第10讲

完善测量系统

主要内容

- 修改DAC输出信号频率
- 提高ADC采样频率
- 产生、测量谐波波形
- 动手练习10

修改DAC输出信号频率

- 上面的例子中，AD采样频率为1kHz
- DAC信号输出频率为20Hz
- 如果要将DAC输出正弦信号的频率提高到50Hz，如何修改？

修改DAC输出信号频率

```
uint16_t SineWaveData[DAC_BUFFER_SIZE] = {
2047,2304,2557,2801,3034,3251,3449,3625,3776,3900,3994,4058,4090,4090,4058,3994,3
900,3776,3625,3449,3251,3034,2801,2557,2304,2048,1791,1538,1294,1061,844,646,470,3
19,195,101,37,5,5,37,101,195,319,470,646,844,1061,1294,1538, 1791
 };
```

- 数组SineWaveData中有50个数据（一个周期的正弦波形数据），在定时器的控制下循环赋值给DAC数据寄存器，输出波形
- 决定DAC输出信号频率的参数：数组中数据点数和定时器更新频率
- 如果还是用上述50点的数据，使信号频率为50Hz，则定时器的更新频率应该是？

单选题 1分

设置

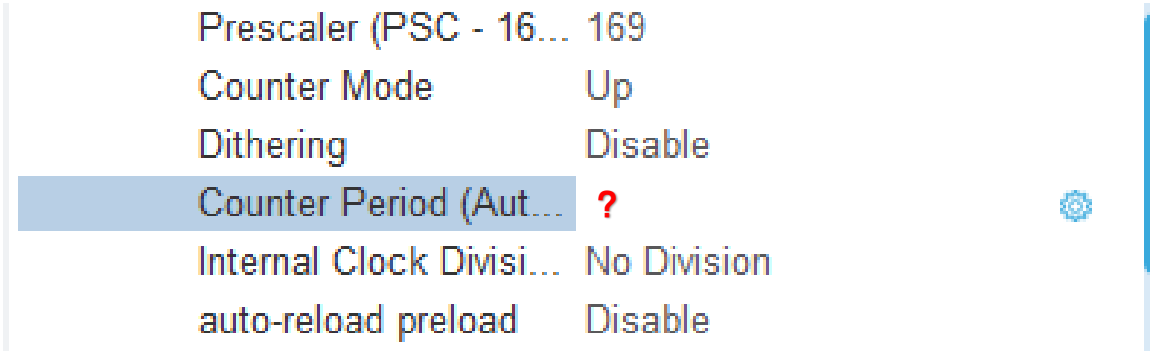
定时器的更新频率为2.5kHz，系统频率170MHz，定时器预分频因子169，则Counter Period应为多少？

A 99

B 199

C 299

D 399

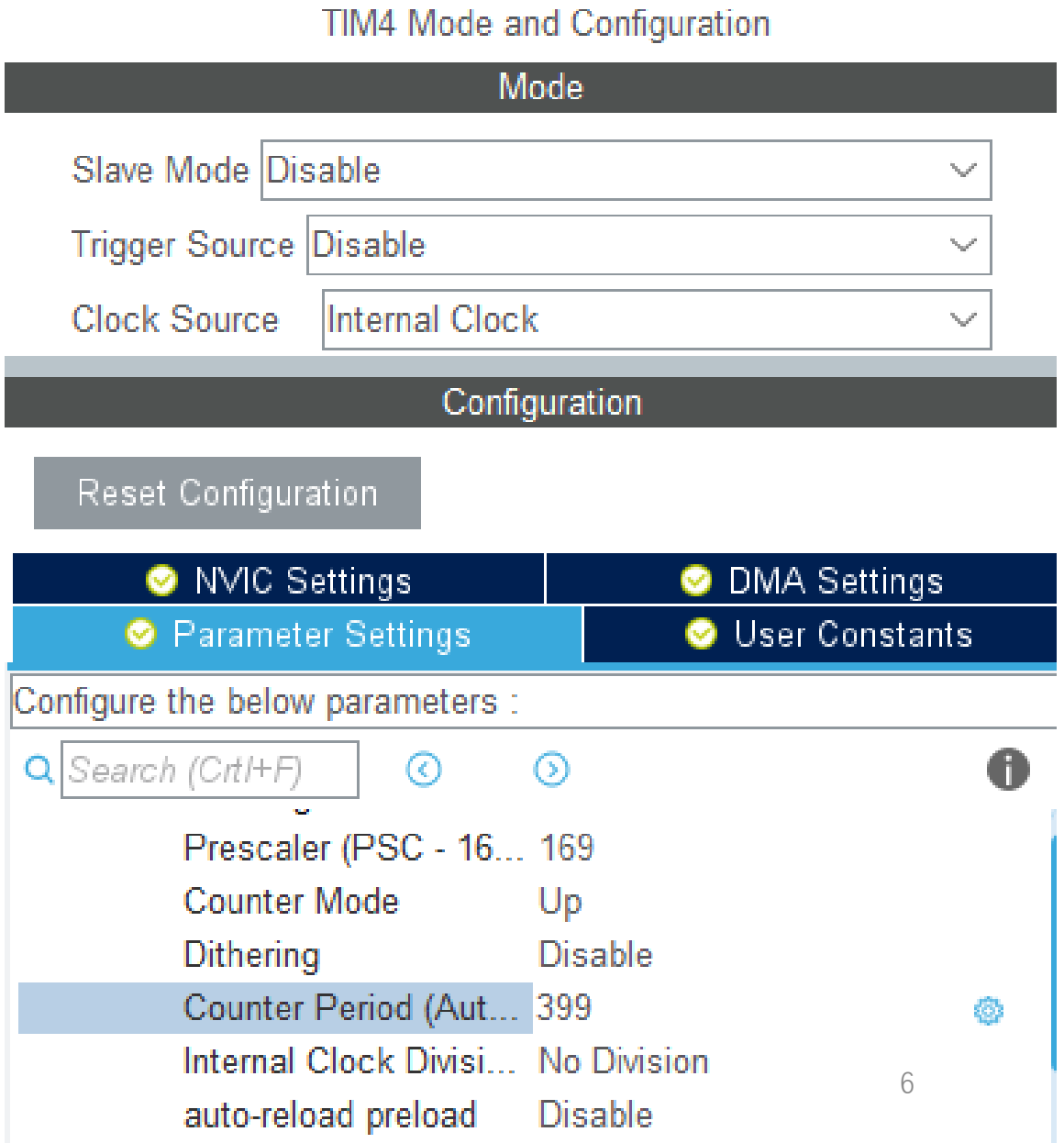


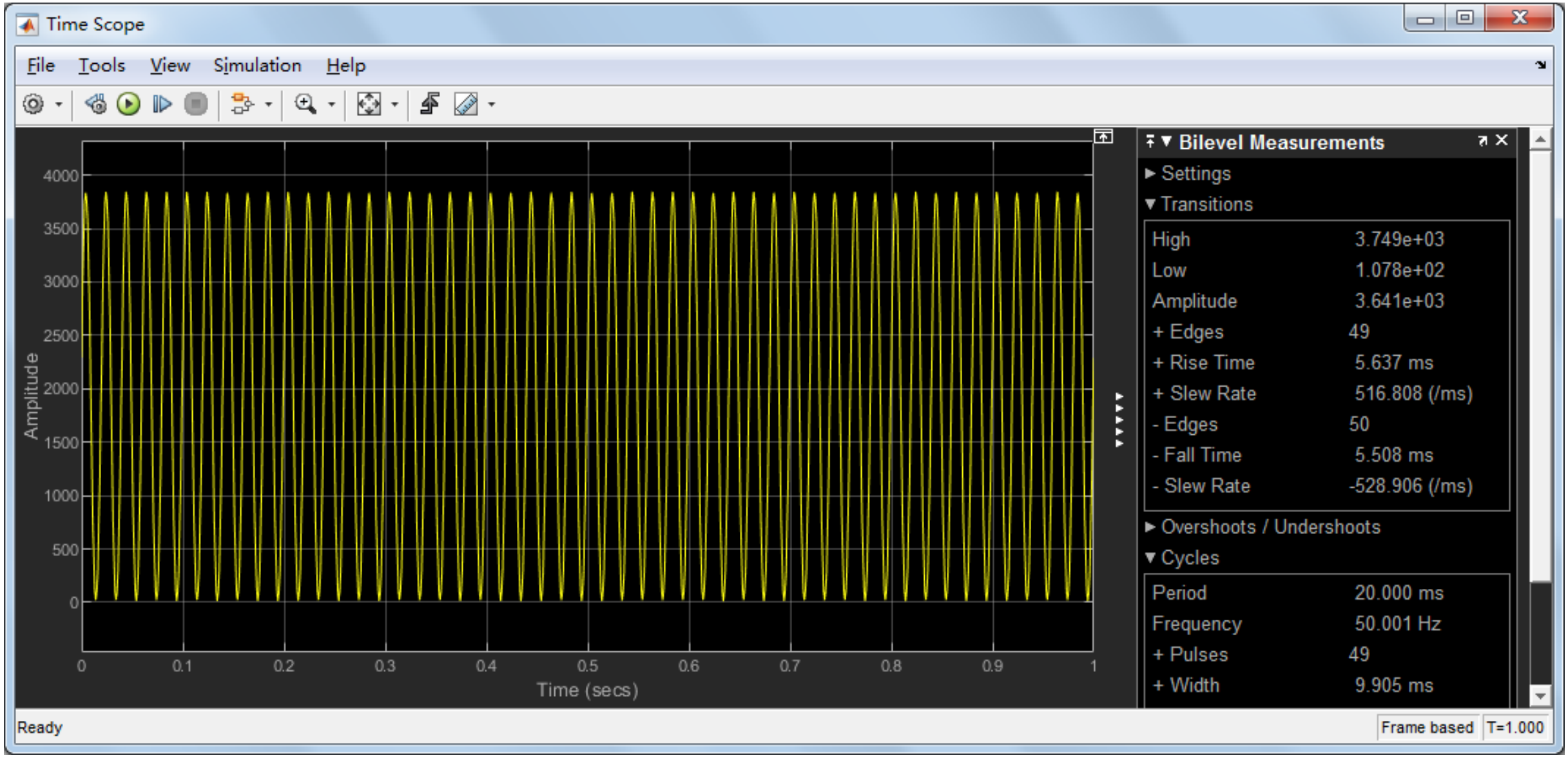
提交

修改定时器TIM4的参数

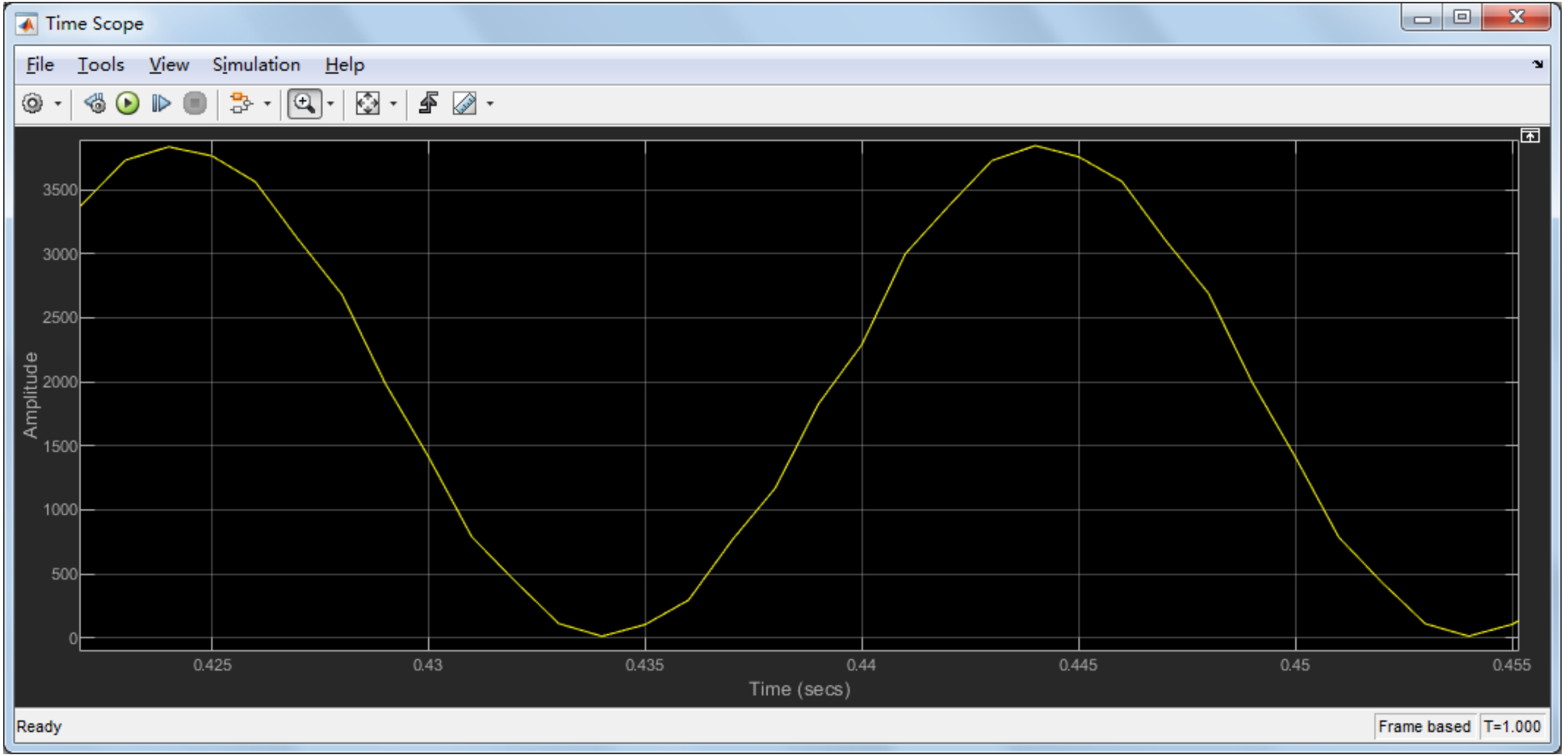
- 修改TIM4参数
- 保持计数器的预分频因子为169不变
- 计数器周期修改为399
- 其他参数不变

DAC输出信号频率：50Hz

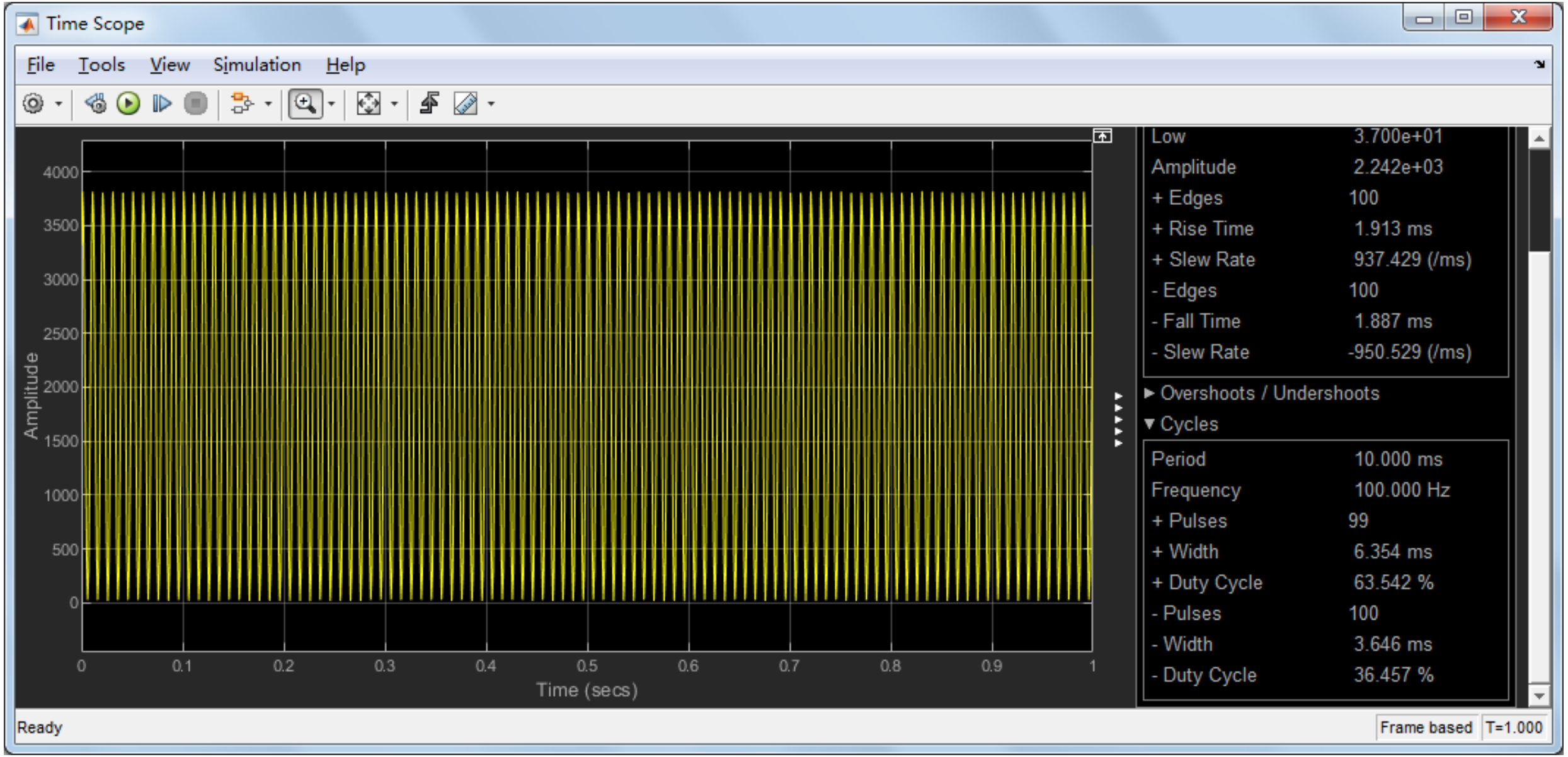




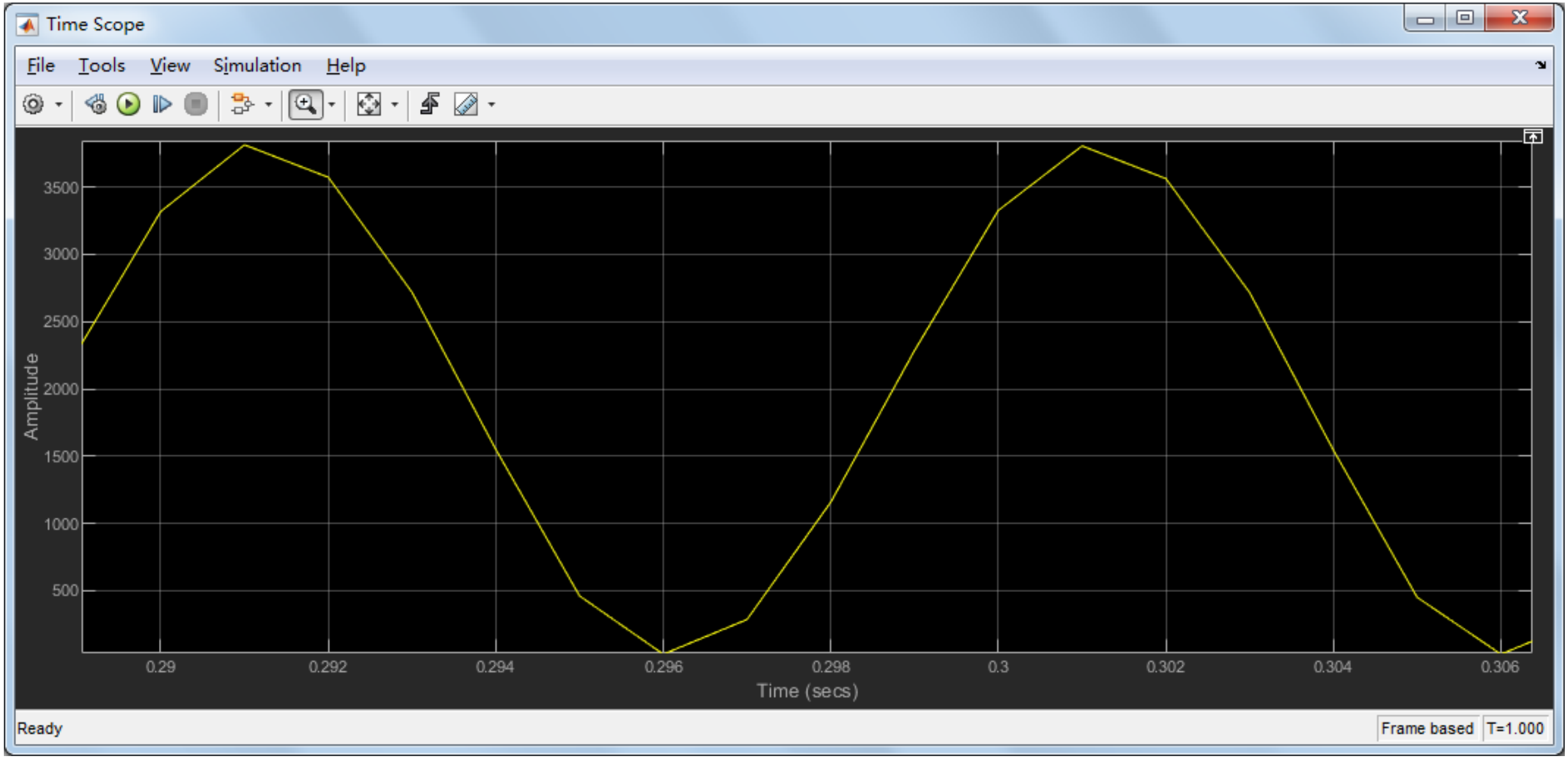
DAC输出信号频率：50Hz



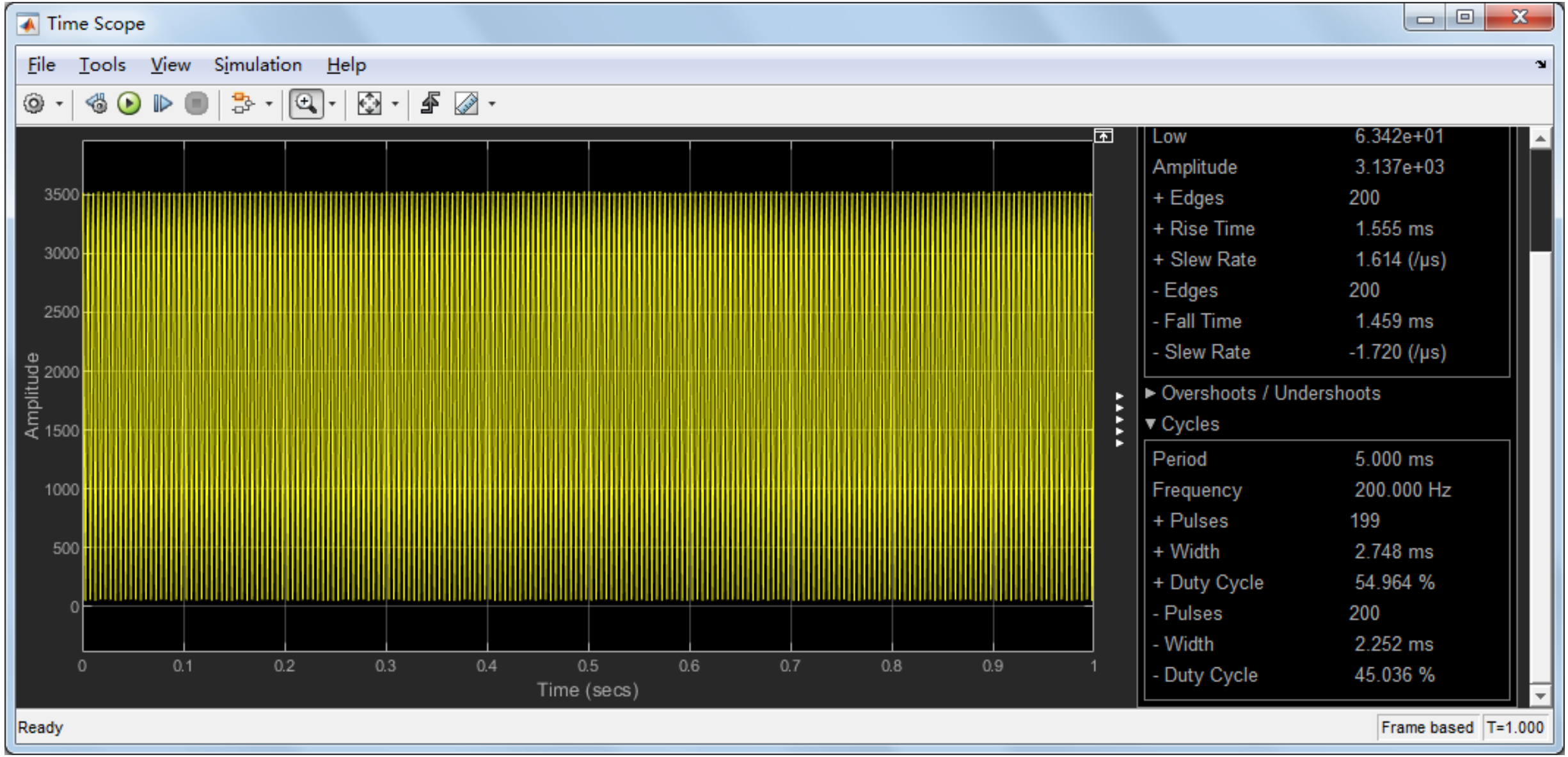
DAC输出信号频率：50Hz



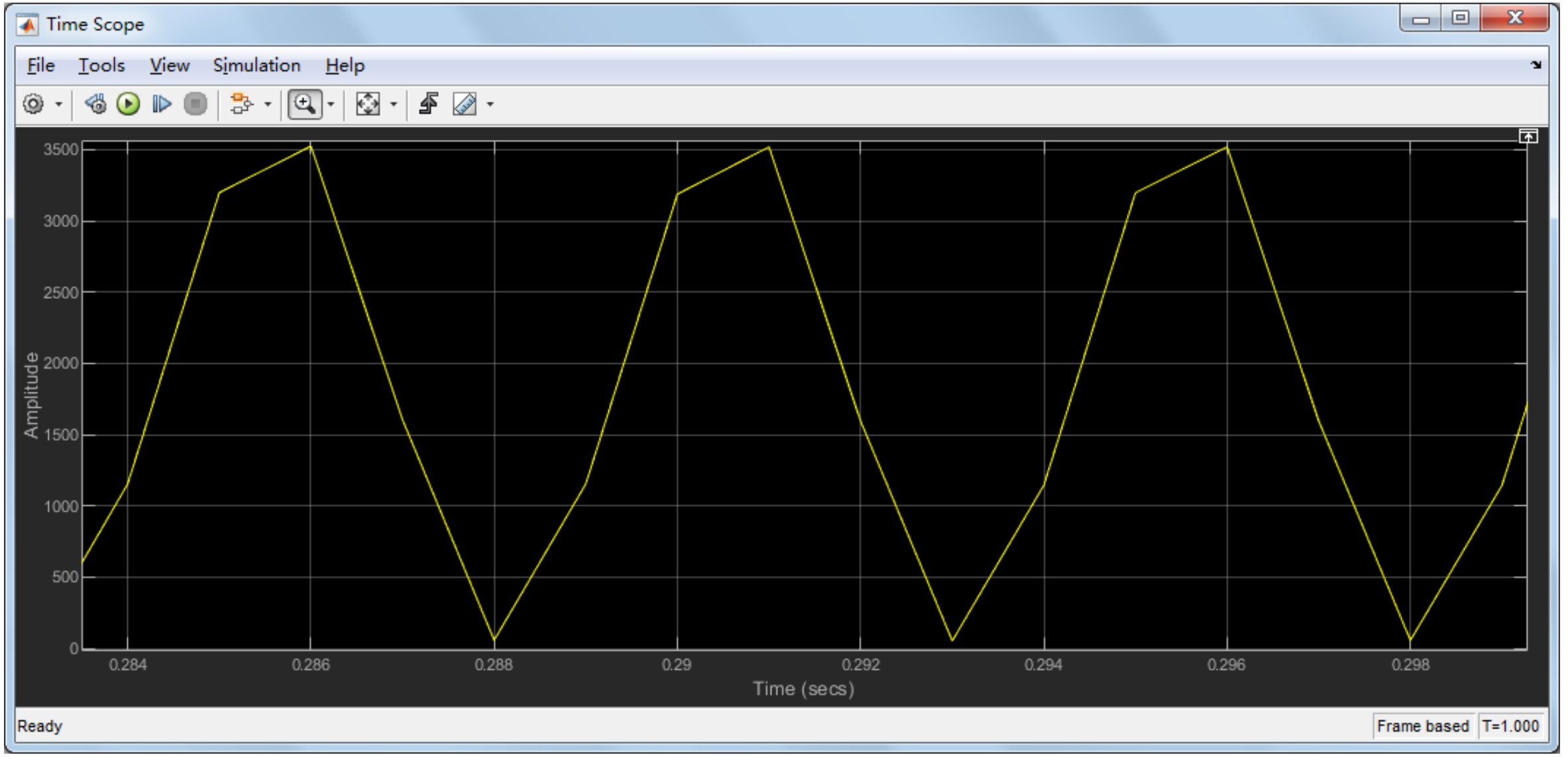
DAC输出信号频率：100Hz



DAC输出信号频率：100Hz



DAC输出信号频率：200Hz



DAC输出信号频率：200Hz

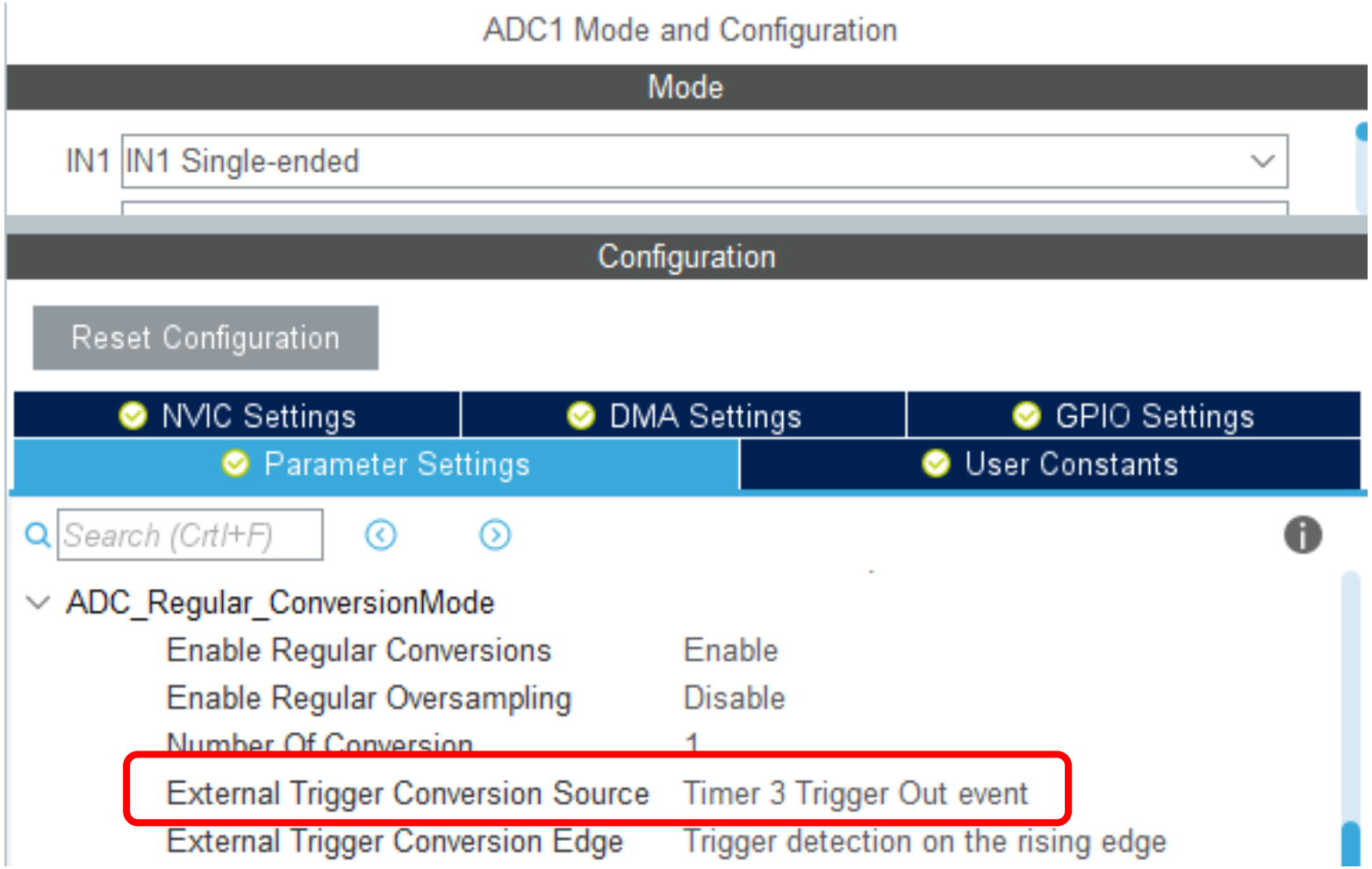
练习10：修改DAC输出信号频率

任务10.1、在任务9.2的基础上，修改参数，分别使DAC输出信号频率为50Hz、100Hz，200Hz。利用simulink模型，查看结果。

提高ADC采样频率

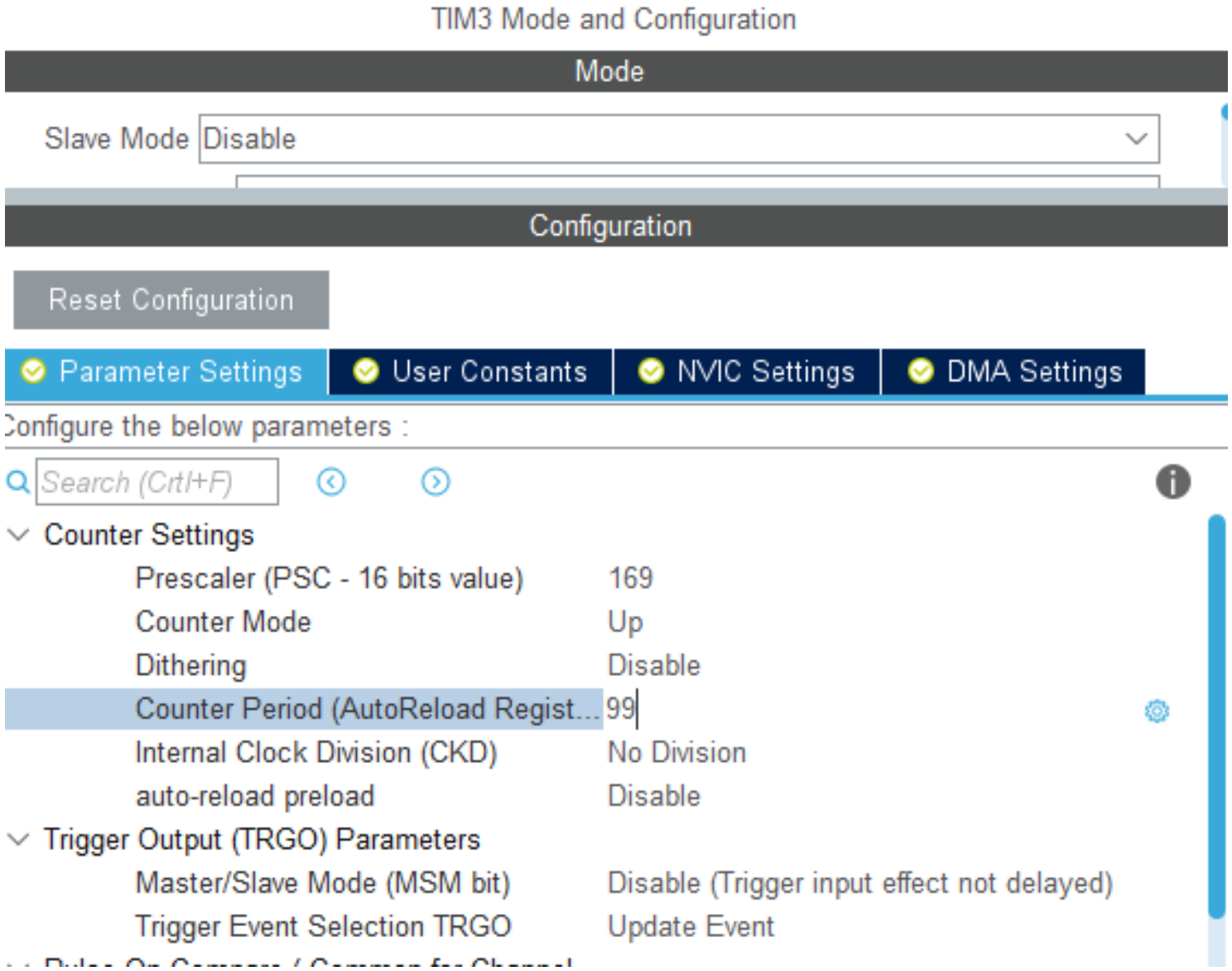
修改ADC的采样频率

- ADC采样频率有定时器TIM3控制
- 如果要提到ADC采样频率到10kHz，如何修改？

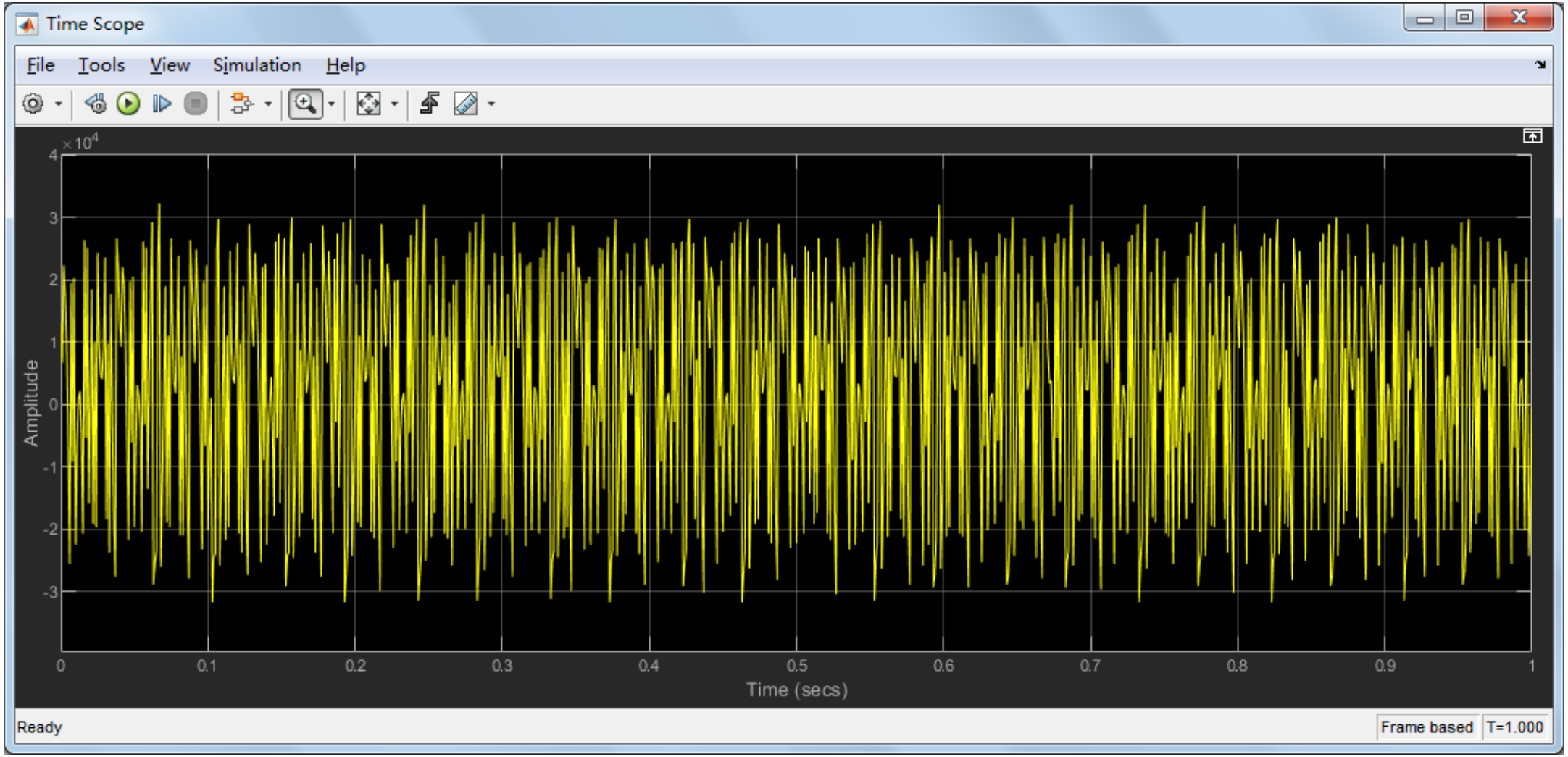


修改ADC的采样频率

- ADC采样频率由定时器TIM3控制



可能得到这样的波形…


Time Scope
File Tools View Simulation Help
×10^4
4
3
2
1
0
-1
-2
-3
Amplitude
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Time (secs)
Ready
Frame based
T=1.000

串口发送数据的问题

- ADC采样频率10kHz，DMA传送60个采样值后，通过串口发送数据

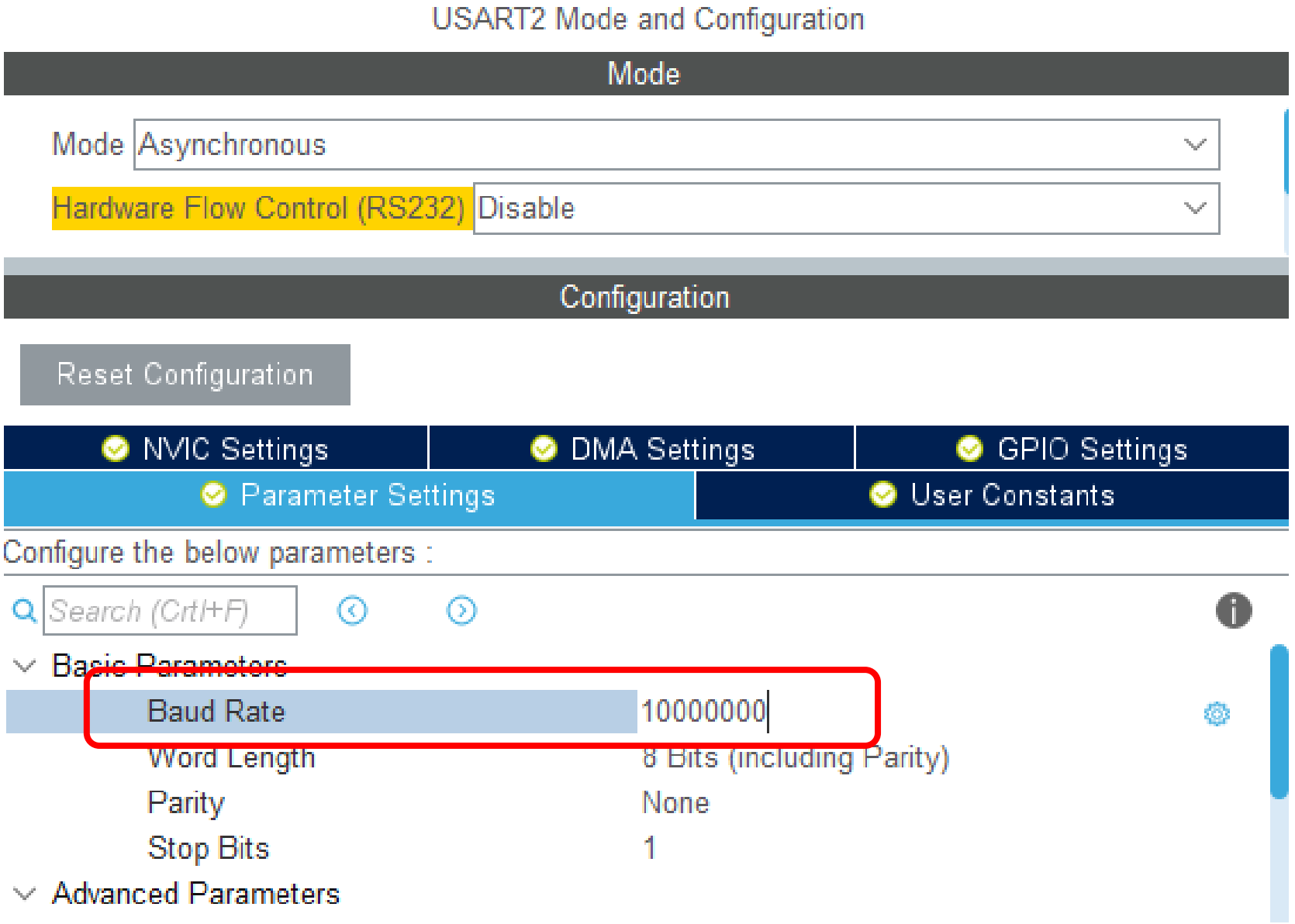
```
#define ADC_CONVERTED_DATA_BUFFER_SIZE (uint16_t) 60
```

- 60个采样值120字节，对应二进制位为1200（一个字节的数虽只有8位，但串口发送时还需起始位、停止位等，通常至少需10位）
- 串口波特率为115200bps，发送1200位需要时间：1200/115200s，约10.4ms
- 在ADC采样率为1kHz时，采样一个点需要1ms，则DMA传递一次数据（60个ADC采样值）所需至少的60ms。可获得正确的数据。

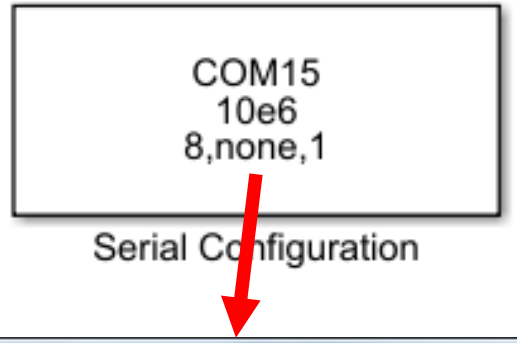
串口发送数据的问题

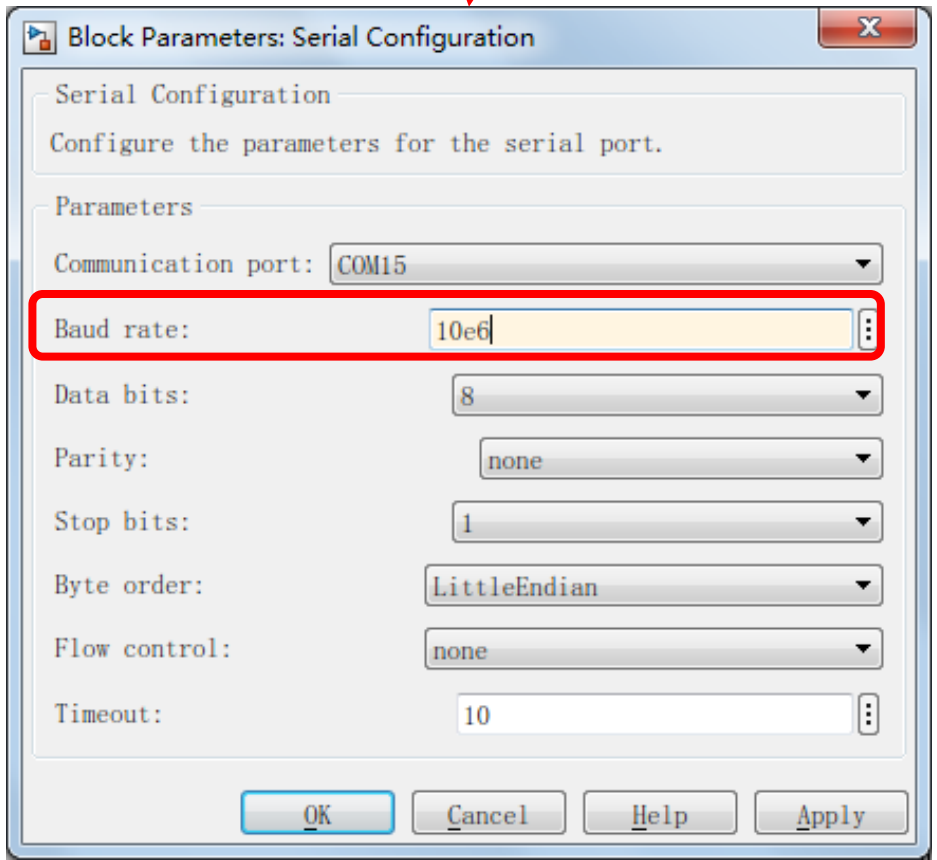
- 但若将ADC的采样率提高到10kHz，则DMA传递60个采样点数据至少需要6ms。如果仍然用115200的波特率，由于串口发送需要约10ms的时间，所以会发送冲突，从串口送上来的数据就会是错乱的。
- 此时，可以考虑提高串口波特率。譬如提高至10Mbps。此时，串口发送60个AD采样点，只需要0.12ms。

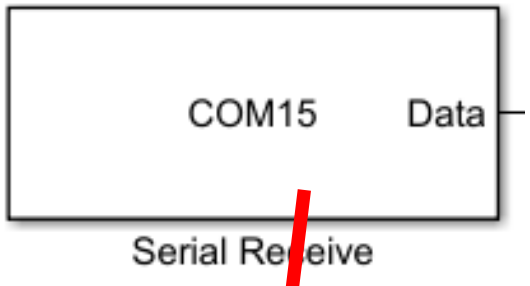
修改串口波特率

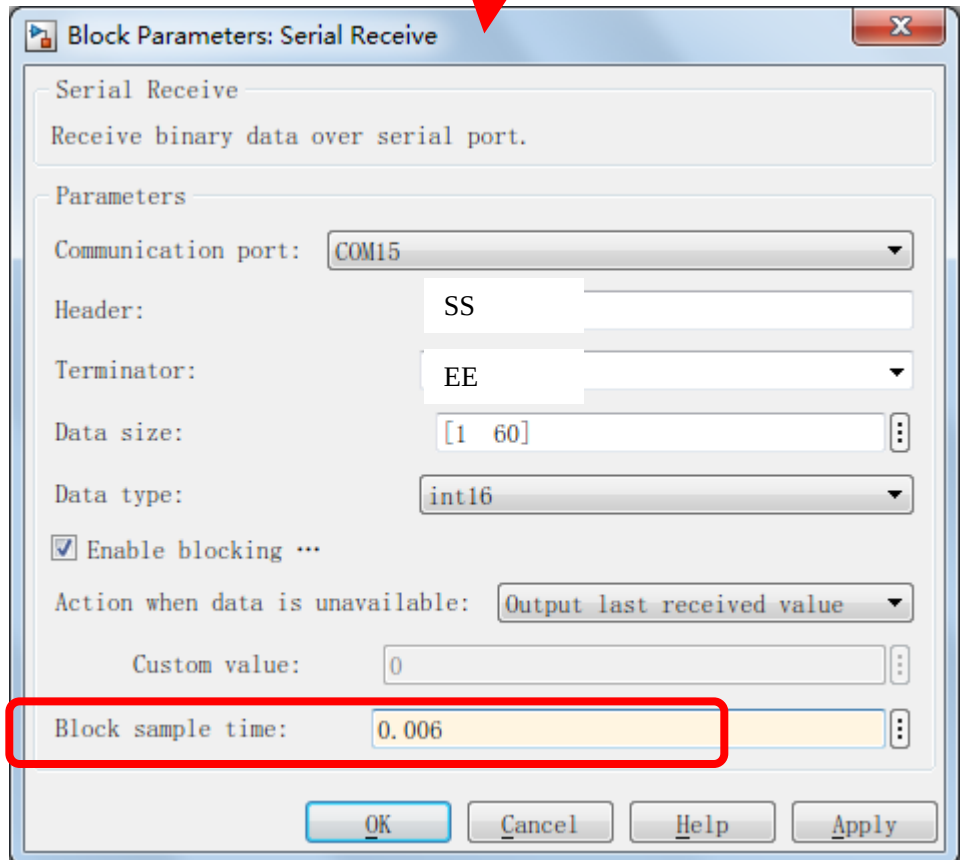

USART2 Mode and Configuration
Mode
Mode
Asynchronous
Hardware Flow Control (RS232)
Disable
Configuration
Reset Configuration
NVIC Settings
DMA Settings
GPIO Settings
Parameter Settings
User Constants
Configure the below parameters :
Search (Crtl+F)
Basic Parameters
Baud Rate
10000000
Word Length
8 Bits (including Parity)
Parity
None
Stop Bits
1
Advanced Parameters

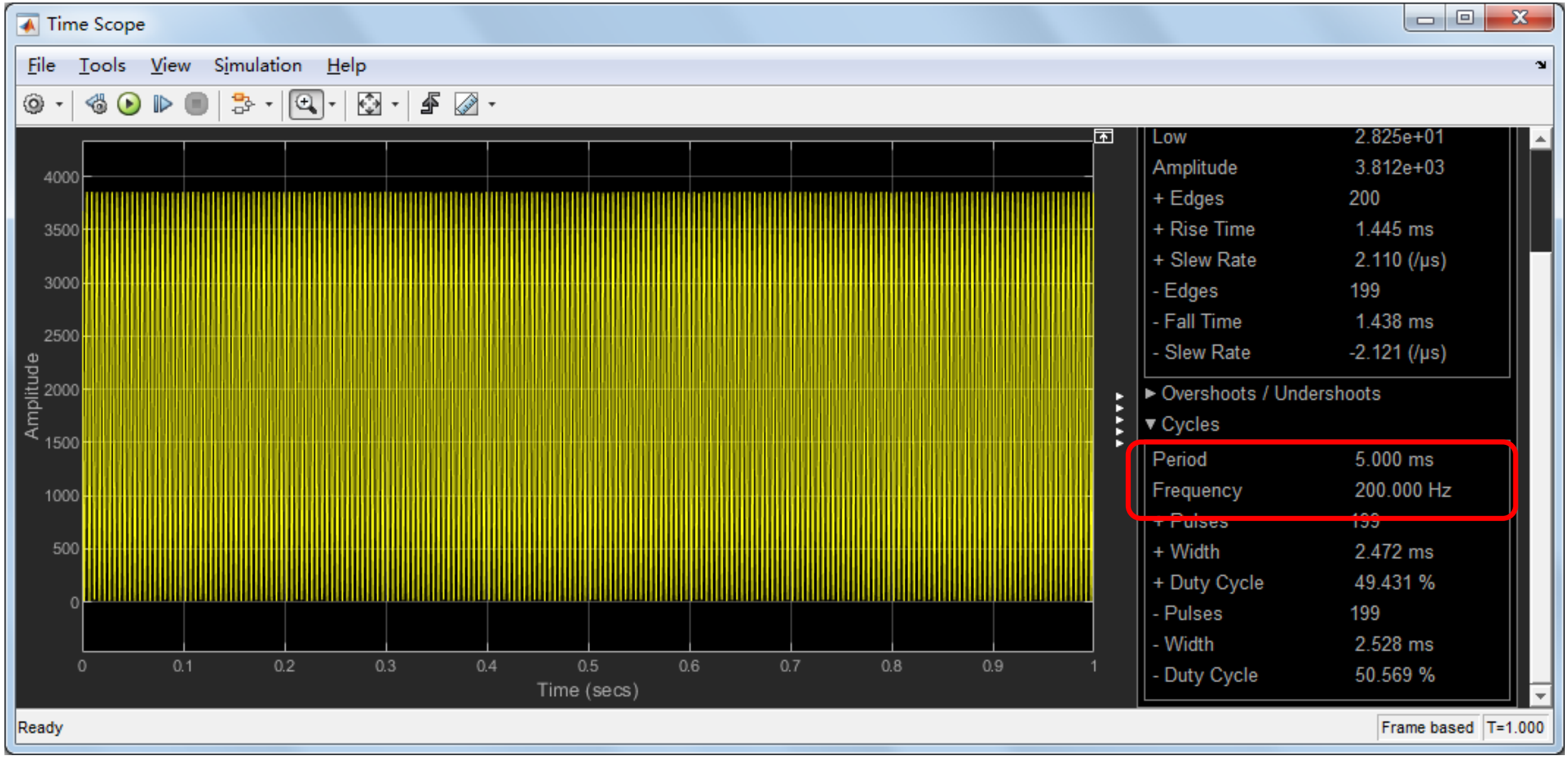
修改simulink模型



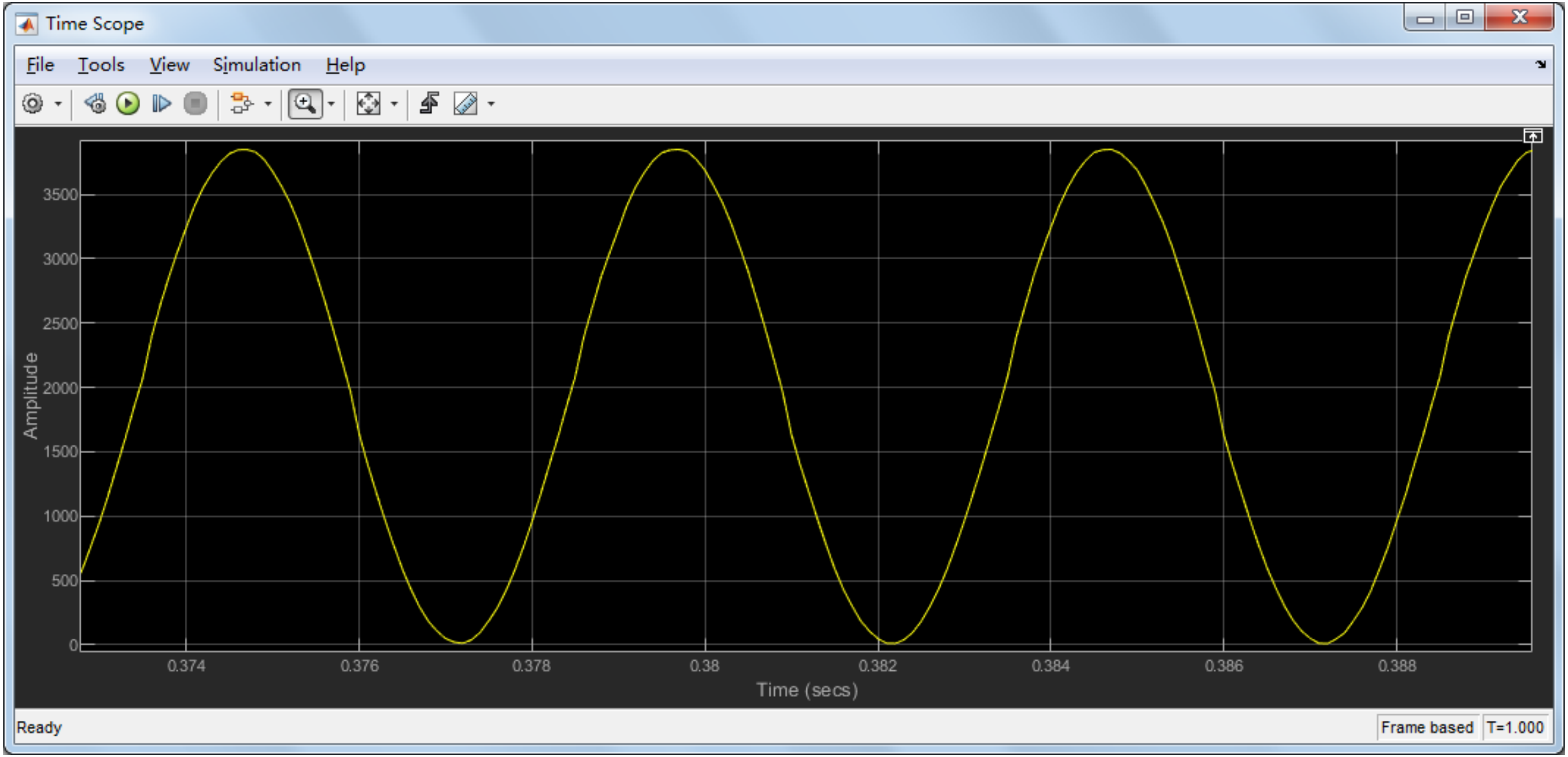








ADC采样频率10kHz；DAC输出信号频率：200Hz

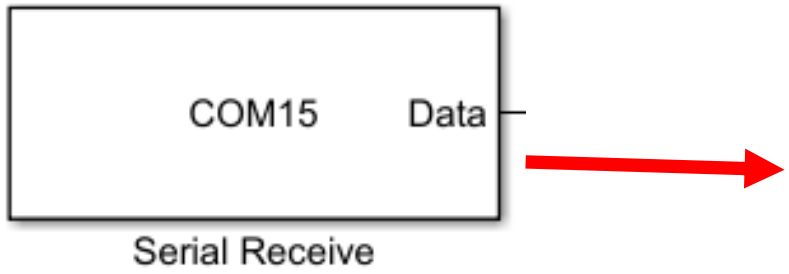


ADC采样频率10kHz；DAC输出信号频率：200Hz

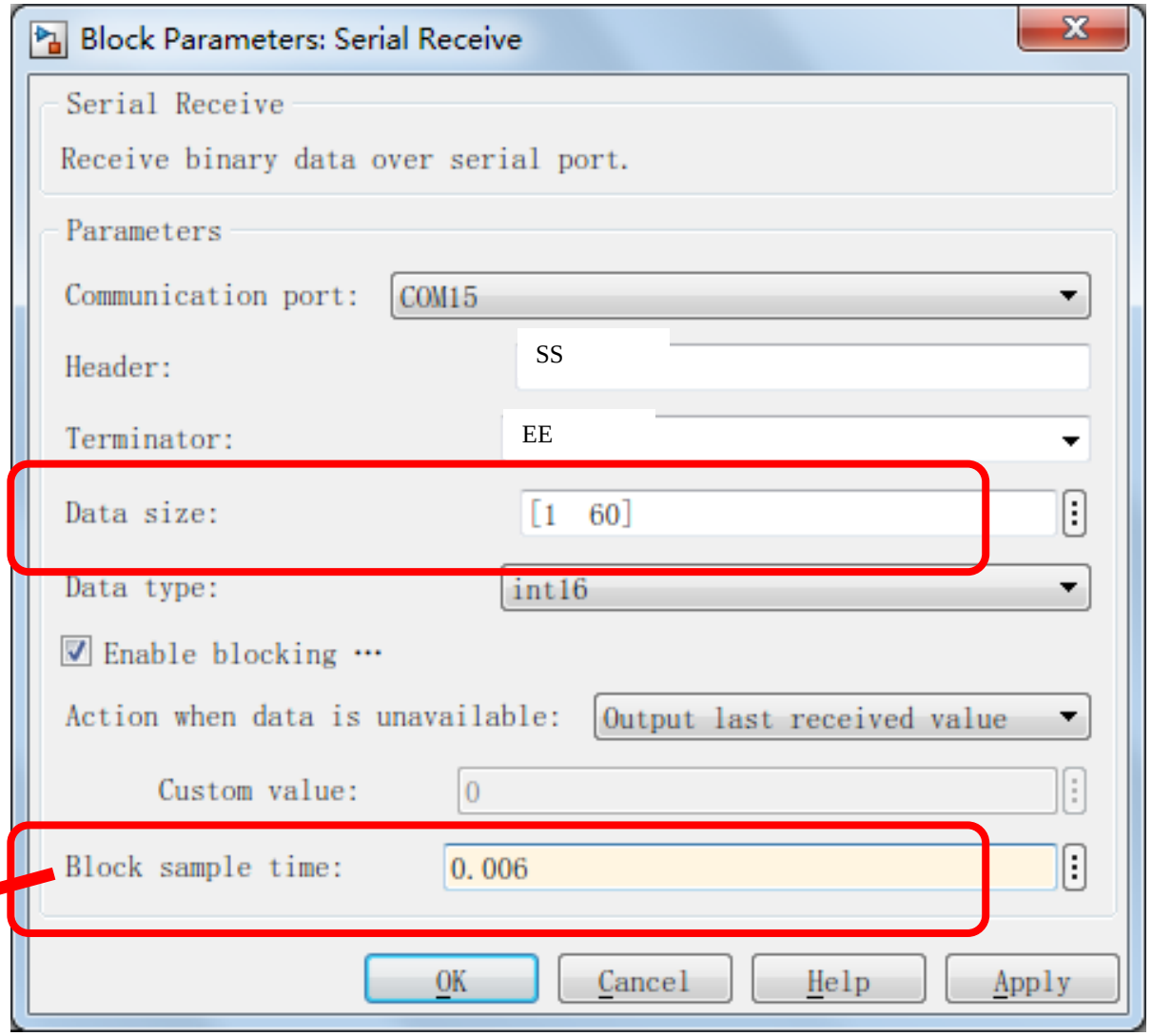
练习10：修改ADC采样频率

任务10.2、在任务10.1的基础上（DAC输出信号频率为200Hz），修改参数，将ADC的采样频率修改为10kHz。利用simulink模型，查看结果。

修改simulink模型



几十ms



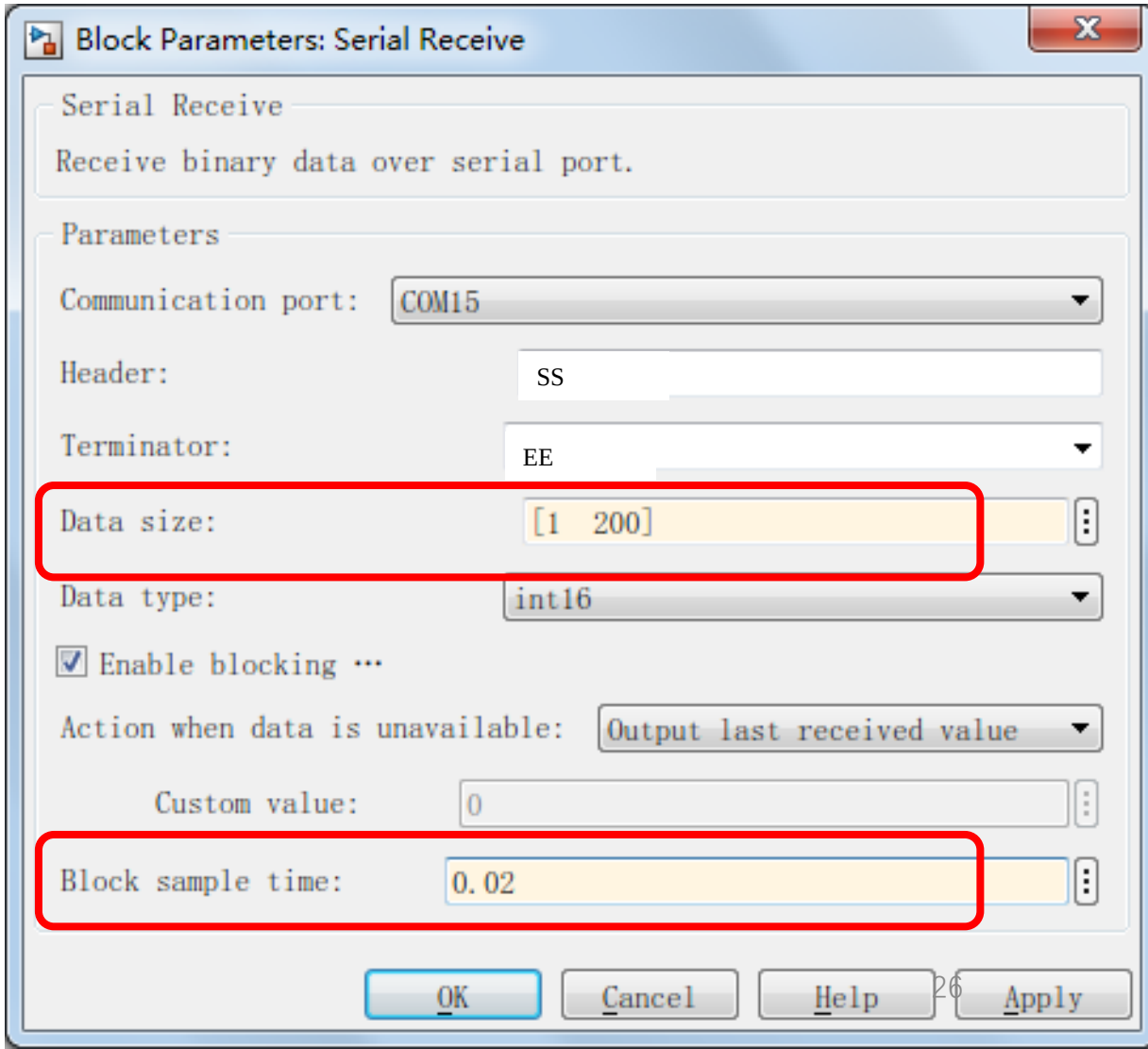
■ 修改AD采样值缓冲区数组长度

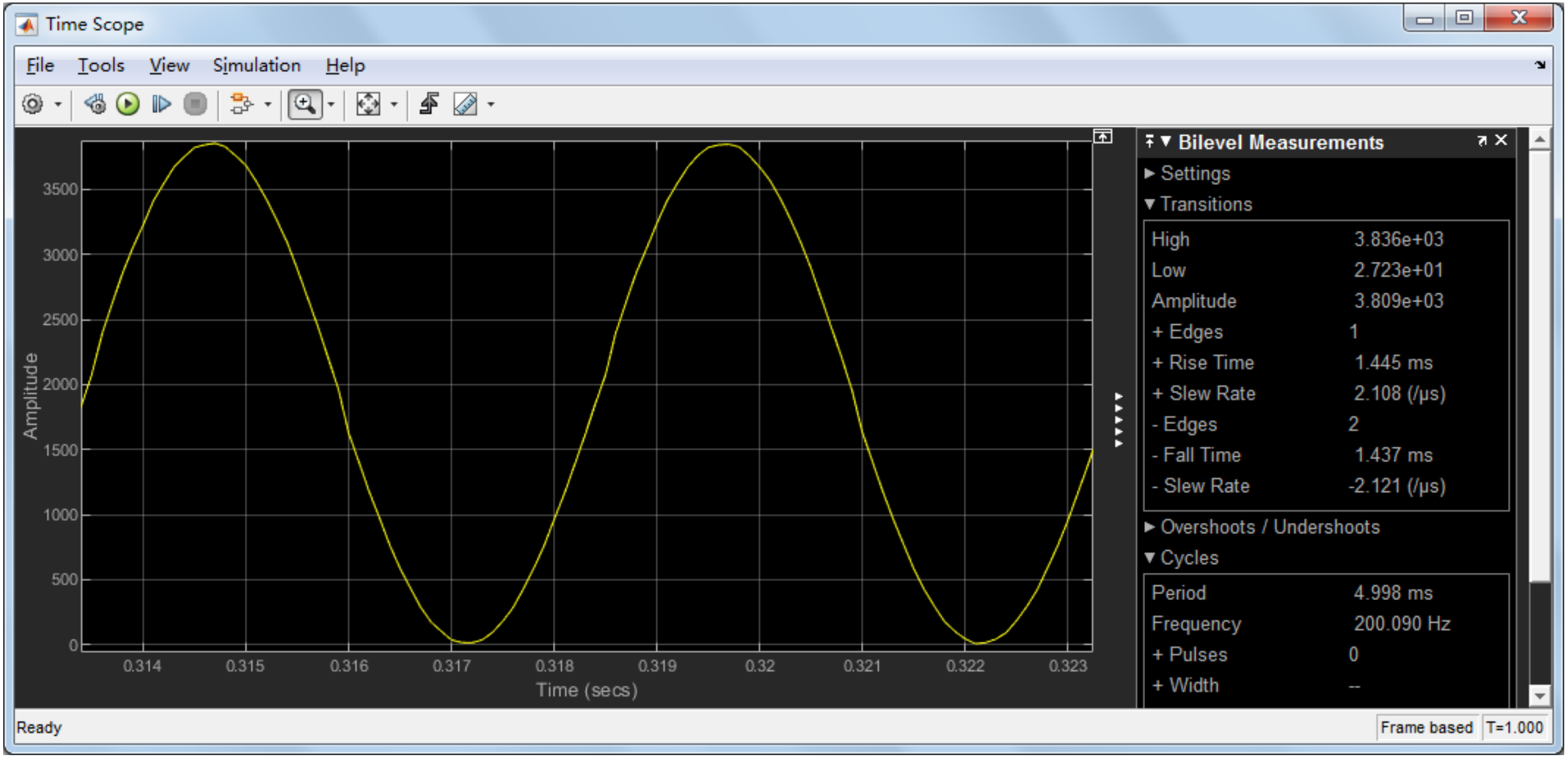
#define ADC_CONVERTED_DATA_BUFFER_SIZE (uint16_t) 200

■ 修改Serial Receive参数

✓ Data size [1 200]

✓ Sample time 0.02





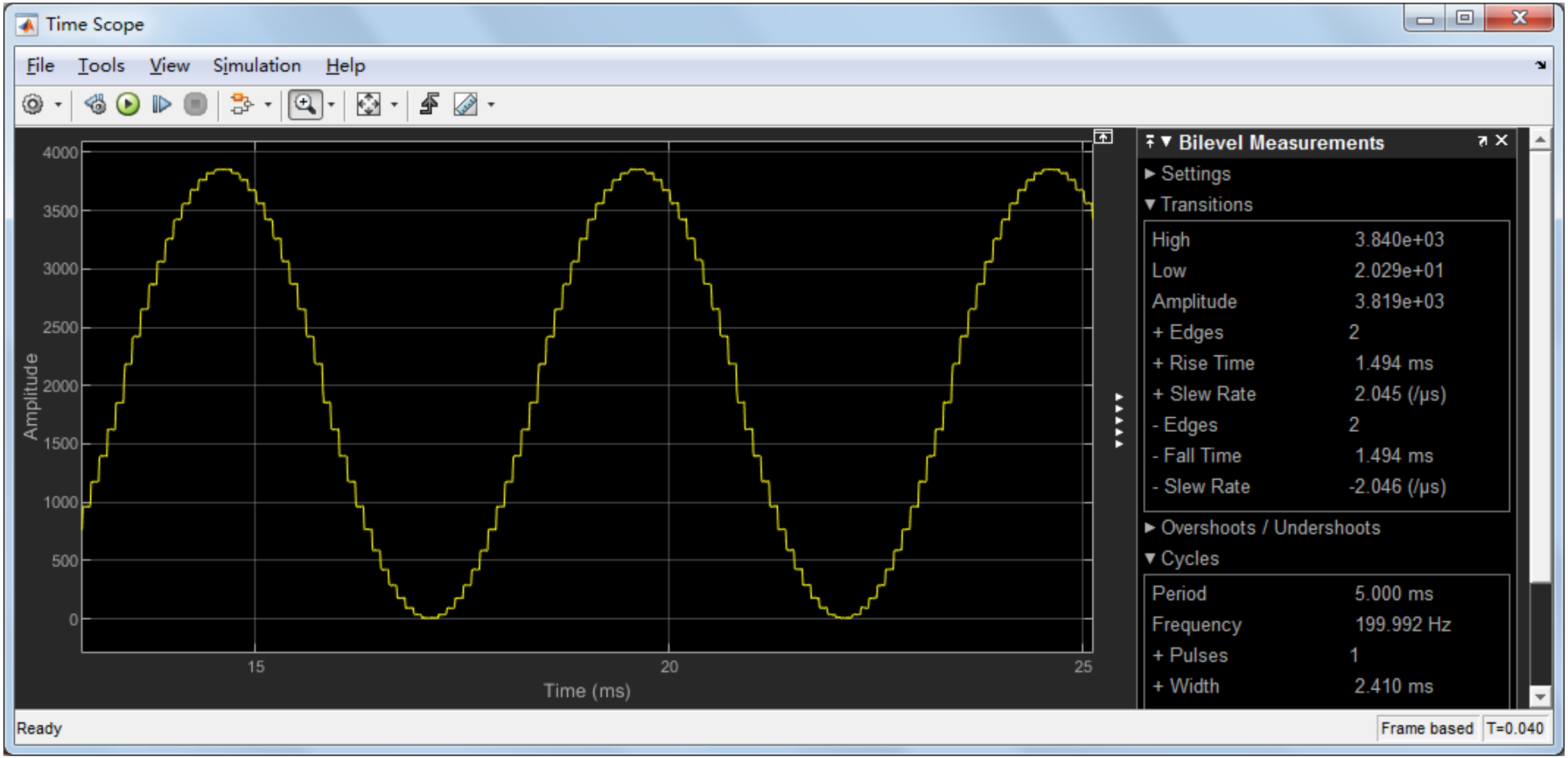
ADC采样频率10kHz；DAC输出信号频率：200Hz

练习10：修改ADC采样频率

任务10.3、在任务10.2的基础上（DAC输出信号频率为200Hz），修改参数，将ADC的采样频率修改为**100kHz**。利用simulink模型，查看结果。

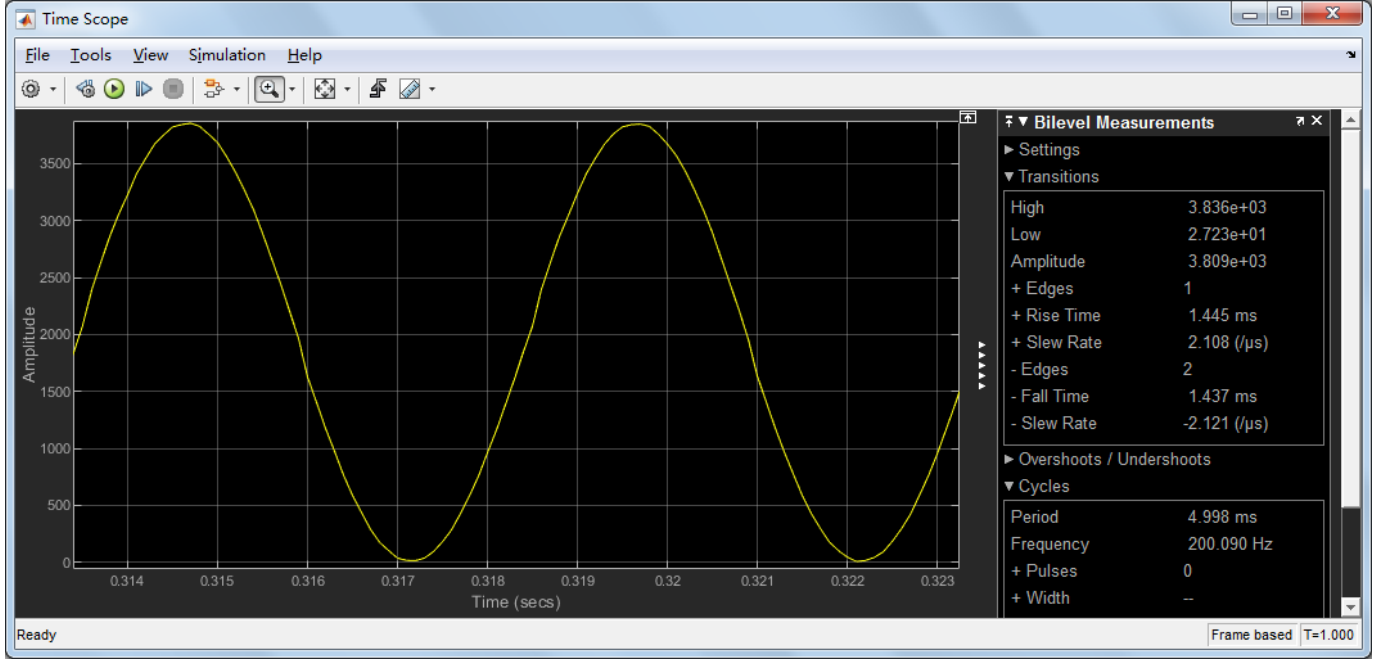
需要修改的参数

- TIM3计数器周期：9
- AD采样值缓冲区长度：2000
- Simulink模型中Serial Receive参数
  - ✓ Data size [1 2000]
  - ✓ Sample time 0.02

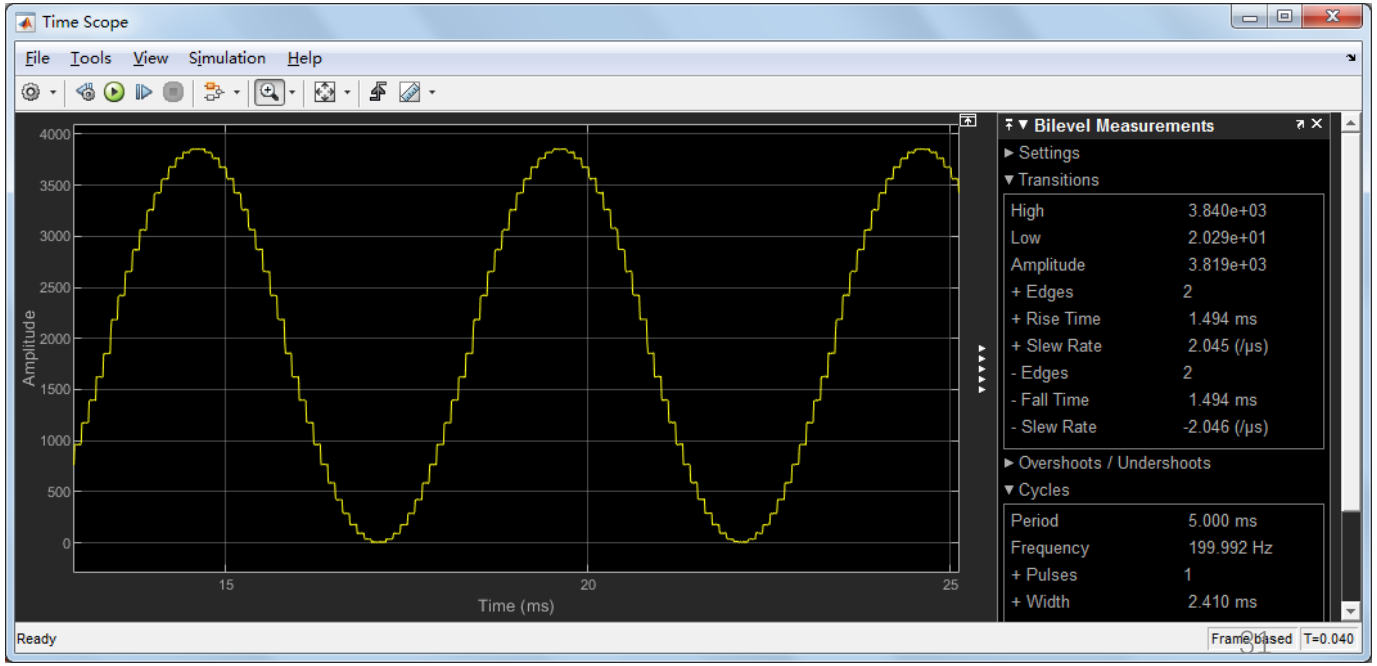


ADC采样频率100kHz；DAC输出信号频率：200Hz

ADC采样频率10kHz；
DAC输出信号频率：200Hz



ADC采样频率100kHz；
DAC输出信号频率：200Hz

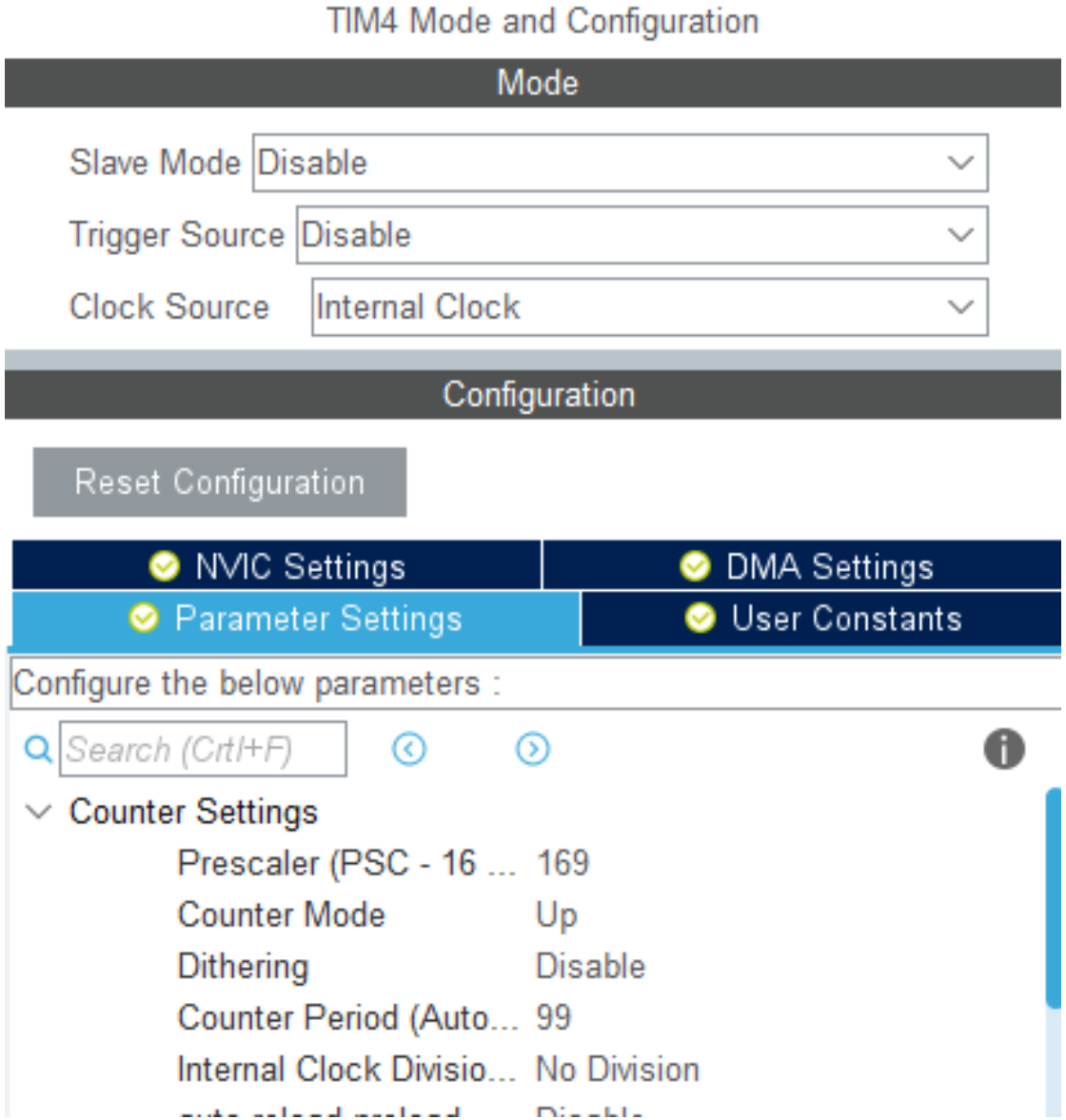


■ DAC波形

✓ 50点

✓ 定时器更新频率

```
uint16_t
SineWaveData[DAC_BUFFER_SIZE] = {
2047,2304,2557,2801,3034,3251,3449,3
625,3776,3900,3994,4058,4090,4090,40
58,3994,3900,3776,3625,3449,3251,303
4,2801,2557,2304,2048,1791,1538,1294
,1061,844,646,470,319,195,101,37,5,5
,37,101,195,319,470,646,844,1061,129
4,1538, 1791
 };
```

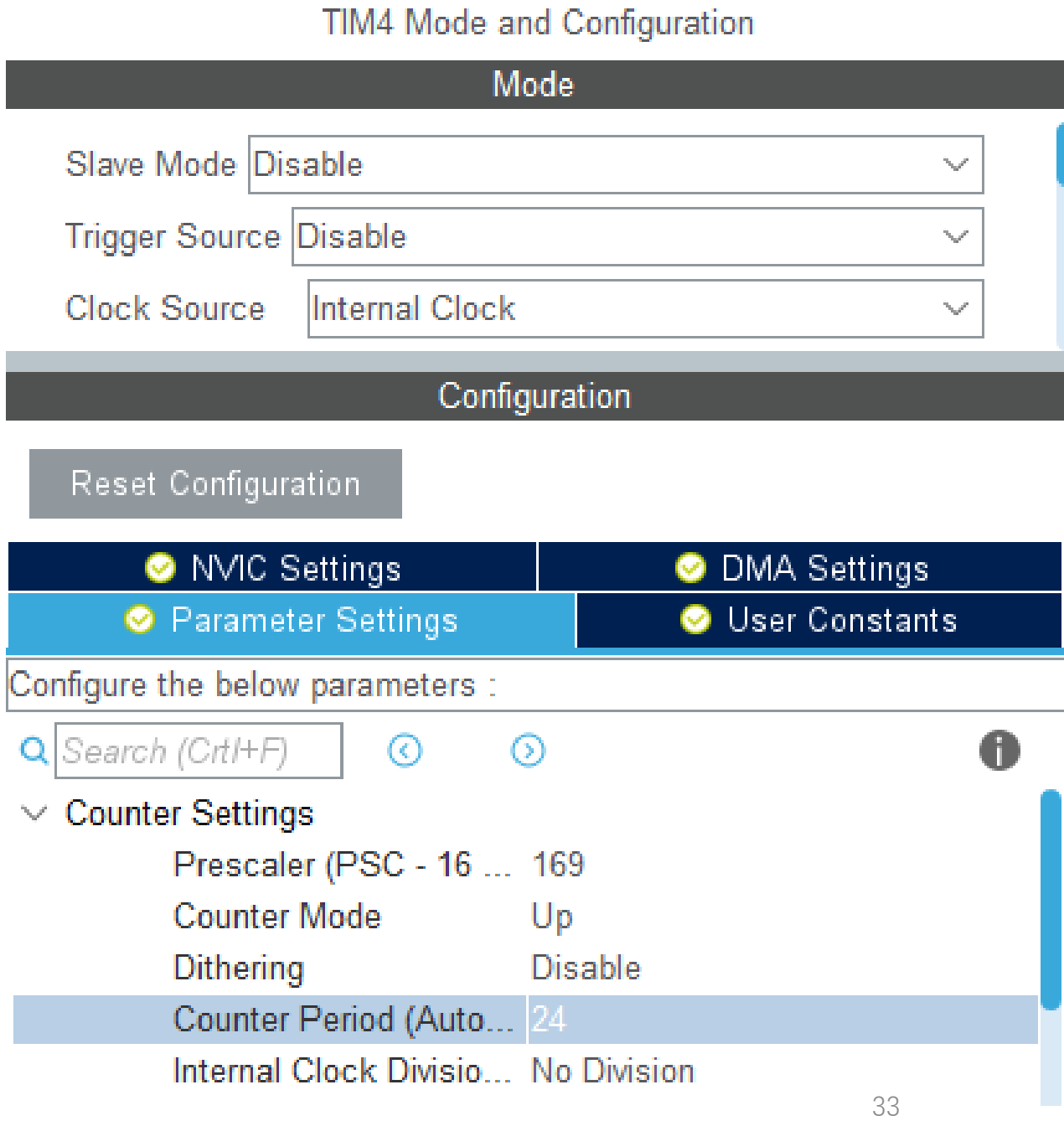


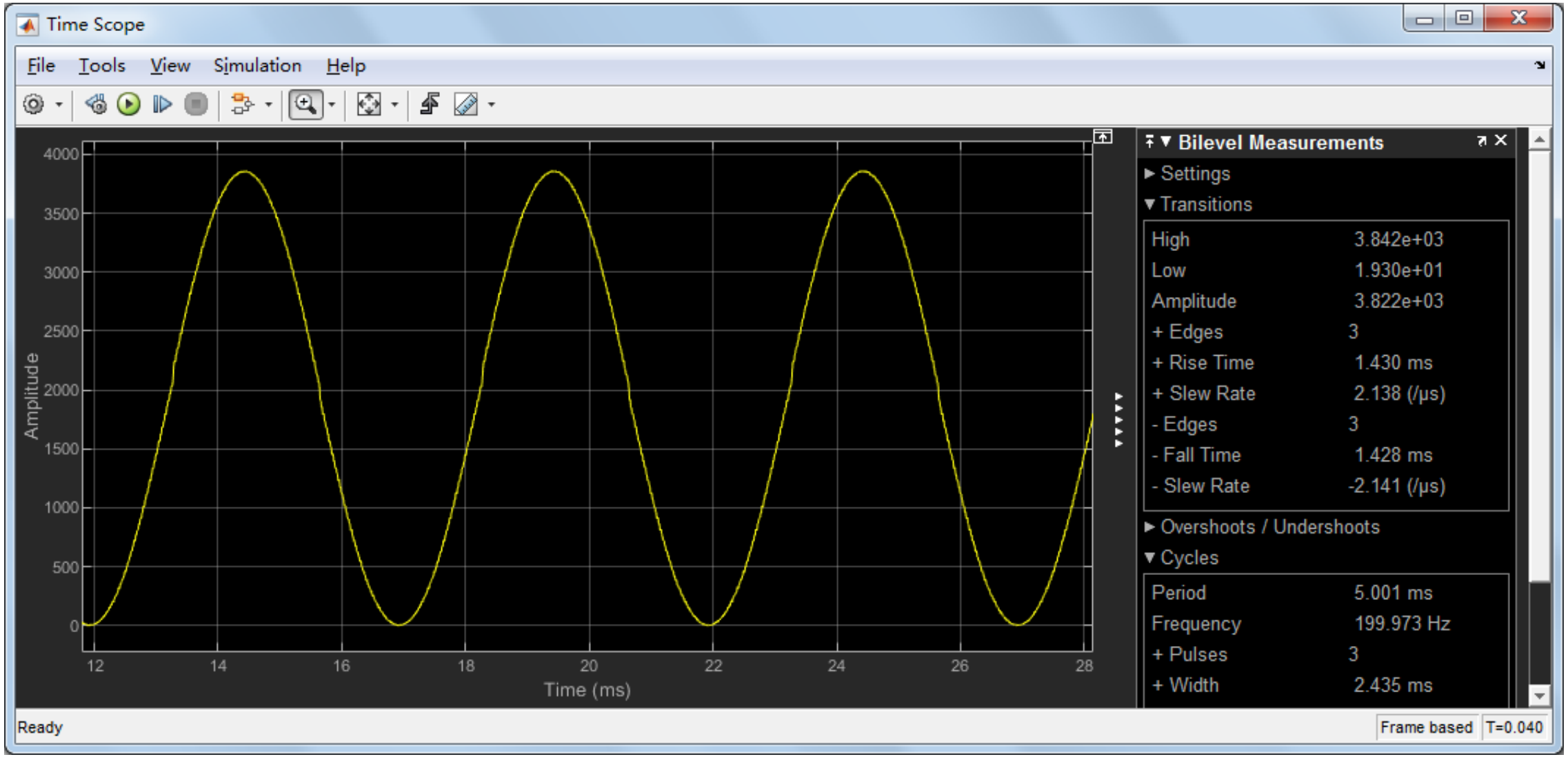
■ 保持DAC波形频率为200Hz

✓ 增加点数：200点

✓ 定时器更新频率：40kHz

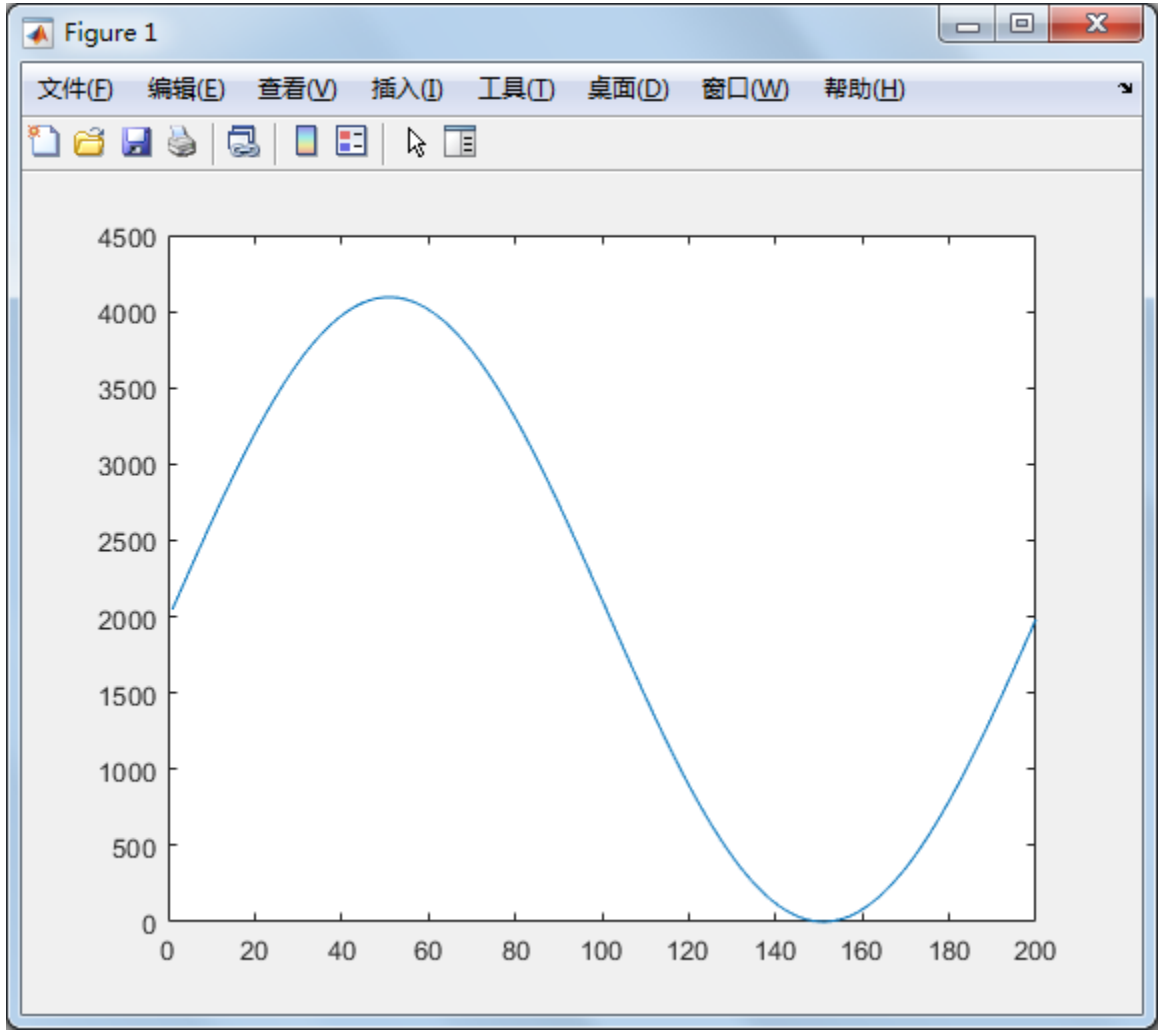
```
uint16_t SineWaveData[DAC_BUFFER_SIZE] = {
2047,2112,2176,2240,2304,2368,2431,2494,2557,2619,268
0,2741,2801,2860,2919,2977,3034,3090,3144,3198,3251,3
302,3352,3401,3449,3495,3540,3583,3625,3665,3704,3741
,3776,3809,3841,3871,3900,3926,3951,3973,3994,4013,40
30,4045,4058,4069,4078,4085,4090,4093,4094,4093,4090,
4085,4078,4069,4058,4045,4030,4013,3994,3973,3951,392
6,3900,3871,3841,3809,3776,3741,3704,3665,3625,3583,3
540,3495,3449,3401,3352,3302,3251,3198,3144,3090,3034
,2977,2919,2860,2801,2741,2680,2619,2557,2494,2431,23
68,2304,2240,2176,2112,2048,1983,1919,1855,1791,1727,
1664,1601,1538,1476,1415,1354,1294,1235,1176,1118,106
1,1005,951,897,844,793,743,694,646,600,555,512,470,43
0,391,354,319,286,254,224,195,169,144,122,101,82,65,5
0,37,26,17,10,5,2,0,2,5,10,17,26,37,50,65,82,101,122,
144,169,195,224,254,286,319,354,391,430,470,512,555,6
00,646,694,743,793,844,897,951,1005,1061,1118,1176,12
35,1294,1354,1415,1476,1538,1601,1664,1727,1791,1855,
1919,1983
};
```




Time Scope
File Tools View Simulation Help
Amplitude
Time (ms)
4000
3500
3000
2500
2000
1500
1000
500
0
12 14 16 18 20 22 24 26 28
Bilevel Measurements
Settings
Transitions
High 3.842e+03
Low 1.930e+01
Amplitude 3.822e+03
+ Edges 3
+ Rise Time 1.430 ms
+ Slew Rate 2.138 (/µs)
- Edges 3
- Fall Time 1.428 ms
- Slew Rate -2.141 (/µs)
Overshoots / Undershoots
Cycles
Period 5.001 ms
Frequency 199.973 Hz
+ Pulses 3
+ Width 2.435 ms
Ready
Frame based
T=0.040

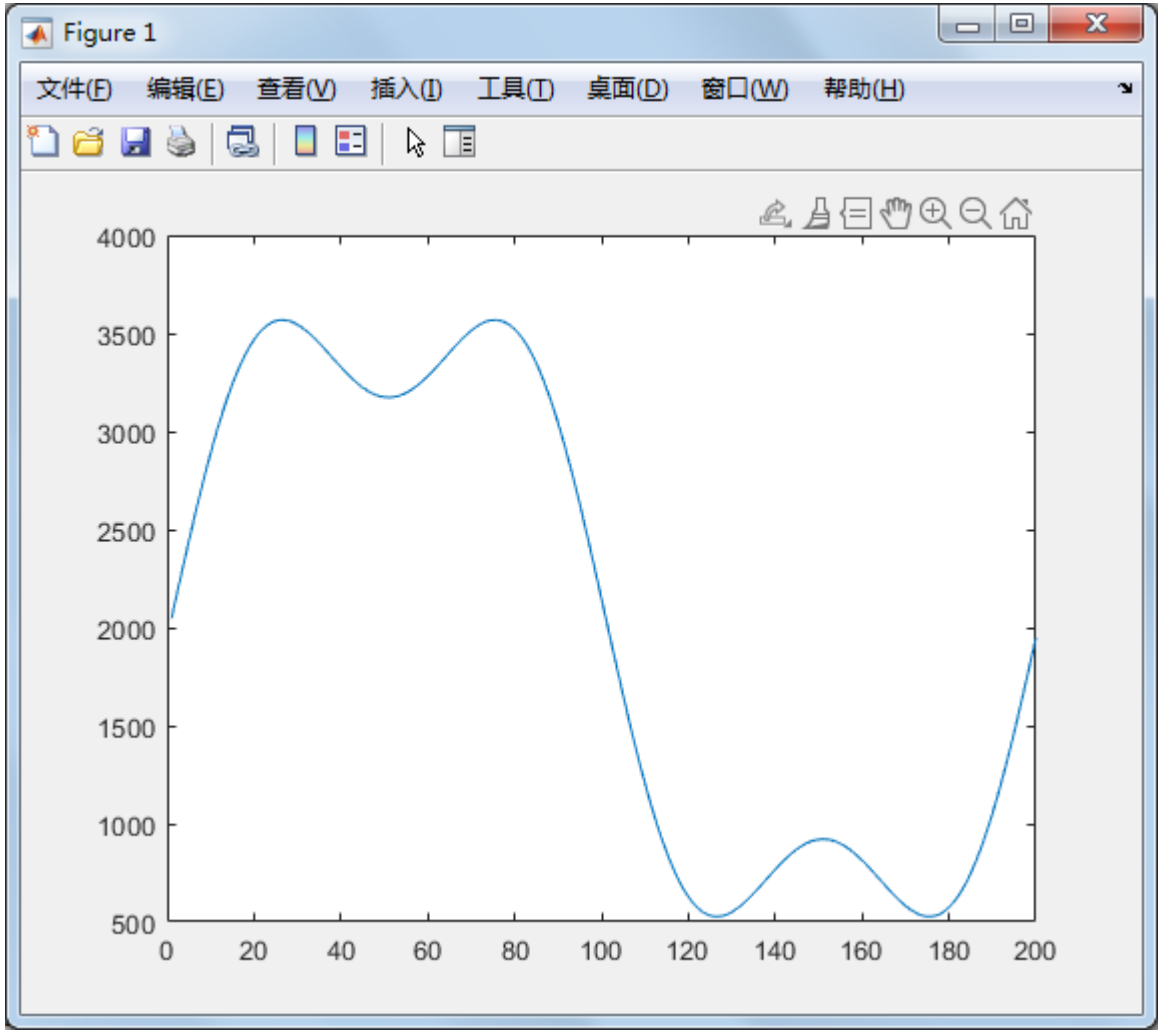
产生波形数据的方法

```
A=4096/2-1;%信号幅值
N=200;%一周期内数据点数
Ph=0;%初始相位
SineData=ceil(A*sin(Ph:2*pi/N:2*pi*(1-1/N)+Ph)+A);
Fid = fopen('SineWaveData.txt','w');
fprintf(Fid,'%d,',SineData);
fclose(Fid);
```



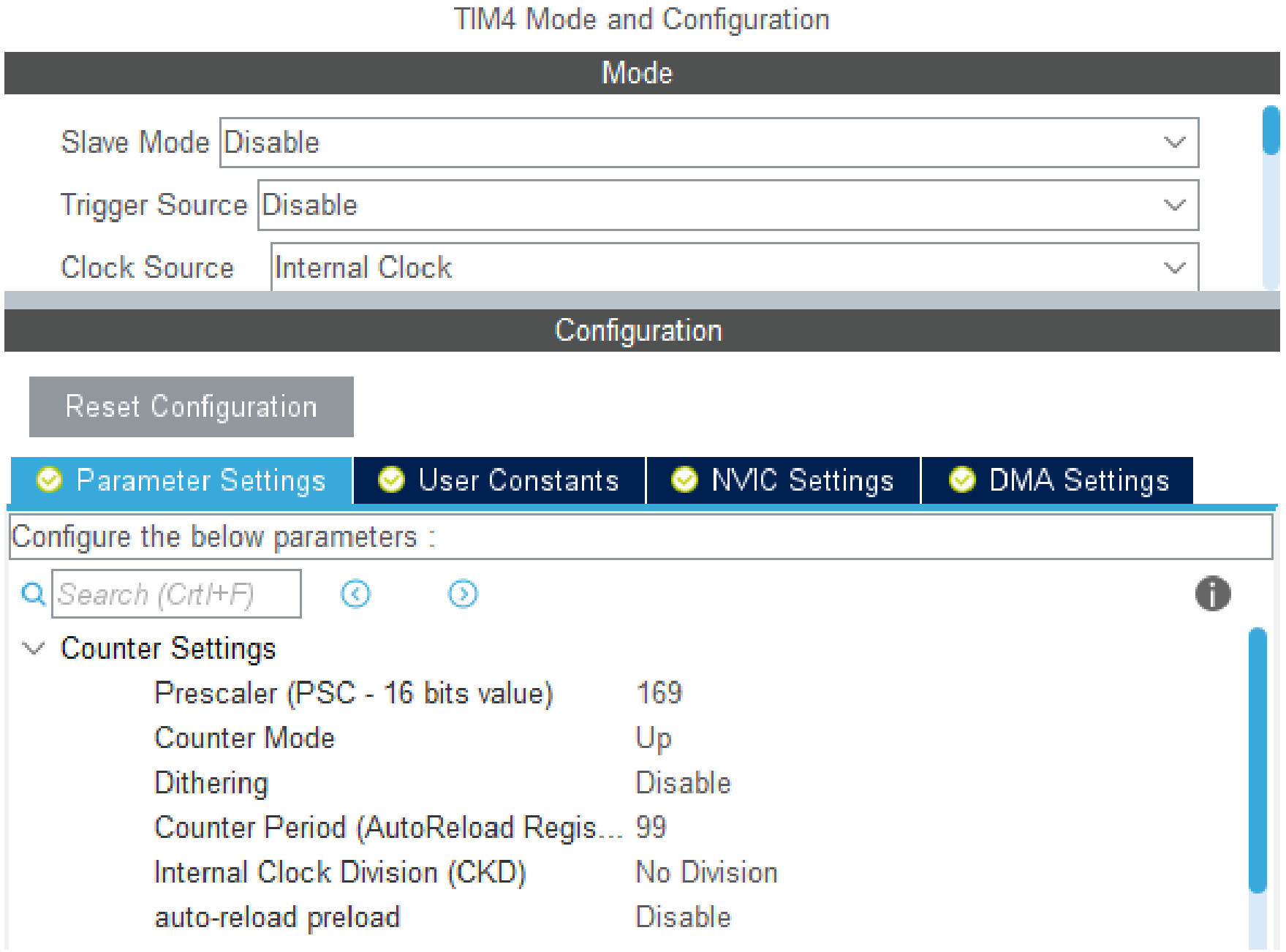
产生谐波数据

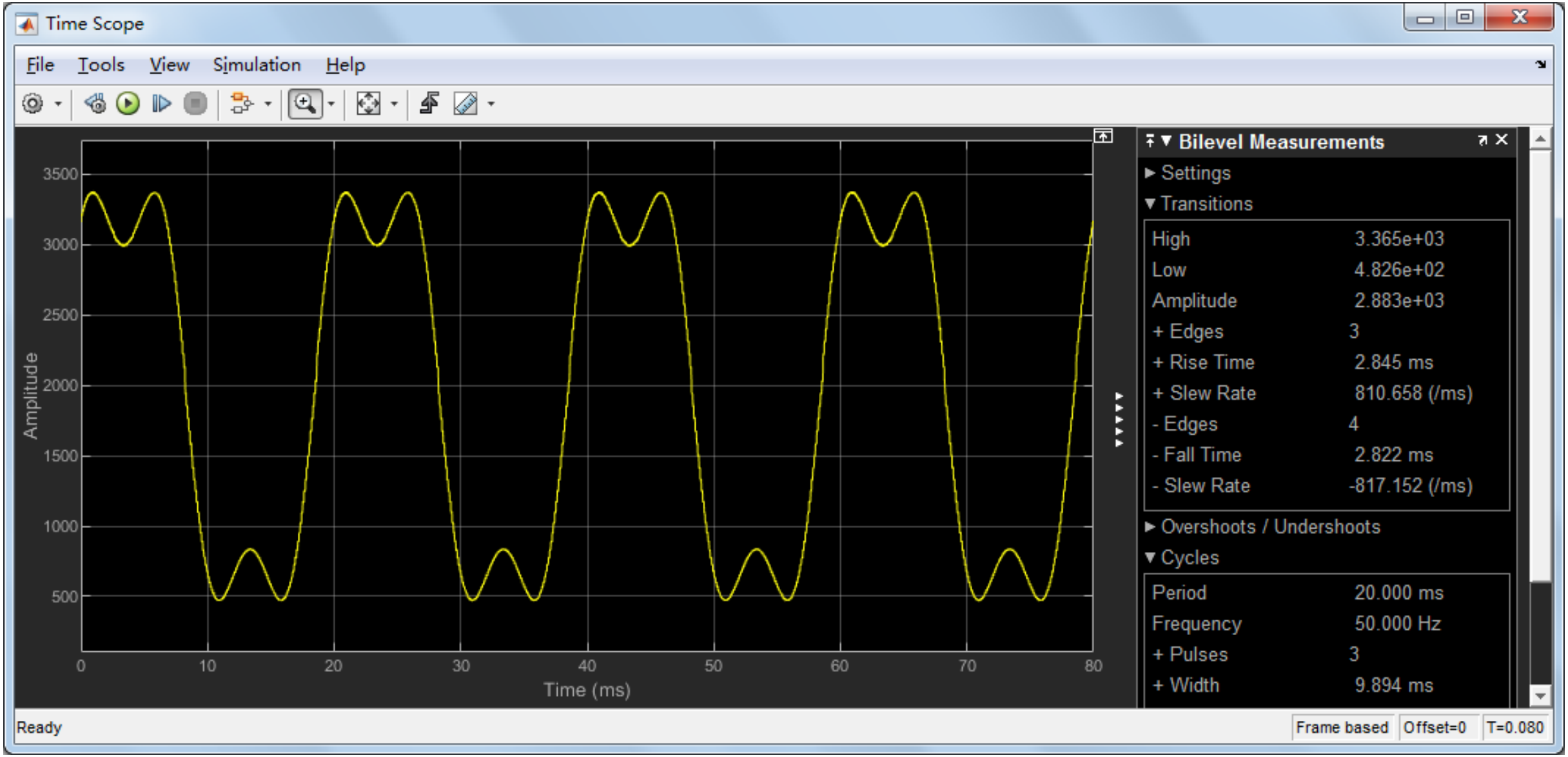
```
A=4096/2-1;%信号幅值
N=200;%一周期内数据点数
Ph=0;%信号初始相位
y1=sin(Ph:2*pi/N:2*pi*(1-1/N)+Ph);%基波
y3=sin(Ph:6*pi/N:6*pi*(1-1/N)+Ph);%3次谐波
SineData=ceil(0.8*A*y1+0.25*A*y3+A);
```



练习10：修改ADC采样频率

任务10.4、在任务10.3的基础上，用谐波数据替换DAC正弦波数据；修改配置参数，使DAC输出波形的基波为50Hz；ADC采样频率为**100kHz**不变。利用simulink模型，查看结果。


TIM4 Mode and Configuration
Mode
Slave Mode
Disable
Trigger Source
Disable
Clock Source
Internal Clock
Configuration
Reset Configuration
Parameter Settings
User Constants
NVIC Settings
DMA Settings
Configure the below parameters :
Search (Crtl+F)
Counter Settings
Prescaler (PSC - 16 bits value)
169
Counter Mode
Up
Dithering
Disable
Counter Period (AutoReload Regis...
99
Internal Clock Division (CKD)
No Division
auto-reload preload
Disable


Time Scope
File Tools View Simulation Help
Bilevel Measurements
Settings
Transitions
High 3.365e+03
Low 4.826e+02
Amplitude 2.883e+03
+ Edges 3
+ Rise Time 2.845 ms
+ Slew Rate 810.658 (/ms)
- Edges 4
- Fall Time 2.822 ms
- Slew Rate -817.152 (/ms)
Overshoots / Undershoots
Cycles
Period 20.000 ms
Frequency 50.000 Hz
+ Pulses 3
+ Width 9.894 ms
Amplitude
3500
3000
2500
2000
1500
1000
500
0 10 20 30 40 50 60 70 80
Time (ms)
Ready
Frame based
Offset=0
T=0.080

课程结题项目

■设计频率、幅值可调的信号发生器

- ✓ 同时输出**两路**波形
- ✓ **波形类型**：正弦、方波、三角波等（至少3种）
- ✓ **频率、幅值可调**：输出信号频率最高10kHz，幅值最高3V
- ✓ 输出为正弦波形时，可**任意添加谐波分量**（奇数次，至少3/5/7/9）和**谐波含量**（占基波的比例）
- ✓ **PC侧软件**控制波形输出类型、幅值、频率及谐波（正弦波形时），并显示输出波形（用simulink等工具）

■ 提交项目工程文件（压缩包）以及PC侧软件；撰写课题报告（包含实现方案及具体模块的实现说明，字数不限，格式不限）；将上述文件提交至网络学堂

谢　谢!