Physics 427 Lab # 2

TIME-VARYING VOLTAGES

1. Digital storage oscilloscope

Turn on the BK Precision 4011A function generator (FG). Choose a sine wave. Set the frequency to about 500 Hz. Set the amplitude (OUTPUT LEVEL) to about in the middle. Turn on the Tektronix TDS 2002 digital storage oscilloscope (DSO), and wait for it to go through its initialization. Connect a BNC cable from the OUTPUT of the FG to CH1 of the DSO.

a) To acquire a signal on the DSO, it is often possible to just push the black AUTO SET button. Once a signal appears on the screen, try using the SEC/DIV knob to change the sweep rate, the VOLTS/DIV knob to change the gain in the vertical amplifier in CH1, and the POSITION for CH1 to move the trace on the screen. Try changing the frequency and amplitude of the FG and adjust the knobs on the DSO to get a useful display.

b) Push the MEASURE button to display the measurement function on the right side of the screen. You will see that they correspond to various measurements on the waveform. To change these, push one of the five unmarked “soft-keys” (also called “option buttons”) on the right side of the screen. Then push the top button to change the channel, then the second button to change the function. After getting the function you want, push the back button to go back to the measurement display. As an example, set the DSO up to acquire measurement data for CH1 with these functions: peak-to-peak, frequency, and period.

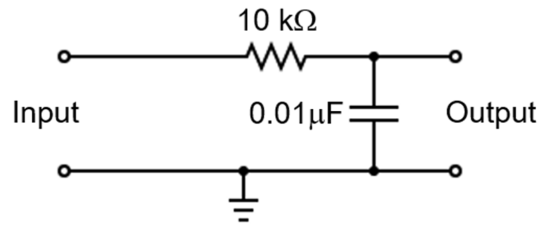
c) Measure the FG output for several frequencies: 5 Hz, 50 Hz, 500 Hz, 5000 Hz, 50 kHz, and 500 kHz. You will notice that the measurement functions may not work unless you change the settings to allow several periods of the waveform to display on the screen. Or alternatively, you might just push the AUTO SET button after changing the frequency (and then you have to push MEASURE again). Do you believe the DSO measurements of frequency or the setting of the knob on the FG?

d) Change the TRIGGER level and see how the arrow on the right side of the screen moves up and down. The very center of the screen is the point at which the trigger starts acquiring data, but these DSOs can display the signal that came before the trigger occurred, since they are continually acquiring data. Note the green arrow at the top of the screen, with the green “Trig’d” notation. This can be moved right or left with the HORIZONTAL position knob. Push the TRIG MENU button to get the Trigger Menu and notice the options.

e) Now push the square wave button on the FG and set the frequency at 500 Hz. Push the AUTO SET button and you will see a square wave on the screen. Push the soft-keys and see what they do. To measure the rise time of the square wave or pulse, choose MEASURE and set up one of the soft-keys to measure CH1 Rise Time. You have to expand the rising edge of the waveform in time on the screen in order to make this measurement accurate.

2. RC circuit

Construct the RC circuit shown below. Use the breadboard and the FG. The CH1 Menu should be chosen by pushing the yellow button and be sure that it is set for DC coupling, Probe 1x, and Invert OFF.



Use a square wave with a frequency of 500 Hz as the input and observe the output with the DSO.

a) Determine the time for the output to climb from 0 % to 63 % of the whole rising process. Use the cursor functions by pushing the CURSOR button and then use the two VERTICAL knobs to move the cursors (notice the green LEDs come on to indicate that these knobs are actively controlling the cursors). You can choose the type of cursor with the soft-keys. You may need some strategies, e.g., optimizing the position and magnification of the curve, and using both the horizontal and vertical cursors, to measure the time interval as accurate as possible. One key point is <u>you should know exactly which two points on the curve you are measuring</u>. You will compare the measured time with the time constant of this RC combination.

b) Measure the time for the output to drop from 100% to 37%. Are the measurements in agreement with the RC time constant of the circuit?

3. RC Integrator circuit

Without changing the circuit, you can use the resistor and capacitor from the last part to study the behavior of an RC integrator circuit (which also works as a low-pass filter). Adjust the FG to produce a square wave with a period T <u>much greater</u> than the RC time constant (i.e., T >> RC). Sketch the output waveform. Adjust the frequency to obtain periods such that T = RC and then T << RC and see how the output waveforms differ from the first case. For which case does the circuit function as an integrator?

4. RC differentiator circuit

Reversing the positions of the resistor and capacitor from the last part, construct the RC differentiator circuit (which also functions as a high-pass filter). Use a square wave for the input voltage, and sketch the output voltage waveforms you obtain for the following conditions:

a) T >> RC

b) T = RC

c) T << RC

For which case does the circuit function as a differentiator?

LAB REPORT **Name ___________________________**

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TIME-VARYING VOLTAGES

1. Digital storage oscilloscope

According to your opinion, what is meant by a "good" DSO display of an AC waveform?

How did the frequencies measured by the DSO compare with the digital display of the FG? Include several measurements to estimate the percentage error.

What is the measured value of the rise-time of the square wave FG output?

2. RC circuit

a) Sketch the output waveform seen on the DSO.

What was the rise time of the waveform (0% to 63%)?

How did you measure this?

What was the fall time of the waveform (100% to 37%)?

What was the value of the product τ = RC?

3. RC Integrator circuit

Sketch the output waveforms for each of the following cases:

a) T >> RC
b) T = RC
c) T << RC

Write down the actual period T you used. For which case does the circuit function as an integrator?

4. RC Differentiator circuit

Sketch the output waveforms for each of the following cases:

a) T >> RC
b) T = RC
c) T << RC

Write down the actual period T you used. For which case does the circuit function as a differentiator?