Analog Lab 5:

Experiment2:

First and second order systems

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Class: 電機三全英班

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I. Result

Step 4:

Find the magnification parameter

a	5
b	4.9

$k = \frac{b}{a}$	0.996

Find time parameters (Method 1)

c	116us
$\tau = kc$	115.536us

Find time parameters (Method 2)

$0.632ak$	3.160
τ	90.0us

Transfer function experimental values	Transfer function theoretical value
$T_{real}(s) = \dfrac{k}{\tau s+1} = \dfrac{0.996}{[115*10^{(-6)}]s+1}$	$T(s) = \dfrac{1}{10^{-4}s+1}$

Step 7:

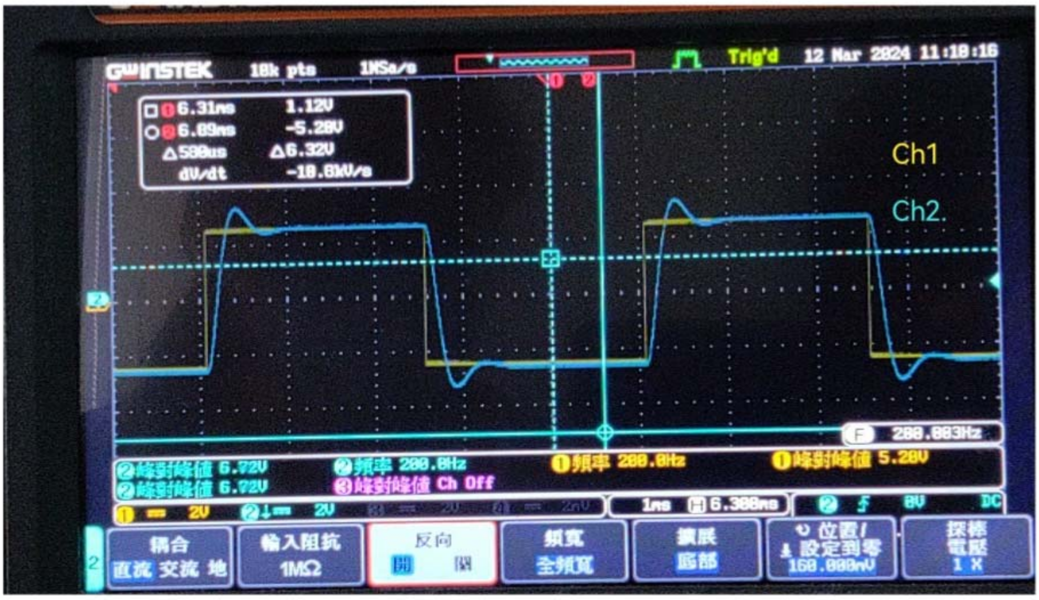

Fig. 2-12

Experimental value		Theoretical value	
a'	5.06V	ζ	0.5
b'	760mV		
$M_p\% = \dfrac{b'}{a'}\times 100\%$	15.02%	$M_p\% = e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}\times 100\%$	16.3%

Table 2-4 percent maximum overshoot

Experimental value		Theoretical value	
t_p	344us	ω_n	10^4
		ζ	0.5

		$t_p = \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}}$	362.76 μs

Table 2-5 the time of maximum overshoot

Experimental value		Theoretical value	
10% 時間 t_{10}	50.0us	ω_n	10^4
90% 時間 t_{90}	206us	ζ	0.5
$t_r = \lvert t_{90} - t_{10} \rvert$	156us	$t_r \simeq \dfrac{1-0.4167\zeta+2.917\zeta^2}{\omega_n}$ sec	152.09 μs

Table 2-6 rise time

Experimental value		Theoretical value	
$a' \times 105\%$	5.313	ω_n	10^4
$a' \times 95\%$	4.807	ζ	0.5
t_s	625us	$t_s \simeq \dfrac{-1}{\zeta\omega_n}\ln(0.05\sqrt{1-\zeta^2})$ sec	627.915 μs

Table 2-7 settling time 穩態到5%.

II. Questions and Discussion:

(1) Briefly describe the advantages and disadvantages of negative feedback in control systems.

Advantages: Negative feedback improves stability, reduces distortion, and enhances accuracy in control systems by correcting errors and maintaining desired performance.

Disadvantages: However, excessive negative feedback can slow system response, increase complexity, and introduce noise or oscillations, impacting overall performance and responsiveness.

(2) How is the $-10^4/s$ block diagram in Figure 2-13 generated? Try to calculate it.

The transfer function of first order system is:
$T(s) = Y(s)/U(s) = k/(\tau+1)$
For the magnification parameter k=1, and time parameter $\tau=10^{(-4)}$ second, we can get
$T(s)=1/(10^{(-4)}*s+1)=10^4/(s+10^4)=(10^4/s)/(1+10^4/s)$
Hence there is a $-10^4/s$ block in the diagram.

(3) As shown in Figure 2-13, the dotted circle area includes a convergence point of two signals and a -1 function block diagram. This internship is based on which application of OPA in internship 1 to implement the circuit? Try to explain it.

The -1 block suggests an inversion operation of OPAs that represent an inverting amplifier configuration. In an inverting amplifier, the output signal is phase-shifted by 180 degrees compared to the input signal and its magnitude is determined by the feedback resistors connected to the OPA.

(4) Please write down your experimental experience of this internship and your suggestions or improvements to the content of this internship.

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This electrical engineering experiment provided me with a deeper understanding of the resistor-capacitor (RC) inverting amplifier and first-order and second-order circuits. The experiment's complexity lay not in the circuit itself, but rather in the meticulous calculation of various parameters and precise measurements using an oscilloscope. Despite encountering significant data errors at times, I learned invaluable lessons in coping with complex circuit designs and optimizing experimental techniques to minimize errors. This experiment proved to be a valuable learning experience, enhancing my comprehension of circuit design and measurement techniques.

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The experiment exploring first and second-order system circuits with operational amplifiers was a practical journey into understanding transient response dynamics. By measuring overshoot and rising time, particularly focusing on underdamped outputs, we gained valuable insights into circuit performance. Overshoot measurements revealed the system's stability and response to input stimuli, guiding us in designing circuits with optimal transient characteristics. Utilizing the oscilloscope's cursor function to analyze rising time provided further understanding of how quickly the circuits responded to changes in input signals. This hands-on experience underscored the practical relevance of theoretical concepts like damping ratio and natural frequency, enhancing our ability to design and optimize electronic circuits for real-world applications. Overall, the experiment served as a vital bridge between theory and practice, equipping us with essential skills for effective circuit design and analysis.