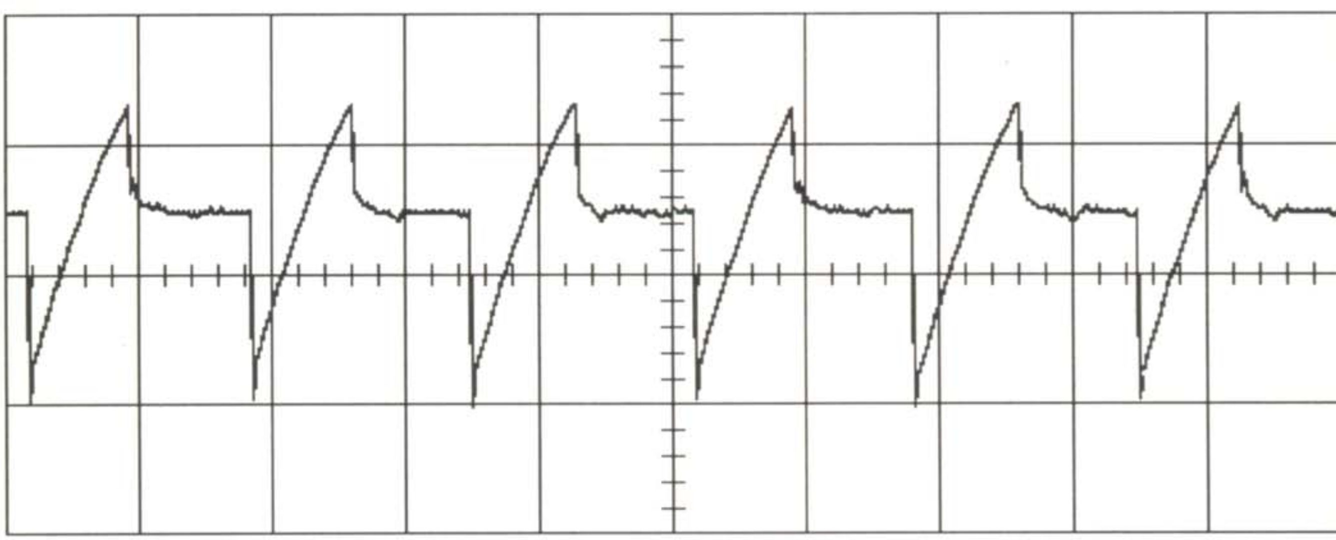
RG600 Series

Instruction Manual for the RG610 Regenerative Motor Control



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LTRG610 (IM-RG610-0997)

Table of Contents

Overview

Introduction to the RG610

The Dart Controls model RG610 is a microprocessor-based, four-quadrant regenerative motor control. It is used to control the speed or torque of any permanent-magnet or shunt-wound DC motor in the 1/15 to 2 horsepower range. Either a 115VAC or 230VAC source may be used to power the RG610, and it can be provided in an open chassis or in a NEMA-4/12 enclosure.

Regenerative Motor Control

A "four-quadrant" speed control provides driving *and* braking torque, as required to maintain a speed set by the user. This concept is illustrated below in figure 1.

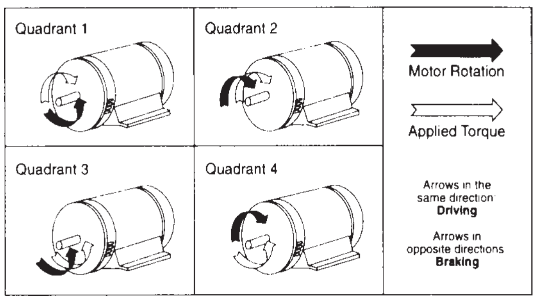


Figure 1

When operating in quadrant 2 or 3, torque is being applied in the same direction the motor is rotating, and the control is driving the motor like a standard DC control. When operating in quadrant 1 or 4, a regenerative control will behave differently than other DC controls by applying torque in a direction that opposes motor rotation, providing braking. During braking, the energy contained in the motor and its load is converted into electrical energy and "regenerated" back into the AC source. This capability gives the regenerative control its name, and provides excellent control of motor speed.

RG610 Advantages

The RG610 offers many features that are beyond the reach of standard regenerative controls. This is because Dart has combined the toughest hardware design available with a powerful microprocessor, which functions as the "brain" of the control. The microprocessor allows tremendous flexibility when customizing the unit, so you can do complex tasks easily. There are no mechanical trimpots on the RG610 for you to set; all adjustments are made through its simple user interface. This means that once an item has been adjusted, there will be no drifting or accidental bumps changing the setting.

Standard Features

- **Full-wave, four-quadrant operation:** Regenerative braking allows high-speed reversing and excellent speed control, even with overhauling loads.
- **Speed or torque control:** The RG610 can be used to control either the speed or torque of a motor, the selection of which is done with a soft trimmer setting.
- **Electrically isolated control circuitry:** This eliminates the possibility of damaging the control by accidentally grounding the “common” signal path.
- **Dual supply voltage:** The RG610 can be powered by either a 115VAC or 230VAC source, the selection of which is done with a simple on-board slide switch.
- **Dual supply frequency:** The control automatically adjusts to operate from a 50Hz or 60Hz power source.
- **Microprocessor-based:** This allows greater customization of the control to fit your application exactly. All of your settings are stored digitally in nonvolatile memory (the control will “remember” your settings, even when power is removed, and be ready to go when power is reapplied).
- **No mechanical trimpots:** The RG610 has “soft trimmers” (the digital equivalent of mechanical trimpots, only much more reliable) that are set through its simple user interface. Unlike mechanical trimpots, the soft trimmers do not drift in value over time, or change in value or get broken off when something bumps the control.
- **P-I-D control settings:** Proportional, integral, and derivative gains may be set for optimal system performance and fast settling time.
- **Armature feedback, analog tachometer feedback, or open-loop:** In speed control mode, there is the choice between using armature voltage feedback, analog (dc) tachometer feedback, or no feedback (open-loop operation). 1% speed regulation is possible with armature feedback, or 1/2% with analog tachometer feedback.
- **30:1 speed range using an analog tachometer, 20:1 using armature feedback**
- **150% overload capacity for one minute**
- **Transient voltage protection**
- **True zero-speed position with any potentiometer configuration**
- **Shunt field supply provided:** 50VDC or 100VDC is available when using 115VAC power. 100VDC or 200VDC is available when using 230VAC power.
- **5KΩ speedpot with leads, dial, and knob included**
- **4 – 20mA isolated signal follower:** With the addition of an external 250Ω, 0.1% tolerance resistor (consult factory for availability), 4 - 20mA following capability is available.
- **External voltage follower:** Motor speed may be controlled using any external grounded or isolated signal. There are two ranges selectable: 0 to +5VDC or -10VDC to +10VDC.
- **Inhibit circuit permits start and stop without breaking AC lines:** The drive may be inhibited by using an external logic-level signal.
- **Barrier-type terminal strip**
- **Two 15A AC line fuses**

Soft Trimmer Quick Reference: Speed Control Mode

Page No.	Item No.	Soft Trimmer Name	Manual Page
1	1	Reverse Current Limit	A-1, B-1
	2	Forward Current Limit	A-1, B-1
	3	Reverse Acceleration	A-1, B-1
	4	Forward Acceleration	A-2, B-1
	5	Reverse Maximum Speed	A-2, B-1
	6	Forward Maximum Speed	A-2, B-1
	7	Reverse Deceleration	A-3, B-1
	8	Forward Deceleration	A-3, B-1
	9	Reverse Minimum Speed	A-3, B-1
	10	Forward Minimum Speed	A-4, B-1
2	1	PID – P Gain	A-5, B-2
	2	PID – I Gain	A-5, B-2
	3	PID – D Gain	A-5, B-2
	4	IR Compensation	A-6, B-2
	5	Forward, Reverse, & Inhibit Input Setup	A-6, B-2
	6	Inhibit Function Selection	A-6, B-2
	7	Inhibit Delay	A-7, B-2
	8	Speed/Torque Mode Selection	A-8, B-2
	9	Feedback Mode Selection	A-8, B-3
	10	PID Aggression Adjustment	A-9, B-3
3	1	Speed Command Source	A-10, B-4
	2	Speedpot Minimum Calibration	A-11, B-4
	3	Speedpot Maximum Calibration	A-11, B-4
	4	Speedpot Center Calibration	A-11, B-4
	5	Speedpot Deadband Width	A-12, B-4
	6	Speed Setpoint	A-12, B-5
	9	Default Display Selection	A-13, B-5

Soft Trimmer Quick Reference: Torque Control Mode

Page No.	Item No.	Soft Trimmer Name	Manual Page
1	1	Reverse Speed Limit	C-1, D-1
	2	Forward Speed Limit	C-1, D-1
	3	Reverse Acceleration	C-2, D-1
	4	Forward Acceleration	C-2, D-1
	5	Reverse Maximum Torque	C-2, D-1
	6	Forward Maximum Torque	C-2, D-1
	7	Reverse Deceleration	C-2, D-1
	8	Forward Deceleration	C-3, D-1
	9	Reverse Minimum Torque	C-3, D-1
	10	Forward Minimum Torque	C-3, D-1
2	1	PID – P Gain	C-4, D-2
	2	PID – I Gain	C-4, D-2
	3	PID – D Gain	C-4, D-2
	5	Forward, Reverse, & Inhibit Input Setup	C-4, D-2
	6	Inhibit Function Selection	C-5, D-2
	7	Inhibit Delay	C-5, D-2
	8	Speed/Torque Mode Selection	C-5, D-2
	9	Feedback Mode Selection	C-6, D-3
	10	PID Aggression Adjustment	C-6, D-3
3	1	Torque Command Source	C-7, D-4
	2	Torquepot Minimum Calibration	C-8, D-4
	3	Torquepot Maximum Calibration	C-8, D-4
	4	Torquepot Center Calibration	C-8, D-4
	5	Torquepot Deadband Width	C-9, D-4
	6	Torque Setpoint	C-9, D-5
	9	Default Display Selection	C-9, D-5

Quick-Start Installation

Soft Trimmer Factory Settings

The following is a list of the factory settings for the RG610. These will be the settings of the control "out of the box" when you receive it. This is also what the settings will become any time you reset the soft trimmers to their factory default settings.

Forward and Reverse Current Limit	12 amperes
Forward and Reverse Acceleration	1.0 seconds (from zero speed to maximum speed)
Forward and Reverse Deceleration	1.0 seconds (from maximum speed to zero speed)
Forward and Reverse Maximum Speed	90/180V across armature (depends on 115VAC/230VAC input voltage selection)
Forward and Reverse Minimum Speed	0V across armature
PID – P Gain	Preset 13 (33%)
PID – I Gain	Preset 14 (35%)
PID – D Gain	Preset 1 (0%)
PID Aggression Adjustment	Preset 12 (30%)
IR Compensation	Preset 1 (0%)
Forward, Reverse, and Inhibit Input Setup	Forward and Reverse continuous contact, Inhibit active-low
Inhibit Function Selection	Decelerate to a stop
Speed/Torque Mode Selection	Speed control mode
Feedback Mode Selection	Armature feedback mode
Speed Command Source	Speedpot, single direction
Speedpot Maximum Calibration	Preset 40 (100%)
Speedpot Deadband Width	Preset 4 (10%)
Default Display Selection	Power Indicator (top 2 & bottom 2 lights on)

Using the Enclosed RG610

The enclosed version of the RG610 comes with a speedpot, direction selection switch, and a power switch already connected. This is depicted in figure 2 below. Your AC input voltage should connect to the pair of terminals labeled “enclosed”. The direction selection switch has three positions:
The top position selects the forward direction, the bottom position selects the reverse direction, and the middle position selects the inhibit function (by selecting **neither** direction).

The direction selection switch is only functional when the control is in single-direction mode. In other modes, this switch does NOTHING.

Aside from having the previously mentioned controls already wired into the enclosure, the enclosed version is exactly the same as the chassis version.

Enclosed RG610 Faceplate

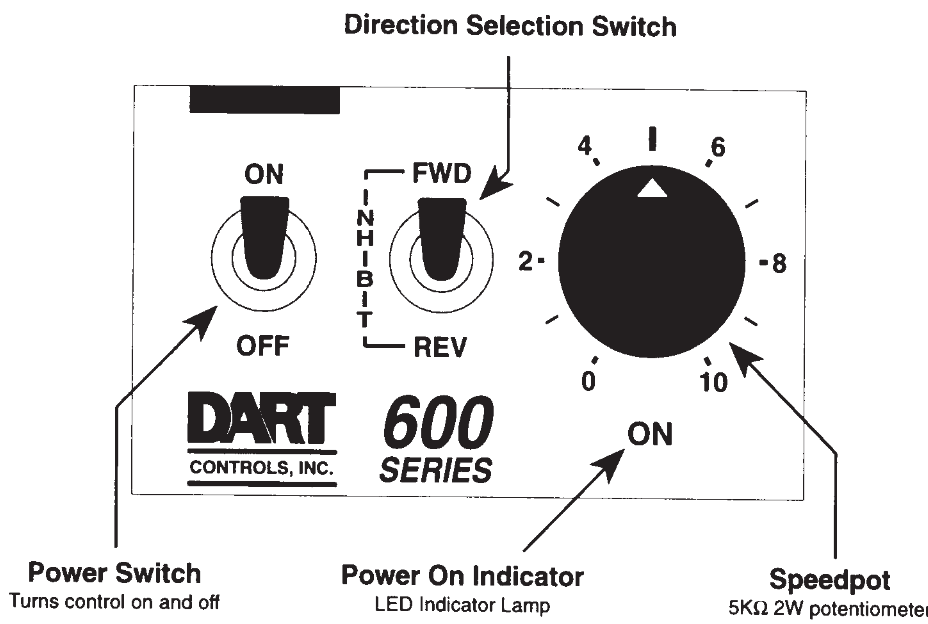


Figure 2

Connections shown are for use with RG610 factory settings

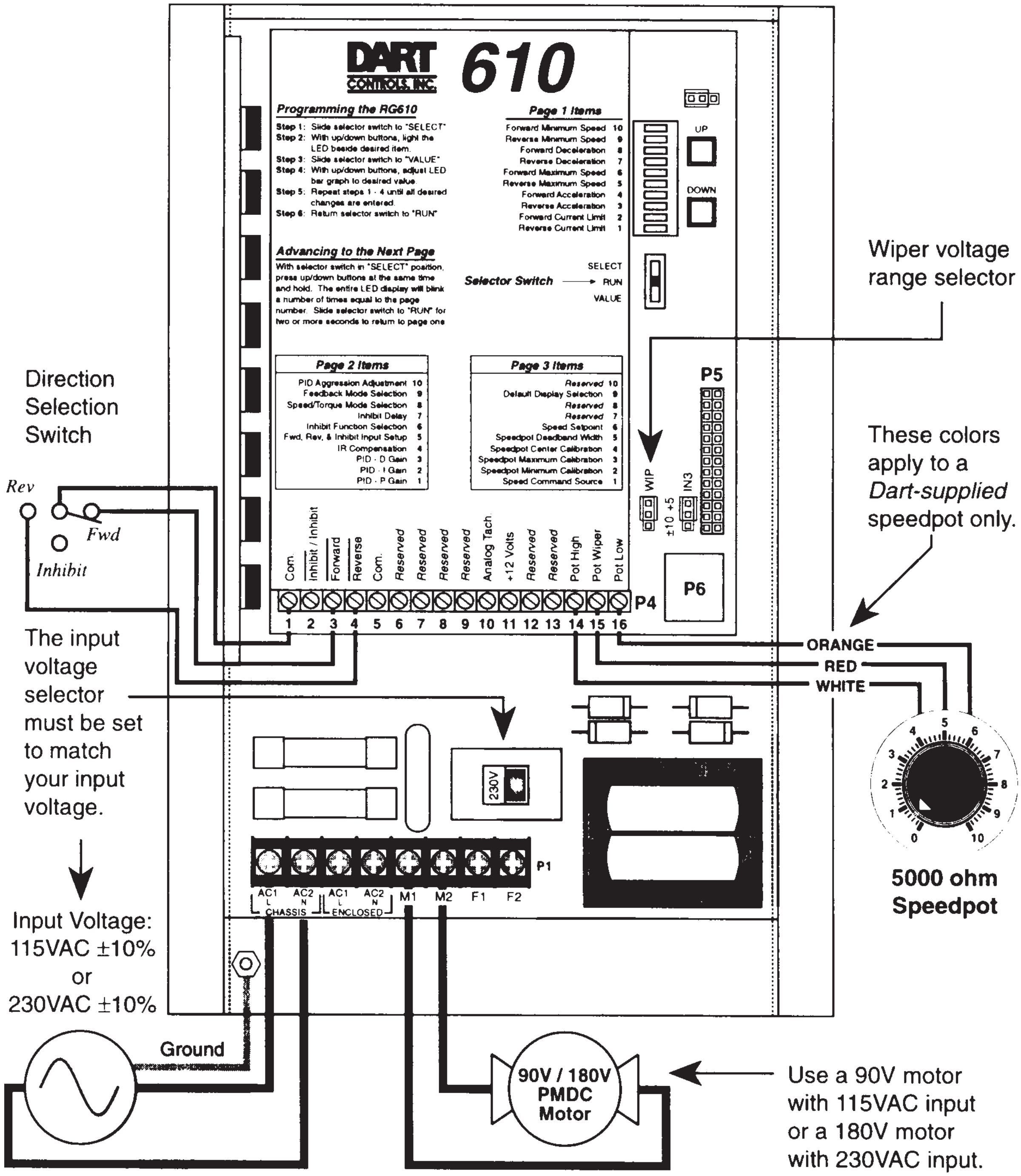


Figure 3

This abbreviated instruction set is intended for use in combination with figure 3 (on the preceding page) and the factory settings of the RG610. Complete installation and wiring information is found in section 5, "Complete Installation".

Quick-start connections for chassis or enclosed version:

Connecting a Permanent -Magnet Motor

Permanent-magnet (PM) motors have two wires, and they are connected to M1 and M2 on connector P1, as shown in figure 3. Reversing these two wires will cause the motor to rotate the opposite way. This may be necessary if you want a certain direction of motor rotation to correspond to "Forward" or "Reverse" on the control. In the forward direction, M1 will be positive with respect to M2.

Connecting AC Power

The RG610 accepts 115VAC or 230VAC on its AC inputs for controlling 90V or 180V motors, respectively. The input voltage selector must be set to match the voltage connected to the control. AC power attaches as shown in figure 3, unless you have the enclosed version, in which case the AC power attaches to the terminals labeled "enclosed". At power-up, the control will automatically adjust to operate at any AC line frequency between 48 Hz and 62 Hz. The two most common line frequencies are 50 Hz and 60 Hz.

Connecting an Earth Ground

If you have an earth ground available, you should connect it to the ground connector shown in figure 3. This will prevent the control's metal housing from becoming "hot" (connected to AC) in the event of an accidental wire breakage.

Additional quick-start connections for chassis version only:

Connecting Dart's Speedpot

The white, red, and orange wires on the Dart-supplied 5KΩ (2W) speedpot should be connected to P4-14, P4-15, and P4-16, respectively. This is shown in figure 3. Alternate speedpot values can be used—just keep the resistance value between 1KΩ and 15KΩ. The wiper voltage range selector (labeled "WIP") must be in the +5V position when using a speedpot in this way.

Connecting a Direction Selection Switch

The easiest way to select directions is to use a 3-position switch, as shown in figure 3. The center switch position shouldn't connect either the forward (P4-3) or reverse (P4-4) pins to the common point (P4-1). This position, with neither direction selected, will inhibit the control.
The forward, reverse, and inhibit pins are all internally pulled high (+5V) through 10KΩ resistors. So they can be pulled low with switching transistors also, if that suits your application better.

Connectors & Jumpers Defined

Lower Board

There is only one connector on the lower board. It is illustrated in figure 4 below.

RG610 Lower Board Connector

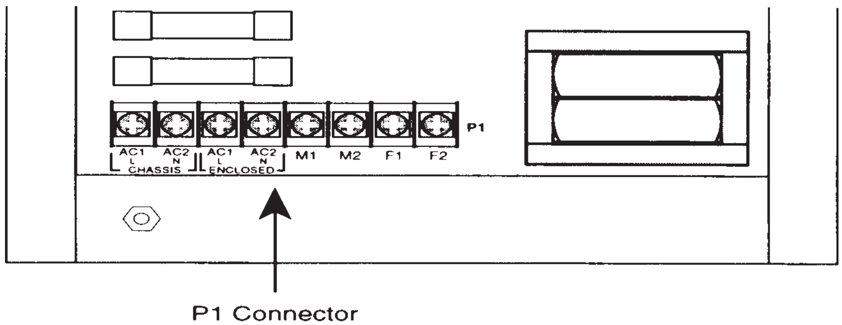


Figure 4

P1 – Power, Motor, and Field Connector

Pin	Description
AC1 (L) *(chassis)*	Connects to one wire from the AC power source (in countries that use "L" and "N" designators, the "hot" wire is connected to this point).
AC2 (N) *(chassis)*	Connects to the other wire from the AC power source (in countries that use "L" and "N" designators, the neutral wire is connected to this point).
AC1 (L) *(enclosed)*	Connects to one wire from the AC power source (in countries that use "L" and "N" designators, the "hot" wire is connected to this point).
AC2 (N) *(enclosed)*	Connects to the other wire from the AC power source (in countries that use "L" and "N" designators, the neutral wire is connected to this point).
M1	Connects to one motor armature wire (M1 is positive with respect to M2 in the forward direction)
M2	Connects to the other motor armature wire (M2 is positive with respect to M1 in the reverse direction)
F1	Connects to the negative field winding (if using a shunt-wound motor)
F2	Connects to the positive field winding (if using a shunt-wound motor)

Upper Board

There are three connectors and two jumpers that can be used on the RG610's upper board. They are illustrated in figure 5 below.

RG610 Upper Board Connectors & Jumpers

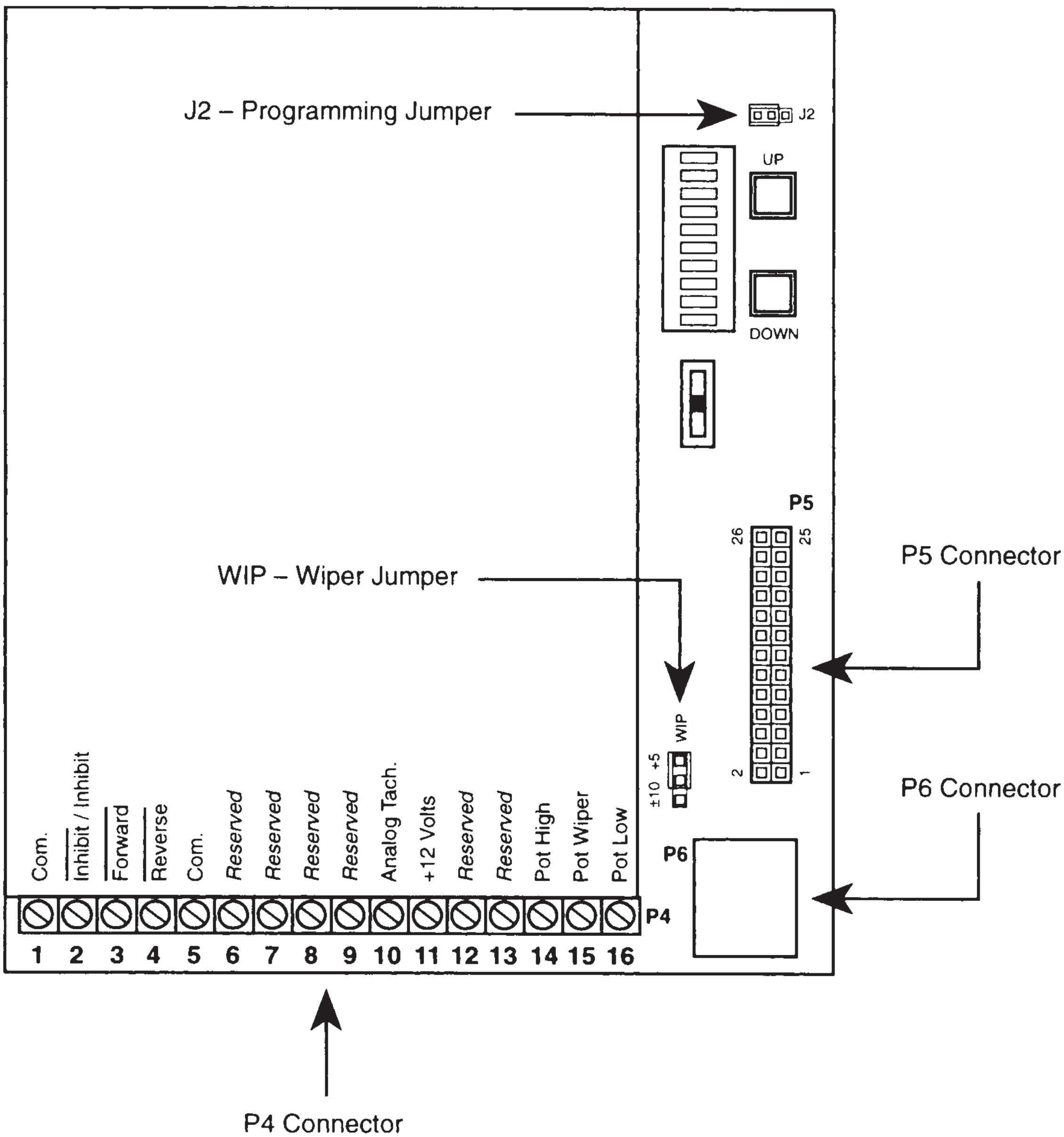


Figure 5

Refer to figure 5 for the location of the P4 connector. This connector is intended to be used for connecting the control signals to the RG610.

P4 – Control Connector

Pin	Description
1	**Floating Common** The reference point for all signals on the top board.
2	**Inhibit Input** Connect to / disconnect from (depending on Inhibit Input Setup) floating common to inhibit the control. This input is internally pulled high through a 10KΩ resistor.
3	**Forward Input** Single-direction mode only: Connect to floating common to select the forward direction. This input is internally pulled high through a 10KΩ resistor.
4	**Reverse Input** Single-direction mode only: Connect to floating common to select the reverse direction. This input is internally pulled high through a 10KΩ resistor.
5	**Floating Common** The reference point for all signals on the top board—the same as pin 1.
6 – 9	***Reserved***
10	**Analog Tachometer Input** Analog Tachometer Feedback Mode only: This input accepts ±50VDC per 1000 rpm (3,800 rpm maximum), referenced to floating common.
11	**+12V Output** This output can supply up to 50mA of current to external circuitry.
12 – 13	***Reserved***
14	**Pot High** A +5V supply for potentiometers used as speedpots or torquepots.
15	**Pot Wiper** This is where the wiper of a speedpot or torquepot connects. If you are using an external voltage or a 4 – 20mA signal instead of a speedpot or torquepot, this is where it connects.
16	**Pot Low** The common point for a potentiometer, external voltage, or 4 – 20mA signal. This point is electrically the same as the floating common.

The P5 connector provides alternate access points for some of the control signals. Refer to figure 5 for the location of the P5 connector, the programming jumper, and the wiper jumper.

P5 – Alternate Control Connector

Pin	Description
1, 3,..., 25 (all odd pins)	**Floating Common (Pot Low)** See description for P4-16.
2	**Pot High** See description for P4-14.
6	**Cloning Pin** Used for cloning (see the "Cloning" section).
4, 8, 10, 12, 14, 16	***Reserved***
18	**Pot Wiper** See description for P4-15.
20	**Inhibit Input** See description for P4-2. Also used for cloning (see the "Cloning" section).
22	**Forward Input** See description for P4-3. Also used for cloning (see the "Cloning" section).
24	**Reverse Input** See description for P4-4. Also used for cloning (see the "Cloning" section).
26	***No Connection***

J2 – Programming Jumper

When this jumper is in the position shown in figure 5, the RG610 can be programmed normally. Moving the programming jumper to the other position disables RG610 programming. Under this condition, soft trimmer values can still be observed, but not changed.

WIP – Wiper Jumper

This jumper allows for the use of either of two voltage ranges for speed/torque command on the Pot Wiper input. Use the ±10V position for use with an external -10V to +10V signal that you provide. Use the +5V position in all other cases. The voltage range that you use has **NOTHING** to do with the selection between single or dual direction mode of operation.

Complete Installation

Connecting a Permanent-Magnet Motor

Permanent-magnet (PM) motors are connected to the RG610 just as shown in figure 2 in “Quick-Start Installation”. These motors have just two wires to hook up, and they can be connected either way without damaging the motor or the control. Reversing the motor lead connections will simply cause the motor shaft to rotate in the opposite direction.

Sometimes it is important to know which way the motor will turn before it happens. For this reason you might need to know the polarity of the two motor connections, M1 and M2, in relation to the forward and reverse directions. On the RG610, the forward direction corresponds to M1 being positive with respect to M2. Likewise, in the reverse direction, M2 will be positive with respect to M1.

> *Note: The factory settings of the RG610’s soft trimmers set the control up for a standard 90VDC or 180VDC motor. The two standard situations are the following: The control is powered with 115VAC to run a 90VDC motor OR the control is powered with 230VAC to run a 180VDC motor. This applies to either a permanentmagnet motor or a shunt-wound motor.*

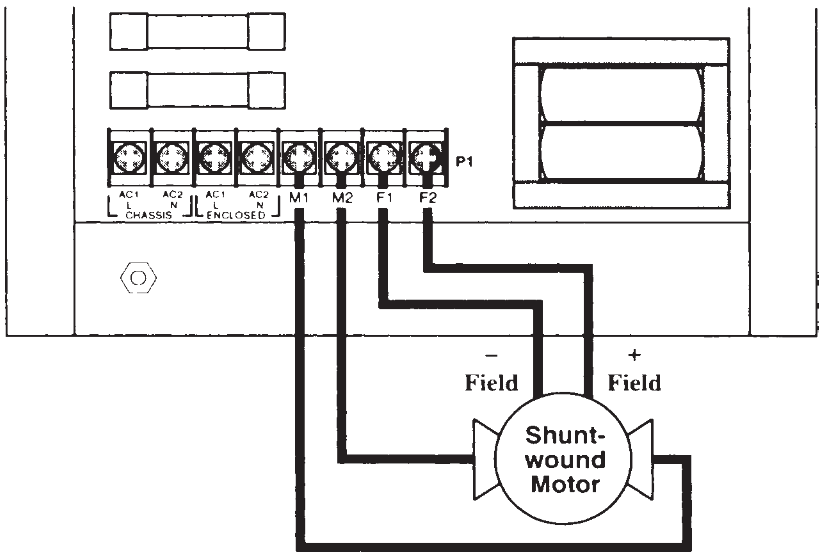
Connecting a Shunt-Wound Motor

Shunt-wound motors typically have four wires, two for the armature winding and two for the field winding. The two armature wires connect to M1 and M2 on the P1 connector just as they do on a PM motor (see figure 6).

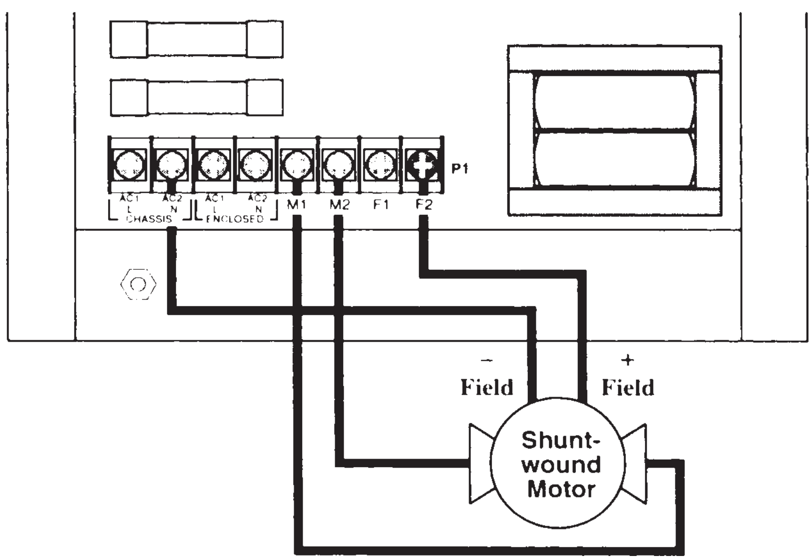
The field wires can be connected in two different configurations, which are illustrated in figure 6. The top portion of figure 6 shows what can be referred to as the “full-voltage” connection. This connection arrangement will provide a 200VDC field when the control is powered with 230VAC, or a 100VDC field when the control is powered with 115VAC. The bottom portion of figure 6 shows the “half-voltage” connection. This connection arrangement will provide a 100VDC field when the control is powered with 230VAC, or a 50VDC field when the control is powered with 115VAC. Even though figure 6 shows the negative field connection for the “half-voltage” field going to AC2, AC1 will work just as well. So use the one that is more convenient for you.

> **WARNING: When using a shunt-wound motor, the field wires must be connected to the control BEFORE power is applied. Field wires MUST NOT BE DISCONNECTED during operation of the control. Otherwise, serious damage to the motor can occur.**

Motor Connections for 200VDC Field Supply (230VAC Input) or 100VDC Field Supply (115VAC Input)



Motor Connections for 100VDC Field Supply (230VAC Input) or 50VDC Field Supply (115VAC Input)



Connecting a Potentiometer for Speed/Torque Command

The white, red, and orange wires on the Dart-supplied 5KΩ (2W) potentiometer should be connected to P4-14, P4-15, and P4-16, respectively. This is shown in figure 2 in “Quick-Start Installation”. Alternate potentiometer values can be used—just keep the resistance value between 1KΩ and 15KΩ. When using a potentiometer in this way, the wiper jumper (WIP – see the “Connectors & Jumpers Defined” section) should be in the +5V position.

Connecting an External Voltage for Speed/Torque Command

Two standard ranges of external voltage can be used for speed/torque command: a 0 – +5V signal range or a -10V – +10V signal range. You will need to move the wiper jumper (WIP – see the “Connectors & Jumpers Defined” section) to the position that corresponds to your signal range. In either case, your signal will connect to P4-15 (Pot Wiper), and your common (or reference) will connect to P4-16 (Pot Low). The voltage range that you use has **NOTHING** to do with the selection between single or dual direction mode of operation.

Connecting a 4 – 20mA Current Source for Speed/Torque Command

Using a 4 – 20mA current source for speed/torque command requires the use of an external 250Ω resistor (0.1% tolerance). This is illustrated in figure 7. The wiper jumper (WIP – see the “Connectors & Jumpers Defined” section) should be in the +5V position, since this 250Ω resistor converts the 4 – 20mA current signal into a 1V – 5V voltage signal. To effectively use this signal range in single direction mode, the speedpot/torquepot deadband width (Page 3, Item 5) should be set to preset 8. To effectively use this signal range in dual direction mode, the speedpot/torquepot minimum calibration (Page 3, Item 2) should be set to preset 8.

Connections for a 4 – 20mA Current Source

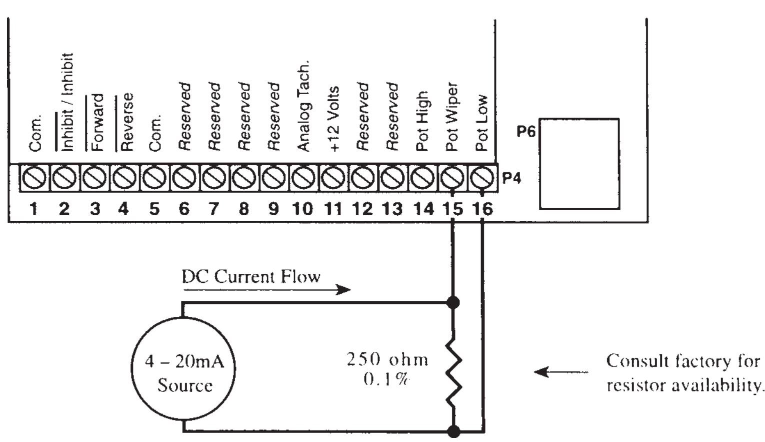


Figure 7

Connecting an Analog Tachometer

If you are using an analog tachometer it will have two wires, just like a DC motor. One of the two wires will connect to Common on the upper board (P4-1 or P4-5), and the other will connect to Analog Tach. (P4-10). You should connect these wires so that a positive voltage is present on Analog Tach. (referenced to Common) when your motor is spinning in the forward direction. This will produce a negative voltage on Analog Tach. (referenced to Common) when your motor is spinning in the reverse direction.

Note: It is very important that the analog tachometer be connected with the right polarity, as described above. If it is connected backwards, the control will go to maximum speed in the requested direction and stay there.

Connecting AC Power

First, the input voltage range selector (see figure 2 in "Quick-Start Installation") must be set to match the level of your source voltage, which can be either 115VAC ±10% or 230VAC ±10%. Then connect your AC source voltage to the two screws labeled "AC1" and "AC2" on the P1 connector (see the "Connectors & Jumpers Defined" section). In the United States, it doesn't matter which wire you connect to which screw, but be certain to use the pair of screws that is intended for the version (chassis or enclosed) of the control that you have. In countries that use "L" and "N" designators, the neutral wire from the source connects to the screw labeled "N", and the "hot" wire from the source connects to the screw labeled "L".

At power-up, the control will automatically adjust to operate at any AC line frequency between 48Hz and 62Hz. The RG610 will determine the line frequency at power-up only, however, so the line frequency must be stable. If the line frequency is outside the range of 48 – 62 Hz, the bottom four lights on the bargraph display will flash, and the control will not function until this power problem is fixed. Excessive noise on the AC line can also cause this to happen, but this problem can sometimes be eliminated by using an AC line filter.

Connecting an Earth Ground

If you have an earth ground available, you should connect it to the ground connector shown in figure 2 in "Quick-Start Installation". This will prevent the control's metal housing from becoming "hot" (connected to AC) in the event of an accidental wire breakage.

Programming the RG610

What are “Soft Trimmers”?

Soft trimmers are the digital equivalent of mechanical trimpots. They allow you to customize the control to suit your particular application, and they include such common adjustments as current limit, maximum speed, minimum speed, and many others. Since there are no mechanical trimpots on this control, there has to be a special way to adjust these values. The adjustments are made through the “User Interface”.

Introduction to the User Interface

Don’t let the name throw you; it’s just a name used to refer to the two buttons, one slide switch, and the row of lights you will use to make adjustments to the control. Let’s take a look at it.

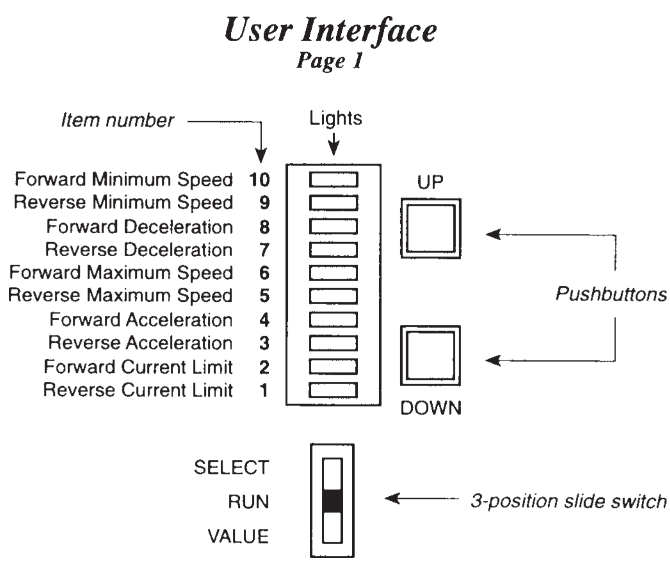


Figure 8

Each soft trimmer is referred to as an “item” on a “page”. Notice that the ten soft trimmers listed in figure 8 have item numbers associated with them. These are the ten items on page 1; they are the most common adjustments on any motor control. There are three pages with ten items per page; we’ll focus on page 1 in this section as we demonstrate how to change the values of the items (soft trimmers).

Changing Soft Trimmer Values with the User Interface

Step 1: Slide the selector switch to the “SELECT” position. Now one and only one light will be on at a time.

Step 2: Using the “UP” and “DOWN” pushbuttons, select the soft trimmer whose value you want to change by causing the light beside it to go on.

Step 3: Slide the selector switch to the “VALUE” position. This will change the column of lights into a bar graph display, which indicates the value of the selected soft trimmer.

Step 4: Using the “UP” and “DOWN” pushbuttons, adjust the bar graph to the desired value. It takes four button presses to change the display by one light. So, there are forty different settings for each soft trimmer. Each of these settings is referred to as a “preset”. So the forty settings are called *preset 1 through preset 40*.

Step 5: Repeat steps 1 - 4 until all desired changes have been entered.

Step 6: Return the selector switch to the “RUN” position.
You may have noticed that with the selector switch in the “SELECT” position, the light that is on blinks once every second or so. This single blink is telling you that you are on page 1. On page 2, the light blinks twice rapidly every second or so, telling you that you are on page 2. And of course, when the light blinks three times rapidly every second or so, you are on page 3.

> ***Special note regarding the storage of the soft trimmer values:***
> ***Soft trimmer values change as you adjust them, but they are not stored until the selector switchis moved out of the “VALUE” position. Also, the control will always power up with the User Interface returned to page 1.***

Interpreting the Bargraph

There are two types of soft trimmers. One type is like all of the page 1 trimmers, and the bar graph display is interpreted much like a thermometer—as more lights come on and the display creeps upward, the value is increasing. 21 of the 27 soft trimmers on the RG610 are of this type. It is this type of trimmer that has 40 different settings that are referred to as *presets*. The display for this type of soft trimmer is compared to a mechanical trimpot in figure 9.

We can see from figure 9 that the bottom light blinking slowly on the bar graph (preset 1) corresponds to a mechanical trimpot at its most counterclockwise position. Likewise, half of the lights on (preset 20) corresponds to a mechanical trimpot in the center of its rotation. And all of the lights fully on (preset 40) corresponds to a mechanical trimpot at its most clockwise position.

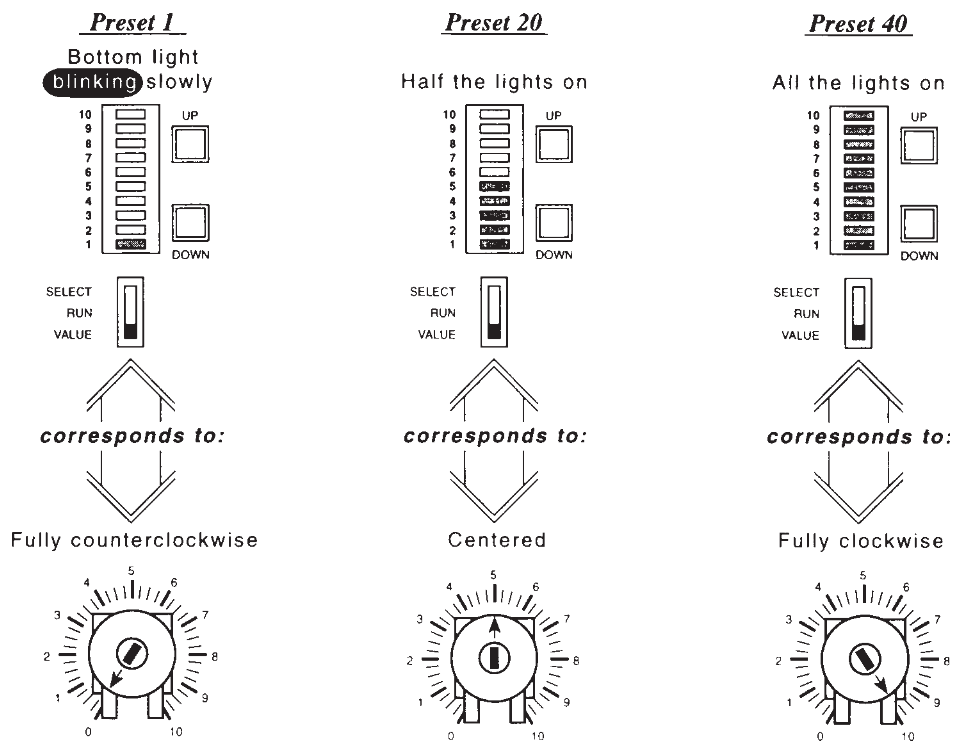


Figure 9

There are six soft trimmers of a second type. This second type of soft trimmer doesn't have just one value that increases or decreases when you adjust it. The display for these trimmers isn't interpreted like a thermometer, and they don't have forty different settings. They have ten or fewer settings, each represented by a different fully-on light. The setting of one of these soft trimmers is simply referred to as the number of the light that is on (or the selection that's been made), without referring to it as a preset. For example, one of these six is Page 3, Item 1, which is Speed Command Source. You'll select one of ten possible setups, with each of the ten lights representing one particular setup. In this case, the settings are referred to as 1 through 10. This simple idea will become clear after you've adjusted a few trimmer values.

Advancing to the Next Page

With the selector switch in the “SELECT” position, press both the “UP” and the “DOWN” pushbuttons at the same time and hold them down. After a couple of seconds, the entire column of lights will blink a number of times equal to the page number at which you have just arrived. For example, when the entire column of lights blinks two times, you have arrived at page 2. Likewise, if you continue holding the pushbuttons down after that, the entire column of lights will blink three times; this means you have arrived at page 3. When you arrive at the page number you want, release the pushbuttons. Now you can change the items (soft trimmers) on that page in the same manner used on page 1. To return to page 1, slide the selector switch to the “RUN” position and keep it there for at least 2 seconds.

Restoring Soft Trimmers to Factory Settings

Should the need arise, it is possible to restore all of the soft trimmers to their factory-settings. First, remove power from the control. Second, place the selector switch in the “VALUE” position. Third, press both the “UP” and “DOWN” pushbuttons at the same time and hold them down while reapplying power to the control. After two or three seconds you will see the bargraph light up from bottom to top, and then change to display the value of the Page 1, Item 1 soft trimmer (reverse current limit). All of the soft trimmers will now be restored to their factory settings.

Setting the Speed Control Loop Parameters

Introduction to PID

PID compensation has existed for many years, and has become a common method of "tuning" a motor control to a particular motor and load. It offers a way to customize the way the RG610 controls your motor. This is done with three "gains" or settings called P, I, and D.

Definition of PID and Related Settings

The following is an explanation of the PID settings, which is followed by an explanation of other settings that play important roles in the overall "tuning" of the control. **PID values cannot be set properly without considering the impact of these other values.**

P-Gain: This is a multiplier placed on the difference between the target speed and the actual speed (as measured by the armature feedback signal or the analog tachometer signal). The effect of making this gain larger is to increase the aggressiveness of the RG610's response to a difference between target speed and actual speed. When this value is too small, the RG610 will respond too slowly to a speed change. When it is too large, the RG610 will attempt to respond too quickly and create a speed error in the opposite direction, and an oscillation can occur. This oscillation can be violent when the PID Aggression Adjustment (Page 2, item 10) is set too high, and can even damage the motor if **extreme care** is not taken to increase this value slowly.

I-Gain: This is a multiplier placed on the integral of the difference between the target speed and actual speed. It causes the RG610 to compensate more and more as a speed error exists for a longer and longer period of time. This gain is necessary to reduce the steady-state error in speed to zero. When this gain is too low, the reaction of the control will be sluggish, and it will take a long time to attain the target speed. When the I-gain is too high, excessive overshoot of the motor speed can occur, along with an unwanted oscillation of motor speed around the target speed.

D-Gain: This is a multiplier placed on the rate-of-change of the difference between target speed and actual speed. This gain causes the control to react quicker as this rate-of-change increases, and it can actually smoothen the overall response of the control. D-Gain can also play an important role in compensating for a load that has a lot of inertia.

PID Aggression Adjustment: As advertised, this setting adjusts the aggression with which the P, I, and D gains are allowed to carry out their respective tasks. It basically alters the range of these gains, with higher settings creating larger ranges. The forty settings for P, I, and D on the LED bargraph will become more coarse as this value increases, to cover the wider range.

Acceleration and Deceleration: These parameters determine how fast the motor speed is allowed to increase or decrease. When these are set too low, it becomes possible to drive the motor too hard. When they are set too high, the response of the control becomes sluggish.

IR Compensation (Armature Feedback Mode Only): This parameter causes the applied throttle to increase with increasing motor current. This is necessary when using armature feedback, due to the voltage drop across the resistance of the motor windings. As the motor current increases, the voltage measured across the armature will increase, giving a falsely high indication of motor speed. This trimmer compensates for the control's tendency to reduce the applied throttle when this occurs.

Too little IR Compensation can allow the motor's speed to decrease when loaded. Too much IR Compensation can cause unwanted oscillations of motor speed.

Setting Up the PID Values

Setting the values for PID, acceleration, deceleration, and IR compensation to achieve optimum performance for a particular motor and load may take some time. However, the following method will help you get the job done.

If you have an application that allows you to tune the control while the motor is attached to its load, then do it that way. But tuning the control with the motor unloaded will often get you close to the correct settings, so that finishing the tuning with the motor loaded won't be difficult.

In addition to the motor and AC power, you will need to have a direction selection switch and speedpot hooked up (as shown in Figure 3 in "Quick-Start Installation").

1) Set the soft trimmers to their factory default settings (see "Programming the RG610" for instructions on doing this).

2) Set P-Gain and I-Gain to 0% (preset 1).

3) Turn the speedpot to about 75% of maximum, and select forward with the direction switch.

Setting P-Gain:

4) Increase P-Gain until the motor is spinning slowly but smoothly.

5) Deselect the forward direction, and wait for the motor to stop.

6) Switch back to the forward direction, and listen to the motor to determine whether it overshoots its target speed, or sounds rough or choppy as it turns. This will be obvious when it occurs, so don't worry about missing anything that's difficult to hear.

If P-Gain is less than 7 full lights, read this:

If the motor did overshoot or sound rough, reduce P-Gain to the last value that didn't cause this, and proceed to step #7. Otherwise, increase P-Gain by 4 button-presses and return to step #5.

If P-Gain is equal to or more than 7 full lights, read this:

If the motor still didn't overshoot or sound rough, increase the PID Aggression Adjustment by 1 button-press and return to step #5. Otherwise, reduce the PID Aggression Adjustment or P-Gain (whichever one you last increased) to the last value that didn't cause overshoot or roughness, and proceed to step #7.

Setting I-Gain:

7) Increase I-Gain to 1 full light.

8) Deselect the forward direction, and wait for the motor to stop.

9) Switch back to the forward direction, and listen to the motor's response. If it takes a long time for

it to achieve its target speed, then increase I-Gain by 4 button-presses (1 light) and return to step #8. If it overshoots its target speed, then reduce I-Gain until the overshoot is acceptable to you. A quick response time with little or no overshoot is usually achievable with proper adjusting of P-Gain and IGain.

Setting D-Gain:
In a lot of applications, it won't be necessary to use D-Gain. However, if you have a load with high inertia, you may need to increase D-Gain to compensate for the load's sluggishness. In this case, simply increase D-Gain 1 or 2 button-presses at a time until the motor's response is acceptable. You may need to alter the P-Gain and/or I-Gain during this process to achieve the best results.

Setting Acceleration and Deceleration
The tuning process above will give you PID values that work using acceleration and deceleration times equal to 1.0 seconds (preset 4) or longer (higher presets). If you need to use acceleration or deceleration times faster than 1.0 seconds (presets 1 – 3), you may need to adjust the PID values somewhat.

Setting IR Compensation (Armature Feedback Mode Only)
Now that the PID values are set, IR Compensation can be added. It was initially set to 0% (preset 1), which is the factory default setting. This is to ensure that it doesn't interfere with the PID tuning.
Now the following method can be used to properly adjust IR Compensation:

1) Run the motor unloaded at about 75% of the maximum speed.

2) Record the motor speed while unloaded.

3) Apply a full load to the motor. The motor speed will decrease somewhat.

4) Increase IR Compensation 1 button-press at a time until the motor speed matches the speed recorded in step #2.

Note: As a rule, too little IR Compensation is better than too much. For this reason, it should be set when the motor is cold. Armature resistance will increase as the motor gets warmer; setting IR Compensation with the motor hot will cause the control to overcompensate when the motor is cold.

Now the RG610's speed control loop is set.

> ***For more information about tuning PID-controlled systems, we recommend the following book: "Controller Tuning and Control Loop Performance", by David W. St. Clair, published by Straight-Line Control Company, Inc..***

Torque Control Mode

What is Torque Control?
Torque can be thought of as a rotating, or twisting force. There are applications in which it's necessary to control a motor's output torque instead of its speed. In these applications, you will use torque control mode on the RG610.

A motor's output torque is directly proportional to the current flowing through its armature. So torque is controlled by simply controlling the current flowing through the motor. This relationship between torque and motor current is the reason you often hear people speak of torque in terms of amps, or current. That will be the case in this manual, also.

Applications of Torque Control
Here are just a few examples to give you ideas about what torque control can be used for: 1) Controlling winding tension on spools of material when the diameter of the spool's wound material doesn't change very much. If the diameter changes more than a little, tension can't be controlled by simply controlling torque. 2) Materials testing which involves pulling things apart. 3) Dynamometers providing constant-torque loading of other motors. 4) Applications in which precise tightening is necessary.

Using Torque Control
The RG610 is placed in torque control mode by setting the Speed/Torque Mode Selection (Page 2, Item 8) to 2. You'll have to remove and reapply AC power for this change to take place. When you reapply power, the control will behave very differently than it does in speed control mode. One big difference you will notice is that the signal that was being used for speed command (for example, a speedpot) is now used for torque command (the speedpot will now be a "torquepot").

The RG610 is shipped from the factory in speed control mode, so the programming label on the front of it is printed to match that. When in torque control mode, the RG610 is reconfigured almost completely, and most of the soft trimmers have slightly or entirely different names and meanings. For example, what was reverse current limit in speed control mode is reverse speed limit in torque control mode. Most of the differences between the speed and torque control modes are explained by the terms "speed" and "torque" simply swapping positions. However, it's important to read and understand the soft trimmer descriptions and listing for torque control mode in appendices C and D, respectively.

Setting the Torque Control Loop Parameters

Introduction to PID

PID compensation has existed for many years, and has become a common method of "tuning" a motor control to a particular motor and load. It offers a way to customize the way the RG610 controls your motor. This is done with three "gains" or settings called P, I, and D.

Definition of PID and Related Settings

The following is an explanation of the PID settings, which is followed by an explanation of other settings that play important roles in the overall "tuning" of the control. **PID values cannot be set properly without considering the impact of these other values.**

P-Gain: This is a multiplier placed on the difference between the target torque and the actual torque (as measured by the current-sensing circuit). The effect of making this gain larger is to increase the aggressiveness of the RG610's response to a difference between target torque and actual torque. When this value is too small, the RG610 will respond too slowly to a torque change. When it is too large, the RG610 will attempt to respond too quickly and create a torque error in the opposite direction, and an oscillation can occur. This oscillation can be violent when the PID Aggression Adjustment (Page 2, item 10) is set too high, and can even damage the motor if **extreme care** is not taken to increase this value slowly.

I-Gain: This is a multiplier placed on the integral of the difference between the target torque and actual torque. It causes the RG610 to compensate more and more as a torque error exists for a longer and longer period of time. This gain is necessary to reduce the steady-state error in torque to zero. When this gain is too low, the reaction of the control will be sluggish, and it will take a long time to attain the target torque. When the I-gain is too high, excessive overshoot of the motor torque can occur, along with an unwanted oscillation of motor torque around the target torque.

D-Gain: This is a multiplier placed on the rate-of-change of the difference between target torque and actual torque. This gain causes the control to react quicker as this rate-of-change increases, and it can actually smoothen the overall response of the control. D-Gain can also play an important role in compensating for a load that has a lot of inertia.

PID Aggression Adjustment: As advertised, this setting adjusts the aggression with which the P, I, and D gains are allowed to carry out their respective tasks. It basically alters the range of these gains, with higher settings creating larger ranges. The forty settings for P, I, and D on the LED bargraph will become more coarse as this value increases, to cover the wider range.

Acceleration and Deceleration: These parameters determine how fast the motor torque is allowed to increase or decrease. When these are set too low, it becomes possible to drive the motor too hard. When they are set too high, the response of the control becomes sluggish.

Setting Up the PID Values

Setting the values for PID, acceleration, and deceleration to achieve optimum performance for a particular motor and load may take some time. However, the following method will help you get the job done.

If you have an application that allows you to tune the control while the motor is attached to its load, then do it that way. But tuning the control with the motor shaft locked in place will often get you close to the correct settings, so that finishing the tuning with the motor loaded normally won't be difficult.

In addition to the motor and AC power, you will need to have a direction selection switch and torquepot hooked up (as shown in Figure 3 in "Quick-Start Installation"). You will also need an analog DC current meter in series with the motor. A current meter that displays ±15 amperes, with zero in the center, makes this easy. You will also have to put the control in torque control mode. This is done by setting the Speed/Torque Mode Selection soft trimmer (Page 2, Item 8) to 2.

1) Set the soft trimmers to their factory default settings (see "Programming the RG610" for instructions on doing this).

2) Set P-Gain and I-Gain to 0% (preset 1).

3) Turn the torquepot to about 75% of maximum, and select forward with the direction switch.

Setting P-Gain:

4) Increase P-Gain until the current meter is displaying 1-2 amperes, and is fairly constant.

5) Deselect the forward direction. This will stop the current flow.

6) Switch back to the forward direction, and watch the current meter to determine whether it overshoots the target torque, or displays some instability. This will be obvious when it occurs, so don't worry about missing anything that's difficult to see.

If P-Gain is less than 7 full lights, read this:

If the motor current did overshoot or display instability, reduce P-Gain to the last value that didn't cause this, and proceed to step #7. Otherwise, increase P-Gain by 4 button-presses and return to step #5.

If P-Gain is equal to or more than 7 full lights, read this:

If the motor current still didn't overshoot or display instability, increase the PID Aggression Adjustment by 1 button-press and return to step #5. Otherwise, reduce the PID Aggression Adjustment or P-Gain (whichever one you last increased) to the last value that didn't cause overshoot or instability, and proceed to step #7.

Setting I-Gain:

7) Increase I-Gain to 1 full light.

8) Deselect the forward direction. This will stop the current flow.

9) Switch back to the forward direction, and watch the current meter. If it takes a long time for it to achieve its target torque, then increase I-Gain by 4 button-presses (1 light) and return to step #8. If it overshoots its target torque, then reduce I-Gain until the overshoot is acceptable to you. A quick response time with little or no overshoot is usually achievable with proper adjusting of P-Gain and IGain.

Setting D-Gain:
In a lot of applications, it won't be necessary to use D-Gain. However, if you have a load with high inertia, you may need to increase D-Gain to compensate for the load's sluggishness. In this case, simply increase D-Gain 1 or 2 button-presses at a time until the motor's response is acceptable. You may need to alter the P-Gain and/or I-Gain during this process to achieve the best results.

Setting Acceleration and Deceleration

The tuning process above will give you PID values that work using acceleration and deceleration times equal to 1.0 seconds (preset 4) or longer (higher presets). If you need to use acceleration or deceleration times faster than 1.0 seconds (presets 1 – 3), you may need to adjust the PID values somewhat.

Now the RG610's torque control loop is set.

> ***For more information about tuning PID-controlled systems, we recommend the following book: "Controller Tuning and Control Loop Performance", by David W. St. Clair, published by Straight-Line Control Company, Inc..***

Cloning

Introduction to Cloning

Cloning is the term used to describe the process of automatically copying all of the soft trimmer settings from one control to another. This is commonly done when one control has been carefully set up for a specific application, and you want to copy your settings to one or more other controls. This relieves you of the burden of manually setting each control, when each of them is intended for the same application.

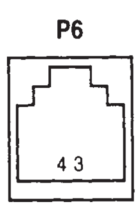
When you have properly set a control for your application, and are ready to copy settings *from* it, this control must be placed in "master" cloning mode. The control or controls you want to copy the settings *to* must be placed in "slave" cloning mode. Up to 32 clone slaves may be attached to a clone master at any one time.

Cloning Cables

To make cloning multiple RG610s easier, you may want to purchase the Universal Cloning Board (available from Dart Controls). This cloning board allows you to use standard telephone cables for cloning, which can't be done if you connect RG610s directly together. The connectors on the ends of standard phone cables are inverted (or "flipped") with respect to one another. The Universal Cloning Board takes care of this inconvenience for you, allowing you to use standard cables available at any store that has a phone supplies department.

If you intend to clone without using a Universal Cloning Board, you will need to make your own special "unflipped" cable. One way to do this is to take a standard phone cable and clip off one of the end connectors, noting its orientation; then crimp on a new end connector that is "flipped" in relation to the one you clipped off. This will create an "unflipped" cable, which connects the pin 4s together and the pin 3s together on the P6 connector on each RG610 (see figure 10 below). By the way, you will want to use 4-pin modular connectors on the ends if you are using phone cable. The only two pins that are used to clone an RG610 are pins 3 and 4, so don't worry if you notice that phone wire has only four conductors.

Cloning Connections on the RG610's P6 Connector



Pin 4 of the clone master must connect to pin 4 of the clone slave, and pin 3 must connect to pin 3. Pins 1, 2, 5, and 6 are not used.

Figure 10

Preparing Controls for Cloning

There are certain pins on the P5 connector that must be connected together to place an RG610 into either master or slave cloning mode. These connections are described below, and are the same with or without a cloning board. Figures 11, 12, and 13 on the following pages illustrate how to connect controls for cloning with and without a cloning board. The cloning cable(s) may be attached either before or after configuring a control for cloning; it won't damage the control either way.

Master Cloning Mode

To place a control in master cloning mode, follow these steps:

Step 1: Remove AC power from the control.

Step 2: On connector P5, connect pins 6, 20, and 22 together.

Step 3: Apply AC power to the control.

On the bar graph display, LEDs 6-10 (the top five) will come on solid for about 5 seconds. Then the bottom five LEDs and the top five LEDs will flash in blocks, alternately, while the information is being transmitted out the communications port, P6. When finished transmitting information, regardless of whether another control is attached, LEDs 6-10 will come on for about 5 seconds again, and the process will continue until power is removed from the control.

Slave Cloning Mode

To place a control in slave cloning mode, follow these steps:

Step 1: Remove AC power from the control.

Step 2: On connector P5, connect pins 6, 20, and 24 together.

Step 3: Apply AC power to the control.

On the bar graph display, LEDs 1-5 will come on solid. The display will remain like this until the slave control recognizes a master control that is connected to it. This can take as long as one cloning session (about a minute-and-a-half), which is the length of time it takes the master control to transmit all of its information one time. Once the master control is recognized, LED 6 will come on in addition to LEDs 1-5.

At this time, various compatibility issues are assessed. LED 9 will come on if a software incompatibility is found, and LED 10 will come on if a hardware incompatibility is found. If either of these conditions occurs, the control will be stuck in this condition until power is removed and re-applied.

If no incompatibilities are detected, LED 7 will come on in addition to LEDs 1-6, and cloning will begin. As cloning takes place, LEDs 8,9, and 10 will flash simultaneously. If there is a problem with the clone, a maximum of two more attempts will be made.

When the clone has been successfully completed, all 10 LEDs will come on and stay on until power is removed.

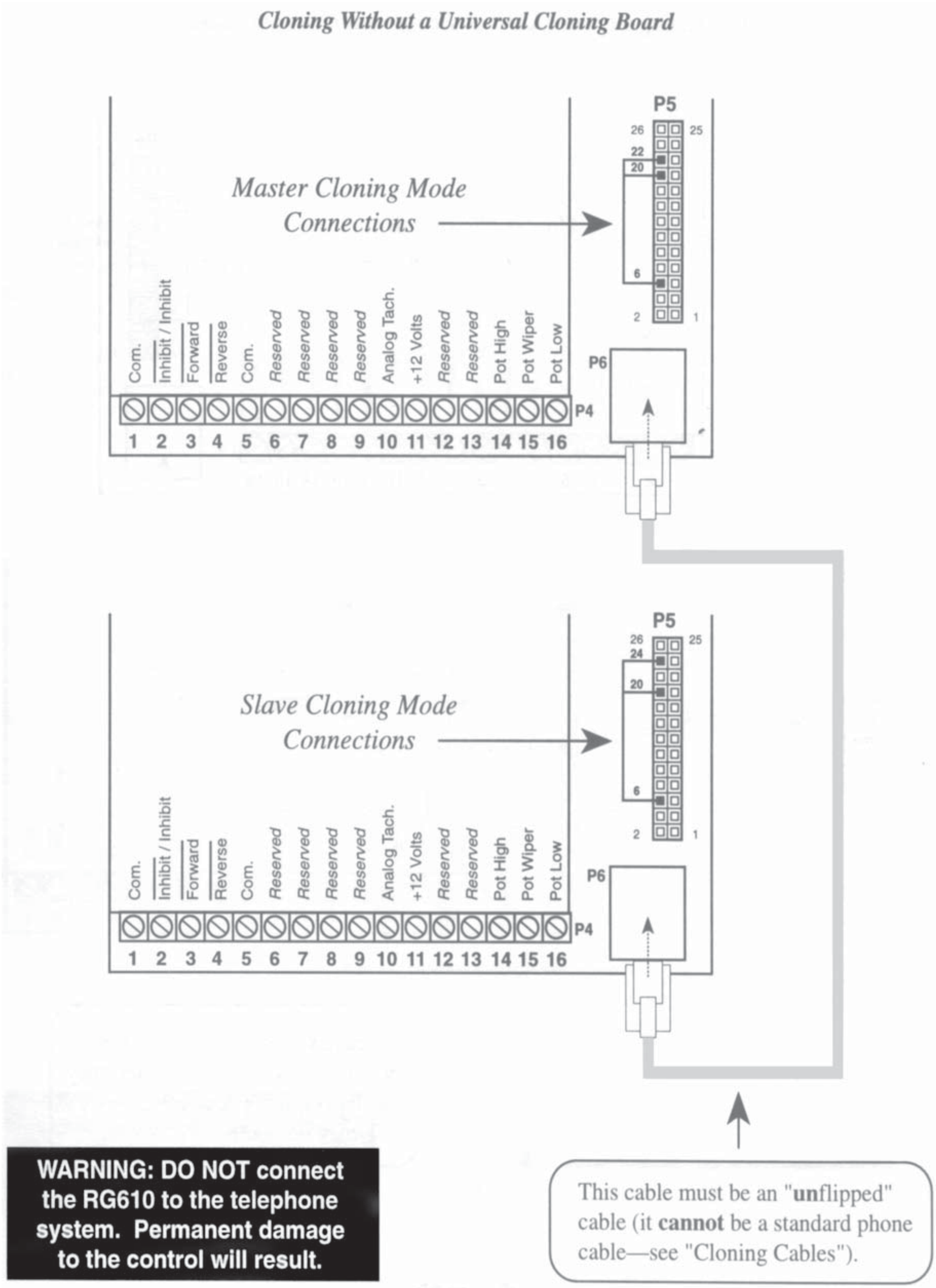

Cloning Without a Universal Cloning Board
Master Cloning Mode Connections
P5
26
25
22
20
6
2
1
P6
P4
Com.
Inhibit / Inhibit
Forward
Reverse
Com.
Reserved
Reserved
Reserved
Reserved
Analog Tach.
+12 Volts
Reserved
Reserved
Pot High
Pot Wiper
Pot Low
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Slave Cloning Mode Connections
P5
26
24
25
20
6
2
1
P6
P4
Com.
Inhibit / Inhibit
Forward
Reverse
Com.
Reserved
Reserved
Reserved
Reserved
Analog Tach.
+12 Volts
Reserved
Reserved
Pot High
Pot Wiper
Pot Low
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
WARNING: DO NOT connect the RG610 to the telephone system. Permanent damage to the control will result.
This cable must be an "unflipped" cable (it cannot be a standard phone cable—see "Cloning Cables").

Figure 11

Connecting a Clone Master to Universal Cloning Board

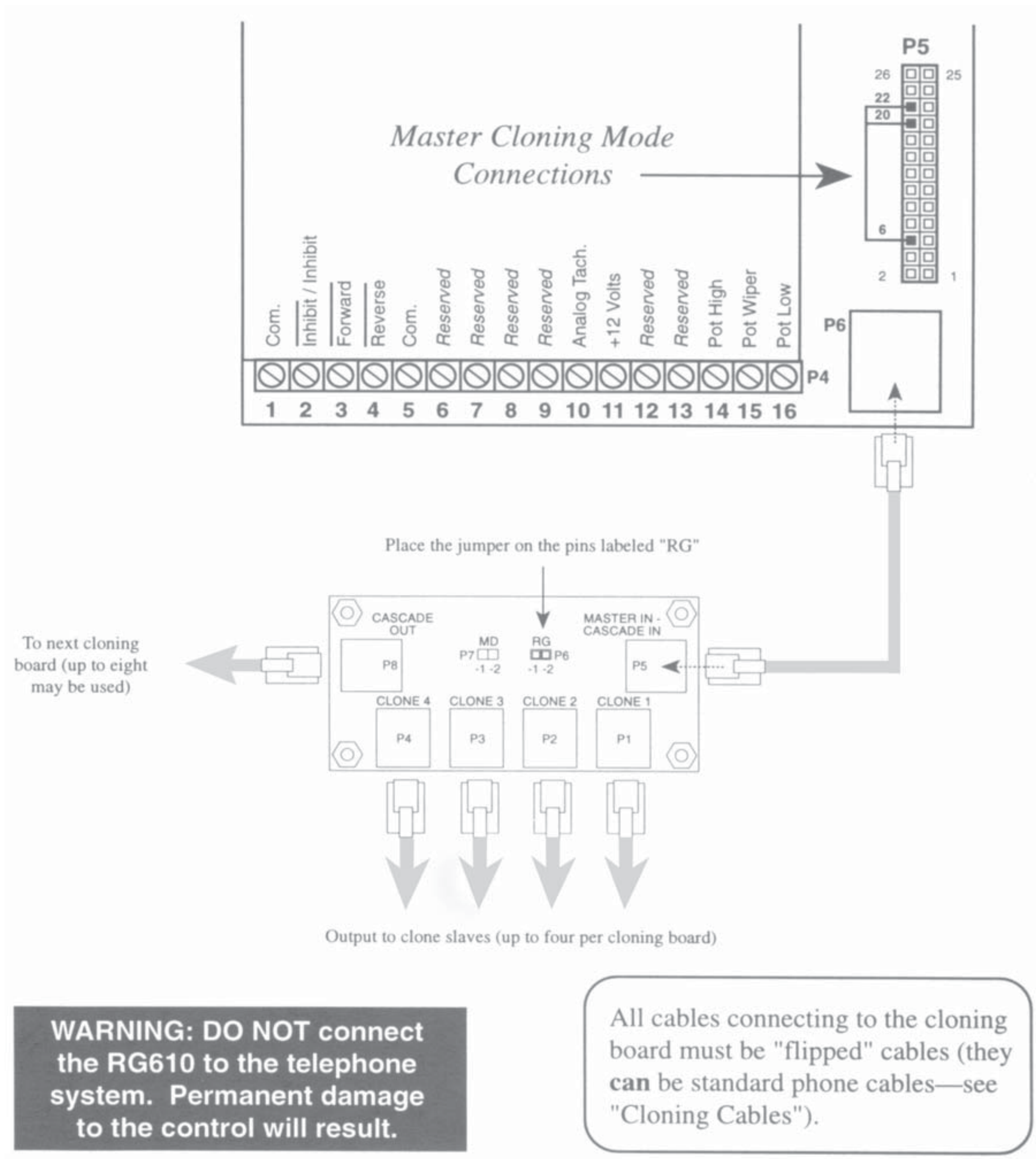


Figure 12

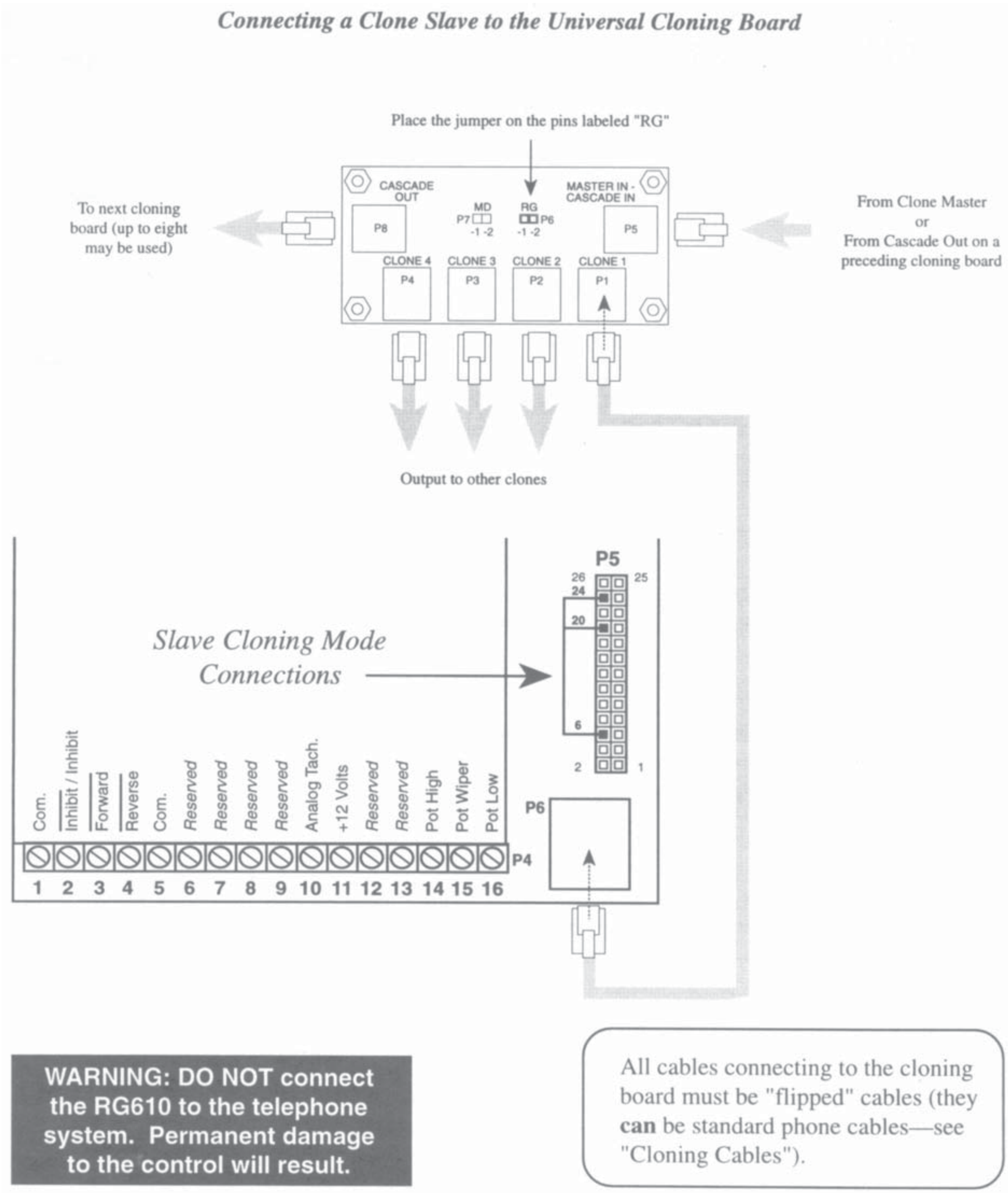

Connecting a Clone Slave to the Universal Cloning Board
Place the jumper on the pins labeled "RG"
CASCADE OUT
MD
P7
RG
P6
MASTER IN - CASCADE IN
P8
P5
To next cloning board (up to eight may be used)
From Clone Master or From Cascade Out on a preceding cloning board
CLONE 4
CLONE 3
CLONE 2
CLONE 1
P4
P3
P2
P1
Output to other clones
P5
Slave Cloning Mode Connections
Com.
Inhibit / Inhibit
Forward
Reverse
Com.
Reserved
Reserved
Reserved
Reserved
Analog Tach.
+12 Volts
Reserved
Reserved
Pot High
Pot Wiper
Pot Low
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
P4
P6
WARNING: DO NOT connect the RG610 to the telephone system. Permanent damage to the control will result.
All cables connecting to the cloning board must be "flipped" cables (they **can** be standard phone cables—see "Cloning Cables").

Figure 13

Appendix A
Soft Trimmer Descriptions: Speed Control Mode

Note: This appendix is intended to provide in-depth information beyond that contained in Appendix B. Both appendices must be read to fully understand the soft trimmers.

Page 1 Items

Item 1: Reverse Current Limit

This is the maximum amount of average reverse current that will be allowed to flow through the motor. The maximum setting is 15 amps, which would be indicated on the user interface by having all 10 lights fully-on (preset 40). Each light represents 1.5 amps, and each button-press represents one-fourth of this.

Example: Let's say you want to limit the reverse current through the motor to 6 amps. Since each full light represents 1.5 amps, it will take 4 full lights to represent 6 amps. The formula for this would look like this: (6 amps)/(1.5 amps/light) = 4 lights. This would be a setting of preset 16, since there are 4 presets per light.

Item 2: Forward Current Limit

This is the maximum amount of average forward current that will be allowed to flow through the motor. The maximum setting is 15 amps, which would be indicated on the user interface by having all 10 lights fully-on (preset 40). Each light represents 1.5 amps, and each button-press represents one-fourth of this.

Example: Let's say you want to limit the forward current through the motor to 8 amps. Since each full light represents 1.5 amps, 5 lights would represent 7.5 amps and 6 lights would represent 9 amps. So the correct setting lies between 5 and 6 full lights (closer to 5 than to 6, since 8 amps is closer to 7.5 than to 9). So you would set this value to 5 full lights *plus 1 or 2 button-presses*. This would end up being either preset 21 or 22.

Item 3: Reverse Acceleration

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this is the approximate amount of time it will take for the target speed to increase from zero-speed to the reverse maximum speed (Page 1, Item 5). Incorrect PID settings (Page 2, Items 1, 2, 3, and 10) and/or a low reverse current limit setting (Page 1, Item 1) can affect the accuracy of this item.

When the feedback mode is set to 6 (open-loop, or no feedback), this is the amount of time it will

Page 1 Items continued

take for the conduction angle to increase from zero to the reverse maximum setting (Page 1, Item 5). The reverse current limit setting (Page 1, Item 1) is the only other trimmer that can alter this time, since PID settings do not apply to open-loop operation.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix B for the 40 settings.

Note: It's very important to have the reverse maximum speed set correctly for your application in order for the reverse acceleration to work optimally.

Item 4: Forward Acceleration

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this is the approximate amount of time it will take for the target speed to increase from zero-speed to the forward maximum speed (Page 1, Item 6). Incorrect PID settings (Page 2, Items 1, 2, 3, and 10) and/or a low forward current limit setting (Page 1, Item 2) can affect the accuracy of this item.

When the feedback mode is set to 6 (open-loop, or no feedback), this is the amount of time it will take for the conduction angle to increase from zero to the forward maximum setting (Page 1, Item 6). The forward current limit setting (Page 1, Item 2) is the only other trimmer that can alter this time, since PID settings do not apply to open-loop operation.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix B for the 40 settings.

Note: It's very important to have the forward maximum speed set correctly for your application in order for the forward acceleration to work optimally.

Item 5: Reverse Maximum Speed

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this setting is the maximum speed allowed in the reverse direction.

When the feedback mode is set to 6 (open-loop, or no feedback), this setting is actually the maximum conduction angle allowed in the reverse direction.

Item 6: Forward Maximum Speed

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this setting is the maximum speed allowed in the forward direction.

When the feedback mode is set to 6 (open-loop, or no feedback), this setting is actually the maximum conduction angle allowed in the forward direction.

Page 1 Items continued

Item 7: Reverse Deceleration

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this is the approximate amount of time it will take for the target speed to decrease from the reverse maximum speed (Page 1, Item 5) to zero-speed. Incorrect PID settings (Page 2, Items 1, 2, 3, and 10) and/or a low reverse current limit setting (Page 1, Item 1) can affect the accuracy of this item.

When the feedback mode is set to 6 (open-loop, or no feedback), this is the amount of time it will take for the conduction angle to decrease from the reverse maximum setting (Page 1, Item 5) to zero. The reverse current limit setting (Page 1, Item 1) is the only other trimmer that can alter this time, since PID settings do not apply to open-loop operation.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix B for the 40 settings.

Note: It's very important to have the reverse maximum speed set correctly for your application in order for the reverse deceleration to work optimally.

Item 8: Forward Deceleration

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this is the approximate amount of time it will take for the target speed to decrease from the forward maximum speed (Page 1, Item 6) to zero-speed. Incorrect PID settings (Page 2, Items 1, 2, 3, and 10) and/or a low forward current limit setting (Page 1, Item 2) can affect the accuracy of this item.

When the feedback mode is set to 6 (open-loop, or no feedback), this is the amount of time it will take for the conduction angle to decrease from the forward maximum setting (Page 1, Item 6) to zero. The forward current limit setting (Page 1, Item 2) is the only other trimmer that can alter this time, since PID settings do not apply to open-loop operation.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix B for the 40 settings.

Note: It's very important to have the forward maximum speed set correctly for your application in order for the forward deceleration to work optimally.

Item 9: Reverse Minimum Speed

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this setting is the minimum speed allowed in the reverse direction.

When the feedback mode is set to 6 (open-loop, or no feedback), this setting is actually the minimum conduction angle allowed in the reverse direction.

Page 1 Items continued

Note: Whether zero-speed (or zero conduction angle) is allowed is determined not only by the minimum speed setting, but also by the deadband width setting (Page 3, Item 5). If it is set to anything other than 0% (preset 1), there will still be a target speed (or conduction angle) of zero when the Speedpot Signal input is in the deadband region, regardless of the minimum speed setting.

\Item 10: Forward Minimum Speed

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this setting is the minimum speed allowed in the forward direction.

When the feedback mode is set to 6 (open-loop, or no feedback), this setting is actually the minimum
conduction angle allowed in the forward direction.

Note: Whether zero-speed (or zero conduction angle) is allowed is determined not only by the minimum speed setting, but also by the deadband width setting (Page 3, Item 5). If it is set to anything other than 0% (preset 1), there will still be a target speed (or conduction angle) of zero when the Speedpot Signal input is in the deadband region, regardless of the minimum speed setting.

Page 2 Items

Special note regarding the PID settings (Page 2, Items 1, 2, 3, and 10): It's important that the reverse and forward maximum speed settings (Page 1, Items 5 and 6, respectively) are set correctly for your application for the PID settings to work optimally.

Item 1: PID – P Gain

This is a multiplier placed on the difference between the target speed and the actual speed (as measured by the armature feedback signal or the analog tachometer signal). The effect of making this gain larger is to increase the aggressiveness of the RG610's response to a difference between target speed and actual speed. When this value is too small, the RG610 will respond too slowly to a speed change. When it is too large, the RG610 will attempt to respond too quickly and create a speed error in the opposite direction, and an oscillation can occur. This oscillation can be violent when the PID aggression adjustment (Page 2, Item 10) is set too high, and can even damage the motor if **extreme care** is not taken to increase this value slowly.

Note: This trimmer is meaningful only when the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback). When operating the control in the openloop
mode (feedback mode set to 6), this trimmer has no effect.

Item 2: PID – I Gain

This is a multiplier placed on the integral of the difference between the target speed and actual speed (as measured by the armature feedback signal or the analog tachometer signal). It causes the RG610 to compensate more and more as a speed error exists for a longer and longer period of time. This gain is necessary to reduce the steady-state error in speed to zero. When this gain is too low, the reaction of the control will be sluggish, and it will take a long time to attain the target speed. When the I-gain is too high, excessive overshoot of the motor speed can occur, along with an unwanted oscillation of motor speed around the target speed.

Note: This trimmer is meaningful only when the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback). When operating the control in the openloop
mode (feedback mode set to 6), this trimmer has no effect.

Item 3: PID – D Gain

This is a multiplier placed on the rate-of-change of the difference between the target speed and actual speed (as measured by the armature feedback signal or the analog tachometer signal). This gain causes the control to react quicker as this rate-of-change increases. D-Gain can also play an important role in compensating for a load that has a lot of inertia.

Note: This trimmer is meaningful only when the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback). When operating the control in the openloop mode (feedback mode set to 6), this trimmer has no effect.

Page 2 Items continued

Item 4: IR Compensation

This trimmer causes the applied throttle to increase with increasing motor current. This is necessary when using armature feedback, due to the voltage drop across the resistance of the motor windings. As the motor current increases, the voltage measured across the armature will increase, giving a falsely high indication of motor speed. This trimmer compensates for the control's tendency to reduce the applied throttle when this occurs. Too little IR compensation can allow the motor's speed to decrease when loaded. Too much IR compensation can cause unwanted oscillations of motor speed.

Note: This trimmer is meaningful only when the feedback mode (Page 2, Item 9) is set to 1 (armature feedback). In any other mode, it has no effect.

Item 5: Forward, Reverse, & Inhibit Input Setup

This setting determines whether the Forward and Reverse direction signals (P4-3 and P4-4, respectively) will be interpreted as momentary or continuous contact, and whether the Inhibit signal (P4-2) is active-low or active-high. When momentary contact is selected, a direction signal must be pulled low (connected to Common) for at least 40 milliseconds to be recognized as a command. When continuous contact is selected, the direction signal must be pulled low for the entire time that direction is desired. The Forward and Reverse signals are both pulled high internally through 10Ký resistors, and are always active-low.

When the Inhibit signal is active-low, the drive will be inhibited when this signal is pulled low (connected to Common). When the Inhibit signal is active-high, the drive will be inhibited when this signal is **not** pulled low (this signal is pulled high internally through a 10Ký resistor).

Item 6: Inhibit Function Selection

There are three different actions that can be initiated by the Inhibit signal, and this input can be configured to be momentary or continuous contact, just like the Forward and Reverse inputs. It can be helpful to refer to the momentary contact setting on the Inhibit input as the "forced completion" mode, since that's the effect it has. In this mode, the control will be forced to complete the inhibit cycle even if the Inhibit signal is removed. In other words, you can't change your mind once the inhibit is initiated. Alternatively, if continuous contact is chosen, the control will resume normal operation as soon as the Inhibit signal is removed.

Note: When in single direction mode, if no direction is selected, the control will be inhibited. That is the only way the control will enter Inhibit mode other than by intentionally inhibiting it through its normal input.

This setting defines the Inhibit function as one of these three things: 1) Decelerate to a stop, 2) Coast, or 3) Emergency stop.

Page 2 Items continued

Decelerate to a stop:

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this setting causes the Inhibit signal to initiate an action identical to placing the speed command signal in deadband. The motor will slow to zero-speed in the normal fashion, using the programmed values for deceleration times (Page 1, Items 7 and 8). Drive will be removed, and braking may be applied as needed to achieve zero-speed.

When the feedback mode is set to 6 (open-loop, or no feedback), this setting causes the Inhibit signal to initiate a simple reduction of the conduction angle to zero. This reduction will take place at whatever deceleration time you have programmed (Page 1, Item 7 or 8). No braking can occur in open-loop mode; the control merely stops driving.

Coast to a stop:

Regardless of the feedback mode (Page 2, Item 9) you have selected, this setting causes the Inhibit signal to initiate the immediate removal of any drive to the motor. When this happens, the motor will simply assume the speed that is dictated by any other forces that are exerted on it.

Emergency stop:

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this setting causes the Inhibit signal to initiate a braking to a stop that is limited only by the current limit setting (Page 1, Item 1 or 2).
When the feedback mode is set to 6 (open-loop, or no feedback), this setting has the same effect as the previous setting, coast to a stop.

Item 7: Inhibit Delay

This setting has meaning only when the inhibit function selection (Page 2, Item 6) is set to one of the forced-completion (momentary contact) modes.

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), this setting determines the amount of time the control will remain inhibited after reaching *zero-speed.*

When the feedback mode is set to 6 (open-loop, or no feedback), this setting determines the amount of time the control will remain inhibited after reaching *zero conduction angle (zero drive).*

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix B for the 40 settings.

Page 2 Items continued

Item 8: Speed/Torque Mode Selection

This item has only two values, one for selecting speed control and the other for selecting torque control. When you change this setting, it will take effect after power has been removed and reapplied to the control.

Item 9: Feedback Mode Selection

There are three settings for this item, two of which select between feedback sources and one that selects that *no* feedback be used. The three alternatives are described below.

Note: We recommend stopping the motor before changing the value of this item. Changes made “on the fly” could result in damage to the motor.

Armature feedback:

In this mode, the control uses an on-board signal that is proportional to the motor armature voltage as an estimate of the motor’s speed. This information, or feedback, is used to determine whether the requested speed is being achieved.

This feedback is only an estimate, and its accuracy will decline with increasing motor current. This is why IR compensation (Page 2, Item 4) is used, but even that won’t fix everything. As a motor heats during operation, the resistance of its windings will change. So it’s unreasonable to expect any one setting of IR compensation to be adequate under all operating conditions. However, the combination of armature feedback and IR compensation provides acceptable performance in many applications.

Analog tachometer feedback:

In this mode, the control is given (or fed) a signal from an analog tachometer, the shaft of which is attached to the motor shaft, and spins along with it. The analog tachometer can be thought of as an unloaded DC motor which is being turned by your motor. The RG610 supports analog tachometers with an output of 50 volts per 1000 RPM.

Just as putting a voltage across a motor makes it spin, making the analog tachometer spin creates a corresponding voltage across its armature. This voltage will be proportional to the motor speed, and it is this voltage that is used by the control as feedback. It remains accurate regardless of the current through your motor, since there is still no current flowing through the analog tachometer. IR compensation is therefore unnecessary (not to mention useless), and this mode of feedback is accurate regardless of motor load. See “Complete Installation” for a description of analog tachometer
connections.

No feedback:

This is called open-loop mode, or conduction angle control mode. The speed of the motor is not observed by the control in any way. Rather than a requested speed, as in the two previously

Page 2 Items continued

discussed modes, in this mode there is a requested conduction angle.

In the two previous modes, if you applied a fixed speed command signal, the control would vary the output drive or even apply braking if required, to maintain the requested speed. That would be similar to the cruise control feature in an automobile.

However, in this mode, if you applied a fixed conduction angle request signal, the output drive from the control would not change, regardless of the motor's load or speed. This would be similar to putting the throttle in an automobile in one place and not changing the setting. As the car went up and down hills, for instance, the car's speed would vary accordingly—no attempt would (or could) be made by the car to restore the original speed.

Item 10: PID Aggression Adjustment

Note: This setting is one of the most important and powerful, and if it were possible for this section to be written in red neon light, it would be. Careless use of this item can cause the control to permanently damage your motor.

As advertised, this setting adjusts the aggression with which the P, I, and D gains are allowed to carry out their respective tasks. It basically alters the range of these gains, with higher settings creating larger ranges. The forty settings on the LED bargraph will become more coarse as this value increases, to cover the wider range. This setting should be increased only when the factoryset value does not allow proper PID tuning to be accomplished.

The factory setting of preset 12 allows the control to be tuned to drive an average motor with what we consider to be a reasonable amount of gain. Settings lower than this (presets 1 – 11) cause the PID tuning range to be milder and more sluggish than the factory setting. Higher settings (presets 13 – 40) are provided to give the control the ability to ***aggressively*** drive a motor, because this is sometimes necessary for tight control. However, great care should be taken to avoid demagnetizing a permanent magnet motor.

When changing this setting, the present values of the P, I, and D gains will change with it. It's a good idea to reduce them all before significantly increasing this setting.

Page 3 Items

Special note regarding Page 3, Items 1-6: The word "speedpot" is used as shorthand notation. When it's used, it certainly includes speedpots (actual potentiometers), but it's intended to include the use of external voltage supplies or a 4-20mA current signal as well. Any of these signals are connected to the control at pin 15 of the P4 connector on the upper board when they're used. "Speedpot" refers to any signal that connects to that point.

Item 1: Speed Command Source

This setting instructs the control to pay attention to *either* the speedpot *or* to a fixed speed setpoint (Page 3, Item 6) for its speed commands. This setting also instructs the control regarding the issues of single or dual direction, "neutral safety", and "hysteresis".

When single direction operation is chosen, the Forward and Reverse inputs (pins 3 and 4, respectively, on the P4 connector) must be used to specify a direction to operate in. A direction is selected by connecting its pin to the Common pin (pin 1 or 5 on the P4 connector). Then the entire speedpot signal's range is used for that direction only.

Note: In single direction mode, if no direction is selected, the control will be in Inhibit mode (see Page 2, Item 6).

When **dual-direction mode** (also called bidirectional or "wig-wag" mode) is chosen, the speedpot signal's range is divided into two parts, one part for each direction, according to the speedpot setup trimmers (Page 3, Items 2-5). In this case, the Forward and Reverse inputs are unnecessary, since both speed and direction are selected with the speedpot signal.

When **neutral safety** is enabled (turned on), its effect will be seen at power-up only. This feature keeps the control from turning the motor until the speedpot signal enters the deadband, or until the Inhibit input is activated and released. Then the RG610 allows the control to function normally. This keeps the control from causing the motor to take off at full-blast (or any other speed) when you turn the power on.

When **hysteresis** is enabled (turned on), the control will ignore any *very small* changes in speed request. This is sometimes necessary in electrically "noisy" environments, when spurious (accidental) signals can be falsely interpreted as very small changes in the speedpot signal. Turning hysteresis on in a situation like this can keep the noise from changing the motor speed. Sometimes this effect will be noticed when you try to change the speedpot setting just a little bit, and find that you can't do it. In cases like this, you must change the speed a significant amount (an amount that is large enough to get the control's attention—clearly **not** noise), and then change the speed back to where you want it.

Fixed Speed Setpoint: Hysteresis does not apply when using a fixed speed setpoint. Neutral safety can be selected, however, in which case the Inhibit input must be activated and released before the control will drive the motor.

Page 3 Items continued

Item 2: Speedpot Minimum Calibration

This setting indicates the low end (near 0V in the 0 – 5V mode, or near -10V in the -10 – +10V mode) of the speedpot signal range you are using.

Example: You are using a potentiometer and are in the 0 – 5V mode, but the travel of your speedpot is restricted for some reason (it happens!), and it can't turn fully counterclockwise to the 0V position. It can only turn the signal down to 0.5V, which is 10% of the way into the 0 – 5V range. Since the 0 – 5V range is represented by the 40 settings of the bargraph display, you would set the display to read 10% of its maximum, or preset 4 (remember that the minimum setting is preset 1, so this is 3 button-presses up from the minimum). This would be a setting of one full light. Now the low end of your speedpot signal range would be 0.5V, instead of 0V, and the signal would be properly interpreted by the control.

Note: This setting is used in dual-direction mode only—in single-direction mode, the deadband width (Page 3, Item 5) is used for this function.

Item 3: Speedpot Maximum Calibration

This setting indicates the high end (near 5V in the 0 – 5V mode, or near +10V in the -10 – +10V mode) of the speedpot signal range you want/need to use.

Example: Let's use the same potentiometer from the previous example that can turn counterclockwis to only 0.5V. Now let's assume that its travel is also restricted in the clockwise direction, and that it can turn the speedpot signal up to only 4V, instead of 5V. Since this is 80% of the maximum setting, you would simply set the bargraph display to 80% of its maximum value, or 8 full lights. Since each full light is equivalent to 4 button-presses, this setting is also 8 buttonpresses down from the maximum setting of 40, or preset 32. Now the speedpot signal range is set up to be 0.5V – 4V to match the potentiometer's range.

Item 4: Speedpot Center Calibration

This setting indicates the position of the center of the speedpot signal range. We use the word "center" loosely here, since it can be set anywhere within the speedpot signal range. It is actually the dividing line between the forward and reverse directions. The deadband width (Page 3, Item 5) will be centered around this position.

Note: This setting is used in dual-direction mode only.

Example: In this example, you're using an external voltage for speed command with a range of -10V to +10V. Now you need to center the deadband around -5V for some reason. This means that -5V will be the "center" (operationally) of the speed command signal range; -5V will be the dividing line between the forward and reverse directions. The signal range spans 20V, from -10V on the low end to +10V on the high end, and this range is represented by the 10 lights on the bargraph display. So each of the 10 lights represents a 2V chunk of the signal range. You can

Page 3 Items continued

think of the -5V point as being 5V higher than the lowest setting of -10V, or as being 25% of the way into the signal range. Either way, the correct setting will be 2.5 lights, or 2 full lights *plus two button-presses* (preset 10). Now you'll be operating in the reverse direction when the speed command signal is between -10V and -5V, and in the forward direction when the speed command signal is between -5V and +10V.

Item 5: Deadband Width

This setting determines the width of the deadband, of course—the deadband being that portion of the speedpot signal range in which zero-speed (or zero conduction angle in open-loop operation) is requested. In dual-direction mode, this width will be centered around the speedpot center calibration (Page 3, Item 4). In single direction mode, this width will extend from the low end point (0V or -10V, depending on voltage range selected) upward.

Note: If you are using nonzero minimum speed settings, and do *not* want a speed (or conduction angle in open-loop operation) request of zero to be possible, you must set the deadband width to preset 1 (0%). Otherwise, the speed request will be zero any time the speed command signal enters the deadband region.

Item 6: Speed Setpoint

When the feedback mode (Page 2, Item 9) is set to 1 (armature feedback) or 2 (analog tachometer feedback), and the speed command source (Page 3, Item 1) is set to 9 or 10 (fixed speed setpoint), the value of this item will be used as the requested speed, and the speedpot signal will be ignored.

In this case, the lower half of the bargraph display is used for reverse speed requests, and the upper half for forward speed requests. The setting in the very center of the display (preset 20) is a speed request of zero. Settings from preset 19 to preset 1 represent speed requests from reverse minimum speed (Page 1, Item 9) to reverse maximum speed (Page 1, Item 5), respectively. Likewise, settings from preset 21 to preset 40 represent speed requests from forward minimum speed (Page 1, Item 10) to forward maximum speed (Page 1, Item 6), respectively.

When the feedback mode is set to 6 (open-loop, or no feedback), and the speed command source (Page 3, Item 1) is set to 9 (fixed speed setpoint), the value of this item will be used as the requested conduction angle, and the speedpot signal will be ignored.

In this case, the lower half of the bargraph display is used for reverse conduction angle requests, and the upper half for forward conduction angle requests. The setting in the very center of the display (preset 20) is a conduction angle request of zero. Settings from preset 19 to preset 1 represent conduction angle requests from reverse minimum speed (Page 1, Item 9) to reverse maximum speed (Page 1, Item 5), respectively. Likewise, settings from preset 21 to preset 40 represent conduction angle requests from forward minimum speed (Page 1, Item 10) to forward maximum speed (Page 1, Item 6), respectively.

Page 3 Items continued

Item 7: ***Reserved***

Item 8: ***Reserved***

Item 9: Default Display Selection

This setting determines what the LED bargraph will display when the slide switch is in the "RUN" (center) position. This is the position the switch will be in the majority of the time, and you can pick what you want the bargraph to display, if anything.

Item 10: ***Reserved***

Appendix B
Soft Trimmer Listing: Speed Control Mode

Note: This appendix is intended to serve as a quick reference once you are familiar with the soft trimmers. Complete soft trimmer descriptions are contained in Appendix A.
Note: Trimmer values are active as they are changed (see "Programming the RG610").

Page 1 Items

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
1	Reverse Current Limit	0 – 15 Amps (Preset 1 – Preset 40)	12 Amps (Preset 32)		Maximum reverse motor current– *each full light is 1.5 Amps*
2	Forward Current Limit	0 – 15 Amps (Preset 1 – Preset 40)	12 Amps (Preset 32)		Maximum forward motor current– *each full light is 1.5 Amps*
3	Reverse Acceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target speed/conduction angle to increase from zero to reverse maximum setting
4	Forward Acceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target speed/conduction angle to increase from zero to forward maximum setting
5	Reverse Maximum Speed	0 – 100% Max. AFB (0 – 150V or 0 – 300V) (Preset 1 – Preset 40)	60% Max. AFB (90/180V) (Preset 24)		*Armature Feedback Mode*
6	Forward Maximum Speed	0 – 3,800 RPM (Preset 1 – Preset 40)	2,280 RPM (Preset 24)		*Analog Tachometer Feedback Mode (50V/KRPM only)*
	Shaded area applies to both items 5 & 6	0 – 100% conduction (Preset 1 – Preset 40)	60% conduction (Preset 24)		*Open-Loop Mode*
7	Reverse Deceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target speed/conduction angle to decrease from reverse maximum setting to zero
8	Forward Deceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target speed/conduction angle to decrease from reverse maximum setting to zero
9	Reverse Minimum Speed	0 – 100% Max. AFB (0 – 150V or 0 – 300V) (Preset 1 – Preset 40)	0% Max. AFB (0/0V) (Preset 1)		*Armature Feedback Mode*
10	Forward Minimum Speed	0 – 3,800 RPM (Preset 1 – Preset 40)	0 RPM (Preset 1)		*Analog Tachometer Feedback Mode (50V/KRPM only)*
	Shaded area applies to both items 9 & 10	0 – 100% conduction (Preset 1 – Preset 40)	0% conduction (Preset 1)		*Open-Loop Mode*

*See the table at the bottom of page B-3 for the times associated with each of the presets.

Page 2 Items

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
1	PID – P Gain	0 – 100% (Preset 1 – Preset 40)	60% (Preset 24)		PID Proportional gain
2	PID – I Gain	0 – 100% (Preset 1 – Preset 40)	30% (Preset 12)		PID Integral gain
3	PID – D Gain	0 – 100% (Preset 1 – Preset 40)	0% (Preset 1)		PID Derivative gain
4	IR Compensation	0 – 100% (Preset 1 – Preset 40)	0% (Preset 1)		Applies in Armature Feedback mode only
5	Forward, Reverse, & Inhibit Input Setup	1 – 4	1	1 2 3 4	Fwd, Rev continuous contact; Inhibit active-low Fwd, Rev continuous contact; Inhibit active-high Fwd, Rev momentary contact; Inhibit active-low Fwd, Rev momentary contact; Inhibit active-high
6	Inhibit Function Selection	1 – 6	1	1 2 3 4 5 6	When inhibited, decelerate to a stop When inhibited, coast to a stop When inhibited, perform current-limited emergency stop #1 *with forced completion (momentary contact)* #2 *with forced completion (momentary contact)* #3 *with forced completion (momentary contact)*
7	Inhibit Delay	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Delay after a forced-completion inhibit is executed
8	Speed/Torque Mode Selection	1 – 2	1	1 2	Speed Control Mode Torque Control Mode

*See the table at the bottom of page B-3 for the times associated with each of the presets.

Page 2 Items continued

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
9	Feedback Mode Selection	1 – 6	1	1	Armature Feedback Mode
				2	Analog Tachometer Feedback Mode (50V/KRPM only)
				3	Same as #1
				4	Same as #1
				5	Same as #1
				6	Open-Loop Mode (no feedback)
					Changes in the feedback mode should only be made with the motor stopped!
10	PID Aggression Adjustment	0 – 100% (Preset 1 – Preset 40)	30% (Preset 12)		See soft trimmer description in Appendix A before adjusting

Acceleration, Deceleration, & Inhibit Delay Times

Preset	Time (seconds)	Preset	Time (seconds)	Preset	Time (seconds)	Preset	Time (seconds)
1	0.3	**11**	3.2	**21**	12	**31**	40
2	0.5	**12**	3.7	**22**	13	**32**	45
3	0.7	**13**	4.0	**23**	15	**33**	51
4	1.0	**14**	4.5	**24**	17	**34**	58
5	1.3	**15**	5	**25**	19	**35**	65
6	1.5	**16**	6	**26**	22	**36**	74
7	1.8	**17**	7	**27**	25	**37**	83
8	2.1	**18**	8	**28**	28	**38**	94
9	2.4	**19**	9	**29**	32	**39**	105
10	2.8	**20**	10	**30**	36	**40**	120

Page 3 Items

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
1	Speed Command Source	1 – 10	1	1	Speedpot, single direction
				2	Speedpot, single direction, neutral safety
				3	Speedpot, single direction, hysteresis
				4	Speedpot, single direction, neutral safety, hysteresis
				5	Speedpot, dual direction
				6	Speedpot, dual direction, neutral safety
				7	Speedpot, dual direction, hysteresis
				8	Speedpot, dual direction, neutral safety, hysteresis
				9	Fixed Speed Setpoint
				10	Fixed Speed Setpoint, neutral safety
2	Speedpot Minimum Calibration†	0 – 100% of Speedpot Signal Input Range (Preset 1 – Preset 40)	0% (Preset 1)		Calibrates the speedpot input's fully counterclockwise (low end) position Applies in dual direction mode only—use Speedpot Deadband Width (Page 3, Item 5) in single direction mode
3	Speedpot Maximum Calibration†	0 – 100% of Speedpot Signal Input Range (Preset 1 – Preset 40)	100% (Preset 40)		Calibrates the speedpot input's fully clockwise (high end) position
4	Speedpot Center Calibration†	0 – 100% of Speedpot Signal Input Range (Preset 1 – Preset 40)	50% (Preset 20)		Calibrates the speedpot input's center position Applies in dual direction mode only
5	Speedpot Deadband Width†	0 – 100% of Speedpot Signal Input Range (Preset 1 – Preset 40)	10% (Preset 4)		Calibrates the width of the speedpot input's deadband This region will be centered around the Speedpot Center Calibration (Page 3, Item 4)

†Figure 14 on page B-6 is provided to help visualize the meaning of this trimmer.

Page 3 Items continued

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
6	Speed Setpoint	Rev. Maximum Speed – Fwd. Maximum Speed (Preset 1 – Preset 40)	Zero-Speed (Preset 20)	Preset 1 ... Preset 19 Preset 20 Preset 21 ... Preset 40	Reverse Maximum Speed *...linear range* Reverse Minimum Speed Zero Speed Forward Minimum Speed *...linear range* Forward Maximum Speed
7	*Reserved*				
8	*Reserved*				
9	Default Display Selection	1 – 8	2	 1 2 3 4 5 6 7 8	Defines what the bargraph display will indicate when the slide switch is in the "RUN" (center) position Nothing (all lights off) Power Indicator (top 2 & bottom 2 lights on) Target Setting (0 – 100%) Feedback (0 – 100%) Conduction Angle (0 – 100%) Motor Current (0 – 15 amps) Speedpot Input (0 – 100% of calibrated range) Control Status Flags: **LED1 – Power Indicator** **LED2 – Direction Indicator** on = forward drive off = reverse drive **LED3 – Neutral Safety Indicator** on = preventing drive off = not preventing drive **LED4 – Zero-speed Indicator** on = feedback indicates zero-speed off = feedback indicates rotation **LED5 – Inhibit Indicator** on = drive inhibited off = drive enabled **LED6 – Current Limit Indicator** on = drive in current limit off = drive not in current limit **LED7 – Conduction Angle Status** on = conduction angle at maximum off = conduction angle < maximum **LED8 – Accel/Decel Status** on = accel/decel in progress off = accel/decel completed ***LED9–LED10 Reserved***
10	*Reserved*				

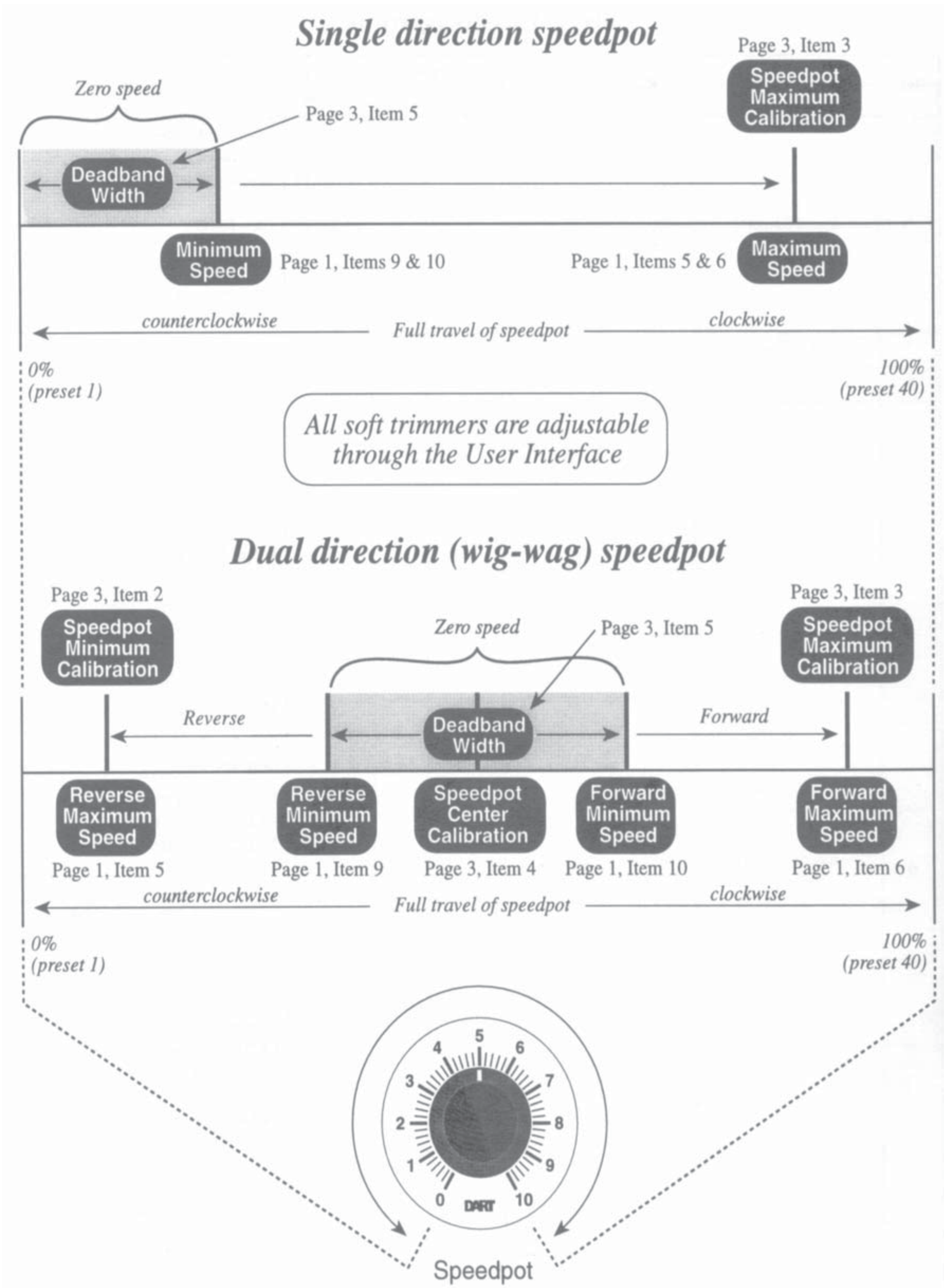

Single direction speedpot
Zero speed
Page 3, Item 5
Page 3, Item 3
Speedpot Maximum Calibration
Deadband Width
Minimum Speed
Page 1, Items 9 & 10
Page 1, Items 5 & 6
Maximum Speed
counterclockwise
Full travel of speedpot
clockwise
0% (preset 1)
100% (preset 40)
All soft trimmers are adjustable through the User Interface
Dual direction (wig-wag) speedpot
Page 3, Item 2
Speedpot Minimum Calibration
Zero speed
Page 3, Item 5
Page 3, Item 3
Speedpot Maximum Calibration
Reverse
Deadband Width
Forward
Reverse Maximum Speed
Reverse Minimum Speed
Speedpot Center Calibration
Forward Minimum Speed
Forward Maximum Speed
Page 1, Item 5
Page 1, Item 9
Page 3, Item 4
Page 1, Item 10
Page 1, Item 6
counterclockwise
Full travel of speedpot
clockwise
0% (preset 1)
100% (preset 40)
0 1 2 3 4 5 6 7 8 9 10
DART
Speedpot

Figure 14

Appendix C
Soft Trimmer Descriptions: Torque Control Mode

Note: This appendix is intended to provide in-depth information beyond that contained in Appendix D. Both appendices must be read to fully understand the soft trimmers.

Page 1 Items

Item 1: Reverse Speed Limit

This is the maximum average motor speed that will be allowed in the reverse direction. This limit exists so that you can keep the motor from going to full speed if it is unexpectedly (or expectedly) unloaded. The motor speed will be measured by one of two methods that is chosen with feedback mode selection (Page 2, Item 9).

Example: Let's say you're using an analog tachometer to measure motor speed, and you want to limit the average reverse speed to 1000 RPM. The RG610 allows you to use a tachometer with an output of 50V per 1000 RPM, with a maximum speed of 3800 RPM. So all ten lights fully-on (preset 40) would represent 3800 RPM, and you need to determine what setting would represent 1000 RPM. The preset number you need is (1000/3800)*40 = 10.5, so you would round to the nearest whole number and use preset 11 as your setting. Since there are 4 button-presses per light, this would be one button-press less than 3 lights.

Item 2: Forward Speed Limit

This is the maximum average motor speed that will be allowed in the forward direction. This limit exists so that you can keep the motor from going to full speed if it is unexpectedly (or expectedly) unloaded. The motor speed will be measured by one of two methods that is selected with feedback mode selection (Page 2, Item 9).

Example: This time let's say you're using armature feedback to measure motor speed, and you have a motor with a rated voltage of 180V (which implies you are powering the RG610 from a 230V AC source). Let's also say you need to limit the average forward speed to that which corresponds to 60V across the armature. Since the maximum armature voltage allowed is 300V, that's what all ten lights fully-on (preset 40) would represent. So you would need a setting of (60/300)*40 = 8. In this case no rounding would be required, and the correct setting would be preset 8. This would be 2 fully-on lights.

Page 1 Items continued

Item 3: Reverse Acceleration

This is the approximate amount of time it will take for the target torque to increase from zerotorque to the reverse maximum torque (Page 1, Item 5). The PID settings (Page 2, Items 1,2,3, and 10) and the reverse speed limit setting (Page 1, Item 1) can affect the accuracy of this item.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix D for the 40 settings.

Item 4: Forward Acceleration

This is the approximate amount of time it will take for the target torque to increase from zerotorque to the forward maximum torque (Page 1, Item 6). The PID settings (Page 2, Items 1,2,3, and 10) and the forward speed limit setting (Page 1, Item 2) can affect the accuracy of this item.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix D for the 40 settings.

Item 5: Reverse Maximum Torque

This setting is the maximum torque allowed in the reverse direction. The minimum value is zero, which would be indicated on the user interface by the bottom light blinking slowly (preset 1).

The maximum value is 15 amps, which would be indicated on the user interface by having all 10 lights full-on (preset 40). Each light represents 1.5 amps, and each button-press represents onefourth of this.

Item 6: Forward Maximum Torque

This setting is the maximum torque allowed in the forward direction. The minimum value is zero, which would be indicated on the user interface by the bottom light blinking slowly (preset 1). The maximum value is 15 amps, which would be indicated on the user interface by having all 10 lights full-on (preset 40). Each light represents 1.5 amps, and each button-press represents one-fourth of this.

Item 7: Reverse Deceleration

This is the approximate amount of time it will take for the target torque to decrease from the reverse maximum torque (Page 1, Item 5) to zero-torque. The PID settings (Page 2, Items 1,2,3, and 10) and the reverse speed limit setting (Page 1, Item 1) can affect the accuracy of this item.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix D for the 40 settings.

Page 1 Items continued

Item 8: Forward Deceleration

This is the approximate amount of time it will take for the target torque to decrease from the forward maximum torque (Page 1, Item 6) to zero-torque. The PID settings (Page 2, Items 1,2,3, and 10) and the forward speed limit setting (Page 1, Item 2) can affect the accuracy of this item.

The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix D for the 40 settings.

Item 9: Reverse Minimum Torque

This setting is the minimum torque allowed in the reverse direction. The minimum value is zero, which would be indicated on the user interface by the bottom light blinking slowly (preset 1). The maximum value is 15 amps, which would be indicated by all 10 lights fully-on (preset 40). Each light represents 1.5 amps, and each button-press represents one-fourth of this.

Note: Whether zero-torque is allowed is determined not only by the minimum torque setting, but also by the deadband width setting (Page 3, Item 5). If it is set to anything other than 0% (preset 1), there will still be a target torque of zero when the Torquepot Signal input is in the deadband region, regardless of the minimum torque setting.

Item 10: Forward Minimum Torque

This setting is the minimum torque allowed in the forward direction. The minimum value is zero, which would be indicated on the user interface by the bottom light blinking slowly (preset 1). The maximum value is 15 amps, which would be indicated by all 10 lights fully-on (preset 40) Each light represents 1.5 amps, and each button-press represents one-fourth of this.

Note: Whether zero-torque is allowed is determined not only by the minimum torque setting, but also by the deadband width setting (Page 3, Item 5). If it is set to anything other than 0% (preset 1), there will still be a target torque of zero when the Torquepot Signal input is in the deadband region, regardless of the minimum torque setting.

Page 2 Items

Item 1: PID – P Gain

This is a multiplier placed on the difference between the target torque and the actual torque. The effect of making this gain larger is to increase the aggressiveness of the RG610's response to a difference between target torque and actual torque. When this value is too small, the RG610 will respond too slowly to a torque change. When it is too large, the RG610 will attempt to respond too quickly and create a torque error in the opposite direction, and an oscillation can occur. This oscillation can be violent when the PID aggression adjustment (Page 2, Item 10) is set too high, and can even damage the motor if **extreme care** is not taken to increase this value slowly.

Item 2: PID – I Gain

This is a multiplier placed on the integral of the difference between the target torque and actual torque. It causes the RG610 to compensate more and more as a torque error exists for a longer and longer period of time. This gain is necessary to reduce the steady-state error in torque to zero. When this gain is too low, the reaction of the control will be sluggish, and it will take a long time to attain the target torque. When the I-gain is too high, excessive overshoot of the motor torque can occur, along with an unwanted oscillation of motor torque around the target torque.

Item 3: PID – D Gain

This is a multiplier placed on the rate-of-change of the difference between the target torque and actual torque. This gain causes the control to react quicker as this rate-of-change increases.

Item 4: ***Reserved***

Item 5: Forward, Reverse, & Inhibit Input Setup

This setting determines whether the Forward and Reverse direction signals (P4-3 and P4-4, respectively) will be interpreted as momentary or continuous contact, and whether the Inhibit signal (P4-2) is active-low or active-high. When momentary contact is selected, a direction signal must be pulled low (connected to Common) for at least 40 milliseconds to be recognized as a command. When continuous contact is selected, the direction signal must be pulled low for the entire time that direction is desired.

When the Inhibit signal is active-low, the drive will be inhibited when this signal is pulled low (connected to Common). When the Inhibit signal is active-high, the drive will be inhibited when this signal is **not** pulled low (this signal is pulled high internally).

Page 2 Items continued

Item 6: Inhibit Function Selection

There are two different actions that can be initiated by the Inhibit signal, and this input can be configured to be momentary or continuous contact, just like the Forward and Reverse inputs. It can be helpful to refer to the momentary contact setting on the Inhibit input as the "forced completion" mode, since that's the effect it has. In this mode, the control will be forced to complete the inhibit cycle even if the Inhibit signal is removed. In other words, you can't change your mind once the inhibit is initiated. Alternatively, if continuous contact is chosen, the control will resume normal operation as soon as the Inhibit signal is removed.

Note: When in single direction mode, the control will be inhibited if no direction is selected. This setting defines the Inhibit function as one of these two things: 1) Decelerate to zero-torque, or 2) Coast with zero-torque.

Decelerate to zero-torque:

This setting causes the Inhibit signal to initiate an action identical to placing the torque command signal in deadband. The control will remove drive from the motor in the normal fashion, using the programmed value for deceleration time (Page 1, Item 7 or 8).

Coast with zero-torque:

This setting causes the Inhibit signal to initiate the immediate removal of any drive to the motor.

Item 7: Inhibit Delay

This setting has meaning only when the inhibit function selection (Page 2, Item 6) is set to one of the forced-completion (momentary contact) modes.

This setting determines the amount of time the control will remain inhibited after reaching *zerotorque*. The range of this trimmer is from 0.3 seconds to 120 seconds, and the 40 settings on the bar graph are **not** linear. See the soft trimmer listing in Appendix D for the 40 settings.

Item 8: Speed/Torque Mode Selection

This item has only two values, one for selecting speed control and the other for selecting torque control. When you change this setting, it will take effect after power has been removed and reapplied to the control.

Page 2 Items continued

Item 9: Feedback Mode Selection

This item selects one of two ways to measure motor speed, which is used to determine if a speed limit has been reached. The two alternatives are described below.

Armature feedback:

In this mode, the control uses an on-board signal that is proportional to the motor armature voltage as an estimate of the motor's speed.

Analog tachometer feedback:

In this mode, the control is given (or fed) a signal from an analog tachometer, the shaft of which is attached to the motor shaft, and spins along with it. The RG610 supports analog tachometers with an output of 50 volts per 1000 RPM. See "Complete Installation" for a description of analog tachometer connections.

Item 10: PID Aggression Adjustment

Note: This setting is one of the most important and powerful, and if it were possible for this section to be written in red neon light, it would be. Careless use of this item can cause the control to permanently damage your motor.

As advertised, this setting adjusts the aggression with which the P, I, and D gains are allowed to carry out their respective tasks. It basically alters the range of these gains, with higher settings creating larger ranges. The forty settings on the LED bargraph will become more coarse as this value increases, to cover the wider range. This setting should be increased only when the factoryset value does not allow proper PID tuning to be accomplished.

When changing this setting, the present values of the P, I, and D gains will change with it. It's a good idea to reduce them all before significantly increasing this setting.

Page 3 Items

Special note regarding Page 3, Items 1-6: The word "torquepot" is used as shorthand notation. When it's used, it certainly includes torquepots (actual potentiometers), but it's intended to include the use of external voltage supplies or a 4-20mA current signal as well. Any of these signals are connected to the control at pin 15 of the P4 connector on the upper board when they're used. "Torquepot" refers to any signal that connects to that point.

Item 1: Torque Command Source

This setting instructs the control to pay attention to *either* the torquepot *or* to a fixed torque setpoint (Page 3, Item 6) for its torque commands. This setting also instructs the control regarding the issues of single or dual direction, "neutral safety", and "hysteresis".

When single direction operation is chosen, the Forward and Reverse inputs (pins 3 and 4, respectively, on the P4 connector) must be used to specify a direction to operate in. A direction is selected by connecting its pin to the Common pin (pin 1 or 5 on the P4 connector). Then the entire torquepot signal's range is used for that direction only.

Note: When in single direction mode, the control will be inhibited (see Page 2, Item 6) if no direction is selected.

When **dual-direction mode** (also called bidirectional or "wig-wag" mode) is chosen, the torquepot signal's range is divided into two parts, one part for each direction, according to the torquepot setup trimmers (Page 3, Items 2-5). In this case, the Forward and Reverse inputs are unnecessary, since both torque and direction are selected with the torquepot signal.

When **neutral safety** is enabled (turned on), its effect will be seen at power-up only. This feature keeps the control inhibited after power-up until the torquepot signal enters deadband, then allows the control to function normally. This keeps the control from causing the motor to take off at fullblast (or any other torque) when you turn the power on.

When **hysteresis** is enabled (turned on), the control will ignore any *very small* changes in torque request. This is sometimes necessary in electrically "noisy" environments, when spurious (accidental) signals can be falsely interpreted as very small changes in the torquepot signal. Turning hysteresis on in a situation like this can keep the noise from changing the motor torque. Sometimes this effect will be noticed when you try to change the torquepot setting just a little bit, and find that you can't do it. In cases like this, you must change the torque a significant amount (an amount that is large enough to get the control's attention—clearly **not** noise), and then change the torque back to where you want it.

Fixed Torque Setpoint: Hysteresis does not apply when using a fixed torque setpoint. Neutral safety can be selected, however, in which case the Inhibit input must be activated and released before the control will drive the motor.

Page 3 Items continued

Item 2: Torquepot Minimum Calibration

This setting indicates the low end (near 0V in the 0 – 5V mode, or near -10V in the -10 – +10V mode) of the torquepot signal range you are using.

Example: You are using a potentiometer and are in the 0 – 5V mode, but the travel of your torquepot is restricted for some reason (it happens!), and it can't turn fully counterclockwise to the 0V position. It can only turn the signal down to 0.5V, which is 10% of the way into the 0 – 5V range. Since the 0 – 5V range is represented by the 40 settings of the bargraph display, you would set the display to read 10% of its maximum, or preset 4 (remember that the minimum setting is preset 1, so this is 3 button-presses up from the minimum). This would be a setting of one full light. Now the low end of your torquepot signal range would be 0.5V, instead of 0V, and the signal would be properly interpreted by the control.

Note: This setting is used in dual-direction mode only—in single-direction mode, the deadband width (Page 3, Item 5) is used for this function.

Item 3: Torquepot Maximum Calibration

This setting indicates the high end (near 5V in the 0 – 5V mode, or near +10V in the -10 – +10V mode) of the torquepot signal range you want/need to use.

Example: Let's use the same potentiometer from the previous example that can turn counterclockwise to only 0.5V. Now let's assume that its travel is also restricted in the clockwise direction, and that it can turn the torquepot signal up to only 4V, instead of 5V. Since this is 80% of the maximum setting, you would simply set the bargraph display to 80% of its maximum value, or 8 full lights. Since each full light is equivalent to 4 button-presses, this setting is also 8 buttonpresses down from the maximum setting of 40, or preset 32. Now the torquepot signal range is set up to be 0.5V – 4V to match the potentiometer's range.

Item 4: Torquepot Center Calibration

This setting indicates the position of the center of the torquepot signal range. We use the word "center" loosely here, since it can be set anywhere within the torquepot signal range. It is actually the dividing line between the forward and reverse directions. The deadband width (Page 3, Item 5) will be centered around this position.

Note: This setting is used in dual-direction mode only.

Page 3 Items continued

Item 5: Deadband Width

This setting determines the width of the deadband, of course—the deadband being that portion of the torquepot signal range in which zero-torque is requested. In dual-direction mode, this width will be centered around the torquepot center calibration (Page 3, Item 4). In single direction mode, this width will extend from the low end point (0V or -10V, depending on voltage range selected) upward.

Item 6: Torque Setpoint

When the torque command source (Page 3, Item 1) is set to 9 or 10 (fixed torque setpoint), the value of this item will be used as the requested torque, and the torquepot signal will be ignored.

The lower half of the bargraph display is used for reverse torque requests, and the upper half for forward torque requests. The setting in the very center of the display (preset 20) is a torque request of zero. Settings from preset 19 to preset 1 represent torque requests from reverse minimum torque (Page 1, Item 9) to reverse maximum torque (Page 1, Item 5), respectively. Likewise, settings from preset 21 to preset 40 represent torque requests from forward minimum torque (Page 1, Item 10) to forward maximum torque (Page 1, Item 6), respectively.

Item 7: *Reserved*

Item 8: *Reserved*

Item 9: Default Display Selection

This setting determines what the LED bargraph will display when the slide switch is in the “RUN” (center) position. This is the position the switch will be in the majority of the time, and you can pick what you want the bargraph to display, if anything.

Item 10: *Reserved*

Appendix D
Soft Trimmer Listing: Torque Control Mode

Note: This appendix is intended to serve as a quick reference once you are familiar with the soft trimmers. Complete soft trimmer descriptions are contained in Appendix C.
Note: Trimmer values are active as they are changed (see "Programming the RG610").

Page 1 Items

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
1	Reverse Speed Limit	**0 – 100% Max. AFB (0 – 150V or 0 – 300V) (Preset 1 – Preset 40)**	**80% Max. AFB (120/240V) (Preset 32)**		***Armature Feedback Mode***
2	Forward Speed Limit	**0 – 3,800 RPM (Preset 1 – Preset 40)**	**3,040 RPM (Preset 32)**		***Analog Tachometer Feedback Mode (50V/KRPM only)***
	Shaded area applies to both items 1 & 2				
3	Reverse Acceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target torque to increase from zero to reverse maximum setting
4	Forward Acceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target torque to increase from zero to forward maximum setting
5	Reverse Maximum Torque	0 – 15 Amps (Preset 1 – Preset 40)	9 Amps (Preset 24)		Maximum reverse motor torque
6	Forward Maximum Torque	0 – 15 Amps (Preset 1 – Preset 40)	9 Amps (Preset 24)		Maximum forward motor torque
7	Reverse Deceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target torque to decrease from reverse maximum setting to zero
8	Forward Deceleration Time	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Time for target torque to decrease from reverse maximum setting to zero
9	Reverse Minimum Torque	0 – 15 Amps (Preset 1 – Preset 40)	0 Amps (Preset 1)		Minimum reverse motor torque
10	Forward Minimum Torque	0 – 15 Amps (Preset 1 – Preset 40)	0 Amps (Preset 1)		Minimum forward motor torque

*See the table at the bottom of page D-3 for the times associated with each of the presets.

Page 2 Items

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
1	PID–P Gain	0 – 100% (Preset 1 – Preset 40)	60% (Preset 24)		PID Proportional gain
2	PID–I Gain	0 – 100% (Preset 1 – Preset 40)	30% (Preset 12)		PID Integral gain
3	PID–D Gain	0 – 100% (Preset 1 – Preset 40)	0% (Preset 1)		PID Derivative gain
4	*Reserved*				
5	Forward, Reverse, & Inhibit Input Setup	1 – 4	1	1	Fwd, Rev continuous contact; Inhibit active-low
				2	Fwd, Rev continuous contact; Inhibit active-high
				3	Fwd, Rev momentary contact; Inhibit active-low
				4	Fwd, Rev momentary contact; Inhibit active-high
6	Inhibit Function Selection	1 – 6	1	1	When inhibited, decelerate to zero-torque
				2	When inhibited, coast with zero-torque
				3	Same as #2
				4	#1 *with forced completion (momentary contact)*
				5	#2 *with forced completion (momentary contact)*
				6	#2 *with forced completion (momentary contact)*
7	Inhibit Delay	0.3 – 120 seconds (Preset 1 – Preset 40)	1.0 seconds (Preset 4)	*	Delay after a forced-completion inhibit is executed
8	Speed/Torque Mode Selection	1 – 2	1	1	Speed Control Mode
				2	Torque Control Mode

*See the table at the bottom of page D-3 for the times associated with each of the presets.

Page 2 Items continued

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
9	Feedback Mode Selection	1 – 6	1	1	Armature Feedback Mode
				2	Analog Tachometer Feedback Mode (50V/KRPM only)
				3	Same as #1
				4	Same as #1
				5	Same as #1
				6	Same as #1
					Changes in the feedback mode should only be made with the motor stopped!
10	PID Aggression Adjustment	0 – 100% (Preset 1 – Preset 40)	30% (Preset 12)		See soft trimmer description in Appendix C before adjusting

Acceleration, Deceleration, & Inhibit Delay Times

Preset	Time (seconds)	Preset	Time (seconds)	Preset	Time (seconds)	Preset	Time (seconds)
1	0.3	**11**	3.2	**21**	12	**31**	40
2	0.5	**12**	3.7	**22**	13	**32**	45
3	0.7	**13**	4.0	**23**	15	**33**	51
4	1.0	**14**	4.5	**24**	17	**34**	58
5	1.3	**15**	5	**25**	19	**35**	65
6	1.5	**16**	6	**26**	22	**36**	74
7	1.8	**17**	7	**27**	25	**37**	83
8	2.1	**18**	8	**28**	28	**38**	94
9	2.4	**19**	9	**29**	32	**39**	105
10	2.8	**20**	10	**30**	36	**40**	120

Page 3 Items

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
1	Torque Command Source	1 – 10	1	1	Torquepot, single direction
				2	Torquepot, single direction, neutral safety
				3	Torquepot, single direction, hysteresis
				4	Torquepot, single direction, neutral safety, hysteresis
				5	Torquepot, dual direction
				6	Torquepot, dual direction, neutral safety
				7	Torquepot, dual direction, hysteresis
				8	Torquepot, dual direction, neutral safety, hysteresis
				9	Fixed Torque Setpoint
				10	Fixed Torque Setpoint, neutral safety
2	Torquepot Minimum Calibration†	0 – 100% of Torquepot Signal Input Range (Preset 1 – Preset 40)	0% (Preset 1)		Calibrates the torquepot input's fully counterclockwise (low end) position Applies in dual direction mode only—use Torquepot Deadband Width (Page 3, Item 5) in single direction mode
3	Torquepot Maximum Calibration†	0 – 100% of Torquepot Signal Input Range (Preset 1 – Preset 40)	100% (Preset 40)		Calibrates the torquepot input's fully clockwise (high end) position
4	Torquepot Center Calibration†	0 – 100% of Torquepot Signal Input Range (Preset 1 – Preset 40)	50% (Preset 20)		Calibrates the torquepot input's center position Applies in dual direction mode only
5	Torquepot Deadband Width†	0 – 100% of Torquepot Signal Input Range (Preset 1 – Preset 40)	10% (Preset 4)		Calibrates the width of the torquepot input's deadband This region will be centered around the Torquepot Center Calibration (Page 3, Item 4)

†Figure 15 on page D-6 is provided to help visualize the meaning of this trimmer.

Page 3 Items continued

Item	Trimmer Name	Range of Values	Factory Setting	Possible Values	Brief Description
6	Torque Setpoint	Rev. Max. Torque – Fwd. Max. Torque (Preset 1 – Preset 40)	Zero-Torque (Preset 20)	Preset 1 ... Preset 19 Preset 20 Preset 21 ... Preset 40	Reverse Maximum Torque *...linear range* Reverse Minimum Torque Zero Torque Forward Minimum Torque *...linear range* Forward Maximum Torque
7	*Reserved*				
8	*Reserved*				
9	Default Display Selection	1 - 8	2	 1 2 3 4 5 6 7 8	Defines what the bargraph display will indicate when the slide switch is in the "RUN" (center) position Nothing (all lights off) Power Indicator (top 2 & bottom 2 lights on) Target Setting (0 – 100%) Feedback (0 – 100%) Conduction Angle (0 – 100%) Motor Current (0 – 15 amps) Torquepot Input (0 – 100% of calibrated range) Control Status Flags: **LED1 – Power Indicator** **LED2 – Direction Indicator** on = forward drive off = reverse drive **LED3 – Neutral Safety Indicator** on = preventing drive off = not preventing drive **LED4 – Zero-speed Indicator** on = feedback indicates zero-speed off = feedback indicates rotation **LED5 – Inhibit Indicator** on = drive inhibited off = drive enabled **LED6 – Speed Limit Indicator** on = drive in speed limit off = drive not in speed limit **LED7 – Conduction Angle Status** on = conduction angle at maximum off = conduction angle < maximum **LED8 – Accel/Decel Status** on = accel/decel in progress off = accel/decel completed ***LED9–LED10 Reserved***
10	*Reserved*				

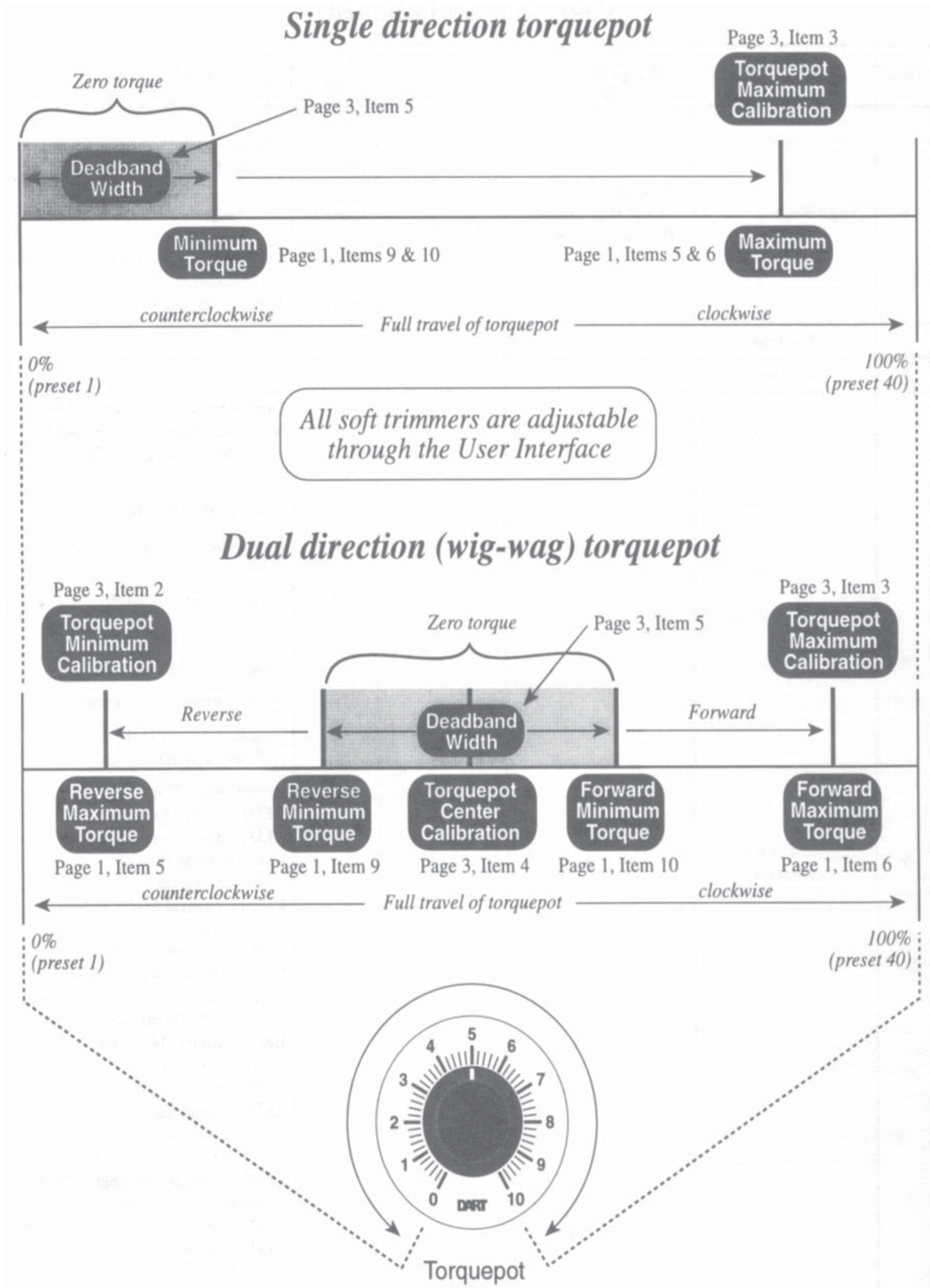
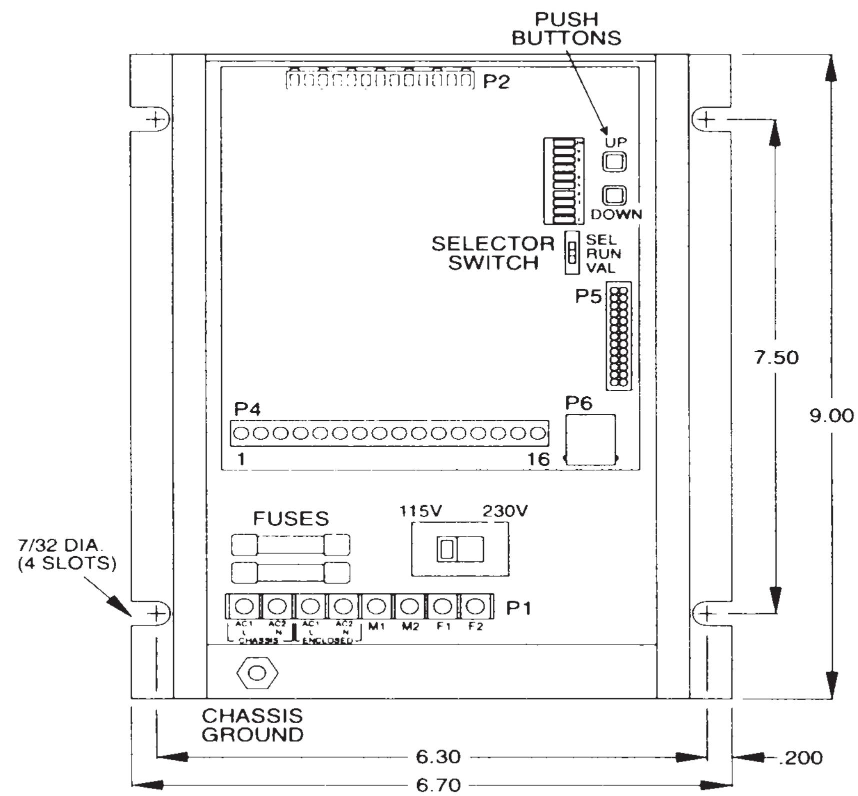

Single direction torquepot
Zero torque
Page 3, Item 5
Page 3, Item 3
Torquepot Maximum Calibration
Deadband Width
Minimum Torque
Page 1, Items 9 & 10
Page 1, Items 5 & 6
Maximum Torque
counterclockwise
Full travel of torquepot
clockwise
0% (preset 1)
100% (preset 40)
All soft trimmers are adjustable through the User Interface
Dual direction (wig-wag) torquepot
Page 3, Item 2
Torquepot Minimum Calibration
Zero torque
Page 3, Item 5
Page 3, Item 3
Torquepot Maximum Calibration
Reverse
Deadband Width
Forward
Reverse Maximum Torque
Reverse Minimum Torque
Torquepot Center Calibration
Forward Minimum Torque
Forward Maximum Torque
Page 1, Item 5
Page 1, Item 9
Page 3, Item 4
Page 1, Item 10
Page 1, Item 6
counterclockwise
Full travel of torquepot
clockwise
0% (preset 1)
100% (preset 40)
0 1 2 3 4 5 6 7 8 9 10
DART
Torquepot

Figure 15

Appendix E
Mounting Dimensions

Appendix E
Mounting Dimensions

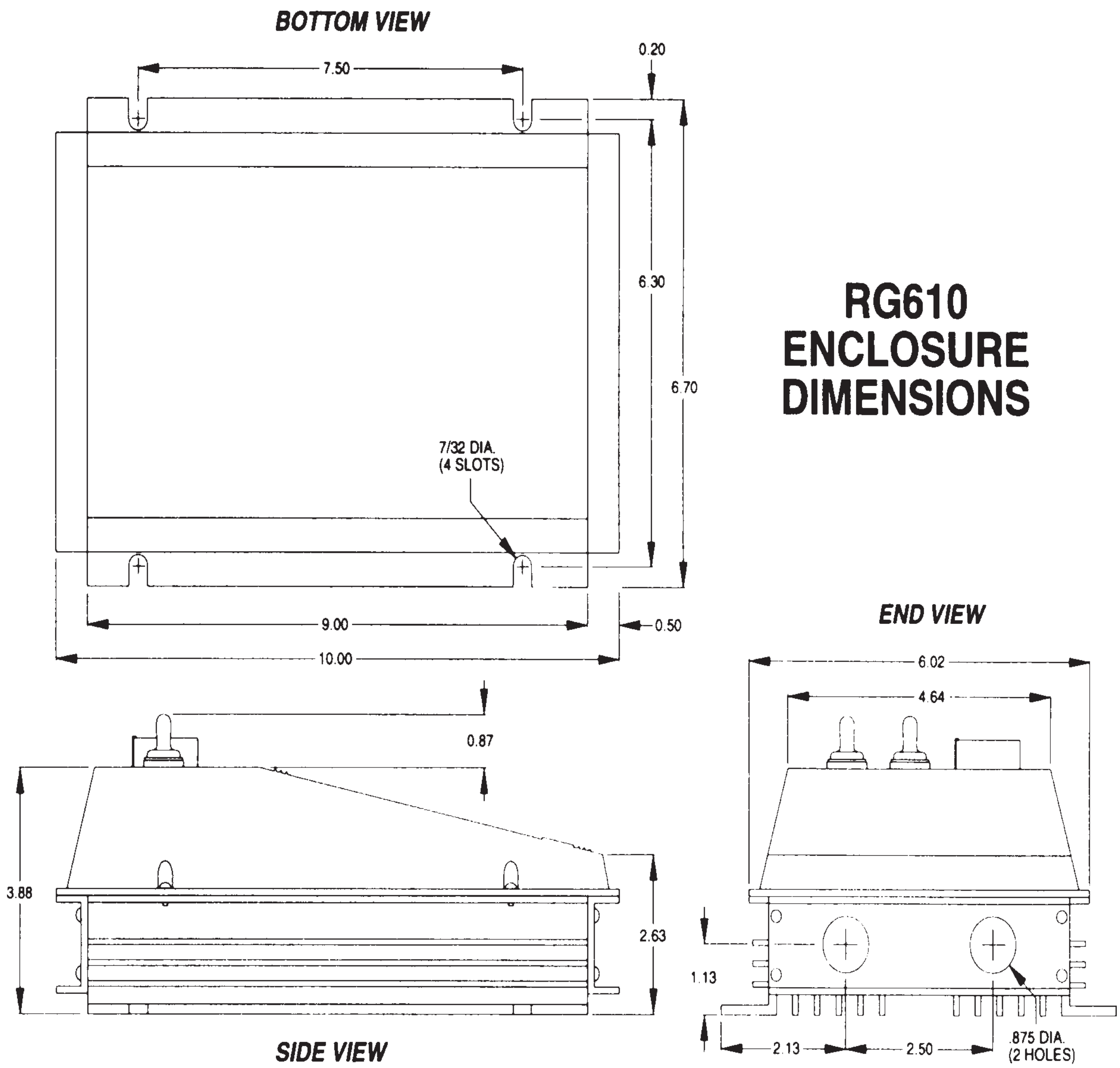


Open Chassis Version

Dimensional Specifications

Model	Width	Length	Depth	Weight
Chassis	6.70 in. (17.02 cm)	9.00 in. (22.86 cm)	2.60 in. (6.60 cm)	40 oz. (1132 gm)

Figure 16



Dimensional Specifications

Model	*Width*	*Length*	*Depth*	*Weight*
Enclosed	6.70 in. (17.02 cm)	10.00 in. (25.40 cm)	4.75 in. (12.07 cm)	48 oz. (1358 gm)

Figure 17

Appendix F
Specifications

Operating Environment

Ambient Temperature Range	0½ – 45½C (32½ – 113½F)
Relative Humidity	Up to 99% non-condensing
Altitude	Up to 3,000 feet above sea level without derating *(Derate Horsepower and Maximum Continuous Output Current by 10% per 1,000 feet above 3,000)*

Power In

AC Input Voltage	115V ± 10% or 230V ± 10%
AC Input Frequency	50/60 Hz
Fuse Protection	Two 15A AC Line Fuses
Analog Tachometer Voltage Range	±50VDC per 1,000 RPM (±190VDC Maximum)

Power Out

Armature Voltage Range	0 – 150VDC (115VAC Input)
Armature Voltage Range	0 – 300VDC (230VAC Input)
Horsepower Range	1/15 – 1.0 HP (115VAC Input)
Horsepower Range	1/8 – 2.0 HP (230VAC Input)
Maximum Continuous Output Current	10.2 ADC
Overload Capacity	150% for 1 minute
Field Voltage	50VDC or 100VDC (115VAC Input)
Field Voltage	100VDC or 200VDC (230VAC Input)
Field Output Current	1.0 ADC

Adjustment Ranges

Acceleration Time	0.3 – 120 seconds
Deceleration Time	0.3 – 120 seconds
Current Limit	1.0 – 15.0 ADC
Speed Regulation	1% Using Armature Feedback
Speed Regulation	0.5% Using Analog Tachometer Feedback
Speed Range	20:1
Minimum Speed	0% – Maximum Speed
Maximum Speed	Minimum Speed – 100%

Mechanical

See appendix E, “Mounting Dimensions”.

Model Selection Chart

RG610C	Chassis Model	
RG610E	Nema 4/12 Enclosed Model	
Input Voltage*	115 VAC	230 VAC
Input Current	12 Amps AC	12 Amps AC
Horsepower	1/15 – 1.0 hp	1/8 – 2.0 hp
Output Voltage	0 – 90 VDC	0 –180 VDC
Output Current	0 – 10.2 ADC	0 – 10.2 ADC
Field Output	50 or 100 VDC @ 1.0 ADC	100 or 200 VDC @ 1.0 ADC

* Both the chassis and enclosed versions are dual-voltage. The specifications in each column correspond to the selected input voltage.

Appendix G
Glossary of Terms

Active-high

This phrase is common when discussing digital signals, which typically have only two levels. It means that the function in question will be initiated or activated by a digital signal that is in its "high" state (also referred to as a logic "1").

Active-low

This phrase is common when discussing digital signals, which typically have only two levels. It means that the function in question will be initiated or activated by a digital signal that is in its "low" state (also referred to as a logic "0").

Analog tachometer

A device that is used to determine the speed of a motor, and which generates a voltage level that is proportional to that speed. The analog tachometer output necessary for use with the RG610 is 50VDC per 1000 RPM.

Armature

This is the term used to refer to the actual windings of a motor. This is the part of a motor that the variable output voltage from the RG610 is applied across, which causes the motor to turn.

Closed-loop

This is the term used to refer to the "loop" that is created when either speed or torque information is sent back to the RG610 from some measuring device. This torque or speed information is then used by the control to determine whether a target torque or speed is being maintained, and the output from the control is adjusted when necessary.

Coast

This is a term used to describe what the motor does when no drive is applied. Under these circumstances, the motor's speed and direction will be determined by the forces that are exerted on it by everything other than the RG610. This is sometimes referred to as "freewheeling".

Conduction angle

This term is reported as a percentage from 0% to 100%. It indicates how much of the total time during each half-cycle of power that the control is actually driving the motor. This is the basic quantity that is adjusted to change "how hard" the control is driving the motor.

Deadband

When it is present (not set to 0%), it is that portion of the speed, torque, or conduction angle command signal that is interpreted as a request of zero.

Default

The condition which will be the case if nothing is done to change it. The factory settings of the RG610 are its default settings, which will remain in effect until they are changed by the user.

Derivative

First of all, this is what the “D” in PID stands for. It’s a gain based on the rate-of-change of the difference between the target speed (or torque) and the actual speed (or torque) of the motor.

Feedback

This is a term used to refer to speed or torque information that is acquired by some measuring device and then used by the control to appropriately adjust its output. Feedback is necessary to control speed or torque.

Forced completion

This is the term given to the Inhibit modes that require only a momentary signal to start them. The idea is that the control is forced to complete the Inhibit cycle even if the signal which initiated the cycle is removed.

Hysteresis

This is a function which causes *very small* changes in the speed, torque, or conduction angle command signal to be ignored. This is sometimes necessary in electrically “noisy” environments.

Integral

First of all, this is what the “I” in PID stands for. It’s a gain based on the length of time that a difference between target speed (or torque) and actual speed (or torque) has existed. The Integral quantity is necessary to produce a speed (or torque) error of zero; the Proportional and Derivative gains can’t do this by themselves.

Isolated signal

This is a signal that is referenced to a “floating” common point. This type of common point is **not** connected to earth ground or any other fixed electrical reference.

Item

On the RG610, this is a soft trimmer. Each soft trimmer is referred to as an “item” on a “page”.

Linear

This expresses a relationship between two quantities, or variables. It just means that a change of a given amount in one of the quantities always corresponds to a change of a given amount in the other quantity. For example, the displayed value of the reverse current limit (Page 1, Item 1) has a linear relationship with the current limit itself. Each additional full light (4 button-presses) corresponds to an additional 1.5 amperes of current limit. In contrast, the displayed value of reverse acceleration time (Page 1, Item 3) does **not** have a linear relationship with the acceleration time itself. Each additional full light on the display adds more time than the previous light did; this is an example of a nonlinear relationship.

Neutral safety

This is a safety feature that, upon power-up only, causes the control to require that the speed (or torque) command signal enter the deadband before any drive will be output to the motor. This keeps the motor from taking off unexpectedly when power is applied.

Nonvolatile memory

This is the kind of memory that doesn't get erased when the power is removed. All of the soft trimmer values are stored in this kind of memory.

Open-loop

This is a mode of operation in which no feedback information is used by the control, except that required for current limiting purposes. In this mode, the speedpot command signal merely requests a conduction angle.

Overhauling

This is the term used to describe the situation in which a motor's load causes the motor to turn faster than the speed that is being requested.

Overshoot

This is the term used to describe the situation in which the motor speed (or torque), after a change in the requested value, momentarily goes beyond the new requested speed (or torque) before returning to the new value. For example, when increasing motor speed from 1,000 RPM to 2,000 RPM, the motor speed may go up to 2,500 RPM before returning to 2,000 RPM. This can be controlled by properly setting the PID gains for the application.

Page

This is the location, in memory, of a given set of 10 "items" (soft trimmers). It's just a convenient way of thinking about how the soft trimmers are arranged and stored. There are 3 "pages" on the RG610, each containing 10 "items", or soft trimmers.

PID

This is the abbreviation for "Proportional – Integral – Derivative". This is the method of motor control used on the RG610.

Preset

This is the term used to refer to any one of the forty different settings on the bargraph display (on the user interface). The settings are referred to as "preset 1" through "preset 40".

Proportional

First of all, this is what the "P" in PID stands for. It's a gain based on the difference between the target speed (or torque) and the actual speed (or torque) of the motor.

RPM

This is a common abbreviation for "revolutions per minute".

Requested speed

This is the speed that is being requested by the value of the speedpot command signal.

Requested torque

This is the torque that is being requested by the value of the torquepot command signal.

Shunt-wound

This is the term given to a special type of motor that uses "field windings" to produce a magnetic field, instead of using permanent magnets. This type of motor requires a separate source of power for the field windings; this power source is referred to as the "field supply" on the RG610.

Soft trimmer

This is the term given to each of the parameter adjustments that can be made on the RG610. They are adjusted through the user interface, and are stored in nonvolatile memory. Soft trimmers are also referred to as "items".

Target speed

This is the requested speed, modified by the acceleration or deceleration time that is being used. When no acceleration or deceleration is taking place, the target speed is the same as the requested speed.

Target torque

This is the requested torque, modified by the acceleration or deceleration time that is being used. When no acceleration or deceleration is taking place, the target torque is the same as the requested torque.

Torque

Torque can be thought of as a rotating, or twisting force. A motor's output torque is directly proportional to the current flowing through its armature. For this reason, motor torque is controlled by simply controlling the motor current.

Transient voltage

This is an undesirable, yet unavoidable electrical spike. There are several categories of them that a motor control must endure to provide trouble-free operation in harsh environments.

User interface

This is the term used to refer to the two buttons, one slide switch, and bargraph display that are used to adjust the soft trimmer values on the RG610.

Value

The number, or bargraph representation of a number, to which an item is set through the user interface.

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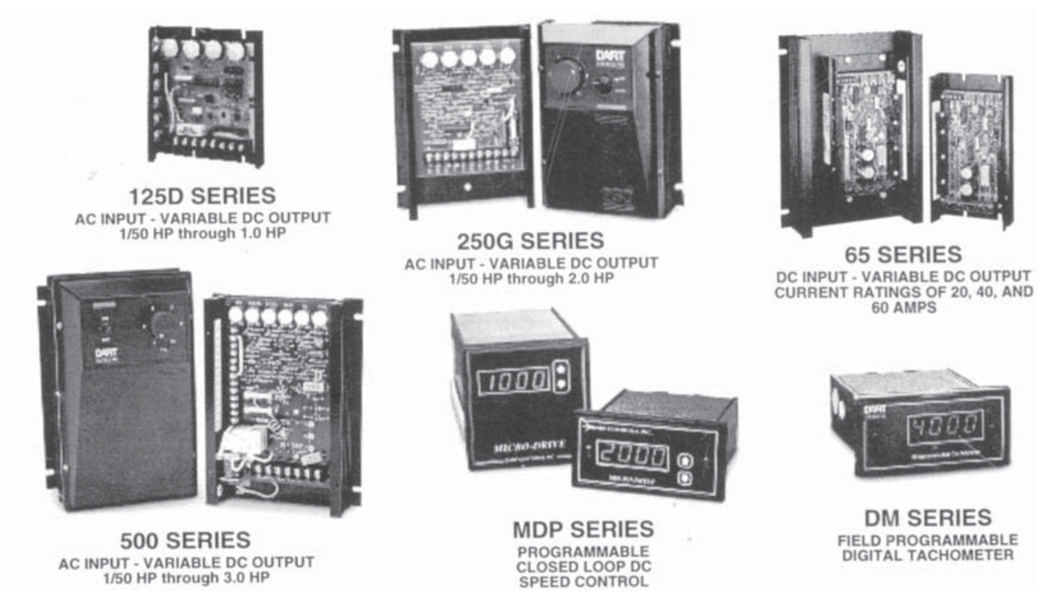

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