

Michigan Scientific Corporation

Wheel Force Transducer System



Model: LW25 with CT3
for Telemetry set-ups

For Motorcycles and Light Vehicles



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corporation

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Introduction

The Michigan Scientific Wheel Force Transducer (WFT) system is a 6-axes transducer that measures forces and moments on a vehicle wheel. Michigan Scientific WFTs are around known for their accuracy, reliability, simple installation, ease of set-up, and use.

The WFT gets mounted to a Rim Adapter and hub adapter. Once bolted together, this assembly replaces the production wheel. A standard tire is mounted the rim adapter in the same manner as it is mounted to a production wheel. The system is designed such that all forces and moments on the wheel must pass through the WFT, where they are measured, before being transferred to the vehicle hub.

The WFT has six independent strain gauge bridges that measure the forces and moments. Each WFT contains approximately 100 strain gauge elements. The transducer is designed to have low cross talk between channels and to be insensitive to temperature change and magnetic fields. An Telemetry & Encoder Ring gets bolted to the WFT and provides excitation and amplification to the strain gauged bridges. The Telemetry Transmitter digitizes all signals before transmitting them to the Telemetry Stator. The Telemetry Stator combines the received force and moment channels with the Encoder signal, and send these signals to the CT3. Each Induction Module contains a embedded Smart Sensor. The Smart Sensor contains all the calibration information, last Zero off-set values, and test set-up selections.

A consequence of incorporating the sensing elements of the Rotating WFT, is that a Coordinate Transformation is required to provide the output signals in a fixed coordinate system. Coordinate transformation is handled by the CT3 User Interface Box. In addition, the CT3 handles Zeroing, Cross-talk correction, Shunt Calibration system check, Polarity Correction to put all WFTs into a global vehicle coordinate system, and movement of measurement origin. Standard signal outputs for CT3 are CAN 2.0, CANFD, and Ethernet via OpenDAQ. With additional modules, CT3 can provide Analog signal outputs or output through EtherCat. The CT3 has an internal webpage for selecting set-up options, are accessed through USB or Ethernet connection to a laptop or mobile device.

Specifications

MSC LW25
6-Axis Wheel Force Transducer
Aluminum

Capacities

Maximum Force Capacity	[Fx, Fz]	5,600 lb	25 kN
	[Fy]	2,000 lb	8.9 kN
Maximum Torque Capacity	[Mx, Mz]	1,500 lb-ft	2.0 kN-m
Maximum Torque Capacity	[My]	2,500 lb-ft	3.4 kN-m
Maximum Recommended Static Corner Weight		1200 lb.	550 kg

Other

Transducer	6 independent, full strain gage bridges
Nonlinearity	Less than 0.25% of full-scale output
Hysteresis	Less than 0.25% of full-scale output
Cross Axis Sensitivity after correction	<0.4% of full-scale
Radial Sensitivity Variation	<0.3% of radial load
Transducer Temperature Range	-40 to 125 C (-40 to 257 F)
Insulation Resistance from Bridge to Case	Exceeds 1000 Mohm
Vehicle Power Input Voltage	9 to 36 VDC
Telemetry Frequency Range	2.4 GHZ

Mass of Components, Typical

Component	Lbs.	Kg
Wheel Force Transducer	3.2	1.5
Telemetry Ring	1.9	0.9
Telemetry Stator with Cable	1.7	0.76
CT3 Electronics	2.5	1.1

System Components

The Wheel Force Transducer Measurement System is made up of multiple components.

Transducer



Six Axes Wheel Force Transducer. Each transducer has 6 full bridge strain gage outputs, one for each force, and one for each moment.

Telemetry & Encoder Ring



The Telemetry & Encoder Ring, TEL-ENC-25 has built-in RF Telemetry Transmitter, induction regulator, encoder magnet ring, & secondary induction coil. The telemetry transmitter provides excitation and amplification to the strain gage bridges. It also contains the precision shunt calibration resistors with low temperature coefficients which insure good performance over all temperature ranges.

The Telemetry Transmitter frequency is set in the factory and must be used with a Telemetry Stator set at the same frequency.

The TEL-ENC-25 is bolted to the LW25 transducer at the factory and should remain mated with the transducer that shares its serial number, as they were calibrated as a mated pair.

Telemetry Stator



The Telemetry Stator, TEL-STATOR-25, contains the RF Telemetry Receiver, Primary induction coil, and Hall Effect sensors. The RF Telemetry Receiver detects and processes the signals from the Telemetry Transmitter. These signals along with the encoder pulse signals are digitized and sent the CT3 for signal processing. The frequency of each Telemetry Stator is programmed in the factory to match the RF frequency of the transmitter built-in to a particular WFT. The frequency of each Telemetry Stator can be changed with the CT3 webpage, see page 69. Two Stator Temperature channels give the internal temperature of the radio circuits in the Telemetry Stator. If conducting tests with significant braking, these should be monitored and the Telemetry Stator temperature should be kept below 125 degC. Perform cooling laps or use industrial fans to cool the Telemetry Stator and vehicle brakes.

CT3 Electronics



CT3 Electronics. This is the User Interface for WFT System. Detailed instructions start on page 38. Pictured above with the CT3 with CT3 baseplate installed.

Induction Module



Induction Module. The Induction Module has two major functions. It plugs into the CT3, and the Telemetry Stator cable plugs into it. It converts DC power provided by CT3 to AC power which is supplied to the Telemetry Stator Primary induction coil. The Induction Module also contains the Smart Sensor for the WFT. The smart sensor has all the calibration information, RFID of the WFT transmitter, Zero values, and software settings. The SN of the WFT must match the SN of the Induction Module.

Hub Adapter



1-PC Conventional Wheel Hub Adapter



1-PC Motorcycle Wheel 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.

For LW25 two types of hub adapters are made. The first type is for a ‘conventional wheel’ type, and the second type is a ‘motorcycle wheel’, which will mount on a motorcycle with double sided swing arm.

Both types of hub adapters are machined from aluminum.

If you intend to design and manufacture WFT adapters yourselves or have a 3rd party company manufacture them, please follow the Adapter Design Guides, so boundary conditions are consistent and the WFT provides the most accurate results. Contact Michigan Scientific for adapter design guidelines.

Rim Adapter



1-PC Conventional Wheel Rim Adapter



1-PC Motorcycle Wheel Rim Adapter

Michigan Scientific (MSC) makes two types of rim adapters for the LW25 WFT. The first type is for a ‘conventional wheel’ type, and the second type is a ‘motorcycle wheel’ type which are narrower and usually larger diameter.

Both types of hub adapters are machined from aluminum forgings or plate.

If you intend to design and manufacture WFT adapters yourselves or have a 3rd party company manufacture them, please follow the Adapter Design Guides, so boundary conditions are consistent and the WFT provides the most accurate results. Contact Michigan Scientific for adapter design guidelines.

Power Cable



Power Supply cable. This cable is supplied from the factory with no connector on one end. An active fuse is located in the CT3 electronics. The white lead is for 9-36 VDC power high. The black lead is power ground.

Optional Analog Output Module



CT3 Analog Output Module. This module converts digital signals to Analog outputs.

Optional Tinned Lead Analog Output Module Cables



CT3 Analog Output Module Cables with tinned leads. Each cable can connect to four channels. Analog Output Module cables with BNC cables also available.

USB-A to USB-C Cable



Connect CT3 to Laptop or mobile device with USB-C cable. After cable is connect, open the web browser go to www.CT3.local

CAN Bus Cable



CAN Bus Signal output cable. They can be made with a DB9 or eDAQ connector on them. CT3s send high speed data through their interconnector, so each CT3 does not need a CAN connector plugged in.

With 4 WFTs, the max sample rate with for one CAN 2.0 Bus is 550 Hz. With 4 WFTs, the max sample rate with two CAN 2.0 Buses is 1024Hz.

CT3 Grounding Cable



CT3 Chassis Grounding cable

Optional Ethernet Cable



Ethernet Cable can be used to send signal outputs via Ethernet through OpenDAQ standard or to computer with MSC's recording software. Also connects the CT3 to a computer to access the embedded CT3 webpage as an alternative to the USB connection. To connect CT3 via Ethernet, change the static IP address of the connected device, and use the CT3 webpage address, 192.168.0.28.

Telemetry Alignment Tool

This alignment tool is used to properly align the Telemetry Stator to the Telemetry Ring. The alignment tool sets both the concentricity and gap. One curved surface should be in contact with the outside of the Telemetry Ring and the other curved surface should be in contact with the outer surface of the Telemetry Stator.



Telemetry Stator Bracket



Adjustable bracket used to secure the Telemetry Stator to the Carrier bolt on the brake caliper.

WFT and Telemetry Stator Frequencies

The telemetry used in Michigan Scientific WFT-TELS broadcasts in the 2.407 to 2.487 GHz range. Each Transducer is set to a distinct frequency channel within that range so that each set of transducers do not interfere with each other. Each Telemetry Stator is programmed to a certain channel matching only one of the WFT-TELS in that set. Together they form a matched pair. If a Telemetry Stator gets damaged, a spare can be reprogrammed by the customer to the needed channel to replace the damaged Telemetry Stator. Information on reprogramming the Telemetry Stator can be found on page 69.

Spinning Telemetry Assembly Instructions

This section of the manual describes the assembly of the Transducer with Telemetry and Encoder Ring, wheel and hub adapters, Telemetry Stator Brackets, and Induction Module.

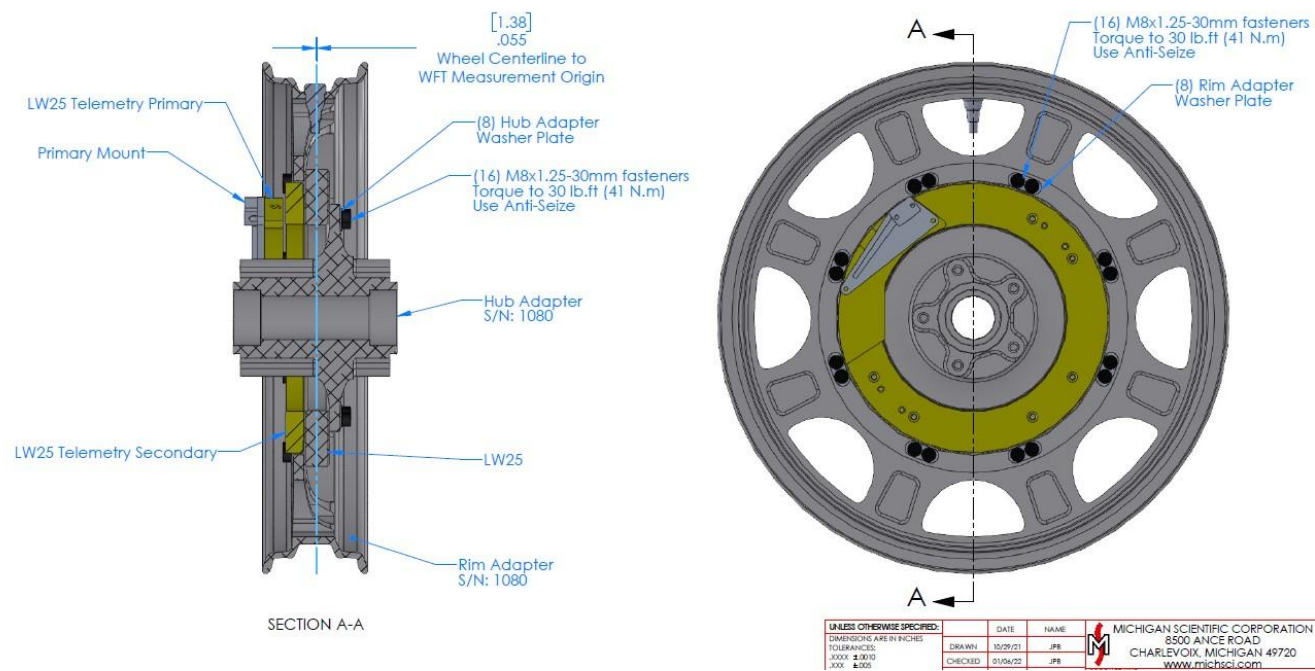
Before Assembly

- Be sure that all mating surfaces are free of dirt.
- Use care when assembling the transducer to avoid damage to any part of the system.
- Use care when installing the tire to insure that the adapter mating surfaces and transducer do not get damaged.

Note: First install the tire onto the rim adapter. This can be done on a standard tire change machine.

Example Assembly Diagram

Customer Drawing



Assembly Motorcycle Wheel

- Place the WFT up to the hub adapter as shown, and install sixteen M8-1.25 x30mm bolts with washer plates and anti-seize on the bolt thread through the hub adapter and into the transducer.



- Turn the WFT & hub adapter assembly over and set the rim adapter on of the WFT & hub adapter assembly. Install sixteen M8-1.25 x30mm bolts with washer plates and anti-seize on the bolt thread through the rim adapter and into the transducer.



- With a star pattern, tighten all M8 bolts to 30 lb.ft (40 N.m).
- Install WFT assembly onto Motorcycle.

Installing the Telemetry Stator Bracket for Motorcycle

Michigan Scientific can provide an adjustable Telemetry Stator Bracket. However motorcycle installations often require some custom bracketry. Any custom brackets must be rigid enough to prevent Telemetry Stator movement and prevent contact with any rotating components.

The adjustable telemetry stator bracket is made up of the following components:



1. Caliper bolt
Attachment 1 -left



2. Caliper bolt
Attachment 2 – right



3. Bracket elbow



4. M10 bolts & sleeves



5. TEL-STATOR backing
Plate - left



6. TEL-STATOR backing
Plate - right



7. 0.500" low carbon steel rod; Cut to length, as needed.

Below is an example of the Telemetry Stator Bracket fully installed on a Motorcycle wheel. The axle center bolt can sometimes be used to mount the Telemetry Stator bracket, as shown.



- Use the Alignment tool to ensure proper alignment between the Telemetry Ring and a Telemetry Stator. This provides both concentricity and proper gap setting. Concentricity between the Telemetry Ring and Telemetry Stator is the most important.
- Tighten all bracket bolts. If using MSC provided bracketry, tighten bolts to the specified torque below.

Bolt Size	Tightening Torque	Bolt location
M4 x 20mm SHCS	2.25 N.m	Telemetry Stator to Backing plate
M10 SHCS, varying lengths	54 N.m	Bracket elbow to backing plate/caliper bolt attachment
M8 set screw	10 N.m	Bracket elbow to steel rod
M14 Caliper bolt	190 N.m or manufacturer's spec.	Caliper bolt attachment to Brake Caliper

- After tightening, re-check alignment with Alignment Tool. You should be able to press against the Telemetry Stator by hand without the bracketry shifting. If the bracketry is sufficiently tight and alignment is still proper then proceed to Cable Routing.

Cable Routing.

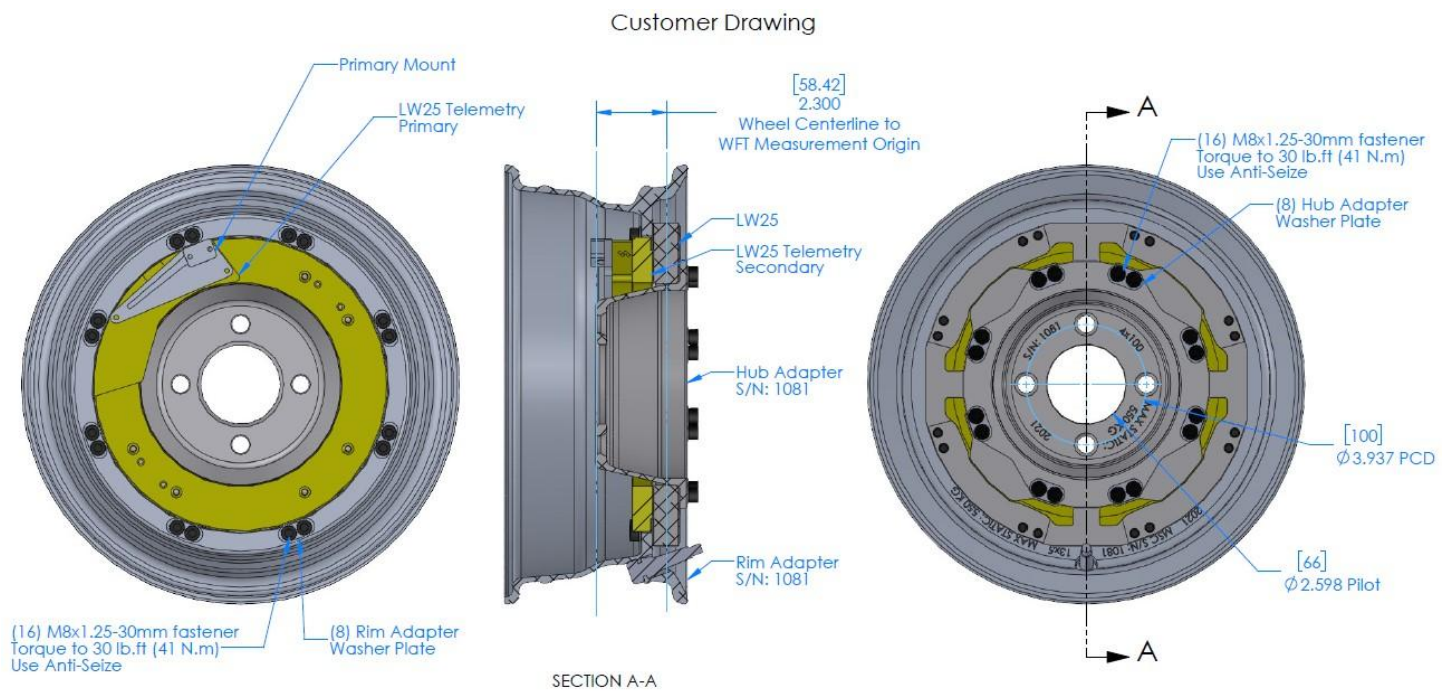
- Secure the Telemetry Stator Bracket cable to the motorcycle forks allowing sufficient cable slack for suspension travel.



- Turn the wheel its full range of motion to ensure that the cable will at no point contact a rotating component.
- Route Telemetry Stator cable to the CT3.



Assembly Diagram Conventional Wheel



Assembly Conventional Wheel

- Place the Transducer with Telemetry on end, insert the hub adapter, and install two M8-1.25 x30mm bolts with washer plates anti-seize on the bolt thread through the hub adapter and into the transducer.



- Set the hub adapter on a flat surface and install the remaining M8-1.25 x30mm bolts with washer plates anti-seize on the bolt thread. The bolt can remain hand tight for now.



Installing the Telemetry Stator Bracket

Michigan Scientific can provide an adjustable Telemetry Stator Bracket. The provided Bracket may not fit all vehicles. If the provided bracket cannot mount in your vehicle a custom bracket must be fabricated by the customer. Any custom brackets must be rigid enough to prevent Telemetry Stator movement and prevent contact with any rotating components. Custom bracket should also include a heat shield.

The adjustable telemetry stator bracket is made up of the following components:



1. Caliper bolt
attachment 1 -left



2. Caliper bolt
attachment 2 – right



3. Bracket elbow



4. M10 bolts & sleeves



5. TEL-STATOR backing
Plate - left



6. TEL-STATOR backing
Plate - right



7. 0.500" low carbon steel rod; Cut to length, as needed.

Here is an example of the Telemetry Stator Bracket fully installed.



Below are the installation instructions for the adjustable Telemetry Stator Bracket. All Telemetry Stator Bracket bolts should be installed with a small amount of anti-seize.

1. Remove wheel from vehicle.



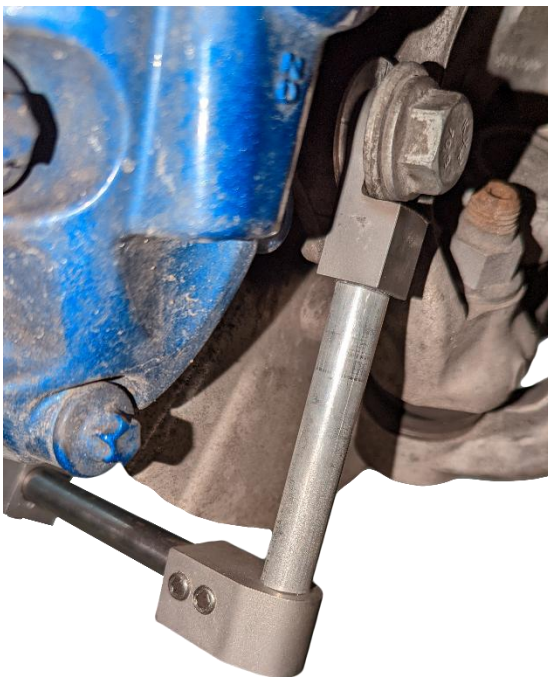
2. Remove the carrier bolt/Caliper bolt which holds the brake caliper to the knuckle.



3. Depending on vehicle specifics, install the **Caliper bolt attachment #1** or **Caliper bolt attachment #2** between the Caliper bolt and the brake caliper bracket.



4. Find the appropriate length **M10 bolt and sleeve** to connect the **Caliper bolt attachment part** and **Bracket Elbow** while just having clearance past the brake rotor. In some applications there is little clearance between the brake rotor and Wheel inner diameter.



5. Install the appropriate **TEL-STATOR Backing plate** to the **Telemetry Stator** with 3 M4x20mm bolts. Then install a **Bracket Elbow** to the **TEL-STATOR Backing plate** with an **M10 Bolt and sleeve**.



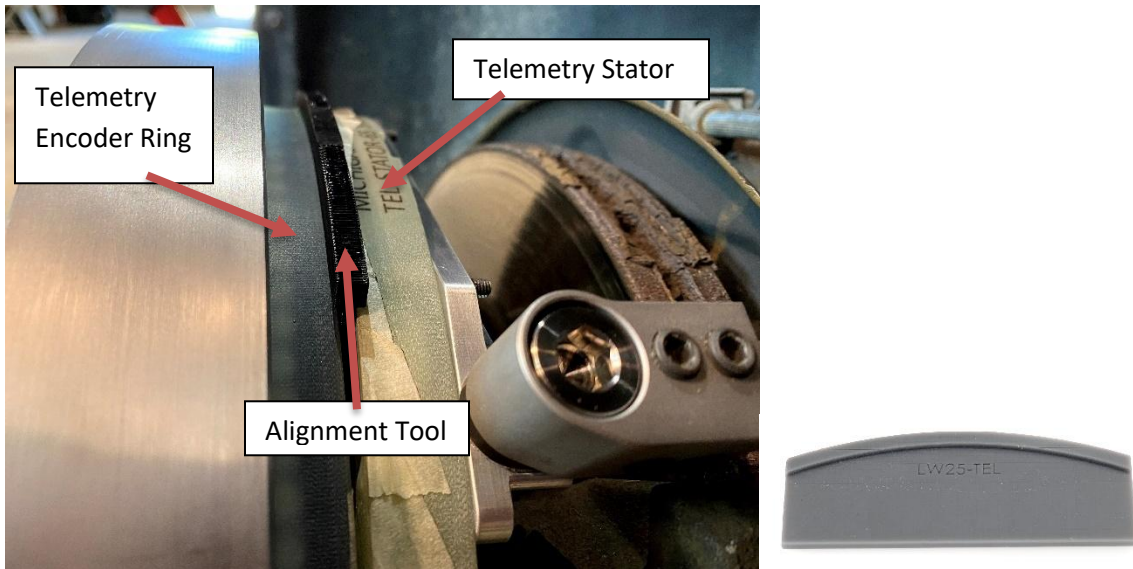


6. Install the WFT and hub adapter assembly to the vehicle hub.



7. Bring the Telemetry Stator near the WFT and use the **Alignment Tool** to locate the Telemetry Stator into its exact location. **The Telemetry Stator concentricity**

to the Telemetry Encoder Ring is critical. Find out the length of steel rod that is required to join the two **Bracket Elbows** and cut the 0.50” provided steel rod to the correct length.



8. Install the entire Telemetry Stator Bracket. Use the M8 set screws to tighten the Bracket Elbows to the 0.50” steel rod. The set screws should make a small indent into the rod. Check alignment. At this time you may need to adjust the **M10 Bolt & Sleeve** length or the **0.50” Steel rod length** to improve the alignment.
9. Once proper alignment is achieved, all bolts must be tightened to proper specification. A small amount of anti-seize should be used on all bolts.

Bolt Size	Tightening Torque	Bolt location
M4 x 20mm SHCS	2.25 N.m	Telemetry Stator to Backing plate
M10 SHCS, varying lengths	54 N.m	Bracket elbow to backing plate/caliper bolt attachment
M8 set screw	10 N.m	Bracket elbow to steel rod
M14 Caliper bolt	190 N.m or manufacturer's spec.	Caliper bolt attachment to Brake Caliper



10. After tightening, re-check alignment with Alignment Tool. You should be able to press against the Telemetry Stator by hand without the bracketry shifting. If the bracketry is sufficiently tight and alignment is still proper then proceed to Cable Routing.
11. Temporarily connect Telemetry Stator to CT3 and try to perform an Angle Zero. With CT3 in set-up mode, press Angle Zero. Then rotate WFT until Angle Zero light starts to flash, indicating the index pulse has been found. Then point Z+ arrow vertically towards the ground, and press Angle Zero button a second time. If this is successful, then Telemetry Stator alignment is good.

Cable Routing.

12. Secure the Telemetry Stator Bracket cable to the brake caliper or steering knuckle being sure to clear the brake rotor with an air gap between the cable and brake rotor. The cable must also clear the ID of the wheel adapter. Routing the

cable towards the center of the wheel is recommended and minimizes movement while steering.



13. Turn the wheel its full range of motion to ensure that the cable will at no point contact the wheel adapter or brake rotor.
14. Route Telemetry Stator cable back into the cab of vehicle where the CT3 will be located. Typically the cable is either routed under the vehicle and then into the cab or behind the wheel well lining and then through the window of the vehicle. Be sure to properly secure cable to the vehicle, avoid any moving parts, and leave slack in the cable so that the wheel can fully steer and suspension can fully compress/extend without damaging the cable.
15. Once the Telemetry Stator Bracket is properly aligned and all the bolts are properly tightened, and cable has been routed, remove the WFT/Hub Adapter Assembly

16. Place the WFT/Hub Adapter assembly onto the Rim adapter, install sixteen M8-1.25 x30mm bolts with washer plates and anti-seize on the bolt thread through the transducer and into the rim adapter.



17. Torque all of the M8 bolts to 30 lb.ft (41 N.m) torque using a crisscross pattern:
18. Install the WFT assembly on the vehicle being careful not to contact the Telemetry Stator or its cable. Check clearance between the Telemetry Stator bracket and the ID of the rim adapter. Make adjustments to the bracket, as needed, if there is contact. Again check the cable clearance to the rim adapter. Be sure to turn the wheel full left and right to check cable clearance. Tighten the lug nuts to the vehicle manufacturer's specified torque.



CT3 Cable Connections and Signal Outputs

- Connect the other end of the Telemetry Stator to the Induction Module with the SN of the Induction Module matching the WFT SN.
- Connect the Induction Module to the Input connector of the CT3.
- Connect the power cable to the CT3 electronics.
- Connect other end of the power cable to a DC voltage source in the range of 9 to 36 volts. The white wire is for power high. The black wire is for power ground.

CAN Bus Signal Outputs

- If using CAN Bus signal output, connect one end of the CAN Bus cable to the CT3 and the other end to the data acquisition/controller. If using one CAN Bus for all CT3s, connect the cable to the top CT3 box and select 'All-to-Top' mode in CT3 webpage. If using two CAN buses select '2-to-1' mode in the CT3 webpage and

plug a CAN cable into each CT3 set to Left side of vehicle. For example LF CT3 will output signals from LF & RF. If using one CAN bus for each CT3 select 'Direct Output' mode in the CT3 webpage and plug a CAN cable into each CT3. A .dbc file specific to your test can be downloaded from the CT3 webpage. In addition to force, moments, speed and position output, additional telemetry diagnostic channels will be output on CAN. They are two stator temperature channels, two RSSI channels, TX power, Pod power, & No RF signal channel.

Analog Signal Outputs

- If using analog outputs, connect the CT3 Analog Module to the CT3. Then use DB9 connector output cables, to the data acquisition/controller. CT3 Analog outputs are Floating Single-Ended Outputs. The delay on the Analog signal outputs for Telemetry based systems is 2.0 milliseconds. The charts below show the AUX channel assignments and the output cable wiring diagram.

CT3 Analog Output Module - 9/19/2024	
AUX Channel Mapping	
AUX #	Telemetry
1	(Reserved)
2	(Reserved)
3	(Reserved)
4	StatorTemp0
5	SineWFT
6	CosWFT
7	StatorTemp1
8	(Reserved)

CT3 Analog Output Module - Output Cable Pinout			2/15/2023
Pin#	Function	Description	Color
1	GND	NC	NC
2	Output 2	Signal 2 High	White
3	GND	Signal 2 Low	Brown
4	Output 4	Signal 4 High	Yellow
5	GND	Signal 4 Low	Green
6	Output 1	Signal 1 High	Red
7	GND	Signal 1 Low	Blue
8	Output 3	Signal 3 High	Pink
9	GND	Signal 3 Low	Gray
NC = Not Connected			

CT3 Chassis Ground Connection

- In many Spinning application tests the CT3 will perform without noise issue without connection to chassis ground.
- If there is a potential noise issue or the smart sensor cannot be read or written, connect the CT3 to vehicle chassis ground. **This can be done in one of the two following ways.** Be sure to not create a grounding loop by connection the CT3 and Data Acquisition both to the vehicle chassis.

Ground Connections in vehicle (select only one of these)

- 1 Connect one end of the CT3 Grounding Cable to the banana plug in the back of the CT3 and connect the other end of the cable to the vehicle chassis or if Data logger is already connected to the vehicle chassis then connect the grounding cable to the Data logger grounding stud.
- 2 Connect the shield of the CT3 power cable to the vehicle chassis or if Data logger is already connected to the vehicle chassis then connect the grounding cable to the Data logger grounding stud.

CT3 Power-up

- Turn the power switch on to the CT3 with the Power button on the back of the CT3. At power-up, the CT3 will automatically read the information stored in the smart sensor of the Induction Module. This information includes RF ID of the transmitter, zero values, shunt calibration values, desired full scale outputs, transducer information, and CT3 webpage settings. Since the calibration information is stored in the Induction Module and not the CT3, the CT3s are interchangeable.
- At this time (if CT3 is in Run mode & Spinning Mode), the force, moment, and position channels are held at zero and the screen will display 'ROTATE WHEEL' until the CT3 receives an index pulse from the Encoder.

CT3



Introduction

One CT3 is used for each wheel force transducer. The CT3 is the User Interface. It also performs coordinate transformation, cross-talk correction, zero off-set adjustments, and vehicle position polarity adjustment in real time. The CT3 buttons can initiate a Zero function, a Shunt Calibration function, Zero Angle, and be set for Vehicle position of installed WFT. The CT3 also has an embedded webpage to access additional set-up options, configure CAN Bus output, and create a .dbc file. The front of the CT3 has a display which will tell you the SN of the WFT connected, current User selected settings in the CT3 and any current Faults or Errors in the system.

Main CT3 Set-up Functions

The main set-up functions that should be done at every new test installation and set-up are Position, Zero, Shunt, and Zero Angle. The position button allows the user to indicate to the CT3 what wheel position the transducer is mounted and this should be done first so all stacked CT3s can communicate. The remaining functions can be done in any order. The Shunt button performs a Shunt calibration and compares it to the factory Shunt calibration. This verifies that the Transducer and Telemetry are working properly. The Zero adjusts the off-set of each WFT channel. This must be done each time the

transducer re-bolted to the adapters. The Zero Angle sets the Z reference angle of each WFT. Details of each main set-up function are described further below.

Important CT3 Website selections

One main set-up function that should be checked in the CT3 Webpage for each Test set-up is the Measurement Origin. The default Measurement Origin is the center of the transducer. See page 57, to change the WFT Measurement Origin. You should also verify that the Coordinate system set in the CT3 webpage matches your desired Measurement Origin. The current Measurement Origin setting can be seen on the Display. If being used in a Non-spinning application, you should check the 'For Simulator Use' Box on the CT3 webpage.

CT3 Basics

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 button is located on the rear panel and position/screen advance control is located on the front panel.

Powering Up

Note: It is good practice to first connect all cables to the CT3 electronics before powering it up. If this is not done, possible damage may occur. In addition, the CT3 reads important transducer information, from the smart sensor in the induction module, at startup. If the smart sensor is not read on power-up, the FAULT light will be lit.

The power switch turns the power on and off. When the CT3 is turned on, it defaults to Run Mode. This will be indicated by green light on the front panel. Transducer offsets, sensitivities and other information is read from the smart sensor during power up.

Display

The CT3 has a display on the Front. The display will always show the user which Serial Number WFT it is connected and which Wheel Position is selected. In RUN mode,

pressing the POSITION/ADVANCE button will jog through various CT3 User selected option, for easy viewing without connecting to the CT3 webpage. To change any of these setting, the user must connect to the CT3 webpage.

If there are any FAULTs or ERROR codes, these will be displayed on the Display as well.

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. If an error occurs during the Zero process 'ZERO ERROR' will be indicated on the display. The zeroing sequence records data and calculates an offset value. This offset is recorded into the smart sensor located in the Induction Module so it is not lost when power is interrupted or a different CT3 is used. When set to Spinning Mode, the CT3 uses 2 or 8 revolutions of the tire 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 CT3 senses that the wheel is turning above 15 rpm, it uses 8 revolutions to get a better on-road-averaged value. (The is referred to as rolling zero). When set to Non-Spinning Mode, the CT3 nulls all channels.

Zero Angle

To initiate a Zero Angle, ensure the CT3 is in Set-up mode with the wheels off of the ground and able to rotate freely. **If CT3s are stacked, pressing the Zero Angle button will initiate the Zero Angle function for only the top box. To Zero Angle lower boxes, hold the 'Position/Advance' of the desired CT3, then press the Zero Angle button on the top box. See pictures below.**

Press the Zero Angle button, rotate the wheel until the Zero Angle light starts to flash. Then point the Z+ arrow on the transducer or amplifier vertically towards the ground and press the Zero Angle button a second time. If the wheel has already been rotated while the CT3 has been powered on, then the Zero Angle light will flash immediately upon pressing the button the first time. A level or digital protractor should be used across the

bolts of the WFT to ensure that the Z+ arrow is completely vertical before pressing the Zero Angle button the second time.



ZERO ANGLE of top CT3



ZERO ANGLE of lower CT3

Shunt

The *Shunt* light is used to indicate shunt related features. The button located on top CT3 to invoke a shunt sequence for **all CT3s in the stack**. The shunt sequence performs a Shunt calibration and compares these field Shunt values to the factory Shunt values. After a successful shunt sequence, the Shunt light turns off and updates the smart sensor. If the field Shunt value and Factory Shunt value differ by more than 2.5%, the fault and Shunt light stay lit and 'SHUNT ERROR' will be indicated on the display. This often indicates an issue with the transducer or amplifier.

To perform a **SHUNT on only one CT3**, hold in the POSITION/ADVANCE button, then press the SHUNT button of the top CT3, as shown below.



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 for Set-up and Troubleshooting. Zero, Shunt, Zero Angle, and Position features cannot be accessed unless the CT3 has been switched to Setup mode. In set-up mode, coordinate transformation and zero off-set adjustment are not performed.

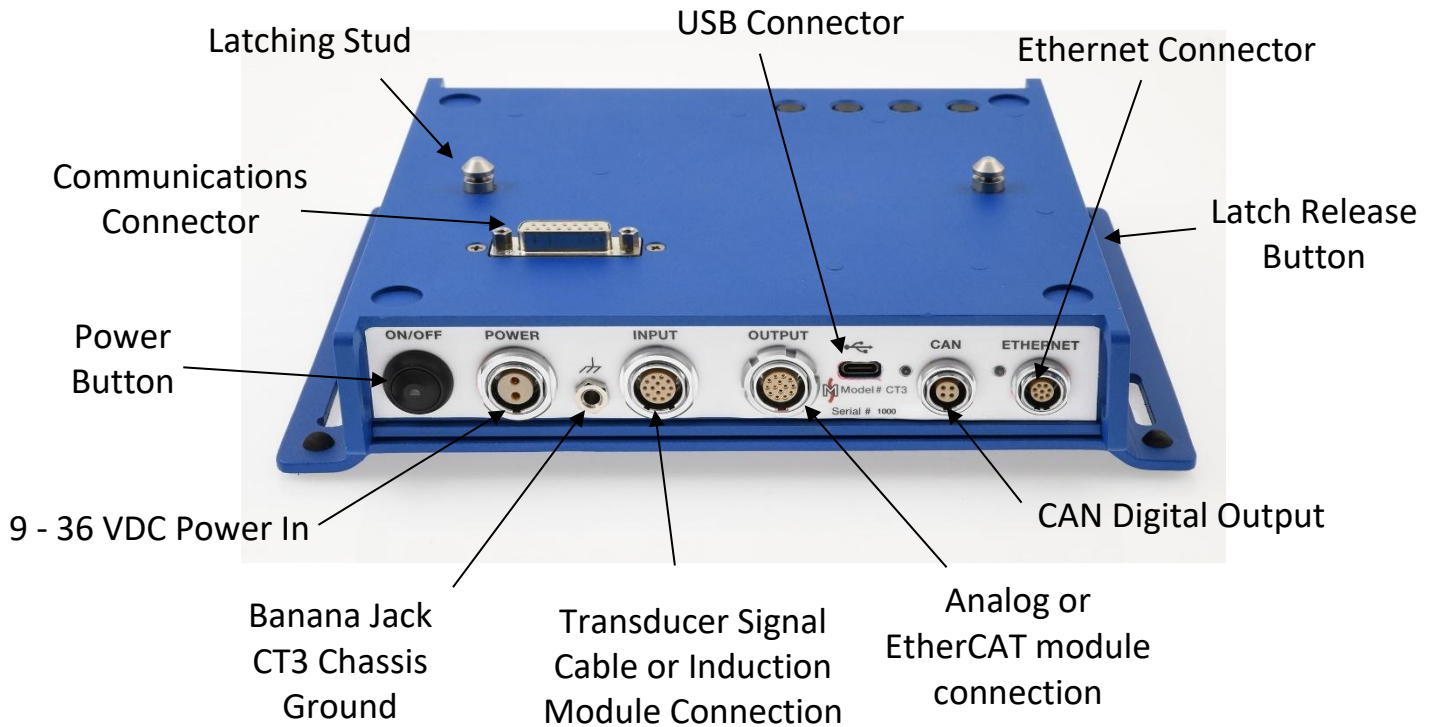
Fault

The fault light indicates that there is a problem with the module. It can be lit in conjunction with other lights or by itself. The corresponding fault message will be indicated on the display.

Position

The position button allows the user to indicate to the CT3 what wheel position the transducer is mounted. Different coordinate transformation equations are used on the right vs. the left side of the vehicle. This information is also used by the CT3 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 CT3 units, the position information is shared between the CT3 electronics. If two or more CT3 electronics are assigned to the same wheel location, 'DUPLICATE POS' message will be displayed on the display.



Connectors

Connectors located on the back panel of the CT3 are for power, ground, Transducer signal cable/Induction Module, Analog output module/EtherCAT output module, USB connection to webpage, Ethernet connection, and CAN digital Signal output. The D-sub connectors located on top and bottom of the enclosure are used for communications between multiple CT3 electronics.

Multiple CT3s



Each CT3 is used with one Wheel Force Transducer. When using multiple Wheel Force Transducers systems, the CT3 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 CT3 electronics communicate with each other using a digital bus interface. This allows the operator to control all of the CT3s with one set of controls. Notice that the control buttons are located on top of the enclosure. When one CT3 is stacked on top of another, the buttons on the lower one are covered. All functions are controlled by the top CT3 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 CT3.

The power supply cable can be connected to any one of the CT3 electronics. That CT3 will supply power to the rest in the stack, therefore only one power cable is required.

Each CT3 retains its own power switch and must be turned on individually. At power up, the CT3 checks the state of the other boxes and then sets itself to match.

Up to four CT3 electronics can be stacked together. If you want to stack more together, please contact Michigan Scientific to discuss your specific application.

Power Requirements

The CT3 requires 9 to 36 VDC power. Power draw is 10 watts for each WFT system.

One power cable will power a stack of CT3s (up to 4)

Individual CT3 Shunt or Zero

If you have a stack of CT3s, pressing the SHUNT button on the top CT3 perform a SHUNT for all CT3 boxes in the stack. If you only want to perform the SHUNT for one WFT, then hold in the Position/Advance button, then press the SHUNT button on the top box.

If you have a stack of CT3s, pressing the top ZERO button if perform a ZERO for all boxes in the stack. If you only want to perform the ZERO for one WFT, then hold in the Position/Advance button, then press the ZERO button on the top box.

Signal Outputs

Eight main signal outputs are available from each CT3 along with additional diagnostic channels. The channels are for force and moments about the x, y, and z axes, and also Wheel Speed, & Wheel position. In the CT3 webpage you have the option to replace Wheel Speed and Wheel Position with Sine and Cosine Outputs in the digital outputs.

Using CAN Signal Outputs

The CT3s send high speed data through their internal connection allowing the CAN data to all be output from the top CT3, if desired. There are three user selectable CAN output option, 'All-to-Top', '2-to-1', and 'Direct Output'. With 'All-to-Top' selected all the data from the stacked CT3s will be output on a single Bus from the Top CT3 CAN connector.

With '2-to-1' selected the data from a single axle will be output to the Left side CT3. For example LF CT3 will output signals from LF & RF.

With 'Direct Output' Selected the data from each WFT will be output on their own CT3 CAN port. For example with 4 CT3s stacked, you will have 4 CAN Buses to connect to the data logger.

CAN cables can be built with either a DB9 or Turk connectors (for eDAQ).

See more about this is in CT3 CAN Bus configuration section, on page 63.

A .dbc file can be created and downloaded from the CT3 webpage. Once the .dbc file is loaded into the data acquisition, and the systems are connected, all the channels will be properly labeled (according to Wheel Position) and scaled (in engineering units). The drawback of using CAN signal output is signal delay, which is dependent on output rate. It is 3.9 milliseconds for 2000/2048 Hz, 5.8 milliseconds for 1000/1024 Hz, and 9.3 milliseconds for 500/512 Hz. The chart below shows the channels output on CAN:

Output Channel Sensitivities Full Scales		
X Force	30,000N	6,744 lb
Y Force	10,000N	2,248 lb
Z Force	30,000N	6,744 lb
X Moment	2,500 N-m	1,844 lb-ft
Y Moment	4,000 N-m	2,950 lb-ft
Z Moment	2,500 N-m	1,844 lb-ft
Velocity	2000 rpm	
Position	0 - 360 deg	
SINE	± Full Scale	
COSINE	± Full Scale	

Diagnostic Signals available on Digital Outputs		Range
Stator Temp 0	Temperature of Telemetry Stator Radio 0	-256 to 254 degC
Stator Temp 1	Temperature of Telemetry Stator Radio 1	-256 to 254 degC
Stator RSSI 0	Telemetry Stator Receive Signal Strength Radio 0	-128 to 127 dB

Stator RSSI 1	Telemetry Stator Receive Signal Strength Radio 1	-128 to 127 dB
TX Power	Telemetry Transmitter Power Level (Volts)	4.82 to 6.94
POD Power	Induction Module Power Level	0 to 100 Percent
No RFSig	Indicator of No Signal Received from Telemetry	1 for Data Valid. 0 for no signal

Using Analog Signal Outputs

An Optional Analog Output Module and output cables can be purchased. The default voltage for the Analog output is +/- 10 VDC. This voltage can then be converted to their engineering units by multiplying by the sensitivity listed on the Quick Reference Calibration Sheet supplied with the WFT. Also see Appendix 3 on page 86.

All the analog outputs are single ended and isolated from power ground. See diagram in appendix 1. The CT3 webpage allows the user to replace Wheel Speed and Wheel Position with Sine and Cosine, if desired.

The time delay when using Analog Signal Outputs is 2.0 milliseconds. See page 55 for channels and ranges with Analog Outputs.

Shunt Calibration Sequence

Shunt Sequence - The CT3 calculates an internal fine digital gain, used to make output sensitivities match the values programmed into the Smart sensor.

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 9 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. If this happens the display would indicate 'SHUNT ERROR'. The shunt sequence commands the Telemetry Transmitter to invoke a shunt calibration resistor at each strain gage bridge in the transducer. The CT3 reads the voltage change, caused by the shunt, and adjusts the gain of each channel to match the sensitivity programmed into the *smart sensor*. This calculated gain is recorded into the smart sensor located in the Induction Module so this information is not lost when power is interrupted or a different CT3 is used. If the calculated gain is more than 2.5% different than what is programmed into the smart sensor, the Fault light will come on indicating a likely problem with the transducer or amplifier.

Note: This sequence can be performed at any time (on the ground or hoisted.) Just be sure not to change load on the WFTs during the Shunt sequence.

Shunt Hold - The CT3 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 (approximately 1 second).
- The *Shunt* light will flash 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 Quick Reference calibration sheet lists sensitivity and Delta Shunt values in lbf/lb.ft and N/N.m. If desired, the user may check the sensitivity by recording the outputs during a shunt sequence and calculating the delta Shunt value (magnitude of change from positive shunt to negative shunt, divided by two).

Spinning Use System Set-up

The CT3 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, perform a figure 8 maneuver, and two or more hard brake stops.**

There are two zeroing procedures for Spinning Applications.

Zeroing on the Hoist

This Zeroing method uses the weight of the wheel and tire to determine the zero offsets. This method is recommended for best accuracy.

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.

- Turn on the CT3.
- Lift the tires clear of the ground.
- 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 *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 CT3 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. Always apply force to the Lugnuts using a socket and wrench only. Rotate in one direction until the amber *Zero* light goes out, this should take 2 revolutions.

Using more than one transducer with stacked CT3s

- You may rotate each transducer independently.
- To zero only one wheel, you will need to turn off the CT3 electronics, on the wheels that you do not want to zero, or un-stack them.

When the CT3 completes the zero procedure, it will write the calculated offset value to the smart sensor located in the amplifier. This way the transducer does not need to be zeroed every time the power is interrupted or if a different CT3 is used with the transducer.

Rolling Zero on the Road

This Zero method occurs when the wheel speed is above 15 rpm, and uses the weight of the vehicle to determine the zero offsets. The Fy (Lateral) transducer channel may have real, non-zero values during this mode of operation due to toe-in and tire conicity. 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 CT3 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.

- When the CT3 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 CT3 is used with the transducer.

Verifying the Zero Procedure

To check the quality of the zero, set the CT3 to *Run* mode and *Vehicle* coordinates. Observe the output from each channel with the wheel lifted off of the ground. The x and y-axes forces should have very little output. While hoisted the Fz force should read the negative weight of the wheel and tire. The My and Mz moments should have little output. The Mx moment should have some output proportional to the weight of the wheel and tire multiplied by the moment arm from the wheel centerline to the transducer centerline. (if the measurement origin is at the default, transducer centerline.)

Spin the wheel and observe the x and z-axes force outputs. There should be very little ripple in the outputs.

Web Page Selectable Options

The CT3 contains an embedded web page that can be used to change system settings or select features. This web page is available to any device with a USB or Ethernet port and web browser.

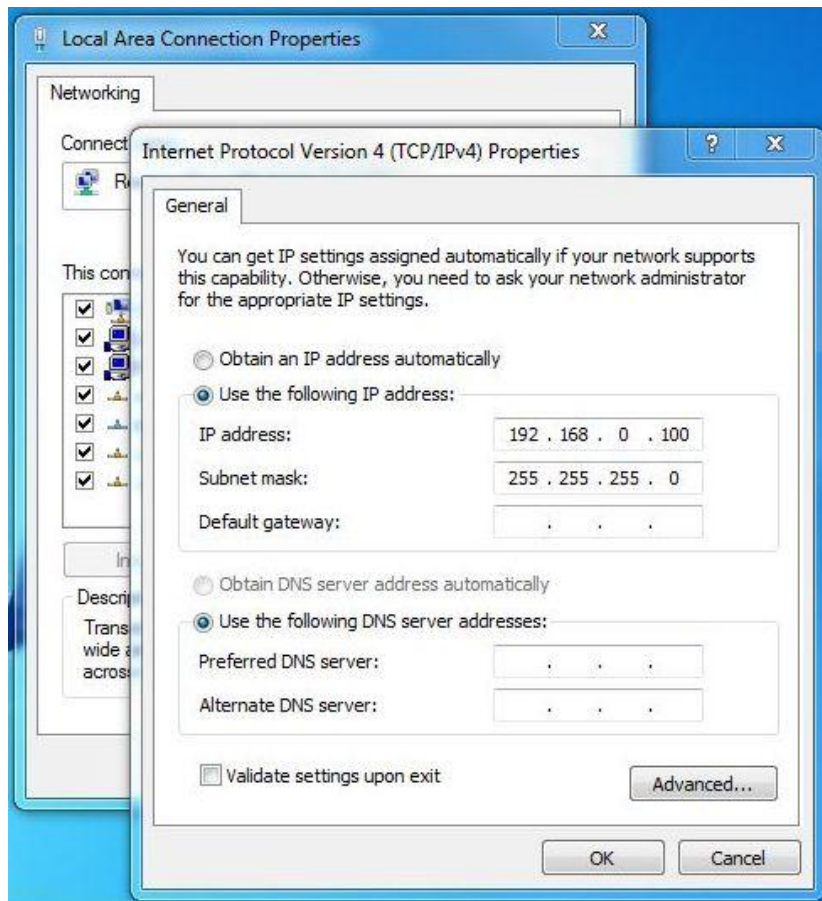
Connecting to the CT3 via USB

To access the web page via USB use a USB-C cable.

- Plug the USB C connector of the provided cable into the top CT3 and connect the USB A connector into the laptop.
- Open a web browser and type CT3.local and click enter.
- The web page, shown on the following page, will appear in the web browser

Connecting to the CT3 via Ethernet

- Connect the Ethernet cable (provided with appropriate connectors) to one of the CT2s 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 and enter the IP address of the CT2 (192.168.0.28) into the browser
- The web page, shown on the following page, will appear in the web browser

Note: To make system changes, all CT3s must be connected to their respective wheel force transducer and powered up.

CT3

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CT3 User Interface

Menu

Configure CT3

Coordinate System

Static Values

Realtime Plots

Transducer Info

CAN Data Settings

CT3 Info

Telemetry Info

Network Settings

About/Contact MSC

CT3 Configuration

CT3 Serial Number: 1013 RR

Wheel Force Transducer

Model: LW60

Serial Number: 1136

Position: RR

Calibration Date: Wed Jan 03 2024

Default Coordinates on Power-Up (Updated in all active CT3 boxes):

☒ Spinning
☐ Non-Spinning

Full Scale Rotational Velocity:

☐ 1000 RPM
☒ 2000 RPM
☐ 3000 RPM
☐ 4000 RPM

☐ Replace Velocity/Position in CAN Output with Sine/Cosine

Analog Output Range:

☒ +/-10V
☐ +/-5V
☐ 0 to 5V

Synchronization Setting:

☒ Local
☐ PTPv2
☐ EtherCAT

Ethernet Streaming Mode:

☒ openDAQ
☐ CT3 Recorder

Enter Slip Ring/Encoder Reference Angle:

0.00

Degrees Clockwise from Vertical

Measurement Origin:

Units of Entered Values:

☐ Inches
☒ Millimeters

Measurement Center Offset along Y-Axis (a):

100.0

(-1,829 to 1,829 mm)

Definition of "a" & "RR"

☐ Update All Active CT3 Boxes with these settings

Update

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Powered by [w3.css](#)

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CT3 Serial Number/Wheel Position

Near the top of the page is a drop down box allowing the user to select CT3 serial numbers paired with the selected Wheel Position for that CT3, shown below.

A light gray rectangular box containing the text "CT3 Serial Number:" followed by a dropdown menu. The dropdown menu is open, showing "1051 RF" and a downward arrow.

The CT3 that the USB cable is connected to, will check for the presence other CT3 Boxes. 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 with the selected Wheel Position will appear in the pull down menu. Selecting a different serial number allows the user to set up each CT3 separately.

☐ Update All Active CT3 Boxes with these settings

Update

If settings for all the CT3 units are to be the same, the "Update All Active CT3 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 Force Transducer Information shown below CT3 serial number is information for the WFT that is connected to the selected serial number.

Default Coordinates on Power-Up

Here the user can select whether the CT3 powers up in Wheel or Vehicle Coordinates. If the WFTs will mostly be used in Spinning Applications, select Vehicle. If the WFTs will mostly be used in Non-Spinning Applications select Wheel.

Default Coordinates on Power-Up (Updated in all active CT3 boxes):

☒ Spinning ☐ Non-Spinning

Note: All CT3 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 CT3 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, 3,000, and 4,000 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.

Full Scale Rotational Velocity:

☐ 1000 RPM ☒ 2000 RPM ☐ 3000 RPM ☐ 4000 RPM
☐ Replace Velocity/Position in CAN Output with Sine/Cosine

Analog Output Sensitivities Options.

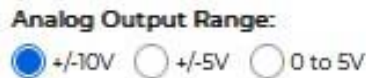
The default Analog output range is $\pm 10V$. The CT3 allows the user to choose analog output ranges of $\pm 10V$, $\pm 5V$, and 0-5V. Because of that, the number shown in the chart below is the full scale value for each channel. This number needs to be divided by the full scale voltage to calculate the sensitivity in units/volt. Example - If the full scale analog outputs are set to ± 10 Volt, the X Force sensitivity for LW25 will be 3,000 N/V (30,000 N /10 volts). If the analog outputs are set to 0-5 Volt, X Force the sensitivity will be 12,000 N/Volt with a 2.5 volt offset.

NOTE: When using Analog signal outputs, it is recommended to perform a Shunt Calibration and compare the Delta Shunt through the data acquisition to the Shunt value listed on the Quick Reference Calibration sheet, to ensure proper scaling.

Output Channel Sensitivities Full Scales		
X Force	30,000N	6,744 lb
Y Force	10,000N	2,248 lb
Z Force	30,000N	6,744 lb
X Moment	2,500 N-m	1,844 lb-ft
Y Moment	4,000 N-m	2,950 lb-ft
Z Moment	2,500 N-m	1,844 lb-ft
Velocity	2000 rpm	
Position	0 - 360 deg	
SINE	$\pm$ Full Scale	
COSINE	$\pm$ Full Scale	

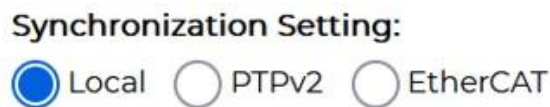
Changing Analog Output Range

To change the Analog Output range, select the desired Analog output range, Check the Update All box, and click Update on the bottom of the page.



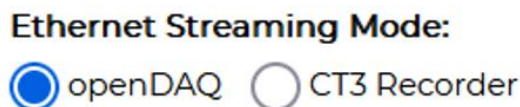
Synchronization Settings

The stack of CT3s can synchronize in three ways, Locally, through PTPv2, or through EtherCAT. The default setting is local which synchronizes all stacked CT3s to each other.



Ethernet Streaming Mode

The CT3 will provide signal output via Ethernet from the Top Box of the CT3 stack if All-to-Top is selected from the CAN Data Settings page. OpenDAQ should be selected to output the data via Ethernet to an OpenDAQ compatible system or to view and record the data through the 'Realtime Plots' tab of the CT3 webpage. To view and record the WFT data with the CT3 Recorder software supplied by MSC, select CT3 Recorder. When view and recording data via either OpenDAQ or CT3 Recorder, we recommend using an Ethernet connection instead of the USB connection.



OpenDAQ Ethernet Output

When recording data via Ethernet with an OpenDAQ compatible device (Client), scale factors are negotiated between the CT3 and OpenDAQ Client at initialization. When

using OpenDAQ Ethernet output along with PVPv2 synchronization, then filter time delay correction and synchronization is achieved.

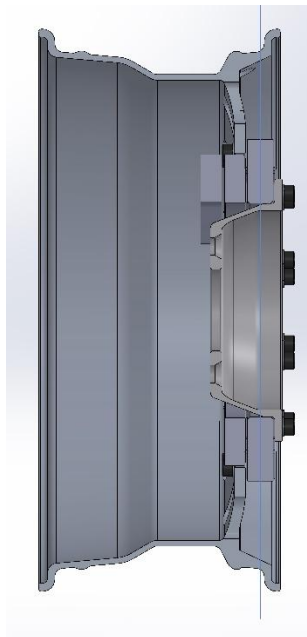
Slip Ring/Encoder Reference Angle

For Telemetry based WFTS, the Slip Ring/Encoder Reference Angle is the Angle set during the Zero Angle function. The CT3 uses this information to correct the reference angle when performing the coordinate transformation. This field will automatically be filled after a Zero Angle is performed.

Enter Slip Ring/Encoder Reference Angle:
130.96 Degrees Clockwise from Vertical

Measurement Origin

The default measurement origin of the LW25 is the center of rotation and a plane that runs through the center of the transducer. The distance to the measurement origin plane to either edge surface of the transducer is 0.45" (11.43 mm).



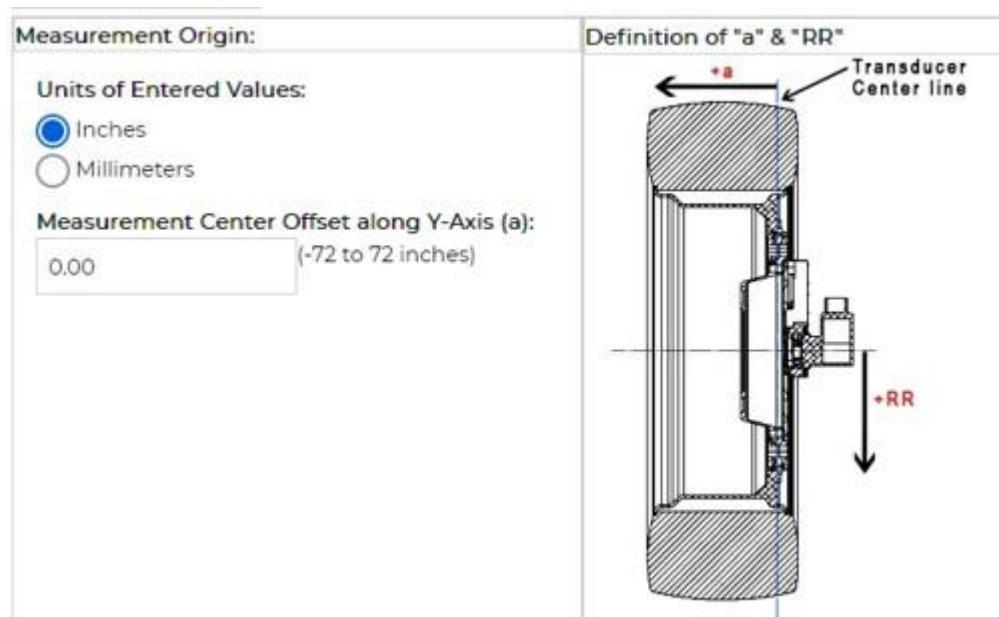
To move the measurement origin to the hub face or tire center, input the “a” value in the CT3 webpage. The value of “a” is provided on adapter assembly drawing if MSC made your adapters. Value “a” can also be measured.

If the user wants to move the measurement origin to the tire patch surface, this input box can be accessed by clicking the “RR” over the diagram.

To use this option:

- Check the button labeled “User Defined with Respect to Center of WFT”
- Select “Inches” or “Millimeters” to indicate which units will be used.
- Enter an “a” value if moving the origin along the y-axis.
- Click update at the bottom of the page.

The image below indicates “a” and “RR” values.



Note: Only the Mx and Mz channels are affected by these calculations.

Non-Spinning Applications

In the CT3 webpage, only when Non-Spinning Coordinates has been selected, the “For Simulator Use Only” box will appear. If the transducer is mounted with the Z+ arrow pointing vertically towards the ground, leave this box at 0.00. If the transducer is not mounted with the Z+ arrow pointing vertically towards the ground, measure the degrees clockwise from Vertical of the Z+ axis, then enter it into the box and click Update.

For Simulator Use Only

Mounting Angle Degrees Clockwise from Vertical:

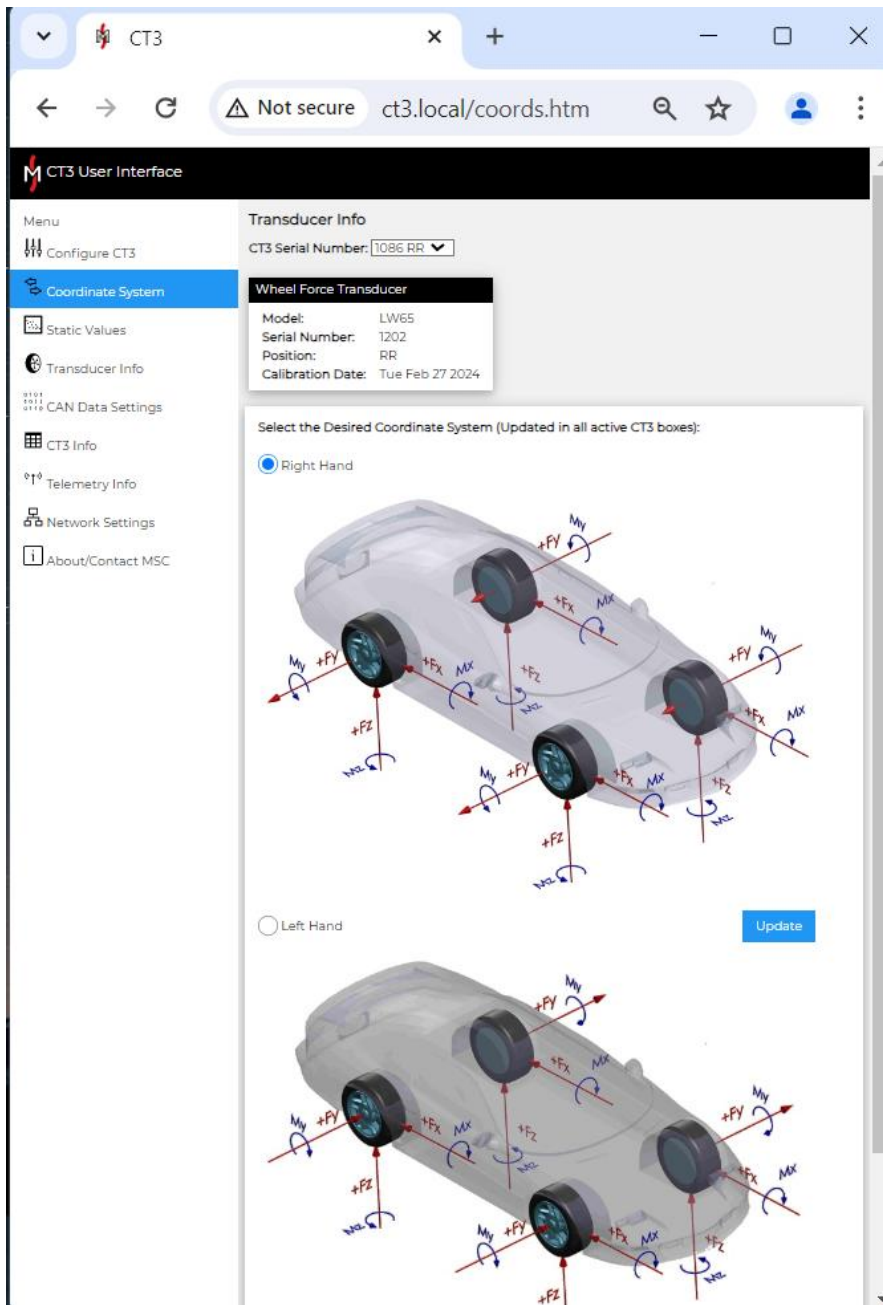
0.00

☐ Update All Active CT3 Boxes with these settings

Update

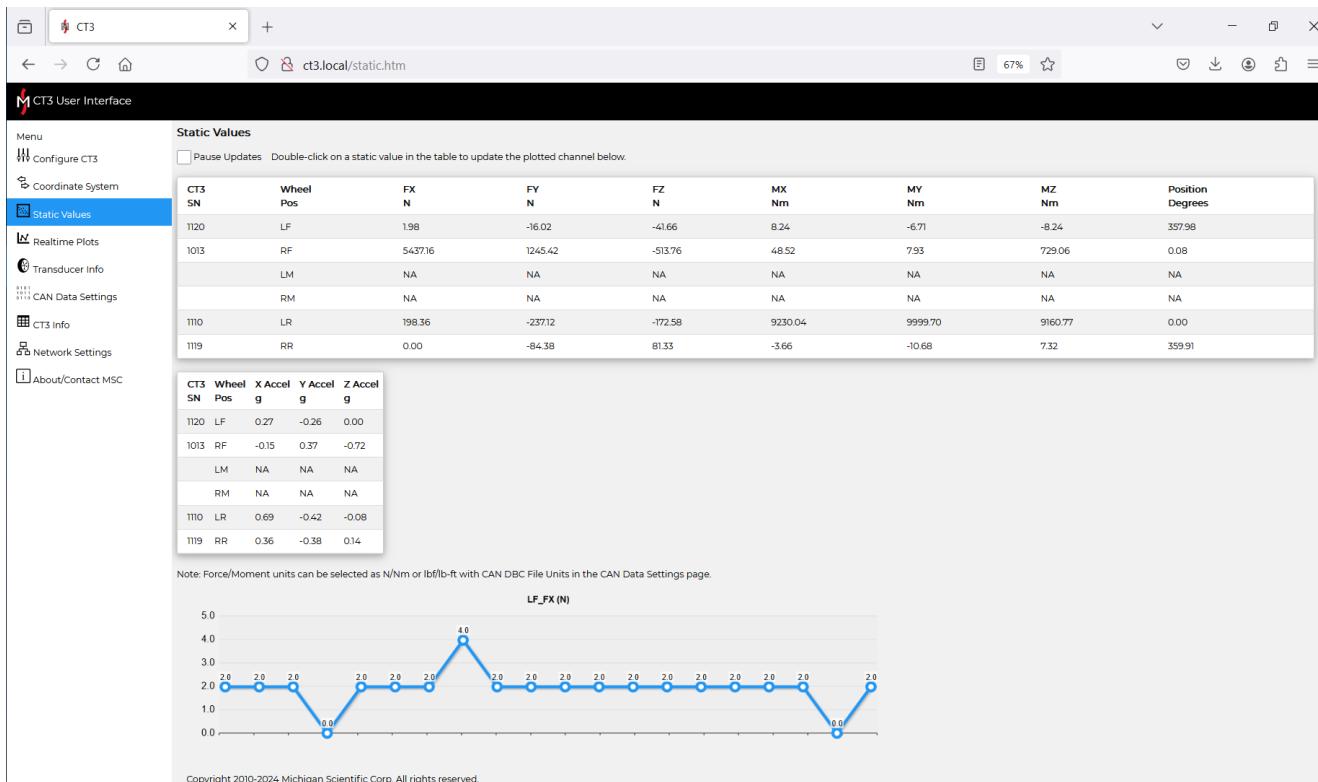
Changing WFT Coordinate System

The default WFT coordinate system is the Right Hand Coordinate System shown below. In the Coordinate System tab on the CT3 webpage the WFT 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 CT3 boxes stacked and powered up. The WFT Coordinate System is explained further on page 72.



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 WFT systems including a 20 point plot, shown below. To change the channel in the plot, just click in the WFT and channel that you want displayed.

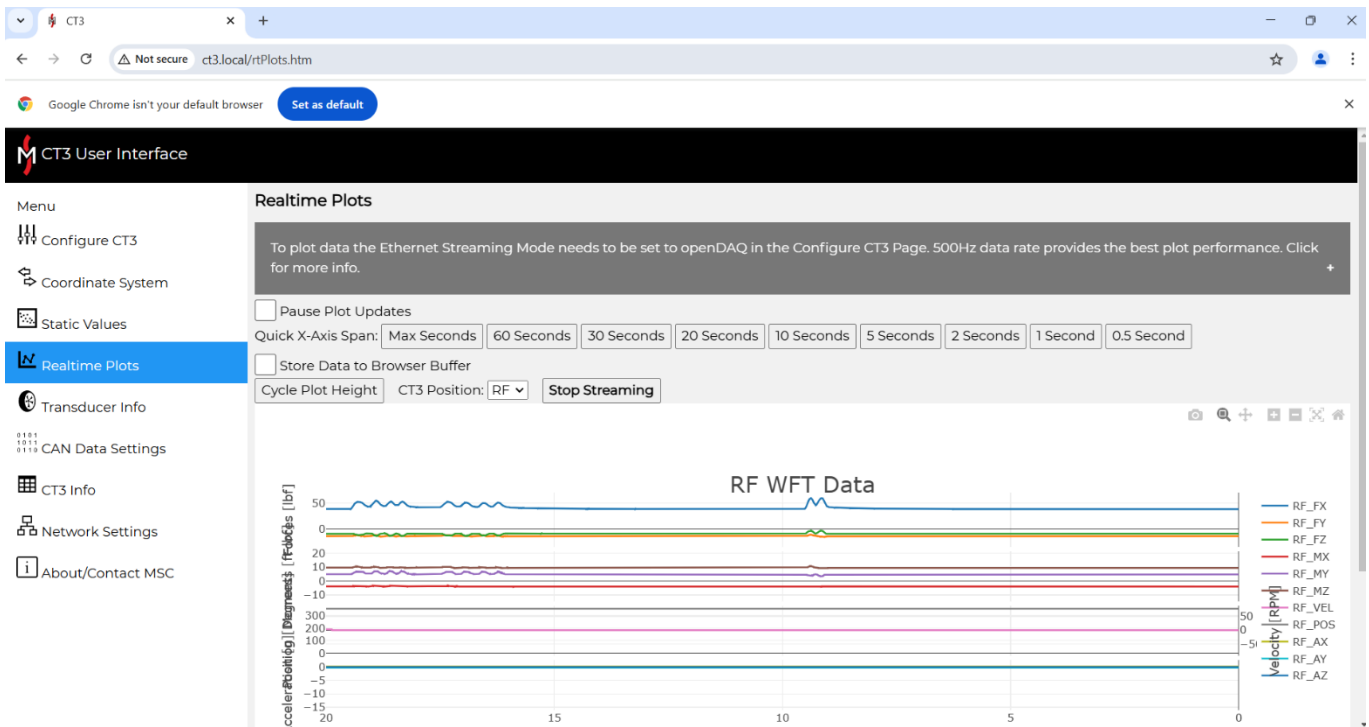


Refresh rates for the Static Values is once per second. The points on the plot are updated once per second as well.

Realtime plots

Realtime data can be plotted and recorded by first selecting “Realtime Plots” tab on the left side of the web page. OpenDAQ Ethernet option must be selected in the “Configure CT3” tab. If connected by USB cable to the laptop, 500 Hz Data rate should be selected under “CAN Data Settings”. If connected to the laptop by Ethernet cable, up to 2000 Hz Data Rate can be plotted and recorded.

Click the ‘Start Streaming’ button to start the live data plot and select which WFT/CT3 Position you want displayed. If you want to record/store the data to the Browser buffer, check the ‘Store Data to Browser Buffer’ check-box. Then uncheck the box to stop recording. The data will be stored in your Downloads folder, in an .RSP file format.



Transducer Information

Information for each WFT system can be viewed by clicking on “Transducer Info”. The CT3 Serial number/Wheel Position drop down menu allows the user to select which system the information is for.

CT3 User Interface

Menu

- Configure CT3
- Coordinate System
- Static Values
- Transducer Info**
- CAN Data Settings
- CT3 Info
- Network Settings
- About/Contact MSC

Transducer Info

CT3 Serial Number: 1051 RF

Wheel Force Transducer Information

	X Force	Y Force	Z Force
Shunt Cal Value (N)	92058.0	47226.0	91769.0
Factory Scale Factor	1.042	1.410	1.036
Field Scale Factor	1.044	1.411	1.037
Scale Factor % Difference	0.119	0.073	0.038
Analog Full Scale Output(+/-N)	180000.00	90000.000	180000.00
Transducer Offset(Volts)	0.032	-0.216	-0.008
Transducer Offset(N)	574.753	-1940.011	-136.650

	X Moment	Y Moment	Z Moment
Shunt Cal Value (Nm)	25115.0	20095.0	25190.0
Factory Scale Factor	1.385	1.094	1.389
Field Scale Factor	1.386	1.094	1.390
Scale Factor % Difference	0.075	0.002	0.086
Analog Full Scale Output(+/-Nm)	45000.000	45000.000	45000.000
Transducer Offset(Volts)	0.079	0.013	-0.009
Transducer Offset(Nm)	353.538	57.820	-40.096

Configuration Settings:

Full Scale Rotational Velocity: 2000 RPM

Spinning Mode Slip Ring/Encoder Reference Angle: 0.000 Degrees Clockwise from Vertical

Transducer Z-Axis is Set to Vertical (Affects Non-Spinning Outputs Only): 0.000 degrees

CT3 CAN Bus Configuration

CAN bus data output settings are configured using the “CT3 Data Settings” tab located on the left side of the web page. Here the CAN type (2.0 or CAN-FD), Output Sample Rate, CAN output mode (Direct, All-to-Top, or 2-to-1) and Desired Units are selected. After making any changes click update and these setting will update for all CT3 boxes that are stacked together.

CT3

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ct3.local/digitalCAN.htm

CT3 User Interface

Menu

Configure CT3

Coordinate System

Static Values

Transducer Info

CT3 Data Settings

CT3 Info

Network Settings

About/Contact MSC

CT3 Data Settings

CAN 2.0B Bus Bit Rate:

1 Mbps

CAN-FD Arbitration Rate:

1 Mbps

CAN-FD Data Rate:

4 Mbps

CAN Output Sample Rate:

500

CAN Format:

☒ CAN 2.0B
 ☐ CAN-FD

CAN Output Mode:

☒ Direct Output
 ☐ All-to-Top
 ☐ 2-to-1

CAN DBC File Units:

☐ N, Nm
 ☒ lb, lb-ft

Update

CAN Database File (.dbc)

Filename:

CT3.dbc

Download DBC File

VERSION ""

NS_:

NS_DESC_

CM_

BA_DEF_

BA_

VAL_

CAT_DEF_

CAT_

FILTER

BA_DEF_DEF_

EV_DATA_

ENVVAR_DATA_

SGTYPE_

SGTYPE_VAL_

BA_DEF_SGTYPE_

BA_SGTYPE_

SIG_TYPE_REF_

VAL_TABLE_

SIG_GROUP_

SIG_VALTYPE_

SIGTYPE_VALTYPE_

BO_TX_BU_

BA_DEF_REL_

BA_REL_

BA_DEF_DEF_REL_

BU_SG_REL_

BU_EV_REL_

BU_BO_REL_

CC_REL_VAL_

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- 64 -

The Baud Rate of the Data logger must be set to 1 mbps for CAN 2.0. This is the amount of data that can be transferred on a standard CAN Bus.

Note: It is necessary that the CT3 box receive a CAN acknowledge bit from the connected data acquisition system. Do not use passive (listen-only) mode on your data acquisition.

Maximum Output/Sample Rates with CAN 2.0

The following sampling rate limitations apply to CAN 2.0.

If connecting 4 WFTs to one CAN bus (All-to-Top) the max output rate is 512 Hz.

If connecting 2 WFTs to one CAN bus (using 2-to-1 for 4 WFTs or using 'All-to-Top' with two WFT connected) the max output rate is 1024 Hz.

If connecting 1 WFTs to one CAN bus (Direct Output) the max output rate is 2048 Hz.

Delay

There is signal delay caused by filtering performed by the CT3 to decimate the data down to the selected output rate. The filter delay is listed in the chart below.

CT3 Output Filter Delays (milliseconds)	
Telemetry Type	
2.0 ms	Analog Outputs
9.3 ms	500/512 Hz Digital Output Rate
5.8 ms	1000/1024 Hz Digital Output Rate
3.9 ms	2000/2048 Hz Digital Output Rate

Unit Selection

Select the desired output units. Either lbs/lb.ft or N/N.m can be selected.

There are 3 CAN messages output per sample for each CT3 box

CAN Bus Termination

A 120 Ohm CAN termination resistor is automatically turned on in the CT3s. The CAN Bus termination should also be turned on in the Data Acquisition.

DBC file creation

A CAN database (.dbc) file is needed by the data acquisition to de-code the digital data sent by the CT3. A .dbc file is created by the CT3, by clicking the 'Download DBC File' button. A window should pop-up enabling you to save the file to your computer. If browser is not up to date or pop-ups have been disabled, this button may not work properly. In that case copy all the text in the text box below and paste it into Notepad. Save the notepad .txt file. Then go back and change the extension of that file from .txt to .dbc. Then the .dbc can be imported to the data acquisition.

CT3 Info

The embedded web page allows the user to easily update firmware without having to send the CT3 back to the factory. Current CT3 firmware is available for download from MSC's website. This page also shows past Error Codes. First it shows error codes associated with the WFT stored in the smart sensor, then it shows error codes associated with the CT3.

CT3 Info

CT3 Serial Number: 1111 RR ▾

CT3						
Serial Number:	1111					
Position:	RR					
FW Version:	003_035_019_018					
Amp FW Version:	4p00					
POD FW Version:	N/A					

[Update CT3 Firmware \(Connected CT3 Only\)](#)

History Codes

History Code(Amp)	Code Description	WFT SN	CT3 SN	Index	Extra Info 1	Extra Info 2
00		0	0	0	0.00	0.00
00		0	0	0	0.00	0.00
00		0	0	0	0.00	0.00
00		0	0	0	0.00	0.00
00		0	0	0	0.00	0.00
00		0	0	0	0.00	0.00
00		0	0	0	0.00	0.00
00		0	0	0	0.00	0.00

To install a firmware updates;

- Click 'Update CT3 Firmware'
- 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 CT3.
- Once power has been cycled, the new firmware is ready to be used.

Caution: Do not disconnect the CT3 or power down the computer or CT3 during the update.

Note: Only the CT3 connected to the USB Cable will be updated. Each CT3 electronics must be updated separately.

Note: Update all CT3 electronics with the same version of firmware before using them in a stacked configuration.

Telemetry Info

The Telemetry Info page can be used to changing the RFID programming into the Telemetry Stator. It can also be used to view diagnostic signals from the Telemetry System.

CT3

ct3.local/telem.htm

CT3 User Interface

Menu

Configure CT3

Coordinate System

Static Values

Realtime Plots

Transducer Info

CAN Data Settings

CT3 Info

Telemetry Info

Network Settings

About/Contact MSC

CT3 Telemetry Info / Stator Frequency Update

Make sure that ONLY the CT3 box for the telemetry stator being updated is powered on. No other CT3 boxes should be powered. Before Programming, Verify that the Induction Module SN and it's mated WFT SN match.

Source	Name	Value	Units
Induction Module	WFT Model:	LW60	
Induction Module	WFT Serial Number:	1136	
Induction Module	Calibration Date:	Wed Jan 03 2024	
Induction Module	Induction Module PWR:	40	Percent
Transmitter	TX SN:	1136	
Transmitter	TX PWR:	179 / 6.3	(Raw/Volts)
Transmitter	CAL:	0	
Stator	RSSI 0:	49	dB
Stator	RSSI 1:	42	dB
Stator	STATOR TEMP 0:	34	Degrees C
Stator	STATOR TEMP 1:	36	Degrees C
Induction Module	Factory RFID:	75	
Stator	Current RADIO 0 RFID:	75	Re-load page to Update
Stator	Current RADIO 1 RFID:	75	the Current RFID Values.

Before Programming, Verify that the Induction Module SN and it's mated WFT SN match. Make sure that ONLY the CT3 box for the telemetry stator being updated is powered on.

Warning: Leave the "Use Alternate RFID Value" blank unless instructed to do so by Michigan Scientific.

Leave blank to Program the Factory RFID or Enter Alternate RFID Value: (decimal)

Program RFID into Telemetry Stator

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WFT Stator Reprogramming

Background

Each Telemetry (and Encoder) Ring has a fixed Telemetry transmission RFID (Telemetry frequency). The Telemetry Stators can all be programmed to use with different Telemetry and Encoder Rings. When first receiving your system, one container should contain a paired system. If the Telemetry Stators are to be used with different Telemetry Rings or a spare Telemetry Stator is used, you will have to reprogram the Telemetry Stator.

Procedure

Make Sure the Serial number of the Induction Module is being used matches the Serial number of the WFT and Telemetry Ring.

Power up the CT3 and and connect to the webpage. Go to the Telemetry Info tab, and press the 'Program RFID into Telemetry Stator' button.

Before Programming, Verify that the Induction Module SN and it's mated WFT SN match. Make sure that ONLY the CT3 box for the telemetry stator being updated is powered on.

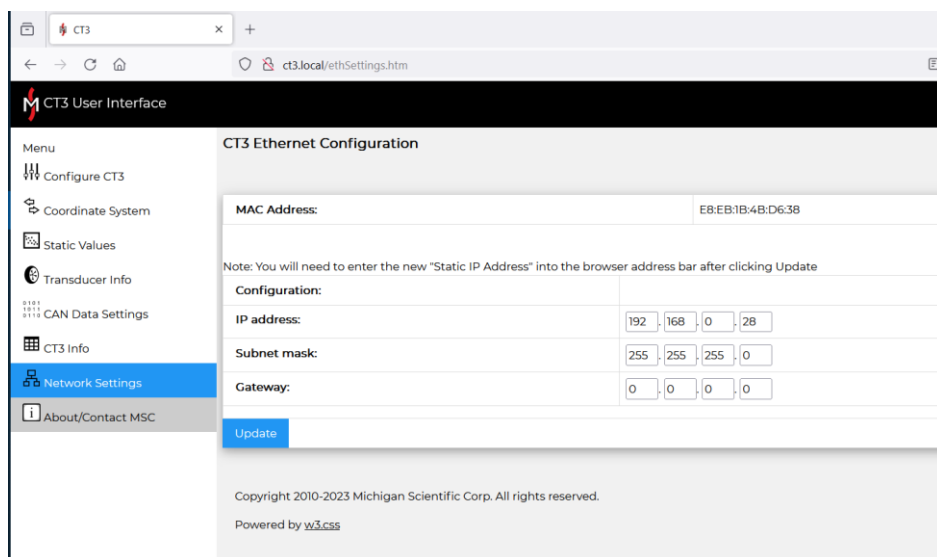
Warning: Leave the "Use Alternate RFID Value" blank unless instructed to do so by Michigan Scientific.

Leave blank to Program the Factory RFID or Enter Alternate RFID Value: (decimal)

Program RFID into Telemetry Stator

Network Setting

Default IP addresses are set at 192.168.0.28 at the factory for all CT3s. A new IP address can be set by going to the "Network Settings" 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.



Display Messages

The table below gives possible CT3 display message and their definition and possible remedy.

CT3 Screen Message	Definition	Remedy
ROTATE WHEEL	WFT has not passed the index pulse after power cycle	Rotate WFT until encoder passes the index pulse
DUPLICATE POS	Two or more WFTs are set to the same vehicle corner	With CT3 in Set-up mode, press the Position/Advance button until the proper position is selected.
DIFF CAN RATES	WFTs are set to different CAN output rates	Go into the CT3 webpage with all CT3s stacked and set the CAN output rate
DIFF CAN MODES	WFTs are set to different CAN modes	Go into the CT3 webpage with all CT3s stacked and set the desired CAN mode
DIFF COORD SYS	WFTs are set to different Coordinate Systems	Go into the CT3 webpage with all CT3s stacked and set the Coordinate System

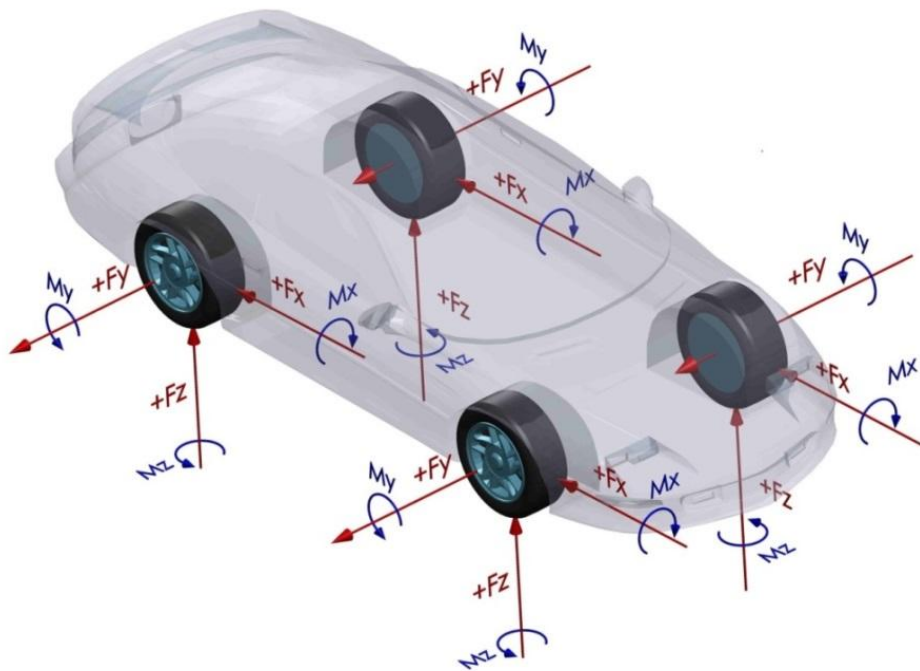
NO SMART SENSOR	The CT3 did not read the smart sensor on power up.	Make sure the cable is connected to the CT3 and amplifier on power up. Possible damaged cable.
NO DATA FROM AMP	No digital stream of data from the amplifier.	Make sure the cable is connected to the CT3 and amplifier on power up. Possible damaged cable.
SHUNT ERROR	The field Shunt values differ from the factory Shunt values by more than 2.5%.	Possible transducer or amplifier damage.
ZERO ERROR	The CT3 is trying to Zero out more than 40% of the full scale.	Check for mechanical short. Possible damage to the transducer or amplifier.
I2C3 ERROR	Internal communication error on I2C3	Cycle power on CT3
TELEM ERROR	Telemetry Error	
IND COM ERROR	Error communicating with Induction Module	Cycle power on CT3
CDBUS ERROR	Internal communication error on CDBUS	Cycle power on CT3
CHECK TEL SETUP	No RF received at TEL-STATOR from Telemetry Ring.	Make sure Induction Module SN is matched with WFT SN. Then with power off to all CT3 except one, in the CT3 webpage, pair the TEL STATOR with the WFT Telemetry Ring.
ERROR	Undefined Error	

Sampling Frequency

Much of the work done with WFTs for durability with a frequency of interest below 100 Hz. Common sample rates for WFT are 500/512 and 1000/1024 Hz depending on your test.

WFT Coordinate System

The default coordinate system is referred to Right Hand Rule. With the Vehicle hoisted, pressing on the bottom of any tire will produce positive F_z force. Pressing on the front of any tire will produce a positive F_x force. Associated moments are per *the right hand rule*. See figure below.



The WFT channels are defined as:

F_x = Longitudinal Force

F_y = Lateral Force

F_z = Vertical Force

M_x = Roll Moment (Wheel Camber)

M_y = Pitch Moment (Wheel Torque)

M_z = Yaw Moment (Wheel Steer)

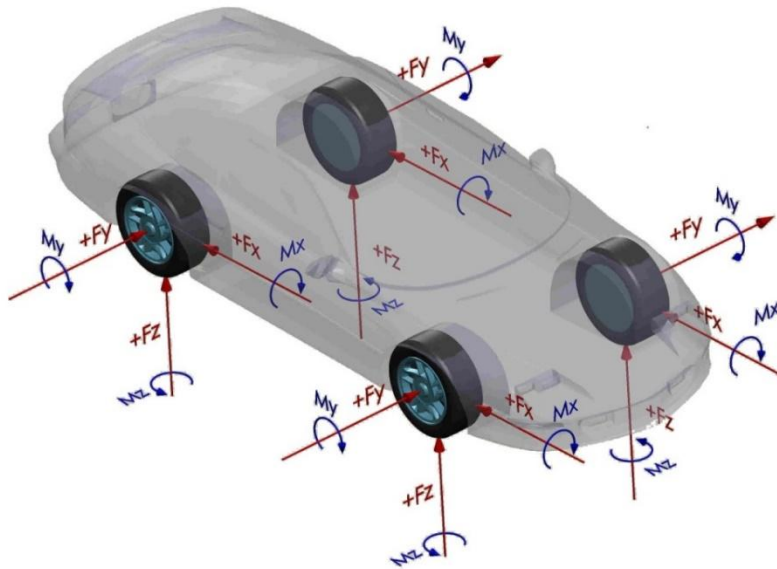
Accel X = Longitudinal Acceleration

Accel Y = Lateral Acceleration

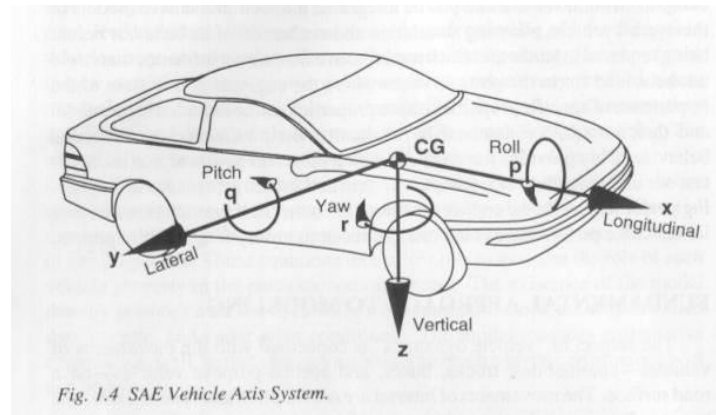
Accel Z = Vertical Acceleration

Left Hand Rule Coordinate System (Optional)

The Optional Left Hand Rule Coordinate will switch the polarity of the F_y and M_y outputs only.



The Left Hand Rule Coordinate System gives the reaction force for a vehicle traveling in the SAE defined directions, per the drawing below.



Weatherproofing

The WFT system is IP67 rated when all connectors are mated

Recommended Static Load Rating and Overload

For each WFT model MSC gives recommended static load rating. This is a generalized rating that MSC uses to help customers select the proper WFT. This is calculated by taking the dynamic Fz load rating and dividing by 5. In almost all cases using these rating will prevent transducer overload. However there are extreme cases, for example Supercars & off-road jump maneuvers, that can create overload and damage a transducer, while staying under the recommended Static load rating.

If testing a vehicle capable of inputting extreme loads into the WFT, monitor the Mx channel closely. This should be Mx at the transducer center-line. MSC transducer are rated for 50,000 Mx cycles at full scale. If Mx loads go significant above full scale, the strain gage bridge can be damaged with very low cycles.

Transducer Field Checks

Field checks can be done by comparing WFT Fz output to a scale. To compare to a scale, first record the WFT Fz output when the vehicle is hoisted. This is the weight of the tire, rim adapter, and half the WFT, it will be negative. Then set the vehicle on the ground and record the WFT Fz output. Add the absolute value of these two numbers together and then compare that value to the output of the scales.

If you suspect the WFT system has been damaged or has some issue, there are a couple of field checks that can be made.

1. Perform a Shunt Calibration. If no fault light comes on, this means the Shunt value is within 2.5% of the Factory Shunt calibration.
2. The transducer off-set is reported on the NIST calibration sheet. If the transducer bridge has some damage, it would likely change the transducer off-set. If the off-set has not changed by less the 0.05 volts, and the WFT passes the Shunt, it should be in good condition

To check the transducer off-set perform the following.

- Remove hub and wheel adapters.
- Set the transducer flat on the bench.
- Connect the amplifier to the transducer.
- Connect the cable to the slip ring and CT3.
- Power up the CT3.
- Press the *Mode* button to put the CT3 into *Setup* mode.
- Record the output for each channel.

Factory Calibration

MSC recommends bi-annual calibrations for all it's Wheel Force Transducers. These can only be performed properly by MSC. MSC can calibrate all WFTs in Charlevoix, MI USA. Calibrations for car to light truck sized WFTs can also be performed in Shanghai, China.

Calibration values and cross-axis sensitivity coefficients are programmed into the amplifier smart sensor for each transducer. The wheel force transducer was statically calibrated in an Automated calibration machine with calibration adapters replicating rim and hub adapters.

During manufacturing radial forces were applied around the perimeter of the outer ring at 45° intervals to check for radial uniformity.

Troubleshooting

Symptom	Possible Causes	Solution
CT3 Does not power up when the power switch is turned on.	Power cord not connected to power. Power supply polarity is incorrect. Internal overload circuit is tripped.	Check that power cord has power supplied to it and try to power up the CT3 again. Check polarity. See appendix 1. If incorrect, reverse power supply leads and try to power up the CT3 again. Cycle the power on the CT3.
Sine wave in Fx, Fz, Mx, & Mz channels while spinning	Encoder system not working properly.	Check Telemetry Stator Alignment.
Sine wave in Mx & Mz or Fx & Fz only while spinning	Transducer bridge or telemetry transmitter individual channel	A ZERO may temporarily fix the problem. Send faulty parts to MSC for evaluation and repair.
Zero light does not go out.	Did not complete two full revolutions. Encoder Issue	Continue rotating wheels. Check Telemetry Stator Alignment
After zero sequence, Zero light goes out but Fault light illuminates. Screen displays ZERO ERROR.	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 CT3 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 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. Screen displays SHUNT ERROR	Force input to the transducer during shunt sequence causes out of tolerance shunt. Transducer or amplifier is out of tolerance by 2.5% or more.	Jack up vehicle, cycle power, and repeat the shunt sequence. The problem is with the transducer or telemetry and it must be returned to Michigan Scientific.
Channels, which should have no load, have an offset even after the zero procedure is performed.	CT3 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. If using Analog outputs, Data acquisition system has some offset. Offsets are too large for the CT3 to zero them. Damage to transducer.	Switch CT3 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 the Lugnuts with a socket and 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 CT3. If the outputs are indeed zero, null the offsets in the data acquisition system. The wheel may have been damaged. Remove from the wheel and hub adapters and place on the bench. Change the CT3 to setup mode. Check the offset. If it is out of range, send in for checkout and repair.
Fz and Fx channels have opposite polarity than expected	ZERO ANGLE was done with incorrect	Perform ZERO ANGLE again. Make sure Z+ arrow point vertically towards the ground . Each CT3 must have ZERO ANGLE performed individually.

Symptom	Possible Causes	Solution
Outputs from CT3 stay zero for all channels even when force is present.	CT3 is not turned on. Encoder has not found an index pulse. The data acquisition cabling is not connected improperly.	Check to see if the CT3 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 the output from the CT3 with a volt meter. If the output is correct, check the cabling or data acquisition setup.
The channel offsets change during use.	If off-set is only present in Fy channel, transducer may not have been exercised. A severe event caused some shifting in the bolted joints between the transducer and adapters. A severe event overloaded the transducer.	Exercise transducer by driving car. Perform figure 8 maneuver in both directions and perform two hard brake stops, then re-zero. 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 CT3 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. Incorrect Induction Module Transducer is damaged. Telemetry is damaged.	Check data acquisition system. The correct sensitivities are listed on the calibration sheet in the back of this manual. Check that the correct Induction Module is being used with the transducer. Check the transducer offsets and shunt values. Send in for checkout and repair if needed. 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. Cable to data acquisition is improperly connected. Sensitivity is incorrect in the data acquisition system. Zero Angle was not done properly Coordinate System is not as expected	Check to see if switch is correct. Change if needed. Check the voltage from the CT3. If correct, check pin-out for signal cable to the data acquisition system. Check the voltage from the CT3. If correct, check the sensitivities in the data acquisition system. Perform Zero Angle function. Check the selected Coordinate System in the CT3 webpage
Data appears noisy	CT3 chassis ground not connected to vehicle chassis	Connect one end of a banana plug cable to the CT3 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 CT3 power cable to the vehicle chassis.

Appendix 1- Wiring and Shielding

CT3 Power Connector Pin-Out

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

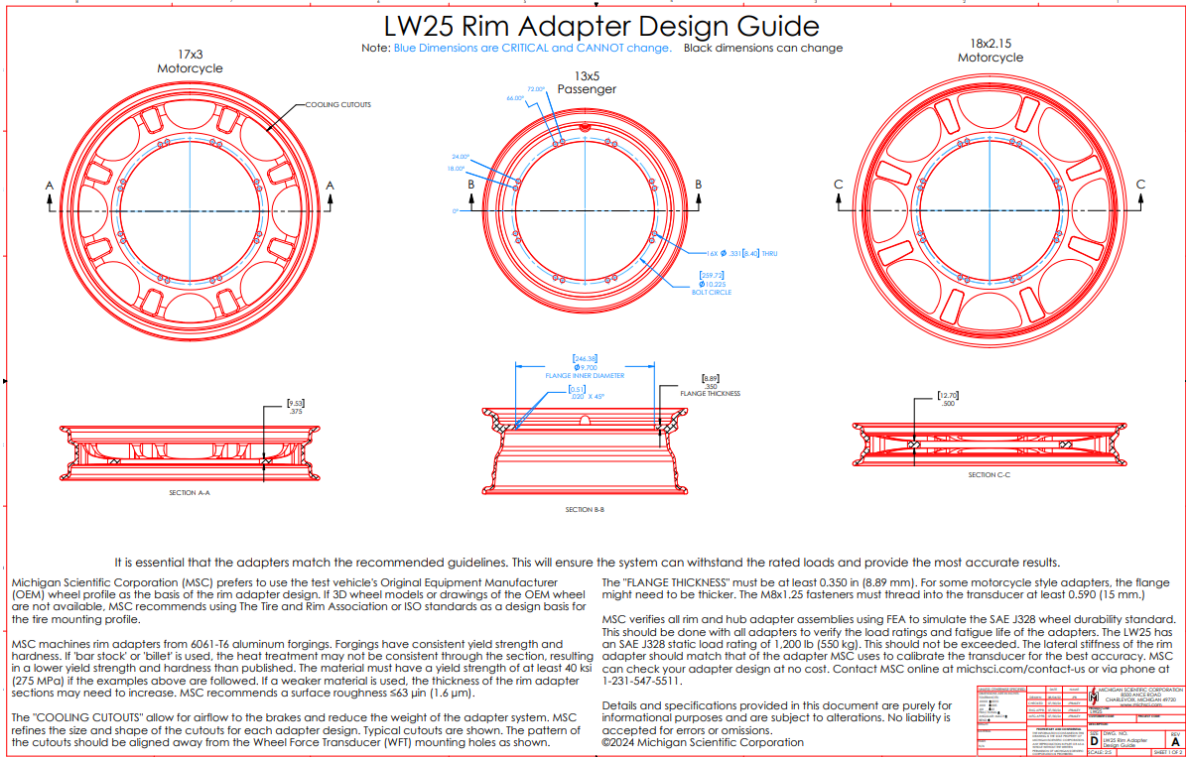
CT3 Analog Output Module Cable Pinout

CT3 Analog Output Module - Output Cable Pinout			2/15/2023
Pin#	Function	Description	Color
1	GND	NC	NC
2	Output 2	Signal 2 High	White
3	GND	Signal 2 Low	Brown
4	Output 4	Signal 4 High	Yellow
5	GND	Signal 4 Low	Green
6	Output 1	Signal 1 High	Red
7	GND	Signal 1 Low	Blue
8	Output 3	Signal 3 High	Pink
9	GND	Signal 3 Low	Gray
NC = Not Connected			

Appendix 2- Adapter Design Guidelines

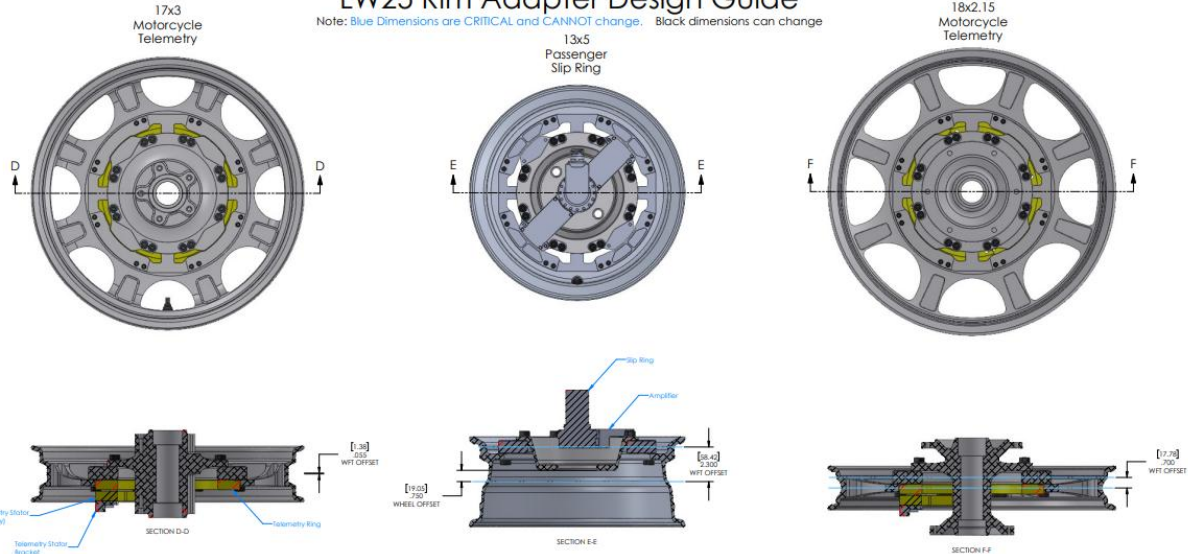
The latest Adapter Guidelines can be downloaded from our website:

[Model LW25 Wheel Force Transducer • Michigan Scientific Corporation](#)



LW25 Rim Adapter Design Guide

Note: Blue Dimensions are CRITICAL and CANNOT change. Black dimensions can change



It is essential that the adapters match the recommended guidelines. This will ensure the system can withstand the rated loads and provide the most accurate results.

The "WFT OFFSET" is the distance from the centerline of the rim to the centerline of the transducer. The "WFT OFFSET" should be as small as possible to reduce the moment load on the WFT. The WFT and adapters need at least 0.15 in (3.81 mm) of clearance to the brake and suspension components to prevent interference. Additional clearance may be needed when using telemetry to accommodate the telemetry stator and bracket mount.

3D models and 2D drawings of the LW25 are available for download on MSC's website. (michsci.com)

Note: Blue Dimensions are CRITICAL and CANNOT be changed.
Black dimensions can be changed

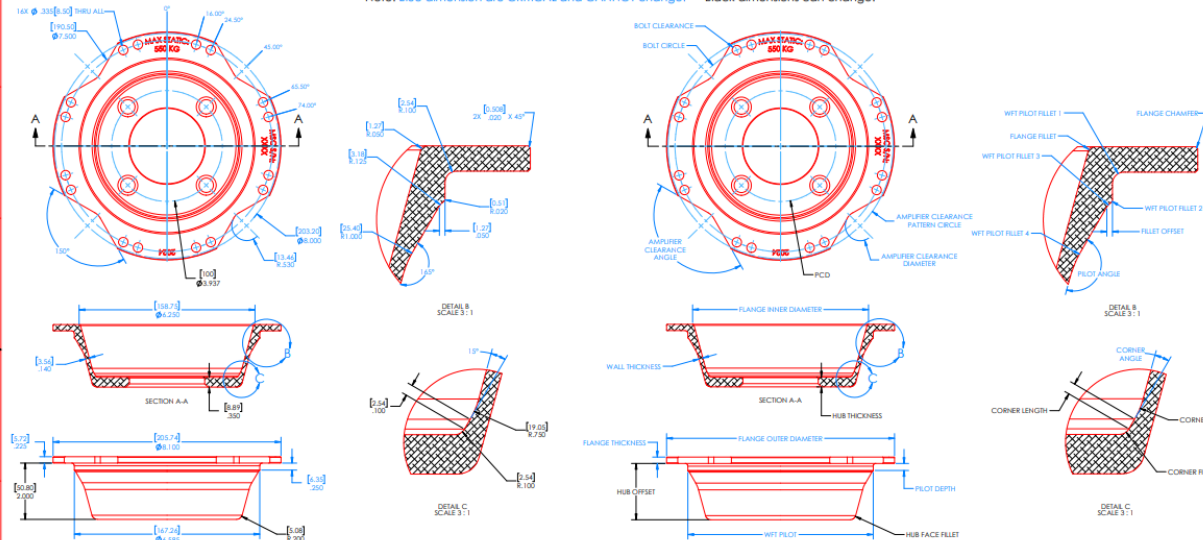
MSC verifies all rim and hub adapter assemblies using FEA to simulate the SAE J328 wheel durability standard. This should be done with all adapters to verify the load ratings and fatigue life of the adapters. The LW25 has an SAE J328 static load rating of 1,200 lb (550 kg). This should not be exceeded. MSC can check your adapter design at no cost. Contact MSC online at michsci.com/contact-us or via phone at 1-231-547-5511.

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REV	DESCRIPTION	DATE	BY	CHK
1	Initial Release	01/2024	J. Smith	M. Jones
2	Revised Dimensions	03/2024	J. Smith	M. Jones
3	Added Notes	05/2024	J. Smith	M. Jones
4	Final Review	07/2024	J. Smith	M. Jones

LW25 Hub Adapter Design Guide

Note: Blue dimension are CRITICAL and CANNOT change. Black dimensions can change.



It is essential that the adapters match the recommended guidelines. This will ensure the system can withstand the rated loads and provide the most accurate results. The critical features are shown in blue. Customers may change all other geometry. Examples of permitted changes are shown on the second sheet.

The "HUB THICKNESS" should not be less than 0.350 in (8.89 mm).

Detail D shows geometry that reduces the material stresses to increase the adapter fatigue life.

Michigan Scientific Corporation (MSC) machines hub adapters from 7075-T6 aluminum. The material must have a yield strength of at least 40 ksi (275 MPa) if the examples above are followed. If a weaker material is used, the thickness of the hub adapter sections might need to increase. MSC recommends a surface roughness $\leq 63 \mu\text{in}$ (1.6 μm).

MSC verifies all rim and hub adapter assemblies using FEA to simulate the SAE J328 wheel durability standard. This should be done with all adapter systems to verify the load ratings and fatigue life of the adapters. The LW25 has an SAE J328 static load rating of 1,200 lb (550 kg.) This should never be exceeded.

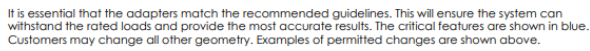
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Note: Blue dimension are CRITICAL and CANNOT change. Black dimensions can change.

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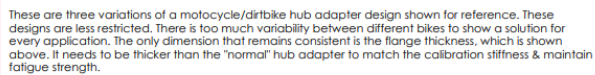


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[illegible]

Note: Blue dimension are CRITICAL and CANNOT change. Black dimensions can change.

Note: Blue dimension are CRITICAL and CANNOT change. Black dimensions can change.



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Appendix 3 - Example LW25-TEL Quick Reference Calibration Sheets



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Milford, MI 48381
Voice: (248) 685-3939
Fax: (248) 684-5406
www.michsci.com

8500 Ance Road
Charlevoix, MI 49720
Voice: (231) 547-5511
Fax: (231) 547-7070
www.michsci.com

Quick Reference Sheet

Transducer Serial Number:

LW25 1221

Calibration Date:

01/29/2026

Wheel Force Transducer Electronics: CT3

Gain and offset adjustments are handled in the CT3. The CT3 uses a shunt calibration sequence to adjust the gain so that the following sensitivities are correct. It is good practice to invoke the Shunt sequence by pressing the Shunt button at the start of each new test set-up. The Shunt sequence also compares the factory Shunt output to the field Shunt output. If these values differ by more than 2.5%, the fault and shunt lights will stay lit. This indicates a likely issue with the transducer or amplifier.

Sensitivity

Fx	1 Volt =	674 lb	3,000 N
Fy	1 Volt =	225 lb	1,000 N
Fz	1 Volt =	674 lb	3,000 N
Mx	1 Volt =	184 lb.ft	250 N.m
My	1 Volt =	295 lb.ft	400 N.m
Mz	1 Volt =	184 lb.ft	250 N.m

The Sensitivities listed above are the default settings which correspond with a ± 10 Volt Analog Output range. In the CT3 webpage it is possible to change the Analog output range. If the Analog output range is changed the above listed sensitivities will also change correspondingly.

Shunt Calibration

Fx	4.023 V* =	2,713 lb	12,070 N
Fy	5.083 V* =	1,143 lb	5,083 N
Fz	4.034 V* =	2,720 lb	12,101 N
Mx	4.153 V* =	766 lb.ft	1,038 N.m
My	4.413 V* =	1,302 lb.ft	1,765 N.m
Mz	4.139 V* =	763 lb.ft	1,035 N.m

When recording analog signal outputs, it is good practice to check the delta shunt output for each channel through the data acquisition and compare it to the engineering unit values listed above. If done, this will ensure that each channel is properly connected and scaled in the data acquisition. To calculate the delta shunt output add the absolute value of the positive Shunt output to the absolute value of the negative Shunt output and divide by two. The delta Shunt output you calculated should match the above value within 0.5%.

*Shunt voltage listed is nominal, the actual voltage may vary.

Speed and Position

Speed Sensitivity	1 Volt =	200 RPM
Position Sensitivity	1 Volt =	36 Degrees

The Speed Sensitivity listed above is the default setting (this corresponds to 2000 RPM full scale). The Speed Sensitivity can be changed to 100 or 300 RPM per volt in the CT3 webpage (corresponding to 1000 or 3000 RPM full scale). Check the CT3 webpage for current settings. Speed is updated at each encoder pulse.

Notes: