Automation Technology

MOTOR TEST SYSTEM

MTS 3800

Motor Test System with Patented Digitorque® Full Performance Test Technology

Automation Technology Inc. manufactures a complete line of testing and process control products including:

- Armature Test Systems
- Rotor Test Systems
- Stator Test Systems
- Field Coil Test Systems
- No-load Motor Test Systems
- Patented Digitorque® Full-load Motor Test Systems
- Benchtop Surge Testers
- Scratched Wire Detectors
- Turns Counters
- Life Test Systems
- Final Product Testers
- Wire Bonding Process Equipment

theory of digitorque® operation

What began as a project to develop a better torque transducer/load test method soon developed into a rethinking of how torque is measured. As in all good research, the basic principles of physics were reexamined and, although all prior methods were studied, thinking was not allowed to simply begin where previous research had ended. The result was the invention of the digital torque measurement method. Now referred to as Digitorque®, this revolutionary method has all the advantages of load testing without its calibration / maintenance woes, typical slowness and high costs. Indeed, the Digitorque® method can measure hundreds of torque / speed points - enough to characterize the entire torque / speed curve including locked-rotor, pull-up, breakdown, and full load points - in just a few seconds; about the same amount of time most no-load and signature methods require. Simply put, this all-digital method renders laboratory results at

The Digitorque® method is founded upon a basic physics principle: The torque applied to a rotating mass of known inertia can be calculated by measuring the change in speed over a fixed period of time.

$$\text{Torque} = \text{Inertial Load} \times \text{Acceleration}$$

OR

$$\text{Torque} = \frac{\text{Inertial Load x change in speed}}{\text{time}}$$

Generally, this formula is used to determine the torque required of a motor to accelerate an "Inertial Load" from zero speed to full speed in a finite time. The Digitorque® method utilizes it to calculate torque.

In a system employing the Digitorque® method, the motor under test is mechanically connected to the test system via a test fixture consisting primarily of a rotating shaft supported upon high-quality bearings and a flywheel of known inertia and a high-resolution rotary digital encoder mounted on that shaft (see Figure 1).

The flywheel is used as an "inertial load." Its value is a constant in the above equation. The measurement time interval is also a fixed value generated by a crystal oscillator. Time is measured from one zero line crossing to the next on the AC line cycle. Thus, the only remaining parameter required to calculate torque is the change in speed.

The change in speed is determined via the industrial grade digital optical encoder which, together with support electronics, is capable of resolving extremely small changes in speed.

Torque and speed are computed using this method for each line crossing from the time power is applied to the motor until it reaches its maximum "no-load speed." The flywheel size is selected so it will take about four seconds for the motor to accelerate to that speed from a standstill. The exact time is not critical. The result is, that about 480 torque and speed measurements are made during this acceleration time. This is more than enough points to accurately describe the entire torque versus speed curve of the motor from locked-rotor to full load.

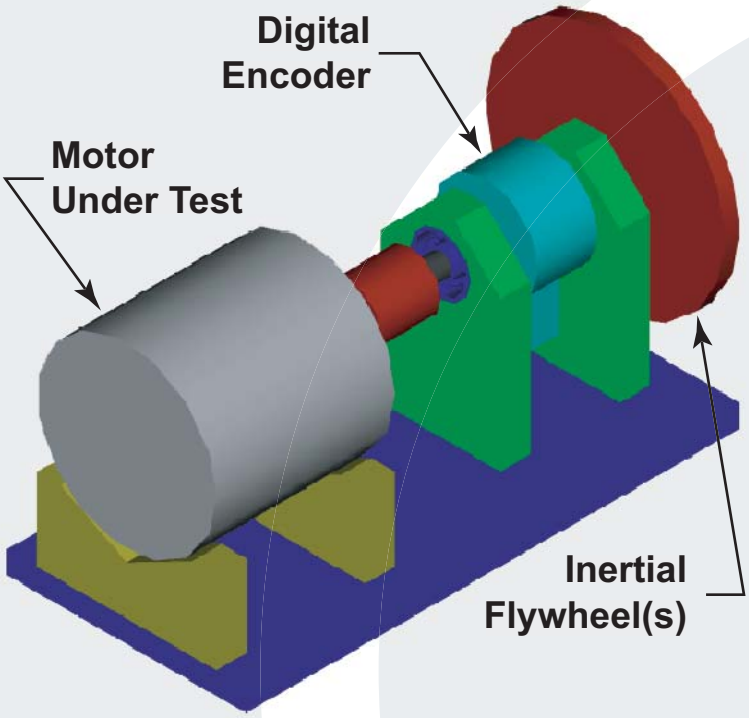


Figure 1: *Simplified Digitorque® Diagram*

Motor power and current are also continually measured during the Digitorque® test and both are plotted along with torque versus speed. The test system computer then employs algorithms to instantly pick out each specific point of interest (locked-rotor torque and current, pull-up torque, breakdown torque and speed, full load speed, current and power for induction motors) from the curves. The system also allows limits for torque or speed to be set at up to 5 user-defined points.

summary of additional tests

TORQUE RIPPLE

Torque ripple, as the name implies, is oscillation or ripple on the torque curve which can be easily seen on the graph generated by Digitorque®. An algorithm calculates a ripple torque value which may then be compared to limits for test acceptance. Torque ripple can be indicative of a number of many manufacturing and material defects such as bad bearings, a bent shaft, a non-uniform air gap, rotor out of balance, rotor hits, and open rotor bars. Most of these defects are not even detectable using the traditional test methods.

SWITCH SPEED

The speed at which the governor switch removes power from the start winding is an important design parameter in motors so equipped. That switch speed is an obvious feature on the Digitorque® graph. An algorithm determines the switch speed from the graph which may then be compared to limits for test acceptance. The Time to Switch can also be reported and/or compared to acceptance limits. In addition, the Switch transition time can also me measured and compared to acceptance limits.

FRICTION TORQUE

ATI's Patented Friction Torque Test measures the friction torque of a motor. Excessive friction torque is typically due to some defect in the bearing system. The measured friction torque of the motor may then be compared to limits for test acceptance or the entire torque/speed graph may be adjusted to compensate for the friction torque and therefore graph the true torque developed by the motor itself.

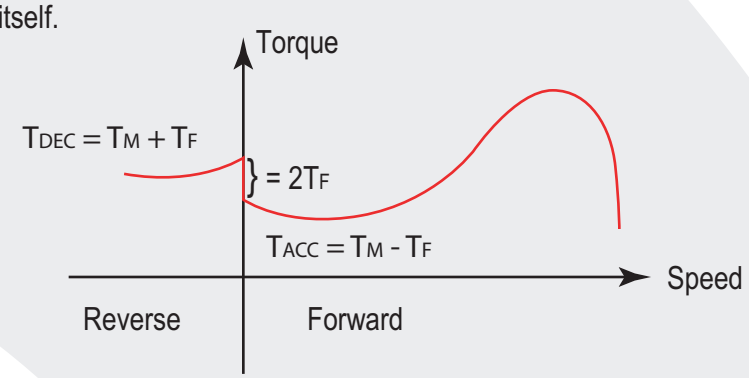
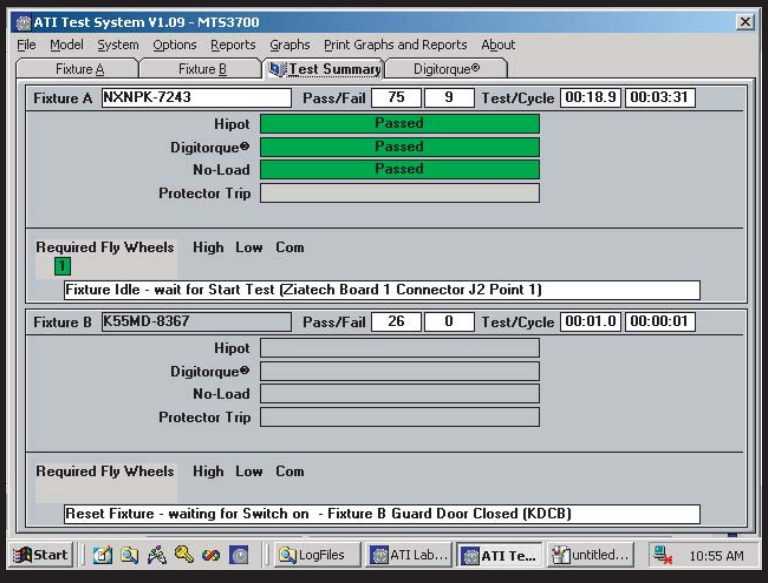
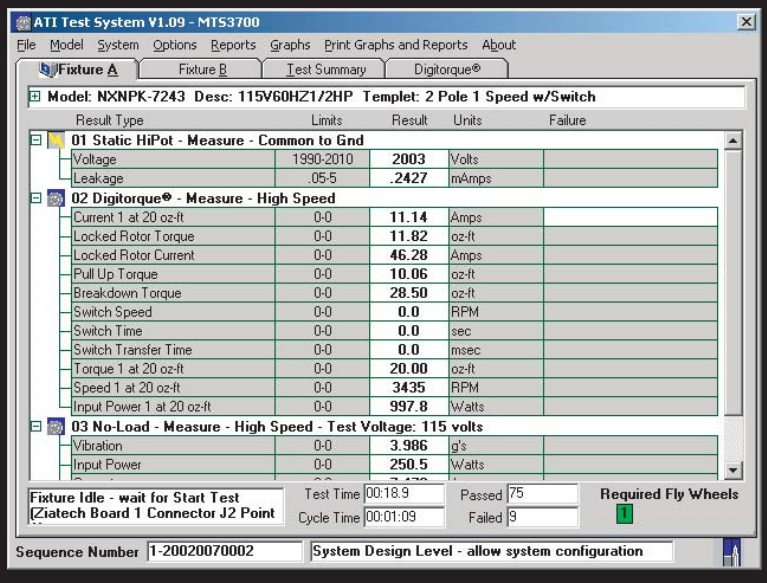


Figure 2: *Friction Torque Sample*

See Figure 2: In order to measure the friction torque, the motor under test is rotated in the reverse direction to some low speed (i.e. 200 RPM). Power is then applied to the motor to cause it to try to rotate in the forward direction. As the motor decelerates (T_{DEC}) before starting to rotate in the forward direction, there are two forces slowing the motor, one being Motor Torque (T_M) and the other being Friction Torque (T_F). Once the motor reaches 0 RPM and starts to accelerate (T_{ACC}) in the forward direction, torque during acceleration is equal to Motor Torque (T_M) minus Friction Torque (T_F). Therefore, the negative step in torque that occurs at 0 RPM is equal to two times the Friction Torque ($2T_F$).



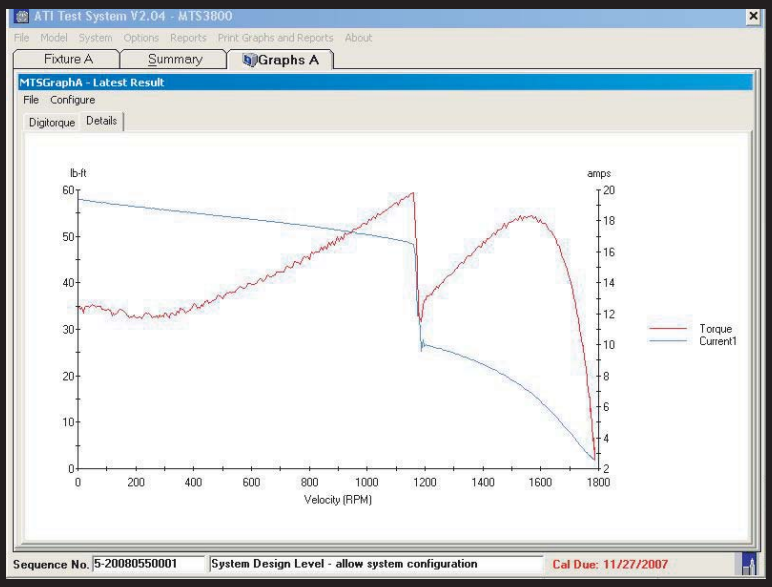
Test Summary Screen: *This screen displays the model number being tested in each fixture, the flywheels required for the model being tested, the fixture status and the result of each*



Fixture Detail Screen: *There are one of these screens for each fixture. These screens display actual numerical measured data for each test being conducted.*

ADDITIONAL OPTIONAL TESTS

- HiPot/Dielectric
- Ground Continuity
- Resistance & Resistance Balance
- Corona Detection
- Protector Trip Test
- Noise Test
- Vibration Test
- Pretest Run-in



Digitorque® *screen showing graph of motor with start switch cut-out.*

manual or automated *fixturing*

ATI offers a complete range of system configurations from manual to fully automatic. Systems can be integrated into new or existing manufacturing lines.

For applications requiring run-in prior to test, carousel type systems with multiple nests (i.e. 12, 24, 48, etc.) work very well and require minimal floor space. Systems can be configured to provide both low voltage run-in and nominal voltage run-in prior to test.

Coupling to the motor shaft can be accomplished in many different ways. Some of the more unique ways ATI has coupled include the use of collets, helical gear/pinion and unidirectional bearings.

For manual load/unload applications, multiple test fixtures may be connected to one system. This enables one fixture to be unloaded and loaded with a motor while the motor in the other fixture is being tested. With dual test fixtures, test rates exceeding 400 motors/hour may be acheived.

standard & optional *features*

STANDARD FEATURES:

- Industry Leading Two-year Limited Warranty
- Automatic Setting of HiPot and Test Voltage
- Easy to Use Windows® Operating System
- Results Management (Statistical Analysis)
- Comprehensive Diagnostics Utilities
- Inkjet Data Printer
- Dual Hard Drives with Automatic File Backup Software
- Modem and Software to Provide Remote Diagnostics
- Power Regulation and Power Transient Protection
- Learn Mode with Percentage or Standard Deviation Tolerances and Adjustable Thresholds
- Capable of Network Interface

OPTIONAL FEATURES:

- Reject label Printer
- Bar Code Reader
- Touch Screen
- Automatic Passed Part Marker
- Automatic Terminal Release
- Motor Label Printer

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Automation Technology

ATI Products may be manufactured under one or more of the following U.S. Patents 5,404,108 5,218,860 5,505,078 5,440,915 5,675,247 5,140,2765,637,793 5,907,244