INSTALLATION, OPERATION, AND TROUBLESHOOTING GUIDE FOR DIGITAL HP/KW-H METERS, PRECISION SINGLE AND DUAL-RANGE TORQUEMETERS

Revision B

Applies to

MCRT® 48000P, MCRT® 49000P,

MCRT® 48700V, MCRT® 49700V, MCRT® 59700V, MCRT® 79700V

Customer: . . . .
Model Number: . . . .
Serial Number: . . . .
Factory Reference Number: . . . .
Rated Horsepower at Rated Torque & Maximum Speed: . . . .
Rated Torque, High Range (lbf-in): . . . .
Rated Torque, Low Range (if present) (lbf-in): . . . .
Torque Overload Capacity (lbf-in): . . . .
Overrange Rating: 150% on all outputs.
Maximum Speed (rpm): . . . . *Performance Code:* . . . .
Foot Mount: ( ) Yes ( ) No
Speed/Horsepower: ( ) Yes ( ) No
Energy Option: ( ) Yes ( ) No
Special Features: . . . .
. . . .
. . . .

Factory Installed Scaling, Units of Measure, Filter & Pin Selection, Cal Values
Torque Range(s): . . . . *Speed Range:* . . . .
Power Range: . . . . *Energy Range:* . . . .

Full Scale Analog Output And Connector Pin Assignments:

Connector Pin	Parameter	Full Scale	Analog Voltage Output
A			
B			
C			

Calibration Data is listed in the attached Calibration Certificate. Calibration data is automatically loaded on power up. Calibration data can also be accessed using a PC and the supplied software.
Filter Cutoff Frequency (Hertz): . . . .
Password Protection: ( ) On ( ) Off

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I. Introduction

These transducers measure and output ***shaft power, energy, torque and speed***. Speed and power are optional on V suffix models; energy is an option of P suffix models and unavailable on V suffix devices. They have no pots, switches or manual adjustments. Null, scaling and units of measure are stored in non-volatile memory. Digital computation of power and energy are errorless. Fifty-one common units of measure are supported. Eleven selectable Bessel filters *avoid delay distortion and overshoot* and assure optimal measurement response. Input power is a single, unregulated dc supply. Reverse polarity protection is standard.

If you re-calibrate, previous calibration values are archived. Pin strapping and serial commands enable simultaneous, traceable* power/torque/speed calibrations, and remote zeroing. Energy reset is done via the serial port. Password protection may be invoked if needed. Included software operates on Windows-based PC's. It displays and plots real time data, and does time and X-Y plots when speed/power signals are present. Use it to select 5V or 10V analog outputs, filter cutoff frequency, scaling, units of measure and/or to control measurements.

* NIST traceable calibration performed in our accredited Cal Lab (NVLAP LAB Code 200487-0). For details visit www.himmelstein.com or www.nist.gov.

Rotary transformers connect the rotating strain gages to stationary output circuitry. They provide brushless signal coupling between rotor and stator. Rotary transformers don't generate noise or wear. They are immune to ambient noise, vibration, lubricants and other hostile environments.

Circuitry is shielded from RFI and external magnetic fields which fact, combined with the absence of low level cables, yields extraordinary noise immunity, even close to large electric machines. Elimination of slip rings, brushes, fragile ferrites, radio transmitters and other limited-life, noise-generating and noise susceptible elements further increases performance and reliability. Moreover, the *non-ferrite design* makes these transducers suitable for diesel and other hostile applications.

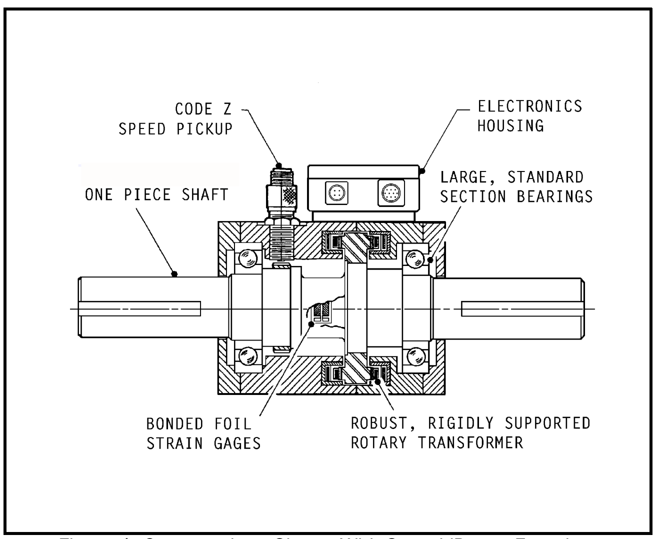

Figure 1. Construction - Shown With Speed/Power Function.

A. Mechanical Installation

A.1 Applicability
This discussion is applicable to all models including MCRT® shaft, and flanged end devices.

A.2 Reference Document
MCRT® 48000P, 49000P, 48700V, 49700V, 59700V and 79700V transducers are mechanically identical to their MCRT® 48000V, 49000V, 59000V and 79000V DC Operated Torquemeter models. That is, they share the same physical structure and measure torque and speed in a similar manner.

However, unlike the torquemeters, they
- use advanced digital technology to measure torque,
- have integral digital speed[1] conditioning and output circuitry valid to zero speed,
- calculate shaft power[1] and energy (an option),
- eliminate all manual adjustments,
- output three 5V or 10V analog signals,
- have eleven selectable filter cutoff frequencies,
- have a full duplex RS232 port,
- come with PC interface software,
- support 51 mouse selectable units of measure.

1. An option of the V suffix Torquemeter versions.

MCRT® 48000P, 48700V and 79700V devices are mechanically equivalent to the MCRT® 48000V DC Torquemeter *with the same maximum torque rating*. MCRT® 49000P, 49700V and 59700V devices are mechanically equivalent to the MCRT® 49000V and 59000V Torquemeter *with the same torque rating. This manual refers to the DC Operated Torquemeter Manual, Revision E (attached) for information concerning mechanical installation, ratings and maintenance.* By way of emphasis, refer to that document for:

- **Coupling Selection**, page 3 and Appendix I
- **Coupling Installation**, page 4
- **End-to-End Orientation**, page 5
- **Vertical Installations and Belt/Chain Drives**, page 5 and Appendices II and VII
- **Allowable Torque Loads**, page 8
- **Overload Considerations**, page 8
- **Fatigue Considerations**, page 9 and Appendix III
- **Starting High Inertias with Electric Motors**, page 9
- **Allowable Bearing Loads**, page 9
- **Allowable Extraneous Loads**, page 10
- **Operating Speeds**, page 11 and Appendix IV
- **Lubrication**, page 11
- **Contaminants**, page 11
- **Hazardous Environments**, page 12 and Appendix VI

B. Electrical Installation

B.1 Applicability
This section is applicable to all MCRT® Horsepower/kW-h Meters and Precision Digital Torquemeters.

B.2 Stator Connectors
Four stator connectors are used, as follows:
- Input Power (2 Pins)
- Analog Outputs and Cal Enable (10 Pins)
- Speed Signal (6 Pins)
- Com Port (4 Pins)

Mating connectors are supplied for Power and Analog Outputs plus Cal Enable. A speed cable is installed when speed/power outputs are present. A com port to PC cable is always furnished.

B.2.1 Earth Ground Connection

Connect the transducer stator directly to earth ground – a buildings' structural steel or a floor rod. If neither is available, drive a six foot copper rod into the floor. Then run separate ground straps between it and the test stand components as shown in Figure 2. Don't "daisy chain" the connections.

If an IGBT-based variable frequency drive (VFD) is used, follow its' installation manual. Improperly installed VFD's can cause premature motor and cable failures, and reading errors from excessive noise. VFD's should have shielded power and motor cables. Belden Types 29500 thru 29507 cables are designed for VFD use. See "Cable Alternatives for PWM AC Drive Applications" available at www.belden.com. Himmelstein recommends the connection in Figure 2. For best results, use a differential input amplifier in these electrically noisy environments.

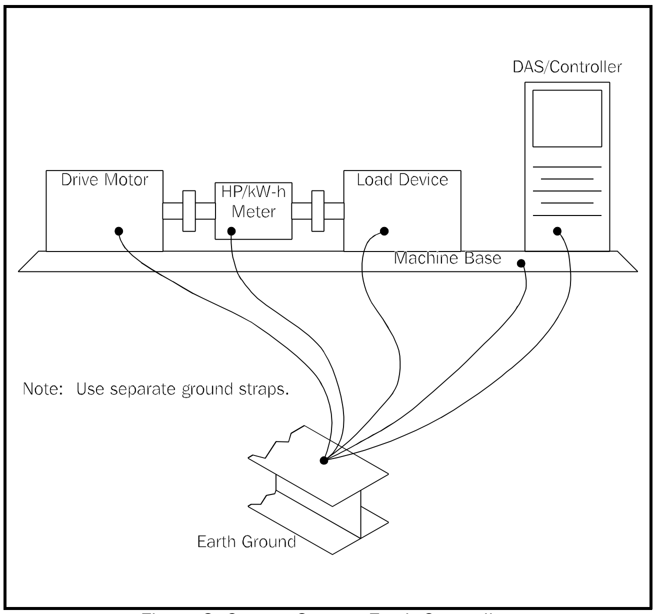

Figure 2. Correct System Earth Grounding

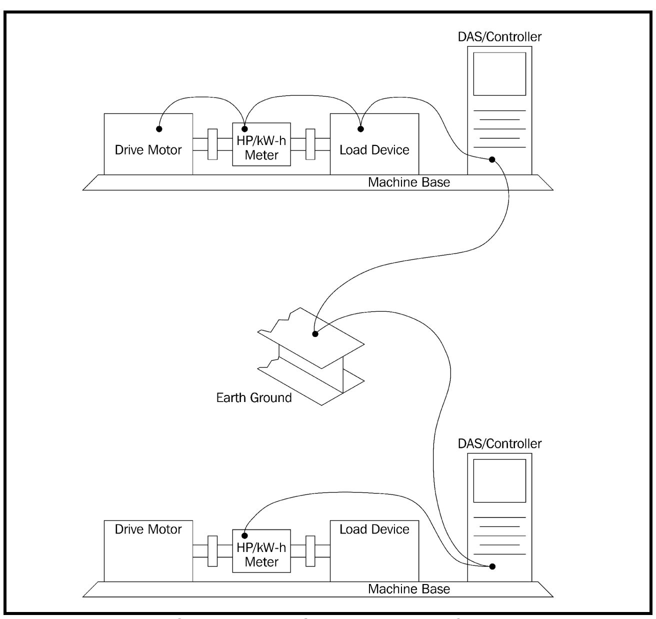

Figure 3. Examples of Incorrect Earth Grounding

B.2.2 Power Input; 2 Pin Connector

The power connector has two pins with pinout as follows:

Pin A	+ Power In (11 to 24 VDC)
Pin B	Power Return

Reverse polarity protection is standard. Although any wire may be used for connections, *shielded cable will perform best in noisy environments and is recommended*. *Note:* The shield should float at the Transducer end. The other end should be tied to earth ground; see Figure 4.

Caution: Don't connect a Transducer to a Power Supply that also drives inductors or solenoids. Induced switching transients may cause damage or noise.

B.2.3 Analog Outputs, Cal Enable, Torque Zeroing; 10 Pin Connector

Shielded cable is recommended for these connections. The shield should float at the Transducer end and be tied to earth ground at the other end. See Figure 4.

B.2.3.1 Analog Outputs

Three analog signals are output on the ten pin connector. Any output can be assigned to any of these three pins. For example; Pins A and B can both be assigned to Torque and Pin C can be assigned to Power, etc. If special pin assignments are specified by the customer, they are installed at the factory. Actual pin assignments, as shipped, are listed on the front page of this document. The user may reassign pins with the use of a PC and supplied software.

The analog signals may have full scale values as follows:

Power	CW = +10V, CCW = -10V, or CW = +5V, CCW = -5V
Energy	CW = +10V, CCW = -10V, or CW = +5V, CCW = -5V
Torque	CW = +10V, CCW = -10V, or CW = +5V, CCW = -5V
Speed	CW = +10V, CCW = +10V, or CW = +5V, CCW = +5V

The polarity of the output signals can be inverted using the furnished software. Thus, if Pin C is assigned +5V for Torque Output and Pin B is assigned -5V for the same Torque Signal Output, then you will have a 10V differential output signal between Pins C and B. Differential signals have higher noise immunity than single ended signals.

Analog output voltage selections, as shipped, are listed on the front page of this document. The user may reassign voltage selection(s) with the use of a PC and supplied software.

CW torque causes the shaft to turn CW when viewed from the driven end. CCW torque causes the opposite rotation. Power and Energy polarities track the torque. Energy accumulation is algebraic or net.

B.2.3.1.1 Analog Output Default Pin Assignments
Unless requested differently, units are shipped with the following pin assignments:

B.2.3.1.1.1 MCRT® 48000P, 49000P, 48700V, 49700V, 59700V with Speed Option - Default Pin Assignments

Pin C: ±10V Torque Output
Pin B: +10V Speed Output
Pin A: ±10V Power Output

B.2.3.1.1.2 MCRT® 48700V, 49700V, 59700V without Speed Option - Default Pin Assignments

Pin C: ±10V Torque Output
Pin B: ±5V Torque Output
Pin A: ∓5V Torque Output

B.2.3.1.1.3 MCRT® 79700V with Speed Option - Default Pin Assignments

Pin C: ±10V High Range Torque Output
Pin B: ±10V Low Range Torque Output
Pin A: +10V Speed Output

B.2.3.1.1.4 MCRT® 79700V without Speed Option - Default Pin Assignments

Pin C: ±10V High Range Torque Output
Pin B: ±10V Low Range Torque Output
Pin A: ±5V High Range Torque Output

B.2.3.2 Cal Check Enable
Internal Calibration Check Circuitry may be remotely enabled by pin strapping and/or via the com port using furnished software. Invoking a Cal Check produces simultaneous calibration signals for Power, Torque, and Speed. As a result, the Energy (∫Power dt) will start accumulating when present. Pin strapping is accomplished by **shorting the designated pin on the ten pin connector, to Common (Pin D).**

CW Cal Short Pin F to Pin D

CCW Cal Short Pin E to Pin D

The calibration signal will remain on until the short is released. For that reason it should be invoked while the driveline torque is at zero; if locked-in torque is present, break one of the shaft couplings.

Calibration can also be invoked from a remote computer using the furnished software.

Equivalent calibration values, in engineering units of measure, are listed on the Calibration Certificate which documents NIST traceability. Calibration values were determined in S. Himmelstein and Company's accredited* (NVLAP Lab Code 200487-0) calibration laboratory. They can also be accessed using the furnished software. The user may perform a dead weight calibration and store the results in memory, using furnished software. The original cal data is archived.

*For details visit www.himmelstein.com or follow the accreditation link at www.nist.gov.

B.2.3.3 Torque Zeroing
TORQUE ZEROING SHOULD ONLY BE DONE WHEN THE DRIVELINE TORQUE IS ZERO. If locked-in torque is present, break one of the shaft couplings to remove it.

The Torque Channel can be remotely zeroed by *simultaneously* strapping the CW and CCW Cal enable lines (Pins E & F) to Pin D, and holding that condition for five (5) seconds. When this is done, any residual system offsets will be removed.

Torque Zeroing can also be invoked from a remote computer using the furnished software.

B.2.4 Speed Signal Connector; 6 Pins
The Zero Velocity Speed Sensor is equipped with an integral cable which is terminated in a connector that mates with the 6 Pin stator body speed connector. The sensor is powered and read via that cable. No external connections are required.

B.2.5 Com Port Connector; 4 Pins
Transducers are shipped with a 20 foot Sensor to PC cable. The cable is made per Figure 4. If required, we can supply a 50 foot cable. RS232 cable runs greater than 50 feet require a repeater.

The Baud rate is fixed at 38,400. Eight data bits are used without parity. Neither handshaking nor an ID is employed. If you wish to write your own software, see Appendix IV for serial communication commands.

C. PC Interface Software

C. 1 PC Interface Software Description
Sensors are shipped with Windows-based PC interface software. That software provides for several functions as follows:

- Change Setup; units of measure, filters, etc.
- Display Measured and Computed Data
- Control Test Functions
- Perform dead weight calibration and archive cal data

All PC operated functions are accomplished by selecting options shown on the screen. The following paragraphs summarize the functions available. Page 1 lists the installed setup as shipped. If desired, a user may write his own communication software; see Appendix IV for information on the Serial Command Structure.

C.2 Change Sensor Setup
- Select any of 51 units of measure. Default units are: *hp, lbf-in. rpm, kW-h*. See Appendix II for a complete listing.

- Select any of 11 data filter cutoff frequencies from 0.1 to 200 Hz in 1-2-5 steps. The default is 10 Hz. The Torque and Speed channel filters are set to the selected cutoff frequency; they have no delay distortion or overshoot. Power and Energy are computed 50 times/second.

- Select 5V or 10V full scale for any of the three analog outputs. The defaults are: ±10V for Power, Torque and Energy; +10V for Speed.

- Reassign any or all of the analog outputs. The defaults are listed in ¶B.2.3.1 for a sensor with Torque, Speed and Power outputs and one with Torque only output. Pin D (Common) is not re-assignable.

- Adjust the value of the analog output voltage. These are factory set at ±5.000V and ±10.000V and should not be re-adjusted without accurate measuring equipment.

- Change the full scale range of any or all parameters. Except for torque, range changing will alter the increment of measurement. If the torque range is changed, the 5V/10V analog output will be reset to the new range; but, the torque increment of measurement will not change. See the first page of this document for factory range settings.

- Invoke or disable password protection and enter a new password. Default condition is password protection disabled. The default password is **SHC**. You can change the password to an alphanumeric string but, record the new one in a secure place.

Setup changes made using the PC Interface Software, do not require recalibration of the Digital MCRT® Transducer. Any change will automatically re-configure dependent parameters. For example, if only the torque units of measure are changed from *lbf-in* to *N-m*, power and energy readings will read correctly *without further user adjustments* and all parameter Cal Checks will be correct.

C.3 Display Measured and Computed Data

- Displays Power, Torque, Speed and Energy (an Option) numeric data with units of measure
- Displays real time plots of Power, Torque, Speed and Energy (an Option)
- Displays X-Y plots of Power, Torque, Speed and Energy (an Option)

C.4 Test Control

You can initiate the following actions from a PC:

- Invoke Cal Check
- Invoke Torque Zeroing
- Reset the Energy Totalizer

C.5 Perform Dead Weight Calibration

Units are shipped with an NIST traceable dead weight calibration performed in our accredited laboratory; a Calibration Certificate is shipped with the sensor. The results of that calibration are stored in non-volatile memory and automatically loaded on power up. Remote, initiated either via PC (per ¶C.4) or by strapping (per ¶B.2.3.2), Calibration Checks are referenced to it.

The user can perform a dead weight calibration and store it in memory. The interface program prompts you through the process. If done, the original factory calibration will be archived as will subsequent dead weight calibrations.

However, ***unless you have accurate, accredited calibration facilities, you should not substitute a field calibration for the factory calibration***. Rather, you can perform a field calibration for use as a rough check of operation. If an inaccurate or erroneous calibration is inadvertently stored, the original calibration may be recovered.

C.6 Calibration Intervals

For continuous or intermittent service, make periodic Calibration Checks per ¶B.2.3.2 or ¶C.4, above.

In applications requiring high accuracy, perform *a dead weight calibration in an accredited torque calibration laboratory at intervals specified by your QC Procedures.* If you do not have an established QC procedure, then we recommend an initial one year interval.

If the MCRT® Transducer is overloaded or operates abnormally, then calibrate/inspect it at once.

Himmelstein offers certified dead weight calibration service, traceable to NIST, for all its' products. Its' calibration laboratory is accredited (Laboratory Code 200487-0) by NVLAP an arm of the NIST. For further information visit our website at www.himmelstein.com or, follow the accreditation link at www.nist.gov.

D. Troubleshooting

D.1 Scope

These discussions suggest procedures for identifying a defective system component. They are an aid for operating personnel. Special training and adequate inspection, test and assembly fixtures are needed for extensive service.

Potential faults include the installation, the Transducer, the cabling and the terminal device. The best procedure is to isolate the problem part, then correct or replace it. Otherwise return the defective part to the factory.

D.2 Preliminary Inspection

D.2.1 Transducer

Inspect the sensor for physical damage. If the shaft is locked or a rub exists, remove the speed pickup per instructions contained in ¶D.4.3. If the fault clears, reinstall the pickup following ¶D.4.3 instructions. Otherwise return the unit to the factory.

D.2.2 Cabling and Earth Grounding

Make electrical checks for continuity and shorts; see ¶B.2.2 and ¶B.2.3 and Figures 2, 3 and 4 for connections. ***Verify that the mating 10 pin connector is installed and secured.*** Erratic connections, omission of shields and poor grounds can produce noise. If noise is a problem, then replace the cable with one that is shielded and ***provide a good earth ground to the motor, machine base and Transducer housing per ¶B.2.1.*** Examine all cables for damage. Replace damaged cables. Clean connectors with an approved contact cleaner.

D.2.3 Readout Instrument/Data Acquisition System/Controller

Examine for physical damage, blown fuses and/or loose parts. Correct any defects; refer to the manufacturers' manual, as necessary.

D.3 Torque Subsystem

D.3.1 No Output When Torque is Present

Verify input power is present, its' polarity is correct, and the cable is intact, i.e., between 11 and 24 VDC appears at the Transducer terminals. Finally, verify the load is within the specified maximums.

Operate the Cal Check. If the correct calibration value appears on the PC display but not at the analog output, make sure the torque analog is assigned to that pin. If necessary, reassign it. If the analog output has the correct Cal Signal but the PC does not, then check the PC cable connections and verify the port is set per ¶B.2.5. If all checks are negative, the problem is in the sensor. Return it for factory service.

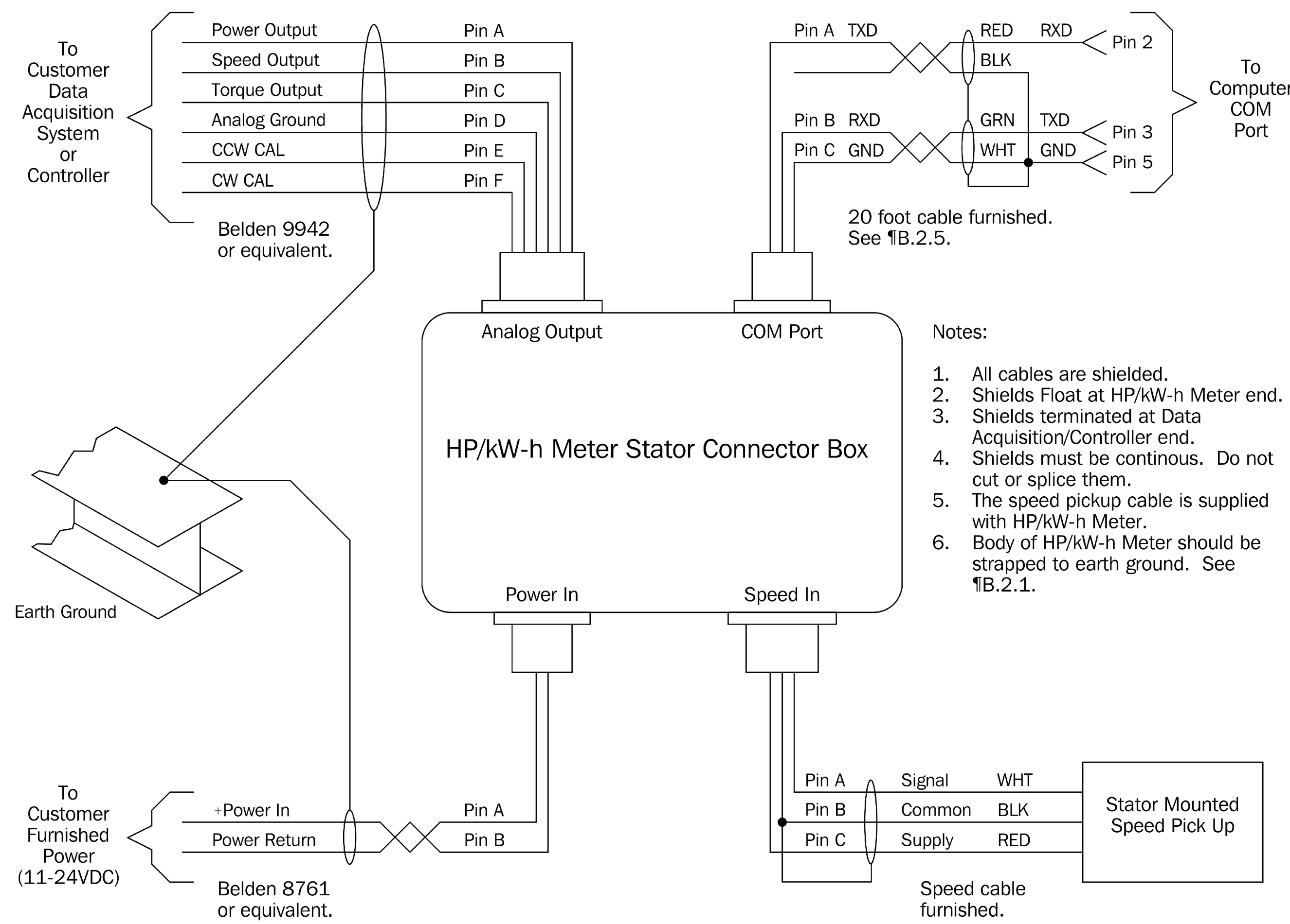

Figure 4. Cable Connections Illustrated with HP/kW-h Meter.

D.3.2 Constant Output Regardless of Shaft Torque

If the ¶D.3.1 above checks are performed and found normal, then the problem is the sensor. Return it for factory service.

D.3.3 Apparent Zero Drift

- **Check the Cabling.** See ¶D.2.2.

- **Check for Driveline Torque Offsets.**
  Transducers installed in a drive which has hysteresis or friction torques, may *appear* to have long term drift when there is none. For example, when installed between a pump and a gear drive, the torque reading may not return to zero after a test because of locked-in friction torque. The sensor sees and reads that locked-in torque. ***Always zero the Transducer with no torque on the driveline*** — in the case cited, with a coupling disassembled. At the end of the test, the shaft should be mechanically "shaken" or a coupling broken, to return to zero. Otherwise, the sensor will read locked-in torque. A rub between any rotating and stationary part is a common cause of friction. Verify the shaft couplings and other rotating parts have adequate clearance.

D.3.4 Signal Instability

- Check the Cabling. See ¶D.2.2 above.

- **Check For Driveline Torque Variations.** The driveline may have a low frequency oscillation which the sensor reads (see Reference Manual,¶C.2.1). Use the Transducers' low frequency filter to suppress signals above 1 Hertz. If the readings become steady, then you may wish to identify the physical cause of the shaft torque variation or, remove it with mechanical filtering techniques; see ¶E.4 of the Reference Manual. Oscillographic signal analysis is often helpful under these conditions; however, you should ***use a high frequency signal filter and the analog output*** during this analysis. If very large, high inertia machines are used, or large machines are used in a control loop, torque and speed oscillations can be present below 1 hertz. They can be identified with the Transducers' signal filters.

D.3.5 System Will Not Zero

- **Check the Cabling.** See ¶D.2.2 above.

- **Verify the Torque Input is Zero.** If the sensor is installed in a driveline, break or remove one of the couplings. If the system still can't be zeroed, then the problem is either the cable or the Transducer. Verify cable integrity, configuration and connections and check the Transducer per ¶D.2.1.

- **Verify A Good Installation Earth Ground**, per ¶**B.2.1**, is present.

D.4 Speed Subsystem

Speed measurement problems can originate in several components. They include the speed pickup, the readout device, and the interconnect cable. The best procedure is to isolate the defective element and then correct or replace that element.

D.4.1 No Signal Output When Shaft is Rotating

- **Examine the Speed Cable and Connector.** Verify the cable is plugged into the 6 pin stator connector. If the cable or connector are damaged, order a replacement speed pickup and install per ¶D.4.3. Replacement part number is 900-8101-X for all models except those with torque overload ratings greater than 750,000 lbf-in. Contact the factory for larger models. Otherwise, substitute the measured cable length in inches for the X in the part number.

- **Verify the Shaft Speed is Within the Measurement Range.** When operating at very low speeds, even though the speed sensor will operate at near zero speed, you may be below the reading threshold or resolution. That resolution is one part in 10,000 (digital) and 5,000 (analog). Thus, if the Speed Scaling is set for 20,000 rpm at full scale, the minimum detectable speed is 2 rpm(digital) and 4 rpm (analog). To eliminate this as the problem, either reset the scaling or, increase the shaft speed to well above the system threshold.

D.4.2 Erratic Output

- **Examine the Speed Cable and Connector** per ¶D.4.1 above.

- **Verify Your Drive Speed is Stable.** Some drives have significant speed variations caused by control system instability, torsional vibrations, etc. To eliminate this possibility, use another drive source — preferably a direct drive motor running between 600 and 3,000 rpm. Alternately, observe the torque variations on an oscilloscope. If they track the speed variations and both signals are stable with the shaft stationary, then the drive is probably unstable and the instruments are reporting real speed variations.

- **Verify A Good Installation Earth Ground**, per ¶**B.2.1**, is present.

D.4.3 Speed Pickup Replacement

Speed pickups are threaded into the sensor stator housing and locked with a jam nut.

To remove the defective pickup, ***with shaft motion stopped***, proceed as follows:

- Disengage the electrical connector.
- Loosen the jam nut.
- Back out the defective speed pickup.

To install the replacement pickup, proceed as follows:

- *With shaft motion stopped*, turn the new pickup in until it makes contact with the rotor assembly.
- Back off the pickup one quarter of a turn.
- Tighten the jam nut.
- Slowly rotate the shaft to verify no rub occurs. If you detect a rub, re-adjust the pickup.
- Plug the connector into the 6 pin stator connector.

D.5 Power and Energy Subsystem

When the torque and speed subsystems operate properly and either the power or energy does not, the problem must be in the onboard processor. That is because Power and Energy are computed from the Speed and Torque signals. Under those highly unlikely circumstances, return the Transducer for factory service.

Appendix I

Specifications for MCRT® 48000P and 49000P Horsepower/kW-hour Meters are contained in Bulletin 7404, attached.

Specifications for MCRT® 48700V, 49700V and 59700V Precision Digital Torquemeters are contained in Bulletin 7408, attached.

Specifications for MCRT® 79700V Precision Digital Dual Range Torquemeters are contained in Bulletin 7705, attached.

Appendix II

Installed Units of Measure

Supported Units of Measure (the first unit in each category is default)	
Power	**hp** (550ft-lbf/s), hp (metric), kW, W, ft-lbf/min, ft-lbf/s, Btu/h, Btu/min, Btu/s, ton, cal/h cal/min, cal/s
Torque	**lbf-in**, lbf-ft, ozf-in, ozf-ft, N-m, kN-m, N-cm, kgf-m, kgf-cm, gf-cm
Speed	**rpm**, rps, rph, rad/s, rad/min, rad/h, degree/min, degree/s, degree/h, grad/s
Energy (option)	**kW-h**, MW-h, kW-min, kW-s, W-h, W-min, W-s, kJ, J, hp-h, hp-h (metric), kcal, cal, Btu, therm, in-lbf, ft-lbf, N-m

Appendix III

Mating Stator Connector Part Numbers

Transducers are furnished with mating connectors and cables. Mating Connectors are supplied for Power (2 Pins) and for Analog Outputs and Cal Enable (10 Pins). Both a Speed and Com Port-to-PC cable are also provided. Those cables have connectors installed. The speed cable is factory installed on the sensor.

To order spare connectors, use the following part numbers (P/N):

	P/N
Power Connector:	320-1275
Analog Output/Cal Enable:	320-1255
Speed Connector:	320-1271
Com Port Connector:	320-1273

Appendix IV

Serial Communications for the MCRT Horsepower/kW-h Meter and Precision Digital Torquemeters

This specification of the serial communications for the MCRT Horsepower/kW-h Meters and Precision Digital Torquemeters is subject to change at *any* time *without* notice.

- Lines that end in "=a.b" apply only to version a.b
- Lines that end in ">c.d" apply only to versions >c.d
- Lines that end in "<e.f" apply only to versions <e.f

General conventions used in this document

- <OK> stands for the string "OK"
- <index> is an alphanumeric character (A-Z or 0-9)
- <chnnum> is a channel number (1, 2, 3)
- <CR> is a carriage return (^M / 13 decimal / 0D hexadecimal / 15 octal)
- <LF> is a line feed (^J / 10 decimal / 0A hexadecimal / 12 octal)
- <float> is a floating point number string (e.g. "1234.57")
- <string> is a string (e.g. "LBF-IN")
- <hexNUM> is a hexadecimal string that is NUM characters long (e.g. hex4 could be "8FC4")
- <HF> is an 8 character hexadecimal string that represents an IEEE-float. (A 1-bit sign, 8-bit exponent biased by 126, and a 23-bit mantissa with an implied MSB of 1)
    - 0x80000000: Sign (0 = positive, 1 = negative)
    - 0x7F800000: Exponent
    - 0x007FFFFF: Mantissa
        - if (sign = 0) then value = (2 ^ (Exponent - 24)) * (Mantissa + 0x800000)
        - else value = -(2 ^ (Exponent - 24)) * (Mantissa + 0x800000)
- Channel numbers
    - Channel 1 is Torque
    - Channel 2 is Speed
    - Channel 3 is Power
    - Channel 4 is Energy (if enabled)

General information

- All messages to and from the Transducer are terminated with a <CR> or <LF>.
    - The default termination character is <CR>.
- To set a value on the Transducer, find the message that retrieves the data you want to change. Then append to that message the desired value of the parameter. The Transducer should respond with "OK".
- All hexadecimal/binary data from the Transducer is in big-endian (MSB first) format.

In response to any command, the Transducer returns one of the following:

- "string" where string is the data requested.
- "OK" operation was successful.
- "!Command:xx" command "xx" is not recognized.
- "!Channel" command is inappropriate for the given channel.
- "!Arg" parameter is malformed.
- "!Index" an index <index> is bad (see "CC" for example).
- "!Invalid" there is some other error.
- "!Unknown Error" an unknown error occurred.
- "!Signal Too Small" calibration signal is too small in magnitude.
- "!Signal Too Large" calibration signal is too large in magnitude.
- "!Signal has wrong sign" calibration signal is of the wrong sign for the requested calibration.

Examples:

Remember *ALL* messages to and from the MCRT Horsepower/kW-h Meter and Precision Digital Torquemeter series end with a <CR> or a <LF>.

- Retrieve data for channel 1:
  Send "DC1" to the Transducer. The "DC" is the data current command, and the "1" is for channel 1. The return message should look something like "1234.56".
- Retrieve data for channel all channels:
  Send "DC0" to the Transducer. The "DC" is the data current command, and the "0" designates all channels. The return message should look something like "1234.56,987.654,11.2233".
- Retrieve the filter on channel 2:
  Send "FL2" to the Transducer. The return message should be something like "07" which implies (referring to the appropriate list under the "FL" message) that channel 2 has a filter of 20 Hz.
- Set the filter of channel 2 to 100 Hz:
  Refer to the list under the "FL" (filter) command to find that a 100 Hz filter corresponds to the value 09. Therefore, send "FL209" to the Transducer. The Transducer should respond with "OK" if the operation was successful.
- Change the unit name of channel 1 to "LBF-IN":
  Send "UN1LBF-IN" to the Transducer. The Transducer should respond with "OK" if the operation was successful.
- Calibrate channel 1:
  (assume the calibration type is load) Unload the transducer and send "CL1A" to the Transducer to perform the zero calibration. Wait for an "OK" reply. Then put the + load on the transducer and send "CL1B". Wait for an "OK" reply. Then put the - load on the transducer and send "CL1C". Wait for an "OK" reply.
- Retrieve the version number of the Transducer:
  Send "VR" to the Transducer. The return message should be something like "Model MCRT Horsepower/kW-h Meter v1.2".

Informational Only Messages:

- These messages can only retrieve information from the Transducer -- they can not change any data on the Transducer.
- The time returned is the number of 2kHz clock ticks since the Transducer was powered on.
- If chnnum is a "0", then the data is returned for all appropriate channels in a comma separated list.

MESSAGE	REPLY	MEANING
DC <chnnum>	<float>	Current data for the given channel.
DC0	<float>, <float>, <float>	Current data for all channels.
EC <chnnum>	<hex8>, <float>	Time and Current data for the given channel
EC0	<hex8>, <float>, <float>, <float>	Time and Current data for all channels.
XC <chnnum>	<hex4>	Current hexadecimal data for the given channel.
XC0	<hex4> <hex4>	Current hexadecimal data for torque and speed.
YC <chnnum>	<hex8> <hex4>	Time and Current hexadecimal data for the given channel.
YC0	<hex8> <hex4> <hex4>	Time and Current hexadecimal data for torque and speed.
PF <chnnum>	<hex8>	Pole Four(4) for the given channel
ZZ MESSAGE	VARIOUS	Repeatedly return the result of the serial command "MESSAGE" until BOTH CAL lines are grounded. • **Caution: Do not ground both CAL lines for more than 3 seconds, since that might zero the torque! See manual for details** • **This command is *VERY* unusual. Use with caution.**
SE	<string>	Serial number of the transducer
MD	<string>	Model number of the transducer
CR	<string>	Retrieve the Cal resistor value of the transducer.

System Messages:

MESSAGE	REPLY	MEANING
TM	<hex8>	TiMe on Transducer • The base unit of time is 0.0005 seconds (2kHz).
VR	<string>	Version number of the Transducer • **READ-ONLY!** • The format of the string is similar to "1.2"
PP	<hex4>	Password protection state • **READ-ONLY!** • <hex4>: ▪ 0x0000: EEPROM Password protection disabled ▪ 0x0001: EEPROM Password protection enabled: disallow ALL writes to EEPROM ▪ 0x0002: EEPROM Password protection enabled, but still allow Torque Zeroing
PC <string>: <string>: <string>	<OK>	Change the EEPROM password from the first string to the second string (which must equal the third string)
PS <index> <string>	<OK>	Set EEPROM Password protection • <index>: ▪ 0: Disable EEPROM Password protection ▪ 1: Enable EEPROM Password protection ▪ 2: Enable EEPROM Password protection, but still allow Torque Zeroing • <string>: ▪ Must equal the EEPROM password

Analog Output Messages:

MESSAGE	REPLY	MEANING

AC <chnnum>	<hex12>	Analog output <chnnum> info
		• Chars 01-04: A/D corresponding to 10/5 volts
		• Chars 05-08: A/D corresponding to 0 volts
		• Chars 09-10: Which channel drives analog output <chnnum>
		• Chars 11-12: 10/5V mode
		  ▪ 0x00: Analog output <chnnum> is in 10V mode
		  ▪ 0x01: Analog output <chnnum> is in 5V mode

AI <chnnum>	<hex28>	Internal Tweak data for analog output <chnnum>
		• Chars 01-04: D/A value corresponding to 0V in 10V mode
		• Chars 05-08: D/A value corresponding to +10V in 10V mode
		• Chars 09-12: D/A value corresponding to -10V in 10V mode
		• Chars 13-16: D/A value corresponding to 0V in 5V mode
		• Chars 17-20: D/A value corresponding to +5V in 5V mode
		• Chars 21-24: D/A value corresponding to -5V in 5V mode
		• Chars 25-26: 0
		• Chars 27-28: what-done
		  ▪ 0x01: D/A value corresponding to 0V in 10V mode changed
		  ▪ 0x02: D/A value corresponding to 10V in 10V mode changed
		  ▪ 0x04: D/A value corresponding to -10V in 10V mode changed
		  ▪ 0x08: D/A value corresponding to 0V in 5V mode changed
		  ▪ 0x10: D/A value corresponding to 5V in 5V mode changed
		  ▪ 0x20: D/A value corresponding to -5V in 5V mode changed

AX <chnnum>	<hex36>	Real-time structure for analog output <chnnum> • **THIS DATA IS READ-ONLY!** • Chars 01-04: address of data to send to analog output • Chars 05-12: positive multiplier • Chars 13-20: negative multiplier • Chars 21-24: data offset value • Chars 25-28: analog output offset • Chars 29-32: max legitimate data value • Chars 33-36: min legitimate data value

Temperature Related Messages:

MESSAGE	REPLY	MEANING
TC	<hex24>	Temperature Compensation structure • Chars 01-08: Ambient Factor A - determined by calibration laboratory (IEEE float) • Chars 09-16: Ambient Factor B - determined by technicians (IEEE float) • Chars 17-20: Ambient Temperature A (in units of C-degrees/16) - determined by calibration laboratory • Chars 21-24: Ambient Temperature B (in units of C-degrees/16) - determined by technicians
TP	<hex12>	Real time temperature structure • Chars 01-04: current temperature in units of C-degrees/16 • Chars 05-08: current temperature compensation for torque • Chars 09-12: data for analog output (currently unused)

Torque Specific Messages:

MESSAGE	REPLY	MEANING
MX	<hex4> <hex4>	Max and min of torque
MR	<OK>	Reset the max / min of torque
TR	<hex4>	Current tare value (16 bits) • Chars 1-4: Current tare value in A/D units
OF	<hex4>	Current Cal-Zero offset (16 bits) • Chars 1-4: Current Cal-Zero Offset value in A/D units
SC	<HF> <HF>	Scaling Constants positive, negative • Chars 1- 8: Positive scaling constant (IEEE-float) • Chars 9-16: Negative scaling constant (IEEE-float)
AS <index>	<OK>	Apply Shunt to AC-Carrier channel • <index>: ▪ A: no-shunt applied ▪ B: Apply Positive Cal Signal ▪ C: Apply Negative Cal Signal
HS <index>	<hex76>	Retrieve Load Calibration history (352 bits) • An <index> of '0' returns the factory calibration • Other indexes give subsequent calibrations • Chars 13-20 is the same format as the "FS1" command • Chars 21-28 is the same format as the "CC1A" command • Chars 29-36 is the same format as the "CC1B" command ▪ Chars 01-04: Calibration date ▪ 0x8000: 0 indicates an external calibration ▪ 0x7E00: Year - 2000 ▪ 0x01E0: Month 1=Jan, ..., 12=Dec ▪ 0x001F: Day of month (1-31) ▪ Chars 05-08: Calibration time ▪ 0xF800: Hour (0-23) ▪ 0x07E0: Minute ▪ 0x001F: Zero ▪ Chars 09-12: Resistor value (350K=3503=0xDAF, 1.9M=1904=0x770) ▪ Chars 13-20: Full Scale in engineering units (IEEE-float) ▪ Chars 21-28: Positive Load value in engineering units (IEEE-float) ▪ Chars 29-36: Negative Load value in engineering units (IEEE-float) ▪ Chars 37-44: Positive Scaling Constant (IEEE-float) ▪ Chars 45-52: Negative Scaling Constant (IEEE-float) ▪ Chars 53-56: Cal-Zero Offset In A/D Units ▪ Chars 57-60: Current Gain ▪ Chars 61-68: Positive Cal Value In A/D Units (IEEE-float) ▪ Chars 69-76: Negative Cal Value In A/D Units (IEEE-float)
FT <hex4>	<OK>	Do Filter Test • 0xFFFF: Value of Torque to exceed
FR	<hex12>	Get results of Filter Test • 0xFFFF00000000: Time (in clock ticks) for Torque to exceed value • 0x0000FFFF0000: Max of Torque • 0x00000000FFFF: Min of Torque

Energy Specific Messages:

MESSAGE	REPLY	MEANING
EN	<hex4>	Is the Energy channel enabled? • 0x0000 : Energy channel disabled • 0x0001 : Energy channel is enabled
ER	<OK>	Set the data for the energy channel to 0.

Channel Specific Messages:

MESSAGE	REPLY	MEANING

FS <chnnum>	<HF>	Full Scale
		• **Changing this requires a re-calibration of the channel ("CL" command)**
		• 0xFFFFFFFF : Full Scale of channel *in native units* (IEEE-float)
		  ▪ The native units:
		    ▪ For Torque: lbf-in
		    ▪ For Speed : rpm
		    ▪ For Power : Hp
		    ▪ For Energy: kW-h

CC <chnnum> <index>	<HF>	Calibration Constants
		• 0xFFFFFFFF : Desired data *in native units* (IEEE-float)
		• If the type of <chnnum> is Torque:
		  ▪ **Changing this requires a re-calibration of the channel ("CL" command)**
		  ▪ <index>:
		    ▪ A: Plus Value *in lbf-in*
		    ▪ B: Minus Value *in lbf-in*
		• If the type of <chnnum> is Speed:
		  ▪ <index>:
		    ▪ A: Xdcr Frequency *in Hz*
		    ▪ B: Xdcr Value *in rpm*
		• If the type of <chnnum> is Power:
		  ▪ **Don't change this**
		  ▪ <index>:
		    ▪ A: Calculation Constant *in lbf-in * rpm / Hp*
		• If the type of <chnnum> is Energy:
		  ▪ **Don't change this**
		  ▪ <index>:
		    ▪ A: Calculation Constant *in 0.02 * Hp / kW-h*

UN <chnnum>	<string>	Unit Name

DS <chnnum>	<HF>	Display Scaling
		• 0xFFFFFFFF : Display Scaling (IEEE-float)
		  ▪ The native units (lbf-in, rpm, Hp, kW-h) for the channel's data are multiplied by this number before being sent to the user.
		  ▪ **Only DATA for the channel is subject to this scaling**

Channel Specific Messages (cont.):

MESSAGE	REPLY	MEANING

FL <chnnum>	<hex2>	FiLter (0-10) (4 bits)
		• If the type of <chnnum> is NOT a CALC:
		    ▪ 0x00: 0.1Hz
		    ▪ 0x01: 0.2Hz
		    ▪ 0x02: 0.5Hz
		    ▪ 0x03: 1Hz
		    ▪ 0x04: 2Hz
		    ▪ 0x05: 5Hz
		    ▪ 0x06: 10Hz
		    ▪ 0x07: 20Hz
		    ▪ 0x08: 50Hz
		    ▪ 0x09: 100Hz
		    ▪ 0x0A: 200Hz
		• If the type of <chnnum> is a CALC:
		    ▪ Ignored

CF <chnnum>	<hex4>	Calibration Flags
		• If the type of <chnnum> is Speed:
		    ▪ 0xFFFF: Zero-return value in multiples of 4.096ms
		• If the type of <chnnum> is Torque:
		    ▪ 0xFFFF: Ignored
		    ▪ 0x50DA: Zero Drift Test Mode
		        ▪ If –Cal line is NOT grounded:
		            ▪ Torque Gain set to 0xFFF, and Torque Tare set to 0
		        ▪ Else
		            ▪ Torque Gain set to 0x000, and Torque Tare set to –200 (1% of FS)

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