Michigan Scientific Corporation

Wheel Torque Transducer System

Model: TW12.8 & TW12.8ER

For Cars, SUVs, & Light trucks

MICHIGAN SCIENTIFIC corporation

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Introduction

The Michigan Scientific TW12.8 Wheel Torque Transducer is a single channel strain gage based transducer that measures wheel driving and braking torque. A rim adapter is required to adapt to the vehicle's tire(s) and a hub adapter is required to adapt to the vehicle's hub.

High grade stainless steel material and weatherproof sealing provide excellent resistance to corrosion and environmental conditions. Temperature compensation ensures stable output throughout a wide temperature range. All wires are precisely located to reduce sensitivity to magnetic effects.

The WIP amplifier package provides excitation and amplification to the torque transducer strain gage bridge, and has an internal smart transducer which stores all the transducer calibration information and is read by the TW2 at power-up. The TW2 is the User interface for the system for the system. It provides easy Zero and Shunt calibration check for the system. It also can provide both CAN and Analog signal outputs.

A 10-circuit slip ring is used to transfer signal and power to the amplifier package and contains an internal 512-pulse optical encoder.

Specifications

TW12.8 / TW12.8ER
1-Axis Wheel Torque Transducer
Stainless Steel

	Capacity
TW12.8 My Torque Capacity	6000 lb.ft (8100 N.m)
TW12.8ER My Torque Capacity	4000 lb.ft (5400 N.m)
Maximum recommended static load	2250 lb (1020 kg)

Other	
Transducer	4 arm strain gage bridges
Nonlinearity	Less than 0.1% of full-scale output
Hysteresis	Less than 0.05% of full-scale output
Transducer Temperature Range	-40 to 125 C (-40 to 257 F)
Excitation Voltage	10 VDC
Insulation Resistance from Bridge to Case	Exceeds 5000 Mohm
Vehicle Power Input Voltage	9 to 36 VDC

Mass of Components, Typical

Component	lbs	Kg
Wheel Torque Transducer	10.25	4.65
WIP6-SG Amplifier Package	1.2	0.5
Slip Ring and Encoder	0.5	0.2
Hub Adapter	Size dependent	
Wheel Rim Adapter	Size dependent	
Fasteners (approximate)	0.5	0.2

System Components

The Wheel Torque Transducer System is made up of multiple components.

Transducer

TW12.8 and TW12.8ER Wheel Torque Transducer. The transducer is strain gaged based, temperature compensated, and weatherproof.

TW2 Electronics

The TW2 is the User Interface for the System. It reads calibration information from Amplifier at power-up. Provides power and reads signals from the Amplifier package. It also allows the user performs Shunt calibration check and Zero the system.

Amplifier, Slip Ring, and Wheel Adapter Plate

The Slip ring is mounted to the Amplifier Package, and the Amplifier package is mounted to the Wheel Adapter Plate.

Each amplifier and transducer is a matched pair. This is important; data is stored in the amplifier package has calibration information for a specific transducer. The amplifier is designed to provide a low noise signal with good performance over all temperature ranges. A Ten circuit weatherproof instrumentation quality Slip ring with 512-pulse encoder is mounted to the amplifier package.

Signal Cable

Signal Cable connects from the slip ring to the TW2 Electronics (20ft/6m length).

Power Cable

Power Supply cable. This cable is supplied from the factory with no connector on one end. White wire is DC power high. Black wire is DC power ground. An active fuse is located in the TW2 electronics.

Optional Analog Signal Breakout Cable

The signal break-out cable provides a connection for recording Analog signals from the TW2. Customer can specify output connector type.

Ethernet Cable

Ethernet Communications Cable (8 ft/2.4m length).

CAN Bus Cable

CAN Bus Signal output cable (8 ft/2.4m length).

TW2 Grounding Cable

TW2 Chassis Grounding cable (4 ft/1.2m length).

Collet Lug nuts

Collet Lug nuts grab onto production lug nuts or lug bolts and mount the WIP amplifier package

Hub Adapter

The hub adapter mates to the smaller bolt circle of the transducer and is designed to match the offset of the production wheel. If used in conjunction with rim adapter, proper wheel off-set and brake clearance is maintained. Standard hub adapters are machined from solid high strength stainless steel.

Michigan Scientific also offers lightweight titanium hub adapters.

Rim Adapter

2-Piece Rim Adapter. Limited Load Rating

Solid Aluminum Rim Adapter from Forging. Load Rating matches WTT.

Michigan Scientific (MSC) makes two types of rim adapters for the TW12.8 series. First type is made from solid aluminum forging. These are the strongest adapters and will carry the same recommended static load rating as the Wheel Torque Transducer.

The second type is a 2-piece Rim Adapter. This consists of an off the shelf aftermarket wheel barrel paired with an MSC made adapter flange. This will have a recommended load rating below the WTT maximum, but which is sufficient for many vehicles. While there are many wheel barrel sizes offered, some wheel sizes are not available in this type of adapter.

In some cases MSC can also provide welded aluminum or welded steel rim adapters. These carry lower load rating and can only be used in certain tests. Consult MSC for recommendations on your application.

MVSR

Magnetic Vehicle Stator Restraint

Restraint Rod

Slip Ring Rotational Restraint Rod

Assembly Instructions

This section of the manual describes the assembly of the transducer, wheel and hub adapters, amplifier package, and slip ring.

Tire Installation

Install tires onto the wheel adapters before assembly if using in a dual wheel configuration. If using in a single wheel configuration the tire can be mounted before or after assembly. If it is not possible to balance the dual wheel assembly, it may be necessary to balance first one and then the other wheel adapter/transducer/hub adapter assembly. If this method is used, mark the wheel adapter orientation to the transducer so that they are indexed the same after reinstallation.

Assembly

- Place the hub adapter as shown.

- Set the transducer on the hub adapter as shown.

- Install eighteen custom M10x1.5 fasteners hand tight with a small amount of anti-seize on the thread and under the bolt head as shown above. The bolts are custom because they require a smaller OD than conventional M10 bolts.

- Place the transducer and hub adapter assembly into the wheel adapter as shown below. Be sure to align the valve stem with the notch provided in the transducer.

Note: The tire can be installed before or after the transducer assembly is bolted together. If installing after, care must be taken to not damage the transducer or adapters.

- Install twelve M10x1.5 custom socket head cap screws. Use Anti-seize on bolts as described above.
- Torque all of the M10x1.5 bolts to the following torque using a crisscross pattern:

Transducer to Rim adapter bolts, if solid aluminum or 2-piece rim: 60 lb-ft (81 N.m)

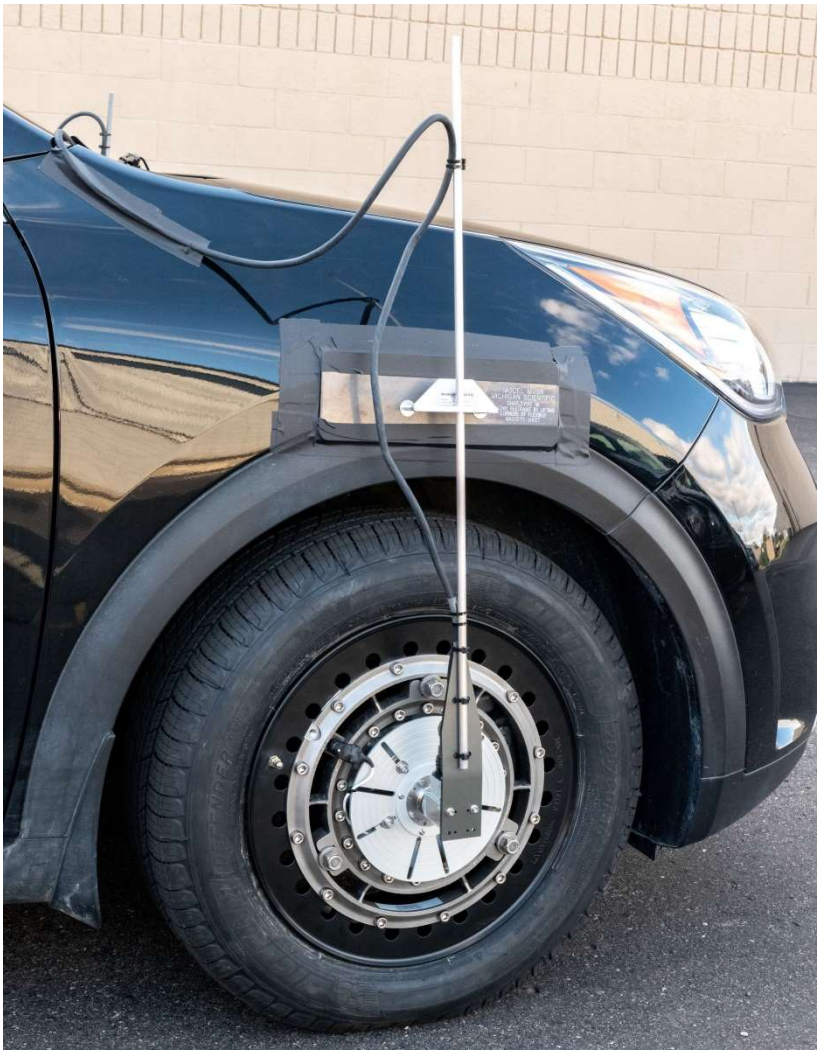
Transducer to Stainless Steel or Titanium Hub adapter bolts: 60 lb-ft (81 N.m)

Transducer to Rim adapter bolts, if welded aluminum rim adapter: 27 lb-ft (37 N.m). Note: if using welded aluminum rim adapter max recommended static corner load is reduced to 500 kg. Welded aluminum rim adapters over 17" are not recommended.

- If not already done, mount tire on rim adapter, then have the Torque Wheel assembly with tire balanced.

Vehicle Installation

Note that each amplifier and transducer is a matched pair. This is important; data is stored in the amplifier package for each specific transducer.



- Mount the magnetic vehicle stator restraint (MVSR) to the fender directly above the wheel hub. If the body is aluminum or plastic use tape to fix MVSR to the fender.

- Remove production lug nuts and production wheel from the vehicle. Slide the Transducer Assembly over the vehicle lug studs, then secure using one of the following procedures: 1) If Threaded Extended Lug-Nuts are being used, replace three (four in the case of a four bolt wheel) of the standard lug nuts with the extended lug nuts. Torque all lug-nuts to the recommended specification. 2) If Quick Connect Collet Lug-Nut Extensions are being used, install the production lug nuts and torque all lug-nuts to the recommended specification. Verify that you have the correct Quick Connect Collet Lug-Nut Extension size for the vehicle lug-nuts by placing one onto a lug-nut and tightening the ¼-20 cap-screw until the

collet clamps securely onto the lug-nut; remove once the correct size is verified. If the collet will not open enough to fit onto the lug-nut or will not close enough to fasten securely onto the lug-nut, you have two options. First, you might need to replace production lug-nuts (many are over-sized for appearance purposes) with standard, tapered ones. If the collet will still not fit onto the lug-nut or doesn't clamp securely, contact the factory for alternate sizes.

- Mount the Amplifier, Slip Ring, and Wheel Adapter plage assembly to the vehicle using one of the following procedures: 1) If Threaded Extended Lug-Nuts are being used, mount the Wheel Adapter Plate to the extended lug-nuts using the ¼-20 cap-screws. 2) If Quick Connect Collet Lug-Nut Extensions are being used, unscrew the ¼-20 cap-screw from the top of the collet. Place the small washer onto the screw and insert the screw through the appropriate slot in the Wheel Adapter Plate. Place the large washer over the screw on the bottom side of the plate and thread the screw into the top of the collet. Repeat this procedure in the appropriate slots for a minimum of three connections per wheel, using four on four bolt wheels. Now slide each collet onto the corresponding lug-nut, making sure each is fully seated on the lug-nut. Tighten the ¼-20 screws to secure the slip-ring assembly to the lug-nuts. In both cases, mount the slip-ring assembly with the minimum amount of radial run-out.
- Fasten the restraint rod to the slip-ring housing using the #8-32 x ½" socket-head cap screws and washers provided.
- Connect the 6 meter torque signal cable to the slip ring assembly. Secure it to the stator restraint rod with cable ties.
- Re-enforce the MVSR restraint with tape.
- Repeat this process for each wheel in the system.

Cable Connections

- Connect one end of the 6 meter long cable to the slip ring. Connect the other end of the cable to the TW2 electronic box which should be mounted inside the vehicle.
- Connect the power cable to the TW2 electronics. White wire is DC power high. Black wire is DC power ground.
- Connect other end of the power cable to a DC voltage source in the range of 9 to 36 volts. The current draw is less than 0.75 amps per TW2 at 13.8 volts and reduces proportionately at higher supply voltages.
- If using analog outputs, connect the Analog Signal Break-out Cable to the TW2. Then use 3 BNC cables to connect to the data acquisition.
- If using CAN Bus signal output, connect one end of the CAN Bus cable to the TW2 and the other end to the data acquisition.
- Connect the TW2 chassis ground to the vehicle chassis ground. This will prevent noise in the system. This can be done in one of the two following ways.

    1. Connect one end of the TW2 Grounding Cable to the banana plug in the back of the TW2 and connect the other end of the cable to the vehicle chassis or data acquisition chassis ground.
    2. Connect the shield of the TW2 power cable to the vehicle chassis

    Be careful not to create a ground loop when connecting the TW2 grounding cable. If the data acquisition is already connected to the vehicle chassis ground, then connect TW2 grounding cable to data acquisition grounding stud. See appendix for Proper TW2 Power and Signal Grounding Diagram.
- Turn the power switch on.
- At this time, all channels are held at zero until the TW2 receives an index pulse if the TW2 is in SPINNING ZERO MODE.

TW2 Operation

Introduction

One TW2 is used for each wheel torque transducer (WTT) and is the user interface for the system. The main functions of the TW2 are zero procedure for automated the transducer-offset adjustment, Shunt calibration and fault check, putting WTT global vehicle coordinate system, and providing both Analog and CAN signal output. TW2 are interchangeable and not mated with any WTT.

Lights and Controls

All controls located on top of the enclosure are momentary contact switches. They correspond to the labels located on the front panel. Power and position controls are located on the front panel.

Power Switch

The power switch turns the power on and off. Transducer offsets, sensitivities and other information is read from the amplifier smart transducer during power up of the TW2.

Zero

The Zero light indicates that the module is performing a zeroing sequence, invoked by the Zero button on top of the enclosure. This button is only active during the Setup Mode. The light is also used to indicate an error in the zeroing sequence when used in conjunction with the Fault light. The zeroing sequence records data and calculates an offset value. This offset is recorded into the memory chip located in the amplifier package so it is not lost when power is interrupted or a different TW2 is used.

There are two type of ZEROING available, Tare and Spinning. In TARE MODE mode the TW2 just removes the torque off-set present when the button is press. In SPINNING MODE, the TW2 uses 2 or 8 revolutions of the wheel to calculate the offset. If the wheel is not turning when the Zero button is pressed, the calculation will be based off of the next 2 revolutions. If the TW2 senses that the wheel is turning, it uses 8 revolutions to get a better on-road-averaged value.

Shunt

The *Shunt* light is used to indicate shunt related features. The button located on top of the enclosure can be used to invoke a shunt sequence or to command the TW2 to invoke a positive shunt to allow the user to set up their data acquisition system. After a successful shunt sequence, the TW2 stores the serial number of the transducer internally.

Mode

The Mode lights indicate whether the module is in Setup or Run Mode. The Mode button on top of the enclosure toggles between the modes. Run mode is used whenever data is being collected. Setup mode is only used when the transducer is being set up or when the operator is checking the transducer offsets. Zero, Shunt, and Position features cannot be accessed unless the TW2 has been switched to Setup mode.

Bridge Power

The Bridge Power light indicates whether excitation is being supplied to the strain gage bridges. When the light is illuminated, power is being supplied to the bridges. The Bridge Power button on top of the enclosure toggles the bridge power on and off. You may want to kill the bridge excitation to check for background noise. With bridge excitation interrupted, any signal activity is noise. It is best to perform this operation with the engine on and vehicle moving. The bridge power light goes off when the Bridge Power button on top of the enclosure is pressed. At this time, the module does not transform the data to vehicle coordinates and will perform no other function until the bridge power is turned back on.

Zeroing Mode

The Tare and Spinning lights indicate which Zeroing method is selected.

Fault

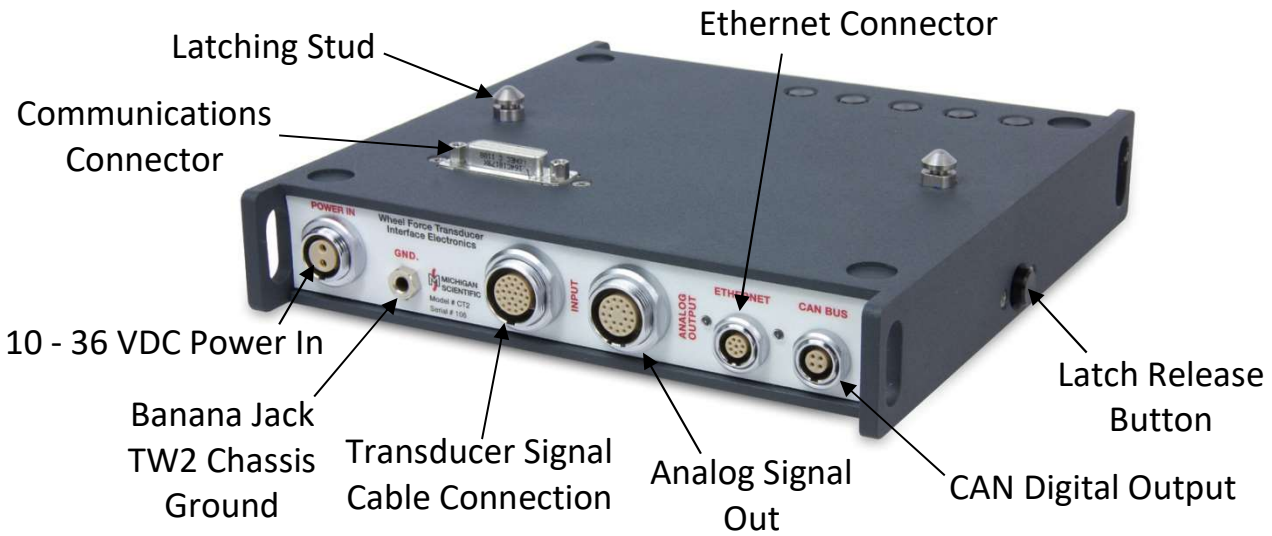
The fault light indicates that there is a problem with the module. It can be lit in conjunction with other lights or by itself. More information is available in the trouble shooting section of this manual.

Position

The position button allows the user to indicate to the TW2 what wheel position the transducer is mounted. The TW2 corrects the outputs depending on whether the WTT is

installed on the right vs. the left side of the vehicle to put all WTTs in a global vehicle coordinate system. This information is also used by the TW2 electronics to indicate in the CAN DBC file the identification of data being transmitted. In addition this allows the user to keep track of which electronics is attached to which wheel.

When stacked with one or more other TW2 units, the position information is shared between the TW2 electronics. If two or more TW2 electronics are assigned to the same wheel location, the position lights on those electronics will blink slowly to alert the user.



Connectors

Connectors located on the back panel of the TW2 are for power, ground, transducer signal cable, analog output signal, Ethernet connection, and CAN digital Signal output. The connectors located on top and bottom of the enclosure are used for communications between multiple TW2 electronics.

Output Channels

Three analog outputs are available via CAN bus signal output and optional Analog Signal Break-out Cable. They are torque about the y axis, wheel velocity, and Wheel rotational position. Sine and Cosine can be additional outputs if required. All the analog outputs are single ended and isolated from power ground. See diagram in appendix.

CAN Bus Signal Outputs

To record CAN Bus signal outputs, one CAN cable connector must be connected to each TW2. MSC can provide 1 to 1, 2 to 1, & 4 to 1 CAN cables. For example, with a 4 to 1

CAN cable, all signals from 4 WTT systems would be output onto one CAN Bus. The CAN data from all stacked TW2s is synchronized. There will be a fixed signal delay on all CAN signal outputs of 34 milliseconds (with default 500 Hz output rate. See appendix for signal delay equation at other output rates). There is potential for this fixed time delay to be different through the data acquisition depending on how the data acquisition imports the CAN data and filtering used filtering of other channels.

The CAN Bus signal outputs are all labeled by the Position set on the TW2 box that they are connected to. For Example for the Right Front position, the data will be labeled; LF_MY_Moment, LF_Velocity, & LF_Position. The data will be transmitted in engineering units. In the default mode, the Baud rate will be set to 1 Mbps, Output rate set to 500 Hz, and the Torque units will be N.m. It is possible to change these setting via the TW2 webpage.

Analog Output Channel Sensitivities

The output channels for all systems are scaled as shown below. The TW2 default Analog output is ±10V. The TW2 webpage allows for the user to change analog output ranges to ±5V, ±2.5V, and 0-5V. Because of that, the number shown in the chart below is the full scale value for each channel. This number needs to be divided by the full scale voltage to calculate the sensitivity in units/volt. Example - If the full scale analog outputs are set to the default ±10 Volt, the Y Moment Torque sensitivity will be 900 N-m/V (9,000 N-m /10 volts). If the user changes the analog output range to 0-5 Volt, Y Moment sensitivity will now be 3600 N-m/Volt with a 2.5 volt offset.

NOTE: VERIFY OUTPUT CHANNEL SENSITIVITY BY MONITORING SHUNT CALIBRATION VOLTAGES AND COMPARING THE TO THE SHUNT CALIBRATION EQUIVALENT LOAD. THIS CAN BE FOUND ON THE CALIBRATION SHEET OF THE TRANSDUCER. CHANNEL SCALING MAY BE SET-UP DIFFERENTLY ON SOME TRANSDUCERS.

Output Full Scale Channel Sensitivities		
TW12.8- Y Moment	9,000 N-m	6667 lb-ft
TW12.8ER - Y Moment	6,000 N-m	4445 lb-ft
Velocity	2000 rpm (default)	
Position	0 - 360 deg	
SINE	± Full Scale	
COSINE	± Full Scale	

Output Channel; Offset and Sensitivity Function Table				
Control States			Outputs	
Mode	Zeroing Mode	Bridge	Offset	Sensitivity
Run	Tare	On	Yes	Yes
Run	Spinning	On	Yes	Yes
Setup	Tare	On	No	Yes
Setup	Spinning	On	No	Yes
N/A	N/A	Off	No	Yes

Sensitivity adjustments are always performed to the data inside the TW2 electronics. Offset adjustment are not always performed. The above table summarizes these states.

Multiple TW2s

Each TW2 is used with one Wheel Torque Transducer. When using multiple Wheel Torque Measurement systems, the TW2 is designed to be stacked. Latch studs are mounted on top of the enclosure and a latching mechanism is mounted on the bottom. When the boxes are set on top of each other, they latch together. A button on each side of enclosure releases the latches. Electrical connections are made via the D-sub connectors mounted on top and bottom of the enclosure. When not stacked it is recommended that the dust covers provided with the enclosure be used to cover the D-sub connectors. This will protect the connectors and reduce the chance of electrical damage to the electronics.

The TW2 electronics communicate with each other using a digital bus interface. This allows the operator to control all of the TW2s with one set of controls. Notice that the control buttons are located on top of the enclosure. When one TW2 is stacked on top of another, the buttons on the lower one are covered. All functions are controlled by the top TW2 at this time.

A base is available to provide better stability and tie down locations. This base also protects the D-sub connector on the bottom TW2.

The power supply cable can be connected to any one of the TW2 electronics. That TW2 will supply power to the rest in the stack.

Each TW2 retains its own power switch and must be turned on individually. At power up, the TW2 checks the state of the other boxes and then sets itself to match.

Up to six TW2 electronics can be stacked together. If you want to stack more together, please contact Michigan Scientific to discuss your specific application.

Power Requirements

The TW2 requires 9 to 36 VDC power. Power draw is less than 0.75 amps at 12 volts for each WTT system.

Zeroing Modes

An electrical balance is critical to assure accuracy of wheel torque measurements.

The wheel torque transducer is electrically balanced during fabrication. It is then temperature compensated to have minimum balance shift from –40 up to 200°F. The amplifiers and TW2 are also designed to have minimal thermal offset over a wide temperature range.

The TW2 has a Zero feature that automates the zeroing process. With any zeroing method used below, it is recommended that the transducers be exercised before any zeroing is done. To exercise the transducers, simply drive the vehicle around a parking lot.

There are three zeroing procedures. When the TW2 completes the zero procedure, it will write the calculated offset value to the memory chip located in the amplifier. This way the transducer does not need to be zeroed every time the power is interrupted or if a different TW2 is used with the transducer.

1. Tare Zero

- Press the *Setup Mode* button
- The blue *Setup Mode* light will illuminate.

- Press the *Zero* button.
- The amber *Zero* light will illuminate.
- Once the procedure is complete, the light will go out.

2. Spinning Zero

Caution: *While it does not matter which direction you turn the wheel during the zero sequence, changing the direction of rotation during the zero procedure will cause errors. Remember when turning one wheel on a drive axle, the one on the other side will turn the opposite direction. This is OK as long as the wheel does not change direction of rotation during the sequence.*

- Press the *Setup Mode* button.
- The blue Setup Mode light will illuminate.
- Press the *Zero* button. Note: The wheel must not be rotating when the *Zero* button is pressed.
- The amber *Zero* light will illuminate.

Caution: *While it is not important that the wheel be turned at a steady rate, do not impart excessive acceleration or deceleration to the wheel while turning it. This may cause calculation errors. To reduce errors, the TW2 uses position-based sampling for this procedure.*

- Rotate the transducer. When rotating the transducer, never apply force to the tire itself. This can cause an error in the zero calculations. Apply force to a wrench on the lugnut/lug bolt. Rotate in one direction until the amber *Zero* light goes out, this should take 2 revolutions.

Using more than one transducer with stacked TW2s

- You may rotate each transducer independently.
- To zero only one wheel, you will need to turn off the TW2 electronics, on the wheels that you do not want to zero, or un-stack them.

3. Spinning Zero on the Road

The My (Torque) may also have a real non-zero value due to drive line torque and brake or seal drag. Use rolling zero only when lower accuracy can be tolerated.

- Press the *Setup Mode* button.
- The blue *Setup Mode* light will illuminate.
- Coast the vehicle along a smooth and level section of road or parking lot.
- Press the *Zero* button.
- The amber *Zero* light will illuminate.
- The TW2 detects that the tires are turning and will use the average of the next 8 revolutions to compute the offset.
- Once the procedure is complete, the light will go out.

Once the initial setup is accomplished, data collection can continue for several days without readjustment. The vehicle should be lifted occasionally to verify the zero stability.

Factory Calibration

Calibration values are programmed into the amplifier for each transducer. The wheel torque transducer was statically calibrated in a load frame with a rigid outer ring in place of the rim adapter.

An electrical shunt calibration was performed during physical calibration in the laboratory. During physical calibration, shunt resistors values are determined to establish equivalent physical torque values. Sensitivity calibration values in kilo-Newton/volt and pounds/volt are presented in the Appendix of this manual.

Shunt Calibration Sequence

Shunt Sequence - The TW2 calculates an internal gain, used to make output sensitivities match the values programmed into the Memory chip.

To invoke a shunt sequence.

- Press the *Mode* Button to enter *Setup Mode*
- Press and release the Shunt button.
- The Shunt light will illuminate to indicate a shunt sequence is in progress. Once the Shunt light goes out (about 12 seconds), the shunt sequence is complete.
- Press the *Mode* button to return to *Run Mode*.

If the Shunt light does not go out and the Fault light illuminates, the shunt sequence did not pass. The shunt sequence commands the amplifier package to invoke a shunt calibration resistor at each strain gage bridge in the transducer. The TW2 reads the voltage change, caused by the shunt, and adjusts the gain of each channel to match the sensitivity programmed into the *memory chip*. This calculated gain is recorded into the memory chip located in the amplifier package so this information is not lost when power is interrupted or a different TW2 is used. If the calculated gain is more than 2.5% different than what is programmed into the memory chip, the shunt sequence does not pass.

Note: This sequence can be performed with the wheels on or off the ground with equal accuracy. However, if the wheels are on the ground, anything that causes torque variations such as movement of the vehicle can cause errors in the shunt cal.

Shunt Hold - The TW2 can be commanded to invoke and hold shunt calibration. This can be used to write down the transducer off-sets and shunt voltages.

To invoke the shunt hold:

- Press the *Mode* Button to enter *Setup Mode*
- Press and hold the *Shunt* button until the shunt light starts flashing rapidly (approximately 1 second).
- The *Shunt* light will flash rapidly and the outputs will hold a positive shunt until the shunt button is pressed again.
- Then the system outputs will hold a negative shunt calibration until the shunt button is pressed again.

The calibration sheet lists sensitivity in lb-ft full scale and N-m full scale and a shunt values in pounds and Newton meter for each channel. If desired, the user may check the sensitivity by recording the outputs during a shunt sequence and calculating the delta

(magnitude of change from positive shunt to negative shunt). The shunt value listed in the calibration sheet is defined as half of this delta.

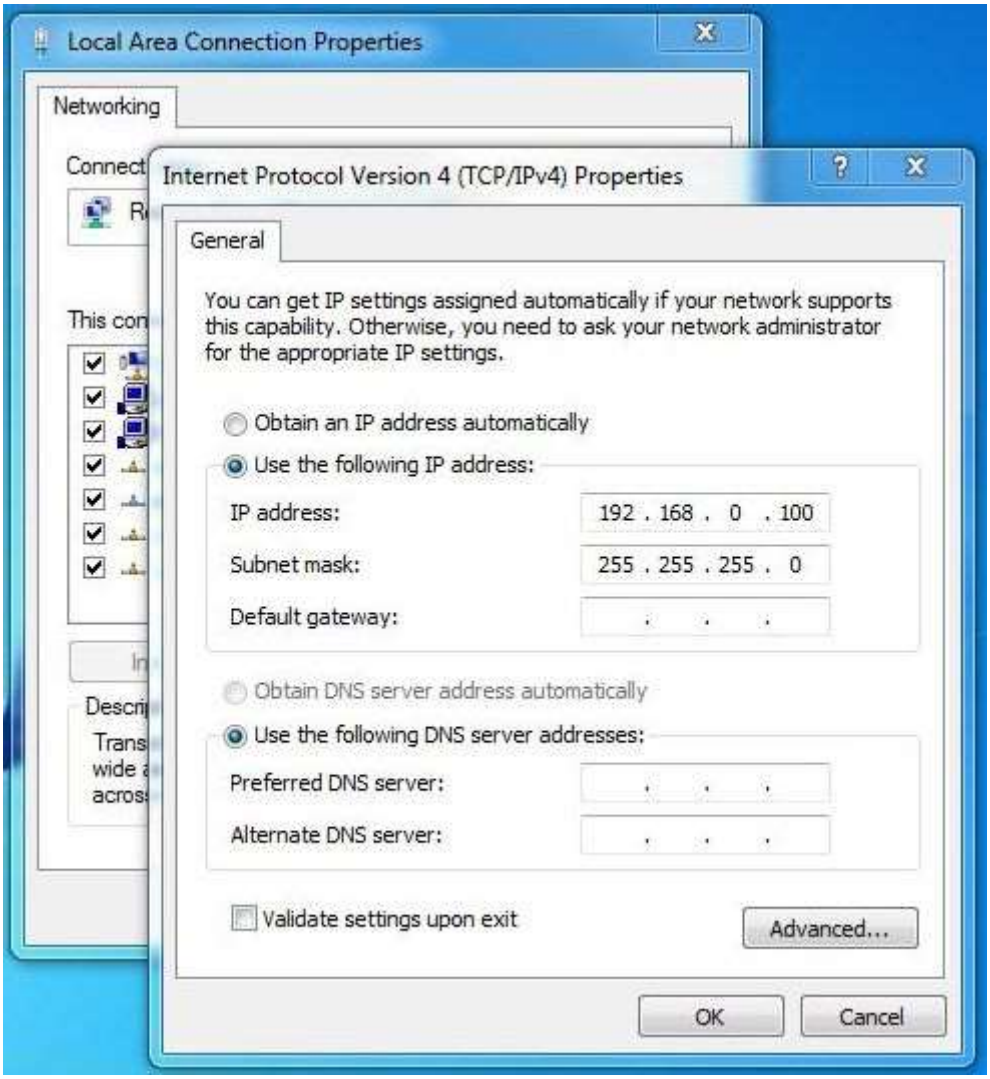
Physical re-calibration services are available from Michigan Scientific.

Web Page Changeable Parameters

The TW2 contains an embedded web page that can be used to change a couple system parameters. The TW2 has many parameters available that are not applicable to the Wheel Torque Transducers (WTT) system. We will just highlight the ones application to WTT systems. This web page is available to any device with an Ethernet port and web browser.

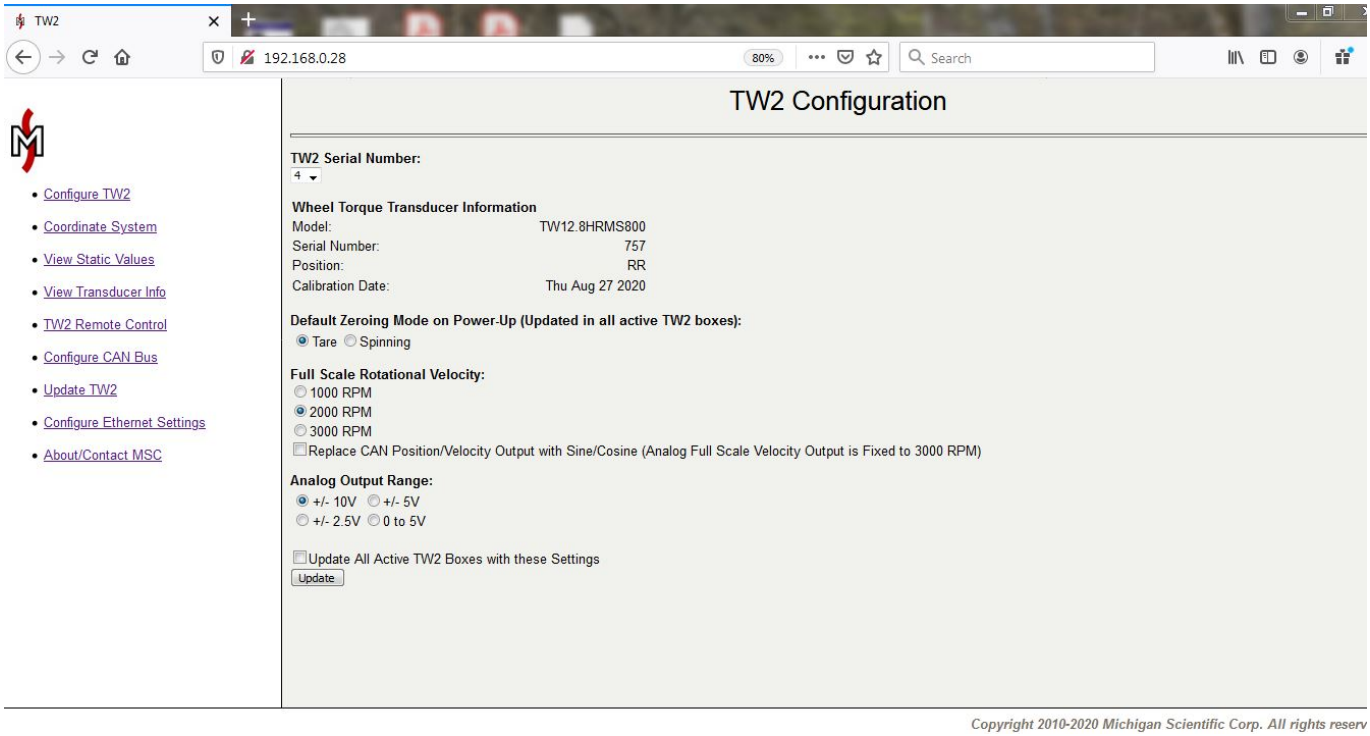
To access the web page.

- Connect the Ethernet cable (provided with appropriate connectors) to one of the TW2s and a computer. Note: To avoid network conflicts wireless networking should be turned off on the computer.
- Change the IP address on the computer's Local Area Connection Properties.



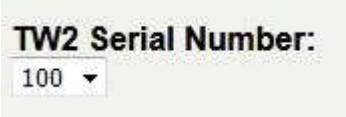
- Pull up a web browser
- Enter the IP address of the TW2 into the browser bar (see below for more information on IP addresses)
- The web page, shown on the following page, will appear in the web browser

Note: To make system changes, all TW2s must be connected to their respective wheel torque transducer and powered up.

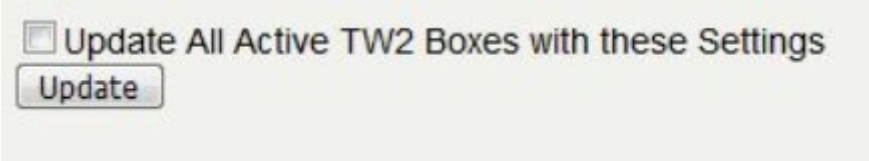


TW2 Serial Number

Near the top of the page is a drop down box allowing the user to select TW2 serial numbers, shown below.



The TW2 that is connected by Ethernet cable will check for the presence other TW2 electronics. These other units need to be stacked together and all units need to be turned on. If other units are present, and turned on, the serial numbers of these units will appear in the pull down menu. Selecting a different serial number allows the user to set up each TW2 separately.



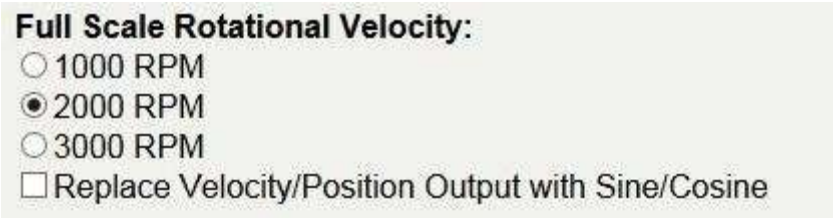
If settings for all the TW2 units are to be the same, the "Update All Active TW2 Boxes with these Settings" button can to be pressed before the "Update" button is pressed. Updating all units at once avoids the need for the user to go through the settings for each serial number individually if settings for all units are to be the same.

The Wheel Torque Transducer Information shown below serial number is information for the WTT that is connected to the selected serial number.

Note: All TW2 electronics, shown in the serial number drop down menu when this setting is changed, will take the new setting even if the "Update All Active TW2 Boxes with these Settings" button is not checked.

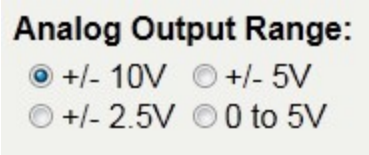
Full Scale Velocity

This setting is used to set the full scale velocity of the wheel speed signal derived from the encoder. There are three optional full scale velocities. The full scale velocities are 1,000, 2,000, and 3,000 rpm full scale. The default setting is 2,000 rpm full. The user may also select to replace the position and velocity signals with Sine and Cosine signals.



Analog Output Ranges

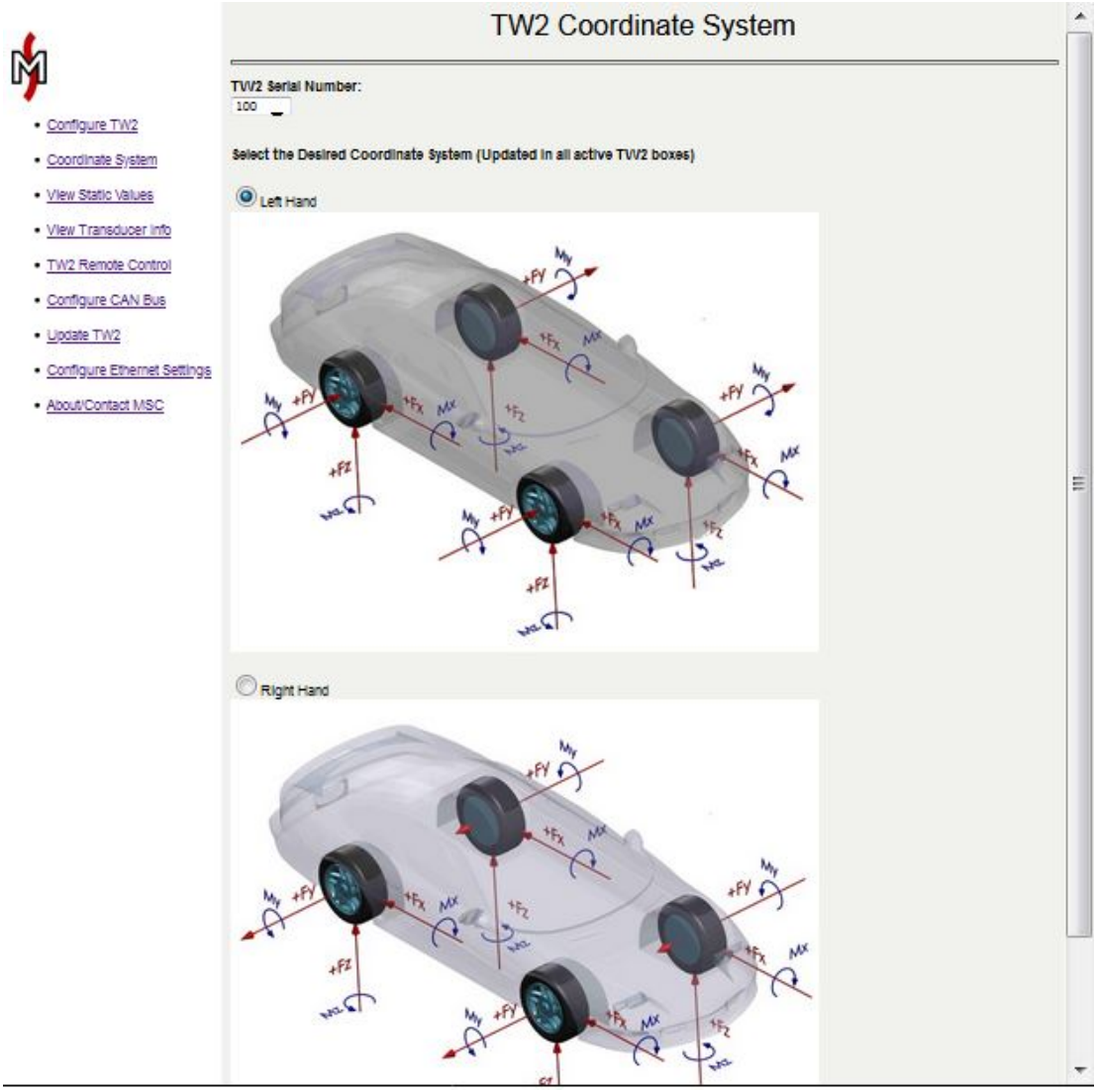
For the Analog outputs, the full scale output voltage can be set as shown below to accommodate data acquisitions systems that cannot accept ±10 volt signals. The TW2 changes the output sensitivity to use the full scale range.



Note: The Analog outputs use a 16 bit DAC. When a different voltage range is selected, the resolution of the data is no longer 16 bits because the TW2 does not utilize the full 16 bit range of the DAC. When using +-5 volt range the resolution is reduced to 15 bits. When using +-2.5 or 0-5 volts the resolution is 14 bits.

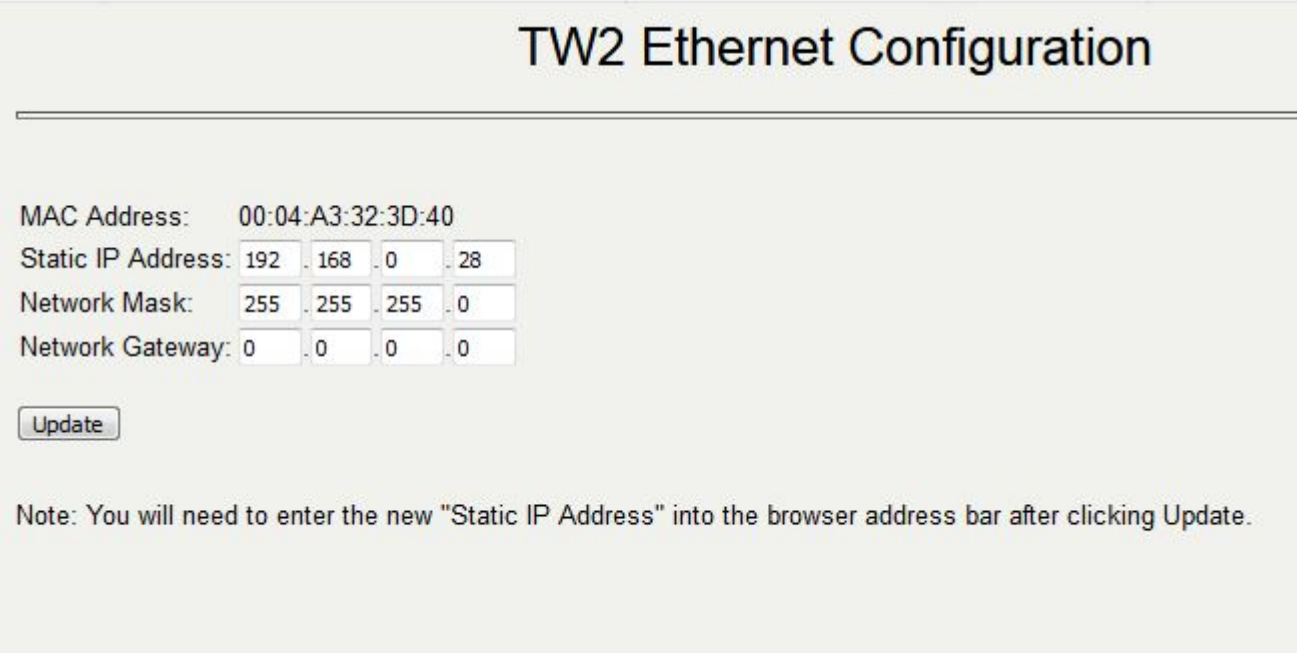
Changing WTT Coordinate System

The default WTT coordinate system is the Right Hand Coordinate System shown below. In the Coordinate System tab on the TW2 webpage the WTT coordinate system can be switched to a Left Hand Coordinate System by checking the button labeled “Left Hand” then clicking update at the bottom of the page. This will update all TW2 boxes stacked and powered up. Changing Coordinate System will change the Polarity of My.



TW2 Ethernet Configuration

Default IP addresses are set at 192.168.0.28 at the factory for all TW2s. A new IP address can be set by going to the "Configure Ethernet Setting" tab located on the left side of the web page. The IP address, Network Mask, and Network Gateway can be changed by entering a new number and pressing the Update button as shown below.



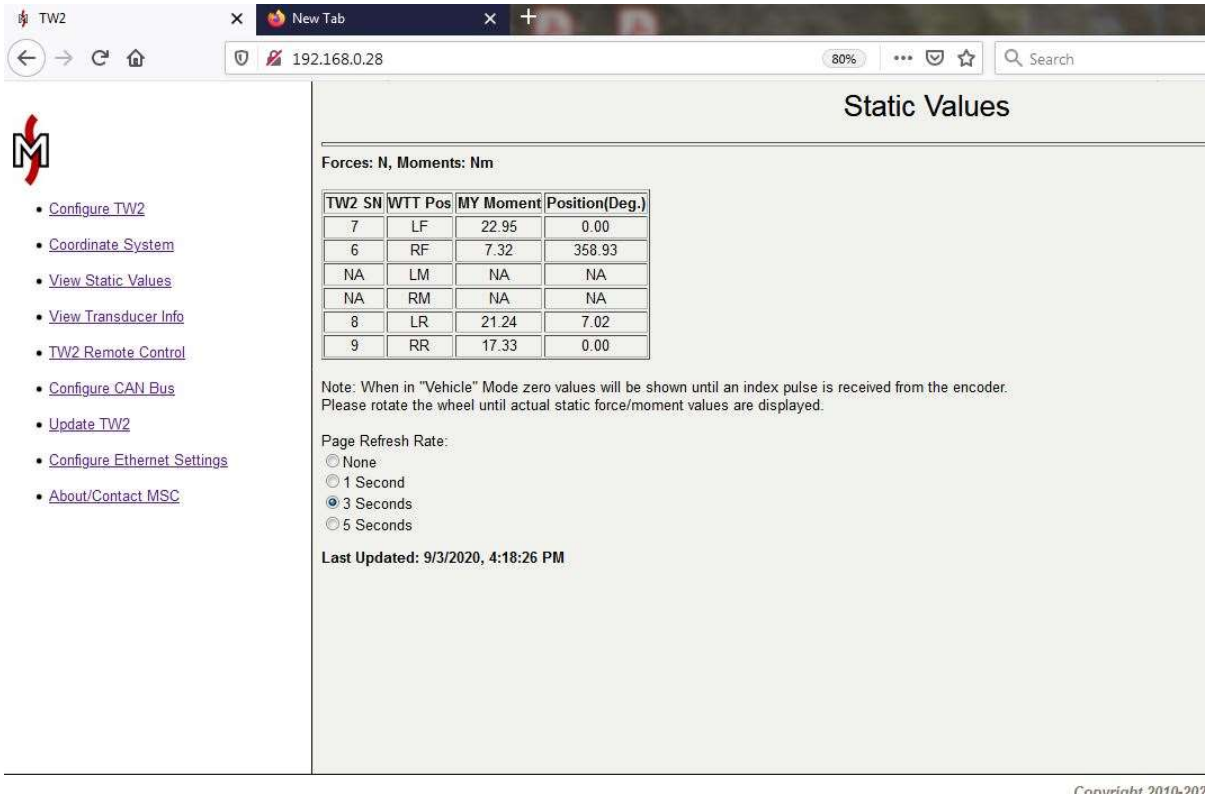
In the event that the Ethernet Configuration was changed away from the default setting and not recorded, it can be reset to the defaults shown above.

To reset the Ethernet Configuration Settings to the values shown above,

- Shut off the power switch on the TW2
- Press the position button
- Turn on the power switch while continuing to hold the position switch for a minimum of 1 second after the TW2 powers up.
- The Ethernet Configuration Settings will reset to the values shown above.

Static Values

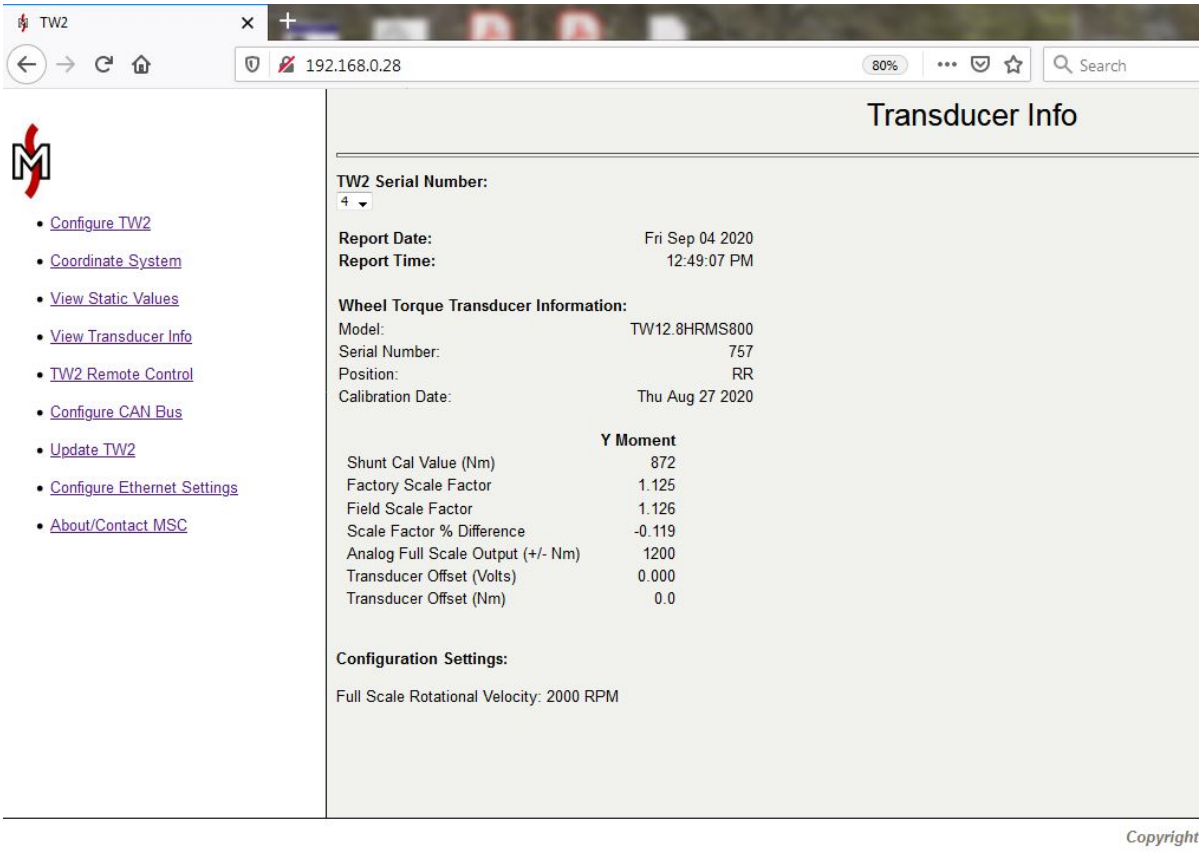
The Web page can be used to view static transducer output values during setup. Select "Static Values" on the upper left side of the web page. The web page displays the static values for all active WTT systems, shown below.



Refresh rates can be changed by selecting from the options at the bottom of the page.

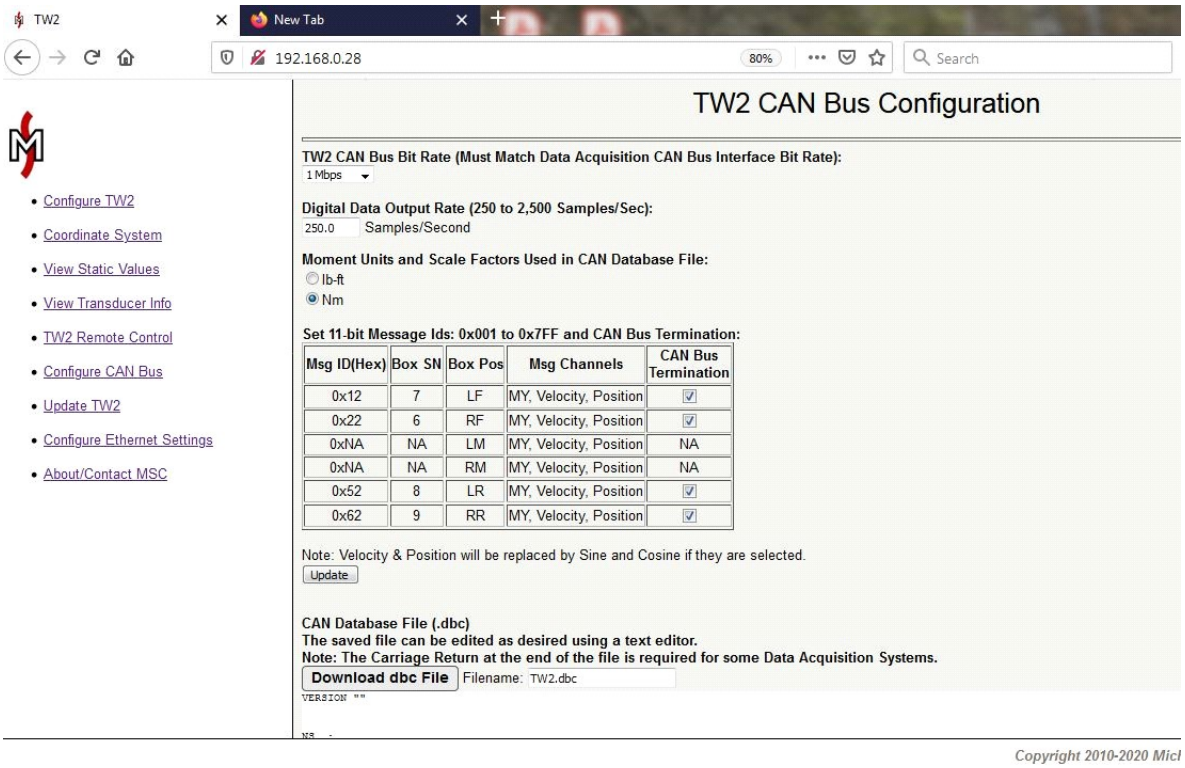
Transducer Information

Information for each WTT system can be viewed by clicking on “Transducer Info”. The TW2 Serial number drop down menu allows the user to select which system the information is for.



TW2 CAN Bus Configuration

CAN bus data output settings are configured using the “TW2 CAN Bus Configuration” option located on the left side of the web page. The TW2 CAN bus interface bit rate must be set to match the CAN bus interface bit rate of your data acquisition system. If they do not match then TW2 data will not be recognized by the data acquisition system. The CAN bus bit rate directly affects the number of samples per second that the TW2 can place on the CAN bus as well as the number of possible error retransmissions if an error occurs with a CAN message. Clicking update will update this setting for all active TW2 boxes that are stacked together.



Note: It is necessary that the TW2 box receive a CAN acknowledge bit from the connected data acquisition system. Do not use passive (listen-only) mode on your data acquisition.

Another factor that affects the number of samples per second that can be output on the CAN bus is the number of TW2 boxes per CAN bus interface on your data acquisition system. The chart below gives some recommended guidelines as to the maximum TW2 CAN output rates that you should use based on how many TW2 boxes are connected to each CAN bus interface on your data acquisition. The chart assumes a CAN bit rate of 1 Mbps and that no other devices are on the CAN bus.

	Recommended Maximum CT2 CAN Output Rates	
# of CT2 Boxes per CAN Bus @ 1 Mbps	Sample Output Rate (Samples/ Sec)	# of Possible Error Retrans.
1	2,048	1
2	1,250	1
4	650	2

The CAN Bus data output rate can be adjusted between 250 to 2500 samples per second. A decimal place is allowed (e.g. 409.6 samples/second). Note: You should verify that your data acquisition is capable of sampling CAN data at your desired TW2 digital data output rate. Clicking update will update this setting for all active TW2 boxes that are stacked together. The approximate through delay from the analog input to the start of frame bit of the 1st message on the CAN bus is displayed in milliseconds for the entered data output rate.

A CAN database (.dbc) file that can be imported by many data acquisition systems is dynamically created for all active TW2 boxes that are stacked together. This file describes which CAN message id and corresponding data bytes go with each data channel/wheel position. It also describes each channel's name, units and scale factors. The engineering units and scale factors used in the .dbc file can be selected as Newton-Meters (Nm) or Pound-Feet (lb-ft).

Note: If alternate unit text is desired it can easily be edited by changing the unit text between quotes in the .dbc file.

There are 2 CAN messages output per sample for each TW2 box. These messages must have a unique 11-bit message id to be recognized by the data acquisition system. Here you can change these CAN message ids for each active TW2 box that are stacked together. In the table you will find the TW2 box sn, pos and data channels that correspond with each CAN message id.

CAN Bus Termination

Also in the table, you can set whether 120 ohm CAN bus termination is supplied per each active TW2 box by checking the CAN Bus Termination Box. Every CAN bus must have 120 ohm end-to-end termination. For 1 TW2 box connected to 1 data acquisition CAN interface, both the TW2 box and the data acquisition should have 120-ohm terminators. Additional TW2 boxes (nodes) connected between the end-to-end points must not have 120-ohm CAN termination. For example, for a 2 to 1 CAN cable, one CAN BUS Termination Box must be checked and the other one must be unchecked. For a 4 to 1 CAN cable, one CAN BUS Termination Box must be checked and the other three must be unchecked. When using two 2 to 1 CAN cables, the user must identify which SN TW2s are connected to each CAN cable. Then the user must uncheck the CAN Bus Termination Box for one of the two TW2s connected to each cable.

Set 11-bit Message Ids: 0x001 to 0x7FF and CAN Bus Termination:

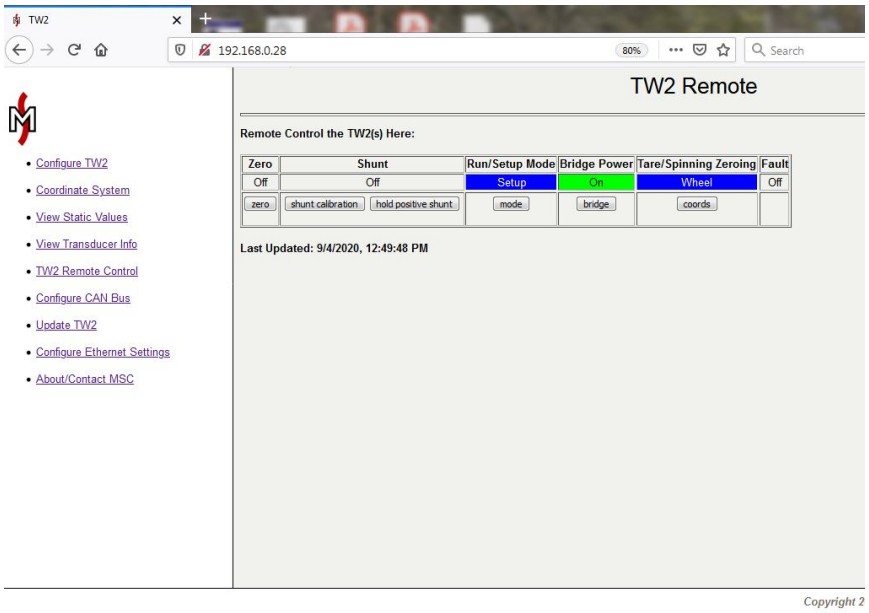
Msg ID(Hex)	Box SN	Box Pos	Msg Channels	CAN Bus Termination
0xNA	NA	LF	MY, Velocity, Position	NA
0xNA	100	RF	MY, Velocity, Position	☑
0xNA	NA	LM	MY, Velocity, Position	NA
0xNA	NA	RM	MY, Velocity, Position	NA
0xNA	NA	LR	MY, Velocity, Position	NA
0xNA	NA	RR	MY, Velocity, Position	NA

Note: Velocity & Position will be replaced by Sine and Cosine if they are selected.

Update

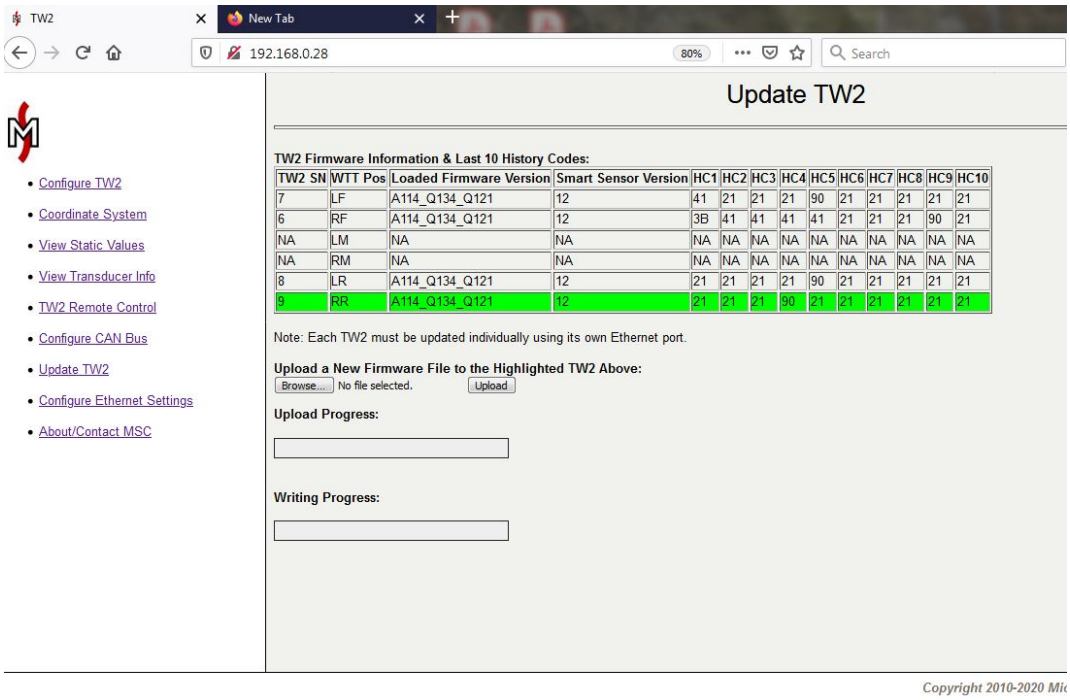
TW2 Remote Control

The TW2 stack can be controlled via the web page by selecting "TW2 Remote Control" at the upper left side of the web page. This allows the buttons on the TW2 to be controlled remotely via the Ethernet connection. This is especially useful when used in the lab because it allows the user to control the TW2 from the control room.



Updating Firmware in TW2

The embedded web page allows the user to easily update firmware without having to send the TW2 back to the factory. This allows updates or repairs to be done in the field.



TW2 SN	WTT Pos	Loaded Firmware Version	Smart Sensor Version	HC1	HC2	HC3	HC4	HC5	HC6	HC7	HC8	HC9	HC10
7	LF	A114_Q134_Q121	12	41	21	21	21	90	21	21	21	21	21
6	RF	A114_Q134_Q121	12	3B	41	41	41	41	21	21	21	90	21
NA	LM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	RM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	LR	A114_Q134_Q121	12	21	21	21	21	90	21	21	21	21	21
9	RR	A114_Q134_Q121	12	21	21	21	90	21	21	21	21	21	21

If an update is available, Michigan Scientific will provide an installation file. Save this file in a convenient location.

To update the TW2:

- Connect the Ethernet cable to the electronics to be updated.
- Press the Browse button and select the installation file.
- Press the Upload button
- The file will be uploaded. Follow the prompts on the web page.
- Once complete you will be prompted to cycle power on the TW2.
- Once power has been cycled, the new firmware is ready to be used.

Caution: *Do not disconnect the TW2 or power down the computer or TW2 during the update. Possible damage may occur which will require the electronics to be sent back to Michigan Scientific for repair.*

Note: Only the TW2 connected to the Ethernet Cable will be updated. Each TW2 electronics must be updated separately.

Note: Update all TW2 electronics with the same version of firmware before using them in a stacked configuration.

Transducer Offset Check

It is recommended that the customer keep track of the transducer offset over time. If the offsets for each channel remain consistent with the factory offset listed on the calibration sheet, re-calibration is not necessary.

- Remove hub and wheel adapters. Hub and Wheel adapters can cause a small shift in transducer offset when they are bolted up. This is normal and the transducer will return to its original offset once they are removed.
- Set the transducer flat on the bench.
- Connect the amplifier to the transducer.
- Connect the cable to the slip ring and TW2.
- Power up the TW2.
- Press the *Mode* button to put the TW2 into *Setup* mode.
- Record the output for each channel.

Insulation Check

Insulation resistance of the wheel torque transducer bridge circuits to the metal should be checked occasionally or if malfunction is suspected. The insulation resistance should be greater than 1000 M-ohms. Lower insulation resistance values may result from contamination of the connectors or breakdown of the strain gage insulation. If care is taken to clean the connector area and low values persist the transducer should be returned to Michigan Scientific for correction and re-calibration.

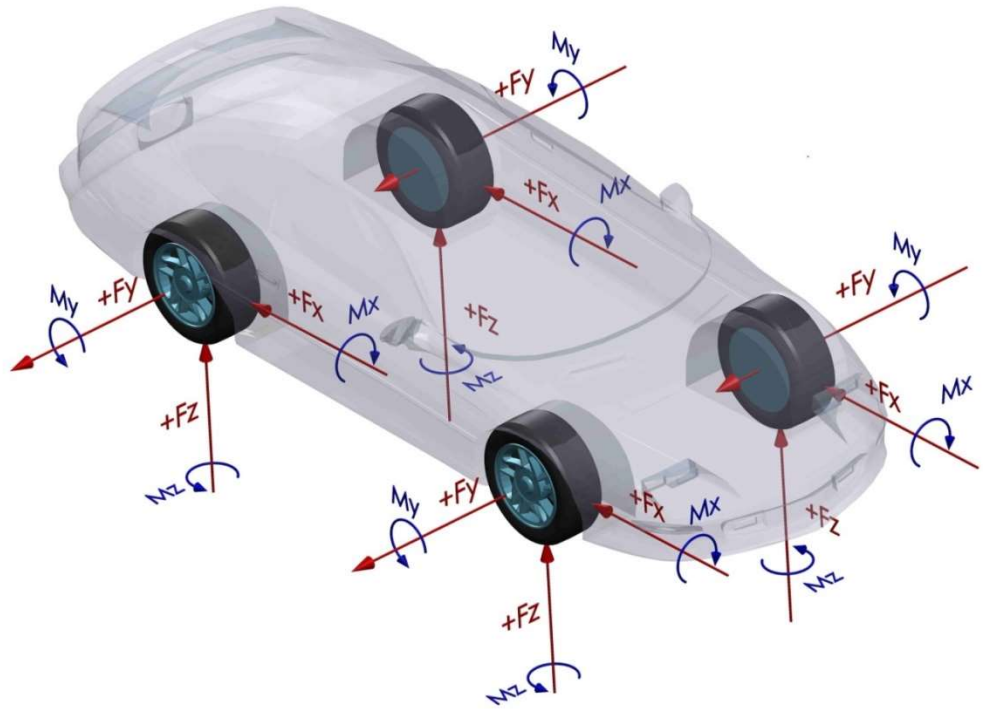
Weatherproofing

The connectors are weatherproof but using the tape provides some extra protection.

Sampling Frequency

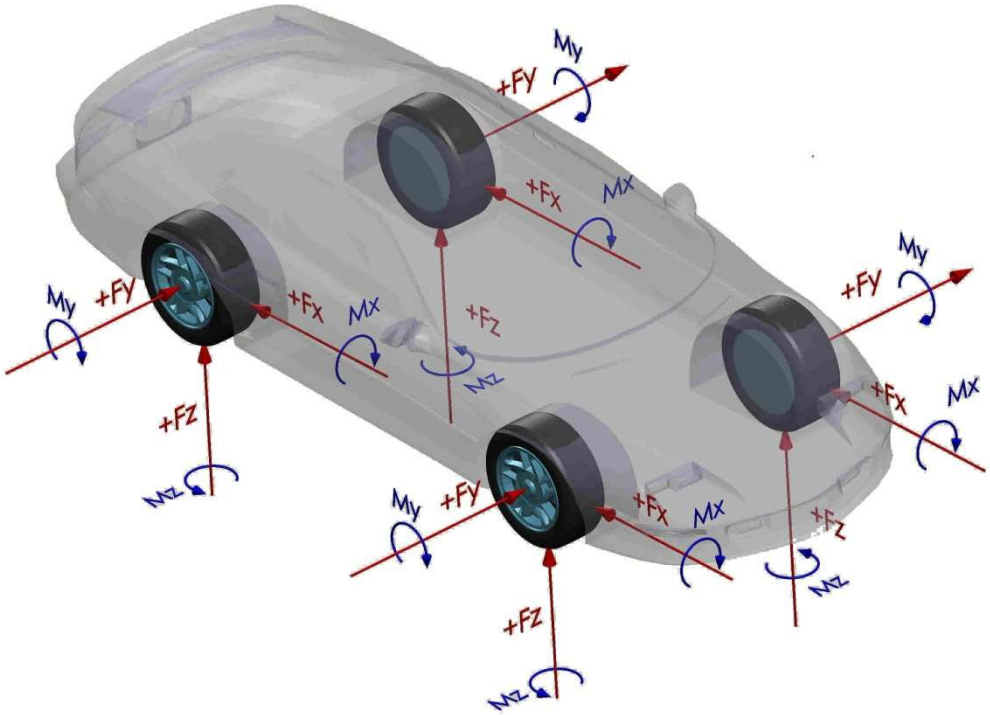
Much of the work done with WTTs is for driveline and efficiency measurements with a frequency of interest below 50 Hz. We recommend sampling rate of 500 Hz. The TW2 CAN output rate can be set between 250 and 2048 Hz.

Right Hand Rule Coordinate System (default)



This coordinate system will give positive My when accelerating the vehicle.

Left Hand Rule Coordinate System (Optional)



This coordinate system will give positive My when braking the vehicle.

Troubleshooting

Symptom	Possible Causes	Solution
TW2 Does not power up when the power switch is turned on.	Internal overload circuit is tripped. Power cord not connected to power. Power supply polarity is incorrect.	Cycle the power on the TW2. Check that power cord has power supplied to it and try to power up the TW2 again. Check polarity. See appendix. If incorrect, reverse power supply leads and try to power up the TW2 again.
Fault light illuminates at startup	Signal cable not connected properly. Memory chip communication failure.	Check signal cable connections. Cycle power, leave box off for 5 seconds before turning back on Cycle power, leave box off for 5 seconds before turning back on. Check for grounding loops and ensure proper TW2 grounding.
Fault light is flashing	No digital data stream from amplifier	Check signal cable for damage.
Position button flashes slowly	Two TW2s are set to the same vehicle position	Set all TW2s to the proper vehicle position corresponding to the location of the transducer it is connected to.
Position button flashes fast	The TW2s are set to different CAN output rates.	Stack and power all TW2s. Then connect to the TW2 webpage. Under the Configure CAN Bus tab, enter desired setting and hit the update button. This will set all stacked TW2s to the same CAN output rate
Zero light does not go out in Spinning Zero mode.	Did not complete two full revolutions.	Continue rotating wheels.
After zero sequence, Zero light goes out but Fault light illuminates.	Transducer offset greater than 4 volts. The electronics will still zero the channel that has greater than 4 V offset but it alerts the user. This condition can cause the system output to saturate before it reaches full scale. The Fault light will go out next time the power is cycled.	With wheel off of the ground, change TW2 to Setup mode and check output voltages. Confirm which channel has an offset greater than 4 V. Unbolt the wheel & hub adapter. If offset goes away, check adapters for damage. If offset does not go away, send transducer in to Michigan Scientific for Checkout and repair.

Symptom	Possible Causes	Solution
Shunt light does not go out and fault light illuminates after a shunt sequence.	Torque input to the transducer during shunt sequence causes out of tolerance shunt. TW2 failed to record data in memory chip. Transducer is out of tolerance.	Jack up vehicle, cycle power, and repeat the shunt sequence. Check the cable connections, cycle power, and repeat the shunt sequence. Send the transducer in for checkout and calibration.

Symptom	Possible Causes	Solution
Channels, which should have no load, have an offset even after the zero procedure is performed.	TW2 is in Set-up mode Data channels have error due to rolling zero procedure Incorrect zero, direction of wheel rotation was changed during the zero procedure. External forces were imposed during the zero procedure on the hoist. Incorrect zero, on-the-road zero was performed on a rough surface. Data acquisition system has some offset. TW2 electronics are damaged. Offsets are too large for the TW2 to zero them. Damage to transducer.	Switch TW2 to RUN mode If the rolling zero procedure was performed on the road, there will be real forces that will be zeroed out. For best accuracy, perform the zero on the hoist. Further discussion is in the zeroing section of this manual Be sure that the wheel is turned only in one direction during the zero procedure. When turning the wheels, be sure to apply force only on lug nuts with a wrench. This insures that no forces are imposed through the transducer. Redo the zero procedure. For best accuracy, perform the zero on the hoist. Using a volt meter, check the outputs from the TW2. If the outputs are indeed zero, null the offsets in the data acquisition system. Swap the TW2 with another unit, if available, and try to zero it. If the problem goes away, send the TW2 electronics in for checkout and repair The wheel may have been damaged. Remove from the wheel and hub adapters and place on the bench. Change the TW2 to setup mode. Check the offset. If it is out of range, send in for checkout and repair.

Symptom	Possible Causes	Solution
Outputs from TW2 stay zero for all channels even when force is present.	TW2 is not turned on. In Spinning Zero mode, Encoder has not found an index pulse. The bridge power kill feature is invoked. Signal cable from transducer has been disconnected. Signal Cable from transducer has been damaged. Output cable from the TW2 is disconnected or damaged. The data acquisition cabling is not connected improperly.	Check to see if the TW2 is turned on. The output channels stay at zero until the encoder sees an index pulse. Turn tire at least one complete revolution. Check outputs. Check to see if the bridge power light is on. If it is not, press the Bridge Power button. The light should illuminate. Turn off the TW2 electronics, reconnect the cable and turn the TW2 electronics back on. Inspect cable for damage. A cable diagram is located in the appendix. Check connection and inspect cable for damage Check the output from the TW2 with a volt meter. If the output is correct, check the cabling or data acquisition setup.
The channel offsets change during use.	A severe event caused some shifting in the bolted joints between the transducer and adapters. A severe event overloaded the transducer.	While it is not common, a severe event could cause some offset in channels. Perform the zero sequence. Check the transducer offsets. Remove the wheel and hub adapters. Change the TW2 to Setup Mode Check the offsets for each channel with a voltmeter. If the offsets have changed, send the transducer in for checkout and possible repair.

Symptom	Possible Causes	Solution
Higher or lower than expected output from one or more channels	The data acquisition system sensitivities are incorrect.	Check data acquisition system. The correct sensitivities are listed on the calibration sheet in the back of this manual.
	Incorrect amplifier package	Check that the correct amplifier package is being used with the transducer.
	Transducer is damaged.	Check the transducer offsets and shunt values. Send in for checkout and repair if needed.
	Amplifier package is damaged.	Send in for checkout and repair if needed
One or more output channels output incorrect polarity.	Right/Left Switch is not in the correct position.	Check to see if switch is correct. Change if needed.
	Cable to data acquisition is improperly connected.	Check the voltage from the TW2. If correct, check pin-out for signal cable to the data acquisition system.
	Sensitivity is incorrect in the data acquisition system.	Check the voltage from the TW2. If correct, check the sensitivities in the data acquisition system.
	Coordinate System is not as expected	Check the selected Coordinate System in the TW2 webpage
Data appears noisy	TW2 chassis ground not connected to vehicle chassis	Connect one end of a banana plug cable to the TW2 and connect the other end to the vehicle chassis or to data acquisition grounding stud, if the data acquisition is grounded to Chassis, not both.. Or Connect the shield of the TW2 power cable to the vehicle chassis.

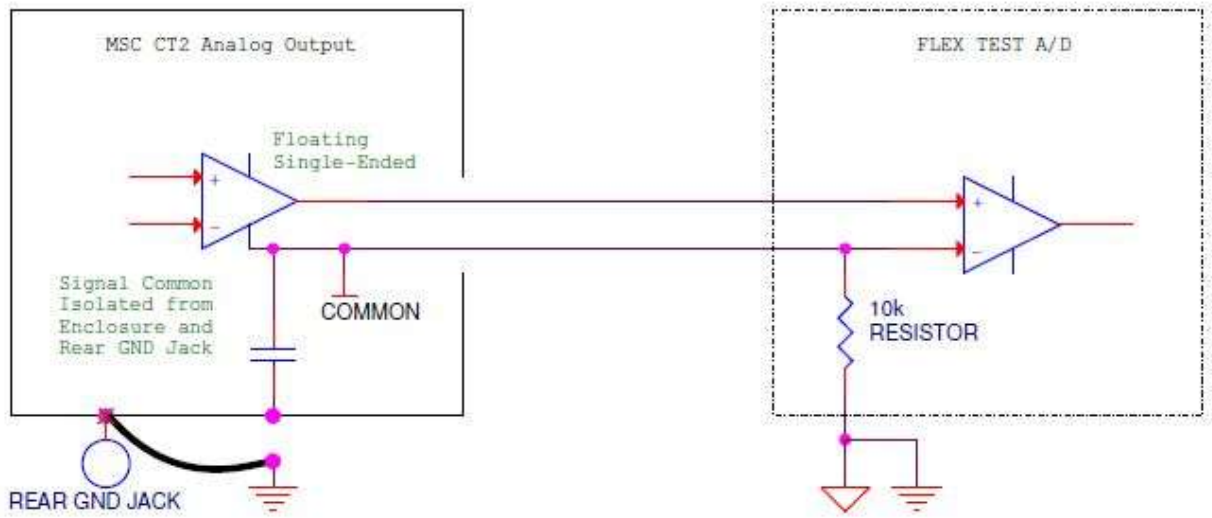
Appendix 1

Wiring and Shielding

TW2 *Power* Connector Pin-Out

Mating Connector for Power:		
1	Ground	Black Wire
2	Power High	White Wire
Case	Shield/Ground	

Proper TW2 Power and Signal Grounding Diagram



CAN Signal Delay Equation

The CAN signal delay is constant and fixed based on selected output rate. The default output rate is 500 Hz, which gives a delay of 34 milliseconds. The following equation can be used to calculate delay at different output rates.

TW2:

Instructions to calculate the total delay of the TW2 system's CAN signal outputs*

For CT2 CAN Output Sample Rate of 250 to 499 Hz:

Approximate Through Delay in ms = ((63.5 / (CAN Data Rate in Hz * 8)) + 0.002295) * 1000

For CT2 CAN Output Sample Rate of 500 to 999 Hz:

Approximate Through Delay in ms = ((63.5 / (CAN Data Rate in Hz * 4)) + 0.002295) * 1000

For CT2 CAN Output Sample Rates ≥ 1000 Hz:

Approximate Through Delay in ms = ((63.5 / (CAN Data Rate in Hz * 2)) + 0.002295) * 1000

Example Quick Reference Calibration Sheet

Notes: