Bardac drives

Advanced User Guide

Optidrive Plus 3^{GV}

IP20 & Enclosed IP55 / Nema 12

AC Variable Speed Drive
0.37 – 160kW (0.5 – 250HP)

Installation and operating instructions

Revision History:

Revision	Date	Description
3.00	1/10/08	First draft release
3.01	30/10/08	PDF Conversion errors resolved
3.02	3/12/08	Revised output current vs switching frequency for FS5 & FS6
3.03	4/2/09	Revised EMC statement in line with new EU Directive Revised Safety Information Page
3.04	1/5/09	Revised Size 5 Dimensions Corrected Firmware Update parameter settings
3.05	1/10/09	Revised in line with Firmware Version 3.10 release

Declaration of Conformity:

Invertek Drives Ltd hereby states that the Optidrive Plus 3GV product range conforms to the relevant safety provisions of the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC and has been designed and manufactured in accordance with the following harmonised European standards:

EN 61800-5-1: 2003	Adjustable speed electrical power drive systems. Safety requirements. Electrical, thermal and energy.
EN 61800-3 2nd Ed: 2004	Adjustable speed electrical power drive systems. EMC requirements and specific test methods
EN 55011: 2007	Limits and Methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment (EMC)
EN60529 : 1992	Specifications for degrees of protection provided by enclosures

Electromagnetic Compatibility

All Optidrives are designed with high standards of EMC compliance in mind. All versions suitable for operation on Single Phase 230 volt and Three Phase 400 volt supplies and intended for use within the European Union are fitted with an internal EMC filter. This EMC filter is designed to reduce the conducted emissions back into the 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 2004/108/EC. When using an Optidrive with an internal or optional external filter, compliance with the following EMC Categories, as defined by EN61800-3:2004 can be achieved:

Drive Type / Rating	**EMC Category**		
	Cat C1	**Cat C2**	**Cat C3**
1 Phase, 230 Volt Input ODP-x2xxx	No additional filtering required Use shielded motor cable		
3 Phase, 400 Volt Input ODP-x4xxx	Use External Filter OD-Fx34x	No additional filtering required	
	Use screened motor cable		
Note	For motor cable lengths greater than 100m, an output dv / dt filter must be used (part number OD-OUTFx, please refer to the Invertek Stock Drives Catalogue for further details)		
	For Frame Size 5 and 6 drives, a ferrite ring must be installed on the output motor cable, with all three phases of the motor cable being wrapped one turn around the ferrite ring.		
	Vector Speed and Torque control modes may not operate correctly with long motor cables and output filters. It is recommended to operate in V/F mode only for cable lengths exceeding 50m		

All Invertek Optidrive Plus 3GV units carry a 2 year warranty against manufacturing defects from the date of manufacture. The manufacturer accepts no liability for any damage caused during or resulting from transport, receipt of delivery, installation or commissioning. The manufacturer also accepts no liability for damage or consequences resulting from inappropriate, negligent or incorrect installation, incorrect adjustment of the operating parameters of the drive, incorrect matching of the drive to the motor, incorrect installation, unacceptable dust, moisture, corrosive substances, excessive vibration or ambient temperatures outside of the design specification.

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.

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 V3.10 Optidrive Plus 3GV Firmware. The firmware version can be displayed in Parameter P0-29.

Advanced User Guide Issue 3.05

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.

Contents:

1. Introduction

1.1. Important safety information

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

WARNING	**Indicates a potentially hazardous situation which, if not avoided, could result in injury or death.**	CAUTION	**Indicates a potentially hazardous situation which, if not avoided, could result in damage to property.**

WARNING	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.
	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.
	The level of integrity offered by the Optidrive control 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.
	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 driven motor can start at power up if the enable input signal is present.
	The STOP function does not remove potentially lethal high voltages. ISOLATE the drive and wait 10 minutes before starting any work on it.
	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.
	Where supply to the drive is through a plug and socket connector, do not disconnect until 10 minutes have elapsed after turning off the supply.
	Ensure correct earthing connections. The earth cable must be sufficient to carry the maximum supply fault current which normally will be limited by the fuses or MCB. Suitably rated fuses or MCB should be fitted in the mains supply to the drive.
	Flammable material should not be placed close to the drive
	Parameter P1-01 can be set to operate the motor at up to 120,000 rpm, hence use this parameter with care.
	If it is desired to operate the drive at any frequency/speed above the rated speed (P1-09/ P1-10) of the motor, consult the manufacturers of the motor and the driven machine about suitability for over-speed operation.
CAUTION	Carefully inspect the Optidrive before installation to ensure it is undamaged
	The Optidrive Plus 3GV has an Ingress Protection rating of IP20 or IP55 depending on the model. IP20 units must be installed in a suitable enclosure.
	Optidrives are intended for indoor use only.
	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.
	The entry of conductive or flammable foreign bodies should be prevented
	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 motor
	Wherever control cabling is close to power cabling, maintain a minimum separation of 100 mm and arrange crossings at 90 degrees Ensure that all terminals are tightened to the appropriate torque setting

2. Specifications

2.1. Input voltage ranges

Depending upon model and power rating, the drives are designed for direct connection to the following supplies:

Model Number	Supply Voltage	Phases	Frequency
ODP-12xxx	200 – 240 Volts + / - 10%	1	50 – 60Hz + / - 5%
ODP-22xxx		1	
ODP3-22xxx		3	
ODP-32xxx		3*	
ODP-42xxx		3*	
ODP-52xxx		3*	
ODP-62xxx		3*	
ODP-24xxx	380 – 480 Volts + / - 10%	3*	
ODP-34xxx		3*	
ODP-44xxx		3*	
ODP-54xxx		3*	
ODP-64xxx		3*	
ODP-25xxx	500 – 600 Volts + / - 10%	3*	
ODP-35xxx		3*	
ODP-45xxx		3*	
ODP-55xxx	480 – 525 Volts + / - 10%	3*	
ODP-65xxx		3*	

* For all power ratings above 2.2kW in 230V and all power ratings in 400V, operation on a single phase supply is possible with a 50% derating of the output current capacity. See section 6.10 for details.

All Optidrive Plus units have phase imbalance monitoring. A phase imbalance of > 3% will result in the drive tripping. For input supplies which have supply imbalance greater than 3% (typically the Indian sub- continent & parts of Asia Pacific including China) Invertek Drives recommends the installation of input line reactors. Alternatively, the drives can be operated as a single phase supply drive with 50% derating.

2.2. Output Power and Current ratings

The following tables provide the output current rating information for the various Optidrive Plus models. Invertek Drives always recommend that selection of the correct Optidrive is based upon the motor full load *current* at the incoming supply voltage.

200-240V ±10% - 1 Phase Input – 3 Phase Output

Model (kW)	kW	Model (HP)	HP	Frame Size	Nominal Input Current	Fuse Or MCB (type B)	Supply Cable Size	Nominal Output Current	150% Output Current 60 secs	Motor Cable Size	Max Motor Cable Length	Min Brake Res Value
					Amps	Amps	mm^2	Amps	Amps	mm^2	m	Ω
ODP-12037	0.37	ODP-12005-USA	0.5	1	6.7	10	1	2.3	3.45	1	25	-
ODP-12075	0.75	ODP-12010-USA	1	1	12.5	16	1.5	4.3	6.45	1	25	-
ODP-12150	1.5	ODP-12020-USA	2	1	19.3	20	4	7	10.5	1.5	25	-
ODP-22150	1.5	ODP-22020-USA	2	2	19.3	20	4	7	10.5	1.5	100	33
ODP-22220	2.2	ODP-22030-USA	3	2	28.8	32	6	10.5	15.75	1.5	100	22
NOTE	For cUL compliance, fuse type Bussmann KTN-R / KTS-R or equivalent must be used kW values stated are typical values for a 230 Volt Supply HP Values stated are typical values for a 230 volt supply											

200-240V ±10% - 3 Phase Input drive set for 1 Phase Operation – 3 Phase Output

Model (kW)	kW	Model (HP)	HP	Frame Size	Nominal Input Current	Fuse Or MCB (type B)	Supply Cable Size	Nominal Output Current	150% Output Current 60 secs	Motor Cable Size	Max Motor Cable Length	Min Brake Res Value
					Amps	Amps	mm^2	Amps	Amps	mm^2	m	Ω
ODP-32030	1.5	ODP-32040-USA	2	3	19.3	20	4	7	11.5	1.5	100	15
ODP-32040	2.2	ODP-32050-USA	3	3	28.8	32	6	9	13.5	1.5	100	15
ODP-32055	3	ODP-32075-USA	4	3	37.5	40	6	12.5 (12)	18.75 (18)	2.5	100	15
ODP-42075	4	ODP-42100-USA	5	4	46.6	50	10	19.5	29.25	2.5	100	6
ODP-42110	5.5	ODP-42150-USA	7.5	4	54.1	63	16	23	34.5	4	100	6
ODP-42150	7.5	ODP-42200-USA	10	4	69.6	80	25	30.5	45.25	10	100	6
ODP-42185	9	ODP-42250-USA	12	4	76.9	80	25	36	54	10	100	6
ODP-52220	11	ODP-52300-USA	15	5	92.3	100	35	45	67.5	16	100	3
ODP-52300	15	ODP-52400-USA	20	5	116.9	125	50	55	82.5	16	100	3
ODP-52370	18.5	ODP-52500-USA	25	5	150.2	160	70	75	112.5	25	100	3
ODP-52450	22	ODP-52600-USA	30	5	176.5	200	90	90	135	25	100	3
ODP-62055	30	ODP-62075-USA	40	6	217.2	250	120	101	151.5	35	100	3
ODP-62075	37	ODP-62100-USA	50	6	255.7	315	120	120	180	55	100	3
ODP-62090	45	ODP-62120-USA	60	6	302.4	315	170	150	225	70	100	3

NOTE
Values shown in brackets are the maximum for UL applications
For cUL compliance, fuse type Bussmann KTN-R / KTS-R or equivalent must be used
kW values stated are typical values for a 230 Volt Supply
HP Values stated are typical values for a 230 volt supply

200-240V ±10% - 3 Phase Input – 3 Phase Output

Model (kW)	kW	Model (HP)	HP	Frame Size	Nominal Input Current	Fuse Or MCB (type B)	Supply Cable Size	Nominal Output Current	150% Output Current 60 secs	Motor Cable Size	Max Motor Cable Length	Min Brake Res Value
					Amps	Amps	mm^2	Amps	Amps	mm^2	m	Ω
ODP3-22150	1.5	ODP3-22020-USA	2	2	9.2	16	2.5	7	10.5	1.5	100	33
ODP3-22220	2.2	ODP-22030-USA	3	2	13.7	20	4	10.5 (9)	15.75 (13.5)	1.5	100	22
ODP-32030	3	ODP-32040-USA	4	3	16.1	20	4	14	21	2.5	100	15
ODP-32040	4	ODP-32050-USA	5	3	17.3	32	6	18	27	2.5	100	15
ODP-32055	5.5	ODP-32075-USA	7.5	3	25	40	6	25 (24)	37.5 (36)	4	100	15
ODP-42075	7.5	ODP-42100-USA	10	4	46.6	50	10	39	57	10	100	6
ODP-42110	11	ODP-42150-USA	15	4	54.1	63	16	46	69	10	100	6
ODP-42150	15	ODP-42200-USA	20	4	69.6	80	25	61	90.5	16	100	6
ODP-42185	18.5	ODP-42250-USA	25	4	76.9	80	25	72	54	16	100	6
ODP-52220	22	ODP-52300-USA	30	5	92.3	100	35	90	67.5	25	100	3
ODP-52300	30	ODP-52400-USA	40	5	116.9	125	50	110	82.5	35	100	3
ODP-52370	37	ODP-52500-USA	50	5	150.2	160	70	150	112.5	55	100	3
ODP-52450	45	ODP-52600-USA	60	5	176.5	200	90	180	135	70	100	3
ODP-62055	55	ODP-62075-USA	75	6	217.2	250	120	202	151.5	90	100	3
ODP-62075	75	ODP-62100-USA	100	6	255.7	315	120	240	180	120	100	3
ODP-62090	90	ODP-62120-USA	120	6	302.4	315	170	300	225	170	100	3

NOTE
Values shown in brackets are the maximum for UL applications
For cUL compliance, fuse type Bussmann KTN-R / KTS-R or equivalent must be used
kW values stated are typical values for a 230 Volt Supply
HP Values stated are typical values for a 230 volt supply

380-480V ±10% - 3 Phase Input drive set for 1 Phase Operation – 3 Phase Output

Model (kW)	kW	Model (HP)	HP	Frame Size	Nominal Input Current	Fuse Or MCB (type B)	Supply Cable Size	Nominal Output Current	150% Output Current 60 secs	Motor Cable Size	Max Motor Cable Length	Min Brake Res Value
					Amps	Amps	mm²	Amps	Amps	mm²	m	Ω
ODP-24075	0.37	ODP-24010-USA	0.5	2	2.9	6	1	1.1	1.6	1	50	47
ODP-24150	0.75	ODP24020-USA	1	2	5.4	6	1	2	3	1	100	47
ODP-24220	1.1	ODP-24030-USA	2	2	7.6	10	1.5	2.9	4.4	1	100	47
ODP-24400	2.2	ODP-24050-USA	3	2	12.4	16	2.5	4.7	7.1	1.5	100	33
ODP-34055	3	ODP34075-USA	4	3	16.1	20	2.5	7	10.5	1.5	100	22
ODP-34075	4	ODP-34100-USA	5	3	17.3	20	4	9	13.5	1.5	100	22
ODP-34110	5.5	ODP-34150-USA	7.5	3	25	25	4	12.5 (12)	18.8 (18)	2.5	100	22
ODP-34150[2]	*7.5*	*ODP-34200-USA[2]*	*10*	*3*	*32.9*	*32*	*6*	*15*	*22.5*	*2.5*	*100*	*22*
ODP-44185	9	ODP44250-USA	12	4	46.6	50	10	19.5	29.2	4	100	12
ODP-44220	11	ODP44300-USA	15	4	54.1	63	16	23	34.5	4	100	12
ODP-44300	15	ODP-44400-USA	20	4	69.6	80	25	30.5	45.8	6	100	12
ODP-44370	18.5	ODP-44500-USA	25	4	76.9	80	25	36	54	10	100	12
ODP-44450[1]	22	ODP-44600-USA[1]	30	4	92.3	100	35	45	*49.5[1]*	10	100	12
ODP-54450	22	ODP-54600-USA	30	5	92.3	100	35	45	67.5	10	100	6
ODP-54550	30	ODP-54750-USA	40	5	116.9	125	50	55	82.5	16	100	6
ODP-54750	37	ODP-54100-USA	50	5	150.2	160	70	75	112.5	16	100	6
ODP-54900	45	ODP-54120-USA	60	5	176.5	200	90	90	135	25	100	6
ODP-64110	55	ODP-64150-USA	75	6	217.2	250	120	101	151.5	35	100	6
ODP-64132	75	ODP-64175-USA	100	6	255.7	315	120	120	180	55	100	6
ODP-64160	90	ODP-64210-USA	120	6	302.4	315	170	150	225	70	100	6

NOTE

Values shown in brackets are the maximum for UL applications
kW values stated are typical values for a 400 Volt Supply
HP Values stated are typical values for a 460 volt supply
For cUL compliance, fuse type Bussmann KTN-R / KTS-R or equivalent must be used

1) *ODP-44450 & ODP-44600-USA have 110% overload capacity only*
2) *15kW / 20HP rated units not UL listed*

380-480V ±10% - 3 Phase Input – 3 Phase Output

Model (kW)	kW	Model (HP)	HP	Frame Size	Nominal Input Current	Fuse Or MCB (type B)	Supply Cable Size	Nominal Output Current	150% Output Current 60 secs	Motor Cable Size	Max Motor Cable Length	Min Brake Res Value
					Amps	Amps	mm²	Amps	Amps	mm²	m	Ω
ODP-24075	0.75	ODP-24010-USA	1	2	2.9	6	1	2.2	3.3	1	50	47
ODP-24150	1.5	ODP24020-USA	2	2	5.4	6	1	4.1	6.2	1	100	47
ODP-24220	2.2	ODP-24030-USA	3	2	7.6	10	1.5	5.8	8.5	1.5	100	47
ODP-24400	4	ODP-24050-USA	5	2	12.4	16	2.5	9.5	14.3	1.5	100	33
ODP-34055	5.5	ODP34075-USA	7.5	3	16.1	20	2.5	14	21	2.5	100	22
ODP-34075	7.5	ODP-34100-USA	10	3	17.3	20	4	18	27	2.5	100	22
ODP-34110	11	ODP-34150-USA	15	3	25	25	4	25 (24)	37.5 (36)	4	100	22
ODP-34150[2]	*15*	*ODP-34200-USA[2]*	*20*	*3*	*32.9*	*50*	*6*	*30*	*45*	*6*	*100*	*22*
ODP-44185	18.5	ODP44250-USA	25	4	46.6	50	10	39	58.5	10	100	12
ODP-44220	22	ODP44300-USA	30	4	54.1	63	16	46	69	10	100	12
ODP-44300	30	ODP-44400-USA	40	4	69.6	80	25	61	91.5	16	100	12
ODP-44370	37	ODP-44500-USA	50	4	76.9	80	25	72	108	16	100	12
ODP-44450[1]	45	ODP-44600-USA[1]	60	4	92.3	100	35	90	*99[1]*	25	100	12
ODP-54450	45	ODP-54600-USA	60	5	92.3	100	35	90	135	25	100	6
ODP-54550	55	ODP-54750-USA	75	5	116.9	125	50	110	165	35	100	6
ODP-54750	75	ODP-54100-USA	100	5	150.2	160	70	150	225	55	100	6
ODP-54900	90	ODP-54120-USA	150	5	176.5	200	90	180	270	70	100	6
ODP-64110	110	ODP-64150-USA	160	6	217.2	250	120	202	303	90	100	6
ODP-64132	132	ODP-64175-USA	200	6	255.7	315	120	240	360	120	100	6
ODP-64160	160	ODP-64210-USA	250	6	302.4	315	170	300	450	170	100	6

NOTE

Values shown in brackets are the maximum for UL applications
kW values stated are typical values for a 400 Volt Supply
HP Values stated are typical values for a 460 volt supply
For cUL compliance, fuse type Bussmann KTN-R / KTS-R or equivalent must be used

1) *ODP-44450 & ODP-45600 have reduced 110% overload capacity*
2) *15kW / 20HP rated units not UL listed*

480-525V ±10% - 3 Phase Input – 3 Phase Output

Model (kW)	kW	Model (HP)	HP	Frame Size	Nominal Input Current	Fuse Or MCB (type B)	Supply Cable Size	Nominal Output Current	150% Output Current 60 secs	Motor Cable Size	Max Motor Cable Length	Min Brake Res Value
					Amps	Amps	mm^2	Amps	Amps	mm^2	m	Ω
ODP-55550	55	N/A	75	5	92.3	100	35	90	135	25	100	6
ODP-55750	75		100	5	116.9	125	50	110	165	35	100	6
ODP-55900	90		120	5	150.2	160	70	150	225	55	100	6
ODP-65132	132		175	6	217.2	250	120	202	303	90	100	6
ODP-65160	160		210	6	255.7	315	120	240	360	120	100	6
ODP-65200	200		250	6	290	315	170	270	405	170	100	6
NOTE	480 – 525 volt rated units are NOT UL listed kW values stated are typical values for a 525 Volt Supply HP Values stated are typical values for a 525 volt supply											

500-600V ±10% - 3 Phase Input – 3 Phase Output

Model (kW)	kW	Model (HP)	HP	Frame Size	Nominal Input Current	Fuse Or MCB (type B)	Supply Cable Size	Nominal Output Current	150% Output Current 60 secs	Motor Cable Size	Max Motor Cable Length	Min Brake Res Value
					Amps	Amps	mm^2	Amps	Amps	mm^2	m	Ω
ODP-25075	0.75	ODP-25010-USA	1	2	2.2	3	1	1.7	2.6	1	50	47
ODP-25150	1.5	ODP-25020-USA	2	2	4.1	6	1	3.1	4.7	1	100	47
ODP-25220	2.2	ODP-25030-USA	3	2	6.1	6	1	4.1	6.2	1	100	47
ODP-25370	3.7	ODP-25050-USA	5	2	7.6	10	1.5	6.1	9.2	1.5	100	47
ODP-25550	5.5	ODP-25075-USA	7.5	2	11.7	16	2.5	9	13.5	2.5	100	47
ODP-35075	7.5	ODP-35100-USA	10	3	16.1	20	2.5	14	21	2.5	100	22
ODP-35110	11	ODP-35150-USA	15	3	17.3	20	4	18	27	2.5	100	22
ODP-35150	15	ODP-35200-USA	20	3	24.1	25	4	24	36	4	100	22
ODP-45220	22	ODP-45300-USA	30	4	46.6	63	10	39	58.5	10	100	12
ODP-45300	30	ODP-45400-USA	40	4	54.1	63	16	46	69	10	100	12
ODP-45450	45	ODP-45600-USA	60	4	69.6	80	25	62	93	16	100	12
NOTE	For cUL compliance, fuse type Bussmann KTN-R / KTS-R or equivalent must be used kW values stated are typical values for a 575 Volt Supply HP Values stated are typical values for a 575 volt supply An external input choke must be fitted for all Frame Size 2 units											

2.3. Maximum supply ratings for UL compliance

Drive rating	Maximum supply voltage	Maximum supply short-circuit current
230V ratings 0.37kW (0.5HP) to 18.5kW (25HP)	240V rms (AC)	5kA rms (AC)
230V ratings 22kW (30HP) to 90kW (120HP)	240V rms (AC)	10kA rms (AC)
400/460V/600V ratings 0.75kW (1.0HP) to 37kW (50HP)	500V/600V rms (AC)	5kA rms (AC)
400/460V/600V ratings 45kW (60HP) to 132kW (175HP)	500V/600V rms (AC)	10kA rms (AC)
400/460V/600V ratings 160kW (210HP)	500V/600V rms (AC)	18kA 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.		

For more details about the drive power rating/size information, please refer to the latest Optidrive brochure.

2.4. Short Circuit Capacity

The Maximum permissible prospective short circuit current at the Optidrive Input Power Terminals as defined in IEC60439-1 is 100kA.

2.5. Earth Leakage Circuit Breakers

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

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

2.6. Self Protection features

The Optidrive Plus can detect and shut down in the event of the following fault conditions arising:

- Output Phase to Phase short circuit
- Output Phase to Earth short circuit
- Output Phase over-current trip
- Output current thermal overload (I^2t)
- Brake resistor short circuit
- Brake resistor thermal overload (I^2t)
- Heatsink thermal over temperature (trip > 97 °C)
- Heatsink thermal under temperature (trip < -10 °C)
- DC Link Over voltage
- DC Link Under voltage
- Input phase loss protection (for 3 phase input unit)
- Input phase imbalance protection (for 3 phase input unit)

2.7. Conformance

All Optidrive Plus units conform to the following international standards:

EN 61800-5-1	Adjustable speed electrical power drive systems
EN 61800-3	EMC product standard for Variable speed drive systems
EN 55011	Limits and Methods of measurement of radio interference characteristics of Industrial Equipment
UL 508C	Power Conversion equipment

Enclosure protection rating according to NEMA 250, EN 60529
Flammability rating according to UL 94

2.8. Environmental

Ambient temperature range	Operational	: -10 … 50 °C
	Storage	: -40 °C … 60 °C
Max altitude for rated operation		: 1000m
Derating above 1000m (to 4000m max)		: 1% / 100m
Relative Humidity		: < 95% (non condensing)
Protection rating		: IP20, NEMA 0

2.9. EMC

Immunity	:	EN 61800-3
Radiated Emissions	:	EN 61800-3
Conducted Emissions	:	EN 61800-3

2.10. Output Current Capacity vs. Switching Frequency

The following table gives the maximum permissible continuous output current from the drive at the available switching frequencies.

200-240V ±10% - 1 Phase, 3 Phase Output								
				Effective Switching Frequency (P2-24)				
Model	kW	Model	HP	32kHz	24kHz	16kHz	8kHz	4kHz
				Amps	Amps	Amps	Amps	Amps
ODP-12037	0.37	ODP-12005-USA	0.5	2.3	2.3	2.3	2.3	2.3
ODP-12075	0.75	ODP-12010-USA	1	4.3	4.3	4.3	4.3	4.3
ODP-12150	1.5	ODP-12020-USA	2	7	7	7	7	7
ODP-22150	1.5	ODP-22020-USA	2	7	7	7	7	7
ODP-22220	2.2	ODP-22030-USA	3	10.5	10.5	10.5	10.5	10.5

200-240V ±10% - 3 Phase Input drive model set for 1 Phase Operation, 3 Phase Output								
				Effective Switching Frequency (P2-24)				
Model	kW	Model	HP	32kHz	24kHz	16kHz	8kHz	4kHz
				Amps	Amps	Amps	Amps	Amps
ODP-32030	1.5	ODP-32040-USA	2	N/A	7	7	7	7
ODP-32040	2.2	ODP-32050-USA	3	N/A	9	9	9	9
ODP-32055	3	ODP-32075-USA	4	N/A	12.5 (12)	12.5 (12)	12.5 (12)	12.5 (12)
ODP-42075	4	ODP-42100-USA	5	N/A	19.5	19.5	19.5	19.5
ODP-42110	5.5	ODP-42150-USA	7.5	N/A	23	23	23	23
ODP-42150	7.5	ODP-42200-USA	10	N/A	30.5	30.5	30.5	30.5
ODP-42185	9	ODP-42250-USA	12	N/A	36	36	36	36
ODP-52220	11	ODP-52300-USA	15	N/A	N/A	45	45	45
ODP-52300	15	ODP-52400-USA	20	N/A	N/A	55	55	55
ODP-52370	18.5	ODP-52500-USA	25	N/A	N/A	75	75	75
ODP-52450	22	ODP-52600-USA	30	N/A	N/A	90	90	90
ODP-62055	30	ODP-62075-USA	40	N/A	N/A	101	101	101
ODP-62075	37	ODP-62100-USA	50	N/A	N/A	120	120	120
ODP-62090	45	ODP-62120-USA	60	N/A	N/A	150	150	150

200-240V ±10% - 3 Phase Input, 3 Phase Output								
				Effective Switching Frequency (P2-24)				
Model	kW	Model	HP	32kHz	24kHz	16kHz	8kHz	4kHz
				Amps	Amps	Amps	Amps	Amps
ODP3-22150	1.5	ODP3-22020-USA	2	7	7	7	7	7
ODP3-22220	2.2	ODP3-22030-USA	3	10.5	10.5	10.5	10.5	10.5
ODP-32030	3	ODP-32040-USA	4	N/A	14	14	14	14
ODP-32040	4	ODP-32050-USA	5	N/A	18	18	18	18
ODP-32055	5.5	ODP-32075-USA	7.5	N/A	25 (24)	25 (24)	25 (24)	25 (24)
ODP-42075	7.5	ODP-42100-USA	10	N/A	39	39	39	39
ODP-42110	11	ODP-42150-USA	15	N/A	46	46	46	46
ODP-42150	15	ODP-42200-USA	20	N/A	61	61	61	61
ODP-42185	18.5	ODP-42250-USA	25	N/A	72	72	72	72
ODP-52220	22	ODP-52300-USA	30	N/A	N/A	90	90	90
ODP-52300	30	ODP-52400-USA	40	N/A	N/A	110	110	110
ODP-52370	37	ODP-52500-USA	50	N/A	N/A	N/A	150	150
ODP-52450	45	ODP-52600-USA	60	N/A	N/A	N/A	N/A	180
ODP-62055	55	ODP-62075-USA	75	N/A	N/A	202	202	202
ODP-62075	75	ODP-62100-USA	100	N/A	N/A	N/A	240	240
ODP-62090	90	ODP-62120-USA	120	N/A	N/A	N/A	N/A	300

380-480V ±10% - 3 Phase Input drive model set for 1 Phase Operation, 3 Phase Output								
				Effective Switching Frequency (P2-24)				
Model	kW	Model	HP	32kHz	24kHz	16kHz	8kHz	4kHz
				Amps	Amps	Amps	Amps	Amps
ODP-24075	0.37	ODP-24010-USA	0.5	1.1	1.1	1.1	1.1	1.1
ODP-24150	0.75	ODP-24020-USA	1	2.1	2.1	2.1	2.1	2.1
ODP-24220	1.1	ODP-24030-USA	2	2.9	2.9	2.9	2.9	2.9
ODP-24400	2.2	ODP-24050-USA	3	4.8	4.8	4.8	4.8	4.8
ODP-34055	3	ODP-34075-USA	4	N/A	7	7	7	7
ODP-34075	4	ODP-34100-USA	5	N/A	9	9	9	9
ODP-34110	5.5	ODP-34150-USA	7.5	N/A	N/A	12.5 (12)	12.5 (12)	12.5 (12)
ODP-34150	7.5	ODP-34200-USA	10	N/A	N/A	15	15	15
ODP-44185	9	ODP-44250-USA	12	N/A	N/A	19.5	19.5	19.5
ODP-44220	11	ODP-44300-USA	15	N/A	N/A	23	23	23
ODP-44300	15	ODP-44400-USA	20	N/A	N/A	30.5	30.5	30.5
ODP-44370	18.5	ODP-44500-USA	25	N/A	N/A	36	36	36
ODP-44450	22	ODP-44600-USA	30	N/A	N/A	45	45	45
ODP-54450	22	ODP-54600-USA	30	N/A	N/A	45	45	45
ODP-54550	30	ODP-54750-USA	40	N/A	N/A	55	55	55
ODP-54750	37	ODP-54100-USA	50	N/A	N/A	N/A	75	75
ODP-54900	45	ODP-54120-USA	60	N/A	N/A	N/A	N/A	90
ODP-64110	55	ODP-64150-USA	75	N/A	N/A	101	101	101
ODP-64132	75	ODP-64175-USA	100	N/A	N/A	N/A	120	120
ODP-64160	90	ODP-64210-USA	120	N/A	N/A	N/A	N/A	150

380-480V ±10% - 3 Phase Input – 3 Phase Output								
				Effective Switching Frequency (P2-24)				
Model	kW	Model	HP	32kHz	24kHz	16kHz	8kHz	4kHz
				Amps	Amps	Amps	Amps	Amps
ODP-24075	0.75	ODP-24010-USA	1	2.2	2.2	2.2	2.2	2.2
ODP-24150	1.5	ODP-24020-USA	2	4.1	4.1	4.1	4.1	4.1
ODP-24220	2.2	ODP-24030-USA	3	5.8	5.8	5.8	5.8	5.8
ODP-24400	4	ODP-24050-USA	5	9.5	9.5	9.5	9.5	9.5
ODP-34055	5.5	ODP-34075-USA	7.5	N/A	14	14	14	14
ODP-34075	7.5	ODP-34100-USA	10	N/A	18	18	18	18
ODP-34110	11	ODP-34150-USA	15	N/A	N/A	25 (24)	25 (24)	25 (24)
ODP-34150	15	ODP-34200-USA	20	N/A	N/A	30	30	30
ODP-44185	18.5	ODP-44250-USA	25	N/A	N/A	39	39	39
ODP-44220	22	ODP-44300-USA	30	N/A	N/A	46	46	46
ODP-44300	30	ODP-44400-USA	40	N/A	N/A	61	61	61
ODP-44370	37	ODP-44500-USA	50	N/A	N/A	72	72	72
ODP-44450	45	ODP-44600-USA	60	N/A	N/A	90	90	90
ODP-54450	45	ODP-54600-USA	60	N/A	N/A	90	90	90
ODP-54550	55	ODP-54750-USA	75	N/A	N/A	110	110	110
ODP-54750	75	ODP-54100-USA	100	N/A	N/A	N/A	150	150
ODP-54900	90	ODP-54120-USA	150	N/A	N/A	N/A	N/A	180
ODP-64110	110	ODP-64150-USA	160	N/A	N/A	202	202	202
ODP-64132	132	ODP-64175-USA	200	N/A	N/A	N/A	240	240
ODP-64160	160	ODP-64210-USA	250	N/A	N/A	N/A	N/A	300

480-525V ±10% - 3 Phase Input – 3 Phase Output								
				Effective Switching Frequency (P2-24)				
Model	kW	Model	HP	32kHz	24kHz	16kHz	8kHz	4kHz
				Amps	Amps	Amps	Amps	Amps
ODP-55550	55	N/A	75	N/A	N/A	90	90	90
ODP-55750	75		100	N/A	N/A	110	110	110
ODP-55900	90		120	N/A	N/A	150	150	150
ODP-65132	132		175	N/A	N/A	202	202	202
ODP-65160	160		210	N/A	N/A	240	240	240
ODP-65200	200		250	N/A	N/A	270	270	270

500-600V ±10% - 3 Phase Input – 3 Phase Output								
			Effective Switching Frequency (P2-24)					
Model	kW	Model	HP	32kHz	24kHz	16kHz	8kHz	4kHz
				Amps	Amps	Amps	Amps	Amps
ODP-25075	0.75	ODP-25010-USA	1	1.7	1.7	1.7	1.7	1.7
ODP-25150	1.5	ODP-25020-USA	2	3.1	3.1	3.1	3.1	3.1
ODP-25220	2.2	ODP-25030-USA	3	4.1	4.1	4.1	4.1	4.1
ODP-25370	3.7	ODP-25050-USA	5	6.1	6.1	6.1	6.1	6.1
ODP-25550	5.5	ODP-25075-USA	7.5	9.0	9.0	9.0	9.0	9.0
ODP-35075	7.5	ODP-35100-USA	10	N/A	N/A	14	14	14
ODP-35110	11	ODP-35150-USA	15	N/A	N/A	18	18	18
ODP-35150	15	ODP-35200-USA	20	N/A	N/A	24	24	24
ODP-45220	22	ODP-45300-USA	30	N/A	N/A	39	39	39
ODP-45300	30	ODP-45400-USA	40	N/A	N/A	46	46	46
ODP-45450	45	ODP-45600-USA	60	N/A	N/A	61	61	61

2.11. Under / Over Voltage Trip Levels

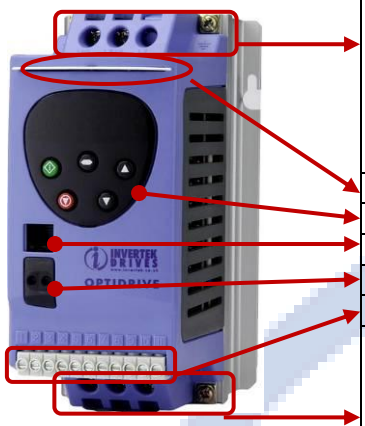
The following levels are not user adjustable, and define the operating voltage levels of the drive and brake chopper circuit.

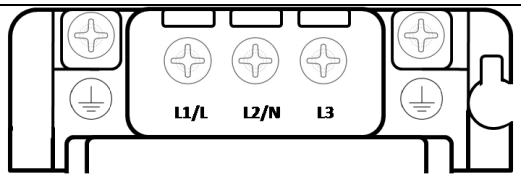
Drive Rated Supply Voltage	DC Bus Voltage Level (Volts DC)				
	Brake Chopper On	Brake Chopper Off	Under Voltage Trip	Minimum Operating	Over Voltage Trip
200 – 240 Volts AC	390	378	160	239	418
380 – 480 Volts AC	780	756	320	478	835
480 – 525 Volts AC	890	862	360	540	930
500 – 600 Volts AC	975	945	400	598	1020

3. Mechanical Installation

3.1. Mechanical dimensions and mounting

3.1.1. Frame Size 1





Incoming Power Terminals

Help Card

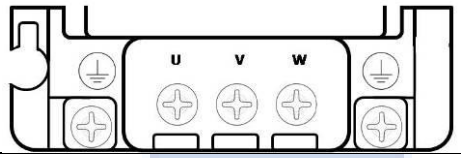
Keypad & Display – See Section 6 on page 26

RJ11 Connector – See Section 10.2 on page 59

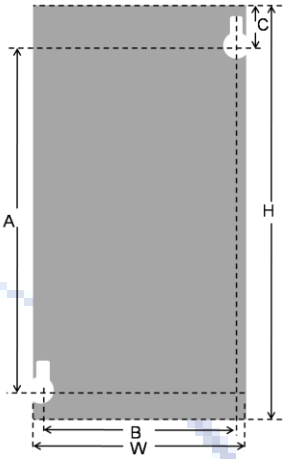
Infra Red Interface – See Section 10.1 on page 59

Control Terminals – See Section 4.8 on page 23

Motor Connection Terminals



Overall Dimensions



Height	155mm
Width	80mm
Depth	130mm
A	105mm
B	72mm
C	25mm

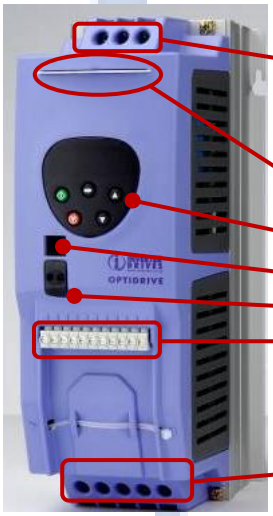
Footprint View

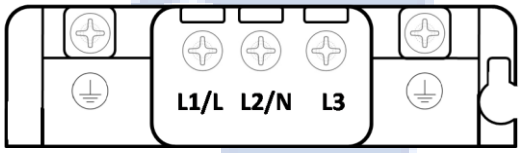
Weight : 1.1Kg

Fixings : 2 x M4 Keyhole slots

Power Terminals Torque Setting : 1Nm

3.1.2. Frame Size 2





Incoming Power Terminals

Help Card

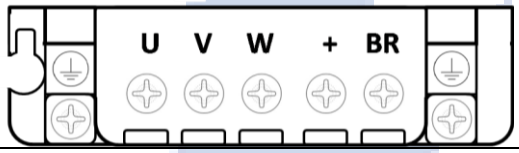
Keypad & Display – See Section 6 on page 26

RJ11 Connector – See Section 10.2 on page 59

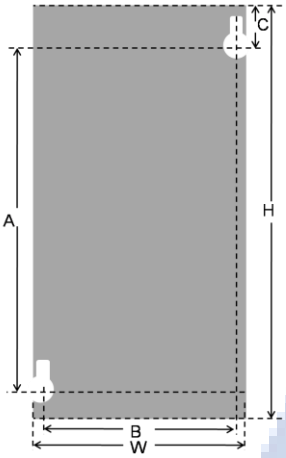
Infra Red Interface - See Section 10.1 on page 59

Control Terminals – See Section 4.8 on page 23

Motor & Brake Resistor Connection Terminals



Overall Dimensions



Height	260mm
Width	100mm
Depth	175mm
A	210mm
B	92mm
C	25mm

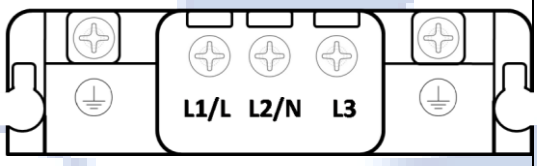
Footprint View

Weight : 2.6Kg

Fixings : 2 x M4 Keyhole slots

Power Terminals Torque Setting : 1Nm

3.1.3. Frame Size 3



Incoming Power Terminals

Help Card

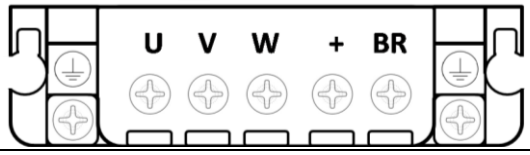
Keypad & Display – See Section 6 on page 26

RJ11 Connector – See Section 10.2 on page 59

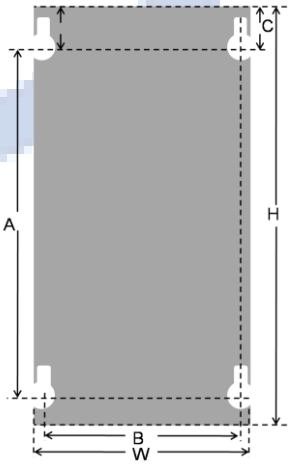
Infra Red Interface - See Section 10.1 on page 59

Control Terminals – See Section 4.8 on page 23

Motor & Brake Resistor Connection Terminals



Overall Dimensions



Height	260mm
Width	171mm
Depth	175mm
A	210mm
B	163mm
C	25mm

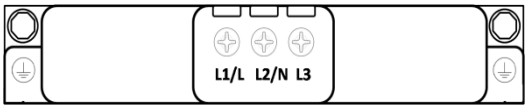
Footprint View

Weight : 5.3Kg

Fixings : 4 x M4 Keyhole slots

Power Terminals Torque Setting : 1Nm

3.1.4. Frame Size 4



Incoming Power Terminals

Help Card

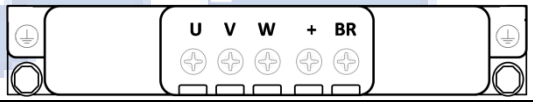
Keypad & Display – See Section 6 on page 26

RJ11 Connector – See Section 10.2 on page 59

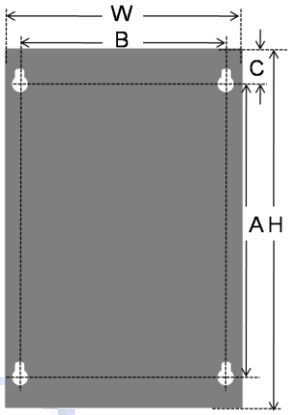
Infra Red Interface - See Section 10.1 on page 59

Control Terminals – See Section 4.8 on page 23

Motor & Brake Resistor Connection Terminals



Overall Dimensions



Height	520mm
Width	340mm
Depth	220mm
A	420mm
B	320mm
C	50mm

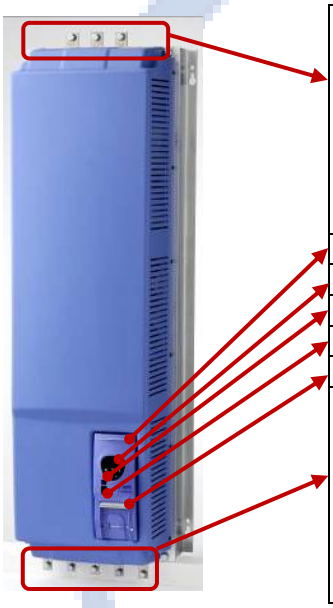
Footprint View

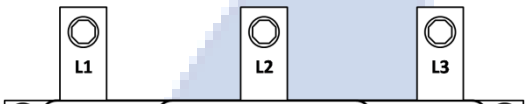
Weight : 28Kg

Fixings : 4 x M8 Keyhole slots

Power Terminals Torque Setting : 4Nm

3.1.5. Frame Sizes 5 & 6





Incoming Power Terminals

Help Card

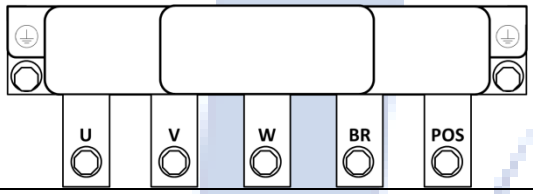
Keypad & Display – See Section 6 on page 26

RJ11 Connector – See Section 10.2 on page 59

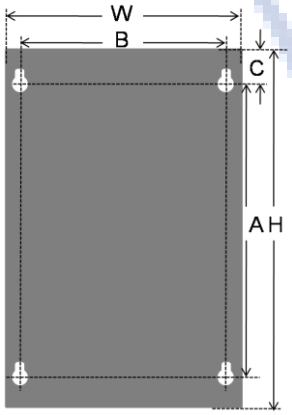
Infra Red Interface - See Section 10.1 on page 59

Control Terminals – See Section 4.8 on page 23

Motor & Brake Resistor Connection Terminals



Overall Dimensions



Height	1100mm
Width	340mm
Depth	330mm
A	945mm
B	320mm
C	50mm

Footprint View

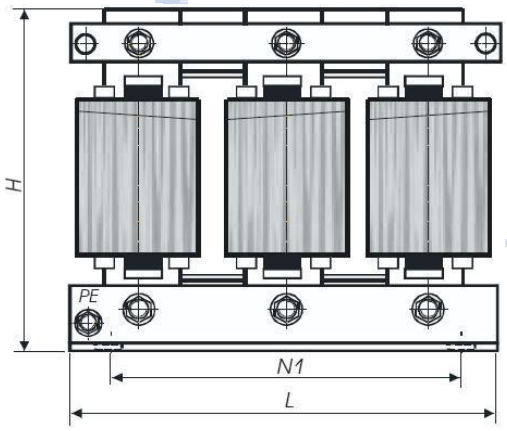
Weights :
Size 5 : 67Kg
Size 6 : 55Kg
(+ 27Kg Choke)

Fixings : 4 x M8 Keyhole slots

Power Terminals Torque Setting : 8Nm

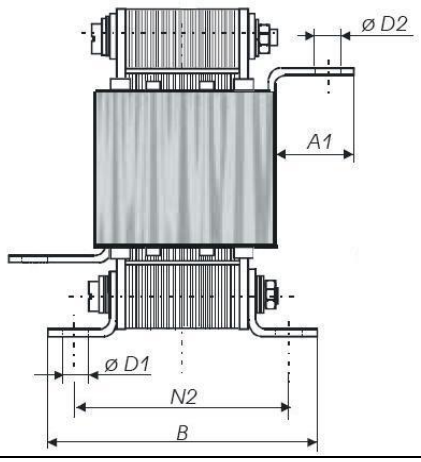
3.1.6. Frame Size 6 Additional Input Choke

Optidrive Plus Frame Size 6 is supplied complete with an external Input Choke, which must be installed in the supply line to the drive



Overall Dimensions

Height H	230mm
Length L	240mm
Depth B	250mm
Mounting Holes	
Centres N1	160mm
Centres N2	105mm
Slots D1	8.5 x 22mm
Busbar Connections	
Length A1	40mm
Connection Diameter D2	9mm



Note: The choke is always supplied with the drive, and MUST be used.

3.2. Before Installation

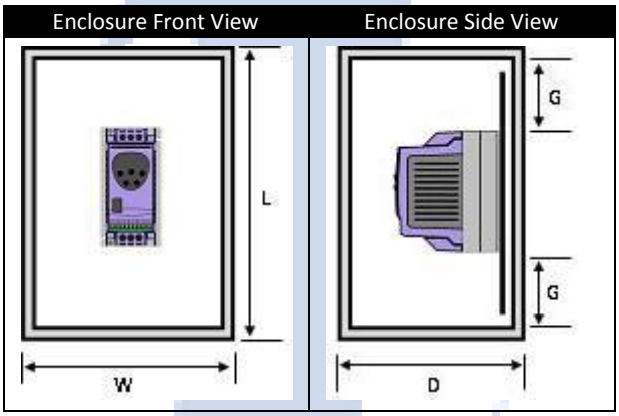
- Carefully Unpack the Optidrive and check for any signs of damage. Notify the shipper immediately if any exist.
- Check the drive rating label to ensure it is of the correct type and power requirements for the application.
- Store the Optidrive in its box until required. Storage should be clean and dry and within the temperature range –40°C to +60°C

3.3. General Installation

- The Optidrive should be mounted in a vertical position only on a flat, flame resistant vibration free mounting using the integral mounting feet.
- The Optidrive must be installed in a pollution degree 1 or 2 environment only.
- Do not mount flammable material close to the Optidrive
- Ensure that the minimum cooling air gaps, as detailed in section 3.4 are left clear
- Ensure that the ambient temperature range does not exceed the permissible limits for the Optidrive given in section 2.8
- Provide suitable clean, moisture and contaminant free cooling air for the Optidrive, see section 3.4

3.4. Guidelines for Enclosure mounting

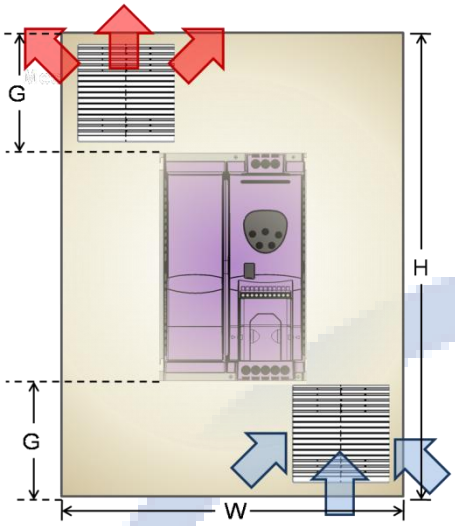
- Installation should be in a suitable enclosure, according to EN60529 or other relevant local codes or standards.
- Enclosures should be made from a thermally conductive material.
- Where vented enclosures are used, there should be venting above the drive and below the drive to ensure good air circulation – see the diagram below. Air should be drawn in below the drive and expelled above the drive.
- In any environments where the conditions require it, the enclosure must be designed to protect the Optidrive 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.
- High moisture, salt or chemical content environments should use a suitably sealed (non-vented) enclosure.



The enclosure design and layout should ensure that the adequate ventilation paths and clearances are left to allow air to circulate through the drive heatsink. Invertek Drives recommend the following minimum sizes for drives mounted in non-ventilated metallic enclosures:-

	Enclosure Minimum Dimensions			
Drive Power rating	**H**	**W**	**D**	**G**
Size 1 0.75kW 230V	300	250	200	50
Size 1 1.5kW 230V	400	300	250	75
Size 2 1.5kW 230V / 2.2kW 400V	400	300	300	60
Size 2 2.2kW 230V / 4kW 400V	600	450	300	100

For drives mounted in ventilated enclosures of force ventilated enclosures, Invertek Drives recommend the following minimum sizes and airflow requirements:-



Drive Power Rating	Free-Vented unit			
	L	W	D	G
Size 1 1.5 kW	400	300	150	75
Size 2 4 kW	600	400	250	100
Size 3 15 kW	800	600	300	150
Size 4 22 kW	1000	600	300	200
Size 4 37 kW	-	-	-	-
Size 5 90 kW	-	-	-	-
Size 6 160 kW	-	-	-	-

Force-vented unit				
L	W	D	G	Air Flow
275	150	150	50	> 15m^3 /h
320	200	200	75	> 45m^3 /h
400	250	200	100	> 80m^3 /h
800	500	250	130	> 300m^3 /h
800	500	250	130	> 300m^3 /h
1500	600	400	200	> 900m^3 /h
1600	600	400	250	>1000m^3 /h

4. Electrical Installation

4.1. Grounding the Drive

WARNING	**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.**
WARNING	**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.**
WARNING	**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.**

Grounding Guidelines

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

Protective Earth Conductor

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

Safety Ground

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

Motor Ground

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

Ground Fault Monitoring

If a system ground fault monitor is to be used; only Type B devices should be used to avoid nuisance tripping.

Shield Termination (Cable Screen)

The safety ground terminal provides a grounding point for the motor cable shield. The motor cable shield connected to this terminal (drive end) should also be connected to the motor frame (motor end). Use a shield terminating or EMI clamp to connect the shield to the safety ground terminal.
When shielded cable is used for control and signal wiring, the shield should be grounded at the source end only, not at the drive end.

4.2. Wiring Precautions

Connect the Optidrive according to section 4.4 Connection Diagram, ensuring that motor terminal box connections are correct. There are two connections in general: Star and Delta. It is essential to ensure that the motor is connected in accordance with the voltage at which it will be operated. For more information, refer to section 4.6 Motor Terminal Box Connections.

It is recommended that the power cabling should be 3-core or 4-core PVC-insulated screened cable, laid in accordance with local industrial regulations and codes of practice.

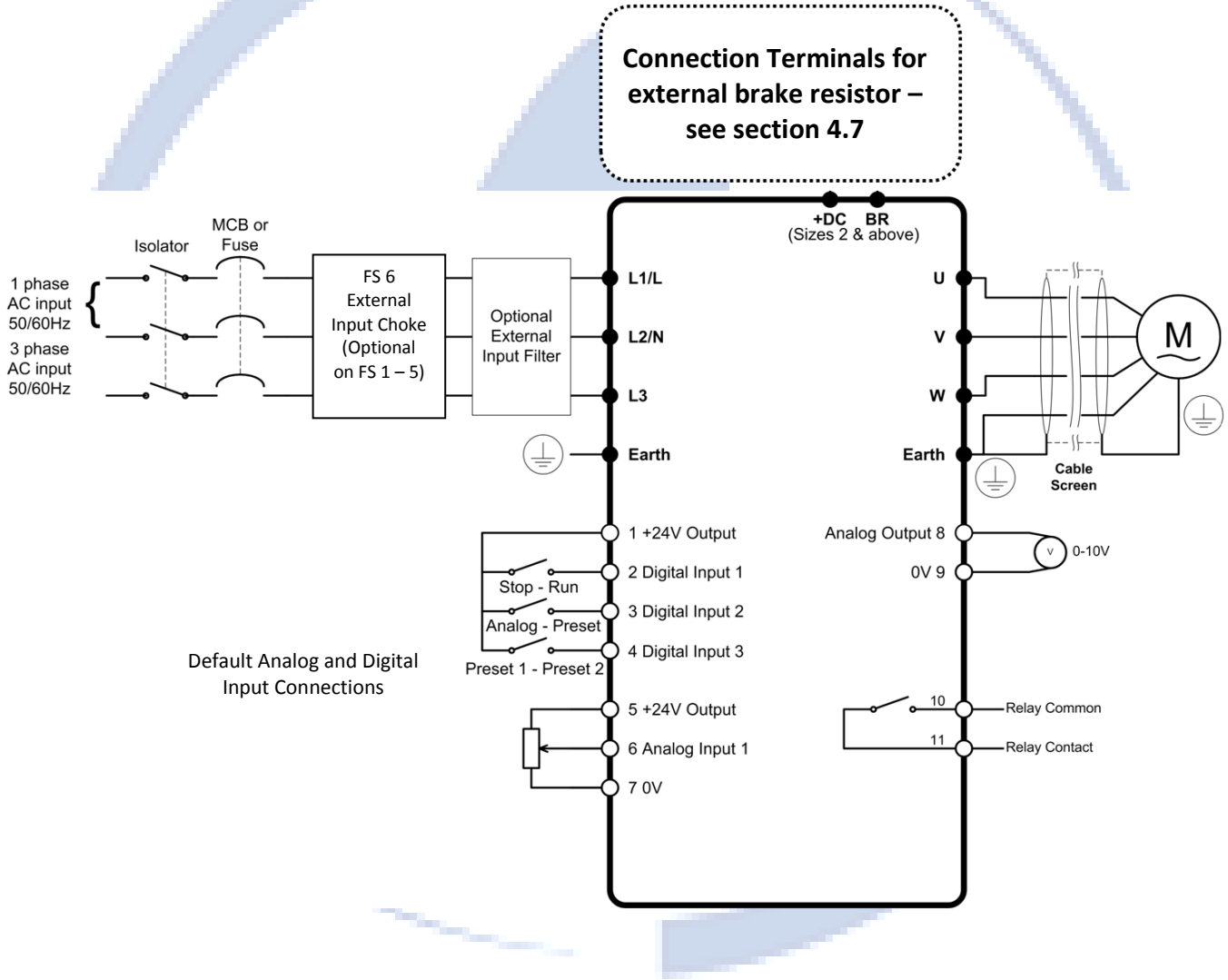
4.3. Incoming Power Connection

- For 1 phase supply power should be connected to L1/L, L2/N.
- For 3 phase supplies power should be connected to L1, L2, and L3. Phase sequence is not important.
- For compliance with CE and C Tick EMC requirements, a symmetrical shielded cable is recommended.
- The Optidrive should be connected to a fixed supply using a suitable disconnecting device between the Optidrive and the AC Power Source. The disconnecting device must conform to the local safety code / regulations.
- The cables should be dimensions according to any local codes or regulations. Guideline dimensions are given in section 2.2.
- Suitable fuses to provide wiring protection should be installed in the incoming supply line, according to the data in section 2.2. The fuses must comply with any local codes or regulations in place. In general, IEC type gG or UL type T fuses are suitable. The operating time of the fuses must be below 0.5 seconds.
- Where allowed by local regulations, suitably dimensioned circuit breakers may be utilised in place of fuses. Thermal overload protection is not required, as the Optidrive provides thermal protection for the motor and motor cable. Guideline dimensions are given in section 2.2.
- When the power supply is removed from the drive, a minimum of 30 seconds should be allowed before re-applying the power. A minimum of 5 minutes should be allowed before removing the terminal covers or connection.
- The maximum permissible short circuit current at the Optidrive Power terminals as defined in IEC60439-1 is 100kA.

- For Crane and hoist applications, where the power supply to the drive is via a busbar and brush gear system, Invertek Drives recommends the use of an input AC Input Inductor to ensure reliable operation for all drives that do not have a factory fitted internal inductor.
- An Input Choke should also be installed in the supply line for frame size 1 to 3 Optidrives where any of the following conditions occur:-
    - The incoming supply impedance is low or the fault level / short circuit current is high
    - The supply is prone to dips or brown outs
    - An imbalance exists on the supply (3 phase drives)
    - All installations of Frame Size 2 drives on 575 Volt Supply
- In all other installations, an input choke is recommended to ensure protection of the drive against power supply faults. Part numbers are shown in the table.

Supply	Frame Size	AC Input Inductor
230 Volt 1 Phase	2	OD-IL221-IN
	3	OD-IL321-IN
400 Volt 3 Phase	2	OD-IL-243-IN
	3	OD-IL-343-IN

4.4. Connection Diagram



Default Analog and Digital Input Connections

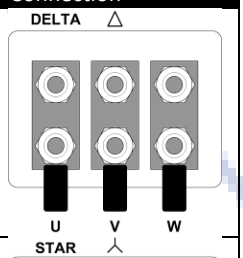
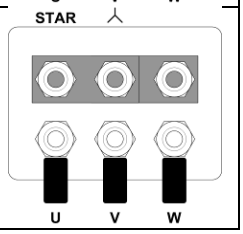
4.5. Drive and motor connections

For 1 phase supply power should be connected to L1/L, L2/N.
For 3 phase supplies power should be connected to L1, L2, and L3. Phase sequence is not important.
The motor should be connected to U, V, and W
For drives that have a dynamic brake transistor, an optional external braking resistor can be connected to +DC and BR when required. The brake resistor should be protected by a suitable thermal protection device, using a circuit design that disconnects the AC supply to the drive in the event of a trip. See section 0 on page 23 for further information.

4.6. Motor Terminal Box Connections

Most general purpose motors are wound for operation on dual voltage supplies. This is indicated on the nameplate of the motor

This operational voltage is normally selected when installing the motor by selecting either STAR or DELTA connection. STAR always gives the higher of the two voltage ratings.

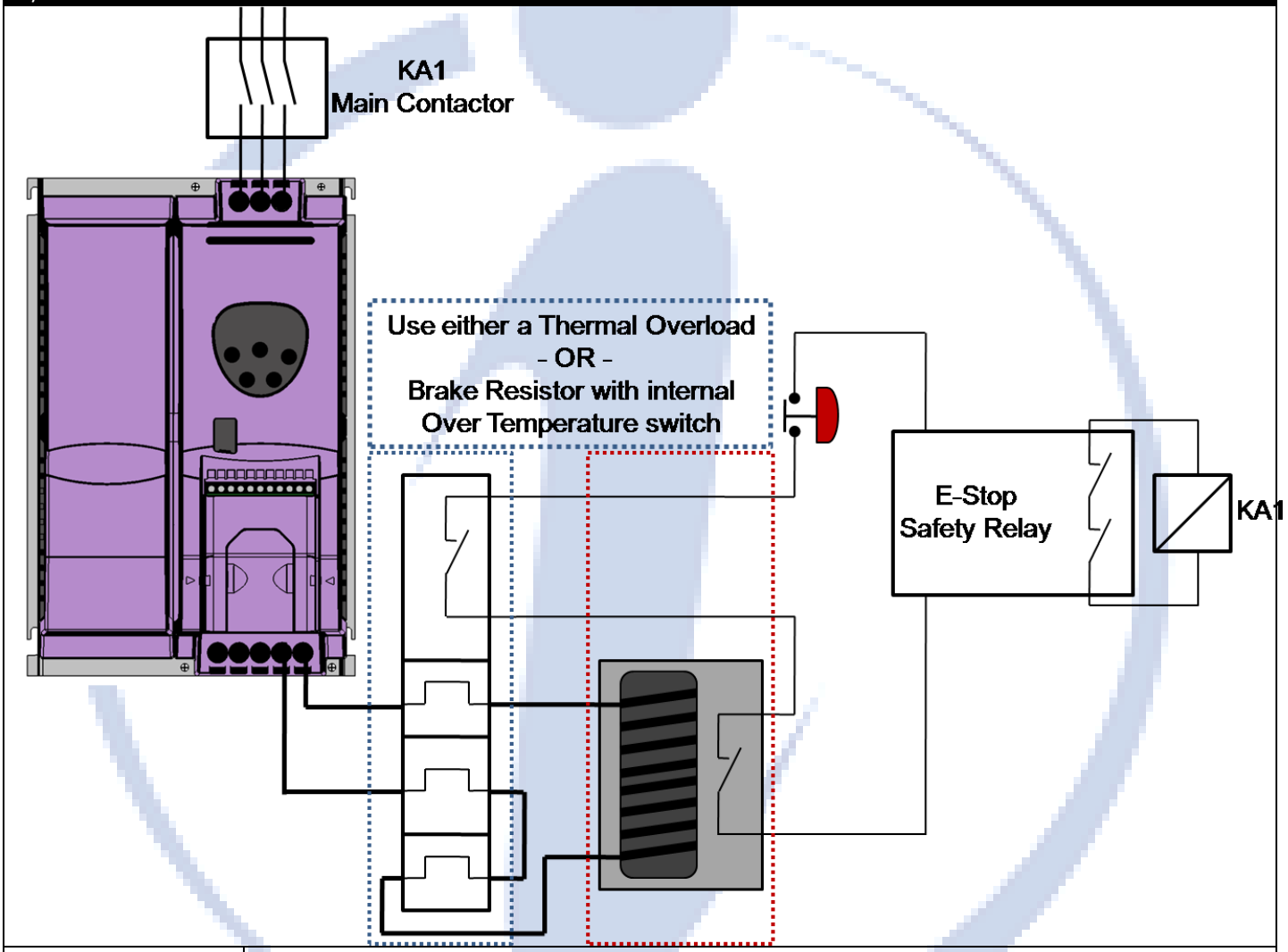
Incoming Supply Voltage	Motor Nameplate Voltages		Connection
230	230 / 400	Delta	
400	400 / 690		
400	230 / 400	Star	

4.7. Optional Dynamic Braking Resistor Connections (Size 2 and above units only)

Optidrive Plus size 2 units and above have provision to connect an optional dynamic braking resistor. The internal chopper is rated for 100% continuous braking at drive rated power. The minimum resistance value for each drive model shown in section 2.2 must be observed. Connecting a resistance below this value may well result in damage to the drive.

CAUTION	**The Optidrive Plus has internal software monitoring for the brake resistor, to prevent overheating, based on the setting of P2-23 (see section 7.3 for further details). Where this protection is disabled (by setting P2-23 = 3), Invertek Drives recommend that external thermal protection, such as a thermal overload or thermistor be used to prevent overheating of the resistor.**
WARNING	**The Braking resistor connects to the DC Bus terminal connections of the drive, which can carry voltages in excess of 800 Volts DC. Safe installation is of paramount importance.**

Dynamic Brake Resistor with Thermal Overload Protection



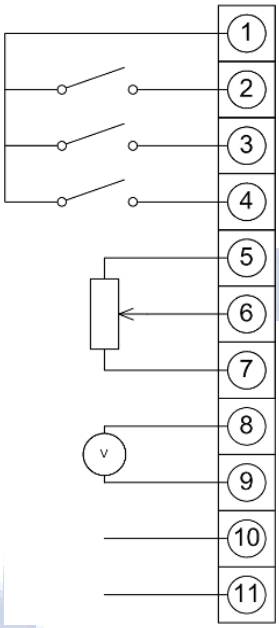
WARNING	**If the brake resistor has an internal thermal protection device with volt free contacts, this can be used. Alternatively, the brake resistor manufacturer may recommend a suitable thermal overload device. The thermal overload protection should be connected to ensure the drive is immediately disabled in the event of a fault, and for best safety practice, this should disable the main contactor supply to the drive and the apply the motor brake.**

4.8. Control Terminal Wiring

- All analog signal cables should be suitably shielded. Twisted pair cables are recommended.
- Analog and Digital signal cables should be routed separately where possible
- Signal levels of different voltages e.g. 24 Volt DC and 110 Volt AC, should not be routed in the same cable.

4.9. Control Terminal Connections

Default Connections



Control Terminal	Signal	Description
1	+24V User Output,	+24V, 100mA user control output
2	Digital Input 1	Positive logic “Logic 1” input voltage range: 8V … 30V DC “Logic 0” input voltage range: 0V … 8V DC
3	Digital Input 2 / Digital Output 3	Input : Positive logic “Logic 1” input voltage range: 8V … 30V DC “Logic 0” input voltage range: 0V … 8V DC Output : 24V 10mA Max ‘Drive Healthy’ Output
4	Digital Input 3 / Analog Input 2	Digital : “Logic 1” input voltage range : 8 to 30V DC “Logic 0” input voltage range : 0 to 8 V DC Analog: 0 to 10V, 0 to 20mA or 4 to 20mA
5	+24V User Output	+24V, 100mA, 1kΩ minimum
6	Bipolar analog Input / Digital Input 4	Digital : “Logic 1” input voltage range : 8 to 30V DC “Logic 0” input voltage range : 0 to 8 V DC Analog: 0 to 24V, 0 to 10V, -10 to +10V, -24 to + 24V
7	0V	User ground, connected to terminal 9
8	Analog Output / Digital Output	Analog: 0 to 10V DC, 10 to 0 V DC, 20mA Maximum 4 to 20mA, 20 to 4 mA Digital: 0 to 24V DC, 20mA Maximum
9	0V	User ground, connected to terminal 7
10	Relay Common	Volt free contacts. Maximum load should not exceed 250Vac, 6A / 30Vdc, 5A
11	Relay NO Contact	

5. EMC Correct installation

5.1. Overview

EMC stands for Electromagnetic Compatibility, and is a general term covering a range of electromagnetic effects and potential disturbances such as harmonics, radio frequency interference and parasitic effects, which may affect the operation of electrical and electronic equipment. All variable speed drives are potential sources of interference, and steps should be taken to ensure these effects are avoided. Within the European Union, the EMC Directive 89/336/EMC applies, however the end user should always pay attention to any local standards or codes which must be adhered to.

Optidrives are designed to high standards of EMC and can optionally be 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 89/336/EEC, EMC.

5.2. General Guidelines

Avoiding potential EMC related problems involves careful attention to the overall system design and installation of the Optidrive, and the following are a simple set of guidelines for most installations which if followed correctly, will generally result in the elimination of any potential problems.

Electrical Cabinets

Electrical Cabinets should always be manufactured from conductive materials. Any openings required should be kept to a minimum, whilst access points such as doors require a good, low impedance earth connection, such as a flat braided cable link to the main chassis, connected through the largest surface area possible. Any cable gland plates also require a good, low impedance earth connection to the main cabinet body. Cabinets side plates and top covers which are removable should have earth connections to the main chassis at regular intervals. Any screw connectors on painted cabinets should use special serrated washers, or the paint should be removed prior to installation of the screw to ensure a good earth bond between the sections.

Cable Entries

Any cable connections to the control panel need to be correctly glanded to ensure a continuous earth between the screen of the cable and the panel itself, particularly motor and power connection cables. Conductive glands should be used, and special care should be taken to ensure the screen of the cable is in contact with the gland body throughout its whole circumference, and that the gland is in contact with the panel surface through the greatest surface area possible, either with a serrated washer, or by removing paint from the panel surface to achieve this.

Panel Components

Individual components should be grouped and segregated according to their potential for both being the potential source of a problem or likely to be affected by EMC generated from other sources. In general, sensors, PLCs, Microcontrollers etc are devices most likely to be affected by EMC emitted from other sources within a control panel enclosure, and therefore it is recommended to mount these devices away from inverters. The effects of EMC generally decrease with distance, so the largest practical distance should always be used.
All relay and contactor coils must be suppressed.

Internal Panel Wiring

Power and signal cables should always be segregated within a control panel enclosure as far as possible. Where cables need to cross, this should be at right angle to minimise any potential effects. Sensitive signal cables should be screened, and the use of twisted pair signal cables is also recommended.
Optidrives, Optifilters and chokes are best mounted on a bare conductive mounting plate, which provides a good, low resistance path to earth. Where this is not practically possible, an alternative low impedance earth should be used, such as a flat braided cable connected to earth through a large surface area.
Motor cables used internally within panels should be overall screened to avoid the risk of possible interference, and the screen should be bonded to earth at both ends leaving the shortest possible unscreened connection tails. The outer screen should be bonded to earth throughout its entire circumference.

Incoming Power Supply Cables

For best EMC performance, a shielded symmetrical cable is recommended, dimensions according to the drive input current requirements and any local codes. The shield should be bonded to earth at the drive and distribution board through the largest possible surface area.

Motor Cables

For best EMC performance, a suitably shielded cable should be used. Copper or aluminium shields generally provide the lowest impedance and the greater the surface area of the shield in relation to the cable size, the better the performance offered. Alternatively, the cable can be installed in a suitable metallic conduit, away from all signal cables. The conduit should be suitably grounded utilising a low impedance ground connection, such as a flat braid.

6. Managing the Keypad

The drive is configured and its operation monitored via the keypad and display.

6.1. Keypad Layout and Function

	NAVIGATE	Used to display real-time information, to access and exit parameter edit mode and to store parameter changes
	UP	Used to increase speed in real-time mode or to increase parameter values in parameter edit mode
	DOWN	Used to decrease speed in real-time mode or to decrease parameter values in parameter edit mode
	RESET / STOP	Used to reset a tripped drive. When in Keypad mode is used to Stop a running drive.
	START	When in keypad mode, used to Start a stopped drive or to reverse the direction of rotation if bi-directional keypad mode is enabled

6.2. Changing Parameters

Procedure	Display shows...
Power on Drive	StoP
Press and hold the for >2 seconds	P1-01
Press the Key	P1-02
The and can be used to select the desired parameter	P1-03 etc..
Select the required parameter, e.g. P1-02	P1-02
Press the button	0.0
Use the and keys to adjust the value, e.g. set to 10	10.0
Press the key	P1-02
The parameter value is now adjusted and automatically stored. Press the key for >2 seconds to return to operating mode	StoP

6.3. Advanced Keypad Operation Short Cuts

Function	When Display shows...	Press...	Result	Example
Fast Selection of Parameter Groups Note : Parameter Group Access must be enabled P1-14 = 101	Px-xx		The next highest Parameter group is selected	Display shows P1-10 Press + Display shows P2-01
	Px-xx		The next lowest Parameter group is selected	Display shows P2-26 Press + Display shows P1-01
Select lowest Group Parameter	Px-xx		The first parameter of a group is selected	Display shows P1-10 Press + Display shows P1-01
Set Parameter to minimum value	Any numerical value (Whilst editing a parameter value)		The parameter is set to the minimum value	When editing P1-01 Display shows 50.0 Press + Display shows 0.0
Adjusting individual digits within a parameter value	Any numerical value (Whilst editing a parameter value)		Individual parameter digits can be adjusted	When editing P1-10 Display shows 0 Press + Display shows _0 Press Display shows 10 Press + Display shows _10 Press Display shows 110 Etc...

6.4. Drive Operating Displays

Display	Status	
StoP	Drive mains power applied, but no Enable or Run signal applied	
AUto-t	Motor Autotune in progress.	
H x.x	Drive running, display shows output frequency (Hz)	Whilst the drive is running, the following displays can be selected by briefly pressing the button on the drive. Each press of the the button will cycle the display through to the next selection.
A x.x	Drive running, display shows motor current (Amps)	
P x.x	Drive Running, display shows motor power (kW)	
For drive fault code displays, refer to section 16.1 on page 84		

6.5. Resetting Parameters to Factory Default Settings

Factory Reset, Retaining Motor Autotune Data

To reset all drive parameters to factory default settings, *except* the motor autotune data (Parameter Group 5), press + + for >2s. The display shows P-dEF . Press the button to acknowledge and reset the drive.

Factory Reset All Parameters

To reset all drive parameters to factory default settings, *including* the motor autotune data (Parameter Group 5), press + + + for >2s. The display shows P-dEF . Press the button to acknowledge and reset the drive.

Factory Reset – 3 Phase drives for Single Phase Operation

In order to use 3 Phase drives on Single Phase supplies, the following procedure should be observed.
Connect the Supply Live to the drive L1 Terminal
Connect the Supply Neutral to the L2 Terminal
Press + + for >2s. The display shows P-dEF. Press the button to acknowledge and reset the drive.
The correct supply voltage for the drive used must be maintained, e.g. ODPx2xxx drives require 200 – 240 Volt supply, ODPx4xxx drives require 380 – 480 volt supply. The maximum setting in P1-08 for motor rated current will automatically be reduced by 50%.

6.6. Terminal Control

When delivered, the Optidrive is in the factory default state, meaning that it is set to operate in terminal control mode and all parameters have the default values as indicated in section 7.

- Connect the drive to the supply, ensuring the correct voltage and fusing / circuit breaker protection – see section 2.2.
- Connect the motor to the drive, ensuring the correct star/delta connection for the voltage rating - see section 4.6.
- Enter the motor data from motor nameplate; P1-07 = motor rated voltage, P1-08 = motor rated current, P1-09 = motor rated frequency.
- Connect a control switch between the control terminals 1 and 2 ensuring that the contact is open (drive disabled).
- Connect a potentiometer (1kΩ min to 10 kΩ max) between terminals 5 and 7, and the wiper to terminal 6.
- With the potentiometer set to zero, switch on the supply to the drive. The display will show StoP.
- Close the control switch, terminals 1-2. The drive is now 'enabled' and the output frequency/speed are controlled by the potentiometer.
- On first enable from factory default parameters, the Optidrive will carry out an Autotune, and the display shows AUto-t. Leave the control switch closed an allow this to complete. See section 6.8 for further details.
- Following completion of the Autotune, the display shows zero speed in Hz (H 0.0) with the potentiometer turned to minimum.
- Turn the potentiometer to maximum. The motor will accelerate to 50Hz, (60Hz for USA drives), the default value of P1-01, under the control of the acceleration ramp time P1-03. The display shows 50Hz (H 50.0) at max speed.
- If the potentiometer is turned to minimum, the motor will decelerate to 0Hz, the default minimum speed set in P1-02, under the control of the deceleration ramp P1-04. The output speed can be adjusted anywhere between minimum and maximum speed using the potentiometer.
- To display motor current (Amps), briefly press the (Navigate) key.
- Press again to display the motor power.
- Press again to return to speed display.
- To stop the motor, disable the drive by opening the control switch (terminals 1-2).
- If the enable/disable switch is opened the drive will decelerate to stop at which time the display will show StoP.

6.7. Keypad Control

To allow the Optidrive to be controlled from the keypad in a forward direction only, set P1-12 =1:

- Connect the supply and motor as for terminal control above.
- Enable the drive by closing the switch between control terminals 1 & 2. The display will show StoP.
- Press the key. If this is the first enable from factory default parameters, the drive will carry out an Autotune as described above. On completion of the Autotune, the display shows H 0.0.
- Press to increase speed.
- The drive will run forward, increasing speed until is released.
- Press to decrease speed. The drive will decrease speed until is released. The rate of deceleration is limited by the setting in P1-04
- Press the key. The drive will decelerate to rest at the rate set in P1-04.
- The display will finally show StoP at which point the drive is disabled
- To preset a target speed prior to enable, press the key whilst the drive is stopped. The display will show the target speed, use the & keys to adjust as required then press the key to return the display to StoP.
- Pressing the key will start the drive accelerating to the target speed.
- To allow the Optidrive to be controlled from the keypad in a forward and reverse direction, set P1-12 =2:
- Operation is the same as when P1-12=1 for start, stop and changing speed.
- Press the key. The display changes to H 0.0.
- Press to increase speed
- The drive will run forward, increasing speed until is released. Acceleration is limited by the setting in P1-03. The maximum speed is the speed set in P1-01.
- To reverse the direction of rotation of the motor, press the key again.

6.8. Motor Autotuning

Optidrive Plus uses a sophisticated Voltage Vector Control Method as a factory default setting to ensure best possible motor operation. This control method requires the Optidrive to carry out an autotune to measure certain motor parameters prior to operation, to ensure this function operates correctly, and reduce the risk of nuisance tripping.

WARNING	**Whilst the autotune procedure does not drive or spin the motor, the motor shaft may still turn. It is not normally necessary to uncouple the load from the motor; however the user should ensure that no risk arises from the possible movement of the motor shaft.**

6.8.1. Autotune after Factory Reset or from Factory Set Parameters

Following a factory reset (See section 6.8), the correct data from the motor nameplate should be entered in

- P1-07 Motor Rated Voltage
- P1-08 Motor Rated Current
- P1-09 Motor Rated Frequency
- (Optional) P1-10 Motor Rated Speed (Rpm)

Providing that P1-08 is adjusted from the factory default setting, the Optidrive will automatically carry out an autotune on the motor the first time it is enabled. During the autotune, the display will show AUto-t. The test procedure may take several minutes to complete depending on the motor. Once the autotune is completed, the drive will operate as normal, and no further autotuning will be required unless the motor or drive control mode is changed (P4-01).

6.8.2. User Selected Autotune

The user can program the drive to carry out an autotune if required, as follows:-

- Ensure the motor nameplate values are correctly entered as described above.
- Set P1-14 = 101 to allow access to Parameter Groups 2, 3 and 4
- Set P4-02 = 1

6.9. Operating in Sensorless Vector Speed Control Mode

Optidrive Plus can be programmed by the user to operate in Sensorless Vector mode, which provides enhanced low speed torque, optimum motor speed regulation regardless of load and accurate control of the motor torque. In most applications, the default Voltage Vector control mode will provide adequate performance, however if Sensorless Vector operation is required, section 9.1 describes how to correctly commission the drive.

6.9.1. Sensorless Vector Torque Control Mode

For applications which require the drive to control motor torque as opposed to motor speed, the Optidrive Plus can be programmed to operate in Torque Control mode. When operating this way, the drive internal ramp times (P1-03 and P1-04) are disabled except during starting and stopping. See section 9.1 for details on using the torque control function.

6.10. Operation of Three Phase drives on Single Phase Supplies

Applies to: - Optidrive Plus, 230 Volt Supply versions, Size 3 and above
Optidrive Plus, 400 Volt Supply versions, Size 2 and above

It is possible to operate the above drive units from a single phase supply of the same rated voltage. When used in this way, the maximum output current capacity is reduced by 50%. In order to operate on a single phase supply, the supply MUST be connected to the L1 and L2 terminals of the drive. The user must then press + + for >2s. The display will show P-dEF, and all parameters will be reset to factory default settings. Press the button to acknowledge and reset the drive. The maximum motor rated current setting in P1-08 will now be limited to 50% of its original value, and the Phase Loss and Phase Imbalance Protection features will be disabled.

7. Parameters

7.1. Parameter Set Overview

The Optidrive Plus 3GV Parameter set consists of 7 groups as follows:

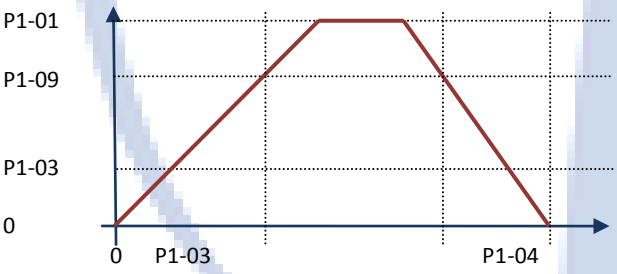
- Group 0 – Read Only Monitoring Parameters
- Group 1 – Basic Configuration Parameters
- Group 2 – Extended Parameters
- Group 3 – PID Control Parameters
- Group 4 – High Performance Motor Control Parameters
- Group 5 –Motor Parameters
- Group 6 – Application Specific Parameters

When the Optidrive is reset to factory defaults, or in its factory supplied state, only Group 1 Parameters can be accessed. In order to allow access to parameters from the higher level groups, P1-14 must be set to the same value as P2-37 (Default setting = 101). With this setting, parameter groups 1 – 4 can be accessed, along with the first 30 parameters in Group 0.

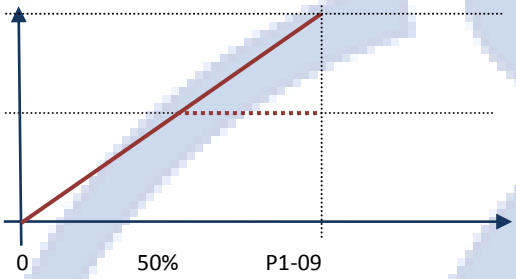
For advanced parameter access, P1-14 can be set to 702, which allows access to all parameter groups and ranges.

7.2. Parameter Group 1 – Basic Parameters

Par.	Description	Range	Units	Default	Explanation
P1-01	Maximum Frequency / Speed	P1-02 to 5*P-09 (max 500Hz) OR P2-24 / 16	Hz Rpm	50.0 (60.0)	Maximum speed limit – Hz or rpm. If P1-10 >0, the value entered / displayed is in Rpm
P1-02	Minimum Frequency / Speed	0.0 to P1-01 (max 500Hz)	Hz Rpm	0.0	Minimum speed limit – Hz or rpm. If P1-10 >0, the value entered / displayed is in Rpm
P1-03	Acceleration ramp time	0.0 to 3000.0	seconds	5.0	Acceleration ramp time from 0 to base speed (P-1-09) in seconds.
P1-04	Deceleration ramp time	0.0 to 3000.0	seconds	5.0	Deceleration ramp time from base speed (P1-09) to standstill in seconds. When set to zero, fastest possible ramp time without trip is activated

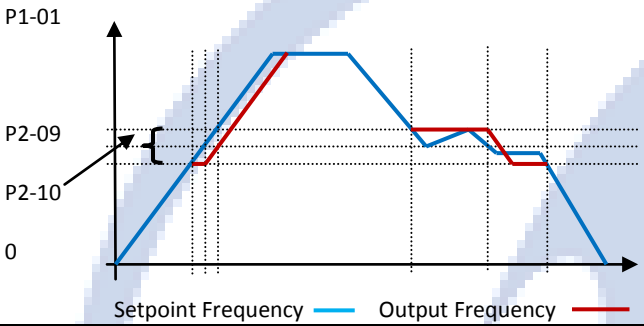
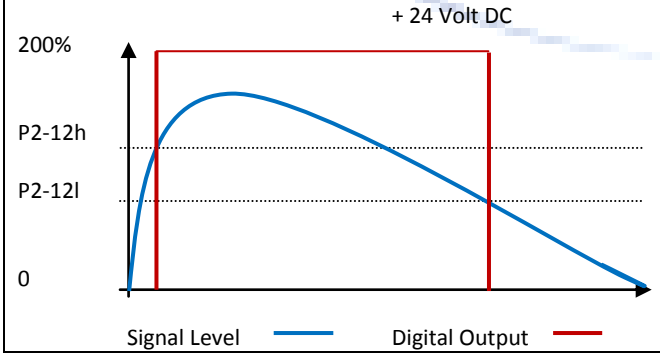


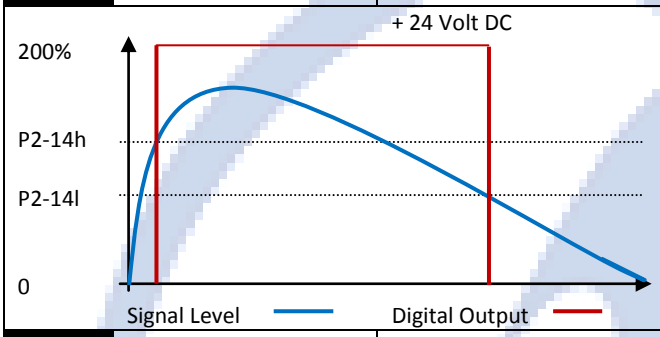
Following a start command, the drive will ramp immediately to minimum frequency, or the selected frequency setpoint, whichever is the greater. The setpoint can never exceed the maximum frequency set in P1-01. If an analog setpoint is used, the drive automatically scales the input, see parameter P2-30 & P2-33 for further details.
The time taken to ramp to motor *base speed* is set in P1-03. If the setpoint frequency is above base speed, the time to reach setpoint speed will be longer than the time set in P1-03.
On stopping, the drive will ramp to zero speed. P1-04 sets the time taken to ramp from motor *base speed* to zero, hence if the setpoint speed is above base speed, the drive will take longer than the value of P1-04 to reach zero speed.
If P1-10 = 0 (Default setting), the values of P1-01 and P1-02 are entered in Hz, and the Optidrive uses the value of P1-09 (Default 50 / 60Hz). All values are displayed in Hz.
The acceleration ramp *rate* (e.g. rate of change of output frequency) is then defined as **a = Value of P1-09 / Value of P1-03**
The deceleration ramp *rate* is then defined as
d = Value of P1-09 / Value of P1-04

Par.	Description	Range	Units	Default	Explanation
P1-05	Stop mode select	0 : Ramp stop (brown-out ride-through) 1 : Coast to stop 2 : Ramp to stop (fast stop)	-	0	**0** : When the enable signal is removed, the drive will ramp to stop, with the rate controlled by P1-04 as described above. If the mains supply is lost, the drive will try to continue running by reducing the speed of the load, and using the load as a generator. **1** : When the enable signal is removed, or if the mains supply is lost, the motor will coast (freewheel) to stop **2** : If the mains supply is lost, the drive will ramp to stop using the P2-25 decel ramp time. If P2-25 = 0, the drive will coast to stop.
P1-06	Energy Optimiser	0: Disabled 1: Enabled	-	0	
P1-07					When enabled, the Optidrive will automatically reduce the applied motor voltage on light load conditions above 50% of motor base speed. The voltage is never reduced below 50% of the motor rated voltage.
P1-07	Motor rated voltage	0, 20 to 250 0, 20 to 500	Volts	230 400 (460)	Rated (nameplate) voltage of the motor (Volts). Value limited to 250V for low voltage drives. Setting to zero disables voltage compensation
P1-08	Motor rated current	25% -100% of drive rated current	Amps	Drive rating	Rated (nameplate) current of the motor
P1-09	Motor rated frequency	25Hz to 500Hz	Hz	50.0 (60.0)	Rated (nameplate) frequency of the motor
P1-10	Motor rated speed	0 to 30 000 rpm	Rpm	0	Entering the value from the motor nameplate enables the slip compensation function, and the Optidrive display will now show motor speed in estimated rpm. All speed related parameters, such as Minimum and Maximum Speed, Preset Speeds etc will also be displayed in Rpm.
P1-11	Preset Speed 1	-P1-01 to P1-01	Hz	50.0 (60.0)	Sets the speed the drive runs at when Preset Speed 1 is selected
P1-12	Terminal / Keypad / PID Drive Control Mode Selection	0.Terminal control 1. Keypad control – fwd only 2. Keypad control – fwd and rev 3. PID Control 4. Modbus RTU Control	-	0	Primary Control Mode of the drive. **0** : Terminal control **1** : Uni-directional keypad control. Keypad START button does not reverse direction. **2** : Bi-directional keypad control. Keypad START button toggles between forward and reverse. **3** : User PID control with external feedback signal **4** : Modbus RTU Control
P1-13	Trip log	Last four trips stored	-	Read only	Previous 4 trips stored in order of occurrence, with the most recent first. Press UP or DOWN to step through all four. The most recent trip is always displayed first. UV trip is only stored once.
P1-14	Extended menu access	Code 0 to 9 999	-	0	To gain access to Parameter Groups 2, 3, 4 and 0, P1-14 must be set to the value of P2-37 (Factory Default = 101). To gain access to Parameter Groups 5 and 6, Parameter P1-14 must be set to 702.

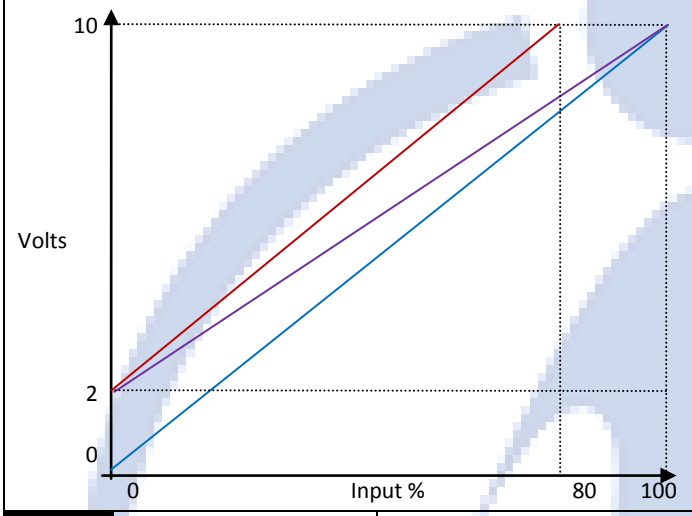
Following a factory reset, or when installing a drive for the first time, only Group 1 Parameter access is available. To allow access to Parameters Groups 0, 2, 3 and 4, Parameters P1-14 and P2-37 must contain the same value. The factory set value for P2-37 = 101

7.3. Parameter Group 2 - Extended parameters

Par.	Description	Range	Units	Default	Explanation
P2-01	Digital input function select	0 to 22	-	0	Defines the function of the digital inputs depending on the control mode setting in P1-12. See section 8 for more information.
P2-02	Preset Speed 2	-P1-01 to P1-01	Hz	0.0	Sets jog / preset speed 2
P2-03	Preset Speed 3	-P1-01 to P1-01	Hz	0.0	Sets jog / preset speed 3
P2-04	Preset Speed 4	-P1-01 to P1-01	Hz	0.0	Sets jog / preset speed 4
P2-05	Preset Speed 5	-P1-01 to P1-01	Hz	0.0	Sets jog / preset speed 5
P2-06	Preset Speed 6	-P1-01 to P1-01	Hz	0.0	Sets jog / preset speed 6
P2-07	Preset speed 7	-P1-01 to P1-01	Hz	0.0	Sets jog / preset speed 7
P2-08	Preset speed 8	-P1-01 to P1-01	Hz	0.0	Sets jog / preset speed 8
P2-09	Skip frequency	P1-02 to P1-01	Hz	0.0	Centre point of skip frequency band set up in conjunction with P2-10
P2-10	Skip frequency band	0 to P1-01	Hz	0.0	Width of skip frequency band centred on frequency set in P2-09
					The skip frequency function can be used to prevent the drive operating at a particular frequency point, e.g. if a particular motor speed causes resonance or vibration that may be potentially damaging to a machine. The Skip Frequency band is defined as Low Point = P2-09 – (P2-10 / 2) High Point = P2-09 + (P2-10 / 2) The drive will ramp *through* the Skip Frequency band at the ramp rates set in P1-03 & P1-04. If the setpoint frequency falls within the band, the drive will maintain the output frequency either just above or just below the skip frequency band, based on the following Setpoint > P2-09, Output Frequency = P2-09 + (P2-10 / 2) Setpoint < P2-09, Output Frequency = P2-09 – (P2-10 / 2)
P2-11	Analog output / Digital Output 1 Function select	Digital output mode 0 : Drive enabled 1 : Drive healthy 2 : Motor at target speed 3 : Motor Speed >0 4 : Motor speed >= limit 5 : Motor torque >= limit 6 : 2nd Analog Input >= limit Analog Output Mode 7 : Motor speed 8 : Motor torque 9 : Motor power 10 : Motor current		7	Digital Output Mode. Logic 1 = +24V DC **0** : Logic 1 when the drive is enabled (Running) **1**: Logic 1 When no Fault condition exists on the drive **2** : Logic 1 when the motor speed matches the setpoint speed **3** : Logic 1 when the motor runs above zero speed Options 4 to 6 : the Digital output is enabled using the level set in P2-12h and P2-12L Analog Output Mode **7** : Motor Speed, 0 to 10V = 0 to P-01 **8** : Motor torque, 0 to 10V = 0 to 200% of motor rated torque **9** : Motor power, 0 to 10V = 0 to 150% of drive rated power **10** : Motor Current, 0 to 10V = 0 to 200% of P1-08
P2-12h	Digital Output Control High Limit	0.0 to 200.0	%	100.0	With P2-11 = 4 to 6, Digital Output 1 is set to Logic 1 (+24V DC) when the value set in P2-12h is exceeded, and returns to Logic 0 (0V) when the selected value reduces below the limit set in P2-12L
P2-12L	Digital Output Control Low Limit	0.0 to P2-12h	%	100.0	
					When P2-11 is set to 4, 5 or 6, P2-12 controls the level at which the output switches. P2-12 contains two values, the 'Switch High' level (P2-12h) and the 'Switch Low' level, P2-12l. This allows for some hysteresis to be programmed, to prevent the output switching rapidly with small signal variations. The output switches high (+24V DC) when the selected signal source exceeds the threshold percentage level set in P2-12h. The output will then remain high until the signal falls below the value set in P2-12l, when it will return to 0V DC.

Par.	Description	Range	Units	Default	Explanation
P2-13	User Relay Output Function Select	0 : Drive enabled 1 : Drive healthy 2 : Motor at target speed 3 : Motor Speed >0 4 : Motor speed >= limit 5 : Motor torque >= limit 6 : 2nd Analog Input >= limit		0	Selects the function assigned to the relay output. **0** : Logic 1 when the drive is enabled (Running) **1**: Logic 1 When no Fault condition exists on the drive **2** : Logic 1 when the motor speed matches the setpoint speed **3** : Logic 1 when the motor runs above zero speed. The zero speed threshold level is defined in P6-04 **Options 4 to 6** : the Digital output is enabled using the level set in P2-14h and P2-14L
P2-14h	Relay Output Control High Limit	0.0 to 200.0	%	100.0	With P2-13 = 4 to 6, the User Relay Output is set to Logic 1 (+24V DC) when the value set in P2-14h is exceeded, and returns to Logic 0 (0V) when the selected value reduces below the limit set in P2-12L
P2-14L	Relay Output Control Low Limit	0.0 to P2-14h	%	100.0	
					When P2-13 is set to 4, 5 or 6, P2-14 controls the level at which the output switches. P2-12 contains two values, the 'Switch High' level (P2-14h) and the 'Switch Low' level, P2-14l. This allows for some hysteresis to be programmed, to prevent the output switching rapidly with small signal variations. The output switches high (+24V DC) when the selected signal source exceeds the threshold percentage level set in P2-14h. The output will then remain high until the signal falls below the value set in P2-14l, when it will return to 0V DC.
P2-15	Relay Output Mode	0 : Normally Open 1 : Normally Closed	-	0	Inverts the operating status of the User Relay **0** : Logic 1 = Relay Contacts Closed **1** : Logic 1 = Relay Contacts Open The drive must be powered for the contacts to close
P2-16	Zero Speed Holding Time	0 to 60	s	0.2	Determines the time for which the drive output is held at zero speed when stopping, before the drive output is disabled. This can be useful when a motor with a brake is used, as it allows time for the brake to operate before the drive output is disabled.
P2-17	Start Mode Select	EdgE-r AUto-0 AUto- 1 to 5	-	AUto-0	Edge-r : Following Power on or reset, the drive will not start if Digital Input 1 remains closed. The Input must be closed following a power on or reset to start the drive. Auto-0 : Following a Power On or Reset, the drive will automatically start if Digital Input 1 is closed. Auto 1 to 5 : Following a Fault, the drive will make up to 5 attempts to restart at 20 second intervals. The drive must be powered down to reset the counter. The numbers of restart attempts are counted, and if the drive fails to start on the final attempt, the drive will fault with, and will require the user to manually reset the fault.
P2-18	Spin Start Enable	0 : Disabled 1 : Enabled	-	0	When enabled, on start up the drive will attempt to determine if the motor is already rotating, and will begin to control the motor from its current speed. A short delay may be observed when starting motors which are not turning.

Par.	Description	Range	Units	Default	Explanation
P2-19	Keypad Restart Mode	0 : Minimum Speed, Edge-r 1 : Previous Speed, Edge-r 2 : Minimum Speed, Auto-r 3: Previous Speed, Auto-r	-	0	Active *only* when P1-12 = 1 or 2 **0** : Following a stop and restart, the drive will run at minimum speed **1** : Following a stop and restart, the drive will run at the last setpoint speed **2** : As per setting 0, except that the Run command will be determined by the status of Digital Input 1, and the user is not required to press the keypad start button **3** : As per setting 1, except that the Run command will be determined by the status of Digital Input 1, and the user is not required to press the keypad start button
P2-20	Standby Mode	0.0 to 60.0	seconds	0.0	When P2-20 > 0, the drive enters standby mode if the minimum speed is maintained for the time period set in P2-20. The drive display will shows StAndbY, and the output to the motor is disabled until the setpoint frequency moves above the minimum frequency (P1-02)
P2-21	Display Scaling Factor	0.000 to 30.000	-	0.000	Disabled if P2-21 is set to 0. If P2-21 is set >0, the variable selected in P2-22 is multiplied by the factor entered in P2-21, and displayed whilst the drive is running
P2-22	Display Scaling Source	0 : 2nd Analog Input 1 : Motor Speed 2 : Motor Torque 3 : Motor Current	-	0	
P2-23	Brake Circuit Enable	0 : Disabled 1: Enabled, Low Duty 2: Enabled, High Duty 3 : Enabled, No Protection	-	0	Enables the internal brake chopper on Size 2 and above drives. Settings 1 and 2 provide software monitoring of the braking power consumption. Setting 3 disables the protection, and externally monitoring must be used. See section 9.6 for further information.
P2-24	Effective Switching Frequency	4 to 16 / 24 / 32 Drive Power Rating Dependent	kHz	16 8 4	Effective power stage switching frequency. Higher frequencies reduce the audible 'ringing' noise from the motor, and improve the output current waveform, at the expense of increased drive losses
P2-25	2nd Deceleration Ramp time	0.0 to 3000	seconds	0.0	Deceleration 2nd ramp down time Selected Automatically on mains power loss if P1-05 = 2 Can also be selected by digital inputs, dependent on P2-01 setting. When set to 0.0, the drive decelerates as quickly as possible, whilst preventing an overvoltage trip.
P2-26	Modbus Communication Baud Rate	t9.6, t19.2, t38.4, t57.6, t115.2 r9.6, r19.2, r38.4, r57.6, r115.2	kbaud	t115.2	Modbus RTU serial data link communication Baud Rate. A 't' suffix indicates the drive will trip if communication with the network master is lost, after a time period set in P6-08. An 'r' suffix indicates that the Optidrive will Ramp to stop in the event of a loss of communication with the network master, after the time period set in P6-08.
P2-27	Drive Communication Address	0: Disabled 1 to 63	-	1	Sets the communication address for the drive when connected on an Optibus or Modbus RTU Network. The same drive address is used on both networks.
P2-28	Master / Slave Mode Select	0 : Slave Mode 1 : Master Mode	-	0	When in Master Mode, the drive transmits its operational status via the serial data link. All drives on the data link must have unique addresses. Only one drive can be programmed as a Master
P2-29	Digital / Slave speed reference scaling factor	0.0 to 500.0	%	100.0	Scaling factor applied to any speed reference on the serial data link, e.g. in Master / Slave operation, a Slave drive will apply this scaling factor to the transmitted Master speed reference

Par.	Description	Range	Units	Default	Explanation
P2-30	Bipolar analog input format	U 0-24 = 0 - 24V DC U 0- 10 = 0 - 10V DC - 10 - 10 = -10 to + 10V DC -24 -24 = -24 to + 24V DC	-	U 0-24	Configures the analog input signal to match the reference connected to terminal 6. Only voltage signals can be directly connected, mA reference signals require an external resistor connection.
P2-31	Bipolar analog input scaling	0.0 to 500.0	%	100.0	Scales the analog input by this factor, e.g. if P2-30 is set for 0 – 10V, and the scaling factor is set to 200.0%, a 5 volt input will result in the drive running at maximum speed (P1-01)
P2-32	Bipolar analog input offset	-500.0 to 500.0	%	0.0	Sets an offset, as a percentage of the full scale range of the input, which is applied to the analog input signal
					The Optidrive converts the analog input signal value to a percentage, which can be viewed in P0-01. If the input is used as a speed reference, the scaling within the drive is automatic so that 0% = P1-02 setting and 100% = P1-01. If the input is used as a torque reference, the scaling again is automatic so that 0% = P4-08 setting and 100% = P4-07 setting. If an alternative scaling is required, this can be achieved using a combination of P2-31 and P2-32. See the Blue Line. P2-32 defines an offset applied to the analog input. With P2-32 set to 20%, any values below 20% of the full scale range of the analog input are treated as zero, e.g. with P2-31 set for a 0 – 10 volt signal, values below 2 volt. Since this is an offset only, the full scale value is reduced by the same percentage, e.g. with P2-32 set to 20%, when 10 volts is applied to the analog input (assuming P2-30 is set for 0 – 10 volt format), it will be treated as 80% of the full scale value. See the Red Line P2-31 can then be used to apply a scaling factor. This is a multiplication factor applied to the signal, e.g. if an 8 volt signal is required to give the full range output with the input format set to 0 – 10 volts, then P2-31 = 10/8 x 100% = 125%. See the Purple Line
P2-33	2nd analog input format	d 0-24 = Digital U 0- 10 = 0 to 10V DC A 4-20 = 4 to 20mA A0-20 = 0 to 20mA	-	d 0-24	Selects the format for the 2nd analog input Selecting d 0-24 sets the input up as a digital input
P2-34	2nd analog input scaling	0.0 to 500.0	%	100.0	Scales the 2nd analog input by the factor set in this parameter
P2-35	Digital speed reference scaling control	0 : Disabled (No Scaling) 1 : Scaled by P2-29 2 : Scaled by P2-29, then bipolar analog input added as an offset 3 : Scaled by P2-29 *and* by bipolar analog input	-	0	Active in Keypad mode (P1-12 = 1 or 2) and Master / Slave mode only. 1 : Actual Speed = Digital Speed x P2-29 2: Actual Speed = (Digital Speed x P2-29) + bipolar analog reference 3 : Actual Speed = Digital Speed x P2-29 x bipolar analog reference
P2-36	Analog output format	U 0- 10 = 0 to 10V A 4-20 = 4 to 20mA U 10-0 = 10 to 0V A 20-4 = 20 to 4mA	-	U 0- 10	Selects the analog output signal format
P2-37	Extended menu access code	0 to 9999	-	101	Defines the access code which must be entered in P1-14 to access parameter groups above Group 1
P2-38	Parameter Lock	0 : Unlocked 1 : Locked	-	0	When locked, all parameter changes are prevented
P2-39	Hours Run Counter	0 to 99999	Hours	-	Indicates the number of hours for which the drive has run
P2-40	Drive Type / Rating	N/A	-	-	Read only parameter, showing the drive type and power rating

7.4. Parameter Group 3 – PID Control

Par.	Description	Range	Units	Default	Explanation
P3-01	Proportional gain	0.1 to 30.0	-	2.0	PID Controller Proportional Gain. Higher values provide a greater change in the drive output frequency in response to small changes in the feedback signal. Too high a value can cause instability
P3-02	Integral time constant	0.0 to 30.0	seconds	1.0	PID Controller Integral Time. Larger values provide a more damped response for systems where the overall process responds slowly
P3-03	Differential time constant	0.00 to 1.0	seconds	0.00	PID Differential Time Constant
P3-04	PID operating mode	0 : Direct 1 : Inverse	-	0	Direct operation – Motor speed *increases* with an increase in the feedback signal Inverse Operation – Motor speed *decreases* with an increase in the feedback signal
P3-05	PID Setpoint / reference select	0 : Digital 1 : Analog	-	0	Selects the source for the PID Reference / Setpoint 0 : P3-06 is used 1 : Bipolar analog input is used
P3-06	PID digital reference	0.0 to 100.0	%	0.0	Sets the preset digital PID reference / setpoint
P3-07	PID controller high limit output	P3-08 to 100.0	%	100.0	Limits the maximum value output from the PID controller
P3-08	PID controller low limit output	0.0 to P3-07	%	0.0	Limits the minimum output from the PID controller
P3-09	User PID output limit / function control	0 : Digital output limits 1 : Analog Upper Limit 2: Analog Lower Limit 3 : PID added to Bipolar analog input reference	-	0	0 : PID output range limited by P3-07 & P3-08 1 : PID maximum output limited by the signal applied to the bipolar analog input 2: PID minimum output limited by the signal applied to the bipolar analog input 3: PID output is added to the speed reference applied to the bipolar analog input
P3-10	PID feedback source select	0 : 2nd Analog Input 1 : Bipolar analog input	-	0	Selects the source of the PID feedback signal
For further details on using the PID Controller, refer to section 9.5 on page 52					

7.5. Parameter Group 4 – High Performance Motor Control

	WARNING	**Incorrect adjustment of parameters in menu group 4 can cause unexpected behaviour of the motor and any connected machinery. It is recommended that these parameters are only adjusted by experienced users.**			
Par.	Description	Range	Units	Default	Explanation
P4-01	Control Mode	0 : Vector Speed Control 1 : Vector Torque Control 2 : V/F Speed Control	-	2	Selects the motor control method. An autotune must be performed following a change, see section 6.4
P4-02	Motor parameter autotune	0 : Disabled 1 : Enabled	-	0	When set to 1, the drive immediately carries out a non-rotating autotune to measure the motor parameters for optimum control and efficiency
P4-03	Speed controller proportional gain	0 to 4096	-	300	Sets the proportional gain value for the speed controller. Higher values provide better output frequency regulation and response. Too high a value can cause instability or even over current trips. For applications requiring best possible performance, the value should be adjusted to suit the connected load by gradually increasing the value and monitoring the actual output speed of the load until the required dynamic behaviour is achieved with little or no overshoot where the output speed exceeds the setpoint. In general, higher friction loads can tolerate higher values of proportional gain, and high inertia, low friction loads may require the gain to be reduced.
P4-04	Speed controller integral time	0.050 to 1.000	seconds	0.050	Sets the integral time for the speed controller. Smaller values provide a faster response in reaction to motor load changes, at the risk of introducing instability. For best dynamic performance, the value should be adjusted to suit the connected load.
P4-05	Motor power factor	0, 0.50 to 1.00	-	-	Motor nameplate power factor, which must be entered for Vector operation (P4-01 = 0 or 1)
P4-06	Torque reference source select	0 : Preset Value (P4-07) 1 : Bipolar analog input 2 : 2nd analog input 3 : Modbus RTU 4 : Master / Slave	-	0	When operating in vector mode (P4-01 = 0 or 1), selects the source of the torque reference
P4-07	Maximum torque limit / torque reference	0 to 200.0	%	200.0	If P4-01 = 1 and P4-06 = 0, sets the preset torque reference If P4-01 = 0, sets the maximum torque limit
P4-08	Minimum torque limit	0 to 150.0	%	0.0	Sets a minimum torque limit, see the warning below
P4-09	V/F characteristic adjustment frequency	0.0 to P1-09	Hz	0.0	When operating in V/F mode (P4-01 = 2), sets a frequency point at which the voltage applied in P4-10 is applied to the motor. Care must be taken to avoid overheating and damaging the motor when using this feature
P4-10	V/F characteristic adjustment voltage	0 to P1-07	-	0	In conjunction with P4-09, in V/F mode (P4-01 = 2), sets the voltage applied to the motor at the adjustment frequency set in P4-09

7.6. Parameter Group 5 – Motor Parameters

	WARNING	**Incorrect adjustment of parameters in menu group 5 can cause unexpected behaviour of the motor and any connected machinery. In general, these parameters should NOT be adjusted by the user, and it is recommended that these parameters are only adjusted by experienced users.**			
Par.	**Description**	**Range**	**Units**	**Default**	**Explanation**
P5-01	Motor Stator resistance (Rs)	Drive dependent	Ω	-	During an autotune, the drive measures / calculates these parameters to optimise the motor control performance. The values can be adjusted by the user, however this may have a negative effect on the motor behaviour, or cause unexpected results, and this is not recommended.
P5-02	Motor Rotor resistance (Rr)	Drive dependent	Ω	-	
P5-03	Stator inductance (Ls)	Drive dependent	-	-	
P5-04	Magnetising current (Id rms)	10% to 80% of motor rated current	A	-	
P5-05	Leakage coefficient (sigma)	0.025 to 0.250	-	-	
P5-06	Reserved		-	-	
P5-07	Quick Rs measurement Enable	0: Disable 1: Enable	-	0	Since an auto-tune is usually carried out during the commissioning process, the motor is usually cold when this happens. Temperature dependent parameters – especially stator resistance – can vary significantly during operation. Whenever the drive is enabled from a stopped condition, the drive will normally start from the Auto-tuned (cold) parameters. To cater for the possible variance in stator resistance, the drive can carry out a quick stator resistance measurement on enable. This is carried out during the magnetisation phase and can add a delay of one magnetisation time constant (typically 100 – 200 ms) before the drive will start to ramp up in speed. This parameter enables (1) or disables (0) the motor stator resistance quick measurement when the drive run signal is given. This function is only active when the drive is in vector control mode.
P5-08	Reserved		-	-	
P5-09	Over voltage current limit	0 to 100% of motor rated current.	%	0	This parameter is only valid in vector speed control mode. This parameter will come into function once the drive DC bus voltage increase over certain limit. This voltage limit is set internally just below the over voltage trip level. This parameter will effectively limit the output torque current in order to prevent large current going back to the drive, which may cause over voltage trip. A small value in this parameter will limit the motor control torque once drive DC bus over this control level. A higher value may cause big distortion on the motor current, which may cause an aggressive behaviour of the motor.
P5-10	Re-generation current limit	0.0 to 200% of motor rated current	%	100.0	This parameter defines the control current limit when motor in regenerating mode. The value in this parameter represents the percentage value of motor rated current that is defined in P1-08. The current limit that defined in this parameter will override the normal torque producing current limit when motor goes into regeneration mode. Too high a value may cause big motor current distortion and the motor may behaviour aggressively once motor goes into regeneration mode. The output torque of the motor may reduce during regeneration if the value in this parameter is too small.
P5-11	Pulse width limitation	0...500 (Time = value *16.67ns)	Ms	-	This parameter is used to limit the minimum output pulse width, which can be used for long cable applications. Increasing the value of this parameter will reduce the risk of over-current trips on long motor cables, but will also reduce the maximum available output motor voltage for a given input voltage.
P5-12	V/F mode magnetising period	0...2000ms	ms	-	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.

7.7. Application Specific Parameters

Par.	Description	Range	Units	Default	Explanation
P6-01	Software upgrade enable	0 : Disable 1 : I/O En 2 : DSP En	-	0	Enables the Application Macro loading / firmware upgrade process, see section 13
P6-02	Thermal management enable	0 : Disable 1 : Enable	-	0	When set to 1, the drive will automatically reduce the output switching frequency with increasing heatsink temperature, to reduce the risk of an over temperature trip.
P6-03	Auto-reset delay time	1s…60	s	20	Sets the delay time allowed between consecutive reset attempts when Auto Reset is enabled (see P2-17)
P6-04	User relay speed hysteresis band	0.0 … 25.0	%	0.3	This parameter defines a band around zero speed as a percentage of P1-09. When P2-11 or P2-13 = 2 or 3, output frequencies below this value are treated as 'zero speed'. This function is used to prevent "chatter" on the output if the operating speed coincides with the level at which the digital / relay output changes state. E.g. if P2-13 = 3, P1-01 = 50Hz and P6-04 = 5%, the relay contacts close above 2.5Hz
P6-05	Encoder Feedback Enable	0 … 1	-	0 (Disabled)	Enables the Encoder Feedback Option. See section 9.8 for further information.
P6-06	Encoder PPR	0 .. 10000	-	0	Sets the number of Pulses Per Revolution for the encoder
P6-07	Encoder Speed Error Limit	0.0 … 50.0	%	5.0	This parameter defines the allowed speed error between the encoder feedback and the Optidrives own estimated rotor speed. When set to zero, the protection is disabled.
P6-08	Modbus communication loss timer	0: disabled 1..60	s	2	This parameter controls the behaviour of the drive in the event of a loss of communication between drive and Modbus Network Master whilst the drive is operating. When set to zero, the drive will continue running if communication with the Modbus master is lost. When set to a value larger than zero, the drive will trip after the number of seconds specified in this parameter. This parameter is active regardless of the setting of P1-12; hence even if the Modbus Network Master is being used to monitor the drive rather than control it, a loss of communication will still cause the drive to trip.
P6-09	Speed droop control	0.0 …25.0% of P1-09	Hz	0 (Disabled)	This parameter only applies when the drive is in vector speed control mode. (P4-01=0) When set to zero, the speed droop control function is disabled. If P6-09 > 0, this parameter effectively defines a slip speed at motor rated output torque. The droop speed is the percentage value of P1-09. Depending on the motor load condition, the reference speed will be reduced by a certain droop value before goes into speed controller. See equations below: Droop speed = P6-09 * P1-09 Droop value = Droop speed * (Motor real torque / Motor rated torque) Speed controller input = Speed reference – Droop value
P6-10	Brake Chopper Duty Cycle when Under Temperature	0.0…20.0	%	2.0	This parameter defines the duty cycle applied to the brake chopper whilst the drive is in an under temperature trip state. A Brake resistor can be mounted to the drive heat sink, and used to warm the drive until the correct operating temperature is reached. **This parameter should be used with extreme care**, as incorrect adjustment may result in exceeding the rated power capacity of the resistor. External thermal protection for the resistor should always be used to avoid this risk – see section 0
P6-11	Preset Speed Run Time On Enable	0.0..600.0	S	0.0	Defines a time period for which, following an enable signal being applied to the drive, the drive will run at the speed programmed in Preset Speed 7 (P2-07). This feature can be used on pumps to provide a reverse spin on start up, to avoid potential blockages.

Par.	Description	Range	Units	Default	Explanation
P6-12	Preset Speed Run Time on Disable	0.0..600.0	S	0.0	Defines a time period for which, following removal of the enable (Run) signal and the drive ramping to standstill, the drive will then operate at the speed set in Preset Speed 8 (P2-08). This feature can be used in applications such as underground PCP pumps to provide an unwind of the driveshaft on stopping.

7.8. Parameter Group 0 – Monitoring Parameters (Read Only)

Par.	Description	Display range	Units	Explanation
P0-01	Bipolar analog input value	0 to 100	%	100% = max input voltage
P0-02	2nd Analog input value	0 to 100	%	100% = max input voltage
P0-03	Pre Ramp Speed Reference	-500 to 500	%	100% = P1-09
P0-04	Digital speed reference	-P1-01 to P1-01	Hz / Rpm	Digital speed reference
P0-05	Torque controller reference	0 to 200	%	Torque reference setpoint
P0-06	PID Reference	0 to 100	%	PID reference / setpoint
P0-07	PID Feedback	0 to 100	%	PID controller feedback value
P0-08	PID error	0 to 100	%	Actual PID error
P0-09	PID P Term	0 to 100	%	Proportional component
P0-10	PID I term	0 to 100	%	Integral component
P0-11	PID D term	0 to 100	%	Differential component
P0-12	PID Output	0 to 100	%	Output from PID controller
P0-13	Output Torque	0 to 200	%	100% = motor rated torque
P0-14	Magnetising current	Drive dependent	A	Motor rms magnetising current
P0-15	Rotor Current	Drive dependent	A	Rotor rms current
P0-16	Field Strength	0 to 100	%	Magnetic field strength
P0-17	Stator resistance	Drive dependent	Ohms	Phase to phase stator resistance
P0-18	Stator Inductance	Drive dependent	H	Stator inductance
P0-19	Rotor resistance	Drive dependent	Ohm	Calculated rotor resistance
P0-20	DC Bus Voltage	0 to 1000	Volts	Internal DC Bus voltage
P0-21	Drive Temperature	0 to 120	ºC	Measured heatsink temperature
P0-22	Supply voltage L1 – L2	Drive dependent	Volts	Phase to phase supply voltage
P0-23	Supply voltage L2 – L3	Drive dependent	Volts	Phase to phase supply voltage
P0-24	Supply voltage L3 – L1	Drive dependent	Volts	Phase to phase supply voltage
P0-25	Estimated rotor speed	Drive dependent	Hz / Rpm	In vector mode, estimated speed of motor
P0-26	kWh meter	0 to 999.9	kWh	Cumulative energy consumption
P0-27	MWh meter	0 to 60,000	MWh	Cumulative energy consumption
P0-28	Software ID – IO Processor	Drive dependent	-	Version number & checksum
P0-29	Software ID – Motor Control	Drive dependent	-	Version number & checksum
P0-30	Drive serial number	Drive dependent	-	Unique drive serial number
P0-31	Drive serial number #2			
P0-32	DSP bootloader version	E.g. “ 1.00”		
P0-33	Measured Cos phi	E.g. 0.78		
P0-34	Comms error count (DSP)	0 … 65535		
P0-35	Configuration register value	Internal value		
P0-36	Digital input status	Internal value		
P0-37	Analog out internal value	Internal value		
P0-38	Current Phase U offset	Internal value		
P0-39	Current Phase U ref	Internal value		
P0-40	Current Phase V offset	Internal value		
P0-41	Current Phase V ref	Internal value		
P0-42	Brake resistor max on time	Time in milliseconds		
P0-43	Brake resistor duty cycle	Internal value		
P0-44	Uq internal ref value	Internal value		
P0-45	Ud internal ref value	Internal value		
P0-46	Measured spin start speed	Internal value		
P0-47	Calculated slip speed value	Internal value (V/F mode only)		
P0-48	Hoist boost speed	Internal value		
P0-49	Rated Iq internal value	Internal value		
P0-50	Motor voltage	V ph-ph (rms)		
P0-51	Switching frequency internal	Internal value		
P0-52	Speed hysteresis value	Internal value		
P0-53	PID DC bus feedback value	0..4096		
P0-54	Modbus comms error	0 … 65535		
P0-55	Modbus speed reference	Internal value		
P0-56	Droop speed	Internal value		
P0-57	Encoder Speed	-P1-01 to P1-01	Hz / Rpm	Displays the encoder speed
P0-58	Speed jump zone	Internal value		
P0-59	Modbus write command data value	Register dependent		
P0-60	Motor control loop ID	0 … 65535		

8. Digital Input Functions

8.1. Terminal mode (P1-12 =0)

P2-01	Digital input 1 (T2)	Digital input 2 (T3)	Digital input 3 (T4)	Analog input (T6)
0	Open: Stop (disable) Closed: Run (enable)	Open : Bipolar analog speed ref Closed : Preset speed ref	Open : Preset Speed 1 Closed : Preset Speed 2	Bipolar analog input
1	Open: Stop (disable) Closed: Run (enable)	Open: Preset Speed 1 Closed: Preset speed 2	Open: Preset speed 1 / 2 Closed: Preset speed 3	Open : Preset Speed 1 / 2 / 3 Closed : Preset Speed 4
2	Open: Stop (disable) Closed: Run (enable)	**Digital Input 2** / **Digital Input 3**	**Bipolar analog input**	**Speed Setpoint**
		Open / Open	Open	Preset Speed 1
		Closed / Open	Open	Preset Speed 2
		Open / Closed	Open	Preset Speed 3
		Closed / Closed	Open	Preset Speed 4
		Open / Open	Closed	Preset Speed 5
		Closed / Open	Closed	Preset Speed 6
		Open / Closed	Closed	Preset Speed 7
		Closed / Closed	Closed	Preset Speed 8
3	Open: Stop (disable) Closed: Run (enable)	Open : Forward Closed : Reverse	Open: Bipolar analog ref Closed: Preset Speed 1	Bipolar analog input
4	Open: Stop (disable) Closed: Run (enable)	Open : Forward Closed : Reverse	Analog input 2 Speed Reference	Bipolar analog input (e.g. Torque Reference)
5	Open: Stop (disable) Closed: Run (enable)	Open : Forward Closed : Reverse	**Digital Input 3** / **Bipolar analog input** / **Speed Setpoint**	
			Open / Open / Preset Speed 1	
			Closed / Open / Preset Speed 2	
			Open / Closed / Preset Speed 3	
			Closed / Closed / Preset Speed 4	
6	Open: Stop (disable) Closed: Run (enable)	Open : Forward Closed : Reverse	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
7	Open: Stop (disable) Closed: Fwd Run (enable)	Open: Stop (disable) Closed: Rev Run (enable)	Open: Bipolar analog speed ref Closed: Preset Speed 1	Bipolar analog input
8	Open: Stop (disable) Closed: Fwd Run (enable)	Open: Stop (disable) Closed: Rev Run (enable)	Open: Bipolar analog speed ref Closed: Preset Speed 1	Bipolar analog input
9	Open: Stop (disable) Closed: Forward Run (enable)	Open: Stop (disable) Closed: Reverse Run (enable)	**Digital Input 3** / **Bipolar analog input** / **Preset Speed**	
			Open / Open / Preset Speed 1	
			Closed / Open / Preset Speed 2	
			Open / Closed / Preset Speed 3	
			Closed / Closed / Preset Speed 4	
10	Open: Stop (disable) Closed: Forward Run (enable)	Open: Stop (disable) Closed: Reverse Run (enable)	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
11	Open: Stop (disable) Closed: Run (enable)	Open : Bipolar analog speed ref Closed : Preset speed 1	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
12	Open: Stop (disable) Closed: Run (enable)	Open : Preset Speed 1 Closed : Bipolar analog speed ref	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
13	Normally Open (NO) Momentarily Close to Run	Normally Closed (NC) Momentarily Open to Stop	Open: Bipolar analog speed ref Closed: Preset Speed 1	Bipolar analog input
14	Normally Open (NO) Momentarily Close to Run Fwd	Normally Closed (NC) Momentarily Open to Stop	Normally Open (NO) Momentarily Close to Run Rev	Bipolar analog input
15	Open: Stop (disable) Closed: Run (enable)	Open : Forward Closed : Reverse	Open: Decel Ramp 1 (P1-04) Closed: Decel Ramp 2 (P2-25)	Bipolar analog input
16	Open: Stop (disable) Closed: Run (enable)	Open : Forward Closed : Reverse	Open: Decel Ramp 1 (P1-04) Closed: Decel Ramp 2 (P2-25)	Open: Preset Speed 1 Closed : Preset speed 2
17	Normally Open (NO) Momentarily Close to Run Fwd	Normally Closed (NC) Momentarily Open to Stop	Normally Open (NO) Momentarily Close to Run Rev	Open: Preset Speed 1 Closed : Keypad Speed Ref
18	Open: Stop (disable) Closed: Run (enable)	**Digital Input 2** / **Digital Input 3**	**Preset Speed Ref**	
		Open / Open	Preset Speed 1	Open : Preset Speed Ref Closed : Keypad Speed Ref
		Closed / Open	Preset Speed 2	
		Open / Closed	Preset Speed 3	
		Closed / Closed	Preset Speed 4	
19	Open: Stop (disable) Closed: Run (enable)	Open : Bipolar analog speed ref Closed : Analog input 2 speed ref	Analog input 2	Bipolar analog input
20	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	Open : Bipolar analog speed ref Closed : Preset Speed 1	Bipolar analog input
21	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	Open : Forward Closed : Reverse	Bipolar analog input
22	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input

NOTE	Negative Preset Speeds will be inverted if Run Reverse selected. The external trip input can be used to connect a motor thermistor

8.2. Keypad mode (P1-12 = 1 or 2)

P2-01	Digital input 1 (T2)	Digital input 2 (T3)	Digital input 3 (T4)	Bipolar analog input (T6)
0	Open: Stop (disable) Closed: Run (enable)	Closed : remote UP push-button When stopped, closing inputs 2 & 3 simultaneously starts the drive	Closed : remote DOWN push-button	No Function
1	Open: Stop (disable) Closed: Run (enable)	Closed : remote UP push-button	**External trip input :** Open: Trip, Closed: No Trip	Closed : remote DOWN push-button
2	Open: Stop (disable) Closed: Run (enable)	Closed : remote UP push-button	Open: Digital speed ref Closed: Preset speed 1	Open : Forward Closed : Reverse
3..9, 13, 14 & 16	Open: Stop (disable) Closed: Run (enable)	Closed : remote UP push-button When stopped, closing inputs 2 & 3 simultaneously starts the drive	Closed : remote DOWN push-button	Open : Forward Closed : Reverse
10	Open: Stop (disable) Closed: Run (enable)	Open : Digital speed ref Closed : Bipolar analog speed ref	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
11	Open: Stop (disable) Closed: Run (enable)	Open : Digital speed ref Closed : Preset speed 1	**External trip input :** Open: Trip, Closed: No Trip	Open : Forward Closed : Reverse
12	Open: Stop (disable) Closed: Run (enable)	Open : Preset speed 1 Closed : Digital speed ref	**External trip input :** Open: Trip, Closed: No Trip	Open : Forward Closed : Reverse
15	Open: Stop (disable) Closed: Run (enable)	Open : Digital speed ref Closed : Preset speed 1	Open: Decel Ramp 1 (P1-04) Closed: Decel Ramp 2 (P2-25)	Open : Forward Closed : Reverse
17	Open: Stop (disable) Closed: Run (enable)	Open : Digital speed ref Closed : Bipolar analog speed ref	Open : Digital / Analog ref Closed : Preset speed 1	Bipolar analog input
18	Open: Stop (disable) Closed: Run (enable)	Open : Digital speed ref Closed : Preset speed ref	**Digital Input 3** / **Bipolar analog input** / **Preset reference** Open / Open / Preset Speed 1 Closed / Open / Preset Speed 2 Open / Closed / Preset Speed 3 Closed / Closed / Preset Speed 4	
19	Open: Stop (disable) Closed: Run (enable)	Open : Digital speed ref Closed : Analog input 2 ref	Analog input 2	Open : Forward Closed : Reverse
20, 21	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	Open : Digital speed ref Closed : Preset speed 1	Open : Forward Closed : Reverse
22	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	**External trip input :** Open: Trip, Closed: No Trip	Open : Forward Closed : Reverse

NOTE

By default, if the enable signal is present the drive will not Enable until the START button is pressed. To automatically enable the drive when the enable signal is present set P2-19 = 2 or 3. This then disables the use of the START & STOP buttons

In keypad mode, the speed can be adjusted using the ▲ & ▼ keys on the built in keypad, or a remote mounted Optiport Plus keypad, in addition to pushbuttons connected to the digital inputs

The reverse input only functions under the following conditions

- P1-12 = 1, P2-19 = 2 or 3. P2-35 must not be 2 or 3
- P1-12 = 2. P 2-35 must not be 2 or 3

The external trip input can be used to connect a motor thermistor, see diagram below

8.3. User PI control mode (P1-12 = 3)

P2-01	Digital input 1 (T2)	Digital input 2 (T3)	Digital input 3 / Analog input 2 (T4)	Bipolar analog input (T6)
0..10, 13..16, 18	Open: Stop (disable) Closed: Run (enable)	No Function	Analog input 2	Bipolar analog input
11	Open: Stop (disable) Closed: Run (enable)	Open : PID control Closed : Preset speed 1	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
12	Open: Stop (disable) Closed: Run (enable)	Open : Preset speed 1 Closed : PID control	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
17	Open: Stop (disable) Closed: Run (enable)	Open : PID Control Closed : Bipolar analog ref	Analog input 2	Bipolar analog input
19	Open: Stop (disable) Closed: Run (enable)	Open : PID Control Closed : Analog input 2 ref	Analog input 2	Bipolar analog input
20, 21	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	Analog input 2	Bipolar analog input
22	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
NOTE	When P3-05 = 1, Bipolar analog input controls PID setpoint. The feedback must then be connected to Analog input 2 and P3-10 must be set to 0 (Default setting)			

	The external trip input only functions when the feedback source is the Bipolar analog input (P3-10 = 1)

8.4. Digital Input Configuration – Modbus Control Mode

P2-01	Digital input 1 (T2)	Digital input 2 (T3)	Digital input 3 / Analog input 2 (T4)	Bipolar analog input (T6)
0..2, 4, 6..9, 13..16, 18	Open: Stop (disable) Closed: Run (enable)	No Function	No Function	Bipolar analog input
3	Open: Stop (disable) Closed: Run (enable)	Open : Forward Closed : Reverse	Open: Modbus Speed Reference Closed: Preset Speed 1 Reference	Bipolar analog input
5	Open: Stop (disable) Closed: Run (enable)	Open : Modbus Speed Ref Closed : Preset Speed	**Digi Input 3** / **Bipolar Analog Input** / **Preset Speed** Open / Open / Preset Speed 1 Closed / Open / Preset Speed 2 Open / Closed / Preset Speed 3 Closed / Closed / Preset Speed 4	
10	Open: Stop (disable) Closed: Run (enable)	Open : Master Speed Ref Closed : Digital Speed Ref	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
11	Open: Stop (disable) Closed: Run (enable)	Open : Master Speed Ref Closed : Preset Speed 1	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
12	Open: Stop (disable) Closed: Run (enable)	Open : Master Speed Ref Closed : Bipolar Analog Ref	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input
17	Open: Stop (disable) Closed: Run (enable)	Open : Master Speed Ref Closed : Bipolar Analog Ref	Open: Modbus / Analog Ref Closed: Preset Speed 1	Bipolar analog input
19	Open: Stop (disable) Closed: Run (enable)	Open : Master Speed Ref Closed : Analog Input 2 Ref	Analog Input 2	Bipolar analog input
20, 21	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	Open : Master Speed Ref Closed : Preset Speed 1	Bipolar analog input
22	Open: Stop (disable) Closed: Run (enable)	**Digital Output :** Drive Healthy = +24V	**External trip input :** Open: Trip, Closed: No Trip	Bipolar analog input

9. Advanced Drive Functions

9.1. Vector Speed Control

9.1.1. Overview

Vector Speed Control is designed to provide enhanced control over standard induction motors without the requirement to install an encoder. Vector Speed control provides

- Enhanced regulation of motor speed with respect to load changes, typically motor speed is maintained within + / - 0.5% for up to 200% change in applied load
- Enhanced low speed and starting torque, up to 200% starting torque can be generated

Vector Speed Control is particularly suited to

- Applications with high starting torque requirements
- Applications require accurate speed holding with changing loads

Vector Speed Control should not be used when

- Multiple motors are connected to a single Optidrive
- Output dv / dt filters are used
- High output frequencies are required, typically greater than 100HZ
- Long motor cables are used, Invertek recommends a maximum of 50metres
- The Energy Optimisation function is in use, see parameter P1-05 in section 7.2

9.1.2. Commissioning

Vector Speed Control requires accurate motor data to be entered into the drive parameters for correct operation. Any incorrect entries or errors made can cause unexpected results and poor motor performance. The following parameters are required:-

- P1-07 – Motor Rated Voltage
- P1-08 – Motor Rated Current
- P1-09 – Motor Rated Frequency
- P4-05 – Motor Rated Power Factor

These values should all be available on the motor nameplate. If they are not, the motor manufacturer should be consulted to obtain the correct details. If all values are available except the motor power factor, then P4-05 can be set to 0, and the Optidrive will attempt to determine the value during autotune. It is always recommended to use the motor manufacturer's value if this can be obtained.

Once the parameters are entered, Vector mode can be selected, and an autotune carried out. It is important when using Vector Mode that an autotune is successfully carried out by the Optidrive to measure the key motor parameters which are required for best performance. The values measured are:-

- P5-01 – Stator Resistance
- P5-02 – Rotor Resistance
- P5-03 – Stator Inductance
- P5-04 – Magnetising Current
- P5-05 – Leakage Co-efficient

Whilst these parameters are user adjustable, it is **NOT** recommended that they be adjusted by the user, as this will most likely result in poor or even dangerous motor performance.

Vector Speed Control Mode is selected by setting P4-01 = 0. The autotune is carried out by setting P4-02 = 1.

WARNING	**Whilst the autotune procedure does not drive or spin the motor, the motor shaft may still turn. It is not normally necessary to uncouple the load from the motor; however the user should ensure that no risk arises from the possible movement of the motor shaft.**
	The Autotune procedure begins immediately when the parameter is set. No external enable signal is required. The user should ensure that the machine is completely safe and the motor is connected to the drive prior to commencing the autotune.

Whilst the drive is carrying out the Autotune, the display will show AUto-t. It is important to wait until this returns to StoP before proceeding.

Once the autotune has completed, the Optidrive can now be operated. A new autotune should always be carried out if any changes are made to the following:-

- The Motor
- The Motor Connection Cable
- The Optidrive Motor Parameters (P1-07, P1-08, P1-09, P1-10 and P4-05)
- The Optidrive Operating Mode (P4-01)
- The Effective Switching Frequency (2-24)

9.1.3. Speed Loop Tuning

When operating in Vector mode, the Optidrive estimates the speed of the connected motor, and this can be displayed in Parameter P0-25. This value is then used to continuously adjust the output frequency of the Optidrive to ensure the motor speed exactly matches the required setpoint. To achieve this, a PI loop is used, which allows the behaviour of the drive to be fine tuned for best performance in any given application. The tuning parameters are:-

- P4-03 – Speed Loop Proportional Gain
- P4-04 – Speed Loop Integral Time

The speed loop gains can be tuned in the same way as any other PID loop, but monitoring the actual motor behaviour in relation to the desired behaviour and modifying the PI parameters to achieve the best results. The speed loop gains should always be tuned with the motor and load coupled, they cannot be correctly set if a load is not applied to the motor.

If a high value of Proportional Gain is used, the system can quickly become unstable, particularly if there is very little friction in the system and a relatively high inertia. Systems with low inertia and high friction can typically tolerate a higher value of Proportional Gain. Too low a gain can result in poor speed holding and a slower response to setpoint speed changes.

The setting of the I time depends on the mechanical system, in practice the default value works well in most applications, and should only be adjusted for applications requiring very fast response to setpoint changes with low inertia loads.

9.1.4. Troubleshooting

The most likely causes of poor performance in Vector Mode are:-

- Incorrect Motor Details entered, or details not set
- No Autotune carried out, or Autotune not completed

In all cases of poor performance, verify

- The Motor data is correct and entered correctly in all parameters
- The Motor is correctly connected in Star or Delta, depending on the voltage etc.
- An Autotune has been correctly completed

If the motor turns, but is unstable, try reducing P4-05 in steps of 100, and check that performance improves.

9.2. Vector Torque control

The Optidrive Plus 3GV can operate in either full torque control mode (P4-01=1) in which the reference input will directly control the output torque of the motor rather than the speed of the motor, or in speed control with torque limiting (P4-01=0) where the drive predominantly operates to control the motor speed, however torque can also be limited which may affect the speed control.

Torque control is not possible in V/F mode, therefore it is important that the Optidrive is correctly commissioned and relevant motor parameters correctly set as described in section 6.8 prior to using any Torque Control functions.

9.2.1. Key torque control parameters:

P4-06 Torque reference select

This parameter is used to set the motor output torque reference value. The available choices are:

0: Fixed Preset	Torque reference is preset by P4-07. If this option is used, the motor output torque reference value will be fixed by the percentage value of motor rated torque set in parameter P4-07. The motor rated torque is determined automatically by the auto-tune.
1: Bipolar analog input	If a variable torque reference is required, the analog input can be used as the torque reference. In this case, the reference value could be changed in real time in proportion to the analog input signal. The correct analog input signal format should be set in parameter P2-30. The input signal format must be unipolar. Bipolar references are not supported for a torque limit.
2: 2nd Analog input	The second analog input will be used as the motor output torque reference. The correct analog input signal format should be set in parameter P2-33.
3: Modbus torque reference	When this option is selected, the motor torque limit is given by the Modbus master. The value can range from 0% to 200%. For more information about the Modbus control function and the Modbus register map, see section 10.3

P4-08 Minimum torque reference/limit

This parameter will limit the minimum torque reference input value, and is usually used to prevent the rotor from locking when operating with low torque reference values. The default setting for this parameter is zero. This parameter should be adjusted with extreme care, as setting too high a value can cause the motor to rapidly accelerate, or exceed the speed reference. In general, this parameter should only be used in specific applications, where a minimum torque level must always be applied, and it is safe to do so in the application for which the drive is used.

If the analog input is used to vary the torque reference, the torque will be scaled linearly in proportion to the analog input from P4-08 to maximum torque limit in P4-07.

For all torque control applications, the maximum speed of the motor can never exceed the speed limit set in P1-01.

9.2.2. Torque control with variable speed limits:

Torque control mode is selected using P4-01 = 1 (vector torque control). The torque reference source is selected using P4-06. Set P4-06 = 2 and P2-01 = 4 to use the 2nd analog input signal as torque control reference.

In this configuration, the bipolar analog input will be selected as the speed limit. Digital input 2 will control the motor spin direction.

Alternatively, setting P2-01=19 and opening digital input 2 results in the 2nd analog input being used as a variable torque reference and the bipolar analog input as a variable speed limit.
If digital input 2 is closed in torque control mode (P4-01=1), then the drive speed will be limited to P1-01 (maximum speed limit)

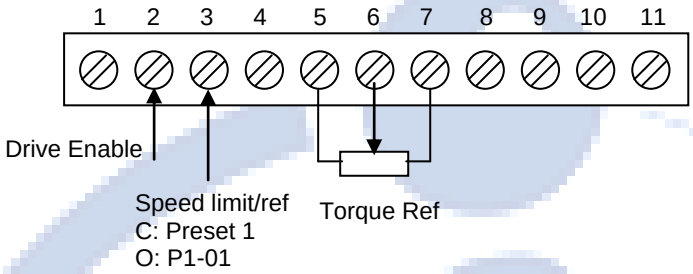
When operating in torque control mode (P4-01=1), the user should avoid selecting the same analog input signal for both speed limit and torque limit. In such conditions, maximum speed value in P1-01 will be used as speed limit.

Increasing P1-03 may also help to reduce the speed overshoot on start up for certain applications.

9.2.3. Example 1 : Variable torque reference, fixed speed limit

P1-12 = 0 (terminal mode)
P2-01 = 0 (digital input function select)
P4-01 = 1 (torque mode)
P4-06 = 1 (bipolar analog input used for torque reference)

The drive operates in terminal control mode with the torque reference provided by the bipolar analog input. If digital input 2 is open, the speed is limited by P1-01 (max speed limit). If digital input 2 is closed, the speed is limited to speed preset 1. See drive terminal strip connection diagram below:



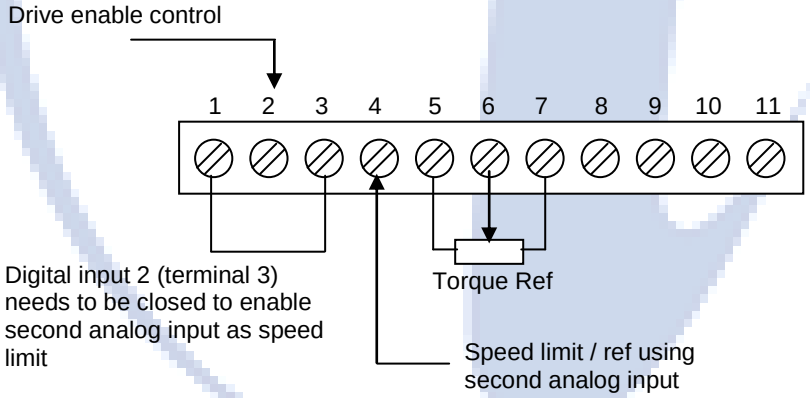
Different settings for P2-01 will give different options, including the connection of an external trip input, selection of different max speed limits via the preset speed parameters etc.

In torque control mode, the maximum output speed is limited by the speed reference value. In keypad control mode the speed reference is set by digital pot, in terminal mode it is set by the status of the digital inputs and function of the digital inputs set in P2-01.

9.2.4. Example 2 : Variable torque reference, variable speed limit

P1-12 = 0 (terminal mode)
P2-01 = 19 (analog input 1 / analog input 2 select)
P4-01 = 1 (torque mode)
P4-06 = 1 (bipolar analog input used for torque reference)

In this case, the max speed limit is set dynamically by the analog input. The second digital input must be closed so that the second analog input is selected as the speed limit. The bipolar analog input now acts as torque reference and the second analog input as variable maximum speed limit. See drive terminal strip connection diagram below:



Note that if the speed reference and torque reference share the same input source (this would be the case if the second digital input is open), then the output speed will be limited by the maximum speed limit (P1-01).

It may also be required to limit the speed to one of the digital preset speeds. This is equally possible, depending only on the setting of P2-01.

When running in torque control mode, the estimated rotor speed rather than the requested speed will be shown on the drive display.

9.3. Master – Slave Function

9.3.1. General

The Optidrive Plus has a built in Master Slave function, which uses the Optibus Plus communications protocol. This is a dedicated protocol for Optidrive Plus, allowing the Master Slave communication to take place. Up to 63 drives can be connected together on a communications network, using the RJ11 connector. One drive must be configured as the Master, with the remaining drives configured as Slaves. The Master drive outputs its operating state (e.g. Stopped, Running) and output frequency every 30ms. The slave drives will then follow the Running / Stopped status of the Master drive, and the Master drive's output frequency becomes the setpoint frequency for all the slave drives. This can then be further scaled as described below to allow speed ratios and offsets to be programmed.

9.3.2. Configuring the Network

All drives connected on a network must have a unique communications address. This is set in Parameter P2-27. If the addresses are not unique, the network will not function. Section 10.2 provides details of the RJ11 connector configuration. Invertek drives can supply connection cables in various lengths and splitters to allow a network to be quickly and easily connected together – please see section 11.4 for details. Depending on the overall length of the network cables and number of slaves connected, it may be necessary to install RS485 repeaters in the network.

9.3.3. Configuring the Master Drive

The Master drive on any network must be address 1 on that network. P2-27 must be set to 1, and P2-28 must also be set to 1.

9.3.4. Configuring the Slave Drive(s)

Each connected slave drive must have a unique Slave communications address set in P2-27. The range of slave addresses available is 0, and 2 – 63, hence up to 62 Slaves can be connected to a single Master drive.

Note

The Communications address Parameter P2-27 also affects the Modbus communication address and the communications address used with Optiwand PDA (see section 11.2) and Optistore Plus (see section 11.3) software packages.

Slave Drive Speed Scaling and Offset

Each Slave drive receives the output frequency reference from the Master drive, and this is then used as the Slave drives frequency setpoint. The drives internal parameters then allow an offset and scaling factor to be applied to this reference. This is controlled using parameters P2-35 and P2-29.

P2-35 – Digital Speed Scaling Source & P2-29 Digital Scaling Factor

Setting: 0	No scaling is used, and the Slave drive follows the Master drive's output frequency.
	E.g. Master drive runs at 25Hz, Slave drive will also run at 25Hz
Setting: 1	Scaling preset by P2-29 (Default 100.0%)
	Slave output Frequency = Master Output Frequency x P2-29(%)
	E.g. Master drive runs at 25Hz, Slave has P2-29 = 50.0, Slave drive output frequency = 12.5Hz

9.4. Speed Droop Control (Load Sharing)

9.4.1. Overview

Where multiple motors each are used to drive a common load, Speed Droop Control provides a simple means to ensure that the load is distributed evenly between all the motors. Each motor must be controlled from a separate Optidrive 3GV operating in Vector Speed Control (P4-02 = 0). By automatically reducing the output frequency of each drive in relation to the output torque, the Optidrives effectively share the load.

9.4.2. System Requirements

For correct performance, it is necessary to ensure that all the motors are of the same type and power rating, and drive the load through the same mechanical system. If different size motors or different gear ratios or pulley sizes are used, it is most likely not possible to use Droop Control.

All the Optidrives should be controlled from the same speed reference; this can be achieved very simply using the Master / Slave function as described in section 9.3. Combining the Master / Slave function with droop control provides a very cost effective solution for systems where multiple motors are required to mode a common load with even load sharing.

9.4.3. Commissioning

All Optidrives should be commissioned in Vector Speed Control mode as described in section 6.9. Droop Control is then adjusted using P6-09. P6-09 defines a drooped frequency, as a percentage of P1-09 (Motor rated frequency) whereby at rated full load output, the Optidrive will reduce the output frequency by this percentage.

E.g. If P1-09 = 50Hz, P6-09 = 5% and a drive speed reference of 40Hz, when the motor runs with no load, the Optidrive output frequency will be 40Hz. As the load increases, the Optidrive will reduce the output frequency in a linear fashion relative to the applied load. At 100% (full) load, the output frequency is reduced by (P1-09 x P6-09) = (50Hz x 5%) = 2.5Hz

When droop control is enabled, the Optidrive actual output frequency can be calculated using the following equation:-

$$\text{Output Frequency} = \text{Setpoint Frequency} - \frac{(\text{P6-09}(\%) \times \text{P1-09} \times \text{Actual Output Torque})}{\text{Motor Rated Torque}}$$

The value of P6-09 depends on the individual system and the slip characteristics of the motors in use. All Optidrives in the system should have the same value in P6-09, and the torque load of each drive should be monitored, whilst the value of P6-09 is adjusted to allow stable load sharing. Typically, the value will be in the 4 – 10% range; however this should be determined during commissioning.

9.5. PID Closed Loop Controller

9.5.1. General

Optidrive Plus 3GV supports full 3 term PID control of motor speed. PID control allows the drive to automatically adjust the speed of a connected motor to maintain a preset operating parameter, based on a feedback signal, e.g. controlling a pump speed to maintain a constant pressure, or a fan speed to maintain a constant temperature. Setpoints can be fixed digital or user adjustable analog. Feedback can be 0 – 10 volt or 0 / 4 – 20mA. All values are treated as % internally by the drive to assist in the simple set up.

9.5.2. Setpoint Selection

Optidrive Plus 3GV supports analog or digital setpoints, selected by P3-05.
P3-05 = 0 (Digital, Default) allows a fixed setpoint to be entered in P3-06, range 0.0 to 100.0%. This setpoint remains fixed in the drive, and can only be adjusted by changing the value in P3-05. This setting is ideal for systems that never require changes to the setpoint.
P3-05 = 1 (Analog) allows an analog signal to be connected to the Bipolar analog input to control the setpoint. This setting should be used for systems which require the user or operator to be able to easily adjust the setpoint.

9.5.3. Feedback Selection

A feedback signal can be connected to either the Bipolar Analog input, or Analog input 2. If the setpoint is connected to the Bipolar Analog Input, then the feedback signal must be connected to Analog Input 2. P3-10 selects the source of the feedback signal.
P3-10 = 0 (Analog Input 2, Default) selects Analog Input 2 as the source of the feedback. Signal can be 0 – 10 Volt or 4 – 20mA.
P3-10 = 1 (Bipolar Analog Input) selects the Bipolar Analog Input as the feedback source. This can only be used if P3-05 = 0. Signal must be a voltage signal, 24 Volt maximum, e.g. 0 – 10 Volt, 0 – 5 Volt, 0 – 24 Volt.
With the default mode of operation, an increase in the feedback signal causes a decrease in motor speed. This can be inverted, so that an increasing feedback signal causes an increase in output frequency, by setting P3-04 = 1.

9.5.4. PID Output Range

The maximum and minimum output range of the PID controller can be limited using P3-07 (High Limit) and P3-08 (Low Limit). This can be useful to control the speed range of a motor e.g. to prevent a pump running dry or over speeding. Both parameters can be set in the range 0.0 to 100.0%

9.5.5. Tuning PID Gains

As with any PID controller, the response and behaviour of the system is controlled by the Proportional Gain (P3-01), the Integral Time Constant (P3-02) and the Differential Time Constant (P3-03). Correct setting of these parameters is essential for stable and reliable system operation. There are many methods and text books available explaining how these terms work and how they can be tuned, and so only a brief summary is given below.

P3-01 Proportional Gain : Range 0.1 to 30.0, Default Setting 2.0

Proportional gain acts as a multiplier of the difference between the Feedback and Setpoint signals. The PID controller firstly determines the PID Error, assuming direct operation

PID Error = PID Setpoint – PID Feedback

The proportional gain is then used to multiply this error. If the Integral and Differential Time constants are both set to zero,

PID Output = Proportional Gain x (PID Setpoint – PID Feedback)

From this, it becomes clear that a large value will cause a greater change in output frequency for a small difference between the Feedback and Setpoint. If the value is too large, the system is likely to be unstable, and will often overshoot the setpoint. Higher values are acceptable on dynamic applications requiring fast response. Lower values should be used for slower responding systems, such as fan and pump control applications. If the system tends to overshoot, reducing the P gain will help resolve the problem.

P3-02 Integral Time Constant : Range 0.0 to 30.0, Default Setting 1.0

The integral time constant is a time based function, which modifies the output of the PID controller based on the change in PID Error for the preset time period. The effect of the Integral Time Constant is always to try to reduce the PID Error towards zero, so that Feedback = Setpoint. For dynamic systems which respond quickly, the value will need to be shorter. Slow response systems, such as temperature control applications will require a correspondingly longer time setting.

P3-03 Differential Time Constant : Range 0.00 to 1.00, Default 0.00

The differential time constant is also a time based function, this time modifying the PID output based on changes in the Setpoint. In many applications, setting to zero will give good results.

9.6. Dynamic Braking

9.6.1. General

Dynamic Braking allows the energy generated by a load during stopping to be dissipated using a suitable resistor. This allows reduced stopping times with high inertia loads, or control over loads which operate against with gravity, such as hoists or lifting type applications.

9.6.2. Connecting a Braking Resistor

Optidrive Plus size 2 units and above have provision to connect an optional dynamic braking resistor. The internal chopper is rated for 100% continuous braking at drive rated power. The minimum resistance value for each drive model shown in section 2.2 must be observed. Connecting a resistance below this value may well result in damage to the drive. An example wiring diagram can be found in section 0 on page 23.

CAUTION	**The Optidrive Plus has internal software monitoring for the brake resistor, to prevent overheating, based on the setting of P2-23 (see section 7.3 for further details). Where this protection is disabled (by setting P2-23 = 3), Invertek Drives recommend that external thermal protection, such as a thermal overload or thermistor be used to prevent overheating of the resistor.**
WARNING	**The Braking resistor connects to the DC Bus terminal connections of the drive, which can carry voltages in excess of 800 Volts DC. Safe installation is of paramount importance.**

9.6.3. Brake Chopper Operating Voltage

Drive Supply Voltage Range	Brake Chopper Operating Voltage
200 – 240 + / - 10%	360 Volts
380 – 480 + / - 10%	760 Volts
480 – 525 + / - 10%	890 Volts
500 – 600 + / - 10%	975 Volts

9.6.4. Selecting a Braking Resistor

There are three separate parameters to consider when selecting a Braking Resistor for an application.

Resistance

The resistance should **never** be less than the minimum value suitable for the drive in use as shown in the selection tables in section 2.2. Using a lower value can cause damage to the Optidrive. The resistance value effectively controls the maximum braking torque that the drive can achieve. A higher resistance value reduces the maximum available braking torque.

Power Rating & Duty

Braking resistor power levels are usually given as the continuous power rating the resistor can dissipate. Most resistors can typically dissipate many times this power level for a reduced time period and duty cycle. The power rating required for a resistor should be calculated based on the expected loading and duty cycle of the intended application. Further details of the resistors available from Invertek Drives can be found in section 11. Multiple resistors can be connected in Series and Parallel to achieve a higher power level and duty, providing that the minimum resistance value of the drive is observed.

Simple Example – Flywheel type application

Where an application has high inertia, but very infrequent stops, the duty cycle of the braking resistor is low. For example, consider a motor driving a large grinding wheel via a belt drive system.

Grinding Wheel Diameter = 1 Metre
Grinding Wheel Mass = 500 Kg
Flywheel Speed = 500 Rpm
Motor Speed = 1500 Rpm
Motor & Optidrive rated Power = 7.5kW
Required Stopping Time = 30 Seconds
Stopping Frequency = 2 Times per hour

Firstly, calculate the inertia of the driven load. The grinding wheel is effectively a solid flywheel, so the inertia, J is

$$J = ½ \times M \times r^2$$

Where M = Mass, r = radius
So in this example, $J = ½ \times 500 \times 0.5 \times 0.5 = 62.5\ Kgm^2$
Secondly, convert the speeds to radians per second

$$\text{Flywheel Speed} = \frac{500 \times 2 \times \pi}{60} = 52.4\ rads^{-1}$$

$$\text{Motor Speed} = \frac{1500 \times 2 \times \pi}{60} = 157.1\ rads^{-1}$$

The braking energy is transferred to the motor from the driven load, so the *reflected inertia* at the motor shaft should be considered. Reflected inertia is calculated by dividing by the square of the drive ratio. In this case

$$\text{Drive Ratio} = \frac{\text{Motor Speed}}{\text{Load Speed}} = 3$$

$$\text{Reflected Inertia} = \frac{62.5}{9} = 6.9\ \text{Kgm}^2$$

NOTE It is important when carrying out actual calculations to consider the *total* reflected inertia. This would include the inertia of the motor, the pulleys and belts and any other components. This becomes more important when considering dynamic applications with short stopping times, where the small differences in inertia can have a dramatic effect on the system performance. Additionally, frictional losses and inefficiencies in the mechanical system can also assist in reducing the overall braking requirements, and can be considered in calculations.

Now, calculate the braking torque

$$\text{Braking Torque} = \frac{\text{Total Inertia x Angular Velocity}}{\text{Required Stopping Time}} = \frac{6.9 \times 157.1}{30} = 36.13\ \text{Nm}$$

Peak Braking Power will always occur at the highest speed, so the braking power can be calculated as follows

$$\text{Power} = \text{Torque x Angular Velocity} = 36.13 \times 157.1 = 5676\ \text{Watts}$$

Assuming a linear deceleration rate, the average braking power during stopping

$$\text{Average Braking Power} = \frac{\text{Peak Braking Power}}{2} = 2838\ \text{Watts}$$

Based on the repeat cycle time, this power rating is required twice per hour for 30 seconds, so our duty is 1.7%. In this case, a brake resistor capable of 5.7kW peak, 2.8kW for 30 seconds at 1.7% duty is required.

Simple Example – Hoist Type Application

Any applications that involve lifting or lowering against gravity generally require a much higher duty cycle. For example, if we consider a vertical hoist raising and lowering a load.

Maximum Load = 1000Kg (Including lifting platform or hook)
Total Lifting Height = 10 Metres
Time required to Lift & Lower = 30 seconds
Repeat Cycle Time = 30 times per hour

The *energy* required during lifting

$$\text{Energy Required} = \text{Force x Distance}$$

Since the hoist is vertical, the Force involved is gravity, multiplied by the load mass

$$\text{Energy Required} = 9.8 \times 1000 \times 10 = 98{,}000\ \text{Joules}$$

So the Power required

$$\text{Power} = \text{Energy per Second} = 98{,}000 / 30 = 3267\ \text{Watts}$$

The same power will be required to be dissipated in the brake resistor during lowering. Any losses in the system will reduce the power requirement, however in the case of lifting and hoisting equipment, it is always advisable to allow some safety margin in the calculations. Calculations must also allow for accelerating and decelerating the load to and from rest.

In this case, assuming a time of 5 seconds for both acceleration and deceleration, the maximum linear speed of the load can be calculated as :-

$$\text{Maximum Linear Speed} = \frac{\text{Total Distance}}{(\tfrac{1}{2} \times \text{Accel Time} + \tfrac{1}{2} \times \text{Decel Time} + \text{Linear Speed Time})} = \frac{10}{25} = 0.4\ \text{ms}^{-1}$$

From this, the acceleration *rate* can be calculated

$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Time Taken}} = \frac{0.4}{5} = 0.08\ \text{ms}^{-2}$$

So, when decelerating the load, the additional *Force* placed on the lifting equipment

Force = Mass x Acceleration = 1000 x 0.08 = 80 Newtons

The distance covered by the load can be calculated

Distance Moved = ½ x Acceleration x Time^2 = 0.5 x 0.08 x 5 x 5 = 1 Metre

So the *total* energy required when decelerating the load

Energy = Force x Distance = 80 x 1 = 80 Joules

And the power

$$\text{Power} = \frac{80}{5} = 16 \text{ Watts}$$

In this example, with relatively long acceleration and deceleration rates, the additional power is negligible, but with short ramps, it would become much more significant.

Consideration needs to given the overall duty cycle. The system operates 30 times per hour; therefore the cycle time is 2 minutes or 120 seconds. During this time period, we need to consider when the braking resistor may be needed to operate. This will depend on the mechanical design of the system, however if we consider a worst case example, we would

Accelerating the load downwards for 5 seconds – Requires 3.2kW
Lowering at linear speed for 20 seconds – Requires 3.3kW
Decelerating the load to standstill for 5 seconds - Requires 3.3kW

So we require 3.3kW for 30 seconds every 120 seconds, or with a 25% duty cycle.

NOTE The mechanical design of the hoist plays a significant part in the overall calculation, and this example illustrates only how the braking resistor size should be selected when the mechanical system has been designed optimally for the rated load and lifting speed. The true calculation should allow for the motor and drive power and torque at actual operating speed, and the efficiency of the mechanical drive system, e.g. gearboxes etc.

9.7. Automatic Low Temperature Heating Function

9.7.1. Overview

Optidrive Plus 3GV has a built in function to allow the drive to automatically warm up its heatsink and power electronics in the event that the external ambient temperature is below the permissible range for drive operation. This function requires a brake resistor to be mounted onto the drive heatsink and connected to the Brake resistor terminals on the Optidrive, and this is utilised to provide the heating function.

CAUTION	**The Optidrive Plus has internal software monitoring for the brake resistor, to prevent overheating, based on the setting of P2-23 (see section 7.3 for further details). For safety reasons, Invertek Drives recommend that external thermal protection, such as a thermal overload or thermistor be used to prevent overheating of the resistor.**
WARNING	**The Braking resistor connects to the DC Bus terminal connections of the drive, which can carry voltages in excess of 800 Volts DC. Safe installation is of paramount importance.**
WARNING	**This function is designed to allow the Optidrive to heat itself only, and not to provide heating for ancillary components. The Optidrive must be completely free from frost and condensation prior the mains power being applied. Any moisture ingress will almost certainly result in damage to the Optidrive if the mains power is applied.**
WARNING	**Incorrect programming of the heating function can result in excessive power being applied to the dynamic brake resistor, with a potential risk of fire or failure. It is recommended that external thermal protection or a resistor with a failsafe internal fuse be used to prevent possible damage.**

9.7.2. Brake Resistor Installation

The brake resistor must be mounted to the Optidrive heatsink, with good thermal contact. Invertek can supply suitable resistors designed for this type of mounting. These resistors are generally suitable for light duty braking only, and can be used to provide the heating function and low duty braking. If a high braking duty is required, typically > 5%, an alternative resistor should be used.

9.7.3. Commissioning

In order to enable this function, the brake resistor should be enabled by setting P2-23 > 0. The actual setting of P2-23 will depend on whether external thermal protection is in use and the power capacity of the connected resistor. Typically, setting 1 will provide adequate heating in most applications.

The heat generated by the resistor will be determined by

- The Incoming Supply Voltage
- The Brake Resistor Resistance. This must never be below the minimum rating for the drive shown in section 2.2
- The Brake Resistor Heating Duty Cycle (P6-10)

$$\text{Heat Output} = \frac{(\text{Supply Voltage} \times \sqrt{2})^2}{\text{Brake Resistor Resistance}} \times \text{P6-10(\%)}$$

The resistor used must be capable of operating continuously at this power rating, and so the value of P6-10 should be selected to stay within the continuous power rating of the resistor.

For a drive operating on a 400 volt supply and using a resistor of 50R at 10% duty

$$\text{Heat Output} = \frac{(400 \times \sqrt{2})^2}{50} \times 10\% = \sim 640 \text{ Watts}$$

Since the supply voltage largely determines the power generated, Invertek drives recommends the following resistors sizes as a guide:-

		Resistor		
Optidrive	Supply Voltage	Resistance (Ω)	Power (Watts)	P6-10 Setting (%)
Frame Size 2	200 – 240	100	200	10.0
	380 – 480	100	200	4.5
	480 – 600	100	200	2.5
Frame Size 3	200 – 240	33	500	14.0
	380 – 480	33	500	3.5
	480 – 600	33	500	2.3
Frame Size 4	200 – 240	33	500	14.0
	380 – 480	33	500	3.5
	480 – 600	33	500	2.3
Frame Size 5	200 – 240	33	500	14.0
	380 – 480	33	500	3.5
	480 – 525	33	500	3.0
Frame Size 6	200 – 240	33	500	14.0
	380 – 480	33	500	3.5
	480 – 525	33	500	3.0

9.8. Closed Loop Encoder Feedback Option

9.8.1. Overview

Where a motor feedback encoder is to be used, an additional encoder interface module (part number ODP-ENCOD) must be used to interface the signal to the drive. See section 11.5 for encoder module information. The encoder must be rigidly fixed to the motor shaft, to provide an accurate shaft speed feedback for the drive.

9.8.2. Parameters

The following parameters affect the behaviour of the drive when an encoder is used:-

Par.	Description	Range	Units	Default	Explanation
P1-07	Motor rated voltage	0, 20 to 250 0, 20 to 500	Volts	230 400 (460)	Rated (nameplate) voltage of the motor (Volts). Value limited to 250V for low voltage drives. Setting to zero disables voltage compensation
P1-08	Motor rated current	25% -100% of drive rated current	Amps	Drive rating	Rated (nameplate) current of the motor
P1-09	Motor rated frequency	25Hz to 500Hz	Hz	50.0 (60.0)	Rated (nameplate) frequency of the motor
P1-10	Motor rated speed	0 to 30 000 rpm	Rpm	0	When operating a motor with an encoder, this value **MUST** be set to the rated (nameplate) rpm of the driven motor. The Optidrive display will now show motor speed in estimated rpm. All speed related parameters, such as Minimum and Maximum Speed, Preset Speeds etc will also be displayed in Rpm.
P1-14	Parameter Access Coder	0..30000	-	101	Enables access to the extended drive parameters. Set to 702 to enable access to the encoder configuration parameters.
P4-01	Control Mode	0 : Vector Speed Control 1 : Vector Torque Control 2 : V/F Speed Control	-	2	Selects the motor control method. An autotune must be performed following a change, see section 6.4
P4-02	Motor parameter autotune	0 : Disabled 1 : Enabled	-	0	When set to 1, the drive immediately carries out a non-rotating autotune to measure the motor parameters for optimum control and efficiency
P4-03	Speed controller proportional gain	0 to 4096	-	300	Sets the proportional gain value for the speed controller. Higher values provide better output frequency regulation and response. Too high a value can cause instability or even over current trips. For applications requiring best possible performance, the value should be adjusted to suit the connected load by gradually increasing the value and monitoring the actual output speed of the load until the required dynamic behaviour is achieved with little or no overshoot where the output speed exceeds the setpoint. In general, higher friction loads can tolerate higher values of proportional gain, and high inertia, low friction loads may require the gain to be reduced.
P4-04	Speed controller integral time	0.050 to 1.000	seconds	0.150	Sets the integral time for the speed controller. Smaller values provide a faster response in reaction to motor load changes, at the risk of introducing instability. For best dynamic performance, the value should be adjusted to suit the connected load.
P6-05	Encoder Feedback Enable	0 : Disabled 1 : Enabled	-	0	Enables or Disables the encoder feedback option. Set to 1 to enable the motor holding brake
P6-06	Encoder PPR	0..10000	-	0	If P3-08 >0, this value **must** be set to the PPR of the connected encoder.
P6-07	Speed Error Trip Level	0..50.0	%	5.0	When an encoder is in use, sets the allowed % speed differential between the drives calculated motor speed and the signal feedback from the encoder. When the threshold is exceeded, the drive trips.

9.8.3. Installation Overview

The drive, encoder module and encoder should be connected as shown in section 11.5 using the supplied RJ11 connection cable. The cable used to connect the encoder to the encoder module should be an overall shielded twisted pair cable. The screen should be bonded to earth at both ends to minimise the risk of noise on the signal cable.

9.8.4. Commissioning

For optimum performance, the Optidrive should firstly be commissioned in Sensorless vector mode as described in sections 9.1 for Speed Control Operation or sections 9.2 for Torque Control Operation. P6-05 should be set to 0 to disable encoder feedback until all of the following steps have been completed. Operation with an encoder is largely the same as operation in standard Vector Speed or Torque Mode, and the same guidelines for operation apply, however the Optidrive now has an accurate feedback of the motor speed, which will provide improved behaviour when operating close to or at zero speed. It is recommended to test the operation of the drive in Vector Mode before enabling the encoder, to ensure the motor operates correctly.

Once the Optidrive is operating correctly in vector mode without the encoder option enabled, the motor nameplate RPM and the encoder PPR values should be entered into the relevant parameters. Following this, a speed polarity check should be made to ensure that the sign of the feedback signal matches that of the speed reference in the drive. Carry out the check as follows:-

- Ensure the Encoder feedback control is disabled (P6-05 is set to zero)
- Run the Optidrive with a low positive speed, e.g. 10Hz
- Monitor the encoder feedback speed in parameter P0-57.
- If the value in this parameter is positive, the encoder wiring is correct.
- If the value is negative, the speed feedback is inverted. To correct this, reverse the A and B signals from the encoder.

Varying the drive output speed should then result in the value of P0-57 changing to reflect the change of the actual motor speed. If this is not the case, check the wiring of the whole system.

If the above check is passed, the feedback control function can be enabled by setting P6-05 to 1.

To get the best speed control performance in vector speed control mode (P4-01 =0), the speed control loop parameters (P4-03, P4-04) will need to be adjusted. In general, reducing the value of P4-03 (e.g. P4-03 = 200) and increasing the value of P4-04 (e.g. P4-04 = 0.150) will improve low speed control performance.

10.Serial communications

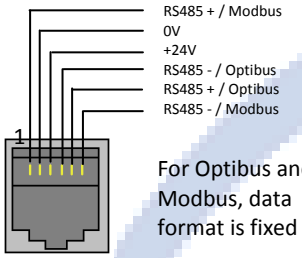
10.1. IRDA communications

The Optidrive Plus has an integrated IrDA port, for use with a Pocket PC and Optiwand PDA software. This allows access to all parameters for drive set-up and monitoring during operation. To allow multiple drives to be configured, the drive communications address is configured using parameter P2-27. The protocol used is Invertek's own Optibus Plus protocol.

10.2. RS-485 communications

In addition to the IrDA data link, Optidrive Plus has an RJ11 connector on the front of the control panel. This connector allows the user to set up a drive network via a wired connection. The connector contains two independent RS485 connections, one for Invertek's Optibus Protocol and one for Modbus RTU. Both connections can be used simultaneously.

The electrical signal arrangement of the RJ11 connector is shown as follows:



RS485

For Optibus and Modbus, data format is fixed as:

The Optibus data link uses the same communication protocol as is used for IrDA communication. This is used for the Master / Slave function (see section 9). Up to 62 slaves can be connected to one master drive.

The Modbus interface allows connection to a Modbus RTU network as described below.

10.3. Modbus RTU Communications

10.3.1. Modbus RTU Specification

Protocol	Modbus RTU
Error check	CRC
Baud rate	9600bps, 19200bps, 38400bps, 57600bps, 115200bps (default)
Data format	1 start bit, 8 data bits, 1 stop bits, no parity.
Physical signal	RS 485 (2-wire)
User interface	RJ11 (see section 10.2 for more information)

10.3.2. Modbus Telegram Structure

The Optidrive Plus 3GV supports Master / Slave Modbus RTU communications, using the 03 Read Holding Registers and 06 Write Single Holding Register commands. Many Master devices treat the first Register address as Register 0; therefore it may be necessary to convert the Register Numbers detail in section 10.3.3 by subtracting 1 to obtain the correct Register address. The telegram structure is as follows:-

Command 03 – Read Holding Registers						
Master Telegram	**Length**			**Slave Response**	**Length**	
Slave Address	1	Byte		Slave Address	1	Byte
Function Code (03)	1	Byte		Starting Address	1	Byte
1st Register Address	2	Bytes		1st Register Value	2	Bytes
No. Of Registers	2	Bytes		2nd Register Value	2	Bytes
CRC Checksum	2	Bytes		Etc...		
				CRC Checksum	2	Bytes

Command 06 – Write Single Holding Register						
Master Telegram	**Length**			**Slave Response**	**Length**	
Slave Address	1	Byte		Slave Address	1	Byte
Function Code (06)	1	Byte		Function Code (06)	1	Byte
Register Address	2	Bytes		Register Address	2	Bytes
Value	2	Bytes		Register Value	2	Bytes
CRC Checksum	2	Bytes		CRC Checksum	2	Bytes

10.3.3. Modbus Register Map

Register Number	Par. Number	Type	Supported Commands	Function Low Byte	Function High Byte	Range	Explanation
1	-	R/W	03,06	Drive Control Command		0..3	16 Bit Word. Bit 0 : Low = Stop, High = Run Enable Bit 1 : Low = No Function, High = Fault Reset Bit 2 : Low = Decel Ramp 1 (P1-04), High = Decel Ramp 2
2	-	R/W	03,06	Modbus Speed reference setpoint		0..5000	Setpoint frequency x10, e.g. 100 = 10.0Hz
3	-	R/W	03,06	Torque reference		0..2000	Torque Setpoint %x10, e.g. 1000 = 100.0%
4	*For Firmware release V2.xx with 3GV-M application Macro loaded :*						
	-	R/W	03,06	Acc ramp time	Dec ramp time	0..255	Ramp time in seconds x 10, e.g. 250 = 25 seconds
	For Firmware release V3.xx :						
	-	R/W	03,06	Acceleration & Deceleration Time		0..6000	Ramp times in seconds x 10. Simultaneously controls both acceleration and deceleration ramp times
5	-	R	03	Reserved			
6	-	R	03	Error code	Drive status		Low Byte = Drive Error Code, see table below High Byte = Drive Status as follows :- 0 : Drive Stopped 1: Drive Running 2: Drive Tripped
7	-	R	03	Output Motor Frequency		0..5000	Output frequency in Hz x10, e.g. 100 = 10.0Hz
8	-	R	03	Output Motor Current		0..6000	Output Motor Current in Amps x10, e.g. 10 = 1.0 Amps
9	P0-13	R	03	Output Motor Torque		0..2000	Output Motor Torque %x10, e.g. 1000 = 100.0%
10	-	R	03	Output Motor Power		0..3200	Output Motor Power in kW x10, e.g. 100 = 10.0kW
11		R	03	Digital input status		0..15	Indicates the status of the 4 digital inputs Lowest Bit = 1 Input 1
12		R	03	Rating ID		0..1000	Analog input % of full scale x10, e.g. 1000 = 100%
13		R	03	Power rating		0..1000	Analog input % of full scale x10, e.g. 1000 = 100%
14		R	03	Voltage rating		0..1000	DC Bus Voltage in Volts
15		R	03	Software version		0..100	Drive heatsink temperature in ºC
21	P0-01	R	03	Bipolar analog input value		0..1000	One decimal place 156=15.6%
22	P0-02	R	03	2nd analog input value		0..1000	One decimal place 156=15.6%
23	P0-03	R	03	Post Ramp Speed Reference		0..1000	156=156%
24	P0-04	R	03	Digital speed reference		0..1000	Internal value
25	P0-05	R	03	Motor torque reference		0..1000	2000=200.0%
26	P0-06	R	03	User PID reference		0..1000	One decimal place 156=15.6%
27	P0-07	R	03	User PID feedback		0..1000	One decimal place 156=15.6%
28	P0-08	R	03	User PID error input		0..100	One decimal place 156=15.6%
29	P0-09	R	03	User PID P term output		0..1000	One decimal place 156=15.6%
30	P0-10	R	03	User PID I term output		0..1000	One decimal place 156=15.6%
31	P0-11	R	03	User PID D term output		0..1000	One decimal place 156=15.6%
32	P0-12	R	03	User PID Output		0..1000	One decimal place 156=15.6%
33	P0-13	R	03	Motor output torque		0..1000	1000 = 100.0%
34	P0-14	R	03	Magnetizing current		0..1000	One decimal place 156=15.6A
35	P0-15	R	03	Rotor current		0..1000	One decimal place 156=15.6A
36	P0-16	R	03	Field strength		0..100	One decimal place 156=15.6%
37	P0-17	R	03	Stator resistance		0..10000	Size 1: Two decimal place 156=1.56ohm Other: Three decimal place 156=0.156ohm
38	P0-18	R	03	Stator inductance		0..10000	Four decimal place 156=0.0156h
39	P0-19	R	03	Rotor resistance		0..10000	Size 1: Two decimal place 156=1.56ohm Other: Three decimal place 156=0.156ohm
40	P0-20	R	03	DC bus voltage		0..1000	256 = 256V
41	P0-21	R	03	Drive temperature		0..120	23 = 23 0C
42	P0-22	R	03	Supply voltage L1		0..660	230 = 230V
43	P0-23	R	03	Supply voltage L2		0..660	230 = 230V
44	P0-24	R	03	Supply voltage L3		0..660	230 = 230V
45	P0-25	R	03	Estimated rotor speed (Hz / Rpm)			In Vector Mode, shows actual motor speed
46	P0-26	R	03	KWh meter			One decimal place 156=15.6Kwh
47	P0-27	R	03	MWh meter			156=156Mwh
129	P1-01	R/W	03, 06	Max speed limit		0 to 7200	Internal value
130	P1-02	R/W	03, 06	Min speed limit		0 to 7200	Internal value
131	P1-03	R/W	03, 06	Accel ramp time		0 to 30000	One decimal place 300=30.0s

Register	Par.	Type	Supported	Function	Range	Explanation
132	P1-04	R/W	03, 06	Decel ramp time	0 to 30000	One decimal place 300=30.0s
133	P1-05	R/W	03, 06	Stop mode select	0 to 2	0: Ramp to stop 1: Coast to stop 2: Ramp to stop
134	P1-06	R/W	03, 06	Energy Optimiser	0 ,1	0: Disable 1: Enable
135	P1-07	R/W	03, 06	Motor rated voltage	20 to 250 (Low) 20 to 500 (High)	
136	P1-08	R/W	03, 06	Motor rated current	Drive dependent	One decimal place 300=30.0A
137	P1-09	R/W	03, 06	Motor rated frequency	25 to 500	Data unit in Hz
138	P1-10	R/W	03, 06	Motor rated speed	0 to 60000	Data unit in RPM
139	P1-11	R/W	03, 06	Preset speed 1	-P1-01 to P1-01	Internal value
140	P1-12	R/W	03, 06	Control mode	0 to 4	0: Terminal 1: Keypad forward only 2: Keypad forward and reverse 3: PID control mode (N/A) 4: Modbus control mode
141	P1-13	R/W	03, 06	Trip log		Last four trips (See Appendix for details)
142	P1-14	R/W	03, 06	Access code	0 to 30000	
143	P2-01	R/W	03, 06	Digital inputs function	0 to 21	See user guide for function details
144	P2-02	R/W	03, 06	Preset speed 2	-P1-01 to P1-01	Internal value
145	P2-03	R/W	03, 06	Preset speed 3	-P1-01 to P1-01	Internal value
146	P2-04	R/W	03, 06	Preset speed 4	-P1-01 to P1-01	Internal value
147	P2-05	R/W	03, 06	Preset speed 5	-P1-01 to P1-01	Internal value
148	P2-06	R/W	03, 06	Preset speed 6	-P1-01 to P1-01	Internal value
149	P2-07	R/W	03, 06	Preset speed 7	-P1-01 to P1-01	Internal value
150	P2-08	R/W	03, 06	Preset speed 8	-P1-01 to P1-01	Internal value
151	P2-09	R/W	03, 06	Skip frequency 1	-P1-01 to P1-01	Internal value
152	P2-10	R/W	03, 06	Skip freq band 1	P1-02 to P1-01	Internal value
153	P2-11	R/W	03, 06	Analog output function	0 to 10	See user guide for function details
154	P2-12h	R/W	03, 06	Digital output ctrl limit (h)	0 to 100	Located in lower byte
	P2-12L	R/W	03, 06	Digital output ctrl limit (L)	0 to P2-12h	Located in higher byte
155	P2-13	R/W	03, 06	Relay output function	0 to 6	See user guide for function details
156	P2-14h	R/W	03, 06	Relay control limit (h)	0 to 100	Located in lower byte
	P2-14L	R/W	03, 06	Relay control limit (L)	0 to P2-14h	Located in higher byte
157	P2-15	R/W	03, 06	Relay output mode	0 to 1	0: Normally open 1: Normally closed
158	P2-16	R/W	03, 06	Zero speed holding time	0 to 60s	600 = 60.0s
159	P2-17	R/W	03, 06	Start mode select	0 to 6	0: Edgr-r 1: Auto_0 2…6: Auto_1 to Auto_5
160	P2-18	R/W	03, 06	Spin Start Enable	0 to 1	0 : Disabled 1 : Enabled
161	P2-19	R/W	03, 06	Keypad restart mode	0 to 3	See user guide for details
162	P2-20	R/W	03, 06	Enable standby	0 to 600	Data unit in second (s) x 10
163	P2-21	R/W	03, 06	Display scaling factor	0 to 30000	Three decimal place 300=0.3.00
164	P2-22	R/W	03, 06	Display scaling source	0 to 1	0: 2nd analog input 1: Drive speed
165	P2-23	R/W	03, 06	Brake circuit enable	0 to 3	See user guide for function details
166	P2-24	R/W	03, 06	Effective switching freq.	0 to 4	0 = 4KHz, 1 = 8KHz, 2 = 16KHz

Register	Par.	Type	Supported	Function	Range	Explanation
					(drive rating dependent)	3 = 24KHz, 4 = 32KHz
167	P2-25	R/W	03, 06	2nd Decel ramp time (s)	0 to 30000	One decimal place 300=30.0s
168	P2-26	R/W	03, 06	Modbus baudrate	0 to 4	0 = 9600bps 1 = 19200bps 2 = 38400bps 3 = 57600bps 4 = 115200bps
169	P2-27	R/W	03, 06	Drive comms address	1 to 63	
170	P2-28	R/W	03, 06	Master/Slave mode	0 to 1	This is for Optibus application only, not for Modbus.
171	P2-29	R/W	03, 06	Speed scaling factor	0 to 5000	One decimal place 300=30.0%
172	P2-30	R/W	03, 06	Bipolar an input format	0 to 3	0: 0..24V 1: 0..10V 2: -10..10V 3: -24V ..24V
173	P2-31	R/W	03, 06	Bipolar an input scaling	0 to 5000	One decimal place 300=30.0%
174	P2-32	R/W	03, 06	Bipolar an input offset	-5000 to 5000	One decimal place 300=30.0%
175	P2-33	R/W	03, 06	2nd an input format	0 to 3	0: 0/24V Digital 1: 0..10V 2: 4..20mA 3: 0..20mA
176	P2-34	R/W	03, 06	2nd an input scaling	0 to 5000	One decimal place 300=30.0%
177	P2-35	R/W	03, 06	Digital speed reference scaling control	0 to 3	See user guide for function details
178	P2-36	R/W	03, 06	Analog output format	0 or 3	0: 0..10V 1: 4..20mA 2: 10..0V 3: 20..4mA
179	P2-37	R/W	03, 06	Extended access code	0 to 9999	
180	P2-38	R/W	03, 06	Parameter lock	0 or 1	0: Unlock 1: Locked
181	P2-39	R/W	03, 06	Drive run time	Read only	Read value as hours
182	P2-40	R/W	03, 06	Drive power rating	Read only	Power with 2 decimal place
183	P3-01	R/W	03, 06	User PID P-Gain	1 to 300	One decimal place 200=20.0
184	P3-02	R/W	03, 06	User PID integral time constant	1 to 300	One decimal place 200=20.0s
185	P3-03	R/W	03, 06	Differential time constant	0 to 100	Two decimal place 20=0.20s
186	P3-04	R/W	03, 06	User PID operating mode	0 or 1	0: Direct mode 1: Inverse mode
187	P3-05	R/W	03, 06	User PID reference select	0 or 1	0: digital 1: Bi-polar analog input
188	P3-06	R/W	03, 06	User PID digital ref	0 to 1000	One decimal place 300=30.0%
189	P3-07	R/W	03, 06	User PID output high limit	0 to 100	No decimal place 100=100%
190	P3-08	R/W	03, 06	User PID output low limit	0 to 100	No decimal place 100=100%
191	P3-09	R/W	03, 06	PID output limit control	0 to 3	See user guide for function details
192	P3-10	R/W	03, 06	User PID feedback select	0 to 1	0: 2nd analog input 1: Bipolar analog input
199	P4-01	R/W	03, 06	Control mode	0, 1, 2	0: Vector speed control 1: Vector torque control 2: V/F speed control
200	P4-02	R/W	03, 06	Motor parameter auto-tune	0 or 1	
201	P4-03	R/W	03, 06	Speed controller P-gain	0 to 4096	
202	P4-04	R/W	03, 06	Speed controller integral time constant	0.001 to 0.100s	1 = 0.001s
203	P4-05	R/W	03, 06	Motor power factor	0.50 to 0.99	78 = 0.78
204	P4-06	R/W	03, 06	Torque reference select	0 to 3	0: digital preset value 1: Bipolar analog input 2: 2nd analog input 3: Modbus reference
205	P4-07	R/W	03, 06	Maximum torque limit/Ref	0 to 200%	100= 100%
206	P4-08	R/W	03, 06	Minimum torque limit	0 to 150.0%	100 = 10.0%
207	P4-09	R/W	03, 06	V/F characteristic adjustment frequency	0 to P1-09	500 = 50.0Hz
208	P4-10	R/W	03, 06	V/F characteristic adjustment voltage	0 to P1-07	100 = 100V

11.Options and Accessories

11.1. Optiport Plus Remote Keypad

General

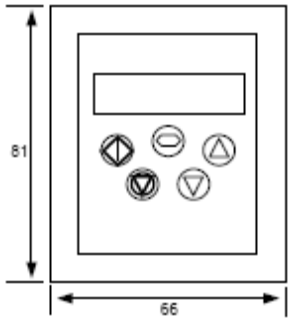
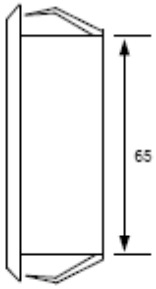
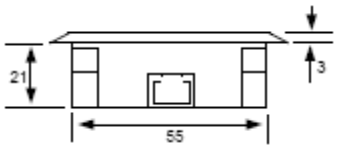
The Optiport Plus is a remote keypad unit for use with Optidrive Plus 3GV. The keypad communicates to the drive using Invertek's own Optibus profile, via the RJ11 connector on the front of the drive. An Optibus network can consist of up to 63 nodes, with a maximum of two Optiport Plus Keypads, the other nodes being Optidrive Plus. Power is normally supplied to the Optiport Plus from the RJ11 connector on a connected drive.

Specification

Signal Interface	:	Standard 6-way RJ11 connector
Supply Input	:	10V … 36V DC, 30mA
RS485 signal	:	industry standard 2-wire +5V differential
Environmental	:	Operational 0 … 50 °C
Storage		-40 °C … 60 °C
Relative Humidity	:	< 95% (non condensing)
Protection rating	:	IP54
Max cable length	:	20m (total length)

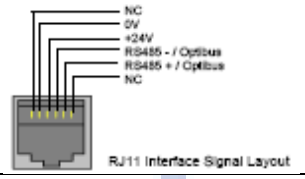
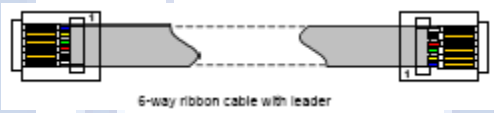
Mechanical Installation

The Optiport Plus is designed to be through panel mounted.

Front Face View	Side View	Bottom (Connector) View
		

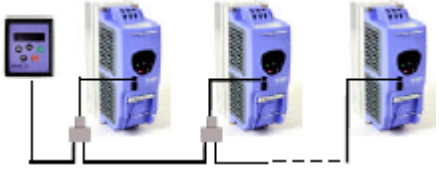
Electrical Installation

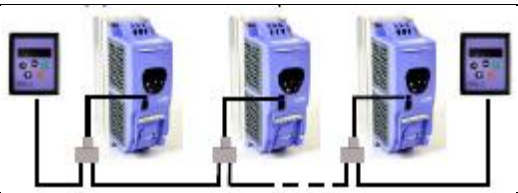
The Optiport Plus is uses a standard RJ11 6-Way connector as its electrical interface, which provides a simple solution for the user to setup their system using a standard RJ11 6-Way data cable. The signal layout of the connector is as follows:

	
Standard 6-way data cables with plugs are available from Invertek Drives Ltd on request in lengths of 0.3, 1 and 3 metres. If the data cable is made up on site, ensure that the connection pin out is correct : Pin 1 to Pin 1, Pin 6 to Pin 6 etc.	Incorrect cable connection may damage the drive. Extra care should be taken when using third party cable.

Example Configurations

Depending on the requirement of the application, Optiport Plus can be used in the following four different ways:

Single Optidrive Plus 3GV, Single Optiport Plus Keypad	Up to 63 Optidrive Plus 3GV, Single Optiport Plus Keypad
	
Single Optidrive Plus 3GV, 2 Optiport Plus Keypads	Up to 63 Optidrive Plus 3GV, 2 Optiport Plus Keypads



START UP

Selecting the Optidrive Network Address

By default, the Optiport Plus will try to communicate with the Optidrive that has address 1 in the network after powering up for the first time. The Optidrive Plus' network address is configured in parameter P2-27 on each Optidrive Plus. Each node on the network *must* have a unique address assigned for the network to function.

The Optiport Plus will display "SCAn.." after power up, which indicates that the Optiport Plus is searching the drive with the correct drive address in the network. Once the drive has been found, the message "LoAd.." will be displayed on the Optiport Plus display window, which indicates that the Optiport Plus is reading the configuration information from the drive. Usually it will take 1~2 seconds for the Optiport Plus to read this information. After the data has been loaded, the Optiport Plus will display the drive real time status.

If the Optiport Plus doesn't find a drive with address 1 in the network, i.e. there is only one drive in the network and its address is not equal to 1, the Optiport Plus will request the user to input an alternative address with which to establish communication. The default communication address will be displayed on the monitor window as "Adr-01". The user can then adjust the address from 1 to 63 by using the ▲ or ▼ buttons on the Optiport Plus.

Once the address has been changed to a value to match that of the connected drive, the ▼ button must be pressed to enable the Optiport Plus to search for the drive again.

On networks with multiple Optidrives, the user can select which Optidrive network address to communicate with.

Pressing the ▼ and ▼ buttons together results in the message "Adr-XX", where "XX" represents the present address. Using the ▲ or ▼ button to select the desired Optidrive address. After selecting the new address, pressing ▼ and ▼ button together again will result in the Optiport Plus establishing communications with the drive that has the selected address.

Changing the Optiport Plus network address

A maximum of two Optiports can be connected on the same network, to communicate with the same drive or different drives.

When using two Optiports with the same drive, the user needs to change the Optiport network address on the second Optiport to ensure correct operation. All Optiport Plus units are set to device 1 by default.

To change the device number, press the ⬭, ▼ and ▼ buttons together. The message "Port-H" (H = 1 or 2) will be displayed. The user can then use the ▲ or ▼ buttons to change the device number to 1 or 2 as required. Press ⬭, ▼ and ▼ button together again to return to normal operation.

Note:

- For networks using only one Optiport Plus, this must be address 1, and all Optidrives must be set for address 2 or higher.
- For Networks with two Optiport Plus units connected, the Optiport Plus's must be configured for network addresses 1 and 2, and all Optidrives must be configured for network address 3 or greater
- When a network has 2 Optiport Plus units connected, it is no longer possible to use Optistore PC software to communicate with the Optidrives.

11.2. Optiwand PDA Pocket PC Software

Optiwand software is a Windows Compact Edition application, available as Optiwand PDA for Pocket PC's (PDAs). This unique concept allows users to commission drives and retain parameter records without the requirement for an expensive lap top PC or complex connection cables, saving both time and costs. Parameter sets are stored as files for simple editing and later transfer to a PC. Communication can take place through transparent materials, such as glass and perspex.

- Real Time Parameter Access and Monitoring
- Infra Red based comms, no cable required
- Multi Language
- Online Parameter Help and Descriptions
- Fast Copy Facility
- Remote Control and Monitoring

Optiwand SP and Optiwand PDA are compatible with most Pocket PCs and Smartphones running the Windows Mobile 5.0 operating system. If you are considering purchasing a Pocket PC, we are UNABLE to support any Pocket PC's that use the OMAP microprocessor; these are generally the mobile phone versions.

Drive Compatibility

- Optiwand SP - Optidrive E2
- Optiwand PDA - Optidrive E2, Plus, VTC

11.3. Optistore Plus PC Software

Optistore is a Windows application program for pc's, allowing quick and accurate communication with Optidrive networks for parameter management and network monitoring.

- Plug and go, simple and easy PC parameter access
- Individual drive or drive network use
- PC based data storage and file management
- Runs on windows 2000 & XP
- Parameter set transfer to or from an Optiwand CE Plus
- File management: naming, storing, printing, emailing etc.
- Connects to Optidrive Plus 3GV & VTC using USB-RS485 communications adaptor (OD-485AD)
- For drive network management including configuration, monitoring and control
- Parameter Export facility allows the user to insert parameter settings in other programs e.g. Microsoft WORD (*.rtf format)

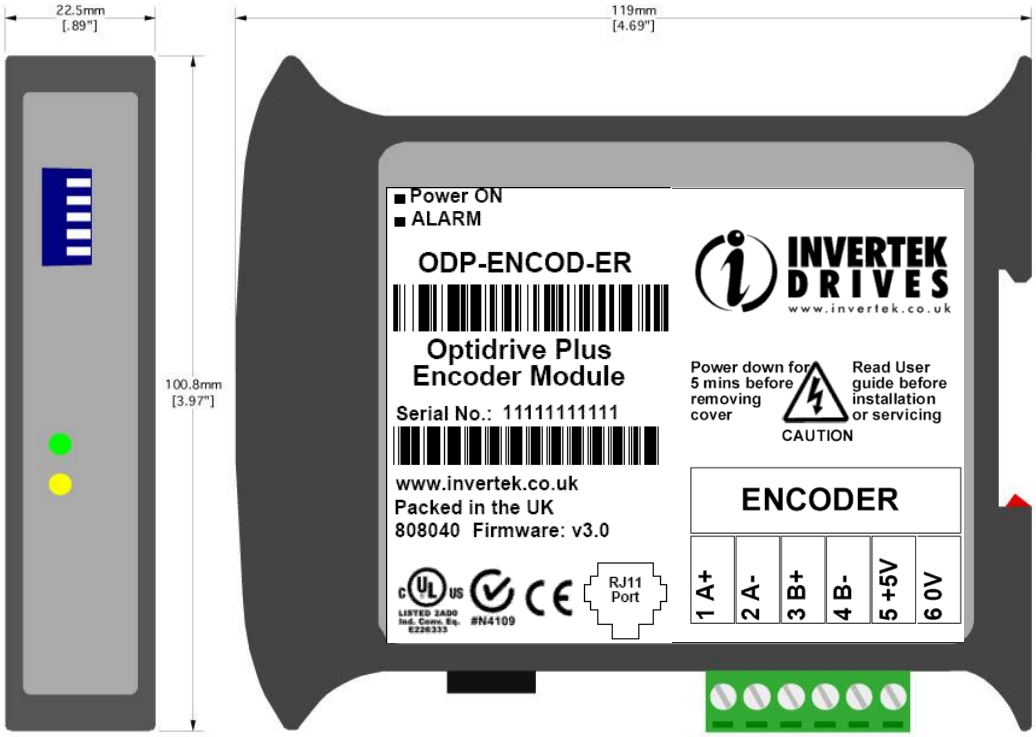
11.4. Communication Cables and Splitters

Cable	Description	Comprises
OD-48503-IN	RS-485 data cable, 0.30m	Cable with RJ11 terminations at each end
OD-48510-IN	RS-485 data cable, 1.0m	Cable with RJ11 terminations at each end
OD-48530-IN	RS485 data cable, 3.0m	Cable with RJ11 terminations at each end
Cable Accessory	**Description**	**Comprises**
OD-485SP-IN	RS485 data cable splitter	RS 485 splitter, 1 to 2 connection

11.5. Encoder Feedback Interface

An optional encoder feedback module is available, to allow connection of a motor feedback encoder. The encoder feedback module connects to the Optidrive via the RJ11 connector on the front cover, and is supplied with power directly from the Optidrive. Only one Encoder module may be connected to each drive, and multiple drives and encoder modules must **not** be networked to each other. The module can work with either single ended or differential encoders with operating voltages from 5 – 30 volts DC.

Note : For supply voltages greater than 5 volts (e.g. HTL encoders), the encoder must be powered from a separate power supply. 5 Volt (e.g. TTL) encoders can be powered directly from the Encoder Interface.



RJ11 Connector to Optidrive

Encoder Connection Terminals

LED Status Indication

The encoder module has 2 LEDs – Green and Yellow.

- The Green LED indicates power
- The Yellow LED indicates a fault condition. This may be a communication fault or encoder wiring fault. The fault code is indicated on the drive display as noted above. For transient faults, the LED will remain illuminated for 50ms to ensure that fast transient faults can be observed.

11.6. Dynamic Braking Resistors

Available Range

All Optidrive Plus 3GV sizes 2 and above have internal brake choppers fitted to allow connection to external resistors. Invertek Drives can supply the following resistors.

Part Number	Resistance Ω	Power Rating Continuous	Peak (0.125s)	Style	Dimensions (mm) L	W	Dp
OD-BR100-IN	100	200W	12000W	IP20	188	40	9
OD-BRES4-IN	33	500W	21000W	IP20	188	40	9
OPT-BR050-IN-I55	50	200W	12000W	IP55	250	21	40

The resistors are designed to be mounted to the Optidrive heatsink, for ease of installation and better heat dissipation capacity.

Overload Capacity

20 times rated power for 1 second every minute –OR- 4 times rated power for 5 seconds every minute.

12.Application Examples

12.1. Pump PID Pressure Control

Overview

Optidrive Plus 3GV drives can be used in a variety of pump control applications. A common application is where a pump is required to automatically maintain a constant pressure, in for example a water feed system. This uses the internal PID controller of the Optidrive.

PID Overview

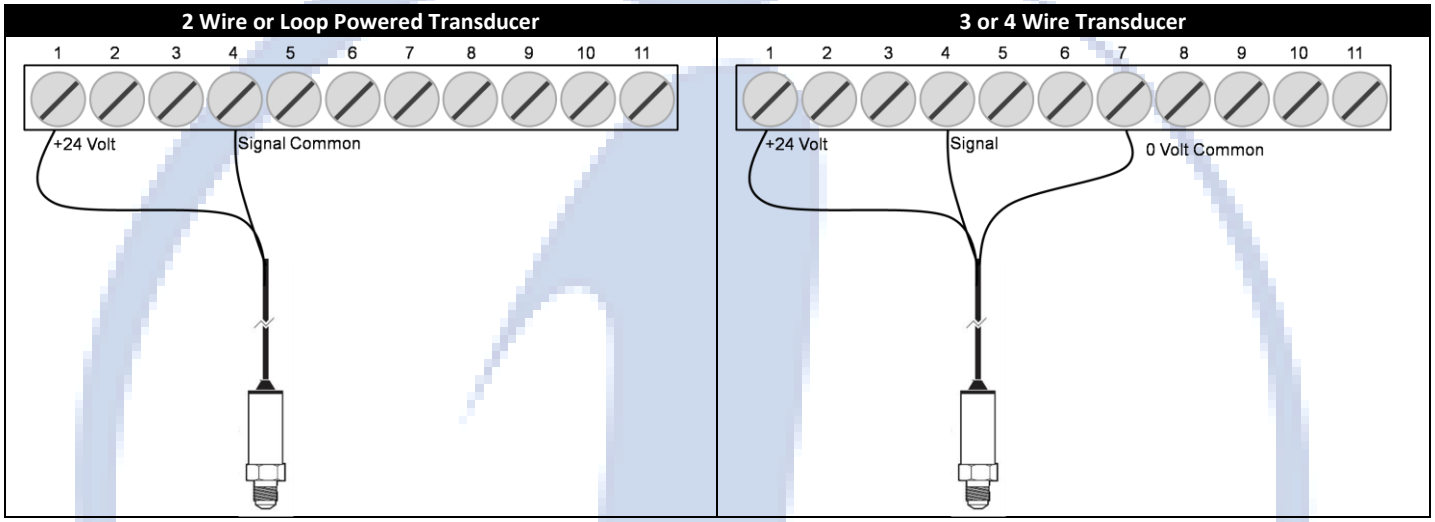
PID control is widely used in many applications. A PID system requires

- A Setpoint – In this case a pressure level which the pump is required to maintain, e.g. 1.5 Bar
- A Feedback Signal – this is the signal from the pressure transducer

The drive will continuously monitor the feedback signal and compare it to the setpoint, and then adjust the speed of pump automatically to try to maintain the correct pressure level.

Feedback Transducers

There are generally two types of transducers, and an example of how to connect each of these to the drive is shown below.



For a simple application with only PID Control required, the only other connection required is a Start / Stop switch link between terminal 1 and terminal 2.

PID Parameter Settings – Simple Fixed PID Setpoint

Par	Function	Example Setting	Explanation
P1-02	Minimum Frequency	10 - 30Hz	Prevents the pump speed from becoming too low
P1-03	Acceleration Ramp Time	10 – 30 seconds	Allows for smooth starting and stopping of the system
P1-04	Deceleration Ramp Time	10 – 30 seconds	
P1-07	Motor Rated Voltage	-	Enter the values from the motor nameplate, to avoid damaging the motor.
P1-08	Motor Rated Current	-	
P1-09	Motor Rated Frequency	-	
P1-12	Control Selection	3	Enables PID Control
P1-14	Access Code	101	Allows Access to PID Parameters
P2-33	2nd Analog Input Format	4-20mA	Set to match the transducer signal type
P3-01	PID Gain	0.5 – 2	See Below
P3-02	PID Integral Time	1 – 5seconds	See Below
P3-06	PID Setpoint	-	See Below

PID Setpoint P3-06

For a simple system with a fixed setpoint, the value for P3-06 can be calculated from the transducer range.
E.g. if a system is required to hold a constant pressure of 1.5 Bar, and uses a transducer for feedback with measurement range 0 to 10 Bar, the value of P3-06 can be calculated as

$$\frac{1.5\text{Bar} \times 100\%}{10\text{Bar}} = 15\%$$

PID Gain P3-01

In simple terms, the PID gain parameter controls how great a variation in pump speed will be seen relative to a change in pressure. IF the value used is too high, the pump will continuously change speed, and the pressure will be unstable. Typically on a pump system, the factory set value of 2 will provide good performance. If the pump speed is unstable, reduce the value.

PID Integral Time P3-02

The Optidrive monitors the change of feedback over time to determine the average pressure and how rapidly it is changing. This time filter helps to provide smooth operation. In most cases, the factory set value of 1 second provides good operation, however the value may need to be increased on systems where the pressure changes relatively slowly in the system.

Sleep / Wake Function

The Optidrive Plus has a built in Sleep / Wake function, which allows the pump to automatically switch off completely when the pump is not required to maintain pressure. This function should only be used on systems where the pressure can be maintained even when the pump is stopped.

In order to use this function, the Minimum Frequency Parameter P1-02 must be set to a value greater than 0, typically this will be 20 – 30 Hz for a pump system. P2-20 then allows the user to set a timer, whereby if the pump is running at minimum speed and pressure is maintained for the preset time, the Optidrive will switch off the pump, and the display will show StAndbY. A value around 10 – 30 seconds is usually best.

12.2. Air Compressor

Overview

Optidrive Plus 3GV drives can be used to control the speed of compressors used in compressed air systems, providing automatic regulation of the compressor speed to maintain a constant pressure, and automatic switch off and restart if required. This application uses the Optidrives on board PID control function.

PID Overview

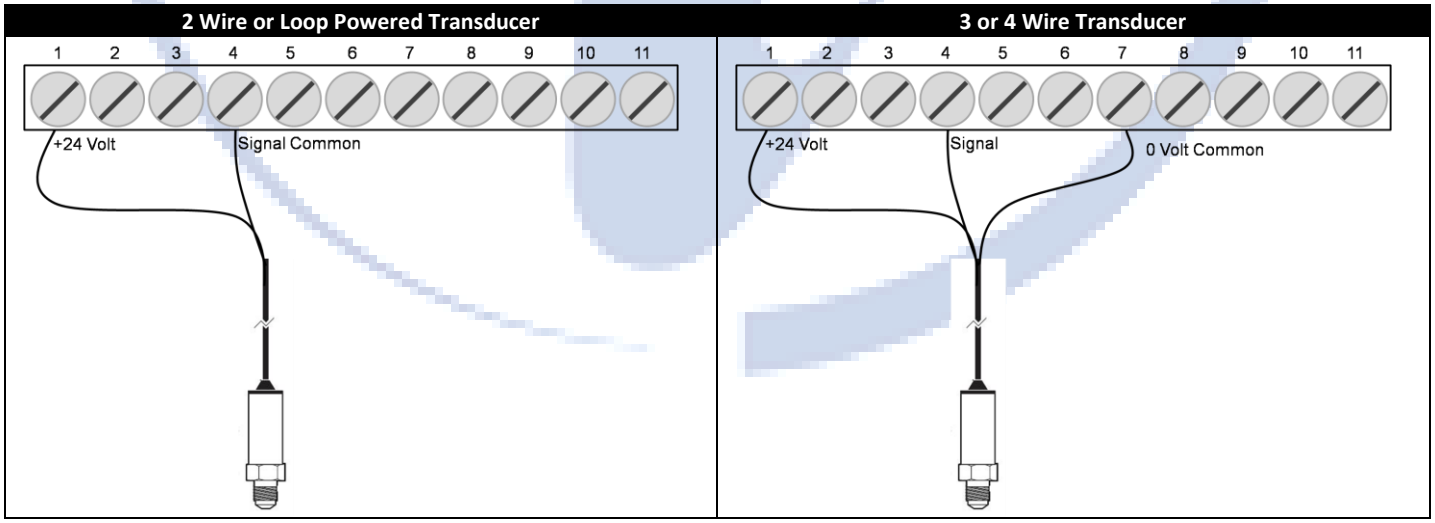
PID control is widely used in many applications. A PID system requires

- A Setpoint – In this case a pressure level which the pump is required to maintain, e.g. 1.5 Bar
- A Feedback Signal – this is the signal from the pressure transducer

The drive will continuously monitor the feedback signal and compare it to the setpoint, and then adjust the speed of pump automatically to try to maintain the correct pressure level.

Feedback Transducers

There are generally two types of transducers, and an example of how to connect each of these to the drive is shown below.



For a simple application with only PID Control required, the only other connection required is a Start / Stop switch link between terminal 1 and terminal 2.

PID Parameter Settings – Simple Fixed PID Setpoint

Par	Function	Example Setting	Explanation
P1-02	Minimum Frequency	20 - 30Hz	Prevents the compressor speed from becoming too low
P1-03	Acceleration Ramp Time	10 – 30 seconds	Allows for smooth starting and stopping of the system
P1-04	Deceleration Ramp Time	10 – 30 seconds	
P1-07	Motor Rated Voltage	-	Enter the values from the motor nameplate, to avoid damaging the motor.
P1-08	Motor Rated Current	-	
P1-09	Motor Rated Frequency	-	
P1-12	Control Selection	3	Enables PID Control
P1-14	Access Code	101	Allows Access to PID Parameters
P2-33	2nd Analog Input Format	4-20mA	Set to match the transducer signal type
P3-01	PID Gain	0.5 – 2	See Below
P3-02	PID Integral Time	1 – 5seconds	See Below
P3-06	PID Setpoint	-	See Below

PID Setpoint P3-06

For a simple system with a fixed setpoint, the value for P3-06 can be calculated from the transducer range.
E.g. if a system is required to hold a constant pressure of 6 Bar, and uses a transducer for feedback with measurement range 0 to 10 Bar, the value of P3-06 can be calculated as

$$\frac{6\text{Bar} \times 100\%}{10\text{Bar}} = 60\%$$

PID Gain P3-01

In simple terms, the PID gain parameter controls how great a variation in compressor speed will be seen relative to a change in pressure. If the value used is too high, the pump will continuously change speed, and the pressure will be unstable. Typically on a compressed air system, the factory set value of 2 will provide good performance. If the pump speed is unstable, reduce the value.

PID Integral Time P3-02

The Optidrive monitors the change of feedback over time to determine the average pressure and how rapidly it is changing. This time filter helps to provide smooth operation. In most cases, the factory set value of 1 second provides good operation, however the value may need to be increased on systems where the pressure changes relatively slowly in the system.

Sleep / Wake Function

The Optidrive Plus has a built in Sleep / Wake function, which allows the compressor to automatically switch off completely when it is not required to maintain pressure. This function should only be used on systems where the pressure can be maintained even when the compressor is stopped. Some compressors motor runs continuously to provide lubrication for the compressor, and the compressor is simply cycled on and off load using a clutch type arrangement. In this type of system, the sleep / wake function should **NOT** be used. This can usually be determined either by consulting the compressor manufacturer, or by monitoring the compressor during normal use prior to fitting the Optidrive. If the motor runs continuously, Sleep / Wake most likely should not be used.

If the standby system can be safely used, the Minimum Frequency Parameter P1-02 must be set to a value greater than 0, typically this will be 30 – 40 Hz for a compressed air system. P2-20 then allows the user to set a timer, whereby if the pump is running at minimum speed and pressure is maintained for the preset time, the Optidrive will switch off the pump, and the display will show StAndbY. A value around 10 – 30 seconds is usually best.

Continuous Motor Operation Systems

On systems where the motor operates continuously for lubrication purposes, and is cycled on and off load by a clutch arrangement, additional energy savings can be achieved by using a control system that allows the motor to run at an idle speed when the compressor is off load. The on load / off load switching of the clutch is controlled automatically by the compressor control system, and the Optidrive only needs to detect whether the compressor is on or off load during running. To minimise the control wiring required, this can be done automatically within the drive.

This method of operation requires the drive to detect when the compressor is on or off load, which can be determined by the motor current. The simplest method to achieve this is to commission the drive as described above and run the compressor, then monitor the motor current on the drive display. This will typically be 80 to 100% of the motor rated current when the compressor is on load and significantly less when the compressor is off load. The two values should be noted, and then calculated as a percentage of the motor rated current, for example

Motor rated at 45kW, full load current of 84 Amps.
Current measured by drive when compressor on load = 78 Amps. 78 / 84 = 92.8%
Current measured by drive when compressor off load = 41 Amps. 41 / 84 = 48.8%

From these two values, we can define a window whereby the drive will switch to idle speed if the motor load drops below a certain level, which will be when the compressor switches off load. A further 'on load' level can then be defined to allow the system to operate automatically. These values are entered in P2-12h and P2-12l. As a guide,

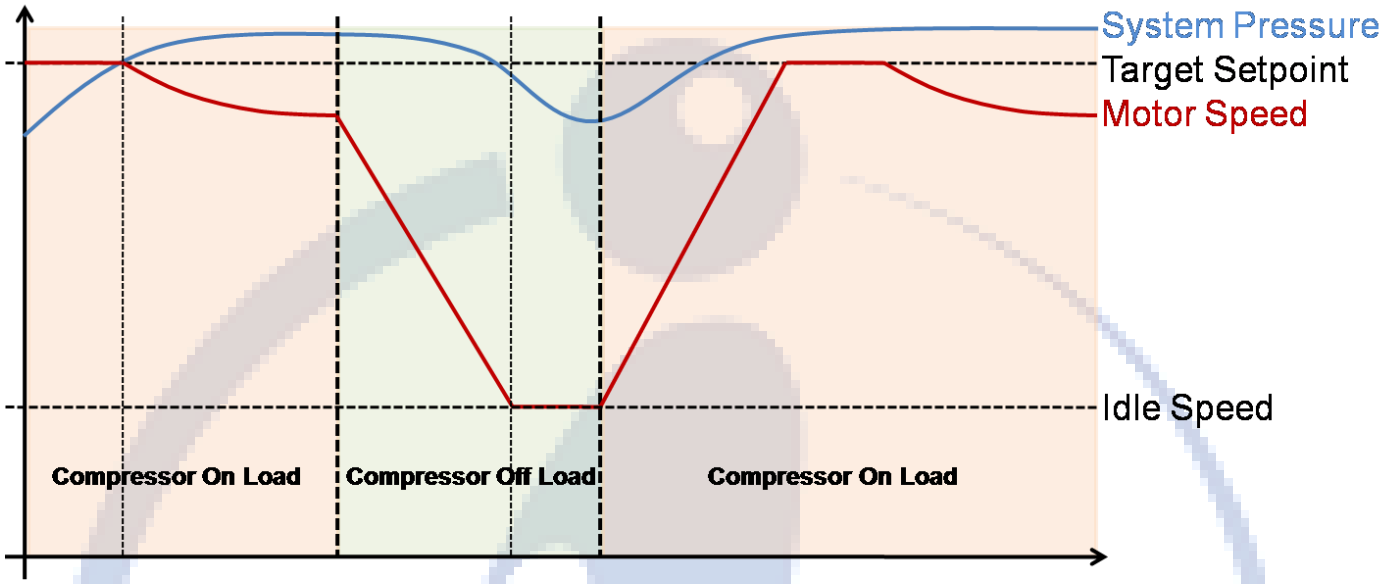
P2-12h = 5 – 10% less than the on load value calculated above, e.g. 83%

P2-12l = 5 – 10% more than the off load value calculated above e.g. 59%

Once the values have been entered, the operation of the compressor can be tested, and the values adjusted if necessary, to ensure that the PID control operates correctly as soon as the compressor comes on load.

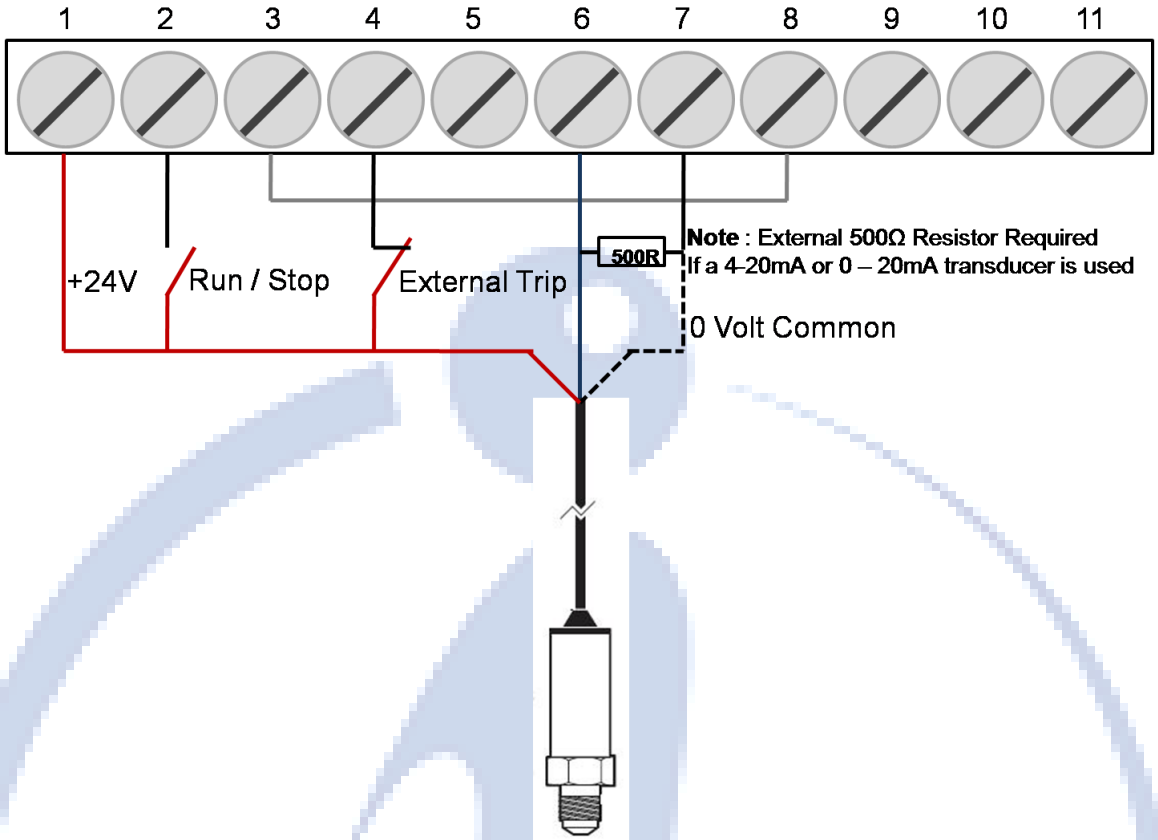
The compressor manufacturer can advise on a suitable idle speed, typically this will be around 20Hz minimum.

Operation Timing Diagram



Under normal operation, the Optidrive operates to maintain pressure in the system, so when the pressure is low, the drive will ramp to full speed. As the pressure setpoint reaches the required level, the Optidrive will begin to reduce the motor speed, such that the speed is sufficient to maintain the pressure correctly in the system. The existing compressor control system also monitors the system pressure, and when either based on the pressure level, or time beyond a certain level, it will switch the compressor off load. The Optidrive detects the drop in motor current, and automatically ramps the motor down to the idle speed, which is sufficient to maintain compressor lubrication, but provides enhanced energy savings in the compressor system. As the system pressure drops over time, the compressor control system will switch the compressor back on load, at which point the Optidrive detects the increased motor load, and switches back to automatic PID control, thereby ramping up the motor speed and controlling again to maintain pressure.

Connection Diagram



Parameter Settings

Par	Function	Example Setting	Explanation
P1-02	Minimum Frequency	20 - 30Hz	Prevents the compressor speed from becoming too low
P1-03	Acceleration Ramp Time	10 – 30 seconds	Allows for smooth starting and stopping of the system
P1-04	Deceleration Ramp Time	10 – 30 seconds	
P1-06	Energy Optimiser	1	Allows improved energy saving
P1-07	Motor Rated Voltage	-	Enter the values from the motor nameplate, to avoid damaging the motor.
P1-08	Motor Rated Current	-	
P1-09	Motor Rated Frequency	-	
P1-11	Preset Speed 1	20 – 30Hz	Idle Speed for compressor, see above
P1-12	Control Selection	3	Enables PID Control
P1-14	Access Code	101	Allows Access to PID Parameters
P2-01	Digital Input Functions	12	Selects correct input configuration
P2-11	Analog Output Function	5	Analog Output switches high or low at preset torque
P2-12h	Output High Level Switch	60 – 80%	On load / off load thresholds, as described above
P2-12l	Output Low Level Switch	50 – 70%	
P2-30	Analog Input Format	0-10	Transducer Signal now 0 – 10 Volt
P2-31	Analog Input Scaling	0 – 10 Volt Transducer Output = Set to 100% 4 or 4 – 20mA Transducer Output = Set to 125%	
P2-32	Analog Input Offset	0 – 10 Volt or 0 – 20mA Transducer Output = Set to 0% 4 – 20mA Transducer Output = set to 20%	
P3-01	PID Gain	0.5 – 2	See Above
P3-02	PID Integral Time	1 – 5 Seconds	See Above
P3-06	PID Setpoint	-	See Above
P3-10	PID Feedback Source	1	Analog Input 1 is Source

13.Updating the Drive Firmware

13.1. Introduction

CAUTION	**The firmware upgrade process should be carried out by Invertek Drives trained Service Personnel only. The required firmware files are not available to general end users of the Optidrive Product range. Failure to follow the procedure correctly, or use of incorrect files may result in damage to the Optidrive or render the unit inoperable.**

To maximise flexibility and future compatibility, the Optidrive Plus has been designed to be upgradeable using its Infrared communication link and a Pocket PC installed with the Optiwand PDA software. The software is freely available from the Invertek Drives website, www.invertek.co.uk. Always ensure that the latest version is in use.

Firmware upgrade files are only available to authorised Invertek Drives Sales and Service Partners, and can be obtained from the VIP area of the website. Details of local contacts can also be found on the website.

To be able to upgrade the drive firmware, Optiwand PDA must be running on the Pocket PC and official Optidrive firmware upgrade software files must be present in the internal memory of the Pocket PC.

13.2. Procedure

The whole upgrade process is outlined in Figure 1. Please follow every stage of the process to guarantee a successful upgrade

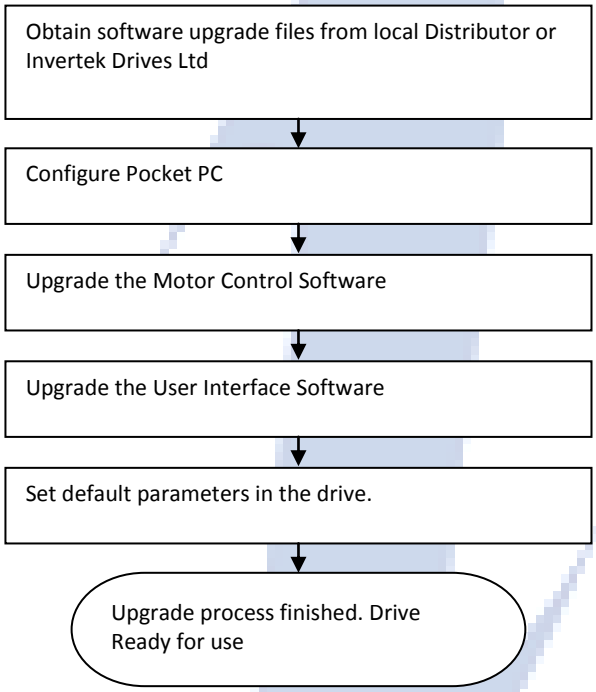


Figure 1

13.2.1. Firmware upgrades filename structure

Upgrading the drive firmware always requires 2 files, Motor Control Software and the User Interface (I/O) Software. The upgrade software filename structure is defined below. The firmware upgrade is carried out by downloading both files to the Optidrive. The Motor Control software should be downloaded first, followed by the I/O Processor Firmware.

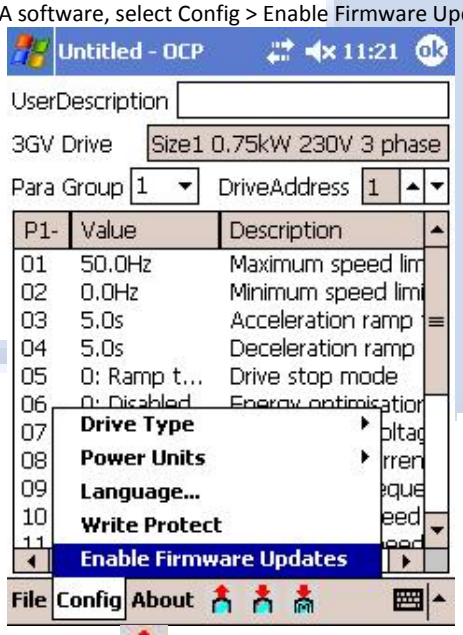
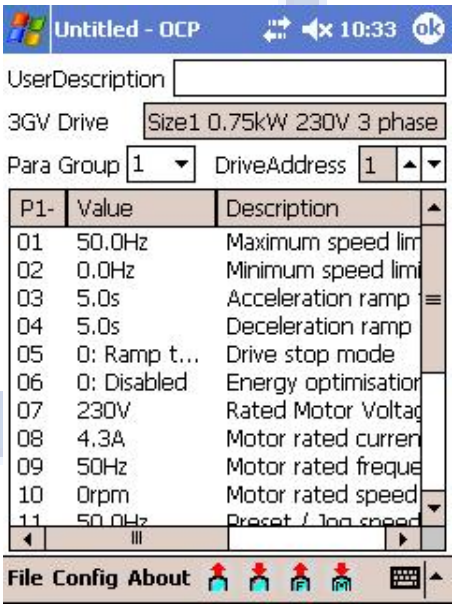
Motor Control Software filename format

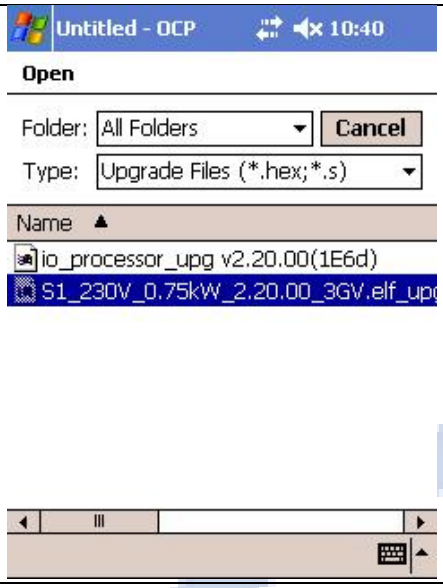
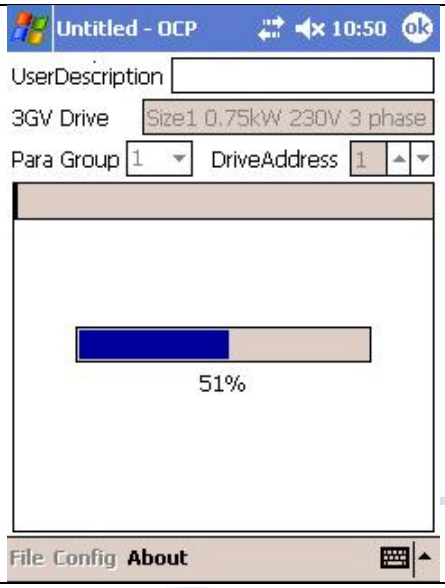
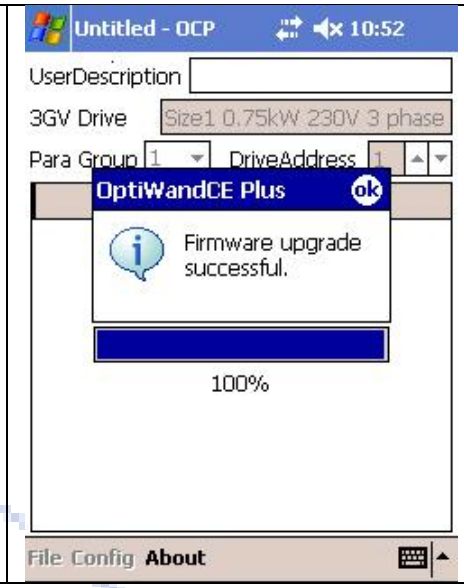
S1	**_**	**230V**	**_**	**0.37kW**	**_**	**3GV**	**_**	**2.20.00**	**elf_upg.s**
									Version
									Type
									Power Rating & Type
									Supply Voltage
									Frame Size

User Interface (IO) Software filename format

io_processor_upg	**_**	**v2.20.00**	**(1E6D)**	**.hex**
				Checksum
				Version

13.3. Upgrade Process

CAUTION	**For safety reasons we recommend that you remove the all control connections from the drive, by removing the 11-way connector.** **All drive parameter settings will be lost during the upgrade process, please backup your settings before proceeding**
1	Set P1-14 = 702. This enables access to the required parameters
2	Set P6-01 = 2. This enables the Motor Control Firmware Update Procedure.
3	Power off the drive completely. Wait for the display to go blank, then allow a further 30 seconds
4	Power on the drive. The display should now show '**Prog_**'
NOTE	If the display does not show prog, repeat steps 3 and 4 above, allowing a longer period before powering up the drive
5	In the Optiwand PDA software, select Config > Enable Firmware Updates   A new Upgrade Firmware icon ( ) will now appear at the bottom of the screen, as shown above. This icon initiates the upgrade process on the Pocket PC.
6	Click on the Upgrade Firmware icon ( ).
7	Select the appropriate file for upgrade depending and drive type and rating as defined previously. A progress indicator in the Pocket PC application window provides an indication as to how much of the file has been transferred as below. Usually data transfer will be complete within approximately 20s.

		
		
9	When data transfer is completed, the drive will verify the integrity of the software and then upgrade itself automatically and a message will be displayed in the Pocket PC application window. The drive display will change to "dAtA-F", indicating that the parameter values have been set to default values. Press "StoP" to reset this message. The drive is now ready to upgrade the user interface (IO) software.	
10	Set P1-14 = 702	
11	Set P6-01 = 1 The Optidrive display should now show "------"	
12	Click on the Upgrade Firmware icon ( ).	
13	Select the appropriate file for upgrade depending and drive type and rating as defined previously. A progress indicator in the Pocket PC application window provides an indication as to how much of the file has been transferred. Usually data transfer will be complete within approximately 15s.	
14	When data transfer is completed, the drive will verify the integrity of the software and then upgrade itself automatically and a message will be displayed in the Pocket PC application window. The drive display will change to "StoP".	
15	Set the factory default parameters, by pressing UP, DOWN and STOP for >2s. The display shows "P-dEF". Press the STOP button to acknowledge and reset the drive. The upgrade process is now complete and the drive is ready to use.	

13.3.1. Trouble Shooting

"Comms lost…" Message

If the data transfer procedure is interrupted for some reason, the Optiwand CE will try to re-send the last data frame several times in order to continue the upgrade operation. During this period, a message of "Comms lost…" will appear instead of the progress indicator, if the data communication link between Pocket PC and the drive cannot be re-established. After approx 10s, a "Firmware upgrade failed" message will be displayed in the Pocket PC application window.

Loss of communications is usually caused by poor signal strength (out of range or poor direction).

If the firmware upgrade fails with "Comms loss" time out, then try to transfer the whole file again. If the problem persists, then please contact Invertek Drives Ltd for technical help.

14.Vertical Market Application Macros

14.1. Introduction

In order to offer a flexible yet simple solution to specific applications, Invertek Drives have developed the following Vertical Market Application Macros for the Optidrive Plus 3GV. These Application Macros can be loaded to the drive by a pocket PC with Optiwand PDA software, using the procedure detailed in section 13. Once loaded, an application specific drive parameter set which differs from the standard parameter set becomes available. The sections below describe the function of these Application Macros, and the changes made to the drive parameter set.

14.2. 3GV-W – Complex Loads Application Macro

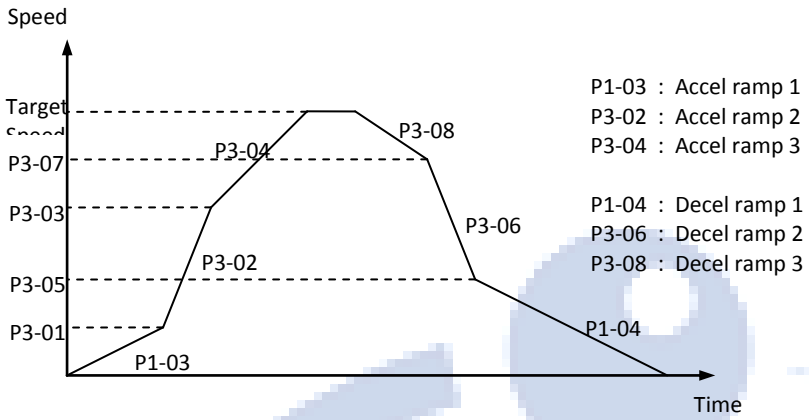
14.2.1. Introduction

The Optidrive Plus 3GV-W Application Macro firmware has functionality specifically to suit use with high inertia centrifugal loads, such as Washing Machines and Centrifuges. The modified Parameter Group 3 allows the user to specify up to 3 acceleration and deceleration rates, that the drive will use depending on the output speed of the motor. This provides improved stopping time when used with high inertia loads. An additional 2 acceleration ramp times and 2 deceleration ramp times are added to the drive when compared with the standard Optidrive Plus 3GV, along with speed threshold values at which these ramp times are switched.

14.2.2. Parameter Set Changes

Par.	Description	Range	Units	Def.	Explanation
P1-12	Terminal / Keypad / Modbus RTU Drive Control Mode Selection	0.Terminal control 1. Keypad control – fwd only 2. Keypad control – fwd and rev	-	0	Primary Control Mode of the drive. 0 : Terminal control 1 : Uni-directional keypad control. Keypad START button does not reverse direction. 2 : Bi-directional keypad control. Keypad START button toggles between forward and reverse.
P3-01	Acceleration Ramp 1 Speed Setpoint	0.1 to 30.0	%	0.0	Speed set point for acceleration ramp 1, defined as a percentage value of P1-01. Acceleration ramp value in P3-02 will be used when the drive speed exceeds this set point. When the speed is less than this set point, ramp time P1-03 is used.
P3-02	Acceleration Ramp 2	0.0 to 3000.0	seconds	5.0	Acceleration ramp time 2. This ramp time will be used when the motor speed exceeds the limit set in P3-01, provided P3-01 is not equal to zero. When the speed is less than the set point in P3-01, acceleration ramp time P1-03 is used.
P3-03	Acceleration Ramp 2 Speed Setpoint	0.00 to 1.0	%	0.0	Speed set point for acceleration ramp 2, defined as a percentage value of P1-01. Acceleration ramp value in P3-04 will be used when the drive speed exceeds this set point. When the speed is less than this set point, ramp time P3-02 is used.
P3-04	Acceleration Ramp 3	0.0 to 3000.0	seconds	5.0	Acceleration ramp time 3. This ramp time will be used when the motor speed exceeds the limit set in P3-03 provided P3-03 is not equal to zero. When the speed is less than the set point in P3-03, acceleration ramp time P3-02 is used.
P3-05	Deceleration Ramp 1 Speed Setpoint	0 : Digital 1 : Analog	%	0.0	Speed set point for deceleration ramp 1, defined as a percentage value of P1-01. Acceleration ramp value in P3-06 will be used when the drive speed exceeds this set point. When the speed is less than this set point, ramp time P1-04 is used.
P3-06	Deceleration Ramp 2	0.0 to 3000.0	seconds	5.0	Deceleration ramp time 2. This ramp time will be used when the motor speed exceeds the limit set in P3-05, provided P3-05 is not equal to zero. When the speed is less than the set point in P3-05, deceleration ramp time P1-04 is used.
P3-07	Deceleration Ramp 2 Speed Setpoint	P3-08 to 100.0	%	0.0	Speed set point for deceleration ramp 2, defined as a percentage value of P1-01. Acceleration ramp value in P3-08 will be used when the drive speed exceeds this set point. When the speed is less than this set point, ramp time P3-06 is used.
P3-08	Deceleration Ramp 3	0.0 to 3000.0	seconds	5.0	Deceleration ramp time 3. This ramp time will be used when the motor speed exceeds the limit set in P3-07, provided P3-07 is not equal to zero. When the speed is less than the set point in P3-07, deceleration ramp time P3-06 is used.

14.2.3. Diagrammatic representation of the Group 3 Variable Ramp control parameters



Notes In normal operation, ramp times are dependent on motor speed and parameter settings.
A special control mode is available which allows the ramp times to be switched between P1-03 / P1-04 and P3-02 / P3-06 using digital input 3. Set P1-12 = 0, P2-01 = 5 and P6-08 = 1 to enable this function.

14.3. 3GV-P – Pump Jack Application Macro

14.3.1. Introduction

The Invertek Optidrive 3GV-P is an AC Variable Speed drive designed to provide optimised, transducer free speed control for Beam Pump applications. The drive has two parameter selectable operating modes, Standard AC Variable speed mode (default setting) plus an additional Automatic Beam Pump Control Mode.

Based on the Optidrive Plus 3GV, the standard operating mode provides speed control for AC Motors, including high performance Vector control. The Optidrive can therefore be used in a wide variety of standard AC Variable Speed drive applications.

Beam Pump Mode

Intended for fully automatic control of 'Nodding Donkey' or Beam pumps typically used in the oil industry. Following a simple commissioning procedure, the Optidrive will automatically control the pump speed to maintain a preset well level, providing maximum oil production with minimum energy consumption. The drive monitors the average torque over each complete cycle of the pump, and uses this to optimise the speed of the pump. Additionally, the user can set up the transmission ratio (gearbox & pulley wheel ratios), so that the maximum and minimum pumping speed limits can be expressed in pump cycles per minute (set up in P3-03, P3-04 – see section 3), taking into account the motor nameplate rated speed in rpm set up in P1-10.

The drive also has an automatic start mode, where a constant pump speed can be given for a specified time period. This is required to ensure that the pump conditions have stabilised before the pump-off controller (level controller) takes over.

In the event of a well being pump-off, the drive will automatically stop after a preset period of operating on the control limit. The drive will restart after a second independent specified delay period, allowing the oil in the well to recover. The restart delay period is typically 60 minutes.
This condition only tends to occur if the pump is running continuously too fast (e.g. pump-off controller not enabled), or if the well is nearing the end of its life.

During commissioning, the automatic level control is overridden by operating at a fixed speed, either as a keypad speed or via the potentiometer. A digital input switches between fixed speed and automatic control.
Once the required operating point i.e. oil level has been reached, the digital input is opened from which point onwards the drive will maintain the same level of oil in the well by slowly varying the average pump speed.

Note that the speed of the pump may increase for short periods during the pumping cycle. This so-called "overhauling" is normal and is part of the process that provides a solution which eliminates braking resistors.

Special features of this operating mode are:-

- Continuous Monitoring and Control of Output Torque level to determine well characteristics
- Automatic Motor Speed adjustment to suit well conditions
- No Brake resistor required
- No Position Sensor Required
- Modbus RTU communications for feedback of power, torque and pump cycles for control system monitoring
- Automatic Pump Off shuts down the pump on low well level, and restarts after a preset time

14.3.2. Parameter Set Changes

Par.	Description	Range	Units	Default	Explanation
P1-06	Energy Optimiser	Function not available with 3^{GV-P}			
P2-18	Spin Start Enable	Function not available with 3^{GV-P}			
P3-01	Operating Mode	0 : Standard Speed Control 1 : Screw Pump Mode	-	0	
	Beam Pump Mode :				See Commissioning Guide in section 14.3.4
P3-02	Transmission Ratio	50.0 to 300.0	-	150.0	
P3-03	Maximum Pump Speed		Strokes / Min	1.0	
P3-04	Minimum Pump Speed	0.0 .. P3-03	Strokes / Min	1.0	
P3-05	Starting Speed	P3-04 .. P3-03	Strokes / Min	1.0	
P3-06	Starting Speed Duration	2 .. 240	Minutes	10	
P3-07	Minimum Torque Pulse Duration	10..240	Degrees	140	
P3-08	Reserved				
P3-09	Torque Pulse Sampling Threshold	5.0..100.0	%	25.0	
P3-10	Operating Point for Pump Off Controller	5.0..100.0	%	50.0	
P3-11	Pump Off Controller Gain	1.0..50.0	-	2.0	
P3-12	Pump Off Delay Timeout	0..60	Minutes	0	
P3-13	Pump Off Restart Delay	1..240	Minutes	60	

14.3.3. Modbus Register Map

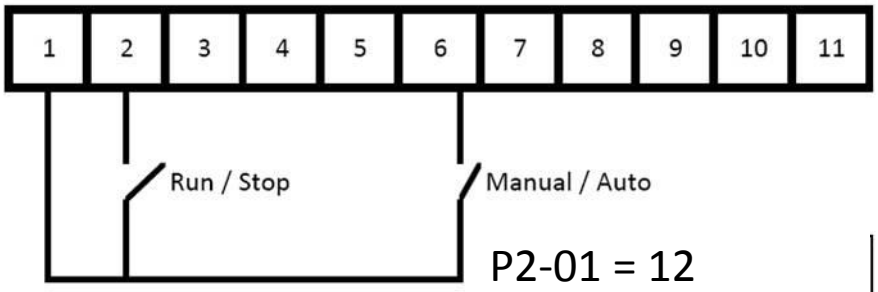
The Optidrive Plus 3GV-P Application Macro features Modbus RTU communications for monitoring of drive functions only. The drive cannot be controlled via Modbus. The register map is essentially as per the 3GV-M drive, as detailed in section 0, however the following registers are changed.

Register Number	Type	Commands	Function Low Byte	High Byte	Range	Explanation
1	Not available					
2	Not available					
3	Not available					
4	Not available					
5	Not available					
26	R	03	Measured Pump Cycles / Minute		0..1000	One decimal place 156=15.6%
27	R	03	Real Pump Cycle Time		0..1000	One decimal place 156=15.6%
28	R	03	Average Torque at Reference Speed		0..200.0	One decimal place 156=15.6%
29	R	03	Measured Cycle Time		0..1000	Value in ms
78	R	03	Timer for Pump Off			
79	R	03	Timer for Pump Restart			
80	R	03	Period Counter Value			
81	R	03	Period Counter Value			
82	R	03	Maximum Counter Period Value			
83	R	03	Maximum Counter Period Value			
183	R	03	P3-01 Value		Read only	
184	R	03	P3-02 Value		Read only	
185	R	03	P3-03 Value		Read only	
186	R	03	P3-04 Value		Read only	
187	R	03	P3-05 Value		Read only	
188	R	03	P3-06 Value		Read only	
189	R	03	P3-07 Value		Read only	
190	R	03	P3-08 Value		Read only	
191	R	03	P3-09 Value		Read only	
192	R	03	P3-10 Value		Read only	
193	R	03	P3-11 Value		Read only	
194	R	03	P3-12 Value		Read only	
195	R	03	P3-13 Value		Read only	
196	R	03	P3-14 Value		Read only	
197	R	03	P3-15 Value		Read only	
198	R	03	Reserved		Read only	Read as zero

14.3.4. Commissioning Procedure – Pump Jacks

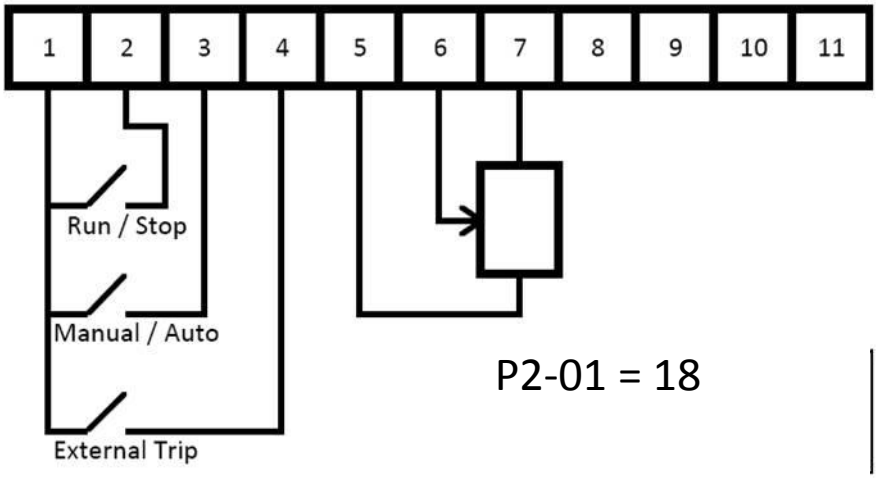
The following procedure is a guideline for setting the parameters of the Optidrive Plus 3^{GV-P} in a beam pump type application.

Suggested Control Wiring Examples



The control terminal functions are determined by the setting of P2-01, see the table in section 8.1 for further details. The simplest options to use are shown in the diagrams on the left.

With P2-01 = 12
Manual – Pump Speed adjusted via Keypad Up and Down buttons
Auto – Fully automatic pump speed control



With P2-01 = 18
Manual – Pump speed adjusted via the potentiometer connected to the bipolar analog input
Auto – Fully automatic pump speed control

Enter the Motor Nameplate Data & Autotune
Beam Pump Control requires the drive to control the motor in Vector mode to obtain the necessary level of control and torque monitoring for best performance. In order to do this, the following parameters must be set correctly using the values from the motor nameplate.

- P1-07 = Motor Rated Voltage
- P1-08 = Motor Rated Current (Full Load Current, Amps)
- P1-09 = Motor Rated Speed (Rpm)
- P1-10 = Motor Rated Frequency (Hz)
- P4-05 = Motor Rated Power Factor (Cos Ø)

Notes : If no value is available for the Motor Rated Power Factor, this should be set to 0.
To access parameter P4-05, ensure P1-14 = 101

Once the values above are entered, the drive motor control mode should be set to Vector Speed Control, and an autotune carried out using the following parameters.

P4-01 = 0 Selects Vector Speed Control Operation
P4-02 = 1 Starts Motor Autotune

CAUTION	**The autotune will begin immediately when P4-02 is set to 1, and no external enable signal is required. During the autotune procedure, the motor shaft may turn. It is not normally necessary to uncouple the load from the motor, however the user should ensure any that no risk arises from the possible movement of the motor shaft.** **It is important that the drive operates correctly in vector speed control prior to commissioning the pump control function.** **For larger pumps with greater inertia, it may be necessary to reduce the Speed Controller Gain in parameter P4-03 to obtain smooth operation.**

The Optidrive will now correctly control the connected motor in Vector Speed Control.

Select Pump Jack Mode & Minimum Torque Limit

To select Pump Jack control mode, set P3-01 = 1. In order for the system to operate correctly without a braking resistor, a minimum torque level must be set in the Optidrive, to ensure that the motor is always driven, and does not regenerate. As a consequence of this, the motor

speed will vary during the pumping cycle, this is normal, and the drive monitors the pump cycle and pump speed in strokes per minute independently of motor Rpm. The minimum torque limit should be entered into P4-08, typically this will be approximately 6%, and the user can adjust as required.

Pump Drive Ratio

In order to accurately monitor the pump cycles, the Optidrive needs to know the ratio between motor speed and pump speed. This is usually the gearbox ratio multiplied by the pulley ratio. Incorrect setting can lead to errors on the pump cycle count. This value should be entered in P3-02. The minimum setting is 50.0, and the maximum setting is 300.0.

Pump and Motor Speed Limit Settings

The maximum motor speed (P1-01, Rpm) and pump speed (P3-03, Strokes per Minute) are set independently within the drive parameters; however the pump speed is always limited by the maximum motor speed. During the regenerative part of the stroke described above, the Optidrive will accelerate the motor to avoid the regenerative energy being passed to the drive. This means the maximum motor speed needs to allow for the motor accelerating at certain points in the cycle. The maximum value should be determined by the mechanical constraints of the pump jack. Typically a value around 1.6 times the Motor Nameplate Rpm is suitable for 4 or 6 pole motors, although this should be checked to ensure safe operation.

Once the motor speed limit has been determined, this should be entered in P1-01. The maximum range of P3-03 will then be limited, and can be calculated from the following:-

Maximum P3-03 Setting = P1-01 (Rpm) x P3-02 x 0.625

A minimum motor speed (P1-02, Rpm) and pump speed (P3-04, Strokes per Minute) can also be programmed if required to prevent the pump and motor running too slow. The higher of the two values entered will always take precedence.

Pump Starting Speed & Duration

To allow the pump operation and well conditions to stabilise on start-up, a starting speed (in strokes per minute) and duration (in minutes) can be programmed into the Optidrive. Once this time has elapsed, the Optidrive will switch to fully automatic control. The Starting Speed should be entered in P3-05 (Minimum Value & Default Value = 1.0), and the Duration entered in P3-06 (Minimum Value 2 Minutes, Default Value 10 Minutes, Maximum Value 240 Minutes). Typically, the Starting Speed should be set to a value midway between the Minimum and Maximum pump speeds. This function only operates in Automatic mode.

Monitoring the Torque Profile

The output torque profile from the drive can be monitored either from the drives analog output using an oscilloscope, or via a Modbus RTU communications Master device connected to the RJ11 connector on the drive. To use the analog output, set P2-11 = 8. The output signal format can be 0 – 10 Volts DC or 2 – 20mA, where 10 Volts DC / 20mA = 200% of motor rated torque. To use the Modbus RTU communications, please refer to section 10.3 for further details.

Torque Pulse Sampling and Threshold

During the pump cycle, the motor torque required varies considerably dependent on the position of the beam. Typically, there will be two distinct torque pulses per cycle, and the Optidrive uses these pulses to determine the pump strokes per minute and to trigger the torque cycle monitoring. The actual level and duration of these pulses will vary from well to well, and so the parameters that control the triggering of the measurement are also adjustable to allow for this. In practice, the default values will work in most cases, however if the pump cycle count does not match the actual number of cycles of the pump when observing, the levels can be adjusted to correct this by monitoring the actual pulse level and duration with a scope meter connected to the Optidrives Analog Output, or by using the Modbus communications feedback to a PLC, Scada system or PC.

Pump Off Controller Operating Point & Gain

Whilst in pump jack mode, the Optidrive continuously averages the output torque during a pumping cycle, to determine the well level. The automatic control mode then adjusts the motor speed to maintain the required level of torque. In order to set the operating point, the drive should be run in manual mode first (see wiring schematics above for how to connect a Manual / Automatic selector switch), and the well level monitored whilst adjusting the pump speed to determine a suitable level. Once the required level is achieved, the operator can then simply switch to automatic mode, and the Optidrive will maintain the preset well level. Alternatively, the operator can program a preset level in parameter P3-10.

Parameter P3-11 sets the gain control for the Automatic Pump Speed Control function. The setting range is 1.0 to 50.0, with a default setting of 2.0. This gives a 0.2Hz change in average motor output frequency per pump cycle for a 1% change in the average torque monitored. Too high a value can lead to large changes in pump speed over a short number of pump cycles, whereas too low a value may empty the well if the inflow is low. Typically, the default setting provides a good starting point, and the value can be increased if the well has a tendency to empty.

Automatic Switch Off and Restart Function

The Optidrive can be programmed to shut down the pump in the event that the well level drops too low and the drive is running at minimum speed. A timer is used to determine how long the pump needs to remain at minimum speed before switching off. To enable this mode, P2-20 must be set to any value greater than 0, and the delay time is set in minutes in P3-12 (Minimum 1 Minute, Maximum 60 Minutes, disabled as default). The drive will then remain off for a further delay time, programmed in P3-13 (Minimum 1 Minute, Maximum 240 Minutes, default 60 Minutes), before automatically restarting operation.

15.IP55 Enclosed Drive

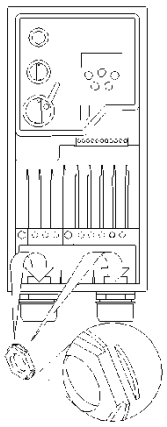
15.1. Overview

Optidrive Plus 3GV is optionally available in an IP55 enclosed version for power ratings up to 4kW / 5HP. Un-switched versions have no built in controls. Switched versions have built in local isolator, Potentiometer and control switch.

15.2. Models and Ratings

200-240V ±10% - 1 Phase Input – 3 Phase Output						
Model (kW)	**kW**	**Model (HP)**	**HP**	**Frame Size**	**Nominal Input Current**	**Nominal Output Current**
					Amps	**Amps**
ODP-12037-*xx*-I55	0.37	ODP-12005-USA-I55	0.5	1	6.7	2.3
ODP-12075-*xx*-I55	0.75	ODP-12010-USA-I55	1	1	12.5	4.3
ODP-12150-*xx*-I55	1.5	ODP-12020-USA-I55	2	1	19.3	7
ODP-22150-*xx*-I55	1.5	ODP-22020-USA-I55	2	2	19.3	7
ODP-22220-*xx*-I55	2.2	ODP-22030-USA-I55	3	2	28.8	10.5
200-240V ±1% - 3 Phase Input – 3 Phase Output						
Model	**kW**	**Model**	**HP**	**Frame Size**	**Nominal Input Current**	**Nominal Output Current**
					Amps	**Amps**
ODP3-22150-xx-I55	1.5	ODP3-22020-USA-I55	2	2	9.2	7
ODP3-22220-xx-I55	2.2	ODP-22030-USA-I55	3	2	13.7	10.5 (9)
380-480V ±10% - 3 Phase Input – 3 Phase Output						
Model	**kW**	**Model**	**HP**	**Frame Size**	**Nominal Input Current**	**Nominal Output Current**
					Amps	**Amps**
ODP-24075-*xx*-I55	0.75	ODP-24010-USA-I55	1	2	2.9	2.2
ODP-24150-*xx*-I55	1.5	ODP24020-USA-I55	2	2	5.4	4.1
ODP-24220-*xx*-I55	2.2	ODP-24030-USA-I55	3	2	7.6	5.8
ODP-24400-*xx*-I55	4	ODP-24050-USA-I55	5	2	12.4	9.5
500-600V ±10% - 3 Phase Input – 3 Phase Output						
Model (kW)	**kW**	**Model (HP)**	**HP**	**Frame Size**	**Nominal Input Current**	**Nominal Output Current**
					Amps	**Amps**
ODP-25075	0.75	ODP-25010-USA	1	2	2.2	1.7
ODP-25150	1.5	ODP-25020-USA	2	2	4.1	3.1
ODP-25220	2.2	ODP-25030-USA	3	2	5.4	4.1
ODP-25370	3.7	ODP-25050-USA	5	2	7.6	6.1
ODP-25550	5.5	ODP-25075-USA	7.5	2	11.7	9
NOTE	For switched versions, an 'S' is added to the end of the part number, E.g. ODP12037-I55**S** All other rating data is as per IP20 units, see section 2.2 *xx* = Country Specific Model Code					

15.3. Power and Motor Cable Installation



Some types of gland nut will require modification for correct installation. Remove one or more flanges as shown until the nut will fit in the apertures.
Any Metal conduit used MUST be earth bonded by means of suitable earthing washer or gland adaptor.
Lock Off: On the switched models the main power isolator switch can be locked in the 'Off' position using a 20mm standard shackle padlock (not supplied).

Gland Hole Sizes:

	I/P & O/P Power (Φ)	Centred Knockout (Φ)	Terminal Cover Knockout (Φ)
Size 1	(22mm)	(22mm)	(17mm)
Size 2	(25mm)	(22mm)	(17mm)

Recommended Gland Type: SkinTop UL approved (UL94-V0) Type12/IP55 non-metallic cable gland or non-rigid conduit

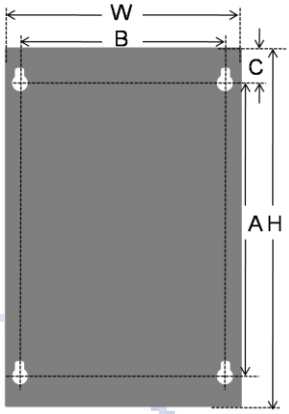
	I/P & O/P Power	Centred Knockout	Terminal Cover Knockout
Size 1	PG13.5 / M20	PG13.5 / M20	PG9 / M16
Size 2	PG16 / M25	PG13.5 / M20	PG9 / M16

15.4. Dimensions and Mounting

Optidrive Plus IP55 Size 1 Layout, Dimensions and Mounting

Height	200mm
Width	140mm
Depth	162mm
Weight	2.3Kg
Display	
Keypad	
IR Interface	
Control Terminals	
Power Input Terminals	
Motor Output Terminals	

Footprint View



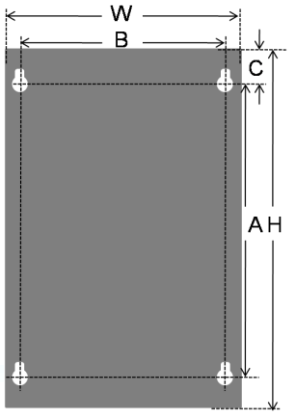
Height	200mm
Width	140mm
Depth	162mm
A	141.5mm
B	127.5mm
C	25mm

Fixings : 4 x M8 Keyhole slots

Optidrive Plus IP55 Size 2 Layout, Dimensions and Mounting

Height	310mm
Width	165mm
Depth	176mm
Weight	4.5Kg
Display	
Keypad	
IR Interface	
Control Terminals	
Power Input Terminals	
Motor Output Terminals	

Footprint View

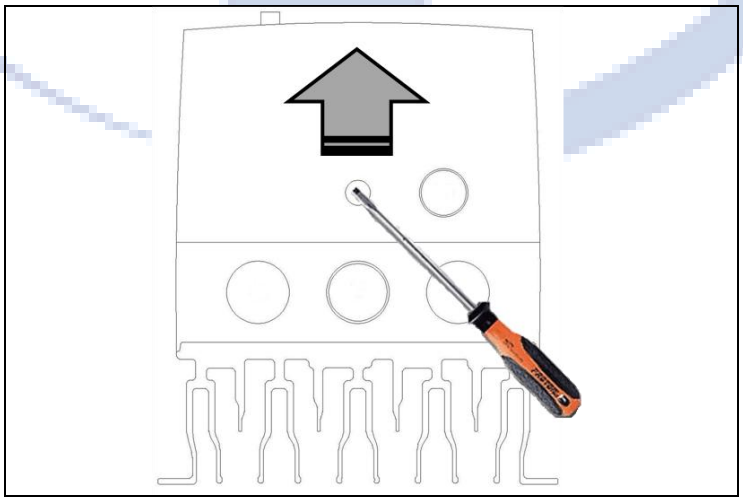


Height	310mm
Width	165mm
Depth	176mm
A	251.5mm
B	153mm
C	25mm

Fixings : 4 x M8 Keyhole slots

15.5. Removing the Terminal Cover

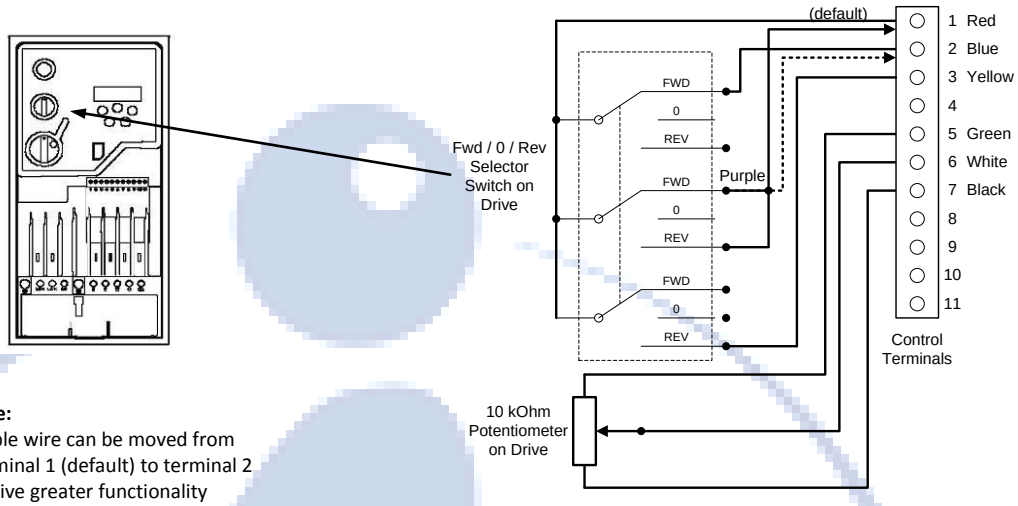
To access the connection terminals, the drive front cover needs to be removed as shown below.



15.6. Control Terminal Wiring – None Switched Version

Wiring configuration and terminal connections for the none switched IP55 version are identical to those of the IP20 version, as shown in section 4.4.

15.7. IP55 / Nema 12K Switched Version - Wiring diagram for in-built switches



Note:
Purple wire can be moved from terminal 1 (default) to terminal 2 to give greater functionality - see table below.

15.8. Settings for typical Run / Stop switch configurations (Switched Version)

The table below shows the possible configurations that can be achieved by connecting the Purple wire to the designated terminal, and setting a combination of P1-12 and P2-01. Unless otherwise stated, each of the following configurations utilise the potentiometer mounted on the front of the IP55S drive (switched variant) for speed variation and control.

Purple Wire in Terminal	Switch Position			P1-12	P2-01	Notes
						
1	Stop	Stop	Run Forward	0	0	Factory Default Configuration
2	Preset Speed 1	Stop	Run Forward	0	0	Preset Speed 1 provides a 'Jog' Speed
1	Run Reverse	Stop	Run Forward	0	7, 8, 9, 10	
2	Run in Speed Control	Stop	Run in PID Control	3	17	In Speed Control, Pot controls speed In PID Control, pot controls setpoint
2	Run in Speed Control	Stop	Run in PID Control	3	11	In Speed Control, P1-11 sets the Preset Speed In PID Control, pot controls setpoint
2	Run in Hand	Stop	Run in Auto	4	17	Hand – Speed reference from Pot Auto – Speed Reference from Modbus
2	Run in Hand	Stop	Run in Auto	4	17	Hand – Speed reference from Preset Speed 1 Auto – Speed Reference from Modbus

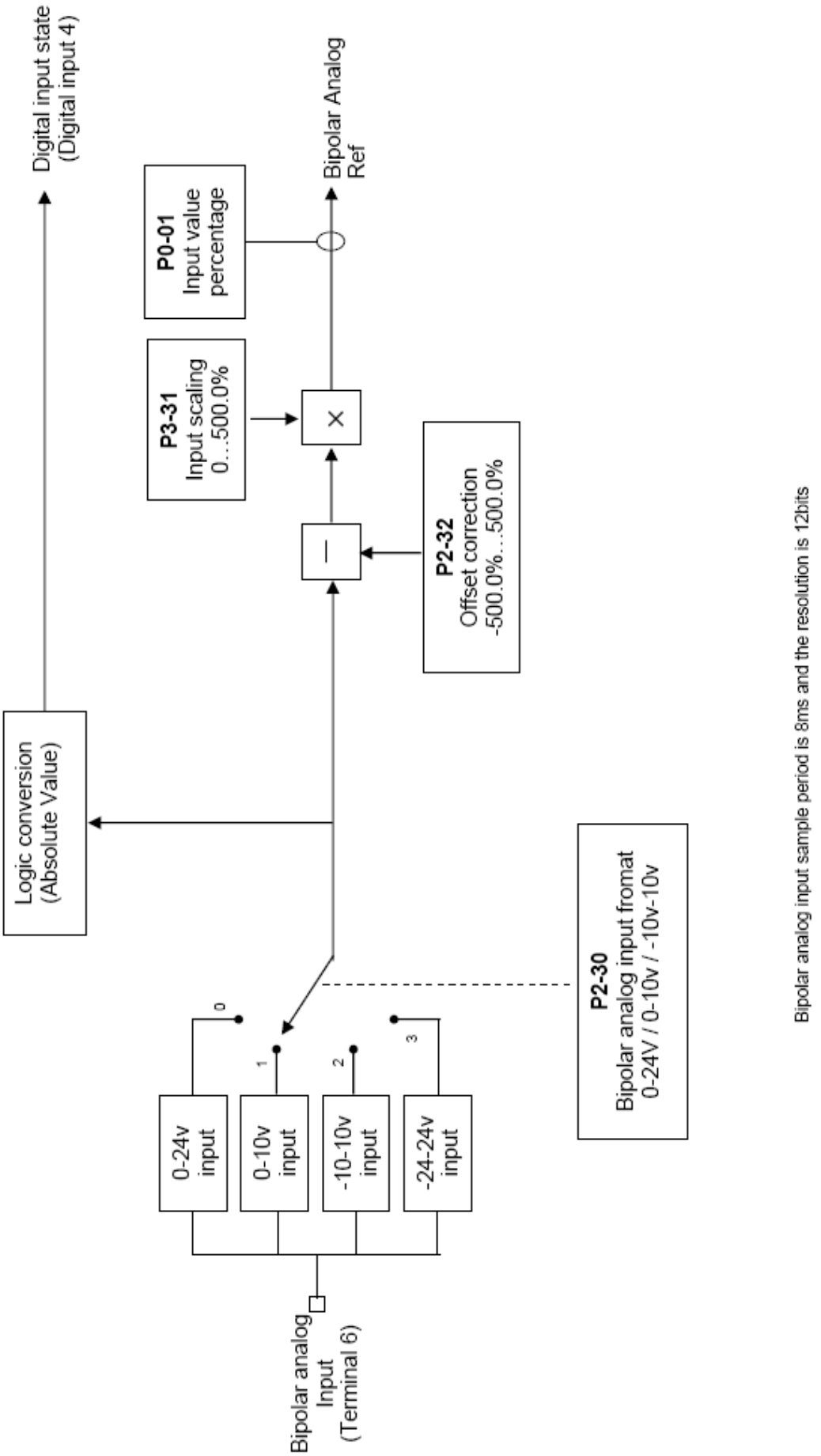
16.Troubleshooting

16.1. Fault messages

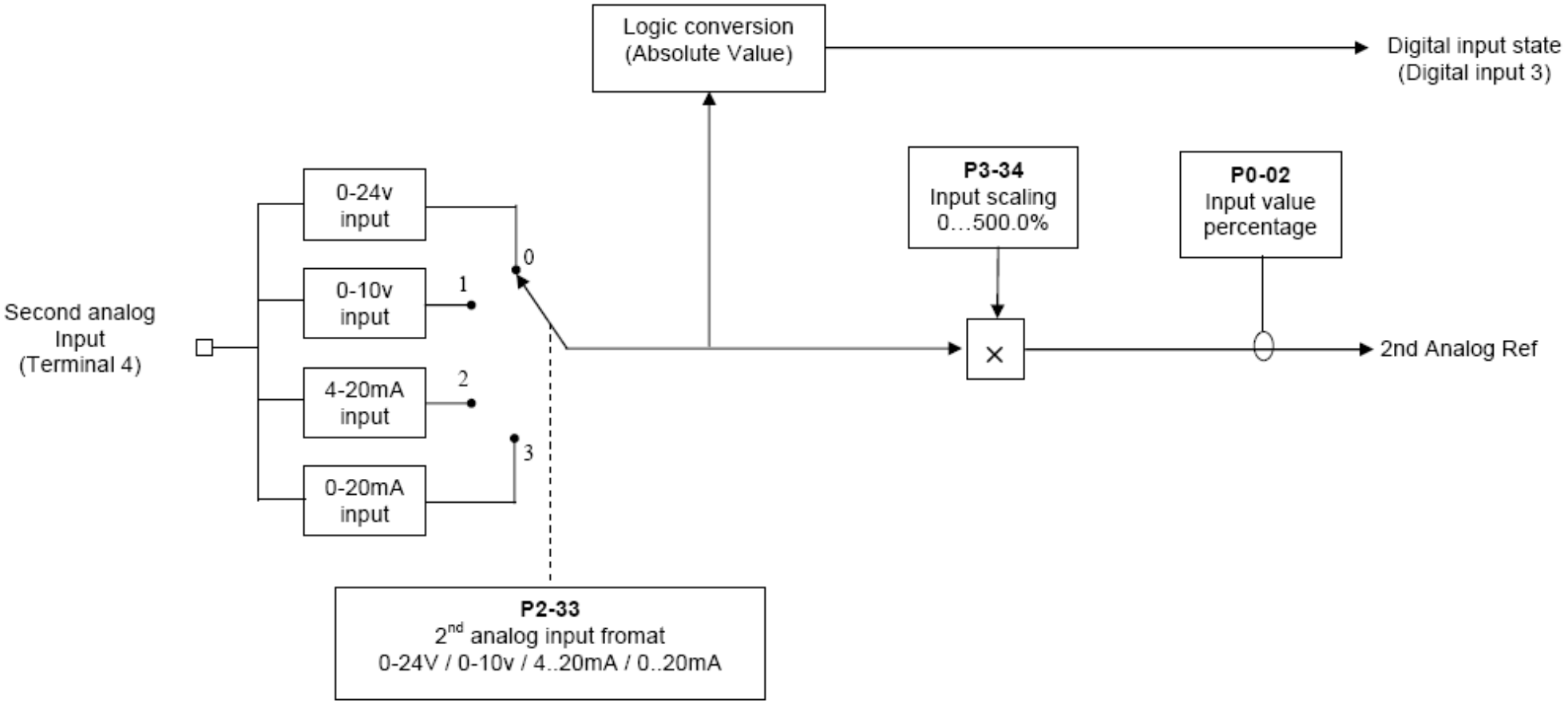
Fault Code	Description	Corrective Action
P-dEF	Factory Default parameters have been loaded	Press STOP key, the drive is now ready to be configured for the required application
O-I hO-I	Instantaneous over current on drive output. Excess load on the motor. Over temperature on the drive heatsink	Check the motor and motor connection cable for phase – phase and phase – earth short circuits. Check the load mechanically for a jam or stalled condition, or shock loads. Ensure the motor nameplate parameters are correctly entered, P1-07, P1-08, P1-09. If operating in Vector mode (P4-01 – 0 or 1), also check the motor power factor in P4-05. Ensure an autotune has been successfully completed for the connected motor. Increase the ramp up time in P1-03. If operating in Vector mode (P4-01 – 0 or 1), reduce the speed loop gain in P4-03
I_ t-trP	Drive has tripped on overload after delivering >100% of value in P1-08 for a period of time.	Check to see when the decimal points are flashing (drive in overload) and either increase acceleration rate or reduce the load. Check motor cable length is within spec. Ensure the motor nameplate parameters are correctly entered, P1-07, P1-08, and P1-09. If operating in Vector mode (P4-01 – 0 or 1), also check the motor power factor in P4-05. Ensure an autotune has been successfully completed for the connected motor. Check the load mechanically to ensure it is free, and no jams, blockages or other mechanical faults exist
OI-b	Brake channel over current	Over current in the brake resistor circuit. Check the cabling to the brake resistor. Check the brake resistor value. Ensure minimum resistance values form the rating tables are observed.
OL-br	Brake resistor overload	Brake resistor overload. Increase deceleration time, reduce load inertia or add further brake resistors in parallel, observing the minimum resistance value for the drive in use.
PS-trP	Fast over current trip	Check wiring to motor, look for ph-ph or ph-Earth short circuit. Check drive ambient temp, additional space or cooling needed? Check drive is not forced into overload.
O_Uo lt	Over voltage on DC bus	Supply problem, or increase decel ramp time P1-04.
U_Uo lt	Under voltage on DC bus	This occurs routinely when power is switched off. If it occurs during running, check power supply voltage.
O-t	Heatsink over temperature	Check drive ambient temp. Additional space or cooling required.
U-t	Under temperature	Trip occurs when ambient temperature is less than 0°C. Temperature must be raised over 0°C in order to start the drive.
th-FLt	Faulty thermistor on heatsink.	Refer to your IDL Authorised Distributor.
E-tr iP	External trip (on digital Input 3)	E-trip requested on digital input 3. Normally closed contact has opened for some reason. If motor thermistor is connected check if the motor is too hot.
4-20 F	4-20mA Signal Lost	The reference signal on analog input 2 (Terminal 4) has dropped below the minimum threshold of 3mA. Check the signal source and wiring to the Optidrive terminals.
SC-trP	Comms loss trip	Check communication link between drive and external devices. Make sure each drive in the network has its unique address.
P-LOSS	Input phase loss trip	Drive intended for use with a 3 phase supply has lost one input phase.
Ph-Ib	Phase Imbalance	Mains incoming supply voltage has an imbalance of >3% for over 30 seconds. Check incoming supply and fuses
dAtA-F	Internal memory fault.	Parameters not saved, defaults reloaded. Try again. If problem recurs, refer to your IDL Authorised Distributor.
At-F01	Autotune Failed	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.
At-F02		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.
At-F03		Measured motor inductance is too low. Ensure the motor is correctly connected and free from faults.
At-F04		Measured motor inductance 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.
At-F05		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.
SP in-F	Spin Start Failure	Spin start function (P2-18=1) failed to detect motor speed Check motor and connections. Ensure motor speed is less than maximum speed (P1-01). Make sure motor base frequency (P1-09) is <100Hz
Enc-01	Encoder Feedback Faults (Only visible when an encoder module is connected and enabled)	Speed Feedback Error – The measured encoder speed exceeds the calculated motor speed
Enc-02		Reserved
Enc-03		Incorrect Encoder PPR count set in P3-09
Enc-04		Motor Rated Speed (P1-10) outside allowed range
Enc-05		Internal Calculation Error
Enc-06		Encoder Channel A Fault
Enc-07		Encoder Channel B Fault
Enc-08		Encoder Channels A & B Fault
Enc-09		Motor Base Frequency (P1-09) outside allowed range

17.Control function flowcharts

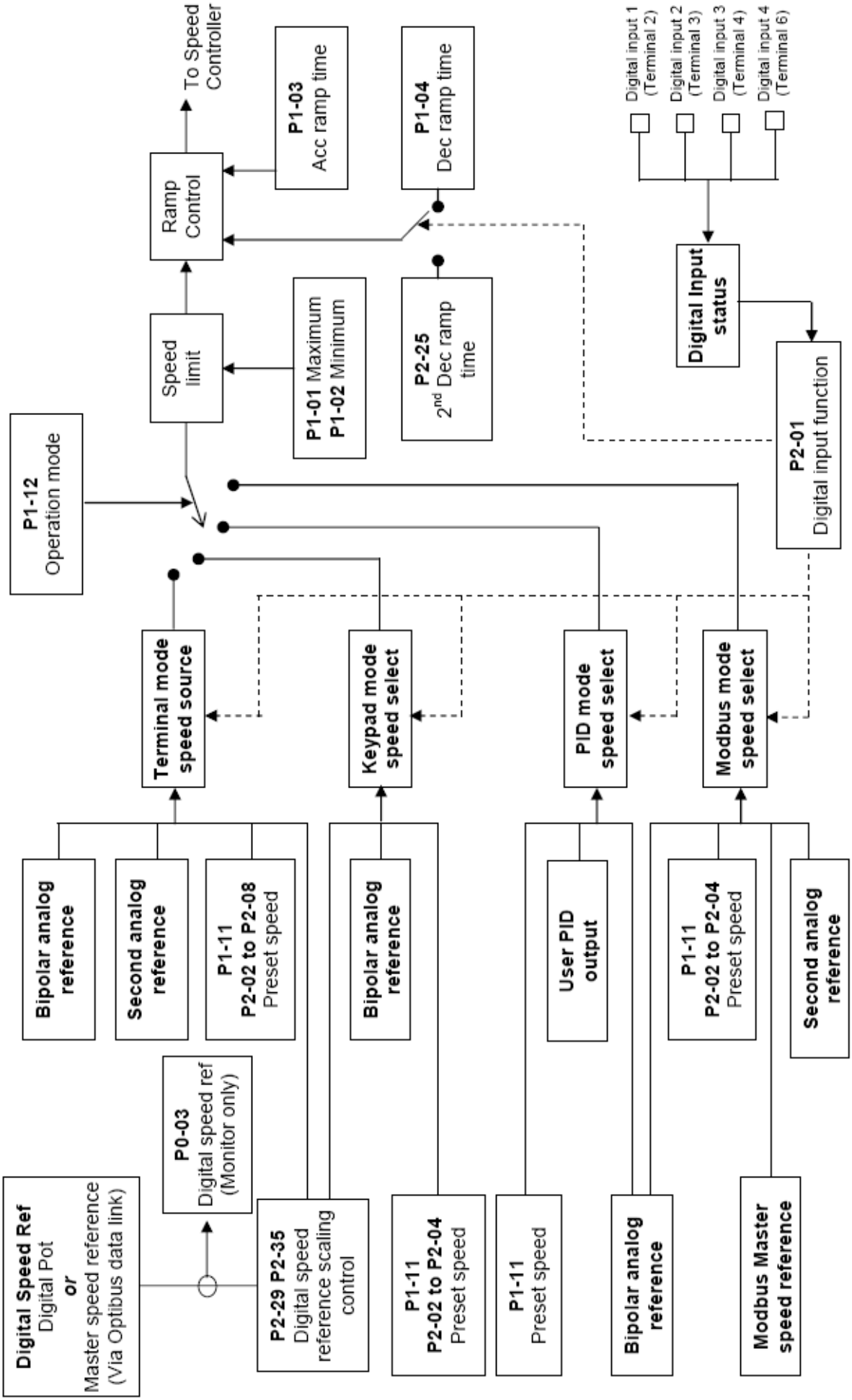
1. Bipolar analog input function setup flowchart



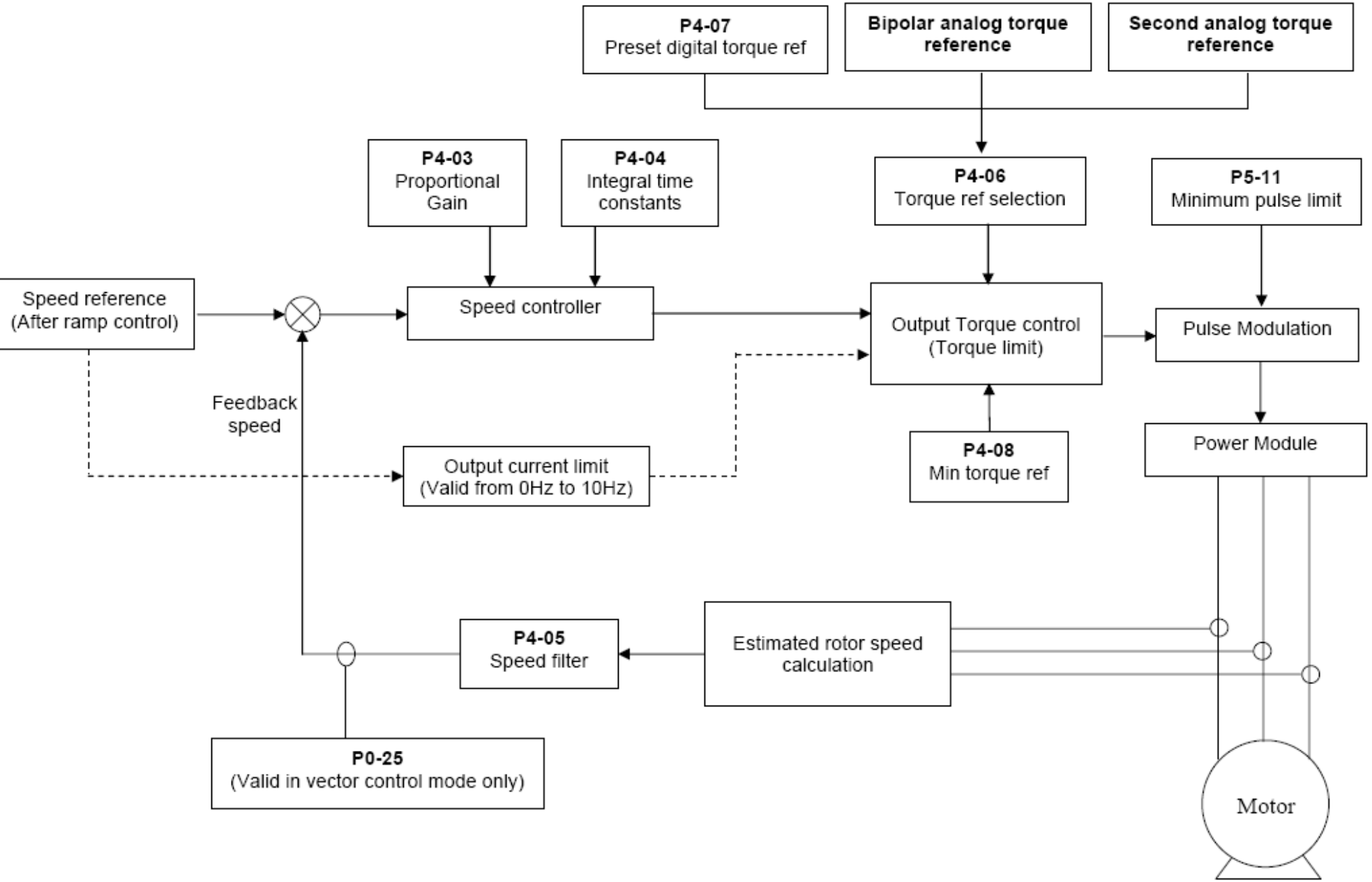
2. Second analog input function setup flowchart



3. Ramp control flowchart



4. Vector speed control logic flowchart

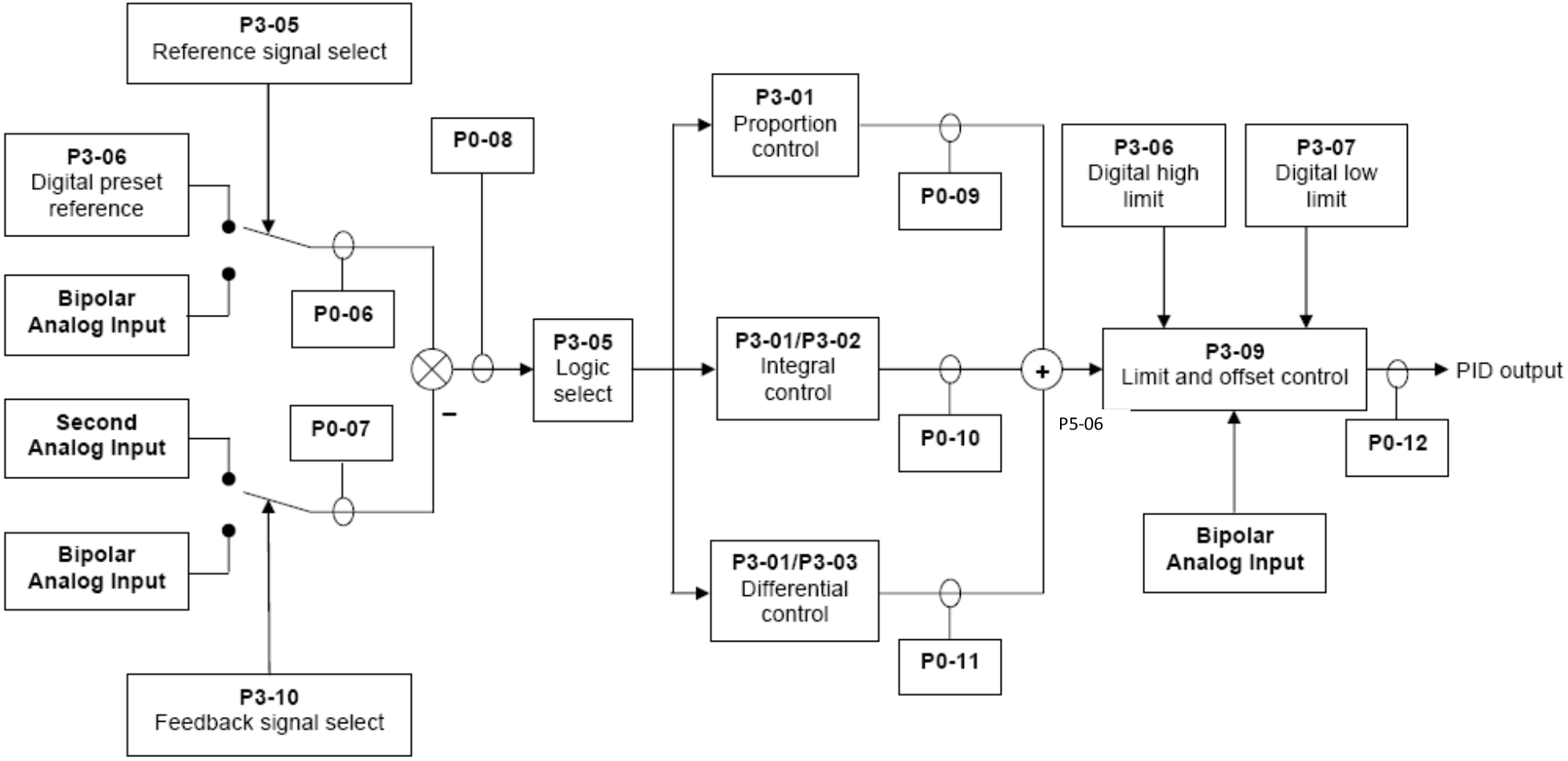


5. PID control flowchart

PID control Algorithm:

$$PIDoutput = Kp \times e(k) + Kp \cdot \frac{T}{Ti} \sum_{j=1}^{k} e(j) + Kp \cdot \frac{Td}{T} \cdot [e(k) - 2e(k-1) + e(k-2)]$$

Where, Kp = P3-01, Ti = P3-02, Td = P3-03 and T = 10ms.



NOTES