**Chapter 19: Two Port Network**

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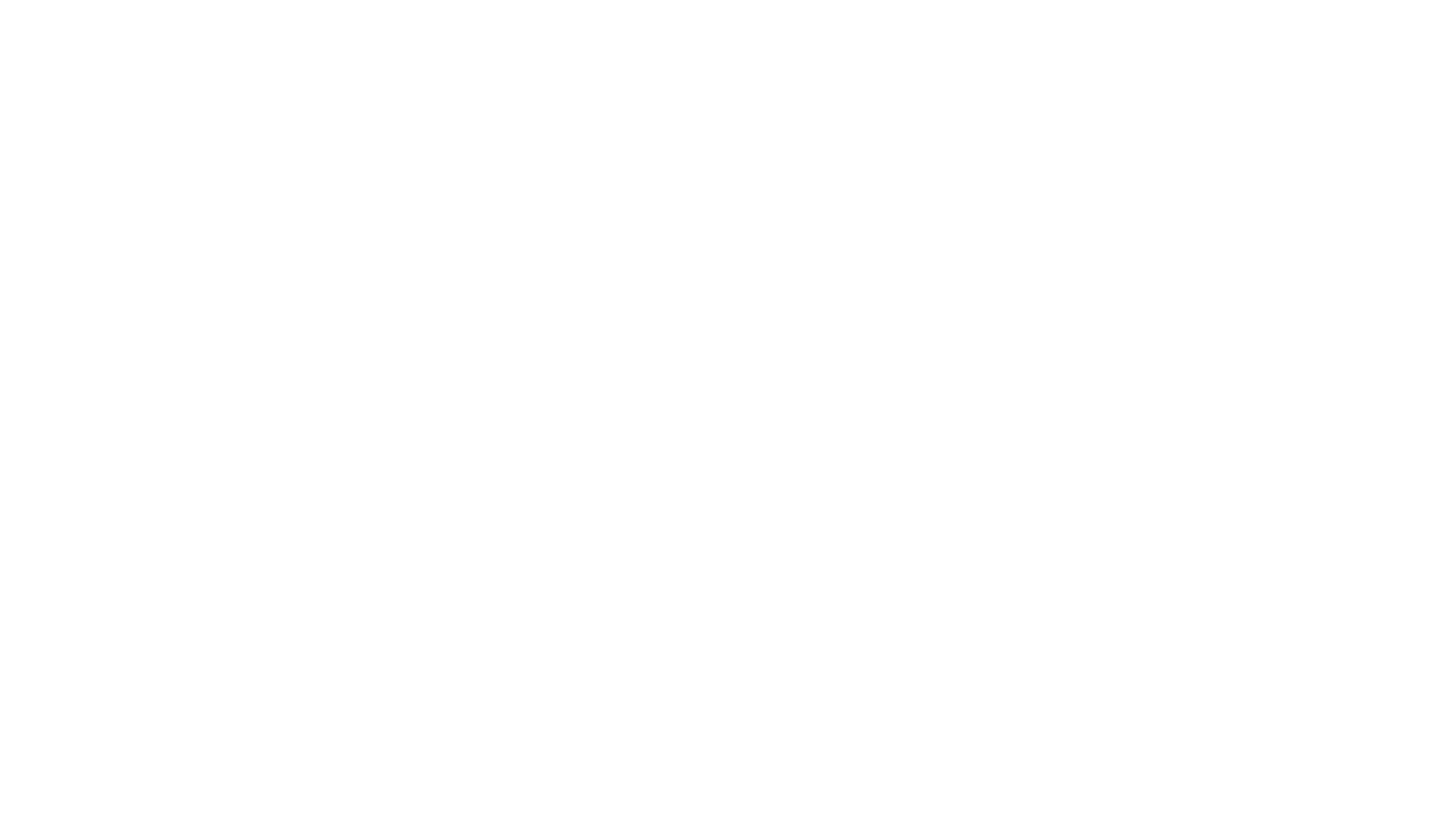
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## 19.1 Introduction

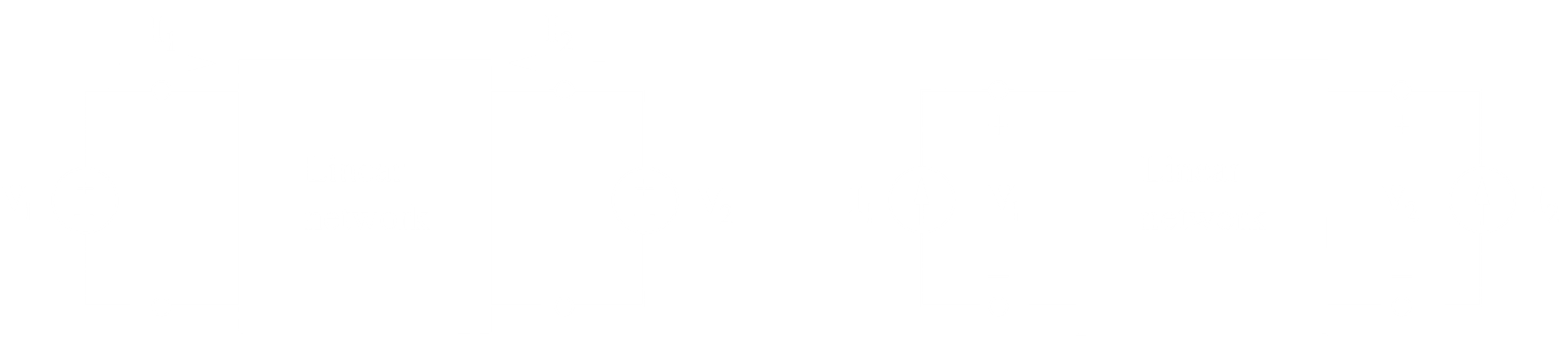
A pair of terminals through which a current may enter or leave a network is called a port. Two terminal devices (like resistors or capacitors) result in one-port networks. In general, a network may have ports.

A two-port network is an electrical network of two separate ports for input and output. The current entering one terminal in the pair leaves through the other terminal. Knowing the parameters of a two-port network allows us to treat it as a black box when embedded in a larger network.



## 19.2 Impedance Parameter

Impedance and admittance parameters are commonly used in filter design (where frequency above or below a certain level is filtered out) and in impedance matching and power distribution networks.



Linear Two Port Networks Driven by Voltage and Current Sources

or

Here, the terms are called the impedance parameters. The parameters can be evaluated by setting (input port is open circuited) or (output port is open-circuited).

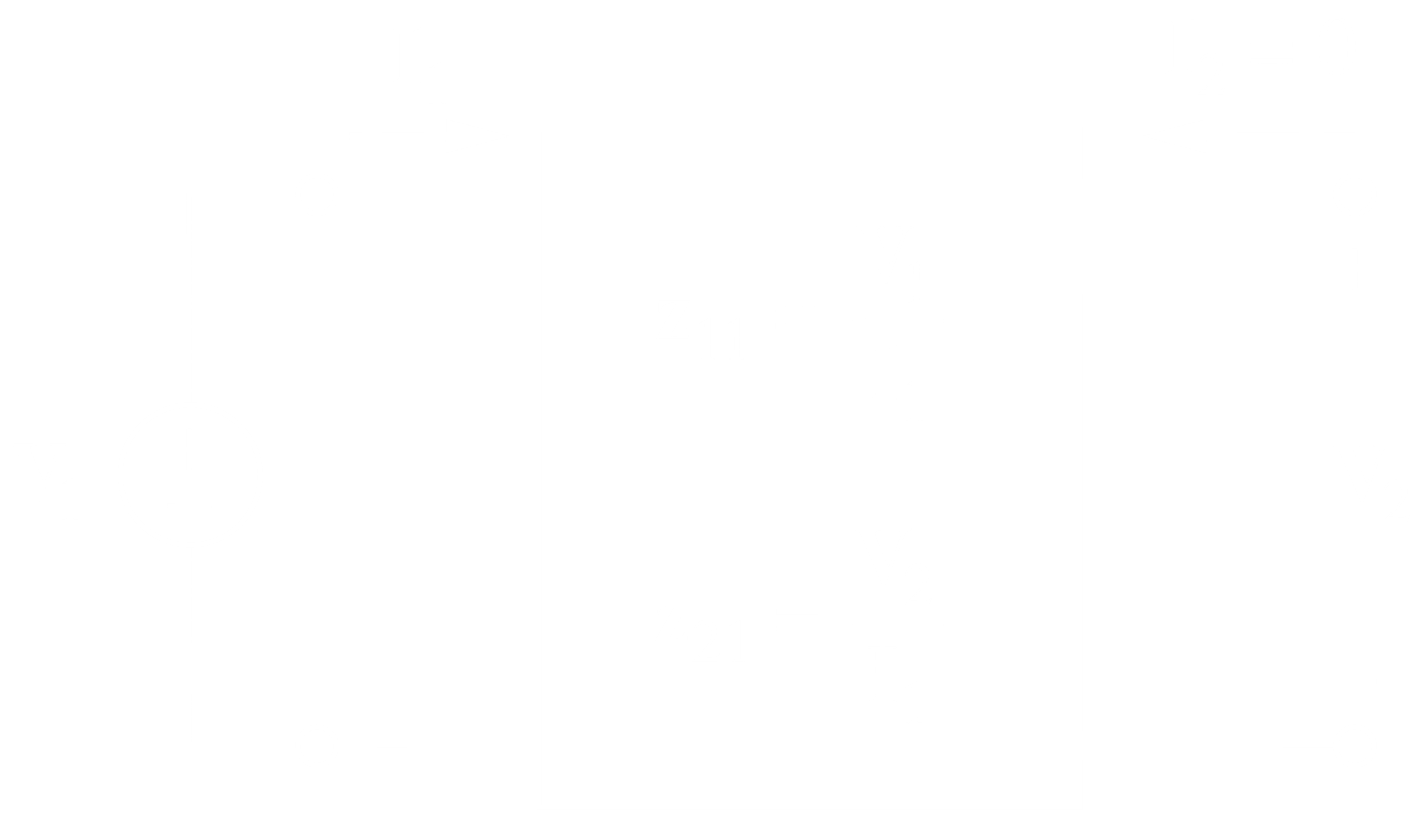
- open circuit input impedance

- open circuit transfer impedance from port to

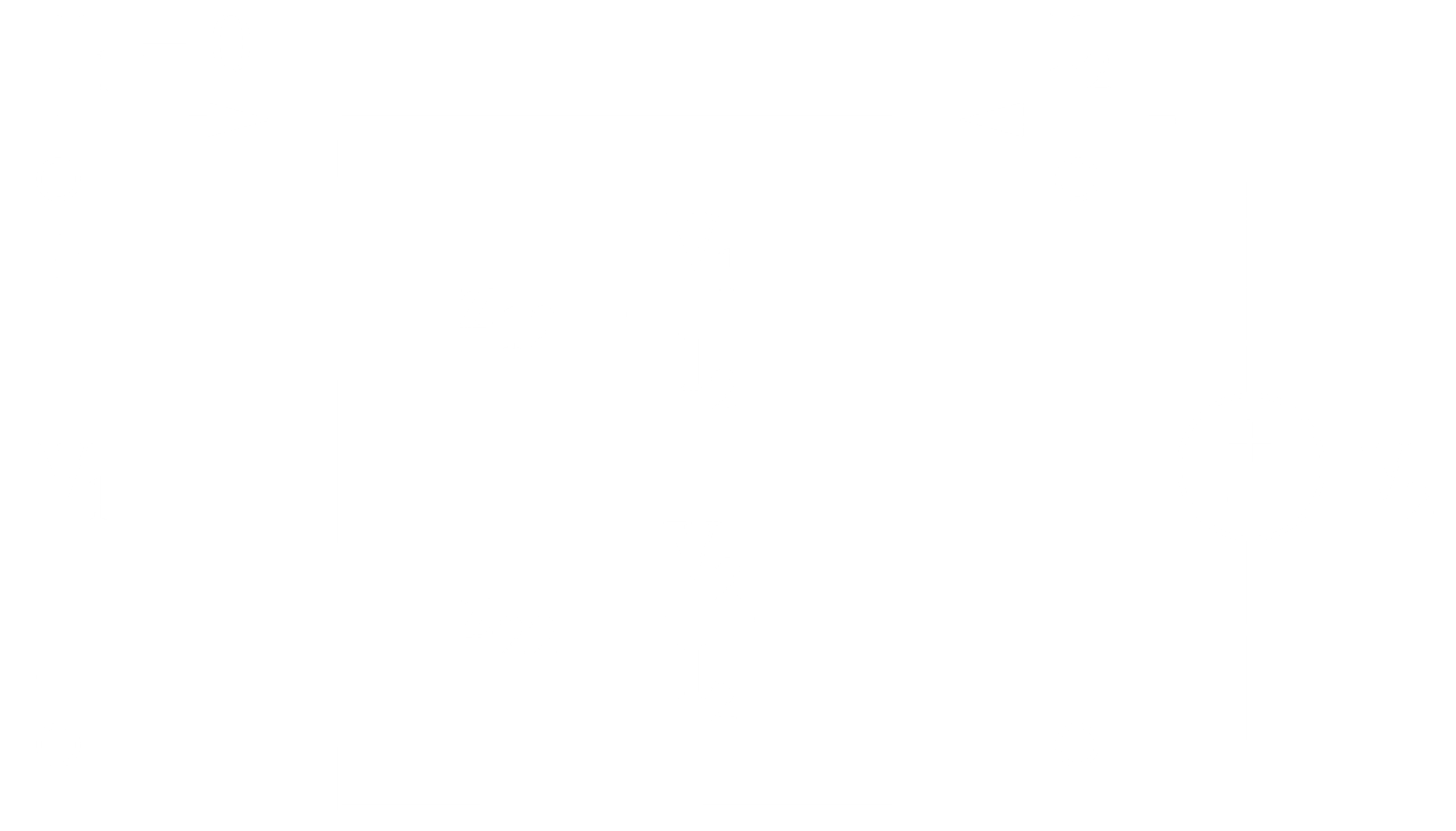
- open circuit transfer impedance from port to

- open circuit output impedance

What these equations mean is that we obtain and by connecting a voltage source or a current source to port 1, leaving port 2 open-circuited as shown below.

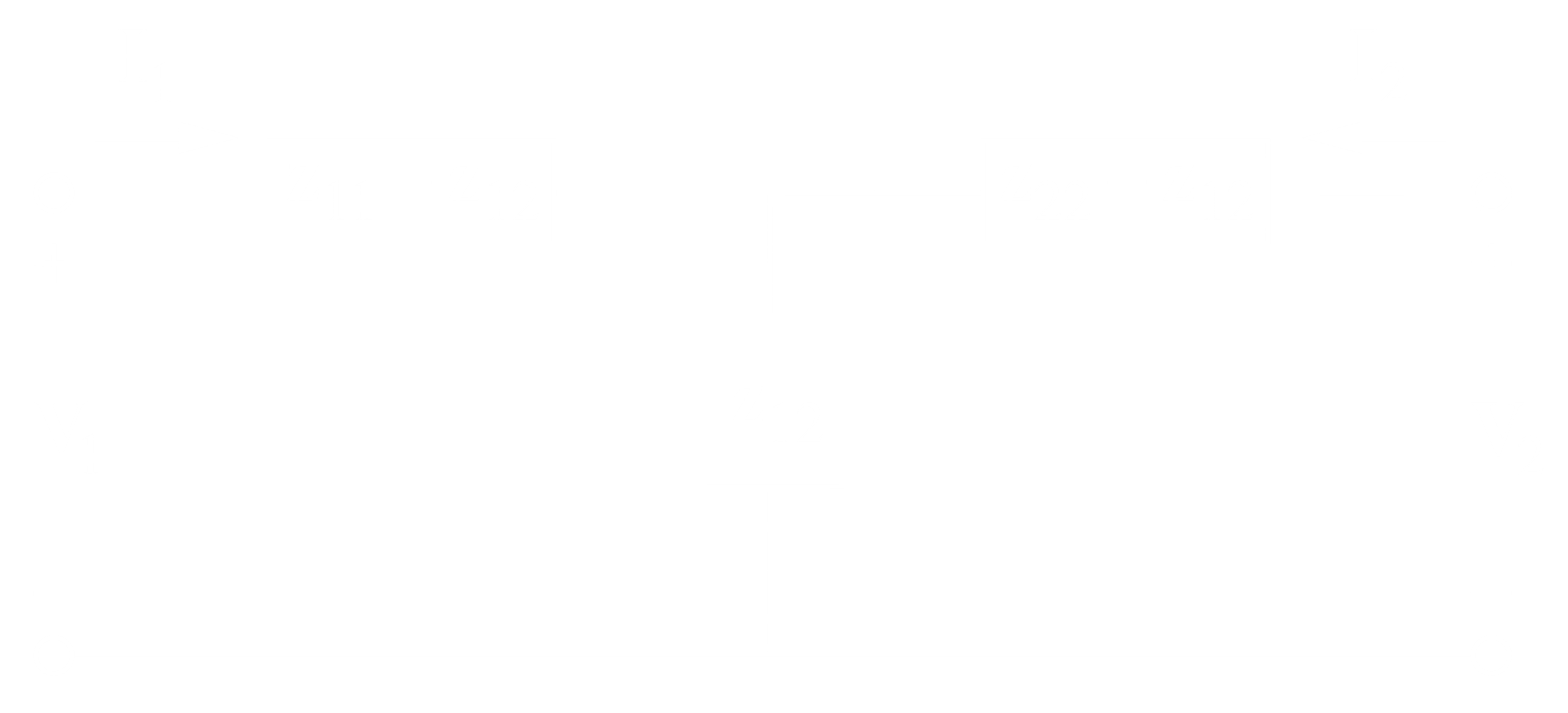


Similarly, we obtain and by connecting a voltage source or a current source to port 2, leaving port 1 open-circuited.

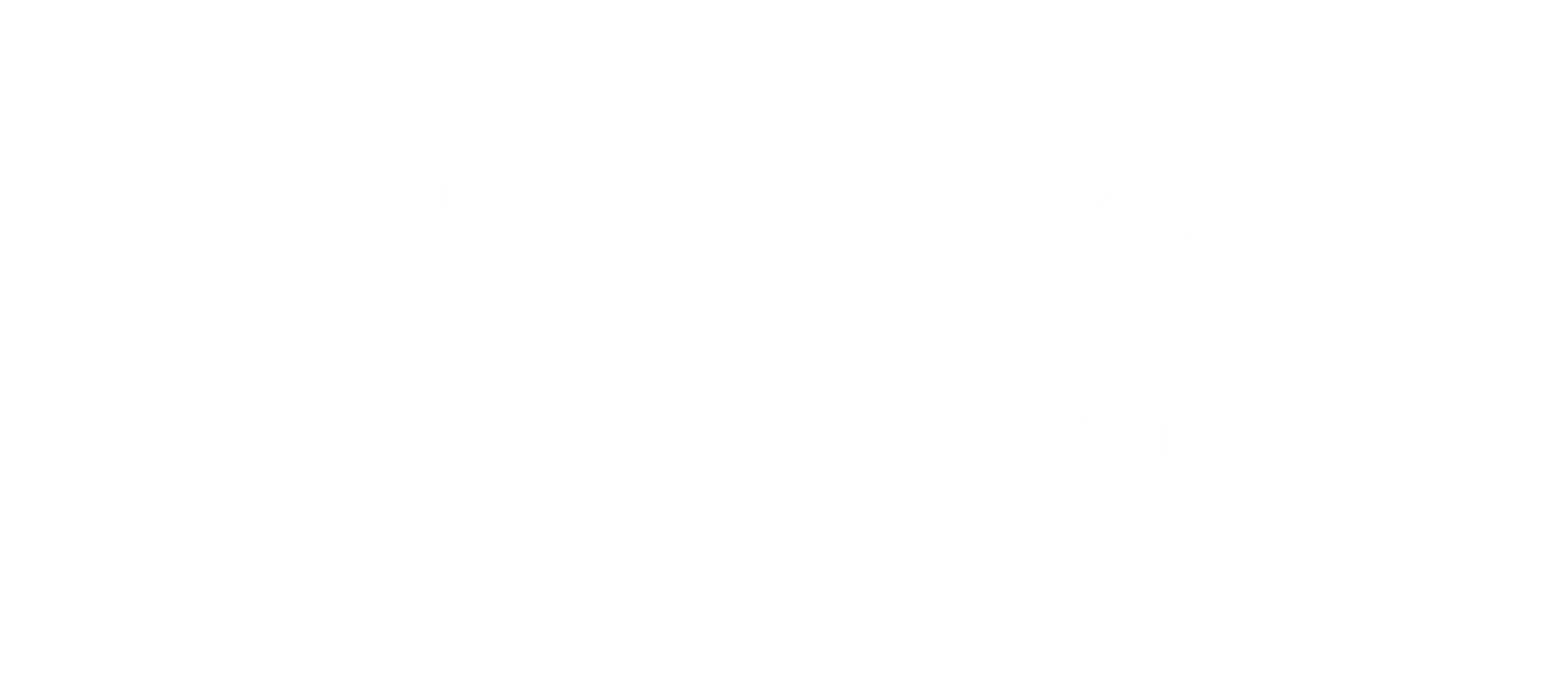


and are called driving point impedances. A driving point impedance is the input impedance of a one port device. Thus is the input driving point impedance with the output port open circuited, and is the output driving point impedance with the input port open circuited. When , the two-port network is said to be symmetrical. This means that the network can be divided along a line into two similar halves.

When the two-port network is linear and has no dependent sources, the transfer impedances and are equal and the network is said to be reciprocal. Any two-port network made entirely of resistors, capacitors and inductors must be reciprocal. A reciprocal network can be replaced with a T-equivalent network.

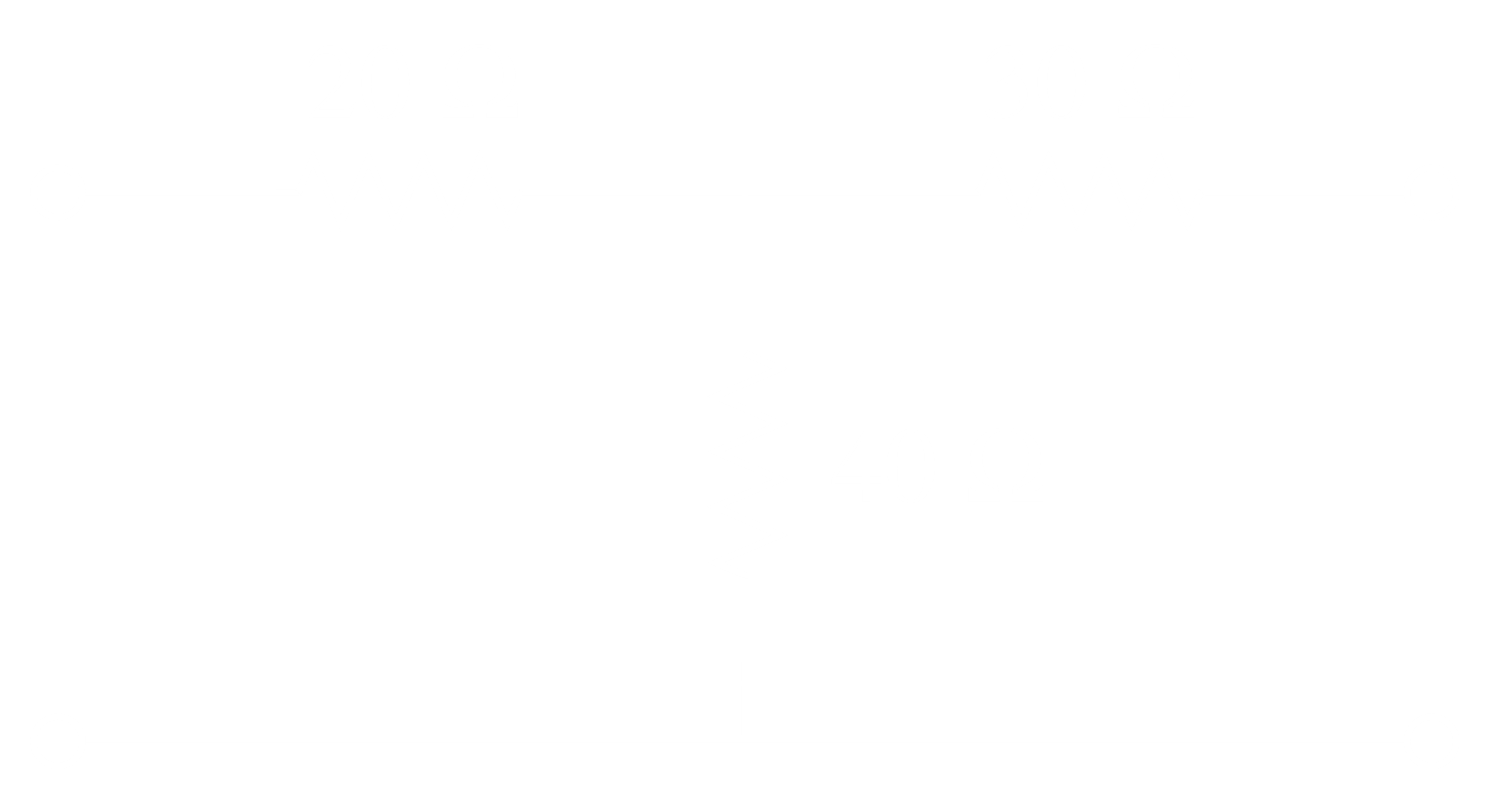


If the network is not reciprocal, the general equivalent network can be used.

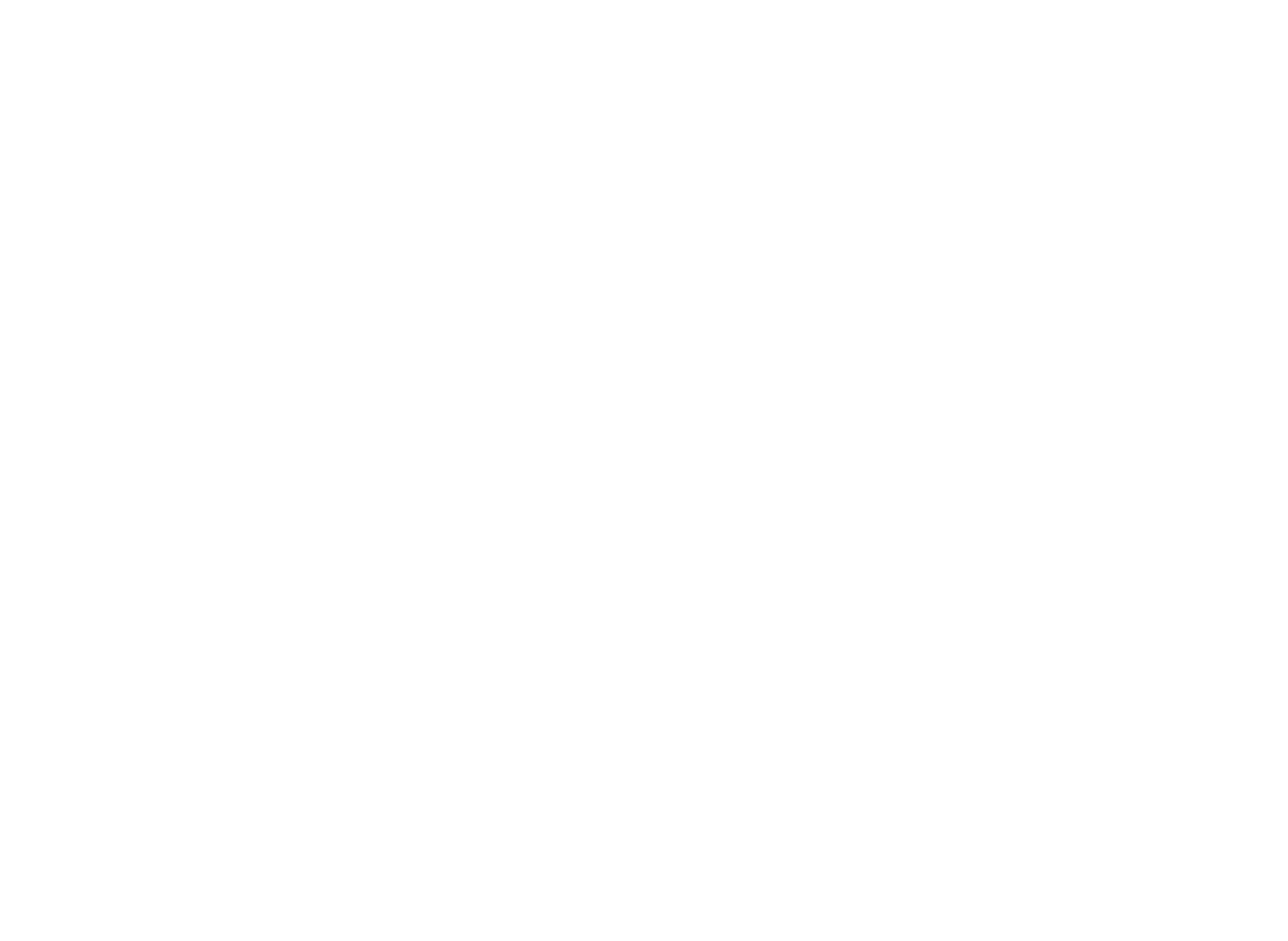


Example 19.1

Determine the parameters.

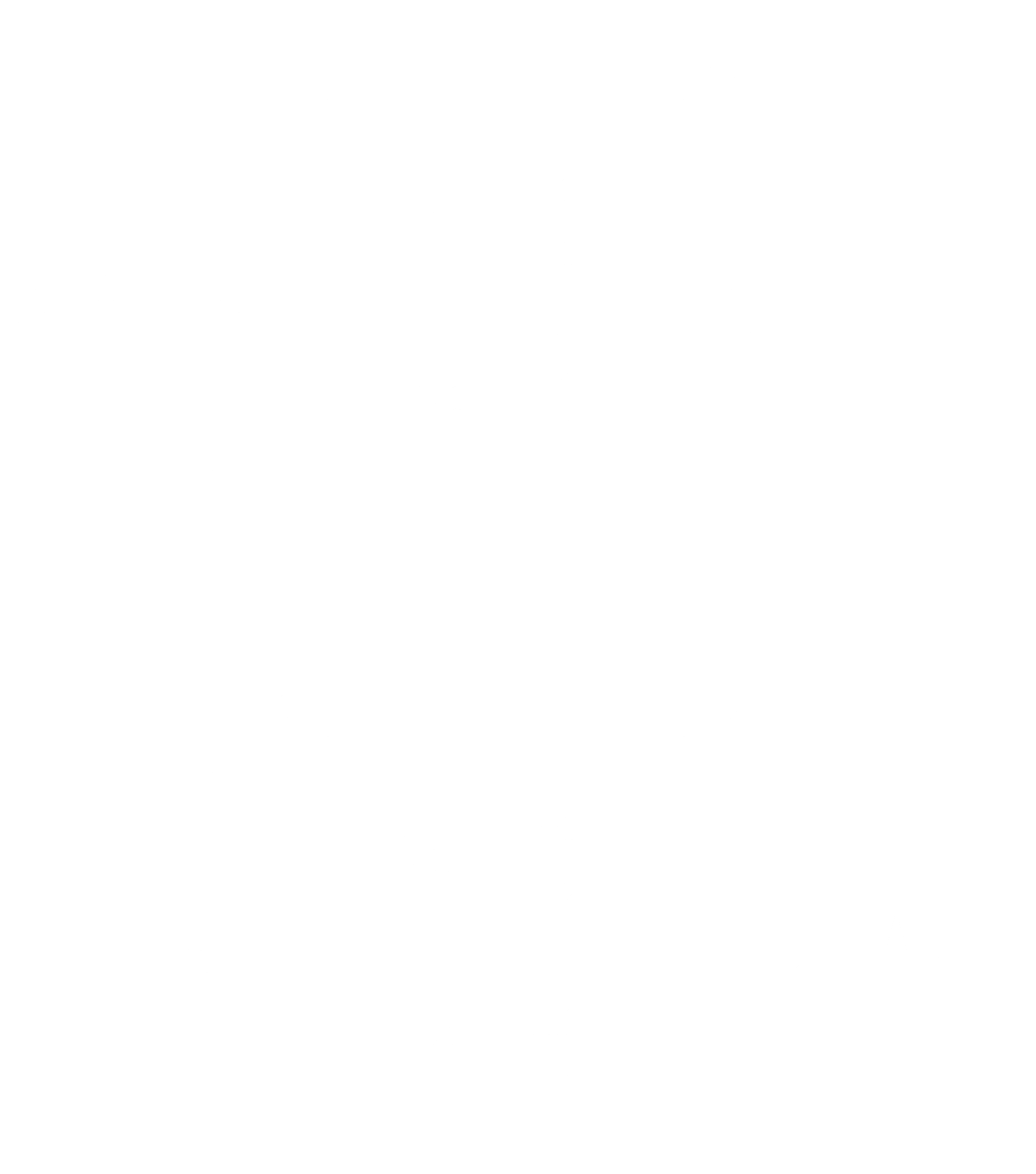


Practice Problem 19.1



## 19.3 Admittance Parameter

A circuit may not always have impedance parameters. In such a scenario, admittance parameters may be used to describe the circuit. The admittance parameters, or terms, are measured in siemens ().



The -terms can be obtained by either short circuiting the input port () or the output port ().

- short circuit input admittance

- short circuit transfer admittance from port to

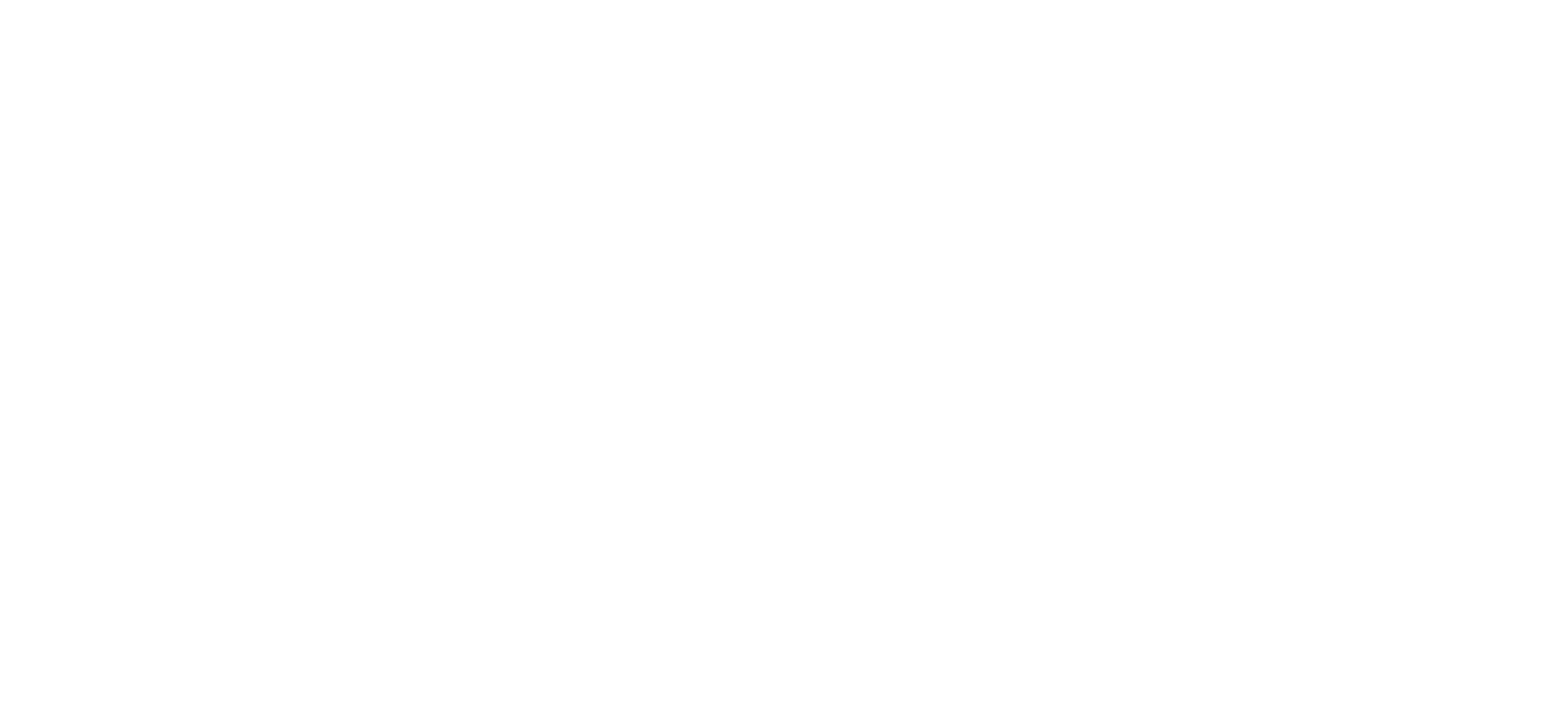
- short circuit transfer admittance from port to

- short circuit output admittance

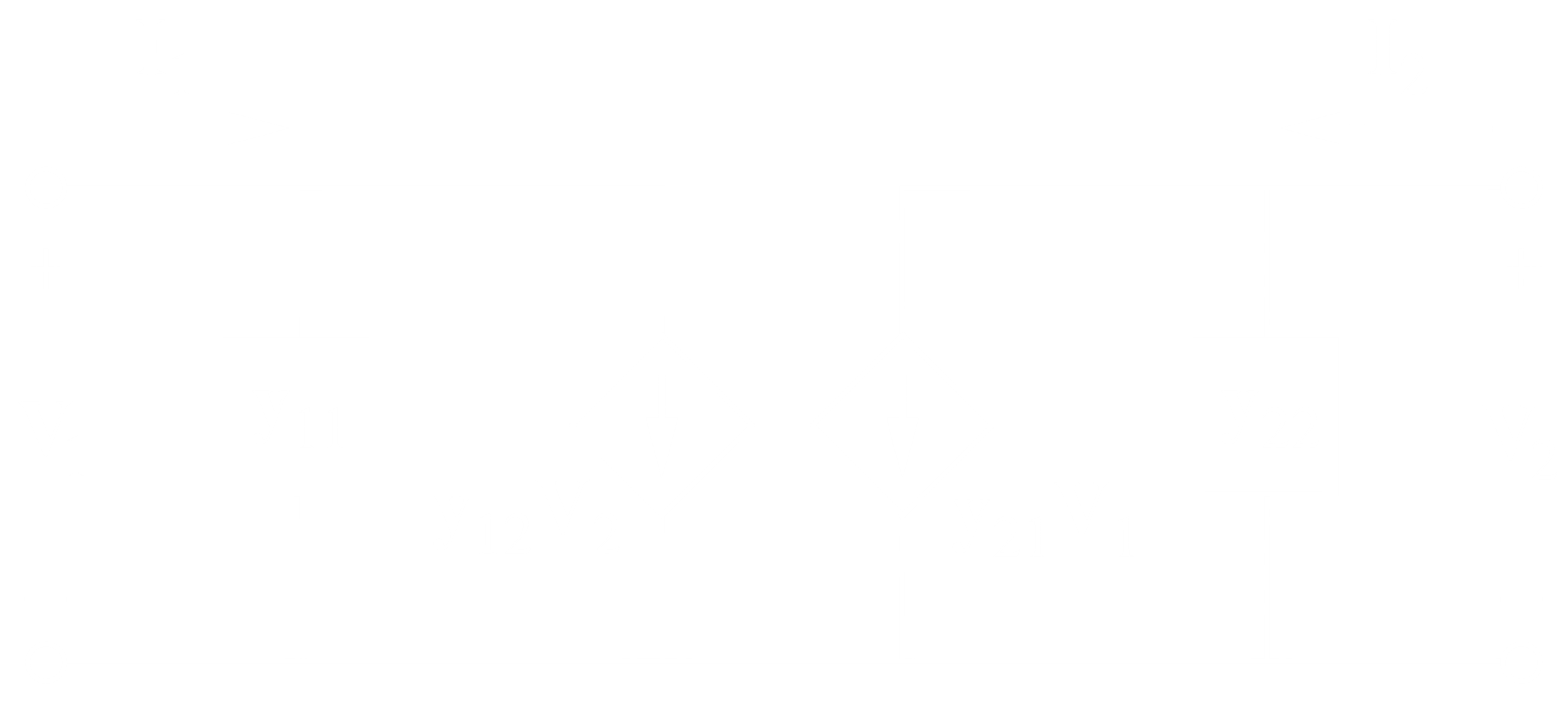
Thus, and are obtained by connecting a current source to port 1 and short circuiting port 2, and and are obtained by connecting a current source to port 2 and short-circuiting port 1.

The impedance and admittance parameters are collective called the immittance parameters.

For a linear two-port network with no dependent sources, the transfer admittances and are equal. Such a network is said to be a reciprocal network. A reciprocal network can be replaced with the -equivalent network shown below.



If the network is not reciprocal, the general equivalent network may be used.



Example 19.3



𝑥

This can be solved more easily -equivalent circuit.

## 19.4 Hybrid Parameters

The impedance and admittance parameters of a two-port network do not always exist. Thus, a third set of parameters must be made based on making and the dependent variables. Thus,

or

The -terms are known as hybrid parameters

- short circuit input impedance

- open circuit reverse voltage gain

- short circuit forward current gain

- open circuit output admittance

Hybrid parameters are found in a similar manner. A voltage or current source is applied to the appropriate port, while the other port is either open-circuited or short-circuited depending on the parameter of interest.

For reciprocal networks, .

Alternatively, the inverse hybrid parameters, or parameters can be used.

or

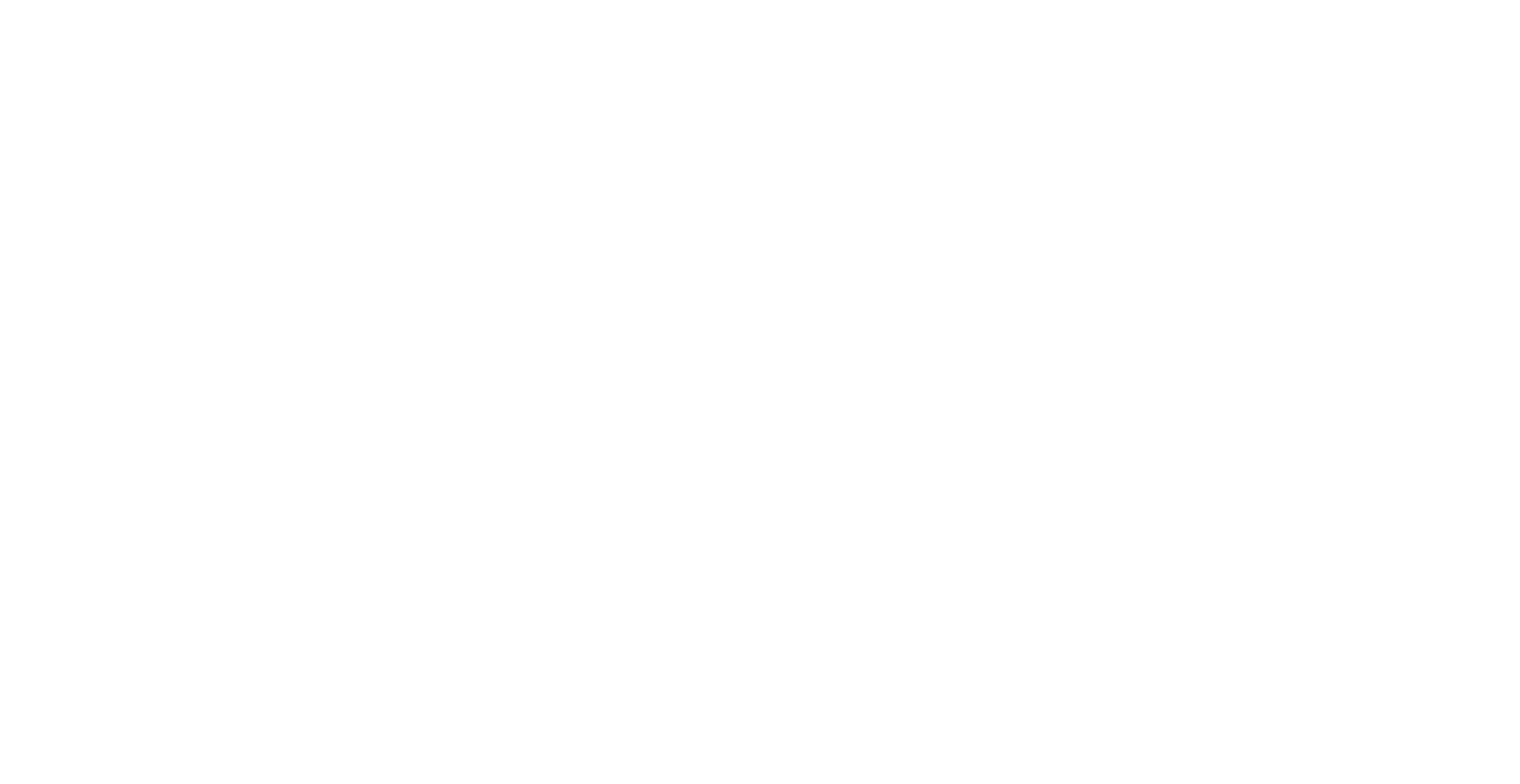
- open circuit input admittance

- short circuit reverse current gain

- open circuit forward voltage gain

- short circuit output impedance

Example 19.5



Find the hybrid parameters.

## 19.5 Transmission Parameters

Transmission parameters express sending-end variables in terms of receiving-end variables (thus the name). They are also called parameters.

Thus,

where is the open circuit voltage ratio

is the negative short circuit transfer impedance (in ohms)

is the open circuit transfer admittance (in siemens)

is the negative short circuit current ratio

Inverse Transmission Parameters

The inverse transmission parameters, or parameters, express the variables at the output port in terms of the variables at the input port. Thus, they are given by:

where is the open circuit voltage gain

is the negative short circuit transfer impedance (in ohms)

is the open circuit transfer admittance (in siemens)

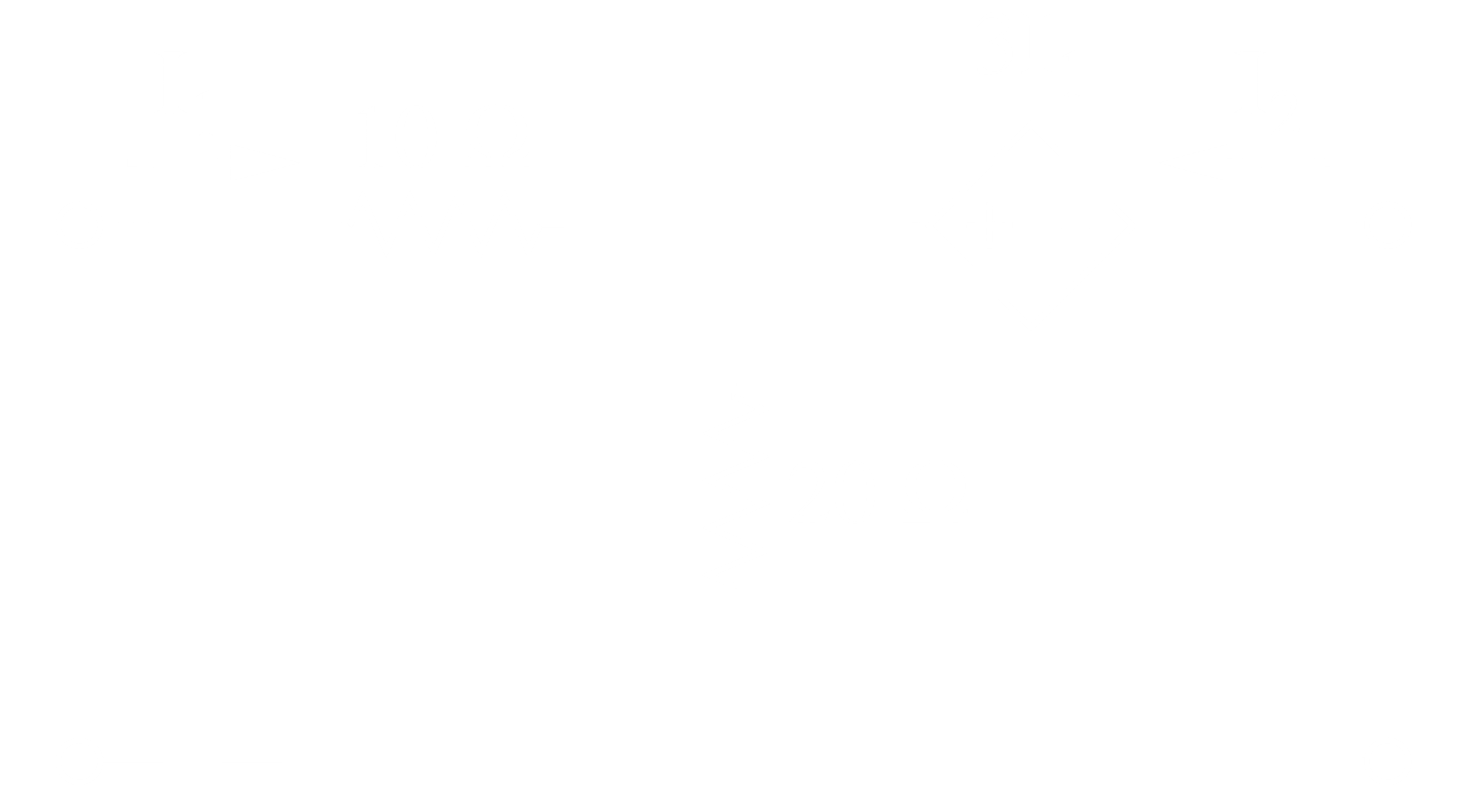
is the negative short circuit current gain

For a reciprocal network,

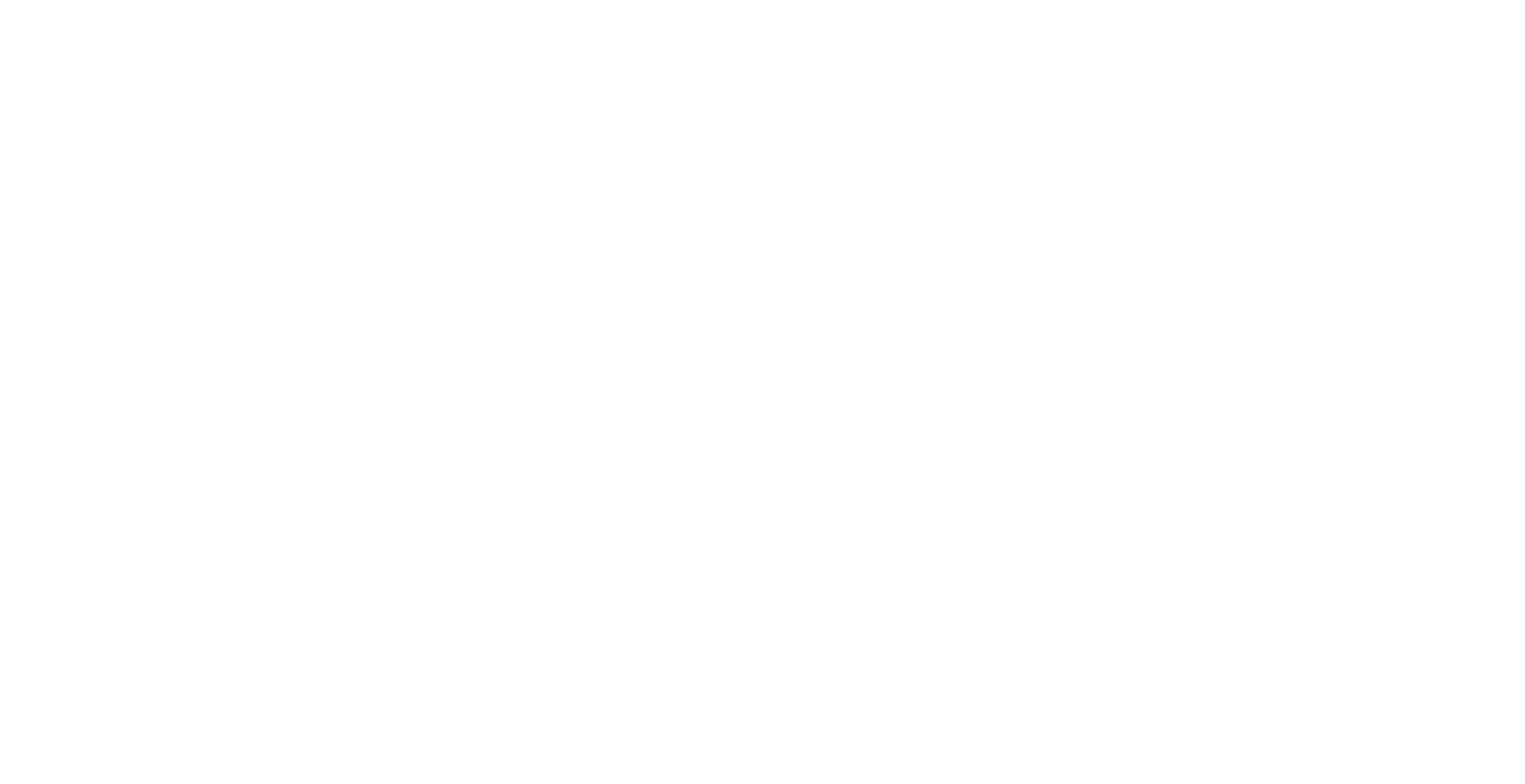
and

Example 19.8

Find the transmission parameters.



For ,



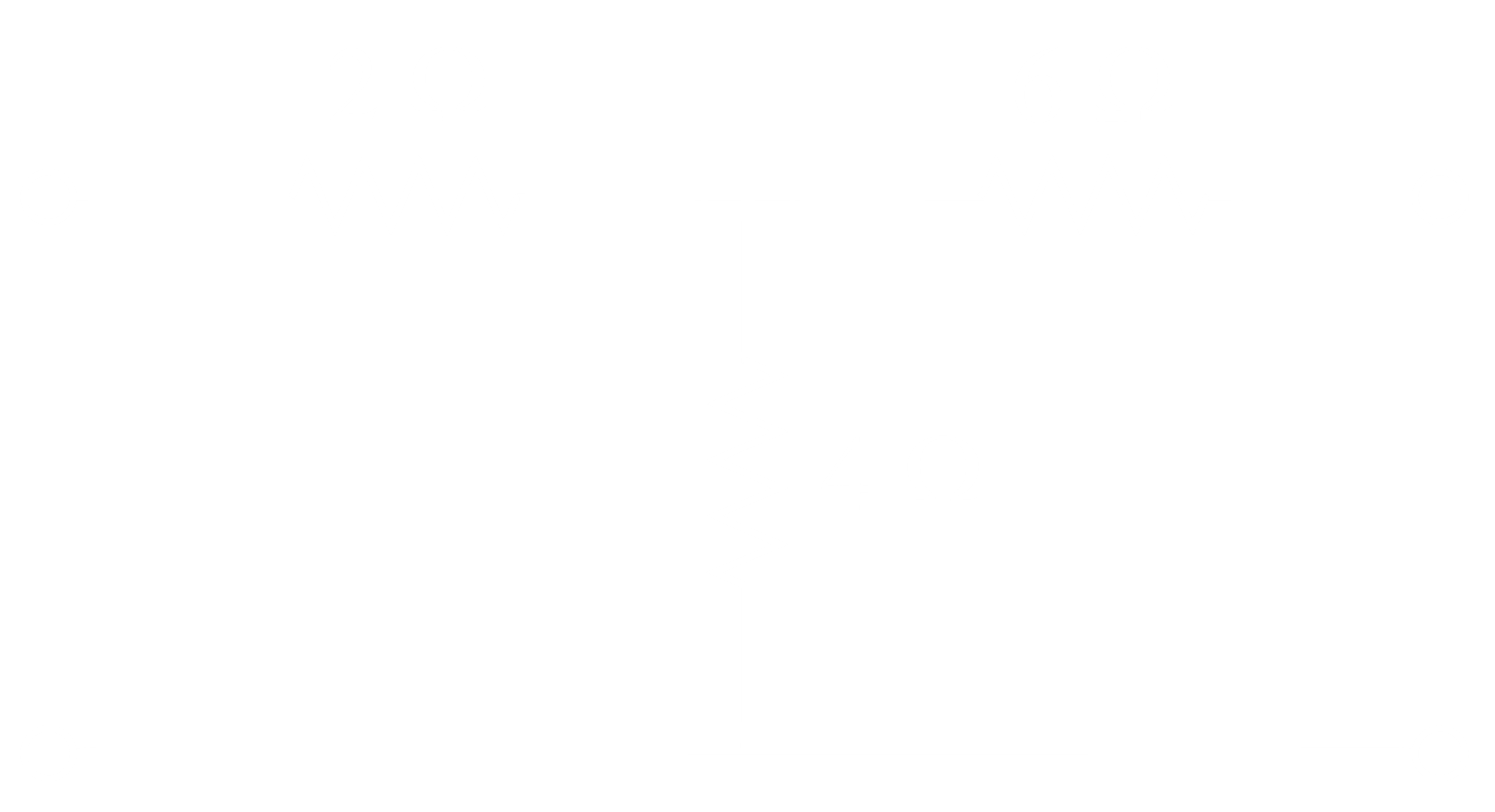
For ,



At the node ,

Thus,

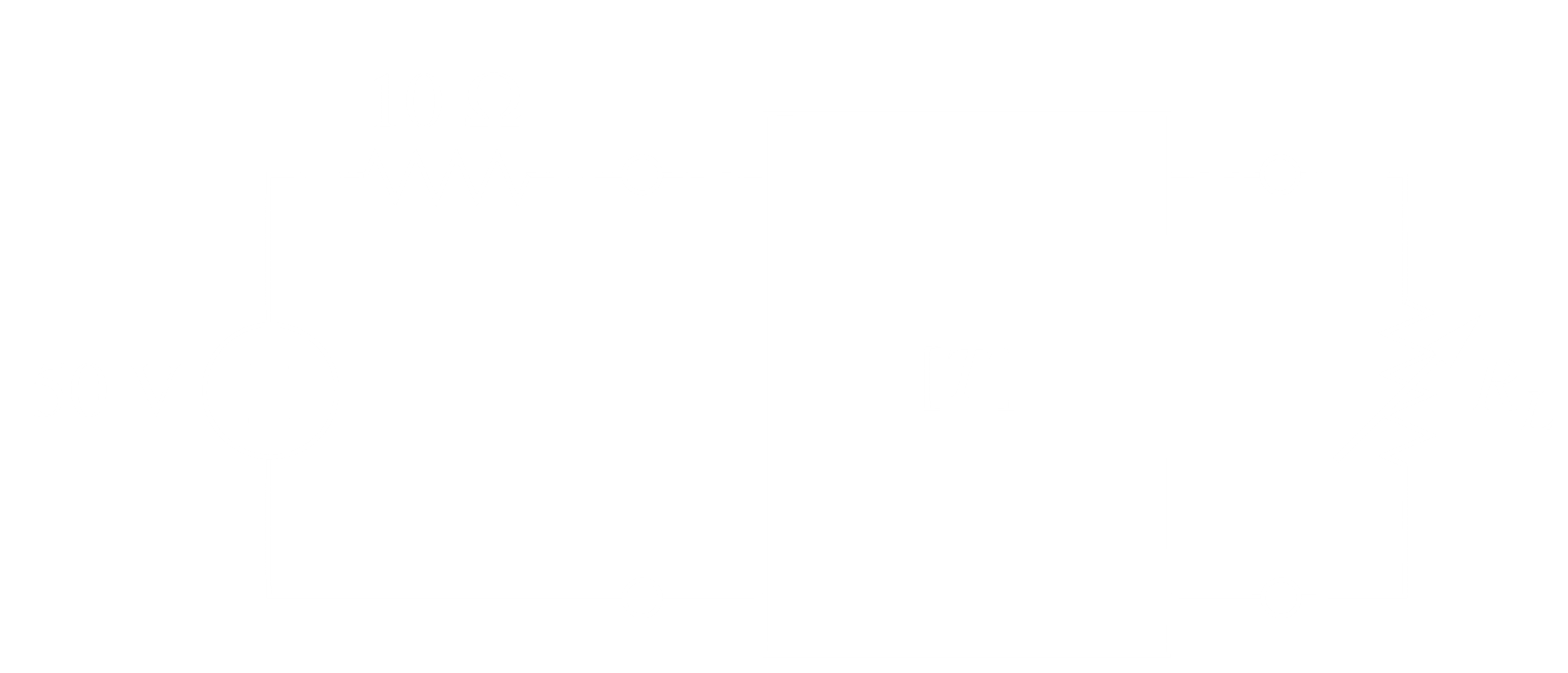
Practice Problem 19.8



For ,

For ,

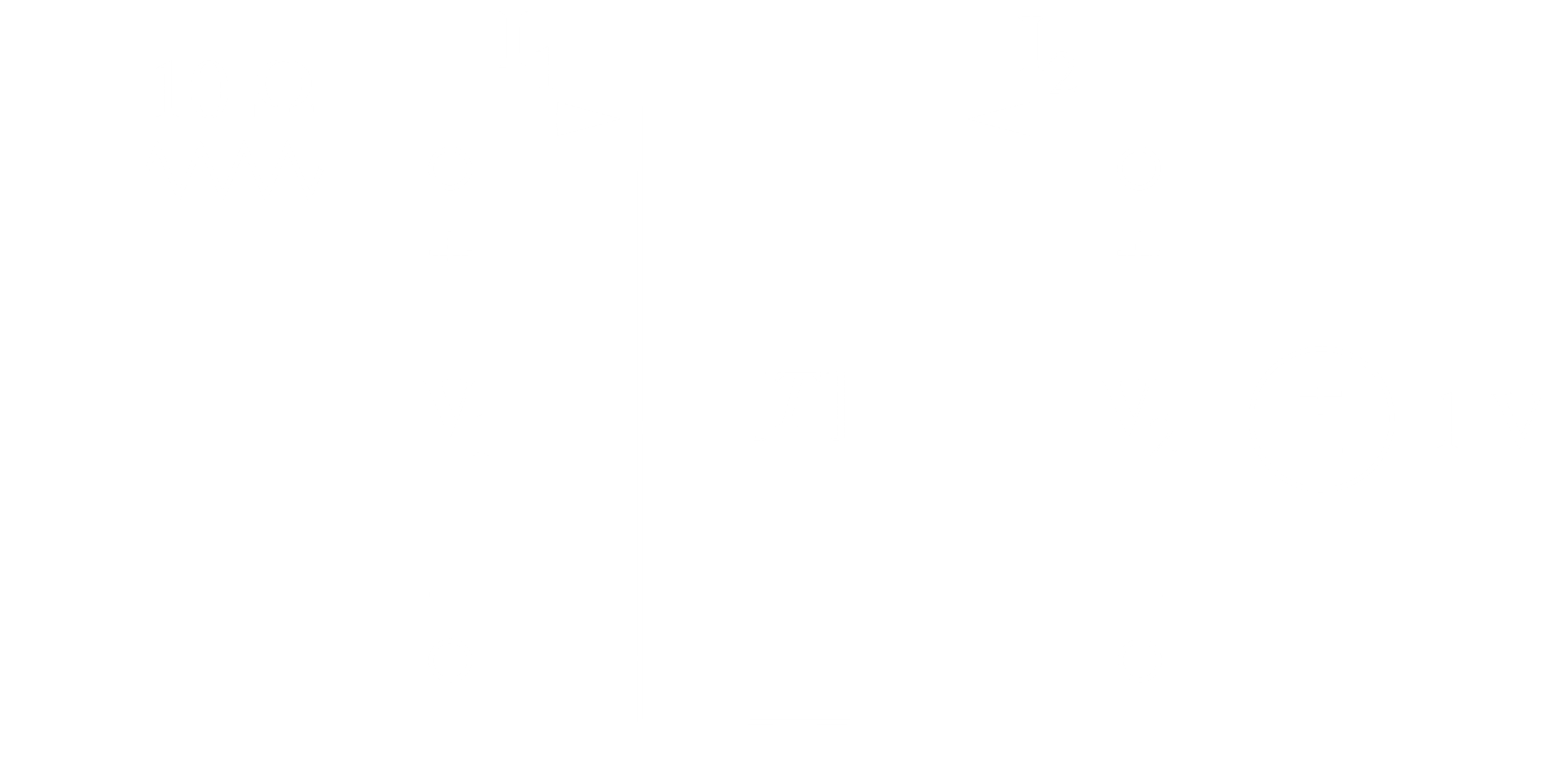
Example 19.9



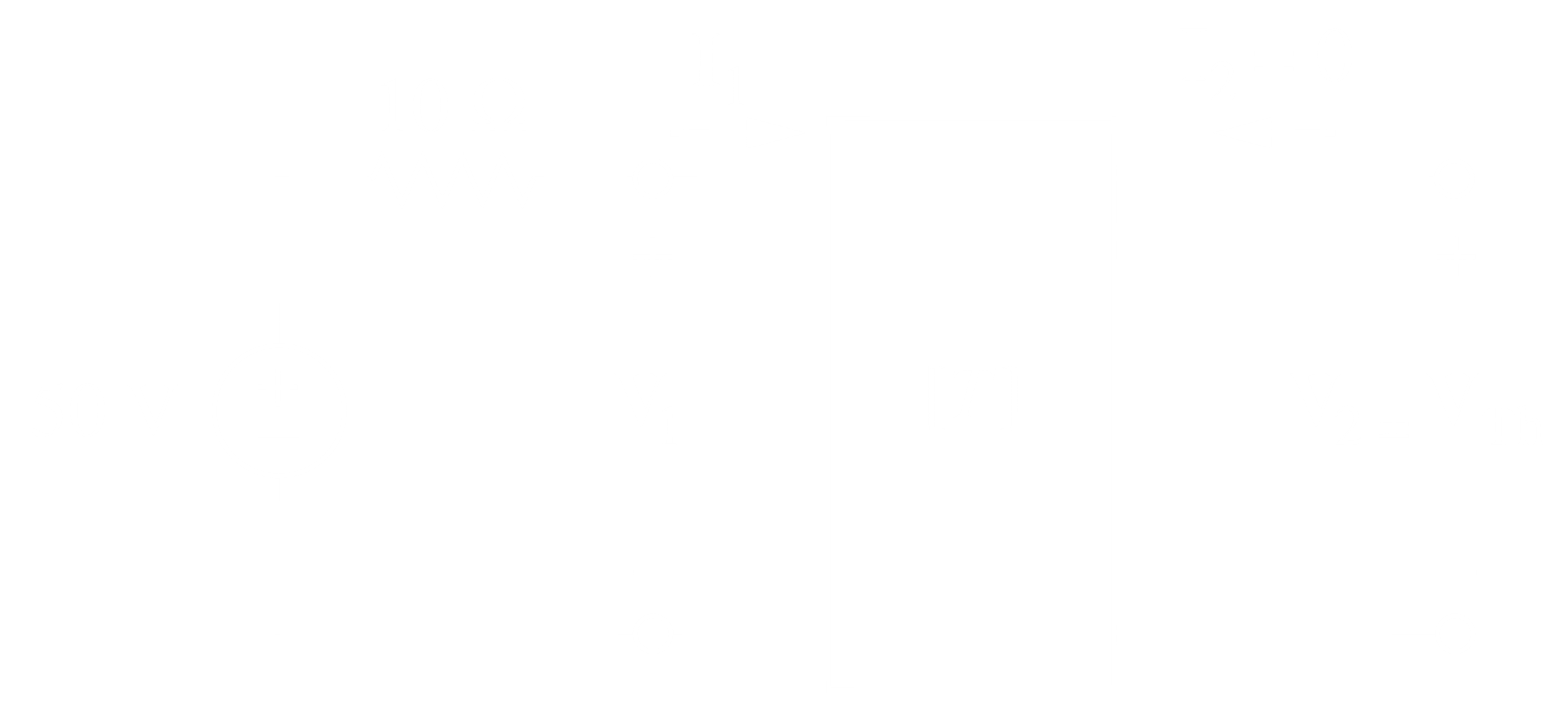
The parameters are:

Find and the maximum power transferred.

First, we remove the independent voltage source and add a voltage source at .

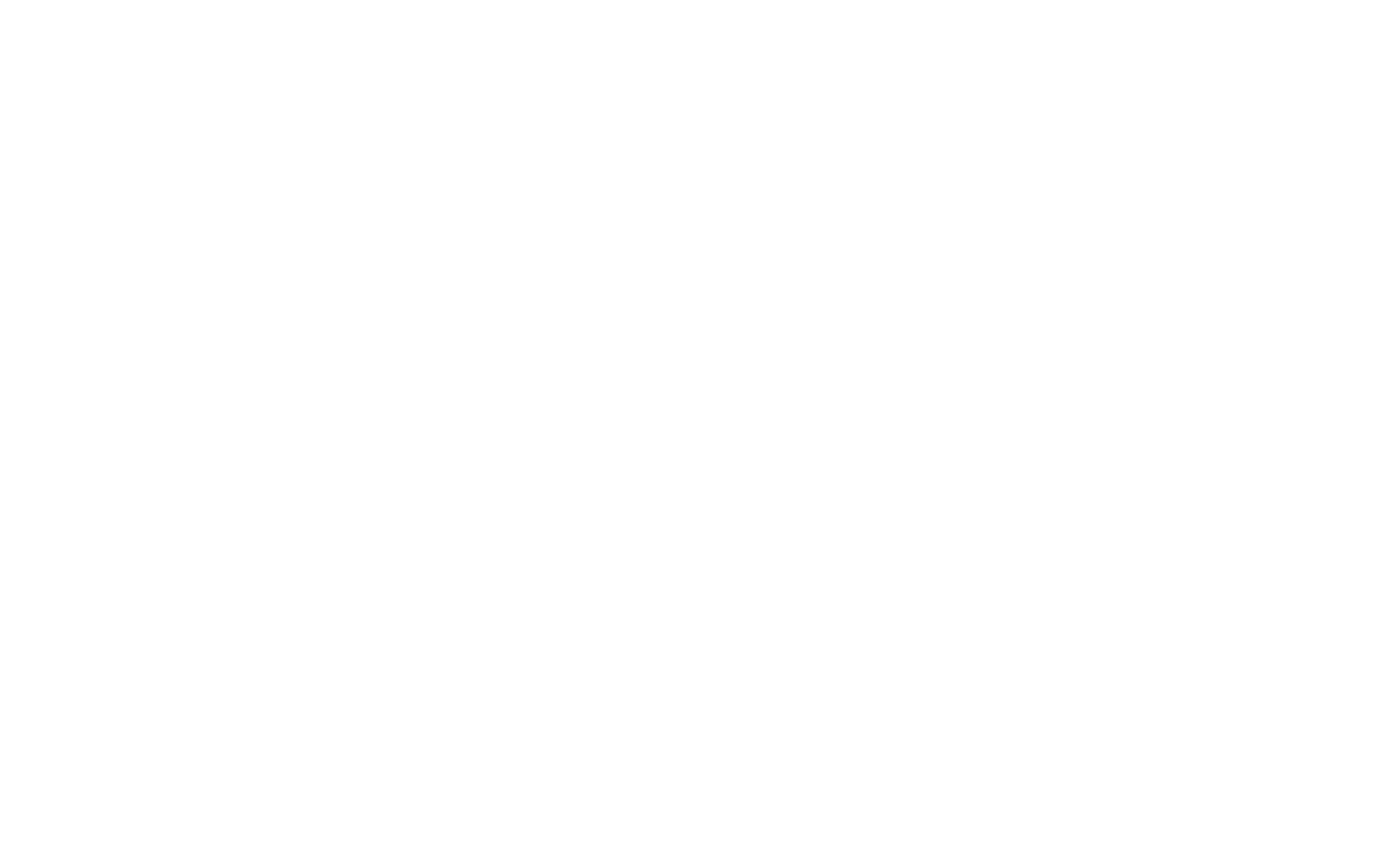


Next, we consider the open circuit voltage at .

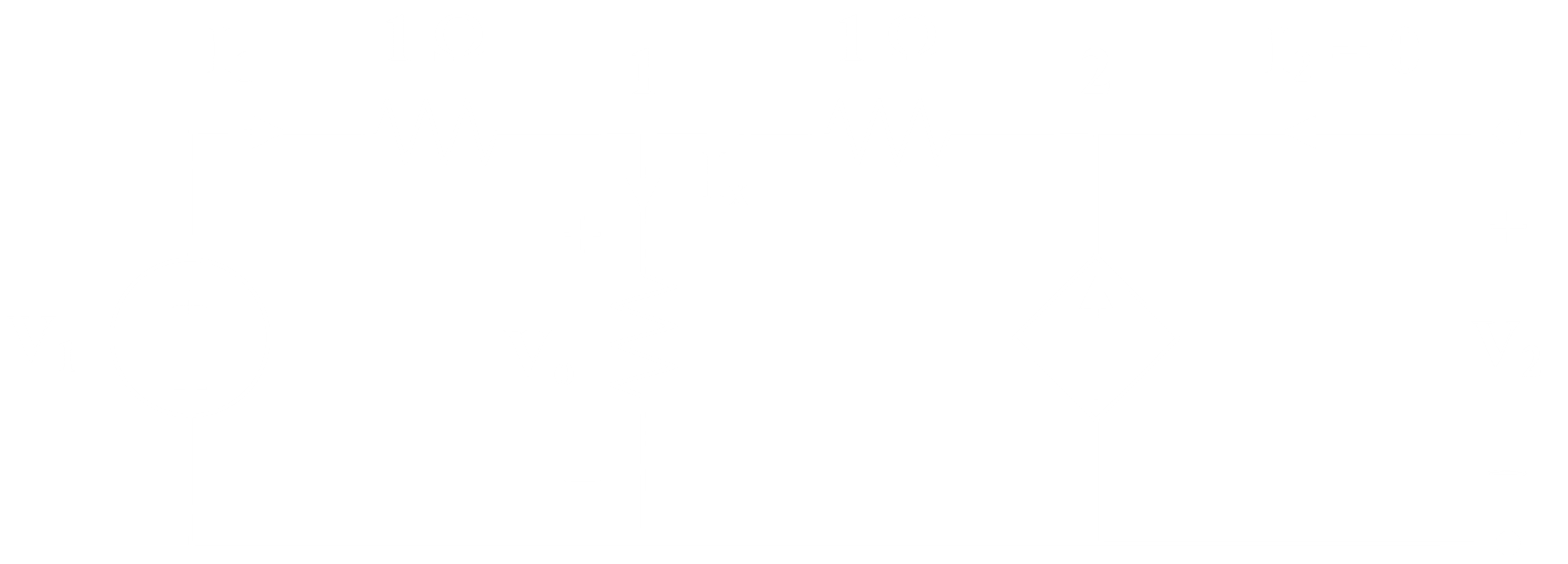


For a purely resistive load,

Exercise 19.46



For ,



For ,

