Basic Electrical Circuits
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Lecture – 33
Power and Energy in a Voltage Source

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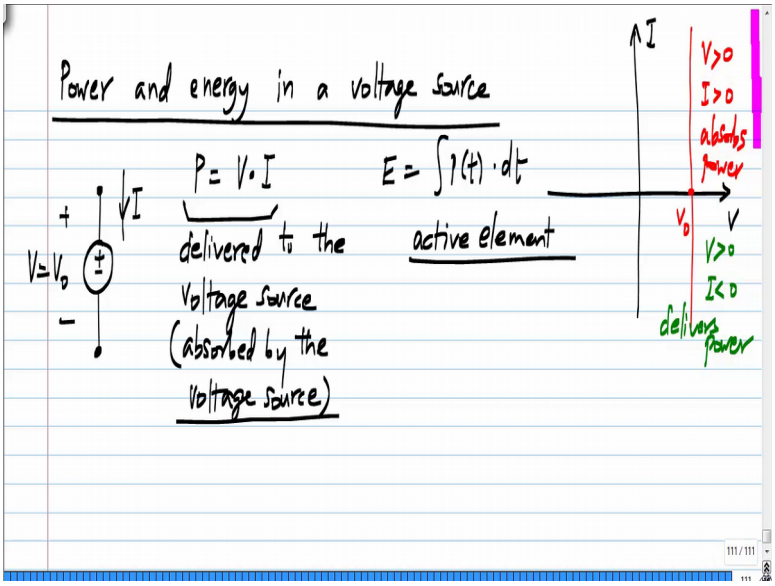

We have defined power and energy in an electrical element and also looked that power and energy and elements like resistor, capacitor and inductor and founds that these components of all passive. Now we will look at power and energy in independent sources such as the voltage source and current source, and see that they can be active. So, this is the voltage source it maintains a given voltage V equals V naught regardless of the current flowing through it and as always I use passive sign convention for the voltage and current definitions. Now of course, just like for any other element, the power is the product of V and I, it is important remember that this is the power deliver to the voltage source or in other words absorbed by the voltage source, this is the power absorbed by the voltage source and the energy of absorbed will be just the integral of power nothing special about it. If you want to find the energy observed over given a interval, you integrate the power over that interval.

Now let me draw the I-V characteristics of a voltage source, I will assume that this V naught is positive. We know from earlier discursion that characteristic the vertical line at V equals V naught. So, regardless of the current the voltage is V naught. Now if you look at the first quadrant, V is positive and I is positive, and the voltage source actually observes power,

because the product V I is greater than zero. And if you look at the fourth quadrant V is of course greater than zero, but I is smaller than zero that is I defined in this direction is negative that means that current will be flowing out of the positive terminal if it is operating in the fourth quadrant. And in this condition, it delivers power.

So, voltage source can either absorb power or deliver power, because there is the possibility of the voltage source delivering power, it is an active element meaning it is not passive. So, voltage source can be arranged observe power, but it also can be arranged should deliver power. So, it is not passive when it is operating in the fourth quadrants, this will be clear by looking at the few examples.

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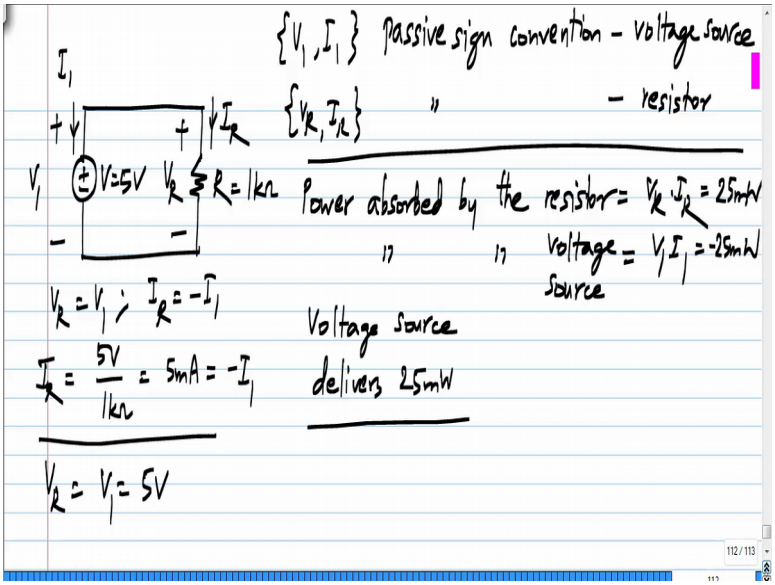

Let me consider a voltage source of value five volts connected to a resistor of a value one kilo ohm. Now we will do this carefully we do not always have do it this formally, but you have to be very mindful of that directions of current and voltages that you consider. So, now, what I will do is I will define voltage across the voltage source V 1 and I will use the correct passive sign convention for V 1 and define I 1 this way. So, V 1 is the voltage across the voltage source; I 1 is the current through the voltage source, and it is clear that I have chosen passive sign convention for this.

I will do the same for the resistor. Let say I call this voltage V R and given this polarity of V R. I have to choose the direction of I R to be that way so that this follows passive sign convention for the resistor. So, V 1 and I 1 are defined with passive sign convention applied to the voltage source and similarly V R and I R are defined with the same thing apply to the

register. So, like I said we would not always do this formally because all of you will recognize that V R equal V 1 and I R will be equal to minus I 1 and you will also see that the voltage across resistors as the five volts and the current by ohms law would be I R is 5 volt divided by 1 kilo ohm is 5 milli amperes. So, if this for just circuits analysis problem you would not define. So, many variables, but I am trying to make a point here about power precipitated and generated. So, we will proceed formally in the beginning.

So, now, what is the power absorbed by the resistor it is V R times I R which is five milli amps times five volts which is twenty five milli watts. So, let me also write it here V R which is V 1 is five volts and I R is five milli amps and that is also equal to minus I 1 and the power absorbed by the voltage source equals V 1 I 1 is minus 25 milli watts. So, this means that the power absorbed by the voltage source is negative in other words it is delivering power of course, I could have said this just by looking at having one source and one load and saying that voltage source delivers the power, but when it is come to multiple elements and given the fact voltage source can observe all deliver power first proceed with calculation very carefully defining the voltages and current correctly after that you will be able do this lot more easily. So, in other words, the voltage source delivers 25 milli watts which goes into the resistors. Now in general ,if you have a single voltage source that is apply to the circuit with resistors which are passive then that voltage source will be delivering power.

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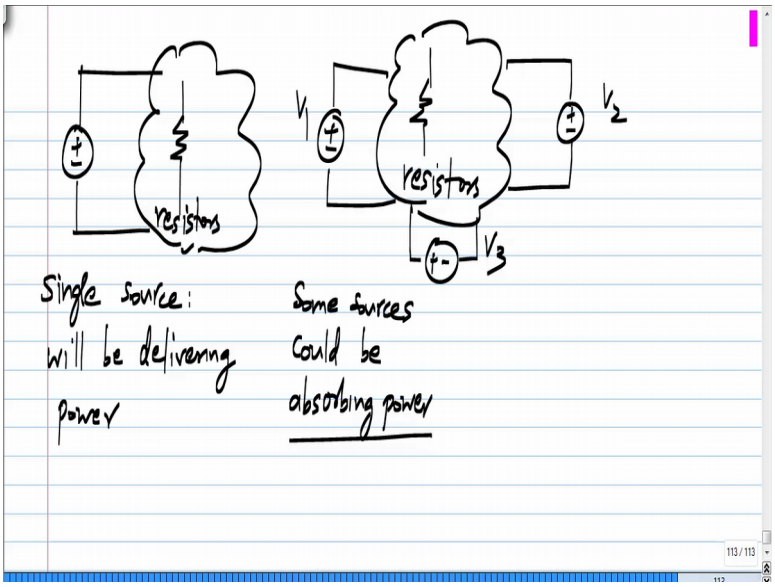

If I have single voltage source and this consists only of resistors. Let say then this is the only source of power in the circuit and it will be delivering power on the other hand if you have multiple independent sources just to be consistence with this picture I will show in the middle

a circuits consisting of only resistors and I will show another source on another side. So, let say this is V 1 and this is V 2, and we could have even more have let say I have V 3 and so on we could also have current sources, but for now I will consider voltage sources now we have multiple sources these sources together will be delivering power to the circuit, but each one of them could be observing or delivering power. So, it is possible that V 1 is delivering power and both V 2 and V 2 are observing power. So, some sources could be observing power, so this is possible.

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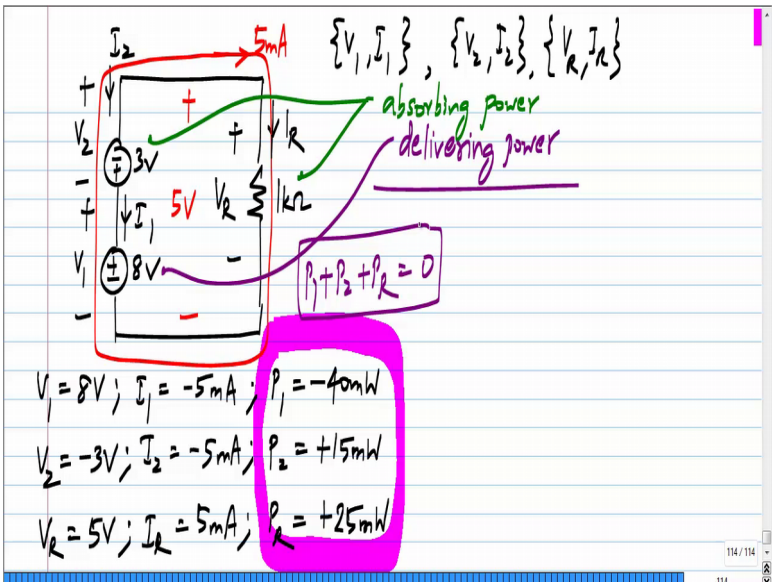

So, we will take example of this very simple extension of the earlier example. So, let me consider an eight volt source and three volt source with polarity like this and again one kilo ohm resistors connected to it. Now I will again proceed formally, I will call is V 1 and for passive sign convention, I have to take I 1 going into this terminal by the way V 1 is the voltage across this voltage source this is I 1. Now I will consider the three volt source and I can define the first variable any way I want. So, deliberately I will define like this V 2. Note that V two is opposite in the polarity to the voltage source voltage itself, but that does not matter once I choose V 2, I have to consider I 2 like this for passive sign convention.

Similarly, I will consider V R and I R. So, V 1, I 1, V 2, I 2, V R, I R each of them has been chosen for the two voltage sources and the resistor and consistence with the passive sign convention now the analysis of this circuits is real and many of you can do it in your head the part of seconds the voltage across this combination the series combination of voltage sources is five volts and we have therefore, five milliamp going to the resistor. So, now, we will compute each of these currents and voltages. So, first of all V 1 equal eight volts because it is

the same as the voltage of the voltage source and I 1 is defined this way, but in the circuit the five milli amp current is flowing in the clockwise direction like that.

So, I 1 is minus five milli amperes and their product V 1 I 1 the power absorbed by the eight hold voltage source is minus forty milli watts and similarly for the second voltage source V two defined this way is minus three volts because i have taken V two the be opposite in polarity to this one, but no matter V two happen this minus three then i two which is the current flowing down words this way is also minus five milli amperes. So, p two is minus p times minus five which is plus fifteen mille watts this is again the power absorbed in three volt source. And finally, the resistor voltage V R is five volts and the current I R is 5 milli amperes. So, the power pr is plus twenty five mill watts. So, it means that this voltage source and the resistor of course, are absorbing power that resistor of course, always absorb power, but the voltage source could either observe or deliver power in this particular case the three volts source is absorbing power where as the eight volt source is delivering power. So, this is an example to show that and independent voltage source could be absorbing power as well. So, that depends on the operating point of the circuit.

Another thing, I want mention which we will go into detail perhaps later if you look at the sum of power absorb then every element in the circuits p one plus p two plus pr this is equal to zero or this is not a point same this is the property of circuits and it can be prove one from Kirchhoff’s current law Kirchhoff’s voltage law. So, if you take every element of circuit, and calculate the power absorbed by them that is the products of V and I, so the according to the passive sign convention then the sum of all those powers will be zero. They will be some sources delivering power they will some other elements absorbing power, but the net will be zero.

So, summary is that voltage source can either absorb or deliver power and if it is operating in the fourth quadrant or the second quadrant, it will be delivering power which operating in the first of third quadrant, it will be absorbing power. A resistor whose characteristics are always only in the first and third quadrant will be always be observing power, of course, I am considering positive resistors. When you have a number of sources they will be at least one source delivering power and the other could be either absorbing or delivering power, if you have a circuit to the single source that is source will be delivering power.