ECEN301 : Embedded Systems
Assignment 1 Submission

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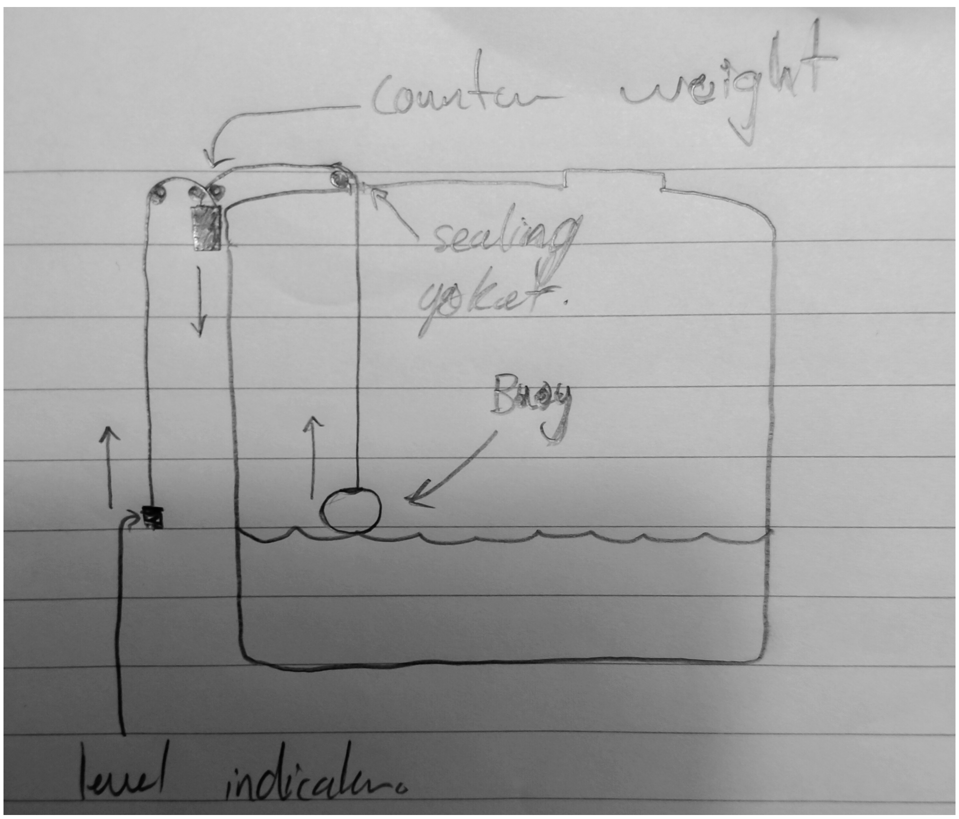
Question 1

Mk I



- Simple construction, with electrical requirements
- Is a non-reverse indicator. If properly aligned the level indicator will align with the internal water level
- If buoy is sized correctly to the tanks overflow level, they should be no or minimal clipping of mini/max levels.
- Included materials are 4 pulleys, rope, a seal, buoy, level indicator (small stainless steel ball/etc), counter-weight (sand filled plastic container), and mounting hardware. Total material cost should be below $100 and take a maximum of 2 hours to install.

Mk II

MK I succeeds in simplicity and durability, but does not offer much extra. Points that can be improved include:

- Quantifiable output, i.e. volume, days left of consumption.
- Remote monitoring and alerts
- software based extension and future support.

Utilising the MB7369 ultrasonic water level sensor, which is IP-68 water resistant, has a 7.65 meter range, 1cm resolution and 200,000 rating hours of inter-servicing operating time, it can be mounted above the overflow line inside the tank and the cable feed and sealed through a drill hole (or using an existing inspection hole) and provide and can provide either an analog voltage reading, PWM or digital (RS232) signal to a compatible micro-controller.

cost: \$40.00

To drive the system, the ESP32 controller can be installed in a weather project box at the base of tank and powered via a DC PSU from the nearby main connection. The sensor has a low current draw of 3.4mA @ 3-5V5 so can be driven from the onboard V-reg. This board provides low power Bluetooth, wifi, and a duel core processor with lower power functionality.

cost: \$3-\$6

With this an external display can be driven either mounted at the box or remotely connect indoors (via BLE or wifi). It will display the current level in meters/volume and estimated remaining days calculated from usage.

cost: \$15

All extra component cost under \$50 and time and development time estimated at 15-20hr.

The system provide the possible expansion via firmware updates (ESP32 allows this to be set up remotely) to a Mk III installation of a possible mobile app or website based monitoring

Question 2

$E = 2.2{\times}10^{11}\ N/m^2,\ S_{max} = 5.5{\times}10^{8}\ N/m^2,\ G = 2.2$

$x = 8cm,\ t = 0.15cm,\ w = 2.5cm,\ R = 150\Omega$

$$E = \frac{S}{\varepsilon} \Rightarrow \varepsilon = \frac{S}{E} = 2.5{\times}10^{-3}$$

$$\varepsilon = \frac{6xF}{wt^2E} \Rightarrow F = \frac{\varepsilon wt^2E}{6X} = 67.03N$$

$$G = \frac{\Delta R/R}{\varepsilon} \Rightarrow \Delta R = G\varepsilon R = 0.825\Omega$$

Question 3

$$0.1\ arcmin = 0.001667^\circ$$

$$360/0.001667 = 215956.8 \Rightarrow \text{round to } 215957$$

$$log_2(215957) = 17.72,\ \text{ie } \mathbf{18bit} \text{ absolute encoder}$$

Question 4

$\varepsilon_{emf} = -S\Delta T$

$$750\mu V = -S(70-10) \ \therefore \ -S = 12.5\mu V/^{\circ}C$$
$$520\mu V = 12.5(t-10)$$
$$t = \frac{520}{12.5} + 10 = 51.6^{\circ}C$$

With the rough estimate of sensitivity above of $12.5\mu V/^{\circ}C$, this closest resembles a type R, platinum-rhodium thermocouple, which have a nomnial sensitivity of around 9 at room temp. As opposed to a type K (chromel and alumel) of 41.

Question 5

$$\varepsilon_{emf} = -S\Delta T$$
$$= 12.5(-35) = -437.5\mu V$$

Question 6

i) Taking the pot as a voltage divider:

$$V_{oc} = Vs\left(\frac{R_p x}{R_p x + R_p(1-x)}\right)$$

With load resistance, R_{out} becomes $R_p x /\!/ R_L$

$$V_L = V_s\left(\frac{R_p x /\!/ R_L}{R_p x /\!/ R_L + P_p x(1-x)}\right)$$
$$= V_s\left(\frac{\frac{R_p x \cdot R_L}{R_p x + R_L}}{\frac{R_p x \cdot R_L}{R_p x + R_L} + R_p x(1-x)}\right)$$
$$= Vs\left(\frac{R_L x}{R_L + R_p x(1-x)}\right)$$
$$= x \cdot Vs\left(\frac{1}{1 + R_p R_L x(1-x)}\right)$$

Loading error is defined as: $N(x) = V_{oc} - V_L$

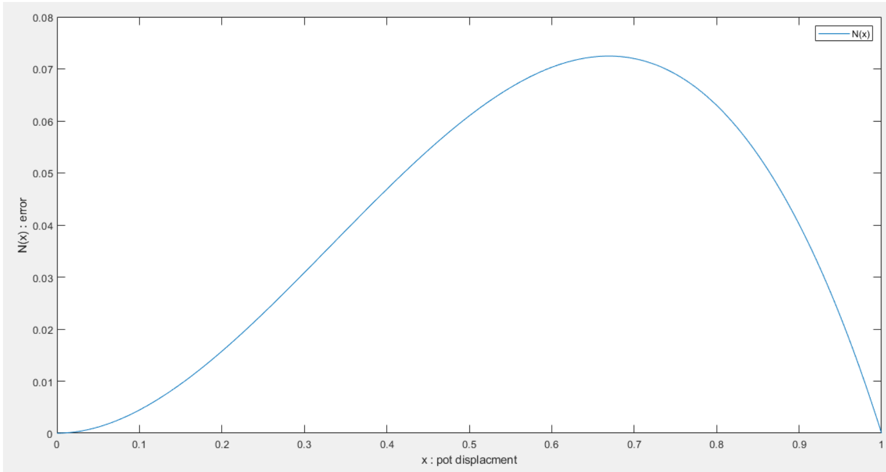
$$N(x) = Vs\left(\frac{R_p x}{R_p x + R_p(1-x)} - \frac{x}{1 + R_p R_L x(1-x)}\right)$$

ii) If $\frac{R_p}{R_L} << 1$ then the Loading error can be simplified to $V_s \cdot (x^2 - x^3) \cdot \frac{R_p}{R_L}$

Differentiate: $V_s \cdot \frac{R_p}{R_L} \cdot (2x - 3x^2)$

$(2x - 3x^2) = 0 \ : \ x = 2/3$

$N(x)_{max} = (4/27) V_s \cdot \frac{R_p}{R_L} \ \therefore$ maximum error percentage is $N(x)_{max}/V_s \times 100 = 400/27 \cdot \frac{R_p}{R_L} = 400/27 = 14.814815 \approx 15 \cdot \frac{R_p}{R_L}$

iii) 

iv) By knowing the points of maximum error and the characteristics of how the system approaches it, the transducer can be designed in such a way as to the operating region.

v) (a,b) Using max error will ensure it's under requirement across whole displacement, ie fore both, 0.2 and 0.67.

$$0.1 = 15(1k/R_L)$$

$$R_L = 15k/0.1 = 150k$$