DSP Homework 06

Li, Wentao 1

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Contents

Abstract

Understand how to use electromagnetic wave to transmit information between devices, further deepen their understanding of the shared folder project; Through the further understanding of Nyquist sampling, we learn the sampling method of rising cosine function.

1 Thoughts on the video

1.1 How Bluetooth Works

1.1.1 Short summary

In the video, the author compares the data exchange between a mobile phone and Bluetooth to the traffic light signal when we are crossing the street. First of all, we know that the signal between the two is represented by electromagnetic waves of specified frequency to represent "0" and "1". In the previous audio coding video, we have learned how these binary codes encode information into binary codes. Mobile phones and headphones can understand these binary codes and output the information. Binary code of the communication between mobile phone and headset electromagnetic wave frequency in the range of 2.4835 to 2.4 Ghz, in order to satisfy the different devices in a complex electromagnetic environment can accurately to connect to the target device and information transmission, electromagnetic spectrum is divided into 79 different partitions, also known as channel, on every channel, There are certain frequencies for "1" and "0".

At any given time, your devices are only communicating over one channel. Each time they send a signal, they package the information into a packet. This packet contains an access code for synchronization between devices, and a header that describes part of the body of the packet, followed by the body of the packet. The device switches between 79 channels continuously, which prevents eavesdropping by others. At the same time, because our data is transmitted in the form of packets, if the receiving device does not receive a packet, it is referred to as "packet loss", and it will request the sending device to resend the packet.

1.1.2 Bluetooth and 5G

From the device using bluetooth data transfer between I thought of my own erection of the Shared folder, I shall not don't want to know the specific work mode, he first of all, I Shared folder is deployed on the raspberry pie and link network for transmission, it is bound to be involved in wifi network, I placed in the dormitory of the router has two frequency bands: 2.4G and 5G, through the query, in 2.4G frequency band, there are 13 channels, the spacing is 5MHz. Due to the use of modulation technology, WiFi wireless networks need to use a 22Mhz channel for transmission, so there are only three non-overlapping channels in the 2.4G band (the most commonly used are 1, 6 and 11). Currently, there are 13 non-overlapping channels in the 5g band used for Wi-Fi, which are 5.8G (149, 153, 157, 161 and 165) before 802.11ac and 5.2g (36, 40, 44, 48, 52, 56, 60 and 64) since 802.11ac, because of its high frequency. So the wavelength is shorter, the travel distance is shorter, so more base stations are needed to support it, but also thanks to its high frequency, the signal travels faster.

1.2 How to Learn Anything Fast

1.2.1 Short summary

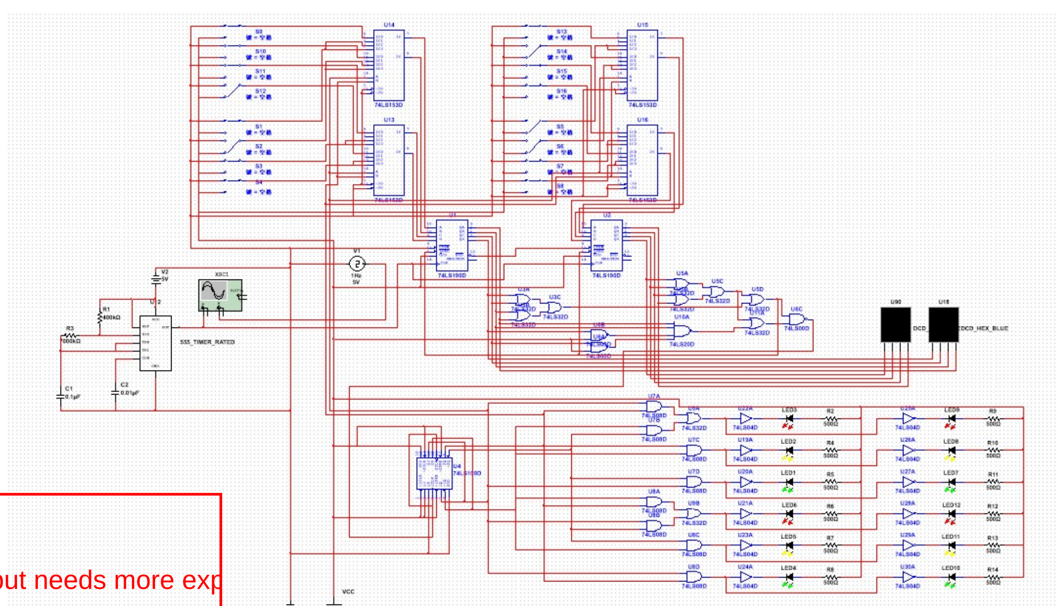
How good is a person's memory? Can it be trained? The speaker in the video showed the powerful of human memory for us, it has invited the five guest, let them write down a 6 digits on a whiteboard respectively, thus get a 30 digital sequence, then he let a guest in turn this number sequence read it for yourself and for memory, and then he accurate back out of the whiteboard 30 numerical sequence.

Then he put forward his own point of view: human memory can be trained, and the key to training lies in "output". After we learn something initially, we need to IMPLEMENT the output of our memory or "knowledge" through the three steps of "REFLECT", "implement" and "SHARE". After learning something, we should reflect on what we have learned. In the long run, we will learn to learn with problems, which is very helpful for our study; At the same time, we should put what we have learned into practice, which can not only deepen our understanding of knowledge, but also help us really improve their ability; Finally, we can teach what we have learned to others, and at the same time, we can test what we have learned.

1.2.2 "Output" twice as long as "input"

Recalling my learning process, I immediately found that I was deficient in knowledge output. In previous learning, I often received cramming learning. How to achieve output? The answer is obvious, and that is to put what you learn into practice. The correct way to learn is how to apply what you have learned to solving practical problems.

For example, after studying the digital circuit, is the right to use knowledge in circuit design method of study, under the guidance of the teacher, I started from scratch in the design of intersection traffic light circuit system, using the learned knowledge and query data, analyze problems, to the layout of the overall circuit module and the module of meticulous research.



Good, but needs more exp

Figure 1: A traffic light circuit system designed by me

Through the design of electronic signal lamp, I have basically mastered the basic process of device electronic design, and deeply realized the importance of the overall target layout and the operability of modular analysis before starting the design. In the later electronic design, I will carefully layout in advance and learn more about functional chips, so as to achieve a more reasonable electronic design and complete the target.

2 Reliability of the Shannon/Nyquist sampling method

2.1 Problem description

Use the Fourier series to develop a sampling method and compare it with the Shannon/Nyquist sampling method through examples.

2.2 The ideality of Nyquist sampling

First, we recall the conditions that the system impulse should satisfy in the case of baseband transmission without intersymbol interference:

$$x(nT_s) = \begin{cases} 1, & n = 0, \\ 0, & n \neq 0. \end{cases} \tag{1}$$

The necessary and sufficient conditions are

$$\sum_{n=-\infty}^{\infty} X(f + \frac{m}{T_s}) = T_s \tag{2}$$

So let's prove it, You take the Fourier transform of both sides

$$\sum_{n=-\infty}^{\infty} x(t)e^{-j2\pi\frac{m}{T_s}t} = T_s\delta(t) \tag{3}$$

$$x(t) \cdot \frac{1}{T_s} \sum_{n=-\infty}^{\infty} e^{-j2\pi\frac{m}{T_s}t} = \delta(t) \tag{4}$$

Leverage the following relationships

$$\sum_{n}(t - nT_s) = \frac{1}{T_s}\sum_{k} e^{j2\pi\frac{m}{T_s}t} \tag{5}$$

So we can convert (3) and (4) into the following formula

$$x(t) \cdot \sum_{n=-\infty}^{\infty} \delta(t - nT_s) = \delta(t) \tag{6}$$

$$\sum_{n=-\infty}^{\infty} x(nT_s)\delta(t - T_s) = \delta(t) \tag{7}$$

In this way, we verify the correctness of (2). In the last weekly assignment, we learned that when T_s is equal to $\frac{1}{2W}$ (where W is the cutoff frequency of the overall transfer function $X(f)$ of the system), we have the ideal sampling function if $X(f)$ satisfies the following formula

$$X(f) = \begin{cases} T_s, & |f| \leq W, \\ 0, & f \quad is \quad some \quad other \quad value. \end{cases} \tag{8}$$

The corresponding $x(t)$ is

$$x(t) = sinc(2Wt) \tag{9}$$

2.3 The practical application of Nyquist sampling

In the above ideal case, although the system reaches the limit of band utilization, this $x(t)$ is the sinc function, which is not feasible

Through reference [1] and calculation, I found the function of cosine of rise, the spectrum of this function can be approximated to the ideal function for sampling

$$x(t) = \frac{\sin(\frac{\pi t}{T_s})}{\frac{\pi t}{T_s}} \cdot \frac{\cos(\frac{\pi\alpha t}{T_s})}{1 - 4\alpha^2\frac{t^2}{T_s^2}} \tag{10}$$

$$X(f)=\begin{cases} T_s, & 0\le |f|\le \frac{1-\alpha}{2T_s}, \\ \frac{T_s}{2}\left\{1+\cos[\frac{\pi T_s}{\alpha}(|f|-\frac{1-\alpha}{2T_s})]\right\}, & \frac{1-\alpha}{2T_s}<|f|\le\frac{1+\alpha}{2T_s} \\ 0, & |f|>\frac{1+\alpha}{2T_s} \end{cases} \tag{11}$$

For Nyquist sampling, the sampling work is shown below

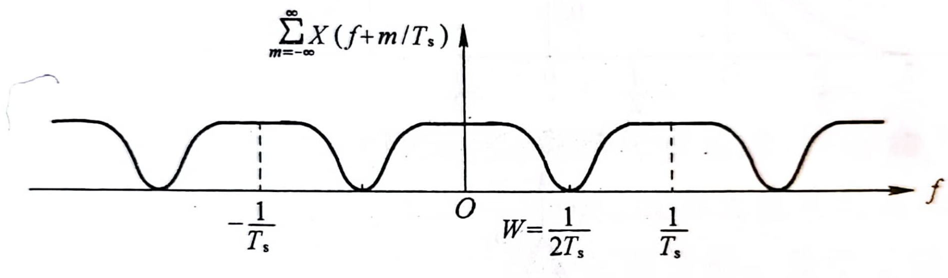
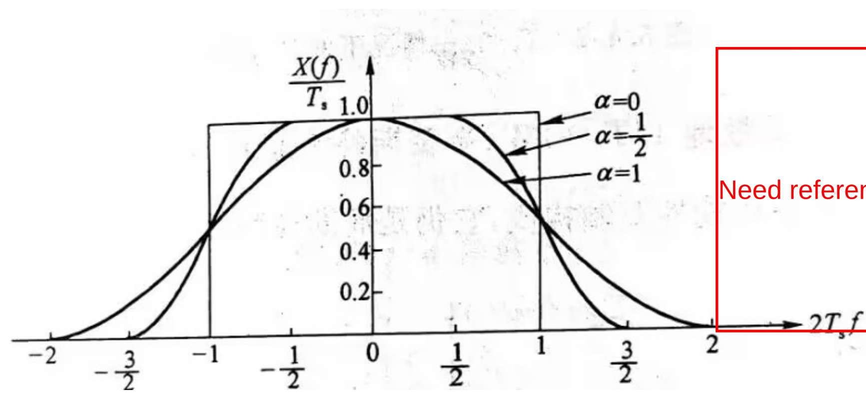


Figure 2: The spectrum curve at ideal sampling

The spectral curve of the rising cosine and the impact response are as follows



Need reference, otherwise it's p

Figure 3: Frequency response of the rising cosine filter

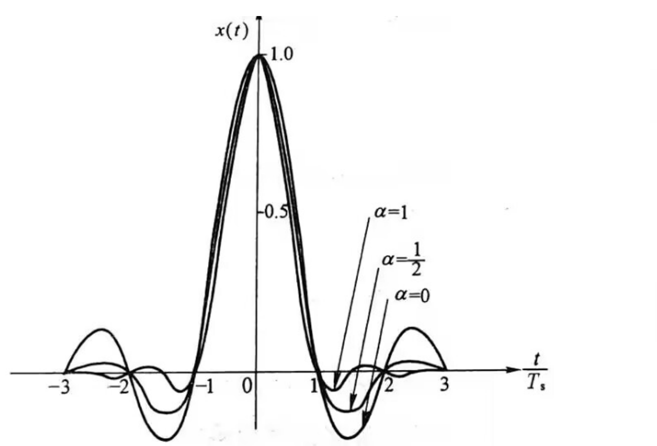


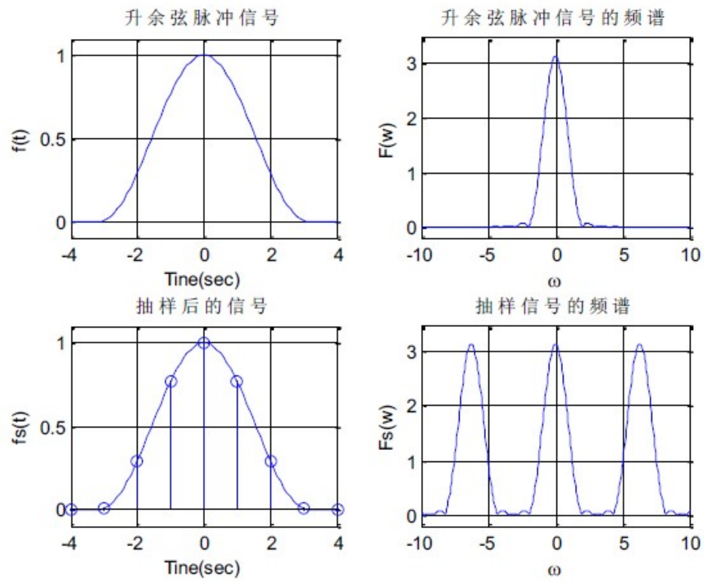
Figure 4: Impulse response of rising cosine filter

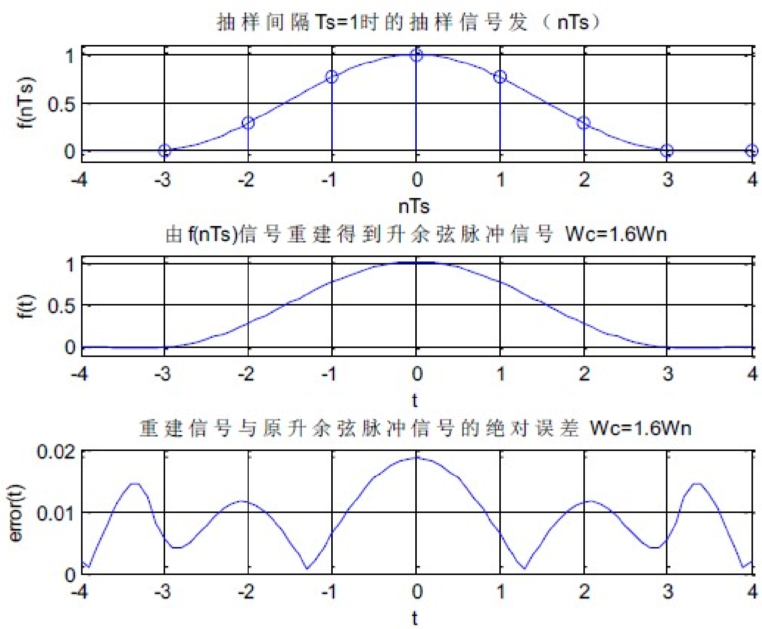
2.4 Example

The sampling theorem shows that when the sampling frequency is less than the Nyquist interval, the sampling signal can be used to uniquely represent the original signal, that is, the reconstruction of the signal. In order to recover the micro-error signal from the spectrum, an ideal low-pass filter with cutoff frequency $W_c \ge W_n (W_n$ is Nyquist rate) can be selected.

Assuming that the cut-off frequency of 2 sampling interval is 1 using cut-off frequency $1.5 * 2$ Low-pass filter of the sampling signal filtering reconstruction after the signal $f(t)$ and calculation of signal reconstruction Absolute error from the original rising cosine pulse.

MATLAB programming is used to realize the sampling signal and its spectrum obtained after impulse sampling





2.4.1 Summary and Analysis

The continuous signal is discretized by sampling the rising cosine signal, and then the signal is reconstructed by inverse Fourier transform. The figure shows that the error of signal reconstruction by Fourier transform in the time domain is larger than that by frequency filtering, so the filter is very important in signal processing. Signal components above Nyquist frequencies are filtered out by a low-pass filter prior to sampling. According to the above graph data analysis, it can be seen that the reduction signal distortion degree is the smallest around $1.6W_m$.

This system of ascending cosine signal sampling, spectrum analysis, and basic determine set filter by frequency and the relationship between the original signal frequency, but not in the system analysis the other signal filter cutoff frequency setting method, also have no specific in the point set is the most reasonable, has certain one-sidedness.

3 Key conclusions

(1) The method of using channel to transmit electromagnetic wave is understood.

(2) Rising cosine function sampling is a good sampling method to approach the ideal sampling.

4 Code listings

```
Ts=1;
dt=0.1;
t1=-4:dt:4;
gate=rectpuls(t1,2*pi);
ft=((1+cos(t1))/2).*gate;
subplot(221)
plot(t1,ft),grid on
axis([-4 4 -0.1 1.1]);
xlabel('Tine(sec)'),ylabel('f(t)')
title('Rising cosine pulse signal')
N=500;
k=-N:N;
w=pi*k/(N*dt);
Fw=dt*ft*exp(-j*t1'*w);
subplot(222)
plot(w,abs(Fw)),grid on
axis([-10 10 -0.2 1.1*pi])
xlabel('\omega'),ylabel('F(w)')
title('The spectrum of the rising cosine pulse')
t2=-4:Ts:4;
fst=((1+cos(t2))/2).*rectpuls(t2,2*pi);
subplot(223)
plot(t1,ft,':'),hold on
stem(t2,fst),grid on
axis( [-4 4 -0.1 1.1] );
xlabel('Tine(sec)'),ylabel('fs(t)')
title('The sampled signal'),hold off
Fsw=Ts*fst*exp(-j*t2'*w);
subplot(224)
plot(w,abs(Fsw)),grid on
axis([-10 10 -0.2 1.1*pi])
xlabel('\omega'),ylabel('Fs(w)')
title('The spectrum of the sampled signal')
```

```
wn=2;
wc=1.6*wn;
Ts=1;
n=-100:100;
nTs=n*Ts;
fs=((1+cos(nTs))/2).*rectpuls(nTs,2*pi);
t=-4:0.1:4;
ft=fs*Ts*wc/pi*sinc((wc/pi)*(ones(length(nTs),1))*t-nTs
'*ones(1,length(t)));
t1=-4:0.1:4;
f1=((1+cos(t1))/2).*rectpuls(t1,2*pi);
subplot(311)
plot(t1,f1,':'),hold on
stem(nTs,fs),grid on
axis([-4 4 -0.1 1.1])
xlabel('nTs'),ylabel('f(nTs)');
hold off
subplot(312)
plot(t,ft),grid on
axis([-4 4 -0.1 1.1])
xlabel('t'),ylabel('f(t)');
hold off
error=Ts*abs(ft-f1);
subplot(313)
plot(t1,error),grid on
xlabel('t'),ylabel('error(t)');
```

References

[1] *communication theory*. Beijing University of Posts and Telecommunications Press.