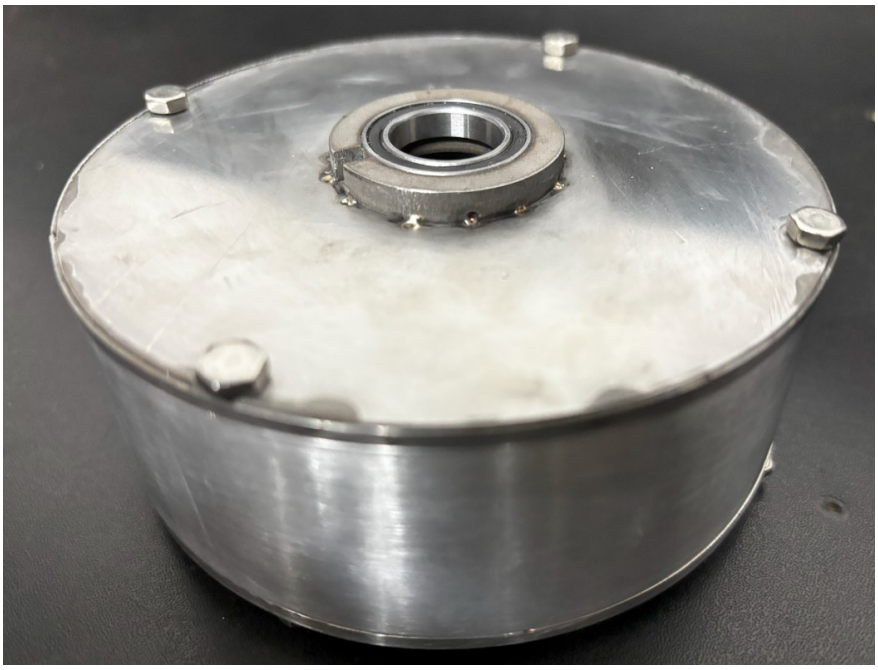
Capacitive Torque Sensor
Version-1.0
User Manual



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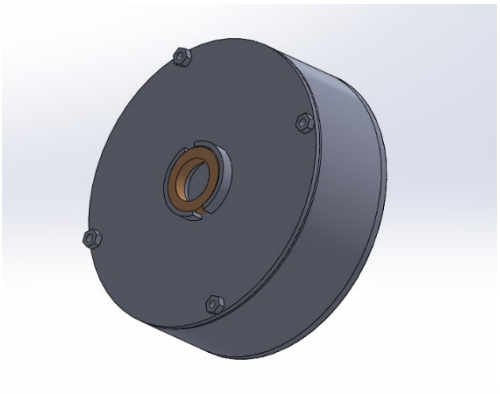
Chapter 1:

1.1 Introduction

The Capacitive Torque Sensor is a precision-engineered device designed to measure applied static torque in rotating systems. It uses differential capacitive sensing with high-resolution digital conversion to deliver exceptional sensitivity.



Suitable for robotics, automotive testing, and industrial automation.

SolidWorks Design Real Product

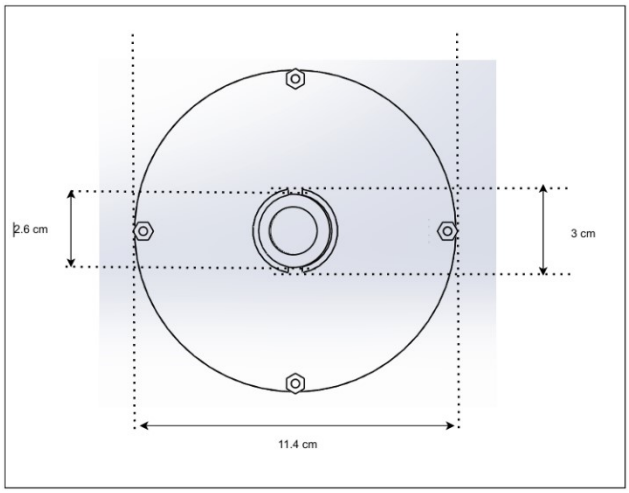
1.2 Specifications

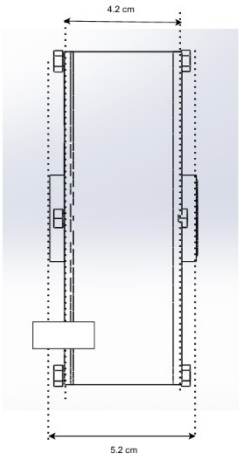
General Information

Parameter	Value
Shaft Material	Aluminium Alloy 6061-T6
Dielectric Material	FR4 (Glass Epoxy)
Shaft Dimensions	1.7 cm (ends), 0.6 cm (middle)
Operating Temperature	Up to 140°C
Weight	Approx. 500 g

Technical Specifications

Parameter	Value
Sensing Principle	Differential Capacitive Sensing
Capacitance Range	±50 pF
Capacitance Resolution	156 aF at 1 kHz (PCAP04)
Torque Range	0 – 1 Nm
Measurable Capacitance Change	~357.4 fF at 1 Nm
Sampling Rate	1000 samples/second
Microcontroller	ATmega32U4, 16 MHz
Flash Memory	32 KB
RAM	2.5 KB
USB Support	Native USB 2.0





Mechanical Specifications

Front View

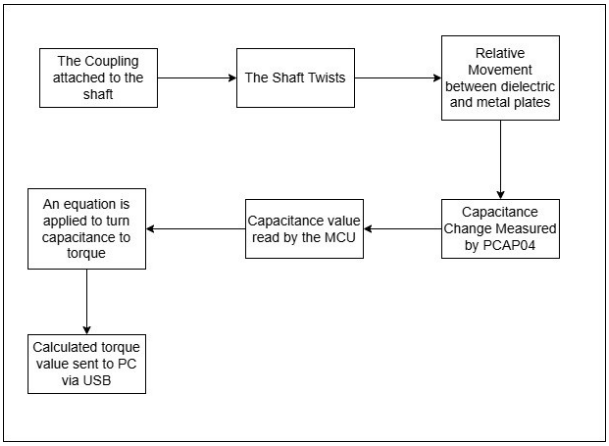
Side View

Electrical Specifications

	Min	Typ	Max	Units

1.3 Theory of Operation

The sensor measures torque by detecting changes in capacitance between differential plates. This happens due to the relative movement of the metal and dielectric plates mounted on the shaft. These changes are converted into digital data using a PCAP04 CDC chip and that result turned to torque values by substituting to an equation. The torque value is then transmitted to computer through USB communication.

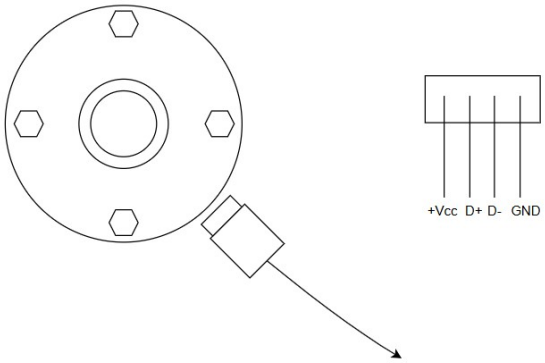


Functional Block Diagram

Chapter 2:

Installation

- **Manpower Required:** One technician with basic electronics and mechanical knowledge.
- **Tools Required:** Allen keys, USB cable, torque driver.
- **Materials Required:** Mounting screws, coupler connector, alignment tools.
- **Connection Diagram:** USB-powered to Sensor by PC.

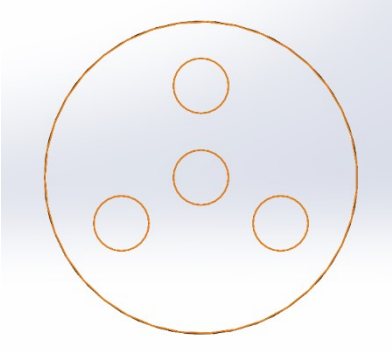


USB Connection to the Sensor

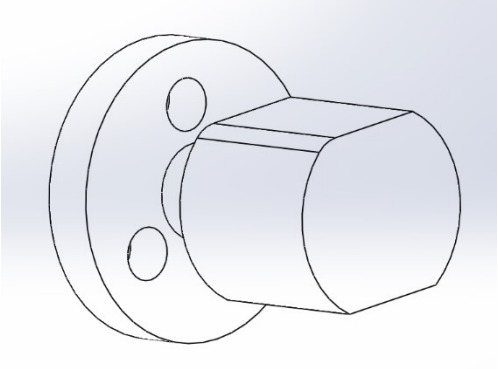
- ## Steps of Installation:

Step 1: Prepare the Setup

- Clean the workspace.
- Gather necessary tools (screwdrivers, Allen keys).
- Ensure all components are available: sensor, screws, USB-B cable.



Face of the shaft

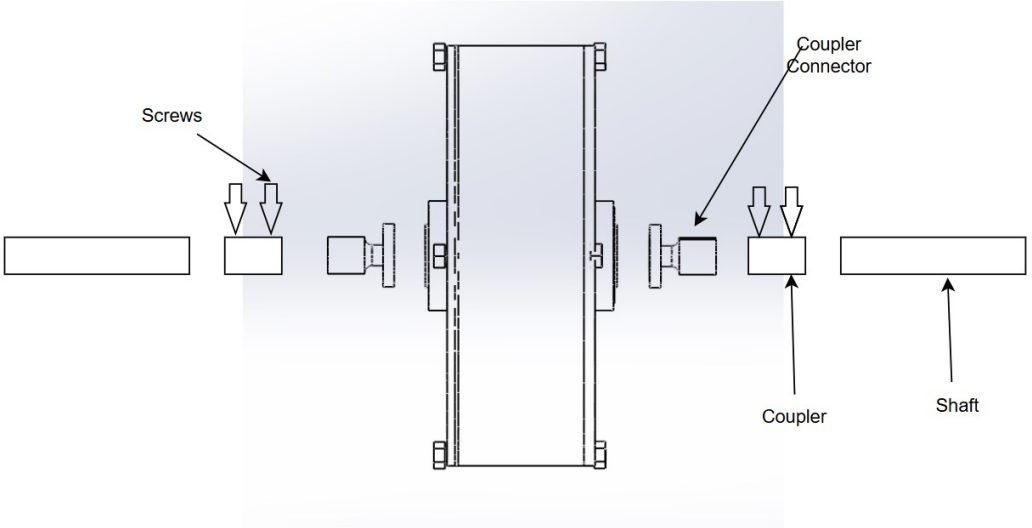


The coupler connector

Step 2: Mount the Sensor Mechanically

The coupler connector connects shaft to couplers of standard sizes.

- Identify the input and output shafts.
- Attach coupler connector of proper size to both: Select connectors matching the shaft diameter and secure them with set screws.
- Attach the connectors to proper couplers: Ensure the connectors align with the coupler's keyways or slots for a firm fit.
- Attach one of the couplers to the input shaft which is connected to torque generator (Motor):
- Attach the other coupler to the output shaft connecting the load.
- Use alignment tools to ensure no angular misalignment: Employ a laser alignment tool or dial indicator to confirm precise shaft alignment.



How sensor is connected to shafts via coupling

Chapter 3:

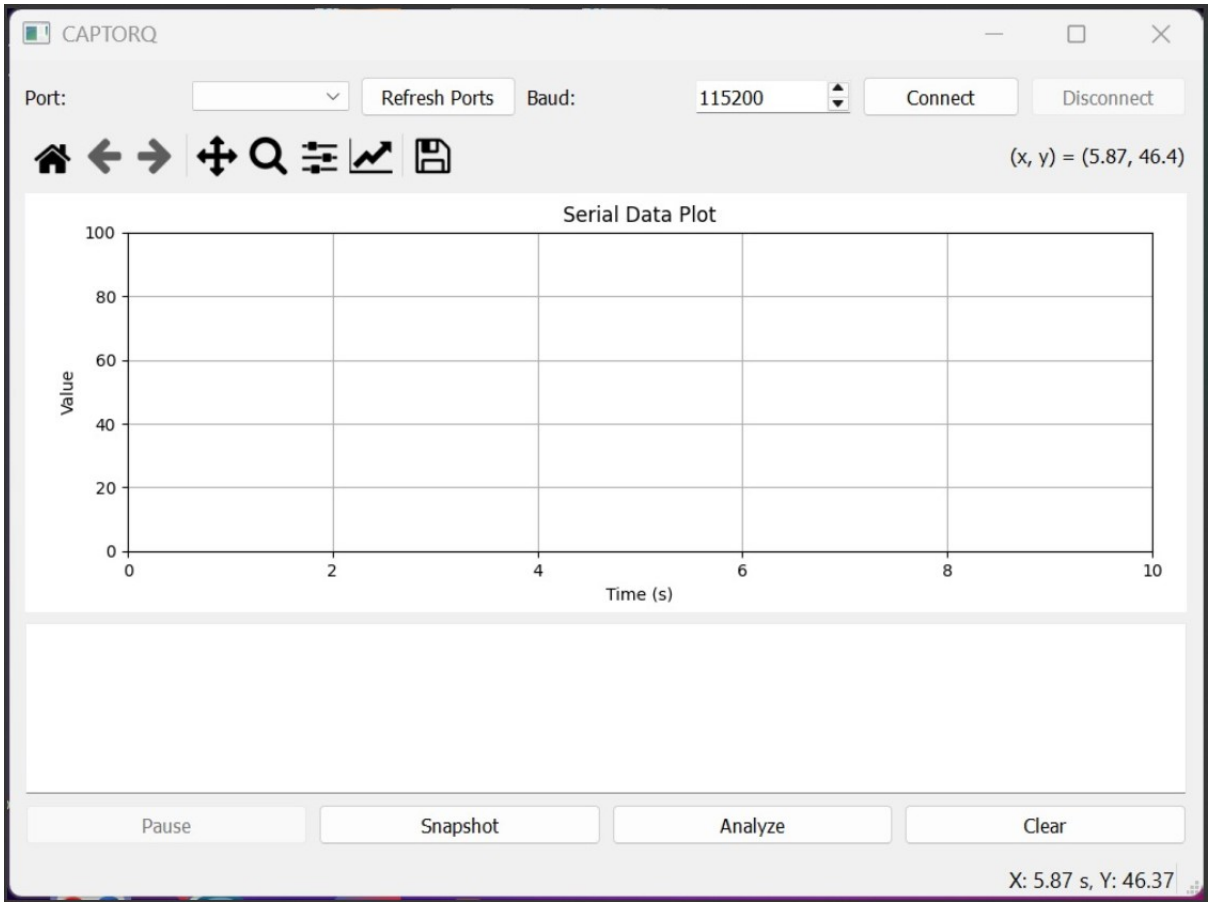
Operating Instructions

- Refer to the **front panel drawing**

Step 3: Launch the Software

- **Open the torque sensor GUI software in your PC:** Double-click the torque sensor GUI application icon on your desktop, or navigate to the installation directory (e.g., C:\Program Files\TorqueSensorGUI) and launch the executable file.
- **Ensure USB drivers are properly installed in sensor:** Verify that the latest USB drivers for the torque sensor are installed on your PC. If not, download them from the manufacturer's website and follow the installation wizard.

- **Confirm the system detects the sensor:** In the GUI software, go to the "Device" or "Connection" menu and select "Detect Sensor." Wait for the software to scan and display the sensor's serial number or model details in the status window. If the sensor is not detected, disconnect and reconnect the USB cable, then retry the detection process.
- **Ensure the port number detect correctly:** Check the software's connection settings to confirm the correct COM port (e.g., COM3) or USB port is assigned to the sensor. If the port is incorrect, manually select the appropriate port from the dropdown menu based on the PC's port assignment (visible in Device Manager).



Step 4: Calibrate the Sensor (Optional but Recommended)

- Enter calibration mode in the software.
- Apply known torque and note the output.
- Adjust settings for accurate measurement (gain, offset).
- Get the coefficient by polynomial curve fitting. Upload the coefficients to the microcontroller through USB.

Step 5: Final Testing

- Apply torque and check if real-time values are displayed.
- Verify stable, consistent readings.
- Ensure all mechanical and electrical parts are secure.

Chapter 4:

Maintenance

4.1 Preventive Maintenance

- **Manpower:** One technician.
- **Tools & Equipment:** Multimeter, torque calibrator software.
- **Procedure:**

    1. **Inspect enclosure and shaft weekly:** Visually check the enclosure for cracks, dust accumulation, or signs of wear. Examine the shaft for misalignment, corrosion, or physical damage.
    2. **Check USB and connection integrity**: Inspect the USB cable for fraying, bends, or loose connectors. Test the connection by plugging/unplugging and ensuring a secure fit.
    3. **Clean sensor with non-corrosive cloth:** Refer to section 4.3
    4. **Calibrate monthly:** Connect the torque calibrator software to the MCU via USB. Apply a known torque using a torque reference standard. Adjust the capacitance-to-digital converter settings based on the software's calibration prompts**.**

4.2 Troubleshooting

Problem	**Possible Cause**	**Solution**
Not powering on	No power, faulty cable	Check 5V source and USB
Inaccurate reading	Misalignment	Realign plates
Noise in signal	EMI from environment	Use shielded USB cables
Flat output	No torque / sensor damaged	Check load, inspect plates, Test the cable, see if LED light is visible through the USB opening
Drift in	Temperature	Implement temperature

readings	variations, aging components	compensation, periodic recalibration
Zero offset error	Mechanical preload, residual stress	Perform zero calibration with no load, check mounting for stress
Unstable readings	Mechanical vibration or loose assembly	Secure sensor mounting, dampen vibrations, tighten screws
Sensor overheating	Short circuit or overcurrent from USB supply	Check for shorts, ensure proper current draw, add protection circuitry
USB not recognized	Faulty USB cable or damaged USB connector	Try a different cable, inspect and clean USB port, check USB connector soldering

4.3 Cleaning

Follow these steps for cleaning the torque sensor to ensure continued proper operation.

- Power off the system and disconnect it from the USB.
- Gently wipe the sensor plates with a non-corrosive, lint-free cloth to remove dust or debris.
- Use compressed air and a small brush to clear hard-to-reach areas, avoiding excessive pressure.
- Ensure no moisture or residue remains on the sensor surfaces.