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The K-Tron GraviDrive™ Motor Controller Reference

Produced by the K-Tron Institute

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K-Tron GraviDrive Digital Motor Controller

Overview

Introduction

This manual is prepared to show how to install, wire, program, operate and troubleshoot the K-Tron GraviDrive Digital Motor Controller. To navigate through this manual, please use the table of contents and the index. The index will focus on key block labels, those bold labels on the left of the page, to help you find information quickly.

Continued on next page

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Overview, Continued

Definitions

Item	Description
Drive Command	The frequency signal that establishes the operation setpoint of the motor drive. Normally, 10kHz = 2000 rpm.
Drive Enable Signal	This signal is required when in the Standard or Serial Mode to permit the GraviDrive to run.
GraviDrive	Digital motor controller for motors to 2 Hp.
Jog Input	An input that permits jogging the GraviDrive at programmable speeds. You can use this control to empty a feeder that uses the GraviDrive.
7 segment display- D1	Indicator that shows drive command, motor current and alarm conditions.
7 segment display- D2	Indicator that shows status of signals and inputs to the GraviDrive.
OR1-A, OR1-B, OR2-A, OR2-B	This relay is the Run Relay output for the GraviDrive.
Rel NO, Rel NC	Alarm or Remote relay contacts.
Serial Mode	The control signals and programming for the GraviDrive come via the K10S Internal Data Channel at several baud rates.
Speed Feedback	The signal from the motor, in Hz, that defines motor velocity.

Continued on next page

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Overview, Continued

Definitions, con't

Item	Description
Standard Mode	The control signals for the GraviDrive come via the K10S frequency and level signals of the fanout pc board.
Switch SW#1	Programs the drive for motor current and other variables.
Trip A - Trip B	This is the input to trip the GraviDrive circuit breaker and remove AC power from the drive. Connecting the two inputs together will cause an AC power trip.

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Overview, Continued

Brief description of the GraviDrive

The all digital GraviDrive motor controller is designed to work with DC motors, both permanent magnet and field wound in horsepower ratings from 1/6 hp to 2.0 hp. Armature ratings of 100 and 200 Vdc are supported based upon line voltages of 115 Vac or 230 Vac accordingly.

The GraviDrive compares the setpoint and motor speed feedback and if a difference is detected, the output power to the motor is modified to bring them into balance. With digital precision, high motor speed accuracy and control is maintained

The unit is mounted in a finned aluminum housing that is mounted so that the fins are vertical to make use of the "chimney effect". All displays, connections and programming are on the GraviDrive panel.

Next is a diagram that shows connection to the K10S control system using the "Standard Mode" connections. "Standard Mode" implies that the control signals will come from the K10S system fanout pc board to the GraviDrive as frequencies and control levels.



Note on GMD part numbers:

K-Tron has made improvements to the Gravi-Drive over the years. New electronic hardware is now in place. The new hardware is not backward compatible with the original electronic software design. The function and basic operation of the old and new drives however, are the same. Here are the part numbers for your reference. A new GMD can replace the old with no changes except possible DIP switch programming changes. Please see this manual for details on DIP switch programming.

Voltage	Old GMD	New GMD
115	2401-300280	2401-300450
230	2401-300270	2401-300460

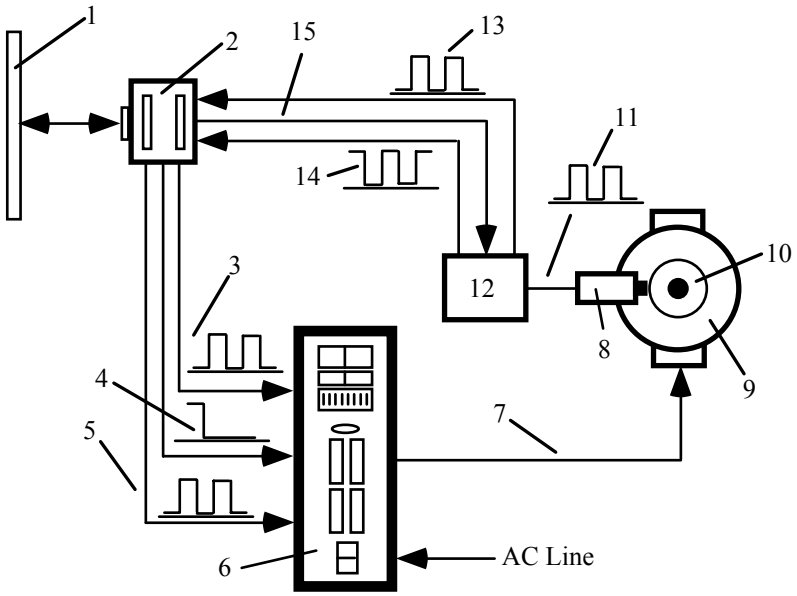
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Overview, Continued

Block diagram of GraviDrive connections in a K10S control system

This diagram shows the primary signals between the K10S controller and the GraviDrive.



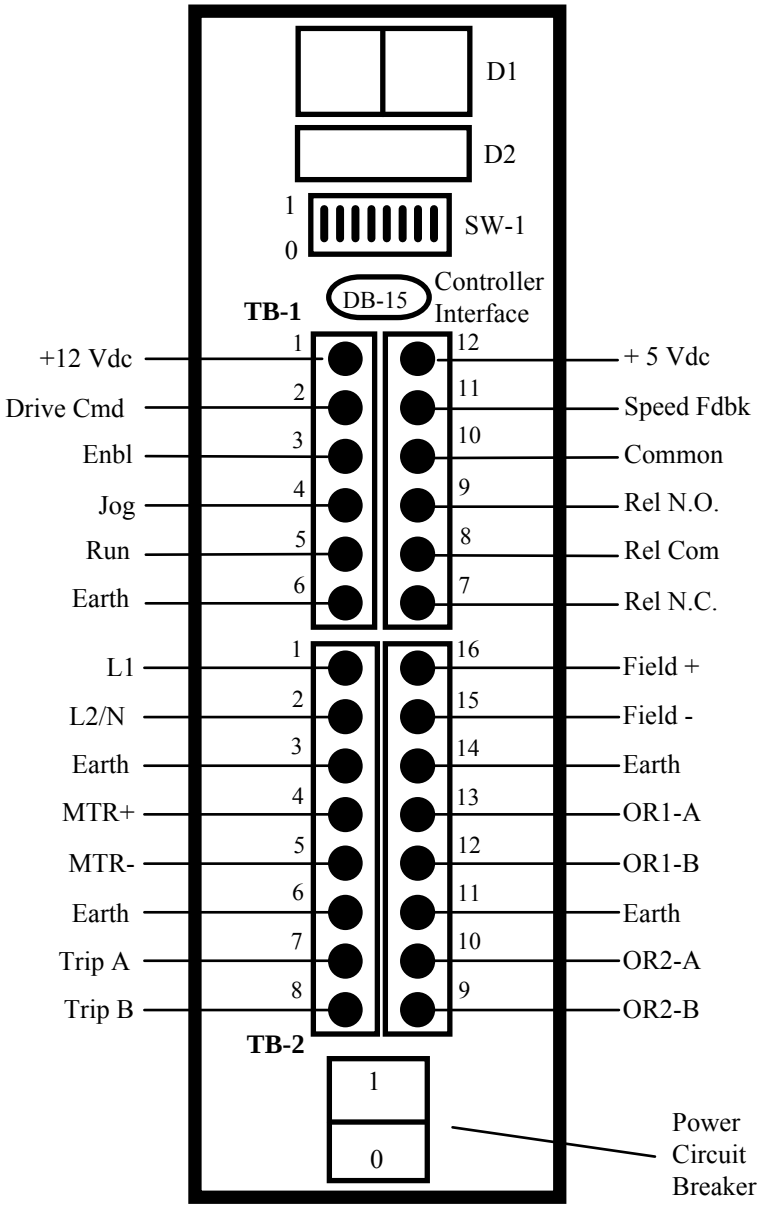
1- K10S control pc board, either in a chassis or rack assembly
2- K10S fanout pc board
3 - Drive Command signal from K10S controller
4 - Enable signal from K10S controller
5 - Re-Transmitted Speed Feedback signal from K10S controller
6 - GraviDrive motor controller
7 - DC power to motor
8 - Speed pick-up
9 - Motor
10 - Pick-up toothed gear
11 - Motor speed feedback signal to Scale Interface pc board
12 - Scale Interface pc board, mounted in feeder area
13/14 - Differential speed signals to the K10S controller
15- +12 Vdc to Scale Interface pc board

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Overview, Continued

Terminal Connections



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Installation

Introduction

This section outlines the requirements for installation including wiring and mounting information.

Tools

A small straight blade screwdriver, wire cutters and wire strippers and suitable wrenches to attach the mounting screws are required.

Safety

Do not wire or make connection to the GraviDrive with AC power applied. High voltage is present on many terminal points. Also power off any devices to which the GraviDrive may be connected to prevent errant damage.

GraviDrive mounting

The GraviDrive should be mounted so that the cooling fins are vertical to maximize cooling. Hardware including 2 right angle mounting brackets is provided to mount the unit to a surface plate.

GraviDrive dimensions: Height: 265 mm or 10.44 in
Depth: 250 mm or 9.85 in

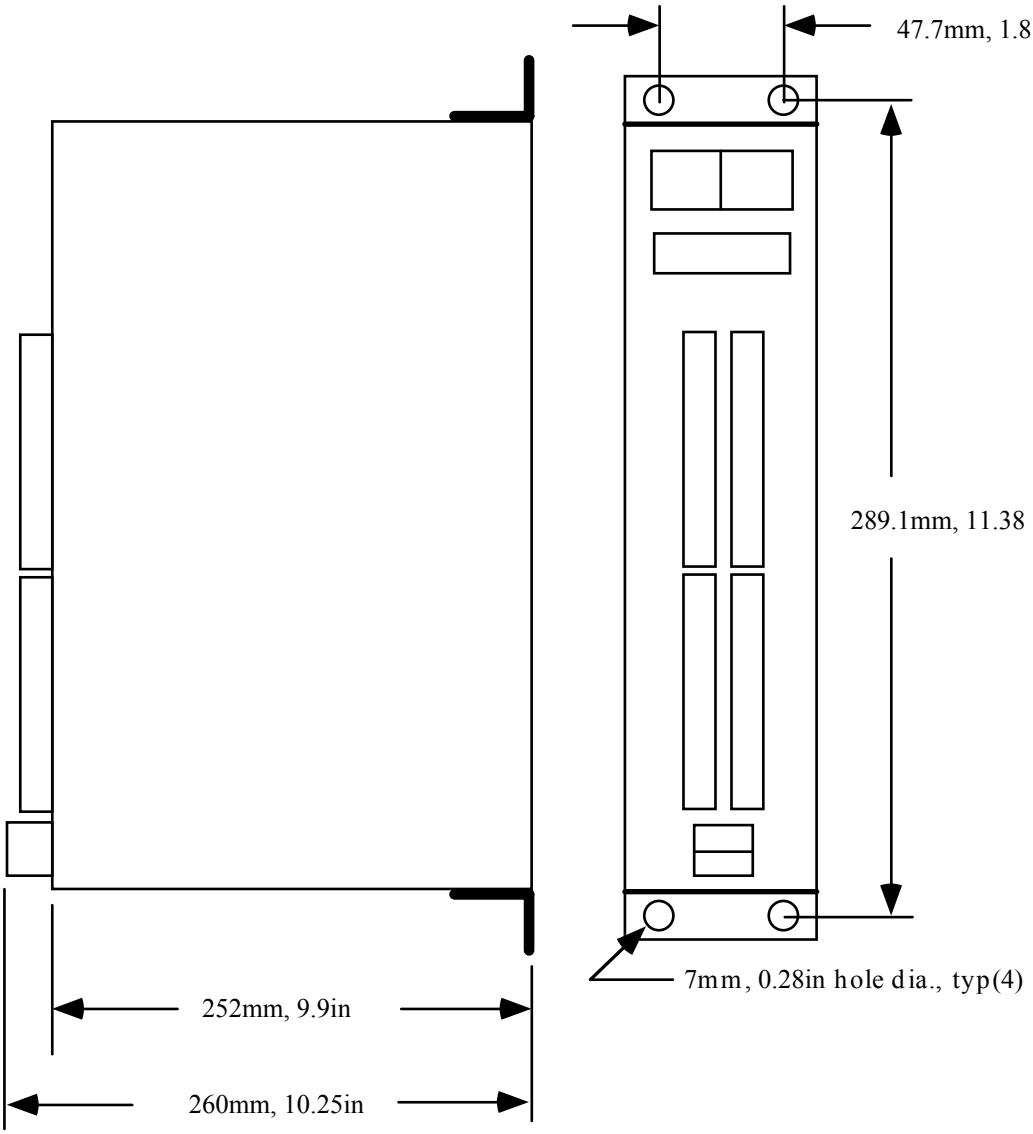
The diagram on the next page will show this detail.

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Installation, Continued

GraviDrive mounting diagram



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Installation, Continued

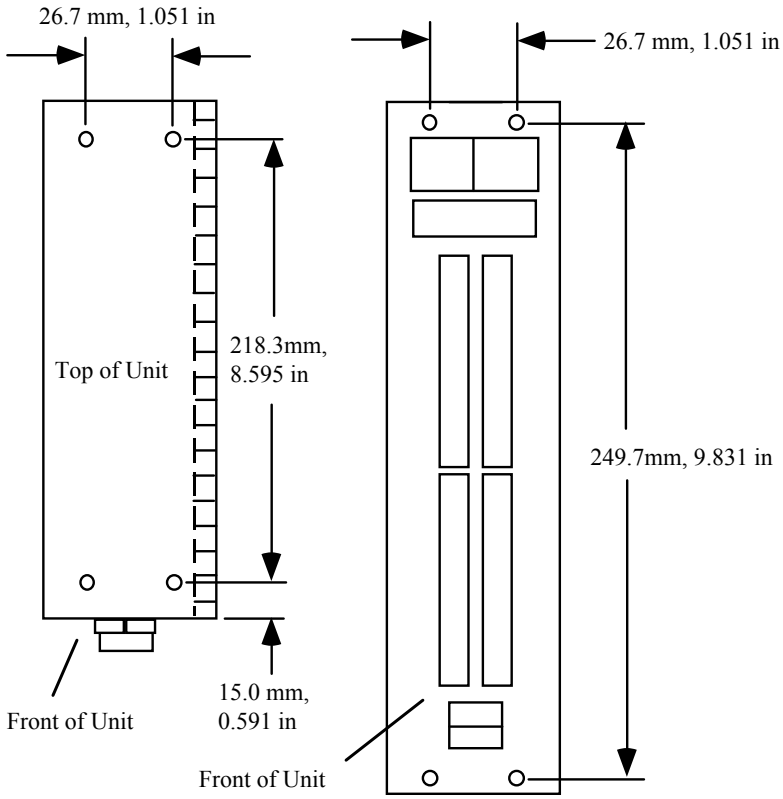
GraviDrive mounting, con't

In the event that horizontal mounting is needed, you must de-rate the power rating by 20%. It is recommended that cooling fans be used when horizontal mounting is used. Air must circulate over the cooling fins.

Note: In all cases, leave at least 1" or 25 mm of space around the drive to maintain adequate cooling.

GraviDrive hole patterns

The next drawing shows mounting holes on the GraviDrive itself. Mounting holes are drilled and tapped for 4 mm machine screws. Do not allow the screws to penetrate more than 1.5 mm (0.06") into the enclosure.



The front and rear of the GraviDrive exhibit the same hole patterns. The top and bottom hole pattern of the drive are the same but do not duplicate the front and rear hole patterns.

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Installation, Continued

DC power ratings

The power rating of the GraviDrive is 1.6 kW or 2 HP. Below is a table that specifies the maximum armature current for motors that are either 90 VDC or 180 VDC devices. If the 90 VDC motor you use exceeds the 8 Amp limit, use a 180 VDC motor instead and then the appropriate line voltage.

Motor Armature Voltage	Maximum Motor Armature Current	Nominal AC Line Voltage
90 VDC	8.9 Amps DC	115 VAC
180 VDC	8.9 Amps DC	230 VAC

AC Line ratings

Line power is single phase, 50/60 Hz. The GraviDrive has an auto-sense on the power line to correctly set the input voltage selection based upon applied voltage.

Nominal AC Line Voltage	Maximum AC Line Current
115 VAC	7.5 Amps {860 Watts, 80% eff.}
230 VAC	8.3 Amps {1920 Watts, 80% eff.}

External disconnect ratings

It may be convenient to add an external power disconnect to the mains for the GraviDrive. Here are the requirements for your circuit breaker or fuse to be used with this system.

Nominal AC Line Voltage	Recommended External Disconnect Device Rating	Delay
115 VAC	10 Amps	Motor Start
230 VAC	10 Amps	Motor Start

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Installation, Continued

Wire sizes

Wire sizes should follow a conservative 500 cir mil/amp rating for both AC line power and motor leads. This chart helps define wire sizes based upon that figure.

Note that 12 AWG wire is the largest that can be accommodated in the terminal strip used on the GraviDrive.

Wire Gage	Amp Rating	Cir Mils
12 AWG	13.0 Amps	6530
14 AWG	8.2 Amps	4110
16 AWG	5.1 Amps	2580

You can also calculate voltage drop in a power wire by the following formula.

Voltage drop = 22* Wire Length in Ft* Current in Amps/Cir.. Mils

The voltage drop should be less than 2 Volts in any installation.

ex: Current = 10 Amps, Wire length is 500 Ft, 10 AWG wire.

V Drop = 22*500*10/10400 = 10.57 V or significantly greater than 2 V. A larger wire size is needed.

So you have to figure the AC and motor current levels, and from that select the wire to be used. Stranded wire that meets 600 V, 80°C ratings is recommended.

A ground wire must always be attached and a 14 AWG wire is satisfactory.

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Installation, Continued

Figuring wire sizes to use

How do you go about it. Let's look an example.

ex: Armature current = 5.7 A, Motor Voltage = 90 VDC, Motor distance to GraviDrive = 50 Ft. AC Line to Drive = 10 ft.

What do we know? AC Line = 115 VAC. We can estimate AC current by multiplying the Armature current by 90/115 = 0.783*5.7 = 4.5 Amps AC.

Let's pick a wire gage and begin. Let's use 12 AWG wire with an area of 6530 cir mils.

We figure the motor voltage drop first.

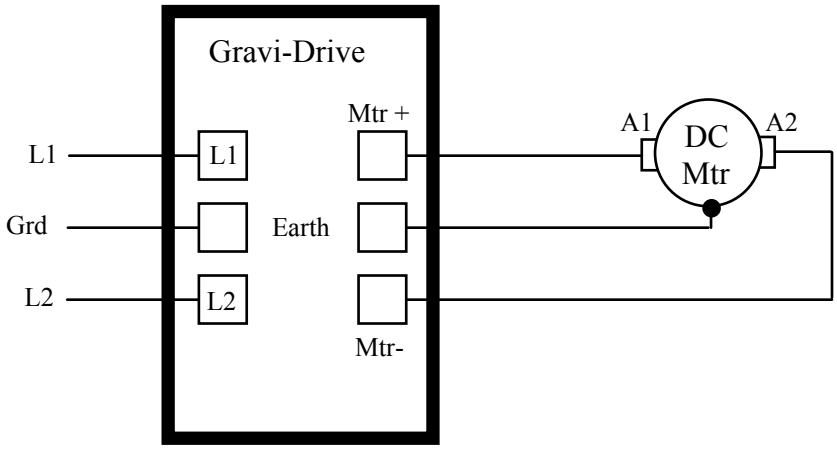
V Drop(Mtr) = 22*50*5.7/6530 = 0.96 Volts < 2 VDC. We are OK with this selection.

We can then select the AC line wiring. Let's use 12 AWG also.

V Drop(Line) = 22*10*4.5/6530 = 0.15 VAC. We are doing great!

Power connections to GraviDrive

This diagram shows basic power wiring for a DC PM motor. To change motor rotation swap leads A1 and A2.



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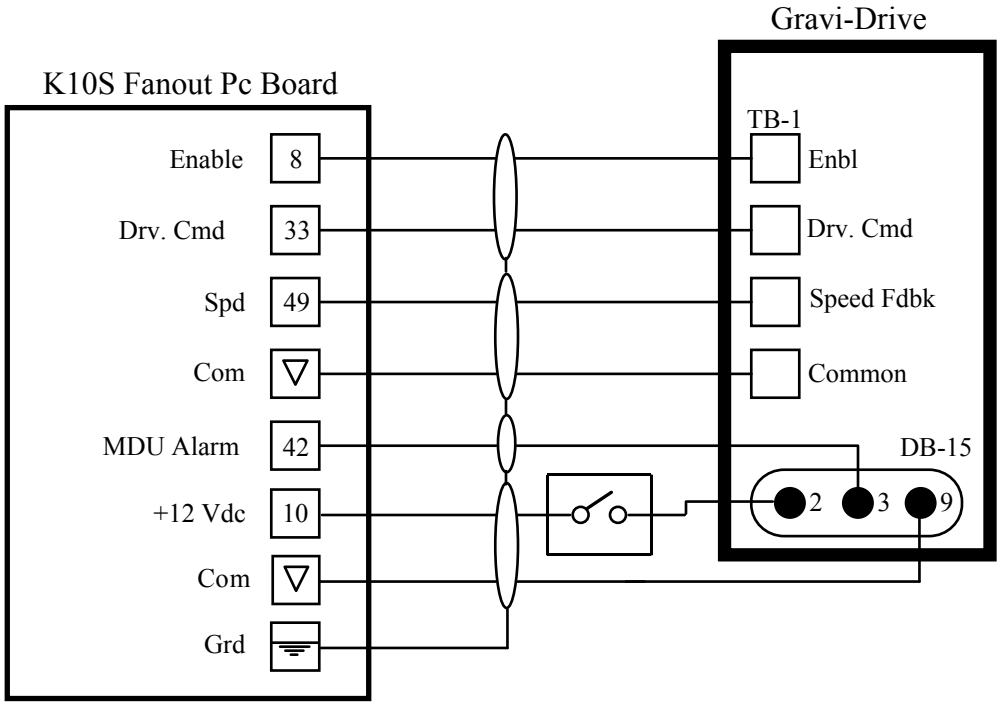
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Installation, Continued

Signal wiring to the GraviDrive from K10S controller fanout pc via TB-1

In addition to the power wiring to the motor and AC load center, you need to wire the signals to control the drive. A brief schematic is provided. For more information, see the wiring diagrams that came with your equipment.

Note: the cable length from fanout to GraviDrive is a maximum of 10 meters or 33 ft.



Use 22-24 AWG stranded copper, foil shielded wire with a separate drain lead for all signal wiring. Belden #9728 or equivalent is a good choice. Or you can select Belden #9729 and run two cables, one to TB-1, the other to the DB-15 connector. Be careful of your shielding and grounding.

Note: The optional switch shown in the diagram must be closed for the GraviDrive to run. This switch can be located away from the drive, say near the feeder as a safety interlock. The switch should interrupt the Safety Switch + line as shown, or both. Remember current has to flow in term #2 and out#9 for the GraviDrive to run.

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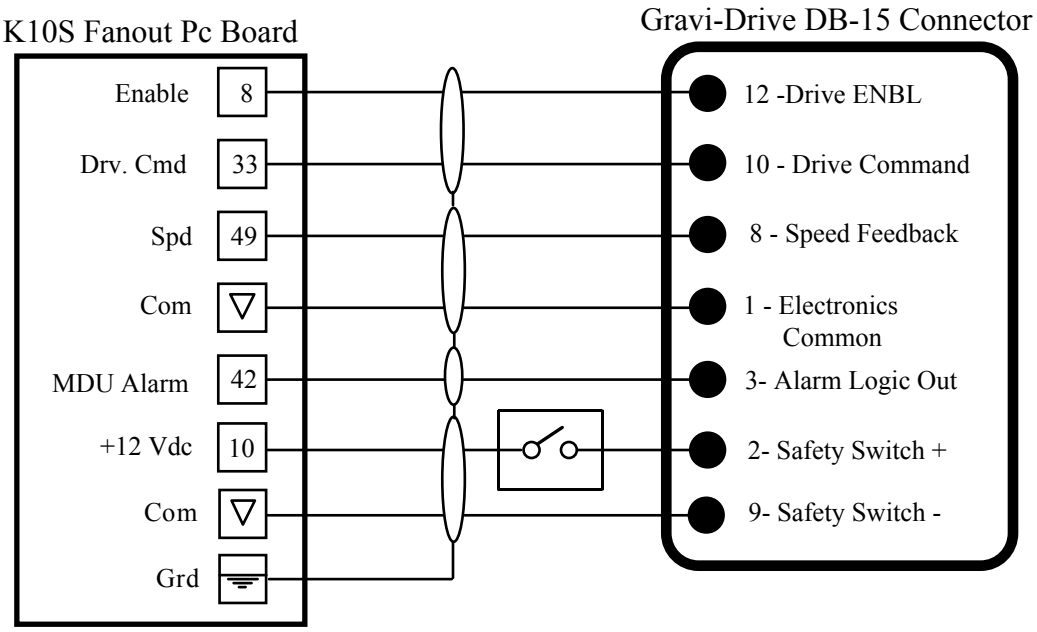
Installation, Continued

Signal wiring to the GraviDrive from the K10S controller fanout pc via the DB-15 connector

In addition to the power wiring to the motor and AC load center, you need to wire the signals to control the drive. A brief schematic is provided. For more information, see the wiring diagrams that came with your equipment.

Note: the cable length from fanout to GraviDrive is a maximum of 10 meters or 33 ft.

Note: This diagram is shown to permit you to locate the test points on the fanout pc board as the normal GraviDrive cable is DB-15 to DB-15 and the connection of this cable to the fanout pc is via that means.



Use 22-24 AWG stranded copper, foil shielded wire with a separate drain lead for all signal wiring. Belden #9728 or equivalent is a good choice. Be careful of your shielding and grounding.

Note: The optional switch shown in the diagram must be closed for the GraviDrive to run. This switch can be located away from the drive, say near the feeder as a safety interlock. The switch should interrupt the Safety Switch + line as shown, or both. Remember current has to flow in term #2 and out #9 for the GraviDrive to run.

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Installation, Continued

Terminal connection summary, TB2

The following is a summary list of all connections to the GraviDrive.

Terminal Name	Where	Function
L1	TB2-1	AC Line - Hot
L2/N	TB2-2	AC Neutral
Earth	TB2-3	Ground- Safety
MTR+	TB2-4	+ DC motor power
MTR-	TB2-5	- DC motor power
Earth	TB2-6	Ground- Safety
Trip A	TB2-7	One side of circuit breaker trip input
Trip B	TB2-8	Other side of circuit breaker trip input
Field +	TB2-16	DC field power to motor (+)
Field -	TB2-15	DC field power to motor (-)
Earth	TB2-14	Ground- Safety
OR1-A	TB2-13	Run relay - Common
OR1-B	TB2-12	Run relay - NO contact
Earth	TB2-11	Ground- Safety
OR2-A	TB2-10	Run relay - Common
OR2-B	TB2-9	Run relay - NO contact

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Installation, Continued

Terminal connection summary, TB1

The following is a summary list of all connections to the GraviDrive.

Terminal Name	Where	Function
+12 VDC Output *Note: I max ≤ 0.5 A*	TB1-1	+12 VDC isolated power from internal GraviDrive components.
Drv Cmd Input	TB1-2	Drive command frequency from K10S controller-setpoint input to GraviDrive.
ENBL Input	TB1-3	Enable signal to GraviDrive.
Jog Input	TB1-4	Jog input to permit pulsing the motor without Drive Command or ENBL signal.
Run Output	TB1-5	A logic output indicating the motor is running.
Earth	TB1-6	Ground- Safety.
+5 VDC *Note: I max = ≤ 0.5 A*	TB1-12	+5 VDC isolated power from internal GraviDrive components. Same common reference as +12 VDC output.
Speed Fdbk Input	TB1-11	Speed feedback frequency signal from either pick-up or K10S controller.
Common	TB1-10	Common reference for +12 and + 5 VDC outputs and digital logic I-O.

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Installation, Continued

Terminal connection summary, TB1, con't

The following is a summary list of all connections to the GraviDrive.

Terminal Name	Where	Function
Rel NO	TB1-9	NO alarm relay contact
Rel Com	TB1-8	Common alarm relay contact
Rel NC	TB1-7	NC alarm relay contact

Continued on next page

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Installation, Continued

Terminal connection summary, controller interface, DB-15

Pin Number	Terminal Function
1	Electronics common
2	Safety switch input contact #1
3	Alarm logic output
4	Unused
5	Internal Channel RS485 Rx- (referenced to master)
6	Internal Channel RS485 Rx+ (referenced to master)
7	Internal Channel RS485 Tx+ (referenced to master)
8	Speed feedback frequency input
9	Safety Switch input contact #2
10	Drive command frequency
11	Unused
12	Drive enable input
13	Common for isolated power for I-O functions
14	Internal Channel RS485 Tx- (referenced to master)
15	+12 VDC isolated power from internal GraviDrive components. I max ≤ 0.5 A

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DIP Switch Programming

Introduction

This section outlines the programming that occurs with the GraviDrive controller via the DIP switch SW-1. It is necessary to check this switch for correct programming or the GraviDrive will not work with your system.

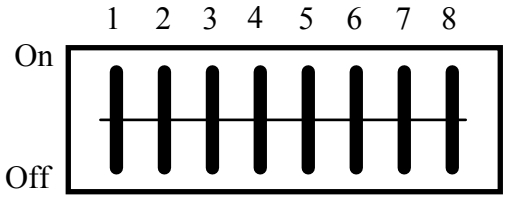
Note: Be sure the GraviDrive is powered **off** prior to setting the DIP switch to be sure that the new switch codes are read correctly on power-up.

SW#1 DIP switch programming conventions

The following chart is for a unit that does not use the serial interface to control the GraviDrive. All input signals come to the terminal blocks.

Convention: On = Closed = 1,
Off = Open = 0

Here is a graphic of the DIP switch showing the 8 individual switches. Pushing down where the numbers are places that switch in the On position. Pushing the switch down opposite the number turns it to Off.



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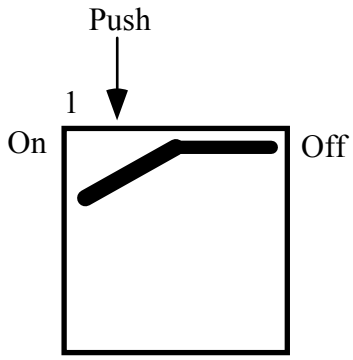
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DIP Switch Programming, Continued

SW#1 **DIP switch programming conventions, con't**

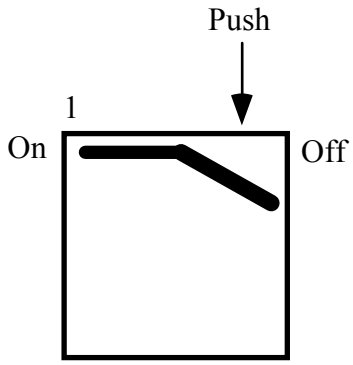
The following is convention for this switch. Looking at the switch from the end view we see: Position #1 is On or Closed or "1".

Switch Position - ON-CLOSED-"1"



The next graphic shows the switch position #1, Open or Off or "0"

Switch Position - OFF-OPEN - "0"



Toggles may replace the push lever on some DIP switches. Push the toggle to either on or off position as required.

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DIP Switch Programming, Continued

Standard mode SW#1 programming

Position 1 should be open
This table is configured for the standard mode of the GraviDrive. This means that the K10S controller signals that tell the GraviDrive what to do are presented to the GraviDrive terminal connections and normally come via the 15-pin cable from the K10S Fanout pc board.

Note: Position 1 is always open for Standard Mode using the control signals from the K10S Fanout pc board. Position 1 must always be open for operation.

Special case to have position 1 closed
It is possible to send and receive data on the Controller Interface in 8-bit format at 9600 baud using a PC while the GraviDrive is running in this way. This is normally done in the factory to configure the GraviDrive.

Pulses per rev setting of SW#1 in standard mode

Switch positions 2,3 and 4 set the desired count for the feedback in pulses per revolution of the motor shaft. This is only important when "Standard Mode" is selected. See chart labeled " Speed Pick-Up Gears- Pulses per Rev" in the section titled Speed Pick-Up Sensor.

Pulses per Rev.	Pos. 2	Pos. 3	Pos. 4
60	0	0	0
90	1	0	0
100	0	1	0
120	1	1	0
240	0	0	1
260	1	0	1
Invalid	0	1	1
Invalid	1	1	1

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DIP Switch Programming, Continued

Special note on power up

A special code is displayed on the LED display on power up of the GraviDrive unit. If the code U4 and lower is displayed then Dip Switch 1 positions 5 thru 8 set the current limits for the GraviDrive. If the code U5 and above and UU2.0 and above is displayed on power up the DIP Switch 1 positions 5 thru 8 set the power limit (watts) for the GraviDrive

There is also a special feature of version UU2.1 and later. By opening the case, a voltage select switch will permit changing AC voltage input levels to suit need. Choose either 115 or 230 vac. Mark the front panel with the selected voltage to minimize possible internal damage.

Max Current setting for revision U4

Switch positions 5, 6, 7, and 8 are set from the motor nameplate rated current in Amps. Select the next higher current value that will insure that the motor will achieve maximum power. This set-up is only used in "Standard Mode". ex: If Motor Nameplate = 2.7 Amps, pick 3.0 Amps for entry.

Nameplate Current - Amps	Pos. 5	Pos. 6	Pos. 7	Pos. 8
0.5 Amps	0	0	0	0
1.0 Amps	1	0	0	0
1.5 Amps	0	1	0	0
2.0 Amps	1	1	0	0
2.5 Amps	0	0	1	0
3.0 Amps	1	0	1	0
3.5 Amps	0	1	1	0
4.0 Amps	1	1	1	0
4.5 Amps	0	0	0	1
5.0 Amps	1	0	0	1
6.0 Amps	0	1	0	1
7.0 Amps	1	1	0	1
8.0 Amps	0	0	1	1
9.0 Amps	1	0	1	1
10.0 Amps	0	1	1	1
11.0 Amps	1	1	1	1

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Dip Switch Programming, Continued

HP to watts conversion table

To convert HP rating from motor nameplate into watts, use this table

HP	Watts
1/8	100
1/4	200
1/2	400
3/4	600
1	800
1 1/2	1200
2	1600

Maximum power setting Code "U5" and higher plus "UU" codes

Switch positions 5, 6, 7, and 8 are set from the motor nameplate rated hp or kw rating. This set-up is only used in "Standard Mode". Check start-up code for U5 or greater before using this chart.

GraviDrive Line Voltage @ 115VAC

Watts	Pos. 5	Pos. 6	Pos. 7	Pos. 8
50	0	0	0	0
100	1	0	0	0
150	0	1	0	0
200	1	1	0	0
250	0	0	1	0
300	1	0	1	0
350	0	1	1	0
400	1	1	1	0
450	0	0	0	1
500	1	0	0	1
550	0	1	0	1
600	1	1	0	1
650	0	0	1	1
700	1	0	1	1
750	0	1	1	1
800	1	1	1	1

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DIP Switch Programming, Continued

Maximum power setting Code "U5" and higher plus "UU" codes

Switch positions 5, 6, 7, and 8 are set from the motor nameplate rated hp or kw rating. This set-up is only used in "Standard Mode". Check start-up code for U5 or greater before using this chart.



GraviDrive Line Voltage @ 230VAC

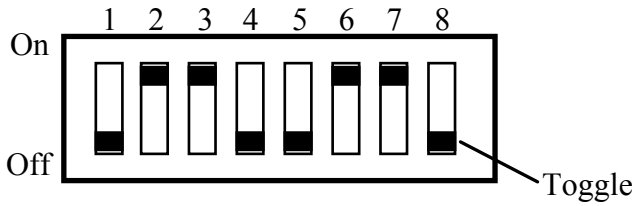
Watts	Pos. 5	Pos. 6	Pos. 7	Pos. 8
100	0	0	0	0
200	1	0	0	0
300	0	1	0	0
400	1	1	0	0
500	0	0	1	0
600	1	0	1	0
700	0	1	1	0
800	1	1	1	0
900	0	0	0	1
1000	1	0	0	1
1100	0	1	0	1
1200	1	1	0	1
1300	0	0	1	1
1400	1	0	1	1
1500	0	1	1	1
1600	1	1	1	1

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DIP Switch Programming, Continued

DIP switch programming example



Refer to the prior pages for the code, but it is indicated here.

Note: This is only an example only for this specified configuration. It is met only to show how the DIP switch might appear for that configuration.

Position	On/Off	Code
1	Off or "0"	Standard Mode for connections
2	On or "1"	Positions 2-4 set gear teeth count at 120
3	On or "1"	Positions 2-4 set gear teeth count at 120
4	Off or "0"	Positions 2-4 set gear teeth count at 120
5	Off or "0"	Positions 5-8 set for 3.5 amps or 350 watts @115vac or 700 watts @ 230vac
6	On or "1"	Positions 5-8 set for 3.5 amps or 350 watts @115vac or 700 watts @ 230vac
7	On or "1"	Positions 5-8 set for 3.5 amps or 350 watts @115vac or 700 watts @ 230vac
8	Off or "0"	Positions 5-8 set for 3.5 amps or 350 watts @115vac or 700 watts @ 230vac

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Using the LED's located on the GraviDrive

Introduction

This section details the simple operation of the GraviDrive unit and explains how to decode the indicators D1 and D2.

Power switch

The switch on the lower portion of the GraviDrive unit is a power switch and circuit protection all in one. Pressing on the "1" or upper portion of the rocker switch will turn the GraviDrive unit on. Pressing on the lower portion of the switch or "0", turns the unit off.

Start-up operation

To start the system, be sure that all wiring is secure. Power the control system then the GraviDrive or power them together. The control system with an entered setpoint will do the rest. Please refer to your operating instructions for your controller.

If the drive does not run the motor, check for drive command and the enable signals. Verify that no interlocks are active.

Continued on next page

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Using the LED's located on the GraviDrive, Continued

Decoding led D1

Indicator D1 has two 7 segment displays - 2 digits- that are useful in determining correct operation. The left most digit indicates the amount of Drive Command coming from the K10S controller. It can also signal an alarm condition in the GraviDrive when an "E" is showing.

Left Digit Display	Meaning
--	Motor is off
1	Drive command = 0-10%
2	Drive command = 10-20%
3	Drive command = 20-30%
4	Drive command = 30-40%
5	Drive command = 40-50%
6	Drive command = 50-60%
7	Drive command = 60-70%
8	Drive command = 70-80%
9	Drive command = 80-90%
A	Drive command = 90-100%
b	Drive command = 100-110%
C	Drive command = 110-120%
d	Drive command = >120%
E	Alarm Condition , See Right-hand digit

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Using the LED's located on the GraviDrive, Continued

Decoding led D1, con't

The right hand digit shows the amount of current being drawn by the motor. It also can show certain alarm conditions.

This chart shows motor current or motor power as a percentage of the DIP switch value as entered in the Programming section. This chart is only valid if the left hand digit is not an "E".

Right Digit Display	Meaning
--	Motor is off
1	Motor current = 0-10% or Power = 10%
2	Motor current = 10-20% or Power=20%
3	Motor current = 20-30% or Power=30%
4	Motor current = 30-40% or Power=40%
5	Motor current = 40-50% or Power=50%
6	Motor current = 50-60% or Power=60%
7	Motor current = 60-70% or Power=70%
8	Motor current = 70-80% or Power=80%
9	Motor current = 80-90% or Power=90%
A	Motor current = 90-100% or Power=100%
b	Motor current = 100-110% or Power=110%
C	Motor current = 110-120% or Power=120%
d	Motor current = >120% or Power >120%

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Using the LED's located on the GraviDrive, Continued

Alarm messages from led D1

This section outlines the alarms that the controller will display when the left digit of D1 is an "E".

D1-Left	D1-Right	Meaning
E	1	EEPROM failure inside the GraviDrive. This alarm is caused on power-up if there is a failure of the EEPROM checksum. To correct, see the troubleshooting section that follows.
E	2	Motor is running but is not supposed to be running. This alarm self clears when the condition is corrected.
E	3	It can indicate a speed pick-up failure. A general motor failure is also likely as a shorted output. This alarm self clears when the problem goes away within 5 seconds. If the condition persists for more than 5 seconds the GraviDrive will stop. To clear the fault, execute a stop and then re-start the feeder via the controller interface.
E	4	Safety Switch Active when drive is trying to run. The motor will stop when this condition exists. To clear the fault, execute a stop and then re-start the feeder via the controller interface.
E	5	Speed ≠ setpoint. This alarm will stop the drive. To clear the fault, execute a stop and then re-start the feeder via the controller interface.

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Using the LED's located on the GraviDrive, Continued

Alarm messages from led D1, con't

D1-Left	D1-Right	Meaning
E	6	Safety Switch is now clear after an E4 message. To clear the fault, execute a stop and then re-start the feeder via the controller interface.
E	7	Invalid DIP switch setting
E	8	The maximum current or power limit has been exceeded. This limit is to protect both the GraviDrive and the motor
E	A	A +/-5% speed deviation will cause this alarm to be displayed. The alarm is self-clearing. This will not shut down the drive. Check speed pickup adjustment.

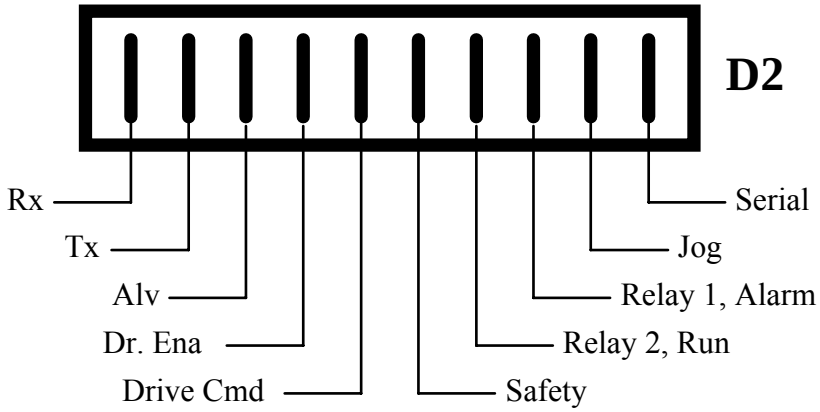
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Using the LED's located on the GraviDrive, Continued

Decoding of led D2

Indicator D2 helps to define if all signals necessary to run the GraviDrive are present. Here is the indicator shown with the description of each light segment.



Indicator	Function
Rx led	Shows data coming from the Controller Interface data channel to the GraviDrive or host PC if monitoring. *Not yet implemented. This is controlled by DIP switch position #1. This led must be off.*
Tx led	Shows data transmitted from the GraviDrive to the Controller Interface data channel or host PC if monitoring. *Not yet implemented. This is controlled by DIP switch position #1. This led must be off.*
Alv led**	Alive led must be blinking. Shows that the basic control is functioning.
Drv. Enbl led**	The Drive Enable signal must be present to permit the drive to run. This signal comes from an external source., normally the K10S controller via the fanout pc board, term #8. Led is on for enable.

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Using the LED's located on the GraviDrive, Continued

Decoding of led D2, con't

Indicator	Function
Drv Cmd led**	This led, when on, shows that a drive command or operating setpoint signal is present at the GraviDrive unit.
Safety led**	If illuminated, the safety switch is activated or closed and the motor is permitted to run.
Relay 2 - Run - led	When on, the motor is being supplied power from the power driver stage.
Relay 1 -Alarm - led	When on, an alarm has been detected or remote relay function is active.
Jog led	Led is on, when the Jog function is used.
Serial led	If illuminated, SW#1, position #1 is On and 9 bit serial data must be present at leds Rx, and Tx from the K10S Internal Data Channel. If Off and the Controller Interface is used, 8 bit ASCII data is being used from a PC. Acts as a monitor only. *Not yet implemented.*

Note: Leds marked as **, must be on or blinking for the GraviDrive to run.

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I/O Connections

I-O Logic Functions

Introduction

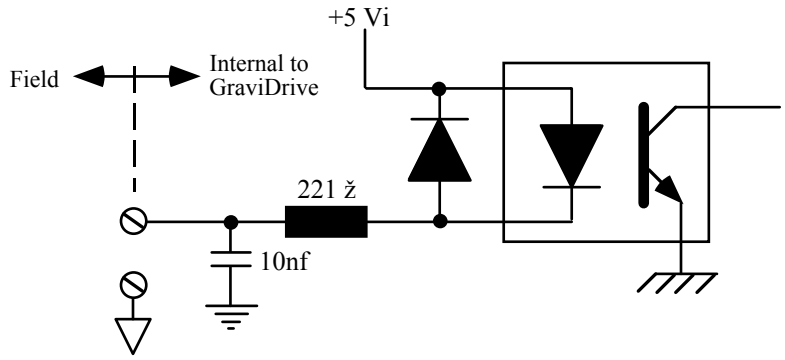
This section shows the I-O of the GraviDrive and how to connect to it for proper operation. The symbol is for your connections. The circuitry shown is inside the GraviDrive and is provided to help make the I-O connection easier to understand.

All opto-isolated inputs and outputs have 5k volts isolation between field connections and the internal components of the GraviDrive.

Digital inputs; drv. cmd & speed fdbk

The diagram of the following input is for the following inputs. These signals typically come from the K10S controller via the Fanout pc board.

Signal Name	Type	Range	Connection
Drive Command Input	Frequency	0-10kHz, 5 VDC Sq. wave, 16 ma sink.	TB1, Trm 2
Speed Feedback Input	Frequency	0 < 10 kHz, 5 VDC Sq. wave, 16 ma sink	TB1, Trm 11



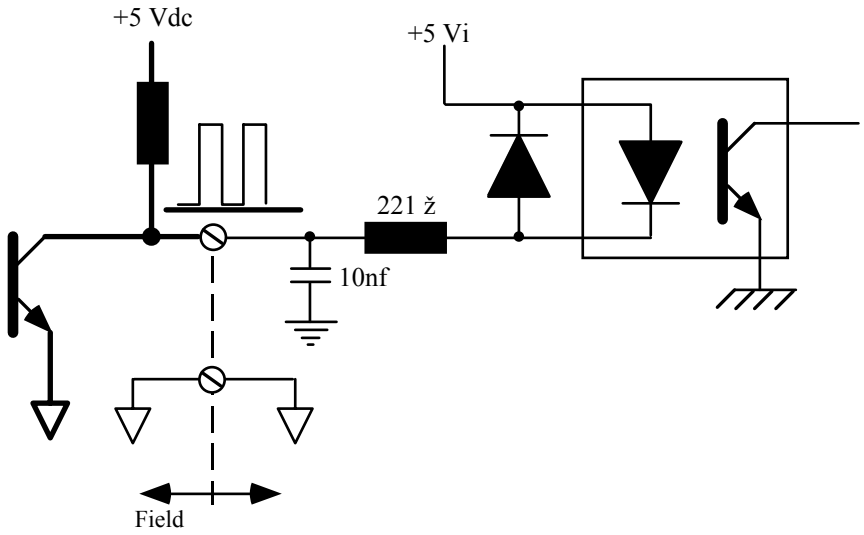
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I-O Logic Functions, Continued

Digital inputs; drv. cmd & fdbk, con't

In the next drawing, the frequency signal comes from the K10S controller
Note: Bold connections are in the K10S system.



The frequency signal amplitude is about 5 VDC, a square wave with about a 50% duty cycle. Frequencies range from 0 to 12.5 kHz.

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I-O Logic Functions, Continued

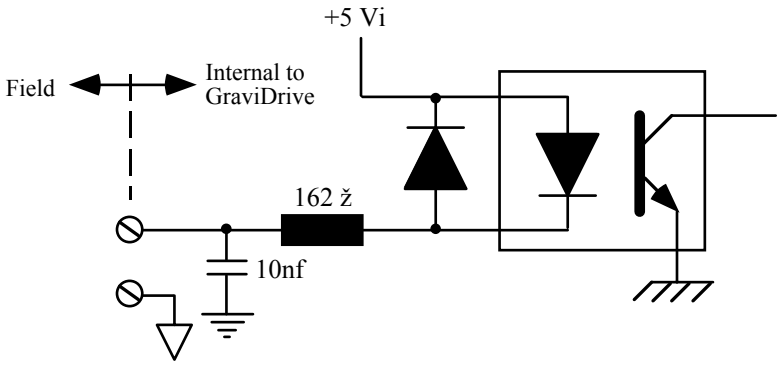
Digital inputs; drv enbl, & jog

The Drive Enable signal normally comes from the K10S controller via the Fanout pc board. The Jog signal is normally activated by a push-button, one side to the terminal #4, the other side to circuit common.

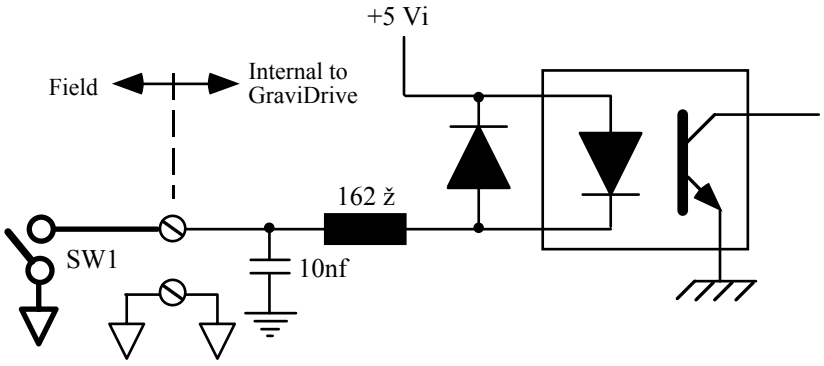
Note: The motor runs at about 1500 rpm when the Jog input is asserted.

Activation Level: Sink to Common: 5 VDC max input, 18 ma sink

Signal Name	Type	Range	Connection
Drive Enable Input	Level; 0 = enable drive 1 = Off	On ≤0.5 VDC Off ≥ 4.3 VDC	TB1, Trm 3
Jog Input	Level; 0 = jog 1 = Off	On ≤0.5 VDC Off ≥ 4.3 VDC	TB1, Trm 4



In the next drawing, the switch SW1, when closed, enables the jog function.
Note: Bold connections are by the user.



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I-O Logic Functions, Continued

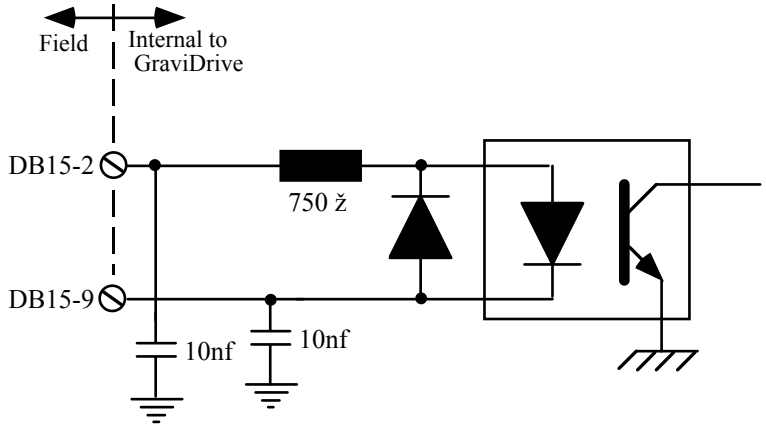
Digital inputs; safety

The diagram below is for the following inputs. Safety is a special condition. To make it failsafe, the user needs to supply enough voltage to the + Safety Input so that when the - Safety Input is taken to circuit common, enough current flows to trip the opto-isolator

Note: The Safety Inputs must be used to permit the GraviDrive to run.

Activation Level: Sink to Common. 14.3 ma at Vin of 12 VDC

Signal Name	Type	Range	Connection
+ Safety Input	Level; 1 = activation 0 = Off	On = current flow of ≥ 10 ma. Off = current flow of ≤ 0.5 ma	DB-15, Pin 2
- Safety Input	Level; 0 = activation 1 = Off	Same as above	DB-15, Pin 9



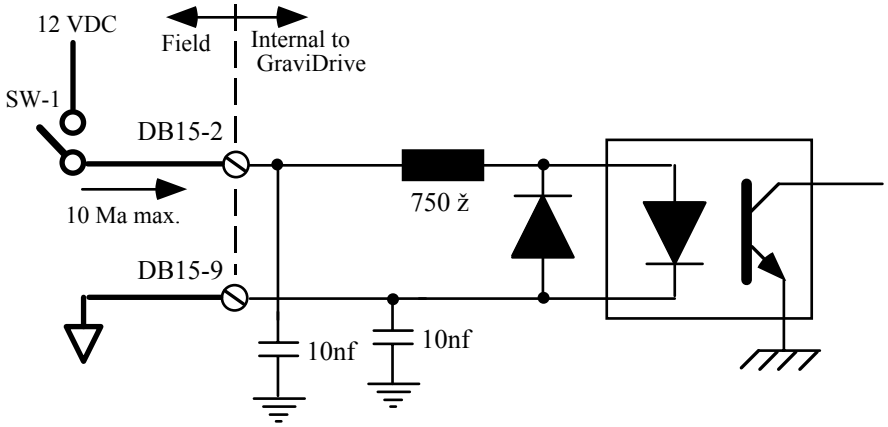
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I-O Logic Functions, Continued

Digital inputs; safety, con't

In the next drawing, the switch SW1, when closed, enables the safety function. Note that 10 ma minimum must flow to enable the safety input. Note: Bold connections are by the user.



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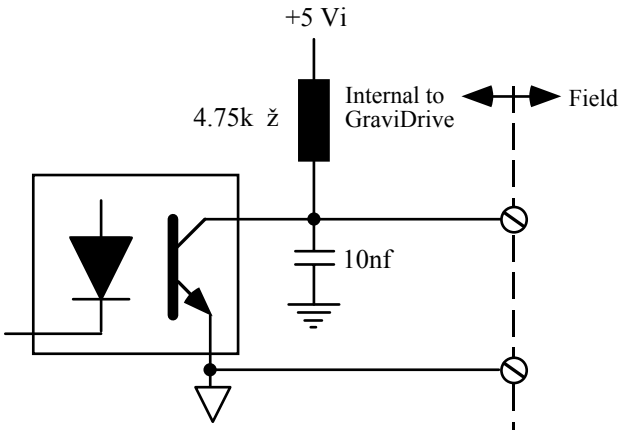
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I-O Logic Functions, Continued

Digital outputs, mtr run, alarm

This block identifies the digital outputs, the internal circuits in the GraviDrive and limitations. Output current limit is 10 ma. dc.

Signal Name	Type	Range	Connection
Mtr. Running Output	Level; 0 = Motor Run 1 = Motor Off	On = ≤ 0.5 VDC Off = ≥ 4.75 VDC	TB1, Trm 5
GraviDrive Alarm Output	Level; 0 = Alarm 1 = No Alarm	Same as above	DB15, Pin 3



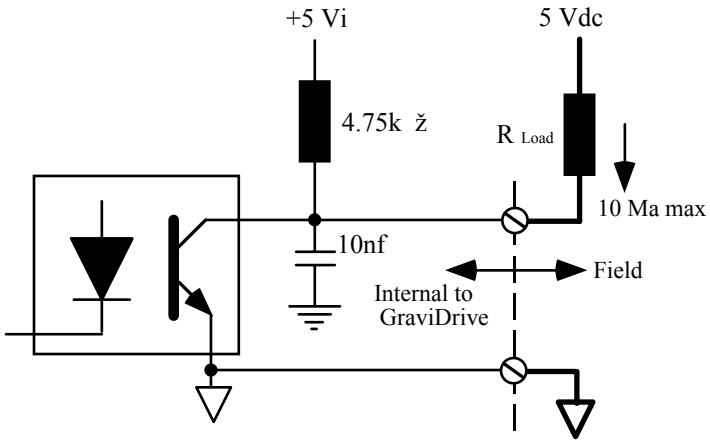
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I-O Logic Functions, Continued

Digital outputs, mtr run, alarm, con't

In the next drawing, for either output, when the output is active, current flows through the load RLoad. Note the maximum current allowed. Note: Bold connections are by the user.



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I-O Power Functions

Introduction

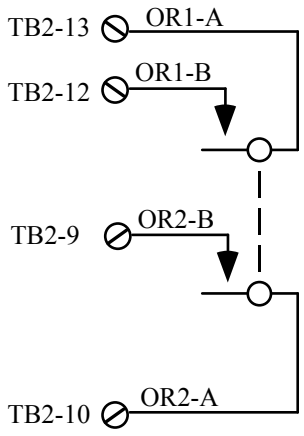
This section outlines the connections and functions of relay or power I-O that is used in the GraviDrive.

Drive running relay output

This output is a relay that indicates that the GraviDrive is to be running. May not indicate that the motor is running.

Power Output Name	Type	Contact Limits	Connection
Drive Running Relay Output	DPDT Relay	250 VAC, 28 VDC, 5A either AC or DC, Isolation ≥ 5 Kv contact to coil or > 2 Kv contact to contact.	TB2, Trm 9 TB2, Trm 10 TB2, Trm 12 TB2, Trm 13

The relay is shown here in the Non Running state. It can be used to operate an agitator control system through appropriate contactors. It can also be used to provide switched field power to the connected motor.



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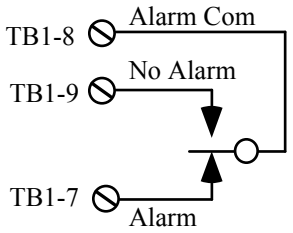
I-O Power Functions, Continued

Alarm relay output

This output is a relay that indicates that the GraviDrive is in alarm.

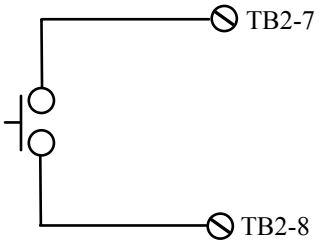
Power Output Name	Type	Contact Limits	Connection
Alarm Relay Output	SPDT Relay	250 VAC, 28 VDC, 5A either AC or DC, Isolation ≥ 5 kV contact to coil.	TB1, Trm 7 TB1, Trm 8 TB1,Trm 9

The relay is shown here in the "alarm" or de-energized state.



Trip input

The following connections permit remote tripping of the GraviDrive circuit breaker. Pushing the external button will trip the breaker and shutdown power to the GraviDrive.



Note: This input can also be used to trip the GraviDrive when a motor overheats if this input is connected to the motor thermostat.

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Speed Feedback System

Speed Pick-Up Sensor

Introduction

The speed feedback measuring device is an important feature of the motor speed control system. If the motor system does not function in a linear and repeatable manner, the gravimetric control of the equipment will not be satisfactory.

Speed pickup - how it works

The speed sensor is a small magnetic device which senses the passage of ferrous gear teeth on a 60 pitch gear. Depending upon equipment type the number of teeth per revolution of the wheel will be 90, 120, 240 or 260 teeth. We can easily calculate the RPM of the gear wheel by measuring the frequency from the speed pick-up as

RPM = { Frequency * 60 } / Gear Teeth

An example of this is: You are at the feeder and you want to know the drive motor RPM. Taking a frequency counter at the scale interface Pc board you measure a frequency of 2,464 Hz and you know the speed pick-up wheel has 240 teeth. You calculate the motor speed as:

RPM = 2464*60/240 = 616 RPM at the motor.

Gear teeth per rev.

Feeder Type	Teeth
T20/T22/T35/T37 and S200	120
S500/T65/T90	240
W1000 Belt Feeder and pump systems	240
W300/W600 Belt Feeders. As of mid 1998, all new designs are 120t. This gear is 4.1mm (0.164“) thick versus the 2.6mm (0.104“) for the older design 260t gear. The thicker 120t gear is required for the metal encased speed sensor.	260 or 120
Modular Feeders (Small)	90
Modular Feeders (Large)	120
K2 Feeders	120
KCLT20/KQX feeders (using Bison motors)	100
K2T20 using Nema C frame motors	120

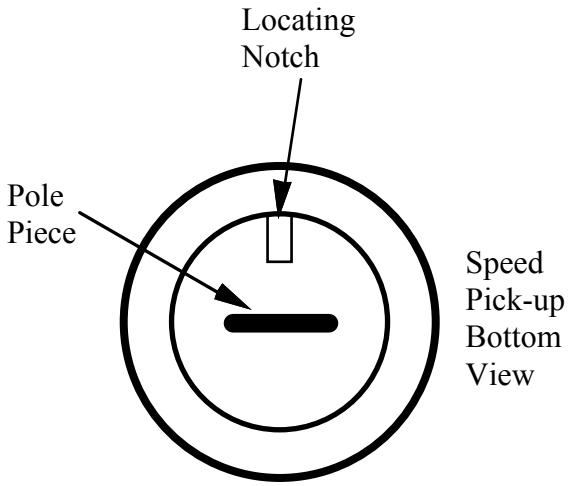
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Speed Pick-Up Sensor, Continued

Speed pickup mounting

It is important to carefully mount the pick-up correctly near the motor shaft. Orientation of the pole piece on the pick-up to the gear tooth is critical. A notch in the side of the pick-up along with a special tanged washer insures correct alignment. The alignment must be as indicated in the graphic. The orientation notch must be visually in-line with the speed pick-up pulley and the pole piece must be parallel to the gear tooth face. *Contacting the pick-up gear when it is in motion with the face of the pick-up will likely cause permanent damage to the pick-up.*



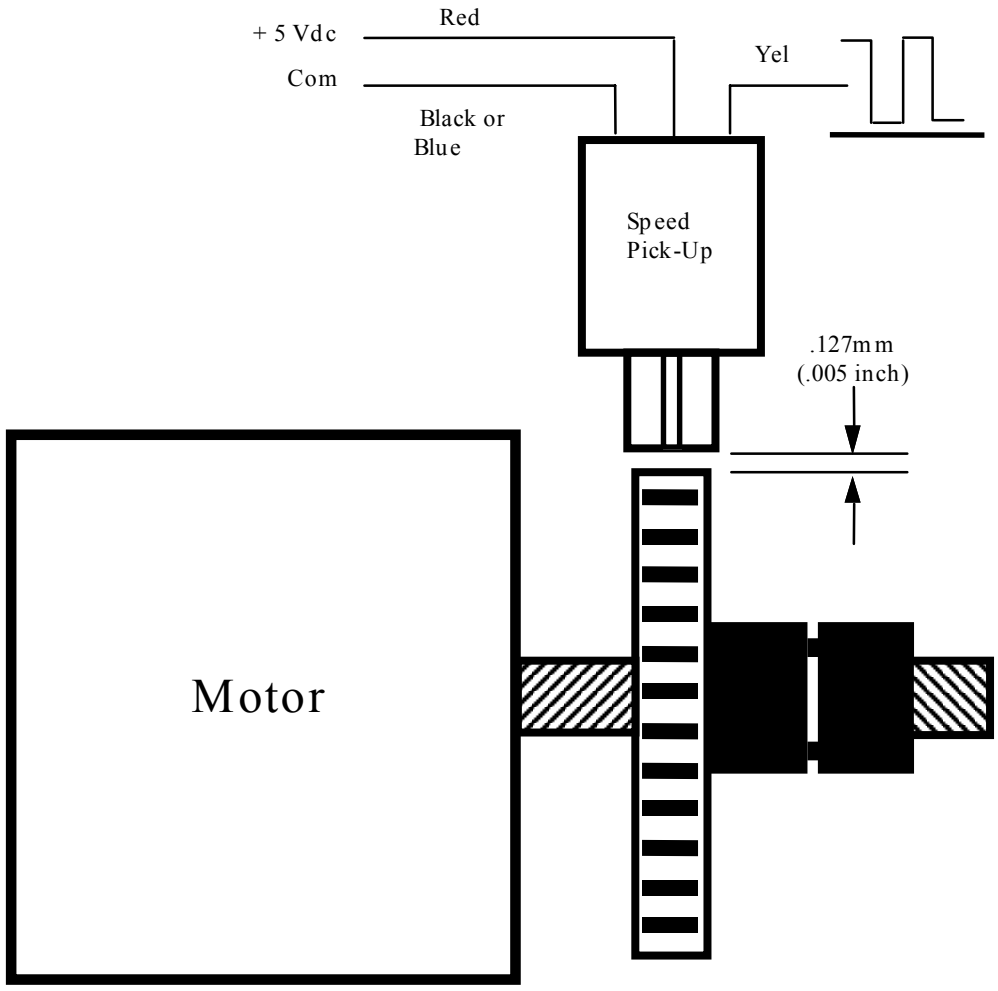
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Speed Pick-Up Sensor, Continued

Speed pickup spacing

Spacing of the gear and pick-up is also critical for accurate results. A distance of 0.127 mm (0.005 inches) will guarantee results. Also, the pick-up must be in vertical alignment with the gear as well. Also check to see that the gear is securely mounted to the motor shaft.



Note: Two types of pick-ups are used. They function the same. The common return wire may either be black or blue. Color coding for the optical sensor on the Bison motor drives is not shown as no adjustment is required.

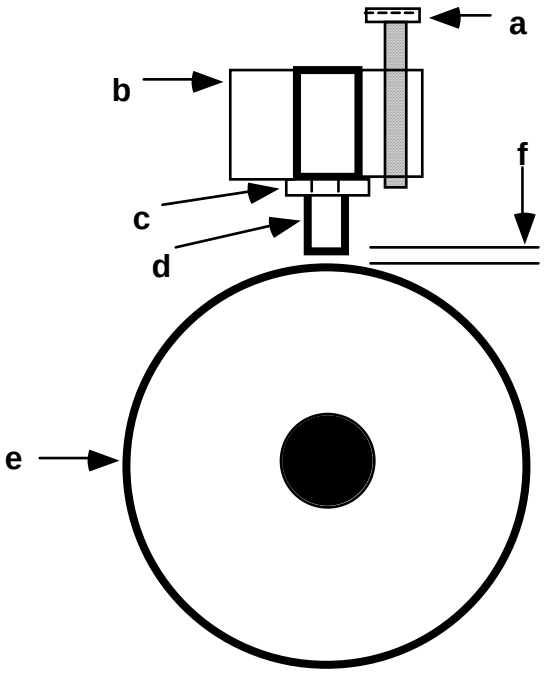
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Speed Pick-Up Sensor, Continued

Speed pickup adjustment

For K-Modular and Standard Screw feeders. The K2 feeder line does not have an adjustment screw. If you have a K2 feeder, refer to manual sections 4506 or 4512 for replacement of the speed sensor.



Part	Description
a	Pickup adjustment screw. Clockwise adjustment will move pickup **away** from gear. Counter clockwise adjustment will move pickup **closer** to gear.
b	Pickup bracket
c	Pickup retaining nut. Holds pickup in bracket
d	Speed Pickup
e	Pickup gear
f	Clearance. Set at 0.127 mm or .005 inches

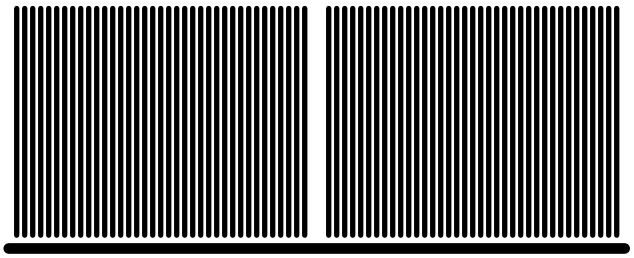
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Speed Pick-Up Sensor, Continued

Speed pickup adjustment with scope

When setting the pick-up adjustment, there must be a continuation of pulses from the gear with no misses. This situation can be verified by the scope at a slow sweep speed. Looking for missing pulses is required in the adjustment. Also notice that the screw for adjustment turns ccw for a closer adjustment and cw for more clearance. Missing pulses will cause unstable motor speed.



Note: Contact with the rotating pick-up gear may cause permanent expensive damage to the speed pick-up.

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Speed Pick-Up Sensor, Continued

Speed pickup adjustment procedure

The following procedure should be followed to ensure proper adjustment of the speed pickup. Please refer to specific feeder mechanical sections for location of speed pickup assembly.

Step	Action
1	With power removed from motor drive unit. and open the access cover to the speed pickup assembly.
2	Using a 0.005" or 0.127 mm feeler gauge (non-magnetic) inserted between face of pickup and gear, turn the adjusting screw counter-clockwise until the pickup just touches the feeler gauge. Remove gauge. Rotate the gear by hand to ensure uniform clearance for a complete revolution.
3	For some feeders like the older T20, T35 and S200 feeders it is almost impossible to insert a feeler gauge in the limited space available. For these style feeders go to Step 5.
4	All feeders should then be checked using an oscilloscope.
5	Connect an oscilloscope to the proper terminals of the scale interface board at the feeder. Or use the outputs of the speed pick-up directly.
6	Apply power to the motor drive unit.
7	With feeder running in volumetric mode, turn the pickup adjustment screw counter -clockwise while observing the wave form on the scope. The wave form should be an approximate 60/40 duty cycle with no missing pulses. The proper waveform is shown below. See section prior. 

If you have Interface Board	Connect scope to
9191-00128	TB-1: 3 or 4(+) and 2 (-)
9191-30301	18 or 19 (+) and 21(-)
9191-70053	TB-1: 7 or 8 (+) and 2 (-)
9191-601650	LK-4 : (+) to 47 or 48, (-) to 42

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Technical Data

Specifications

Introduction

This section outlines environmental limitations and provides a block diagram of the GraviDrive for aid in understanding operation.

Environmental limits

The following are environmental limits for the GraviDrive.

Specifications	Limits
Operating temperature	0°C minimum, +50°C maximum 32°F min , 122°F max
Storage temperature	-25°C minimum, +70°C maximum -13°F min, 158°F max
Altitude Deratings	Max power to 1000 meters, above 1000 m, derate by 0.5% per 100 meters. Max power to 3300 ft, above 3300 ft, derate by 0.5% per 330 feet.
Humidity limits	The relative humidity cannot exceed 95%, non-condensing @ 35°C.
Isolation Class	VDE 0113 Class B. All opto-isolators will meet VDE 0109, Class III.
Electro-magnetic compatibility	Meets K-Tron specification 06.15-0034. The device is intended for panel mounting.
Enclosure rating	Meets Nema 1 or IP-30 standards. Must be mounted in an appropriate enclosure for the environment in question.

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Specifications, Continued

Environmental limits, con't

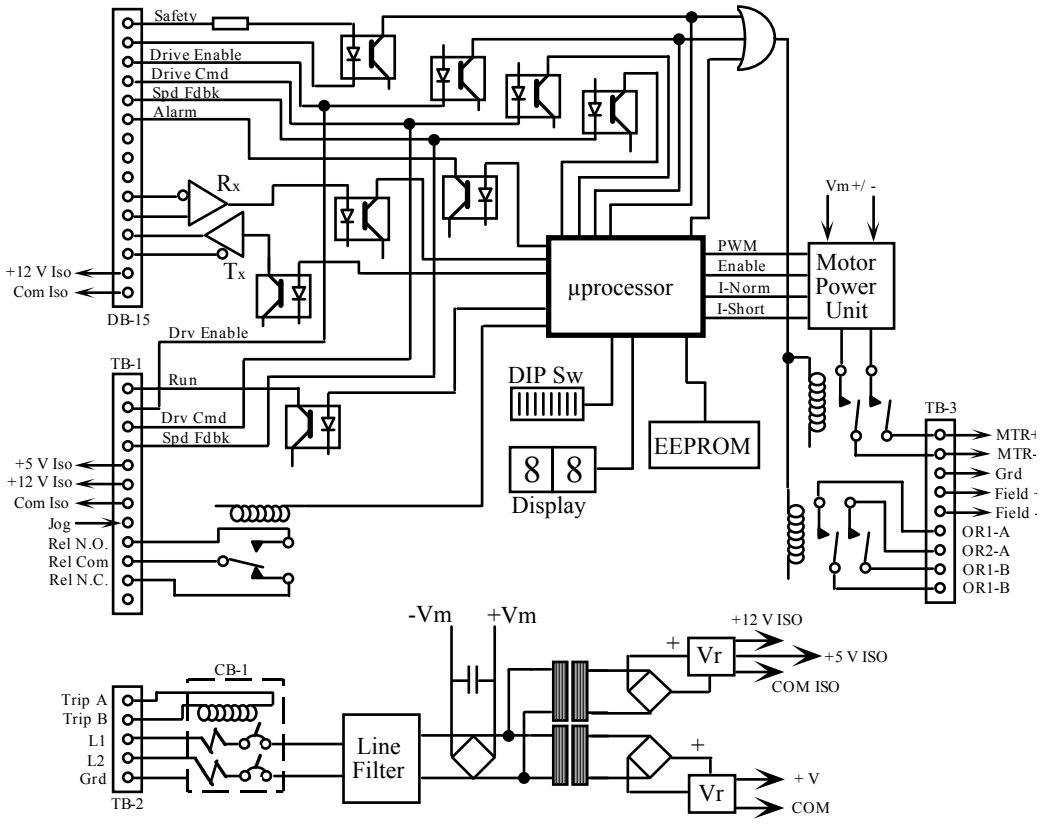
Specifications	Limits
Line Voltage Limits	115 VAC nominal: Max: 127 VAC, Min: 104 VAC, 45-66 Hz 230 VAC nominal: Max: 264 VAC, Min: 207 VAC, 45-66 Hz
Power rating	Input AC power: 2000 W max. DC output power: 1600 W max. Derate by 20% if the GraviDrive is mounted horizontal.
Field current ratings	115 VAC line: 90 VDC, Imax ≤ 2.0A 230 VAC line: 180 VDC, Imax ≤ 2.0A
Maximum Speed Frequency Input	< 30 kHz
Maximum Setpoint (Drive Command) Frequency	< 30 kHz
Speed Resolution	1 rpm
Operating Speed Range	10-2500 rpm representing 0.5-125% setpoint range. Between 0 and 0.5%, speed is clamped to zero.
Speed Accuracy	< 2% @ <10% of setpoint < 1% @ > 10% of setpoint
Voltage Isolation Ratings	4 kV between line communications components and contacting parts. 4 kV between line communication components and relay contacts.

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Electrical Design

Electrical block diagram

The following is the electrical block diagram of the GraviDrive.



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Electrical Design, Continued

Electronic design concepts

The AC line input is protected by circuit breaker CB-1 and is filtered with a line filter and the power output is disconnected via relay K2. Autosensing of the power line voltage is also provided requiring no selection by the user.

The basic design uses a pulse-width modulated MOSFET power stage output to precisely set the power to the motor such that motor speed will be maintained at the desired setpoint. The setpoint for most applications is "drive command" that comes from the K-Tron feeder controller. Drive command is a 5 VDC square wave with a nominal range of 0-10 kHz for 0-full scale motor speed. Feedback or motor velocity is measured by a sensor, normally a magnetic, zero-speed device that either is a magneto-resistive device that senses the presence of a ferrous metal gear tooth on a shaft mounted gear or is a hall-effect device that senses magnetic poles embedded in a wheel mounted to the motor shaft. The output of either sensor is a 5 VDC square wave signal, the frequency of which is a function of motor speed, the number of poles or gear teeth on the pick-up gear, and the motor RPM.

The GraviDrive compares the setpoint and motor speed feedback and if a difference is detected, the output pulse width modulation is modified to bring them into balance.

The signal inputs are opto-isolated for protection. The GraviDrive is also protected against motor overload and output short-circuits.

There are no adjustments on the main circuit board. Most of the pc board components are soldered in place so repair is best left to the folks at K-Tron. There are input controls provided for "jog" , "drive enable" and a "safety interlock". There are outputs for "alarm" , "motor running" and a programmable relay output. The programmable relay output is functional only via the serial data channel programming.

The GraviDrive also has a serial data input that may be used in place of the frequency inputs from the field. Software does not yet implement this feature.

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Troubleshooting Procedures

Faults and Solutions

Introduction

This section outlines a procedure for troubleshooting problems with the GraviDrive.

Motor doesn't run

Step	Action
1	Check to see that power is applied and that the Power Rocker Switch is "On".
2	Verify that ALV led is blinking. This tells that the internal microprocessor is operational.
3	Check for Safety Switch activity. Check connections and function. See led list in prior section.
4	Verify that Drive Command and Enbl leds are on.
5	Verify that the leds labeled D1 do not have an error code E1, E3, E4 or E7 alarm.
6	Check DIP programming for correct set-up including motor current.
7	Check motor wiring and brushes if necessary.

Motor runs too slow or stalls

Step	Action
1	Check DIP switch to verify programming for the motor current and pick-up pulse count desired.
2	Check D1 values for Drive command(left) and Motor current (right) to see if either is at maximum value. Determine correct values for proper operation and verify.
3	Check motor and feeder for jams. Turn off power prior to placing hands into feeder.
4	Drive may have failed, if all other checks indicate no other problem. Replace drive.

Continued on next page

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Faults and Solutions, Continued

Motor runs away

Step	Action
1	Check to see that a speed signal is present when the motor is turning.
2	If no speed signal, correct the lack of speed signal by referring to the section on "Speed Pick-Up Sensor".
3	If motor is running at full speed, with no drive command, the GraviDrive has failed. Replace the GraviDrive.

Motor runs erratic

Step	Action
1	Check to see that a speed signal is present and is stable when the motor is turning. See speed pick-up adjustment procedure.

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Repairs to the GraviDrive

Software upgrade for GraviDrive

While doing internal repairs to the GraviDrive™ is not permitted, it is possible to upgrade its software in the field as it is available from K-Tron.

The following procedure is for upgrading software in the GraviDrive™ motor drive unit. All work must be done by trained individuals using appropriate safety precautions for both equipment and themselves.

Step	Action
1	Shut off all AC power to GraviDrive™
2	Unplug connectors
3	Remove GraviDrive™ unit from its mounting
4	Take GraviDrive to anti-static work station and using approved anti-static procedures do the following:
5	Remove the sheet metal cover, and with a suitable plcc chip extractor, remove the processor and reinstall the new one with the new version software. Re-attach the cover and program the DIP switch per the application. Remount, wire and test.

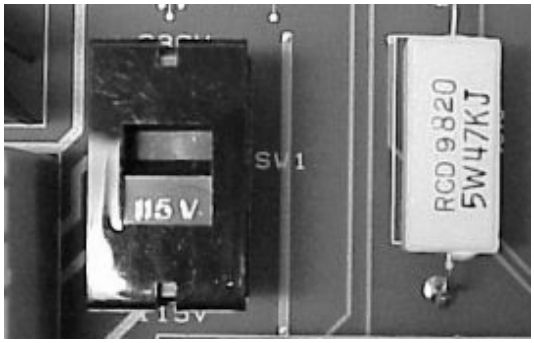
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Repairs to the GraviDrive, Continued

115/230VAC Line Switch

Follow this procedure to set the required AC line power.

Step	Action
1	Shut off all AC power to GraviDrive™
2	Remove the sheet metal cover – extract 13 screws.
3	Locate the large Power Switch on the main pc board. Slide the lever to the desired power input required. The switch toggle will display the selected line voltage. Re-install cover and connect GraviDrive.  **Note:** A 90-100Vdc motor requires a 115 Vac line. A 180-200 Vdc motor requires a 230Vac line.
4	Change power label on GraviDrive to reflect current AC input requirements.

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Repairs to the GraviDrive, Continued

Spare parts	The GraviDrive is a complex box and no field repairs are possible. To have a GraviDrive repaired, please call the K-Tron Service Department.
Call for service	To call for K-Tron service, dial (856) 589-0500 or (856) 589-9083

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