Re: Capacitor charging configurations

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* *From*: Magneto <magneto_no@xxxxxxxx>
* *Date*: Sat, 18 Jun 2005 22:07:25 −0400

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John Popelish wrote:

     Magneto wrote:



          I was thinking about the classic voltage doubler
          using caps today, and this got me thinking about
          the basics of capacitor charge/discharge math, and
          eventually I thought up a simple design but wasn't
          quite sure what the effects would be:

          First (basic) case:
          Take two caps of equal capacitance, I'll pick 1
          farad for simplicity, and one (C1) is charged at 1
          volt while the other (C2) is at 0 volts. When
          connected together C1 will charge C2, and the
          steady−state voltage of each will be 0.5 volts.


             +----------+
           + |          | +
          C1 === 1V  0V === C2
          1F  |          |  1F
              V          V



          Now the simple math that gets us there is this:
          Initial:
          Q(C1) = C(C1) * V(C1) = 1 Farads*Volts = 1 Coulomb
          Q(C2) = 0



          Steady state:
          Q(C1+C2) = Q(C1) + Q(C2) = 1 Farads*Volts = 1 Coulomb
          C(C1+C2) = C(C1) + C(C2) = 2 Farads
          V(C1+C2) = V(C1) = V(C2) = Q(C1+C2) / C(C1+C2) = 0.5 Volts


          and in lamens terms we can describe it by saying
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the charge in C1, which produces 1 volt there, will distribute itself evenly among the total capacitance and result in half of the charge left in C1 and half in C2, thus producing 0.5 volts in each capacitor.

And each capacitor has had a total voltage change of 0.5 volt.

Second case:
Building on the first case, add a constant voltage source of 1 volt on the left side, boosting the voltage from C1:

```
       E
        |+
   +----||----+
   |    |     |
   |   1V     |
 + |          | +
C1 === 1V  0V === C2
1F  |          |  1F
   V          V
```

And, of course, the catch is that there is an unobtrusive controller & sensor (not shown obviously), that will break the circuit the moment C1 loses all its charge (if that's what's going to happen), so as to avoid inducing a reverse voltage on it, or when steady state is achieved (if that's what's going to happen).

Just keep in mind that any charge that flows through C2 must also flow through C1, so the total change of voltage across C2 must equal the total voltage change across C1.

At that point, when C1 loses its charge or steady-state is achieved and the circuit is stopped, what will the charge and voltage be on C2?

Neglecting oscillations, the circuit will reach equilibrium when C2 has 1 volt across it and C1 has zero volts across it. At that point, each capacitor has had a 1 volt total change.

> Why?
> The reason I ask is that, if the voltage source simply boosts the final charge in C2 like I think it might, then a rather simple & dynamic charge pump can be made to go up to any voltage with only a 1V input (say it's from a cheap solar panel), 2 caps, a few FETs, and a tiny micro. It would work like this:
>
> After C2 is charged as far as it can go, the resting voltage should be above one volt while C1 will be less than one volt (likely 0v).

Yes, exactly zero.

> At that point the micro will switch off a couple of FETs and switch on a couple of other FETs, reversing the polarity of the battery. Example:

```
         E
       +|
   +-----||-----+
   |     |      |
   |    1V      |
 + |            | +
C1 === 0V  1.5V === C2
1F  |           |  1F
    V           V
```

Except that C2 cannot experience more voltage change from the common current than C1 did.

> And of course the cycle continues. It would be akin to a pendulum, with the constant voltage source

> > just barely offsetting the voltage at the right time (because of the micro) to push the current in the desired direction, each cycle building up the overall voltage, albeit tenths of a volt at a time with this example.

> Sorry, with perfect components, the 1 volt just sloshes back and forth between the capacitors, and energy is consumed from the 1 volt source with each slosh. You might as well hook a resistor across the 1 volt supply to waste the power.

Almost forgot about this post.
Yes, I see your point. I drew up several different arrangements and did the calculations, you're right, the system can never gain more than a volt because it's closed loop. In fact, all the voltage source does is either speed up each cycle or allow it to reach full swing. My flaw was that I forgot that in a simple circuit using just a voltage source and a capacitor the same thing happens, a charge is still forced from one plate and moved to another, up to the potential of the source.

Thanks

> > Once the target voltage has been reached, the caps could be put together in parallel or series, without the voltage source (maybe it would be switched over to pumping another pendulum circuit), to feed into a holding capacitor or battery.
> >
> > The beauty of this, if it works, is that if the voltage source increases for a short while (say the cloudy day turns into a sunny day, hitting the solar panel harder) the pendulum simply swings higher faster, nothing has to be recompensated or clamped, the frequency of the switching is completely dependent on when the micro senses a steady−state condition.

Does this make sense? If there is a flaw in this design please speak up!

Magneto

Done.

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