

## Direct and Alternating Voltages, the Oscilloscope

### *Required Equipment*

1. A Tektronix TDS3024B Digital Phosphor Oscilloscope
2. Function Generator
3. DC Power Supply
4. Potentiometer
5. Various resistors

### *Introduction*

The aim of this lab is to familiarize you with the TDS3024B 200Mhz oscilloscope that you will use throughout the course. Where earlier oscilloscopes used beams of electrons in cathode ray tubes to “paint” voltage waveforms, this Digital Phosphor Oscilloscope (DPO) uses fast Analog to Digital Converters (ADC’s) to take samples of the voltage as a function of time, store it in memory and then display it on a color LCD screen. This fully digital design results in a lighter instrument with extensive capabilities due to its fully digital design.

### *Getting Familiar with the Oscilloscope*

Each DPO comes equipped with a Reference Manual that we will use to become familiar with some of its features.

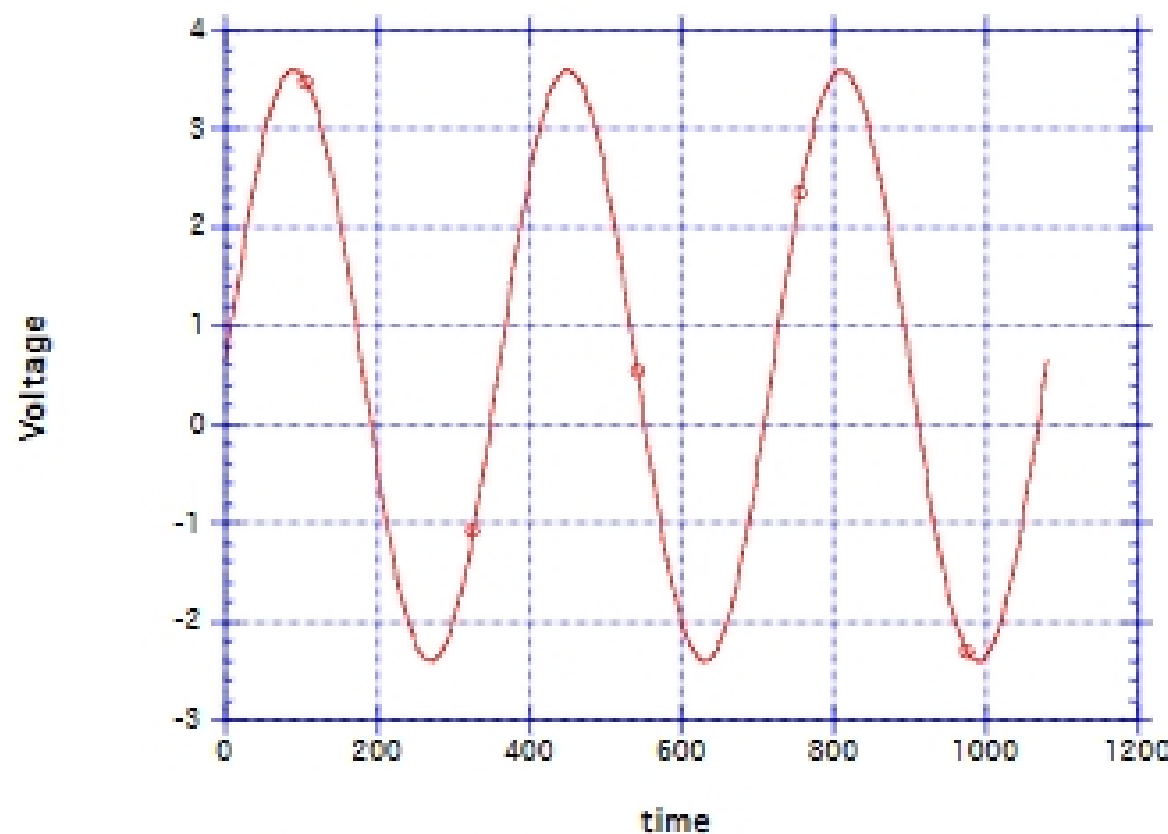
Turn on the oscilloscope and observe as it goes through its setup procedures. Copy its IP address in your lab notebook. This will be a series of four numbers with a format like 35.122.113.64. Turn on your function generator (pulser) to output sinusoidal waves with amplitude 1 V and frequency 1 MHz and connect the output to both Channels 1 and 2 of the DPO using a coaxial cable. Following the instructions in the reference manual exercise the following features of the DPO until you become familiar with them:

- Quick Menu. Simple measurements of waveforms can be performed with this feature without resort to more advanced features.
- Acquire Menu. This menu controls the data acquisition features of the DPO that are activated by pushing the Run/Stop button. The status of the acquisition is indicated on the upper left hand corner of the screen.
- Cursor Menu. This gives you control over both horizontal and vertical cursors used in making timing and voltage measurements.
- Display Menu. The features are self-explanatory. Get familiar with the XY Display by going to the Triggered XY mode. What kind of display would you expect if the X and Y channels were both connected to the same signal?
- Measure Menu. Practice measuring the period and frequency of the input signals on both channels. Do they agree with the pulser settings? Measure the rise and fall times, defined as the time for the signal to go from 10% to 90% of its maximum value. Do the measurements agree with your expectations?
- Trigger Menu. Set the trigger source alternately to Ch1 and Ch2. Change the trigger level and slope and observe their effects. Change the coupling features of the trigger to DC (from AC).

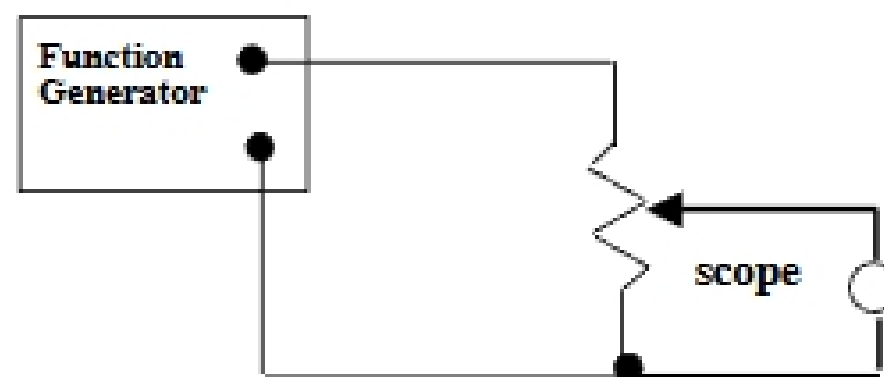
In order to print the scope displays or to remotely control the scope from your PC, it has to be connected to the Internet. Go through the procedure in Appendix G of the User Manual to set the scope up for Internet use. Make sure that it is connected to the laboratory Ethernet backbone with an appropriate cable. To test the connection print out a display of a sine wave on your scope and paste it into your laboratory notebook.

### AC-DC Signals

1. *Scope Coupling:* The scope y inputs can be AC or DC coupled. The AC coupling blocks the constant part of the signal. Add some DC offset to the function generator output and switch between AC and DC coupling. Observe the effects on the scope.



**Figure 2: A 3 V sine wave with 0.6 V offset**



**Figure 1: AC level control.**

Figure 1 shows a sine wave with an offset.

2. Explain how to use ac-coupling to measure the small ripple in the output of a power supply. Typical ripple might be a 120 Hz sine wave, 10 mV peak-to-peak, added to a

constant 5-Volt output from the power supply. Try to find a ripple in one of the lab power supplies.

3. *AC level control*: Use a potentiometer to attenuate an AC signal as shown in Figure 1. This is the essence of an audio volume control.
4. *Passive Summer*: The summer adds the DC voltage from the power supply to offset the ac voltage from the function generator (Figure 3). Suppose the function generator is an ideal voltage source (no internal resistance) creating a sine voltage  $V_{AC} = 5 \sin(2\pi ft)$ , where  $f$  is the frequency and the amplitude is 5 volts. Assume that the 10-volt supply is an ideal voltage source. **To be done before class**: Show that the output is always positive and looks like the curve in Figure 4 below.

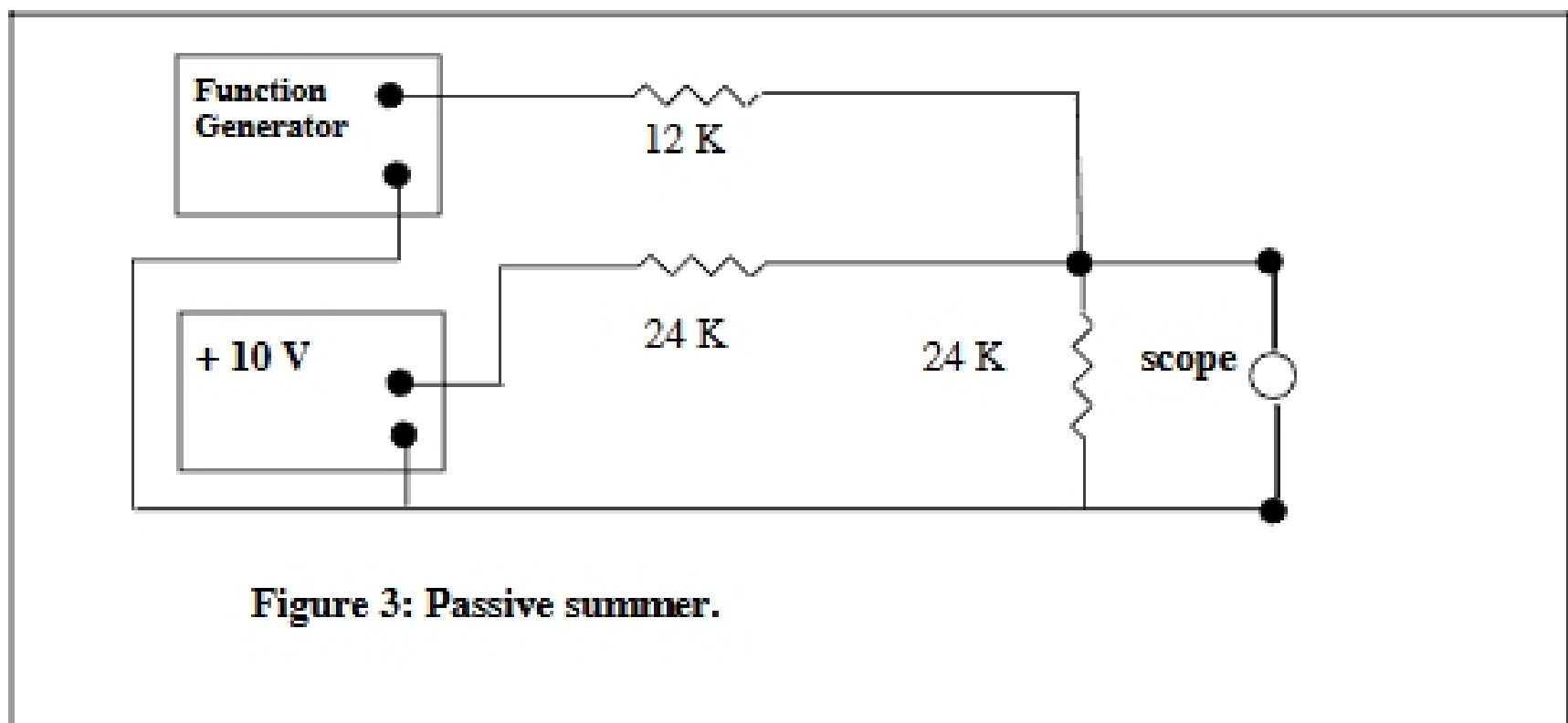


Figure 3: Passive summer.

Print the resulting waveform and paste it into your lab notebook.

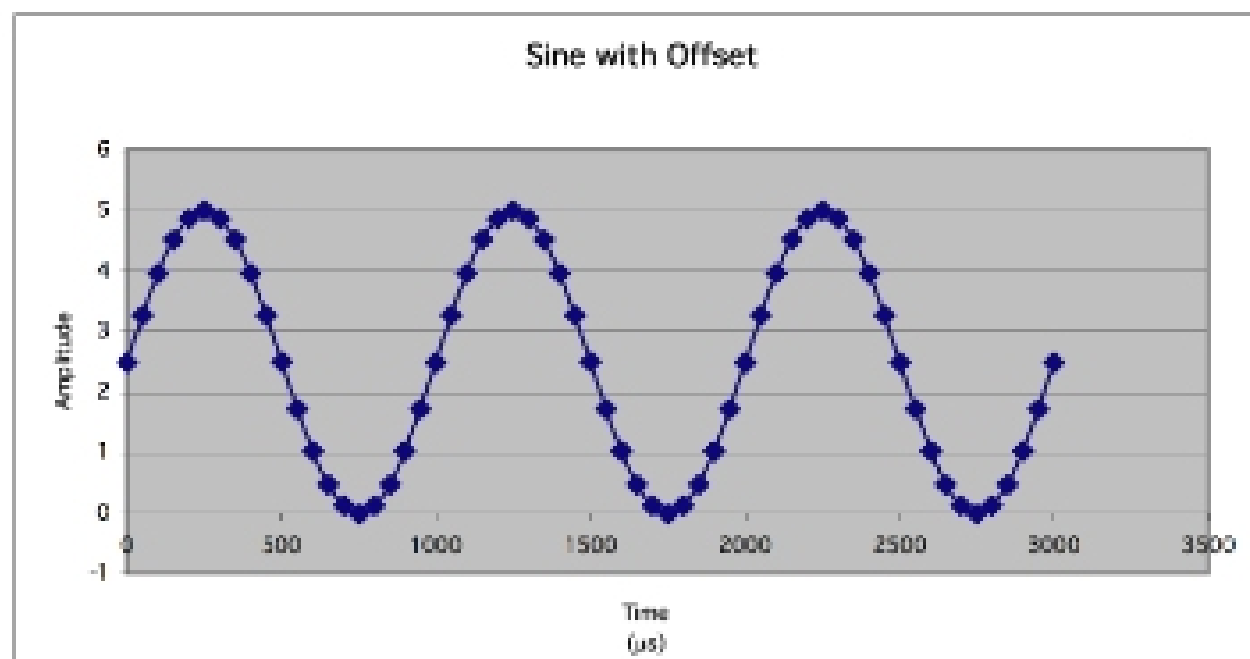


Figure 4: Sine wave with positive offset.