User Guide

ENGINEERING TOMORROW

Danfoss CDS203 Drive

Installation & Operating Instructions

http://cc.danfoss.com

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 is disconnected. If in doubt, refer to your Sales Partner for further information.

This manual is intended as a guide for proper installation. Danfoss 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 CDS 203 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.

Danfoss hereby states that the CDS 203 product range conforms to the relevant safety provisions of the following council directives: 2014/30/EU (EMC), 2014/35/EU (LVD) 2006/42/EC (Machinery Directive), 2011/65/EU (RoHS 2) and 2009/125/EC (Eco-design).

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

BSEN 61800-3:2018	Adjustable speed electrical power drive systems. Part 3: EMC requirements and specific test methods (IEC 61800-3:2017).
BSEN 61000-3-12:2011	Electromagnetic Compatibility (EMC). Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16A and < 75A per phase (IEC 61000-3-12:2011). Three phase 400V CDS 203 18A and 24A models comply with IEC 61000-3-12 with respect to the THC without the need for Line Reactors, provided that the short-circuit power Ssc is greater than or equal to SSC (min) at the interface point between the user's supply and the public system. It is the responsibility of the installer or user of the equipment to ensure, by consultation with the distribution network operator if necessary, that the equipment is connected only to a supply with a short-circuit power S_{SC} greater than or equal to $S_{SC\,(min)}$ calculated as: $S_{SC\,(min)} = 350 \times V_{rated} \times I_{rated}$. Where V_{rated} is the drive rated voltage (phase to phase) and I_{rated} is the drive rated current (per phase)
BSEN61000-3-2:2014	Electromagnetic Compatibility. Part 3-2: Limits — Limits for harmonic current emissions (equipment input current < 16 A per phase) (IEC 61000-3-2:2014).Single Phase input 230V variants only.
BSEN 61800-9-2:2017	Adjustable speed electrical power drive systems. Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters (IEC 61800-9-2:2017).

Safe Torque OFF ("STO") Function

CDS 203 incorporates a hardware STO (Safe Torque Off) Function, designed in accordance with the standards listed below.

Standard	Classification	Independent Approval
EN 61800-5-2:2016	SIL 3	TUV
EN ISO 13849-1:2015	PL "e"	
EN 61508 (Part 1 to 7):2010	SIL 3	
EN 60204-1: 2006 & A1: 2009	Uncontrolled Stop "Category 0"	
EN 62061: 2005 & A2: 2015	SIL CL 3	

*__NOTE__ TUV Approval of the "STO" function is relevant for drives which have a TUV logo applied on the drive rating label. The STO input must not be used for any safety related function if the drive unit does not carry the TUV logo on the rating label.

Electromagnetic Compatibility

All CDS 203 are designed with high standards of EMC in mind. All versions 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 supply via the power cables for compliance with 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. Within the European Union, equipment into which this product is incorporated must comply with the EMC Directive 2014/30/EU. This User Guide provides guidance to ensure that the applicable standards may be achieved.

This User Guide is for use with version 1.05 Firmware. The firmware version can be viewed in parameter P0-28.

User Guide Revision update

Danfoss 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.

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 (CDS 203) 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 CDS 203 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 CDS 203, including the specified environmental limitations.

Do not perform any flash test or voltage withstand test on the CDS 203. Any electrical measurements required should be carried out with the CDS 203 disconnected. Internal surge arrestors are fitted, intended to protect against damage due to mains borne spikes, which will result in the product failing the flash test.

Electric shock hazard! Disconnect and ISOLATE the CDS 203 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 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 98/37/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 CDS 203 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.

CDS 203 are intended for indoor use only.

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 no. of phases (1 or 3 phase) correspond to the rating of the CDS 203 as delivered.

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. This may cause the drive protection to activate, resulting in a trip and loss of operation.

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 CDS 203. In the case of suspected fault or malfunction, contact your local Danfoss Sales Partner for further assistance.

Use of the CDS203 with Flammable Refrigerants

The CDS 203 is not suitable for use in EX classified areas (Atex directive).

When this product is used with flammable refrigerants, the following considerations apply:

- The product has been evaluated in accordance with IEC 60335-2-40:2022 clause 22.116 and verified to be compliant.
  - o Electrical components within the drive that could normally create arcs or sparks are limited to the relays.
  - o These relays have been independently tested as per clause 22.116.3 and are not considered an ignition risk.
- The product has been evaluated in accordance with IEC 60335-2-40:2022 clause 22.117 and verified to be compliant.
  - o Hot Surfaces within the product have been verified to remain below the auto-ignition temperatures of the following refrigerants (to list a few) by a margin of at least 100k – R32, R290, R600a, R1270, R454A, R454B, R454C, R455A, R1234yf, R1234ze.
  - o The product has built-in protection to detect and trip under conditions of locked rotor, we recommend that this functional test is carried out for system compliance in accordance with IEC 60335-2-34.
- It is still recommended and good practice to further mitigate the risk resulting from leaked refrigerant by the following:
  - o Separate product from any area where flammable refrigerant could accumulate.
  - o Ventilate areas where there is risk of accumulation of flammable refrigerant.

The CDS 203 is a high efficiency variable frequency drive with world-leading motor control performance when operating any of the following motor technologies:

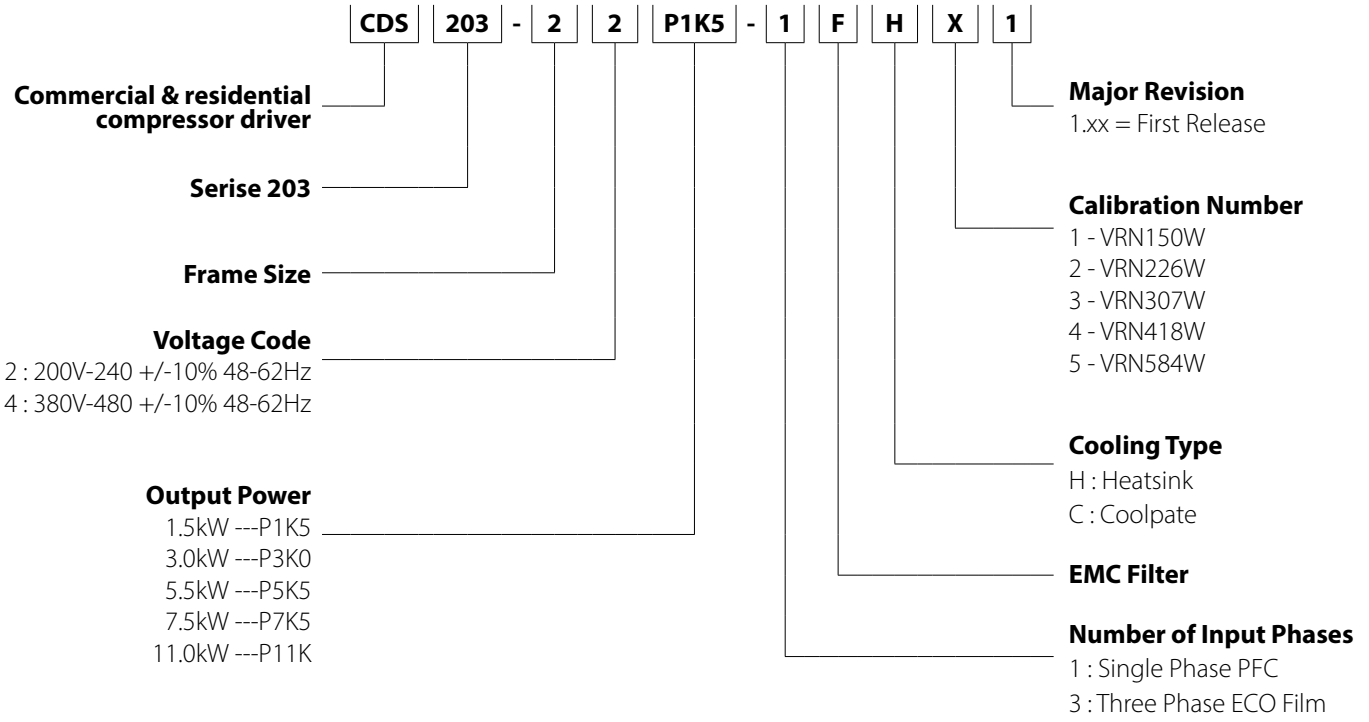
- Synchronous Brushless DC Motor

The product range has been specifically designed for OEM and machine-builders alike with through panel mounting and cold-plate technology options available. The drive has no direct keypad/display but shows drive status with two status indicating LEDs on the front.

The three phase input drives are low harmonic drives which do not need an input choke to comply with the THC limits provided in the relevant standard, BSEN 61000-3-12:2011. The single-phase input drives have built-in active PFC (Power Factor Correction) and in turn, are compliant with the requirements of BSEN 61000-3-2.

2.1. Identifying the Drive by Model Number

Each drive can be identified by its model number, shown below. The model number is on the shipping label, the drive rating label on the upper surface of the drive and on the front surface on the product identifier. The model number includes the drive and factory fitted options.



2.1.1. Model Variants

200 – 240V +/-10% Single Phase Input				
Model Code	**Frame**	**kW**	**HP**	**Amps**
CDS203-22P1K5-1FH11	2	1.5	2	7.0
CDS203-22P3K0-1FH21 CDS203-22P3K0-1FH31	2	3	3	12.0
CDS203-22P4K0-1FH41	2	4	5.5	16.0
380 – 480V +/-10% Three Phase Input				
Model Code	**Frame**	**kW**	**HP**	**Amps**
CDS203-24P5K5-3FH31 CDS203-24P5K5-1FH41	2	5.5	7.5	14
CDS203-24P11K-3FH51 CDS203-24P11K-3FH61	2	11	15	24

Replace 'H' with 'C' for coldplate version.

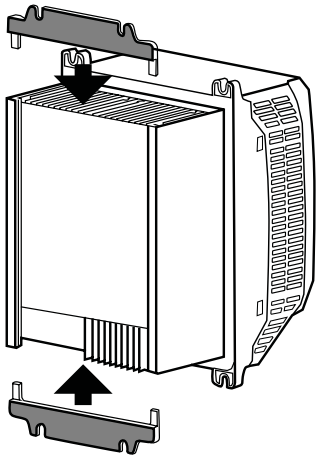
2.2. Accessories

2.2.1. Panel mounting kit

116B9001

The CDS 203 (heatsink version) is designed to primarily be mounted 'through-panel' with the heatsink protruding outside of the electrical panel.

NOTE This mounting kit does not come with the drive and must be ordered separately.



2.2.3 Ferrite Rings

To ensure conformity to the EMC directive with the single phase 230V PFC drives, it is required to install a ferrite core (e.g. Fair-Rite round cable snap ferrite 0431176451), one around the supply cable and the second around the supply earth as detailed in chapter *3.3. EMC Compliant Installation* on page 14.

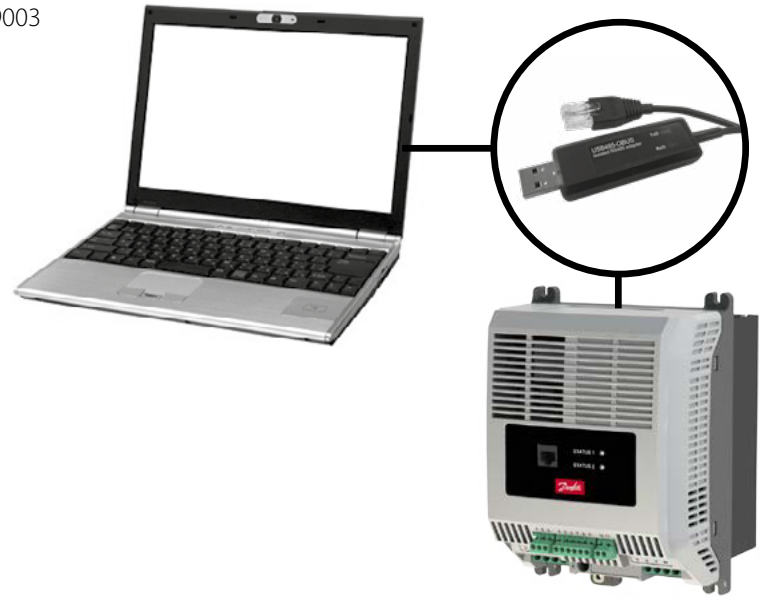
NOTE The use of some split-core ferrites can add to the acoustic noise generated by the installation. Whole ferrites can provide the required benefits without adding to the acoustic noise of the installation.

2.2.4. CDS203 LCP – Remote TFT Text LCD Display for commissioning and diagnostics with RJ45 cable

116B9002

2.2.5. USB cable gateway for CoolSetting software

116B9003



3.1. Mechanical Installation

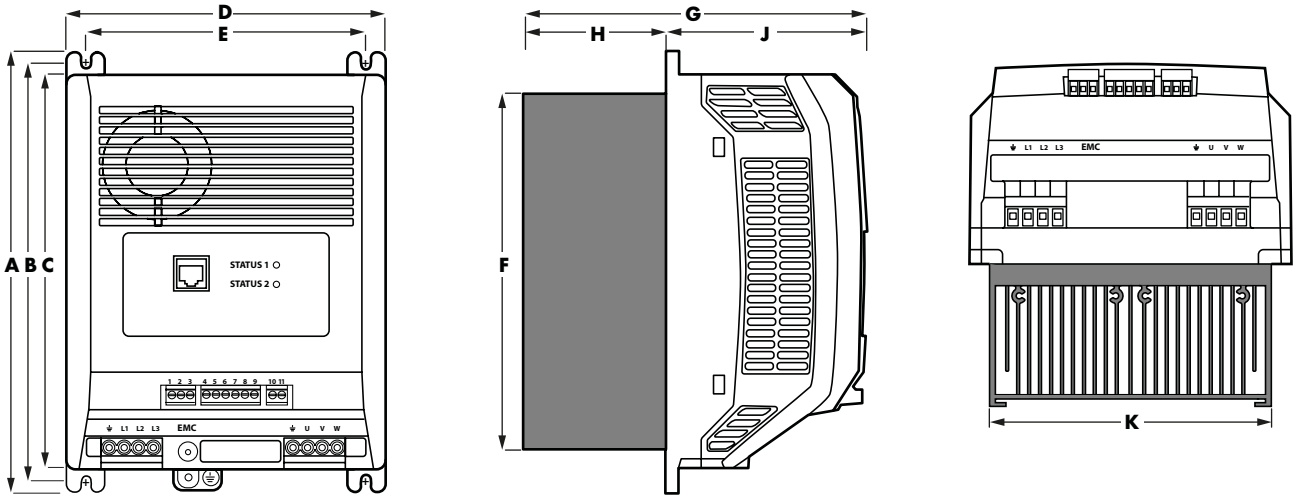
3.1.1. General

- The CDS 203 has been designed to be installed in a suitable enclosure. The drive can be through panel mounted or mounted directly onto the back of a panel using the appropriate mounting kit.
- Using the drive as a template, or the dimensions shown below, mark the locations for drilling.
  - o Ensure that when mounting locations are drilled, the dust from drilling does not enter the drive.
  - o Mount the drive to the cabinet backplate using suitable mounting screws.
  - o Position the drive, and tighten the mounting screws securely.
- The front of the drive is IP20 and must be installed in a pollution degree 1 or 2 environment only.
- In any environments where the conditions require it, the enclosure must be designed to protect the drive against ingress of airborne dust, corrosive gases or liquids, conductive contaminants (such as condensation, carbon dust, and metallic particles) and sprays or splashing water from all directions.
- Enclosures should be made from a thermally conductive material.
- Do not mount flammable material close to the CDS 203.
- Ensure that the minimum cooling air gaps, as detailed in section Ventilation and clearance.
- Ensure that the ambient temperature range does not exceed the permissible limits given in section *6.3. Temperature and Switching Frequency De-rating Requirements for CDS 203* on page 52. Typical heat losses generated by the drives are given in section *3.1.8. Cold-plate Capacity Calculation* and should be considered when designing the enclosure size and ventilation to ensure that the drive is not operated outside of its design conditions.

3.1.2. Before Installation

- Carefully Unpack the CDS 203 and check for any signs of damage. Notify the shipper immediately if any exist.
- Check the drive rating label to ensure it is of the correct type and power requirements for the application.
- To prevent accidental damage always store the CDS 203 in its original box until required. Storage should be clean and dry and within the temperature range –40°C to +70°C.

3.1.3. Drive Dimensions



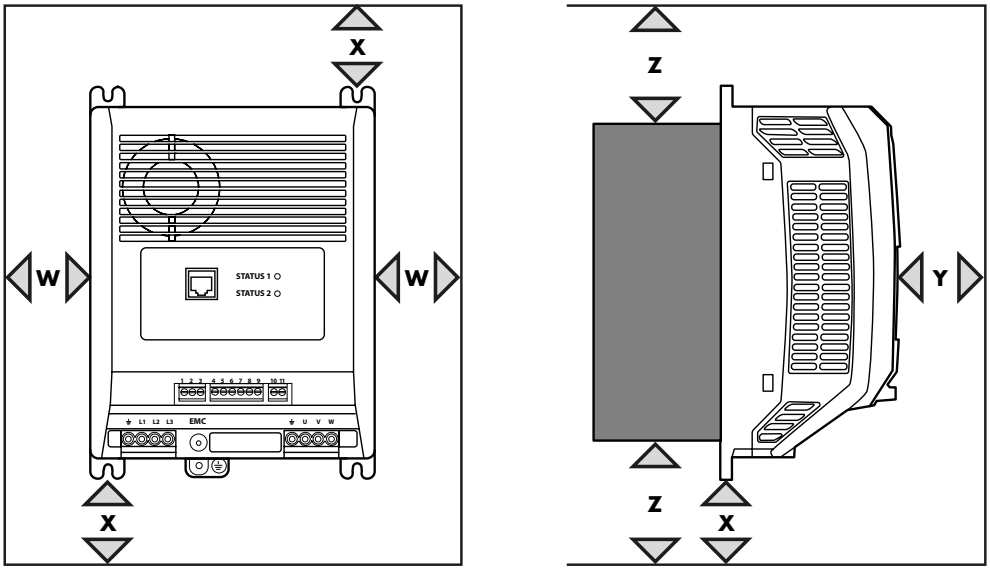
A		B		C		D		E		F		G		H		J		K	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
226.3	8.9	215.2	8.5	201.4	7.9	165.3	6.5	144.8	5.7	182	7.2	177	6.96	71.7	2.82	104.4	4.11	145	5.7

Tightening Torques		
	Required Torque	
Control Terminals	0.5 Nm	4.5 lb-in
Power Terminals	1 Nm	9 lb-in

Weights	
400V Heatsink	3.05kg
230V PFC Heatsink (7/12A)	3.4kg
230V PFC Heatsink (16/20A)	3.74kg

3.1.4. Ventilation and Clearance

In order for the drive to maintain it's temperature, a minimum clearance is required around the drive as shown in the diagram below:



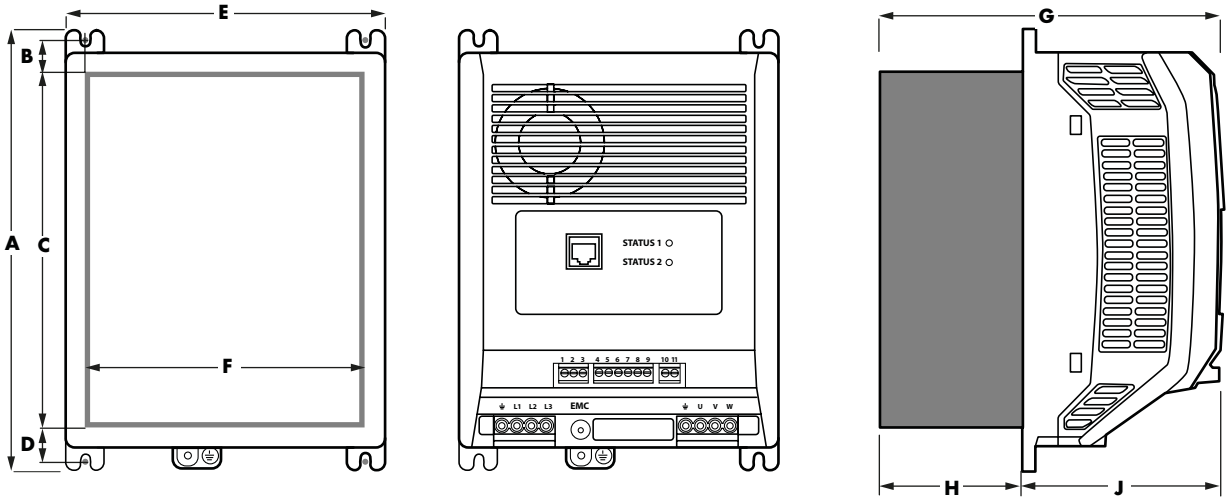
W		X		Y		Z*	
mm	in	mm	in	mm	in	mm	in
20	0.787	78	3.07	10	0.394	100	3.94

The losses generated by each drive are explained in section *3.1.8. Cold-plate Capacity Calculation*.

NOTE Value 'Z' is not applicable to the coldplate variant. These dimensions are the absolute minimum recommended clearances to allow sufficient air flow. The enclosure itself must be significantly wider or taller than the values given above in at least one direction.

3.1.5. Through panel mounting

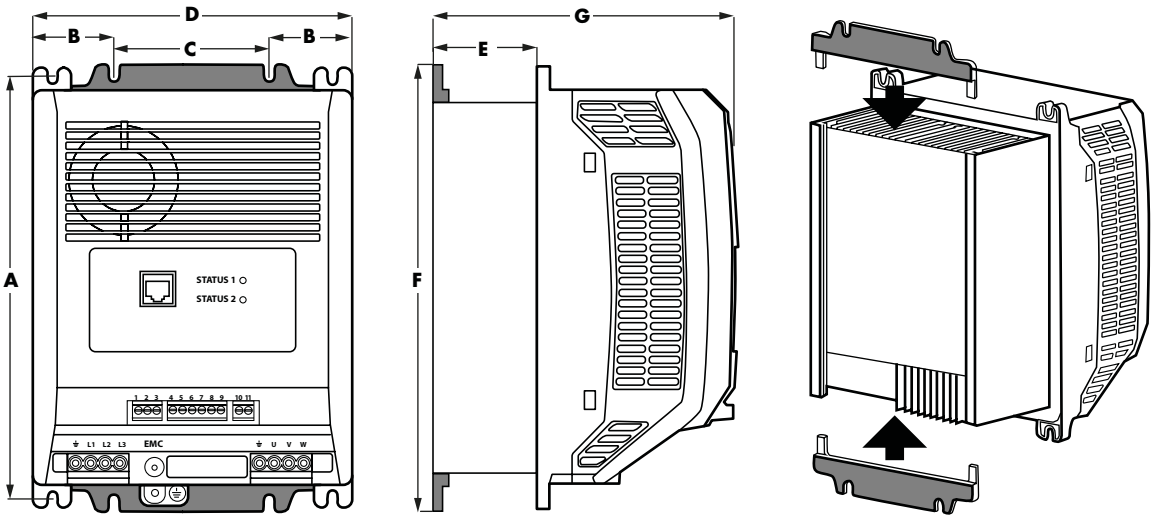
Through panel mounting is the most efficient installation in terms of both panel space and thermal management. With the heatsink protruding through the back of the electrical panel, the heat generated by the drive will be exhausted outside of the electrical panel.



A		B		C		D		E		F		G		H		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
226.3	8.9	15.6	0.61	184	7.24	15.6	0.61	165.3	6.5	147	5.78	177	6.96	71.7	2.82	104.4	4.11

3.1.6. Panel mounting (with the panel mounting kit)

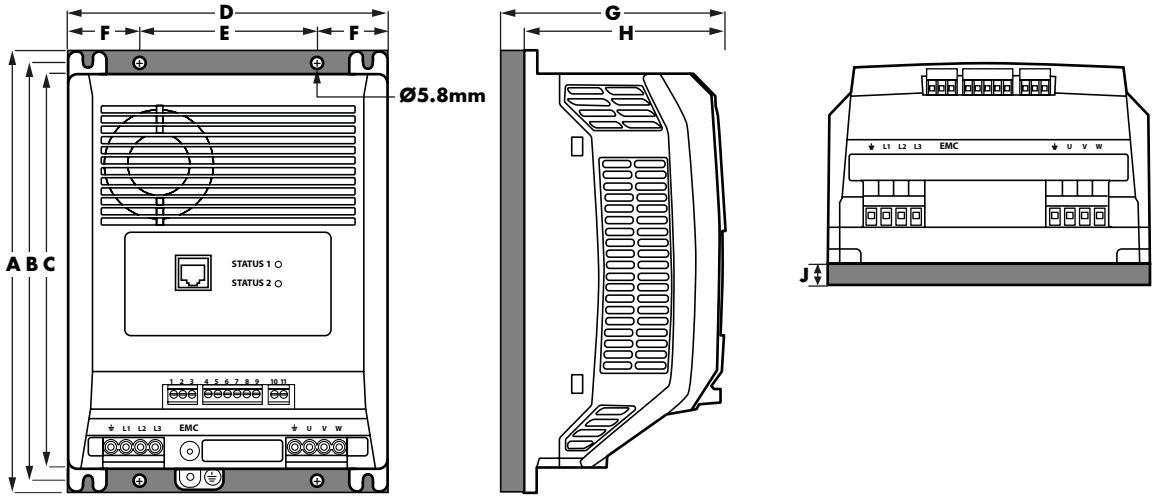
If the installation does not lend itself to through panel mounting, the drive can be mounted to a back-plate of a panel using the optional panel mounting kit.



A		B		C		D		E		F		G	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
215.2	8.47	42.7	1.68	80	3.15	165.3	6.5	73.7	2.9	228	8.98	179	7.04

3.1.7. Panel mounting the cold-plate variant

The CDS 203 is also available without a heatsink but with a coldplate that needs to be mounted onto a heat transfer surface, removing the drive losses and maintaining the coldplate temperature as shown in the table in section *3.1.8. Cold-plate Capacity Calculation on page 11*.



A		B		C		D		E		F		G		H		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
226.3	8.9	215.2	8.5	201.4	7.9	165.3	6.5	90	3.5	37.7	1.48	113.9	4.48	104.4	4.11	9.5	0.37

Tightening Torques		
	Required Torque	
Control Terminals	0.5 Nm	4.5 lb-in
Power Terminals	1 Nm	9 lb-in

Weights	
All 400V Coldplate Drive	2.03kg
230V PFC Coldplate Drives (7A & 12A)	2.4kg
230V PFC Coldplate Drives (16A & 20A)	2.74kg

3.1.8. Cold-plate Capacity Calculation

The coldplate variants of the CDS 203 are designed to be mounted to a metallic, heat conducting surface, removing the heat generated as losses within the drive. Thermostrate or heat transfer compound must be added to ensure optimal heat transfer and minimum thermal resistance.

In order to ensure that the drive remains within the design temperatures, use the following table containing the typical losses and the maximum temperatures the drive can reach.

Please be aware that drive loses are dependent of switching frequencies. Danfoss default values are marked in the table with a "*".

A special care shall be taken when designing the cooling device to avoid any condensation phenomena on the drive.

- Select the desired PWM operating frequency from the available options in Parameter P5-06
- Determine the maximum permissible drive temperature, T_{MAX} from table X below
- Calculate the motor absorbed electrical power, P_{MOT}, based on the motor rated voltage, current and efficiency

  $P_{MOT} = \sqrt{3} * \text{Rated Voltage} * \text{Rated Current} * \text{Power Factor} * \text{Efficiency}$
- Calculate the losses in the drive, P_{LOSS}, based on the required motor power

  $P_{LOSS} = P_{MOT} * (1 - \text{Drive Efficiency})$

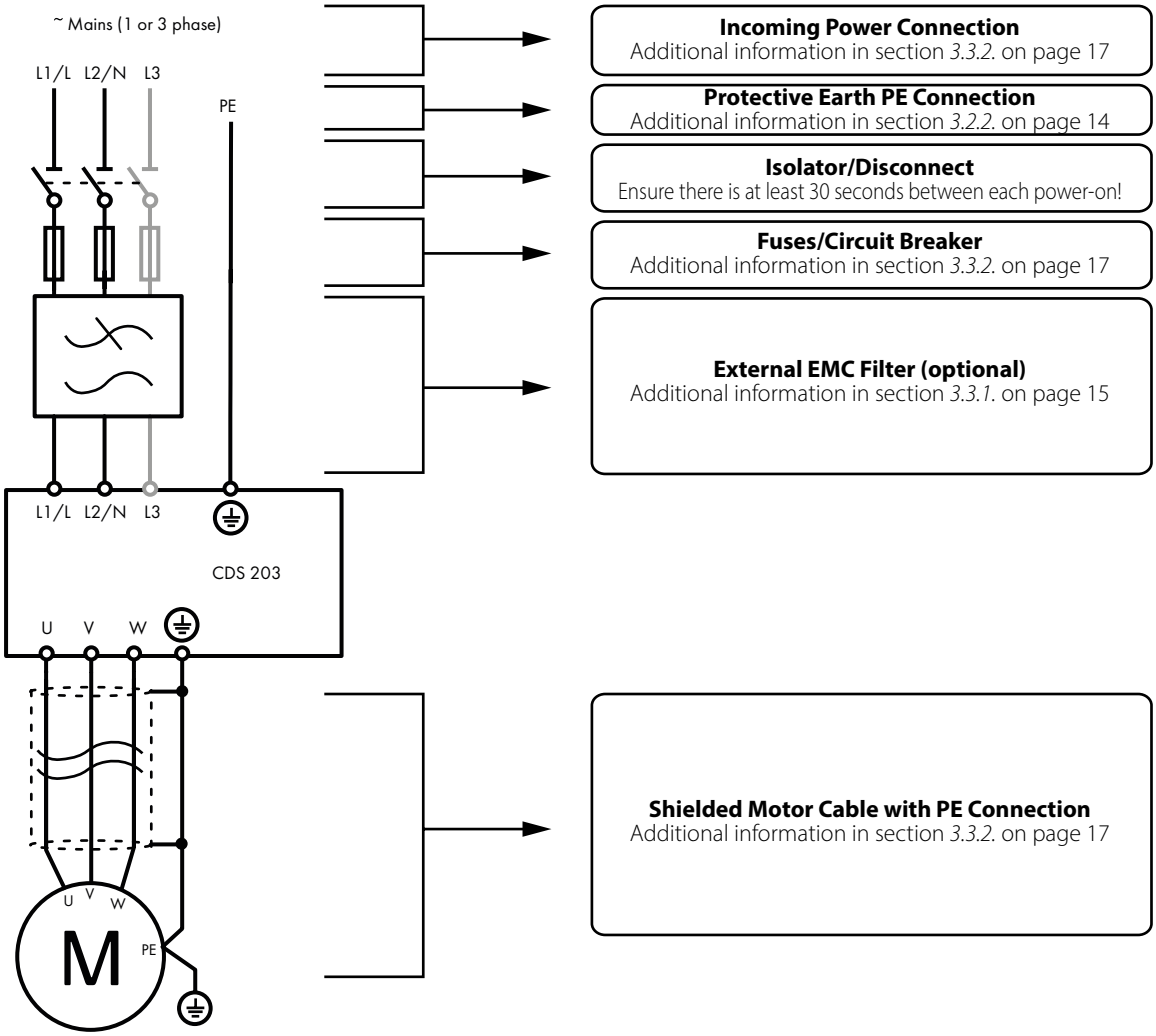
Typical drive efficiency values are shown in the table below for each available effective switching frequency:

Supply Rating		Output Rating		Product Part Number	Switching frequency	Typical Output Power	Approximate losses at typical power	Maximum coldplate or Heatsink temperature
V	Ph	A	kW	Model	kHz	kW	W	°C
200-240V +/-10%	1	7	1.5	CDS203-22P1K5-1FC11 CDS203-22P1K5-1FH11	4	1.5	75.45	95
					8*		85.5	92
					12		95.1	89
					16		102.45	86
					24		121.95	83
					32		147.75	80
200-240V +/-10%	1	12	3	CDS203-22P3K0-1FC21 CDS203-22P3K0-1FH21	4	3	165.3	95
					8		179.4	92
					12*		180.9	89
					16		201.6	86
					24		230.7	83
					32		231.3	80
200-240V +/- 10%	1	16	4	CDS203-22P4K0-1FC41 CDS203-22P4K0-1FH41	4	4	225	95
					8		249	92
					12*		278	89
					16		305	86
					24		358	83
					32		411	80
380-480V +/-10%	3	14	5.5	CDS203-24P5K5-3FC31 CDS203-24P5K5-3FH41	10	5.5	184	91
					12*		198	89
					14		211	88
					16		217	87
					18		235	85
					20		246	84
380-480V +/-10%	3	24	11	CDS203-24P11K-3FC51 CDS203-24P11K-3FH51	10	11	358	91
					12*		359	89
					14		363	88
					16		370	87
					18		383	85
					20		393	84

3.2. Connection Diagram

All power terminal locations are marked directly on the product with AC power input and motor connections located at the bottom of the unit.

3.2.1. Electrical Power Connections



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This CDS 203 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.

3.2.2. Grounding Guidelines

The ground terminal of each CDS 203 should be individually connected DIRECTLY to the site ground bus bar (through the filter if installed). CDS 203 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.

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.

Motor Ground

The motor ground must be connected to one of the ground terminals on the drive.

Ground Fault Monitoring

As with all inverters, a leakage current greater than 3.5mA to earth can exist. The CDS 203 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 (or B+) 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 CDS 203 as opposed to one protection device serving many.

Shield Termination (Cable Screen)

The safety ground terminal provides a grounding point for the motor cable shield. The motor cable shield connected to this terminal (drive end) should also be connected to the motor frame (motor end). Use a shield terminating or EMI clamp to connect the shield to the safety ground terminal.

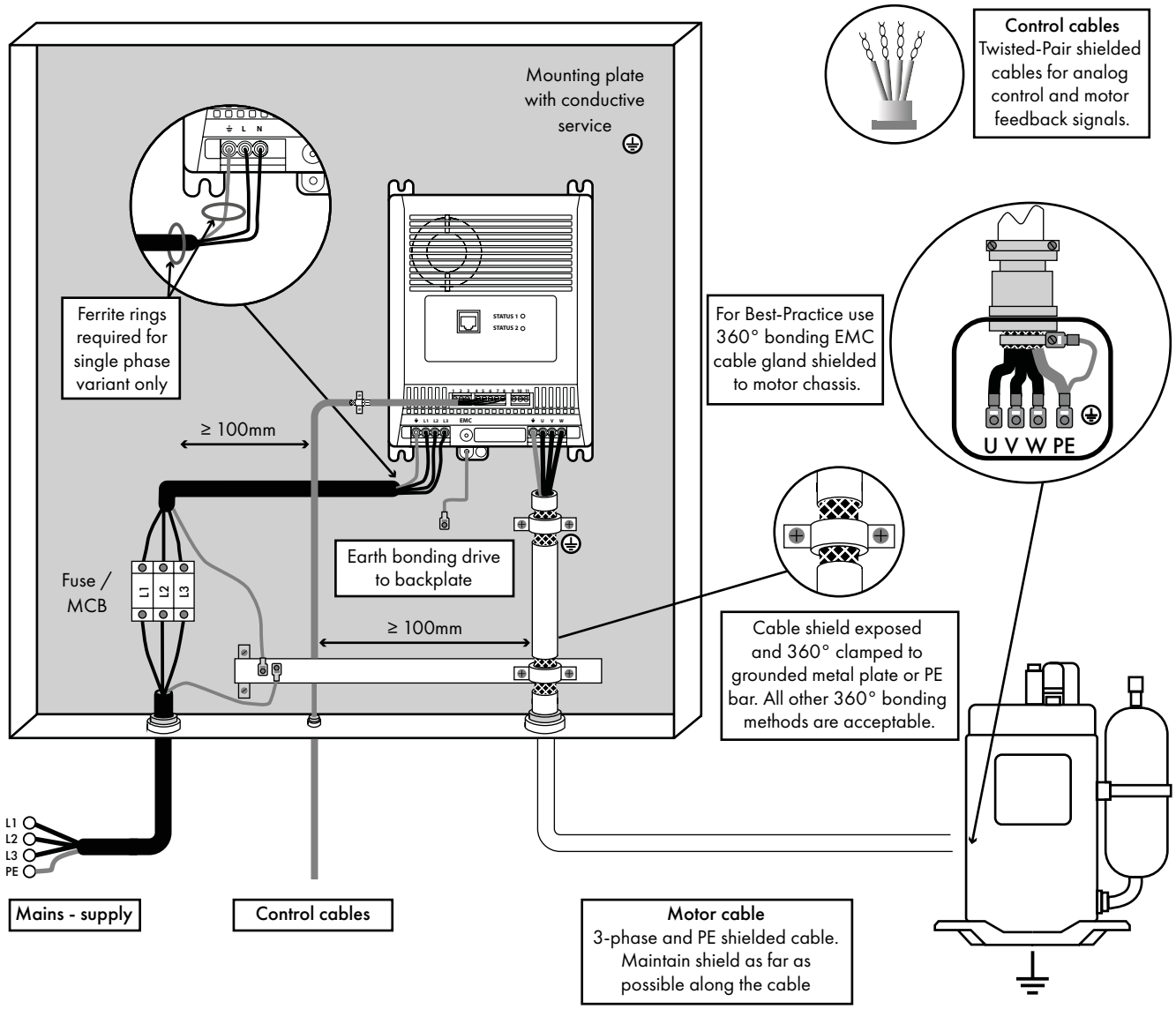
3.3. EMC Compliant Installation

The CDS 203 is designed in compliance with stringent EMC standards. All models are supplied with an internal EMC filter, which is specifically designed to reduce the emissions in conformity with harmonised European Standards. It is the installer's responsibility that the device or system within which the CDS 203 is incorporated, is in compliance with the Standards in force in the country of use. The relevant EMC directive in force in the European Union is the EMC 2014/30/EU.

The CDS 203 is intended to be incorporated inside fixed installation devices, only installed by skilled individuals. Conformity with the EMC Standard can only be achieved if the guidance provided in this chapter is strictly adhered to.

NOTE It is the responsibility of the installer to ensure that the final product containing the CDS 203 complies with any standard necessary for that final product.

3.3.1. Recommended Installation for EMC Compliance



Power Supply	Model Code	kW	Amps	Maximum shielded cable length (m)	
				Category C1 (conducted)	Category C2 (conducted & radiated)
1x 200-240V	CDS203-22P1K5-1F	1.5	7	2.5	5*
	CDS203-22P3K0-1F	3	12	2.5	5*
	CDS203-22P4K0-1F	4	16	require external EMC filter	5*
3x 380-480V	CDS203-24P5K5-3F	5.5	14	2.5	5
	CDS203-24P11K-3F	11	24	2.5	5

* To ensure compliance with category C2 radiated emissions with the single phase 230V PFC drives, it is necessary to install a ferrite core. Should an additional external EMC filter be used, the maximum permissible cable length is extended to double of the values stated in the table.

General

[1] Compliance with category C1 conducted emissions only is achieved. To ensure compliance with category C2 radiated emissions with the single phase 230V PFC drives, it is necessary to install a ferrite core (e.g. Fair-Rite round cable snap ferrite 0431176451), one around the supply cable and the second around the supply earth.

NOTE The use of some split-core ferrites can add to the acoustic noise generated by the installation. Whole ferrites can provide the required benefits without adding to the acoustic noise of the installation.

Supply Cable

[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.

Motor Cable

[3] A screened (shielded) cable suitable for fixed installation with the relevant 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 – in this case, ensure that metal tube is adequately grounded.

[4] The cable shield should be terminated at the motor end using an EMC type gland or clamp allowing connection to the motor body through the largest possible surface area. The shield must also be terminated at the drive end, as close as practically possible to the drive output terminals. Where drives are mounted in a steel control panel enclosure, the cable screen may be terminated directly to the control panel backplate using a suitable EMC clamp or gland fitted as close to the drive as possible. The drive earth terminal must also be connected directly to this point, using a suitable cable which provides low impedance to high frequency currents.

Control Cable

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

3.3.2. Incoming Power Connection

Cable Selection

- For 1 phase supply, the mains power cables should be connected to L1/L, L2/N.
- 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 and C Tick EMC requirements, refer to section *3.3. EMC Compliant Installation* on page 14.
- A fixed installation is required according to IEC61800-5-1 with a suitable disconnecting device installed between the CDS 203 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 *6.2. Detailed Product Rating Tables* on page 51.

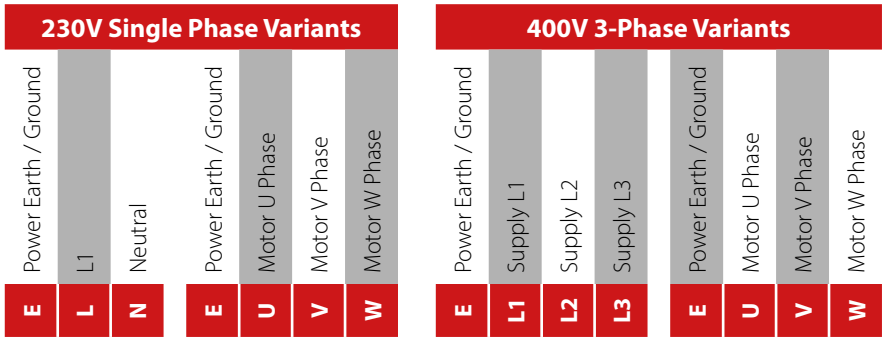
Fuse / Circuit Breaker Selection

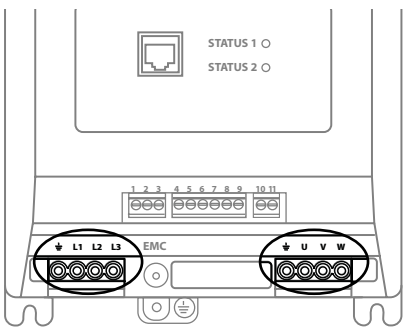
- Suitable fuses to provide wiring protection of the input power cable should be installed in the incoming supply line, according to the data in section *6.2. Detailed Product Rating Tables*. The fuses must comply with any local codes or regulations in place. In general, type gG (IEC 60269) or UL type 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 CDS 203 Power terminals as defined in IEC60439-1 is 100kA.

Motor Connection

- The drive inherently produces fast switching of the output voltage (PWM) to the motor compared to the mains supply, for motors which have been wound for operation with a variable speed drive then there is no preventative measures required, however if the quality of insulation is unknown then the motor manufacturer should be consulted and preventative measures may be required.
- The motor should be connected to the CDS 203 U, V, and W terminals using a suitable 3 or 4 core cable. Where a 3 core cable is utilised, with the shield operating as an earth conductor, the shield must have a cross sectional area at least equal to the phase conductors when they are made from the same material. Where a 4 core cable is utilised, the earth conductor must be of at least equal cross sectional area and manufactured from the same material as the phase conductors.
- The motor earth must be connected to one of the CDS 203 earth terminals.
- Maximum permitted motor cable length for all models: 10 metres shielded, 20 metres unshielded.

Power Connections

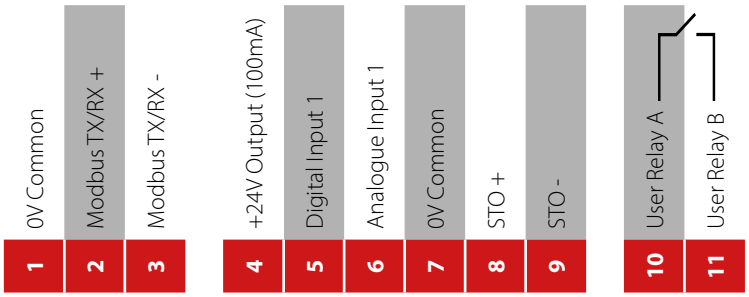


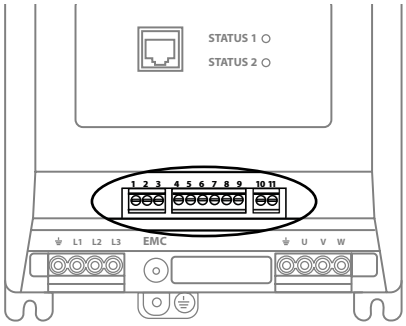


3.3.3. Control Wiring

The CDS 203 has pluggable control terminals to support easy installation. There are three pluggable control terminal blocks split into:

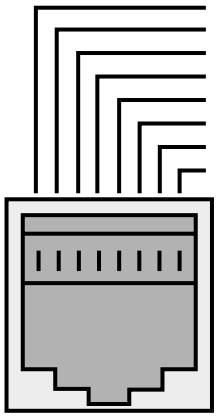
- Serial Communications (T1-T3)
- Inputs (T5 – T9)
- Output Relay (T10 – T11)



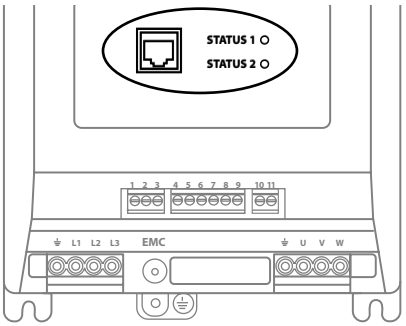


RJ45 Port

This port is intended for connection to a PC running Cool Setting configuration software or to connect the drive to a system controller using ModBus RTU



1	Not used
2	Not used
3	0 Volts
4	-RS485 (PC)
5	+RS485 (PC)
6	+24 Volt
7	RS 485- Modbus RTU
8	RS 485+ Modbus RTU



Warning:

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

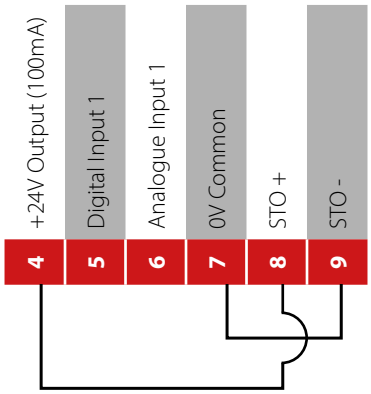
The RJ45 port has some terminals that are internally connected in parallel with the pluggable control terminals as shown below:

Pluggable Control Terminal	RJ45 Terminal	Description
1	3	0 Volt Common
2	8	Modbus RTU TX/RX + (RS485)
3	7	Modbus RTU TX/RX - (RS485)
4	6	User +24 Volt (100mA Max)
-	5	PC-Tools TX/RX + (RS485 Optibus)
-	4	PC-Tools TX/RX - (RS485 Optibus)

3.3.4. Safe Torque Off

Safe Torque OFF will be referred to as "STO" through the remainder of this section. If the "STO" function is not required in your installation, you must link out the "STO" circuit by linking terminal 4 to terminal 8 and linking terminal 7 to terminal 9 as shown in the figure below. Please read the remainder of this chapter for further information about the functionality and limitations of the "STO" circuit.

Showing the links needed if the STO is not required



Responsibilities

The overall system designer is responsible for defining the requirements of the overall "Safety Control System" within which the drive will be incorporated; furthermore the system designer is responsible for ensuring that the complete system is risk assessed and that the "Safety control System" requirements have been entirely met and that the function is fully verified, this must include confirmation testing of the "STO" function before drive commissioning.

The system designer shall determine the possible risks and hazards within the system by carrying out a thorough risk and hazard analysis, the outcome of the analysis should provide an estimate of the possible hazards, furthermore determine the risk levels and identify any needs for risk reduction. The "STO" function should be evaluated to ensure it can sufficiently meet the risk level required.

What STO Provides

The purpose of the "STO" function is to provide a method of preventing the drive from creating torque in the motor in the absence of the "STO" input signals (Terminal 8 with respect to Terminal 9), this allows the drive to be incorporated into a complete safety control system where "STO" requirements need to be fulfilled.[1] The "STO" function can typically eliminate the need for electro-mechanical contactors with cross-checking auxiliary contacts as per normally required to provide safety functions.[2] The drive has the "STO" function built-in as standard and complies with the definition of "Safe torque off" as defined by IEC 61800-5-2:2016. The "STO" function also corresponds to an uncontrolled stop in accordance with category 0 (Emergency Off), of IEC 60204-1. This means that the motor will coast to a stop when the "STO" function is activated, this method of stopping should be confirmed as being acceptable to the system the motor is driving. The "STO" function is recognised as a fail-safe method even in the case where the "STO" signal is absent and a single fault within the drive has occurred, the drive has been proven in respect of this by meeting the following safety standards.

Safe Torque Off (STO)	IEC 61800-5-2:2016	SIL 3
	EN ISO 13849-1:2015	PL "e"
	EN 61508 (Part 1 to 7): 2010	SIL 3
	EN 60204-1: 2006 & A1: 2009	Cat 0
	EN 62061: 2005 & A2: 2015	SIL CL 3
	Independent Approval	TUV Rheinland

NOTE Periodic testing of the entire safety circuit within which the drive STO is integrated, is a mandatory requirement. The testing should be repeated every three months or less to ensure the integrity level of the safety circuit is maintained.

What STO Does Not Provide

Disconnect and ISOLATE the drive before attempting any work on it. The "STO" function does not prevent high voltages from being present at the drive power terminals.

[1] **NOTE** The "STO" function does not prevent the drive from an unexpected re-start. As soon as the "STO"inputs receive the relevant signal it is possible (subject to parameter settings) to restart automatically, Based on this, the function should not be used for carrying out short-term non-electrical machinery operations (such as cleaning or maintenance work).

[2] **NOTE** In some applications additional measures may be required to fulfil the systems safety function needs: the "STO" function does not provide motor braking. In the case where motor braking is required a time delay safety relay and/or a mechanical brake arrangement or similar method should be adopted, consideration should be made over the required safety function when braking as the drive braking circuit alone cannot be relied upon as a fail safe method.

When using permanent magnet motors and in the unlikely event of a multiple output power devices failing then the motor could effectively rotate the motor shaft by 180/p degrees (Where p denotes number of motor pole pairs).

"STO" Operation

When the "STO" inputs are energised, the "STO" function is in a standby state, if the drive is then given a "Start signal/command" (as per the start source method selected in P1-11) then the drive will start and operate normally.

When the "STO" inputs are de-energised then the STO Function is activated and stops the drive (Motor will coast), the drive is now in "Safe Torque Off" mode.

To get the drive out of "Safe Torque Off" mode then any "Fault messages" need to be reset and the drive "STO" input needs to be re-energised.

"STO" Status and Monitoring

There are a number of methods for monitoring the status of the "STO" input, these are detailed below:

- **Optional Remote CDS203 LCP**

  In Normal drive operation (Mains AC power applied), when the drives "STO" input is de-energised ("STO" Function activated) the drive will highlight this by displaying "InHibit" on the remote keypad and bit 5 of the status word will become active.

NOTE If the drive is in a tripped condition then the relevant trip will be displayed on the remote keypad and not "InHibit".

- **Drive Output Relay**

  Drive relay 1: Setting P3-05 to a value of "5" will result in relay opening when the "STO" function is activated.

"STO" Fault Code

Fault Code	Code Number	Description	Corrective Action
"Sto-F"	29	A fault has been detected within either of the internal channels of the "STO" circuit.	Refer to your Danfoss Sales Partner
		The Sto-F trip can also indicate that the STO circuit was opened momentarily whilst the drive was running.	Check the wiring of the STO circuit and any switches or devices within that circuit.

"STO" Function Response Time

The total response time is the time from a safety related event occurring to the components (sum of) within the system responding and becoming safe. (Stop Category 0 in accordance with IEC 60204-1).

- The response time from the "STO" inputs being de-energised to the output of the drive being in a state that will not produce torque in the motor ("STO" active) is less than 1ms.
- The response time from the "STO" inputs being de-energised to the "STO" monitoring status changing state is less than 20ms.
- The response time from the drive sensing a fault in the STO circuit to the drive displaying the fault on the display/Digital output showing drive not healthy is less than 20ms.

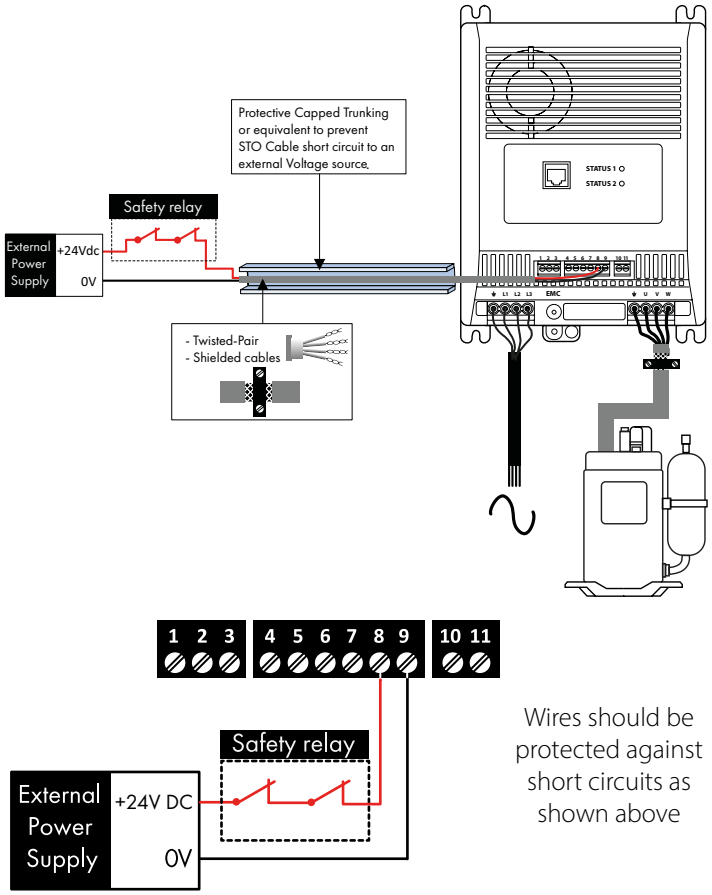
"STO" Electrical Installation

The "STO" wiring shall be protected from inadvertent short circuits or tampering which could lead to failure of the "STO" input signal, further guidance is given in the diagrams below.

In addition to the wiring guidelines for the "STO" circuit below, section *3.3. EMC Compliant Installation* on page 14 should also be followed. The drive should be wired as illustrated below; the 24Vdc signal source applied to the "STO" input can be either from the 24V dc on the drive or from an External 24V dc power supply.

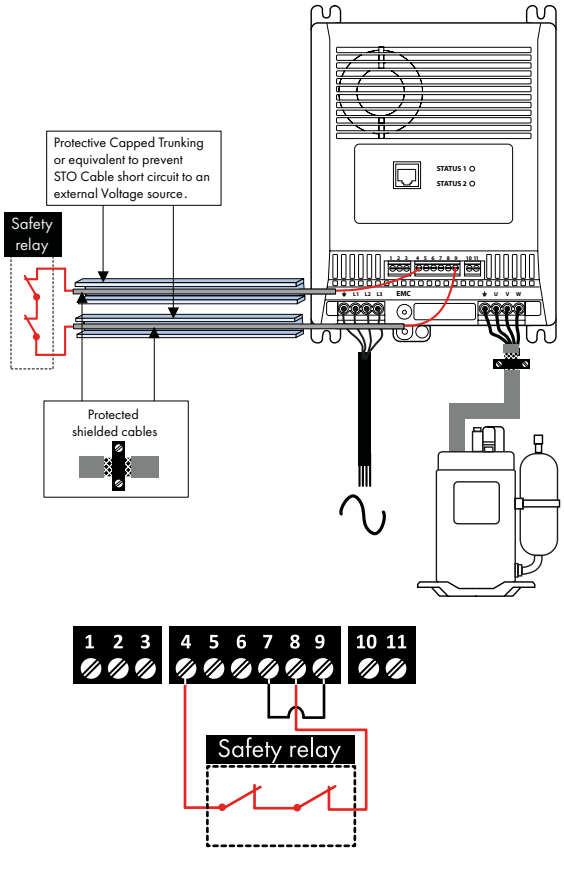
3.3.5. Recommended "STO" Wiring

Using an External 24V DC Power Supply



Wires should be protected against short circuits as shown above

Using the Drives On-board 24V DC Supply



NOTE The Maximum cable length from Voltage source to the drive terminals should not exceed 25 metres.

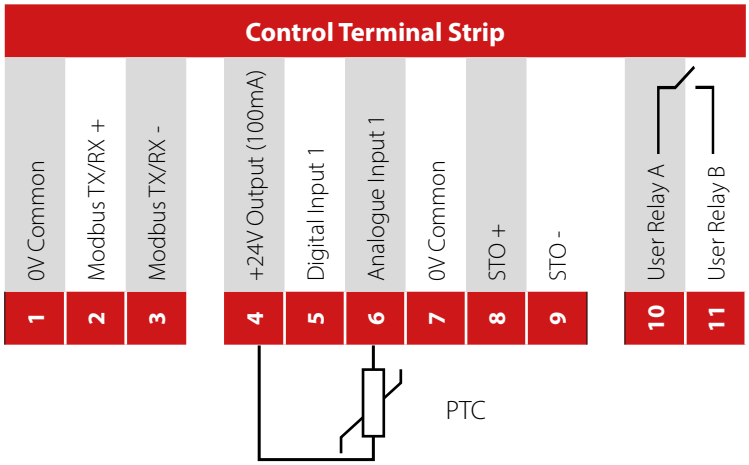
3.3.6. Motor Thermal Overload Protection

Internal Thermal Overload Protection

The drive has an in-built motor thermal overload function; this is in the form of an "I.t-trP" trip after delivering >100% of the compressor rated current for a sustained period of time (e.g. 130% for 10 seconds).

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.
- When using a motor thermistor connected to the drive analogue input is shown in the diagram, Parameter P3-10 (Modbus register 310) must be set to a value of 8 (PTC).

4.1. Basic Checks Before Commissioning

It is vitally important to ensure that the CDS 203 that you have purchased is suitable for the supply that you intend to connect it to, as is the importance of ensuring that this is matched to the compressor to be connected to.

4.1.1. Operating Limits and Ramp Rates

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
1-01	101	Maximum Motor Speed	DD	P1-02	500	Rps	R/W
1-02	102	Minimum Motor Speed	DD	0	P1-01	Rps	R/W
1-03	103	Acceleration Ramp Time from 0rps to Rated Speed	120	30	6000	s	R/W
1-04	104	Deceleration Ramp Time from Rated Speed to 0rps	120	30	6000	s	R/W

4.1.2. Start-up Sequence

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
2-01	201	Start Speed 1	37	P1-02		Rps	R/W
2-02	202	Start Speed 1 Time	60	0	600	s	R/W
2-03	203	Start Speed 1 Acceleration Ramp 0rps to Start Speed 1	30	0	6000	s	R/W
2-04	204	Start Speed 2	0	P1-02		Rps	R/W
2-05	205	Start Speed 2 Time	0	0	600	s	R/W
2-06	206	Start Speed 2 Acceleration Ramp 0rps to Start Speed 2	0	0	6000	s	R/W
2-07	207	Start Speed 3	0	P1-02		Rps	R/W
2-08	208	Start Speed 3 Time	0	0	600	s	R/W
2-09	209	Start Speed 3 Acceleration Ramp 0rps to Start Speed 3	0	0	6000	s	R/W

If the start-up sequencing (or part of the start-up sequencing) is not required, set that Start Speed Time to 0s to disable that function. e.g. if you want to have one part of the start up sequence, set Start Speed 1 (P2-01) to the desired speed in rps, set the time for the motor to sit at speed 1 in P2-02 and set the desired ramp rate in P2-03 – then ensure that P2-05 and P2-08 are both set to 0s. On start-up in this example, the drive will ramp the speed set in P2-01 using the ramp rate set in P2-03 for a duration set in P2-02 before then following the chosen speed reference.

NOTE The ramp rates here are entered in seconds per rated speed of the motor (e.g. 5.0s to go from 0rps to 60rps).

4.1.3. Re-start Blocking

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
2-10	210	Minimum Off Time	180	0	6000	s	R/W
2-11	211	Minimum On Time	180	0	6000	s	R/W
2-12	212	Re-start Delay (Start-to-start Delay)	600	0	6000	s	R/W
2-13	213	Re-start Function	10	0	Auto-10	-	R/W

NOTE Setting the minimum on time can mean that the drive will continue to run when the stop command is given. Removal of the STO signal will override any other command. If the analogue input is configured as a PTC input which reaches a reading which cause the drive to trip then this will also override the minimum run time.

4.1.4. Control Mode

see illustrations in section *4.5. Modbus Connections on page 29* for minimum control wiring required for each control mode.

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
1-11	111	Command Source 0: Modbus Mode 1: Terminal Control 2: Terminal Control (AI1 Start) 3: User PID Mode	1 – Terminal	0	3	-	R/W
1-05	105	Stop Mode 0: Ramp to Stop 1: Coast to Stop 2: AC Flux Braking (IM Motor only) 3: Ramp to Minimum Speed then Coast to Stop	1	0	3	-	R/W

The primary command source setting in P1-11 makes a significant difference to how the drive is operated or controlled. The following table provides an overview of how the control commands vary for each setting.

P1-11	Drive Enable	Run/Stop	Speed Ref.	Ramps	Fault reset
0 – Modbus	Safety (STO)	Modbus	Modbus	Parameters	DI1 / Modbus
1 – Terminal	Safety (STO)	DI1	AI1	Parameters	DI1
2 – Terminal AI Start	Safety (STO)	AI1>10% / AI1<5%	AI1	Parameters	DI1
3 – User PI	Safety (STO)	DI1	PI Output	Parameters	DI1

4.1.5. Thermal Protection

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
5-09	509	Motor Thermal Overload Management (Ixt)	0	0	1	-	R/W
5-10	510	Drive Thermal Overload Management (Drive Temperature Based)	0	0	1	-	R/W
5-11	511	Motor Thermal Overload Retention Enable	1	0	1	-	R/W

4.1.6. Slow Acting Current Limit

In certain applications, it is possible that the drive will go into overload where the motor current will exceed the compressor rated current. When enabled, this function is intended to slowly ramp the drive down towards minimum speed at the ramp rate set in P5-20 if the current exceeds the value set in P5-19 as a percentage of compressor rated current. If the motor current then drops below this threshold for a period of 5s, the drive will return to the configured reference using the defined acceleration ramp. This function is disabled if the Slow Acting Current Limit Ramp (P5-20) is set to 0.

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
5-19	**519**	**Slow Acting Current Limit** When enabled (P5-20 > 0), this parameter defines a current as a percentage of the compressor rated current at which the drive will internally set the speed reference equal to the minimum speed (P1-02) and ramp down slowly to this speed at a rate set in P5-20 in seconds per rated speed. When the current drops below this level the drive will return to the configured speed reference using the ramp rate set in P1-03.	**100**	**50**	**130**	**%**	**R/W**
5-20	**520**	**Slow Acting Current Limit Ramp** This is the ramp rate in seconds per rated speed which is used to ramp down to minimum speed if the slow acting current limit (P5-19) as a percentage of the compressor rated current is reached. Setting the value to 0s will disable the function.	**0**	**0**	**300**	**s**	**R/W**

4.2. Oil Return Requirement

In some refrigeration systems or heat pumps, it is possible for the oil to migrate to various parts of the circuit leaving a shortage of oil in the sump to lubricate the moving parts of the compressor. This can result in permanent damage to the compressor and systems are consequently designed to mostly mitigate this issue. Where system design can support the mitigation of excessive oil migration, the transit time of the oil and refrigerant through the system can also influence the problem of oil migration, particularly if the compressor has been operating at a low speed for a period of time. For this reason, it is sometimes necessary to reduce the transit time by speeding up the compressor for a fixed period of time after continued operation at lower speeds, thus ensuring the return of migrated oil to the compressor itself.

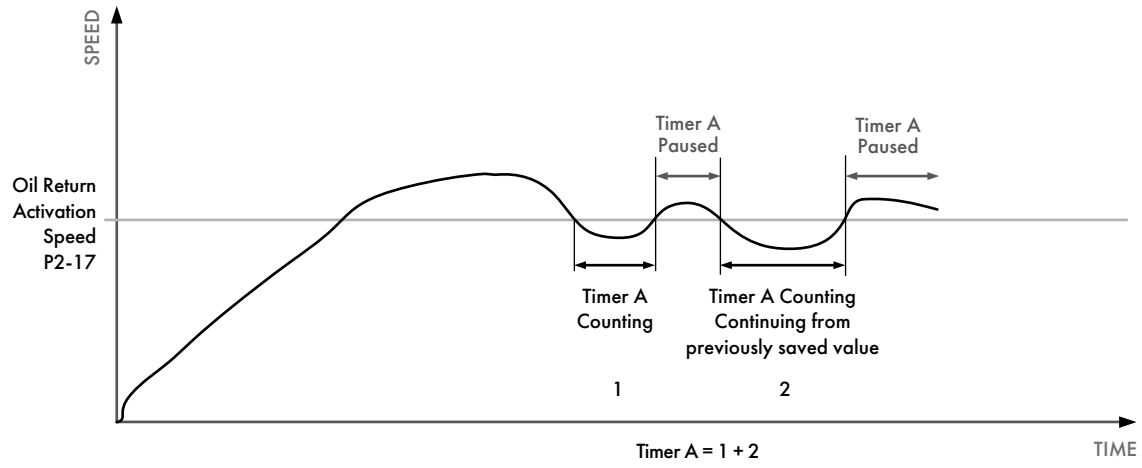
4.2.1. Oil Return Feature Within the Drive

This feature is configured by the following four parameters:

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
P2-17	217	'Oil Return Activation Speed' where operation of the compressor at or below this speed will activate the counter within this feature.	**50**	**P1-02**	**P1-01**	**rps**	
P2-18	218	'Oil Return Activation Time' at which the drive will need to run at or below the 'Activation Speed''A' before it will activate the increased speed operation (the timer is accumulative as shown in the illustration below). The feature will be disabled if this time is set to 0s. The compressor must reach minimum speed after start-up and not be in the start-up sequence before this timer will start counting.	**1800**	**0**	**6000**	**s**	
P2-19	219	'Oil Return Boost Speed' is the minimum speed at which the compressor will run at once activated from the above two settings for a period configured in the 'Oil Return Time'.	**70**	**P1-02**	**P1-01**	**rps**	
P2-20	220	'Oil Return Duration' is the time that the compressor will apply the 'Oil Return Boost Speed' once activated.	**60**	**0**	**600**	**s**	

When the feature has been activated, if the speed demand increases above the 'Oil Return Boost Speed', the compressor speed will increase but it will be prevented from falling below the 'Oil Return Boost Speed' until the 'Oil Return Time' has elapsed.

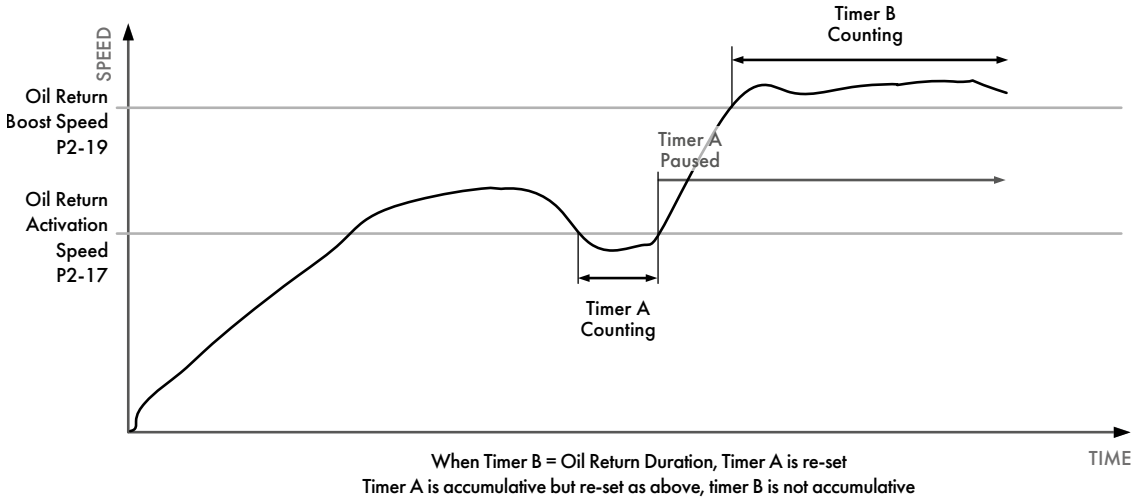
Timers to operate as shown below:



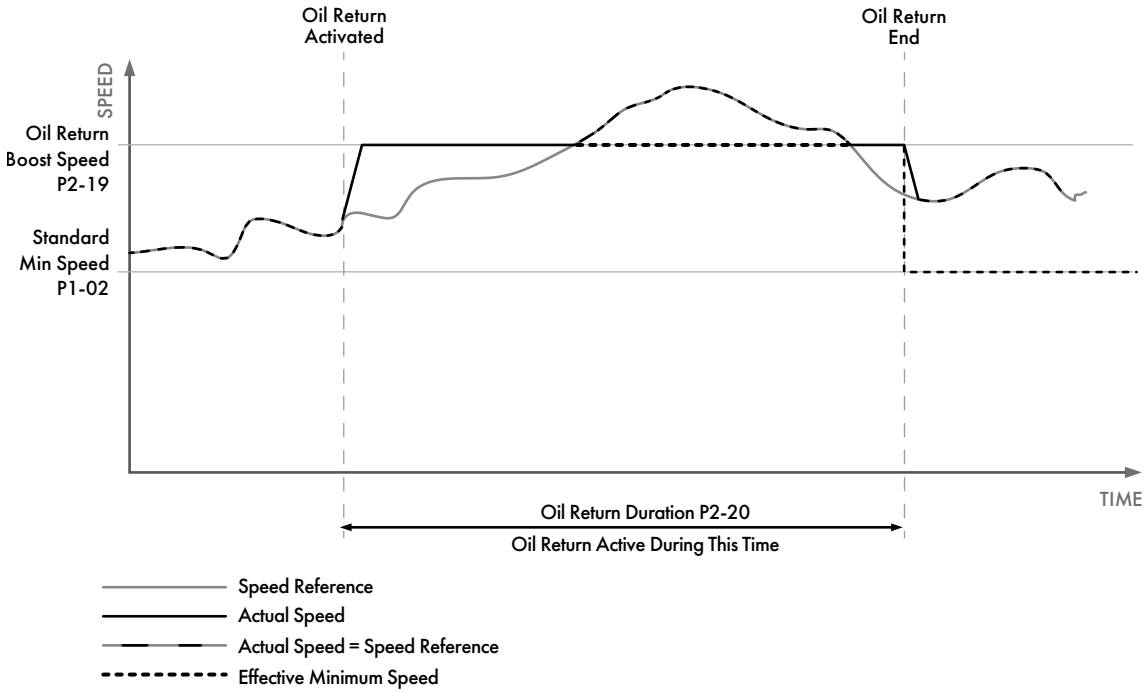
The above illustrates that the timer will count when the speed is below the activation speed and the value in the timer will be held and used the next time that the speed falls below the activation speed – this is a cumulative timer.

The Oil return boost speed will then be implemented as a minimum speed clamp when timer A has reached the value in P2-18.

The timer (Timer A) is re-set when the drive speed has been equal to or greater than the Oil Return Speed for the Oil Return Duration as shown below (or when the drive has stopped):



When the timer is re-set (Timer A), the minimum speed clamp is returned to the value set in P1-02 and P2-19 is ignored until the next activation of the Oil Return Feature.



If the drive run command is removed whilst the oil-return feature is active, the drive will follow the selected ramps to a stop and normal operation will commence on next start. The only deviation from this would be if the minimum on time set in the drive had not yet been observed, and the drive would continue to operate as indicated above until the minimum on time had been observed.

It must also be noted that it is the responsibility of the OEM or machine builder to ensure that the system is designed and built in a manner that ensures suitable oil return. The implementation of this oil return feature cannot overcome inadequacies in the system design in all cases. It is also very important to note that the activation of this feature when the condensing fans are not enabled could also significantly adjust the pressures and temperatures in the system causing the main controller to shut down the system.

When this feature is activated, bit-14 of the status word will be HIGH (logic 1) and the status LED will indicate as follows:

LED 1 – constant green

LED 2 – fast flashing yellow

4.3. Use of the CDS203 product with Flammable Refrigerants

The CDS203 is not suitable for use in EX classified areas (Atex directive).

When this product is used with flammable refrigerants, the following considerations apply:

- The product has been evaluated in accordance with IEC 60335-2-40:2022 clause 22.116 and deemed compliant.
  - Electrical components within the drive that could normally create arcs or sparks are limited to the relays.
  - These relays have been independently tested as per clause 22.116.3 and are not considered an ignition risk.
- The product has been evaluated in accordance with IEC 60335-2-40:2022 clause 22.117 and deemed compliant.
  - Hot Surfaces within the product have been verified to remain below the auto-ignition temperatures of the following refrigerants by a margin of at least 100k – R290.
  - The product has built-in protection to detect and trip under conditions of locked rotor, for system compliance in accordance with IEC 60335-2-34.
- It is still recommended and good practice to further mitigate the risk resulting from leaked refrigerant by the following:
  - Separate product from any area where flammable refrigerant could accumulate
  - Ventilate areas where there is risk of accumulation of flammable refrigerant

NOTE The acceptability of the CDS203 in end use applications where flammable refrigerant is employed shall be reviewed and judged by the end use application.

4.4. Locked Rotor Protection

During an attempted start of a compressor with a locked rotor, the precise outcome will depend on the level of current that flows into the motor windings and subsequently, one of the following protection modes will activate:

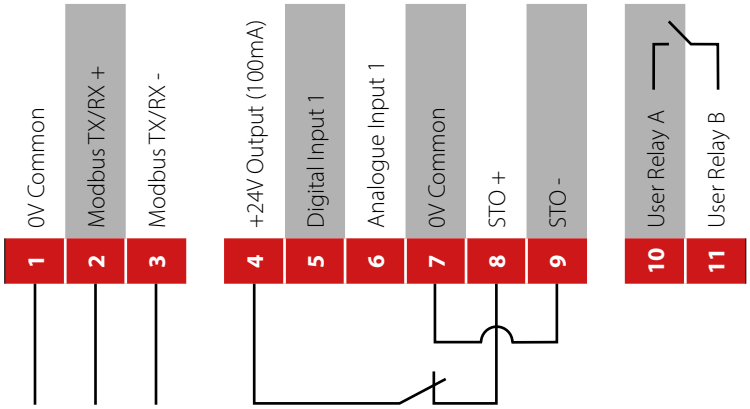
H-OI	Hardware overcurrent
OI	Software overcurrent
It	Motor Overload
Locked Rotor	Motor rotor is locked

4.5. Modbus Connections

4.5.1 Minimum Control Wiring Required For Each Control Mode

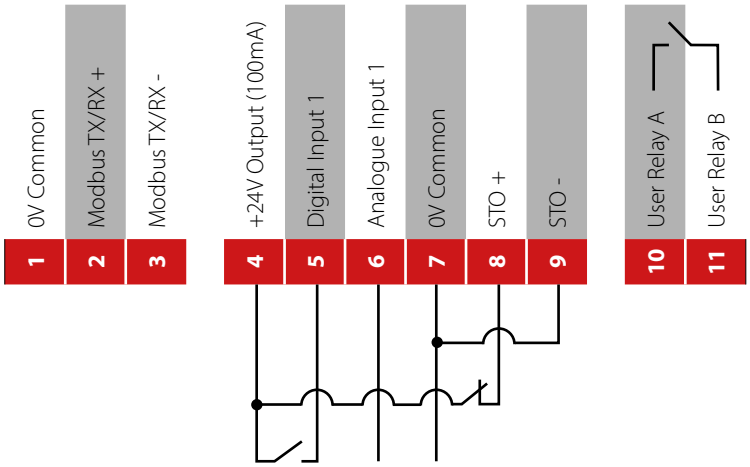
See parameter 1-11 in section *4.1.4. Control Mode on page 24*.

P1-11 = 0 - Modbus control



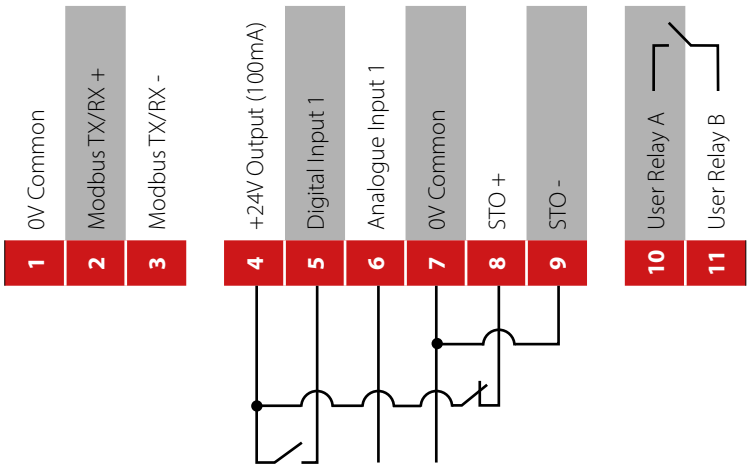
STO signal must be provided in order to permit running the motor. Start/Stop commands and speed reference are provided by serial communication. In Modbus mode, the digital input and analogue input can be used as remote I/O by the controller, the relay output can also be configured to be controlled by Modbus and used by the controller if required. In Modbus mode, the drive can be re-set from a fault by toggling bit 3 of the command word.

P1-11 = 1 or 2 Terminal mode



STO signal must be provided in order to permit running the motor. Start/Stop command provided by the Digital Input (P1-11 = 1) or when the analogue input level is greater than 1% (if P1-11 =2) and speed reference provided by the Analogue input. The drive can be re-set from a fault by removing and re-applying the digital input.

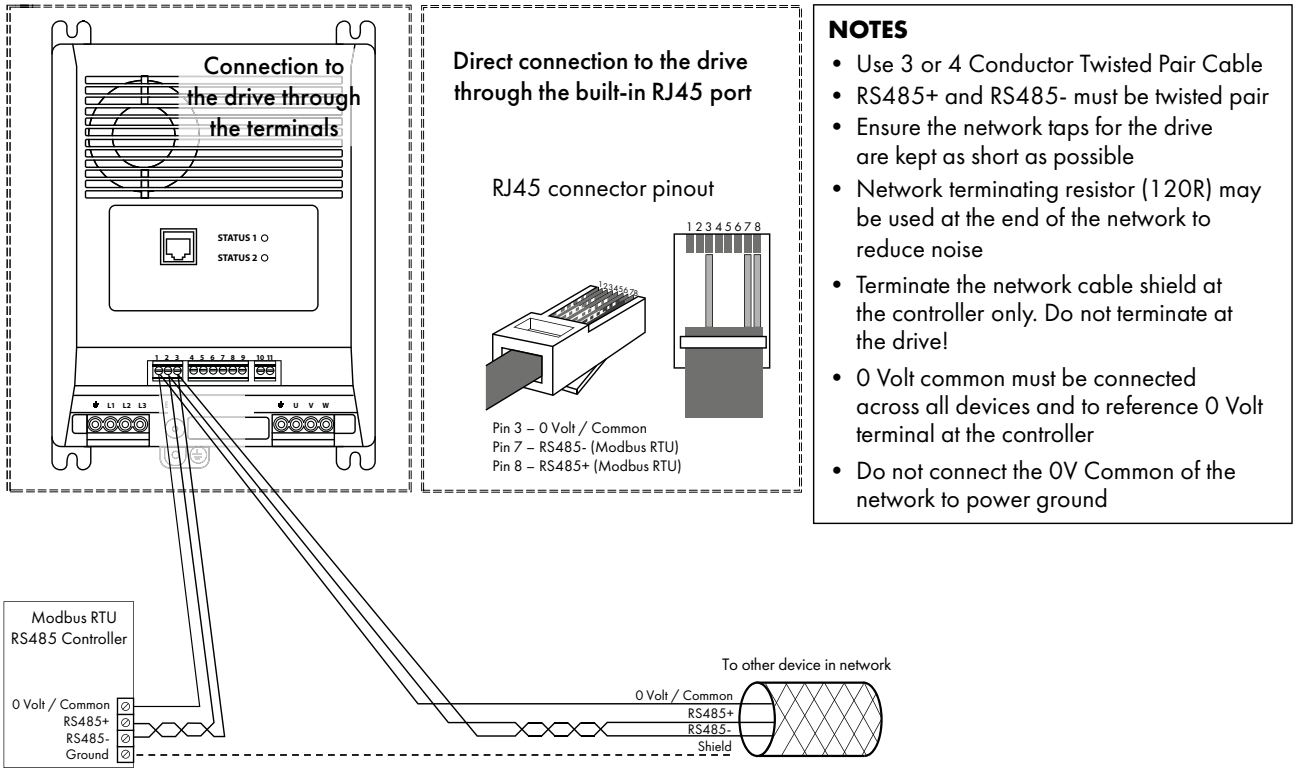
P1-11 = 3 Internal PI mode



STO signal must be provided in order to permit running the motor. Start/Stop command provided by the Digital Input. The speed reference is provided by the output of the PI controller and the PI feedback is provided by the analogue input. The drive can be re-set from a fault by removing and re-applying the digital input.

4.5.2. RS-485 Communications Electrical Connections

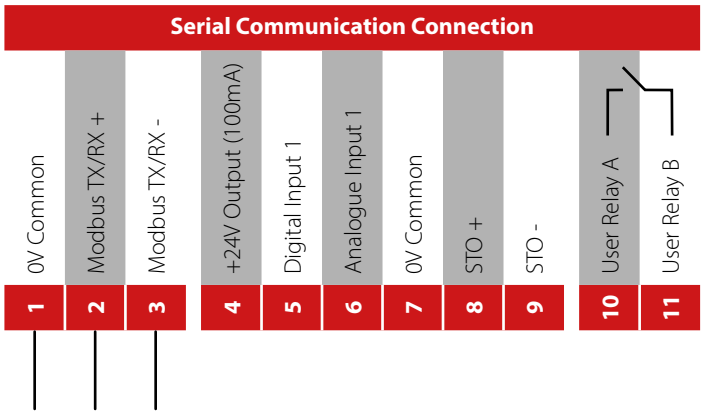
The CDS 203 has two separate points where you can access the Modbus RTU communications. The Modbus RTU connection can be made via the RJ45 connector or control terminals 1, 2 & 3. As shown below:

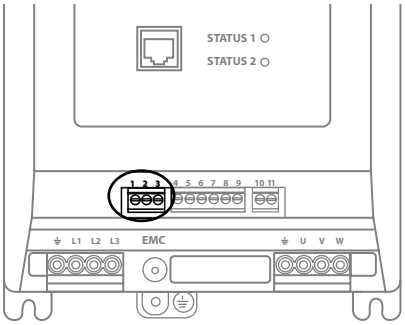


NOTES

- 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
- Network terminating resistor (120R) may be used at the end of the network to reduce noise
- 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

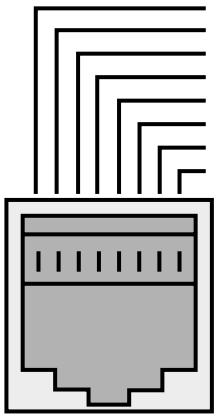
4.5.3. RS-485 Communications Electrical Connections via Control Terminals





4.5.4. RS-485 Communications Electrical Connections via RJ45 Port

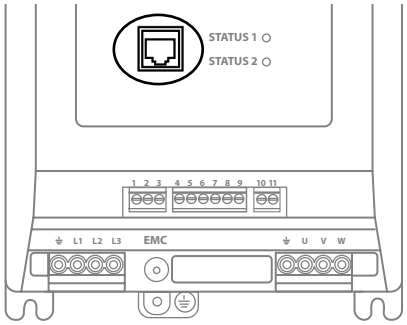
This port is intended for connection to a PC running Cool Setting configuration software or to connect the drive to a system controller using ModBus RTU



1	Not used
2	Not used
3	0 Volts
4	-RS485 (PC)
5	+RS485 (PC)
6	+24 Volt
7	RS 485- Modbus RTU
8	RS 485+ Modbus RTU

Warning:

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



The RJ45 port has some terminals that are internally connected in parallel with the pluggable control terminals as shown below:

Pluggable Control Terminal	RJ45 Terminal	Description
1	3	0 Volt Common
2	8	Modbus RTU TX/RX + (RS485)
3	7	Modbus RTU TX/RX - (RS485)
4	6	User +24 Volt (100mA Max)
-	5	PC-Tools TX/RX + (RS485 Optibus)
-	4	PC-Tools TX/RX - (RS485 Optibus)

4.5.5. Modbus Telegram Structure

The CDS 203 supports Master / Slave Modbus RTU communications, using the 03 Read Multiple Holding Registers and 06 Write Single Holding Register commands and 16 Write Multiple Holding Registers (Supported for registers 1 – 4 only). Many Master devices treat the first Register address as Register 0; therefore it may be necessary to convert the Register Numbers detail in section *4.5. Modbus Connections on page 29* and section *4.6. Parameter List and Modbus Registers on page 34* by subtracting 1 to obtain the correct Register address.

4.5.6. Drive Status Word (Modbus Register 6)

The drive status has two status words where word 1 consists of two individual bytes that can be read in Modbus register 6.

The Status word bit functions are defined as below:

Bit	Function	Explanation
0	Drive Running	0 : Drive stopped 1 : Drive enabled, output pulse enabled
1	Drive Tripped	0 : No trip 1 : Drive tripped
2	Minimum Off-Time Counting down	0 : Count-down at zero 1 : Minimum Off-Time counting Down
3	Minimum On-Time Counting down	0 : Count-down at zero 1 : Minimum On-Time counting Down
4	Re-start Delay Counting down	0 : Count-down at zero 1 : Re-start delay counting Down
5	Inhibit	0 : No inibit (operation possible) 1 : STO circuit open, drive shows inhibit, operation not possible
6	Standby Mode	0 : Normal operation, not in standby 1 : Drive in Standby Mode
7	Drive Ready	0 : Drive not Ready 1 : Drive Ready, defined as ▪ Mains power applied ▪ No Trip ▪ No Inhibit ▪ Enabled input present
8	Current limit Active	0 : Current Limit Inactive 1 : Current Limit Active
9	Power Limit Active	0 : Power Limit Inactive 1 : Power Limit Active
10	Motor Thermal Management Active (Ixt)	0 : Motor Thermal Management Inactive 1 : Motor Thermal Management Active
11	Drive Thermal Management Active (Heatsink Temperature)	0 : Drive Thermal Management Inactive 1 : Drive Thermal Management Active
12	Switching Frequency Reduction Active	0 : Switching Frequency Reduction Not Active 1 : Switching Frequency Reduction Active
13	Reserved	
14	Reserved	
15	Reserved	

The Drive Status Word two consists of one individual byte:
Single Byte showing the last fault code when the drive has tripped.

4.5.7. Drive Control Word (Modbus Register 1)

- Bit 0: Run/Stop command: Set to 1 to enable (run) the drive. Set to 0 to disable (stop) the drive.
- Bit 1: Reserved
- Bit 2: Coast stop request: Set to 1 to issue a coast stop command.
- Bit 3: Reset Fault Request: Set to 1 in order to reset the drive following a trip / fault.

NOTE This bit must be reset to zero once the fault is cleared to prevent unexpected reset.

- Bit 4: User Relay Control: Set to 1 to close the onboard relay and set to 0 to open the onboard relay.

NOTE This function only operates when parameter P3-05 = 6.

- Bit 5: Reserved
- Bit 6: Reserved
- Bit 7: Reserved

4.6. Parameter List and Modbus Registers

Register	Comment	Command	Type	Scaling	Parameter
1	Drive Control Command Word	03, 06, 10	Read/Write		-
2	Speed Set Point (RPS)	03, 06, 10	Read/Write	600 = 60.0 rps	-
4	Modbus User Ramp Time	03, 06, 10	Read/Write	3000 = 300.0 Seconds	-
5	Speed Reference (IDL format)	03, 06, 10	Read/Write	3000 = 50.0Hz	-
6	Drive Status	3	Read Only		-
7	Output Frequency (Motor Speed)	3	Read Only	600 = 60.0 rps	P00-60
8	Output Current	3	Read Only	100 = 10.0 Amps	-
9	Trip Code	3	Read Only		-
10	Output Power	3	Read Only	1000 = 10.00kW	-
11	Digital Input Status	3	Read Only	Bit 0 = Digital input 1, etc	P00-03
12	Rating ID	3	Read Only		P00-29
13	Power Rating	3	Read Only		P00-29
14	Voltage Rating	3	Read Only		P00-29
15	IO Processor Software Version	3	Read Only	100 = 1.00	P00-28
16	Motor Control Processor Software Version	3	Read Only	100 = 1.00	P00-28
17	Drive Type	3	Read Only		P00-29
20	Analog Input Signal Level	3	Read Only	1000 = 100.0%	P00-01
22	Pre Ramp Speed Reference (RPS)	3	Read Only	600 = 60.0 rps	P00-04
23	DC bus Voltage	3	Read Only	600 = 600 Volts	P00-20
24	Drive Temperature	3	Read Only	40 = 40°C	P00-21
25	Drive Serial Number 4	3	Read Only		P00-30
26	Drive Serial Number 3	3	Read Only		P00-30
27	Drive Serial Number 2	3	Read Only		P00-30
28	Drive Serial Number 1	3	Read Only		P00-30
29	Relay Output Status	3	Read Only	0 = Open, 1= Closed	-
30	Last two faults	3	Read Only	High Byte / Low Byte	P00-13
31	Previous two faults	3	Read Only	High Byte / Low Byte	P00-13
32	kWh Meter	3	Read Only	100 = 10.0kWh	P00-26
33	MWh Meter	3	Read Only	100 = 100MWh	P00-27
34	Running Time – hour	3	Read Only		P00-31
35	Running Time – min/sec	3	Read Only		P00-31
36	Running Time since last enable – hour	3	Read Only		P00-34
37	Running Time since last enable – min/sec	3	Read Only		P00-34
39	Room (Control PCB) Temperature	3	Read Only	40 = 40°C	P00-05
40	Speed Reference value	3	Read Only	3000 = 50Hz	
42	Motor Speed (IDL Format)	3	Read Only	3000 = 50Hz	
43	Motor output voltage	3	Read Only	100 = 100V (AC)	P00-11
44	Indirect Parameter Access Index	3	Read/Write		-
45	Indirect Parameter Access Value	3	Read/Write		-

Par	Description	Display Range	Note	Comms Register
P0-01	Analog input value	-100.0 …100.0%	1dp, 0.0%~99.9% or 100%	20
P0-03	Digital input status	Binary: 00 ... 11 (Drive input)	Drive terminal input result (MSB = Digital input 1, LSB = AI1)	11
P0-04	Speed controller reference	- P1-02 … P1-01	600 = 60.0rps with one decimal place	40
P0-05	Internal temperature	°C	No decimal place	39
P0-07	Speed ref via communications	- P1-02 … P1-01	600 = 60.0rps with one decimal place	-
P0-08	User PI reference	0.0%…100%	1= 0.1%, 0.0% ~ 99.9% or 100%	-
P0-09	User PI feedback	0.0%…100%	1= 0.1%, 0.0% ~ 99.9% or 100%	-
P0-10	User PI output	0.0%…100%	1= 0.1%, 0.0% ~ 99.9% or 100%	-
P0-11	Applied motor voltage	V rms	No decimal place, 1 = 1V	43
P0-13	Trip log	Recent 4 trips with time tag	Four entries each with the trip code and the time stamp	30 31
P0-14	Magnetising current (Id)	A (rms)	Current shown with one decimal place	-
P0-15	Torque producing current (Iq)	A (rms)	Current shown with one decimal place	-
P0-16	Off time count down time	s	Displays the time remaining before the drive will be permitted to start as a consequence of the setting in P2-10	-
P0-17	On time count down time	s	Displays the time remaining before the drive will be permitted to stop as a consequence of the setting in P2-11	-
P0-18	Restart delay count down time	s	Displays the time remaining before the drive will be permitted to re-start as a consequence of the setting in P2-12	-
P0-20	DC bus voltage	V dc	No decimal place. 100 = 100V	23
P0-21	Heatsink temperature	Degrees C (calculated)	No decimal place. 10 = 10°C	24
P0-22	DC bus voltage ripple	V rms	No decimal place. 100 = 100V	-
P0-23	Time accumulated above 85°C (H/sink)	Display in hours and minutes		-
P0-24	Time accumulated above 80°C (ambient)	Display in hours and minutes		-
P0-25	Rotor speed	rps	600 = 60.0rps with one decimal place	-
P0-26	kWh meter	0.0 … 999.9 kWh	Total power consumed by the drive and compressor since the date of manufacture. This parameter rolles over to P0-27 when it reaches 999.9kWh.	32
P0-27	MWh meter	0.0 … 65535 MWh	Total power consumbed by the drive and compressor since the date of manufacture when greater than 999.9kWh.	33
P0-28	Software version and checksum	Eg "IO 1.00 326B" "PS 1.00 526E"	Two entries First is IO version and checksum (no checksum over Modbus) Second is DSP version and checksum (no checksum over Modbus)	- 15 16
P0-29	Drive type	Size info, input voltage, power rating, Output phases, drive type etc	Four entries over Modbus First is frame size and input voltage level, as "F2 230" Second is power rating, as " 1.5" or "HP 10" Third is output phase number, as "3P-out" Fourth is the drive ID	- 12 13 14 17
P0-30	Drive Serial number	Unique drive identifier fixed during production	Four entries over Modbus to make up the serial number	25 26 27 28
P0-31	Hours run since date of manufacture	Display in hours and minutes	Two entries over Modbus - First is Hour Second is minute and second	34 35
P0-32	Run time since last trip (1)	Display in hours and minutes since last trip		-
P0-33	Run time since last trip (2)	Display in hours and minutes since previous trip		-

Par	Description	Display Range	Note	Comms Register
P0-34	Run time since enable	Display in hours and minutes since enable	Two entries over Modbus - First is Hour Second is minute and second	36 37
P0-35	Drive cooling fan run time	Display in hours		-
P0-36	DC bus voltage log (256ms)	Most recent 8 samples prior to trip	Eight entries	-
P0-37	DC bus voltage ripple log (20ms)	Most recent 8 samples prior to trip	Eight entries	-
P0-38	Heatsink temperature log (30s)	Most recent 8 samples prior to trip	Eight entries	-
P0-39	Ambient temperature log (30s)	Most recent 8 samples prior to trip	Eight entries	-
P0-40	Motor current log (256ms)	Most recent 8 samples prior to trip	Eight entries	-
P0-41	Critical fault counter – O-I	O-I trip counter (including h O-I)	No decimal place	-
P0-42	Critical fault counter – O-Volts	Over volts trip counter	No decimal place	-
P0-43	Critical fault counter – U-Volts	Under volts trip counter	No decimal place	-
P0-44	Critical fault counter – O-Temp (H/sink)	IGBT over temperature trip counter	No decimal place	-
P0-46	Critical fault counter – O-Temp(Amb)	Trip level is 85 degree C	No decimal place	-
P0-47	Internal I/O comms error count	0 … 65535	No decimal place	-
P0-48	Internal DSP comms error count	0 … 65535	No decimal place	-
P0-49	Modbus comms error count	0 … 65535	No decimal place	-
P0-53	Current Phase U offset and ref	Internal value		-
P0-54	Current Phase V offset and ref	Internal value		-
P0-55	Current Phase W offset and ref	Internal value		-
P0-56	Drive life time	Hour/min/sec		-
P0-57	Ud/Uq	Internal value	No decimal place	-
P0-58	Output Current	A		-
P0-59	Output Power	kW		-
P0-60	Output Frequency	rps	600 = 60.0rps with one decimal place	-
P0-61	Post ramp speed reference	rps	600 = 60.0rps with one decimal place	-
P0-62	User ramp value	S2…S3 0.00 to 600s;	S2…S3 1 = 0.01s with 1dp display as 0.01s~0.09s, 0.1s ~9.9s, 10s~600s	-
P0-63	Overload level	%	% of overload level	-
P0-64	Switching frequency internal	4 ~ 32kHz		-
P0-65	Motor control lib version	1	motor control lib version	-

4.7. Full Parameter List and Modbus Registers

4.7.1. Group 1 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
1-01	**101**	**Maximum Speed Limit**	**DD**	**P1-02**	**120**	**Rps**	**R/W**
		Sets the upper limit for the speed of the motor in rps (revolutions per second). This can be set to any value between the minimum speed limit (P1-02) and 5x the motor rated speed (as set in P1-10).					
1-02	**102**	**Minimum Speed Limit**	**DD**	**15**	**P1-01**	**Rps**	**R/W**
		Sets the lower limit for the speed of the motor in rps (revolutions per second). This can be set to any value between 0 and the maximum speed limit (P1-01).					
1-03	**103**	**Acceleration Ramp Time from 0 rps to Rated Speed**	**120**	**30**	**6000**	**s**	**R/W**
		Active if the start-up sequence is not configured or has been completed					
1-04	**104**	**Deceleration Ramp Time from Rated Speed to 0 rps**	**120**	**30**	**6000**	**s**	**R/W**
1-05	**105**	**Stop Mode**	**0**	**0**	**3**	**-**	**R/W**
		Determines the action taken by the drive in the event of the drive enable signal being removed. **0: Ramp to Stop.** When the enable signal is removed, the drive will ramp to stop, with the rate controlled by P1-04 as described above. **1: Coast to Stop.** When the enable signal is removed, the drive output is immediately disabled, and the motor will coast (freewheel) to stop. **2: AC Flux Braking (IM Motor only).** This mode is only valid for induction motors. AC Flux braking provides improved braking torque during stopping and deceleration. **3: Ramp to minimum speed and then coast to stop.** When the enable signal is removed, the drive will ramp down to the minimum speed at the configured deceleration ramp. When the minimum speed is reached, the output is immediately disabled, and the motor will coast (freewheel) to stop.					
1-11	**111**	**Primary Command Source**	**1**	**0**	**3**	**-**	**R/W**
		0: Modbus Mode. The drive is controlled by serial communications. **1: Terminal Mode.** The drive is start/stop is controlled by the digital input and the speed reference provided by the anlaogue input. **2: Terminal Mode (AI1 > 10% Start).** The drive is enabledby the digital input and the speed reference provided by the anlaogue input. The start command is given when the analogue input exceeds 10%. **3: User PI Mode.** The drive is enabled by the digital input and the speed is controlled by the internal PI controller.					

4.7.2. Group 2 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
2-01	**201**	**Start Speed 1 (rps)**	**37**	**P1-02**	**P1-01**	**Rps**	**R/W**
		Start-up sequence speed 1. If Start Speed 1 Time (P2-02) is greater than zero, the drive will ramp up to the speed set in this parameter for the time set in P2-02 on each start-up. If the time set in P2-02 is zero, this section of the start-up sequence is ignored.					
2-02	**202**	**Start Speed 1 Time**	**60**	**60**	**600**	**s**	**R/W**
		This time is the time that the drive will sit at Start Speed 1 on each start-up. This section of the start-up sequence is disabled if this time is set to zero.					
2-03	**203**	**Start Speed 1 Acceleration Ramp**	**30**	**30**	**6000**	**s**	**R/W**
		This is the acceleration ramp used to ramp up from 0 rps to Start Speed 1 if the function is enabled. Ramp rate is defined as time to get to rated speed from zero speed.					
2-04	**204**	**Start Speed 2 (rps)**	**0**	**P1-02**	**P1-01**	**Rps**	**R/W**
		Start-up sequence speed 2. If Start Speed 2 Time (P2-05) is greater than zero, the drive will ramp up to the speed set in this parameter for the time set in P2-05 on each start-up. If the time set in P2-05 is zero, this section of the start-up sequence is ignored.					
2-05	**205**	**Start Speed 2 Time**	**0**	**0**	**600**	**s**	**R/W**
		This time is the time that the drive will sit at Start Speed 2 on each start-up. This section of the start-up sequence is disabled if this time is set to zero.					
2-06	**206**	**Start Speed 2 Acceleration Ramp**	**0**	**0**	**6000**	**s**	**R/W**
		This is the acceleration ramp used to ramp up from Start Speed 1 up to Start Speed 2 if the function is enabled Ramp rate is defined as time to get to rated speed from zero speed.					
2-07	**207**	**Start Speed 3 (rps)**	**0**	**P1-02**	**P1-01**	**Rps**	**R/W**
		Start-up sequence speed 3. If Start Speed 3 Time (P2-08) is greater than zero, the drive will ramp up to the speed set in this parameter for the time set in P2-08 on each start-up. If the time set in P2-08 is zero, this section of the start-up sequence is ignored.					
2-08	**208**	**Start Speed 3 Time**	**0**	**0**	**600**	**s**	**R/W**
		This time is the time that the drive will sit at Start Speed 3 on each start-up. This section of the start-up sequence is disabled if this time is set to zero.					
2-09	**209**	**Start Speed 3 Acceleration Ramp**	**0**	**0**	**6000**	**s**	**R/W**
		This is the acceleration ramp used to ramp up from Start Speed 2 to Start Speed 3 if the function is enabled. Ramp rate is defined as time to get to rated speed from zero speed.					
2-10	**210**	**Minimum Off Time**	**180**	**0**	**6000**	**s**	**R/W**
		This parameter when set greater than 0, defines the minimum time that the drive must be stopped for before allowing a re-start. The remaining time before the drive can start is available in P0-16. **NOTE** This time is valid also from first power-up.					
2-11	**211**	**Minimum On Time**	**180**	**0**	**6000**	**s**	**R/W**
		This parameter when set greater than 0, defines a minimum time that the drive must run for once it has started, it will delay a stop command if the time set in this parameter has not elapsed. Please note that if the drive is configured for Coast to stop (P1-05 = 1) or if the drive is below minimum speed when the stop command is issued, this function will be ignored. The STO input overrides this function. The remaining time before the drive can be stopped is available in P0-17.					
2-12	**212**	**Re-start Delay**	**600**	**0**	**6000**	**s**	**R/W**
		This parameter configures the minimum time between each compressor starts. Any start command requests given to the drive before the time set in this parameter has elapsed will be ignored until the Re-start delay time has been observed. The remaining time before the next permitted start can be seen in P0-18.					

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
2-13	**213**	**Drive Re-Start Function**	**Auto-10**	**0**	**10**	**-**	**R/W**

Defines the behaviour of the drive relating to the enable digital input and also configures the Automatic Restart function. This function is not active if P1-11 is = 0 Modbus Mode

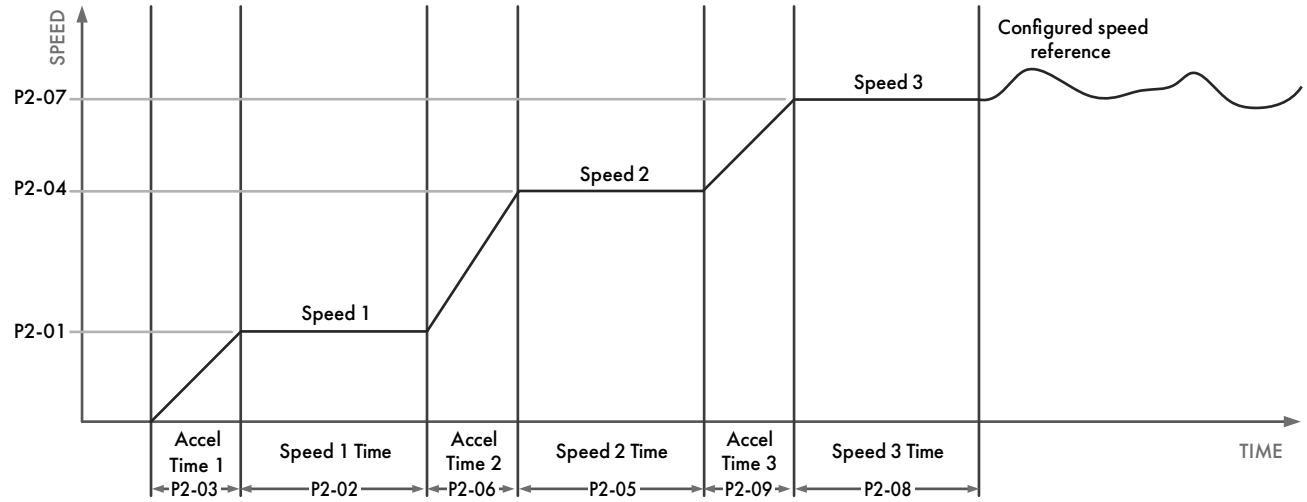
Edge-r: Following Power on or reset, the drive will not start if Digital Input 1 remains closed. The Input must be closed after a power on or reset to start the drive (e.g. Edge Triggered).

Auto-0: Following a Power On or Reset, the drive will automatically start if Digital Input 1 is closed before power on.

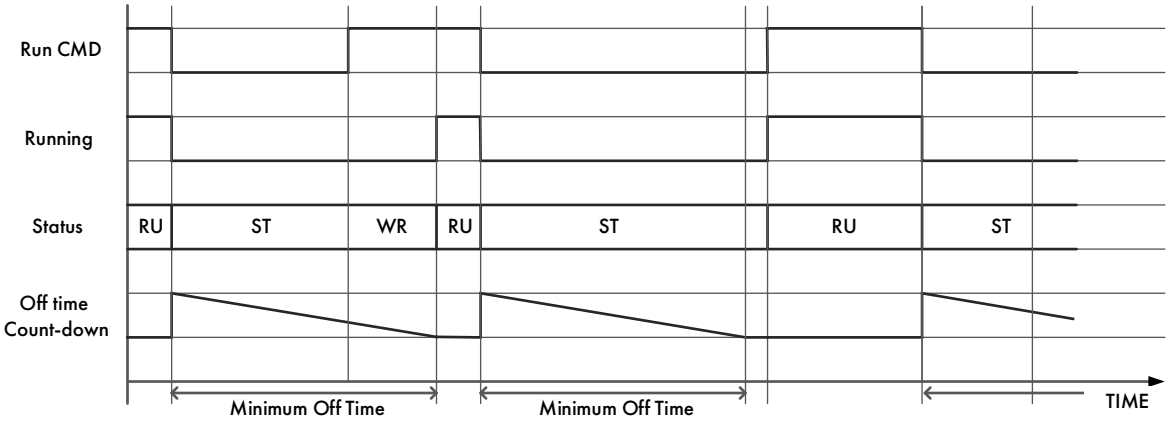
Auto-1 to Auto-10: Following a trip, the drive will make up to 10 attempts to restart at intervals defined by P6-03 (default 20 seconds).

NOTE The counter will decrease by 1 after each 30 minutes of running time after the drive has been reset. If the drive cannot reset the fault after the number of attempts set in P2-13 the drive will have to be manually reset or power cycled after further investigation of the faults and conformation that the fault condition is cleared.

Start-Up Speed Profile



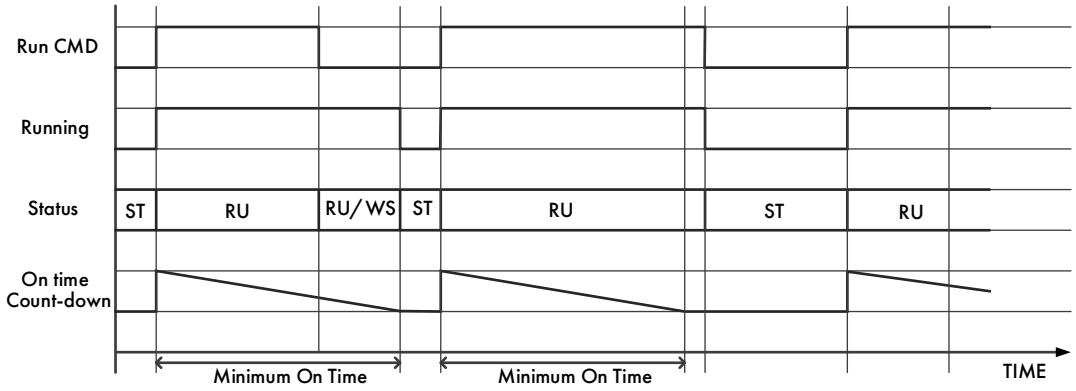
Minimum Off Time Sequencing



KEY:

RU Running **ST** Stopped **WR** Waiting to Run

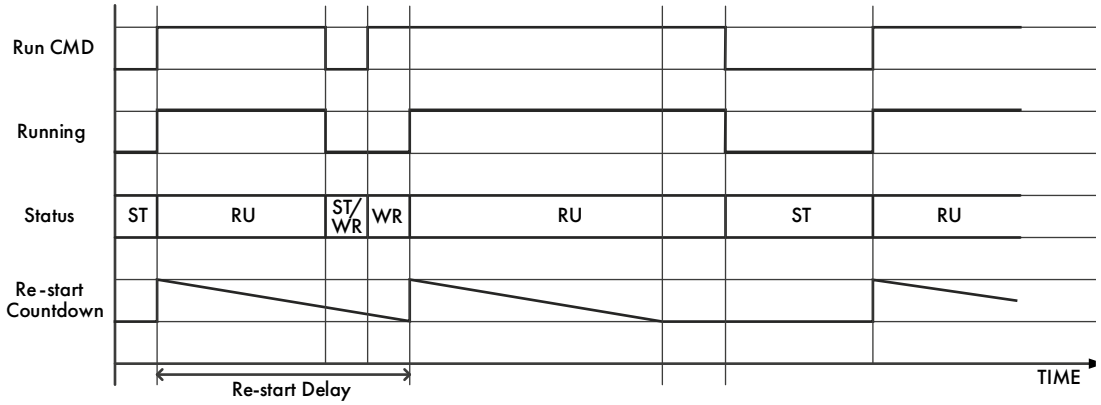
Minimum On Time Sequencing



KEY:

RU Running **ST** Stopped **WS** Waiting to Stop

Re-Start Delay



KEY:

RU Running **ST** Stopped **WS** Waiting to Stop **WR** Waiting to Run

4.7.3. Group 3 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
3-01	**301**	**Skip Speed 1 Centre Point**	**0.0**	**0.0**	**P1-01**	**rps**	**R/W**
		Defines the centre point of skip frequency 1 band. The width of the skip frequency band is defined by: Lower Limit = P3-01 – P3-02/2 Upper Limit = P3-01 + P3-02/2					
3-02	**302**	**Skip Speed 1 Bandwidth**	**0.0**	**0.0**	**5.0**	**rps**	**R/W**
		The width of skip frequency 1 band is defined by: Lower Limit = P3-01 – P3-02/2 Upper Limit = P3-01 + P3-02/2					
3-03	**303**	**Skip Speed 2 Centre Point**	**0.0**	**0.0**	**P1-01**	**rps**	**R/W**
		Defines the centre point of skip frequency 2 band. The width of the skip frequency band is defined by: Lower Limit = P3-03 – P3-04/2 Upper Limit = P3-03 + P3-04/2					
3-04	**304**	**Skip Speed 2 Bandwidth**	**0.0**	**0.0**	**5.0**	**rps**	**R/W**
		The width of skip frequency 2 band is defined by: Lower Limit = P3-03 – P3-04/2 Upper Limit = P3-03 + P3-04/2					
3-05	**305**	**User Relay Output Function Select**	**1**	**0**	**12**	**-**	**R/W**
		0: Drive Running **1: Drive Healthy (Not Tripped)** **2: Drive Tripped** **3: At Speed** **4: Speed >0** **5: STO Status** **6: Fieldbus control (control word)** **7: Motor speed > P3-07 (off when < P3-06)** **8: Motor current > P3-07 (off when < P3-06)** **9: Analogue Input > P3-07 (off when < P3-06)** **10: PI error > P3-07 (off when < P3-06)** **11: Ready to run**					
3-06	**306**	**User Relay Function Upper Limit**	**100**	**P3-07**	**200**	**%**	**R/W**
		Sets the upper limit for the relay control when P3-05 is set to a value between 7 - 10.					
3-07	**307**	**User Relay Function Lower Limit**	**0.0**	**0.0**	**P3-06**	**%**	**R/W**
		Sets the lower limit for the relay control when P3-05 is set to a value between 7 - 10.					
3-10	**310**	**Analogue Input Format**	**0**	**0**	**8**	**-**	**R/W**
		0: 0-10V **1: 10-0V** **2: t4-20mA (trip on signal loss)** **3: t20-4mA (trip on signal loss)** **4: p4-20mA (run at P3-11 speed on signal loss)** **5: p20-4mA (run at P3-11 speed on signal loss)** **6: 0-20mA** **7: 20-0mA** **8: PTC (Motor Thermistor Trip)**					
3-11	**311**	**Signal Loss Run Speed**	**37**	**P1-02**	**P1-01**	**Rps**	**R/W**
		Defines the speed at which the drive will run at in the event of a loss of analogue signal if P3-10 is set equal to 5 or 6, or in the event of loss of serial communications if P1-11 is set to 0 (Modbus control) and P6-05 is set to 3.					
3-12	**312**	**Analogue Input Scaling**	**100**	**0.0**	**2000**	**%**	**R/W**
		Output Value = (Input Value – Offset) x Scaling					
3-13	**313**	**Analogue Input Offset**	**0**	**-500**	**+500**	**%**	**R/W**
3-14	**314**	**Analogue Input Filter**	**0**	**0**	**1**	**-**	**R/W**
		When enabled, this parameter applies a 500ms averaging filter to the analogue input value measured at the drive terminals. **0: Disable 1: Enable**					
3-15	**315**	**Relay Output Logic**	**0**	**0**	**1**	**-**	**R/W**
		This parameter can be used to invert the relay output status, the relay function is still selected by P3-05. **0: Standard 1: Inverted**					

4.7.4. Group 4 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
4-01	401	**PI Controller Proportional Gain**	1	0.1	30.0	-	R/W
		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.					
4-02	402	**PI Controller Integral Time**	1	0.0	30.0	S	R/W
		Larger values provide a more damped response for systems where the overall process responds slowly.					
4-03	403	**PI Operating Mode**	0	0	1	-	R/W
		0: Direct Operation. Use this mode if a reduction in the feedback signal should result in an increase in the motor speed. **1: Inverse Operation.** Use this mode if an increase in the feedback signal should result in an increase in the motor speed.					
4-04	404	**PI Set-Point**	0.0	0.0	100	%	R/W
		This parameter sets the digital reference (setpoint) used for the PID Controller.					
4-05	405	**User PI Controller Output High Limit**	100	P4-06	100	%	R/W
		Limits the maximum value output from the PI controller.					
4-06	406	**User PI Controller Output Low Limit**	0	0	P4-05	%	R/W
		Limits the minimum output from the PI controller.					
4-07	407	**PI Error To Enable Ramps**	0.0	0.0	25.0	%	R/W
		Defines a threshold PI error level, whereby if the PI error is less than the set threshold, the internal ramps of the drive are disabled.					
4-08	408	**PI Error Wake-Up Level**	5.0	0.0	100	%	R/W
		Sets an error level (difference between the PID reference and feedback values) above which the PID controller will wake from Standby mode.					
4-09	409	**Standby Speed Threshold**	0	0	P1-01	Rps	R/W
		Specifies the speed boundary below which the drive enters Standby mode after the delay period P4-10. If the speed increases above this threshold when the drive is in Standby mode, normal operation will be resumed.					
4-10	410	**Standby Mode Timer**	0	0	60	S	R/W
		Enables the standby mode, **0: Standby mode disabled.** **Non-zero: The drive will enter standby mode (output disabled) if the Standby Speed Threshold (P4-09) is maintained for the time specified in this parameter.** Operation automatically resumes as soon as the PI Error increases above the value set in P4-08.					
4-11	411	**PI Reset Control**	0	0	1	-	R/W
		Selects whether the internal PI controller operates continuously, or is disabled when the drive stops. With continuous operation, the PI function is always active, which can result in the PI controller reaching maximum output whilst the drive is disabled. Resetting the PI controller on drive disable means the PI output will always start from zero when the drive is enabled. **0: PI loop will run continuously as long as P gain (P4-01) is not zero.** **1: PI loop will only run when the drive is enabled.** If the drive is not running, the PI output will be reset to 0 (including the integral result).					

4.7.5. Group 5 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
5-06	506	**Effective Power Stage Switching Frequency**	12	0	5	kHz	R/W
		Higher frequency reduces the audible 'ringing' noise from the motor, and improves the output current waveform, at the expense of increased heat losses within the drive.					
5-07	507	**Maximum Current Limit**	110	20	150	%	R/W
		This parameter defines the maximum current limit used by the drive as a percentage of the compressor rated current.					
5-09	509	**Motor Thermal Overload Management**	0	0	1	-	R/W
		When Motor Overload Management is enabled, full overload current will be available until the overload integrator (P0-63) approaches the I.t trip level. At this point, the current limit will be reduced automatically to the maximum level that can be sustained on a continuous basis. This will normally result in the speed of the motor automatically reducing. This feature is typically used in applications where overload trips need to be avoided and a reduction in speed can be accepted. When Thermal Overload Management is disabled, full overload current will be available until the drive trips on "It-trP".					
5-10	510	**Drive Thermal Overload Management**	0	0	1	-	R/W
		When enabled (P5-10 = 1), the drive will automatically set the current limit to 80% of the compressor rated current if the heatsink temperature is greater than 90 degree C.					
5-11	511	**Motor Thermal Overload Retention Enable**	1	0	1	-	R/W
		When enabled, the motor thermal memory retention function will save the calculated motor thermal history on drive power down, using this saved value as the starting value on next power up. If this function is disabled, the motor thermal history is reset to zero on every power up.					
5-12	512	**Discontinuous Modulation Mode Select**	1	0	7	-	R/W
		0: 3-Pase Modulation. **1: 2-Phase Modulation.** 2-Phase modulation mode slightly improves drive efficiency of the drive but can cause more audible noise in the motor.					
5-13	513	**Enable Reverse Speed Selection**	0	0	1	-	R/W
		If this parameter is set to 1 (Enabled), it will allow a -ve speed reference to be written by serial communications to the drive which will cause reverse speed operation. This setting should be kept as 0 (disabled) if prevention of reverse operation is required.					
5-15	515	**BLDC Low Load Optimisation**	1	0	1	-	R/W
		When P5-01 = 0 (BLDC Motor Control) and P5-16 = 1 (Enabled) the drive will reduce the output voltage during light load operation in order to improve motor efficiency. This setting has no effect if the motor is driven close to its nominal current where the nominal flux level will be applied					
5-16	516	**C02 Compressor Mode Enable**	0	0	1	-	R/W
		This mode increases the gain of the flux regulator to allow the drive to maintain control of some 2-stage compressors that have a low level of stability during ramp-up. This mode can work well with most compressors but should be disabled if aggressive start-up behaviour is observed with single stage low pressure compressors.					
5-17	517	**Stator Resistance Check on Run**	0	0	1	-	R/W
		This parameter allows the stator resistance to be measured on each run or the first run after power up. This can help to improve torque on start-up if the compressor has been flooded with super cold refrigerant which could reduce the stator resistance and affect the drive performance. **0: Disabled** **1: Enable on run** **2: Enable on first run only**					

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
5-19	**519**	**Slow Acting Current Limit**	**100**	**50**	**130**	**%**	**R/W**
		When enabled (P5-20 > 0), this parameter defines a current as a percentage of the compressor rated current at which the drive will internally set the speed reference equal to the minimum speed (P1-02) and ramp down slowly to this speed at a rate set in P5-20 in seconds per rated speed. When the current drops below this level the drive will return to the configured speed reference using the ramp rate set in P1-03.					
5-20	**520**	**Slow Acting Current Limit Ramp**	**0**	**0**	**300**	**s**	**R/W**
		This is the ramp rate in seconds per rated speed which is used to ramp down to minimum speed if the slow acting current limit (P5-19) as a percentage of the compressor rated current is reached. Setting the value to 0s will disable the function.					

4.7.6. Group 6 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
6-01	**601**	**Fieldbus Drive Address**	**31**	**1**	**63**	**-**	**R/W**
		Sets the drive network address when using a Fieldbus or Master Slave function					
6-02	**602**	**Modbus RTU Baud Rate**	**1**	**0**	**5**	**kbps**	**R/W**
		0: 9.6 kbps 1: 19.2 kbps 2: 38.4 kbps 3: 57.6 kbps 4: 115.2 kbps 5: 76.8 kbps					
6-03	**603**	**Modbus Data Format**	**3**	**-**	**3**	**-**	**R/W**
		0: None Parity 1 stop bit **1 : None parity 2 stop bits** **2 : Odd parity 1 stop bit** **3 : Even parity 1 stop bit**					
6-04	**604**	**Communications Loss Timeout**	**15**	**0**	**60**	**S**	**R/W**
		Sets the watchdog time period for the communications channel. With an active communication link, if a valid telegram is not received by the drive within this time period, the drive will assume a loss of communications has occurred and react as set in P6-05.					
6-05	**605**	**Communications Loss Action**	**0**	**0**	**3**	**-**	**R/W**
		Controls the behaviour of the drive following a loss of communications. **0: Trip** **1: Ramp to Stop then trip** **2: Ramp to stop (No trip)** **3: Signal Loss speed (P3-11)**					
6-06	**606**	**Fieldbus Ramp Control Enable**	**0**	**0**	**1**	**-**	**R/W**
		Selects whether the acceleration and deceleration ramps are control directly via the Fieldbus, or by internal drive parameters. **0: Disabled.** Ramps are control from internal drive parameters. **1: Enabled.** Ramps are controlled directly by the Fieldbus (ModBus Register 103 & 104).					
6-07	**607**	**Modbus Response Delay**	**0**	**0**	**16**	**Char**	**R/W**
		Defines the response delay time for Modbus communications. The value entered represents the delay expressed as the number of characters added to the minimum permitted Modbus response delay time. The actual delay time will vary depending on the Modbus communications baudrate.					

4.7.7. Group 7 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
7-06	**706**	**V/F Mode Magnetising Delay Time**	**-**	**0**	**5000**	**Ms**	**R/W**
		This parameter is used to set up a minimum delay time for the magnetising current control in V/F mode when drive run signal is given. Too small a value may cause the drive to trip on over-current if the acceleration ramp is very short.					
7-07	**707**	**Low Frequency Torque Boost Level**	**10**	**0.0**	**100**	**%**	**R/W**
		Boost current applied at start-up, as % of the compressor rated current. The drive provides a boost function that can inject some current into the motor at low speed to help ensure the rotor alignment is maintained and to allow effective operation of the motor at lower speeds. To implement low speed boost, run the drive at the lowest frequency required by the application and increase boost levels to provide both required torque and smooth operation.					
7-08	**708**	**Low Frequency Torque Boost, Frequency Limit**	**10**	**0.0**	**50**	**%**	**R/W**
		Frequency range for applied boost current (P7-07) as a % of motor rated frequency (P1-09). This sets the frequency cut-off point above which boost current is no longer applied to the motor.					

5.1. Trips

Fault Code	No.	Description	Suggested Remedy
no-FLt	00	No Fault or No Trip	No fault in trip log – no problem with the drive
O-I	03	Instantaneous over current	High current from either – short-circuit on the drive output / acceleration ramps too short / incorrect motor data. **NOTE** Setting the maximum peak motor current too low in P5-18 could also lead to this trip.
I_t-trP	04	Motor Thermal Overload (I2t)	Drive has been delivering more than the configured motor rated current for a period of time – check the operating point of the compressor
PS-trP	05	Power stage trip	Hardware fault, contact the supplier of the drive
O-UoLt	06	Over voltage on DC bus	DC Bus Overvoltage from either - the supply voltage is too high, a spike in the supply voltage, motor instability, try setting P1-05 = 3
U-UoLt	07	Under voltage on DC bus	Usually caused by the supply voltage dropping too low – check connections and voltage at the drive terminals
O-t	08	Heatsink over temperature	Check the ambient temperature, check that the ventilation is not restricted, check the cooling system for the coldplate version
U-t	09	Under temperature	Drive heatsink temperature is too low
P-dEF	10	Factory Default parameters have been loaded	Warning to advise that the drive has been returned to factory defaults
E-tr iP	11	External trip	The external trip will be generated when the drives STO circuit is opened while the drive is running.
SC-Obs	12	Optibus comms loss	Loss of communications between drive and remote keypad or PC tools
FLt-dc	13	DC bus ripple too high	Check for supply phase imbalance or phase loss
P-LOSS	14	Input phase loss trip	Input phase loss trip – similar to FLt.dc above
h O-I	15	Instantaneous over current on drive output	Hardware overcurrent on drive output – similar to O-I trip above
th-FLt	16	Faulty thermistor on heatsink	If the drive heatsink temperature is within limits, contact the supplier of the drive
dAtA-F	17	Internal memory fault (IO)	If not coinciding with a firmware upgrade procedure, contact the supplier of the drive
4-20 F	18	4-20mA Signal Lost	Analogue input configured for 4-20mA but less than 3mA detected on drive terminals
dAtA-E	19	Internal memory fault (DSP)	If not coinciding with a firmware upgrade procedure, contact the supplier of the drive
U-dEF	20	User Default Parameters Loaded	User Default Parameters Loaded
F-Ptc	21	Motor PTC thermistor trip	Drive configured to monitor motor temperature through the PTC and resistance increases above 2.5k
FAn-F	22	Cooling Fan Fault	Drive cooling fan not running at demanded speed – check for any blockages in the cooling fan
O-hEAt	23	Environmental temperature too high	Check ambient temperature and ventilation system
OUt-F	26	Drive output fault	Check for wiring faults, loose connections or badly terminated cables between the drive and the motor
E-trP		Safety circuit momentarily opened during drive running	Check the wiring of the STO circuit and any switches or devices within that circuit. Ensure that any intermediate devices are not activating momentarily during drive operation
Sto-F	29	Slow rising edge on 24V supply Safety input circuit error	Can happen if an external 24V supply is used and the voltage ramps up slowly on power-up. Could also happen if the drive 24V rail is overloaded and collapses momentarily, check the loading of the 24V rail and all control connections Contact the supplier of the drive for further advice
LocHEd rotor	31	Locked Rotor	A speed error has been detected (Locked Rotor)
AtF-01	40	Measured motor stator resistance varies between phases	Check the motor wiring, disconnect the drive and measure the phase to phase resistance from the motor cable
AtF-02	41	Measured motor stator resistance is too large	Check the motor wiring, disconnect the drive and measure the phase to phase resistance from the motor cable and refer to motor datasheet
AtF-03	42	Measured motor inductance is too low	Check the motor wiring

Fault Code	No.	Description	Suggested Remedy
AtF-04	43	Measured motor inductance is too large	Check the motor wiring
AtF-05	44	Measured motor parameters are not convergent	Check the motor wiring
OUt-Ph	49	Motor output phase loss	Check the motor wiring
SC-F01	50	Modbus comms loss fault	Check the Modbus wiring, ensure that the 0V common is used, ensure that the communication wiring is kept away from any power wiring

5.2. Status LED Indication

Two LEDs are used to indicate the drive status as follows:

Drive Status	LED 1 Status		LED 2 Status
	Green	Red	Yellow
Stop	Slow flashing	Off	Off
Inhibit	Slow Flashing	Off	Slow Flashing alternate
Running	Constant On	Off	Slow flashing if in overload
Standby	Constant On	Off	Blink every 3s
Trip / Fault	Off	Constant On	Off
Internal Comms Loss	Off	Blink every 3s	Off
Oil Return Active	Constant On	Off	Fast Flashing Yellow
DSP Firmware Upgrade	All three LEDs lights up in order (Green->Yellow->Red->Yellow…)		
IO Firmware Upgrade	All LEDs on with weak light		

6.1. General

Input Ratings	
Supply Voltage	200 - 240V ± 10%
	380 - 480V ± 10%
Maximum Isc	100kA when installed in a suitable enclosure
Supply Frequency	48 - 62Hz
Displacement Power Factor	>0.98
Permissible phase imbalance	3% maximum
Inrush Current	< rated current
Power Cycles	120 per hour evenly spaced

Output Ratings	
Output Power	200V: 1.5 - 5.5kW
	400V: 5.5 - 11kW
Overload Capacity	130% for 10s - see rating tables for detailed values
Output Frequency	0-500Hz
Acceleration Time	0.01 - 600s
Deceleration Time	0.01 - 600s
Maximum Motor Cable Length	10m shielded, 20m unshielded

Ambient Conditions	
Temperature	Storage: -40°C to 70°C
	Operation: -20°C to 60°C
Altitude	Up to 1000m ASL without derating
	Up to 2000m ASL UL approved
	Up to 4000m ASL maximum (non UL)
Humidity	95% Maximum, non-condensing
Vibration	Conforms to EN61800-5-1

Environmental	
Ingress Protection (IP)	Front IP20
	Rear (Through Panel Mounting) IP55
Coated PCBs	Designed for operation in 3S2/3C2 environments according to IEC 60721-3-3

Programming	
Modbus RTU (RS485)	Modbus RTU on Pluggable terminals and through RJ45 port
PC Tools	PC Tools software for Diagnostics and parameter configuration (RJ45 port only)
Keypad	Optional Remote CDS203 LCP with TFT display for diagnostic and programming

Control Specification	
Output Voltage	0 - Vin
PWM Frequency	4 – 32kHz
Stop Mode	Ramp to stop, Ramp to minimum speed then coast to stop, Coast to stop
Skip Frequency	2 skip frequencies, band user adjustable
Control Modes	Modbus RTU (RS485) Terminal Control Digital / Analogue Terminal Control PI mode

I/O Specification	
Power Supply	24 Volt DC, 100mA, Short Circuit Protected
Digital Inputs	1 (24V Positive Logic)
Analogue Inputs	1 (0-10V, 0-20mA, 4-20mA, PTC)
Relay Outputs	1 (AB type) Maximum Voltage 250VAC, 30VDC Switching Current Capacity: 6A AC, 5A DC Resistive Load
Safe Torque Off (STO)	Independently approved STO input

Safe Torque Off (STO)	
IEC 61800-5-2:2016	SIL 3
EN ISO 13849-1:2015	PL "e"
EN 61508 (Part 1 to 7): 2010	SIL 3
EN 60204-1: 2006 & A1: 2009	Cat 0
EN 62061: 2005 & A2: 2015	SIL CL 3

Application Features	
PI Control	Internal PI Controller.
3 – Step start-up profile	Start-up profile configurable with up to 3-steps to reduce the risk of oil migration and support better charge distribution in the system.
Compressor start-up protection	Several configurable built-in compressor protection features including Minimum Compressor On Time, Minimum Compressor Off Time and Compressor Restart Delay.
Intelligent Drive Thermal Management	Reduced-load operation of the compressor can be configured under high drive temperatures to prevent nuisance tripping.
Intelligent Motor Thermal Management	Reduced-load operation of the compressor can be configured under continued motor overload to prevent nuisance tripping.
Serial Communications-Loss Fall-Back Speed	The ability to configure the drive to run at a 'safe' speed in the event of a loss of serial communication. Can prevent loss of cooling/heating.
Slow Acting Current Limit	Intelligent load management to slowly ramp down the speed of the compressor to prevent excessive current
Motor Demagnetisation Protection	Configurable peak current trip level to protect against demagnetisation of the motor

Maintenance & Diagnostics	
Fault Memory	Last 4 trips stored with time stamp
Data Logging	Logging of data prior to last trip for diagnostic purposes: ▪ Output Current ▪ Drive Temperature ▪ DC Bus Voltage.
Monitoring	Hours Run Meter kWH

Conformance	
The CDS 203 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 & A1:2017 & A11:2021	Adjustable speed electrical power drive systems. Part 5-1: Safety requirements. Electrical, thermal and energy (IEC 61800-5-1:2007).
EN 61800-3: 2004 & A1 2012	Adjustable speed electrical power drive systems. EMC requirements and specific test methods.
EN 55011: 20016 & A1: 2017	Limits and Methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radiofrequency equipment (EMC).
EN60529: 1992 & A2: 2013	Specifications for degrees of protection provided by enclosures.
RohS EN 63000:2018	Tech documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.

6.2. Detailed Product Rating Tables

Part Number	Power Rating		Input Current	Fuse or MCB (Type B)		Max Input Cable Size		Continuous Output Current	Overload Output Current	Maximum Output Cable Size		Maximum Motor Cable Length	
	kW	HP	A	Non UL	UL	mm²	awg	A	A	mm²	awg	m	ft
CDS203-22P1K5-1FH11	1.5	2.0	8.9	16	15	16	6	7	9.1	6	10	10	33
CDS203-22P3K0-1FH21 CDS203-22P3K0-1FH31	3.0	3.0	15.8	25	20	16	6	12	13.2	6	10	10	33
CDS203-22P4K0-1FH41	4.0	5.5	21.3	25	25	16	6	16	20.8	6	10	10	33
CDS203-22P1K5-1FC11	1.5	2.0	8.9	16	15	16	6	7	9.1	6	10	10	33
CDS203-22P3K0-1FC21 CDS203-22P3K0-1FC31	3.0	3.0	15.8	25	20	16	6	12	13.2	6	10	10	33
CDS203-22P4K0-1FC41	4.0	5.5	21.3	25	25	16	6	16	20.8	6	10	10	33
CDS203-24P5K5-3FH31 CDS203-24P5K5-3FH41	5.5	7.5	12.0	16	35*	6	10	14	18.2	6	10	10	33
CDS203-24P11K-3FH51 CDS203-24P11K-3FH61	11.0	15.0	22.0	25	35*	6	10	24	28.0	6	10	10	33
CDS203-24P5K5-3FC31 CDS203-24P5K5-3FC41	5.5	7.5	12.0	16	35*	6	10	14	18.2	6	10	10	33
CDS203-24P11K-3FC51 CDS203-24P11K-3FC61	11.0	15.0	22.0	25	35*	6	10	24	28.0	6	10	10	33

NOTE Maximum permissible motor cable without the use of output filters is 10m with shielded cable and 20m with unshielded cable – for all ratings.

6.3. Temperature and Switching Frequency De-rating Requirements for CDS 203

6.3.1 230V Single Phase

CDS203-22P1K5-1FH11 / CDS203-22P1K5-1FC1

Switching Frequency	Maximum continuous output current at ambient temperature (°C)						
	0	10	20	30	40	50	60
4 kHz	7	7	7	7	7	7	7
8 kHz*	7	7	7	7	7	7	7
12 kHz	7	7	7	7	7	7	7
16 kHz	7	7	7	7	7	7	7
24 kHz	7	7	7	7	7	7	4.7
32 kHz	7	7	7	7	7	6.6	3.7

CDS203-22P3K0-1FH21 / CDS203-22P3K0-1FC21
CDS203-22P3K0-1FH31 / CDS203-22P3K0-1FC31

Switching Frequency	Maximum continuous output current at ambient temperature (°C)						
	0	10	20	30	40	50	60
4 kHz	12	12	12	12	12	12	11.5
8 kHz	12	12	12	12	12	12	10
12 kHz*	12	12	12	12	12	11.5	9
16 kHz	12	12	12	12	12	11	8.5
24 kHz	12	12	12	12	12	10.5	8
32 kHz	12	12	12	12	12	9.5	7.5

CDS203-22P4K0-1FH41 / CDS203-22P4K0-1FC41

Switching Frequency	Maximum continuous output current at ambient temperature (°C)						
	0	10	20	30	40	50	60
4kHz	16	16	16	16	16	16	16
8kHz	16	16	16	16	16	16	16
12kHz*	16	16	16	16	16	16	15.5
16kJz	16	16	16	16	16	16	13.5
24kHz	16	16	16	16	14	11.5	9.5
32kHz	16	16	16	16	11.5	9	8

6.3.2 400V 3-phase Models

CDS203-24P5K5-3FH31 / CDS203-24P5K5-3FC31

Switching Frequency	Maximum continuous output current at ambient temperature (°C)						
	0	10	20	30	40	50	60
10 kHz	14	14	14	14	14	14	14
12 kHz*	14	14	14	14	14	14	14
14 kHz	14	14	14	14	14	14	13.5
16 kHz	14	14	14	14	14	14	13
18 kHz	14	14	14	14	14	14	12.5
20 kHz	14	14	14	14	14	14	11.5

CDS203-24P11K-3FH51 / CDS203-24P11K-3FC51

Switching Frequency	Maximum continuous output current at ambient temperature (°C)						
	0	10	20	30	40	50	60
10 kHz	24	24	24	24	24	24	22
12 kHz*	24	24	24	24	24	23	18
14 kHz	24	24	24	24	24	21	16.5
16 kHz	24	24	24	24	24	19	15
18 kHz	24	24	24	24	24	17.5	14
20 kHz	24	24	24	24	24	17	13

* - Danfoss default setting

- The drive is protected against short-circuit from power output to protective earth for all rated cable lengths, cable sizes and cable types.
- The maximum cable lengths stated here are based on hardware limitations and do NOT take into consideration any requirements for compliance to any EMC standards. Please see section *3.3. EMC Compliant Installation on page 14* for further information.
- Supply and motor cable sizes should be dimensioned according to local codes or regulations in the country or area of installation.
- For UL compliant installation, use Copper wire with a minimum insulation temperature rating of 70°C, UL Class CC or Class J Fuses.

6.4. Input Power Supply Requirements

Supply Voltage	200 – 240 RMS Volts for 230 Volt rated units, + /- 10% variation allowed. 380 – 480 Volts for 400 Volt rated units, + / - 10% variation allowed.
Imbalance	Maximum 3% voltage variation between phase – phase voltages allowed. All CDS 203 units have phase imbalance monitoring. A phase imbalance of > 3% will result in the drive tripping.
Frequency	50 – 60Hz + / - 5% Variation.

Table showing the electrical frequency of the power applied to the Compressor and the rotational speed of the motor in both rpm (revolutions per minute) and rps (revolutions per second):

6 Poles		
Hz	**rpm**	**rps**
15	300	5
30	600	10
45	900	15
60	1200	20
75	1500	25
90	1800	30
105	2100	35
120	2400	40
135	2700	45
150	3000	50
165	3300	55
180	3600	60
195	3900	65
210	4200	70
225	4500	75
240	4800	80
255	5100	85
270	5400	90
285	5700	95
300	6000	100
315	6300	105
330	6600	110
345	6900	115
360	7200	120
375	7500	125