Power Electronics

Lab 1

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Date Performed: 2019/3/4

Overall

Score

Abstract(About100 words, 10 points)

The objective of lab 1 is getting familiar with some common waveforms in Power Electronics and their parameter measurement by Oscilloscope, and then is to generate the PWM signal with the help of TL494. As to the measurement, frequency, the root-mean-square value, the mean, and the peak value are included. In terms of the PWM signal, it is required to construct the correct circuit with the TL494, so the PWM signal can be generated with even the DC source after adjusting the proper duty cycle.

Score

Calculations and Results (Calculations, data tables and figures;)

1. Data Tables

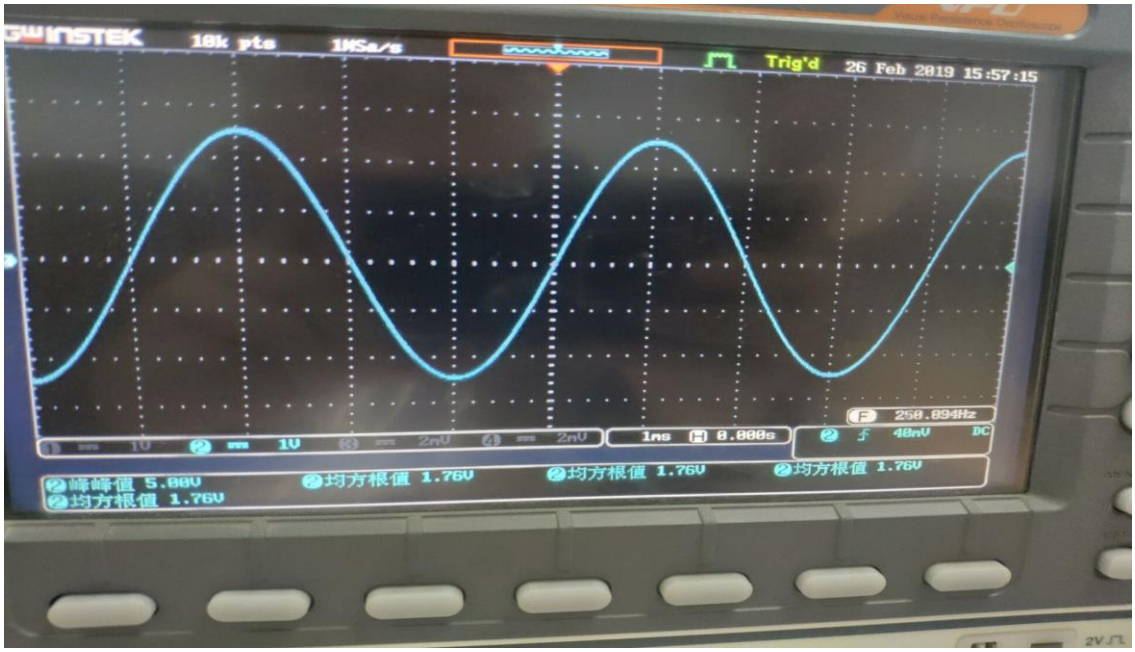
Exp 1:

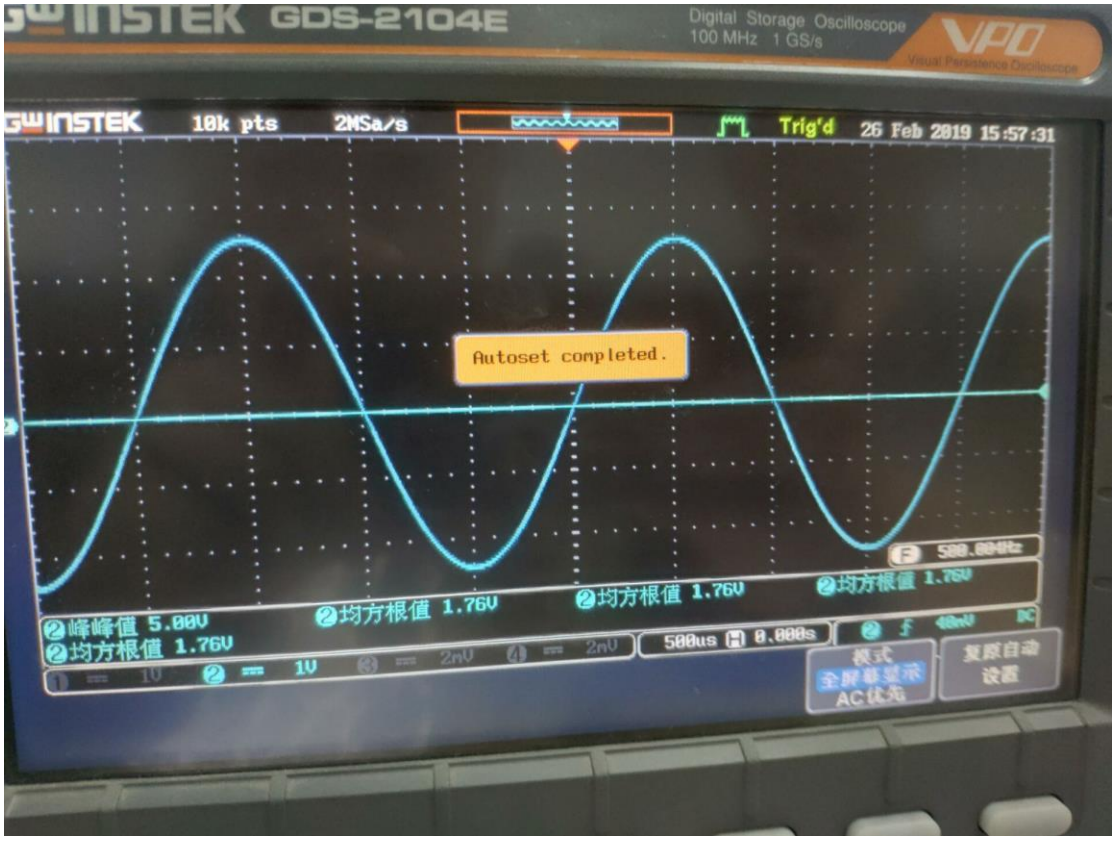
Waveform: sinusoidal

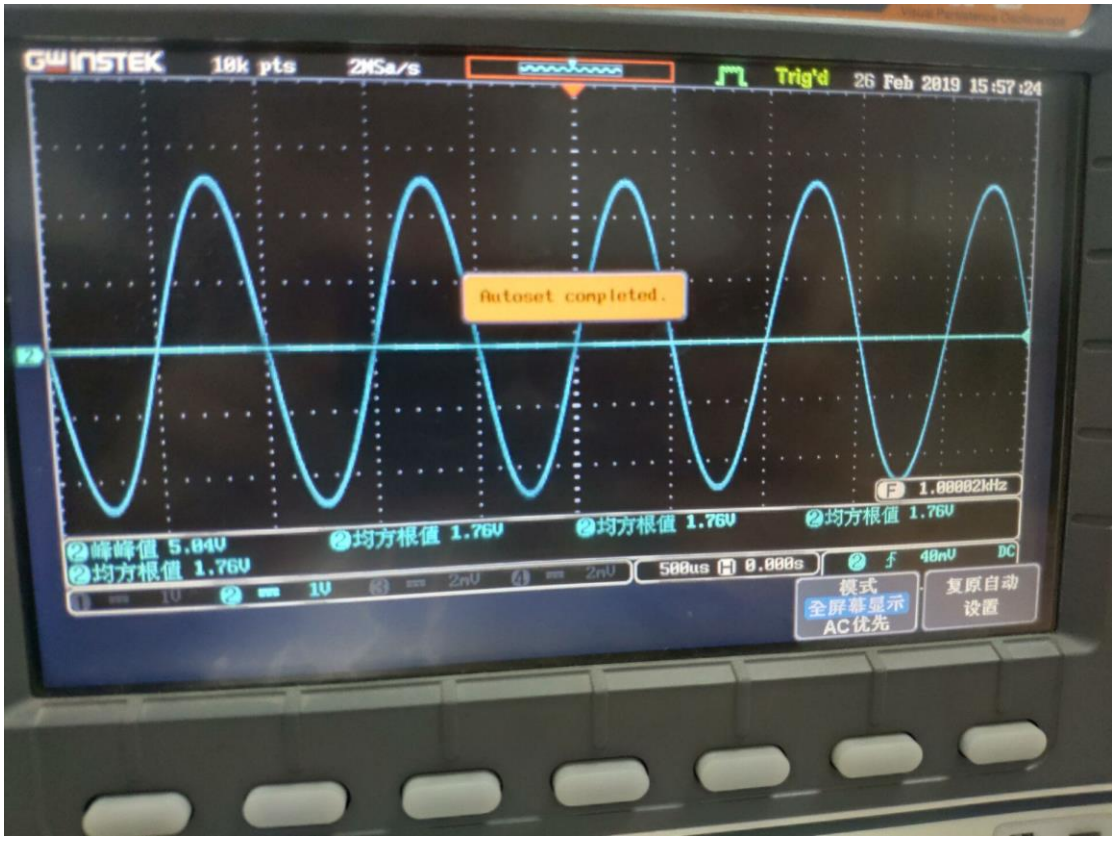
Frequency range: 1kHz

Voltage amplitude: 5V

Period/ms	1	2	4
Frequency/Hz	1k	500	250







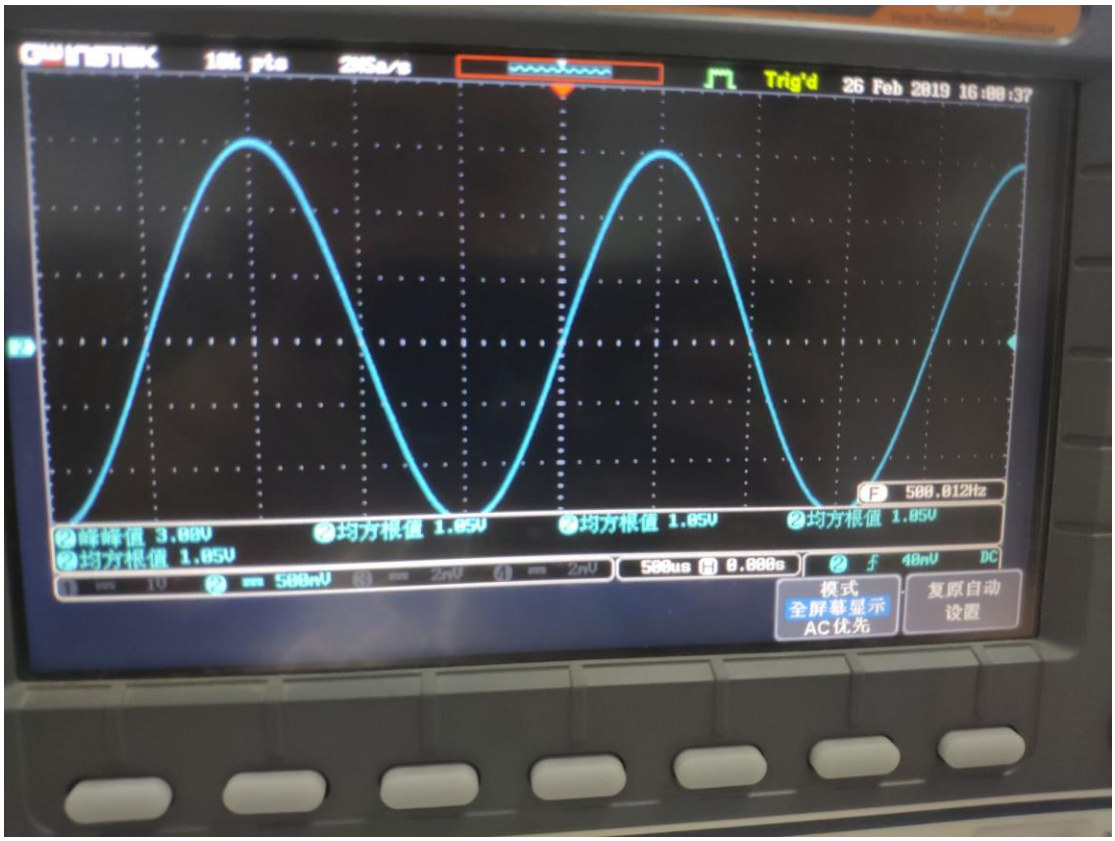
Exp 2:

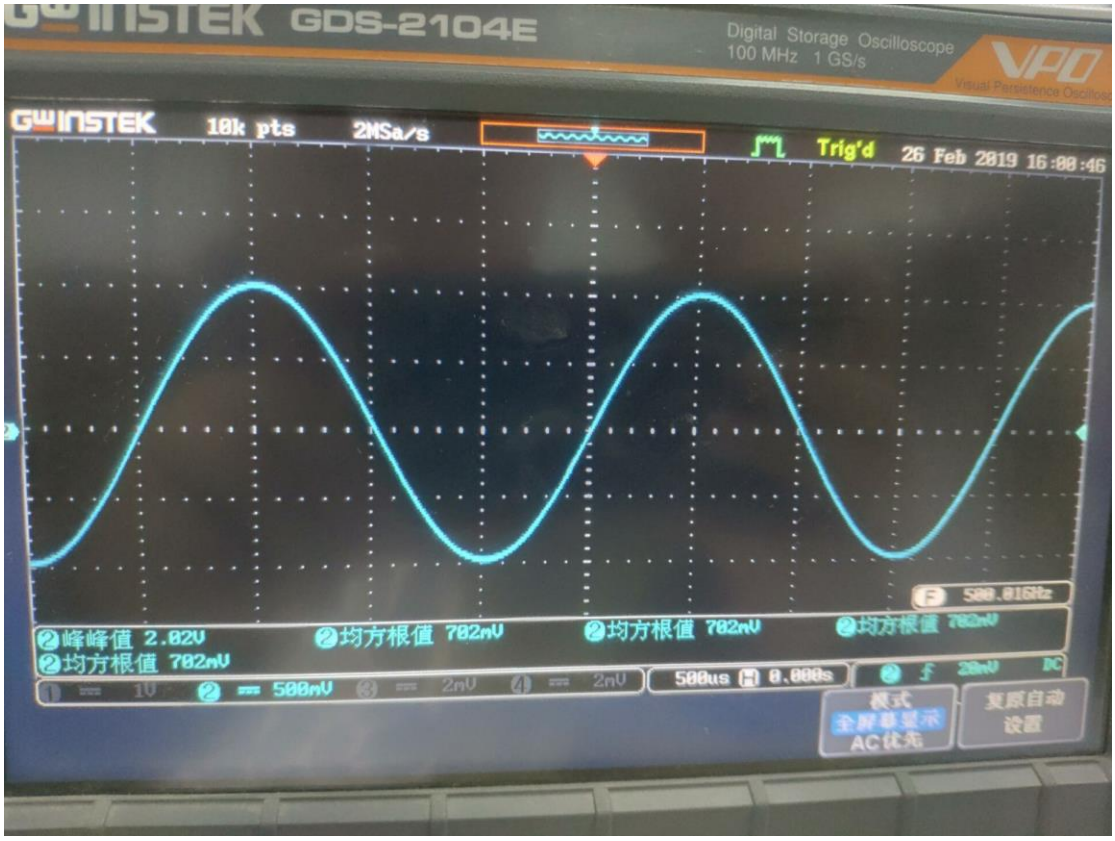
Waveform: sinusoidal

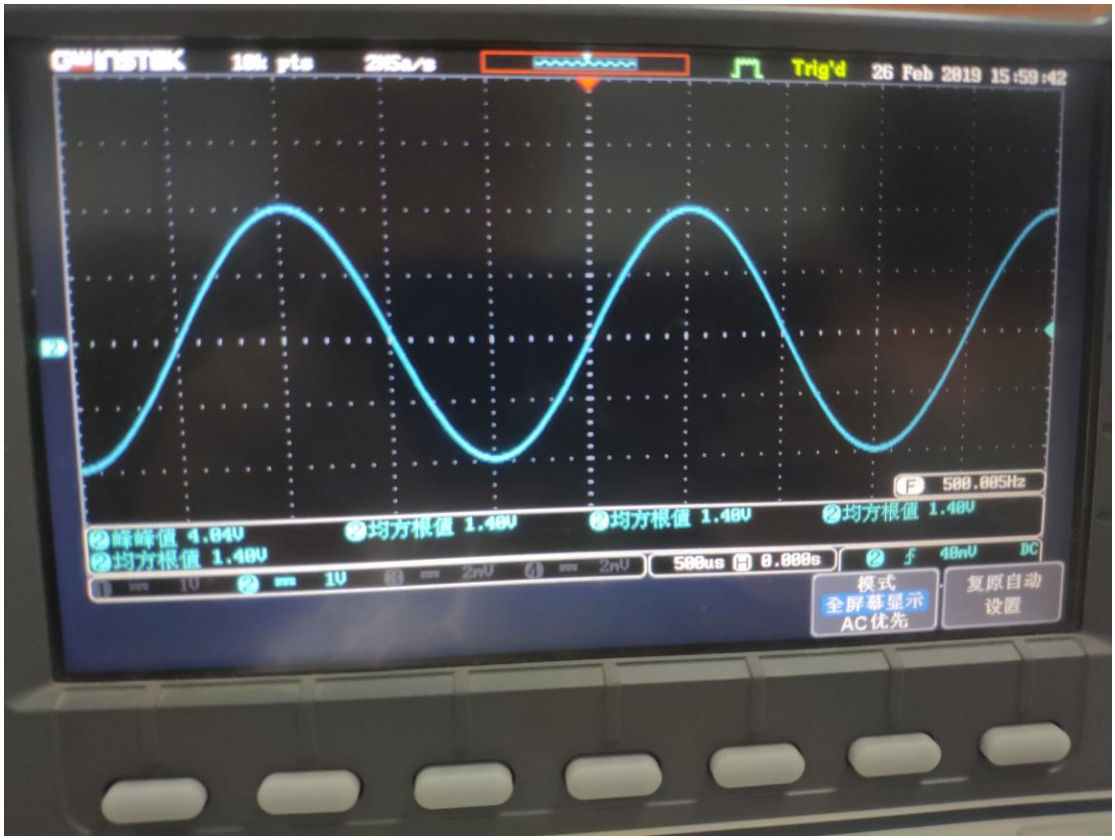
Frequency range: 500Hz

DMM :0.69 0.89 1.29 0.99 1.09

Peak voltage/V	1.50	1.01	2.02
RMS voltage/V	1.05	0.702	1.40
RMS voltage by DMM/V	1.09	0.69	1.29




GDS-2104E
Digital Storage Oscilloscope
100 MHz 1 GS/s
GW INSTEK
10k pts
2MSa/s
Trig'd
26 Feb 2019 16:08:46
峰峰值 2.02V
均方根值 702mV
均方根值 702mV
均方根值 702mV
均方根值 702mV
500mV
500us
0.000s
模式
全屏幕显示
AC优先
复原自动
设置

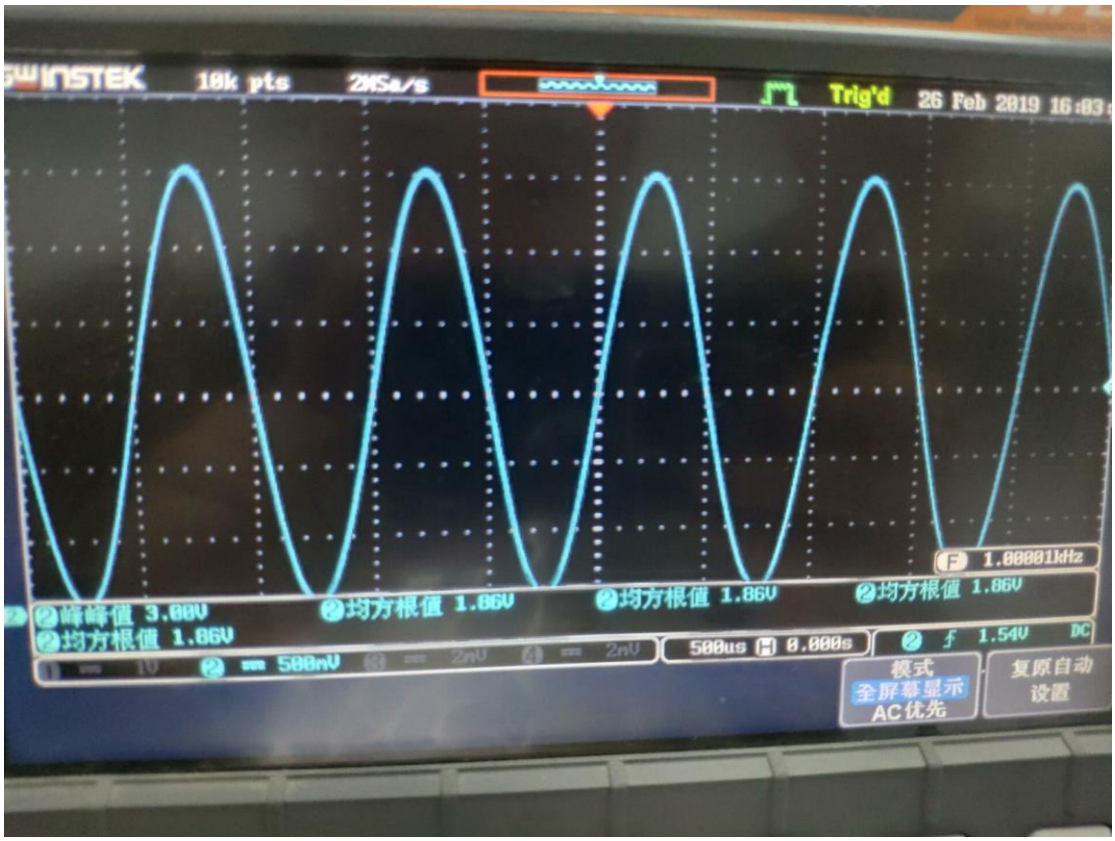

GW INSTEK
10k pts
Trig'd
26 Feb 2019 15:59:42
500.005Hz
峰峰值 4.04V
均方根值 1.40V
均方根值 1.40V
均方根值 1.40V
均方根值 1.40V
1V
500us
0.000s
模式
全屏幕显示
AC优先
复原自动
设置

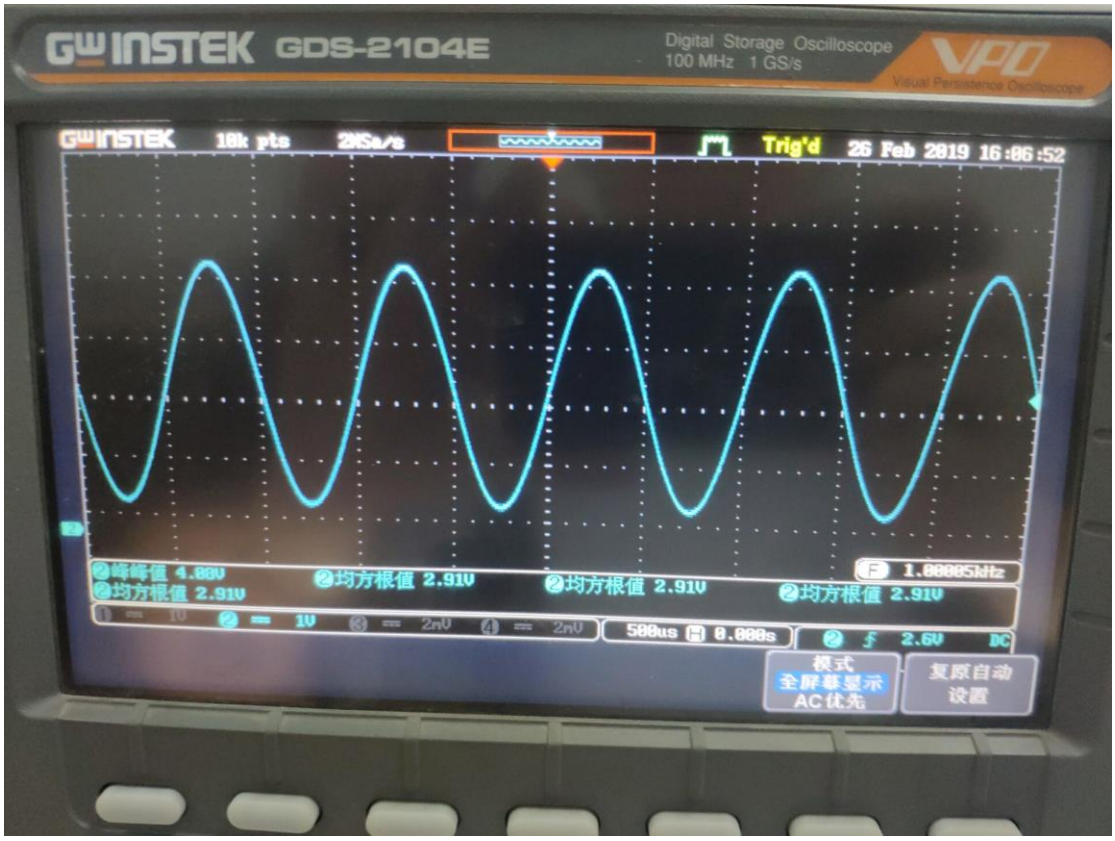
Exp 3:

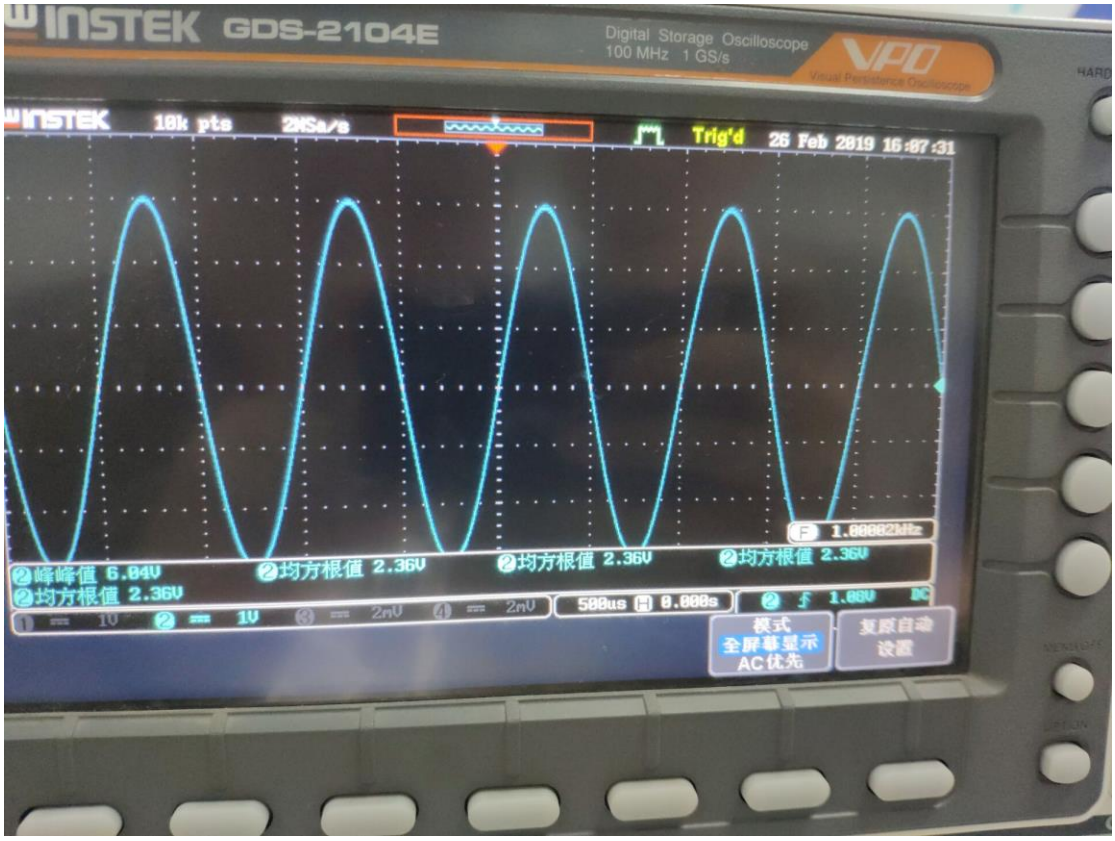
Waveform: sinusoidal

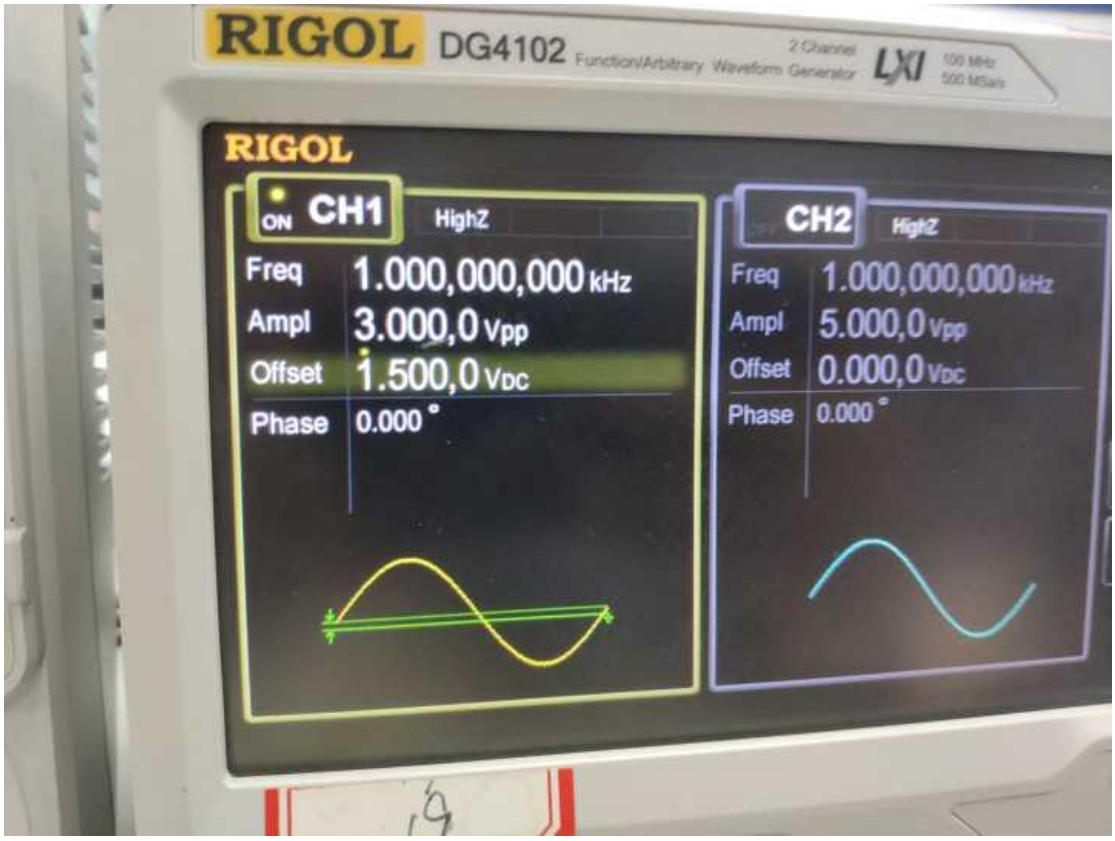
Frequency range: 1kHz

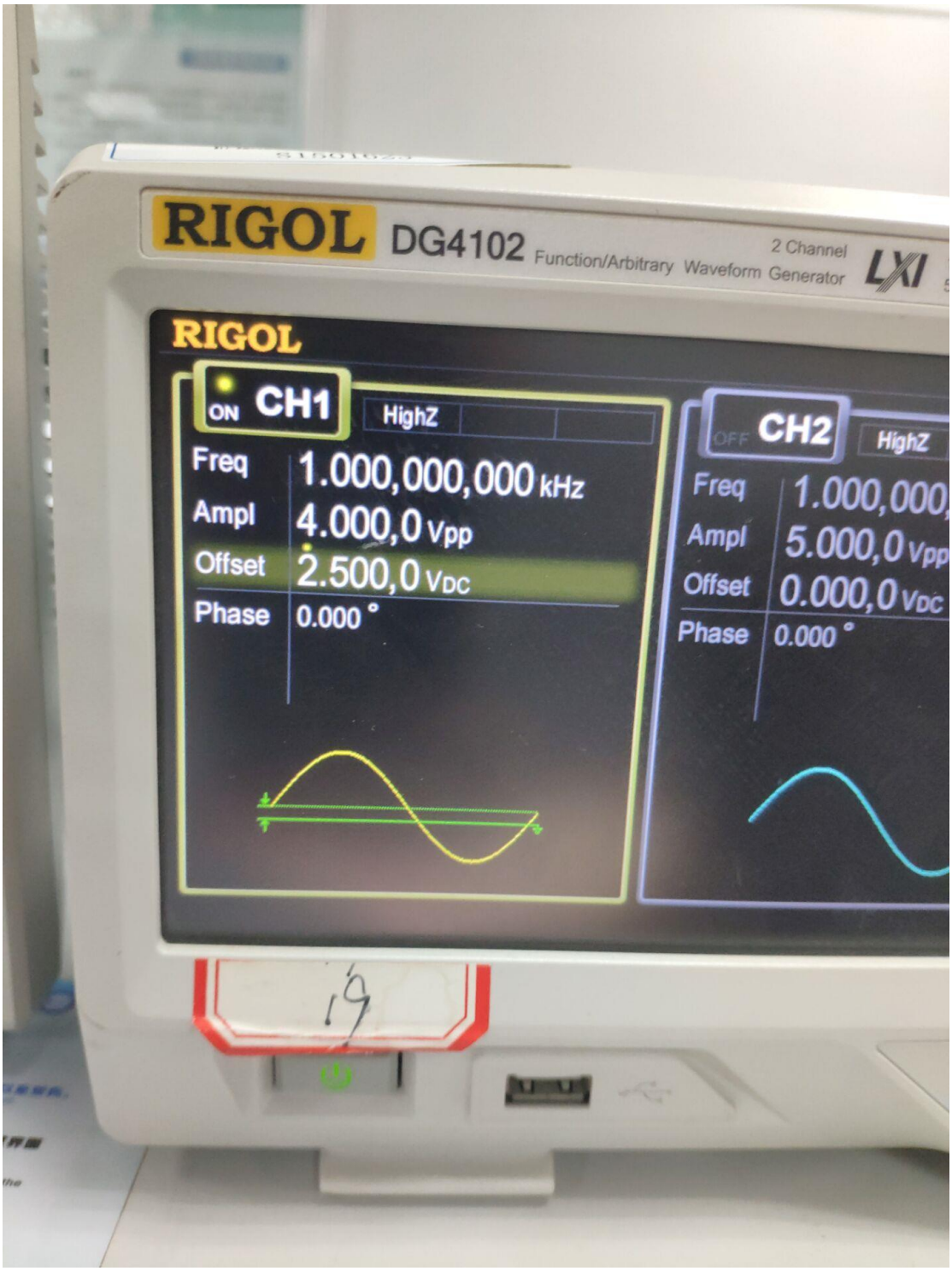
AC Peak value/V	1.50	2.00	3.02
DC Peak value/V	1.54	2.60	1.00
AC RMS voltage/V	1.06	1.41	2.14
Total RMS value/V	1.86	2.91	2.36




GW INSTEK GDS-2104E
Digital Storage Oscilloscope
100 MHz 1 GS/s
VPO
Visual Persistence Oscilloscope
GW INSTEK 10k pts 2MSa/s Trig'd 26 Feb 2019 16:06:52
峰峰值 4.80V
均方根值 2.91V
均方根值 2.91V
均方根值 2.91V
均方根值 2.91V
1.00005MHz
1V 2nV 2nV
500us 0.000s
2.6V DC
模式
全屏幕显示
AC优先
复原自动
设置


GW INSTEK GDS-2104E
Digital Storage Oscilloscope
100 MHz 1 GS/s
VPO
Visual Persistence Oscilloscope
GW INSTEK 10k pts 2MSa/s Trig'd 26 Feb 2019 16:07:31
峰峰值 6.04V
均方根值 2.36V
均方根值 2.36V
均方根值 2.36V
均方根值 2.36V
1.00002MHz
1V 2nV 2nV
500us 0.000s
1.08V DC
模式
全屏幕显示
AC优先
复原自动
设置

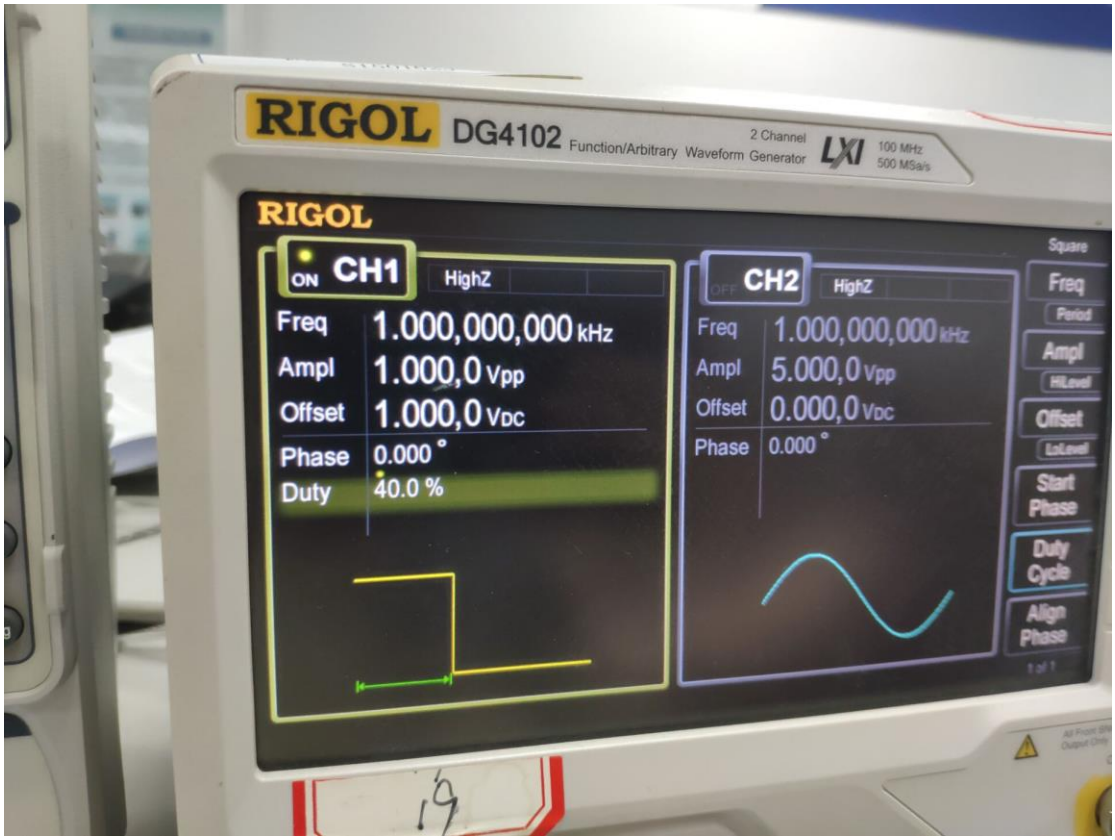

RIGOL
DG4102
Function/Arbitrary Waveform Generator
RIGOL
ON CH1
HighZ
Freq 1.000,000,000 kHz
Ampl 3.000,0 Vpp
Offset 1.500,0 VDC
Phase 0.000 °
CH2
HighZ
Freq 1.000,000,000 kHz
Ampl 5.000,0 Vpp
Offset 0.000,0 VDC
Phase 0.000 °

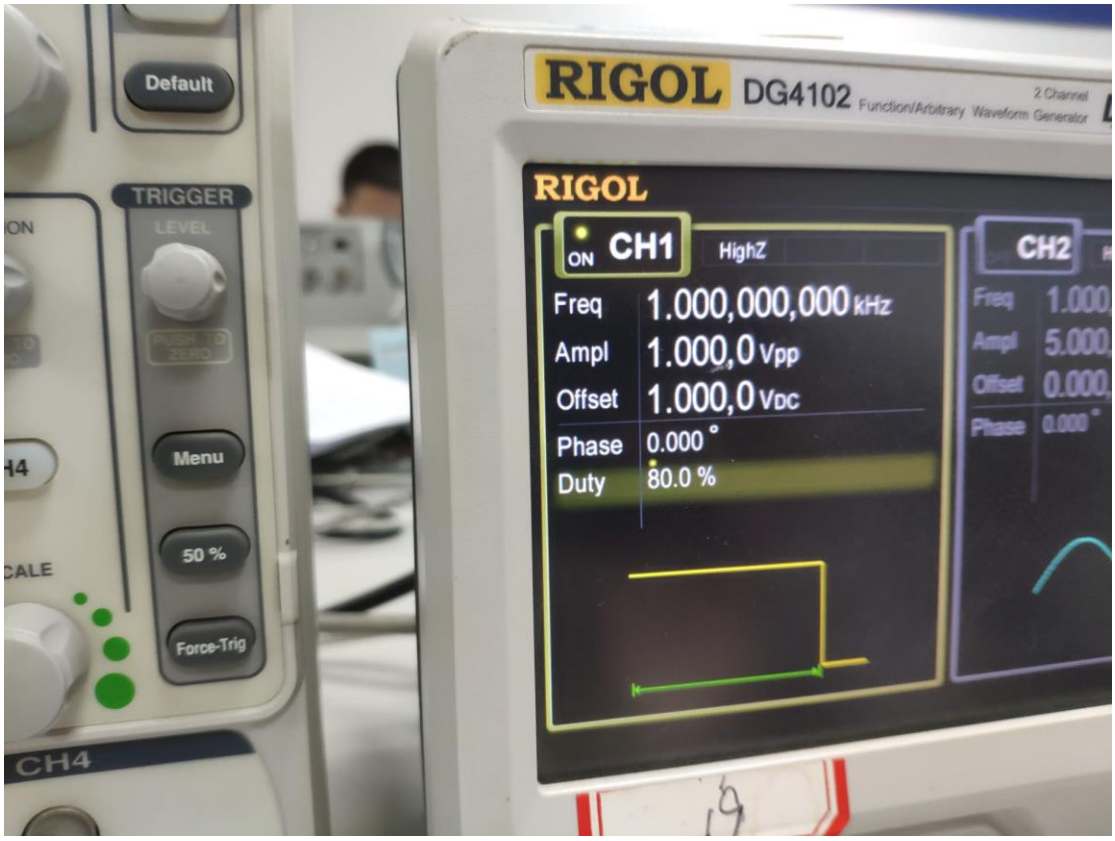

RIGOL
DG4102
Function/Arbitrary Waveform Generator
2 Channel
LXI
RIGOL
ON CH1
HighZ
Freq 1.000,000,000 kHz
Ampl 4.000,0 Vpp
Offset 2.500,0 VDC
Phase 0.000 °
OFF CH2
HighZ
Freq 1.000,000,
Ampl 5.000,0 Vpp
Offset 0.000,0 VDC
Phase 0.000 °

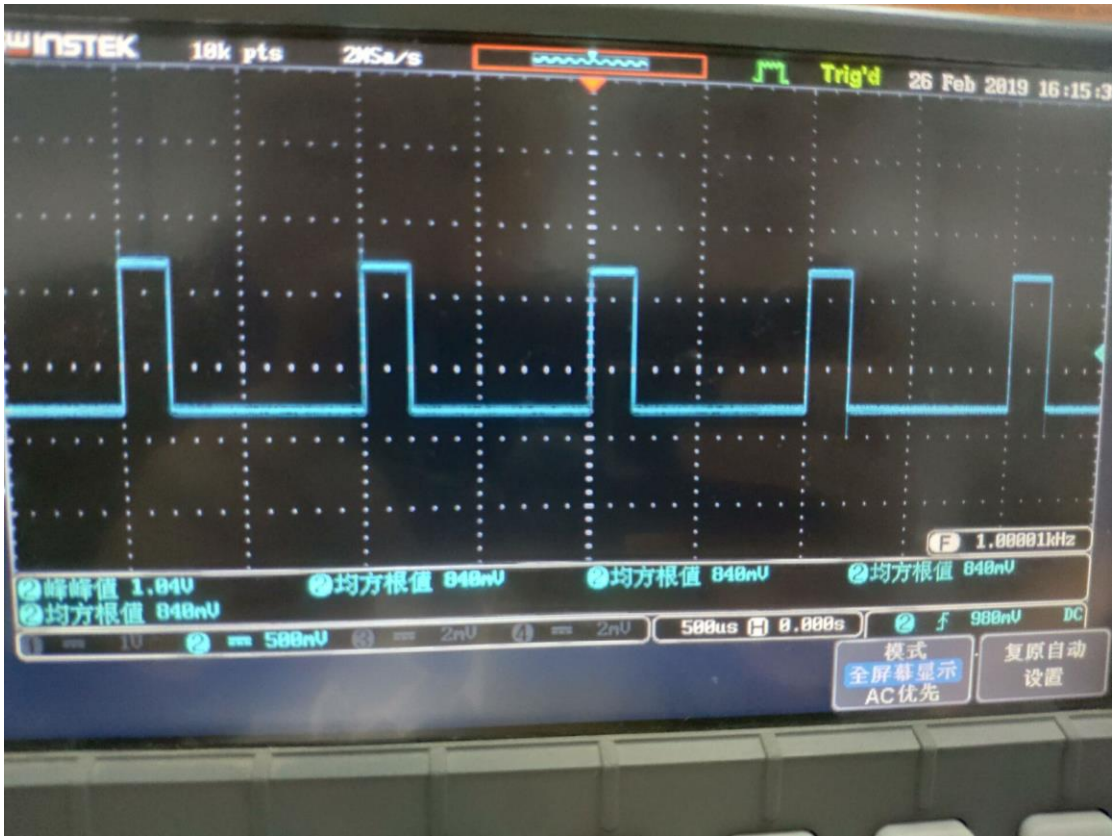
Exp 4&Exp 5
Waveform: square wave
Frequency range: 1kHz

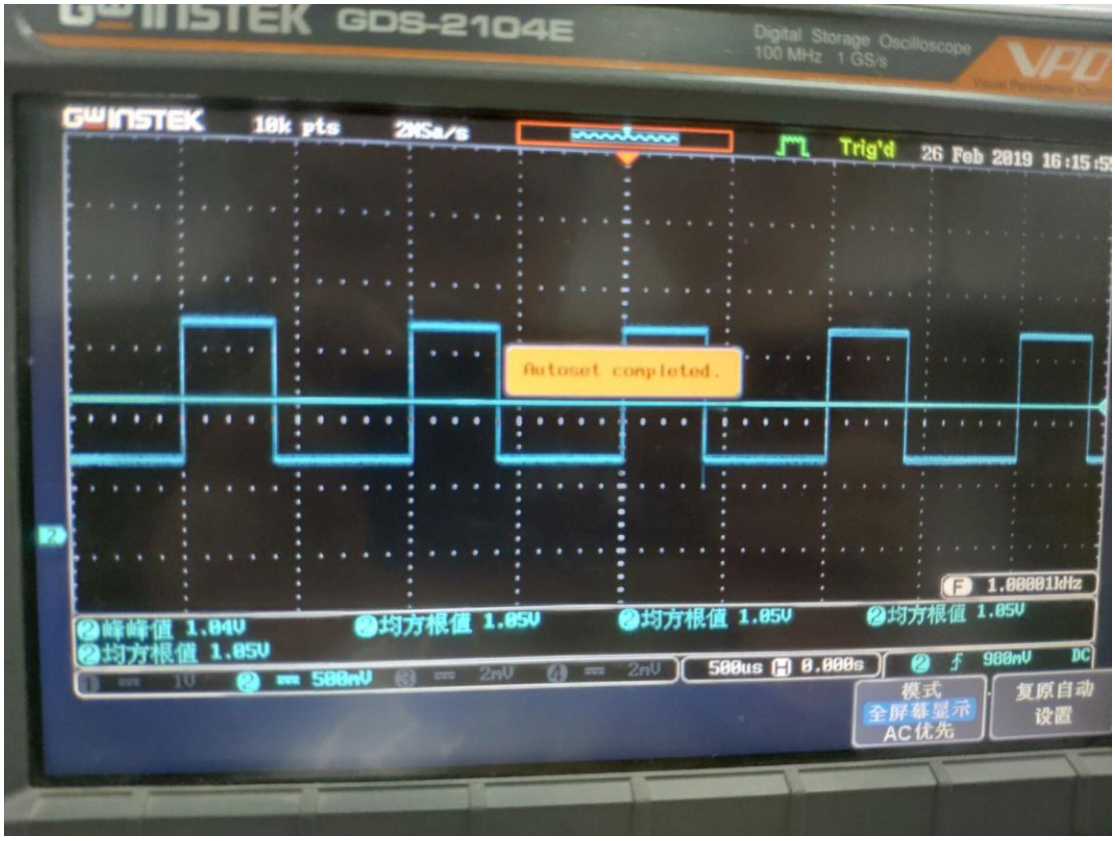
The initial setup is to produce a 2V waveform with DC offset such that the lower voltage level is 0V (see Figure 8). This is achieved by setting the Voltage Amplitude and the DC Offset knobs and checking the waveform on the oscilloscope

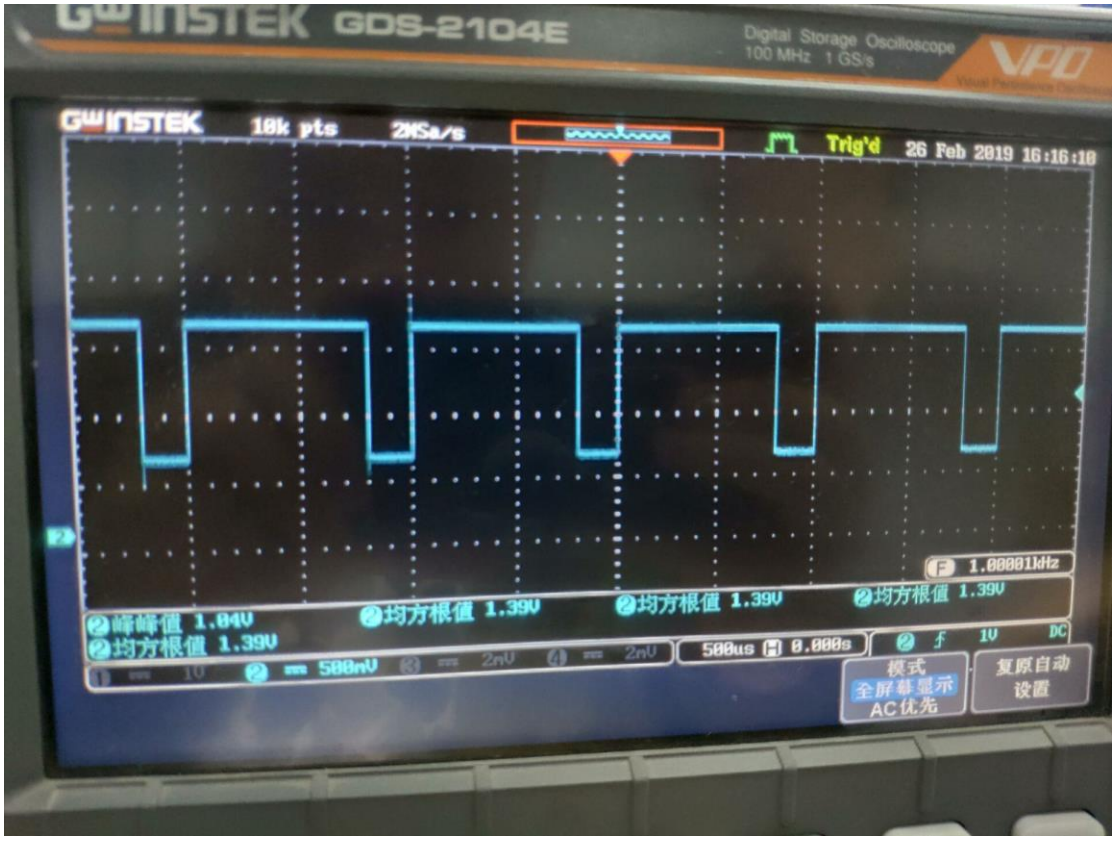

RIGOL
DG4102
Function/Arbitrary Waveform Generator
2 Channel
100 MHz
500 MSa/s
RIGOL
ON CH1
HighZ
Freq 1.000,000,000 kHz
Ampl 1.000,0 Vpp
Offset 1.000,0 VDC
Phase 0.000 °
Duty 20.0 %
CH2
HighZ
Freq 1.000,000,000 kHz
Ampl 5.000,0 Vpp
Offset 0.000,0 VDC
Phase 0.000 °
Square
Freq
Ampl
Offset
Start Phase
Duty Cycle
Align Phase


RIGOL
DG4102
Function/Arbitrary Waveform Generator
2 Channel
100 MHz
500 MSa/s
RIGOL
ON CH1
HighZ
Freq 1.000,000,000 kHz
Ampl 1.000,0 Vpp
Offset 1.000,0 VDC
Phase 0.000 °
Duty 40.0 %
CH2
HighZ
Freq 1.000,000,000 kHz
Ampl 5.000,0 Vpp
Offset 0.000,0 VDC
Phase 0.000 °
Square
Freq
Ampl
Offset
Start Phase
Duty Cycle
Align Phase


RIGOL
DG4102
Function/Arbitrary Waveform Generator
2 Channel
Default
TRIGGER
LEVEL
Menu
50 %
Force-Trig
CH4
RIGOL
ON CH1
HighZ
Freq 1.000,000,000 kHz
Ampl 1.000,0 Vpp
Offset 1.000,0 VDC
Phase 0.000 °
Duty 80.0 %
CH2


INSTEK
10k pts
2MSa/s
Trig'd
26 Feb 2019
峰峰值 1.04V
均方根值 848mV
均方根值 848mV
均方根值 848mV
均方根值 848mV
500us
0.000s
500mV
2mV
2mV
988mV
DC
模式
全屏幕显示
AC优先
复原自动
设置


GW INSTEK GDS-2104E
Digital Storage Oscilloscope
100 MHz 1 GS/s
GW INSTEK 10k pts 2MSa/s Trig'd 26 Feb 2019 16:15:5
Autoset completed.
峰峰值 1.04V
均方根值 1.05V
均方根值 1.05V
均方根值 1.05V
均方根值 1.05V
500mV 2nV 2nV
500us 0.000s
900mV DC
模式
全屏幕显示
AC优先
复原自动
设置


GW INSTEK GDS-2104E
Digital Storage Oscilloscope
100 MHz 1 GS/s
GW INSTEK 10k pts 2MSa/s Trig'd 26 Feb 2019 16:16:10
峰峰值 1.04V
均方根值 1.39V
均方根值 1.39V
均方根值 1.39V
均方根值 1.39V
500mV 2nV 2nV
500us 0.000s
1V DC
模式
全屏幕显示
AC优先
复原自动
设置

Exp 6 will be shown in AtQ.

2. Calculations

%Error = ((Vtheory −Vmeasured)/ Vtheory) x 100%

Exp 1:
Freq=1/period
1kHz=1/1ms
500Hz=1/2ms
250Hz=1/4ms

Exp 2:
RMS voltage= Peak voltage/$\sqrt{2}$

1.06= 1.50/$\sqrt{2}$
0.71= 1.01/$\sqrt{2}$
1.43=2.02/$\sqrt{2}$

Exp 3:
VTotal rms =$\sqrt{V_{AC\ rms}^2 + V_{DC\ rms}^2}$

AC RMS voltage= AC Peak voltage/$\sqrt{2}$

AC Peak voltage=(Vmax-Vmin)/2

Vdc peak=Vdc mean=Vdc rms

Vdc=Vmin+ AC Peak voltage

AC PEAK	TOTAL(from the measurement)	DC	AC RMS	OFFSET	TOTAL(By calculation)
1.5	1.86	1.1673	1.06066	1.54	1.86992
2	2.91	3.23405	1.414214	2.6	2.95973
3.02	2.36	0.5047	2.135462	1	2.358008

Exp 4&Exp 5:

Duty Cycle (D) = ton/ τ

V_{mean}=DV_{peak} (for square wave)

DMM/V	0.39	0.82	1.59
Duty cycle	20%	40%	80%

Calculated peak value	1.95	2.05	1.9875

Exp 6 will be shown in AtQ.

Score

Answers to Questions

Exp 6:

Use Figure 3 in the data sheet to choose timing components to achieve an oscillator frequency of about 50 kHz. What values of RT and CT did you choose? On which pin does the sawtooth waveform appear? Measure the amplitude and frequency of the sawtooth.

as for the choice of RT and CT, Figure 3 below is needed. Since the vertical resistance is about 50k, then we have two sets of choice based on the CT value. Choices are labelled in the next picture with blue.

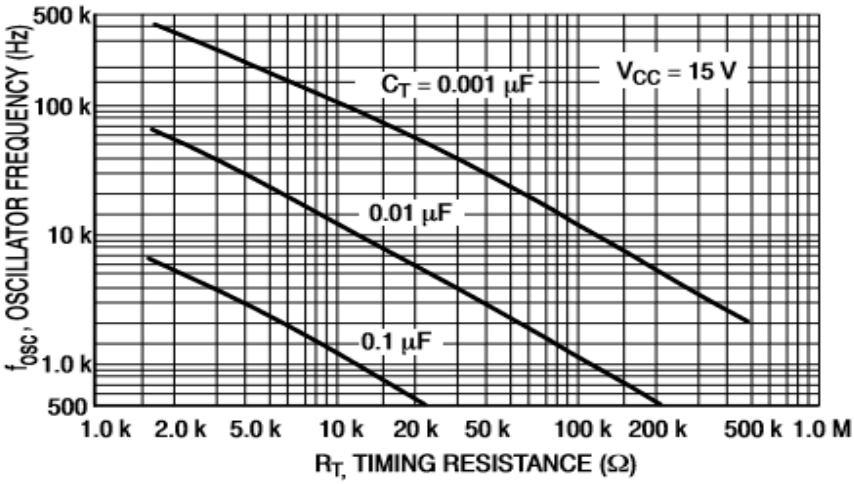


Figure 3. Oscillator Frequency versus Timing Resistance

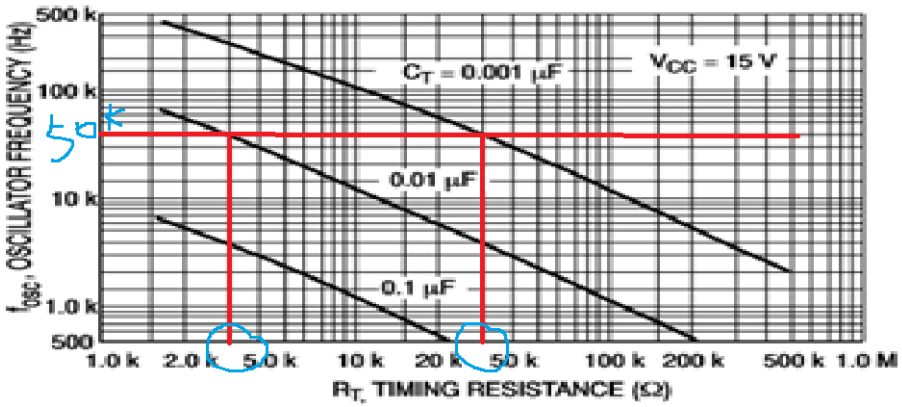
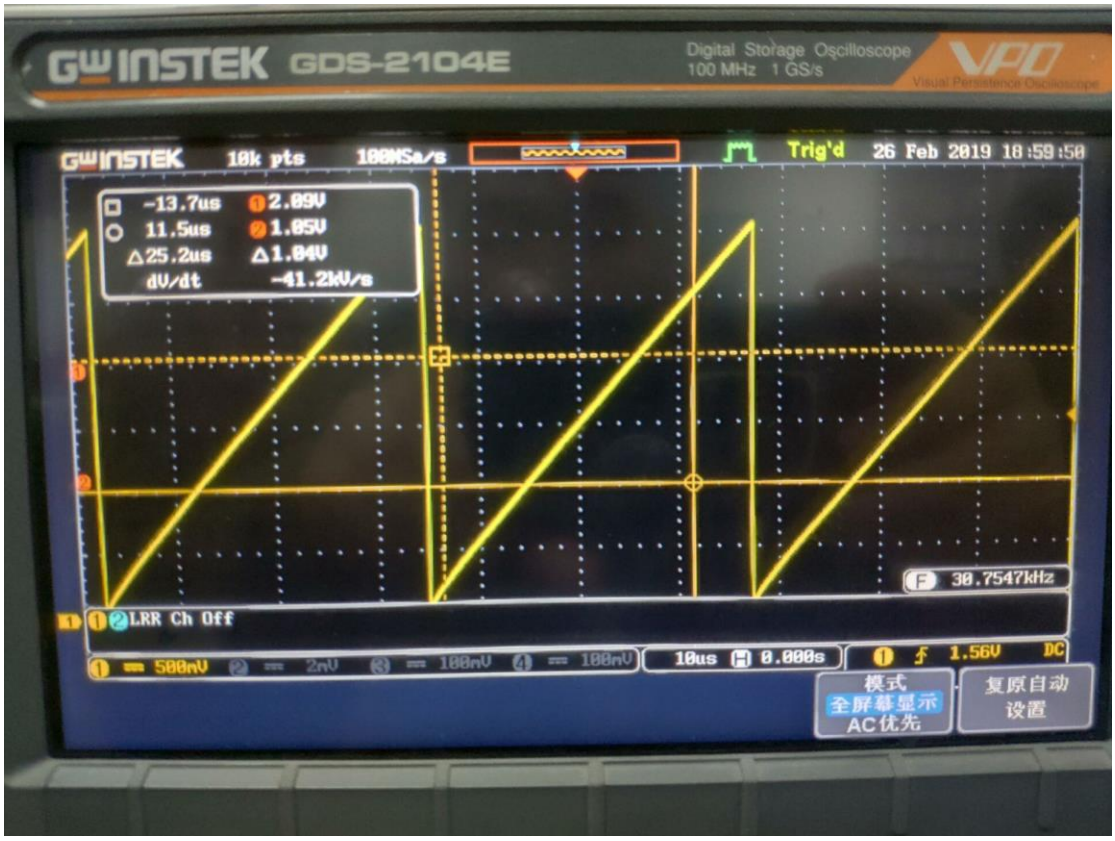


Figure 3. Oscillator Frequency versus Timing Resistance

In the pin5, we capture the sawtooth wave below, with the amplitude 1.04V and the frequency 30.75kHz.



Measure the Reference output voltage at pin 14. Use a voltage divider circuit to generate a variable voltage 0.5V~3.5V from the Reference output voltage. We will use this variable voltage as the control signal and it will be fed to pin 1. Pin 2 and 3 are connected to enable the Amplifier 1 to be a voltage follower. - What value resistors would you choose and why?

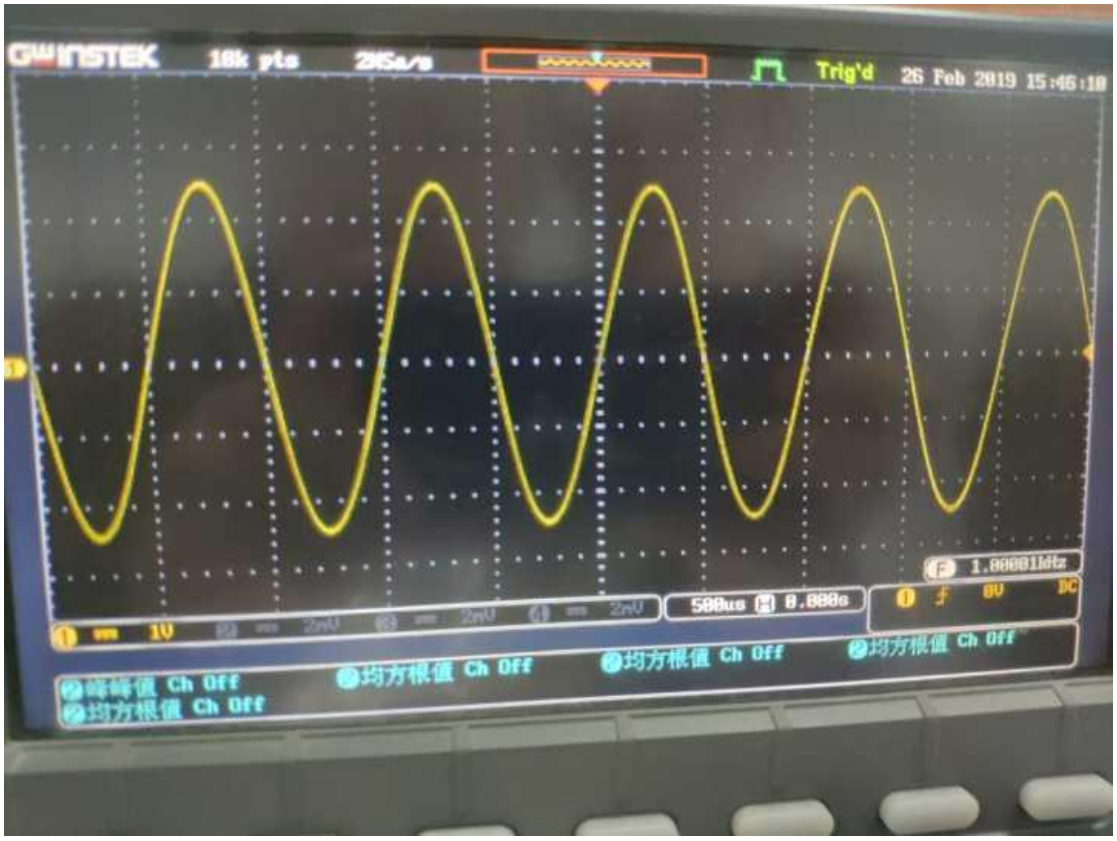
R1=20k

R2=120k

R3=60k

(errors exist in these resistors)

Then the sinusoid wave was shown below.



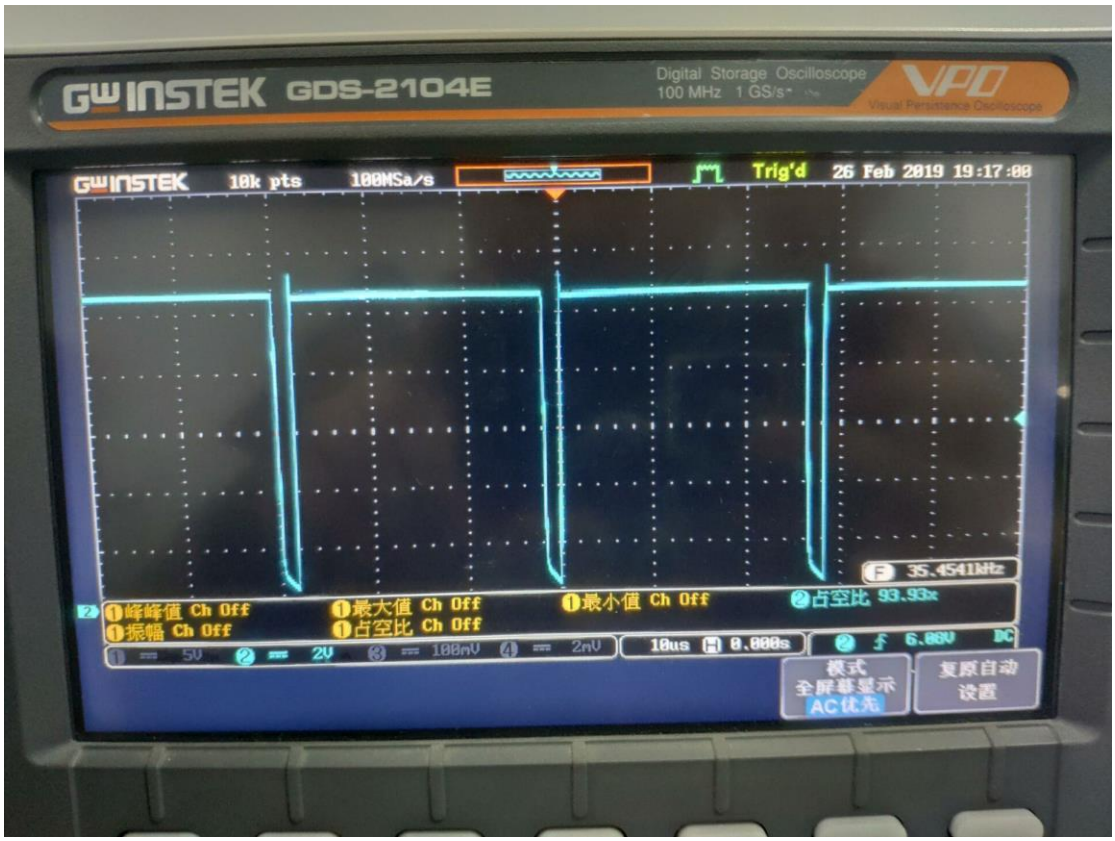
Pin 13 is tied to the ground. Using the information of Figure 17 of the data sheet connect your TL494 in the single-ended configuration. Remember that the chip outputs Q1 and Q2 are open collector and you will need to tie the emitters to ground via a resistor. - What value resistor would you choose and why? Now vary your input control voltage at pin 1 from low to high, while observing the output from Q1 and Q2. - What is the minimum control voltage to produce any output? - What is the maximum control voltage when the output saturates? - What is the maximum duty cycle you can achieve?

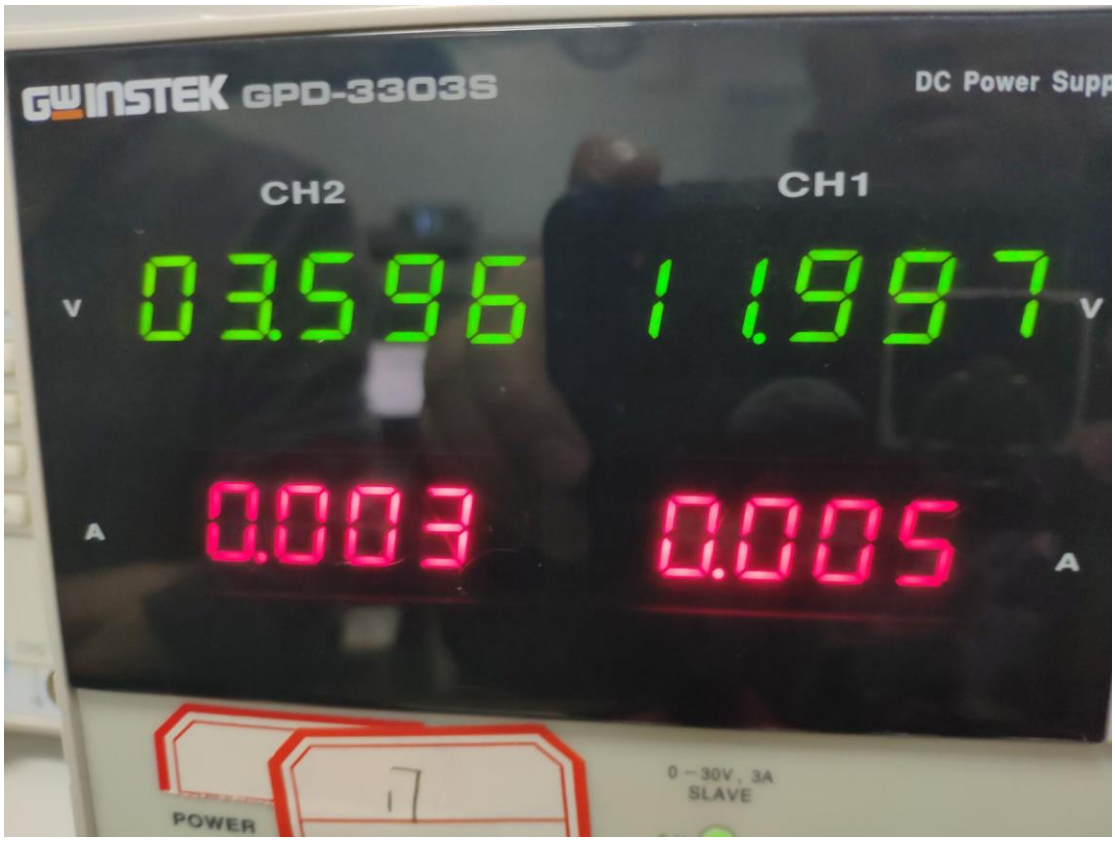
The minimum voltage is about 0.9V, during which the minimum duty cycle was reached, almost about 7.39%

The maximum voltage is about 3.5V, during which the maximun duty cycle was reached, almost about 93.93%


GW INSTEK
10k pts
100MSa/s
Trig'd
26 Feb 2019 19:17:47
Autoset completed.
峰峰值 Ch Off
振幅 Ch Off
最大值 Ch Off
占空比 Ch Off
最小值 Ch Off
占空比 7.39%
35.467kHz
10us
0.000s
5.76V
模式
全屏幕显示
AC优先
复原自动
设置


GW INSTEK GPD-3303S
DC Power Supply
CH2
CH1
00.898
1.997
0.003
0.007


GW INSTEK GDS-2104E
Digital Storage Oscilloscope
100 MHz 1 GS/s
10k pts
100MSa/s
Trig'd
26 Feb 2019 19:17:08
35.4541kHz
峰峰值 Ch Off
振幅 Ch Off
最大值 Ch Off
占空比 Ch Off
最小值 Ch Off
占空比 93.93%
10us
6.00V
模式
全屏幕显示
AC优先
复原自动
设置


GW INSTEK GPD-3303S
DC Power Supp
CH2
CH1
V
03.596
11.997
V
A
0.003
0.005
A
POWER
0 ~ 30V, 3A
SLAVE