Circuits De-mystified:

Measuring Impedance

Question:

- How do you work out the (source) impedance of a circuit (at a given point)?

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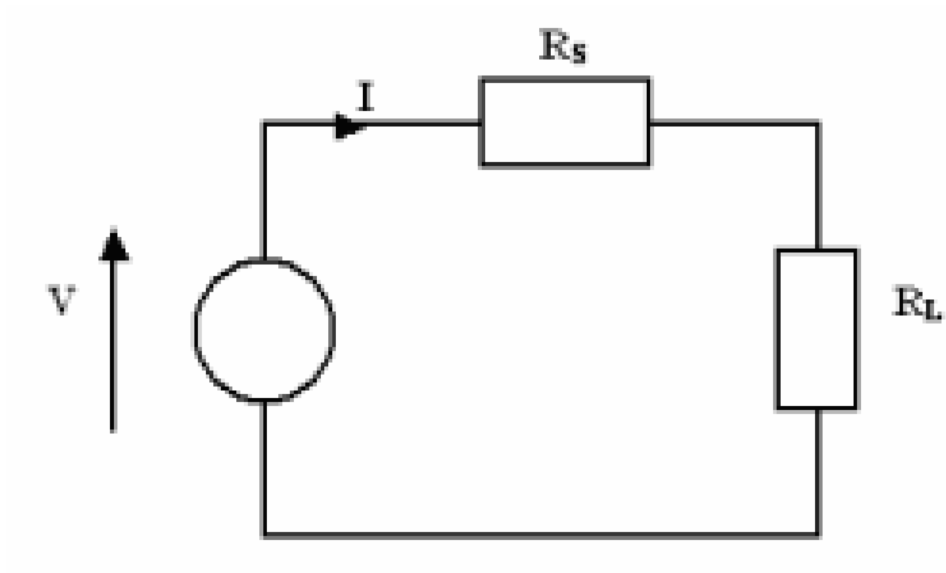
Answer:

- You do not need need a whole lot of complicated maths!

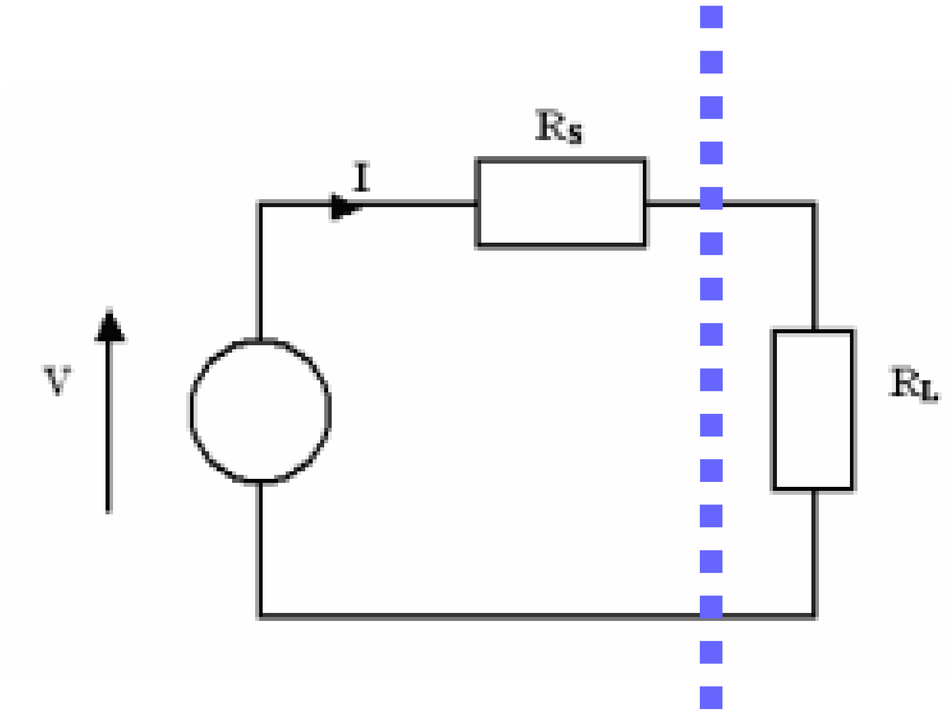
- You can use some basic circuit principles instead



Source: https://commons.wikimedia.org/wiki/File:Maxpowertheorem.png
Source: https://en.wikipedia.org/wiki/Maximum_power_transfer_theorem

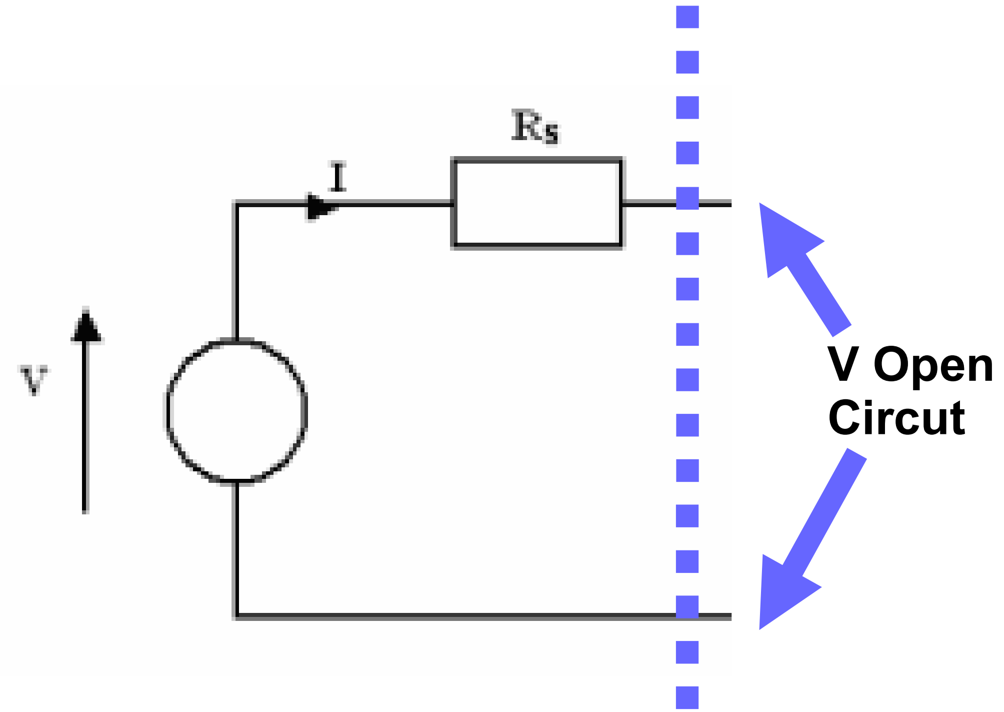
- In every “source”, we have an ideal voltage, V, and some Source Resistance, R_S

- 'looks like the “model” of the internal resistance of a battery – it's the same idea really

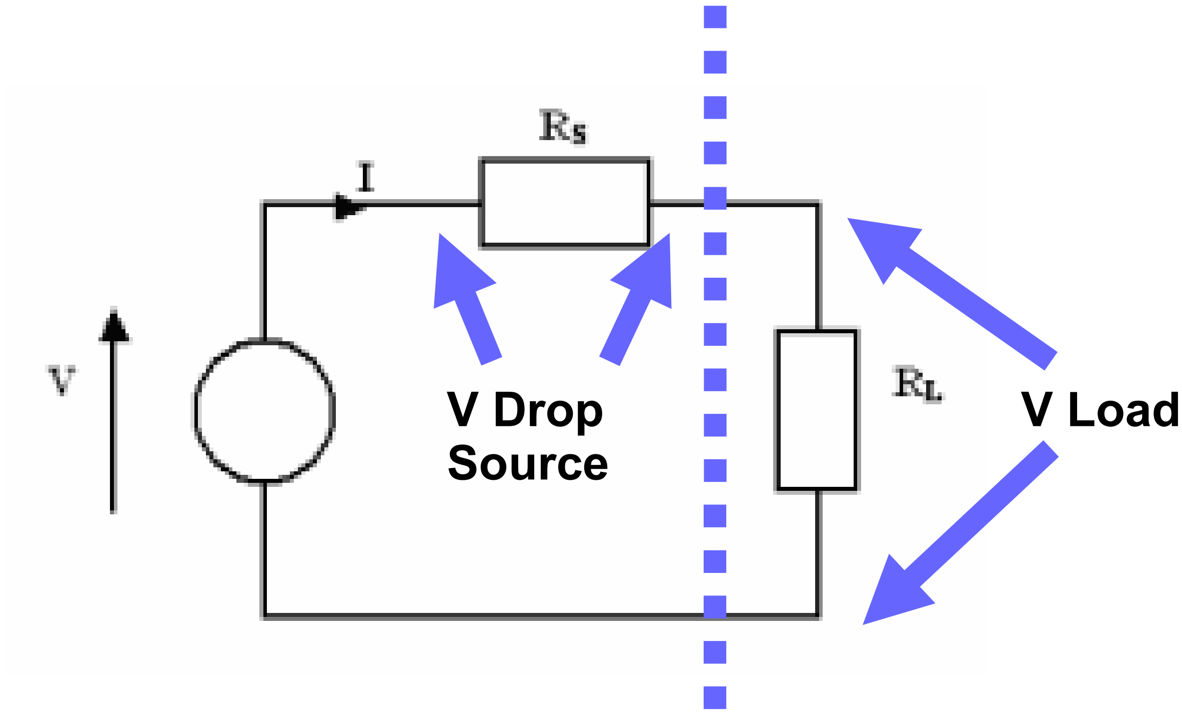


- The load resistance is R_L

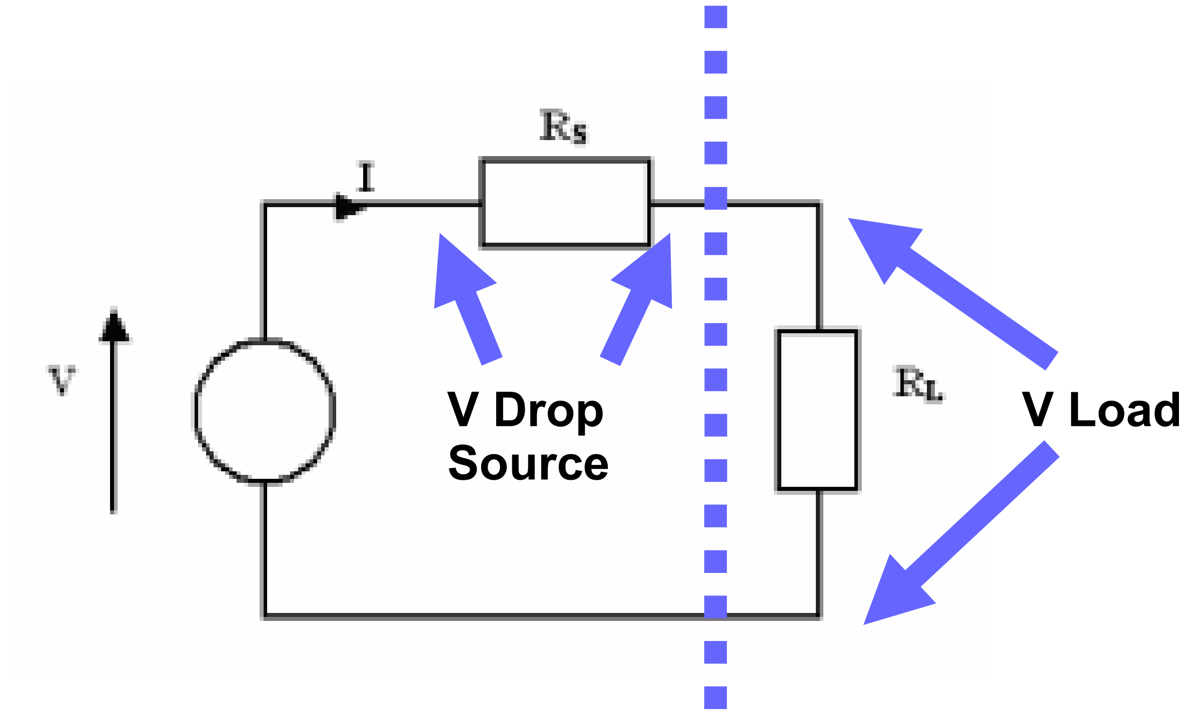
- *(In an alternating current circuit, Z=R+Xj, we will look at this later...)*



- If the circuit has no load, "Open circuit voltage" will be the same as the perfect source voltage

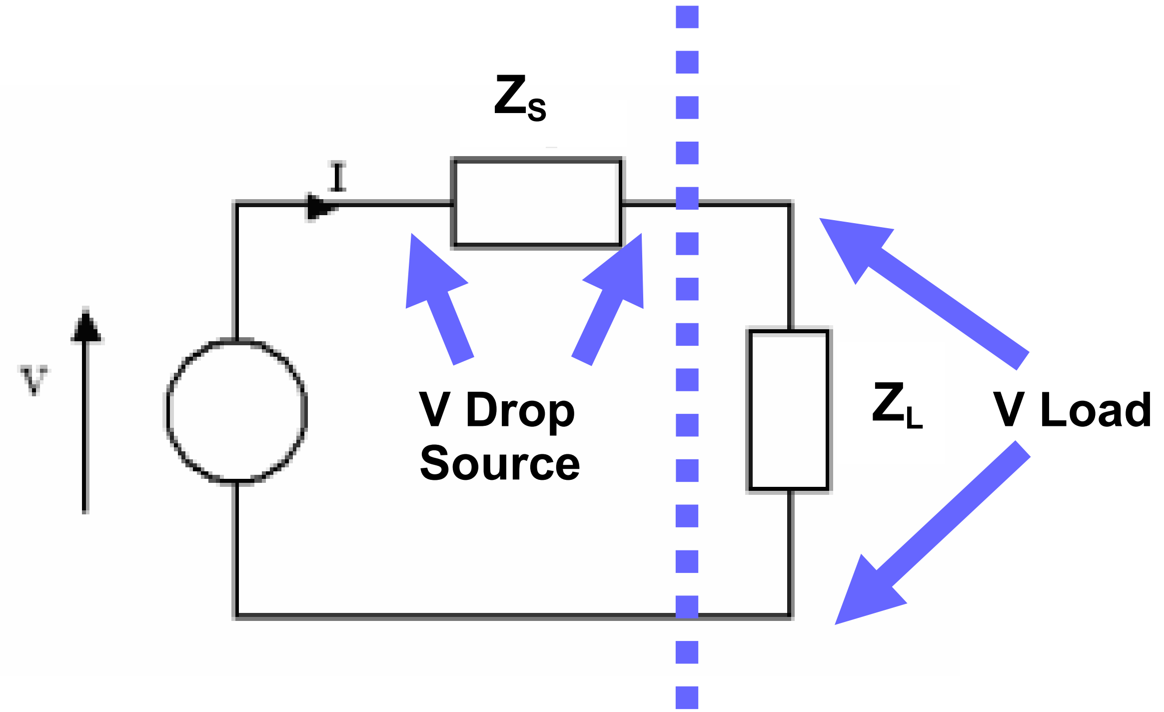


- As load increases, from Ohm's law, voltage will "drop" across the internal resistance, R_S



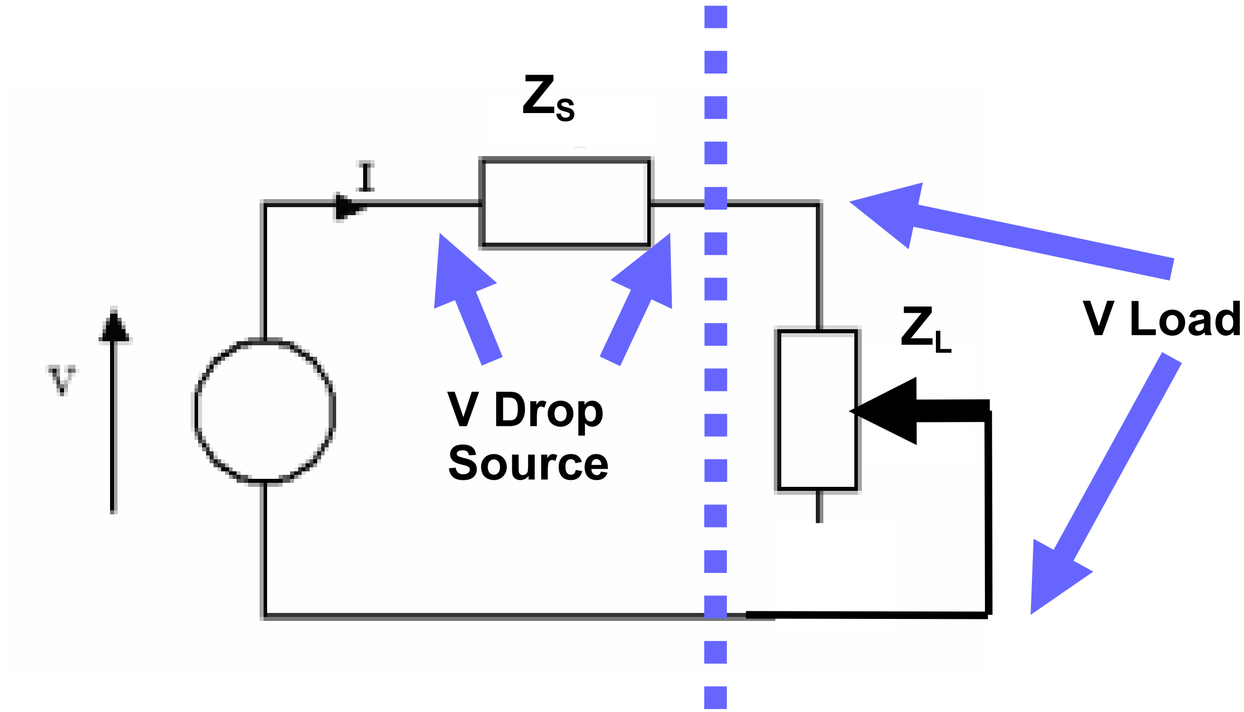
- By inspection, if $R_L = R_S$, then the voltage across both will be equal

- **This means the load voltage will be half the voltage of the Open Source voltage**



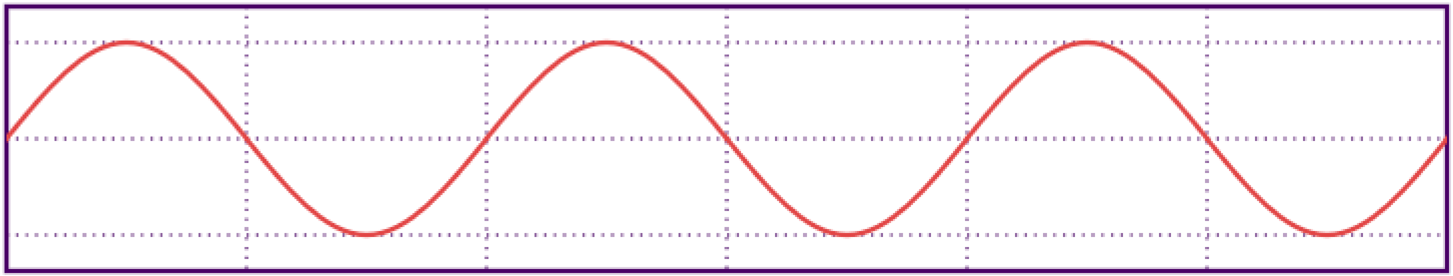
- It can be shown for an a.c. circuit, the same principle applies for Impedance

- When $Z_L = Z_S$, then the voltage across both impedances will be equal



- Using the voltage halving idea, we can apply a variable load to see the change this makes to the (load) voltage in the circuit

- When V Load= (1/2) * V Open Circuit, then $Z_L = Z_S$



V Open Circuit

Source: https://en.wikipedia.org/wiki/Sine_wave#/media/File:Waveforms.svg
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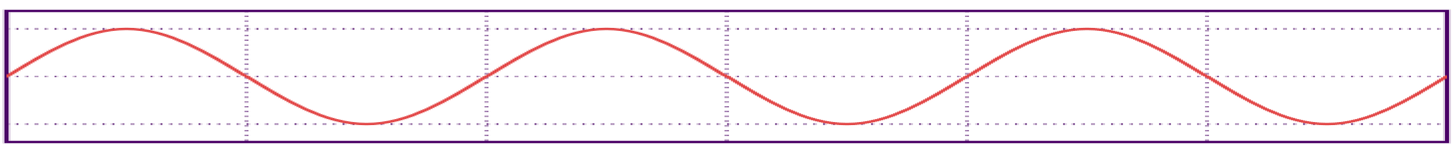
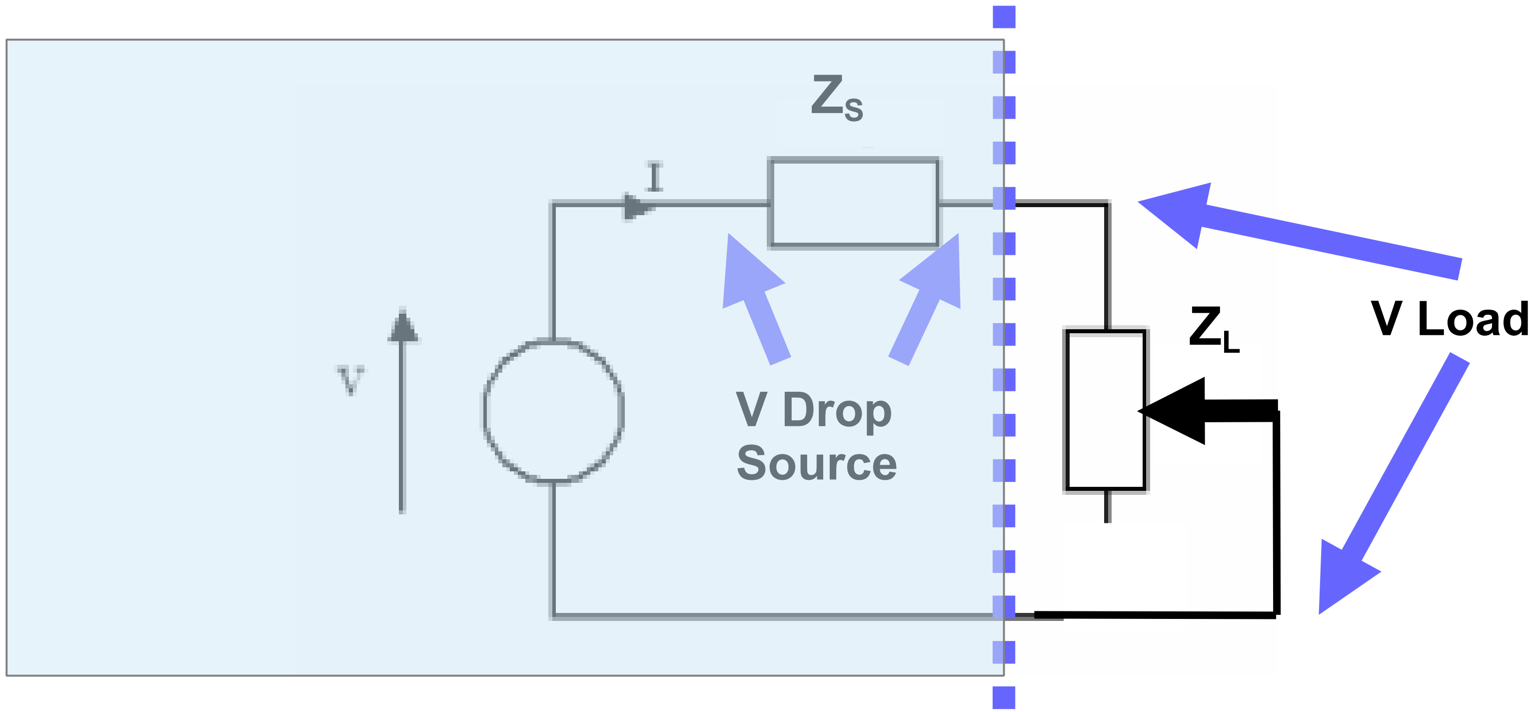


V Load

- When V Load= (1/2) * V Open Circuit, then $Z_L = Z_S$

- There is a video from W2AEW, Alan, that shows this in action: https://www.youtube.com/watch?v=ieAhBejHe2M



- In principle this idea could be applied to any given point in a circuit, so you would have a technique to measure impedance for different parts of the circuit – provided there is a source voltage to measure

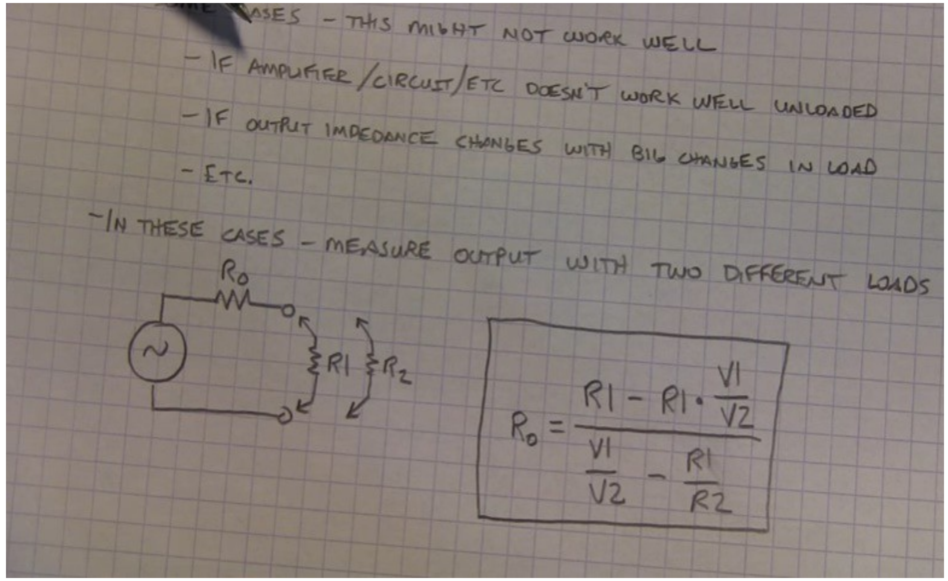
Practicalities and challenges!

- Not all circuits work with this technique or are easily measurable at RF frequencies (due to reflection), as Alan W2AEW describes

- Some circuits prefer a high impedance load only or behave strangely depending on load or measure better if the source is “smooth” like a sine wave or constant voltage

- 'a circuit loaded to a point it's voltage halves... though it may not be able to dissipate that much power or have been designed to do that

The in-depth method?



Source: https://www.youtube.com/watch?v=ieAhBejHe2M

- You can measure voltage of the circuit for two "normal" loading points and infer impedance from this

- Could be more suitable in some cases

Any questions?