With this exercise we will explore the concept of equivalent circuits and power transfer.

Let’s start with the circuit shown below. The terminals labeled $ACH0^+$, $ACH0^-$, $ACH1^+$, etc. are used for performing measurements of the circuit at the corresponding nodes.

In this circuit the resistor $R_2$ represents the load resistance. $R_s$ is a current sensing resistor and its value is small compared with the other resistors in the circuit. By knowing the value of $R_s$ a simple measurement of the voltage drop across it gives us the amount of current flowing through it.

Before proceeding with the experiment do the following calculations:

1. Derive an expression for $R_2$ as a function of $V_B$, $V_o$, $R_1$, and $R_s$.

2. For $R_s \ll R_1$ and $R_2$, derive the expression for the power dissipated in $R_2$ as a function of the circuit parameters.
Now construct the circuit on your protoboard and make the connections as indicated. For $R_2$ use your 20k$\Omega$ variable resistor. For $R_s$ use a 91$\Omega$ resistor.\(^1\)

Download the instrument called “Power_Transfer_1” from the class web site. Run it and vary $R_2$. Observe the behavior of the circuit.

At what resistance is the power dissipated in $R_2$ maximized?

In the space below draw the power dissipated in $R_2$ as a function of $R_2$.

Does your experimental result agree with your calculations?

\(^1\) Any other resistance values could be used for $R_s$ and $R_3$. But since we have the 91$\Omega$ and the 5.1k$\Omega$ in our kit we use these.
Now let’s modify the circuit by changing $R_1$ to 10kΩ and adding the 5.1kΩ $R_3$ resistor as indicated in the schematic below. Again use a 91Ω resistor for $R_s$.

Before proceeding with the experimentation with this circuit let’s analyze it.

1. Determine the Thevenin equivalent circuit seen by resistor $R_2$.

2. Calculate the voltage $V_o$ across resistor $R_2$ as a function of the circuit parameters.
Download the instrument called "Power_Transfer_2" from the class web site. Run it and vary $R2$ and observe the behavior of the circuit. (Note: turn the previous instrument Power_Transfer_1 off before proceeding with this one)

The instrument measures the power dissipated in $R2$ and plots it as a function of $R2$. This is accomplished while you are trimming (changing the value) of the variable resistor $R2$.

In the space below redraw the results you are observing from the measurements

![Graph showing Power vs R2]

At what value of $R2$ does the power dissipated in $R2$ becomes a maximum in this case?

Do you see how that optimum value is related to $R1$ and $R3$? (We still have $Rs \ll R1, R2,$ and $R3$).