VOLTAGE DIVIDERS

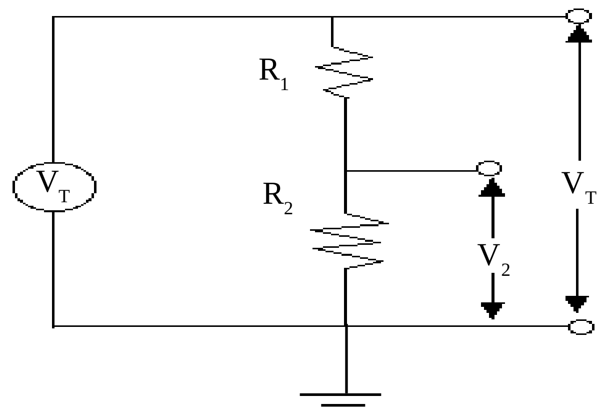
Purpose

To study the voltage divider, learn to use a function generator, practice with the oscilloscope, and begin to work with a proto-board (breadboard).

Introduction

Most electronic devices require a variety of voltage levels for its circuitry. Rarely is the value of a given voltage appropriate for all parts of a circuit. Whether it is an AC signal level or a DC bias, the voltage usually must be raised or reduced to a desired level. The most common method of voltage reduction is by the action of a voltage divider circuit. Shown below is a simple series of 2 resistors.

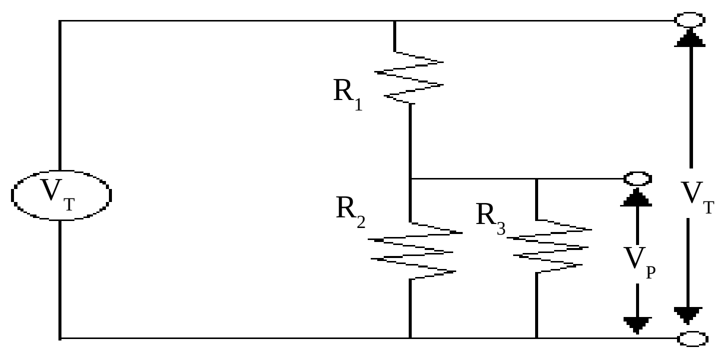
Step 1



Since $I_1 = I_2 = I_T$ we may recall that in a series circuit R_1 / R_2 equals V_1 / V_2 . Hence, by a suitable choice of resistors, the original or total voltage (V_T) can be reduced to any desired voltage (V_1 or V_2 or both). In its multiple resistor form, it consitutes the calibrated vertical sensitivity control of the oscilloscope. In its variable form, it constitutes the vertical and horizontal position controls. Each time you adjust the volume control of your stereo, you are altering the voltage ratio in a voltage divider circuit which in turn controls the amplitude of the amplifier output.

There are, however, some limitations. First the amount of current extracted from V_1 (or V_2) must be much less than the total current flowing throught the voltage divider or the division ratio will become altered. For instance, if an external load (resistor, R_3) uses V_2, there is a shunting effect. That is, this load and R_2 would be parallel and $1/(1/R_3 + 1/R_2)$ would have to be substituted into the resistor ratio. Thus in theory, the original resistor ratio of R_1 / R_2 is only perfect if zero current is extracted using V_2 . In practice, a rule of thumb states that the voltage divider is valid if less than 10% of the resistor current is diverted into an external load. Consider R_3 as the external load using V_2;

Step 2



A second limitation of the divider is more subtle. For AC signals, the voltage divider action is not only due to resistance, but must also include any reactance which may be due to capacitance. This can be particularly troublesome at high frequencies and at large ratios. The effects of this AC limitation is demonstrated in step 3.

Procedure

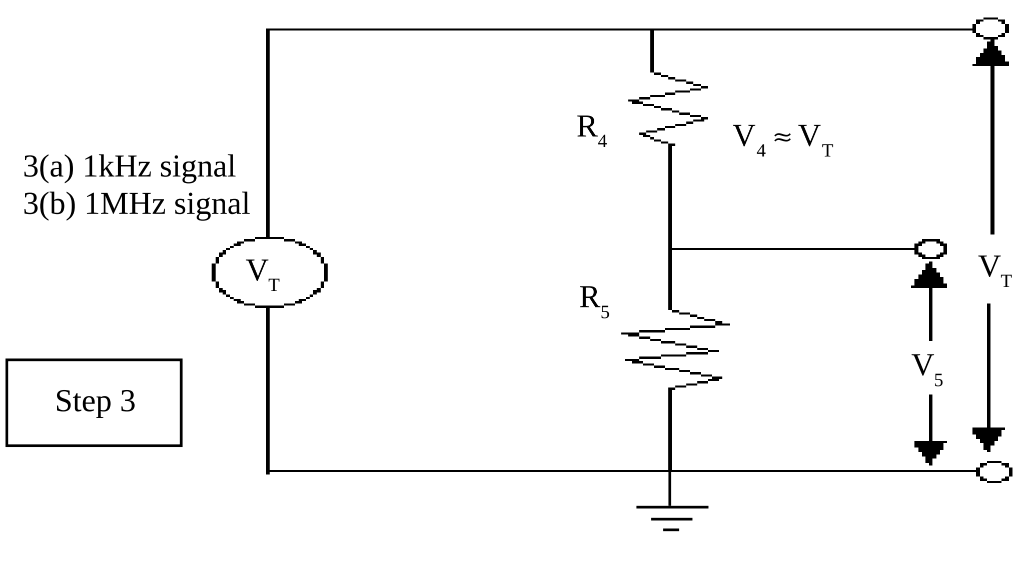
Step 1 See the diagram on the previous page. Connect two unequal resistors in series. (Use resistors from 1kΩ to 50kΩ with the same third color band. We don't want to make the resistor ratio too large.) Apply a signal of a little more than 1kHz frequency and adjust the output to a 5-15V peak-to-peak voltage (V_{PP}). Connect this signal to the two series resistors. Use the oscilloscope to measure V_2 and V_T . Calculate V_1 . Note that the scope cannot measure V_1 directly because both the scope and the function or signal generator have one terminal connected to the chassis and, therefore, to the grounding plug on the AC line cords. This limitation due to common grounds is ubiquitous when using test equipment. Always be aware of common ground problems. Record the values of R_1 and R_2 . Compare the voltage ratio with the resistor ratio using:

$$\frac{|N_1 - N_2|}{\frac{N_1 + N_2}{2}} \times 100 = \_\_\_\_\_\_\_\_\_\% \text{ deviation}$$

Where N_1 and N_2 are the two ratios being compared.

Step 2 Leave R_1 and R_2 as before, connect a third resistor R_3 in parallel with R_2 as shown on the previous page. Think of R_3 as an external load resistor in parallel to R_2 . Measure V_T and V_P as before. Record the values of the three resistors. Calculate R_P for the parallel combination of R_2 and R_3 . Again compare the voltage (V_1 / V_P) and resistor (R_1 / R_P) ratios and calculate % deviation.

Step 3(a) Repeat step 1 with R_4 (100kΩ to 600kΩ) but R_5 (100Ω to 300Ω). Connect R_5 (as the lower resistor) to ground. In this case, $R_4 >> R_5$ and hence the measurement of V_T and V_5 will require a wide range of values for the vertical(voltage) sensitivity selector of the scope. Notice the noise level visible when measuring V_5 . Recored the resistor values.



Step 3(b) Repeat 3(a) using a frequency greater than 1MHz.

VOLTAGE DIVIDER WORKSHEET

Name ____________________
Period __________

Put all answers in decimal form.

Step 1 Series Divider

V_T = __________ V V_2 = ____________ V R_1 = _______ Ω R_2 = ________ Ω

V_1 = __________ V V_1 / V_2 = __________ R_1 / R_2 = ____________

$$\frac{|\_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_|}{\_\_\_\_\_\_\_\_\_\_\_\_} \times 100$$ = _________ % deviation

Step 2 Parallel Divider

V_T = ____________ V V_P = ____________ V

R_1 = _________ Ω R_2 = __________ Ω R_3 = ____________ Ω R_P = __________ Ω

V_1 = ____________ V V_1 / V_P = ____________ R_1 / R_P = _____________

$$\frac{|\_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_|}{\_\_\_\_\_\_\_\_\_\_\_\_} \times 100$$ = _________ % deviation

Step 3(a) Series Divider ($R_4 >> R_5$) with f around 1kHz.

V_T = _____________ V V_5 = _____________ V R_4 = __________ Ω R_5 = ____________ Ω

V_4 = _____________ V V_4 / V_5 = ______________ R_4 / R_5 = _______________

$$\frac{|\_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_|}{\_\_\_\_\_\_\_\_\_\_\_\_} \times 100$$ = _________ % deviation

Step 3(b) Series Divider ($R_4 >> R_5$) with f around 1MHz.

V_T = _____________ V V_5 = _____________ V R_4 = __________ Ω R_5 = ____________ Ω

V_4 = _____________ V V_4 / V_5 = ______________ R_4 / R_5 = _______________

$$\frac{|\_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_|}{\_\_\_\_\_\_\_\_\_\_\_\_} \times 100$$ = _________ % deviation

Instructor’s verification for extra credit ________________________