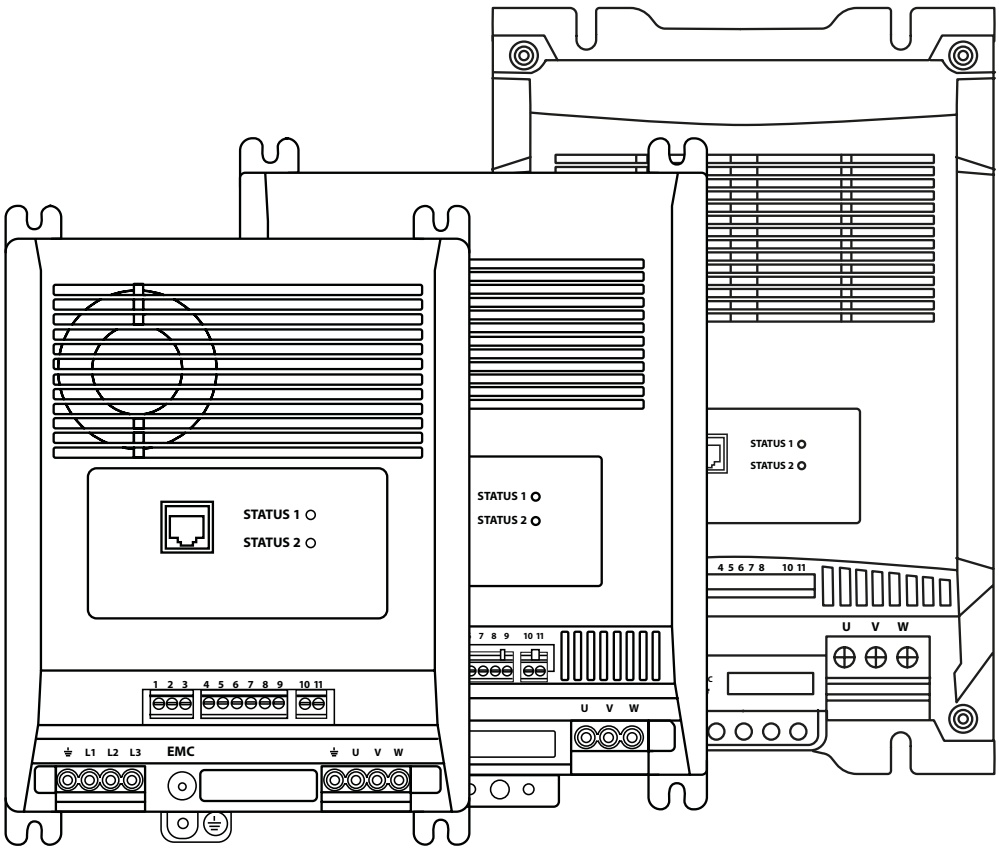
Invertek Drives.com

User Guide

OPTIDRIVE™ coolvert

AC Variable Speed Drive

7.0 – 20.0A 200V Single Phase Input
14.0 – 75.0A 400V Three Phase Input



Declaration of Conformity

Invertek Drives Ltd hereby states that the Optidrive Coolvert 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:

EN 61800-5-1:2007 + A1:2017	Adjustable speed electrical power drive systems. Part 5-1: Safety requirements. Electrical, thermal and energy (IEC 61800-5-1:2007).
EN 61800-3:2018	Adjustable speed electrical power drive systems. Part 3: EMC requirements and specific test methods (IEC 61800-3:2017).
EN 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 Optidrive Coolvert 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)
EN 61000-3-2:2014	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.
EN 61800-9-2:2017	Adjustable speed electrical power drive systems. Part 9-2: Ecodesign for power drive systems, compressor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and compressor starters (IEC 61800-9-2:2017).

Safe Torque OFF ("STO") Function

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

Standard	Classification	Independent Approval
EN 61800-5-2:2017	SIL 3	Size 2 TUV/UL Size 3/4/5 UL
EN ISO 13849-1:2023	PL "e"	
EN 61508 (Part 1 to 7):2010	SIL 3	
EN 60204-1: 2006 & A1: 2009	Uncontrolled Stop "Category 0"	
EN IEC 62061:2021	SIL 3	

*__NOTE__ UL Approval of the "STO" function is relevant for drives which have a UL 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 UL logo on the rating label.

Electromagnetic Compatibility

All Optidrives 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.

3 Year Warranty: All Invertek Optidrive Coolvert units carry a 3 year warranty against manufacturing defects from the date of manufacture. The manufacturer accepts no liability for any damage caused during or resulting from transport, receipt of delivery, installation or commissioning. The manufacturer also accepts no liability for damage or consequences resulting from inappropriate, negligent or incorrect installation, incorrect adjustment of the operating parameters of the drive, incorrect matching of the drive to the compressor, incorrect installation, unacceptable dust, moisture, corrosive substances, excessive vibration or ambient temperatures outside of the design specification. The local distributor may offer different terms and conditions at their discretion, and in all cases concerning warranty, the local distributor should be contacted first.

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

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

This user guide is for use with version 1.08 Firmware (frame size 2) and version 2.00 Firmware (frame size 3, 4, and 5). The firmware version can be viewed in parameter P0-28.

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

	When installing the drive on any power supply where the phase-ground voltage may exceed the phase-phase voltage (typically IT supply networks or Marine vessels) it is essential that the internal EMC filter ground is disconnected. If in doubt, refer to your Sales Partner for further information.
	This manual is intended as a guide for proper installation. Invertek Drives Ltd 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 Optidrive 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.
	ESD precautions should be taken when handling the control terminals of the drive including the RJ45 port.

1. Important Safety Information

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

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

This variable speed drive product (Optidrive) 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 Optidrive 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 Optidrive, including the specified environmental limitations.

Do not perform any flash test or voltage withstand test on the Optidrive. Any electrical measurements required should be carried out with the Optidrive 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 Optidrive 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 Optidrive 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 compressor 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, Compressor or Compressor cable whilst the input power is still applied.

The Optidrive can be programmed to operate the driven compressor at speeds above or below the speed achieved when connecting the compressor directly to the mains supply. Obtain confirmation from the manufacturers of the compressor and the driven machine about suitability for operation over the intended speed range prior to machine start up.

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

Optidrives 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 Optidrive 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 compressor. 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 Optidrive. In the case of suspected fault or malfunction, contact your local Invertek Drives Sales Partner for further assistance.

2. Use with Flammable Refrigerants

The Optidrive Coolvert 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.
  - 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 verified to be compliant.
  - 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, R454A, R454B, R454C, R455A, R1234yf, R1234ze
  - 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:
  - 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 Optidrive Coolvert in end use applications where flammable refrigerant is employed shall be reviewed and judged by the end use application.

3. Product Introduction

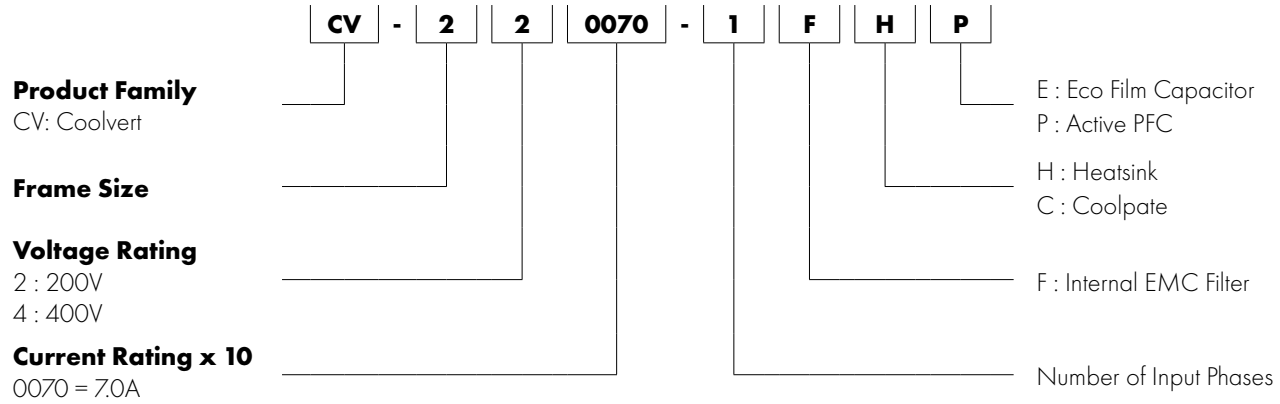
The Optidrive Coolvert is a high efficiency variable frequency drive with world-leading compressor control performance dedicated for use with hermetic scroll and rotary compressors.

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, EN 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 EN 61000-3-2.

3.1. 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.



3.1.1. Model Variants

200 – 240V +/-10% Single Phase Input				
Model Code	**Frame**	**kW**	**HP**	**Amps**
CV-220070-1FHP	2	1.5	2	7.0
CV-220120-1FHP	2	3	4	12.0
CV-220160-1FHP	2	4	5	16.0
CV-220200-1FHP	2	5.5	7.5	20.0
380 – 480V +/-10% Three Phase Input				
Model Code	**Frame**	**kW**	**HP**	**Amps**
CV-240140-3FHE	2	5.5	7.5	14
CV-240180-3FHE	2	7.5	10	18
CV-240240-3FHE	2	11	15	24
CV-340300-3FHE	3	15	20	30
CV-340390-3FHE	3	18.5	25	39
CV-440460-3FHE	4	22	30	46
CV-440580-3FHE	4	30	40	58
CV-540650-3FHE	5	37	50	65
CV-540750-3FHE	5	40	50	75

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

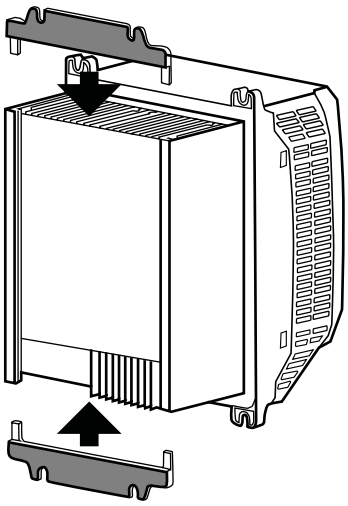
3.2. Accessories

3.2.1. *Panel mounting kit*

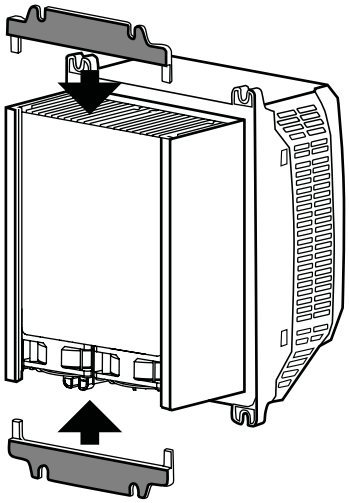
The Coolvert (heatsink version) is designed to primarily be mounted 'through-panel' with the heatsink protruding outside of the electrical panel.

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

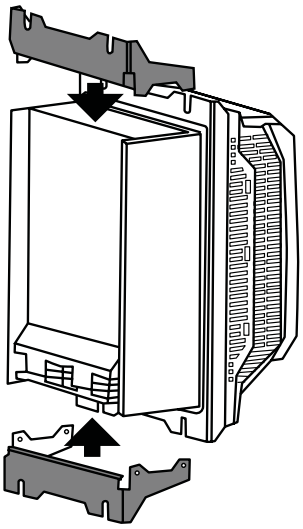
NOTE Size 4/5 mounting brackets should be secured to the drive heatsink with the screws supplied before mounting the drive.



Size 2
Part number OPT-3-CVBKT-S2



Size 3
Part number OPT-3-CVBKT-S3



Size 4/5
Part number OPT-3-CVBKT-S4/5

3.2.2. *Optional External EMC Filters*

External EMC filters are available to achieve C1 conducted emission compliance with longer compressor cable lengths. See chapter *4.3. EMC Compliant Installation on page 24* for further information. Available models are as follows:

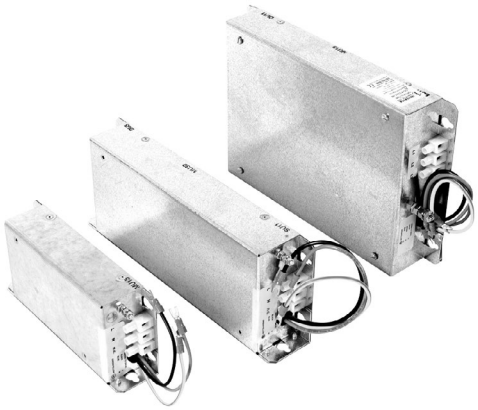
OPT-2-E1010-20 EMC Filter, 10A, 1 Ph 230V IP20

OPT-2-E1025-20 EMC Filter, 25A, 1 Ph 230V IP20

OPT-2-E3016-20 EMC Filter, 16A, 3 Ph 400V IP20

OPT-2-E3025-20 EMC Filter, 25A, 3 Ph 400V IP20

Contact your local partner for detailed information and dimensions.



3.2.3 *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 *4.3.1. Recommended Installation for EMC Compliance on page 24.*

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.

3.2.4. OptiPad – Remote TFT Text LCD Display for commissioning and diagnostics with RJ45 cable

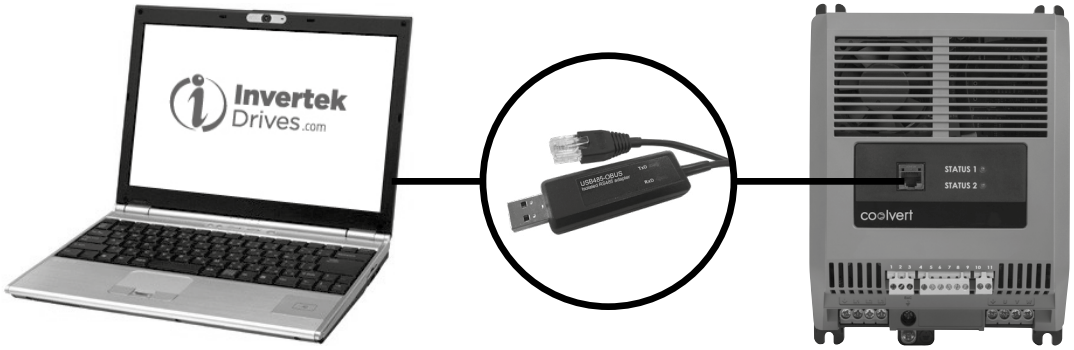
OPT-3-OPPAD-IN

3.2.5. Optistick Smart – Bluetooth / PC Interface with Parameter cloning function

OPT-3-STICK-IN

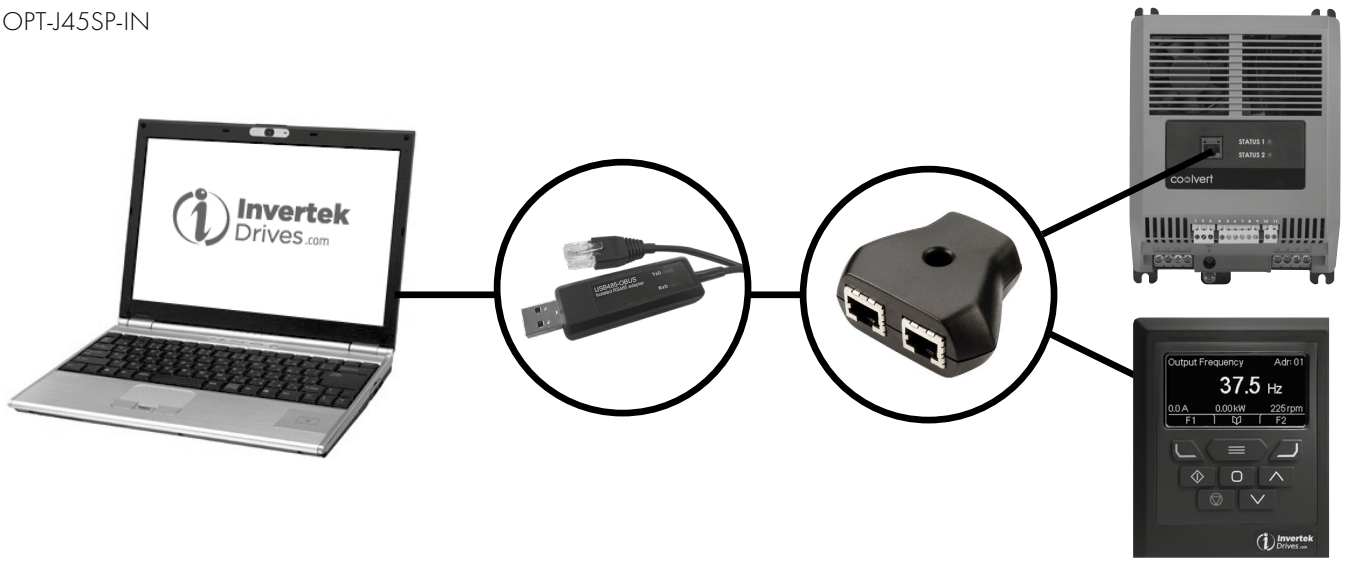
3.2.6. Isolated USB to RS485 converter - USB PC Connection Kit

OPT-2-USB-OBUS



3.2.7. RJ45 Data Cable Splitter

OPT-J45SP-IN



4. Installation

4.1. Mechanical Installation

4.1.1. General

- The Optidrive Coolvert can be mounted vertically (top up), horizontally (heatsink/coldplate down) or on its side (heatsink/coldplate to the side) providing that the ventilation and required clearances are observed. We recommend thorough thermal testing of the drive in the end application in all cases.
- The Optidrive Coolvert 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 UL Open type 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 Optidrive.
- 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 *7.3. Temperature and Switching Frequency De-rating Requirements for Coolvert on page 69*. Typical heat losses generated by the drives are given in section *4.1.10. 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.

4.1.2. Before Installation

- Carefully unpack the Optidrive 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 Optidrive in its original box until required. Storage should be clean and dry and within the temperature range –40°C to +70°C.

4.1.3. UL Compliant Installation

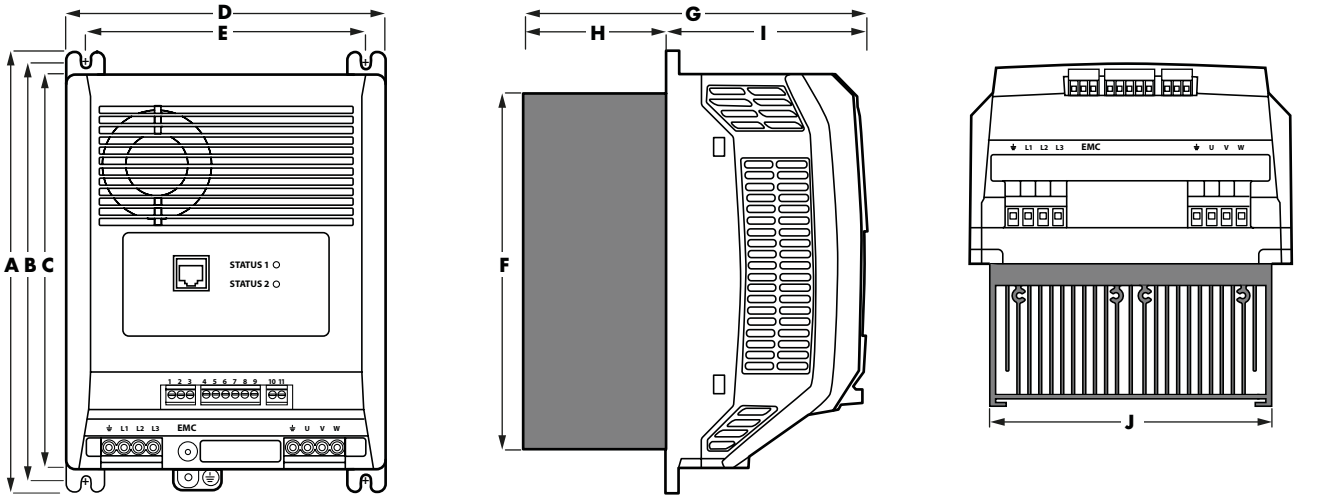
Note the following for UL-compliant installation:

- The heatsink variants of the Coolvert are UL listed whereas the coldplate variants are UL recognised as they require additional thermal devices to operate.
- For an up to date list of UL compliant products, please refer to UL listing E226333. For UL 60730-1 approved products, please refer to UL listing E543000 in addition to E226333
- The drive can be operated within an ambient temperature range of -20°C to +60°C. For further information, see section *7.1. General on page 65*.
- The front of the drive is UL open Type, installation is required in a pollution degree 1 environment.
- The rear of the drive is UL Type 4X, installation in a pollution degree 2 environment is permissible.
- If the drive is through panel mounted, ensure the correct environment is maintained for each section of the drive as indicated above.
- If the drive is mounted directly on a back plate within a suitable electrical enclosure, then the enclosure should provide pollution degree 2 protection.
- UL Listed ring terminals / lugs must be used for all bus bar and grounding connections.
- The drive is designed to be installed in a suitable enclosure.
- Certain models require specific fuse selection for full UL compliant installation. Please refer to section *7.5. Additional Information for UL Approved Installations* for further information.

Refer to section *7.5. Additional Information for UL Approved Installations*.

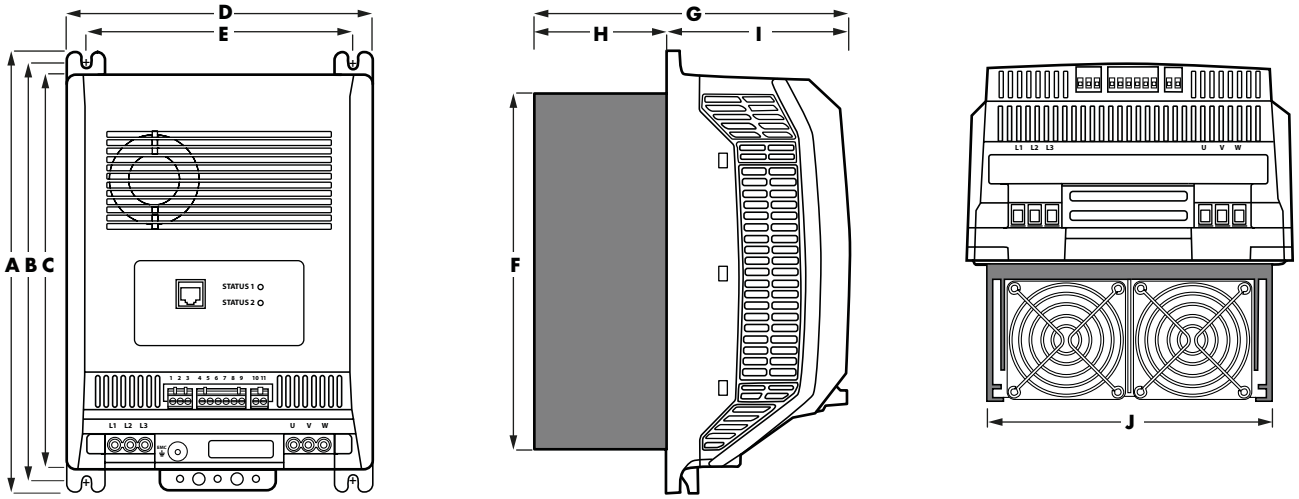
4.1.4. Drive Dimensions

Size 2



A		B		C		D		E		F		G		H		I		J	
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	7	71.7	2.82	104.4	4.1	145	5.7

Size 3



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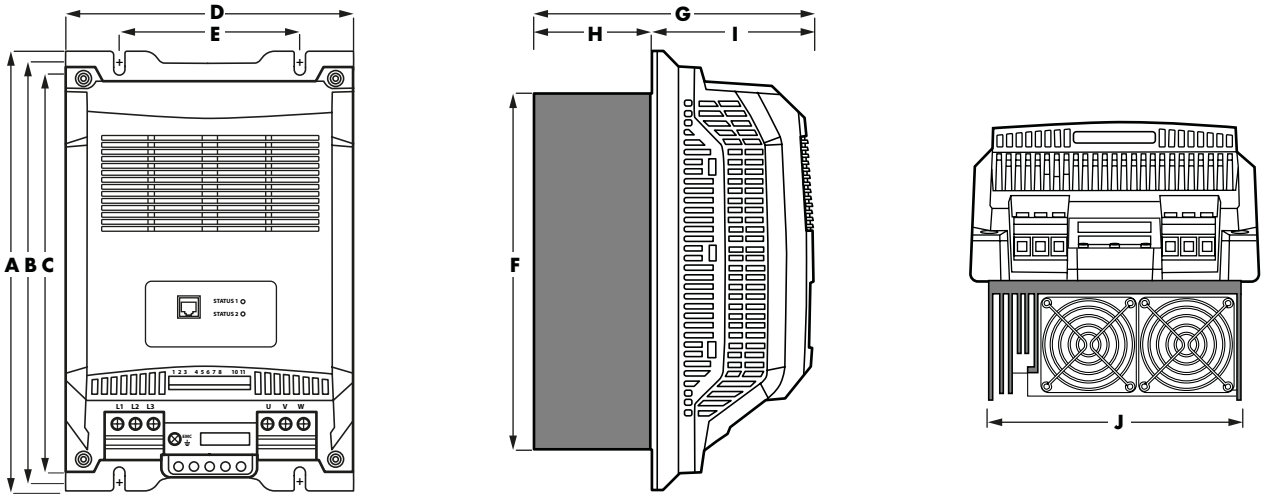
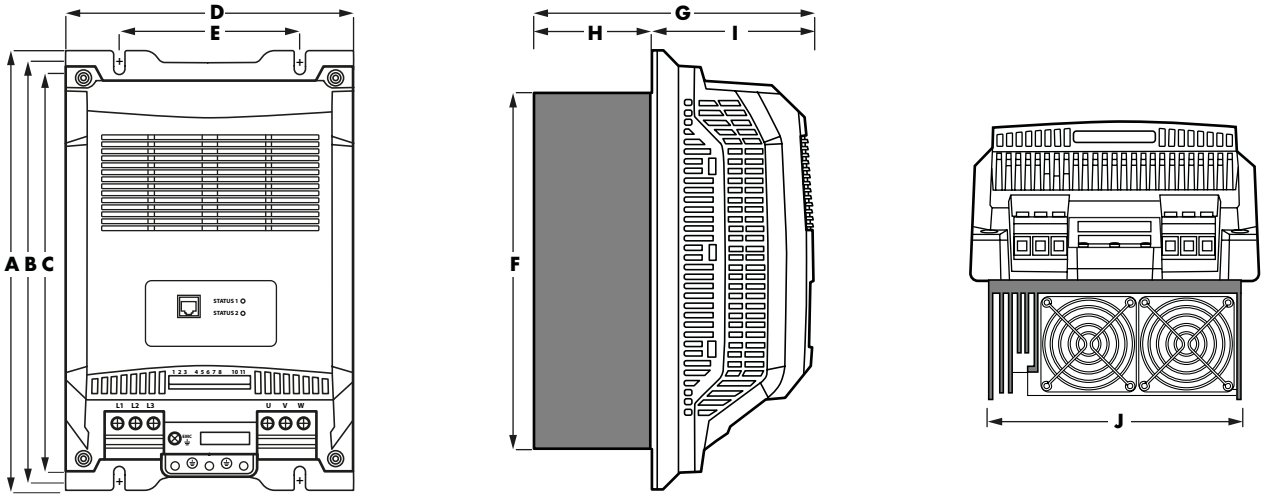
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
277.5	10.9	262.6	10.3	247.2	9.7	193.6	7.6	168.9	6.6	224	8.8	200.3	7.9	84.3	3.3	116	4.6	170	6.7

Size 4



A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	337	13.3	310	12.2	239.5	9.4	150	5.9	291.5	11.5	231	9.1	98	3.9	133	5.2	209.5	8.2

Size 5

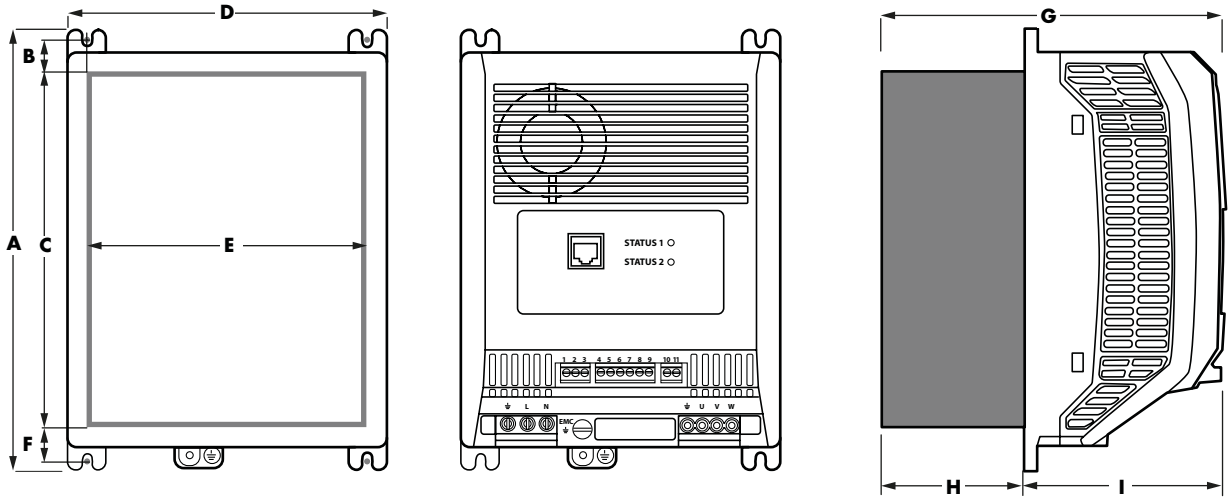


A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	337	13.3	310	12.2	239.5	9.4	150	5.9	291.5	11.5	239.5	9.4	107	4.2	133	5.2	209.5	8.2

4.1.5. Through panel mounting

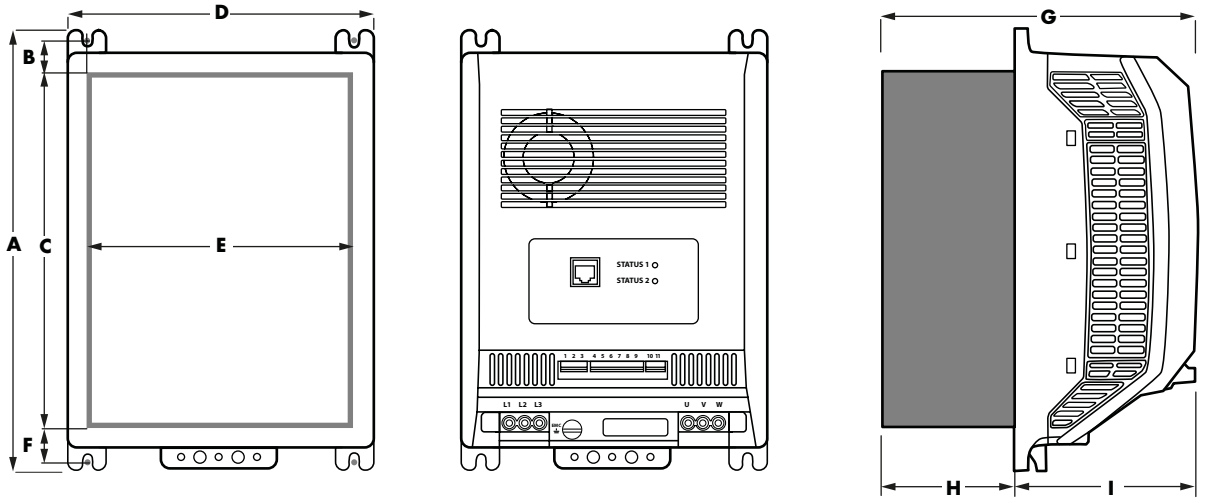
Through panel mounting is the most efficient installation in terms of both panel space and thermal management. With the heatsink protruding through the back of the electrical panel, the heat generated by the drive will be exhausted outside of the electrical panel.

Size 2



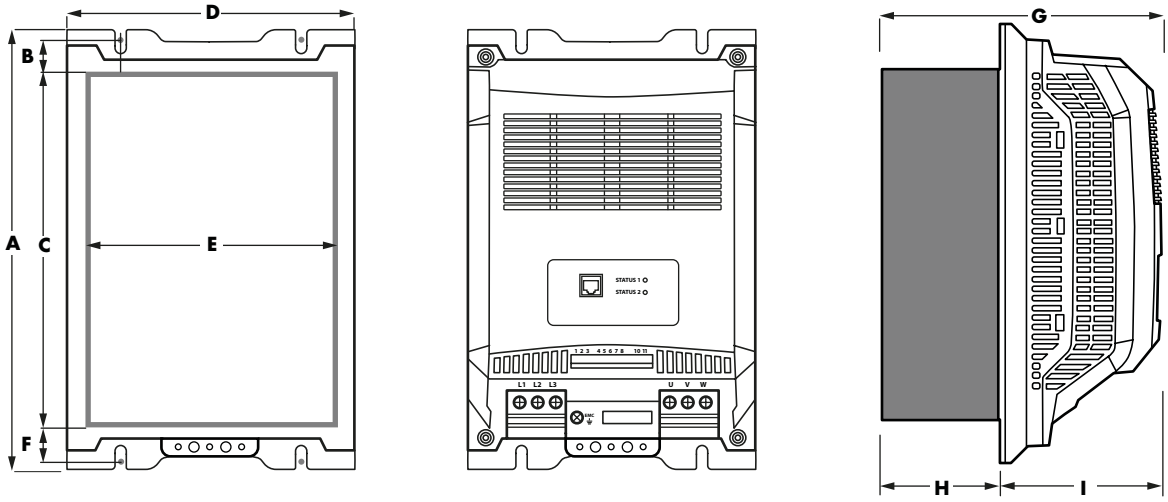
A		B		C		D		E		F		G		H		I	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
226.3	8.9	15.6	0.6	184	7.2	165.3	6.5	147	5.8	15.6	0.6	178	7	73.6	2.9	104.4	4.1

Size 3



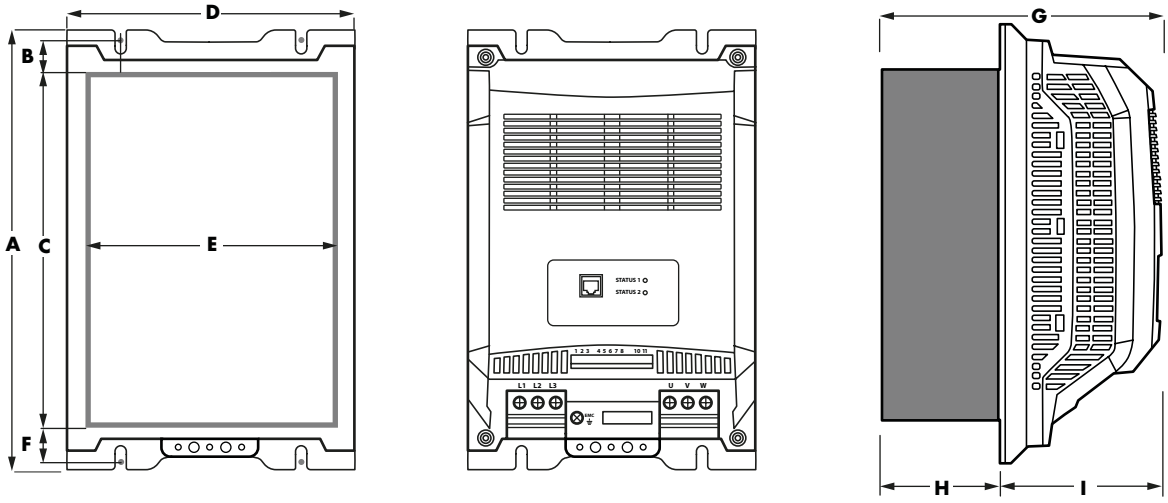
A		B		C		D		E		F		G		H		I	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
277.5	10.9	18.8	0.7	227.1	8.9	193.6	7.6	173.1	6.8	16.7	0.7	200.3	7.9	84.3	3.3	116	4.6

Size 4



A		B		C		D		E		F		G		H		I	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	21.8	0.9	294.5	11.6	239.5	9.4	212.5	8.4	19.9	0.8	231	9.1	98	3.9	133	5.2

Size 5

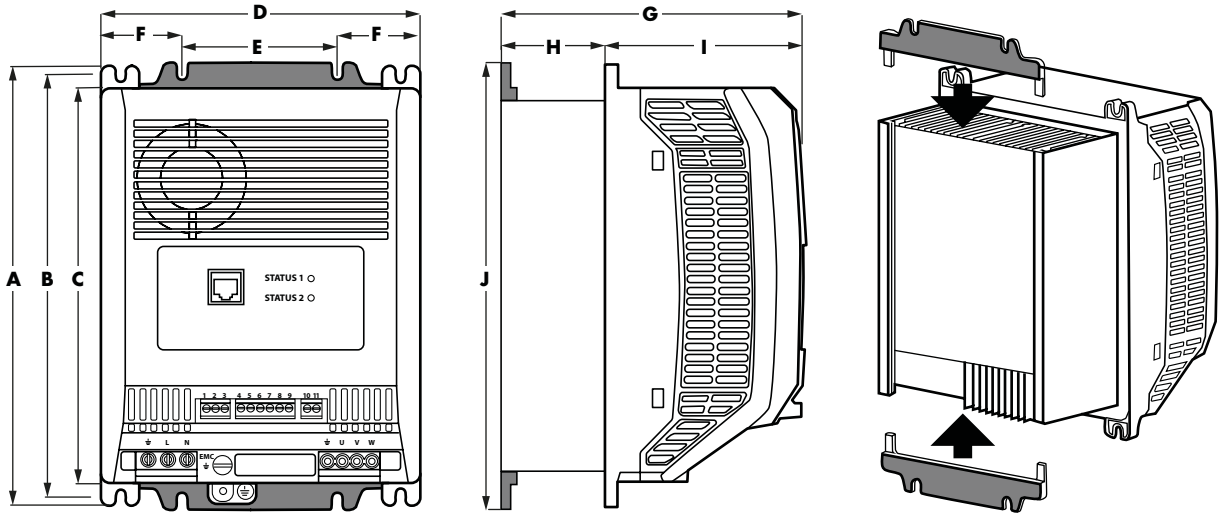


A		B		C		D		E		F		G		H		I	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	21.4	0.8	293	11.5	239.5	9.4	212.5	8.4	20.3	0.8	239.5	9.4	107	4.2	133	5.2

4.1.6. Panel mounting (with the panel mounting kit)

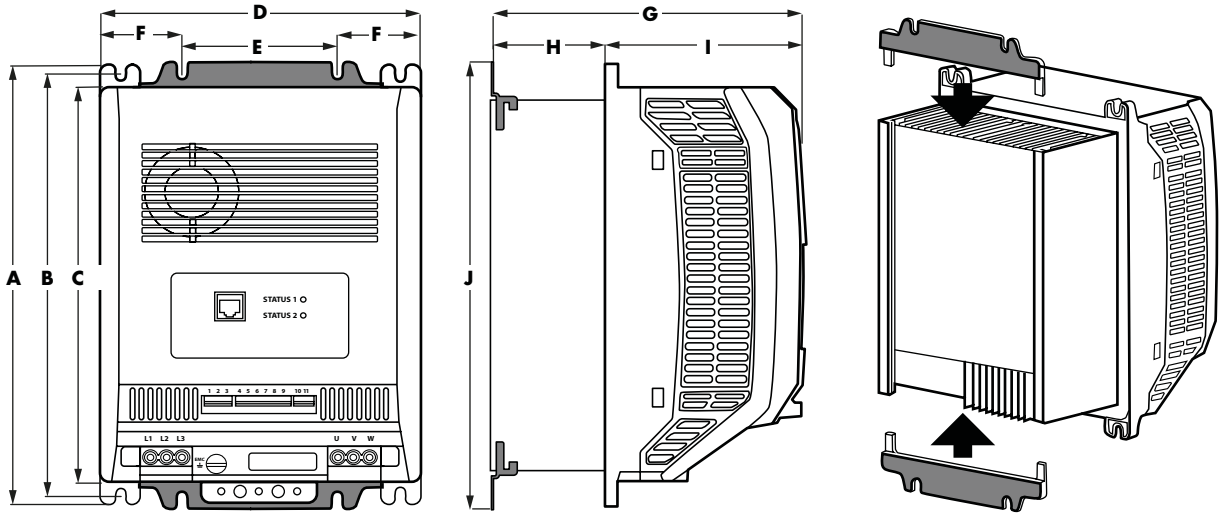
If the installation does not lend itself to through panel mounting, the drive can be mounted to a back-plate of a panel using the optional panel mounting kit.

Size 2



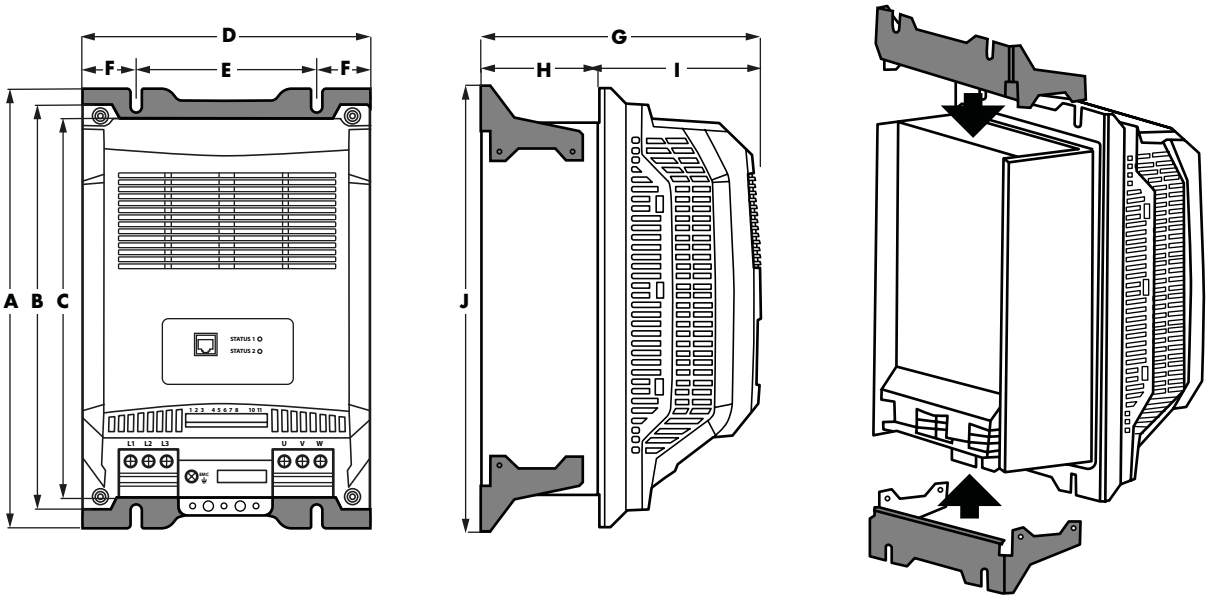
A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
226.3	8.9	215.2	8.5	201.4	7.9	165.3	6.5	80	3.1	42.7	1.7	178	7	73.6	2.9	104.4	4.1	228	9

Size 3



A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
277.5	10.9	266	10.5	247.2	9.7	193.6	7.6	100	3.9	47	1.9	200.3	7.9	84.3	3.3	116	4.6	282	11.1

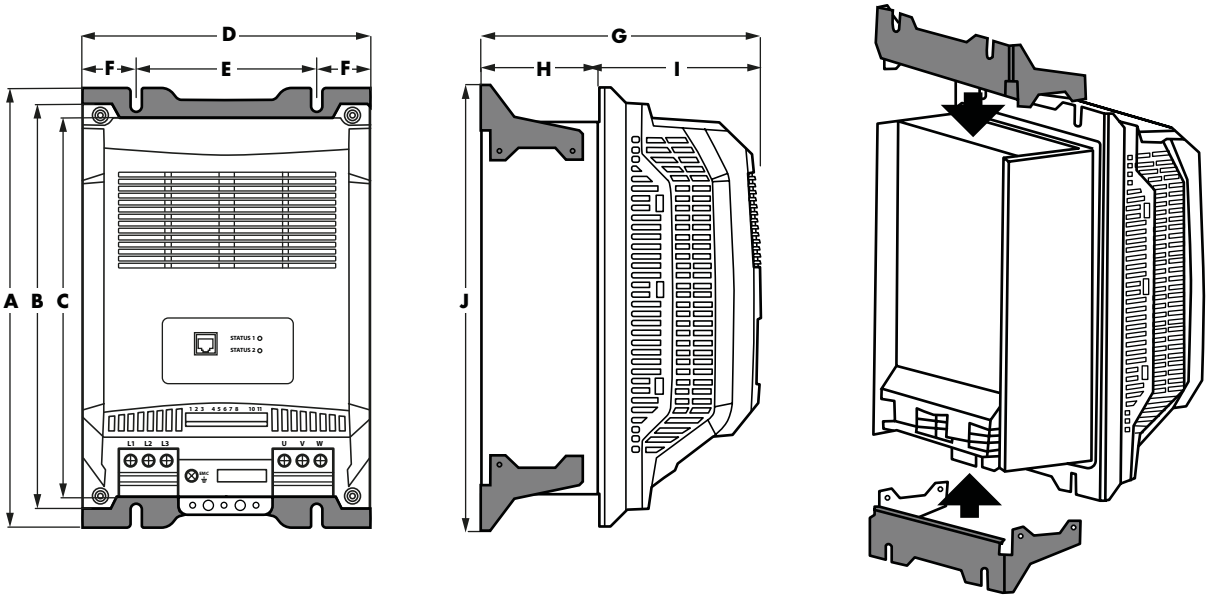
Size 4



A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	337	13.3	310	12.2	239.5	9.4	150	5.9	44.8	1.8	233.5	9.2	101.5	4	133	5.2	363.5	14.3

NOTE 8 off M4 x 8 mm pozidrive screws are provided with the size 4 brackets to secure them to the drive. Tightening Torque is 1.5Nm.

Size 5



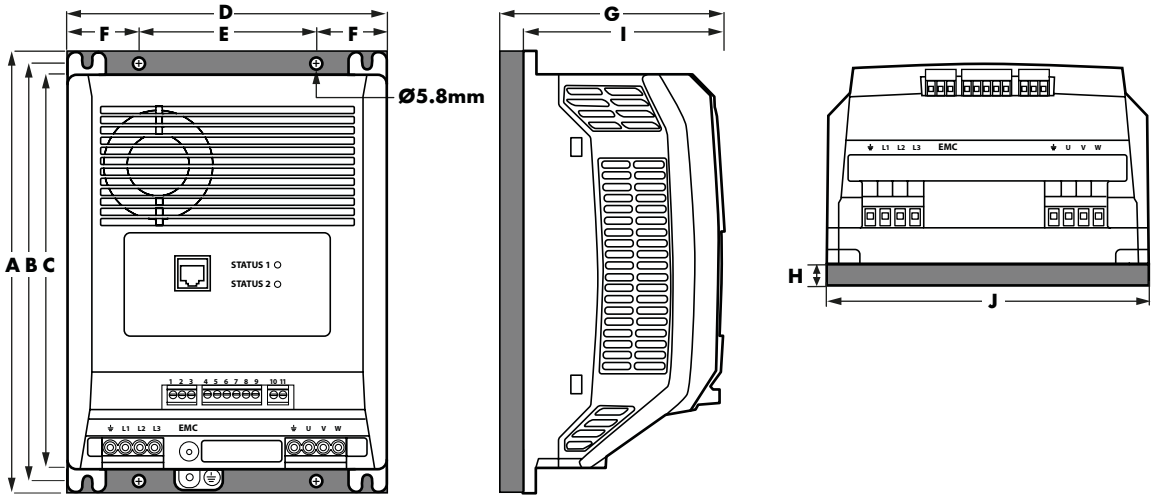
A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	337	13.3	310	12.2	239.5	9.4	150	5.9	44.8	1.8	244	9.6	110	4.4	133	5.2	363.5	14.3

NOTE 8 off M4 x 8 mm pozidrive screws are provided with the size 5 brackets to secure them to the drive. Tightening Torque is 1.5Nm.

4.1.7. Panel mounting the cold-plate variant

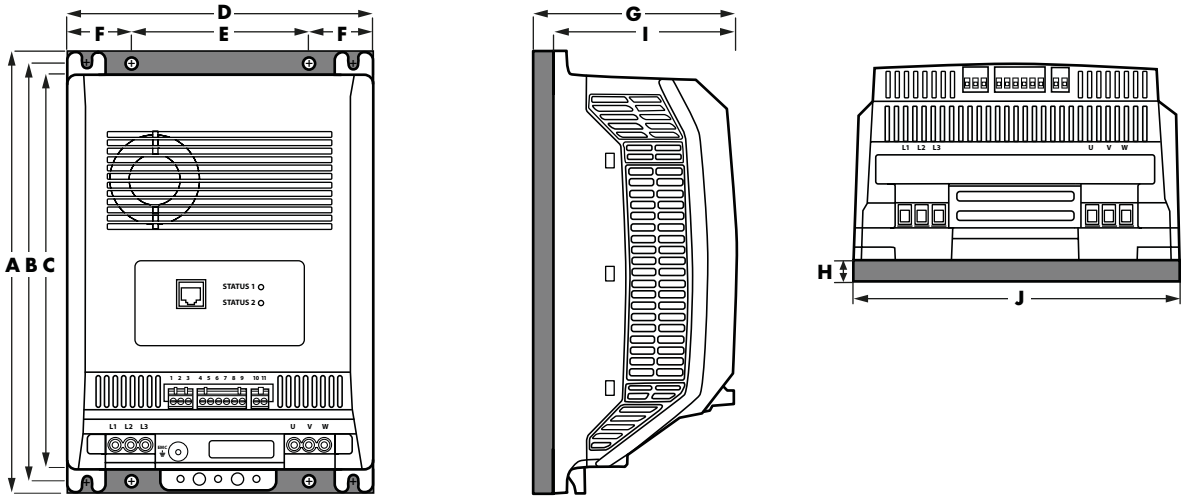
The Optidrive Coolvert is also available without a heatsink but with a coldplate that needs to be mounted onto a heat transfer surface removing the drive losses and maintaining the coldplate temperature as shown in the table in section *4.1.10. Cold-plate Capacity Calculation on page 20.*

Size 2



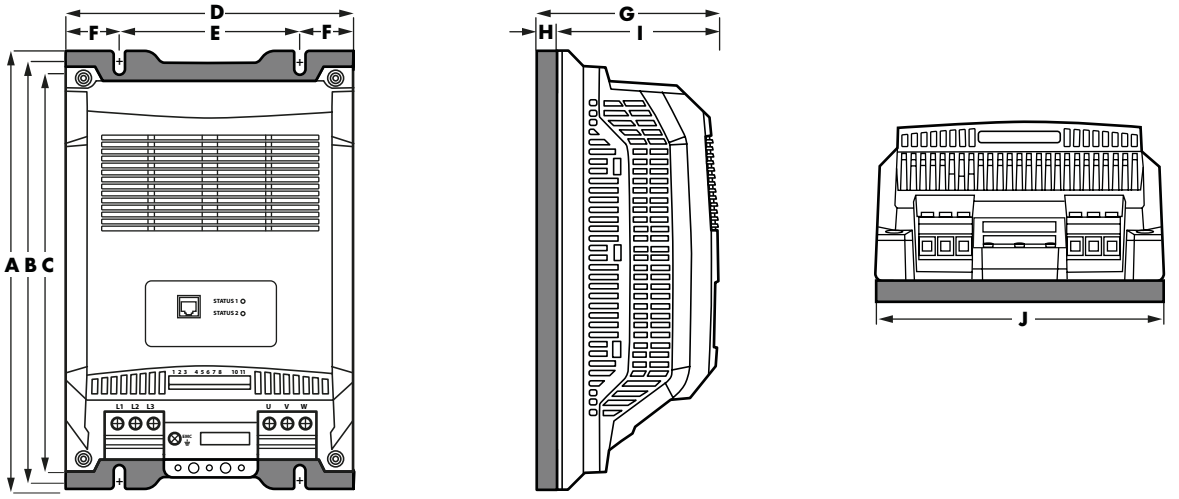
A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
226.3	8.9	215.2	8.5	201.4	7.9	165.3	6.5	90	3.5	37.7	1.5	113.9	4.5	9.5	0.4	104.4	4.1	165.3	6.5

Size 3



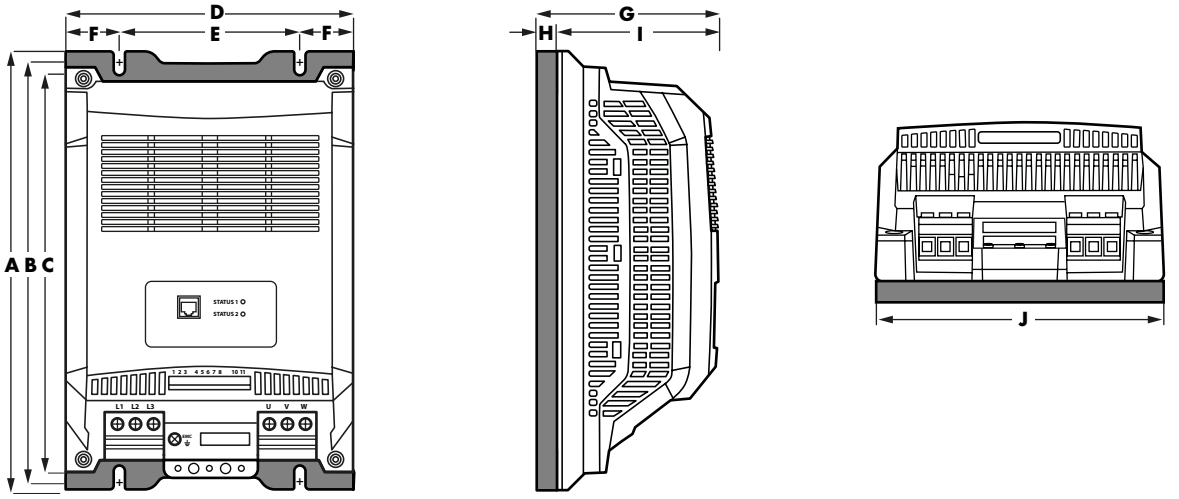
A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
277.8	10.9	262.6	10.3	247.2	9.7	193.6	7.6	110	4.3	42	1.7	125.8	5	9.8	0.4	116	4.6	194.1	7.6

Size 4



A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	337	13.3	310	12.2	239.5	9.4	150	5.9	44.8	1.8	140.3	5.5	9.8	0.4	130.5	5.1	232.5	9.2

Size 5



A		B		C		D		E		F		G		H		I		J	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
364	14.3	337	13.3	310	12.2	239.5	9.4	150	5.9	44.8	1.8	140.3	5.5	9.8	0.4	130.5	5.1	232.5	9.2

4.1.8. Drive Weights & Tightening Torques

Drive Weights

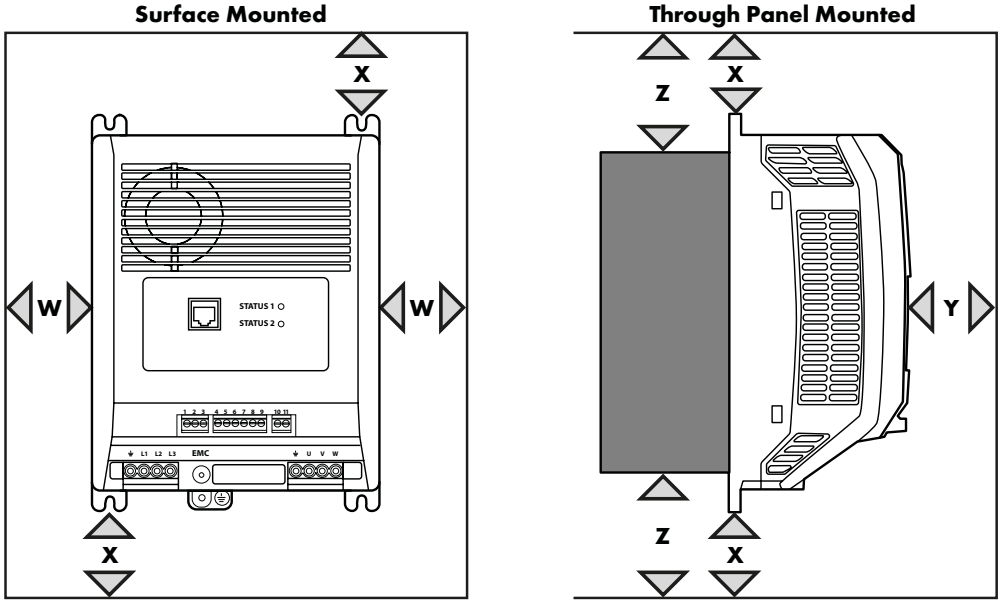
Frame Size	Drive Weight	
Size 2	400V Heatsink	3.05 kg
	230V PFC Heatsink (7/12A)	3.4 kg
	230V PFC Heatsink (16/20A)	3.74 kg
	400V Coldplate	2.03 kg
	230V PFC Coldplate (7/12A)	2.4 kg
	230V PFC Coldplate (16/20A)	2.6 kg
Size 3	All Heatsink Drives	5 kg
	All Coldplate Drives	3.1 kg
Size 4	All Heatsink Drives	9.5 kg
	All Coldplate Drives	5 kg
Size 5	All Heatsink Drives	10 kg
	All Coldplate Drives	5.7 kg

Tightening Torques

Frame Size	Required Torque		
Size 2	Control Terminals	0.5 Nm	4.5 lb in
	Power Terminals	1 Nm	9 lb in
Size 3	Control Terminals	0.5 Nm	4.5 lb in
	Power Terminals	2 Nm	18 lb in
Size 4	Control Terminals	0.5 Nm	4.5 lb in
	Power Terminals	2 Nm	18 lb in
Size 5	Control Terminals	0.5 Nm	4.5 lb in
	Power Terminals	2 Nm	18 lb in
External EMC Filter	Power Terminals	2 Nm	18 lb in
	Mounting Feet	2 - 3 Nm	18 - 27 lb in

4.1.9. 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:



Frame Size	W		X		Y		Z*	
	mm	in	mm	in	mm	in	mm	in
2	20	0.79	78	3.07	10	0.39	100	3.94
3	20	0.79	75	2.95	20	0.79	100	3.94
4	20	0.79	65	2.56	20	0.79	100	3.94
5	20	0.79	65	2.56	20	0.79	100	3.94

The losses generated by each drive are explained in section *4.1.10. Cold-plate Capacity Calculation.*

NOTE The maximum dimensions above for X, Y & Z should be observed regardless of the installation method. 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.

4.1.10. Cold-plate Capacity Calculation

The coldplate variants of the Optidrive Coolvert 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, the following information should be considered when designing the system:

- Select the desired PWM operating frequency from the available options in Parameter P5-06
- Determine the maximum permissible drive temperature, T_{MAX} from table below
- Calculate the compressor absorbed electrical power, P_{MOT}, based on the compressor rated voltage, current and efficiency
  $P_{MOT} = \sqrt{3}$ * Rated Voltage * Rated Current * Power Factor * Efficiency
- Calculate the losses in the drive, P_{LOSS}, based on the required compressor power
  $P_{LOSS} = P_{MOT}$ * (1 - 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	Typical 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	CV-220070-1FHP	4	1.5	96	(95) 87
					8		111	(92) 84
					12		124	(89) 81
					16		137	(86) 78
					24		166	(83) 75
					32		197	(80) 72
200-240V +/-10%	1	12	3	CV-220120-1FHP	4	3	195	(95) 87
					8		219	(92) 84
					12		230	(89) 81
					16		246	(86) 78
					24		292	(83) 75
					32		292	(80) 72
200-240V +/-10%	1	16	4	CV-220160-1FHP	4	4	225	(95) 87
					8		249	(92) 84
					12		278	(89) 81
					16		305	(86) 78
					24		358	(83) 75
					32		411	(80) 72
200-240V +/-10%	1	20	5.5	CV-220200-1FHP	4	5.5	308	(95) 87
					8		337	(92) 84
					12		374	(89) 81
					16		400	(86) 78
					24		462	(83) 75
					32		521	(80) 72
380-480V +/-10%	3	14	5.5	CV-240140-3FHE	10	5.5	234	(91) 83
					12		253	(89) 81
					14		272	(88) 80
					16		280	(87) 79
					18		306	(85) 77
					20		322	(84) 76

Supply Rating		Output Rating		Product Part Number	Switching frequency	Typical Output Power	Typical losses at typical power	Maximum Coldplate or Heatsink Temperature
V	Ph	A	kW	Model	kHz	kW	W	°C
380-480V +/-10%	3	18	7.5	CV-240180-3FHE	10	7.5	244	(91) 83
					12		262	(89) 81
					14		274	(88) 80
					16		271	(87) 79
					18		291	(85) 77
					20		298	(84) 76
380-480V +/-10%	3	24	11	CV-240240-3FHE	10	11	444	(91) 83
					12		416	(89) 81
					14		421	(88) 80
					16		426	(87) 79
					18		442	(85) 77
					20		460	(84) 76
380-480V +/-10%	3	30	15	CV-340300-3FHE	10	15	373.2	(95) 87
					12		382.2	(95) 87
					14		406.3	(92) 84
					16		434.3	(89) 81
					18		461.6	(86) 78
					20		487.8	(83) 75
380-480V +/-10%	3	39	18.5	CV-340390-3FHE	10	18.5	498	(95) 87
					12		513.5	(95) 87
					14		543	(92) 84
					16		574.7	(89) 81
					18		605.3	(86) 78
					20		640.5	(83) 75
380-480V +/-10%	3	46	22	CV-440460-3FHE	10	22	567.9	(95) 87
					12		598.7	(95) 87
					14		630.3	(92) 84
					16		665.1	(89) 81
					18		697.7	(86) 78
					20		734.4	(83) 75
380-480V +/-10%	3	58	30	CV-440580-3FHE	10	30	579.4	(95) 87
					12		799.2	(95) 87
					14		853.4	(92) 84
					16		899	(89) 81
					18		940.8	(86) 78
					20		985.9	(83) 75
380-480V +/-10%	3	65	37	CV-540650-3FHE	10	37		
					12			
					14			
					16			
					18			
					20			
380-480V +/-10%	3	75	40	CV-540750-3FHE	10	40		
					12			
					14			
					16			
					18			
					20			

NOTE In the Maximum Coldplate or Heatsink Temperature column the value in brackets is the power module trip level.

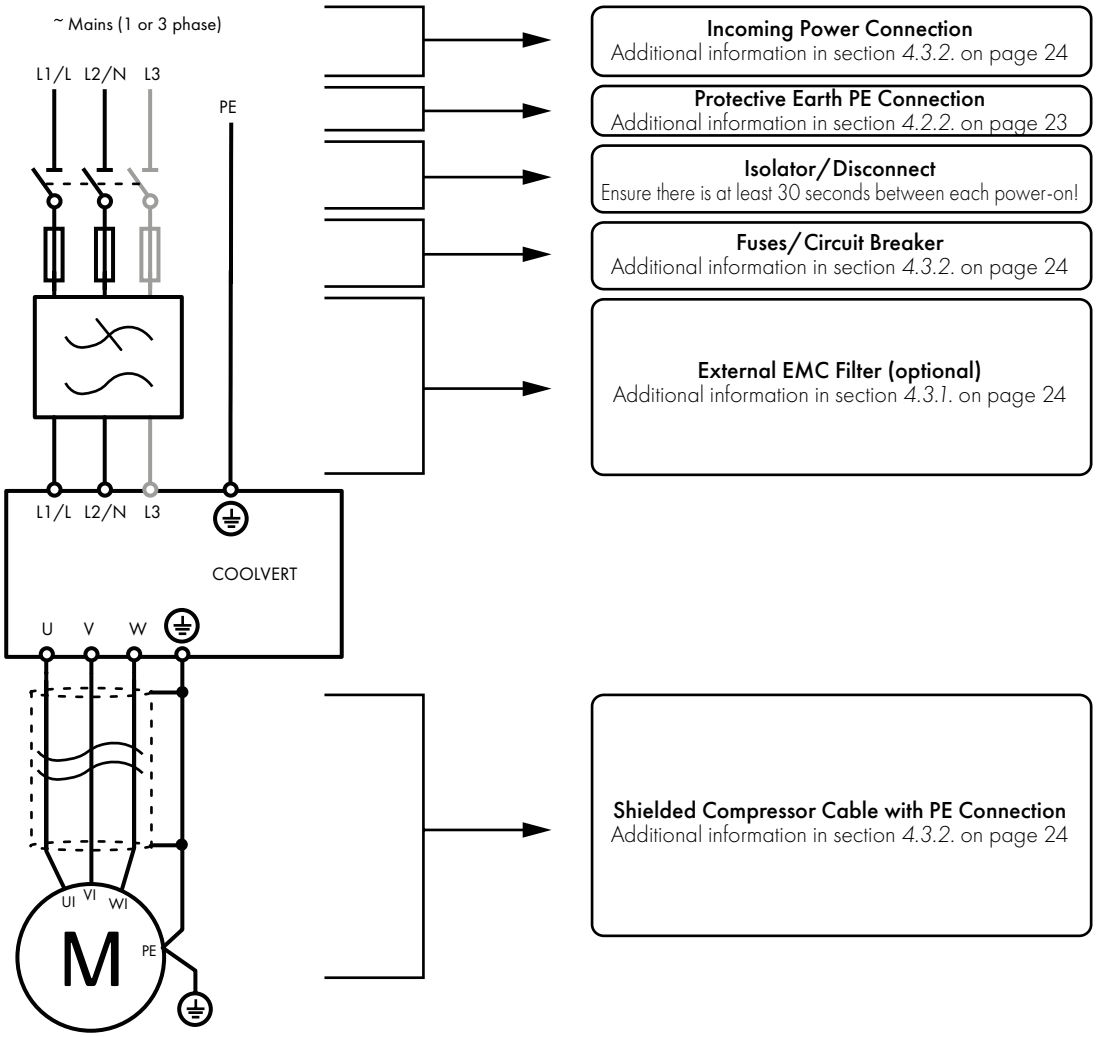
NOTE Replace 'H' with 'C' for Coldplate variant.

NOTE The heatsink temperature can be read in parameter P0-21 (Modbus register 24).

4.2. Connection Diagram

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

4.2.1. Electrical Power Connections



⚠	This manual is intended as a guide for proper installation. Invertek Drives Ltd 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 Optidrive contains high voltage capacitors that take time to discharge after removal of the main supply. Before working on the drive, ensure isolation of the main supply from line inputs. Wait ten (10) minutes for the capacitors to discharge to safe voltage levels. Failure to observe this precaution could result in severe bodily injury or loss of life.
⚠	Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life.

4.2.2. Grounding Guidelines

The ground terminal of each Optidrive Coolvert should be individually connected DIRECTLY to the site ground bus bar (through the filter if installed). Optidrive Coolvert ground connections should not loop from one drive to another, or to, or from any other equipment. Ground loop impedance must conform to local industrial safety regulations. To meet UL regulations, UL approved ring crimp terminals should be used for all ground wiring connections. The drive Safety Ground must be connected to system ground. Ground impedance must conform to the requirements of national and local industrial safety regulations and/or electrical codes. The integrity of all ground connections should be checked periodically.

Protective Earth Conductor

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

Safety Ground

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

Compressor Ground

The compressor 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 Optidrive Coolvert is designed to produce the minimum possible leakage current whilst complying with worldwide standards. The level of current is affected by compressor 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 Optidrive Coolvert as opposed to one protection device serving many.

Shield Termination (Cable Screen)

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

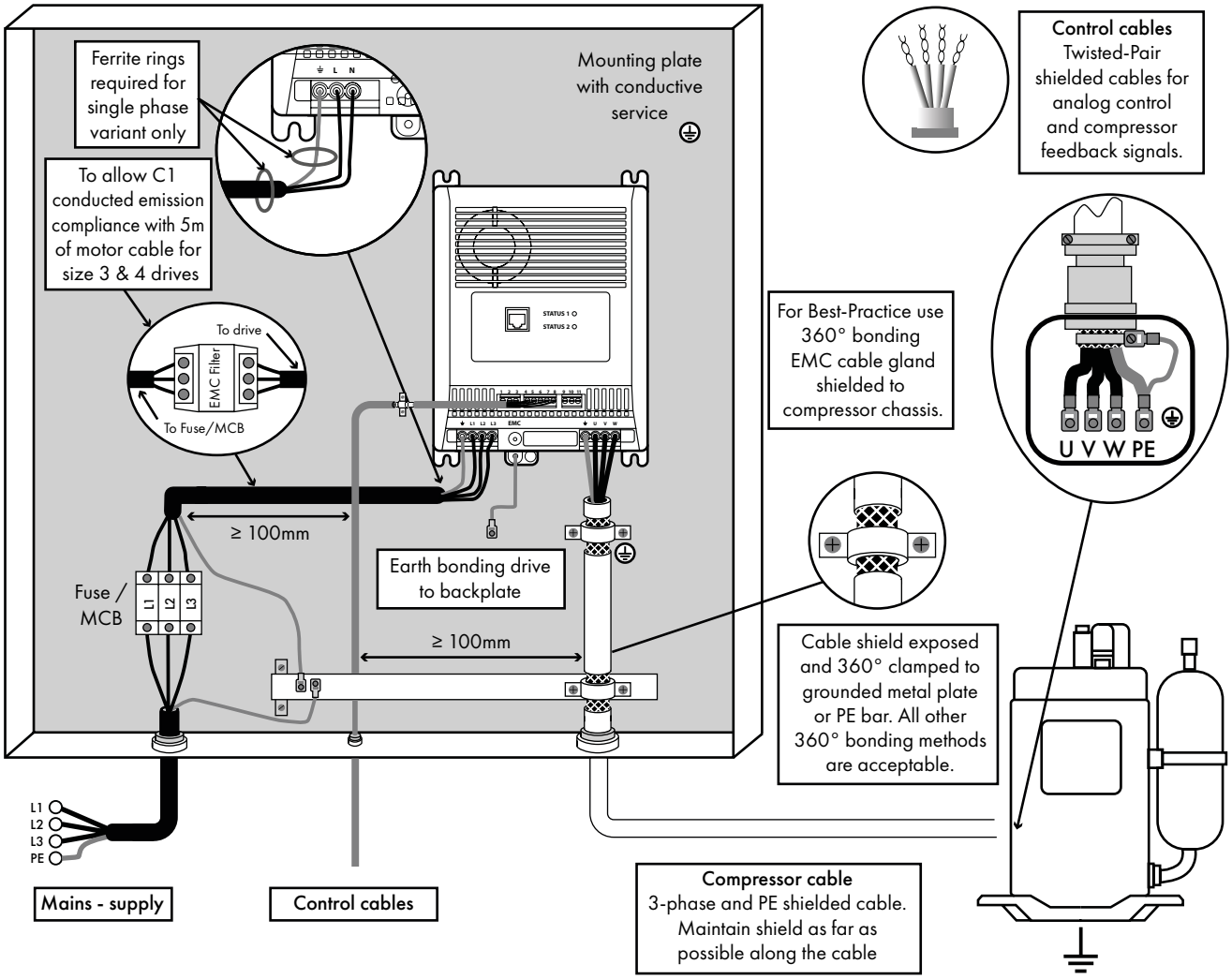
4.3. EMC Compliant Installation

The Optidrive Coolvert 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 Optidrive Coolvert 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 Optidrive Coolvert 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 Optidrive Coolvert complies with any standard necessary for that final product.

4.3.1. Recommended Installation for EMC Compliance



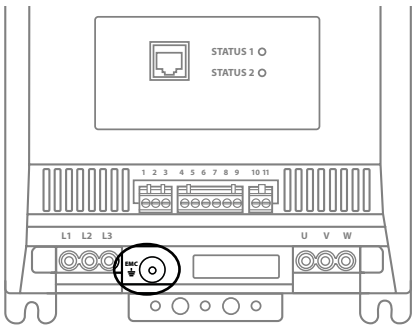
NOTE The drive must be bonded to the main incoming supply earth/ground and the compressor must also be earthed/grounded to the drive using the compressor cable.

General

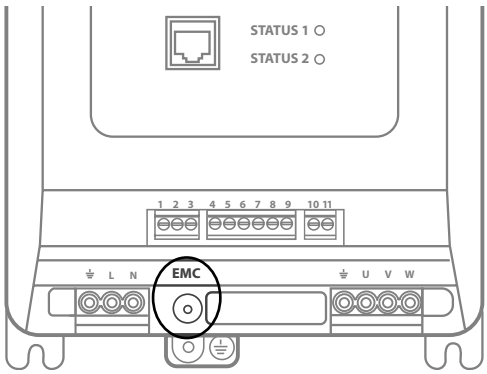
The EMC screw can be removed to disable the on board EMC filter. This should be done in the following cases:

- If the drive is connected to an IT supply.
- If the drive is to undergo a HIPot (insulation resistance) test.

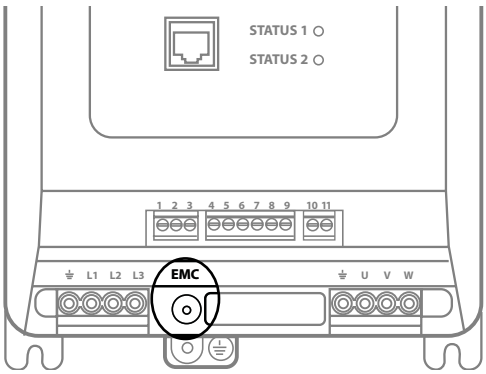
The EMC screw must be removed completely, not just loosened.



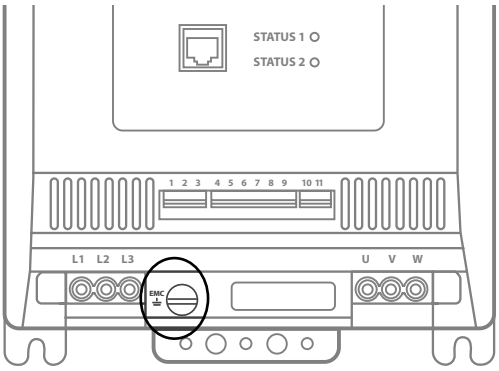
Size 2 Single Phase 200V



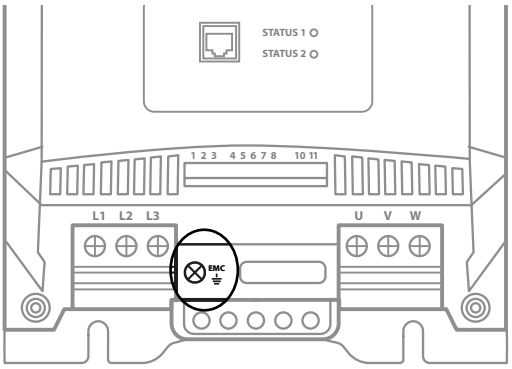
Size 2 400V



Size 3 400V



Size 4/5 400V



The EMC screw can be removed to disable the on board EMC filter. This should be done if carrying out a Hi Pot test.

Power Supply	Drive Model Code	KW	Rated Current	Conducted Emmissions				Radiated Emmissions
				C1 Max Cable length		C2 Max Cable length		
				External EMC Filter	Internal EMC Filter	External EMC Filter	Internal EMC Filter	
Single Phase 200V	CV-220070-1FHP	1.5	7	5 Meters	2.5 Meters	10 Meters	5 Meters	C2
	CV-220140-1FHP	3	14	5 Meters	2.5 Meters	10 Meters	5 Meters	C2
	CV-220160-1FHP	4	16	5 Meters	N/A	5 Meters	5 Meters	C2
	CV-220200-1FHP	5.5	20	5 Meters	N/A	5 Meters	5 Meters	C2
Three Phase 400V	CV-240014-3FHE	5.5	14	5 Meters	2.5 Meters	10 Meters	5 Meters	C2
	CV-240018-3FHE	7	18	5 Meters	2.5 Meters	10 Meters	5 Meters	C2
	CV-240240-3FHE	11	24	5 Meters	2.5 Meters	10 Meters	5 Meters	C2
	CV-340300-3FHE	15	30	5 Meters	N/A	5 Meters	5 Meters	C2
	CV-340390-3FHE	18.5	39	5 Meters	N/A	5 Meters	5 Meters	C2
	CV-440460-3FHE	22	46	5 Meters	N/A	5 Meters	5 Meters	C2
	CV-440580-3FHE	30	58	5 Meters	N/A	5 Meters	5 Meters	C2
	CV-540650-3FHE	37	65	5 Meters	N/A	5 Meters	5 Meters	C2
	CV-540750-3FHE	40	75	5 Meters	N/A	5 Meters	5 Meters	C2

NOTE Due to the vast variation in impedances of different compressor motors, if radiated EMC performance is not as expected, improvements can be made by adding ferrite cores in the motor cable.

Details of optional external EMC filters listed in section *3.2.2. Optional External EMC Filters on page 7*.

NOTE AC Drives and filters may produce electromagnetic interference up to 300GHz that may effect the functionality of pacemakers and other implanted medical devices.

General

Size 2 Drives

[1] Category C1 compliance is achieved only for conducted emissions. 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.

Size 3 Drives

C2 compliance is achieved for conducted commissions.

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

[3] 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.

Compressor Cable

[4] 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.

[5] The cable shield should be terminated at the compressor end using an EMC type gland allowing connection to the compressor 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

[6] It is recommended to use shielded cable for all IO connections with the drive.

4.3.2. 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 RCM EMC requirements, refer to section *4.3. EMC Compliant Installation on page 24*.
- A fixed installation is required according to IEC61800-5-1 with a suitable disconnecting device installed between the Optidrive 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 *7.2. Detailed Product Rating Tables on page 68*.

Fuse / Circuit Breaker Selection

- For UL compliance installations, please reference the fusing requirement indicated in section *7.2. Detailed Product Rating Tables* for UL fuse ratings.
- 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 7.2. Detailed Product Rating Tables. UL 60730-1 fuses are intended to protect the drive itself. 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 Optidrive Power terminals as defined in IEC60439-1 is 100kA.

Safety Considerations

- AC Drives and filters may produce electromagnetic interference up to 300GHz that may effect the functionality of pacemakers

and other implanted medical devices.

Compressor Connection

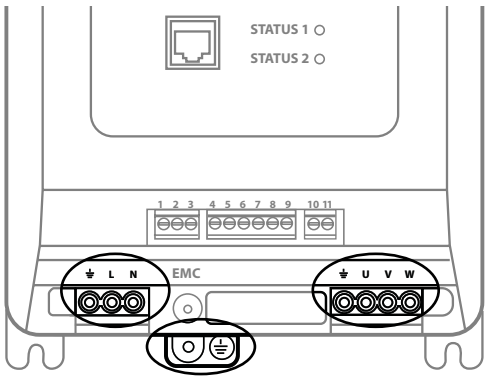
- The drive inherently produces fast switching of the output voltage (PWM) to the compressor compared to the mains supply, for compressors which have been wound for operation with a variable speed drive then there is no preventative measures required, however if the quality of insulation is unknown then the compressor manufacturer should be consulted and preventative measures may be required.
- The compressor should be connected to the Optidrive 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 compressor earth must be connected to one of the Optidrive earth terminals.
- Maximum permitted compressor cable length for all models: 10 metres shielded, 20 metres unshielded.

Power Connections

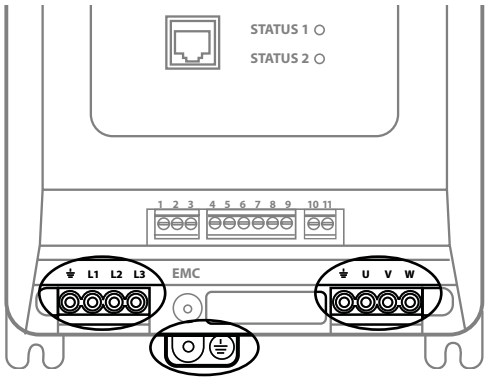
230V Single Phase Variants							
Power Earth / Ground	L1 (200VAC)	Neutral	Power Earth / Ground	Compressor U Phase	Compressor V Phase	Compressor W Phase	
E	L	N	E	U	V	W	

400V 3-Phase Variants								
Power Earth / Ground	Supply L1	Supply L2	Supply L3	Power Earth / Ground	Compressor U Phase	Compressor V Phase	Compressor W Phase	
E	L1	L2	L3	E	U	V	W	

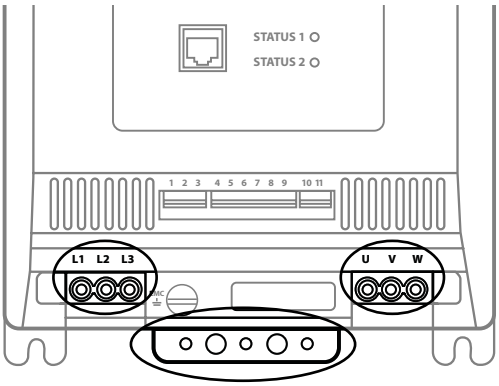
Size 2 Single Phase 200V



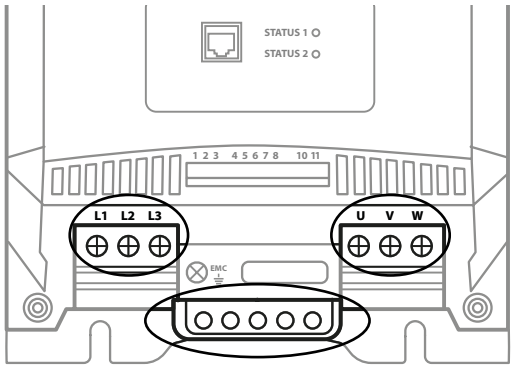
Size 2 400V



Size 3 400V



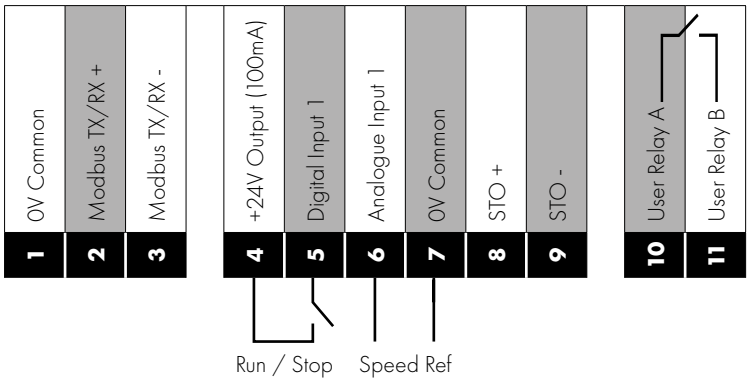
Size 4/5 400V

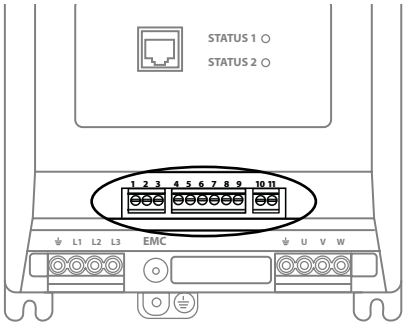


4.3.3. Control Wiring

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

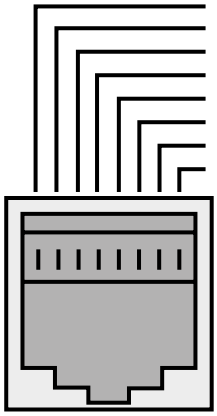
- Serial Communications (T1-T3)
- Inputs (T5 – T9)
- Output Relay (T10 – T11)





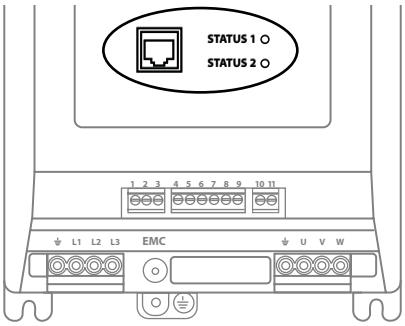
RJ45 Port

This port is intended for use with the Optistick Smart or isolated 485 to USB cable for parameter cloning or for connection to the mobile App (Optistick Smart only) or to PC Tools or for Master Follower configuration of drives.



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)

4.3.4. Safe Torque Off

Description of safety function

Safety function and safe state

The safe torque off (STO) function of Coolvert series AC drive is implemented only by hardware and no software is involved to perform the STO function.

The STO function is available for operator to turn off the motor torque. It is intended to be used in the safety related applications up to SIL 3 acc. to EN 61800-5-2, EN 61508 and EN 62061, and up to Cat. 4 / PL e acc. to EN ISO 13849-1.

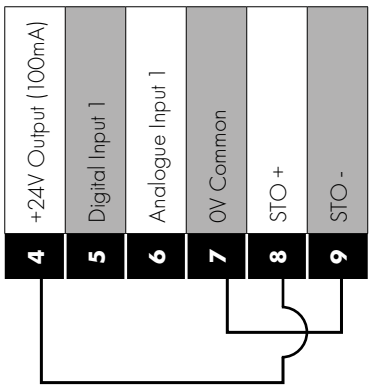
Safety function

The power that can cause rotation (or motion in the case of a linear motor) shall be switched off from the motor when demanded.

Safe state

The safe state is when the power supply of the motor is switched 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 compressor 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 compressor 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 compressor 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 61800-5-2:2017	SIL 3
	EN ISO 13849-1:2023	PL "e"
	EN 61508 (Part 1 to 7): 2010	SIL 3
	EN 60204-1: 2006 & A1: 2009	Cat 0
	EN IEC 62061:2021	SIL 3
	Independent Approval	Size 2 TUV/UL Size 3/4/5 UL

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 compressor braking. In the case where compressor 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 compressors 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 compressor 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 (compressor 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 Keypad**

  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 Invertek Sales Partner
"Sto-r"	101	The STO circuit has ben opened while the drive is running, if the STO is used to connect safety devices to the drive then check for momentary opening of the safety device(s)	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 compressor ("STO" active) is approximately 100ms.
- The response time from the "STO" inputs being de-energised to the "STO" monitoring status changing state 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 *4.3. EMC Compliant Installation on page 24* 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.

4.3.5. Recommended "STO" Wiring

Installation, Commissioning and maintenance instructions

The STO function corresponds to an uncontrolled stop in accordance with category 0 of EN 60204-1;

The STO function is not appropriate to be used to prevent an unexpected re-start. As soon as both STO inputs are re-energised, it will be possible (subject to parameter settings) for the drive to re-start automatically. This function should not be used for short term non-electrical machinery operations (such as cleaning or maintenance work);

It should be considered that in some applications additional measures may be required to fulfil the application's needs: the STO function does not give motor braking. In the case where motor breaking is required a time delay safety relay and or a mechanical brake arranged externally could give the level of protection required;

The system designer will be responsible for defining the requirements of the overall "Safety Control System" within which the drive will be used and ensuring that drive configuration, system risk assessment and settings are correct for the safety rating required;

When using permanent magnet motors, in the case of multiple IGBT power semiconductor failures, the system could produce torque which may rotate the motor shaft by 180/p degrees: where p denotes the number of motor pole pairs;

Setup and Operation of the STO

Start-Up Condition: This test checks that the STO outputs are not enabled automatically upon application of power when the STO inputs are not present.

STO Interlock – Drive Output Idle: This test checks that, when the drive is idle, removal of one or both STO inputs results in torque being removed from the motor and that the control signals cannot override this state. The STO state is also verified to be correctly reported to the user via the remote keypad and LED indications.

The test is summarised as follows:

With the drive switched on both STO inputs are applied.

Drive verified to transition into STOP state, and correctly reported on the remote keypad and LED indications.

STO_1 input is removed by opening the associated switch.

Drive verified to transition into INHIBIT state, and correctly reported on the remote keypad and LED indications.

STO_2 input is toggled in this state and is observed to have no effect on the INHIBIT state.

STO_1 input is returned, and drive verified to transition back to STOP state.

The test is then repeated for the STO2 channel.

STO Interlock – Drive Output Active: This test checks that, when the drive is running a motor, removal of one or both STO inputs results in torque being removed from the motor and that the control signals cannot override this state. The STO state is also verified to be correctly reported to the user via the user display.

The test is summarised as follows:

With the drive switched on both STO inputs are applied.

Drive verified to transition into STOP state, and correctly reported on the remote keypad and LED indications.

Digital input 1 asserted.

Drive verified to transition into motor running state, with output details reported on the remote keypad and LED indications.

STO_1 input is removed by opening the associated switch.

Drive verified to transition into INHIBIT state with an E-Trip (external trip), and correctly reported on the remote keypad and LED indications.

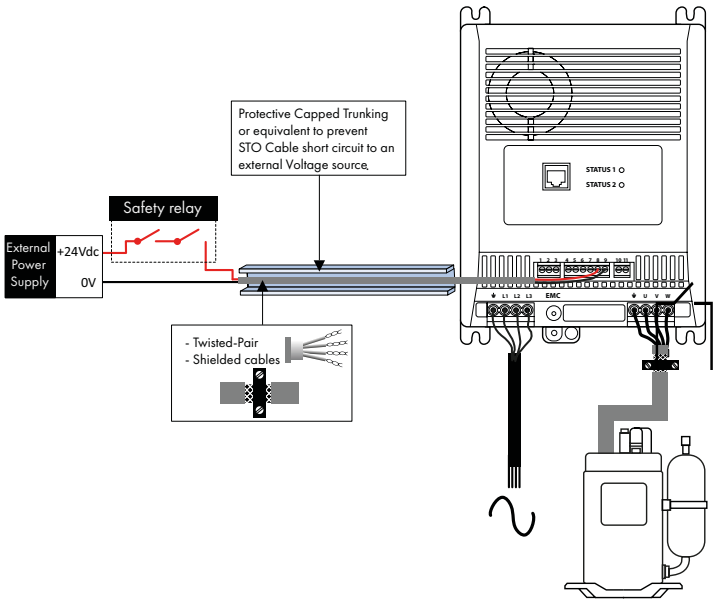
STO_2 input is toggled in this state and is observed to have no effect on the INHIBIT state.

STO_1 input is returned, and drive verified to transition back to motor running state.

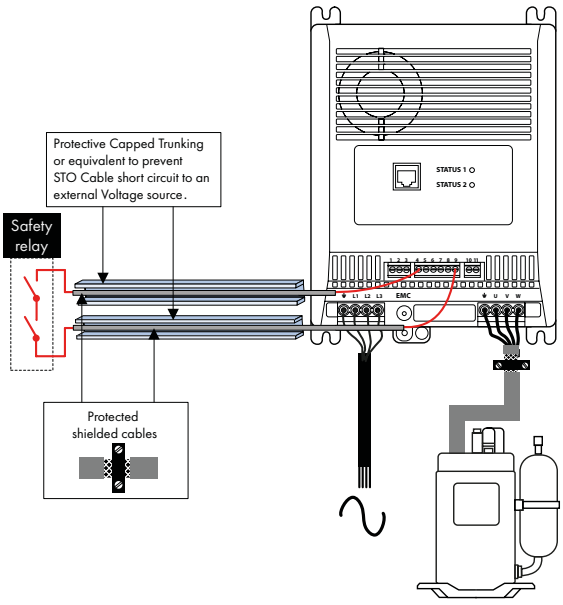
The test is then repeated for the STO2 channel.

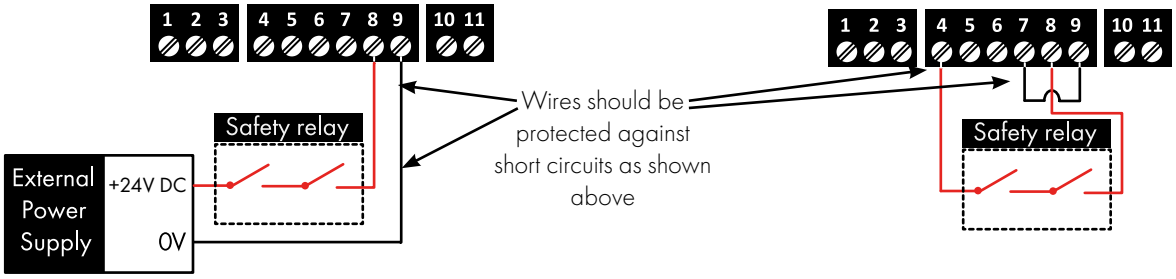
NOTE See section *6.3. Status LED Indication on page 64* for LED status indications.

Using an External 24V DC Power Supply



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.

	SIL (Safety Integrity Level)	PFHd (Probability of Dangerous Failures per Hour)	SFF (Safe Failure Fraction %)	Proof Test Interval	HFT	FIT
EN 61800-5-2	3	3.75E-12 1/h	99.94	10 Yrs	1	0.0038

	PL (Performance Level)	CCF (%) (Common Cause Failure)	MTTFd (a)	Category
EN ISO 13849-1	PL e	5	921	3

	SIL
EN 62061	SIL 3

NOTE The values achieved above may be jeopardised if the drive is installed outside of the ambient and environmental limits detailed in section *7.1. General on page 65*.

Dangerous failure modes

A short circuit in the wiring between the switch and the STO terminal can lead to a hazardous condition.

To minimize this risk, a safety relay with wiring diagnostics or a wiring method that reduces short-circuit hazards, such as shielded grounding or channel separation, is recommended.

Grounding of protective shields

- Ground the shield in the cabling between the activation switch and the control unit at the control unit only.
- Ground the shield in the cabling between two control units at one control unit only.

Requirements of proof test

This device shall be subjected to a proof test at least once every 10 years. Please contact the factory or your local Invertek sales representative.

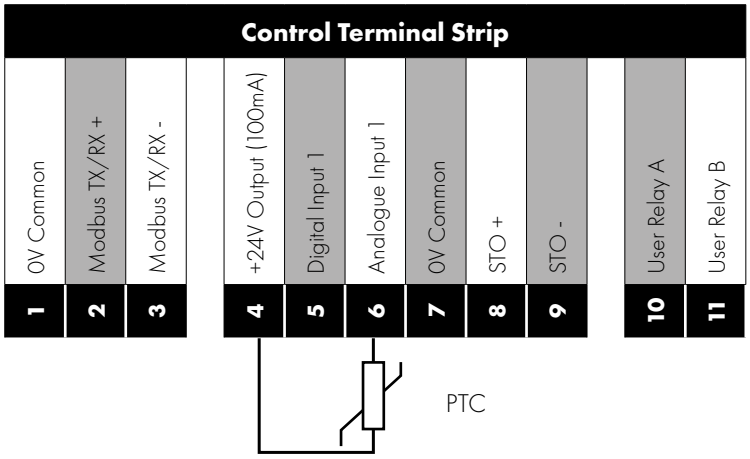
4.3.6. Compressor Thermal Overload Protection

Internal Thermal Overload Protection

The drive has an in-built compressor thermal overload function; this is in the form of an "I.t-trP" trip after delivering >100% of the value set in P1-08 for a sustained period of time (e.g. 130% for 10 seconds).

Compressor Thermistor Connection

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



Additional Information

- Compatible Thermistor: PTC Type, 2.5kΩ trip level.
- When using a compressor 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).

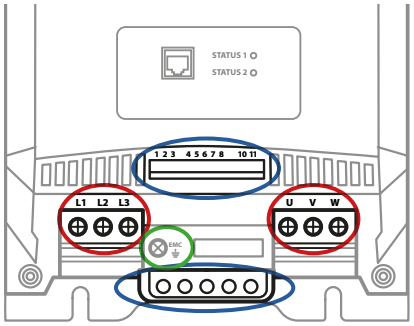
4.3.7. HiPot (Insulation Reistance) Testing

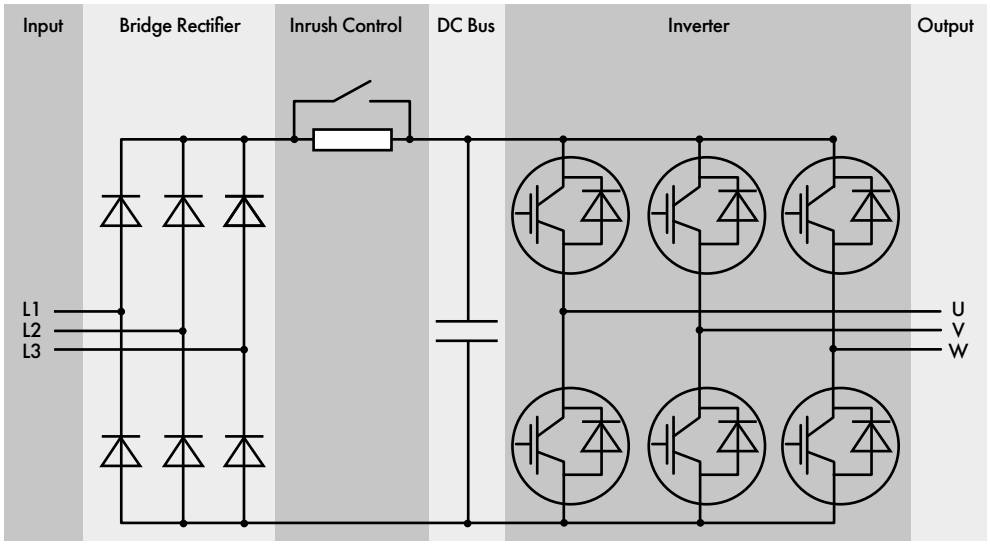
During production testing is a 'high-pot test' is carried out, which means that it is not necessary to carry out any further high-pot tests on the drive in the end application. If, however, local or international regulations or legislation require this procedure to be carried out on the drive in its end application, the following procedure should be adhered to:

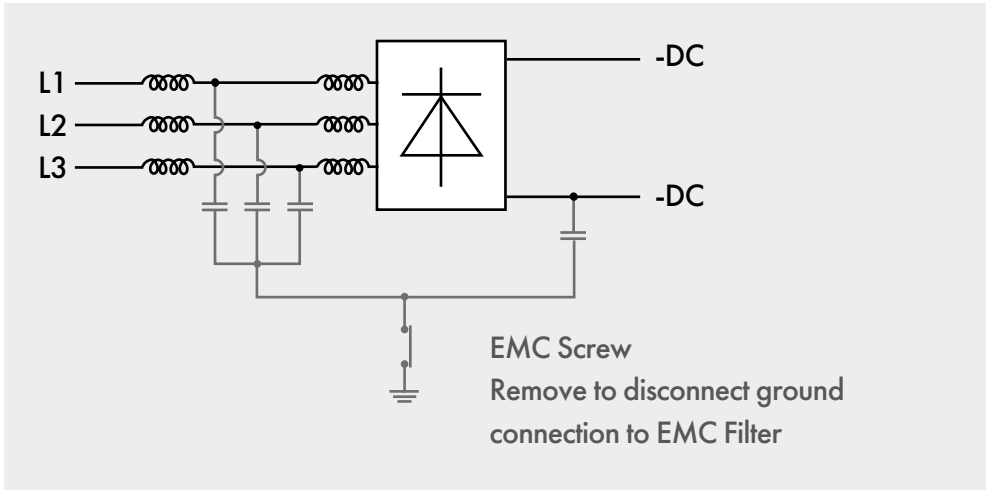
- For 380-480Vac 3-phase input drives, connect the positive terminal of the flash tester to all the following terminals at the same time:
  - L1, L2, L3, U, V, W (highlighted in Red below)
- Connect the negative terminal of the flash tester to all of the following terminals at the same time:
  - Power earth terminal, all IO terminals (highlighted in Blue below)
- Disconnect the EMC ground connection by removing the EMC ground screw (indicated in Green below)
  - The screw must be removed not just loosened
  - Ensure that the screw is not lost, this must be replaced at the end of test to ensure EMC compliance
- For 380-480Vac 3-phase input drives, apply a AC Voltage as follows:
  - Level = 2.447 kVAC (or less)
  - Ramp-up time = 3 s
  - Hold time = 2 s
  - Ramp-down time = 10 s
  - Leakage maximum = 3.5 mA
- For 200-230Vac 1-phase input drives, apply a AC Voltage as follows:
  - Level = 1.5 kVAC (or less)
  - Ramp-up time = 3 s
  - Hold time = 2 s
  - Ramp-down time = 10 s
  - Leakage maximum = 3.5 mA
- Replace the EMC ground connection screw (indicated in Green below)

Please note that type tests are performed at levels above the requirements of EN 61800-5-1, which is where the above values are referenced from.

Size 4/5 400V


STATUS 1
STATUS 2
1 2 3 4 5 6 7 8 10 11
L1 L2 L3
U V W
EMC


Input
Bridge Rectifier
Inrush Control
DC Bus
Inverter
Output
L1
L2
L3
U
V
W


L1
L2
L3
-DC
-DC
EMC Screw
Remove to disconnect ground
connection to EMC Filter

5. Set-up and Operation

5.1. Basic Checks Before Commissioning

The following points should be considered before connecting the drive to its supply.

1. That the Voltage rating of the drive is suitable for the supply

2. That the drive current rating is suitable for the compressor to be connected.

The compressor nameplate data needs to be entered accurately before attempting to run the compressor. The format of the information can vary depending on the technology of the compressor. It is very important to ensure that the data entered is in the correct format. A common mistake is to enter an incorrect value for the back emf of a permanent magnet compressor at rated speed as it can be written as a peak voltage, rms voltage and phase to phase voltage, line voltage and so on.

5.1.1. Compressor Type and Control Mode

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
5-01	501	Compressor Control Mode – select according to the compressor connected to the drive: 0: BLDC Vector Speed Control 1: Permanent Magnet Vector Speed Control 2: Induction Compressor Vector Speed Control (CT) 3: Induction Compressor Vector Speed Control (VT) 4: Induction Compressor V/F 5: Synchronous Reluctance Vector Speed Control 6: LSPM Speed Control	0	0	6	-	R/W

5.1.2. Compressor Datasheet Information

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
1-07	107	Compressor Rated Voltage (phase-to phase rms) Or Back EMF at Rated Speed for permanent magnet compressor types (phase to phase rms)	-	-	-	V	R/W
1-08	108	Compressor Rated Current (nominal)	-	-	-	A	R/W
1-09	109	Compressor Rated Frequency at Rated Speed (nominal)	180	20	500	Hz	R/W
1-10	110	Compressor Rated Speed at Rated Frequency	60	0	500	rps	R/W
5-05	505	Induction Motor Compressor Power Factor – cos phi. Only necessary for Induction Motors.	-	0.5	0.99	-	R/W
7-03	703	Motor Stator Resistance (Rs) phase to phase (enter the value provided from the compressor datasheet)	-	-	-	Ω	R/W
7-04	704	Motor Stator Inductance (Lsd) per phase (enter the value provided from the compressor datasheet)	-	-	-	mH	R/W
7-05	705	Motor Stator Inductance (Lsq) per phase (enter the value provided from the compressor datasheet)	-	-	-	mH	R/W

5.1.3. Operating Limits and Ramp Rates

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
1-01	101	Maximum Compressor Speed	60	P1-02	500	rps	R/W
1-02	102	Minimum Compressor Speed	20	0	P1-01	rps	R/W
1-03	103	Acceleration Ramp Time from 0rps to Rated Speed	5.0	0	6000	s	R/W
1-04	104	Deceleration Ramp Time from Rated Speed to 0rps	5.0	0	6000	s	R/W
5-06	506	Compressor Switching Frequency (24 x max frequency)	-	-	-	kHz	R/W
5-07	507	Maximum Torque / Current Limit	110	20	150	%	R/W
5-18	518	Maximum Peak Output Current (Motor Demagnetising Current). Too low a setting of this parameter can lead to random O-I trips.	Drive rating dependant			Apk	R/W
2-21	221	Stop ramp - this ramp is used if the run command is removed, if set to 0 the this ramp is disabled and the standard deceleration ramp is used P1-04	0.0	0	300	s	R/W

5.1.4. Start-up Sequence

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
2-01	201	Start Speed 1	30	P1-02	P1-01	rps	R/W
2-02	202	Start Speed 1 Time	0	0	600	s	R/W
2-03*	203	Start Speed 1 Acceleration Ramp Rate 1	5.0	0	6000	s	R/W
2-04	204	Start Speed 2	30	P1-02	P1-01	rps	R/W
2-05	205	Start Speed 2 Time	0	0	600	s	R/W
2-06*	206	Start Speed 2 Acceleration Ramp Rate 2	5.0	0	6000	s	R/W
2-07	207	Start Speed 3	30	P1-02	P1-01	rps	R/W
2-08	208	Start Speed 3 Time	0	0	600	s	R/W
2-09*	209	Start Speed 3 Acceleration Ramp Rate 3	5.0	0	6000	s	R/W

If the start-up sequencing (or part of the start-up sequencing) is not required, set the 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 compressor 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 compressor (e.g. 5.0s to go from 0rps to 60rps).

5.1.5. Re-start Blocking

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

5.1.6. Control Mode

See illustrations in section *5.5. Modbus Connections on page 44* 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 4: Slave Mode	0	0	4	-	R/W
1-05	105	Stop Mode 0: Ramp to Stop 1: Coast to Stop 2: AC Flux Braking (IM Compressor only) 3: Ramp to Minimum Speed then Coast to Stop	0	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	Crankcase Heating
0 – Modbus	Safety (STO)	Modbus	Modbus	Parameters	DI1 / Modbus	Modbus
1 – Terminal	Safety (STO)	DI1	AI1	Parameters	DI1	STO / Modbus
2 – Terminal AI Start	Safety (STO)	AI1>10% / AI1<5%	AI1	Parameters	DI1	DI1 / Modbus
3 – User PI	Safety (STO)	DI1	PI Output	Parameters	DI1	STO / Modbus
4 – Slave Mode	Safety (STO)	Master	Master	Parameters	DI1	DI1 / Modbus

5.1.7. System Tuning

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
5-03	503	Vector Speed Controller Proportional Gain	50	0.1	400	%	R/W
5-04	504	Vector Speed Controller Integral Time Constant	0.050	0.001	2.00	s	R/W
7-01	701	Minimum Switching Frequency – Thermal Management	-	-	-	kHz	R/W
7-02	702	Auto-reset Delay	20	10	200	s	R/W
7-04	704	Compressor Stator Inductance (Lsd) per phase	-	-	-	mH	R/W
7-05	705	Compressor Stator Inductance (Lsq) per phase	-	-	-	mH	R/W
7-06	706	PM Motor Magnetising Period	-	0	5000	ms	R/W
7-07	707	Low Frequency Torque Boost Level	0.0	0.0	100	%	R/W
7-08	708	Low Frequency Torque Boost, Frequency Limit	0.0	0.0	50	%	R/W

It is recommend that P7-07 and P7-08 both be set to 10% as a starting point to support improved starting of the compressor.

5.1.8. Thermal Protection

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
5-07	507	Maximum Current Limit	110	20	150	%	R/W
5-08	508	Compressor Power Limit based on Drive kVA rating at 400 V	130	0	130	%	R/W
5-09	509	Compressor Thermal Overload Management (Ixt)	0	0	1	-	R/W
5-10	510	Drive Thermal Overload Management (Drive Temperature Based) Automatic switching frequency reduction	0	0	1	-	R/W
5-11	511	Compressor Thermal Overload Retention Enable	1	0	1	-	R/W
7-01	701	Minimum Switching Frequency – Thermal Management	-	-	-	kHz	R/W
7-02	702	Auto-reset Delay	20	10	200	S	R/W

5.1.9. Slow Acting Current Limit

In certain applications, it is possible that the drive will go into overload where the compressor 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 compressor 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**	**100**	**50**	**130**	**%**	**R/W**
		When enabled (P5-20 > 0), this parameter defines a current as a percentage of compressor rated current (P1-08) 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 compressor rated current (P1-08) is reached. Setting the value to 0s will disable the function.					

5.1.10. Locked Rotor Detection and Protection

The Optidrive Coolvert provides locked rotor detection and protection of the compressor. The following guidance relates to configuring the locked rotor parameters in an appropriate manner.

Testing of the function with the chosen settings and a given compressor should be done in accordance with applicable standards such as IEC60335-2-34 to ensure compliance.

When P7-12 & P7-13 are set correctly and the drive runs below the speed threshold set in P7-12 for the time set in P7-13 the drive will trip on Locked Rotor.

It is possible that other trips may be generated such as over current depending on the compressor motor characteristics.

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
7-11	**711**	**Edit Locked Rotor**	**0**	**0**	**1**	**-**	**R/W**
		This parameter permits or blocks the edditing of the locked rotor parameters. 0: Disable - prevents write access to P7-12 and P7-13 1: Enable - permits write access to P7-12 and P7-13 This parameter will reset to a value of 0 (Disable) after a power cycle. **NOTE**: setting this parameter to 'Disable' does not disable the locked rotor detection feature.					
7-12	**712**	**Locked Rotor Speed Threshold**	**20**	**0**	**P1-01**	**rps**	**R/W**
		If the speed correlating to the drive output frequency remains below this threshold for the time configured in P7-13, the drive will trip on either the locked rotor trip or an over current trip. Setting this value to zero will disable the function. P7-11 must be set to 1 to allow the editing of this parameter.					
7-13	**713**	**Locked Rotor Time**	**10**	**10**	**600**	**s**	**R/W**
		If the speed correlating to the drive output frequency remains below the value set in P7-12 for the time configured in this parameter, the drive will trip on either the locked rotor trip or an over current trip. P7-11 must be set to 1 to allow the editing of this parameter.					

The following guidance will help you configure the locked rotor parameters and to avoid false trips, but to ensure that the feature has been configured correctly, it is advisable to test under known locked rotor conditions in accordance with the relevant standards such as IEC 60335-2-34 to ensure that detection and protection is achieved.

It is recommended that the locked Rotor Speed Threshold (P7-12) is set at about 80% to 90% of the minimum speed. For example, if the minimum speed for our compressor/application is set to 20.0rps in P1-02, then a setting of 16.0 to 18.0rps would be a good value to use in P7-12.

In order to avoid nuisance false trips, it is recommended to ensure that the Locked Rotor Time (P7-13) is set such that the compressor would have plenty of time to accelerate above the speed threshold using the selected ramp rates.

If the start profile in menu 2 is used in order to run up to a fixed speed for a fixed time, then the ramp rate set in P2-03 should be considered, otherwise the ramp rate set in P1-03 should be considered and a margin of at least 5 to 10s should be added. Note that ramp rates in the Coolvert are set in seconds per rated speed.

Example:

The drive has a minimum speed set of 20.0rps (P1-02), the start profile is used with a ramp rate of 20s (P2-03) and a rated speed of 60.0rps (P1-10), the following settings would be suggested as a starting point for testing:

Locked Rotor Speed Threshold = 80% of P1-02, = 20.0 x 80/100 = 16.0rps

The time taken to ramp up to 16.0rps under normal conditions is calculated as follows:

20s per 60.0rps = 3rps/s (= 60/20).

16.0rps/3rps/s = 5.3333s

Adding a margin of about 10s would return a Locked Rotor Time setting of 15s.

In this example, we would set P7-11 = 1 (Enable), P7-12 = 16.0rps and P7-13 = 15s.

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
I.t-trP.	Motor overload
RotorL	Motor rotor is locked

5.2. Crankcase Heating Function

The Crankcase heating function when activated, delivers current into the compressor without creating rotation in order to raise or maintain the temperature inside the compressor. The level of current is determined by the setting P2-14 as a percentage of the compressor rated current (P1-08). The crankcase heating can only be activated if it is enabled in P2-16 and the time set in the heating delay in P2-15 has elapsed after the drive has stopped. Please also note that the STO must be active (enabled) for this function to operate.

The actual activation of the crankcase heating depends on the settings of P2-15 and P2-16 and the configuration of the Primary Command Source set in P1-11:

See the following table of activation methods based on the setting of P1-11

P1-11	Crankcase Heating Enable	Crankcase Heating Activation Source 1	Crankcase Heating Activation Source 2	Crankcase Heating Delay
0 – Modbus Control	P2-16 = 1	Modbus Register 1, Bit 5	N/A	P2-15
1 – Terminal Control	P2-16 = 1	STO active	Modbus Register 1, Bit 5	P2-15
2 – Terminal Control AI Start	P2-16 = 1	DI1 active	Modbus Register 1, Bit 5	P2-15
3 – PI Control	P2-16 = 1	STO active	Modbus Register 1, Bit 5	P2-15
4 – Slave Control	P2-16 = 1	DI1 active	Modbus Register 1, Bit 5	P2-15

CAUTION Delivering too much current into the compressor could cause excessive heating of the compressor and potentially damage the compressor. It is the responsibility of the person or company that commission the drive to ensure that these settings are appropriate and safe for the system connected to.

Par.	Modbus Address	Description	Def	Min	Max	Unit	R/W
2-14	**214**	**Crankcase Heating Current**	**0**	**0**	**50**	**%**	**R/W**
		When this function is activated, it will inject this percentage of the compressor rated current into the compressor in pulses when the drive is not running in order to heat-up the crankcase. The STO must be active to permit this function to operate. **CAUTION** Too high a setting of this current activated for too long could cause damage to the compressor.					
2-15	**215**	**Crankcase Heating Delay**	**0**	**0**	**6000**	**s**	**R/W**
		When the crankcase heating function is activated, this parameter set's a delay in seconds from the moment the drive stops running before it starts to deliver the heating current into the compressor. This allows the compressor temperature to decrease before starting to warm it up again.					
2-16	**216**	**Crankcase Heating Enable**	**0**	**0**	**1**	**-**	**R/W**
		This parameter is the permissive enable for the crankcase heating, if the function is not enabled in this parameter then it cannot be enabled by the designated source. **0: Disable** **1: Enable** The STO must be active to permit this function to operate.					
1-11	**111**	**Primary Command Source**	**0**	**0**	**4**	**-**	**R/W**
		Command Source **0: Modbus Mode** **1: Terminal Control** **2: Terminal Control (AI1 Start)** – start command is given when AI1 > 10%, speed reference is then scaled as 10% = min speed 100% = max speed. **3: User PID Mode** **4: Slave Mode**					

5.3. 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.

NOTE Configuring and enabling the oil return feature within the Coolvert will mean that under certain conditions, (i.e. when the oil return feature is implementing a temporary increased minimum speed to force the return of the oil back into the compressor), the drive can override the speed signal demanded by the controller. This could have negative implications to the system and it is the responsibility of the party that consciously enables this feature to ensure that all possible outcomes have been considered and accounted for.

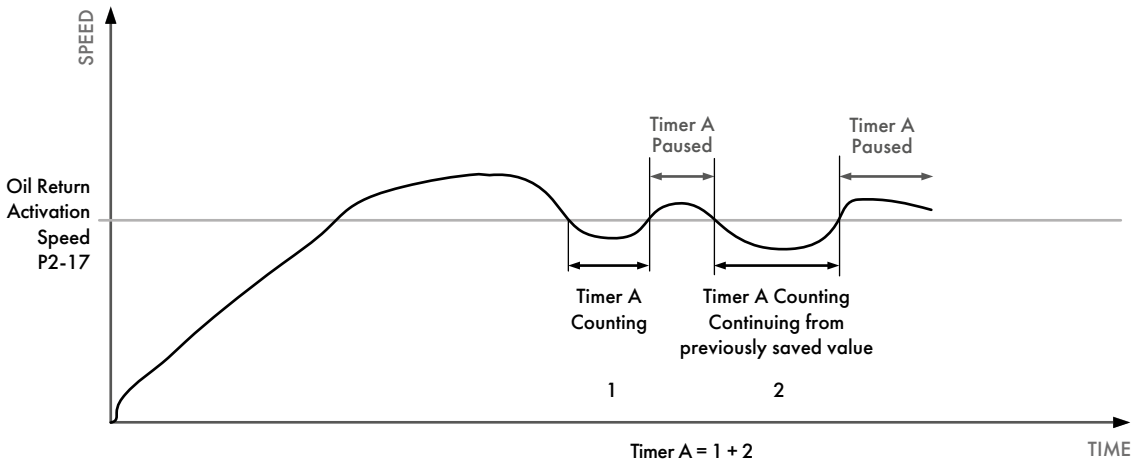
5.3.1. Oil Return Feature Within the Drive

This feature is configured by the following four parameters:

Par.	Description	Units	DP	Default
P2-17	'Oil Return Activation Speed' operation of the compressor at or below this speed will cause the Oil Return Activation Timer to increase.	rps	1dp	20
P2-18	'Oil Return Activation Time' if the compressor runs at the 'Oil Return Activation' Speed for the time set in this parameter the drive will run at or above the 'Oil Return Min Speed' set in P2-20. The time 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.	s	0dp	0
P2-19	'Oil Return Min 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'.	rps	1dp	20
P2-20	'Oil Return Duration' is the time that the compressor will apply the 'Oil Return Min Speed' once activated.	s	0dp	0

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

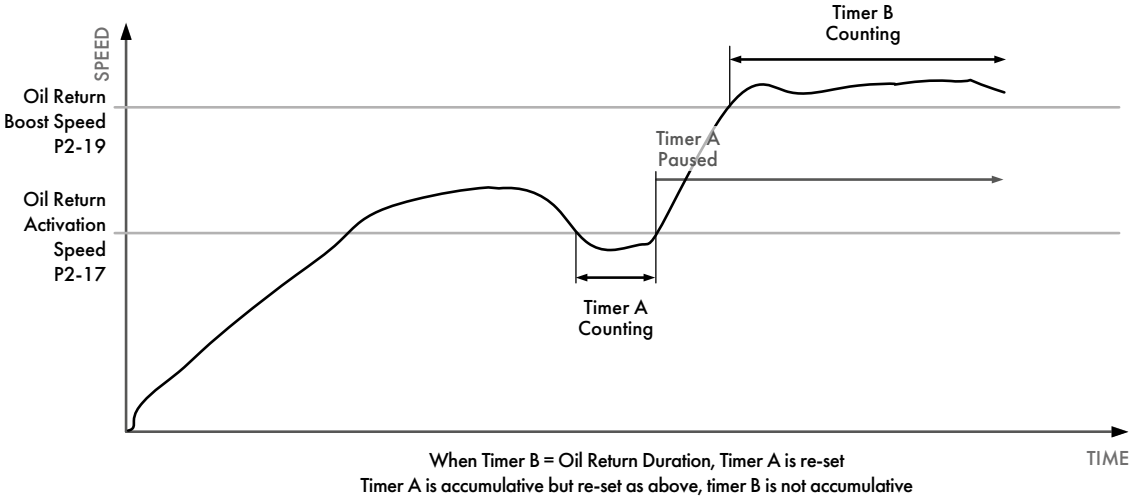
Timers to operate as shown below:



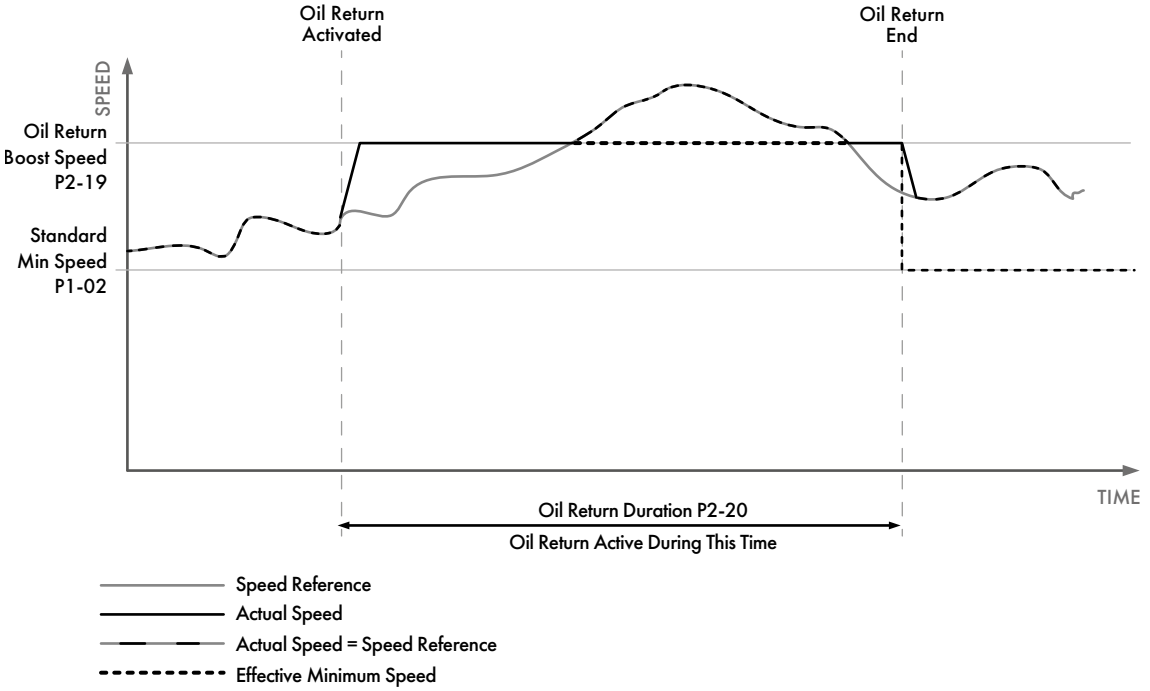
The above illustrates that the timer will count when the speed is below the activation speed and the value in the timer will be held and used the next time that the speed falls below the activation speed – this is a cumulative timer.

The Oil return minimum speed will then be implemented as a minimum speed clamp when timer A has reached the value set 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 Time 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 – green constant on

LED 2 – yellow constant on

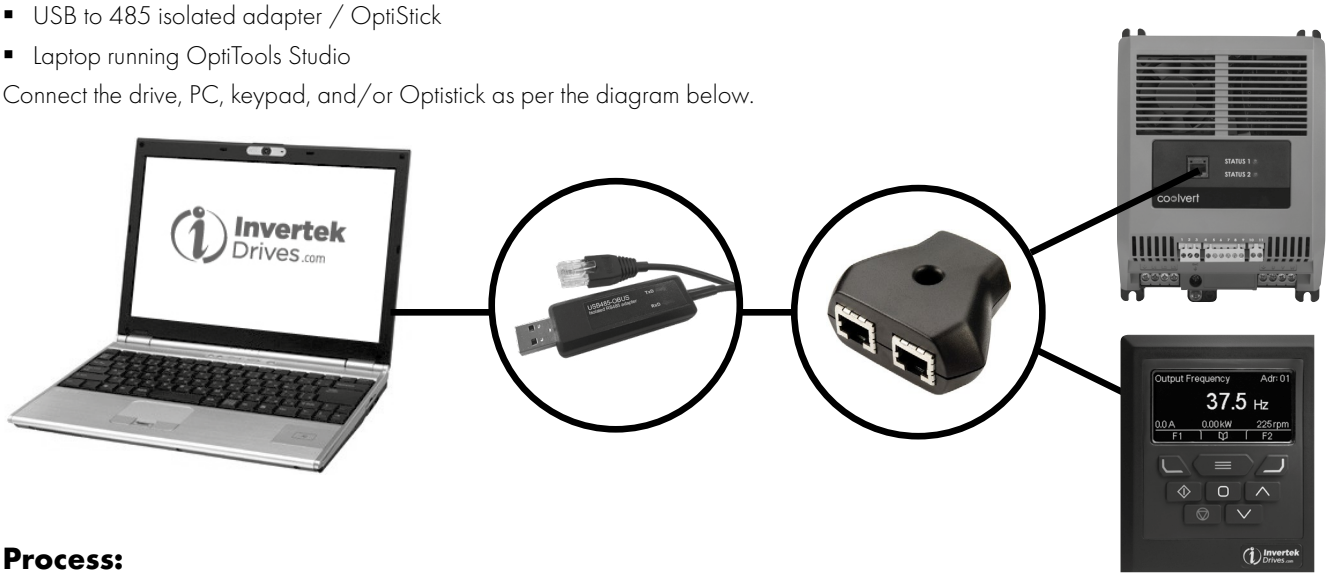
5.4 Drive Optimisation

5.4.1. Procedure for optimising the Coolvert drive

Tools required:

- OptiPad TFT remote keypad
- RJ45 (parallel) splitter
- RJ45 patch leads
- USB to 485 isolated adapter / OptiStick
- Laptop running OptiTools Studio

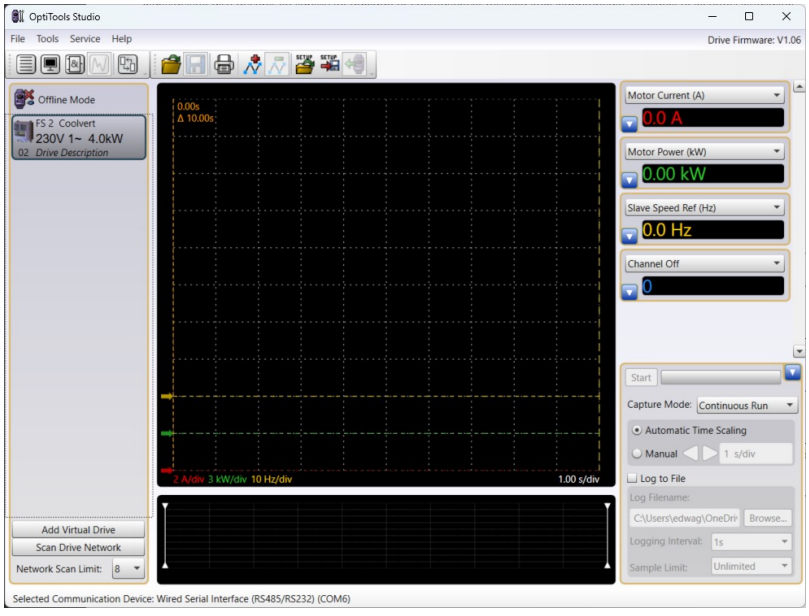
Connect the drive, PC, keypad, and/or Optistick as per the diagram below.



Process:

Once the drive, PC, and keypad are connected, open OptiTools on the PC and set the scope function to monitor the following variables.

1. Motor Current (A)
2. Motor Power (kW)
3. Slave Speed Ref (Hz)



Press Start in OptiTools Studio to start the scope trace.

Start the compressor.

Once the system is in a stable state and running around mid-speed and load, on the TFT remote keypad, access parameter P7-05 (Motor Stator Inductance (Lsq), reduce the value by 0.4mH (or 10%, whichever is smallest value) and confirm the change. You should see a reduction in current in the OptiTools Studio scope trace.

Repeat this in increments of 0.4mH (or 10%, whichever is smallest value) until there is no drop in current on the scope trace. Increase the value in P7-05 by 1 step to prove that you are at the lowest value in P7-05 without the current being further reduced.

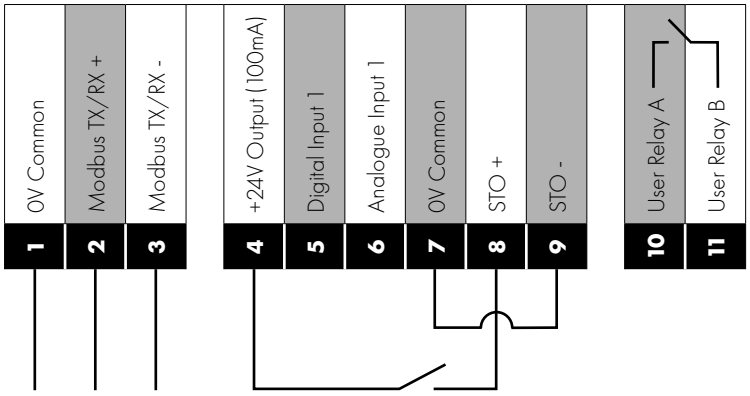
It is important that the value of P7-05 is not reduced too far as this could lead to the motor being under fluxed.

5.5. Modbus Connections

5.5.1. Minimum Control Wiring Required For Each Control Mode

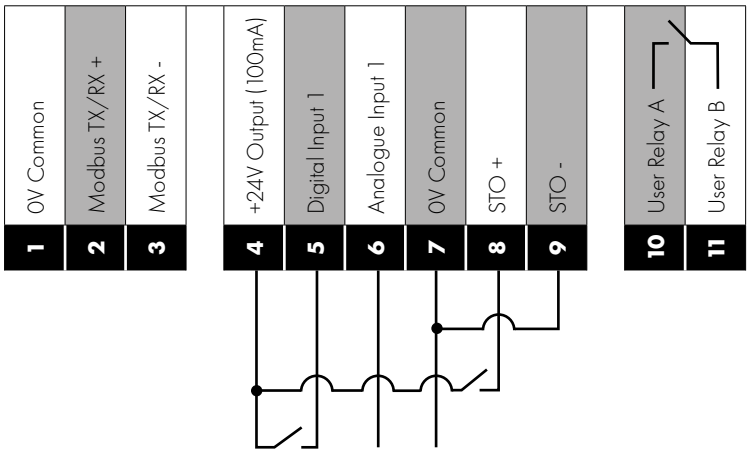
See parameter 1-11 in section *5.1.6. Control Mode on page 37.*

P1-11 = 0 - Modbus control



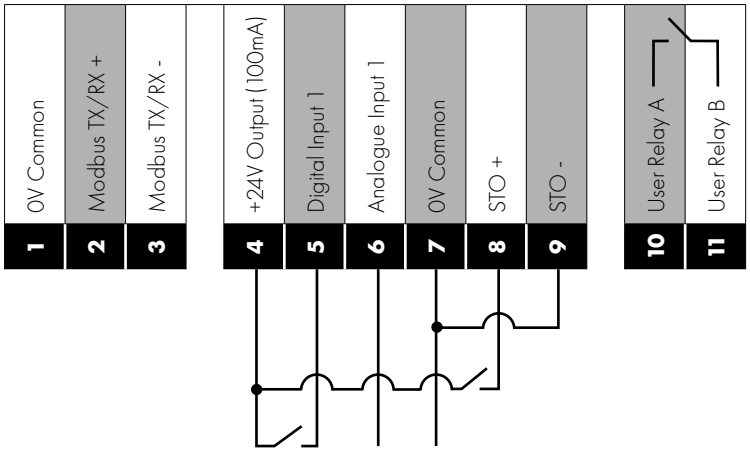
STO signal must be provided in order to permit running the compressor. Start/Stop commands and speed reference are provided by serial communication. In Modbus mode, the digital input and analogue input can be used as remote I/O by the controller, the relay output can also be configured to be controlled 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



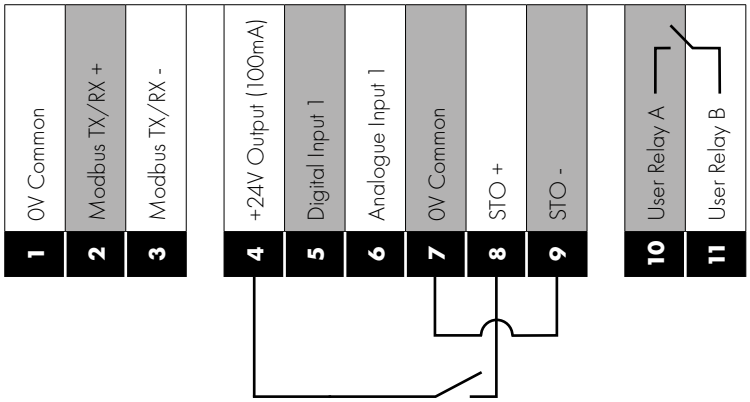
STO signal must be provided in order to permit running the compressor. Start/Stop command provided by the Digital Input (P1-11 = 1) or when the analogue input level is greater than 1% (if P1-11 =2) and speed reference provided by the Analogue input. The drive can be re-set from a fault by removing and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

P1-11 = 3 Internal PI mode



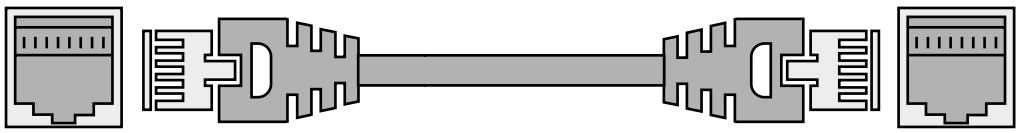
STO signal must be provided in order to permit running the compressor. Start/Stop command provided by the Digital Input. The speed reference is provided by the output of the PI controller and the PI feedback is provided by the analogue input. The drive can be re-set from a fault by removing and re-applying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

P1-11 = 4 Slave mode



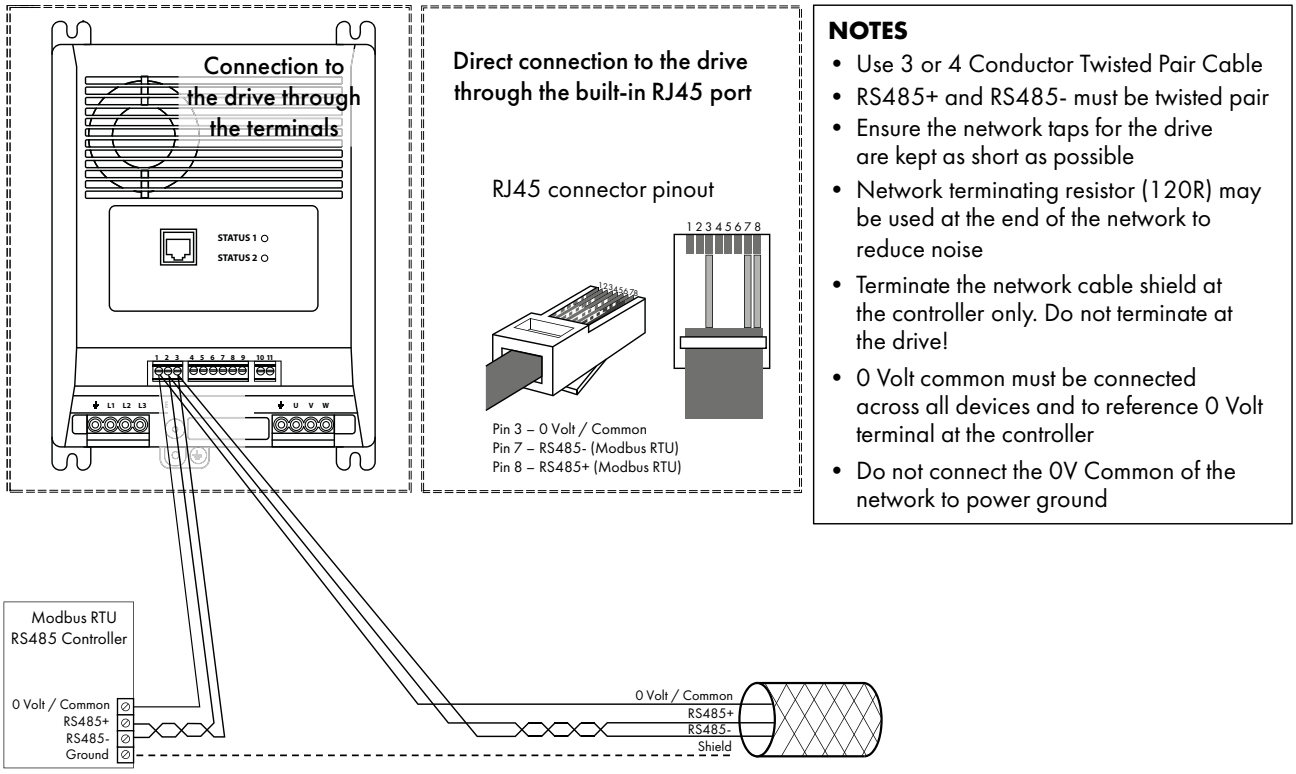
STO signal must be provided in order to permit running the compressor. Run enable is provided by the Digital Input with the Start/Stop command coming from the master drive. Speed reference also comes from the master drive. The slave drive must be connected to the master drive by a straight through (no crossover) RJ45 patch lead. The drive can be re-set from a fault by removing and re-applying the digital input.

Master RJ45 **Slave RJ45**



5.5.2. RS-485 Communications Electrical Connections

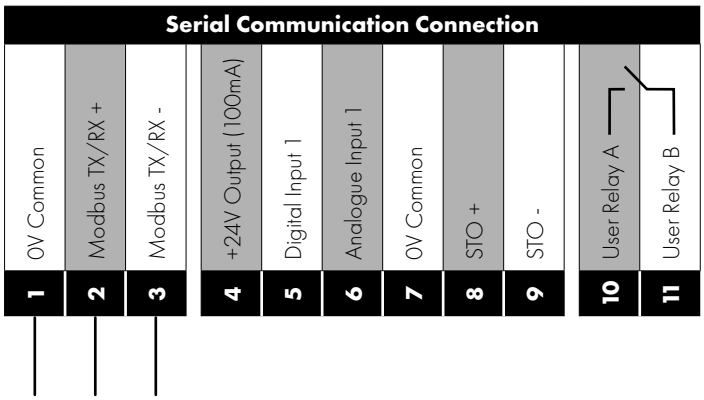
The Optidrive Coolvert has two separate points where you can access the Modbus RTU communications. The Modbus RTU connection can be made via the RJ45 connector or control terminals 1, 2 & 3. As shown below:

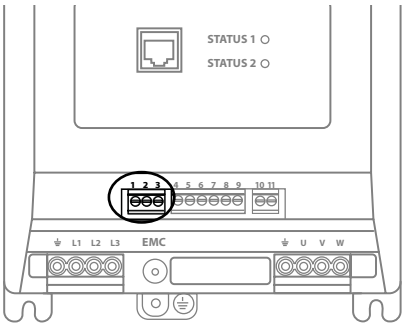


NOTES

- 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

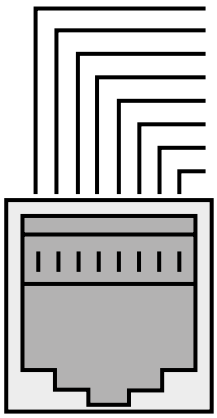
5.5.3. RS-485 Communications Electrical Connections via Control Terminals





5.5.4. RS-485 Communications Electrical Connections via RJ45 Port

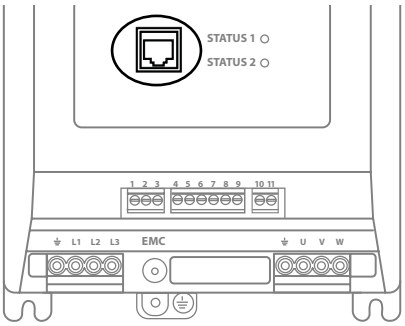
This port is intended for use with the Optistick Smart for parameter cloning or for connection to the mobile App or to PC Tools or for Master Follower configuration of drives.



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)

5.5.5. Modbus Telegram Structure

The Optidrive Coolvert 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 *5.5. Modbus Connections on page 44* and section *5.7. Full Parameter List and Modbus Registers on page 51* by subtracting 1 to obtain the correct Register address.

5.5.6. 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 ▪ Drive running at or above zero speed.
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	Compressor Thermal Management Active (Ixt)	0 : Compressor Thermal Management Inactive 1 : Compressor 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	Crankcase Heating Active	0 : Crankcase Heating Not Active 1 : Crankcase Heating Active
14	Oil Return Active	0 : Oil Return System Inactive 1 : Oil return System Active
15	Reserved	

The drive status word 2 consists of one individual byte:

Single Byte showing the last fault code when the drive has tripped.

5.5.7. 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 un-expected 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: Activate Crank Case heating function. See section *5.2. Crankcase Heating Function on page 40* for details.
- Bit 6: Reserved
- Bit 7: Reserved

5.6. Read-only 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 (Requires the P6-06 to be set to Enable to use Modbus ramps)	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 (Compressor 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	Compressor Control Processor Software Version	3	Read Only	100 = 1.00	P00-28
17	Drive Type	3	Read Only		P00-29
20	Analogue 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	Compressor Speed (IDL Format)	3	Read Only	3000 = 50Hz	
43	Compressor 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	Analogue 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 compressor voltage	V rms	No decimal place, 1 = 1V	43
P0-13	Trip log	Last 4 trips with time stamp	Four entries each with the trip code and the time stamp	30 31
P0-14	Magnetising current (Id)	A (rms)	Magnetising Current is shown with 1 decimal place and is only applicable to IM and BLDC machines	-
P0-15	Torque producing current (Iq)	A (rms)	Torque producing Current is shown with 1 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	-
P0-19	Crankcase Heating Current	A	Displays the actual current injected into the compressor during the crankcase heating operation	-
P0-20	DC bus voltage	V dc	No decimal place. 100 = 100V	23
P0-21	Heatsink temperature	Degrees C	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	Accumulated time the drives heat sink is above 85°C	-
P0-24	Time accumulated above 80°C (ambient)	Display in hours and minutes	Accumulated time the ambient temperature in which the drive is installed is above 80°C	-
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. 100 = 10.0kWh	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. 100 = 100MWh	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

Par	Description	Display Range	Note	Comms Register
P0-32	Run time since last trip (1)	Display in hours and minutes since last trip	Time since the last time the drive tripped	-
P0-33	Run time since last trip (2)	Display in hours and minutes since previous trip	Time since the second to last trip	-
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	The run time of the fan displayed 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	Compressor 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	Total Output Current	-
P0-59	Output Power	kW	Total Output Power	-
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	Actual Switching Frequency	-
P0-65	Motor Control Version Checksum	1	Compressor control lib version	-
P0-66	Class B Library Checksum	-	Version number / Uniques Identifier	1012/1013
P0-67	Input Phase L1 Loss Counter	Phase Loss Counter	Once the drive has tripped on a class B lockout there will be a delay of 2 minutes before it can be reset or the power should be removed and reapplied. If the drive trips on any one of the class B trips between power cycles 10 times then it will trip with a class B lock out trip.	1014
P0-68	Input Phase L2 loss Counter	Phase Loss Counter		1015
P0-69	Input Phase L3 Loss Counter	Phase Loss Counter		1016
P0-70	I x t Fault Counter	IxTCounter		1017
P0-71	Locked Rotor Trip Counter	Locked Rotor Counter		1018
P0-72	L1 Voltage Measurement	0 - 1000		-
P0-73	L2 Voltage Measurement	0 - 1000		-
P0-74	L3 Voltage Measurement	0 - 1000		-

5.7. Full Parameter List and Modbus Registers

5.7.1. Group 1 Parameters & Modbus Registers

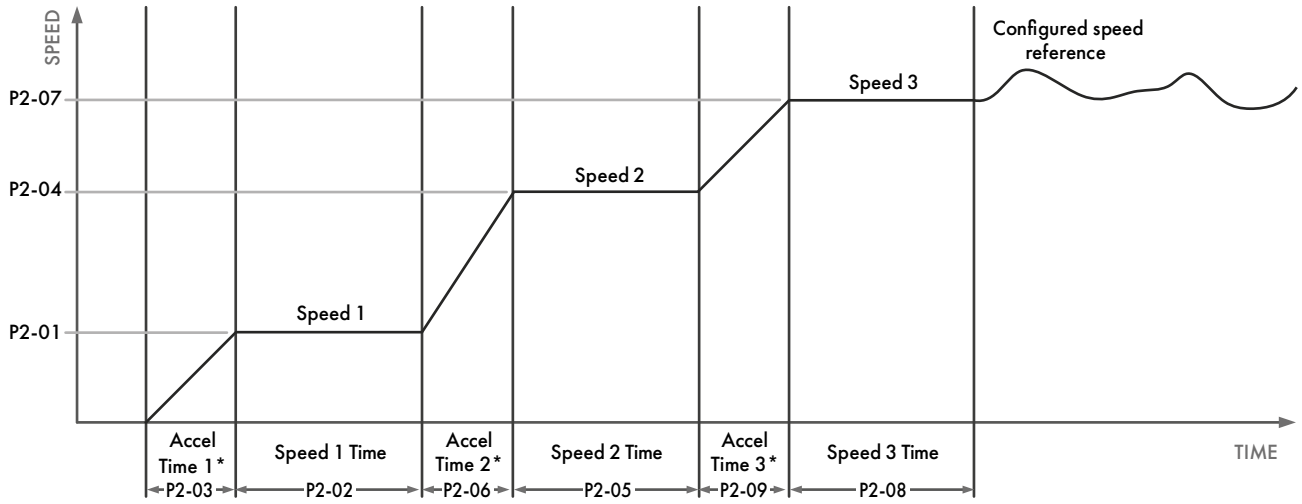
Par	Mod Add	Description	Def	Min	Max	Unit	R/W
1-01	101	**Maximum Speed Limit**	60	P1-02	500	rps	R/W
		Sets the upper limit for the speed of the compressor in rps (revolutions per second). This can be set to any value between the minimum speed limit (P1-02) and 5x the compressor rated speed (as set in P1-10).					
1-02	102	**Minimum Speed Limit**	20	0	P1-01	rps	R/W
		Sets the lower limit for the speed of the compressor 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 (P1-10) – time set is the time from 0 rps to rated speed**	5.0	0	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 (P1-10) to 0 rps – time from rated speed to 0 rps**	5.0	0	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 compressor will coast (freewheel) to stop. **2: AC Flux Braking (IM Compressor 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 compressor will coast (freewheel) to stop.					
1-06	106	**V/F Torque Boost**	2.5	0.1	20	%	R/W
		Torque Boost is used to increase the applied compressor voltage and hence compressor current at low output frequencies. This can improve starting torque and torque at low speeds. Increasing the boost level will increase compressor current at low speed, which may result in the compressor temperature rising - forced ventilation of the compressor may then be required. In general, the lower the compressor power, the higher the boost setting that may be safely used. This parameter is only operational in V/F mode with P5-01 = 4. For PM or BLDC motors see P7-07 & P7-08.					
1-07	107	**Compressor Rated Voltage (Phase to Phase)**	-	-	-	V	R/W
		Compressor Rated Voltage (phase-to phase rms) Or Back EMF at Rated Speed for permanent magnet motor types (phase to phase rms).					
1-08	108	**Compressor Rated Current**	-	-	-	A	R/W
		By setting the compressor rated current in the drive, the compressor overload protection is configured to match the compressor rating.					
1-09	109	**Compressor Rated Frequency**	180	20	500	Hz	R/W
		The rated frequency of the compressor. This is the frequency at which rated voltage (set in P1-07) is applied to the compressor. Below this frequency, the applied compressor voltage will be reduced.					
1-10	110	**Compressor Rated Speed at Rated Frequency In Rps (Revolutions per Second)**	60	0	500	rps	R/W
1-11	111	**Primary Command Source**	0	0	4	-	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).** In this mode the drive is enabled by the digital input and the speed reference provided by the anlaogue input. The start command is given when the analogue input exceeds 10%. The compressor will stop using the selected stop mode when the analogue input drops below 5%. **3: User PI Mode.** The drive is enabled by the digital input and the speed is controlled by the internal PI controller. **4: Slave Mode.** The drive is enabled by the digital input but the start/stop and speed reference is controlled by the connected Coolvert drive operating in Master mode.					

5.7.2. Group 2 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
2-01	**201**	**Start Speed 1 (rps)**	**30**	**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**	**0**	**0**	**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**	**5.0**	**0**	**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)**	**30**	**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**	**5.0**	**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)**	**30**	**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**	**5.0**	**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**	**0**	**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 also applies if the drive trips on a drive fault.					
2-11	**211**	**Minimum On Time**	**0**	**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**	**0**	**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.					

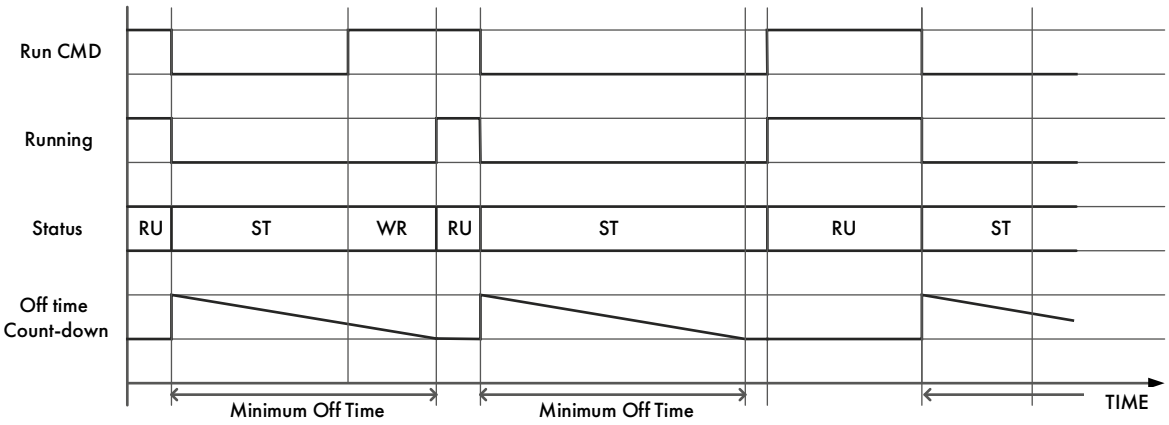
Par	Mod Add	Description	Def	Min	Max	Unit	R/W
2-13	**213**	**Drive Re-Start Function**	**0**	**0**	**11**	**-**	**R/W**
		Defines the behaviour of the drive relating to the enable digital input and also configures the Automatic Restart function. **Edge-r:** Following Power on or reset, the drive will 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 P7-02 (default 20 seconds). The drive will count the number of reset attempts and if the maximum number is reached as defined by this parameter then the drive will trip on the original fault. If the drive trips in this condition then it must be powered down or reset manually to reset the counter. The following faults cannot be reset by the auto reset function. Error code 10 'P-dEF' Error code 17 'dAtA-F' Error code 19 'dAtA-E' Error code 29 'Sto-F'					
2-14	**214**	**Crankcase Heating Current**	**0**	**0**	**50%**	**%**	**R/W**
		When this function is activated, it will inject this percentage of the compressor rated current into the compressor in pulses when the drive is not running in order to heat-up the crankcase. The STO must be active to permit this function to operate. See section *5.2. Crankcase Heating Function on page 40* for details. **CAUTION** Too high a setting of this current activated for too long could cause damage to the compressor.					
2-15	**215**	**Crankcase Heating Delay**	**0**	**0**	**6000**	**s**	**R/W**
		When the crankcase heating function is activated, this parameter set's a delay in seconds from the moment the drive stops running before it starts to deliver the heating current into the compressor. This allows the compressor temperature to decrease before starting to warm it up again.					
2-16	**216**	**Crankcase Heating Enable**	**0**	**0**	**1**	**-**	**R/W**
		This parameter is the permissive enable for the crankcase heating, if the function is not enabled in this parameter then it cannot be enabled by the designated source. **0: Disable** **1: Enable** The STO must be active to permit this function to operate. See section *5.2. Crankcase Heating Function on page 40* for further information on this feature.					

Start-Up Speed Profile



NOTE *This is a ramp rate in seconds per rated speed

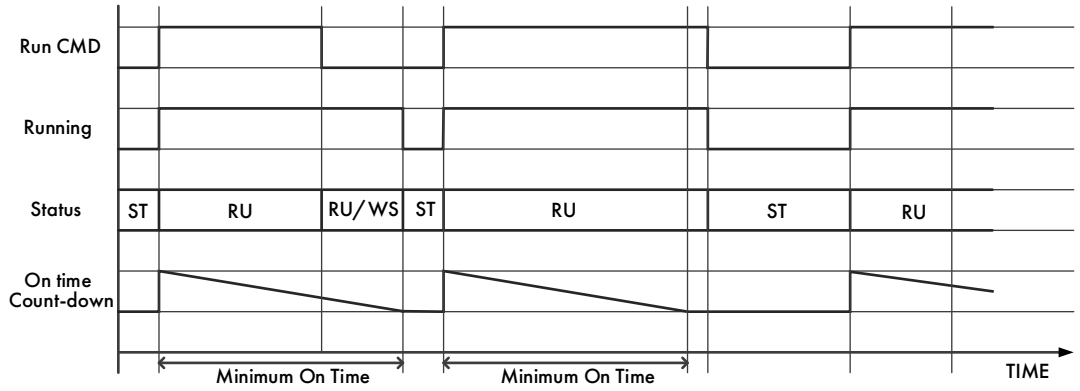
Minimum Off Time Sequencing



KEY:

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

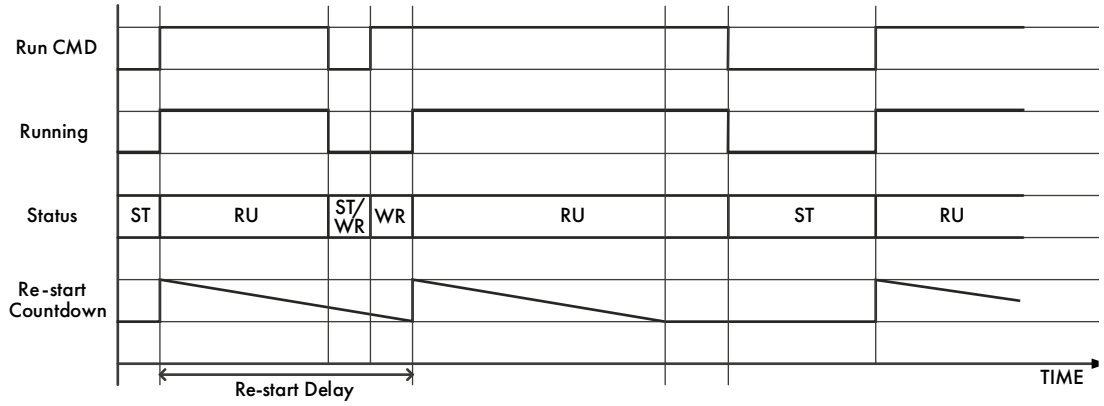
Minimum On Time Sequencing



KEY:

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

Re-Start Delay



KEY:

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

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
2-17	**217**	**Oil Return Activation Speed**	**50**	**P1-02**	**P1-01**	**rps**	**R/W**
		If the drive is running below the speed set in this parameter for a time equal to or longer than that set in P2-18 then the oil return feature will be activated.					
2-18	**218**	**Oil Return Activation Time**	**1800**	**0**	**6000**	**s**	**R/W**
		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 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.					
2-19	**219**	**Oil Return Boost Speed**	**70**	**P1-02**	**P1-01**	**rps**	**R/W**
		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'.					
2-20	**220**	**Oil Return Time**	**60**	**0**	**600**	**s**	**R/W**
		The time that the compressor will apply the 'Oil Return Min Speed' once activated.					
2-21	**221**	**Stop Ramp**	**60**	**0**	**300**	**s**	**R/W**
		The stop ramp is used when the drive run command is removed i.e. commanded to stop.					

The stop ramp P2-21 is the setting used to ramp the drive to zero speed when the run command is removed or the stop command is initiated. The ramp is disabled if the setting is zero and will be used when set greater than zero.

If the drive is commanded to change speed during normal running the standard ramps P1-03 & P1-04 are used.

All ramps times are set in seconds per rated speed.

5.7.3. 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**	**10% * P1-10**	**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**	**10% * P1-10**	**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: Compressor speed > P3-07 (off when < P3-06)** **8: Compressor 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.					

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
3-08	308	**Slave Speed Scaling Control (Set in the Master)**	0	0	1	-	R/W
		0: No Scaling **1: Slave Speed = Master Speed x P3-09**					
3-09	309	**Slave Speed Scaling Factor (Set in the Master)**	100	-500	+500	%	R/W
		Slave speed scaling factor used in conjunction with P3-08.					
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 (Compressor Thermistor Trip)**					
3-11	311	**Signal Loss Run Speed**	30	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 4 or 5, 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**					

5.7.4. 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 compressor speed. **1: Inverse Operation.** Use this mode if an increase in the feedback signal should result in an increase in the compressor 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.					

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
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**	**6000**	**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).					

5.7.5. Group 5 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
5-01	**501**	**Compressor Control Mode**	**0**	**0**	**6**	**-**	**R/W**
		0: BLDC vector speed control **1: Permanent Magnet Vector Speed Control** **2: Induction Compressor Vector Speed Control (CT)** **3: Induction Compressor Vector Speed Control (VT)** **4: Induction Compressor V/F** **5: Synchronous Reluctance Vector Speed Control** **6: LSPM speed control**					
5-02	**502**	**Compressor Parameter Autotune**	**0**	**0**	**1**	**-**	**R/W**
		When set to 1, the drive immediately carries out a non-rotating autotune to measure the compressor parameters for optimum control and efficiency. Following completion of the autotune, the parameter automatically returns to 0.					
5-03	**503**	**Vector Speed Controller Proportional Gain**	**50**	**0.1**	**400**	**%**	**R/W**
		Sets the proportional gain value for the speed controller when operating in Vector Speed compressor control mode (P5-01 <> 4).					
5-04	**504**	**Vector Speed Controller Integral Time Constant**	**0.050**	**0.001**	**2.00**	**s**	**R/W**
		Sets the integral time for the speed controller in Vector Speed control mode (P5-01 <> 4).					
5-05	**505**	**Compressor Power Factor (Cos Ø)**	**-**	**0.5**	**0.99**	**-**	**R/W**
		When operating with induction compressors in Vector Speed or Vector Torque compressor control modes, this parameter must be set to the compressor nameplate power factor before autotuning.					
5-06	**506**	**Effective Power Stage Switching Frequency**					
		Single Phase Drive	**8**	**4**	**32**	**kHz**	**R/W**
		Three Phase Drive	**10**	**10**	**20**	**kHz**	**R/W**
		Higher frequency reduces the audible 'ringing' noise from the compressor, and improves the output current waveform, at the expense of increased heat losses within the drive.					
5-07	**507**	**Maximum Current Limit**	**110**	**20**	**130**	**%**	**R/W**
		This parameter defines the maximum current limit used by the drive as a percentage of compressor rated current (P1-07).					

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
5-08	**508**	**Compressor Power Limit**	**130**	**25**	**130**	**%**	**R/W**
		This parameter sets the power limit of the drive in percentage of drive rating. If this power limit is reached, the drive will fold back the output frequency to keep within the configured limit. The power limit is based on the drives kVA rating to allow for overload. To calculate the power limit for a 24 Amp 400 Volt drive use the following calculation: 24 x 400 x 1.73 = 16.6kVA If we require a 7kW power limit from the drive then the setting of P5-08 = 7 / 16.6 x 100 = 42% To calculate the power limit for a 20 Amp 200 Volt drive use the following calculation: 20 x 200 x 1.73 = 6.9kVA If we require a 4kW power limit from the drive then the setting of P5-08 = 4 / 6.9 x 100 = 57%					
5-09	**509**	**Compressor Thermal Overload Management**	**0**	**0**	**1**	**-**	**R/W**
		When Compressor Overload Management is enabled, full overload current will be available until the overload integrator 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 compressor 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**	**Compressor Thermal Overload Retention Enable**	**1**	**0**	**1**	**-**	**R/W**
		When enabled, the compressor thermal memory retention function will save the calculated compressor thermal history on drive power down, using this saved value as the starting value on next power up. If this function is disabled, the compressor thermal history is reset to zero on every power up.					
5-12	**512**	**Discontinuous Modulation Mode Select**	**0**	**0**	**2**	**-**	**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 compressor. **2: Variable Modulation Depth.** When this option is selected the variable modulation depth can be adjusted in parameter P7-14.					
5-13	**513**	**Enable Reverse Speed Selection**	**0**	**0**	**1**	**-**	**R/W**
		If this parameter is set to 1 (Enabled), it will allow a negative 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.					
5-14	**514**	**Spin-start Enable**	**0**	**0**	**2**	**-**	**R/W**
		When Enabled, the drive will attempt to determine if the compressor is already rotating on start up, and to detect rotational speed and direction. The drive will begin control of the compressor from its present (detected) speed. A short delay may be observed when starting the drive whilst the spin start function is completed. **0 : Disabled** **1 : Enabled** **2 : Enabled following Trip, Brown Out or Coast Stop**					
5-15	**515**	**BLDC Low Load Optimisation**	**1**	**0**	**1**	**-**	**R/W**
		When P5-01 = 0 (BLDC Compressor Control) and P5-16 = 1 (Enabled) the drive will reduce the output voltage during light load operation in order to improve compressor efficiency. This setting has no effect if the compressor 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.					

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
5-17	517	**Stator Resistance Check on Run**	0	0	2	-	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**					
5-18	518	**Maximum Peak Current Output**	Drive dependant			A	R/W
		This parameter sets the Peak Compressor Current level at which the drive will trip on overcurrent (OI). The parameter can be used to minimise the risk of demagnetising the compressor by setting this value at or below the demagnetising peak current stated on the compressor datasheet. Note that setting this value too low can result in nuisance overcurrent trips.					
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 compressor rated current (P1-08) 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 compressor rated current (P1-08) is reached. Setting the value to 0s will disable the function.					

5.7.6. Group 6 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
6-01	601	**Fieldbus Drive Address**	1	1	63	-	R/W
		Sets the drive network address when using a Fieldbus or Master Slave function					
6-02	602	**Modbus RTU Baud Rate**	115	9.6	115	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**	0	0	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**	5	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.					
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.					

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
6-08	608	**Modbus Address**	0	0	200	-	R/W
		When this parameter is set to a value greater than 0 then it will set the Modbus address and P6-01 will be the Optibus address. If P6-08 is set to 0 then P6-01 is the Modbus and Optibus address					

5.7.7. Group 7 Parameters & Modbus Registers

Par	Mod Add	Description	Def	Min	Max	Unit	R/W
7-01	701	**Automatic Thermal Management Minimum Switching Frequency**	0	0	5	-	R/W
		During operation, the drive measures the power module temperature and will switch automatically to a lower switching frequency if the temperature reaches a pre-defined limit. This parameter determines the lowest switching frequency that can be used. In the event that the power module temperature continues to increase, the drive will trip on over temperature.					
7-02	702	**Auto-reset Time Delay**	20	10	200	s	R/W
		Sets the delay time which will elapse between consecutive drive reset attempts when Auto Reset is enabled in P2-13.					
7-03	703	**Compressor Stator Resistance (Rs)**	-	0.00	-	ohm	R/W
		This is the compressor phase to phase resistance value in ohms.					
7-04	704	**Compressor Stator Inductance (Lsd)**	-	0.0	-	mH	R/W
		For induction compressors: phase stator inductance value. For permanent magnet motors: phase d-axis stator inductance in Henry (H).					
7-05	705	**Compressor Stator Inductance (Lsq)**	-	0.0	-	mH	R/W
		For permanent magnet compressors : phase d-axis stator inductance in Henry (H).					
7-06	706	**V/F Mode Magnetising Delay / PM motor alignment 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**	0.0	0.0	100	%	R/W
		Boost current applied at start-up, as % of compressor rated current (P1-08). The drive provides a boost function that can inject some current into the compressor at low speed to help ensure the rotor alignment is maintained and to allow effective operation of the compressor 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. This parameter is only operational in BLDC or PM mode with P5-01 = 0 or 1.					
7-08	708	**Low Frequency Torque Boost, Frequency Limit**	0.0	0.0	50	%	R/W
		Frequency range for applied boost current (P7-07) as a % of compressor rated frequency (P1-09). This sets the frequency cut-off point above which boost current is no longer applied to the compressor. This parameter is only operational in BLDC or PM mode with P5-01 = 0 or 1.					
7-11	711	**Edit Locked Rotor**	0	0	1	-	R/W
		This parameter enables the editing of the Locked Rotor Parameters.					
7-12	712	**Locked Rotor Speed**	0	0	P1-01	rps	R/W
		This parameter sets the speed threshold below which the drive will trip during a Locked Rotor Condition.					
7-13	713	**Locked Rotor Time**	10	10	600	s	R/W
		This parameter sets the time for which the compressor must run below the Locked Rotor Speed threshold to detect a Locked Rotor condition.					
7-14	714	**Variable Modulation Depth**	50	30	80	%	R/W
		When 2-Phase Modulation Variable is selected (P5-12 = 2), the modulation index at which the drive switches over to 2-phase modulation is determined by this variable. There is a 10% hysteresis to switch on and off the 2-phase modulation. This setting is useful when running a 200V compressor from a 400 V drive / supply.					

6. Diagnostics

6.1. Trips

Class A trip codes standard drive trips

Trip Code	Error Code	Error Description	Trip classification		
3	O-I	Over Current trip	A	Instantaneous over current on drive output	High current from either – short-circuit on the drive output / acceleration ramps too short / incorrect compressor data. **NOTE** Setting the maximum peak compressor current too low in P5-18 could also lead to this trip.
5	PS-trP	Power stage trip	A	Hardware fault	Hardware fault, contact the supplier of the drive
6	O-Volt	Over Voltage	A	DC Bus Overvoltage, either the supply is too high or spike in the supply voltage	DC Bus Overvoltage from either – the supply voltage is too high, a spike in the supply voltage, compressor instability, try setting P1-05 = 3.
7	U-Volt	Under Voltage	A	DC Bus Undervoltage caused due to supply voltage dropping too low	This occurs routinely when power is switched off. If it occurs during running, check the incoming supply voltage, and all connections into the drive, fuses, contactors etc.
10	P-DEF	Load default parameters	A		Warning to advise that the drive has been returned to factory defaults.
11	E-Trip	External trip	A	The STO circuit has opened while the drive is running	Check the integrity of all connections and devices in the STO circuit.
12	SC-OBS	Optibus serial comms fault	A	Optibus comms loss	Loss of communications between drive and remote keypad or PC tools.
13	Flt-DC	Excessive DC bus ripple	A	Excessive DC Ripple	Check for supply phase imbalance or phase.
14	P-Loss	Input phase loss	A	Input phase loss trip	See fault code 13 this fault could be caused by the same conditions or the drive is being powered down.
15	h-O-I	Hardware over current	A	Instantaneous over current	Hardware over current on drive output – similar to O-I trip
17	DATA-F	I/O Processor data error	A	Internal memory fault (IO)	If not coinciding with a firmware upgrade procedure, contact the supplier of the drive.
18	4-20F	4-20mA Signal out of range	A	4-20mA Signal Lost	Analogue input configured for 4-20mA but less than 3mA detected on drive terminals.
19	DATA-E	Motor Control Processor data error	A	Internal memory fault (DSP)	If not coinciding with a firmware upgrade procedure, contact the supplier of the drive.
20	U-DEF	User Parameters default	A		User Default Parameters Loaded.
21	F-PTC	Motor PTC overheat	A		Drive configured to monitor motor temperature through the PTC and resistance increases above 2.5kΩ.
22	FAN-F	Drive Cooling Fan fault	A	This fault is generated from the stirrer fan on the front of the drive not the heatsink fan	Drive cooling fan not running at demanded speed – check for any blockages in the cooling fan.
23	O-hEAt	Ambient Temperature too high	A	Environmental temperature too high	Check ambient temperature and ventilation system.
26	Out-F	Drive output fault	A		Drive output fault, Confirm all 3 motor phases are connected, check for wiring faults, loose connections, or badly terminated compressor cables.
29	STO-F	Fault in STO Circuit	A	Slow rising edge on 24V supply / Safety input circuit error	This fault can be generated 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.

Trip Code	Error Code	Error Description	Trip classification		
40	AtF-01	Stator Resistance unbalance	A	The drive has failed to measure the compressor stator resistance during an Auto Tune	Measured motor stator resistance varies between phases. Ensure the motor is correctly connected and free from faults. Check the windings for correct resistance and balance.
41	AtF-02	Stator Resistance too large	A	The measured stator resistance from the Auto Tune is too large	Measured motor stator resistance is too large. Ensure the motor is correctly connected and free from faults. Check that the power rating corresponds to the power rating of the connected drive.
42	AtF-03	Motor Inductance too low	A		Measured motor inductance is too low. Ensure the motor is correctly connected and free from faults.
43	AtF-04	Motor Inductance too large	A		Measured motor inductance is too large. Ensure motor is correctly connected and free from faults. Check that the power rating corresponds to the power rating of the connected drive.
44	AtF-05	Parameters not convergent	A		Measured motor parameters are not convergent. Ensure the motor is correctly connected and free from faults. Check that the power rating corresponds to the power rating of the connected drive.
49	Out-Ph	Motor output phase loss	A		Check motor wiring.
50	SC_F01	Modbus comms fault	A	Modbus comms loss fault	Check the Modbus wiring, ensure that the 0V common is used, ensure that communication wiring is kept away from any power wiring.
81	OI-U	Phase U over current	A	Over Current in U phase	High current from either – short-circuit on the drive output / acceleration ramps too short / incorrect motor data.
82	OI-V	Phase V over current	A	Over Current in V phase	
83	OI-W	Phase W over current	A	Over Current in W phase	
88	Out-U	Phase U output fault	A	U Phase PWM output Loss	U, V or W phase is not connected to the drive or is loose. Check connections and integrity of compressor power cable.
89	Out-V	Phase V output fault	A	V Phase PWM output Loss	
90	Out-W	Phase W output fault	A	W Phase PWM output Loss	
97	SC Loss	IO- PS comms loss	A	Communication lost between IO processor and PS (DSP) processor	If the fault persists contact the supplier of the drive.
98	DATA-03	Wrong VDo3 checksum	A	Internal memory fault	Communication lost between IO processor and PS (DSP) processor.
101	STO-R	STO opened at drive running	A	STO Input opens while drive is running	Check the integrity of all connections and devices in the STO circuit. If pressure switches are connected to the STO circuit check system pressure for spikes.
102	ML-Run	Mains loss at running	A	3 Phase input loss whilst running	Is the drive being turned off? Check 3 phase power supply.
103	FW-Err	PS firmware is changed	A	PS software changed outside a firmware upgrade	PS software not programmed through OptiTools.
253	HW-ID	Hardware ID not supported	A		Incorrect Hardware identification.
254	Type-E	Drive ID not supported	A		Incorrect drive identification.

NOTE A classification 'B' trip is part of the drives safety system. These trips are detected by the class 'B' firmware in the drive which is part of the 60730 certification, these include input and output phase losses, locked rotor, and overload protection. Class B trips cannot be re-set for a period of two minutes after they are initiated.

When 10 trips of any one kind occur between power cycles a class B lockout trip will be generated, once a class 'B' lockout trip has been generated the drive MUST be power cycled to clear the fault.

A classification 'A' trip is a standard drive trip which can be reset manually or automatically in some cases, the following trips cannot be reset by the auto reset function - error code 10 'P-def', error code 17 'Data-F', error code 19 'Data-E', error code 29 'STO-F'.

UL60730-1 Class B trip codes

Trip Code	Error Code	Error Description	Trip classification		
4	I.t-trP	Motor Thermal Overload (I2t)	B	Drive has tripped on overload after delivering >100% of value in P1-08 for a period of time	Check motor cable length is within the limit specified for the relevant drive (maximum permitted compressor cable length for all models: 10 metres shielded, 20 metres unshielded). Ensure the motor nameplate parameters are correctly entered in P1-07, P1-08, P1-09, P1-10, P7-03, P7-04 & P7-05. Ensure an autotune has been successfully completed for the connected compressor. Check the load mechanically to ensure it is free, and that no jams, blockages.
8	O-T	Over Temperature trip	B	Heatsink temperature exceed maximum limit. The limit is set based on the switching frequency. 200 V single phase drives 4kHz 91°C 8kHz 89°C 12kHz 88°C 16kHz 87°C 24kHz 85°C 32kHz 84°C 400 V three phase drives 10kHz 96°C 12kHz 96°C 14kHz 93°C 16kHz 90°C 18kHz 87°C 20kHz 84°C	The heatsink temperature can be displayed in P0-21. A historical log of the last 8 values is stored at 30 second intervals prior to a trip in parameter P0-38. Check the drive ambient temperature. Ensure the drive internal cooling fan is operating. Ensure there is the required space around the drive as shown in section *4.1.9. Ventilation and Clearance on page 19*, and that the cooling airflow path to and from the drive is not restricted. Reduce the effective switching frequency setting in parameter P5-06. Reduce the load on the compressor / drive.
9	U-T	Under Temperature trip	B	Heatsink Under temperature	Trip occurs when ambient temperature is less than -20°C. The temperature must be raised over -20°C in order to start the drive.
16	Th-Flt	Thermistor Fault	B	Faulty thermistor on heatsink	If the drive heatsink temperature is within limits, contact the supplier of the drive. See P0-21.
85	Outph-U	Output Phase U missing	B	Output phase U not connected/detected	Check the compressor connections making sure they are secure and connected.
86	Outph-V	Output Phase V missing	B	Output phase V not connected/detected	
87	Outph-W	Output Phase W missing	B	Output phase W not connected/detected	
92	Ph-L1	L1 input phase loss	B	Input phase L1 not connected/detected	Check the mains connections making sure they are secure and connected.
93	Ph-L2	L2 input phase loss	B	Input phase L2 not connected/detected	
94	Ph-L3	L3 input phase loss	B	Input phase L3 not connected/detected	
104	Rotor-L	Locked rotor has been detected	B	Locked Rotor (stall)	Rotor speed less than threshold speed (P7-12) for more than stall time (P7-13).
105	CLB-LK	Class B software lockout	B	UL60730-1 Class B Lockout	If there are 10 trips of any one of the class B trips then the drive will trip on a Class B lockout, which can only be reset by power cycling the drive.

6.2 Overload Trips

If the drive trips on O-I or H O-I over current trips there will be a delay before the drive can be reset.

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

This is to prevent damage that may occur through enabling the drive into a fault condition.

6.3. 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
Crankcase Heating Active	Slow Flashing	Off	Constant On
Standby	Constant On	Off	Blink every 3s
Trip / Fault	Off	Constant On	Off
Internal Comms Loss	Off	Blink every 3s	Off
Optistick Transfer Pass	Fast Flashing 2s	Off	Off
Optistick Transfer Fail	Off	Fast Flashing 5s	Off
Optistick Fail Other	Off	Off	Fast Flashing 5s
Oil Return Active	Constant On	Off	Constant on
DSP Firmware Upgrade	All three LEDs lights up in order (Green->Yellow->Red->Yellow...)		
IO Firmware Upgrade	All LEDs on with weak light		

7. Technical Data

7.1. General

Input Ratings	
Supply Voltage	200 - 240V +/- 10% Single Phase Supplies
	380 - 480V ± 10%
Maximum Isc	100kA
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 - 40kW
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 Compressor 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 no derating.
	Up to 2000m ASL derate 1% per 100m above 1000m
Humidity	95% Maximum, non-condensing
Vibration	Conforms to EN61800-5-1

Environmental	
Ingress Protection (IP)	UL Open Type
	Rear (Through Panel Mounting) UL Type 4X
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 Keypad with TFT display for diagnostic and programming

Control Specification	
Output Voltage	0 - Vin
PWM Frequency	4-32kHz (200V)
	10-20kHz (400V)
Stop Mode	Ramp to stop, Ramp to minimum speed then coast to stop, Coast to stop
Skip Frequency	2 skip frequencies, user adjustable
Control Modes	Modbus RTU (RS485)
	Terminal Control Digital / Analogue
	Terminal Control PI mode
	Master / Slave 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)	
EN 61800-5-2:2017	SIL 3
EN ISO 13849-1:2023	PL "e"
EN 61508 (Part 1 to 7): 2010	SIL 3
EN 60204-1: 2006 & A1: 2009	Cat 0
EN IEC 62061:2021	SIL 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 Compressor Thermal Management	Reduced-load operation of the compressor can be configured under continued compressor 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.
Master Follower Configuration	The ability to run a cascade of compressors with one Master regulating the operating point in PI Control.
Slow Acting Current Limit	Intelligent load management to slowly ramp down the speed of the compressor to prevent excessive current.
Compressor Demagnetisation Protection	Configurable peak current trip level to protect against demagnetisation of the compressor
Crankcase heating	Built-in feature to inject current into the compressor to raise or maintain the temperature inside the compressor.
Stop Ramp	The stop ramp P2-21 is the setting used to ramp the drive to zero speed when the run command is removed or the stop command is initiated.
Oil Return	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. The drives Oil return system is designed to mitigate oil migration.

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 Coolvert 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. Safety requirements. Electrical, thermal and energy.
EN 61800-3: 2004 & A1 2012	Adjustable speed electrical power drive systems. EMC requirements and specific test methods.
EN60529: 1992 & A2: 2013	Specifications for degrees of protection provided by enclosures.
UL61800-5-1 2022 Second Edition	UL listed for Heatsink version UL recognised for Coldplate version Size 2, 3, & 4 only
UL EN 63000:2018	Tech documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.

Drive variants with a heatsink are UL listed whereas the coldplate variants are UL recognised.

7.2. Detailed Product Rating Tables

Part Number	Power Rating		Input Current	MCB (Type B) or Fuse				Max Input Cable Size		Continuous Output Current	Overload Output Current	Maximum Output Cable Size		Maximum Motor Cable Length Unscreened / Screened	
	kW	HP	A	Non UL	UL 61800-5-1	IEC 60730	UL 60730	mm²	awg	A	A	mm²	awg	m	ft
CV-220070-1FHP	1.5	2	8.9	16A	Class J 20A	N/A	N/A	16	6	7	9.1	6	10	20/10	66/33
CV-220120-1FHP	3	3	15.8	32A	Class J 35A	N/A	N/A	16	6	12	13.2	6	10	20/10	66/33
CV-220160-1FHP	4	5.5	21.3	35A	Class J 40A	N/A	N/A	16	6	16	20.8	6	10	20/10	66/33
CV-220200-1FHP	5.5	7.5	25.6	40A	Class J 50A	N/A	N/A	16	6	20	22	6	10	20/10	66/33
CV-240140-3FHE	5.5	7.5	12	16A	L70QS 20A	N/A	N/A	6	10	14	18.2	6	10	20/10	66/33
CV-240180-3FHE	7.5	10	16	32A	L70QS 30A	N/A	N/A	6	10	18	23.4	6	10	20/10	66/33
CV-240240-3FHE	11	15	22	32A	L70QS 35A	N/A	N/A	6	10	24	28	6	10	20/10	66/33
CV-340300-3FHE	15	20	26.5	32A	Class J 30A	32A	A4J30 Mersen	16	6	30	39.9	16	6	20/10	66/33
CV-340390-3FHE	18.5	25	30.8	50A	Class J 40A	50A	A4J40 Mersen	16	6	39	51.8	16	6	20/10	66/33
CV-440460-3FHE	22	30	37.9	50A	Class J 50A	50A	A4J50 Mersen	35	2	46	61.1	35	2	20/10	66/33
CV-440580-3FHE	30	40	51.9	63A	Class J 70A	63A	A4J70 Mersen	35	2	58	77.1	35	2	20/10	66/33
CV-540650-3FHE	37			80A	AJT80 Mersen		-			65				20/10	66/33
CV-540750-3FHE	40			100A	AJT100 Mersen		-			75				20/10	66/33

NOTE Replace 'H' with 'C' for Coldplate version in above table.

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

NOTE Drive models CV-220070-1FXP, CV-220120-1FXP, CV-220160-1FXP, CV-220200-1FXP, CV-340300-1FXP, CV-340390-1FXP, CV-440460-1FXP, CV-440580-1FXP are suitable for use on a circuit capable of delivering not more than 100kA RMS symmetrical Amperes at max Volts and when protected with Class J fuses with ratings in the above table.

NOTE Drive models CV-240140-3FXE, CV-240180-3FXE, CV-240240-3FXE, are suitable for use on a circuit capable of delivering not more than 100kA RMS symmetrical Amperes at max Volts and when protected with L70QS semi conductor fuse with ratings in the above table.

NOTE For UL 61800-5-1 2022 Second Edition compliance, the fuse in that column alone is required.

NOTE For IEC 60730 compliance, the fuse listed in the Non UL column and the fuse listed in the IEC 60730 column must both be used.

NOTE For UL 60730 compliance, the fuse listed in the 61800-5-1 UL column and the fuse listed in the UL 60730 column must both be used.

NOTE For non 60730 compliance, use either the fuse in the Non UL or the UL61800-5-1 columns.

NOTE Replace 'X' for 'H' or 'C' for Heatsink or Coldplate in the above part numbers.

7.3. Temperature and Switching Frequency De-rating Requirements for Coolvert

7.3.1 230V Single Phase

CV-220070-1FHP / CV-220070-1FCP

Switching Frequency	Maximum continuous output current at ambient temperature						
	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	6.5	3.7

CV-220120-1FHP / CV-220120-1FCP

Switching Frequency	Maximum continuous output current at ambient temperature						
	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

CV-220160-1FHP / CV220160-1FCP

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

CV-220200-1FHP / CV220200-1FCP

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
4 kHz	20	20	20	20	20	20	20
8 kHz	20	20	20	20	20	20	20
12 kHz	20	20	20	20	20	19	16.5
16 kHz	20	20	20	20	20	17	14
24 kHz	20	20	20	18.5	14	13	11.5
32 kHz	20	20	20	15.5	12.5	11	10

7.3.2 400V 3-phase Models

CV-240140-3FHE / CV-240140-3FCE

Switching Frequency	Maximum continuous output current at ambient temperature						
	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

CV-240180-3FHE / CV-240180-3FCE

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
10 kHz	18	18	18	18	18	18	18
12 kHz	18	18	18	18	18	18	16.5
14 kHz	18	18	18	18	18	18	15
16 kHz	18	18	18	18	18	18	13.5
18 kHz	18	18	18	18	18	17	12
20 kHz	18	18	18	18	18	16	10

CV-240240-3FHE / CV-240240-3FCE

Switching Frequency	Maximum continuous output current at ambient temperature						
	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

CV-340300-3FHE / CV-340300-3FCE

The maximum current indicated in the table below is given for a supply voltage of 480Vac. Typical values based on a 400Vac supply are shown in the brackets.

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
10 kHz	30	30	30	30	30	30	30
12 kHz	30	30	30	30	30	30	30
14 kHz	30	30	30	30	30	30	30
16 kHz	30	30	30	30	30	30	26 (30)
18 kHz	30	30	30	30	30	29 (30)	22 (26)
20 kHz	30	30	30	30	30	26 (28)	12 (16)

CV-340390-3FHE / CV-340390-3FCE

The maximum current indicated in the table below is given for a supply voltage of 480Vac. Typical values based on a 400Vac supply are shown in the brackets.

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
10 kHz	39	39	39	39	39	39	36 (38)
12 kHz	39	39	39	39	39	37 (39)	33 (36)
14 kHz	39	39	39	39	38 (39)	35 (38)	31 (35)
16 kHz	39	39	39	39	37 (39)	33 (35)	26 (30)
18 kHz	39	39	39	37 (39)	36 (39)	29 (31)	22 (26)
20 kHz	39	39	39	36 (39)	33 (36)	26 (28)	12 (16)

CV-440460-3FHE / CV-440460-3FCE

The maximum current indicated in the table below is given for a supply voltage of 480Vac. Typical values based on a 400Vac supply are shown in the brackets.

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
10 kHz	46	46	46	46	46	46	46
12 kHz	46	46	46	46	46	46	44 (46)
14 kHz	46	46	46	46	46	46	37 (39)
16 kHz	46	46	46	46	46	44 (46)	24 (27)
18 kHz	46	46	46	46	46	29 (32)	18 (21)
20 kHz	46	46	46	46	46	24 (27)	14 (17)

CV-440580-3FHE / CV-440580-3FCE

The maximum current indicated in the table below is given for a supply voltage of 480Vac. Typical values based on a 400Vac supply are shown in the brackets.

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
10 kHz	58	58	58	58	58	58	48 (50)
12 kHz	58	58	58	58	58	58	44 (47)
14 kHz	58	58	58	58	56 (58)	49 (52)	37 (39)
16 kHz	58	58	58	58	53 (56)	44 (47)	24 (27)
18 kHz	58	58	58	56 (58)	50 (53)	29 (32)	18 (21)
20 kHz	58	58	58	53 (56)	46 (49)	24 (27)	14 (17)

CV-540650-3FHE / CV-540650-3FCE

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
10 kHz							
12 kHz							
14 kHz							
16 kHz							
18 kHz							
20 kHz							

CV-540750-3FHE / CV-540750-3FCE

Switching Frequency	Maximum continuous output current at ambient temperature						
	0	10	20	30	40	50	60
10 kHz							
12 kHz							
14 kHz							
16 kHz							
18 kHz							
20 kHz							

- 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 *4.3. EMC Compliant Installation on page 24* for further information.
- Supply and compressor 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 75°C, UL Class CC or Class J Fuses.

7.4. Input Power Supply Requirements

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

7.5. Additional Information for UL Approved Installations

Optidrive Coolvert is designed to meet the UL requirements. In order to ensure full compliance, the following must be fully observed.

Input Power Supply Requirements				
Short Circuit Capacity	Voltage Rating	Min kW (HP)	Max kW (HP)	Maximum supply short-circuit current
	All	All	All	100kA rms (AC)
	All the drives in the above table are suitable for use on a circuit capable of delivering not more than the above specified maximum short-circuit Amperes symmetrical with the specified maximum supply voltage when installed in a suitable enclosure.			
Incoming power supply connection must be according to section *4.3.2. Incoming Power Connection.*				
All Optidrive Coolvert units are intended for indoor installation within controlled environments which meet the condition limits shown in section *7.1. General.*				
Branch circuit protection must be installed according to the relevant national codes. Fuse ratings and types are shown in section *7.2. Detailed Product Rating Tables.*				
Suitable Power and motor cables should be selected according to the data shown in section *4.3.2. Incoming Power Connection* and section *7.2. Detailed Product Rating Tables.*				
Power cable connections and tightening torques are shown in section *4.1.2. Before Installation* and section *4.3.2. Incoming Power Connection.*				
Optidrive Coolvert provides compressor overload protection in accordance with the National Electrical Code (US). ▪ Where a compressor thermistor is not fitted, or not utilised, Thermal Overload Memory Retention must be enabled by setting P5-11 = 1. ▪ Where a compressor thermistor is fitted and connected to the drive, connection must be carried out according to the information shown in section *4.3.6. Compressor Thermal Overload Protection.*				

For Canadian Installations: transient surge suppression shall be installed on the line side of this equipment and shall be rated as shown below, suitable for over voltage category III and shall provide protection for a rated impulse withstand voltage peak of 2.5kV.

Supply Voltage Rating of the Drive	Phase-Phase Surge Protection Voltage Rating	Phase-Ground Surge Protection Voltage rating
200-240V AC +/- 10%	230V AC	230V AC
380-480V AC +/- 10%	480V AC	480V AC

8. Useful Conversions and Formula

Table showing the electrical frequency of the power applied to the compressor and the rotational speed of the compressor in both rpm (revolutions per minute) and rps (revolutions per second) for motors with different number of electrical poles:

2 Poles		
Hz	**rpm**	**rps**
5	300	5
10	600	10
15	900	15
20	1200	20
25	1500	25
30	1800	30
35	2100	35
40	2400	40
45	2700	45
50	3000	50
55	3300	55
60	3600	60
65	3900	65
70	4200	70
75	4500	75
80	4800	80
85	5100	85
90	5400	90
95	5700	95
100	6000	100
105	6300	105
110	6600	110
115	6900	115
120	7200	120
125	7500	125
130	7800	130
135	8100	135
140	8400	140

4 Poles		
Hz	**rpm**	**rps**
6	180	3
12	360	6
24	720	12
32	960	16
40	1200	20
50	1500	25
60	1800	30
70	2100	35
80	2400	40
90	2700	45
100	3000	50
110	3300	55
120	3600	60
130	3900	65
140	4200	70
150	4500	75
160	4800	80
170	5100	85
180	5400	90
190	5700	95
200	6000	100
210	6300	105
220	6600	110
230	6900	115
240	7200	120
250	7500	125
260	7800	130
270	8100	135

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
390	7800	130
405	8100	135
420	8400	140

8 Poles		
Hz	**rpm**	**rps**
20	300	5
40	600	10
60	900	15
80	1200	20
100	1500	25
120	1800	30
140	2100	35
160	2400	40
180	2700	45
200	3000	50
220	3300	55
240	3600	60
260	3900	65
280	4200	70
300	4500	75
320	4800	80
340	5100	85
360	5400	90
380	5700	95
400	6000	100
420	6300	105
440	6600	110
460	6900	115
480	7200	120
500	7500	125
520	7800	130
540	8100	135
560	8400	140

9. Energy Efficiency Classification

Please scan the QR code or visit **www.invertekdrives.com/ecodesign** to learn more about the Ecodesign Directive and for specific product efficiency classification and part load loss data in accordance with IEC 61800-9-2:2017.

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