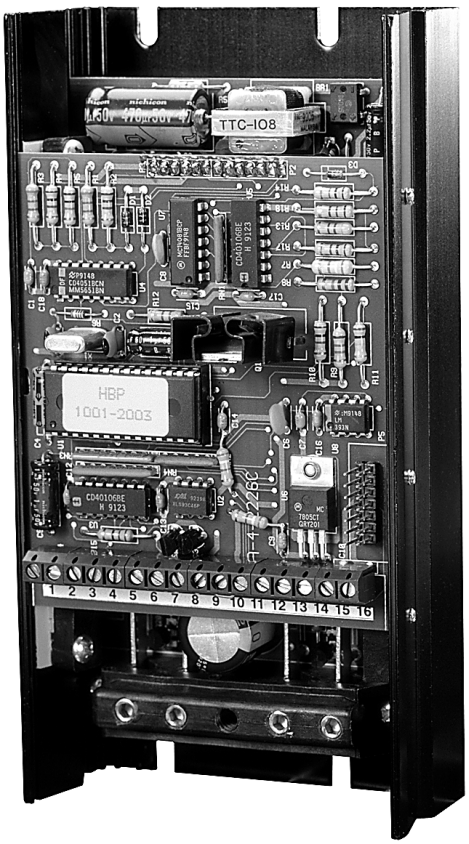
HBP CONTROL SERIES

DART CONTROLS, INC.

Instruction Manual

Programmable Regenerative Battery Operated Motor Speed Control



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IMPORTANT

WARNING

IMPROPER INSTALLATION OR OPERATION OF THIS CONTROL MAY CAUSE INJURY TO PERSONNEL OR CONTROL FAILURE. THIS CONTROL MUST BE INSTALLED AND GROUNDED IN ACCORDANCE WITH LOCAL, STATE AND NATIONAL SAFETY CODES.

WARRANTY

Dart Controls, Inc. (DCI) warrants its products to be free from defects in material and workmanship. The exclusive remedy for this warranty is DCI factory replacement of any part or parts of such product which shall within 12 months after delivery to the purchaser be returned to DCI factory with all transportation charges prepaid and which DCI determines to its satisfaction to be defective. This warranty shall not extend to defects in assembly by other than DCI or to any article which has been repaired or altered by other than DCI or to any article which DCI determines has been subjected to improper use. DCI assumes no responsibility for the design characteristics of any unit or its operation in any circuit or assembly. This warranty is in lieu of all other warranties, express or implied; all other liabilities or obligations on the part of DCI, including consequential damages, are hereby expressly excluded.

NOTE: Carefully check the control for shipping damage. Report any damage to the carrier immediately. **Do not attempt to operate the drive if visible damage is evident to either the circuit or to the electronic components.**

All information contained in this manual is intended to be correct, however information and data in this manual are subject to change without notice. DCI makes no warranty of any kind with regard to this information or data. Further, DCI is not responsible for any omissions or errors or consequential damage caused by the user of the product. DCI reserves the right to make manufacturing changes which may not be included in this manual.

WARNING

MAKE CERTAIN THAT THE POWER SUPPLY IS DISCONNECTED BEFORE ATTEMPTING TO SERVICE OR REMOVE ANT COMPONENTS!!! IF THE DISCONNECT POINT IS OUT OF SIGHT, LOCK IT IN DISCONNECTED POSITION AND TAG TO PREVENT UNEXPECTED APPLICATION OF POWER.

ONLY A QUALIFIED ELECTRICIAN OR SERVICEMAN SHOULD PERFORM ANY ELECTRICAL TROUBLESHOOTING OR MAINTENANCE.

AT NO TIME SHOULD CIRCUIT CONTINUITY BE CHECKED BY SHORTING TERMINALS WITH A SCREWDRIVER OR ANY OTHER METAL DEVICE.

STANDARD FEATURES

- **4-quadrant H-bridge PWM drive, employing power MOSFET's.**
- **Integral all solid state forward/reverse with dynamic and regenerative braking; no moving parts or external wiring.**
- **High efficiency drive increases equipment range and running time. Current flows back into battery during regenerative braking operation.**
- **Microprocessor based, addresses an extended range of applications through the use of field programming.**
- **No trimpots to adjust, drift, or be tampered with — all operating instructions are stored digitally in non-volatile memory.**
- **24-42 VDC operation.**
- **User selectable operation mode for single-ended (with FWD/REV switch) or "wig-wag" (joystick type) throttle/direction controls.**
- **User selectable input device type, for use with potentiometer or 0 to +5 volt DC output throttle/direction control.**
- **Selectable Automatic/Manual joystick center calibration (wig-wag mode).**
- **Separately adjustable *linear* acceleration and deceleration ramps.**
- **Electromechanical brake output logic provided with a delay that can be customized by user. Brake activates upon zero throttle position (after delay).**
- **30:1 speed range, ultra-smooth operation at all speeds.**
- **Selectable "Hi-pedal" lockout prevents the control from being powered-up with the throttle applied.**
- **Selectable automatic throttle failure detection (potentiometer input mode only) forces drive into "limp-home" mode.**
- **Provision for low-power keyswitch input to disable drive and place motor in dynamic braking mode.**
- **Customizable "Intelligent" microprocessor-controlled current limit protects drive while allowing significant short-term overload capacity.**
- **Three *exclusive* "User Assignable Outputs" — can be used to drive electromechanical brakes, relays, annunciators, etc. Outputs can be "connected" to *any combination* of up to eight different "condition signals" internal to the HBP.**
- **Thermal limit sensor protects the drive from failure due to excessive heatsink temperatures. Current limit is automatically reduced until temperature cools again.**
- **Inhibit input allows *any* number of external conditions, such as battery charger connected, manual brake defeat, etc. to be "wire-ORed" together to disable the drive. An output from the HBP can also be selected to annunciate when this has occurred, i.e. to drive a warning light/alarm, etc.**
- **Silent PWM switching frequency of 15KHz.**
- **Exclusive high current connector for battery and motor connections. Terminal strip for control console connection.**
- **Anodized aluminum chassis heatsink.**

USER-CUSTOMIZED FEATURES

Note: Drive is shipped with usable factory settings listed in “Trimmer Descriptions and Values” section.

- **Acceleration time**
- **Deceleration time**
- **Maximum forward throttle**
- **Maximum reverse throttle**
- **Forward current limit**
- **Reverse current limit**
- **Forward “limp-home” speed**
- **Reverse “limp-home” speed**
- **Delay-before-(electromechanical) brake time**
- **Throttle “deadband” width (used in wig-wag mode only)**
- **Forward Throttle “span” calibration (for less than “full-travel" throttle controllers)**
- **Reverse Throttle “span” calibration (for less than “full-travel" throttle controllers)**
- **Throttle control type**
- **Single Direction/Wig-Wag Throttle Operation Mode Select**
- **"Hi-pedal disable" Select**
- **Automatic/Manual Joystick Centering Select**
- **Manual Joystick Center Point (used with "Manual Joystick Centering")**
- **Motor/Battery Voltage calibration**
- **“Low” battery threshold**
- **“Lower” battery threshold**
- **I.R. Drop Compensation**
- **User-assignable outputs 1, 2, & 3 mode select (N.O., N.C.)**
- **User-assignable outputs 1, 2, & 3 "input selector" matrix**
- **User-assignable outputs 1, 2, & 3 " input inverter" matrix**

Conditions "Connectable" to User-Assignable Outputs 1, 2, & 3

- **Throttle controller (Potentiometer-type *only*) failure**
- **Battery below "Low" or "Lower" threshold voltage**
- **Drive "Inhibited"**
- **Drive Direction (Forward/Reverse)**
- **Current limit exceeded**
- **Brake (electromechanical) enable signal**
- **Thermal limit exceeded**
- **"Hi-Pedal" disable (HBP "Powered-up" with throttle applied)**

SPECIFICATIONS and OPERATING CONDITIONS

Current Capacities:

24v Operation —

Continuous Duty ..... 28/40* amperes
30 Second Overload ..... 150% of Continuous Duty

36v Operation —

Continuous Duty ..... 20/30* amperes
30 Second Overload ..... 150% of Continuous Duty

*Rating with -HS auxiliary heatsink option, or equivalent

Adjustment/Control Ranges:

Acceleration Time ..... Adjustable, Zero to approx. 1 minute

Deceleration Time ..... Adjustable, Zero to approx. 1 minute

Forward/Reverse Speed ..... Separately Adjustable, Zero to Full Speed (100% of Battery)

Forward/Reverse Current Limit (continuous) ..... Separately Adjustable, 4 — 60 amperes

Forward/Reverse “Limp-Home” Speed ... Separately Adjustable, Zero to Full Speed (100% of Battery)

Delay-Before-Mechanical Brake Time ..... Adjustable, Zero to 35 seconds

Throttle Potentiometer Resistance (nominal, potentiometer input type selected) . 5,000 ohms, linear taper

Maximum Throttle Voltage Range (voltage input type selected) ..... 0 to +5vdc

If Single Direction Mode ..... 0vdc = 0 speed; +5vdc = full speed

If Wig-Wag Mode ..... 0vdc = full reverse; +5vdc = full forward; +2.5vdc = off

Throttle Deadband Width ..... Adjustable, Zero — 50% of full throttle

Throttle Centering Adjustment (“wig-wag” mode selected only) . Selectable Automatic/Manual

“Low” Battery Detect Threshold ..... Adjustable, 0 to 50v

“Lower” Battery Detect Threshold ..... Adjustable, 0 to 50v

Environment/Power:

Ambient Temperature ..... -10° to +45°C

Thermal Limit Trip Point (current is automatically reduced above this point until heatsink cools) 75°C

Power Input Frequency ..... D.C. only

Power Input Voltage ..... 11 — 36vdc nominal

User-Assignable Outputs:

Max. Continuous Voltage/Current, User Assignable Output 1 (FET) 60vdc, 1a

Max. Continuous Voltage/Current, User Assignable Outputs 2&3 (NPN) 60vdc, 100ma

Dimensions/Weight:

HBP alone: ..... 3.62 in. (9.20 cm.)**W** x 7.00 (17.78)**L** x 2.52 (6.40)**D**. Weight: 17 oz. (482 gm.)

HBP-HS: ..... 6.70 in. (17.02 cm.)**W** x 9.00 (22.86)**L** x 3.17 (8.05)**D**. Weight: 38 oz. (1077 gm.)

Caution: Control is sensitive towards static electricity. Use proper grounding procedures when handling control.

CONNECTOR DESCRIPTIONS

P1 - Power/Motor Connector

PIN	DESCRIPTION
1	**Motor (P1-1)** Connects to one side of motor armature, usually representing +VDC OUT for forward direction. Note: One side of the motor (armature) should always be disconnected simultaneously with the +Battery when turning power OFF to the control (reference figures 2 and 3).
2	**+Battery (P1-2)** Connects to the positive battery post or the +VDC of a DC power supply. Note: An alternative to disconnecting motor during power down is to add a diode (6A 100V) across the on-off switch or relay (reference figures 2 and 3).
3	**-Battery (P1-3)** Connects to the negative battery post or the -VDC of a DC power supply.
4	**Motor (P1-4)** Connects to one side of motor armature, usually representing +VDC OUT for reverse direction. Note: One side of the motor (armature) should always be disconnected simultaneously with the +Battery when turning power OFF to the control (reference figures 2 and 3).

P4 - Control Connector

PIN	DESCRIPTION	PIN	DESCRIPTION
1	Future Expansion (Do NOT Connect)	9	Keyswitch 2 Input — *MUST* be connected together for HBP to operate
2	+5vdc output (25ma. max.)	10	Keyswitch 1 Input — *MUST* be connected together for HBP to operate
3	Inhibit Input (GND to Inhibit Drive)	11	GND (-Battery)
4	+Battery Output (to external devices)	12	Forward Switch Input
5	Output 1 (Source)	13	Reverse Switch Input
6	Output 1 (Drain)	14	Pot Hi (DO NOT CONNECT for Voltage Throttle)
7	Output 2 (Collector)	15	Pot Wiper (or 0 to 5v throttle voltage input)
8	Output 3 (Collector)	16	Pot Lo (DO NOT CONNECT for Voltage Throttle)

P5 - RS232 Data Connector

PIN	DESCRIPTION	PIN	DESCRIPTION
1	Future Expansion (Do NOT Connect)	8	Inhibit Input (Used for "Cloning" ONLY)
2	RS232 Data Input TO Drive	9	Future Expansion (Do NOT Connect)
3	RS232 Data Output FROM Drive	10	User Out 3 (used as"CLONING DONE")
4	+5VDC out to ext. device (20ma. max.)	11	Fwd. Switch (Used for "Cloning" ONLY)
5	RS232 Signal Common (only)	12	Rev. Switch (Used for "Cloning" ONLY)
6	GND (-Battery)	13	Future Expansion (Do NOT Connect)
7	No Connection	14	No Connection

MOUNTING DIMENSIONS

Caution: Control is sensitive towards static electricity. Use proper grounding procedures when handling control.

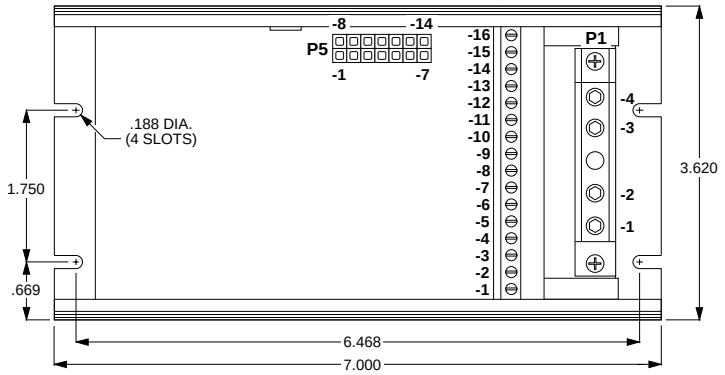


Figure 1

HBP HOOK-UP DIAGRAMS

WARNING: **If using a "voltage-type" throttle controller**, connect between P4-15 and P4-11. **DO NOT USE P4-14 or P4-16**

SPEEDPOT THROTTLE (Neutral Throttle at Center)

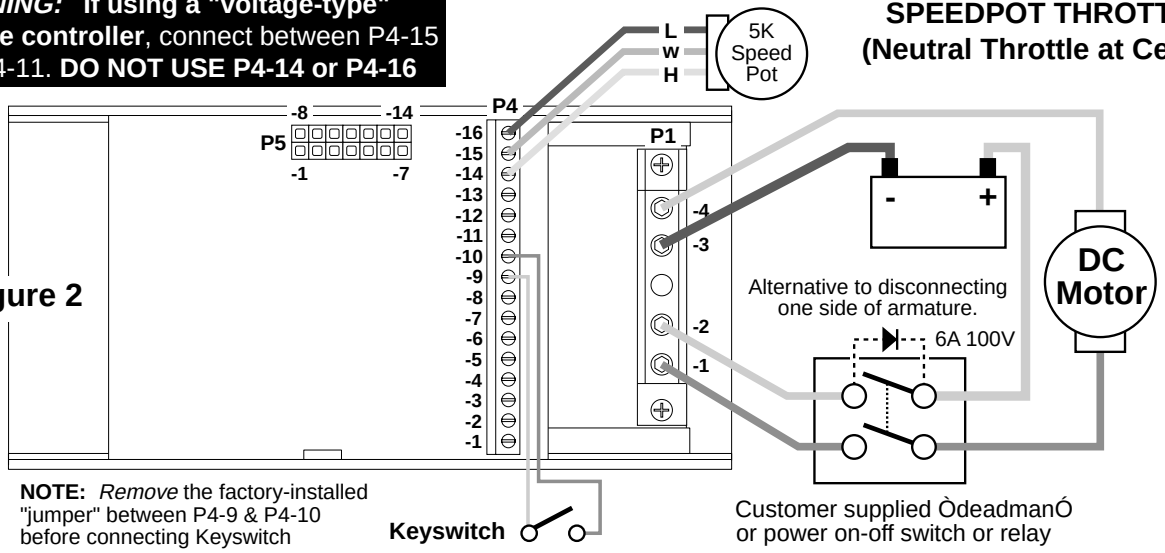


Figure 2

Basic Connections for "Wig-Wag" operation with "SpeedPot" input

WARNING: **If using a "voltage-type" throttle controller**, connect between P4-15 and P4-11. **DO NOT USE P4-14 or P4-16**

SPEEDPOT THROTTLE (Zero Throttle at full CCW)

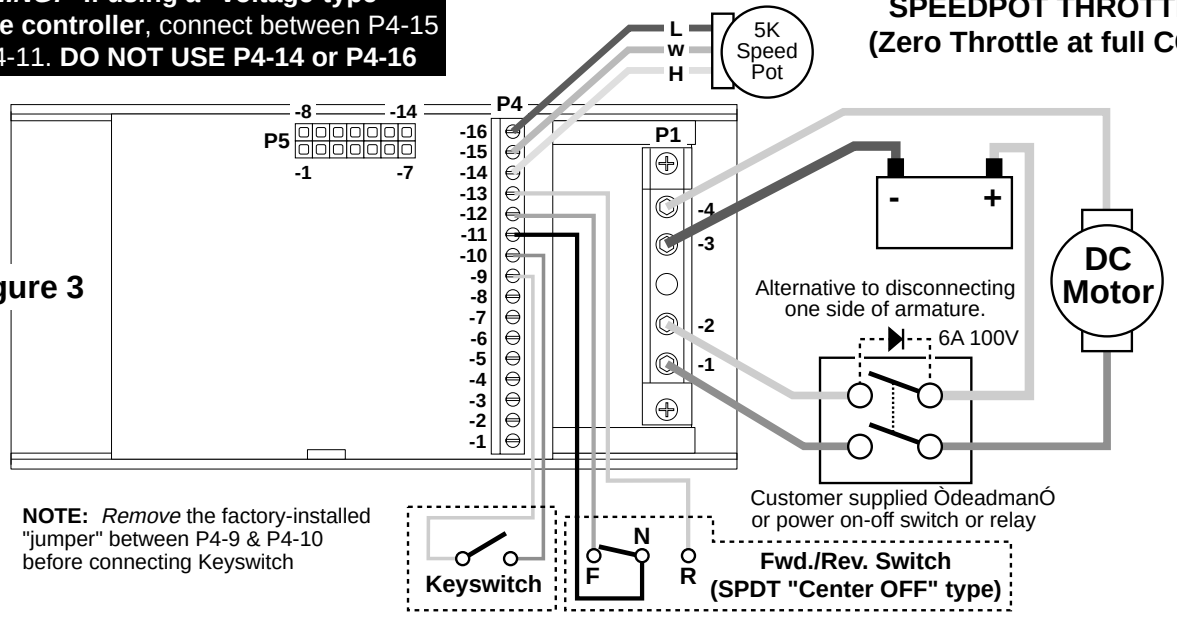
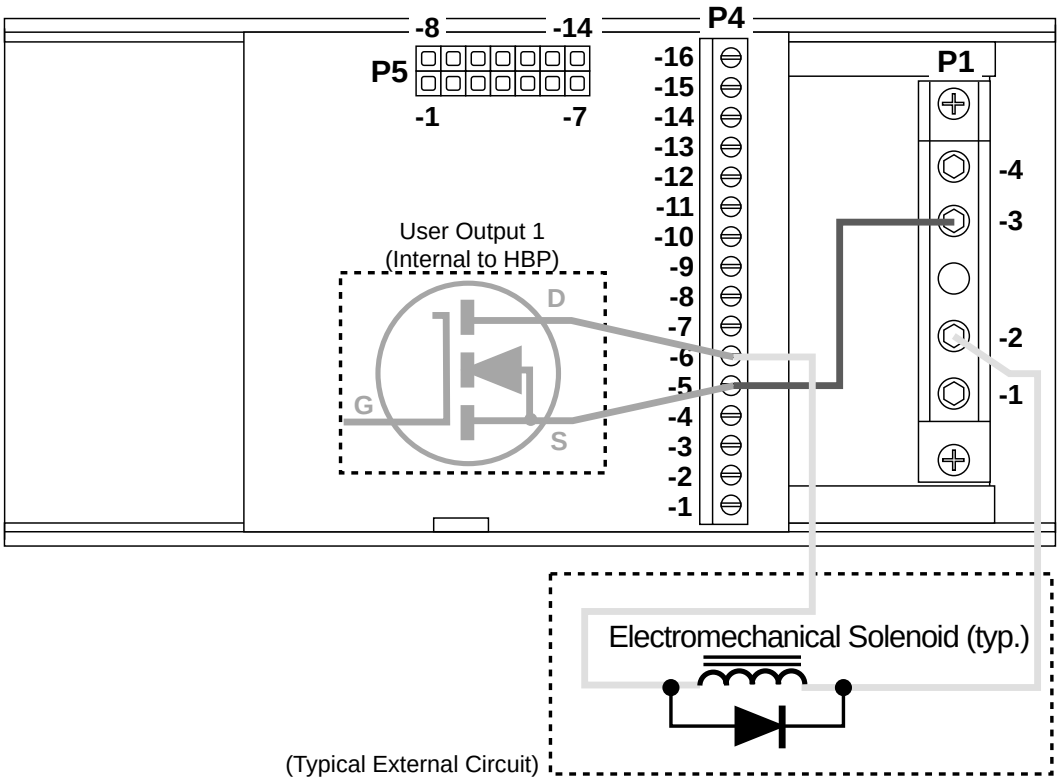


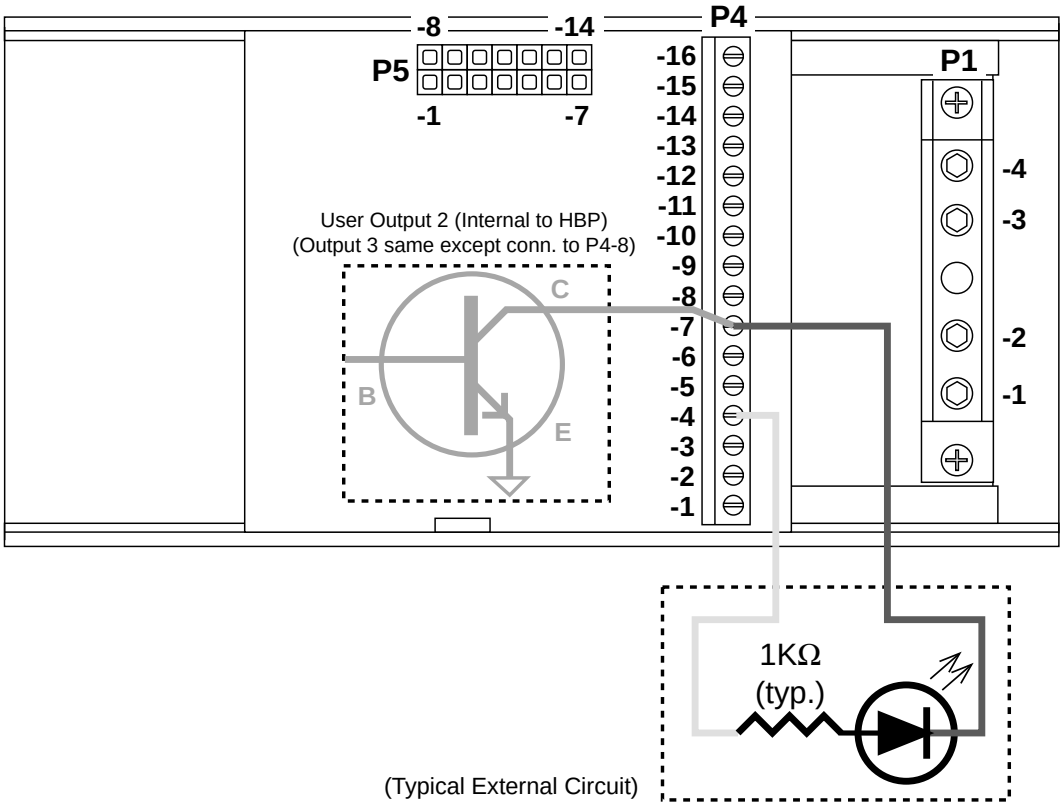
Figure 3

As above *except* "Single Direction" operation (using Direction Switch)

Caution: Control is sensitive towards static electricity. Use proper grounding procedures when handling control.



User Output 1 Typical Connections
Figure 4



User Output 2 & 3 Typical Connections

Figure 5

Basic Connections for RS232 Data Connector

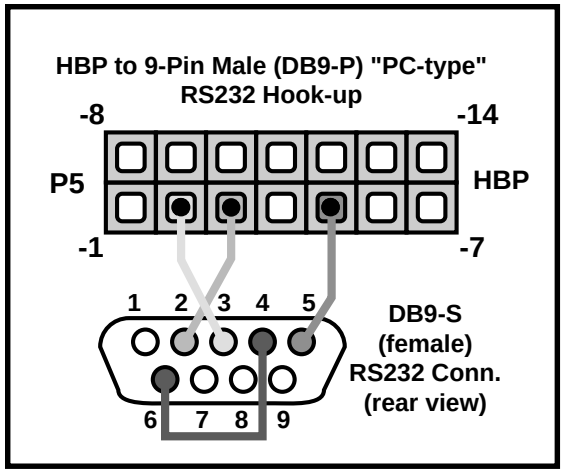


Figure 6

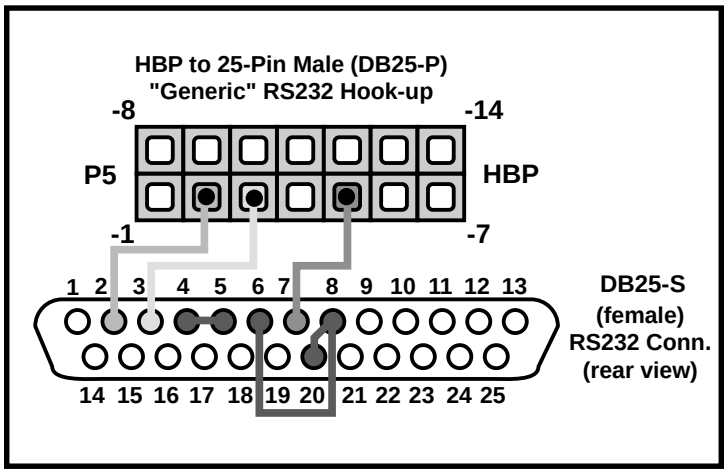


Figure 7

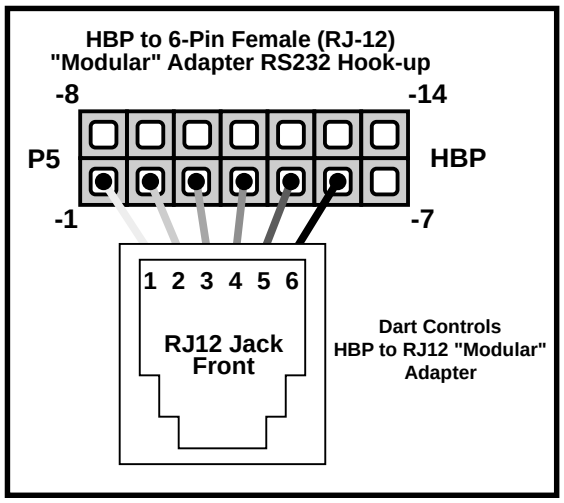


Figure 8

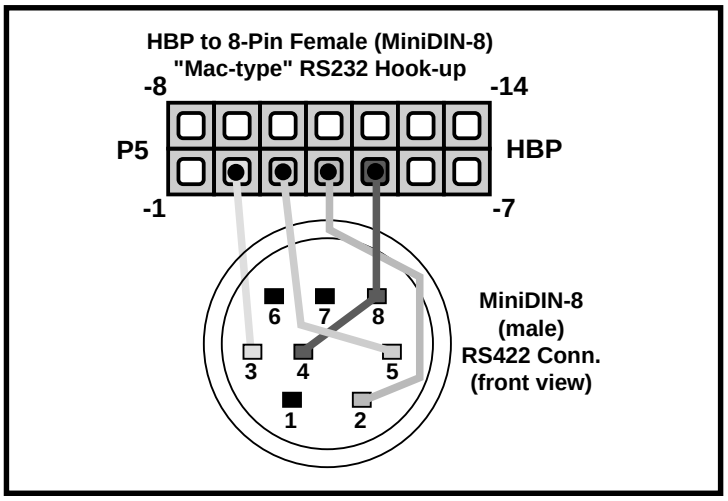


Figure 9

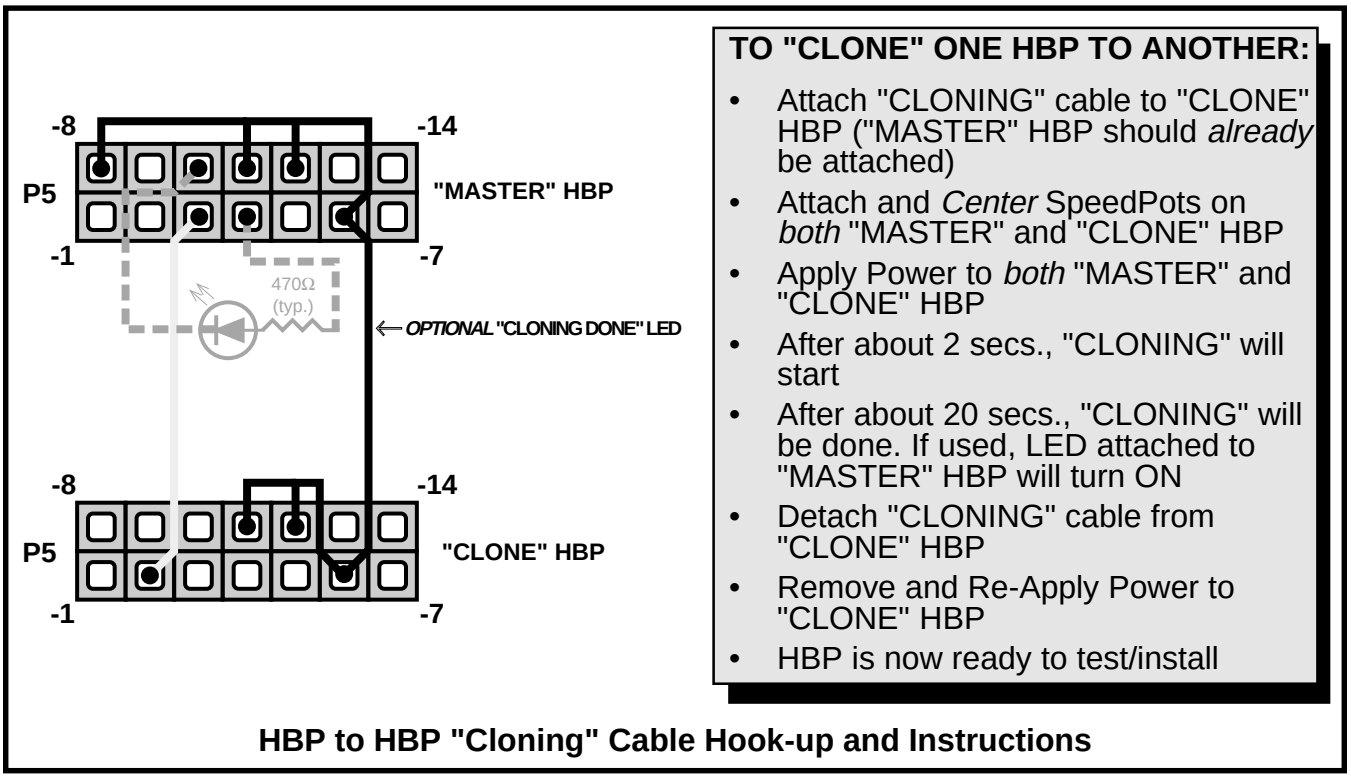


Figure 10

DESCRIPTION OF OPERATION

Overview

The Dart Controls HBP is a microprocessor-based, four-quadrant regenerative MOSFET Pulse-Width-Modulation (PWM) adjustable-speed drive for brush-type permanent magnet motors. The control has many advanced features, such as "intelligent" current limit and user-assignable outputs, that are only practical through the use of microprocessors. Although primarily intended for battery-powered applications from 24vdc to 36vdc nominal, the HBP is versatile and powerful enough to find its way into a wide range of applications operating from d.c. power supplies as well.* Incorporated into the operation of the control are numerous additional features that make it particularly suitable for APV and similar applications, such as an "Inhibit" input, Electromechanical Brake Logic with adjustable delay, selectable "Throttle Potentiometer Failure Detect" (with "limp-home mode"), and "Throttle Applied During Power-up"(aka "Hi-Pedal Disable") to name just a few.

Instead of "Trimpots" and "DIPswitches" to customize behavior, the HBP employs an advanced "trimmerless" design. All operational parameters can be quickly and easily customized through the use of the HBP's RS232 communications port (Note: drive is shipped with usable factory settings listed in “Trimmer Description and Values” section). By connecting a computer terminal, or a computer running a terminal program, the customizable features of the HBP can be "set" or "read", or the entire list of settings can be "transmitted", either for convenient viewing or print-out, or to be "captured" by a computer for later use, such as "playback" into another HBP. To facilitate mass-production for the OEM user, the HBP also allows the duplication, or "cloning" of the settings *directly* from one HBP to another, using only a simple connecting cable, no computer needed. Although they are all referred to as "Trimmers" or "Calibrations", some of the adjustments are actually more like "DIPswitch" arrays, in that the values they are set to *actually* represent the "on/off" settings of a group of "option switches". Let's get familiar with some of these switches now...

"Throttle Controller" Type

The HBP has four "switches" which govern its basic operation: "Throttle Input Type", "Single Dir./Wig-Wag Throttle Mode", "Manual/Automatic Joystick Centerpoint", and "Neutral Safety ON/OFF (Hi-Pedal Disable)". All of these "switches" are contained within "Trimmer" #19, "Operation Mode". See the section "CUSTOMIZING THE HBP" for details on how to set and/or view "Trimmer" values.

The first switch, "Throttle Input Type" (#1), is used to tell the HBP what kind of throttle controller you will be using. Two basic types of controllers are allowed: "Potentiometer" type - connected to terminals P4-14, -15, -16; and "Voltage" type - connected to terminals P4-15 and P4-11. Set this "switch" to "OFF" if you wish to use a conventional Potentiometer, Joystick, or "SpeedPot" type of throttle control. Set this "switch" to "ON" if you wish to use a controller that produces a 0 to +5vdc control voltage (max.). The action of these two modes is basically identical, but for obvious reasons, when "Voltage Throttle" type is selected, the automatic "Throttle Controller Failure" feature is *bypassed*, and the inputs "Pot Hi" and "Pot Lo" are *not used*. If however, "SpeedPot Throttle" type is selected, the integrity of the throttle potentiometer as well as its associated wiring is checked *continuously*, and if a failure *is* detected, the HBP automatically switches to "Limp Home" mode. Once in this mode, the "SpeedPot" is *ignored*, and the control gets its *direction* information (Forward/Neutral/Reverse) from an attached "Direction Switch", which is attached to the normal "FWD" and "REV" switch terminals, P4-12 and P4-13, respectively. See the section "HB HOOK-UP DIAGRAMS" (figure 3) for details on how to attach the "Fwd./Rev." switch. In "Limp Home" mode, *throttle* information is obtained from "Trimmers" #8 & 9, "Limp Mode Forward Speed" and "Limp Mode Reverse Speed". Once entered, the HBP will *stay* in "Limp Home" mode *until power is removed and re-applied.*

* For regenerative operation, power supply *must* be well filtered and *capable of "sinking" (absorbing) the "regen" energy.*

"Single Direction" / "Wig-Wag" Modes

The second "switch" contained within "Trimmer" #19, "Operation Mode" (#2), is known as the "Single Direction/Wig-Wag" mode switch. The "Single Dir."/"Wig-Wag" "switch" controls several aspects of the HBP. These are:

- Whether the setting for "zero throttle" is about in the *middle* or "center" of the throttle control's range, or all the way at one "end".
- Whether or not "Fwd./Rev." direction switches are *needed* for "normal" operation.

  (NOTE: "Fwd./Rev." switches are still *necessary* for "Limp Home" mode. See preceeding subtopic for details on "Limp Home" mode.)
- Whether or not automatic "Joystick Centering" is performed each time the HPB is "Powered-up" (regardless of the setting of the "Auto/Manual Joystick Centerpoint" "switch")

Let's take the two modes ("Single Direction"/"Wig-Wag") one-at-a-time:

In "Wig-Wag" mode, *both* throttle *and* direction information are supplied from the position of the throttle controller; *no "Fwd./Rev." switch is needed.* In fact, *unless* the HBP drops into "Limp Home" mode, any action of the "Fwd./Rev." input terminals is completely ignored.*

In normal "Wig-Wag" operation, when the control is moved out of the "deadband" region, the HBP first "turns off" the signal condition that can be used to drive an electromechanical brake or such, and then begins to accelerate at a rate determined by "Trimmer" # 1, "Acceleration Speed" (within the boundaries of "Current Limit"), and in a direction determined by whether the throttle control is "above" or "below" the center of the controller's range. "Forward" direction is selected when the *voltage* measured between the "Pot Wiper" input (P4-15) and "ground" is nominally *above* the "centerpoint" (whether Automatically or Manually set). Acceleration continues in this manner until the motor drive voltage is at the level corresponding to the throttle controller setting.

When the throttle is moved to a lower setting, the HBP attempts to decelerate at a rate determined by "Trimmer" #2, "Deceleration Speed" (within the boundaries of *braking* "Current Limit", fixed at approx. 60a), and, if the throttle controller is within the "deadband" region, activates the "electromechanical brake" signal *after* a delay determined by "Trimmer" #10, "Delay Before Brake". This signal (like many others) can be "assigned" to a "User-Assignable Output" if needed. If the throttle controller is moved *past* the "center point" of its range *without* stopping in the "deadband" region first, the HBP will first decelerate, then change direction and acclerate, at the appropriate rates (within the boundaries of "Current Limit") *without* activating the "electromechanical brake" signal along the way.

"Single Direction" mode is essentially the same, with the following exceptions:

- The "zero throttle" position is *not* in the center; it is when the "Pot Wiper" voltage is nominally "zero" volts d.c. Automatic "Centering" of throttle controller is *not* performed, and Trimmer #18, "Manual Joystick Center Calibration", as well as Switch #3 of Trimmer #19 "Auto/Manual Joystick Centerpoint" both have *no effect*.
- The "Fwd./Rev." switch (with center "neutral" position) is used to determine direction.* Throttle control operates in one direction over its *entire* range, not just "one side of center".

* For *both* "Wig/Wag" and "Single Direction" modes, the "Fwd./Rev." switch *must* be in the center ("neutral") posn. on Powerup

"Automatic"/"Manual "Joystick Centering Select

As its name implies, this "switch" (#3), also contained in Trimmer #19, determines whether the HBP will attempt to automatically determine the "centerpoint" of a "Wig-Wag" type controller upon powerup, *or* will simply use the value of Trimmer #18 "Manual Joystick Center Calibration" as the centerpoint for the throttle.
In *Automatic* Joystick Centering, *upon application of power*, the HBP first waits to see if the throttle control is within the "deadband" region (as determined by Trimmer #5, "Deadband Width"). If *not*, the "Hi-Pedal Disable" condition is activated, and the HBP will wait paitently until the throttle is returned to the "deadband" area, near the *center* of the throttle controller's range. Once that has been accomplished, the HBP determines the throttle controller's "center point" automatically, then begins normal "Wig-Wag" mode of operation.
There are, however, two other "switch" settings (both contained in Trimmer #19) that will *override* the setting of this switch, forcing "Manual" Joystick Centering:

- Setting the "Wig-Wag/Single Dir." switch (#2) to the "Single Direction" mode
- Setting the "Neutral Safety" ("Hi-Pedal Disable") switch (#4) to the "OFF" position

Selecting either or both of these options will *force* the HBP to use "Manual Joystick Centering", and will *ignore* the setting of the "Automatic/Manual Joystick Centering" switch (#3).

"Neutral Safety" (Hi-Pedal Disable) Select

The fourth and final switch (#4) located within Trimmer #19 is the "Neutral Safety" or "Hi-Pedal Disable" switch. When this switch is OFF (its normal position), the HBP *requires* that the throttle controller be within the "deadband" region (neutral throttle) upon powerup. This is to prevent unwanted action of any device attached to the HBP when it is first started up. When the switch is in the ON position (*defeating* the "Hi-Pedal Disable" function), the HBP will immediately respond to *any* throttle setting upon powerup.

Selecting this option (by setting switch #4 to the "ON" position), will *force* the HBP to use "Manual Joystick Centering" (if in "Wig-Wag" mode). This is due to the fact that since we are allowing the Joystick to be *out* of the "deadband" region upon powerup, there is no way to *automatically* determine the Joystick's "Centerpoint" at that time.

SETTING SOFTSWITCHES

Like many other devices, the HBP has the ability to select between a number of "yes/no" or "on/off" options, depending upon the application. Traditionally, this sort of option-selecting is done with some sort of physical switch or switches, such as a DIPswitch assembly. There are two problems with this approach to option selection: 1) DIPswitch assemblies are somewhat bulky, and most require that the device be at least partially disassembled to gain access to them; 2) On a device with more than just a very few options, the number and combinations of switches quickly becomes overwhelming.

Because of these drawbacks, the HBP takes a different approach (where appropriate): "SoftSwitches".

It is easiest to think of a Trimmer containing SoftSwitches as a DIPswitch assembly containing from one to eight switches. But instead of actually "flipping" a switch to the appropriate position, the editor (or user) can set and read these switches as a Binary-Coded-Decimal, or BCD number. Now before you say "Binary numbers! Those are for computers!", let's look at this another way: Each switch, from switch #1 through switch #8, has been assigned a decimal number that represents its position in the make-believe DIPswitch assembly. When that number is used, it means that switch is "*on*". For example, the decimal number that represents switch #4 is 8, the number that represents switch # 6 is 32, and so on. See the table below for a full explanation of these values.

Switch#	BCD Value
1	**1**
2	**2**
3	**4**
4	**8**
5	**16**
6	**32**
7	**64**
8	**128**

So, the Binary-Coded-Decimal number contained in a SoftSwitch Trimmer is nothing more than the sum of the numbers representing the "*on*" switches. For example, if you wanted to set switches #1, #4, and #7 to the "*on*" position, you would place the number 73 (1 + 8 + 64) into the Trimmer containing those SoftSwitches; if you wanted to set switches #5 and #6 "*on*", you would place the number 48 (16 + 32) into the Trimmer, and so forth. Simply "add-up" the BCD values of the switches you wish to turn "*on*", and place the total, or "sum" into the Trimmer containing the SoftSwitches.

You can also "read" the settings of SoftSwitches in the same way: If a Trimmer containing SoftSwitches has the number 11 in it, you can tell that switches #1, #2, and #4 (or 1 + 2 + 8) are "*on*". You can tell this by *subtracting* the BCD values, from highest to lowest, *starting at the highest value that is less than or equal to the "total"*. Keep subtracting, but if you get a negative number as a result, then don't subtract that BCD value (add it back in before proceeding). Work your way "downward" toward switch #1, but when your total reaches *zero*, you are finished.

Try a few examples of your own, and you will soon get the hang of setting and reading SoftSwitches.

USER-ASSIGNABLE OUTPUTS

One of the most advanced features of the HBP is its "User-Assignable Outputs". This feature allows the OEM user to configure the three *physical* output circuits, one employing an uncommitted N-channel FET capable of switching up to 60vdc at 1ampere, and two that use an NPN "open collector" output switch "to -Battery"capable of switching 60vdc at 100ma. See the section "HBP HOOK-UP DIAGRAMS" (figures 4 and 5) for more information about proper wiring of the User-Assignable Outputs. Each output can be "connected" to *any combination* of up to eight different "conditions", such as "current limit exeeded", "battery low", etc. by using its "Assignment Matrix" trimmer. Through the use of each output's "Inverter Matrix" trimmer, the *opposite* of any condition(s) can be used instead ("battery *not* low", "current limit *not* exceeded", etc.) for even more flexibility. Additionally, each output can be set to either "Normally Open" (N.O.) or "Normally Closed" (N.C.) operation with the "Output Selection" trimmer. See the section "CUSTOMIZING THE HBP" for details on how to set trimmers on the HBP. This output arrangement provides the OEM user with literally *thousands* of possible combinations, while keeping the actual electronic complexity (and cost) of the control to a minimum.

There are two different ways that the "circuitry" of *each* User-Assignable Output can be expressed. For those familiar with digital logic symbols, please refer to the top figure on the next page for a "circuit" description. If you are more familiar with "Ladder Logic" symbology, please refer to the bottom figure instead for a "schematic" representation. However, *regardless* of which method you are more comfortable with, it is important to remember a few things:

- This "circuitry" is actually implemented in <u>software</u>, *not* <u>hardware,</u> and although it actually makes little difference to the final output produced, that fact should be kept in mind.
- *Both* figures on the next page represent *one* of the *three* User-Assignable Outputs.
- Often there is more than one way to "connect-up" the signals and inverters to achieve the desired result; but NOTE: Signal "polarity" is *always* a tricky problem in "logic circuits". Sometimes it takes a bit of careful planning to arrange "inverted" and "non-inverted" signals properly.

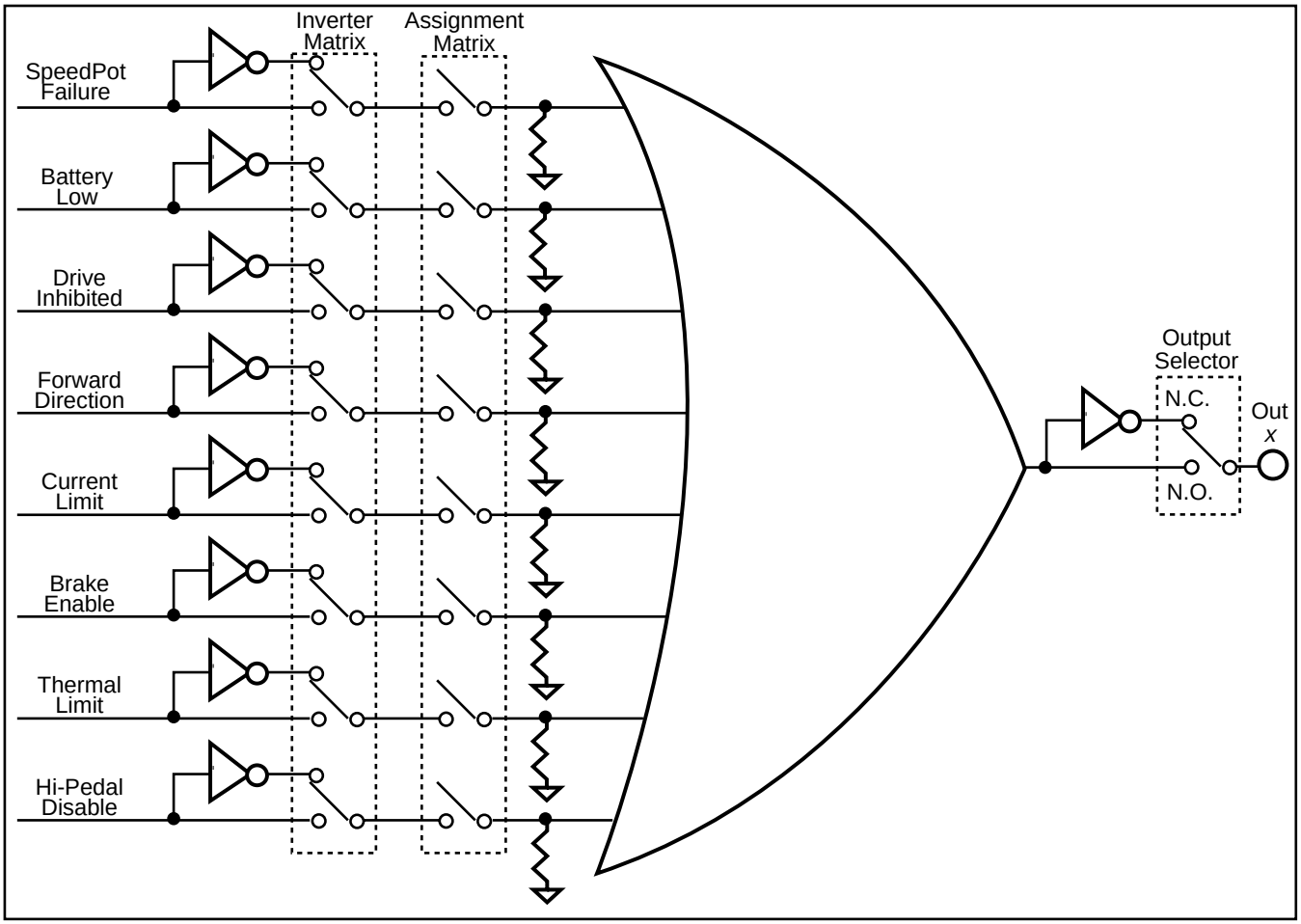
Examples:

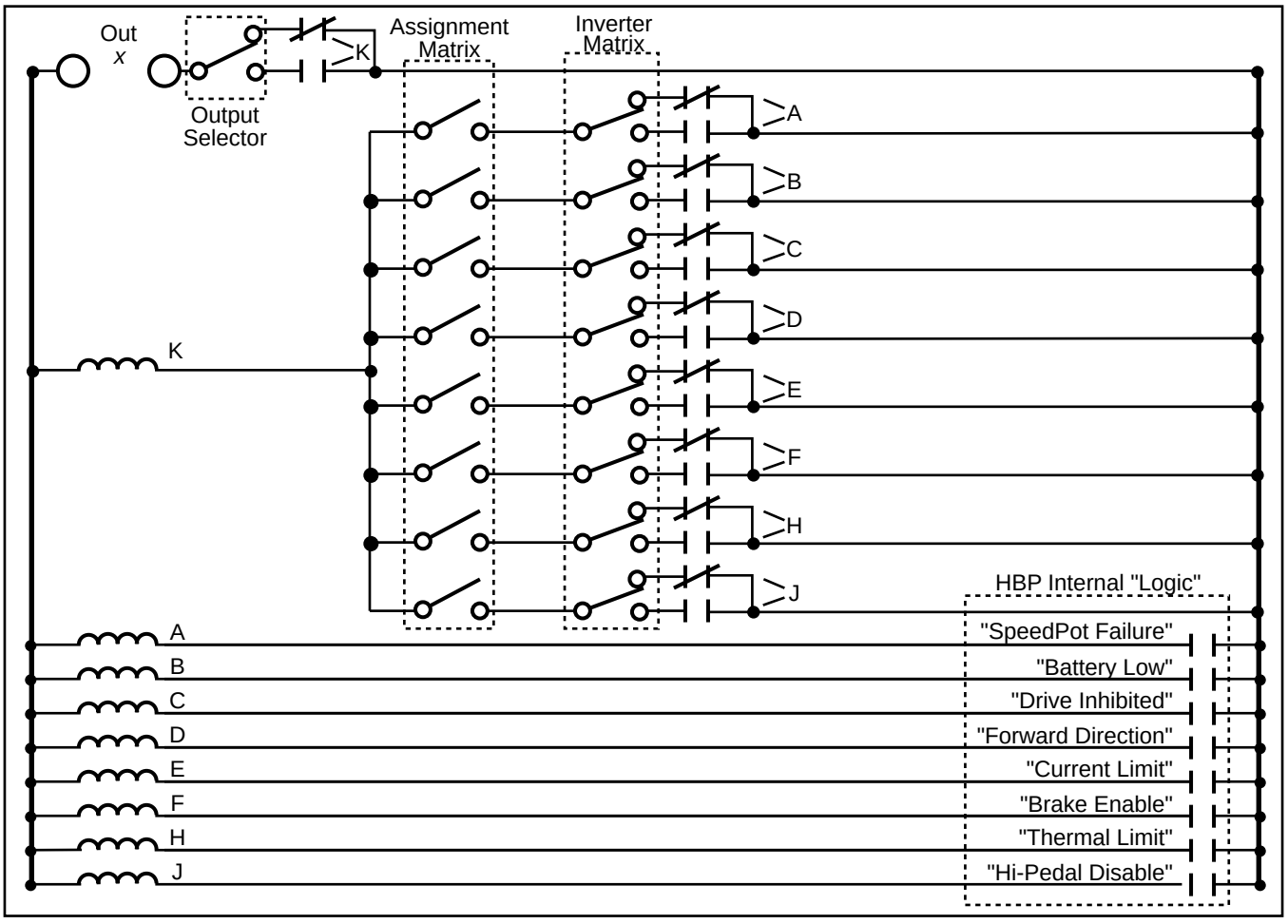
Problem: Setup Output 1 to activate an Electromechanical brake on an APV; Outputs 2 & 3 are unused. The brake is *engaged* when power is *not* applied. NOTE: Trimmer #10 sets the brake delay after throttle returns to neutral (within "deadband") position.

Solution: Set Trimmer #21(Output 1 "Assignment Matrix") to a value of 128 ("brake"); set Trimmer #24 (Output 1 "Inverter Matrix") to a value of 0 ("none inverted"); set Trimmer #20 ("Output Selection") to a value of 1 (Output 1 N.C., Output 2 & 3 N.O.).

Problem: Setup Output 1 to activate a "Scrub Brush" assembly for a motorized Floor Scrubber. The Scrub Brush must operate *only* if the throttle is *not* in "neutral" *and* the battery is *not* "low". Output 2 is used to operate an electronic "Backup Horn" to warn persons behind the scrubber that it is in "Reverse". Output 3 is used to light an LED when the control is in "Inhibit", (in this case, a condition activated by attaching a battery charger to the unit.) NOTE: Trimmer #10 sets the "brush-turn-off" delay after throttle returns to neutral (within "deadband") position.

Solution: Set Trimmer #21(Output 1 "Assignment Matrix") to a value of 160 (128+32, or "brake"+ "battery low"); set Trimmer #24 (Output 1 "Inverter Matrix") to a value of 0 ("none inverted"); set Trimmer #22 (Output 2 "Assignment Matrix") to a value of 1 ("Forward Direction); set Trimmer #25 (Ouput 2 "inverter Matrix") to a value of 1 (*invert* the "Forward Direction" signal); set Trimmer # 23 (Output 3 "Assignment Matrix") to a value of 16 ("Inhibit"); set Trimmer #26 (Output 3 "Inverter Matrix") to a value of 0 ("none inverted"); set Trimmer #20 ("Output Selection") to a value of 1 (Output 1 N.C. ("inverted"), Output 2 & 3 N.O.).


Inverter Matrix
Assignment Matrix
SpeedPot Failure
Battery Low
Drive Inhibited
Forward Direction
Current Limit
Brake Enable
Thermal Limit
Hi-Pedal Disable
Output Selector
N.C.
N.O.
Out x


Out x
Output Selector
K
Assignment Matrix
Inverter Matrix
A
B
C
D
E
F
H
J
K
HBP Internal "Logic"
A "SpeedPot Failure"
B "Battery Low"
C "Drive Inhibited"
D "Forward Direction"
E "Current Limit"
F "Brake Enable"
H "Thermal Limit"
J "Hi-Pedal Disable"

DESCRIPTION OF TRIMMERS AND SOFTSWITCHES

Trimmer 1, Acceleration Speed:

Controls the rate at which the HBP "speeds up" the motor, for both foward and reverse. The higher the number, the faster the acceleration, within the boundaries of current limit. Legal values range from 1 (about 1 minute) to 255 (nearly instantaneous). A value of zero is not useful, as the HBP will never accelerate the motor under that condition.

Trimmer 2, Deceleration Speed:

Controls the rate at which the HBP "slows down" the motor, for both forward and reverse. The higher the number, the faster the deceleration, within the boundaries of braking current limit (fixed at approx. 60a). Legal values range from 1 (over 1 minute) to 255 (rapid deceleration). A value of zero is not to be used, as it will cause the HBP to "stick" at a speed, with no deceleration possible.

Trimmer 3, Forward Direction Current Limit:

Sets the *continuous*, or "long term" current limit for the forward drive direction. Keep in mind that the HBP has "intelligent" current limit that has been designed to safely allow significant short-term overloads, while still protecting the control and motor. The higher the number, the higher the current limit setting, with an average increase of around .39a per "step". Useful trimmer settings range from about 40 (about 10a) to around 154 (about 60a). Lower and higher settings are possible, but probably not practical.

Trimmer 4, Reverse Direction Current Limit:

Same as Trimmer 3, but for the reverse drive direction.

Trimmer 5, Deadband Width:

Sets the *width* of the "neutral" region between forward and reverse throttle direction for "Wig-Wag" mode, or The region *below which* no throttle is applied in "Single Direction" mode. When the throttle controller is within this region, the HBP will decelerate to a stop, and after a timeout controlled by trimmer 10, "Delay Before Brake", sends a signal that could be used to activate an electromechanical brake, deactivate a "brush assembly", etc. Higher numbers create wider deadband widths. The upper limit of practical settings is likely in the range of 25 to 30. If the setting is too high (close to 255), the HBP will probably appear not to run at all.

Trimmer 6, Maximum Forward Speed:

Sets the maximum forward drive of the HBP. The higher the number, the faster the maximum speed, up to a value of 255 (maximum output). Other factors contributing to the final maximum output are the setting of trimmer 5 ("Deadband Width"), the setting of trimmers 11 & 12 ("Joystick Range Calibrations"), the setting of trimmer 17 ("Motor EMF Calibration"), and to some extent, both the Current Limit Setting as well as the condition of the battery (if using batteries).

Trimmer 7, Maximum Reverse Speed:

Same as Trimmer 6, but for the reverse drive direction.

Trimmer 8, Limp Mode Forward Speed (used after "Pot Fail" error occurs):

Sets the *fixed* throttle setting (X2) that is used if the HBP detects a defective throttle *potentiometer*, or wiring to same. Use of this feature requires three things: 1) That the HBP be using a *potentiometer-type* throttle controller; 2) That the setting of switch #1 ("Throttle Type") in SoftSwitch "trimmer" 19, "Operation Mode", be "OFF"; 3) The connection of a "Forward-Neutral-Reverse" SPDT *center-off* type switch, as shown in the section "HBP HOOK-UP DIAGRAMS", under the heading "Single-Direction Operation" (figure 3). Note that in "Wig-Wag" mode, this switch is ignored until a "Pot Fail" is detected. *NOTE:* This trimmer setting is limited to a value of 110, which will translate to "full throttle", since the setting of this trimmer is multiplied by 2 by the HBP.

Trimmer 9, Limp Mode Reverse Speed:

Same as Trimmer 8, but for the reverse drive direction.

Trimmer 10, Delay Before (electromechanical) Brake:

Sets the timeout after the throttle is within the "Deadband" region, or the " forward-neutral-reverse" switch is in the "neutral" position (for "Single-Direction" or "Pot Fail" modes), before the "Electromechanical Brake Output" signal is active. The user may, at their discretion, then route this signal to a "user-assignable output", where it can be used to drive an electromechanical brake, deactivate a "brush assembly", etc. Delay values increase at a rate of about .142 seconds per step, with values ranging from zero (nearly instantaneous) to 255 (about 36 seconds).

Trimmer 11, Forward Direction Joystick Range Calibration:

Used to adjust the "sensitivity" or "gain" of the throttle control input, primarily to compensate for less than "full-

travel" throttle controllers. In *most* situations, the factory default setting of 75 should be sufficient, but if your throttle controller has less than full travel, this trimmer should be set using the following procedure:

1. Set *both* the forward and reverse "Maximum Speed" Trimmers (Trimmers 6 & 7) to 255 (full speed) by sending **SC,6,255<cr>**, then **SC,7,255<cr>** to the HBP's RS232 input.
2. Attach a d.c. voltmeter across the "Motor" output of the HBP (P1-1 and P1-4).
3. Advance the Throttle controller to its maximum full travel position and observe the voltmeter.
4. Set the Joystick Range Calibration Trimmer (Trimmer 11) to the *next higher* value than that which gives full output (approximately the same as battery voltage) when the throttle is at its maximum.
5. Reset the "Maximum Speed" trimmers (Trimmers 6 & 7) as desired for your application.

Trimmer 12, Reverse Direction Joystick Range Calibration:
Same as Trimmer 11, but for the reverse drive direction.

Trimmer 13, Low Battery Threshold:
Sets the voltage *below which* the HBP will activate the "Low Battery" signal, as a steady-state output. This signal can then be routed to a "user-assignable output", or used in combination with other conditions to form a useful signal. The higher the number, the higher the threshold, with an increase of about .180 volts per step. The useful range is about 55 (around 10v) to about 200 (around 36v). A setting of zero defeats this signal entirely. This Trimmer should be set such that average high-current draws do *not* cause this signal to appear with fully charged batteries. Typically, this will be at a value of around 2 volts *below* the "nominal" battery voltage (i.e. 22v for "24v" operation).

Trimmer 14, *Lower* Battery Threshold:
Primarily intended for use with a visual indicator, this Trimmer sets the voltage *below which* the HBP will activate the "Low Battery" signal, as a "*flashing"* output. This signal can then be routed to a "User-Assignable Output", if desired. The range of values is the same as Trimmer 14. *NOTE:* This Trimmer should be set to a value *less than* Trimmer 13 ("Low Battery Threshold"), or to zero (to defeat this function). If the "Low Battery" signal is used to drive a relay, or in combination with another signal routed to a "User-Assignable Output", this function should *not* be used, as it could cause an undesirable On-Off,On-Off "flashing" output signal.

Trimmer 15, Current Limit Onset Rate:
Controls the rate at which an over/under current condition is controlled by the HBP. The higher the setting of this trimmer, the *faster* the HBP will respond to an over/under current condition, allowing the user to decide how much of a *momentary* over current condition will be allowed, as required by their specific application.

Trimmer 16, Motor "I.R. Drop" Compensation:
Used to compensate for the internal electrical resistance in the motor armature winding. This trimmer creates a modest *increase* in "throttle" automatically as the current draw ("load") increases, within the boundaries of current limit. Most useful in "small motor"/"large load"/"low throttle setting" situations, such as trying to "crawl" up a ramp with an APV or other vehicle. I.R. compensation amount *increases* with higher settings of this Trimmer. If the I.R. Compensation Trimmer value is set too *high*, the tendency will be for the motor speed to "oscillate" under heavy load conditions. With I.R. compensation, the rule is generally "*less* is better". Start out with a value of zero (no I.R. Compensation) and gradually work your way up to a value that is right for your application. Useful values for this Trimmer are typically from zero to about 20. *NOTE:* It is best to bring the motor up to its typical running temperature before setting this trimmer; otherwise, the value could be set too *high* inadvertently, due to the large change in motor winding resistance with changes in temperature.

Trimmer 17, Motor E.M.F. Calibration:
This Trimmer compensates for different power supply voltages used with the HBP. The useful settings for this control are: 8 for 36v and 12 for 24v operation. For operation at other voltages, consult the factory.

Trimmer 18, MANUAL "Wig-Wag" Throttle Center Calibration:
Sets a MANUAL center point for joystick throttle controllers, if automatic "center calibration" upon startup is *not* desired. *This trimmer is only active if Swtich #3 of SoftSwitch Trimmer #19 is set to the "ON" position.* Values represent .2v per "step" from 0 to 5v. A value of 128 is nominally 2.5v (the "ideal" center point).

NOTE: **"Trimmers" 19 — 26 are actually groups of "Option Settings", known as "SoftSwitches". For an explanation of how to use SoftSwitches, see the section "SETTING SOFTSWITCHES" earlier in this manual.**

NOTE: **In the tables below, the *normal factory setting* for each SoftSwitch listed in the table is shown enclosed in brackets"[ ]".**

Trimmer 19, Operation Mode ("Switches 1, 2, 3 and 4 used *only*):

Controls four different conditions in the HBP that define its basic mode of operation:

Switch #	Description	"OFF" Setting	"ON"Setting
1	Throttle Controller Type Used	[Use a Potentiometer]	Use a Voltage
2	Single/"Wig-Wag" Directional Mode	[Wig-Wag Mode]	Single-Dir. Mode
3	Auto./Manual Joystick Centering *****	[Auto. Centering]	Manual Centering
4	MUST the Throttle be in "Neutral" upon powerup?	[Yes]	No *****

This Trimmer can be set from zero to 15, depending on the desired option "selection(s)".

*** Setting switch #4 to the "ON" position *forces* "Manual Joystick Centering" also, *regardless* of switch #3**

See the sections "SETTING SOFTSWITCHES" and "USER-ASSIGNABLE OUTPUTS" for further explanation.

Trimmer 20, N.C/N.O. Selection for User Assignable Outputs 1 through 3 (Switches 1, 2 and 3 used *only*):

Independently sets *each* User-Assignable Output to either "Normally OPEN" or "Normally CLOSED" operation:

Switch #	Description	"OFF" Setting	"ON"Setting
1	User Assignable Output 1 N.O./N.C.	[Normally "Open"]	Normally "Closed"
2	User Assignable Output 2 N.O./N.C.	[Normally "Open"]	Normally "Closed"
3	User Assignable Output 3 N.O./N.C.	[Normally "Open"]	Normally "Closed"

Below is a list of all "legal" values for this Trimmer, and what each of them means.

0- Sets all 3 User-Assignable Outputs to "N.O." operation.

1- Output 1 set to "N.C.", Outputs 2 & 3 set to "N.O."

2- Output 2 set to "N.C.", Outputs 1 & 3 set to "N.O."

3- Output 1 & 2 set to "N.C.", Output 3 set to "N.O."

4- Output 3 set to "N.C.", Outputs 1 & 2 set to "N.O."

5- Output 1 & 3 set to "N.C.", Output 2 set to "N.O."

6- Output 2 & 3 set to "N.C.", Output 1 set to "N.O."

7- Sets all 3 User-Assignable Outputs to "N.C." operation.

Trimmer 21,22,23, Assignment Matrix for User Assignable Outputs 1 (21), 2 (22), & 3 (23):

Determines which HBP internal signal(s) is assigned to a User-Assignable Output:

Switch #	Description	"OFF" Setting	"ON"Setting
1	Use/Don't Use the "Forward Direction" Signal	Don't Use It	Use It
2	Use/Don't Use the "Hi-Pedal Disable" Signal	Don't Use It	Use It
3	Use/Don't Use the "Temperature Limit" Signal	Don't Use It	Use It
4	Use/Don't Use the "Limp Home Mode" Signal	Don't Use It	Use It
5	Use/Don't Use the "Inhibit" Signal	Don't Use It	Use It
6	Use/Don't Use the "Low" (or "Lower") Battery Signal	Don't Use It	Use It
7	Use/Don't Use the "Current Limit" Signal	Don't Use It	Use It
8	Use/Don't Use the "Electromechanical Brake" Signal	Don't Use It	Use It

This Trimmer can be set from zero to 255, depending on the desired signal "selection(s)".

See the sections "SETTING SOFTSWITCHES" and "USER-ASSIGNABLE OUTPUTS" for further explanation.

Trimmer 24,25,26, Inverter Matrix for User Assignable Outputs 1 (24), 2 (25), & 3 (26):

Selects the "non-inverted" or"inverted" version for *each signal assigned* by the Assignment Matrix above:

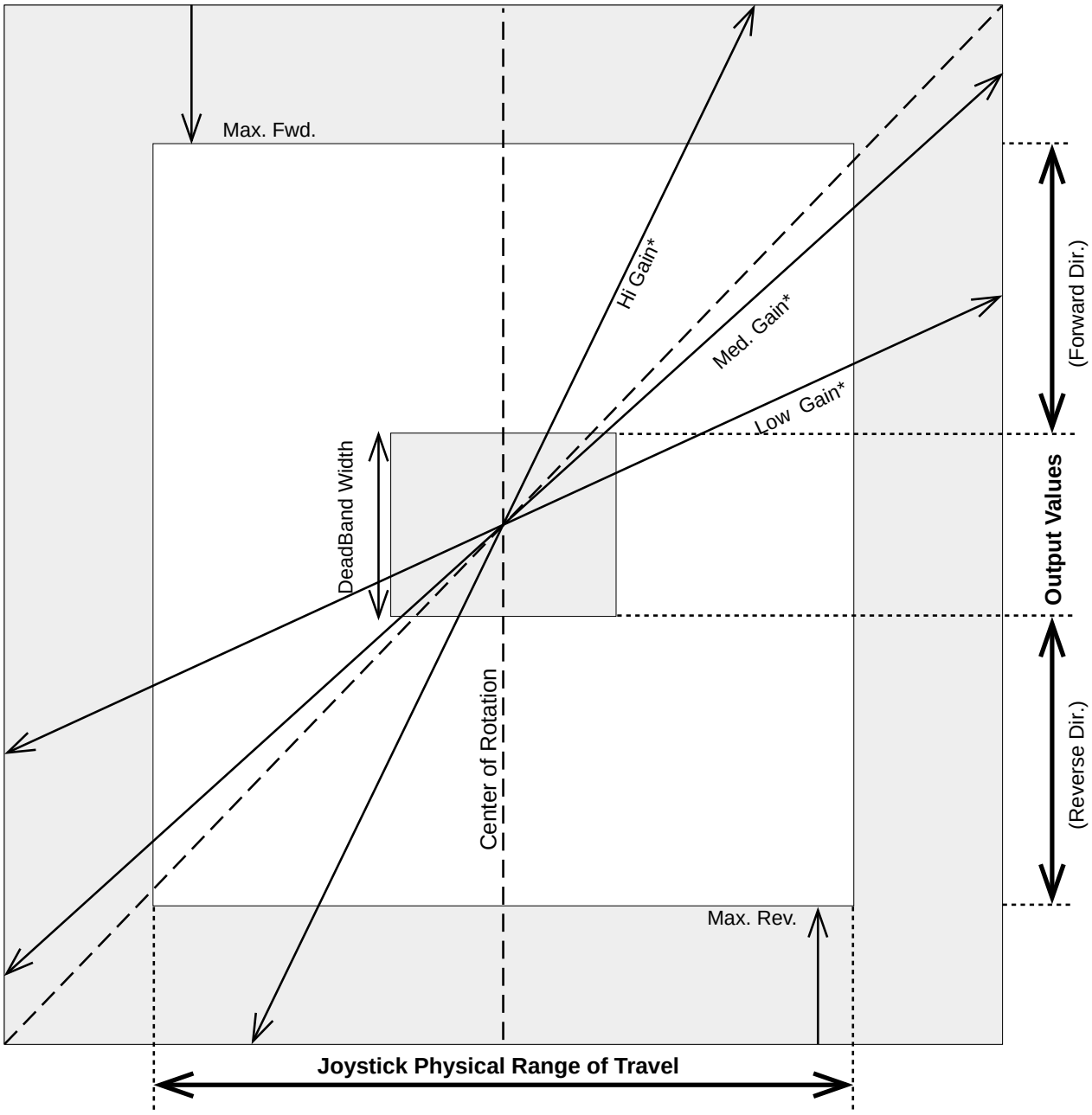
Switch #	Description	"OFF" Setting	"ON"Setting
1	Invert/Don't Invert the "Forward Direction" Signal	Don't Invert It	Invert It
2	Invert/Don't Invert the "Hi-Pedal Disable" Signal	Don't Invert It	Invert It
3	Invert/Don't Invert the "Temperature Limit" Signal	Don't Invert It	Invert It
4	Invert/Don't Invert the "Limp Home Mode" Signal	Don't Invert It	Invert It
5	Invert/Don't Invert the "Inhibit" Signal	Don't Invert It	Invert It
6	Invert/Don't Invert the "Low" (or "Lower") Battery Signal	Don't Invert It	Invert It
7	Invert/Don't Invert "Current Limit" Signal	Don't Invert It	Invert It
8	Invert/Don't Invert the "Electromechanical Brake" Signal	Don't Invert It	Invert It

This Trimmer can be set from zero to 255, depending on the desired inverter "selection(s)".

See the sections "SETTING SOFTSWITCHES" and "USER-ASSIGNABLE OUTPUTS" for further explanation.

THE UNIVERSE OF JOYSTICK GAINS

As can be seen from the figure below, there are several factors that contribute to the HBP's response to a given throttle input. Trimmers #5, #6, #7, #11, #12, #17, and if appropriate, #18, as well as the "range" of output (or "travel") of the throttle controller itself, all play a part in determining what happens at a given setting of the throttle. For example, when you *increase* the "deadband" width (with Trimmer #5), you have effectively placed more of your throttle controller's values in "no-man's land", and thus, could affect the max. speed, unless you also *increase* the "Joystick Range Calibration" for that direction. Also, note that the "Max. Fwd." and "Max. Rev." *chop off* any values higher than their settings. The bottom line is these trimmers *interact*, so beware, it may take some "fiddling", but there is enough adjustment range to handle almost *any* combination of "limited-travel" controllers, "crazy motors" and so forth.



* "Gain" is actually "Joystick Range Calibration (for a given direction)" vs. "Motor EMF Calibration"

= "Unattainable" Output Values (out of range because of "Gain" or Joystick Physical Range of Travel, or both)

CUSTOMIZING THE HBP

The HBP comes with pre-set factory "trimmer" settings that will allow it to be used "right-out-of-the-box" for many applications; however, it *does* allow the user to customize its behavior if desired. To do this, the HBP control communicates over an RS232 data interface with a simple ASCII "command set". The interface is used for the setting and/or reading of "trimmers" as well as another function, "*cloning*". Specifications for the interface are as follows:

Protocol ..... RS232C, Half Duplex
Data Rate ..... 300 Baud (non-adjustable)
Number of Data Bits 8
Number of Stop Bits 1
Parity ..... None
Linefeeds .. Incoming Linefeeds are ignored, Outgoing Linefeeds NOT sent

You may communicate with the HB with any RS232 terminal, a computer or laptop running a terminal emulation program, (or any other program for sending and receiving ASCII messages over a serial port), or a modem. The command set is as follows:

NOTE: CAUTION, ALL PROGRAMMING SHOULD BE DONE WITH THE HBP IN "NEUTRAL" (Throttle in "deadband").

NOTE: ALL COMMAND MESSAGES (and responses) ARE TERMINATED WITH A CARRIAGE RETURN (ASCII 13 decimal). We will show this as <CR> in our descriptions.

NOTE: POWER *MUST* BE APPLIED BEFORE PROGRAMMING CAN BE ACHIEVED!

SC SET CALIBRATION

DESCRIPTION: **Sets a "trimmer" to a particular value (0 to 255)**
USAGE: **SC,<trimmer#>,<value><CR>**
EXAMPLE: **SC,15,200<CR>** Sets Trimmer #15 to a value of 200
RESPONSE: **Y<CR>, if successful; N<CR> if an error (such as a value >255) occured.**

RC READ CALIBRATION

DESCRIPTION: **Reads the current value (0 to 255) of a particular "trimmer"**
USAGE: **RC,<trimmer#>,0<CR>**
EXAMPLE: **RC,3,0<CR>** Reads the value of trimmer #3
RESPONSE: **<3 digit number><CR>, if successful; N<CR> if an error (such as too high of a trimmer#) occured.**
NOTE: **The response will *always* be 3 digits. i.e., the value "20" would appear as 020, etc.**

TC TRANSMIT CALIBRATION(s)

DESCRIPTION: **Lists/ Transmits the values of *all* trimmers**
USAGE: **TC,<delay-before-start (in .5 sec. increments)>,0<CR>**
EXAMPLE: **TC,4,0<CR>** Delays 2 secs., then transmits the trimmers
RESPONSE:
SC,001,<trimmer #1 value><CR>
SC,002,<trimmer #2 value><CR>
⋮
SC,026,<trimmer #26 value><CR>
NOTE: **This list can be simply viewed on a computer or terminal screen; captured for later "playback" into another HBP; or can be used to "clone" one HBP drive's trimmer settings into another HBP.**

NOTE: ALL HBP CONTROLS ARE SHIPPED WITH THE TRIMMERS ALREADY SET TO "FACTORY SETTINGS"

TRIMMER DESCRIPTIONS AND VALUES

#	Description	Low Limit	Hi Limit	Factory Setting	User Setting
1	Acceleration Speed (higher #s are faster)	1	255	255 (fastest)	
2	Deceleration Speed (higher #s are faster)	1	255	255 (fastest)	
3	Forward Direction Current Limit (about .39A/step)	1	255	154 (60A)	
4	Reverse Direction Current Limit (about .39A/step)	1	255	154	
5 *	Deadband Width	0	255	16	
6	Maximum Forward Speed	0	255	255	
7	Maximum Reverse Speed	0	255	255	
8	Limp Mode Forward Speed (do not set above 127)	0	110	110 (full spd)	
9	Limp Mode Reverse Speed (do not set above 127)	0	55	55 (1/2 spd)	
10	Delay Before Brake (.142 sec./step)	1	255	7 (1 sec)	
11	Forward Dir. Joystick Range Calibration	0	255	75	
12	Reverse Dir. Joystick Range Calibration	0	255	75	
13	Low Battery Threshold (.180v/step)	0	255	128 (23v)	
14	LOWER Battery Threshold (.180v/step)	0	255	0 (defeat)	
15	Current Limit Onset Rate (higher #s are faster)	0	254	20	
16	I.R. Compensation	0	255	0	
17	Motor EMF Calibration (*nominal* values:) (8=36v 12=24v 24=12v operation)	1	255	12 (for 24v)	
18 *	MANUAL Joystick Center Calibration (.2v/step)	0	255	128 (2.5v)	
19 *	Operation Mode SoftSwitches (add up values to determine Mode "switch" settings) 1= Voltage Throttle | 2=Single Dir. Mode 0= SpeedPot Throttle | 0=Wig-Wag Mode 4=MANUAL Centering | 8=Neutral Safety OFF 0=Auto. Centering ON | 0=Neutral Safety ON	0	15	0 (SpdPot/Wig-Wag /Auto. Center /Neut. Safety ON)	
20	NC/NO Output Selection for User Outputs (add up values to determine Polarity "switch" settings) 4= Out3 N.C. | 2= Out2 N.C. | 1= Out1 N.C. 0= Out3 N.O. | 0= Out2 N.O. | 0= Out1 N.O.	0	7	0 (ALL Norm. Open)	
21	User Output 1 Assigment Matrix	0	255	128 (brake)	
22	User Output 2 Assigment Matrix	0	255	64 (cur. lim.)	
23	User Output 3 Assignment Matrix	0	255	32 (low bat.)	
24	User Output 1 Inverter Matrix	0	255	0 (none inv.)	
25	User Output 2 Inverter Matrix	0	255	0 (none inv.)	
26	User Output 3 Inverter Matrix	0	255	0 (none inv.)	

Write YOUR Custom Settings (if any) Here

***** Power must be removed and re-applied for changes in this trimmer to take effect.

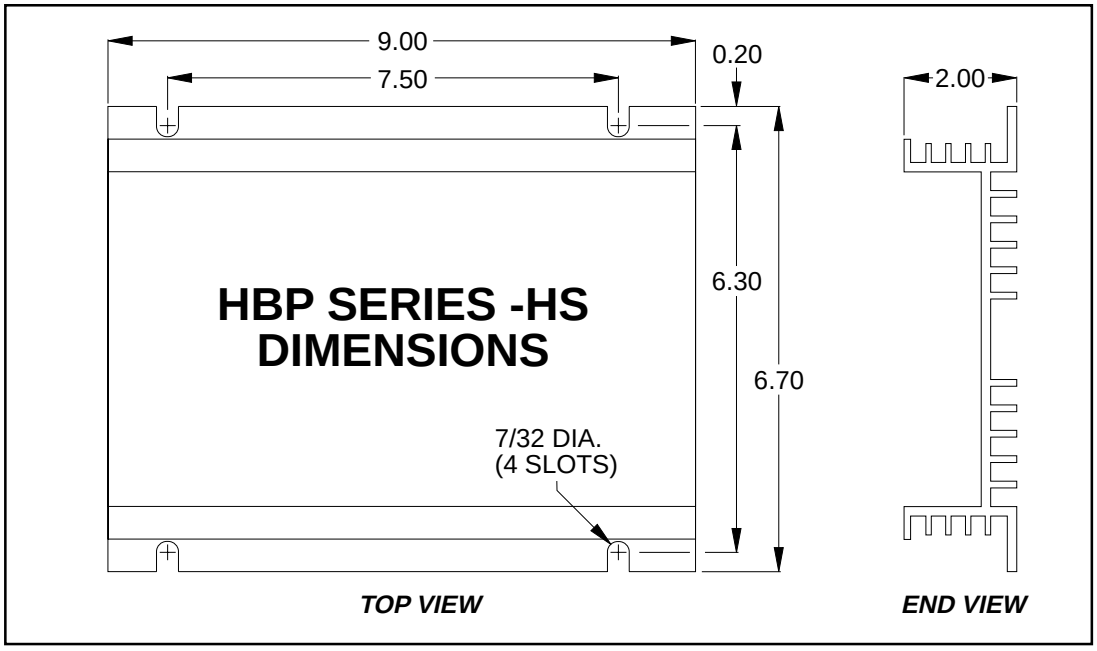
VALUES FOR USER OUTPUT ASSIGNMENT/INVERTER MATRIX **

Value	Description
128	Produces Output When Electromechanical Brake Should Activate
64	Produces Output When in Current Limit
32	Produces Steady Output When Battery is Below “Low Battery” Threshold; Output “Flashes” when Battery is Below “LOWER Battery” Threshold
16	Produces Ouput When “Inhibit” Input to Control is Low (drive inhibited)
8	Produces Output When in “Limp Home” Mode (SpeedPot Failure Detect)
4	Produces Output When Temperature Limit has Activated
2	Produces Output When Joystick Out of Deadband upon Power-up (Hi-Pedal Disable)
1	Produces Output When Control is Driving Motor in Forward Direction

****** See the sections "SETTING SOFTSWITCHES" and "USER-ASSIGNABLE OUTPUTS" for further explanation of how to set "SoftSwitch" trimmers 19 through 26.

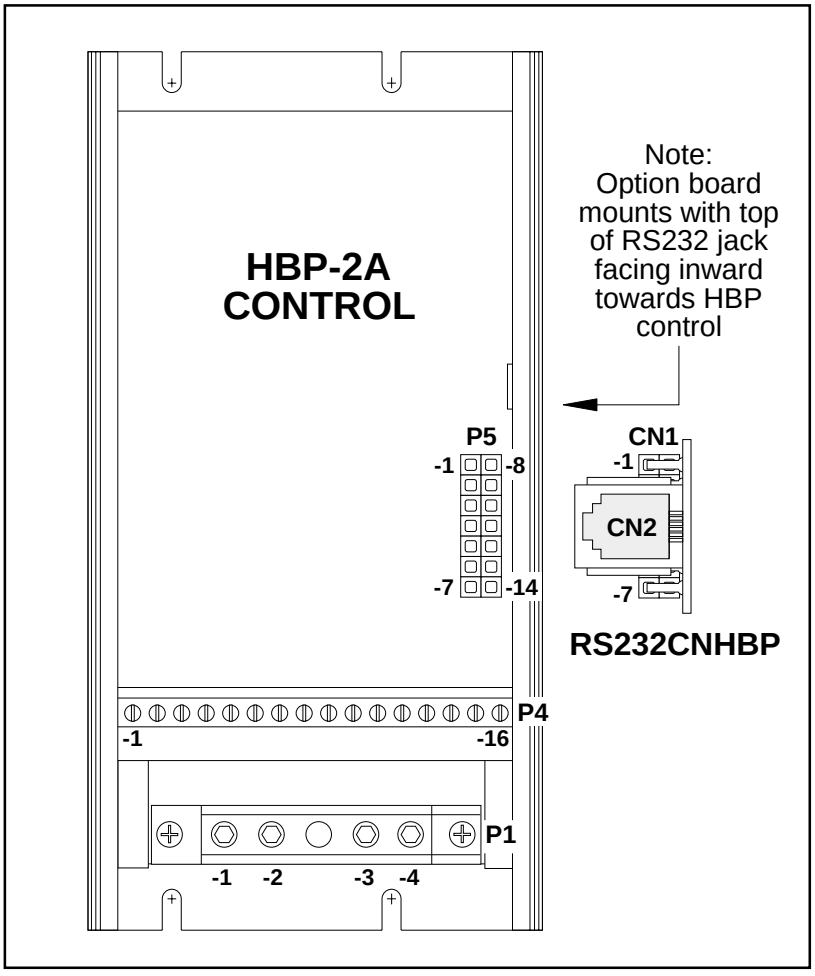
OPTION DESCRIPTION

AUXILIARY HEATSINK ..... -HS



ACCESSORY DESCRIPTION

RS232 COMMUNICATION INTERFACE BOARD RS232CNHBP



REPAIR PROCEDURE

In the event that a Product manufactured by Dart Controls Incorporated (DCI) is in need of repair service, it should be shipped, freight paid, to: Dart Controls, Inc., 5000 W. 106th Street, Zionsville, IN. 46077, ATTN: Repair Department.

Please include with each order a P.O. number to cover any repair charges (a P.O. is needed even on warranty returns to cover misuse or other failures that have voided warranty), and include a note with a brief description of the problem experienced. NO WORK WILL BE DONE ON ANY ORDER WITHOUT A P.O. NUMBER.

Completed repairs are returned with a Repair Report that states the problem with the control and the possible cause. Repair orders are returned via UPS Ground unless other arrangements are made. If you have further questions regarding repair procedures, contact your Dart Distributor or Representative.

ALSO AVAILABLE FROM DART CONTROLS, INC.

125D SERIES
AC INPUT - VARIABLE DC OUTPUT
1/50 HP through 1.0 HP

250G SERIES
AC INPUT - VARIABLE DC OUTPUT
1/50 HP through 2.0 HP

65 SERIES
DC INPUT - VARIABLE DC OUTPUT
CURRENT RATINGS OF 20, 40, AND 60 AMPS

500 SERIES
AC INPUT - VARIABLE DC OUTPUT
1/50 HP through 3.0 HP

MDP SERIES
PROGRAMMABLE CLOSED LOOP DC SPEED CONTROL

DM SERIES
FIELD PROGRAMMABLE DIGITAL TACHOMETER

Dart offers the industry's broadest range of electronic DC and AC motor speed controls rated to 3 horsepower, as well as speed control accessories.

Shown above is just a sampling of the expanded line of Dart controls that feature the latest in electronic technology and engineering. Products are manufactured in the U.S.A. at our Zionsville (Indianapolis, Indiana) production and headquarters facility - with over 2,000,000 variable speed units in the field.

In addition to the standard off-the-shelf products, you can select from a wide variety of options to customize controls for your specific application. For further information and application assistance, contact your local Dart sales representative, stocking distributor, or Dart Controls, Inc.

Dart Controls, Inc.

Manufacturer of high quality DC and AC motor speed controls and accessories since 1963.

P.O. Box 10
5000 W. 106th Street
Zionsville, Indiana 46077
Phone: (317) 873-5211
Fax: (317) 873-1105