Re: generalized Thevenin?

Source: http://sci.tech−archive.net/Archive/sci.electronics.design/2007−07/msg02755.html

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- *From*: "Jon Slaughter" <Jon_Slaughter@xxxxxxxxxxx>
- *Date*: Fri, 20 Jul 2007 04:39:36 GMT

"Jens Tingleff" <jensting@xxxxxxxxxxxx> wrote in message
news:f7nb0b01jpl@xxxxxxxxxxxxxxxxxx

> In article <fZCni.39974$Um6.1086@xxxxxxxxxxxxxxxxxxxxxxxxxxx>, Jon
> Slaughter
> says...
>
>> "Jon Slaughter" <Jon_Slaughter@xxxxxxxxxxx> wrote in message
>> news:IHCni.39972$Um6.28321@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
>>
>>> "Robert" <Robert@xxxxxxxxx> wrote in message
>>> news:CfCni.9752$zA4.6770@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
>>>
>>>> "Jon Slaughter"
>>>> <Jon_Slaughter@xxxxxxxxxxx> wrote in
>>>> message
>>>> news:SHzni.2490$Dx2.1132@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
>>>>
>>>>> Is there a generalized
>>>>> Thevenin's theorem for
>>>>> arbitrary "black boxes"?
>>>>>
>>>>> i.e., Suppose I have
>>>>> something like
>>>>>
>>>>> −−−> I
>>>>> V +−−−[ ]−−− 0
>>>>>
>>>>> where [] is a black box.
>>>>>
>>>>> I should be able to write

something like

V = Z(t, V, I)*I

which sorta resembles ohms
law. V and I generally
depend on t.

if [ ] is a resistor then
Z(t,V,I) = R and in general
Z also depends
on
a set of parameters.

But what about more
complex black boxes?

If its a resistor and a
capacitor then what?

V ---||---/\/\/\/\---- 0

Then Z(t,V,I) = ?

For passive components is Z
a linear differential
equation?

Any other ways to simplify
such expressions?

The reason I ask is I have a
circuit that has a lot of these
"paths"
that are connected in some
way but each path is the
same configuration
with only the "constants" of
the components that are
different.

Thanks,
Jon

> > > There's Middlebrook's Theorems but I don't
> > > think that's what you're
> > > asking about.
> > >
> > > http://en.wikipedia.org/wiki/Extra_element_theorem
> > >
> > > Robert

> > Actually it looks very similar and it seems close to my
> > problem.
> > Essentially I have a circuit where each "branch" looks
> > identical(Actually
> > its not but uses identical topology... its almost fractal like)
> > and I am
> > trying to use that symmetry to make it easier to solve. I'll
> > have to
> > read
> > up on it to see what exactly it doing though.

> hmm... actually it doesn't seem to be what I want. My problem is similar
> to
> his but each branch in the graph has the same "structure".
>
> For example, take any graph and treat an edge as a black box that contains
> passive elements. Then each edge is described by a linear differential
> equation L_E where E is the edge indicator which really only depends on
> the
> passive elements characteristics. Then is there a way to simplify the
> graph/solve the system for the voltages and currents?

In a passive circuit, the complexity of finding the solution grows with
the
number of nodes − sorry :−(Think of finding the voltages along a string
of
resistors. For two resistors, the voltage at the middle point depends on
the
value of two resistors. For three resistors (same structure in each
branch...)
both of the two internal voltages depend on the value of three resistors,
etc
etc. (However, if you know in advance that all the resistors have the same
value, you can easily calculate the solutions for all the internal nodes.)

Solving the network to find all node voltages / branch currents can
certainly be
done the "hard way." This uses admittance matrices, as in i = Y v (with
"v" the
vector of internal voltages and "i" the vector of external currents and
"Y" the
admittance matrix).

http://users.ecs.soton.ac.uk/mz/CctSim/chap1_2.htm (for instance)

I think there's actually hope for solving your problem if you have a very
simple
and regular structure. In that case, you might be able to find the inverse
of
the Y matrix (this is what you need in order to solve the circuit
equations) in
a way simpler than the general way. An advantage of this approach is that
you
don't need to use the actual elements in each branch, you can use a symbol
for
each distinct branch admittance and enter the actual branch admittances in
the
solution.

Symbolic simplification of matrix inversions is pretty difficult to do,
though.

Well, luckily I can use a CAS to do most of the work. I'm actually not interested in extremly complex circuits so it won't actually be to much work. But of course its still not that easy ;/

So, the short answer is that going from simple circuits like a resistive
divider
to more general circuits is not simple.

[..]

So essentially between any two nodes we have Vb − Va = Z*I which is just ohms law in some sense but Z is somewhat arbitrary. The problem is that in general Z depends on the nodes, current, and time along with all the other components that exist on that branch.

Worse − the voltages at the ends of this branch depend on all other
voltages.

Yes, at all nodes there will be unknown voltages except at end nodes were the voltages will be known. But because all paths/branches/edges "look the same" all the equations will be the same and there is probably someway to exploit this.

> > You can think of it very similar to solving the graphs of resistors that most people do in basic electronics or physics courses except I want to replace them with more general components. In the case of a resistor its very simple. In the case of a capacitor it is not.
>
> Actually, for a circuit with only capacitors, it's not different from a purely
> resistive circuit (just a lot more unknown voltages at DC...).

Well, for a capacitor if you want to know the transient voltages it is much more complicated because your dealing with integrals over unknowns.

> > Since I want to take
> > into account the transients I get system of integeral equations(because of the non−constant/non−sinusodial input voltages and unknown node voltages).
> > Of course these integral equations are equivilent to a system of differential equations.
> >
> > Essentially you can think of each branch representing a linear differential
> > equation. But each linear DE "looks" the same as every other one except for
> > the constant coefficients and it might depend on different currents and voltages.
> >
> > It seems though I should be able to recursively simplify the
> > circuit until I find all the unknowns. well, this should be obvious but the
> > issue is, is the size. Just hoping for a way to reduce the complexity because of the "symmetry" that exists.

> For some very special circuits, yes (e.g. resistor strings, delta or star
> shaped
> circuits, etc). In general, I think not.

No, I do not mean that the topology is simplifiable but that because of the symmetry of the equations it reduces the overall complexity. Its like comparing a network of resistors to something else. Because they are all resistors it makes it "easy" to solve(sure it could still be a bitch though). In this case we don't have a resistor but its like a resistor in that each component is similar to all the others. (its not like I have some transistors on one branch, and inductor on another, etc...

> > Anyways, probably no way to do what I want but I can wish...

> It's worth thinking about this. I studied in a group where the professor
> made a
> Big Discovery as a young student when hearing about a deceptively simple
> result
> at a conference (for all passive circuits, the sum of voltages in the
> solution
> is always constant − or something[1]) and asking himself if that could
> really be
> true and then wondering what the consequences were. The answer was the
> companion
> circuit and its use for sensitivity analysis :−). He thought it was so
> trivial
> that he didn't publish it right away. Tut tut. Two lessons in that
> anecdote ;−)
>
> Good luck

Well, I doubt that will happen here ;/ Chances are I won't be able to make any progress but its always fun to try ;)

Thanks,
Jon

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