Based on Deliveriables.pdf from canvas

Project Overview: (1 minute max)

Very brief intro into the task and 3 phases, and some client requirements:

* Analogue components only
* PoC focus – functional system. That means:
* No size constraint (but be sensible)
* No budget constraint (but be sensible)

Phase 1: (2 minutes max)

Overview: change in capacitance with presence or absence of water

Only relevant parameter is capacitance range

Same operating conditions – including temperature, mechanical stress, chemical environment etc.

PVC gives higher capacitance range with presence or absence of water

Phase 2: (5 minutes max)

Overview: Transmit capacitance data using light – more specifically, with frequency modulation

Overall cct considerations (both phase 2 and 3):

Opamps aren’t ideal – Mohm range across input terminals

* Therefore resistors in Kohm range, ideally less than 100k so opamp input impedance is approx. infinite
* Also high resistances have inductance because of their physical construction – noise so having smaller resistors **decreases noise**
* Cannot be too low otherwise too much current draw and loading previous cct so above 1k
* Tried to reduce different resistor values across RX and TX – decreased different parts required to order if mass produced

5V supply block – used recommended peripherals (capacitors) from datasheet

Midpoint supply block - used recommended peripherals for unity gain cct from datasheet. Midpoint is less than 5/2=2.5V, since opamp max supply is 4.4V, not 5V

Main CCT–

Overview – constraints of the probe (very small capacitance) means very high frequency (fast charge/discharge). Main challenge was to decrease frequency. To help this, modified the cct to add a capacitor in parallel to the probe – increase the capacitance across every value and **more accurate** (linear is easier to process)

Integrator block – chose resistor to decrease ramping speed of intergrator while still under the 100k resistor range – to decrease frequency.

Comparator block – chose hysteresis band that was large while using low Kohm resistors. Large hysteresis band means the integrator needs to increase/decrease its output voltage sufficiently to trigger comparator -> decreases frequency

Additional notes:

Touch very briefly on linearity of frequency range (supposed to be in phase 3, but issue is addressed in phase 2)

Above stuff addresses frequency range, stability and accuracy.

Doesn’t address TX/RX range, power and lifespan -> stuff needs to be mentioned

Phase 3: (6 minutes)

Overview: Receive signal from TX and produce a voltage that corresponds to capacitance/water level. Includes amplification of tiny light signal (since signal decreases to distance^2) with accuracy, and producing useful corresponding output (voltage levels)

Overall cct considerations:

Same opamps used as phase 2 – non ideal opamps to tried to use 1k-100k resistors

5V and midpoint supply blocks are same as phase 2

Main CCT –

Detector block – sufficient amplification (by configuring resistor value) to amplify the tiny signal from the photodiode, while minimizing resistor value – (to **decrease noise** and maximise bandwidth increasing accuracy)

Capacitor makes the opamp double as low pass filter to filter out DC (ambient light level)

Only 1 decoupling capacitor necessary (for stability and **less noise**, any additional adds unnecessary complexity.

Amplifier block – further amplification to trigger the following capacitor block.

Comparator block – generate square wave based on received frequency from previous blocks. Small hysteresis required to **reduce noise**

Rising edge detector – stores fixed energy on every rising edge – changing duty cycle to convert frequency to average voltage. Appropriate stored energy amount (capacitor size) and charge/discharge rate (resistors)

Comparator block – normalizes the charged time of the rising edge detector.  
Omitted hysteresis – **minimal noise** because of capacitors in previous (rising detector) block and following filter. A hysteresis using 1Mohm resistor range would be required introducing noise

Unity gain – used values from datasheet to not load the output when connected to following voltage conditioner and **improve accuracy**

Inverting amplifier – appropriate amplification (to 2V range) and offset introduced for ideal output (1V-3V range. Added modified capacitor to function as a low pass filter -> now 2nd order – further smooths output voltage (ripple from 0.4V to 0.1V) and **improves accuracy**

Additional notes:

Above stuff addresses stability and accuracy. These are the only criteria that need to be mentioned.

Concluding notes: (2 minutes max)

Battery – pair of 18650 batteries -> super common for power electronics like power tools or computers although BMS (battery controller) is required

Solar panel size

CCT recommendations – SMD design for better component tolerance, smaller physical size and less noise (no stretches of long wire)

TX/RX pair, upgrade to more powerful LED or go into infrared spectrum. And/or a light array (stack multiple LEDs) and a reflector funnel on the photodiode.