Re: PWM Amp Design

Source: http://sci.tech−archive.net/Archive/sci.electronics.design/2005−04/msg02078.html

- *From*: Chris Carlen <crcarleRemoveThis@xxxxxxxxxxxxxxx>

- *Date*: Mon, 11 Apr 2005 10:59:47 −0700

Larry Brasfield wrote:

> > What kind of DC accuracy do you need? Can
> > gain variation induced by 80V supply variation
> > be handled by an outer loop? Or does this power
> > amp have to have very tight gain and offset specs?
> > (Until it appears necessary, I hesitate to add a pole
> > at zero just to reduce maybe tolerable error.)

Yes, tight DC performance is needed. Gain can vary a few % but offset not.

There are also nonlinearities in the transfer of the SA60 that should be servoed out. Thus, an integrator is desired.

> Upon further reflection, an integrator in the forward
> path to get precise gain and offset is no big deal.
> With a little tweaking to get the 3 poles properly
> related to each other, the group delay easily falls
> within a couple uS band out to 400 Hz. With even
> more effort, (ajusting the zero positions and care
> in setting loop gain), the 3 poles could be made to
> conform to a cookbook equiripple group delay LPF.
> From the initial results of simulation, I see no need
> to bother with that mathematical exercise.
>
> ...
>
> > > They will be designed to hold up at least
> > > 75% of their inductance to 10A.
>
> > Gapped parts would do better. If the open−loop
> > response can be kept more predictable, it will be
> > easier to control the close−loop phase delay. The
> > LC poles do not have to be kept so far out.

I don't want to use a gapped core since they don't work well with the physical constraints. I want a low profile off the PCB. I am choosing to use a Magnetics Inc. Kool−mu toroid core. I originally calculated for

100kHz switching freq., 10kHz LPF cutoff, so 27uH. Bumping the inductance down a little bit should make the same cores actually hold better than the original 75% of inductance at 10A. Haven't done the math again yet, but hopefully about 80%.

> For the simulation included below, I set the LC poles about 10 times closer to the origin, similar damping. This should take down the ripple most of 40 dB. It can work to set the filter higher, but the shifted poles get closer to the switching frequency than I would like to see.

But that doesn't help much. A pair of 225uH inductors + 2x72uF of caps that can handle 10A is likely to be larger than my equalizer and may very well dissipate a lot of power anyway. Maybe the equalizer isn't so bad. Remember, for the real application, there really will be almost no frequency content above 150Hz. The extended bandwidth is just for phase flatness at the low end.

> > > So far I haven't dealt with any cases of having complex poles in the open loop, so this is virgin territory.
>
> > That's were it becomes fun. With a few more answers, I am inclined to simulate a controller and idealization of your plant.

> Following is source for an LTSPice simulation (see http://www.linear.com/company/software.jsp) with the 2 zeroes and 1 pole in H, and 1 pole at 0) in G. This is not any kind of final design, but it does demonstrate how easy it will be to attain the performance so far mentioned. For a real circuit, there may need to be a bit more filtering to keep switching junk out of the first near-differentiator (or it may be fine as is). It will certainly work to use slower op-amps.

[edit]

> The above simulation should be a convincing demonstration that using the controller to get the PWM filtered output response apparently desired by the OP is feasable and unlikely to present serious problems. Obviously, gains and maybe offsets will need adjustment once the VCVS is replaced by the PWM IC. When current limiting is put into place, some attention to limiting in the controller will be in order. A sensitivity analysis for L and C variation would be smart. It might be a good idea to make sure no limit cycles are possible, using time domain simulation and a range of step inputs.

Ok, other than the question marks to which Genome unsurprisingly overreacted, I can use the simulation.

Thanks for the demo. I think I can learn to compensate in this manner. For now, it seems to my advantage to procede with the simple but functional circuit that I'm using. But your input has provided material for further investigation.

The smart thing to do would be to make the PCB design flexible enough to implement several compensation approaches. I'm already planning to make it switchable to become a current source. That would ultimately make more sense for a position servo. But for now I'm in voltage drive due to legacy issues.

Thanks for the input.

Good day!

--

Christopher R. Carlen
Principal Laser/Optical Technologist
Sandia National Laboratories CA USA
crcarleRemoveThis@xxxxxxxxxxxxxxxx
NOTE, delete texts: "RemoveThis" and "BOGUS" from email address to reply.
.