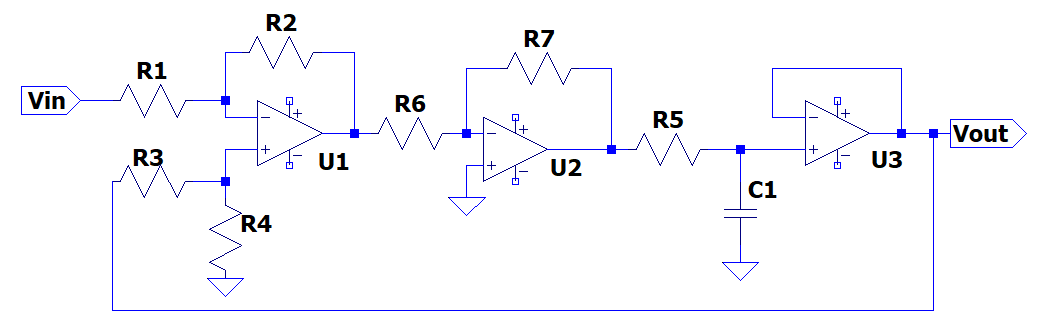
**REPORT**

|  |
| --- |
| **Experiment 1:** **RC circuit with unit feedback** |



5V

5V

-5V

-5V

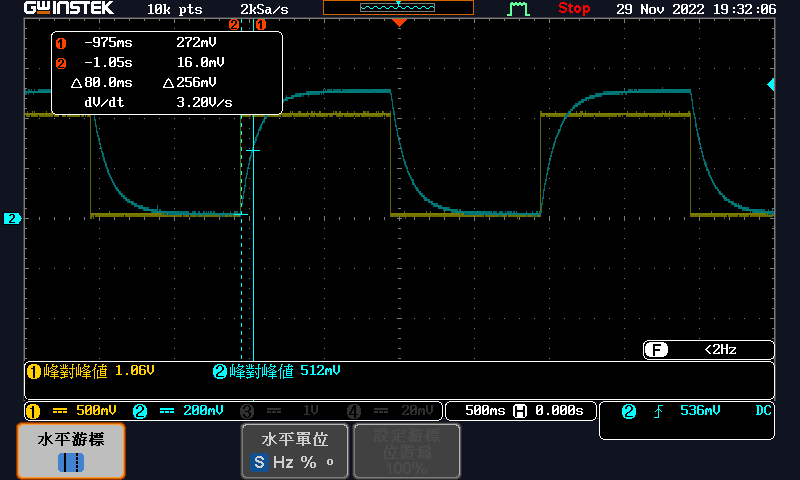
5V

-5V

|  |  |  |  |
| --- | --- | --- | --- |
|  | **rise time** (s) | **delay time** (s) | **steady-state error (V)** |
| **Theoretical Result** |  |  | **0.5** |
| **Experiment Result** | **0.285** | **0.080** | **0.530** |
| **Simulation Result** | **0.2197** | **0.0737** | **0.5000** |

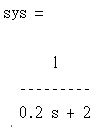
注意事項:請參考投影片第5頁的定義

1. Calculate the **closed loop transfer function**.
2. Vout and Vin waveform (1 pic):

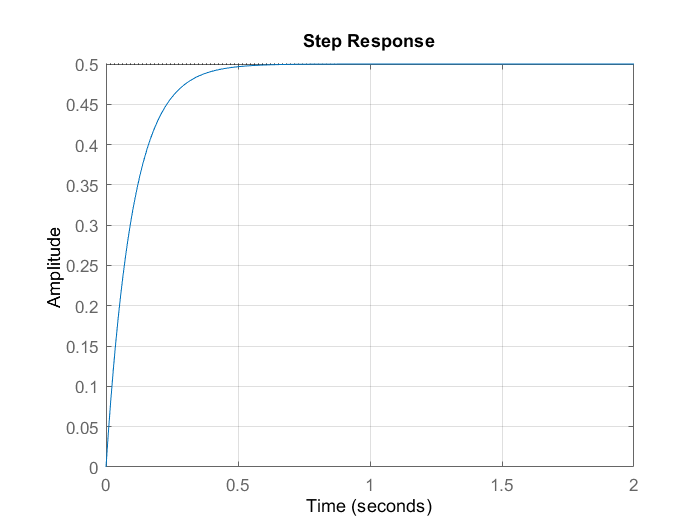


1. Simulation

Closed loop transfer function from command window:



The unit step response(1 pic):



ans =

struct with fields:

RiseTime: 0.2197

SettlingTime: 0.3912

SettlingMin: 0.4523

SettlingMax: 0.5000

Overshoot: 0

Undershoot: 0

Peak: 0.5000

PeakTime: 1.0546

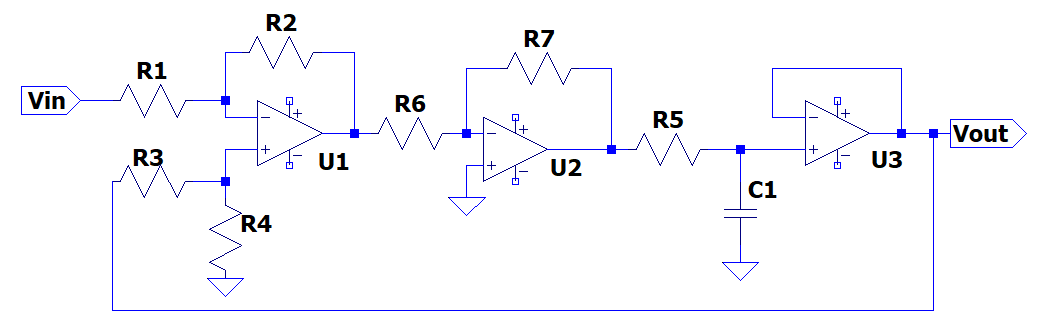
delayTime =

0.0737

sserror =

0.5000

|  |
| --- |
| **Experiment 2: RC circuit with P-controller and unit feedback** |



5V

5V

-5V

-5V

5V

-5V

|  |  |  |  |
| --- | --- | --- | --- |
|  | **rise time** (s) | **delay time** (s) | **steady-state error (V)** |
| **Theoretical Result** |  |  | **0.0909** |
| **Experiment Result** | **0.050** | **0.014** | **0.1** |
| **Simulation Result** | **0.0399** | **0.0134** | **0.0909** |

注意事項:請參考投影片第5頁的定義

1. Calculate and the **closed loop transfer function**.

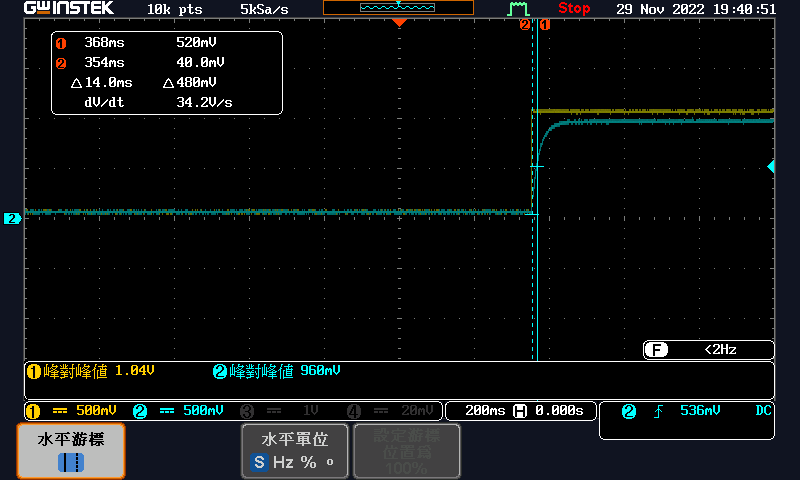
Assume is the output of U1. The relation of input and output of difference amplifier:

Assume is the output of U2. The relation of input and output of inverting amplifier:

Substitute :

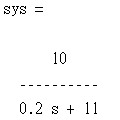
The relation of input and output of plant:

1. Vout and Vin waveform (1 pic):

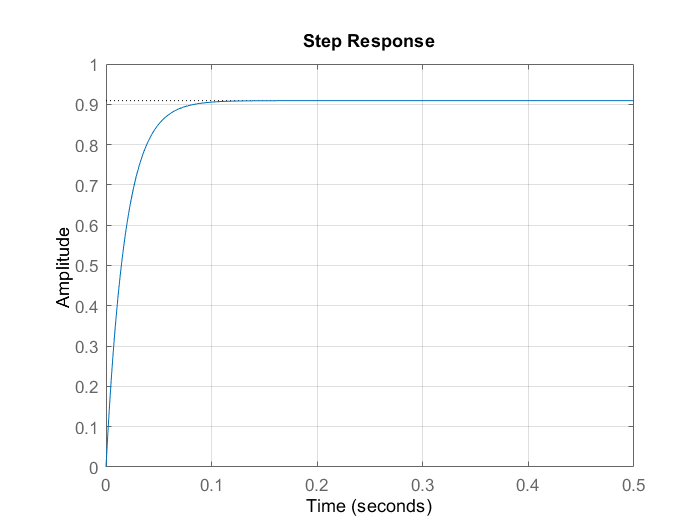


1. Simulation

Closed loop transfer function from command window:



The unit step response(1 pic):



ans =

struct with fields:

RiseTime: 0.0399

SettlingTime: 0.0711

SettlingMin: 0.8223

SettlingMax: 0.9091

Overshoot: 0

Undershoot: 0

Peak: 0.9091

PeakTime: 0.1917

delayTime =

0.0134

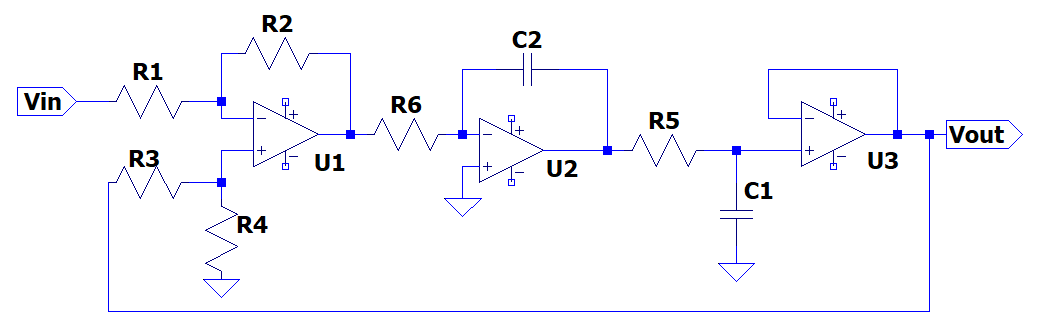
sserror =

0.0909

**Discuss:**  
Try to explain the effect of the gain on the overall system.

Make the response faster and improve the steady state error.

|  |
| --- |
| **Experiment 3: RC circuit with I-controller and unit feedback** |



5V

5V

-5V

-5V

5V

-5V

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Maximum overshoot (%)** | **peak time (s)** | **rise time (s)** | **delay time (s)** | **settling time for 5% (s)** | **steady-state error (V)** |
| **Theoretical Result** |  |  |  |  |  | **0** |
| **Experiment Result** | **52.83** | **0.150** | **0.092** | **0.055** | **1.31** | **0.010** |
| **Simulation Result** | **70.2118** | **0.1405** | **0.0509** | **0.2817** | **1.5630** | **0.0064** |

注意事項:請參考投影片第7頁的定義

1. Calculate and the **closed loop transfer function**.

The output of U1 is equal to

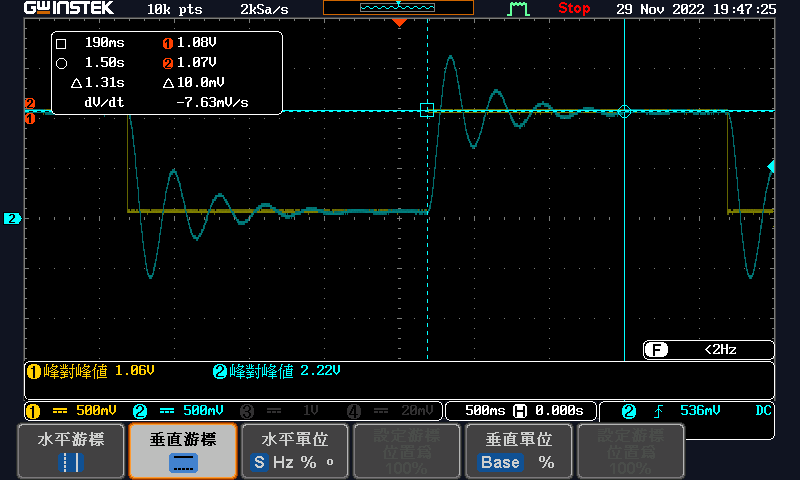
The relationship between and around U2 is

Substitute :

The relationship between and :

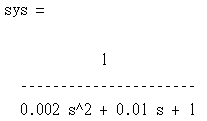
Substitute :

1. Vout and Vin waveform (1 pic):

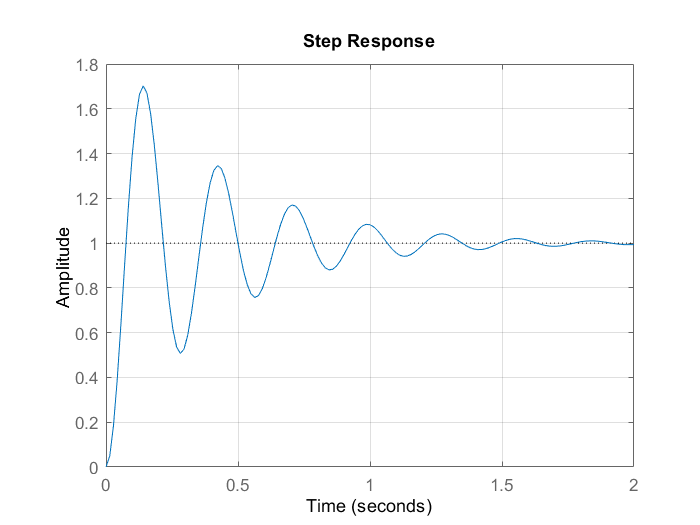


1. Simulation

Closed loop transfer function from command window:



The unit step response(1 pic):



ans =

struct with fields:

RiseTime: 0.0509

SettlingTime: 1.5630

SettlingMin: 0.5072

SettlingMax: 1.7021

Overshoot: 70.2118

Undershoot: 0

Peak: 1.7021

PeakTime: 0.1405

delayTime =

0.2817

sserror =

0.0064

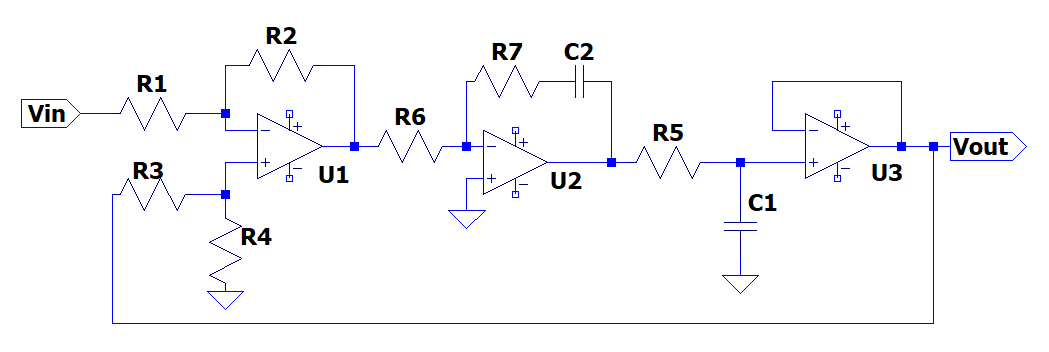
**Discuss:**

Try to explain why the steady-state error is close to zero and the effect of the gain on the overall system.

When the output reach steady state, capacitor C2 will be open circuit because the current through it is approximately 0. Therefore, the steady state error is close to zero.

The effect of the gain is to eliminate the steady state error.

|  |
| --- |
| **Experiment 4: RC circuit with PI-controller and unit feedback** |



5V

5V

-5V

-5V

5V

-5V

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Maximum overshoot (%)** | **peak time (s)** | **rise time (s)** | **delay time (s)** | **settling time for 5% (s)** | **steady-state error (V)** |
| **Theoretical Result** |  |  |  |  |  | **0** |
| **Experiment Result** | **3.774** | **0.085** | **0.070** | **0.019** | **0.198** | **0.004** |
| **Simulation Result** | **4.8838** | **0.0974** | **0.0358** | **0.0127** | **0.2007** | **0.00064794** |

注意事項:請參考投影片第7頁的定義

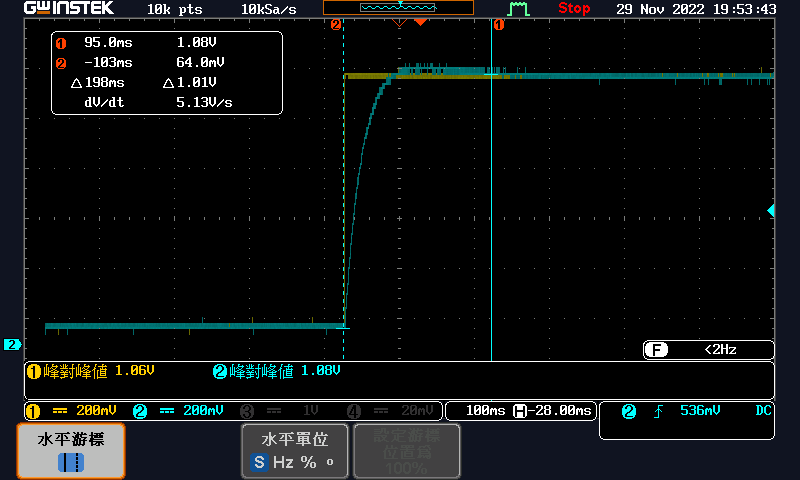
1. Calculate , and the **closed loop transfer function**.

The difference amplifier:

The PI controller:

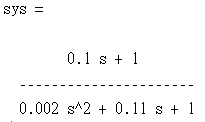
The plant:

1. Vout and Vin waveform (1 pic):

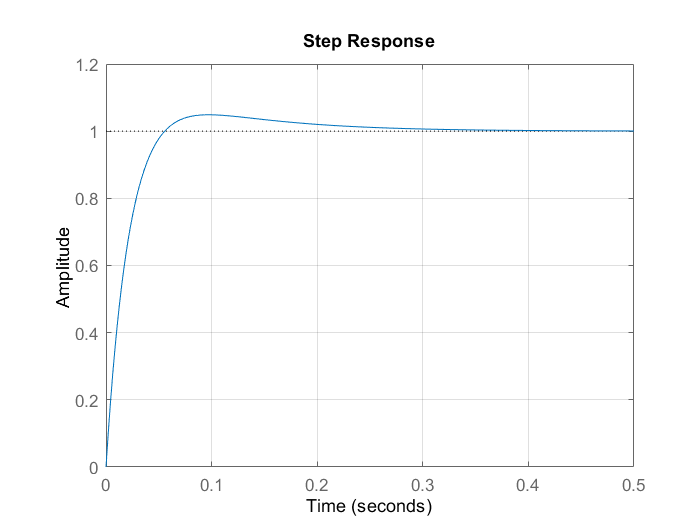


1. Simulation

Closed loop transfer function from command window:



The unit step response(1 pic):



ans =

struct with fields:

RiseTime: 0.0358

SettlingTime: 0.2007

SettlingMin: 0.9017

SettlingMax: 1.0488

Overshoot: 4.8838

Undershoot: 0

Peak: 1.0488

PeakTime: 0.0974

delayTime =

0.0127

sserror =

6.4794e-04

**Discuss:**

Try to explain the effect of PI-controller on the overall system and how to design and .

The PI-controller both the rise time and the steady state errors of the system.

Increasing results in a faster response of the control system. However, an increase in above a certain value can make the system unstable.

Increasing helps in eliminating steady-state error, but increases oscillations and overshoot.