Re: transient analysis of linear system

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- *From*: "Abstract Dissonance" <Abstract.Dissonance@xxxxxxxxxxx>
- *Date*: Fri, 18 Aug 2006 11:46:08 −0500

"wombat" <wombat@xxxxxxxxxxxxxxxxxxxxxxxx> wrote in message
news:44e5db1b$0$35081$4fafbaef@xxxxxxxxxxxxxxxxxxxxxx

Fred Bloggs wrote:

First of all this is not homework it's just that linear systems
and
transient circuit analysis hasn't been in the job description for
a
while, actually ever.

```
R1 A R2 B R3
+−−−/\/\/\/\−−−−+−−−−−/\/\/\/\−−−−−+−−−−−/\/\/\/\−−−−−−−+
| | | |
x(t) | | C1 | C2 | y(t)
===== −−−−− −−−−− =====
=== −−−−− −−−−− ===
| | | |
| | | |
+−−−−−−−−−−−−−−−+−−−−−−−−−−−−−−−−−−+−−−−−−−−−−−−−−−−−−−+
GND
```

Anyway the circuit is shown above. Clearly in steady state
it's just a
voltage divider of the difference of Vx and Vy. The problem
is that Vx
and Vy vary with time (out of my control). I need to report
VA and VB to
the user but it must be the steady state result. In other words I
must
filter out the transient effects caused by x and y. Please note
that I
can't modify the circuit in any way. I know all the values for
caps and
I can also measure *all* voltages. I even know the nominal

values for
the resistors. The point of all this is to 'see' if the resistors
change
through the "fog" caused the time varying sources.

My idea was to somehow use the system response [h(t)] to
work out the
steady state result for A and B. Perhaps divide VA(t) by h(t)
????
eg in the case of VA:

x(t) −−−>| |
| h(t) |−−−> VA(t)
y(t) −−−>| |

I guess the first thing is, am I on the right track?

Not even close.

Secondly I could do with some tips on calculating h(t) at A
and B.

I really appreciate any help.

Your system is undetermined. The problem statement is to predict a new steady state for Va and Vb as a function of R1,2,3. These resistors are on the order of 2e15 ohms and the capacitors are on the order of 2e−12 for a time constant of 4e3, or thousands of seconds, and this holds for relatively minor +/−10% change in R. Then Vx and Vy exhibit a drift characteristic on the order of hundreds of seconds. You can get an idea of what happens by thinking of C1 and C2 as DC sources, batteries, of magnitude steady state Va and Vb. As the resistor fluctuate at a rate nearly instantaneous relative to the circuit time constants, all voltages remain unchanged, and charge will be circulated through the resistors to maintain those node voltages constant. Looks like you have everything wrong, attempting to measuring a circuit parameter that nature is forcing to be constant, meaning you have to measure *current* to detect the resistor changes, the voltage measurements will barely move by ppm and be undiscernible from drift. And what does this have to do with your original ill−posed resistor network that was another failed identification problem? You're a starting to look like a big waste of time.

> My original post was probably a little premature and therefore misleading with regard to the problem statement so I'll clarify.
>
> "I need to know if the resistors change by more than 10% while having to contend with the sources of x and y moving up and down."
>
> Regarding the time constant, I have modelled the circuit. As an example: When R2 decreases it's resistance by 10% (to 1800G) point B changes to it's maximum voltage (however only 0.4% change) in under 8 secs.
>
> Unfortunately the current through the resistors can't be measured so I have to rely on voltage measurement. It sounds pretty extreme, 0.4% accuracy is hard to come by but if I measure differentially across the resistor it equates to ~5% change − definitely achievable.
>
> The previous problem is related but my methodology changed when I realised I couldn't do it that way. It wasn't solvable.

I'm still not sure what your after but if I interpret what you said above correctly then all you want to do is determine the change in R?

This is quite easy if you can measure the sources and have some standard value of R to compare to. All you have to do is measure the voltage across R and the voltage sources and compare it to what would theoretically be expected with the standard value that R is suppose to be.

i.e., You use the "theoretical" values of the resistanaces and capacitances and the experimental voltages sources and then the experimental values for all and then compare for differences.

If your circuit is fixed and you can solve it algebraically then all you have to do is "plug in" the measured values and the theoretical values and compare. If you can't solve the circuit algebraically then you will have to do numerics on it to get the results.

You could do more advanced mathematics(stochastic DE's and such) but I think for your problem it would be quite easy since you can measure the voltage of the voltage source. (else it would be impossible for an arbitrary voltage source because you can't tell if the extra voltage drop on the resistors are coming from the change in resistance or from the voltage source)

for example,

```
R
+−−−/\/\/\/\−−−−+
| |
```

Vx(t)| | C
===== −−−−− === −−−−− | | |
| +−−−−−−−−−−−−−−−+ GND

If, say, you are trying to figure out the change in R then its quite easy.

Vx − I*R − Q/C = 0

==>

I = dQ/dt

so

Vx − dQ/dt*R − Q/C = 0

and Q(t) = exp(−t/RC)*(Q0 + int(Vx(s)*exp(s/RC)/R,s=0..t))

but VR(t) = dQ/dt*R =

so the voltage drop across the resistor is given by

VR(t) = Vx(t) − exp(−t/RC)/RC*int(Vx(s)*exp(s/RC),s=0..t) − VC0*exp(−t/RC)

But we can measure VR(t), Vx(t), and VC0 and hopefully we know the theoretical value for C(else its more complicated and probably impossible to measure) then we can calculate the value R for this(numerically).

i.e., say the theoretical value for R is 10ohms. Then we can measure and plug into the equation above and test for different R's until we get a true statement. This R then can be compared with 10 ohms to see how much it varied to a "hidden" variable.

If, say, C = 1, VC0 = 0, and Vx(t) = t when we start measuring(So we will have to sample the voltage sourc) and suppose that we measure the voltage across the resistor at the end of 1 sec to be 1/2V

then

1/2 = 1 − exp(−1/R)*int(s*exp(s/R),s=0..1)

we get the equation

1/2 = 1 − R^2*exp(−1/R) − R^2 + R

We can solve this numerically to find out what R has to be to produce those measurements: This equation has solutions at about 1.065 ohms.

So one would have a change in about 9 ohms.

Anyways, Thats just an example and the measurements are made up for the purpose of demonstrating what you could do. It might not be the best way to do this though depending on the circuit and such. If you could measure the current then it would be hell of a lot easier as you would only need to measure the voltage and current of the resistor you want to measure and then compute its value using ohms law... and it would be correct regardless of the circuit topology(for the most part).

The above method may not work well though since its possible to have multiple solutions and there might be stability issues in trying to implement it.

Ultimately it would probably be much easier to just measure the current along with the voltage. You can also do the same to measure the capacitance since V = Q/C and I = dQ/dt but you will need to sample the current enough to build a history for the integration.

Ofcourse if this was some type of research then you would be using much more complication mathematics and physics to get the answers but I doubt you want to spend the next 10 years on that.

Hopefully I'm on the right track with what you want to do. If so then one thing you have to realize is that there are probably thousands of factors that can change the resistance and can complicate matters. Even the simple RC circuit above is quite complicated in this aspect if both the resistance and capacitance can change. If you don't know what is making them change and cannot model that sufficiently then it can be very difficult to measure there change by limiting yourself to measuring only one aspect of them(such as there voltage). The reason is simple. What we measure as a change of resistance my actually be from a change of capacitance and vice versa. So you would have to be vary careful not to allow this type of situation to occur in your method. Also, say, assuming the capacitance is constant when it is not could contribute. So, in this problem is not only what you measure but what you don't. This is not to say that there might be simplifications and approximations that could make the problem much easier to deal with. I'm just not completely clear on what you are trying to do.

Anyways,

Jon

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