EXPERIMENT 4
WAVEFORM GENERATION AND MEASUREMENT

I) Pre-lab Assignment

Read and familiarize yourself with the documents (User’s Guide) describing how to operate an HP33120A 15-MHz Function/Arbitrary Waveform Generator, and an Agilent 54622D Mixed Signal Oscilloscope. The electronic version of the documents can be located via an Internet search. Do not print them.

II) Laboratory experiments

This laboratory acquaints the student with the operation of a Function/Arbitrary Waveform Generator, and provides experience in measuring the waveform parameters with an oscilloscope.

a) Sine wave generation and measurement

1) Connect the function generator directly to input 1 of the oscilloscope using a coaxial cable with BNC connectors on each end.
2) Select the sine waveform on the function generator and its frequency to \( f = 4 \text{ kHz} \).
3) Set the amplitude on the function generator to 640 mV_{pp}.
4) Select input 1 on the oscilloscope. Choose DC coupling, and set the probe factor to 1:1.
5) Press the EDGE key under trigger, select trigger source as 1, and choosing the rising edge.
6) Press the MODE/COUPLING key and set the trigger coupling to DC.
7) Adjust the Volts/div on channel 1 and Horizontal time/div knob so that two to three cycles of the waveform with a deflection of at least ±2 divisions appears on the display. Adjust the trigger level if necessary to obtain a stable display. **Before proceeding, demonstrate this step to the instructor.**
8) Record the trace display using Microsoft Excel installed on the lab computer connected to the oscilloscope via the GPIB connection.
9) Press the QUICK MEAS key. Select Pk-Pk and push the MEASURE softkey to make a measurement of the peak-to-peak voltage of the waveform.
10) Select Frequency and make the frequency measurement.
11) Select Period and make the period measurement.
b) Triangle wave generation and measurement.

1) Select the triangle wave on the function generator.
2) Set the function generator frequency to $f = 1.5$ kHz.
3) Change the amplitude setting on the function generator to $850$ mV$_{pp}$.
4) Adjust the oscilloscope so that two to three cycles of the triangle wave with a deflection of at least $\pm 2$ divisions appear on its display.
5) Record the trace display.
6) Measure the peak-to-peak voltage, frequency, and period of the wave using the measurement functions on the oscilloscope.


c) Sawtooth wave generation and measurement

7) Select the sawtooth waveform on the function generator.
8) Set the function generator frequency to $f = 5.3$ kHz.
9) Change the amplitude setting on the function generator to $390$ mV$_{pp}$.
10) Adjust the oscilloscope so that two to three cycles of the sawtooth wave with a deflection of at least $\pm 2$ divisions appear on its display.
11) Record the trace display.
12) Measure the peak-to-peak voltage, frequency, and period of the wave using the measurement functions on the oscilloscope.


d) Square wave generation and measurement

13) Select the square wave on the function generator.
14) Set the function generator frequency to $f = 3.5$ kHz.
15) Change the amplitude setting on the function generator to $1$ V$_{pp}$.
16) Set the duty cycle to 50%.
17) Adjust the oscilloscope so that two to three cycles of the square wave appear on its display.
18) Record the trace display.
19) Measure the peak-to-peak voltage, frequency, period, and duty cycle of the wave using the measurement functions on the oscilloscope.
20) Repeat steps 17 and 19 for duty cycle settings on the function generator of 23% and 77%.
21) Reset the duty cycle on the function generator to 50%.
22) Verify that the trigger slope is on the rising edge. Set the horizontal time base to 10 ns/div.
23) Use the oscilloscope measurement function to measure the rise time of the waveform.
24) Set the trigger slope to the falling edge.
25) Measure the fall time of the waveform.
e) Function generator source resistance

The oscilloscope has relatively high input impedance, and thus does not draw a significant current from the function generator. The source resistance of the function generator can be determined by a load test similar to that used in Lab #3.

26) Set the function generator frequency to 2 kHz, select a sine wave, and adjust the amplitude to 2 V_{pp}. At this point, the oscilloscope is still the only device connected to the function generator.
27) Adjust the oscilloscope so that two to three cycles of the sine wave appear on its display.
28) Use the oscilloscope to measure the peak-to-peak voltage.
29) Set the Decade Resistance Box to 2270 Ω, and connect it in the system as shown in order to provide a load to the function generator.

30) Adjust the value of the Decade Resistance Box so that the oscilloscope measures a peak-to-peak voltage that is \( \frac{1}{2} \) the value measured in step 28. Record the value of the resistance box as \( R_s \), the output resistance of the function generator.
31) Compare the voltage measured with the load in place in step 30 with the \( V_{pp} \) amplitude setting of the function generator. Does the function readout generator indicate open circuit voltage? Or does it indicate voltage with an optimum load \( (R_L=R_s) \)?
III) Lab Report

The lab report should be in standard format and include the following specific items:

1) Purpose
2) Model numbers of all test equipment used.
3) Block diagrams of test setup used
4) Test procedures
5) Graphics of the four oscilloscope displays recorded (parts a, b, c, and d). Each graphic should have a caption explaining what it represents.
6) Tables for each part showing a comparison of the parameters set on the function generator (amplitude, frequency, duty cycle) and the values measured by the oscilloscope. Also, compare of the measured period with the value calculated as $T = 1/f$.
7) Compute deviations from nominal.

$$%_{dev} = \frac{Parameter \ measured \ on \ oscilloscope - Parameter \ displayed \ on \ function \ generator}{Parameter \ displayed \ on \ function \ generator}$$

8) The value of $R_s$ determined using the load test.
9) Comparison of the rise and fall times measured with and without the load.
10) Answer to the question asked in step 31.
11) Conclusions

This lab report will not require circuit schematics, just block diagrams.