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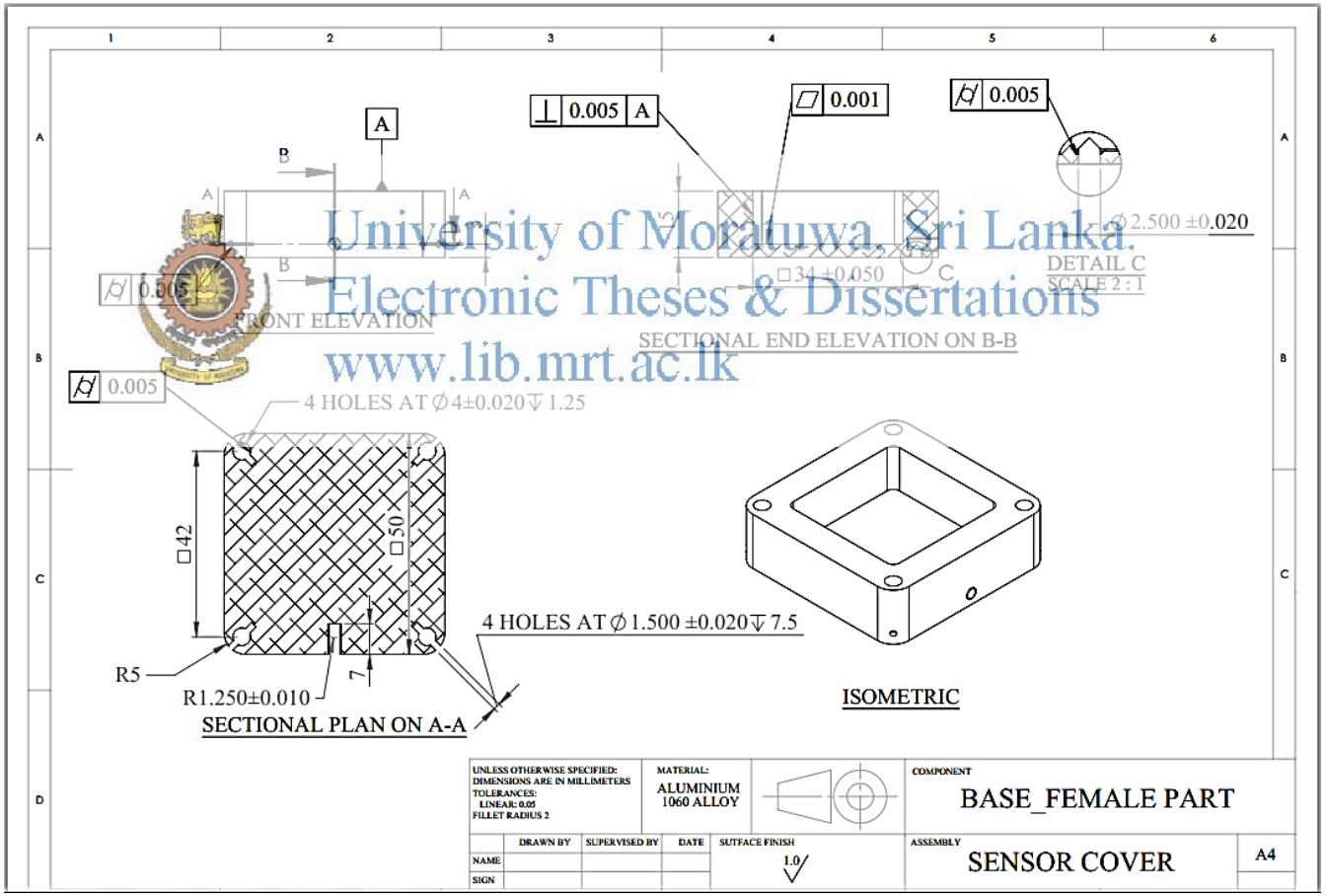
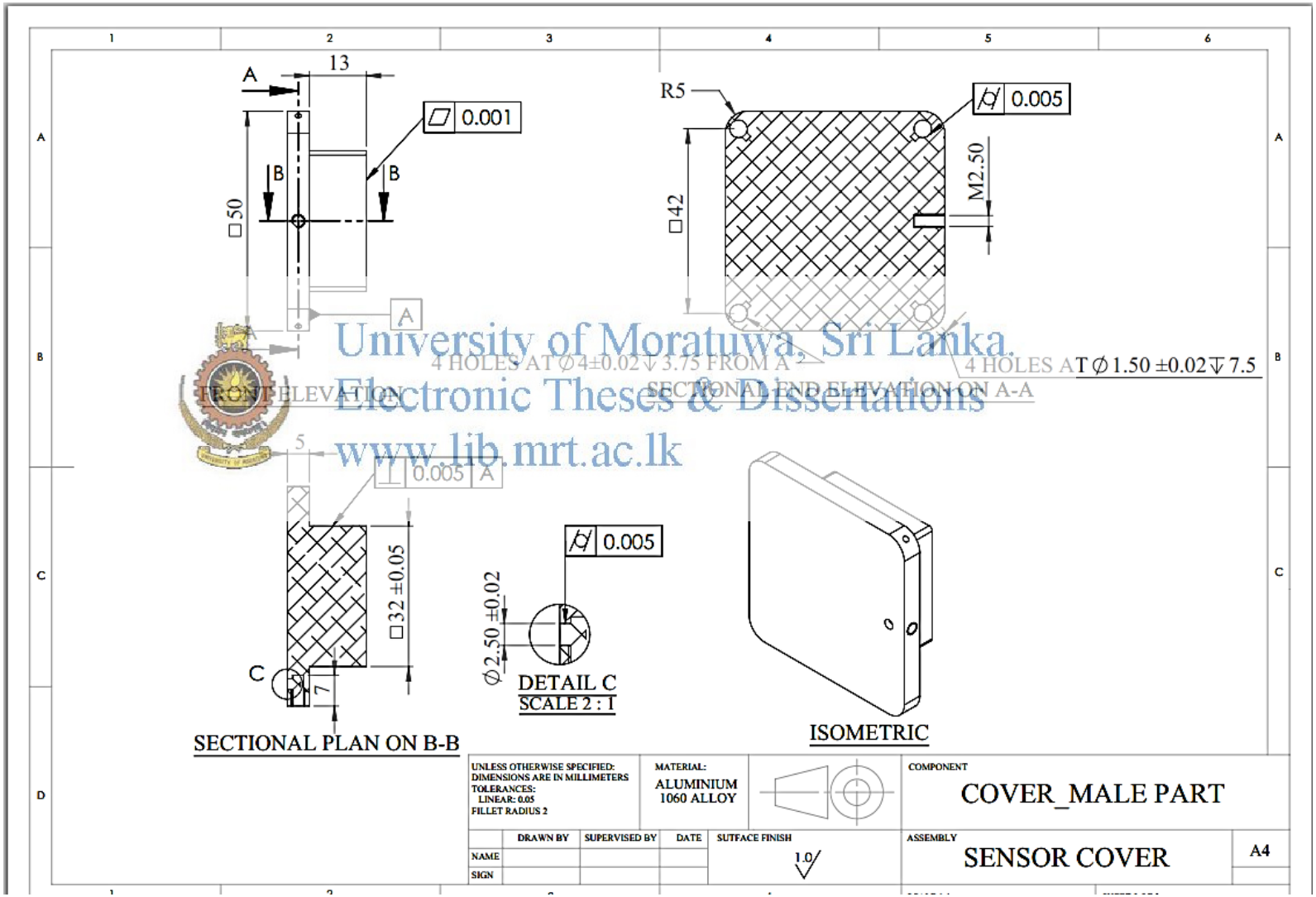
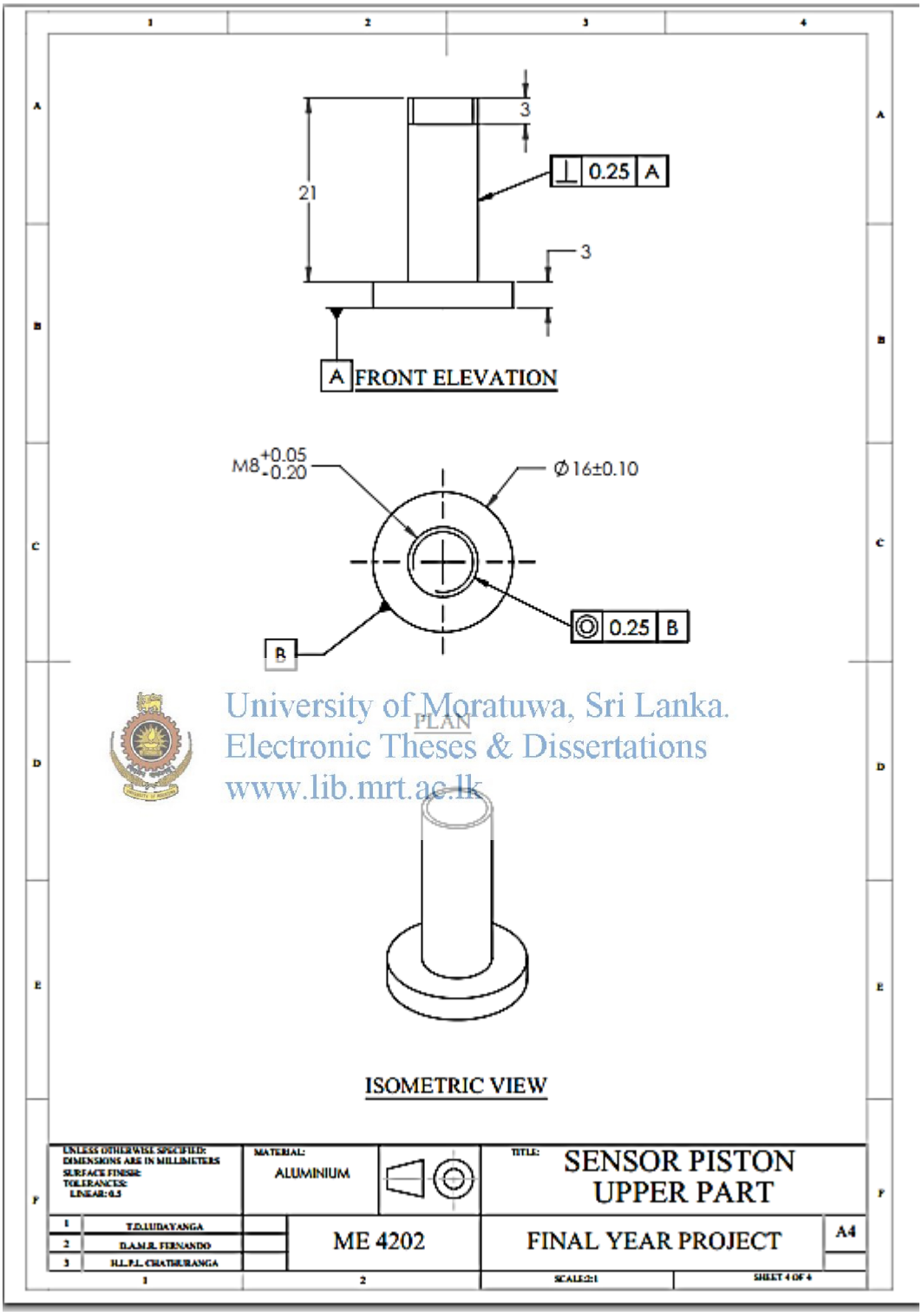
APPENDICES

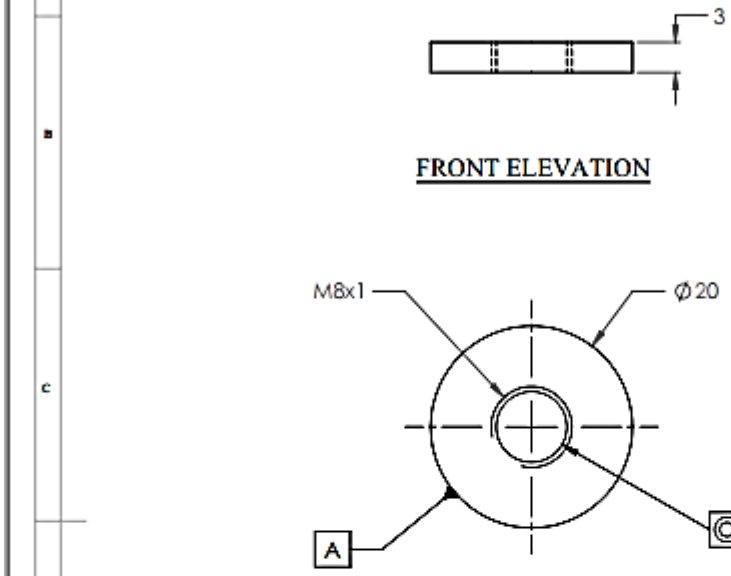
Appendix A: Sensor Enclosure (Design 1)



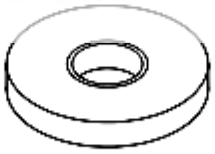


Appendix B: Production Drawings of Sensor Structure (Design 2)



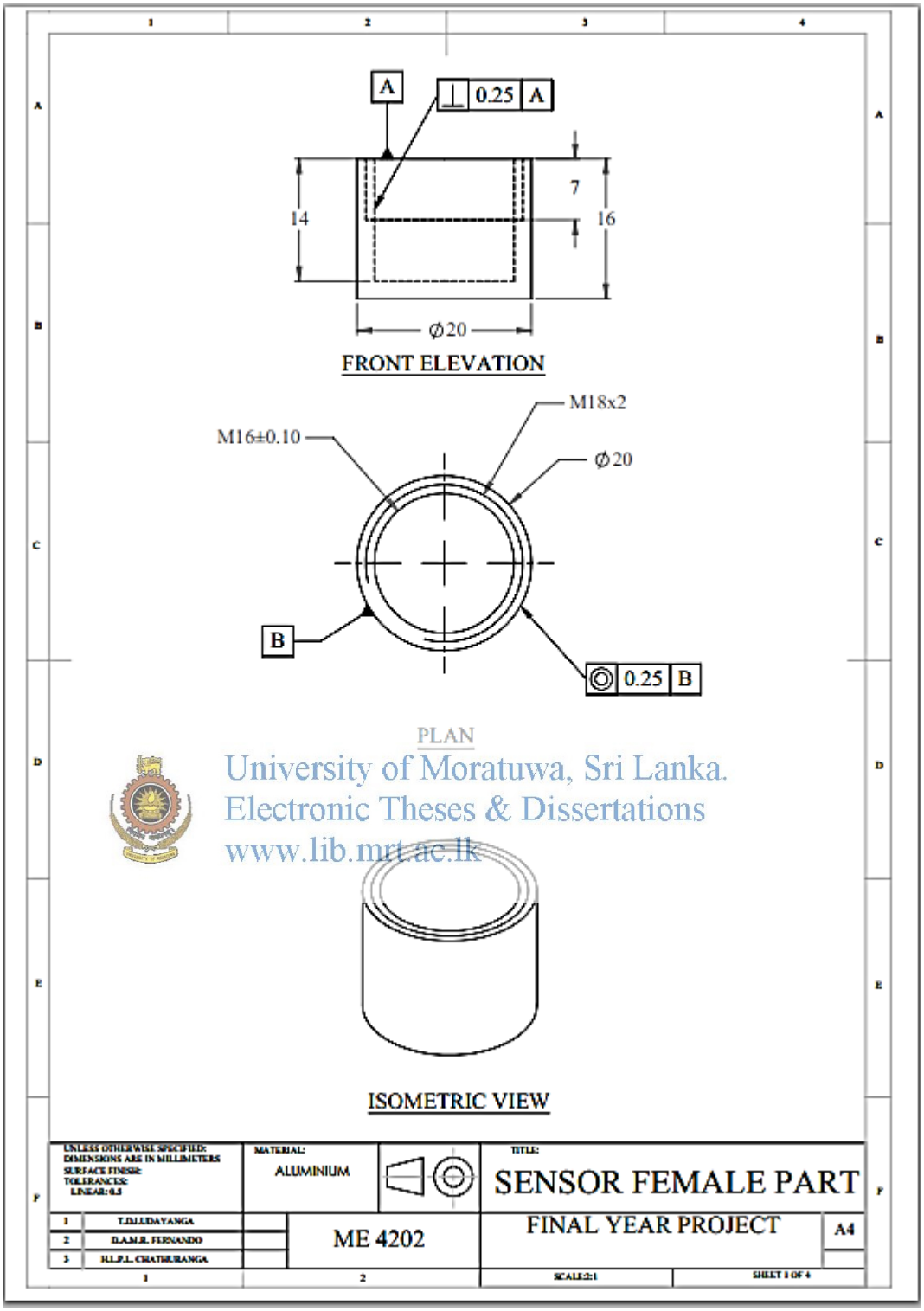


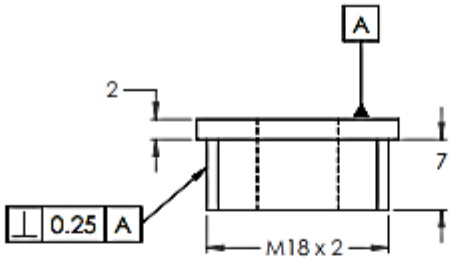
FRONT ELEVATION



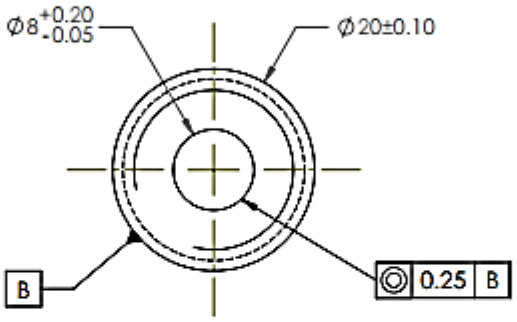
ISOMETRIC VIEW

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: 0.5	MATERIAL: ALUMINIUM		TITLE: SENSOR PISTON LOWER PART	
1 T.D.UDAYANGA		ME 4202	FINAL YEAR PROJECT	A4
2 D.A.M.R. FERNANDO				
3 H.L.P.L. CHATHURANGA				
1	2		SCALE:2:1	SHEET 3 OF 4





FRONT ELEVATION



PLAN

ISOMETRIC VIEW

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: 0.5	MATERIAL: ALUMINIUM		TITLE: SENSOR CUP
1 T.D.L.I.DAYANGA 2 D.A.M.R. FERNANDO 3 H.L.P.L. CHATHURANGA		ME 4202	FINAL YEAR PROJECT A4
		SCALE:2:1	SHEET 3 OF 4

Appendix C: Material Properties Chart

ASTM A228

Categories: Metal; Ferrous Metal; ASTM Steel; Carbon Steel; High Carbon Steel

Material Notes: Cold drawn. High tensile strength and uniform mechanical properties. Music wire springs are not recommended for service temperatures above 121°C (250° F).

Applications: High quality springs and wire forms subject to high stresses or requiring good fatigue properties.

Key Words: spring steel, music wire, AMS 5112, UNS K08500

Vendors: No vendors are listed for this material. Please click here if you are a supplier and would like information on how to add your listing to this material.

Physical Properties	Metric	English	Comments
Density	7.85 g/cc	0.284 lb/in³	Typical of ASTM Steel

Mechanical Properties	Metric	English	Comments
Hardness, Rockwell C	41 - 60	41 - 60	
Tensile Strength, Yield	1590 - 1760 MPa @Diameter 6.35 mm	231000 - 255000 psi @Diameter 0.250 in	
	1640 - 1820 MPa @Diameter 5.26 mm	238000 - 264000 psi @Diameter 0.207 in	
	1690 - 1860 MPa @Diameter 4.50 mm	245000 - 270000 psi @Diameter 0.177 in	
	1740 - 1920 MPa @Diameter 3.81 mm	252000 - 278000 psi @Diameter 0.150 in	
	1770 - 1950 MPa @Diameter 3.56 mm	257000 - 283000 psi @Diameter 0.140 in	
	1800 - 1990 MPa @Diameter 3.18 mm	261000 - 289000 psi @Diameter 0.125 in	
	1870 - 2070 MPa @Diameter 2.54 mm	271000 - 300000 psi @Diameter 0.100 in	
	1940 - 2150 MPa @Diameter 2.00 mm	281000 - 312000 psi @Diameter 0.0787 in	
	2020 - 2230 MPa @Diameter 1.60 mm	293000 - 323000 psi @Diameter 0.0630 in	
	2090 - 2310 MPa @Diameter 1.30 mm	303000 - 335000 psi @Diameter 0.0512 in	
	2170 - 2410 MPa @Diameter 1.05 mm	315000 - 350000 psi @Diameter 0.0394 in	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	2500 - 2760 MPa @Diameter 0.500 mm	363000 - 400000 psi @Diameter 0.0197 in	
	2600 - 2880 MPa @Diameter 0.300 mm	377000 - 418000 psi @Diameter 0.0118 in	
	2750 - 3040 MPa @Diameter 0.200 mm	399000 - 441000 psi @Diameter 0.00787 in	
	3030 - 3340 MPa @Diameter 0.100 mm	439000 - 484000 psi @Diameter 0.00394 in	
Modulus of Elasticity	210 GPa	30500 ksi	
Poissons Ratio	0.313	0.313	Calculated
Shear Modulus	80.0 GPa	11600 ksi	

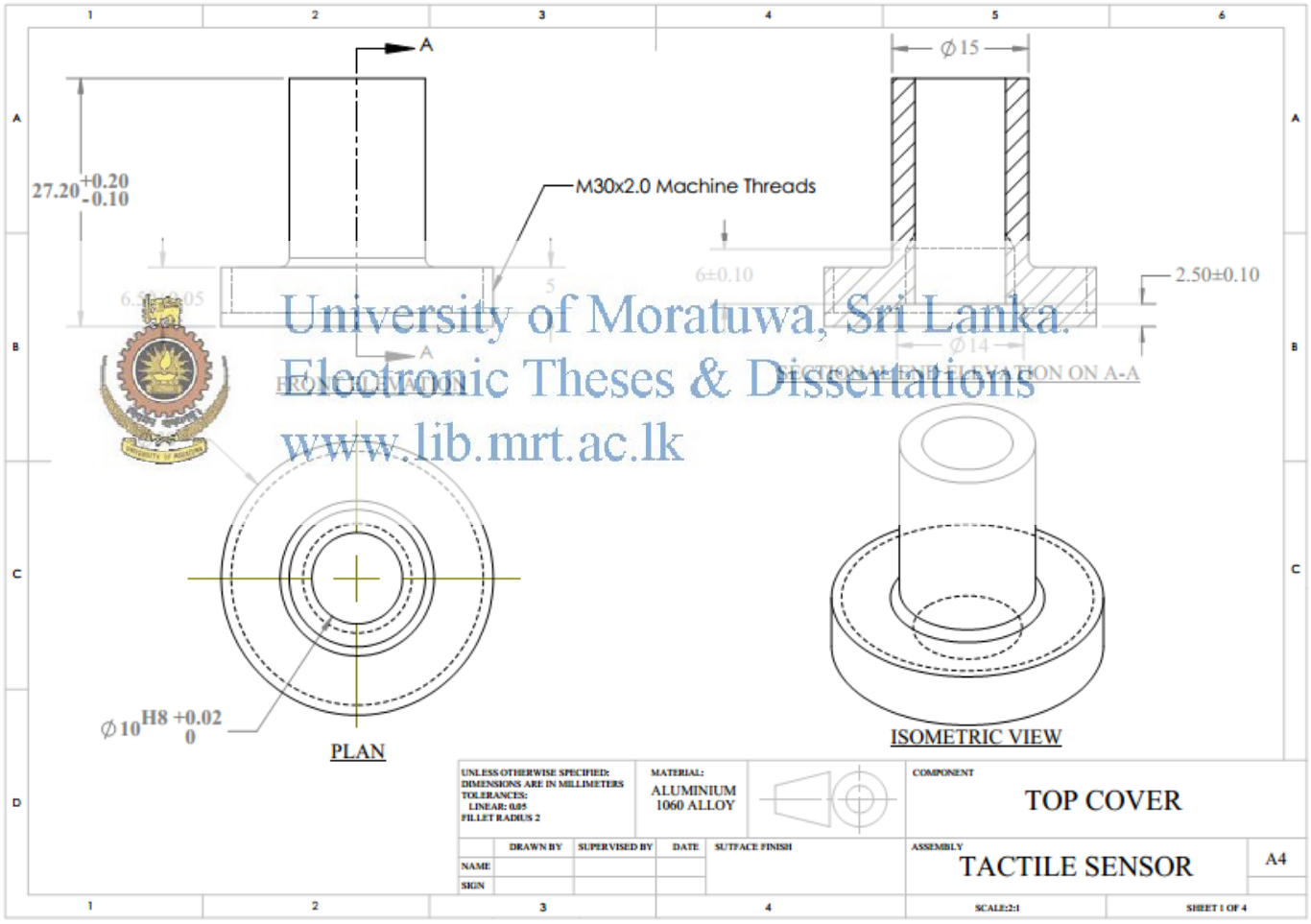
Thermal Properties	Metric	English	Comments
Maximum Service Temperature, Air	120 °C	248 °F	

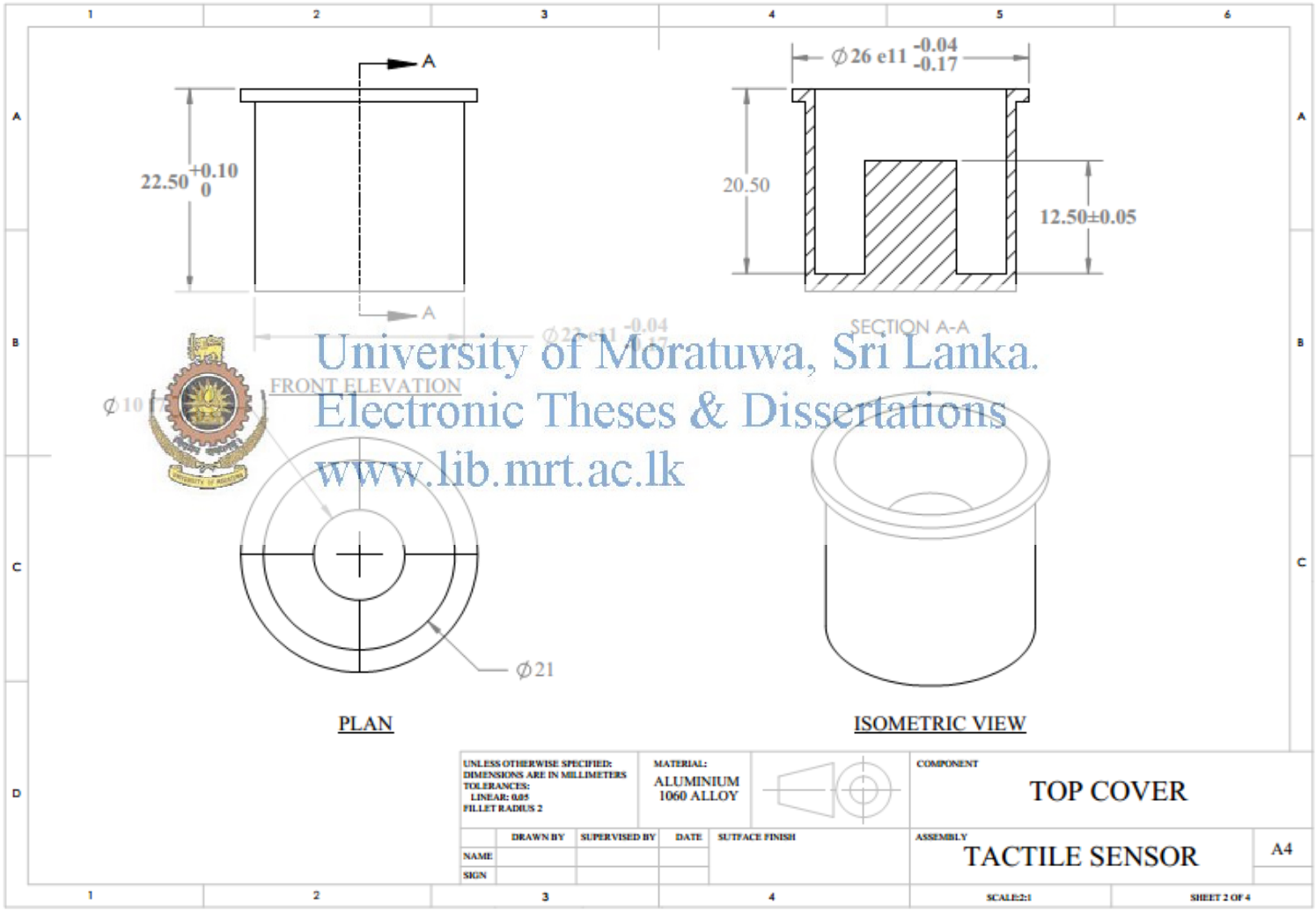
Component Elements Properties	Metric	English	Comments
Carbon, C	0.70 - 1.0 %	0.70 - 1.0 %	
Iron, Fe	97.8 - 99 %	97.8 - 99 %	
Manganese, Mn	0.20 - 0.60 %	0.20 - 0.60 %	
Phosphorous, P	<= 0.025 %	<= 0.025 %	
Silicon, Si	0.10 - 0.30 %	0.10 - 0.30 %	
Sulfur, S	<= 0.030 %	<= 0.030 %	

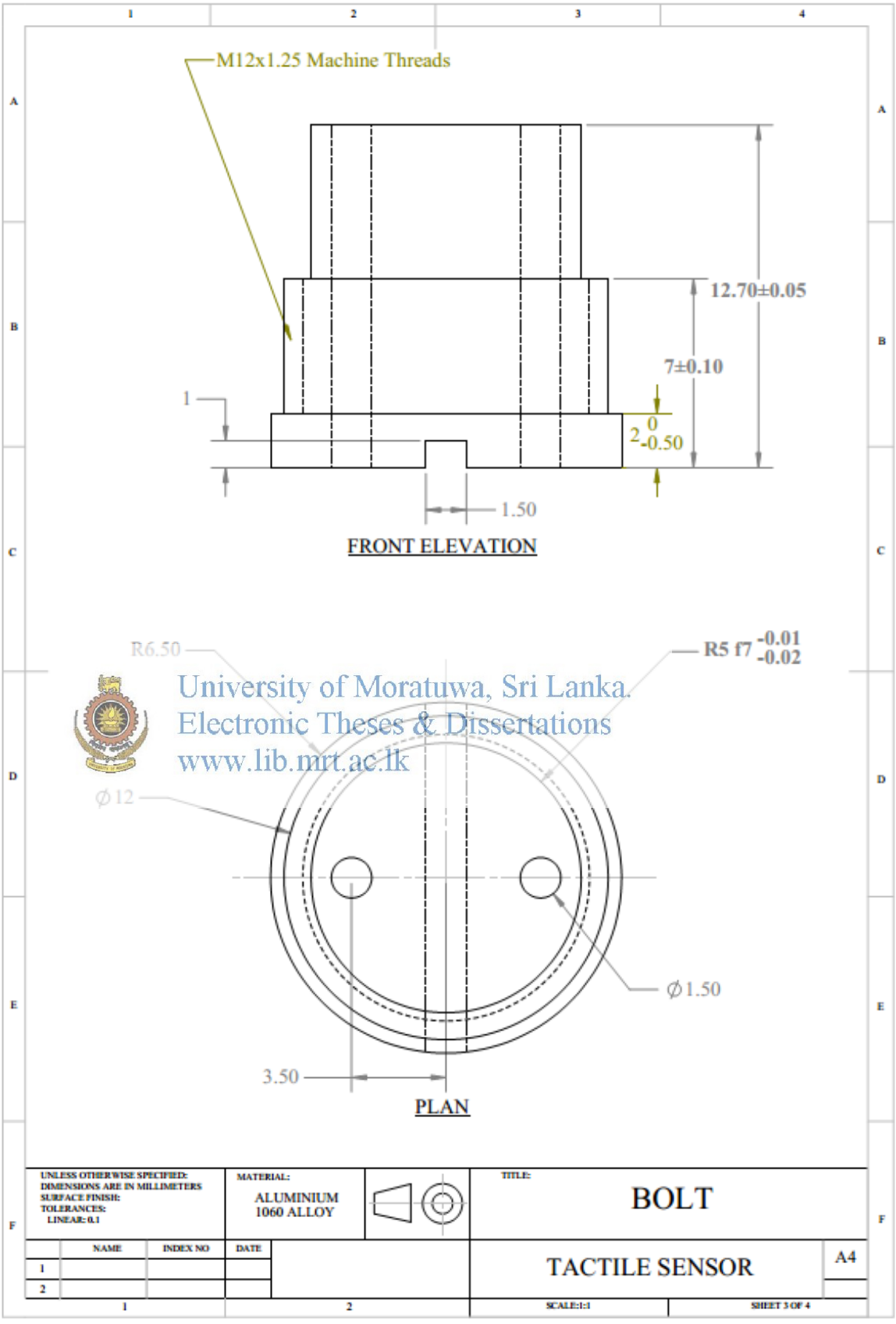
Some of the values displayed above may have been converted from their original units and/or rounded in order to display the information in a consistent format. Users requiring more precise data for scientific or engineering calculations can click on the property value to see the original value as well as raw conversions to equivalent units. We advise that you only use the original value or one of its raw conversions in your calculations to minimize rounding error. We also ask that you refer to MatWeb's terms of use regarding this information. Click here to view all the property values for this datasheet as they were originally entered into MatWeb.

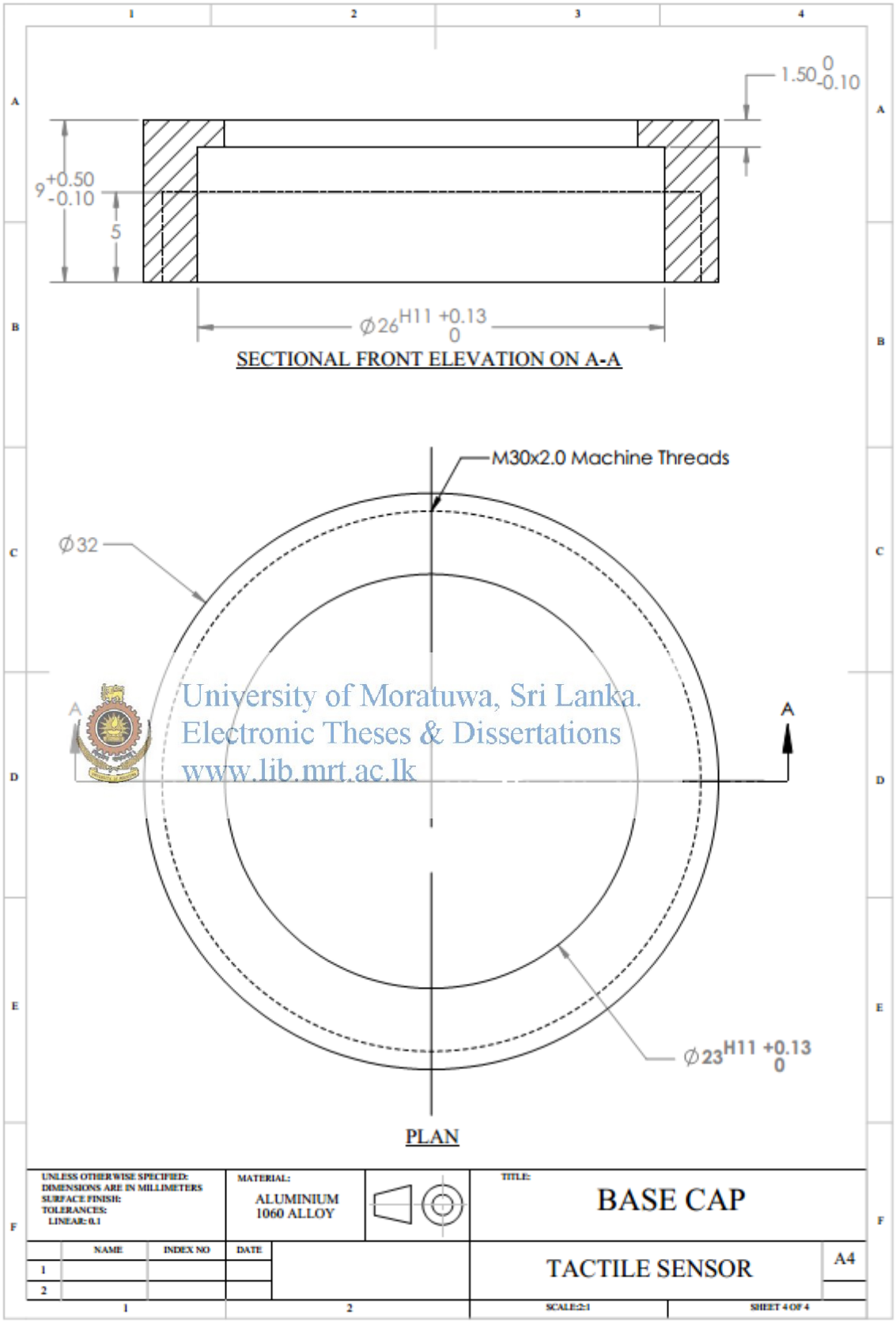
MatWeb, Your Source for Materials Information - WWW.MATWEB.COM / Page 1 / 1

Appendix D: Production Drawings of Sensor structure (Enclosed sensor)









Appendix E: Arduino Code of Graphical User Interface

LIFA_BASE

```
// Standard includes.  These should always be included.
#include <Wire.h>
#include <SPI.h>
#include <Servo.h>
#include "LabVIEWInterface.h"

void setup()
{
  // Initialize Serial Port With The Default Baud Rate
  syncLV();

}

void loop()
{
  // Check for commands from LabVIEW and process them.

  checkForCommand();

  if(acqMode==1)
  {
    sampleContinously();
  }
}
```


LabVIEWInterface.h

```
#define FIRMWARE_MAJOR 02
#define FIRMWARE_MINOR 00
#if defined(__AVR_ATmega1280__) || defined(__AVR_ATmega2560__)
#define DEFAULTBAUDRATE 9600   // Defines The Default Serial Baud Rate (This must match the baud rate specifid in LabVIEW)
#else
#define DEFAULTBAUDRATE 115200
#endif
#define MODE_DEFAULT 0          // Defines Arduino Modes (Currently Not Used)
#define COMMANDLENGTH 15        // Defines The Number Of Bytes In A Single LabVIEW Command (This must match the packet size specifid in LabVIEW)
```

```
#define STEPPER_SUPPORT 1          // Defines Whether The Stepper Library Is Included - Comment This Line To Exclude Stepper Support


// Declare Variables
unsigned char currentCommand[COMMANDLENGTH];    // The Current Command For The Arduino To Process
//Globals for continuous aquisition
unsigned char acqMode;
unsigned char contAcqPin;
float contAcqSpeed;
float acquisitionPeriod;
float iterationsFlt;
int iterations;
float delayTime;

/Synchronizes with LabVIEW and sends info about the board and firmware (Unimplemented)/

void syncLV();

/Sets the mode of the Arduino (Reserved For Future Use)/

void setMode(int mode);

/Checks for new commands from LabVIEW and processes them if any exists./

int checkForCommand(void);

/Processes a given command/

void processCommand(unsigned char command[]);

/Write values to DIO pins 0 - 13.  Pins must first be configured as outputs./

void writeDigitalPort(unsigned char command[]);

/Reads all 6 analog input ports, builds 8 byte packet, send via RS232./

void analogReadPort();
```

/Configure digital I/O pins to use for seven segment display. Pins are stored in sevenSegmentPins array./

void sevenSegment_Config(unsigned char command[]);

/Write values to sevenSegment display. Must first use sevenSegment_Configure/

void sevenSegment_Write(unsigned char command[]);

/Set the SPI Clock Divisor/

void spi_setClockDivider(unsigned char divider);

/Sens / Receive SPI Data/

void spi_sendReceive(unsigned char command[]);

/Compute Packet Checksum/

unsigned char checksum_Compute(unsigned char command[]);

/Compute Packet Checksum And Test Against Included Checksum/

int checksum_Test(unsigned char command[]);

/Parse command packet and write speed, direction, and number of steps to travel/

void AccelStepper_Write(unsigned char command[]);

/Returns several analog input points at once./

void sampleContinously(void);

/Returns the number of samples specified at the rate specified./

void finiteAcquisition(int analogPin, float acquisitionSpeed, int numberOfSamples);

/Prints Data to the LCD With The Given Base/

void lcd_print(unsigned char command[]);

Appendix F: Production Drawings of 5-DOF MEMS Sensor Structure