INSTRUCTION MANUAL

HORSEPOWER OPTION
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I. INTRODUCTION

Description: The model 7530 (with Digital Panel Meter option-“DC” instrument) or the model 7540 (with Digital Panel Meter option-“carrier” instrument) when equipped with the Horsepower/R.P.M. option contains the following features:

1. 3 simultaneous phase-coherent analog outputs (Torque, R.P.M. and Horsepower) providing either "real-time" plots or Analog to Digital input without "skew".

2. Front panel selectable, and Digital Panel Meter controllable, display of Torque, R.P.M. and Horsepower including: Trick count (multiply x 1, x 2, x 4, x 5, x 10, x 20, x 40 and x 50) for each display mode and decimal select for each display mode.

3. Highly linear, low-drift, Frequency to Voltage converter built around a crystal-derived, digital one-shot. R.P.M. input is totally immune to type of waveform, duty cycle and amplitude variations.

4. Precision calibrate reference for R.P.M. (front-panel enabled) containing 9 frequencies from 100Hz to 50KHz.

5. By merely adjusting R.P.M. front-panel span, gears sensed by mag pick-up other than 60 tooth can be referenced to the calibrate frequency and read in true R.P.M. (see set-up example #2).

Overview: The purpose of this manual is to provide you with an efficient way to learn, on a "want to know" basis, how to apply a model 7530 or model 7540 with this option to the "job at hand". We suggest you follow the hands-on instrument-option familiarization section and read the set-up examples section to get up and running.
SPECIFICATIONS

Parameter                  Description

Torque Input:             0 - ± .7350 VDC = ± Full Scale
                          from model 7530 or model 7540
                          "Host" instrument.

R.P.M. Input:
Waveform: Sine, square or triangular
Symmetry: at 80/20% maximum duty-cycle from
Frequency: 10Hz to 50KHz with
Amplitude: 1V P-P (.3536 VRMS) minimum to
Impedance: 70V P-P (24.75 VRMS) maximum into
50KΩ, <12.4 V P-P (4.384 VRMS),
decreasing to a minimum of
*7.382KΩ at 70V P-P.

R.P.M. Output:
Voltage: 0 - +1.000 VDC at 2 MA maximum
Response: <.05% non-linearity.

H.P. Output: (See R.P.M. output)

Torque Output: (See "set-up examples" section)

Ext. Controls
R.P.M. Span (Coarse) 22 turn pot able to set either
                    end of range selected (see range
                    switch) = Full Scale
R.P.M. Span (Fine)  22 turn pot controls ± 10% of
                    R.P.M. (coarse) pots adjustment.
H.P. Span (Coarse)  22 turn pot able to set calculated
                    Horsepower reading at either end
                    of range selected.
H.P. Span (Fine)  22 turn pot controls ± 10% of
                    horsepower (coarse) pots adjustment.

4-Pushbutton Gang Switch: 3 interlocking maintained select
                          "Torque", "R.P.M." or "Horsepower"
                          for display, also 1 momentary
                          "R.P.M. Cal".

-2- IM 312
Internal Controls
Range Select Switch: 10 - 100 Hz, 100 Hz - 1 kHz, 1 kHz - 10 kHz and 10 kHz - 50 kHz = Full Scale
Cal Frequency 100, 200, 500, 1K, 2K, 5K, 10K, 20K and 50 kHz
Select Switch: ±0.01% (derived from an 800 kHz crystal)

Miscellaneous
Power Requirements:
To Option: ±11V analog supply, voltage reference and ±12V digital supplied by "Host" instrument
To Outside: ±12V (fused) to power an active rpm pickup

*To calculate Zin (impedance) between 12.4V P-P and 70V P-P, use the following:

\[
Zin = \frac{12.4 \ (50K) + ((Vin \ P-P - 12.4) \ (3.24K))}{Vin \ P-P}
\]
WARNING: IN ORDER TO PERFORM THE FAMILIARIZATION BELOW AS WELL AS THE SET-UP IN SECTION II, THE INSTRUMENT COVER MUST BE REMOVED. DANGEROUS VOLTAGES ARE PRESENT AT SEVERAL POINTS INSIDE THE INSTRUMENT. TO PREVENT ELECTRICAL SHOCK, DO NOT TOUCH EXPOSED CONNECTIONS OR COMPONENTS WHEN THE INSTRUMENT IS OPERATED WITH THE COVER REMOVED.

HORSEPOWER OPTION FAMILIARIZATION

The purpose of this section is to acquaint you with all instrument - option inputs, outputs and controls by function and location. We suggest you spend approximately 15 minutes (with the instrument cover off) finding out where everything is.

Then proceed to the set-up example section where full application of this precision instrument is discussed.

<table>
<thead>
<tr>
<th>Function</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Torque Input Connector - Provides excitation and accepts input signal from Torque transducer.</td>
<td>On rear panel of &quot;Host&quot; instrument.</td>
</tr>
<tr>
<td>3.) &quot;R.P.M. Input&quot; Terminals - Accepts input from magnetic pick-up for option board. +12V Output Terminal - Provides power (up to 1/8 amp for &quot;active&quot; pick ups.</td>
<td>On rear panel barrier strip.</td>
</tr>
<tr>
<td>4.) &quot;Torque Output&quot; Terminal - Provides fully conditioned Torque analog voltage for plotting, control or Analog to Digital input.</td>
<td>On rear panel barrier strip.</td>
</tr>
<tr>
<td>5.) &quot;R.P.M. Output&quot; Terminal - Provides fully conditioned R.P.M. (Frequency to Voltage) analog for plotting, control or Analog to Digital input.</td>
<td>On rear panel barrier strip.</td>
</tr>
<tr>
<td>6.) &quot;Horsepower Output&quot; Terminal - Provides fully conditioned Horsepower analog for plotting, control or Analog strip. to Digital input.</td>
<td>On rear panel barrier strip.</td>
</tr>
<tr>
<td>7.) Torque &quot;Zero&quot; Control - Adjusts instrument zero to compensate for transducer offset. Torque &quot;Span&quot; Control - Adjusts gain of instrument to desired Full-Scale.</td>
<td>Center right front - panel.</td>
</tr>
</tbody>
</table>
Function

8.) R.P.M. Coarse Span Control - Adjust gain of R.P.M. (displayed and analog out) over a 10:1 ratio.

R.P.M. Fine Span Control - Adjusts gain of R.P.M. (displayed and analog out) over ±10% of coarse span range.

Horsepower Coarse Span Control - Adjusts gain of Horsepower (displayed and analog out) over a 10:1 ratio.

Horsepower Fine Span Control - Adjusts gain of Horsepower (displayed and analog out) over ±10% of coarse span range.

9.) 4 Push-Button Gaug Switch (L - R)

"Torque" Switch - Selects Torque for display and enables scaling, conversions and decimal point set (see Digital Panel Meter controls).

"R.P.M." Switch - Selects R.P.M. and disconnects Torque or Horsepower from display.

"Horsepower" Switch - Selects Horsepower and disconnects R.P.M. or Torque from display.

"R.P.M. Cal" Switch - When held in, disconnects R.P.M. input from rear panel of "Host" instrument and connects internal option frequency calibration standard selected.

10.) "+ Cal" Switch - Applies resistor (located on "Cal R" terminals) from + signal to + excitation simulating a clockwise torque reading.

"- Cal" Switch - Applies "Cal R" resistor from + signal to - excitation simulating a counter-clockwise torque reading.

11.) Torque Display Filter Switch - Sets 5-pole Bessel filter for either .4 or 4Hz.

12.) Torque Analog Out/In Switch - In "out" position analog out is bandwidth of instrument. When "in" is selected analog out is filtered at whatever torque display filter switch is set.
Function

13.) Range Switch - Selects appropriate pulse width in the Frequency to Voltage converter for maximum input frequency expected.

14.) Cal. Frequency Select Switch - Sets calibration frequency standard used when "R.P.M. Cal" switch is depressed.

<table>
<thead>
<tr>
<th>FREQUENCY RANGE SWITCH</th>
<th>CAL. FREQUENCY SWITCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANGE (HZ)</td>
<td>POSITION</td>
</tr>
<tr>
<td>10K - 50K</td>
<td>1</td>
</tr>
<tr>
<td>20K</td>
<td>2</td>
</tr>
<tr>
<td>1K - 10K</td>
<td>2</td>
</tr>
<tr>
<td>2K</td>
<td>5</td>
</tr>
<tr>
<td>100 - 1K</td>
<td>3</td>
</tr>
<tr>
<td>200</td>
<td>8</td>
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<td>100</td>
<td>9</td>
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<tr>
<td>100</td>
<td>10</td>
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<tr>
<td>10 - 100</td>
<td>4</td>
</tr>
</tbody>
</table>

Digital controls for each display mode (Torque, R.P.M. and Horsepower)

Function

1.) (1 each) Decimal Point Select Switch - Sets decimal point for a display mode.

2.) (1 each) Trick-Count (Multiplier) Switch Banks - Sets multiplication factor for a display mode.

3.) (Torque) Conversion Factor Switch Bank - Sets 8 bidirectional conversion factors for display.

Location

Inside instrument on option board (center left).

Inside instrument on option board (center left).

Rear of Digital Panel Meter option board.

(See sketch #1)

(See sketch #1)
II. SET-UP & OPERATION

BEFORE PROCEEDING, READ THE WARNING UNDER HORSEPOWER OPTION FAMILIARIZATION ON PAGE 4.

This section contains set-up examples which will supply the basic information needed for most applications.

There is a sketch of the range and conversion switches, which are located on the Digital Panel Meter board, on page 8. For complete information on the Digital Panel Meter, see the Digital Panel Meter option instruction manual.

Also included, on page 9, is a sketch of the Horsepower circuit board which shows the location of the R.P.M. range and calibration switches.

Use the information in this section with the Familiarization section on page 4 to gain the best understanding of the instrument operation.
LOCATION OF R.P.M. AND CALIBRATION FREQUENCY SELECTOR SWITCHES

CAL FREQ

INPUT FREQ RANGE

FRONT OF INSTRUMENT
SET-UP EXAMPLES

Problem #1: Find the Horsepower curve of a 1HP electric motor as load is applied in even increments. Furthermore, find the Torque developed at peak Horsepower and full load R.P.M.

Assumed equipment set-up: See sketch below:

![Diagram of equipment set-up](image)

Given: R.P.M. at no load = 3600
       R.P.M. P.U. gear = 60 tooth
       Rated Horsepower at full load = 1
       Torque sensor rating = 100 lb-in

Step #1 - Turn on instrument and allow at least 20 minutes warm-up before adjusting controls.

Step #2 - Decouple either end of Torque transducer.

Step #3 - (Torque Calibration)
   A.) Remove cover of instrument and set Torque filter select switch (on main board) to 4Hz position (if not already). Then set analog out/in switch (main board) to "in" position.
   B.) Set Torque decimal switch (DPM board) to position #3 (XXX.0).
   C.) Making sure Torque, display is selected, set display to 0 lb-ins with zero control.

-10-
D.) Next consult Torque sensor manual for + shunt calibration number (assume, in this case, it is 71.5 lb-ins).

E.) Holding + calibration switch in, adjust span control to obtain a display reading = 71.5 lb-ins. Recheck zero (if must adjust, touch-up span).

Step #4 - (R.P.M. Calibration)

A.) Set "range" switch (on Horsepower/R.P.M. board) to 1K - 10KHz (position #2).

B.) Set "calibration frequency select" switch (on Horsepower/R.P.M. Board) to 2KHz (position #5).

C.) Set R.P.M. multiplier (on digital panel meter board) at X 2.

D.) Select R.P.M. display and hold "R.P.M. Cal" switch in while adjusting R.P.M. coarse (then fine) span controls for 2000 R.P.M. displayed.

Step #5 - (Horsepower Calibration)

A.) Calculate Horsepower reading using 71.5 lb-in as Torque calibration number and 2000 R.P.M. as speed calibration number according to:

\[
\text{H.P. (Cal)} = \frac{\text{Torque (cal)} \times \text{R.P.M. (cal)}}{63024} - 2.269 \text{ H.P.}
\]

B.) Set Horsepower decimal point (on digital panel meter board) to (X.000).

C.) Set Horsepower multiplier (on Digital Panel Meter board) to X 4.

D.) Select Torque display and touch-up 0 or span (if necessary) to agree with Step #3 E.). Now select Horsepower display.

E.) Depress "+Cal" and "R.P.M.- Cal", adjust Horsepower coarse (then fine) span to obtain 2.269 Horsepower.

Step #6 - Recouple Torque transducer in set-up and select Torque display (should read 0 lb-ins).

Step #7 -

A.) "Cal" Torque and set gain of recorder to cause 71.5% of Full Scale deflection desired (= 71.5 lb-ins).

B.) "Cal" R.P.M. and set gain of recorder to cause 55.5% of Full Scale deflection desired (= 2000 R.P.M.).

C.) "Cal" Horsepower and set gain of recorder to cause 100% of Full Scale deflection desired (= 2.269 Horsepower).

D.) Run test and interpret data at each step.
Problem #2: Find the efficiency curve of an automatic transmission.

Assume the following equipment set-up: (See sketch #3).

Given:  
R.P.M. (input shaft) maximum = 2400  
R.P.M. (output shaft) maximum (4th) = 2750  
Horsepower (input shaft) maximum = 195  
Horsepower (output shaft) maximum = 155  
Torque Sensor (input shaft) rating = 10K lb-ins.  
Torque Sensor (output shaft) rating = 15K lb-ins
Step #1 and #2 - See problem #1.

Step #3 - (Torque Calibration) - input shaft

   A.) See problem #1
   B.) Set Torque multiplier (on Digital Panel Meter board) to X 5
   C.) See problem #1.
   D.) Next consult Torque sensor (input shaft) manual for + shunt calibrate number (assume, in this case, it is ~ 7,150 lb-in).
   E.) Set in this number as in Problem #1.

Step #4 - (R.P.M. Calibration) - input shaft.

   A.) Set "range" switch (on Horsepower/R.P.M. board) to 100Hz - 1KHz (position #3).
   B.) Set "Cal frequency select" switch (on Horsepower/R.P.M. Board) to 1KHz (position #6).
   C.) See Problem #1.
   D.) Select R.P.M. display and hold "R.P.M. Cal" switch in while setting R.P.M. coarse (then fine) span controls for *1818 R.P.M. displayed. *Compensates for 33 tooth sprocket (I.E. 1000/1818 33/60).

Step #5 - (Horsepower Calibration) - input shaft

   A.) Calculate Horsepower reading using 7,150 lb-in as Torque number and 1818.18 R.P.M. as speed calibrate number according to:

   \[
   \text{H.P. (Cal)} = \frac{\text{Torque (Cal)} \times \text{R.P.M. (Cal)}}{63024} = 206.27 \text{ H.P.}
   \]

   B.) Set Horsepower decimal point (on Digital Panel Meter board) to (XXX.0).
   C.) Set Horsepower multiplier (on Digital Panel Meter board) to X 2
   D.) See Problem #1.
   E.) Calibrate Horsepower as in Problem #1 only set display to read between 206.2 and 206.4 H.P. instead.

Step #6 - See Problem #1
Step #7 -
A.) Calibrate Torque and compare to Step #3 E.
B.) Calibrate R.P.M. and compare to Step #4 D.
C.) Calibrate Horsepower and set gain of X1 and X2 (of XYY plotter) to same Full Scale deflection.

Step #8 - (Torque Calibration) - output shaft
A.) See Problem #1 - Step #3A
B.) Set Torque multiplier (on Digital Panel Meter board) to X 10
C.) See Problem #1 - Step #3C
D.) Next consult Torque sensor (output shaft) manual for + shunt calibrate number (assume, in this case, it is 10,725 lb-ins.
E.) Set this in as in Problem #1 - Step #3E, only adjust display to read between 10,720 and 10,730 lb-ins instead.

Step #9 - (R.P.M. Calibration) - output shaft
A.) B.) See Problem #2 - Step #4 A.) B.)
C.) See Problem #1 - Step #4C
D.) Set as in Problem #1 - Step #4D, only adjust display to read 1,000 R.P.M. instead.

Step #10 - (Horsepower Calibration) - output shaft
A.) Calculate Horsepower reading using 10,725 lb-ins as a Torque shunt calibrate number and 1,000 R.P.M. as a speed calibrate number according to:

\[
\text{H.P. (Cal) = \frac{\text{Torque (Cal) x R.P.M. (Cal)}}{63024}} = 170.2 \text{ HP}
\]

B.), C.) See Problem #2 - Step #5B, and C.
D.) See Problem #1 - Step #5D
E.) Calibrate Horsepower as in Problem #1 - Step #5E, only set display to read 170.2 H.P. instead.

Step #11 - See Problem #1 - Step #6.

Step #12 -
A.) Double check calibration made in Step #8E, Torque.
B.) Double check calibration made in Step #9D, R.P.M.
C.) Double check calibration made in Step #10E, Horsepower.
Step #13 - Run test and calculate efficiency at any point desired by the following:

\[
\%\text{EFF} = \frac{Y_1}{Y_2} \times 100
\]

- This concludes the set-up example section -
III. MAINTENANCE

WARNING: THE MAINTENANCE INSTRUCTIONS CONTAINED IN THIS SECTION ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY MAINTENANCE OPERATIONS UNLESS YOU ARE QUALIFIED TO DO SO.

Alignment Procedure

This instrument has been "soaked" @130°F, under power, for 96 hours to relieve any stress-related offsets or non-repeatabilities in the active components.

It will, however, require periodic alignment to maintain overall accuracy. A maximum of one year (for lab conditions) and 6 months (for field conditions) is recommended, with 6 months and 3 months, respectively, suggested.

Following is the step-by-step procedure for alignment:

Equipment Needed:

A Digital Voltmeter capable of resolving .0001 VDC in 1 VDC (or 1 part in 10,000) with stability (Fluke 8600A or equivalent); a frequency counter capable of viewing 400,000 Hz to the nearest Hz (or 1 part in 400,000) (Fluke 1900A or equivalent); a Lebow #7905-103 bridge substitution box (an equivalent may be used if "host" instrument is a #/530). In the case of a #/540, however, the 7905-103's "balanced" wiring insures .01% ratio accuracy at carrier frequencies.

Preliminary Steps:

A) Hook #7905-103 and cable to transducer input

B) Turn instrument on and allow 20 minutes for "warm-up"

C) Locate Horsepower/R.P.M. option assembly drawing #C-29371 and Horsepower/R.P.M. option block diagram #B-29519 (following sections of this manual) and spend 15 minutes locating all the adjustments listed below:

P1 - Horsepower analog out span adj.

P2 - R.P.M. analog out span adj.

P3 - R.P.M. "coarse" span (front panel)

3/8" sq. trimmer (W/W)

1 1/4" rect. (W/W)
P4 - Horsepower "coarse" span (front panel)  1 1/4" rect. (W/W)
P5 - TRQ buffer zero trim  3/8" sq. trimmer
P6 - AP-2 zero trim (RPM)  3/8" sq. trimmer
P7 - AP-4 zero trim (RPM)  3/8" sq. trimmer
P8 - AP-6 zero trim (H.P.)  3/8" sq. trimmer
P9 - AP-8 zero trim (H.P.)  3/8" sq. trimmer
P10- Horsepower analog out zero trim  3/8" sq. trimmer
P11- R.P.M. analog out zero trim  3/8" sq. trimmer
P12- 800KC oscillator trim  3/8" sq. trimmer
P13- R.P.M. "fine" span (front panel)  1 1/4" rect. (cermet)
P14- Horsepower "fine" span (front panel)  1 1/4" rect. (cermet)

SW1- Digital cal. freq. select switch  1 pole - 10 positions
SW2- Range select switch  2 pole - 5 positions
SW3A, B & C - "TRQ" "RPM" and "H.P." select switch  Respectively
SW3D - "RPM Cal" switch (SW3A, B, C, & D on front panel)

Alignment Proper:

IMPORTANT: When done properly, this procedure allows you to adjust the instrument to its original performance specifications. Any trouble you find during the procedure should be corrected before continuing. See section on Diagnosing Trouble.

H.P.

1) Hook Digital Voltmeter to "T.P.-1" on Horsepower/R.P.M. Option Board and Common (observing proper polarity).

2) Adjust front panel zero of "host" instrument (with 0/MV/V from #7905-103) to read ± .0000 VDC
3) Adjust front panel span of "host" instrument (with +2 MV/V from #7905-103) to read +.7350 VDC on Digital Voltmeter. Return #7905-103 to OMV/V setting.

4) Set range switch (SW-1) to position #3 (1K-100Hz) and "Cal. Freq. Select" switch (SW-2) to position #6 (lKC).

5) Hook frequency counter to "TP-OS" on Horsepower/R.P.M. Option Board and adjust P-12 to read 400,000 Hz ± 1Hz. Remove counter.

6) Reverify steps #2 and #3 - Touch up controls if necessary.

7) Hook Digital Voltmeter to "TP-2" and adjust P-5 (Torque Buffer Zero) to ±.0000/VDC while holding "RPM Cal" switch (SW3-D) in.

8) Hook Digital Voltmeter to "TP-7" and adjust P-8 (Zero Trim) to ± .0000 VDC.

9) Push 2MV/V button on #7905-103

10) Hook Digital Voltmeter to "TP-9" and adjust Horsepower (coarse and fine) span (P4 and P14, respectively), for a reading of approx..58 VDC., while holding "RPM CAL" switch. Return #7905-103 to OMV/V.

11) Now adjust P-9 (M-8 Zero Trim) to read ± .0000 VDC on Digital Voltmeter.

12) Repeat Step #10 only this time set voltage at "TP-9" to exactly ± .5831 VDC.

13) Hook Digital Voltmeter to "TP-10" and adjust P-10 (Horsepower analog out zero trim) to read ± .0000/VDC.

14) Push 2MV/V button on #7905-103 and while holding in "RPM CAL" switch, adjust P1 to yield a +1.0000 VDC ± .0001 VDC on Digital Voltmeter. Release "RPM CAL" switch and return #7905-103 to OMV/V.

R.P.M.

15) Hook Digital Voltmeter to "TP-3" and adjust P-6 (AP-2 zero trim) to achieve ± .0000 VDC.
16) Hook Digital Voltmeter to "TP-5" and adjust P7 (AP-4 zero trim) until a reading of ± .0000 VDC is achieved.

17) Hook Digital Voltmeter to "TP-5" and depress "RPM CAL" switch. Now adjust front panel R.P.M. span (both coarse and fine, P3 and P13, respectively) for a reading of ± .7350 VDC. Release "RPM CAL" switch.

18) Hook Digital Voltmeter to "TP-6" and set P11 (R.P.M. analog out zero trim) such that a reading of ± .0000 VDC is achieved.

19) Depress "RPM CAL" switch and adjust P2 (R.P.M. analog out span) until ± 1.0000 VDC ± .0001 VDC is read.

Alignment Verification

A) Hook Digital Voltmeter to TP-1 again and reverify steps 2 and 3. If drift has occurred touch up zero and span on front panel.

B) Digital Panel Meter controls (inside instrument) should be set as follows: (See Sketch #1)

- Torque = Fully clockwise
- RPM Decimal = Fully clockwise
- Horsepower Decimal = XX.00 (position #4 from fully clockwise)
- Torque Multiplier = X 1's
- RPM Multiplier = X 1's
- Horsepower Multiplier = X 2's

C) Select Torque display mode (SW3-A) and push 2 MV/V button on #7905-103 calibrator. Display should read + 1.000 (Assume 1000 lb-in of clockwise Torque if not see Note #1). Release 2 MV/V button and display should now read ± 0 (± 0 MV/V).

D) Select R.P.M. display mode (SW3-B). Display should read ± 0. (If not see Note #2) Hold "RPM Cal" switch in and display should now read +1000 (assume 1000 RPM). (If not see Note #2) Release switch.

E) Select Horsepower display mode (SW3-C). Display should read + .00. Hold in "RPM Cal" switch and display still read + .00. (If not see Note #3) While holding "RPM Cal" switch, push 2 MV/V button on #7903-103. Now display should read 15.86 Horsepower according to:

\[
\text{Horsepower} = \frac{1000 \text{ lb. in} \times 1000 \text{ RPM}}{63024}
\]

(if not see Note #4)
1) If Torque display does not read +1000, check DC voltage @ TP-1. This should read +.7350 VDC on Digital Voltmeter (see Steps #2 & 3). If Horsepower analog voltage @ "TP-9" is not +.5831 VDC, and Steps #2 & 3 are verified, realign Horsepower section (Steps 4-14).

2) If R.P.M. displayed (zero & span) don't agree, make sure you have +.0000 VDC (as set in Step #17) and +.7350 VDC (as set in Step #16) @ "TP-5". Repeat R.P.M. alignment if necessary.

3) If Horsepower displayed (zero & span) don't agree, make sure you have +.0000 VDC (as set in Step #11) and +.5831 VDC (as set in Step #10) @ "TP-9". (If not see Note #1)

4) If Horsepower displayed zero moves, repeat Step #7. Align any subsequent zero trim Pots as needed following from Step #7.
DIAGNOSING TROUBLE

Most instrument problems fit into the following 3 areas:

1. Damage or errors in cabling. Transducer malfunction.

2. Errors in instrument set-up or calibration.

3. Instrument malfunction.

The following discussion should help the user locate, and in many cases, solve the problem.

1. Cabling and Transducer Problems

The easiest way to locate problems in this area is by substituting a cable or transducer that is known to be good. If that is not possible, the cable should be checked for correct wiring and open circuits. Refer to the cable wiring drawings in the main instrument manual and in this manual. Often, the transducer problem can be identified by comparing the resistance readings which were taken when the transducer was shipped, with the readings taken when the problem appeared. Read across the excitation pins and the signal pins of the transducer and compare those readings with the ones recorded in the transducer manual.

2. Set-up and Calibration Problems

Re-read the set-up examples in this manual. In the case of the Torque input, be sure that the torque transducer capacity, measurement units, and shunt calibration resistor values are all correct for the application. The R.P.M. range switch, and calibration frequency switch must be set for the speed range being used. Separate multiplier and decimal switches are used for Torque, R.P.M., and Horsepower readings on the digital display. They must be properly set for the engineering units being used.

3. Instrument Malfunction

Before attempting to trouble-shoot the instrument, read the trouble-shooting and theory of operation sections in this manual as well as the basic instrument manual. These sections are written for the person who is already familiar with digital and analog circuits and who has access to high quality test equipment.
TROUBLE-SHOOTING FLOW-CHART

The purpose of this chart is to help you quickly identify any easily remedied set-up or instrument problems.

Difficulties beyond the scope of this section should be referred to Lebow Products, Division of Eaton Corporation.

How to use this Chart:

Starting with Branch #1, trace difficulty until a (balloon) is reached and note. Follow Branch #2, then #3 in the same manner and again note which balloon is reached (notice __________ denotes main test path and ________ denotes a second test path through same block). Finally, while referring to "Signal Routing" sketches and block diagram (overall picture), follow result analysis flow-chart indications.
Result Analysis - (Set-Up)

S1 Check transducer for proper fixturing and/or usage (see Lebow Torque Sensor Catalog #250-C)

S2 Repair or replace old cable

S3 Repair or replace old cable

S4 Check R.P.M. pick-up for metal filings in connector "well". If clean and problem persists, use new R.P.M. pick-up.

S5 Check R.P.M. input signal routing from rear barrier of host instrument, through SW 3-D, to R-14 (input of Frequency to Voltage converter).

S6 Find out if going back to Torque sensor or external R.P.M. pick-up causes problem to reappear and follow either S1 or S3, S4, and S5 respectively.

S7 Find out if going back to original Torque sensor cable causes problem to reappear. If it does follow S2.
RESULT ANALYSIS (Instrument)

(Torque)

Refer to sketch below for A — D.

A. Locate Torque analog "out/in" filter SW (found on "host" instrument main board). If this switch is set on "out" position problem is in .4/.4 Hz display low-pass. If this switch is set on "in" position then problem is in Digital Panel Meter. In either event, see appropriate manual for alignment and/or service details.

B. Problem is in analog buffer stage of "host" instrument. Refer to that manual for service.

C. Locate Torque analog "out/in" filter SW (found on "host" instrument main board). If this switch is set on "out" position, refer to (adjustments) alignment procedure of "host" instrument and realign, and if necessary, service. If this switch is set on "in" position, a second error resides solely in the analog buffer in addition to the primary error in main signal path. Again realign and/or service (as outlined previously).

D. Locate Torque analog "out/in" filter SW (found on "host" instrument main board). If this switch is set on "out" position, problem lies in stages previous to display low-pass filter. If switch is set on "in" position, problem may be in display low-pass itself. Set switch to "out" position to find out. In either case, see "host" instrument manual for alignment.
RESULT ANALYSIS (Instrument)

(R.P.M.)

Refer to sketch below for E

E Problem is in either SW J-B and interconnect between Horsepower/R.P.M. Option Board to Digital Panel Meter Option Board or in Digital Panel Meter option itself. Refer to appropriate manual as signal routing is traced.

F Problem is in R.P.M. analog output stage (AP-5, P-22) on Horsepower/R.P.M. option board. Refer to alignment procedure and schematic diagram in this manual for repair.

G A second error resides solely in this stage in addition to main error in previous stage(s). Use "0 & full-scale" method while working backward to problem stage(s). Note: Take into account individual stage gain (see block diagram)----See H for Frequency to Voltage Section Trouble-Shooting.

H Starting with AP-4 work backward to problem stage(s) using "0 & full-scale" method while taking into account individual stage gains. If problem persists at pin number 4 DIC-6 (use Digital Voltmeter to integrate pulse) then refer to following procedure. (See Schematic & Theory of Operation)
Frequency to Voltage Section - Trouble Shooting

1) Trace square-wave signal through AP-1 from R-14 using R.P.M. Calibrate (Int.) as signal source.

2) Make sure when external R.P.M. signal (sine-wave) is inputed square wave (rail to rail) appears at pin number 1 (AP-1).

3) Make sure a 0 to 11 VDC square wave appears @ pin number 7 (AP-1) and identically @ pin number 5 (DIC-9).

4) Measure pin number 5 (DIC-9), pin number 1-10 (DIC-8). Pin number 1-10 (DIC-8) should be a pulse width approximately 1/8 of period of signal @ pin number 5 (DIC-9) and occurring only on each positive transition.

5) Check to make sure appropriate frequency "reference" appears on pin number 3 (DIC-8) for each range switch (SW1-A, setting ---- in the event step #4) does not hold true.

Horsepower - See R.P.M./Horsepower Signal Routing Sketch

I) Problem is in either SW 3-C and interconnections between Horsepower/R.P.M. option board to Digital Panel Meter option board or in Digital Panel Meter option itself. Refer to appropriate manual as signal routing is traced.

J) Problem is in Horsepower analog output stage (AP-9, Pl) on Horsepower/R.P.M. option board. Refer to Alignment Procedure and schematic diagram in this manual for repair.

K) A second error resides solely in this stage in addition to main error in previous stage(s). Use "0 & Full-Scale" method while working backward to problem stage(s). NOTE: Take into account individual stage gain (see block diagram) ---- See(L) for Horsepower multiplier section Trouble-Shooting.

L) Starting with AP-8 work backward to problem stage(s) using "0 & Full Scale" method while taking into account individual stage gains. If, when using a Digital Voltmeter to integrate pulse @ pin number 4 (DIC-7), the problem persists, refer to following procedure. (See schematic and theory of operation)

Horsepower Multiplier Section - Trouble-Shooting

1) Make sure proper Torque levels are at "Torque in" (TP-1) .7350 VDC = F.S. Torque, & TP-2 (≈ 2.013 VDC = Full-Scale Torque). Also "0" is zero (if not realign).
2) Make sure Frequency to Voltage pulse-train (match to pin number 3, 14 and 15 of DIC-6) is present on pin number 9 (DIC-7). Use fast-rise oscilloscope for this measurement.

3) Finally, make sure amplitude of pulse-train output (pin number 4 DIC-7) equals that of D.C. voltage at TP-2.
IV. THEORY OF OPERATION

Refer to block diagram drawing #B-29519 during the following explanation and schematic #D-29372 for any additional circuit details desired.

R.P.M. Section

The Frequency to Voltage converter (R.P.M. Section) accepts either an input from the "outside world" (R.P.M. pick-up) with S3-D (R.P.M. CAL) normally out or the calibration frequency selected by SW-2 (S3-D held in). The first stage of this section (AP-1) buffers, provides high gain and limits the (now square wave) signal within logic limits. DIC-9 and DIC-8 form a novel digital one-shot with its pulse width determined by a crystal-derived reference frequency. The range select switch (SW-1) routes 1 of 4 such frequencies to the "one-shot". DIC-6 now improves the rise and fall times of the pulse while forcing amplitude to equal V-REF and "low" equal to zero volts D.C. AP-2, 3, and 4 (with their associated components) comprise a 5-pole, gain-adjustable, "bessel" filter which extracts the D.C. average of DIC-6's constant pulse-width; constant amplitude; input frequency-modulated, pulse-train and is proportional to R.P.M. AP-4 also provides buffered R.P.M. analog to the Digital Panel Meter input when "RPM" display switch (SW3-3) is selected. AP-5 provides buffered, spannable output to the "outside world" via "host instrument" rear barrier strip.

Horsepower Section

The Horsepower multiplier (DIC-2) takes the R.P.M. pulse train (output of DIC-6) and amplitude-modulates it with a Torque, analog, buffered by BF-1 and AP-10, derived from, and band width limited by the "host instrument". DIC-2's output is next passed through a 5-pole Bessel filter, made from AP-6, 7 & 8 (identical with R.P.M. section) to extract the D.C. average proportional to Horsepower. AP-8 also provides buffered Horsepower analog to the Digital Panel Meter input when "Horsepower" display switch (S3-C) is selected. Finally, AP-9 provides buffered, spannable output to the "outside world" via "host instrument" barrier strip on rear panel.
V. DOCUMENTATION

Magnetic Pick-up Wiring
Schematic Diagram
Assembly Drawing
Parts List
Sales Representatives
Warranty
INSTRUMENT CONNECTIONS

PASSIVE MAGNETIC PICK-UP

COAX CABLE

ZERO VELOCITY MAGNETIC PICK-UP

BELDEN 8424 CABLE

MAGNETIC PICK-UP WIRING

LEBOW ASSOCIATES, INC.
TROY, MICHIGAN

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