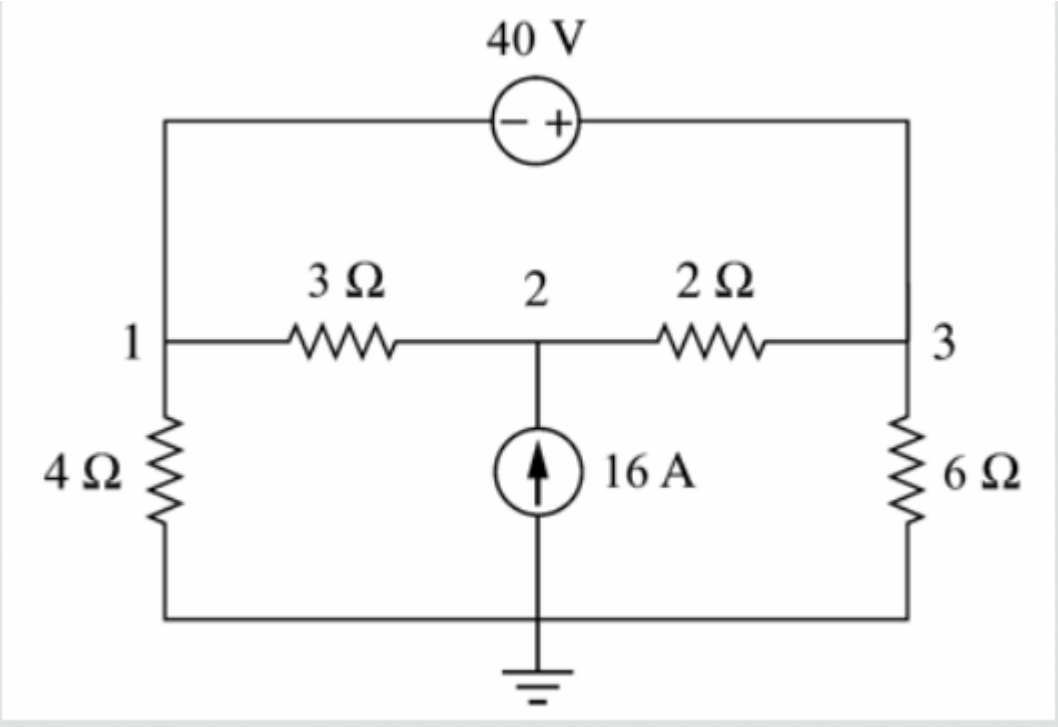
How to find the nodal voltage when there is a voltage source across two nodes?

Asked 2 years, 10 months ago Modified 2 years, 10 months ago Viewed 3k times



How to find the nodal voltage when there is a 40V across Node 1 & 3?

V1= 22.4 V V2= 65.6V V3= 62.4 V

My Nodal Analysis

Node 1 (SuperNode):

- -V1/4 - V1-V2/3 + V2-V3/2 - V3/6 = 0

Node 2

- V1-V2/3 + 16 - V2-V3/2 = 0

Constraint Equation

- V1-V3 = 40

Any help is greatly appreciated!

circuit-analysis nodal-analysis

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edited Aug 30, 2020 at 9:01

asked Aug 30, 2020 at 7:56

Dugong98

195 2 9

1 Have you tried using superposition? – Andy aka Aug 30, 2020 at 8:35

1 This type of connection gives rise to an equation of the form V_3 = V_1 +40V. Use it along with other equations and solve as usual. – AJN Aug 30, 2020 at 8:35

@Andyaka I tried using superposition, but I didn't get the answer – Dugong98 Aug 30, 2020 at 8:46

You should show what you did (put it in your question) then maybe someone can see where you went wrong. – Andy aka Aug 30, 2020 at 8:48

@Andyaka I've added my nodal analysis! Any help is greatly appreciated – Dugong98 Aug 30, 2020 at 8:56

4 Answers

Sorted by:

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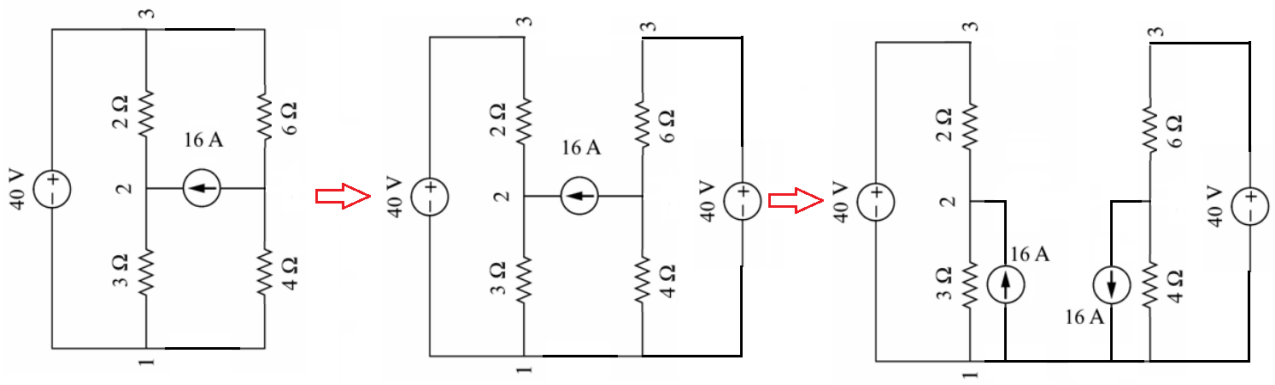
8

I'd just rearrange the diagram and use source-splitting techniques: -



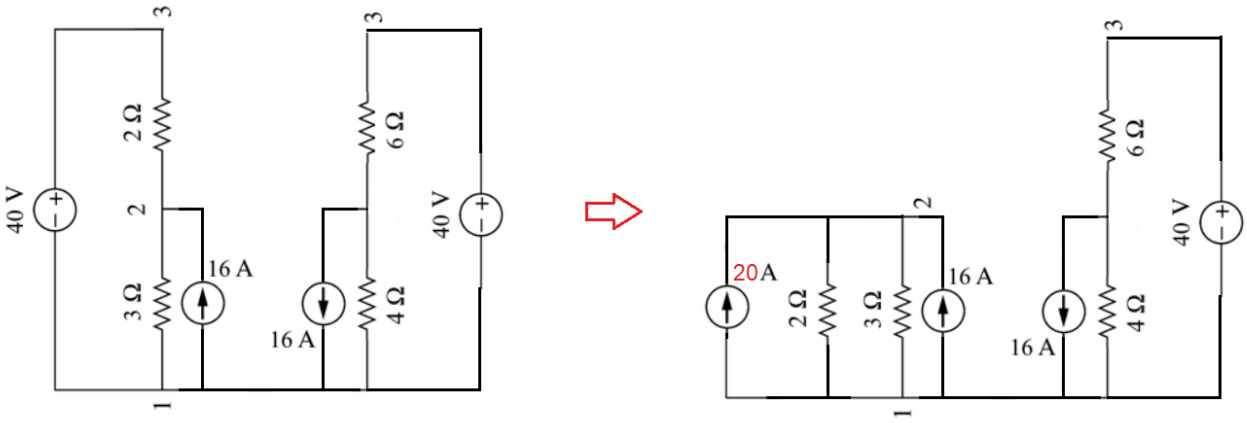
From left to right, it's the same circuit but, breaking it down step by step is easier to analyse. Each step saves maths and is a pictorial record of what you did thus, making it easier to parse.

\boxed{\text{So, why do I prefer this method?}}

Well, my turn to solution is simulation (because I don't do exams any more) but, source-splitting is my 2nd choice because it's clearer at each stage and, teaches you how to properly analyse circuits using your brain. It makes you more EE savvy.

So, from the diagram on the above right, I'm going to calculate the voltage between node 1 and node 2. Note that the earth/ground point originally in the question's circuit is irrelevant here.

The 40 volt source in series with the 2 ohm resistor is equivalent to a current source of 20 amps in parallel with 2 ohms. That current source and 2 ohm resistor are now in parallel with a 3 ohm resistor and a 16 amp current source: -

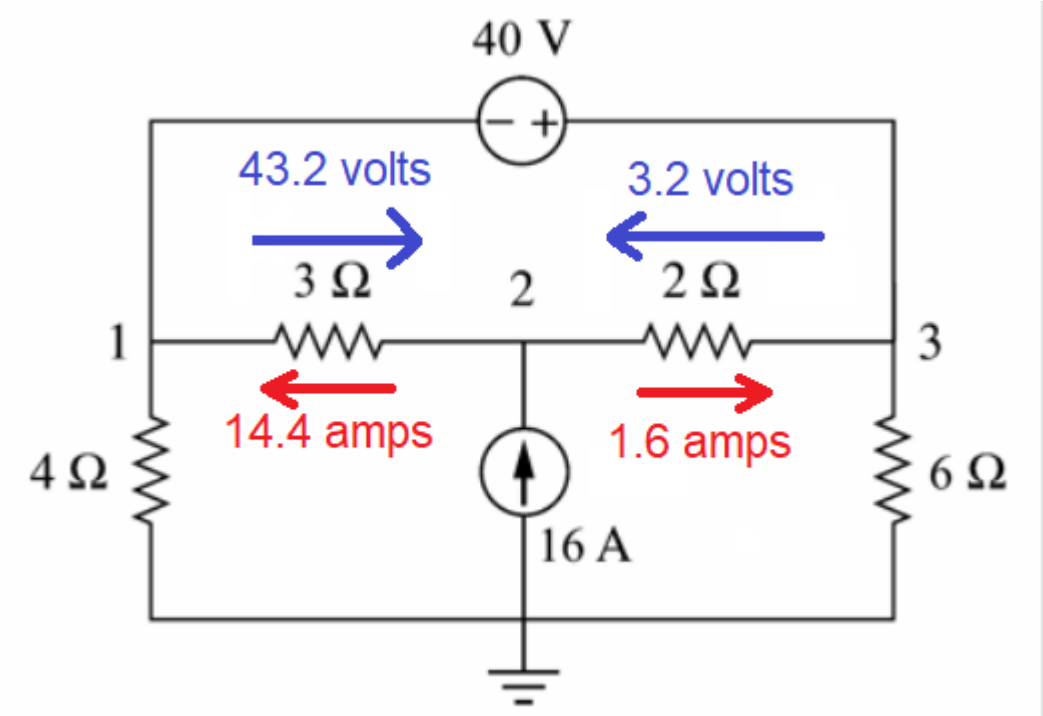


Hence, the voltage between node 1 and node 2 is

$(20\text{ amps}+16\text{ amps})\cdot\dfrac{3\text{ ohms}\times 2\text{ ohms}}{3\text{ ohms}+2\text{ ohms}} = 43.2 \text{ volts}$

And, if you looked at the answer given (V1= 22.4 V V2= 65.6V) that is what you see.

Then just add what you know (from one calculation) to your original circuit: -



And I'm going to stop here in the expectation that the OP will solve the rest.

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edited Aug 30, 2020 at 14:14

answered Aug 30, 2020 at 9:28

Andy aka

429k 28 348 760

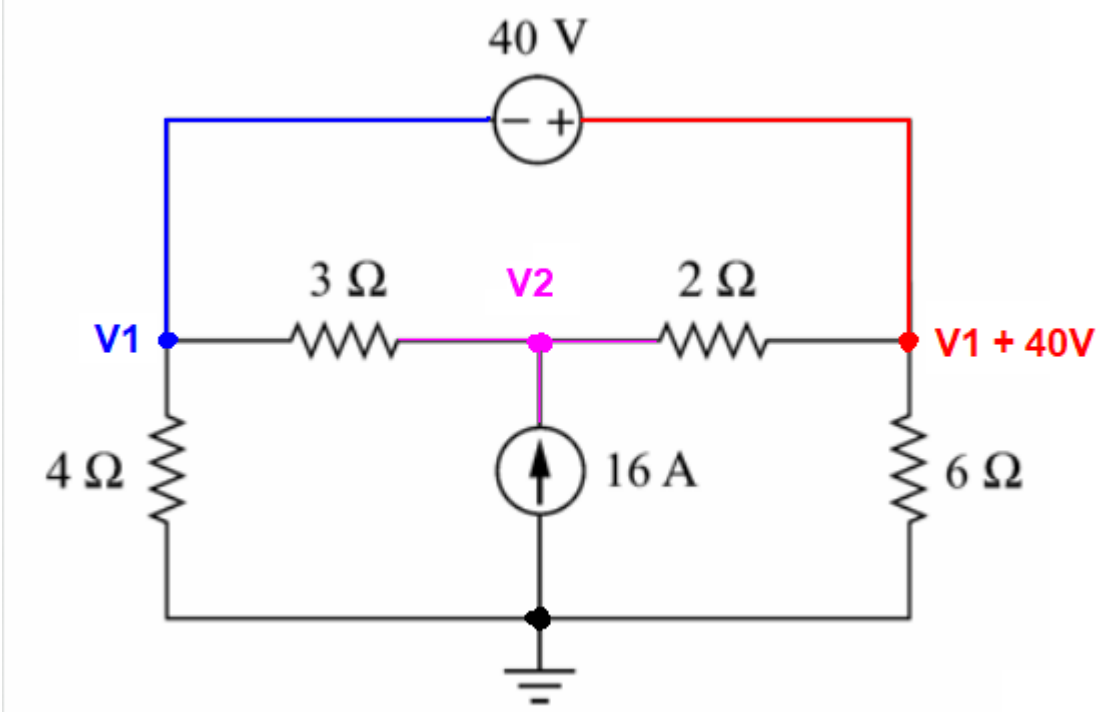
Thanks for your very clear explanation! @Andyaka. What are the reasons why you don't use Nodal Analysis? Whenever I do nodal Analysis, I have problems finding which direction the current is flowing. whether in or out of the node? Any tips to solve such a problem? – Dugong98 Aug 30, 2020 at 9:57

I don't use nodal analysis. I either solve in a simulator or use the above. – Andy aka Aug 30, 2020 at 9:58

1 Yep this answer is better than mine, by splitting the source he has made two Thevenin equivalents on each side , and driven each of these with 16A. Just solving massive equations all the time just makes your head ache, and you don't really understand what is happening. The general approach to all of these problems is to try and re-arrange the problem into simple solvable blocks. Save all the algebra for Laplace domain problems. – BobT Aug 30, 2020 at 10:14

3

The classic book method is to use a supernode:



Thus we are only left with two unknowns nodal voltages V_1 andV_2

And the nodal equation for two nodes are:

V_1 Super-node, additional I assume that all current flows out from V_1 node (V_1 is the highest voltage and this is whyV_1 is "always first" in the numerator).

\frac{V_1}{4\Omega} + \frac{V_1 - V_2}{3\Omega} + \frac{V_1+40V}{6\Omega}+ \frac{(V_1 +40V) - V_2}{2\Omega} = 0

And for the V_2 node, and again I assume that V_2 is the highest voltage so, all the current will flow out of the V_2 node (this is whyV_2 is "always first" in the numerator).

\frac{V_2 - V_1}{3\Omega}+\frac{V_2 - (V_1 +40)}{2\Omega} - 16A = 0

So all you need to do is to solve it:

https://www.wolframalpha.com/input/?i=x1%2F4+%2B+%28x1+-+x2%29%2F3+%2B+%28x1%2B40%29%2F6+%2B+%28x1%2B40+-+x2%29%2F2%3D0%2C+%28x2+-+x1%29%2F3+%2B+%28x2+-+%28x1+%2B40%29%29%2F2+-16%3D0

And if you have time try to watch this

https://www.youtube.com/watch?v=NA_zlZTDiKU&feature=emb_logo

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edited Aug 30, 2020 at 14:49

answered Aug 30, 2020 at 13:12

G36

13.3k 1 18 32

Thank you so much @G36 – Dugong98 Aug 31, 2020 at 2:36

1

OK , Here is the basic method

1. Move the ground connection to node 1 , and just call the old ground node 4
2. Set the 40v source to zero volts, as a voltage source, it has zero ohms impedance, so this step basically shorts together nodes 1 and 3
3. Call nodes 1+3 node 0 (i.e. ground), you then have a current source with the positive end connected to ground via 3//2ohms and the negative end connected to ground via 4//6ohms, you can then work out currents sources contributions to each resistors voltage, write this down somewhere.
4. Set the voltage source back to 40v , and set current source to zero , (i.e. disconnect it)
5. Now work out the voltages across the 2 and 3 ohm resistors, should be 2/5 and 3/5 of 40v , 16v and 24v ; and the 4 and 6 ohm resistors 4/10ths and 6/10ths of 40 or 24v and 16v , write these down somewhere.
6. Now simply add algebraically the voltages for each resistor from steps 2 and 5 , (the voltage on the 2ohm resistor will be slightly less than 16v and 3 ohm slightly more than 24v)
7. Now subtract the voltage across the 4ohm resistor from all nodes, this will result in node 4 being at 0v , i.e. ground potential, and all the other node voltages will be the wanted voltages.

This is not the only method, but shows one way to break the problem down to manageable steps. Another approach would be to work out the thevenin equivalent of the voltage source and resistors)this will give 2 thevenin voltages and resistance, then apply the current across the thevenin equivalent and work from there. You should really try both ways. You can also convert the current source to its equivalent thevenin voltage source , then paralle both thevenin sources. You will find if you try all three methods, you will find yourself seeing the same numbers in each step. There is even a boring yet very complex way of working it out by writing equations for each resistance .

The circuit shown is actually a Wheatstone bridge, more obvious if you rotate it 90 degrees CCW.

Getting back to your working , it is common to use subscripts to denote voltages so V1 is then V_1 and the voltage of node 2 wrt node one is V_1_2

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edited Aug 30, 2020 at 9:59

answered Aug 30, 2020 at 8:50

BobT

624 3 8

Thanks for sharing BOB, I have added my nodal analysis. But i still got the equation wrong! Care to share where i went wrong? – Dugong98 Aug 30, 2020 at 8:52

Hi @Dugong98 , you wrote " V1= 22.4 V V2= 65.6V V3= 62.4 V " is this the right answer?, or your wrong answer? I'll just find a bit of paper to scribble on..... – BobT Aug 30, 2020 at 9:14

That is the right answer! Thanks a lot @BobT – Dugong98 Aug 30, 2020 at 9:16

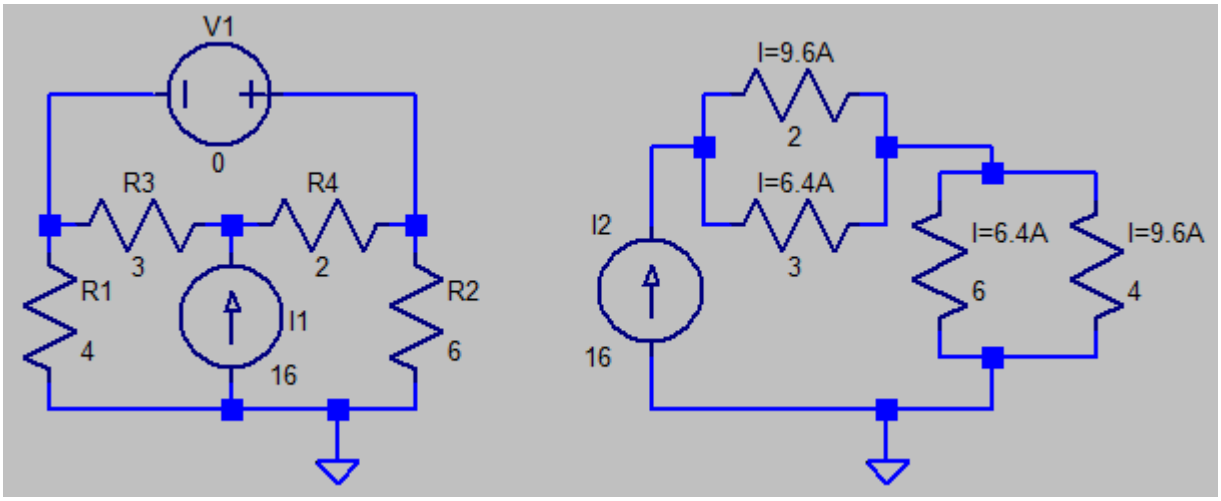
You probably have the sign wrong somewhere, that's the usual problem e.g V12 is the negative of V21. or brackets in wrong place, it would be easier to label the resistors Ra Rb Rc Rd , and the voltage across each being Va Vb Vc Vd , using the sign convention that left is negative. – BobT Aug 30, 2020 at 9:25

Ok this line is missing brackets -V1/4 - V1-V2/3 + V2-V3/2 - V3/6 = 0 , Should be -V1/4 - (V1-V2)/3 + (V2-V3)/2 - V3/6 = 0 (this is the cuurents in one side and out the other of the voltage source) – BobT Aug 30, 2020 at 9:49

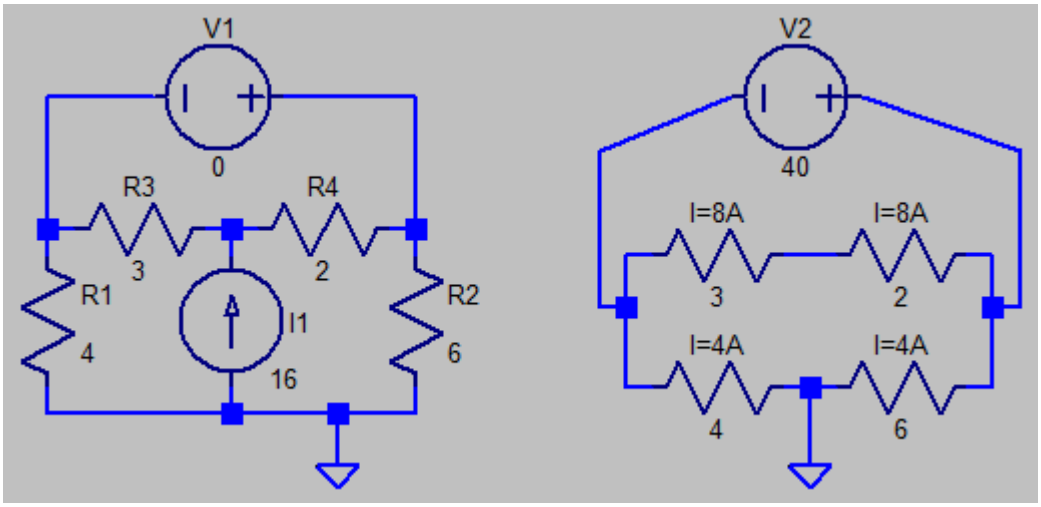
1

BobT's answer uses *superposition*. Normally, I avoid superposition because it is so very difficult to keep current directions straight, and sum them properly. It takes practice to find a way to be consistent with assigning current directions. But in this case, superposition is fairly straightforward...

First, isolate the current source by shorting the voltage source. It helps to re-draw the circuit - once you do so, solving currents becomes super-easy. 16 amps gets divided into two parts \frac{2}{5}16 , \frac{3}{5}16:



Now open up the current source, and make the voltage source active. Again redraw the circuit, which makes solving currents very straightforward. This skill of re-drawing circuits is one that needs practice. An electrical engineer is adept at re-arranging circuit components this way. Again, solving currents in the two paths is super-easy:



Now the most difficult part is summing both together, and then assigning current direction to the final answer. Note that current directions from each source acting alone *oppose each other* in the 4-ohm and 2-ohm resistor. Usually, we don't write final currents as signed numbers, but translate signs to a direction - an **assignment marker** will appreciate this sign-assignment: it saves him/her some extra work.

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answered Aug 30, 2020 at 14:11

glen_geek

23k 1 22 49