AE222-MPM
TASK-1

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SC19B028

OBJECTIVES & CONSTRAINTS

Objectives

- Design a housing to accommodate the three sensors and the PCB board described.
- Identify machining operations and their sequence to manufacture the housing.
- Identify machining tools and cutting tools for performing the operations.
- Identify measuring methods and instruments to verify the tolerances/dimensions given in the design.

Constraints

- Overall size of housing:200±5 x 200±5 x 100±5 mm
- Preferable weight of housing < 3Kg
- Raw material given: Metal blanks of size 250 x 250 x 60 mm – 2nos
- Surfaces marked 'TOP' on the sensors should be exposed out of the housing.
- D-Pin connectors of the PCB board should be exposed out of the housing.
- A gap of 10 mm should exist above and below the PCB board.

ASSUMPTIONS

- Sensor-1 and sensor-2 can be wired from underneath.
- In addition to the given raw material, we assume a cylindrical rod of radius 60mm and height 60 mm to be given.
- All kinds of machine tools and cutting tools are available.
- Mass of PCB board is assumed to be 50 g.

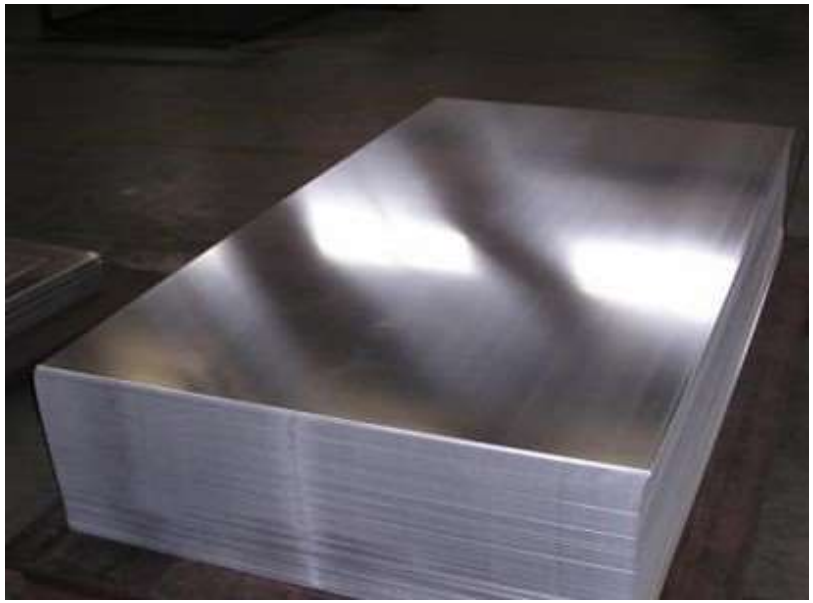
GENERAL PROCEDURE

- All machining operations are done using CNC machining.
- Lathe operations are performed in CNC Lathe.
- Milling operations are performed in CNC column-and-knee (vertical-spindle) milling machine.
- Drilling operations are performed in CNC drilling machines.
- Metrology is performed on a surface table.
- General Dimensioning and tolerance standard used in every drawing: ISO 2768 – m K 

RAW MATERIAL SELECTION

Aluminium 6061 T6

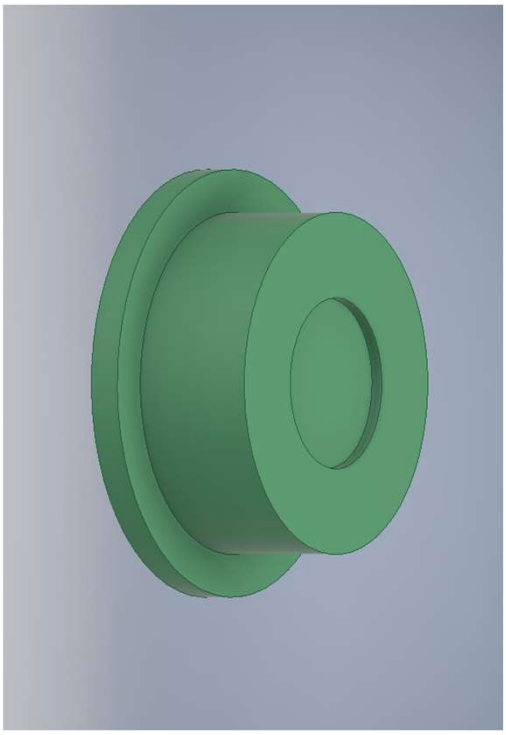
- high strength to weight ratio
- Density-2.72 gcc
- Fairly Machinable: machinability grade ‘C’
- Corrosion resistance



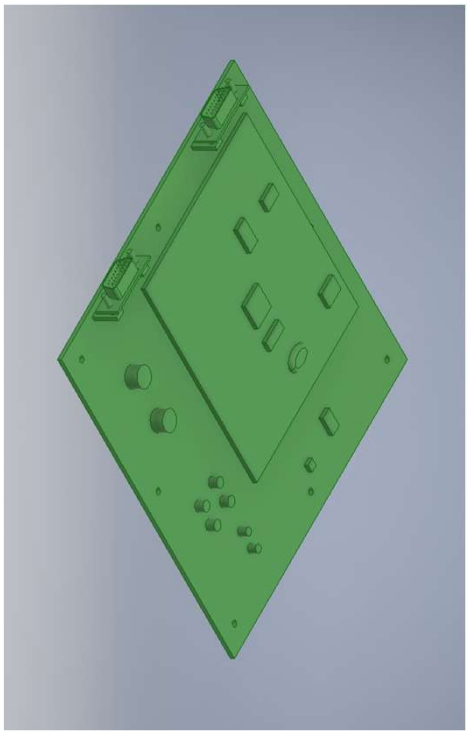
Source: Indiamart

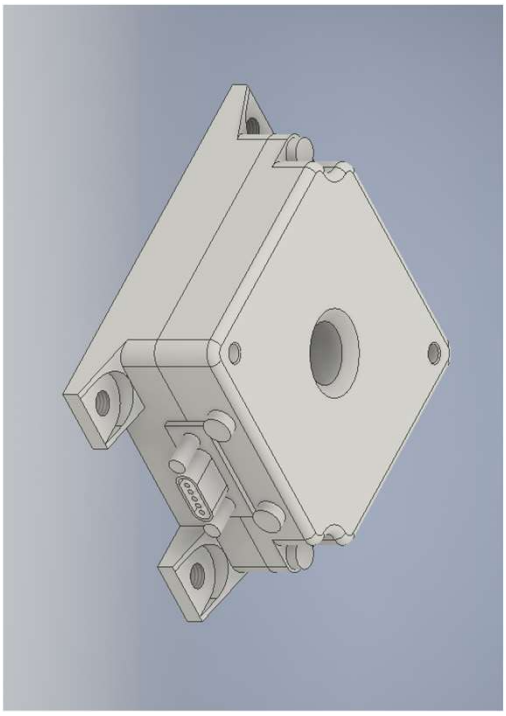
SENSORS AND PCB

Sensor-2

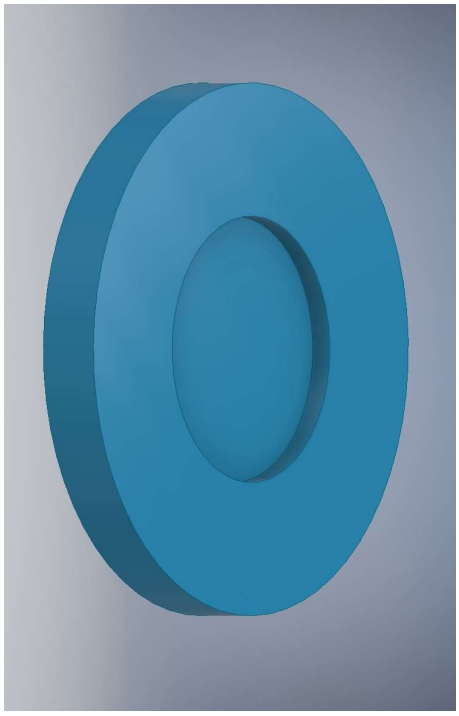


PCB





Sensor-3



Sensor-1

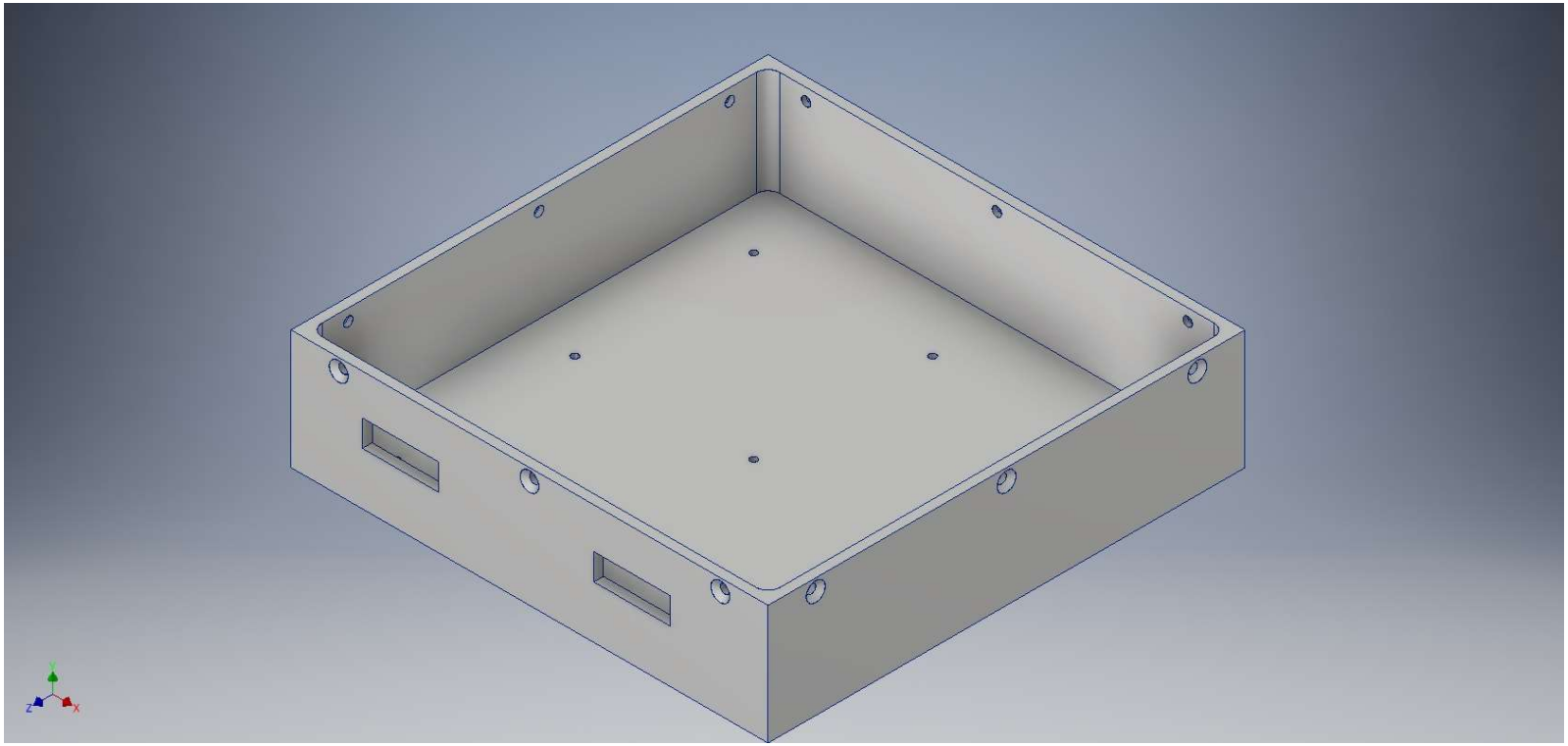
GENERAL MACHINING SEQUENCE

- Since we require different starting blocks from the given material, we prepare them beforehand.
- For the housing, we take the two 250x250x60 mm blocks and cut into desired pieces using metal saw to produce:
  - 200x200x56 mm blank for top part
  - 200x200x50 mm blank for bottom part
- For the lid of the housing, we use a metal sheet of dimension 200x200 mm and thickness 3 mm
- For the locks of two of the sensors, we take the cylindrical rod and cut into two pieces using grooving tool in lathe (parting off) to produce:
  - Cylindrical block of radius 60 mm and height 40 mm which is later turned across the length to produce a cylindrical blank of radius 55 mm and height 40mm for lock of sensor-1
  - Cylindrical blank of radius 60 mm and height 11 mm for lock of sensor-2.
- For the lock of third sensor, we use the remains of the given square blocks to produce two blanks of dimensions 68x12x15 mm.
- All the blanks have their surfaces finished using surface grinding.

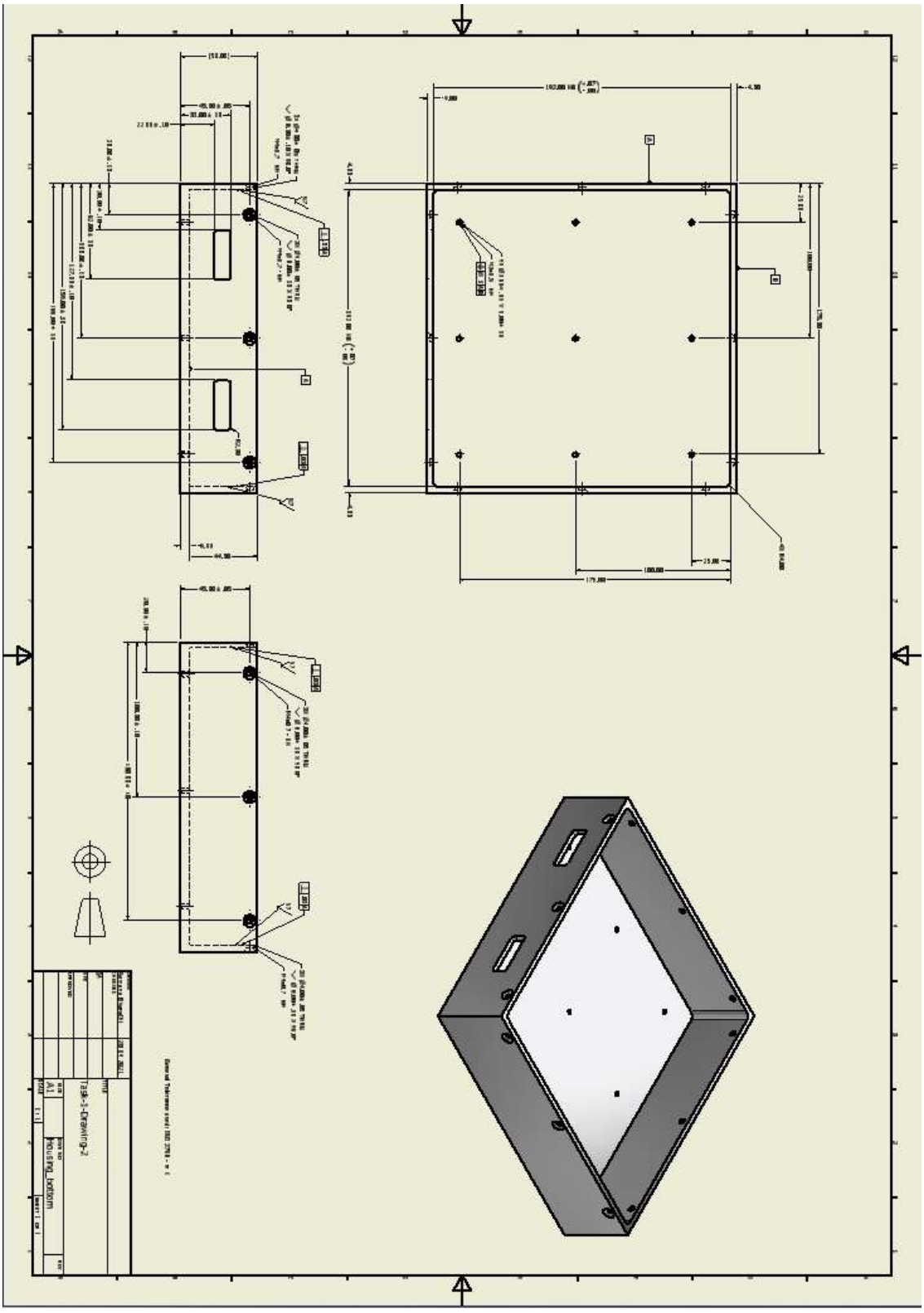
HOUSING: BOTTOM PART - DESIGN FEATURES

- Open structure (box type)
- Threaded holes for attaching the spacers on which the PCB board will be mounted.
- Square through holes on the side for exposing the two D-Pin connectors on the board.
- Threaded through holes near the top of the side walls to attach with the top part.

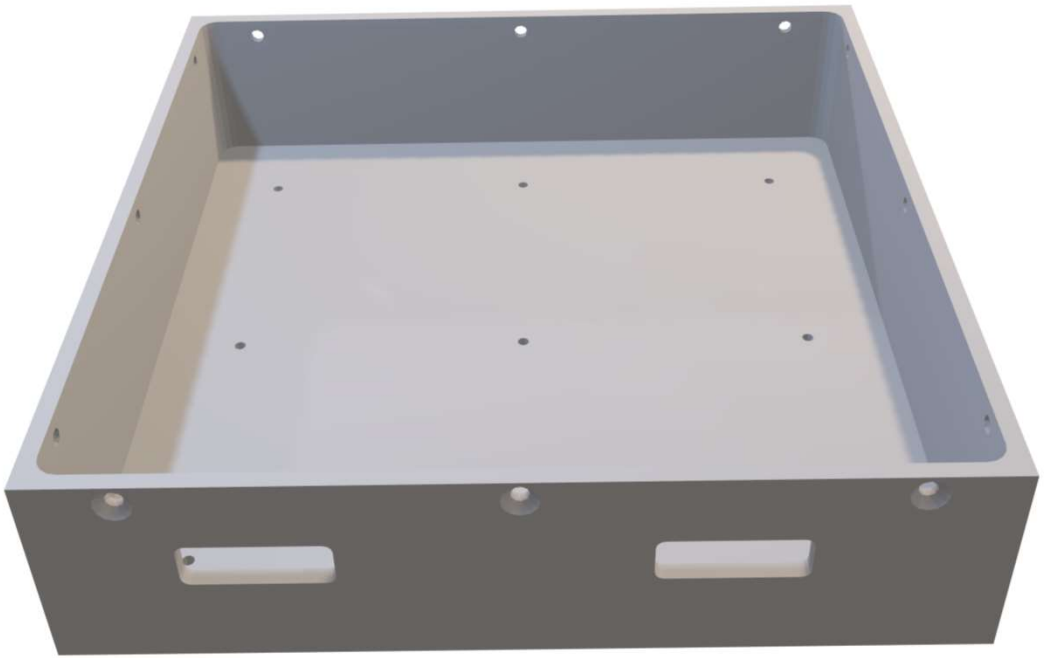
HOUSING: BOTTOM PART - IMAGE



HOUSING: BOTTOM PART - DRAWING



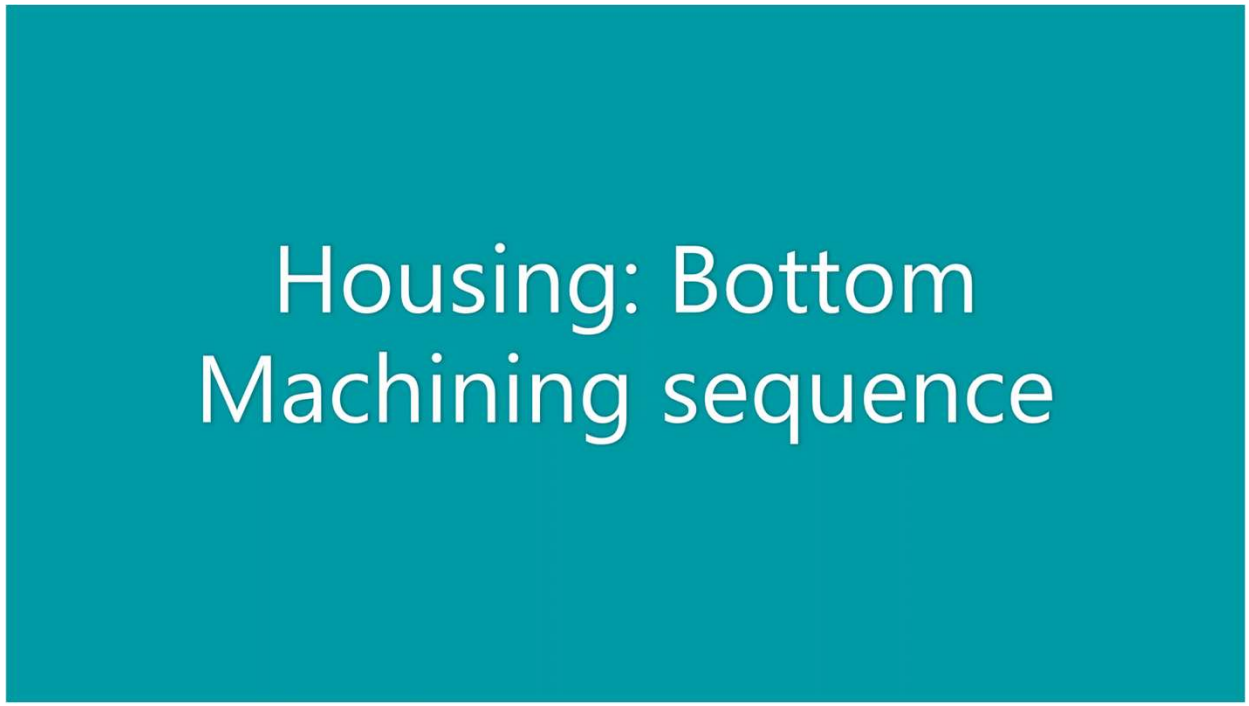
HOUSING: BOTTOM PART – 3D



HOUSING: BOTTOM PART - MACHINING SEQUENCE

- We start with 200x200x50 mm blank.
- The square pocket is made using drilling and circular milling. A hole is drilled at the centre using the drilling machine and enlarged (bored) enough to fit the shoulder end mill cutter. Then the shoulder end mill cutter is fitted into the hole and driven in circle and eventually squares to make the square pocket. Another technique that can be used is circular ramping (shoulder end mill cutter goes around in spiral from top to down-drilling not required).
- The two square through holes at the side are made using drilling and circular milling/circular ramping. Since the holes are too small, Wire EDM is preferable if available.
- The 9 holes on the base are drilled using drilling machine (drilling machine, 3mm drill bit) and threaded using tapping (drilling machine, tap).
- The 12 holes on the upper side of the walls are drilled (drilling machine, 4mm drill bit) and countersunk (drilling machine, countersink drill bit) and threaded using tapping (drilling machine, tap)
- Inner walls are finished using reaming (drilling machine, reamer)
- All the holes are deburred and surfaces are cleaned. The bottom part is completed.

HOUSING: BOTTOM PART - MACHINING SEQUENCE



HOUSING: BOTTOM PART - METROLOGY

- Linear dimensions are measured using vernier callipers.
  - Length, width, height of the part
  - depth of the pocket
  - Length, width and location of square holes
- Diameter of threaded holes are measured using inside micrometer. Depth of threaded holes can be measured using depth micrometer.
- Position tolerance of the holes is measured using Co-ordinate measuring machine (CMM).
- Perpendicularity of surfaces is measured using height gauge and dial indicator.

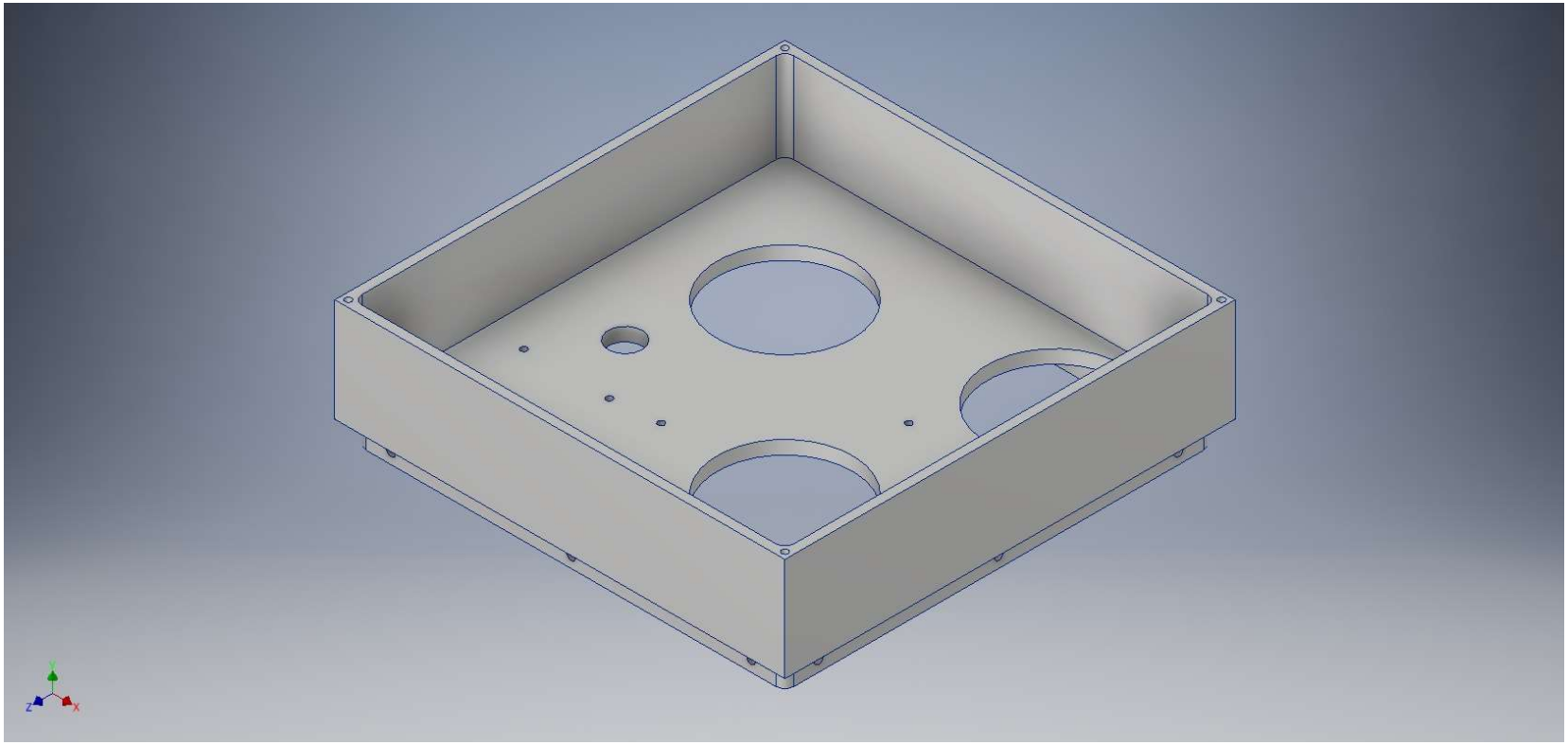
HOUSING: TOP PART - DESIGN FEATURES

- Open structure (box type)
- Threaded holes on the base for attaching locks of sensor-2 and sensor-3.
- Wiring allowance: Through holes on the base for each sensor and a common through hole so that wires can connect the sensors in the top part to the board in the bottom part.

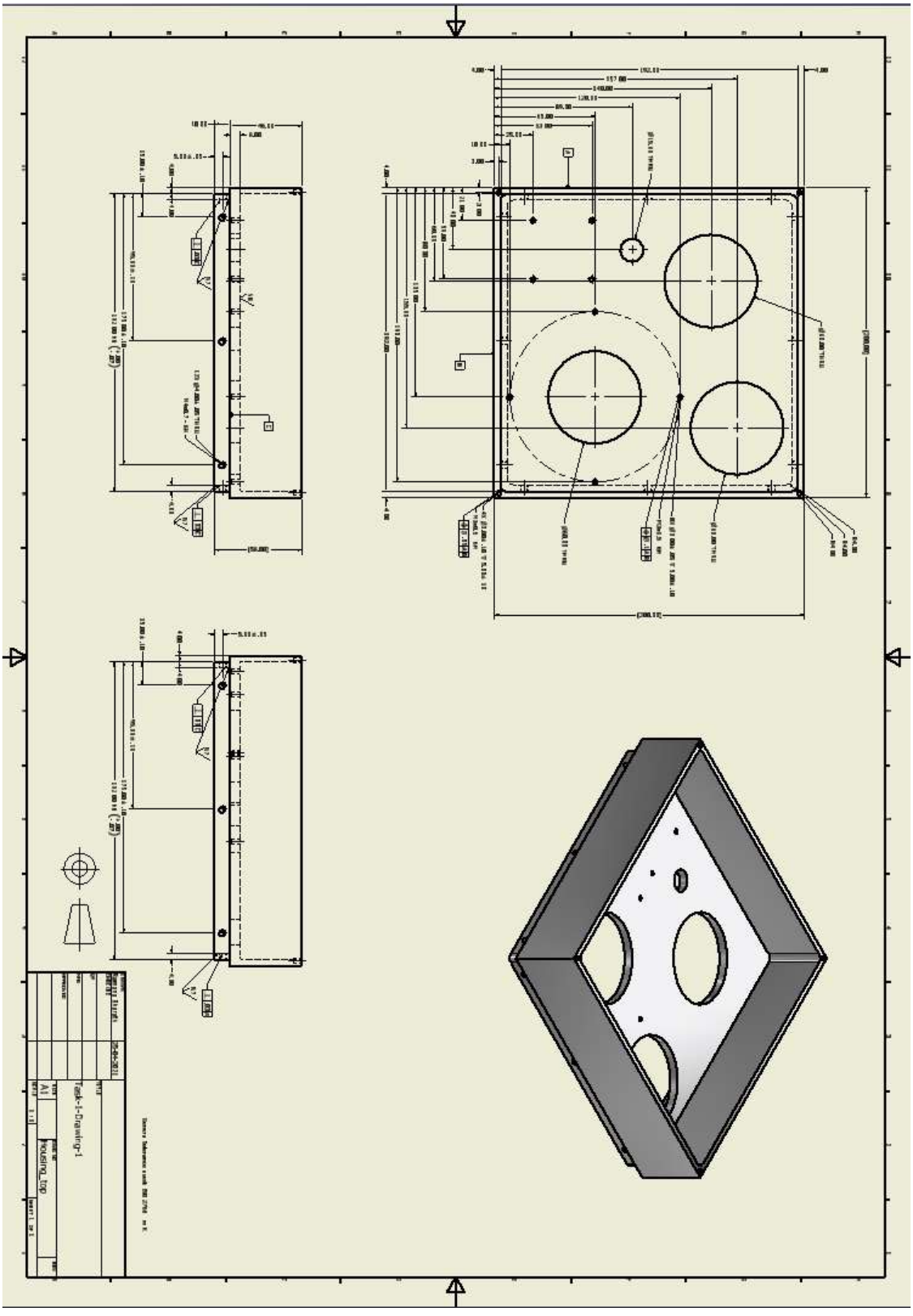
(Note that it is been assumed that sensor-1 and sensor-2 can be wired from underneath but they can be wired through the common hole if that's not possible)

- Protrusion with threaded holes at the bottom face to mate(snug fit) and attach with the bottom part and threaded holes in the top corners of the box to attach with the lid.

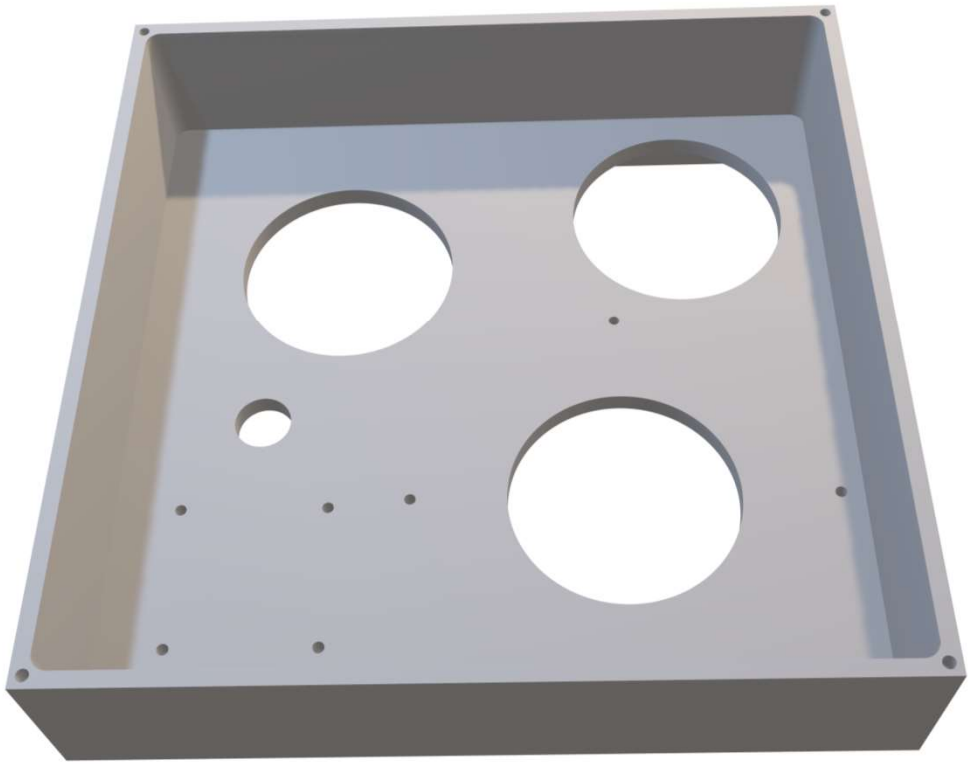
HOUSING: TOP PART - IMAGE



HOUSING: TOP PART - DRAWING



HOUSING: TOP PART – 3D



HOUSING: TOP PART – MACHINING SEQUENCE

- We start with the 200x200x56 mm blank.
- The square pocket is made using drilling and circular milling/circular ramping (described in machining sequence of bottom part of housing)
- Underneath extension is made by using drilling and circular milling (drilling machine, drill bit, milling machine, shoulder end mill cutter) in the centre and shoulder milling (milling machine, square shoulder cutter/end mill cutter) on the periphery.
- The larger wiring holes are made using trepanning (drilling machine, trepanning tool) and the small hole is drilled (drilling machine, 15 mm drill bit).
- The sensor mounting holes on the base are drilled (drilling machine, 3 mm drill bit) and threaded using tapping (drilling machine, tap)
- The 4 holes on the 4 corners of the walls are drilled (drilling machine, 3 mm drill bit) and threaded using tapping (drilling machine, tap)
- 12 Holes are drilled (drilling machine, 4mm drill bit) on the extension and threaded using tapping (drilling machine, tap)
- All the holes are deburred and surfaces are cleaned. The top part is completed.

HOUSING: TOP PART – MACHINING SEQUENCE

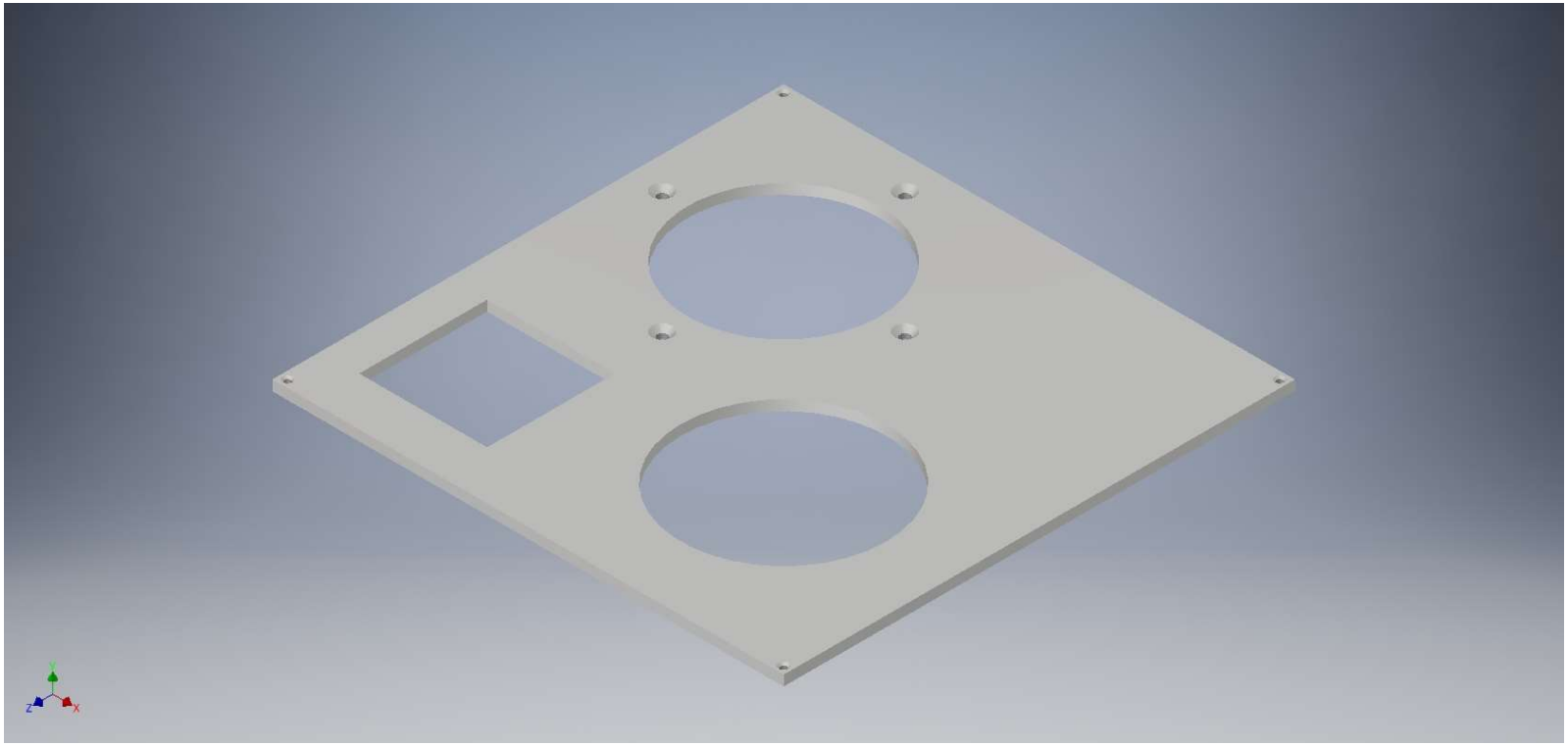
HOUSING: TOP PART - METROLOGY

- Linear dimensions are measured using vernier callipers.
  - Length, width, height of the part
  - depth of the pocket
- Diameter of the large holes are measured using bore gauge.
- Diameter of threaded holes are measured using inside micrometer. Depth of threaded holes can be measured using depth micrometer.
- Position tolerance of the threaded holes is measured using Co-ordinate measuring machine (CMM).
- Perpendicularity of surfaces underneath is measured using height gauge and dial indicator.

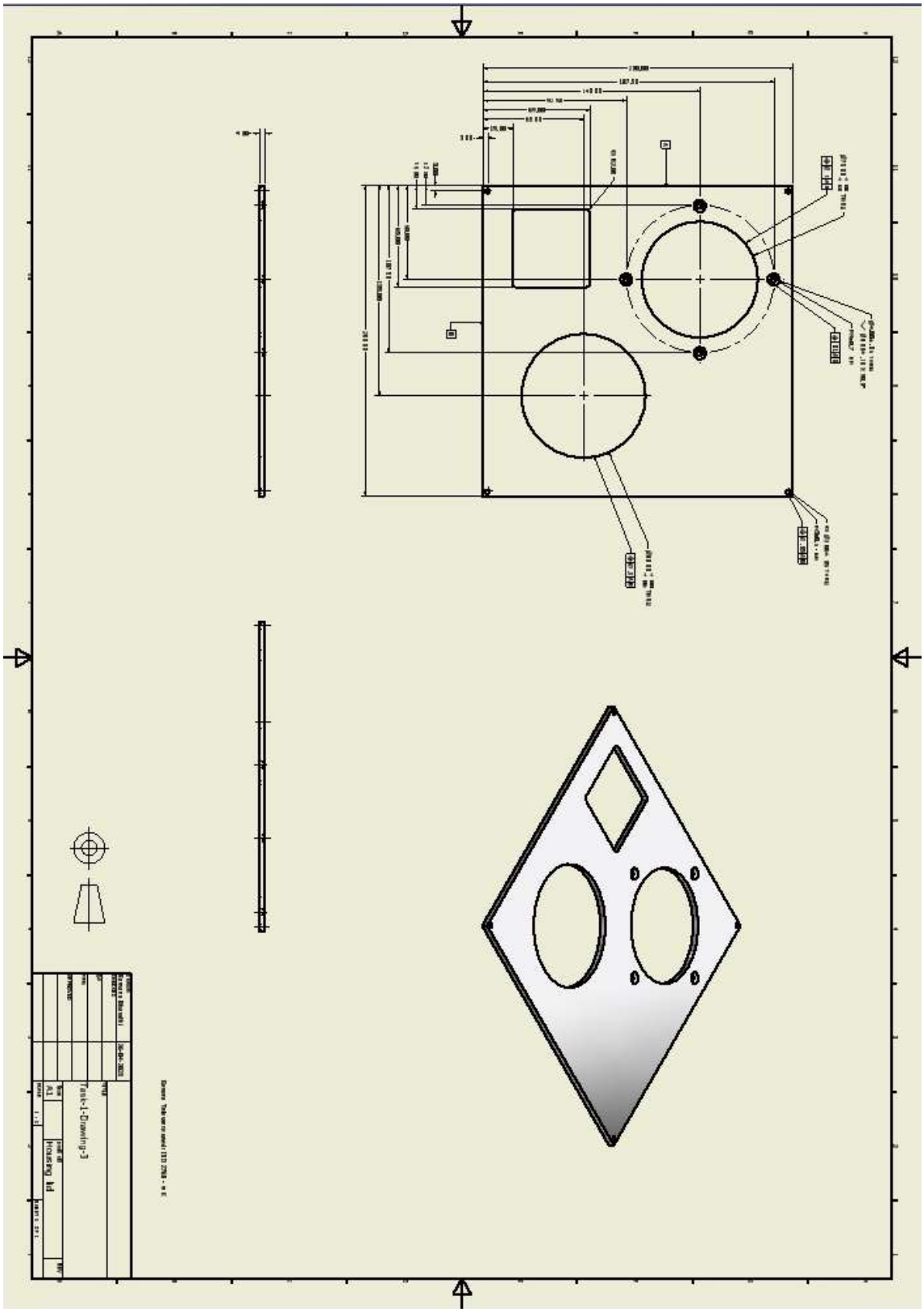
HOUSING: LID - DESIGN FEATURES

- Square metal sheet
- Through holes for exposing the three sensors
- Threaded holes at the four corners to attach to the top part.

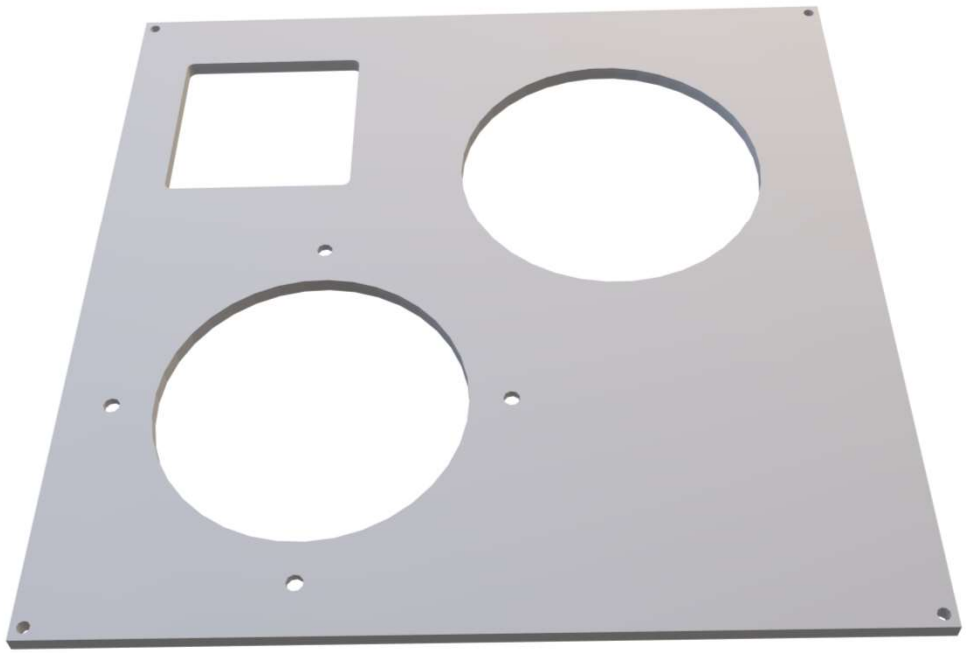
HOUSING: LID- IMAGE



HOUSING: LID- DRAWING



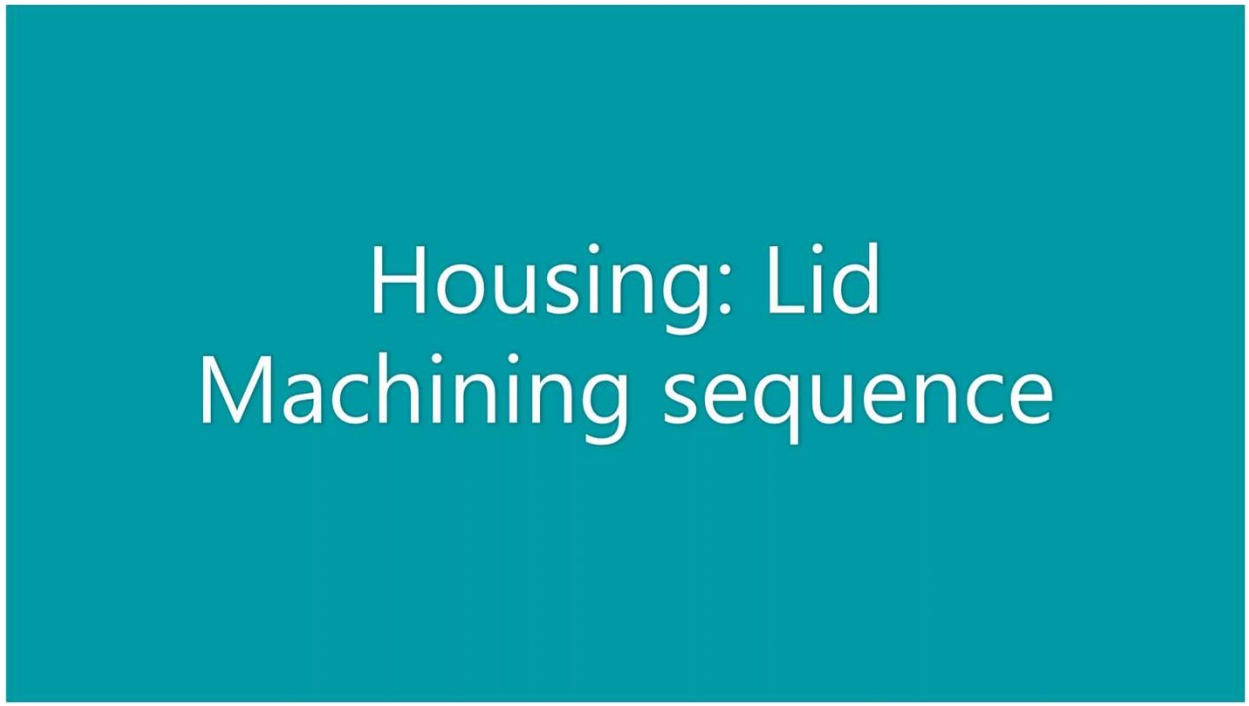
HOUSING: LID – 3D



HOUSING: LID- MACHINING SEQUENCE

- We start with 200x200x3 mm metal sheet.
- The two circular holes are made using trepanning (drilling machine, trepanning tool) and the square hole is made using circular ramping. (milling machine, shoulder milling cutter)
- The 4 holes for attaching lock for sensor-1 are drilled (drilling machine, 4 mm drill bit), countersunk (drilling machine, countersink drill bit)and threaded using tapping (drilling machine, tap)
- The 4 holes at the corners are drilled (3 mm drill bit) and threaded using tapping.
- All the holes are deburred and surfaces are cleaned. The lid is completed.

HOUSING: LID- MACHINING SEQUENCE



HOUSING: LID- METROLOGY

- Linear dimensions are measured using vernier callipers.
  - Length, width, height of the part
  - depth of the pocket
  - Length, width and location of square hole
- Diameter of holes are measured using bore gauges
- Diameter of threaded holes are measured using inside micrometer.
- Position tolerance of the circular holes are verified using Co-ordinate measuring machine (CMM).

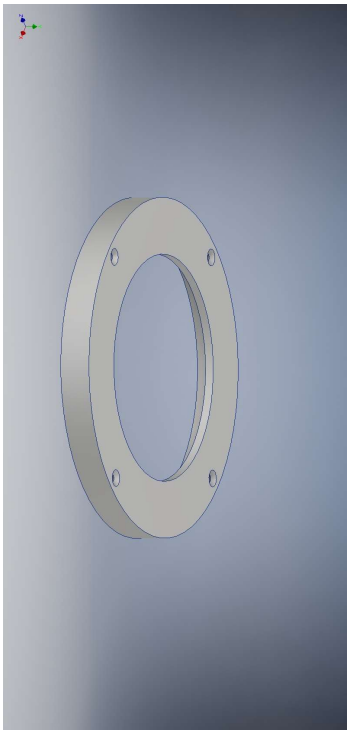
ACCESSORIES FOR ASSEMBLY

- Spacers (male-to-male, M3 bolts, spacing width:10 mm) for mounting the PCB board (X9)
- Locks for each sensor so that the sensors can latched on
- Fasteners:
  - AS 1427 M3 X 8 (X8) [rounded screws]
  - AS 1427 M3 X 16 (X4) [countersunk screws]
  - AS 1427 M4 X 6 (X4) [countersunk screws]
  - AS 1427 M4 X 8 (X16) [countersunk screws]
  - AS 1112 – M3 TYPE 5 (X8) [nuts]

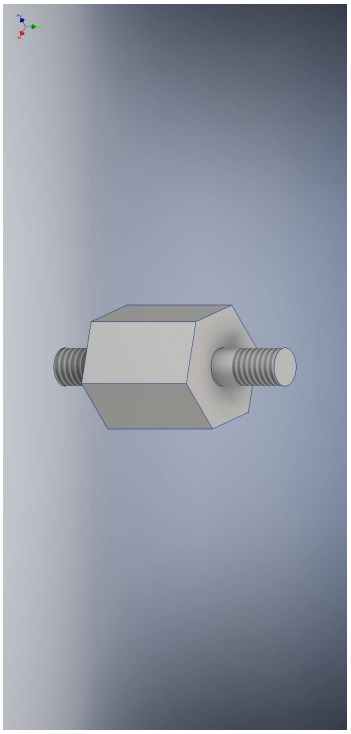
➢ The spacers and the fasteners can be bought COTS, but the locks have to be custom made.

LOCKS AND SPACERS

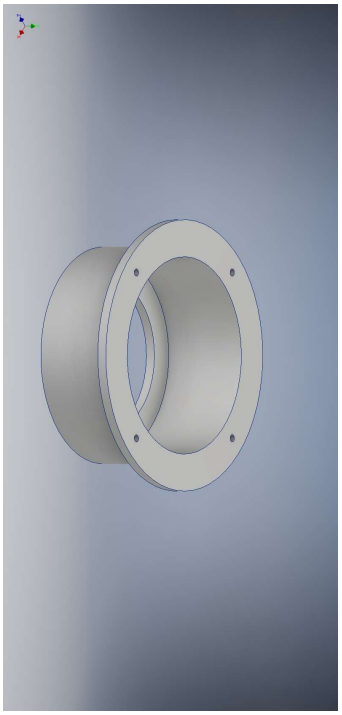
Sensor-2 lock



spacer

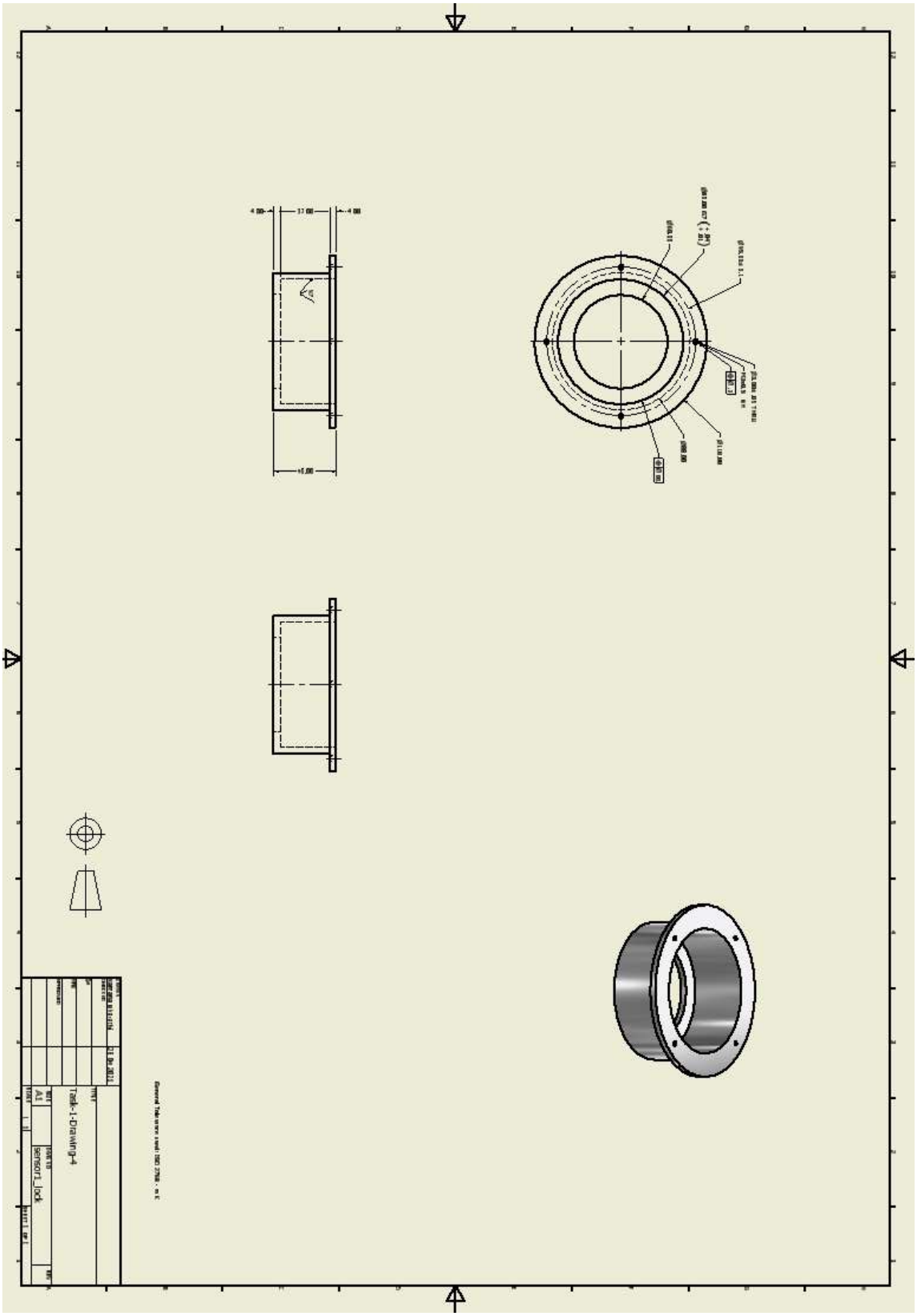


Sensor-3 lock

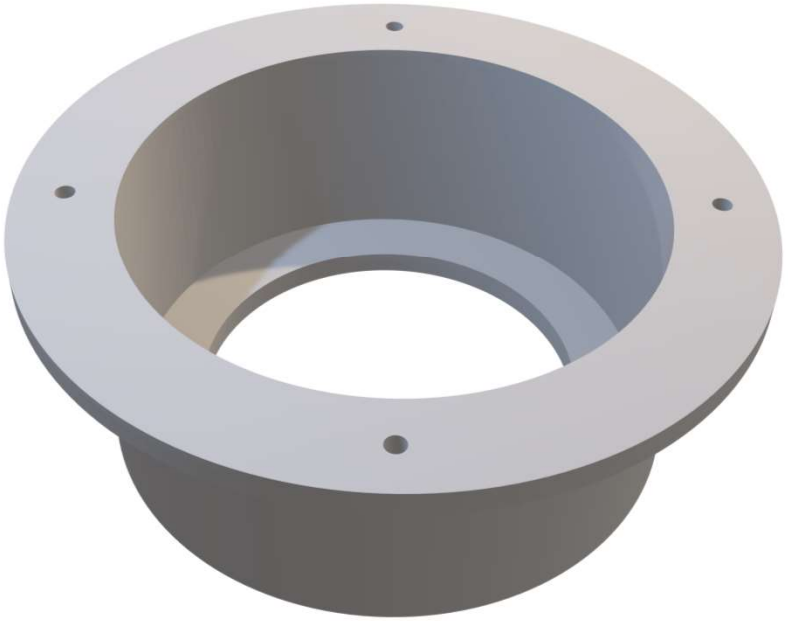


Sensor-1 Lock

LOCK FOR SENSOR-1 - DRAWING



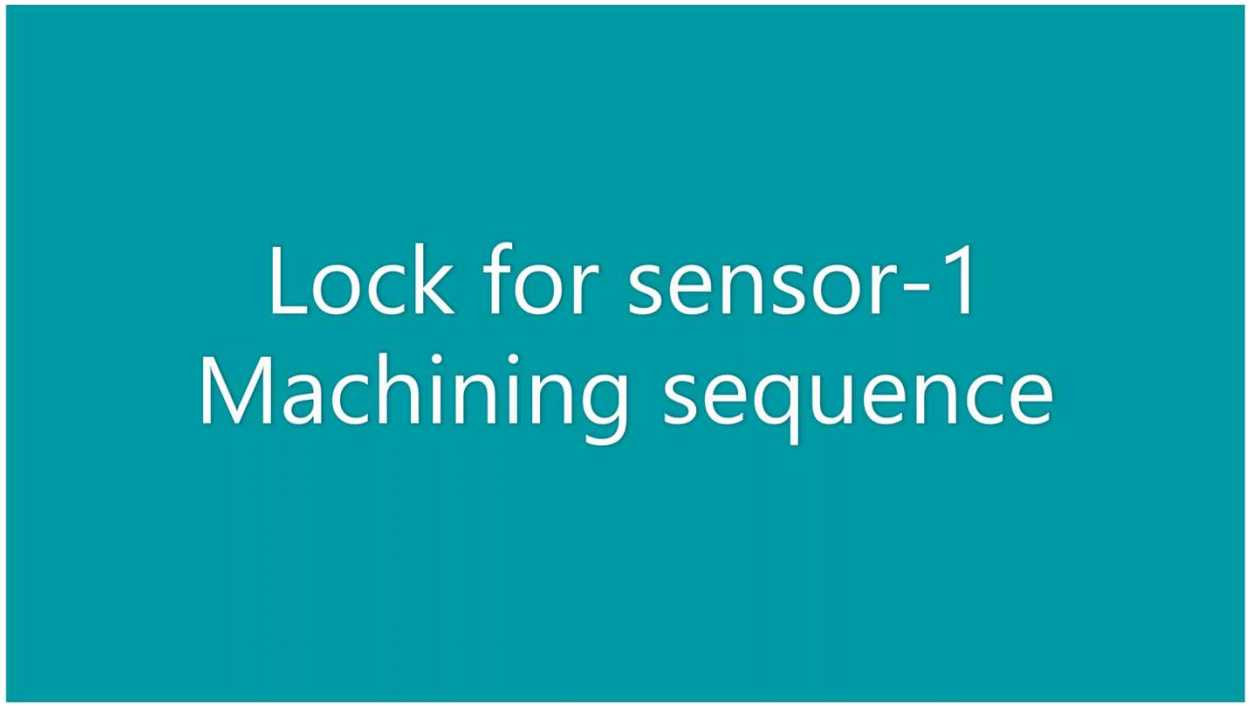
LOCK FOR SENSOR-1 - 3D



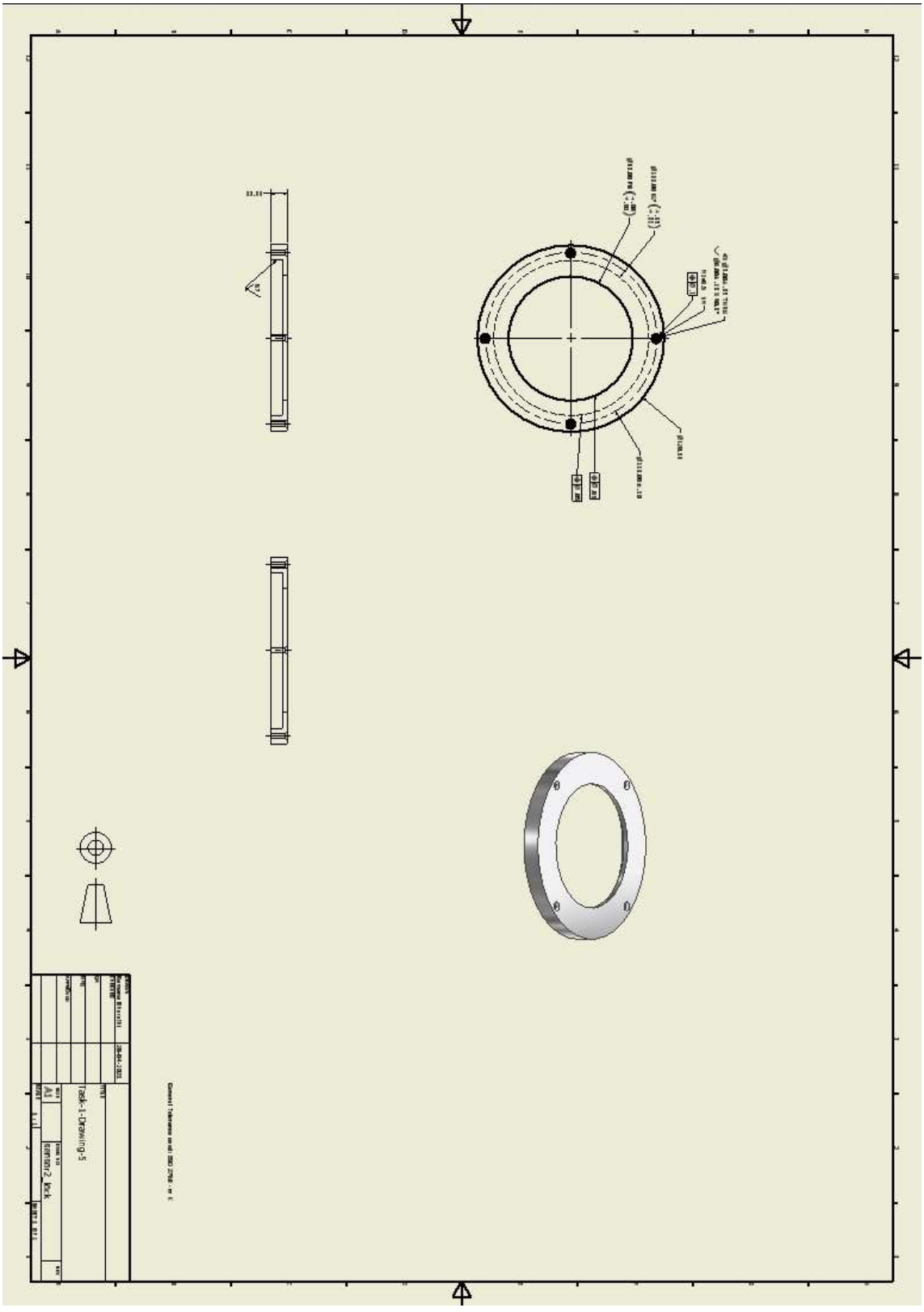
LOCK FOR SENSOR-1 - MACHINING SEQUENCE

- We start with the cylindrical blank of radius 55 mm and height 40 mm.
- The blank is turned (lathe, single-point cutting tool) from below to make the cylindrical T feature.
- A through hole is drilled and bored (lathe, drill bit, boring tool) at the centre.
- The hole is still bored (lathe, boring tool) leaving a step to create vacant space to accommodate the sensor and then finished using reaming (lathe, reamer)
- The 4 holes on the periphery are drilled (drilling machine, 4mm drill bit) and threaded using tapping (drilling machine, tap)
- All the holes are deburred and surfaces are cleaned. The lock for sensor-1 is completed.

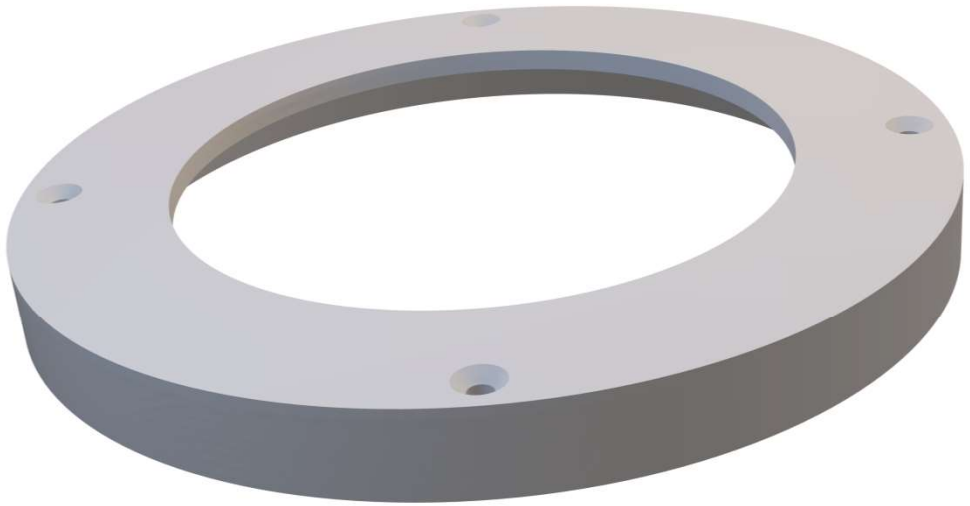
LOCK FOR SENSOR-1 - MACHINING SEQUENCE



LOCK FOR SENSOR-2 - DRAWING



LOCK FOR SENSOR-2 - 3D

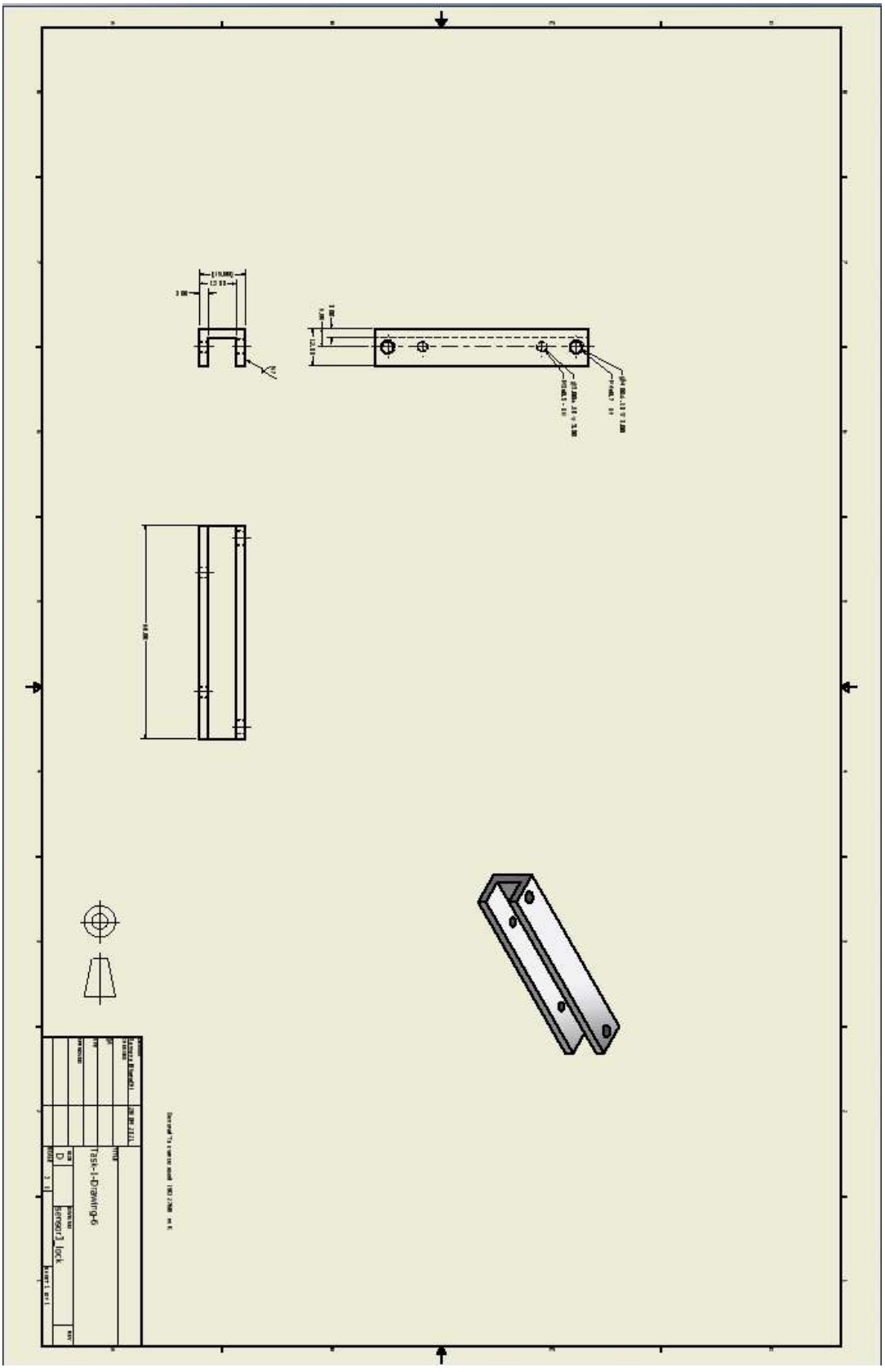


LOCK FOR SENSOR-2 - MACHINING SEQUENCE

- We start with the cylindrical blank of radius 60 mm and height 11 mm.
- The through hole is drilled and bored (lathe, drill bit, boring tool)
- It is turned upside down and bored(lathe, boring tool) to produce the circular step.
- The hole surfaces are finished using reaming. (lathe, reamer)
- The 4 holes on the periphery are drilled (drilling machine, 3mm drill bit) and threaded using tapping (drilling machine, tap)
- All the holes are deburred and surfaces are cleaned. The lock for sensor-2 is completed.

LOCK FOR SENSOR-2 - MACHINING SEQUENCE

LOCK FOR SENSOR-3 - DRAWING

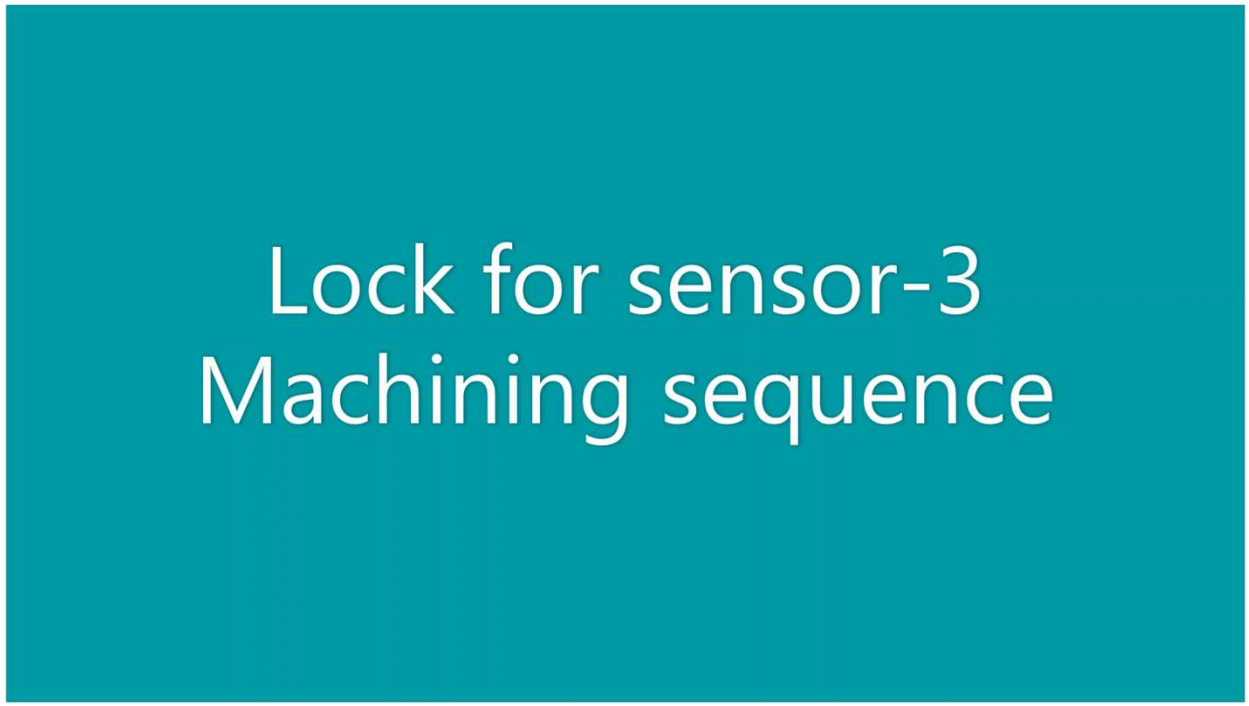


LOCK FOR SENSOR-3 – 3D

LOCK FOR SENSOR-3 - MACHINING SEQUENCE

- We start with the 68x12x15 mm blank.
- The side slot is made using slotting (milling machine, slotting cutter) or end milling (milling machine, end mill cutter)
- The 4 holes on the top and bottom surfaces are drilled (drilling machine, 3mm and 4mm drill bits) countersunk (drilling machine, countersink drill bit) and threaded using tapping (drilling machine, tap)
- Upper surface of the lock is finished using surface grinding.
- All the holes are deburred and surfaces are cleaned. One lock for Sensor-3 is completed. Another one is done in the same way.

LOCK FOR SENSOR-3 - MACHINING SEQUENCE



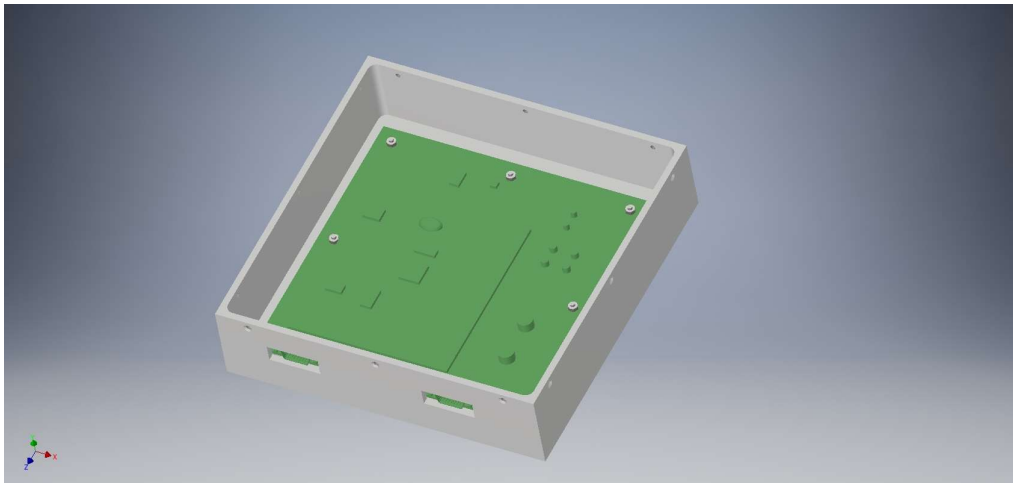
ACCESSORIES FOR ASSEMBLY - METROLOGY

- Linear dimensions are measured and sizes of the holes using vernier callipers.
  - Height, inner diameter, outer diameter, depth for first two locks.
  - Height, width, length, thickness in third lock
- Diameter of holes are measured using inside micrometer.
- Position tolerance of the holes is measured using Co-ordinate measuring machine (CMM).
- Fits of the holes can be verified using pin gauges.

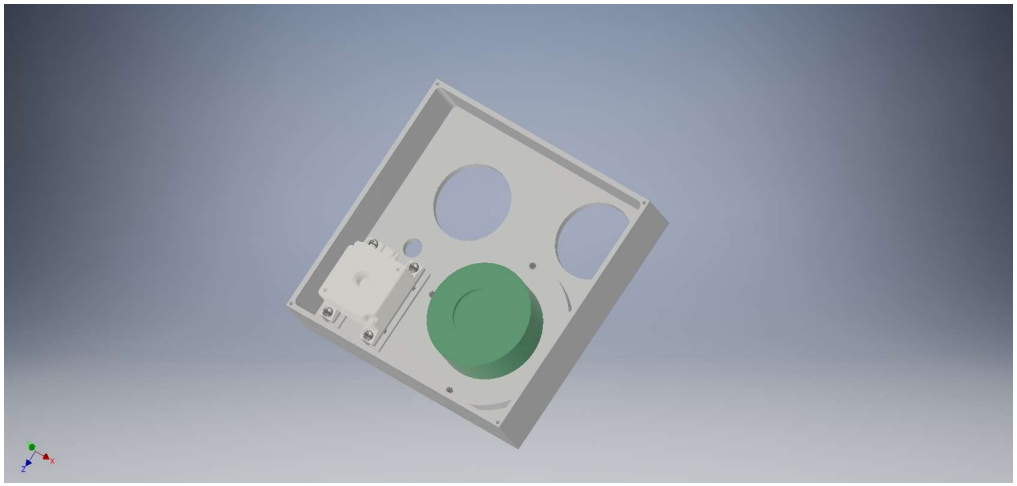
ASSEMBLY

- For the bottom part,9 M3 spacers are fastened on its base and the PCB board is mounted on them such that the D-Pin connectors get exposed through the square holes and the PCB board is held in place using 8 M3 nuts over the spacers. (the PCB board can be minimally mounted using only 4 spacers on the corners)
- For the top part, 2 locks for sensor-3 are attached on the base using two M3 screws each and sensor-3 is mounted on top using four screws. Sensor-2 is inserted into its lock (sliding fit) and the lock is attached to the base using 4 long M3 screws.
- For the lid, the 4 discs of sensor-1 is placed into its lock one by one (sliding fit) and the lock is attached to the lid using 4 M4 screws.
- All the wiring working is done and the top part is mounted (snug fitted) on the bottom part and attached using 12 M4 screws (3 a side) and lid is mounted on the top part and is attached using 4 M3 screws on the corners.

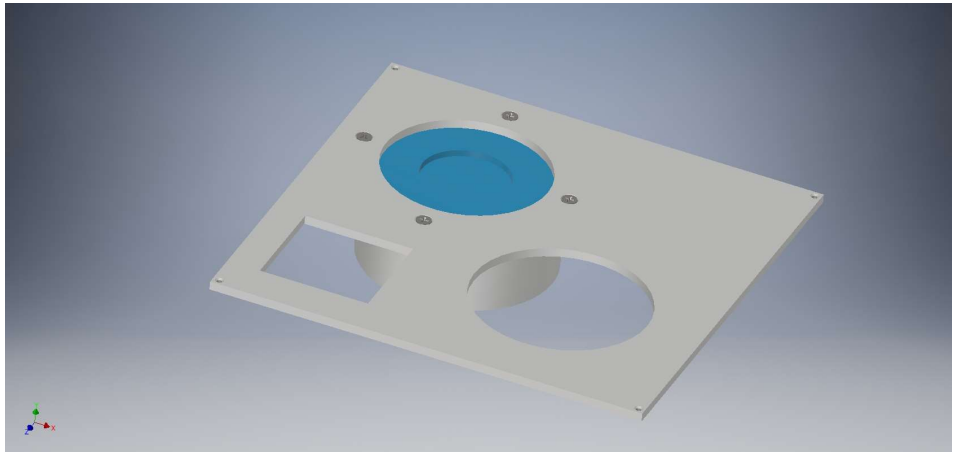
Housing: Bottom part assembled



Housing: Top part assembled

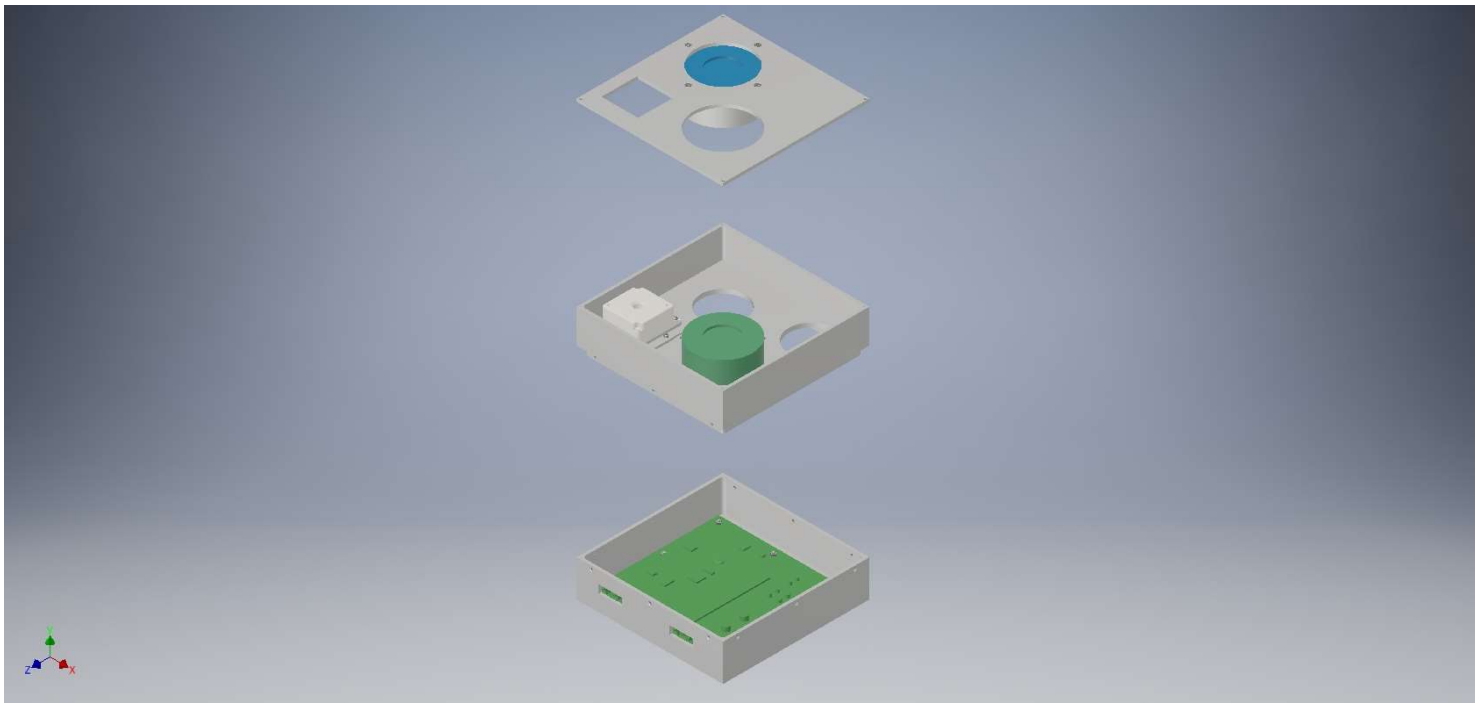


Housing: lid assembled

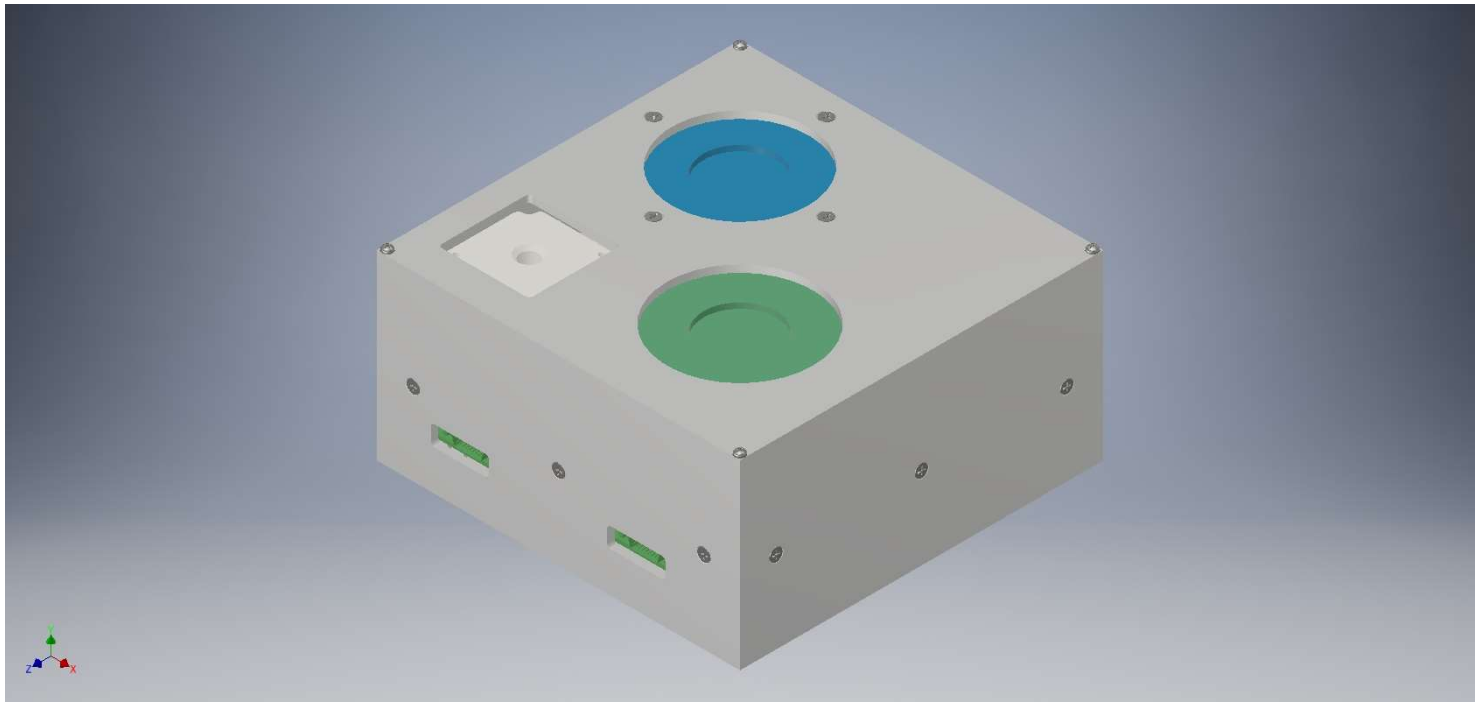


ASSEMBLY – 3D

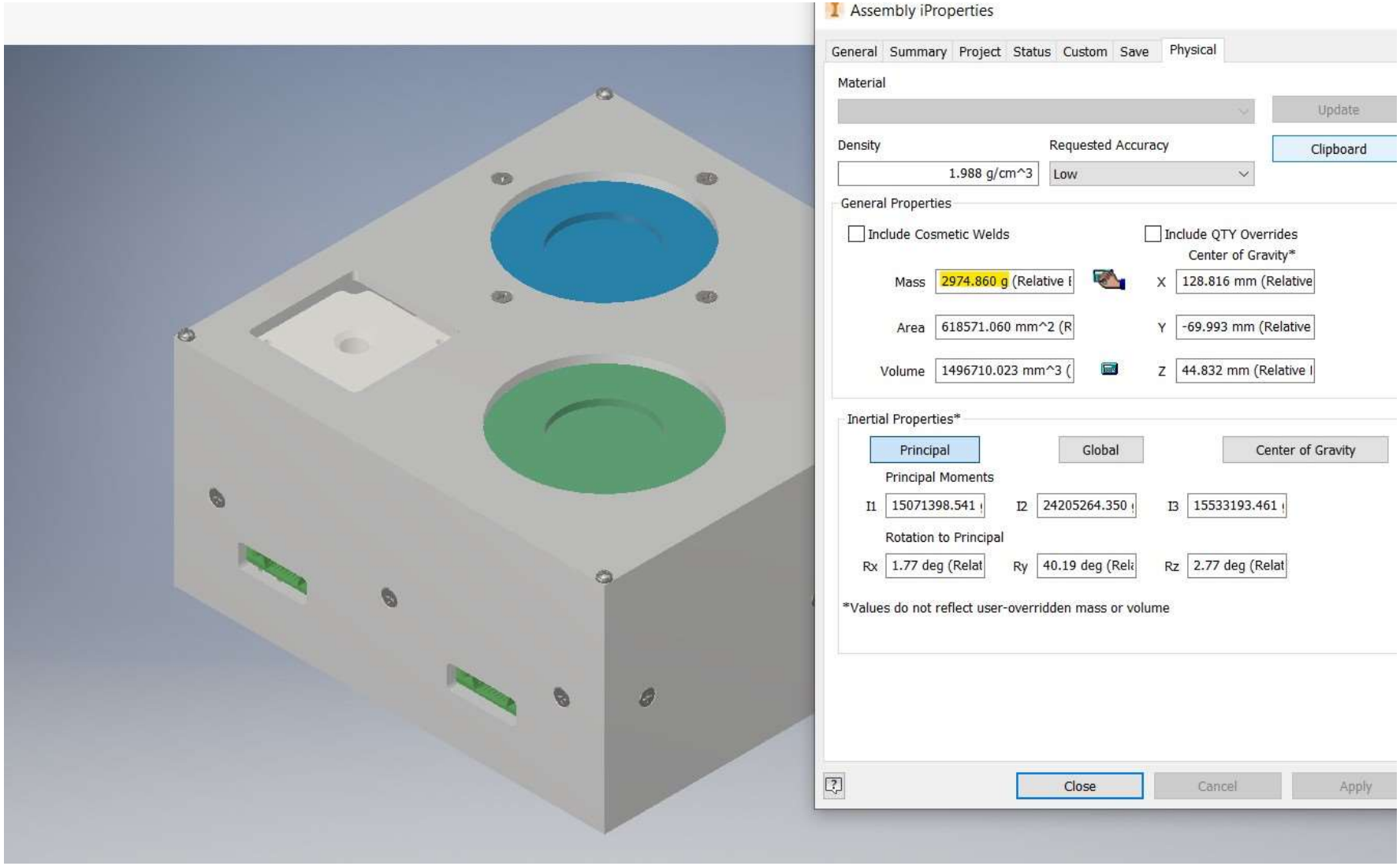
ASSEMBLY - IMAGE (EXPLODED)



ASSEMBLY - IMAGE



OVERALL MASS 2974.860 g



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