUTION: *the U-V-W motor phase sequence of the connector at the drive side must match the U-V-W motor phase sequence of the connector at the motor side.*

Tab. 2.10 - J5 Power Connector for DBS 3/9, 6/15, 8/22, 15/42
Panel side: male, type Harting 09.06.015.2912 (code AK5955)
Wiring side: female, type Harting 09.06.215.2871 (code AK4961)

Name	Function
U1	"L1" phase, three-phase input voltage 400Vac (or 460Vac)
P1	Internal recovery resistance. See P2
V1	"L2" phase, three-phase input voltage 400Vac (or 460Vac)
P2	Internal recovery resistance. The female connector has a jumper between P1 and P2 (factory setting) which connects a 56Ω/240W internal resistor to +HV. To use an external resistor this jumper must be disconnected. See Fig.2.2
W1	"L3" phase, three-phase input voltage 400Vac (or 460Vac)
⏚	Protective bonding
⏚	Motor ground
U2*	"U2" phase, three-phase output voltage to motor
V2*	"V2" phase, three-phase output voltage to motor
W2*	"W2" phase, three-phase output voltage to motor
R.R.	External recovery resistor, if applicable. In this case the
R.R.	the jumper between P1 and P2 must be disconnected.

* only one wire and one pin per phase shall be used

Fig. 2.7 - J5 Power Connector for DBS 3/9, 6/15, 8/22, 15/42
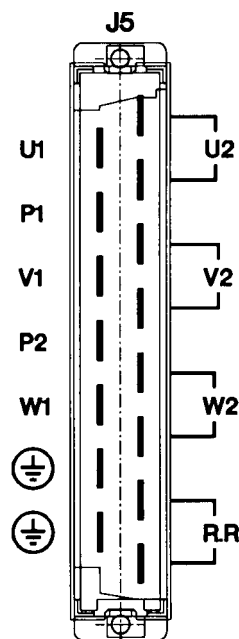
CAUTION: *the jumper between P1 and P2 must be disconnected before connecting an external recovery resistance on small DBS drives (see Fig.2.2)*

Tab. 2.11A - J5 Output Power Connector for DBS 25/70 to 60/180 OLD Version

Panel side: power connector type Harting Hank 4/0 with 4 female contacts (code AK4958)
Wiring side: power connector type Harting Hank 4/0 with 4 male contacts (code AK5950)

Name	Function
U2	"U2" phase, three-phase output voltage to motor
V2	"V2" phase, three-phase output voltage to motor
W2	"W2" phase, three-phase output voltage to motor
⏚	Motor ground

Tab. 2.11B - J6 Power Connector for DBS 25/70 to 60/180 OLD Version

Terminal blocks, type Phoenix HDFK 10 - 07 07 07 3 (code AK7420)

Name	Function
U1	"L1" phase, three-phase input voltage 400Vac (or 460Vac)
V1	"L2" phase, three-phase input voltage 400Vac (or 460Vac)
W1	"L3" phase, three-phase input voltage 400Vac (or 460Vac)
⏚	Protective bonding
R.R.	External recovery resistor
R.R.	

Fig. 2.8 - J5 And J6 Power Connectors for DBS 25/70 to 60/180, OLD Version
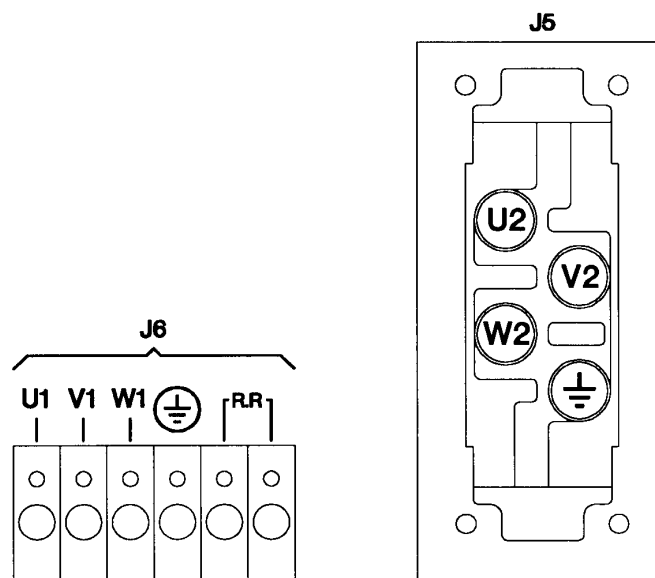
Tab. 2.11C - J5 and J6 Power Connectors for DBS 25/70 to 60/180
NEW Version for DBS UL Listed
Terminal blocks type Phoenix HDFK 16 (code AK7427). See also par.2.6.1.

	Name	Function
	+AT	Output Dc-Bus. This optional output can be used to supply
	-AT	the Dc-Bus of another DBS drive (e.g. DBS of same size with a 50% contemporaneity factor)
J6	U1	"L1" phase, three-phase input voltage 400Vac (or 460Vac)
	V1	"L2" phase, three-phase input voltage 400Vac (or 460Vac)
	W1	"L3" phase, three-phase input voltage 400Vac (or 460Vac)
	⏚	Protective bonding
	R.R.	External recovery resistor
	R.R.	
J5	U2	"U2" phase, three-phase output voltage to motor
	V2	"V2" phase, three-phase output voltage to motor
	W2	"W2" phase, three-phase output voltage to motor
	⏚	Motor ground

Fig. 2.9 - J5 and J6 Power Connectors for DBS 25/70 to 60/180, NEW Version
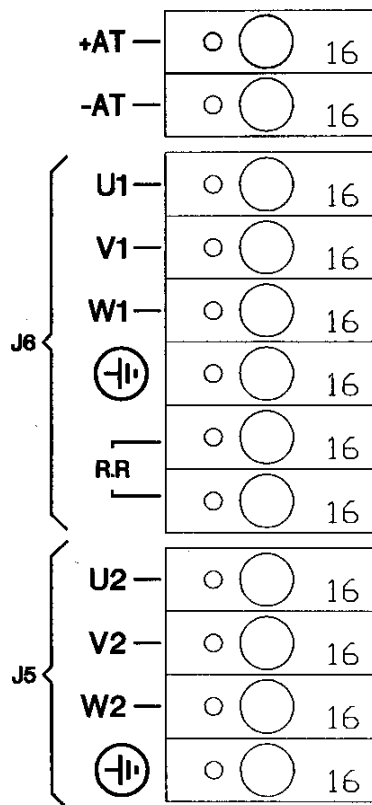
Tab. 2.12A - J5 and J6 Power Connector for DBS 100/240, W120/240
OLD Version: it will be replaced by new terminal blocks (see Tab.2.12B)
Terminal blocks by Phoenix type HDFK 25 (code AK7421), HDFK 4 (code AK7418)

			Name	Function
J6		HDFK 25	U1	"L1" phase, three-phase input voltage 400Vac (or 460Vac)
		HDFK 25	V1	"L2" phase, three-phase input voltage 400Vac (or 460Vac)
		HDFK 25	W1	"L3" phase, three-phase input voltage 400Vac (or 460Vac)
		HDFK 25	⏚	Protective bonding
		HDFK 25	R.R.	External recovery resistor
		HDFK 25	R.R.	External recovery resistor
		HDFK 4 HDFK 4	LOW TEMP SWITCH (*)	Thermal switch. Normally closed contact (max 5A). Rated to open at 40°C ±3°C heatsink temperature. With intermittent water flow, It can be used to start the water pump when the heatsink temperature becomes > 40°C. With continuous water flow, it can be used to check the water temperature (the drive overtemperature protection trips at 71°C).
		HDFK 4 HDFK 4	24 Vdc	DBS 100/240: 24 Vdc (1 A) input voltage for fans. DBS W120/240: 24 Vdc (0.6 A) input voltage for the anti-condensation fans. *CAUTION: fans must be powered on 5 min. before*
J5		HDFK 25	U2	"U2" phase, three-phase output voltage (to motor)
		HDFK 25	V2	"V2" phase, three-phase output voltage (to motor)
		HDFK 25	W2	"W2" phase, three-phase output voltage (to motor)
		HDFK 25	⏚	Motor ground

Fig. 2.10 - J5 and J6 Power Connectors for DBS 100/240, W120/240, OLD Version
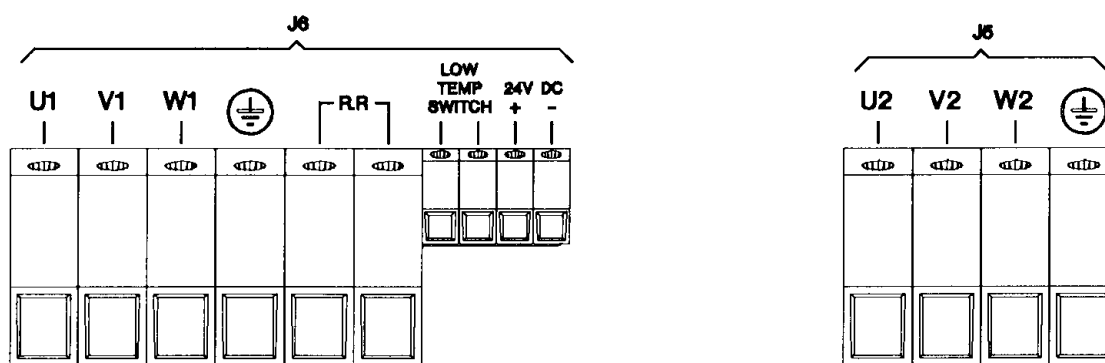
(*) NOTE: the Low Temp.Switch is mounted only on DBS W120/240

Tab. 2.12B - J5 and J6 Power Connector for DBS 100/240, W120/240 NEW Version for DBS UL Listed

Terminal blocks by Phoenix type HDFK 50 (code AK7428), HDFK 25 (code AK7421), HDFK 4 (code AK7418). See also par.2.6.1.

	Terminal Block Type	Name	Function
	HDFK 50	+AT	Output Dc-Bus. This optional output can be used to supply
	HDFK 50	-AT	the Dc-Bus of another DBS drive (e.g. DBS of same size with a 50% contemporaneity factor)
	HDFK 50	U1	"L1" phase, three-phase input voltage 400Vac (or 460Vac)
	HDFK 50	V1	"L2" phase, three-phase input voltage 400Vac (or 460Vac)
	HDFK 50	W1	"L3" phase, three-phase input voltage 400Vac (or 460Vac)
J6	HDFK 50	⏚	Protective bonding
	HDFK 25	R.R.	External recovery resistor
	HDFK 25	R.R.	
	HDFK 4	LOW TEMP	Thermal switch. Normally closed contact (max 5A).
	HDFK 4	SWITCH (*)	Rated to open at 40°C ±3°C heatsink temperature. With intermittent water flow, It can be used to start the water pump when the heatsink temperature becomes > 40°C. With continuous water flow, it can be used to check the water temperature (the drive overtemperature protection trips at 71°C).
	HDFK 4	+24 Vdc	DBS 100/240: 24 Vdc (33 W) input voltage for fans.
	HDFK 4	-24 Vdc	DBS W120/240: 24 Vdc (12 W) input voltage for the anti-condensation fans. *CAUTION: fans must be powered on 5 min. before start up.*
	HDFK 50	U2	"U2" phase, three-phase output voltage to motor
	HDFK 50	V2	"V2" phase, three-phase output voltage to motor
J5	HDFK 50	W2	"W2" phase, three-phase output voltage to motor
	HDFK 50	⏚	Motor ground

Fig. 2.11 - J5 and J6 Power Connectors for DBS 100/240, W120/240, NEW Version
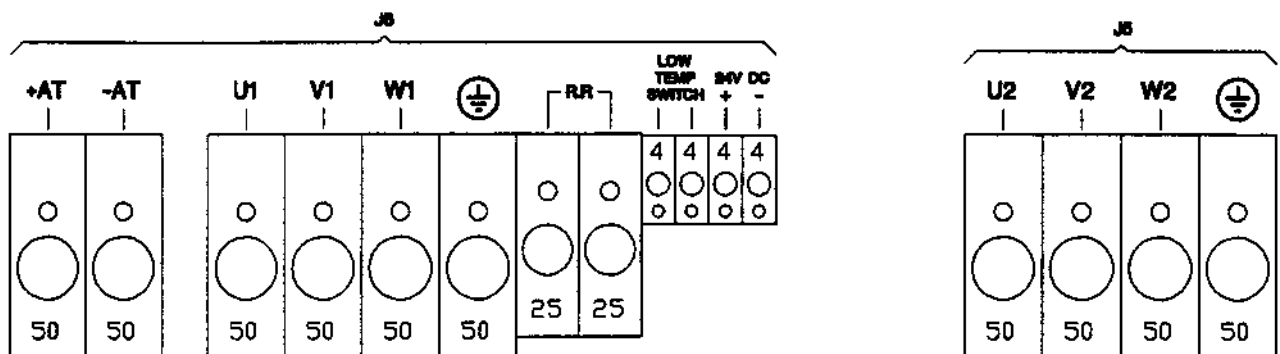
(*) NOTE: the Low Temp.Switch is mounted only on DBS W120/240

Tab. 2.13 - J5 and J6 Power Connectors for DBS 180/320

Terminal blocks by Phoenix, type HDFK 4 (code AK7418), HDFK 25 (code AK7421), HDFK 95 (code AK7429). See also par.2.6.1.

	Terminal Block Type	Name	Function
J6 LINE	HDFK 95	(ground symbol)	Protective bonding
	HDFK 95	U1	"L1" phase, three-phase input voltage 400Vac (or 460Vac)
	HDFK 95	V1	"L2" phase, three-phase input voltage 400Vac (or 460Vac)
	HDFK 95	W1	"L3" phase, three-phase input voltage 400Vac (or 460Vac)
J5 MOTOR	HDFK 95	U2	"U2" phase, three-phase output voltage to motor
	HDFK 95	V2	"V2" phase, three-phase output voltage to motor
	HDFK 95	W2	"W2" phase, three-phase output voltage to motor
	HDFK 95	(ground symbol)	Motor ground
J6	HDFK 25	R.R.	External recovery resistor
	HDFK 25	R.R.	
	HDFK 25	+AT	Output Dc-Bus. This optional output can be used to supply the Dc-Bus of another DBS drive (max DBS 60/180)
	HDFK 25	-AT	
	HDFK 4	0V	24 Vdc/ 55 W input to supply the fans
	HDFK 4	24VDC	

Fig. 2.12 - J5 and J6 Power Connectors for DBS 180/320
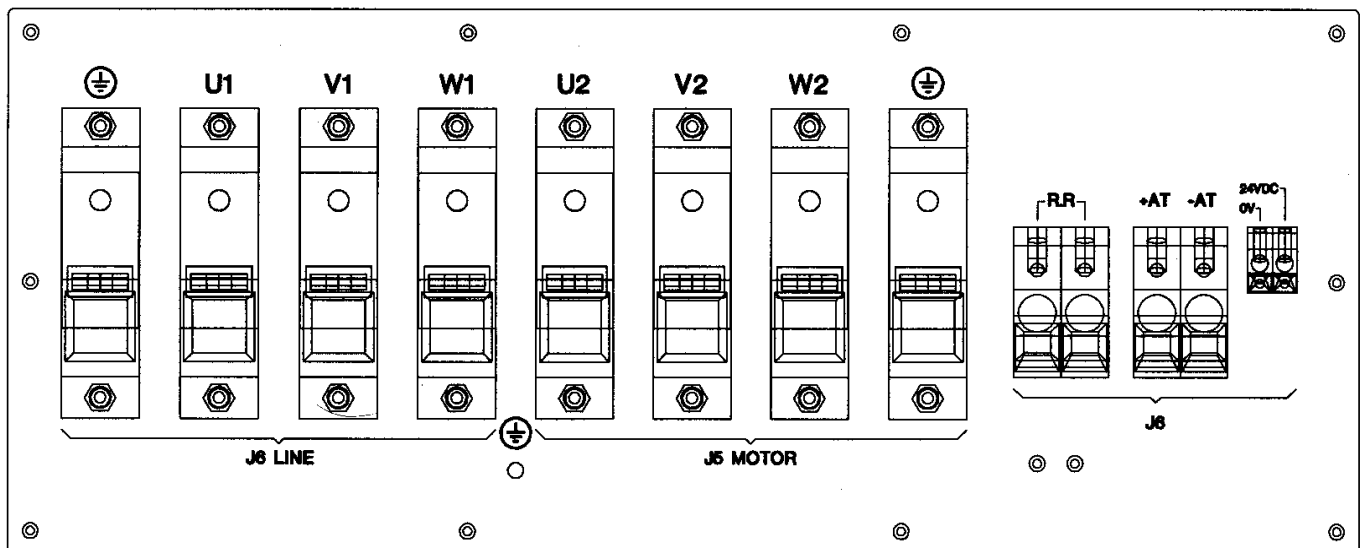
2.7 Recovery Circuit

The recovery circuit is formed by a switching regulator, a recovery transistor and a recovery resistance. While braking the motor returns energy which cannot be sent to the line since the rectifier circuit is not regenerative. Returned energy tends to increase the Dc-Bus voltage. When HV reaches 680V (790V for 460 Vac) the switching regulator brings the recovery transistor into conduction, thus connecting the recovery resistance in parallel with filter capacitors. The recovery resistance is formed by enameled wire fixed resistor(s).

If the recovery resistance works for intervals shorter than the time necessary to reach thermal equilibrium, the resistor can temporarily handle power levels up to 10 times the nominal power rating of the resistor (short time overload).

If not specifically requested, systems are provided with:

DBS 3/9, DBS 6/15, DBS 8/22: 56Ω, 250W (internal)
DBS 15/42: 47 Ω, 250W (internal)
DBS 25/70 and DBS 35/90: 12Ω, 370W (external)
DBS 50/140 and DBS 60/180: 8.2 Ω, 750W (external)
DBS 100/240, W120/240, 180/320: 3.9Ω, 1000W (external)

For UL purposes, the following recovery resistors have been tested. The UL mark on the drive covers applications up to these ratings.

DBS 25/70 and DBS 35/90: 12Ω, 750W, 1.6% duty cycle
DBS 50/140 and DBS 60/180: 8.2 Ω, 2000W, 2.9 % duty cycle
DBS 100/240, W120/240: 3.9Ω, 3000W, 2.1 % duty cycle

WARNING: do not touch recovery resistor during operation to avoid scalds.

WARNING: High Voltage - The recovery resistor is connected to the internal Dc-Bus and can reach a value of 810 Vdc

*CAUTION: **DBS 3/9, DBS 6/15, DBS 8/22 and DBS 15/42** have internal recovery resistor. To disable the internal resistor and connect an external resistor it is necessary to disconnect the jumper between P1 and P2 on J5.*

CAUTION: an unusual application with motor driven by the load, a large portion of the time, could result in overheating of the recovery resistor.
If the application requires frequent decelerations, with high inertia, starting from high speed and in short times, it may be necessary to use a non standard external recovery resistor. It is suggested contacting our Customer Service.

CAUTION: shielding of the recovery resistor cable, provided in kit for test purposes, is recommended for ensuring compliance with the EMC standards.

CAUTION: for UL approval in the end-use installation, the Dynamic Brake Unit Recovery Resistor, when external, shall have the connection wiring made with R/C (AVLV2) or insulated with R/C (YDPU2) or R/C (UZCW2)

2.8 Serial Link Connection

DBS drive is equipped with the low speed serial link hardware and associated software drivers for the protocol implementation. The purpose of the link is the inspection and modification of drive related parameters; monitoring of the drive status and errors, and the communication of the commands and parameters during the installation phase. Up to 15 DBS drives might be connected in parallel to the RS485 bus. Drives will have the slave role, they will respond to the queries sent by the master. The role of the master normally takes the hand-held terminal. When available, an industrial PC or a notebook may be connected to the RS485 bus via the RS232/RS485 adapter.

The link is made according to the "EIA-485 standard for electrical characteristics of generators and receivers for use in balanced digital multipoint systems", issued by the *Electronic Industries Association, TR-30.1 Subcommittee on Signal Quality,* April 1983.

Receiver of the DBS RS485 line is continuously enabled. Transmitter is enabled only at the intervals when the DBS is sending the messages to the caller.

The BAUD RATE can be adjusted from 1200 to 19200 Baud's. The default value is BR=9600. The DBS does not support automatic baud-rate adjustment. That is, the drive is not able to detect the baud-rate of the caller, so it will not auto-adapt. Due to this reason, it is necessary that the initial baud rate setting of both the caller and receiver be the same. If the communication is not established at the first power-up, it is necessary to close the G3P drop on the control board and reset the drive. This action will set the baud rate of the DBS to a default of 9600 baud's.

The characters used in commands are ASCII encoded. The format of each character is 1 start bit, 8 data bits, 1 parity bit, and 1 stop bit. Each command consists of a series of characters / a string, followed by <CR> character. The drive responses are strings as well.

The string of the DBS response on the serial link begins and ends with a <CR> character. When a command or a new parameter setting is received by the DBS drive, the drive will first "clear the hand-held screen" by sending the character sequence <FF>,<US>,<CR>,<CR>. At the same time, such a response will acknowledge the command reception, and the master will be informed that its message is correctly received and understood. When inquired for the status-word value or a current parameter value, the DBS drive will always end the response string with a <CR> character.

2.8.1 Keypad

REMARK: for the first installation it is strongly recommended to use either the optional keypad or the DBTALK communication program.

The keypad is an optional accessory product which can be used for drive setup and monitoring. It must be connected to J2 connector.
If problems occur when attempting to communicate, the keypad is most likely set incorrectly. To start the setup procedure press <CTRL>, then <CR>. For each parameter the current setting is displayed, together with a question asking if you want to change it.
The correct setting is:

> BAUD = 9600
> WORD = 8D+E+1 STOP
> BLOCK MODE
> SINGLE LINE MODE
> FLASHING OFF
> KEY REPEAT ON SLOW

Be sure to save at the end of the procedure by pressing <Y> when the display shows: "Make changes permanent Y/N".

2.8.2 Connection to Personal Computer

2.8.2.1 RS232/RS485 Full-duplex Converter

The RS422 interface wiring is based on one-to-one, no multidrop, principle. Four wires are used. With RS422, you can transmit and receive data simultaneously (full-duplex). The RS485 half-duplex uses only two wires. It allows multidrop communication. With RS485 half-duplex, you cannot transmit and receive simultaneously. DBS drive supports RS485 full-duplex with four wires (RS422 compatible). Up to 15 DBS drives can be connected in multidrop configuration.

- **RS232/485 CONVERTER KIT**

This very small external converter provides a full-duplex interface between PC and DBS. The converter must be fit directly into a COM port (RS232) of a PC. This way the link becomes purely RS485, less susceptible to noise and able to transmit over much longer distances than RS232.
The kit includes:
- the converter to fit into DB25-S connector of the PC (COM port)
  The DTE/DCE switch of the converter must be set to DCE (Data Communications Equipment)
- a DB25 to DB9 interface (to be used if the PC COM port is DB9-S)
- a 2 m cable to connect the converter to J2 connector

- An optoisolated PC board RS 485 full-duplex driver can also be used. The following wiring must be used.

RS485 full duplex
Connector   **DBS J2 Connector**

                                    Male   **Female**

```
           (+Tx)          1 (+Rx)
           (-Tx)          2
           (+Rx)          3 (+Tx)
           (-Rx)          4 - 5
           (Gnd)          6 (-Rx)
                          7 (Gnd)
                          8 (-Tx)
                          9
```
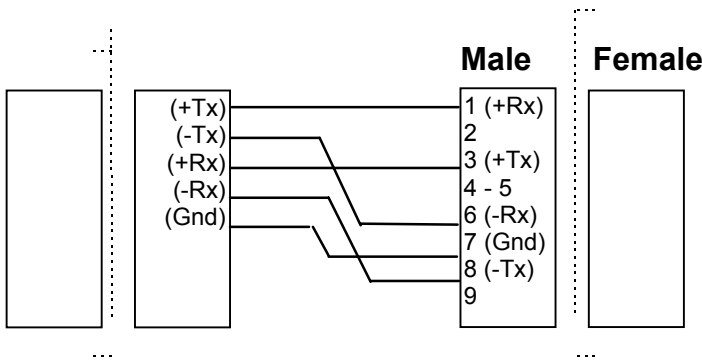
2.8.2.2 DBTALK Program

- **PC REQUIREMENTS**
- 80286, 80386, 80486 microprocessor or better
- Hard disk and one diskette drive. You need 2 Mbytes of disk space and 512 kbytes of RAM
- CGA, EGA, VGA, MCGA graphics card (color VGA recommended)
- MS-DOS 6.2 or later
- ANSI.SYS in CONFIG.SYS

- **DBTALK PROGRAM** (CN5501 code)
The DBTALK program is available on floppy disk
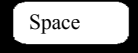
- **INSTALL PROGRAM**
- Insert diskette into drive A or drive B
- Type <a:install> (or <b:install>)
  The installation program will create the Directory C:\DBTALK, will copy all the files in this new directory and will start the program

- **START PROGRAM** (after the first installation)
- Type <cd dbtalk>
- Type <start>

- **MOVE IN THE PROGRAM**

Key	Action
↵	Start the selected procedure
⇥	Select the field
Space	Reread parameters
↑ ↓	Move up/down
← →	Go to previous/next screen
Esc	Exit/Go to previous menu

- **SELECT PROGRAM**

⇒ DBM linker

⇒ DBS linker

⇒ PDBS Linker (see PDBS Application Manual)

⇒ Setup

```
┌─────────────────────────────────────────┐
│  ┌───────────────────────────────────┐  │
│  │  SELECTING DESIRED PROGRAM        │  │
│  │                                   │  │
│  │  DBM LINKER                       │  │
│  │  DBS LINKER                       │  │
│  │  PDBS LINKER                      │  │
│  │  SETUP PROGRAM                    │  │
│  └───────────────────────────────────┘  │
└─────────────────────────────────────────┘
```
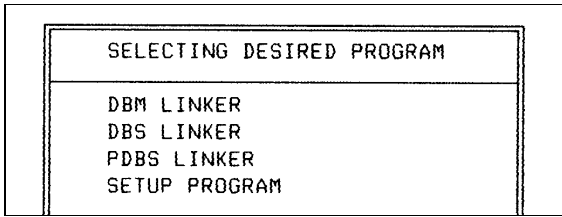
- **SETUP** to choose

⇒ Language: Italian or English

⇒ Serial link : COM1 or COM2

```
┌─────────────────────────────┐
│  PROGRAM SETUP MENU         │
│                             │
│     LANGUAGE                │
│     SERIAL LINK             │
│                             │
│  ESC per Chiudere           │
└─────────────────────────────┘
```

```
┌─────────────────────────────┐   ┌─────────────────────────────┐
│  PROGRAM SETUP MENU         │   │  PROGRAM SETUP MENU         │
│                             │   │                             │
│     ITALIANO                │   │     COM1: at 3F8            │
│     ENGLISH                 │   │     COM2: at 2F8            │
│                             │   │                             │
│  ESC per Chiudere           │   │  ESC per Chiudere           │
└─────────────────────────────┘   └─────────────────────────────┘
```
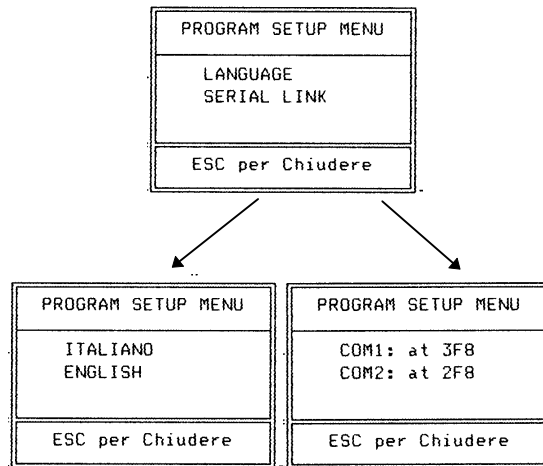
- **UTILITY** to

⇒ Scan Baud rates

	C	BAUD	C	BAUD	C	BAUD	C	BAUD	C	BAUD	C	BAUD
ADDRESS AND BAUDRATE AUTOMATIC SCANNING												
M	1	9600	18		35		52		69		86	
–	2	9600	19		36		53		70		87	
	3	9600	20		37		54		71		88	
E	4		21		38		55		72		89	

⇒ Scan Faults

06-17-1996	AUTOMATIC FAULT SCANNING		20:06:40
C	FAULT DESCRIPTION	C	FAULT DESCRIPTION
A01 FA000000 P00000 MA000 B000			
A02 FA000000 P00000 MA000 B000			
A03 FA000000 P00000 MA000 B000			

⇒ Restore/store Personality Card parameters

To save the actual parameter set, select STORAGE PARAMETER, select the file (e.g. ST1), press <TAB> to change the description and press <CR>

```
┌─────────────────────────────┐  ┌─────────────────────────────────┐
│   SETUP PERSONALITY CARD     │  │     FILE SETUP SELECTION        │
│                             │  │                                 │
│ COM :  FUNCTION SELECTION    │  │  POLI=6/6 RPM=3000 SE=1024      │
│                             │  │                                 │
│                             │  │  DF1   ST1   ST5   ST9  ST13 ST17│
│          RESTORE PARAMETER   │  │  DF2   ST2   ST6   ST10 ST14 ST18│
│          STORAGE PARAMETER   │  │  DF3   ST3   ST7   ST11 ST15 ST19│
│                             │  │  DF4   ST4   ST8   ST12 ST16 ST20│
└─────────────────────────────┘  └─────────────────────────────────┘
```

⇒ Set Baud rates

⇒ Start the Autophasing procedure

⇒ Set the "Adjustment of Torque/Speed curve" procedure

- **MANUAL** to

⇒ See/Reset Faults

If the fault condition is not present anymore, the fault will be reset automatically. To reset the fault on the screen, go to the next screen with the arrow keys

```
┌──────────────────────────────────────────────────────────────────┐
│ ┌────────────────────┬───────────────────────┬─────────────────┐ │
│ │ Send Command        │                       │ 1st ADDRESS[01]]│ │
│ │ Driver Answer       │                       │                 │ │
│ │ Communication Status│    -- REGULAR --      │ SET ADDRESS [01]│ │
│ └────────────────────┴───────────────────────┴─────────────────┘ │
│                                                                  │
│  ┌─────────────────────────┐    ┌─────────────────────────┐      │
│  │   POWER SUPPLY FAULT     │    │   SELECTED AXIS FAULT    │      │
│  │                         │    │                         │      │
│  │ OVERTEMPERATURE          │    │ MOTOR OVERTEMPERATURE    │      │
│  │ BRAKING CIRCUIT          │    │ RESOLVER DISCONNECTED    │      │
│  │ 220Vac INPUT             │    │ AXIS SHORT CIRCUIT       │      │
│  │                         │    │ NOT CONGRUENT PHASE      │      │
│  │ PERSONALITY CARD         │    │ VELOCITY ERROR           │      │
│  │                         │    │ I2T Protection           │      │
│  └─────────────────────────┘    └─────────────────────────┘      │
│                                                                  │
│  ┌─────────────────────────┐    ┌─────────────────────────┐      │
│  │ (A) MODULE FAULT (DBM)   │    │ (B) MODULE FAULT (EBM)   │      │
│  │                         │    │                         │      │
│  │ OVERTEMPERATURE          │    │ OVERTEMPERATURE          │      │
│  │ BUS BAR VOLTAGE          │    │ BUS BAR VOLTAGE          │      │
│  │ AUX VOLTAGE Ref. - AT    │    │ AUX VOLTAGE Ref. - AT    │      │
│  └─────────────────────────┘    └─────────────────────────┘      │
└──────────────────────────────────────────────────────────────────┘
```

⇒ Display the Status

```
┌──────────────────────────────────────────────────────────────────┐
│ ┌────────────────────┬───────────────────────┬─────────────────┐ │
│ │ Send Command        │                       │ 1st ADDRESS[01]]│ │
│ │ Driver Answer       │                       │                 │ │
│ │ Comunication Status │    -- REGULAR --      │ SET ADDRESS [01]│ │
│ └────────────────────┴───────────────────────┴─────────────────┘ │
│                                                                  │
│  ┌──────────────────────────┐   ┌──────────────────────┬────────┐│
│  │   MODULE STATUS          │   │  SELECTED AXIS STATUS │ENABLED ││
│  │                         │   │                      │        ││
│  │ REFERENCE ENABLE    ON   │   │ DRIVE ENABLE         │  ON    ││
│  │ Opto DRIVE OK OUTPUT OFF │   │ TORQUE ENABLE        │  OFF   ││
│  │ PRIORITY (G2 DROP) KEYBOARD│  │ REFERENCES           │ DIGITAL││
│  │ EXPANSION  (EBM)  ADVISED │   │ ILIMIT               │ DIGITAL││
│  │                         │   │ SYSTEM CONTROL       │VELOCITY││
│  │                         │   │ ROTATION             │C.CLOCKWISE│
│  └──────────────────────────┘   └──────────────────────┴────────┘│
│                                                                  │
│  ┌──────────────────────────┐   ┌──────────────────────────┐     │
│  │   SPARE OUTPUT           │   │ (B) MODULE FAULT (EBM)   │     │
│  │                         │   │                         │     │
│  │ ANALOG OUT 1  EV AXIS 2  │   │ OVERTEMPERATURE          │     │
│  │ ANALOG OUT 2  IOUT AXIS 3│   │ BUS BAR VOLTAGE          │     │
│  │                         │   │ AUX VOLTAGE Ref. - AT    │     │
│  └──────────────────────────┘   └──────────────────────────┘     │
└──────────────────────────────────────────────────────────────────┘
```

⇒ See/Change parameters

To change one parameter type the command string on the PC keypad. Example: 1VE3000

Send Command Driver Answer Communication Status	1VE3000 -- REGULAR --	1st ADDRESS[01] SET ADDRESS [03]

MODULE S

REFERENCE EN
Opto DRIVE O
PRIORITY (G2
EXPANSION (

SPARE OU
ANALOG OUT 1
ANALOG OUT 2

COM		COM		COM		COM	
NP	6	AC	0	IT	7	SE	1024
PR	1	DE	0	PC	50	RX	16
		EV	0	IL	100	RN	12
RS	15168						
CP	1742	OV	128	MV	3000	ET	80
		OC	128	MR	10.0	ES	16
VE	0			KI	20		
VS	1	CU	128	KP	80	BR	9600
DF	0	CV	128				

FIG. 2.13 - CONTROL CARD - JUMPERS

G1P

G2P

G3P

G4P

G5P
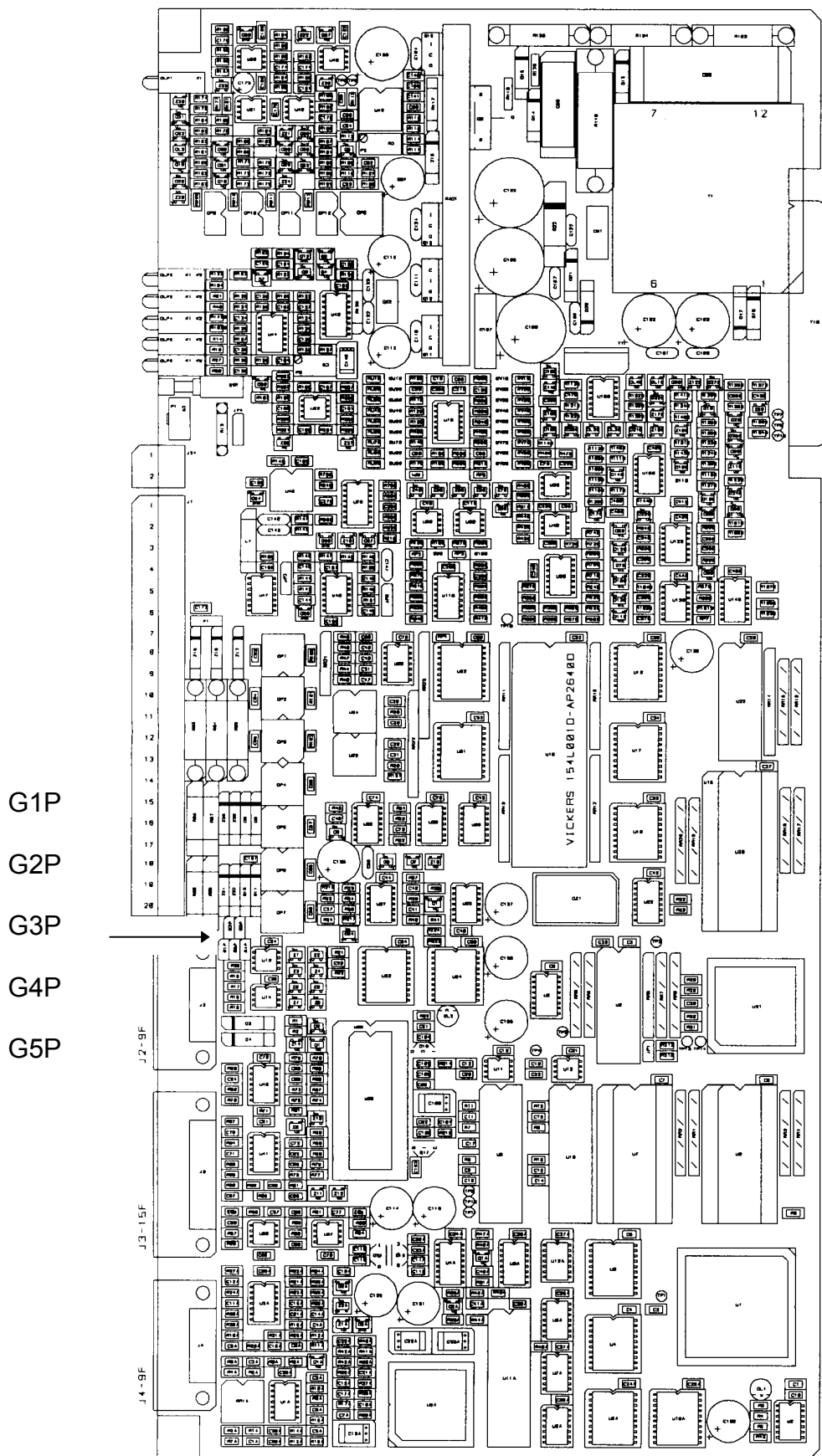
FIG. 2.14 - G1P, G2P, G3P, G4P, G5P JUMPERS
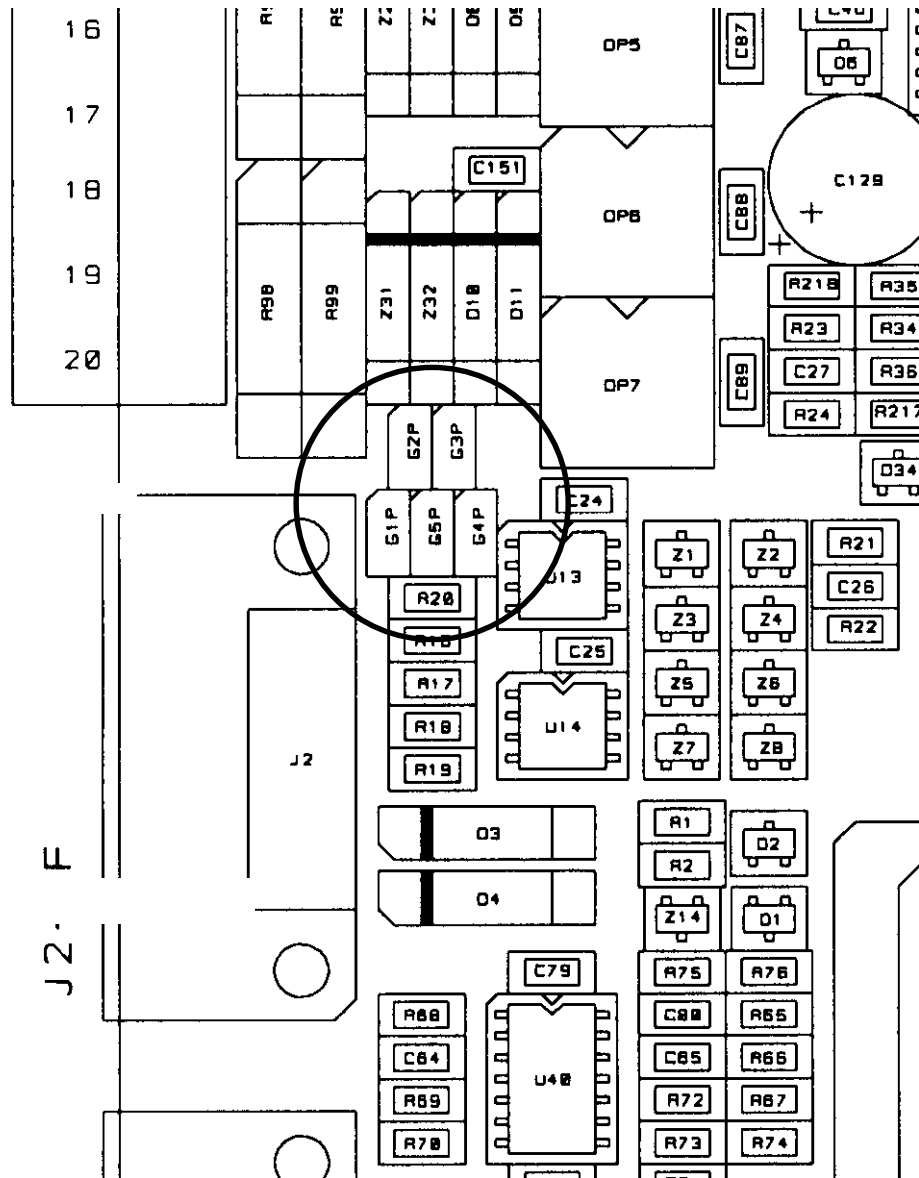
2.9 G_P Jumpers (see Fig. 2.13 and Fig. 2.14)

On the control (common) panel there are 5 jumpers which have the following functions. These jumpers can be accessed by unscrewing two screws on the front and by extracting the control panel (see Fig. 1.2).

2.9.1 "Keypad" or "Opto" Priority (G2P)

G2P open = keypad priority = the keypad (or the device connected to the serial link) is the master, i.e. it allows to enable or disable motor current, whereas the optocouplers can only disable (protection); they can enable after resetting only.
The "Drive Enable" and "Reference Enable" opto-isolated signals (J1/pos.15 and pos.16) must be driven at +15V. To enable the drive the ON command must be used.
Such a procedure should be followed during installation and drive test.

G2P closed =opto priority =the optocouplers are the master and the keypad can only be used for parameters setup.

2.9.2 Default Initialization (G3P)

G3P open (default)   = no initialization
G3P closed and G2P closed   = "normal" default initialization (sets BR=9600 and SA=A)
G3P closed and G2P open   = "total" default initialization (sets the values of Tab.5.2)

2.9.3 Serial Link (G1P, G4P, G5P)

G1P closed (default) =   connects TX- of serial link to OV via pull-down resistor
G4P closed (default) =   connects TX+ of serial link to +5V via a resistor
G5P closed (default) =   connects a 820 Ω resistor between RX+ and RX- of the serial link
.

Note: in case of multidrop (DBS drive allows for the parallel connections of up to 15 drives) G1P, G4P and G5P must be closed only on the last DBS of the multidrop, and must be open on all the other drives.

2.10 Starting Sequence

- Check the correct setting of the switch 400V/460V on the top of the drive
- Switch on 400 Vac (or 460Vac) three phase power supply
- Wait for Drive OK optoisolated output
- Check if NP (pole number), PR (motor/resolver pole ratio), MR (max reference), KI (integral gain), KP (proportional gain), ST (status), SE (simulated encoder, if applicable) parameters are OK for the application

WARNING: *High Voltage - Discharge Time Approx. 6 Minutes.*
CAUTION: *in case of repetitive switching off and on, wait 1 minute between off and*
on.

2.10.1 Autophasing

• Check that the motor is free to rotate in both directions.
• Check that no fault condition occurs (red drive-fault leds off).
• Check that the analog drive enable is on via positive logic and digital drive enable off.
• Send the password command for the module.
• Send the autophasing 1AP command and save.

2.10.2 Wiring Check

Axis being phased it is possible to check the wiring by rotating the motor with no load via its digital reference.

• Set KI=10 and KP=20 to avoid motor vibrations.
• Set DF=0 (digital filter disabled).
• Enable analog drive-enable and reference-enable via positive logic.
• Send the ON command (to enable digital drive-enable) , the VE command (for CW slow rotation), the VE- command (for CCW slow rotation), the OF command (to disable the digital drive-enable).

2.10.3 CNC Priority

With CNC, the following procedures must be followed.

2.10.3.1 Setting Of Analog References

To set the modules to use the analog references from the CNC, it is necessary to enter the password, to send the AR command and to save. ST command can be sent to check if the commands have been accepted.

2.10.3.2 Drive Enable With CNC Priority

To give the priority for enabling and disabling the drive from the CNC, it is necessary, to close G2P jumper.

When the above procedure is completed, the CNC is the master and the keypad is the slave, as follows:
PARAMETERS MANAGED BY CNC: drive enable, reference enable, speed references.
PARAMETERS MANAGED BY KEYPAD: all dynamic parameters (acceleration, deceleration, KI, KP, etc.), status and fault.

2.10.4 Velocity Offset

With analog reference (AR), sometimes the motor rotates also with REF EN=0 or with zero analog speed reference. You can adjust this <u>analog</u> velocity offset via VO command for an automatic adjustment. A fine adjustment can be done with successive steps via OV command.

REMARK: the adjustment of the <u>digital</u> velocity offset is reserved to <u>setup technicians</u>.

2.11 Resolver To Encoder Option

For position sensing a resolver to encoder option (simulated encoder) is available.
Encoder signals are 7V, 100 Ω impedance, as follows:

- 2 channels of square wave output with a resolution from 64 to 16384 pulses per electrical revolution. Channel B leads channel A by 90° for clockwise rotation when viewed from shaft end.
- 1 marker pulse per electrical revolution (i.e. 1∗ 3 = 3 marker pulses per mechanical revolution with a 6 pole resolver).
- . complementary outputs $\overline{A}$, $\overline{B}$ and $\overline{C}$.

The simulated encoder resolution can be modified with SE command.

Fig. 2.15 -   Simulated Encoder (CW Rotation When Viewed From Shaft End)
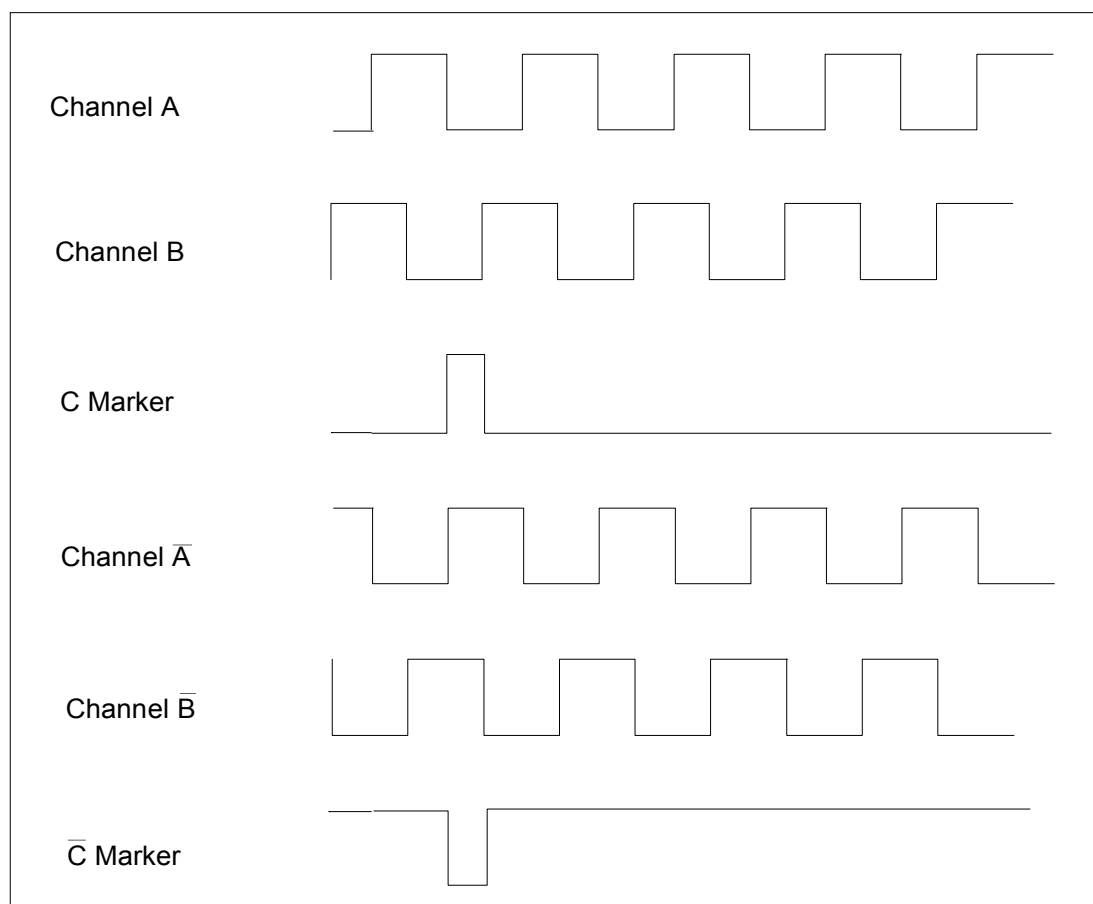
Note: to make C marker high when Channel A and Channel B are high (like Siemens), exchange Channel A with Channel $\overline{A}$ and Channel B with Channel $\overline{B}$.

2.12 Mechanical Brake

FAS series servomotors have as option a 24 Vdc electromagnetic safety brake.

CAUTION: safety brake must be clamped and released with motor at standstill. Dynamic brakes can seriously damage the brake and reduce the braking torque.

The release of the brake (from 0V to +24V) and the clamp (from +24V to 0V) must follow the sequence in Fig. 2.16.

FIG. 2.16 - Braking Sequence, Timing Chart

Note: T1 $\geq$ 200 ms, T2 = application dependent, T3 = 100 ms, T4 $\geq$ 200 ms
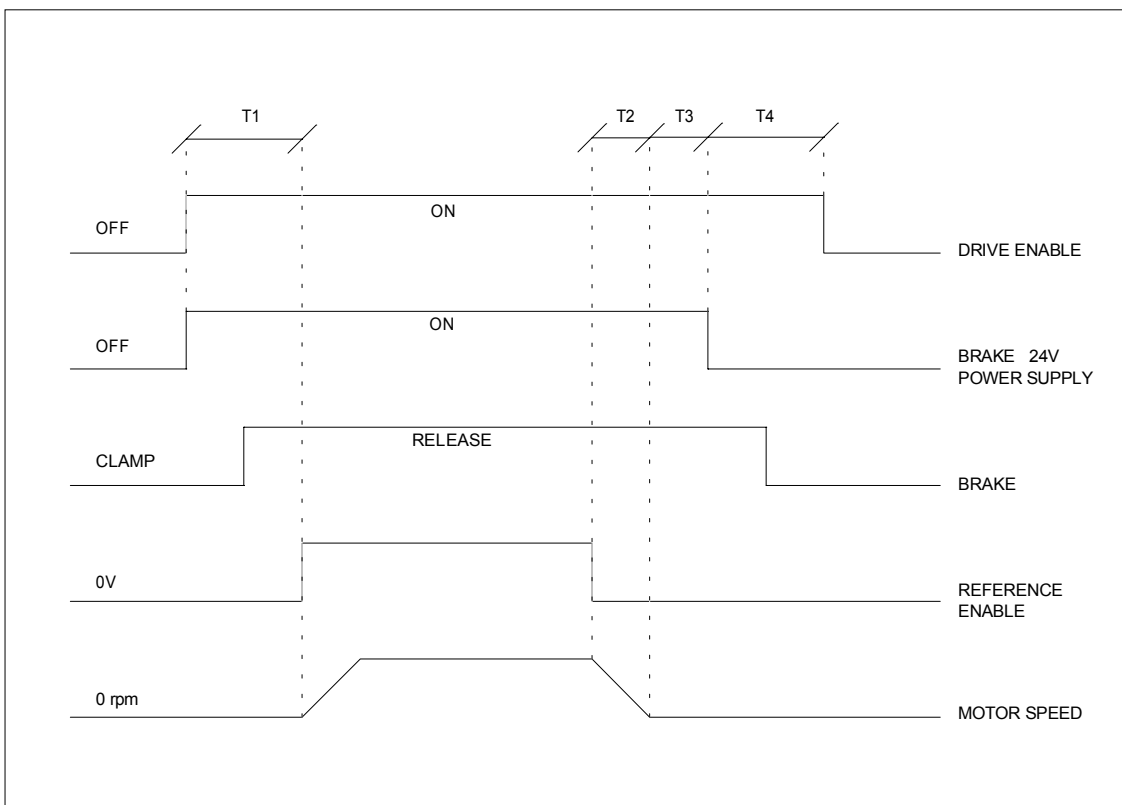
2.13 - Sizing of Power Supply Circuit

2.13.1 Sizing of Power Transformer

DBS drive is designed to allow direct operation from a 400/460 Vac 50/60 Hz 3-phase source. An isolation transformer may still be required to meet local electrical safety regulations. It is the user responsibility to determine if an isolation transformer is required to meet these requirements.

To size the transformer it is necessary:
- to refer to the rated output power of the motors (the output power with 65K winding overtemperature is included in the Technical Data table of catalogs of servomotors)
- to sum the power of single axes and to multiply the sum by the contemporaneity factor (factors often utilized are K_c=0.63 for 2 axes, K_c=0.5 for 3 axes, K_c=0.38 for 4 axes, K_c=0.33 for 5 axes, K_c=0.28 for 6 axes) in case of multi-axis application
- to multiply by a correction coefficient (=1.2), accounting for the losses of the motor/drive system.

$$P = \Sigma\, P_{im} * K_c * 1.2 \qquad [W]$$

2.13..2 Auxiliary Power

For a correct sizing, especially for small drives, auxiliary power (30 W for each module) and fan power P_{fan} (7 W for DBS 3-6-8-15-25-35 and 15W for DBS 50-60) must be added.

$$P_{aux} = 30 + P_{fan} \qquad [W]$$

2.14 - Power Dissipation

To calculate cabinet cooling requirements, table below provides estimated equipment power dissipation values. If the application employs continuous braking, it is necessary to include the recovery resistor power dissipation (use the nominal power of recovery resistor if actual application recovery dissipation is unknown).

	DBS Model									
	3/9	**6/15**	**8/22**	**15/42**	**25/70**	**35/90**	**50/140**	**60/180**	**100/240**	**180/320**
Power Dissipation	100 W	150 W	190 W	310 W	475 W	650 W	900 W	1100 W	1600 W	2700 W

SECTION 3 - ELECTROMAGNETIC COMPATIBILITY (EMC)

3.1 European Directive (89/336/EC)

Compliance with the European Directive 89/336/EEC is required for all electric and electronic products brought onto the European market after December 31st, 1995.
DBS drives with FASTACT motors meet the following EMC product standard related to the Directive:

EN 61800-3 (1996) and EN 61800-3/A11 (2000): "Adjustable speed electrical power drive systems. Part 3: EMC product standard including specific test methods".
Second environment (industrial) compatibility levels.

Remark: equipments not intended to be used on a low-voltage public network which supplies domestic premises. May cause radio frequency interference.

Tests have been made in an independent, competent body, test house.

The installer of the drive is responsible for ensuring compliance with the EMC regulations that apply where the drive is to be used. We recommend filtering as per par.3.2 and wiring, grounding and screening as per par.3.3 and 3.4.

3.2 Filtering

3.2.1 Filter Types

The following filters are recommended.

Code	Trade-mark	Rated Current [A] at 50°C (40°C)	Max Voltage [Vac] at 50°C	Drive type
AT6017	Schaffner FN 2070-3-06	(3)	250	DBS with optional 24Vdc input
AT6009	Schaffner FN 258-7/07	7 (8.4)	3 x 480	DBS 3/9, DBS 6/15, DBS 8/22
AT6010	Schaffner FN 258-16/07	16 (19.2)	3 x 480	DBS 15/42
AT6011	Schaffner FN 258-30/07	30 (36)	3 x 480	DBS 25/70
AT6012	Schaffner FN 258-42/07	42 (50.4)	3 x 480	DBS 35/90, DBS 50/140
AT6013	Schaffner FN 258-55/07	55 (66)	3 x 480	DBS 60/180
AT6015	Schaffner FN 258-100/35	100 (120)	3 x 480	DBS 100/240, DBS W120/240
	Schaffner FN 258-180/07	180 (216)	3 x 480	DBS 180/320

3.2.2 Filter Sizing

The filter/drive coupling in the previous table is a standard coupling. The filter can be undersized according to the rms input current of the actual application. This should be done not only because, as a matter of fact, undersizing the filter means less money, but because the undersized filter provides better performance to EMC.

3.2.3. Filter Dimensions

Code	Trade-mark	Dimensions [mm]							Weight
		L1	L2	L3	L4	L5	L6	l7	[kg]
AT6017	Schaffner FN 2070-3-06*	85	75	54	0	65	40.3	fast-on terminal	0.25
AT6008	Schaffner FN 250-6/07*	85	75	54	0	65	30	300	0.24
AT6009	Schaffner FN 258-7/07	255	240	50	25	225±0.8	126±0.8	300	1.1
AT6010	Schaffner FN 258-16/07	305	290	55	30	275±0.8	142±0.8	300	1.7
AT6011	Schaffner FN 258-30/07	335	320	60	35	305	150	400	1.8
AT6012	Schaffner FN 258-42/07	329	314	70	45	300	185	500	2.8
AT6013	Schaffner FN 258-55/07	329	314	80	55	300	185	500	3.1
AT6014	Schaffner FN 258-75/34	329	314	80	55	300	220	terminal block	4
AT6015	Schaffner FN 258-100/35	379±1.5	364	90±0.8	65	350±1.2	220±1.5	terminal block	5.5
	Schaffner FN 258-180/07	438±1.5	364	90±0.8	50	350±1.2	220±1.5	terminal block	11

*= FN2070-3-06 has fast-on terminals at both sides, FN250-6/07 has wiring leads (length=300mm) at both sides.

TOP VIEW
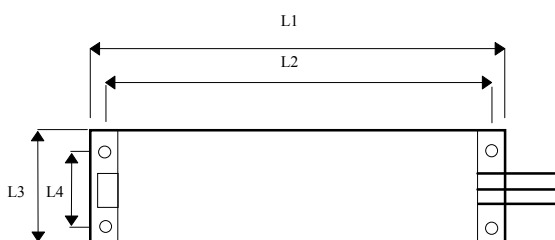
SIDE VIEW
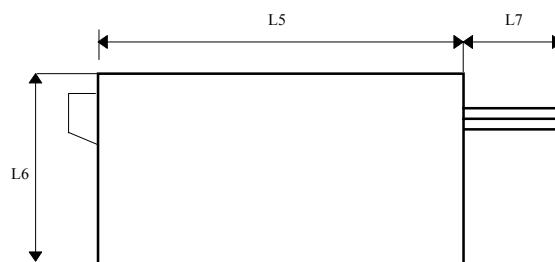
3.2.4 Filter Installation

- The filter must be mounted on the same panel as the drive.

CAUTION: leave a clear space of at least 60mm around the filter for air circulation when the cabinet does not have forced ventilation.

- The filter must be connected as close as possible to the drive input. If the separation between filter and drive exceeds around 30 cm (1 ft.) then a flat cable should be used for the RF connection between filter and drive

REMARK: when mounting the drive and the filter to the panel, it is essential that any paint or other covering material be removed before mounting the drive and the filter.

- The maximum torque of mounting screws is as follows:

FILTER	Max torque
FN 2070-3-06	0.8 Nm
FN 250 - 6/07	0.8 Nm
FN 258 - 7/07	0.8 Nm
FN 258 - 16/07	0.8 Nm
FN 258 - 30/07	1.8 Nm
FN 258 - 42/07	1.8 Nm
FN 258 - 55/07	3.0 Nm
FN 258 - 75/34	3.0 Nm
FN 258 - 100/35	4.0 Nm
FN 258 - 180/07	4.0 Nm

- The filter can produce high leakage currents (see Table)

FILTER	Leakage current *
FN 2070-3-06	0.4 mA
FN 250 - 6/07	1.3 mA
FN 258 - 7/07	17 mA
FN 258 - 16/07	19 mA
FN 258 - 30/07	25 mA
FN 258 - 42/07	26 mA
FN 258 - 55/07	26 mA
FN 258 - 75/34	26 mA
FN 258 - 100/35	26 mA
FN 258 - 180/07	26 mA

* Note: if two phases are interrupted, worst case leakage current could reach 6 times higher levels

- The capacitors within the filters have discharge resistors.

CAUTION: the filter must be connected to ground before connecting the supply

WARNING: HIGH VOLTAGE - DISCHARGE TIME APPROX. 10 seconds

3.3 Wiring And Grounding

All the following cables must be shielded, with 85% minimum shielding coverage:

- power motor cable (see Fig.3.1 and 3.2)

NOTES: if a power terminal board is used at motor side, the shield must be RF connected to a metallic PG gland.
- connectors at motor side can have a threaded clamp. Cable shield must be grounded in the same way as in Fig.3.2

- resolver cable (see Fig.2.5 and 3.2 motor side)

Fig. 3.1 - Grounding Of Shield To Motor Connector At Drive Side
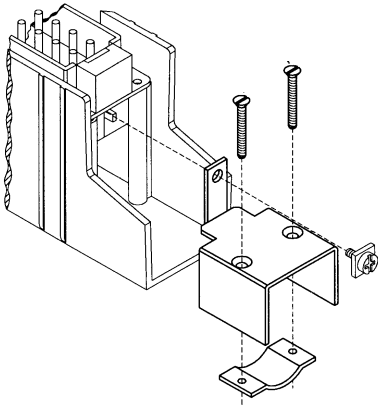
- external recovery resistor cable
CAUTION: the unshielded cable provided with the drive is only for test purposes and not EMC compliant.

- Reference, Enable and OK cable

- RS485 cable

- simulated encoder cable (if applicable)

Fig. 3.2 - Grounding Of Shield To Connectors At Motor Side

Cable shield — Metal shell
Shield must be clean and clamp tightened
Motor and resolver connector
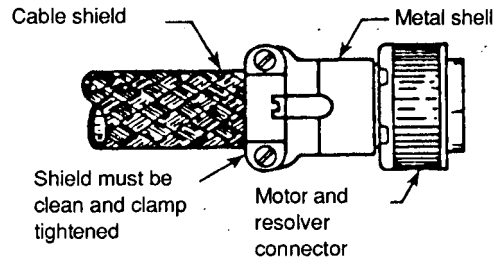
The shields of the cables must be connected at both ends to the proper housing via full circumferential bond to metallic connectors or hose clamps.
In case of Sub-D connector, cable shield must be grounded to the metallic hood.
When there is not connector at drive side, a kit with stand-off, screws and hose clamps is provided.
The shield of the cable must be uncovered from insulation coating and RF connected to the stand-off through the hose clamp, as in Fig.3.3 .

Fig. 3.3 - Grounding Of Shield Without Connector

Fig. 3.4 - Grounding At Drive Side

1 = Reference, Enable, OK cable
2 = Recovery resistor cable
3 = Motor power cable

Sub-D and unshielded cables not shown
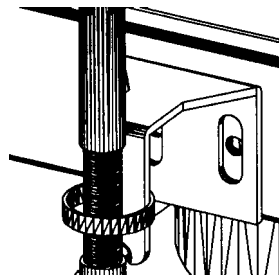
It is not necessary to shield the input power wires.

REMARKs:
- the shields of cables inside the cabinet must be 360° clamped to the cabinet wall (see Fig. 3.5).
- "noisy" cables must be kept away from "sensitive" cables by at least 30 cm (12 in). Noisy cables include input-power wires, motor power and brake wiring. Sensitive cables include analog or digital signal cables: resolver cable; reference, enable and OK cable; RS485 serial link; simulated encoder wiring.
- where noisy cables must cross power cables, this must be done with angles as near to 90° as possible.

FIG. 3.5 - Backpanel Connection

Backpanel (earth)

Screen is effectively earthed 360° of its radius
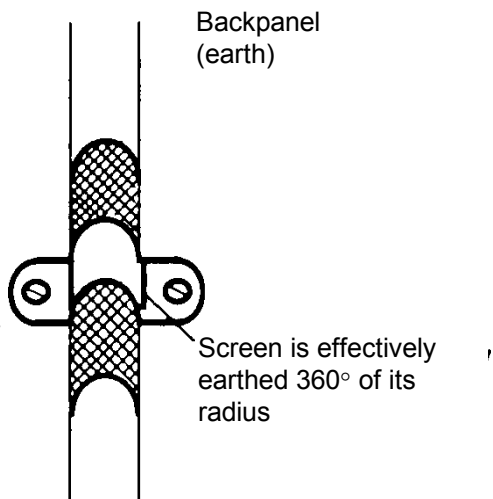
FIG. 3.6 - Partition Penetration

Enclosure — Strap — Cable Shield

Hex Head Bolt
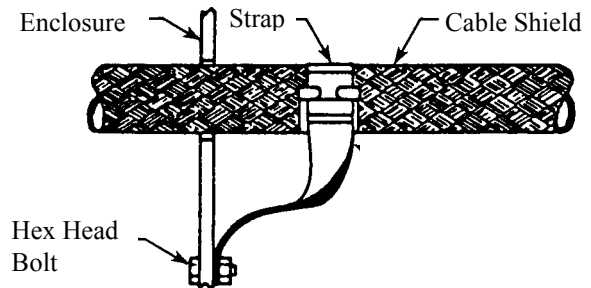
- the crossing of the cabinet should be accomplished with a low impedance connection between cable shield and enclosure. If a connector is not involved, the shortest practical lengths of connecting strap should be used (see Fig.3.6).

3.4. Recovery Resistor / Motor Choke

To meet the EMC Directive, the enclosures containing dynamic braking resistors must be conductive. The cable of recovery resistor must be shielded and the shield must be 360° clamped at both sides.
In some applications (some size 3 FAS T motors) a choke in series for each motor phase has to be added. This choke must be shielded.

REMARK: when mounting the enclosure of recovery resistor or motor choke to the panel, it is essential that any paint or other covering material be removed before mounting the enclosure of recovery resistor or motor choke.

3.5 Screening

To effectively screening the system all the single screens (CNC, electronic cabinet, machine, motor housing, cables) must be connected together to effectively form one screen (see Fig.1.8).

3.6 Safety Aspects

Noise suppression of Motor and Drive systems involves consideration of the earthing system, and its effectiveness at high frequencies. It should not be forgotten that is the safety system too and that the safety must take priority over EMC.
To reduce the radiated emissions, the use of capacitance to earth is very effective. In fact DBS drives have Y-type capacitors near the input power supply connector and Schaffner filters also include them. These capacitors conduct current from phase to earth; this can be in the order of hundreds of milliamperes.

WARNING: *appropriate safety measures should be taken to ensure that this potentially dangerous current flows to earth.*

CAUTION: *it is recommended to disconnect the drive and the EMC filters to carry out the AC Voltage Tests of EN 60204-1 (1997), par.19.4, in order to not damage the Y-type capacitors between phases and ground. Moreover the DC voltage dielectric test required by EN 50178 (1997), product family standard, has been carried out in factory as a routine test. The DC Insulation Resistance Tests of EN 60204-1 (1997), par.19.3, may be carried out without disconnecting the drive and the EMC filters.*

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SECTION 4 - PROTECTIONS AND TROUBLESHOOTING

4.1 Protections

Protection	Led	FA bit	Optoisolated Output	RESET
Resolver not ok	DRIVE FAULT RES FAULT	b1	DRIVE OK	Button, Remote Reset, FA command
Auxiliary voltages out of tolerance	DRIVE FAULT	b13	DRIVE OK	Button, Remote Reset, FA command
Motor over temperature	DRIVE FAULT M OVT	b2	DRIVE OK MOTOR OK	Button, Remote Reset, FA command
Power fault	DRIVE FAULT PWR FAULT	b3	DRIVE OK	OFF/ON
EEPROM error	DRIVE FAULT	b11	DRIVE OK	Button, Remote Reset, FA command
Bus not normal	DRIVE FAULT	b12	DRIVE OK	Button, Remote Reset, FA command
Drive overtemperature	DRIVE FAULT DRV OVT	b14	DRIVE OK	OFF/ON
IT	IT(*)	b6	-	OFF/ON
Watchdog	DRIVE FAULT WTD	-	DRIVE OK	Button, Remote Reset, FA command
Overspeed	DRIVE FAULT	b5	DRIVE OK	Button, Remote Reset, FA command

(*) when the IT LED becomes blinking, it indicates the activation of the IT protection; when the IT LED becomes steady illuminated, it indicates the activation of an internal protection. In this case please ask the Service Centers.

REMARK: the reset via Remote Reset can be used only in fault conditions. This reset is carried out by sending a pulse (15V for a time t $\geq$ 200 ms) on J1 connector (pos.17).

4.1.1 Resolver not ok

Indicated by: DRIVE FAULT LED, RES FAULT (Resolver Fault) LED, optoisolated output DRIVE OK, bit b1 of the FA string (see FA command).

Set condition: when the resolver is not connected or in short circuit at the power up, when the resolver fails or is disconnected during running.

Effect: the drive inhibit torque.

Reset condition: if the condition is not present anymore, reset button on drive, send pulse to REMOTE RESET or send FA command.

4.1.2 Auxiliary voltages out of tolerance

Indicated by: DRIVE FAULT LED, optoisolated output DRIVE OK, bit b13 of the FA string (see FA command).

Set condition: when the level of +/- 15V or 5V becomes out of tolerance.

Effect: inhibit torque.

Reset condition: if the condition is not present anymore, reset button on drive, send pulse to REMOTE RESET or send FA command.

4.1.3 Motor over temperature

Indicated by: DRIVE FAULT LED, M OVT LED, optoisolated outputs DRIVE OK and MOTOR OK, bit b2 of the FA string (see FA command).

Set condition: when a limit temperature is reached inside the motor.

Effect: the drive inhibit torque.

Reset condition: if the condition is not present anymore, reset button on drive, send pulse to REMOTE RESET or send FA command.

Notes: the fault information via LED's and opto is reset when the motor temperature goes down the limit, while the drive is disabled until the reset condition has been met.

4.1.4 Power fault

Indicated by: DRIVE FAULT LED, PWR FAULT LED, optoisolated output DRIVE OK, bit b3 of the FA string (see FA command).

Set conditions:
1. When a short circuit is detected between motor phases, phase and ground, phase and HV.
2. When overcurrent is detected in motor phases.
3. Overheating of power modules (locked rotor condition).
4. Undervoltage of internal supply of power modules

Effect: the drive inhibit torque.

Reset condition: if the condition is not present anymore, power off and on the power supply. In case of condition 3. (overheating) wait at least 3 minutes before power up the drive.

4.1.5 EEPROM error

Indicated by: DRIVE FAULT LED, optoisolated output DRIVE OK, bit b11 of the FA string .

Set condition: when error in writing data into the EEPROM is detected..

Effect: inhibit torque.

Reset condition: if the condition is not present anymore, reset button on drive, send pulse to REMOTE RESET or send FA command.

4.1.6 Bus not normal.

Indicated by: DRIVE FAULT LED, POWER OK LED, optoisolated output DRIVE OK, bit b12 of the FA string (see FA command).

Set condition: when the bus bar voltage is over/under than the fixed thresholds (see fig. 4.1 and fig.4.2)

Effect: inhibit torque.

Reset condition: if the condition is not present anymore at analog level (with hysteresis), reset button on drive, send pulse to REMOTE RESET or send FA command.

FIG. 4.1 Bus Bar Voltage (400V)

720 V (overvoltage)
680 V (Recovery circuit enabled)
620 V (Reset max voltage)
560 V (Bus nominal voltage)
440 V (Reset min voltage)
410 V (Undervoltage)
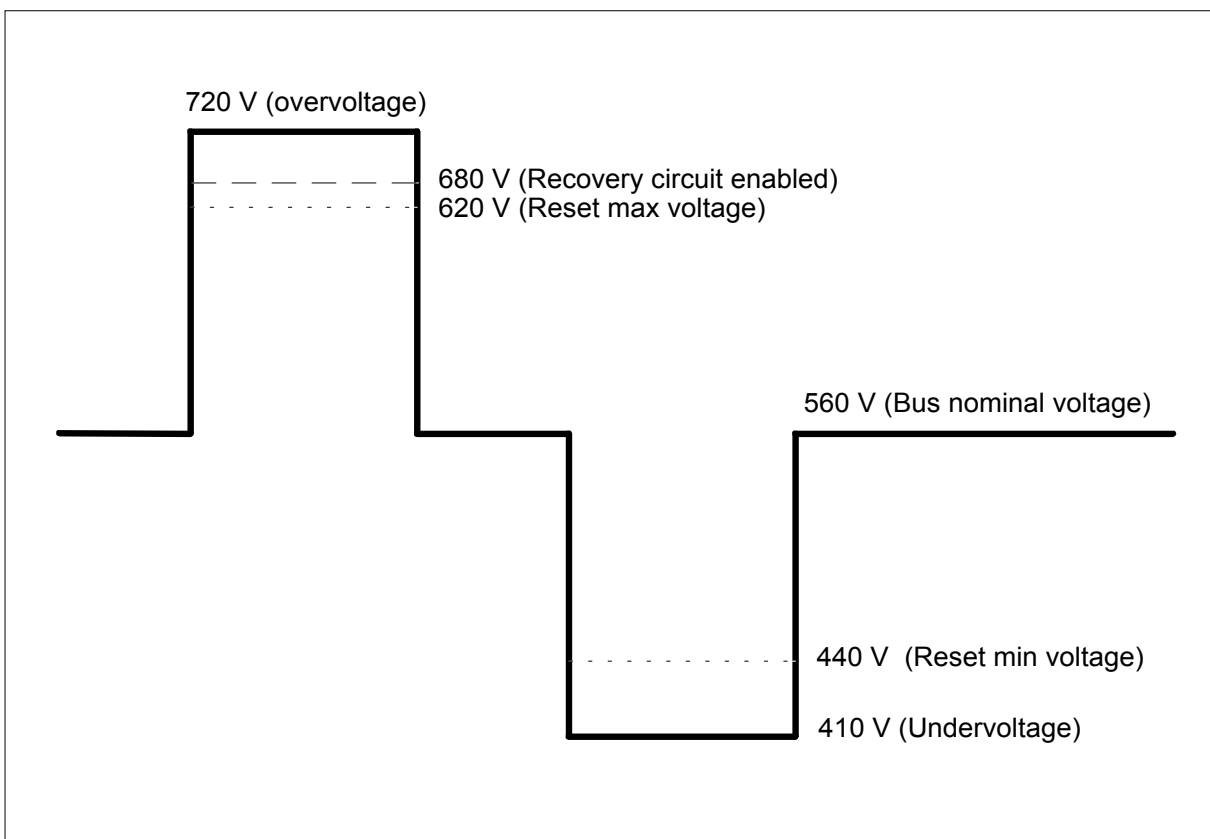
FIG. 4.2 Bus Bar Voltage (460V)

810 V (overvoltage)

790 V (Recovery circuit enabled)

690 V (Reset max voltage)

650 V (Bus nominal voltage)

495 V (Reset min voltage))

470 V (Undervoltage)
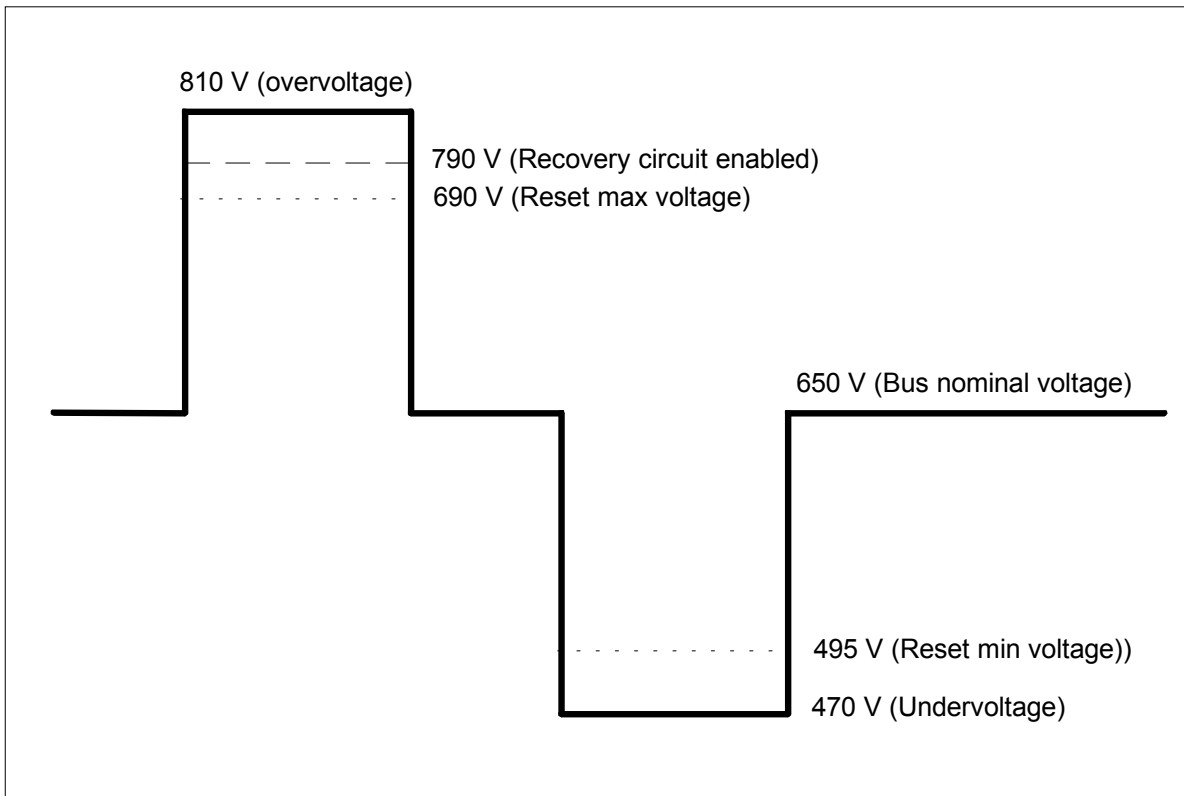
4.1.7 Drive overtemperature.

Indicated by: DRIVE FAULT LED and DRV OVT LED, optoisolated output DRIVE OK, bit b14 of the FA string (see FA command).

Set condition: when a limit temperature is reached on the heatsink.

Effect: inhibit torque.

Reset condition: if the condition is not present anymore, power off and on the power supply.

Notes: the temperature limit is detected by thermo-switch.

4.1.8 IT

Indicated by: IT LED, bit b6 of the FA string (see FA command).

Set condition: when the current exceeds the nominal motor current for a time longer than the time stated by the motor thermal model (see IT command and Tab.3.4).

Effect: when the fault is going on the current limit is reduced to the level of the motor rated current (set by PC command).

Reset condition: when the set condition is not present anymore. Power OFF and ON the drive to reset the protection.

REMARK: when the IT LED becomes blinking, it indicates the activation of the IT protection; when the IT LED becomes steady illuminated, it indicates the activation of an internal protection. In this case please ask the Service Centers.

4.1.9 Watchdog.

Indicated by: DRIVE FAULT LED, WTD LED, optoisolated output DRIVE OK.

Set condition: when the micro controller or DSP fails.

Effect: inhibit torque.

Reset condition: if the condition is not present anymore, reset button on drive, send pulse to REMOTE RESET.

4.1.10 Overspeed

Indicated by: DRIVE FAULT LED, optoisolated output DRIVE OK, bit b5 of the FA string (see FA command).

Set condition: when an error between set speed and actual speed bigger than the programmed via EV command is detected.

Effect: inhibit torque.

Reset condition: if the condition is not present anymore, reset button on drive, send pulse to REMOTE RESET or send FA command.

4.2 Troubleshooting

FIG. 4.3 - POWER OK green LED off

```
                              ┌─────────────────────┐
                              │   Green LED          │
                              │   POWER OK = OFF     │
                              └─────────────────────┘
                                         │
                                         ▼
  ┌──────────────────┐        NO      ◇◇◇◇◇◇◇◇◇◇◇◇◇◇
  │ Connect 3-phase  │◄────────────── Is 3-phase 400 Vac
  │ 400 (or 460) Vac │                (or 460) Vac +/-10%
  └──────────────────┘                connected to DBS?
                                        ◇◇◇◇◇◇◇◇◇◇◇◇◇◇
                                            │
                                          YES
                                            │
                                            ▼
                                     ┌──────────────┐
                                     │ Internal fault│
                                     └──────────────┘
```
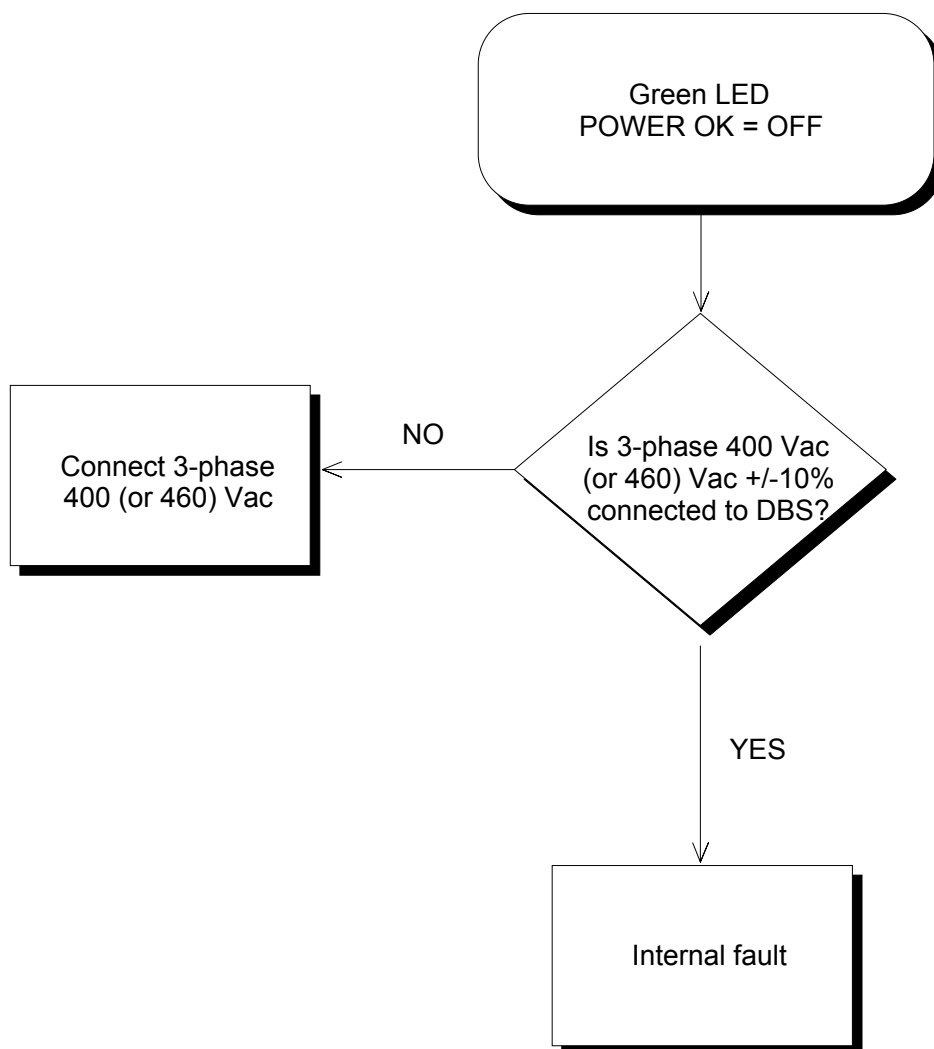
FIG. 4.4 - AUX PWR green LED off
Auxiliary Power Fault

Green LED AUX PWR = OFF

Power supply present?

NO → Connect power supply

YES → Fault of auxiliary power circuit

FIG. 4.5 - REF EN green LED off
Reference Enable

Green LED REF EN = OFF

Internal +15V used?
(J1/pin 7)

NO

Verify that 8.5 to 25Vdc voltage with 8 mA min current is applied to J1/pin 16 and 0V to J1/pin 8.

YES

J1/pin 6 (common) connected to J1/pin 8 (opto common)?

NO

Make connection

YES

Fault on input circuit

FIG. 4.6 - DRV EN green LED off
Drive Enable

Green LED DRV EN = OFF

Internal +15V used?
(J1/pin 7)

NO → Verify that 8.5 to 25Vdc voltage with 8 mA min current is applied to J1/pin 15 and 0V to J1/pin 8.

YES

J1/pin 6 (common) connected to J1/pin 8 (opto common)?

NO → Make connection

YES

Fault on input circuit

**FIG. 4.7 - M OVT red LED on
Motor Overtemperature**

Red LED
M OVT = ON

Motor PTC
connected to J4?

Connect PTC

NO

YES

PTC value at 20°C
correct?
(20 to 400 ohm)

Fault on motor PTC

NO

YES

Undersize the duty
cycle

**FIG. 4.8 - WTD red LED on
Watch Dog**

Red LED WTD = ON

Reset via:
- Pushbutton on front
  panel
- Remote Reset

Red LED WTD =
OFF ?

YES → Check ground
connections

NO → 8031 or DSP fault

FIG. 4.9 - DRV OVT red LED on
Drive Overtemperature

Red LED DRV OVT = ON

Ambient temperature > 40 °C ?

YES → Verify the correct cooling of cabinet

NO

Fans running?

NO → Fault on fan drive circuit or locked fans

YES

Internal recovery resistor undersized

Output current > nominal current

**FIG. 4.10 - PWR FAULT red LED on
Short Circuit or Locked Rotor**

Red PWR FAULT = ON

Motor phases
short circuited or
grounded?

YES → Change motor

NO

Locked
rotor?

YES → Change motor or
eliminate the locked
rotor condition

NO

Fault on power stage o
on control board

FIG. 4.11 - RES FAULT red LED on
Resolver Fault

Red LED RES FAULT = ON

Random fault ?

YES

Is the resolver shield connection OK?

NO

YES

NO

Make correct connection

Fault on oscillator circuit

NO

Vref carrier present on J4 (20 Vpp, 10 kHz)?

YES

Resolver fault or connection not OK at motor side

NO

Sin and cos signals present on J4 (6.5 Vpp max, 10 kHz for Vickers resolver)?

YES

Internal fault
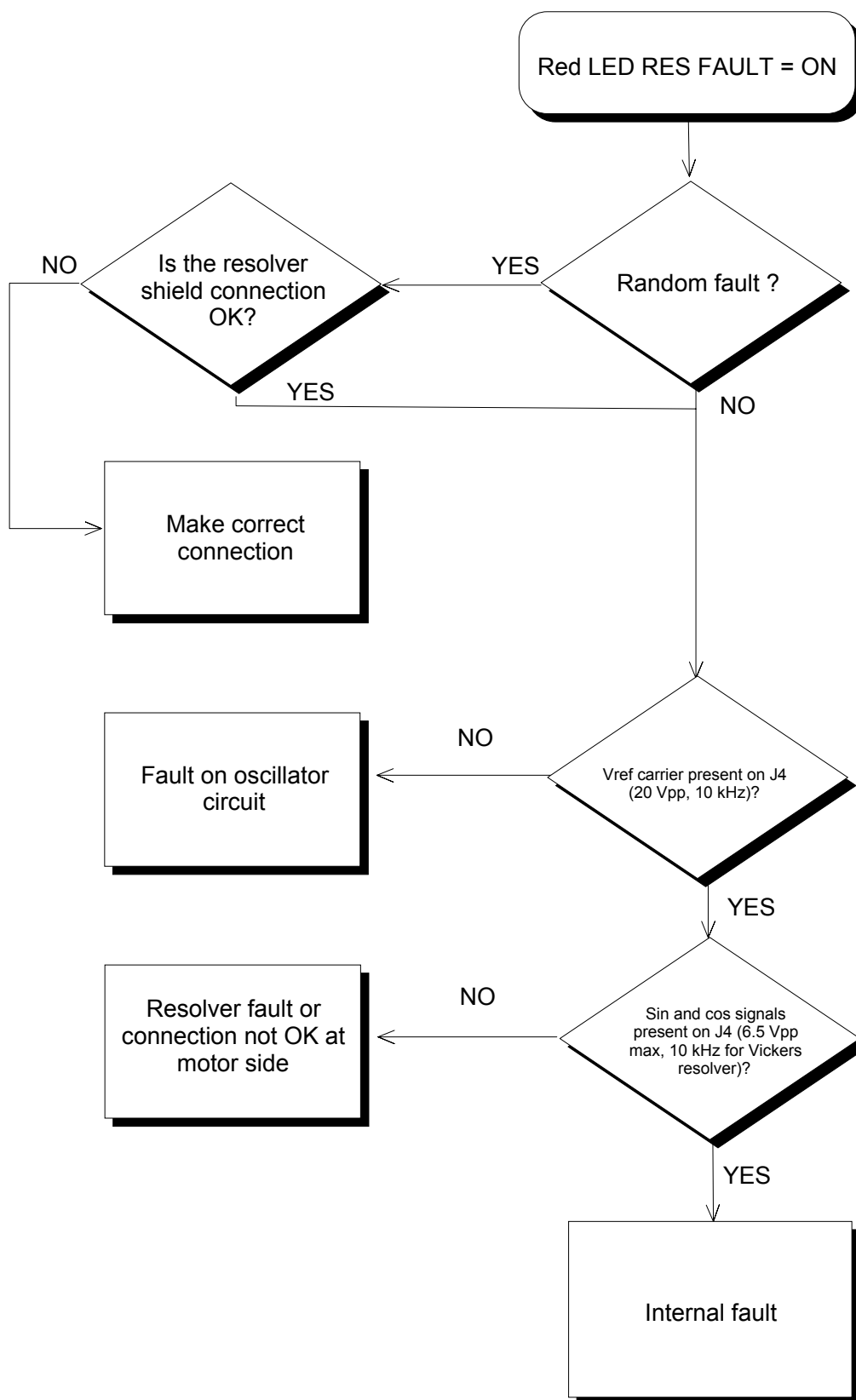
FIG. 4.12 - DRIVE FAULT red LED on

Red LED
DRIVE FAULT = ON

Other red LEDs lit ?

NO

Check via FA command the fault not reported by LEDs.
It can be:
- Velocity error (see EV command)
- EEPROM error
- Bus Bars overvoltage/ undervoltage.

YES

See the figure with the proper LED/fault

FIG. 4.13 - Motor vibrates

Axis enabled. Motor with overspeed or running at a speed not related to the reference or vibrates

6 resolver/motor poles or 8 resolver/motor poles ?

NO

YES

2 pole resolver with 6 pole motor?

YES

Check via RS command. RS = approx. 6000 or 27000 or 49000?

NO   NO

YES

Check via RS command. RS = approx. 48000 ?

YES

Check power and resolver connections. Remake Autophasing.

Internal fault.

FIG. 4.14 - Keypad fault

```
                                    ┌─────────────────────┐
                                    │  Keypad does not work│
                                    └──────────┬──────────┘
                                               │
                                               ▼
                    NO                 ╱───────────────╲
         ┌────────────────────────────  Serial cable and/or
         │                             ╲  J10 cable OK?  ╱
         ▼                              ╲───────┬───────╱
  ┌──────────────┐                              │ YES
  │ Make correct │                              ▼
  │  connection  │                     ╱───────────────╲
  └──────────────┘          YES        │ Baud rate > 9600 ?│
         ┌────────────────────────────╲               ╱
         ▼                              ╲───────┬───────╱
  ┌──────────────┐                              │ NO
  │  Close G3 on │                              ▼
  │Personality Card│                   ╱───────────────╲
  │(Baud rate set to│        NO         │Keypad Baud Rate │
  │     9600)    │ ◄────────────────────│  and other      │
  └──────────────┘                      │  parameters     │
         ▼                              ╲  correct?      ╱
  ┌──────────────────────────┐           ╲───────┬───────╱
  │Adjust the keypad setting.│                   │ YES
  │Press <CTRL>, then <CR>.  │                   ▼
  │Correct parameters are:   │           ┌──────────────┐
  │    BAUD=9600             │           │Internal fault.│
  │WORD=8D+E+1 STOP          │           └──────────────┘
  │   BLOCK MODE             │
  │ SINGLE LINE MODE         │
  │  FLASHING OFF            │
  │KEY REPEAT ON SLOW        │
  │  Save at the end         │
  └──────────────────────────┘
```

FIG. 4.15 - Motor at zero speed

Axis enabled. Motor at zero speed with speed reference not zero

REF EN = ON ?

NO → Make REF EN = ON on J1/pin 16

YES ↓

AR = ON with digital reference or DR = ON with analog reference?

YES → Check via ST command. Use coherent reference.

NO ↓

KI = 0 ?

YES → Set correct value for KI (standard value = 10)

NO ↓

Internal fault.

FIG. 4.16 - IT red LED on

Red LED
IT = ON

Blinking ?

NO → Internal protection.
Ask the Service Center

YES

Undersize the duty
cycle

FIG. 4.17 - Runaway or Locked motor (6 pole motor and resolver)

Runaway or locked motor
(6 pole motor and resolver)

Resolver wiring OK ?
- NO → Correct resolver wiring (see Fig.2.5)
- YES ↓

RS = 59000 ?
- YES → Wrong motor connection. Exchange V with U
- NO ↓

RS = 38000 ?
- YES → Wrong motor connection. Exchange W with V
- NO ↓

RS = 16000 ?
- YES → Wrong motor connection. Exchange U with W
- NO ↓

Ask the Service Center

SECTION 5 - COMMANDS

5.1 General Features

The DBS drive performs the "slave" function on the RS485 serial link. That is, the drive does not initiate any communication by itself. Any communication sequence begins with the reception of the command string from the hand-held terminal or a PC computer via DBTALK program. The drive than responds with the response string.

The only exception from the "slave" role is the period after the power-up. After the reset, the DBS will send the "wake-up" message "DBS V.xx" (where .xx is the software version). If the initialization and the self-test procedure is passed, the RS485 link will slip into the "slave" mode, and respond only when interrogated.

5.1.1 Format of the command string

In a multidrop configuration, the command format is:

[Address] CHAR#1 CHAR#2 CHAR#3 [numerical value] <CR>

__Address:__   Uppercase letters A-O, with the significance of
the drive address (A-O equivalent to 1-15).

__Character #1__: Numbers 1, 2 or the character '*'. Significance:
- parameter set - : 1=First, 2=Second *=current (1 or 2,
depending of the 0 or 1 status of 'spare input' signal,
see J1/pos.18).

__Character #2__: These characters are uppercase letters A-Z with
__Character #3__: the significance of the command mnemonic.

__Numerical value__: If there is not numerical value, than the command issued is an
interrogation; the DBS should answer and report the current value of
specific parameter or status word. Otherwise the command issued
attempts to set the new value for specific parameter. The characters from
the 5th to the 9th might be a decimal number. This number might have
from 1 to 5 digits (0-99999). The only exception is the VE command
(digital speed reference) which will be accepted with the leading minus
sign ('-') followed by 1-3 decimal digits.

<CR>   Following the last (least significant) digit, a <CR> will end the message.

5.1.2 Address

Multidrop serial link protocol of the DBS drive allows for the parallel connection of up to 15 drives. For the proper operation of this structure, each drive must have generic address. The drive address might be one from the following set: **A, B, C, D, E, F, G, H, I, J, K, L, M, N, O.**

If the drive address is A (first), the DBS will accept the commands without the leading drive address. This feature is adopted in order to preserve full compatibility with all previously shipped DBS drives. Hence, for the first (A) drive, it is not necessary to enter the commands with the leading drive address such as A1KP, A1KP255, A1PW91, A1AP. The drive will equally respond to the same commands without the leading character: 1KP, 1KP255, 1PW91, 1AP.

By closing the G3P drop on the DBS board, the DEFAULT INITIALIZATION of the DBS will set the drive address to **A** (see par.2.8.2 and Tab.5.2 for normal or total default initialization). The address may be changed further by using the command "**SA**" as described in par. 5.2 (see SA command).
Default value is given with each command.

5.1.3 Sets of parameters

DBS drive might memorize, use, and permanently save 2 sets of drive most important parameters. Putting into the command sequence '**1**' or '**2**' (after the drive address A-O) will address the first or the second parameter set, respectively. Some parameters do not have two copies, and these parameters might be set or interrogated by putting '1' at the beginning of the command string (example: digital speed reference, 1VE command).

The DBS drive is using the first or the second parameter set depending on the status of the opto-isolated "Spare Input" at the J1 connector. The current - active value of specific parameter that exist in 2 sets might be interrogated by putting '*' character after the drive address into the command string.

5.1.4 Type of Commands

There are four different types of commands that can be exchanged via RS485 serial link. Short description of these four types is given below.

5.1.4.1 Drive commands

Through the serial link, the DBS drive may be switched ON or OFF, initiated into speed or torque control mode, the status flags may be set and reset, and the parameters may be saved into non-volatile memory. Example: "A1ON", "A1VC", "A1DR", "A1SV", or, for the first DBS drive only, "1ON", "1VC", "1DR", "1SV", etc.

5.1.4.2 Interrogation: status and parameters

Drive parameters (such as feedback gains, filter cut-off frequencies, error levels, programmable limits, digital references etc.) may be read through the DBS RS485 serial link. Typical interrogation sequence will be initiated by sending, for example, "1KP<CR>" from the hand-held terminal to the drive. The drive will respond with the "1KP" string followed by the numerical value of the "KP" parameter belonging to the first parameter set.
DBS drive response will not indicate the drive address within the response message.

In the same way, the drive status and faults may be interrogated using the "A1ST" and "A1FA", or, for the first DBS drive only, "1ST" and "1FA" messages. Detailed description is given with each command.

5.1.4.3 Parameter setting

Programmable parameters of the drive control structure and protection mechanism might be set by sending command mnemonic and the value of the parameter to be set.
After reception of the set command, the DBS drive will check the parameter range, eventual password protection of the parameter, and finally set the new value for the parameter.
DBS will "clear the hand-held screen" by sending the character sequence <FF>, <US>, <CR>, <CR>. At the same time, such a response will acknowledge the command reception, and the master will be informed that its message is correctly received and understood. Parameter modification will be effectuated if the attempted value lies within the range related to specific parameter, and the password check is passed. In situation when parameter value attempted is out of range, the DBS will send the error message "OUT OF RANGE" and discard the parameter (that is, keep the previous value of the parameter). In cases when parameter is password protected, and the password is not entered, the DBS will discard the new parameter value and report "PASSWORD PROTECTED" error message.

5.1.4.4 Response messages:

Startup, warning and error messages: At the startup time, the DBS sends the "wake-up" message "DBS V.xx" (where .xx is the software version) .

Note: care must be taken that the message will be emitted only if the drive address is A (one). The "wake-up" message consist of the string "DBS" followed by the number describing the software release. In a multidrop configuration, this message is emitted by the first ("A") DBS drive in the group of parallel connected DBS drives. Other drives (having the addresses different from "A") will not send the "wake-up" message at the power-up. Such a behavior is necessary since (otherwise) simultaneous emission of several "wake-up" messages at the power-up will provoke collision on the bus.

Similar, text messages are emitted by the DBS in the case of erroneous commands and wrong numerical values; such as "Protected by password", "Command not valid", "Parameter out of range", fatal EEPROM/PROCESSOR error messages which are emitted regardless the drive address. Also in the cases when the drive self-test fails, the DBS will send the error message disregarding the drive address.

5.2 Commands

Short summary of all the command mnemonics is listed below along with the brief description of each command. Detailed description of the commands and their use is given in the following paragraph.

Tab. 5.1 List of Commands

1.	AC	Set/Read acceleration ramp time in [ms] units.
2.	AL	Select the drive current limit from "analog limit" input.
3.	AP	Command that starts the auto-phasing procedure
4.	AR	Select the reference from the "Analog reference" input.
5.	AS	Address show
6.	BR	Set/Read the Baud rate of the RS485 serial link.
7.	CG	Set/Read the gain of the current control loop.
8.	CP	Reads the motor shaft position found at the startup time.
9.	CU	Current loop offset compensation parameter for phase U
10.	CV	Current loop offset compensation parameter for phase V
11.	DE	Set/Read deceleration ramp time in [ms] units.
12.	DF	Set/Read the cutoff frequency of the digital filter.
13.	DI	Inversion of the reference direction of the shaft rotation.
14.	DL	Select the drive current limit according to "IL" parameter.
15.	DR	Select the "digital" reference, the one set by "1VE".
16.	EV	Set/Read the maximum acceptable value of the speed error.
17.	FA	Read and attempt Reset of the drive FAULT flags.
18.	IL	Set/Read the digital current limit of the drive in [%].
19.	IT	Set/Read the time constant for the software I2T protection.
20.	KI	Set/Read the integral gain of the speed controller.
21.	KP	Set/Read the proportional gain of the speed controller.
22.	MR	Set/Read the full scale of the input analog reference.
23.	MV	Set/Read the maximum shaft speed in [rpm].
24.	ND	Set/Read the depth of the notch filter (optional)
25.	NF	Set/Read the frequency of the notch filter (optional)
26.	NP	Set/Read the number of resolver poles.
27.	NW	Set/Read the width of the notch filter (optional)
28.	OC	Set/Read the speed reference digital offset.
29.	OF	Command for switching OFF the drive power section.
30.	ON	Command for turning ON the drive power section.
31.	OV	Set/Read the speed reference analog offset.
32.	PC	Set/Read the current level for I2T protection.

33.	**PF**	Parameter for Torque/Speed adjustment
34.	**PG**	Parameter for Torque/Speed adjustment
35.	**PH**	Parameter for Torque/Speed adjustment
36.	**PQ**	Parameter for Torque/Speed adjustment
37.	**PR**	Motor/Resolver pole ratio parameter
38.	**PS**	Display the active parameter set, 1 or 2.
39.	**PW**	Switch the password ON or OFF.
40.	**PX**	Parameter for Torque/Speed adjustment
41.	**PY**	Parameter for Torque/Speed adjustment
42.	**RN**	Set/Read the lower limit of the R/D converter resolution.
43.	**RX**	Set/Read the upper limit for the R/D converter resolution.
44.	**RS**	Set/Read the angle between motor and resolver shafts.
45.	**SA**	Base Address - select the drive address (for multidrop).
46.	**SE**	Set/Read the number of the "simulated encoder" pulses.
47.	**SM**	Automatic Save Enable bit setting and clearing
48.	**ST**	Display the drive status flags.
49.	**SV**	Save the drive settings into non-volatile memory.
50.	**TC**	Establish the torque control mode of the drive.
51.	**VC**	Establish the speed control mode of the drive.
52.	**VE**	Set/Read the digital speed reference.
53.	**VO**	Automatic compensation of analog velocity offset
54.	**VS**	1-of-4 'Velocity_Structure'- structures of the speed controller selection (0-1-2-3)

TAB 5.2 - Standard/Default Configuration

	G2P open G3P closed	Standard	1st set value	2nd set value
AC	0	0		
AL	DL	DL		
AR	DR	DR		
BR	9600	9600		
CG	0	-		
CU	128	-		
CV	128	-		
DE	0	0		
DF	255	0		
DL	DL	DL		
DR	DR	DR		
EV	0	0		
IL	100	100		
IT	0	see Tab.5.4		
KI	20	10		
KP	80	20		
MR	100	100		
MV	3000	-		
ND	0	-		
NF	0	-		
NP	6	-		
NW	0	-		
OC	128	-		
OV	0	0		
PC	100	see Tab.5.4		
PF	255	see Tab.7		
PG	0	see Tab.7		
PH	0	see Tab.7		
PQ	128	see Tab.7		
PR	1	-		
PX	128	see Tab.7		
PY	255	see Tab.7		
RN	10	-		
RS	49152	-		
RX	14	-		
SA	1 (A)	1 (A)		
SE	128	-		
SM	0	0		
TC	VC	VC		
VC	VC	VC		
VO	128	128		
VS	1	1		

[grey box] = 2nd set not available

Note: with G2P closed and G3P closed only BR=9600 and SA=1(A) are set.

REMARK'S

- **address letter** (see par. 5.1.2): in all following command descriptions, [A] symbol in command string stands for the drive address letter, A-O. This address is optional for the drive address of A=1. As an option, it is given between the brackets [ ].
- **parameter set** (see par. 5.1.3): in all following command descriptions, the first character after the [A] symbol in command string stands for the parameter set: 1 or 2. In the interrogation mode it is possible to use the * character instead of 1 and 2. This means that for SPARE_IN = OFF (conn. J1/pos.18), the first parameter set will be selected and for SPARE_IN = ON, the second parameter set will be selected.
The availability of two sets of parameter is outlined in the "second set" row.

AC - Set/Read acceleration ramp time

Function:	Acceleration parameter is used to limit the rate of change of the speed reference. In other words, when AC is different that zero, any speed reference change will have a limited positive slope. The slope limit allows the speed reference to be changed from zero to the [MV] value in [AC] milliseconds.
Syntax:	**[A]1AC<CR>** reads the current value of AC. **[A]1ACnnn<CR>** will set the new value of the AC parameter.
Range:	10 to 999 ms or 0 [disabled]
Range protection:	YES
Default:	0
Password:	NO
Second set:	NO
See also:	DE, Fig. 5.1

FIG.5.1 - Acceleration/Deceleration
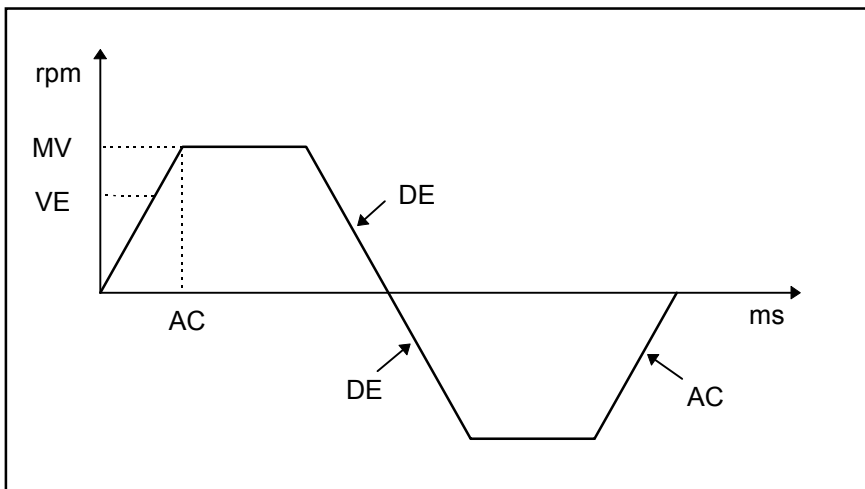
AL - Select the analog input for the drive current limit

Function:	The drive might have the current limit imposed by the software parameter IL ('the digital limit') or the 'analog' limit taken from the drive analog inputs. The AL command will select the 'analog' current limit. The analog input might vary from 0 to 10 [V] and that will correspond to the current limit 0-100% of the drive peak capacity
Syntax:	**[A]1AL<CR>** selects the analog input for the drive current limit.
Range:	-
Range protection:	-
Default:	Digital limit
Password:	YES
Second set:	-
See also:	DL

Note: the status can be interrogated via ST command (bit b9).

AP - Command that starts the auto-phasing procedure

Function:	The correct operation of the drive calls for the exact knowledge of the spatial displacement between motor and resolver shafts. The angular displacement ranging from 0 to 360 degrees corresponds to the parameter RS range of [0..65535]. In order to measure this displacement in an automatic manner, the 'auto phasing' routine might be performed. This routine implies injection of the DC current into the motor windings. If the auto phasing is correctly performed, the message 'AXES PHASED' will be sent by the DBS. When an error occurs during the auto phasing, the message 'ERROR IN AUTOPHASING' will be transmitted by the drive.
Syntax:	**[A]1AP<CR>** will initiate the auto phasing procedure. The drive will confirm the action with the response 'AUTOPHASING IN PROGRESS'. The auto phasing will not be performed if the drive is in the fault conditions.
Range:	-
Range protection:	-
Default:	-
Password:	YES
Second set:	-
See also:	-

Note: to execute AP the drive must have the G2P drop on the control board open (keyboard priority), analog Drive Enable "on" (conn. J1/pos. 15) and digital Drive Enable "off" via OF command.

REMARK: as in this phase the motor can rotate for a revolution fraction, it is opportune to make sure it is free to rotate to avoid risk of friction, which could compromise phasing accuracy. So, motor must   be disconnected from load.

AR - Select the reference from the "Analog reference" input

Function:	The speed reference for the DBS speed loop might be the digital one, set by the '1VE' command, or the analog speed reference taken from the DBS analog input port. The 'AR' command selects the 'analog' reference mode.
Syntax:	**[A]1AR<CR>** selects the analog reference
Range:	-
Range protection:	-
Default:	Digital reference
Password:	YES
Second set:	-
See also:	-

Note: the status can be interrogated via ST command (bit b8).

AS - Address Show

Function:	it allows display of the basic address of a module, if unknown. To avoid simultaneous answers on the line from more than one module, it is necessary that serial flat is connected only to the questioned module. It is different from SA command, which is used to change the address.
Syntax:	***AS<CR>** reads the address
Range:	-
Range protection:	-
Default:	-
Password:	no
Second set:	-
See also:	SA

BR - Set/Read the Baud rate of the RS485 serial link

Function:	The DBS RS485 serial link might use several baud rate values. The baud rate is set and saved through the 'BR' parameter.
Syntax:	**[A]1BR<CR>** reads the current value of BR. **[A]1BRnnnn<CR>** will set the new value of the BR parameter.
Range:	1200, 2400, 4800, 9600, 19200
Range protection:	NO
Default:	9600
Password:	YES
Second set:	NO
See also:	-

CG - Set/Read the gain of the current control loop.

Function:	The current loop gain of the DBS drive might be adjusted through the serial link communication. A dedicated CG parameter with 4 discrete values is introduced in order to set the current error gain.
Syntax:	**[A]1CG<CR>** reads the current value of CG **[A]1CGn<CR>** will set the new value of the CG parameter
Range:	0=very low gain 1=medium low 2=medium high 3=very high
Range protection:	YES.
Default:	motor dependent
Password:	YES
Second set:	NO
See also:	-

CP - Reads the motor shaft initial position

Function:	Initial shaft position is read after the drive reset and stored within the internal RAM memory of the DBS drive. That is, after each reset, the new value of the initial position will be read.
Syntax:	**[A]1CP<CR>** command will interrogate the DBS drive. The drive will respond with the string 'current position = nnnn'
Range:	0 to 4095
Range protection:	YES
Default:	-
Password:	NO
Second set:	NO
See also:	-

CU - Set/Read the current loop DC offset compensation parameter for the phase "U" (only for setup technicians)

Function:	DC offset in the current loop of the Brushless motor servo drives is a well known cause of "one-per-electrical-period" ripple of the speed and position. In order to avoid trimmers the necessity to open the drive when performing the trimming, parameter 'CU' is introduced for fine trimming of the current loop offset. CU parameter is responsible for the "U" motor phase. The value 128 gives zero offset compensation. The values below and above 128 give positive and negative corrections. Parameter 'CU' is available in one (first) parameter set.
Syntax:	**[A]1CU<CR>** reads the value of 1CU parameter. **[A]1CUnnn<CR>**
Range:	0-255
Range protection:	YES
Default:	drive dependent
Password:	YES
Second set:	-NO
See also:	-

REMARK: do not change CU parameter. A wrong set of CU increases torque ripple.

CV - Set/Read the current loop DC offset compensation parameter for the phase "V" <u>(only for setup technicians)</u>

Function:	DC offset in the current loop of the Brushless motor servo drives is a well known cause of "one-per-electrical-period" ripple of the speed and position. In order to avoid trimmers the necessity to open the drive when performing the trimming, parameter 'CV' is introduced for fine trimming of the current loop offset. CU parameter is responsible for the "V" motor phase. The value 128 gives zero offset compensation. The values below and above 128 give positive and negative corrections. Parameter 'CV' is available in one (first) parameter set.
Syntax:	**[A]1CV<CR>** reads the value of 1CV parameter. **[A]1CVnnn<CR>**
Range:	0-255
Range protection:	YES
Default:	drive dependent
Password:	YES
Second set:	NO
See also:	-

REMARK: do not change CV parameter. A wrong set of CV increases torque ripple.

DE - Set/Read deceleration ramp time.

Function:	Deceleration parameter is used to limit the rate of change of the speed reference. In other words, when DE is different that zero, any speed reference change will have limited negative slope. The slope limit allows the speed reference to be changed from [MV] [rpm] to zero in [DE] milliseconds.
Syntax:	**[A]1DE<CR>** reads the current value of 11DE. **[A]1DEnnn<CR>** will set the new value of the 1DE parameter.
Range:	10 to 999 ms or 0 [disabled]-
Range protection:	YES
Default:	0 [disabled]-
Password:	NO
Second set:	NO
See also:	AC, Fig. 5.1

DF - Set/Read the cutoff frequency of the digital filter.

Function:	Control structure of the digital speed controller built into the DBS drive comprises the digital second order filter. This filter might process the speed reference or the speed error, depending on the version of the control structure applied. The damping factor of the filter is fixed to x = 0.707. The cutoff frequency of this low-pass filter might be set through the DF parameter.
Syntax:	**[A]1DF<CR>** reads the value of 1DF **[A]2DF<CR>** reads the value of 2DF **[A]*DF<CR>** reads the current active value of DF parameter **[A]1DFnnn<CR>** will set the new value of 1DF **[A]2DFnnn<CR>** will set the new value of 2DF
Range:	0 to 255
Range protection:	YES
Default:	0
Password:	YES
Second set:	YES
See also:	ND, NF, NW, VS

Tab. 5.3 - Filter Bandwidth

DF	Frequency	DF	Frequency	DF	Frequency	DF	Frequency
1	1 Hz	65	72 Hz	130	155 Hz	195	254 Hz
5	5 Hz	70	77 Hz	135	162 Hz	200	262 Hz
10	10 Hz	75	84 Hz	140	169 Hz	205	271 Hz
15	15 Hz	80	90 Hz	145	176 Hz	210	280 Hz
20	21 Hz	85	96 Hz	150	183 Hz	215	288 Hz
25	26 Hz	90	102 Hz	155	191 Hz	220	297 Hz
30	32 Hz	95	108 Hz	160	198 Hz	225	307 Hz
35	37 Hz	100	115 Hz	165	206 Hz	230	316 Hz
40	43 Hz	105	121 Hz	170	214 Hz	235	325 Hz
45	48 Hz	110	128 Hz	175	221 Hz	240	335 Hz
50	54 Hz	115	134 Hz	180	229 Hz	245	345 Hz
55	60 Hz	120	141 Hz	185	237 Hz	250	355 Hz
60	66 Hz	125	148 Hz	190	246 Hz	255	366 Hz

DI - Change the sense of rotation

Function:	it allows to change the sense of rotation of the motor.
Syntax:	**[A]1DI<CR>** toggles the value of the status bit for the sense of rotation. **[A]*DI<CR>** toggles the value of the status bit for the sense of rotation. The DBS does not respond to the command. Hence, the screen of the hand-held terminal is not cleared, and the command string '*DI' remains within the display buffer. Therefore, it is sufficient to press <CR> again and the 'DI' command will be executed again. This feature might be used to achieve successive speed reversals during the optimization of the speed loop gains at the installation phase.
Range:	-
Range protection:	-
Default:	-
Password:	NO
Second set:	-
See also:	-

Note: the status can be interrogated via ST command (bit b11).

DL - Select the digital current limit

Function:	The drive might have the current limit imposed by the software parameter IL ('the digital limit') or the 'analog' limit taken from the drive analog inputs. The DL command will select the 'digital' current limit. The 'IL' parameter defines the current limit from 0 to 100% of the peak drive current.
Syntax:	**[A]1DL<CR>** selects the digital input for the drive current limit.
Range:	-
Range protection:	-
Default:	Digital limit
Password:	YES
Second set:	-
See also:	AL, IL

Note: the status can be interrogated via ST command (bit b9).

DR - Select the "digital" reference mode.

Function:	The speed reference for the DBS speed loop might be the digital one, set by the '1VE' command, or the analog speed reference taken from the DBS analog input port. The 'DR' command selects the 'digital' reference mode.
Syntax:	**[A]1DR<CR>** selects the digital speed reference for the DBS speed controller.
Range:	-
Range protection:	-
Default:	Digital reference
Password:	YES
Second set:	-
See also:	-

Note: the status can be interrogated via ST command (bit b8).

EV - Set/Read the speed error limit

Function:	When using the drive in speed control mode, the 'velocity error' fault might be generated in the cases when the speed error exceeds the value imposed by 'EV' parameter. This feature is useful as an additional protection of the CNC's 'spatial error' mechanism. The setting EV = 0 [rpm] will switch off the speed error protection mechanism, and the 'velocity error' fault will never be generated.
Syntax:	**[A]1EV<CR>** reads the current value of 1EV **[A]1EVnnnn<CR>**
Range:	0 to MV [rpm].
Range protection:	YES
Default:	0
Password:	YES
Second set:	NO
See also:	-

Remark: while testing the drives via step response, it is advisable to disable this protection or set a high value of tolerated error, to avoid continuous faults.

FA - Read and attempt Reset of the drive FAULT flags.

Function:	Drive fault flags might be inspected and a reset of the fault flags might be attempted by using the '1FA' command. For a number of faults, the reading through the 'FA' command is the only way to detect the erroneous situation. If the cause that originated a fault vanished prior to the 'FA' command execution, the fault flag related to the fault will be reset. Notice that the fault flags will be displayed first, and only after that the reset will be attempted (*).
Syntax:	**[A]1FA<CR>** will command the DBS to respond with a string comprising the fault flags
Range:	-
Range protection:	-
Default:	-
Password:	NO
Second set:	-
See also:	-

REMARK: the format of the fault string is the following:

FA b1 b2 b3 b5 b6   **P** b7 b8 b9 b10 b11   **MA** b12 b13 b14   **B** b15 b16 b17

When all the bits are 0, the status is 'DRIVE_OK' and 'MOTOR_OK' the main power might be turned on.
The meaning of specific bits is given below:

b1	Resolver wiring	0 = OK	1 = not correct
b2	Motor temperature	0 = OK	1 = overheated
b3	Power section	0 = OK	1 = short circuit
b5	Velocity error	0 = OK	1 = excessive
b6	Software IT protection (**)	0 = OK	1 = protection ON
b11	EEPROM	0 = OK	1 = memory error
b12	DC-bus	0 = OK	1 = over/under voltage
b13	Auxiliary power +/-15V	0 = OK	1 = not OK
b14	Heat sink temperature	0 = OK	1 = over temperature

(*) In 'analog priority' mode; with the G2P closed, the faults will not be reset until the drive enable opto-coupler is switched OFF. Hence, with G2P closed, the 'fault reset' procedure is:
i) Switch OFF the drive enable input;
ii) Clear the faults by using 1FA command
iii) Turn the drive enable input ON again, and the drive will restart.

(**) All the faults except IT will switch the drive OFF. IT fault will set the fault bit, reduce the current limit to the level of the 'PC' parameter, and keep the drive 'ON'.

IL - Set/Read the digital current limit

Function:	Parameter 'IL' defines the digital current limit in terms 0-100%, where 100% level corresponds to the drive peak current. Parameter 'IL' exists in two parameter sets. The values 1IL or 2IL are used depending on the status of the SPARE_IN input. IL parameter is enabled by DL command.
Syntax:	**[A]1IL<CR>** reads the value of 1IL **[A]2IL<CR>** reads the value of 2IL **[A]*IL<CR>** reads the current active value of IL parameter **[A]1ILnnn<CR>** will set the new value of the 1IL parameter **[A]2ILnnn<CR>** will set the new value of the 2IL parameter
Range:	0-100 [%]
Range protection:	YES
Default:	100 [%]
Password:	YES
Second set:	YES
See also:	DL

IT - Set/Read the time constant for I2T protection.

Function:	Software I2T protection performs the thermal simulation of the motor thermal model via 1IT parameter. The nominal ratings of the motor is defined by 1PC parameter. When the thermal model runs above the temperature limit, the I2T fault flag will be set, the current limit will be reduced to the 'PC' (rated) level, but the drive will not be switched OFF.
Syntax:	**[A]1IT<CR>** reads the value of IT parameter. **[A]1ITnnn<CR>** will set the new value of the 1IT parameter.
Range:	0 to 255
Range protection:	YES
Default:	motor dependent
Password:	YES
Second set:	protected
Opposite to:	-
See also:	-

Note: the status can be interrogated via FA command (bit b6). The activation of IT protection is also indicated by the led on the front panel (see Sect.4).

CAUTION: do not change IT parameter. A wrong set of IT can damage the motor

Tab. 5.4 - IT Protection

The following table shows IT and PC values set in factory.

FAS T-V	DBS	IT	PC	Operating time at drive peak current [s]	IL
FAS T0 V2 060	3/9	6	17	4.4	100
FAS T0 V4 060	3/9	4	23	12.1	100
FAS T0 V8 030	3/9	5	19	6.6	100
FAS T0 V8 060	6/15	4	28	18.2	100
FAS T1 V2 030	3/9	3	26	20.8	100
FAS T1 V2 060	6/15	3	30	28.0	100
FAS T1 V4 030	6/15	3	31	30.0	100
FAS T1 V4 045	6/15	3	39	49.1	100
"	8/22	3	27	22.5	100
FAS T1 V6 030	6/15	3	40	51.9	100
"	8/22	3	27	22.5	100
FAS T1 V6 045	8/22	3	40	51.9	100
"	15/42	3	21	17.4	88
FAS T1 V8 030	6/15	3	46	70.7	100
"	8/22	2	31	45.1	100
FAS T1 V8 045	15/42	2	25	28.8	100
FAS T2 V2 030	8/22	3	32	32.1	100
FAS T2 V2 045	15/42	3	28	24.3	100
FAS T2 V4 020	8/22	2	36	61.9	100
FAS T2 V4 030	15/42	2	28	36.4	100
FAS T2 V6 020	15/42	2	27	33.8	100
FAS T2 V6 030	15/42	2	39	73.6	100
"	25/70	3	23	31.1	73
FAS T2 V8 020	15/42	2	35	58.3	100
"	25/70	4	21	23.8	65
FAS T2 V8 030	15/42	2	52	140.7	100
"	25/70	2	31	45.1	100
FAS T3 V2 020	15/42	2	42	86.6	100
FAS T3 V2 030	25/70	2	38	69.6	100
FAS T3 V3 020	25/70	2	35	58.3	100
FAS T3 V3 030	25/70	2	47	111.4	100
"	35/90	2	36	61.9	100
FAS T3 V4 020	25/70	2	42	86.6	100
FAS T3 V4 030	35/90	2	47	111.4	100
FAS T3 V6 012	25/70	2	38	69.6	100
FAS T3 V6 020	35/90	2	41	82.1	100
FAS T3 V8 012	35/90	2	35	58.3	100
FAS T3 V8 020	50/140	2	36	61.9	100
"	60/180	2	28	63.3	77

REMARK: the "operating time at drive peak current" is the operating time after a reset. In a steady state condition, this time is reduced according to the motor thermal simulation.
An overtemperature protection via PTC on the motor windings is also provided.

KI - Set/Read the integral gain of the speed controller.

Function:	Parameter 'KI' determines the integral action of the speed controller. Integral gain is available in two parameter sets, 1KI in set 1 and 2KI in set 2. The opto-isolated drive input SPARE_IN determines whether 1KI or 2KI is used as the proportional gain.
Syntax:	**[A]1KI<CR>** reads the value of 1KI **[A]2KI<CR>** reads the value of 2KI **[A]*KI<CR>** reads the current active value of KI parameter. **[A]1KInnn<CR>** will set the new value of 1KI **[A]2KInnn<CR>** will set the new value of 2KI
Range:	0 to 255
Range protection:	YES
Default:	10
Password:	NO
Second set:	YES
See also:	KP

KP - Set/Read the proportional gain of the speed controller

Function:	Parameter 'KP' determines the proportional action of the speed controller. Proportional gain is available in two parameter sets, 1KP in set 1 and 2KP in set 2. The opto-isolated drive input SPARE_IN determines whether 1KP or 2KP is used as the proportional gain.
Syntax:	**[A]1KP<CR>** reads the value of 1KP **[A]2KP<CR>** reads the value of 2KP **[A]*KP<CR>** reads the current active value of KP parameter. **[A]1KPnnn<CR>** will set the new value of 1KP **[A]2KPnnn<CR>** will set the new value of 2KP
Range:	0 to 255
Range protection:	YES
Default:	20
Password:	NO
Second set:	YES
See also:	KI

MR - Set/Read the full scale of the input analog reference

Function:	When the analog speed reference is used, the level of the analog input signal that will be interpreted as the speed reference of MV[rpm] might be set by the 'MR' parameter, the 'Maximum Reference'. The range 50..100 of the MR parameter corresponds to input voltage levels from 5 to 10 [V]. Parameter 'MR' is available in two parameter sets, 1MR in set 1 and 2MR in set 2. The opto-isolated drive input SPARE_IN determines whether 1MR or 2MR is used as the analog input range.
Syntax:	**[A]1MR<CR>** reads the value of 1MR **[A]2MR<CR>** reads the value of 2MR **[A]*MR<CR>** reads the current active value of MR parameter **[A]1MRnnn<CR>** will set the new value of 1MR **[A]2MRnnn<CR>** will set the new value of 2MR
Range:	50 to 100 (5V to 10V) -
Range protection:	YES
Default:	100
Password:	YES
Second set:	YES
See also:	MV

MV - Set/Read the maximum shaft speed in [rpm].

Function:	it allows to set max velocity, referred to MR command. Anyway, such a max. speed can never be overcome, either by analog reference or by keyboard command.
Syntax:	**[A]1MV<CR>** reads the value of 1MV **[A]2MV<CR>** reads the value of 2MV **[A]*MV<CR>** reads the current active value of MV parameter **[A]1MVnnnn<CR>** will set the new value of 1MV **[A]2MVnnnn<CR>** will set the new value of 2MV
Range:	200 to 10000 [rpm]
Range protection:	YES
Default:	motor dependent
Password:	YES
Second set:	YES
See also:	MR

ND - Set/Read the depth of the notch filter (optional).

Function:	the notch filter with programmable frequency, depth and width is available to the user. It may be used together with the present error/reference digital low pass filter. The ND command allows to set and read the notch filter depth, that is the amount of suppressing the spectral components at the notch filter.
Syntax:	**[A]1ND<CR>** reads the value of 1ND parameter. **[A]1NDnnn<CR>** will set the new value of the 1ND parameter.
Range:	1 to 255 (corresponding to 0dB to 50dB)
Range protection:	
Default:	-
Password:	YES
Second set:	NO
See also:	NF, NW

NF - Set/Read the frequency of the notch filter (optional)

Function:	the notch filter with programmable frequency, depth and width is available to the user. It may be used together with the present error/reference digital low pass filter. The NF command allows to set and read the notch filter frequency. When selecting 1NF=0, the notch filter is switched off.
Syntax:	**[A]1NF<CR>** reads the value of 1NF parameter. **[A]1NFnnn<CR>** will set the new value of the 1NF parameter.
Range:	1 to 5375 (corresponding to: 0.1 to 537.5 Hz)
Range protection:	
Default:	0
Password:	YES
Second set:	NO
See also:	ND, NW

NP - Set/Read the number of resolver poles.

Function:	The number of resolver poles plays important role in the velocity observation. Therefore, this number must be available for the purpose of drive internal calculations. Parameter 'NP' defines the number of resolver poles (not the pole pairs). Parameter NP does not exist in two parameter sets, and has to be addressed by using '1NP' command string.
Syntax:	**[A]1NP<CR>** reads the value of 1NP parameter. **[A]1NPn<CR>** will set the new value of the 1NP parameter.
Range:	2, 4, 6, or 8
Range protection:	YES
Default:	resolver dependent
Password:	YES
Second set:	NO
See also:	PR

NW - Set/Read the width of the notch filter (optional).

Function:	the notch filter with programmable frequency, depth and width is available to the user. It may be used together with the present error/reference digital low pass filter. The NW command allows to set and read the notch filter width. The width at -9dB is defined as [1/1000] relative units.
Syntax:	**[A]1NW<CR>** reads the value of 1NW parameter. **[A]1NWnnn<CR>** will set the new value of the 1NW parameter.
Range:	1 to 255 (corresponding to 0.1% to 25.5%)
Range protection:	-
Default:	-
Password:	YES
Second set:	NO
See also:	NF, ND

OC - Digital speed offset (<u>only for setup technicians</u>)

Function:	it allows to set the digital velocity offset. The value 128 gives zero offset compensation. The values below and above 128 give positive and negative corrections.
Syntax:	**[A]1OC<CR>** reads the value of 1OC **[A]2OC<CR>** reads the value of 2OC **[A]*OC<CR>** reads the current active value of OC parameter. **[A]1OCnnn<CR>** will set the new value of 1OC **[A]2OCnnn<CR>** will set the new value of 2OC
Range:	0 to 255
Range protection:	YES
Default:	-
Password:	NO
Second set:	YES
See also:	OV, VO

OF- Command for switching OFF the drive power section.

Function:	The DBS drive might be set in 'keyboard priority' mode by opening the G2P drop on the control board, or, in the 'analog priority' mode, achieved by closing the drop G2P. During the installation phase, G2P is normally open. Once the drive is installed, it is normally in 'analog priority' mode. The major difference is that the former calls for '1ON' and '1OF' commands on the serial link in order to switch the drive ON or OFF, while the later switches the drive according to the opto isolated drive enable input signal. When in "keyboard priority", the '1OF' command switches the drive OFF. '1ON' and '1OF' commands will be prevented in 'analog priority' mode, and a warning message will be sent ('not possible').
Syntax:	**[A]1OF<CR>** switches the drive OFF**.**
Range:	-
Range protection:	-
Default:	OFF
Password:	NO
Second set:	-
See also:	ON

Note: - to execute OF the drive must have the analog Drive Enable "on" (conn. J1/pos. 15).
     - the status can be interrogated via ST command (bit b7).

ON - Command for turning ON the drive power section.

Function:	The DBS drive might be set in 'keyboard priority' mode by opening the G2P drop on the control board, or, in the 'analog priority' mode, achieved by closing the drop G2P. During the installation phase G2P is normally open. Once the drive is installed, it is normally in 'analog priority' mode. The major difference is that the former calls for '1ON' and '1OF' commands on the serial link in order to switch the drive ON or OFF, while the later switches the drive according to the opto isolated drive enable input signal. When in 'keyboard priority', the '1ON' command turns the drive ON. '1ON' and '1OF' commands will be prevented in 'analog priority' mode, and a warning message will be sent ('not possible').
Syntax:	**[A]1ON<CR>** switches the drive ON.
Range:	-
Range protection:	-
Default:	OFF
Password:	NO
Second set:	-
See also:	OF

Note: - to execute ON the drive must have the analog Drive Enable "on" (conn. J1/pos. 15).
    - the status can be interrogated via ST command (bit b7).

OV - Set/Read the analog velocity offset

Function:	it allows to monitor and to set the analog offset of speed/ torque analog reference. A fine adjustment of the analog offset can be done with successive steps by setting and monitoring the OV parameter.
Syntax:	**[A]1OV<CR>** reads the value of 1OV **[A]1OVnnn<CR>** will set the new value of the 1OV parameter
Range:	0 (no compensation) 1 to 127 (positive compensation) 255 to 128 (negative compensation)
Range protection:	YES
Default:	0 (no offset compensation)
Password:	NO
Second set:	NO
See also:	VO

Note: - this OV range is operative from DSP software version V11.
    - from version V06.1, OV range was from 0 to 255 (128=no compensation).
    - in previous versions the range was from -500 [mV] to +500 [mV] (0=no compensation).

PC - Set/Read the current level for I2T protection

Function:	Software I2T protection performs the thermal simulation of the motor thermal model.. Parameter 1IT defines the thermal time constant of the motor. The nominal ratings of the motor is defined by 1PC parameter. When this thermal model runs above the temperature limit, the I2T fault flag will be set, the current limit will be reduced to the 'PC' (rated) level, but the drive will not be switched OFF.
Syntax:	**[A]1PC<CR>** reads the value of PC **[A]1PCnnn<CR>** will set the new value of the 1PC parameter.
Range:	0 to 100 [%]
Range protection:	YES
Default:	see Tab. 5.4
Password:	YES
Second set:	protected
See also:	IT

CAUTION: *do not change PC parameter. A wrong set of PC can damage the motor.*

PF - Parameter for the adjustment of Torque/Speed curve

Function:	Current loop of a typical AC drive suffers the phase lag at extremely high output frequencies (speeds). This lag reduces the resulting torque-per-amp ratio. To counterbalance this phenomenon, the current vector relative to the motor flux is advanced, through PF, PG, PH, PX, PY, and PQ parameters (see the dedicated Section #7). The values PF=255, PG=0, PH=0, PQ=128, PX=128 and PY=255 disable the function.
Syntax:	**[A]1PF<CR>** reads the value of the parameter. **[A]1PFnnn<CR>** will set the new value of the parameter.
Range:	0 to 255
Range protection:	YES
Default:	see Tab. 7
Password:	YES
Second set:	NO
See also:	PG, PH, PX, PY, PQ

PG - Parameter for the adjustment of Torque/Speed curve

Function:	Current loop of a typical AC drive suffers the phase lag at extremely high output frequencies (speeds). This lag reduces the resulting torque-per-amp ratio. To counterbalance this phenomenon, the current vector relative to the motor flux is advanced, through PF, PG, PH, PX, PY, and PQ parameters (see the dedicated Section #7). The values PF=255, PG=0, PH=0, PQ=128, PX=128 and PY=255 disable the function.
Syntax:	**[A]1PG<CR>** reads the value of the parameter. **[A]1PGnnn<CR>** will set the new value of the parameter.
Range:	0 to 255
Range protection:	YES
Default:	see Tab. 7
Password:	YES
Second set:	NO
See also:	PF, PH, PX, PY, PQ

PH - Parameter for the adjustment of Torque/Speed curve

Function:	Current loop of a typical AC drive suffers the phase lag at extremely high output frequencies (speeds). This lag reduces the resulting torque-per-amp ratio. To counterbalance this phenomenon, the current vector relative to the motor flux is advanced, through PF, PG, PH, PX, PY, and PQ parameters (see the dedicated Section #7). The values PF=255, PG=0, PH=0, PQ=128, PX=128 and PY=255 disable the function.
Syntax:	**[A]1PH<CR>** reads the value of the parameter. **[A]1PHnnn<CR>** will set the new value of the parameter.
Range:	0 to 255
Range protection:	YES.
Default:	see Tab. 7
Password:	YES
Second set:	NO
See also:	PF, PG, PX, PY, PQ

PQ - Parameter for the adjustment of Torque/Speed curve

Function:	Current loop of a typical AC drive suffers the phase lag at extremely high output frequencies (speeds). This lag reduces the resulting torque-per-amp ratio. To counterbalance this phenomenon, the current vector relative to the motor flux is advanced, through PF, PG, PH, PX, PY, and PQ parameters (see the dedicated Section #7). The values PF=255, PG=0, PH=0, PQ=128, PX=128 and PY=255 disable the function.
Syntax:	**[A]1PQ<CR>** reads the value of the parameter. **[A]1PQnnn<CR>** will set the new value of the parameter.
Range:	0 to 255
Range protection:	YES.
Default:	see Tab. 7
Password:	YES
Second set:	NO
See also:	PF, PG, PH, PX, PY

PR - Parameter ratio between the motor and resolver pole number

Function:	The number of the motor poles might be different than the number of resolver poles. For the proper operation, the ratio must be an integer. That is to say, the number of motor poles must be a multiple of the number of resolver poles. For an increase drive flexibility, this ratio is set by PR parameter; this number must be available for the purpose of drive internal calculations. Parameter 'PR' might be inspected and changed through the PR command. Parameter PR does not exist in two parameter sets, and has to be addressed by using '1PR' command string.
Syntax:	**[A]1PR<CR>** reads the value of 1PR parameter. **[A]1PRn<CR>** will set the new value of the 1PR parameter.
Range:	1 to 15
Range protection:	YES
Default:	motor/resolver dependent
Password:	YES
Second set:	NO
See also:	NP

REMARK: the motor/resolver pole ratio has its effect on the speed loop gains. That is, for the same KP and KI values, equivalent gain will increase as the number or resolver pole pairs increase.
Example: two FAS K 8-pole motors with different resolver pole pairs, the first one with 8-pole resolver, the second with 2-pole resolver. To have the same dynamic behavior, the KP and KI gains of motor with 2-pole resolver must have approx. four times the KP and KI gains of motor with 8-pole resolver. This can be done in two ways:
- by multiplying (if it possible, i.e. when KI < 63) KP and KI by 4.
- by using a structure VS=0 or VS=2 which internally multiply the gains by 4.

PS - Display the active parameter set, 1 or 2.

Function:	Parameters SE, DF, IL, KI, KP, MR and MV exist in two different sets, { 1SE, 1DF, 1IL, 1KI, 1KP, 1MR, 1MV } and { 2SE, 2DF, 2IL, 2KI, 2KP, 2MR, 2MV }. The opto-isolated input SPARE_IN determines which parameter set will be used for the drive operation and control. The SPARE_IN = OFF will select the first parameter set, while the SPARE_IN = ON will point to the second parameter set. The status of the SPARE_IN and the parameter set currently active might be read through the serial link by using '1PS' command.
Syntax:	**[A]1PS<CR>** command will interrogate the DBS drive. The drive will respond with the <CR> followed by the string 'parameter set 1' or the string 'parameter set 2'. DBS will end the response with a <CR> character.
Range:	-
Range protection:	-
Default:	-
Password:	NO
Second set:	-
See also:	-

PW - Switch the password ON or OFF

Function:	Crucial parameters of the drive are protected by the password. That is, the access to these parameters will not be granted unless a proper password is entered. When the password status is OFF, the '1PW' command will be interpreted as an attempt to set the password status ON. In this case, the password will be switched ON only for command strings '1PW91'. When the password status is ON, the '1PW' command will be interpreted as an attempt to set the password status OFF. In this case, the PW command does not have to have any argument, the string '1PW<CR>' will switch the password status OFF.
Syntax:	**[A]1PW91<CR>** will attempt to switch the password ON. Wrong argument will be followed by 'access denied' response. Correct argument will provoke 'password on' response. If the password status was ON already at the time of the command execution, the drive will respond 'password off' and switch the password OFF. **[A]1PW<CR>** will switch the password OFF.
Range:	-
Range protection:	-
Default:	-
Password:	NO
Second set:	-
See also:	-

PX - Parameter for the adjustment of Torque/Speed curve

Function:	Current loop of a typical AC drive suffers the phase lag at extremely high output frequencies (speeds). This lag reduces the resulting torque-per-amp ratio. To counterbalance this phenomenon, the current vector relative to the motor flux is advanced, through PF, PG, PH, PX, PY, and PQ parameters (see the dedicated Section #7). The values PF=255, PG=0, PH=0, PQ=128, PX=128 and PY=255 disable the function.
Syntax:	**[A]1PX\<CR\>** reads the value of the parameter. **[A]1PXnnn\<CR\>** will set the new value of the parameter.
Range:	0 to 255
Range protection:	YES.
Default:	see Tab. 7
Password:	YES
Second set:	NO
See also:	PF, PG, PH, PY, PQ

PY - Parameter for the adjustment of Torque/Speed curve

Function:	Current loop of a typical AC drive suffers the phase lag at extremely high output frequencies (speeds). This lag reduces the resulting torque-per-amp ratio. To counterbalance this phenomenon, the current vector relative to the motor flux is advanced, through PF, PG, PH, PX, PY, and PQ parameters (see the dedicated Section #7). The values PF=255, PG=0, PH=0, PQ=128, PX=128 and PY=255 disable the function.
Syntax:	**[A]1PY<CR>** reads the value of the parameter. **[A]1PYnnn<CR>** will set the new value of the parameter.
Range:	0 to 255
Range protection:	YES.
Default:	see Tab. 7
Password:	YES
Second set:	NO
See also:	PF, PG, PH, PX, PQ

RN - Set/Read the lower R/D resolution limit.

Function:	The R/D converter resolution is switched on-line in order to obtain the best possible overall drive performance. At very high speeds, the resolution is reduced in order to make possible the speed and the position measurement in a situation whence the number of revolutions per second is very high. On the other hand, at lower speed, the resolution is increased automatically so as to reduce the measurement noise, the ripple, and to increase the precision of the motion control. Hence, the actual resolution of the R/D converter will vary from 10 to 16 bit, depending on the drive operating conditions. Parameter 'RN' might impose the lower limit of the R/D converter resolution to a value higher than 10 bit. This might be necessary in applications that utilize simulated encoder pulses produced by DBS. When the resolution of simulated encoder is high, reduction of the R/D resolution cannot be permitted below certain level (see SE command for more details). Parameter 'RN' exists in two parameter sets. The values 1RN or 2RN are used depending on the status of the SPARE_IN input.
Syntax:	**[A]1RN<CR>** reads the value of 1RN and 1RX **[A]2RN<CR>** reads the value of 2RN and 2RX **[A]*RN<CR>** reads the current active value of RN and RX **[A]1RNnn<CR>** will set the new value of 1RN **[A]2RNnn<CR>** will set the new value of 2RN
Range:	10, 12, 14 or 16 [bits]
Range protection:	YES
Default:	motor dependent
Password:	YES
Second set:	YES-
See also:	RX, Tab. 5.5

Note: RN must be ≤ RX. If the value of 'RN' attempted is higher than the current value of 'RX', the error message will be transmitted and the new value of 'RN' will not be rejected.

Tab. 5.5 - Max speed versus R/D resolution

	Resolution (bit)			
	10	**12**	**14**	**16**
Max speed with 2 pole resolver (rpm)	28800	12000	3510	877
Max speed with 6 pole resolver (rpm)	16000	4600	1170	292
Max speed with 8 pole resolver (rpm)	12000	3510	877	219

RS - Set/Read the angle between motor and resolver shafts.

Function:	The correct operation of the drive calls for the exact knowledge of the spatial displacement between motor and resolver shafts. The angular displacement ranging from 0 to 360 degrees corresponds to the parameter RS range of [0..65535]. In order to measure this displacement in an automatic manner, the 'auto phasing' routine might be performed. If the autophasing has been correctly made: **RS=48000 ± 1000 for PR=1** (e.g. 6 pole motor/ 6 pole resolver) **RS=6000 or 27000 or 49000 ± 1000 for PR=3** (e.g. 6 pole motor/ 2pole resolver). Otherwise, the value of 'RS' might be entered directly through the hand-held terminal and the serial link.
Syntax:	**[A]1RS<CR>** reads the value of 1RS **[A]1RSnnnn<CR>** will set the new value of 1RS parameter.
Range:	0 to 65535
Range protection:	YES
Default:	-
Password:	YES
Second set:	NO
See also:	-

RX - Set/Read the upper R/D resolution limit.

Function:	The R/D converter resolution is switched on-line in order to obtain the best possible overall drive performance. At very high speeds, the resolution is reduced in order to make possible the speed and the position measurement in a situation whence the number of revolutions per second is very high. On the other hand, at lower speed, the resolution is increased automatically so as to reduce the measurement noise, the ripple, and to increase the precision of the motion control. Hence, the actual resolution of the R/D converter will vary from 10 to 16 bit, depending on the drive operating conditions. Parameter 'RX' might impose the upper limit of the R/D converter resolution to a value lower than 16 bit. This might be necessary in application with excessive acceleration rates. Parameter 'RX' exists in two parameter sets. The values 1RX or 2RX are used depending on the status of the SPARE_IN input.
Syntax:	**[A]1RX<CR>** reads the value of 1RN and 1RX **[A]2RX<CR>** reads the value of 2RN and 2RX **[A]*RX<CR>** reads the current active value of RN and RX **[A]1RXnn<CR>** will set the new value of 1RX **[A]2RXnn<CR>** will set the new value of 2RX
Range:	10, 12, 14 or 16 [bits]
Range protection:	YES
Default:	motor dependent
Password:	YES
Second set:	YES
See also:	-

Note: RX must be $\geq$ RN. If the value of 'RX' attempted is lower than the current value of 'RN', the error message will be transmitted and the new value of 'RX' will not be rejected.

SA - Selection of the drive address.

Function:	The SA command is used for setting the drive address. This command is related to the applications where DBS drives are used in a multidrop environment, that is, where unique RS485 serial link bus connects all the DBS drive in parallel and links them to the master. Multidrop serial link protocol of the DBS drive allows for the parallel connection of up to 15 drives. For the proper operation of this structure, each drive must have generic address.
Syntax:	**INITIAL SETTING**: At the default initialization, which might be achieved by closing the drop G3P (see par.2.7.1), the initial value of the address is A (1). Therefore, after the default initialization, the drive will respond to all commands in their shorter form, without the drive address at the beginning of the command string. Hence, command strings such as '1SA' will be accepted. The drive will also accept all the commands in their full format, with the drive address at the beginning of the command string, providing that they begin with 'A', the address of the first drive. Hence, command strings such as "A1SA" will be accepted as well. **MODIFICATION OF THE ADDRESS**: For the purpose of setting the new drive address, the hand-held terminal or the host computer RS485 port must be connected to the DBS drive only (point-to-point). Command string '1SAn<CR>' should be entered by the terminal/host; putting the new drive address in the numerical presentation 1-15 as the number 'n' within the string shown. After this action, parameters should be saved by using the save command. Notice that '1SV' command string will not take effect after the address modification. Instead, save command with the leading drive address should be used. Example: for the second drive, save command 'B1SV<CR>" should be entered. A non-zero drive address might be modified as well. Example: for the second drive in the set, the modification might be done by inserting the command string "B1SAn<CR>", with 'n' being the number corresponding to the new address. An insertion of the save command is necessary in this case as well.
Range:	1=A, 2=B, 3=C, 4=D, 5=E, 6=F, 7=G, 8=H, 9=I, 10=J, 11=K, 12=L, 13=M, 14=N, 15=O
Range protection:	YES
Default:	1 (corresponding to A address)
Password:	YES
Second set:	NO
See also:	-

SE - Set/Read the number of the "simulated encoder" pulses (optional)

Function:	The shaft sensor obligatory for the use of the motor in conjunction with the DBS drive is the shaft resolver. Most CNC's though, call for the incremental encoder signals. For that reason, internal hardware and software of the DBS produces 'simulated' encoder pulses, that is, the pulses that a hypothetical encoder would produce. The number of 'pulses per turn' of this 'simulated' encoder is programmable by the 'SE' parameter.
Syntax:	**[A]1SE<CR>** reads the value of 1SE **[A]2SE<CR>** reads the value of 2SE **[A]*SE<CR>** reads the current active value of SE parameter. **[A]1SEn<CR>** will set the new value of 1SE * **[A]2SEn<CR>** will set the new value of 2SE *
Range**:	64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384
Range protection:	YES
Default:	RN dependent
Password:	YES
Second set:	YES
See also:	RN

* REMARK: to enable a new SE value (after setting and saving), reset button on front panel or send pulse to REM Reset.

** in the software versions before vers.11, the range was:

    0=128 pulses per electrical revolution
    1=256
    2=512
    3=1024
    4=2048
    5=4096
    6=8192
    7=16384

From the software vers.11.0, the SE command is now transparent and compatible with the old versions (i.e. 1024 ppr can be set with SE=1024 or with SE=3). The version of the software can be checked at the power-up.

REMARK: the DBS will not accept 'SE' values incongruent with the 'RN' parameter. Derivation of the encoder signals from the position information coming from the resolver limits the maximum number of simulated encoder pulses according to the 'RN' parameter; that is, the minimum resolution of the R/D converter. Attempt to enter wrong 'SE' value will not be accepted, and the drive will respond 'SE TOO HI FOR GIVEN RN'.

RN=10 limits SE(max) to SE = 256
RN=12 limits SE(max) to SE = 1024
RN=14 limits SE(max) to SE = 4096
RN=16 limits SE(max) to SE = 16384

SM - Automatic Save Enable bit setting and clearing

Function:	Parameters of the DBS drives are saved into 2402 EEPROM. Read/Save procedure is performed through the I2C bus when SAVE (1SV) command is executed, or, optionally, after each modification of any drive parameter. The mode of SAVE operation is defined by SM (Save Mode) bit. For SM=0, the SAVE operation is performed only when 1SV command is executed. When the SM bit 1is set to 1, SM=1, parameters are being saved after each modification of any drive parameter, providing that the parameter modification is successful. In "AUTO_SAVE" mode; that is, SM=1; the save operation is avoided if the modification of the parameter is not successful due to password protection or when the attempted value is out of range.
Syntax: .	**[A]1SM<CR>** reads the value of 1SM **[A]1SMn<CR>** will set the new value of 1SM
Range:	0 or 1
Range protection:	YES
Default:	0 (manual)
Password:	YES
Second set:	NO
See also:	SV

ST - Display the drive status flags.

Function:	Set of binary signals and flags, internal to the drive and external as well, is called 'the drive status'. The status string might be inspected by using the '1ST' command.
Syntax:	**[A]1ST<CR>** will command the DBS to respond with a string comprising the status bits.
Range:	-
Range protection:	-
Default:	-
Password:	NO
Second set:	-
See also:	-

REMARK: the format of the status string is the following:

ST b1 b2 b3   **E** b4 b5 b6   **I** b7 b8 b9 b10 b11

The meaning of specific bits is given below:

ST   =Status
b1   =Priority mode   0 = analog (opto)   1 = keyboard
b2   =DRIVE OK opto output   0 = fault condition 1 = OK
b3   =DPRAM status   0 = OK   1 = errors detected

E   =External
b4   =Analog Drive Enable   0 = OFF   1 = ON
b5   =Reference Enable   0 = OFF   1 = ON
b6   =A/D status   0 = OK   1 = errors detected

I   =Internal
b7   =Digital Drive Enable (OF and ON commands) 0 = OFF   1 = ON
b8   =Reference (AR and DR commands) 0 = analog   1 = digital
b9   =I LIMIT (AL and DL commands)   0 = analog   1 = digital
b10   =Control (TC and VC commands)   0 = speed   1 = torque
b11   =Rotation (DI command)   0 = CW (default)   1 = CCW

SV - Save the drive settings into non-volatile memory

Function:	All the drive parameters might be saved into the non-volatile memory. At the drive startup time, or, after each reset, these parameters are recovered from the non-volatile memory and used in the drive operation. During the installation phase, the drive parameters are set to the values best suited for the application. After selecting preferred parameters, it is necessary to use the '1SV' command in order to permanently save parameter values.
Syntax:	**[A]1SV<CR>** will command the DBS to start the procedure of saving all the parameters into non-volatile memory. The error message is foreseen if the saving operation is not completed correctly.
Range:	-
Range protection:	-
Default:	-
Password:	YES
Second set:	-
See also:	SM

TC - Establish the torque control mode of the drive

Function:	The DBS might work in the speed control mode or the torque control mode. That is, the reference value may be interpreted as the speed reference or the torque reference. In the speed control mode, the speed error is calculated and the speed controller algorithm is executed; while in the torque control mode the input reference signal determines the torque to be generated by the servo motor. The operation mode is selected by the status bit speed/torque control mode (see '1ST' command). The '1TC' command will put the DBS drive into the torque control mode. Note that, in this case, VE and MV parameters ("velocity" and "max velocity") mean "torque" and "max torque".
Syntax:	**[A]1TC<CR>** will command the DBS to assume the torque control mode.
Range:	-
Range protection:	-
Default:	velocity control
Password:	YES
Second set:	-
See also:	VC

Note: the status can be interrogated via ST command (bit b10).

VC - Establish the speed control mode of the drive

Function:	The DBS might work in the speed control mode or the torque control mode. That is, the reference value may be interpreted as the speed reference or the torque reference. In the speed control mode, the speed error is calculated and the speed controller algorithm is executed; while in the torque control mode the input reference signal determines the torque to be generated by the servo motor. The operation mode is selected by the status bit speed/torque control mode (see '1ST' command). The '1VC' command will put the DBS drive into the speed control mode.
Syntax:	**[A]1VC<CR>** will command the DBS to assume the speed control mode.
Range:	-
Range protection:	-
Default:	velocity control
Password:	YES
Second set:	-
See also:	TC

Note: the status can be interrogated via ST command (bit b10).

VE - Set/Read the digital speed reference

Function:	The DBS drive might work in the 'analog reference mode' or in the 'digital reference mode' (see 1ST command). When in the 'digital reference mode, the speed reference is defined by the 'VE' parameter. This parameter should be interpreted as the speed reference in [rpm]. Direction of rotation might be changed by 'DI' command if necessary. If the drive is configured as torque actuator (see TC command), VE command allows to set torque.
Syntax:	**[A]1VE<CR>** reads the value of the digital reference. **[A]1VEnnnn<CR>** will set the new value of the digital speed reference. Numerical value of the speed reference might have the leading minus sign. An 'OUT OF RANGE' message will be transmitted if the value of 'VE' attempted is higher than the 'MV' parameter. If the command is sent while the drive is in 'analog reference mode', the warning message 'keyboard disabled' will be transmitted.
Range:	0 to MV [rpm]
Range protection:	YES
Default:	0
Password:	NO
Second set:	NO
See also:	DR, TC, MV, VC

VO - Automatic compensation of analog velocity offset

Function:	The A/D converter offset might be automatically adjusted by '1VO' command and memorized in non-volatile memory. The measurement sequence initiated by '1VO' command requires the drive disabled: OFF status if G2P is open, analog DRV EN grounded if G2P closed. In case of residual offset after VO command, a finest adjustment can be done with OV command.
Syntax:	**[A]1VO<CR>** command will initiate the offset measurement procedure.. When the command is executed while the drive is ON, the warning message is transmitted and the execution of the command is stopped.
Range:	0 to 255
Range protection:	YES
Default:	128 (no offset compensation)
Password:	YES
Second set:	NO
See also:	OV

Note: VO range from 0 to 255 is operative from V06.1 DSP software version. In previous versions the range was: -500 [mV] to +500 [mV].

VS - Parameter, selection 1 out of 4 possible speed controllers

Function:	DBS has 4 different speed controller structures built into the standard software package. These structures might be selected by the VS parameter: **1VS=0**. It will select the speed controller structure with the gains 4 times higher relative to the DBM01 standard. Second order digital filter (see DF parameter) is filtering the speed reference signal. **1VS=1**. It will select the speed controller structure with the gains equivalent to those of the standard DBM01 specification. Second order digital filter (see DF parameter) is filtering the speed reference signal. **1VS=2**. It will select the speed controller structure with the gains 4 times higher relative to the DBM01 standard. Second order digital filter (see DF parameter) is filtering the speed error signal. **1VS=3**. It will select the speed controller structure with the gains equivalent to those of the standard DBM01 specification. Second order digital filter (see DF parameter) is filtering the speed error signal. Whatever setting of the VS parameter, the DF = 0 will select the DBM01 standard speed controller structure with no digital filtering of the speed reference nor the speed error. Still, even in this case (DF = 0) VS=0 and VS=2 will select the gains KP and KI increased 4 times, while VS=1 or VS=3 setting will produce the same gains as those of the standard DBM01 (for more information see the block diagram of the speed controller). Parameter VS does not exist in two parameter sets, and has to be addressed by using '1VS' command string.
Syntax:	**[A]1VS<CR>** reads the value of VS parameter. **[A]1VSn<CR>** will set the new value of the VS parameter.
Range:	0, 1, 2, or 3
Range protection:	YES
Default:	1
Password:	YES
Second set:	NO
See also:	DF

SECTION 6 - BLOCK DIAGRAM OF THE CONTROL STRUCTURE

Control functions of the DBS are illustrated in the following figures. Summary of all functions is given in Fig. 1. In Fig. 1, it might be seen that the synchronous motor with permanent magnet excitation is the object of control. The motor has an electromagnetic resolver as the shaft sensor. As a part of the drive analog circuitry, the R/D converter receives the 'SIN' and 'COS' signals, detected in resolver windings, and converts them into the digital word. This digital word (' Digital 16-bit position ' in Fig. 1) is fed to the digital signal processor.
As the received information (that is, the motor shaft position) does not present the motor shaft speed, it is necessary to process the input information in order to obtain a proper speed feedback.
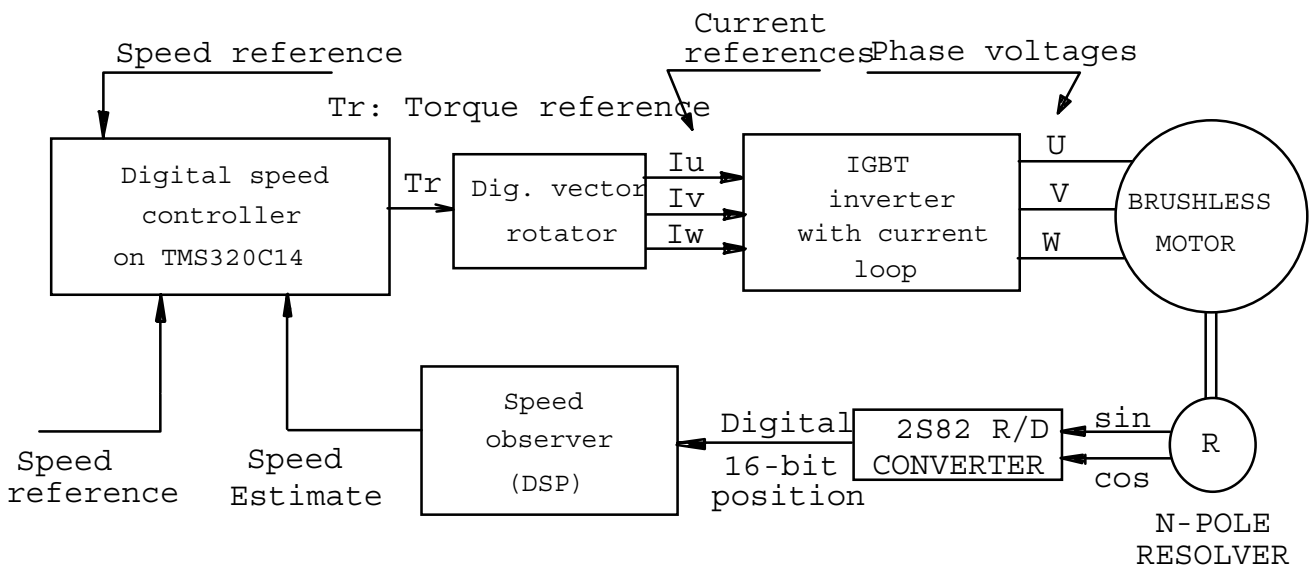

Fig. 1

Simple way to obtain the speed from the digital word representing the shaft position is by taking the first derivative. Though, due to the nature of the derivation and the environment of the drive brings in an unacceptable noise. For that reason, the speed signal is obtained from a reduced order speed observer. The inputs to the observer are digital shaft position and the torque, while the output is estimated ripple-free shaft speed. The input -- output transfer function of the observer is not a linear one, and the order of the observer sub-system is third. Observer equations are executed each 100 ms.
For the purpose of analytical prediction of the drive behavior, or, eventual computer simulation, delays in the speed feedback signals caused by the observer and the R/D network must be taken into account. Assuming that the speed loop bandwidth will never exceed BW = 100Hz, the R/D and the observer might be modeled by the real pole $W_{RDO}(s)$ = 1/ (1 + t s) in continuous domain, having the time constant t = 0.5 ms. When required, $W_{RDO}(s)$ might be transformed into the z-domain. Since the sampling time of the speed loop is T = 300 μs, the approximation of W_{RDO} in z-domain is $W_{RDO}(z)$ = z /(2 z - 1).

Having available the speed feedback and the sped error, the digital signal processor executes the speed control routine, illustrated in Fig. 2. The sampling time of the speed control loop is T = 300 ms. Speed controller is basically a PI controller with the AWU (anti wind up) mechanism. Besides PI control actions, the Fig. 2 shows a pre-filter of the proportional action, the output torque filter, and the programmable filter of the speed error WF(z). Notice that the same transfer functions WF(z) exists in both proportional and integral actions. Separation in two units was necessary in order to obtain proper AWU feature.
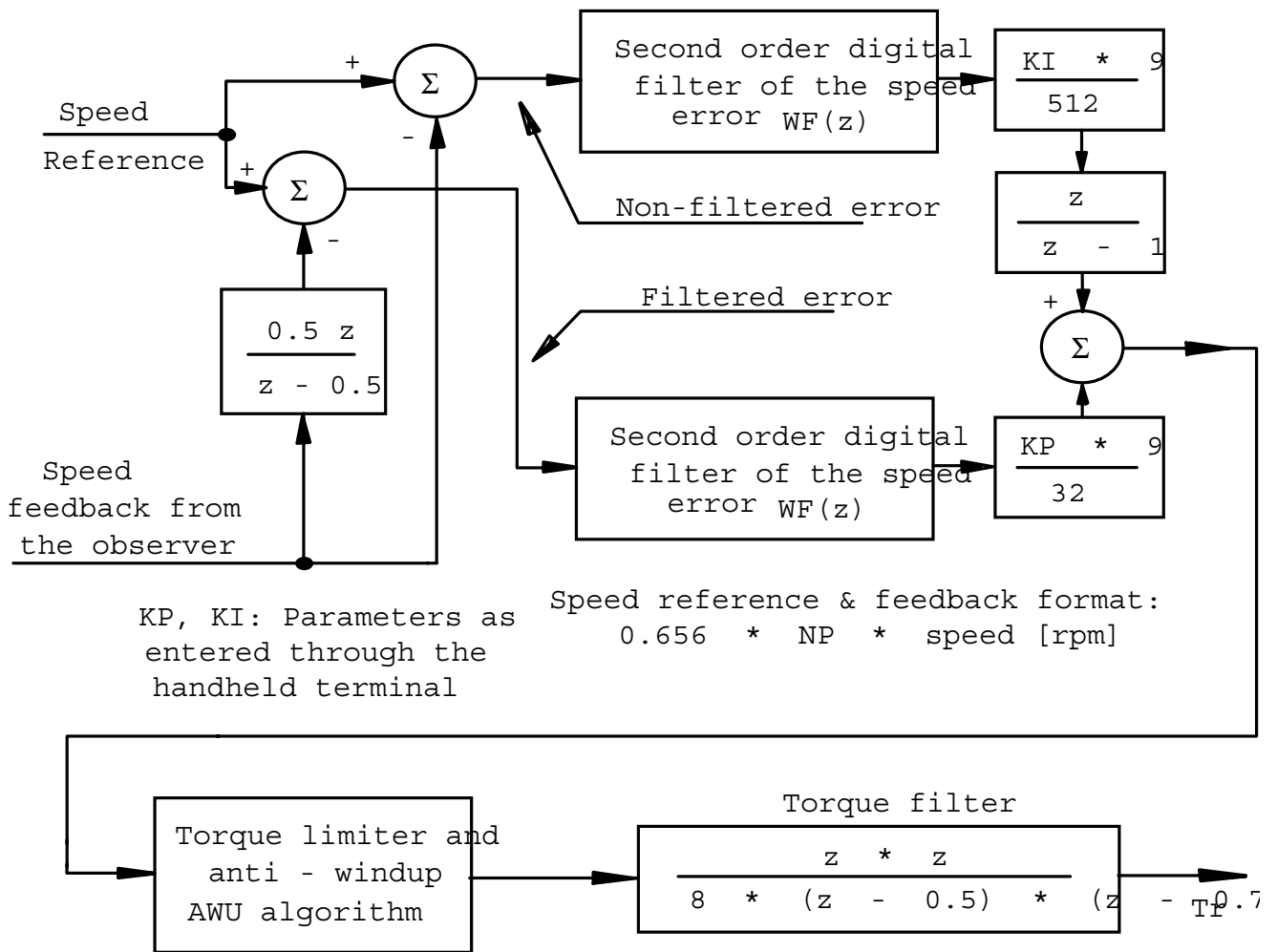
KP, KI: Parameters as entered through the handheld terminal

Speed reference & feedback format:
0.656 * NP * speed [rpm]

Tr: Output torque commandes to the vector rotator
Tr: Torque reference format +/- 32768
corresponding to +/- 100% drive peak torque

Fig. 2

The error filter in Fig. 2 is a second order digital filter of the speed error. The damping factor x of the filter is fixed to 0.707. The complex poles of the filter might be programmed by the

DF parameter of the drive in such a way that the module of the complex poles w=2pf$_{bw}$ is varied from 2.6 to 367 Hz:

$$f_{bw} \text{ [Hz]} = \ln (1 / (1 - DF/200)) / (2 \, p \, T)$$

where T = 300 uS; p = 3.1415926 ln = natural logarithm; DF = DF parameter having the range 0-100 for the filter frequency range 2.6 - 367 Hz. If DF = 0 the filter is switched OFF. The transfer function WF(z) is given by the expression below:

$$WF \ (z) = \frac{z \, \omega^2 T^2}{z^2 + (\omega^2 T^2 - 2 + 2\xi\omega T)z + 1 - 2\xi\omega T}$$

For the purpose of defining the closed loop gain of the system, it is necessary to understand the format of the numbers that appear at the input and on the output of the speed controller. The speed reference and the speed error (at the level of error discriminator, left part of the Fig. 2) have the same format. This format depends on the number of resolver poles. The digital words representing the speed reference and the speed feedback at the summation point are numerically equal to the speed in [rpm] multiplied by the number of resolver poles and the scaling constant 0.656, that is Speed[internal to DSP] = 0.656 * NP * Speed [rpm]. At the output of the speed controller, the torque reference is generated.   The range of the internal number 'Tr' [- 2^{15} ... 0 ... + 2^{15}] corresponds to the range of the output torque [- T$_{max}$ ... 0 ... + T$_{max}$] . The peak drive torque T$_{max}$ is the torque developed by the motor supplied by the DBS peak current.

EXAMPLE:

An example that brings the light to the KP and KI adjustment and the effect of these parameters on the drive behavior is given hereafter. In the following analysis, the filters in Fig. 2 will be neglected for simplicity, and the load torque will be considered zero. If we assume that the drive peak torque (that is, the motor torque constant multiplied by the drive maximum RMS output) is T$_{max}$[Nm], the number of resolver poles is NP, the total drive & load inertia J[kgm^2]; the closed loop gain of the speed loop can be derived from Fig. 2 as:

$$W_{pp}(s) = \frac{NP \ T_{max}}{J} \left[KP \frac{0.0000537}{s} + KI \frac{0.0112}{s^2} \right]$$

The speed controller closed loop transfer function will be W(s) = W$_{pp}$(s) / (1 + W$_{pp}$(s)). Behavior of the closed loop system might be judged from the poles of the characteristics polynomial F(s) = 1 + W$_{pp}$(s). If we assume T$_{max}$ = 7 Nm, NP = 8, J = 0.001 kgm^2; KP = 80 (default) and KI = 20 (default), the closed loop poles will be:

$$s_{1/2} = -120 + / - \ j43$$

and will result in a well damped response and the speed loop bandwidth of approximately 17 Hz.

The torque reference is further processed through the vector rotator (see Fig. 1) in order to obtain the references for the phase currents of the motor. These references (I_U, I_V, and I_W in Fig. 3) are calculated as multiples of the torque reference and the cosine function having the shaft position as the argument.
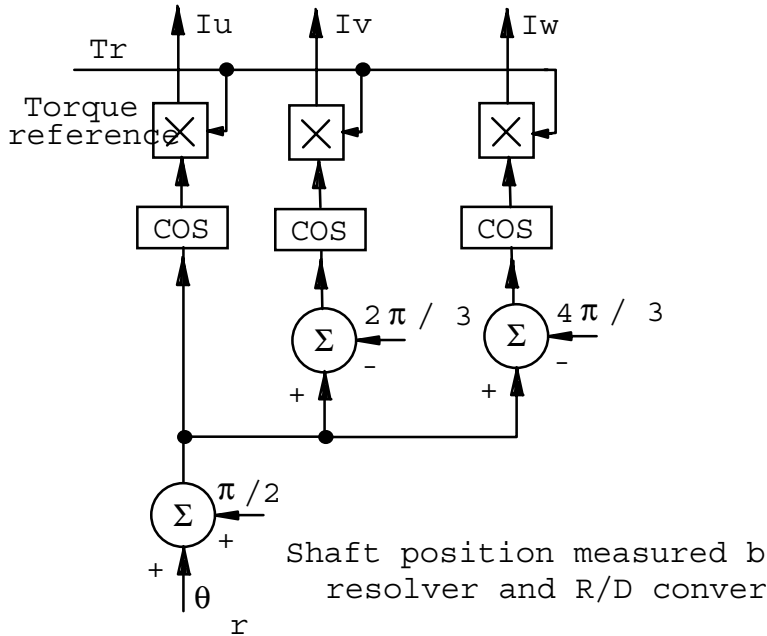
Fig. 3

The phase current references I_U, I_V, and I_W (obtained at the output of the vector rotator) are fed to the DAC - digital to analog converter. Analog signals, ranging from -10V to +10V are fed as analog references to the current controller.

The DBS current controller is implemented in the analog form. The current references are compared with the measured phase currents and the current error is derived. After processing the current error for each phase through the PI gain block implemented in an analog form, resulting signals are used to control the three phase inverter given in Fig. 4.
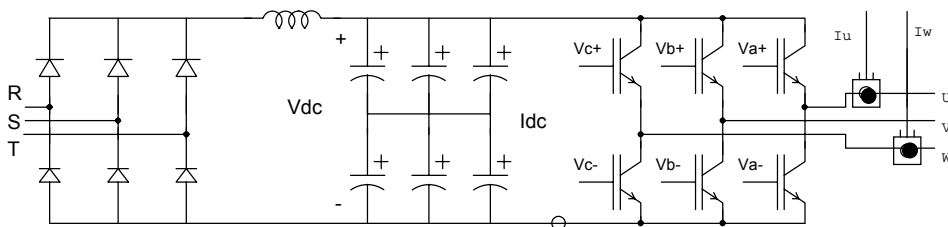
Fig. 4

The IGBT switches are controlled through the PWM method with the symmetrical (triangular) carrier. That is, the modulating signal is being fed from the output of the PI block to the comparator that determines the sign of the difference between the modulating signal and the triangular 5kHz carrier (see Fig. 5 below). The width of the pulses in Fig. 5 depend upon the level of the modulating signal m, and so the average phase voltage as well. As might be seen, the current control takes effect in correcting the average phase voltage in such a way that any current error detected in error discriminators is gradually driven to zero.
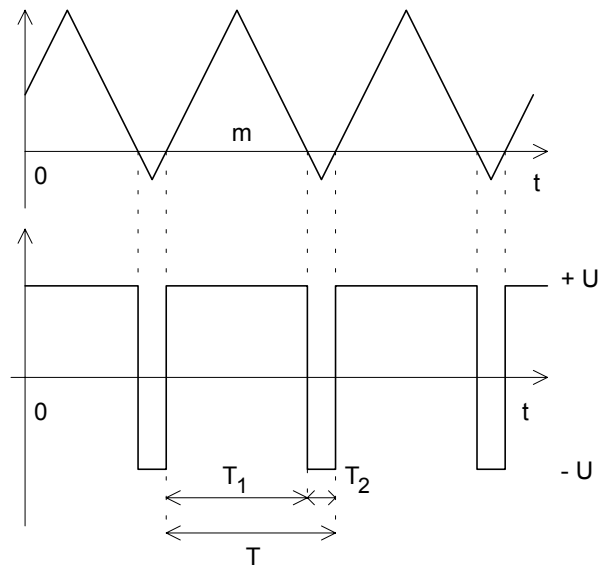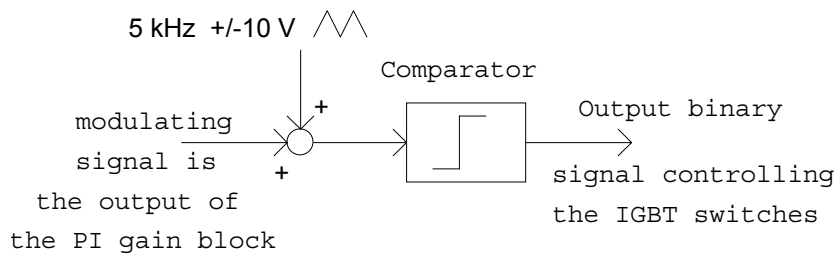
Fig. 5

To make sure that the steady state DC error is always driven to zero, the current controller comprises; besides the proportional gain, an integral gain as well. The way in which the proportional and integral gains are implemented is illustrated in Fig. 6:
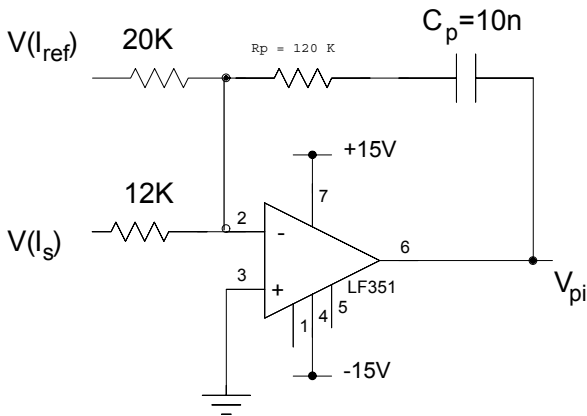
Fig. 6

The signal marked as V(Iref) in Fig. 6 is the phase current reference in the analog form. The signal marked with V(Is) is the current feedback measured with LEM sensors. The output Vpi in Fig. 6 is the modulating signal, playing the role of the voltage reference. This signal is not fed directly to the comparator, but rather first processed through the slope limiter. The reason for introducing the slope limitation might be seen from the traces in Fig 7, featuring the triangular carrier along with the modulating signal. In the situations whence the slope of the amplified current error exceeds the slope of the carrier, multiple IGBT switching within same period of the carrier might occur, leading to the drive overheating and eventual failure.
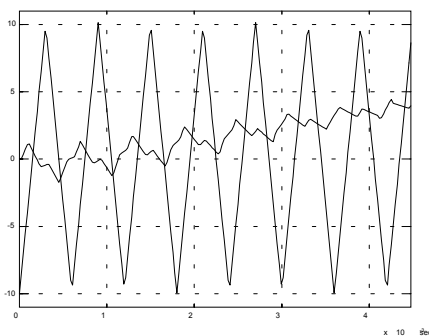
Fig. 7

The slope limiter (illustrated in Fig. 8 along with its step response) is implemented by using the 'external compensation' capacitors in conjunction with LM201 type operational amplifier.

Rate limiter

(a)

(b)
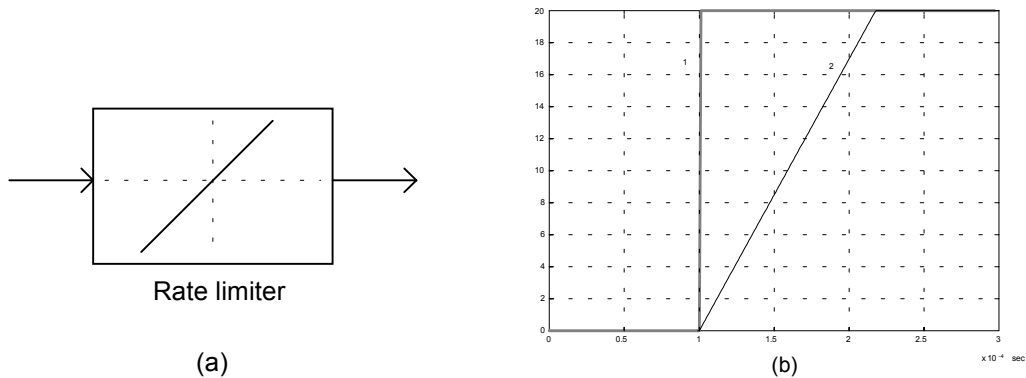
Fig. 8

Complete block diagram of the current controller is given in Fig. 9. As might be seen, only two blocks with PI gains are implemented. The current controller is implemented in such a way since the third gain block is obsolete. Since the star point of the motor phase windings is not externally connected, the sum of the three motor phase currents is identically equal to zero. Hence, three independent current controllers would be redundant and only two of them are applied. Fig. 9 shows that only two phase currents are measured.

The third phase current is reconstructed from the former two. The same way, the modulating signal -- or, the voltage reference -- is derived for two phases only; the third one is reconstructed as well. The gains of the current controller should be adjusted according to the motor leakage inductance. These gains are defined by Rp and Cp in Fig. 6. Values given in Fig. 6 (120 kW and 10 nF) correspond to the motor leakage inductance of 3.3 mH. The gains should be proportionally increased (or decreased) when the motor leakage inductance is lower -- or higher -- respectively. More specifically, the multiple $L_{motor}{}^{*} C_p$ and the quotient L_{motor} / R_p should be kept constant.
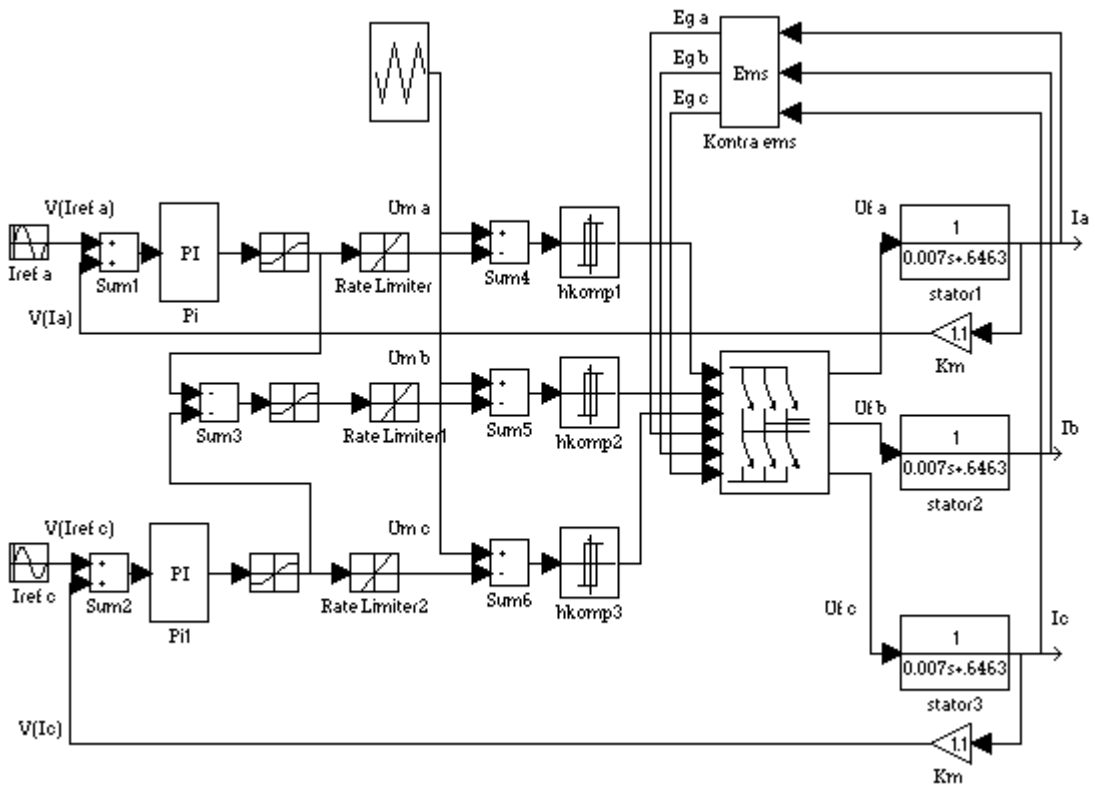
Fig. 9

Resulting amplitude characteristic of the transfer function of current controller is given in Fig. 10. Frequency axes is given in [rad/s]. The bandwidth of the current controller is approximately 1kHz.

Kp=8.333   Ti=0.001
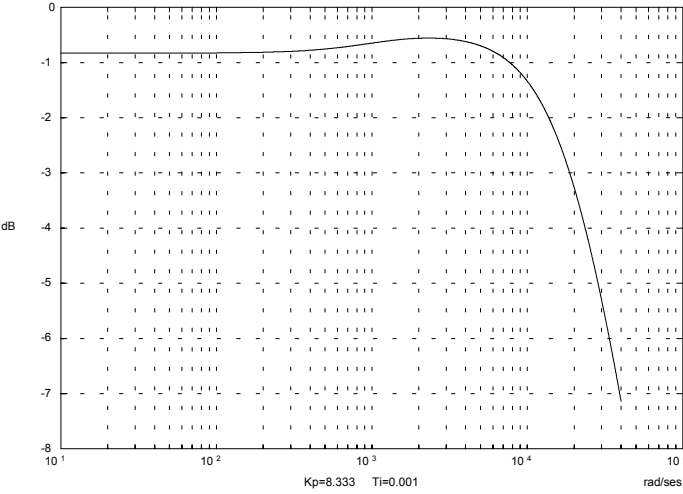
Fig. 10

In order to illustrate the phase characteristic of the current controller and the resulting phase delay at relevant frequencies, the phase current references and the measured waveforms are given in Fig. 11 for the fundamental frequency of 30 Hz and 200Hz:
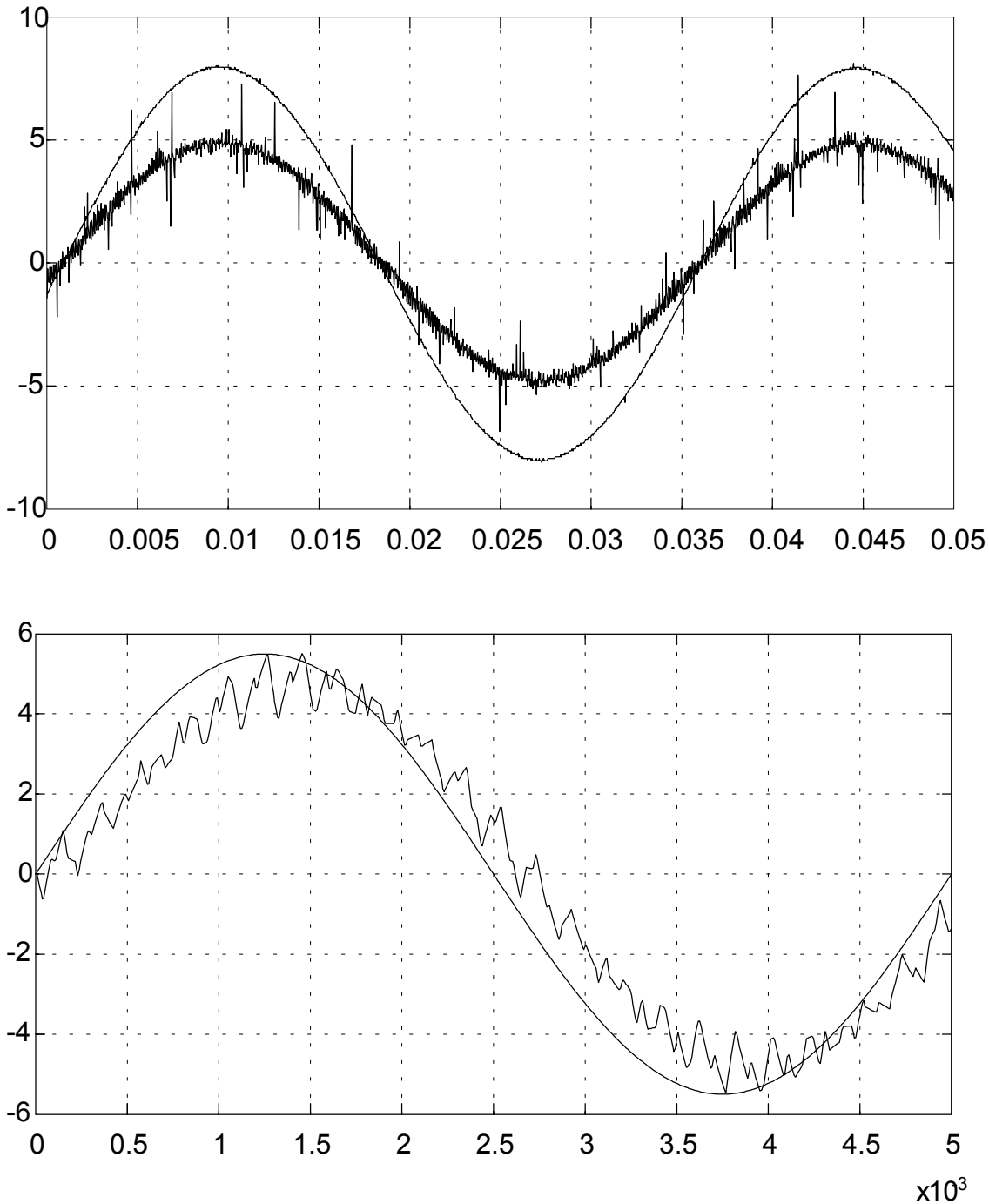
Fig. 11

Notice: for particular applications the PWM modulation with the commutation frequency of 10kHz might be used. Higher commutation frequency will decrease the current ripple and provide for better torque control. Though, certain increase of the drive power losses is to be expected, since the commutation losses increase proportionally to the commutation frequency.

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SECTION 7 - ADJUSTMENT OF TORQUE/SPEED CURVE

In most of the DBS applications, the magneto-motive force (MMF, that is, the stator current vector) is perpendicular to the rotor flux. In such a way, the torque constant ([Nm] per Ampere) is maximized.

In some applications requiring extremely high speed and high frequency of the stator current, the phase lag caused by the current controller imperfection might degrade the drive torque constant. The current controller implemented within the DBS drive results in a phase lag of 9 degrees at the output frequency of 270 Hz.

Due to the phase lag, the spatial displacement between the rotor flux and the stator MMF will be less than 90 degrees (electrical) and the torque will diminish as the cosine function of the phase lag.

DBS drive might compensate this phase lag and the lack of torque through the user programmable phase advance. That is, an additional phase advance might be inserted into the drive vector rotator, rendering the possibility to compensate for the current controller phase lag and to optimize the Torque/Speed curve.

Along with the conventional synchronous PM motors, the DBS might run PM motors with pronounced saliency effect ($L_d \neq L_q$) and ensuring reluctance torque. The peak of total electromagnetic torque for this family of PM motors is obtained with flux-MMF angles different that 90 electrical degrees.

For the purpose of maximizing the torque per Amp constant of synchronous reluctance motors, the phase advance in function of the speed and stator current is provided as a standard feature of the DBS.

7.1 Phase-speed relation

According to the requirements, the phase-speed curve equals zero for all the speeds below the speed **S1**[rpm] (see Fig. 7.1). Above that speed, the phase rises with the speed with a constant slope. Hence, two parameters (**PF** and **PG** in the following text) are sufficient for the purpose of customising the phase-speed demagnetisation curve. **PF** parameter will define the speed **S1**[rpm]. From the stall up to the **S1**[rpm], the phase(speed) correction will have the value zero. Above **S1**[rpm], the phase(speed) correction will rise up with the constant slope. This slope is defined by the second, **PG** parameter.

Fig. 7.1 - Phase-Speed Curve
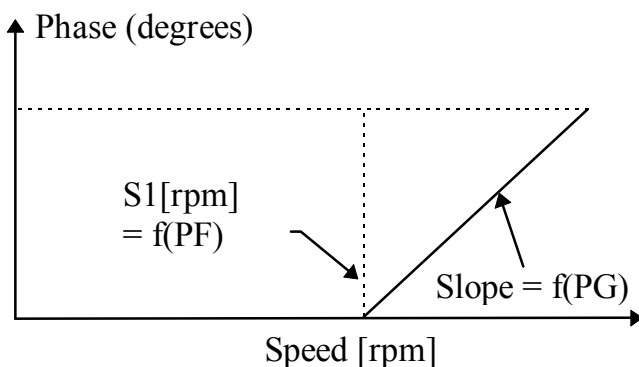
7.2 Phase-current relation

The phase-current curve might start with the value different from zero. That is, the phase correction might not be zero for very small values of the current IQ. Therefore, a dedicated parameter **PH** is provided for adjusting the initial (IQ=0) value of the phase angle correction of the phase-current curve. The curve phase(IQ) is linearly rising or falling for the currents IQ>0. The phase attains the value defined by **PX** parameter at the current level S2[%], defined by the **PY** parameter.

Fig. 7.2 - Phase-Current Curve
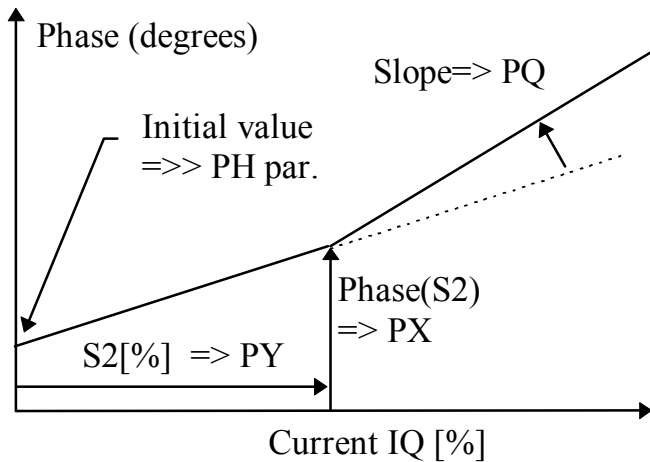
Hence, the point S2[%] - phase(S2) is defined by **PX** and **PY** parameters. At the same time, these two parameters along with the **PH** parameter will determine the slope of the phase curve in the interval IQ = [0..S2]. According to requirements, the phase-current curve might increase at a steeper slope for the values of IQ superior to S2[%]. For this purpose, the sixth, **PQ** parameter is provided in order to program the slope of the phase-current curve for the values bigger than S2[%].

7.3 Parameters Setting for FAS T-V

To optimize the match between FAST-V brushless servomotors and DBS (400V) drive, the following parameters settings have been found to be the best choice. With these parameters the motor provides, at the nominal speed and with $360V_{ac}$ (corresponding to $400V_{ac}$- 10%) power supply, a Max Torque from 1.5 to 3 times the Max Torque without the optimization algorithm.

Tab. 7.1 - Parameters Setting for 400V and 6-pole resolver

FAS T-V	DBS	IL	PF	PG	PH	PY	PX	PQ
FAS T00 V2 100	3/9	77	46	1	0	255	128	128
FAS T0 V2 060	3/9	100	30	5	0	115	128	147
V4 060	3/9	100	30	6	0	87	128	154
V8 030	3/9	100	15	12	0	76	128	143
V8 060	6/15	100	53	8	0	127	128	149
FAS T1 V2 030	3/9	100	19	15	0	94	128	150
V2 060	6/15	100	53	8	0	127	128	149
V4 030	6/15	100	29	13	0	166	128	158
V4 045	6/15	100	44	10	0	133	128	150
"	8/22	100	29	9	0	89	128	153
V6 030	6/15	100	29	13	0	127	128	149
"	8/22	100	21	13	0	87	128	147
V6 045	8/22	100	46	12	0	127	128	149
"	15/42	88	30	10	0	66	128	156
V8 030	6/15	100	30	14	0	97	128	142
"	8/22	100	24	14	0	66	128	144
V8 045	15/42	100	30	8	0	74	128	151
FAS T2 V2 030	8/22	100	16	11	0	51	128	150
V2 045	15/42	100	30	10	0	102	128	154
V4 020	8/22	100	15	17	0	76	128	145
"	15/42	75	12	12	0	51	128	147
V4 030	15/42	100	18	13	0	74	128	145
V6 020	15/42	100	16	24	0	69	128	143
V6 030	15/42	100	27	15	0	66	128	142
"	25/70	73	27	17	0	40	128	150
V8 020	15/42	100	16	16	0	102	128	144
"	25/70	65	15	14	0	61	128	155
V8 030	15/42	100	29	10	0	204	128	145
"	25/70	100	26	14	0	102	128	144
FAS T3 V2 020	15/42	100	15	14	0	140	128	151
V2 030	25/70	100	21	13	0	135	128	149
V3 020	25/70	100	14	16	0	122	128	148
V3 030	25/70	100	27	17	0	79	128	143
"	35/90	100	23	17	0	61	128	143
V4 020	25/70	100	18	18	0	94	128	147
V4 030	35/90	100	26	14	0	76	128	145
V6 012	25/70	100	11	29	0	112	128	147
V6 020	35/90	100	15	23	0	0	128	137
V8 012	35/90	100	10	32	0	76	128	142
V8 020	50/140	100	15	19	0	0	128	138
"	60/180	77	15	19	0	0	128	141

Tab. 7.2 - Parameters Setting for 400V and 2-pole resolver

FAS T-V	DBS	IL	PF	PG	PH	PY	PX	PQ
FAS T00 C4 100	3/9	100	25	13	0	127	128	142
FAS T0 C2 060	3/9	100	10	16	0	115	128	147
C4 060	3/9	100	10	19	0	87	128	154
C8 060	3/9	100	15	11	0	153	128	149
"	6/15	100	17	26	0	127	128	149
FAS T1 C2 030	3/9	100	6	45	0	94	128	150
C2 060	6/15	100	17	26	0	127	128	149
C4 030	6/15	100	9	40	0	166	128	158
C4 045	6/15	100	14	31	0	133	128	150
"	8/22	100	9	27	0	89	128	153
C6 030	6/15	100	9	40	0	127	128	149
"	8/22	100	7	41	0	87	128	147
C6 045	8/22	100	15	37	0	127	128	149
"	15/42	88	10	31	0	66	128	156
C8 030	6/15	100	10	44	0	97	128	142
"	8/22	100	8	44	0	66	128	144
C8 045	15/42	100	10	26	0	74	128	151
FAS T2 C2 030	8/22	100	5	35	0	51	128	150
C2 045	15/42	100	10	31	0	102	128	154
C4 020	8/22	100	5	51	0	76	128	145
C4 030	15/42	100	6	40	0	74	128	145
C6 020	15/42	100	5	74	0	69	128	143
C6 030	15/42	100	9	46	0	66	128	142
"	25/70	73	9	51	0	40	128	150
C8 020	15/42	100	5	49	0	102	128	144
"	25/70	65	5	44	0	61	128	155
C8 030	25/70	100	8	42	0	102	128	144
FAS T3 C2 020	15/42	100	5	44	0	140	128	151
C2 030	25/70	100	7	41	0	135	128	149
C3 020	25/70	100	4	50	0	122	128	148
C3 030	25/70	100	7	51	0	79	128	143
"	35/90	100	9	53	0	61	128	143
C4 020	25/70	100	6	55	0	94	128	147
C4 030	35/90	100	8	42	0	76	128	145
C6 012	25/70	100	3	89	0	112	128	147
C6 020	35/90	100	5	71	0	0	128	137
C8 012	35/90	100	3	97	0	76	128	142
C8 020	50/140	100	5	59	0	0	128	138
"	60/180	77	5	59	0	0	128	141

Tab. 7.3 - Parameters Setting for 460V and 6-pole resolver

FAS T-V	DBS	IL	PF	PG	PH	PY	PX	PQ
FAS T0 V2 060	3/9	100	39	6	0	163	128	157
V4 060	3/9	100	41	7	0	140	128	159
V8 060	6/15	100	64	8	0	204	128	163
FAS T1 V2 030	3/9	100	24	15	0	145	128	154
V2 060	6/15	100	64	8	0	204	128	163
V4 030	6/15	100	38	14	0	245	128	216
V4 045	6/15	100	56	13	0	235	128	172
"	8/22	100	46	13	0	158	128	159
V6 030	6/15	100	38	14	0	238	128	178
"	8/22	100	29	14	0	161	128	158
V6 045	8/22	100	58	15	0	230	128	163
"	15/42	88	35	11	0	120	128	161
V8 030	6/15	100	38	14	0	245	128	181
"	8/22	100	30	13	0	166	128	152
V8 045	15/42	100	43	10	0	151	128	155
FAS T2 V2 030	8/22	100	27	18	0	143	128	152
V2 045	15/42	100	44	12	0	174	128	172
V4 020	8/22	100	23	14	0	197	128	171
V4 030	15/42	100	30	14	0	166	128	158
V6 020	15/42	100	19	21	0	166	128	152
V6 030	15/42	100	36	14	0	222	128	193
"	25/70	73	33	13	0	133	128	178
V8 020	15/42	100	26	17	0	235	128	190
"	25/70	65	26	22	0	140	128	192
V8 030	15/42	100	15	3	0	255	128	128
"	25/70	100	38	13	0	225	128	181
FAS T3 V2 020	15/42	100	24	18	0	230	128	184
V2 030	25/70	100	38	26	0	225	128	187
V3 020	25/70	100	24	24	0	217	128	175
V3 030	25/70	100	38	17	0	225	128	205
"	35/90	100	30	18	0	174	128	156
V3 030+1.5mH	25/70	100	23	17	0	143	128	152
"+1.5mH	35/90	100	19	16	0	110	128	152
V4 020	25/70	100	25	21	0	225	128	187
V4 030	35/90	100	38	22	0	230	128	199
V4 030+1.5mH	35/90	100	27	21	0	133	128	150
V6 012	25/70	100	15	29	0	243	128	150
V6 020	35/90	100	21	24	0	148	128	146
V8 012	35/90	100	13	24	0	207	128	157
V8 020	50/140	100	23	19	0	189	128	160
"	60/180	77	23	19	0	145	128	168
V8 020+1.5mH	50/140	100	13	23	0	112	128	148
"+1.5mH	60/180	77	13	23	0	87	128	153

Tab. 7.4 - Parameters Setting for 460V and 2-pole resolver

FAS T-V	DBS	IL	PF	PG	PH	PY	PX	PQ
FAS T0 C2 060	3/9	100	13	19	0	163	128	157
C4 060	3/9	100	13	23	0	140	128	159
C8 060	6/15	100	21	24	0	204	128	163
FAS T1 C2 030	3/9	100	8	47	0	145	128	154
C2 060	6/15	100	21	24	0	204	128	163
C4 030	6/15	100	12	44	0	245	128	216
C4 045	6/15	100	14	31	0	235	128	172
"	8/22	100	15	41	0	158	128	159
C6 030	6/15	100	12	44	0	238	128	178
"	8/22	100	9	44	0	161	128	158
C6 045	8/22	100	19	47	0	230	128	163
"	15/42	88	11	35	0	120	128	161
C8 030	6/15	100	12	44	0	245	128	181
"	8/22	100	10	39	0	166	128	152
C8 045	15/42	100	14	32	0	151	128	155
FAS T2 C2 030	8/22	100	9	55	0	143	128	152
C2 045	15/42	100	14	36	0	174	128	172
C4 020	8/22	100	7	44	0	197	128	171
C4 030	15/42	100	10	44	0	166	128	158
C6 020	15/42	100	6	63	0	166	128	152
C6 030	15/42	100	12	44	0	222	128	193
"	25/70	73	11	41	0	133	128	178
C8 020	15/42	100	8	51	0	235	128	190
"	25/70	65	8	66	0	140	128	192
C8 030	25/70	100	12	39	0	225	128	181
FAS T3 C2 020	15/42	100	8	55	0	230	128	184
C2 030	25/70	100	12	79	0	225	128	187
C3 020	25/70	100	8	72	0	217	128	175
C3 030	25/70	100	10	55	0	225	128	205
"	35/90	100	12	53	0	174	128	156
C3 030+1.5mH	25/70	100	7	51	0	143	128	152
"+1.5mH	35/90	100	6	50	0	110	128	152
C4 020	25/70	100	8	63	0	225	128	187
C4 030	35/90	100	12	66	0	230	128	199
C4 030+1.5mH	35/90	100	9	64	0	133	128	150
C6 012	25/70	100	5	88	0	243	128	150
C6 020	35/90	100	7	74	0	148	128	146
C8 012	35/90	100	4	74	0	207	128	157
C8 020	50/140	100	7	57	0	189	128	160
"	60/180	77	7	57	0	145	128	168
C8 020+1.5mH	50/140	100	4	70	0	112	128	148
"+1.5mH	60/180	77	4	70	0	87	128	153

MOOG