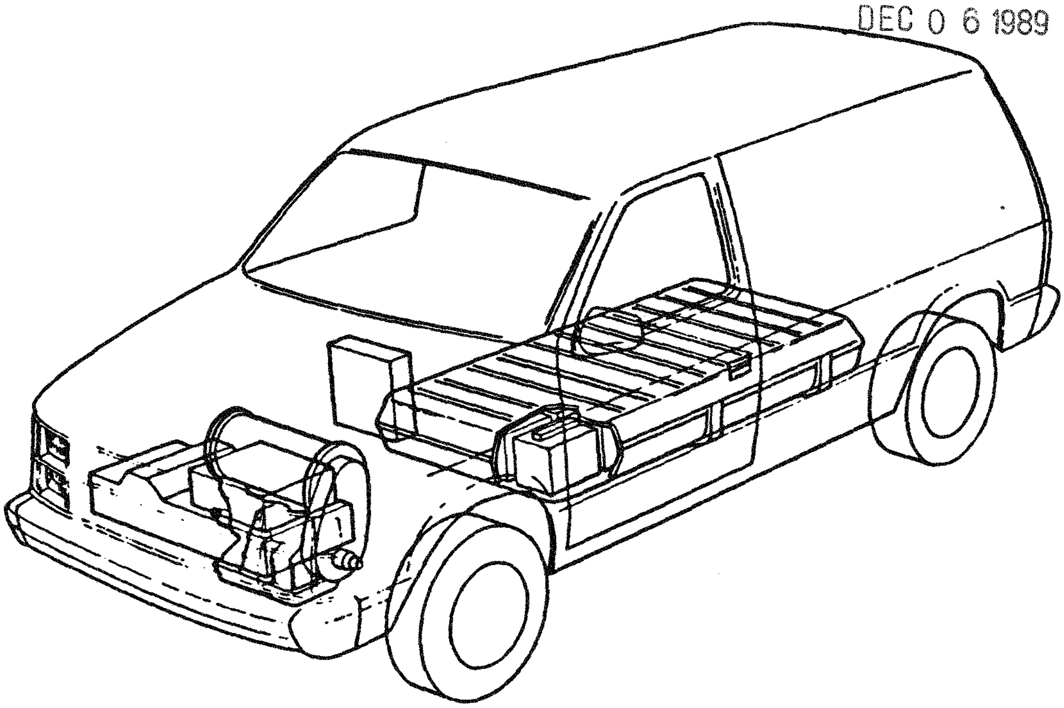
DOE/NV/10366-10



DSEP Advanced Dual Shaft Electric Propulsion System Technology Development Program

MAINTENANCE MANUAL SUPPLEMENT
for the DSEP Vehicles NVH & TB-2
September 1989

Prepared by:
Eaton Corporation — Corporate Research & Development-Detroit Center

Contract DE-AC07-84NV10366
Program Management: Idaho National Engineering Laboratory

U.S. Department of Energy Conservation and Renewable Energy
Office of Vehicle and Engine R&D

EATON

DOE/NV/10366--10

DE90 003404

DSEP Maintenance Manual Supplement for the NVH and TB-2 Vehicles

Eaton Technical Report #89044

Authors: D. Canini
R. DiBartolomeo
A. North
D. St. John

Foreword

This maintenance manual supplement covers maintenance and vehicle support information for the DSEP electric minivans additional to that contained in the Operations and Maintenance Manual of August 1989. This supplementary information is not required for day to day operation and maintenance but may be useful over the course of months and years to keep the DSEP vehicles operational. The supplement is intended to capture maintenance, repair and support procedures well understood at the time of completion and delivery by Eaton for possible future use by both EG&G Idaho and Eaton.

TABLE OF CONTENTS

1. SPEED SENSOR REPLACEMENT

The shaft mounted incremental encoders for motor and transaxle speeds are fragile and require special care on installation. The motor sensor is particularly difficult to fit without damaging it when the motor is already in the vehicle. In both cases when a unit is being filled, there is only one chance. Incorrect fitting requires destruction of the unit to remove it and starting again with a fresh device.

1.1 Motor Hewlett-Packard Sensor Replacement

The HP HEDS 5000 encoder was selected for the motor at an early stage in the DSEP program. Unfortunately, HP wishes to supersede this design with the HEDS-5500 unit which is cheaper but which has less end play (±10 thou instead of ± 20 thou) and which requires a different pin out and assembly procedure.

TB-2:

Removal

Step A
- Remove ribbon cable from signal conditioning box.

Step B
- With a small screwdriver, lift off snaps of encoder body.
- Separate encoder body from encoder base plate.

Step C
- Remove encoder from shaft.

Step D
- Loosen screws from encoder base plate and remove base plate from motor base plate.

NOTE:
- Once encoder has been removed from shaft, do not reuse encoder again. Permanent encoder damage results when encoder is removed from shaft.

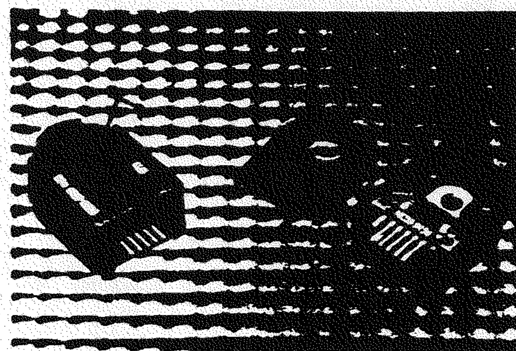
HEWLETT PACKARD

QUICK ASSEMBLY OPTICAL ENCODER

HEDS-5500 SERIES

Features

- QUICK AND EASY ASSEMBLY
- NO SIGNAL ADJUSTMENT REQUIRED
- LOW COST
- SMALL SIZE
- HIGH PERFORMANCE
- HIGH RESOLUTION
- INSENSITIVE TO RADIAL AND AXIAL PLAY
- -40°C TO 100°C OPERATING TEMPERATURE
- TWO CHANNEL QUADRATURE OUTPUT
- TTL COMPATIBLE OUTPUTS
- SINGLE 5 V SUPPLY



The encoder may be quickly and easily mounted onto a motor. No mechanical or electrical adjustments are required.

The two channel digital outputs and the single 5 V supply input are accessed through 0.025 inch square pins located on 0.1 inch centers.

Description

The HEDS-5500 is a high performance, low cost, optical incremental encoder which emphasizes high reliability, high resolution and easy assembly.

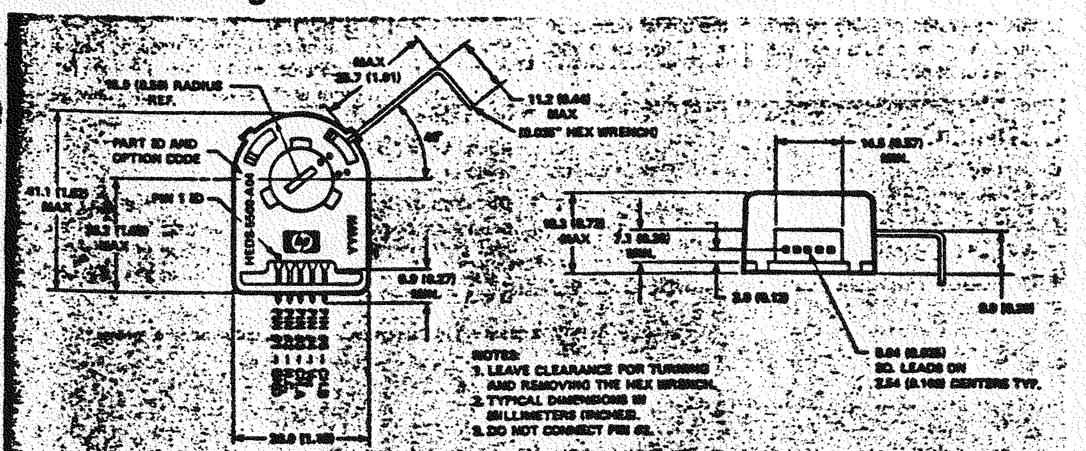
The encoder contains a lensed LED light source, an integrated circuit with detectors and output circuitry, and a code wheel which rotates between the emitter and detector IC. The outputs of the encoder are two square waves in quadrature. The collimated light and special photodetector configuration allow for high resolution and excellent encoding performance as well as increased long life reliability.

Applications

The HEDS-5500 provides motion detection at a low cost, making it ideal for high volume applications. Typical applications include printers, plotters, tape drives, positioning tables and automatic handlers.

ESD WARNING: NORMAL HANDLING PRECAUTIONS SHOULD BE TAKEN TO AVOID STATIC DISCHARGE.

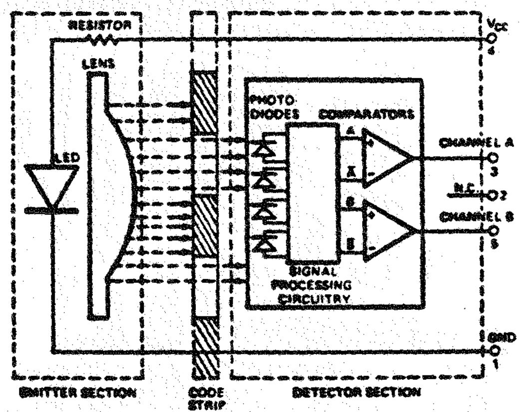
Outline Drawing



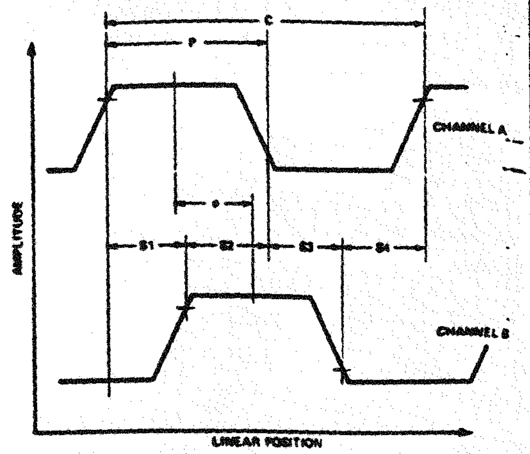
MOTION SENSING AND CONTROL

TB2

Block Diagram



Output Waveforms



Theory of Operation

The HEDS-5500 translates rotary motion of a shaft into a two channel digital quadrature output.

As seen in the block diagram, the HEDS-5500 encoder contains a single Light Emitting Diode (LED) as its emitter. The light is collimated into a parallel beam by means of a single lens located directly over the LED. Opposite the emitter is an integrated detector circuit. This IC consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The code wheel rotates between the emitter and detector, causing the light beam to be interrupted by the code wheel's pattern of spaces and bars. The photodiodes which detect these interruptions are arranged in a pattern that corresponds to the radius and design of the code wheel. These detectors are also spaced such that a light period on one pair of detectors corresponds to a dark period on the adjacent pair of detectors. The photodiode outputs are then fed through the signal processing circuitry resulting in A, $\bar{A}$, B and $\bar{B}$. Two comparators receive these signals and produce the final outputs for channels A and B. Due to this integrated phasing technique, the digital output of channel A is in quadrature with that of channel B (90 degrees out of phase).

Definitions

Count (N): The number of bar and window pairs or counts per revolution (CPR) of the code wheel.

Electrical Degree (°e): The dimension of one bar and window pair divided by 360.

1 Cycle (C): 360 electrical degrees (°e), 1 bar and window pair.

1 Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error ($\Delta\Theta$): The normalized angular difference between the actual shaft position and its position as indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

Pulse Width (P): The number of electrical degrees that an output is high during 1 cycle. This value is nominally 180°e or 1/2 cycle.

Pulse Width Error (ΔP): The deviation, in electrical degrees, of the pulse width from its ideal value of 180°e.

State Width (S): The number of electrical degrees between a transition in the output of channel A and the neighboring transition in the output of channel B. There are 4 states per cycle, each nominally 90°e.

State Width Error (ΔS): The deviation, in electrical degrees, of each state width from its ideal value of 90°e.

Phase (ϕ): The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B. This value is nominally 90°e for quadrature output.

Phase Error ($\Delta\phi$): The deviation of the phase from its ideal value of 90°e.

Direction of Rotation: When the code wheel rotates in the counterclockwise direction (as viewed from the encoder end of the motor), channel A will lead channel B. When the code wheel rotates in the clockwise direction, channel B will lead channel A.

Absolute Maximum Ratings

meter	Symbol	Min.	Typ.	Max.	Units	Notes
ge Temperature	T_S	−40		100	Celsius	
ating Temperature	T_A	−40		100	Celsius	
ply Voltage	V_{CC}	−0.5		7	Volts	
put Voltage	V_O	−0.5		V_{CC}	Volts	
put Current per Channel	I_O	−1.0		5	mA	
ration				20	g	5 to 1000 Hz
ft Axial Play				±0.25 ±(0.010)	mm (inch)	
aft Eccentricity Radial Play				0.1 (0.004)	mm (inch) TIR	
locity				30 K	R.P.M.	
celeration				250 K	Rad/Sec²	

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Notes
Temperature	T_A	−40	100	Celsius	
Supply Voltage	V_{CC}	4.5	5.5	Volts	Ripple < 100 mV_{P-P}
Load Capacitance	C_L		100	pF	3.2 k pull-up resistor
Count Frequency[1]	f		100	kHZ	$\frac{\text{Velocity (rpm)} \times N}{60}$
Shaft Perpendicularity Plus Axial Play			±0.25 ±(0.010)	mm (inch)	6.9 mm (0.27 inch) from mounting surface
Shaft Eccentricity Plus Radial Play			0.04 (0.0015)	mm (inch) TIR	6.9 mm (0.27 inch) from mounting surface

Note:
1. The encoder performance is guaranteed to 100 kHz but can operate at higher frequencies.

Encoding Characteristics

Encoding characteristics over Recommended Operating range and recommended mounting tolerances. Values are for the worst error over the full rotation.

Parameter	Symbol	Typ.[2]	Max.	Units	Notes
Pulse Width Error	ΔP	7	45	elec. deg.	
Logic State Width Error	ΔS	5	45	elec. deg.	
Phase Error	$\Delta\phi$	2	20	elec. deg.	
Position Error	$\Delta\theta$	10	40	minutes of arc	
Cycle Error	ΔC	3	5.5	elec. deg.	

Note:
2. Typical errors are computed as the absolute value of the mean error.

MOTION SENSING AND CONTROL

Mechanical Characteristics

Parameter	Symbol	Dimension	Tolerance	Units
Standard Shaft Diameters		2 3 4 5 6 8	+0.000 −0.015	mm
		5/32 1/8 3/16 1/4	+0.0000 −0.0007	inches
Moment of Inertia	J	0.6 (8.0 x 10^{-6})		gcm^2 (oz-in-s^2)
Required Shaft Length[3]		14.0 (0.55)	±0.5 (±0.02)	mm (inches)
Bolt Circle	2 screw mounting	19.05 (0.750)	±0.13 (±0.005)	mm (inches)
	3 screw mounting	20.90 (0.823)	±0.13 (±0.005)	mm (inches)
Mounting Screw Size	2 screw mounting	M 2.5 or (2-56)		mm (inches)
	3 screw mounting	M 1.6 or (0-80)		mm (inches)
Encoder Base Plate Thickness		0.33 (0.130)		mm (inches)
Hub Set Screw		(2-56)		(inches)

Note:
3. An 8.9 mm (0.35") diameter hole through the housing of the HEDS-5500 is available for extended motor shafts. Please consult your Hewlett-Packard sales representative for further information.

Electrical Characteristics

Electrical Characteristics over Recommended Operating Range, typical at 25°C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		17	40	mA	
High Level Output Voltage	V_{OH}	2.4			Volts	$I_{OH} = -40\ \mu A$ Max.
Low Level Output Voltage	V_{OL}			0.4	Volts	$I_{OL} = 3.2$ mA
Rise Time	t_r		200		ns	$C_L = 25$ pF,
Fall Time	t_f		50		ns	$R_L = 11$ K Pull-up

Note:
1. For improved performance in noisy environments or high speed applications, a 3.3 kΩ pull-up resistor is recommended.

Suggested Connectors

Manufacturer	Part Number
AMP	103686-4
	640442-5
Berg	65039-032 with 4825X-000 terminals
	65801-034
Molex	2695 series with 2759 series terminals

Ordering Information

HEDS-5500 Option F 06

Resolution[4]	(Cycles per revolution)	
K - 96 CPR	E - 200 CPR	H - 400 CPR
C - 100 CPR	F - 256 CPR	A - 500 CPR
D - 192 CPR	G - 360 CPR	I - 512 CPR

Shaft Diameter	
01 - 2 mm	06 - 1/4 in.
02 - 3 mm	11 - 4 mm
03 - 1/8 in.	12 - 8 mm
05 - 3/16 in.	14 - 5 mm
04 - 5/32 in.	

Note:
4. Other code wheel resolutions are available. Please consult your Hewlett-Packard sales representative for further information.

Mounting Considerations

The HEDS - 5500 can be mounted to a motor using either the two screw or three screw mounting option as shown in figure 1. If the encoder is attached to the motor with the screw sizes and mounting tolerances specified in the encoding characteristics section without any additional mounting bosses, the encoder output errors will be within the maximums specified in the encoding characteristics section.

The optional alignment pins shown in figure 2 can be used with either the two or three screw mounting option to improve the alignment of the encoder to the motor. This improved alignment will result in better encoder performance.

The best encoder performance will be obtained by mounting the encoder onto the motor using the optional motor boss with either the two or three screw mounting option as shown in figure 2.

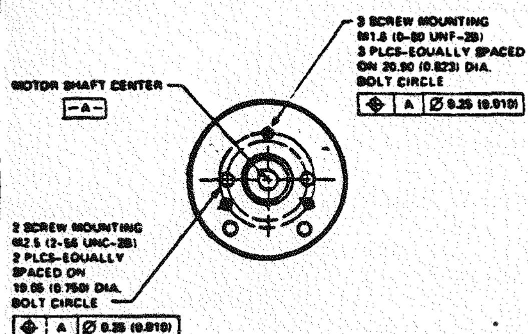


Figure 1. Mounting Holes

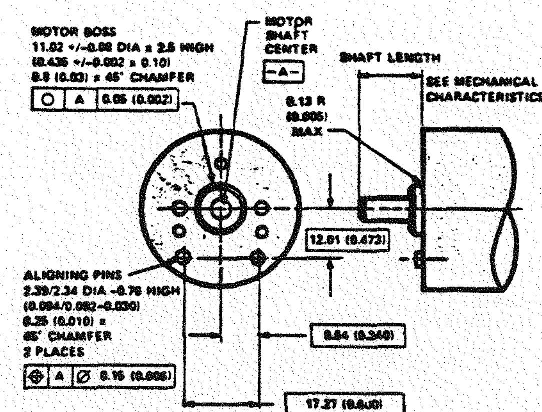
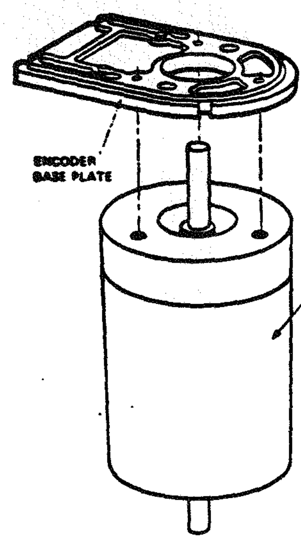


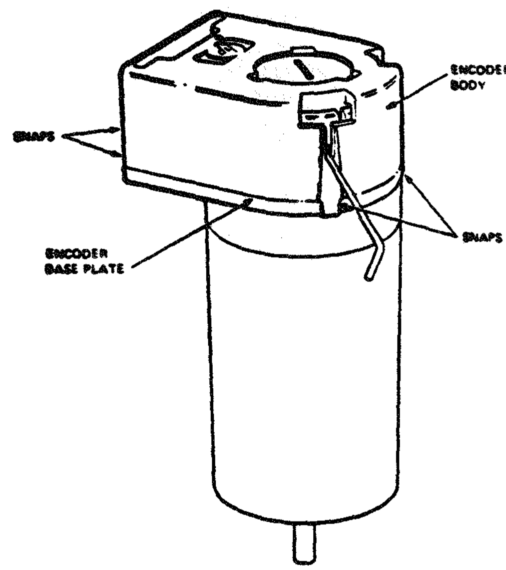
Figure 2. Optional Mounting Aids

MOTION SENSING AND CONTROL

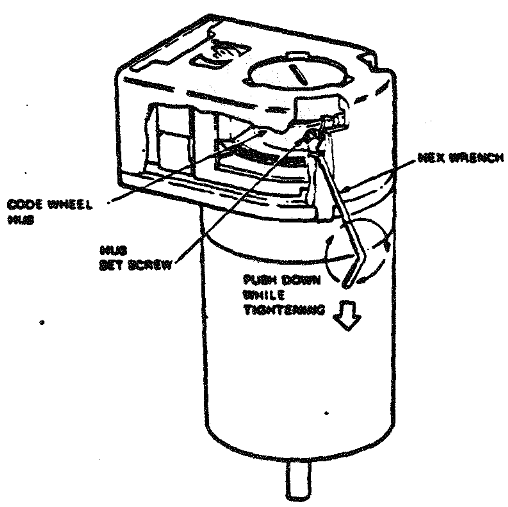
Encoder Mounting and Assembly



1. Mount encoder base plate onto motor. Tighten screws. (Reference page 5 for mounting considerations).



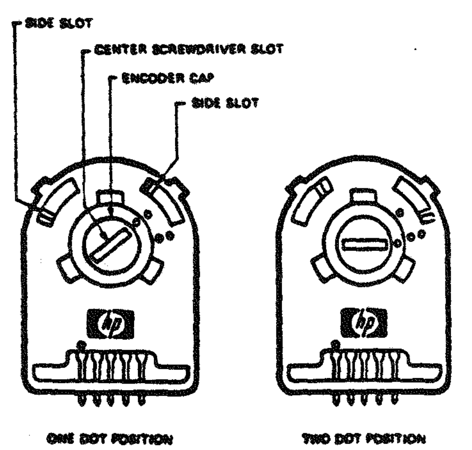
2. Snap encoder body onto base plate locking all 4 snaps.



3a. Push the hex wrench into the body of the encoder to ensure that it is properly seated into the code wheel hub set screw. Then apply a downward force on the end of the hex wrench. This sets the code wheel gap by levering the code wheel hub to its upper position.

3b. While continuing to apply a downward force, rotate the hex wrench in the clockwise direction until the hub set screw is tight against the motor shaft. The hub set screw attaches the code wheel to the motor's shaft.

3c. Remove the hex wrench by pulling it straight out of the encoder body.



4. Use the center screwdriver slot, or either of the two side slots, to rotate the encoder cap dot clockwise from the one dot position to the two dot position. Do not rotate the encoder cap counter-clockwise beyond the one dot position.

The encoder is ready for use!

- HEDS-5500 encoder to signal conditioning box ribbon cable pin out is as follows:

HEDS-5500	RIBBON CABLE
1	3 or 6
4	7 or 9
3	1
5	8

CAUTION:

Clean motor shaft with fine emery cloth until shaft is smooth.

Any force down or removal of encoder once placed on the shaft will result in permanent encoder damage.

NVH:

Note:

- Remove ribbon cable from signal conditioning box before removing encoder body.
- An HEDS-5500 encoder can be used instead of a HEDS-5000 on NVH, but the base plate on the motor has to be replaced with a modified thinner base plate (supplied) to allow more of the motor shaft to be exposed. This is necessary for proper HEDS-5500 encoder operation.
- For proper installment of HEDS-5500, see installation instructions for TB-2.

1.2 Transaxle BEI Encoder

Removal of BEI M15:

Step A

- Unplug encoder ribbon cable from signal conditioning box.
- Raise front end of vehicle so front wheels are off the ground and are free to move.
- With front wheels still, remove mounting screws.
- Hold encoder firmly in place.
- Start vehicle and put into DRIVE, let wheels rotate between 300 and 1200 rpm.

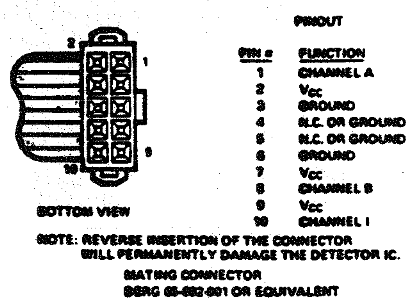


Figure 7. Connector Specifications

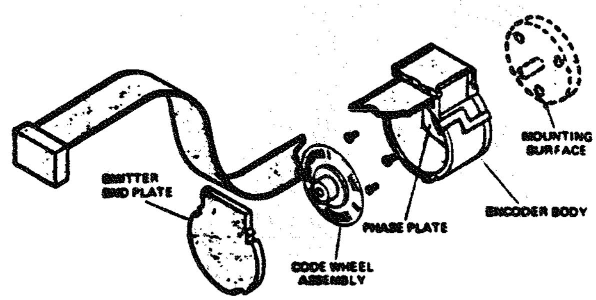


Figure 8. HEDS-5000 Series Encoder Kit

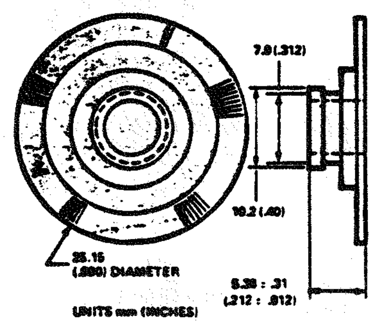


Figure 9. Code Wheel

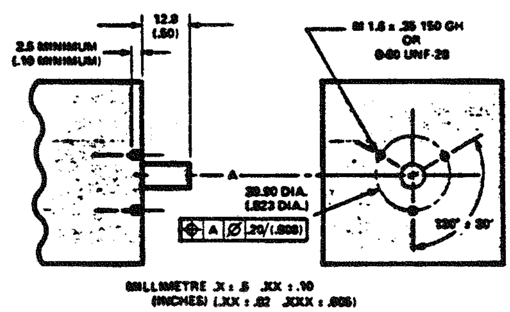
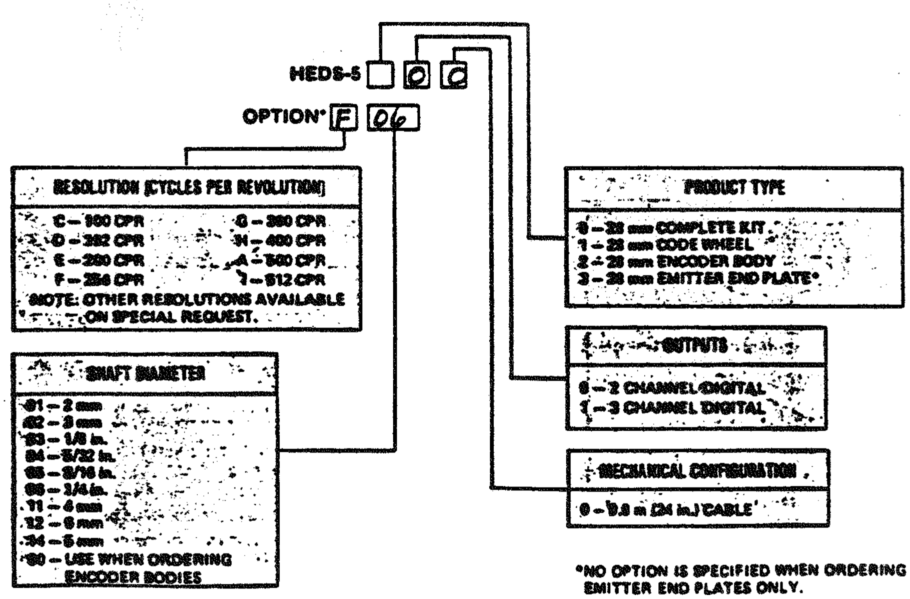


Figure 10. Mounting Requirements

Ordering Information



*NO OPTION IS SPECIFIED WHEN ORDERING EMITTER END PLATES ONLY.

Shaft Encoder Kit Assembly **See Application Note 1011 for further discussion.**

The following assembly procedure represents a simple and reliable method for prototype encoder assembly. High volume assembly may suggest modifications to this procedure using custom designed tooling. In certain high volume applications encoder assembly can be accomplished in less than 30 seconds. *Consult factory for further details. Note: The code wheel to phase plate gap should be set between* 0.015 in. and 0.045 in.

WARNING: THE ADHESIVES USED MAY BE HARMFUL. CONSULT THE MANUFACTURER'S RECOMMENDATIONS.

READ THE INSTRUCTIONS TO THE END BEFORE STARTING ASSEMBLY.

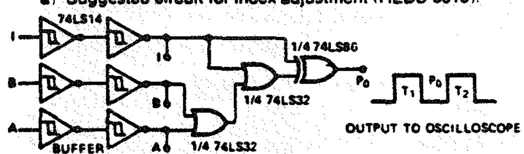
1.0 SUGGESTED MATERIALS

1.1 Encoder Parts
Encoder Body
Emitter End Plate
Code Wheel

1.2 Assembly Materials
RTV — General Electric 162
— Dow Corning 3145
Epoxy—Hysol 1C
Acetone
Mounting Screws (3)
RTV and Epoxy Applicators

1.3 Suggested Assembly Tools
a) Holding Screwdriver.
b) Torque Limiting Screwdriver, 0.36 cm kg (5.0 in. oz.).
c) Depth Micrometer or HEDS-8922 Gap Setter.
d) Oscilloscope or Phase Meter (Described in AN 1011). Either may be used for two channel phase adjustment. An oscilloscope is required for index pulse phase adjustment.

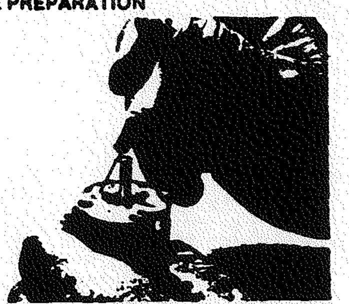
1.4 Suggested Circuits
a) Suggested circuit for index adjustment (HEDS-5010).



For optimal index phase, adjust encoder position to equalize T_1 and T_2 pulse widths.

b) Phase Meter Circuit
Recommended for volume assembly. Please see Application Note 1011 for details.

2.0 SURFACE PREPARATION



THE ELAPSED TIME BETWEEN THIS STEP AND THE COMPLETION OF STEP 8 SHOULD NOT EXCEED 1/2 HOUR.

2.1 Clean and degrease with acetone the mounting surface and shaft making sure to keep the acetone away from the motor bearings.

2.2 Load the syringe with RTV.

2.3 Apply RTV into screw threads on mounting surface. Apply more RTV on the surface by forming a daisy ring pattern connecting the screw holes as shown above.

CAUTION: KEEP RTV AWAY FROM THE SHAFT BEARING.

3.0 ENCODER BODY ATTACHMENT

3.1 Place the encoder body on the mounting surface and slowly rotate the body to spread the adhesive. Align the mounting screw holes with the holes in the body base.

3.2 Place the screws in the holding screwdriver and thread them into the mounting holes. Tighten to approximately 0.36 cm kg (5.0 in. oz.) using a torque limiting screwdriver if available (See notes a and b below). Remove centering cone if used.

Notes:
a At this torque value, the encoder body should slide on the mounting surface only with considerable thumb pressure.
b The torque limiting screwdriver should be periodically calibrated for proper torque.

4.0 EPOXY APPLICATION

CAUTION: HANDLE THE CODE WHEEL WITH CARE.

4.1 Collect a small dab of epoxy on an applicator.

4.2 Spread the epoxy inside the lower part of the hub bore.

4.3 Holding the code wheel by its hub, slide it down the shaft just enough to sit it squarely. About 3 mm (1/8").

5.0 CODE WHEEL POSITIONING

5.1 Take up any loose play by lightly pulling down on the shaft's load end.

5.2 Using the gap setter or a depth micrometer, push the code wheel hub down to a depth of 1.65 mm (.065 in.) below the rim of the encoder body. The registration holes in the gap setter will align with the snaps protruding from the encoder body near the cable.

5.3 Check that the gap setter or micrometer is seated squarely on the body rim and maintains contact with the code wheel hub.

5.4 No epoxy should extrude through the shaft hole.

DO NOT TOUCH THE CODE WHEEL AFTER ASSEMBLY.

6.0 EMITTER END PLATE

6.1 Visually check that the wire pins in the encoder body are straight and straighten if necessary.

6.2 Hold the end plate parallel to the encoder body rim. Align the guiding pin on the end plate with the hole in the encoder body and press the end plate straight down until it is locked into place.

6.3 Visually check to see if the end plate is properly seated.

7.0 PHASE ADJUSTMENT

7.1 The following procedure should be followed when phase adjusting channels A and B.

7.2 Connect the encoder cable.

7.3 Run the motor. Phase corresponds to motor direction. See output waveforms and definitions. Using either an oscilloscope or a phase meter, adjust the encoder for minimum phase error by sliding the encoder forward or backward on the mounting surface as shown above. See Application Note 1011 for the phase meter circuit.

7.4 No stress should be applied to the encoder package until the RTV cures. Cure time is 2 hours @ 70° C or 24 hrs. at room temperature.

Note: After mounting, the encoder should be free from mechanical forces that could cause a shift in the encoder's position relative to its mounting surface.

CODE WHEEL REMOVAL

In the event that the code wheel has to be removed after the epoxy has set, use the code wheel extractor as follows:

1 Remove the emitter end plate by prying a screwdriver in the slots provided around the encoder body rim. Avoid bending the wire leads.
2 Turn the screw on the extractor counter-clockwise until the screw tip is no longer visible.
3 Slide the extractor's horseshoe shaped lip all the way into the groove on the code wheel's hub.
4 While holding the extractor body stationary, turn the thumb screw clockwise until the screw tip pushes against the shaft.
5 Applying more turning pressure will pull the hub upwards breaking the epoxy bond.
6 Clean the shaft before reassembly.

8.0 INDEX PULSE ADJUSTMENT (HEDS-5010)

8.1 Some applications require that the index pulse be aligned with the main data channels. The index pulse position and the phase must be adjusted simultaneously. This procedure sets index phase to zero.

8.2 Connect the encoder cable.

8.3 Run the motor. Adjust for minimum phase error using an oscilloscope or phase meter (see 7.3).

8.4 Using an oscilloscope and the circuit shown in 1.4, set the trigger for the falling edge of the I output. Adjust the index pulse so that T_1 and T_2 are equal in width. The physical adjustment is a side to side motion as shown by the arrow.

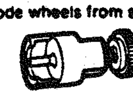
8.5 Recheck the phase adjustment.

8.6 Repeat steps 8.3-8.5 until both phase and index pulse position are as desired.

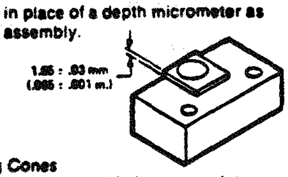
8.7 No stress should be applied to the encoder package until the RTV has cured. Cure time: 2 hours @ 70° C or 24 hrs. at room temperature.

SPECIALITY TOOLS — Available from Hewlett-Packard

a. HEDS-8920 Hub Puller
This tool may be used to remove code wheels from shafts after the epoxy has cured.

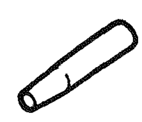


b. HEDS-8922 Gap Setter
This tool may be used in place of a depth micrometer as an aid in large volume assembly.

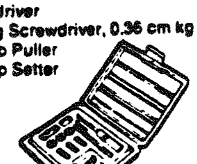


c. HEDS-892X Centering Cones
For easier volume assembly this tool in its appropriate shaft size may be used in step 3.0 to initially center the encoder body with respect to the shaft and aid in locating the mounting screw holes. Depending on the resolution and accuracy required this centering may eliminate the need for phase adjustment steps 7 and 8.

Part Number	Shaft Size
HEDS-8923	2 mm
HEDS-8924	3 mm
HEDS-8925	1/8 in.
HEDS-8926	5/32 in.
HEDS-8927	3/16 in.
HEDS-8928	1/4 in.
HEDS-8929	4 mm
HEDS-8931	5 mm



d. HEDS-8930 HEDS-5000 Tool Kit
1 Holding Screwdriver
1 Torque Limiting Screwdriver, 0.36 cm kg (5.0 in. oz.)
1 HEDS-8920 Hub Puller
1 HEDS-8922 Gap Setter
1 Carrying Case



Step B

- With a simultaneous lifting/tilting motion, slightly tilt the encoder case toward the cable assembly and smoothly pull the encoder off the shaft.

CAUTION!

Do not wiggle or tilt encoder away from cable assembly when removing. This movement will cause the encoder disc to crash into the mask and electronics resulting in damage.

Step C

- Apply brakes to vehicle and put into PARK.
- Removal is complete.

Installation:

Step A

- Clean shaft and transaxle face. (Clean shaft with fine emery cloth).
- Start vehicle again and put into DRIVE. Let wheels rotate between 300 and 1200 rpm.

Step B

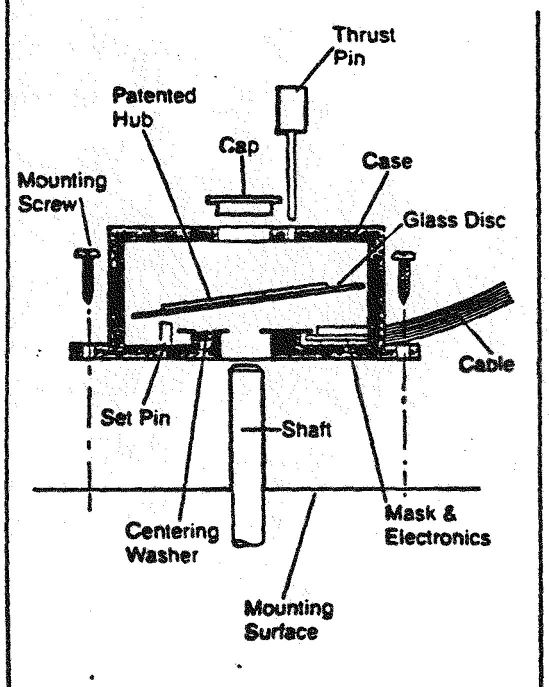
- Center encoder over rotating shaft.
- Push encoder smoothly down until case is flush with the mounting surface.
- Do not force encoder down or encoder damage will result.

Step C

- Hold encoder firmly against mounting surface.
- While shaft is rotating, place thrust pin or small Allen wrench in 1/16" hole. (Hole is on top of encoder).
- Press thrust pin on Allen wrench smoothly downward until glass disc contacts set pin.
- Remove pin on Allen wrench.
- Apply brakes to vehicle and put into PARK.

Step D

- While shaft is stopped, align mounting screws.
- Insert and tighten mounting screws.


Thrust Pin
Patented Hub
Cap
Case
Mounting Screw
Glass Disc
Cable
Set Pin
Shaft
Centering Washer
Mask & Electronics
Mounting Surface

2. VEHICLE CONTROLLER TEST CABINET OPERATION

The vehicle controller test cabinet is used to ensure that a new, revised or suspect controller board is ready to interface safely with the inverter and the vehicle.

The board is tested complete with programmed EPROM chips.

Observations can be made visually, by GRiD Diagnostics computer and by oscilloscope.

Software cycle times can be checked but a special set of EPROM's is needed to request the data to be written out.

2.1 Description

1. INV.FLT. (INVERTER FAULT) - This switch is normally in the ON position with led lit. To cause an inverter fault move switch to OFF position, led should go off & system should stay in a fault mode until switch is moved to the ON position.

   NOTE: If the switch is moved to the ON position and the fault does not clear, the reset button on the controller (NVH OR TB-2) must be pressed to clear the fault. This will happen only if the INV.FLT. switch is left in the OFF (fault) position for approx. 25 seconds.

2. SYS.P. (SYSTEM PRESSURE) - Will emulate system pressure when switch is in the ON position.

3. PRESSURE 1 (LOW PRESSURE SWITCH) - Will emulate low pressure switch.

4. PRESSURE 2 (HIGH PRESSURE SWITCH) - Will emulate high pressure switch.

5. CLRFLT (CLEAR FAULT) - LED will flash when a fault is clear.

6. DSEP-1 THRU DSEP-4 - These LEDS are not used.

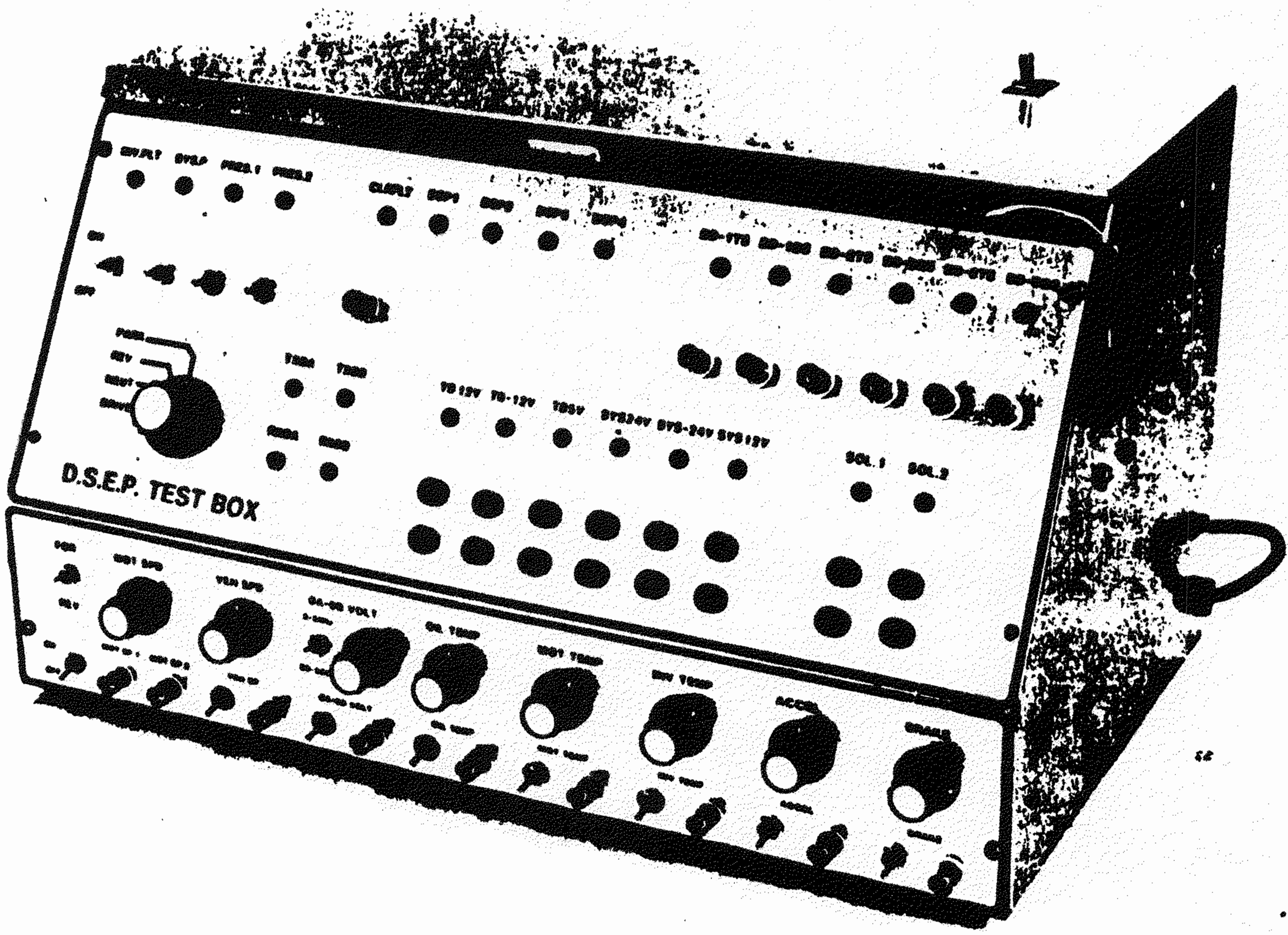


FIGURE 2-1

DSEP CONTROLLER TEST CABINET

7. BD-1TS(A+), BD-1BS(A-), BD-2TS(B+), BD-2BS(B-), BD-3TS(C+), and BD-3BS(C-) - Emulates the base drive of each transistor turning on (LED lit) and turning off (LED off).

8. GEAR SELECTOR SWITCH - Can select PARK, REVERSE, NEUTRAL, & DRIVE. Always start system with gear selector switch in neutral.

9. TXDA, TXDB, RXDA, & RXDB (transmit & receive) - With LEDS lit the controller is transmitting and receiving signals from the test box.

10. TB12V, TB-12V, TB5V, SYS24V, SYS-24 & SYS12V - These voltages can be used as test voltages or to check system voltages and are generally not used.

11. SOL.1 & SOL.2 (LOW GEAR & HIGH GEAR SOLENOID) - Can be used to check the low and high gear voltages. This is generally not used on the test box. A GRiD computer plugged into the controller can monitor the low & high gear solenoid.

12. FOR & REV (FORWARD & REVERSE SWITCH) - The switch will change the motor speed either in a forward or reverse direction.

13. MOT SPD (MOTOR SPEED POTENTIOMETER) - Turning the potentiometer will increase or decrease motor speed.

14. MOTOR SPEED SWITCH - Moving the switch to the ON position will transfer the motor speed signal to the two BNC connectors labeled MOT. SP. 1 and MOT. SP. 2.

15. VEH. SPD (VEHICLE SPEED POTENTIOMETER) - Turning the potentiometer will increase or decrease motor speed.

16. VEHICLE SPEED SWITCH - Moving the switch to the 'ON' position will transfer the vehicle speed signal to the BNC connector labeled 'VEH SP'.

17. OA-OB VOLT (BUSS OR BATT VOLTAGE POTENTIOMETER) - This potentiometer is not used. In order to emulate buss or batt an external voltage (0-12 volts) must be applied to the battery input resistors on the controller board (R34 & R35) or across the 100k ohm resistor located on the back of the controller board. The buss/battery voltage can be monitored from the GRiD computer.

18. OA-OB VOLT SWITCH - This switch is not used (see #17 for explanation).

19. OIL TEMPERATURE - not used.

20. OIL TEMPERATURE SWITCH - not used.

21. MOTOR TEMPERATURE - not used.

22. MOTOR TEMPERATURE SWITCH - not used.

23. INV TEMP (INVERTER TEMPERATURE POTENTIOMETER) - This potentiometer is not used. In order to emulate inverter temperature an external voltage (0-12 volts) must be applied to the inverter temp input resistors on the back of the controller board. This voltage can also be monitored from the GRiD computer.

24. INV TEMP SWITCH - This switch is not used (see #23 for explanation).

25. ACCEL (ACCELERATOR POTENTIOMETER) - This Potentiometer is used to increase or decrease acceleration.

26. ACCEL SWITCH - Moving the switch to the 'ON' position will transfer the acceleration signal to the BNC connector labeled accel.

27. BRAKE (BRAKE POTENTIOMETER) - This potentiometer is used to adjust the amount of regeneration.

28. BRAKE SWITCH - Switching to the 'ON' position will transfer the brake signal to the BNC connector labeled brake.

NOTE: All function listed above can be monitored from the GRiD computer by connecting the RS-232C port from the GRiD to the MTA (three pin) connector labeled C1 on the controller board. (See operators manual for proper use of the GRiD computer.

2.2 Connections and Usage

For proper testing of NVH/TB-2 controllers, an interface box (supplied) must be connected to the test box. J3 & J4 connectors from test box must be connected to interface box labeled J3 (top) and J4 (bottom). The output of the interface box is labeled G1, J1 & J2, G1 connector (gear selector) must be connected to the 4 Pin MTA connector located on the controller board. J1 & J2 must be connected to the header connectors via ribbon cables to the controller board. The 5 Pin Bendix connector wire on the test box is connected to the controller power supply (5 Pin MTA connector) via an interface connector that is supplied.

Before turning on test box, make sure gear selector switch is in Neutral and the inverter fault switch is in the ON position. Also, if the GRiD computer is going to be used, it must be connected to the controller at this time. Turn on test box and move gear selector switch to DRIVE. The base drive LEDS should start sequencing (on and off). If LEDS are off, check all connections from test box to controller; also recheck gear selector and inverter fault switches. Also check to make sure that motor speed switch in in the OFF position. If LEDS are still off, controller board must be reset via switch 1 (SW1). If LEDS are still off, a serious problem exists either in test box or controller (see schematics or contact Eaton Corp.).

There are three tests that should be done first:

1) Increase and decrease the motor speed and acceleration potentiometers. The LEDS should sequence (turn on and off) in direct proportion to the potentiometers.

2) Turn INV.FLT switch to OFF position. The base drive LEDS should go off, to start base drive LEDS again, move inverter fault switch to the ON position. If LEDS still do not light, controller must be reset.

3) Move gear selector to NEUTRAL or PARK. The base drive LEDS should turn off. To start LEDS again, move gear selector to DRIVE or REVERSE. To check or to monitor other functions, turn GRiD computer on and insert the DSEP diagnostic disc (see Operations Manual for GRiD computer operations and diagnostics).

3. INVERTER TRANSISTOR AND BASE DRIVE BOARD TEST FIXTURE OPERATION

TEST STAND
DSEP BASE DRIVE

THIS MANUAL DESCRIBES THE TEST STAND THAT IS USED TO CALIBRATE AND TEST THE DSEP BASE DRIVE ASSEMBLY #61233.

BASIC CONCEPTS

SEE SCHEMATIC

Q2 CONTAINS AN INTERNAL DIODE THAT IS USED AS A FLYBACK DIODE FOR L1.

Q2 MUST BE REVERSED BIASED TO PREVENT IT FROM CONDUCTING.

Q1 SIMULATES 1/6 OF THE INVERTER POWER BRIDGE.

L1 SIMULATES A MOTOR WINDING.

THE BASE DRIVER TEST BOX IS A CURRENT COMPARATOR . ADVANCE TEST BOX CONTROL CLOCKWISE UNTIL CIRCUIT RUNS.

ADJUST I-PEAK AND I-HOLD ON BASE DRIVE BOARD WITH TRIMPOTS PROVIDED.

NOTE THAT 3 LAB POWER SUPPLIES ARE REQUIRED BUT ARE NOT INCLUDED AS PART OF THE DELIVERABLE TEST STAND.

3. INVERTER TRANSISTOR AND BASE DRIVE BOARD TEST FIXTURE OPERATION

3.1 Description

Base Drive Board:

The inverter has 6 identical base drive boards--one for each of the 6 main power Darlington transistors. They are numbered 1 thru 6 based on their location in the inverter. Each board has a serial number stamped on its heat sink for identification when removed from the inverter.

Base Drive Board Functions:

These printed circuit boards convert the low power current loop signals from the controller into the positive and negative volts and amps required to drive the output power transistors. Additionally, they detect over-current conditions in the power transistor, turn off the transistor, and signal a "fault" to the interface board. The last function of the boards is to measure the temperature of the heat sink under the power transistor. The temperature signals of all the base drive boards are averaged by the interface board.

Base Drive Board Connections:

Each base drive board has connections to a power transistor, the power supply board, and the interface board.

The emitter terminal of the Darlington power transistor is the zero volt reference for the board. Transistor base and emitter connections are double pin connections because they are high current connections. The transistor's collector connection is used to measure the base-to-collector voltage of the transistor (Vcb). This measurement input is used to actively regulate Vcb during the transistor's "on" time and to detect desaturation of the transistor due to over-current.

The base drive board's power supply connector contains plus and minus 6 volts and plus 10 volts. All these signals are near the battery positive or negative terminal potential.

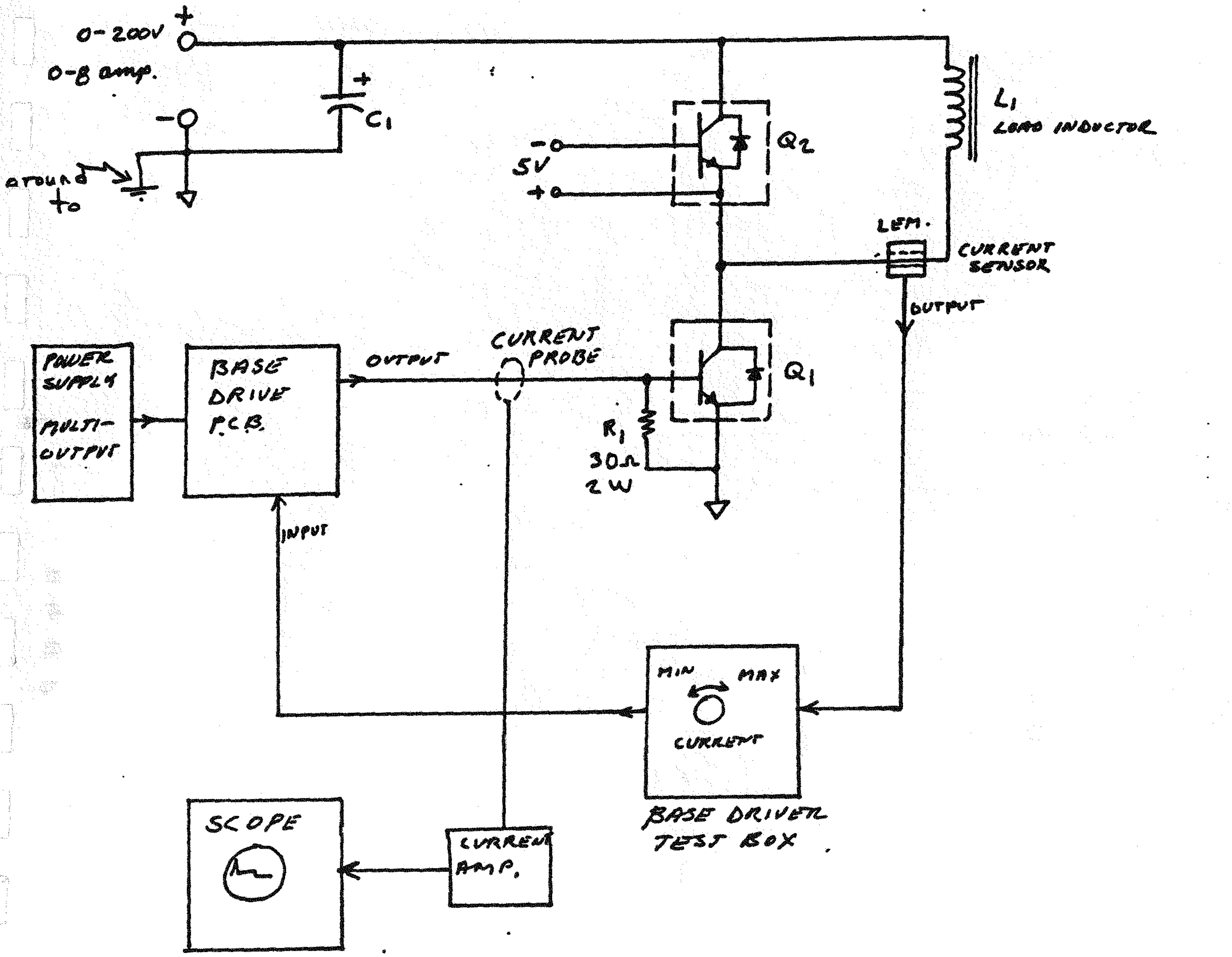
Control signals are contained in the connector for the interface board. They all are at near controller ground potential. Two lines provide the path for the opto-isolated gating signals for the power transistor. The signals originate from the controller board and are not conditioned by the interface board. Two lines are tied to the temperature sensor on the board. The temperature sensor is a precision positive temperature-coefficient resistor. The last two lines are the desaturation "fault" current loop. Interruption of the current in this loop will set the interface board fault latches.

Test Stand:

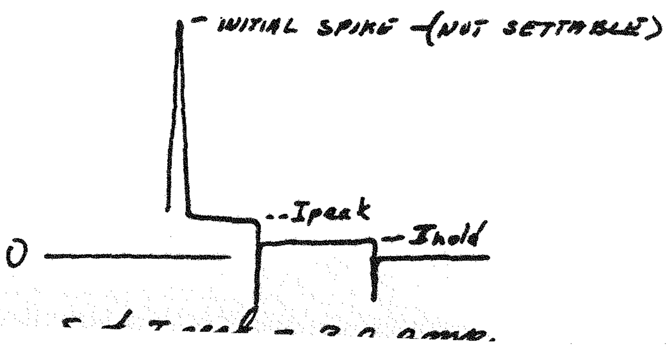
See Figures 3-1, block schematic diagram, and 3-2, tester connection setup details.

FIGURE 3-1

TESTER SCHEMATIC



Q_1 BASE CURRENT WAVE FORM



Q_1 COLLECTOR CURRENT WAVEFORM

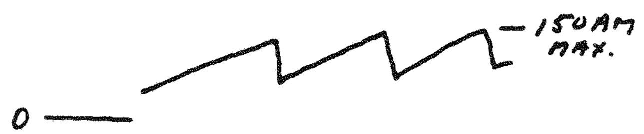
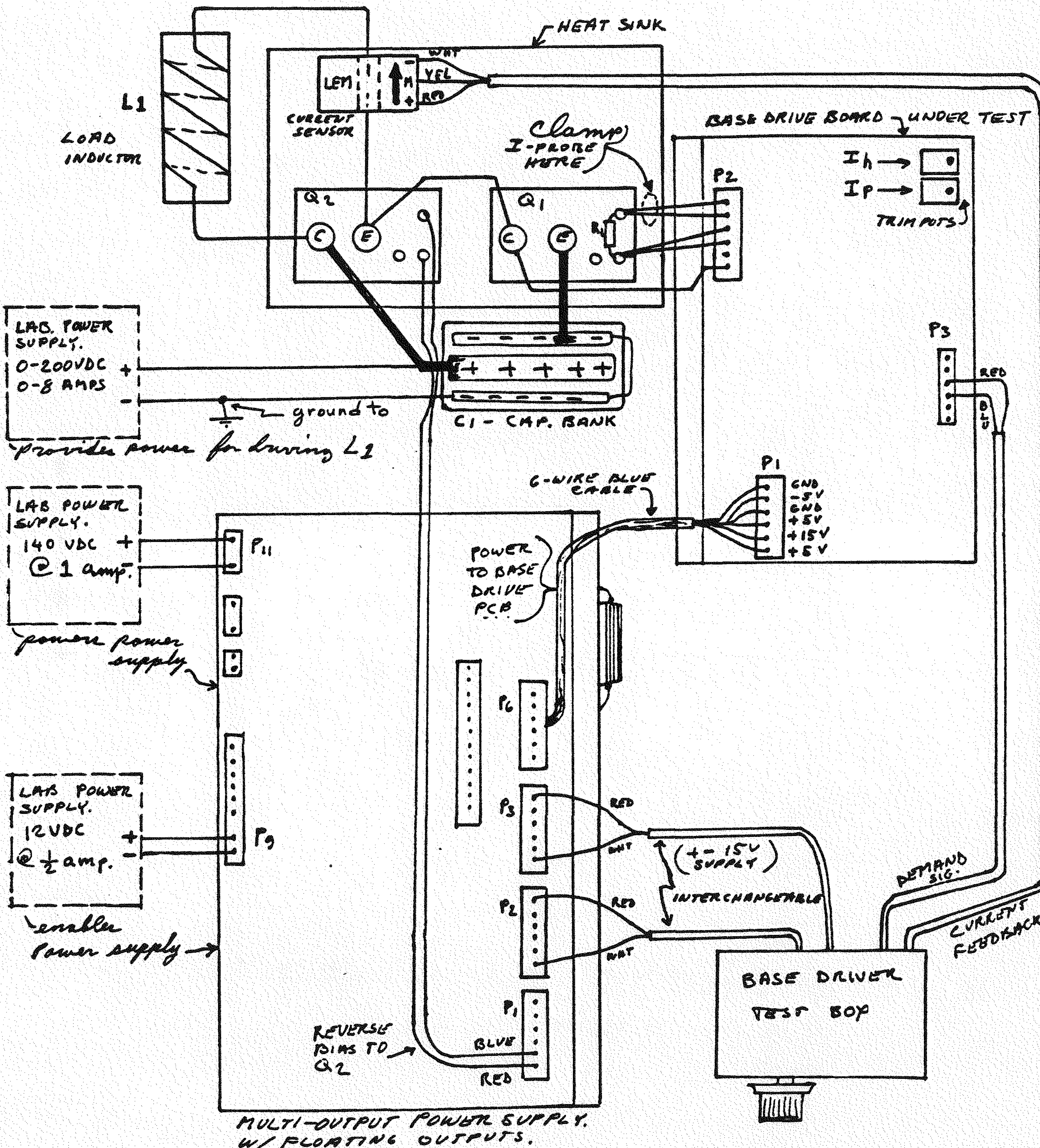


FIGURE 3-2 TESTER SET-UP



3.2 Connections

The test fixture equipment includes:

- heat sink with two power transistors mounted as a leg of the inverter, and a LEM current sensor
- load inductor (LI)
- capacitor bank
- multi-output power supply PCB
- base driver test box

The user must supply:

- high power lab supply: 0-200Vdc, 8 amp
- high power lab supply: 140Vdc, 1 amp
- lab supply: 12Vdc, 0.5 amp
- Textronic current probe and scope

Items under test:

- the base drive board, or
- if desired, a good base drive board and transistors of questionable status (although usually transistors can be determined to be good or bad by simple resistance check on an electronic multimeter).

Be sure to connect up completely and correctly, making all ground connections. Use good lab procedure in bringing up power supplies for the first time as described in the next section.

3.3 Adjustments

WARNING: DANGEROUS VOLTAGE POTENTIALS ARE PRESENT ON MUCH OF THIS EQUIPMENT. ONLY PROPERLY TRAINED PERSONNEL SHOULD WORK WITH OR NEAR THIS TEST STAND.

The base drive boards require two adjustments for proper operation. We refer to these adjustments as the "peak" and "hold" base drive current adjustments. The peak current adjustment sets the base drive current limit. The hold current is an indirect measurement of the active baker clamp voltage adjustment. Both of these adjustments may be made with the base drive test stand.

The base drive board test stand is used to adjust these two settings. First, the equipment shown in the "tester set-up" diagram must be assembled. It is helpful to provide some distance between the field-producing inductor and all other electronic equipment. If base drive being adjusted has never been used before, both pots should be set to mid-scale before applying power to any of the circuit. With the Test Box current control knob fully counterclockwise (off), power should be applied in the following sequence: 140Vdc, 12Vdc, then 200Vdc. Turn the current control knob clockwise until approximately 150 amperes peak appears on the power transistor collector circuit. The transistor base-current wave-form similar to the sketch on the "tester schematic" should be visible on the oscilloscope.

Peak (labeled "P") and hold (labeled "H") pots on the base drive board must be adjusted so the base drive provides 3 and 2.5 amperes respectively. Both pots provide increasing current by turning clockwise. Hold current varies with power transistor temperature so the adjustment should be made with a room temperature power transistor. After making the two adjustments, the 200V power supply can be shut-off so the power circuit will partially discharge the filter capacitors.

4. CONTROL SOFTWARE MODIFICATION

GENERAL

Modification of the DSEP control software requires the following list of basic elements:

IBM-PC or compatible computer
Text Editor (ASCII)
Intel PL/M-96 compiler (controller)
Intel ASM-96 assembler (controller)
Intel MCS-96 Linker/Locater (controller)
Intel PL/M-51 compiler (SOCM)
Intel MCS-51 Linker/Locater (SOCM)
Source code for DSEP control software
Link list (includes files to be linked and specific system controls)
EPROM programming device

The software development cycle is as follows:
Write source code modules / Compile source code modules / Link compiled modules from compiler output/ Generate Hex formatted file from linker output / Program Hex formatted file into EPROMS with EPROM programming device.

4.1 Vehicle Controller Software

The vehicle controller software is written in PL/M-96 and ASM-96 programming languages. Modification to the DSEP controller software should only be done in consultation with the Eaton Corporation Engineering Department.

The final, deliverable software is numbered in the following manner:

```
Example -  NVH050R.HEX
           ^   ^ ^  ^
           |   | |  |__ hex formatted file
           |   | |_____ R = equation constants in ROM
           |   |_______ revision # (numbered 0 to 50)
           |___________ NVH = NVH  vehicle
                        TB2 = TB-2 vehicle
```

Software revisions 30 - 50R are available from Eaton Corporate Engineering.

4.2 SOCM Software

The SOCM software is written in the PL/M-51 programming language. Modification to the DSEP SOCM software should only be done in consultation with the Eaton Corporation Engineering Department.