PG DRIVES TECHNOLOGY

I-DRIVE CONTROLLER FAMILY

TECHNICAL MANUAL

SK76977-07

TABLE OF CONTENTS

About this manual

This manual is divided into 7 chapters.

Chapter 1 – Operation

This chapter deals with the controls and functionality of the i-Drive controller.

Chapter 2 – Installation

This chapter deals with the mounting, connection, wiring and set-up procedures of the i-Drive controller.

Chapter 3 – Programming

This chapter provides an overview of the programmable parameters held within the i-Drive controller.

Chapter 4 – Diagnostics

This chapter provides an overview of the diagnostic capabilities of the i-Drive controller.

Chapter 5 – TruCharge Module

This chapter deals with the mounting, connection and wiring of the TruCharge control panel module.

Chapter 6 – Warning Summary

This chapter summarizes the warnings shown throughout the manual.

Chapter 7 – Specifications

This chapter lists the electrical specifications of the i-Drive controller.

Icons

Throughout this manual, icons are used to draw the reader's attention.

The icons used are:

Note – A general point for best practice.

Caution – A point of safety which if ignored could result in damage to the control system or the vehicle.

Warning – A point of safety which if ignored could cause injury to the individual.

PG Drives Technology accepts no liability for any losses of any kind if these points are not followed.

CHAPTER 1 – OPERATION

1 Introduction

The relevant contents of this chapter should be included in the machine operating guide. Further copies are available from PGDT in either written or disk (Microsoft Word) format. Copies should not be made without the express permission of PG Drives Technology.

Operation of the i-Drive controller is simple and easy to understand. The controller incorporates state-of-the-art electronics, the result of many years of research, to provide you with ease of use and a very high level of safety. In common with other electronic equipment, correct handling and operation of the unit will ensure maximum reliability.

This chapter covers all types of operation. It is the responsibility of the machine manufacturer to ensure that only the relevant sections of this chapter are included in the i-Drive's operating manual.

Please read this chapter carefully - it will help you to keep your machine reliable and safe.

2 General

2.1 Handling

Avoid knocking your controller and especially the connectors. Be careful not to strike obstacles with the controller. Never drop the controller.

When transporting your machine, make sure that the controller is well protected. Avoid damage to cables.

2.2 Operating Conditions

Your controller uses industrial-grade components throughout, ensuring reliable operation in a wide range of conditions. However, you will improve the reliability of the controller if you keep exposure to extreme conditions to a minimum.

Do not expose your controller or its components to damp for prolonged periods.

3 Controls

Depending on the specification of the machine to which the i-Drive is fitted, some or all of the following controls will be used.

3.1 On/Off Switch

The On/Off switch applies power to the controller electronics, which in turn supplies power to the machine's motor. Do not use the On/Off switch to stop the machine unless there is an emergency. (If you do, you may shorten the life of the machine drive components).

Some machines may have a keyswitch in addition to the normal On/Off switch; the function of the keyswitch is the same as the On/Off switch.

3.2 Status Indicator

Depending on the machine model, the status indicator may be a single bulb (or LED) or a PGDT TruCharge battery and diagnostics indicator.

The status indicator shows you that the machine is switched on. It also indicates the operating status of the machine. Details are given in Section 8.

3.3 Throttle

The throttle controls the speed of the machine. The further you push the throttle, the faster your machine will move. When you release the throttle, the brake is automatically applied.

Depending on the machine model, the throttle configuration may be one of three types – wig-wag, single-ended or unipolar.

3.3.1 Wig-wag Throttle

In this configuration, the throttle controls both the speed and the direction of the machine. To drive forwards, push the throttle in one direction; to drive in reverse, push the throttle in the other direction.

3.3.2 Single-ended Throttle

In this configuration, the throttle controls just the speed of the machine. When the throttle is pushed, depending on the position of the reverse switch (refer to Section 3.6), the machine will drive in either the forward or reverse direction.

3.3.3 Unipolar Throttle

In this configuration, the throttle controls just the speed of the machine. When the throttle is moved, in either direction, depending on the position of the reverse switch (refer to Section 3.6), the machine will drive in either the forward or reverse direction.

3.4 Tiller Switch

A tiller switch is generally fitted on 'walkie' type machines to provide a safety interlock. The tiller arm is usually sprung to the vertical position and is pulled towards the horizontal to remove a drive inhibit.

3.5 Direction Switches

Direction switches are sometimes used in combination with the throttle to effect drive. After switching on the machine, either the forward or reverse direction switch must be operated in conjunction with the throttle to enable drive.

3.6 Reverse Switch

This switch will be fitted to the machine if the throttle configuration is single-ended or unipolar (refer to Sections 3.3.2 & 3.3.3). The switch is used to change between forward and reverse drive.

3.7 Speed Limiting Potentiometer

This control sets the maximum speed of the machine. Turn the knob clockwise to increase the maximum speed setting or anti-clockwise to decrease the maximum speed setting.

3.8 Belly Button

This device is a safety feature that is activated each time the machine is placed in reverse. If the button is activated, the machine will stop its reverse drive and immediately begin to move forwards at a programmed speed.

3.9 Slow/Fast Switch

This switch selects the driving mode – either slow or fast – of the machine. You can use this switch to limit the machine's driving behavior in environments where that may be desirable or necessary, e.g. if you are driving in an enclosed space.

3.10 Audible Alarm

This provides an audible warning when the machine is being driven in the reverse direction. The alarm may also be used to signal other conditions, such as when the machine is in freewheel.

4 Getting Ready to Drive

Check that the speed limiting control is turned to a position that suits you.

Operate the On/Off switch. Either:

A TruCharge type status indicator will blink and remain on after half a second.

A single bulb (or LED) type status indicator will blink and remain on after half a second.

During the first half-second after the machine is switched on, the controller is performing important safety checks within itself and the rest of the machine's electrical system. Therefore, if you push the throttle during this time, you will not be able to drive until you have returned the throttle to the rest position and switched the controller off and on again.

If the machine has a single-ended or unipolar throttle, use the reverse switch to select the direction you want to drive in and then push the throttle to control the speed. If the machine has a wig-wag throttle, push the throttle in the direction you want to drive. Depending on the configuration of the machine, you may also have to operate a direction switch and/or a tiller switch before drive commences.

If you do not push the throttle as you switch the machine on and the status indicator flashes rapidly, then there may be a trip. Refer to Section 8 for details.

5 Tips for Using Your Controller

5.1 Driving - General

Make sure that all the controls are within easy reach and are comfortable to operate.

5.2 Driving Technique

The controller interprets the throttle movements and reverse switch setting (if fitted) and drives the machine in the correct direction at the appropriate speed. You will need very little concentration to control the machine, which is especially useful if you are inexperienced.

The further you push the throttle away from the rest position, the faster the machine will go.

The intelligent speed controller minimizes the effects of slopes and different types of terrain.

The machine user must be capable of driving a machine safely. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

6 Precautions for Use

In the event of the machine moving in an unexpected way, RELEASE THE THROTTLE. This action will stop the machine under any circumstances.

6.1 Hazards

Do not drive the machine:

Beyond restrictions indicated in your machine user manual, for example inclines, curb heights etc.

In places or on surfaces where a loss of wheel grip could be hazardous, for example on wet grassy slopes.

If you know that the controller or other crucial components require repair.

Although the i-Drive is designed to be extremely reliable and each unit is rigorously tested during manufacture, the possibility of system malfunction always exists (however small the probability). Under some conditions of system malfunction the controller must (for safety reasons) stop the machine instantaneously. If there is any possibility of the user falling out of the machine as a result of a sudden braking action, it is imperative that a restraining device such as a seat belt is supplied with the machine and that it is in use at all times when the machine is in motion. PGDT accepts no liability for losses of any kind arising from the unexpected stopping of the machine, or arising from the improper use of the machine or controller.

Do not operate the i-Drive if the machine behaves erratically or shows abnormal signs of heating, sparks or smoke. Turn the i-Drive off at once and consult your service agent. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

Electro Magnetic Interference (EMI) can affect electronic equipment. Such interference may be generated by radio stations, TV stations, other radio transmitters and cellular phones. If the machine exhibits erratic behavior due to EMI, turn the controller off immediately and consult your service agent. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

It is the responsibility of the machine manufacturer to ensure that the machine complies with appropriate National and International EMC legislation. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The machine user must comply with all machine safety warnings. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

7 Safety Checks

The electronic circuits in the i-Drive have been designed to be extremely safe and reliable. The on-board microprocessor carries out safety checks at up to 100 times per second. To supplement this safety monitoring you should carry out the following periodic checks.

If the controller fails any of these checks, do not use the machine and contact your service agent.

These checks should be conducted in an open space and a restraining device such as a seat belt should always be used. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

7.1 Daily Checks

Throttle:

- With the machine switched off, check that the throttle mechanism is not bent or damaged and that it returns to the rest position when you push and release it. If there is a problem, do not continue with the safety checks and contact your service agent.

7.2 Weekly Checks

Throttle:

- Put the throttle to the full speed forward position and switch the machine on. The machine should not move. To show you that you have switched the machine on with the throttle already pushed, a TruCharge type status indicator may flash seven bars, whereas a single bulb (or LED) type status indicator will flash seven times in sequence.
- If the machine does move, contact your service agent.

Parking brake:

- This test should be carried out on a level surface with at least one meter clear space around the machine.
- Switch the machine on.
- Check that the status indicator remains on, or flashes slowly, after half a second.
- Go to drive the machine slowly in the forward direction until you hear the parking brake operate (if fitted). The machine may start to move.
- Immediately release the throttle. You must be able to hear the parking brake operate within a few seconds.
- Repeat the test in the reverse direction.

Cables and connectors:

- Check that all connectors on the machine are securely mated and ensure that all cables are free from damage.

7.3 Servicing

To ensure continued satisfactory service, we suggest you have your machine and controller inspected by your service agent after a period of one year from commencement of service. Contact your service agent for details, when the inspection is due.

8 Status Indication

Depending on the machine model, the status indicator may be a single lamp (or LED) or a TruCharge battery gauge and diagnostics display. Both types indicate the status of the controller.

A number of supposedly faulty controllers returned to PGDT are subsequently found to operate correctly. This indicates that many faults are due to problems on the machine rather than within the controller.

8.1 Single Lamp and LED Status Indicators

8.1.1 Status Indicator Steady

This indicates that all is well.

8.1.2 Status Indicator Flashes Slowly and Continuously

The controller is functioning correctly, but the battery voltage has fallen below the level set by either Battery Lockout Voltage or Battery Lockout Voltage 2.

Do not operate the machine if the battery is nearly discharged.

8.1.3 Status Indicator Flashes Slowly, Pauses, Then Flashes Slowly Again (even with throttle released)

The controller safety circuits have operated and the controller has been prevented from moving the machine.

This indicates that there is a trip. Please follow this procedure:

- Switch off the machine.
- Make sure that all connectors on the machine are mated securely.
- Check the condition of the battery.
- If the fault persists, count the number of flashes after a pause and then try using the self-help guide in Section 8.3.
- Switch the machine on again and try to drive. If the safety circuits operate again, switch off and do not try to use the machine.
- Contact your service agent.

When a system trip occurs and the parameter Diagnostic Flash Sequence has been set to 'PG', a series of flashes will be reproduced on the lamp or LED status indicator. The number of flashes will mimic the TruCharge Status Indicator Trip Types, e.g. when the lamp or LED flashes 2 times, pauses, then flashes 2 times again etc., the controller has detected a bad motor connection. Refer to Section 8.3 for the full list of trip types.

8.1.4 Status Indicator Blinks On Every 3½ Seconds

The controller has entered Sleep Mode. Recycle the power to reset.

8.1.5 Status Indicator Flashes Rapidly And Continuously (even with throttle released)

The controller safety circuits have operated and the controller has been prevented from moving the machine.

This indicates that there is a trip. Please follow this procedure:

- Switch off the machine.
- Make sure that all connectors on the machine are mated securely.

- Check the condition of the battery.
- Switch the machine on again and try to drive. If the safety circuits operate again, switch off and do not try to use the machine.
- Contact your service agent.

8.2 TruCharge Indicator

The way in which the TruCharge Indicator should be read depends on whether the controller is driving, is in Sleep Mode or is in Trip Mode. Each case is explained below.

8.2.1 TruCharge Indicator Steady

If the TruCharge Indicator shows red, yellow and green, the batteries are charged.

If the TruCharge Indicator shows just red and yellow, then you should charge the batteries as soon as you can.

If the TruCharge Indicator shows just red then you should charge the batteries immediately.

8.2.2 TruCharge Indicator Flashing 1 Bar Slowly And Continuously

The controller is functioning correctly, but the battery voltage has fallen below the level set by either Battery Lockout Voltage or Battery Lockout Voltage 2.

Do not operate the machine if the battery is nearly discharged.

8.2.3 TruCharge Indicator Flashes Slowly, Pauses, Then Flashes Slowly Again (even with throttle released)

The controller safety circuits have operated and the controller has been prevented from moving the machine.

This indicates that there is a trip. Please follow this procedure:

- Switch off the machine.
- Make sure that all connectors on the machine are mated securely.
- Check the condition of the battery.
- If the fault persists, count the number of flashes / bars and then try using the self-help guide in Section 8.3.
- Switch the machine on again and try to drive. If the safety circuits operate again, switch off and do not try to use the machine.
- Contact your service agent.

When a system trip occurs and the parameter Diagnostic Flash Sequence has been set to 'PG', a series of flashes / bars will be reproduced on the TruCharge Indicator. The number of flashes / bars will mimic the TruCharge Status Indicator Trip Types, e.g. when the TruCharge Indicator flashes 2 times / bars, pauses, then flashes 2 times / bars again etc., the controller has detected a bad motor connection. Refer to Section 8.3 for the full list of trip types.

8.2.4 TruCharge Indicator Blinks On Every 3½ Seconds

The controller has entered Sleep Mode. Recycle the power to reset.

8.2.5 TruCharge Indicator Flashing Rapidly

The controller safety circuits have operated and the controller has been prevented from moving the machine.

This indicates that there is a trip. Please follow this procedure:

- Switch off the machine.

- Make sure that all connectors on the machine are mated securely.
- Check the condition of the battery.
- If you can't find the problem, count the number of flashing bars and use the self-help guide in Section 8.3.
- Switch the machine on again and try to drive. If the safety circuits operate again, switch off and do not try to use the machine.
- Contact your service agent.

8.3 Self-Help Guide

Below is a list of self-help actions. Try to use the following table before you contact your service agent. Go to the number in the list that matches the number of flashing bars and follow the instructions.

1 Bar 	The battery needs charging or there is a bad connection to the battery. Check the connections to the battery. If the connections are good, try charging the battery.
2 Bar 	There is a bad connection to the motor. Check all connections between the motor and the controller.
3 Bar 	The motor has a short circuit to a battery connection. Contact your service agent.
4 Bar 	Not used.
5 Bar 	Not used.
6 Bar 	The controller is being inhibited from driving.
7 Bar 	A throttle fault is indicated. Make sure that the throttle is in the rest position before switching on the machine.
8 Bar 	A controller fault is indicated. Make sure that all connections are secure.
9 Bar 	The parking brakes have a bad connection. Check the parking brake and motor connections. Make sure the controller connections are secure.
10 Bar 	An excessive voltage has been applied to the controller. This is usually caused by a poor battery connection. Check the battery connections.

8.4 Slow or Sluggish Movement

If the machine does not travel at full speed and the battery condition is good, check the position of the speed limiting control. If adjusting the speed limiting control does not remedy the problem then there may be a non-hazardous fault.

Contact your service agent.

9 Battery Gauge

Depending on the type of machine you have, the battery gauge may be a single bulb (or LED) or a TruCharge display. How to read each type is described in the previous section.

The battery gauge is included to let you know how much charge is left in your batteries. The best way for you to use the gauge is to learn how it behaves as you drive the machine. Like the fuel gauge in a car, it is not completely accurate, but it will help you avoid running out of 'fuel'.

Depending on the type of machine you have, the battery gauge may also show you the charging status of the batteries.

The battery gauge works in the following way.

When you switch on the controller, after half a second, the battery gauge shows an estimate of the remaining battery charge.

The battery gauge gives you a more accurate reading about a minute after you start driving the machine.

When you replace worn out batteries, fit the type recommended by the machine manufacturer. If you use another type, the battery gauge may be inaccurate.

The amount of charge in your batteries depends on a number of factors, including the way you use your machine, the temperature of the batteries, their age and the way they are made. These factors will affect the distance you can travel in your machine. All machine batteries will gradually lose their capacity as they age.

The most important factor that reduces the life of your batteries is the amount of charge you take from the batteries before you recharge them. Battery life is also reduced by the number of times you charge and discharge the batteries.

To make your batteries last longer; do not allow them to become completely flat. Always recharge your batteries promptly after they are discharged.

If your battery gauge reading seems to fall more quickly than usual, your batteries may be worn out.

9.1 How To Read A Single Bulb (or LED) Battery Gauge

Refer to Section 8.1 for full details.

9.2 How To Read A TruCharge Battery Gauge

Refer to Section 8.2 for full details.

10 Pushing your Machine

The machine will be fitted with a freewheel mechanism which allows the machine to be pushed if there is a fault, the batteries are disconnected or not fitted.

Depending on the type of freewheel mechanism, it may be possible for the machine to freewheel at potentially dangerous speeds. Therefore, do not push the machine up or down inclines on which you cannot stop or hold the machine. Never sit on the machine if the freewheel mechanism is disengaged. PGDT accepts no liability for losses of any kind arising from the machine being moved while the freewheel mechanism is disengaged.

Do not freewheel the machine faster than the programmed Maximum Speed, e.g. by towing. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

11 Programming

If you cannot find a position on the speed limiting control that suits you, the controller can be programmed to meet your needs. The controller can be programmed in three ways – with an SP1 programmer, a DTT Programmer or specialist PC software and interface cable.

The SP1 is a small hand-held unit, which can be plugged into the controller to alter parameter values.

The DTT is PGDT's latest hand-held programmer. With a larger LCD screen than the SP1, many parameters can be viewed at the same time. The DTT can also be plugged directly into the controller to alter parameter values.

The PC Programmer contains a software CD and an interface cable. When the software is installed onto a PC, it can then be connected to the controller by using the special programming cable. The i-Drive can then be programmed in a Windows™ type environment.

The programming tools may be included with your machine. If they are not, your machine distributor or service agent or machine manufacturer will be able to program your controller for you.

If you have a programmer, read the user guide before you use it.

If you re-program your controller, make sure that you observe any restrictions given in your machine user manual. Note any changes you make for future reference.

Programming should only be conducted by electronic service professionals with in-depth knowledge of PGDT controllers. Incorrect programming could result in an unsafe set-up of a machine for a user. PGDT accepts no liability for losses of any kind if the programming of the controller is altered from the factory preset values.

12 Warranty

The i-Drive controller is covered by a warranty period defined by the machine manufacturer. For details of the warranty period, please contact your service agent.

The warranty will be void if the i-Drive has:

- Not been used in accordance with the i-Drive Technical Manual, SK76977.
- Been subject to misuse or abuse.
- Been modified or repaired by non-authorized persons.

13 Servicing

All repairs and servicing must be carried out by authorized service personnel. Opening or making any unauthorized adjustments or modifications to the controller or its components will invalidate any warranty and may result in hazards to yourself or other people, and is strictly forbidden.

PGDT accepts no liability for losses of any kind arising from unauthorized opening, adjustment or modifications to the i-Drive controller.

If the i-Drive controller is damaged in any way, or if internal damage may have occurred through impact or dropping, have the product checked by qualified personnel before operating. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The warranty will be void if the i-Drive has not been used in accordance with the i-Drive Technical Manual SK76977, the i-Drive has been subject to misuse or abuse, or if the i-Drive has been modified or repaired by unauthorized persons.

CHAPTER 2 – INSTALLATION

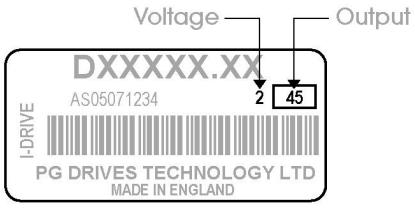
I Documentation

I.I i-Drive Versions

Eight models of i-Drive are available to suit either 24V or 36V dc system voltages. The product codes for the full i-Drive family are as follows.

Model Name	Nominal Supply Voltage	Max. Output Rating
i24-45	24V dc only	45 Amps
i36-45	24 or 36V dc	45 Amps
i24-70	24V dc only	70 Amps
i36-70	24 or 36V dc	70 Amps
i24-140	24V dc only	140 Amps
i36-140	24 or 36V dc	140 Amps
i24-180	24V dc only	180 Amps
i36-180	24 or 36V dc	180 Amps

To identify which type of i-Drive you have, the voltage and output current rating is shown on the controller's serial number label as detailed below.



The number in the box indicates the output current; the single digit number to the left of the box indicates the operating voltage.

2 = 24V dc only.

3 = 24V dc or 36V dc.

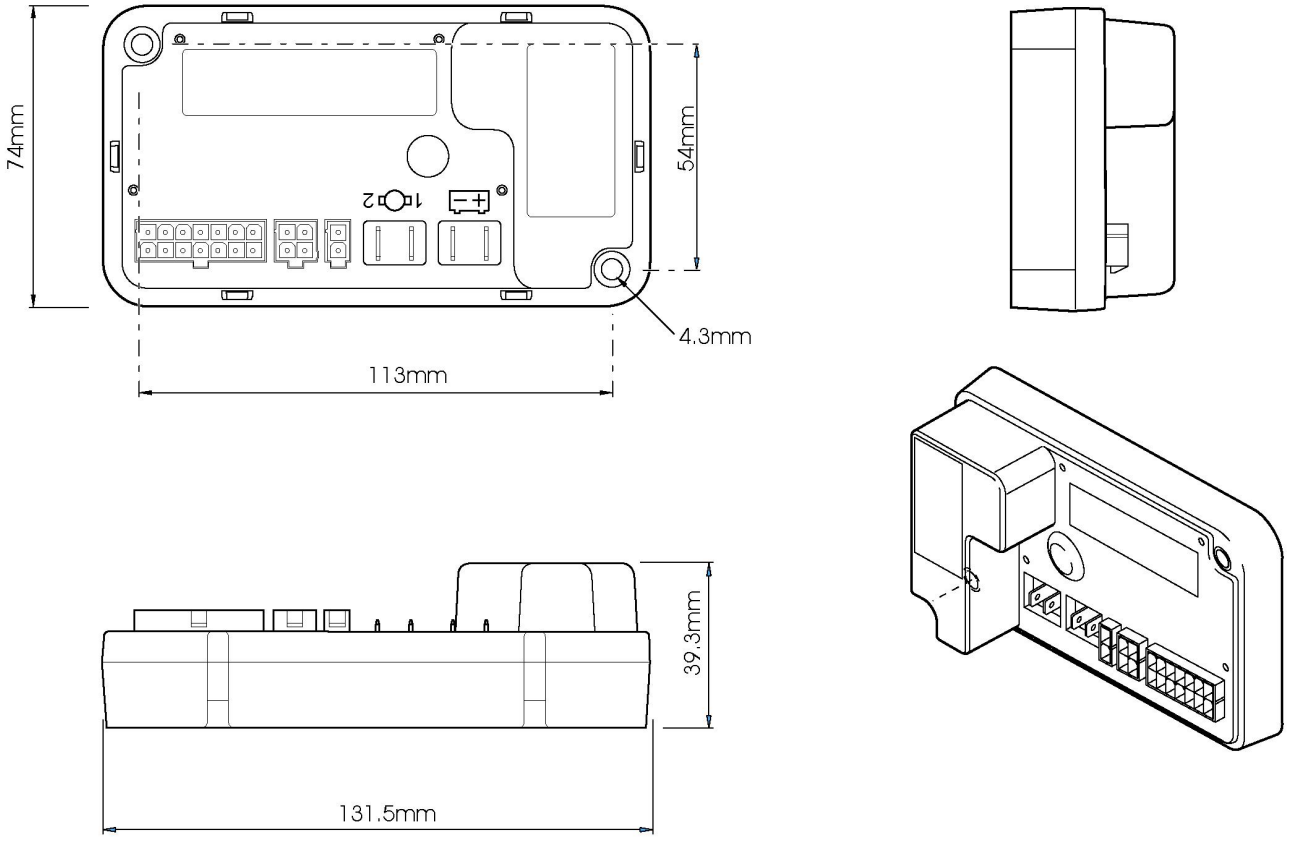
I.2 i-Drive Operation

Study Chapter 1: Operation. It is important that the information in Chapter 1 is supplied with the machine, either as part of the machine user handbook or as a separate document.

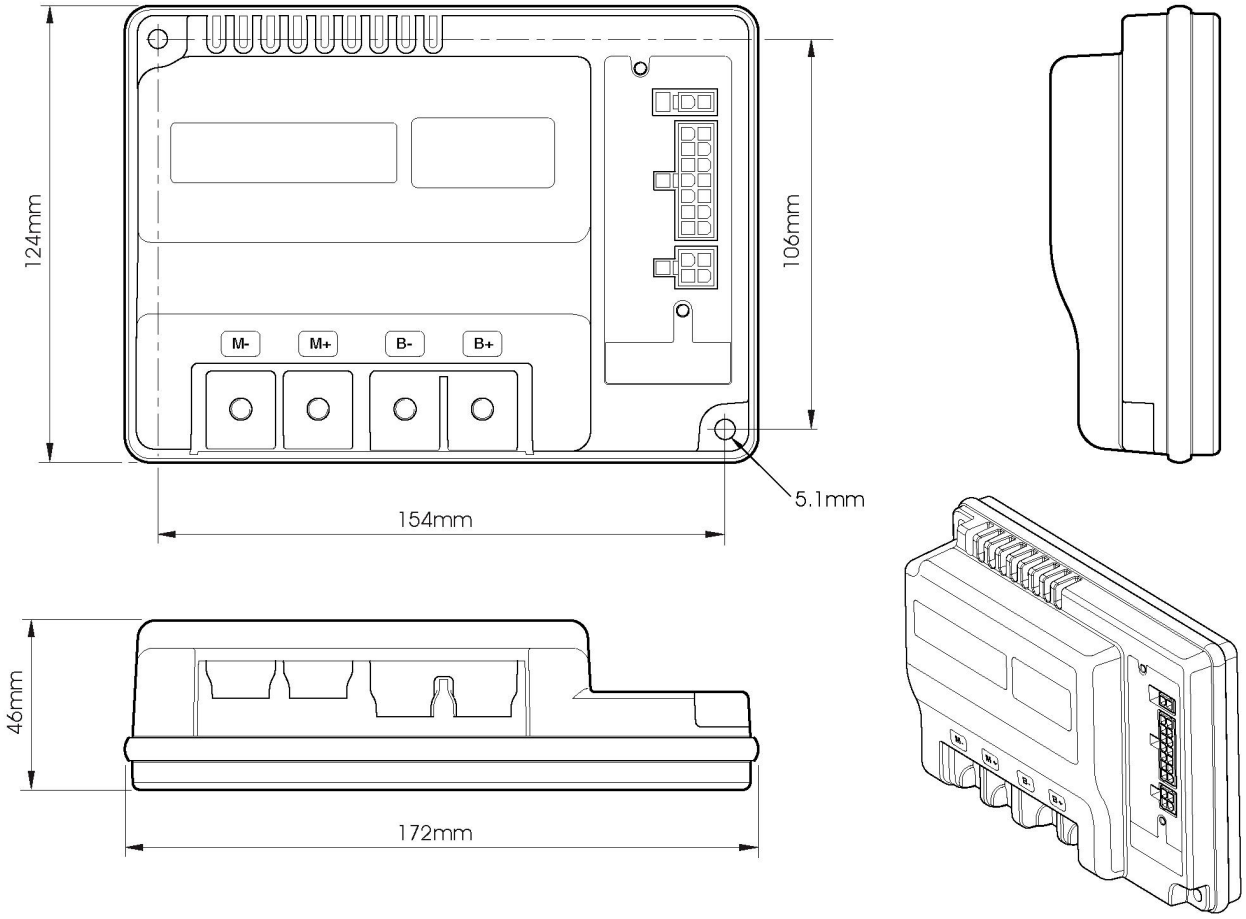
This chapter sets out the installation conditions that must be complied with in order to meet the safety requirements of EN60335/2/72.

1.3 Dimensions

1.3.1 i-Drive 45A and 70A Controllers



1.3.2 i-Drive 140A and 180A Controllers



1.4 Program Settings

Controllers are always supplied by PGDT with the preset settings shown on the data sheet.

It is the manufacturer's responsibility to program the control system to suit the machine model and ensure safe operation in compliance with relevant legal requirements over the whole of the operating range. PGDT accepts no liability for losses of any kind due to failure to, or incorrect programming of, the i-Drive controller. Refer to Chapter 3 for details of programmable parameters.

The machine must stop within the maximum distance specified for the country in which the machine will be used.

If the machine requires very low braking rates and this results in a longer stopping distance, the maximum speed must be reprogrammed so that the stopping distance requirement is satisfied.

State in the machine user handbook that it is the responsibility of the person programming the controller to make sure that the stopping distance requirement is satisfied. If the braking rate is low, the forward and reverse maximum speed settings may need to be reprogrammed.

To assist the person in this task, include a graph in the machine user handbook showing the relationship between the maximum forward/reverse speed settings and the forward/reverse braking rate which is required to ensure the correct stopping distance.

It may be possible to program settings which compromise the stability of the machine. Perform suitable tests to establish which programming restrictions are needed to prevent instability. State any programming restrictions in the machine user handbook.

State in the machine user handbook that it is the responsibility of the person programming the controller to make sure that the settings are safe and to note any programming changes that they make.

Programming should only be conducted by electronic service professionals with in-depth knowledge of PGDT electronic controllers. Incorrect programming could result in an unsafe set-up of a machine for the user. PGDT accepts no liability for losses of any kind if the programming of the controller is altered from the factory preset values. PGDT accepts no liability for losses of any kind if the drive or stability characteristics of the machine are altered without prior notification and discussion with PGDT.

1.5 Soft-Stop

If the version of i-Drive you have has the Soft-Stop function enabled (see controller data sheet), you must ensure that the emergency stopping distance is within the distance specified for the country in which the machine will be used.

1.6 Other Information

You must provide a diagram in the machine user handbook showing the user controls. In addition, you should include a brief specification of operating supply voltage range and operating temperature range.

2 Immobilizing the Machine

2.1 Prevention of Unauthorized Use

Some markets require the machine to have a means of preventing unauthorized use. This typically means fitting a keyswitch that can prevent the controller from being switched on.

2.2 Charger Interlock

Legislation may require you to provide a means of preventing the use of the machine while the batteries are being charged. The i-Drive includes 2 inhibit inputs either of which can be used to provide this function. Refer to Sections 4.11 and 4.12 for details.

Contact PGDT if you need advice.

The machine manufacturer is responsible for providing a means of preventing the use of the machine while the batteries are being charged. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

3 Connections

3.1 General

Study the data sheet for the controller to identify:

- The output current, ratings and restrictions.
- The connector pin assignments.

Recommendations for the cross-sectional area, ratings and materials for wiring are shown in Section 3.4. These depend on the application. You are responsible for establishing the suitability of the particular wiring arrangement used on the machine. PGDT can make general recommendations for wiring to the i-Drive controller, but PGDT accepts no responsibility for the wiring arrangement used.

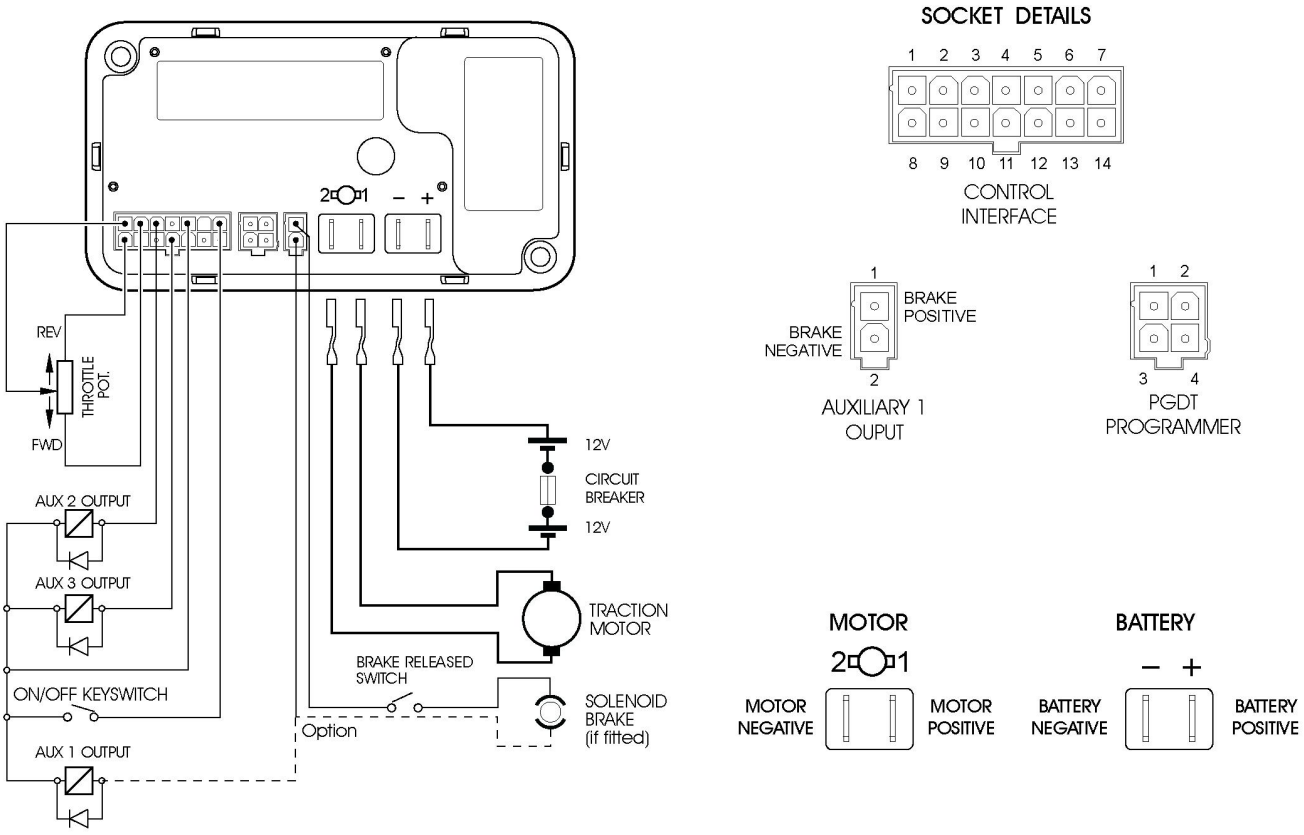
Make sure that the connectors you use are reliable under all operating conditions and correctly wired with no short circuits. Do not use unsuitable components - it may result in poor machine reliability. Refer to the following illustrations for basic connection details.

The machine manufacturer is responsible for establishing the suitability of the particular wiring arrangements used on the machine, for both normal use and stalled conditions. PGDT can make general recommendations for wiring the i-Drive controller, but PGDT accepts no responsibility for, and accepts no liability for losses of any kind arising from, the actual wiring arrangement used.

The machine manufacturer is responsible for ensuring that only the mating connectors specified by PGDT on the controller's specific data sheet or in this manual are used to connect to the controller. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

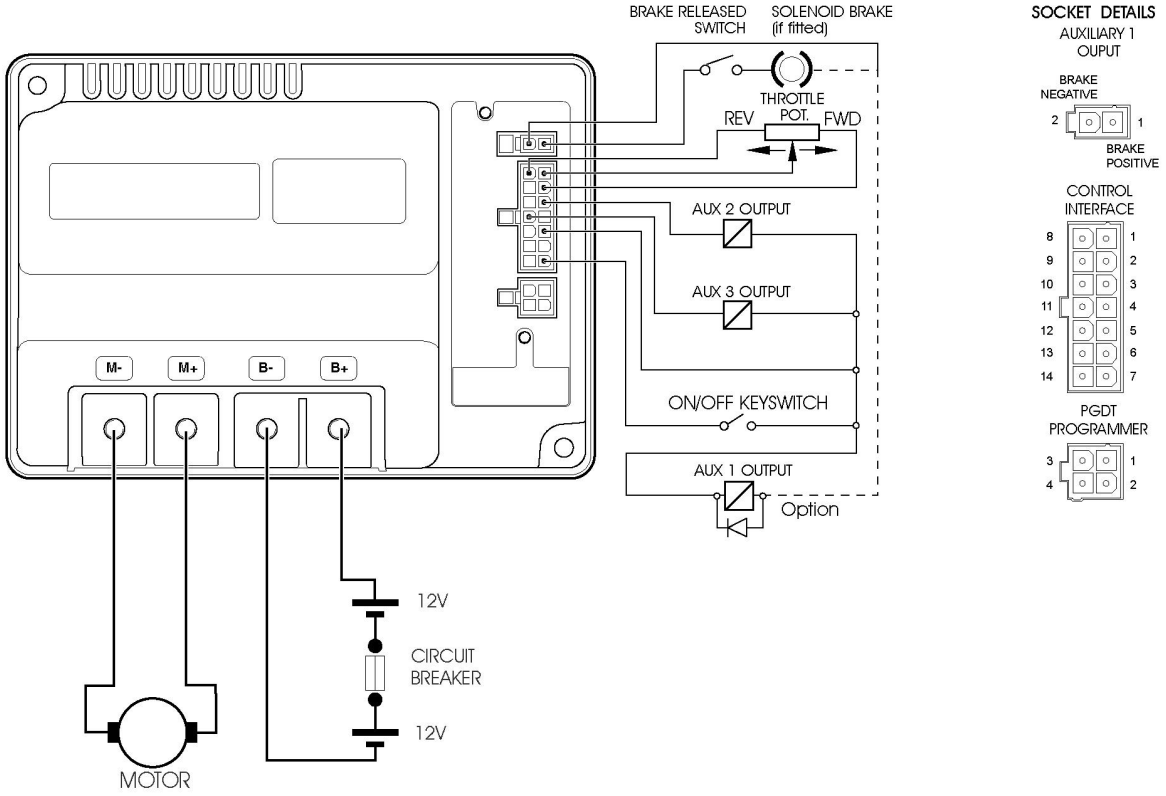
The machine manufacturer is responsible for ensuring that suitable connectors are used and securely mated throughout the machine wiring system and that the workmanship associated with the wiring system is of a good enough quality. Failure to meet this condition could result in intermittent operation, sudden stopping or veering, or even create a burn or fire hazard. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

3.1.1 Wiring Configuration i45 & i70



Suitable suppression diodes should be fitted across all Aux Output relay coils, as shown above.

3.1.2 Wiring Configuration i140 & i180



A suitable suppression diode should be fitted across an Aux I Output relay coil, as shown above.

3.2 Connectors & Connector Kits

Battery & Motor Connectors	
i24-45, i36-45, i24-70 & i36-70	0.25" 6.35mm Faston spade
i24-140, i36-140, i24-180 & i36-180	M6 screw terminals
Molex Connectors	
All i-Drive family variants	PGDT kit reference - D50319

3.2.1 Motor And Battery

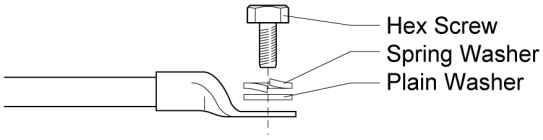
3.2.1.1 i45 & i70

The battery and motor connections on the i45 and i70 controllers use 0.25" 6.35mm Faston type terminals. The mating female parts should be sourced from a reputable manufacturer or supplier and these parts must be tested for suitability by the machine manufacturer.

It is the responsibility of the machine manufacturer to ensure that the mating female Fastons are suitable for use on the intended application. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

3.2.1.2 i140 & i180

The battery and motor connections on the i140 and i180 controllers use M6 threaded holes. These are identified as B+, B-, M+ and M-. The controller is provided with suitable screws, spring washers and flat washers for fastening the battery and motor cables. PGDT recommends the arrangement of screw, spring washer and flat washer as shown below.



Screws should not be tightened too more than 5.5Nm.

If alternate screws or bolts are used, it is essential that the thread insertion depth is less than 14mm. Damage to the controller may occur if this depth is exceeded.

When crimping the i140 & i180 high current connections, the use of AMP®, AMPower III™ or Solistrand™ copper tube terminals is recommended.

It is the responsibility of the machine manufacturer to ensure that the high current crimp connections are suitable for use on the intended application. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

3.2.2 Aux 1 Connector

The Aux 1 connector fitted to the i-Drive is a Molex 'Mini-Fit Jr' part.

The mating connector parts are as follows:

Molex 'Mini-Fit-Jr.' 2 socket receptacle:	39-01-2020
Molex 'Mini-Fit-Jr.' Crimp terminal:	39-00-0039

Refer to Section 3.3 for crimping and extraction tool information.

3.2.3 Tiller Interface Connector

The tiller interface connector fitted to the i-Drive is a Molex 'Mini-Fit Jr' part.

The mating connector parts are as follows:

Molex 'Mini-Fit-Jr.' 14 socket receptacle:	39-01-2140
Molex 'Mini-Fit-Jr.' Crimp terminal:	39-00-0039

Refer to Section 3.3 for crimping and extraction tool information.

3.2.4 Programming Connector

The programming interface connector fitted to the i-Drive is a Molex 'Mini-Fit Jr' part.

This connector should only be mated with a dedicated PGDT programming tool, i.e. an SPI, DTT or Industrial PC programmer. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

3.3 Crimping

Good quality crimping is essential in ensuring the long term reliability of the machine's electrical system. Poor quality crimps may initially appear to be satisfactory but, over time, they may cause problems. It is recommended that crimp quality is maintained by implementing the procedures detailed in IEC-60352-2 1990.

Defective or poor quality crimps may affect the warranty of the controller. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

Hand tools for crimping and extraction are available from Molex. The relevant part numbers are as follows.

Molex 'Mini-Fit-Jr.' Crimp tool: 69008-0724 or 63819-0900

Molex 'Mini-Fit-Jr.' Extraction tool: 11-03-0044

Only use the exact tool as specified.

For information on your closest Molex distributor refer to www.molex.com

PG Drives Technology can supply all the Molex connectors and crimps required by the i-Drive as kit 'D50319'.

3.4 Wire Gauge and Types

The table below gives the minimum recommended wire sizes for the i-Drive family.

Model	Battery		Motor		Auxiliary 1		Tiller	
	mm²	AWG	mm²	AWG	mm²	AWG	mm²	AWG
i45	2.5	13	2.5	13	0.5	20	0.22	23
i70	4.0	11	4.0	11	0.5	20	0.22	23
i140	10.0	7	10.0	7	0.5	20	0.22	23
i180	16.0	5	16.0	5	0.5	20	0.22	23

The wire gauges of the tiller interface Fused B+ and 0V connections, pins 7 and 13, may require increasing if the machine manufacturer wishes to run auxiliary circuits, such as lighting, from these points.

It is the responsibility of the machine manufacturer to ensure that all wire gauges are suitable for the intended application.

These recommendations are derived from well proven field experience of various international machine manufacturers. Nevertheless, manufacturers must confirm these recommendations by carrying out suitable tests. Keep wire lengths as short as possible.

Battery and motor wires should use Tri-rated PVC equipment wire rated at 105°C.

3.5 Battery Connection

The i-Drive incorporates sophisticated current limiting circuitry as protection for the components inside the controller.

However, it is recommended that you provide protection against short circuits in the battery wiring and power loom or in the extremely unlikely event of a short circuit in the controller.

It is recommended that the high current wiring to the i-Drive be kept as short as possible.

The machine manufacturer must install a suitable circuit breaker to provide protection against short circuits in the battery wiring, power loom or the controller. Failure to comply with this condition could result in a fire hazard. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

Applications that use an external line contactor to isolate the battery supply at 'key-off', may require an additional 'pre-charge' resistor to be connected across the contacts. Please call PGDT if you require further advice.

3.6 Motor Connection

If a circuit breaker is fitted in series with the motor, it is essential that the machine assumes a safe condition the moment the circuit breaker operates. You must therefore fit a circuit breaker with an auxiliary switch that inhibits the machine from driving.

3.7 Auxiliary 1 Output

The Auxiliary 1 connector is a self-protected output with a 1.25A rating which can be programmed to operate one of a range of functions depending on the machine's specifications. The parameter, which must be programmed, is Auxiliary 1 Output Mode.

The Auxiliary 1 Output Mode parameter sets when this output will be active.

The output can be used to control a Solenoid Brake or to drive an Auxiliary load.

3.7.1 Solenoid Brake

Connect the brake positive to pin 1 of the Auxiliary 1 Connector and brake negative to pin 2; refer to the relevant i-Drive wiring configuration diagram. The i-Drive's brake output has a continuous rating of 1.25A. If the continuous current is greater than this level, then the controller may shut down the brake output in order to protect it. If the solenoid brake current is less than 10mA, the controller will detect an open-circuit brake condition.

If the brake is manually disengaged in order to freewheel the machine, then a Brake Released switch must be fitted and connected as shown in the i-Drive wiring diagram. This will result in the controller preventing drive, detecting a freewheel situation and indicating this as a solenoid brake trip.

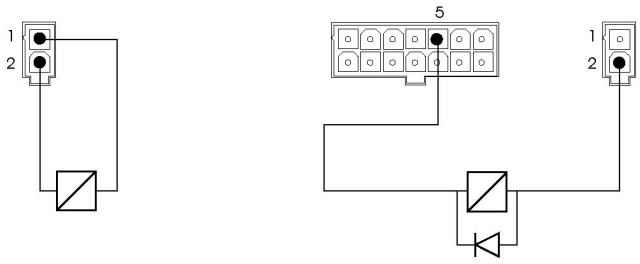
Due to the i-Drive's ability to operate at low voltages, the solenoid brake(s) fitted must also be capable of operating over the same range.

It is the responsibility of the machine manufacturer to test the effectiveness of the solenoid brake(s) over the entire operating range of the i-Drive.

3.7.2 Auxiliary 1 Other Modes

This output can also be used to drive an auxiliary motor, via a relay, such as a brush or vacuum motor.

When using Aux 1 Output with the mode not set to Solenoid Brake AND Off Delay > 0, then the positive side of the load device should be connected to pin 5 of the Tiller connector, On/Off Switch, not the brake positive output. If this recommendation is not followed, when drive has reached zero, the bridge relay will open causing any device expected to remain on to lose its positive supply. This will also drain the bridge capacitors and cause an error trip.



Aux 1 Off Delay = 0 Secs Aux 1 Off Delay >0 Secs

The output will be active depending on how the parameter Auxiliary 1 Output Mode is programmed. The three modes, which should be used to control an auxiliary motor, are Forward Traction, Reverse Traction or Traction.

Forward Traction	Means the Output is only active when the machine is driving forwards.
Reverse Traction	Means the Output is only active when the machine is driving in reverse.
Traction	Means the Output is active when the machine is driving in either direction.

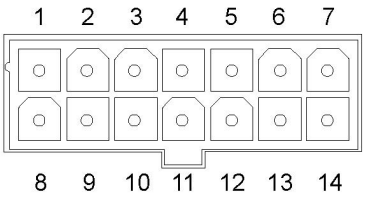
Setting Aux I Output Mode to any option other than Solenoid Brake automatically disables the Solenoid Brake check (open circuit detection).

When the parameter Aux I Output Mode is set to Solenoid Brake, the parameters Auxiliary Output I Off Delay and Inhibit 'x' Target, if set to Aux I, will have no effect. For this instance only, the parameter Brake Time is effective.

A suitable suppression diode should be fitted across an Aux I Output relay coil, as shown above.

4 Tiller Interface

The Tiller Interface connections are via a 14 way Molex 'Mini-Fit-Jr.' connector. PGDT can supply these parts or Molex can be contacted directly. Refer to Section 3.2.3 for part numbers and connector details.



Pin Number	Description
1	Throttle Wiper
2	Throttle High Reference
3	Auxiliary 2 Output
4	Slow/Fast Switch
5	On/Off Switch
6	Inhibit 1 / Forward Direction Switch*
7	Fused B+ Supply
8	Throttle Low Reference
9	Speed Limiting Potentiometer Wiper / Belly Button Input
10	Status Indicator
11	Auxiliary 3 Output
12	Reverse Switch / Auxiliary 3 Input / Reverse Direction Switch*
13	0V
14	Inhibit 2 / Tiller Switch*

***This functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.**

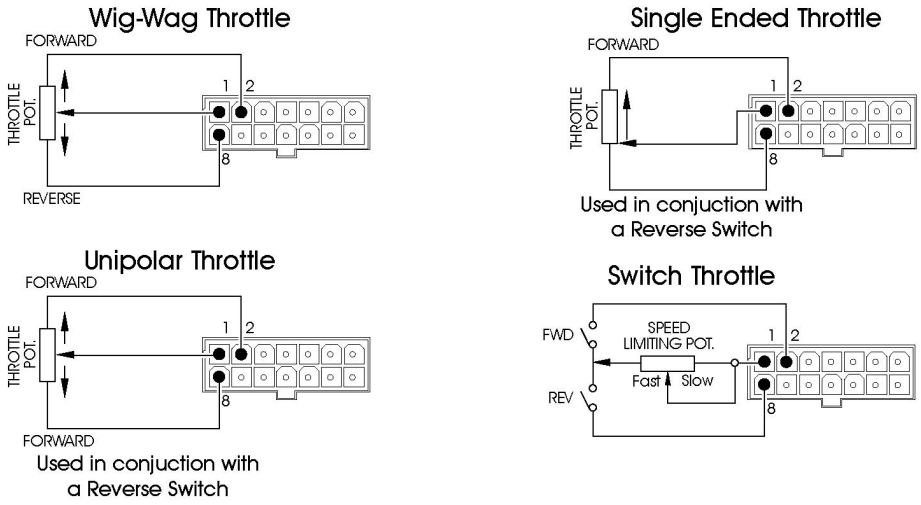
The i-Drive family provides a versatile method of machine control. To maximize this versatility, the tiller interface can be wired in many different ways to suit a range of machine functionality. Each method of connection is individually described in this section.

4.1 Throttle Potentiometer Configuration

Pins 1, 2 and 8 are the connections to the throttle potentiometer. Wig-wag, single-ended and unipolar throttle configurations can be used but you should ensure the controller is programmed to the correct type. Refer to Chapter 3.

The value of the potentiometer should be 5kΩ ± 20%. If the full electrical span of the potentiometer is not used, Throttle Gain can be programmed such that full speed can be achieved. Refer to Chapter 3.

If the machine has a wig-wag throttle configuration it is possible, by programming, to reverse the polarity of operation of the throttle. For single-ended throttles the polarity of operation of the reverse switch can be selected. Refer to Chapter 3.



If a switch operated throttle is required, the parameter Throttle Type must be set to Wig-wag and the parameter Throttle Reference Test must be set to Off.

Other factory programmed throttle inputs are available, e.g. an input configuration that accepts signals in the range of 0-5V. If this configuration is used, a 10kΩ resistor must be connected in series with the throttle wiper and the Throttle Reference Test must be set to 'Off'.

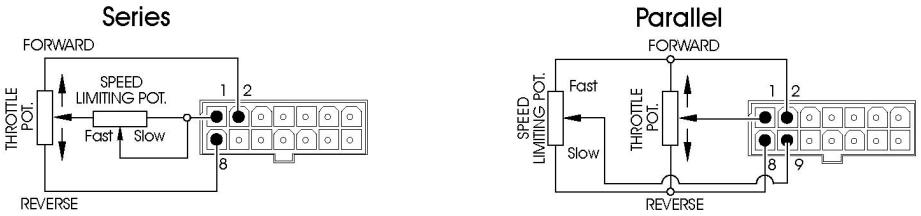
4.2 Speed Limiting Potentiometer / Belly Button Input

4.2.1 Speed Limiting Potentiometer Configuration

A speed limiting potentiometer may be connected in two ways.

In series with the throttle potentiometer wiper.

In parallel with the throttle potentiometer, through pin 9.



The illustration shows both connection variants with a wig-wag throttle.

If a series type connection is made a value of 25kΩ will result in the machine driving at 30% of maximum speed.

If a parallel type connection is made a potentiometer of 100kΩ ± 20% value should be used. The potentiometer should be fitted so that its wiper is connected to the throttle high reference when the potentiometer is in the 'fast' position. The effect of the potentiometer is explained in the section table.

When a parallel type connection is made the i-Drive should be programmed as follows.

Drive Direction	Potentiometer Position	Machine Maximum Speed
Forward	Slow Position	As set by Min. Fwd Speed
Forward	Fast Position	As set by Max. Fwd Speed
Reverse	Slow Position	As set by Min. Rev Speed
Reverse	Fast Position	As set by Max. Rev Speed

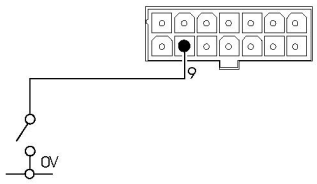
The parameter Speed Limit Pot. Enabled must also be set to On.

4.2.2 Belly Button Configuration

A Belly Button is a safety feature used on pallet trucks, floorcare machines etc., which prevents the operator being trapped between the machine and obstructions such as walls when reversing. It is normally a protruding switch, which is mounted on the control handle / vehicle body at waist height and is automatically depressed by the operator's body as the machine reverses against the obstruction. Once actuated, the machine instantly stops reversing and automatically drives forward away from the obstruction at a set speed until the button is released.

It is the responsibility of the machine manufacturer to ensure the mechanical arrangement of the Belly Button is suitable for the intended application. PGDT accepts no liability for losses of any kind arising from the incorrect mechanical arrangement of the Belly Button or the type of Belly Button switch used.

Pin 9 allows the connection of a Belly Button switch as follows.



Belly Button Function Associated Parameters.

Speed Limit Pot. Enabled.

Belly Button Switch Type.

Belly Button Speed.

Belly Button Time.

Setting the parameter Speed Limit Pot. Enabled to Off and programming the Belly Button Time > 0 enables the Belly Button function.

Set the parameter Belly Button Switch Type to Normally Open for a Belly Button switch that is activated when closed. Select Normally Closed for a Belly Button switch, which is activated when open.

The parameter Belly Button Speed selects the speed at which the machine will travel forward when the Belly Button is pressed, as a percentage of maximum speed.

The parameter Belly Button Time sets the period that the Belly Button Speed will be applied for, if the switch is not released.

When suitably programmed, the switch is actuated AND the controller is in reverse drive, the Belly Button mode is initiated. This will:

Instantly reduce drive to 0%.

Accelerate in the forward direction to the programmed Belly Button Speed within 0.5s.

Drive forwards at the programmed Belly Button Speed until the switch is released or if the switch is not released, for a period set by the programmed Belly Button Time.

Decelerate from the Belly Button Speed to a halt in 1s.

Exit Belly Button mode and resume normal operation once the next throttle signal is received.

The throttle command must be allowed to reset before new commands can be accepted.

Once initiated, the Belly Button mode will complete this sequence regardless of throttle commands.

The machine manufacturer is responsible for ensuring that the wiring of the Belly Button switch and the programming of the Belly Button parameters are suitable for the intended application. PGDT accepts no liability for losses of any kind arising from the incorrect wiring or programming of the Belly Button function.

4.3 Fused B+ Supply

Pin 7 is a battery positive supply for the keyswitch circuit. The output has a self resetting fuse internally fitted. PGDT recommend that no more than 3A is drawn from this output.

This connection should have no external capacitance connected to it and care should be taken not to exceed the fuse rating if lights or other auxiliary functions are connected.

4.4 On/Off Switch

Pin 5 is the On/Off switch input to the i-Drive.

Due to the i-Drive's low current drain when in the off state, the positioning of large capacitors on the On/Off line, between pins 5 & 7, could have a detrimental effect on the controller's ability to switch off and on.

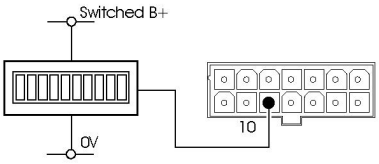
It is the responsibility of the machine manufacturer to test the effectiveness of the On/Off switch.

4.5 Status Indicator

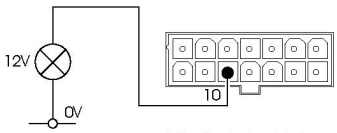
This output controls either a PGDT TruCharge type status indicator or a single bulb (or LED) type Status Indicator.

If you are using a PGDT TruCharge indicator, the data connection must be to pin 10.

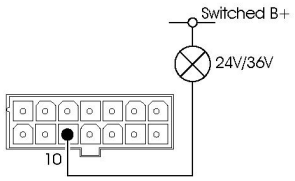
The maximum current rating of the output is 50mA; you must ensure that the indicator does not draw more current than this value.



If you are using a bulb, the bulb can be connected directly between pin 10 and 0V (Highside) or pin 10 and switched B+ (Lowside). The bulb must be 12V with a maximum rating of 600mW when connected Highside and 24V / 36V with a maximum rating of 600mW when connected Lowside.

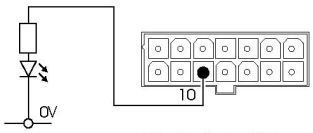


Highside Drive

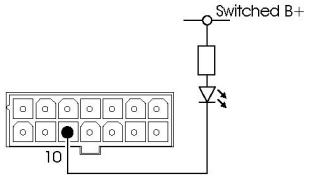


Lowside Drive

If you are using an LED, it is connected between the same points but you must provide a series connected current limiting resistor.



Highside Drive



Lowside Drive

If you are using an Analogue 12V Status Indicator, it is must be connected between pin 10 and 0V.

For each connection and indicator type the controller will require programming to suit. The parameter that will require adjustment is Status Output Type.

This will require programming to one of the following:

TruCharge	**Suitable for Lamp and LED Status Indicators on Highside Drive connections and the TruCharge Status Indicator.**
Sink	**Suitable for Lamp and LED Status Indicators on Lowside Drive connections.**
Analogue	**Suitable for Analogue 12V Status Indicator.**

4.5.1 Status Indicator Diagnostic Setting

For each Status Indicator type the controller will require programming to suit. The parameter that will require adjustment is Diagnostic Flash Sequence.

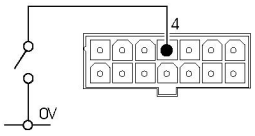
This will require programming to one of the following:

None	No diagnostic indication.
TruCharge	PGDT diagnostic information. Refer to Chapter 1 Section 8.
PG	Suitable for Lamp or LED Status Indicators. The Status Indicator will flash the equivalent message of the TruCharge display.

Refer to Chapter 3 for details.

4.6 Slow/Fast Switch

Pin 4 is an input that can be used to limit the forward and reverse speeds, the forward and reverse acceleration and the forward and reverse deceleration of the machine.



If pin 4 is connected to 0V the controller will drive using the programmed slow speed and rates. These speeds are listed below.

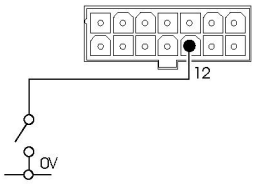
If pin 4 is open then the controller will drive using the programmed fast speed and rates. These speeds are listed as follows:

Forward Accel'n	fast : xx	slow: xx	Forward Decel'n	fast : xx	slow: xx
Reverse Accel'n	fast : xx	slow: xx	Reverse Decel'n	fast : xx	slow: xx
Max. Fwd Speed	fast : xx	slow: xx	Min. Fwd Speed	fast : xx	slow: xx
Max. Rev Speed	fast : xx	slow: xx	Min. Rev Speed	fast : xx	slow: xx

4.7 Reverse Switch / Auxiliary 3 Input / Reverse Direction Switch

4.7.1 Reverse Switch

Pin 12 is a connection for a reverse switch. This is required to select reverse drive, only if the controller is being used with single-ended or unipolar throttle configurations.



The direction of drive is programmable and can be changed using the Throttle Invert parameter. Refer to Chapter 3 for details.

With Throttle Invert set to Off, the drive will be in reverse if pin 12 is connected to 0V.

With Throttle Invert set to On, the drive will be forwards if pin 12 is connected to 0V.

4.7.2 Auxiliary 3 Input

If a wig-wag throttle is fitted to the machine then this input can be used to control the Auxiliary 3 Output. In this instance, the Auxiliary 3 Input parameter sets the function of the pin. Refer to Chapter 3 for details.

If set to None, the output will be active as per the Auxiliary 3 Output Mode.

If set to Reverse Switch, the Auxiliary 3 Output will only be active when the switch is closed.

4.7.3 Reverse Direction Switch

If the machine is fitted with direction switches, the reverse direction switch should be connected to this pin. For reverse drive to commence, this switch must be closed in conjunction with throttle demand. The function of the switch is programmable and can be changed using the Direction Switches parameter. Refer to Chapter 3 for details.

If set to No, then pin 12 will operate in the normal way, i.e. reverse switch input for single-ended and unipolar throttles.

If set to Yes, reverse drive will only commence when pin 12 is connected to 0V and throttle demand is detected.

Direction Switch functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

4.8 Auxiliary 2 Output

Pin 3 is a self-protected output, which can be programmed to operate one of a range of functions depending on the machine's specifications. The parameter that must be programmed is Auxiliary 2 Output Mode.

The current rating of pin 3 is dependent on the model of i-Drive and will be altered if the Auxiliary 3 Output is operated at the same time.

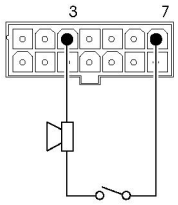
Model	Pin 3 - Aux 2 Output only	Pin 3 - Simultaneous Aux 3 Output operation
i24-45 & i24-70	800mA	500mA
i36-45 & i36-70	420mA	340mA
i24-140 & i24-180	1A	1A
i36-140 & i36-140	1A	1A

The Auxiliary 2 Output Mode parameter sets when this output will be active.

The output can be used to control a Diagnostic/Reverse Alarm, a Brake Light or an Auxiliary load.

4.8.1 Diagnostic/Reverse Alarm

To install a 24V / 36V sounder (dependant on i-Drive model) the positive terminal of the sounder should be connected, via the On/Off switch, to battery positive. The negative terminal of the sounder should be connected to pin 3.



To enable this function, Auxiliary 2 Output Mode should be set to Diagnostic/Reverse Alarm.

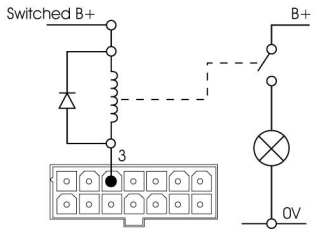
Once configured as a Reverse Alarm the output can be programmed to work three further functions. Each parameter must be programmed individually. Refer to Chapter 3 for details.

Brake Alarm	If an open circuit in the brake wiring is detected, such as when the freewheel switch is activated, the alarm will sound.
Low Batt Alarm	The alarm will sound when the battery voltage reaches the programmed Battery Lockout value.
Diagnostic Alarm	This will create a pulsed type alarm, which will sound the equivalent of the TruCharge diagnostic indicator.

The diagnostic alarm will sound a warning signal to alert the user that a diagnostic alarm pattern is about to be sounded. The signal will be a set of fast beeps lasting two seconds. The slower diagnostic pattern will then be sounded once.

4.8.2 Brake Light

Pin 3 can also be connected and programmed as a brake light indicator. The brake light will be illuminated as soon as the throttle is released and will remain illuminated for approximately 1-2 seconds after the machine has stopped completely.



If the current drawn is less than the value shown in the preceding table, the relay is not required and the lamp can be connected directly between Switched B+ and pin 3

To enable this function, Auxiliary 2 Output Mode should be set to Brake Light.

When using i45 or i70 controllers, the parameter Brake Light must also be set to On.

When this parameter is enabled, no alarm functions will operate.

When the parameter Auxiliary 2 Output Mode is set to Diagnostic/Reverse Alarm or Brake Light, the parameters Auxiliary Output 2 Off Delay and Inhibit 'x' Target, if set to Aux 2, will have no effect.

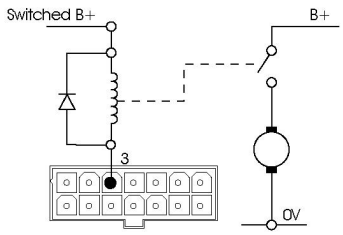
i45 & i70 controllers should be fitted with a suitable suppression diode, as shown above.

The Brake Light relay coil should be connected to 'Switched B+', not the battery positive terminal.

4.8.3 Auxiliary 2 Other Modes

Pin 3 can also be used to drive an auxiliary motor, via a relay, such as a brush or vacuum motor.

Pin 3 will be active depending on how the parameter Auxiliary 2 Output Mode is programmed. The four modes, which should be used to control an auxiliary motor, are Continuous, Forward Traction, Traction and Reverse Traction.



Continuous	Means the Output is active the entire time the control system is powered up.
Forward Traction	Means the Output is only active when the machine is driving forwards.
Traction	Means the Output is only active when the machine is driving.
Reverse Traction	Means the Output is only active when the machine is driving in reverse.

i45 & i70 controllers should be fitted with a suitable suppression diode, as shown above.

The Aux 2 relay coil should be connected to 'Switched B+', not the battery positive terminal.

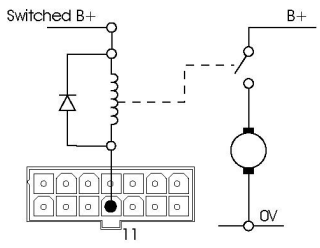
4.9 Auxiliary 3 Output

Pin 11 is a self-protected output, which can be programmed to operate a range of functions depending on the machine's specifications. The parameter that must be programmed is Auxiliary 3 Output Mode.

The current rating of pin 11 is dependent on the model of i-Drive and will be altered if the Auxiliary 2 Output is operated at the same time and/or if the Aux 3 Output is PWM.

Model	Pin 11 - Aux 3 Output only	Pin 11 - Simultaneous Aux 2 Output operation and/or Aux 3 Output PWM
i24-45 & i24-70	800mA	500mA
i36-45 & i36-70	420mA	340mA
i24-140 & i24-180	1A	1A
i36-140 & i36-140	1A	1A

Pin 11 will be active depending on how the parameter Auxiliary 3 Output Mode is programmed. The four modes, which should be used to control an auxiliary motor, are Continuous, Forward Traction, Reverse Traction and Traction.



Continuous	Means the Output is active the entire time the control system is powered up.
Forward Traction	Means the Output is only active when the machine is driving forwards.
Reverse Traction	Means the Output is only active when the machine is driving in reverse.
Traction	Means the Output is only active when the machine is driving.

i45 & i70 controllers should be fitted with a suitable suppression diode, as shown above.

The Aux 3 relay coil should be connected to 'Switched B+', not the battery positive terminal.

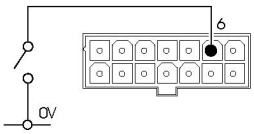
4.10 0 Volts

Pin 13 provides the battery negative connection to the machine's tiller. This pin has a current rating of 3A via an internal self-resetting fuse.

4.11 Inhibit 1 / Forward Direction Switch

This input is located on pin 6 of the 14-way tiller connector. The function of the input is programmable and can be changed using the Direction Switches parameter. Refer to Chapter 3 for details.

4.11.1 Inhibit 1



Each Inhibit input has been designed to either inhibit a specific function or control an auxiliary function such as a brush or vacuum motor. The Inhibits can be used to either limit the maximum speed of the machine, stop it completely or in the case of an auxiliary output, stop and start the output device.

See the example in Section 4.11.6.

Inhibit 1 input has 5 programmable parameters.

Inhibit 1 Debounce.

Inhibit 1 Mode.

Inhibit 1 Target.

Inhibit 1 Speed.

Inhibit 1 Operation.

4.11.2 Inhibit 1 Debounce

This parameter sets the amount of time a connection to Inhibit 1 must be stable before it is interpreted as a valid condition. This parameter is particularly useful for interlock switches such as a seat switch, which can bounce momentarily as the operator passes over bumpy terrain.

The parameter is programmable between 0s and 5s in 0.5s steps.

If set to 0, then the normal inherent debounce will be applied to the input.

Inhibit Debounce functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

4.11.3 Inhibit 1 Mode

This parameter refers to the state in which the inhibit is active.

The parameter can be set to Disabled, Pull Low or Open Circuit.

4.11.4 Inhibit 1 Target

This parameter sets the function(s) which will be affected when the inhibit switch is in the required state. These are as follows.

None	No functions will be inhibited.
Forward Drive	Forward drive only is inhibited.
Reverse Drive	Reverse drive only is inhibited.
Aux 1	Auxiliary 1 Output is inhibited.
Aux 2	Auxiliary 2 Output is inhibited.
Aux 3	Auxiliary 3 Output is inhibited.

Selecting both Forward Drive and Reverse Drive will mean all traction is inhibited.

Setting this parameter to Aux 1 will allow control of the Auxiliary 1 Output. Inhibit 1 input can then be used to switch Aux 1 Output on and off.

4.11.5 Inhibit 1 Speed

This parameter sets the maximum speed of the machine when the Inhibit 1 input is active and the Target is set as Forward Drive, Reverse Drive or both. The parameter is adjustable between 0 and 100% in steps of 1%.

When Inhibit Speed = 0 this acts as an inhibit. At this time the controller will refer to the Inhibit Operation parameter to establish what type of inhibit will be created.

If the Inhibit Speed is greater than 0 then the controller will not enter an inhibit state.

4.11.6 Inhibit 1 Operation

This parameter is only effective if the Inhibit 1 Speed parameter has been set to 0.

The parameter can be set to one of two states:

Latched	Means the inhibitor, such as a safety switch, must be deactivated and the controller turned off and on before the machine can be operated again.
Non-Latched	Means the controller can be reset to an operational state by removing the inhibitor.

If set to Latched, then when Inhibit 1 is active the TruCharge display will flash 6 bars and a trip will appear in the diagnostic log.

Example 1 - To provide a speed inhibit function that is active when Inhibit 1 is connected to 0V and is non-latching, program as follows.

Mode = Pull Low

Target = Forward Drive and Reverse Drive

Speed Limit Value = 40%

Operation = Non-Latched

If this inhibit is activated, the controller will cause the machine to decelerate to the programmed speed limit value. This could be activated by a microswitch on a brush head lever that is closed when the brush is lowered to the ground. In this instance the TruCharge indicator will remain unchanged.

Example 2 - To provide a trip inhibit function that is active when Inhibit 1 is connected to 0V and is latching, program as below.

Mode = Pull Low

Target = Forward Drive and Reverse Drive

Speed Limit Value = 0

Operation = Latching

If this inhibit is activated, the controller will not allow drive. This could be activated by an on-board charger being connected to the line. The TruCharge indicator will display a 6-bar trip.

4.11.7 Forward Direction Switch

If the machine is fitted with direction switches, the forward direction switch should be connected to this pin. For forward drive to commence, this switch must be closed in conjunction with throttle demand. The function of the input is programmable and can be changed using the Direction Switches parameter. Refer to Chapter 3 for details.

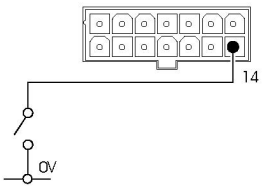
If set to No, then pin 6 will operate in the normal way, i.e. as Inhibit 1.

If set to Yes, forward drive will only commence when pin 6 is connected to 0V and throttle demand is detected.

Direction Switch functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

4.12 Inhibit 2 / Tiller Switch

This input is located on pin 14 of the 14-way tiller connector. The function of the switch is programmable and can be changed using the Tiller Switch parameter. Refer to Chapter 3 for details.



4.12.1 Inhibit 2

Each Inhibit input has been designed to either inhibit a specific function or control an auxiliary function such as a brush or vacuum motor. The Inhibits can be used to either limit the maximum speed of the machine, stop it completely or in the case of an auxiliary output, stop and start the output device.

See the example in Section 4.12.6.

Inhibit 2 input has 5 programmable parameters.

Inhibit 2 Debounce.

Inhibit 2 Mode.

Inhibit 2 Target.

Inhibit 2 Speed.

Inhibit 2 Operation.

4.12.2 Inhibit 2 Debounce

This parameter sets the amount of time a connection to Inhibit 2 must be stable before it is interpreted as a valid condition. This parameter is particularly useful for interlock switches such as a seat switch, which can bounce momentarily as the operator passes over bumpy terrain.

The parameter is programmable between 0s and 5s in 0.5s steps

If set to 0, then the normal inherent debounce will be applied to the input.

Inhibit Debounce functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

4.12.3 Inhibit 2 Mode

This parameter refers to the state in which the inhibit is active.

The parameter can be set to Disabled, Pull Low or Open Circuit.

4.12.4 Inhibit 2 Target

This parameter sets the function(s) which will be affected when the inhibit switch is in the required state. These are as follows.

None	No functions will be inhibited.
Forward Drive	Forward traction only is inhibited.
Reverse Drive	Reverse traction only is inhibited.
Aux 1	Auxiliary 1 Output is inhibited.
Aux 2	Auxiliary 2 Output is inhibited.
Aux 3	Auxiliary 3 Output is inhibited.

Selecting both Forward Drive and Reverse Drive will mean all traction is inhibited.

Setting this parameter to Aux 2 will allow control of the Auxiliary 2 Output. Inhibit 2 input can then be used to switch Aux 2 Output on and off.

4.12.5 Inhibit 2 Speed

This parameter sets the maximum speed of the machine when the Inhibit 2 input is active and the Target is set as Forward Drive, Reverse Drive or both. The parameter is adjustable between 0 and 100% in steps of 1%.

When Inhibit Speed = 0 this acts as an inhibit. At this time the controller will refer to the Inhibit Operation parameter to establish what type of inhibit will be created.

If the Inhibit Speed is greater than 0 then the controller will not enter an inhibit state.

4.12.6 Inhibit 2 Operation

This parameter is only effective if the Inhibit 2 Speed parameter has been set to 0.

The parameter can be set to one of two states:

Latched	Means the inhibitor, such as a safety switch, must be deactivated and the controller turned off and on before the machine can be operated again.
Non-Latched	Means the controller can be reset to an operational state by removing the inhibitor.

If set to Latched, then when Inhibit 2 is active the TruCharge display will flash 6 bars and a trip will appear in the diagnostic log.

Example 1 - To provide a speed inhibit function that is active when Inhibit 2 is connected to 0V and is non-latching, program as follows.

Mode = Pull low

Target = Forward Drive and Reverse Drive

Speed Limit Value = 40%

Operation = Non-Latched

If this inhibit is activated, the controller will cause the machine to decelerate to the programmed speed limit value. This could be activated by a microswitch on a brush head lever that is closed when the brush is lowered to the ground. In this instance the TruCharge indicator will remain unchanged.

Example 2 - To provide a trip inhibit function that is active when Inhibit 2 is connected to 0V and is latching, program as below.

Mode = Pull low

Target = Forward Drive and Reverse Drive

Speed Limit Value = 0

Operation = Latching

If this inhibit is activated, the controller will not allow drive. This could be activated by an on-board charger being connected to the line. The TruCharge indicator will display a 6-bar trip.

4.12.7 Tiller Switch

If the machine is fitted with a tiller switch, it should be connected to this pin. For drive to commence, this switch must be closed in conjunction with throttle demand. The function of the switch is programmable and can be changed using the Tiller Switch parameter. Refer to Chapter 3 for details.

If set to No, then pin 14 will operate in the normal way, i.e. as Inhibit 2.

If set to Yes, drive will only commence when pin 14 is connected to 0V and throttle demand is detected.

Tiller Switch functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

5 Drive Motors

The controller is designed to be connected to a permanent magnet DC motor, fitted with a suitable gearbox and solenoid brake.

In order to optimize the performance of the machine, the controller must be matched to the motor terminal impedance. This matching is implemented by programming the controller. The parameter for adjustment is Motor Compensation. Refer to Chapter 3.

The Motor Compensation value should be set in accordance with the armature resistance of the motor and all cables and connectors between the i-Drive and the motor. The value is set in milli-Ohms (mΩ). A recommended value is:

60% of the (armature resistance + cables and connectors)

Motor manufacturers should be able to supply figures for armature resistance and cable and connectors may typically be 40mΩ.

Example:

Motor has an armature resistance of 200mΩ

Cables and connectors are 40mΩ

Set Motor Compensation to 0.6 x (200 + 40) = 144mΩ

Failure to match the controller with the motors may result in poor control characteristics.

If you have any doubts about the suitability of a particular motor type or you need advice on measuring motor impedance, contact PGDT.

The machine manufacturer is responsible for ensuring that the controller is matched to the motor armature resistance. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The machine manufacturer is responsible for always ensuring that any replacement motors or gearboxes are fully compatible with the originals that the controller was designed to match. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

Users or service personnel must not move a controller from one machine type to install it on a different machine type. Controllers with different part numbers may have both hardware and software differences to ensure that they are compatible with the electrical and dynamic characteristics of their specific target vehicles. The characteristics of one type of controller may not be compatible with a different machine. Failure to observe this warning could result in an unsafe set-up for the machine user and may create a fire hazard depending on the motors, wiring, connectors and circuit breakers installed on the unauthorized machine. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

5.1 Gradient Performance

To achieve the most comfortable performance on a gradient, it is desirable to minimize the roll-back and roll-forward of the machine. By minimizing these effects, user comfort is improved and drive train reliability increased.

Roll-back occurs when the throttle is released while driving uphill, the machine will stop and then may roll-back slightly before the brake is applied.

Roll-forward occurs when the throttle is released while driving downhill and results in the brake being applied while the machine is still moving.

The following programming is provided to allow these two conditions to be minimized.

Motor Compensation, Slope Factor, Anti-Rollback Level, Pull-Away Delay and Anti-Rollback Velocity. Refer to Chapter 3 for details.

5.2 Freewheeling

There are two typical methods for providing a machine freewheel function.

Disengaging the motor and brake assembly from the remainder of the drive train and allowing the wheels to freely rotate.

Disengaging the solenoid brake from the motor and allowing the wheels and motor to rotate.

If the latter method is used, the i-Drive can detect the motor rotating above a certain speed and then brake it automatically, thus removing the possibility of the machine freewheeling at an excessive speed. This function will operate if the machine is switched off and even if there are no batteries fitted or connected.

It is the responsibility of the machine manufacturer to ensure that adequate precautions are taken to warn the user against the hazards of freewheeling the machine at excessive speeds. It is also the responsibility of the machine manufacturer to utilize a suitable freewheel mechanism to reduce these risks. PGDT accepts no liability for losses of any kind resulting from excessive freewheel speeds of a machine.

Do not freewheel the machine faster than the programmed Maximum Speed, e.g. by towing. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

6 Programming Connection

The i-Drive controller has a dedicated connector for a PGDT programming device, e.g. an SP1, DTT or PC Programmer. This connector should be used for this purpose only.

The Molex 4-way connector can only be used as a communications port for a PGDT programmer. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

7 Batteries

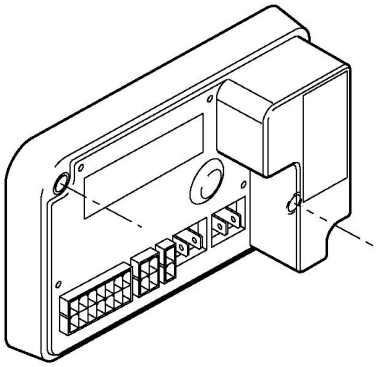
Depending on the controller type, the i-Drive is designed for operation with either 24V or 36V lead acid batteries. The batteries may be wet or gel electrolyte types.

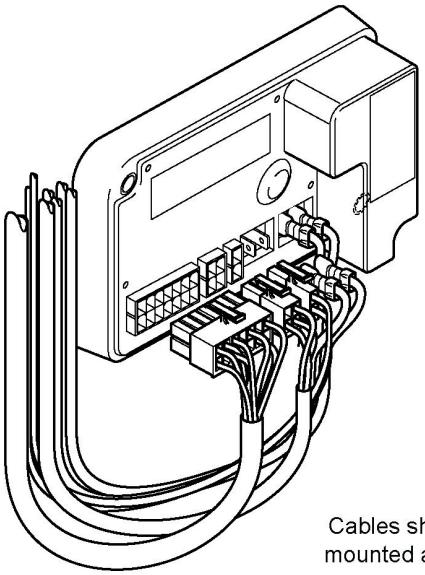
Refer to Section 1 to determine which model of i-Drive you have.

8 Mounting

8.1 Mounting the i-Drive

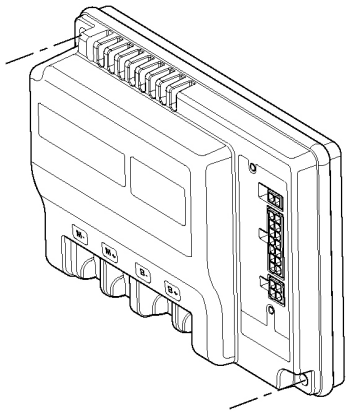
8.1.1 i45 & i70

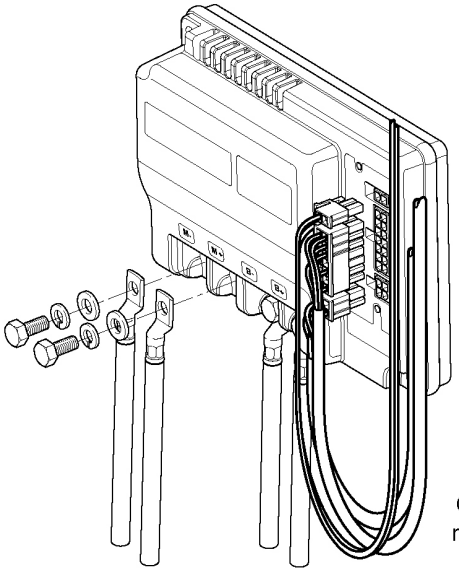




Cables should be mounted as shown

8.1.2 i140 & i180





Cables should be mounted as shown

8.1.3 Orientation

The recommended mounting orientation is such that the connectors must be lowermost. The function of the controller is not sensitive to mounting orientation. The electronics compartment of the controller has an IPX5 ingress protection rating.

If the i-Drive is to be fitted with an i-Cover, the mounting orientation will be different. Refer to Section 8.2 for details.

8.1.4 Position

The controller must be mounted in a position where it is not exposed to levels of water, dust, shock or vibration above those expected on typical industrial machine applications e.g. scrubber dryers.

The controller has excellent thermal performance but, to improve this further, the baseplate may be secured against a metal part of the machine chassis. To provide even better thermal performance, a non-silicone, thermally conductive paste or pad may be applied between the baseplate and the machine chassis.

Contact PGDT if you need further advice.

Under strenuous driving conditions it is possible for metal sections of the controller's case to exceed 41°C (106°F) in temperature. Under such conditions, the machine manufacturer should ensure that either the user cannot touch these surfaces, or that the user is warned not to touch these surfaces. While 41°C (106°F) is very close to normal body temperature, prolonged contact with surfaces above 41°C (106°F) can result in burns to the skin. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

8.1.5 Cables

The cables to the controller must be routed and secured in such a way as to prevent damage to them, for example by cutting or crushing.

It is suggested that the cables are mounted so that they loop up to the i-Drive, therefore minimizing the flow of moisture into the connectors.

8.2 Mounting the i-Drive & i-Cover

Once the controller is securely mounted to the machine the i-Cover can be applied. To mount the i-Cover use the following procedure:

- Position the rubber gasket.
- Push the connector cables into the rubber cable seal.
- Connect the cables to the i-Drive.
- Position the i-Cover over the gasket and seal.
- Place the screws into position and secure.

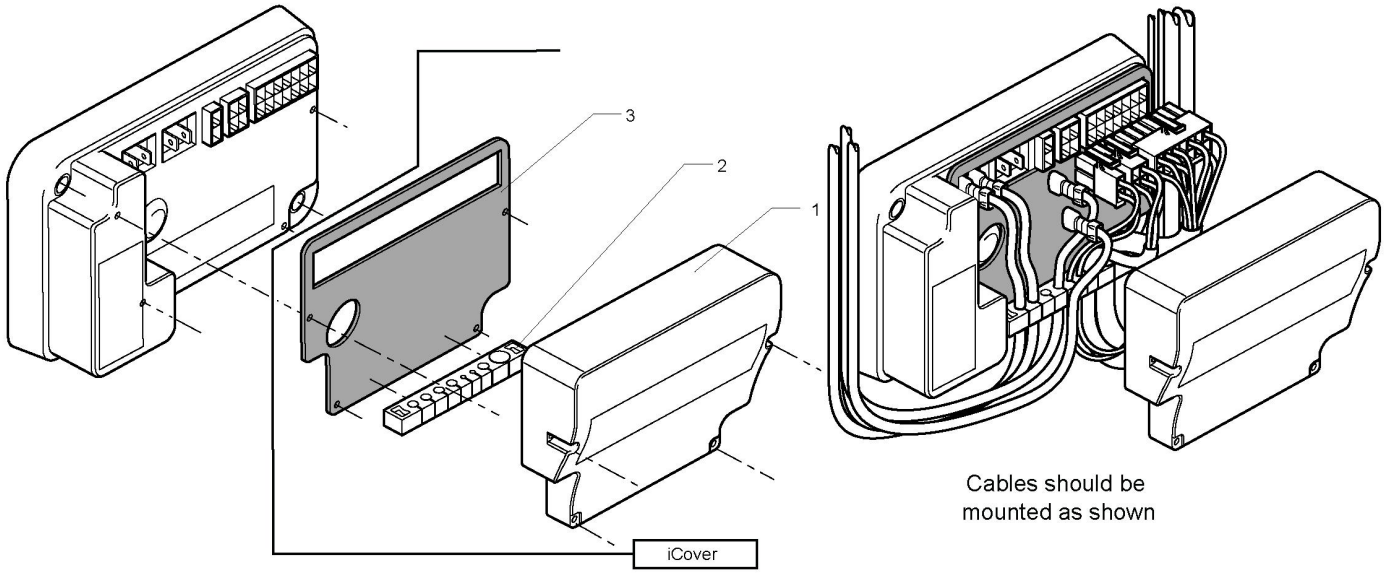
The i45 and i70 kit comprises of a molded metal cover (1), a rubber cable seal (2), rubber gasket (3) and 4 screws. These items are available in kit format from PG Drives Technology.

i45 and i70 i-Cover kit number is: D50434

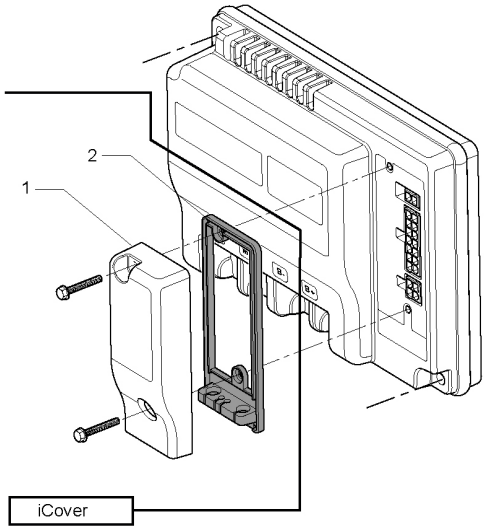
The i140 and i180 Kit comprises of a molded metal cover (1), a rubber cable seal / gasket (2) and 2 screws. These items are available in kit format from PG Drives Technology.

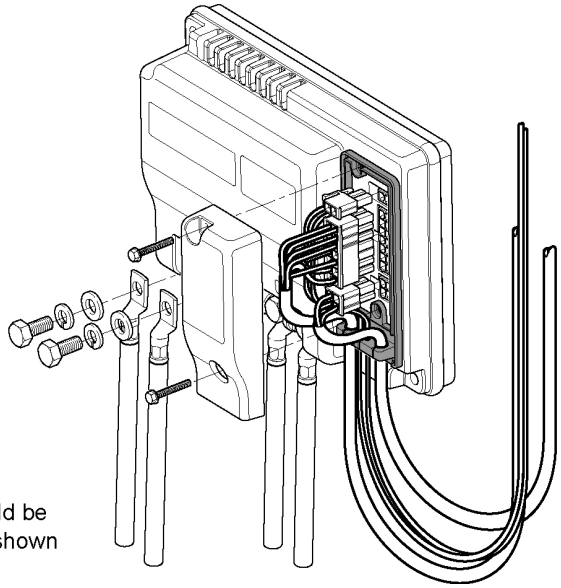
i140 and i180 i-Cover kit number is: D51160

8.2.1 i45 & i70 + i-Cover



8.2.2 iI40 & iI80 + i-Cover





Cables should be mounted as shown

8.2.3 Orientation

The recommended mounting orientation is such that the connectors must be uppermost. The function of the controller is not sensitive to mounting orientation. The electronics compartment of the controller has an IPX5 ingress protection rating.

8.2.4 Position

The controller must be mounted in a position where it is not exposed to levels of water, dust, shock or vibration above those expected on typical industrial machine applications e.g. scrubber dryers.

The controller has excellent thermal performance but, to improve this further, the baseplate may be secured against a metal part of the machine chassis. To provide even better thermal performance, a non-silicone, thermally conductive paste or pad may be applied between the baseplate and the machine chassis.

Contact PGDT if you need further advice.

Under strenuous driving conditions it is possible for metal sections of the controller's case to exceed 41°C (106°F) in temperature. Under such conditions, the machine manufacturer should ensure that either the user cannot touch these surfaces, or that the user is warned not to touch these surfaces. While 41°C (106°F) is very close to normal body temperature, prolonged contact with surfaces above 41°C (106°F) can result in burns to the skin. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

8.2.5 Cables

The cables to the controller must be routed and secured in such a way as to prevent damage to them, for example by cutting or crushing.

It is suggested that the cables are mounted so that they loop up to the i-Drive, therefore minimizing the flow of moisture into the connectors.

9 Battery Gauge

Refer to Chapter 1 Sections 8 and 9 for how to read the battery gauge.

The battery gauge will start to flash one bar slowly when the Battery Lockout function has been triggered. The Battery Lockout Voltage setting controls the level at which this indication is given. Refer to Chapter 3.

For optimum accuracy of the battery gauge and low battery indicator, the controller should be programmed with the approximate nominal capacity of the machine battery. However, accuracy is not greatly affected if the programmed type and capacity do not closely match the battery.

The most important factor affecting the accuracy of the battery gauge is the resistance of the cable and connections between the battery and the controller. The controller must be matched approximately to the cable resistance of your machine to make the battery gauge accurate. Refer to Chapter 3.

As a guide, 2.5mm^2 cable has a resistance of about 8mΩ per meter; 4 mm^2 cable has about 5mΩ per meter and 6mm^2 has about 3.3mΩ per meter. Circuit breakers and connectors usually account for about 15mΩ.

These values will be chosen at the time the controller is being specified by the machine manufacturer. Once these values are decided they are programmed into controllers during manufacture and should never need changing.

If you need advice, contact PGDT

10 Electromagnetic Compatibility (E.M.C.)

The i-Drive controller series has been tested for compliance with the EMC requirements of EN12895:2000. The guidelines in this section will help you to make sure that your machine installation will meet the requirements. You should consider EMC and perform relevant tests as early as possible in the design phase.

10.1 Emissions

Observe the following recommendations to minimize radio frequency emissions.

10.1.1 Motor Suppression

Solder a suitable suppression capacitor between the brush holders of each motor, inside the motor cases. Keep the lead length as short as possible. We recommend a value of 4n7F 250V AC ceramic. The maximum value you should use is 10nF. A typical type is Roderstein WY0472MCMCF0K.

For 4 pole motors, a capacitor should be fitted between each pair of brushes.

10.1.2 Cables

You do not need to use screened battery and motor looms, but,

- Keep the length of all wiring to a minimum.
- Make sure the loop area of the wiring is minimized. Route the positive and negative wires to each motor together.
- Route the battery positive and negative wires together. Where possible, route the battery and motor looms together.
- Secure the motor and battery looms to the machine frame over as much of their length as is practical.
- Do not use the controller connectors as junction points for the battery connections. Separate junction points away from the i-Drive should be provided for the other electrical machine functions.

10.2 Immunity

The i-Drive controller has been stringently tested for susceptibility to electromagnetic radiation over the frequency range 26 MHz to 1 GHz.

Follow the recommendations in Section 10.1.2 to ensure maximum immunity to electromagnetic radiation.

11 Electro-Static Discharge (E.S.D.)

With electronic control systems being installed in more small electric vehicle applications it is important to understand how to prevent ESD (Electrostatic Discharge) damaging or disrupting systems.

Electrostatic Discharges occur when a charged body comes into close contact with an electrically conductive surface. In the case of a vehicle the causes are:

A charged operator touching the control panel or machine.

The machine becoming charged and touching an operator or obstacle.

One part of the machine becoming charged through movement or operation (e.g. cleaning brushes) and a flashover occurring to another part of the machine or electrical system.

When a discharge occurs the currents flowing can be very high with a very fast rise time. This may cause damage or disruption to the control system either directly or indirectly via transient coupling effects.

In all cases prevention of the prime cause is better than cure. Although measures can be taken to route ESD away from sensitive areas or protection components added to the system, subtle changes to the system often make cures unreliable. Different batches of components, slightly different wiring paths or atmospheric conditions etc. will make the system behave differently.

Designing ESD protection is concerned with the performance of the complete operating system, not the individual components. Items which are exposed to the outside world must normally be protected against high ESD voltages and currents. 'Under-bonnet' is either concerned with preventing charge build up or preventing flashover under ESD transient conditions.

There are various international standards currently under development for this aspect of the system's performance. The controller is tested to IEC 61000-4-2.

11.1 Electrical Masses

In most electric vehicle systems there are several large electrically conductive masses. The first is the electrical wiring system itself, including the control system and battery. The others are any electrically conductive mass around the vehicle. The major one will be the chassis or other major parts of the structure. However, not only can the chassis on some vehicles be non-conductive (plastic, GRP) but there are often sub-chassis or large metallic components which are electrically isolated from each other.

Each of these electrically conductive masses may become charged by various means. If the charge voltage becomes sufficiently high then a flashover to another electrically conductive mass such as the electrical system can occur. The electrostatic discharge produced by this method can be very large and damaging.

Items such as motor cases are also electrically conductive masses that can charge up and cause flashover.

Flashover can either take the form of intermittent large-scale events or as continuous small discharges depending on the voltage and charge levels. The latter can be the cause of failure when conducting radiated emissions testing for EMC approvals.

11.2 Prevention of Flashover

Prevention mainly concerns preventing differential charge build up on all the different electrical masses around the vehicle. The electrically conductive masses comprise the electrical system and any large metallic masses around the vehicle such as the sub-chassis and large electrical components etc.

There are two main methods.

1) Provide electrically conductive discharge or drain paths between the electrically conductive masses around the machine.

This is best achieved by providing a drain wire, which connects all the electrically conductive masses around the vehicle together. The path of the wire or wires should be kept as short as possible. In some applications a resistor of a suitable value may be inserted in all or one of these lines. Varistors may also be used in some applications.

Resistors can prevent large ESD currents flowing that may cause unpleasant shocks to operators but at the same time prevent differential charge build up occurring.

Varistors appear open circuit to battery voltages but will limit charge build up to a safe level. They can be used where a battery ground circuit is the only drain path available.

2) Prevent charge build up.

The action of the vehicle travelling over certain surfaces or certain actions carried out by the vehicle (e.g. cleaning brush operation) may cause a significant charge build up by all or part of the vehicle. Static dissipating straps, wheel materials or careful material selection can reduce or prevent charge build up.

11.2.1 Control Panels

Control panels and their components should be made from non-conductive materials in order to prevent any form of electrostatic discharge. This not only protects the control system but also prevents the operator experiencing shocks.

If the panels are made from a conductive material then a drain wire must be connected to the main chassis or other conductive masses around the vehicle. On some designs the only available solution is to connect the panel to a battery ground via a varistor. However, ESD may still cause disruption to the signals from the control panel as large discharges will cause disturbances in the ground line.

Where conductive user control systems are used (e.g. metal toggle switches) the body must be connected to the panel (assuming it is conductive). If the control panel is not conductive then the body of the control must be connected to the chassis by drain wire or battery ground via a varistor. Some user control systems will be unsuitable, as they will provide an ESD path to and from the outside world (perhaps by a hidden path) but no means of providing a drain path.

Membrane keyboards can provide a high degree of protection. However, they must be made of sufficiently thick material (the supplier should be able to advise). Other design details such as ensuring the switch tracks are well away from the edge of the keyboard and providing conductive barrier tracks can also improve reliability.

11.2.2 Electrical System to Chassis Paths

It is important to provide an ESD discharge path between the electrical/control system and any electrically conductive masses in close proximity to it (chassis etc.). Failure to do say may result in uncontrolled flashovers leading to damage or malfunction.

All PGDT control systems incorporate conduction paths between the battery 0V connection and the heatsink/case. The screws that mount the controller case or heatsink to the vehicle chassis or metalwork normally complete the circuit path between electrical system and chassis. If the control system is mounted on a non-conductive surface then another means of providing the circuit path must be provided.

PGDT control systems either incorporate an internal varistor or resistor in series with the battery 0V to heatsink/case connection. The resistor is adequate for most purposes. However, if system ESD tests show a problem then a varistor should be fitted externally.

11.2.3 Electrical Components

Large electrical components such as motor casings can store appreciable amounts of ESD energy if they are not grounded. This can flash over to sensitive circuitry. If a separate drain wire is not possible then a drain resistor or varistor connected to a power circuit connection can be used. However, issues such as circuit isolation, potential standby battery drain and noise propagation must be considered.

11.2.4 Ensuring Repeatability

Various precautions should be taken to ensure repeatable protection from ESD. Connections to ESD drain wires etc. should not be made through painted surfaces. The routing of drain wires must be consistent. Any significant modifications to components or routings should be tested for its effect on ESD performance.

11.2.5 Drain Path Components

There are various options on providing drain paths for ESD.

Drain Wires

These components are not suitable for use in ESD discharge paths.

Advantages – low cost, low impedance, maximizes protection from ESD by minimizing transients.

Disadvantages – ESD currents can be high and unpleasant if experienced by operators. Connecting to a battery terminal may compromise safety, as chassis components etc. will become 'live'. Drain wires may also contribute to ground loops in some systems or compromise EMC performance.

Resistors

Resistors provide a suitable discharge path for charges occurring or generated between the electrical masses of the system. Typical values range from 10mΩ to 10kΩ.

Advantages – can limit ESD discharge currents (unless a flashover occurs) to operators etc. Can be used in series with drain paths to battery ground (0V) terminals as chassis isolation is provided, however, leakage currents must be at a safe level. Resistors also limit the possibility of creating ground loops or propagating electrical noise (compromising EMC performance).

Disadvantages – do not provide a low impedance path for ESD so may be ineffective when large ESD discharges occur.

Varistors

These components provide an effective ESD path where isolation from battery voltages is required. The varistor continuous voltage rating is normally around twice the battery voltage (1.5 times minimum). Harris varistor type V82Z2 has proven effective in many 24V and 36V applications.

Advantages – provides circuit isolation and low impedance.

Disadvantages – the low impedance implies that varistors will not protect operators from large discharge currents.

Capacitors & Inductors

These components are not suitable for use in ESD discharge paths. Capacitors tend to offer protection by breaking down and operating like a varistor; by implication the capacitor is progressively damaged. Inductors have a high impedance to fast transients. However, ferrite beads may provide some additional protection where other solutions prove marginal.

Spark Gaps

Spark gaps designed into PCBs may provide some very useful, front line defence against large ESD discharges. However, they need careful design, a low impedance ground connection and their performance will vary with surface finish and contamination.

12 Production Tests

Perform the following tests, in order, on each machine before dispatch.

These tests should be conducted in an open space and for ride-on vehicles a restraining device such as a seat belt should always be used. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

12.1 Mounting

Make sure that the controller is securely mounted. Do not overtighten any securing screws.

12.2 Cables and Connectors

Check all cables and connectors for damage. Make sure that all connectors are securely mated.

12.3 Preset Settings

Make sure that the controller is using the correct program settings for the machine.

Controllers are always supplied with the settings shown on the relevant data sheet.

12.4 Operational Test

This test should be carried out on a level floor with at least one meter clear space around the machine.

- Switch on the controller.
- Check that the status indicator remains on, or flashes slowly, after one second.
- Go to drive the machine slowly in the forward direction until you hear the solenoid brake (if fitted) operate. The machine may start to move.
- Immediately release the throttle. You must be able to hear the solenoid brake operate within a few seconds.
- Repeat the test in the reverse direction.

12.5 Test Drive

Drive the machine and make sure that it operates correctly for all positions of the user controls.

12.6 Soft-Stop Test

Drive the machine at full forward speed and switch the controller off. The machine must not stop suddenly, but should decelerate to standstill.

In addition, ensure that the requirements in Section 1.4 of this chapter are satisfied.

CHAPTER 3 – PROGRAMMING

1 Introduction

This chapter gives an overview of the programmable parameters within the i-Drive Controller. The i-Drive can be programmed with a hand-held SP1, DTT or PGDT's Industrial PC Programmer.

This chapter does not give details of how to make adjustments; for these details please refer to the relevant documentation for the programmer you are using.

Programming should only be conducted by electronic service professionals with in-depth knowledge of PGDT controllers. Incorrect programming could result in an unsafe set-up of a machine for a user. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

1.1 SP1a & DTT

The SP1a and DTT handheld programmers are intended to give dealers and service engineers access to basic programmable parameters and diagnostic information. The standard functions are:

Acceleration

Deceleration

Forward Speed

Reverse Speed

Throttle Invert

Sleep Timer

Read System Log

Read Timer

For details of how to use the SP1a or DTT, refer to the relevant documentation.

1.2 PC Programmer

There are two versions of the PC Programmer.

iPCPa Dealer level access, equivalent to SP1a and DTT.

iPCPb OEM level access, suitable for the machine manufacturer and their service engineers.

The OEM level access variant also includes a suite of functions, which make it suitable for 'end-of-line' programming.

For details of how to use these programming packages with the i-Drive, refer to the documentation supplied with the software.

1.3 Parameters

The i-Drive parameters are separated into workable groups for easy referencing.

The groups and their sections are:

Speeds – Section 2

Forward Acceleration

Forward Deceleration

Reverse Acceleration

Reverse Deceleration

Max. Forward Speed

Min. Forward Speed

Max. Reverse Speed

Min. Reverse Speed

Speed Limit Pot. Enabled

Throttle – Section 3

Sleep Timer
Throttle Invert

Operation – Section 4

Throttle Type
Throttle Deadband
Throttle Gain
Throttle Operated at Power-Up
Throttle Reference Test
ISO Tests Resistor
Direction Switches

Battery – Section 5

Cable Resistance
Calibration Factor
Battery Lockout Voltage
Battery Lockout Voltage 2
Battery Lockout Time
Battery Lockout Type
Battery Lockout Input Select
Low Battery Alarm

Inhibits – Section 6

Inhibit 1 Debounce, Mode, Operation, Speed and Target
Inhibit 2 Debounce, Mode, Operation, Speed and Target
Tiller Switch

General – Section 7

Soft Stop
Brake Time
Output Voltage
Status Output Type
Diagnostic Flash Sequence
Reverse Alarm
Pulsed Reverse Alarm
Diagnostic Alarm
Brake Disconnected Alarm
Brake Fault Detect
Brake Light
Freewheel Speed Limit

Motor – Section 8

Current Limit Max.
Current Limit Min.
Boost Drive Current
Boost Drive Time
Current Foldback Threshold
Current Foldback Time
Current Foldback Level
Motor Cooling Time
Current Foldback Temperature
Motor Compensation
Slope Factor
Anti-Rollback Level
Pull-Away Delay
Anti-Rollback Velocity

Belly Button – Section 9

Belly Button Switch Type
Belly Button Speed
Belly Button Time

Factory – Section 10

Abs. Max. Acceleration
Abs. Min Acceleration
Abs. Max. Deceleration
Abs. Min Deceleration
Abs. Max. Forward Speed
Abs. Min Forward Speed
Abs. Max. Reverse Speed
Abs. Min. Reverse Speed

Supply Voltage

Auxiliary Outputs – Section 11

Aux 1 Output Mode	Aux 1 Off Delay
Aux 2 Output Mode	Aux 2 Off Delay
Aux 3 Output Mode	Aux 3 Input Type
Aux 3 Output Voltage	Aux 3 Off Delay

Memory Functions – Section 12

Read System Log	Clear System Log
Read Control Log	Clear Control Log
Read Timer	Clear Timer

2 Speed Parameters

2.1 Forward Acceleration

This parameter adjusts the value for forward acceleration of the machine, in increments of 1. There are two settings:

Fast This value is used when the slow/fast switch is set to fast.

Slow This value is used when the slow/fast switch is set to slow.

The values are approximately displayed in units of 100ms and correspond to the time taken to reach full forward speed from standstill, i.e. the higher the value the slower the acceleration.

Setting this value too low could cause the machine to tip when accelerating up a slope.

2.2 Forward Deceleration

This parameter adjusts the value for forward deceleration (or braking) of the machine, in increments of 1. There are two settings:

Fast This value is used when the slow/fast switch is set to fast.

Slow This value is used when the slow/fast switch is set to slow.

The values are approximately displayed in units of 100ms and correspond to the time taken to reach standstill from full forward speed, i.e. the higher the value the slower the deceleration.

It is the responsibility of the machine manufacturer to ensure that the emergency stopping distance is within the distance specified for the country in which the machine will be used.

2.3 Reverse Acceleration

This parameter adjusts the value for reverse acceleration of the machine, in increments of 1. There are two settings:

Fast This value is used when the slow/fast switch is set to fast.

Slow This value is used when the slow/fast switch is set to slow.

The values are approximately displayed in units of 100ms and correspond to the time taken to reach full reverse speed from standstill, i.e. the higher the value the slower the acceleration.

2.4 Reverse Deceleration

This parameter adjusts the value for reverse deceleration (or braking) of the machine, in increments of 1. There are two settings:

Fast This value is used when the slow/fast switch is set to fast.

Slow This value is used when the slow/fast switch is set to slow.

The values are approximately displayed in units of 100ms and correspond to the time taken to reach standstill from full reverse speed, i.e. the higher the value the slower the deceleration.

It is the responsibility of the machine manufacturer to ensure that the emergency stopping distance is within the distance specified for the country in which the machine will be used.

Setting this value too low could cause the machine to tip when stopping, whilst reversing down a slope.

2.5 Max. Forward Speed

This parameter sets the MAXIMUM forward speed of the machine.

So long as a Slow/Fast switch is fitted to the machine then there are two available settings.

Fast This value is used when the slow/fast switch is set to fast.

Slow This value is used when the slow/fast switch is set to slow.

The value is displayed as a percentage of the machine's total available output. Therefore if the Fast value is set to 80% then the machine will be able to drive at up to 80% of the total available speed when the Slow/Fast switch is in the Fast position.

This value is adjustable between 0 and 100% in steps of 1%.

If there is no Slow/Fast switch fitted then only the Fast value will be relevant.

Ensure the stability of the machine is maintained, especially when cornering at the programmed Max. Forward Speed.

2.6 Min. Forward Speed

This parameter sets the MINIMUM forward speed of the machine.

For this parameter to operate, a Speed Limiting Potentiometer must be fitted and correctly programmed. The Speed Limiting Potentiometer must be fitted in Parallel, refer to Chapter 2 Section 4.2. Under these conditions there are two available settings.

Fast This value is used when the machine's Speed Limiting Potentiometer is set to Slow and the Slow/Fast switch is set to Fast.

Slow This value is used when the machine's Speed Limiting Potentiometer is set to Slow and the Slow/Fast switch is set to Slow.

The value is displayed as a percentage of the machine's total available output. Therefore if the Fast value is set to 40% then the machine will be able to drive at up to 40% of the total available speed when the Slow/Fast switch is in the Fast position and the Speed Limiting Potentiometer is in the Slow position.

This value is adjustable between 0 and 100% in steps of 1%.

If there is no Slow/Fast switch fitted then only the Fast value will be relevant.

This parameter cannot be set to a greater value than the Max. Forward Speed.

2.7 Max. Reverse Speed

This parameter sets the MAXIMUM reverse speed of the machine.

So long as a Slow/Fast switch is fitted to the machine then there are two available settings.

Fast This value is used when the slow/fast switch is set to fast.

Slow This value is used when the slow/fast switch is set to slow.

The value is displayed as a percentage of the machine's total available output. Therefore if the Fast value is set to 60% then the machine will be able to drive at up to 60% of the total available speed when the Slow/Fast switch is in the Fast position.

This value is adjustable between 0 and 100% in steps of 1%.

If there is no Slow/Fast switch fitted then only the Fast value will be relevant.

2.8 Min. Reverse Speed

This parameter sets the MINIMUM reverse speed of the machine.

For this parameter to operate, a Speed Limiting Potentiometer must be fitted and correctly programmed. The Speed Limiting Potentiometer must be fitted in Parallel, refer to Chapter 2 Section 4.2. Under these conditions there are two available settings.

Fast This value is used when the machine's Speed Limiting Potentiometer is set to Slow and the Slow/Fast switch is set to Fast.

Slow This value is used when the machine's Speed Limiting Potentiometer is set to Slow and the Slow/Fast switch is set to Slow.

The value is displayed as a percentage of the machine's total available output. Therefore if the Fast value is set to 20% then the machine will be able to drive at up to 20% of the total available speed when the Slow/Fast switch is in the Fast position and the Speed Limiting Potentiometer is in the Slow position.

This value is adjustable between 0 and 100% in steps of 1%.

If there is no Slow/Fast switch fitted then only the Fast value will be relevant.

This parameter cannot be set at a greater value than the Max. Reverse Speed.

2.9 Speed Limit Pot. Enabled

This parameter selects whether pin 9 is to be unused, used for a parallel type speed limiting potentiometer or configured for a Belly Button switch. The parameter can be set to On or Off.

If set to Off, the i-Drive will not perform any potentiometer checks on pin 9.

If set to Off and Belly Button Time is > 0, the i-Drive will operate as per the Belly Button function, see Chapter 2, Section 4.2.2.

If set to On, then the i-Drive will check for the presence of a valid speed limiting potentiometer signal at pin 9, refer to Chapter 2 Section 4.2. If a valid signal is not detected, the i-Drive will default to the programmed minimum speeds.

If a speed limiting potentiometer and a Belly Button switch are both required, the speed limiting potentiometer must be wired in series with the throttle wiper input. It is the machine manufacturer's responsibility to ensure that any such arrangement is suitable for the intended application.

If a parallel type speed limiting potentiometer is fitted, this parameter must be set to ON or the machine will only drive at the maximum programmed speed settings.

3 Operation Parameters

3.1 Sleep Timer

If the controller detects no throttle movement for a set period of time, it can be programmed to enter a sleep state. This will be indicated to the machine operator via the status indicator, refer to Chapter 1 Section 8.1.4. This parameter sets the period of inactivity before the i-Drive goes to sleep.

The time can be adjusted in 1minute steps between 0 and 20 minutes.

If the value is set to 0, the sleep function is disabled.

3.2 Throttle Invert

This parameter selects the polarity of operation of a wig-wag throttle or, on a single-ended throttle system, the polarity of drive with the reverse switch. You can set the Throttle Invert Polarity to On or Off.

On a wig-wag system, setting Throttle Invert Polarity to Off means that if the throttle potentiometer wiper is approaching the high reference then direction will be forwards, On is opposite to this.

On a single-ended type system, Off means that if the reverse switch input is connected to 0V then direction will be reverse, On is opposite to this.

4 Throttle Parameters

4.1 Throttle Type

This parameter can be set to one of three types. Refer to Chapter 2 for wiring details.

Single-ended	Stands for single-ended throttle type.
Wig-wag	Stands for wig-wag throttle type.
Unipolar	Stands for unipolar throttle type.

4.2 Throttle Deadband

This parameter sets the amount of throttle potentiometer movement before the solenoid brake (if fitted) is disengaged and the machine starts to drive. It is expressed as a percentage of the potentiometer full forward/reverse movement.

The following two examples cover the cases of single-ended and wig-wag throttle types.

Example 1:	For a single-ended throttle, if the throttle deadband is 10% and the potentiometer is 5kΩ, then there will be no drive until the potentiometer wiper is at the 500Ω position.
Example 2:	For a wig-wag throttle, if the throttle deadband is 10% and the potentiometer is 5kΩ, then there will be no drive when the potentiometer wiper is between the 2.25kΩ and 2.75kΩ positions.

This value is adjustable between 3% and 100% in steps of 1%, and should always be set greater than the mechanical repeatability of the throttle mechanism.

4.3 Throttle Gain

This parameter amplifies the drive signal to the i-Drive, thus allowing throttle mechanisms that do not employ the full electrical angle of the throttle potentiometer to be used. The parameter can be set between 5% and 1250% in steps of 5%. A value of 100% means no amplification is applied.

Example 1: If a 5kΩ throttle potentiometer is being used in a wig-wag configuration and the mechanical arrangement of the throttle means the potentiometer's wiper reaches the high reference when the throttle is fully deflected, the Throttle Gain should be set to 100%.

Example 2: If a 5kΩ throttle potentiometer is being used in a wig-wag configuration and the mechanical arrangement of the throttle means the potentiometer's wiper reaches only 4kΩ when the throttle is fully deflected, then Throttle Gain should be set as follows.

This example assumes a Throttle Deadband setting of 10%.

Full electrical angle = 5kΩ - 2.75kΩ = 2.25kΩ.

Actual electrical angle = 4kΩ - 2.75kΩ = 1.25kΩ.

Required gain = 2.25 / 1.25 = 1.8.

Set Throttle Gain to = 180%.

4.4 Throttle Operated At Power-Up

This parameter sets the behavior of the controller when it is switched on with the throttle already deflected. There are three options:

Drive The i-Drive will drive if it is switched on while the throttle is already deflected.

Inhibit The i-Drive will not drive if it is switched on while the throttle is already deflected but once the throttle has been returned to its home position it will then allow the machine to drive.

Trip The i-Drive will not drive if it is switched on while the throttle is already deflected, it will record a trip in the system log and it will require the machine to be switched off and on again.

Setting this parameter to Drive may contravene some international vehicle safety legislation. If, under exceptional circumstances, the condition set by Drive is required, it becomes the sole responsibility of the machine manufacturer. PGDT accepts no liability for losses of any kind resulting from this parameter being set to Drive.

4.5 Throttle Reference Test

This parameter sets whether the controller checks for the presence of the high and low throttle references.

The parameter can be set to On or Off.

If set to Off, all throttle reference checks are disabled to allow the use of a voltage source input.

If set to On, the controller will check the high and low throttle references.

4.6 ISO Tests Resistor

This parameter can be set to On or Off.

If the machine has no ISO-Test resistor fitted (refer to Chapter 2) the parameter must be set to Off.

If the machine already has an ISO-Test resistor fitted, then to ensure the machine can reach maximum speed, the parameter should be set to On.

If an ISO-Test resistor is fitted and a series connected speed limiting potentiometer is used, then depending on the setting of the potentiometer, it may not be possible to detect a short-circuit between the throttle side of the potentiometer and either of the throttle references.

4.7 Direction Switches

This parameter allows for industrial vehicles fitted with direction switches. Direction switches must be operated in conjunction with the throttle to effect drive.

This parameter can be programmed to Yes or No and sets the function of pins 6 and 12 on the 14-way Tiller Interface.

If set to No, pins 6 and 12 will operate in the normal way, i.e. as Inhibit 1 and Reverse Switch / Auxiliary 3 Input respectively.

If set to Yes, then shortly after power-up, if pin 6 is connected to 0V, a signal from the throttle will result in forward drive.

If set to Yes, then shortly after power-up, if pin 12 is connected to 0V, a signal from the throttle will result in reverse drive.

If neither input is connected to 0V and a throttle signal is detected, the i-Drive will display an error and no drive will be possible until the throttle is returned to neutral and the power is recycled.

If both inputs are connected to 0V, the i-Drive will display an error and no drive will be possible until both inputs are open circuit, the throttle is returned to neutral and the power is recycled.

Direction Switch functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

5 Battery Parameters

5.1 Cable Resistance

This parameter sets the value of cable and connector resistance between the controller and the batteries. The value corresponds to the total resistance in both the positive and negative paths.

You can set this between 10mΩ and 250mΩ in steps of 5mΩ.

5.2 Calibration Factor

This parameter allows further fine calibration of the TruCharge battery gauge. This is normally set at the factory and should not need adjustment.

Please contact PGDT if you are considering altering this parameter.

5.3 Battery Lockout Parameters

The battery lockout parameters allow the functionality of a machine to be restricted once the battery voltage has dropped below the battery manufacturer's recommended discharge level for a set time. Typically, these parameters allow the OEM to configure the machine such that the operator is forced to return the machine to the charging point before the batteries are damaged.

5.3.1 Battery Lockout Voltage

This parameter sets the threshold voltage at which the controller will lockout the function as set by the Battery Lockout Type parameter and is adjustable in 0.1V steps from 14V to 38V.

5.3.2 Battery Lockout Voltage 2

This parameter sets an alternate threshold voltage at which the controller will lockout the function as set by the Battery Lockout Type parameter and is adjustable in 0.1V steps from 14V to 38V.

5.3.3 Battery Lockout Time

This parameter sets the time for which the battery voltage must be below the programmed Battery Lockout Voltage or Battery Lockout 2 Voltage to be effective and is adjustable in 1 second steps from 0 to 60 seconds.

If Battery Lockout Time is set to '0', Battery Lockout functionality is disabled.

5.3.4 Battery Lockout Type

This parameter selects which function will be locked out or inhibited once the voltage is below the programmed threshold level for the programmed time. Any combination of the following functions can be selected:

None.

Traction.

Aux 1.

Aux 2.

Aux 3.

5.3.5 Battery Lockout Input Select

This parameter allows the OEM to choose which input will be used to select the alternate programmed threshold voltage, Battery Lockout Voltage 2. One of the following inputs can be selected:

None.

Inhibit 1.

Inhibit 2.

Reverse Switch.

Example:

An i-drive is being used to control the traction and other functions of a small pedestrian operated floorcare machine. The Inhibit 1 input and Aux 1 Output are used to control a relay that controls the machine's cleaning brushes. The machine can be used with 2 types of batteries 'A' and 'B', which should not be discharged below 22.3 and 21.8V respectively. The Inhibit 2 input is connected to 0V via a 3rd pin on the Type 'B' battery connector, allowing the i-Drive to detect which battery type has been fitted. The parameters are set as follows:

Battery Lockout Voltage	22.3V.
Battery Lockout Voltage 2	21.8V.
Battery Lockout Time	20 seconds.
Battery Lockout Type	Aux 1.
Battery Lockout Input Select	Inhibit 2.

The machine is in use with a type A battery; when the voltage drops below 22.3V, the timer is initiated. Once 20 seconds have elapsed, the Aux 1 Output is inhibited, so that the cleaning brushes switch off. The operator returns to the charging point, removes the type A batteries and places them on charge. The operator then fits the type B batteries and the machine is fully functional until the voltage drops again, this time below 21.8V for 20 seconds before the brushes are 'locked out'.

When the Diagnostic Flash Sequence is set to PG or TruCharge, the BDI will produce the 1 bar low battery flash when the active Battery Lockout Voltage threshold is reached.

5.4 Low Battery Alarm

This parameter sets whether the i-Drive will give an audible alarm to signal a Battery Lockout condition. If enabled, the Low Battery Alarm will sound when the battery voltage has fallen below the active Battery Lockout Voltage threshold for the Battery Lockout Time.

The parameter can be set to On or Off.

6 Inhibit Parameters

6.1 Inhibit 1 Debounce, Mode, Operation, Speed & Target

For full details of these parameters refer to Chapter 2 Section 4.11.1.

6.2 Inhibit 2 Debounce, Mode, Operation, Speed & Target

For full details of these parameters refer to Chapter 2 Section 4.12.1.

6.3 Tiller Switch

This parameter allows for industrial vehicles fitted with a tiller switch. The tiller arm is usually sprung to the vertical position and is pulled towards the horizontal to remove a drive inhibit. The switch must be closed in conjunction with throttle demand to effect drive.

This parameter can be programmed to Yes or No and sets the function of pin 14 on the 14-way Tiller Interface.

If set to No, then pin 14 will operate in the normal way, i.e. as Inhibit 2.

If set to Yes, drive will only commence when pin 14 is connected to 0V and throttle demand is detected.

Tiller Switch functionality is standard on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

7 General Parameters

7.1 Soft-Stop

This parameter selects whether the soft-stop facility is enabled. Soft-stop means that if you switch the control system off whilst driving, the machine will steadily decelerate to a standstill.

You can turn this function On or Off.

If this function is On, you must ensure that the emergency stopping distance is within the distance specified for the country in which the machine will be used.

7.2 Brake Time

This parameter sets the period of time between the controller detecting zero motor speed and the application of the solenoid brake.

This value should be set long enough to ensure the machine doesn't jerk or skid on a level surface, but short enough to minimize roll-back or roll-forward on slopes.

You can set this between 0 and 200 in steps of 1, which roughly represent 10ms.

7.3 Output Voltage

This parameter sets the value of voltage applied to the motor when the throttle potentiometer is at the full drive position and the relevant speed, forward or reverse, is set to 100%. This feature allows you to choose a motor voltage value such that the machine's top speed will remain constant all the time the battery voltage is above that value.

This value can be set between 20V and 42V in steps of 1V.

7.4 Status Output Type

This parameter matches the Status Output signal to the type of device used.

There are three programmable options.

TruCharge	Suitable for Lamp and LED Status Indicators on Highside Drive connections and the TruCharge Status Indicator.
Sink	Suitable for Lamp and LED Status Indicators on Lowside Drive connections.
Analogue	Suitable for Analogue 12V Status Indicators.

For details of the functionality of these settings and their associated configurations refer to Chapter 2 Section 4.5.

7.5 Diagnostic Flash Sequence

This parameter sets the type of diagnostic flash sequence output by the controller.

There are three programmable options.

None	No signal.
TruCharge	TruCharge indication.
PG	Sequence flashes that simulate the TruCharge indication.

For details of the TruCharge and Sequence indication, refer to Chapter 1 Section 8.

7.6 Reverse Alarm

This parameter sets whether an audible warning is output when the vehicle is reversing.

The parameter can be set to On or Off.

Off A warning alarm connected to Auxiliary 2 Output will not sound when the vehicle is reversing.

On A warning alarm connected to the Auxiliary 2 Output will sound when the vehicle is reversing.

The parameter Reverse Alarm is programmable on i140 and i180 only. Please contact PGDT if this functionality is required on your i45 or i70 application.

7.7 Pulsed Reverse Alarm

This parameter sets whether the reverse alarm will be pulsed or continuous. The pulsing signal is approximately 1Hz.

The parameter can be set to On or Off.

Off Continuous.

On Pulsed.

The parameter Pulsed Reverse Alarm is only active if Aux 2 Output Mode is set to Diagnostic/Reverse Alarm.

7.8 Diagnostic Alarm

The diagnostic alarm will create a pulsed type alarm that will sound the equivalent to the TruCharge sequence diagnostic indicator.

The parameter can be set to On or Off.

The diagnostic alarm will sound a warning signal to alert the user that a diagnostic alarm pattern is about to be sounded. The signal will be a set of fast beeps lasting two seconds. The slower diagnostic pattern will then be sounded once.

7.9 Brake Disconnected Alarm

This parameter sets whether the alarm will sound whenever the controller senses a break in the solenoid brake circuit e.g. during freewheel.

The parameter can be set to On or Off.

7.10 Brake Fault Detect

This parameter sets whether the i-Drive detects a fault in the machine's electrical brakes or the connections to them. The parameter can be set to On or Off.

Off Means the i-Drive will not detect brake faults.

On Means the i-Drive will detect brake faults.

This parameter should only ever be set to Off if there are no electrical brakes fitted to the machine.

7.11 Brake Light

If the parameter Auxiliary 2 Output Mode is set to Brake Light, this parameter must also be set to On when using i45 or i70 controllers.

The parameter can be set to On or Off.

This parameter is not required to be set when using il40 or il80 controllers.

7.12 Freewheel Speed Limit

If the solenoid brake is disconnected from the motor, allowing the wheels and motor to rotate, the i-Drive can detect the motor rotating above a certain speed and brake it automatically, thus removing the possibility of the machine freewheeling at an excessive speed. This function will operate if the machine is switched off and even if there are no batteries fitted or connected.

This parameter is factory set and should not require adjustment. For further details contact PGDT.

It is the responsibility of the machine manufacturer to ensure that adequate precautions are taken to warn the user against the hazards of freewheeling the machine at excessive speeds. It is also the responsibility of the machine manufacturer to utilize a suitable freewheel mechanism to reduce these risks. PGDT accepts no liability for losses of any kind resulting from excessive freewheel speeds of a machine.

8 Motor Parameters

8.1 Current Limit

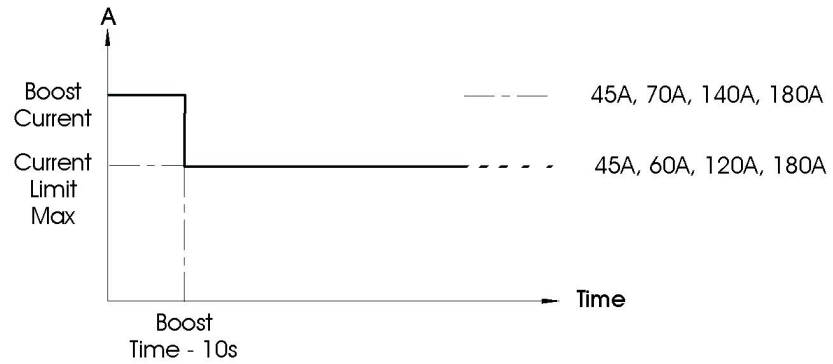
These parameters allow the maximum and minimum current limits to be altered in 1A steps, where dependencies permit.

Min. Sets the current output of the i-Drive when it is at 80°C, 10A to Current Limit Max.

Max. Sets the continuous current output of the i-Drive, 10A to 180A.

8.2 Boost Drive Current and Boost Drive Time

These parameters provide a current boost for a set length of time if the controller recognizes a drive demand that causes the motor to require more current, such as when the machine is being driven up a gradient. Refer to the following graph.



Boost Drive Current Sets the maximum current available during the boost period.

Boost Drive Time This sets the period for which the Boost Drive Current will be available.

Boost Drive Current can be set in 1A steps between 10A and 180A but not less than the Current Limit Max. setting.

Boost Drive Time can be set in 1-second steps between 0 and 10 seconds.

The following table shows the maximum permissible values for Current Limit Max. & Min., Boost Drive Current and Boost Drive Time for each of the i-Drive family variants.

Model	i45	i70	i140	i180
Current Limit Max.	45 Amps	60 Amps	120 Amps	180 Amps
Boost Drive Current	45 Amps	70 Amps	140 Amps	180 Amps
Boost Drive Time	10 seconds	10 seconds	10 seconds	10 seconds
Current Limit Min.	45 Amps	55 Amps	120 Amps	180 Amps

8.3 Current Foldback Threshold, Current Foldback Time, Current Foldback Level and Motor Cooling Time

The parameters Current Foldback Threshold, Time, Level and Motor Cooling can be used to protect the motor from overheating. If the motor current exceeds the value set by Threshold for a period set by Time, then the i-Drive's current output will be reduced to a value set by Level. After this has occurred, full current is only permissible after a time period set by Motor Cooling.

Current Foldback Threshold Adjustable between 1A and the value of Current Limit Max. in steps of 1A.

Current Foldback Time Adjustable between 0s and 255s in steps of 1s.

Current Foldback Level Adjustable between 25% and 100% in steps of 1%.

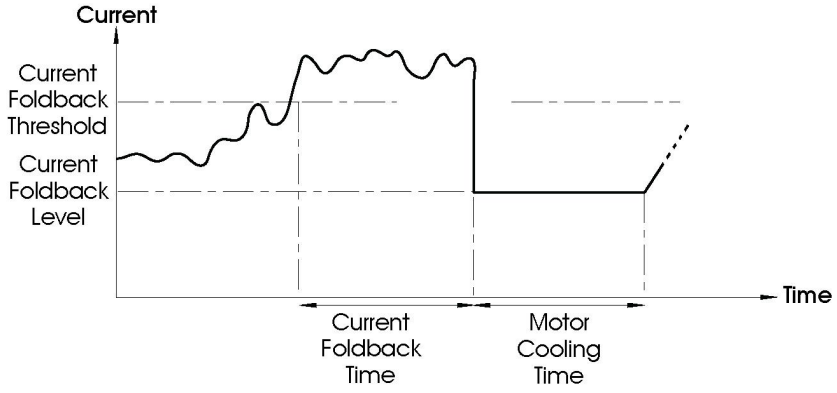
Motor Cooling Time Adjustable between 0s and 3825s in steps of 15s.

This is useful for protecting motors against potential damage when the machine is being used on a long gradient.

Example:

Current Limit Max.= 60A, Threshold = 40A, Time = 30s, Level = 50% and Motor Cooling = 150s.

If the motor current is greater than 40A for 30s, then the i-Drive's maximum output current will be reduced to 50% of 60A = 30A. The maximum possible output current will then be 30A for the next 150s. After that time, full current capability will be restored.

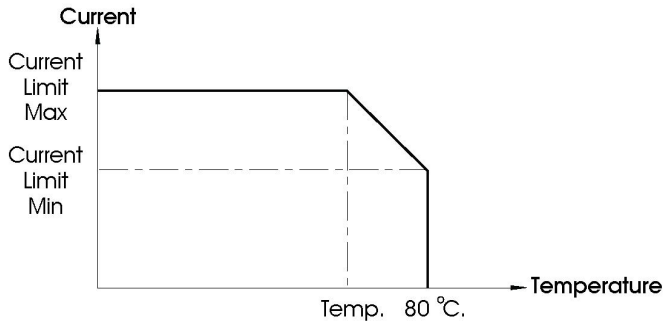


8.4 Current Foldback Temperature

The parameter Current Foldback Temperature sets the temperature at which the i-Drive starts to reduce its maximum current capability to protect the controller. The temperature is measured at the i-Drive's heatsink.

Current Foldback Temperature **Adjustable between 0°C and 80°C in steps of 1°C.**

The following graph shows the operation of this function.



If the i-Drive's internal temperature reaches the value set by Current Foldback Temperature, the maximum current output will be reduced from the value set by Current Limit Max. The reduction will be linear to a value set by Current Limit Min. at a fixed internal temperature of 80°C.

The value of Current Foldback Temperature should never be set higher than 80°C. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

8.5 Controlling a Machine on a Slope

The i-Drive controller contains a set of anti roll-back parameters, which allow smooth precise control, especially when starting and stopping on inclines. This section explains how to set this group of co-relational parameters.

Motors and gearboxes due to their construction, normally display evidence of gear backlash. This will be evident by a small amount of wheel rotation as the solenoid brake is engaged/disengaged.

8.5.1 Motor Compensation

This matches the controller to different motor types in order to achieve optimal performance and control, especially regarding anti-rollback and braking on gradients. PGDT recommend that you set this value to 60% of the resistance of the motor armature and all connectors and cables to it.

Motor manufacturers should be able to supply figures for armature resistance, and typical cable and connectors would be about 40mΩ.

You can set this value between 0 and 1250mΩ in steps of 5mΩ.

If you do not have the exact values of resistance, some basic test driving can be used to determine the value required. See section Set-up Procedure for details.

Motor Compensation should never exceed 60%.

The machine manufacturer is responsible for ensuring that the controller is matched to the motor resistance. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The machine manufacturer is responsible for always ensuring that any replacement motors are fully compatible with the originals that the controller was designed to match. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

8.5.2 Slope Factor

This parameter can be used to fine tune the performance of the machine when stopping on a gradient. The parameter can be adjusted in steps of 5 between 0 and 1275. When this parameter is set correctly, the machine should:

Have almost no roll-back while stopping on a gradient, driving up or down a slope.

Be almost completely stopped before the brake is applied.

The optimum value for this parameter can only be determined by test driving the machine. Refer to Section 8.6 for details.

8.5.3 Anti-Rollback Level

This parameter should never require adjustment.

For further details contact PGDT.

8.6 Set-up Procedure

The i-Drive controller, when set-up correctly, can offer exceptional control of the machine on a gradient. It is possible to minimize roll-back and in some cases, eliminate it completely. The degree to which this can be achieved depends on many machine variables, such as weight, type of motor, backlash in transaxle etc.

Below is a procedure that if followed carefully should produce good results on nearly all machine types.

1. Set Compensation for the i45 & i70 to 100mΩ, Slope Factor to 150 and Brake Time to 1 second.

   Set Compensation for the i140 & i180 to 25mΩ, Slope Factor to 500 and Brake Time to 1 second.

2. Set Forward Acceleration, Forward Deceleration, Reverse Acceleration and Reverse Deceleration to values that feel good for the machine on a level surface. At this stage, don't worry if there is a slight jolt when the machine comes to rest.

3. With a cool motor, drive the machine very slowly up a 10° slope and gently release the throttle. Observe what happens in the 1 second before the brake comes on.

   - If the machine continues to drive forward, then the value of Compensation is too high and should be reduced.
   - If the machine rolls back down the slope, then the value of Compensation is too low and should be increased.

   When adjusting the value, make changes of 10mΩ each time and re-try. The target for this test is for the vehicle to hold stationary for the 1 second until the brake is applied.

4. Take the machine back onto a level surface, drive forwards at full speed and release the throttle. Observe what happens in the 1 second before the brake comes on.

   - If the machine recoils (drives slightly in reverse) before the brake comes on, then the value of Slope Factor is too low and should be increased.
   - If the machine is still moving when the brake comes on, then the value of Slope Factor is too high and should be decreased.

   When making adjustments in the value, make changes of 10 each time.

Even if the machine feels good initially, it is recommended that Slope Factor be reduced until slight recoil is felt, then the value increased again until the recoil just disappears.

Adjustments to Brake Time or Anti Rollback Level should not be necessary.

8.7 Pull-Away Delay

This parameter can be used to reduce roll-back or roll-forward when the machine is being started on a slope.

The parameter can be adjusted in steps of 10ms between 0 and 1 second.

The delay represents the amount of time between the machine's motor starting to drive and the brake being released. If the parameter is incorrectly set then one of the following conditions will be noticeable.

Too Low On gradients the machine may roll backwards or roll forwards prior to the motor properly engaging and moving the machine in the desired direction.

Too High On a level surface the machine will not react swiftly enough to throttle displacement.

PGDT recommend a value of 300ms for the Pull-Away Delay as an optimum setting. This should be verified for each application by the machine manufacturer.

8.8 Anti-Rollback Velocity

This parameter should never require adjustment.

For further details contact PGDT.

9 Belly Button

9.1 Belly Button Switch Type

This parameter selects the input state in which the Belly Button mode will be active.

The parameter can be set to Normally Open or Normally Closed.

Normally Open Belly Button switch is normally open when not activated.

Normally Closed Belly Button switch is normally closed when not activated.

9.2 Belly Button Speed

This parameter sets the Belly Button speed as a percentage of the maximum speed of the machine.

The parameter is adjustable between 0 and 100% in steps of 1%.

9.3 Belly Button Time

This parameter sets the time that the Belly Button Speed will be applied for, if the switch is not released.

The parameter is adjustable between 0 and 5 seconds in 1 second steps.

The machine manufacturer is responsible for ensuring that the wiring of the Belly Button switch and the programming of the Belly Button parameters are suitable for the intended application. PGDT accepts no liability for losses of any kind arising from the incorrect wiring or programming of the Belly Button function.

10 Factory

10.1 Safety Fences

Absolute limits (or fences) can be applied to some dealer accessible programmable parameters. These limits are known as safety fences and are programmed by PGDT when the i-Drive is manufactured. The purpose of these fences is to prevent the machine being programmed to be too fast or too severe in its acceleration or deceleration. The parameters which can have fences applied to them are:

Maximum and Minimum Acceleration.

Maximum and Minimum Deceleration.

Maximum and Minimum Forward and Reverse Speed.

Standard PGDT settings are 0 for the minimum fence value and 100 for the maximum fence value, meaning there is a full range of adjustment.

PGDT accepts no liability for losses of any kind if the machine manufacturer does not specify appropriate safety fence values for a particular application.

10.2 Supply Voltage

This parameter allows the operating voltage of the controller to be set to either 24V or 36V.

This parameter may not be accessible dependant on PGDT factory programming.

11 Auxiliary Outputs

11.1 Auxiliary 1 Output Mode

This parameter sets the operating mode for the Auxiliary 1 Output.

The parameter can be programmed to one of the following modes:

Off	The output is never active.
Solenoid Brake	The output will correctly control a Solenoid Brake.
Forward Traction	The output is only active when the machine is driving forwards.
Reverse Traction	The output is only active when the machine is driving backwards.
Traction	The output is active when the machine is driving in either direction.

Traction mode differs from the Solenoid Brake mode such that the parameters Auxiliary 1 Output Off Delay and Inhibit 1 or 2 Target, function as per Forward and Reverse Traction modes.

Setting Auxiliary 1 Output Mode to any option other than Solenoid Brake automatically disables the Solenoid Brake check (open circuit detection).

When the parameter Auxiliary 1 Output Mode is set to Solenoid Brake, the parameters Auxiliary Output 1 Off Delay and Inhibit 1 or 2 Target, if set to Aux 1, will have no effect. For this instance only, the parameter Brake Time is effective.

11.2 Auxiliary 1 Output Off Delay

This parameter sets the time in seconds that the Auxiliary 1 Output remains switched on whenever the condition defined by the parameter Auxiliary 1 Output Mode is no longer true or Battery Lockout is active or the relevant inhibit input is active for the following modes:

Forward Traction.

Reverse Traction.

Traction.

The parameter can be set between 0 and 60 seconds in 1 second steps for i45 & i70 and 0.25 second steps for i140 & i180.

Example:

Aux 1 Output Mode	Forward Traction.
Aux 1 Output Off Delay	10 seconds.
Inhibit 1 Target	Aux 1.
Battery Lockout Type	Aux 1.

Auxiliary 1 Output is on when the controller is in forward drive.

Auxiliary 1 Output remains on when the throttle returns to neutral and the Auxiliary 1 Output Off Delay timer is initiated.

10 seconds elapse and the Auxiliary 1 Output switches off.

If the controller re-enters forward drive before the timer has expired, the Auxiliary 1 Output remains on and the Auxiliary 1 Output Off Delay timer is reset to zero.

If the Inhibit 1 input becomes active when the Auxiliary 1 Output is on, the timer is initiated and the output will switch off, once the delay timer has expired.

If the Inhibit 1 input becomes active whilst the Auxiliary 1 Output Off Delay is incrementing, the timer will continue with the original count and the Auxiliary 1 Output will switch off once the delay timer has expired. If the controller re-enters forward drive before the timer has expired, the inhibit takes priority and the count will continue uninterrupted, the output will switch off once the Auxiliary 1 Output Off Delay expires and remain off until the inhibit state changes to inactive and the controller enters forward drive once more.

If the battery lockout function becomes active, then the output will be inhibited in the same manner as an active Inhibit 1 or 2 input as above.

11.3 Auxiliary 2 Output Mode

This parameter sets the operating mode for the Auxiliary 2 Output.

The parameter can be programmed to one of the following modes:

Off	The output is never active.
Diagnostic/Reverse Alarm	The output will operate a diagnostic/reverse alarm.
Brake Light	The output will operate a brake light.
Continuous	The output is active the entire time the control system is powered-up.
Forward Traction	The output is only active when the machine is driving forwards.
Traction	The output is active when the machine is driving in either direction.
Reverse Traction	The output is only active when the machine is driving backwards.

When the parameter Auxiliary 2 Output Mode is set to Diagnostic/Reverse Alarm or Brake Light the parameters Auxiliary 2 Output Off Delay and Inhibit 1 or 2 Target, if set to Aux 2, will have no effect.

11.4 Auxiliary 2 Output Off Delay

This parameter sets the time in seconds that the Auxiliary 2 Output remains switched on whenever the condition defined by the parameter Auxiliary 2 Output Mode is no longer true or Battery Lockout is active or the relevant inhibit input is active for the following modes:

Forward Traction.

Reverse Traction.

Traction.

Continuous.

The parameter can be set between 0 and 60 seconds in 1 second steps for i45 & i70 and 0.25 second steps for i140 & i180. Refer to Auxiliary 1 Output Off Delay for example.

When set to Continuous, the Auxiliary 2 Output Off Delay Timer can only be initiated by an Inhibit state.

11.5 Auxiliary 3 Output Mode

This parameter sets the operating mode for the Auxiliary 3 Output.

The parameter can be programmed to one of the following modes:

Off	The output is never active.
Continuous	The output is active the entire time the control system is powered-up.
Forward Traction	The output is only active when the machine is driving forwards.
Reverse Traction	The output is only active when the machine is driving backwards.
Traction	The output is active when the machine is driving in either direction.

11.6 Auxiliary 3 Input Type

This parameter allows the reverse switch input to be used to control the Auxiliary 3 Output. This parameter can only be used when fitted to a machine using a wig-wag throttle type.

The parameter can be set to None or Reverse Switch.

None	The output will be active as per the Auxiliary 3 Output Mode.
Reverse Switch	The Auxiliary 3 Output will only be active when the switch is closed. At this time, the Auxiliary 3 Output Mode will be active as per the parameter settings.

11.7 Auxiliary 3 Output Voltage

This parameter allows the output voltage to be set between 6V and 36V in 1V steps.

Note that the highest possible actual voltage output is equal to the system voltage. When set to a value lower than the system voltage, the controller will maintain the output voltage regardless of variation in supply voltage.

The controller uses a low frequency PWM to produce a voltage lower than the supply voltage. Any load connected to this output will be exposed to the peak supply voltage during the PWM 'on' period.

11.8 Auxiliary 3 Output Off Delay

This parameter sets the time in seconds that the Auxiliary 3 Output remains switched on whenever the condition defined by the parameter Auxiliary 3 Output Mode is no longer true or Battery Lockout is active or the relevant inhibit input is active for the following modes:

Forward Traction.

Reverse Traction.

Traction.

Continuous.

The parameter can be set between 0 and 60 seconds in 1 second steps for i45 & i70 and 0.25 second steps for i140 & i180. Refer to Auxiliary 1 Output Off Delay for example.

When set to Continuous, the Auxiliary 3 Output Off Delay Timer can only be initiated by an Inhibit state.

12 Memory Functions

12.1 Diagnostic Logs

Diagnostic logs are used to record the history of events encountered by the i-Drive during its operational life. These logs provide valuable information about the type of errors that have been experienced, as well as detailing how many times a particular 'trip' has occurred. They allow quick error diagnosis and provide useful data regarding intermittent problems.

Every error will have an assigned code that is transmitted to the appropriate log when the controller detects a fault. The fault will be categorized as either a System error or a suspected Controller error.

System error	Stored within the System Log and accessible via a dealer level hand-held or PC Programmer. It is likely that the error will have been induced by an external component on the machine itself, e.g. an open circuit motor connection, '3B01'.
Controller error	Stored within the System Log as a generic '4401' error, the actual code is also written to the Control Log and is accessible via an OEM level hand-held or PC Programmer. It is possible that the error will have been induced by an internal controller fault. Before returning the controller, all wiring and connections should be checked and the battery charged. Contact PGDT for further advice if necessary.

Each diagnostic log can hold up to 8 different error codes with an associated count of up to 255. Once a count of 255 has been reached, the number of entries will be held at 255 and will not reset back to 0.

New types of fault are recorded in the order in which they occur. The newest type of fault is displayed by the programmer on the first line. If a fault type has already been logged and this error occurs again, it will be added to the number of instances of that type of fault, rather than listed in a separate position.

When a log is full, i.e. there are 8 different error codes recorded, a 9th new error will overwrite the historical entry with the least number of occurrences.

When interrogating fault logs, it is advisable to concentrate on the number of instances of a particular error rather than its position in the log.

12.1.1 Read System Log

This allows you to view the contents of the i-Drive's System Log.

12.1.2 Clear System Log

This function clears the i-Drive's System Log and is only accessible using an OEM level programmer.

12.1.3 Read Control Log

This allows you to view the contents of the i-Drive's Control Log and is only accessible using an OEM level programmer.

12.1.4 Clear Control Log

This function clears the i-Drive's Control Log and is only accessible using an OEM level programmer.

12.2 Timer

The i-Drive has a timer which records how long the machine has been driven for. The timer runs whenever the throttle is moved into a drive state and stops when the throttle is returned to the home position. Although the timer records both hours and minutes, only full hours are displayed.

12.2.1 Read Timer

This allows you to view the number of hours the machine has been 'driven' for.

12.2.2 Clear Timer

This function resets the i-Drive's timer and is only accessible using an OEM level programmer.

CHAPTER 4 – DIAGNOSTICS

1 Introduction

The primary objective of this chapter is to assist service personnel in finding the likely area of a detected fault within the whole electrical system. It is important to realize that even though the i-Drive is signalling a trip, it may not be the control system itself that is defective. This is because the i-Drive is able to detect problems in other electrical components (motors, batteries, solenoid brakes, etc.) or, more importantly, the wiring to them.

Using this guide, it is possible to define a trip as belonging to one of 10 types. Once the type has been established, there are suggestions as to what the possible cause may be.

The guide should only be used to decide the starting point of your own diagnosis, as it is possible for the controller to indicate a fault in another component, even though the controller itself may be defective. Nevertheless, experience has shown that connectors and wiring are the major cause of machine problems, so it is necessary to examine these more vulnerable areas first.

Diagnostics should only be conducted by electronic service professionals with in-depth knowledge of PGDT electronic control systems. An incorrect or badly effected repair could result in an unsafe set-up of a machine. PGDT accepts no liability for losses of any kind arising from an incorrect or badly effected repair.

1.1 Diagnostic Procedure

For efficient and effective diagnosis the following basic steps should be taken:

- Observe the Status Indicator or use a PGDT programmer to confirm the i-Drive is tripping or has tripped intermittently in the past.
- Refer to the trip table shown in this chapter.
- Refer to the possible cause shown in the table and carry out the recommended investigative and corrective action.

1.2 Detecting A Trip Has Occurred

Firstly, observe the Status Indicator. Depending on the machine model, the status indicator may be a single lamp (or LED) or a TruCharge battery gauge. Both types indicate the status of the controller and will flash to indicate a trip. Refer to Chapter 1, Section 8 for details on how to interpret this information.

If the Status Indicator shows the controller is tripping, plug a PGDT programmer in to the 4-way Molex connector fitted to the i-Drive. Note the trip code and refer to the table in Section 2.

If the Status Indicator is not denoting a trip but you suspect an intermittent problem, interrogate the controller's diagnostic logs with the programmer. Note the contents of the logs and refer to the table in Section 2 for assistance. Further information about the diagnostic logs can be found in Chapter 3, Section 12.

2 Trip Types And Possible Causes

Once the trip type has been established, refer to the relevant section below for further information.

Trip Code	Trip Type	Description & Reference
0300	-	Throttle Trip. Refer to Section 2.7.1
0815	7	Throttle Trip. Refer to Section 2.7.2
0A00	6	Sleep Mode. Refer to Section 2.6.3
0E07	7	Throttle Trip. Refer to Section 2.7.3
1500	9	Short Circuit In Solenoid Brake. Refer to Section 2.9.1
1502	9	Open Circuit In Solenoid Brake. Refer to Section 2.9.2
1600	10	High Battery Voltage. Refer to Section 2.10.1
1601	10	Very High Battery Voltage. Refer to Section 2.10.2
1E08	6*	Inhibit 1 Active. Refer to Section 2.6.1
1E09	6*	Inhibit 2 Active. Refer to Section 2.6.2
2C00	1	Low Battery Voltage. Refer to Section 2.1.1
2C01	1	Very Low Battery Voltage. Refer to Section 2.1.2
2F01	7*	Throttle Displaced At Start-Up. Refer to Section 2.7.4
3B01	2	Motor Open Circuit. Refer to Section 2.2
3D02	3	Motor Shorted To Battery Positive. Refer to Section 2.3.1
3D03	3	Motor Shorted To Battery Negative. Refer to Section 2.3.2
4401	-	Record Of Possible Control Fault. Refer to Section 2.8.2
5300	8	Programmable Setting Changed. Refer to Section 2.11
7901	7	Belly Button Active At Start-Up. Refer to Section 2.7.5
All Other Codes	8	Possible Controller Fault. Refer to Section 2.8.1

*Dependant on programming.

Trip Types 4 and 5 are not used for i-Drive.

2.1 Trip Type 1 – Low Battery Voltage

2.1.1 Low Battery Voltage

This occurs when the controller detects that the battery voltage has fallen below approximately 13.5V. Check the condition of the batteries, connectors and relevant wiring to the i-Drive.

If the trip is still present after the batteries, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.1.2 Very Low Battery Voltage

This occurs when the controller detects a sudden drop in battery voltage. Check the condition of the batteries, connectors and relevant wiring to the i-Drive.

If the trip is still present after the batteries, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.2 Trip Type 2 – Motor Open Circuit

This occurs when the controller detects that the motor has become disconnected at start-up or in standby. Check the motor, connectors and relevant wiring to the i-Drive.

If the trip is still present after the motor, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.3 Trip Type 3 – Motor Wiring Trip

2.3.1 Motor Shorted To Battery Positive

This occurs when the controller detects that the motor wiring has been shorted to Battery Positive. Check the motor, connectors and relevant wiring to the i-Drive.

If the trip is still present after the motor, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.3.2 Motor Shorted To Battery Negative

This occurs when the controller detects that the motor wiring has been shorted to Battery Negative. Check the motor, connectors and relevant wiring to the i-Drive.

If the trip is still present after the motor, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.4 Trip Type 4 – Not Used

2.5 Trip Type 5 – Not Used

2.6 Trip Type 6 – Inhibit Active

2.6.1 Inhibit 1 Active

This occurs when the controller detects that the Inhibit 1 input is active, Inhibit 1 Speed has been set to '0' and Inhibit 1 Operation has been set to 'Latched'. This input is located on pin 6 of the 14-way Tiller Connector. Check the state of the input, Inhibit 1 programming, connectors and relevant wiring to the i-Drive.

If the trip is still present after the state of the input, programming, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.6.2 Inhibit 2 Active

This occurs when the controller detects that the Inhibit 2 input is active, Inhibit 2 Speed has been set to '0' and Inhibit 2 Operation has been set to 'Latched'. This input is located on pin 14 of the 14-way Tiller Connector. Check the state of the input, Inhibit 2 programming, connectors and relevant wiring to the i-Drive.

If the trip is still present after the state of the input, programming, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.6.3 Blink – Sleep Mode

This occurs when the controller enters Sleep Mode. Turn the controller off and then on to awake the system. To disable Sleep Mode, program the parameter Sleep Timer to 0 minutes.

2.7 Trip Type 7 – Throttle Trip

2.7.1 Parallel Speed Pot. Wiper Error

This occurs when the controller detects that the Parallel Speed Limit Potentiometer Wiper is open circuit or has been shorted to one of the throttle references. The Parallel Speed Limit Potentiometer Wiper input is located on pin 9 of the 14-way Tiller Connector. If this error occurs, the controller will allow drive to continue but at the minimum programmed speed. Check the parallel speed potentiometer, connections and relevant wiring to the i-Drive.

If the trip is still present after the potentiometer, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.7.2 Throttle Reference Error

This occurs when the controller detects an error with one of the throttle references, either high or low. The throttle references are located on pins 2 and 8 of the 14-way Tiller Connector, respectively. Check the throttle potentiometer, connectors and relevant wiring to the i-Drive.

If the trip is still present after the potentiometer, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.7.3 Series Speed Pot. Wiper Error

This occurs when the controller detects that the Series Speed Limit Potentiometer Wiper is shorted to one of the throttle references, either high or low. The Series Speed Limit Potentiometer Wiper input is located on pin 1 of the 14-way Tiller Connector. The trip is only applicable if an ISO-test resistor is fitted and programmed correctly. Check the throttle potentiometer, programming, connectors and relevant wiring to the i-Drive.

If the trip is still present after the potentiometer, programming, connectors and wiring have been checked, the controller may be defective. Section 3.

2.7.4 Throttle Displaced At Start-Up

This occurs when the controller detects that the Throttle Potentiometer has been displaced at start-up and the parameter Throttle Operated At Power-Up has been set to 'Trip'. Check that the operator is not deflecting the throttle at power-up, the throttle potentiometer, connectors and relevant wiring to the i-Drive.

If the trip is still present after the operator use, potentiometer, connectors and wiring have been checked, the controller may be defective. Section 3.

2.7.5 Belly Button Active At Start-Up

This occurs when the controller detects that the Belly Button Switch has been operated at power-up. The Belly Button Input is located on pin 9 of the 14-way Tiller Connector. Check the Belly Button Switch, connectors and relevant wiring to the i-Drive.

If the trip is still present after the switch, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.8 Trip Type 8 – Possible Controller Fault

2.8.1 Possible Controller Fault

This occurs when the controller suspects an internal problem. Check the batteries, motor, connectors and wiring to the i-Drive.

If the trip is still present after these checks have been conducted, the controller may be defective. Section 3.

2.8.2 Record Of Possible Controller Fault

'4401' is not actually a trip code but rather a historical record of the number of times the i-Drive has tripped with a suspected controller fault. Each time the i-Drive trips with an error not shown in the table above, it records one instance of the code '4401' in the controller's System Log. The actual controller trip code is also recorded in the i-Drive's Control Log. The number of '4401' trips shown in the System Log should therefore equal the cumulative number of trip occurrences shown in the Control Log. More information on the i-Drive's diagnostic logs can be found in Chapter 3, Section 12. Check the batteries, motor, connectors and wiring to the i-Drive.

Please contact PGDT for further advice before returning a controller based solely on the presence of historical '4401' trips in the System Log.

2.9 Trip Type 9 – Solenoid Brake Trip

2.9.1 Short Circuit In Solenoid Brake

This occurs when the controller detects a short circuit in the solenoid brake. Check the solenoid brake, connectors and relevant wiring to the i-Drive.

If the trip is still present after the brake, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.9.2 Open Circuit In Solenoid Brake

This occurs when the controller detects an open circuit in the solenoid brake at start-up or in standby. Check the solenoid brake, connectors and relevant wiring to the i-Drive.

If the trip is still present after the brake, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.10 Trip Type 10 – High Battery Voltage

2.10.1 High Battery Voltage

This occurs when the controller detects that the battery voltage has exceeded approximately 35V on 24V i-Drives and approximately 45V on 36V i-Drives. Check the condition of the batteries, connectors and relevant wiring to the i-Drive.

If the trip is still present after the batteries, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.10.2 Very High Battery Voltage

This occurs when the controller detects that the battery voltage has exceeded approximately 45V on 24V i-Drives and approximately 49.5V on 36V i-Drives. Check the condition of the batteries, connectors and relevant wiring to the i-Drive.

If the trip is still present after the batteries, connectors and wiring have been checked, the controller may be defective. Refer to Section 3.

2.11 Programmable Setting Changed

This occurs whenever the value of a parameter is altered using a programmer. Turn the controller off and then on to reset the trip.

3 Servicing Of Defective Units

There are no serviceable parts within the controller. Consequently, any defective units must be returned to PGDT or a PGDT approved service organization for repair.

Opening or making any unauthorized adjustments or modifications to the controller or its components will invalidate any warranty and may result in hazards to the operator and is strictly forbidden.

PGDT accepts no liability for losses of any kind arising from unauthorized opening, adjustment or modification to the controller.

CHAPTER 5 – TRUCHARGE MODULE

1 Introduction

Study Chapters 1 & 2, they describe the intended functionality of the TruCharge Module and the details for connection to the i-Drive Controller.

The i-Drive Status Output Type parameter will require adjustment before the TruCharge indicator will work correctly. The parameter must be set to TruCharge. Refer to Chapter 2 Section 4.5.

There are two variants of the TruCharge Module. These are:

Surface mount variant.

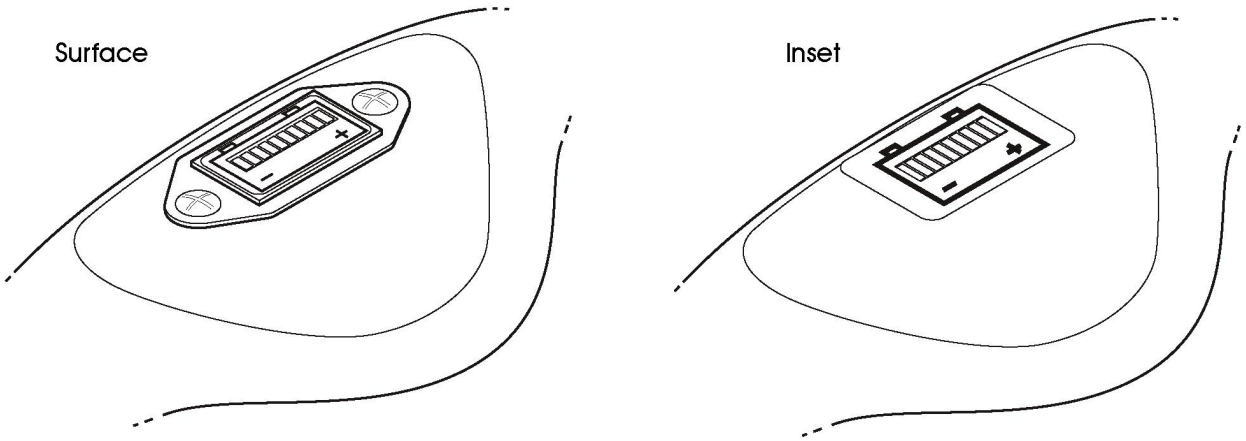
Inset variant.

1.1 Surface Mount Variant

The Surface Mount variant attaches to the machine's control panel from the outside (see the following illustration). The electronics compartment of the TruCharge Module has an IPX5 ingress protection rating.

Surface mount variant – D50826 (24V – 48V operation).

D50826 consists of: 1 TruCharge Display Module, 1 TruCharge Display Cable and 1 Gasket.



1.2 Inset Variant

The Inset variant must be embedded within the machine's control panel (refer to the illustration). The electronics of the controller will then take on the ingress protection rating of the machine control panel.

Inset variant - D50066 / D50032 (Both parts 24V operation only).

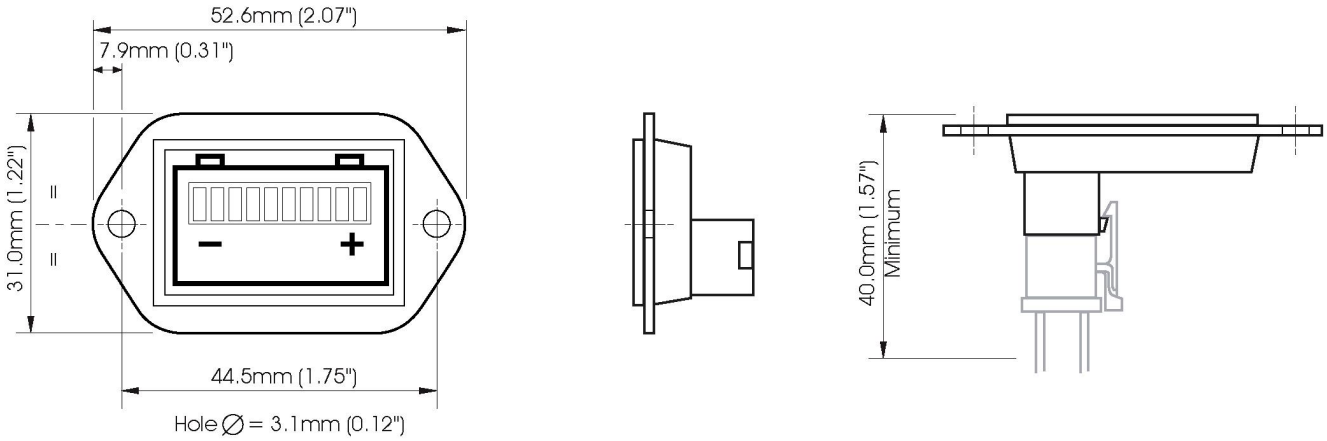
D50066 Consists of: 1 TruCharge Display Module, 1 Label and 1 Double-sided Adhesive Gasket.

D50032 Consists of: 1 TruCharge Display Module and 1 Double-sided Adhesive Gasket.

2 Dimensions

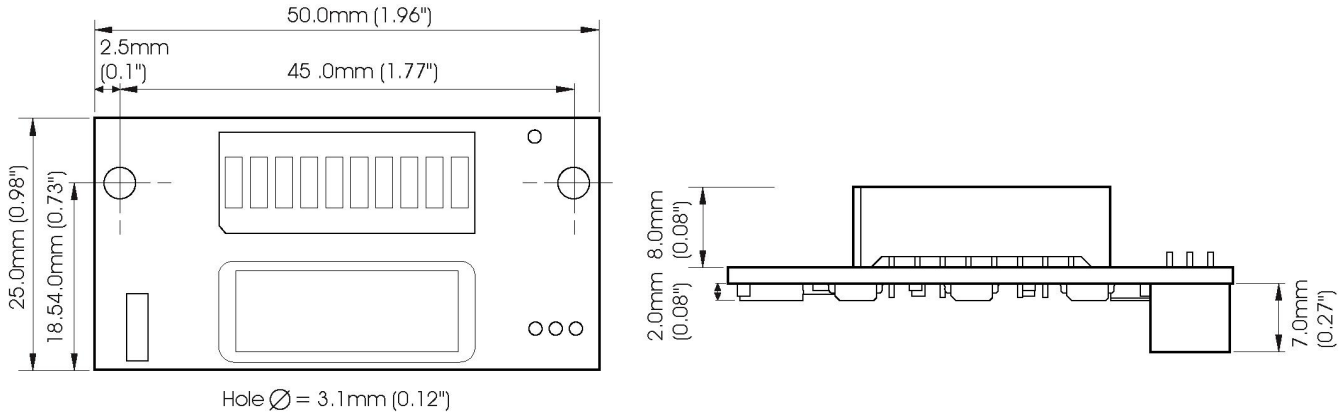
2.1 Surface Variant

The Surface Mount TruCharge Module has the dimensions shown in the following illustration.



2.2 Inset Variant

The Inset TruCharge Module has the dimensions shown in the following illustration.



3 Mounting

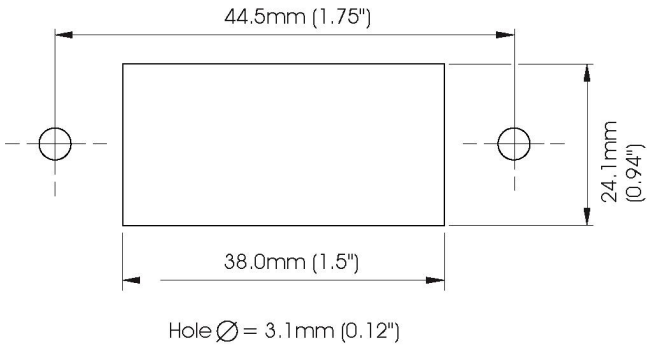
3.1 Handling

The TruCharge Module contains electronic components that may be sensitive to static electricity. Always store the modules in the original packaging until they are ready to be used. When the modules are removed from the packaging, ensure correct anti-static precautions are observed.

3.2 Surface Variant

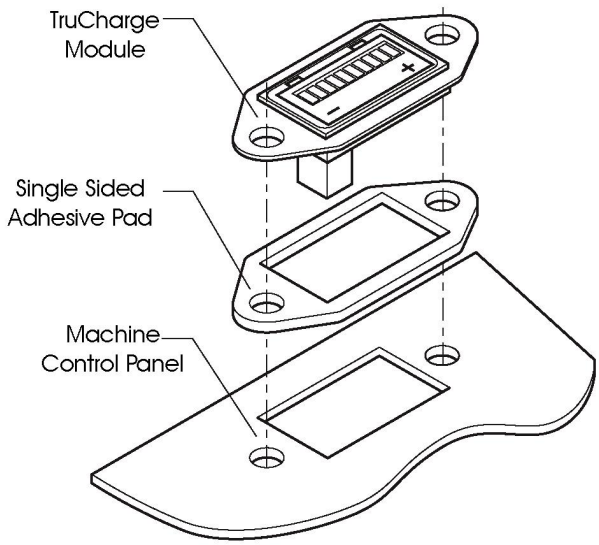
3.2.1 Fixing

The machine's control panel should be fitted with holes as suggested in the diagram below.



3.2.2 Sealing

The supplied single-sided adhesive gasket (adhesive uppermost) should be used to create a seal between the TruCharge Module and the machine's control panel. See the following illustration.



When correctly fitted, this arrangement will give the TruCharge Module an IPX5 ingress protection rating.

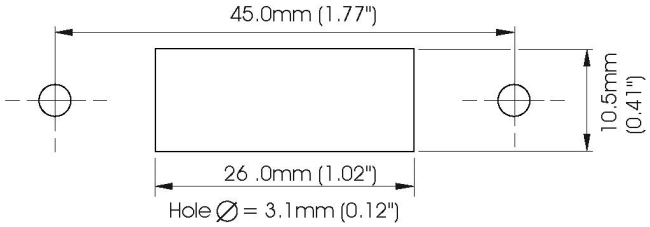
3.3 Inset Variant

3.3.1 Fixing

The machine's control panel should be fitted with holes as suggested in the diagram below.

The supplied double-sided adhesive pad should be used to secure the TruCharge Module to the machine's control panel. See the following illustration.

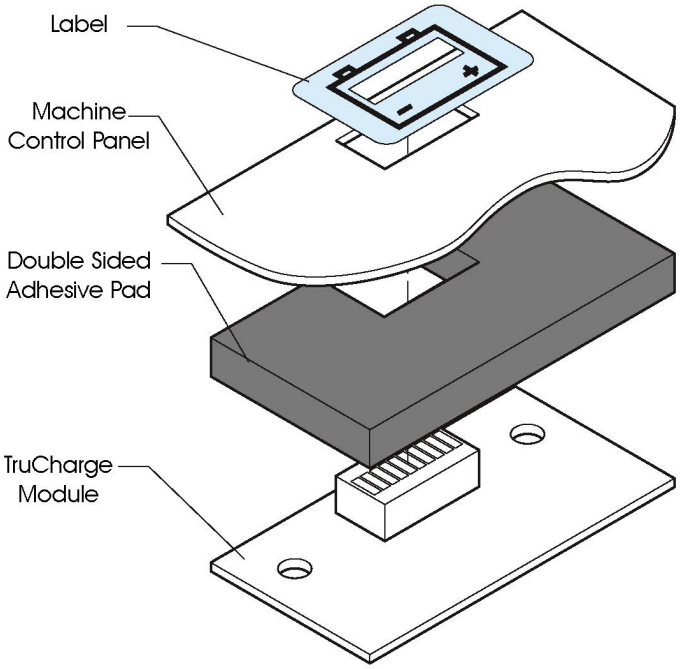
If the adhesive pad is being used to attach the TruCharge Module then the screw holes either side of the central rectangle will not be required.



Alternatively M3 (4-40 UNC) hardware can be used. The height of the display from the printed circuit board is 8.0mm (0.31"). Suitable spacers should be used so that the display is fixed slightly below the machine's control panel. Ensure that the metallic fixing hardware (nuts, washers etc.) do not touch the conductive tracks on the printed circuit board.

3.3.2 Sealing

The module should be sealed against the ingress of water and dust by placing an adhesive waterproof overlay over the display cut-out. The overlay should contain a suitably sized transparent window and the overall dimensions should be at least 36.0mm x 20.5mm (1.41" x 0.81").



The sealing label is only supplied with the TruCharge Module kit number D50066.

4 Wiring

The machine manufacturer is responsible for establishing the suitability of the particular wiring arrangement used on the machine. PG Drives Technology can make general recommendations for wiring to TruCharge Modules, but PG Drives Technology accepts no responsibility for the wiring arrangement used.

4.1 Wire Gauge

The minimum recommended wire size is 0.22mm^2 for all connections.

4.2 Connectors

4.2.1 Surface Mount Variant

The TruCharge Module is fitted with a Molex 'Mini-fit Jr' 4 way connector.

See www.molex.com for your local distributor.

Part Numbers are as follows:

Molex 'Mini-Fit-Jr.' 4 socket receptacle:	39-01-2040

PG Drives Technology TruCharge Display Cable.

PGDT Part number:	SA76199

Only use the PG Drives Technology TruCharge Display Cable number SA76199 supplied with kit D50826.

Hand tools for crimping and extraction are available from Molex. The references are as below.

Molex 'Mini-Fit-Jr.' Crimp tool:	69008-0724
Molex 'Mini-Fit-Jr.' Extraction tool:	11-03-0044

Only use the exact tools specified.

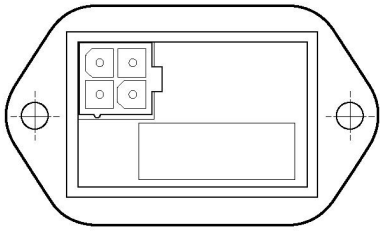
4.2.2 Inset Variant

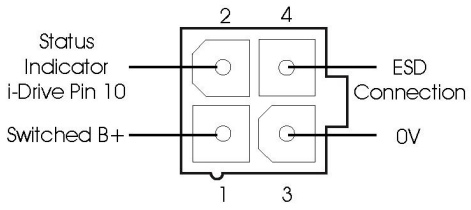
The TruCharge Module is fitted with a 3 way AMP CT series connector, part number 175487-3. The mating crimps and connector housing have Amp part numbers 179227-1 and 179228-3 respectively. Only these parts should be used.

There is also a solder/ring tag point for an Electro-Static Discharge (ESD) drain path wire.

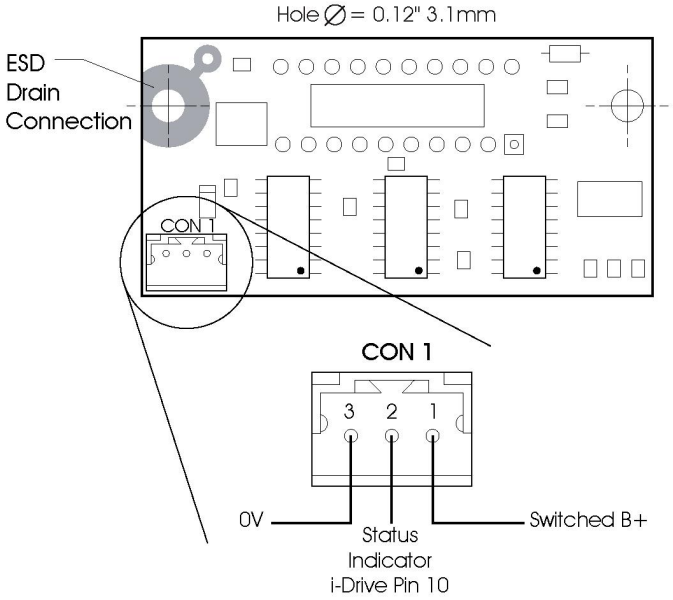
5 Connections

5.1 Surface Variant





5.2 Inset Variant



5.3 Controller Connections

TruCharge Module Type	TruCharge Module Connector	Function	TruCharge Interface
Inset	1	Switched B+	Pin 5
Inset	2	Status Indicator	Pin 10
Inset	3	0V	Pin 13
Surface	1	Switched B+	Pin 5
Surface	2	Status indicator	Pin 10
Surface	3	0V	Pin 13
Surface	4	ESD	--

5.4 ESD Connection

5.4.1 Surface Mount Variant

This is an optional connection and may not be required, refer to Section 6.2 for details.

If the connection is required then connection point 4 in the Molex 'Mini-fit Jr' 4 way connector must be utilized

5.4.2 Inset Mount Variant

This is an optional connection and may not be required, refer to Section 6.2 for details.

If the connection is required there are two methods available. Firstly, a solder hole for wires or electrical suppression components. Secondly, if screws are used to secure the TruCharge Module, then a ring terminal can be used.

6 Electromagnetic Compatibility (EMC)

The controller has been tested to allow compliance with EN12895:2000. The guidelines in this section will help you to make sure that your machine installation will easily meet the requirements of the directive. You should consider EMC and perform relevant tests as early as possible in the design phase.

6.1 Immunity and Emissions

Refer to the Electromagnetic Compatibility section earlier in this technical manual.

6.2 Electro-Static Discharge (ESD)

The control panel module is the most vulnerable area on the machine to electro-static discharges. These discharges may cause disruption of operation or even permanent damage. The TruCharge Module incorporates extensive protection against ESD; however, you should follow the precautions set out in Chapter 2 to prevent high levels of energy entering the machine's electronic system.

- The tiller module has a connection point, ESD; this can be used to provide an ESD drain path. The path should be via a varistor connected between the ESD pin and the machine's metalwork. A suitable device is manufactured by Harris, type GE-MOV V82ZA2.

7 Production Tests

7.1 Mounting

Make sure that the TruCharge Module is securely mounted. Do not overtighten any securing screws.

Ensure that the adhesive sealing overlay is fully pressed down.

7.2 Cables and Connections

Check all cables and connections to the TruCharge Module for damage. Ensure there are no dry solder joints.

7.3 Operational Test

The following tests should be carried out on a level floor with at least one meter of clear space around the machine.

With the machine switched off, displace the throttle and then switch the machine on. The TruCharge display should 'ripple' up and down. When you have observed that all the bars illuminate, release the throttle and the display should now become steady and indicate the battery condition.

There are two conditions when this test cannot be performed. Firstly, if the controller is programmed (Throttle Operated at Power-Up) to instantly trip if it is powered-up with the throttle displaced. Secondly, if the controller is programmed (High Pedal Disable) to drive immediately after power-up regardless of throttle position.

If this test cannot be performed due to the above conditions, then the only other test method is to power-up the machine with fully charged batteries and check that all the TruCharge bars illuminate.

CHAPTER 6 – WARNING SUMMARY

1 Introduction

This section summarizes all of the very important warnings that appear throughout the text of this manual. Do not install, maintain or operate the machine without reading, understanding and observing the following warnings. Failure to observe these warnings could result in UNSAFE CONDITIONS for the user of a machine or affect the reliability of the controller. PG Drives Technology accepts no liability for losses of any kind arising from failure to comply with any of the conditions in the warnings listed below. Failure to observe these warnings will invalidate the i-Drive warranty.

The machine manufacturer may wish to use this section as a checklist, to ensure the risk areas identified below have been addressed within their own machine designs and associated documentation.

2 Warnings

2.1 Driving Technique

The machine user must be capable of driving a machine safely. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.2 Hazards

Although the i-Drive is designed to be extremely reliable and each unit is rigorously tested during manufacture, the possibility of system malfunction always exists (however small the probability). Under some conditions of system malfunction the controller must (for safety reasons) stop the machine instantaneously. If there is any possibility of the user falling out of the machine as a result of a sudden braking action, it is imperative that a restraining device such as a seat belt is supplied with the machine and that it is in use at all times when the machine is in motion. PGDT accepts no liability for losses of any kind arising from the unexpected stopping of the machine, or arising from the improper use of the machine or controller.

Do not operate the i-Drive if the machine behaves erratically or shows abnormal signs of heating, sparks or smoke. Turn the i-Drive off at once and consult your service agent. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

Electro Magnetic Interference (EMI) can affect electronic equipment. Such interference may be generated by radio stations, TV stations, other radio transmitters and cellular phones. If the machine exhibits erratic behavior due to EMI, turn the controller off immediately and consult your service agent. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

It is the responsibility of the machine manufacturer to ensure that the machine complies with appropriate National and International EMC legislation. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The machine user must comply with all machine safety warnings. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.3 Safety Checks

These checks should be conducted in an open space and a restraining device such as a seat belt should always be used. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.4 Pushing Your Machine

Depending on the type of freewheel mechanism, then it may be possible for the machine to freewheel at potentially dangerous speeds. Therefore, do not push the machine up or down inclines on which you cannot stop or hold the machine. Never sit on the machine if the freewheel mechanism is disengaged. PGDT accepts no liability for losses of any kind arising from the machine being moved while the freewheel mechanism is disengaged.

Do not freewheel the machine faster than the programmed Maximum Speed, e.g. by towing. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.5 Programming

Programming should only be conducted by electronic service professionals with in-depth knowledge of PGDT controllers. Incorrect programming could result in an unsafe set-up of a machine for a user. PGDT accepts no liability for losses of any kind if the programming of the controller is altered from the factory preset values.

2.6 Servicing

PGDT accepts no liability for losses of any kind arising from unauthorized opening, adjustment or modifications to the i-Drive controller.

If the i-Drive controller is damaged in any way, or if internal damage may have occurred through impact or dropping, have the product checked by qualified personnel before operating. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The warranty will be void if the i-Drive has not been used in accordance with the i-Drive Technical Manual SK76977, the i-Drive has been subject to misuse or abuse, or if the i-Drive has been modified or repaired by unauthorized persons.

2.7 Program Settings

It is the manufacturer's responsibility to program the control system to suit the machine model and ensure safe operation in compliance with relevant legal requirements over the whole of the operating range. PGDT accepts no liability for losses of any kind due to failure to, or incorrect programming of, the i-Drive controller. Refer to Chapter 3 for details on programming individual parameters.

Programming should only be conducted by electronic service professionals with in-depth knowledge of PGDT electronic controllers. Incorrect programming could result in an unsafe set-up of a machine for the user. PGDT accepts no liability for losses of any kind if the programming of the controller is altered from the factory preset values. PGDT accepts no liability for losses of any kind if the drive or stability characteristics of the machine are altered without prior notification and discussion with PGDT.

2.8 Charger Interlock

The machine manufacturer is responsible for providing a means of preventing the use of the machine while the batteries are being charged. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.9 General

The machine manufacturer is responsible for establishing the suitability of the particular wiring arrangements used on the machine, for both normal use and stalled conditions. PGDT can make general recommendations for wiring the i-Drive controller, but PGDT accepts no responsibility for, and accepts no liability for losses of any kind arising from, the actual wiring arrangement used.

The machine manufacturer is responsible for ensuring that only the mating connectors specified by PGDT on the controller's specific data sheet or in this manual are used to connect to the controller. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The machine manufacturer is responsible for ensuring that suitable connectors are used and securely mated throughout the machine wiring system and that the workmanship associated with the wiring system is of a good enough quality. Failure to meet this condition could result in intermittent operation, sudden stopping or veering, or even create a burn or fire hazard. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.10 Motor And Battery

It is the responsibility of the machine manufacturer to ensure that the mating female Fastons are suitable for use on the intended application. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.11 i140 & i180

It is the responsibility of the machine manufacturer to ensure that the high current crimp connections are suitable for use on the intended application. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.12 Programming Connector

This connector should only be mated with a dedicated PGDT programming tool, i.e. an SPI, DTT or Industrial PC programmer. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.13 Crimping

Defective or poor quality crimps may affect the warranty of the controller. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.14 Wire Gauge and Types

It is the responsibility of the machine manufacturer to ensure that all wire gauges are suitable for the intended application.

2.15 Battery Connection

The machine manufacturer must install a suitable circuit breaker to provide protection against short circuits in the battery wiring, power loom or the controller. Failure to comply with this could result in a fire hazard. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.16 Belly Button Configuration

It is the responsibility of the machine manufacturer to ensure the mechanical arrangement of the Belly Button is suitable for the intended application. PGDT accepts no liability for losses of any kind arising from the incorrect mechanical arrangement of the Belly Button or the type of Belly Button switch used.

The machine manufacturer is responsible for ensuring that the wiring of the Belly Button switch and the programming of the Belly Button parameters are suitable for the intended application. PGDT accepts no liability for losses of any kind arising from the incorrect wiring or programming of the Belly Button function.

2.17 Fused B+ Supply

This connection should have no external capacitance connected to it and care should be taken not to exceed the fuse rating if lights or other auxiliary functions are connected.

2.18 Inhibit 1 & 2 Speed

If the Inhibit Speed is greater than 0 then the controller will not enter an inhibit state.

The machine manufacturer is responsible for ensuring that the controller is matched to the motor resistance. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.19 Drive Motors

The machine manufacturer is responsible for ensuring that the controller is matched to the motor armature resistance. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The machine manufacturer is responsible for always ensuring that any replacement motors or gearboxes are fully compatible with the originals that the controller was designed to match. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

Users or service personnel must not move a controller from one machine type to install it on a different machine type. Controllers with different part numbers may have both hardware and software differences to ensure that they are compatible with the electrical and dynamic characteristics of their specific target vehicles. The characteristics of one type of controller may not be compatible with a different machine. Failure to observe this warning could result in an unsafe set-up for the machine user and may create a fire hazard depending on the motors, wiring, connectors and circuit breakers installed on the unauthorized machine. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.20 Freewheeling

It is the responsibility of the machine manufacturer to ensure that adequate precautions are taken to warn the user against the hazards of freewheeling the machine at excessive speeds. It is also the responsibility of the machine manufacturer to utilize a suitable freewheel mechanism to reduce these risks. PGDT accepts no liability for losses of any kind resulting from excessive freewheel speeds of a machine.

Do not freewheel the machine faster than the programmed Maximum Speed, e.g. by towing. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.21 Programming Connection

The Molex 4-way connector can only be used as a communications port for a PGDT programmer. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.22 Position

Under strenuous driving conditions it is possible for metal sections of the controller's case to exceed 41°C (106°F) in temperature. Under such conditions, the machine manufacturer should ensure that either the user cannot touch these surfaces, or that the user is warned not to touch these surfaces. While 41°C (106°F) is very close to normal body temperature, prolonged contact with surfaces above 41°C (106°F) can result in burns to the skin. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.23 Production Tests

These tests should be conducted in an open space and for ride-on vehicles, a restraining device such as a seat belt should always be used. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.24 Introduction

Programming should only be conducted by electronic service professionals with in-depth knowledge of PGDT controllers. Incorrect programming could result in an unsafe set-up of a machine for a user. PGDT accepts no liability for losses of any kind if the programming of the controller is altered from the factory preset values.

2.25 Forward Acceleration

Setting this value too low could cause the machine to tip when accelerating up a slope.

2.26 Forward Deceleration

It is the responsibility of the machine manufacturer to ensure that the emergency stopping distance is within the distance specified for the country in which the machine will be used.

2.27 Reverse Deceleration

It is the responsibility of the machine manufacturer to ensure that the emergency stopping distance is within the distance specified for the country in which the machine will be used.

Setting this value too low could cause the machine to tip when stopping, whilst reversing down a slope.

2.28 Max. Forward Speed

Ensure the stability of the machine is maintained, especially when cornering at the programmed Max. Forward Speed.

2.29 Speed Limit Pot. Enabled

If a parallel type speed limiting potentiometer is fitted, this parameter must be set to ON or the machine will only drive at the maximum programmed speed settings.

2.30 Throttle Operated At Power-Up

Setting this parameter to Drive will contravene international 'mobility' vehicle safety legislation. If, under exceptional circumstances, the condition set by Drive is required, it becomes the sole responsibility of the machine manufacturer. PGDT accepts no liability for losses of any kind resulting from this parameter being set to Drive.

2.31 Soft-Stop

If this function is On, you must ensure that the emergency stopping distance is within the distance specified for the country in which the machine will be used.

2.32 Brake Fault Detect

This parameter should only ever be set to Off if there are no electrical brakes fitted to the machine.

2.33 Freewheel Speed Limit

It is the responsibility of the machine manufacturer to ensure that adequate precautions are taken to warn the user against the hazards of freewheeling the machine at excessive speeds. It is also the responsibility of the machine manufacturer to utilize a suitable freewheel mechanism to reduce these risks. PGDT accepts no liability for losses of any kind resulting from excessive freewheel speeds of a machine.

2.34 Current Foldback Temperature

The value of Current Foldback Temperature should never be set higher than 80°C. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.35 Motor Compensation

Motor Compensation should never exceed 60%.

The machine manufacturer is responsible for ensuring that the controller is matched to the motor resistance. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

The machine manufacturer is responsible for always ensuring that any replacement motors are fully compatible with the originals that the controller was designed to match. Failure to do this may result in poor control characteristics, which in extreme instances can make a machine uncontrollable and potentially unsafe. PGDT accepts no liability for losses of any kind arising from failure to comply with this condition.

2.36 Pull-Away Delay

PGDT recommend a value of 300ms for the Pull-Away Delay as an optimum setting. This should be verified for each application by the machine manufacturer.

2.37 Belly Button Time

The machine manufacturer is responsible for ensuring that the wiring of the Belly Button switch and the programming of the Belly Button parameters are suitable for the intended application. PGDT accepts no liability for losses of any kind arising from the incorrect wiring or programming of the Belly Button function.

2.38 Safety Fences

PGDT accepts no liability for losses of any kind if the machine manufacturer does not specify appropriate safety fence values for a particular application.

CHAPTER 7 – SPECIFICATIONS

I Electrical Specifications

Version	i24-45	i24-70	i36-45	i36-70	i24-140	i24-180	i36-140	i36-180
Supply Voltage	24Vdc		24Vdc or 36Vdc		24Vdc		24Vdc or 36Vdc	
Operating Voltage	16 – 30Vdc		16 – 45Vdc		16 – 30Vdc		16 – 45Vdc	
Peak Voltage	35Vdc		45Vdc		35Vdc		45Vdc	
Reverse Battery Voltage	40Vdc		60Vdc		40Vdc		60Vdc	
Auxiliary 1	1.25 max. sink							
Auxiliary 2	800mA max. sink*		420mA max. sink*		1A max. sink			
Auxiliary 3	800mA max. sink*		420mA max. sink*		1A max. sink			
Status Output	Programmable 12V, 50mA sink or source							
Inhibit Input	Programmable polarity							
Output Current	45A	70A	45A	70A	140A	180A	140A	180A
PWM Frequency	20kHz + / - 1%							
Power Connection	6.35mm (0.25") Faston spade				M6 screw terminals			
Brake Connection	2-way Molex Mini-fit Jr							
Programmer Connection	4-way Molex Mini-fit Jr							
Tiller Connection	14-way Molex Mini-fit Jr							
Moisture Resistance	Electronics to IPX5 / Connections to IPX4 with iCover							
Operating Temperature	-25°C to +50°C							
Storage Temperature	-40°C to +65°C							
Safety	Multiple hardware & software strategy designed to EN60335/2/72							
EMC Susceptibility	Tested at 30V/m to EN12895:2000							
EMC Emissions	To EN12895:2000							
ESD	IEC 61000-4-2							

*These values will be lower if both outputs are operated simultaneously and/or Aux 3 Output is PWM. Refer to Chapter 2 for details.