What is the Voltage Divider Basic and Rule?

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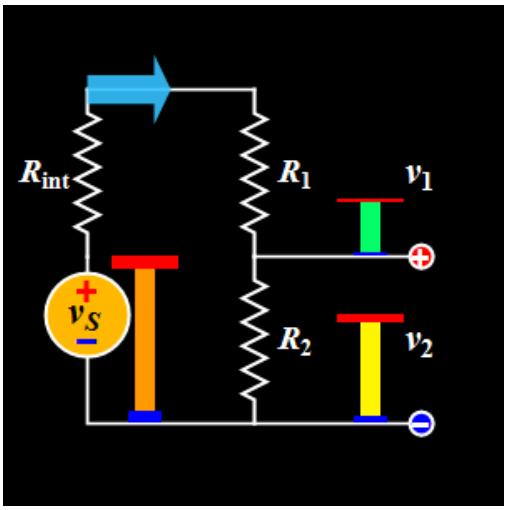
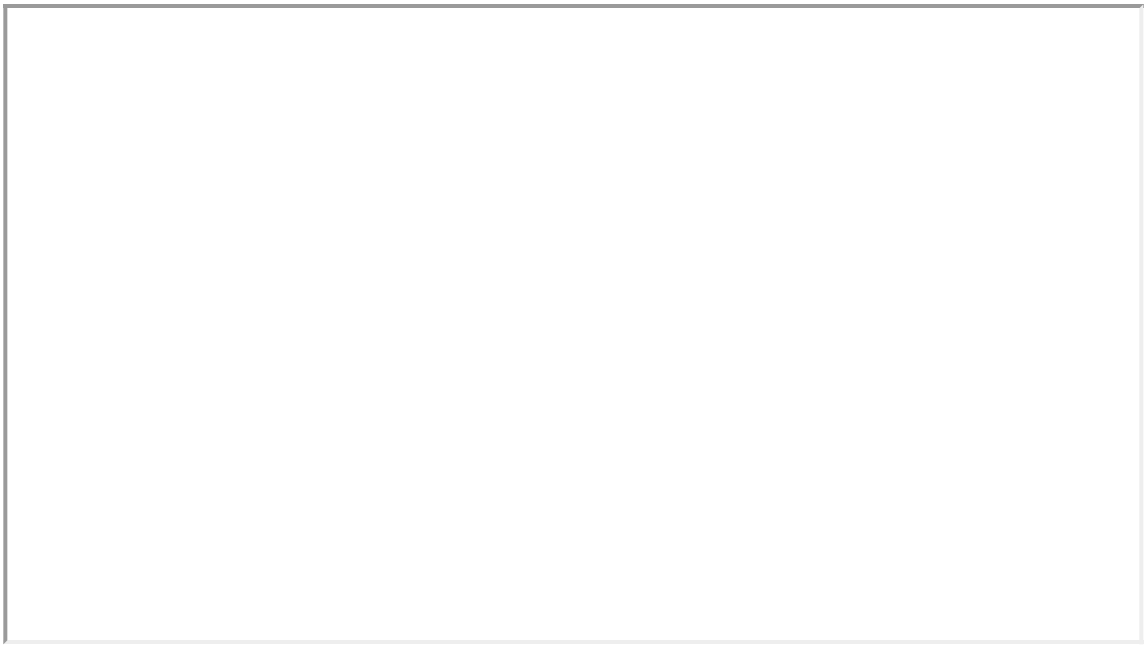


Introduction

A voltage divider is a passive linear circuit used to create a voltage less than or equal to the input voltage. It is a conversion device composed of a high-voltage arm and a low-voltage arm. The measured high voltage acts on the device, and the output voltage is got from the low voltage arm. The components of the high and low voltage arms are usually resistors and capacitors. The corresponding devices are called resistor dividers, capacitor dividers, and resistance-capacitance voltage divider. Voltage dividers are one of the most fundamental circuits in electronics.



What are Voltage Dividers, and How Do They Work?

Catalog

I Overview of Voltage Divider

1.1 Voltage Divider Structure

The voltage divider is a special instrument for on-site measurement, measuring DC high voltage and AC high voltage. The voltage divider adopts a balanced equipotential shielding structure, and high-quality electronic components are used inside the body. So that it has the characteristics of accurate test, good linearity, stable performance, reasonable structure, easy to carry, simple operation, intuitive display, etc.

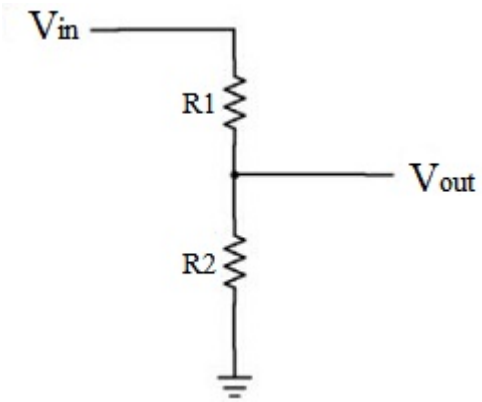


Figure 1. Voltage Divider Circuit

1.2 Voltage Divider Circuit

Voltage usually contains two important terms: electromotive force (EMF) and potential difference (PD). When something provides a voltage, such as a battery, it provides the force required to pull electrons along the circuit because of emf. When a component consumes the voltage in the circuit, the amount of voltage drop on it called potential difference. Some rules about voltage can help circuit design, including:

1) Series voltages accumulate.

2) The parallel voltage is always the same.

3) The PD in the component is proportional to its resistance.

4) Polarity is decisive.

5) Sum EMF around the circuit is equal to the sum of PD.

The rule that voltages in series always accumulate affects both EMF and PD. If the batteries are connected in series, their voltages will add up. If there are series-connected components, then you can apply this rule, whose combined PD is the output voltage. Although it is easy to identify potential differences, make sure to pay close attention to the polarity of the power source. Because the battery reverses minus the combined voltage.

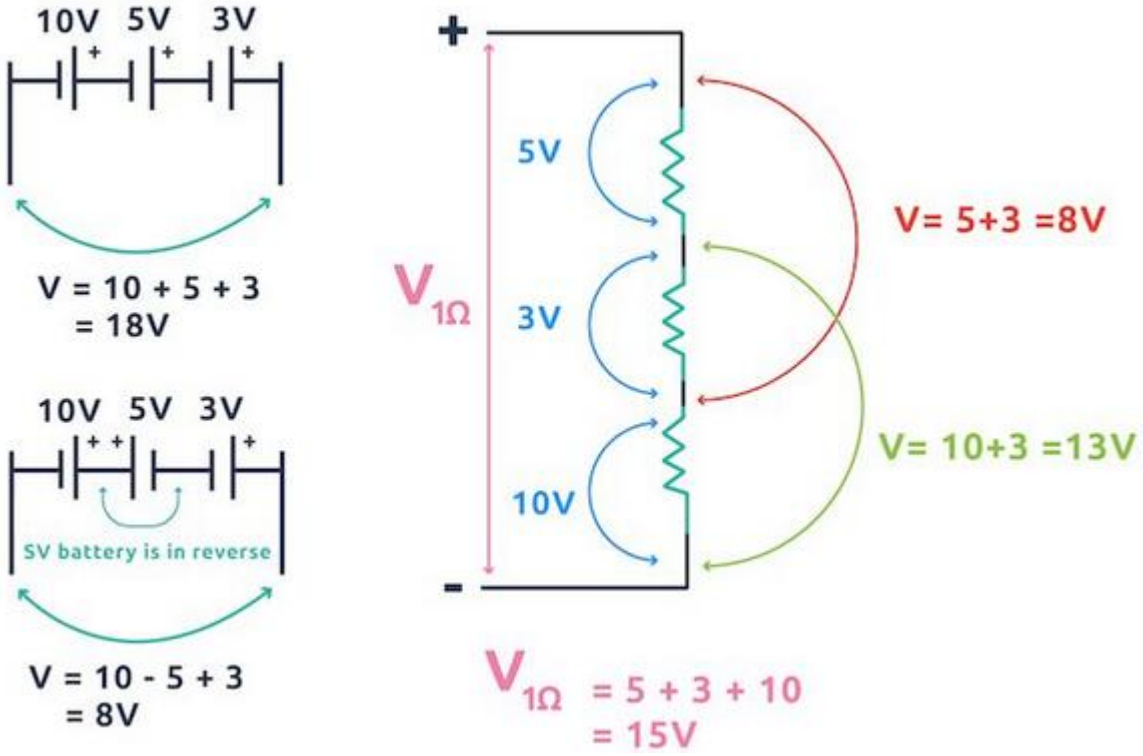


Figure 2. An Example of a Series of Voltages Added Up

Parallel voltages are always the same. It is one of the reasons why it is not a good idea to connect batteries in parallel with different voltages. For example, when two batteries with different voltages are connected in parallel, the battery with the larger voltage will try to charge the smaller battery, which may damage it.

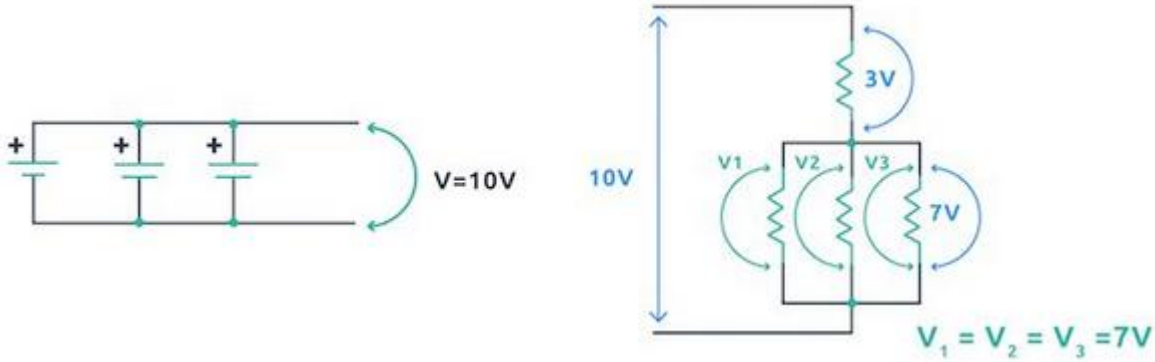


Figure 3. An Example of Parallel Voltage Circuit

We have known that the series voltages add up and the voltages in parallel are the same. There are also some questions. How does the voltage separate between the elements in the series circuit? What determines the voltage of each component? The voltage division (called potential difference) is determined by the ratio of the

resistance of the element to the resistance of the series circuit. This is directly related to the voltage rule: The value of the PD on the component is proportional to its resistance.
Basically, this means that the greater the resistance of the component (compared to the series circuit), the greater its potential difference. In fact, the voltage on the component is equal to

$$V = V_{EMF} * \frac{R_{component}}{R_{series\ total}}$$

When considering the classic divider circuit, the formula is usually written as $V_{OUT} = V_{in} \frac{R_1}{R_1+R_2}$

The following is a typical voltage divider circuit with approximately 3.3V from a 5V power supply:
(This circuit can be used to connect a 5V output device to the 3.3V input on the microcontroller, such as particle photon.)

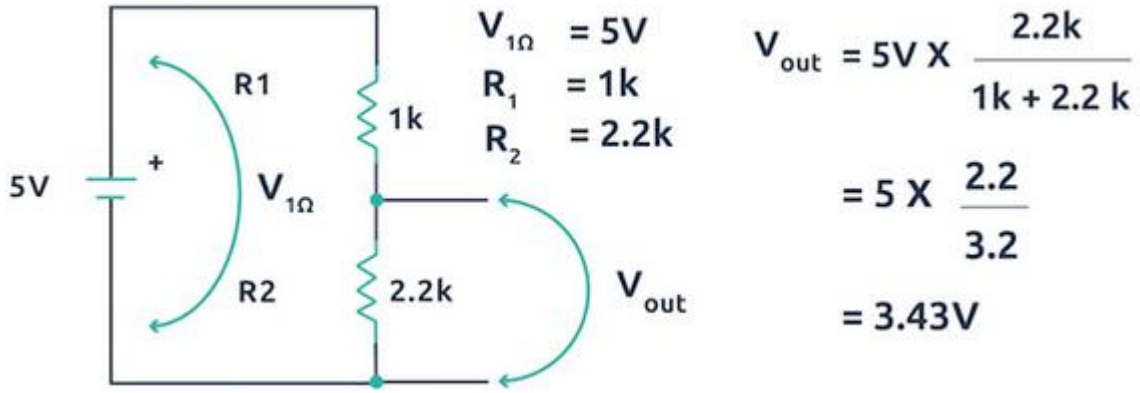


Figure 4. An Example of a Classic Voltage Divider Circuit

When a voltage (EMF) is applied to the circuit, the sum of all potential differences on the series elements will equal the EMF. For example, the voltage provided by the battery will be divided among the components connected in series, and the sum of all these divided voltages will be equal to the voltage of the battery.

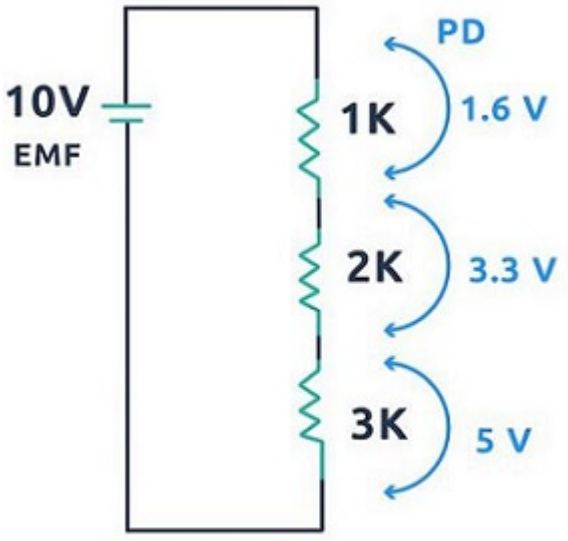


Figure 5. Series Voltage Circuit

II Types of Voltage Divider

1. According to the application

a) For laboratory

b) For power system

2. According to the measured voltage

a) AC voltage divider

There are two types: resistive type and capacitive type. The resistive type is composed of non-inductive resistance elements suitable for measuring AC voltages with low frequency. The capacitive type is composed of capacitive elements. It basically does not consume power and can be used for higher voltage measurement. The measurement voltage ranges from thousands of volts to millions of volts. So it has a wide rang applications.

b) Impulse voltage divider

Impulse voltage is a non-periodic pulse voltage with fast changes and many harmonic components. To accurately measure its waveform and amplitude, the impulse divider is required to have good response characteristics. There are three types: resistive, capacitive, and resistance-capacitance.

c) DC voltage divider

It is composed of two (groups) resistance elements, and a high-impedance voltmeter is usually used to measure the voltage on the low-voltage arm.

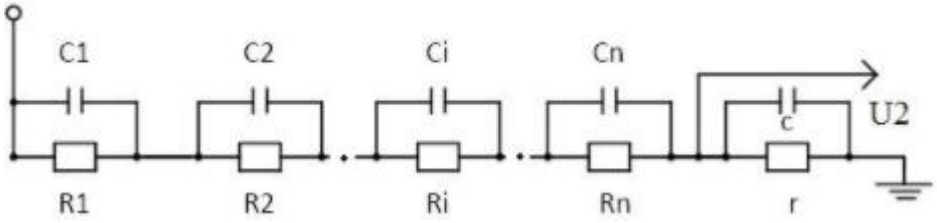


Figure 6. High-voltage Divider

3. According to the principle of voltage divider

a) Capacitor divider

The capacitor divider used to measure the pulse voltage can be divided into two types. One's high-voltage arm of a voltage divider is composed of multiple high-voltage capacitors stacked, and the high-voltage arm of the other voltage divider has only one capacitor.

The former voltage divider is mostly assembled with an oil-paper-insulated pulse capacitor with an insulating shell, which requires that the inductance of this capacitor is relatively small and can withstand short circuit discharge. A high-voltage oil-paper capacitor is assembled by multiple components in series and parallel. Each component not only has capacitance, but also has inherent inductance and contact resistance in series, as well as parallel insulation resistance. Of course, each component has stray capacitance to ground. This kind of voltage divider should be regarded as a distributed parameter, so it is called a distributed capacitor divider.

The distributed capacitor divider is formed by stacking multiple pulse capacitors, with only amplitude error and no waveform error. As for the amplitude error, it can be completely eliminated after calibration with a standard voltage divider. However, when measuring steep waves, since the capacitance of the capacitor divider is much larger than the stray capacitance of the shielding ring of voltage divider, the response time is also much longer. So in terms of measuring steep waves, the response characteristics of the capacitor voltage divider are not as good as the shielded resistor divider. The single-capacitor divider does not consume energy and has no trouble of heating. For measuring waves with a longer wavefront and half-peak time, a capacitor divider is better than a resistor divider. In addition, the capacitor divider can also be used as a load capacitor for adjusting the waveform.

The high-voltage arm of the centralized capacitor divider can use a standard capacitor charged with compressed gas. The capacitance value of this capacitor is very accurate and stable, and the dielectric loss is small. Because it is shielded, the capacitance value is not affected by surrounding objects. In power frequency measurement, it has been used very commonly. However, when it is used as an impact capacitor voltage divider, some problems will occur. That is, superimposed high-frequency oscillation.

b) Resistor divider

Its internal resistance is pure resistance, with characteristics of simple structure, easy to use, good stability, etc. The error generated by it when measuring the transient pulse voltage is related to the product of the resistance value and the stray capacitance to the ground, so the size and impact of the stray capacitance to the ground should be minimized, and the resistor divider should reduce inductance.

c) Resistance-capacitance divider

The resistance-capacitance voltage divider can be divided into a series-type voltage divider and a parallel-type voltage divider according to the connection mode.

The resistor-capacitor series voltage divider is also called the damping capacitor voltage divider. Recently, the high-voltage divider belongs to this type. It overcomes the residual inductance of the capacitor circuit and prevents the voltage divider from oscillating, and has excellent performance. According to the difference of the added damping, the RC series voltage divider can be divided into two types: high damping divider and low damping divider. The high damping capacitor voltage divider cannot be used as the load (wave modulation) capacitor of the impulse voltage generator. It is only used as a conversion device for measuring voltage. The series damping resistance of the low damping capacitor voltage divider is very small, and its connection will not make it difficult to generate standard waves in the test circuit. It can also be used as a load capacitor and is a general voltage divider. From the point of view of ease of use, it has more advantages than the high damping capacitor voltage divider. From the response characteristics, it is not as good as the high damping capacitor

voltage divider because it also contains oscillation.

Theoretically speaking, when the voltage changes rapidly, the voltage divider ratio is mainly determined by the capacitance; when the change is slow, it is determined by the resistance. The device resistance wire is tightly wound on the porcelain tube positively and negatively, and connected in parallel with each capacitor. Practice has proved that the selected resistance value cannot be too small, otherwise it will affect the output load of the generator, so it is generally selected to be relatively large. However, the effect is small. It is similar to a pure capacitive voltage divider without resistance.

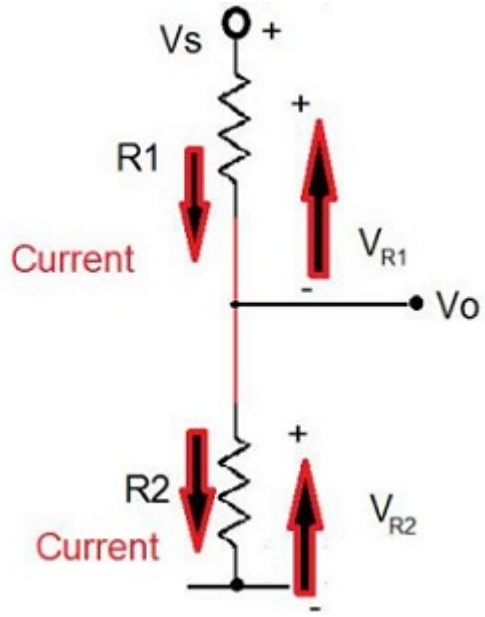


Figure 7. Voltage Divider Current

III Voltage Divider Characteristics

3.1 Voltage Divider Basic

1) The voltage divider adopts high-precision resistor and capacitor assembly, special process potting, and dry seal, so there is no oil leakage problem.

2) High input impedance: the test current is reduced, the power consumption is small, the product is small and light, the performance is stable, and the measurement accuracy is high.

3) The voltage divider, multi-value kilovolt meter and special cables are all placed in an aluminum alloy box, which is safe and reliable, easy to carry and transport.

4) The multi-value kilovolt meter can directly read the DC average value, AC peak value, effective value, peak value and other voltage values.

5)The organic composite insulating jacket is used above 150KV, which increases the surface creeping distance, and greatly reduces the height of the product. So the device is more convenient to use and carry.

3.2 Two Major Points in the Voltage Divider Circuit

1) Input terminal

It is necessary to analyze where the input signal voltage is input to the voltage divider circuit, and what is the

specific input current loop. The method of determining the current loop in circuit analysis is as follows: Start from the input end of the signal voltage, follow at least two components (not necessarily resistors) to the ground.

2) Output terminal

The signal voltage output by the voltage divider circuit must be sent to the next level circuit. Theoretically, the input of the next level circuit is the output terminal. However, sometimes it is difficult to analyze the input end of the next-level circuit. So you can use a simpler method to analyze: find all the components in the voltage divider circuit, analyze from the ground line to the upper end, and then find a certain component connects with other circuits. This connection point is the output terminal of the voltage divider circuit, and is also the output voltage of the voltage divider circuit.

In the process of analyzing the voltage divider circuit, it is often necessary to figure out the size of the output voltage.

The calculation method of the output voltage: ***Uo=R2/R1+R2·Ui***

where Ui is the input voltage, Uo is the output voltage.

The output voltage is less than the input voltage, because the voltage divider circuit attenuates the input signal voltage. That is, changing the size of Rl or R2 resistance can change the output voltage Uo.

3.3 Common Voltage Divider Features

Resistor Divider

(1) When it is wound by constantan wire with a small temperature coefficient or kama wire with a small temperature coefficient and high resistance, its temperature stability is high, and the long-term stability is also high during operation.

(2) Using a compressive resistor divider structure, its response characteristics may be relatively high.

Capacitor Divider

(1) The distributed capacitor divider is formed by stacking multiple pulse capacitors, with only amplitude error and no waveform error.

(2) The high-voltage arm of the centralized capacitor divider can use a standard capacitor filled with compressed gas. The capacitance value of this capacitor is very accurate and stable, and the dielectric loss is small. Because it is shielded, the capacitance value is not affected by surroundings.

Resistance-capacitance Divider

The high damping capacitor voltage divider cannot be used as the load (wave modulation) capacitor of the impulse voltage generator. It is only used as a conversion device for measuring voltage. The series damping resistance of the low damping capacitor voltage divider is very small, and its access will not make it difficult to generate standard waves in the test circuit. It can also be used as a load capacitor, which is a general voltage divider.

3.4 Voltage Divider Formula

How do you calculate voltage divider? In a series circuit, the voltage distribution is proportional to the size of the resistance, that is, the larger the resistance is, the greater the voltage is distributed; on the contrary, the smaller the resistance is, the smaller the voltage is distributed. Voltage divider produces an output voltage (Vout) that is a fraction of its input voltage (Vin).
In a series circuit, the voltage across the conductors is proportional to their resistance.

By ***I1=I2, U1/R1=U2/R2*** is $\frac{U_1}{U_2} = \frac{R_1}{R_2}$

Using **Apogee's Voltage Divider Calculator** helps determine the output voltage of the divider circuit given the input (or source) voltage and the resistor values. Simply enter a few values, and this tool will show the illustrated results for you immediately.

IV Voltage Divider Rule

When use and test voltage divider, you should take care of the following rules:
1) There should be no debris on the test site, so as not to affect the measurement accuracy.
2) The ground wire must be connected firmly to ensure a safe operating distance.
3) After the test, it must be fully discharged.
4) It is strictly prohibited to use over-rated voltage.
5) Ensure that the surface of the equipment is clean and stored in a cool, dry place.

V Voltage Divider Potentiometer

The potentiometer is a varistor that can be used to create an adjustable voltage divider. Its absolute resistance value will not affect the output voltage, and the output voltage is proportional to the input voltage. Commonly used potentiometers have poor resistance accuracy and temperature coefficient. However, as long as the resistance of the potentiometer is uniform, the voltage will be divided evenly. Assuming that the slider is connected to a high-impedance circuit, the contact resistance of the slider will not affect the output voltage. The sliding sheet contact resistance is a value at the contact point of the sliding sheet.
When the potentiometer acts as a variable resistor, its resistance accuracy and temperature coefficient will affect the circuit. The contact resistance of the slide will affect the resistance of the circuit, and the contact resistance of the slide will change with changes in position, temperature, vibration and time.

VI Main Differences between Voltage Divider and Transformer

1) The transformer changes the ac voltage of by causing the induced electromotive force through the change of the magnetic flux. The capacitor divider changes the alternating voltage through the capacitive reactance during the charging and discharging process.
2) The transformer can step up or step down; the capacitor divider cannot step up.

3) The input power of the ideal transformer changes with the change of the output power; while the input power of the voltage divider does not change when there is no load.
4) When an ideal transformer works, the magnetic flux passing through the iron core is constant. The voltage across the coil follows Faraday's law of electromagnetic induction, in addition, when the voltage divider works, its loop current is a constant value.

Frequently Asked Questions about Voltage Divider Basic

1. How do voltage dividers work?
A voltage divider can be used to scale down a very high voltage so that it can be measured by a volt meter. The high voltage is applied across the divider, and the divider output—which outputs a lower voltage that is within the meter's input range—is measured by the meter.

2. What is the voltage divider formula?
Using the voltage divider ratio rule, we can see that the largest resistor produces the largest I*R voltage drop. Thus, R1 = 4V and R2 = 8V. Applying Kirchhoff's Voltage Law shows that the sum of the voltage drops around the resistive circuit is exactly equal to the supply voltage, as 4V + 8V = 12V.

3. What is voltage divider and current divider?
Voltage Divider and Current Divider. ... Parallel circuits are also known as current divider circuits because, in these circuits, the current is divided through each resistor. Whereas, series circuits are known as voltage divider circuits because here voltage is divided across all the resistors.

4. Does a voltage divider waste power?
A voltage divider is a simple circuit consisting of two resistors that has the useful property of changing a higher voltage (Vin) into a lower one (Vout). ... Less than that and the circuit will waste a lot of power flowing through R1 and R2 to ground.