

Physics 37100 Advanced Physics Laboratory I

Lab #5

(PART I: PID---The Process Function)

- 1) The process function $V(n)$ of a PID controller maps the control variable n to the process variable V . That is $V=V(n)$. You will make a PID controller to control the average brightness of an LED as measured by a photoresistor. In this system the process variable V will be the measured average brightness of the LED in counts 0-1023, and the control variable n will be the value sent to `analogWrite()` to change the brightness of the LED. To begin you will measure the process function $V(n)$. From lab 3 and 4 we know that the LED driven by `analogWrite()` is pulse-width-modulated (pwm). That means that it is actually turning on and off, but at a high enough rate to not be noticed by our eyes. In lab you found that the frequency is $\sim 490\text{Hz}$. Use the function `getPhoto()` (below) to measure the average brightness. `getPhoto(na,dta)` takes 2 arguments. `na` is the number of averages and `dta` is the sampling time. The exact period of the pwm output is $2040\mu\text{s}$ so we take 15 samples at $136\mu\text{s}$ each to give $2040\mu\text{s}$ total. By averaging over exactly one cycle we eliminate some noise. Briefly explain why?

- a. Use `getPhoto()` to measure and plot $V=V(n)$ for every value of n $[0,255]$, where n is the input to `analogWrite(n)` and V is the value of `getPhoto()`. You should pause about 100ms between changing `analogWrite()` and measuring the brightness using `getPhoto()`.

```
float getPhoto(int na = 15, int dta = 136) {
    int n;
    unsigned long dt;
    float vS = 0;

    for (n = 0, dt = micros(); n < na; n++) {
        while (micros() - dt < dta);
        dt = micros();
        vS += analogRead(inPin);
    }
    return (vS / na);
}
```

- b. From the plot of the process function $V(n)$ estimate the maximum value of the variable P in a proportional controller given by the equation $n=P*e$, where $e=V_{\text{set}}-V$ is the error and V_{set} is the control set point. Use $V_{\text{set}}=V(128)$ for the estimate.