A Comparison of Torque Measurement Systems

A Technical White Paper by Interface

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Over the past 20 years, non-contact rotary torque measurement systems have become indispensable, especially for high rpm or long duration testing that damages transducers with bearings. To meet these needs, several systems have been offered by different manufacturers including the AxialTQ™ system from Interface.

The AxialTQ, as with many products, is the result of years of experience with similar devices. Lessons learned through use are incorporated in new models that result in a better performing, more user-friendly product. To see how well the AxialTQ system was keeping up with other systems on the market, we tested one head-to-head with a leading competitor's system. Software for digitally logging the readings for the competing system had to be purchased separately. For the purposes of these tests, the ±10VDC outputs were used for both systems and a Keithley model 2700 was used as an interface to log data. How do things stack up?

	AxialTQ		T40B		Notes
	Spec	Results	Spec	Results	
Non-linearity	0.03	0.019	0.03	0.01	100% RO
Temp effecton zero	0.05	0.032	0.1	0.016	per 10˚ C
Temp effect on span	0.05	*	0.2	*	
Repeatability	0.03	0.016	0.03	0.01	
Shunt signal tolerance	No Spec	0.0	0.05	.01	%RO
Nominal temperature range	10 to 70	✓	10 to 70	✓	˚C Compensated
Operating temperature range	-20 to 70		-20 to 85	✓	
Storage temperature range	-40 to 85	✓	-40 to 85	✓	
Overhung moment	250 Nm	✓	220 Nm		
Safe axial load	20		19		kN
Axial crosstalk	No Spec	0.0002	No Spec	0.006	%FS change, 2 kN applied
Built in dual output		✓		✘	
Scalable outputs		✓		✘	
Hassle free install		✓		✘	

***No apparatus to test within acceptable uncertainty**

The Tests

A DIN120, 1k Nm AxialTQ system was tested against a competing DIN120, 1k Nm system for both performance to specifications and ease of use. The tests performed were:

- Zero balance stability
- Shunt calibration stability and repeatability
- Measurement repeatability
- Measurement non-linearity
- Measurement hysteresis
- Axial force crosstalk
- Zero balance over operating temperature
- Axial gradient temperature performance

Installation

The competing system has a full loop stator that needs to be carefully aligned with the rotor. The top half stator coil can be removed to complete the installation. The radial gap is only 1mm and the axial gap is ±2mm when installed.

The competing rotor was slightly easier to install to a mating flange due to its shorter length.

Figure 1. AxialTQ complete installation process with rotor and mating flange.

The AxialTQ has a stator coil that only covers 120° of the rotor's circumference and can be mounted in several different orientations. The large axial gap of up to 6mm and radial gap of 12mm means the rotor/stator connection is tolerant of small installation misalignments or rotor movement that would cause a failure in systems that require a small gap. The stators of both the AxialTQ and the competing system have multicolor status LEDs that indicate proper alignment and data transmission.

Figure 2. AxialTQ axial gap up to 6mm.

Performance

Both systems performed well and met their respective operating specifications. Some of the dynamic testing was performed only once due to time constraints. This testing also has a greater uncertainty of measurement because of the test setup.

The zero-balance change over four hours after warm-up for the competitor, was almost nonexistent, the AxialTQ change over four hours after warm-up was 0.007 %FS. The shunt calibration had the opposite results, with the AxialTQ showing no change and the competitor showing a maximum change of 0.01 %FS over a 4-hour period after warm-up.

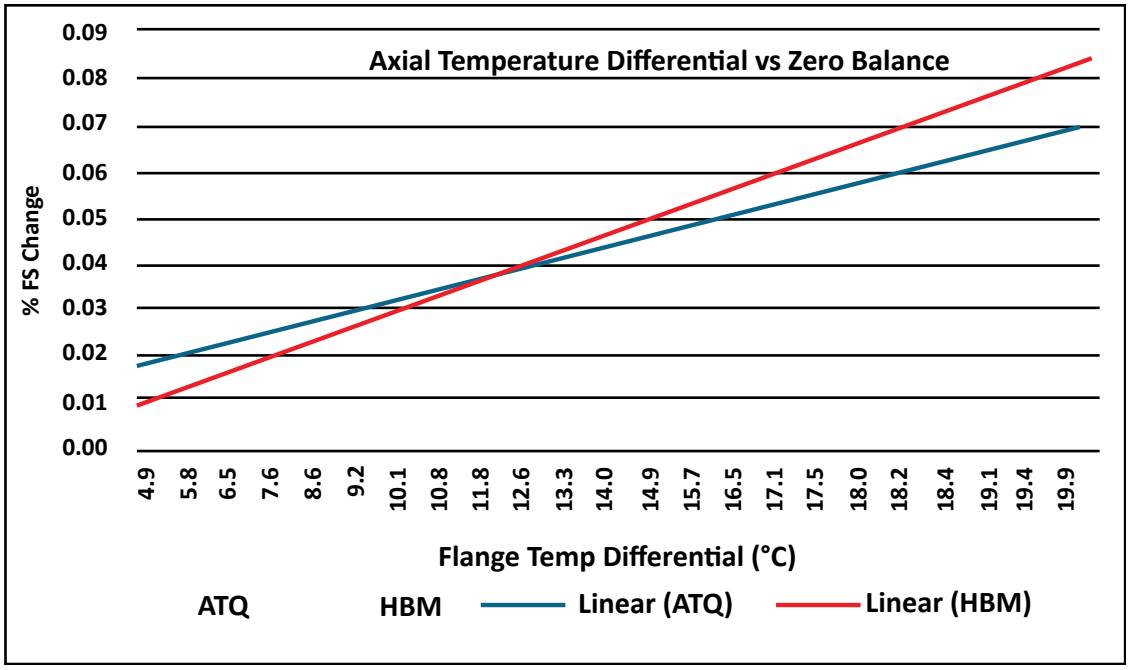
Both systems were put through a static calibration with five torque points in both the CW (clockwise) and CCW (counter clockwise) directions and one descending hysteresis point in each direction. The AxialTQ and the competing system both had repeatability of ±0.01 5%FS over five CW runs and ±0.01 %FS over five CCW runs. The non-linearity of the competing system was better, with an average of 0.01%FS versus 0.019 %FS† for the AxialTQ. Hysteresis was low and comparable for both systems, well below the AxialTQ specification of ±0.03 %FS.

There is no specification for axial force crosstalk for either product, only a maximum allowed safe axial force which was not tested. When measuring torque in a system using an electrical induction motor, some axial force could be applied when the motor shaft centers in the magnetic field. This is limited by the allowed bearing travel.

With 2kN of applied axial force, the zero-balance reading of the AxialTQ changed by 0.0002 %FS. The competing system showed a shift of 0.006 %FS. At 4kN force, the AxialTQ had a 0.006%FS change versus a 0.009 %FS change for the competing system.

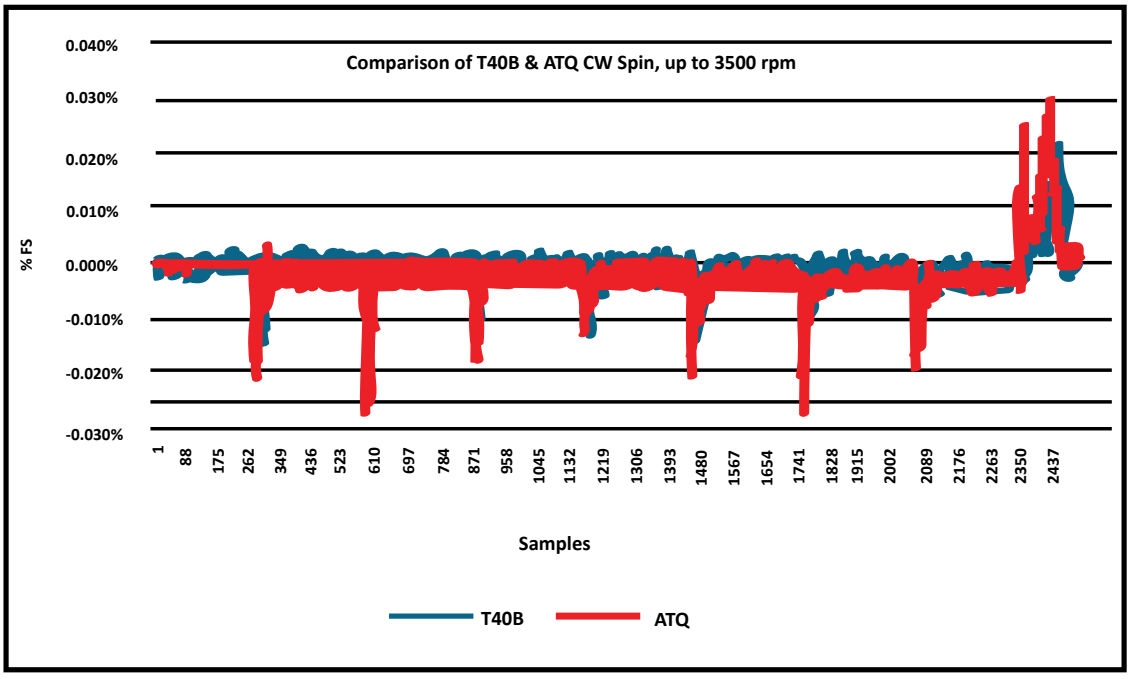
AxialTQ performance over the 10 to 70°C operating temperature range was well within the specified ±0.05 %FS/10°C at 0.032 %FS/°C, the competing system was .016 %FS/10°C.

An axial gradient temperature change was tested, with one flange being heated and the other held at 25°C. There is no specification for this behavior for either system, so the data is informational only. A linear fit was used in the graph below due to a great deal of uncertainty in the test results.



In-house spin testing (no applied torque, both directions), up to 3500 rpm showed little change in zero balance above what may have been caused by wind resistance.

A test lab spin only in the CW direction seemed to indicate the competing system has less zero error with speed; however, there was also some zero-drag causing a very small, abrupt shift in the zero readings after the torque pulse caused by the step change in the speed. The larger excursions at the step changes seen in the AxialTQ plot below may be due to the higher rotor mass of the AxialTQ vs competing system (2.8kg vs 1.9kg respectively), or the AxialTQ's lower stiffness or possibly slightly better response from the AxialTQ electronics.



We were not able to run tandem, dynamic testing with applied torque within a meaningful uncertainty. However, the resolution and response of both systems seemed similar.

The AxialTQ rotor electronics ADC (analog to digital converter) sample the resistive bridge at 38400, 24-bit samples per second. The readings are then put through a 4800 Hz FIR (finite impulse response) filter and decimated to 4800 processed data packets per second. The decimation part of the filter is used to remove successive duplicate readings that aren't needed. The processed data packet includes not only the 24-bit reading, but diagnostic information as well.

Configuration

Unlike the competing system, the AxialTQ has one analog – voltage or current output, two analog frequency outputs, and a digital serial output which are all active and independently scalable and filtered. This means that by applying different scaling to two different outputs, the AxialTQ can operate like a dual range sensor. The competing system has one or two outputs that can't be user-scaled. Software is provided as part of the AxialTQ system and an application note is available explaining the communication protocol allowing users to write their own software. The competing system does not require a separate output module for normal operation, but the analog outputs are not user scalable and user software is a separate purchase.

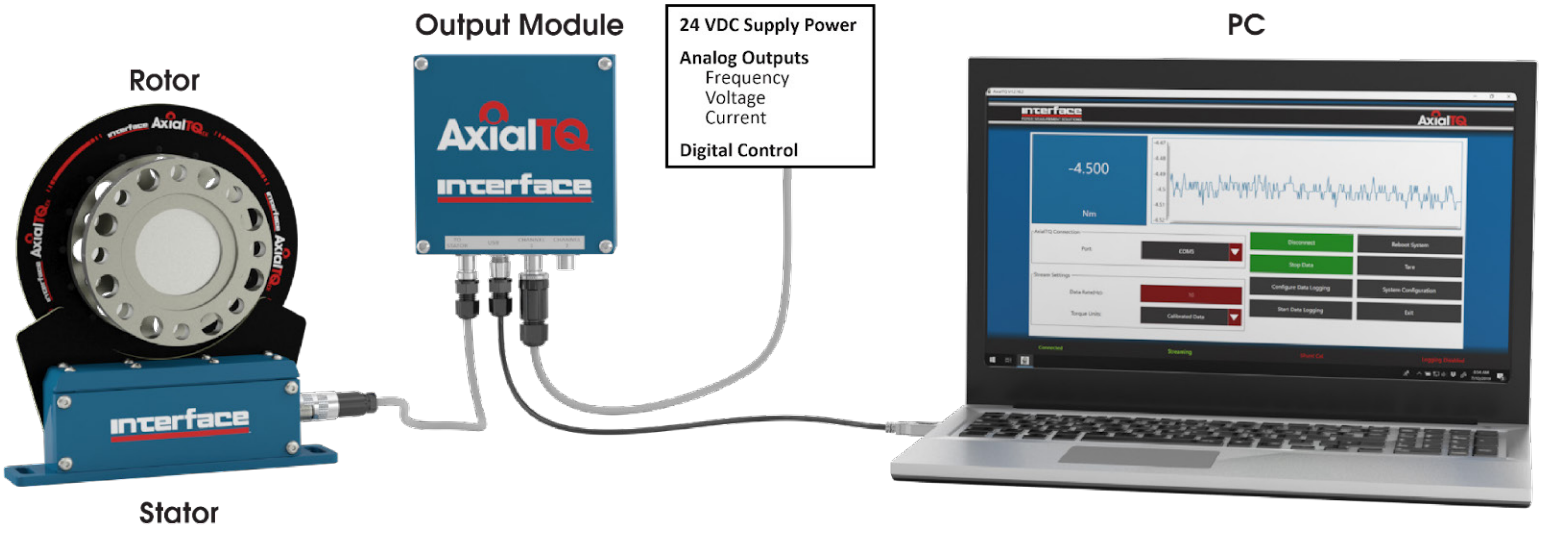
Durability

As mentioned above, the large axial (up to 6mm) and radial (typically 12 mm) gaps between the rotor and stator make it highly unlikely that the rotor will make contact with the stator because of harmonic vibration, torque pulse or some other event.

Competing devices typically have a 1 or 2mm radial gap, where the radial gap is the most susceptible to contact due to unbalance or vibration.

Both the rotor and stator coils of the AxialTQ are fabricated from 0.125in (3.18mm) thick FR4, with any conductors located at least 0.05in (1.27mm) from the edge. If damaged, these coils are easily replaced in the factory.

The competing system has the rotor coil recessed from the outer edge of the transducer, which will protect it from contact damage or accidental drops but would be difficult to repair.



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