**深 圳 大 学 实 验 报 告**

**课程名称：­ 信号与系统**

**实验名称： 信号的卷积实验**

**学 院： 电子与信息工程学院**

**专 业： 电子信息工程**

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| 一、Experiment purpose and requirement：   1. Master the convolution of signals. 2. Master the convolutional relationship between the input, unit impulse response and output of the system. 3. Through observation experiments, the understanding of theoretical calculation and practical convolution process is deepened 4. Design and implement software experiments: Use MATLAB programming language to design and implement the experiment for signal convolution. The input signal should be a periodic square wave signal, and the impulse response signal should be the impulse response of the RC circuit. |
| 二、Experimental apparatus   1. One ELF-BOX experiment box (motherboard). 2. A computer. 3. One piece of linear system integrated experiment module. 4. Several wires. 5. 5. Oscilloscope RIGOL DS1102E. |
| 三、Experimental principle  Examine the RC integrated circuit below: From the circuit analysis, it can be seen that the voltage at both ends of the capacitor is:    Figure 2-1 The RC integrated circuit  Where e(t) is the input signal of the system, Vc(t) is the output signal of the system, VC(0-) is the initial voltage at both ends of the capacitor C, also known as the initial state of the system. If VC(0-)=0, then the above formula is:  Obviously, the above circuit system is equivalent to the following LTI system, where x(t)= e(t)u(t), y(t)= Vc(t),  is the unit impulse response of the system.  *x*(*t*) *y*(*t*)  The input and output conform to the convolution operation: |
| 四、Experimental process   1. Plug the 220V power cord into the socket, plug in the USB printer cable to the motherboard, and then turn on the power switch of the ELF-box, the switch indicator light turns red, and the indicator light on the BOX also turns red, and then you will see the ELF BOX perform a self-test program. It can only be used normally after the self-check is completed. 2. there are five nodes on the mainboard are dedicated power ports, from left to right are +12v, -12v, GND, -5v, +5v. See Figure 2-2.:     **+12V**  **-12V**  **GND**  **-5V**  **+5V**  Figure 2-2 The power jack on the motherboard  The module uses positive and negative 12V and ground, the power interface of the module corresponds to one by one, and the linear system integrated experiment module is plugged into the main board. Insert the module in accordance with the hole alignment, and press the module with both hands until the terminal and the hole of the test box are fully in contact. If the insert is not in place, gently press with your hand until you can barely see the metal part.   1. As shown in Figure 2-3, connect the 2.2K resistance of the "Linear System Integrated Experiment Module" and the capacitor marked 103. As shown in Figure 2-3, the other end of the capacitor is grounded (as shown in black), and the other end of the resistor is connected to input 1 (as shown in red). Resistors and capacitors common nodes lead out to output 1 (as shown by the yellow line).     Figure 2-3 Module wiring diagram   1. Double-click the software icon of the experimental platform on the computer desktop, open the software interface, set the serial port, and click "Start scanning", then the linear comprehensive experimental system module will be displayed in the specified position, as shown in Figure 2-4.     Figure 2-4 Main interface of convolutional experiment software   1. Click Stop scanning, connect signal source 1 to module inpuT-1 on the computer software, and connect signal source 1 to oscilloscope channel 2 to observe INPUT and output waveforms at the same time. OUT-1 and oscilloscope channel 1 are connected. After confirming that the template circuit connection is correct, click POWER OFF to make the connection effective. Then click the oscilloscope icon in the upper left corner to enter the interface of signal generator and oscilloscope.     Figure 2-5 Circuit diagram after the mainboard is powered on   1. Open the oscilloscope interface. Click the "Run" button in this interface. Call out the two channels display, respectively observe the output signal corresponding to the high level period of the input signal. (Note that the baselines of C1 and C2 coincide with the level of 0V.)     Figure 2-6 oscilloscope display screen   1. Change the frequency and amplitude of the signal generator and observe the corresponding output signal. 2. The input signal is set to sine wave and triangle wave respectively, and the output signal is observed. 3. By changing the different resistance access in this experiment, the output signals under different systems are observed, and the output signals of the two systems are compared when the input signals are square wave, sine wave and triangle wave respectively. 4. The output and input signal waveforms can be displayed with realistic oscilloscope. The similarities and differences of virtual and real output waveforms are observed and analyzed. 5. When removing the module after the experiment is complete, click "power-off" to Power off, remove -12V, +12V, -5V, +5V, and finally click "Reset" button. When the main interface of the software is shown in Figure 2-7, the module can be removed, otherwise the main board of the experiment box will be short-circuited. |
| 五、Experimental results and analyse  1. Observe the convolution signals at different frequencies and amplitudes of square wave input signals    Figure 2-7 square wave 1V 10kHz    Figure 2-8 square wave 2V 10kHz    Figure 2-9 square wave 1V 1kHz    Figure 2-10 square wave 1V 5kHz  Analysis :  It can be observed that when the frequency of the input signal is low, the convolutional signal is relatively flat, and even tends to be flat for a long period of time, reaching the maximum value of the input signal. However, as the frequency of the input signal increases, the convolutional signal becomes steeper and falls before reaching its maximum.  2. The input signal is set to sine wave and triangle wave respectively, and the output signal is observed.    Figure 2-11 Sinusoidal signal 5kHz and 1V    Figure 2-12 Sinusoidal signal 2kHz and 1V    Figure 2-13 Triangle wave signal 5kHz and 1V    Figure 2-14 Triangle wave signal 2kHz and 1V  Analysis :  By observing the convolution results under the input of square wave signal, triangle wave signal and sinusoidal signal, we can find that from the flatness of convolution signal, sinusoidal signal is the softest, followed by triangle wave and square wave, which is consistent with the characteristics of their signals. In other words, the results of the convolution signal under the sinusoidal signal are most similar to the sinusoidal signal  3.By changing the different resistance access in this experiment, the output signals under different systems are observed, and the output signals of the two systems are compared when the input signals are square wave, sine wave and triangle wave respectively.    Figure 2-15 square wave 1V 5kHz (10kΩ)    Figure 2-16 square wave 1V 5kHz (2.2kΩ)    Figure 2-17 Sinusoidal signal 5kHz and 1V(2.2kΩ)    Figure 2-18 Sinusoidal signal 5kHz and 1V(10kΩ)    Figure 2-19 Triangle wave signal 5kHz and 1V(2.2kΩ)    Figure 2-20Triangle wave signal 5kHz and 1V(10kΩ)  Analysis :  By observing the results of the convolution signal under different resistance values, controlling for other variables being equal, we find that the larger the resistance value, the larger the RC, the larger the time constant, the more difficult it is for the convolution signal to reach its maximum value, that is, it will be closer to the X-axis, the amplitude will be smaller, and it will look more gentle, tending to a horizontal line.  4. The output and input signal waveforms can be displayed with realistic oscilloscope    Square wave signal under reality oscilloscope 1V and 5kHz    Square wave signal under reality oscilloscope 1V and 5kHz    The convolutional signal graph obtained by matlab theoretical calculation  Analysis:  It can be observed that the results of the theoretical calculation and the actual oscilloscope display are roughly the same, the two have a fairly high agreement, but there are some small differences, such as the degree of smoothness of the two, considering the idealization of matlab simulation calculation, these errors can be ignored |
| 六、Experimental conclusion  In the experiment, we first connected the experimental equipment according to the steps of the experimental instructions, and successfully set the experimental parameters through the software. We observe the effects of square-wave input signals of different frequencies and amplifiers on convolution signals. We find that when the input frequency is low, the convolution signal tends to be flat, while the ascending edge of the convolution signal becomes steeper with the increase of frequency. (For a more specific statement, see the analysis section)  In addition, we also test sine wave and triangular wave input signals, and find that the shape of the convolution signal is closely related to the characteristics of the input signal, among which the sine wave signal generates the smoothest convolution signal.  We also investigate the influence of different resistance values on the output signal of the system, and find that the rise time of the convolution signal will be longer, the amplitude of the signal will be reduced, and the overall shape will be smoother. This finding is consistent with the theoretical expectation that the time constant of an RC circuit is proportional to the product of resistance and capacitance.  By comparing the MATLAB theoretical calculation with the actual oscilloscope output, we find that the results of the two have a high consistency. Although there are some small differences, such as the smoothness of the signal, these differences are negligible under the idealized conditions of MATLAB simulation calculations. |
| 七、指导教师批阅意见：  成绩评定：  指导老师签名：  年 月 日 |