



# Steering Wheel Torque and Angle Measurement System

## Model: SW-SR2

# User Manual



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## Steering

### Wheel Torque Measurement System

- Accurate measurement of steering effort torque and steering angle
- Mounts to OEM steering wheel or shaft spline
- Includes transducer, encoder, mounting bracket, and user interface
- Measures steering torque, steering wheel angle, and steering rate (available on CAN output only)
- Analog output and CAN 2.0 signal outputs
- User interface with simple zeroing and shunt calibration controls

## Specifications

Rated Torque Capacity	100 lbf • ft (135 N • m) Nominal Optional 150 lbf • ft (200 N • m) or 220 lbf • ft (300 N • m )
Safe Axial Load at Wheel Edge	100 lbf (440 N)
Signal Outputs	Analog $\pm 10$ V and CAN 2.0
Torque Sensor Type	Full Bridge Strain Gauge
Torque Non-linearity	<0.25 % of full scale output
Steering Angle Range	$\pm 1440$ Degrees
Angle Resolution	0.04 Degrees
Max Speed for Angle Measurement	4500 rpm
Temperature Range, Compensated	70°F to 175°F (24°C to 80°C)
Temperature Range, Operating	0°F to 175°F (-20°C to 80°C)
Input Power	9 Vdc to 36 Vdc
Weight (Transducer Assembly)	9.0 lb (4.0 kg)

# System Overview

The Michigan Scientific Corporation (MSC) Steering Wheel Torque Measurement System measures steering effort torque and rotational position of the steering wheel.

The system is comprised of a precision torque transducer, high resolution encoder, mounting assembly, and signal conditioner. Torque data is amplified and then transmitted from the rotating to stationary via an instrument quality Michigan Scientific slip ring assembly which connects to a stator bracket and stator cable. The stator bracket attaches to an adjustable bracket system with suction cup that should be secured to the windshield. The stator cable connects to the DIGI-STEER unit.



There are two optional mounting arrangements available. In both cases the user will interact with an aftermarket steering wheel which is bolted to the top of the transducer.



With the first option 'Clamping Arms' attach the bottom side of the transducer to the OEM steering wheel.



With the second option, the OEM steering wheel is removed, and the bottom side of the transducer is bolted to a custom spline adapter which mounts directly to the steering wheel shaft.



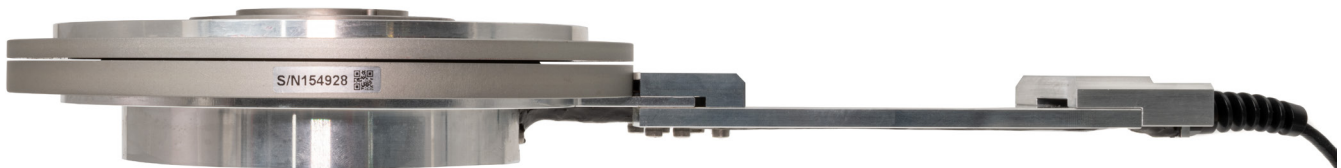
## Transducer

The transducer is a single channel strain gauge based transducer that is gauged and wired to measure torque only. Mounted to the transducer is a Michigan Scientific B6-2 Slip Ring that makes an electrical connection to the strain gauges. The signal is transmitted through the Slip Ring Assembly to the Stator Cable.



## Encoder

A high resolution encoder is mounted in the assembly and uses the bearing in the slip ring to rotate in plane. The rotating component is mounted to the transducer, and the stationary component is mounted to the slip ring stator. The assembly creates the necessary air gap between the two components of the encoder assembly.





## DIGI-STEER User Interface and Signal Conditioner

The DIGI-STEER unit provides power to the strain gauge bridge and encoder assembly, has user control switches, and provides Analog and CAN 2.0 signal outputs for both Torque and Rotational Angle.

A power supply of 10 Vdc to 36 Vdc is required to operate the DIGI-STEER which makes it ideal for automotive applications.

The DIGI-STEER unit has four switches which are Power, Zero, Shunt Calibration, and Encoder Zero Set

Operating details of the DIGI-STEER are on page 11.



# Installation Instructions

## Precautions

- **WARNING !** - Remove airbag to prevent injury.
- To avoid damage use care when working with any part of the transducer system.

## Clamping Arms Installation:

Remove airbag from vehicle. Then remove the steering wheel center bolt holding the OEM steering wheel to the steering shaft.

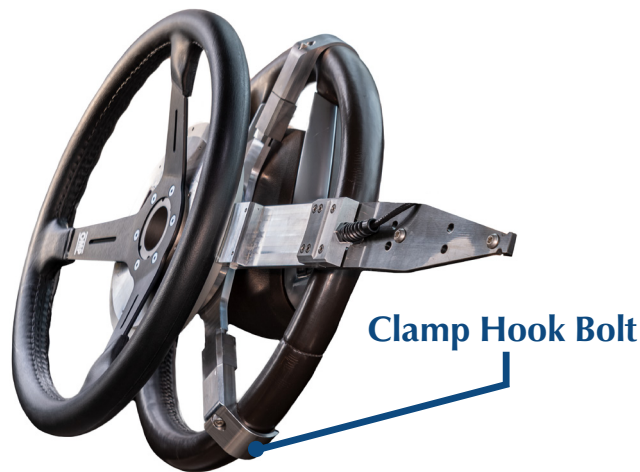
Next, place the steering wheel center bolt into the provided Cylinder Alignment tool, re-install the steering wheel bolt into the steering shaft as shown below. The Cylinder Alignment tool is for installation only and is used to align the Steer Wheel Torque System on the steering wheel center of rotation.



The Steering Wheel Transducer System attaches to the production steering wheel with three Clamp Hooks. The Clamp Hooks have an inner radius of 0.75" bolt to the Y adapter with ½-20" SHCS bolts. Clamp Hook extenders and different size Y adapters are available to fit varying sized steering wheels. MSC offers four different size Y Adapters for fitting to different sized steering wheels. See the Appendix for Y Adapter sizing options. Clamp Hook extenders are also available for further adaptation options.



Place the Steering Wheel Transducer System with Clamping Hooks into place as shown below. The Clamping Hooks will grab the OEM steering wheel and the Cylinder Alignment Tool will pilot the Steering Wheel Transducer to the production steering wheel. Tighten the M6 or ¼-20" Clamp Hook Bolts incrementally until the SW-SR2 Steering Wheel can be fully turned without any slip between the OEM and SW-SR2 steering wheel (see note below). Finally remove the Cylinder Alignment Tool and re-install the steering wheel center bolt.



## Notes

The amount of torque required to properly tighten Clamp Hook bolts to the steering wheel will vary based on the material and shape. If damage to the steering wheel is a concern, wrap tape around the wheel prior to mounting the Clamp Hooks.

## Spline Adapter Installation:

The steering wheel transducer can be secured to the steering shaft spline when used with a spline adapter. The vehicle specific spline needs to be cut into the spline adapter by MSC or by the end user.

After the spline adapter has the appropriate spline for your vehicle steering shaft, bolt spline adapter to bottom of transducer with twelve M4 or #6-32 bolts and tighten to 24 lbf · in (2.7 N · m).



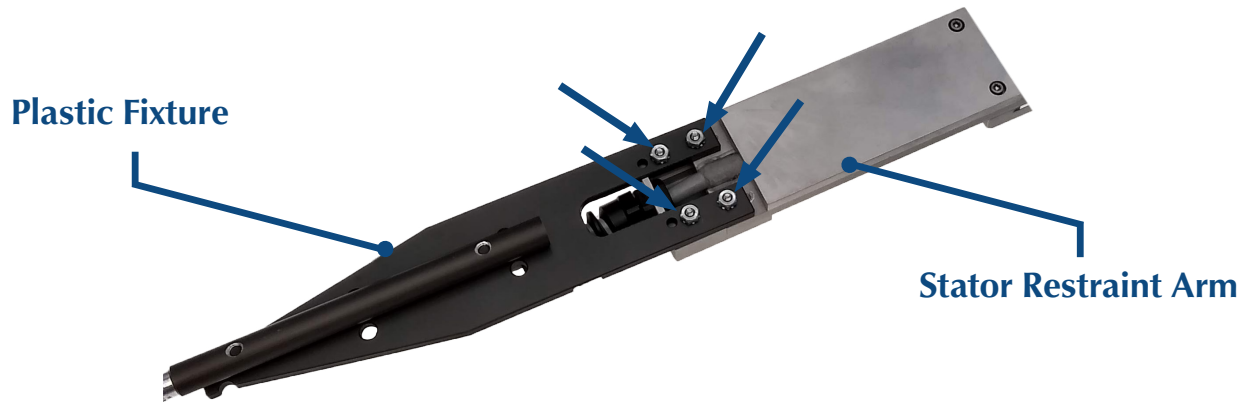
Remove the Original Vehicle Steering Wheel until steering shaft male spline is exposed.

Mate SW-SR2 with the spline adapter onto the Steering shaft spline and install the Steering Wheel Center Bolt to secure the SW-SR2 to the steering shaft.



## Anti-Rotation Bracket Installation:

Secure the Anti-Rotation stator bracket to the vehicle windshield to establish a stationary reference for the encoder. Use four 6-32 socket head cap screws and 6-32 nuts with lock washers to fasten the Plastic Fixture to the Stator Restraint Arm.



Secure the suction cup to the vehicle windshield out of the main view of the driver. It is recommended to clean the windshield before attaching the suction cup assembly. Then tighten each of the ball pivot locks securely so that there is minimal play in the Anti-Rotation Bracket when turning the steering wheel.





# Operation

## Cable Connections

Connect the steering wheel transducer cable to the 'Input' Connector on the back of the DIGI-STEER unit .

Connect the power cable to the DIGI-STEER unit and connect the other end of the power cable to a DC voltage source in the range of 10 Volts to 36 Volts.

Connect the output cables to the BNC output connectors and connect the other end to the data acquisition. Both the Torque and Encoder signals provide a  $\pm 10$  Volt DC signal output. Alternatively, connect a CAN adapter to the 'CAN' Sub-D 9 pin connector.



## Control Switches

The DIGI-STEER unit has four switches on the front panel.

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



## Torque Zeroing

The Zero switch controls whether to null the torque output. The blue LED located on the front panel will illuminate when Zero switch is ON and nulling is enabled. When the Zero switch is OFF, nulling is not enabled. The Zero switch should remain ON while in operation. When the Zero is initially switched ON, the torque data is sampled for 2 seconds. The average torque measured during this time is used as an offset to null the torque output signal. This offset value is applied, and the blue LED remains lit until the Zero switch is turned OFF. Switching ON again will capture a new offset value. The offset value is stored in memory and applied upon each new power cycle as long as the Zero switch remains in the ON position.



## Shunt Calibration

The Shunt Calibration Switch controls the shunt resistor located in the amplifier of the DIGI-STEER. 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 yellow LED located on the front panel is illuminated when the shunt calibration switch is active.

## Shunt Calibration Explanation

This Shunt Calibration operation provides the method to relate the output torque voltage to the corresponding measurement. Each SW-SR2 has been calibrated statically in a torque calibration machine. The recorded data has been entered into a least-squares transducer calibration program to compute a best fit ratio between applied torque (lbf-ft or N·m) and bridge output. The “100K Shunt” reported on the transducer calibration sheet, is the torque equivalent to bridge output when one arm of the bridge is shunted with a 100 k $\Omega$  resistance, which is installed in the amplifier. To perform a shunt calibration, ensure no torque is applied to the SW-SR2 transducer. 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 (voltage change from Shunt Off to POS Shunt) corresponds to the 100 k $\Omega$  shunt value recorded on the calibration sheet. A relationship between the signal output voltage and torque can be made to set-up the data acquisition.

See the calibration sheets that were shipped with your equipment. Be sure to return the shunt switch to the center before recording data.

## Angle Encoder Zeroing

The Angle switch sets the zero-position point (i.e. datum) for the SW-SR2 angular encoder. The red LED located on the front panel will illuminate when the switch is pressed and released, and the zeroing process begins. The zeroing process is a two-part process which requires operator interaction to complete successfully. During the first part of the process, the red LED will flash to prompt the operator to rotate the steering wheel clockwise by more than 5 degrees and then stop the rotation. Once moved, the red LED will stop flashing and illuminate solid for 2 more seconds. Once the red LED turns OFF, the zeroing process is complete. The new datum is set to the location where the steering wheel was when the operator first pressed the zeroing switch to begin the process. This datum is stored in memory until another zeroing process is completed.

For best results, ensure the vehicle wheels are straight before beginning a zeroing procedure. Then, press and release this switch to begin the zeroing process for setting the new steering wheel datum.

The encoder keeps track of position and number of turns when powered off if conditions are correct. The encoder turn count may not be accurate if it rotates without power. When power is applied, the position is compared to the position in memory. If movement is detected the red LED will light. It is best to reset zero if the wheel has been turned without power to the system. The output saturates at  $\pm 1440$  degrees and the red LED will light if the turn count exceeds  $\pm 4$  turns.

## SW-SR2 Analog Outputs

The full scale output range for the Torque and Angle Analog Outputs is  $\pm 10$  VDC. The BNC connector on the DIGI-STEER labeled TRQ-OUT is the Analog signal output for the torque channel. The BNC connector on the DIGI-STEER labeled ANGOUT is the Analog signal output for the Angle channel. The data acquisition can be set-up for the SW-SR2 Analog torque output using the Transducer Calibration Sensitivity listed on the Calibration Sheet of Each Transducer. This value gives the amount of torque equivalent to 1 volt of output from the Wheel Torque Transducer System.

It is recommended to perform a Shunt Calibration to verify that the data acquisition is set-up properly. Check that the Shunt Calibration in  $\text{N} \cdot \text{m}$  (or  $\text{lbf} \cdot \text{ft}$ ) matches the Delta change in torque data acquisition.

The Analog Angle output is set-up for 1 volt equals 144 degrees (10 volts = 1440 degrees).

## SW-SR2 CAN Outputs

The DIGI-STEER unit can output torque, steering angle, and steering rate (velocity) on a CAN Bus output. The DB9 connector on the DIGI-STEER box is used to connect to the CAN output. A custom .dbc file is provided by MSC to set-up and scale the CAN outputs in the data acquisition.

## Optional Heads Up Display (HUD)

An Optional Heads Up Display (HUD) can be purchased with the SW-SR2. The HUD is provided with a suction cup assembly to attach it to the windshield. The HUD gives a live read-out Torque and Steering Wheel Angle.

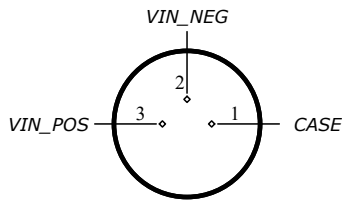


# Appendix

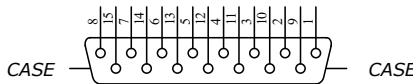
## Cable Wiring Diagram

### DIGISTEER REAR PANEL CONNECTIONS

**POWER**  
M8 3PIN-FEMALE

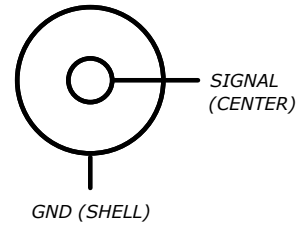


**INPUT**  
DSUB 15PIN-FEMALE

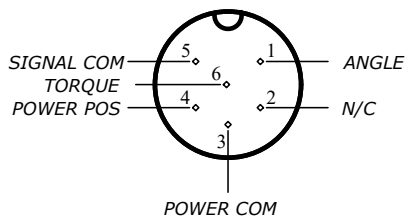


DSUB 15-PIN...  
 1=BPH            6=GND-CH1        11=CLK+ENC  
 2=BSH            7=GND-ENC        12=CLK-ENC  
 3=BSL            8=PWR-ENC        13=DAT+ENC  
 4=BPL            9=ZZS-ENC        14=DAT-ENC  
 5=NC             10=ZZR-ENC       15=SHIELD

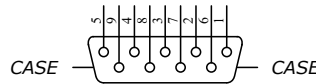
**TRQ-OUT**  
BNC



**HUD**  
M8 6PIN-FEMALE

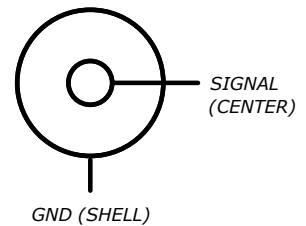


**CAN**  
DSUB 9PIN-FEMALE

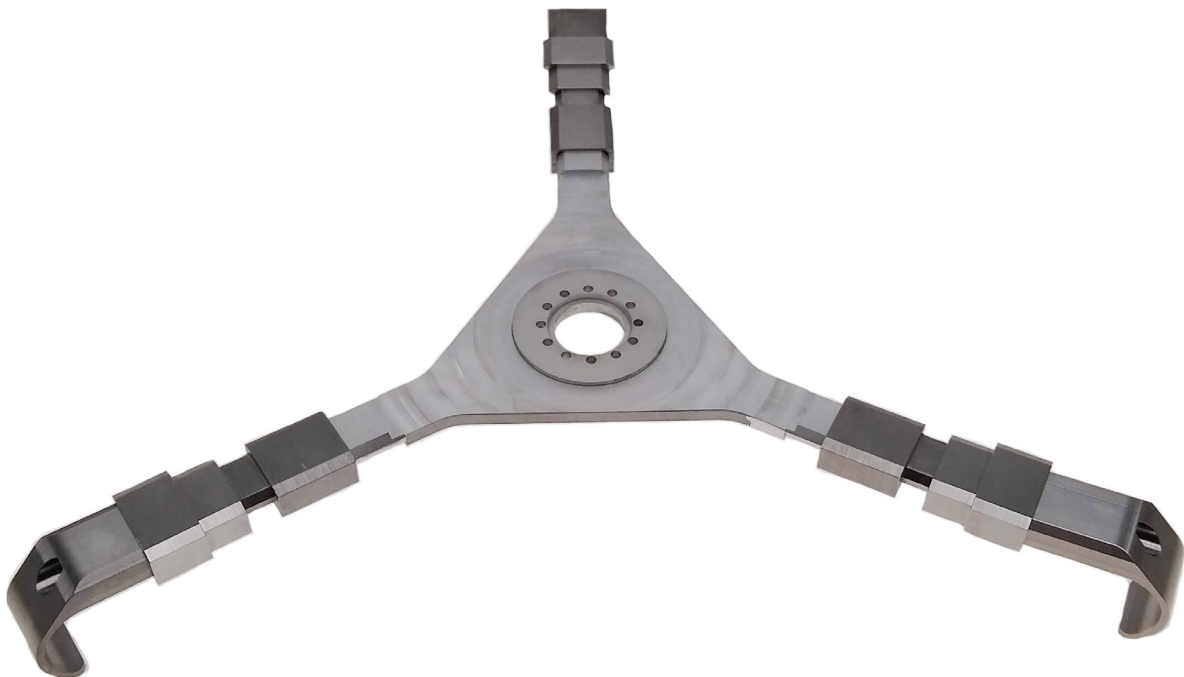
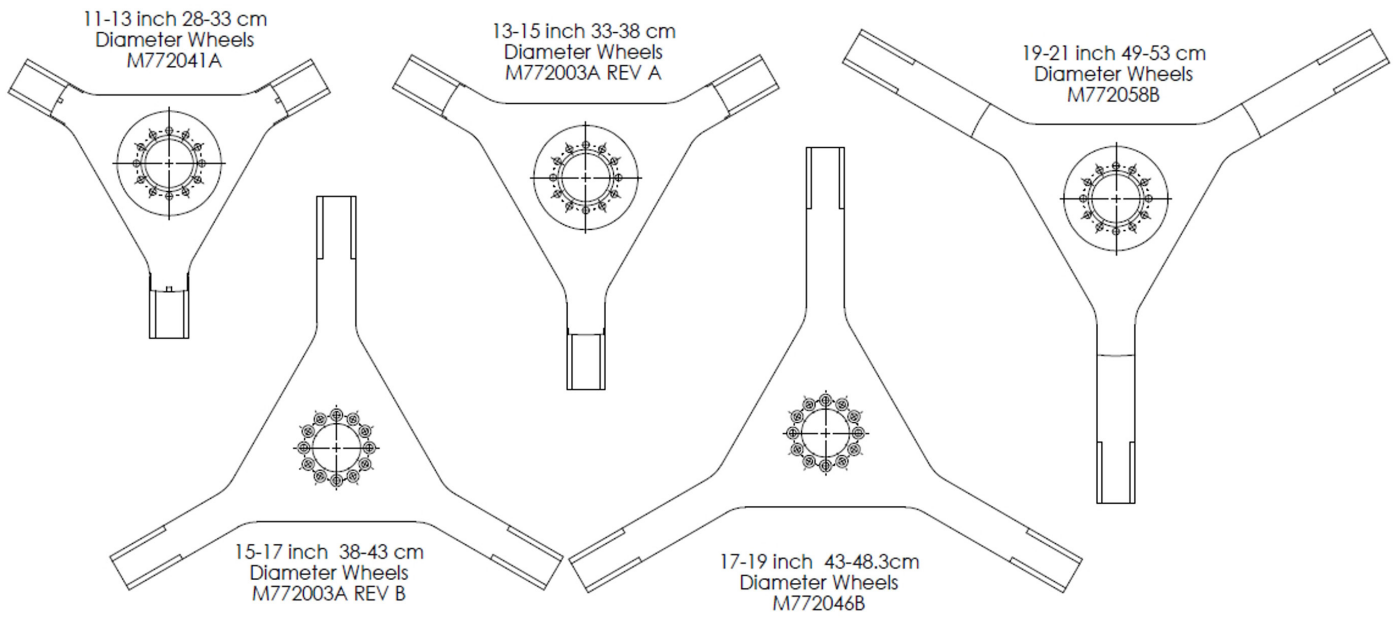


DSUB 9-PIN...  
 2=CAN-LOW  
 3=CAN-GND  
 5=SHIELD  
 7=CAN-HIGH  
 \*1,4,6,8,9=N/C

**ANG-OUT**  
BNC

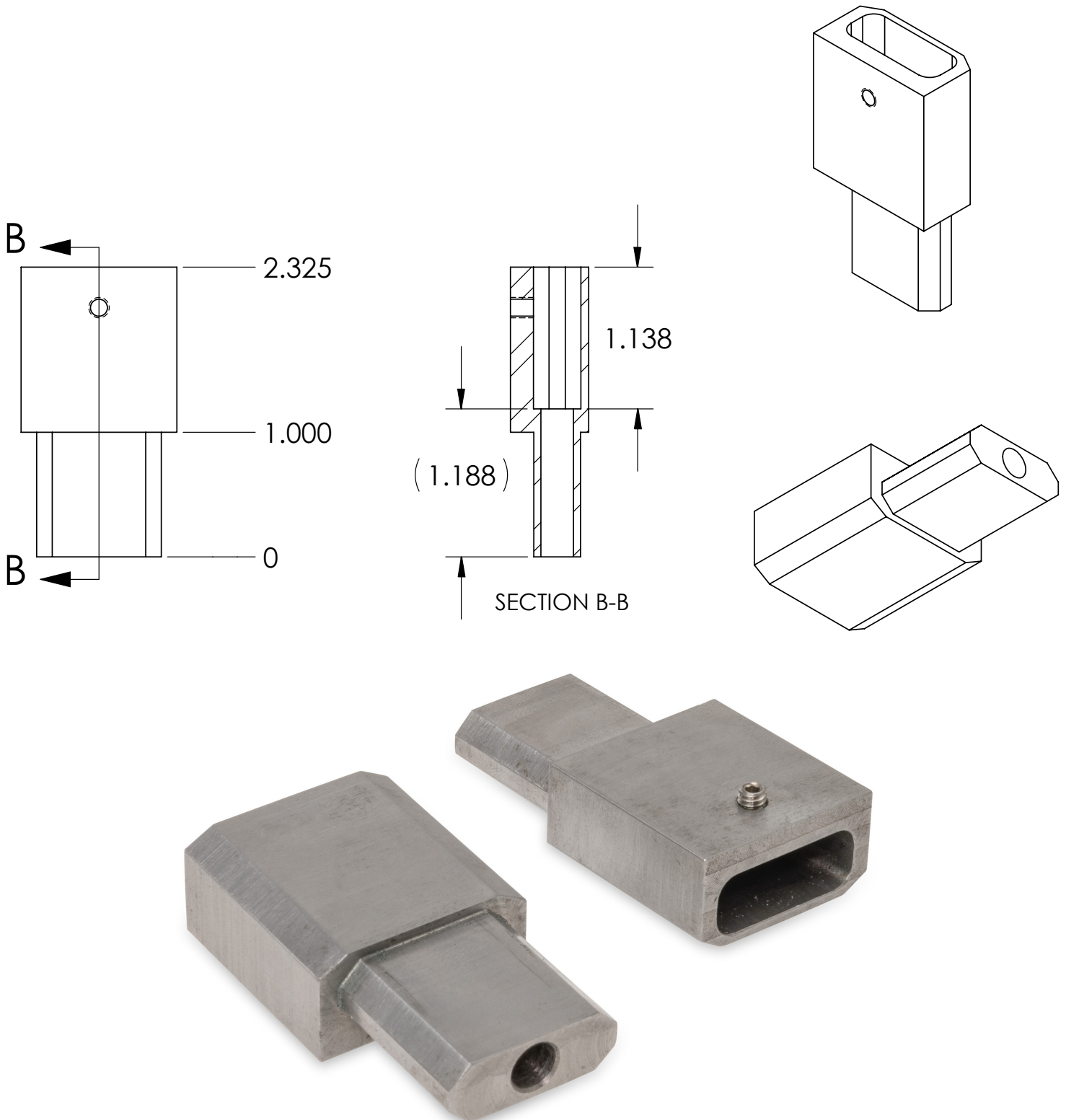


## Y Adapter Options



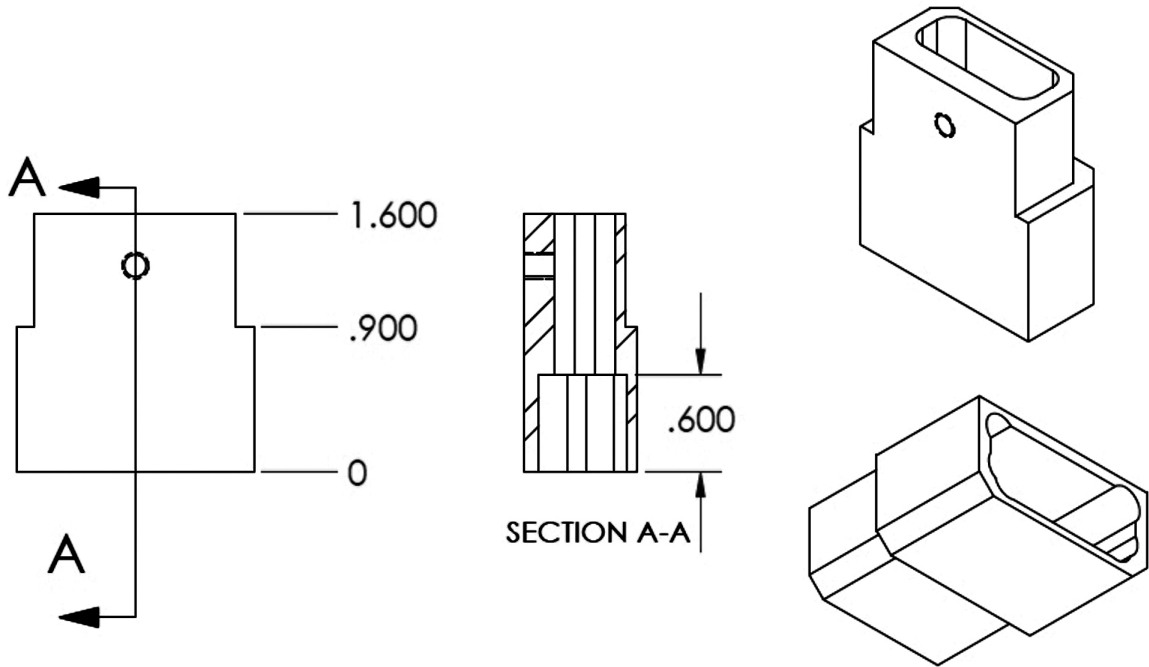
## Optional Clamping Hook Extenders

The Optional Clamping Hook Extenders extend the diameter range of the Y Adapters by approximately 3.5 inches.



## Optional Clamping Hook Extenders

The Optional Clamping Hook Extenders extend the diameter range of the Y Adapters from 0 to 2 inch by fitting over the hooks.





## 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\_  
SG\_MUL\_VAL\_

BS\_:

BU\_:

BO\_ 170 Digisteer: 8 Vector\_\_XXX

SG\_ SteeringSpeed : 0 | 16@1- (0.030517578,0) [0 | 1000] "deg/sec" Vector\_\_XXX

SG\_ SteeringAngle : 16 | 16@1- (0.0439466536,0) [-1440 | 1440] "deg" Vector\_\_XXX

SG\_ SteeringMoment : 32 | 16@1- (0.00030518,0) [10 | -10] "V" Vector\_\_XXX