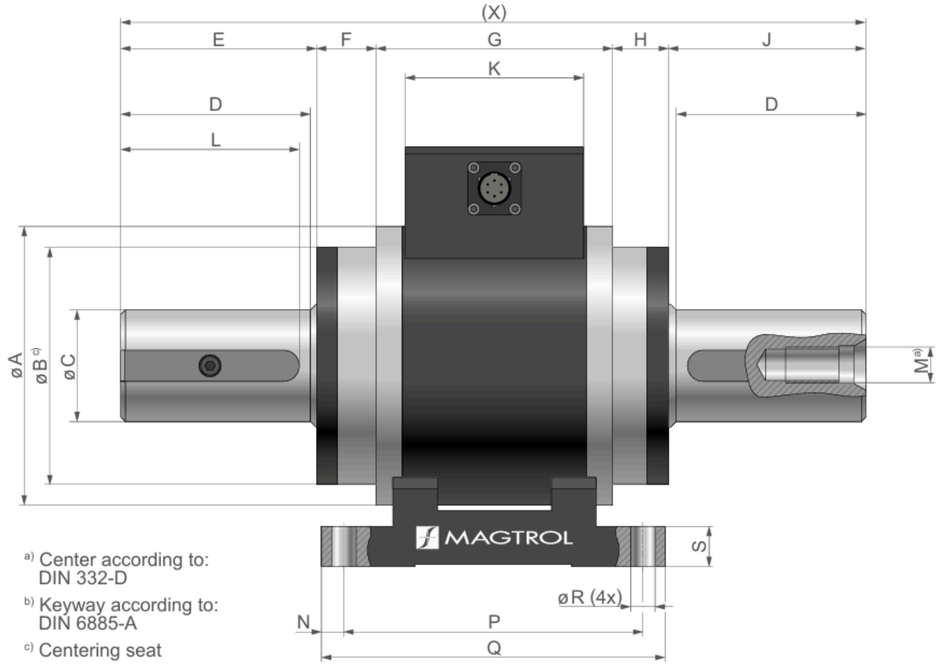
STRAIN GAUGE BASED TORQUE SENSOR

MAGTROL



- Integrated torque and speed conditioning
- Torque Range: from 0.1 N·m to 10 kN·m (0.07 lb·ft to 7375 lb·ft)
- Accuracy: < 0.1 %
- Overload Capacity: 200 %
- Breaking Limit: > 400 %
- High Speed Applications: up to 50 000 rpm
- Non-Contact (no sliprings)
- No Electronic Components in Rotation
- High Electrical Noise Immunity
- Single DC Power Supply: 20 VDC to 32 VDC
- Immediate Speed Detection
- Adjustable Torque Signal Frequency Pass Band up to 5 kHz
- Built-In Test Function (B.I.T.E.)
- Stainless Steel Shaft
- EMC Susceptibility Conforms to European Standards

USER OBSERVATION

WORK ENVIRONMENT ANALYSIS

- High Vibrations & Mechanical Stress
- Temperature Variations
- Dust, Oil & Debris
- Electromagnetic Interference (EMI)

CHALLENGES IDENTIFIED

- **Installation & Setup**
- **Complex Calibration:** Requires specialized tools.
- **Misalignment Issues:** Leads to inaccurate readings.
- **Mounting Difficulties:** Bulky sensors make installation harder.
- **Operational Challenges**
- **Hard-to-Read Displays:** Poor contrast in dim environments.
- **Latency in Data Transmission:** Slow data updates.
- **Lack of Remote Access:** Requires physical presence.
- **Wireless Signal Interference:** Causes delays in data transmission.
- **Maintenance & Durability**
- **Frequent Recalibration:** Increases maintenance workload.
- **Short Battery Life:** Limits long-term monitoring.
- **Mechanical Wear & Tear:** Strain gauge sensors degrade over time.

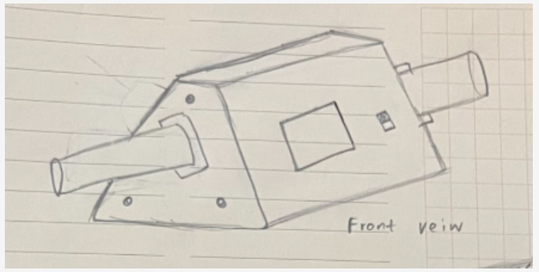
USER BEHAVIOR & FEEDBACK

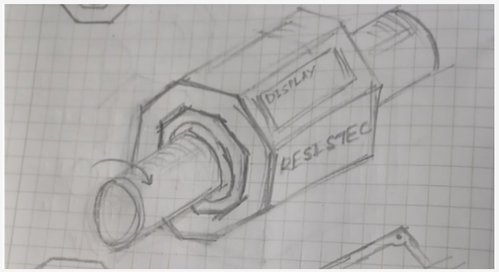
- Industrial Operators
  - Prefer plug-and-play systems.
  - Need large, clear displays for easy reading.
  - Would benefit from haptic or audible alerts.
- Maintenance Engineers
  - Require real-time monitoring & remote diagnostics.
  - Need predictive maintenance capabilities.
  - Demand high-precision measurements.
  - Benefit from multi-sensor integration.

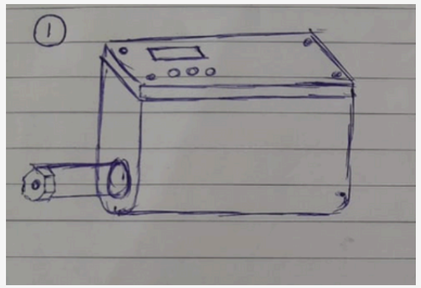
POTENTIAL IMPROVEMENTS

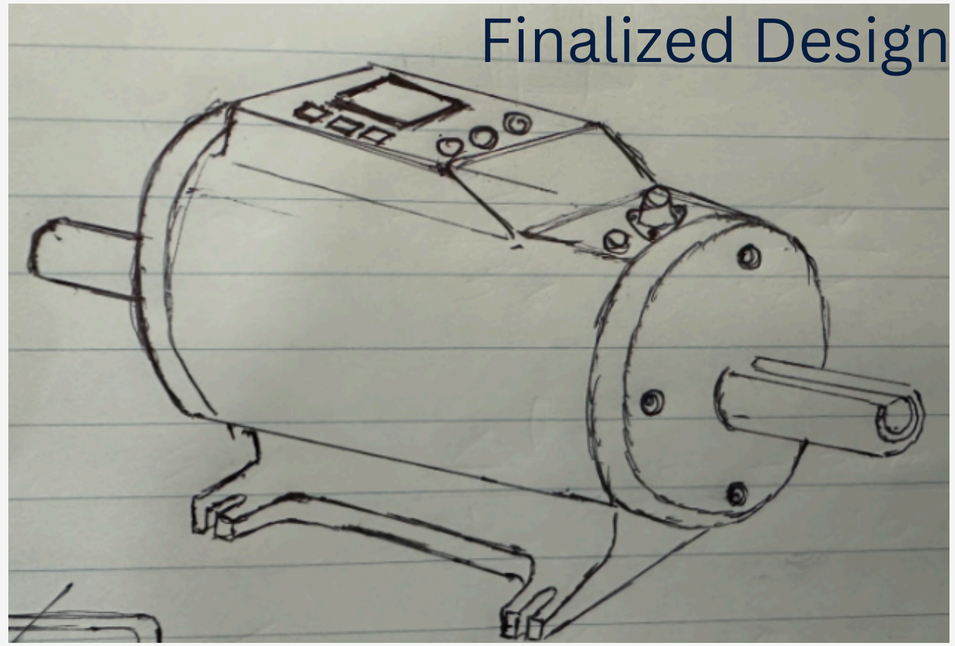
- **Better Display Technology:** High-contrast e-paper or OLED screens.
- **Reliable Wireless Communication:** Transformers instead of Bluetooth/Wi-Fi.
- **User-Friendly Software**: Mobile app or web dashboard for remote monitoring.
- **Durable & Compact Design**: More robust housing for industrial use.

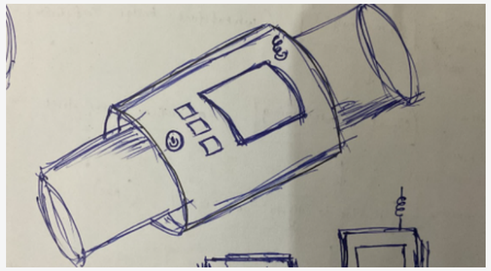
CONCEPTUAL DESIGN

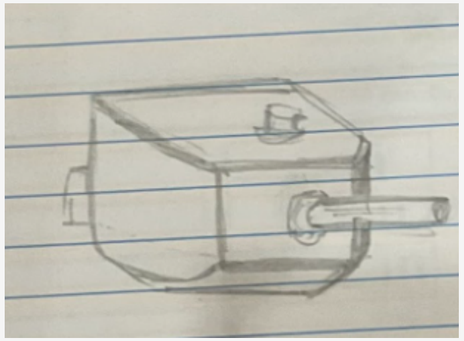


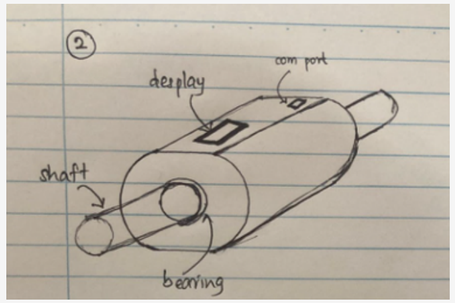






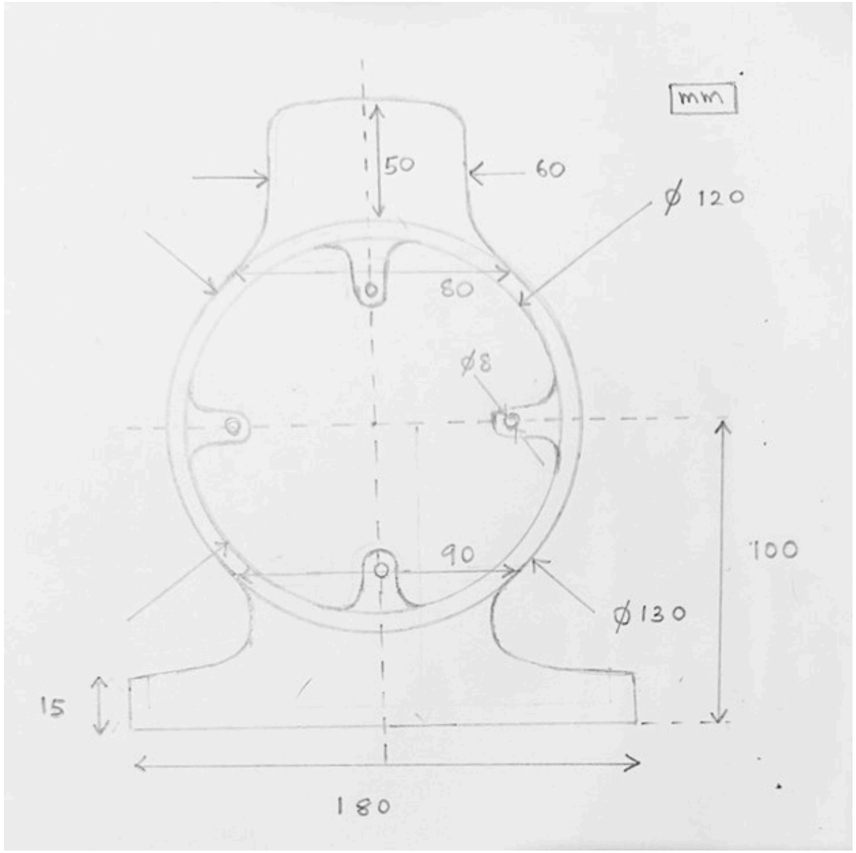


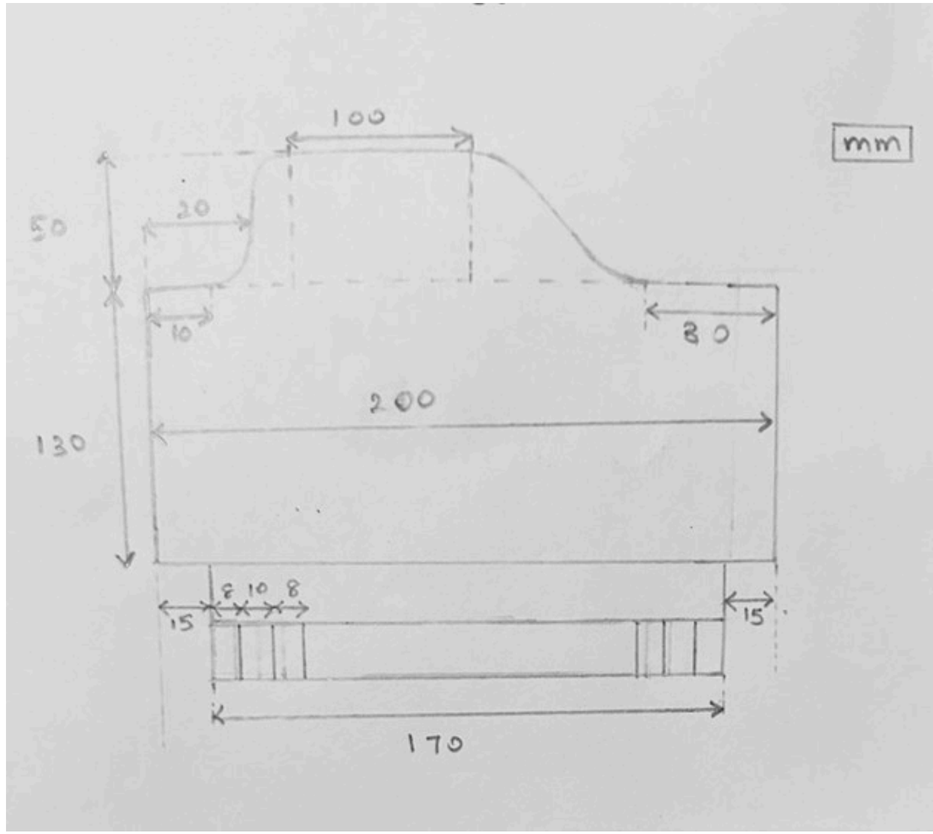




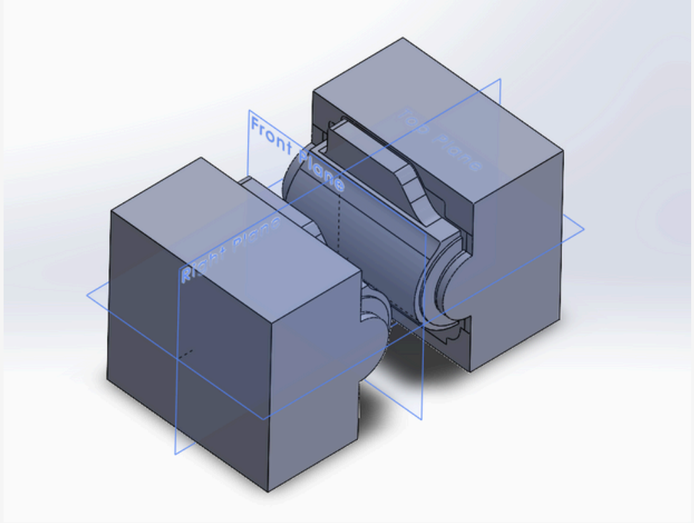
Design No.		1	2	3	4	5	6	7
Enclosure	Ergonomics	5	7	6	6	6	7	9
	Aesthetic	6	7	6	7	7	8	8
	Durability & Robustness	6	6	6	7	7	7	7
	Display Feature	7	7	7	7	7	7	7
	Communication Port	10	10	10	10	10	10	10
	Rechargability	10	10	10	10	10	10	10
	Manufacturability	7	8	7	9	8	7	8
	Cost Effectiveness	8	8	7	8	8	8	8
	Total	59	63	59	64	63	64	67

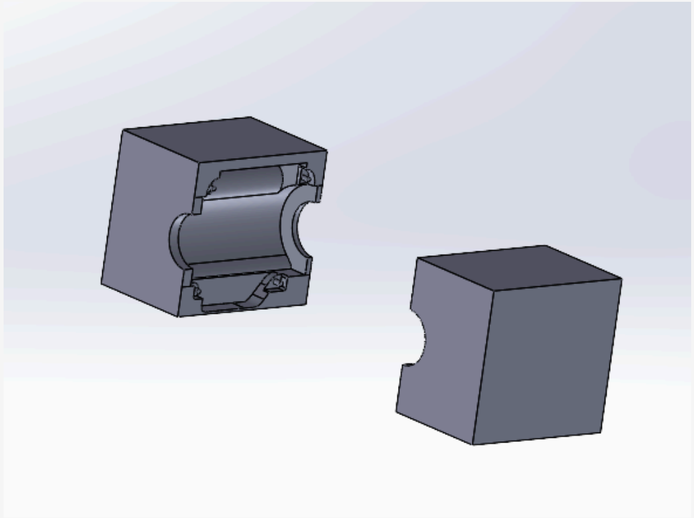
ENCLOSURE DESIGN - SKETCH

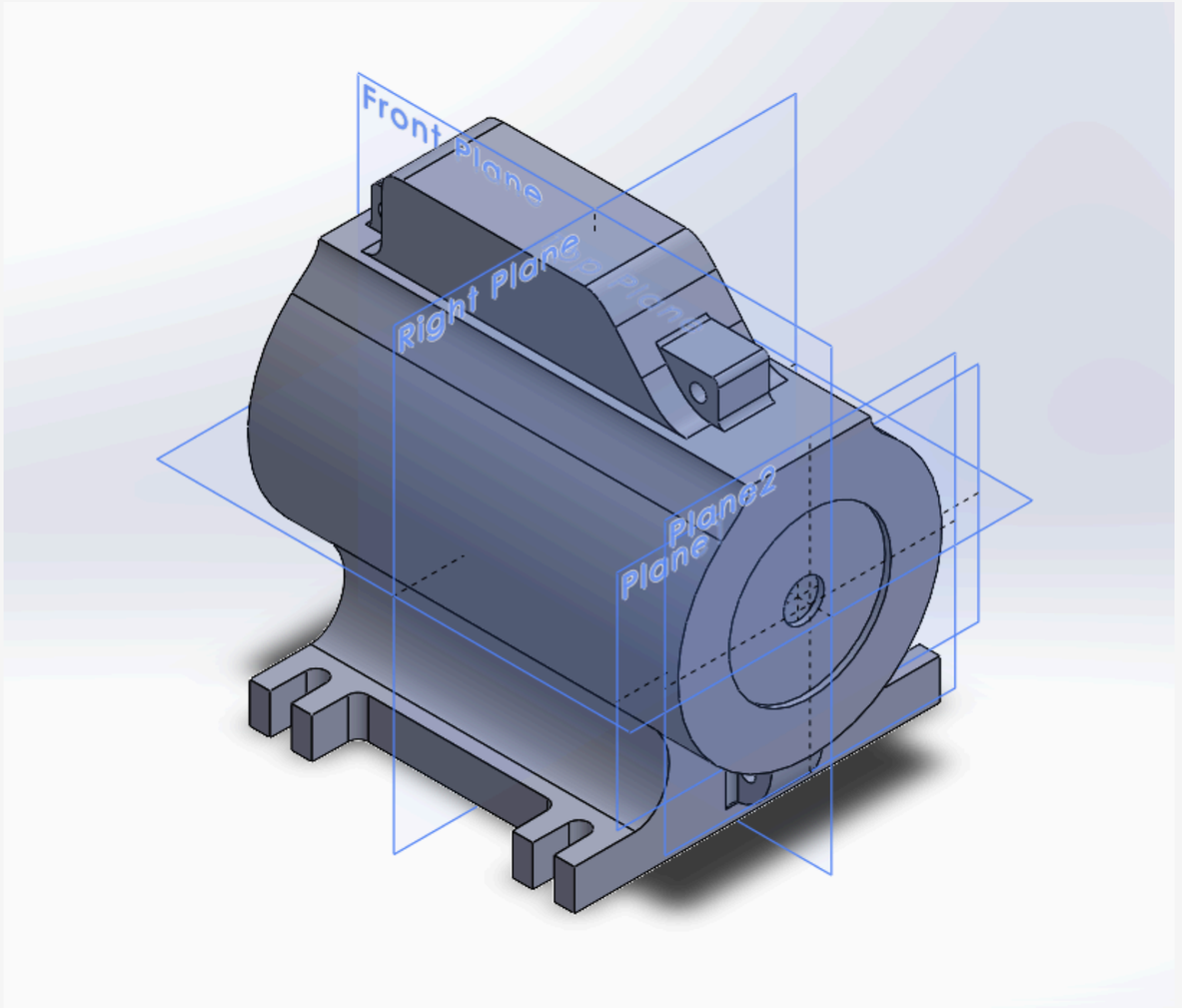




ENCLOSURE DESIGN

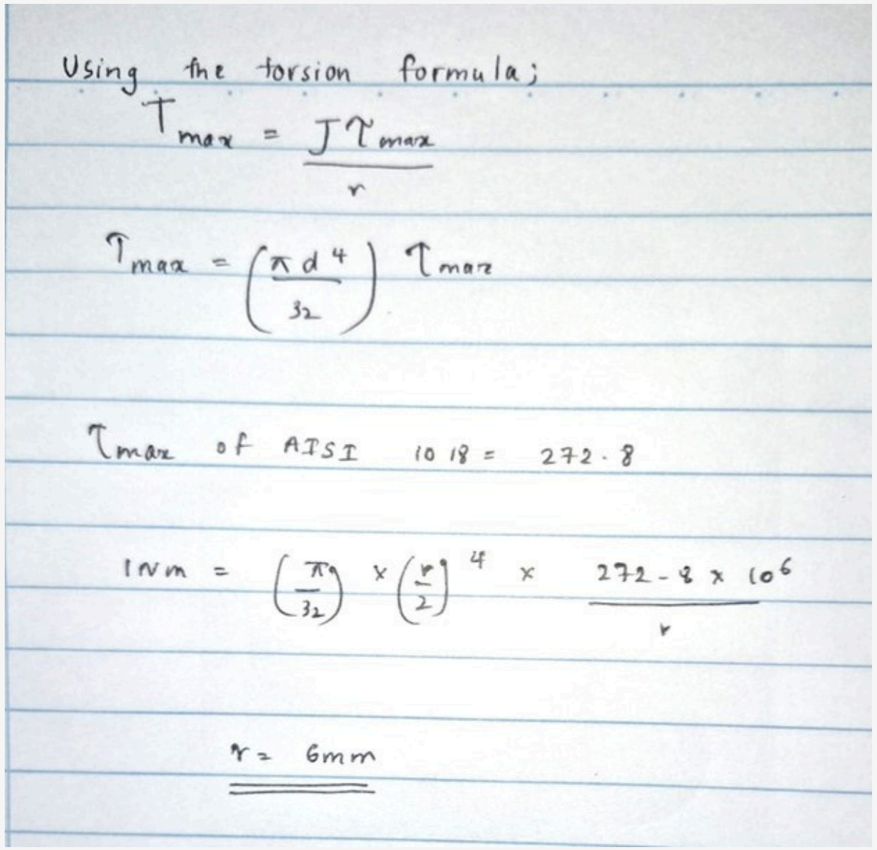






SHAFT DESIGN

Shaft diameter calculation



Shaft material selection

Material Selection Report: Strain Gauge Torque Sensor Shaft

Feature	AISI 1018 (Low Carbon Steel)	AISI 1045 (Medium Carbon Steel)	EN8 (080M40) - Medium Carbon Steel
Yield Strength	~370 MPa	~450 MPa	~400-450 MPa
Tensile Strength	~440 MPa	~620 MPa	~600-700 MPa
Elastic Modulus	~200 GPa	~200 GPa	~200 GPa
Machinability	Excellent	Good	Good
Weldability	Excellent	Moderate	-
Best for	Small, precise torque sensors	Slightly higher torque applications	Rugged torque sensors
Torque Range Suitability	Ideal for 0.5 Nm - 1 Nm (with EN8)	-	Ideal for 0.5 Nm - 1 Nm (with AISI 1018)

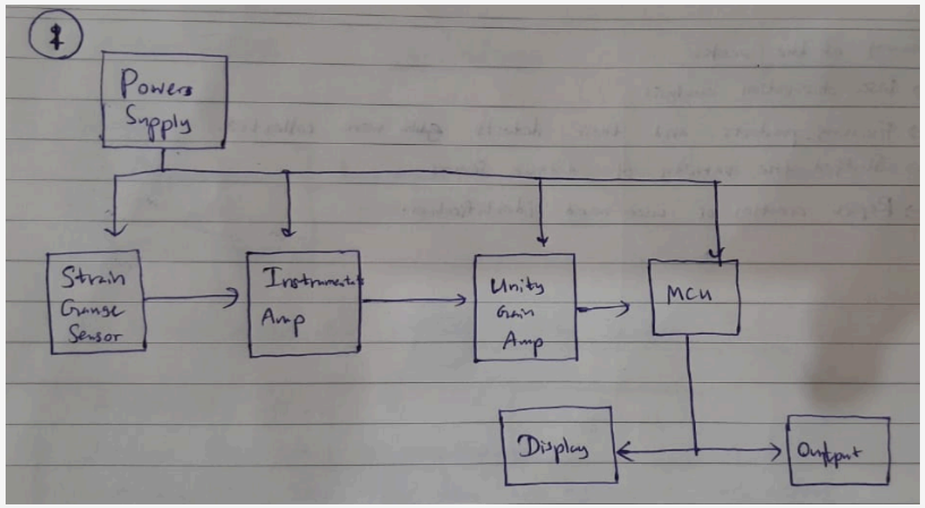
Strain gauge selection

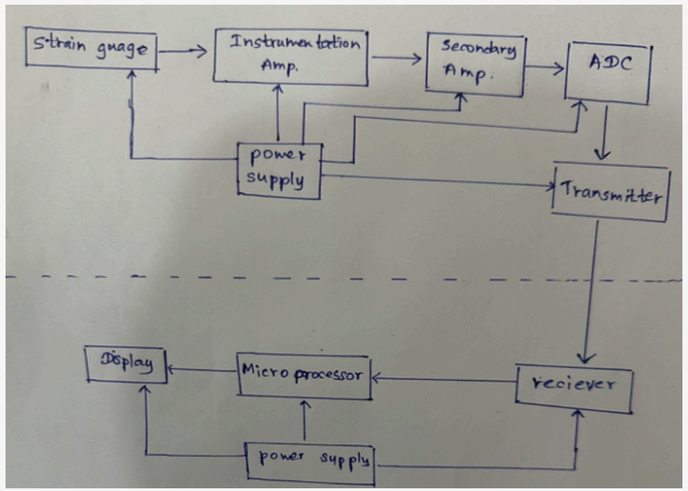
Component	Available Options	Price
Strain Gauges	1)(Dual grid)MMF404956-Micro-Measurements (Division of Vishay Precision Group)	$202.73
	2)(4-Grids)MMF404948- Micro-Measurements (Division of Vishay Precision Group)	$416.70
	3)(Single-grid)Resistive shear strain gauge CF120-AB-A1(XX)	Not recived yet
	4)(Dual grid)SGT-2DC/350-SY11-Omega	$179

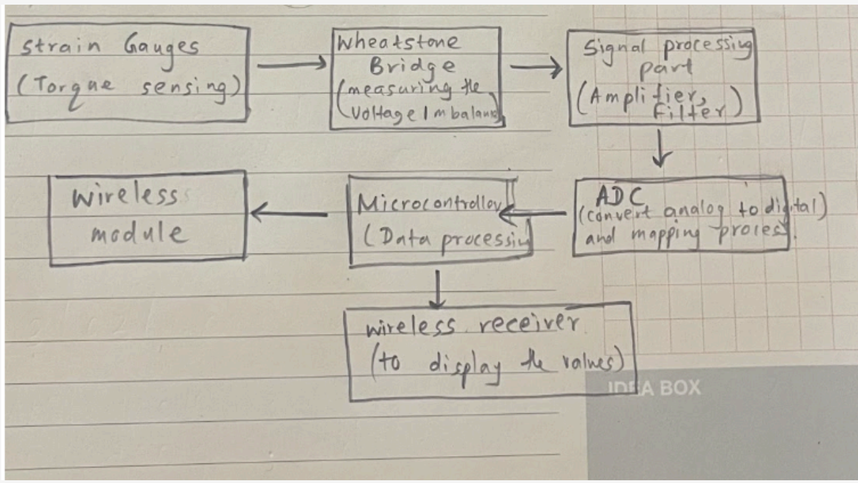
GAGE PATTERN Leads not shown	MODEL NO. Pkg of 5	NOM. RESIS-TANCE (Ω)	DIMENSIONS mm (inch)† GRID A	GRID B	CARRIER C	CARRIER D	MAX V* (Vrms)	TERMINATION	TEMP COMP
Shown actual size 7 mm 	SGT-1D/350-SY11	350	1.4 (0.055)	1.5 (0.059)	7.0 (0.276)	5.1 (0.201)	5.5	Ribbon Leads	ST
	SGT-1D/350-SY13	350	Dual grid, miniature rectangular shear 350 Ω				7.5	Ribbon Leads	AL
	SGT-1D/350-SY41	350					5.5	Solder Pads	ST
	SGT-1D/350-SY43	350					7.5	Solder Pads	AL
Shown actual size 7 mm 	SGT-2DC/350-SY11	350					5.5	Ribbon Leads	ST
	SGT-2DC/350-SY13	350	1.9 (0.075)	1.6 (0.063)	7.0 (0.276)	6.3 (0.248)	8	Ribbon Leads	AL
	SGT-2DC/350-SY41	350	Dual grid, miniature shear all leads/Solder Pads at one end of grid 350 Ω				5.5	Solder Pads	ST
	SGT-2DC/350-SY43	350					8	Solder Pads	AL
Shown actual size 7 mm 	SGT-2D/350M-SY11	350	1.8 (0.071)	1.6 (0.063)	7.0 (0.276)	5.7 (0.224)	5.5	Ribbon Leads	ST
	SGT-2D/350M-SY13	350	Dual grid shear, leads/Solder Pads one at each end of grid 350 Ω				7.5	Ribbon Leads	AL
	SGT-2D/350M-SY41	350					5.5	Solder Pads	ST
	SGT-2D/350M-SY43	350					7.5	Solder Pads	AL

Block diagram evaluations

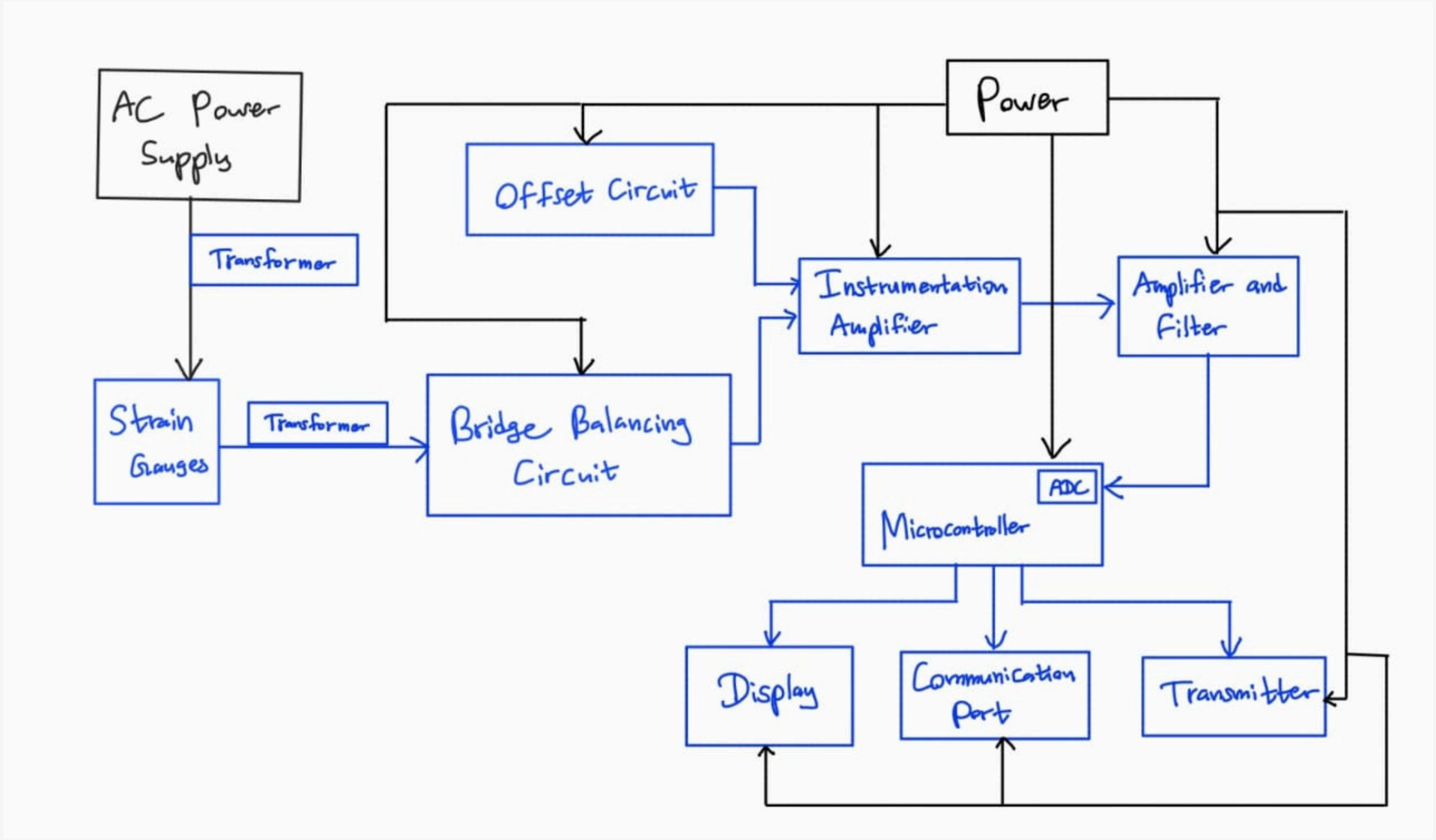
Block Diagram	Cost Effectiveness	6	7	6	8	7	8	7	7
	Accuracy	7	7	7	7	6	6	7	6
	User Experience	8	7	8	7	7	7	7	8
	Total	21	21	21	22	20	21	21	21
Flow Chart	Efficiency	6	7	6	7	7	8	8	7
	Completeness	6	6	6	7	7	7	7	6
	Clarity	7	7	7	7	7	7	7	7
	Performance	10	10	10	10	10	10	10	10
	Power	8	8	8	8	8	8	8	8
	User Experience	7	8	7	7	8	7	8	8
	Total	44	46	44	46	47	47	48	46



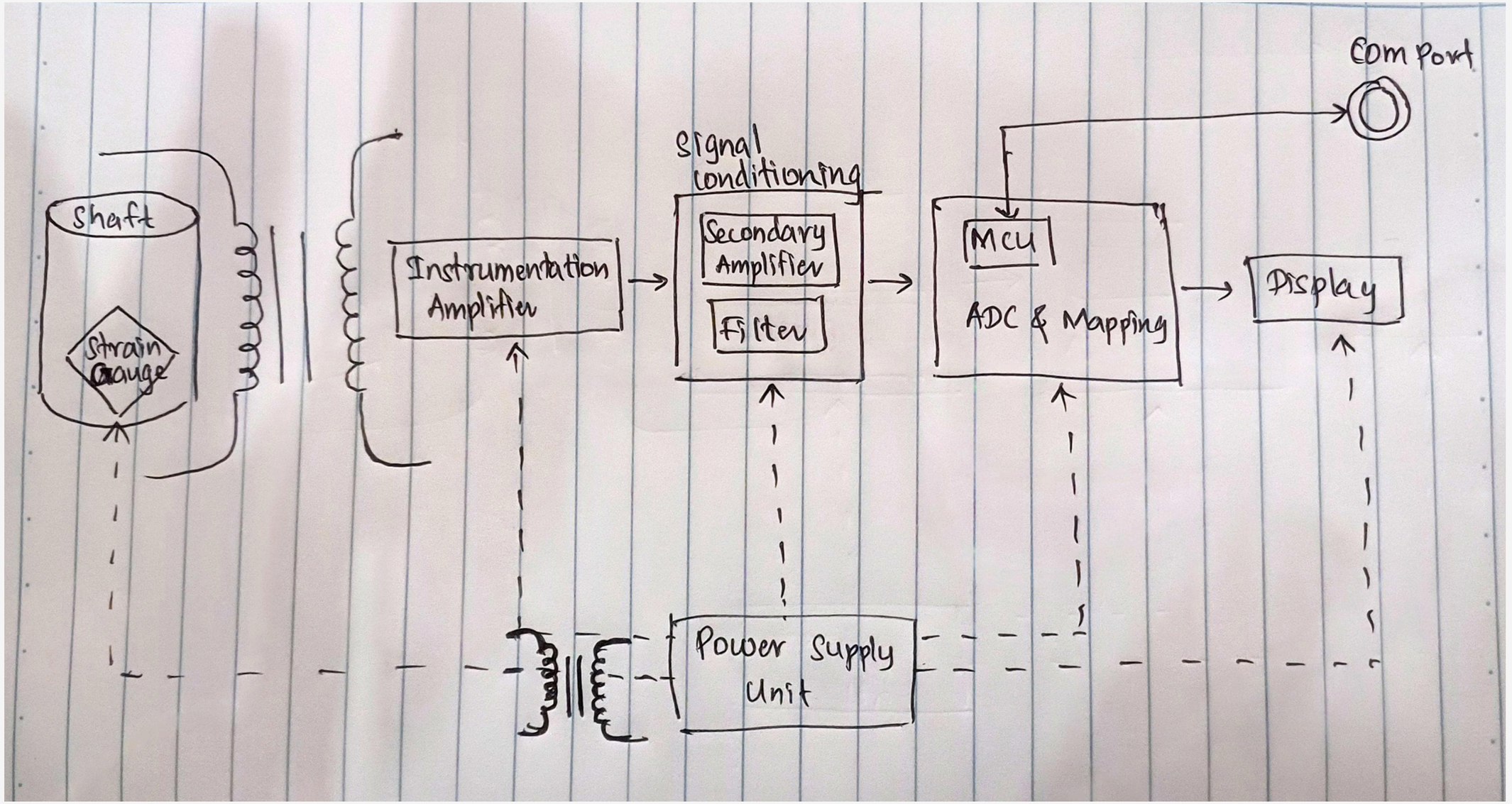




BLOCK DIAGRAM



FINALIZED BLOCK DIAGRAM



Microcontroller Options

MCU Options

Feature	TI MSP430FR Series	NXP S12 MagniV (S12ZVM)	Microchip PIC24FJ128GA010
Architecture	16-bit RISC	16-bit S12Z (HCS12)	16-bit PIC
Operating Voltage	3.3V	5V	3.3V / 5V
ADC Resolution	12-bit / 16-bit	12-bit	10-bit / 12-bit
Max Flash Memory	64 KB FRAM	128 KB	128 KB
Power Consumption	Ultra-low-power (<100 µA/MHz)	Moderate	Moderate
Temperature Range	-40°C to +85°C	-40°C to +125°C	-40°C to +85°C
EMI/EMC Resilience	High	Very High	Moderate
Communication Interfaces	I²C, SPI, UART	CAN, LIN, SCI	I²C, SPI, UART
Built-in Voltage Regulator	No	Yes	No
Industrial Suitability	Moderate	Very High (Automotive/Industrial)	High
Key Advantage	Low power & high ADC precision	Designed for high EMI environments & automotive use	Good balance of power & performance
Price	$4.80(Digikey)	-	$6.42(Digikey)

Electronic Component Options

Instrumentation Amp

Options :- INA333
INA 823
LTC 6373
AD 8421
AD 8290 80
AD 8290 160

Suitable :- AD 8290 160

* very high CMRR (140dB) (critical)
* low offset
* low noise (0.7MV p-p)

Secondary Amp

options :- OPA336
OPA2333
TLV2372
LMV321

Suitable :- OPA336

* rait-to-rail output swing (maximum dynamic range)
* low offset

offset adjustment

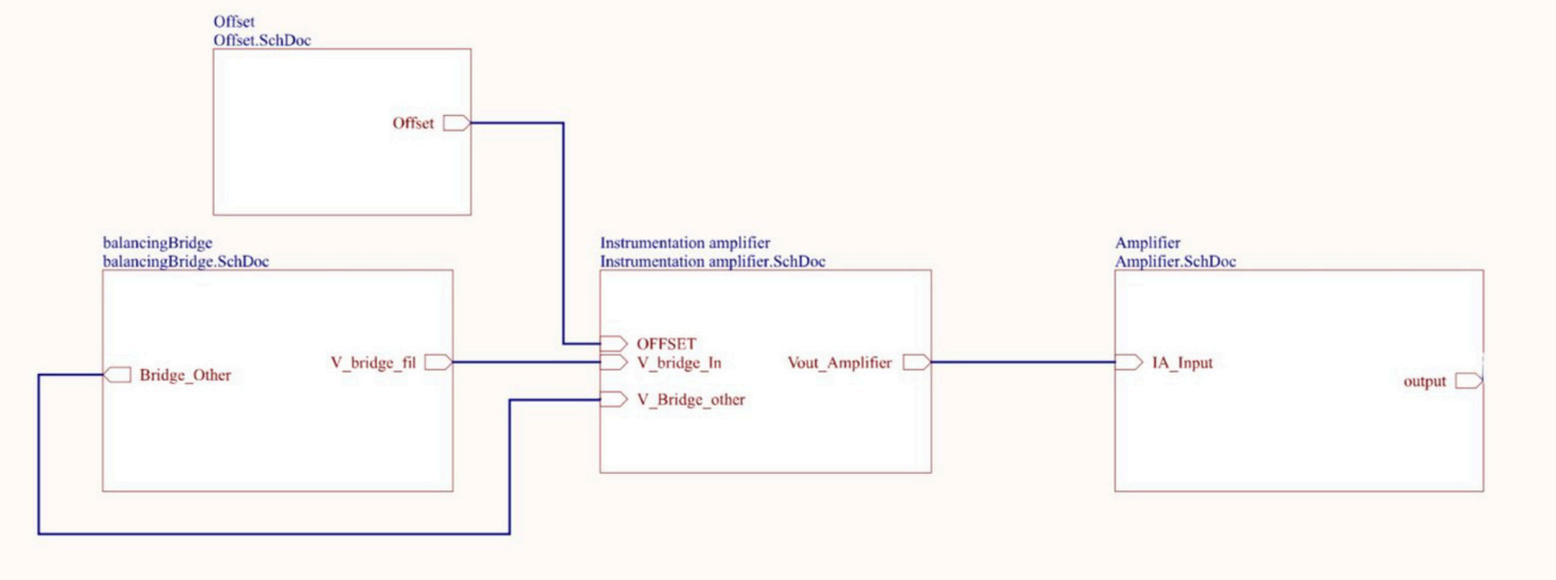
DAC

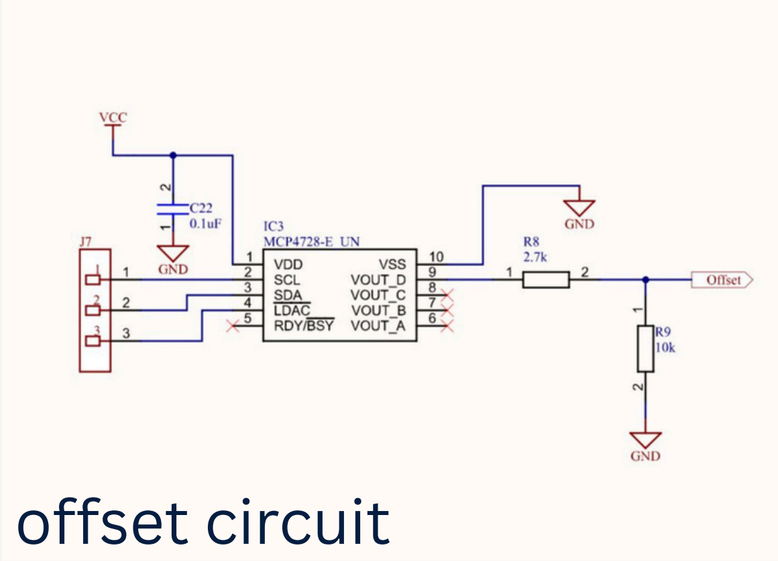
options :- MCP4921
MCP 4728
DAC7571
AD 5693
MCP 4725

Suitable :- MCP4728

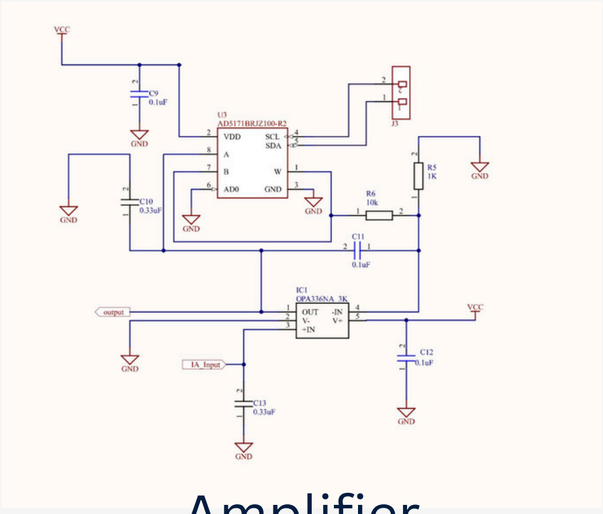
* high resolution (12-bit)
* Non-Volatile memory (EEPROM)
* low power consumption

SCHEMATIC DESIGN

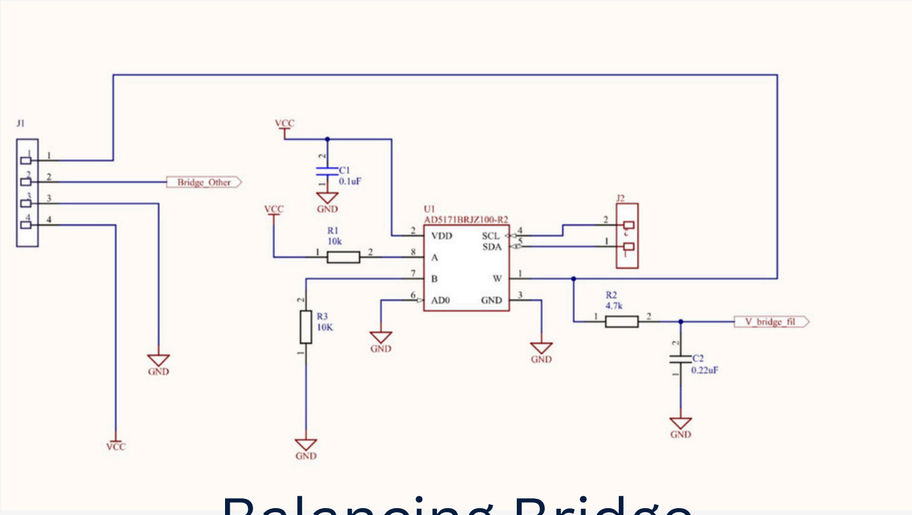




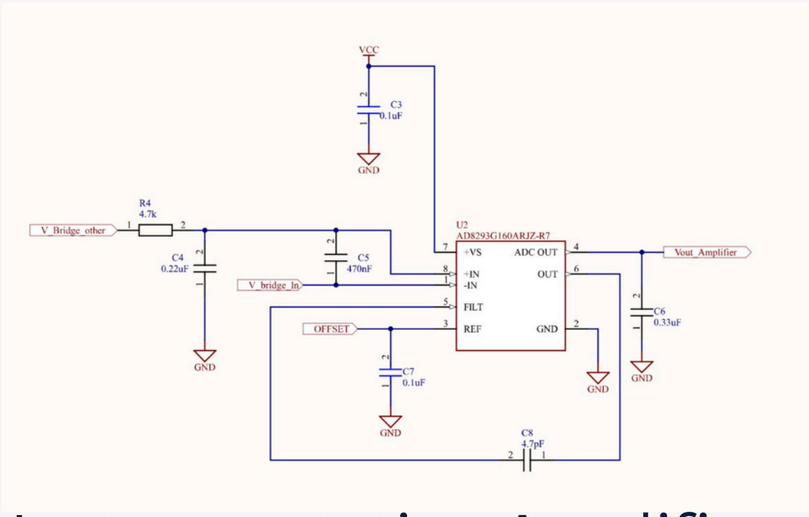
offset circuit



Amplifier

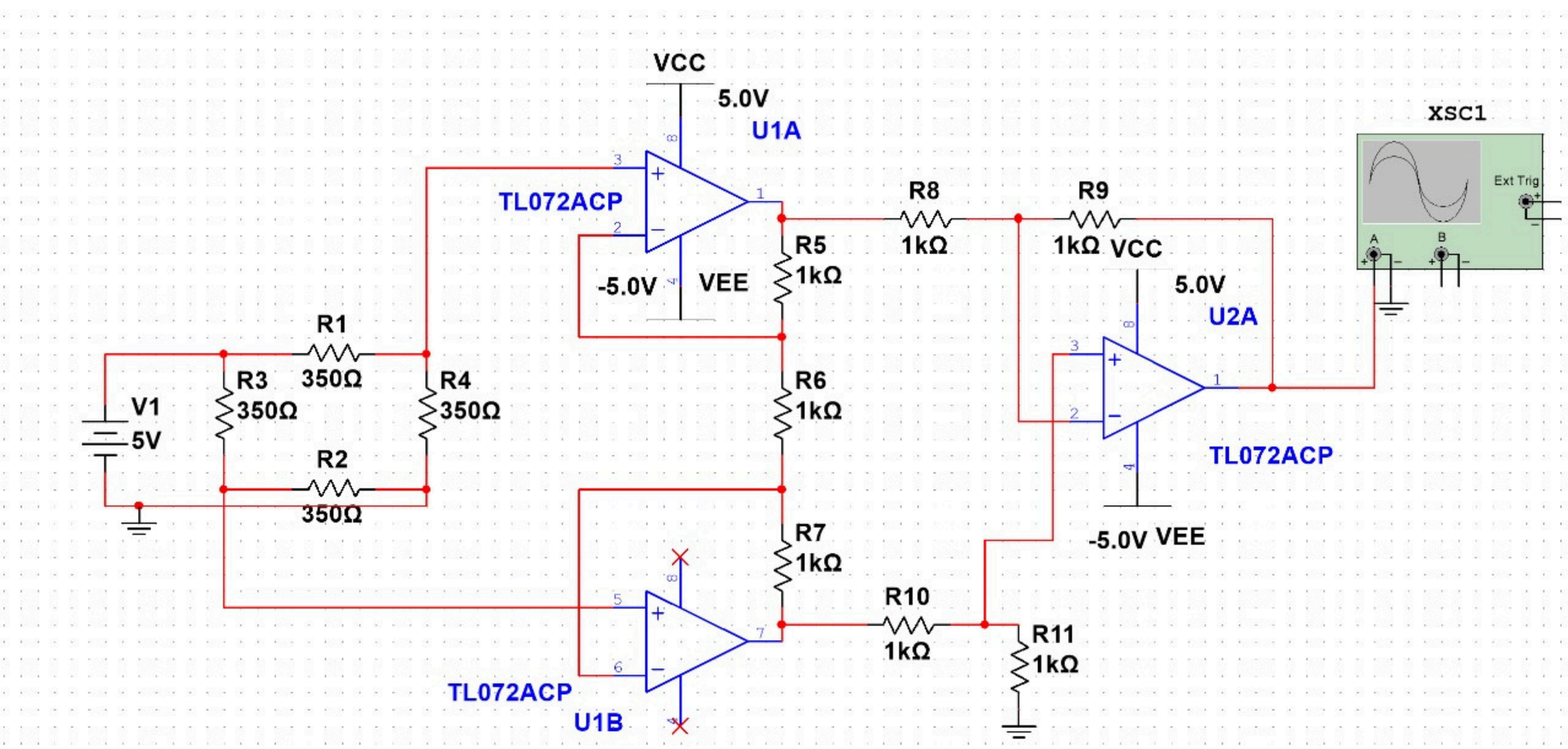


Balancing Bridge



Instrumentation Amplifier

SIMULATIONS (MULTISIM)



THANK YOU