

MICHIGAN SCIENTIFIC CORPORATION

WHEEL TORQUE TRANSDUCER SYSTEM



MODEL: TW12.8 & TW12.8ER

For cars, SUVs, & light trucks



MICHIGAN SCIENTIFIC
corporation

MARCH, 2023

REVISION 1.1

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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.

This transducer is compatible with Michigan Scientifics legacy signal conditioning amplifier package, slip ring, cable, and power supply electronics used with other models of Michigan Scientific wheel torque transducers.

Specifications

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

<i>Capacity</i>	
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)
<i>Other</i>	
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 following components.

Transducer



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

Amplifier, Slip Ring, and Wheel Adapter Plate



The Slip ring is mounted to the WIP, Wheel Instrumentation Package. The WIP is a wheel mounting plate with an internal amplifier.

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.

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.

Collet Lug nuts



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

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.

PS-DC Power Supply



The PS-DC power supply provides power to the Amplifier package. It also has switches to engage the Shunt calibration, and to turn on or off Bridge Excitation.

Signal Cable



Signal Cable connects from the slip ring to the PS-DC and has tinned leads for the Torque and Speed signal output.

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 M10x1.5x18mm fasteners hand tight with a small amount of anti-seize on the thread and under the bolt head as shown above.
- 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 M10x1.5x25mm 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)

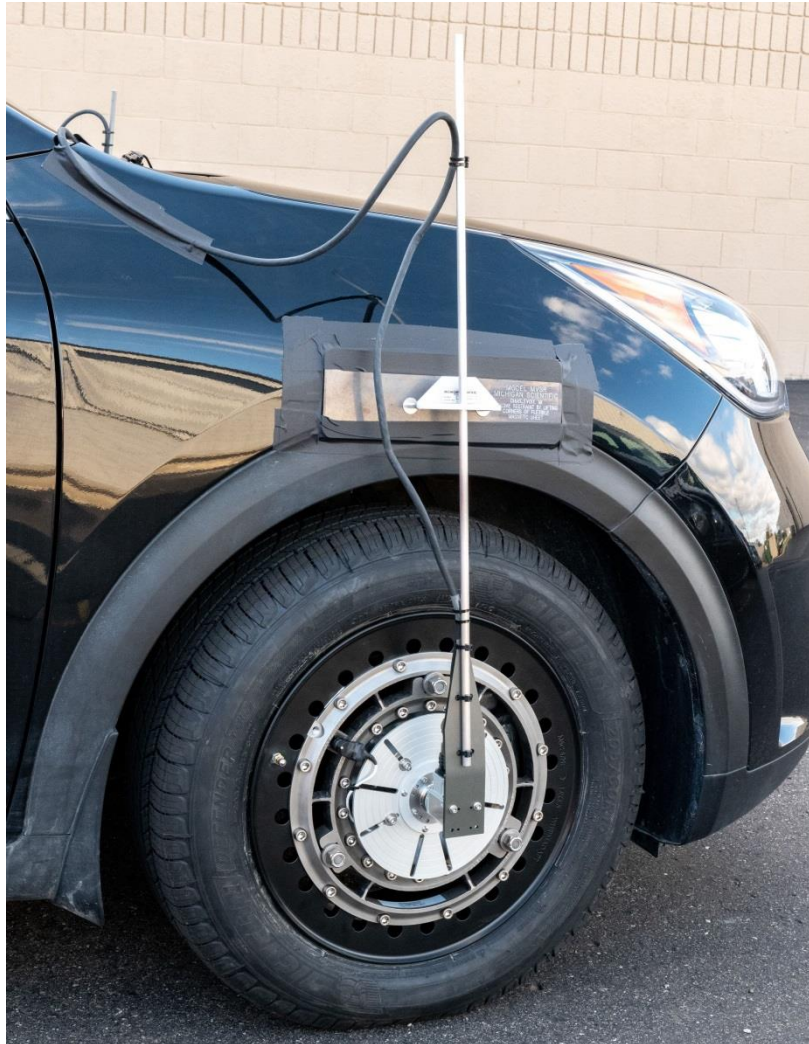
Transducer to Rim adapter bolts, if welded aluminum rim adapter: 27 lb-ft (37 N.m).

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.

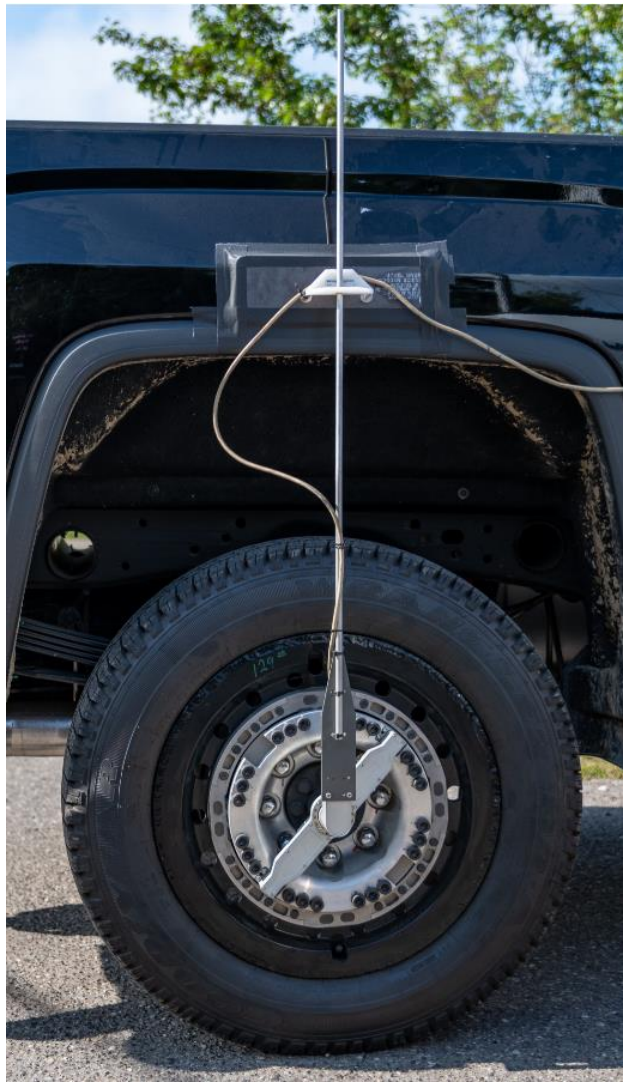
- Mount the Amplifier, Slip Ring, and Wheel Adapter plate assembly to the vehicle using one of the following procedures: 1) If Threaded Extended Lug-Nuts are being used, mount the Wheel Adapter Plate to the extended lug-nuts using the ¼-20 cap-screws. 2) If Quick Connect Collet Lug-Nut Extensions are 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.

Slip Ring Stator Restraints

Michigan Scientific provides a MVSR (Magnetic Vehicle Stator Restraint) and restraint rod with each Wheel Torque Transducer System.



The MVSR and restraint rod should be used to prevent the slip ring stator from rotating. The MVSR should be attached to the vehicle body with the magnet backing and should be placed directly above the slip ring. If the vehicle body is aluminum or plastic, tape can be used to hold the MVSR to the vehicle. Even if the body is steel, some tape should be used to re-enforce. Slide the restraint rod into the 5/8" (16mm) hole in the MVSR and attached the plastic portion of the restraint rod to the Slip Ring with two #8-32 SHCS bolts. These bolts should be installed with Loctite and should be tightened firmly with an Allen Wrench.



Cable Connections

- Connect the 26-pin connector of the 6 meter (20 ft) long cable to the slip ring. The connector is waterproof. For off-road testing, using tape around this connection keeps grit from getting into the connector threads. The connector is difficult to remove if grit enters the threads.
- Connect the 6-pin connector the other end of the cable to the PS-DC. Either Output connector A or B can be used. The other Output connector can connect to a 2nd Wheel Torque Transducer (WTT) signal cable. If more than two WTT will be used together a splitter cable is required for the PS-DC output connectors.



- Connect the power cable to the PS-DC Input Power connector.
- Connect other end of the power cable to a DC voltage source in the range of 10 to 36 volts. The other end of the power cable has a Cigarette Lighter plug for connection to vehicle power.
- Add connectors for your data acquisition to the tinned lead on the Signal Cable. 'SG AMP SIGNALS' is the amplified Torque Signal. 'TACH position' is 0 to 360 degrees sawtooth signal corresponding to rotational position. 'TACH velocity' is the Wheel Speed (rpm) signal. 'Encoder' signals are the raw pulses from the encoder. The full scale voltage output for each signal is +/- 10 Volts. See the Appendix 1 for output signal wiring details.

Torque Signal Output

- The torque signal high (red/white) and torque signal low (brown/white) make up the Torque Signal Output. Torque polarity should be adjusted in the data acquisition by adding negative sign to the sensitivity.

Wheel Speed Signal Output

- The velocity output (blue) and tach signal low (brown) make up the Wheel Speed Signal Output. The default Speed Range (Range 1) is 1000 rpm full scale. Speed Range 2 is 1800 rpm. To switch from Range 1 to Range 2, short together at the end of the cable, velocity full scale option (violet) to option ground (gray). To adjust the Speed polarity short together at the end of the cable, direction polarity option (yellow) to option ground (gray). This will also change the polarity of wheel position signal.

Wheel Speed Signal Output

- The position output (orange) and tach signal low (brown) make up the Wheel Rotational Position Signal Output.

Once wiring is complete and connectors are added, connect to your data acquisition.

Operation

PS-DC Power Supply

The PS-DC-1.0V2 Power Supply has three switches that control power, Bridge Power (for noise checking), and invoke a positive and negative shunt calibration resistor.

The Power Switch turns the power on and off. The LED located on the front panel will illuminate when the supply is operating properly, and the power switch is on.

The Bridge Excitation switch controls the bridge excitation voltage. When the switch is in the ON position, the amplifiers supply excitation voltage to the transducers strain gage bridge. This is normal operating mode. When the switch is in the OFF position, the amplifiers do not provide excitation to the transducers strain gage bridge but the

amplifier is still operational. In this mode, any signal observed on the signal lines is background noise.

The Shunt Calibration Switch controls the shunt resistor located in the amplifier. When the switch is in the center position the transducers operate normally. When the switch is in the POS position, a shunt resistor is placed between the P+ and S+ lines of the strain gage bridge. This causes an electrical offset that corresponds to a calibrated output from the transducer. When the switch is in the NEG position, a shunt resistor is placed between the P+ and S- lines of the strain gage bridge, providing a negative offset. More information is below.

The LED located on the front panel is green when the PS-DC-1.0V2 is in normal operation mode. If the LED is red, either the shunt switch is not in the center position or the bridge excitation is turned off. If the LED is not lit, the power supply is not powered up.

Shunt Calibration

This operation provides one method to relate the output torque voltage to the corresponding measurement.

Each Wheel Torque Transducer has been calibrated statically in a calibration rig. The recorded data has been entered into a least-squares transducer calibration program to compute a best fit ratio between applied torque (lb-ft or N.m) and bridge output. The “200K Shunt” reported on the transducer calibration sheet, is the torque equivalent to bridge output when one arm of the bridge is shunted with a $200k\Omega$ resistance, which is installed in the amplifier.

To perform a shunt calibration, the vehicle should be positioned such that there is no torque variation on any of the wheels (i.e. the vehicle is not moving). Monitor the signal outputs from the transducer with either a multi-meter or the data acquisition system. Invoke the shunt calibration by moving the Shunt switch to the POS position. The delta voltage corresponds to the $200k\Omega$ shunt value recorded on the calibration sheet. A relationship between the signal output voltage and torque can be made.

Be sure to return the shunt switch to the center before recording data.

Appendix 1- Signal Cable Wiring

MICHIGAN SCIENTIFIC WIRING DIAGRAM.

TORQUE WHEEL SYSTEM WITH SR10AW/E512/AX SLIPRING AND WIP6-SG

STRAIN GAGE AMPLIFIER:

TSK (ADVICS), 2-3-23)

CABLES:

6-pin connector
(PT06E-10-6P)

Wire color

Power cable:

A	white/orange
A	orange/white
B	white/green
B	green/white
C	white/violet
F	white/blue

SG signal cable:

-	green
-	white
-	red
-	black
-	red/white
-	brown/white

Encoder signal cable:

-	blue
-	orange
-	yellow
-	violet
-	brown
-	gray

Stator
19-socket connector
(PT06E-14-19S)

Function

A	+15VDC amp power supply
P, jumper to L	+15VDC encoder power
B	amp ground
R, jumper to N	encoder power ground
C	-15VDC amp power supply
D	shunt cal control
E	Torque signal high
F	Torque signal low
G	not used in this application
H	not used in this application
J	not used in this application
K	not used in this application
(S, jumper to M)	encoder signal A
T	encoder signal B
U	encoder signal I
V	encoder signal A+B
(N, jumper to R)	encoder signal low (common)
(N, jumper to R)	encoder signal low (common)

TW12.8HRMS175 serial numnbers: 772

NE cable serial numbers: NE-4021

Project number: MW-0002

Customer: TOSOKU (ADVICS)

WIP6-SG : 392

PS-DC: 609

SR10AW/E512/AX: 3619

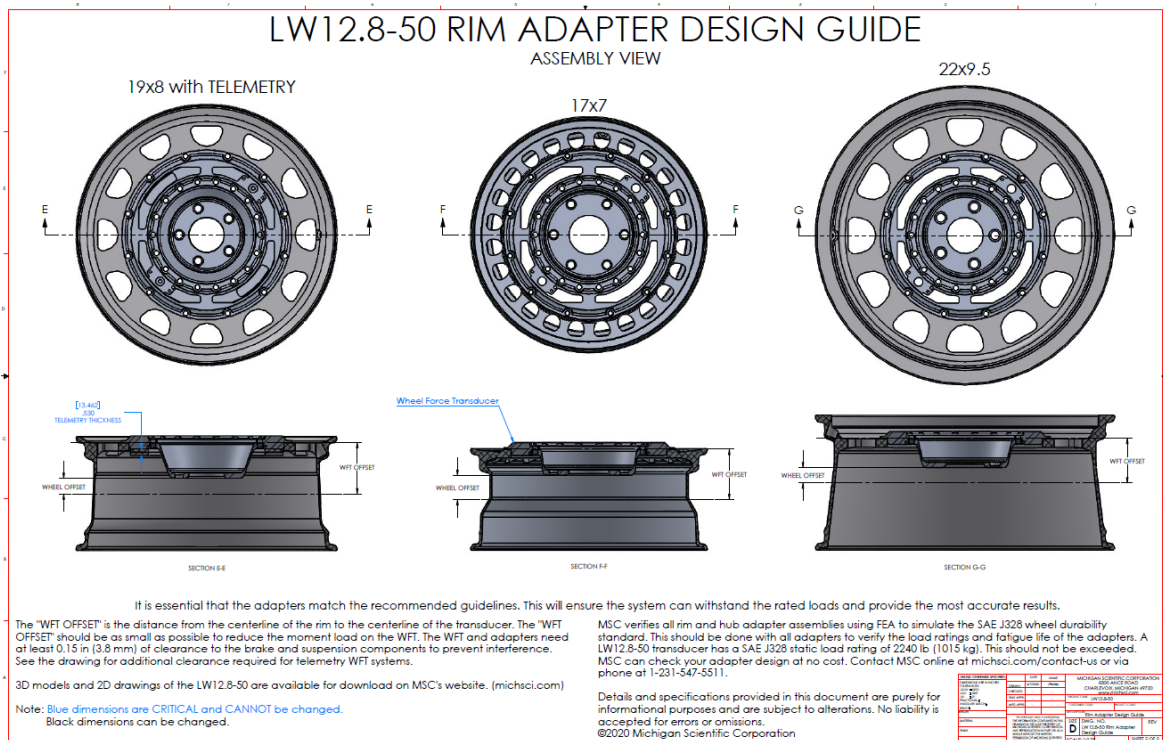
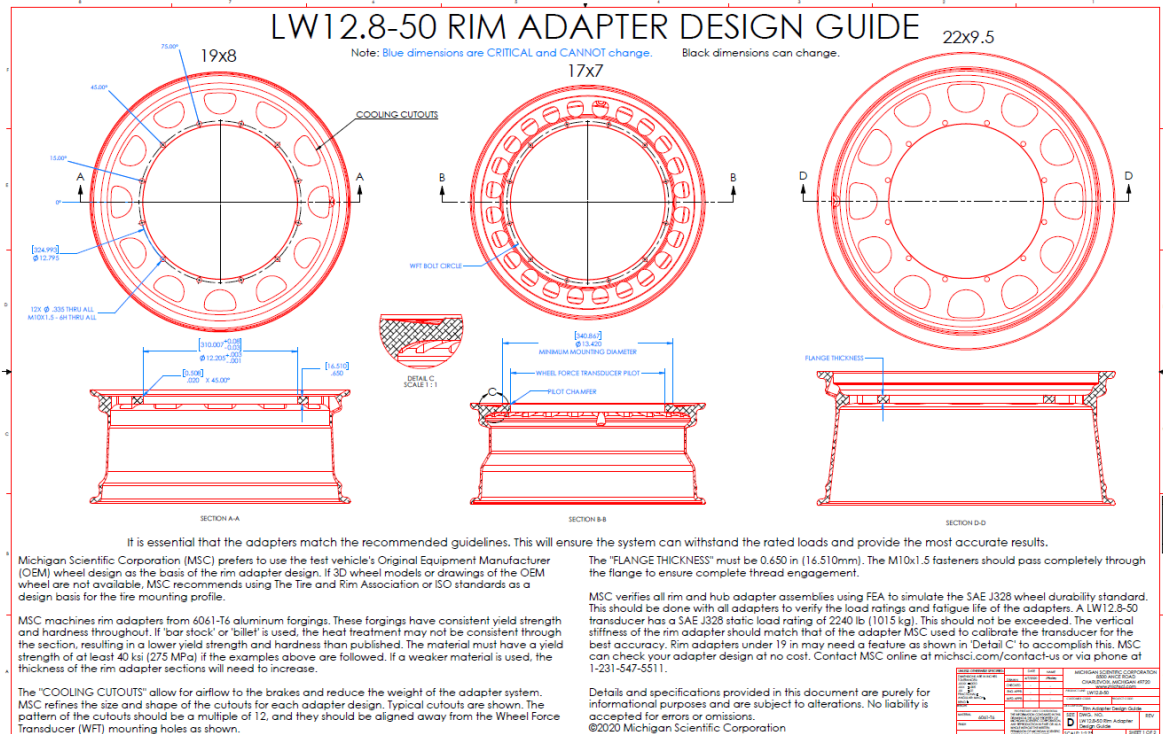
Gain 494, 200K shunt

Appendix 2- Adapter Design Guidelines

The TW12.8HRMS175 adapters follow the same adapter design guidelines as the LW12.8-50.

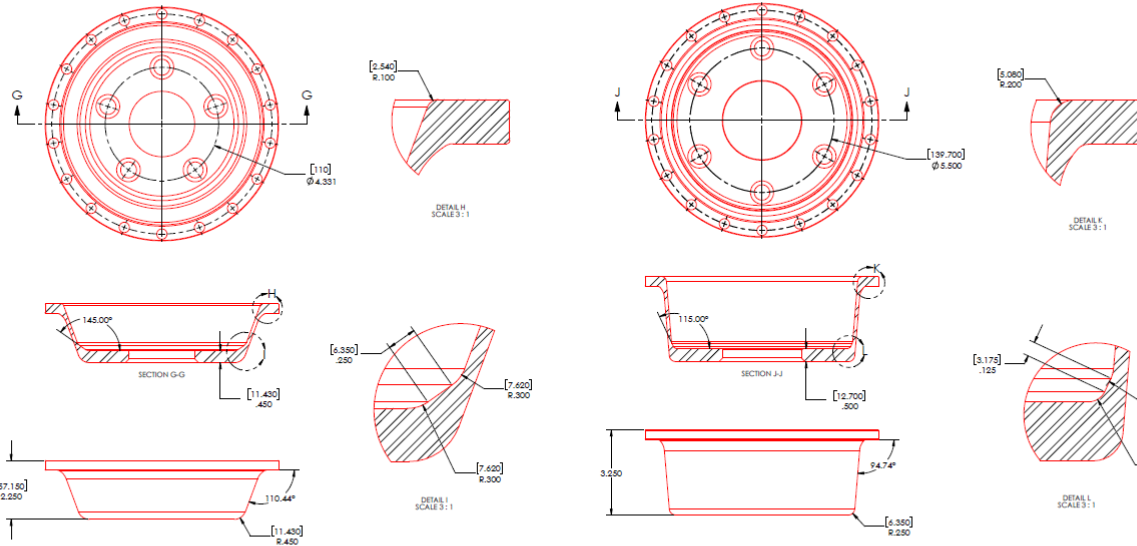
The latest Adapter Guidelines can be downloaded from our website:

https://www.michsci.com/products/transducers/wheel-force-transducers/lw12_8/



LW12.8-50 HUB ADAPTER Design Guide

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



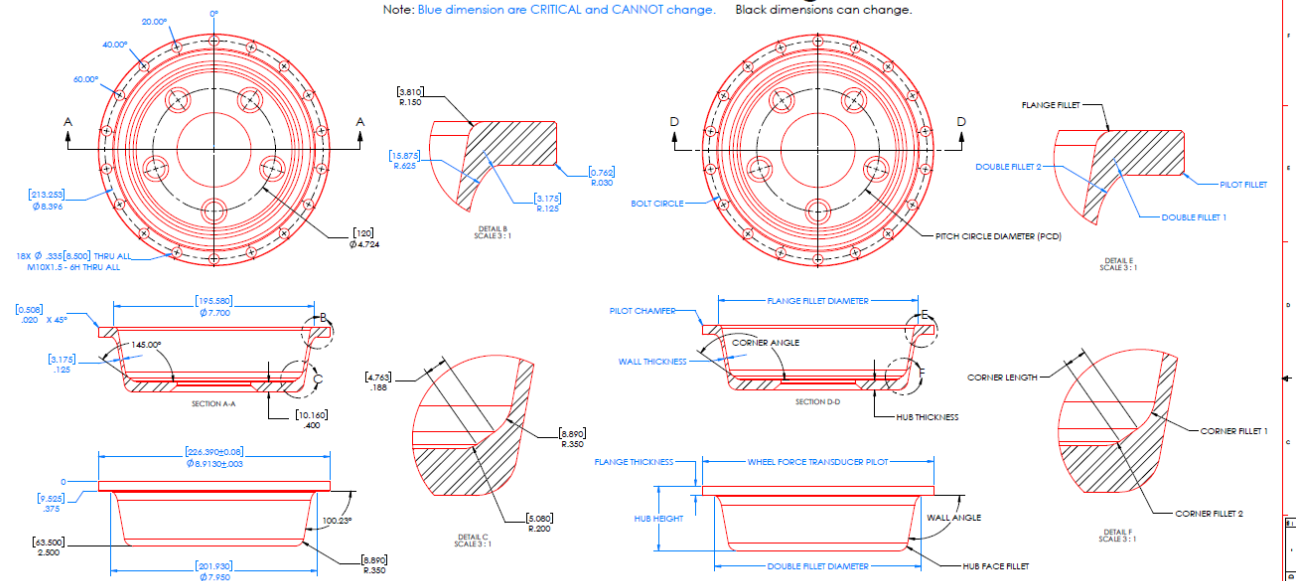
It is essential that the adapters match the recommended guidelines. This will ensure the system can withstand the rated loads and provide the most accurate results. The critical features are shown in blue. Customers may change all other geometry. Examples of permitted changes are shown above.

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REV	DATE	DESCRIPTION	BY	CHKD	APPD
1	12/4/13	Initial Release	MSC	MSC	MSC
2	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
3	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
4	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
5	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
6	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
7	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
8	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
9	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
10	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC

LW12.8-50 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 0.400 in (10.160 mm).

Detail C shows geometry that reduces the material stresses to increase the adapter fatigue life. The "CORNER ANGLE" should be between 115-145 degrees.

Michigan Scientific Corporation (MSC) machines hub adapters from 17-4 H1100 stainless steel. This material provides good insulation from brake heat. Alloy steels can be used but they will conduct brake heat more than the stainless steel. The material should have a yield strength of at least 890 MPa (130 ksi) and a hardness between 32 and 45 HRC.

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. A LW12.8-50 transducer has a SAE J328 static load rating of 2240 lb (1015 kg). This should never be exceeded.

MSC can check your adapter designs at no cost. Contact MSC online at michsci.com/contact-us or via phone at 1-231-547-5511.

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6	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
7	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
8	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
9	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC
10	12/4/13	Revised to match actual dimensions	MSC	MSC	MSC

Appendix 3 –TW12.8 Calibration Sheet Example



Calibration Report: ISOMSC-601106262-104

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

Quick Reference Sheet

Transducer Model & Serial Number:	Calibration Date:
TW12.8 696	12/16/2022

Transducer Offset

Nearly every transducer will have a small signal output at zero load. Be sure to account for this offset when setting up your data acquisition system. It is recommended that this offset be documented or recorded for future reference. The long term stability of the zero offset is an indicator of the health of the transducer. Once the offset has been recorded you may then null out the offset using your data acquisition system.

Shunt Calibration (Recommended for Best Accuracy)

100K Shunt =	4,839.3 lb.ft	6,561.3 N.m
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Shunting an arm of a strain gage electrical bridge circuit with a resistor will produce a shift or change in output voltage. During factory calibration, the shunt resistor is placed between the P+ and S+ comers of the bridge. The exact **shift** or **change** in voltage while applying a shunt with the appropriate ohm resistance is your shunt voltage. This shunt voltage is equivalent to the output that will result when the load listed is applied to the transducer. In the case of Michigan Scientific amplifiers, this shunt resistance is located within the amplifier. The switch labeled SHUNT CALIBRATION on the Michigan Scientific amplifier power supply box controls this shunting feature. Moving the switch up to the POS position applies the shunt resistance. Returning the switch to the center position removes the shunt. The NEG position is not used in most applications.

Transducer Calibration Sensitivity (Nominal)

1 mV/V =	3,701.6 lb.ft	5,018.6 N.m
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Due to normal variations in electronic instrumentation, best accuracy is attained using the shunt calibration. The shunt calibration checks the accuracy of the entire recording system. Transducer calibration sensitivity is listed for those who prefer to use the sensitivity the transducer exhibited during calibration. A transducer that has one volt of bridge excitation applied to it, and has the listed load applied to it, will have nominally 1 mV of output. If 5 volts of excitation is applied, the resulting output with the listed load would be approximately 5 mV. The output is proportional to the load; if half as much of the listed load is applied to the transducer, the output will be nominally 0.5 mV for each volt of excitation, etc.

Transducer Sensitivity with Amplifiers (Nominal)

If the transducer is to be used with an amplifier, the provided calibration sensitivity may still be used. To convert the listed load into terms of volts, merely divide by the bridge excitation voltage, divide by the amplifier gain, and multiply by 1000. For the most accurate measurements, use the shunt calibration.

$$\frac{[\text{listed load}] \text{ lb ft}}{1 \text{ mV/V}} \times \frac{1,000 \text{ mV/V}}{(\text{excitation V}) * (\text{gain})} = \frac{[\text{calculated load}] \text{ lb ft}}{1 \text{ V}}$$

Other Information

Customer: MSC
Project: TWRECAL
Type: Recalibration
Sequence: B

Connector Information

P+	1-RED
S+	2-GREEN
S-	3-WHITE
P-	4-BLACK

Notes: