Imperial College London

DE2 Electronics 2

Tutorial 3

Lab 3 Explained

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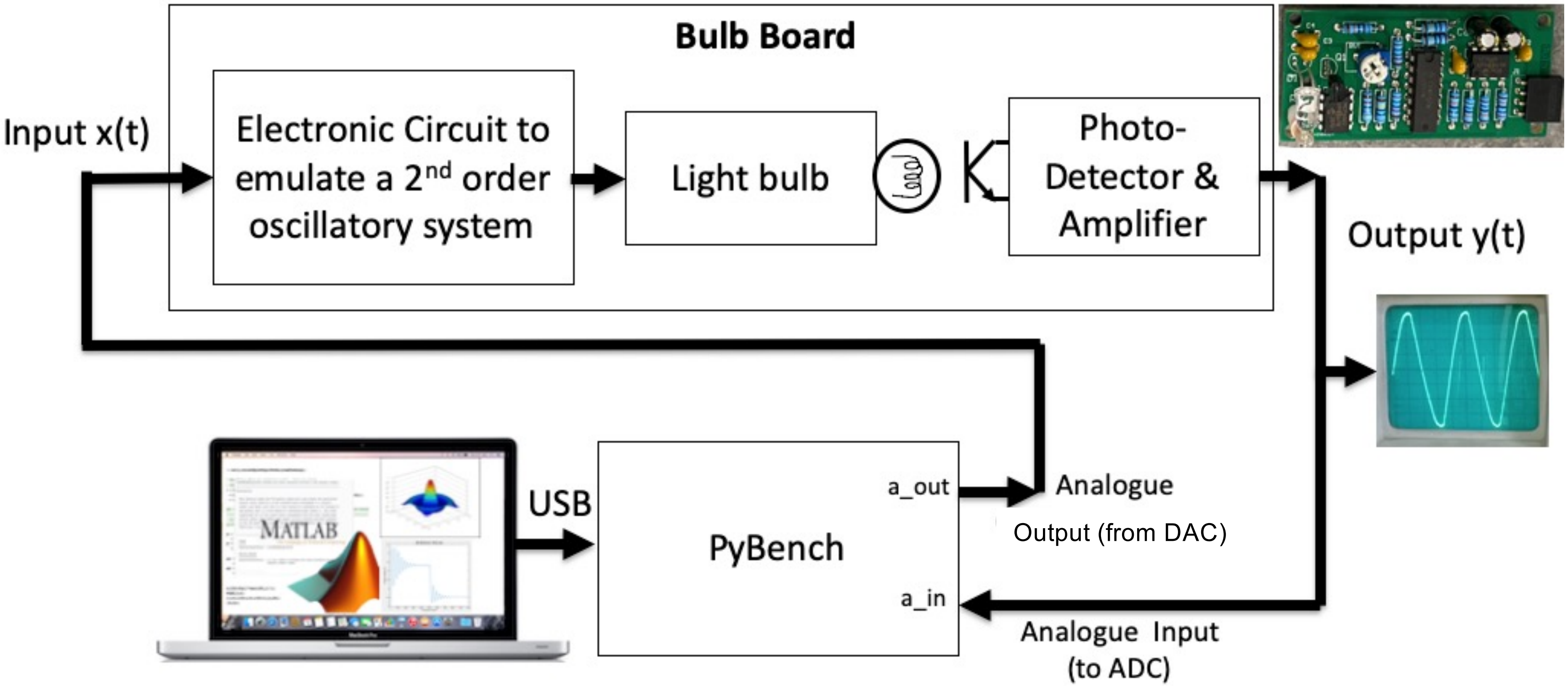
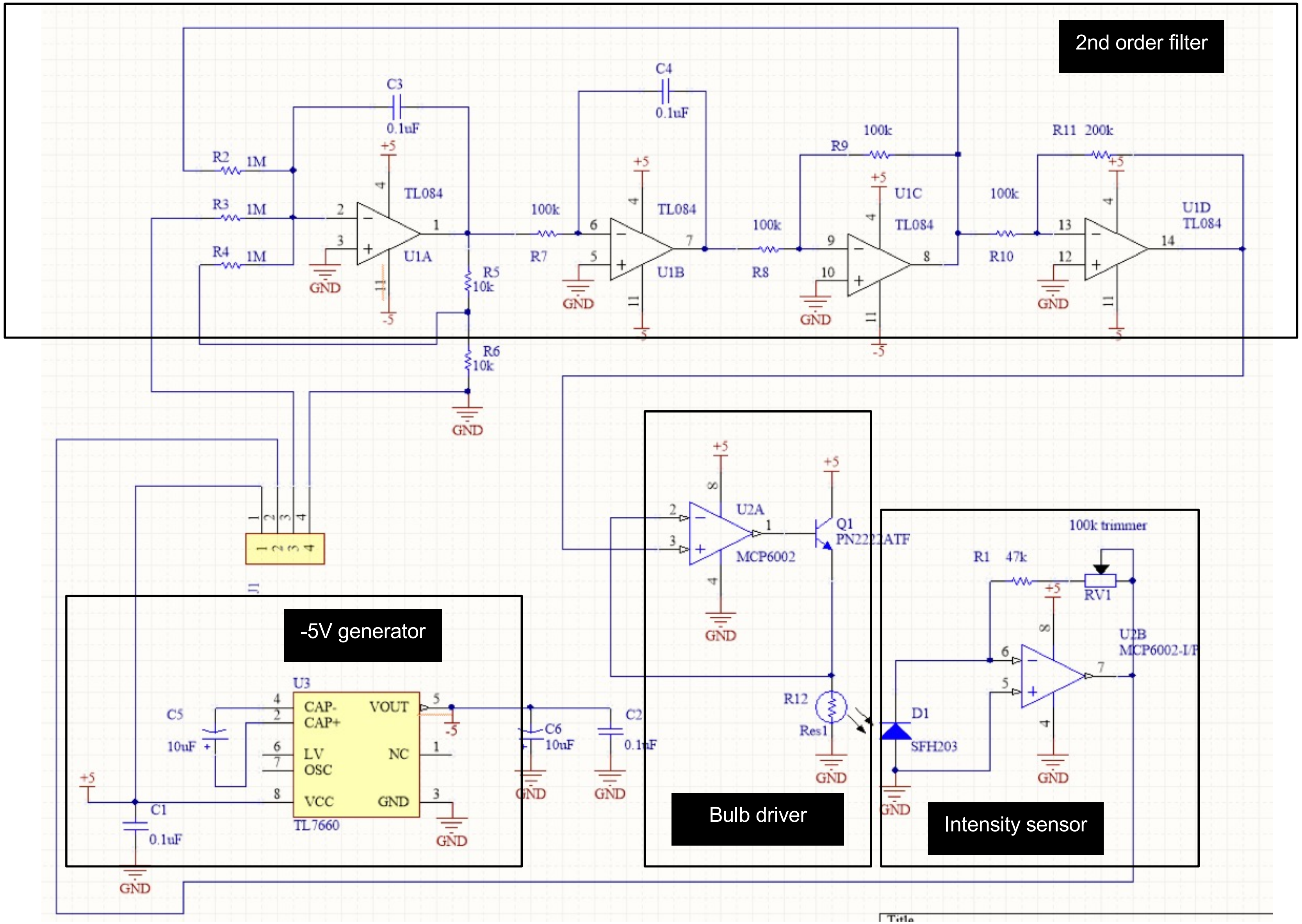
Bulb Board



- We are interested in mathematical modelling system.
- Bulb Board is designed to behave like a 2nd order system + a non-linear system with some delay (the light bulb)
- We want to verify that the mathematical model is a good representation.
- We also want to explore the limitations of this model

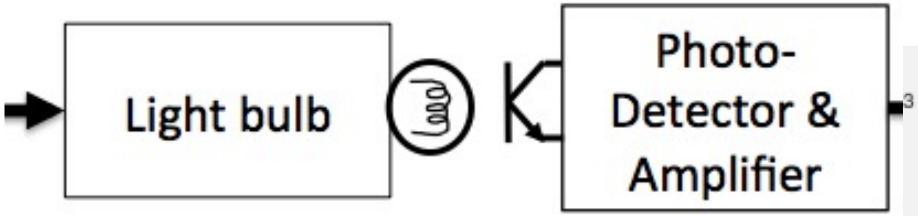
Bulb Board Circuit Schematic



Key aspects of Lab 3

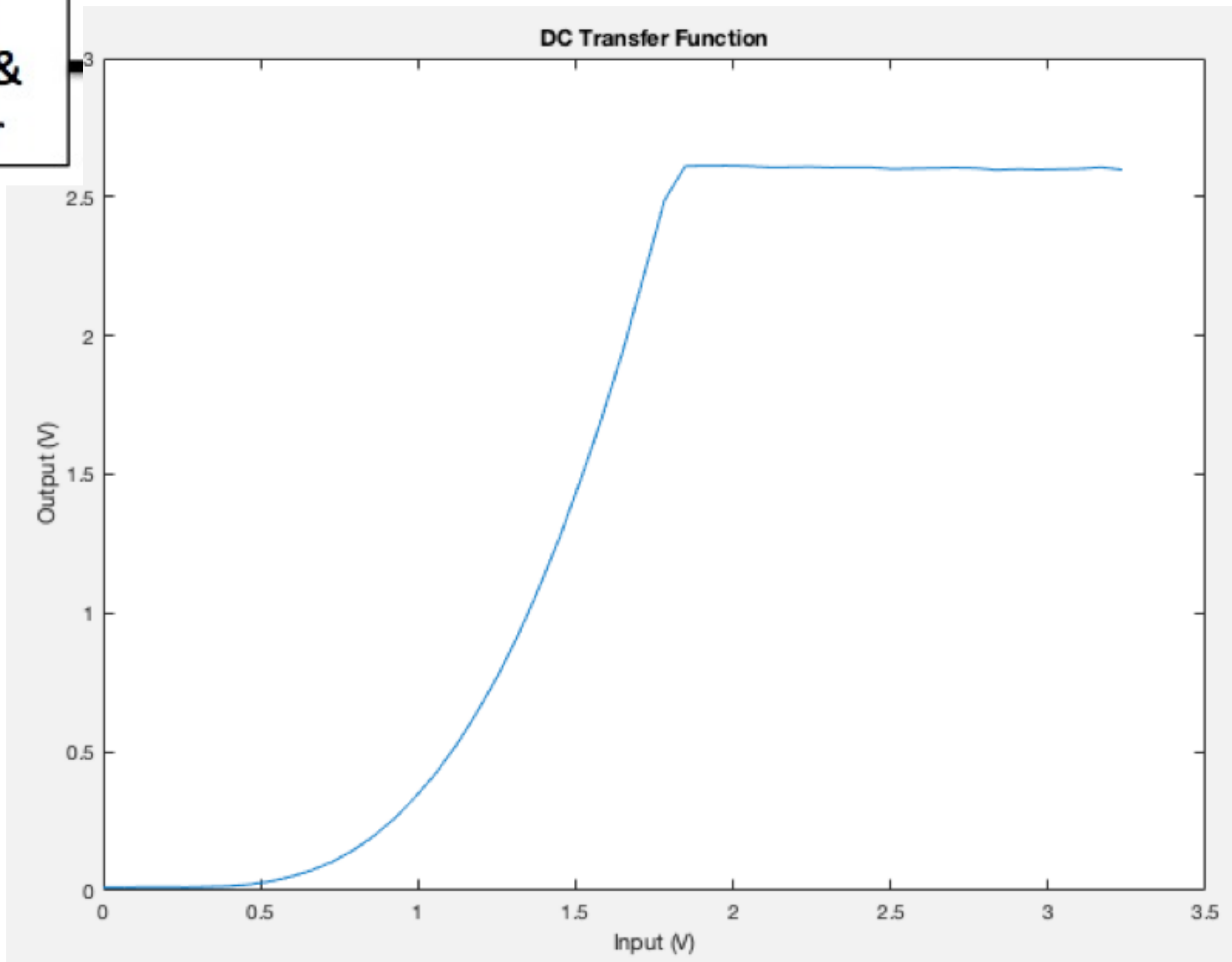
1. DC characteristic – no time variation. Measure light intensities at different drive voltages.
2. Steady state response to sinusoidal signals at different frequencies – we call this **frequency response H(jω)**.
3. Use of Matlab for modelling and simulation using **transfer function** H(s) .
4. Transient behaviour of the system – we call this **step response**.
5. Impact of **non-linearity** in the system.

Task 1 – DC Characteristic



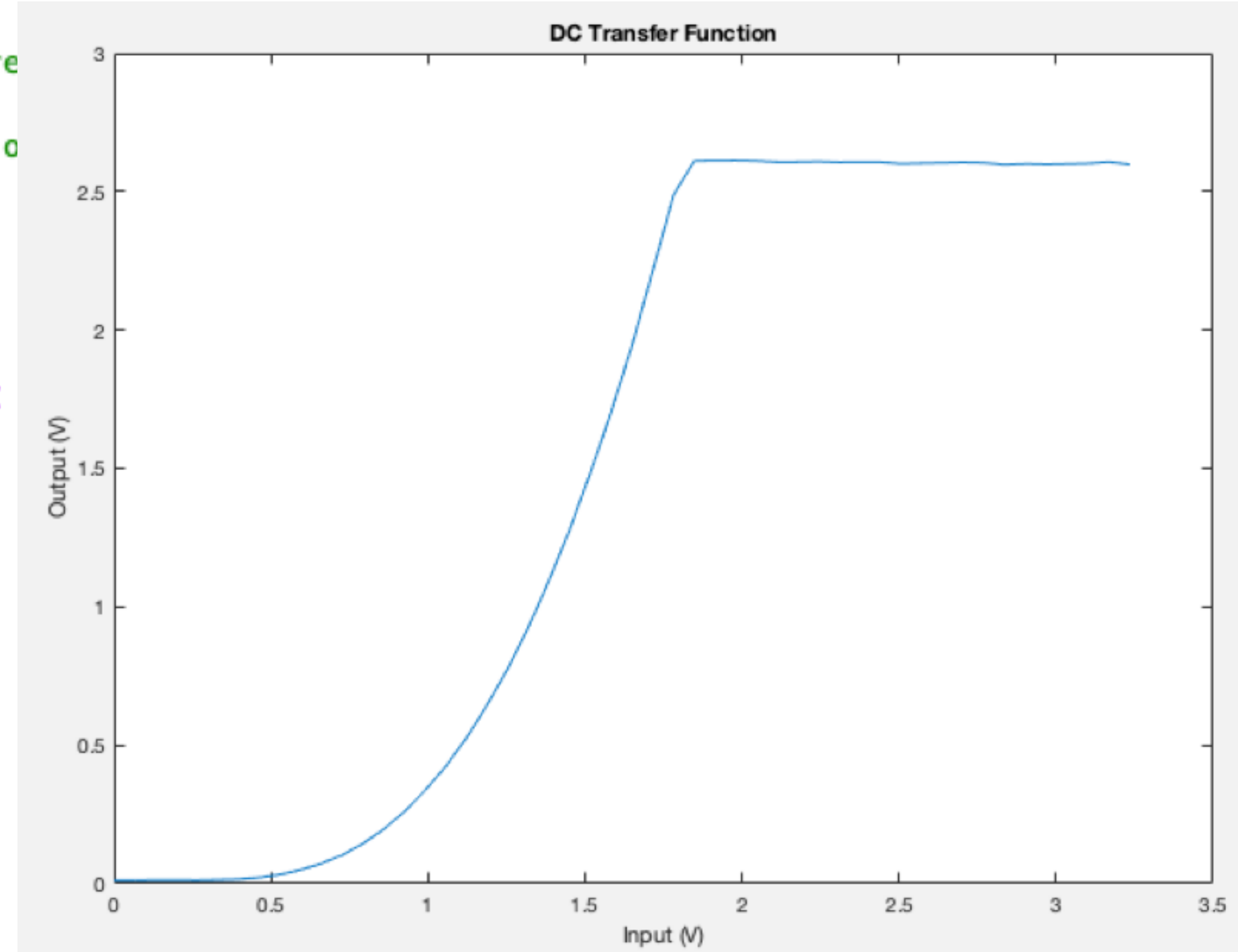
- $y = F(x)$
- F is a non-linear function.
- F is a quadratic function because:

  light intensity $\propto x^2$
- Light is dependent temperature of filament in bulb
- Temperature is dependent on power to bulb
- Power is proportional to x^2.

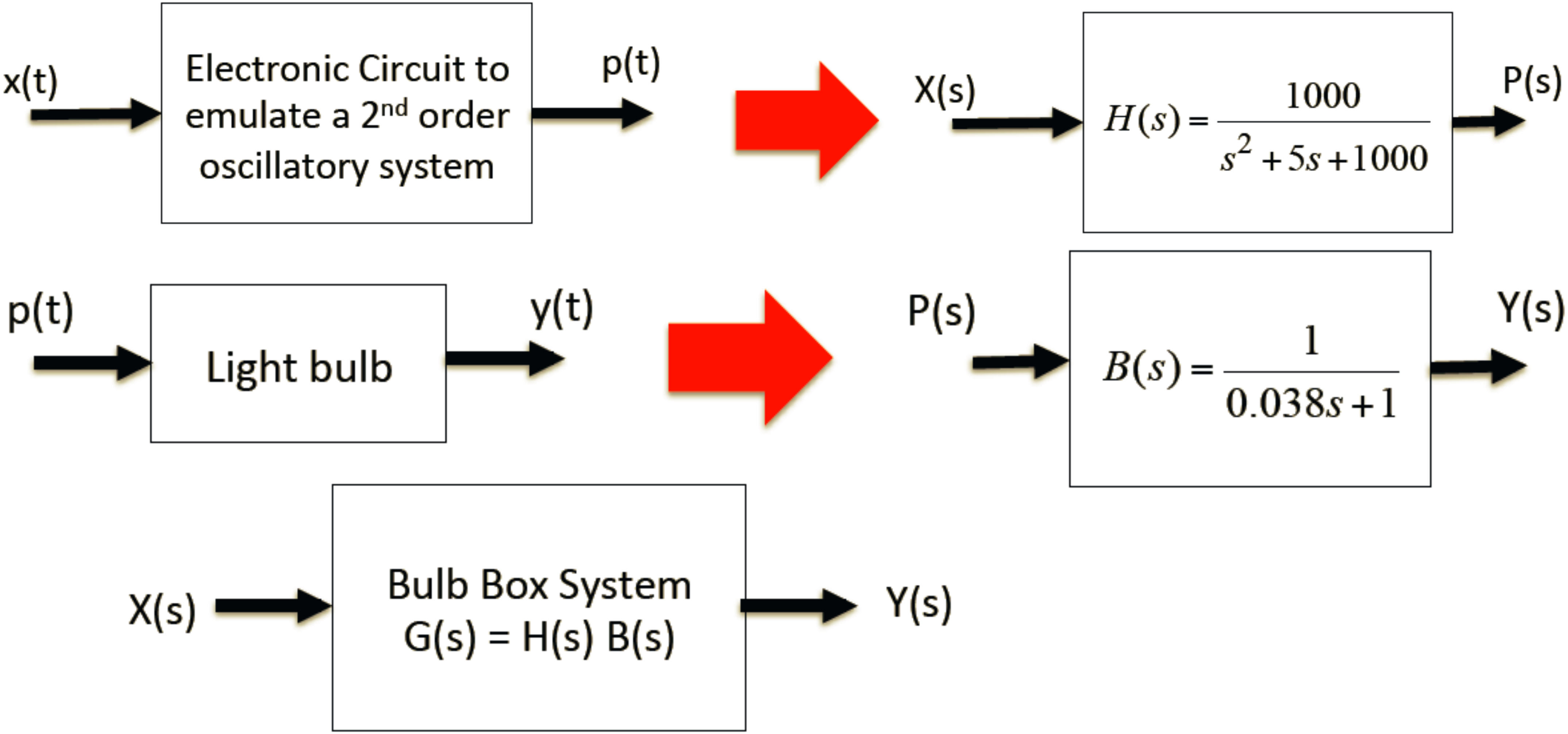


Task 1 – Solution

```
% Lab 3 - Task 1 DC characteristics of the Bulb Boardl
clear all
ports = serialportlist;
pb = PyBench(ports(end));   % cre

%  measure the steady-state DC o
pb.samp_freq = 200;
NSTEPS=50;
input = zeros(NSTEPS,1);
output = zeros(NSTEPS,1);
tic
disp('Sweeping DC output for DC
for i = [1:NSTEPS]
    v = (i-1)*3.3/NSTEPS;
    input(i) = v;
    pb.dc(v);
    pause(0.5);
    data = pb.get_block(10);
    output(i) = mean(data);
end
pb.dc(0.0);
toc
plot(input,output)
xlabel('Input (V)');
ylabel('Output (V)');
title('DC Transfer Function');
fclose(instrfind());
```



Task 2 – Modeling dynamics in a system



$$G(s) = \frac{1000}{0.038s^3 + 1.19s^2 + 43s + 1000}$$

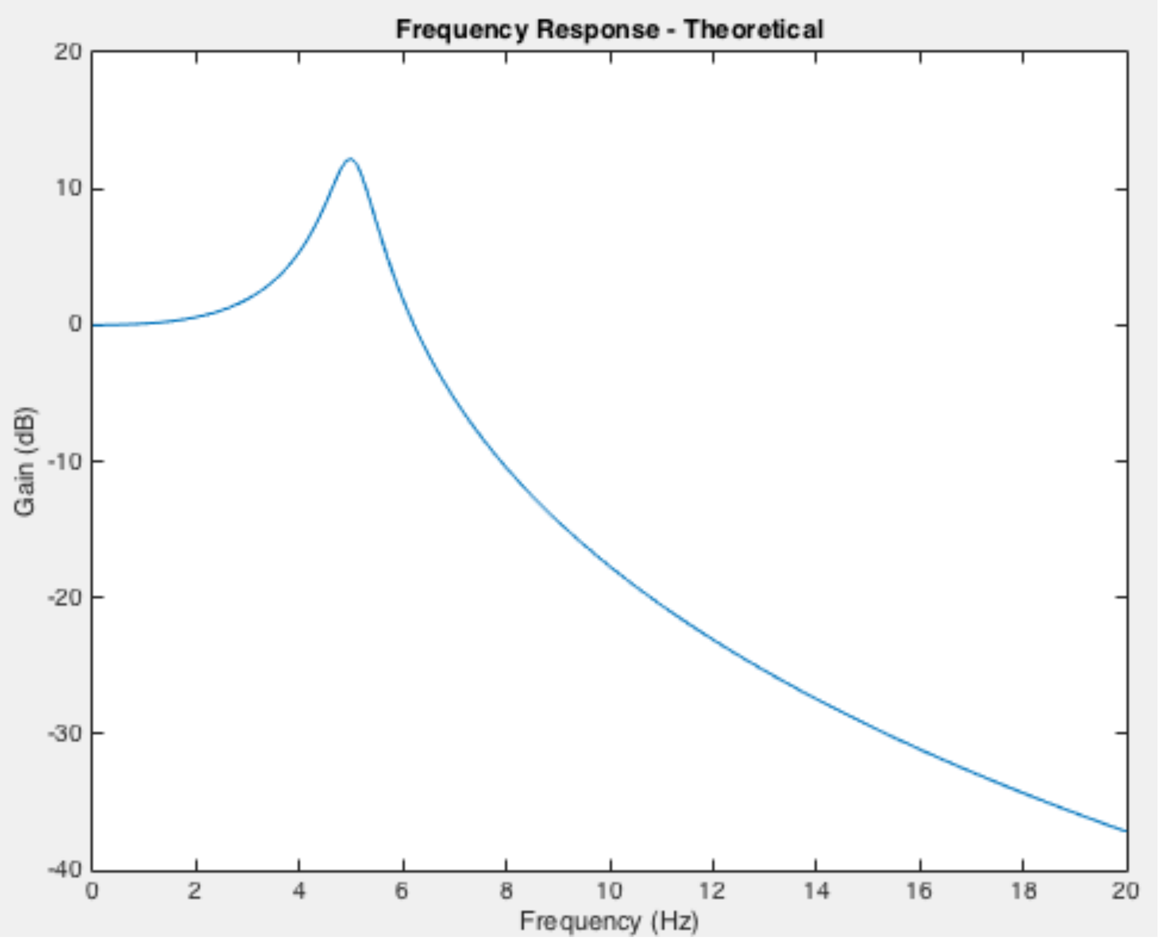
Task 2 – Predict the frequency response

```
% Lab 3 Task 2 - Plot theoretical freq. response of Bu
f = (0:0.1:20);
D = [0.038 1.19 43 1000];    % specify denominator
s = 1i*2*pi*f;                % s = jw (1i is sqrt(-1))
G = 1000./abs(polyval(D,s));  % polynomial evaluation
Gdb = 20*log10(G);           % Gain in dB
figure;
plot(f,Gdb);
xlabel('Frequency (Hz)');
ylabel('Gain (dB)');
title('Frequency Response - Theoretical');
```

$$G(s) = \frac{1000}{0.038s^3 + 1.19s^2 + 43s + 1000}$$

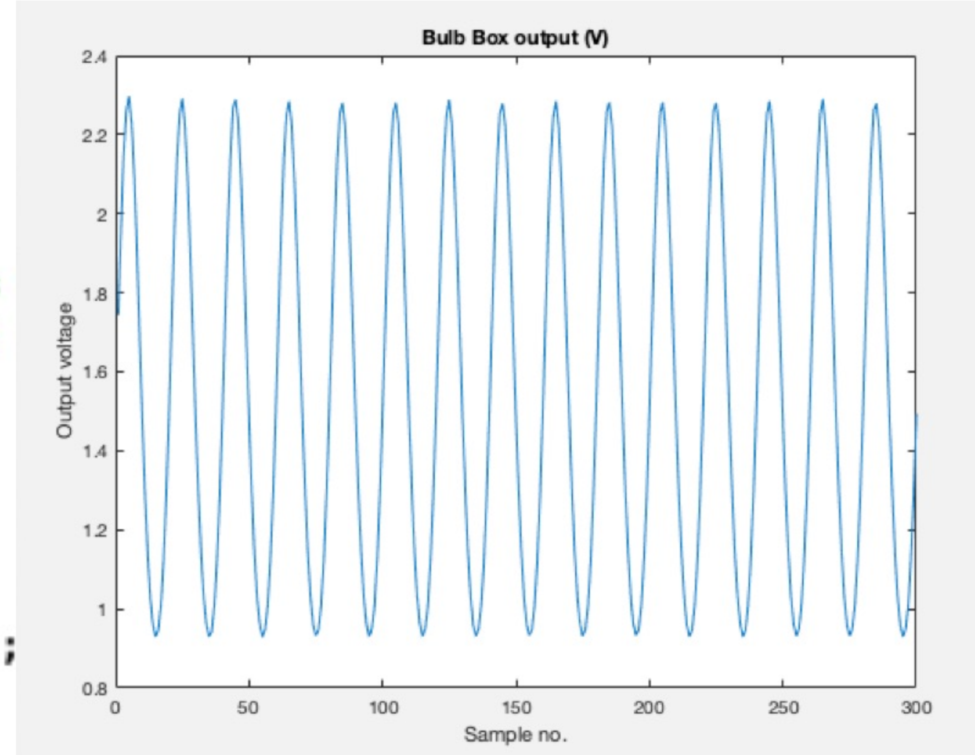
Task 2 – Predict the frequency response

$$G(s) = \frac{1000}{0.038s^3 + 1.19s^2 + 43s + 1000}$$



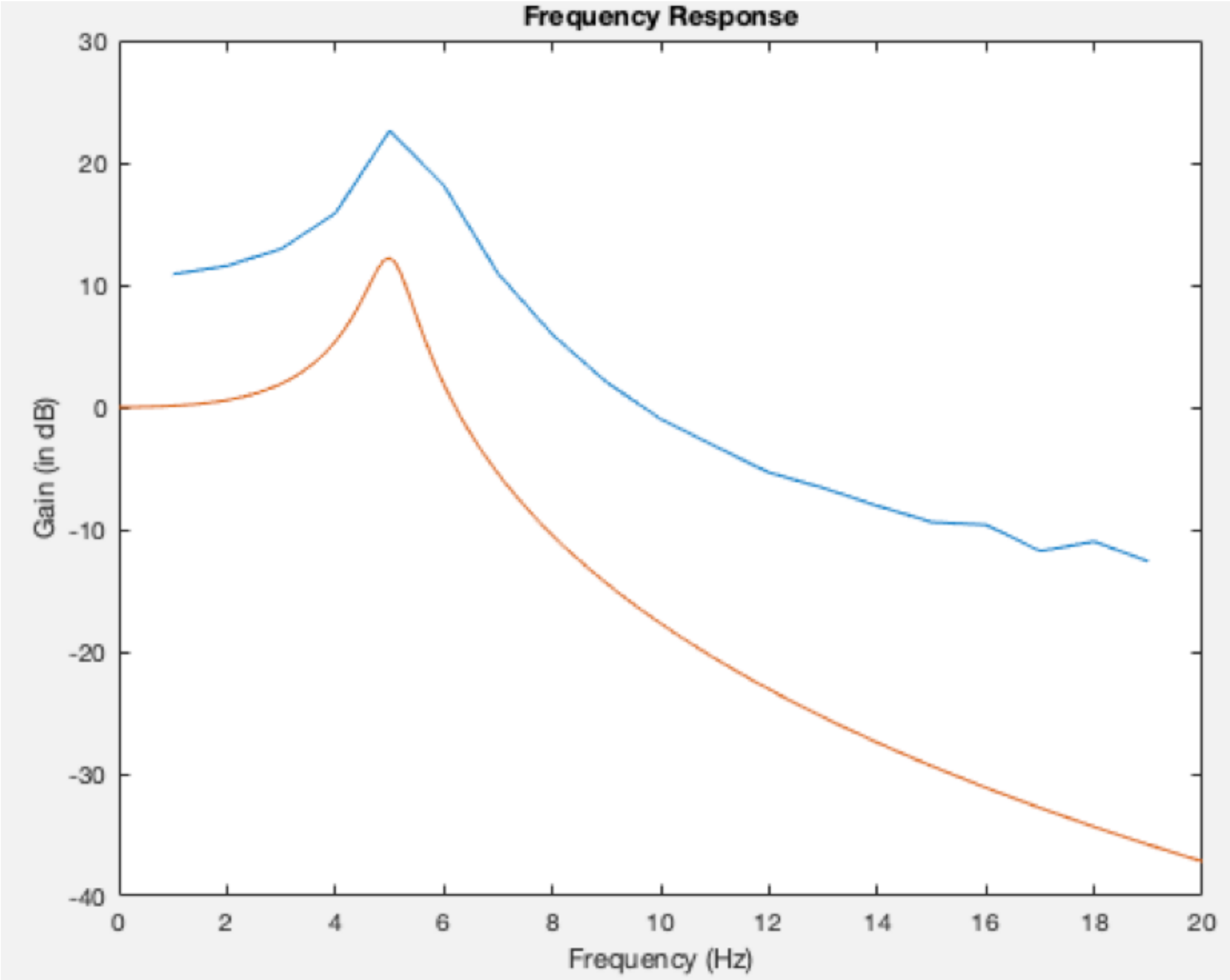
Task 3 – Measure Real Gain at 5Hz

```
% Generate a sine wave at sig_freq Hz
max_x = 1.55;
min_x = 1.45;
f_sig = 5.0;
pb=pb.set_sig_freq(f_sig);
pb=pb.set_max_v(max_x);
pb=pb.set_min_v(min_x);
pb.sine();
pause(2)
% Capture output y(t)
pb=pb.set_samp_freq(100);  %
N = 300;      % no of samples
y = pb.get_block(N);
% plot signal
plot(y);
xlabel('Sample no.');
ylabel('Output voltage');
title('Bulb Box output (V)');
% Compute Gain
x_pk2pk = max_x - min_x;
y_pk2pk = max(y) - min(y);
G = y_pk2pk/x_pk2pk
G_dB = 20*log10(y_pk2pk/x_pk2pk)
```

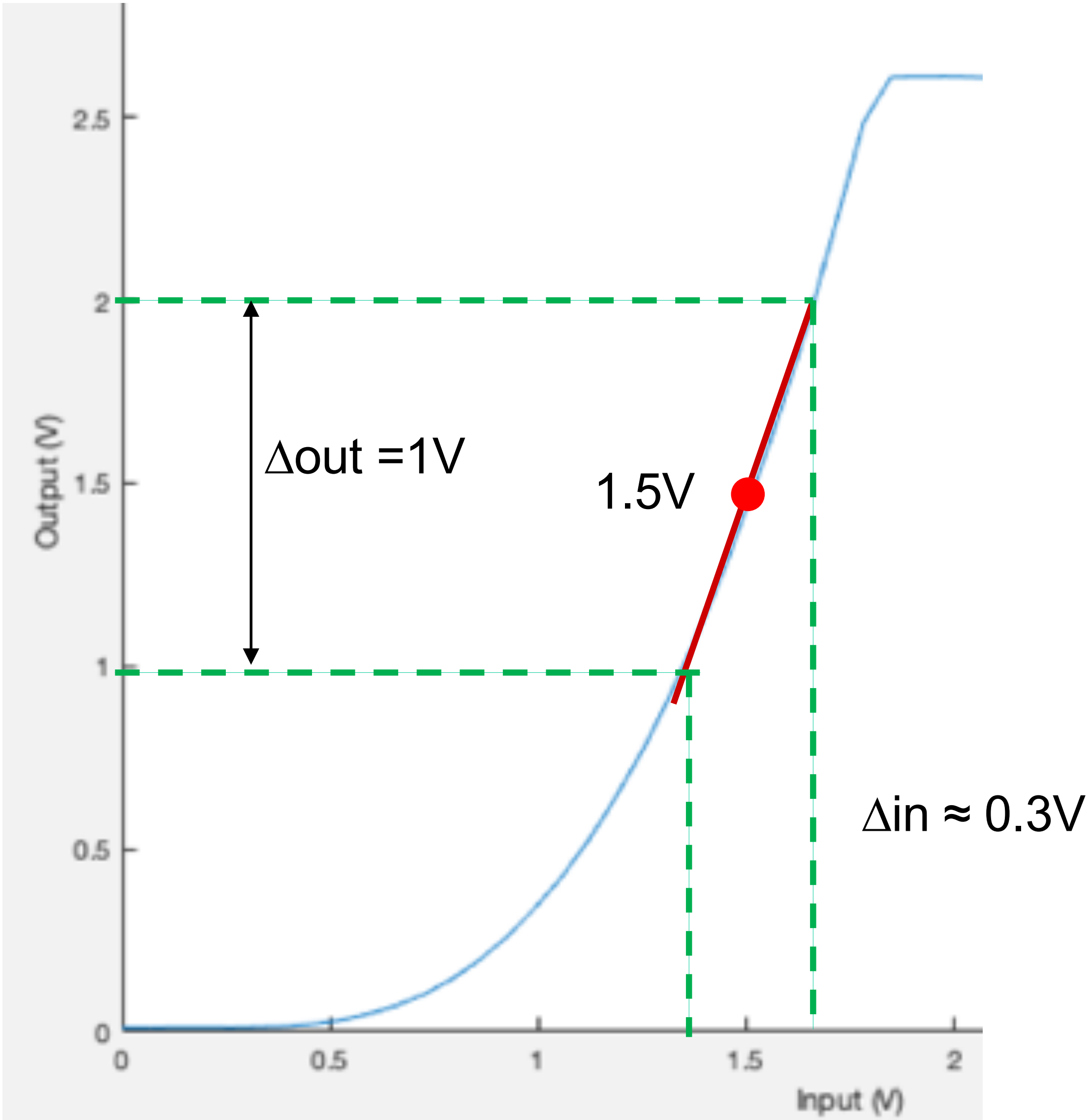



```
G =

   13.6802


G_dB =

   22.7218
```

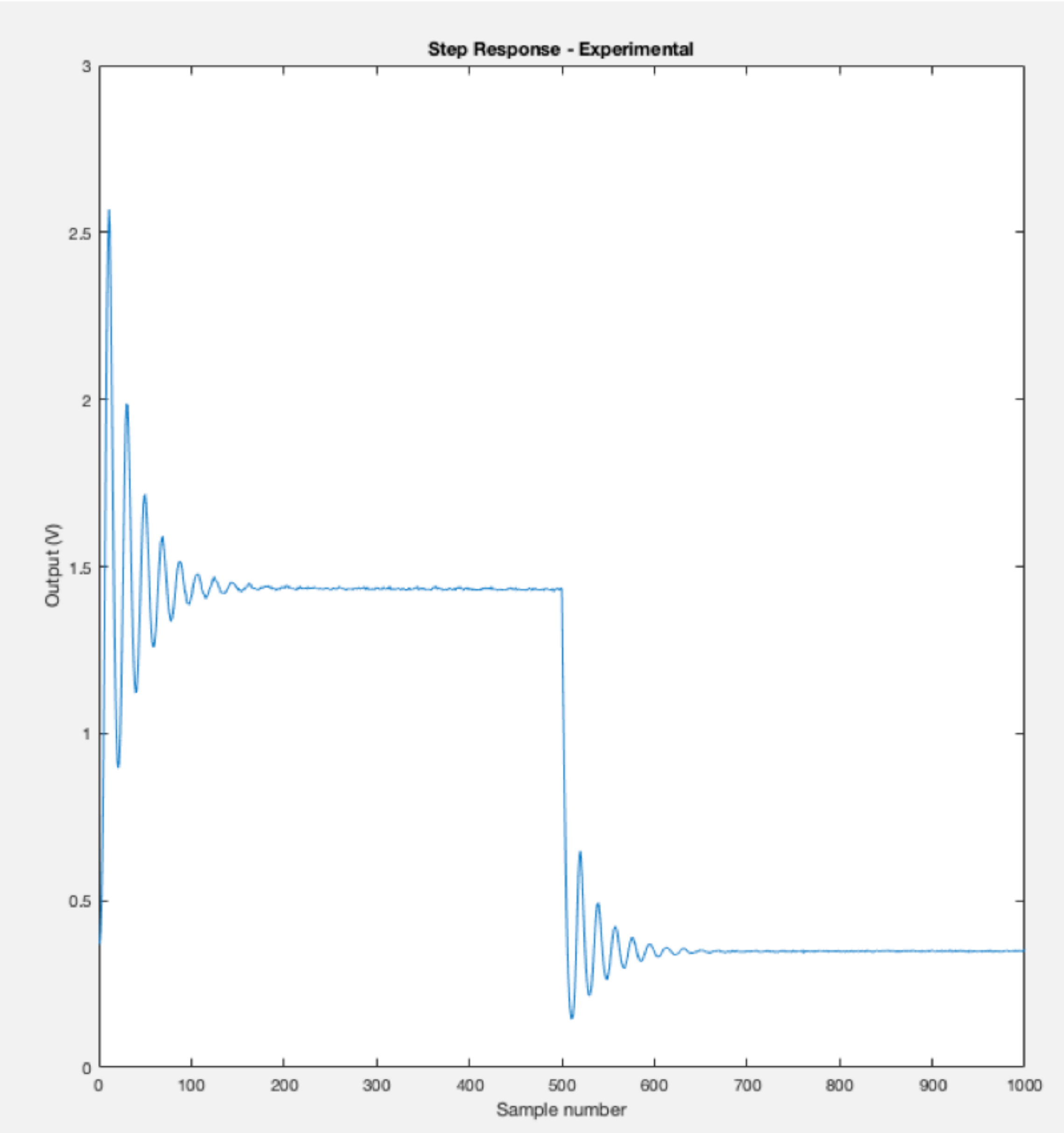
Task 3 – Theory vs Measurements



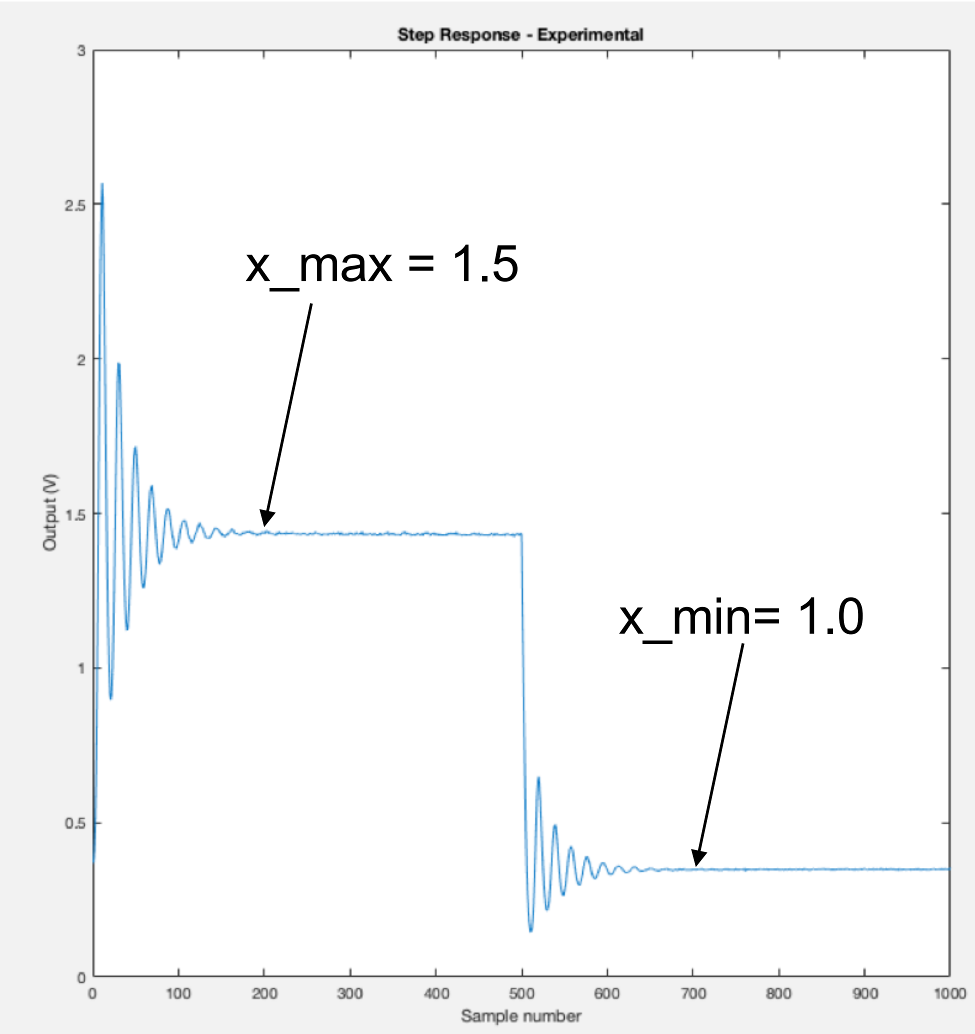
Task 3 – Explain theory vs practice

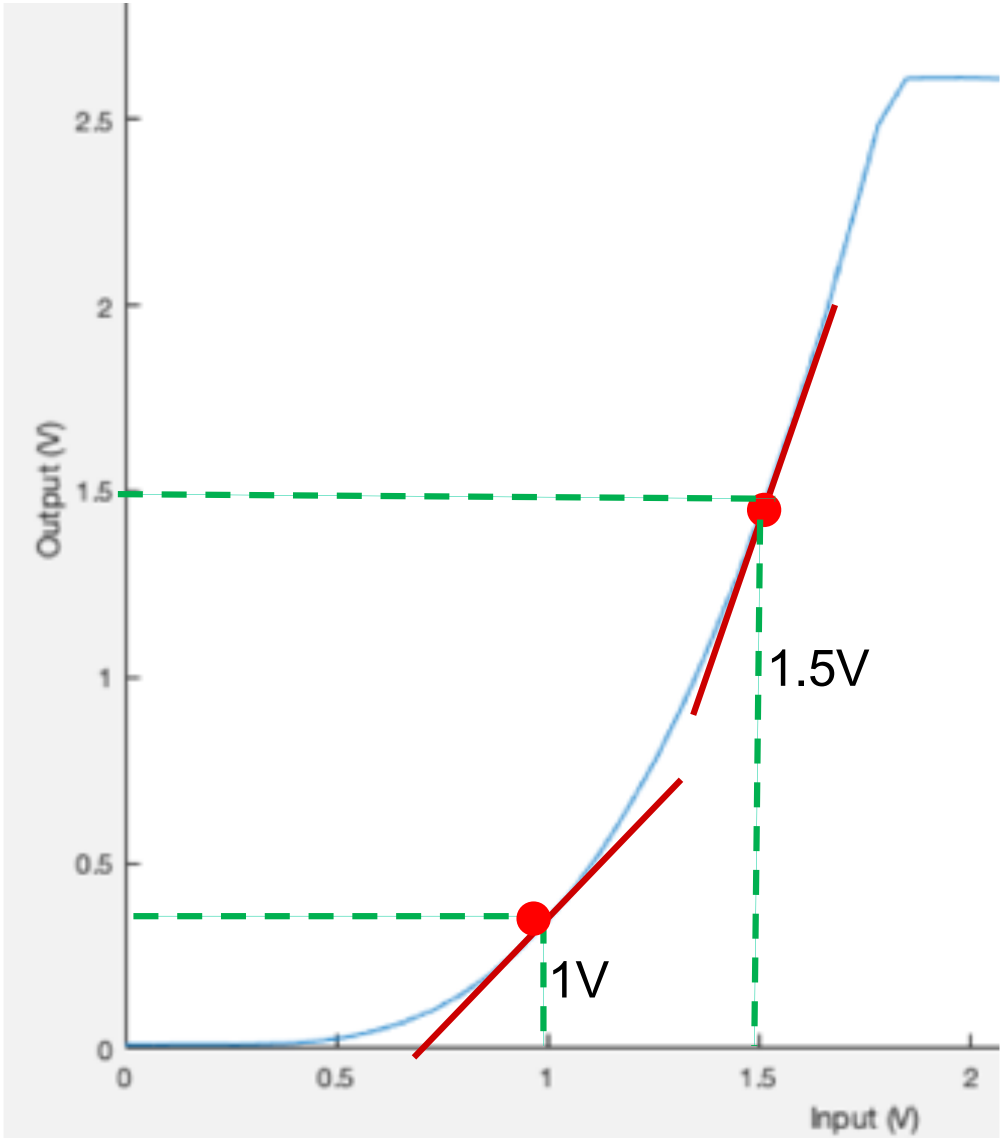


Task 4 – Step Response



Task 4 – Explained





DRAW Week Lab Oral

Performance on the Lab Experiments (put an 'X' on the scale)

1. Logbook Quality and Effectiveness

Highly effective	Effective	OK	Weak	Poor

2. Ability to answer questions from the logbook

Excellent	Good	OK	Poor	Very poor

3. Engagement & effort in completing Lab 1 to 3

Fully engaged Strong evidence	Good engagement Good evidence	Acceptable Engagement	Below expected Engagement	V. poor Engagement

Understanding and Learning Outcomes

4. Explanation on theories behind experiments

Excellent	Good	OK	Poor	Very poor

5. Examiner's opinion on candidate's depth of understanding in general

Broad & deep	Good	Average	Less than average	Poor