INSTALLATION AND OPERATION GUIDE FOR HIMMELSTEIN

STRAIN GAGE REACTION TORQUEMETERS

AND

TORQUE TRANSFER STANDARDS WITH BOTH ANALOG AND DIGITAL OUTPUTS

Applies To Models 2270V, 2280V, 2286V, 2287V, CF2800V AND 2300DV

Customer: ______________________

Model Number: ____________ Serial Number: ____________

Factory Reference Number: ______________________

Rated Torque (lbf-in): ______________________

Torque Overload Capacity (lbf-in): ______________________

Factory Settings

Analog Output: ±10.000V at Rated Torque: ______________________

Filter Cutoff Frequency (Hertz): ______________________

Digital Output Units of Measure: ______________________

Special Features: ______________________

____

____

____

____

Readout/Power Supply Furnished: ( ) Yes ( ) No

If Yes, Readout Model Number: ______________________

Interconnect Cable P/N: ____________ Furnished: ( ) Yes ( ) No

Calibration Data is listed in the attached Calibration Certificate

S. Himmelstein and Company
Designing and Making the Worlds' Best Torque Instruments since 1960
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I. Introduction

Himmelstein Strain Gage Reaction Torque Sensors and Torque Transfer Standards provide static and dynamic measurement of driver and load device torque. The Models 2270V and 2280V are solid flanged devices. The 2270V is the most compact of the group and occupies considerably less radial space than the 2280V Series. The 2280V Series Torquemeters, have mounting bolt circles outboard of their body, which simplifies installation. CF2800V Torquemeters mate directly with NEMA C-Face motors and generators. Additionally, their large through bore facilitates many other applications. 2300DV devices have exceptionally high performance making them ideally suited as Torque Transfer Standards.

All devices measure torque whether the shaft is rotating or stationary. They have high safety margins and stiffness, low deflection and are bidirectional; i.e., their output polarity follows the torque direction. Reaction torquemeters have no bearing or speed limitations and don't require lubrication.

The analog output is factory set to ±10.000V at rated torque; it may be re-scaled to any value between 1 and 10V. Overrange is 150% or 15V maximum for the analog output. The devices are linear in Overrange. Engineering Unit digital data is output via an RS232 port. The same port can be used for re-scaling, invoking Tare and other control functions. Himmelsteins' Model 703 instrument is compatible and will provide power, engineering unit torque display, capture max/mins, evaluate limits, provide RS422 and RS485 com ports and much more. When a speed sensor is available, the Model 723 will also display speed and computed shaft power.

A. Mechanical Installation *(See Appendix 4 for recommended attachment bolts and tightening torques)*

A.1 Reaction Torque Measurement Explained

Reaction torque measurements are based on Newton's third law of angular motion which states, "when a body exerts a torque upon another body, the second exerts an equal torque upon the first in the opposite direction and about the same axis of rotation". To avoid extraneous load errors (see Sections A3 & D3), the reaction torque path must be through the torquemeter only. A correctly installed reaction sensor will accurately measure static and dynamic torque whether the test device rotates or is stationary. Under certain conditions, some dynamic components will not be sensed; see following discussion.

Referring to ***Figure 1***, the test set-up can readily determine clutch applied torque and, when it slips, clutch peak or slip torque. ***Figure 2*** shows a hollow reaction torquemeter measuring the output torque of an air tool. The torquemeter will accurately measure the instantaneous tool output torque even though it rises rapidly (in milliseconds) as the fastener seats. *However, all the reaction torque must pass through the torquemeter* - a rotating union (or equal) must be used at the air supply end to eliminate shunting part of the reaction torque through the air lines and thus producing a measurement error. Although it is possible to satisfy this requirement (no significant unwanted shunt torque paths) in an air tool application, many other applications can have significant, unavoidable shunt torque paths which, in turn, will limit the measurement accuracy. An in-line torque measurement should be used in such cases. ***Figure 3*** shows a measurement similar to ***Figure 2*** but, *with a very important difference.* The torquemeter measures the reaction of the *power absorbing device* instead of the *power producing device*. Assuming no extraneous loads, the torquemeter sees the *total reaction torque of the absorber but, that torque is not necessarily equal to the motor output torque.*

During acceleration (or deceleration), the motor torque equals the sum of load inertia torques, total load windage torques, extraneous torques and the pumps' work load torque. The inertia torques are the product of angular acceleration and all rotor inertias except the motors. No reaction measurement can see, or measure, either the inertia or windage torques. As a result, in a

Figure 1. Measuring Clutch Slip Torque

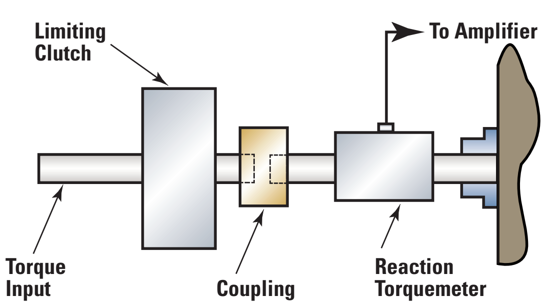

Figure 2. Air Tool torque Measurement

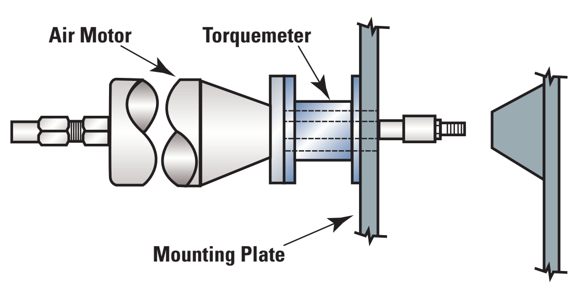

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Figure 3. Measuring Absorber Torque

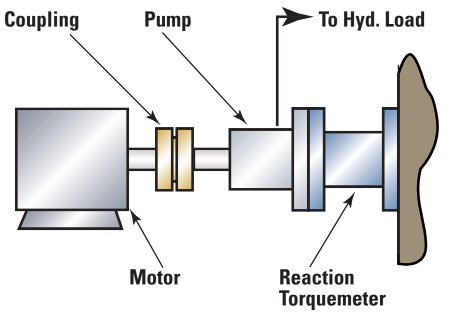


Figure 4. Reaction Torquemeter Senses Rotating Torque

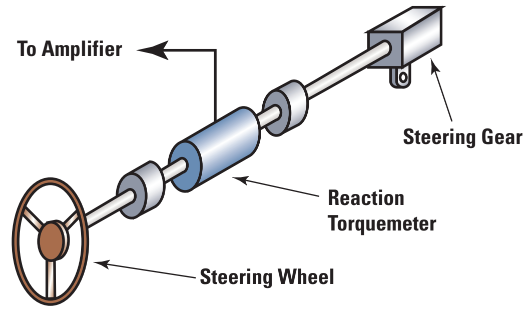


Figure 5. C-Face Torquemeter Measures Load Torque

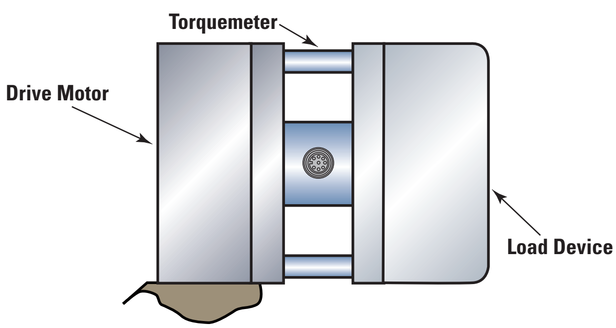


Figure 6. C-Face Torquemeter Measures Motor torque

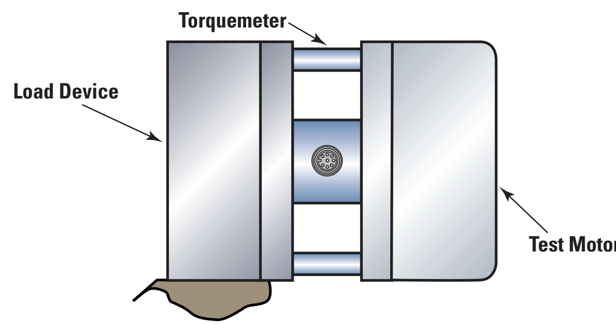


Figure 7. Extraneous Load Definition for Flanged Sensor

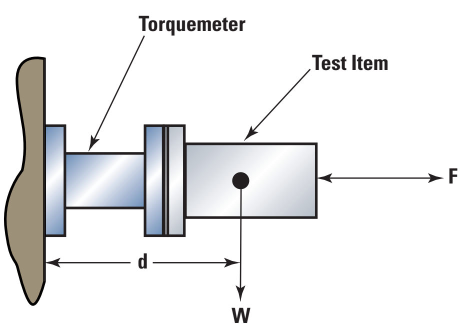
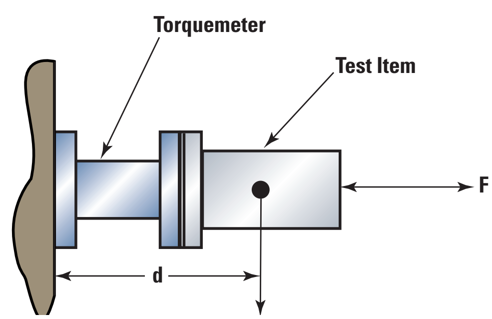


Figure 8. Extraneous Load Definition for Shaft Sensor



setup like this, reaction torque measurements will be in error to the extent they, and extraneous load torques, exist. The acceleration error component disappears during constant speed conditions but, the windage error and extraneous load components are always present. Only in-line torque measurements are immune to these error sources. When angular motion is limited and test cycle rates are low enough to permit "cable windup" without wire fatigue, reaction sensors are an economic torque measurement solution; see *Figure 4*.

A.2 Installation Discussion

To measure reaction torque, one end of the sensor must be mechanically grounded. The ground may be direct, as in *Figures 1, 2 and 3,* or, it can be through the Load or Driver as in *Figures 5 and 6.* As noted on those figures, the sensor is installed on the device whose torque is to be measured and the ground is made via the other device.

A.3 Extraneous Loads

Any force or moment sensor input, other than the reaction torque is an extraneous load. Depending on the installation, see *Figures 7 and 8*, these could include bending moments and axial thrust (tension or compression). The Bulletin describing your torquemeter lists the maximum safe extraneous loads that can be applied,

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assuming they act singly. Crosstalk errors from those loads are typically 1% to 2% and, assuming they are constant, can be electrically canceled.

W = weight of test item
F = thrust force, if any
d = distance to test item center of gravity
Wxd = bending moment

B. Electrical Installation

B.1 Signal Polarity

B.1.1 Definition of Torque Direction

A clockwise (CW) torque is defined as one that will cause shaft rotation in the CW direction *when viewed from the driven end*. A counterclockwise (CCW) torque will cause CCW shaft rotation *when viewed from the driven end.*

B.1.2 Output Signal Polarity (Applies to all Models)

With CCW torque applied to the torquemeter, the output signal is positive. When CW torque is applied to the torquemeter, the output signal is negative. This assignment can be changed using the furnished software.

B.2 Torquemeter Connections

Pin	Function
1	+ Calibration[1,6]
2	RXD
3	Analog Ground[5]
4	TXD
5	Analog Data Out 10.000V[2] at Rated Torque
6	Tare[3,4,6]
7	+ Power Input (10 to 26 VDC)
8	Power Return[5]

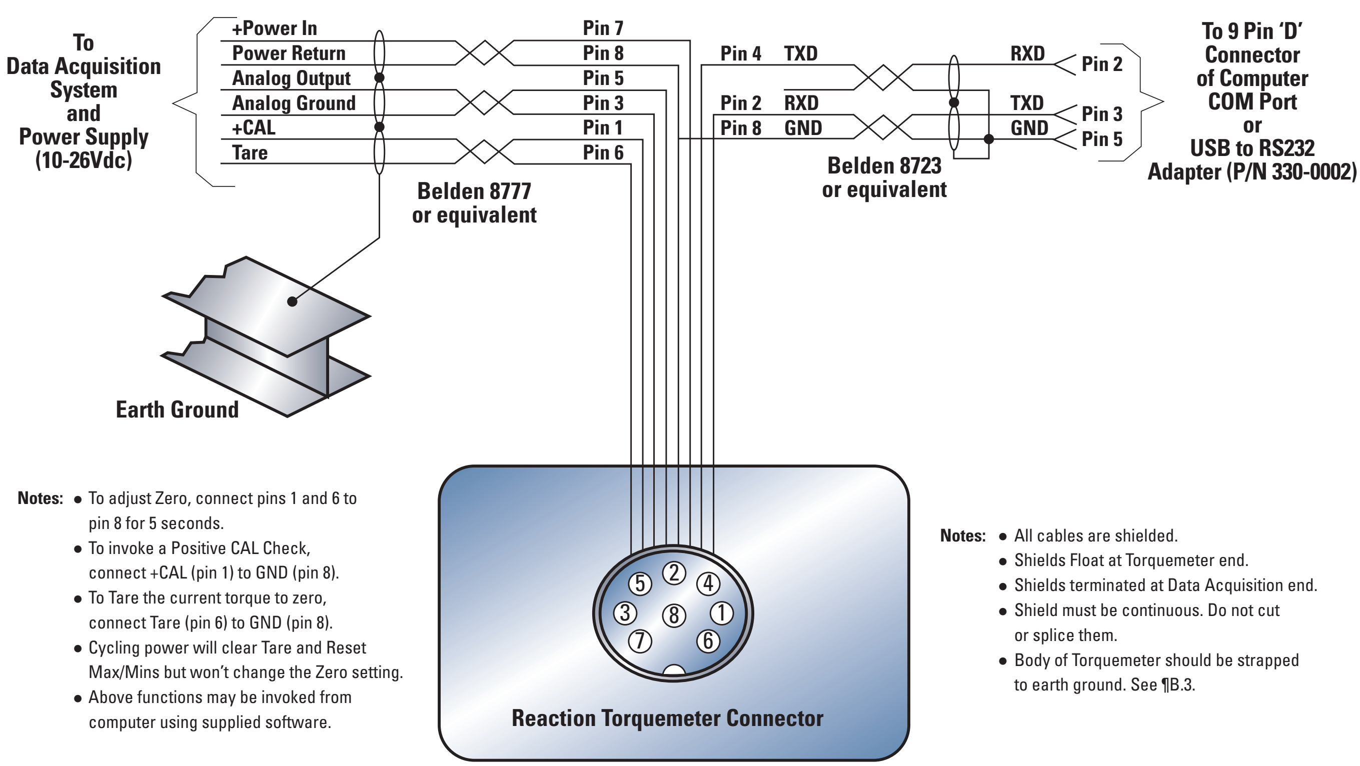
A mating connector with strain relief and boot is furnished. Use P/N 320-1306 to order additional connectors.

Notes

1. Invoke bi-directional cals via the com port with furnished software.
2. May be re-scaled via com port with furnished software to any value from 1 to 10V.
3. Clear Tare via com port with furnished software; see Note 8.
4. Tare and Clear Tare functions are also available via com port.
5. Don't use Pin 8 for analog data return and don't use Pin 3 for Power Return.
6. Zero torquemeter via com port with furnished software or, by simultaneously grounding pins 1 and 6.
7. Stored Maxima and Minima can be re-set with the furnished software.
8. Cycling Power off/on will Clear Tare and Reset Max/Mins but will not change the Zero Setting.

Figure 9 shows recommended cabling when connected to a PC and the users' Data Acquisition System.

Figure 9.Connections Showing Analog Output Driving Data Acquisition System and Digital Output Driving a PC



Notes:
- To adjust Zero, connect pins 1 and 6 to pin 8 for 5 seconds.
- To invoke a Positive CAL Check, connect +CAL (pin 1) to GND (pin 8).
- To Tare the current torque to zero, connect Tare (pin 6) to GND (pin 8).
- Cycling power will clear Tare and Reset Max/Mins but won't change the Zero setting.
- Above functions may be invoked from computer using supplied software.

Notes:
- All cables are shielded.
- Shields Float at Torquemeter end.
- Shields terminated at Data Acquisition end.
- Shield must be continuous. Do not cut or splice them.
- Body of Torquemeter should be strapped to earth ground. See ¶B.3.

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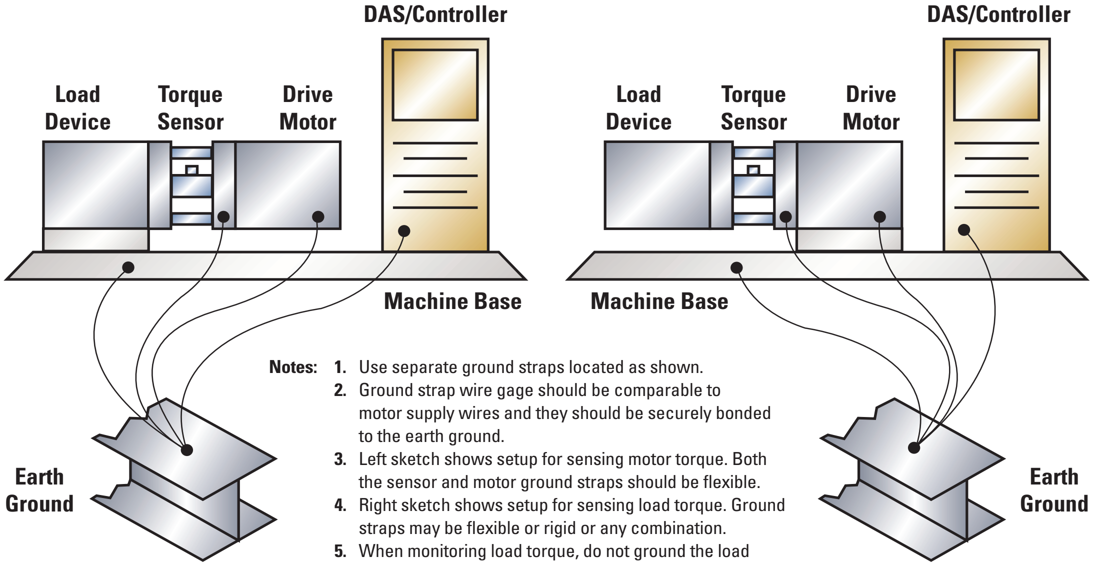
Figure 10. Correct System Earth Grounding



Notes:
1. Use separate ground straps located as shown.
2. Ground strap wire gage should be comparable to motor supply wires and they should be securely bonded to the earth ground.
3. Left sketch shows setup for sensing motor torque. Both the sensor and motor ground straps should be flexible.
4. Right sketch shows setup for sensing load torque. Ground straps may be flexible or rigid or any combination.
5. When monitoring load torque, do not ground the load device unless it produces electrical noise.
6. Locate the motor controller close to the drive motor.

B.3 Valid Earth Ground Connection

Connect the sensor body directly to earth ground - *a buildings' steel frame or a 6' copper rod driven into the floor.* Run separate grounds between it, the machine base, the sensor end closest to the drive motor, the data acquisition/computer/controller ground and the motor frame end farthest from the sensor body. See ***Figure 10*** for details. Do not ground both torquemeter ends.

The above directions are especially important when an electric drive is used. Grounding is normally not as critical when the drive is non-electric; i.e., is hydraulic or air.

B.4 Caution When Using Variable Frequency Drives

If an IGBT-based variable frequency drive (VFD) is used, follow its installation manual. Improperly installed VFD's can cause reading errors from excessive noise, and premature motor and cable failures. VFD's should have shielded power and motor cables. Belden Types 29500 thru 29507 cable are designed for VFD use. For a discussion of connection methods, see "Cable Alternatives or PWM AC Drive Applications" available at www.belden.com. Himmelstein recommends the connection shown in ***Figure 9*** *of that Belden document. For best results, use a differential input amplifier in these electrically noisy environments.*

B.5 Sensor DC Power Supply Caution

Don't connect the sensor to a power supply that also drives inductors, solenoids, motors, actuators or other inductive loads. Induced switching transients may cause damage or blow fuses. Some switching supplies create noise issues. Either use a quiet, low noise switcher or a linear power supply.

B.6 Cables

Shielded cables should be used to avoid noise pickup. The shields should float at the Torquemeter end and all should be terminated at a single earth ground.

Don't run transducer cables in close proximity to power lines.

Refer to the above cable diagrams which illustrate correct cable connections.

B.6.1 Available Mating Cables

Cable lengths (XX) are 20, 50 and 100 feet. RS232 cables are 50 feet maximum.

P/N 224-8636-XX Torquemeter to Model 703	Powers Torquemeter, displays Torque, outputs analog & digital signals, implements all Model 703 Functions.
P/N 224-8840-XX Torquemeter to RS232 + C/F DAQ	Connects Torquemeter digital output to PC implements all Torquemeter software addressable functions. Six unterminated lines for connection to customer furnished power/control/data acquisition system.
P/N 224-8841-XX Torquemeter to RS232 Port & Model 703	Connects Torquemeter digital output to PC, implements all Torquemeter software addressable functions. Powers Torquemeter, displays Torque, outputs analog & digital signals, implements all Model 703 functions.

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B.7 Calibration Function

These Torquemeters have a remotely initiated bi-polar calibration check. The Calibration Signal produced in response to a Cal Command is referenced to the factory dead weight torque calibration and, is NIST traceable. Thus, when invoked, it permits calibration of the users' data acquisition system, traceable to NIST. Furthermore, because it is bidirectional, it verifies operation of the data chain in both the CW and CCW directions. Bi-polar calibrations may be invoked from your PC using the supplied interface software. Alternately you can invoke a positive calibration as follows:

For Positive (CW) Calibration: ground Pin 1 to Pin 8. The calibration signal will remain on until the short is released.

A Calibration command should only be invoked while the driveline torque is at zero; if locked-in torque is present, break a shaft coupling to reduce it to zero. **Always remove the Cal Check command before running a test.**

Equivalent calibration values, in engineering units of measure, are listed on the Calibration Certificate which documents NIST traceability*. They can also be accessed using the furnished software. Calibration values are determined in S. Himmelstein and Company's accredited* (NVLAP Lab Code 200487-0) calibration laboratory. The user may perform a dead weight calibration and store the results in memory, using furnished software. The original cal data is archived. Before performing a field dead weight calibration please read and understand Paragraphs C.5 and C.6.

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

B.8 Clockwise (CW) and Counterclockwise (CCW) Definition

CW torque causes the shaft to turn CW when viewed from the driven end. CCW torque causes the opposite rotation. Himmelstein uses the following polarity definitions:

By default, CW Torque ***applied to the Torquemeter produces*** a positive output signal, CCW torque ***applied to the Torquemeter*** produces a negative output signal. The Torque signal polarity may be changed using the furnished software.

B.9 Tare Function

The Tare function is intended to cancel or "zero" a torque value that is not due to a permanent shift in the Torquemeter itself. For example, if you are interested in seeing the result of a gear shift you can Tare the running Torque before the shift and then see the resultant shift torque.

Caution: Unless you remove the Tare Value, by using the Clear Tare function (or cycling power off/on), subsequent readings will be in error due to the residual Tare. Tare values are deleted when power is turned off. The Tare and Clear Tare functions can be invoked from a remote PC with the software furnished. The Tare function can also be invoked by driving a control pin, as follows:

Invoke Tare by grounding Pin 6 to Pin 8. Then, remove the ground.

Please note, the Torque signal will be zeroed (or Tared) as long as the Tare command is invoked.

B.10 Torque Zeroing

The Zero function is intended to correct a minor long term drift or slight yield in the Torquemeter itself. ***TORQUE ZEROING SHOULD ONLY BE DONE WHEN THE DRIVELINE TORQUE IS ZERO.*** If locked-in torque is present, break a shaft coupling to remove it before attempting to Zero the Torquemeter. Should the Torquemeter Zero shift by more than 1% of the Torquemeter Full Scale Rating, return the Torquemeter to the factory for re-calibration and/or service, if indicated. Zero adjustments are retained during power off and automatically accessed when power is re-applied.

The Zero function can be accessed using the supplied software or, by **simultaneously grounding Pins 1 and 6 to Pin 8.**

B.11 Re-setting Max/Mins

Is accomplished via the supplied interface software or, by cycling power off/on. Max/Min values are only available on the digital output.

B.12 Digital Output

When connecting to a PC using the supplied interface software, the following torque data will be displayed along with the Engineering Unit of Measure selected (default is lbf-in)

- current data
- maximum torque since last re-set
- minimum torque since last re-set
- torque spread (maximum - minimum)

Additionally, a Torque vs Time plot will be displayed with user control of both axis.

B.13 Analog Output

The analog output appears between pins 5 and 3 and reflects current data only. Its' default value is 10.000V at Torquemeter full scale. It may be reset to a lower value. It is linear to 150% (Over-range) or 15V.

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C. Operating Controls and Adjustments

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, Filter Cutoff Frequency, etc.
- Display Measured 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, when shipped.

C.2 Change Sensor Setup

- Select any of 10 units of measure without re-calibration. Default unit is lbf-in. See Appendix II for a complete listing.
- Select any of 11 data filter cutoff frequencies from 0.2 to 500 Hz in 1-2-5 steps. The default is 10 Hz. The Bessel response filters have no delay distortion or overshoot.
- Adjust the value of the analog output voltage. These are factory set at 10.000V and should not be readjusted without accurate measuring equipment. To change/adjust the analog output, use an accurate meter to monitor it. Using the furnished software, increment it (up or down) to the desired value following the instructions on the screen.

Setup changes made using the PC Interface Software, do not require recalibration of the Transducer. Any change will automatically re-configure dependent parameters. For example, if the torque unit of measure is changed from *lbf-in to N-m*, the analog output will remain 10.000V at transducer full scale and the digital output will automatically read correctly in N-m.

C.3 Display Measured and Computed Data

- Displays Current, Max, Min and Spread Torque numeric data with Units of Measure
- Displays real time plots of Torque

C.4 Test Control

You can initiate the following actions from a PC :

- Invoke CW Cal Check
- Invoke CCW Cal Check
- Zero Torque
- Invoke Tare
- Clear Tare
- Reset Max/Mins
- Save Data to PC Storage
- Change Units of Measure
- Select another filter frequency

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 via PC or by pin strapping, 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.7.

In applications requiring high accuracy, perform *a dead weight calibration in a* ***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 accredited dead weight re-calibration service, traceable to NIST, for all its products and virtually any Torquemeter made by others. Its calibration laboratory is accredited (Laboratory Code 200487-0) by NVLAP and arm of the NIST. Accredited calibrations are available for torques from 10 ozf-in (0.071 N-m) thru 4,000,000 lbf-in (452 kN-m). For further information visit our website at www.himmelstein.com or, follow the accreditation link at www.nist.gov.

D. Operating and Safety Considerations

D.1 Applicability

This Section applies to Models 2270V, 2280V, 2286V, 2287V, CF2800V and 2300DV.

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D.2 Allowable Torque Loads

D.2.1 Overload Considerations

Himmelstein Reaction Senors have torque overload ratings between two (2) and five (5) times their full scale rating, model dependent. The overload rating of your sensor is listed on the cover sheet. The torque sensor will not yield (evidenced by a non-return to zero) if subjected to an *instantaneous peak torque* up to its overload value.

Full scale and overload ratings are based on the peak stress seen by the transducer. They are independent of stress duration except, for cyclical (or fatigue) loading. Virtually all rotary power producing and absorbing devices produce pulsating rather than smooth torque. Thus, in addition to its average torque value, the driveline torque usually includes a fundamental (driving) frequency and superimposed harmonics. Those torque perturbations can be multiplied when driveline resonance occurs. Additionally, in production and other real-world applications, accidental loads and other unforseen events can produce higher than expected torque levels. Please refer to Application Note 221101D for more information.

For these reasons, reserve the region between the peak instantaneous torque and the sensor overload rating as a safety margin for unexpected loads. Do not knowingly operate in the overload region. When torques are expected to reach or exceed the full scale rating, change to a higher capacity sensor or one with a higher overload rating.

D.2.2 Fatigue Considerations

The sensor has infinite fatigue life with full torque reversals equal to or less than half the overload rating. If instantaneous peak torques exceed 50% of the overload rating, fatigue failure can occur.

When operating with peak torques greater than half the overload rating, fatigue life is a function of several factors. They include the torque magnitude, the magnitude and type of extraneous loads simultaneously applied, the total number of loading cycles, the driveline damping, etc.

D.3 Allowable Extraneous Loads

Any force or moment the sensor sees, other than the reaction torque input, is an extraneous load. Depending on the installation, they can include bending moments and axial thrust; see ***Figures 7 and 8***. Rated Torque can be simultaneously applied with rated bending or thrust loads without damage, provided the extraneous loads are applied singly. Typical extraneous load crosstalk is 1 to 2%. Crosstalk signals can be electrically canceled. Refer to Section A.3.

D.3.1 Bending Loads

Allowable bending loads are model dependent. Most range from half rated torque to eight times rated torque. Please refer to Model Specifications for complete ratings.

D.3.2 Thrust Loads

Allowable thrust loads are model dependent. Most range, in lbf, from rated torque, in lbf-in, to twenty times rated torque. Please refer to Model Specifications for complete ratings.

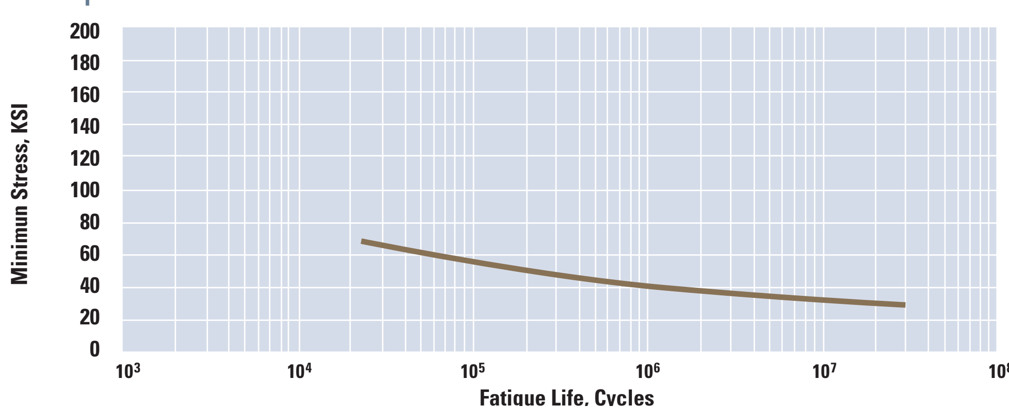
D.4 Contaminants

These devices should not be exposed to corrosive or electrically conductive fluids. They are not waterproof although they are water resistant. Pure water and hydrocarbon lubricants have no effect on operation. As a precaution, they should be shielded from direct liquid spraying.

D.5 Hazardous Environments

If used in a hazardous environment, the sensors must be connected via approved safety barriers. Safety barriers are sealed, passive networks installed in each wire that connects the hazardous and safe locations. They limit electrical energy passing between the two locations to a safe value.

Figure 11. Typical Fatique Life Characteristics



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APPENDIX I

TORQUEMETER SPECIFICATIONS

Detailed specifications for the applicable Torquemeters are contained in the following Bulletins which are attached to this document.

Model 2270V - see Bulletin 7721

Model 2280V - see Bulletin 7721

Models 2286V and 2287V - see Bulletin 7722

Model CF2800V - see Bulletin 7072

Model 2300DV - see Bulletin 775

APPENDIX II

SUPPORTED UNITS OF MEASURE

The following units of measure may be selected using the furnished software. The factory default is lbf-in. Should you select any other, the digital display will automatically report measured values in that unit of measure without the need to re-calibrate . The analog output will remain unchanged, i.e., 10.000V (factory default) full scale unless it has been re-set to another value, in which case, it will remain at that value.

lbf-in (default)	lbf-ft	ozf-in	ozf-ft	N-m
kN-m	N-cm	kgf-m	kgf-cm	gf-cm

APPENDIX III

RECOMMENDED ATTACHMENT BOLTS AND TIGHTENING TORQUES

In a correct installation, the torque load should be carried by face friction, not bolt shear. To accomplish that and avoid slippage, use high strength Socket Head Cap Screws/Bolts meeting ASTM A574 - 13. They should be tightened in accordance with the table below. Mating flanges must be clean, dry and, when mating to a steel transducer, **hardened to at least Rc 40.** Loctite (or equal) each fastener to prevent vibration induced loosening.

The specified tightening torques should be applied to the attachment bolts. Do not apply them through the Torquemeter.

Model	High Strength Socket Head Cap Bolt	Tightening Torque in lbf-ft		
		Cadmium Plated Bolts	Zinc Plated Bolts	Plain Bolts
2271V & 2281V	10 - 32	6.3	11	7.6
2272V & 2282V	1/4 - 20	13	23	16.6
2273V & 2283V	3/8 - 24	99	53	71
2274V & 2284V	7/16 - 20	84	158	113
2275V & 2285V	5/8 - 18	239	445	318
2286V	1 - 12	844	1,580	1,130
2287V	1 1/2 - 12	2,940	5,490	3,920
2856V	3/8 - 16	47	88	63
2882V	1/2 - 13	116	216	154
2884V	1/2 - 13	116	216	154
2302DV	1/4 - 20	13	23	16.6
2304DV	7/16 - 14	75	140	100
2307DV	3/4 - 10	375	700	500

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APPENDIX IV

SERIAL COMMUNICATIONS FOR THE NEXT GENERATION RTM

This specification of the serial communications for the NGRTM is subject to change at any time without notice.

Communication Port Settings

- 8 data bits
- No parity
- No hardware / handshaking
- 1 start bit
- 1 stop bit
- 38400 baud

General conventions used in this document

- OK stands for the string "OK"
- index is an alphanumeric character (A-Z or 0-9)
- CR is a carriage return (^M / 13 decimal / 0D hexadecimal / 15 octal)
- LF is a line feed (^J / 10 decimal / 0A hexadecimal / 12 octal)
- int is an integer number string (e.g. "1234")
- long is a long integer number string (e.g. "1234567")
- string is a string (e.g. "LB-IN")
- hexNUM is a hexadecimal *string* that is NUM characters long (e.g. hex4 could be "8FC4")

General information

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

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

- "string" where string is the data requested.
- "OK" operation was successful
- Some error message starting with a "!" character. Some common error messages include:
  - "!BadArg" command has a bad argement
  - "!BadIndex" The given index is out of range for the given command.
  - "!PasswordProtected" The parameter is password protected from change.
  - "!Unknown" an unknown error occurred.
  - "!xx" Command "xx" is unrecognized

EXAMPLES

- **Retrieve data:**
  Send "d" to the NGRTM. The return message should look something like "1234".
- **Retrieve the filter:**
  Send "CG" to the NGRTM. The return message should be something like "7" which implies (referring to the appropriate list under the "CG" message) that torque has a filter of 10 Hz.
- **Set the filter to 100 Hz:**
  Refer to the list under the "CG" (filter) command to find that a 100 Hz filter corresponds to the value 4. Therefore, send "CG4" to the NGRTM. The NGRTM should respond with "OK" if the operation was successful.
- **Apply the positive shunt calibration signal:**
  Send "ASB" to the NGRTM. To remove this signal send "ASA".

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INFORMATIONAL ONLY MESSAGES

- These messages can only retrieve information from the NGRTM -- they can not change any data on the NGRTM.

Message	Reply	Meaning
VR	long	Return the firmware version. – The version number is returned
TP	long	Return the current rotor temperature. – To convert to Celsius: 5.48815E - 8* "TP" - 8.93
d	int	Return the current 16-bit lbf-in data. – Positive scaling constant: (Full Scale ("CK:) * 104.8576)/Positive Gain ("CD") – Negative scaling constant: (Full Scale ("CK") * 104.8576)/Positive Gain ("CE")
x	hex16	Return the current 16-bit lbf-in data in hexadecimal. – See "d" command
c	long	Return the curent 32-bit lbf-in data. – Positive scaling constant: (Full Scale ("CK") * 0.0064)/Positive Gain ("CD") – Negative scaling constant:(Full Scale ("CK") * 0.0064)/Positive Gain ("CE")
MXO	OK	Reset the Max-Min of Torque
MXX	long	Return the Maximum torque. See "c" message for scaling to lbf-in.
MXN	long	Return the Minimum torque. See "c" message for scaling to lbf-in.

SHUNT MESSAGES

Message	Reply	Meaning
ASindex	OK	Apply Shunt. This equals full scale of the torquemeter. • index: – A: Remove applied Shunt signal – B: Apply positive Shunt signal – C: Apply negative Shunt signal
AS	int	Get Current Shunt status. • int: – 0: No Shunt applied – 1: Positive Shunt applied – 2: Negative Shunt applied

CONFIGURATION MESSAGES

Message	Reply	Meaning
Cindex	long	Return configuration information. – index • A: Calzero offset (A/D units) • B: Positive Gain • C: Negative Gain • D: Positive DAC Gain • E: Negative DAC Gain • F: DAC Zero • G: Filter – 00: 8000 Hz – 01: 500 Hz – 02: 200 Hz – 03: 100 Hz – 04: 50 Hz – 05: 20 Hz – 06: 10Hz – 07: 5Hz – 08: 2 Hz – 09: 1 Hz – 10: 0.5 Hz – 11: 0.2 Hz • H: Temperature during zero calibration (to get temperature in Celsius: 5.48815E-8*"CH"-8.92857) • I: Zero Temperature Compensation • J: Span Temperature Compensation • K: Full Scale (lbf-in) • L: +Shunt Value • M -Shunt Value • N: Minimum Allowed A/D count • O: Maximum allowed A/D count • P: Serial Number • Q: Shaft Number • R: Model Number (String) • S: Customer Name (String)

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