EEE108L: Electronics Laboratory Lab One: Basic Signals and Measurements

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I. INTRODUCTON

THIS lab is an exercise in measurement and equipment usage. The first section investigates the signal generator and it's non-ideal characteristics that impact voltage measurements. The second section introduces the student to a number of advanced techniques with the oscilloscope. Part two uses the Oscilloscope to identify the forward bias on a diode.

II. PART ONE: THE FUNCTION GENERATOR AND OSCILLOSCOPE

IN this section the effect of the signal generator's output impedance on measurements is analyzed. The section "Output Termination" of the Agilent 33120A user manual provides insight into the generator's settings. The voltage displayed is not a measurement of the output it is a stored value for the output setting. The display is an approximation of the output voltage based on a 50Ω terminated circuit. The 50Ω termination setting is designed for representing voltage delivered to terminated loads accurately. The setting halves the voltage output with respect to what is on the display. Figure 1 shows the elements that contribute to this phenomenon diagrammatically. This system can be modeled using a resistive divider, as seen line 1 below.

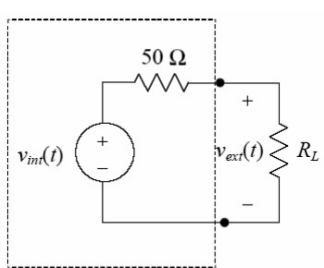

Fig. 1. Thvenin internal view of generator [1]

$$V_{out} = V_{in}\frac{R_2}{R_1 + R_2} \qquad (1)$$

$$V_{ext} = V_{out}(t)\frac{R_L}{R_L + 50\Omega} \qquad (2)$$

Equation 3 shows the result of the resistive divider that a infinite value (hi-z) of R_L will drive the resistive dependent term to one.

$$\lim_{R_L \to \infty} V_{out}(t)\frac{R_L}{R_L + 50\Omega} = V_{out}(t) \qquad (3)$$

Equation 4 shows the other case, if set R_L to 50Ω V_{out} is halved.

$$V_{out}(t)\frac{50\Omega}{50\Omega + 50\Omega} = \frac{V_{out}(t)}{2} \qquad (4)$$

A. Step One

Equation 2 is tested in the experimental environment. Table one lists the experimental data and their discrepancies can be explained by the function generator's terminations settings at 50Ω

TABLE I
LABRATORY DATA

Parameter	Oscilloscope Measurement	Function Generator Display	Scope with 100 Ω load
Amplitude, V_{PP}	3.04	1.4	2.08
Frequency, Hz	600	599.1	600.6
Offset, V	-0.5	-0.550	-0.317

The doubling of the oscilloscope measurement from the function generator display is expected. The $0.4V$ volt discrepancy can be attributed to the non ideal load of the oscilloscope.

B. Step Two: Load the signal generator's output

When the signal generator's output was loaded the reading on it's display did not change. This would be expected as the display is a setting for an internal control system, not a measurement of the output. The voltage on the display also removes DC offset from the input signal. This can be useful when measuring signals that are transmitted across a real medium with inherit capacitance.

C. Step Three: Coupling

Changing the coupling on the oscilloscope centers an AC waveform about the vertical axis. The AC coupling mode provides a convenient way to view a signal without DC offset.

D. Step 4: The trigger signal

The trigger signal changes states based on the output wave. For sine ramp and pulse waveforms the sync signal is logic high when the output voltage is above the average value of the signal, low when it's below [2]. The signal generator user's guide discusses the different operating modes for the sync signal. When the signal's amplitude, and offset parameters are adjusted the sync signal did not change. When the frequency setting is changed the sync signal changes frequency to stay in step with the output waveform. Figure two illustrates the two waveforms at 500Hz.

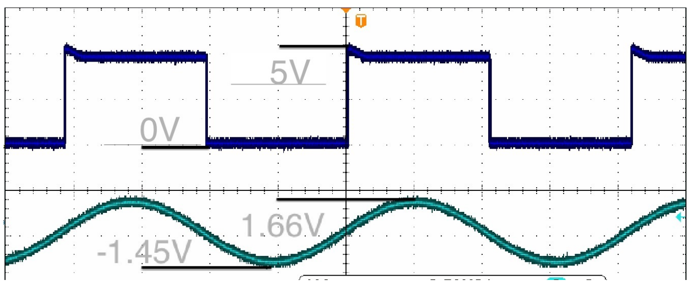

Fig. 2. Function generator output sync and output signals

E. Step 6: Oscilloscope trigger parameter

The sinusoidal input changes amplitude with respect to time. The trigger aligns the signal crossing with the vertical axis, this alignment causes a false horizontal shift to appear.

F. Step 7: Trigger threshold adjustment with square wave

The square wave had a very fast rise time compared to the frequency of the signal. There was no observable movement along the time axis while the trigger was set between the high and low states of the signal.

III. Part Two: A Simple Diode Circuit

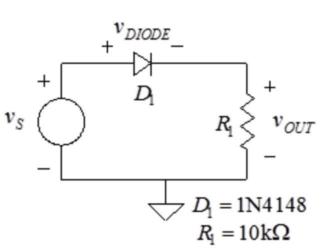

Fig. 3. Circuit specification in lab manual

A single loop diode circuit was assembled as depicted in figure 3. When a alternating current signal was placed across D_1 the signal is rectified. The output signal of the system shows it is behaving as a half wave rectifier.

The dark blue wave in Figure 4 is the input of the system V_s. The light blue signal is V_{out}. Figure 4 shows Diode D_1 experiences maximum forward bias when the input signal is at it's lowest value.

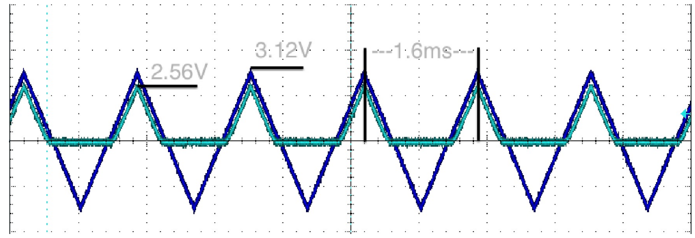

Fig. 4. Rectified triangle wave

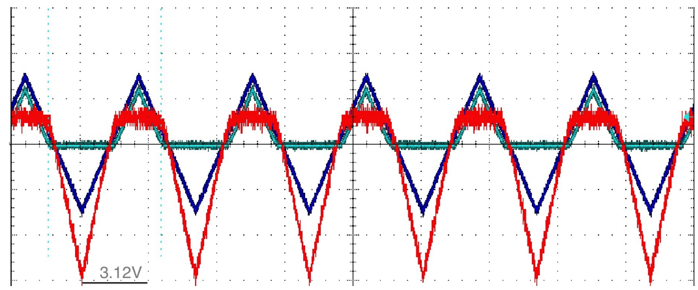

Fig. 5. Rectified triangle wave with difference superimposed

The red wave in figure 5 is the difference between input and output voltage on a scale that's half the blue waveforms $(\frac{1V}{div})$. The red waveform is the amount of forward bias on the diode. The troughs of the blue and red waveforms align showing relationship expected.

IV. Conclusions

A. Item 1

The output voltage of the function generator varies in accordance with Equation 3. Figure 6 is Equation 3 with $V_{out}(t)$ is assumed to be a constant one and R_L is the independent variable.

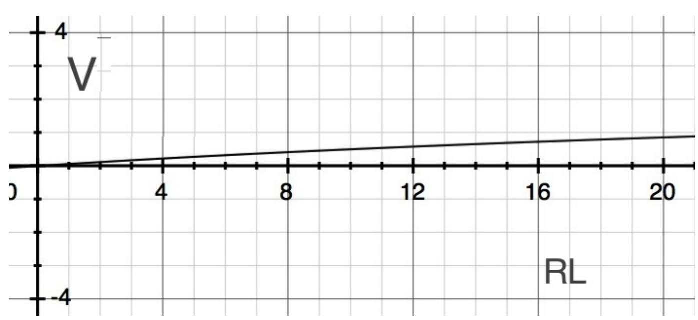

Fig. 6. Unit output voltage as a function of R_L

Figure 6 shows a narrow window to emphasize the change in voltage with respect to the load resistance. The output voltage of the signal generator does change and will only be accurate for 50Ω terminated loads.

B. Item 2

The amplitude on the front panel of the function generator does not change when the signal is loaded by the 100Ω resistor. The amplitude displayed is not a voltage measurement of the output, it is a pre stored calibrated value. The value listed on the function generator is a peak to peak voltage for a 50Ω terminated signal.

C. Item 3

The sync output is always 50% duty cycle this prevents charge from building on the input line and rising above the trigger voltage. It also allows an oscilloscope to synchronize on a fixed point in a generated signal's period.

D. Item 4

The peak current through diode D_1 can be calculated by using the output voltage measured with the oscilloscope.

$$\begin{aligned} I &= \frac{V}{R} \\ I &= \frac{3.12V}{10K\Omega} \\ I &= 3.12mA \end{aligned}$$

E. Item 5

Modeling the function generator as having an output resistance of zero is acceptable in cases when the resistance of the load is much larger then than the generator's source impedance.

References

[1] B. University of California. (2007) Lab 2: Function generator and oscilloscope. [Online]. Available: http://inst.eecs.berkeley.edu/~ee100/su07/lab/lab2-FunctionGeneratorOscilloscope/eecs100_eecs43_lab2-fncn_generator_scope.pdf

[2] Agilent. (2013) Agilent 33220a user's guide. [Online]. Available: http://cp.literature.agilent.com/litweb/pdf/33220-90002.pdf