...I figured that I should be posting here now instead of lengthening my thread in the newcomer section any longer.

I now have my 2.5v 2600F Ultracaps coming in the mail as they were MUCH cheaper than the 3000F 2.7v models. The six that I will have end up at 15VDC in series. Since I want this thing to be very versatile and resilient, (Standalone "battery pack" or augmentation of a battery on a solar charge controller) I was wondering... Would adding two more caps for a 20VDC max charge ceiling do just as well as a balance circuit since this thing should never be exposed to more than 17.5 volts even with just the solar panel? I understand that there will be unused capacity in this configuration but at the price that these caps are going for right now I don't really care.

...Otherwise, the specs on the datasheet for the BCAP0010 lists an ESR of 0.7 mohm, so 70k resistors it is.

============================================================================

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/05/23 21:24

Also... Just to make sure I am getting the right concept here- Is this an appropriate representation of passive balancing with resistors?

============================================================================

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/05/25 07:13

< Thanks to Shiekh for helping me with my questions here back in my original thread in "Introduce yourself" >

============================================================================

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/25 08:00

70k will balance any voltage in the capacitors as long as the charge current in any one capacitor does not exceed 35 microAmps

if any one capacitor is weaker(capacity) it will receive most of the charge...

with these diodes the weakest cap will charge to 2.1V then transfer anything over that to the others http://www.ultracapacitors.org/images/fbfiles/images/ultra-8dd9b1257276d813fe6c92d0be1fd1.GIF

============================================================================

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/05/25 08:13

So then according to your image we would simply place the appropriate number of these diodes in place of the resistor (in this case the 3 1n5401's that you recommended)?

============================================================================

Re:Negate need for balancing with more caps?
well yes if i'm following the threads correctly. This forum is giving me fits at the moment, reply to a message in any thread and zing you're at the forum home.

if you use 3 diodes in the 1n5400 series the 2.5 v capacitors will only see the 2.1 volts

if the weakest one is fully charged the diodes will pass anything over the 2.1V to other capacitors in the chain

it will balance the voltage in each capacitor, even if they are terribly mismatched.

If the 3a is reached (all capacitors charged) the diodes will each put out 2.1W in heat but chances are the panels wont have enough power. (24 diodes rated 2.1 watts ea)

if your solar panels can charge the caps in a short time
more caps are in order

each series string of caps should be close
(all 2F or all 6F)

-----------------------------
In another note the energy stored in the capacitor is in Joules (watt.Seconds) (Kilogram meters)

energy= (C*e^2)/2

for the metal cutting lasers i was using 50uF 10,000V=2500J
These are about the size of an office trashcan and about $400.

these lower voltage ones are a lot smaller for the same amount of power.

============================================================================
Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/25 09:44

ah yes my picture since i found out i couldnt use a fixed width font and uploaded the picture from a text editor converted to gif... has 9 diodes in series 6.3 v total

1n4000 is 1a 6.3v zener (6.3W)
in5400 is 3a 5.3v zener (18W)

a bigger zener requires a heat sink
a small zener with a power transistor still requires the heat sink.
a bunch of diodes have a bunch of surface area and dont require heat sinks.

you can get 6A diodes that dont need heat sinks

You only get heat by generating more power than you can use... so match the source to the load and the storage.
or when the storage is charged.. turn off the source (series regulation)

============================================================================
Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/25 10:49

I'll try again...

3 Si diodes at 0.7V = 2.1 V
9 diodes = 6.3V
Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/25 10:53

hmm im too tall http://www.ultracapacitors.org/images/fbfiles/images/ultra2.GIF

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/05/25 11:04

This is an interesting yet relatively simple approach that I don't believe I have seen elsewhere in the forums ( Have not read them all but I have searched voltage balancing quite a bit )
This method would cap me out at 12.6V which is a good, safe voltage for a 15V bank. That is pretty close to my ideal of 13.5V... Which I picked because it is the upper territory of a topped-off battery, so 12V devices deal with it well. ( I like the picture edit as well! )

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/25 12:24

well another cap and 3 diodes go from 12.6 to 14.7 which is more in tune with a charged 6cell lead acid.

lead acid charging tends to ignore temperature also. This strikes me as utter insanity 12.6 v is almost 20% charge at 70F. in the car with the engine running and charging its probably more like 160F ambient... charging at 70 amps or so adds 1000W of heat to the battery internally
if you put a voltmeter on the battery you may see 16 or 17V.
after the car sits for a few hours 14.8 or so is pretty good

as for the voltage balancing or regulation if you prefer Zener diodes are a simple common shunt regulator

older computer boards TTL based ... i guess im getting old. sometimes had a tie point for logic 1 for unused inputs four diodes in series 2.8V the 1 for TTL.

newer computers lil desktops may have 700W power supplies. most of the 700W is at 2V or less so shunt regulation is out of the ball park

my background is in machine tools. I've worked with ac power, Dc power, relay logic .pratt&witney RTL computers for the machine tools (4 nand gates on 4x6" cards) TTL computers GE mark century...

But its all out there and has been used for years

I you want a place to start looking try Electro-Plating 1000s of amps less than 4 Volts.

and you do want about the same thickness of metal all the way across a large workpiece.
If your car is going above 14.4V something is very wrong with the charging circuit.

Hi. Newbie here. I stumbled across this and am doing the exact same thing. I have 24 BCAP0010 2.5V 2600F Maxwell ultracapacitors which I'm tying to a pair of Harbor Freight (HF) 45W solar panels using eight caps in series for a 12V nominal circuit (14.5V max output from the HF charger) without any balancing resistors/diodes/active circuits. By using eight caps, none of them should see more than 1.8125V, so I figured no balancing circuits were needed it should last a very long time Am I right? I don't see the question ever answered.

Also, I don't understand using diodes instead at all. 1N5400 diodes are 50V@3A diodes... wouldn't three of them in series hooked backwards yield be 150V@1A?

I have read about using LEDs and zeners to balance them, but I don't understand using regular diodes this way, nor do I see the need to balance them if the voltage is kept low enough.

What am I missing?

So you are going for 3 parallel chains of 8 right? That would be roughly 975F... 1.8v is a rather low charge so while you would be giving up a lot of capacity. That is one of the ideas I had too- Just run a few groups in parallel to make up for it.

I have gotten a lot of info on passive balancing lately. It has been a lot to take in and digest and because I don't yet have enough real-world experience in it I am still very paranoid about selecting the right way to do it. Passive balancing means bleeding off energy all the time (and that also means heat).

I'm looking for the older model integration kits now, and I have no idea where to look. Maxwell doesn't seem to answer questions from the little guy so far, and I have only found the kits for the newer 3000F model on Mouser.com.

http://www.scribd.com/doc/44732237/Boost-Cap

I really, REALLY hope I can nail down one.

No need to balance if the voltage stays below specs (per capacitor)

8 series capacitors charged to the same voltage as 6 same capacitors will carry less energy, but cost more.

Using 7 as opposed to 8 might be a better way to go as the array would yield more energy storage at 12 - 14.5 volts?
Caps would still only be charged to 2.07v average...

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/05/29 13:47

14.5/6 = 2.42V, so might as well stay with 6 caps.

http://home.comcast.net/~hlandis0/photos/ucap2600f.pdf

says a surge is also permitted

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/05/29 15:08

Just to show the 8 capacitor series array has less energy than a 6 capacitor series array at the same voltage

8 array energy
8 x 0.5 C (V/8)^2 = one sixteenth C V^2

6 array energy
6 x 0.5 C (V/6)^2 = one twelfth C V^2

it's that V^2 that causes this effect

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/05/29 15:22

If, lets say, 17V was fed into an empty cap array designed for 15v, voltage would drop dramatically as the cap gorged itself on charge and slowly rise as the cap charged, correct? In this way a built-in volt meter on the caps could warn against crossing the arbitrary "safe zone" ( again, as long as I am not overlooking something :) )

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/05/29 15:50

Yes, the voltage is going to rise slowly.

The diode curve

shows why a set of forward biased diodes is not as good as a Zener (which uses the reverse breakdown), as the Zener voltage is much sharper.

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/05/29 16:05

Thanks for the confirmation. ( sometimes I wish I would have taken courses for electronics )

That gives me peace of mind as I begin testing my own caps out in the sunlight. I get worried when I think about the possibility of an accidental overcharge.
That link is a very nice resource as well!

============================================================================

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/29 16:14

Mark

What you miss is the reverse voltage is not the same as the forward.
1n5400 is safe to use with a 15V 3ac transformer to charge a car battery
the diode will not burn out since 15V *1.41 (peak) is 21.5
this is all the voltage it sees it is rated at 25V
if you are indoors on a dry day and have plastic shoes and a carpet and touch the diode... it will go away
if the diode sees 6 amps for a few hours it should be fine... but millisecond voltage spikes cause problems

solar cells are silicon diodes with clear covers
the solar panel weve been discussing has 36 in series
which would indicate 6 diodes with each capacitor (6in series) would give no current ... entirely passive

diodes are in black cases or metal cases so they dont see the light photo diodes have clear cases and generate power.
solar cells are REAL BIG photo diodes

the 50v (1n5401) is the maximum reverse voltage
i just didnt happen to see 1n5400 in the catalog i looked at ... $70 / 1000 for 1n5401 perhaps
1n5406 is cheaper because more ppl buy them and they handle most common voltages like the voltage doubler that
powers your computer with 350V dc
perhaps 1n5400 are marked from a bad batch of 1n5402

the transformer in the computer is HF  gives you 5vac 50Khz at the 300A your little cpu likes
the diodes for that are multilayer fast recovery types generally to220 or bigger case they are multi layer schotky design to
work fast they have a higher forward drop but cost perhaps 40x as much

the diodes in a microwave oven are balanced specially selected and put in series in a case about 3" long
the 6000V 1a diodes 15r16 if i remember correctly
they are about $5 each
1n4008 1 a 800V were $3 for a bag of 100
any 10 of these about $.30 will let me do
8000V at 1A
The $5 6000V diode saw more than 6000... perhaps the refrigerator doesnt have surge protection...
this is a pile of those diodes so if you use a vom you cant check it since the vom has a 9 v battery and the drop thru this
diode is 12v or so it will read infinity both ways put it in series with a light bulb with perhaps 24vac or use a megger

if any diode in the string sees over 800V it fails to a short so if you get some carbon composition resistors 1megohm or
so and in parallel with each diode the will all see an equal voltage you cant use 1/4W resistors 800V will ruin those you
need 1/2 watt in most brands

now if you go behind a thrift shop salvation
you find piles of microwave ovens....
so if you can buy the non working one from them for $1
usually just pic thru the dumpster
you can fix it an sell the working one for $10

at any rate the forward drop thru the diode is non existent until there is some voltage present
from that chart i posted good from 1n5400 to 1n5408
below .2V there is no current (passive no load)

at.9Volts there will be 3A which will take the entire output of the panel this makes it absolutely certain the
capacitor will never see over 2.7 v with a power source from the panel. The active power in this active mode each diode
consumes 2.7 watts with the 60 watt panel this is not a significant number compared to the panel output. 4 diodes make this 3.6V at 3A or 200ma at 2 with every cap at the same voltage

if you start adding strings of caps for more storage and one cap shorts ... you need fuses on each series string the diodes can take 200 amps for a brief time so perhaps a 1" piece of #20 wire in series with each series string

there one thing we didn't talk of and i did look at that maxwell cap ad again it doesn't say anything about reverse voltage.

you may wish to put a reversed biased diode across each cap so they don't see more than .7v reverse this will happen on discharge if they aren't all the same too http://www.ultracapacitors.org/images/fbfiles/images/Untitled.GIF

---

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/30 09:01

not as good for voltage regulation far better for overvoltage draining

note the zener clamps 170v to 60 at about 35% duty cycle

the normal diodes see 2v peak say we wish to supply a 1A or 60W device the zener dissipates 60W regular diodes .7W ea

BSA motorcycle has a pint sized battery and a zener diode on a 6" asterisk heat sink so light bulbs don't burn out cars have bigger generators so use series regulation rather than shunt.

the little foreign voltage converters use this circuit to convert the 220 to 110V for your shaver or hairdryer

but shavers are content to run at 340Vdc 35% duty cycle and actually run cooler since it is a dc motor with laminated cores to make it run on ac... you lose all the magnetizing losses http://www.ultracapacitors.org/images/fbfiles/images/zenervsd.GIF

---

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/05/30 09:48

340V DC is lethal, who uses this?

Does anyone use 86 diodes?

---

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/30 10:29

virtually every electronic appliance since about 1980 uses 340Vdc

older ones will have a little switch near where the power cord goes in says 110v-220v

the newer ones say 90V to 250V and have a little black box inside to decide weather you want to use the caps as voltage doubler or full wave rectified ...

this avoids all the calls to service department from people who dont know if their power is 110V or 220V

as an aside 30 milliamps is lethal Electric chairs generally use a steady 480V with pulses of 4100V and have a doctor standing by with a stethoscope on a long rubber tube to make sure the salted sponges deliver 30 ma
nothing lethal in voltage

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/30 12:23

i missed the second half of the question
ONE 50 watt zener cost $60
100 1n5400 Diodes cost $7
they give the same effect as
a 300Watt zener diode

we were considering some sorta safety to balance and not overcharge the caps or any one cap in the string

the panel that we've now seen the picture of is 36 forward biased diodes he has 6 caps

6 diodes across each cap would be 0 load but still tend to balance

he could cut into the plastic on the back of the panel and put one cap on each string of 6 photodiodes relying on those being matched

these photodiodes would be in the 1000A range if they didnt need to see the light

6 2v panels instead of one 12V then any number of caps could be parallel with each panel and never exceed the panel OCV
This involves preplanning and design not using separate parts for non intended uses as they become available

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/05/30 12:37

Never seen DC in a house

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/05/30 15:40

i guess you only use heaters or incandescent lamps
or perhaps florescent lamps with the old transformer type ballasts.

permanent magnet synchronous motor maybe?
starting current on that may be 40x the running
LRA on a straight induction motor is 5x the full load running

that depletes my list of ac appliances
also notice NO electronics....

i could believe a house like this in 1890. perhaps even 1920

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/01 00:28

First, thanks PeteTy for the idea for using diodes rather than resistors to balance things. Brilliant and original. Still trying to figure it all out (I write software. I break hardware.)
Went ahead and jumped on the sale at Goldmine and ordered a bunch of 1N5401 diodes and more caps, which will bring to me 56 total. A fool and his money...

The panels I'm using put out 23.57 volts max. I may try putting 11 caps in series after a diode, with three balancing diodes per cap, before the charge controller. We'll see when it all arrives and I have time to play with it.

This is getting to be a very expensive hobby. Assuming it works, it will take about 14 years to pay for itself.

But in the zombie apocalypse...it's priceless.

---

**Re:Negate need for balancing with more caps?**

*Posted by PeteTy - 2011/06/01 05:47*

thanks mark for actually measuring your panel. you will find that the diodes exactly complement the output of a solar panel.

i did post the IV curve on the 1n5400 series

3 may not give as high a voltage as you want to utilize the capability of the caps 4 may do better.

the capacitors will charge to identical voltages

the cap iv curve is the opposite of the panel iv curve

the caps in series the one thats at 1.5 takes less current to go from 1.5 to 1.6 than the low one from 1.4 to 1.5 the hi one gets higher faster the low one gets higher slower

this is similar the those 6 PbAcid identical cells in a car battery the weakest one gets the most charge and the most heat for some reason the ones on the ends seem to be in the worse shape after 3-4 years they have more surface exposed to the air so should be cooled the best but 2/3 of the power of the gasoline heats the engine compartment.perhaps the one closest to the radiator goes bad first.

the diode curve is on log liner paper the zener diode curve is on linear paper the regular diode will tolerate 16x its nominal current as well as the zener tolerates 4x its nominal current as the panel approaches ocv there is little current available.

---

**Re:Negate need for balancing with more caps?**

*Posted by XA Hydra - 2011/06/01 06:37*

WOW Mark, did you say 56 caps!? I thought I was splurging at 14!!!

I don't really worry about all the abstract economics as far as paying for itself ( the panel, etc. ) because when I need something like this, it is there and that in itself could be priceless. ( especially when need to radio in STARS when Umbrella corp. gets out of hand lol )

Being serious again, 11 caps in series is quite a few I must say. What will you be running off that high of a voltage? If the panel is a 12v nominal panel then the 23.5 volts is open circuit voltage I am assuming? If you were running 12v loads then you could use some kind of buck-boost or regulating circuit I suppose. I am probably going to stay with 6 in series and keep things capped at 13.3 volts since my regulator was adjusted to cut off there. I may get a more advanced charge controller in the future to expand the system and I noticed float voltages vary from 13 - 14~ish volts ( and more still are adjustable ) If I thought I would cross 13.5v then I would add a 7th in series for safety.

6 gives me 433 Farads and I charge up pretty close to the 15v ceiling.

7 drops us to about 371 Farads and at least in my case I would be a couple of more volts away from the limit, decreasing available energy.

I am doing two parallel strings so these figures double, which would decrease the pain of adding a 7th, but so far I will
avoid it. May design some room for optional expandability in the case I will be building for them.

...I'm all about seeing what you do with 56 of these bad boys :)

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 08:03

"with three balancing diodes per cap"
what voltage do you want to run the capacitors at?

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 08:08

Cheaper, and better, than strings of diodes is a low power Zener controlling a transistor.
http://sound.westhost.com/appnotes/an007.htm
My guess is that is what the Maxwell balancing boards are.

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 09:32

I have thought about trying my hand at a circuit like that after looking at it as an educational project if nothing else (relatively simple). However if I ever did it could be a chore making one for all the caps, and then stuffing them into the enclosure neatly and orderly.

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 09:38

Would probably want to etch some circuit boards to carry the circuit.

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 09:52

That would certainly make for an interesting project... DIY Balance boards!
The Maxwell boards do not just go between the leads of each cap like the resistors/diodes would. They appear to bridge the opposite end terminals opposed to the terminals that are linked by bus bar, with a wire that leads down and bots into the bar.

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 10:13

Interesting how they suggest a need for an Anti-Oxidant Compound.
Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 10:25

Green Tea is full of those ^_^

Out of curiosity, I emailed the guys at Maxwell a few days back and they finally got back with me ( asked if the older kit was available anywhere ). At first the sales fellow said that our caps were a 2.7v part and would get along fine with the new boards. I responded with the links to their own datasheets ( it was an honest mistake I'm sure ) showing 2.5v and the response was that our caps were a discontinued model ( of which I was already aware ) and the person forwarded my inquiry to another person asking if the new boards would work with the older cap. The voltage range for it in the datasheet makes this seem unlikely. Anyways, for those interested I will share what ever results I get.

...Never hurts to ask questions, I say

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 10:47

I've already built everything for 2 5/8" spacing (that of the bars that came with the units)

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 11:11

OK so I've been thinking...

Mark, you are considering a higher voltage string. I was thinking that at first too. Six are doing quite well, and I prefer it at the moment because I can charge pretty close to its 15v cap, therefore getting more usable energy.

Now,

I was looking at better charge controllers ( Every now and then I find good deals on extra solar panels ) and some allow you to set a wide range of charge cutoff/float voltages. We are more flexible with these since batteries are optional. I don't want to go higher than my current controllers lowest setting of 13.3V because I want to keep the caps safe.

I will be adding a small pure-sine inverter (for tiny, sensitive AC loads) to the system soon after I finish the housing, and the average working voltage range is about 10.5 - 15.5 volts. That gives us a lot of charge range! However, there are plenty of 12v loads that I am sure won't work at all or can and will be damaged by 15.5 volts ( I don't want to find out so I will err on the side of caution )

Perhaps the solution to this is a buck-converter circuit?

^ Something like that... That particular one starts at 16V so we would want something that works a bit closer to 12...

^ That person built their own and provides a schematic.

If no-load current draw is an issue, there could be a "regulated 12v" toggle switch that leads to a socket built on this circuit, that way we could use our 12v items over a broader range.

If this would work out I would go ahead and make my two parallel arrays 7-cap based.

Any pros/cons?
Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 11:17

(other than the low amperage ceiling and inefficiencies from heat dissipation)

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 11:27

If I could quit worrying about eating my lunch and look around a bit more.... Here is a better converter from that store..
Right smack in the voltage range of 10-15


Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/06/01 14:52

someone is missing the entire point of this thread
whether that charge controller goes from 4v to 90v
or 12 v to to 14.8 volts weather it costs $0.28 or $20,000
whether you can set it to 13.519386V or 13.51799V
it will do NOTHING for a capacitor that can be damaged if it sees 3V

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 15:04

What!? Yeah, that ^ isn't the point at all. The point is the charge of the whole array. If they are so out of balance that one
is going to 3v in the manner that I was speaking then there are other issues- issues that aren't the focal point here.
And yes it does do something-> it stops charging once it hits the voltage that I determined is safe for my array of
capacitors!
And it is 13.389487659 volts, not 13.519386. Much, much safer.

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 15:07

Repairing your toaster was also not the focal point of my other thread ;)

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 15:14

http://www.maxwell.com/products/ultracapacitors/docs/AN-002_CELL_BALANCING.PDF
I also recall that 3 cells in series don't need balancing.
* From what I can see they may not need balancing at all

* A Zener with transistor seems a good way to avoid cells going over-voltage

============================================================================

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/06/01 16:11

woll ok i guess you mean a bi polar transistor

depending on a lot of factors they may or may not work below 3 v if we are talking discrete transistors....

typical current starts at .3v apply to each jinction

2n3055 is an npn power transistor

put the collector on the +13V buss
put the emitter on the ground
with +1 volt the base you will see 1A collector current
with 2 volts 2 amps
with 3 volts 3 amps
all the way to about 15v and 15 A
the current will be the with any collector voltage to about 60V

this is commonly used for constant current sink or source

this effect is very non linear with base voltage below .5 or collector voltage below 1.5v

2 questions for the cheap hi power zener mentioned

what is the voltage for the low pwr zener to get 2.5V?
can it sink more than 2A? http://www.ultracapacitors.org/images/fbfiles/images/hize.GIF

============================================================================

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 16:48

I was thinking to balance pair-wise, so one has 5V to play with.

The whole point is that the Zener does not sink a lot of current.

============================================================================

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/01 18:39

There’s a lot of issues to consider that deserve separate threads. (For example: why does Firefox4 keep losing all my tabs when I restart it?) But I think this question is answered. As I best understand it:

For a series of more than three caps, we need some form of balancing to limit the maximum voltage seen by each cap. Even if the overall voltage is acceptable, if one of the caps shorts, it could trigger a cascade failure of the rest of the series without the balancing.

PeteTy’s idea of a series of forward-biased diodes appears to be the cheapest and most efficient approach I’ve seen, although it limits the value to multiples of the forward bias value (somewhere around 2.1 volts for 1N54xx diodes). (This is not a limitation for me, because I’d much rather operate them for decades at lower voltage than years at a slightly
higher voltage, in spite of the overall energy I'm giving up.)

This still doesn't eliminate the need for any overall voltage protection and current limiting. If I dropped a wrench shorting out a bank of 56 fully charged caps with no current limiting...not sure if they'd even be able to recognize the charred remains of my body from the dental records.

My thought is to put a 3A125V slow blow fuse on the input side of the diodes on the first cap in the series and an incandescent overload light on the output of the last diodes as a warning if the voltage gets too high. Note sure what size fuse to put on the output side of the caps. It would be nice to put a relay in there so that if it ever overloaded, it would break the circuit but keep the light lit from the caps.

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/01 19:26

If you do use diodes, I'd like to see what you come up with for physical implementation. I was going to attach them to small wires with ring terminals (you will notice that your bus bars that come with those caps have small threaded holes which were probably designed for the cell balance boards) and use either those holes or just use the terminals to run them parallel with each cap.

All of my mentioning of that charge controller :) - That is my way of protecting from overcharging. Same idea as your relays, really.

It's nice to have someone designing something similar at the same time.

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 20:18

Notice how the forward bias curve is not as sharp as the reverse breakdown (as used by Zener's)

http://www.thefullwiki.org/Electronics_Course/Electronic_Components/Diode/PN_Diode

that is why the forward idea is not going to work

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/06/01 21:06

next question

"three caps in series dont need balancing"
here is a 2.5 volt bus
with 2 BCAP0010 caps in series
data sheet: 26000F leakage current 5ma

ok the are identical in every way and balanced the 2.5v
will make neither of them unhappy no matter what we do
each will have 1.75 volts all thing being perfect

get a switch and a 1 ohm resistor
close the switch
RC time constant 26000F 26000 seconds 433 min or 7+hours

so after 7 hours the low cap has .65v and the hi has 1.85 v

question 1:
how long until they both have 2.5V again after opening the switch? (clue 5ma leakage)
question 2:
would you like to try again with 5 volts? http://www.ultracapacitors.org/images/fbfiles/images/capbal.GIF

============================================================================

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/06/01 21:32

as for the sharpness of the curve
you are missing a minor point
the regular diode is on log paper
the zener is on linear paper so the sharpness is a bit misleading for voltage regulation you want a constant current
source on the zener to get a constant voltage output

the regular diode current is under a milliamp at .5v
and 10A at one volt

from the capacitor discharging itself at 5 ma you may not see any difference with 4 diodes if cap is at 2v at 2.5 volt it
should drain 300ma

these diodes again are $7 per 100
a big transistor is $1 a small zener is $1

============================================================================

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 23:04

"the voltage drop across the diode will remain fairly constant"
if fairly constant is enough in this application.
Your own example had it varying by a factor of 2 (0.5 ->1V)

============================================================================

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 23:24

15 x 4.7V 5W Zener's are about $2.99 (+$4.39 shipping) on ebay (for balancing in pairs)

In practice no balancing was needed, as the voltages I measured in my UPS application were

2.234V
2.300V
2.283V
2.233V
2.212V
2.253V

i.e. +/- 2% variation, and nothing remotely close to 2.5V (a 2.8V surge is allowed); so I never did install the 4.7V Zener's

============================================================================

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/01 23:43
Perhaps someone can help me here, it is Maxwell themselves that state that up to 3 capacitors in series don't need balancing, but at the moment I can't find this statement again.

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/02 11:37

By conservation of charge the leakage current is the same in each and every series capacitor (so your example is invalid).

The capacitors are forming a voltage bridge, and given enough time the array will drift back to the 'balance' dictated by this bridge. i.e. it is stable, and given enough time the array will make its way back to this 'balance' I say 'balance' as it will have a skew of its own due to the capacitors not being identical, and that is what we are measuring.

So if one accidently discharged just one of the capacitors, then this imbalance would be corrected given sufficient time; of course if the accidental imbalance was sever enough, damage could be done.

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/03 21:08

Assume I had a series of 10 caps and was charging them with 24V at 3A. Eventually, as the caps charged, would the end of the diodes on the last cap begin to conduct voltage when then caps were charged to 21V (10*2.1V)?

Suppose I put 5 diodes in parallel (15 diodes per cap) to increase the current capacity to 15A. Could I connect one of the micro grid tie converters to the final diode pair to drain the excess voltage?

If this configuration would work, the solar panels would charge the cap series completely and then feed the rest to the grid. If the grid power failed, a regular UPS connected to the cap bank rather than a battery would switch to run off the caps until the grid power was restored.

Now, if using the caps series as a voltage divider (as I described in the DIY Solar UPS II thread), then my thought is to connect nine Any volt3 in parallel to the final cap to drain the final 50% of the series. The result should be:
When the caps are empty, the panels would charge the series to 21VWhen the series is full, the excess power would flow back into the grid via the GTIWhen the grid fails, power would initially be drawn past the half way point in the series (cap 6 at 12.6V)When the charge per cap drops to 1.75V, it would switch to cap 7 at 12.25VWhen the charge per cap drops to 1.5V, it would switch to cap 8 at 12VWhen the charge per cap drops to 1.3125V, it would switch to cap 9 at 11.8125VWhen the charge per cap drops to 1.17V, it would switch to cap 10 at 11.7VWhen the charge per cap drops to 1.05V, it would switch to the AnyVolt3 until the total series dropped to 3VThis would allow me to use about 85% of the theoretical capacity of the series. The first 9.3V of the voltage drop would be extremely efficient. The last 6.3V would be at about 85% efficiency.

If I could connect the solar panels in series via diodes, then I could scale the thing up to 56 caps in series at 117.6V and use it until the entire series dropped to 3V.

Which would be pretty awesome. So I'm guessing I must be missing something.

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/10 12:16

Well, the latest goodies arrived and I've had a chance to try a few things. In no particular order:

Feeding a series of 12 caps with no balancing through a blocking diode from all six solar panels (6*15W=90W) gave me a maximum of 22.29V. The caps showed -7% to +15% variation in voltage from cap to cap versus the average per capThe lower voltage caps drained faster under load than the higher voltage caps, increasing the variation. I didn't expect and don't understand why. It takes way too long for the caps to
rebalance themselves (weeks? years? not even sure how to figure the values out) If some sort of dynamic load is draining some of the caps but not others, it will need an active circuit to rebalance. I haven't had much luck tracking down information on how a series of caps charged at different levels behave. The leads of the diodes aren't long enough to connect between ends of a cap. With three 1N5401 diodes in series, I see 25mA at 1.96V, 115mA at 2.164V. Amperage rose to 132 mAs as the diodes warmed up. Not all the bus bars have holes in them. Balancing by the pair seems a better way to go just for laying out the parts. At 3.301V and 2.4A, the diodes are too hot to hold. Still lots more to figure out. In the mean time, I thought of another balancing topology that's much more efficient. Still working on it.

I'm also a little puzzled by how the caps would behave if a higher voltage at very low amperage was applied. If an empty cap got 20V at 1mA, would it be damaged? I think the answer depends on the chemistry of the cap.

---

Re:Negate need for balancing with more caps?
Posted by XA Hydra - 2011/06/10 12:27

You can charge the caps at a higher voltage. Just keep a meter on the cap and remove the source of charge when the caps voltage approaches its limit. I could put 30v to my 15v bank- voltage would equal the cap and rise slowly (well, depending on the current) I would yank the source away after about 13v or so to be safe.

---

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/11 13:01

I'm not sure if I can charge with a higher voltage or not. From what I've read, the voltage limit is a based on the chemistry within the capacitor. Charging with a higher voltage would eventually damage it (actually damage it a little bit with each charge).

I think it could be charged from another, higher voltage cap, though. The output voltage from that cap would slowly rise and could be used to cut out the charging when the ultracap reached the desired voltage.

I think the balancing diodes need a current limiting resistor too. Perhaps a 70K ohm?

---

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/11 13:29

Such a high resistance would completely negate the Zener, when the Zener is carrying 1 amp the capacitors are now 70,000 volts...

---

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/06/13 16:52

with a 4.7v zener across 2 caps in series

if the charging never exceeds the 1A (5w 5v diode)
Vc1 + Vc2

---

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/13 16:57

I tend to agree with Pete, some sort of voltage limiter is a good idea.
When I look at my tiny 5W Zener's I doubt they could dissipate that sort of power unless soldered into a circuit board.

Using the cross-bars as heat-sinks might be a good idea.

============================================================================

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/13 18:44

Would a .3 ohm 5 watt resistor in series with the diodes to safely limit the current to 3A (the diodes' limit)? (Assuming I never see more than 3V across the cap)

============================================================================

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/13 19:03

3 amp across .3 ohm is about 1V; are you OK going 1V above the Zener voltage? Your Zener would then have to kick in at about 1.5V, not so great.

I would use the transistor trick, bolting the transistor to the cross-bar (as a heat-sink); you might be able build a 60W Zener this way, which might be able to look after itself.

============================================================================

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/13 20:47

I don't think this is going to work.

I set up three ultracaps in series. First is at 0.944V. Second, with three diodes in series shorting it, is at 2.462V. Third is at 1.983V, total 5.39V. Charging all three from a 5.64V power supply around 1600 mA. I see about 1.7V dropping across the diodes at about 170 mA, but the voltage across the middle cap continues to rise. I stopped it when it hit 2.475V.

The problem as I understand it is that when the voltage limit on a cap is reached, the balancing diodes need to pass at least as much as the charging current or the voltage will continue to rise. In this case, if my safe voltage limit was 2.462V, then it would protect it if it was being charged by no more than 170 mA, but not more.

Perhaps the diodes could be used to bias a transistor that would short the cap once the voltage limit is passed?

============================================================================

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/13 20:58

http://sound.westhost.com/appnotes/an007.htm

============================================================================

Re:Negate need for balancing with more caps?
Posted by PeteTy - 2011/06/14 05:03

that zener is exactly the same as my painstaking drawing posted o so many weeks ago it spells out ABOUT 1.5v drop thru the transistor a darlington but now you know to use a transistor you need about a 1V zener for that 2.5v shunt regulator

the troubles are related to the lower voltage

the non linearity of the components at the low voltage
Rod Elliott (ESP):
"A darlington transistor can also be used for higher current, but will add around 1.5V to the zener voltage. Whether this will cause a problem or not depends on the circuit itself, and is not something that can be predicted in advance."

base emitter voltage is pretty much directly related to collector emitter current

if you use this scheme or any other plot an IV curve

---

the zener transistor solution is for higher voltage
the example is 50V
if we are talking about 3a 50V that requires about 100 square inches of heat sink for that tip45

....

Mark has done a wonderful job in actually testing the viability of the various solutions

------------------------------------------------------------------

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/14 07:12

Balance pair-wise, or use a single transistor, and not a darlington.

------------------------------------------------------------------

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/14 15:12

18 hours later, series is at 4.89V (90.72% original charge), cap1 is at 0.846V (89.62%), cap2 at 2.101V (85.34%), and cap3 at 1.940V (97.83%). The charges are a little off because I accidentally shorted it briefly while trying to measure current.

There's a time value in all this, the time it takes for the caps to balance. With passive balancing through a resistor, you can make the circuit balance more quickly by reducing the resistance, but it would have the same problem I think.

Time for more testing...

------------------------------------------------------------------

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/14 15:26

At one point you suggested running from a sub-array then adding a fresh cap, running some more, etc

Not only would this lead to terrible unbalance, it would drive some early capacitors negative, destroying them. I hope you are not doing this.

Yes, rebalancing will be a very slow process, and you probably want to discharge each cap separately, and start over.

------------------------------------------------------------------

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/15 21:36

Another data point:

Balanced three caps to 1.603V each, put them in series, and then charged the series to 7.006V:
2.274V, 2.376V, 2.356V.

Attached the balancing diodes to just the middle cap and left it on the charger overnight at 7.006V:

2.360V, 2.169V, 2.477V

I measured 6.97-7.06V coming from the diodes at 109-112 mA. The diodes worked to bring the voltage down to about what I expected. I then disconnected the charger and let it discharge with the diodes attached. The series ran down to 6.818V (97.32% of the original):

2.325V (98.52%), 2.045V (94.28%), and 2.448V (98.83%)

Even when the voltage is in range, the diodes are putting some additional load on the cap.

I left it with the diodes removed for a while longer. It ran down to 6.770V (99.30% of last measurement):

2.304V (99.10%), 2.036V (99.56%), 2.430V (99.26%)

I'll have to go out and get a 70 K ohm resistor and try it with that for comparison.

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/15 21:42

Not sure what you mean by driving the capacitors negative. Could you explain?

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/16 07:25

Zener diodes should not do anything for balancing, just protect the capacitor from over-voltage, which is all one really needs.

Driving the capacitors negative means charging them the wrong way around, which can harm them.

Take for example a VERY badly balanced array, which is then fully discharged; some of the capacitors will now have a negative voltage. It is hard to be so very unbalanced for this to be an issue, but your idea of adding fully charged capacitors as you go along could cause such a problem.

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/16 11:36

Think of it this way:

run a toy on a set of batteries, till it starts weakening; but you can only find a few replacements, so throw those in anyway.. now the original batteries remaining will run down even further and eventually will be driven into reverse voltage...

The Zener diodes should only by-pass over-voltage, so should not effect the balance at all... why are yours causing unbalance?

Re:Negate need for balancing with more caps?
Posted by markgwoodruff - 2011/06/16 22:17
Only had the diodes connected to the middle cap

Re:Negate need for balancing with more caps?
Posted by shiekh - 2011/06/16 22:24

A book worth recommending is

The Art of Electronics by Horowitz and Hill

Re:Negate need for balancing with more caps?
Posted by faah - 2012/01/30 21:34

need diagrams/link on supercap over voltage protection circuits...tq5

Re:Negate need for balancing with more caps?
Posted by Antonm - 2012/02/03 23:01

I agree with the general approach. A forward biased Si diode will drop about 0.6v at low current. At a high current they may drop as much as a volt, so just remember that 0.7 is a rough number at a moderate current. If you instead go with one Zener diode, you reverse bias it, so the stripe goes the opposite way. Zeners come with different wattage ratings, and a heat sinks helps.

Re:Negate need for balancing with more caps?
Posted by Antonm - 2012/02/03 23:15

The problem with using more caps in series is your capacitance goes down, ie. two 4F in series yeild 2F, four 4F in series yields 1F.

ESR is not the issue, it is how well the capacitance and leakage currents match from cap to cap. You can probably minimize it by using caps from the same manufacturer, of the same capacity and from the same production run. I'd put them in series and put a safe voltage across the bank and make some careful measurements with a DVM with a high input impedance. Then apply your balance network, hopefully, there won't be much it needs to do.

Re:Negate need for balancing with more caps?
Posted by shiekh - 2012/02/04 00:56

That is not a problem at all.

Lets say one has 6 capacitors in series; the capacitance goes down by 6, it is true, but the voltage goes up by 6.

Now, the energy is C V^2/2 so the energy has gone up by a factor of 6

i.e. 6 capacitors in series has 6 times the energy.

Re:Negate need for balancing with more caps?
Posted by faah - 2012/02/08 09:56
for a single super capacitor can i used the parallel diode method for over voltage protection....

Re:Negate need for balancing with more caps?
Posted by shiekh - 2012/02/08 10:53

You'll want a Zener diode for protection, the forward curve is not steep enough.