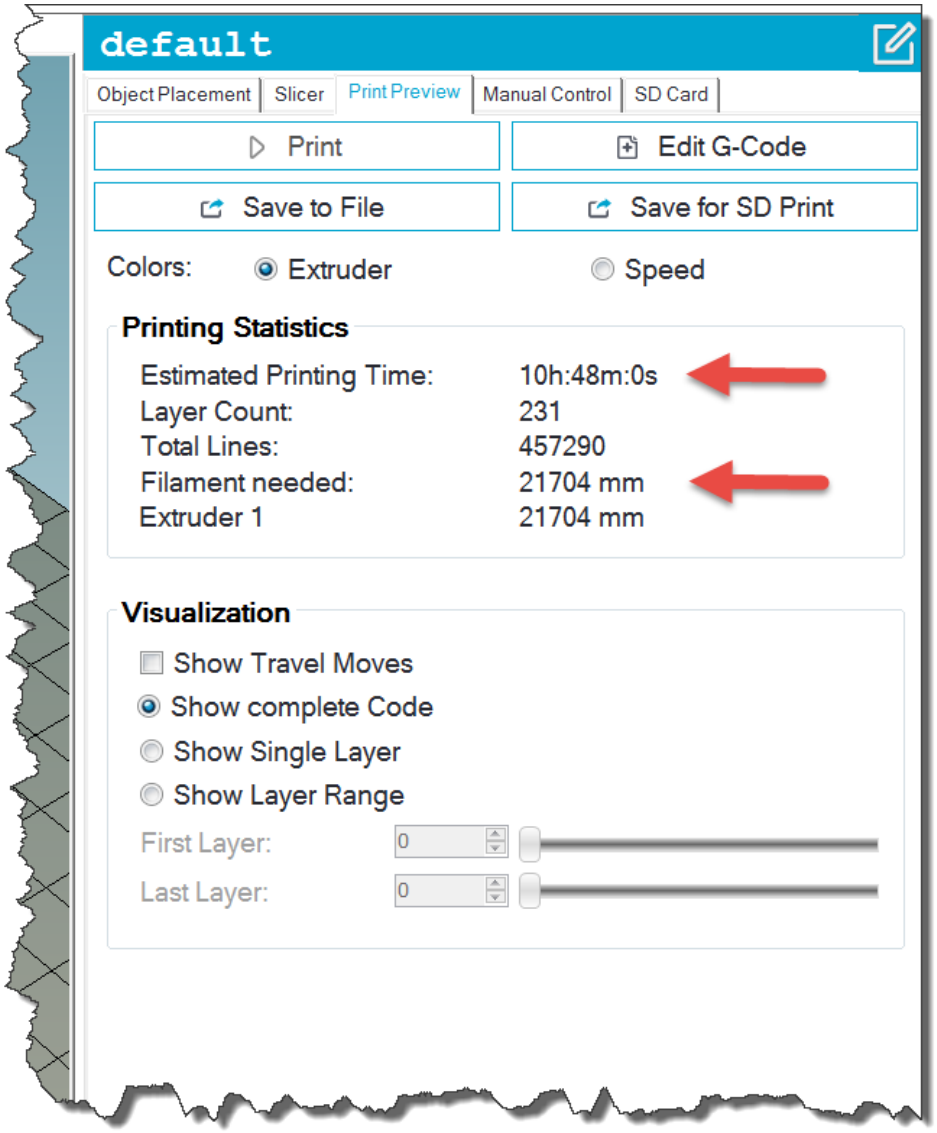
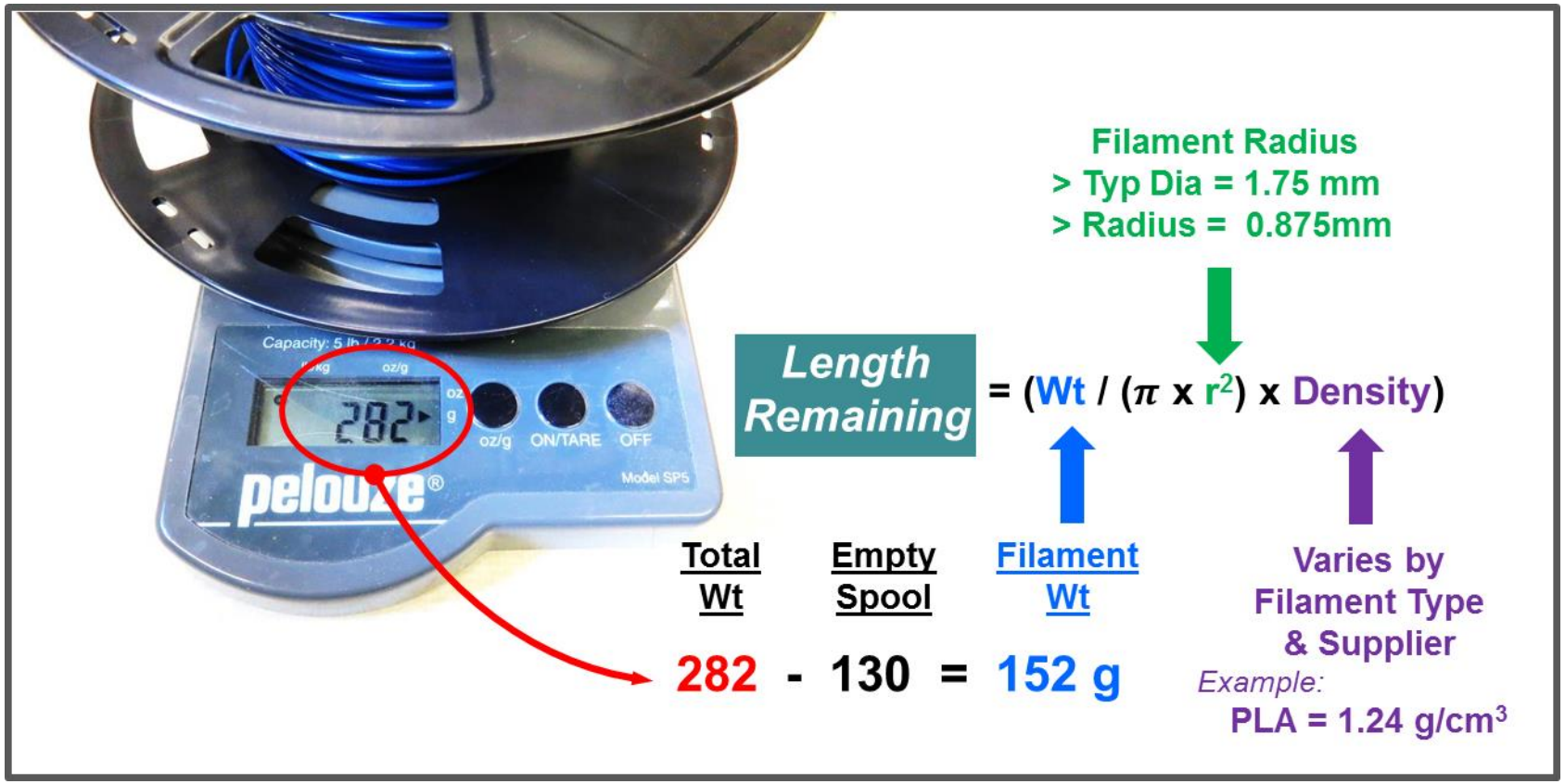
Spool Scale Design & Build Notes

E. Andrews - Last Updated: 8-11-2019

By measuring the weight of a spool of 3D printer filament, it is possible to derive the length of filament remaining on that spool. This value can be compared to the "Filament Needed" estimate provided by the SLICER program (see figure to the right) and used to determine when a spool change is needed. This will prevent filament run-out print failures.



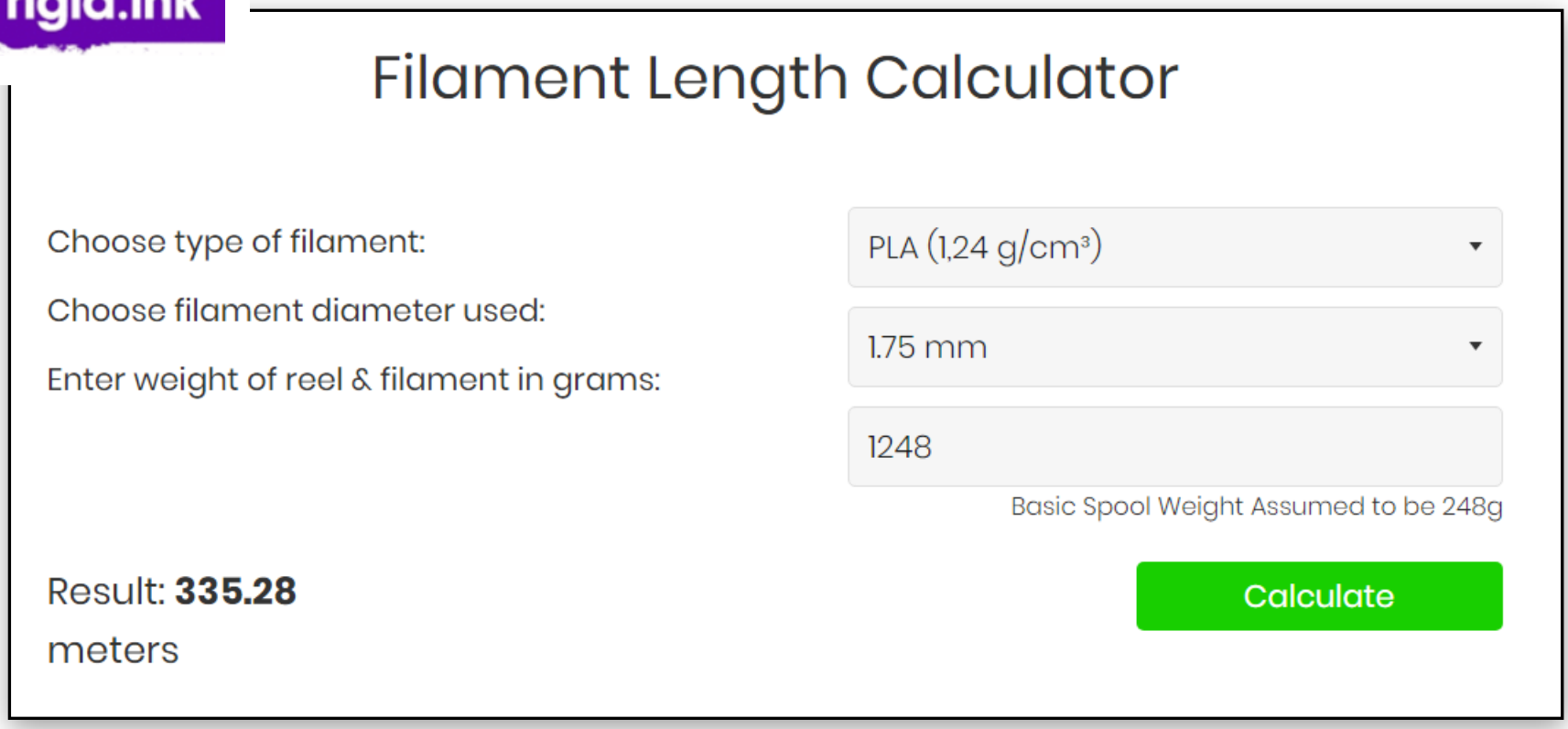
Weight-to-Length Conversion



You can make this weight measurement using a postal or kitchen scale and perform the calculation manually before commencing a big print run in order to rest assured that there is enough filament-remaining to complete the job.

Be sure your WEIGHT, DIAMETER, and DENSITY UNITS are properly managed and that the conversions from mm to cm, etc. is correct.

Alternately, you can try an on-line calculator (link on next page), however, be mindful that your empty spool weight and/or filament densities may vary from the selections available with this tool.

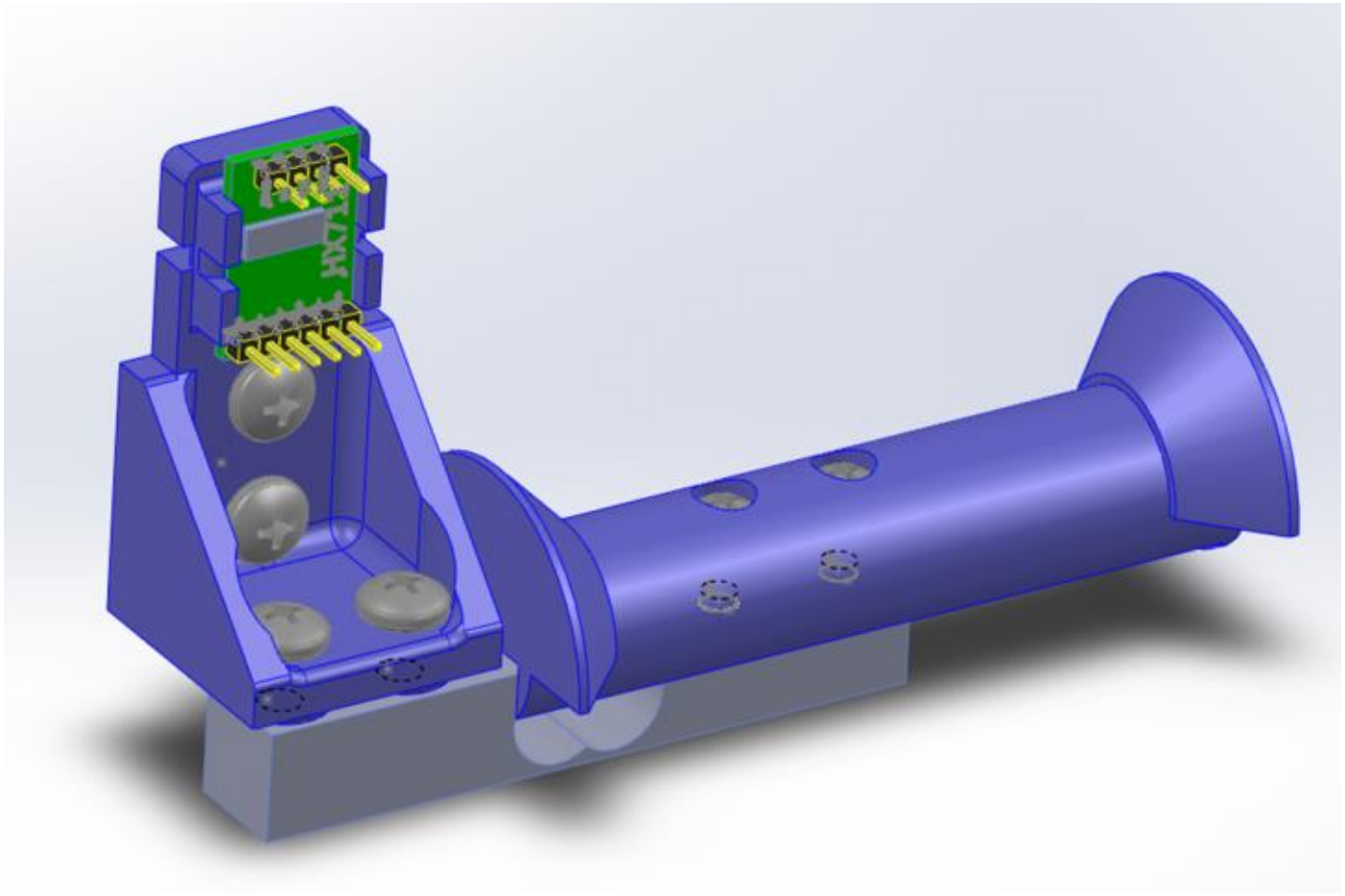


This ON-LINE Filament Length Calculator can be found at:
https://rigid.ink/blogs/news/how-many-meters-of-filament-on-a-spool

This project creates a purpose-built weight-scale tailored for 3D printer filament use. It provides the following features and functions:

- Provides direct readout of 3D printer filament Wt. (Kg) and Length (m).
- Load cell integrated right into the filament spool holder –
  - ✓ Filament weight measurements are made without removing the spool from the printer and placing it onto a scale
  - ✓ A simple printer-frame mounted spool holder can be readily adapted to bench-top holder style
- Empty spool weight values are easily entered using a rotary control
  - ✓ NOTE: An accurate empty spool weight value provides the best results!
- Filament diameter parameter can be easily fine-tuned as needed
- Filament Type is easily selected
  - ✓ A starter data base for PLA, ABS, ASA, PETG, NYLN, and many others is provided “on-board”
  - ✓ Filament names and parameters are easily changed to match the specs of your specific filaments
- Simple, easy to build, inexpensive - *uses readily available modules and parts*
  - ✓ Arduino Nano (or UNO) CPU
  - ✓ 2-5Kg load cell with I2C HX711 Load Cell Interface
  - ✓ 4 line x 20 character LCD display readout
  - ✓ Single push & turn rotary control provides an easy to use operator interface
- Readily powered from wall-wart 9-12VDC supply or a 12 VDC tap right from your printer
- Easy to use ‘ZERO-SCALE’ and weight CALIBRATION routines are built into the operator interface
- Easily programmed and customized – *Arduino Integrated Development Environment to the rescue!*
- Data base values and other settings are stored in EEPROM and automatically updated when changed.
  - ✓ The latest operator updates & calibrations are retained & restored through power on-off cycles
- Compact – *Display fits into a small 3D printed case -OR- can be panel mounted directly to your printer*

Spool Scale Arm Assembly



Made by: E. Andrews Date: 8-11-2019

First Made For: Spool-Scale Project

Filename: Spool Scale Design Notes (Rev Date)

Revision: 1

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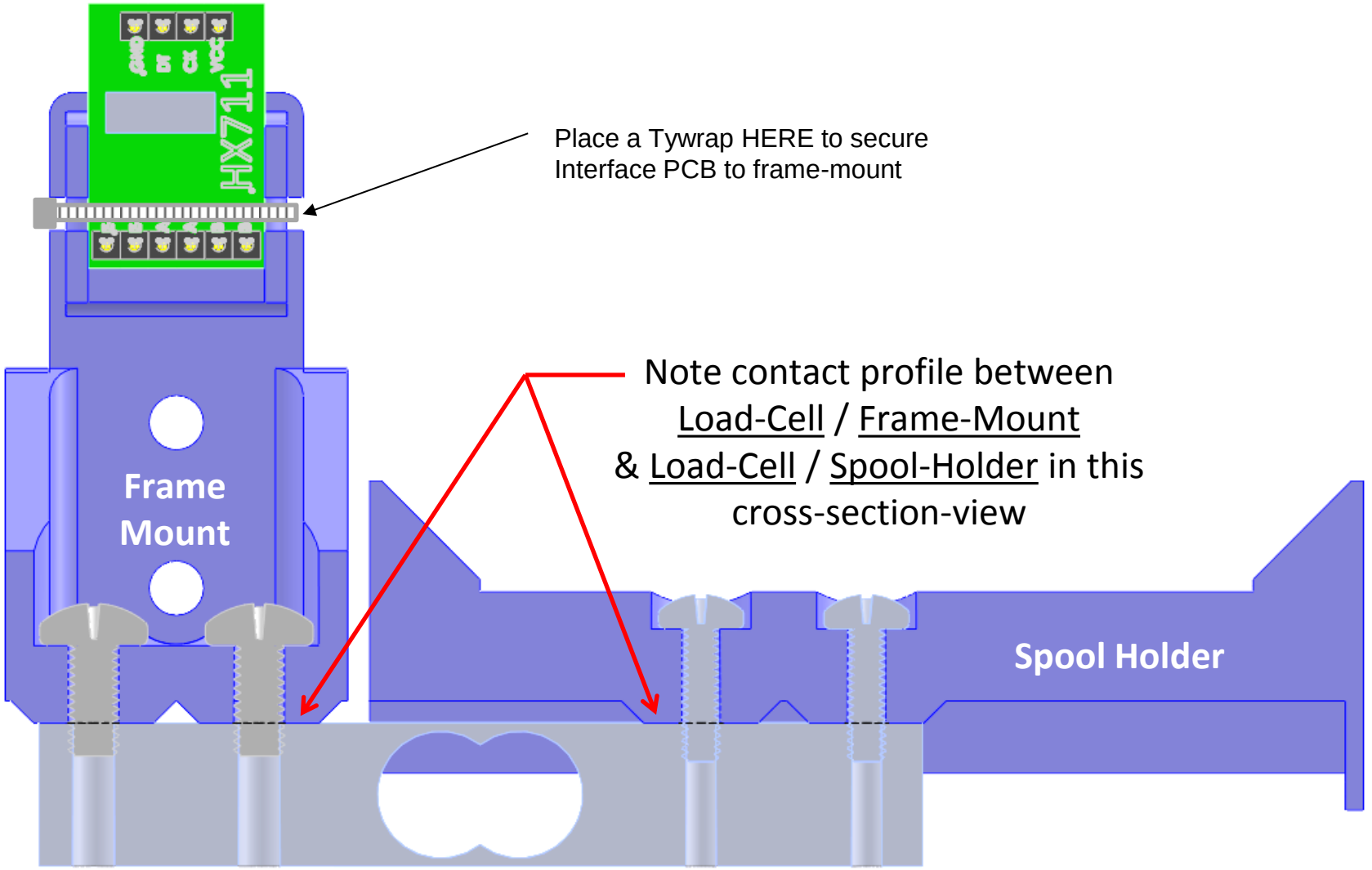
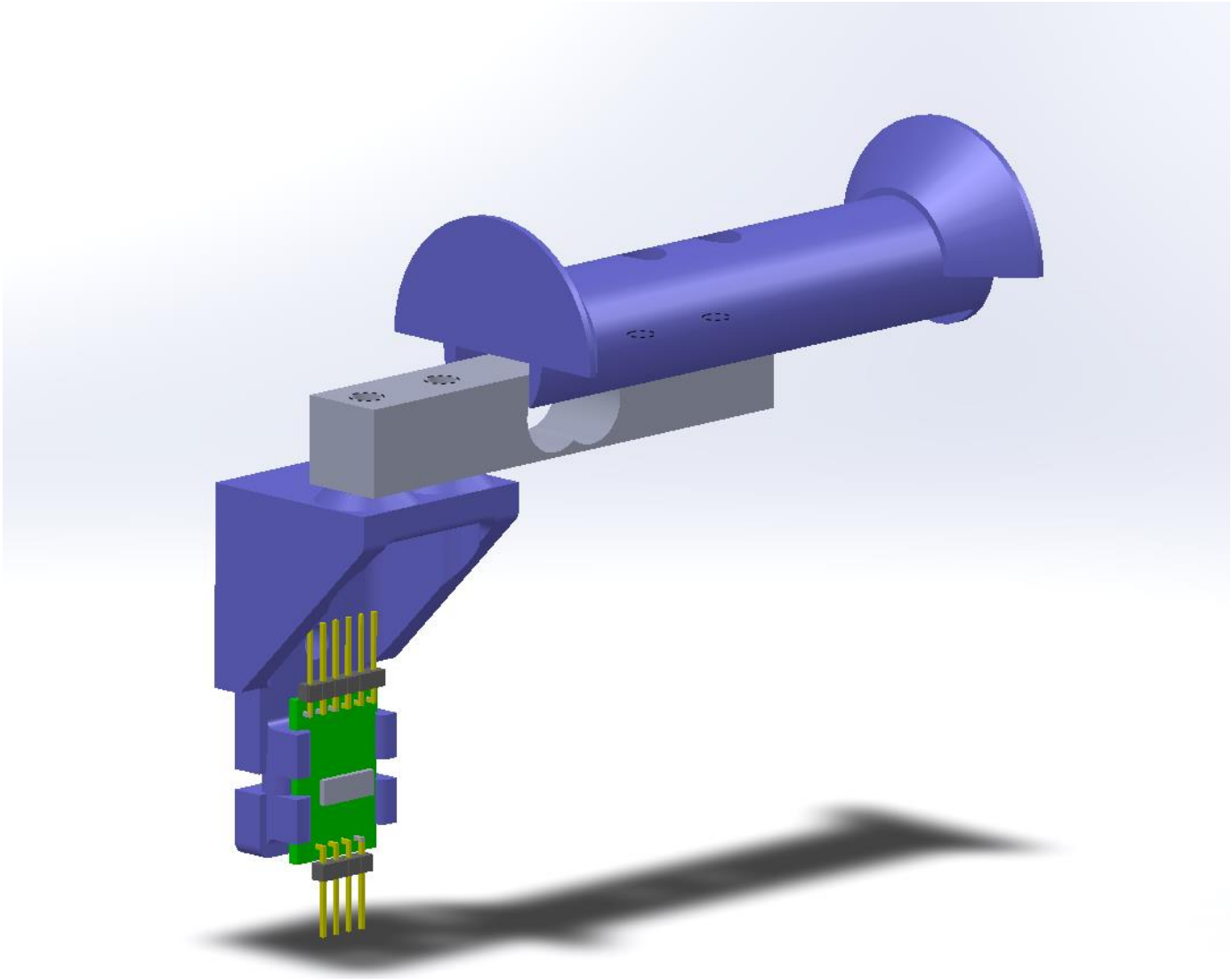
Spool Arm Assembly - Cross Section View



Spool Scale Arm – Alternate Assembly



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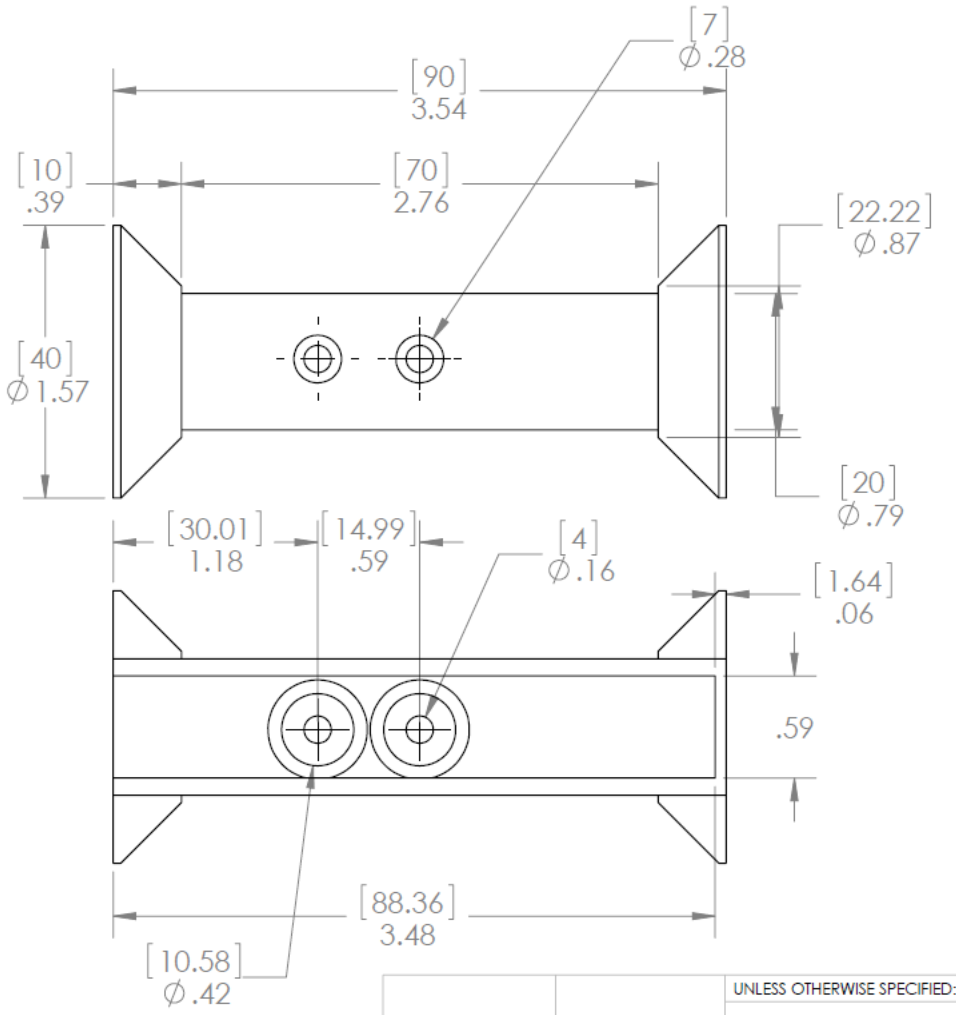

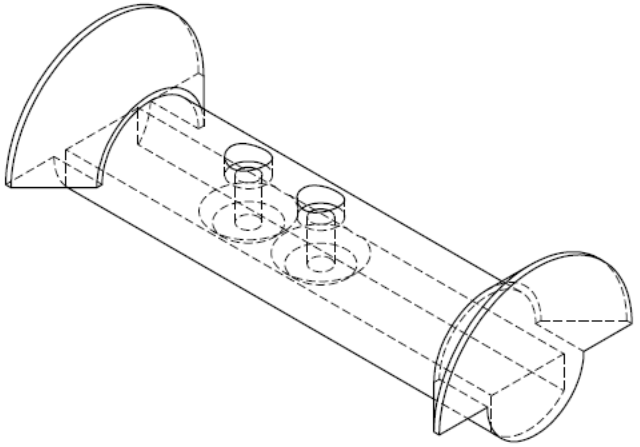

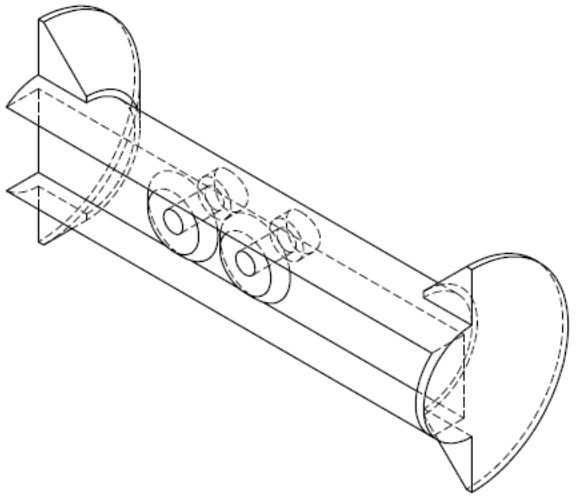

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
			COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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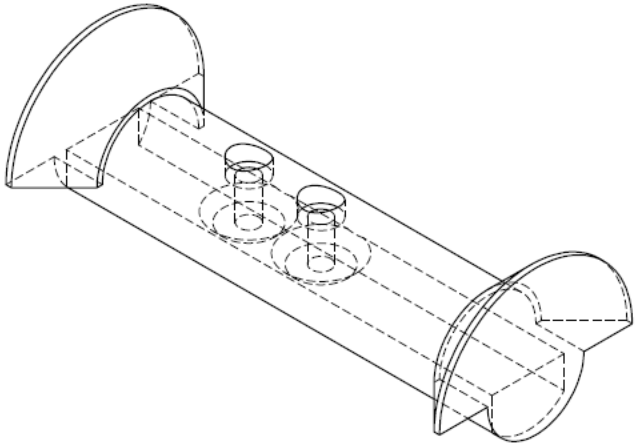
Brookfield, WI USA

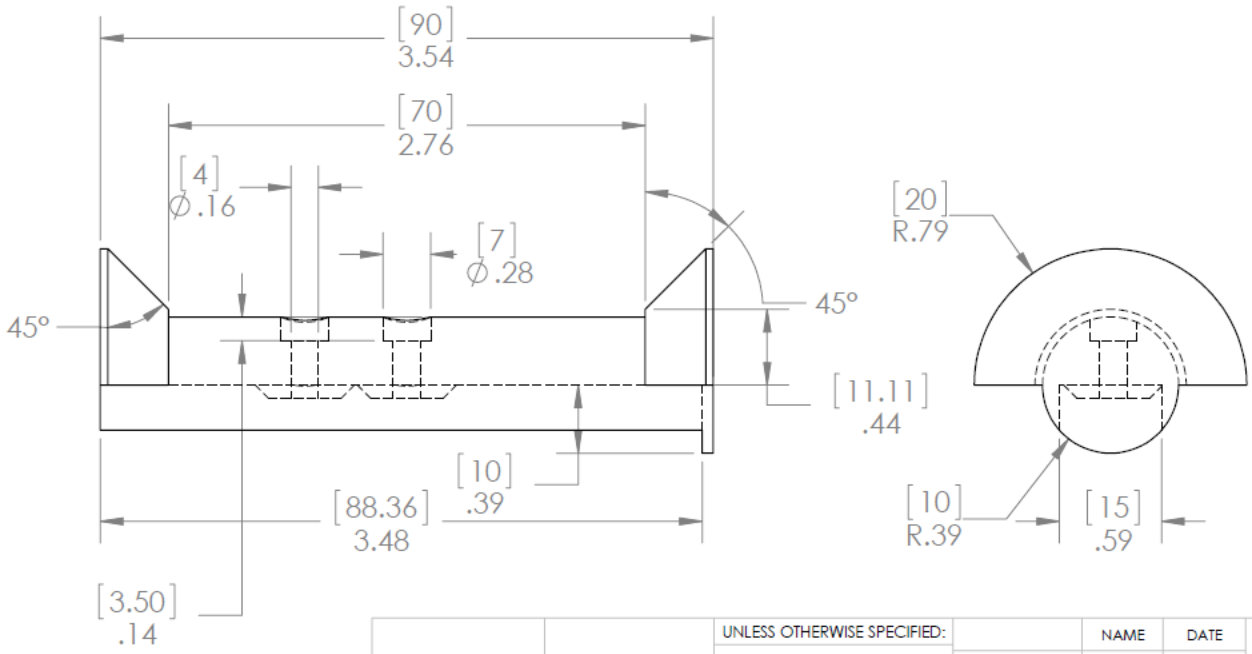
TITLE:

Spool Core

SIZE	DWG. NO.	REV
A	SpoolCore_1	1

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 2





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
			COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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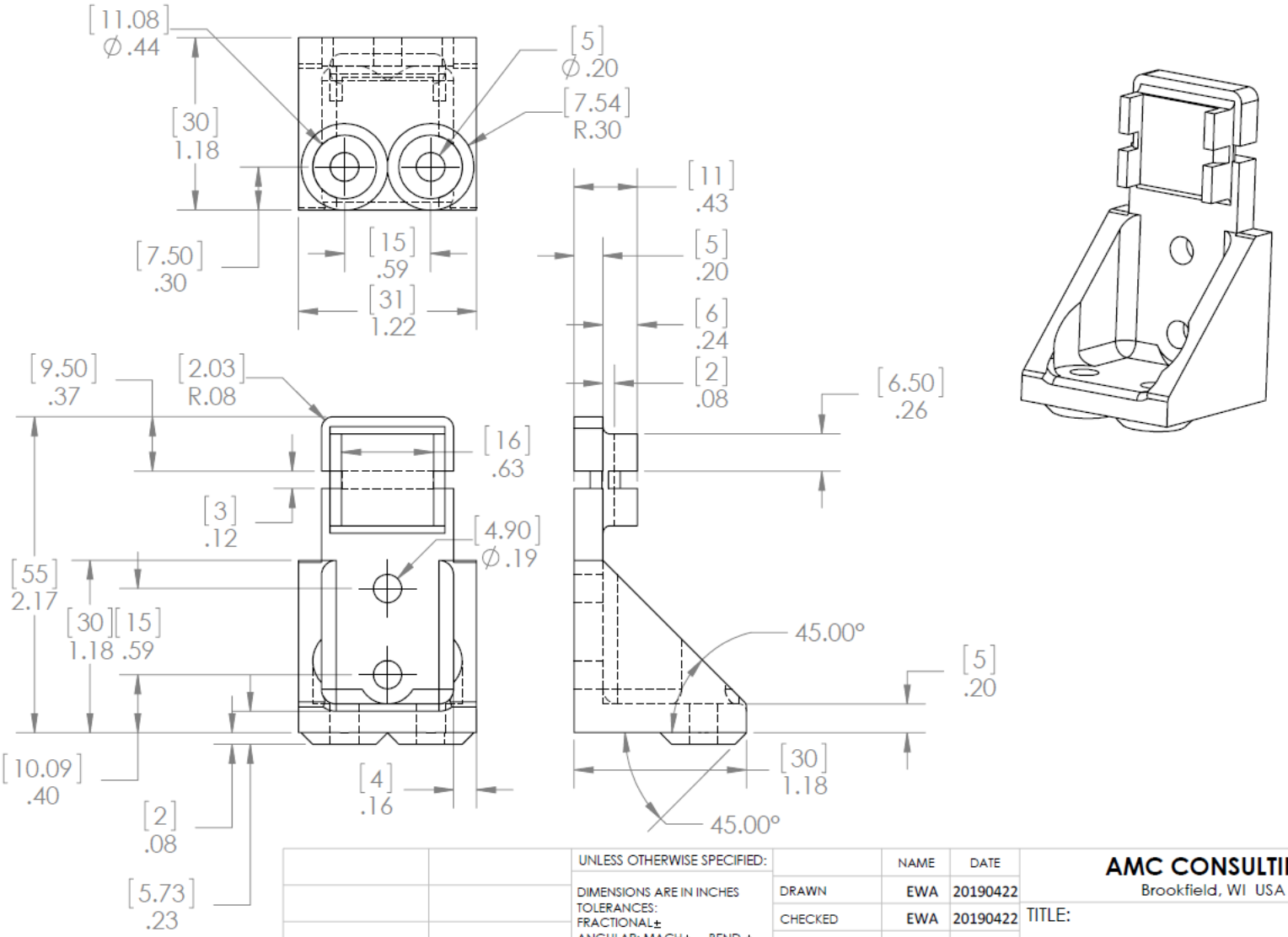
TITLE:

SIZE	DWG. NO.	REV
A	SpoolCore_1	1

SCALE: 1:1 | WEIGHT: | SHEET 2 OF 2



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	20190422
			CHECKED	EWA	20190422
			ENG APPR.	EWA	20190422
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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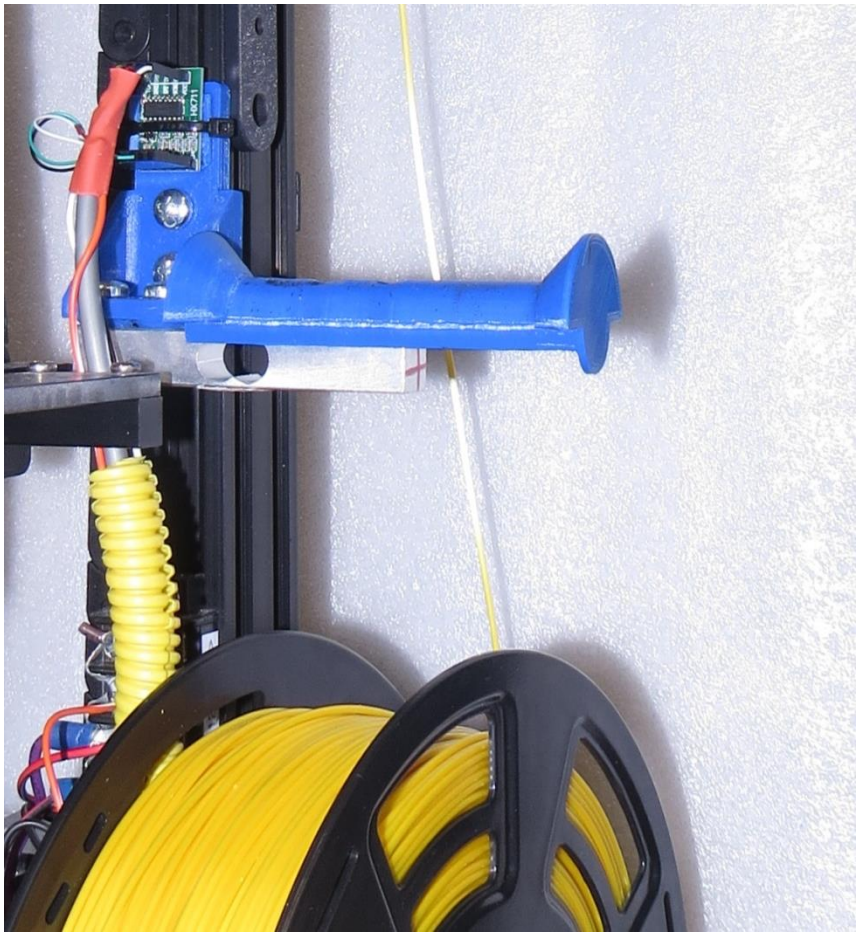
TITLE:

Load Cell Frame Mount

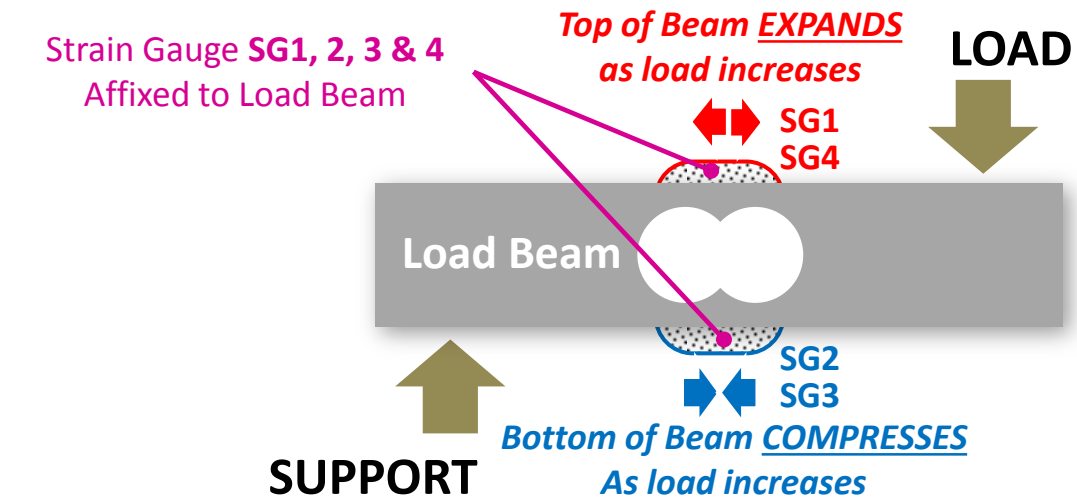
SIZE	DWG. NO.	REV
A	LoadCellFrameMount_2	2

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

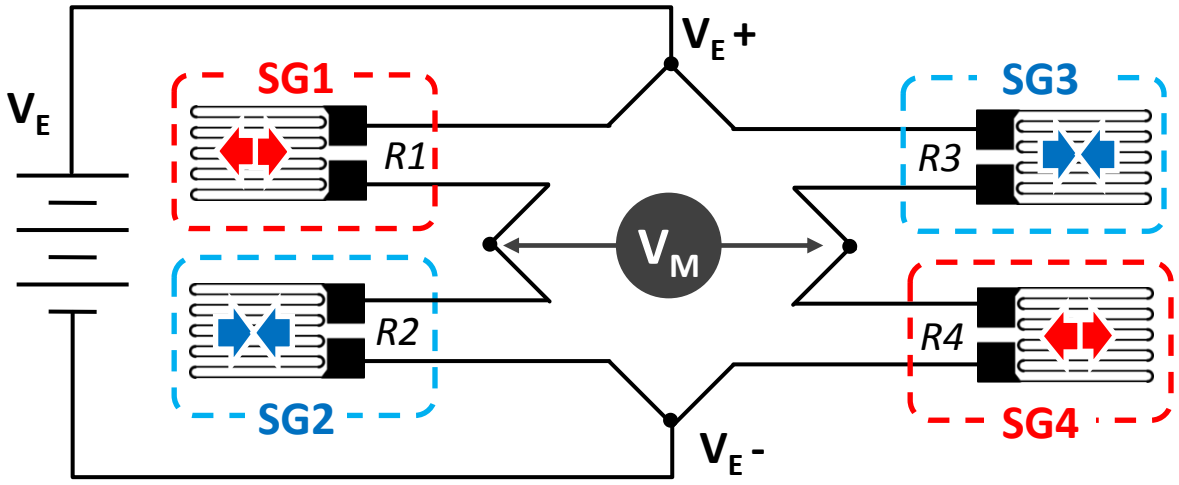
Photo: Load Cell Mounted on Printer Frame



Load Cell Overview



WHEATSTONE BRIDGE

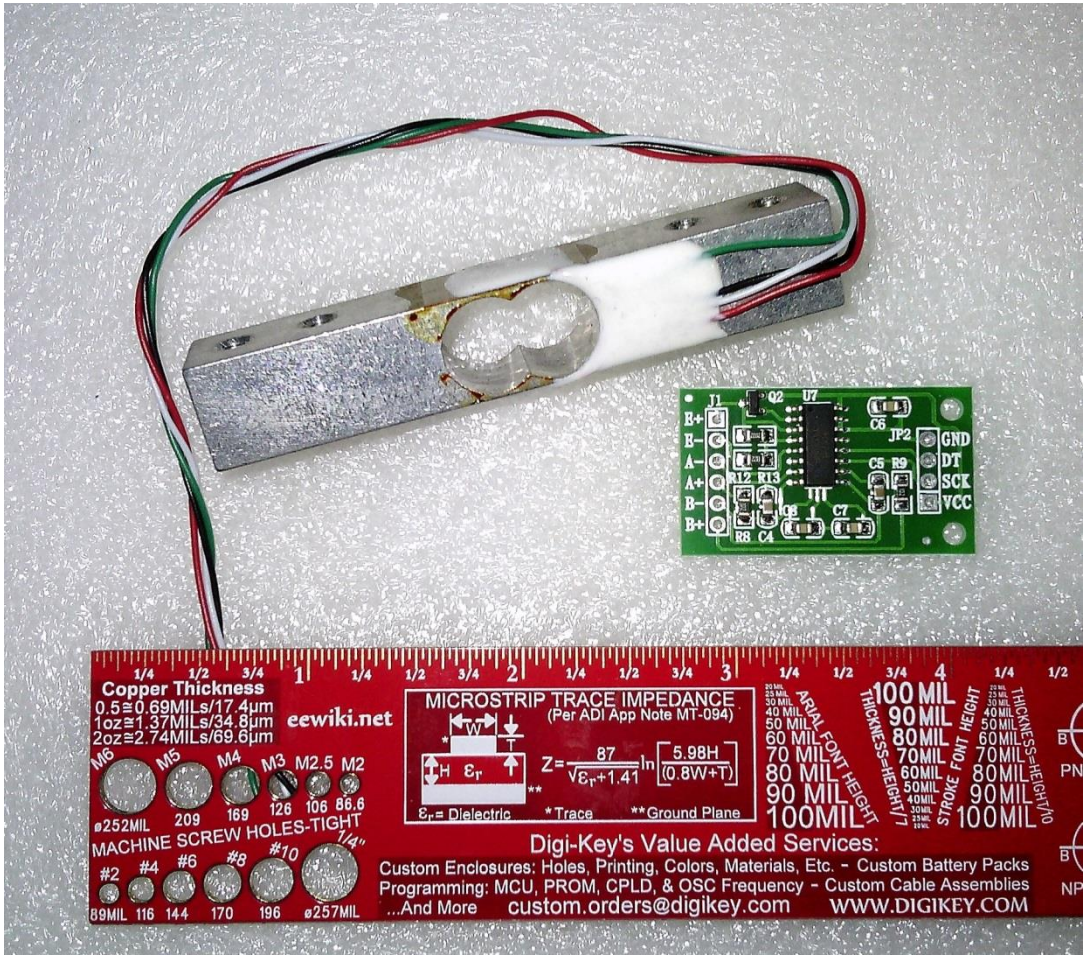


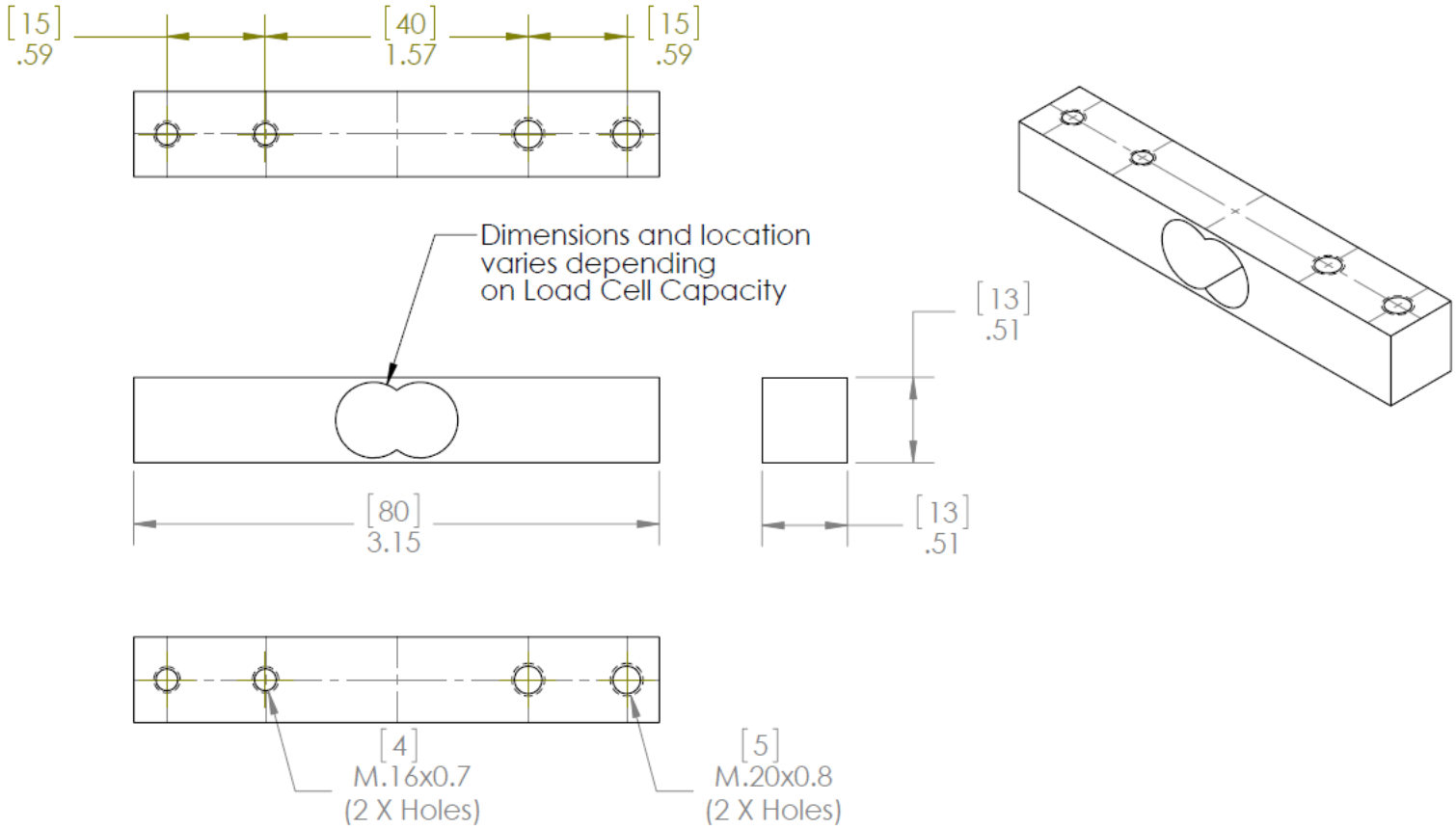
Load Cell Capacity Calculations

Full Filament Wt:	**1000 g**
Empty Spool Wt:	**200 g**
Misc. Mechanics:	**200 g**
Design margin:	**500 g**
Total Max Load:	**1900 g**

Conclusion: Either a 2kg or 5 kg capacity Load Cell Kit should work well.

Photo: Typical Load Cell ‘Kit’





Mtl: Alum.

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			CHECKED		
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		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
			COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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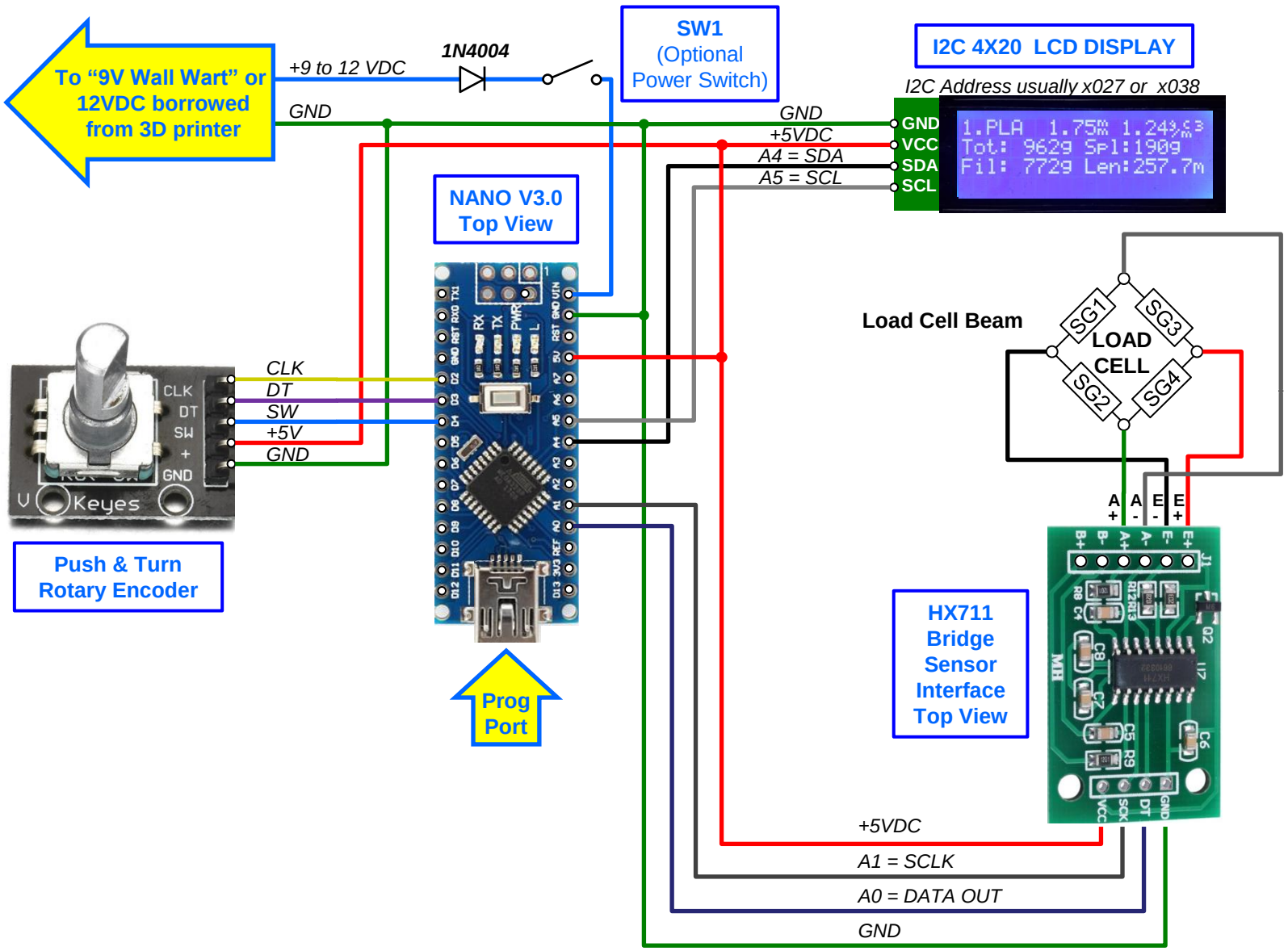
TITLE:

Load Cell

SIZE	DWG. NO.	REV
A	5Kg_LoadCell	0

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

Spool Scale Schematic



RELEASED INTO PUBLIC DOMAIN - NO WARRANTY EXPRESSED OF IMPLIED Made by: E. Andrews Date: 8-11-2019	First Made For Spool-Scale Project	Filename Spool Scale Design Notes (Rev Date)	Revision 1 Printed 8/11/2019 14:28	Page 18

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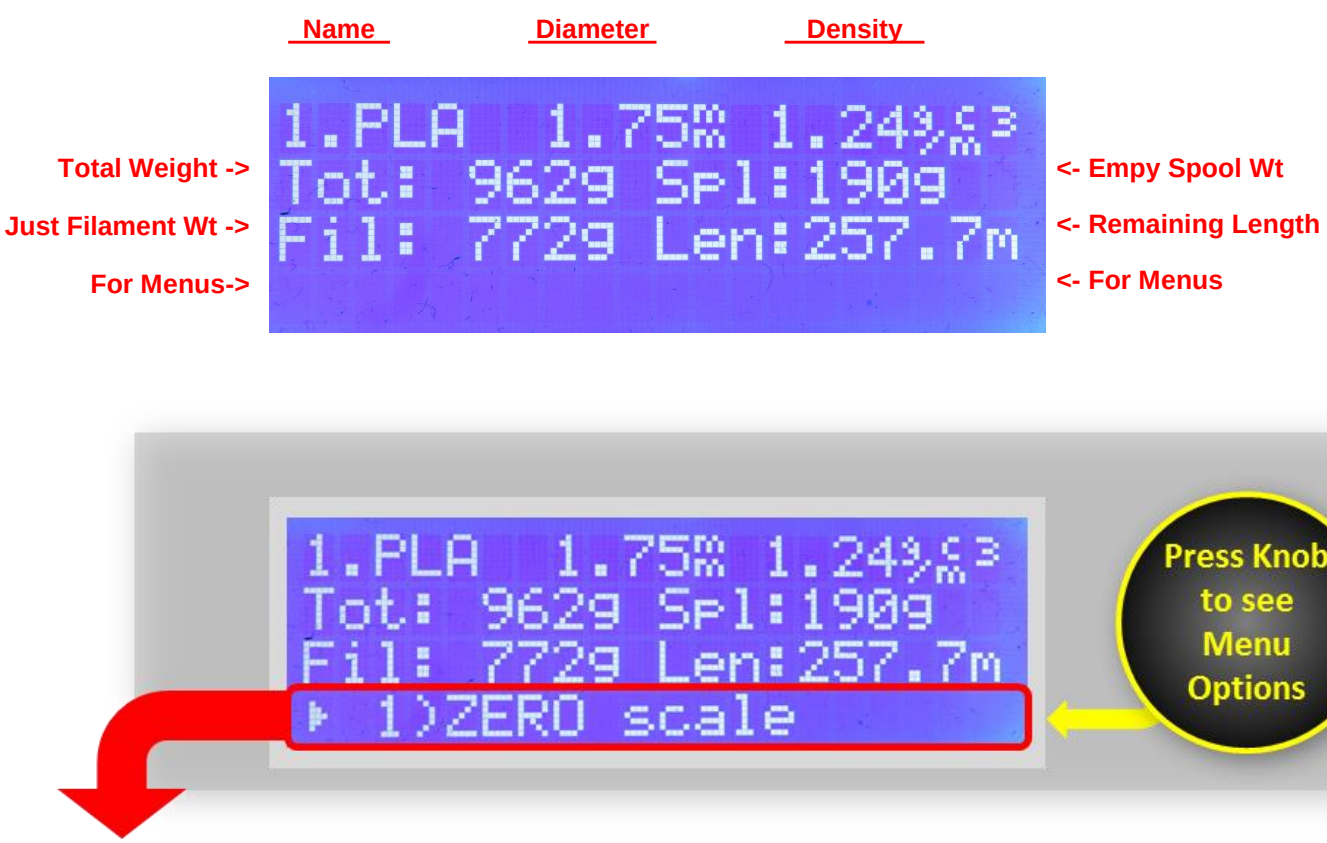
Bill of Materials

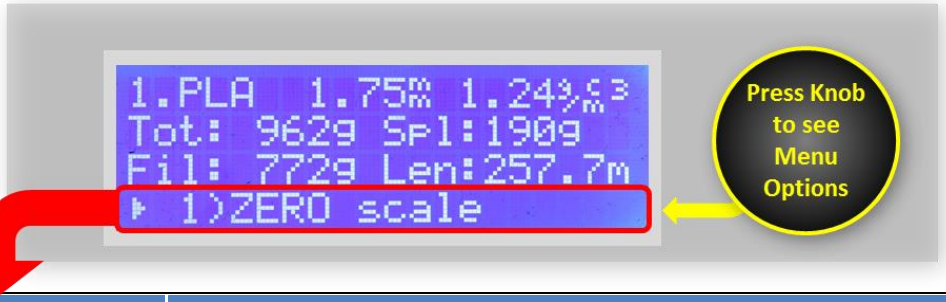
ITEM	QTY	DESCRIPTION	SOURCE	NOTES & ORDERING INFORMATION
Electronics				
1	1	ARDUINO Nano CPU	arduio.cc, eBay,Amazon	Available at arduino.cc & others. Suggest Nano Version 3. Search terms: **NANO V3**
2	1	POWER SUPPLY	Sparkfun, eBay, Amazon	Power for CPU. Consider using +12VDC from 3D printer. Search terms: **Arduino Power Supply**
3	1	ROTARY ENCODER	Sparkfun, eBay, Amazon	Search terms: **ROTARY ENCODER WITH PUSH BUTTON** Be sure unit has CLOCK, DATA & PB-SWITCH outputs
4	1	20X4 A/N LCD DISPLAY with I2C Interface	Sparkfun, eBay, Amazon	Search terms: **4X24 LCD I2C** Order unit with I2C interface; model w/backlight suggested.
5	1	LOAD CELL W/INTERFACE CIRCUIT	Sparkfun, eBay, Amazon	Search terms: **5kg load cell** -or- **2kg load cell** Be sure interface is 5V & uses HX711 with 2 wire interface.
	1	DIODE	Various	Power protection diode, 1N4004 or similar 50V, 1A
6	1	POWER SWITCH	Vaious	Optional, Builder's choice
7	1	MISC WIRING, CONNECTORS, & ASSEMBY HARDWARE	Various	Builder's choice, misc "as required" items.
Mechanics				
8	1	FRAME MOUNT	3D PRINTED	3D PRINT. See ON-LINE DOCS for details and options
9	1	SPOOL HOLDER	3D PRINTED	3D PRINT. See ON-LINE DOCS for details and options
10	2	M5 x 12mm PhilHd	Various	Frame Mount attachement to Load-Cell-Beam
11	2	M4 x 12mm PhilHd	Various	Spool Holder attachement to load-Cell-Beam
12	As Rqd	MISC SCREWS/T-NUTS	Various	Misc fasteners & Tywrap as needed to complete holder ASM.
Control Panel/Enclosure Options				
13	1	FRONT PANEL (Frame Mount)	3D PRINTED	3D PRINT. See ON-LINE DOCS for details and options
14	1	CASE-FRONT/REAR SET (Stand Alone Case)	3D PRINTED	3D PRINT. See ON-LINE DOCS for details and options
15	1	CPU/LCD MOUNTING FRAME	3D PRINTED	3D PRINT. Holds CPU to rear of LCD display. See ON-LINE DOCS for details and options
16	2	TILT MOUNT (Stand Alone Case)	3D PRINTED	3D PRINT. See ON-LINE DOCS for details and options
17	2	TILT BASE (Stand Alone Case)	3D PRINTED	3D PRINT. See ON-LINE DOCS for details and options
18	As Rqd	MISC SCREWS/T-NUTS	Various	4-40 x .5in screws and other fasteners needed to assemble LCD/CPU to front panel and attach rear enclosure panel

Display Format



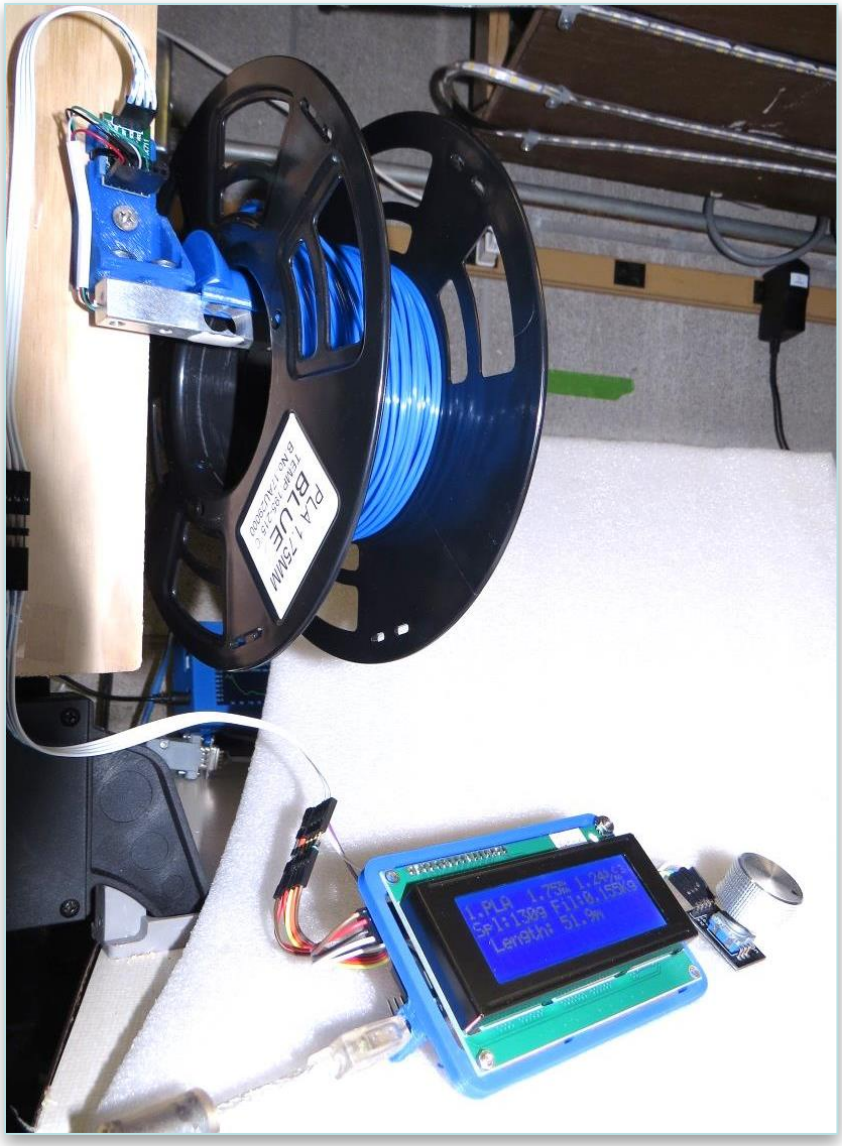
See Next Page for Menu Details

Spool Scale Menu Options



MENU ITEM	DESCRIPTION
1) ZERO scale	Remove all loads from holder and press to perform SCALE-ZERO process. The new SCALE-ZERO point will be auto-saved to EEPROM.
2) Chng SPOOL WT	Change the empty SPOOL WEIGHT VALUE . Changes will be auto-saved to EEPROM.
3) Select Filament	Make a new selection from the FILAMENT DATA BASE. New selection will become the *active filament* and selection auto-saved to EEPROM.
4) Chng FIL DENS.	Change the filament DENSITY value for the currently *active filament* . Changes will become active and be auto-saved into the DATA BASE.
5) Chng FIL DIA.	Change the filament DIAMETER value for the currently *active filament* . Changes will become active and be auto-saved into the DATA BASE.
6) Chng FIL NAME	Change the NAME (4-letter abbreviation) of the currently *active filament* . Changes will become active and be auto-saved into the DATA BASE.
7) Save to EEPROM	Save all active values into the FILAMENT & CAL-CONFIG data bases. *This function is not usually used as each option auto-saves any changes.*
8) Calibrate Scale	Place a known weight (350-1500 g) onto spool-holder and then use the rotary control to dial-in that weight value on the display. Upon completion, a new calibration factor is generated & saved to EEPROM.
9) Set Scale Filter	*Increase* this setting to slow down & stabilize read out, *decrease* the setting to quicken display response. Changes are auto saved to EEPROM.
10) Serial DB Dump	This option will transmit the current data base values to the serial port. Note, IDE must be connected to CPU and the serial monitor active to receive this data; Serial monitor Baud rate must be set to 115200.
11) Erase EEPROM	Erase the EEPROM an use first time defaults. **CAUTION:** All calibration and filament data base changes made by operator will be lost . Scale will reinitialize to hard coded, first-time-start-up values on next power cycle.
12) Exit Menu	Leave *menu-mode* and blank row 4 of the LCD display.

Photo: Testing a Bench Prototype



The Scale Calibration Process

In order to convert 'A/D counts' as received from the HX711 chip into actual weight values in grams, a *zero offset* data point (aka 'scale tare') must be measured and a *counts-to-grams scale factor* must be determined. An easy-to-use SCALE CALIBRATION function helps accomplish these tasks.

To calibrate the spool scale, it is necessary to have a **known weight test load** in the 250 to 1500 gram range that can be hung from the spool holder arm. While you can purchase a precision weight set for calibration (Amazon/eBay search term: *scale calibration weight set*), I simply measured a spool of filament with my postal scale and recorded its weight reading (in grams). I then used this spool as my **known weight test load**. With this 'weight standard' in hand, calibration can begin.

1. Using the push and turn control, bring up the menu bar and select item **8) Scale Calibration**.
    a) Remove all loads from the Spool-Scale-Arm.
    b) When asked *Do you want to ZERO Scale?* , select *YES* and push the knob.
2. When the ZERO process has completed,
    a) Place the **known-weight-test-load** onto the Spool-Scale-Arm.
    b) Use the rotary control and dial-in the postal-scale weight value (in kg) for your **known weight test load**.
    c) Press the knob of the rotary control when the correct value is set to go on.
3. The scale will now average 10 successive A/D measurements and calculate a *calibration factor*.
    a) When asked *ACCEPT and Proceed?* , select *YES* and push the knob.
4. Calibration is now COMPLETE.
    a) The ZERO-OFFSET and CALIBRATION-FACTOR values will be saved to EEPROM.
    b) The scale exits CALIBRATION MODE and will begin running in its normal mainline 'measure & display' loop
5. To Verify calibration:
    a) Leave the **known-weight-test-load** on the Spool-Scale-Arm *after calibration* and let the Spool Scale measure its TOTAL WEIGHT.
    b) The TOTAL WEIGHT reading displayed on the LCD should match your postal scale known-weight value.

Note that menu option #1 allows you to zero-the-scale at any time - do this periodically over time for best accuracy.

Filament Database Structure & Initialization

```
//Define Filament DataBase Structure
struct FILAMENT_DATABASE
{
    char Name[5]; //  5 Bytes - Filament Name(4 chars show on LCD)
    float Dia;    //  4 Bytes - Filament Diameter in mm
    float Dens;   //  4 Bytes - Filament Density in g/cm^3
                  // ---------
                  // 13 Bytes for each filament - type in data base
};
```

```
//Uncomment the appropriate line to set default filament diameter
float const Default_Fil_Diam = 1.75;            //Value is in mm
//float const Default_Fil_Diam = 3.00;          //Value is in mm

// Ram & EEPROM is Tight! With FnumMax = 16, we
// use-up 208 Bytes of RAM & EEPROM (16 x 13 = 208)
// for each FILAMENT_DATABASE structure we define.
struct FILAMENT_DATABASE FilType_DEFAULT[FnumMax] = {
            //Name ,Diameter_mm     ,Density_g/cm^3
            {"PLA ",Default_Fil_Diam,1.24},     //00 (LCD # = 1)
            {"ABS ",Default_Fil_Diam,1.04},     //01
            {"ASA ",Default_Fil_Diam,1.07},     //02
            {"PETG",Default_Fil_Diam,1.27},     //03
            {"NYLN",Default_Fil_Diam,1.08},     //04
            {"PlyC",Default_Fil_Diam,1.20},     //05
            {"HIPS",Default_Fil_Diam,1.07},     //06
            {"PVA ",Default_Fil_Diam,1.19},     //07
            {"TPU ",Default_Fil_Diam,1.20},     //08
            {"TPE ",Default_Fil_Diam,1.20},     //09
            {"PMMA",Default_Fil_Diam,1.18},     //10
            {"Copr",Default_Fil_Diam,3.90},     //11
            {"????",Default_Fil_Diam,0.0},      //12
            {"????",Default_Fil_Diam,0.0},      //13
            {"????",Default_Fil_Diam,0.0},      //14
            {"????",Default_Fil_Diam,0.0}       //15 (LCD # = 16)
};
```

Source Used to Build Initial Database

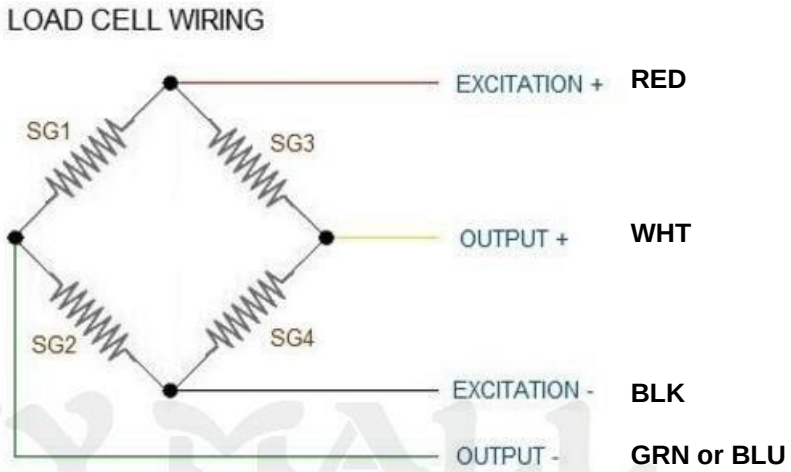
Link to Initial Filament Densities: https://rigid.ink/blogs/news/how-many-meters-of-filament-on-a-spool

Filament Material / Density	500g Spool	750g Spool	1KG Spool	3KG Spool
PLA: 1.24g/cm3	1.75mm = 167.6m 2.85mm = 67.0m	1.75mm = 251.5m 2.85mm = 94.8m	1.75mm = 335.3m 2.85mm = 126.4m	1.75mm = 1005.9m 2.85mm = 379.3m
ABS: 1.04g/cm3	1.75mm = 199.9m 2.85mm = 75.4m	1.75mm = 299.8m 2.85mm = 113.0m	1.75mm = 399.8m 2.85mm = 150.7m	1.75mm = 1,199.3m 2.85mm = 452.1m
ASA: 1.07g/cm3	1.75mm = 194.3m 2.85mm = 73.3m	1.75mm = 291.5m 2.85mm = 109.9m	1.75mm = 388.6m 2.85mm = 146.5m	1.75mm = 1,165.8m 2.85mm = 439.5m
PETG: 1.27g/cm3	1.75mm = 163.7m 2.85mm = 61.7m	1.75mm = 245.6m 2.85mm = 92.6m	1.75mm = 327.4m 2.85mm = 123.4m	1.75mm = 982.2m 2.85mm = 370.2m
Nylon: 1.08g/cm3	1.75mm = 192.5m 2.85mm = 72.6m	1.75mm = 288.8m 2.85mm = 108.9m	1.75mm = 385m 2.85mm = 145.1m	1.75mm = 1,155m 2.85mm = 435.4m
Polycarbonate: 1.20g/cm3	1.75mm = 173.2m 2.85mm = 65.3m	1.75mm = 260m 2.85mm = 98m	1.75mm = 346.5m 2.85mm = 130.6m	1.75mm = 1039.4m 2.85mm = 391.9m
HIPS: 1.07g/cm3	1.75mm = 194.3m 2.85mm = 73.3m	1.75mm = 291.5m 2.85mm = 109.9m	1.75mm = 388.6m 2.85mm = 146.5m	1.75mm = 1,165.8m 2.85mm = 439.5m
PVA: 1.19g/cm3	1.75mm = 174.7m 2.85mm = 65.9m	1.75mm = 262m 2.85mm = 98.8m	1.75mm = 349.4m 2.85mm = 131.7m	1.75mm = 1,048.1m 2.85mm = 395.2m
TPU/TPE: 1.20g/cm3	1.75mm = 173.2m 2.85mm = 65.3m	1.75mm = 260m 2.85mm = 98m	1.75mm = 346.5m 2.85mm = 130.6m	1.75mm = 1039.4m 2.85mm = 391.9m
PMMA: 1.18g/cm3	1.75mm = 176.2m 2.85mm = 66.4m	1.75mm = 264.2m 2.85mm = 99.6m	1.75mm = 352.3m 2.85mm = 132.8m	1.75mm = 1,057m 2.85mm = 398.5m
CopperFill: 3.90g/cm3	1.75mm = 53.3m 2.85mm = 20.1m	1.75mm = 80m 2.85mm = 30.1m	1.75mm = 106.6m 2.85mm = 40.2m	1.75mm = 319.8m 2.85mm = 120.6m

Q: How much does an empty filament spool weigh?
A: For reference, our empty spools weigh 248g. And this is approximately an industry average.

Acknowledgement: This is the most comprehensive specs I have located to date. Thanks to Rigid Ink for making this table available!

Load Cell Supplier Data



RED

WHT

BLK

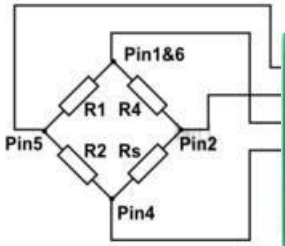
GRN or BLU

HOOKUP NOTES

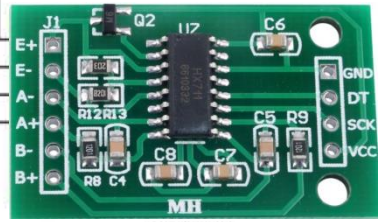
The four wires coming out from the wheatstone bridge on the load cell are usually:

- Excitation+ (E+) or VCC is red
- Excitation- (E-) or ground is black.
- Output+ (O+), Signal+ (S+)+ or Amplifier+ (A+) is white
- O-, S-, or A- is green or blue

Some load cells might have slight variations in color coding such as blue instead of green or yellow instead of black or white if there are only four wires (meaning no wire used as an EMI buffer). You might have to infer a little from the colors that you have, but in general you will usually see these colors



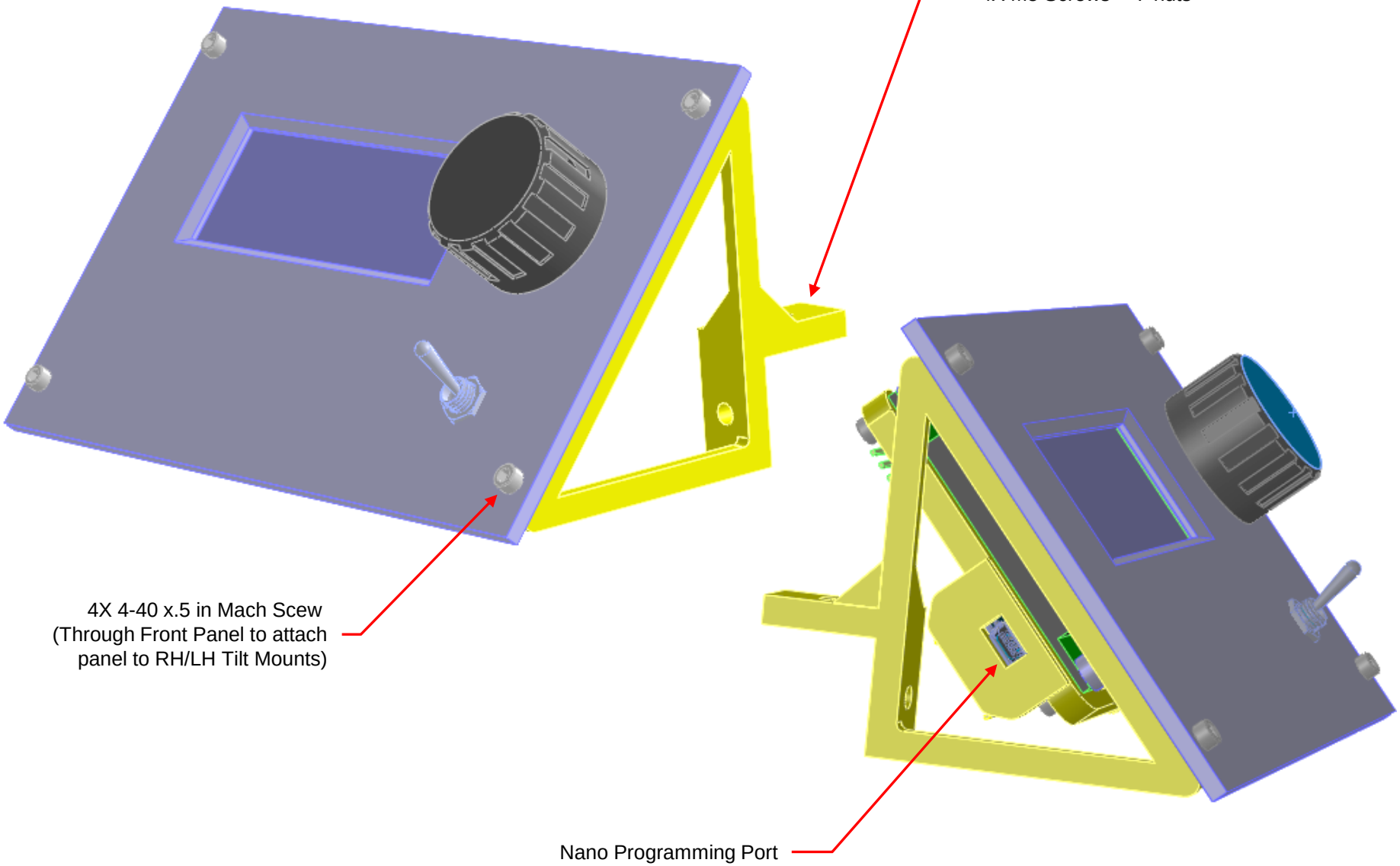
MPS20N0040D
Pressure Sensor
(HCSENS0009)



HX711
Bridge Sensor Interface
(HCMODU0073)

GND
DATA (out)
CLK (In)
3.3/5 V Supply

Frame Mount Panel Assembly (Front View)



Made by: E. Andrews Date: 8-11-2019

First Made For: Spool-Scale Project

Filename: Spool Scale Design Notes (Rev Date)

Revision: 1

Printed: 8/11/2019 14:28

AMC Consulting
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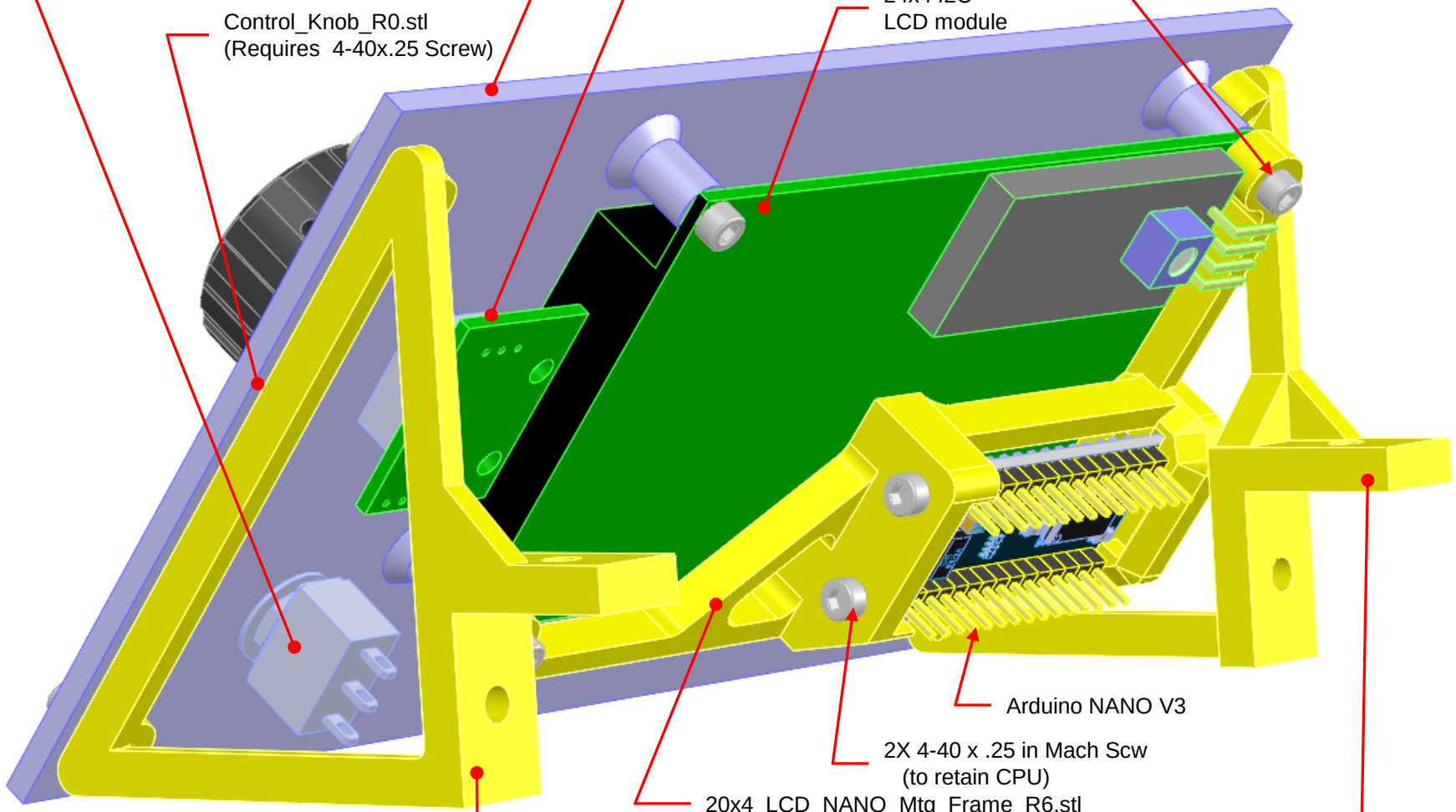
Frame Mount Panel Assembly (Rear View)



Tap 4-40 mounting holes in 5S_SpoolScalePnl & RH/LH_Tilt Mount brackets ***-OR-*** *use self tapping screws where 4-40 hardware is indicated*

Made by: E. Andrews Date: 8-11-2019

First Made For: Spool-Scale Project

Filename: Spool Scale Design Notes (Rev Date)

Revision: 1

Printed: 8/11/2019 14:28

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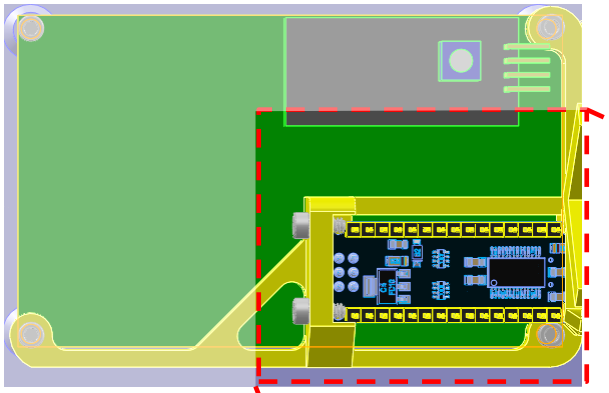
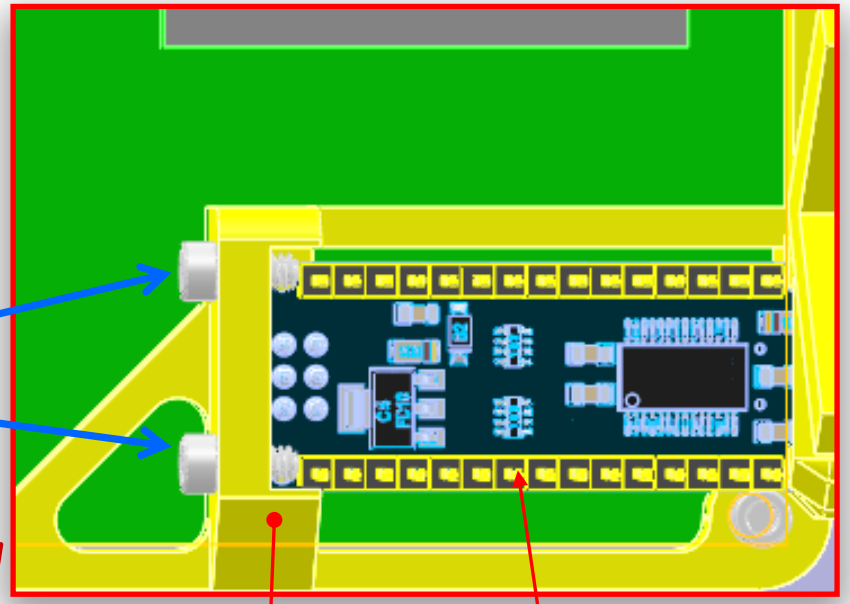
Brookfield, WI USA

Panel Assembly – CPU Retention Screws

LCD MOUNT - REAR VIEW

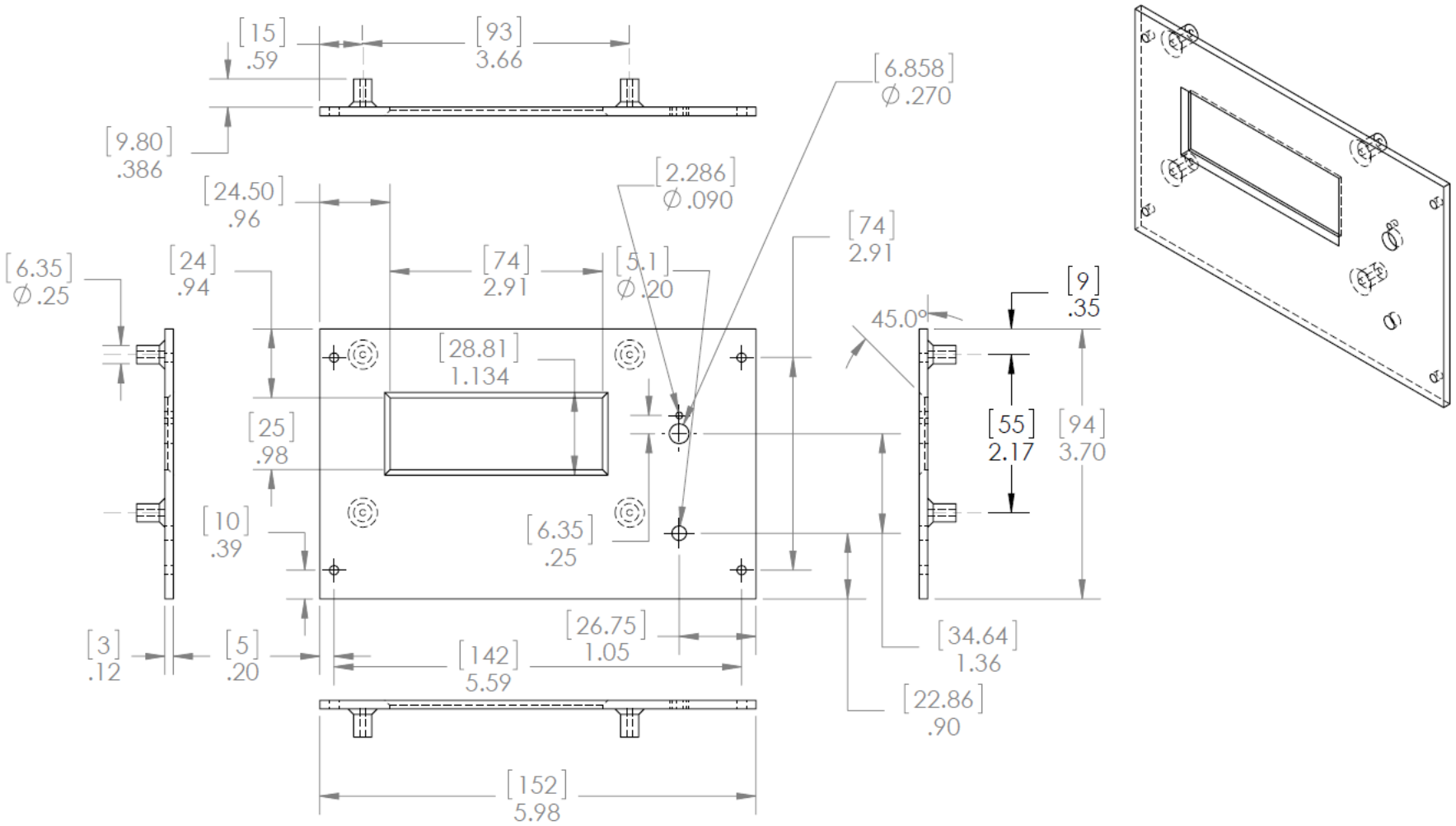




CPU is captured in place using 2X 4-40 x .25 in screws as shown

Arduino NANO V3

20x4_LCD_NANO_Mtg_Frame_R6.stl



3D Print Paramters

Mtl: PLA
Supports: NO
Layer Ht: .2mm
Fill: 20%
Fill Pattern: Any
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-8-19
			CHECKED	EWA	8-8-19
			ENG APPR.	EWA	8-8-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
Released into public domain. No waranty for any application expressed or implied.		APPLICATION	DO NOT SCALE DRAWING		

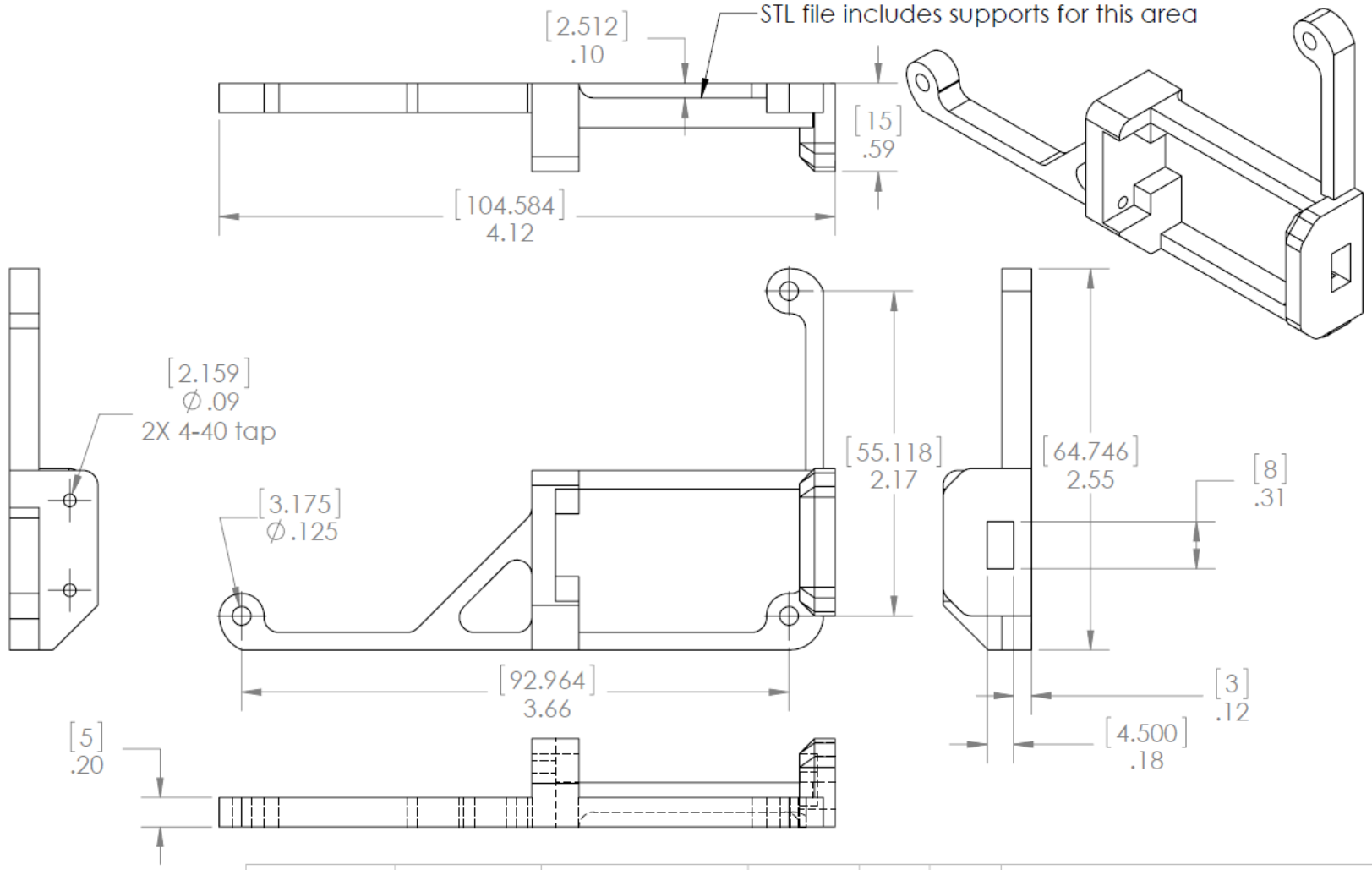
AMC CONSULTING
Brookfield, WI USA

TITLE:
Spool Scale Control Panel

SIZE	DWG. NO.	REV
A	X5S_SpoolScalePnl_R2	2

SCALE: 1:2 | SHEET 1 OF 1

5 4 3 2 1



3D Print Paramters

Mtl: PLA
Supports: NO
Layer Ht: .2mm
Fill: 20%
Fill Pattern: Concentric
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-8-19
			CHECKED	EWA	8-8-19
			ENG APPR.	EWA	8-8-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

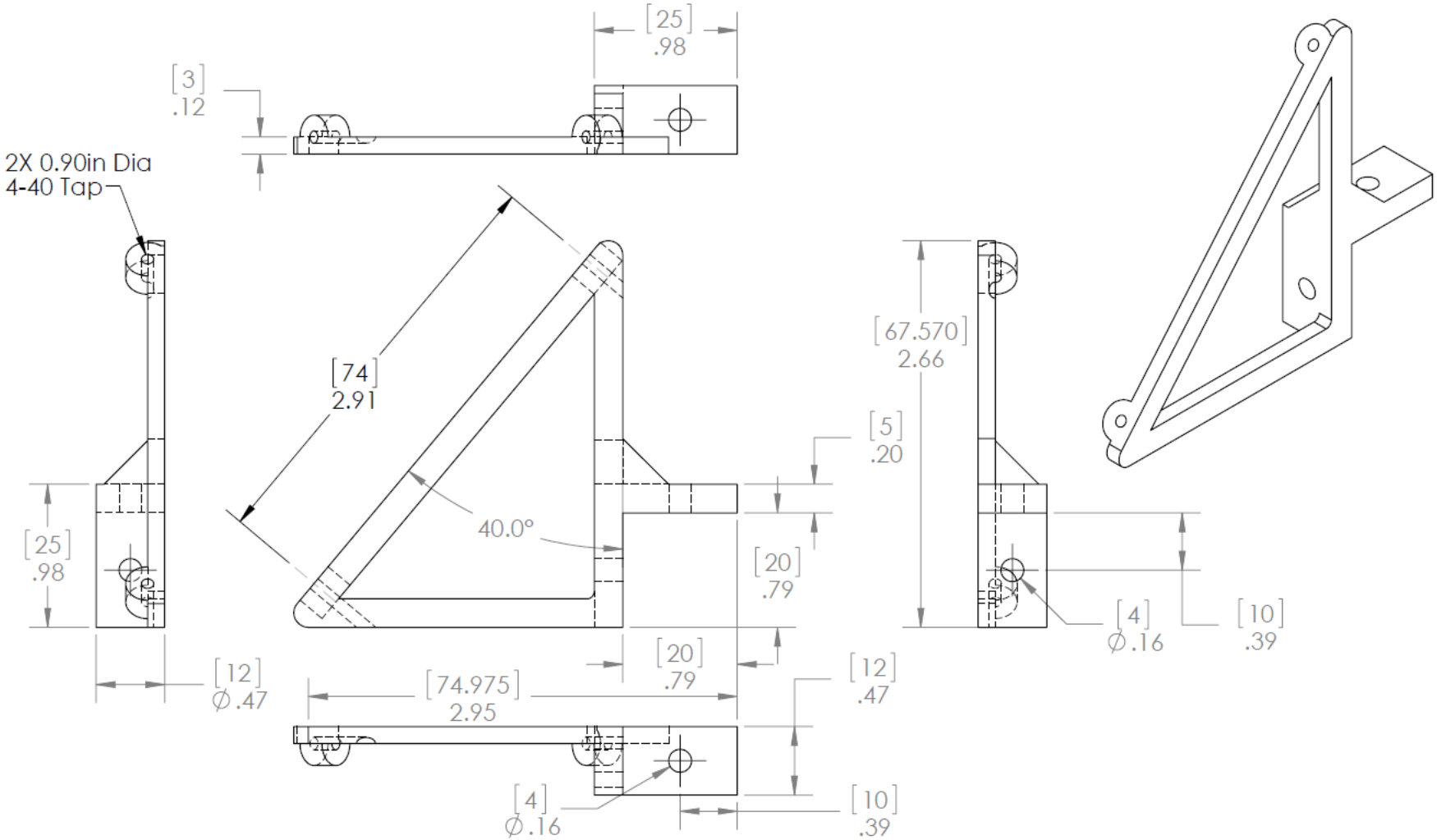
AMC CONSULTING
Brookfield, WI USA

TITLE:
20x4 LCD
NANO CPU Mounting Frame

SIZE	DWG. NO.	REV
A	20x4_LCD_NANO_Mtg_Frame_R6	6

SCALE: 1:1 | SHEET 1 OF 1

5 4 3 2 1



3D Print Paramters

Mtl: PLA
Supports: NO
Layer Ht: .2mm
Fill: 20%
Fill Pattern: Any
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-8-19
			CHECKED	EWA	8-8-19
			ENG APPR.	EWA	8-8-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

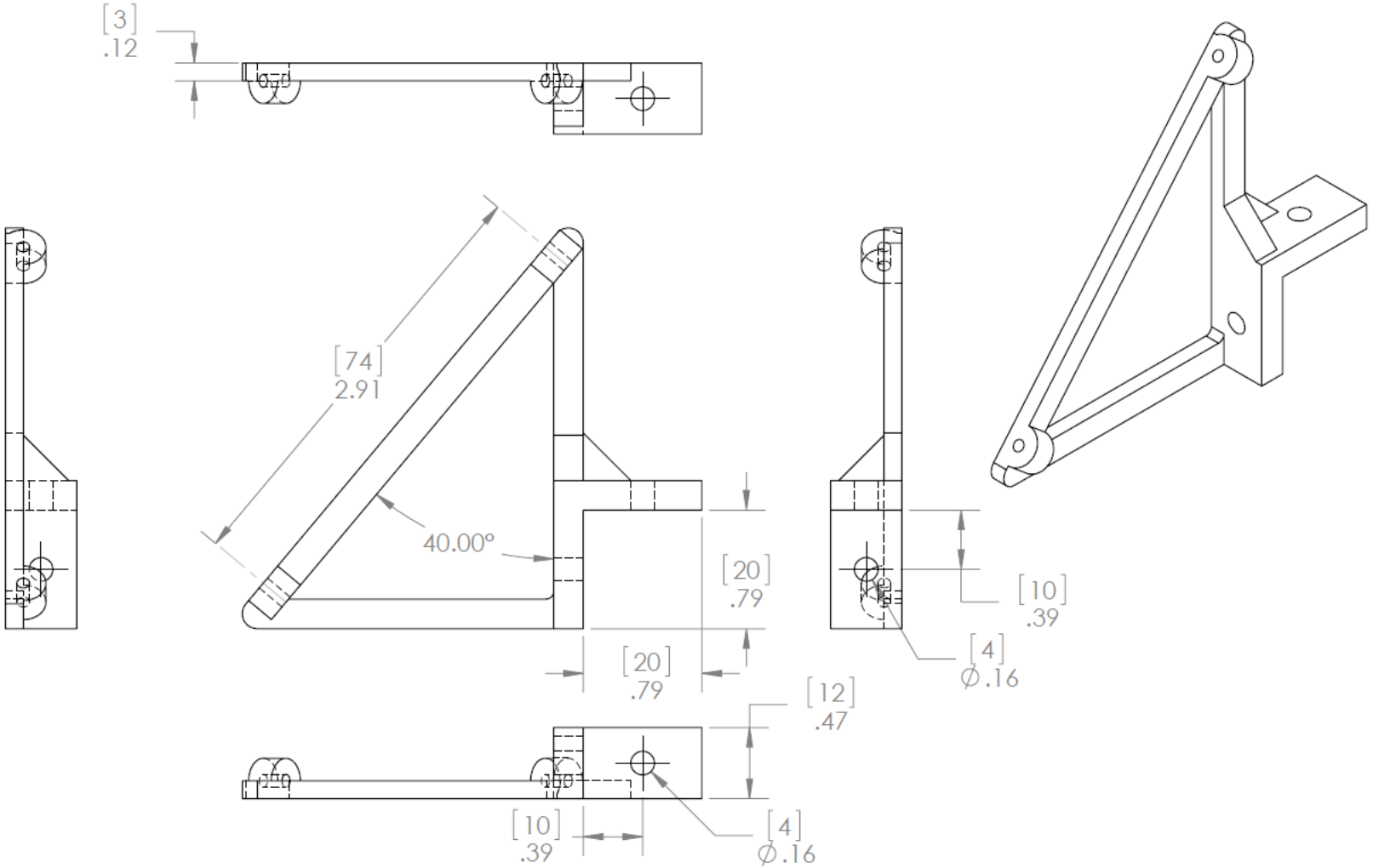
AMC CONSULTING
Brookfield, WI USA

TITLE:
Right-Hand Panel Tilt Mount

SIZE	DWG. NO.	REV
A	X5S_RH_ScalePnl_TiltMnt_2	2

SCALE: 1:2 | SHEET 1 OF 1

5 4 3 2 1



3D Print Paramters

Mtl: PLA
Supports: NO
Layer Ht: .2mm
Fill: 20%
Fill Pattern: Any
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-8-19
			CHECKED	EWA	8-8-19
			ENG APPR.	EWA	8-8-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
Released into public domain. No waranty for any application expressed or implied.	APPLICATION	DO NOT SCALE DRAWING			

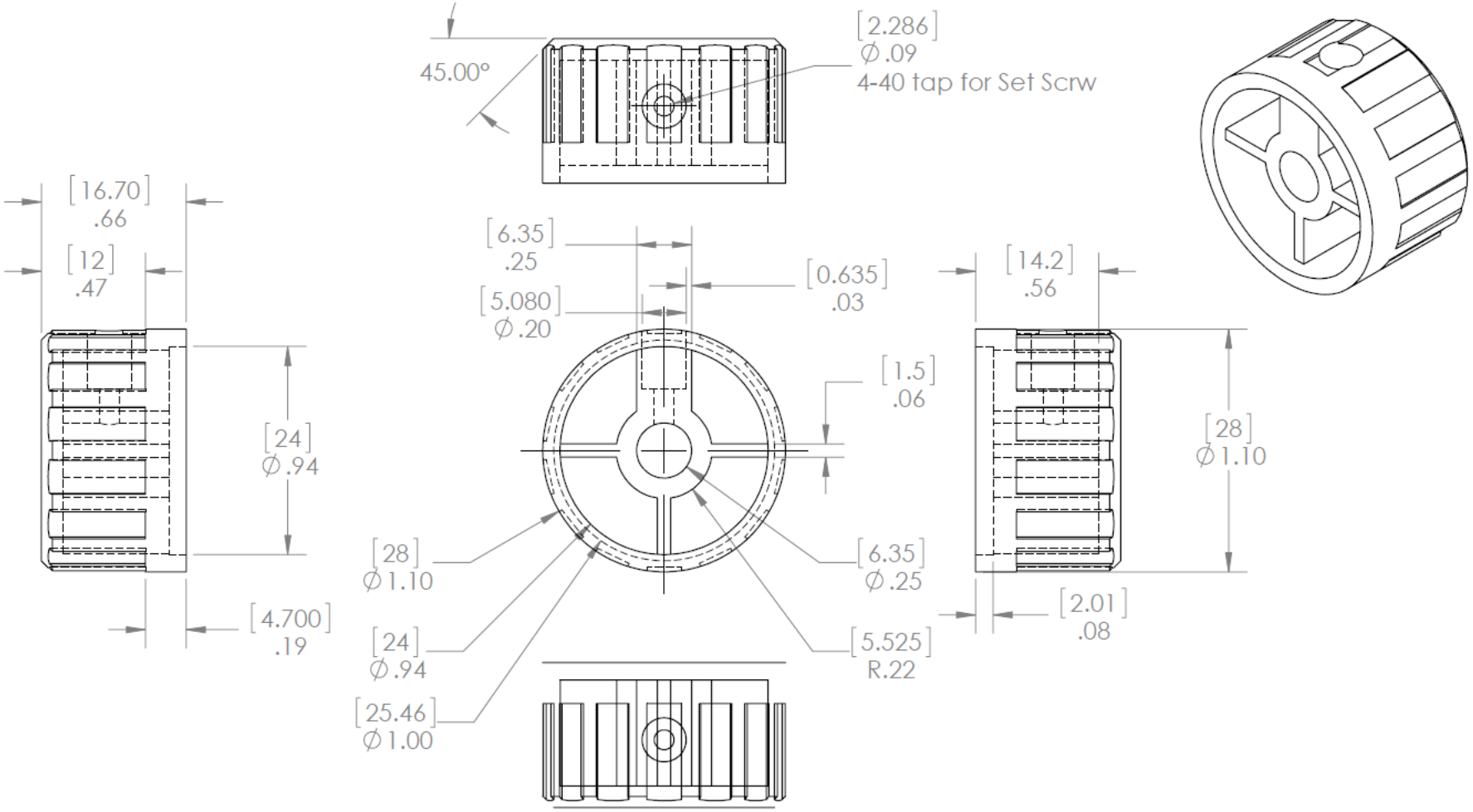
AMC CONSULTING
Brookfield, WI USA

TITLE:
Left-Hand Panel Tilt Mount

SIZE	DWG. NO.	REV
A	X5S_LH_ScalePnl_TiltMnt_2	2

SCALE: 1:2 | SHEET 1 OF 1

5 4 3 2 1



3D Print Paramters

Mtl: PLA
Supports: NO
Layer Ht: .2mm
Fill: 20%
Fill Pattern: Concentric
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-8-19
			CHECKED	EWA	8-8-19
			ENG APPR.	EWA	8-8-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

AMC CONSULTING
Brookfield, WI USA

TITLE:
Control Knob for
Puxh and Turn Encoder

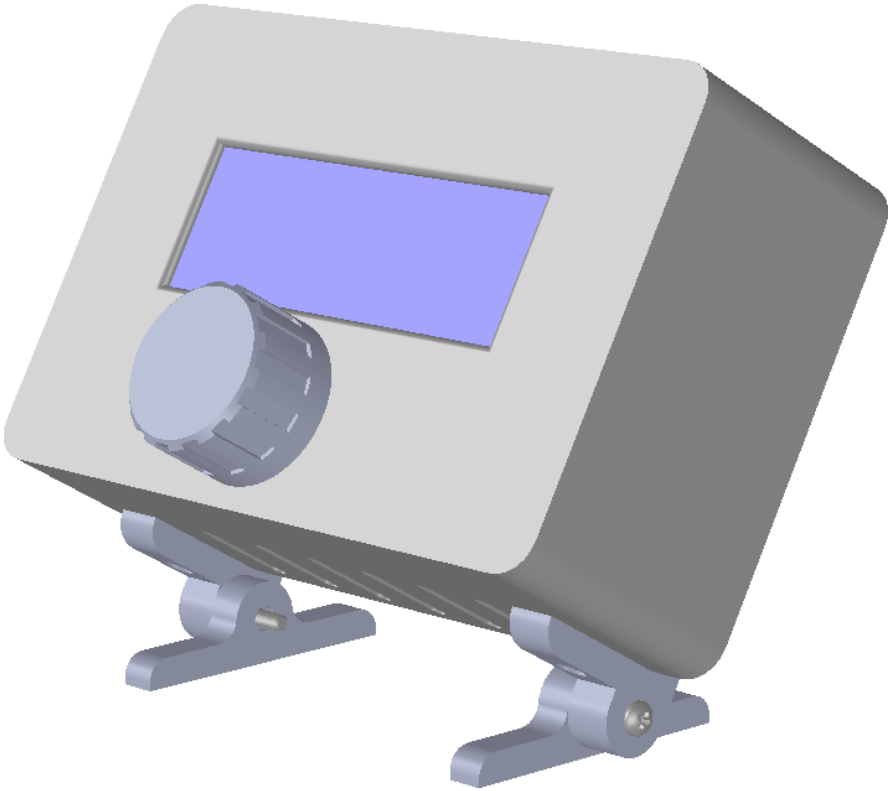
SIZE	DWG. NO.	REV
A	Control_Knob_R1	1

SCALE: 2:1 | SHEET 1 OF 1

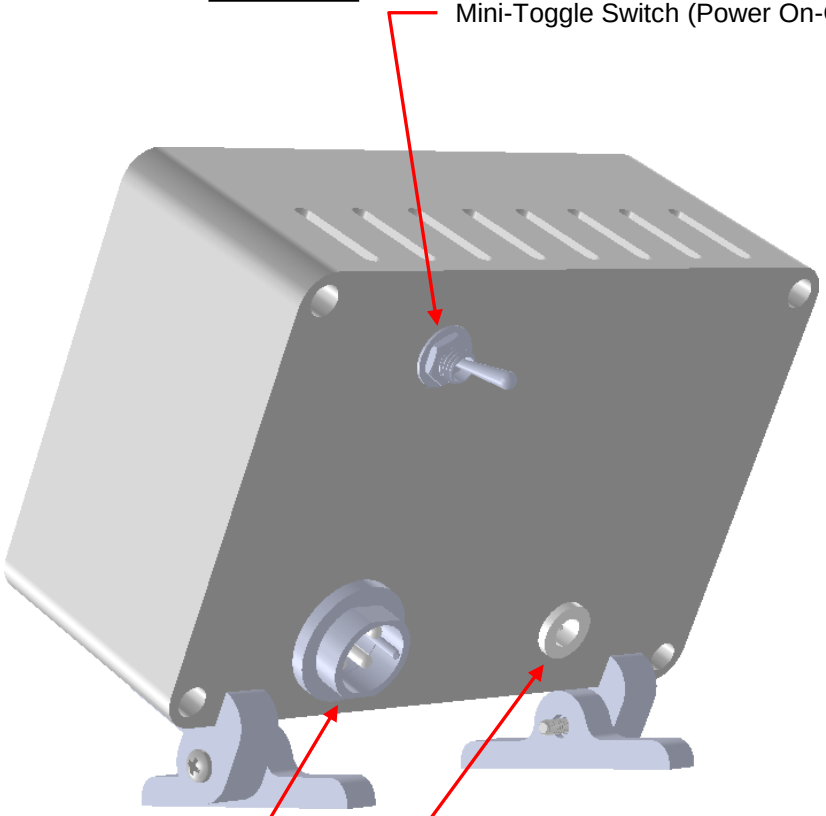
5 4 3 2 1

Stand Alone Enclosure Assembly

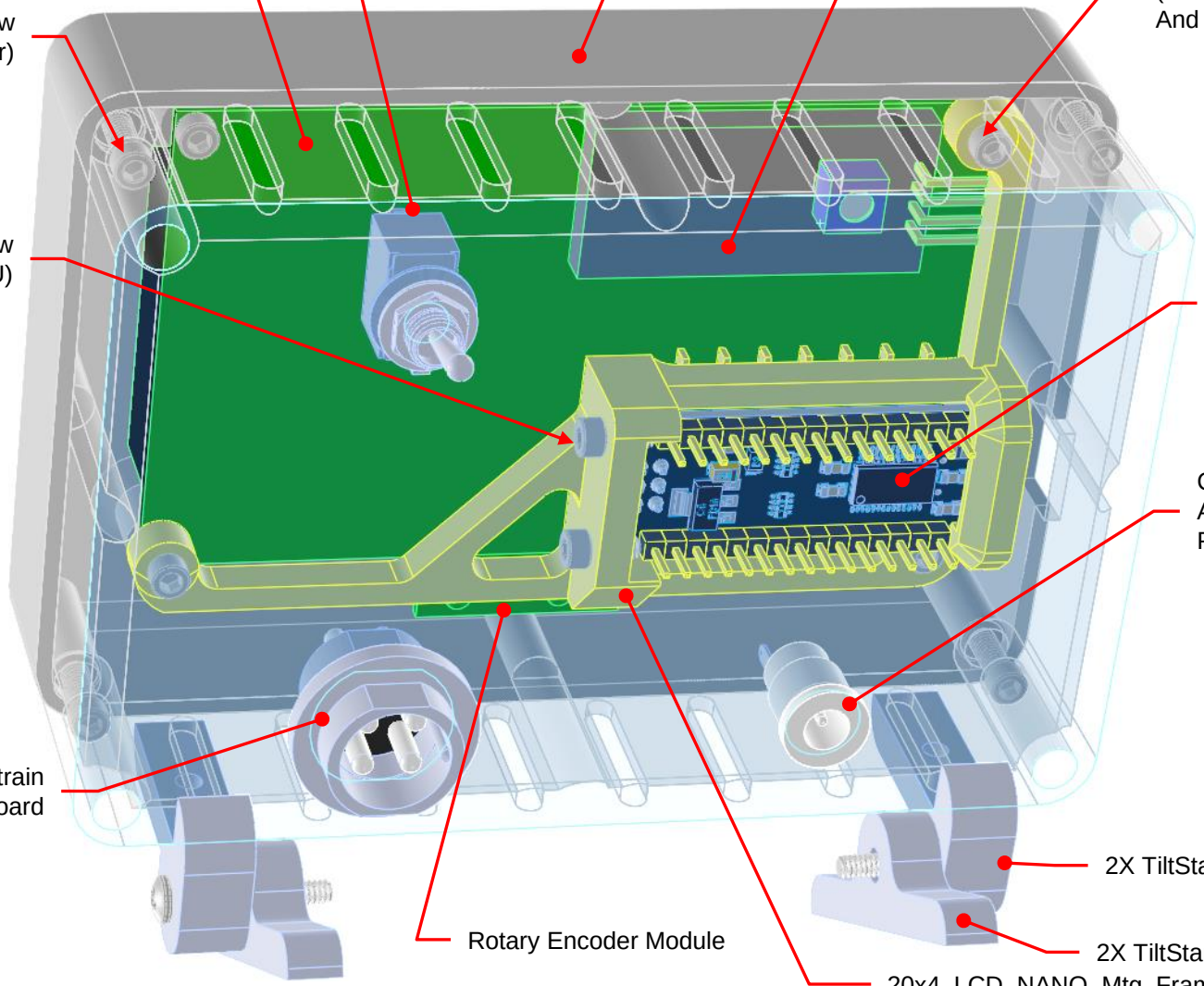
FRONT VIEW



REAR VIEW



Stand Alone Rear View - Internal layout



Made by: E. Andrews Date: 8-11-2019

First Made For: Spool-Scale Project

Filename: Spool Scale Design Notes (Rev Date)

Revision: 1

Printed: 8/11/2019 14:28

AMC Consulting
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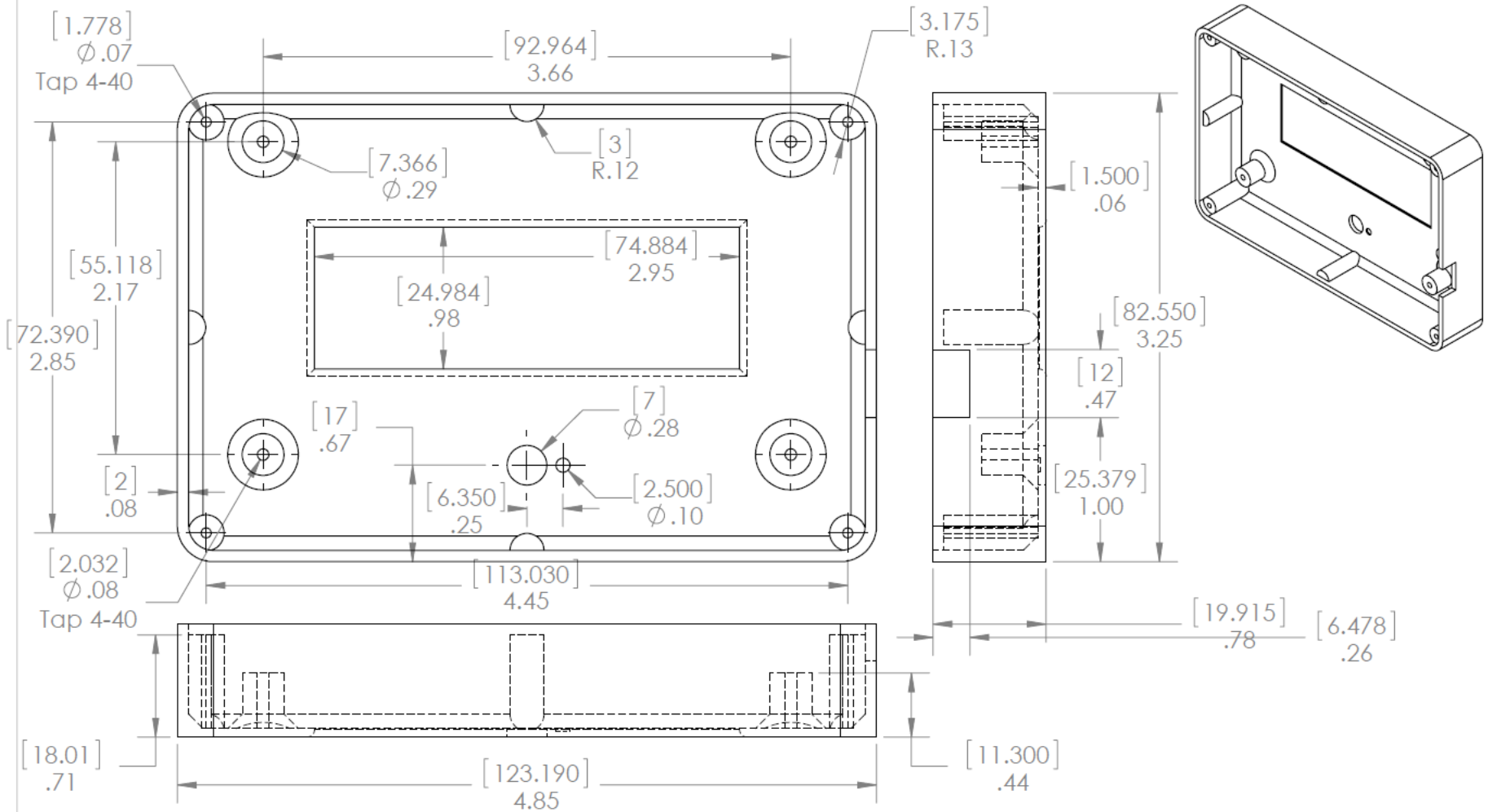


Print Guidelines

Mtl: PLA
Supports: NO
Layer Ht: .2mm
Fill: 20%
Fill Pattern: Any
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-10-19
			CHECKED	EWA	8-10-19
			ENG APPR.	EWA	8-10-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

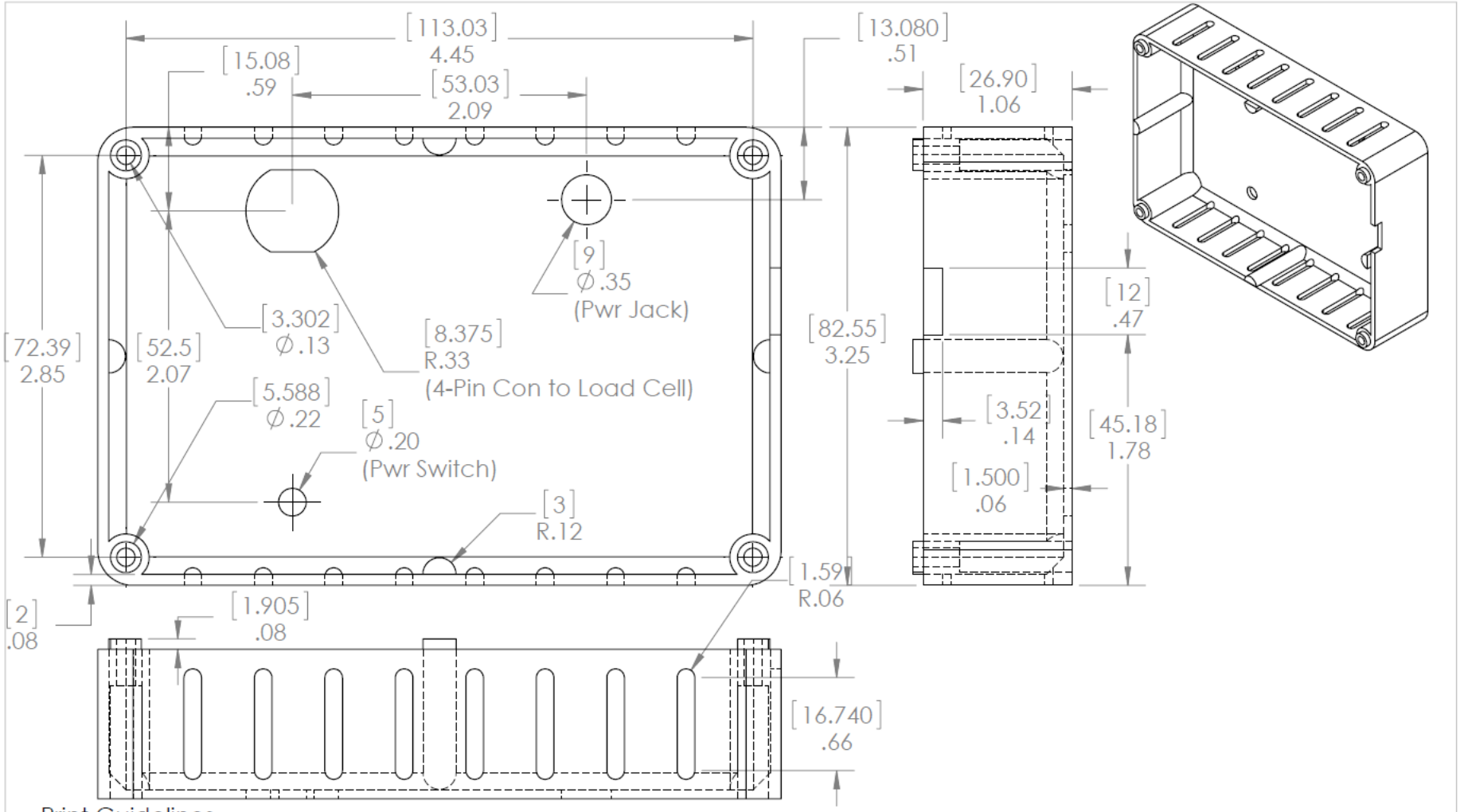
AMC CONSULTING
Brookfield, WI USA

TITLE:
Enclosure Front Panel
20x4 LCD, Nano V3
& Rotary Encoder
(General Use)

SIZE	DWG. NO.	REV
A	SpoolScale_Frnt_Panel_Rev_0	0

SCALE: 1:1 SHEET 1 OF 1

5 4 3 2 1



Print Guidelines

Mtl: PLA
Supports: NO
Layer Ht: .2mm
Fill: 20%
Fill Pattern: Any
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-10-19
			CHECKED	EWA	8-10-19
			ENG APPR.	EWA	8-10-19
			MFG APPR.		
			Q.A.		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

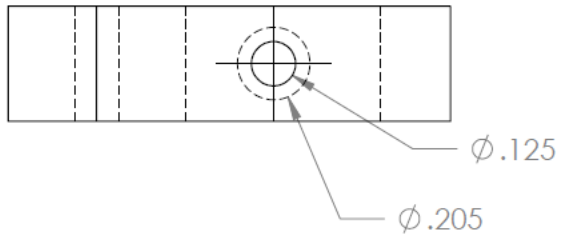
AMC CONSULTING
Brookfield, WI USA

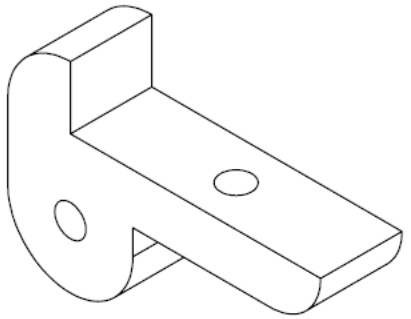
TITLE:
Enclosure Rear Panel
20x4 LCD, Nano V3
& Rotary Encoder
(General Use)

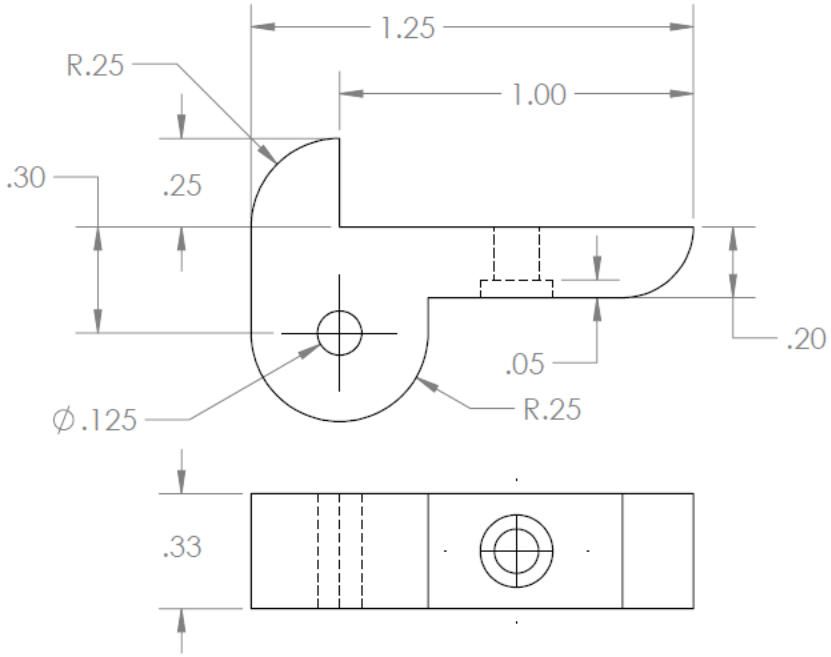
SIZE	DWG. NO.	REV
A	SpoolScale_Rear_Panel_Rev_0	0

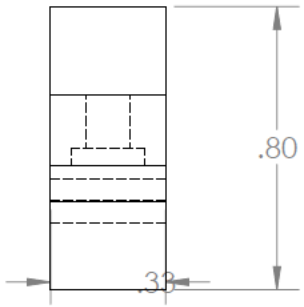
SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1









3D-Print Guidelines
Layer Ht: .2 mm
Fill: 20%
Material: PLA
Supports: Not Req'd

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	2-25-19
			CHECKED	EWA	2-25-19
			ENG APPR.	EWA	2-25-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

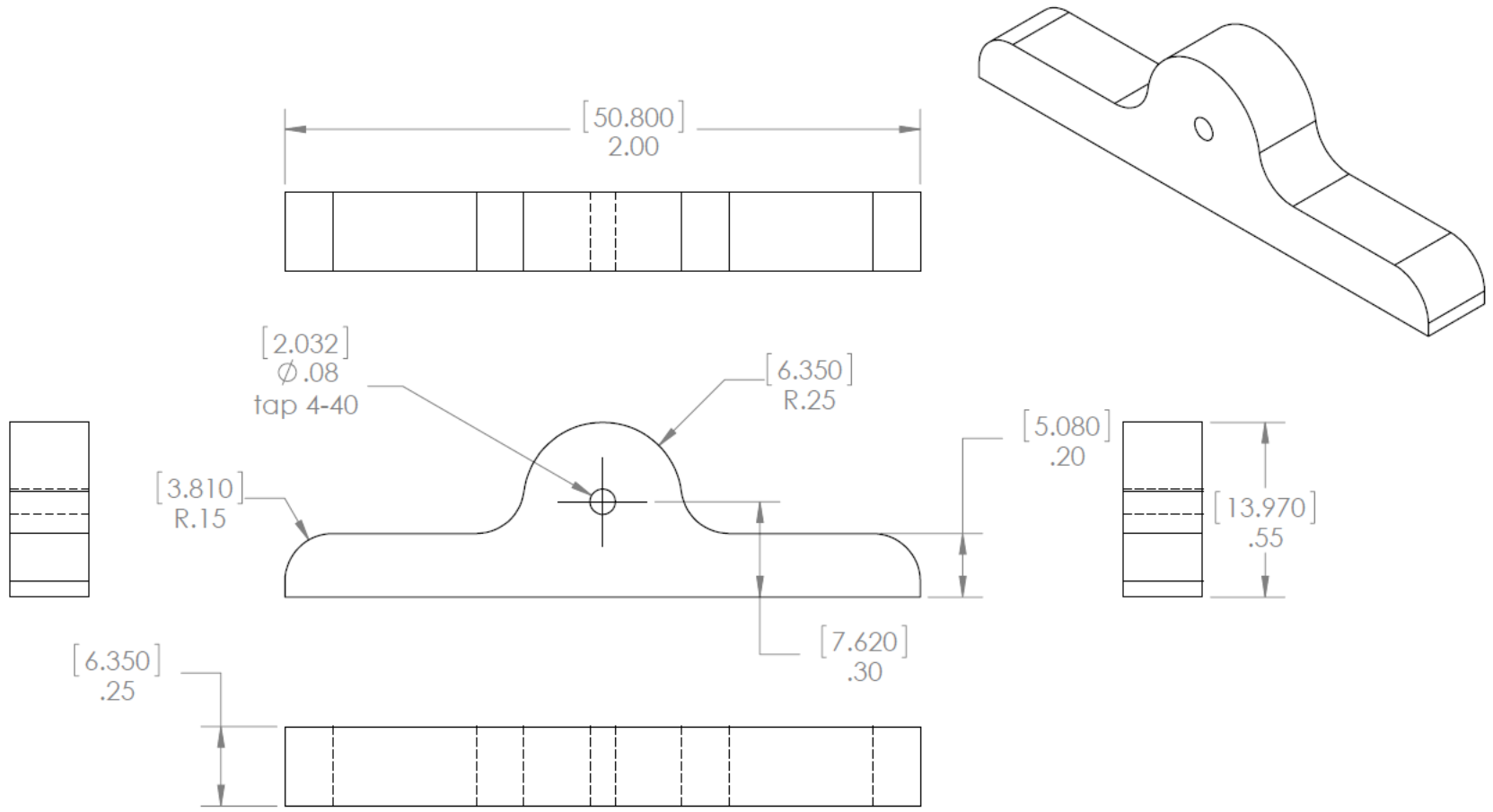
AMC CONSULTING
Brookfield, WI USA

TITLE:
TILT STAND MOUNT

SIZE	DWG. NO.	REV
A	480x320_Lcd_TiltStand2_Mount	2

SCALE: 2:1 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1



Print Parameters

MTL: PLA
Supports: No
Layer Ht: .2
Fill: 20%
Fill Pattern: Any
Color: Any

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-9-19
			CHECKED	EWA	8-9-19
			ENG APPR.	EWA	8-9-19
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

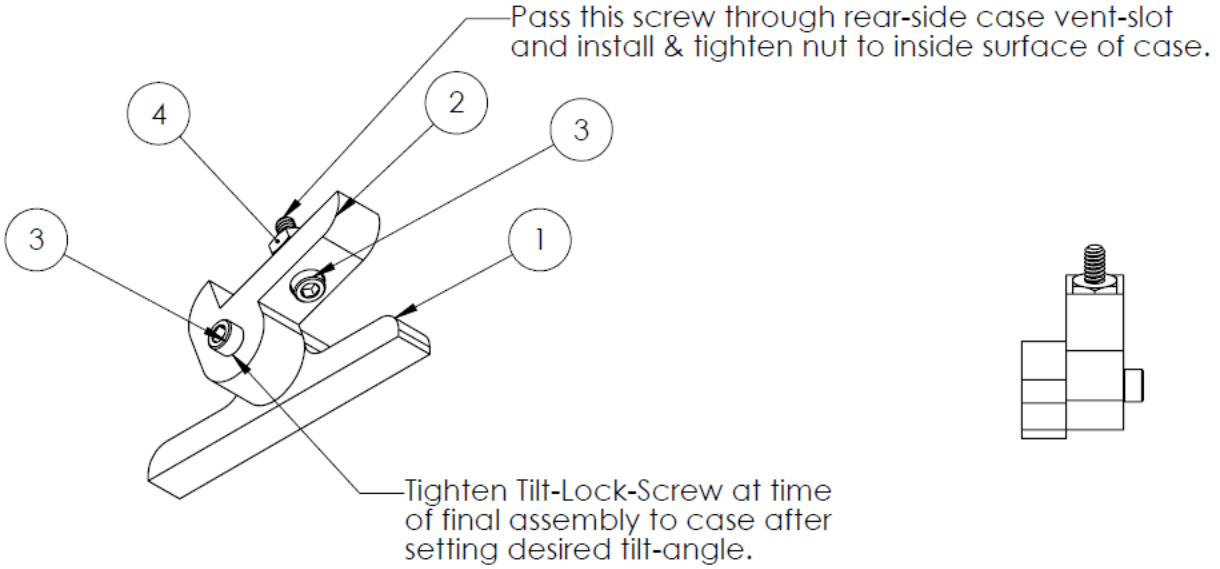
AMC CONSULTING
Brookfield, WI USA

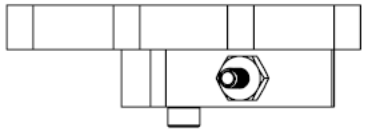
TITLE:
General Use Tilt Stand Base

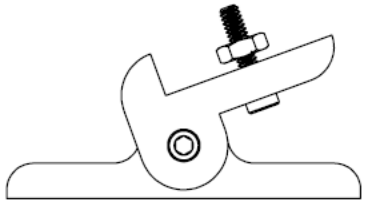
(First made for Trend Thermometer Enclosure)

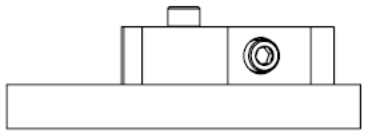
SIZE	DWG. NO.	REV
A	480x320_Lcd_TiltStand4_Base (Threaded)	
SCALE: 1:1		SHEET 1 OF 1

5 4 3 2 1









ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Tilt_Stand_Base	PLA 3D print (4-40 Threaded Hole)	1
2	Tilt_Stand_Mount	PLA 3D Print	1
3	McMaster Carr_PN 92196A110	4-40 x 0.5 in Socket Head Mach Screw; McMaster-Carr or Equiv.	2
4	McMaster-Carr PN 90480A005	4-40 Nut; McMaster-Carr or Equiv.	1

1. Left-Hand tilt stand shown.

2. Right-Hand tilt stand is assembled in a similar fashion.

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	EWA	8-9-219
			CHECKED	EWA	8-9-219
			ENG APPR.	EWA	8-9-219
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

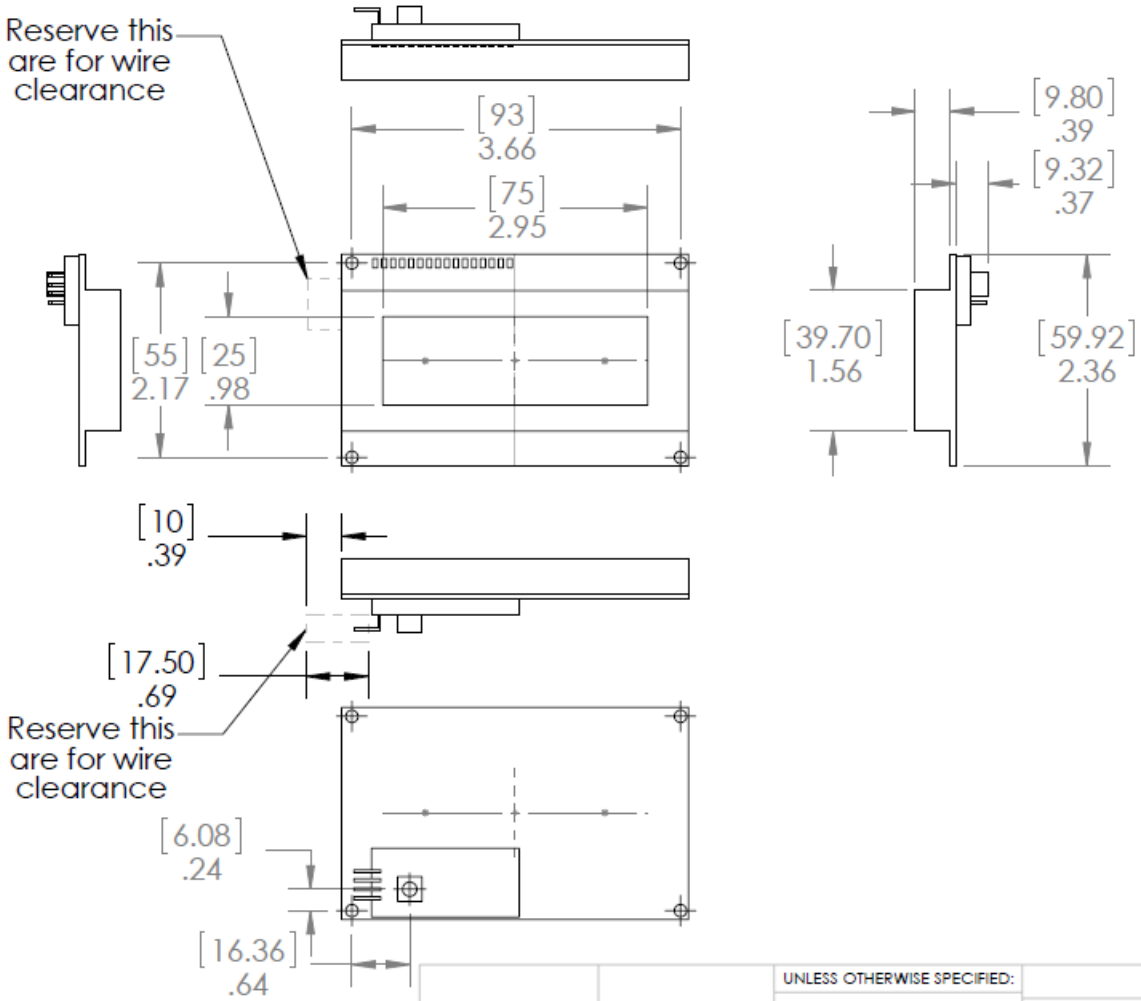
AMC CONSULTING
Brookfield, WI USA

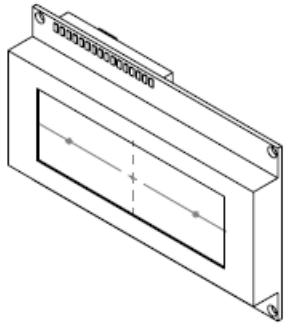
TITLE:
Tilt Stand Sub Assembly

SIZE	DWG. NO.	REV
A	480x320_Lcd_TiltStand2_LH_ASM	1

SCALE: 1:1 SHEET 1 OF 1

5 4 3 2 1





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
		FINISH			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

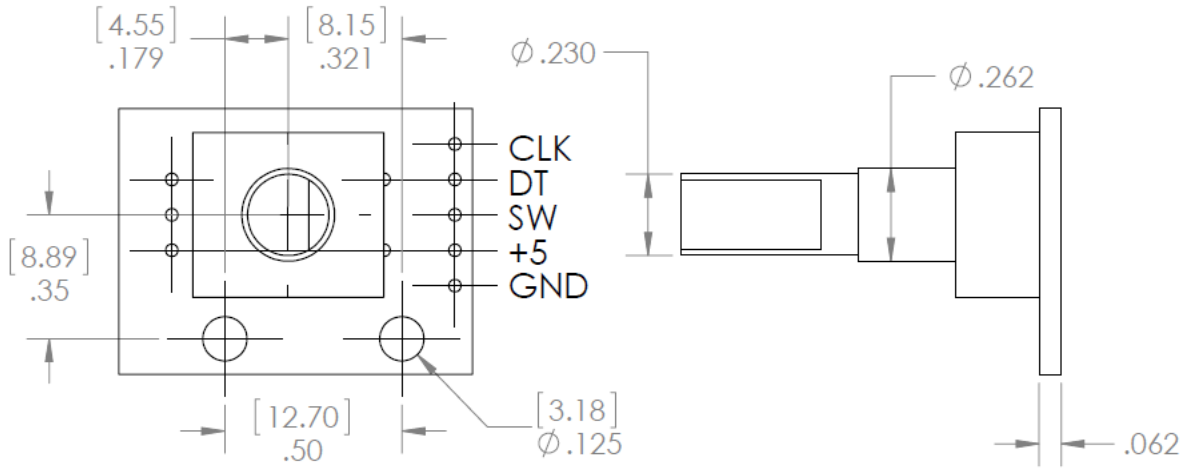
AMC CONSULTING
Brookfield, WI USA

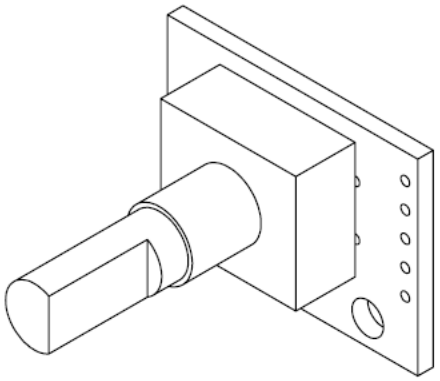
TITLE:

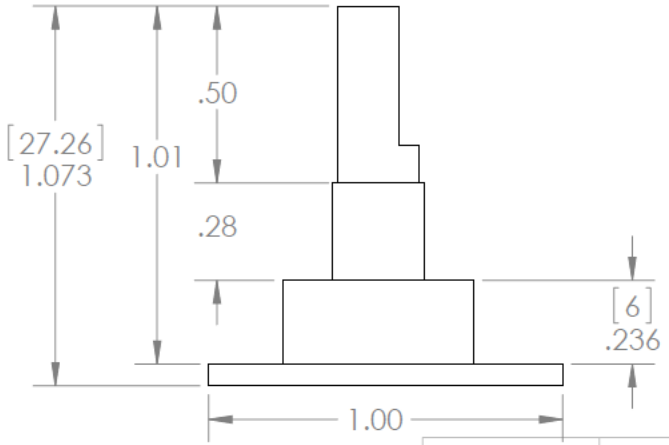
SIZE	DWG. NO.	REV
A	4x24 LCD Display Module_Rev1	

SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

TOP VIEW







		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
			COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

AMC CONSULTING
Brookfield, WI USA

TITLE:

ROTARY ENCODER

SIZE	DWG. NO.	REV
A	RotaryEncoderModule	
SCALE: 2:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

KEY PROJECT LINKS

Spool-Scale Project Software and Hardware Details.
https://github.com/Ed-EE-Eng/Spool_Scale_Project

Bounce2 Push Button Debouncing Library
https://github.com/thomasfredericks/Bounce2

Strain Gauge Scale Interface Libray
https://github.com/bogde/HX711

Push and Turn Encoder Library
http://www.pjrc.com/teensy/td_libs_Encoder.html

ARDUINO IDE LINK

Arduino IDE, Arduino Libraries, & useful guides & references
https://www.arduino.cc/

USEFUL TECH LINKS

Strain gauge operation and their use in digital scale applications
https://en.wikipedia.org/wiki/Strain_gauge

https://wiki.restarters.net/Digital_weighing_scales

Detailed explaination of Wheatstone bridge circuit
https://en.wikipedia.org/wiki/Wheatstone_bridge

IDE NOTE: This code set was developed & tested using Arduino IDE Ver 1.8.9

Other Useful Links

Good overview link on Weight – Length relationship: https://www.fabbaloo.com/blog/2015/9/27/is-it-filament-weight-or-length

Fabbaloo

Essential Explanations of 3D Printing

We found a great conversion table at Toybuilder Lab's site *(see below)*, where they explain the difference in weight vs. volume for PLA and ABS plastic:

- PLA Density: 1.25 g/cm^3
- PLA Volume: 0.80 cm^3/g or 800 cm^3/kg
- 1.75 mm filament length for 1 kg spool: ~ 330 meters / ~ 1080 feet
- 3.00 mm filament length for 1 kg spool: ~ 110 meters / ~ 360 feet

- ABS Density: 1.04 g/cm^3
- ABSVolume: 0.96 cm^3/g or 960 cm^3/kg
- 1.75 mm filament length for 1 kg spool: ~ 400 meters / ~ 1310 feet
- 3.00 mm filament length for 1 kg spool: ~ 130 meters / ~ 430 feet

Using these factors, it's pretty easy to convert into length from weight, permitting you to verify that you have enough material to do a print, even if your slicing software is telling you the requirement in meters. It's also possible to do this style of calculation with other materials, too.

Is volume the correct metric for 3D printer filament instead of weight or length? Perhaps theoretically, but we still don't know of an easy way to measure the volume of a partially used spool without weighing it anyway.

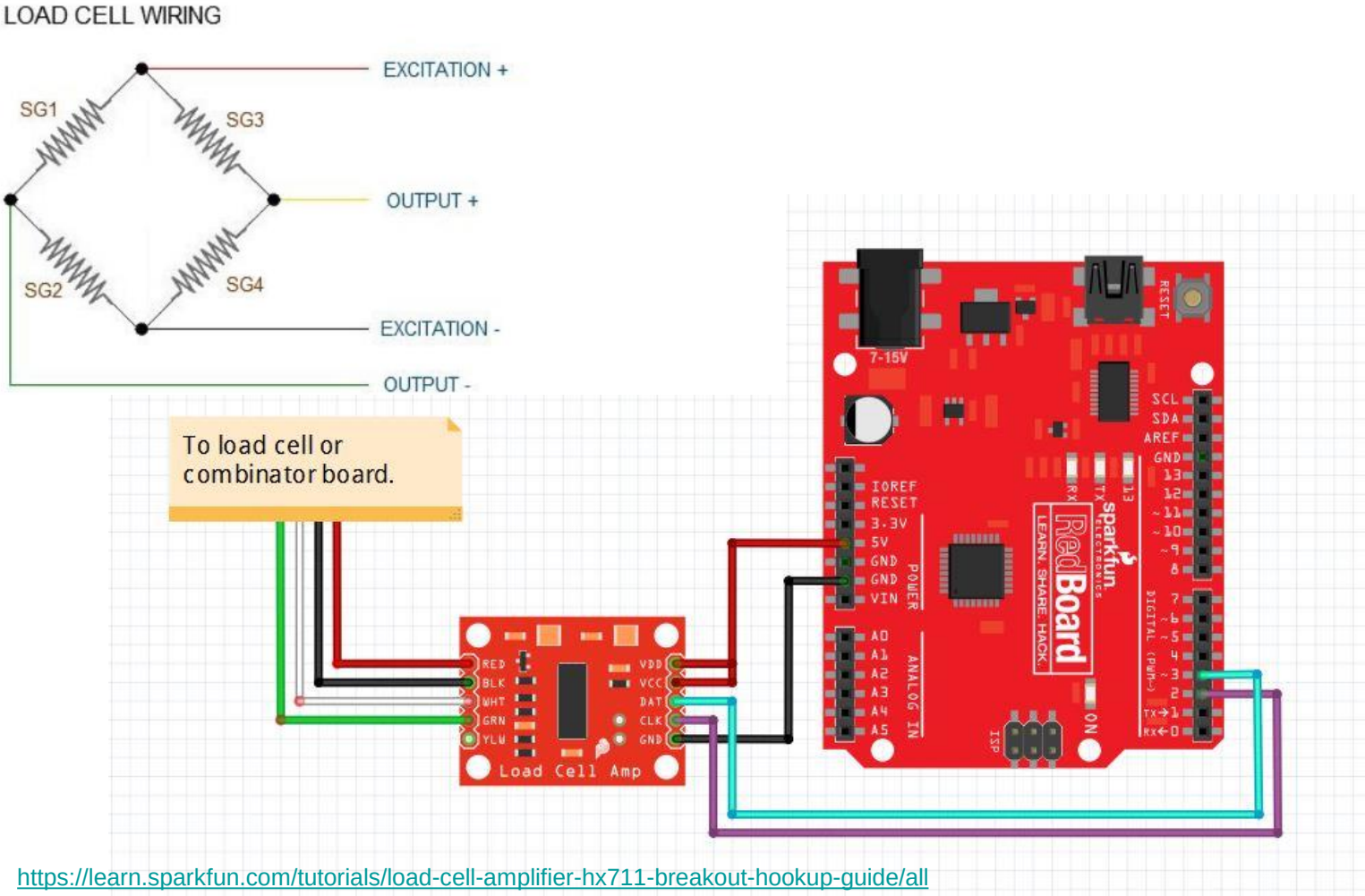
Toybuilder Site: http://www.toybuilderlabs.com/blogs/news/13053117-filament-volume-and-length

Rotary Encoder Library (with/without Interrupts): https://www.arduinolibraries.info/libraries/rotary-encoder
More data on this library: http://www.mathertel.de/Arduino/RotaryEncoderLibrary.aspx
Other rotary Encouder Data: https://playground.arduino.cc/Main/RotaryEncoders/

Ada Encoder (interrupt driven) project page: https://github.com/GreyGnome/AdaEncoder
Library Download: https://github.com/GreyGnome/AdaEncoder/releases
>>>>>> Paul Stoffregen Encoder Library: https://github.com/PaulStoffregen/Encoder

SparkFun Load Cell Example

The HX711 Load Cell Amplifier accepts five wires from the load cell. These pins are labeled with colors; **RED, BLK, WHT, GRN, and YLW**. These colors correspond to the conventional color coding of load cells, where red, black, green and white wires come from the strain gauge on the load cell and yellow is an optional ground wire that is not hooked up to the strain gauge but is there to ground any small outside EMI (electromagnetic interference). Sometimes instead of a yellow wire there is a larger black wire, foil, or loose wires to shield the signal wires to lessen EMI.



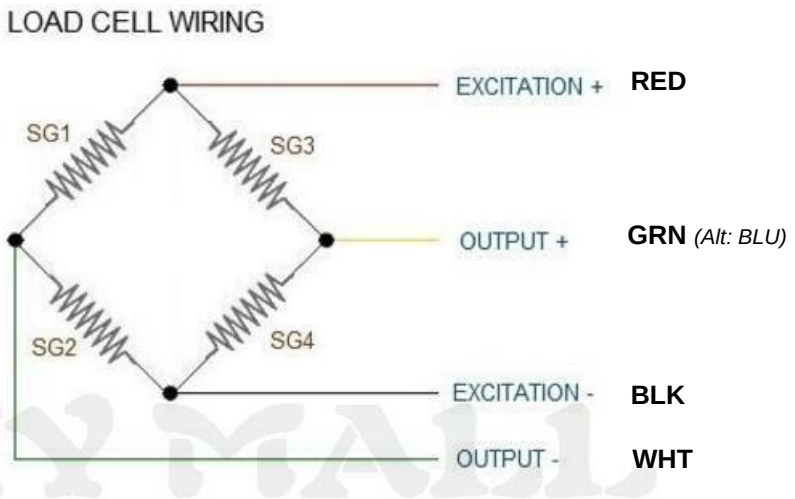
https://learn.sparkfun.com/tutorials/load-cell-amplifier-hx711-breakout-hookup-guide/all

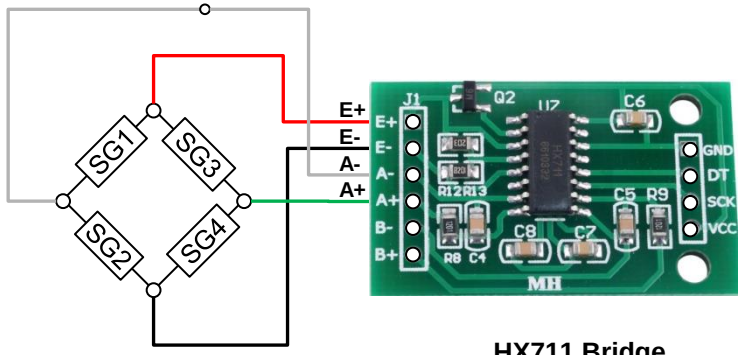
Sample Run Time Code

Support Arduino Library: https://github.com/bogde/HX711

```
/*
 Example using the SparkFun HX711 breakout board with a scale
 By: Nathan Seidle
 SparkFun Electronics
 Date: November 19th, 2014
 License: This code is public domain but you buy me a beer if you use this and we meet someday (Beerware license).

 This example demonstrates basic scale output. See the calibration sketch to get the calibration_factor for your
 specific load cell setup. This example code uses bogde's excellent library: https://github.com/bogde/HX711
 bogde's library is released under a GNU GENERAL PUBLIC LICENSE

 The HX711 does one thing well: read load cells. The breakout board is compatible with any wheat-stone bridge
 based load cell which should allow a user to measure everything from a few grams to tens of tons.
 Arduino pin 2 -> HX711 CLK
 3 -> DAT
 5V -> VCC
 GND -> GND
 The HX711 board can be powered from 2.7V to 5V so the Arduino 5V power should be fine.
*/

#include "HX711.h"
#define calibration_factor -7050.0 //This value is obtained using the SparkFun_HX711_Calibration sketch

#define DOUT  3
#define CLK  2

HX711 scale;

void setup() {
  Serial.begin(9600);
  Serial.println("HX711 scale demo");

  scale.begin(DOUT, CLK);
  scale.set_scale(calibration_factor); //This value is obtained by using the SparkFun_HX711_Calibration sketch
  scale.tare(); //Assuming there is no weight on the scale at start up, reset the scale to 0

  Serial.println("Readings:");
}

void loop() {
  Serial.print("Reading: ");
  Serial.print(scale.get_units(), 1); //scale.get_units() returns a float
  Serial.print(" lbs"); //You can change this to kg but you'll need to refactor the calibration_factor
  Serial.println();
}
```

Load Cell & Power Interface Wiring Ideas



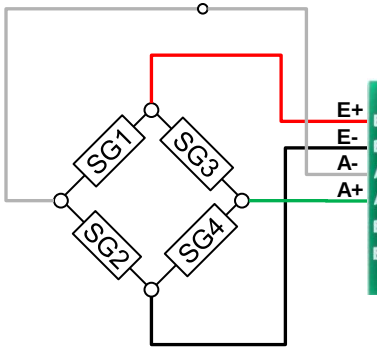


Load Cell

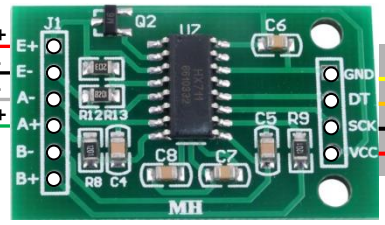
HX711 Bridge Sensor Interface

Connection:

Red:	E+
Black :	E-
Green:	A+
White:	A-



Load Cell



HX711 Bridge Sensor Interface

Actual Wire Colors are *"Builders Choice"*

GND	YEL
DTA	ORN
CLK	BLK
+5V	RED

GND	BRN
DTA	ORN
CLK	YEL
+5V	RED

To Nano CPU

+5V (RED)
GND (BRN)
To LCD Display

Intermediate Single In-line Strip can be used to handle power wiring between the CPU, HX711 Interface, and LCD Display.

Made by: E. Andrews Date: 8-11-2019

First Made For: Spool-Scale Project

Filename: Spool Scale Design Notes (Rev Date)

Revision: 1

Printed: 8/11/2019 14:28

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Brookfield, WI USA