Re: battery charger topology

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- *From*: reggie <veggiedom@xxxxxxxxxxxxxx>
- *Date*: Thu, 31 Jan 2008 05:21:39 −0800 (PST)

On 31 Jan, 01:59, MooseFET <kensm...@xxxxxxxxx> wrote:

> On Jan 30, 11:33 am, reggie <veggie...@xxxxxxxxxxxxxx> wrote:
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> > On 30 Jan, 05:06, MooseFET <kensm...@xxxxxxxxx> wrote:
> >
> > > On Jan 29, 6:29 am, reggie <veggie...@xxxxxxxxxxxxxx>
> > > wrote:
> > >
> > > > Hi all,
> > > >
> > > > My battery charging knowledge is limited,
> > > > but I know a bit about SMPSU
> > > > design.
> > > > I was wondering what topologies and silicon
> > > > could be used to deliver
> > > > substantial powers used to charge a 300Ah
> > > > 24V lead acid battery bank
> > > > (employing three stage charge curve like
> > > > :−http://www.electroparts.com.au/images/bc_chart_large.jpg).
> > > >
> > > > I have thought:−
> > > >
> > > > 1) Front end boost circuit, to give unity PFC
> > > > and constant voltage
> > > > over wide input voltage range

This is a good way to go. Since battery charging doesn't need ripple
free current, you don't need the huge storage capacitors you would
normally have to build into the design.

The down side of making a booster that produces a constant voltage is
that you have to design for both the low line and high line cases.
The high line case, sets the voltage you must boost to. The low line
sets the current in the transistors.

At these high power levels, you may be better off letting the current
peak mains voltage set the booster's output voltage.

> 1.1) But have read that due to high peak
> currents can be unusable at
> powers above 150w (onsemmi switch mode
> PSU reference manual SMPSRM/D
> rev 3B July 2002 page 9)

I think they've set that point a little low. You can get some really
amazing transistors these days. I would still question going over a
few hundred Watts with just a simple booster design.

> 1.2) Should I parallel up boost circuit or go
> to duel−phase for higher
> powers (not just components entire circuit)

If you are going with a booster design, I would suggest that you go 3
phase or perhaps even 5 phase. More phases makes it much

easier to
keep the ripple current of the booster out of the input circuit.
You
are going to end up with some fairly large (physically)
inductors in
the design.

> 1.3) What effect would the input frequency
> swing have on the boost
> circuit?

Within reason, changes in the mains frequency have no great
effect.
The lowest frequency is considered in the size of the storage
capacitors,

> 2) Probably a full isolated bridge with
> synchronous rectification.

At 24V the advantage of synchronous rectification is just
about gone.
If you do go this way, I suggest you put large schottky
recifiers
across the rectifier MOSFETs. This reduces the losses at the
switch
off point. Normally you either end up with the MOSFET
conducting
backwards briefly or its substrate diode takes a pulse of
current.
With the large schottky diodes, you can error in favor of turn
the
MOSFET off a bit too quickly and not have substrate
recovery time
causing losses.

> 3) what effect does the three stage charge
> cycle have on output
> voltage and current the PSU supplies (told
> you I don't know much about
> battery charging)?

You are just making a "variable power supply" and then varying it
based on the battery.

> 4) Are there any good guides for designing lead acid battery chargers
> within this power range?

Buy a face shield.

> 5) any application guides / circuits on the net for this type of
> application?
>
> specification:
>
> Input voltage: 90 − 260 VAC RMS
> Input frequency: 40 − 100 Hz
> Nominal output power: 600 W +/− 5%
> Nominal output current: 25 A
> Rated battery voltage: 24 VDC
> Operating amb. temperature: −25ºC to +40ºC
> Efficiency: >85%
> Cooling: forced air and none forced air
> Package:187mm x 116mm x 50mm− Hide quoted text −

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Thanks for your reply Moosefet,

Just to summarise what I think you said,
and to clarify in my mind the topologies required

−−− mains i/p

Via EMI filtering

−−− full wave rectification

A bit more EMI filtering> −−− res. caps to supply boost circuits

No, the big capacitors are on the output of the PFC circuit. The bridge only has EMI capacitors on it.

−−− say 3 to 5 parallel active boost circuits to minimise ripple current and to perform PFC (with smallish res. caps)

Yes.

−−− I thought constant boost rail but you think variable

Yes, I don't think you should work hard making it constant.

−−− full H bridge circuit with transformer to step the voltage down, provide isolation (100kHz)

100KHz may be a bit fast for the power level. Try to design the transformer and see what happens. Do you need a core you can't get?

−−− secondary side of transformer employing centre tap and two rectification devices (maybe synchronous rectification)

Yes.

Don't forget the output side chokes. You are making a forward converter here.

> At these high power levels, you may be better off letting the
> current
> peak mains voltage set the booster's output voltage.

1) I am not sure what you are getting at, could you please explain.

> The down side of making a booster that produces a constant
> voltage is
> that you have to design for both the low line and high line
> cases.
> The high line case, sets the voltage you must boost to. The
> low line
> sets the current in the transistors.

2) don't you just design components for low line max o/p power, e.g. make sure boost choke doesn't saturate in this condition and also work out power losses,

Yes you work from the low line case to find the stress on the inductor. You also will find that the transistors are conducting their hardest in this case. Lowering the boost rail at low line can save a bit of power in the transistors.

RMS currents throughout circuit to assist in component selection.

Remember that RMS only works when things are resistive. On diodes it is closer to the average current that matters. On MOSFETs, the on voltage is very non−linear near their upper limit. Stay well away from that case.

Then let the control chip worry about keeping the voltage constant. I think i need to get under the hood of the control chip.

Draw out the whole system assuming the control chip must be pure magic. Then think about what the control chip must do. Then find one or add circuits to one to do all the functions you need.

> 3) doesn't the boost rail need to be relatively constant to send to the full bridge converter? However I take your point about ripple current and battery's.

The batteries are not at the same voltage every time nor is the mains voltage. Why should the boost voltage be?

> 4) I have never used synchronous rectification in practice, but I thought as the high currents even with a shottkey power diode the losses would be big. Especially since in one design there is no fan. Why do you say at 24v the benefits are just about gone?

You have to apply a near perfect gate drive to the MOSFETs but there is a large S−D swing on the MOSFET. This makes the drive circuit harder to do. Schottky rectifiers only have a large forward drop if you don't use really huge ones. The MOSFETs will cost nearly what the really huge diodes do.

> > > 4) Are there any good guides for designing
> > > lead acid battery chargers
> > > within this power range?

> > Buy a face shield.

> 5) Squint before you turn it on and build a bunker more like!

Squinting isn't nearly good enough. The can of a capacitor went past by ear so fast I didn't even know what happened. All I knew was that there was a loud bang and I could no longer see the circuit for the smoke. The insides were like a cloud of dust filling the whole room. They eventually settled to the floor and I could see that one capacitor was missing.

> Thanks again,

reggie.− Hide quoted text −

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Thanks again but i have more questions,

1) I take your point about EMI filtering, I cannot possibly describe everything in this forum format. Engineers couldn't be engineers without diagrams!!

2) My silly mistake about the res. cap. after the bridge rectifier; I know the boost circuit requires an un smoothed full wave rectified sine wave from the bridge rectifier so it can do its PFC thing and provide an input current waveform in phase with the voltage.

3)I have never used multiphase active boost circuits only single phase with parallel fets to reduce losses. What controllers would you recommend? Would you go for multi phase as apposed to multiple components single phase:

a) primarily to reduce ripple currents in the boost cap due to this high power specification; thus increase caps. lifetime.
b) reduce emi due to reduced ripple currents in boost cap?
c) distribute losses across many more components.

I know it depends on the application and there are many more things to take into account, but in this application what jumps out at you to go down the multi phase boost route?

4) You think variable boost rail. I take your point about battery's not needing constant V&I and tolerating high ripple currents, but as I don't know much about battery's, I am not sure what to design the PSUs output conditions to.

−For the full bridge o/p:

5) Should I design to deliver to the battery nominal 25A at 600+5%W thus 630/25=25.2 say 26V o/p voltage at min I/P V (thus max full bridge forward fet on time)?

I know it depends on battery charging time lets say (300AH/25A=12H charge cycle) ignoring the three stage charging for the moment.

6) With a variable boost voltage rail I am not sure what the max/min input voltage to the full bridge forward converter would be. Therefore I don't know the max volt seconds across the primary of the transformer thus I cannot work out the primary turns and thus the

turns ratio.

Np=(Vl*dT/Ae*dB) = ((pri V ????− 2fet DS on drops)*Ton)/(Ae dB)

Vl =???
dB = set to say 250mT (using voltage feed forward)
Ae = (need to choose suitable core)
Ton = set to max, at min pri voltage including dead time (also involved in core selection − size/frequency)

7) May be a silly question but if battery's don't mind high ripple currents and voltages then could I get away with a small output choke inductance and small output cap.? If this is the case then how would I implement the feedback loop? It would be all over the place. Sorry for all the questions, just I am not use to designing battery chargers.

The MOSFETs will cost nearly what the really huge diodes do.

8) I take your point about the cost, but I was more interested in losses and heat generation inside the box at these kind of output currents.

For a full bridge Duty Factor for each o/p diode= approx = (0.8T/2)/T = ton/T = 0.4 and for a flat top equivalent current pulse with its peak being the same as the o/p output current, the Iaverage = peak *square root(DF) = 25* square root (0.4) = 15.8A say 16A this would give a loss in one diode of say (vf =assume not checked =0.3)*(I diode av=16) = 4.8W if my maths is correct.

This doesn't seem too bad, but I would have to work out the total losses inside the box and see if I can maintain max component temperatures − de−rating values.

8) I think this is enough for now, but I am trying to figure out what conditions to set the individual topologies to and what output conditions are required for charging a huge 24v battery.

Thanks for your help, it is really making me think...

Reggie.

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