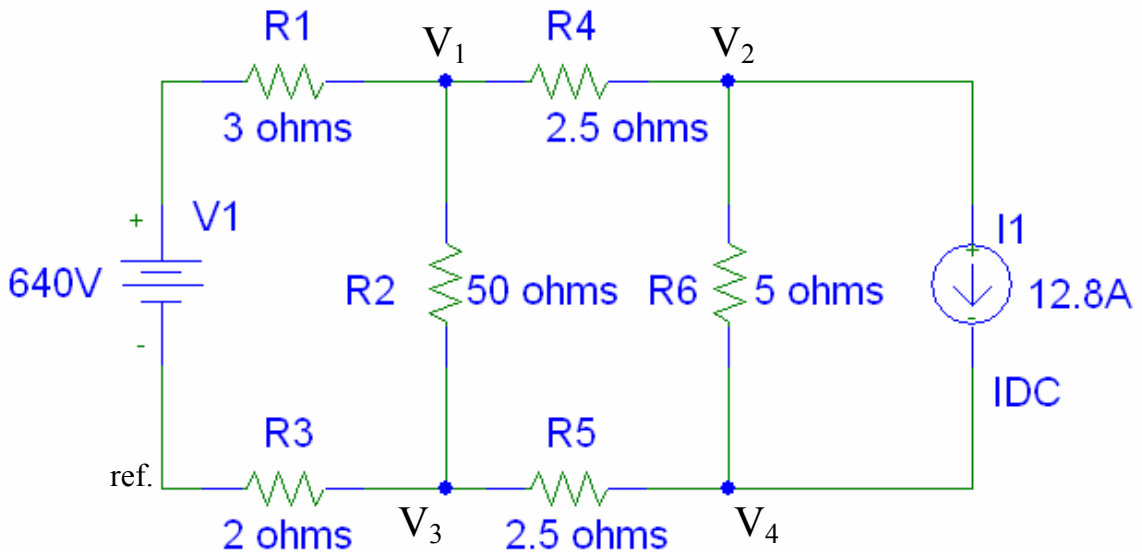


Using a TI-86 to Solve Node Voltage Problems

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Solving Node Voltage circuit problems requires finding the solution of simultaneous equations. The number of equations is equal to the number of nodes in the circuit, and their solution can become very tedious for problems involving more than two nodes. This help sheet will provide an example of how to use your TI-86 effectively to increase solving speed and decrease mistakes in solving complicated Node Voltage circuits.

The circuit we are going to solve is this one:



We need to find the voltage across the 5 ohm resistor. So, you can see that if we can find all 4 node voltages, the voltage across the 5 ohm resistor will be $V_2 - V_4$.

To write the node equations at each node, we follow a procedure. Each term follows the convention

$$\frac{V_{node} - V_R}{R}$$

where V_R is the voltage at the node on the other side of R and R is the resistor connected between V_{node} and V_R .

So, we write node equations for the 4 nodes, using the minus side of the 640V voltage source as our ground reference.

$$\frac{V_1 - 640}{3} + \frac{V_1 - V_3}{50} + \frac{V_1 - V_2}{2.5} = 0$$

$$\frac{V_2 - V_1}{2.5} + \frac{V_2 - V_4}{5} + 12.8 = 0$$

$$\frac{V_3}{2} + \frac{V_3 - V_1}{50} + \frac{V_3 - V_4}{2.5} = 0$$

$$\frac{V_4 - V_3}{2.5} + \frac{V_4 - V_2}{5} - 12.8 = 0$$

This looks like a pretty daunting system of equations to solve! Four equations in four unknowns. However, if we know how to manipulate it into matrix form, we can leave the hard part to our calculator, and have a solution in no time. No more long and involved algebra!

We do need to do one more (simple) algebra step to get it into matrix form. All of the coefficients for each variable must be grouped into a single term in front of that variable. Each of the four variables needs to have a coefficient. Make sure that the variables are listed in increasing order from right to left. If the variable is not listed in the equation, give it a coefficient of 0. Any constant terms get moved to the right side of the equation.

$$\left(\frac{1}{3} + \frac{1}{50} + \frac{1}{2.5}\right)V_1 + \left(-\frac{1}{2.5}\right)V_2 + \left(-\frac{1}{50}\right)V_3 + (0)V_4 = \frac{640}{3}$$

$$\left(-\frac{1}{2.5}\right)V_1 + \left(\frac{1}{2.5} + \frac{1}{5}\right)V_2 + (0)V_3 + \left(-\frac{1}{5}\right)V_4 = -12.8$$

$$\left(-\frac{1}{50}\right)V_1 + (0)V_2 + \left(\frac{1}{2} + \frac{1}{50} + \frac{1}{2.5}\right)V_3 + \left(-\frac{1}{2.5}\right)V_4 = 0$$

$$(0)V_1 + \left(-\frac{1}{5}\right)V_2 + \left(-\frac{1}{2.5}\right)V_3 + \left(\frac{1}{2.5} + \frac{1}{5}\right)V_4 = 12.8$$

These equations can now be easily solved in your TI-86 if proper care is taken to input the values correctly.

On the TI-86, we open up the matrix editor by pressing [2nd] - [MATRX] [F2] to enter Edit mode. Give the matrix a name of A. Then you need to enter the dimensions of the matrix. We have 4 equations in 4 unknowns, so we will need a 4 by 5 matrix. If we had 3 equations in 3 unknowns we would use a 3 by 4 matrix. 2 equations in 2 unknowns requires a 2 by 3 matrix. Your screen should look like this.

```

MATRX:A          4x5
[ 0 0 0 0 ...
[ 0 0 0 0 ...
[ 0 0 0 0 ...
[ 0 0 0 0 ...

```

```

1, 1=0
[INSF | DELF | INSc | DELc | PREAL]

```

Next we need to enter the coefficients into the matrix. We will use the way the four equations are written above for our format. The four coefficients for the V_1 through V_4 terms for the first equation go in the first four columns in the first row, with the right hand side of the equation occupying the fifth column. Basically we will enter the matrix

$$\begin{bmatrix} \left(\frac{1}{3} + \frac{1}{50} + \frac{1}{2.5}\right) & \left(-\frac{1}{2.5}\right) & \left(-\frac{1}{50}\right) & (0) & \frac{640}{3} \\ \left(-\frac{1}{2.5}\right) & \left(\frac{1}{2.5} + \frac{1}{5}\right) & (0) & \left(-\frac{1}{5}\right) & -12.8 \\ \left(-\frac{1}{50}\right) & (0) & \left(\frac{1}{2} + \frac{1}{50} + \frac{1}{2.5}\right) & \left(-\frac{1}{2.5}\right) & 0 \\ (0) & \left(-\frac{1}{5}\right) & \left(-\frac{1}{2.5}\right) & \left(\frac{1}{2.5} + \frac{1}{5}\right) & 12.8 \end{bmatrix}$$

The fractions can be typed in just as they appear here but will be converted to decimal when enter is pressed. You don't need to convert all of these entries to decimals before entering them—just type them in as you see them in the matrix.

After the matrix is entered, your screen should look like this:

```

MATRX:A          4x5
- .02      0      213.3333 ]
- 0        -.2    -12.8   ]
- .92     -.4     0       ]
- .4      .6     12.8    ]

```

```

4, 5=12.8
[INSF | DELF | INSc | DELc | PREAL]

```

Hit [2nd] - [QUIT] to exit the matrix editor and return to the main cursor.

Type A and hit enter to see what is stored in your matrix.

Now, enter the command [2nd] - [MATRX] - [OPS] - [rref] - [ALPHA] - [A] to get

rref A

and hit enter. Your screen should look like this:

```
rref A
[[1 0 0 0 484]
 [0 1 0 0 373]
 [0 0 1 0 104]
 [0 0 0 1 215]]
```

```
NAMES EDIT MATH OPS CPLX
dim Fill ident ref rref ▶
```

And there you have your answers! You can read off your answers in the rightmost column. So the solution to our four equations in four unknowns is now:

$$V_1 = 484V$$

$$V_2 = 373V$$

$$V_3 = 104V$$

$$V_4 = 215V$$

Finally, the voltage across the 50Ω resistor is

$$V_{50} = V_2 - V_3 = 373V - 104V = 269V$$

Knowing how to do this process quickly can save you lots of time on tests and homework. Practice solving equations this way and you will get very good at it.