LAFERTGROUP
Member of Sumitomo Drive Technologies

# HP Integral Smart

## VARIABLE FREQUENCY DRIVE

THE RANGE:

1.5 to 5.5 kW | 2 to 7.5 HP
Three-phase 200-240 V

1.5 to 11 kW | 2 to 15 HP
Three-phase 380-480 V


USER MANUAL

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## Declaration of Conformity

Lafert Group hereby states that the HPI Smart product range conforms to the relevant safety provisions of the following council directives:

2014/30/EU (EMC) and 2014/35/EU (LVD)

Designed and manufacture is in accordance with the following harmonised European standards:

| | |
|---|---|
| EN 61800-5-1: 2007+A11:2021 | Adjustable speed electrical power drive systems. Safety requirements. Electrical, thermal and energy. |
| EN 61800-3: 2018 | Adjustable speed electrical power drive systems. EMC requirements and specific test methods |
| EN 55011: 2007 | Limits and Methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment (EMC) |
| EN60529: 1992 | Specifications for degrees of protection provided by enclosures |

## Electromagnetic Compatibility

All HPI Smarts are designed with high standards of EMC in mind. All versions suitable for operation on Three Phase 230 volt and Three Phase 400 volt supplies and intended for use within the European Union are fitted with an internal EMC filter. This EMC filter is designed to reduce the conducted emissions back into the mains supply via the power cables for compliance with the above harmonised European standards.

It is the responsibility of the installer to ensure that the equipment or system into which the product is incorporated complies with the EMC legislation of the country of use, and the relevant category. Within the European Union, equipment into which this product is incorporated must comply with the EMC Directive 2004/108/EC. This User Guide provides guidance to ensure that the applicable standards may be achieved.



## 2 Year Warranty

All Lafert Group HPI Smart units carry a 2 year warranty against manufacturing defects from the date of manufacture. The manufacturer accepts no liability for any damage caused during or resulting from transport, receipt of delivery, installation or commissioning. The manufacturer also accepts no liability for damage or consequences resulting from inappropriate, negligent or incorrect installation, incorrect adjustment of the operating parameters of the drive, incorrect matching of the drive to the motor, incorrect installation, unacceptable dust, moisture, corrosive substances, excessive vibration or ambient temperatures outside of the design specification.

**This user guide is the "original instructions" document. All non-English versions are translations of the "original instructions".**

The contents of this User Guide are believed to be correct at the time of printing. In the interest of a commitment to a policy of continuous improvement, the manufacturer reserves the right to change the specification of the product or its performance or the contents of the User Guide without notice.

## This User Guide is for use with version 3.11 Firmware. The firmware version can be viewed in parameter P00-28.

## User Guide Revision 1.24

Lafert Group adopts a policy of continuous improvement and whilst every effort has been made to provide accurate and up to date information, the information contained in this User Guide should be used for guidance purposes only and does not form the part of any contract.

| | |
|---|---|
|  | When installing the drive on any power supply where the phase-ground voltage may exceed the phase-phase voltage (typically IT supply networks or Marine vessels) it is essential that the internal EMC filter ground and surge protection varistor ground (where fitted) are disconnected. If in doubt, refer to your Lafert Group Technical Department for further information. |
|  | This manual is intended as a guide for proper installation. Lafert Group cannot assume responsibility for the compliance or the non-compliance to any code, national, local or otherwise, for the proper installation of this drive or associated equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation. |
|  | This HPI Smart contains high voltage capacitors that take time to discharge after removal of the main supply. Before working on the drive, ensure isolation of the main supply from line inputs. Wait ten (10) minutes for the capacitors to discharge to safe voltage levels. Failure to observe this precaution could result in severe bodily injury or loss of life. |
|  | Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life. |

# 1. Safety Warnings

## 1.1. Important Safety Information

Please read the IMPORTANT SAFETY INFORMATION below, and all Warning and Caution information elsewhere.

**Danger: Indicates a risk of electric shock, which, if not avoided, could result in damage to the equipment and possible injury or death.**

This variable speed drive product (HPI Smart) is intended for professional incorporation into complete equipment or systems as part of a fixed installation. If installed incorrectly it may present a safety hazard. The HPI Smart uses high voltages and currents, carries a high level of stored electrical energy, and is used to control mechanical plant that may cause injury. Close attention is required to system design and electrical installation to avoid hazards in either normal operation or in the event of equipment malfunction. Only qualified electricians are allowed to install and maintain this product.

System design, installation, commissioning and maintenance must be carried out only by personnel who have the necessary training and experience. They must carefully read this safety information and the instructions in this Guide and follow all information regarding transport, storage, installation and use of the HPI Smart, including the specified environmental limitations.

Do not perform any flash test or voltage withstand test on the HPI Smart. Any electrical measurements required should be carried out with the HPI Smart disconnected.

Electric shock hazard! Disconnect and ISOLATE the HPI Smart before attempting any work on it. High voltages are present at the terminals and within the drive for up to 10 minutes after disconnection of the electrical supply. Always ensure by using a suitable multimeter that no voltage is present on any drive power terminals prior to commencing any work.

Where supply to the drive is through a plug and socket connector, do not disconnect until 10 minutes have elapsed after turning off the supply.

Ensure correct earthing connections. The earth cable must be sufficient to carry the maximum supply fault current which normally will be limited by the fuses or MCB. Suitably rated fuses or MCB should be fitted in the mains supply to the drive, according to any local legislation or codes.

Ensure correct earthing connections and cable selection as per defined by local legislation or codes. The drive may have a leakage current of greater than 3.5mA; furthermore the earth cable must be sufficient to carry the maximum supply fault current which normally will be limited by the fuses or MCB. Suitably rated fuses or MCB should be fitted in the mains supply to the drive, according to any local legislation or codes.

Do not carry out any work on the drive control cables whilst power is applied to the drive or to the external control circuits.

**Danger: Indicates a potentially hazardous situation other than electrical, which if not avoided, could result in damage to property.**

Within the European Union, all machinery in which this product is used must comply with Directive 2006/42/EC, Safety of Machinery. In particular, the machine manufacturer is responsible for providing a main switch and ensuring the electrical equipment complies with EN60204-1.

The level of integrity offered by the HPI Smart control input functions – for example stop/start, forward/reverse and maximum speed is not sufficient for use in safety-critical applications without independent channels of protection. All applications where malfunction could cause injury or loss of life must be subject to a risk assessment and further protection provided where needed.

The driven motor can start at power up if the enable input signal is present.

The STOP function does not remove potentially lethal high voltages. ISOLATE the drive and wait 10 minutes before starting any work on it. Never carry out any work on the Drive, Motor or Motor cable whilst the input power is still applied.

Do not activate the automatic fault reset function on any systems whereby this may cause a potentially dangerous situation.

When mounting the drive, ensure that sufficient cooling is provided. Do not carry out drilling operations with the drive in place, dust and swarf from drilling may lead to damage.

The entry of conductive or flammable foreign bodies should be prevented. Flammable material should not be placed close to the drive

Relative humidity must be less than 95% (non-condensing).

Ensure that the supply voltage, frequency and 3 Phase Voltage corresponds to the rating of the HPI Smart.

Never connect the mains power supply to the Output terminals U, V, W.

Do not install any type of automatic switchgear between the drive and the motor.

Wherever control cabling is close to power cabling, maintain a minimum separation of 100 mm and arrange crossings at 90 degrees. Ensure that all terminals are tightened to the appropriate torque setting.

Do not attempt to carry out any repair of the HPI Smart. In the case of suspected fault or malfunction, contact your local Lafert Group Technical Department for further assistance.

# 2. General Information and Ratings

This chapter contains information about the HPI Smart including how to identify the drive.

## 2.1. Identifying the Drive by Model Number

Each drive can be identified by its model number, as shown in the table below. The model number is on the shipping label and the drive nameplate. The model number includes the drive and any options.

| X | I | S | 3 | - | 1 | 4 | A | - | F | 1 | A | X | C | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**Drive**

**Product**
I: Motor Mount

**Family**
S: Smart (E3)

**Generation**
3

**Size**
2: 90 Frame
3: 112 Frame

**Voltage**
2: 3x200V
4: 3x400V

**Power**

| | | | |
|---|---|---|---|
| B: 0.75kW | D: 2.2kW | G: 5.5kW | I: 11kW |
| C: 1.5kW | F: 4.0kW | H: 7.5kW | J: 15kW |

**Cable Entry**
N: NPT gland holes
M: Metric gland holes

**Lid Option**
C: Plain lid

**Display**
X: No display

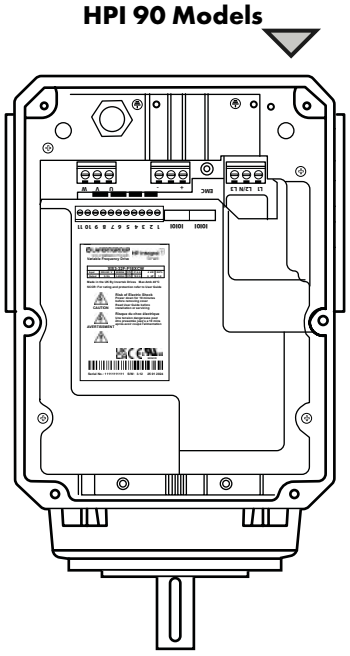
**IP Version**
A: IP66 Non-Switched
E: IP66 With Disconnector

**Brake**
1: Brake Chopper

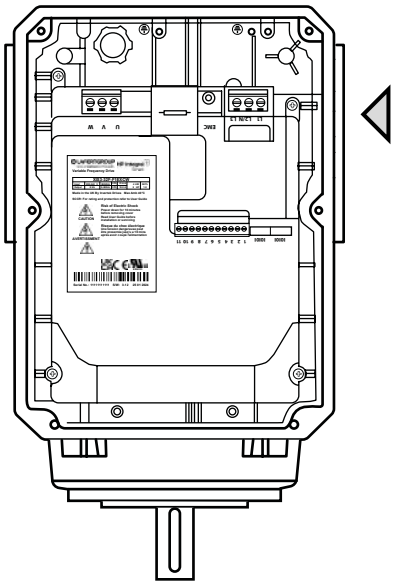
**EMC Filter**
F: Filtered

## 2.2. IP66 Drive Variants

**HPI 90 Models**



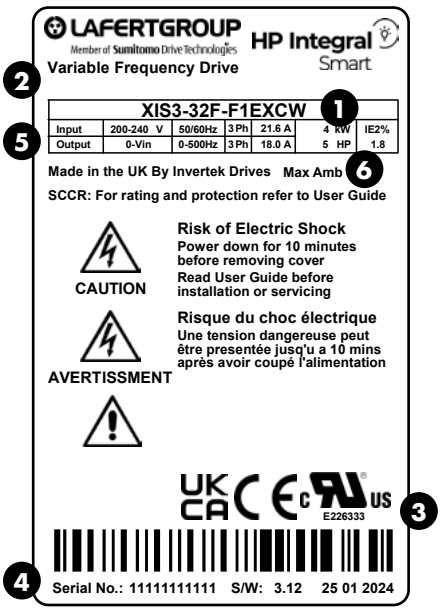
**HPI 112 Models**



## 2.3. Understanding the Rating Label

The product rating label provides the following information

| | Key |
|---|---|
| 1 | Model Code |
| 2 | Enclosure Type and IP Rating |
| 3 | Firmware Version |
| 4 | Serial Number |
| 5 | Technical Data – Supply Voltage |
| 6 | Technical Data – Maximum continuous output current |




## 2.4. Drive Model Numbers

| 3ph 200-240V Metric cable glands | | | | |
|---|---|---|---|---|
| Model Number | | Power [kW] | Output Current [A] | Frame Size |
| Disconnector | Non-Switched | | | |
| XIS3-22C-F1EXCM | XIS3-22C-F1AXCM | 1.5 | 7 | 2 |
| XIS3-22D-F1EXCM | XIS3-22D-F1AXCM | 2.2 | 10.5 | 2 |
| XIS3-32F-F1EXCM | XIS3-32F-F1AXCM | 4 | 18 | 3 |
| XIS3-32G-F1EXCM | XIS3-32G-F1AXCM | 5.5 | 24 | 3 |
| **3ph 200-240V NPT cable glands** | | | | |
| Model Number | | Power [kW] | Output Current [A] | Frame Size |
| Disconnector | Non-Switched | | | |
| XIS3-22C-F1EXCN | XIS3-22C-F1AXCN | 1.5 | 7 | 2 |
| XIS3-22D-F1EXCN | XIS3-22D-F1AXCN | 2.2 | 10.5 | 2 |
| XIS3-32F-F1EXCN | XIS3-32F-F1AXCN | 4 | 18 | 3 |
| XIS3-32G-F1EXCN | XIS3-32G-F1AXCN | 5.5 | 24 | 3 |
| **3ph 380-480V Metric cable glands** | | | | |
| Model Number | | Power [kW] | Output Current [A] | Frame Size |
| Disconnector | Non-Switched | | | |
| XIS3-24C-F1EXCM | XIS3-24C-F1AXCM | 1.5 | 4.1 | 2 |
| XIS3-24D-F1EXCM | XIS3-24D-F1AXCM | 2.2 | 5.8 | 2 |
| XIS3-24F-F1EXCM | XIS3-24F-F1AXCM | 4 | 9.5 | 2 |
| XIS3-34G-F1EXCM | XIS3-34G-F1AXCM | 5.5 | 14 | 3 |
| XIS3-34H-F1EXCM | XIS3-34H-F1AXCM | 7.5 | 18 | 3 |
| XIS3-34I-F1EXCM | XIS3-34I-F1AXCM | 11 | 24 | 3 |
| **3ph 380-480V NPT cable glands** | | | | |
| Model Number | | Power [kW] | Output Current [A] | Frame Size |
| Disconnector | Non-Switched | | | |
| XIS3-24C-F1EXCN | XIS3-24C-F1AXCN | 1.5 | 4.1 | 2 |
| XIS3-24D-F1EXCN | XIS3-24D-F1AXCN | 2.2 | 5.8 | 2 |
| XIS3-24F-F1EXCN | XIS3-24F-F1AXCN | 4 | 9.5 | 2 |
| XIS3-34G-F1EXCN | XIS3-34G-F1AXCN | 5.5 | 14 | 3 |
| XIS3-34H-F1EXCN | XIS3-34H-F1AXCN | 7.5 | 18 | 3 |
| XIS3-34I-F1EXCN | XIS3-34I-F1AXCN | 11 | 24 | 3 |

# 3. Mechanical Installation

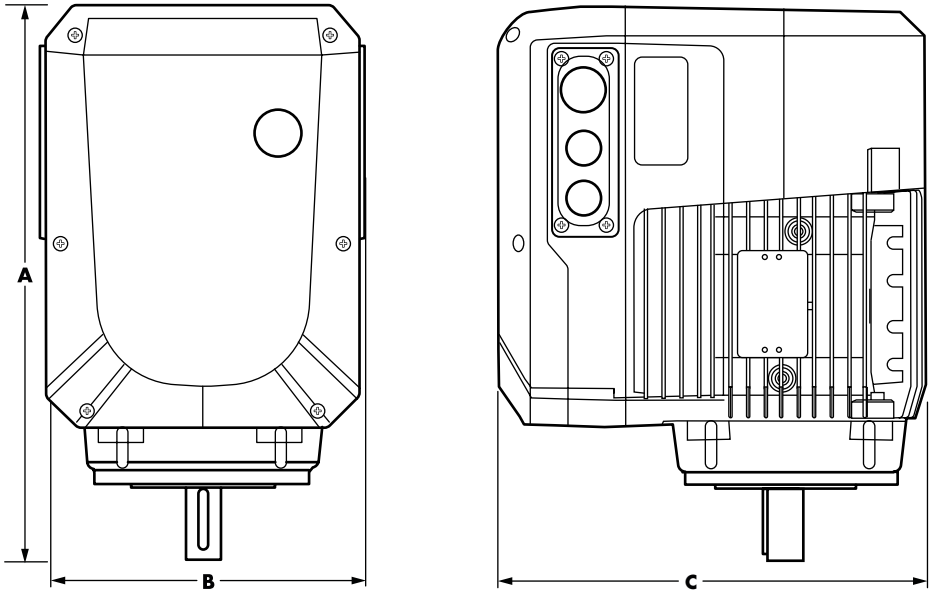
## 3.1. General

- The HPI Smart should be mounted in a vertical position only, on a flat, flame resistant, vibration free mounting using the integral mounting holes.
- Do not mount flammable material close to the HPI Smart.
- Ensure that the minimum cooling air gaps, as detailed in section 3.4. Guidelines for mounting (IP66 Units).
- Ensure that the ambient temperature range does not exceed the permissible limits for the HPI Smart given in section 9.1. Environmental.

## 3.2. UL Compliant Installation

Refer to section 9.4. Additional Information for UL Compliance on page 39 for Additional Information for UL Compliance.

## 3.3. Mechanical Dimensions – IP66 (NEMA 4X) Enclosed Units



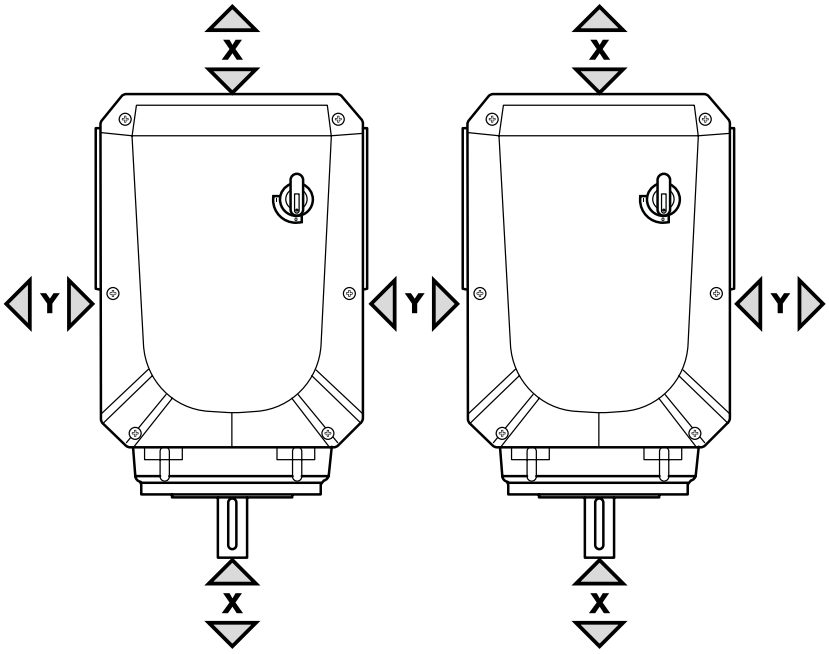

| Drive Size | A | | B | | C | |
|---|---|---|---|---|---|---|
| | mm | in | mm | in | mm | in |
| 2 | 363 | 14.3 | 212 | 8.3 | 278 | 10.9 |
| 3 | 439 | 17.3 | 247 | 9.7 | 336 | 13.2 |

| Mounting Bolts | | |
|---|---|---|
| Frame Size | Metric | UNF |
| All Sizes | M4 | #8 |

| Tightening Torques | | | |
|---|---|---|---|
| | Frame Size | Required Torque | |
| Control Terminals | HPI 90 & 112 | 0.5 Nm | 4.5 lb-in |
| Power Terminals | HPI 90 & 112 | 0.8 Nm | 7 lb-in |

## 3.4. Guidelines for mounting (IP66 Units)

- Before mounting the drive, ensure that the chosen location meets the environmental condition requirements for the drive shown in section 9.1. Environmental.
- The drive must be mounted vertically, on a suitable flat surface.
- The minimum mounting clearances as shown in the table below must be observed.
- The mounting site and chosen mountings should be sufficient to support the weight of the drives.
- Using the drive as a template, or the dimensions shown above, mark the locations required for drilling.
- Suitable cable glands to maintain the ingress protection of the drive are required. Gland holes for power and motor cables are pre-moulded into the drive enclosure, recommended gland sizes are shown below. Gland holes for control cables may be cut as required.




- The mounting location should be free from vibration.
- Do not mount the drive in any area with excessive humidity, corrosive airborne chemicals or potentially dangerous dust particles.
- Avoid mounting close to high heat sources.
- The drive must not be mounted in direct sunlight. If necessary, install a suitable shade cover.
- The mounting location must be free from frost.
- Do not restrict the flow of air through the drive heatsink. The drive generates heat which must be naturally allowed to dissipate. Correct air clearance around the drive must be observed.
- If the location is subject to wide ambient temperature and air pressure variation, install a suitable pressure compensation valve in the drive gland plate.

**NOTE** If the drive has been in storage for a period longer than 2 years, the DC link capacitors must be reformed.

| Drive Size | X Above | | Y Either Side | |
|---|---|---|---|---|
| | mm | in | mm | in |
| 90 | 200 | 7.87 | 200 | 7.87 |
| 112 | 200 | 7.87 | 200 | 7.87 |
| **NOTE** | **Above are guidelines only and the operating ambient temperature of the drive MUST be maintained within the limits shown in section *9.1. Environmental* at all times.** | | | |

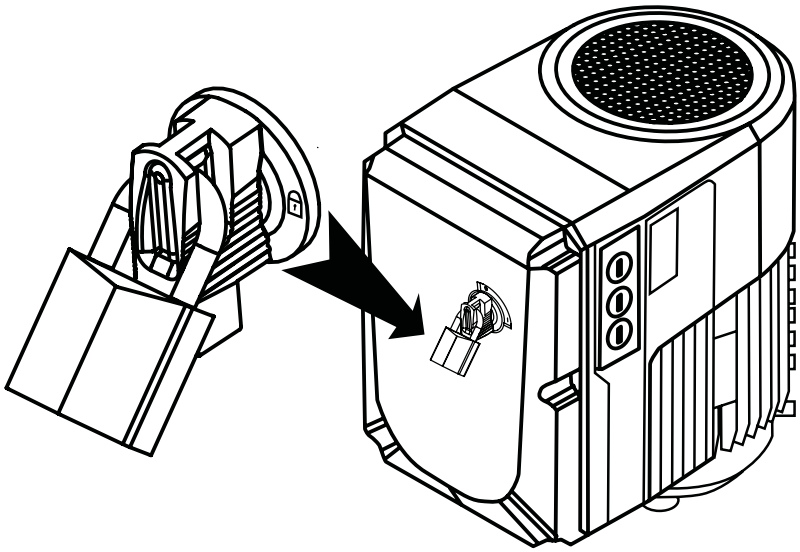
## 3.5. Gland Plate and Lock Off

The use of a suitable gland system is required to maintain the appropriate IP / NEMA rating. The gland plate has pre moulded cable entry holes for power and motor connections suitable for use with glands. Where additional holes are required, these can be drilled to suitable size. Please take care when drilling to avoid leaving any particles within the product.

### Mains switch-disconnector Lock Off

On the switched models the mains switch-disconnector can be locked in the 'Off' position using a 20mm standard shackle padlock (not supplied).

### IP66 / NEMA 4X Unit Lock Off



## 3.6. Routine Maintenance

The drive should be included within the scheduled maintenance program so that the installation maintains a suitable operating environment, this should include:

- Ambient temperature is at or below that set out in section 9.1. Environmental.
- Heat sink fans (where fitted) freely rotating and dust free.
- The Enclosure in which the drive is installed should be free from dust and condensation; furthermore ventilation fans and air filters should be checked for correct air flow.

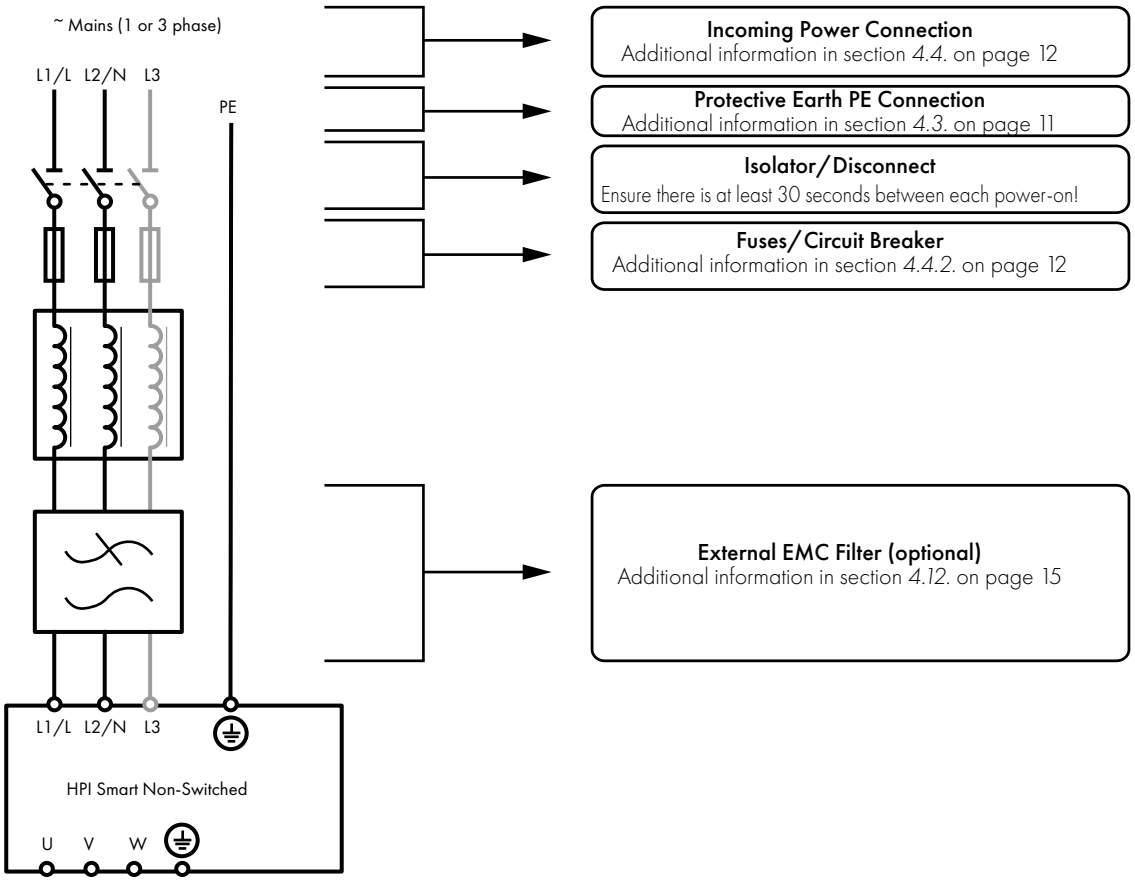
Checks should also be made on all electrical connections, ensuring screw terminals are correctly torqued; and that power cables have no signs of heat damage.

# 4. Power & Control Wiring

## 4.1. Connection Diagram

All power terminal locations are marked directly on the product. DC+/BR/DC- terminals are not available on Size 1 models.

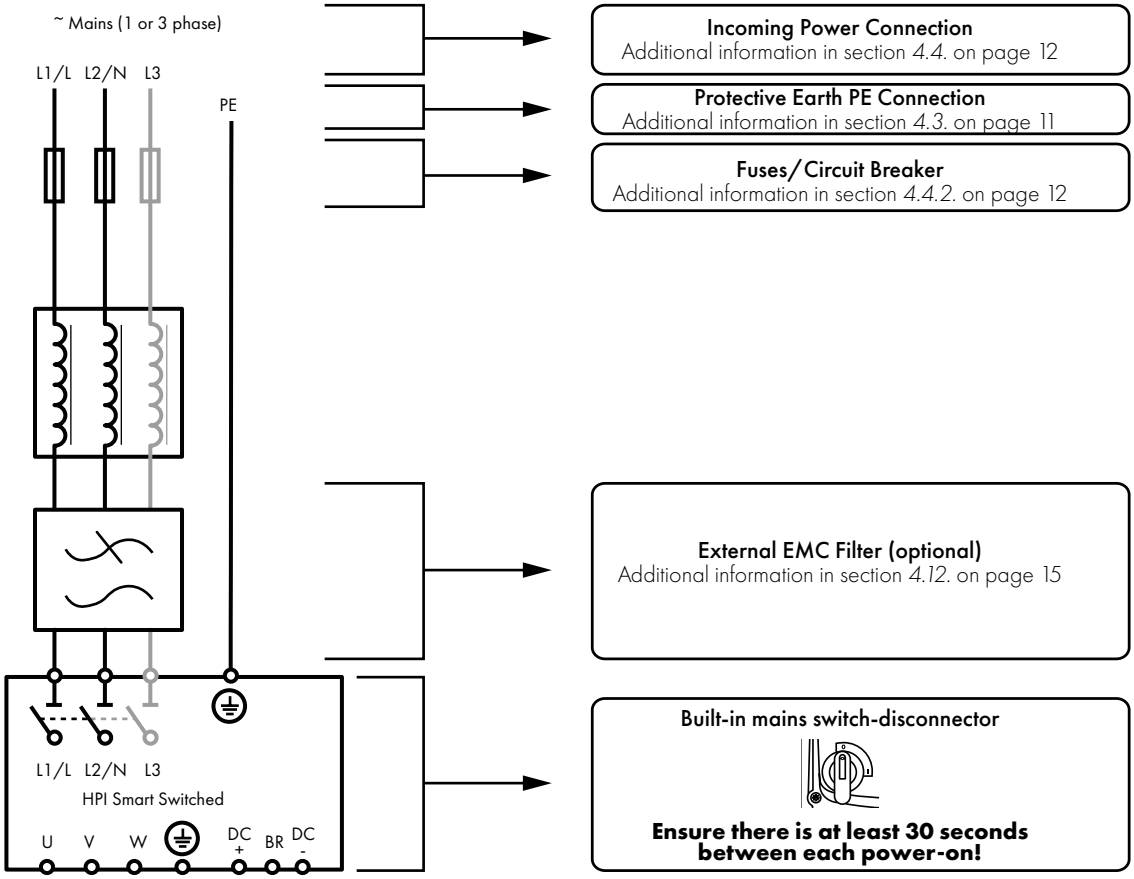
### *4.1.1. IP66 (Nema 4X) Non-Switched Units*




**NOTE** Enclosed drives are not suitable for rigid conduit system connection.

| | |
|---|---|
| ⚠ | This manual is intended as a guide for proper installation. Lafert Group cannot assume responsibility for the compliance or the non-compliance to any code, national, local or otherwise, for the proper installation of this drive or associated equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation. |
| ⚠ | This HPI Smart contains high voltage capacitors that take time to discharge after removal of the main supply. Before working on the drive, ensure isolation of the main supply from line inputs. Wait ten (10) minutes for the capacitors to discharge to safe voltage levels. Failure to observe this precaution could result in severe bodily injury or loss of life. |
| ⚠ | Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life. |

### *4.1.2. Electrical Power Connections – IP66 (NEMA 4X) Switched Models*




## 4.2. Protective Earth (PE) Connection

### Grounding Guidelines

The ground terminal of each HPI Smart should be individually connected DIRECTLY to the site ground bus bar (through the filter if installed). HPI Smart ground connections should not loop from one drive to another, or to, or from any other equipment. Ground loop impedance must confirm to local industrial safety regulations. To meet UL regulations, UL approved ring crimp terminals should be used for all ground wiring connections.

The drive Safety Ground must be connected to system ground. Ground impedance must conform to the requirements of national and local industrial safety regulations and/or electrical codes. The integrity of all ground connections should be checked periodically.

### Protective Earth Conductor

The Cross sectional area of the PE Conductor must be at least equal to that of the incoming supply conductor.

### Safety Ground

This is the safety ground for the drive that is required by code. One of these points must be connected to adjacent building steel (girder, joist), a floor ground rod, or bus bar. Grounding points must comply with national and local industrial safety regulations and/or electrical codes.

### Ground Fault Monitoring

As with all inverters, a leakage current to earth can exist. The HPI Smart is designed to produce the minimum possible leakage current whilst complying with worldwide standards. The level of current is affected by motor cable length and type, the effective switching frequency, the earth connections used and the type of RFI filter installed. If an ELCB (Earth Leakage Circuit Breaker) is to be used, the following conditions apply:

- A Type B Device must be used.
- The device must be suitable for protecting equipment with a DC component in the leakage current.
- Individual ELCBs should be used for each HPI Smart.

## 4.3. Incoming Power Connection

### *4.3.1. Cable Selection*

- For 3 phase supplies, the mains power cables should be connected to L1, L2, and L3. Phase sequence is not important.
- For compliance with CE EMC requirements, refer to section 4.7. EMC Compliant Installation on page 15.
- A fixed installation is required according to IEC61800-5-1 with a suitable disconnecting device installed between the HPI Smart and the AC Power Source. The disconnecting device must conform to the local safety code / regulations (e.g. within Europe, EN60204-1, Safety of machinery).
- The cables should be dimensioned according to any local codes or regulations. Maximum dimensions are given in section 9.2. Rating Tables.

### *4.3.2. Fuse / Circuit Breaker Selection*

- Suitable fuses to provide wiring protection of the input power cable should be installed in the incoming supply line, according to the data in section 9.2. Rating Tables. The fuses must comply with any local codes or regulations in place. In general, type gG (IEC 60269) or UL type J fuses are suitable; however in some cases type aR fuses may be required. The operating time of the fuses must be below 0.5 seconds.
- Where allowed by local regulations, suitably dimensioned type B MCB circuit breakers of equivalent rating may be utilised in place of fuses, providing that the clearing capacity is sufficient for the installation.
- The maximum permissible short circuit current at the HPI Smart Power terminals as defined in IEC60439-1 is 100kA.

### *4.3.3. Optional Input Choke*

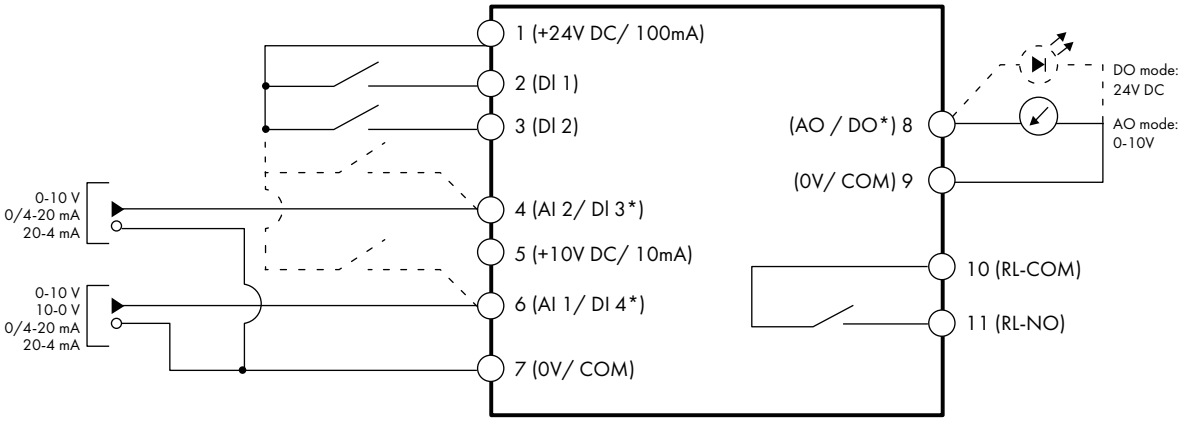
- An optional Input Choke is recommended to be installed in the supply line for drives frame size 1, 2 and 3 where any of the following conditions occur:
  - The incoming supply impedance is low or the fault level / short circuit current is high.
  - The supply is prone to dips or brown outs.
  - An imbalance exists on the supply (3 phase drives).
  - The power supply to the drive is via a busbar and brush gear system (typically overhead Cranes).
- In all other installations, an input choke is recommended to ensure protection of the drive against power supply faults. Part numbers are shown in the table.

| Supply | Frame Size | AC Input Inductor |
|---|---|---|
| 400 Volt 3 Phase | 1 | OPT-2-L3006-66 |
| | 2 | OPT-2-L3010-66 |
| | 3 | OPT-2-L3018-66 |

## 4.4. Control Terminal Wiring

- All analog signal cables should be suitably shielded. 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.
- Signal levels of different voltages e.g. 24 Volt DC and 110 Volt AC, should not be routed in the same cable.
- Maximum control terminal tightening torque is 0.5Nm.
- Control Cable entry conductor size: 0.05 – 2.5mm$^2$ / 30 – 12 AWG.

## 4.5. Control Terminal Connections




**NOTE**
* Dashed lines shows connection for analog inputs and output in digital mode

| Key | | | Default Function | | Sec. | Page |
|---|---|---|---|---|---|---|
| | | | Open | Closed | | |
| 1 | +24V DC | 24 Volt DC Output | On-board +24V DC Supply (100mA) | | | |
| 2 | DI 1 | Digital Input 1 (Run Enable) | STOP | RUN | | |
| 3 | DI 2 | Digital Input 2 | FORWARD | REVERSE | | |
| 4 | AI 2 / DI 3 | Analog Input 2 / Digital Input 3 | AI1 Reference | Preset Speed 1 (P-20) | | |
| 5 | +10V DC | +10Volt DC Output | On-board +10V DC Supply (10 mA) | | | |
| 6 | AI 1 / DI 4 | Analog Input 1 / Digital Input 4 | Speed Reference 1 (0-10V) | | | |
| 7 | 0V / COM | 0 Volt Common | 0V Common for AI/AO/DI/DO | | | |
| 8 | AO | Analog Output | Motor Speed (0-10V) | | | |
| 9 | 0V / COM | 0 Volt Common | 0V Common for AI/AO/DI/DO | | | |
| 10 | RL-COM | Relay Output Common | Drive Faulty | Drive Healthy | | |
| 11 | RL-NO | Relay Output NO Contact | | | | |

**NOTE**
Digital Inputs: Logic High = 8-30V DC (30V DC max)
Analog Output: 0 – 10 Volt (20mA max)
Relay Output: 6A/250V AC, 5A/30V DC (resistive load)

### *4.5.1. Analog Output*

The analog output function may be configured using parameter P-25, which is described in section 5.2. Extended Parameters on page 18.

The output has two operating modes, dependent on the parameter selection:

- Analog Mode
  - o The output is a 0 – 10 volt DC signal, 20mA max load current.
- Digital Mode
  - o The output is 24 volt DC, 20mA max load current.

### *4.5.2. Relay Output*

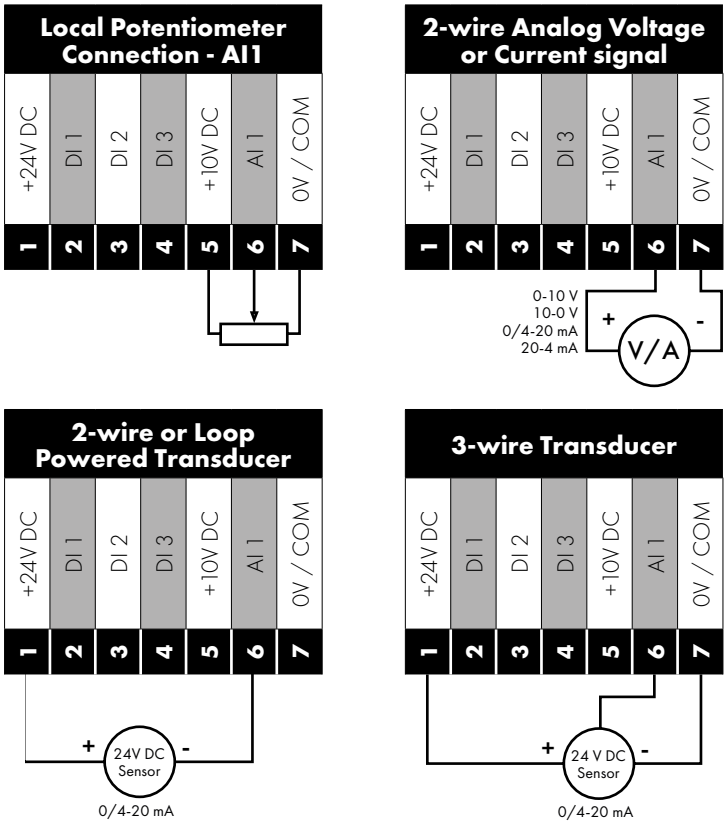
The relay output function may be configured using parameter P-18, which is described in section 5.2. Extended Parameters on page 18.

### *4.5.3. Analog Inputs*

Two analog inputs are available, which may also be used as Digital Inputs if required. The signal formats are selected by parameters as follows:

- Analog Input 1 Format Selection Parameter P-16.
- Analog Input 2 Format Selection Parameter P-47.

These parameters are described more fully in section 5.2. Extended Parameters on page 18.




The function of the analog input, e.g. for speed reference or PID feedback for example is defined by parameters P-15. The function of these parameters and available options is described in section 6. Analog and Digital Input Macro Configurations on page 26.

### *4.5.4. Digital Inputs*

Up to four digital inputs are available. The function of the inputs is defined by parameters P-12 and P-15, which are explained in section 6. Analog and Digital Input Macro Configurations on page 26.

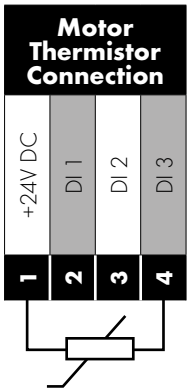
## 4.6. Motor Thermal Overload Protection

### *4.6.1. Internal Thermal Overload Protection*

The drive has an built-in motor thermal overload function; this is in the form of an "I.t-trP" trip after delivering >100% of the value set in P-08 for a sustained period of time (e.g. 150% for 60 seconds).

### *4.6.2. Motor Thermistor Connection*

Where a motor thermistor is to be used, it should be connected as follows:




**Additional Information**

Compatible Thermistor: PTC Type, 2.5kΩ trip level.

- Use a setting of P-15 that has Input 3 function as External Trip, e.g. P-15 = 3. Refer to section 6. Analog and Digital Input Macro Configurations on page 26 for further details.
- Set P-47 = "PtC-tH"

Refer to section 6. Analog and Digital Input Macro Configurations for further information regarding configuration of the input functions.

## 4.7. EMC Compliant Installation

| Category | Supply Cable Type | Motor Cable Type | Control Cables | Maximum Permissible Motor Cable Length |
|---|---|---|---|---|
| C1[6] | Shielded[1] | Shielded[1,5] | Shielded[4] | 1M / 5M[7] |

[1] A screened (shielded) cable suitable for fixed installation with the relevant mains voltage in use. Braided or twisted type screened cable where the screen covers at least 85% of the cable surface area, designed with low impedance to HF signals. Installation of a standard cable within a suitable steel or copper tube is also acceptable.

[2] A cable suitable for fixed installation with relevant mains voltage with a concentric protection wire. Installation of a standard cable within a suitable steel or copper tube is also acceptable.

[3] A cable suitable for fixed installation with relevant mains voltage. A shielded type cable is not necessary.

[4] A shielded cable with low impedance shield. Twisted pair cable is recommended for analog signals.

[5] The cable screen should be terminated at the motor end using an EMC type gland allowing connection to the motor body through the largest possible surface area. Where drives are mounted in a steel control panel enclosure, the cable screen may be terminated directly to the control panel using a suitable EMC clamp or gland, as close to the drive as possible. For IP66 drives, connect the motor cable screen to the internal ground clamp.

[6] Compliance with category C1 conducted emissions only is achieved. For compliance with category C1 radiated emissions, additional measures may be required, contact your Lafert Group Technical Department for further assistance.

[7] Permissible cable length with additional external EMC filter.

## 4.8. Optional Brake Resistor

HPI Smart Frame Size 2 and above units have a built-in Brake Transistor. This allows an external resistor to be connected to the drive to provide improved braking torque in applications that require this.

The brake resistor should be connected to the "+" and "BR" terminals as shown in the diagrams in sections 4.1. Connection Diagram.

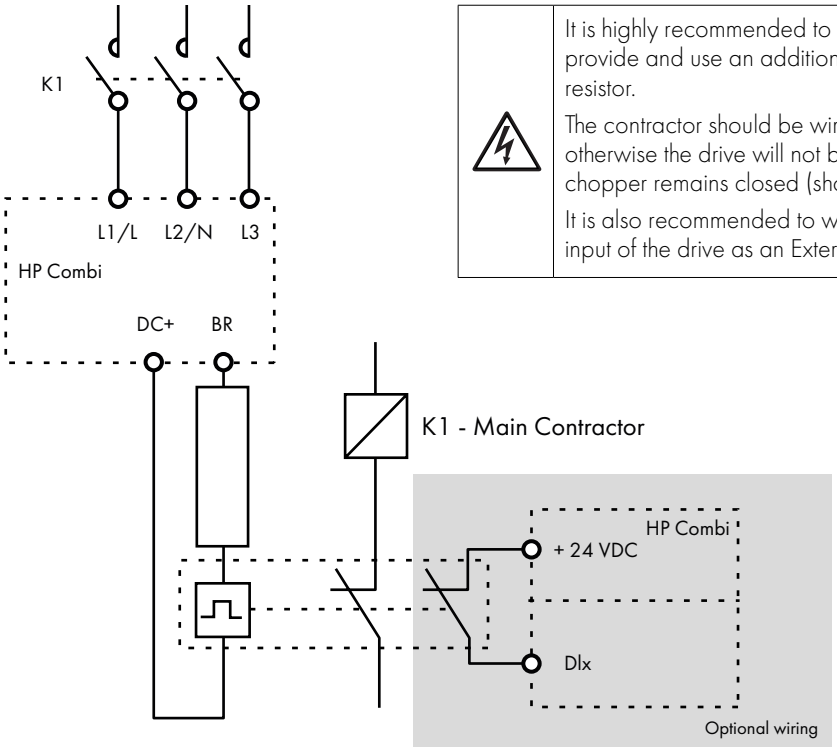
**The voltage level at these terminals may exceed 800VDC.**

**Stored charge may be present after disconnecting the mains power.**

**Allow a minimum of 10 minutes discharge after power off before attempting any connection to these terminals.**

Suitable resistors and guidance on selection can be obtained from your Lafert Group Technical Department. The brake transistor is enabled here by setting P-34 > 0. See section 5. Parameters for more information.

**Dynamic Brake Transistor with Thermal Overload Protection**




It is highly recommended to equip the drive with a main contactor and provide and use an additional thermal overload protection for braking resistor.

The contractor should be wired so that it opens in case the resistor overheats, otherwise the drive will not be able to interrupt the main supply if the brake chopper remains closed (short-circuited) in a faulty situation.

It is also recommended to wire the thermal overload protection to a digital input of the drive as an External Trip.

The voltage level at these terminals may exceed 800VDC.

Stored charge may be present after disconnecting the mains power.

Allow a minimum of 10 minutes discharge after power off before attempting any connection to these terminals.

Thermal Overload / Brake Resistor with internal Over Temperature switch

# 5. Parameters

## 5.1. Standard Parameters

The parameter set is arranged in Groups according to the following structure:

| Parameter Group | Range | Access Level | Access Type |
|---|---|---|---|
| P00 | P00-01 to P00-20 | Extended | Read Only |
| | P00-21 to P00-50 | Advanced | Read Only |
| Basic Parameters | P-01 to P-14 | Basic | Read / Write |
| Extended Parameters | P-15 to P-50 | Extended | Read / Write |
| Advanced Parameters | P-51 to P-60 | Advanced | Read / Write |

Access to all parameter groups is controlled by setting P-14 as follows:

P-14 = P-37 (Factory setting: 101) Allows Extended Parameter Access

P-14 = P-37 + 100 (Factory Setting: 201) Allows Advanced Parameter Access

In order to prevent possible damage to the drive and connected machinery, certain parameters are locked during operation of the drive to prevent change. In the case that the drive is enabled, and the user tries to change the parameter, an "L" is shown on the left of the display.

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| **P-01** | **Maximum Frequency / Speed Limit** | **Motor Rating Dependent** | | | **Hz / RPM** |
| | Maximum output frequency or motor speed limit – Hz or RPM. If P-10 >0, the value entered / displayed is in RPM. | | | | |
| **P-02** | **Minimum Frequency / Speed Limit** | **0.0** | **P-01** | **0.0** | **Hz / RPM** |
| | Minimum speed limit – Hz or RPM. If P-10 >0, the value entered / displayed is in RPM. | | | | |
| **P-03** | **Acceleration Ramp Time** | **0.00** | **600.0** | **5.0** | **s** |
| | Acceleration ramp time from zero Hz / RPM to base frequency (P-09) in seconds. | | | | |
| **P-04** | **Deceleration Ramp Time** | **0.00** | **600.0** | **5.0** | **s** |
| | Deceleration ramp time from base frequency (P-09) to standstill in seconds. When set to 0.00, the value of P-24 is used. | | | | |
| **P-05** | **Stopping Mode / Mains Loss Response** | **0** | **4** | **0** | **-** |

Selects the stopping mode of the drive, and the behaviour in response to a loss of mains power supply during operation.

| Setting | On Disable | On Mains Loss |
|---|---|---|
| 0 | Ramp to Stop (P-04) | Ride Through (Recover energy from load to maintain operation) |
| 1 | Coast | Coast |
| 2 | Ramp to Stop (P-04) | Fast Ramp to Stop (P-24), Coast if P-24 = 0 |
| 3 | Ramp to Stop (P-04) with AC Flux Braking | Fast Ramp to Stop (P-24), Coast if P-24 = 0 |
| 4 | Ramp to Stop (P-04) | No action |

| | | | | | |
|---|---|---|---|---|---|
| **P-06** | **Energy Optimiser** | **0** | **3** | **0** | **-** |

Motor Energy Optimisation is intended for use in applications where the motor operates for extended time periods at constant speed with light load. It should not be used in applications with large, sudden step changes in load or for PI control applications.

HPI Smart Energy Optimisation reduces the drive internal heat losses increasing efficiency however it may result in some vibration in the motor during light load operation. In general, this function is suited to Fan, Pump and Compressor applications.

| Setting | Motor Energy Optimisation | HPI Smart Energy Optimisation |
|---|---|---|
| 0 | Disabled | Disabled |
| 1 | Enabled | Disabled |
| 2 | Disabled | Enabled |
| 3 | Enabled | Enabled |

| | | | | | |
|---|---|---|---|---|---|
| **P-07** | **Motor Rated Voltage / Back EMF at rated speed (PM)** | **Motor Rating Dependent** | | | **V** |
| | This parameter should be set to the Back EMF at the rated speed (Displayed on nameplate) | | | | |
| **P-08** | **Motor Rated Current** | **Motor Rating Dependent** | | | **A** |
| | This parameter should be set to the rated (nameplate) current of the motor. | | | | |

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| P-09 | **Motor Rated Frequency** | **Motor Rating Dependent** | | | **Hz** |
| | This parameter should be set to the rated (nameplate) frequency of the motor. | | | | |
| P-10 | **Motor Rated Speed** | **0** | **30000** | **0** | **RPM** |
| | This parameter can optionally be set to the rated (nameplate) RPM of the motor. When set to the default value of zero, all speed related parameters are displayed in Hz. All speed related parameters, such as Minimum and Maximum Speed, Preset Speeds etc. will also be displayed in RPM.<br>**NOTE** If P-09 value is changed, P-10 value is reset to 0. | | | | |
| P-11 | **Low Frequency Torque Boost** | **Motor Rating Dependent** | | | **%** |
| | Low frequency torque can be improved by increasing this parameter. Excessive boost levels may however result in high motor current and increased risk of tripping on Over Current or Motor Overload (refer to section 9.1. Environmental).<br>This parameter operates in conjunction with P-51 (Motor Control Mode) as follows: | | | | |

| P-51 | P-11 | |
|---|---|---|
| 2 | All | Boost current level = 4*P-11*P-08. |

| P-12 | **Primary Command Source** | **0** | **9** | **0** | **-** |
|---|---|---|---|---|---|

**0: Terminal Control.** The drive responds directly to signals applied to the control terminals.

**1: Uni-directional Keypad Control.** The drive can be controlled in the forward direction only using the internal keypad, or an external remote Keypad.

**2: Bi-directional Keypad Control.** The drive can be controlled in the forward and reverse directions u using the internal keypad, or an external remote Keypad. Pressing the keypad START button toggles between forward and reverse.

**3: Modbus Network Control.** Control via Modbus RTU (RS485) using the internal Accel / Decel ramps.

**4: Modbus Network Control.** Control via Modbus RTU (RS485) interface with Accel / Decel ramps updated via Modbus.

**5: PI Control.** User PI control with external feedback signal.

**6: PI Analog Summation Control.** PI control with external feedback signal and summation with analog input 1.

**7: CAN Control.** Control via CAN (RS485) using the internal Accel / Decel ramps.

**8: CAN Control.** Control via CAN (RS485) interface with Accel / Decel ramps updated via CAN.

**9: Slave Mode.** Control via a connected Lafert Group drive in Master Mode. Slave drive address must be > 1.

**NOTE** When P-12 = 1, 2, 3, 4, 7, 8 or 9, an enable signal must still be provided at the control terminals, digital input 1.

| P-13 | **Operating Mode Select** | **0** | **2** | **0** | **-** |
|---|---|---|---|---|---|

Provides a quick set up to configure key parameters according to the intended application of the drive. Parameters are preset according to the table.

**0: Industrial Mode.** Intended for general purpose applications.

**1: Pump Mode.** Intended for centrifugal pump applications.

**2: Fan Mode.** Intended for Fan applications.

| Setting | Application | Current Limit (P-54) | Torque Characteristic | Spin Start (P-33) | Thermal Overload Limit Reaction (P-60 Index 2) |
|---|---|---|---|---|---|
| 0 | General | 150% | Constant | 0: Off | 0: Trip |
| 1 | Pump | 110% | Variable | 0: Off | 1: Current Limit Reduction |
| 2 | Fan | 110% | Variable | 2: On | 1: Current Limit Reduction |

| P-14 | **Extended Menu Access code** | **0** | **65535** | **0** | **-** |
|---|---|---|---|---|---|
| | Enables access to Extended and Advanced Parameter Groups. This parameter must be set to the value programmed in P-37 (default: 101) to view and adjust Extended Parameters and value of P-37 + 100 to view and adjust Advanced Parameters. The code may be changed by the user in P-37 if desired. | | | | |

## 5.2. Extended Parameters

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| **P-15** | **Digital Input Function Select** | **0** | **19** | **0** | **-** |
| | Defines the function of the digital inputs depending on the control mode setting in P-12. See section 6. Analog and Digital Input Macro Configurations for more information. | | | | |
| **P-16** | **Analog Input 1 Signal Format** | **See Below** | | **U0-10** | **-** |
| | U 0-10 = Uni-polar 0 to 10 Volt Signal. The drive will remain at minimum speed (P-02) if the analog reference after scaling and offset are applied is =<0.0%. 100% signal means the output frequency / speed will be the value set in P-01.<br>b 0-10 = Uni-polar 0 to 10 Volt Signal, bi-directional operation. The drive will operate the motor in the reverse direction of rotation if the analog reference after scaling and offset are applied is <0.0%. e.g. for bidirectional control from a 0 – 10 volt signal, set P-35 = 200.0%, P-39 = 50.0%.<br>A 0-20 = 0 to 20mA Signal.<br>t 4-20 = 4 to 20mA Signal, the HPI Smart will trip and show the fault code 4-20F 500ms after the signal level falls below 3mA.<br>r 4-20 = 4 to 20mA Signal, the HPI Smart will run at Preset Speed 1 (P-20 if the signal level falls below 3mA.<br>t 20-4 = 20 to 4mA Signal, the HPI Smart will trip and show the fault code 4-20F 500ms after the signal level falls below 3mA.<br>r 20-4 = 20 to 4mA Signal, the HPI Smart will run at Preset Speed 1 (P-20 if the signal level falls below 3mA.<br>U 10-0 = 10 to 0 Volt Signal (Uni-polar). The drive will operate at Maximum Frequency / Speed if the analog reference after scaling and offset are applied is =<0.0%. | | | | |
| **P-17** | **Maximum Effective Switching Frequency** | **Motor Rating Dependent** | | | **kHz** |
| | Sets maximum effective switching frequency of the drive. If "rEd" is displayed when the parameter is viewed, the switching frequency has been reduced to the level in P00-32 due to excessive drive heatsink temperature. | | | | |
| **P-18** | **Output Relay Function Select** | **0** | **12** | **1** | **-** |
| | Selects the function assigned to the relay output. The relay has two output terminals, Logic 1 indicates the relay is active, and therefore terminals 10 and 11 will be connected.<br>**0: Drive Enabled (Running).** Logic 1 when the motor is enabled.<br>**1: Drive Healthy.** Logic 1 when power is applied to the drive and no fault exists.<br>**2: At Target Frequency (Speed).** Logic 1 when the output frequency matches the setpoint frequency.<br>**3: Drive Tripped.** Logic 1 when the drive is in a fault condition.<br>**4: Output Frequency >= Limit.** Logic 1 when the output frequency exceeds the adjustable limit set in P-19.<br>**5: Output Current >= Limit.** Logic 1 when the motor current exceeds the adjustable limit set in P-19.<br>**6: Output Frequency < Limit.** Logic 1 when the output frequency is below the adjustable limit set in P-19.<br>**7: Output Current < Limit.** Logic 1 when the motor current is below the adjustable limit set in P-19.<br>**8: Analog Input 2 > Limit.** Logic 1 when the signal applied to analog input 2 exceeds the adjustable limit set in P-19.<br>**9: Drive Ready to Run.** Logic 1 when the drive is ready to run, no trip present.<br>**10: Fire Mode Active.** Logic 1 when Fire Mode is activated.<br>**11: Output Frequency > Limit and not Fire Mode.** As setting 4 however the output relay state does not change if the drive is in Fire Mode.<br>**12: Fieldbus Digital.** Status is controlled by PDO0 Bit 9.<br>**13: Digital Analog.** Analog output value set by PDO2 value, 0 – 4096. | | | | |
| **P-19** | **Relay Threshold Level** | **0.0** | **200.0** | **100.0** | **%** |
| | Adjustable threshold used in conjunction with settings 4 to 7 of P-18.<br>If P-66 = 0, the threshold is also applied to the Digital Output with settings 4 – 7 of P-25. | | | | |
| **P-20** | **Preset Frequency / Speed 1** | **-P-01** | **P-01** | **5.0** | **Hz / RPM** |
| **P-21** | **Preset Frequency / Speed 2** | **-P-01** | **P-01** | **25.0** | **Hz / RPM** |
| **P-22** | **Preset Frequency / Speed 3** | **-P-01** | **P-01** | **40.0** | **Hz / RPM** |
| **P-23** | **Preset Frequency / Speed 4** | **-P-01** | **P-01** | **P-09** | **Hz / RPM** |
| | Preset Speeds / Frequencies selected by digital inputs depending on the setting of P-15.<br>If P-10 = 0, the values are entered as Hz. If P-10 > 0, the values are entered as RPM.<br>**NOTE** Changing the value of P-09 will reset all values to factory default settings. | | | | |
| **P-24** | **2nd Ramp Time (Fast Stop)** | **0.00** | **600.0** | **0.00** | **s** |
| | This parameter allows a 2nd ramp time to be programmed into the drive.<br>This ramp time is automatically selected in the case of a mains power loss if P-05 = 2 or 3. When set to 0.00, the drive will coast to stop.<br>When using a setting of P-15 that provides a "Fast Stop" function, this ramp time is also used.<br>In addition, if P-24 > 0, P-02 > 0, P-26=0 and P-27 = P-02, this ramp time is applied to both acceleration and deceleration when operating below minimum speed, allowing selection of an alternative ramp when operating outside of the normal speed range, which may be useful in pump and compressor applications. | | | | |

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| **P-25** | **Analog Output Function Select** | **0** | **12** | **8** | **-** |
| | **Digital Output Mode. Logic 1 = +24V DC**<br>**0: Drive Enabled (Running).** Logic 1 when the HPI Smart is enabled (Running).<br>**1: Drive Healthy.** Logic 1 When no Fault condition exists on the drive.<br>**2: At Target Frequency (Speed).** Logic 1 when the output frequency matches the setpoint frequency.<br>**3: Drive Tripped.** Logic 1 when the drive is in a fault condition.<br>**4: Output Frequency >= Limit.** Logic 1 when the output frequency exceeds the adjustable limit set in P-19.<br>**5: Output Current >= Limit.** Logic 1 when the motor current exceeds the adjustable limit set in P-19.<br>**6: Output Frequency < Limit.** Logic 1 when the output frequency is below the adjustable limit set in P-19.<br>**7: Output Current < Limit.** Logic 1 when the motor current is below the adjustable limit set in P-19.<br>**Analog Output Mode**<br>**8: Output Frequency (Motor Speed).** 0 to P-01, resolution 0.1Hz.<br>**9: Output (Motor) Current.** 0 to 200% of P-08, resolution 0.1A.<br>**10: Output Power.** 0 – 200% of drive rated power.<br>**11: Load Current.** 0 – 200% of P-08, resolution 0.1A.<br>**12: Fieldbus.** The Output state is digitally controlled by the bit 9 of the fieldbus control word. Fieldbus type is selected by P-12. | | | | |
| **P-26** | **Skip Frequency Hysteresis Band** | **0.0** | **P-01** | **0.0** | **Hz / RPM** |
| **P-27** | **Skip Frequency Centre Point** | **0.0** | **P-01** | **0.0** | **Hz / RPM** |
| | The Skip Frequency function is used to avoid the HPI Smart operating at a certain output frequency, for example at a frequency which causes mechanical resonance in a particular machine. Parameter P-27 defines the centre point of the skip frequency band, and is used in conjunction with P-26. The HPI Smart output frequency will ramp through the defined band at the rates set in P-03 and P-04 respectively, and will not hold any output frequency within the defined band. If the frequency reference applied to the drive is within the band, the HPI Smart output frequency will remain at the upper or lower limit of the band. | | | | |
| **P-28** | **V/F Characteristic Adjustment Voltage** | **0** | **P-07** | **0** | **V** |
| **P-29** | **V/F Characteristic Adjustment Voltage** | **0.0** | **P-09** | **0.0** | **Hz** |
| **P-30** | **Start Mode, Automatic Restart, Fire Mode Operation** | | | | |
| | **Index 1: Start Mode & Automatic Restart** | **N/A** | **N/A** | **Edge-r** | **-** |
| | Selects whether the drive should start automatically if the enable input is present and latched during power on. Also configures the Automatic Restart function.<br>*EdGE-r*: Following Power on or reset, the drive will not start if Digital Input 1 remains closed. The Input must be closed after a power on or reset to start the drive.<br>*AUto-0*: Following a Power On or Reset, the drive will automatically start if Digital Input 1 is closed.<br>*AUto-1* To *AUto-5*: Following a trip, the drive will make up to 5 attempts to restart at 20 second intervals. The numbers of restart attempts are counted, and if the drive fails to start on the final attempt, the drive will trip with a fault, and will require the user to manually reset the fault. The drive must be powered down to reset the counter. | | | | |
| | **Index 2: Fire Mode Input Logic** | **0** | **3** | **0** | **-** |
| | Defines the operating logic when a setting of P-15 is used which includes Fire Mode, e.g. settings 15, 16 & 17.<br>**0: n.C: Normally Closed (NC) Input.** Fire Mode active if input is open.<br>**1: n.O: Normally Open (NO) Input.** Fire Mode active if input is closed.<br>**2: F-N.C: Normally Closed (NC) Input, Fixed Speed.** Fire Mode active if input is open. Fire Mode Speed is Preset Speed 4 (P-23).<br>**3: F-N.O: Normally Open (NO) Input, Fixed Speed.** Fire Mode active if input is closed. . Fire Mode Speed is Preset Speed 4 (P-23). | | | | |
| | **Index 3: Fire Mode Input Type** | **0** | **1** | **0** | **-** |
| | Defines the input type when a setting of P-15 is used which includes Fire Mode, e.g. settings 15, 16 & 17.<br>**0: Off.** The drive will remain in Fire Mode, only as long the fire mode input signal remains (Normally Open or Normally Closed operation is supported depending on Index 2 setting).<br>**1: On.** Fire Mode is activated by a momentary signal on the input. Normally Open or Normally Closed operation is supported depending on Index 2 setting. The drive will remain in Fire Mode until disabled or powered off. | | | | |

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| **P-31** | **Keypad Start Mode Select** | **0** | **7** | **1** | **-** |
| | This parameter is active only when operating in Keypad Control Mode (P-12 = 1 or 2) or Modbus Mode (P-12 = 3 or 4). When settings 0, 1, 4 or 5 are used, the Keypad Start and Stop keys are active, and control terminals 1 and 2 must be linked together. Settings 2, 3, 6 and 7 allow the drive to be started from the control terminals directly, and the keypad Start and Stop keys are ignored.<br>**0: Minimum Speed, Keypad Start**<br>**1: Previous Speed, Keypad Start**<br>**2: Minimum Speed, Terminal Enable**<br>**3: Previous Speed, Terminal Enable**<br>**4: Current Speed, Keypad Start**<br>**5: Preset Speed 4, Keypad Start**<br>**6: Current Speed, Terminal Start**<br>**7: Preset Speed 4, Terminal Start** | | | | |
| **P-32** | **DC Injection Configuration** | | | | |
| | **Index 1: Duration** | **0.0** | **25.0** | **0.0** | **s** |
| | **Index 2: DC Injection Mode** | **0** | **2** | **0** | **-** |
| | **Index 1:** Defines the time for which a DC current is injected into the motor. DC Injection current level may be adjusted in P-59.<br>**Index 2:** Configures the DC Injection Function as follows:<br>**0: DC Injection on Stop.** DC is injected into the motor at the current level set in P-59 following a stop command, after the output frequency has reduced to P-58 for the time set in Index 1.<br>**NOTE** If the drive is in Standby Mode prior to disable, the DC injection is disabled<br>**1: DC Injection on Start.** DC is injected into the motor at the current level set in P-59 for the time set in Index 1 immediately after the drive is enabled, prior to the output frequency ramping up. The output stage remains active during this phase. This can be used to ensure the motor is at standstill prior to starting.<br>**2: DC Injection on Start & Stop**. DC injection applied as both settings 0 and 1 above. | | | | |
| **P-33** | **Spin Start** | **0** | **2** | **0** | **-** |
| | **0: Disabled**<br>**1: Enabled.** When enabled, on start up the drive will attempt to determine if the motor is already rotating, and will begin to control the motor from its current speed. A short delay may be observed when starting motors which are not turning.<br>**2: Enabled on Trip, Brown Out or Coast Stop.** Spin start is only activated following the events listed, otherwise it is disabled. | | | | |
| **P-34** | **Brake Chopper Enable (Not Size 1)** | **0** | **4** | **0** | **-** |
| | **0: Disabled**<br>**1: Enabled With Software Protection.** Brake chopper enabled with software protection for a 200W continuous rated resistor.<br>**2: Enabled Without Software Protection.** Enables the internal brake chopper without software protection. An external thermal protection device should be fitted.<br>**3: Enabled With Software Protection.** As setting 1, however the Brake Chopper is only enabled during a change of the frequency setpoint, and is disabled during constant speed operation.<br>**4: Enabled Without Software Protection.** As setting 2, however the Brake Chopper is only enabled during a change of the frequency setpoint, and is disabled during constant speed operation. | | | | |
| **P-35** | **Analog Input 1 Scaling / Slave Speed Scaling** | **0.0** | **2000.0** | **100.0** | **%** |
| | **Analog Input 1 Scaling.** The analog input signal level is multiplied by this factor, e.g. if P-16 is set for a 0 – 10V signal, and the scaling factor is set to 200.0%, a 5 volt input will result in the drive running at maximum frequency / speed (P-01).<br>**Slave Speed Scaling.** When operating in Slave Mode (P-12 = 9), the operating speed of the drive will be the Master speed multiplied by this factor, limited by the minimum and maximum speeds. | | | | |

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| **P-36** | **Serial Communications Configuration** | **See Below** | | | |
| | **Index 1: Address** | **0** | **63** | **1** | **-** |
| | **Index 2: Baud Rate** | **9.6** | **1000** | **115.2** | **kbps** |
| | **Index 3: Communication loss protection** | **0** | **3000** | **t 3000** | **ms** |
| | This parameter has three sub settings used to configure the Modbus RTU Serial Communications. The Sub Parameters are: | | | | |
| | **1st Index: Drive Address:** Range: 0 – 63, default: 1. | | | | |
| | **2nd Index: Baud Rate & Network type:** Selects the baud rate and network type for the internal RS485 communication port.<br>For Modbus RTU: Baud rates 9.6, 19.2, 38.4, 57.6, 115.2 kbps are available.<br>For CAN: Baud rates 125, 250, 500 & 1000 kbps are available. | | | | |
| | **3rd Index: Watchdog Timeout:** Defines the time for which the drive will operate without receiving a valid command telegram to Register 1 (Drive Control Word) after the drive has been enabled. Setting 0 disables the Watchdog timer. Setting a value of 30, 100, 1000, or 3000 defines the time limit in milliseconds for operation. A '**t**' suffix selects trip on loss of communication. An '**r**' suffix means that the drive will coast stop (output immediately disabled) but will not trip. | | | | |
| **P-37** | **Access Code Definition** | **0** | **9999** | **101** | **-** |
| | Defines the access code which must be entered in P-14 to access parameters above P-14. | | | | |
| **P-38** | **Parameter Access Lock** | **0** | **1** | **0** | **-** |
| | **0: Unlocked.** All parameters can be accessed and changed.<br>**1: Locked.** Parameter values can be displayed, but cannot be changed except P-38. | | | | |
| **P-39** | **Analog Input 1 Offset** | **-500.0** | **500.0** | **0.0** | **%** |
| | Sets an offset, as a percentage of the full scale range of the input, which is applied to the analog input signal. This parameter operates in conjunction with P-35, and the resultant value can be displayed in P00-01.<br>The resultant value is defined as a percentage, according to the following:<br>P00-01 = (Applied Signal Level(%) - P-39) x P-35). | | | | |
| **P-40** | **Index 1: Display Scaling Factor** | **0.000** | **16.000** | **0.000** | **-** |
| | **Index 2: Display Scaling Source** | **0** | **3** | **0** | **-** |
| | Allows the user to program the HPI Smart to display an alternative output unit scaled from either output frequency (Hz), Motor Speed (RPM) or the signal level of PI feedback when operating in PI Mode. | | | | |
| | **Index 1:** Used to set the scaling multiplier. The chosen source value is multiplied by this factor. | | | | |
| | **Index 2:** Defines the scaling source as follows:<br>**0: Motor Speed.** Scaling is applied to the output frequency if P-10 = 0, or motor RPM if P-10 > 0.<br>**1: Motor Current.** Scaling is applied to the motor current value (Amps).<br>**2: Analog Input 2 Signal Level.** Scaling is applied to analog input 2 signal level, internally represented as 0 – 100.0%.<br>**3: PI Feedback.** Scaling is applied to the PI feedback selected by P-46, internally represented as 0 – 100.0%. | | | | |
| **P-41** | **PI Controller Proportional Gain** | **0.0** | **30.0** | **1.0** | **-** |
| | PI Controller Proportional Gain. Higher values provide a greater change in the drive output frequency in response to small changes in the feedback signal. Too high a value can cause instability. | | | | |
| **P-42** | **PI Controller Integral Time** | **0.0** | **30.0** | **1.0** | **s** |
| | PI Controller Integral Time. Larger values provide a more damped response for systems where the overall process responds slowly. | | | | |
| **P-43** | **PI Controller Operating Mode** | **0** | **3** | **0** | **-** |
| | **0: Direct Operation.** Use this mode if when the feedback signal drops, the motor speed should increase.<br>**1: Inverse Operation.** Use this mode if when the feedback signal drops, the motor speed should decrease.<br>**2: Direct Operation, Wake at Full Speed.** As setting 0, but on restart from Standby, PI Output is set to 100%.<br>**3: Inverse Operation, Wake at Full Speed.** As setting 0, but on restart from Standby, PI Output is set to 100%. | | | | |
| **P-44** | **PI Reference (Setpoint) Source Select** | **0** | **1** | **0** | **-** |
| | Selects the source for the PID Reference / Setpoint.<br>**0: Digital Preset Setpoint.** P-45 is used.<br>**1: Analog Input 1 Setpoint.** Analog input 1 signal level, readable in P00-01 is used for the setpoint.<br>**2: Fieldbus PDO2 Setpoint.** Setpoint is determined by the value of Fieldbus PDO2. 0 – 4096 = 0 – 100.0%. | | | | |

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| **P-45** | **PI Digital Setpoint** | **0.0** | **100.0** | **0.0** | **%** |
| | When P-44 = 0, this parameter sets the preset digital reference (setpoint) used for the PI Controller as a % of the feedback signal. | | | | |
| **P-46** | **PI Feedback Source Select** | **0** | **5** | **0** | **-** |
| | Selects the source of the feedback signal to be used by the PI controller.<br>**0: Analog Input 2** (Terminal 4) Signal level readable in P00-02.<br>**1: Analog Input 1** (Terminal 6) Signal level readable in P00-01.<br>**2: Motor Current** Scaled as % of P-08.<br>**3: DC Bus Voltage** Scaled 0 – 1000 Volts = 0 – 100%.<br>**4: Analog 1 – Analog 2** The value of Analog Input 2 is subtracted from Analog 1 to give a differential signal. The value is limited to 0.<br>**5: Largest (Analog 1, Analog 2)** The larger of the two analog input values is always used for PI feedback. | | | | |
| **P-47** | **Analog Input 2 Signal Format** | **-** | **-** | **-** | **U0-10** |
| | U 0-10 = 0 to 10 Volt Signal.<br>A 0-20 = 0 to 20mA Signal.<br>t 4-20 = 4 to 20mA Signal, the HPI Smart will trip and show the fault code 4-20F 500ms after the signal level falls below 3mA.<br>r 4-20 = 4 to 20mA Signal, the HPI Smart will run at Preset Speed 1 (P-20) if the signal level falls below 3mA.<br>t 20-4 = 20 to 4mA Signal, the HPI Smart will trip and show the fault code 4-20F 500ms after the signal level falls below 3mA.<br>r 20-4 = 20 to 4mA Signal, the HPI Smart will run at Preset Speed 1 (P-20) if the signal level falls below 3mA.<br>Ptc-th = Use for motor thermistor measurement, valid with any setting of P-15 that has Input 3 as E-Trip. Trip level: 1.5kΩ, reset 1kΩ. | | | | |
| **P-48** | **Standby Mode Timer** | **0.0** | **60.0** | **0.0** | **s** |
| | When standby mode is enabled by setting P-48 > 0.0, the drive will enter standby following a period of operating at minimum speed (P-02) for the time set in P-48. When in Standby Mode, the drive display shows StndbY, and the output to the motor is disabled. | | | | |
| **P-49** | **PI Control Wake Up Error Level** | **0.0** | **100.0** | **5.0** | **%** |
| | When the drive is operating in PI Control Mode (P-12 = 5 or 6), and Standby Mode is enabled (P-48 > 0.0), P-49 can be used to define the PI Error Level (E.g. difference between the setpoint and feedback) required before the drive restarts after entering Standby Mode. This allows the drive to ignore small feedback errors and remain in Standby mode until the feedback drops sufficiently. | | | | |
| **P-50** | **User Output Relay Hysteresis** | **0.0** | **100.0** | **0.0** | **%** |
| | Sets the hysteresis level for P-19 to prevent the output relay chattering when close to the threshold. | | | | |

## 5.3. Advanced Parameters

| Par. | Description | Minimum | Maximum | Default | Units |
|---|---|---|---|---|---|
| **P-51** | **Motor Control Mode** | **0** | **5** | **2** | **-** |
| | **2: PM motor vector speed control** | | | | |
| **P-52** | **Motor Parameter Autotune** | **0** | **1** | **0** | **-** |
| | **0: Disabled**<br>**1: Enabled.** When enabled, the drive immediately measures required data from the motor for optimal operation. Ensure all motor related parameters are correctly set first before enabling this parameter.<br>For settings 2 of P-51, autotune MUST be carried out AFTER all other required motor settings are entered. | | | | |
| **P-53** | **Vector Mode Gain** | **0.0** | **200.0** | **50.0** | **%** |
| | Single Parameter for Vector speed loop tuning. Affects P & I terms simultaneously. | | | | |
| **P-54** | **Maximum Current Limit** | **0.0** | **175.0** | **150.0** | **%** |
| | Defines the max current limit in vector control modes | | | | |
| **P-55** | **Motor Stator Resistance** | **Motor Rating Dependent** | | | **Ω** |
| | Motor stator resistance in Ohms. Determined by Autotune, adjustment is not normally required. | | | | |
| **P-56** | **Motor Stator d-axis Inductance (Lsd)** | **Motor Rating Dependent** | | | **mH** |
| | Determined by Autotune, adjustment is not normally required. | | | | |
| **P-57** | **Motor Stator q-axis Inductance (Lsq)** | **Motor Rating Dependent** | | | **mH** |
| | Determined by Autotune, adjustment is not normally required. | | | | |
| **P-58** | **DC Injection Speed** | **0.0** | **P-01** | **0.0** | **Hz / RPM** |
| | Sets the speed at which DC injection current is applied during braking to Stop, allowing DC to be injected before the drive reaches zero speed if desired. | | | | |
| **P-59** | **DC Injection Current** | **0.0** | **100.0** | **20.0** | **%** |
| | Sets the level of DC injection braking current applied according to the conditions set in P-32 and P-58. | | | | |
| **P-60** | **Motor Overload Management** | **-** | **-** | **-** | **-** |
| | **Index 1: Thermal Overload Retention** | **0** | **1** | **0** | **1** |
| | **0: Disabled**<br>**1: Enabled.** When enabled, the drive calculated motor overload protection information is retained after the mains power is removed from the drive. | | | | |
| | **Index 2: Thermal Overload Limit Reaction** | **0** | **1** | **0** | **1** |
| | **0: It.trp.** When the overload accumulator reaches the limit, the drive will trip on It.trp to prevent damage to the motor.<br>**1: Current Limit Reduction.** When the overload accumulator reaches 90% of, the output current limit is internally reduced to 100% of P-08 in order to avoid an It.trp. The current limit will return to the setting in P-54 when the overload accumulator reaches 10%. | | | | |
| **P-61** | **Ethernet Service Option** | **0** | **1** | **0** | **-** |
| | 0: Disabled 1: Enabled | | | | |
| **P-62** | **Ethernet Service Timeout** | **0** | **60** | **0** | **mins** |
| | 0: Disabled >0: Timeout in minutes | | | | |
| **P-63** | **Modbus Mode Selection** | **0** | **1** | **0** | **-** |
| | 0: Standard[1] 1: Advanced[2] | | | | |
| **P-64** | **IP66 DI1 Source** | **0** | **4** | **0** | **-** |
| | **Visible only on IP66 Switched Drives**<br>0: Terminal 2 OR Switch Forward OR Switch Reverse<br>1: Terminal 2 Only<br>2: Terminal 2 AND Switch Forward OR Switch Reverse<br>3: Terminal 2 AND (S-Forward OR Switch Reverse)<br>4: Terminal 2 AND Switch Forward | | | | |
| **P-65** | **IP66 DI2 Source** | **0** | **2** | **0** | **-** |
| | **Visible only on IP66 Switched Drive**<br>0: Terminal 3 OR Switch Reverse<br>1: Terminal 3 Only<br>2: Terminal 3 AND Switch Reverse | | | | |
| **P-66** | **Digital Output Adjustable Threshold** | **0.0** | **200.0** | **100.0** | **%** |
| | Adjustable threshold used in conjunction with settings 4 to 7 of P-25.<br>If P-66 = 0, the threshold set in P-19 is used. | | | | |

## 5.4. Commissiong your HPS Motor

***Synchronous Permanent Magnet AC Motors (PM)***

**Suitable Motors**

HPI Smart provides open loop control of permanent magnet AC motors, intended to allow the use of high efficiency motors in simple applications. Both interior and exterior magnets type motors are supported.

Operation is permitted with motors meeting the following criteria:

- The motor Back EMF is >=1 V / Hz.
  - **NOTE** Operation of motors with <1V/Hz Back EMF ratio may be possible with reduced speed range.
- Maximum motor frequency 360Hz.
- RMS Back EMF must not exceed the AC supply voltage during motor operation.
  - **Warning!** If the peak Back EMF exceeds 800V, the drive may be permanently damaged!

**Commissioning Procedure**

When operating with permanent magnet motors, the commissioning steps are as follows:

- Enter the motor Back EMF at Rated Frequency / Speed in parameter P-07.
  - This parameter must not be set to the rated motor voltage, but the actual Back EMF imposed by the motor magnets at the drive output terminals.
- Enter the Motor Rated Current in P-08.
  - It is possible that excessive current levels may permanently damage the motor, therefore this parameter must be set correctly to ensure this cannot occur.
  - Additionally, this current level is used by the autotune to determine the correct inductance values.
- Enter the motor rated frequency in P-09.
- Optionally enter the motor rated speed in P-10.
- Enabled Advanced Parameter Access by setting P-14 = P-37 + 100 (Default : 201).
- Select the appropriate motor type in P-51
  - For PM motor control P-51 = 2
- Carry out an Autotune.
  - An Autotune MUST be carried out.
  - This is achieved by setting P-52 = 1.
  - The autotune will begin IMMEDIATELY following the setting of this parameter! The drive output will be enabled, and the motor shaft may move. It is important to ensure this is safe before carrying out the autotune.
  - For PM motors, the autotune measures the motor stator resistance and both Q and D axis inductance values. Parameters P-55, P-56 and P-57 will be updated following the measurements.
- It should now be possible to operate the motor.
- Low speed and starting of the motor may be further optimised by adjusting P-11.
  - In PM motor control mode, P-11 adjust the additional current injected into the motor at low frequency to help maintain the rotor alignment and ensure reliable starting.
- Speed regulation and response to load changes may be improved by adjusting P-53 Vector Gain to suit the motor and connected load.
  - Higher values will provide a more dynamic behaviour at the risk of instability.

## 5.5. P-00 Read Only Status Parameters

| Par. | Description | Explanation |
|---|---|---|
| **P00-01** | Analog Input 1 Value (%) | 100% = max input voltage. |
| **P00-02** | Analog Input 2 Value (%) | 100% = max input voltage. |
| **P00-03** | Speed Controller Reference (Hz / RPM) | Displayed in Hz if P-10 = 0, otherwise RPM. |
| **P00-04** | Digital Input Status | Drive digital input status. |
| **P00-05** | PI Output (%) | Displays value of the User PI output. |
| **P00-06** | DC Bus Voltage Ripple (V) | Measured DC bus ripple. |
| **P00-07** | Motor Voltage (V) | Value of RMS voltage applied to motor. |
| **P00-08** | DC Bus Voltage (V) | Internal DC bus voltage. |
| **P00-09** | Heatsink Temperature (°C) | Temperature of heatsink in °C. |
| **P00-10** | Run Time Since Date of Manuf. (Hours) | Not affected by resetting factory default parameters. |
| **P00-11** | Run Time Since Last Trip (1) (Hours) | Run-time clock stopped by drive disable (or trip), reset on next enable only if a trip occurred. Reset also on next enable after a drive power down. |
| **P00-12** | Run Time Since Last Trip (2) (Hours) | Run-time clock stopped by drive disable (or trip), reset on next enable only if a trip occurred (under-volts not considered a trip) – not reset by power down / power up cycling unless a trip occurred prior to power down. |
| **P00-13** | Trip Log | Displays most recent 4 trips with time stamp. |
| **P00-14** | Run Time Since Last Enable (Hours) | Run-time clock stopped on drive disable, value reset on next enable. |
| **P00-15** | Dc Bus Voltage Log (V) | 8 most recent values prior to trip, 256ms sample time. |
| **P00-16** | Heatsink Temperature Log (°C) | 8 most recent values prior to trip, 30s sample time. |
| **P00-17** | Motor Current Log (A) | 8 most recent values prior to trip, 256ms sample time. |
| **P00-18** | DC Bus Voltage Ripple Log (V) | 8 most recent values prior to trip, 22ms sample time. |
| **P00-19** | Internal Temperature Log (°C) | 8 most recent values prior to trip, 30 s sample time. |
| **P00-20** | Internal Temperature (°C) | Actual internal ambient temperature in °C. |
| **P00-21** | CAN Process Data Input | Incoming process data (RX PDO1) for CAN: PI1, PI2, PI3, PI4. |
| **P00-22** | CAN Process Data Output | Outgoing process data (TX PDO1) for CAN: PO1, PO2, PO3, PO4. |
| **P00-23** | Accumulated Time with Heatsink > 85°C (Hours) | Total accumulated hours and minutes of operation above heatsink temp of 85°C. |
| **P00-24** | Accumulated Time with Internal Temp > 80°C (Hours) | Total accumulated hours and minutes of operation with drive internal ambient above 80°C. |
| **P00-25** | Estimated Rotor Speed (Hz) | In vector control modes, estimated rotor speed in Hz. |
| **P00-26** | kWh meter / MWh meter | Total number of kWh / MWh consumed by the drive. |
| **P00-27** | Cooling Fan Operating Lifetime (Hours) | Time displayed in hh:mm:ss. First value displays time in hrs, press up to display mm:ss. |
| **P00-28** | Software Version | Version number and checksum. "1" on LH side indicates I/O processor, "2" indicates power stage. |
| **P00-29** | Drive Type | Drive rating, drive type and software version codes. |
| **P00-30** | Drive Serial Number | Unique drive serial number. |
| **P00-31** | Motor Current Id / Iq | Displays the magnetising current (Id) and torque current (Iq). Press UP to show Iq. |
| **P00-32** | Actual Eff. Switching Frequency (kHz) | Actual switching frequency used by drive. |
| **P00-33** | O-I Fault Counter | These parameters log the number of times specific faults or errors occur, and are useful for diagnostic purposes. |
| **P00-34** | O-Volts Fault Counter | |
| **P00-35** | U-Volts Fault Counter | |
| **P00-36** | Heatsink O-Temp Counter | |
| **P00-37** | B O-I Fault Counter | |
| **P00-38** | Internal O-Temp Counter | |
| **P00-39** | Modbus RTU Fault Counter | |
| **P00-40** | CAN Fault Counter | |
| **P00-41** | I/O Comms Fault Counter | |
| **P00-42** | DSP Comms Fault Counter | |
| **P00-43** | Drive Total Life Time (Hours) | Total lifetime of drive with power applied. |
| **P00-44** | Phase U Current Offset & Ref | Internal value. |
| **P00-45** | Phase V Current Offset & Ref | Internal value. |
| **P00-46** | Phase W Current Offset & Ref | Internal value. |
| **P00-47** | Index 1: Fire Mode Total Active Time<br>Index 2: Fire Mode Activation Count | Total activation time of Fire Mode.<br>Displays the number of times Fire Mode has been activated. |
| **P00-48** | Scope Channel 1 & 2 | Displays signals for scope channels 1 & 2. |
| **P00-49** | Scope Channel 3 & 4 | Displays signals for scope channels 3 & 4. |
| **P00-50** | Bootloader and Motor Control | Internal value. |

# 6. Analog and Digital Input Macro Configurations

## 6.1. Overview

HPI Smart uses a Macro approach to simplify the configuration of the Analog and Digital Inputs. There are two key parameters which determine the input functions and drive behaviour:

**P-12** Selects the main drive control source and determines how the output frequency of the drive is primarily controlled.

**P-15** Assigns the Macro function to the analog and digital inputs.

Additional parameters can then be used to further adapt the settings, e.g.

**P-16** Used to select the format of the analog signal to be connected to analog input 1, e.g. 0 – 10 Volt, 4 – 20mA.

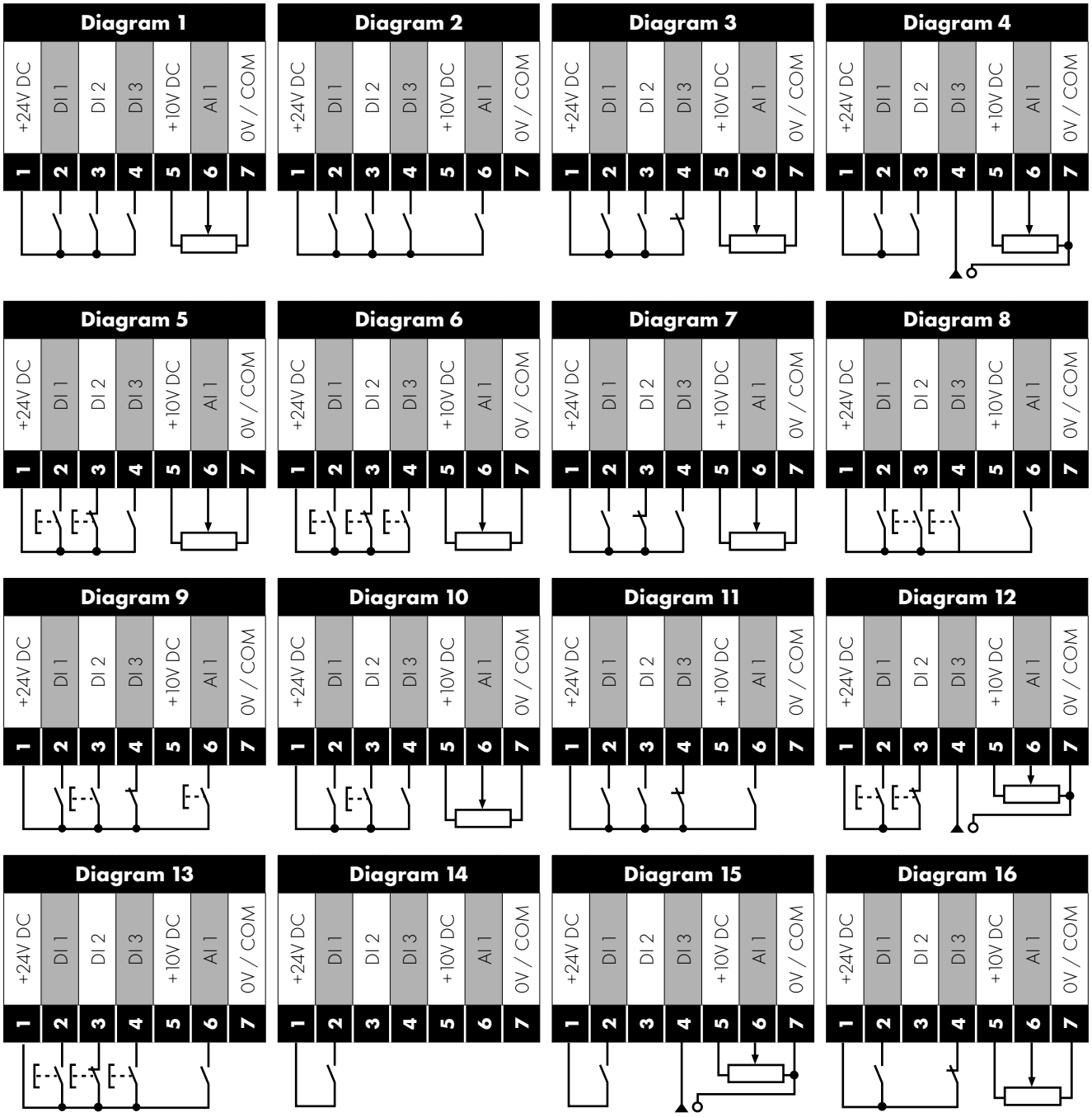
**P-30** Determines whether the drive should automatically start following a power on if the Enable Input is present.

**P-31** When Keypad Mode is selected, determines at what output frequency / speed the drive should start following the enable command, and also whether the keypad start key must be pressed or if the Enable input alone should start the drive.

**P-47** Used to select the format of the analog signal to be connected to analog input 2, e.g. 0 – 10 Volt, 4 – 20mA.

## 6.2. Example Connection Diagrams

The diagrams below provide an overview of the functions of each terminal macro function, and a simplified connection diagram for each.



## 6.3. Macro Functions Guide Key

The table below should be used as a key on the following pages.

| Function | Explanation |
|---|---|
| **STOP** | Latched Input, Open the contact to STOP the drive |
| **RUN** | Latched input, Close the contact to Start, the drive will operate as long as the input is maintained |
| **FWD↻** | Latched Input, selects the direction of motor rotation FORWARD |
| **REV↺** | Latched Input, selects the direction of motor rotation REVERSE |
| **RUN FWD↻** | Latched Input, Close to Run in the FORWARD direction, Open to STOP |
| **RUN REV↺** | Latched Input, Close to Run in the REVERSE direction, Open to STOP |
| **ENABLE** | Hardware Enable Input.<br>In Keypad Mode, P-31 determines whether the drive immediately starts, or the keypad start key must be pressed.<br>In other modes, this input must be present before the start command is applied via the fieldbus interface. |
| **START↥** | Normally Open, Rising Edge, Close momentarily to START the drive (NC STOP Input must be maintained) |
| **^- START -^** | Simultaneously applying both inputs momentarily will START the drive (NC STOP Input must be maintained) |
| **STOP↴** | Normally Closed, Falling Edge, Open momentarily to STOP the drive |
| **START↥FWD↻** | Normally Open, Rising Edge, Close momentarily to START the drive in the forward direction (NC STOP Input must be maintained) |
| **START↥REV↺** | Normally Open, Rising Edge, Close momentarily to START the drive in the reverse direction (NC STOP Input must be maintained) |
| **^-FAST STOP (P-24)-^** | When both inputs are momentarily active simultaneously, the drive stops using Fast Stop Ramp Time P-24 |
| **FAST STOP↴ (P-24)** | Normally Closed, Falling Edge, Open momentarily to FAST STOP the drive using Fast Stop Ramp Time P-24 |
| **E-TRIP** | Normally Closed, External Trip input. When the input opens momentarily, the drive trips showing E-tr iP or Ptc-th depending on P-47 setting |
| **Fire Mode** | Activates Fire Mode |
| **Analog Input AI1** | Analog Input 1, signal format selected using P-16 |
| **Analog Input AI2** | Analog Input 2, signal format selected using P-47 |
| **AI1 REF** | Analog Input 1 provides the speed reference |
| **AI2 REF** | Analog Input 2 provides the speed reference |
| **P-xx REF** | Speed reference from the selected preset speed |
| **PR-REF** | Preset speeds P-20 – P-23 are used for the speed reference, selected according to other digital input status |
| **PI-REF** | PI Control Speed Reference |
| **PI FB** | Analog Input used to provide a Feedback signal to the internal PI controller |
| **KPD REF** | Keypad Speed Reference selected |
| **FB REF** | Selected speed reference from Fieldbus (Modbus RTU / CAN Open / Master depending on P-12 setting) |
| **(NO)** | Input is Normally Open, Close momentarily to activate the function |
| **(NC)** | Input is Normally Closed, Open momentarily to activate the function |
| **INC SPD↥** | Normally Open, Rising Edge, Close momentarily to increase the motor speed by value in P-20 |
| **DEC SPD↴** | Normally Open, Rising Edge, Close momentarily to decrease the motor speed by value in P-20 |

## 6.4. Macro Functions – Terminal Mode (P-12 = 0)

| P-15 | DI1 | | DI2 | | DI3 / AI2 | | DI4 / AI1 | | Diagram |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | |
| **0** | STOP | RUN | FWD ↻ | REV ↺ | AI1 REF | P-20 REF | Analog Input AI1 | | 1 |
| **1** | STOP | RUN | AI1 REF | PR-REF | P-20 | P-21 | Analog Input AI1 | | 1 |
| **2** | STOP | RUN | **DI2** | **DI3** | **PR** | | P-20 - P-23 | P-01 | 2 |
| | | | 0 | 0 | P-20 | | | | |
| | | | 1 | 0 | P-21 | | | | |
| | | | 0 | 1 | P-22 | | | | |
| | | | 1 | 1 | P-23 | | | | |
| **3** | STOP | RUN | AI1 | P-20 REF | E-TRIP | OK | Analog Input AI1 | | 3 |
| **4** | STOP | RUN | AI1 | AI2 | Analog Input AI2 | | Analog Input AI1 | | 4 |
| **5** | STOP | RUN FWD ↻ | STOP | RUN REV ↺ | AI1 | P-20 REF | Analog Input AI1 | | 1 |
| | | ^------FAST STOP (P-24)------^ | | | | | | | |
| **6** | STOP | RUN | FWD ↻ | REV ↺ | E-TRIP | OK | Analog Input AI1 | | 3 |
| **7** | STOP | RUN FWD ↻ | STOP | RUN REV ↺ | E-TRIP | OK | Analog Input AI1 | | 3 |
| | | ^------FAST STOP (P-24)------^ | | | | | | | |
| **8** | STOP | RUN | FWD ↻ | REV | **DI3** | **DI4** | **PR** | | 2 |
| | | | | | 0 | 0 | P-20 | | |
| | | | | | 1 | 0 | P-21 | | |
| | | | | | 0 | 1 | P-22 | | |
| | | | | | 1 | 1 | P-23 | | |
| **9** | STOP | START FWD ↻ | STOP | START REV ↺ | **DI3** | **DI4** | **PR** | | 2 |
| | | ^------FAST STOP (P-24)------^ | | | 0 | 0 | P-20 | | |
| | | | | | 1 | 0 | P-21 | | |
| | | | | | 0 | 1 | P-22 | | |
| | | | | | 1 | 1 | P-23 | | |
| **10** | (NO) | START ↥ | STOP | (NC) | AI1 REF | P-20 REF | Analog Input AI1 | | 5 |
| **11** | (NO) | START ↥ FWD ↺ | STOP | (NC) | (NO) | START ↥ REV ↺ | Analog Input AI1 | | 6 |
| | | ^----------FAST STOP (P-24)----------^ | | | | | | | |
| **12** | STOP | RUN | FAST STOP (P-24) | OK | AI1 REF | P-20 REF | Analog Input AI1 | | 7 |
| **13** | (NO) | START FWD ↻ | STOP | (NC) | (NO) | START REV ↺ | KPD REF | P-20 REF | 13 |
| | | ^----------FAST STOP (P-24)----------^ | | | | | | | |
| **14** | STOP | RUN | DI2 | | E-TRIP | OK | **DI2** | **DI4** | **PR** | 11 |
| | | | | | | | 0 | 0 | P-20 |
| | | | | | | | 1 | 0 | P-21 |
| | | | | | | | 0 | 1 | P-22 |
| | | | | | | | 1 | 1 | P-23 |
| **15** | STOP | RUN | P-23 REF | AI1 | Fire Mode | | Analog Input AI1 | | 1 |
| **16** | STOP | RUN | P-23 REF | P-21 REF | Fire Mode | | FWD | REV | 2 |
| **17** | STOP | RUN | DI2 | | Fire Mode | | **DI2** | **DI4** | **PR** | 2 |
| | | | | | | | 0 | 0 | P-20 |
| | | | | | | | 1 | 0 | P-21 |
| | | | | | | | 0 | 1 | P-22 |
| | | | | | | | 1 | 1 | P-23 |
| **18** | STOP | RUN | FWD ↻ | REV ↺ | Fire Mode | | Analog Input AI1 | | 1 |
| **19** | STOP | RUN | AI1 REF | PR1 REF | No Function | Fire Mode | AI1 | | 1 |
| **NOTE** | **When P-15 = 19, P-30 Index 2 and Index 3 have no effect. When the fire mode input is on, the drive will run regardless of whether the run input is present. Speed reference in Fire Mode is always Preset Speed 4, P-23.** | | | | | | | | |

## 6.5. Macro Functions - Keypad Mode (P-12 = 1 or 2)

| P-15 | DI1 | | DI2 | | DI3 / AI2 | | DI4 / AI1 | | Diagram |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | |
| **0** | STOP | ENABLE | - | INC SPD ↴ | - | DEC SPD ↴ | FWD ↻ | REV ↺ | 8 |
| | | | | ^----------START----------^ | | | | | |
| **1** | STOP | ENABLE | PI Speed Reference | | | | | | 2 |
| **2** | STOP | ENABLE | - | INC SPD ↴ | - | DEC SPD ↴ | KPD REF | P-20 REF | 8 |
| | | | | ^----------START----------^ | | | | | |
| **3** | STOP | ENABLE | - | INC SPD ↴ | E-TRIP | OK | - | DEC SPD ↴ | 9 |
| | | | | ^----------START----------^ | | | | | |
| **4** | STOP | ENABLE | - | INC SPD ↴ | KPD REF | AI1 REF | AI1 | | 10 |
| **5** | STOP | ENABLE | FWD ↻ | REV ↺ | KPD REF | AI1 REF | AI1 | | 1 |
| **6** | STOP | ENABLE | FWD ↻ | REV ↺ | E-TRIP | OK | KPD REF | P-20 REF | 11 |
| **7** | STOP | RUN FWD | STOP | RUN REV ↺ | E-TRIP | OK | KPD REF | P-20 REF | 11 |
| | | ^---------FAST STOP (P-24)---------^ | | | | | | | |
| **8** | STOP | RUN FWD ↻ | STOP | RUN REV ↺ | KPD REF | AI1 REF | AI1 | | 1 |
| **14** | STOP | ENABLE | - | INC SPD ↴ | E-TRIP | OK | - | DEC SPD ↴ | |
| **15** | STOP | ENABLE | PR REF | KPD REF | Fire Mode | | P-23 | P-21 | 2 |
| **16** | STOP | ENABLE | P-23 REF | KPD REF | Fire Mode | | FWD ↻ | REV ↺ | 2 |
| **17** | STOP | ENABLE | KPD REF | P-23 REF | Fire Mode | | FWD ↻ | REV ↺ | 2 |
| **18** | STOP | ENABLE | AI1 REF | KPD REF | Fire Mode | | AI1 | | 1 |
| **19** | STOP | RUN | KPD REF | PR1 REF | No Function | Fire Mode | AI1 | | 1 |
| **9, 10, 11, 12, 13 = Behavior as per setting 0** | | | | | | | | | |

**NOTE**

**When P15=4 in keypad mode, DI2 &DI4 are edge triggered. Digital pot speed will be increased or decreased once for each rising edge. The step of each speed change is defined by the absolute value of Pre-set Speed 1 (P-20).**

**Speed change only happens during normal running condition (no stop command etc.). Digital pot will be adjusted between minimum speed (P-02) and maximum speed (P-01).**

**When P-15 = 19, P-30 Index 2 and Index 3 have no effect. When the fire mode input is on, the drive will run regardless of whether the run input is present. Speed reference in Fire Mode is always Preset Speed 4, P-23.**

## 6.6. Macro Functions - Fieldbus Control Mode (P-12 = 3, 4, 7, 8 or 9)

| P-15 | DI1 | | DI2 | | DI3 / AI2 | | DI4 / AI1 | | Diagram |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | |
| **0** | STOP | ENABLE | FB REF (Fieldbus Speed Reference, Modbus RTU / CAN / Master-Slave defined by P-12) | | | | | | 14 |
| **1** | STOP | ENABLE | PI Speed Reference | | | | | | 15 |
| **3** | STOP | ENABLE | FB REF | P-20 REF | E-TRIP | OK | Analog Input AI1 | | 3 |
| **5** | STOP | ENABLE | FB REF | PR REF | P-20 | P-21 | Analog Input AI1 | | 1 |
| | | ^----START (P-12 = 3 or 4 Only)----^ | | | | | | | |
| **6** | STOP | ENABLE | FB REF | AI1 REF | E-TRIP | OK | Analog Input AI1 | | 3 |
| | | ^----START (P-12 = 3 or 4 Only)----^ | | | | | | | |
| **7** | STOP | ENABLE | FB REF | KPD REF | E-TRIP | OK | Analog Input AI1 | | 3 |
| | | ^----START (P-12 = 3 or 4 Only)----^ | | | | | | | |
| **14** | STOP | ENABLE | - | - | E-TRIP | OK | Analog Input AI1 | | 16 |
| **15** | STOP | ENABLE | PR REF | FB REF | Fire Mode | | P-23 | P-21 | 2 |
| **16** | STOP | ENABLE | P-23 REF | FB REF | Fire Mode | | Analog Input AI1 | | 1 |
| **17** | STOP | ENABLE | FB REF | P-23 REF | Fire Mode | | Analog Input AI1 | | 1 |
| **18** | STOP | ENABLE | AI1 REF | FB REF | Fire Mode | | Analog Input AI1 | | 1 |
| **2, 4, 8, 9, 10, 11, 12, 13, 19 = Behavior as per setting 0** | | | | | | | | | |

## 6.7. Macro Functions - User PI Control Mode (P-12 = 5 or 6)

| P-15 | DI1 | | DI2 | | DI3 / AI2 | | DI4 / AI1 | | Diagram |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | |
| **0** | STOP | RUN | PI REF | P-20 REF | AI2 | | AI1 | | 4 |
| **1** | STOP | RUN | PI REF | AI1 REF | AI2 (PI FB) | | AI1 | | 4 |
| **3, 7** | STOP | RUN | PI REF | P-20 | E-TRIP | OK | AI1 (PI FB) | | 3 |
| **4** | (NO) | START | (NC) | STOP | AI2 (PI FB) | | AI1 | | 12 |
| **5** | (NO) | START | (NC) | STOP | PI REF | P-20 REF | AI1 (PI FB) | | 5 |
| **6** | (NO) | START | (NC) | STOP | E-TRIP | OK | AI1 (PI FB) | | |
| **8** | STOP | RUN | FWD ↻ | REV ↺ | AI2 (PI FB) | | AI1 | | 4 |
| **9** | STOP | RUN | FWD ↻ | REV ↺ | PI REF | PR1 REF | AI1 | | 1 |
| **14** | STOP | RUN | - | - | E-TRIP | OK | AI1 (PI FB) | | 16 |
| **15** | STOP | RUN | P-23 REF | PI REF | Fire Mode | | AI1 (PI FB) | | 1 |
| **16** | STOP | RUN | P-23 REF | P-21 REF | Fire Mode | | AI1 (PI FB) | | 1 |
| **17** | STOP | RUN | FWD ↻ | REV ↺ | E-TRIP | - | AI1 | | 3 |
| **18** | STOP | RUN | AI1 REF | PI REF | Fire Mode | | AI1 (PI FB) | | 1 |
| **2, 9, 10, 11, 12, 13, 19 = Behavior as per setting 0** | | | | | | | | | |
| **NOTE** | **P1 Setpoint source is selected by P-44 (default is fixed value in P-45, AI 1 may also be selected).**<br>**P1 Feedback source is selected by P-46 (default is AI 2, other options may be selected).** | | | | | | | | |

# 7. Modbus RTU Communications

## 7.1. Introduction

The HPI Smart can be connected to a Modbus RTU network via the RJ45 connector on the front of the drive.

## 7.2. Modbus RTU Specification

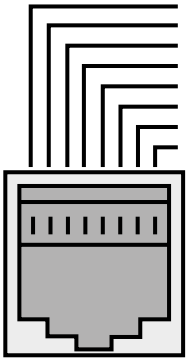
| | |
|---|---|
| Protocol | Modbus RTU |
| Error check | CRC |
| Baud rate | 9600bps, 19200bps, 38400bps, 57600bps, 115200bps (default) |
| Data format | 1 start bit, 8 data bits, 1 stop bits, no parity |
| Physical signal | RS 485 (2-wire) |
| User interface | RJ45 |
| Supported Function Codes | 03 Read Multiple Holding Registers<br>06 Write Single Holding Register<br>16 Write Multiple Holding Registers (Supported for registers 1 – 4 only) |

## 7.3. RJ45 Connector Configuration

For full MODBUS RTU register map information please refer to your Lafert Group Technical Department. Local contacts can be found by visiting our website:

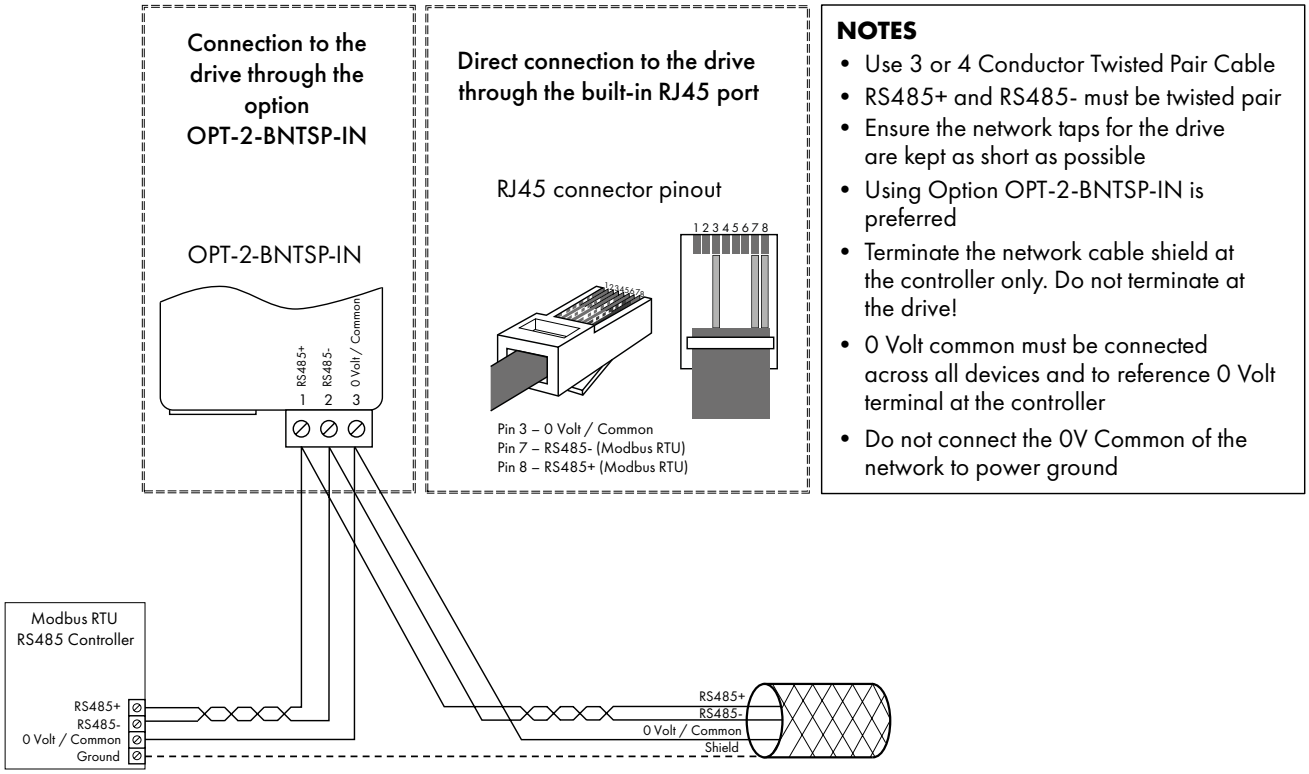
www.lafert.com

When using MODBUS control the Analog and Digital Inputs can be configured as shown in section 6.6. Macro Functions - Fieldbus Control Mode (P-12 = 3, 4, 7, 8 or 9).



| | |
|---|---|
| **1** | CAN - |
| **2** | CAN + |
| **3** | 0 Volts |
| **4** | -RS485 (PC) |
| **5** | +RS485 (PC) |
| **6** | +24 Volt |
| **7** | -RS485 (Modbus RTU) |
| **8** | +RS485 (Modbus RTU) |

**Warning:** This is not an Ethernet connection. Do not connect directly to an Ethernet port.




**NOTES**

- Use 3 or 4 Conductor Twisted Pair Cable
- RS485+ and RS485- must be twisted pair
- Ensure the network taps for the drive are kept as short as possible
- Using Option OPT-2-BNTSP-IN is preferred
- Terminate the network cable shield at the controller only. Do not terminate at the drive!
- 0 Volt common must be connected across all devices and to reference 0 Volt terminal at the controller
- Do not connect the 0V Common of the network to power ground

## 7.4. Modbus Register Map

| Register Number | Par. | Type | Supported Function Codes | | | Function | | Range | Explanation |
|---|---|---|---|---|---|---|---|---|---|
| | | | 03 | 06 | 16 | Low Byte | High Byte | | |
| 1 | - | R/W | ✔ | ✔ | ✔ | PDO0 Control Word | | 0..3 | 16 Bit Word.<br>Bit 0: Low = Stop, High = Run Enable<br>Bit 1: Low = Decel Ramp 1 (P-04),<br>High = Decel Ramp 2 (P-24)<br>Bit 2: Low = No Function, High = Fault Reset<br>Bit 3: Low – No Function, High = Coast Stop Request<br>Bit 8: Relay control, 0 = Open, 1 = Close<br>Bit 9 : DO Control, 1 = Off, 0 = On |
| 2 | - | R/W | ✔ | ✔ | ✔ | PDO1 Frequency Set Point | | 0..5000 | Setpoint frequency x10, e.g. 100 = 10.0Hz |
| 3 | - | R/W | ✔ | ✔ | ✔ | PDO2 PI Setpoint / Analog Output control | | 0 - 4096 | 0 - 4096 = 0 - 100.0% |
| 4 | - | R/W | ✔ | ✔ | ✔ | PDO 3 | | 0..60000 | Ramp time in seconds x 100, e.g. 250 = 2.5 seconds |
| 6 | - | R | ✔ | | | Drive status | Error code | | Low Byte = Drive Error Code, see section 10.1. Fault Code Messages<br>High Byte = Drive Status as follows:<br>0: Drive Running<br>1: Drive Tripped<br>5: Standby Mode<br>6: Drive Ready |
| 7 | | R | ✔ | | | Output Motor Frequency | | 0..20000 | Output frequency in Hz x10, e.g. 100 = 10.0Hz |
| 8 | | R | ✔ | | | Output Motor Current | | 0..480 | Output Motor Current in Amps x10, e.g. 10 = 1.0 Amps |
| 11 | - | R | ✔ | | | Digital input status | | 0..15 | Indicates the status of the 4 digital inputs<br>Lowest Bit = 1 Input 1 |
| 20 | P00-01 | R | ✔ | | | Analog Input 1 value | | 0..1000 | Analog input % of full scale x10, e.g. 1000 = 100% |
| 21 | P00-02 | R | ✔ | | | Analog Input 2 value | | 0..1000 | Analog input % of full scale x10, e.g. 1000 = 100% |
| 22 | P00-03 | R | ✔ | | | Speed Reference Value | | 0..1000 | Displays the setpoint frequency x10, e.g. 100 = 10.0Hz |
| 23 | P00-08 | R | ✔ | | | DC bus voltage | | 0..1000 | DC Bus Voltage in Volts |
| 24 | P00-09 | R | ✔ | | | Drive temperature | | 0..100 | Drive heatsink temperature in °C |
| 2001 | - | R | ✔ | | | Status Word 2 | | | See below |
| 2002 | - | R | ✔ | | | Motor Output Speed | | | Speed in Hz with one decimal place |
| 2003 | - | R | ✔ | | | Motor Output Current | | | Current in A with one decimal place |
| 2004 | - | R | ✔ | | | Motor Output Power | | | Power in kW with one decimal place |
| 2005 | - | R | ✔ | | | IO Status Word | | | See below |
| 2006 | - | R | ✔ | | | Motor Output Torque | | | 0.0% to +/- 200.0% |
| 2007 | P00-08 | R | ✔ | | | DC Bus Voltage | | | 0 – 1000V |
| 2008 | P00-09 | R | ✔ | | | Heatsink Temperature | | | Temperature in °C |
| 2009 | P00-01 | R | ✔ | | | Analog Input 1 | | | 0 ~ 4096 (12bits) |
| 2010 | P00-02 | R | ✔ | | | Analog Input 2 | | | 0 ~ 4096 (12bits) |
| 2011 | - | R | ✔ | | | Analog Output | | | 0.0 to 100.0% |
| 2012 | P00-05 | R | ✔ | | | PI Output | | | 0.0 to 100.0% |
| 2013 | P00-20 | R | ✔ | | | Internal Temperature | | | Temperature in °C |
| 2014 | P00-07 | R | ✔ | | | Motor Output Voltage | | | 0 – 500V |
| 2015 | - | R | ✔ | | | IP66 Pot Input value | | | 0 ~ 4096 (12bits) |
| 2016 | - | R | ✔ | | | Trip Code | | | See user guide for code definition |

All user configurable parameters are accessible as Holding Registers, and can be Read from or Written to using the appropriate Modbus command. The Register number for each parameter P-04 to P-60 is defined as 128 + Parameter number, e.g. for parameter P-15, the register number is 128 + 15 = 143. Internal scaling is used on some parameters, for further details please contact your Lafert Group Technical Department.

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### *7.4.1. Register 2001 definition – New Status Word*

| Bit | Definition | Description |
|---|---|---|
| **0** | Ready | This bit is set if no trip and no mains loss, plus hardware enabled |
| **1** | Running | This bit is set when drive is running |
| **2** | Tripped | This bit is set when drive is under trip condition |
| **3** | Standby | This bit is set when drive is in standby mode |
| **4** | Fire Mode | This bit is set if fire mode is active |
| **5** | Reserved | Read as 0 |
| **6** | Speed Set-point Reached (At Speed) | This bit is set when drive is enabled and reaches speed set point |
| **7** | Below Minimum Speed | This bit is set when drive is enabled and speed less than P-02 |
| **8** | Overload | This bit is set if motor current > P-08 |
| **9** | Mains Loss | This bit is set if mains loss condition happens |
| **10** | Heatsink > 85°C | This bit is set if drive heatsink temperature over 85°C |
| **11** | Control Board > 80°C | This bit is set if control PCB temperature over 80°C |
| **12** | Switching Frequency Reduction | This bit is set if PWM switching frequency foldback is active |
| **13** | Reverse Rotation | This bit is set when motor is in reverse rotation (negative speed) |
| **14** | Reserved | Read as 0 |
| **15** | Live Toggle Bit | This bit will toggle each time this register is read |

### *7.4.2. Register 2005 definition – IO Status Word*

| Bit | Definition | Description |
|---|---|---|
| **0** | DI1 Status | This bit is set when digital input 1 is closed |
| **1** | DI2 Status | This bit is set when digital input 2 is closed |
| **2** | DI3 Status | This bit is set when digital input 3 (AI-2) is closed |
| **3** | DI4 Status | This bit is set when digital input 4 (AI-1) is closed |
| **4, 5** | Reserved | Read as 0 |
| **6** | IP66 Switch FWD | This bit is set when IP66 FWD switch is closed |
| **7** | IP66 Switch REV | This bit is set when IP66 REV switch is closed |
| **8** | Digital Output Status | This bit is set when digital output is active(24V) or Analog output > 0 |
| **9** | Relay Output Status | This bit is set when user relay is closed |
| **10, 11** | Reserved | Read as 0 |
| **12** | Analog Input 1 Signal Lost (4-20mA) | This bit is set when analog input 1 signal loss happens (4..20mA) |
| **13** | Analog Input 2 signal Lost (4-20mA) | This bit is set when analog input 2 signal loss happens (4..20mA) |
| **14** | Reserved | Read as 0 |
| **15** | IP66 Pot Input > 50% | This bit is set when IP66 integrated pot input value > 50% |

# 8. CAN Communication

## 8.1. CAN Communication

The CAN communication profile in the HPI Smart is implemented according to the specification DS301 version 4.02 of CAN in automation (www.can-cia.de). Specific device profiles such as DS402 are not supported.

The CAN communication function is enabled by default after power up. However in order to use any control functions through CAN, the following setting is required: P-12 = 7 or 8.

The CAN communication baud rate can be set by using parameter P-36 (Index 2). Available baud rates are: 125kbps, 250kbps, 500kbps, 1Mbps. (with default setting as 500kbps).

The Node ID is set up through drive address parameter P-36 (Index 1) with the default value of 1.

The tables below show the Index and Sub Index required to address each parameter. All User Adjustable parameters are accessible by CAN, except those that would directly affect the communications.

All parameter values can be read from the drive and written to, depending on the operating mode of the drive – some parameters may not be changed whilst the drive is enabled.

HPI Smart provides the following default COB-ID and functions:

| Type | COB-ID | Function |
|---|---|---|
| NMT | 000h | Network management. |
| Sync | 080h | Synchronous message.<br>COB-ID can be configured to other value. |
| Emergency | 080h + Node address | Emergency message. |
| PDO1 (TX) | 180h + Node address | Process data object.<br>PDO1 is pre-mapped and enabled by default.<br>COB-ID can be configured to other value.<br>PDO2 is pre-mapped and disabled by default.<br>Transmission mode, COB-ID and mapping can be configured. |
| PDO1 (RX) | 200h + Node address | |
| PDO2 (TX) | 280h + Node address | |
| PDO2 (RX) | 300h + Node address | |
| SDO (TX) | 580h + Node address | SDO channel can be used for drive parameter access. |
| SDO (RX) | 600h + Node address | |
| Error Control | 700h + Node address | Guarding and Heartbeat function are supported.<br>COB-ID can be configured to other value. |

**NOTE**

- The HPI Smart SDO channel only supports expedited transmission.
- The HPI Smart can only support up to 2 Process Data Objects (PDO). All PDOs are pre-mapped; however PDO2 is disabled by default. The table below gives the default PDO mapping information.
- Customer configuration (mapping) will NOT be saved during power down. This means that the CANopen configuration will restore to its default condition each time the drive is powered up.

### *8.1.1. PDO Default Mapping*

| | Objects No. | Mapped Object | Length | Mapped Function | Transmission Type |
|---|---|---|---|---|---|
| RX PDO1 | 1 | 2000h | Unsigned 16 | Control command register* | 254 Valid immediately |
| | 2 | 2001h | Integer 16 | Speed reference | |
| | 3 | 2003h | Unsigned 16 | User ramp reference | |
| | 4 | 0006h | Unsigned 16 | Dummy | |
| TX PDO1 | 1 | 200Ah | Unsigned 16 | Drive status register | 254 Send after receiving RX PDO 1 |
| | 2 | 200Bh | Integer 16 | Motor speed Hz | |
| | 3 | 200Dh | Unsigned 16 | Motor current | |
| | 4 | 2010h | Integer 16 | Drive temperature | |
| RX PDO2 | 1 | 0006h | Unsigned 16 | Dummy | 254 |
| | 2 | 0006h | Unsigned 16 | Dummy | |
| | 3 | 0006h | Unsigned 16 | Dummy | |
| | 4 | 0006h | Unsigned 16 | Dummy | |
| TX PDO2 | 1 | 2011h | Unsigned 16 | DC bus voltage | 254 |
| | 2 | 2012h | Unsigned 16 | Digital input status | |
| | 3 | 2013h | Integer 16 | Analog input 1 (%) | |
| | 4 | 2014h | Integer 16 | Analog input 2 (%) | |

* Drive control can only be achieved when P-12=7 or 8 provided that P-31 = 0, 1, 4 or 5.

### *8.1.2. PDO transmission type*

Various transmission modes can be selected for each PDO. For RX PDO, the following modes are supported:

| Transmission Type | Mode | Description |
|---|---|---|
| 0 – 240 | Synchronous | The received data will be transferred to the drive active control register when the next sync message is received. |
| 254, 255 | Asynchronous | The received data will be transferred to the drive active control register immediately without delay. |

For TX PDO, the following modes are supported:

| Transmission Type | Mode | Description |
|---|---|---|
| 0 | Acyclic synchronous | TX PDO will only be sent out if the PDO data has changed and PDO will be transmitted on reception of SYNC object. |
| 1-240 | Cyclic synchronous | TX PDO will be transmitted synchronously and cyclically. The transmission type indicates the number of SYNC object that are. |
| 254 | Asynchronous | TX PDO will only be transferred once corresponding RX PDO has been received. |
| 255 | Asynchronous | TX PDO will only be transferred anytime if PDO data value has changed. |

### *8.1.3. CAN Open Specific Object Table*

| Index | Sub Index | Function | Access | Type | PDO Map | Default Value |
|---|---|---|---|---|---|---|
| 1000h | 0 | Device Type | R | U32 | N | 0 |
| 1001h | 0 | Error Register | R | U8 | N | 0 |
| 1002h | 0 | Manufacturer Status Register | R | U16 | N | 0 |
| 1005h | 0 | COB-ID Sync | RW | U32 | N | 00000080h |
| 1008h | 0 | Manufacturer Device Name | R | String | N | ODE3 |
| 1009h | 0 | Manufacturer Hardware Version | R | String | N | x.xx |
| 100Ah | 0 | Manufacturer Software Version | R | String | N | x.xx |
| 100Ch | 0 | Guard Time (1ms) | RW | U16 | N | 0 |
| 100Dh | 0 | Life Time Factor | RW | U8 | N | 0 |
| 1014h | 0 | COB-ID EMCY | RW | U32 | N | 00000080h+Node ID |
| 1015h | 0 | Inhibit Time Emergency (100µs) | RW | U16 | N | 0 |
| 1017h | 0 | Producer Heartbeat Time (1ms) | RW | U16 | N | 0 |
| 1018h | 0 | Identity Object No. Of entries | R | U8 | N | 4 |
| | 1 | Vendor ID | R | U32 | N | 0x0000031A |
| | 2 | Product Code | R | U32 | N | Drive Dependent |
| | 3 | Revision Number | R | U32 | N | x.xx |
| | 4 | Serial Number | R | U32 | N | Drive Dependent |
| 1200h | 0 | SDO Parameter No. Of entries | R | U8 | N | 2 |
| | 1 | COB-ID Client -> Server (RX) | R | U32 | N | 00000600h+Node ID |
| | 2 | COB-ID Server -> Client (TX) | R | U32 | N | 00000580h+Node ID |
| 1400h | 0 | RX PDO1 comms param. no. of entries | R | U8 | N | 2 |
| | 1 | RX PDO1 COB-ID | RW | U32 | N | 40000200h+Node ID |
| | 2 | RX PDO transmission type | RW | U32 | N | 254 |
| 1401h | 0 | RX PDO2 comms param. no. of entries | R | U8 | N | 2 |
| | 1 | RX PDO2 COB-ID | RW | U32 | N | C0000300h+Node ID |
| | 2 | RX PDO2 transmission type | RW | U8 | N | 0 |
| 1600h | 0 | RX PDO1 1 mapping / no. of entries | RW | U8 | N | 4 |
| | 1 | RX PDO1 1st mapped object | RW | U32 | N | 20000010h |
| | 2 | RX PDO1 2nd mapped object | RW | U32 | N | 20010010h |
| | 3 | RX PDO1 3rd mapped object | RW | U32 | N | 20030010h |
| | 4 | RX PDO1 4th mapped object | RW | U32 | N | 00060010h |
| 1601h | 0 | RX PDO2 1 mapping / no. of entries | RW | U8 | N | 4 |
| | 1 | RX PDO2 1st mapped object | RW | U32 | N | 00060010h |
| | 2 | RX PDO2 2nd mapped object | RW | U32 | N | 00060010h |
| | 3 | RX PDO2 3rd mapped object | RW | U32 | N | 00060010h |
| | 4 | RX PDO2 4th mapped object | RW | U32 | N | 00060010h |
| 1800h | 0 | TX PDO1 comms parameter number of entries | R | U8 | N | 3 |
| | 1 | TX PDO1 COB-ID | RW | U32 | N | 40000180h+Node ID |
| | 2 | TX PDO1 transmission type | RW | U8 | N | 254 |
| | 3 | TX PDO1 Inhibit time (100µs) | RW | U16 | N | 0 |
| 1801h | 0 | TX PDO2 comms param no. of entries | R | U8 | N | 3 |
| | 1 | TX PDO2 COB-ID | RW | U32 | N | C0000280h+Node ID |
| | 2 | TX PDO2 transmission type | RW | U8 | N | 0 |
| | 3 | TX PDO2 Inhibit time (100µs) | RW | U16 | N | 0 |
| 1A00h | 0 | TX PDO1 mapping / no. of entries | RW | U8 | N | 4 |
| | 1 | TX PDO1 1st mapped object | RW | U32 | N | 200A0010h |
| | 2 | TX PDO1 2nd mapped object | RW | U32 | N | 200B0010h |
| | 3 | TX PDO1 3rd mapped object | RW | U32 | N | 200D0010h |
| | 4 | TX PDO1 4th mapped object | RW | U32 | N | 20100010h |

| Index | Sub Index | Function | Access | Type | PDO Map | Default Value |
|---|---|---|---|---|---|---|
| 1A01h | 0 | TX PDO2 mapping / no. of entries | RW | U8 | N | 4 |
| | 1 | TX PDO2 1st mapped object | RW | U32 | N | 20110010h |
| | 2 | TX PDO2 2nd mapped object | RW | U32 | N | 20120010h |
| | 3 | TX PDO2 3rd mapped object | RW | U32 | N | 20130010h |
| | 4 | TX PDO2 4th mapped object | RW | U32 | N | 20140010h |

## 8.2. Additional Information Relating to CAN or Modbus or Both

### *8.2.1 Drive Control Word Format*

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High byte | | | | | | | | Low byte | | | | | | | |

**Bit 0:** Run/Stop command: Set to 1 to enable the drive. Set to 0 to stop the drive.

**Bit 1:** Fast stop request. Set to 1 to enable drive to stop with 2nd deceleration ramp.

**Bit 2:** Reset request. Set to 1 in order to reset the drive if drive is under trip condition.

User must clear this bit when drive is under normal condition to prevent un-expected reset.

**Bit 3:** Coast stop request. Set to 1 to issue a coast stop command.

For normal operation, Bit 3 has the highest priority, bit 0 has the lowest priority (bit 3>bit 1>bit 0). For example if user set command as 0x0009, drive will do a coast stop rather than run. For normal run/start, just set this register to 1.

**NOTE** Start/stop (bit 0), fast stop (bit 1) and coast stop (bit 3) only works if P-31= 0 or 1. Otherwise, start/stop function is controlled by drive control terminals. Reset function (bit 2) works all the time as long as drive is operated under Modbus control mode (P-12=3 or 4).

### *8.2.2 Speed Reference Format*

Speed reference value is transferred with one decimal place (200 = 20.0Hz). The maximum speed reference value is limited by P-01. Either register 2 or register 5 can be used for speed reference control, however only one reference should be used in any control system, otherwise unexpected behaviour can result.

### *8.2.3 Acceleration / Deceleration Ramp Time*

Active only when P-12 = 4, this register specifies the drive acceleration and deceleration ramp time. The same value is applied simultaneously to the acceleration and deceleration ramp times. The value has two decimal places, e.g. 500 = 5.00 seconds.

### *8.2.4 Drive status and error code Word*

High byte gives drive error code. (Valid when the drive is tripped, see 10.1. Fault Code Messages for further details)

Low byte gives drive status information as follows:

**Bit 0:** 0 =Drive Stopped, 1 = Drive Running

**Bit 1:** 0 = OK, 1 = Drive Tripped

**Bit 5:** 0 = OK, 1 = In Standby Mode

**Bit 6:** 0 = Not Ready, 1 = Drive Ready to Run (not tripped, hardware enabled and no mains loss condition)

# 9. Technical Data

## 9.1. Environmental

| | | |
|---|---|---|
| Operational ambient temperature range | : | -20 ... 40°C (frost and condensation free) |
| Storage ambient temperature range | : | -40 ... 60°C |
| Maximum altitude | : | 2000m. Derate above 1000m: 2.5% / 100m |
| Maximum humidity | : | 95%, non-condensing |
| Environmental Conditions | : | HPI Smart products are designed to operate in 3S3/3C3 environments in accordance with IEC 60721-3-3. |

## 9.2. Rating Tables

| Frame Size | kW | HP | Input Current | Fuse / MCB (Type B) | | Maximum Cable Size | | Output Current | Recommended Brake Resistance |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Non UL | UL | mm² | AWG | A | Ω |
| **200 - 240 (+ / - 10%) V 3 Phase Input, 3 Phase Output** | | | | | | | | | |
| 2 | 1.5 | 2 | 8.9 | 16 | 15 | 8 | 8 | 7 | 100 |
| 2 | 2.2 | 3 | 12.1 | 16 | 17.5 | 8 | 8 | 10.5 | 50 |
| 3 | 4 | 5 | 20.9 | 32 | 30 | 8 | 8 | 18 | 25 |
| 3 | 5.5 | 7.5 | 26.4 | 40 | 35 | 8 | 8 | 24 | 20 |
| **380 - 480 (+ / - 10%)V 3 Phase Input, 3 Phase Output** | | | | | | | | | |
| 2 | 1.5 | 2 | 5.6 | 10 | 10 | 8 | 8 | 4.1 | 250 |
| 2 | 2.2 | 3 | 7.5 | 16 | 10 | 8 | 8 | 5.8 | 200 |
| 2 | 4 | 5 | 11.5 | 16 | 15 | 8 | 8 | 9.5 | 120 |
| 3 | 5.5 | 7.5 | 17.2 | 25 | 25 | 8 | 8 | 14 | 100 |
| 3 | 7.5 | 10 | 21.2 | 32 | 30 | 8 | 8 | 18 | 80 |
| 3 | 11 | 15 | 27.5 | 40 | 35 | 8 | 8 | 24 | 50 |

**NOTE** Cable sizes shown are the maximum possible that may be connected to the drive. Cables should be selected according to local wiring codes or regulations at the point of installation.

## 9.3. Single Phase Operation of Three Phase Drives

All drive models except size 4 are intended for operation from three phase mains power supply may be operated from a single phase supply at up to 50% of maximum rated output current capacity.

In this case, the AC power supply should be connected to L1 (L) and L2 (N) power connection terminals only.

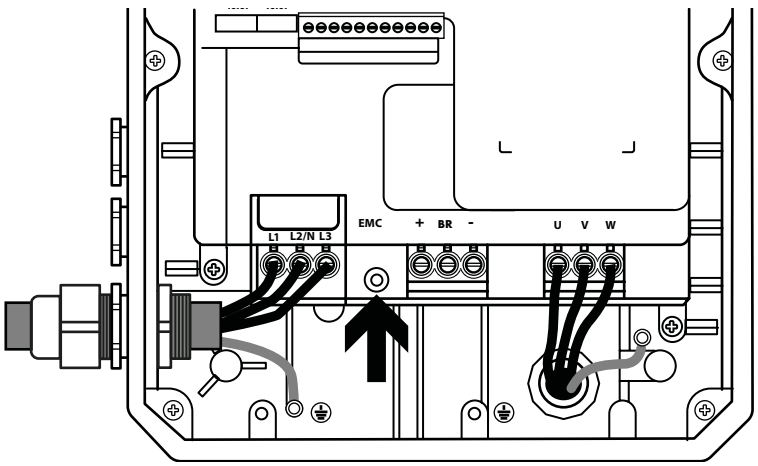
## 9.4. Additional Information for UL Compliance

HPI Smart is designed to meet the UL requirements. For an up to date list of UL compliant products, please refer to UL listing NMMS. E334189. In order to ensure full compliance, the following must be fully observed.

<table>
<tr><th colspan="5">Input Power Supply Requirements</th></tr>
<tr><td>Supply Voltage</td><td colspan="4">200 – 240 RMS Volts for 230 Volt rated units, + /- 10% variation allowed. 240 Volt RMS Maximum.</td></tr>
<tr><td></td><td colspan="4">380 – 480 RMS Volts for 400 Volt rated units, + / - 10% variation allowed, 500 Volts RMS Maximum.</td></tr>
<tr><td>Imbalance</td><td colspan="4">Maximum 3% voltage variation between phase – phase voltages allowed.</td></tr>
<tr><td></td><td colspan="4">All HPI Smart units have phase imbalance monitoring. A phase imbalance of > 3% will result in the drive tripping. For input supplies which have supply imbalance greater than 3% (typically the Indian sub-continent & parts of Asia Pacific including China) Lafert Group recommends the installation of input line reactors.</td></tr>
<tr><td>Frequency</td><td colspan="4">50 – 60Hz + / - 5% Variation</td></tr>
<tr><td rowspan="4">Short Circuit Capacity</td><td>Voltage Rating</td><td>Min kW (HP)</td><td>Max kW (HP)</td><td>Maximum supply short-circuit current</td></tr>
<tr><td>230V</td><td>0.37 (0.5)</td><td>11 (15)</td><td>100kA rms (AC)</td></tr>
<tr><td>400 / 460V</td><td>0.75 (1)</td><td>22 (30)</td><td>100kA rms (AC)</td></tr>
<tr><td colspan="4">All the drives in the above table are suitable for use on a circuit capable of delivering not more than the above specified maximum short-circuit Amperes symmetrical with the specified maximum supply voltage when protected by Class J fuses.</td></tr>
<tr><th colspan="5">Mechanical Installation Requirements</th></tr>
<tr><td colspan="5">All HPI Smart units are intended for installation within controlled environments which meet the condition limits shown in section 9.1. Environmental.</td></tr>
<tr><td colspan="5">The drive can be operated within an ambient temperature range as stated in section 9.1. Environmental.</td></tr>
<tr><th colspan="5">Electrical Installation Requirements</th></tr>
<tr><td colspan="5">Incoming power supply connection must be according to section 4.3. Incoming Power Connection.</td></tr>
<tr><td colspan="5">Suitable Power and motor cables should be selected according to the data shown in section 9.2. Rating Tables and the National Electrical Code or other applicable local codes.</td></tr>
<tr><td>Motor Cable</td><td colspan="4">75°C Copper must be used.</td></tr>
<tr><td colspan="5">Power cable connections and tightening torques are shown in section 3.3. Mechanical Dimensions – IP66 (Nema 4X) Enclosed Units.</td></tr>
<tr><td colspan="5">Integral Solid Sate short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the national electrical code and any additional local codes. Ratings are shown in section 9.2. Rating Tables.</td></tr>
<tr><td colspan="5">Transient surge suppression must be installed on the line side of this equipment and shall be rated 480Volt (phase to ground), 480 Volt (phase to phase), suitable for over voltage category iii and shall provide protection for a rated impulse withstand voltage peak of 4kV.</td></tr>
<tr><td colspan="5">UL Listed ring terminals / lugs must be used for all bus bar and grounding connections.</td></tr>
<tr><th colspan="5">General Requirements</th></tr>
<tr><td colspan="5">HPI Smart provides motor overload protection in accordance with the National Electrical Code (US).<br>• Where a motor thermistor is not fitted, or not utilised, Thermal Overload Memory Retention must be enabled by setting P-50 = 1.<br>• Where a motor thermistor is fitted and connected to the drive, connection must be carried out according to the information shown in section 4.6.2. Motor Thermistor Connection.</td></tr>
</table>

## 9.5. EMC Filter Disconnect

Remove the terminal cover and then disconnect the EMC filter as shown in the illustration opposite.



# 10. Troubleshooting

## 10.1. Fault Code Messages

| Fault Code | No. | Description | Suggested Remedy |
|---|---|---|---|
| no-FLt | 00 | No Fault | Not required. |
| OI-b | 01 | Brake channel over current | Check external brake resistor condition and connection wiring. |
| OL-br | 02 | Brake resistor overload | The drive has tripped to prevent damage to the brake resistor. |
| O-I | 03 | Output Over Current | Instantaneous Over current on the drive output. Excess load or shock load on the motor.<br>**NOTE** Following a trip, the drive cannot be immediately reset. A delay time is inbuilt, which allows the power components of the drive time to recover to avoid damage. |
| I_t-trP | 04 | Motor Thermal Overload (I2t) | The drive has tripped after delivering >100% of value in P-08 for a period of time to prevent damage to the motor. |
| O-uoLt | 06 | Over voltage on DC bus | Check the supply voltage is within the allowed tolerance for the drive. If the fault occurs on deceleration or stopping, increase the deceleration time in P-04 or install a suitable brake resistor and activate the dynamic braking function with P-34. |
| U-uoLt | 07 | Under voltage on DC bus | The incoming supply voltage is too low. This trip occurs routinely when power is removed from the drive. If it occurs during running, check the incoming power supply voltage and all components in the power feed line to the drive. |
| O-t | 08 | Heatsink over temperature | The drive is too hot. Check the ambient temperature around the drive is within the drive specification. Ensure sufficient cooling air is free to circulate around the drive. |
| U-t | 09 | Under temperature | The drive temperature is below the minimum limit and must be increased to operate the drive. |
| P-dEF | 10 | Factory Default parameters loaded | |
| E-trIP | 11 | External trip | E-trip requested on digital input 3. Normally closed contact has opened. If motor thermistor is connected check if the motor is too hot. |
| SC-0bS | 12 | Optibus comms loss | Check communication link between drive and external devices. Make sure each drive in the network has its unique address. |
| FLt-dc | 13 | DC bus ripple too high | Check incoming supply phases are all present and balanced. |
| P-LOSS | 14 | Input phase loss trip | Check incoming power supply phases are present and balanced. |
| h O-I | 15 | Output Over Current | Check for short circuits on the motor and connection cable.<br>**NOTE** Following a trip, the drive cannot be immediately reset. A delay time is inbuilt, which allows the power components of the drive time to recover to avoid damage. |
| th-FLt | 16 | Faulty thermistor on heatsink | |
| dAtA-F | 17 | Internal memory fault (IO) | Press the stop key. If the fault persists, consult you supplier. |
| 4-20 F | 18 | 4-20mA Signal Lost | Check the analog input connection(s). |
| dAtA-E | 19 | Internal memory fault (DSP) | Press the stop key. If the fault persists, consult you supplier. |
| F-Ptc | 21 | Motor PTC thermistor trip | Connected motor thermistor over temperature, check wiring connections and motor. |
| FAn-F | 22 | Cooling Fan Fault (IP66 only) | Check / replace the cooling fan. |
| O-hEAt | 23 | Drive internal temperature too high | Drive ambient temperature too high, check adequate cooling air is provided. |
| OUt-F | 26 | Output Fault | Indicates a fault on the output of the drive, such as one phase missing, motor phase currents not balanced. Check the motor and connections. |
| AtF-02 | 41 | Autotune Fault | The motor parameters measured through the autotune are not correct.<br>Check the motor cable and connections for continuity.<br>Check all three phases of the motor are present and balanced. |
| SC-F01 | 50 | Modbus comms loss fault | Check the incoming Modbus RTU connection cable.<br>Check that at least one register is being polled cyclically within the timeout limit set in P-36 Index 3. |
| SC-F02 | 51 | CAN comms loss trip | Check the incoming CAN connection cable.<br>Check that cyclic communications take place within the timeout limit set in P-36 Index 3. |

**NOTE** Following an over current or overload trip (3, 4, 5, 15), the drive may not be reset until the reset time delay has elapsed to prevent damage to the drive.

## 10.2. Resetting a Fault

When the drive trips, and a fault message is displayed, it can be reset in one of the following ways:

- Completely remove the incoming power supply, and allow the power to power off completely. Re-apply the power.
- Remove and reapply the enable input.
- Press the stop / Reset button.
- If Modbus or CAN are in use, set the reset bit in the control word from 0 to 1.

In the event of O-I, hO-I or I.t-trp faults, in order to prevent damage that may occur through repeatedly enabling the drive into a fault condition, these trips cannot be reset immediately. A delay time according to the following table must be allowed before reset is possible.

| | |
|---|---|
| First Trip | 2 seconds delay before reset is possible |
| Second Trip | 4 seconds delay before reset is possible |
| Third Trip | 8 seconds delay before reset is possible |
| Fourth Trip | 16 seconds delay before reset is possible |
| Fifth Trip | 32 seconds delay before reset is possible |
| Subsequent Trips | 64 seconds delay before reset is possible |

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