Partie 1 Caractérisation du VCO

Q1

5		0,22—0,30	%/°C	no frequency offset
10		0,04—0,05	%/°C	(f_{min} = 0);
15		0,01—0,05	%/°C	see also note 1

Recommended range for R1 and R2: 10 kΩ to 1 MΩ; for C1: 50 pF to any practical value.

1. VCO without frequency offset (R2 = ∞).
   a) Given f_o: use f_o with Fig.7 to determine R1 and C1.
   b) Given f_{max}: calculate f_o from f_o = ½ f_{max}; use f_o with Fig.7 to determine R1 and C1.

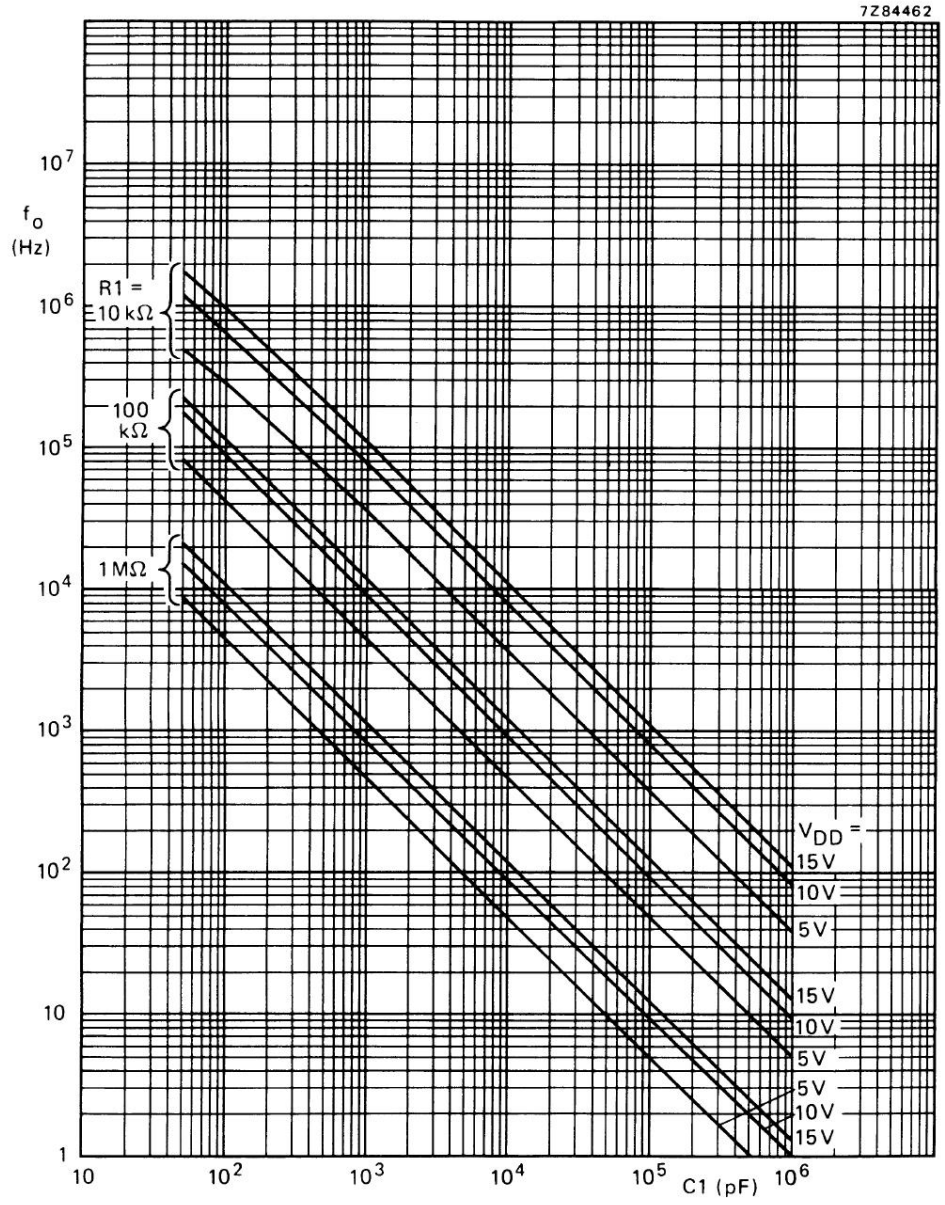
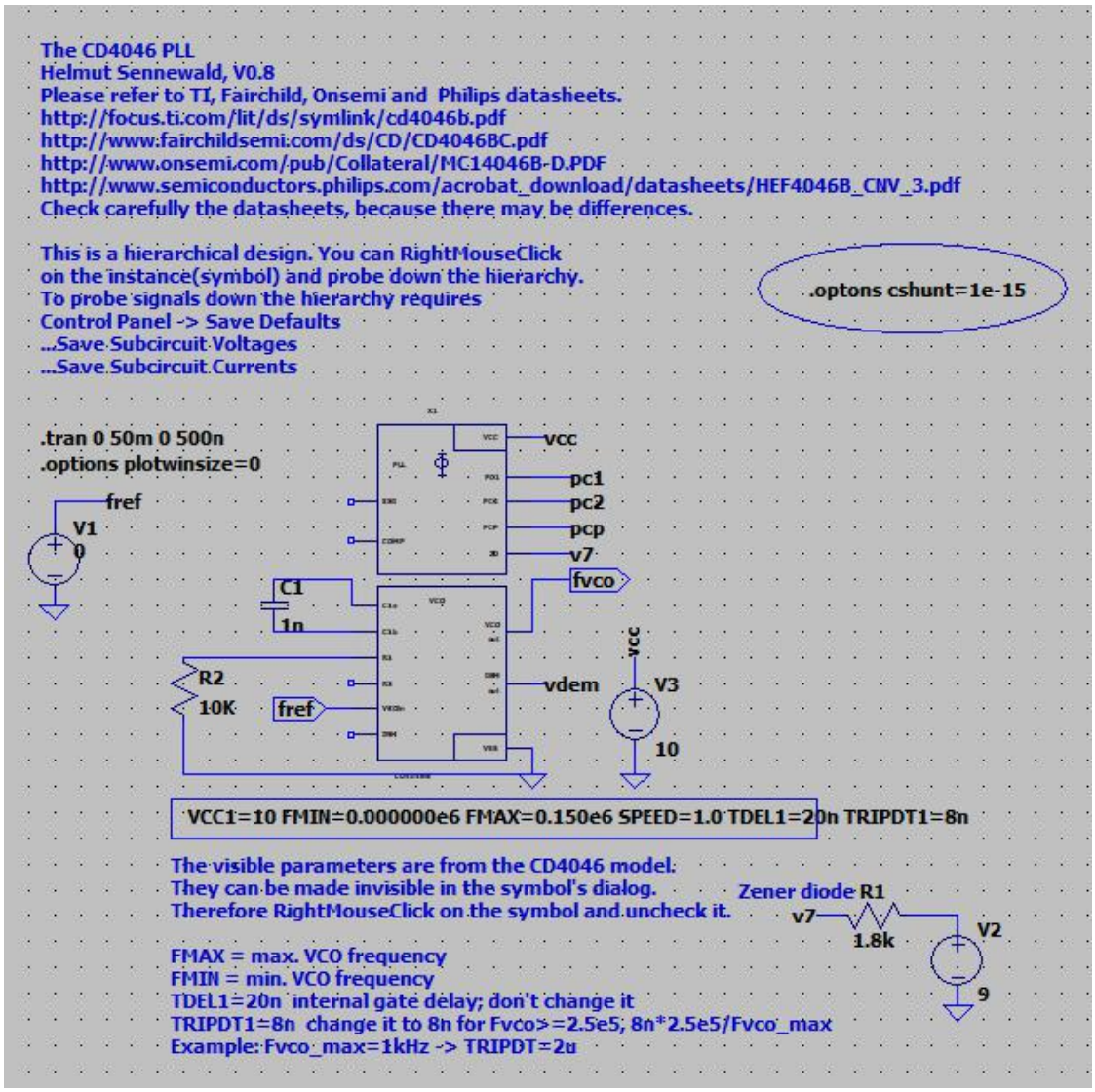


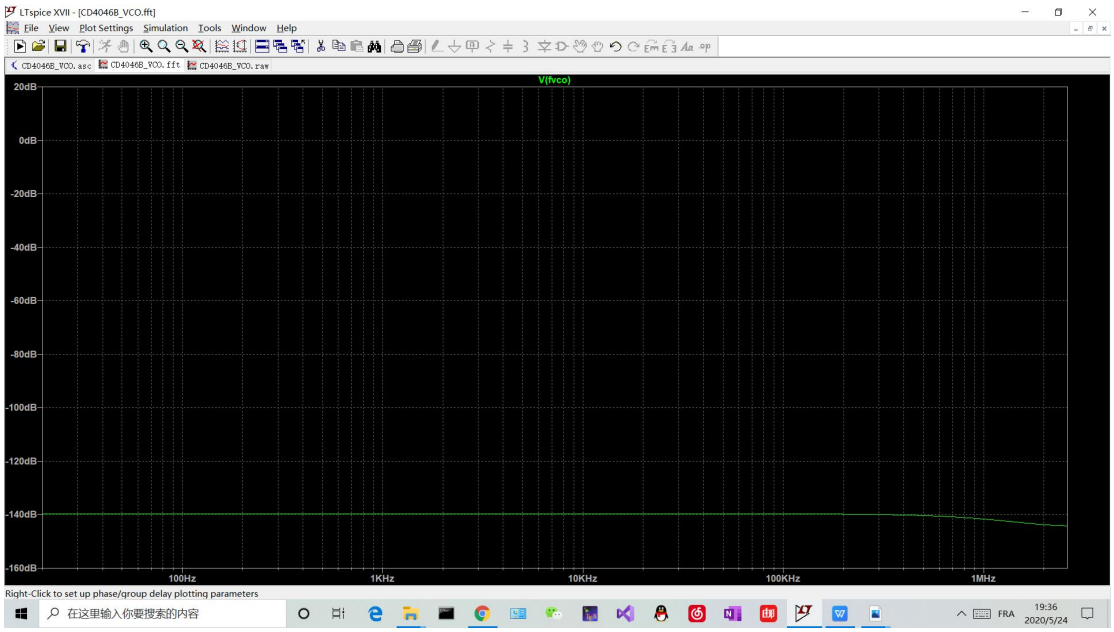
Fig.7 Typical centre frequency as a function of capacitor C1; T_{amb} = 25 °C; VCO_{IN} at ½ V_{DD}; INH at V_{SS}; R_2 = ∞.

Donc, fmin=0Hz, fmax=2*f0=2*7.5e4Hz=0.15MHz

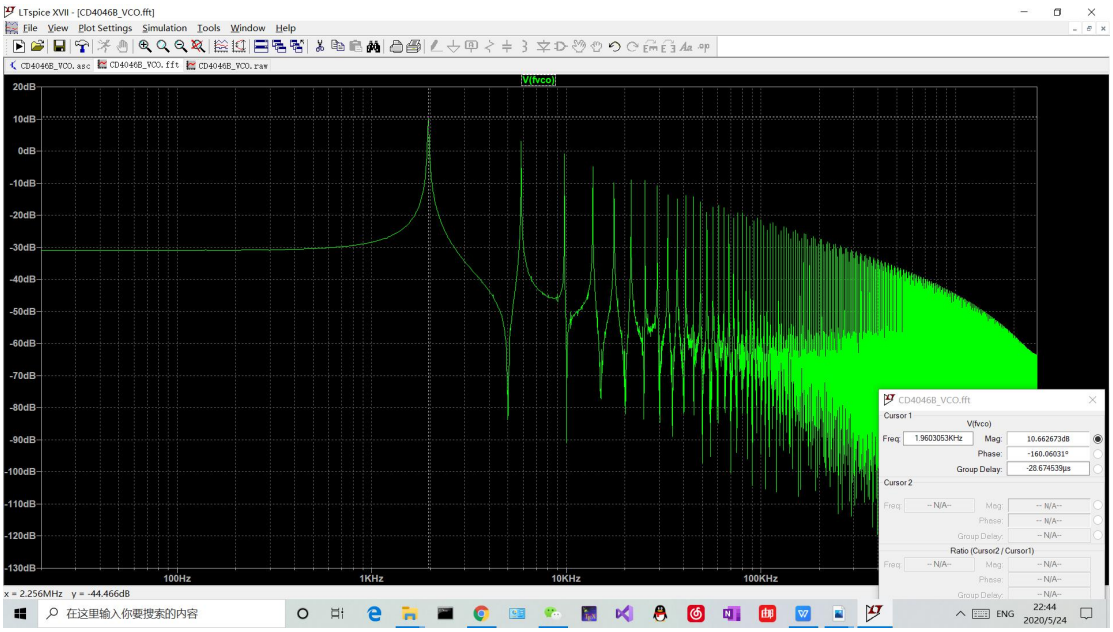
Q2


The CD4046 PLL
Helmut Sennewald, V0.8
Please refer to TI, Fairchild, Onsemi and Philips datasheets.
http://focus.ti.com/lit/ds/symlink/cd4046b.pdf
http://www.fairchildsemi.com/ds/CD/CD4046BC.pdf
http://www.onsemi.com/pub/Collateral/MC14046B-D.PDF
http://www.semiconductors.philips.com/acrobat_download/datasheets/HEF4046B_CNV_3.pdf
Check carefully the datasheets, because there may be differences.
This is a hierarchical design. You can RightMouseClick
on the instance(symbol) and probe down the hierarchy.
To probe signals down the hierarchy requires
Control Panel -> Save Defaults
...Save Subcircuit Voltages
...Save Subcircuit Currents
.optons cshunt=1e-15
.tran 0 50m 0 500n
.options plotwinsize=0
fref
V1
0
C1
1n
R2
10K
vcc
pc1
pc2
pcp
v7
fvco
vdem
V3
10
VCC1=10 FMIN=0.000000e6 FMAX=0.150e6 SPEED=1.0 TDEL1=20n TRIPDT1=8n
The visible parameters are from the CD4046 model.
They can be made invisible in the symbol's dialog.
Therefore RightMouseClick on the symbol and uncheck it.
Zener diode R1
v7
1.8k
V2
9
FMAX = max. VCO frequency
FMIN = min. VCO frequency
TDEL1=20n internal gate delay; don't change it
TRIPDT1=8n change it to 8n for Fvco>=2.5e5; 8n*2.5e5/Fvco_max
Example: Fvco_max=1kHz -> TRIPDT=2u

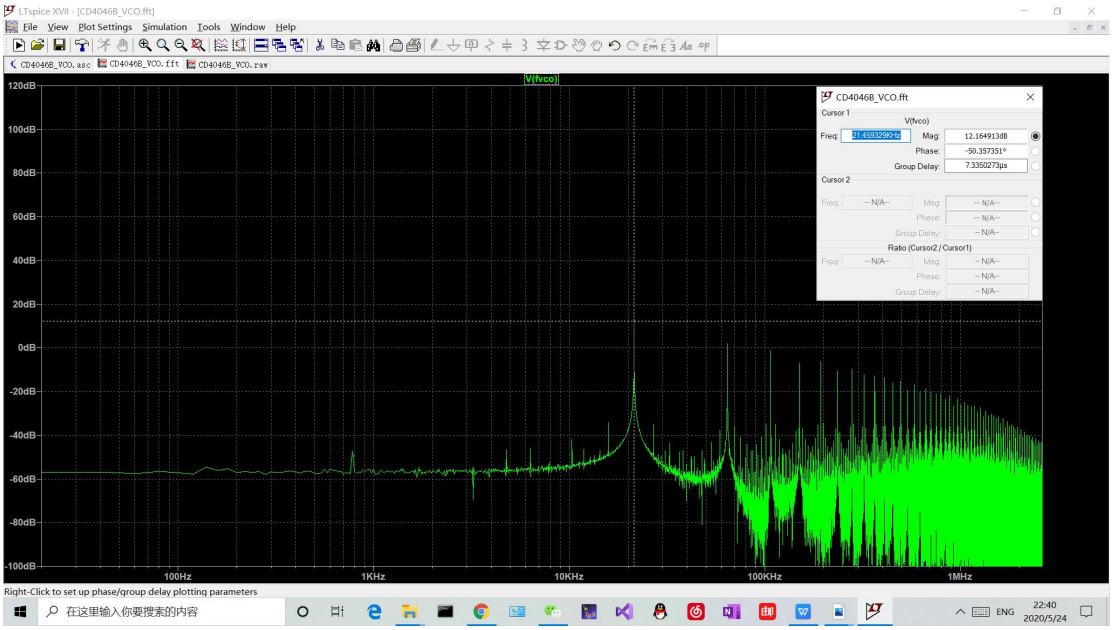
V1=0V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
V(fvco)
20dB
0dB
-20dB
-40dB
-60dB
-80dB
-100dB
-120dB
-140dB
-160dB
100Hz
1KHz
10KHz
100KHz
1MHz
Right-Click to set up phase/group delay plotting parameters

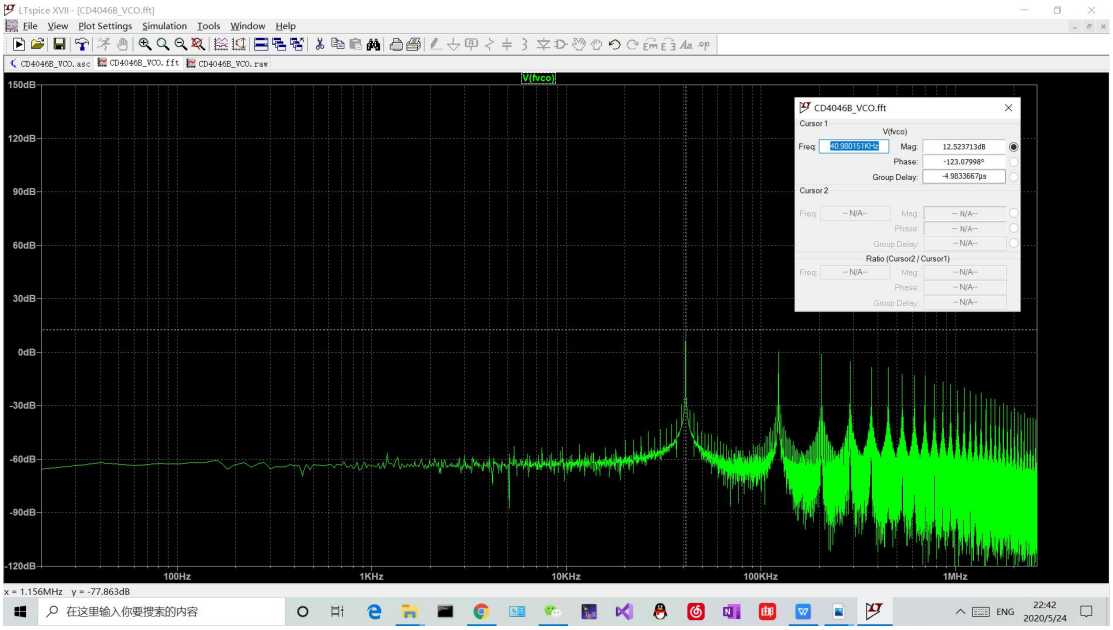
V1=1V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
20dB
10dB
0dB
-10dB
-20dB
-30dB
-40dB
-50dB
-60dB
-70dB
-80dB
-90dB
-100dB
-110dB
-120dB
-130dB
100Hz
1KHz
10KHz
100KHz
x = 2.256MHz y = -44.466dB
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 1.9603053KHz
Mag: 10.662673dB
Phase: -160.06031°
Group Delay: -28.674539µs
Cursor 2
Ratio (Cursor2 / Cursor1)
在这里输入你要搜索的内容
ENG
22:44
2020/5/24

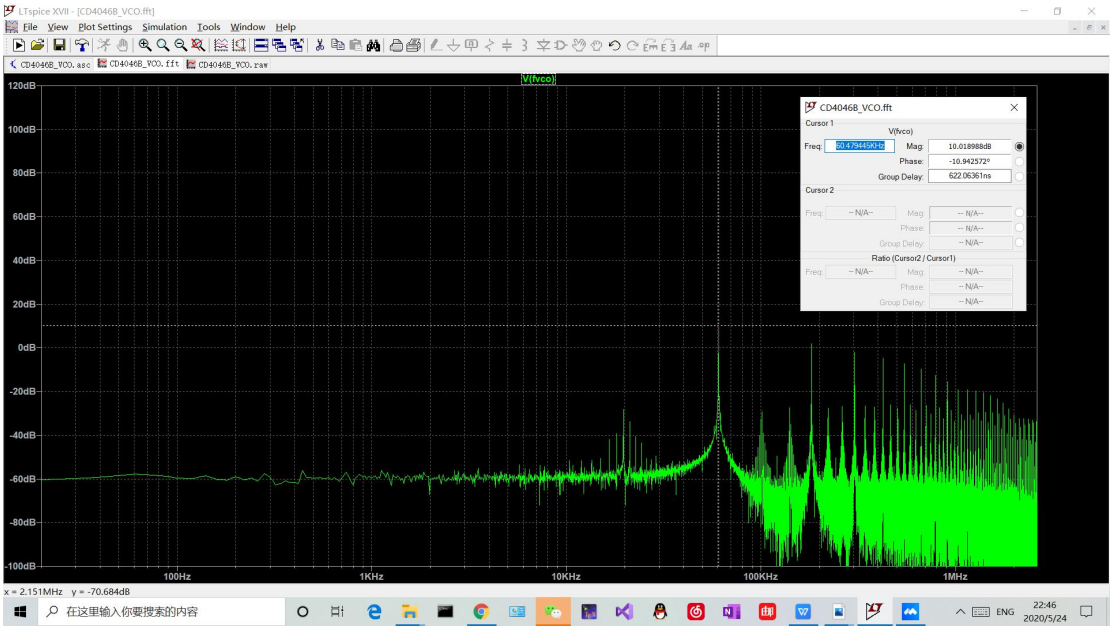
V1=2V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
120dB
100dB
80dB
60dB
40dB
20dB
0dB
-20dB
-40dB
-60dB
-80dB
-100dB
100Hz
1KHz
10KHz
100KHz
1MHz
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 21.459329KHz
Mag: 12.164913dB
Phase: -50.357351°
Group Delay: 7.3350273µs
Cursor 2
Ratio (Cursor2 / Cursor1)
Right-Click to set up phase/group delay plotting parameters
在这里输入你要搜索的内容
ENG
22:40
2020/5/24

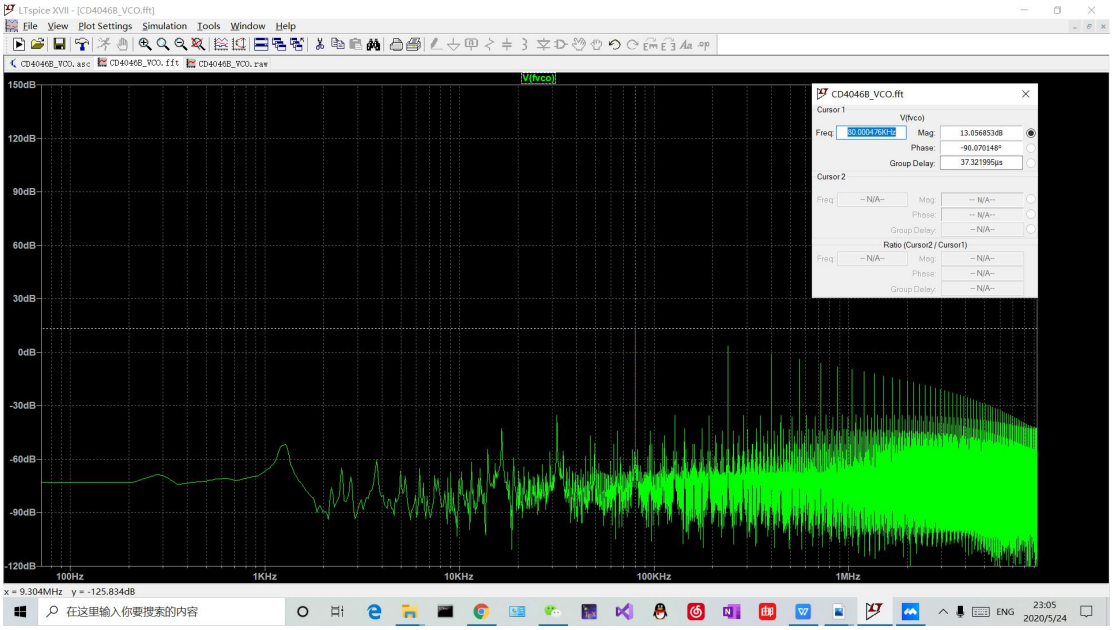
V1=3V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
150dB
120dB
90dB
60dB
30dB
0dB
-30dB
-60dB
-90dB
-120dB
100Hz
1KHz
10KHz
100KHz
1MHz
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 40.980151KHz
Mag: 12.523713dB
Phase: -123.07998°
Group Delay: -4.9833667µs
Cursor 2
Ratio (Cursor2 / Cursor1)
x = 1.156MHz y = -77.863dB
在这里输入你要搜索的内容
ENG
22:42
2020/5/24

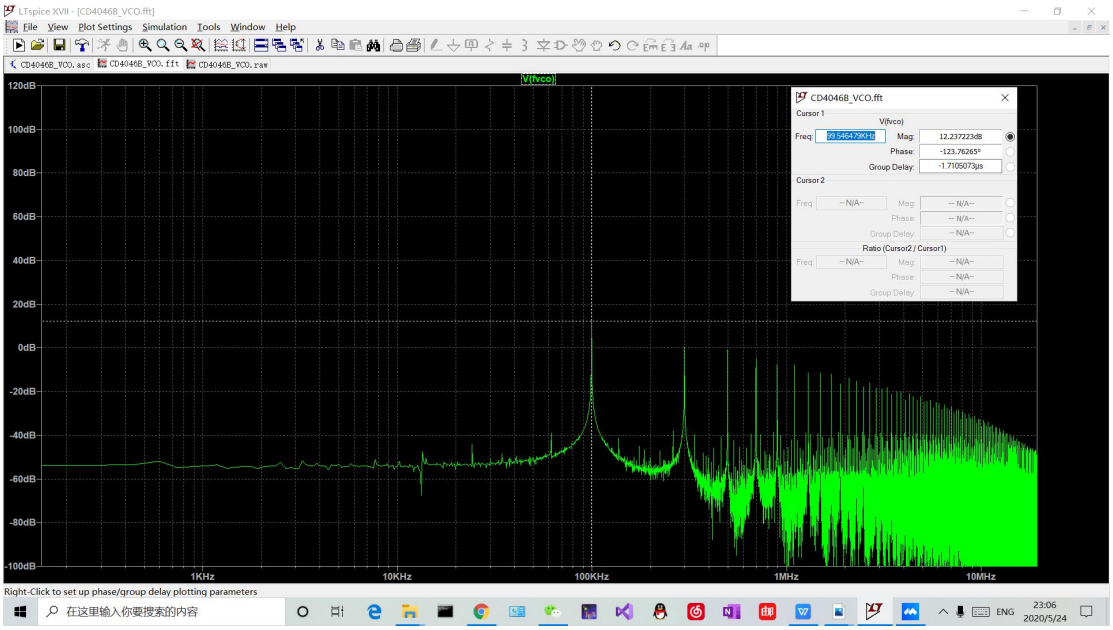
V1=4V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
120dB
100dB
80dB
60dB
40dB
20dB
0dB
-20dB
-40dB
-60dB
-80dB
-100dB
100Hz
1KHz
10KHz
100KHz
1MHz
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 50.479445KHz
Mag: 10.018988dB
Phase: -10.942572°
Group Delay: 622.06361ns
Cursor 2
Ratio (Cursor2 / Cursor1)
x = 2.151MHz y = -70.684dB
在这里输入你要搜索的内容
ENG
22:46
2020/5/24

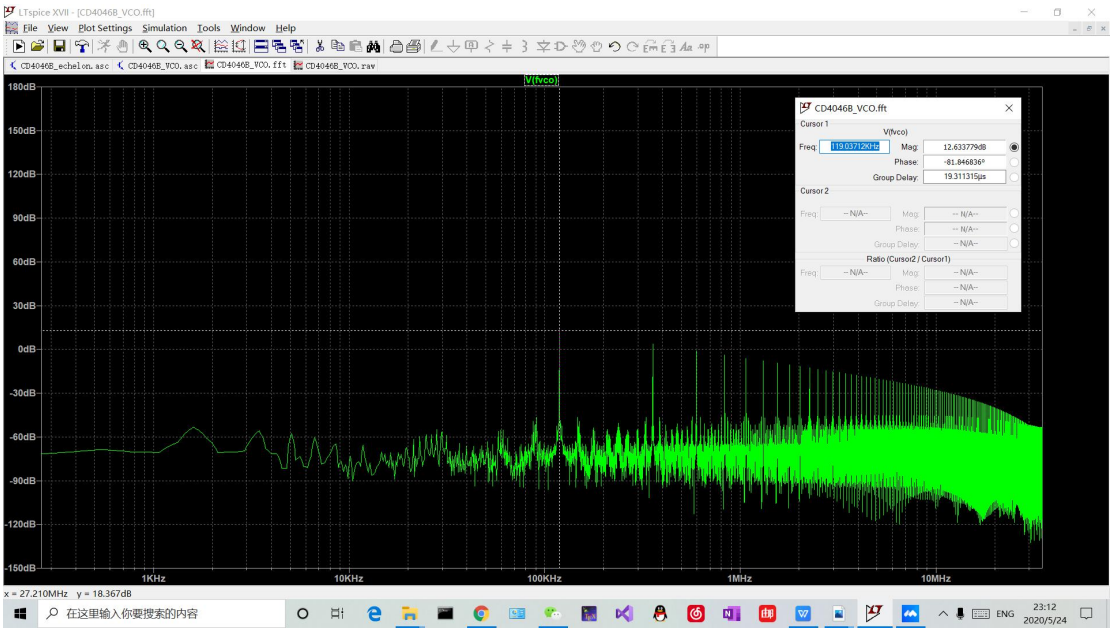
V1=5V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
150dB
120dB
90dB
60dB
30dB
0dB
-30dB
-60dB
-90dB
-120dB
100Hz
1KHz
10KHz
100KHz
1MHz
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 30.000478KHz
Mag: 13.056853dB
Phase: -90.070148°
Group Delay: 37.321995µs
Cursor 2
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Ratio (Cursor2 / Cursor1)
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
x = 9.304MHz y = -125.834dB
在这里输入你要搜索的内容
ENG
23:05
2020/5/24

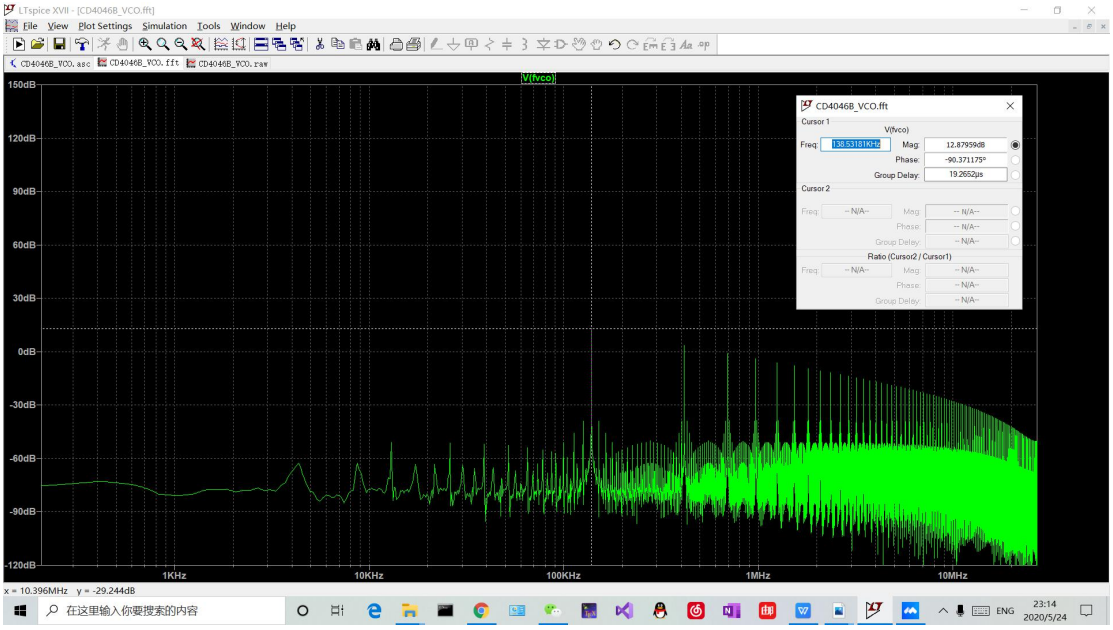
V1=6V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
120dB
100dB
80dB
60dB
40dB
20dB
0dB
-20dB
-40dB
-60dB
-80dB
-100dB
1KHz
10KHz
100KHz
1MHz
10MHz
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 29.5464.79KHz
Mag: 12.237223dB
Phase: -123.76265°
Group Delay: -1.7105073µs
Cursor 2
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Ratio (Cursor2 / Cursor1)
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Right-Click to set up phase/group delay plotting parameters
在这里输入你要搜索的内容
ENG
23:06
2020/5/24

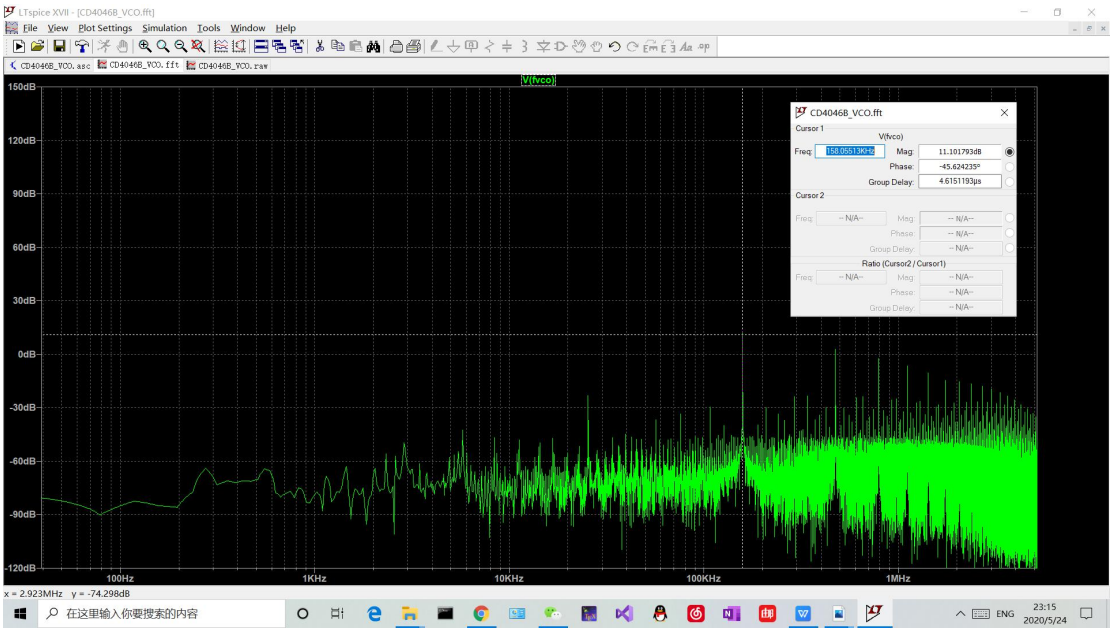
V1=7V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_echelon.asc CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
180dB
150dB
120dB
90dB
60dB
30dB
0dB
-30dB
-60dB
-90dB
-120dB
-150dB
1KHz
10KHz
100KHz
1MHz
10MHz
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 119.03712KHz
Mag: 12.633779dB
Phase: -81.846836°
Group Delay: 19.311315µs
Cursor 2
Ratio (Cursor2 / Cursor1)
x = 27.210MHz y = 18.367dB
在这里输入你要搜索的内容
ENG
23:12
2020/5/24

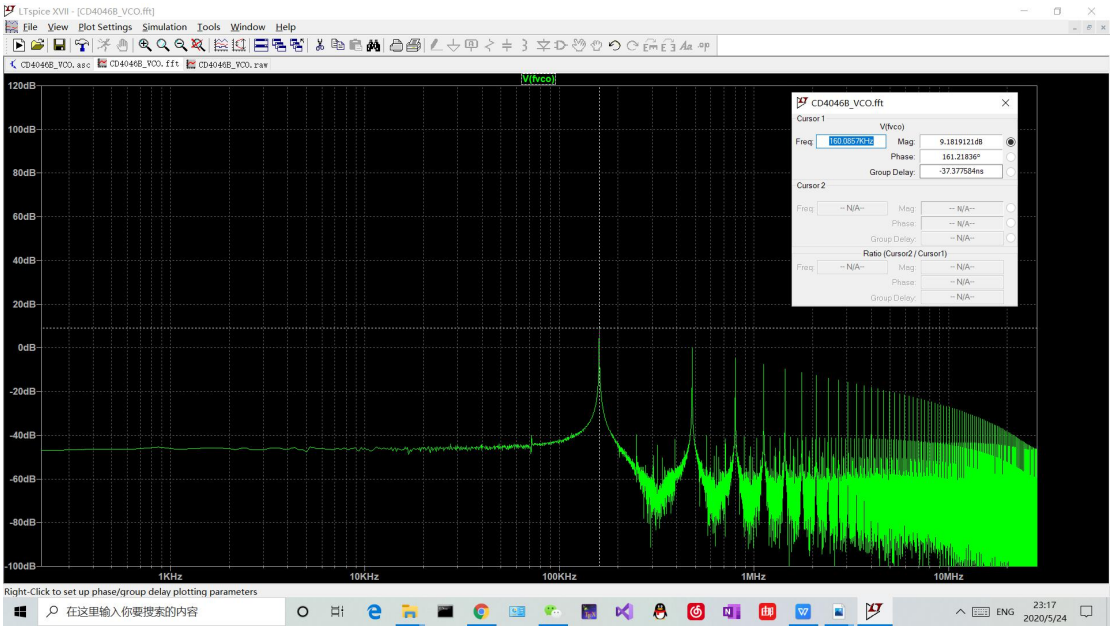
V1=8V


LTspice XVII - [CD4046B_VCO.fft]
File View Plot Settings Simulation Tools Window Help
CD4046B_VCO.asc CD4046B_VCO.fft CD4046B_VCO.raw
V(fvco)
150dB
120dB
90dB
60dB
30dB
0dB
-30dB
-60dB
-90dB
-120dB
1KHz
10KHz
100KHz
1MHz
10MHz
CD4046B_VCO.fft
Cursor 1
V(fvco)
Freq: 138.53181KHz
Mag: 12.87959dB
Phase: -90.371175°
Group Delay: 19.2652µs
Cursor 2
Ratio (Cursor2 / Cursor1)
x = 10.396MHz y = -29.244dB
在这里输入你要搜索的内容
ENG
23:14
2020/5/24

V1=9V



V1=10V

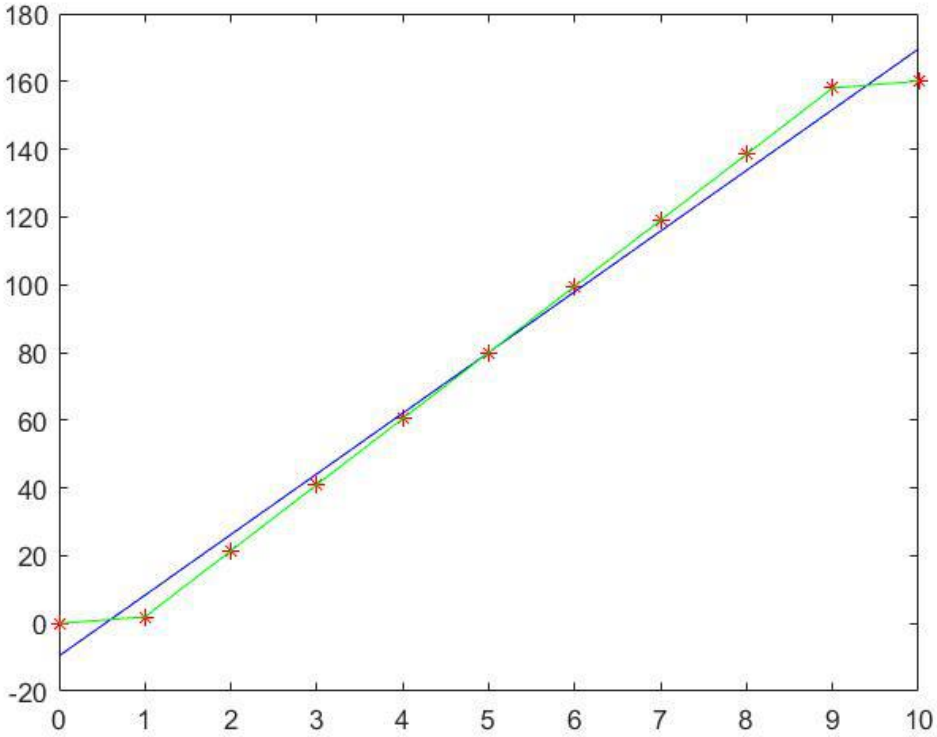


Donc, on a

V1(V)	0	1	2	3	4	5	6	7	8	9	10
f(kHz)	0	1.96	21.46	40.99	60.48	80.00	99.55	119.04	138.53	158.06	160.09

Donc, il est linéaire entre 1V et 9V, en faisant un programmation matlab

```
clear all;
x=[0:10];
y=[0    1.96    21.46   40.99   60.48   80.00   99.55
119.04  138.53  158.06  160.09];
poly10=polyfit(x,y,10);
poly1=polyfit(x,y,1);
plot(x,y,'*r',x,polyval(poly1,x),'b',x,polyval(poly10,
x),'g')
```

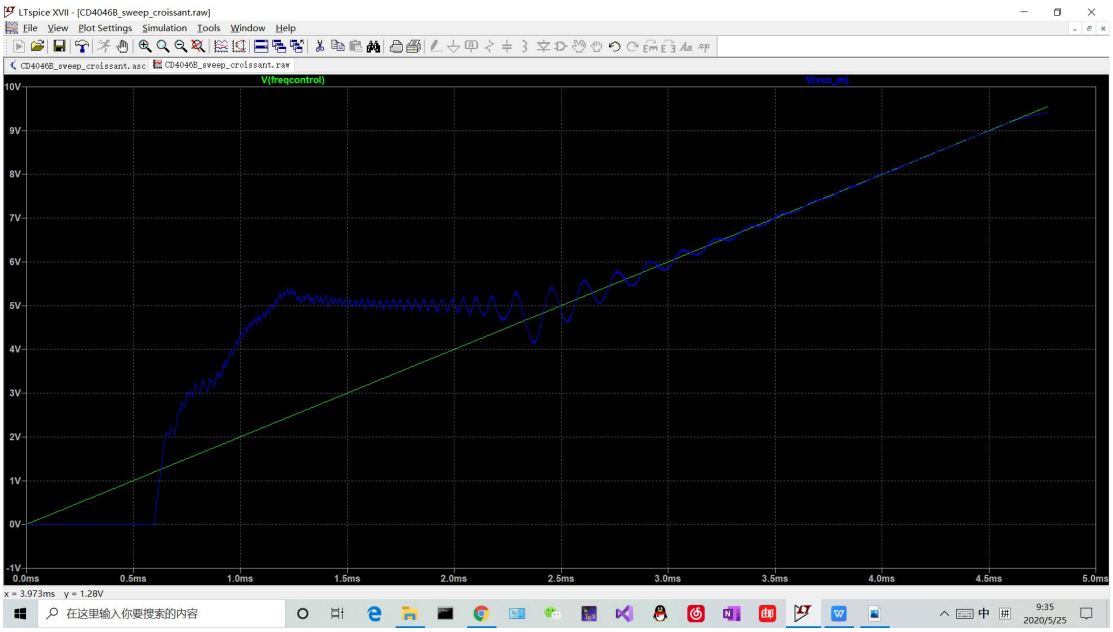


Le polynôme d’ordre 10 est méillieur mais très compliex, on va prendre celui d’ordre 1.

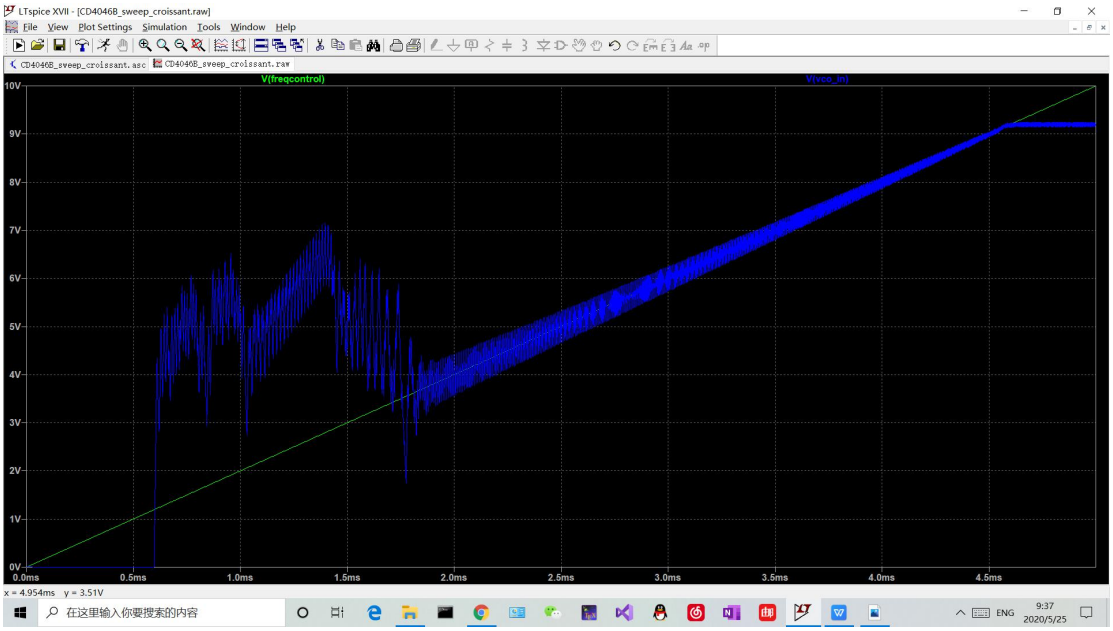
Partie 2 Mesure des plages de capture et de verrouillage

Q3

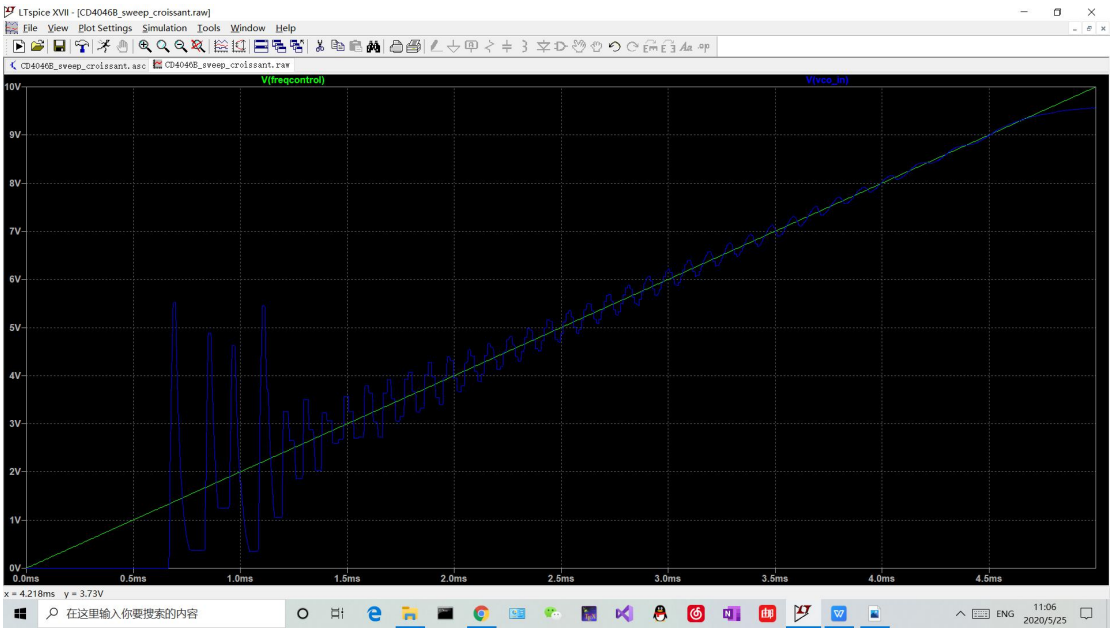
pc1_100nF



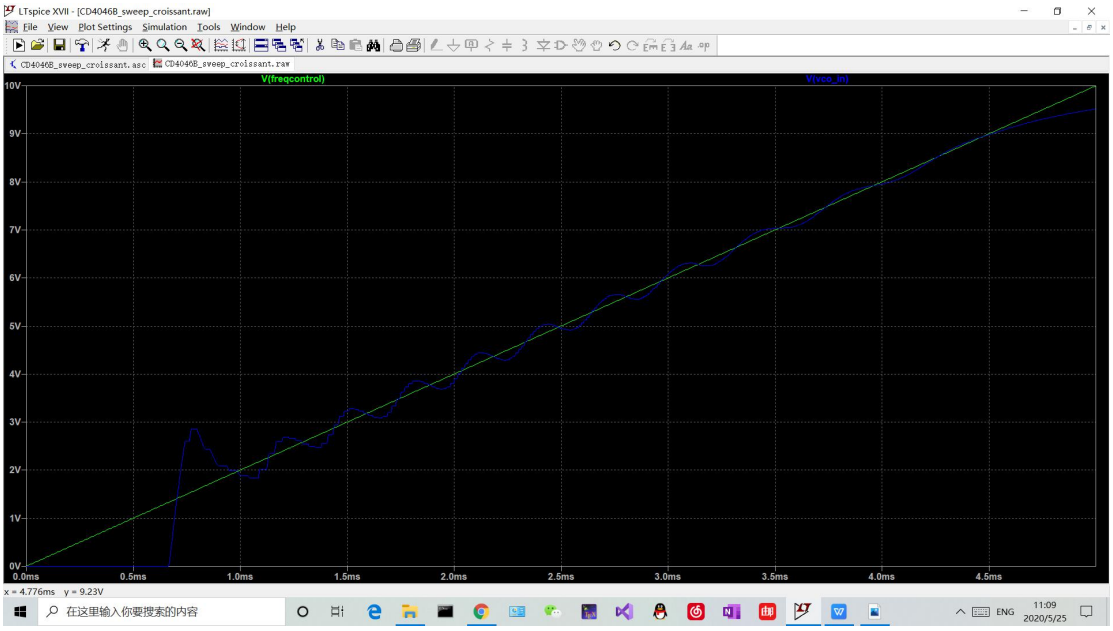
pc1_10nF



pc2_10nF

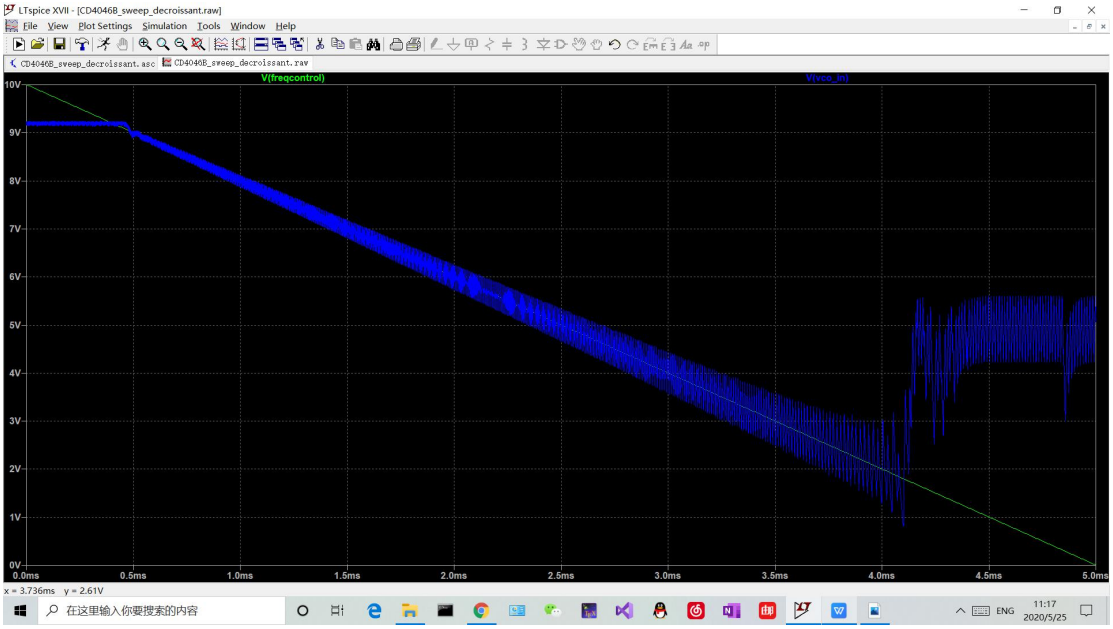


pc2_100nF

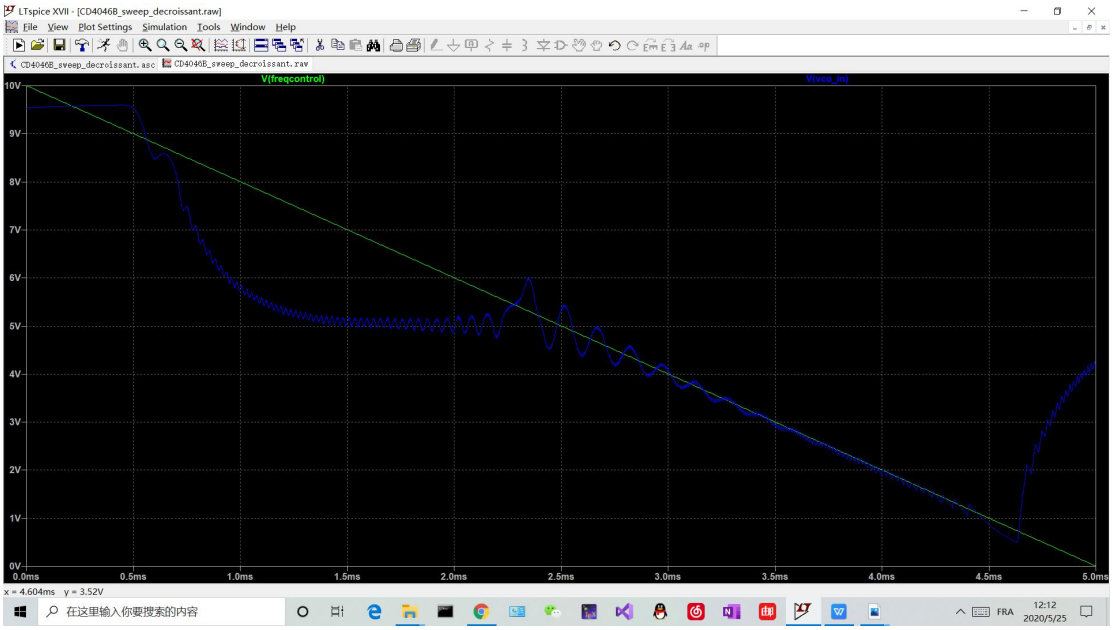


Q4

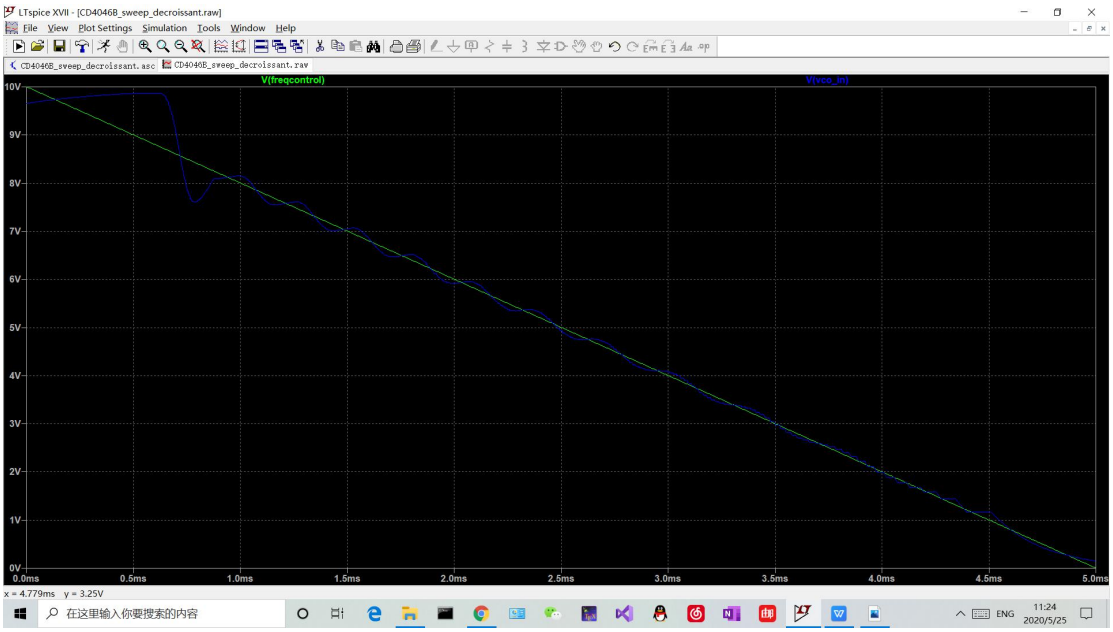
pc1_10nF



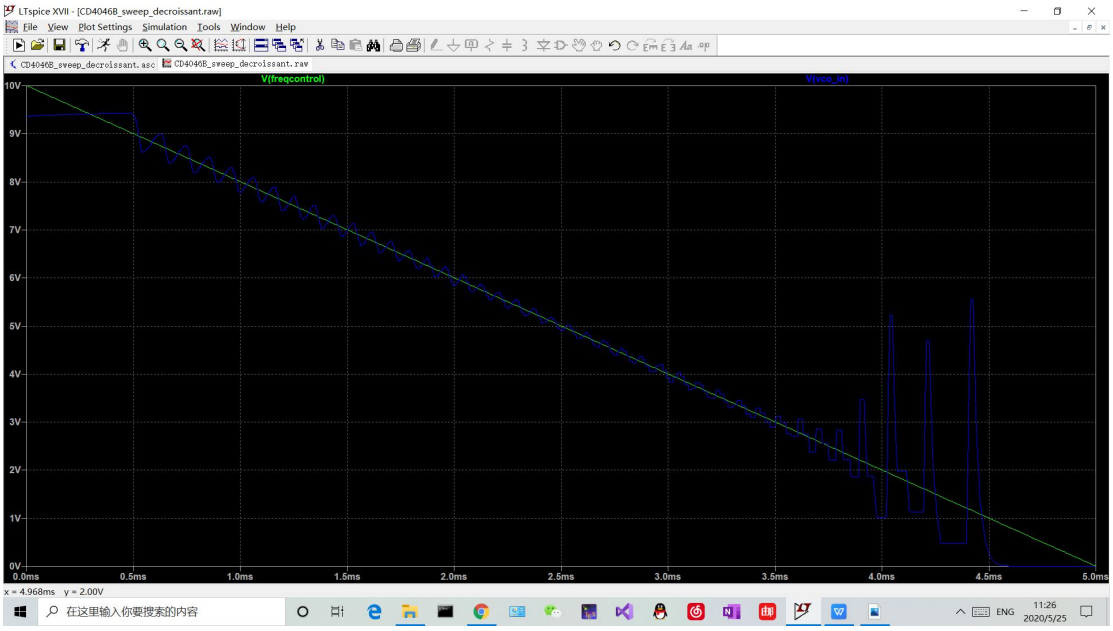
pc1_100nF



pc2_100nF



pc2_10nF



Q5

```
clear all;
%%
x=[0:10];
y=[0    1.96    21.46   40.99   60.48   80.00   99.55
119.04  138.53  158.06  160.09];
poly10=polyfit(x,y,10);
poly1=polyfit(x,y,1);
%plot(x,y,'*r',x,polyval(poly1,x),'b',x,polyval(poly1
0,x),'g')
%%
m=599898;n=3;
data=cell(m,n);
name='CD4046B_sweep_croissantpc1_10nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
%%
m=589425;n=3;
data=cell(m,n);
name='CD4046B_sweep_croissantpc1_100nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
```

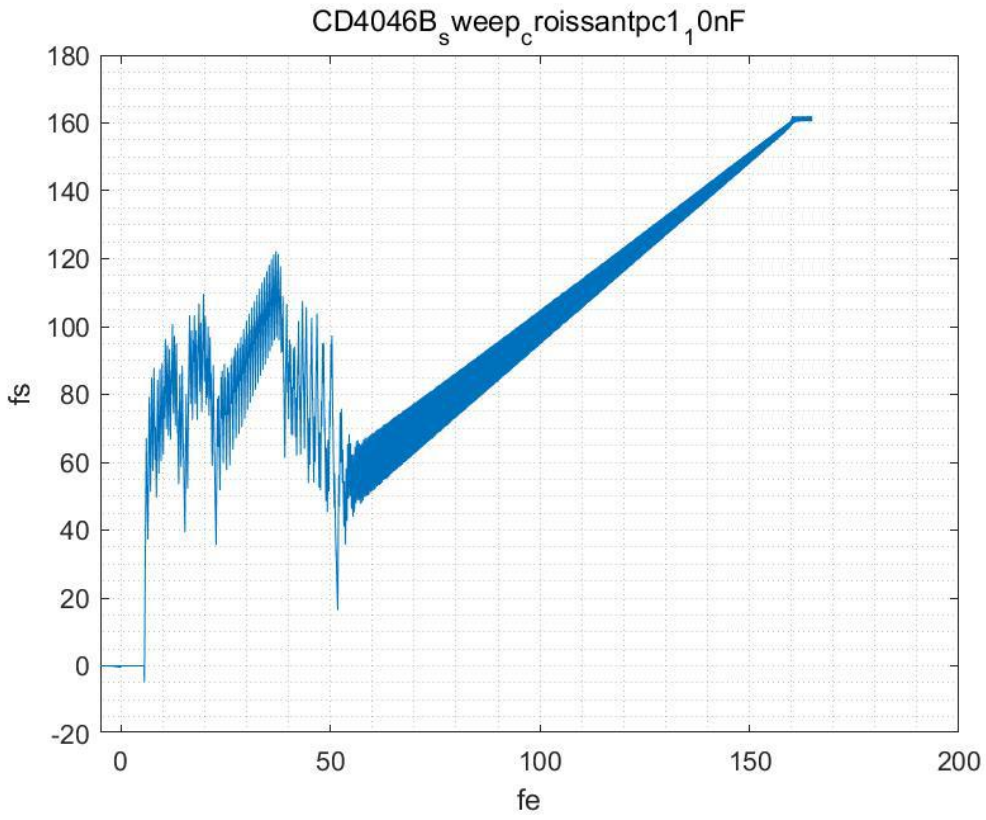
```
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
%%
m=573847;n=3;
data=cell(m,n);
name='CD4046B_sweep_croissantpc2_10nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
%%
m=581072;n=3;
data=cell(m,n);
name='CD4046B_sweep_croissantpc2_100nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
```

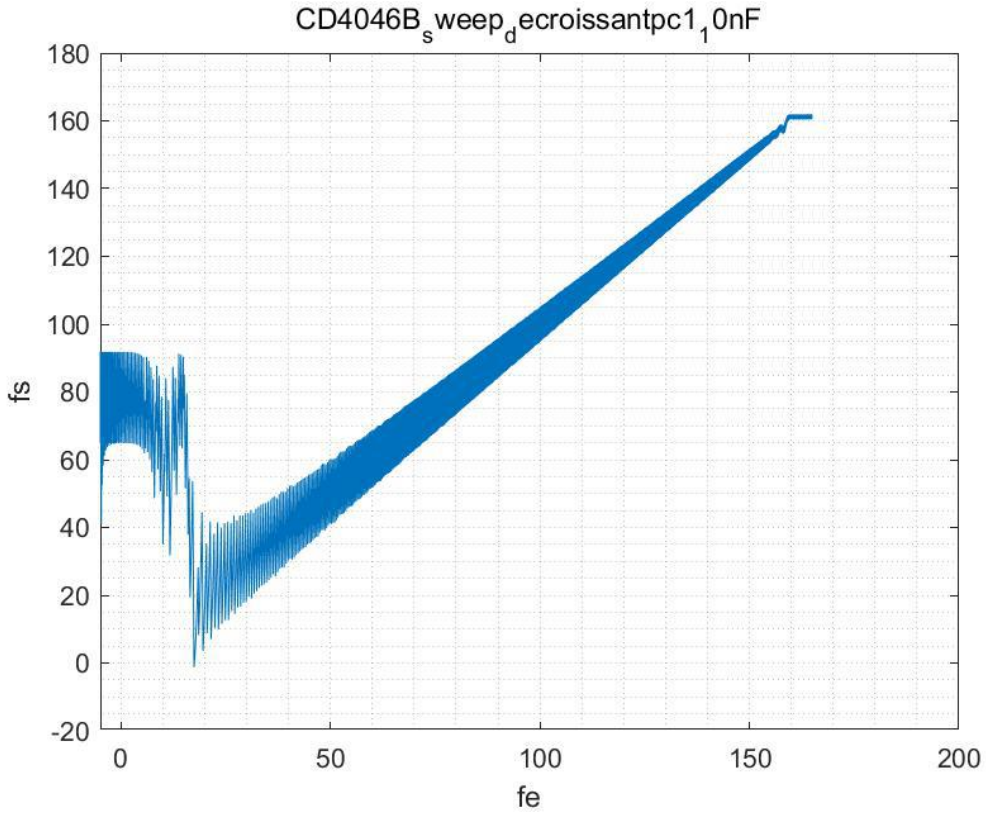
```
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
%%
m=606428;n=3;
data=cell(m,n);
name='CD4046B_sweep_decroissantpc1_10nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
%%
m=529020;n=3;
data=cell(m,n);
name='CD4046B_sweep_decroissantpc1_100nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
```

```
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
%%
m=573845;n=3;
data=cell(m,n);
name='CD4046B_sweep_decroissantpc2_10nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
%%
m=571485;n=3;
data=cell(m,n);
name='CD4046B_sweep_decroissantpc2_100nF';
fid=fopen([name,'.txt'],'r');
%textscan('char','headerlines',1)
fgetl(fid);
for i=1:m
    for j=1:n
        data{i,j}=fscanf(fid,'%f',[1,1]);
    end
```

```
end
fclose (fid);
data1=data(:,2:3);
data2=cell2mat(data1);
data3=polyval(poly10,data2);
plot(data3(:,1),data3(:,2));
xlabel('fe');
ylabel('fs');
title(name);
grid minor
saveas(gcf,name,'jpg');
```

pc1_10nF

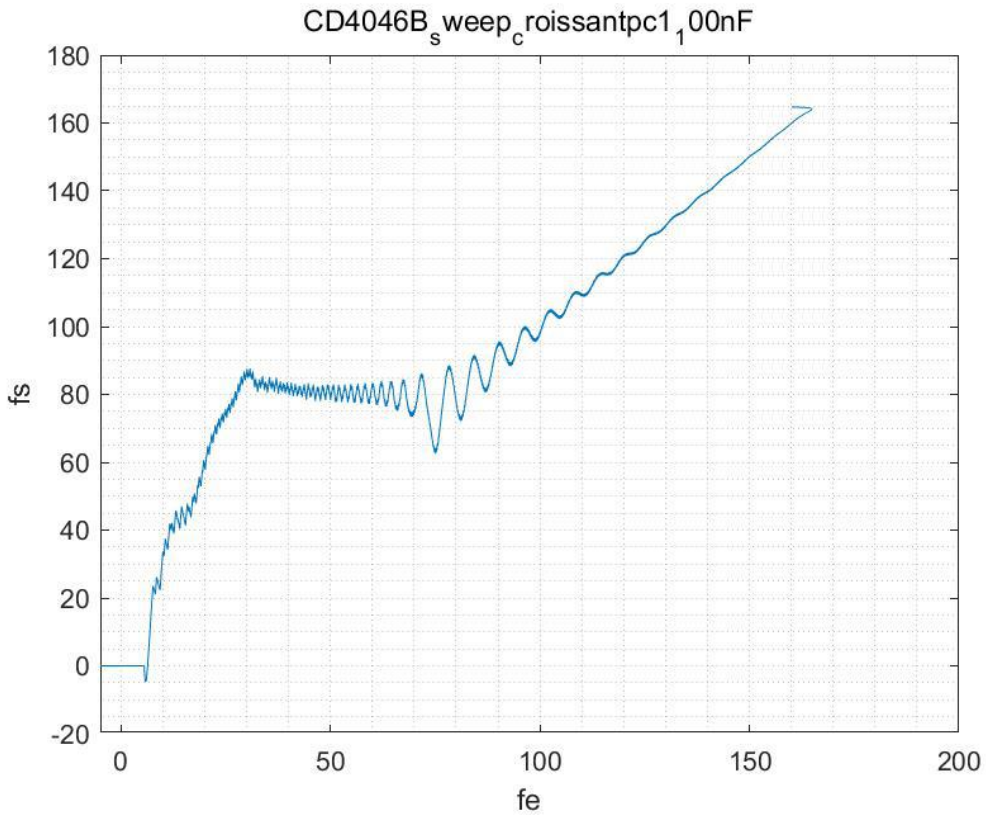


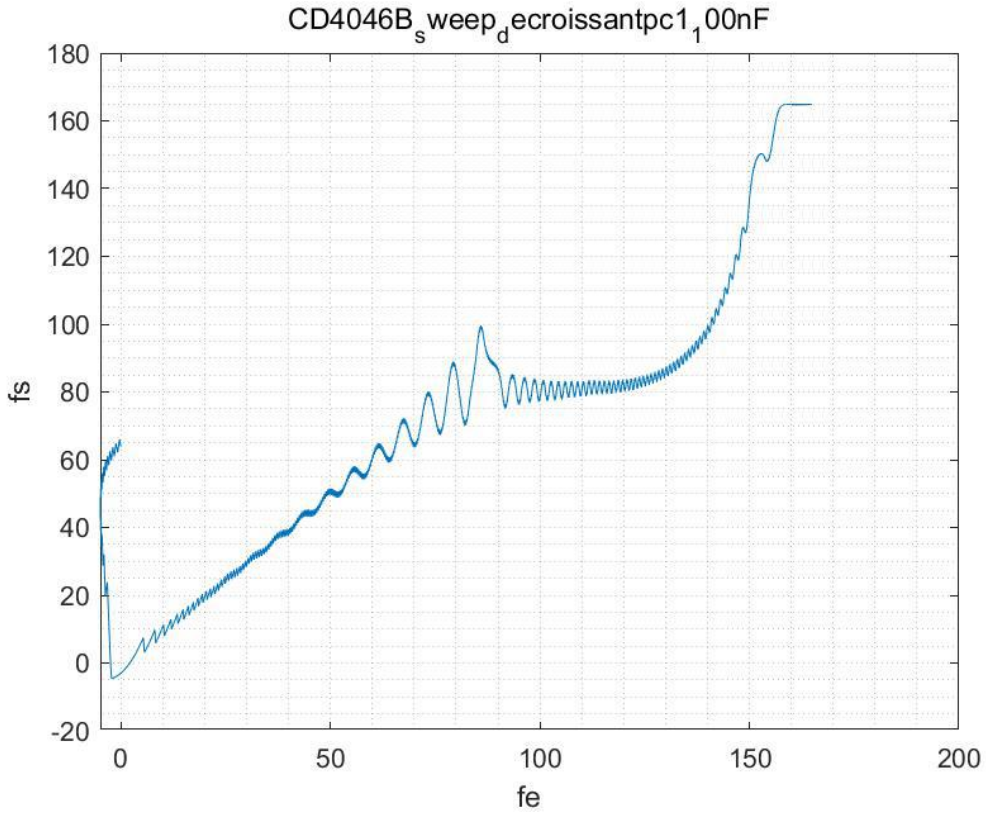


Donc, la plage de verouillage est 18--160 kHz

La plage de capture est 7.5--160kHz

pc1_100nF

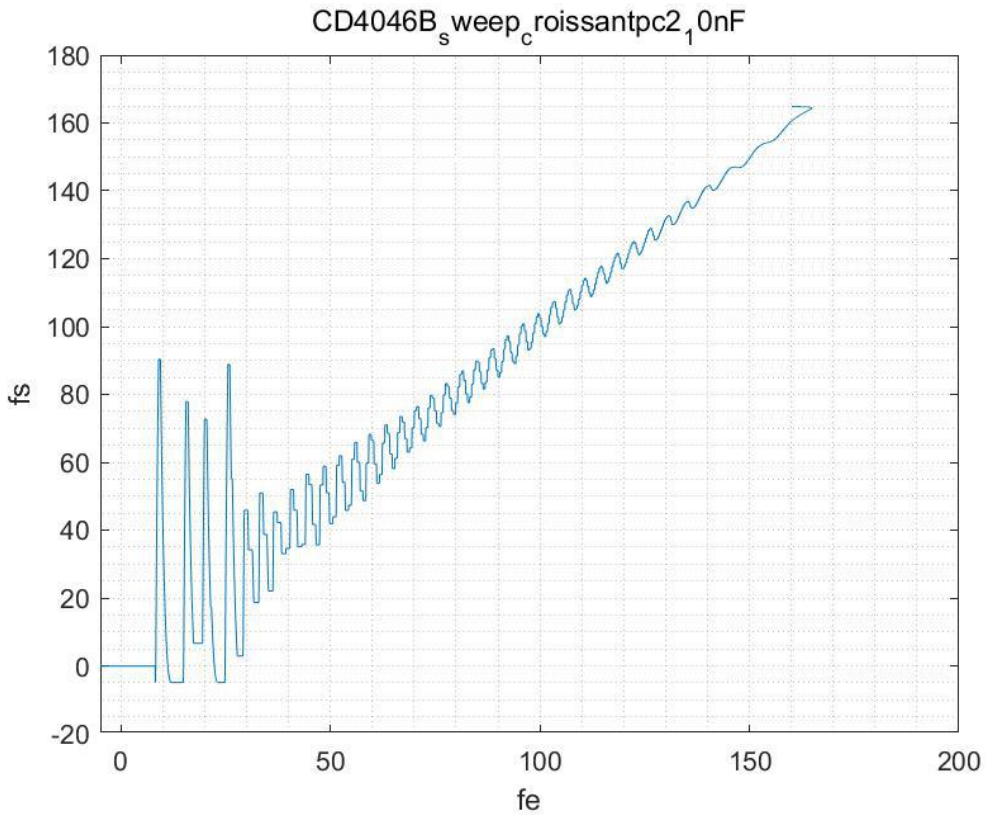


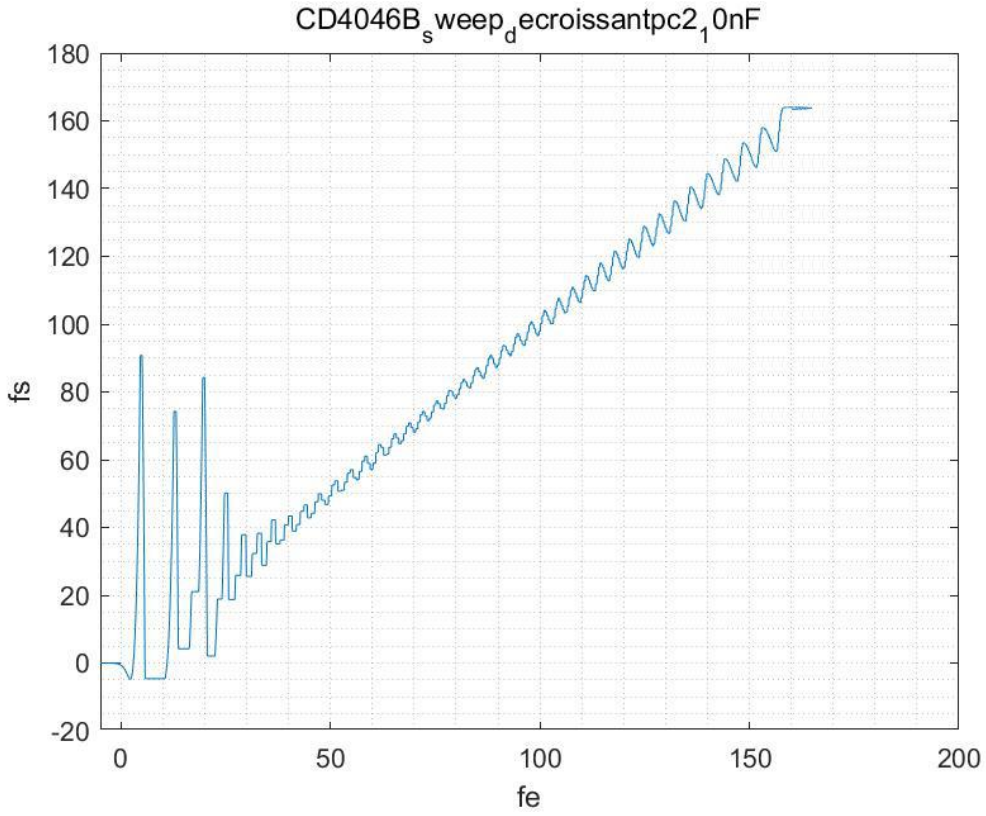


Donc, la plage de verouillage est 6--155 kHz

La plage de capture est 0--165kHz

pc2_10nF

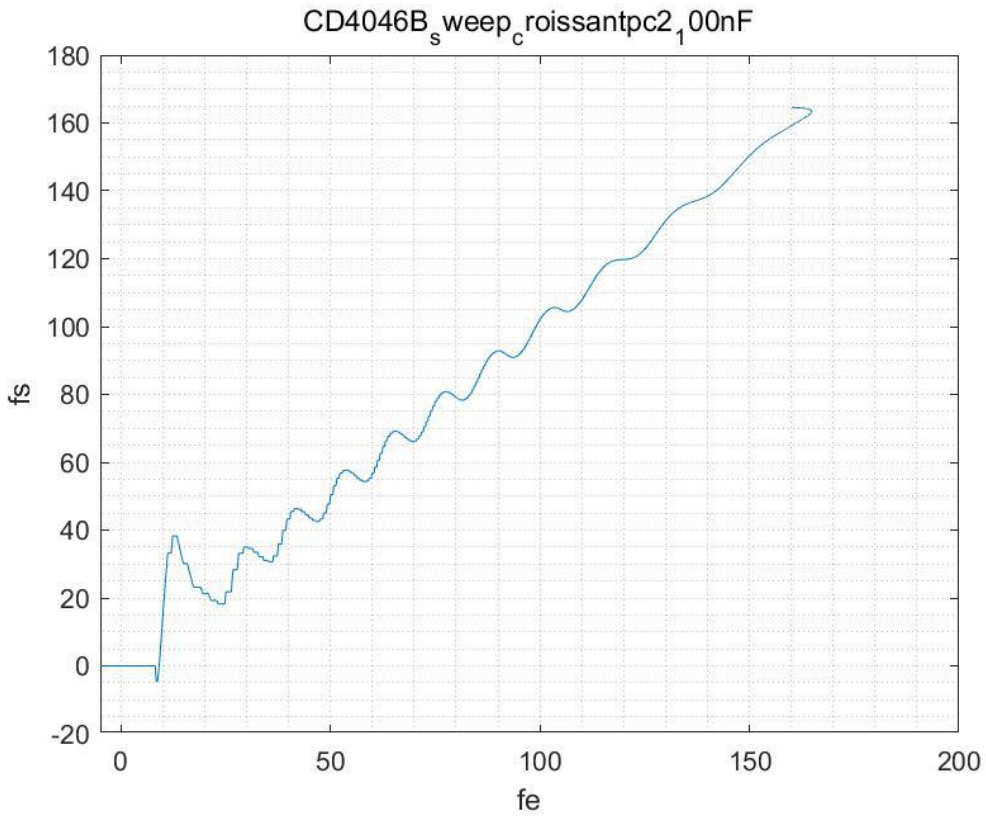


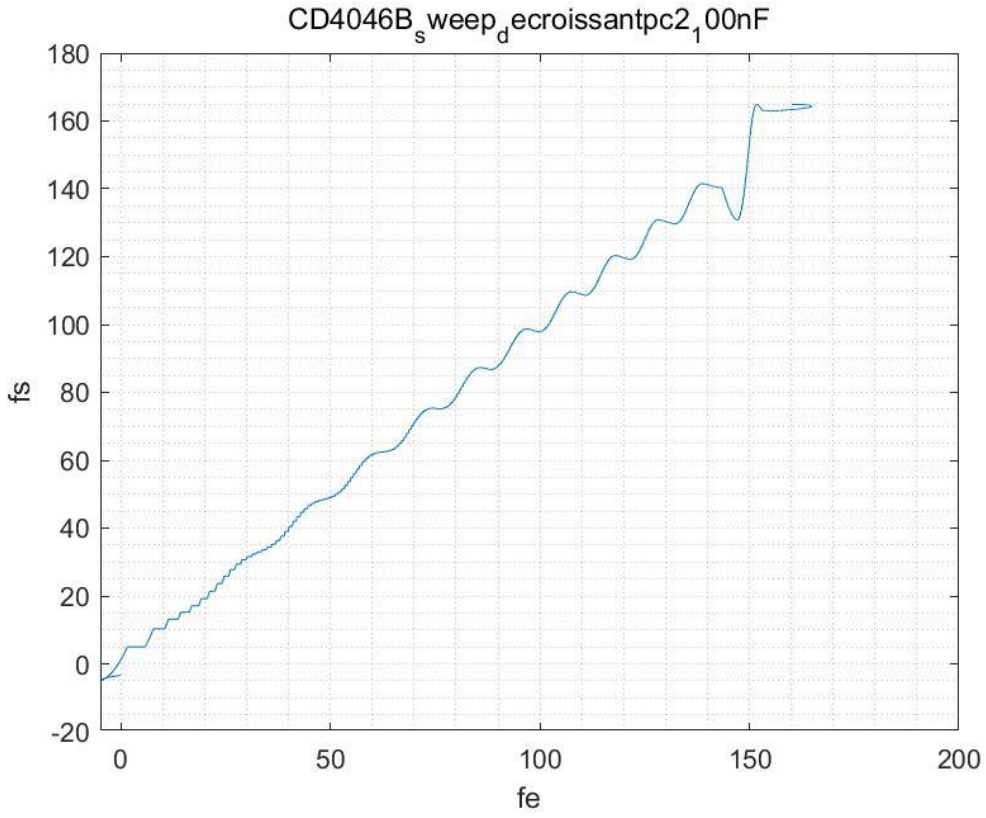


Donc, la plage de verouillage est 8--160 kHz

La plage de capture est 2--165kHz

pc2_100nF





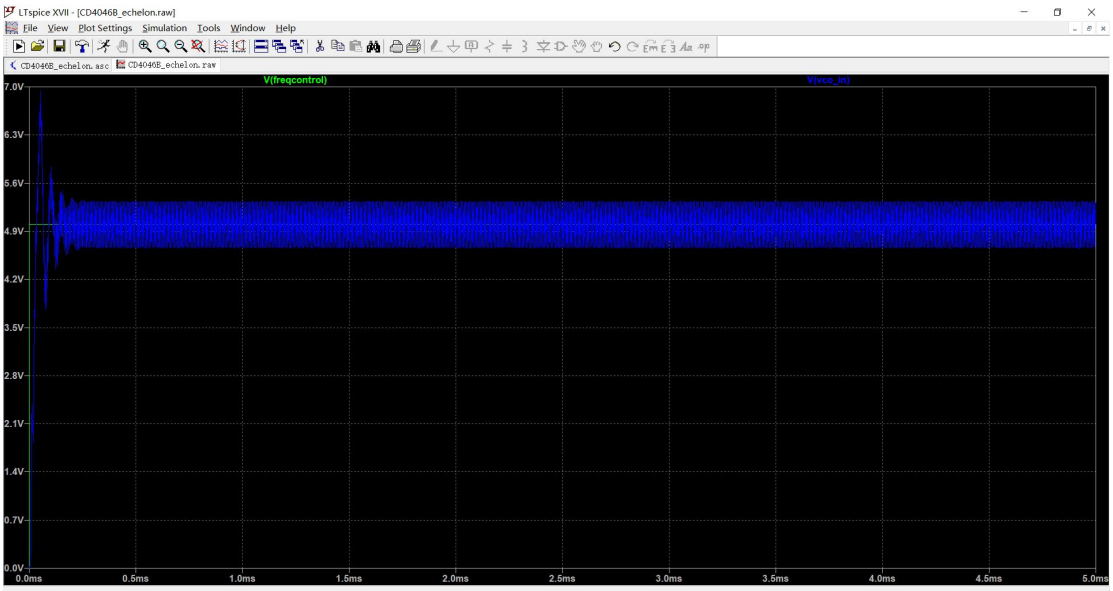
Donc, la plage de verouillage est 8--150 kHz

La plage de capture est 0--165kHz

Partie 3 Réponse de la PLL à un échelon

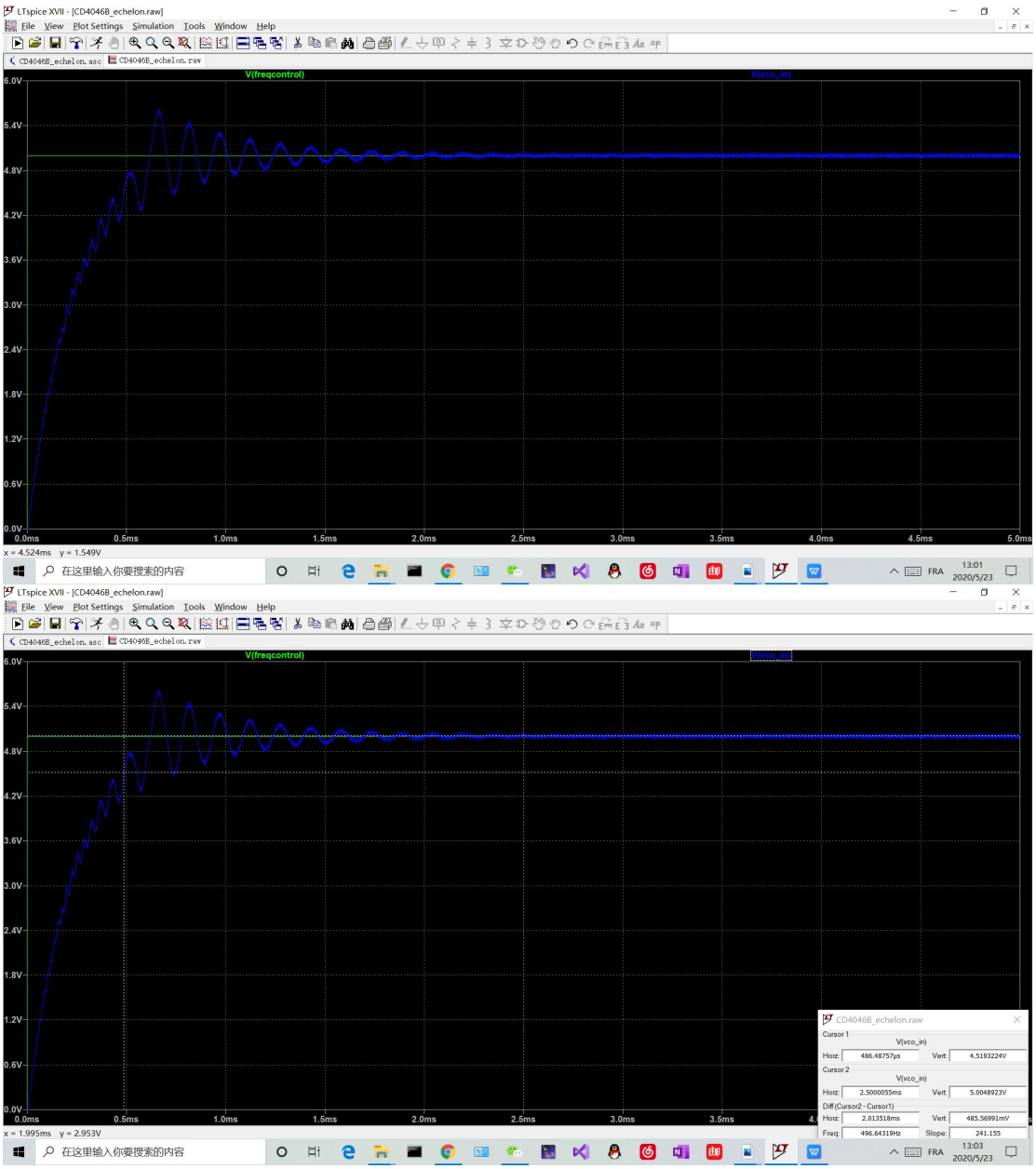
Q1 Q2

pc1_10nF



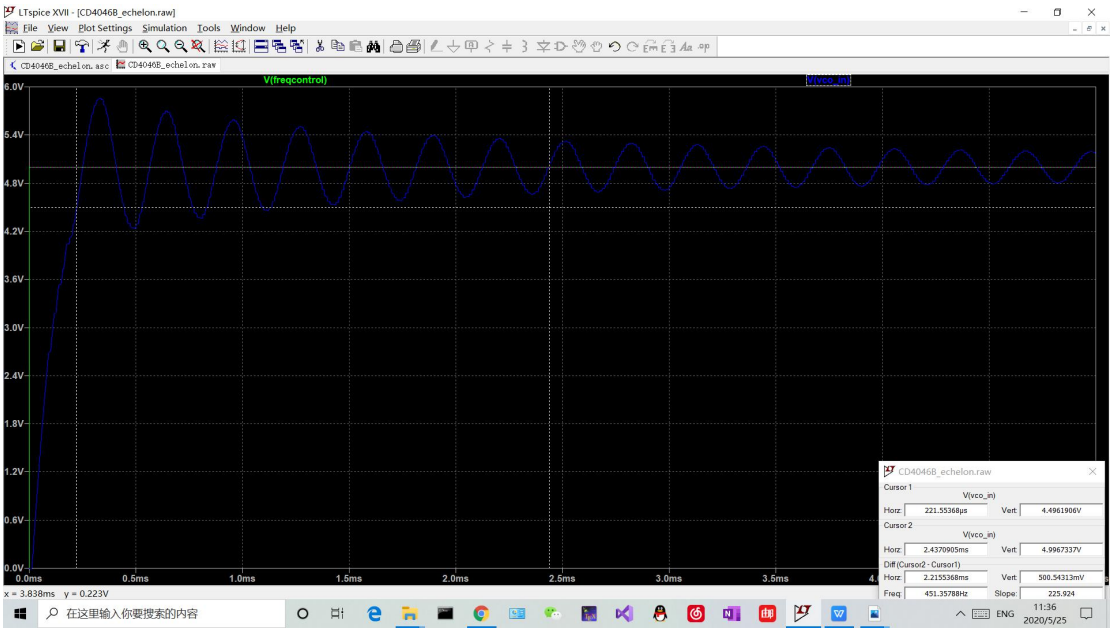
t=30e-6s

pc1_100nF



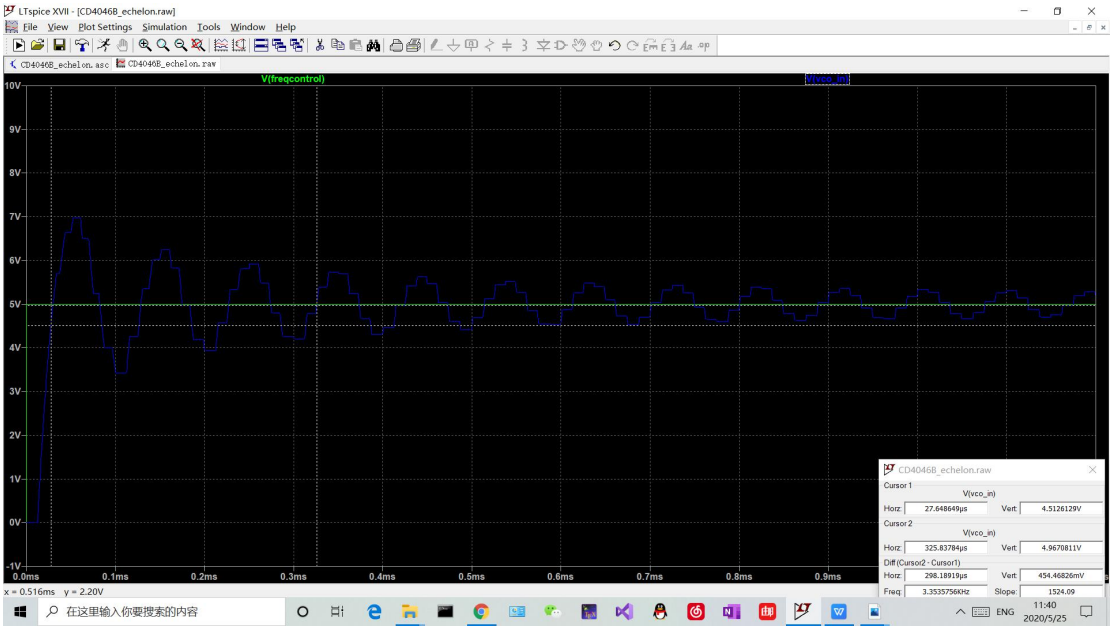
t=486e-6s

pc2_100nF



t=221e-6s

pc2_10nF



t=27e-6s

Q3

C2=10nF

T=R3*C2=18e-6s

Tpc1=30e-6s

Tpc2=27e-6s

C2=100nF

T=R3*C2=180e-6s

Tpc1=486e-6s

Tpc2=221e-6s

Donc, il y a des erreurs mais l’ordre de grandeur est vrai.