HP Integral

VARIABLE FREQUENCY DRIVE

USER MANUAL

ООО «ТИ-СИСТЕМС» ИНЖИНИРИНГ И ПОСТАВКА ТЕХНОЛОГИЧЕСКОГО ОБОРУДОВАНИЯ
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1. Safety Warnings

Symbols below are used in this manual for safety advertising:

Danger: indicates a potentially hazardous situation other than electrical, which could result in damage to property. It may also be used to alert against unsafe practices.

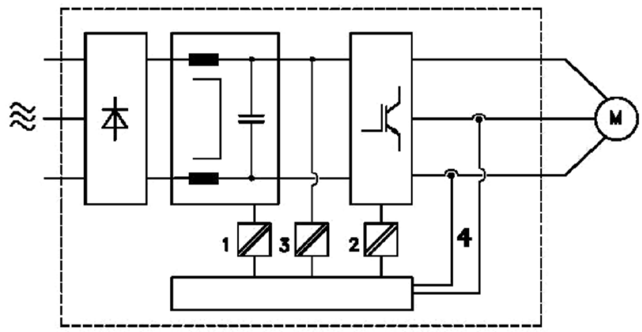
Danger: indicates a risk of electric shock which could result in damage to the equipment and possible death or serious injury.

1.1 Galvanic Isolation (PELV)

Galvanic (ensured) isolation is obtained by fulfilling requirements concerning higher isolation and by providing the relevant clear page/clearance distances.
These requirements are described in the EN 50178 standard.

In HPI Series all control terminals are supplied from or in connection with extra low voltage (PELV).

The components that make up the electrical isolation, as described below, also comply with the requirements concerning higher isolation and the relevant test as described in EN 50178. The galvanic isolation can be shown in three locations (see drawing below), namely:



1. Power supply (SMPS) including signal isolation of VDCbus, indicating the intermediate voltage.
2. Gate drive that runs the IGBTs
3. DCbus Voltage transducer

1.2 Earth Leakage Current

Earth leakage current is primarily caused by the capacitance between motor phases and the motor frame. The RFI filter contributes additional leakage current, as the filter circuit is connected to earth through capacitors (Cy).

The size of the leakage current to the ground depends on the following factors, in order of priority:
1. Switching PWM frequency
2. Motor grounded on site or not

The leakage current is of importance to safety during handling/operation of the drive if (by mistake) the drive has not been earthed.
Ensure correct grounding of the equipment by a certified electrical installer.

The leakage current generates in the ground connection is less than 3.5mA so it is not necessary to take reinforced grounding as indicated by EN/IEC61800-5-1.

1.3 Over Voltage Protection

The voltage in the intermediate circuit is increased when the motor acts as a generator. This occurs in two cases:

1. The load generates energy.
2. During deceleration ("ramp-down") if the moment of inertia is high, the load is low and the ramp-down time is too short for the energy to be dissipated as a loss in the HPI frequency converter, the motor and the installation.
3. The drive turns off to protect the IGBT transistors and the intermediate circuit capacitors when a certain voltage level is reached on DCbus.

1.4 Discharge Time

HPI contains DC-link capacitors, which can remain charged even when the frequency converter is not powered. Failure to wait the specified time after power has been removed before performing service or repair work, could be dangerous.

After AC mains disconnection, wait 5 minutes to a fully capacitors discharge.

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1.5 Main Supply Interferance/Harmonic

An HPI integral drive takes up a non-sinusoidal current from mains. A non-sinusoidal current can be transformed by means of a Fourier analysis and split up into sine wave currents with different frequencies, i.e. different harmonic currents IN with 50 Hz as the basic frequency.

Some of the harmonic currents might disturb communication equipment connected to the same transformer or cause resonance in connection with power-factor correction batteries.
To ensure low, harmonic currents, for the residential and commercial environments, an optional harmonic filter is necessary.

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2. General Information and Ratings

2.1 Introduction

High Performance Integrated (HPI) version of the product includes an integrated drive control system.
High Performance Motors (HPI) are an innovative range of PM **(Permanent Magnet) Synchronous Motors, achieving IE4 Super Premium Efficiency** level that offer improved efficiency and reduced operating costs.

Lafert's in house servo and AC induction motor design and manufacturing capabilities have facilitated the development of this uniquely engineered range of Permanent Magnet IE4 Synchronous Motors.

In order to develop the HP Motor, Lafert used a combination of product designs inspired by the brushless servo motor's electrical design and the AC induction motor's mechanical design. With higher efficiencies than standard AC induction motors they also enhance the power/weight ratio, thereby allowing for significant **size and weight reductions of up to 50%.**

The Lafert PM rotor technology of the HP motor has no losses. Also, stator currents are lower, consequently generating lower losses due to lower current demand (Joule effect). The resulting benefit is a lower rated temperature rise for both the windings and bearings. These limited temperature rises can, in the right design, eliminate the need for a cooling fan and its related losses. Ultimately, the sum of these minimized heat contributions provides higher running speeds and extended bearing life.

Lafert place great emphasis on materials research. This has resulted in reduced dependency on rare earth magnets, allowing the use of more readily available permanent magnets, which ensures price and supply stability into the future.

VALUE ADDED FEATURES & BENEFITS

The primary benefit offered by Lafert's HP synchronous motor is the reduction in the life cycle cost of the motor. The combination of servo brushless and induction motor technology used for the development of this product gives it a high efficiency low noise design. Because of the higher efficiency, the product dissipates lower heat, which improves its operating life.

This motor is primarily targeted toward **HVAC applications** in pumps, fans, compressors, and blowers, where there is an emphasis on reducing the operating cost or weight, and size of the motors. Lafert also offers flexibility in terms of design, customizing the active and mechanical parts of the motor to suit specific customer requirements.

Lafert also can produce this motor in high volume on a regular scheduled delivery basis with modifications as per specific customer requirements. The HP 71 PM synchronous motor is available in a range of power outputs, ranging from **0.37 kW to 2.2kW**, with full flexibility in motor speed up to 6000 RPM; it can be controlled by most standard drives.

TECHNICAL DESCRIPTION

BRIEF DESCRIPTION

The following features of our HP Motors may vary depending on series and type:

- Admissible environmental temperature: from -15 °C up to +40 °C, with altitudes 1000 m above sea level
- Mounting: IM B3, B5, B14, B34, B35
- Flange concentricity degree "N"; balancing: vibration "A/B"; dynamic balancing with half key
- Shaft designed according to the standard version with key (also available without key)
- Available speeds: 1500, 1800, 3000, 3600, 4500 rpm
- Drive operating voltage: 230 or 400 Vac
- Insulation class: "F"; temperature rise to class B (TEFC execution)
- IP55 degree of protection for the whole range
- On-Off PTO switch for thermal protection (NTC and PTC are available)
- Optional feedback on request: resolver, encoder, tacho and Hall sensors (several combinations may be added to this list)
- Reduced dimensions
- Permanent magnets technology

DEFINITIONS

- HPI: High Performance Integral drive motor (SENSORLESS)
- Rated torque (Mn): Torque available on the shaft continuously (service S1) with rated speed and with a winding current equivalent to the rated current, holding the motor in rated working condition.
- Rated current (In): Current supplied to the motor continuously at a rated speed, required to develop rated torque.

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- Voltage constant (Ke): Ratio between voltage induced by the rotor rotation (RMS value for sinusoidal motor, peak value for trapezoidal motor) at a certain number of revolutions and angular speed (ω=2 x ¶ x n/60 where n is the speed expressed in rpm) measured in rad/sec.
- Torque constant (Kt): Ratio between torque on the shaft and the current RMS value for sinusoidal motors, peak value for trapezoidal motors (equivalent to the voltage constant of a trapezoidal motor and to that of a sinusoidal motor multiplied by $\sqrt{3}$).
- Back electromotive force (B.E.M.F): Voltage induced by the rotor rotation (RMS value for sinusoidal motor, peak value for trapezoidal motor) at a certain number of revolutions.

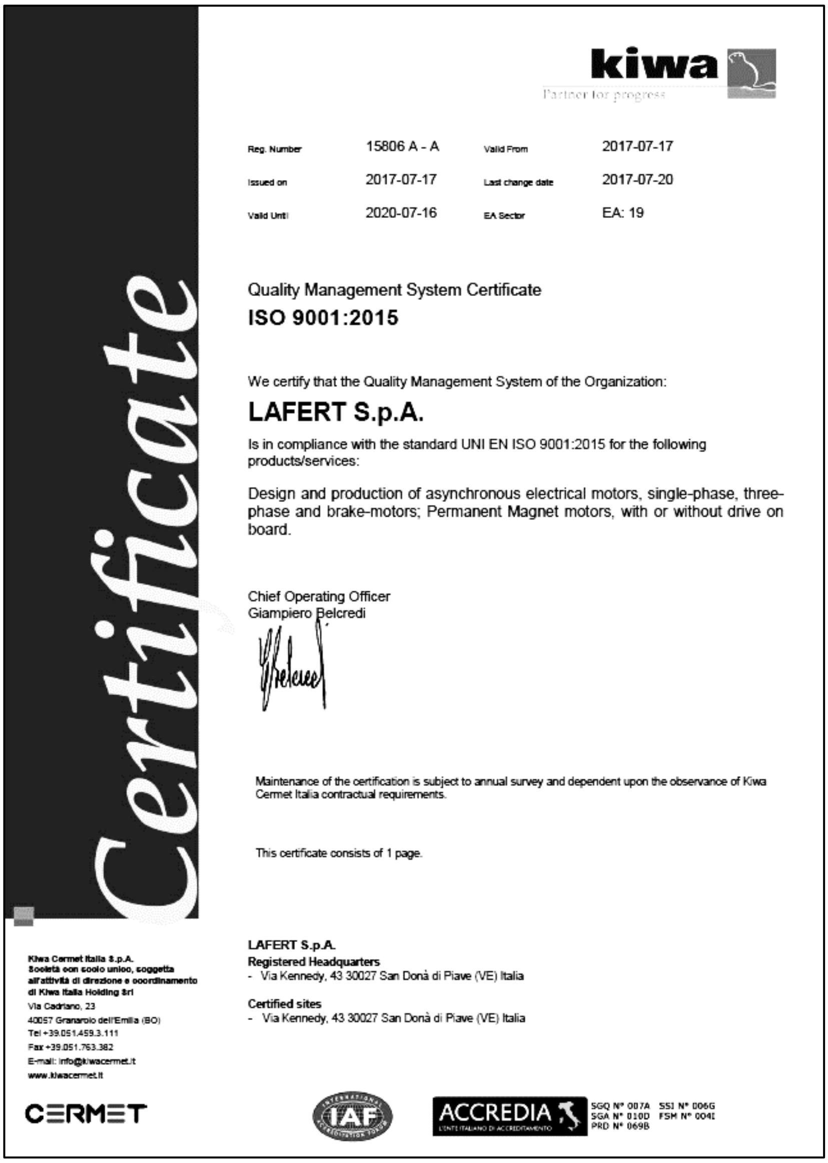
2.2 Standard and Regulations

QUALITY SYSTEM CERTIFICATE

The strictness of our quality control assures the flawless operation and reliability of our products. Our quality is confirmed by the Certificate ISO 9001:2015 awarded by KIWA-CERMET, a certification body authorized by ACCREDIA.

SAFETY STANDARDS

Our motors comply with the requirements of the International Standard IEC 60034 for rotating electrical machines as well as with the following European Directives: Low Voltage Directive (LV) 2014/35/EC, Electromagnetic Compatibility Directive (EMC) 2014/30/EC.
All products comply with the requirements of the Directive Machines (MD) 2006/42/EC. In accordance with this Directive, induction motors are components and intended solely for integration into other machines. Commissioning is forbidden until conformity of the end-product with this Directive is proved.
The CE marking was applied for the first time in 1995.When operating the motor, the observance of the Regulation EN 60204-1 and safety instructions indicated in our Operating Instructions must be complied with.
Motors complied with many other international standards are available on request:
Motors approved by UL Underwriters Laboratories Inc.


Certificate

kiwa
Partner for progress

Reg. Number	15806 A - A	Valid From	2017-07-17
Issued on	2017-07-17	Last change date	2017-07-20
Valid Until	2020-07-16	EA Sector	EA: 19

Quality Management System Certificate
ISO 9001:2015

We certify that the Quality Management System of the Organization:

LAFERT S.p.A.

Is in compliance with the standard UNI EN ISO 9001:2015 for the following products/services:

Design and production of asynchronous electrical motors, single-phase, three-phase and brake-motors; Permanent Magnet motors, with or without drive on board.

Chief Operating Officer
Giampiero Belcredi

Maintenance of the certification is subject to annual survey and dependent upon the observance of Kiwa Cermet Italia contractual requirements.

This certificate consists of 1 page.

Kiwa Cermet Italia S.p.A.
Società con socio unico, soggetta all'attività di direzione e coordinamento di Kiwa Italia Holding Srl
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Certified sites
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CERMET
IAF
ACCREDIA L'ENTE ITALIANO DI ACCREDITAMENTO
SGQ N° 007A SSI N° 006G
SGA N° 010D FSM N° 004I
PRD N° 069B

EFFICIENCY STANDARDS

The HPI motors comply with:
IEC 61800-9-1: Adjustable speed electrical power drive systems – Part 9-1: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – General requirements for setting energy efficiency standards for power driven equipment using the extended product approach (EPA) and semi analytic model (SAM).

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IEC 61800-9-2: Adjustable speed electrical power drive systems – Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters

EFFICIENCY VALUES ACCORDING TO IEC 60034-30-2:2016

Efficiencies are harmonized to the **International Standard IEC 60034-30-2:2016** that extends the efficiency level to Super Premium Efficiency IE4 and IE5.

	IE4 REFERENCE LIMIT				IE5 REFERENCE LIMIT			
Output kW	Rated speed within 600 to 900 /min	Rated speed within 901 to 1200/min	Rated speed within1201 to 1800 /min	Rated speed within 1801 to 6000 /min	Rated speed within 600 to 900 /min	Rated speed within 901 to 1200/ min	Rated speed within 1201 to 1800 /min	Rated speed within 1801 to 6000 /min
0.12	62.3	64.9	69.8	66.5	67.4	69.8	74.3	71.4
0.18	67.2	70.1	74.7	70.8	71.9	74.6	78.7	75.2
0.2	68.4	71.4	75.8	71.9	73.0	75.7	79.6	76.2
0.25	70.8	74.1	77.9	74.3	75.2	78.1	81.5	78.3
0.37	74.3	78.0	81.1	78.1	78.4	81.6	84.3	81.7
0.4	74.9	78.7	81.7	78.9	78.9	82.2	84.8	82.3
0.55	77.0	80.9	83.9	81.5	80.6	84.2	86.7	84.6
0.75	78.4	82.7	85.7	83.5	82.0	85.7	88.2	86.3
1.1	80.8	84.5	87.2	85.2	84.0	87.2	89.5	87.8
1.5	82.6	85.9	88.2	86.5	85.5	88.4	90.4	88.9
2.2	84.5	87.4	89.5	88.0	87.2	89.7	91.4	90.2
3.0	85.9	88.6	90.4	89.1	88.4	90.6	92.1	91.1
4.0	87.1	89.5	91.1	90.0	89.4	91.4	92.8	91.8
5.5	88.3	90.5	91.9	90.9	90.4	92.2	93.4	92.6
7.5	89.3	91.3	92.6	91.7	91.3	92.9	94.0	93.3
11.0	90.4	92.3	93.3	92.6	92.2	93.7	94.6	94.0
15.0	91.2	92.9	93.9	93.3	92.9	94.3	95.1	94.5
18.5	91.7	93.4	94.2	93.7	93.3	94.6	95.3	94.9
22.0	92.1	93.7	94.5	94.0	93.6	94.9	95.5	95.1
30.0	92.7	94.2	94.9	94.5	94.1	95.3	95.9	95.5
37.0	93.1	94.5	95.2	94.8	94.4	95.6	96.1	95.8
45.0	93.4	94.8	95.4	95.0	94.7	95.8	96.3	96.0
55.0	93.7	95.1	95.7	95.3	94.9	96.0	96.5	96.2
75.0	94.2	95.4	96.0	95.6	95.3	96.3	96.7	96.5
90.0	94.4	95.6	96.1	95.8	95.5	96.5	96.9	96.6
110.0	94.7	95.8	96.3	96.0	95.7	96.6	97.0	96.8
132.0	94.9	96.0	96.4	96.2	95.9	96.8	97.1	96.9

NOTE

For the nominal efficiency calculation refer to the IEC 60034-30-2:2016.
The HPI motors also comply with the relevant standards and regulations, especially:

ELECTRONCAL	Safety requirements - Electrical, thermal and energy	IEC 61800-5-1
	EMC requirements and specific test methods	IEC 61800-3
	Ecodesign for power drive systems, motor starters, power electronics and their driven applications	IEC 61800-9-1
	Ecodesign for power drive systems, motor starters, power electronics and their driven applications - Energy efficiency indicators for power drive systems and motor starters	IEC 61800-9-2
	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	IEC 60204-1
ELECTRICAL	Rating and Performance	IEC 60034-1
	Efficiency classes of variable speed AC motors (IE-code)	IEC 60034-30-2
	Terminal markings and direction of rotation of rotating electrical machines	IEC 60034-8
	Selection of Energy-efficient motors including variable speed applications-application guide	IEC/ST 60034-31
	Insulating materials	IEC 60085
MECHANICAL	Dimensions and output ratings	IEC 60072
	Mounting dimensions and relationship frame sizes-output ratings, IM B3, IM B5, IM B14	IEC 60072
	Cylindrical shaft ends for electric motors	IEC 60072
	Degrees of protection	IEC 60034-5
	Methods of cooling	IEC 60034-6
	Mounting arrangements	IEC 60034-7
	Mechanical vibration	IEC 60034-14
	Mounting flanges	DIN 42948

Tolerances of mounting and shaft extensions	DIN 42955
Classification of environmental conditions	IEC 60721-2-1
Mechanical vibration; balancing	ISO 8821

COMPLIANCE WITH EMC DIRECTIVE 2014/34/EU

In the great majority of cases, the HPI Drive is used by professionals of the trade as a complex component forming part of a larger appliance, system or installation. It must be noted that the responsibility for the final EMC properties of the appliance, system or installation rests with the installer.

EMC GENERAL STANDARDS

The product standards are stated in EN 61800-3 (IEC 61800-3): adjustable speed electrical power drive systems-Part 3. EMC product standard including specific test methods.

The HPI Motors comply with:

- EN 61800-3, unrestricted distribution [1)]
- EN 61800-3, restricted distribution
- Residential, commercial and light industrial environment: EN 61000-6-3[2)], EN 61000-6-1
- Industrial environment: EN 61000-6-2, EN 61000-6-4

1) Emission levels stated by EN 61800-3 unrestricted distribution are only fulfilled by HPI Motors with class B-1 filter.

2) Emission levels stated by EN 61000-6-3 are only fulfilled by HPI Motors with class B-1 optional filter.

EMC IMMUNITY

If there are problems with low frequency interference (ground loops), screened cable used for bus, standard bus, control cables and signal interface can be left open at one end.

BASIC STANDARDS, EMISSIONS

- **EN 55011:** Limits and methods of measuring radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment
- **EN 55022:** Limits and methods of measuring radio disturbance characteristics of information technology equipment
- **EN 61000-3-2:** Limits for harmonic current emissions (equipment input current ≤ 16 A)
- **EN 61000-3-12:** Limits for harmonic current emissions (equipment input current > 16 A)
- **EN 61000-6-4:** Electromagnetic compatibility (EMC)-Part 6-4, Generic standards - Emission standard for industrial environments
- **EN 61000-6-3[1)]:** Residential, commercial and light industrial environment

[1)] Emission levels stated by EN 61000-6-3 are only fulfilled by HPI Motors with class B-1 optional filter

BASIC STANDARDS, IMMUNITY

- **EN 61000-2-4 (IEC 61000-2-4)**: Compatibility levels Simulation of voltage and frequency fluctuations, harmonics and commutation notches on the power line
- **EN 61000-4-2 (IEC 61000-4-2):** Electrostatic discharge (ESD) Simulation of electrostatic discharge
- **EN 61000-4-4 (IEC 61000-4-4):** Fast transients, burst 5/ 50 nS Simulation of transients caused by switching of contactors, relays or similar devices
- **EN 61000-4-5 (IEC 61000-4-5):** Surges 1.2/ 50 nS. Simulation of transients caused by e.g. lightning that strikes near an installation
- **EN 61000-4-3: (IEC 61000-4-3):** Radio-frequency electromagnetic field. Amplitude modulated. Simulation of interference caused by radio transmission equipment
- **EN 61000-4-6: (IEC 61000-4-6):** RF common mode. Simulation of the effect from radio-transmitting equipment connected to connection cables
- **ENV 50204:** Radio-frequency electromagnetic field. Pulse modulated. Simulation of interference caused by GSM mobile phones. General aspects of EMC emissions for high frequency shielding, screened cables used for CanBus or RS485, standard bus, control cables and signal interface must in general be connected to the enclosure at both ends
- **EN 61000-6-2:** Electromagnetic compatibility (EMC)-Part 6-2: Generic standards - Immunity for industrial environments
- **EN 61000-6-1:** Residential, commercial and light industrial environment

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2.3 Enviromental Condition

VIBRATION AND SHOCK

HPI Motors have been tested according to a procedure based on the following standards:

- IEC 60068-2-6: Vibration (sinusoidal)
- IEC 60068-2-34: Random vibration broad-band- general requirements
- IEC 60068-2-35: Random vibration broad-band- high reproducibility
- IEC 60068-2-36: Random vibration broad-band- medium reproducibility

HPI Motors comply with requirements that correspond to conditions in the standards mentioned above.

AIR HUMIDITY

HPI Motors have been designed to meet the IEC 60068-2-3 standard, EN 50178 item 9.4.2.2/DIN 40040, class E, at 50°C. Cyclic damp heat according to IEC 60068-2-30, 50°C.

AGGRESSIVE ENVIRONMENTS

In common with all electronic equipment, an HPI drive contains a large number of mechanical and electronic components, all of which are vulnerable to environmental effects to some extent.
Therefore the HPI drive should not be installed in environments with airborne liquids, particles or gases capable of affecting and damaging the electronic components.
Failure to take the necessary protective measures increases the risk of stoppages, thus reducing the life of the drive. Damp and moisture can be carried through the air and condense in the drive. In addition to this, damp and moisture may cause corrosion of components and metal parts.
Steam, oil and salt water may cause corrosion of components and metal parts.
In environments with high temperatures and humidity, corrosive gases such as sulphur, nitrogen and chlorine compounds will cause chemical processes on the drive converter components.
Such chemical reactions will rapidly affect and damage the electronic components.
Mounting HPI Drive in aggressive environments will increase the risk of stoppages and furthermore considerably reduce the life of electronic converter.
Before the installation, the ambient air should be checked for damp and moisture, particles and gases. This may be done by observing existing installations in this environment. Typical indicators of harmful airborne damp and moisture are water or oil on metal parts, or corrosion of metal parts.
Excessive dust particle levels are often found on installation cabinets and existing electrical installations.
One indicator of aggressive airborne gases is blackening of copper rails and cable ends on existing installations.

2.4 Condition of Installation

ELECTRICAL TOLERANCES

For industrial motors to EN 60034-1, certain tolerances must be allowed on guaranteed values, taking into consideration the necessary tolerances for the manufacture of such motors and the materials used. The standard includes the following remarks:

1. It is not intended that guarantees necessarily have to be given for all or any of the items involved. Quotations including guaranteed values subject to tolerances should say so, and the tolerances should be in accordance with the table.
2. Attention is drawn to the different interpretation of the term guarantee. In some countries a distinction is made between guaranteed values and typical or declared values.
3. Where a tolerance is stated in only one direction, the value is not limited in the other direction.

Values for	Tolerance
Efficiency (η) (by indirect determination)	0.15 (1 - η) at $P_N \leq 150$ KW 0.1 (1 - η) at $P_N > 150$ kW
Power factor (cos φ)	1 - cos φ / 6, minimum 0.02, maximum 0.07
Rated current with rated torque and revolutions (measurement in S1 duty cycle at rated speed with ϑamb≤40 °C and altitude ≤1000 m above sea level)	In +/- 5%
Back electromotive force	Bemf +/- 5%
Peak torque (MK)	10 % of the guaranteed value (after allowing for this tolerance, M_K/M_N not less than 1.6)
Moment of inertia (J)	±10 % of the guaranteed value

General Information and Ratings

2

MECHANICAL TOLERANCES

Motors have to be installed according to their mounting arrangements defined by **IEC 60034-7**, *Code I* (in brackets Code II). The mechanical components may be designed in order to work as for the motor mounting code.

According to **IEC 72-1**, the following tolerances on mechanical dimensions of electric motors are permitted:

Parameter	Code	Tolerances	
Shaft height	H	- up to 132 - from 11 to 28 mm	- 0.5 mm j6
Diameter of shaft end [1]	D	- from 38 to 48 mm	k6
Hub key width	F		h9
Flange spigot	N	- up to 132 - over size 132	j6 h6

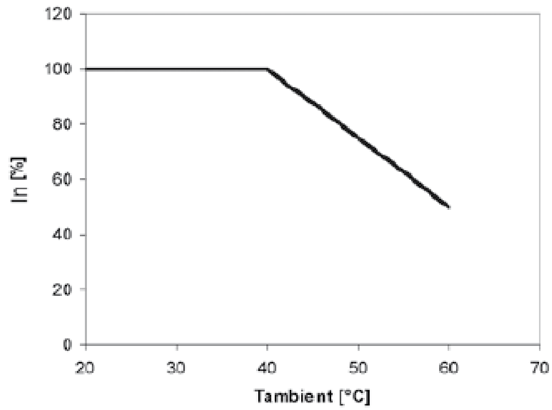
[1] Centring holes in shaft extension to DIN 332 part 2

THERMAL PROTECTION AND DERATING

The HPI Motors are thermally protected in case limits are exceeded (140°C), another protection is provided through the Drive.

DERATING FOR AMBIENT TEMPERATURE

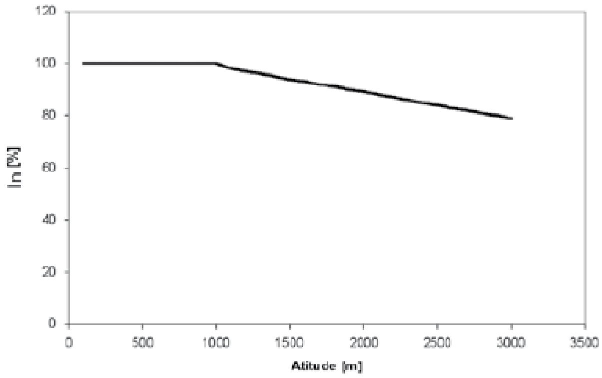
The ambient temperature (TAMAX) is the maximum temperature allowed. If HPI Motor is operated at temperatures above 40 °C, a derating of the continuous output current is necessary.



DERATING FOR AIR PRESSURE

Below 1000 m altitude no derating is necessary. Above 1000 m the ambient temperature (TA) or max. rated output current (IN) must be derated in accordance with the following diagram.

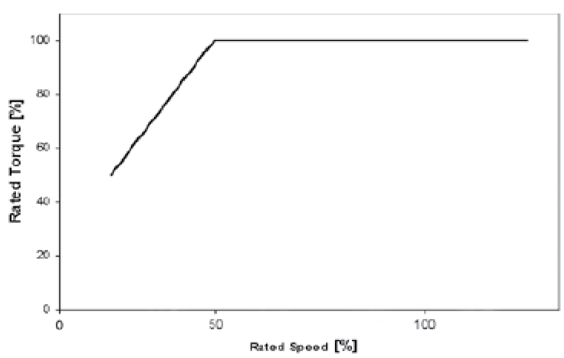
See the below diagram for derating of output current versus altitude at TA = max. 40°C



DERATING FOR RUNNING AT LOW SPEED

When a centrifugal pump or a fan is controlled by a HPI Motor, it is not necessary to reduce the output at low speed because the load characteristic of the centrifugal pumps/fans, automatically ensures the necessary reduction.

HPI motors running constant load torque applications continuously at low speed must be derated (see diagram as example) or an independent fan must be used.

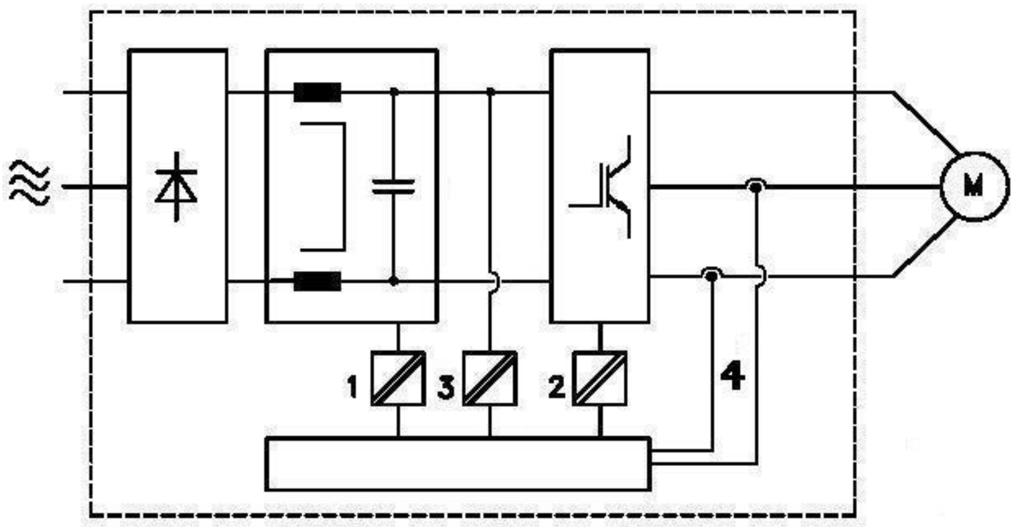


2.5 Electric Design

2.5.1 Galvanic Isolation (Pelv)

Galvanic (ensured) isolation is obtained by fulfilling requirements concerning higher isolation and by providing the relevant clear page/clearance distances. These requirements are described in the EN 50178 standard.
In HPI Series all control terminals are supplied from or in connection with extra low voltage (PELV).
The components that make up the electrical isolation, as described below, also comply with the requirements concerning higher isolation and the relevant test as described in EN 50178. The galvanic isolation can be shown in three locations (see drawing below), namely:

1. Power supply (SMPS) including signal isolation of VDC bus, indicating the intermediate voltage.
2. Gate drive that runs the IGBTs (opt couplers)
3. DC bus Voltage transducer (opt couplers)
4. Current transducers (Hall Effect-Based Current Sensor).



2.5.2 Earth Leakage Current

Earth leakage current is primarily caused by the capacitance between motor phases and the motor frame. The RFI filter contributes additional leakage current, as the filter circuit is connected to earth through capacitors (Cy).
The size of the leakage current to the ground depends on the following factors, in order of priority:

1. Switching PWM frequency
2. Motor grounded on site or not

The leakage current is of importance to safety during handling/operation of the drive if (by mistake) the drive has not been earthed.

2.5.3 Over Voltage Protection

The voltage in the intermediate circuit is increased when the motor acts as a generator. This occurs in two cases:

1. The load generates energy.
2. During deceleration ("ramp-down") if the moment of inertia is high, the load is low and the ramp-down time is too short for the energy to be dissipated as a loss in the HPI frequency converter, the motor and the installation.

The Drive turns off to protect the IGBT transistors and the intermediate circuit capacitors when a certain voltage level is reached on DC bus.

2.5.4 Mains Supply Interference/Harmonics

An HPI Motor takes up a non-sinusoidal current from mains, which increases the input current IRMS. A non-sinusoidal current can be transformed by means of a Fourier analysis and split up into sine wave currents with different frequencies, i.e. different harmonic currents IN with 50 Hz as the basic frequency.

Some of the harmonic currents might disturb communication equipment connected to the same transformer or cause resonance in connection with power-factor correction batteries.
To ensure low, harmonic currents, for the residential and commercial environments, an optional harmonic filter is necessary.

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2.6 Mechanical Design

2.6.1 DEGREES OF PROTECTION

Degrees of mechanical protection for machines are designated in accordance with IEC60034-5 by the letters IP and two characteristic numerals.

First numeral:
Protection against contact and ingress of foreign bodies

IP	Description
0	No special protection
1	Protection against solid foreign bodies larger than 50 mm (Example: inadvertent contact with the hand)
2	Protection against solid foreign bodies larger than 12 mm (Example: inadvertent contact with the fingers)
3	Protection against solid foreign bodies larger than 2.5 mm (Example: Wires, tools)
4	**Protection against solid foreign bodies larger than 1 mm (Example: Wires, bands)**
5	**Protection against dust (harmful deposits of dust)**
6	Complete protection against dust

Second numeral:
Protection against ingress of water

IP	Description
0	No special protection
1	Protection against vertically falling water drops (condensation)
2	Protection against dropping water when inclined by up to 15°
3	Protection against water spray at up to 60°from vertical
4	**Protection against water splashed from any direction**
5	**Protection against water projected by a nozzle from any direction**
6	Protection against heavy seas or water projected in powerful jets

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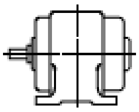
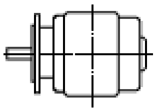
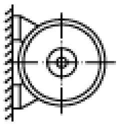
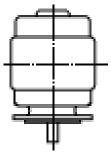
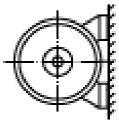
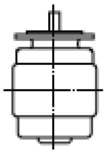
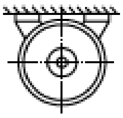
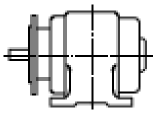
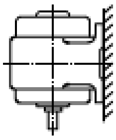
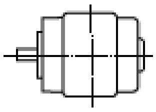
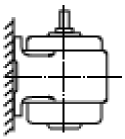
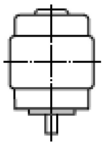
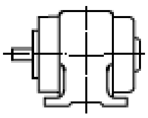
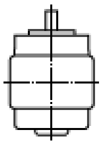
2.6.2 Mounting Arrangements

Mounting arrangements for rotating electrical machines are designated according to IEC 60034-7, Code I (in brackets Code II).

Foot mounting		Flange mounting	
IM B3 (IM 1001)		**IM B5 (IM 3001)** Flange type A to DIN 42 948 at drive end	
IM B6 (IM 1051)		**IM V1 (IM 3011)** Flange type A to DIN 42 948 at drive end	
IM B7 (IM 1061)		**IM V3 (IM 3031)** Flange type A to DIN 42 948 at drive end	
IM B8 (IM 1071)		**IM B35 (IM 2001)** Flange type A to DIN 42 948 at drive end	
IM V5 (IM 1011)		**IM B14 (IM 3601)** Flange type C to DIN 42 948 at drive end	
IM V6 (IM 1031)		**IM V18 (IM 3611)** Flange type C to DIN 42 948 at drive end	
IM B34 (IM 2101) Flange type C to DIN 42 948 at drive end		**IM V19 (IM 3631)** Flange type C to DIN 42 948 at drive end	

It is essential to state the desired mounting arrangement when ordering, as the constructive design depends partly on the mounting arrangement.

2.6.3 Bearing Lubrication and Maintenance

All motors have bearings type 2ZC3 with grease suitable for high and low temperature and permanent lubrication.

Frame size	Speed [rpm]	DE	NDE
71	Up to 4500	6205 2Z C3	6303 2Z C3

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2.6.4 Permissible Axial Forces

Maximum permissible axial forces without additional radial forces*

Frame size	Horizontal shaft					Vertical shaft – force upwards					Vertical shaft – force downwards				
	4500 min^{-1} kN	3600 min^{-1} kN	3000 min^{-1} kN	1800 min^{-1} kN	1500 min^{-1} kN	4500 min^{-1} kN	3600 min^{-1} kN	3000 min^{-1} kN	1800 min^{-1} kN	1500 min^{-1} kN	4500 min^{-1} kN	3600 min^{-1} kN	3000 min^{-1} kN	1800 min^{-1} kN	1500 min^{-1} kN
71	0.25	0.26	0.27	0.30	0.31	0.24	0.25	0.26	0.29	0.29	0.24	0.24	0.25	0.28	0.29

Values for 50 Hz. For service on 60 Hz, reduce values by 10%
* Consult according to direction of force

2.6.5 Permissible Radial Forces

Without additional axial force (Ball bearings). Nominal life = 20.000 h (Lh10).
FR = permissible radial force in kN in load point corresponding to half shaft extension.

Frame size	4500 min^{-1} kN	3600 min^{-1} kN	3000 min^{-1} kN	1800 min^{-1} kN	1500 min^{-1} kN
71	0.57	0.58	0.60	0.64	0.66

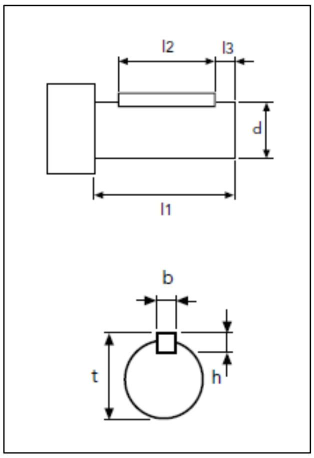
2.6.6 Cooling

TEFC execution as standard. Surface cooling, independent of the direction of rotation.

2.6.7 Vibration

The amplitude of vibration in electric motors is governed by EN 60034-14 Mechanical vibration of rotating electrical machines with shaft heights 56 and larger - methods of measurement and limits. Standard motors are designed to vibration grade A (normal). Vibration grade B is available at extra cost.

Rotors are at present dynamically balanced with half key fitted as per DIN ISO 8821. Other balancing only on request. The motors are identified as follows:
"H" or "blank" means balanced with half key
"F" means balanced with full key
"N" means no key



POSITION AND DIMENSIONS OF KEY (mm)

Frame size	d x l_1	b x h	l_2	l_3	t
71	19 x 40	6 x 6	30	6	21.5

For larger shafts in special design the dimensions l2 and l3 are maintained.

NOISE

Frame size	Speed [rpm]									
	4500		3600		3000		1800		1500	
	LWA	LpA	LWA	LpA	LWA	LpA	LWA	LpA	LWA	LpA
71	78	67	73	63	70	60	53	45	49	42

2.7 Drive Specifications

2.7.1 Main Supply For Single Phase (L N)

Supply Frequency	48 - 62Hz
Supply Voltage	1 x 200/240V ±10%
Max. Imbalance of supply voltage	±2% of rated supply
Switching on supply voltage	Once every 2 minutes

2.7.2 Main Supply For Three Phase (L1 L2 L3)

Supply Frequency	48 - 62Hz
Supply Voltage	3 x 380/480V ±5%
	3 x 200/230V ±5%
Max. Imbalance of supply voltage	2% of rated supply
Switching on supply voltage	Once every 2 minutes

2.7.3 Output Ratings

100% Drive Rated Power continuously	100% Drive Rated Power continuously
150% for 60 secs	150% for 60 secs

2.7.4 Control Specification

Control Method	Sensorless AC Vector Control
Max PWM Frequency	16KHz
Frequency range	up to 400 Hz
Resolution on output frequency	0.1%
Current/Speed sampling time	83 μs

2.7.5 Digital Inputs

Programmable digital inputs	2
Voltage level	0-24VDC
Input Resistance Rin	10KΩ

2.7.6 Pulse Input

Programmable pulse input	1
Voltage level	0-24VDC
Max frequency	16 kHz

2.7.7 Analog Input

Programmable analog voltage input	2
Voltage Level	0:10VDC
Input Resistance Rin	240KΩ
Resolution	12bit
Current/Speed sampling time	83 μs
Max Voltage	24VDC
Max Current	20mA
Programmable analog current inputs	2
Current Range	0(4):20mA
Input Resistance Rin	180Ω
Resolution	12bit
Max Voltage	5VDC
Max Current	20mA

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2.7.8 *Digital Outputs*

Programmable pulse input	2
Voltage level	0-24V DC (pull-up)
Max Current	20mA

2.7.9 Analog Output

Programmable analog voltage input	2
Voltage Level	0:10VDC
Max Current	10mA
External Resistance	>10KΩ
Resolution	12bit
Programmable analog current inputs	2
Current Range	20mA
Max Voltage	24VDC
Max Current	20mA
External Resistance	<1kΩ
Resolution	12bit

2.7.10 *Relay Output*

Programmable relay output	2 (n.o. n.c. com)
Max terminal load	250Vac 5A, 30Vdc 5A (NO)
	250Vac 3A, 30Vdc 3A (NC)

2.7.11 Bus Communication

RS485	For cascade mode
RS485	Serial communication

2.7.12 Externals

Enclosure	IP55 for motor / IP66 for drive
Vibration test	EC 60068-2-6
Max relatively humidity	95% (IEC 60068-2-3)
Operating ambient temperature	0:40°C
Storage ambient temperature	- 25°C:60°C
Min. ambient temperature	
at full operation	0°C
Altitude	0 - 3000m, derate 1% per 100m above 1000m

2.7.13 Compliance with Standards

EN 61800-3:2004	Adjustable speed electrical power drive systems. EMC requirements
IEC 61800-5-1	Adjustable speed electrical drive systems - part 5-1: safety requirements - electrical, thermal and energy
EN 60204-1	Safety of machinery – electrical EMC equipment of machines - part 1: general rules

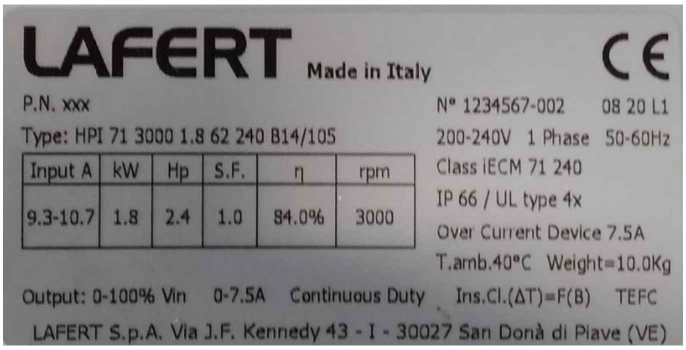
2.7.14 Programming

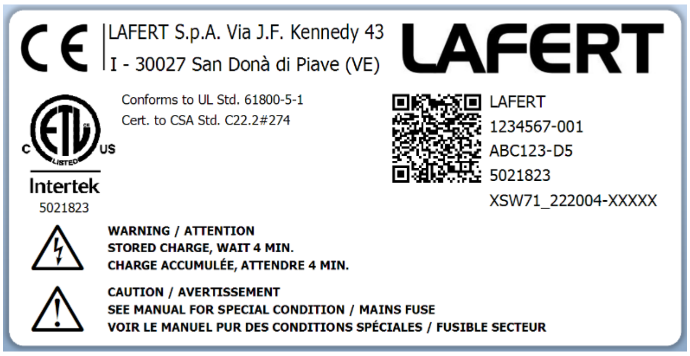
Keypad	No
PC	Yes

2.8 Nameplate Examples

Motor Nameplate

Drive Nameplate





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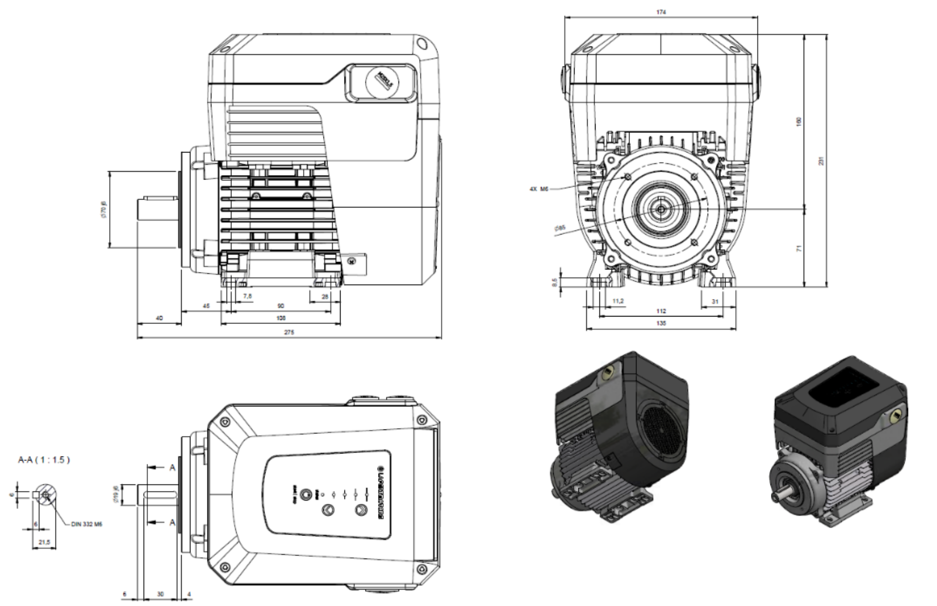
2.9 Performance Data

VALUES @400 V*
TEMPERATURE RISE TO CLASS B

Type	Rated speed	Rated Power	Rated torque	Peak torque	Motor Rated current	Motor Peak current	Efficiency HPI	Rated input current 380Vac	Rated input current 480Vac	Torque constant	Weigth HPI
	n 1/min	P_n kW	M_n Nm	M_{pk} Nm	I_n Arms	I_{pk} Arms	η %	I_{in} Arms	I_{in} Arms	K_t Nm/A	Kg
1500 min-1											
HPI71 1500 12	1500	0.55	3.5	5.3	1.2	1.8	81.1%	1.3	1.0	3	7.3
HPI71 1500 16	1500	0.75	4.8	7.2	1.6	2.4	81.8%	1.7	1.4	3	7.9
HPI71 1500 23	1500	1.1	7.0	10.5	2.3	3.5	83.0%	2.5	2.0	3	8.7
HPI71 1500 32	1500	1.5	9.6	14.4	3.2	4.8	83.6%	3.4	2.7	3	9.5
1800 min-1											
HPI71 1800 12	1800	0.55	2.9	4.4	1.2	1.7	83.3%	1.3	1.0	2.5	7.3
HPI71 1800 16	1800	0.75	4.0	6.0	1.6	2.4	84.9%	1.7	1.4	2.5	7.9
HPI71 1800 23	1800	1.1	5.8	8.8	2.3	3.5	85.3%	2.5	2.0	2.5	8.7
HPI71 1800 32	1800	1.5	8.0	11.9	3.2	4.8	85.8%	3.4	2.7	2.5	9.5
3000 min-1											
HPI71 3000 16	3000	0.75	2.4	3.6	1.6	2.4	85.5%	1.7	1.3	1.5	7.3
HPI71 3000 23	3000	1.1	3.5	5.3	2.3	3.5	86.9%	2.4	1.9	1.5	7.9
HPI71 3000 32	3000	1.5	4.8	7.2	3.2	4.8	87.4%	3.3	2.6	1.5	8.5
HPI71 3000 47	3000	2.2	7.0	10.5	4.7	7.0	87.7%	4.8	3.8	1.5	9.1
3600 min-1											
HPI71 3600 16	3600	0.75	2.0	3.0	1.6	2.4	86.4%	1.7	1.3	1.26	7.3
HPI71 3600 23	3600	1.1	2.9	4.4	2.3	3.5	87.2%	2.4	1.9	1.26	7.9
HPI71 3600 32	3600	1.5	4.0	6.0	3.2	4.8	97.9%	3.3	2.6	1.26	8.5
HPI71 3600 46	3600	2.2	5.8	8.8	4.6	7.0	88.1%	4.8	3.8	1.26	9.1
4500 min-1											
HPI71 4500 23	4500	1.1	2.3	7.0	2.3	3.5	86.4%	2.4	1.9	1	7.3
HPI71 4500 32	4500	1.5	3.2	3.5	3.2	4.8	87.3%	3.3	2.6	1	7.9
HPI71 4500 47	4500	2.2	4.7	6.8	4.7	7.0	88.1%	4.8	3.8	1	8.7
HPI71 4500 64	4500	3	6.4	7.1	6.4	9.6	88.2%	6.5	5.1	1	9.5

*HPI 71 series is available also as single-phase and three-phase @ 230V.
For values @ 230V, please contact us

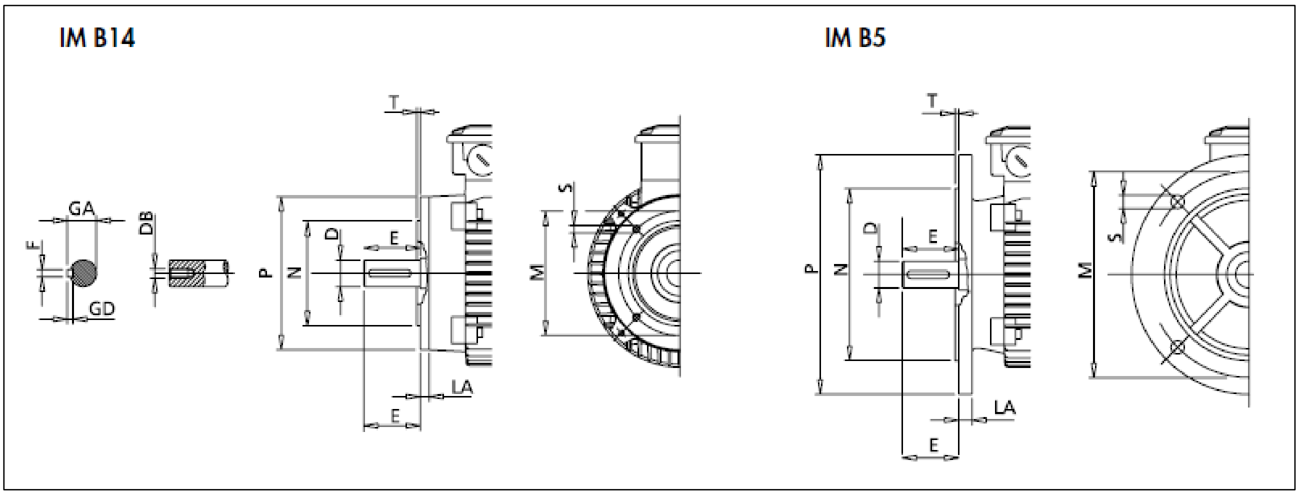


IEC	H	A	B	C	K1)	AB	BB	AD2)	HD2)	AC	HA
714)	71	112	90	45	7	144	109	140	211	160	9

IEC	K1	L	LB	AL	AF	BA	AA	D	E	F	GD	GA	DB3)
714)	17	280	250	200	220	22	30	19	40	6	6	22	M6

1) Clearance hole for screw
2) Maximum distance
3) Centering holes in shaft extensions to DIN 332 part 2
4) Not binding dimensions. Please contact us for more information

IM B5 - IMB14 FLANGE

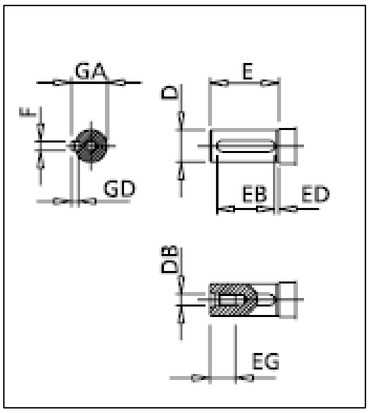


IEC	Small flange B14						Large flange B14						Flange B5					
	P	N	LA	M	T	S 1)	P	N	LA	M	T	S 1)	M	N	P	T	LA	S 1)
71 2)	105	70	11	85	2.5	M6	140	95	8	115	3	M8	130	110	160	3.5	10	M8

1) Clearence hole for screw
2) Not binding dimensions. Please contact us for more information.

IEC	D	E	F h9	GD	GA	DB 1)	EG	EB	ED
71 2)	19 j6	40	6	6	22	M6	16	30	4

1) Centring holes in shaft extension to DIN 332 part 2
2) Not binding dimensions. Please contact us for more information.



Guidelines for Mounting

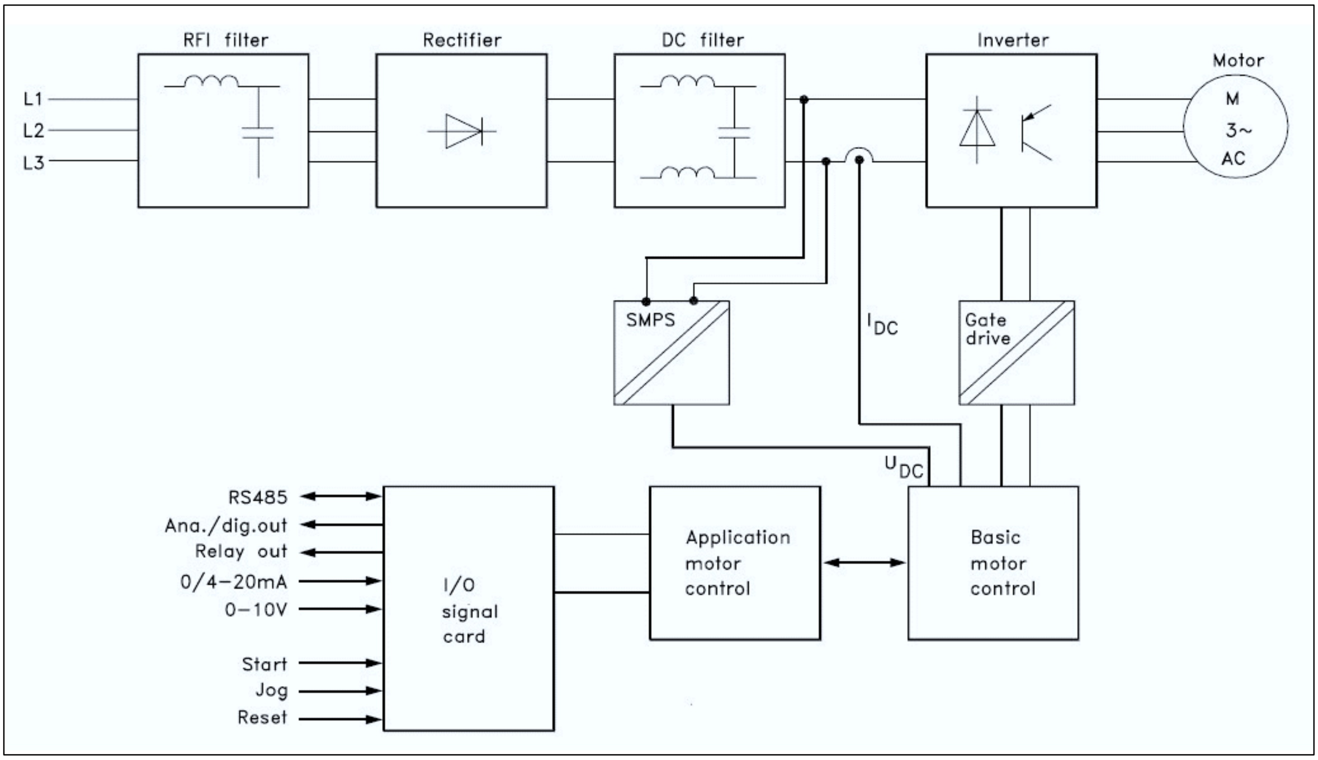
- Before mounting the HPI, ensure that the chosen location meets the environmental condition requirements shown in paragraph 9.1.
- Avoid mounting the HPI close to high heat sources.
- Do not restrict the flow of air coming through the Fan Cover
- The use of a suitable gland system is required to maintain IP 66 / Nema 4X rating. Gland could be metric or NPT.

Below a table with the two different options:

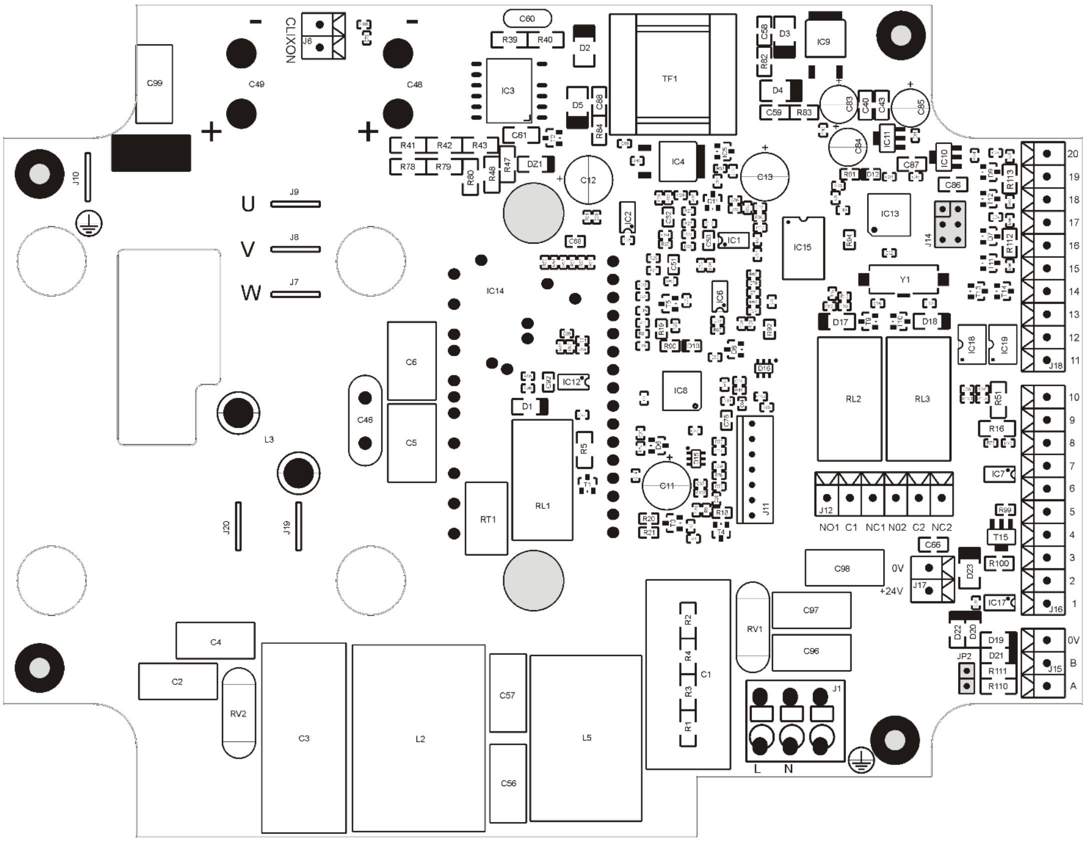
Option	Type	Dimension	Quantity
1	NPT	1 / 2	2
	NPT	3 / 4	1
2	Metric	M20	3

4. Electrical Installation

4.1 Connection Diagram



Single Phase 1kW



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Интернет: www.tisys.ru www.tisys.kz www.tisys.by www.tesec.ru www.ти-системс.рф
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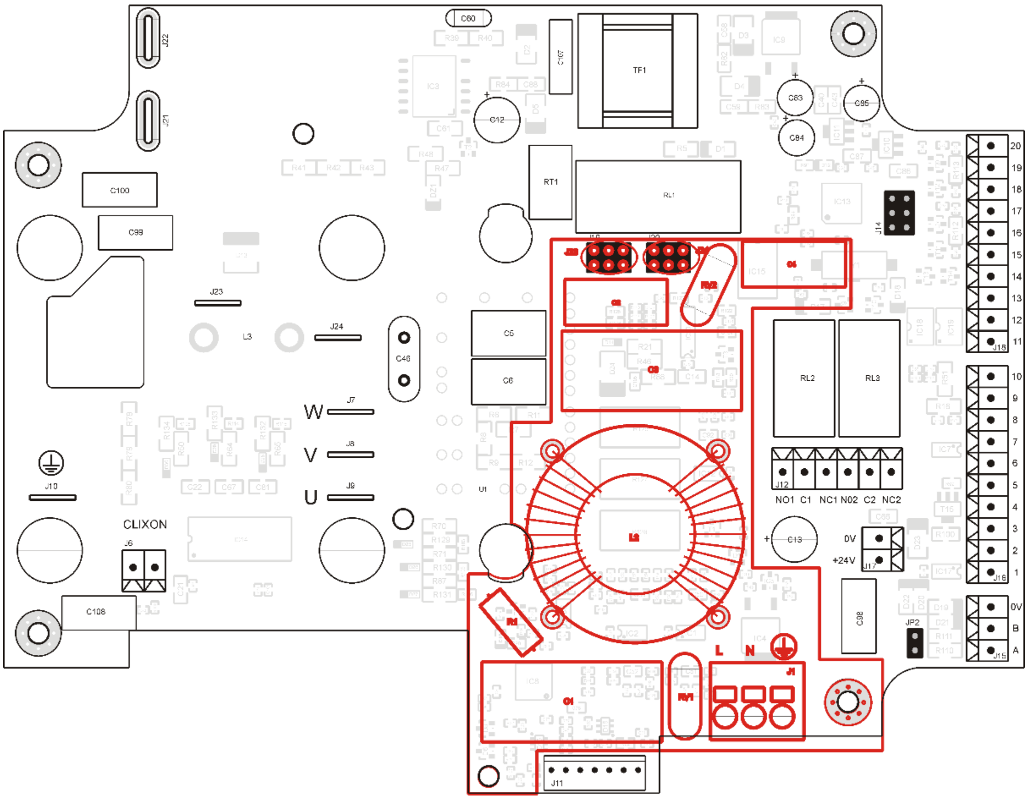
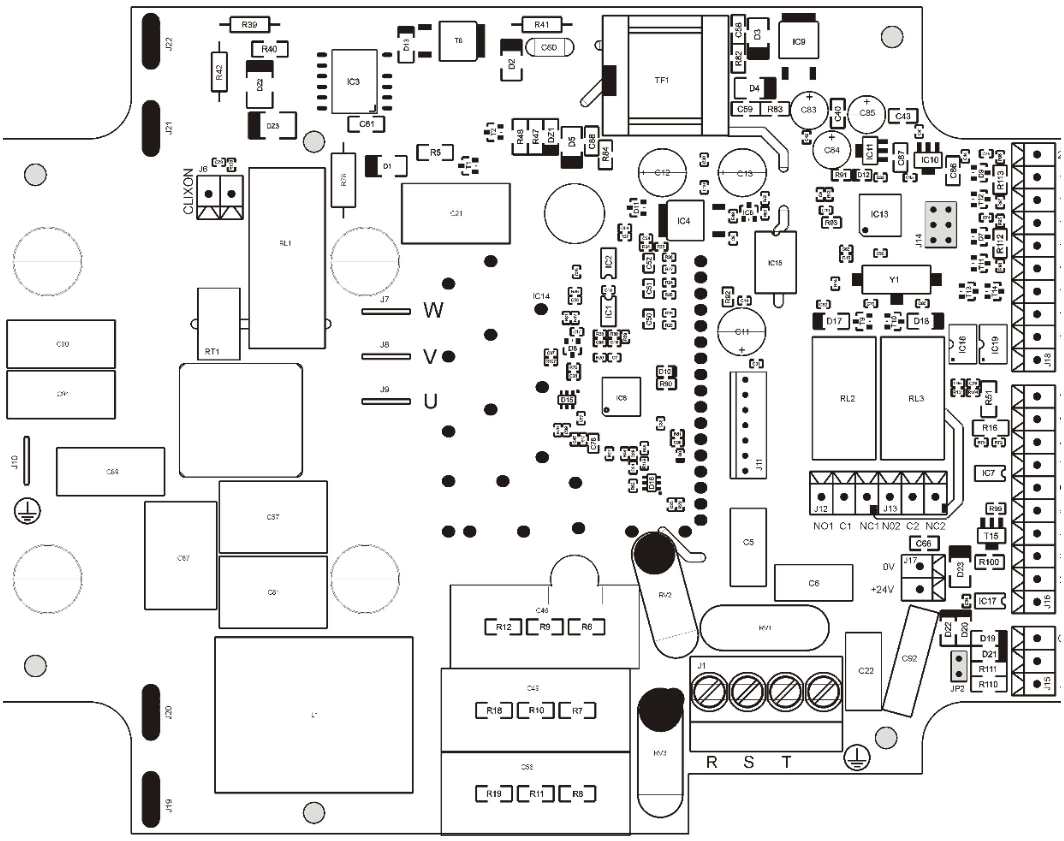
Single Phase 2kW



Three Phase 2kW



4.2 Protective Earth (PE) Connection

- Ground terminal PE must always be grounded. Never use alone a protective device operated by residual current (RCD) as unique shock protective measure.
- The leakage current generates in the ground connection is less than 3.5mA so it is not necessary to take reinforced grounding as indicated by EN/IEC61800-5-1.
- The diameter of the ground terminal must be at least equal than the diameter of the phase conductor.
- The motor ground must be connected to its dedicated ground connection.
- If a residual current device (RCD) is used for extra personal protection:
  - Use only RCD of Type B (detect AC and DC currents)
  - Use RCDs with an inrush delay may be necessary.
  - Dimension RCDs according to the system configuration and environmental considerations.
  - An RCD can only be used to protect a single drive.
- Protective earthing of the drive combined with the use of RCDs must always performed in accordance with applicable local and international standards and directives.

4.3 Incoming Power Connection (J1)

- Dimension the input power cables according to local regulations.
- The input power cables must be able to carry the corresponding load currents. See the below table:

Model				Recommended cable section		Maximum cable section	
Voltage	Phases	Power	Input Current	mm^2	AWG	mm^2	AWG
200-240V	1 Phase	1kW	6,5A	2,5	14	4	12
200-240V	1 Phase	2kW	11A	2,5	12	4	12
380-480V	3 Phase	2kW	6A	2,5	14	4	10

- The cable must be rated for at least 70ºC maximum permissible temperature of the conductor in continuous use.
- The conductivity of the PE conductor must be at least equal to that the phase conductor (same cross-sectional area)
- A three/four conductor system is allowed for input cabling, but a shielded symmetrical cable is recommended.

4.4 Motor Connection (J7 – J8 – J9)

- The motor cable must be connected to the terminals marked 'U', 'V', 'W' and 'PE'.
- The motor ground must be connected to its dedicated ground connection.
- To meet the EMC requirements of the CE keep the motor cable as short as possible (less than 20cm).

4.5 Control Terminal Wiring (J12 - J15 – J16 - J18)

See chapter 7.

4.6 Control Terminal Connections

- Shielded cable is not necessary for I/O signal and communication cables. Twisted pair cables are recommended.
- Power and Control Signal cables should be routed separately where possible and must not be routed parallel to each other.
- Maximum control terminal tightening torque is 0.4Nm.
- Control Cable entry conductor size: 0.2 – 1mm2 / 24 – 17 AWG.

4.7 Motor Thermal Overload Protection (J6)

There are two motor overload protections:

- Motor thermal switch: The thermal switch is directly connected to the driver, in a situation of overtemperature in the motor the switch is activate and the driver disconnects the outputs and gives an alarm signal.
- I2t protection: The I2t protection prevents motor damage due to long over-current operation. In order to set this protection, you need to select a point on the I2t motor thermal protection curve. the maximum current (P-8) and tripping current (P-34) parameters determine the level of protection, the time is set to 15 seconds. Indicates that the driver will stop if the motor is 15 seconds at maximum current (P-8), or the time corresponding to I2t when it is at a current above the tripping current (P-34). If the I2t limit is exceeded the driver disconnects the outputs and gives an alarm signal.

4.8 EMC Compliant Installation

- All models have built-in EMC filter.
- Always use shielded cables for Supply cable. Cables shield must be electrically connected to the earthed device enclosure.
- Shielded cable is not necessary for I/O signal and communication cables.
- The +24Vdc output is not intended to be used as a power supply for other products, if used, the driver might not fulfil the EMC regulations.
- To comply with C1 category emissions an external filter may be required. The cable between the filter and the driver should be as short as possible.

Warning: In a domestic environment this product may cause radio interference in which case supplementary mitigation measures may be required.

4.9 Fuse/Circuit Breaker Selection

- Short-circuit protection for the supply side is not provided with the driver.
- Correct short-circuit protection must always be used in accordance with local and international regulations. In general type gG or UL type J or T fuses are suitable. The operating time of the fuses must be below 0.5 seconds.
- In places where local regulations allow, the fuses can be replaced by circuit breakers of the same rating. Circuit breakers must be designed for protection in a circuit capable of supplying a maximum of 100kA (symmetrical), 480V maximum.

Model				Fuses / MCB	
Voltage	Phases	Power	Input Current	UL Type J, T	non UL Type gG
200-240V	1 Phase	1kW	6,5A	15	16
200-240V	1 Phase	2kW	11A	20	20
380-480V	3 Phase	2kW	6A	15	16

- Short-circuit protection on the motor side is provided by the driver.

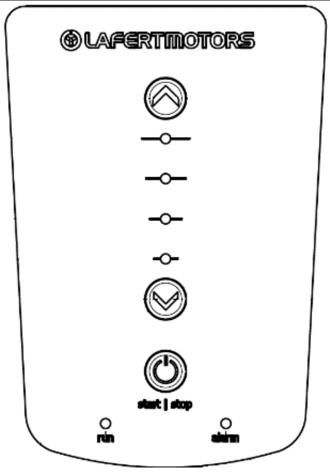
4.10 Input Choke (optional)

- The 1- phase models have an integrated power factor correction module, which gives the following advantages:
  - Increase in inverter power factor.
  - Reduction of RMS input current.
  - Reduction of voltage distortion in the supply network.
  - Increase of the useful life of the bus capacitors.
  - Reduction of harmonic current distortion, these models complies with EN 61000-3-2 class A.
  - Reduction of losses due to overheating due to high current peaks.
  - Avoid oversizing in protection devices.
- In the 3-phase model it may be necessary to add an external input filter to improve these points or under certain circumstances like:
  - If the network impedance is low due to transformers and wiring.
  - Unstable network with sudden voltage changes.
  - Imbalance between phases.
- A 3-phase line reactor of 7-10Arms and 3-5mH is recommended for 3 phase model, examples:
  - Epcos/TDK: B86305L
  - Schaffner: RWK212
  - REO: CNW903

5. Keypad

Below, a table for managing the keypad.
NOTE: please Remember that to use the drive in keypad mode, Par. 28 "Input Type" shall be set as "1".

START/STOP	Push buttom	When in keypad mode, used to Start and stop the drive.
UP/DOWN	Push buttom	Used to increase/decreased the speed (four different steps available).
RUN	Led	Blinking 1 sec ON 1 sec OFF if motor is running. Blinking 1 sec ON 3 sec OFF if motor is in stand-by.
ALARM	Led	Blinking in red in case of alarm. Different blinking refers to different alarm. Refer to page XX for alarm code description.
SPEED	Group of 4 led	If blinking, drive is reaching that speed target. If still, speed target is achieved.



6. Kmd Software and Parameters Setting

6.1 Introduction

KMD software allow to configure parameters of the drive for a better performance of your application and for monitoring important variable as speed, current, voltage, power and temperature.

6.2 How to Communicate

Modbus RS 485 it is used for communication. Please connect in J11 (see picture in section 4).

Cable communication

The communication cable should connect the "A" terminal in the Motor Drive with the "+" terminal in the USB adaptor, and the "B" terminal with the "-" terminal.

NOTE: in some application the EMC conductive disturbance may disturb the communication. In this case, it is recommended to disconnect the ground.

Bluetooth communication

It is possible to use bluetooth communication both in no insulated and insulated configuration. For the insulated configuration only communication with KMD Monitor is possible.

To change the Firmware, the only way is to use the not insulated connector.

Modbus configuration

The Keld Drives typically use a serial configuration of 9600 baud rate, 8bit data, no parity and 2 stop bits unless it's a special development. The drives are provided with Modbus address 1, and can be changed to a different address later.

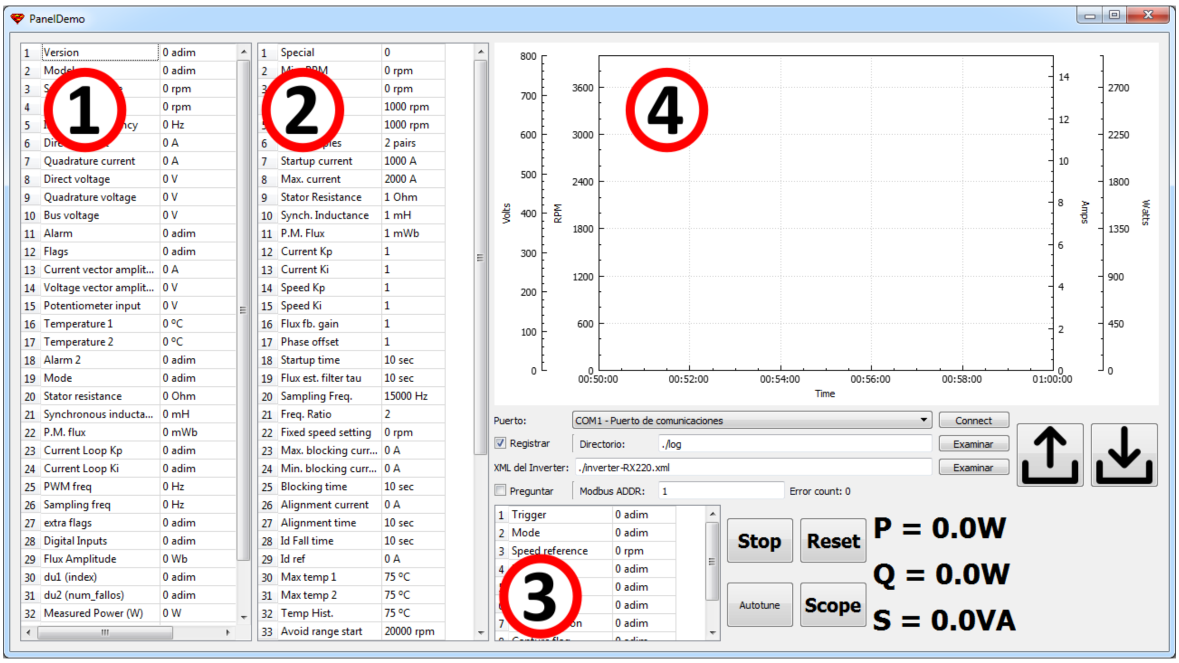
6.3 Previous Configuration

1. Connect USB to 485 adaptor before start the KMD Monitor application.
2. Start the KMD Monitor application.
3. In the "Inverter XML" interface part, select "inverter-RX23T_Lafert.xml" from root directory for the right configuration.
4. Close and restart the KMD Monitor again.
5. Select the correct USB to 485 adaptor in 'Port' section, and press connect to open the port.

6.4 Program Interface

The program has 4 main regions:

1. Input register table: Shows in real time (with 1 second update rate) information about the motor control algorithm and other parameters of the Keld Motor Drive.
2. Holding register table: Allows the user to change different parameters of the Drive. Please, note that depending on the Drive version some parameters may be password protected and can't be modified. Once a parameter is changed, if the data is valid, it will be automatically saved as soon as the motor is stopped, the parameters will not be saved while the motor is running.
3. RAM Holding register table: These are special holding registers that will only be used to control the Drive but not to configure it. These won't be saved and will lose their value when the Drive is powered off.
4. Input register plot: Displays all the input registers which values are expressed by Voltage, Amperes, Watts and RPMs over the span of 10 minutes. All the vertical scales can be adjusted if needed (by double clicking over them).



6.4.1 Input Register Details

1. Version

Indicates the firmware version the Drive is programmed with.

2. Model

Indicates the hardware model of the Drive.

3. Speed Reference

Current reference speed for the motor [rpm].

4. Measured Speed

Actual motor speed [rpm].

5. Imposed Frequency

Electrical frequency [Hz].

6. Direct Current

Direct component of the motor phase current vector [A peak]. To know the line rms current, this value has to be divided by √2

7. Direct Voltage

Quadrature component of the motor phase current vector [A peak]. To know the line rms current, this value has to be divided by √2

8. Quadrature Voltage

Direct component of the motor phase voltage vector [V peak]. To know the line to line rms voltage, this value has to be multiplied by √3/2

9. Synchronous Inductance

Quadrature component of the motor phase voltage vector [V peak]. To know the line to line rms voltage, this value has to be multiplied by √3/2

10. Bus Voltage

DC voltage on the bus capacitors [V]. The drive is continuously monitoring this voltage and will stop the motor in the event of under-voltage or over-voltage.

11. Alarm

First alarm register, together with the "Alarm 2" register, informs of the drive status. See the Alarm table section for more information.

12. Flags

Informs of several internal states of the motor control algorithm, only for development.

13. Current Vector Amplitude

Is the peak value of the line current module [A]. To know the rms value, has to be divided by √2.

14. Voltage Vector Amplitude

Is the peak value of the phase voltage module [V]. To know the rms line to line value, has to be multiplied by √3/2.

15. Potentiometer Input

Measurement of the 0-10V analog input. It can be used to control the motor speed depending on the selection of the "Input type" holding register. Not used at the current devices.

16. Temperature 1

Measurement of the internal temperature of the IGBTs module [°C].

17. Temperature 2

Not used.

18. Alarm 2

Second alarm register, together with the "Alarm 1" register, informs of the drive status.

See the Alarm table section for more information.

19. Mode

Working mode of the Drive. In normal mode it should be always "0" but for tuning a new motor can have different values. See the section "How to tune a new motor" for more information.

20. Stator Resistance

In normal working mode is the same as the "Stator resistance" holding register, but in tuning mode will be the measurement of the motor phase resistance [Ohm]. The algorithm will always assume a star configuration for the measurement.

21. Synchronous Inductance

Motor inductance measurement [mH]. It's not the actual motor inductance, but one "virtual" inductance that the algorithm finds that works well for its internal model during the tuning stage.

22. P.M. Flux

Magnetic flux of the motor magnets [mWb]. Used during the motor tuning to find the correct P.M. flux parameter.

23. Current Loop Kp

Proportional constant of the current control loop. During the motor tuning the Drives determines the best value for this parameter.

24. Current Loop Ki

Integral constant of the current control loop. During the motor tuning the Drives determines the best value for this parameter.

25. PWM Freq

Switching frequency [Hz]. The value may be slightly different from the requested frequency due to the internal rounding in the microcontroller.

26. Sampling Freq

Motor current sampling frequency [Hz]. The value may be slightly different from the requested frequency due to the internal rounding in the microcontroller.

27. Extra Flags

Informs of several internal states of the motor control algorithm, only for development.

28. Digital Inputs

Current value of the digital inputs.

[0]	Both closed inputs
[1]	Input 1 open and Input 2 closed.
[2]	Input 1 closed and Input 2 open
[3]	Both open inputs

29. Input 1

Current value of the analog input 1. Indicates volts or milliamps according to the selected input type, 0-10V or 4-20mA

30. Input 2

Current value of the analog input 2. Indicates volts or milliamps according to the selected input type, 0-10V or 4-20mA

31. UIF_R.var.ina2

Development variable. May have different meanings depending on the application.

32. Measured Power (W)

Electrical output active power from the Drive [W], it may have around 5% of error from the actual value. The formula is:

- P = 3/2 * (id*Vd + iq*Vq)
- Q = 3/2 * (Id*Vq – iq*Vd)

33. Input Current (A)

Electrical input current to the Drive [Arms], it may have around 5% of error from the actual value.

34. Mechanical Power (W)

indicates the instantaneous power on the shaft in watts.
This value is calculated using the formula:
Power shaft = (I_out_rms * Torque constant [Par. 49 - 62] * rpm [Par. 4]) / 9549

35. Version uP2

Indicates the firmware version of the I/O microcontroller.

36. Du1

Not used.

37. Du2

Not used.

38. Du3

Not used.

39. Du4

Not used.

40. Drive Run Status

Drive run status word: (bit definition)
Bit0: 0=Stop / 1=Run
Bit1: 0=Open Loop / 1=Closed Loop
Bit2,3,4: Overload management
Bit2: 0= Output current < Motor rated current / 1= Output current > Motor rated current
Bit3: 0= Output current < Tripping current / 1= Output current > Tripping current
Bit4: 0=Overload time <120sec / 1= Overload time > 120sec
Bit5: 0= IGBts module temperatura < 75°C / 1= IGBts module temperatura > 75°C
Bit6: 0= IGBts module temperatura < 78°C / 1= IGBts module temperatura > 78°C

41. Overload Timer

Countdown of overload management in second.

6.4.2 Holding Registers Details

NOTE: Changing value are stored in EEPROM if the motor is stopped, in RAM if the motor is running. Some parameteres cannot be change while the motor is running.

Parameters

1. Special

This parameter, unlike the rest, is not stored in memory. It's used for special function

[1]	Reset alarm
[2]	Restore fault parameter

2. Min Speed
Minimum motor speed in closed loop mode (normal running). It's also the speed that the algorithm will switch from open loop mode (during startup) to closed loop [rpm]. If the user sends a lower "set speed" the motor will stop.

3. Max Speed
Maximum motor speed [rpm]. If the user sends a higher "set speed" the motor will run at the maximum speed.

4. Acceleration
Determines the maximum acceleration rate that the drive will impose to the motor [rpm/s]. The correct value depends both on the motor and the load.

5. Deceleration
Determines the maximum deceleration rate that the drive will impose to the motor [rpm/s]. The correct value depends both on the motor and the load.

6. Pole Couples
Number of pole pairs. Establishes the relation between electrical and mechanical speed, this value should be noted in the motor specifications. Sometimes the poles are not specified, but the electrical and mechanical speed. In that case it can be calculated as n=60·$f\omega$ where f is the electrical frequency in Hz and ω is the mechanical speed in rpm.

7. Startup Current
Imposed Id peak current during startup [A]. It depends on both the motor and the load, it can be any value between 0 and the "maximum current". In practice, it can have values as low as 10% of the maximum current or as high as 80% of the maximum. The right choise depending on the load inertia.

8. Maximum Current
Is the maximum peak value of the line current [A]. The algorithm will never drive the motor while in closed loop over this value. If the load requires more current than the maximum, the motor speed will automatically be decreased so it's never surpassed.

9. Stator Resistance
Is the resistance of the motor phase as if it were connected in star configuration [Ohm]. Internally the algorithm always supposes star configuration, it doesn't matter for the algorithm the actual configuration, but the resistance value will always be determined as half the line to line resistance. Is best to use the value measured by the drive during tuning and not the actual motor resistance as the motor tuning will have into account also the cable and other internal errors. In some motors the stator resistance will increase due to internal heating, if this effect is very high, it can be beneficial to tune the motor a second time while it's hot.

10. Synchronous Inductance
Is the motor inductance as measured by the Drive during tuning [mH]. In theory should be near 12·(Ld+Lq) but the final value can be adjusted depending on the motor behaviour at different speeds. Usually higher torque requirements will result in an inductance lower than the initial measured value.

11. P.M. Flux
Is the permanent magnets flux as measured by the Drive during tuning [mWb].

12. Current Kp
Proportional constant of the current control loop. Is determined during the tuning stage and usually should be leaved as it is.

13. Current Ki
Integral constant of the current control loop. Is determined during the tuning stage and usually should be leaved as it is.

14. Speed Kp
Proportional constant of the speed control loop. It depends on both the motor and the load, its inertia and is dynamic properties. It should be tuned again if the load is very different than the default.

15. Speed Ki
Integral constant of the speed control loop. It depends on both the motor and the load, its inertia and is dynamic properties. It should be tuned again if the load is very different than the default. Lower value reduce oscillation problem.

16. Startup Time
Is the time the algorithm will take to increase the motor speed during startup from 0 rpm to the minimum speed [s]. It depends mostly on the load inertia.

17. Observer Gain
Gain of the not linear observer gain. Biggest the value, better will be the behaviour of the motor, but can create problem in the passage from Open Loop to Close Loop. So the goal is to find the biggest value maintaining the dynamic stable.

18. Sampling Frequency
Sampling frequency for the motor phase current. The minimum sampling frequency is 4000 Hz and the maximum is 13600 Hz, but for specific development can go up to 15500 Hz if necessary. Decreasing the switching frequency can be necessary to modify PID value.

19. Frequency Ratio
The frequency ratio multiplied by the sampling frequency defines the switching frequency for the motor PWM. It usually is 1 or 2.

20. Max Blocking Current
Max current to allow blocking mode [A].

21. Min Blocking Time

When the Drive detects a phase current lower than the min blocking current, it switches from the blocking mode to the align mode [A].

22. Blocking Time

It's the minimum time the Drive will be in blocking mode, even if the min blocking current is reached before [s].

23. Alignment Time

Is the time the current takes to rise from 0A to the alignment current.

24. Id Fall Time

Is the time the "Id" current takes to drop from the "Startup current" to the "Id ref" current.

25. Id Ref

Is the "Id" current reference, should only be 0A as any other value will result in decreased performance. This parameter is only used in during testing and debugging, it can be useful, for example to cause the motor to heat up intentionally.

26. Max Temp 1

Is the maximum allowed temperature for the Temperature sensor 1. 5°C before this temperature the Drive will enter in de-rating mode and if the temperature goes over this parameter, the temperature alarm will be triggered.

27. Acim Fixed Speed

Not used at the current device

28. Input Type

This parameter is used to select the type of control

[0]	Modbus control (SW, PLC, …)
[1]	Lafert Keypad (if present)
[2]	External I/O

29. Maximum Power

Is the maximum power the Drive will allow [W], if the load on the motor increases over the maximum power, the speed will be automatically reduced. The dynamic behaviour of this control loop is determined by the next two parameters, allowing the adjustment of the overload response.

30. Power Kp

Proportional constant of the maximum power control loop.

31. Power Ki

Integral constant of the maximum power control loop.

32. Input Current Kp

Proportional constant of the maximum input current control loop.

33. Input Current Kpi

Integral constant of the maximum input current control loop.

34. Tripping Current

Is the 130% of the rated current (Par. 47). It can be used for overload management. Value has to be in peak

35. Modbus Address

Is the address for Modbus communication.

36. Outputs

Set the state of digital outputs, relays and analog input configuration. Bit definition:

Bit0: 0=Relay1 open / 1= Relay1 closed

Bit1: 0=Relay2 open / 1= Relay2 closed

Bit2: 0=Digital output1 deactivated / 1= Digital output1 activated

Bit3: 0=Digital output2 deactivated / 1= Digital output2 activated

Bit4: 0=Analog input1 0= 0-10V / 1= Analog input1 in Ampere (see Bit 6)

Bit5: 0=Analog input2 0= 0-10V / 1= Analog input2 in Ampere (see Bit 7)

Bit6: 0=Analog input1 0= 0-20mA / 1= 4-20mA

Bit7: 0=Analog input2 0= 0-20mA / 1= 4-20mA

37. Modbus Baud

Modbus baudrate. If changed, the speed interface parameter has to be changed accordingly. By default is 9.6 [kbps], at higher speeds the behaviour depends on the opto-isolators of each device.

38. Modbus Stop

Modbus stop bit configuration parameter. By default is 0

[0]	8 bit/ No parity/ 2 stop bits
[1]	8 bit/ Odd parity/ 1 stop bit
[2]	8 bit/ Even parity/ 1 stop bit
[3]	8 bit/ No parity/ 1 stop bits

39. Ipfcmax

Input current limit (peak A) if the load on the motor increases or the voltage input decrease causing a current increasing over this limit, the speed will be reduced automatically.

40. Num. Restart

Maximum number of restart is XXX

Set the maximum number of start retries after alarm situation (except short circuit).

41. Drive Status

Set driver status and the rotation direction, bit definition:

Bit0: 0=Stop / 1= Run

Bit1: 0=Clockwise direction / 1= clockwise direction

42. Set Speed

Motor speed set point

5867→Minimum speed (20% rated speed)

32268→Maximum speed (110% of rated speed)

43. Ana. Out 1

Set the analog output 0-10V

0 → 0V

4095 → 10V

44. Max Open Loop

Maximum open loop speed.

Switch point from open loop (startup ramp) to closed loop speed control.

45. Motor Rated Power

Is the rated power of the motor in [W]

46. Motor Rated Voltage

Is the rated voltage of the motor in [V]

47. Motor Rated Current

Is the rated current of the motor in rms [A]

48. Motor Rated Speed

Is the rated speed of the motor in [rpm]

49.- 62 Torque Constant

Is a vector that indicate the torque constant in Nm/A by 1000. Each position of the vector corresponds to a range of current. The interval of current is 0.5A in 1kW drive, 1A in 2kW.
Value in the middle will be the weighted average of the two values.

[par. 49]	0.0 to 0.5 Amp (1kW) / 0.0 – 1.0 Amp (2kW)
[par. 50]	0.5 to 1.0 Amp (1kW) / 1.0 – 2.0 Amp (2kW)
[par. 51]	1.0 to 1.5 Amp (1kW) / 2.0 – 3.0 Amp (2kW)
[par. 52]	1.5 to 2.0 Amp (1kW) / 3.0 – 4.0 Amp (2kW)
[par. 53]	2.0 to 2.5 Amp (1kW) / 4.0 – 5.0 Amp (2kW)
[par. 54]	2.5 to 3.0 Amp (1kW) / 5.0 – 6.0 Amp (2kW)
[par. 55]	3.0 to 3.5 Amp (1kW) / 6.0 – 7.0 Amp (2kW)
[par. 56]	3.5 to 4.0 Amp (1kW) / 7.0 – 8.0 Amp (2kW)
[par. 57]	4.0 to 4.5 Amp (1kW) / 8.0 – 9.0 Amp (2kW)
[par. 58]	4.5 to 5.0 Amp (1kW) / 9.0 – 10.0 Amp (2kW)
[par. 59]	5.0 to 5.5 Amp (1kW) / 10.0 – 11.0 Amp (2kW)
[par. 60]	5.5 to 6.0 Amp (1kW) / 11.0 – 12.0 Amp (2kW)
[par. 61]	6.0 to 6.5 Amp (1kW) / 12.0 – 13.0 Amp (2kW)
[par. 62]	6.5 to 7.0 Amp (1kW) / 13.0 – 14.0 Amp (2kW)

ООО «ТИ-СИСТЕМС» ИНЖИНИРИНГ И ПОСТАВКА ТЕХНОЛОГИЧЕСКОГО ОБОРУДОВАНИЯ
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6.4.3 RAM Holding Register Table

These are special holding registers that will only be used to control the Drive but not to configure it. These won't be saved and will lose their value when the Drive is powered off.

Modbus Configuration

The Keld Drives typically use a serial configuration of 9600 baud rate, 8bit data, no parity and 2 stop bits unless it's a special development. The drives are provided with Modbus address 1, and can be changed to a different address later.

We usually use these functions:

- 0x03 Read Holdings Registers
- 0x04 Read Input Registers
- 0x06 Write Single Register
- 0x10 Write Multiple Register

Alarm Table

Alarm	Alarm 2	Description
0	0	Normal operation, no errors
1	0	Memory error
2	0	Short-circuit
3	0	Loss of synchronism with the motor
4	1	Input voltage outside range (only with motor stopped)
4	32	Bus voltage over 430V during operation (instantaneous measurement)
4	33	Bus voltage below 350V during operation (instantaneous measurement)
4	34	Input relay not closed
4	49	Motor cable U disconnected
4	50	Motor cable V disconnected
4	51	Motor cable W disconnected
4	113	Over-temperature
4	116	Klison error

<u>**Autotuning**</u>

Attention! Motor has to be without load

- Previously set some parameters on "Holding Registers details" (panel (2) in figure 3): number of poles (Par. 6) and maximum current (Par. 8). It is also recommended to enter the rest of known parameters: Min Speed (Par. 2), Max Speed (Par. 3), acceleration (Par. 4), deceleration (Par. 5), start current (Par. 7);
- First execute the tuning of the current loop. In the RAM holding register table (panel (3) in figure3) write 'Mode' to 2. To begin the process, write 1 in the Trigger register. The result of the current tuning is returned in inputs 23 and 24 of "Input register details" (panel (1) in figure 3): Current loop Kp and Ki. Those values have to be written in the corresponding "Holding Registers details": Par. 12 and Par. 13.
- Now tuning the motor parameters, by writing 3 on 'Mode'. To begin the process, write 1 in the Trigger register. Be careful, the motor rotates during the tuning process. The result of the current tuning is returned in inputs of "Input register details": Stator resistor (Par 20), Synchronous inductance (Par 21) and P.M. flux (Par 22). Now write those values in the corresponding holding parameters registers: Par. 9, Par. 10 and par. 11.
- Write again 0 in register 'Mode' to change to normal function.

NOTE: The parameters of speed loop and 'Observer Gain', they should be adjusted with the real load.

Run the motor

Set Mode = 0 and put the speed in rpm in 'Speed reference'. If you want to change the direction, just add a minus before the speed.

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7. Analog and Digital Input / Output Connection

7.1 Overview

The following table shown all Analog and digital input and output

MODBUS CONNECTOR (J15)	
Pin 1	485-A
Pin 2	485-B
Pin 3	GND ISOLATED

RELAYS CONNECTOR (J12)	
Pin 1	RELAY 1 NO
Pin 2	RELAY 1 COM
Pin 3	RELAY 1 NC
Pin 4	RELAY 2 NO
Pin 5	RELAY 2 COM
Pin 6	RELAY 2 NC

I/O CONNECTOR (J16 -J18)	
Pin 1	+24 ISOLATED OUTPUT (200mA)
Pin 2	GND ISOLATED
Pin 3	+10V ISOLATED / Analog Output 4-20mA (+)
Pin 4	Analog Output 4-20mA (-)
Pin 5	Analog Output 0-10V
Pin 6	GND ISOLATED
Pin 7	+24 ISOLATED
Pin 8	Digital Input 1
Pin 9	Digital Input 2
Pin 10	Comm NPN / PNP (jumper)
Pin 11	GND ISOLATED
Pin 12	Digital Output 1 (open collector 20mA)
Pin 13	+24 ISOLATED
Pin 14	Digital Output 2 (open collector 20mA)
Pin 15	Analog Input 1 4-20mA (+)
Pin 16	Analog Input 1 0-10V
Pin 17	+10V ISOLATED
Pin 18	GND ISOLATED
Pin 19	Analog Input 2 4-20mA (+)
Pin 20	Analog Input 2 0-10V

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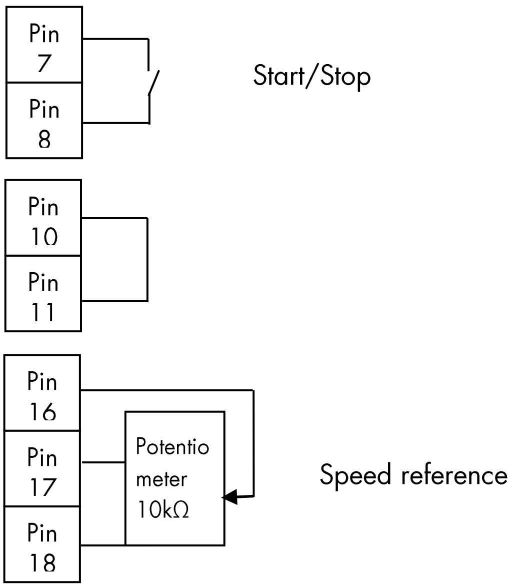
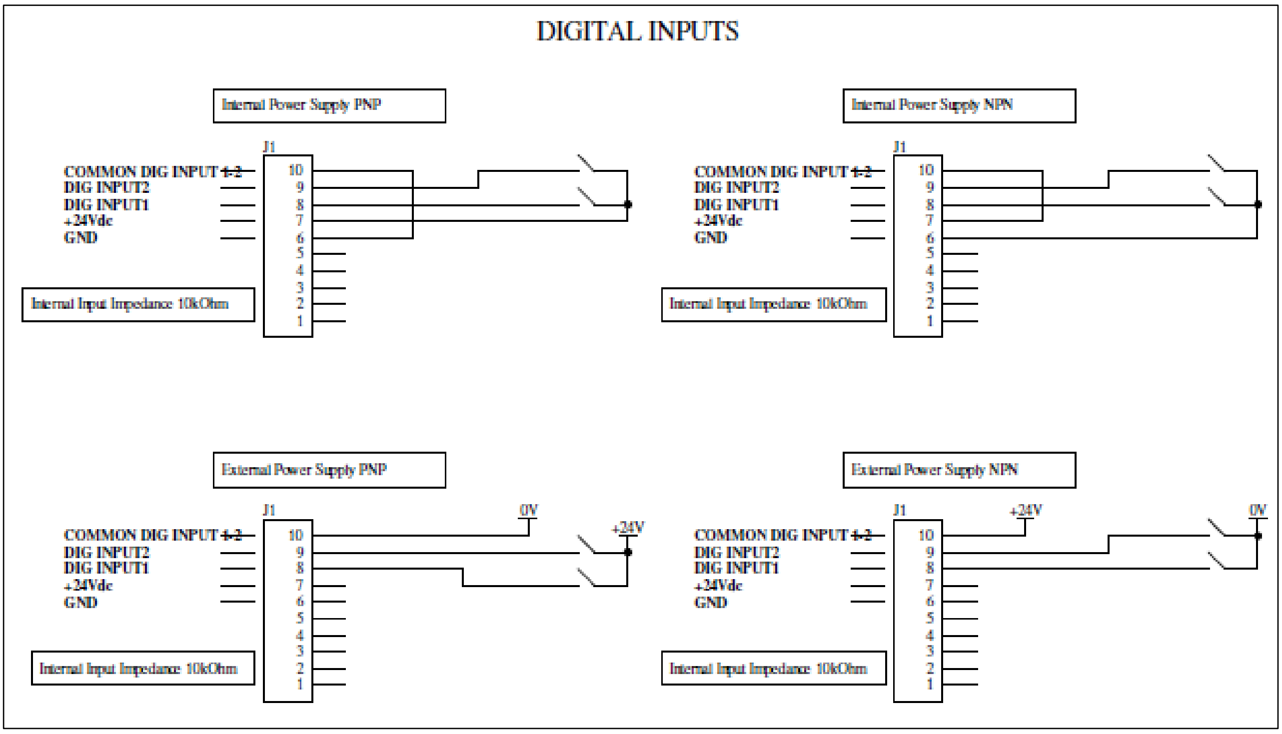
7.2 Example of Connection Diagram

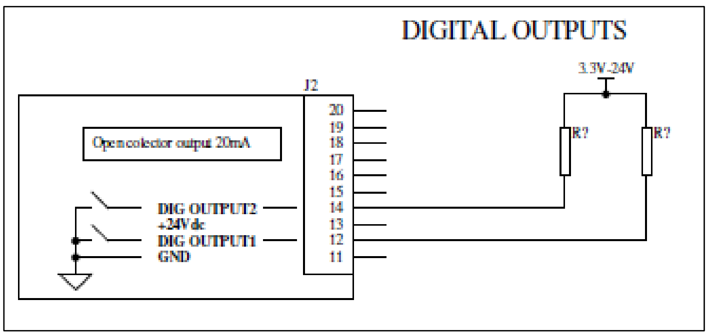
NOTE: please Remember that to use the drive with external reference, Par. 28 “Input Type” shall be set as “2”.



7.3 Digital Inputs



7.4 Digital Outputs



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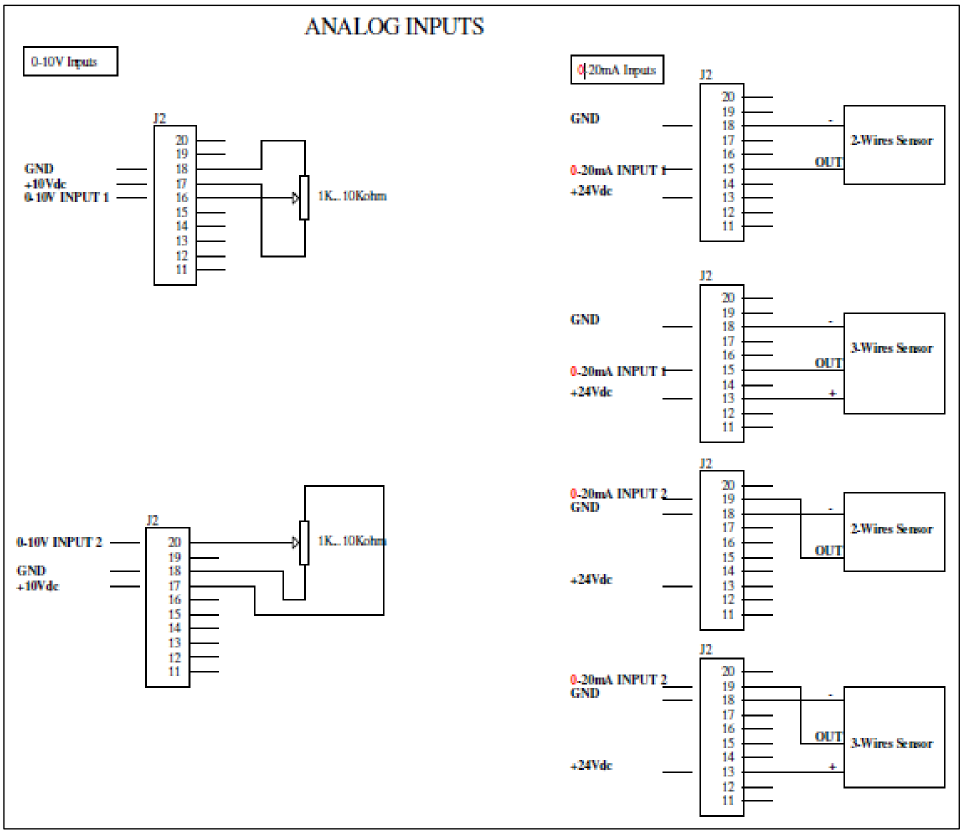
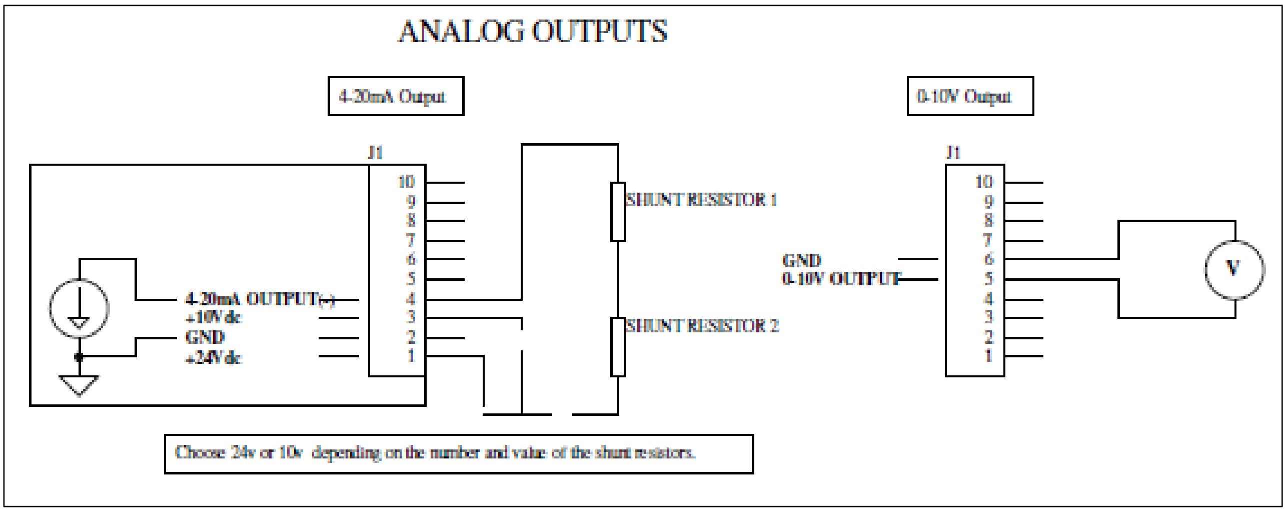
7.5 Analog Inputs



7.6 Analog Outputs



8. Modbus RTU Communications

8.1 Write to VFD (0x06) / read from VFD (0x03)

Variable/Address (WR)	Default Value	Choice
BaudRate / 0x00D4	19200	9600
		19200
		38400
Databits	8	NOT EDITABLE
Parity / 0x00D5	0 / NONE	0
		1
		2
StopBit / 0x006C	2	ONLY READABLE
Address / 0x00D6	1	1 ÷ 247

8.2 Modbus Variable read from VFD (0x04)

READ FROM VFD (0x04)		UNIT
0x0063	INSTANTANEOUS MOTOR CURRENT	A*100
0x0064	BUS DC LINK	[V]
0x0065	INSTANTANEOUS MOTOR SPEED	[RPM]
0x0066	ALARM WORD 1	
0x0067	ALARM WORD 2	
0X0068	RUN/STOP STA+TUS	1 = Run 0 = Stop
0x0069	ANALOG INPUT 1	0:4095 → 0:10V (12bit)
0x006A	DIGITAL INPUT 1	0 / 1
0X006B	MOTOR POWER	[KW*100]
0X006C	MODBUS STOP BITS	
0X006D	DRIVE CARRIER FREQUENCY	[HZ] Fixed at 10.000
0X006E	INSTANTANEOUS MOTOR VOLTAGE	[V]
0X006F	ANALOG INPUT 2	0:4095 → 0:10V (12bit)
0X0070	WARNING STATUS WORD (Phase Loss)	0 / 1
0X0071	DIGITAL INPUT 2	0 / 1
0X0072	MOTOR TORQUE	[Nm]
0X0073	HW Release	
0X0074	FW Release	
0X0075	Drive temperature	[°C * 10]
0x0076	Max Over Current Device (Tripping Current)	[A * 10]

INSTANTANEOUS MOTOR CURRENT [A]

MODBUS PDU Data Point Address (HEX)	Description
0x0063	Request Drive Output current multiplied to 100 i.e. 0x0063 = 100 → Drive Output Current = 1 A

BUS DC LINK [V]

MODBUS PDU Data Point Address (HEX)	Description
0x0064	Vbus is the rectifier voltage of the driver V i.e. 0x0064 = 500 → V Bus = 500 Vdc

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INSTANTANEOUS MOTOR SPEED [rpm]

MODBUS PDU Data Point Address (HEX)	Description
0x0065	Motor Speed in rpm i.e. 0x0065 = 500 → Motor is running at 500 rpm 0x0065 = 1000 → Motor Speed = 1000 rpm

ALARM WORD

MODBUS PDU Data Point Address (HEX)	Bit N°	Alarm1 error description
0x0066	1	Thermal motor protection - Motor Over Temperature (clixon)
	3	Not used
	4	Over Voltage protection - if Vbus > Overvoltage Value programmed the HPI goes in alarm. Not used
	5	Not used
	6	Drive Overcurrent - Phase to phase short circuit phase to earth short circuit
	7	Not used
	12	Under Voltage protection - if Vbus < Undervoltage Value when the motor is running, the HPI goes in alarm.
	14	EEPROM Fault
	Bit0 / Bit2 / Bit3 / Bit4/ Bit5 / Bit8 / Bit9 / Bit10 / Bit11 / Bit13 / Bit15 NOT USED	

ALARM WORD 2

MODBUS PDU Data Point Address (HEX)	Bit N°	Alarm1 error description
0x0067	0	Not used
	3	I2T – OverLoad protection fault
	4	IGBT Overtemperature - related to IGBT Module Temperature
	5	Not used
	8	Rotor Lock Speed - related open to closed loop swap procedure with rotor locked
	Bit0 / Bit1 / Bit2 / Bit5 / Bit6 / Bit7 / Bit9 / Bit10 / Bit11 / Bit13 / Bit14 / Bit15 NOT USED	

RUN/STOP STATUS

MODBUS PDU Data Point Address (HEX)	Description
0x0068	1 = Motor Run 0 = Motor Standby/Alarm

ANALOG INPUT 1

MODBUS PDU Data Point Address (HEX)	Description
0x0069	0:4095 related to 0:10V input (12 bit) in J12 pin 10 (ANIN1) i.e. in pin 10 there are 10 V → 0x0069 = 4095 in pin 10 there are 0 V → 0x0069 = 0

DIGITAL INPUT 1

MODBUS PDU Data Point Address (HEX)	Description
0x006A	Read the status of digital input of the HPI control board J12 pin3 (DIGIN1) Pin3 = +24V → 0x006A = 1 Pin3 = 0V → 0x006A = 0

MOTOR POWER [kW*100]

MODBUS PDU Data Point Address (HEX)	Description
0x006B	Request Drive Output Real Power multiplied to 100 i.e. 0x006B = 123 → Motor Real Power = 1,23 kW

MODBUS STOP BITS

MODBUS PDU Data Point Address (HEX)	Description
0x006C	Default Value = 2

DRIVE CARRIER FREQUENCY [Hz]

MODBUS PDU Data Point Address (HEX)	Description
0x006D	PWM Frequency in Hz

INSTANTANEOUS MOTOR VOLTAGE [V]

MODBUS PDU Data Point Address (HEX)	Description
0x006E	Motor phase to phase rms value [V] i.e. during motor running the drive gives 100 V between U-V phases of motor → 0x006E=100

ANALOG INPUT 2

MODBUS PDU Data Point Address (HEX)	Description
0x006F	0:4095 related to 0:10V input (12 bit) in J3 pin 2 (ANIN2) i.e. in pin 2 there are 10 V → 0x006F = 4095 in pin 2 there are 0 V → 0x006F = 0

WARNING STATUS WORD (Phase Loss)

MODBUS PDU Data Point Address (HEX)	Bit N°	Warning description
0x0070	0	PHASE LOSS (no Drive Fault): in case that 1 mains phase missing the HPI gives a Warning (0x0070 bit0 = 1) and the motor reduce the maximum speed. bit0 = 1 Phase Loss Warning active bit0 = 0 NO Phase Loss Warning active i.e. Considering HPI 112 3600 7.5 165 400 B14/160 The HPI motor has 3960 as maximum speed, if is missing a mains phase: Speed Setpoint = 32268 (max speed) 0x0070= 1 (Warning message)
	Bit1: Bit15 NOT USED	

DIGITAL INPUT 2

MODBUS PDU Data Point Address (HEX)	Description
0x0071	Read the status of digital input of the HPI control board J12 pin4 DIGIN1 Pin4 = +24V → 0x0071= 1 Pin4 = 0V → 0x0071= 0

MOTOR TORQUE [Nm*10]

MODBUS PDU Data Point Address (HEX)	Description
0x0072	Request Motor Torque at the shaft multiplied to 10 i.e. 0x0072 = 123 → Motor Torque = 12,3 Nm

HW Release

MODBUS PDU Data Point Address (HEX)	Description
0x0073	HW Release i.e. 0x0073 = 1 → HW release = 1

FW Release

MODBUS PDU Data Point Address (HEX)	Description
0x0074	FW Release i.e. 0x0074 = 10 → FW release = 1.0

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DRIVE TEMPERATURE

MODBUS PDU Data Point Address (HEX)	Description
0x0075	Drive temperature multiplied to 10 i.e. 0x0075 = 355 → Drive temperature = 35.5 °C

MOTOR NOMINAL CURRENT

MODBUS PDU Data Point Address (HEX)	Description
0x0076	Max Over Current Device (Tripping Current) multiplied to 10 [A*10] It's the value of max current that device can supply continuously i.e. Considering HPI 112 3600 7.5 165 400 B14/160 The HPI motor has 22.7 A as Max Over Current Device → 0x0076= 227

8.3 Modbus variable read only from VFD (0x03)

READ FROM VFD (0x03)		UNIT
0X00CB	MOTOR RATED POWER	[WATT]
0X00CC	MOTOR RATED VOLTAGE	[V]
0X00CD	MOTOR RATED CURRENT	[A]
0X00D0	MOTOR RATED SPEED	[RPM]

MOTOR RATED POWER [W]

MODBUS PDU Data Point Address (HEX)	Description
0x00CB	MOTOR RATED POWER [W] i.e. HPI 112 3600 7.5 165 400 B14/160 → 0x00CB = 7500 0x00CB = 7500 → MOTOR RATED POWER = 7,5 kW

MOTOR RATED VOLTAGE [V]

MODBUS PDU Data Point Address (HEX)	Description
0x00CC	MOTOR RATED VOLTAGE [V] i.e. Considering HPI 112 3600 7.5 165 400 B14/160 → 0x00CC = 400 0x00CC = 400 → MOTOR RATED VOLTAGE = 400 V [380:440] ±10%

MOTOR RATED CURRENT [A]

MODBUS PDU Data Point Address (HEX)	Description
0x00CD	MOTOR RATED CURRENT [A*10] i.e. Considering HPI 112 3600 7.5 165 400 B14/160 → 0x00CD = 165 0x00CD = 165 → MOTOR RATED CURRENT = 16,5 A

MOTOR RATED SPEED [rpm]

MODBUS PDU Data Point Address (HEX)	Description
0x00D0	MOTOR RATED SPEED [rpm] i.e. Considering HPI 112 3600 7.5 165 400 B14/160 → 0x00D0 = 3600 0x00D0 = 3600 → MOTOR RATED SPEED = 3600 rpm

8.4 Modbus variable write to VFD (0x06) / read from VFD (0x03)

WRITE TO VFD (0x06) / READ FROM VFD (0x03)		UNIT
0X00C9	DRIVE STATUS	1 = Run 0 = Stop
0X00CA	MOTOR SPEED SETPOINT	[I.U.] 5867 -> 32268 Min speed -> 110 % Rated speed
0X00D1	ANALOG OUTPUT 1	
0X00D2	RAMP UP	[IU]

0X00D3	SYSTEM RESET	
0X00D4	MODBUS DATA RATE	
0X00D5	MODBUS COMMUNICATION PARITY	
0X00D6	MODBUS ADDRESS	
0X00D7	DIGITAL OUTPUT 1	
0X00D8	DIGITAL OUTPUT 2	
0X00D9	RELAY 1 STATUS	
0X00DA	RELAY 2 STATUS	
0X00DB	ANALOG INPUT 1	
0X00DC	ANALOG INPUT 2	
0X00DD	STARTING CURRENT	[%]
0X00E2	ROTATION DIRECTION	0 = c. clockwise rotation 1 = clockwise rotation
0X00E3	RAMP DOWN	[IU]
0X00E4	Max Open Loop Speed	[RPM]
0X00E5	Minimum Closed Loop Speed	[RPM]

DRIVE STATUS

MODBUS PDU Data Point Address (HEX)	Description
0x00C9	Command drive Start 0x00C9 = 1 Stop 0x00C9 = 0 If value is not 0/1 the HPI gives the Exception Code 0x03

MOTOR SPEED SETPOINT

MODBUS PDU Data Point Address (HEX)	Description
0x00CA	Speed setpoint - range [5867:32268] The speed setpoint is available in range of minimum speed (1/5 of Rated speed) to Motor Maximum Speed (110% of Rated speed): if the value is less of minimum speed (5867) the HPI goes at minimum speed. Considering HPI 112 3600 7.5 165 400 B14/160 - 3.600 rpm Speed Set Point (Write to VFD Function 0x06): 32.268 = 3.960 rpm (110%). i.e. In case 3.600 rpm is requested speed (3.600 rpm = 100%): 0x00CA = 29.334 [29.334 = (3.600/3.960) * 32.268] In case 1.800 rpm is requested speed (1.800 rpm = 50%): 0x00CA = 14.667 [14.667 = (1.800/3.960) * 32.268] Sending 0x00CA >32268 Speed setpoint = 32268 Sending 0x00CA <5867 Speed setpoint = 5867

ANALOG OUTPUT1 [IU]

MODBUS PDU Data Point Address (HEX)	Description
0x00D1	Analog Output 1 0:4095 related to 0:10V output (12 bit) in J12 pin 8 with a load of 500 Ω between pin8 and 9 (GND) Out of range the HPI gives the Exception Code 0x03 i.e. 0x00D1 = 4095 → between pin 8 and GND there are 10 V

RAMP UP [IU]

MODBUS PDU Data Point Address (HEX)	Description
0x00D2	Ramp UP to set the time to rump up from Open Loop Max Speed to 110% speed i.e. 0x00D2 = 50 Considering HPI 112 3600 7.5 165 400 B14/160 Max Speed [rpm] = 3960 (110% of MOTOR RATED SPEED in rpm) Open Loop Max Speed=1200 rpm= 9778 IU Speed Set Point (0x00CA) = 29335 IU (see above 3600rpm) Motor Desired Speed [rpm] = (Speed Set Point (0x00CA) - 1200) * Motor Maximum Speed / 32268 = 1800rpm

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Ramp Time = Drive Ramp Parameter * Speed Set Point * Motor Maximum Speed * 4 / (32268 *10000)
= 50 *(29335-9778) * 3960 *4 / (10000*32268) = 48s

The time to ramp up from 1200 to 3600 rpm = 48 s

SYSTEM RESET

MODBUS PDU Data Point Address (HEX)	Description
0x00D3	Active if the control board is on error: send 1 for reset the control board. If HPI is in Run Status (motor is running) this command will be ignored. Drive respond to PLC, after the drive is reset wait about 2 sec for new communication. If the value is not 0/1 the HPI gives the Exception Code 0x03

MODBUS DATA RATE

MODBUS PDU Data Point Address (HEX)	Description
0x00D4	Data Rate. Default 19200.

MODBUS COMMUNICATION PARITY

MODBUS PDU Data Point Address (HEX)	Description
0x00D5	Default 0.

MODBUS ADDRESS

MODBUS PDU Data Point Address (HEX)	Description
0x00D6	Modbus Device Address. Default 1.

DIGITAL OUTPUT 1

MODBUS PDU Data Point Address (HEX)	Description
0x00D7	Digital Output: 0x00D7 = 1 → pin 5 J3 = +24V 0x00D7 = 0 → pin 5 J3 = 0 V

DIGITAL OUTPUT 2

MODBUS PDU Data Point Address (HEX)	Description
0x00D8	Digital Output: 0x00D7 = 1 → pin 7 J3 = +24V 0x00D7 = 0 → pin 7 J3 = 0 V

RELAY 1 STATUS

MODBUS PDU Data Point Address (HEX)	Description
0x00D9	Relay 1 Out: 0x00D9 = 1 → Energized 0x00D9 = 0 → Not Energized

RELAY 2 STATUS

MODBUS PDU Data Point Address (HEX)	Description
0x00DA	Relay 2 Out: 0x00DA = 1 → Energized 0x00DA = 0 → Not Energized

ANALOG INPUT 1

MODBUS PDU Data Point Address (HEX)	Description
0x00DB	ANALOG INPUT 1 Config: 0x00DB = 0 → (0:10V) 0x00DB = 1 → (0:20mA) 0x00DB = 2 → (4:20mA)

ANALOG INPUT 2

MODBUS PDU Data Point Address (HEX)	Description
0x00DC	ANALOG INPUT 2 Config: 0x00DC = 0 → (0:10V) 0x00DC = 1 → (0:20mA) 0x00DC = 2 → (4:20mA)

STARTING CURRENT [IU]

MODBUS PDU Data Point Address (HEX)	Description
0x00DD	5:100 % of peak drive current. Out of range the HPI gives the Exception Code 0x03 i.e. Considering HPI 112 3600 7.5 165 400 B14/160 Peak Current = 24 24 Arms 0x00DD = 25 → STARTING CURRENT = 25% of peak current Starting Current = 25% 24 Arms = 6 Arms

ROTATION DIRECTION

MODBUS PDU Data Point Address (HEX)	Description
0x00E2	Bit Rotation Direction. The value is 1/0, otherwise the HPI gives the Exception Code 0x03 0x00E2 = 1 Clockwise (from motor shaft side) 0x00E2 = 0 Counter Clockwise (from motor shaft side) In FW 1.2 and later this parameter doesn't need Key to modify. If HPI is in Run Status (motor is running) with one of these commands the HPI will give "Illegal Function Code" (0x01). After sending one of these commands, giving the enable command (0x0068) will cause "Illegal Function Code" (0x01). It needs a reset command [0x00D3]

RAMP DOWN [IU]

MODBUS PDU Data Point Address (HEX)	Description
0x00E3	Ramp DOWN to set the time to rump down from 110% to minimum speed. i.e. 0x00E3 = 50 Considering HPI 112 3600 7.5 165 400 B14/160 Max Speed [rpm] = 3960 (110% of MOTOR RATED SPEED in rpm) Open Loop Max Speed=1200 rpm= 9778 UI Speed Set Point (0x00CA) = 29335 (see above 3600rpm) Motor Desired Speed [rpm] = (Speed Set Point (0x00CA)- 1200) * Motor Maximum Speed / 32268 = 1800rpm Ramp Time = Drive Ramp Parameter * Speed Set Point * Motor Maximum Speed * 4 /(32268 *10000) = 50 *(29335-9778) * 3960 *4 / (10000*32268) = 48s The time to ramp up from 3600 to 1200 rpm = 48s

MAX OPEN LOOP SPEED [RPM]

MODBUS PDU Data Point Address (HEX)	Description
0x00E4	Open Loop Max Speed Range [1/5 Rated Speed:1/3 Rated Speed] i.e. 0x00E4 = 720 Considering HPI 112 3600 7.5 165 400 B14/160 MOTOR RATED SPEED [rpm] = 3600 0x00E4 can be programmed in range of min [1/5 3600 = 720] and max [1/3 3600 = 1200] If HPI is in Run Status (motor is running) with one of these commands the HPI will give "Illegal Function Code" (0x01). After sending of this command, giving the enable command (0x0068) will cause "Illegal Function Code" (0x01). It needs a reset command [0x00D3] N.B. For HPI with 4500 of rated speed the maximum value allowed is 1499

Rated Speed	Min Open Loop Speed	Max Open Loop Speed
3000	600	1000
3600	720	1200
4500	900	1499

MINIMUM CLOSED LOOP SPEED [RPM]

MODBUS PDU Data Point Address (HEX)	Description
0x00E5	Minimum Closed Loop Speed Range [1/5 Rated Speed: Rated Speed] i.e. 0x00E5 = 720 Considering HPI 112 3600 7.5 165 400 B14/160 MOTOR RATED SPEED [rpm] = 3600 0x00E5 can be programmed in range of min [1/5 3600 = 720] and max [Rated Speed = 3600] If HPI is in Run Status (motor is running) with one of these commands the HPI will give "Illegal Function Code" (0x01). After sending of this command, giving the enable command (0x0068) will cause "Illegal Function Code" (0x01). It needs a reset command [0x00D3]

Rated Speed	Lowest Minimum Speed	Highest Minimum Speed
3000	600	3000
3600	720	3600
4500	900	4500

8.5 Modbus Variable Protected by Key

write to VFD (0x06)/read from VFD (0x03)

WRITE TO VFD (0x06) / READ FROM VFD (0x03)		UNIT
0X00DE	SPEED KP	[IU]
0X00DF	SPEED KI	[IU]
0X00E0	OBSERVER GAIN	[IU]

SPEED KP [IU]

MODBUS PDU Data Point AddressL (HEX)	Description
0x00DE	Proportional constant of the speed control loop. It depends on both the motor and the load, its inertia and is dynamic properties. range [1:32767].L

SPEED KI [IU]

MODBUS PDU Data Point Address (HEX)	Description
0x00DF	Integral constant of the speed control loop. It depends on both the motor and the load, its inertia and is dynamic properties. range [1:32767].

OBSERVER GAIN [IU]

MODBUS PDU Data Point Address (HEX)	Description
0x00E0	Gain of the not linear observer gain. Biggest the value, better will be the behaviour of the motor, but can create problem in the passage from Open Loop to Close Loop. So the goal is to find the biggest value maintaining the dynamic stable. It has to be high enough to detect the blocked-rotor situation and remain stable with load at the minimum desired speed.

9. Technical Data

9.1 Environmental

Enclosure	IP55 / IP66 for drive
Vibration test	EN 60068-2-6
Max relatively humidity	95% (IEC 60068-2-3)
Operating ambient temperature	0:40°C
Storage ambient temperature	- 25°C:60°C
Altitude	0 - 3000m, derate 1% per 100m above 1000m

9.2 Rating Tables

Power	0 – 2.2 Kw
Speed	0 – 5000rpm
Output Current 100% Drive Rated Power continuously	
Overload Capacity 150% for 60 secs	

9.3 Voltage Range

Supply Frequency	48 - 62Hz
Supply Voltage	3 x 380/480V ± 10% 1 x 200/240V ± 10%

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10. Trouble Shooting

10.1 Fault Code Blinking

Diode D10 in PCB change its blinking based on drive status. Blinking description in the table below. Code:

Blink ON	Blink OFF	Description
0	0	Normal operation, no errors
1	0	Memory error
2	0	Short-circuit
3	0	Loss of synchronism with the motor
4	1	Input voltage outside range (only with motor stopped)
4	32	Bus voltage over 430V during operation (instantaneous measurement)
4	33	Bus voltage below 350V during operation (instantaneous measurement)
4	34	Input relay not closed
4	49	Motor cable U disconnected
4	50	Motor cable V disconnected
4	51	Motor cable W disconnected
4	113	Over-temperature
4	116	Klison error

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