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## I. Introduction

CF2700 Series Reaction Sensors provide static and dynamic torque feedback from a motor or, its load. The device whose torque is being sensed must have a NEMA C-Face mounting or, a suitable adapter.

CF2700's are strain gage sensors. They measure torque whether the shaft is rotating or stationary. They have high safety margins, are very stiff, have low deflection and are bidirectional, i.e., their output polarity follows the torque direction.

Two versions are offered. The CF2700V Series outputs a zero to  $\pm 10$  Volt analog of torque. The CF2700X version is a 2-wire Torque Transmitter. It outputs a 4-20mA or  $12 \pm 8$  mA current, user selectable. Power input for both versions is a single, unregulated, fused and reverse polarity protected dc supply. If needed, Himmelsteins' Series 700 instruments provide power, engineering unit torque display, display speed and computed shaft power, capture max/mins, have limits, interface a PC and much more.

Both torque meters and transmitters are available in two performance grades; Code N specifies standard performance and Code C enhanced performance. Optional coupling shafts are offered to connect *C-Face motor and load shafts*. When coupling shafts are furnished, we can also supply an optional zero velocity speed pickup.

## A. Mechanical Installation

### A.1 Applicability

This discussion is applicable to both CF2700V Torquemeters and CF2700X Torque Transmitters.

### A.2 Driveline Location

Because they measure reaction torque, the torque path must be through the sensor only. Avoid parasitic torque shunts; they can cause measurement errors.

The sketches illustrate sensor mechanical installation. *Install it on the device whose torque is to be sensed, and foot mount or ground the other device. For best results, orient the connector vertically.*

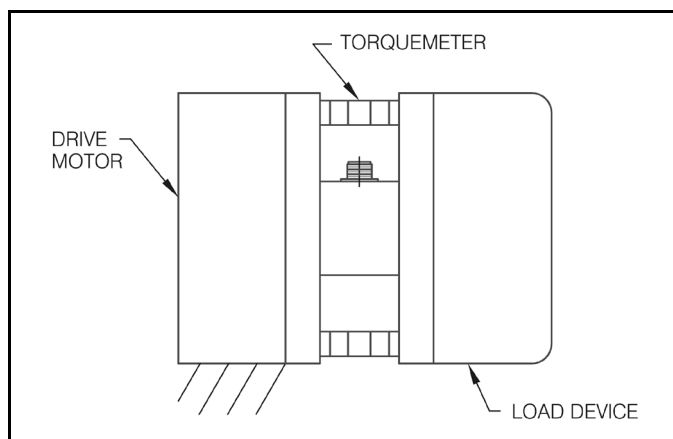


Figure 1. CF2700 Sensor Installed To Measure Load Torque

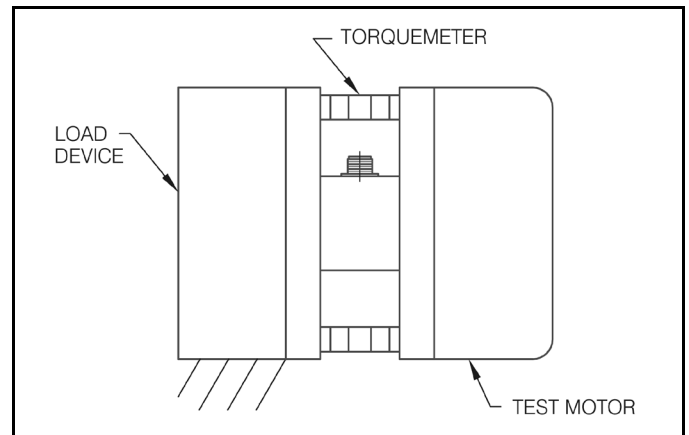


Figure 2. CF2700 Sensor Installed To Measure Motor Torque

### A.3. Shaft Couplings for NEMA C-Face Motor to C-Face Load

The male motor shaft mates with the female load shaft and a key carries the torque. Since the CF2700 Sensor separates the load and motor, a coupling shaft must be used to connect them. Himmelstein offers such shafts suitable for motor speeds of 3,000 rpm maximum. They are illustrated below.

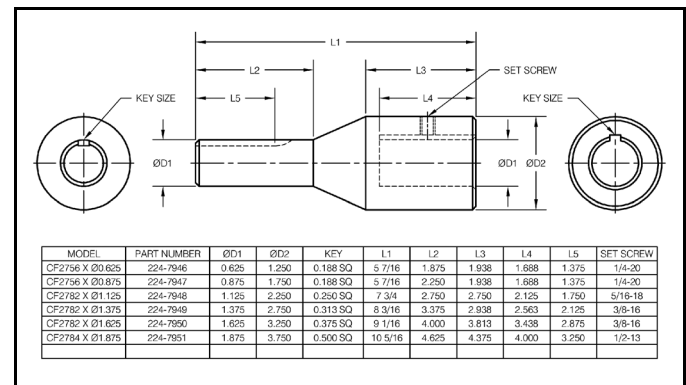


Figure 3. Coupling Shafts for NEMA C-Face To C-Face Installations

### CAUTION!

This torque meter must be mounted to a face flat to within 0.002" (0.05mm) TIR (Total Indicated Runout). Failure to observe this requirement may irreparably damage the Torquemeter and will degrade performance.

### A.3.1 Optional Speed Pickup

The optional Zero Velocity Speed Pickup screws into the sensor body and is held in place by a jam nut. It is installed after the coupling shaft, drive motor and load are in place. When the speed pickup option is ordered, the coupling shaft comes with a permanently installed 60 tooth gear. The arrangement produces constant amplitude 60 pulses per revolution. To install the pickup proceed as follows:

- with the shaft stationary, thread the pickup into the sensor body until it makes contact with the coupling.
- back off the pickup a quarter of a turn.
- tighten the jam nut.
- slowly rotate the shaft to verify there is no rub. If a rub occurs, re-adjust the pickup.
- tighten the jam nut.

### A.4 Shaft Coupling For Non-NEMA C-Face Load

When the load shaft is male, use a conventional double-flex coupling between the driver and load. It will remove residual parallel and angular shaft misalignments. The sensor design provides sufficient clearance for commercially available couplings as well as access for needed tools.

## B. Electrical Installation

### B.1 CF2700V Torquemeters

#### B.1.1 CF2700V Torquemeters Connections

Pin	Function
A	+Power Input (15 to 26 VDC)
B	Power Return (Don't use for Signal Return)
C	No Connection
D	Signal Common (Don't Use for Power Return)
E	Signal Out (0±10V Analog of Torque)
F	Remote Cal (Short to Pin D to Enable Cal)

A mating connector with strain relief and boot is furnished. Figure 4 illustrates the proper torquemeter cabling. Please refer to Section B.3 for a discussion of *valid earth grounds* and to Section B.4 for a discussion of use with *IGBT-based Variable Frequency Drives (VFD's)*.

### B.2 CF2700X 2-Wire Torque Transmitters

#### B.2.1 CF2700X 2-Wire Torque Transmitter Connections

Pin	Function
A	+ Power Input
B	Power Return

A mating connector with strain relief and boot is furnished. Figure 5 illustrates the proper 2-wire transmitter cabling.

#### B.2.2 Allowable Loop Resistance

The Torque Transmitter is specified for use with a loop resistance between zero and 700 Ohm, dependent on loop drive voltage. The allowable resistance may be calculated from the following equation:

$$R_{loop,max} = [50] * [Loop Supply Voltage] - 600 \quad (\text{Ohms})$$

Total loop resistance must not exceed 700 Ohms with a 26 Volt loop supply or, the value calculated from this equation for lesser loop voltages.

### B.3 Valid Earth Ground Connection

**Connect the CF2700 sensor body directly to earth ground – a buildings' structural steel or a six foot copper rod driven into the floor. Then run separate ground straps between it, the machine base, the CF2700 flange closest to the motor, the data acquisition/computer system/controller ground and the motor frame end farthest from the sensor body. See Figures 6 and 7 for details. A CF2700 has provision to connect a ground strap at the appropriate end; don't ground both ends.**

### 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 cables are designed for VFD use. For a discussion of connection methods, see "Cable Alternatives for PWM AC Drive Applications" available at [www.belden.com](http://www.belden.com). Himmelstein recommends the connection shown in Figure 20. For best results, use a differential input amplifier in these electrically noisy environments.**

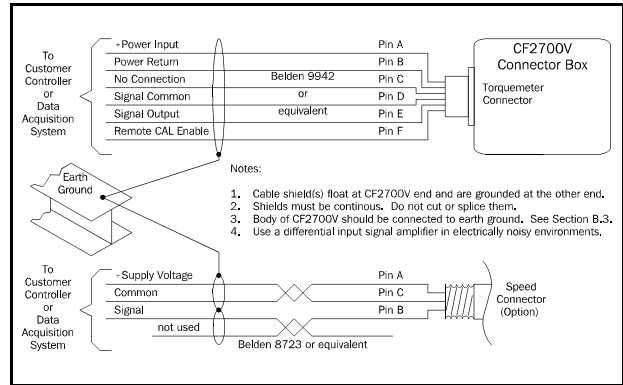


Figure 4. CF2700V Torquemeter Cabling

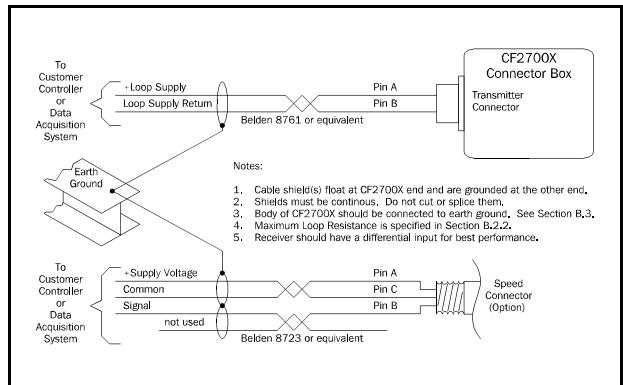


Figure 5. CF2700X 2-Wire Torque Transmitter Cabling

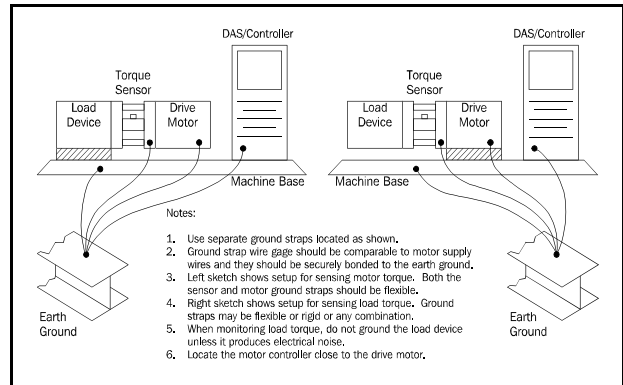


Figure 6. Correct System Earth Grounding

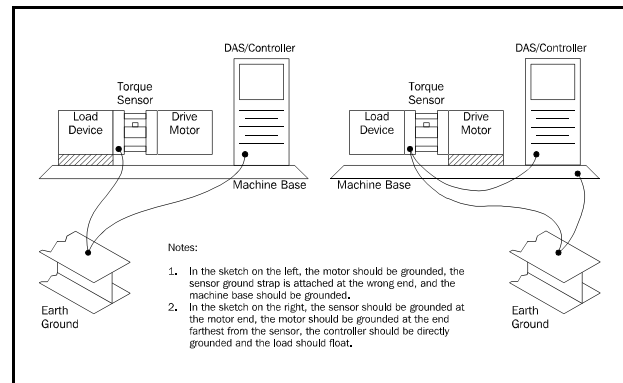


Figure 7. Examples of Incorrect Earth Grounding

### B.5 Optional Zero Velocity Speed Pickup

This Section applies to both the CF2700V Torquemeter and the CF2700X 2-Wire Torque Transmitter. The table below defines the connector pinout.

Pin	Function
A	+ Supply (8 to 26 VDC)
B	Signal (60 PPR @ ~ Supply Voltage)
C	Common

Figures 4 and 5 show cabling diagrams for the speed pickup. Shielded, stranded three conductor cable should be used; Belden Type 8735 or equal. The instrument end should be terminated per instructions contained in the makers manual. When supplied with a Himmelstein Model 723 Torque/Speed/HP Instrument and cables, the cables are terminated at both ends.

### B.6 CF2700 Sensor DC Power Supply Caution

*Don't connect either sensor type to a power supply that also drives inductors or solenoids. Induced switching transients may cause damage or blow fuses.*

## C. Operating Controls and Adjustments

### C.1 Standard Output Signals

CF2700 Sensors are factory calibrated to provide the following outputs.

Driveline Torque	Output Signal	
	CF2700V	CF2700X
Zero	0.00 Volts	4.00mA or 12.00 mA <sup>1</sup>
CW <sup>2</sup> Full Scale	-10.00 Volts	20.00 mA <sup>3</sup>
CCW <sup>2</sup> Full Scale	+10.00 Volts	20.00 mA <sup>3</sup>

1. User switch selectable.
2. Torque direction is through the sensor.
3. User can select increasing or decreasing current in the bidirectional (8±12mA) mode; see Section C.3.1.

The following Sections describe field adjustments.

### C.2 CF2700V Torquemeters

#### C.2.1 Remote Calibration Feature

The sensor was dead weight calibrated in Himmelsteins' accredited calibration laboratory (see Section C.4 for details). A Calibration Certificate documenting NIST traceability is attached. That Certificate includes the Internal Calibration Torque Value determined during calibration and the output voltage it produces.

When Remote Calibration is enabled, by shorting connector Pin F to Pin D, the torquemeter will output the Calibration Torque and Output Voltage listed on the Calibration Certificate. Please note, this procedure should be done with zero torque on the driveline. If calibration is done when the driveline torque is not zero, then the calibration signal will add algebraically with the driveline torque.

**Caution:** If you install a Calibration Enable switch, use a momentary type. That will avoid inadvertent injection of the calibration signal and possible measurement errors.

### C.2.2 Zero and Span Adjustment

*These adjustments must be made with zero torque on the driveline.* To achieve zero torque in installations that can "lock-in" friction torques (between gear drives, on a pump drive or other sealed shafts, etc.), break or disconnect one of the shaft couplings. All user controls are located in the torque connector housing; refer to Figure 8. Proceed as follows:

1. Unscrew and remove the Span/Zero Pot cover plate.
2. Adjust the *zero control* for zero torque output, i.e., 0.00 Volts.
3. *Activate and hold the cal enable*, then adjust the span control for the calibration torque voltage listed on the attached Calibration Certificate.
4. Release the *cal enable* and verify the output is 0.00 Volts. If necessary, re-adjust the *zero control*. Then, repeat steps 2 and 3 until the output is 0.00 Volts when the torque is zero, and the calibration torque output matches the value listed on the Calibration Certificate.
5. Replace the Span/Zero Pot cover plate.

The torquemeter is now calibrated, its output will be 10.00 Volts when full scale torque is applied and 0.00 Volts at zero torque. For other torques, the output will vary linearly, i.e., at half scale it will be 5.00 Volts, at 20% of scale it will be 2.00 Volts, etc.

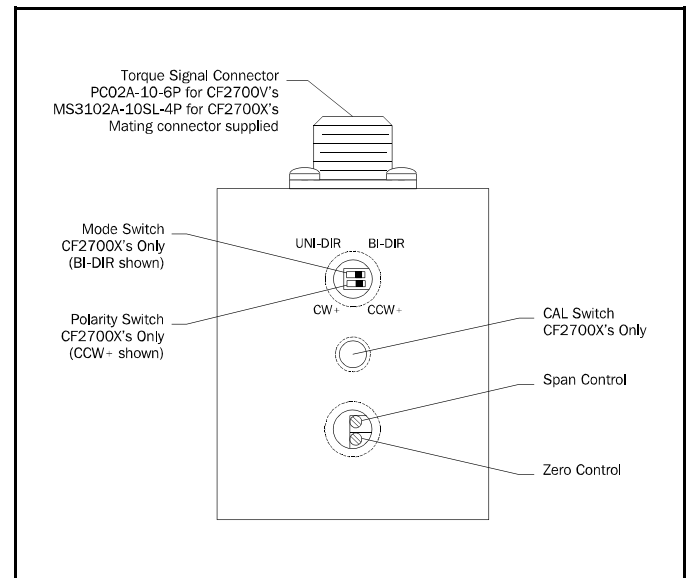


Figure 8. CF2700 Sensor Control Locations

### C.3 CF2700X 2-Wire Torque Transmitters

#### C.3.1 Operating Mode and Polarity Selection

Torque Transmitters have two modes; unidirectional (4-20mA loop current) and bidirectional (8±12mA loop current). Figure 9 illustrates mode and polarity choices. Mode and Polarity are selected by switches inside the connector housing; see Figure 8. Remove the threaded cover to access the switches and replace it after making selections. Torque Transmitters are shipped in the CW, bidirectional mode. That mode permits measurement of bidirectional and/or reversing shaft systems. You may also use it to experimentally determine the torque direction. Then, after it is known, the transmitter mode may be changed as needed. Zero and Span should be re-adjusted after a mode change; see Section C.2.2.

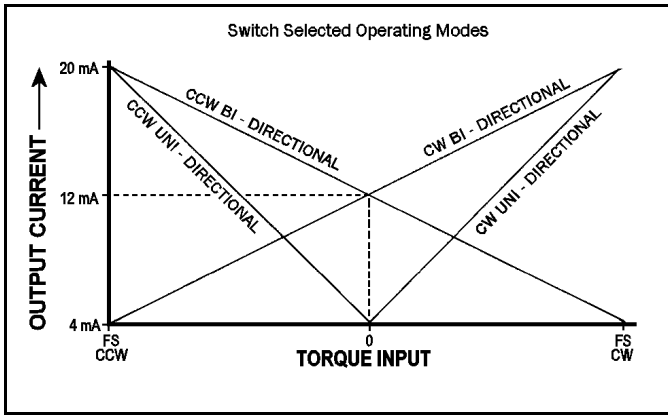


Figure 9. CF2700X Torque Transmitter Operating Modes

### C.3.2 Internal Calibration Feature

The sensor was dead weight calibrated in Himmelsteins' accredited calibration laboratory (see Section C.4 for details). A Calibration Certificate documenting NIST traceability is attached. That Certificate includes the Internal Calibration Torque Value determined during calibration and the loop current it produces.

Internal Calibration is enabled by pressing and holding the Cal Switch located in the connector housing; see Figure 8. While the switch is operated, the transmitter will output the Calibration Torque as the listed Loop Current. Please note, this procedure should be done with zero torque on the driveline. If calibration is done when the driveline torque is not zero, then the calibration signal will add algebraically with the driveline torque.

### C.3.3 Zero and Span Adjustment

*These adjustments must be made with zero torque on the driveline.* To achieve zero torque in installations that can "lock-in" friction torques (between gear drives, on a pump drive or other sealed shafts, etc.), break or disconnect one of the shaft couplings. All user controls are located in the connector housing, refer to Figure 8. Proceed as follows:

1. Unscrew and remove the Span/Zero Pot cover plate.
2. Select the desired Operating Mode and Polarity per Section C.3.1 above.
3. Adjust the zero control for zero torque output, i.e., loop current is 4mA if in the unidirectional mode or, 12mA if in the bidirectional mode.
4. *Depress and hold the cal switch*, then adjust the span control for the calibration torque loop current listed on the attached Calibration Certificate.
5. Release the *cal switch* and verify the output is 4 or 12 mA. If necessary, re-adjust the *zero control*. Then, repeat steps 3 and 4 until the loop current is correct when the torque is zero, and the calibration torque loop current matches the value listed on the Calibration Certificate.
6. Replace the covers for the Mode/Polarity Switches, Cal Switch and the Span/Zero Pots.

The torque transmitter is now calibrated. Its loop current will be 20.00 mA when full scale torque is applied and either 4.00 or 12.00 mA at zero torque. For other torques, the loop

current will vary linearly. Thus, when operating in the unidirectional mode, half scale torque results in a 12.00 mA loop current, 25% of full scale torque produces an 8.00 mA loop current, etc. See Figure 9 for more information.

### C.4 Factory NIST Traceable Dead Weight Calibration

All sensors are dead weight calibrated in our calibration laboratory. Calibrations are bidirectional with ten steps in the clockwise and ten steps in the counterclockwise directions. Data is reported in the attached Calibration Certificate which includes measurement uncertainty values as well as traceability evidence. During calibration, the torque equivalent of the internal calibration network is determined and documented on the Certificate.

Unless you have accurate, accredited calibration facilities, do not substitute a field calibration for the factory calibration. Rather, use a field calibration as a rough check on normal operation and rely on the factory calibration for accurate results.

#### C.4.1 Calibration Laboratory Accreditation

Himmelsteins' Calibration Laboratory is accredited by NVLAP an arm of the NIST (Lab Code 200487-0). To obtain more information on the accreditation, visit our website at [www.himmelstein.com](http://www.himmelstein.com) or follow the accreditation link at [www.nist.gov](http://www.nist.gov).

#### C.4.2 Calibration Intervals

For continuous or intermittent service, make periodic Calibration Checks using the on board calibration networks described in Sections C.2.1 or Section C.3.2, whichever is applicable to your sensor.

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

If your CF2700 Sensor 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 by NVLAP; see Section C.4.1.

### D. Operating and Safety Considerations

#### D.1 Applicability

This Section is applicable to both CF2700V Torquemeters and CF2700X Torque Transmitters.

#### D.2 Allowable Torque Loads

##### D.2.1 Overload Considerations

CF2700 Sensors have torque overload ratings equal to five (5) times their full scale rating with two exceptions. The 5,000 lbf-in Models CF2756\_\_(5-3) have a 20,000 lbf-in overload rating (four times full scale) and the 20,000 lbf-in Models CF2784\_\_(2-4) which have a 60,000 lbf-in overload rating (three times full scale). A Himmelstein 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 unforeseen events can produce higher than expected torque levels.

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 sensor with a higher rating.

#### D.2.2 Fatigue Considerations

CF2700 Sensors can handle full torque reversals whose instantaneous magnitude is equal to or less than half the overload rating. Under those conditions, fatigue life is infinite. When peak torques exceed 50% of the overload rating, then fatigue failure can occur.

When operating with peak torques greater than 50% of the overload, 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.

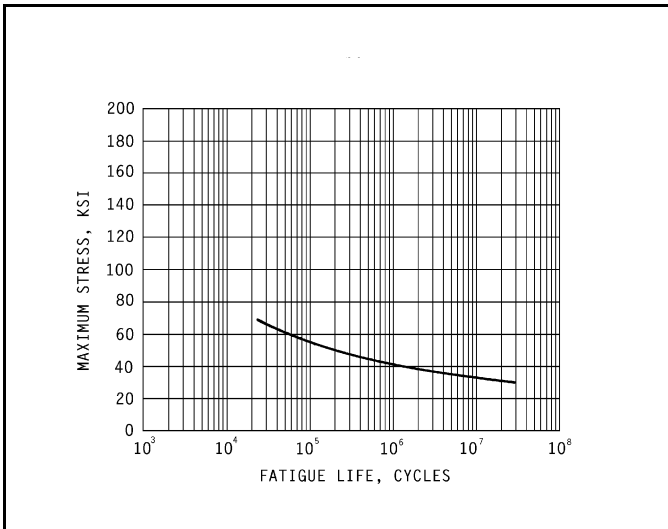


Figure 10. Typical Fatigue Life Characteristics

#### 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 Figure 11. Rated Torque, Bending and Thrust Loads can be simultaneously applied without damage. When a CF2700 is correctly oriented (connector vertical), typical extraneous load crosstalk is 2% for standard performance units and 1% for enhanced accuracy units. Crosstalk signals can be electrically canceled. Referring to Figure 11, the following definitions apply:

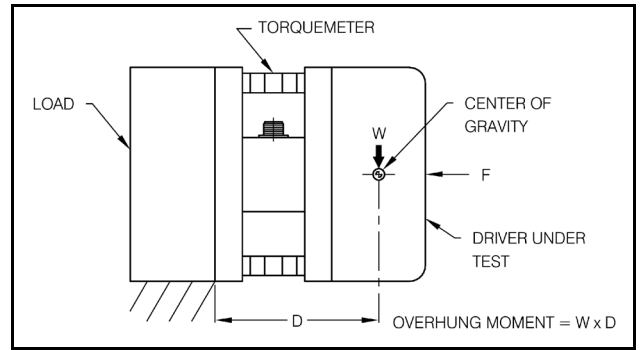


Figure 11. Sensor With Extraneous Loads Applied

W = weight of the supported motor or load plus half the weight of the shaft coupling

F = thrust force

D = distance from the center of gravity of the device being monitored to the grounded sensor flange.

#### D.3.1 Bending Loads

Allowable bending loads are model dependent. They range from a minimum of twice rated torque to eight times rated torque. Please refer to Appendix 1 for complete ratings.

#### D.3.2 Thrust Loads

Allowable thrust loads are model dependent. They range, in lbf, from a minimum equal to rated torque, in lbf-in, to eight times rated torque. Please refer to Appendix 1 for a complete listing.

#### D.4 Contaminants

These devices should not be exposed to corrosive fluids. They are not waterproof although they are water resistant. Clean 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.

Appendix I

Specification for CF2700 NEMA C-Face Hollow Torquemeters & 2-Wire Transmitters

Torque Ranges and Mechanical Specifications

MODEL No. <sup>1</sup>	NEMA Motor Frame	TORQUE RANGE		ALLOWABLE TORQUE OVERLOAD		TORSIONAL STIFFNESS (from face-to-face)		MAX TORSIONAL DEFLECTION (degrees)	WEIGHT (lbs)	MAXIMUM EXTRANEOUS LOAD		
		(lbf-in)	(n-m)	(lbf-in)	(n-m)	(lbf-in/rad)	(n-m/rad)			THRUST (F) (lbf)	BENDING (W x D) (lbf-in)	
CF2756_(5-1)	56C 143TC 145TC	50	5.65	250	28.2	48,000	5,420	0.060	5.5	200	400	
CF2756_(1-2)		100	11.3	500	56.5	135,000	15,250	0.042	5.5	250	600	
CF2756_(2-2)		200	22.6	1,000	113	385,000	43,500	0.030	5.5	300	800	
CF2756_(5-2)		500	56.5	2,500	282	560,000	63,300	0.051	14	500	1,500	
CF2756_(1-3)		1,000	113	5,000	565	1,600,000	181,000	0.036	14	1,000	2,000	
CF2756_(2-3)		2,000	226	10,000	1,130	4,550,000	514,000	0.025	14	2,000	4,000	
CF2756_(5-3)		5,000	565	20,000	2,260	18,000,000	2,034,000	0.016	14	5,000	10,000	
CF2782_(2-2)		182TC 184TC 213TC 215TC 254TC 256TC	200	22.6	1,000	113	250,000	28,300	0.046	11	350	1,500
CF2782_(5-2)			500	51.5	2,500	282	950,000	107,300	0.030	11	500	2,000
CF2782_(1-3)			1,000	113	5,000	565	2,800,000	316,300	0.020	11	1,000	3,000
CF2782_(2-3)	2,000		226	10,000	1,130	3,800,000	429,400	0.030	27	2,000	4,000	
CF2782_(5-3)	5,000		565	25,000	2,820	15,000,000	1,700,000	0.019	27	5,000	10,000	
CF2782_(1-4)	10,000		1,130	50,000	5,650	44,000,000	5,000,000	0.026	27	10,000	20,000	
CF2784_(2-3)	284TC	2,000	226	10,000	1,130	7,200,000	813,500	0.016	17	2,000	5,000	
CF2784_(5-3)		5,000	565	25,000	2,820	14,500,000	1,640,000	0.020	44	5,000	10,000	
CF2784_(1-4)		10,000	1,130	50,000	5,650	42,000,000	4,750,000	0.014	44	10,000	20,000	
CF2784_(2-4)		20,000	2,260	60,000	6,780	119,000,000	13,450,000	0.010	44	20,000	40,000	

Notes: 1. Replace the first underscore with an X for the Transmitter version or a V for the Torquemeter Version. Replace the second underscore with the performance code, either N or C. Thus, the Model Number for a 100 lbf-in 56C Frame Torquemeter with standard performance is CF2756VN(1-2); the 2-Wire Transmitter version is the CF2756XN(1-2).



Appendix I Continued  
 NEMA C-Face Hollow Torquemeters and 2-Wire Torque Transmitters  
 Output and Electrical Specifications

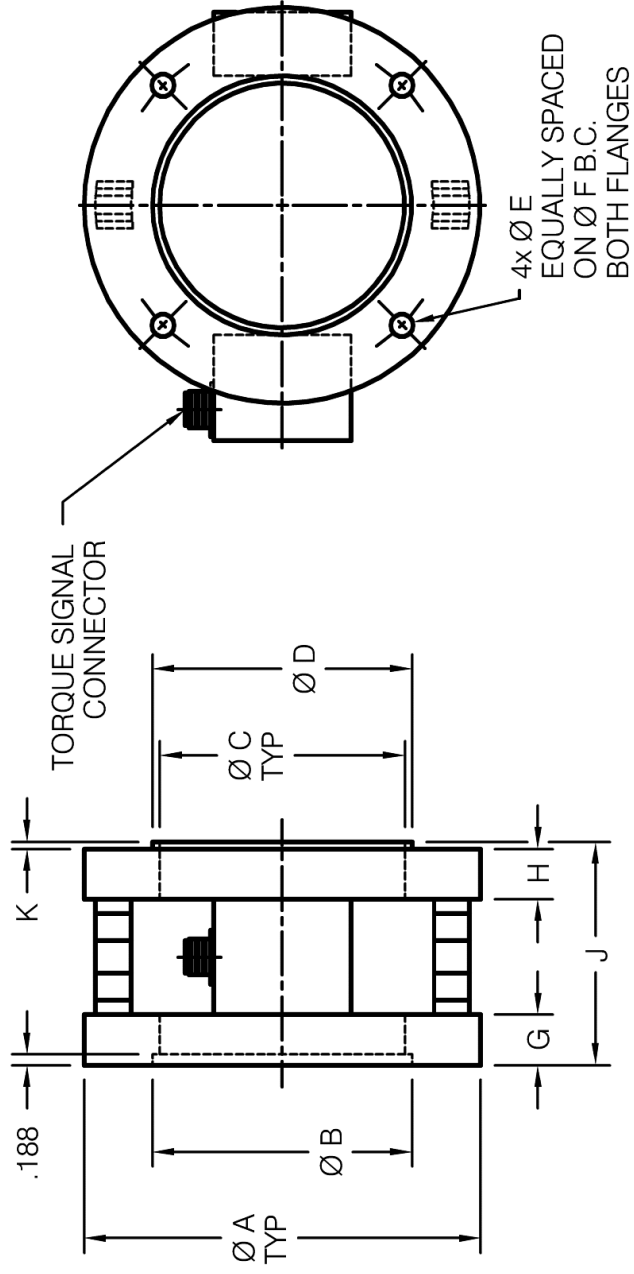
Parameter	Series CF2700V Torquemeters		Series CF2700X 2-Wire Transmitters	
	Performance		Performance	
	Standard Code N	Enhanced Code C	Standard Code N	Enhanced Code C
Nonlinearity (end point method, % of Range)	≤ ± 0.2	≤ ± 0.1	≤ ± 0.25	≤ ± 0.1
Hysteresis (% of Range)	≤ ± 0.2	≤ ± 0.1	≤ ± 0.25	≤ ± 0.1
Nonrepeatability (% of Range)	≤ ± 0.1	≤ ± 0.05	≤ ± 0.1	≤ ± 0.05
Combined Error (Nonlinearity, hysteresis and nonrepeatability, % of Range)	≤ ± 0.25	≤ ± 0.1	≤ ± 0.3	≤ ± 0.1
Typical Thrust Crosstalk <sup>1</sup> (lbf-in)	± 2% of Thrust in lbs	± 1% of Thrust in lbf	± 2% of Thrust in lbs	± 1% of Thrust in lbf
Typical Bending Crosstalk <sup>1</sup> (lbf-in)	± 2% of Bending in lbf-in	± 1% of Bending in lbf-in	± 2% of Bending in lbf-in	± 1% of Bending in lbf-in
Calibration Error (% of Range at 75 deg. F, NIST traceable)	≤ ± 0.1	≤ ± 0.05	≤ ± 0.1	≤ ± 0.05
Calibration Circuit Actuation	Remote, connect Cal line to Common.		By internal Cal Switch	
Temperature Effect On Zero (% of Range per deg. F)	≤ ± .006	≤ ± 0.002	≤ ± 0.006	≤ ± 0.002
Temperature Effect On Span (% of Reading per deg. F)	≤ ± 0.006	≤ ± 0.002	≤ ± 0.006	≤ ± 0.002
Compensated Temperature Range (deg. F.)	+75 to +175 deg. F (+23.9 to +79.4 deg. C)			
Useable Temperature Range (deg. F)	-25 to +185 deg. F (-31.7 to +85 deg. C)			
Storage Temperature Range (deg. F.)	-65 to +200 deg. F (-53.9 to +93.3 deg. C)			
Output Signal	0 to ±10 Volts (Load Resistance => 10kΩ Source Resistance < 1Ω)		4-20mA or 12±8mA, user selectable. See Note 2 for maximum Loop Resistance.	
Output Signal Polarity (for CCW torque through the torquemeter, polarity changes when torque is CW)	Positive		Internal switch sets output current to increase or decrease.	
Measurement Bandwidth <sup>3</sup>	dc to 1000 Hertz			
Supply Voltage <sup>4</sup> (fused and reverse polarity protected)	15 to 26 Volts, dc, unregulated			
Supply Current <sup>4</sup>	80mA, max		20mA, max	
Power Supply Effect	< 0.01% of Range/Volt			
Zero Control and Span Control Ranges	Each are ±10% of Sensor Full Scale, nominal			
Connector Pinouts	A = +Power, B = Power Return, C = Signal, D = Signal Common, E = Remote Cal		A = +Power B = Power Return	

Notes:

1. Torquemeter oriented at 3 or 9 o'clock with the connector pins in the vertical position; see sketches. Crosstalk signals can be electrically zeroed.
2. Model CF2700X allowable loop resistance is zero to 700 Ohms maximum with a 26 Volt Supply or, [(50)\*(Supply Voltage) - (600)] Ohms.
3. Bandwidth is determined by on board signal conditioning. The sensors' self resonant torsional frequency is greater than 1kHz.
4. Himmelstein Models 703 and 706 will provide power, engineering unit display, classify limits, capture max/mins, interface a PC, etc. See Bulletins 374 and 377 for details.
5. Specifications and dimensions are subject to change without notice.

Appendix II

CF2700 Outline Drawing



MODEL	A	B	C	D	E	F	G	H	J	K
CF2756	6.875	4.503/4.501	4.250	4.500/4.498	0.391	5.875	0.875	0.875	3.875	0.125
CF2782	9.125	8.505/8.502	5.375	8.500/8.497	0.515	7.250	1.313	0.875	5.813	0.250
CF2784	11.250	10.505/10.502	7.000	10.500/10.497	0.515	9.000	1.594	1.156	6.500	0.250

C Diameter is thru bore. All dimensions are in inches.  
 For best results, orient with connector vertical; either @ 9 o'clock (as shown) or @ 3 o'clock.

Reaction Torque Measurement Principle & Typical Applications

Reaction torque meters are stationary (non-rotating) sensors that measure static and dynamic torques. Measurements are possible even though the device under test may be rotating at high speed. A reaction torque measurement is based on Newton's third law of angular motion. The law 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". The following paragraphs illustrate several common reaction torque measurement applications.

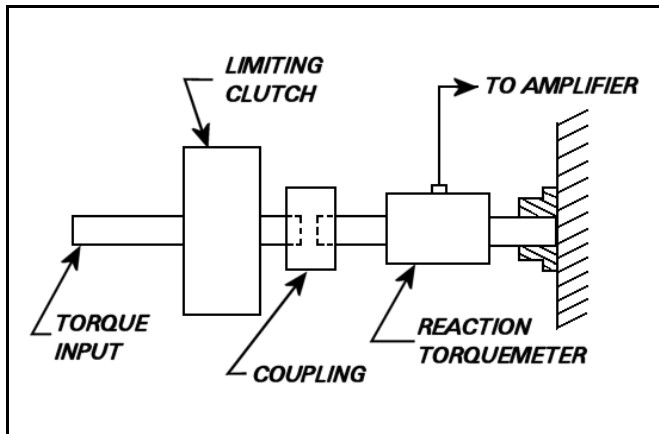


Figure 1. Measuring Clutch Slip or Release Torque

Referring to Figure 1 above, when the reaction torque path is through the torque meter, it will measure the torque applied to the clutch and, with appropriate instruments, this test setup can readily determine peak or clutch slip torque. Either a hollow or solid shaft torque meter is suitable. Himmelstein offers both types as well as Series 700 Instruments which will capture peak torque, provide limits, analog and digital outputs, interface to a PC, etc.

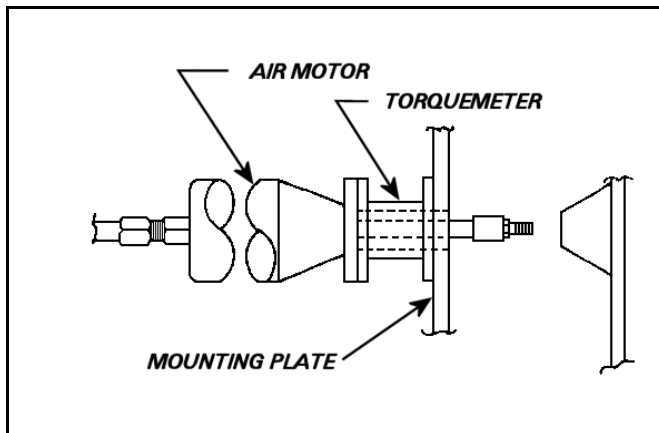


Figure 2. Hollow Torquemeter Measures Fastener Torque

Figure 2 illustrates a hollow reaction torque meter measuring the output of an air screwdriver. It accurately measures the instantaneous tool output torque even though it rises in milliseconds as the fastener seats. However, all the reaction torque must pass through the torque meter - a rotating union should be used at the air supply to avoid shunting part of the reaction through the air lines and causing an error.

Although it is possible to satisfy this requirement, other applications can have significant, unavoidable torque shunt paths. An in-line measurement should be used in such cases.

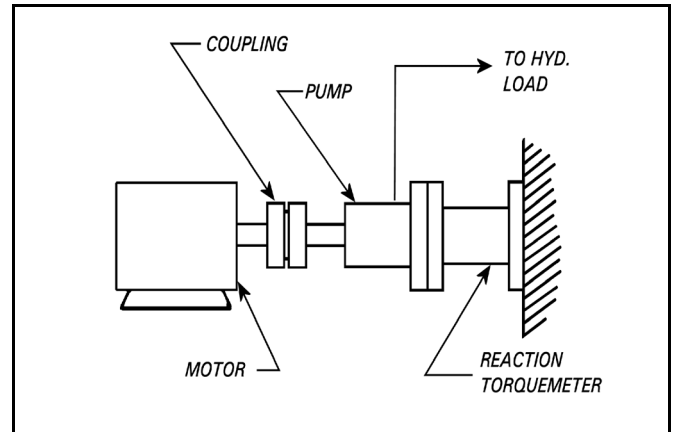


Figure 3. Reaction Measurement of Load (Power Absorber)

The measurement shown in Figure 3 is similar to that of Figure 2 but with a significant difference. The torque meter senses the reaction of the power absorber instead of the driver. Although the reaction torque of the absorber is measured, it is not necessarily equal to that of the driver. For example, when the rotor is accelerated (or decelerated), the motor output torque is the sum of the load acceleration torque (total load inertia times shaft acceleration), the windage torque of the total load and the real torque load of the absorber. A reaction measurement cannot see either the acceleration or windage torques. As a result, to the extent they exist, unavoidable errors occur. The acceleration error disappears at constant speed but windage errors are always present. Only in-line torque meters are immune to such problems. Appendix IV contains a more complete error discussion.

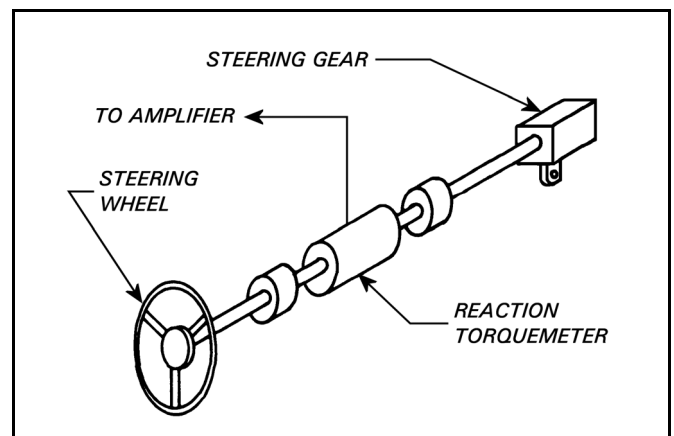


Figure 4. Limited Angular Motion Application

Reaction torque meters are an economical solution when in-line measurements are required but where angular motion is limited. If cycle rates are low, then it is practical to allow the interconnect cable to "wind-up". Ultimately, the cable will fatigue but, the technique is often quite viable.

**USING MOTOR REACTION MEASUREMENTS FOR TORQUE CONTROL**

IDEALLY, THE TORQUE FEEDBACK SIGNAL EQUALS THE TORQUE DELIVERED TO THE LOAD, I.E., THE **LOAD TORQUE (TLD)**. ANY OTHER FEEDBACK COMPONENT IS AN ERROR. THE FOLLOWING DISCUSSION LISTS SIGNIFICANT TORQUES PRESENT AND IDENTIFIES THOSE WHICH ARE **INHERENT ERROR SOURCES** INDEPENDENT OF TORQUEMETER ACCURACY. ASSUMING THE TORQUE PATH IS GROUNDED THROUGH THE TORQUEMETER ONLY, THEN, ACCORDING TO NEWTONS' THIRD LAW OF ANGULAR MOTION, THE TORQUEMETER SEES ALL THE MOTOR DEVELOPED TORQUE (TD) AND THE FOLLOWING RELATIONS EXIST.

MOTOR DEVELOPED TORQUE (TD) = MOTOR OUTPUT TORQUES + INTERNAL TORQUE LOADS

MOTOR OUTPUT TORQUES =           LOAD TORQUE (TLD)  
   + EXTERNAL WINDAGE TORQUE (TXW)  
   ± EXTERNAL ROTOR ACCELERATION TORQUE (TXRA)  
   ± EXTERNAL MOTOR SHUNT TORQUES (TES)  
   + CRADLE BEARING FRICTION TORQUES, IF ANY (TCB)

INTERNAL TORQUE LOADS =         MOTOR BEARING TORQUE (TMB)  
   + INTERNAL WINDAGE TORQUE (TIW)  
   ± MOTOR ROTOR ACCELERATION TORQUE (TMRA)

THEREFORE, **LOAD TORQUE (TLD) = TD - TXW ± TXRA ± TES - TCB - TMB - TIW ± TMRA**

- TXW**,    PRIMARILY A VENTED COOLING FAN BUT CAN INCLUDE SIGNIFICANT COUPLING WINDAGE, IS SENSED AND, BECAUSE IT ISN'T A LOAD TORQUE, **CAUSES A HIGH TORQUE ERROR** .
- TXRA**,   A LOAD TORQUE, IS SENSED AND **IS NOT AN ERROR SOURCE**.
- TES**,    ELECTRIC CABLES, WATER LINES AND OTHER MECHANICAL SHUNT PATHS TO GROUND, ARE SENSED AND, BECAUSE THEY AREN'T LOAD TORQUES, **CAUSE TORQUE ERRORS IN EITHER DIRECTION**.
- TCB**,    A NON-LOAD TORQUE, IS SENSED IN A CRADLED INSTALLATION AND **CAUSES A LOW TORQUE ERROR**.
- TMB**,    A NON-LOAD TORQUE, IS NOT SENSED AND **IS NOT AN ERROR SOURCE**.
- TIW**,    A NON-LOAD TORQUE, IS SENSED AND **CAUSES A HIGH TORQUE ERROR**.
- TMRA**,   A NON-LOAD TORQUE, IS SENSED AND, **CAUSES A HIGH TORQUE ERROR WHEN THE SHAFT IS ACCELERATED**.

ERROR COMPONENTS OF <i>MOTOR REACTION</i> TORQUE MEASUREMENTS SUMMARIZED		
REACTION TORQUE COMPONENT	SHAFT SPEED CONSTANT	SHAFT SPEED CHANGING
<b>TXW</b> - EXTERNAL WINDAGE	CAUSE A HIGH ERROR	CAUSE A HIGH ERROR
<b>TES</b> - EXTERNAL MOTOR SHUNTS	CAUSE HIGH AND LOW ERRORS	CAUSE HIGH AND LOW ERRORS
<b>TCB</b> - CRADLE BEARINGS, IF PRESENT	CAUSE A LOW ERROR	CAUSE A LOW ERROR
<b>TIW</b> - INTERNAL MOTOR WINDAGE	CAUSE A HIGH ERROR	CAUSE A HIGH ERROR
<b>TMRA</b> - MOTOR ROTOR ACCELERATION	NOT AN ERROR SOURCE	CAUSE A HIGH ERROR

- Notes:**
1. *Crosstalk errors from extraneous loads, which are difficult to eliminate, are not included in this summary.*
  2. *With the possible exception (dependent on torque meter location) of External Windage Torque (TXW), rotating torque measurements are not subject to any of these errors.*

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