Like · Reply · 4w

3

James Gertsen Reminds me of the dog in the british cartoon Wallace and Gromit. That dog also has an advanced degree in electrical engineering

Like · Reply · 4w

Ray Ridley Uh oh, would that make me like Wallace?

I think Nick Parks was also an engineer. Who else could be so obsessive?

Like · Reply · 4w

Ray Ridley If they can build a power supply in 4 hours, why can't everyone?

Like · Reply · 4w

Write a reply...

Ray Ridley We have prototyped up to 400 W and 400 V input on these boards.

Like · Reply · 4w

Write a comment...

Ray Ridley
Admin · February 10

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16 5 Comments

Like Comment

David Seal Great value.
Like · Reply · 7w

David Edwards . Hello Ray Ridley,

Does RidleyWorks run properly under both local and online versions of Excel (Excel from Office 2019 and Office 365)? Can these be either 32 or 64 bit?

Like · Reply · 4w

Ray Ridley David Edwards works on all of these.
Like · Reply · 4w

Ray Ridley Retirees get the student pricing. Several 65+ engineers have contributed over the years to its development.

Our LTspice link code writer is actually 74, a lifetime power supply designer and spice user.

Like · Reply · 4w

Ray Ridley I love my student interns who contributed code, but sometimes you have to augment the theory with things that do a practical job.

Like · Reply · 4w

Write a comment...

Kavya Suma
March 3

Hi everyone, I know this might be inappropriate to post here, but I think this might be the only group that actually help me.

I am a master's student in Electrical Engineering at University of Texas at Austin working in Power electronics field, under Prof.Alex, I am looking for an internship opportunity for this summer and fall 2020 in Power electronics field but not able to find any leads and my sole purpose of doing master's was to be able to switch my field from digital area (NVIDIA, where I have been doing digital work full-time) to work in the area of my interest, but I am disappointed that I am not able to do that even after working hard to get here

Sorry for posting this again if this is inappropriate to post it here.

10 19 Comments

Like Comment

Mike West Have you looked at TI, ST Micro, Fairchild Semi and others in Dallas area?
Like · Reply · 4w

Alain Laprade Mike, Fairchild was acquired by ON Semi about 2 years ago.
Like · Reply · 4w

Mike West Alain Laprade and that shows that I am a transformer designer. LOL
Like · Reply · 4w

Simon Broadley If you are interested in power electronics as it applies to audio products, send me a private message. We have some internship openings.
Like · Reply · 4w

Kavya Suma Thank you Simon, please check inbox.
Like · Reply · 4w

Christopher Compton Go to Jabil.com

JABIL.COM
Simplifying Complexity. Delivering Value. | Jabil
Like · Reply · 4w

Nemo Naim Look on Cree's web page, lots of internships available there
Like · Reply · 4w

Kavya Suma Hey Nemo, thank you. i did apply. But not heard back.Please check your inbox.
Like · Reply · 4w

Pranit Pawar in the meanwhile, you can always work with your professor
Like · Reply · 4w

Venkat Karthik Try lucid motors , Infineon, signify and google has an opening for EMC engineer for voltage regulators (internship). And try autonomous vehicle companies(plenty of startups : waymo, zoox aurora , Lyft). At the end of the day you need to know how a buck converter works.
Like · Reply · 4w · Edited

Alain Laprade Adding to Venkat, I'm aware ON Semi is hiring interns this summer, but do not know status of posts. Monitor the web site once in a while. FYI that when someone contacts me, I have to redirect the candidate to our web site.
Like · Reply · 4w

Marcus Lim I think Typhoon HIL is a great internship option for you. You have both power and digital electronics background and Typhoon is working on emulating real power electronics systems in the digital realm. https://www.typhoon-hil.com/careers/ You'll have to travel to Europe though.

Careers - Typhoon HIL

Like · Reply · 4w · Edited

Ray Ridley We also have an internship program. We have our internes do a lot of hands-on work, less of the theoretical. Just like our workshops. Send us a resume with your interests.

Must have US SSN.

Like · Reply · 4w

Bharadwaj Reddy Kavya Suma. Hi kavya please add me on LinkedIn - i can suggest your profile to my network.

Like · Reply · 4w

Henry Newton Try applying to electrical power companies

Like · Reply · 4w

Michael Green I can link you to some people at Ti if you add me on LinkedIn http://linkedin.com/in/michael-green-3768642b

LINKEDIN.COM

Michael Green - Analog and Power Supply Design Engineer - Ball…

Like · Reply · 4w

Ray Ridley I would advise looking at smaller companies, in general. The big companies can't really get you inside real projects, so make sure you ask them exactly what they will have you doing in the internship.

Same question for the small companies, of course.

Like · Reply · 4w

Ray Ridley Make sure you talk to past interns to find out what they were involved in.

Like · Reply · 4w

Chris Merren General Atomics in San Diego is presently looking for interns in power electronics...check out the website..

3

Like · Reply · 4w · Edited

Write a comment...

Paul Shepherd

March 4

Is anyone else here attending Space Power Workshop in Torrance, CA, at the end of April? I will be presenting during the Power Management and Distribution session on Thursday morning. It's my first time attending , so I would love to talk with other attendees to help tailor my presentation to the interests of the audience. Thanks in advance!

6 1 Comment

Like Comment

Chris Merren You most likely will have attendees local to that area such as from Northrop Grumman, SpaceX and Aerospace Corporation... The latest RAD-HARD components is always the main subject... Is there SiC FETS qualified for space ??? What if any ITAR u-controllers are RAD-HARD that are usable for SMPS ??? Many of these companies still use Hybrid SMPS controllers...

1

Like · Reply · 4w · Edited

Write a comment...

How many of you use or don't use the Chan hysteretic core model in your SPICE simulations? And why?

I don't for the following reasons;
1) If your worried about saturation it's easy to prove most designs won't saturate without simulation.
2) I don't believe that you will get accurate core loss prediction based on the information provided on the core data sheets and pre canned models in some simulation packages.

Thoughts?

You, Phil Lane and 3 others — 30 Comments

Like | Comment

David Edwards I only use the Chan model in LTspice where I expect the magnetic device to saturate. One can measure the flux level of a non-saturating magnetic to determine if a Chan model is needed. The Chan model is a very useful tool.

Like · Reply · 4w

Stuart Wood David Edwards why don't you just design the magnetics not to saturate?

Like · Reply · 4w

Darrell Hambley The Chan model has a fixed coercive force, Hc independent of rate of change of flux. This may be OK for square-loop material but I don't think it's good for ferrites.

Like · Reply · 4w · Edited

David Edwards @ Stuart Wood,

Some topologies run a core into saturation as part of normal operation, e.g., magamps, certain self oscillating saturating transformer power circuits. Other topologies are prone to flux walking where the onset of saturation is a significant flux centering mechanism.

Also, fault conditions may lead to saturation, for example, if the primary pulse termination control fails and there is a backup protection, but with delay, it may not act before saturation ensues. This will depend on many factors, including core temperature, so a realistic model is paramount.

Like · Reply · 4w

David Edwards @ Darrell Hambley,

Yes, the Chan model has no frequency dependent mechanism to extend its basic hysteresis loss model. One can add RC networks across the core or run multiple capacitor-coupled chan cores in parallel to widen the loop at higher frequencies, but these are bandaids that rarely are worth the trouble.

Usually I make an Excel spreadsheet for each major magnetic component. This is what I use for loss calculations.

Like · Reply · 4w · Edited

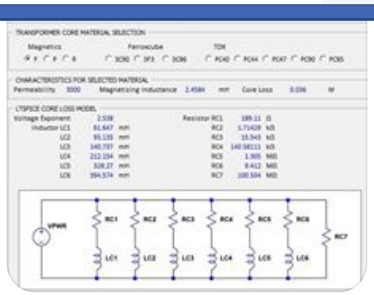
Write a reply...

Stuart Wood David Edwards points out that there are many circuits that are intentionally driven into saturation.

Let's, limit the discussion to SMPS that are not normally run into saturation. How many people take the time to use the Chan Model in these cases?

Like · Reply · 4w · Edited

Ray Ridley Chan is overly complex for a quantityis purely empirical. We use the following simple circuit. Why overcomplicate?



Like · Reply · 4w

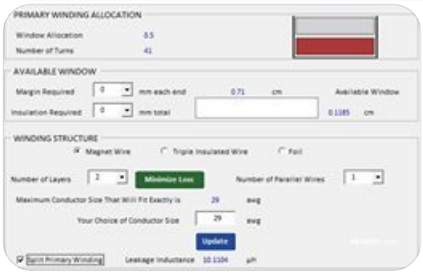
Stuart Wood Ray Ridley does this model also contain the leakage inductance, if you generate it from the frequency response of the primary with the secondary winding shorted?

Like · Reply · 4w

Ray Ridley This model is derived directly from the Core loss curves.

Put in your material, and the circuit model comes out.

The leakage is derived separately from the winding arrangement that is put into the program. We get pretty close, although we don't attempt to model the changing leakage with frequency. The world isn't ready for that yet, apparently.



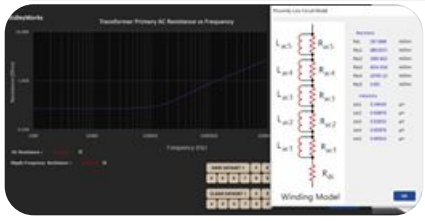
Like · Reply · 4w

Stuart Wood Ray Ridley I'm sorry I'm ment the LR network for the winding loss. Does that include leakage.

Like · Reply · 4w · Edited

Ray Ridley No, separate component. We have an LR network for leakage too, but haven't activated that in our software yet.

You can see in the model below that the 10 uH leakage is not part of the winding model.



Like · Reply · 4w

Write a reply...

David Edwards . Hello Ray Ridley,

The Chan model captures low frequency hysteresis loss only. Your loss model is better in that it represents total core loss over frequency, but it does not model saturation, which, when needed, is a good reason to use the Chan model.

Like · Reply · 4w

Ray Ridley If you have saturation, you shouldn't be designing power supplies.....

Look for it, if you see it, add turns as needed, and stop trying to model it.

David Edwards @ Ray Ridley,

Magamps, self oscillating saturating topologies, flux walking?

Like · Reply · 4w

Ray Ridley The needs of the 1% shouldn't drive the model complexity of the 99%.

I know what you are saying, my first ever design depended on saturation. It was just modeled with a single line of PWL code which did fine. Later on we eliminated the need for a saturating inductor since it overheated - as do just about all of them.

I sincerely doubt any simulation is going to track the realities of flux walking on the bench. That's why we see a lot of examples where a transformer saturates when the designer didn't see it in the simulation.

Like · Reply · 4w

Ray Ridley Our model also captures the extra loss when you have different duty cycles.

Like · Reply · 4w

Stuart Wood I agree, but I'm trying to get a sense of what people generally do. I'm working on a white paper on modeling magnetics. I know what I do but I don't want to speak for the rest of the world.

Like · Reply · 4w

Ray Ridley Tell us what you do, Stuart Wood.

Like · Reply · 4w

Stuart Wood Ray Ridley, I've been heavily influenced by you and others. At the start of a design I don't expect simulations to give me losses. I use them for proof of concept, in the areas of large signal performance, loop stability and rough estimate of losses in my semiconductors.
If thing look ok then I move to a prototype. Build my magnetics and measure them. Build my magnetics models based on the measurements. Repeat Sims to see if they reflect the higher order effects on the prototype. Rinse and repeate. I've seen companies that are trying to reduce snubber losses in sim. When they've never properly characterised there magnetics! Only have a DC resistance and an estimate for leakage...

Like · Reply · 4w

Stuart Wood My general opinion is that engineers in Areospace like to latch onto things like the Chan Model or someone's implementation of Steinmetz equation when doing worst case analysis and think they have this great model, but when they don't study these in depth. It becomes garbage in garbage out.

Like · Reply · 4w · Edited

David Edwards @ Stuart Wood,

Garbage-in, garbage-out is the bane of injudicious simulation.

Like · Reply · 4w

Ray Ridley Completely agree, but it is not just the aerospace industry.

Like · Reply · 4w

Ray Ridley Core manufacturer's data is often woefully inadequate. But what else can you do?

At best it is typical loss, they explicitly say that. No such thing as worst-case data.

Like · Reply · 4w

Stuart Wood Ray Ridley that's one of the reasons I think it's garbage in, garbage out.

Ray Ridley Well, not entirely. A loss estimate, even if it is typical, is better than nothing. Most simulations call the core loss zero, which is even more garbage.

Our models match the curves, and also move with the duty cycle of the signal. They will overestimate, if anything.

Aerospace designers are really in a tough spot. They have to do WCA to satisfy the contract. We at least help them make an informed guess at it. As long as it is backed up by good thermal data, all is OK.

Like · Reply · 4w · Edited

Nicola Rosano I use similar RL ladder models for core losses and proximity effect. Cauer or Foster syntesis network approach

Like · Reply · 4w

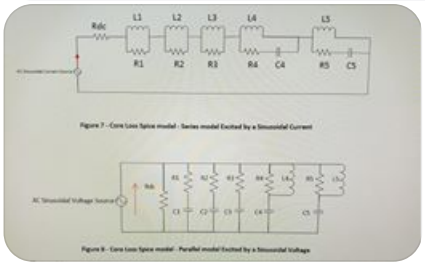
Ray Ridley One day, everyone will do this. Congrats, Nicola Rosano, on being one of the first in our industry to go there.

But it will be SLOOOOOOW for everyone else to get there, especially as the magnetics companies are providing serious friction to this.

With our software, it is so easy. 5 minutes in, and you have LTspice and PSIM models and circuits automatically generated, ready to run. You have to decide if it is worth spending a little money to move your analysis 100 years ahead of the conventional models.

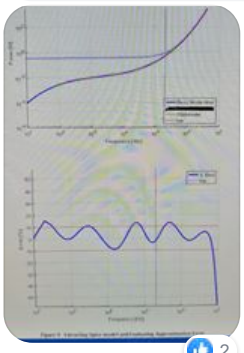
Like · Reply · 4w · Edited

Nicola Rosano Mine. Airbus colleagues in UK confirm they continue to use that approach 🙂



Like · Reply · 4w · Edited

Nicola Rosano Modeling error less than 10%. This was for 3C98 material if I'm not wrong



2

Like · Reply · 4w

Ray Ridley Interesting using Cs instead of Ls. I think I like that.

However the source should not be sinusoidal - has to be raised to a power or the characteristics aren't captured properly.

Like · Reply · 4w

Write a comment...

Ahmed Salah
March 1

Could connecting non-invasive current probes (like hall effect or rogowsky coil) to the power circuit change the circuit performance or reduce the efficiency somehow ? And why ?

You and 3 others — 14 Comments

Like | Comment

Jesus Elias Valdez Resendiz They will always take an small amount of energy to perform the measurment, but it can be considered neglectable in the case of active current probes

Like · Reply · 4w

Bryce Hesterman The data sheets of the Hall effect probes specify the insertion impedance as a function of frequency. The impedance increases significantly above the probe bandwidth. I expect that Rogowski probes would have less effect than Hall probes.

Like · Reply · 4w

Ahmed Salah Bryce Hesterman ok that makes sense, thank you for the information

Like · Reply · 4w

Brian Faley If you have to lengthen the lead of power device or increase the loop inductance, the act of adding the probe can substantially alter circuit behavior for the worse.

Like · Reply · 4w

Ahmed Salah Brian Faley yes I understand. But actually even after that when I insert the probe or take it out the efficiency is different

Like · Reply · 4w

Alex Berestov Yes it could, yes it does. Why: due to the nature of things.

Like · Reply · 4w

probe in series with the inductor because, in this location, it will add its small inductance to the already very-large inductance of the SMPS.

Like · Reply · 4w · Edited

Thomas Mathews By the way, do not use DC current measurements from that type of probe to calculate efficiency. Those probes are maybe on the order of +/-10% accurate for DC, and, this will translate into +/-10% which, for efficiency measurement, is ghastly. For efficiency measurements use in-line ammeters which will have much better accuracy.

Like · Reply · 4w · Edited

Ray Ridley Oh yes, they will change the circuit! Don't try putting them in the secondary of a center tap bridge, for example, you might blow it up!

Some places it is OK. Some places it is not.

Like · Reply · 4w

Brian Faley And remember to de-skew the current probe vs the voltage probe on the oscilloscope. There is phase shift through the probe that will wreck any time correlated measurements. Many lower cost scopes will not do this.

Like · Reply · 4w

Ahmed Salah Just to be clear, I'm not using the probe to measure efficiency, only to observe waveforms. What I observed is when I insert the probe, the converter efficiency drops by around 0.1%.

Like · Reply · 4w

Jay Lee I never thought that 😱

Like · Reply · 4w

Ray Ridley If you can measure efficiency that accurately, that's pretty good. The phase of the moon will cost you that much sometimes.

Like · Reply · 4w

Write a reply...

Paul Ryan It's very tempting to insert them in the source connection of low-side switches, but beware the (very small) impedance they add - if there are big currents & fast edges then it can introduce significant source voltage, causing changes to the swithching or instability. If inserting the probe in the "hot" connection (e.g. drain) beware of probe's sensitivity to fast signals coupled capacitively - probes are usually screened & very good, but not perfect!. To check this, just connect an open-ended wire to the hot connection and clamp the probe around it to see what it might pick up.

1

Like · Reply · 4w

Write a comment...

Ray Ridley
Admin · February 26

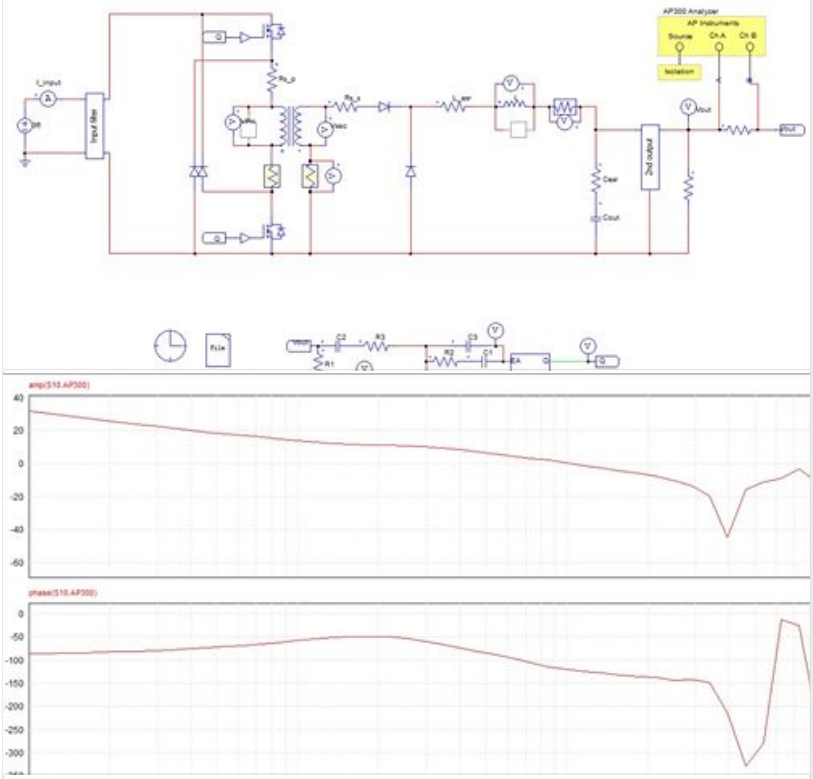
Charting New Territory with PSIM

We are plotting loops from the large-signal transient simulation that have never been done before. Our circuit is exported straight from RidleyWorks into a PSIM schematic.

The loop gain is plotted for a converter INCLUDING the proximity winding model losses of the transformer. The models add an extra 10 inductors to the circuit for simulation.

Here is the new and dramatic part - time to sweep the time-domain circuit from 100 Hz to 100 kHz (as you would on the bench with an AP300 analyzer) -

We have been working with them on this for over a year, and we have finally arrived. We will be demonstrating this for the first time at APEC.



Brian Faley and 38 others 57 Comments

Like Comment

Ray Ridley Just to re-emphasize: there is just ONE circuit built in the simulator, the large-signal switching model. From this, the small-signal sweep is extracted.

Like · Reply · 5w

Amit Kumar Thanks Dr. Ridley!

Like · Reply · 5w

Col Johns That is pretty cool ... a uni could spend a whole year paper in power electronics just on this sort of modelling ...

Like · Reply · 5w

Nicola Rosano I remeber you did it for LTspice. Why with Psim as well?

Like · Reply · 5w

David Edwards PSIM does it much faster and with a much better signal to noise ratio.

Like · Reply · 5w

Nicola Rosano But a normal license is between 15-20k (3zeros)

Like · Reply · 5w

Ray Ridley Nicola Rosano actually PSIM is not nearly that bad. You might be thinking of SIMPLIS.

Like · Reply · 5w

Ray Ridley Send a note to Albert Dunford to get the pricing. I believe they have a lot of optional add on modules that you probably don't need for most work.

Like · Reply · 5w

everything.

Like · Reply · 5w

Nicola Rosano Ray Ridley I used it for years in 3 different companies. Below 15k is hard (1 network license). Without smartCTRL addon.

Like · Reply · 5w

Albert Dunford Nicola Rosano A permanent PSIM Pro standalone licnese without modules is under $4k, there is an annual maintenance program that you can elect not to pay and then you don't get updates and low priority support. This will run any of the circuits exported from Ridleyworks. $15K USD sounds like a network license with a bunch of modules.

Network licenses, modules for digital control, motors, code gen, links to simulink, vhdl, thermal models will add to that.

Like · Reply · 5w

Write a reply...

David Edwards Wasn't PSIM created expressly for this purpose (to measure loop gain in the transient domain)? How is this charting new territory? That the schematic is automatically generated?

Like · Reply · 5w

Ray Ridley No, it was created for speed and convergence. the sweep came later.

Like · Reply · 5w

Nicola Rosano I guess so. The AC sweep multisine function was created time ago and is pretty fast. I use it. The 'mapping procedure' seems to be a new feature.

Like · Reply · 5w · Edited

Hide 14 Replies

Ray Ridley You shouldn't use the multisine injection. theoretically faster if 4 seconds isn't good enough for you, but it is prone to errors.

It's a nonlinear system. You can't superimpose injections.

Like · Reply · 5w

Robert L Rauck Ray Ridley I never use multisine. The sequential sweep method is much slower for complex designs but the results are far superior. Now we are getting high speed.

Like · Reply · 5w

Nicola Rosano Nice point. There are two ways to get AC sweep in Psim (two different algorithms). The speed difference between them is huge. Multisine approach needs to be 'tuned' carefully to work properly.
True they are non linear system but one of psim strenght in just this: look at the stage as piecewise linear function block.
I verified there is pretty good matching between AC multisine results and power stage equivalent linear model.

Like · Reply · 5w

Riccardo Tinivella Multitone analysis is the only way to get control loop from resonant topology not?

Like · Reply · 5w

Bryce Hesterman Nicola Rosano Not

Like · Reply · 5w

Experience gained in LTspice was very useful in doing this.

Last few kinks in the fully automated setup schematic and script files are being resolved right now.

Like · Reply · 5w

David Edwards @ Ray Ridley, One of my coworkers used PSIM (I think it was PSIM). About five or so years ago I compared the transient loop-gain analysis of PSIM to SIMPLIS. SIMPLIS was faster and much cleaner, but it seems now that you have helped PSIM soup up their algorithms and programming and improve their performance.

I asked Mike Engelhardt several times to add this as a native feature to LTspice, but he didn't believe it was necessary when designing the compensation for current mode control ICs (pretty much all LTC makes). Now that Mike has left Analog Devices I don't expect LTspice to improve much except perhaps in the user interface.

Like · Reply · 5w · Edited

Albert Dunford Robert L Rauck We re-worked the sweep so that the sequential perturbation injection is much more intelligent. The original AC sweep in PSIM was very much brute force and a lot of time was wasted waiting for steady state

Like · Reply · 5w

Albert Dunford Riccardo Tinivella no multi-tone or msine is not the only way to get the open loop response of an LLC

Like · Reply · 5w

Ray Ridley David Edwards don't underestimate what ADI might do with LTspice. Mike was a genius at what he did, no one can ever match him.

However, he was philosophically opposed to doing Bode plots, so I wouldn't be surprised to see some improvements in that area.

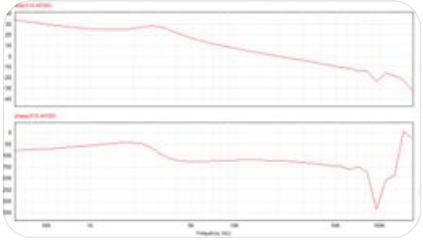
ADI and LT have a culture of hiring really bright people. There are lots of PhDs from Virginia Tech and elsewhere, so I think the future is very promising.

Like · Reply · 5w

Ray Ridley On the PSIM algorithms - they were working way too hard at getting convergence to a given error when I starting working with them. The first attempts at the sweep function were only about 2x faster than LTspice.

We have now accelerated that to be 100x faster than LTspice which is what it should always have been capable of. A little bit of bench knowledge goes a long way in speeding up the simulation whiz kids.

This is the latest sweep while on the phone with them just 5 minutes ago. It is amazingly clean.



Like · Reply · 5w

Nicola Rosano Is there a video about that?

Like · Reply · 5w

We are so busy doing these things, never seem to have time to make a video, but we will endeavor to do so.

Like · Reply · 5w

Nicola Rosano Ray Ridley i'll be happy to join if you go online. Please keep in touch

Like · Reply · 5w

Write a reply...

Ray Ridley I would suggest that no one has swept the loop in PSIM before while including proximity losses for the transformer.

If you can tell me where to find a sweep of a loop including proximity losses has been done, happy to revise my opinion.

Like · Reply · 5w

Robert L Rauck That is indeed new and exciting. I feel like a kid in a candy store!!!

Like · Reply · 5w

Ray Ridley They have also drastically changed the sweeping constraints with our guidance to speed it up a factor of 10 or more. It has been fun.

Last check, we were doing 60x the speed of LTspice.

Like · Reply · 5w

Ray Ridley Here is the official timing:

PSIM sweeps from 100 Hz to 100 kHz with proximity 5 seconds

Like · Reply · 5w

Ray Ridley LTspice sweep from 100 Hz to 100 kHz NO proximity 510 seconds

PSIM goes 100x faster on this problem.

Noise of each sweep is about the same.

Like · Reply · 5w

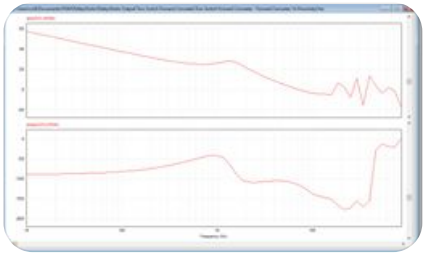
Ray Ridley the speed of LTspice is 100x slower, but it is still a highly useful way to get the results. 8 minutes is not that bad.

Like · Reply · 5w

Ray Ridley Just for completeness, we swept starting at 10 Hz. This is the proper start frequency for any loop in the lab, and in simulation.

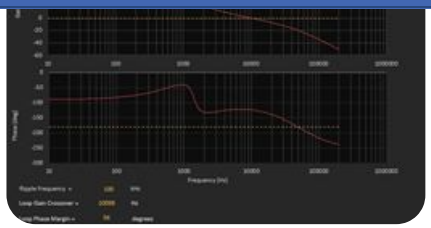
Took only 50 seconds in PSIM. It would have been over 80 minutes in LTspice, but I'm not going to wait that long.

(notice btw, its a different circuit with higher Q)



Like · Reply · 5w

Ray Ridley And here is the result direct from RidleyWorks.



Like · Reply · 5w

Robert L Rauck This is a Godsend!!

Like · Reply · 5w

Nicola Rosano I made a sort of similar comparison time ago for the three basic topologies : buck , boost and buckboost (without proximity). Linear modeling vs AC sweep results were perfectly superimposed for control to output and line to output transfer functions. Some high frequency deviations were present comparing input and output impedances.
I should have 'octave' files somewhere.

Anyway where possible I continue to move for Vorperian solution. With variable frequency stages Psim features (or equivalent) become necessary.

Like · Reply · 5w

Terence Orr What's the advantage of running a transient simulation? Is an AC sim with averaged switch model not even faster? Can you plot this on top of AC sim result to show the difference/advantage?

Like · Reply · 5w

Ray Ridley Terence Orr yes we could plot it but you can too.

For well behaved systems they align well.

Like · Reply · 5w

Ray Ridley Very often you have a control scheme that has not been modeled so no small signal model exists yet.

Simple CT sense current mode with a filter on the current is one example.

Of course we do Vorperian's model as well. It takes the 5 seconds down to a fraction of a second.

Many other advantages to the small signal approach in addition. But as mentioned the models don't always exist.

Like · Reply · 5w

Bryce Hesterman My experience is that transient simulations of current-mode control are much more accurate than averaged simulations because the current ramp gets distorted by things like noise filter, ringing and snubbers.

Like · Reply · 5w

Norman Elias Have you tried the DSIM platform that they're now pushing? Al Dunford just ran a Webinar on it. I'd be interested in hearing confirmation of his claims of 2-4 orders of magnitude of speed improvement over other simulators on the market. Pretty impressive.

Like · Reply · 5w

Albert Dunford Norman Elias If you are in north america I am happy to set you up with a beta license so you can see for yourself.

Like · Reply · 5w

Norman Elias Thanks Albert Dunford. I'll probably take you up on this offer. Please get back to me in a couple of weeks.

Like · Reply · 5w

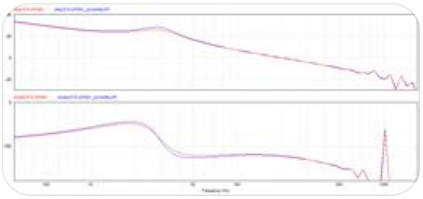
Like · Reply · 5w

Albert Dunford The AC sweeps in PSIM are based on signal injection. So you can determine loop gains or transfer functions of any topology or control scheme, phase shift with PCMC, LLC, 3 phase with dq control, motor drive. DCM, CCM, etc.....

Like · Reply · 5w

Ray Ridley Learning more about PSIM. Here is the before and after of the transfer function with and without transformer proximity losses.

Not a huge change, just a shift in the damping of the LC filter, as might be expected.



Like · Reply · 5w

Ray Ridley Core loss made no difference to the loop. Does anyone know why?

This is another first - the transfer functions of a converter with both core loss and proximity losses taken into account.

Like · Reply · 5w

Nicola Rosano Ray Ridley intuitively speaking if you model core losses paralleling a RL ladder (high values typically) to the primary inductance, the equivalent impedance of the added branch continues to be much greater respect the primary inductance impedance one on all frequency range. It remains transparent.

Like · Reply · 5w

Colin Tuck presumably core loss is small is the main reason...

Like · Reply · 5w

Ray Ridley Not only that, there is more to the answer.

Like · Reply · 5w

Colin Tuck In the fwd topology the core loss is just a load on the HVDC - so does not participate in any type of loop filter ...?

Like · Reply · 5w

Ray Ridley that's right. It's just a parallel load on the transformer and doesn't affect the duty cycle in any way.

Hence you probably would't include it in the PSIM or LTspice sweeps since it will slow things down.

When you are doing the transient sweeps, of course, that is when it works great. Run the sim, click on the core, and you see the loss. No more tables to look up.

Like · Reply · 5w

Norman Elias Ray, do you know if the core loss display is a feature of the simulator or is it built into the transformer model.

Like · Reply · 5w

Ray Ridley We provide the simulator with our core loss model. The simulator can then provide the loss numbers to you.

We do the same for the proximity loss elements.

Like · Reply · 4w

Amit Singh

Like · Reply · 5w

Write a comment...

James Keith
March 2

Full bridge LLC vs PSFB .

Which of these 2 topologies give high efficiency at light loads? Full load efficiency seems to be the same for both topologies (may be +/-0.5 %).

Take an example 400 VDC bus -> 24 V / 65 A/ 1500 W

Assuming center tapped secondary with synchronous mosfets.

This is my understanding about these topologies.

LLC goes into burst mode operation at light loads and the switching frequency goes quite high (in range of 300-450 kHz) and the core loss will be higher and LLC will be operating above the resonant frequency which means the secondary side synchronous mosfets have hard turn off (only ZVS, no ZCS). There is still ZVS on the primary side switches (because there will be magnetizing current I-Lm current charging and discharging the Coss caps).

PSFB also goes into burst mode, but this topology won't increase the switching frequency. And if ZVS for PSFB is designed for 30% - 100% load , on the primary side there can be hard turn ON and turn OFF at less than 30% load. Secondary side mosfets will have hard turn off.

I think LLC should give higher efficiency at light loads compared to PSFB. Can the engineers please share their opinion?

1 15 Comments

Like Comment

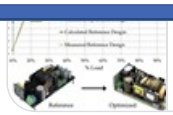
David Edwards Phase-shifted full-bridge efficiency at light load may be improved by designing the transformer to have enough magnetizing current to soft-switch the bridge.

Like · Reply · 4w

Yuri de Klerk I haven't seen a proper working PSFB with synchronized Mosfet's yet.
Most of them 'forget' to switch off the freewheeling phase after de inductor is out of energy. There are solutions but I didn't see it in a product myself yet.
LLC synchronous rectifier is easier /more forgiving to do correctly.
LLC at light load can stop at 200k max if nominal Fs is 100k and dimensioning is allright.
But I didn't do a light load comparison for the both. would be interesting if done right.

Like · Reply · 4w

Manuel Escudero Rodríguez In addition to the Application Notes linked by James Keith I could recommend this other publication related to our demo boards: https://www.mdpi.com/1996-1073/12/19/3723



A Practical Approach to the Design of a Highly Efficient PSFB DC-DC…

Like · Reply · 4w

George T. Ottinger 1) Your claim about the secondary rectifiers is not correct - LLC has ZCS on secondary diodes always.
2) Your claim about always going above resonance is also not strictly true. If your input voltage and transformer turns ratio are set properly, you can operate at resonance. Resonance is (ideally) a load independent operating point. Adjust your input voltage (if possible - assuming a front end boost converter) on the fly to keep the LLC at resonance.
3) Like PSFB, the magnetizing current can be designed to give ZVS to the primary switches, but, higher Imag affects conduction losses in the switches.

Like · Reply · 4w · Edited

Manuel Escudero Rodríguez The claim of the LLC synchronous rectifiers it is correct, they are hard commutated through the primary while working above resonance (Qrr loss) even though they can be always ZVS.

Like · Reply · 4w

James Keith George T. OttingerWhat happens to the frequency during burst mode? how do you ensure the secondary side mosfets to have both ZVS and ZCS during burst mode?

Like · Reply · 4w

George T. Ottinger James Keith The LLC is just a form of a series resonant converter. The secondary side currents are sinusoidal in nature, always. Thus, your rectifiers always naturally commutate when the current "rings" to zero.

If you go above resonance, the time of secondary diode commutation is shifted from the gating of the primary FETs.

ZVS is not applicable. At the moment of switching, for ANY synchronous rectifier, whether it be an LLC or PSFB, the channel of the FET better be off and it is only the diode conducting. If the gate is still on when the diodes want to naturally commutate, you better have a good supply of spare FETs and a good soldering iron.

Perhaps you should simulate the basic circuit to see the waveforms.

Like · Reply · 4w · Edited

George T. Ottinger Manuel Escudero Rodríguez The secondary diodes only commutate when the primary side resonant inductor current equals the magnetizing current. At that point, the transformer current is zero, and the rectifiers naturally commutate at zero current on the secondary. If your synchronous FET gate is on at that time, on either FET, then you have a control problem.

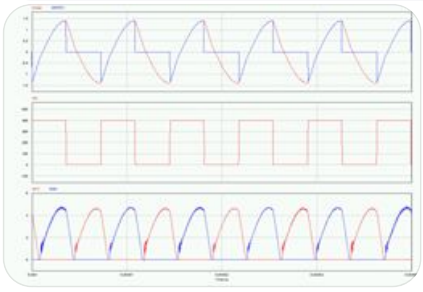
Like · Reply · 4w

Manuel Escudero Rodríguez Dear George, above resonance the diodes start to COMMUTATE after the primary side devices alternate the polarity of the voltage at the input of the series resonant tank. The channel of the synchronous rectifiers can be SWITCHED on (and off) in ZVS and potentially in Zero Current. However, because they are not soft commutated (the only limitation is the series resonant inductor) there is Qrr loss. The waveforms are not sinusoidal above resonance.

Like · Reply · 4w

Manuel Escudero Rodríguez Thank you for your recommendations, I do have simulated the circuit beyond the basics, build many converters and programmed the control for them. No, I do not have any control problem.

Yuri de Klerk Manuel Escudero Rodriguez I think the definition lies in soft commutation. The limitation is the series resonant inductor. Since it is a large inductance value the dI/dt at commutation is very low. One might call it 'soft' :



Like · Reply · 4w

Manuel Escudero Rodríguez Yes, you are right Yuri de Klerk. Thank you.

Like · Reply · 4w

Joel Holland Does load independent point mean that the output voltage will stay the same regardless of transitions in load? I have an LCC converter which I have tried operating at a fixed input voltage and stepping the load from full value to no load, and the gain clearly changes. I suppose with LLC and LCC there are two resonant frequencies, not just one?

Like · Reply · 4w · Edited

Write a reply...

Manuel Escudero Rodríguez And in regard to the synchronous rectifiers control, I do find it much straightforward for PSFB than for an LLC in wide range input/output converters. See as well this other publication in relation to our PSFB control specifically focused on the synchronous FETs: https://ieeexplore.ieee.org/document/8902164

IEEEXPLORE.IEEE.ORG

Synchronous rectifiers drain voltage overshoot reduction in PSFB…

1

Like · Reply · 4w

Alex Berestov Clamp diodes may lead to current pumping in inductor.

Like · Reply · 4w · Edited

Write a comment...

Andrew Ferencz
March 1

I want to get a Rogowski probe for measuring high current in transistors and transformer windings. Any suggestions? Ray - do you have one?

1 17 Comments

Like Comment

gets the most usage in our common applications (3-20kW).
http://www.pemuk.com/products/cwt-current-probe.aspx
We've found then accurate and reliable, with the ultra-minis being pretty robust. We have a designated one that gets used when a pair of pliers is needed to force them into odd spots and it's still going strong.
Powering them is the biggest pain in the rear. If using batteries, they do tend to eat them, and they can go a little strange sometimes when the batteries are getting flat.
My preference is to run them off the AC adapters, but that gets unwieldy if you've got 3-4 on the bench, so it helps to have some extra plug-boards mounted somewhere to keep things tidy.
The bodies are also a little bit annoying, shape wise, and if you stack them then the power buttons can get pushed, leading to irritating troubleshooting. I haven't quite come up with anything convenient for that yet, but eventually may just open them and bridge the switch to be on permanently. The power LED could do with being a bit brighter, too.

PEMUK.COM
CWT Current Probe | PEM

Like · Reply · 4w

Andrew Mosqueda Before measuring, make sure that the circuit is robust because when the transistor blows, goodbye mr. Rogowski 🙂

Like · Reply · 4w

Jonathan Beaver Weird, that has not been my experience at all. We have never killed one, despite using them while testing devices to destruction.

Like · Reply · 4w

Alex Berestov Pretty damn good.It even inspired me to make my own (passive) instead of CT and calibrated it using pemuk.
However it has "zeroing noise" by the looks, so if you are to measure 30A buy 30A probe.
P.S. As a student I've made Rogovski coil to control saturation in push-pull converter (What is the proper name: flux wandering??) but it really did not fly.

Like · Reply · 4w

Brian Faley PEM. Used the mini and ultra mini. Unless you spring for the extra shielding, they do capacitively couple high dv/dt switching edges , so there are some vertical artifacts. And they do not of course work for dc. The only complaint is that the power switch button sticks out for "on", and is in for "off". Keep spare batteries handy. We never used dc adapters, too much risk of high voltage faults. PEM has a flat rate repair price.

Like · Reply · 4w

Ray Ridley Rogowski coils are quite useful. The only problem I ran into is that the HF ringing and overshoot can be a function of the active compensation that is applied, and not representative of the real waveform.

So it depends on what you are wanting to use it for, but you might as well add it to the toolkit.

Like · Reply · 4w

Charlie Elliott As others have said, PEM. I have been using their parts for 20 years+. If you have the space for a slightly fatter coil then get one of the shielded ones. Without this you will get a bit of capacitive coupling pickup. Especially important with high dv/dts.

Like · Reply · 4w

John Baillie Charlie Elliott absolutely agree with this. Before inserting into you circuit it's interesting to place the (closed) probe close to the node you want to measure to see how much capacitive coupling there is.

Andrew Ferencz Thanks, got a quote going. Looks like $1k or so, cheaper than a Tek probe (which I have, 30A version). I understand it is all about the compensating circuit (integrator) ...

Like · Reply · 4w

Ray Ridley Just to reiterate - if you want to see the lower frequencies, it's a great tool. If you want to understand HF ringing and noise in the current, you can't depend on it so much.

I do have one. I would have to go find it, haven't used it for a couple of years, but I definitely need to dig it out for some circuits I am doing right now.

Like · Reply · 4w

Andrew Ferencz claims BW to 30MHz. Don't believe it? My Tek is only 30MHz or so. I just like the convenience of not having to cut something or find a way to get a big probe into a tiny circuit.

Like · Reply · 4w

Ray Ridley Yes it can pass signal to 30 MHz. But is what you see the real noise? does it matter?

Like · Reply · 4w

Andrew Ferencz I can filter with the scope ... but I want to see something close to a rise time...

Like · Reply · 4w

Write a reply...

Charlie Elliott Andrew Ferencz - You could always use a co-ax shunt, How about this "little" beauty

Like · Reply · 4w

Col Johns luv that shunt, RF or just high current (or both perhaps) ..?

Like · Reply · 4w

Charlie Elliott Col Johns Both!

Like · Reply · 4w

Write a reply...

Manfred Wimmer How do you prepare the pcb? Where to stick the coil through? Using a shunt like http://www.vishay.com/resistors-fixed/list/product-30189/ would be comfortable for measuring with PEMs rogowski, but that shunt is quite clunky...
I end up using a 0 Ohm 1206 resistor, that I replace with a manually bent (U shape) piece of wire I solder in instead.

VISHAY.COM

WSK1216 Power Metal Strip® Resistors, Low Value, High Power, Surface…

Conversation Starter · February 29

Weight most important factor - what switching frequency and core material for 20-30kW?

Following on from my optimisation scoring post, I had a new set of scores to me on Friday (1 = most important to customer)

- (Low) Weight = 1
- (Small) Size = 4
- (High) Efficiency = 3
- (Low) Development Cost = 7
- (Fast) Time to Market = 4
- (Low) Unit Cost = 6
- (Good) Robustness/Reliability = 2

Clearly to minimise weight I will want to push switching frequency up and I have the option of using expensive core materials. My gut feel is to look at Nanocrystalline/Amorphous for the transformer(s). Anybody disagree?

6 37 Comments

Like Comment

Jonathan Beaver I recently tried to use nanocrystalline for a transformer in that power range, much to my detriment. It can handle high flux densities, for sure, but the loss density goes through the roof. If you take that path, I'd strongly recommend making sure you allow for the cooling it will require (from a weight perspective).

Like · Reply · 5w · Edited

Charlie Elliott Jonathan Beaver - Out of interest can you say what type of cores you were using? Did you pot them and if so with what?

Like · Reply · 5w

Jonathan Beaver Charlie Elliott MK Magnetics I-bars to create a large custom shape.
We gave up and changed tack to several smaller units.
Edit: Smaller ferrites on standard core shapes, rather than something large, expensive and unwieldy.
Our thermal requirements made the cooling of it unlikely, even with liquid cooling directly in contact with the magnetic elements.

Like · Reply · 5w · Edited

Col Johns For 30kW you either make 10 modules @ 3kW at 200kHz (for min size) or skip to 35kHz for the whole thing ...

Like · Reply · 5w

Charlie Elliott 3 x interleaved 10kW blocks at closer to 100kHz with ferrite?

Like · Reply · 5w

Col Johns you can do 10kW at 100kHz (a lot of forklift chargers do 6kW at 100kHz) but it can get messy ...

Like · Reply · 5w

Daniel Pruna High sw freq. and high power are fully compatible.
https://www.iisb.fraunhofer.de/.../200_kw_full_sic_dcdc...

IISB.FRAUNHOFER.DE
200 kW Full-SiC DC/DC Converter

Like · Reply · 5w

these fantastically dense prototype systems. The engineering is plentiful and superb. They often make use of bleeding edge technology to get there. Not sure how realisable it is for a product though?
Seeing that sea of large MLCCs makes me skeptical that it will last very long on the vibration table unless there is some serious mechnical structure and AV mounts employed = weight!!

Like · Reply · 5w

Col Johns This sort of thing is great as a spur to new designs and no doubt Fraunhofer is in direct competition with ETH Zurich - so they have to come up with something "good" now and again - but if it is fixed step down then it is a limited "break thru " (from 2014) a real DC/DC needs to be able to operate at near no load and with a fairly wide Vout range - this is why LLC (CLL) cannot be used in many apps as it cannot go to 0V Vout ... similarly for PSFB full current at low Vout is a no-no for many designs ...

Like · Reply · 5w

Stephen Berry Col Johns I have designed PSFB converters to drive superconducting magnets. With care they can run all day at full current (8000A in my case) into a perfect short.

Like · Reply · 4w

Col Johns Ah yes - but designed for it, we did an MRI design for 2 quadrant 12V 600A 50ppm way back - using simple H bridge - the main load is the Cu leads to the magnet ...

Like · Reply · 4w

Atish Tailor Stephen Berry for your Interest that particular PSU is still considered successful and still in production. We are now working on a 500A skinnyer version..

Like · Reply · 4w

Write a reply...

Arief Noor Rahman What about the weight for your cooling system?

I made 20kW PFC...around half of the weight is for heatsink+fan

Like · Reply · 5w

Arief Noor Rahman My PFC just operate at 12kHz Fsw because we use igbt

Like · Reply · 5w

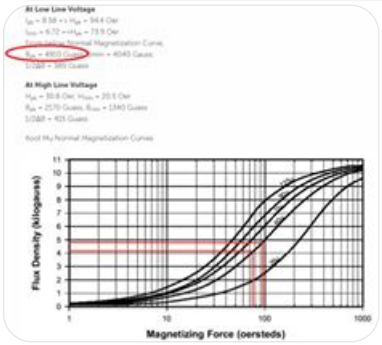
Charlie Elliott Indeed cooling system weight (including any potting compound used) can add a lot on.

Like · Reply · 5w

Alex Berestov My gut feeling is to use soft switching as main volume/weight reduction factor.
Losses are on par with a ferrite, however you can double flux density. This may be beneficial in DC/PFC inductors.
Now bad news.
It's hard to get more than 0.5....0.7T from nano at 50...100k.
Keep in mind that alloy density is about the same as Fe i.e. 7.8 almost two times of a ferrite. There could be no real incentive weight wise.
Cooling is also impeded in tape cores. .
Unless you going to use toroidal X-formers stay away from nanocrystal/amorph even good ones with cobalt
Fringe field and shorts at the cut increase losses 5 to 10 times.
Cheers
P.S. Nnocrystal/amorph technology should of been more mature (less expensive) after 40 years.

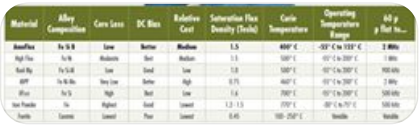
Like · Reply · 5w · Edited

density (0.75 T- 1.5 T) shown for the PFC toroids (powered iron, amorphous Kool mu, Xflux etc) by Magnetics Inc are not practically usable at such high flux densities? Meaning can't I use the kool mu at 0.5 T (datasheet shows 0.75 T). Although no information of temperature is given. But, seems like the calculations shown by Magnetics Inc for PFC boost show that Bmax of around: 0.5 T is reached. https://www.mag-inc.com/.../Kool-Mu-Cores/PFC-Boost-Design



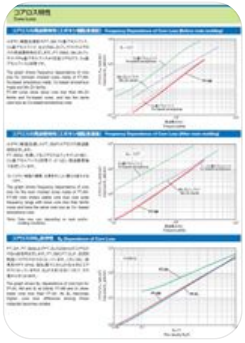
Like · Reply · 5w

Venkat Karthik



Like · Reply · 5w

Alex Berestov Here is a quote from metglas/hitachi it was referred to:



Like · Reply · 5w

Alex Berestov And yes I did use such materials both cut and uncut, pun intended, since late 80's.
From the pic above FT3 material in container (Permalloy anybody) easily operates at B of 0.5...0.7 @ 50...100kHz. Real material is better BTW. However impregnated is not as good cut core even worse.
P.S. Managed to find old spreadsheet for inductors, PFC inductor, 3.3kVA/phase 50kHz, F3CC0040. H=6680, B=.76, H~=930, B~=0.105, Pcore sin=8.2W, Im=27A, Pcu25=4.6W. In reality, under forced air worked @ 7kW.

Like · Reply · 5w

Write a reply...

Arief Noor Rahman I cant really say about magnetic material...

another way to make reduce converter weight is by paralleling many switches to reduce the total losses and distribute it over larger surface...reducing cooling requirement...

Modest Fsw at 20~30kHz should be good enough
Two phase interleave may help as well

Like · Reply · 5w

Never used it myself, but I hear too many stories like the above to even consider it.

Like · Reply · 5w

Hamish Laird If you truly need robustness as a 2 then take really good care of the nanocrystaline core as they have some fantastically weird failure mechanisms from shock and vibration.

Like · Reply · 5w

Colin Tuck In that lineup, assigning reliability (quality) = 2 is a little at odds with unit cost = 6 and dev cost = 7
lowest weight (=1) strongly implies a lowish size which usually requires significant engineering input and testing ...

Like · Reply · 5w · Edited

Charlie Elliott Colin Tuck I should have been clearer. The scores are for Low unit and development cost! The customer is telling me we can put in plenty of engineering and use more expensive parts as those scores have lower priority.

Like · Reply · 5w

Tony Salsich Nanocrystalline cores are at their very best as CM chokes. Yes, they are somewhat delicate, but the boxed cores are fairly well protected. In fact high mu (10-15k) Ferrite is also easy to damage with shock. For either type of material the mu drops if stressed.

Like · Reply · 5w · Edited

Alex Berestov Most failures we had were from improper handling, mostly from mechanical stress, magnetization curve becomes like 100 times wider along with huge magnetostriction. Beware of the rust - most amorphs do.

Like · Reply · 5w

Charlie Elliott I had unexplained significant increase in core loss on a prototype using some VAC cores a number of years ago (20!). I had always wondered whether they had been stressed somehow to cause the problem. They were potted in a reasonably hard material for good thermal conductivity and I was assured there was no magnetostriction to worry about but ....

Like · Reply · 5w

Alex Berestov Magnetostriction was a result of damage. Plastic container became deformed during transformer impregnation process: overheated.

Like · Reply · 5w

Charlie Elliott Meanwhile on the flip side of mechanical stress increasing core loss, let me share a little story. When I worked for a division of Emerson Electric involved in motor design, I visited a factory in the USA. Of the many different process areas I saw, the one that intrugued me most (intellectually) was the "Watt knocking". This involved some guys with arms like tree trunks picking up piles of stamped motor laminations and throwing them down on a large metal table to "knock the watts out" prior to the lams going into the annealing oven. The official line (from the engineers) was that this was to stop the lams sticking together so they were properly annealed and coated. The folk lore of the guys working on the line was that there was something else going on and you had to knock them just the right amount to let the watts out!!

Like · Reply · 5w · Edited

Charlie Elliott I have edited the scoring metrics to be clearer.

Like · Reply · 5w

Alex Berestov If you apply vibration to an iron piece in a presence of Earth magnetic field for prolonged amount of time - it gets magnetized in a direction of the former for the fact. Stamping does exactly that. Perhaps mechanical shock was a cheap "degaussing".

Cameron Stewart I've worked with the amorphous core material, only to migrate back to ferrite for SMPS transformers and powder cores for SMPS inductors.

The curves look good on paper. However, for the same physical size ferrite or powder toroid, the amorphous cores have one half the cross sectional area, due to their being a tape wound structure.

The discrete gap required with amorphous cores for inductors is also a multiple disadvantage compared to using a distributed gap powder core.

So the benefits you see on paper quickly dissappear in actually designing a transformer or inductor.

I think amorphous core materials are best left for special applications:

1) Square loop material for magamps and magnetometer applications.

2) Normal loop for vacuum tube audio output transformers.

Amorphous core materials have also found their way into utility pole and substation transformers, to greatly reduce core loss heating and improve efficiency.

Like · Reply · 4w · Edited

Cameron Stewart Magnetics Inc has a new material called 'XFLUX'. It's a powdered form of Silicon Steel with a distributed gap filler material.

It would be interesting if someone could offer an Amorphous core in powdered form with various permeabilities: Low perm - 60 mu - for inductors, and relatively high perm - 5000 mu - for transformers.

It might eliminate some of the problems that come with a tape wound amorphous core structure.

Like · Reply · 4w · Edited

Col Johns maybe they should call it X-lax, I see it is brown, the performance is not exactly star quality either ...

Like · Reply · 4w

Write a reply...

Alex Berestov For the "weird material" you may look for Hi Silicon Steel. And high means 6.5% made by diffusion process similar to that of semiconductor manufacturers. You can not roll Si steel because it's too brittle.
https://www.jfe-steel.co.jp/.../report/021/pdf/021-04.pdf
https://www.jfe-steel.co.jp/.../elect.../catalog/f1e-002.pdf
Cheers

Like · Reply · 4w · Edited

Charlie Elliott Alex Berestov yep used that jfe steel while back. It is very good for low loss and magnetostriction. Unfortunately it is hard (nigh impossible) to get in uk in small quantities. Previous company that used it for railways chokes and transformers were taken over and then production shipped out east.

Like · Reply · 4w · Edited

Write a reply...

Write a comment...

I am looking for a netfilter for single phase AC less than 10A with a L-C structure not C-L-C preferably with screw terminals certified for use in the US. Does anyone know any such product. Need to filter another device, not mine 😁, that is interfering with power line communication on the same supply.

Like Comment

Write a comment...

Jeremy Lister shared a link.
February 29

Something to peruse...
Love the 'Applied violence' technique

YOUTUBE.COM
Renault Zoe EV inverter (PEB)
A look at the Power Electronics Block, containing the motor inverter and…

You, Darrell Hambley and 19 others 11 Comments

Love Comment

Alex Berestov Quite impressive. However how Renault is Renault? Formula1 experience, perhaps.
Like · Reply · 5w

Grzegorz Sobiegraj Alex Berestov There's Continental logo on one of the PCBs. Today car makers are almost only coordinating orders from third parties.
Like · Reply · 5w

Riccardo Tinivella This is pretty old.was the beginning, today this inverter would be too expensive
Like · Reply · 5w

Simopekka Niskanen Thanks Jeremy, quite interesting. Looks daamn expensive tehcnology.
Like · Reply · 5w

Jonathan Beaver Very interesting, looks pretty typical for early EV electronics from what I've seen. Huge, expensive and complicated, but probably fine for something getting made in the 10-100k/a range. I replaced the on-board charger in my older Nissan Leaf and it's remarkable just how large and heavy that unit is for a 3.3kW on-board charger.
Like · Reply · 5w

like Scrooge X-mas.

Like · Reply · 5w 3

Jonathan Beaver Have you've seen the newer units using the ST Pak devices?

Like · Reply · 5w

Alex Berestov Nope, however, it looks like thermal cycling brought Mask to a senses.
I was kinda surprised of discrete solution.

Like · Reply · 5w

Charlie Elliott Alex Berestov - The discrete solution surprised a lot of people but isn't quite as bad from a thermal power cycling POV as you would think. Having done quite a few automotive motor projects over the years I have been involved in the module vs discrete battle many times. One thing that the plastic moulded device has going for it that a module doesnt is that the bond wires are physically supported. Bond wire "lift off" is one of the most common failures dueing thermal/power cyling. If you put a bit more silicon in and/or improve cooling so that the delta Tj is lower for the discrete solution then .... Details of solder type, PCB design and other secret sauce also help the discretes.
Having said that if you start looking at sintering and pressure contact then you will suddenly get a jump in improvement. The STPAK used in the Tesla Model 3 is sintered. There are also some interesting options for making the electrical connections that improve reliability. Several m/f are now releasing these mini power modules (or are they advanced discretes?) for automotive recognising the packaging and cooling flexibility of not having one large lump.

Like · Reply · 5w

Alex Berestov Sure, I used to work for one of Big Three on NEV a while ago. Nevertheless STpack or SmartPIM etc are are "bottomless" i.e. no copper base plate: DCB mounts on heatsink.
If you take forklift motor drive you see either 247 or even 220 packages. It was a bit ago but if did work.

Like · Reply · 5w

Write a reply...

Bob Gudgel This was a really good teardown ! Mike does a good job.
You beat me to posting it here !

Like · Reply · 4w 1

Write a comment...

Col Johns
February 27

For those who have clients wedded to the TO-247 in their power architectures - the 4 pin TO-247 in SiC...

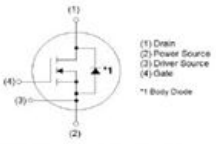
V_{DSS}	1200V
$R_{DS(on)}$ (Typ.)	40mΩ
I_D *1	55A
P_D	262W

●Outline

TO-247-4L

(1) (2)(3)(4)

●Inner circuit



Please note Driver Source and Power Source are not exchangeable. Their exchange might lead to malfunction.

●Features

1) Low on-resistance
2) Fast switching speed
3) Fast reverse recovery
4) Easy to parallel
5) Simple to drive
6) Pb-free lead plating ; RoHS compliant

You, Jay Philippbar and 10 others — 32 Comments

Like — Comment

Col Johns We have used the previous std version with +15V on and -3V off - still going in the field ...

Like · Reply · 5w

Jonathan Beaver We've found the high internal gate impedance (7 ohms in this device) to make life somewhat difficult with this generation of ROHM FETs but otherwise, the 4 leg package has proven to work out well with a variety of other parts.

Like · Reply · 5w · Edited

Col Johns Agreed, even the SCT2080KE has 6.3 ohms, ACR @ 1MHz

Like · Reply · 5w

Jonathan Beaver Col Johns Yeah, we've harassed them about it a bunch and were assured that they're aware of the issue and it'll be better in the next generation.

Like · Reply · 5w

Col Johns Jonathan Beaver do you chaps have a website ... ?

Like · Reply · 5w

Jonathan Beaver Col Johns No, sorry. It's on the 'to do' list! We're a 2-man band who used to work with Qualcomm's wireless EV charging tech, now out on our own.

Like · Reply · 5w

Write a reply...

Cameron Stewart Gate impedance 7 ohms?(!)

Like · Reply · 5w

Col Johns Yup 18Vpk at turn on gives ~ 2.6A into the gate ... 40nS to 17V on the gate ... with inductive drive ...

Like · Reply · 5w · Edited

Jonathan Beaver Or, worryingly, with -3V drive, Vgs(th)min adjusted for 150C junction at 1.7V, that's only 670mA to turn on parasitically, worst case.
We popped a few of the 80mR versions. Fun times.

Like · Reply · 5w · Edited

Col Johns luckily resonant gate drive gives plenty of oomph to get to -3V and stay there ... we only run to 115degC junc

Like · Reply · 5w · Edited

Like · Reply · 5w

Col Johns Nathan Ellis our in house proprietary one - developed over several years

Like · Reply · 5w

Nathan Ellis Col Johns Booo! Haha ok fair enough 😂 I've been working on one with the help of a masters student over the last few months so been reading up on them.

Like · Reply · 5w

Write a reply...

Charlie Elliott ☕ This trend of integrated gate resistance is a pain on many devices not just SiC. I first came across it about 8 years ago on some new Fuji IGBT modules. I am never clear whether it is :
A) Deliberate thinking about multi-die modules where you need some local resistance to prevent oscialltion between dies OR
B) Deliberate as they dont think engineers can be trusted to pick a minimum value of RG!! OR
C) Parasitic and you get what you get

Any body know?

Like · Reply · 5w

Jonathan Beaver I've personally had probably half a dozen conversations with Rohm about this. In the case of these devices, they didn't specifically say what the cause was, but indicated that it was parasitic (edit: i.e. there was nothing they could do about it without major changes that weren't appropriate mid-generation), either on the die, bonds or leadframe.
On the other hand, we've got some of the big Wolfspeed SiC half-bridge modules that definitely have them integrated, I assume to damp resonances through the bonds/leadframe and multiple dies. I think I've got a slightly burned-out die-plate from one sitting around, actually.

Like · Reply · 5w · Edited

Colin Tuck Poly-silicon gate rather than Aluminium ...

Like · Reply · 5w

Brian Faley A mosfet designer once told me it was because of high device transconductance coupled with package inductance - the ringing will destroy the device without the internal resistor to damp it. And they usually use poly-silicon resistor on the die - which means it varies a lot.

Like · Reply · 5w · Edited

Brian Faley Module manufacturers have always placed discrete resistors on gates of parallel die to reduce oscillations between parts. One more reason there is a push in GAN to integrate drivers onto the die. I'm still surprised that anyone still uses TO-247's - 3 or 4 lead - source bond wire has a lot of inductance. That's a long round trip distance.

Like · Reply · 5w

David Edwards ☕. Hello Brian Faley,

At least for MOSFETs a few tens of nano-henrys in the gate drive circuit don't mean much, but any source impedance common to the DS circuit and the GS circuit is to avoided if possible. I imagine that the source leads in the four pin TO-247 package each have their own bond wires directly to the source pads.

Like · Reply · 5w · Edited

paralleled TO-Leadless 300A devices. The gate drive was unipolar for cost reasons. No way that could ever have been done with D2pak-7 lead, TO-247 would have been laughable. TO-247 is about five times higher source inductance. During fault conditions, all the resonant transitions softening the blow of normal operation are out the window. I have been telling mosfet vendors for decades to get the leads out of their packaging and start treating them like the rf devices they are. Few listened, even though we were one of the largest customers for 60V mosfets on the West Coast. Kelvin leads are a start, but it's not a very high hard switched frequency even on a 4 lead package before things blow up without negative drive. I can see exactly why Alex Lidow of EPC has been preaching chip scale packages. It's time to join the 21 st century. TO-247 deserves to be buried. It's decades older than me, and I've been doing this for 38 yrs.

Like · Reply · 5w · Edited

Stephen Berry Charlie Elliott I was in a division of Emerson Electric in the early '90's. We used early HEXFETS from IR. We designed a 10kVA UPS running at 20kHz. Quite twitchy to get it working and we had to buy new scopes and probes to see the edges. Production started, but they started failing in the field. On investigation, IR had changed the internal gate resistors. We found it by connecting gate and source with drain and source on a DC PSU. A nearby coil was connected to a signal generator. The FET blew up when the frequency got to 100MHz.

Like · Reply · 4w

Write a reply...

Andrew Ferencz But you have to figure 1200V, 0.04 ohms, ... even with 7 ohms of internal resistance - it is amazing. A three-leaded device can cause a lot of extra ringing and noise from the common source inductance. So you can't use this at 50MHz .. but I bet if you compare the gate charge/resistance of this part with a MOSFET you are either close to the same or better. And frankly do you really want to hard switch a 1200V node at 1nS? 50A, 1nS ... no way no how will that will ever happen with a leaded package. 1nH = 50V ... What would be needed to know how to make it work reliably in a half bridge - how much external R for turn on is needed to prevent cross conduction - or how much negative drive?

1

Like · Reply · 5w

Jonathan Beaver In our application (PSFB with variable loading), it simply doesn't have enough margin against parasitic turn-on under high dV/dt conditions. Max dV/dt is around 25kV/us which is pretty slow for SiC.
By comparison, we replaced it with a USCi part which we were pushing towards 80kV/us, measured.

Like · Reply · 5w

Andrew Ferencz Jonathan Beaver Thanks for that. I know in the high voltage GAN world (which I think isn't ready for prime time) Panasonic came out with a part that was ... lacking. I have been looking at USCi parts for inverters. Any advice from experience is worth a lot.

Like · Reply · 5w

anecdotal comments about long term failure rates.
In our case, we were R&D focused and found them reliable and high value/performance under a reasonably high-stress test regime.
One of the things we learned from working with the USCi technical team was that they were comfortable with us running somewhat faster than datasheet values (more gate drive) while running at lower average/peak currents than with the datasheet values. They were easy to drive, although we focused more on the 4-leg devices and still kept using bipolar supply for them in order to ensure enough margin.
Since then, we've been looking at similarly specified devices from Infineon and ST, with ST being the current front runner due to reasonably motivated pricing and support.

Like · Reply · 5w

Daniel Pruna Check ON Semi as well, 20mR 1200V.

Like · Reply · 5w

Col Johns @ Jonathan Beaver 80V/nS I can see you guys spending some time on meeting emc - our fastest product was a bi-directional inverter, 840V bus traversed in 25nS - but luckily not all the time by all 18 switches ...

Like · Reply · 5w · Edited

Jonathan Beaver Col Johns Yeah, it's certainly a challenge.

Like · Reply · 5w

Alex Berestov "Advanced" packaging in a module does not do any better. 6 switch CREE part. 30 nH DC connection inductance. BTW bi-dir corrector/rectifier. Is it fashionable thing to do nowadays?
In regard to control: Miller clamp sometimes does miracles and costs nothing - unipolar drive.
Interal gate resistor, if one try to drive SiC really hard, works like a fuse. It looks like thin line on the die picture.
RF LDMOS or VDMOS do have proper gate termination.

Like · Reply · 5w

Write a reply...

Alex Berestov In regard to packaging
some fuse company has killed the whole class of devices. BTW planar casing of such type has been known for ages, it used to be and still is ceramic.
https://media.digikey.com/Photos/IXYS%20Photos/DE-SS-150.jpg

MEDIA.DIGIKEY.COM
media.digikey.com

1

Like · Reply · 5w

Col Johns are you saying they have stopped making the above package?

Like · Reply · 5w

Alex Berestov Not exactly. Most devices are obsolete the rest NRND.

Like · Reply · 5w

Write a reply...

Write a comment...

In your designs, what copper resistivity values do you use for copper loss calculation? Thanks

1 7 Comments

Like Comment

Ray Ridley Is there discussion somewhere about what the value should be?

Pretty fixed number I thought plus a tempco.

Like · Reply · 5w

Casper Hjort Wilson I believe it's about 1,68*10^(-8) at 20C. Look it up and make corrections according to temperature.

Like · Reply · 5w

Col Johns 17E-9 is easy to remember, +30% @ 100 deg C from memory ...

Like · Reply · 5w

Darrell Hambley The number has dimensions: 1.7 µOhm-cm or, 17E-9 Ohm-m. For the normal range of temperature we face you can estimate it's linear so the resistance rises 0.0037 parts per degree C.

Like · Reply · 5w · Edited

Ray Ridley did you get what you need, Wilmar Martinez?

Like · Reply · 5w

Wilmar Martinez Ray Ridley kind of. We were using 0.0171 Ohm · mm²/m, and recently we got a discussion about it, and somehow we saw some tolerance (~5%) between documents.

Like · Reply · 5w

Write a reply...

Alfonso Martínez It can also vary with metallurgic processes, like annealing (1.72 * 10−8 Ω·m)

1

Like · Reply · 5w

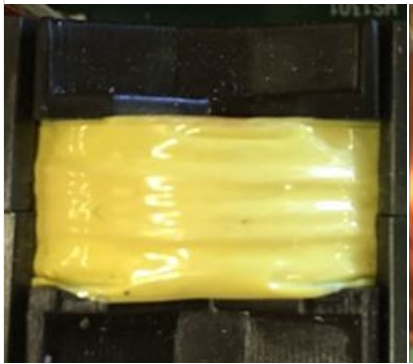
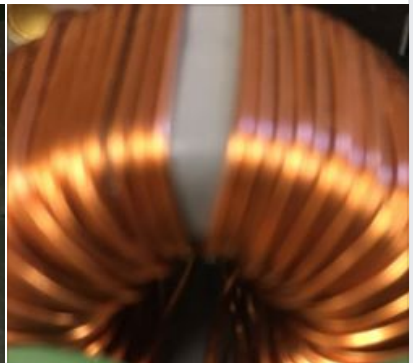
Write a comment...

Ray Ridley
Admin · February 25

PFC Inductors

There are lots of ways to wind inductors for all applications, and the PFC inductor is no exception.

Here are a couple of photos of production parts. Please add your own photos of inductors so we can see the multiple approaches that people use.

You and 20 others 17 Comments

Like Comment

Ray Ridley Come to our workshop. We explain how each of these can work well.

Like · Reply · 5w

Duy Dinh Nguyen 760uH - 15A for PWM rectifier. Made of 2xT184-3 and 76 T of AWG14

Like · Reply · 5w

Col Johns The faster you go - the more the need for a self shielded construct.

Like · Reply · 5w

Yuri de Klerk 6x 50uH for three phase 5kW, 1 Mosfet BCM PFC.

Like · Reply · 5w · Edited

Ray Ridley Is that a boost BCM? must have quite a filter in front of it. Usually as big, or bigger, than the PFC itself.

Like · Reply · 5w

Venkat Karthik Why BCM at 5kW?

Like · Reply · 5w

Colin Tuck Venkat Karthik usually because the diodes can't hack the pace being non SiC ...

Like · Reply · 5w

Yuri de Klerk I will make a picture of the EMC filter later.
BCM because it's single Mosfet PFC for three phase input.
With higher harmonic injection in the current control the harmonics stay within EN61000-3-2 Class A.
The inductors are at the AC input, before the rectifying diodes.

Like · Reply · 5w · Edited

Yuri de Klerk My EMC filter for the 3-phase 5kW BCM boost PFC:
Iron powder chokes for DM noise in AC path. Two CM high-mu chokes in DC path. Two three-phase CM high-mu chokes in AC path. And a lot of capacitors.

Like · Reply · 5w

Ray Ridley Yuri de Klerk nice how is the efficiency for tha bcm?

Like · Reply · 5w

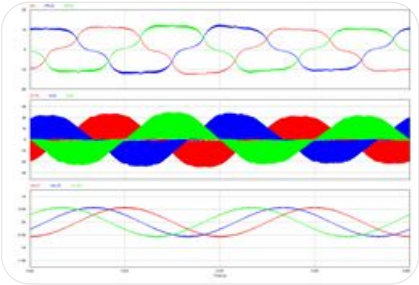
Yuri de Klerk I never had a load for 750Vdc, so only tested in combination with the next stage: Two fet forward with synchronous rectifiers: 24V/200A. Total efficiency 90.5%.
The PFC chokes stay much cooler than I could have guessed.
Next design I think can do with 3x E42/20 for this power.

Like · Reply · 5w

Colin Tuck Would love to see the input current waveforms if some are available ...

Like · Reply · 5w

Yuri de Klerk I have no pictures of real measured current. It looks a lot like the simulation.



Like · Reply · 5w

Yuri de Klerk Harmonics analyzer was used to stay below the limits in the standard. I had some trouble with 13 15 19 harmonic but was solved with tuning of the harmonic injection.

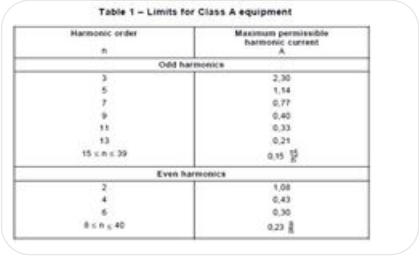


Table 1 – Limits for Class A equipment

Harmonic order n	Maximum permissible harmonic current A
Odd harmonics	
3	2,30
5	1,14
7	0,77
9	0,40
11	0,33
13	0,21
$15 \le n \le 39$	$0,15 \frac{15}{n}$
Even harmonics	
2	1,08
4	0,43
6	0,30
$8 \le n \le 40$	$0,23 \frac{8}{n}$

Like · Reply · 5w · Edited

Write a reply...

Rogério Junior Dr. Ray Ridley, what do you think about creating a similar topic for transformers? I have some interesting photos to share about high frequency transformers for SST applications.

2

Like · Reply · 5w

Charlie Elliott Rogério Junior - Please do create that post - I would be interested and I am sure many others would be as well.

Like · Reply · 5w

Write a reply...

Like · Reply · 5w

Write a comment...

Charlie Elliott
Conversation Starter · February 29

Encouraging customers to tell you what you need to know!!

I always ask customers to give a "importance factor" to our multi-dimensional optimisation problem (AKA designing an SMPS). I get a variety of answers depending on the application. I ask them to give a score of 1-7 (1 = most important) to the following but they can only use a score once.

- (Low) Weight
- (Small) Size
- (High) Efficiency
- (Low) Development Cost
- (Fast) Time to Market
- (Low) Unit Cost
- (Good) Robustness/Reliability

I find the exercise very usfeul as it forces them (and me!) to think and appreciate the complexity of the job they are asking. Very often they want to give the same score to mutiple categories which is a useful conversation to have as well!!

Anybody found a better way of doing this?

14 25 Comments

Like Comment

Jonathan Beaver It's something we've struggled with a fair bit, too. In our situation, we were more cost focused than weight or size, while also having a relatively fixed topology to work with.
Based on that, we linearized as much of the input data as we could for switching element, capacitor and magnetic costs, etc. and then used that to try generate a rough sensitivitiy analysis for some of the primary variables in the product requirements.
That proved to be remarkably effective because when cost is the primary goal, being able to say to a product manager that changing a certain line item will cost $x or save $y, then the entire direction of the conversation changes remarkably.

Like · Reply · 5w

Roswell Bob LaFrank Wouldn't reliability always end up at the top? I'm sure somebody will set me straight, so let's hear it.

Like · Reply · 5w

Charlie Elliott Certainly not for your low cost cost "wall wart"

Like · Reply · 5w

Paul Shepherd Reliability is never the #1 priority unless you are designing for a deep space probe.

Like · Reply · 5w

Charlie Elliott Paul Shepherd - Or something safety critical

Like · Reply · 5w

Roswell Bob LaFrank I see. Different levels of "it has to work"

Like · Reply · 5w

on the usage condition among other things.
If you can get 100% reliability over the lifespan for $1k but 90% reliability for $500, then that's a somewhat different consideration.
In previous designs, especially when cost is super important, I've found that reliability (specifically things like lifespan at extended temperatures, with degraded cooling etc.) is one of the common levers that can be pulled.
Edit: That's exactly why these conversations are so important! Often I find I don't necessarily know enough about the market/application to really predict what the 'correct' answer is to some of the more high level/product requirement level considerations. Having that conversation about what failure rate is acceptable at what price can be a real eye-opener

Like · Reply · 5w · Edited

Roswell Bob LaFrank Jonathan Beaver Thank you for the detailed and well thought out response. I moved from Industrial gear (ABB) to military radio (Harris) and there was an order of magnitude of increase of reliability. Then on to a R&D concern where some in the group were working on space designs - so another bump up in reliability. I fix broken tube radios now 😀

Like · Reply · 5w

Manoj R Iyer I feel size followed by weight is kind of the top most. The thing with reliability - even with a deep space probe is that - it's a fixed target (and with redundant systems in place for Space designs). But size and weight is like ever improve able... and that makes a customer choose or reject an SMPS. So maybe one shouldn't ask the customer to even allott a score to size and weight... just ask how much area do you have and how heavy can the SMPS be? Then ask to score the remaining. That simplifies the task and helps maintain focus to the job at hand.

Like · Reply · 5w

Write a reply...

Manoj R Iyer Reminds me of the article https://cdn2.hubspot.net/.../Oh_%20By%20The%20Way%20%E2...

Like · Reply · 5w · Edited

Ray Ridley A good article from Dean. It's really important that the company you get your test equipment from knows power supplies well, otherwise they can't advise you on how to use it.

Dean got in deep with customer designs. I met him many times and he even offered me a job once!

Unfortunately, he has passed on, leaving us to carry on his philosophy of helping the customer as much as we can with their measurements. It's not just about the equipment, it's teaching people how to use it properly.

Like · Reply · 5w

Ray Ridley The customer will almost always put reliability at number 1.....as long as you meet the cost goal that doesn't let that happen.

What they say they want versus what they actually want are two different things, we have found.

Like · Reply · 5w

Ray Ridley Reliability number 1 as long as the cost is met.

And of course, it fits in the space allocated. 🙂

Like · Reply · 5w

Ray Ridley It's a good excercise, thanks for doing this Charlie Elliott.

Like · Reply · 5w

force unique scores reliability doesn't always come as #1. That is especially so when the realisation dawns that it means unit cost wont be as low as it could be...

Like · Reply · 5w

Colorado Mike Doherty Cheap, good and fast; pick two.

Like · Reply · 5w

Simopekka Niskanen Rather three 🙂

Like · Reply · 5w

Simopekka Niskanen Very nicely put, Charlie. Will keep those in mind.

Like · Reply · 5w

Christopher Compton I think the industry will dictate the scale

Like · Reply · 5w

Charlie Elliott ☕ Which industry and which application within? There are many different "churches" represented on this group!!
Might be an interesting exercise to propose a few different scores for different applications and see what disagreement that causes!!

Like · Reply · 5w

Charlie Elliott ☕ I have clarified the meaning of the metrics as a result of a comment on my other post.

Like · Reply · 5w

Charlie Elliott ☕ "Budget Wall wart" score?
(Low) Weight - 6
(Small) Size - 3
(High) Efficiency - 5
(Low) Development Cost - 2
(Fast) Time to Market - 7
(Low) Unit Cost - 1
(Good) Robustness/Reliability - 4

Like · Reply · 5w

Charlie Elliott ☕ "Aerospace fuel pump module" score?
(Low) Weight - 2
(Small) Size - 4
(High) Efficiency - 3
(Low) Development Cost - 6
(Fast) Time to Market - 7
(Low) Unit Cost - 5
(Good) Robustness/Reliability - 1

Like · Reply · 5w

Charlie Elliott ☕ "F1 KERS motor drive" score?
(Low) Weight - 1
(Small) Size - 2
(High) Efficiency - 5
(Low) Development Cost - 6
(Fast) Time to Market - 3
(Low) Unit Cost - 7
(Good) Robustness/Reliability - 4

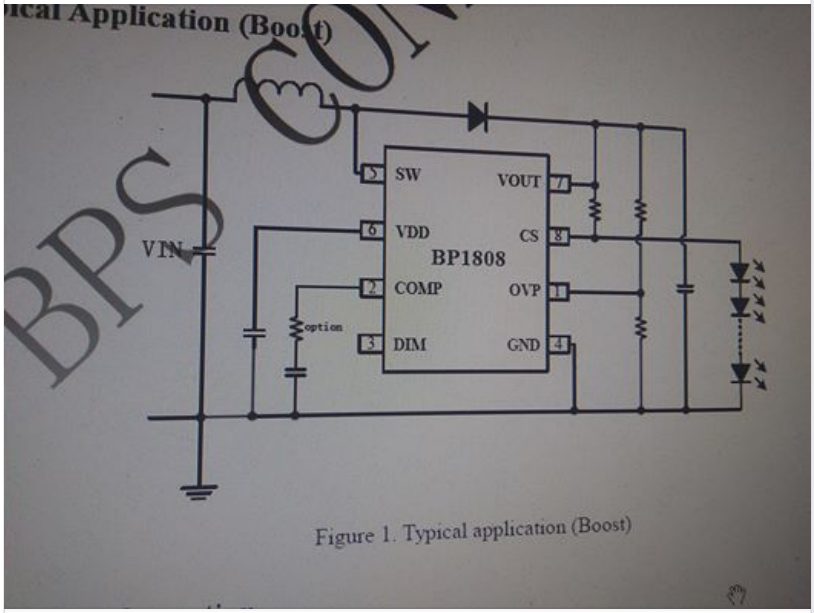
Like · Reply · 5w

Charlie Elliott ☕ "Premium server PSU" score?
(Low) Weight - 7
(Small) Size - 3
(High) Efficiency - 2
(Low) Development Cost - 5
(Fast) Time to Market - 6
(Low) Unit Cost - 4
(Good) Robustness/Reliability - 1

Like · Reply · 5w

Tanvir Fakir
February 7

Hello friends.
I have design 3W boost converter using ic BP1808.
Vin- 12V
Vout- 36V, 100mA
Working fine .
But when i comes to emission test there is failure in RE and CE
Which is at 450KHz 78uV db..
I don't know about EMI filter design for dc to dc supply..any suggestions.



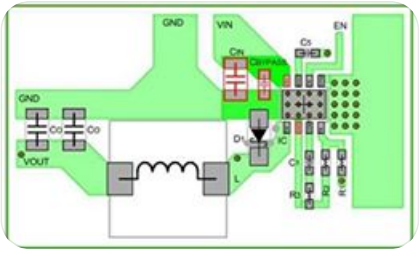
3 29 Comments

Like Comment

Alain Laprade Datasheet states this is a 420 kHz device. You are wrestling with the fundamental harmonic getting back to VIN. You need to add an input EMI filter. If you don't want to do the math yourself for the filter design, I recommend going to the IC manufacturer's web site for a demo board example to see what they recommend as a starting point.

Like · Reply · 8w

Shiv Kumar Mishra I would suggest review your layout as per design recomendation in datasheet. Try reducing ground loop area. Most of CE and RE problems can be overcome by reducing gnd loop. Could you tell us at what frequency your buck converter operating. You may need some input filter of targeted frequency.



Like · Reply · 8w

Tanvir Fakir Shiv Kumar Mishra thanks ..it is booat converter..and operating at 420KHz Freq

Like · Reply · 8w

Like · Reply · 8w

Alain Laprade Example given by Shiv above is incomplete. It needs an input filter.

Like · Reply · 8w

Shiv Kumar Mishra I just downloaded one imgae from web and uploaded to have intial review of.

Like · Reply · 8w

Frank Warnes Measure the switching waveform on pin 5. If there is a lot of ringing a simple RC snubber might help. Also make sure your inductor is the right way round. The switching end needs to be the start of the winding so that the input end shields the noise from getting out. This should sort out the common mode noise

Like · Reply · 8w · Edited

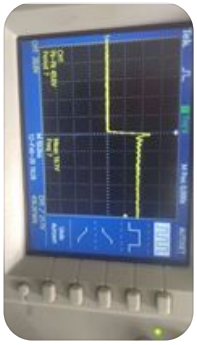
Tanvir Fakir Frank Warnes see the waveform across pin 5..i dont think it is so large noise

Like · Reply · 7w

Tanvir Fakir Frank Warnes hi frand i added rc snubber circuit across pin 5 and ground..but still ringing noise is there

Like · Reply · 7w

Tanvir Fakir I have added rc snubber circuit but still there is ringing noise



Like · Reply · 7w

Ray Ridley Please, make a little effort to turn your graphics the right way!

Like · Reply · 7w

Tanvir Fakir But I don't think ringing noise will affect on conducted emission test

Like · Reply · 7w

Tanvir Fakir Rakesh Panda still finding solutions for CE..any suggestions?

Like · Reply · 7w · Edited

switch frequency

Like · Reply · 7w

Tanvir Fakir So I got LF 4.7uH and CF 10uF..and CD 47uF which 4 time' higher than CIN

Like · Reply · 7w

Tanvir Fakir Hello friends..
Thank you for your support..my product has pass conducted emission by adding filter..but it is failed in radiated emission..am trying remove by adding RC snubber circuit..but remains same unchanged..noise is too high 72uV/db..any suggestions please..?

Like · Reply · 6w · Edited

Write a reply...

Tanvir Fakir Any suggestions to reduce radiated emission ..by adding input filter and RC snubber circuit still there is ringing noise of 50MHz..

Like · Reply · 5w

Matthew Jennings What values did you use for your RC snubber?

Like · Reply · 5w

Ray Ridley Radiated - need shields. Strategically placed.

No easy answers here. Kill noise at the source, filter and shield for what remains. Experience is key in knowing where to put the filters and shields.

Diode choice is key. As is inductor choice.

2

Like · Reply · 5w

Tanvir Fakir Ray Ridley by putting pi filter my conducted noise is removed by good results . before filter it was 80dbuv/m but now it is 45dbuv..
But using this filter my radiated noise not removed..

Like · Reply · 5w

Tanvir Fakir Still remains

Like · Reply · 5w

David Baba as mentioned previously depends on the noise source. Boost converters noisy side is the output but input can also be source of noise. Place filters on both. Follow good layout guide lines for the boost that means a right loop between FET diode output capacitor. Also keeping switch node area as small as possible without causing high IR losses. Don't place vias in the switch node place power planes on the top and Shield with a ground pour on the second layer down. Place snubbers placeholder on the switch node. Hope this helps?

Like · Reply · 5w · Edited

Ray Ridley Radiated goes through the air. You have to put something in the air to catch it - a shield.

Like · Reply · 5w

Col Johns and /or place snubbers on the diode with low lead inductance ...

Like · Reply · 5w

Write a reply...

Write a comment...

Ray Ridley
Admin · February 20

Control Chips Don't Matter

Here is a random thought. If you listen to the semiconductor companies, you would think that the control chip is the heart of a power supply, the most important component.

I am very much a controls person, but I don't think of it that way. The hard work and largest parts are elsewhere, in the magnetics, layout, power devices, thermal, etc. These all get designed first. The last step in the paper design is picking a control chip to fit the job, but the main power design is already done at that stage.

Many control chips, digital, analog, sophisticated or simple can often do the same job. That's why we see a huge array of different parts from one design review to another.

You, Jay Philippbar and 61 others — 54 Comments

Like | Comment

Colorado Mike Doherty Be careful tying the future of a product to a single-source component.

Like · Reply · 6w

Cameron Stewart There are too many control chips to choose from.

This is just in the mixed signal realm, without talking about DSP control, programmable logic array design, or the bevey of other "technology du jour" offerings to choose from.

I would politely describe the control chip situation as "chaotic and overwhelming".

Then there is the learning curve you are privileged to experience, discovering the undocumented bugs in the new control chip you were adventurous enough to try out.

If you are unhappy with the control chip you are using, by all means find another. But if the chip selection you have been using still works for you, I see no need to go looking for something new, just for the sake of it being new.

Like · Reply · 6w · Edited

Alex Borisevich controls chips are prone to silicon bugs.
and smarter the chip, more severe silicon bug can be.
and thus you stuck with a thing that you cant change. power electronics and magnetics you can redesign and tune. but the controller you can just drop and try another one

Sandro Calligaro A bit off topic, but... Sometimes, depending on the control, you can avoid some oversizing of the power parts. In other words, the design of the power stage is affected by the control you will implement.
I'm thinking about digital control and simple converters (like an inverter) doing tough tasks.

Like · Reply · 6w · Edited

Yuval Iz I never use new control chip's in my design,
Always read chip errata and for most chip I wait a year or two before I design with them.
Using this method I minimize silicon error to minimum

Like · Reply · 6w

Broox Le Well, if it's a sufficiently complex controller, sometimes even a few years in, it still has bugs/caveats which are not publicly documented or well-known - partly because few people fully check their designs under all the myriad of conditions and happened to catch it on the scope, and then some IC manufacturers who do have customer forums where they claim they want users to ask questions & share knowledge, actually DELETE polite cordial posts that describe real undocumented issues!

Like · Reply · 6w

Kevin Azul

Like · Reply · 6w

Charlie Elliott ☕ I have two things I constantly tell my junior engineers:
1) The more complex something is, the more there is to go wrong. This applies to designs in general and ICs in particular. The heavily integrated parts with loads of functions and very few pins can be challenging.
2) The wider you open the window, the more the sh*t flies in!! Don't make the bandwidth of anything wider than it needs to be. An increasing challenge as your switching frequency goes up.

Like · Reply · 6w · Edited

Graham Ward I agree. The actual power side of things (accommodating thermal design, component efficiency and density, parasitics, good gate drive etc.) is the most costly bit. Get any of that wrong and you incur significant cost and effort to rectify the problem. While the control side is no less complicated, an oversight is usually easily rectified by changing a resistor value in your feedback loop for example, or changing a parameter or property of your digital control loop.

Like · Reply · 6w

David Seal I have long started each design I make by stating out loud the KISS engineering principle: "Keep It Simple, Stupid." The I.C shown, if used to run or control a power supply, would be the equivalent of using a sledgehammer to kill a mosquito: it can be done, but oh the effort involved.

Like · Reply · 6w

Ray Ridley There are so many controllers out there at this point, there are not enough engineers to get to the bottom of how they all work and what their latent flaws might be.

There are at least half a dozen I really want to try ourselves, but there just isn't time to get it done.

Like · Reply · 6w

requirements from the application perspective. Power electronics is going in more and more high power applications EV , solar etc that indeed require a lot of the complexity to function and deliver benefit. There are myriads of communication protocols to deal with , safety and security hedges and control flexibilities to achieve ZVS , hysteresis control etc.

Like · Reply · 6w

Darrell Hambley I totally agree with Ray's OP: "magnetics, layout, power devices, thermal, ..all get designed first. The last step in the paper design is picking a control chip (or chips, plural). My fellow Mech'l engineer and I are currently designing a complex high power system. As we've done before, all my work is designing magnetics, calculating power loss etc as we manage heat flow and play Tetris to fit it all in the enclosure. I have no worry about finding an IC which has a ramp compared to a feedback signal.

Like · Reply · 6w

David Edwards ☕ High power complicated topologies such as inverters and induction motor control generally have lowish switching frequencies. For these, there is no dedicated quasi-analog controller (except for housekeeping) as the main control most likely will be an all digital micro-controller.

Like · Reply · 6w

Darrell Hambley ...or, all discrete analog control.

Like · Reply · 6w

Ray Ridley So at the end of the power design, you choose the all-digital controller which makes sens in many cases. Then you have the myriad of choices of which of the many options is the best for your application.

But, again, the actual choice of the chip comes last and doesn't determine the power converter choices.

Like · Reply · 6w

David Edwards ☕ . Hello Ray Ridley,

What I wish really would come last is the design of the enclosure. The initial layout should be without constraints and for maximum performance to prove the basic electrical design. Package size and mechanical design should be last.

Like · Reply · 6w

Ray Ridley Constraint #1: Price

Like · Reply · 6w

Ray Ridley Constraint #2: Box

Constraint #3: Schedule

Constraint #4: Development price

Fortunately, in our company, we have the option of saying "no" to many design jobs since the needs just can't be met.

Like · Reply · 6w

Charlie Elliott ☕ Ray Ridley I very often ask customers how they would like to prioritise your #1-4 plus a few others by scoring importance of each one. Can you guess how most reply 😭😤

Like · Reply · 5w

Col Johns Charlie Elliott , Price, Quality, Speed of delivery - pick any two and the third is a function of those picked ...

Like · Reply · 5w

Write a reply...

manufacturers are better some not so. Most of the times you do not have pin to pin substitute.
However NS, Unitrode, Motorola used to have kind of "school of design" a la "school of thought" yielding well thought out IC's tailored to PSU designer's needs.

Like · Reply · 6w

Seppo Turunen Why not use a small FPGA? I am currently using a Lattice XO2-2000 and a couple of A/D converters to control a 1kW current-fed half bridge resonance converter prototype. The control functionality is fully contained in a technology independent VHDL design file so that there is no need to decipher controller data sheets or to guess how microcontroller peripherals are supposed to work.

Like · Reply · 5w

Col Johns Why not...? how many engineer hours has it taken you to get "near working" ? how many more hours for a solidly engineered product ...?

Like · Reply · 5w

Seppo Turunen Col Johns I suppose what is relevant here is to compare the two approaches and, if I understand right, you want to point out that FPGA design is a real work item that requires justification. I could not agree more. If a commercial chip does the job, there is probably no point in replicating its functionality with an FPGA. However, if the required topology, timing, sequencing, security or feedback control is not supported by the controller, it may, in my opinion, be a faster and more predictable choice to program an FPGA to do exactly what is needed rather than to twist the commercial chip by building a kludge around it from discrete components. Also, as an alternative to an MCU, an FPGA could provide faster and more deterministic control. I am clocking the FPGA with 50 MHz so that I have a 20 ns cycle accurate control over everything. In contrast with SW design, VHDL design is parallel, so that adding functionality does not slow down anything designed earlier. In terms of logic design, we are talking about a fairly small project. Mine currently has eight pages of VHDL code and it includes, in addition to the SMPS control, a few auxiliary functions such as LCD control.

Like · Reply · 5w

David Edwards ☕ I am not an FPGA expert, but in the past, FPGAs were expensive, large (way too many internal gates and lots of pins) and required multiple power supplies. Are there now inexpensive, 3.3 volt single supply FPGAs of modest internal size and external pins (<=48)?

FPGAs have the advantage that they can be reconfigured every time they boot up so that field updates are easy and their function can be altered by the main micro-controller depending on user input. I see one of their biggest advantages is speed, which allows creating digital ramps with extremely high precision for precise timing and PWM. These can be created using multiple pipelined ripple counters where each added pipelined stage only cost one clock cycle delay.

Because FPGAs don't do analog well, one has to think outside the analog box to create all digital control mechanisms.

Like · Reply · 5w

Chris Merren I have used the Xilinx zynq 7000 series SoC with SMPS with good results....

Like · Reply · 5w

has no second source? I wonder what the typical production lifetime is of such a part?

Putting a small FPGA on the same silicon or at least the same header as the micro-controller could be very attractive for power product use. Many micro-controllers have PWM modules, which are set up with registers rather than code, so they steal very few cycles from the main processor and processes.

Micro-controllers with three PWM phases are common, but what if you want to have eight, sixteen or some other number of phase outputs all equally spaced in phase over 360 degrees? Programmable (connection configurable) hardware logic would be very good for that.

Like · Reply · 5w

Chris Merren David Edwards The big issue with many micro-controllers is the A-to-D are total BS.... Sampling rate is poor and the data sheet is fool of fibs....If you use too many resources the sampling rate drops... The FPGA is the way to go, especially in the A-D dept and the latency issues with control loops...

Like · Reply · 5w

David Edwards Do FPGA analog-to-digital converters have good over-under voltage protection and are they available on small FPGAs? Also, some of the specifications for some of the FPGA analog comparators I have seen have not been impressive.

Would any members of this group care to recommend a small FPGA suitable for power conversion products? (Should be single supply, perhaps with A/D converters and analog comparators.)

Like · Reply · 5w

Bob White Hamish Laird Sounds like it is time for you to weigh in...

Like · Reply · 5w

Hamish Laird David Edwards Bob White lots of questions here. FPGAs are common in power control for custom peripherals. FPGAs are also falling in cost. We see the prices fall and continue to fall especially for the customers who have large accounts with vendors. There are also FPGAs in all silicon vendor companies which are used for power control chip prototyping.

Like · Reply · 5w

Bob White Hamish Laird OK, but what about combinations of FPGA and microcontroller cores? Don't you typically use a device with a significant FPGA married to an ARM core?

Like · Reply · 5w

Hamish Laird I do not know of the details for Intel or Lattice but Xilinx has made "If you want to buy it we will make it" statements for a long time.

Like · Reply · 5w

Hamish Laird Bob White We do use the FPGA with the ARM core attached as a development platform.We can then move to custom FPGA hardware to meet cost targets.

Like · Reply · 5w

Hamish Laird We do o control in the microcontroller or processor core as processors are just too slow.

Like · Reply · 5w

Hamish Laird That is - We do no control in the nmicrocontroller or processor core as processors are just too slow.

Write a reply...

David Edwards . Hello Hamish Laird,

It seems that micro-controllers can handle loops with 10kHz to 20kHz+ sample rates for a loop gain cross over in the low kHz. This would suffice for outer voltage loop control in most applications, even complete control when the micro-controller has on-chip hardware PWM modules (inverters, motor control, battery chargers and the like). Do you agree?

Also, perhaps you could answer my previous questions:

Are there now inexpensive, 3.3 volt single supply FPGAs of modest internal size and external pins (<=48)?

If these exist, do they include robust, high performance A/D converters and analog comparators with full (or nearly full) 3.3V input range?

For these types of devices (if they exist) what part numbers are out there?

Like · Reply · 5w

Hamish Laird David Edwards - Yes. All of this exists.

Like · Reply · 5w

Hamish Laird David Edwards Good luck.

Like · Reply · 5w

David Edwards . Hello Hamish Laird,

???? Thanks - I think. (I was asking out of curiosity - not working on an FPGA design.)

The Atmel AT40KAL series is 3.3V single supply with 5V tolerance, but it does not seem to offer analog functions.

The Microsemi 40MX and 42MX FPGA families are similar - no analog.

How about coughing up just one part number?

Like · Reply · 5w

Hamish Laird Seriously? Good luck.

Like · Reply · 5w

David Edwards . Hello Hamish Laird,

Is there something uncouth or offensive about my question? I really don't understand. Would an answer from you somehow be impinging upon your business? I am just looking for a little pointer in the right direction. Perhaps an FPGA manufacturer's name would suffice.

I am an analog and power circuit designer. I have done system design including FPGA algorithms, fully digitally simulated, but I leave it up to the digital designers to choose the part and implement the algorithms, which they usually resist because they have no control and stability design expertise (for example, for generating digital ramps, they didn't even understand the need for pipelining digital ripple counters as gate delays add up to spill over a clock period - we had a lot of trouble finding a good digital engineer with FPGA and feedback control experience).

Like · Reply · 5w

Write a reply...

speed PWM feedback signal, filter it with audio bandwidth and feed it to a low cost external comparator the output of which goes back into the FPGA to complete the ADC feedback loop. That might be fun to design. Audio bandwidth should be good enough for controlling inverters, motor drives and the like.

Assume a 250MHz FPGA clock. With a 10 bit counter one could generate a 250kHz sawtooth. A simple three pole filter would filter the one bit PWM by just under 2,000x which would just sufficient for a 20kHz, 1024 step ADC bandwidth. I am just working this out as I type so I may be mistaken. The analog input would also need an anti-aliasing filter if the input contained high frequencies. Overall ADC bandwidth without too much phase shift might be only 5kHz or so. To bump up the bandwidth, one could have the FPGA produce two or three bits or do some oversampling tricks with in the FPGA.

Like · Reply · 5w · Edited

Seppo Turunen I am using the 3.3V variant of a Lattice Mach XO2 FPGA. The one with 2000 logic elements comes in a 100-lead TQFP package and has turned out to be more than sufficient for my project. For analog inputs I use LTC2315-12 5 Msps A/D converters that allow the FPGA to take plenty of samples from current and voltage waveforms for subsequent digital processing such as averaging, threshold detection and feedback control.

Like · Reply · 5w

Joel Holland Do you need a DSP as well? What switching frequency did you use and at what resolution? What do you think the maximum limits for those would be?

Like · Reply · 5w

Seppo Turunen Joel Holland I do not have a DSP. I am switching at 100 khz. The FPGA clock is 50 MHz. I am using registers of different length in the arithmetic, ranging from 12 to 32 bits. The longest ones are only needed as a scratchpad in divisions, though.

Like · Reply · 5w

Ray Ridley Nice.

Like · Reply · 5w

Write a reply...

David Edwards Do any readers here have enough FPGA experience to comment on the last several remarks and/or answer the questions that did not get answered (read starting with the comment that begins, "I am not an FPGA expert . . ."

Like · Reply · 5w

Seppo Turunen There are families of small 3.3V FPGAs on the market with 256 to 50000 logic elements. The pin counts range from 32 and prices from 3-4 usd upwards.

Like · Reply · 5w

David Edwards Seppo Turunen Thanks for answering.

Like · Reply · 5w

exist. I have experience with dsPIC33 and PSoC5. (1) PSoC5 comes with Cortex-M3, probably all you will ever need in terms of instruction set. (2) It has a catalog of analog & digital components you can drag and drop on a schematic & wire up as you please (within limits). This provides versatility I have not found on any other chip. (3) Furthermore it supports creation of custom digital from RTL, although this is the weakest of PSoC features & I wouldn't recommend it for massive digital blocks. The workflow is poor & support is lacking. In my opinion if the application is fine with >3-5us of budget for execution of critical control loop calculation then a software based solution would probably be the right approach. If you need FPGA for control loop and custom PWM features then try Zynq-7000 SoC (zc702) but you wont get ADC/Comparators. Need to use discrete. This development takes time & resources (from experience 🙂). In silicon development world, you are asking for a custom SoC with requires 10+ engineers & couple years, and of course, the most difficult part: a business case to support.

Like · Reply · 5w · Edited

Write a reply...

Manoj R Iyer I have had reasonably good success in grid connected inverters using PSoC chips of Cypress. One IC does it all! Quite

Pranit Pawar
February 26

FEA analysis for Parasitics

hi all! has anyone done FEA analysis of a pcb layout to get the parasitics (inductance mainly)?

3 28 Comments

Like Comment

Daniel Ruiz Not personally, but have been on a team in which we used Ansys for this purpose on multi-MHz switchers.

Like · Reply · 5w

Write a comment...

Pranit Pawar Hi Daniel! Could you put me in touch with some of the team members?

Like · Reply · 5w

Ray Ridley It's a lot of overkill to just get inductance. That doesn't begin to explain all the EM effects you will see due to layout.

I think most applications of FEA will be shooting for more information than that.

Like · Reply · 5w

Pranit Pawar but then if all designs are made by following some general rules, rules we don't know whether they will lead to an optimised design, then how to to be sure that a particular layout version will be the most optimised

Like · Reply · 5w

Ray Ridley No layout is ever "optimized". I think you should let that go as a design objective, or you will spend years in layout.

No one would ever agree on what "optimized" even means.

Like · Reply · 5w

Pranit Pawar I created this thread because I looked for papers for optimal layout design and every paper just gives some 10-20 configurations and shows the resulting parasitics of the arrangement. no reason, just graphs.

Like · Reply · 5w

Like · Reply · 5w

Ray Ridley Experience. And intelligent iteration. That's the fastest way to product.

Like · Reply · 5w

Ray Ridley Graphs are good, that is how good engineering happens.

The modern way is to want to solve it all with a computer, but that will never happen. Doesn't ever stop people trying though.

Like · Reply · 5w

Daniel Ruiz We didn't use it to design or look for an optimized layout as much as to extract parasitic values to use in our simulations.

Like · Reply · 5w

David Edwards For most circuit traces and signals a few nH don't matter much. It's only those with high di/dt that may be problematic. In a switching supply what's always important is the inductance of the common source path between the gate drive and the main switched current of the MOSFET.

Like · Reply · 5w

Pranit Pawar Yes its a GaN high power drive, so di/dt and dv/dt is high

Like · Reply · 5w

Write a reply...

Darrell Hambley Pranit, You can get a good estimation of inductance if you break down your traces into linear elements. Use the equation for a strip-line over a plane:
L=4*pi*l*d/w
Where: l is the length, d is the thickness of the board material and w is the width of the trace. All in cm. If you're working in inches, multiply by 2.54 cm/inch for:
L=32 nH-inch
For example, For w = 0.05 inch, d = 8 mils, l= 1 inch the trace inductance will be:
L = 32nH-inch *1*0.008/0.05=5.1nH.
You can verify this when you see a voltage spike on your o'scope from ground to the source of a MOSFET for example. If you know the rate of climb of current, di/dt, you will see that this spike voltage is close to:
V=L*di/dt

Like · Reply · 5w

Ray Ridley don't forget bond wire inductance. Plus, strip lines over planes probably don't exist in many places.

We should have a rule on the site, perhaps - metric units only!

Like · Reply · 5w

Pranit Pawar And for a plane, similar approach can be used to break down the polygon into small strips and integration has to be done ?

Like · Reply · 5w

Darrell Hambley Many firms in aerospace use inches for board layout dimensions. I did leave the equation there in cm for those who only work in metric, assuming they don't know how to multiply by 2.54. Praint - yes, it can be integrated. Do pay attention to lead wires as Ray suggested. Always include source and drain lead inductance in your models.

Like · Reply · 5w

88.5 pF/cm * Area/d * e. e, Dielectric is about 4.7 for FR4.

Like · Reply · 5w

Ray Ridley inductance and capacitance is a start.

But then you must consider all the antennas and that's where the fun starts.

That's why you can't simulate EMI with any degree of reality.

Like · Reply · 5w

Ray Ridley Aerospace firms and inches....you think the mars lander would have put an end to that but old habits die hard.

Fortunately very few of our course attendees these days know what a circular mil is any more. That's good.

Like · Reply · 5w

Write a reply...

Janaki Ram Gopal Pagolu curious why inductance mainly ? and what type of PCB are you looking at? Ansys package does that but I have seen it applied more for modifications in existing design (you know tweaking here and there) than during design stage, again depending on type of PCB.

Like · Reply · 5w · Edited

Pranit Pawar high di/dt can cause Vds overshoot and damage a 650V GaN operating at 400Vdc bus..
also, GS loop inductance has to be kept minimum to have a stable gate drive
I'm looking at a 4layer pcb

Like · Reply · 5w · Edited

Paul Greenland Janaki Ram Gopal Pagolu unless you use a clamped topology.

Like · Reply · 5w

Pranit Pawar Paul Greenland any clamped topology for 3ph VSI?

Like · Reply · 5w

Janaki Ram Gopal Pagolu Measures to excessively reduce inductance will lead to increase in capacitance (at least as far as tracks go), and depending on topology, or operating conditions like switching frequency e.t.c will make your gains zero. So, I think layout optimization should always be aimed at reducing parasitic as a whole, not just inductance. Every trace is a transmission line!

Like · Reply · 5w · Edited

Write a reply...

Thomas Mathews For RF PC board designs poor via inductance is usually the biggest headache. To get lower inductance ground-path connections and thinner transmission line widths, microwave folks use REALLY thin layers between signal and ground (usually ~0.008"). If via inductance is the problem, you can also lower ground path inductance by using multiple vias to bond a top-side ground plane to the inner plane.

Like · Reply · 5w

Arief Noor Rahman you worried too much, learning the simulation software may give you more problem than the expected benefit...

your PCB doesnt cost that much, unless its a 16layer laptop motherboard...design iteration and paying attention on design pattern among multiple app notes is enough...faster and cheaper...

(perhaps around 10) working on projects for GaN based converter some are at modest frequency and some at over500kHz, and one or two groups pushing over 1MHz

Literally, none use pcb parasitic except the over MHz group, and they are doing it mainly for writing journal, not really for the design itself...

For your curiosity, they use ansys Q3D

Like · Reply · 5w

Write a reply...

Sanchit Mishra I have done it but it is painful to make it an exact replica of what's on the PCB (so I don't think I have gotten to this part). But, it's quite useful to understand trends.

Like · Reply · 5w · Edited

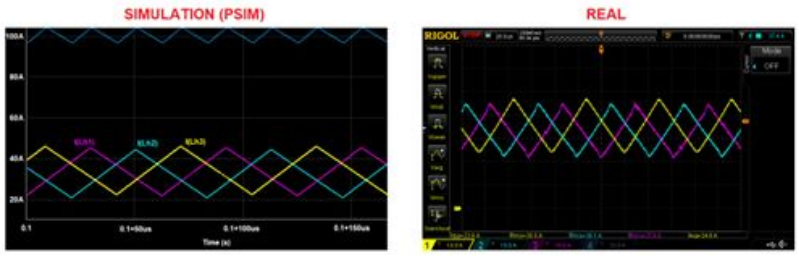
Write a comment...

Fırat Deveci
February 27

I like PSIM simulations a lot. This is very powerful tool for engineers and designers.

I saw Ray Ridley's last post and I wanna share this.

This is 3 phase interleaved boost converter inductor current waveforms.



9 14 Comments

Like Comment

Bob White PSIM is a good tool with some nice advantages. So is SIMPLIS (my preference). For a lower cost ideal switch PWL solver based simulator check out NL5 by Alexi Smirnov.

http://nl5.sidelinesoft.com/

NL5.SIDELINESOFT.COM
NL5 Circuit Simulator

Like · Reply · 5w

Arief Noor Rahman I chat with the owner a while ago, very smart...the company seems like a one man show...haha

Like · Reply · 5w

Ray Ridley Always a new simulator - great to see. I don't think that we will link to this one unless they are willing to put in a lot of work like PSIM have.

Ray Ridley I believe that one of the coming strengths of PSIM is the digital control they are implementing, plus the motor drive aspects. I will let Albert Dunford speak more on that topic.

Like · Reply · 5w

Albert Dunford PSIM provides support for a great deal more than analog power supply. Not sure how NL5 fits into digital control, motor drives, embedded code gen, non-linear switch transitions, stability and convergence in larger simulations, etc.

Like · Reply · 5w

David Edwards .Hello Ray Ridley,

I would love to see a similar comparison between your modification of LTspice, PSIM and SIMPLIS (and perhaps some others - see below). In addition to comparing plots, a listing of run times would be very informative.

This is taken from one my entries in the LTwiki:

The SPICE engine runs on fine tuned Modified Nodal Analysis technology, but competing technologies are emerging. Many simplify all nonlinear elements (diodes and other switches) into piecewise linear equivalents (2 or more line segments). This reduces the simulation to solving a repeating succession of related linear topologies. These are joined at their border points in time, but are perfectly linear in between. Each topology can be quickly solved without the many trial and error points of a nonlinear Newton–Raphson solution. Most notable of this breed are SIMPLIS (SiMetrix), PSIM (Powersim), PLECS (Plexim) and NL5 (Sidelinesoft).

These engines feature very quick steady state solvers for switched circuits and switched mode power supplies. Typically named POP or PSS (Periodic Operating Point or Periodic Steady State), a long, drawn out initial transient is avoided. Near instant POP/PSS and transient run speeds allows a time domain DFT ac analysis to be performed on switched circuits. Loopgain of switching power supplies and class-d amplifiers may be quickly analyzed in the time domain. Only a single nonlinear switched model is required - no need to resort to equivalent circuits with added "sampling effect" networks. Simulated results precisely match lab measurements (Venable, HP4194A, etc.) to and beyond the switching frequency.

Like · Reply · 5w · Edited

Ray Ridley Don't forget our simulation engine in RidleyWorks. Faster than any of them.

Like · Reply · 5w

Ray Ridley Sounds like a good job for someone who is (semi) retired. 😎

Like · Reply · 5w

Ray Ridley Remember, all of these methods depend upon the circuit being stable. Otherwise there is no POP and you have to go back to small-signal models (which you should be using anyway.)

Like · Reply · 5w

Ray Ridley I believe the new-found speed of the PSIM has rendered it a moot point about whether the POP method is needed now. They have certainly cut deep into this prior advantage of Simplis.

LTspice is good too, you just have to wait. But what's the hurry? Layout a board while it does its thing.

So many options. What a great time to be a power designer!

Like · Reply · 5w

Yaqoob Muhammad User interface wise, I think, nothing can beat PSIM.

Like · Reply · 5w

Like · Reply · 5w

Ray Ridley Interesting. what do you like about the PSIM interface versus

1) LTspice
2) Simplis

Like · Reply · 5w

Chris Merren You can make most simulation tools run smoothly if you adjust the settings to favor SMPS .... I have used Cadence for modeling SMPS IC'sfor over 20 years with very good accuracy... In both Time Domain and Freq. Domain for closed loop analysis and plotting....

2

Like · Reply · 5w · Edited

Write a comment...

Ray Ridley
Admin · February 27

Frequency Response Analyzer Performance

As many of you know (and are too polite to mention) many scope makers are now putting Bode plot capabilities in their product. **Congratulations** to the scope makers for making this investment.

This doesn't alarm us at all - it is great to see such awareness of the need for Bode plots. What this is going to do is get people started on the topic, and get the measurements back into education.

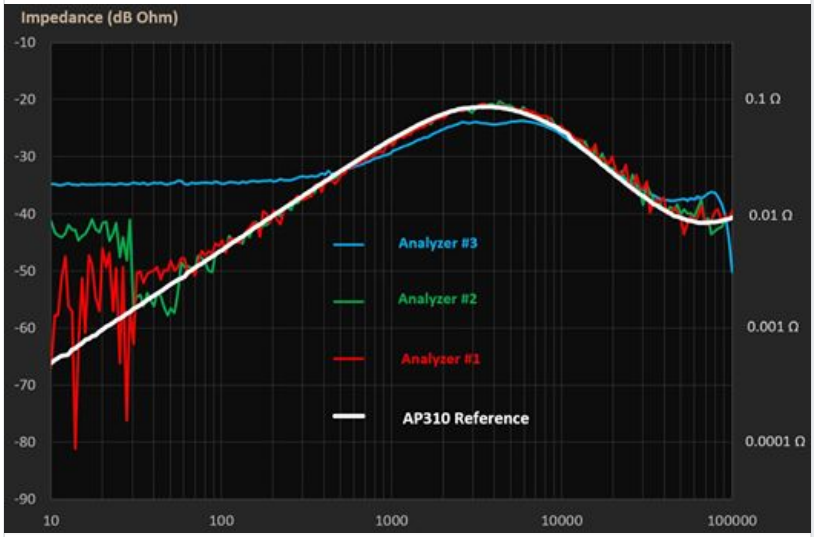
Later, users will find that the performance can be quite erratic, depending on many factors, and what kind of thing your are trying to measure. Passive circuits - all is well. High performance noisy switchers, not so good.

We have been testing diligently for the last few months to see how things stack up versus the AP310, and we are very happy with the results. There are currently at least 8 different analyzers in our lab under review.

The good news for us is that nothing comes close to the AP310 analyzer for performance. You can see this in the plots below of power supply output impedance. The AP310 just cuts through the noise, and gives the same result regardless of circuit setup. Other wannabe analyzers are all over the place, especially in the range from 10 Hz to 100 Hz.

In these tests, the exact same circuit is being used, same cables, same isolator, everything.

If you need a rough idea, use whatever is at hand. But if you need reliable rugged performance under all conditions, the AP310 analyzer is the only one that gives it to you.



You, Jay Philippbar and 25 others 39 Comments

Like Comment

Like · Reply · 5w

Nicola Rosano Is Bode100 in the bunch?

Like · Reply · 5w

Fernando Aguilar Vega Nicola Rosano I think it could be the red line

Like · Reply · 5w

Nicola Rosano Fernando Aguilar Vega mh. Why?

Like · Reply · 5w

Fernando Aguilar Vega Only a guess based on the noise at low frequency

Like · Reply · 5w

Nicola Rosano

Like · Reply · 5w

Write a reply...

Ray Ridley No names, sorry.

Like · Reply · 5w

Ray Ridley We have a lot more data coming.

Like · Reply · 5w

Bob Houf Ah yes - the Bafco 916XH comes to mind. That old relic made a believer out of me that you need the right instrument for the job...

Like · Reply · 5w

Ray Ridley Loved that machine! I cut my teeth on this when my company at the time couldn't afford the Venable. One awesome feature of it was that it had a great 10 V source with fairly low impedance, and we copied that (and more) into the AP310.

Like · Reply · 5w

Ray Ridley The most amazing engineering part of it was the all-analog x-y plotter interface to an HP machine. It would even draw the log axes for you.

Like · Reply · 5w

Bob Houf I had the same one at Allen-Bradley and loved the plots - the department manager was amazed and shook his head, saying, "It just takes all the work out of it...". I closed my first buck control loop with it and used it for years. That experience is why decades later I had all of our Tech Centers around the world (North & South America, Europe, China and India) purchase your Analyzers at my last corporate gig. One cannot do without it. Although I was always impressed with Dr Middlebrook's use of a Vector Voltmeter... 🙂

Like · Reply · 5w

Write a reply...

Mike Tommasi If you don't give names the information is not useful. Too bad.

Like · Reply · 5w

Like · Reply · 5w

Mike Tommasi I mean, not verifiable

Like · Reply · 5w

Mike Tommasi or shall we say, reproducible.

Like · Reply · 5w

Ray Ridley Come visit our labs. It is both verifiable and reproducible. Quite happy to show anybody in person what each one does. Weaknesses and strengths.

For obvious business reasons, we cannot call out what each one is doing and put it in print, but we have plenty of data on them all - more than has probably ever been collected.

One aspect of it all is that we are really not interested in teaching them how to do a better job at what they are trying to do.

Come see us at APEC, we can share more verbally. Happy to do that.

Like · Reply · 5w

Write a reply...

Riccardo Tinivella can you say what are you measuring? seems 8uH parallel 220uF parallel 0.1Ohm

Like · Reply · 5w · Edited

Ray Ridley Oh no, this is an active power supply, two switch forward with 100 V input.

Like · Reply · 5w

Michael Thomason Were any of the VNAs averaging between runs?

Like · Reply · 5w

Ray Ridley No

Like · Reply · 5w

Ray Ridley We also worked hard on getting the best response out of every unit.

Like · Reply · 5w

Hitesh Kumar Ray Ridley : I have a doubt that the real experimental bode must have irregular shape, specially in case of switching power converters, due to the violation of theoretical (ideal) small signal approximation. Isn't it good that we see it ? Does AP310 analyzer give both the actual and the averaged bode? Moreover, among all the 4 analyzer reponses, how do we know that which one is more close to the practical result?

Like · Reply · 5w

Ray Ridley The AP310 measurement lies right on top of the prediction. That is how we know which is correct.

Like · Reply · 5w

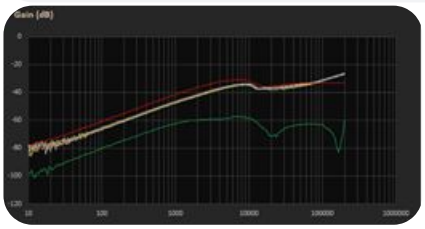
Venkat Karthik Appears to be current mode control output impedance plot

Like · Reply · 5w

Ray Ridley Here is another thing we have learned by testing so much over the last few months. Output impedance and PSRR are the toughest things to measure and this really separates the different pieces of equipment.

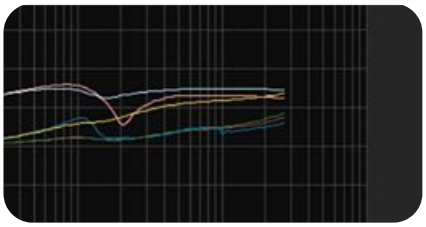
Also, many of them studiously avoid the 10 Hz to 100 Hz region. It is a tough place to measure, but essential because that is where the line frequencies are.

Ray Ridley This was a really illuminating and surprising set of experiments on 9 different analyzers. The AP310 reference is 20 dB below the others. This is a PSRR measurement.



Like · Reply · 5w

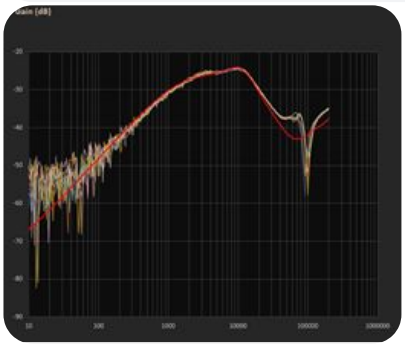
Ray Ridley More variability - see how much fun we have been having here?



Like · Reply · 5w

Ray Ridley Here is one more plot of impedances, and a question. You can see the AP reference trace. Are the other measurements "good enough"?

Probably all depends on your industry, but I don't really know the answer to this.



Like · Reply · 5w

Ray Ridley To be honest, we can squeeze a loop gain out of almost anything. But it takes a lot of experience to do that. Most users won't have the expertise to do that, hence the AP310 with RidleyWorks that makes it a one-button setup.

PSRR and Output Impedance are much tougher to measure well. Many of the machines just can't do it.

Like · Reply · 5w

Modern scopes certainly have processing power to handle it. They probably need to work on optimizing their analog circuitry for the task.

One thing to keep in mind when interpreting loop gain plots, some analyzers may be very good a presenting just the response to the fundamental test frequency, filtering out all harmonics and any other spurious signals. However, this may not yield the best indication of stability margin.

Why? Oscillation occurs at the frequency point which, if you were to magically break the loop at the input to the comparator (where the signals are analog), the signals on both sides of the loop would be identical. However, these may not be sine waves. If there are significant harmonics present, these must be taken into account in computing loop gain.

To be honest, I don't fully understand the math required, but this effect has been demonstrated in self-oscillating class d amplifiers where the oscillation point varies significantly from that predicted from the Bode analysis and enhanced .ac simulations. This problem is best illustrated by attempting to predict (using Bode analysis) the oscillation frequency of a simple Schmidt comparator oscillator circuit.

Like · Reply · 5w · Edited

Ray Ridley There is a conflict of optimizing the analog hardware to be a good scope versus being a good analyzer. Every scope we have measured so far, and some of the analyzers, have the same problem.

It makes them very susceptible to different test setups, which is not a good thing.

Like · Reply · 5w · Edited

Ray Ridley The AP 310 is not susceptible to these DUT setup changes. That is a very significant thing. this is a new realization for us, a result of all the testing we have been doing.

if you have our experience here, you can tell when things are not measuring right and maybe change setups. Without that, you are shooting in the dark, one of the reasons that people get frustrated with FRA measurements.

Like · Reply · 5w

David Edwards Frequency Response Analysis injects a smallish floating ac signal into the control loop, usually at a low impedance point. It then does a vector ratio analysis of signals measured from the two ends of the floating source with respect to ground. Discrete Fourier analysis techniques are used to reject noise.

Without thinking about it, one might assume there would be no need to adjust the size of the floating source over the measurement frequency range. However, at the low frequency end, due to extremely high loop gain, one of the vector signals gets very small and the floating source amplitude must be increased to avoid signal to noise issues. A similar effect happens at the high frequency end past unity loop gain.

I am correct to assume that the AP310 makes these adjustments automatically?

Like · Reply · 5w · Edited

fixed. These adjustments are automatic.

Typically starts at 5 V p-p at 10 Hz, reduces to 20-100 mV at the crossover, depending on your loop and compensator shape.

Automated setup with RidleyWorks, graphically adjustable in the AP310 software if needed.

The curve can be made as complex as you like if noise regions are encountered.

Several of the scope analyzers only allow you to do a step at a frequency, not such a good way to do it. Software fix for later perhaps.

Like · Reply · 5w · Edited

Ray Ridley With true FRA analyzers like the AP310, there is a mixer on the front end. The AP310 also creates an IF bus above 10 kHz, all of this is done in analog RFcircuitry.

It's like a radio receiver tuning in a small signal in a lot of noise. It's one of the reasons that the scopes can never match the range of a true FRA in a noisy environment. Just not possible with straight sampling of a scope and only 8 bits. (or even 12)

Like · Reply · 5w

Write a reply...

Rob Cravens Can you supply a list of analyzers you tested?

Like · Reply · 5w

Ray Ridley We will provide that a little later. Have been collecting data for several months, need to collate it into a presentable format, more so than we have now. Here are the ones that got evaluated but never made it to the proper testing stage:

core technology

Arief Noor Rahman
Conversation Starter · February 23

Hi, I am wondering if there is anybody willing to share a simple project example for TI piccolo MCU series that using asm...

I have been using this MCU for a long time, but now I need to squeeze the simple computation in a shortest time possible, hopefully within less than 60 clock cycles, and I found that my code was taking too much computation time...thus I am considering to use asm to speed it up...

Thanks...

1 18 Comments

Write a comment...

Like Comment

Abhijit Kshirsagar You want the entire thing in asm or just specific fuction calls?

Like · Reply · 5w

Arief Noor Rahman I only need one function call that can access EPwm register

Like · Reply · 5w

Abhijit Kshirsagar search for "intermixing C and assembly" on the E2E forums. There are some examples in the Code Composer Sample Code as well.
There is a function call that loads some ADC calibration data that is included in most ADC example projects. You can use it as a template.

Like · Reply · 5w

Arief Noor Rahman Thanks...

Write a reply...

Luis Rizki Ramelan Have you utilise CLA? It can run parallel with cpu

Like · Reply · 5w

Arief Noor Rahman ☕ I use 28027, no CLA here...haha

Like · Reply · 5w

Luis Rizki Ramelan Haha, I see, then asm is likely the only choice.

Like · Reply · 5w

Arief Noor Rahman ☕ Yep...unfortunately

Like · Reply · 5w

Write a reply...

Scott Styles you might have more luck on the e2e forums?

Like · Reply · 5w

Arief Noor Rahman ☕ I assume TI piccolo is wildly popular...

and i also can get some responds within minutes here...

Like · Reply · 5w

Hamish Laird Ti Compiler manual for calling asm from c, code profile and try not to stall the pipe.

Like · Reply · 5w

George William Tyler I used to do this with microchip's pic processors for power electronics related functions, often had to match times through alternate patches. Used them for class D ups too, to generate the sinewave and control amplitude.

Like · Reply · 5w

Brian Liu Use the TI control suite there are a bunch of examples in asm for many purposes especially for 2p2z and 3p3z compensations, which may cost a lot of time. Besides, the ti forum is another place for these questions.

1

Like · Reply · 5w · Edited

Alex Berestov Yada...yada...yada with zillion stages pipeline those things are "useless" if you need to react to events. Perhaps it forced TI to put DSP inside of DSP. And yes it's pathetic. In late 80's 24 bit DSP made of sectional piecies AMD29XX (not XXX which still controls planes) has 60 to 80 ns per command (12MHz) and about three times of that for branch. Routine executed every 50us i.e. 20 kHz 3rrd order system, invariant control, some house keeping. 30(!) years later 150MHz F335, also being more sophisticated, just barely keeps up with three phase vector controlled PFC: PLL ab-dq, second order compensation at the very same conversion frequency. Good luck with assembly coding and/or finding a crazy one for doing that. I've seen two in my life. One did write his own operating system just for fun another disassembled like 128 kB programs using text editor on PDP11 in order to modify them like in no time.

Like · Reply · 5w · Edited

Arief Noor Rahman ☕ why cant?

I use F28027 for three phase PFC with SVPWM, DDSRF-PLL, abc-dq, and PI for current control in DQ frame, all run at 50us (or 40us...i dont remember exactly)

additionally, I also have high speed data logging performed by F28027 to send up to 16 control variable every 500us to plot in simulink in real time...

all in C...

But, now is different challenge...haha

Alex Berestov Good for you!
But you have missed the point. In 30 years things did not change much. And there are better solutions than 28F series. The only advantage of 28F used to be PWM generation module.

Never squeeze the last drop of performance from any parts of your design, especially software. Choose part or solution with higher performance.
Why would one insert DSP into existing DSP? Why then use DSP for housekeeping/telemetry and low speed tasks?
Cheers

.

Like · Reply · 5w · Edited

Milovan Kovacevic Alex Berestov that will earn you less profit. Sometimes that is acceptable, sometimes it is just too expensive

Like · Reply · 5w

Alex Berestov What does and what kind of profit? Please be more specific,
I stopped climbing ladder quite a while ago and hope some could find some of my experience useful as lot of this group members do. Sharing is kinda human virtue.
Expensive usually means one does not need this or that.

Like · Reply · 5w

Write a reply...

Write a comment...

Soumya Chatterjee
February 26

I am trying to simulate a type iii compensator with its output fed to uc2526 ic. The uc2526 internal error amplifier is transconductance type. I am using it as a unity gain buffer. What will be the transfer function of this buffer. The datasheet says it has 2 meg internal resistance and if you put 100pf cap to ground then a 800hz pole will be created

2 15 Comments

Like Comment

Cameron Stewart My best advice:

Bias the internal transconductance opamp so that it's output is high.

Use a good quality external opamp to drive the compensation pin directly.

Like · Reply · 5w

Michael Green Cameron Stewart I have done this before. He need to check that the pull up is weak and that it can handle the continuous output draw.

Like · Reply · 5w

Alain Laprade Cameron, the OTA can normally do the job without resorting to such means. I have responsibility for numerous PWM ICs which use OTAs for compensation. Your suggestion is occasionally needed, but it is very rare for a design to need to override the OTA.

Like · Reply · 5w · Edited

I've pretty much stopped using the internal pwm error amp on many of my designs, unless there are serious real estate constraints.

Housekeeping supplies and non-critical converters under 200W are the main exceptions.

I deal with custom military supply applications where the customer usually requires higher performance or functionality than can be easily achieved with the poor quality, limited flexibilty, error amplifiers found in most pwm IC's.

Like · Reply · 5w

Cameron Stewart Similar limitations exist with most pwm IC's with respect to the gate drive outputs. They require augmentation as well.

Like · Reply · 5w

Write a reply...

Bob White Just use the internal amplifier as you would any other op-amp. Just be mindful of the current source/sink limitations (no 100 nF capacitors in the compensation network - why?) and stay well within its gain-bandwidth limitation and you will be just fine.

Like · Reply · 5w

Alain Laprade There are numerous PWM ICs which use operational transconductance amplifiers (OTAs) for which I have responsibility. It intrigues me as to why the UC2526 OTA gfs is disguised as a dB gain and pole roleoff. Makes the modeling task more challenging as the OTA's gfs parameter is crucial to the model and MUST be derived if you do not use the TI SPICE model (better yet, extract the modeling parameters from the TI SPICE model if accessible). As to Bob White's warning about capacitance, TAKE NOTICE. the UC2526 OTA has a 100 uA current source capability (see Figure 3 for where I see the information. I assume the same for current sync, but it appears to be unlisted in the datasheet). Using a large capacitor in the compensation network may result in the OTA 'getting pegged' at 100 uA during a large signal event (e.g. soft start, large step load current); small-signal modeling may indicate stable operation, but large-signal conditions may result in 'bang-bang' OTA response due the OTA's inability to keep up with the event. Designing with OTA's is normally not an issue if you keep this in mind.

Like · Reply · 5w

Alain Laprade Soumya, it is somewhat uncommon to resort to a Type III compensation for a current mode IC. I normally see that in situations where the output filter capacitor is an all-ceramic implementation. I'd be interested in understanding your motivation for Type III compensation.

Like · Reply · 5w

Ray Ridley Isn't 2526 voltage mode?

Like · Reply · 5w

Col Johns it has a CS+ & CS- pin for terminating a cycle once 100mV is exceeded...

Like · Reply · 5w

Ray Ridley OK.

Like · Reply · 5w

-30dB attenuation network to force the IC into cycle-by-cycle current mode control, via the CS (+) and CS(-) pins.

If you use the OTA voltage amplifier inside the I.C., you have to operate voltage mode.

The SG2524A, SG2525,and SG2526 were a family of improved derivatives of the original SG2524 plain vanilla. They all featured cycle-by-cycle current limit with voltage mode control.

A lot of half-bridge designs blew up when retrofitted with these I.C.

On the plus side, compared to the UC2825, they run very cool, and are fairly insensitve to board layout and I.C. decoupling problems.

They are fairly flexible as building pwm blocks due to the I.C. pinouts that are available.

Like · Reply · 5w · Edited 2

Alain Laprade Oh my! I completely missed that this IC is a voltage mode control. Soumya, I comprehend your potential need for a Type III. As Cameron points out, there are better choices.

Like · Reply · 5w

Soumya Chatterjee Alain Laprade Now I should check for other ic. But my primary operation is VMC and cycle by cycle transformer overcurrent protection

Like · Reply · 5w

Alain Laprade Soumya Chatterjee That wasn't mentioned in your initial post.

Like · Reply · 5w

Write a reply...

Write a comment...

Jeremy Lister
February 26

Power Integrations..what's going on??

I'm based in the UK.

I have need to talk to PI about one of their devices.

For three days now one admin contact has said go to the forum. Indeed on their website it says for ALL technical queries go to the forum.

Most of my contacts have left PI. Another contact seemed hopeful but now say query your distributor and if required they may refer it to us. I have no contact to talk to. The distributor we may use is Mouser, but could be any of the major players. To my knowledge they have no FAE's

This is totally bonkers. There's no rep, no-one i can talk to. A forum is useless as I am supposed to search thousands of posts, and I am not willing to put our company IP for all and sundry to see.

I conclude for some reason PI do not want to support their customers and have become impenetrable.

Rather frustrated and annoyed at this situation which seems designed to frustrate and hinder and make you do all the work.

What are they playing at?

p.s. guess who's going to get designed out and never looked at again!

You and 5 others 21 Comments

Wow Comment

Nicola Rosano Please tell me it is not Cambridge site

Like · Reply · 5w

suspect we have a few of their field apps engineers lurking on here.

Like · Reply · 5w

Charlie Elliott Jeremy Lister - I have heard exactly the same thing from somebody else in the UK recently. Sadly I am not surpised as FAEs are ofted viewed as overhead by accountants so ....

Like · Reply · 5w

Ray Ridley Here you go -talk to Roland, tell him that I sent you.

https://www.linkedin.com/in/rsaintpierre/

LINKEDIN.COM

Roland Saint-Pierre, Jr. - Technical Director - Power Integrations | LinkedIn

Like · Reply · 5w

Ray Ridley I hope he doesn't get mad at me.....but PI needs to resolve this issue. This group, although it is "just Facebook" it is quite influential on the design community.

I have seen the big companies make decisions like this based upon getting burned by shoddy service just one time. From that point forward, vendors can be excluded for years at the expense of millions of parts.

Field apps engineers are under attack everywhere. The accountants will see the effect showing up on the books eventually, but they will never know where the problem came from.

Like · Reply · 5w

Richard Keller I am a PI fan boy and contractor. I may be able to point you in the right direction.

Like · Reply · 5w

Ray Ridley Experienced advice on these highly complex parts is tremendously valuable. Like all chips they have strange and undocumented modes that you need to know about. Once you understand them all is much better.

Like · Reply · 5w

Richard Keller Ray Ridley Do you know which part is the issue?

Like · Reply · 5w

Ray Ridley I only know what you see here.

Like · Reply · 5w

Write a reply...

John Dillon Jerry they have been after an FAE for the UK. for a few years
I'll contact you tomorrow with the RSM for Europe

Like · Reply · 5w

Ray Ridley How much do they pay for an FAE in the UK? Just curious...

Like · Reply · 5w

Clive Harvey Ray Ridley I would hazard a guess at around £45k, Based on the rest of the electronics market.

Might be more if it's classed as engineering sales.

Like · Reply · 5w

Alfonso Martínez According to LinkedIn:

Like · Reply · 5w

Ray Ridley Could be why they are having trouble getting anyone to fill the role.

Like · Reply · 5w

John Baillie Indeed... this is less than a train driver. And train drivers don't earn enough!

Like · Reply · 5w

Write a reply...

Thomas Mathews When I was FAE for National and TI we were often advised not to waste time helping smaller customers. Nevertheless, I always tried to help small customers and often reminded management that the design community is small and, if we get a bad reputation, it will be known by all customers, big and small. Be aware also that, every day, engineers, buyers, and other decision makers, move from company-to-company. The young engineer that you hung-out-to-dry could be tomorrow's chief engineer at Apple and that person WILL forever remember how they were treated.

Like · Reply · 5w · Edited

Venkat Karthik All semiconductor companies have the same strategy in terms of customer support. Go after big fish since more than half of their company's revenue is decided by the big guys.

Like · Reply · 5w

Tony Salsich I have many designs using their DPA switch and various iterations of the TopSwitch. These things are loaded with clever features and it's all spelled out in their literature.

Like · Reply · 5w · Edited

Col Johns You need to have read all the historical literature to have a solid understanding of many of their current chips ...

Like · Reply · 5w

Ray Ridley they are indeed clever. If you are new to them, it is very hard to figure out all the interactions from the literature, experience is key.

Like · Reply · 5w

Ray Ridley As one of our engineers puts it - when we review a PI design, there is a big sigh. We know it will probably work OK, but lots of work ahead to dig through all the possible modes of operation. But solid engineering usually, so that is good.

When reviewing a design from one of their competitors, you first have to hang a crucifix on the wall and rub garlic on the circuit for good luck.

4

Like · Reply · 5w

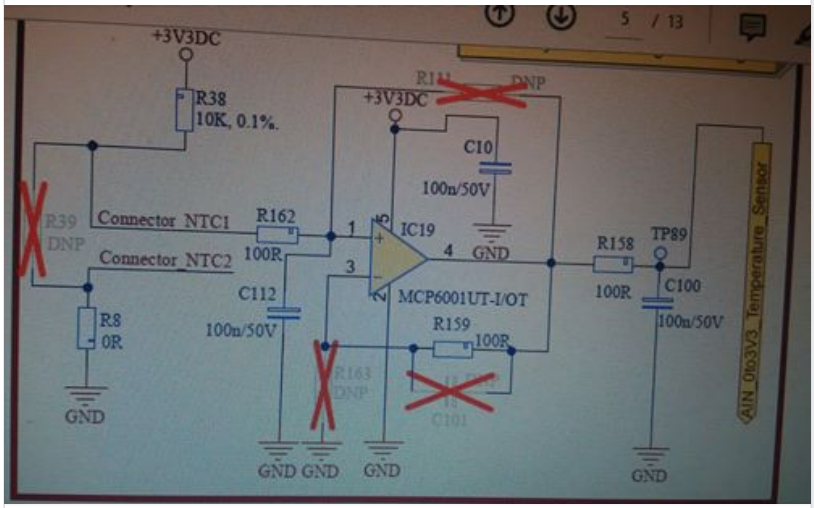
Write a comment...

I am in trouble to measure the NTC temperature using microcontroller adc. I used STM32F405 controller . I did not use external reference in controller for ADC measurement. Internal reference is used. Now the internal reference varies from 1.18V to 1.24V which is approximate 2% of measurement error introduced. So if my temerature range is 0 to 35degC and hence maximum error is 0.7degC.

I can not use external reference for MCU because STM32F405 is not having external reference pin in 64 pin package.
So can anybody suggest me any idea , solution or path to get rid of this problem.

Supply voltage for NTC and Microcontroller is same dc rail and coming from LDO.

For now I am not considering the non linearity of NTC.



5 | 20 Comments

Like | Comment

Ray Ridley Please try to do some cleaner graphic. It is so easy to use the snipping tool, then paste into the comment. People shouldn't have to get eyestrain reading what you post.

Like · Reply · 5w

Ray Ridley Why not add a precision reference if you need more accuracy?

Like · Reply · 5w

Shiv Kumar Mishra STM32F405 do not have external reference pin in 64pin pin package. That's the reason

Like · Reply · 5w

Bob White I think you need to do a full tolerance analysis on the entire sensor circuit. For example, you did not mention the tolerance of the temperature sensor. How does that compare to the error introduced by the variation in the internal reference voltage for the A2D converter?

Like · Reply · 5w

Yuval Iz Simply use an accurate voltage regulator and feed the microcontroller VDD and feed VDDA via a bead and a 0.1uf to gnd using this methode the ADC vref became the regulator voltage Analog device have accurate linear regulator you can use

Like · Reply · 5w

Charlie Elliott Feed a vref into another ADC input and do the compensation in software !

Like · Reply · 5w

achieve this.

Like · Reply · 5w

Charlie Elliott Shiv Kumar Mishra - I and other members of this group are very happy to help but we are typically not prepeared to do the actual job without being paid for it!! Please think carefully about what I have suggested and I am sure what you need to do will become clear.

Like · Reply · 5w

Ray Ridley Let me guess....."can't afford a Vref in this design?"

Like · Reply · 5w

Shiv Kumar Mishra Sometimes we made worng guess. MCU does not have external reference pin 64pin of stm32f405

Like · Reply · 5w

Julio La Leggenda Use a current source to generate a precise voltage reference.

Like · Reply · 5w · Edited

Broox Le What exactly is the problem? - is the error tolerance not tight enough for your application?

Like · Reply · 5w · Edited

Alex Berestov 1. Did not you know If a ruler is 0.7% accurate that's all you gonna get?
2. Did not you read datasheet before you designed thingy of yours?
3. It's a good lesson, next time think before you do.

Introduce good ref into design of yours and measure it with free adc IN.
P.S. It's power supply (not analog or micro) design group BTW.

Like · Reply · 5w · Edited

Syed Rafi Sifath Palal 1. Have a precise regulator is a good option,
2. also possible to calibrate using software, eg use another adc pin and measure a fixed voltage then calculate the variation from your base device then include this variation in you temperature calculation. The varietion input you can take in uart and store in flash
3. You can use a potentiometer in series with ntc and can adjust the output manually for different devices. The resistance of pot might change with temperature though, but I guess this still reduce your error
4. Software calibration using only ntc also possible, you measure your base ntc reading, and target ntc reading, add the variation calculation in Target ntc using uart and store it in a non volatile memory.

Like · Reply · 5w

Frank Warnes I always prefer the LM50 to using an NTC. Gets rid of all the complication

Like · Reply · 5w

Yuri de Klerk Or MP9700

Like · Reply · 5w

Charlie Elliott Yuri de Klerk AKA "the thermistor buster"

Like · Reply · 5w

Milovan Kovacevic Sometimes you earn more money, sometimes you make your life easier, sometimes both, sometimes neither

Like · Reply · 5w

Write a reply...

come up with a way to measure the internal Vref against VCC and then use the thermistor to increase accuracy a bit. 1°C accuracy with a thermistor is pretty good for a low cost circuit.

Like · Reply · 5w 1

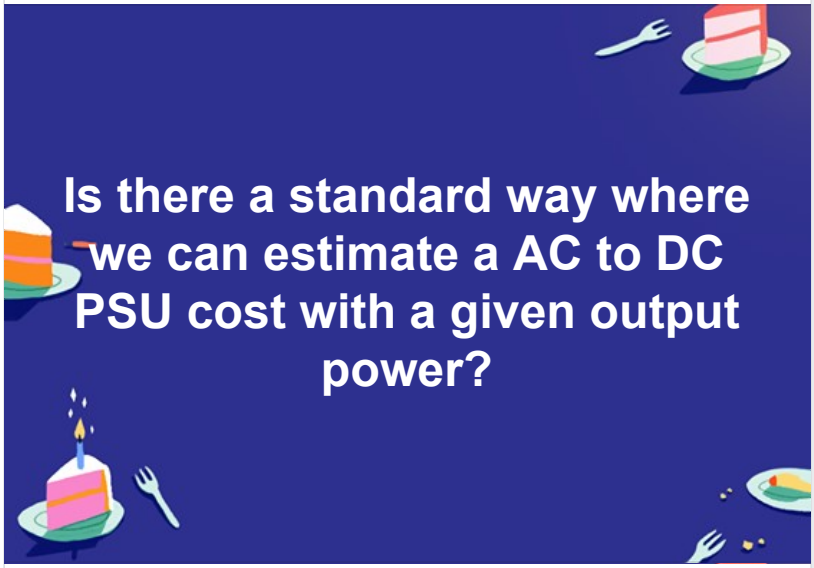
Shiv Kumar Mishra Yes, MCU power supply and NTC power supply are at same dc rail

Like · Reply · 5w

Write a reply...

Write a comment...

Khor San Lee
February 25



1 19 Comments

Like Comment

Kyle Miller Depends on the market and size... But a good rule of thumb is 30-50cents per watt when you're within "normal" voltages (< 600 volts output)... You get outside of normal, so does the price...

Like · Reply · 5w

Khor San Lee Kyle Miller thanks

Like · Reply · 5w

Hamish Laird 3kW telco power supply in volume less than 3 cents a watt.

Like · Reply · 5w

Col Johns that's US $90.00 ex factory for 3kW Telecom psu in volume ..?

Like · Reply · 5w

Hamish Laird Col Johns yep

Like · Reply · 5w

Hamish Laird As power gets bigger cost falls on a per watt basis

Like · Reply · 5w

Khor San Lee Hamish Laird noted. Thanks.

Like · Reply · 5w

Ray Ridley I will respectfully disagree here.

My answer is “no”.

Dave Lafferty You can't estimate cost until you have a product spec and an idea of what type of design is required to meet that spec.

Like · Reply · 5w

Bob White And aside from the very important specifications, what is the production volume? The cost difference between making 100 per year and 100,000 per year is orders of magnitude (see Hamish's note that high volume telco rectifiers sell for US$0.03 per watt).

Like · Reply · 5w

Jeremy Lister The sales manager will define the price and you make the design fit that price...a route to disaster

Like · Reply · 5w

Ray Ridley Corollary to this:

The system definer will define the enclosure, and you make the design fit that space.

Like · Reply · 5w

Ray Ridley Disaster recovery is our thing. By the time people come to us for a design, they need it now, and cost is not the first thing on the list any more. The disaster has already happened, and there is no power supply available for the product because things were designed with only price in mind.

We do FAST prototypes for people in trouble. It's stressful sometimes, but rewarding. Our last fast prototype was 100 W isolated converter design, build and test in 1 week. That included all magnetics designed and wound as part of the process.

Before that was a 400 W flyback converter, also completed in 1 week.

It is not $0.03 per watt 🙂

Like · Reply · 5w · Edited

Ray Ridley As Bob has mentioned, you can't begin to price a product if you don't have the schedule and production quantity.

The Telco rectifiers that we review here have probably 20 man years of development in them, or more. Trying to enter this space without all this investment behind you is not going to work.

The second Telco rectifier you design will be dramatically less. And so on.

Like · Reply · 5w

Ray Ridley One more comment on the Telco rectifiers - I cannot see why anyone would want to be in that business. You look at the products, and cannot imagine being able to make it for the price.

Yet, still, the price pressures continue from purchasing and sourcing departments until it is getting to the point where power supply companies don't even bother quoting a design any more.

Hence the design goes to a new company in a new country that doesn't understand how it all works yet. They will quote anything to get the job!

Like · Reply · 5w

Ray Ridley And who paid for the NRE? Where is it made?

Is this something you are buying now? Or are you planning on designing it?

Crazy world we choose to operate in! 🙂

2

Like · Reply · 5w

Doddapaneni Venkata Nagesh Babu Many specs to consider, not just watts alone to decide cost.

Like · Reply · 5w

standard product...

if you add many requirements and certification...of course price will increase

Like · Reply · 5w

Doddapaneni Venkata Nagesh Babu With all respect, 1) volume 2) procurement strength 3) type of product - not just power circuits . 4) connectivity and accessories ,5) agency compliance 6) single output or multiple output 7) low current or high current rails and etc . It will be miss leading by just throwing numbers by just wattage. Thanks for your patience

Like · Reply · 5w

Write a reply...

Write a comment...

Arief Noor Rahman
Conversation Starter · February 26

Hi,

is there anyway to detect if three phase PLL has reach steady state or loss of lock for three phase inverter?

FYI, I use Double Decoupled SRF PLL

1 3 Comments

Like Comment

Sarthak Jain You can observe the internal vq signal which is controlled by PI to make it 0 in locked condition.

Like · Reply · 5w · Edited 6

Arief Noor Rahman thanks...i think to simply feed the Vq to LPF then use a window comparator with small range i.e. (-5<Vq_filtered<5)

Like · Reply · 5w · Edited

Write a reply...

Davide Bagnara i check... as prsvious comment... but relaxed...

Like · Reply · 5w

Write a comment...

Col Johns
February 25

for the disposable designs out there...

You, Darrell Hambley and 75 others — 19 Comments

Like | Comment

Roswell Bob LaFrank works on tube radios
Like · Reply · 5w

Ray Ridley Can you share the origin of that part? Col Johns
Like · Reply · 5w

Col Johns sent from an engineer who wishes to remain anonymous ...
Like · Reply · 5w

Maxime Berger Maxime Deveau
Like · Reply · 5w

Norman Elias Shielded caps?
Like · Reply · 5w

Dan Watts Similar thing is no uncommon in rechargeable batteries.
Like · Reply · 5w

Dave Lafferty I have done this on vintage equipment that the owner wanted restored and recapped. Put equal or higher voltage caps of better quality than originals in the older cans to maintain the vintage look.
Like · Reply · 5w

Clive Harvey When working in an aerospace company, they all of a sudden had very expensive products going bang on the production line during final test, one after the other.

Route cause came out to be a IC that was fake, simply a empty package with no die.

Managed to track the part back as having passed through China and apparently got swapped out there somewhere.
Like · Reply · 5w

Scott Styles 10A rated cabling burning at 9A... caveat emptor....
https://www.youtube.com/watch?v=wts5EEO7jr0

YOUTUBE.COM
10A Rated IEC Power Cable Running at 9A

Like · Reply · 5w · Edited

Jay Lee Very high esr and esl
Like · Reply · 5w

Like · Reply · 5w

Ray Ridley What is the voltage rating on the outer can? Can't quite see that.

Like · Reply · 5w

Col Johns 50V I believe

Wow · Reply · 5w

Ray Ridley Thanks Col Johns for the smile. I posted this on Linked In feed (your name included) and it is proving very popular. 900 views in the first hour alone - never seen a response like that before.

It might be "fake news" but the real counterfeiting going on is so much more subtle and deadly than this.

Like · Reply · 5w

Col Johns Just as an aside - the lads here at work do a side project building electronic ignitions - they have experimented with AliExpress parts for the large TO-247 pnp & npn power transistors (250V 15A high gain) - a number have had no bond wires inside, or died in seconds on the test bench - luckily the cost of this learning is not high ...

Like · Reply · 5w

Nicholas Procktor This is an interesting (albeit quite specific to sound generator ICs) video about how ICs are faked/ refurbished in China. https://www.youtube.com/watch?v=k72SFBOZ_lw

YOUTUBE.COM
"Fake" chips?

Like · Reply · 5w

Venkat Karthik Even with the batteries: check @4:14
https://www.youtube.com/watch?v=5Q1MPrgea1M

YOUTUBE.COM
EEVblog #1200 - BUSTED! - Energizer & Duracell NiMH

Like · Reply · 5w

Alex Berestov Penny saved is penny earned!

1

Like · Reply · 5w

Alex Berestov Once I've opened auto grade lytic, 470x35V. There were 7 layers of foil with a "paper separator". Pretty much as batteries above. well known manufacturer and specs were met.

Like · Reply · 5w

Write a comment...

Ray Ridley
Admin · February 24

Free Design Software

Downloaded some "free" power design sofware today. It wasn't free - it cost me two hours of finding the bugs, holes, and outright errors. A truly horrible experience! Then straight into the trash can.

Do yourself and your company a favor - buy our design software and save a lot of time and money!

You, Darrell Hambley and 14 others 4 Comments

Like Comment

Ray Ridley If everybody on the group bought a copy of the software, we would just spend all our time teaching this group. It would be great! 😎

But I know how it goes....you ask your manager and they say "but xxx company has FREE software. Why don't you just use that?"

Like · Reply · 5w

Col Johns I am always pleasantly receptive when companies can afford to spend a pretty shiny penny on PE consultants (who have all the gear) to come and solve their power supply issues - but refuse a big Capex item (FRA) for their engineers for a "one off" project - always makes me laugh (when I am back in the car ...)
It's always "one off" because the middle mgmnt project managers never last too long ...

Like · Reply · 5w · Edited

Norman Elias What you want is free software from a known-reliable source. Berkeley Spice was free but the source was Don Pederson. If you found a bug in the latest release you could expect a fix for it. It wasn't perfect but it dod the job.

Like · Reply · 5w

Ray Ridley If the need is for free, we will always be in the state we are in now. Woefully inadequate free offerings, posturing as the real thing.

LTspice is as good as free gets, but it only simulates, it doesn't design for you. There is a difference, but managers tend to not understand that in general.

2

Like · Reply · 5w

Write a comment...

Ray Ridley created a poll.
Admin · February 13

Conference Travel
APEC 2020 is coming up, in the shadow of the corona virus. Semicon in China is already cancelled, as are many conferences in Europe, we hear. There are more papers than ever already planned so there is still so much to learn there.
What is your company travel status?

- [ ] Travel restrictions already in place before this +23
- [ ] I'll be at APEC as always +10
- [ ] No travel right now +7
- [x] Too busy working on power electronics right now. Next year for sure !
  Added by you +2
- [ ] We can travel, but many choose not to

1 More Option...

4 8 Comments

Like Comment

Sad · Reply · 7w 1

Ray Ridley Well I hope you come along anyway Nelson Garcia. It will give us a lot of free time to talk about things we might be able to do together.

Like · Reply · 7w

Ray Ridley I hear that the attendance from the Far East will be way down. But they are probably not your customers anyway.

Like · Reply · 7w

Nelson Garcia Ray Ridley I may actually be at this years APEC and would look forward to chat with you.

Like · Reply · 7w

Nelson Garcia Ray Ridley I sent you an email earlier today.

Like · Reply · 5w

Ray Ridley Sounds great, just come by the booth. Probably see you at the rap session on magnetics too. Our schedule is up in the air since we have no idea what attendance will be.

Like · Reply · 5w

Nelson Garcia Ray Ridley I understand. See you in a few weeks.

Like · Reply · 5w

Write a reply...

Ray Ridley APEC is still on. This direct from the APEC committee.

If you are not afraid of going, it will be a great chance to get the ear of many industry leaders. We will be there, of course.

https://apec-conf.org/

1

Like · Reply · 7w

Write a comment...

Pranit Pawar
February 25

GaN Driver Query -

A lot of GaN based designs (high and low power) that I have seen dont use an active miller clamp driver. Isn't it bold to use unipolar gate drive and still not have a miller clamp? I agree the device capacitances are low, but the dv/dt is high

1 3 Comments

Like Comment

Arief Noor Rahman Careful layout and gate resistance value is another option...

drive as fast as possible may be good to boost efficiency, but will be difficult to contain all the noise

1

Like · Reply · 5w

used for GaN switches driven with unipolar gate drive?

Like · Reply · 5w

Arief Noor Rahman if you dont switch at crazy fast speed...then the I(Cgd) will be not an issue...

I dont know for sure, but EPC often dont use both negative supply and miller clamp, navitas also dont have miller clamp inside (i think)

Like · Reply · 5w

Write a reply...

Abhishek Rao
February 25

Specifications

1 OUTPUT POWER 250 watts

2 INPUT VOLTAGE RANGE 90-270 volts

3 LINE FREQUENCY 47-65 hz

4 OUTPUT VOLTAGE 400 volts

5 SWITCHING FREQUENCY 100000 Khz

6 INDUCTOR RIPPLE CURRENT 20% of Ipeak

7 INDUCTOR REGULATION 1%

For 100khz the wire diameter comes upto 26 Awg

Irms current =2.91 Amps

What will be the current density and utilization factor to be assumed

Planning to design planar inductor for learning and development purpose

2 14 Comments

Like Comment

Ray Ridley Are you planning a boost pfc here?

You haven't specified.

Like · Reply · 5w

Abhishek Rao Yes

Like · Reply · 5w

Abhishek Rao It is boost pfc topology

Like · Reply · 5w

Ray Ridley And at which point of the line voltage do you want to apply your 20% ripple rule?

Like · Reply · 5w

Abhishek Rao Vmin =90 volts

Like · Reply · 5w

Abhishek Rao Ipk=4.12 Amps,ripple current=0.824

Like · Reply · 5w

Ray Ridley Abhishek Rao perhaps it's would be a good idea to post your schematic with the inductor value and current waveform.

What does 1% regulation on the current mean?

Like · Reply · 5w

He might mean that as well.

Like · Reply · 5w

Ray Ridley That makes even less sense in the magnetics world these days, but you might be right.

Like · Reply · 5w

Write a reply...

Sesha Sai Kumar Your electrical specification of converter has nothing much to do with txf current density. It merely depends on your PCB and it's trace thermal rise your are looking for, type of ambient, whether the trace is on outer layer or inner layer, trace copper thickness and even length. your utilisation factor is actually not a great concern in planar designs yet it can be a function of your mechanical size constraints of your transformer, class of PCB insulation and your layer to layer potential etc . Abhishek Rao

Like · Reply · 5w · Edited

David Seal Not to be too picky, but if you want into the US industrial/commercial market, it needs to be 277 VAC on the upper input.

Like · Reply · 5w

Tom Shearer David Seal yes. And add 10% on top

Like · Reply · 5w

Ray Ridley I think most people know where this is going. The PFC inductor has many harmonics in it. DC, double the line, and line harmonics, then the switching frequency and its harmonics.

Applying some kind of rule like #26 awg wire (for skin depth, presumably) just has no bearing on the design at all. Likewise current density and utilization factor. That is ancient art for designing magnetics that should no longer be considered.

I don't know what is meant by a planar by Abhishek Rao, but if he is talking about a PCB winding, just not a good idea for this application. I just don't see those in any products thus far, nor do I expect to. Lots of ways to optimize the inductor, and we are seeing some creativity there, but not with a PCB winding.

1

Like · Reply · 5w

Ray Ridley So let's turn this into something useful for everyone - take a picture of any PFC chokes you have at hand so we can all learn something. I'll start a new thread.

Like · Reply · 5w

Write a comment...

Clive Harvey
Conversation Starter · February 22

Hello all, so for my next question.

High voltage (2Kv), high side current sensing.

My intention is too use a current mirror, the issue with this is dropping 2Kv across a single NPN/PNP, more so the PNP seems hard to source.

So my first thought was too use series transistors to voltage share, but I can't seem to get them too share, it seems to just drop all the voltage across the last transistor in the chain and Vbe drop over the rest.

So, does anyone have any suggestions for high side current sensing, for low current high voltage.

Or maybe some advice on getting series BJT to share voltage evenly(ish).

3 123 Comments

Like Comment

Like · Reply · 6w

Clive Harvey Robert L Rauck I was considering this, but with very low current would this not be difficult?

I will want too set current limits around 10-20mA.

Like · Reply · 6w

Robert L Rauck Transformer turns ratio would be different but it can be done.

Like · Reply · 6w

Colorado Mike Doherty How much current?

Like · Reply · 6w

Hide 15 Replies

Clive Harvey Colorado Mike Doherty 10-20mA

Like · Reply · 6w

Colorado Mike Doherty Clive Harvey can you tolerate a series sense resistor with a set of matched voltage dividers upstream and downstream from the sense resistor? Amplify the difference for current to voltage.

Like · Reply · 6w · Edited

Clive Harvey Colorado Mike Doherty to be fair that's not much different too the current mirror approach, I have a 100Ohm sense resistor that I'm sensing from.

I guess this can be done with a diff amp rather than a current mirror.

But I'm guessing this would be expensive and also wouldn't there be issues with HV common mode rejection?

Like · Reply · 6w

George William Tyler Colorado Mike Doherty resistor tolerance become an issue

Like · Reply · 6w

George William Tyler How accurate must it be?

Like · Reply · 6w

Clive Harvey George William Tyler accuracy wont be a massive issue, this is for output safety protection, preventing a dangerous current, rather than output current control.

Like · Reply · 6w

Clive Harvey George William Tyler I'd have thought 10% wouldn't be an issue.

Like · Reply · 6w

George William Tyler Clive Harvey then sense primary current? Unless it's flyback

Like · Reply · 6w · Edited

Clive Harvey George William Tyler from a safety point of view I'm not sure sensing primary current is suitable.

If it is, then I could just set the primary side current limit accordingly.

Like · Reply · 6w

George William Tyler Human body can take 200a for 50uS

Like · Reply · 6w

Like · Reply · 6w

George William Tyler This is the output of a fence energiser, designed to meet C2 rating. It's all about energy

Like · Reply · 6w

George William Tyler You hace caps on the output? Voltage multiplier? Flyback? How do you control the output current with whatever you sense with?

Like · Reply · 6w

Jay Philippbar How much bandwidth do you need?

Like · Reply · 6w

Clive Harvey George William Tyler do you know of any standards I could read?

My approach at the moment is to diode or the primary and secondary current sense, so if the output current exceeds the safety limit, the controller will start to fold back and go to constant current,

Like · Reply · 6w

Write a reply...

Col Johns High side current sensing has issues if the 2kV moves up and down a bit - consider low side sensing...(?)
We have high side sensing on our 250VDC input MPPT controllers - it is an exercise in analog design to scale up to 2kV, pnp/npn in series and controlled to give a linear result ...

Like · Reply · 6w

Hide 16 Replies

Clive Harvey Col Johns the issue being in the event of an electrocution we don't have control over the return path, hence high side.

I was hoping I could get the normal current mirror to work and share the voltage over several BJT, but I can't seem to get that to work. I've worked a lot more with FET's than BJT's.

Like · Reply · 6w

Col Johns If there was a small P channel SiC device at 2200V the analog level shifting would be easy ...

Like · Reply · 6w · Edited

Col Johns A very simple ckt for peak sensing would be via an opto ...

Like · Reply · 6w

Clive Harvey Col Johns my Monday plan was too look into FET based current mirrors, everything I've seen so far has been BJT, but I can't see why it can't be dont with FET.

So yes, I'm guessing there should be some suitable SiC devices.

Like · Reply · 6w

Clive Harvey Col Johns would you simply put the diode of the opto in series? How accurate do think that would be? What drawbacks do you see?

Like · Reply · 6w

Clive Harvey I'm guessing with the CTR being so variable, it could be abit to crude?

Like · Reply · 6w

a pot (or calibrate in code) - but doable. [diodes in series across the LED part for extreme over currents to protect the LED and at least 2 x opto-couplers for increased fail safe] - there would be degradation over time - so a need for re-cal every 12 months ...

Like · Reply · 6w · Edited

Clive Harvey Col Johns yer this was another concern, when I've worked in Hi-rel the boards with opto's had to be service replacement parts because the reliability was so low.

In this instance it's automotive, so unless we did a cal during PBIT, which I think would be hard, I can't see that working.

Funny how the things that seem simple at first glance can be a challenge lol

Like · Reply · 6w

Col Johns Depends on how hard they are run, 20mA max for a few hours a day - will give a pretty long life - even with slight degradation over time ....

Like · Reply · 6w

Clive Harvey Col Johns how longs pretty long?

I'm very cautious about using opto's for safety functions, mainly because the first you know of them having failed is someone getting electrocuted lol

Wow · Reply · 6w

Col Johns most psu's use opto's to regulate the output - if they fail or degrade too far the Vout flies up to max ... this rarely happens inside 10 years ...

Like · Reply · 6w

Clive Harvey Col Johns ok that's interesting, this post has given me a few options.

Like · Reply · 6w

Nathan Ellis Clive Harvey FETs should be possible if you stack them to divide the voltage amongst them and use a large valued resistor divider to bias their gates appropriately. Wikipedia has a small piece on this under 'Cascode'.

Like · Reply · 5w

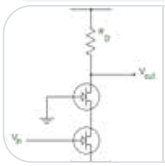
Clive Harvey Nathan Ellis this is was I was just starting to play with.

Do you have a link to the wiki by any chance?

Like · Reply · 5w

Nathan Ellis Clive Harvey under "other applications"

https://en.m.wikipedia.org/wiki/Cascode



EN.WIKIPEDIA.ORG

Cascode - Wikipedia

Like · Reply · 5w

Nathan Ellis Imagining this may end up being more expensive than optocoupler option though (not sure). Also if you want to learn more about cascoding you're prob best off heading to an analog circuit design book.
I'm not sure what transistor mirror circuit you're referring to.

Like · Reply · 5w

Write a reply...

Like · Reply · 6w

Clive Harvey Scott Styles wouldn't the current need to be AC for a current transformer too work?

This is a D.C. Rail.

Also I would imagine this solution is quite expensive, which would be prohibitive.

Like · Reply · 6w

Scott Styles no it is a dc coupled device. it is just a DCCT with a heap of turns on it. ...as for cost can't say but have seen BOM cost angst translated into enormous development expense on many occasions...

Like · Reply · 6w

Clive Harvey Scott Styles in this instance it's for an automotive end use, so every penny counts on the BOM.

That's the real difficulty with automotive products.

If a cost effective solution to an issue like this can't be found, it can kill a product.

Like · Reply · 6w

Clive Harvey Scott Styles just did a quick bit of reading, DCCT do sound interesting. Do you know of any low current DCCT, that would be in the $1-2 price mark?

Like · Reply · 6w

Scott Styles that's not really my world.. get in touch with Raztec and ask them. there is another company in the states that does baby DCCTs like this but name escapes me.

I'm just an NPI engineer. I don't do design. I do get involved in fixing thigs that have been overly KISSed or overly cost wrung out though...

Like · Reply · 6w

Clive Harvey Cheers I'll check them out.

That I can relate too.

Like · Reply · 6w

Write a reply...

David Seal Proportional opto-coupler. Float the high side as high as you want, it won't care.

Like · Reply · 6w

Clive Harvey David Seal does that differ from a normal opto?

Like · Reply · 6w

David Seal The emitting (sensing) LED gives off an amount of light proportional to some given input voltage. This requires internal support circuitry to do, since the LED light curve is not linear. The receiving side is an LED of identical design, and also with support circuitry to keep the proportions linear.

Like · Reply · 6w

Clive Harvey David Seal ok that's interesting and this support circuitry won't mind the high Common mode voltage?

Like · Reply · 6w

David Seal Clive Harvey
https://www.digikey.com/.../optoisolators.../903...

Optoisolators - Transistor, Photovoltaic Output | Isolators |…

Like · Reply · 6w · Edited

Clive Harvey David Seal I was just reading about these. It seems as you said it requires some circuitry on both sides, an op amp to linearise it.

My concern is how to power the op-amp on the high side?

Like · Reply · 6w

David Seal Clive Harvey Look at the spec sheets. Dive into the app notes. There are versions that already have ll that done for you. I will look, I have an entire guide somewhere. I think I also have a development board from TI around here somewhere as well. There are options for split supplies, power couplings, or simply use a off-the shelf isolated modular supplies for the high side isolation. All have varying degrees of common-mode rejection, usually on the spec sheets.

Like · Reply · 6w

Clive Harvey David Seal a copy or link to a guild would be great help.

I'm now wondering if the op-amps are low current enough, I could power them using the voltage drop across a series resistor from the line being sensed.

It's the hard balance of keeping things "cheap", I need to achieve this for $1-2.

Like · Reply · 6w

David Seal Clive Harvey My guide is at home, I am at my office. And then I guess the Allegro current sensors, like the ACS770, which are good for about 8Kv, are also out of the question? HV isolation of control signals is costly. They have some less expensive Hall effect sensors, though, if you look around.

Like · Reply · 6w

Clive Harvey David Seal I've used those before, but they are designed for 10's or 100's of Amps.

Something like 10mV/A.

Like · Reply · 6w

Write a reply...

Cameron Stewart High side current sensing with a 2KV output requires some sort of galvanic isolation in the interest of circuit reliability.

With a pulse transformer, there are many approaches available to accomplish this. For example:

1) Chop the output signal into AC, send it across the pulse transformer, then demodulate and recover the DC information.

2) Perform the current limit comparison high side, then send the current limit shut-down signal across the pulse transformer.

Opto-couplers and digital isolators can also be used for approach #2.

Using current mirrors to send high side current sense information down to return potential is only asking for serious reliability problems.

Like · Reply · 6w · Edited

Cameron Stewart A schematic or block diagram illustrating the application would help. There are too many missing pieces of information.

application is quite simple. It's a HV flyback, I've had a few posts and advice regarding it, I think you have offered some advice on it.

What I'm trying to achieve is an output current limit for safety limit or cut off.

My concern is that if I do this primary side, this won't be suitable for a safety case, that's point of load sensing is what's really needed.

Like · Reply · 6w

Cameron Stewart Clive Harvey

I think sensing primary current is actually safer: There is no way that you can have a secondary current limit fault without it being reflected back to the source at the primary.

Where else is the energy being sourced except at the primary, into the flyback transformer?

So I disagree with your assertion that sensing primary current is somehow not safe.

The main limitation with primary current sensing is accuracy. But accuracy should not be confused with reliability or safety.

If your primary current sensing is only 10% to 15% accurate, from a safety standpoint that is still acceptable. The human body shock threshold will vary far more than that anyway because skin resistance varies so much.

You do not require 1% precision accuracy. You require reliability and low cost. Primary current sensing easily fits the bill.

Like · Reply · 6w · Edited

Clive Harvey Cameron Stewart thanks for this, I think I'll do some testing on this and if I can prove the safety case, that I as you say, all is reflected too the primary this is a great solution.

I guess what I have to confirm is what my variation in primary side current is for the same output current and make sure I can't exceed my safety limit.

Just off the top of my head, if I measure/simulate the primary side current at the output limit, and limit my primary current too this, I shouldn't be able to exceed this.

That side, my primary current varies at input voltage.

So the primary input current at 9v input vs 18v input, would allow for twice the output current.

Given that the primary current can vary so much, that's why I was trying to do output current sense.

Like · Reply · 6w

Cameron Stewart Clive Harvey

The energy into the transformer per cycle is 1/2 LI squared. If the input voltages increases, you simply reach the peak primary current limit point sooner during each cycle.

But current limit at 9V input is the same as current limit input at 18V.

The argument is more mathematical and basic physics than one of safety.

I'm assuming fixed frequency PWM in making this argument.

Things get messier for fixed on time, variable off time operation.

Like · Reply · 6w

question haha

So with a well chosen primary current limit I can protect my output.

The controller I'm currently using does discuss a method for my to clamp the internal reference down to a lower voltage, that with a well chosen shunt, should be enough, simple and cheap.

Like · Reply · 6w

Cameron Stewart Clive Harvey

Find a better controller..... .

Like · Reply · 6w

Write a reply...

Brian Faley Is the current unidirectional or bidirectional? It's pretty easy with a saturating current transformer in the first case. Isolation is determined by wire insulation. Accuracy is determined by permeability of core. I've used metglas core to sense dc current over a three decade range.

Like · Reply · 6w

Hide 17 Replies

Clive Harvey Brian Faley unidirectional

What is the cost of a solution like this?

Like · Reply · 6w

Brian Faley Most of the cost is the core. Couple bucks in low volume. It's been awhile since I used it.

Like · Reply · 6w

Brian Faley The advantage is no active circuitry on the sensed side, and low supply current. It's a pulsed circuit. Drive the sense winding out of saturation with a pulse, measure the voltage across the sense resistor which reflects from the primary. The sampling frequency and core permeability set the power required.

Like · Reply · 6w

Clive Harvey Brian Faley so I should be able to do this with a high turn pulse transformer.

Aslong as it's saturated at my current limit?

I've not used magnetics D.C. so I'll have to do some reading.

Like · Reply · 6w

Brian Faley No it's actually a low turns count. It spends most of its time in saturation, only being driven out for a microsecond or so per sample cycle. We used a 15mm diameter toroid. At your current levels, I'd estimate less than ten turns. Rudy Severns taught me this more than 30 yrs ago. I'll post his paper.

Like · Reply · 6w

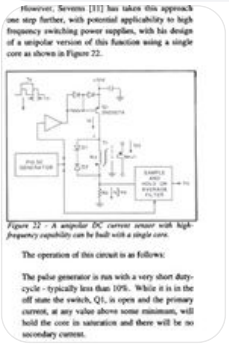
Clive Harvey Brian Faley is be very greatful too read that.

Like · Reply · 6w

Brian Faley The paper is cited below - it appeared in part in a TI design seminar paper authored by Bob Mammano. Current Sensing Solutions for Power Supply Designers.

Severns, R., "Improving and Simplifying High Frequency DC Current Sensors", IEEE APEC Conference, 1986.

Like · Reply · 5w



However, Severns [11] has taken this approach one step further, with potential applicability to high frequency switching power supplies, with his design of a unipolar version of this function using a single core as shown in Figure 22.

Figure 22 - A unipolar DC current sensor with high-frequency capability can be built with a single core.

The operation of this circuit is as follows:

The pulse generator is run with a very short duty-cycle - typically less than 10%. While it is in the off state the switch, Q1, is open and the primary current, at any value above some minimum, will hold the core in saturation and there will be no secondary current.

Like · Reply · 5w · Edited

Brian Faley

2. When the pulse generator is on, Q1 closes and the reversal in voltage across the secondary allows the core to come out of saturation with a current Is = Ip / Ns. At the same time, Vo is developed by sampling the voltage on Rs caused by Is.

This circuit could potentially operate with sampling frequencies up to the megahertz region, allowing reasonable resolution of current waveshape with a bandwidth in excess of 100 kilohertz. An additional benefit is that the low duty-cycle of the excitation voltage acts as a multiplier to the turns ratio and allows very high primary current without a corresponding number of secondary turns. [12]

Like · Reply · 5w

Clive Harvey Brian Faley unfortunately I'm not an ieee member to can't view the paper.

Like · Reply · 5w

Clive Harvey Brian Faley cheers for the screen shoots. That's a clever approach.

So, I guess this is measuring the time it takes for the core to saturate, the lower the current, the slower the core saturates, this then averages the current flow across the sense resistor.

Like · Reply · 5w

Brian Faley no. during the time that the core is driven out of saturation, the current in the sensed winding will flow through the secondary sense resistor - reflected by the turns ratio. The value of the sense resistor times the reflected current equals sensed voltage. It will only appear as long as the pulse is active - so you'll need a sample and hold - or a diode / capacitor circuit to isolate it. It's pretty easy to generate several volts on the sensed winding. It's only for a short time - in my case we ran at 100khz with an on-time of about 500ns.

Like · Reply · 5w

Clive Harvey Brian Faley are there controllers available to do this or does it need discrete design?

Like · Reply · 5w

Brian Faley a really square loop core like metglas has a permeability approaching 100K. Since the saturation is amp turns - a dozen or so turns is plenty to saturate the primary - even at milliamp levels. This is a sampled system. It's going to take some work to figure out what the best turns and core combination is. The advantage is no active circuits on the hv side. We implemented this with a TLC555, a low leakage diode and capacitor, and a p-channel fet. I don't know of an off-the-shelf IC .

Like · Reply · 5w · Edited

My concern is the development time in getting this working, while also keeping to pcb mounted, small and cheap.

Like · Reply · 5w

Brian Faley It's pretty small. with current of a few dozen ma - the core is tiny. I didn't say it was a cookbook recipe. 😉 There are certainly other approaches - hall effect would be hard pressed to have enough sensitivity at this current level.

Like · Reply · 5w

Clive Harvey Brian Faley yer Ive been looking at Hall effect and while I could get there with some amplification, the parts are prohibitively expensive.

I wonder is a planar track, maybe with a ferrite overlay would be sufficient to sense current?

Like · Reply · 5w

Write a reply...

Rob Cravens I use small LEM Hall effect dc current sensors for this type of application. They usually have 100kHz bandwidth if that is important to you.

Like · Reply · 6w

Clive Harvey Rob Cravens what sort of cost do they come in at?

Like · Reply · 6w

Rob Cravens Few dollars to several hundred depending on current and quality

Like · Reply · 6w

Clive Harvey Rob Cravens I was just looking through their site, I didn't see any low current variants.

Like · Reply · 6w

Rob Cravens Clive Harvey try searching "Hall effect current sensor" in google or on digikey. Lower current is out there somewhere.

Like · Reply · 6w

Clive Harvey Rob Cravens I've had a look through digikey, closest I found was 25.5V/A, but at almost £10 per it's too expensive.

Like · Reply · 6w

Rob Cravens Clive Harvey I'll look through my notes next week and se if I can find something. CP Clair seems like a tiny one I've seen.

Like · Reply · 6w

Clive Harvey Rob Cravens that would be great, cheers.

Like · Reply · 6w

Write a reply...

Ray Ridley How about some schematics, Clive Harvey, to describe the situation better?

Like · Reply · 6w

Ray Ridley does it really have to be high side if you are isolating the output? why not a low side resistor?

Like · Reply · 6w

This is to protect for safety, so the return path could be a human, this is to prevent electrocution.

Cameron Stewart has pointed out with a well chosen primary side current limit I should be able to limit my output current sufficiently for safety.

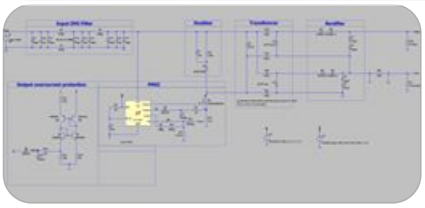
Like · Reply · 6w

Cameron Stewart Clive Harvey

If we had a circuit diagram to view, I think we could show you how to do low side secondary current sensing and still gurantee safety.

Like · Reply · 6w

Clive Harvey Cameron Stewart heres the initial approach.



Like · Reply · 6w

Cameron Stewart Clive Harvey

Just as I thought:

Remove the ground at the bottom side of the L4 / C6 junction.

Connect your current sense resistor from that junction to ground. This eliminates the non-isolated ground as a problem. You will need to sense a negative going current sense signal with respect to ground.

A single supply opamp (LM2904) to sense current limit will perform this function, without a (-) rail housekeeping supply source.

Ground the (-) terminal of the opamp.

Connect a summing resistor from the (+) terminal of the opamp to the current sense resistor negative signal.

Connect a second summing resistor from the (+) terminal to your LT1247 Vref pin.

Install a schottky clamp diode: Cathode at the (+) input. Anode to ground. This prevents the (+) terminal from being pulled below ground and forward biasing the IC substrate.

The output of the current limit opamp will pull down on the LT1247 compensation pin through a series or'ing diode, overiding the voltage loop.

Sometimes, frequency compensation is applied to the opamp to gurantee stability, in the form of a pole zero network. This takes an extra network between the opamp output, the (-) terminal and ground to implement.

Having said that I've noticed one thing, completely unrelated: The EMI filter has no damping network for stability.

Like · Reply · 6w · Edited

Clive Harvey Cameron Stewart owww I hadn't even considered that, so measuring the return path for the output capacitor. I'll read this again tomorrow, as it's silly o'clock here now and I should have been in bed hours ago, just got stuck binge watching a series lol.

Like · Reply · 6w

Cameron Stewart Clive Harvey

I've updated my previous post to correct for wrong polarity issues with the opamp terminals.

Like · Reply · 6w · Edited

measure.

Like · Reply · 6w

Write a reply...

Alex Berestov Sensitec, it used to be 3MHz parts based on GMR. Now it's 500k but still rather impressive.
https://www.sensitec.com/.../current-measurement/cfs1000...

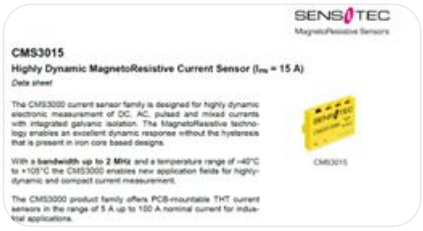
SENSITEC.COM
Expert for AMR current sensor for SMD assembly | Sensitec GmbH

Like · Reply · 6w · Edited

Clive Harvey Alex Berestov I can imagine that would be very useful for BDLC control.

Like · Reply · 6w

Alex Berestov I used to work with finished solution with embedded loop.
Jees, memory seems to fail me, it's 2 and not 3 Mhz parts:


SENSITEC
CMS3015
Highly Dynamic MagnetoResistive Current Sensor (I_{PN} = 15 A)
Data sheet

Like · Reply · 6w

Col Johns The only problem with sensing current on the pri side is that a flyback is a constant power topology - so lets say you allow for 2kV @ 20mA - then some one touches it and you get 1kV @ 40mA which reduces to 500V @ 80mA - all these give the same ave pri side current ...
You would need to measure the reflected flyback volts on the pri side - or the output volts in conjunction with ave pri side current to really know what is going on ...

Like · Reply · 6w

Clive Harvey Col Johns this is along the line of what my brain was trying to say last night at 4am and I decided to give up. Lol

Like · Reply · 6w

Magnus Rosén Shunt resistor + sensitive (2~5mA) optocoupler. Maybe with zener (5V1) in series with OC LED to increase O/C setpoint.
O/C transistor to activate flyback current (output power) foldback.
Optocoupler with 2kV working voltage is not that common but remember its functional insulation, not safety insulation so it should be possible.
A challenge is short circuit ruggedness of shunt resistor and OC Led. Suggest to use pulse proof resistors and zener voltage clamp or current limit resistor for Led.

Like · Reply · 6w · Edited

Col Johns Automotive rated;
VOMA618A-8
https://www.google.com/url?sa=t&rct=j&q=&esrc=s...

1

Like · Reply · 6w

version, set the current limit at 200%.

That means in worsecase my maximum supply current would be half my limit current, but will be somewhere between halfway to the limit.

That could work.

Like · Reply · 6w

Col Johns Clive Harvey or the 130-260 (-8 version) - solder blob trim could be an option

Like · Reply · 5w

Clive Harvey Col Johns I'm it sure what you mean by solder blob trim?

Like · Reply · 5w

Col Johns You have several resistors to alter gain - selected by solder blob on the pcb.

Like · Reply · 5w

Clive Harvey Col Johns are got ya. I was playing with a app not from maxim today, didn't get very far.

https://www.maximintegrated.com/.../ref-circuits/1867.html

I couldn't see to get this too simulate.

MAXIMINTEGRATED.COM

Optocoupler Extends High-Side Current Sen - Maxim Integrated

Like · Reply · 5w

Col Johns Clive Harvey need a high side supply and a linear opto and a few bits but yes ... could work ...

Like · Reply · 5w

Clive Harvey Col Johns yer I was hoping I could use a shunt given the power would be so low, but realised that won't work for high side supply.

Like · Reply · 5w

Write a reply...

Tony Salsich Clive Harvey, Look here for more ideas.https://ac-dc.power.com/applications/chargers-adapters/

AC-DC.POWER.COM

Chargers/Adapters | AC-DC Converters

Like · Reply · 6w

Hide 12 Replies

Clive Harvey Tony Salsich what are you referring to specifically?

Like · Reply · 6w

Tony Salsich I recall that PI had a technique for regulating output current of a flyback from the primary side. I think it was related to their LinkSwitch.

Like · Reply · 6w

Tony Salsich https://ac-dc.power.com/.../linkswitch-3_family_datasheet...

Like · Reply · 6w

It mentioned on/off control, I wonder how noisy the output is?

Like · Reply · 6w

Tony Salsich They do very well at controlling noise in their parts. I have used them for 24 years.

Like · Reply · 6w

Clive Harvey Tony Salsich what sort of price mark do they come in at?

Like · Reply · 6w

Tony Salsich Clive Harvey, Their parts are found in a huge number of wall chargers. That should give you an idea. They have been at this for more than twenty five years.

Like · Reply · 6w · Edited

Clive Harvey Tony Salsich arrr interesting, do you know if there are spice models by any chance?

Like · Reply · 6w

Tony Salsich I do not know of any models, but their design software is quite complete. Try it out.

Like · Reply · 6w

Col Johns I'm not sure if any power integrations parts are automotive rated ... ?

Like · Reply · 6w

Clive Harvey Col Johns that's the other issue. Even finding automotive controllers at all can be a challenge, most don't have models.

Like · Reply · 5w

Col Johns For a flyback - can use a TLC 555 - easy peasy ...

Like · Reply · 5w

Write a reply...

Write a comment...

What's in the Ridley Box?

Come to booth Number 1517 at APEC 2020 to learn about our new product which will shake some things up in our industry. We will just leave it cryptic like that for now.

You, Jay Philippbar and 38 others — 22 Comments

Like | Comment

Ray Ridley Notice we have hired the young generation here at Ridley Engineering to make sure we are keeping up with the times!
Like · Reply · 6w

John Baillie Damping circuit for input filter?
Like · Reply · 6w

Ray Ridley Glad you have being paying attention!
Like · Reply · 6w

Richard Payne Jack in the box
Like · Reply · 6w

Ray Ridley We could have saved some airfare there - good idea for next year!
Like · Reply · 6w

Steve Mowry 60Hz magnetics?
Like · Reply · 6w

Ray Ridley We have some 0.1 Hz magnetics, part of our injection isolator.

Gheorghe Turcan Small pieces of Silicon rocks arranged in a "Bell Labs" way.

Like · Reply · 6w

Kevin Azul

Like · Reply · 6w

Venkat Karthik May be new frequency response analyzer?

Like · Reply · 6w

Alex Berestov Since old one was transfer function analyzer this must be synthesizer.

Like · Reply · 6w

Ray Ridley Like a Theramin?

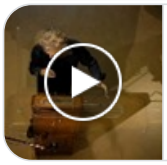
Like · Reply · 6w

Alex Berestov Like a composer for it.

Like · Reply · 6w · Edited

Ray Ridley For those who don't know what a Theremin is....

https://www.youtube.com/watch?v=K6KbEnGnymk



YOUTUBE.COM

THEREMIN - Over The Rainbow

Like · Reply · 6w

David Edwards Ray Ridley I would like Theramin. Good vibrations. Are you giving Theramins away at the show?

Like · Reply · 6w

Write a reply...

Alex Berestov Sorry it's language problem. How would yo call process of putting things together since analyse means opposite i.e. decompose something.

Like · Reply · 6w

Ray Ridley No, no language problem, just having fun with the topic.

We are not going to tell anyone the answer, so guess away!

Like · Reply · 6w

David Edwards . Hello Ray Ridley,

Perhaps among other things, the box contains individually packaged wireless battery powered oscilloscope channels where the display and controls are on a laptop, tablet or phone device?

Ray Ridley That sounds like a wish list.
Like · Reply · 6w

Alex Berestov Told ya!
https://www.pes-publications.ee.ethz.ch/.../3_Concept_and...
Ive'got a quote but could not convince the boss. It was around 3 grands per channel so I purchased 2024 with HV probes instead.
1
Like · Reply · 6w

Andrew Ferencz Shaking up the industry? A vibrating power supply?
2
Like · Reply · 5w · Edited

Lonne Mays Is that a magnetostrictive inuendo?
Like · Reply · 5w

Write a reply...

Write a comment...

Alexandros Tsourekis
February 22

Hi all,

I have been going through a push-pull transformer design from a textbook written by G. Hurley. In his book he states core data for a N87 MnZn ferrite. He makes use of the steinmetz coefficients to aid in sizing the core.

I can't make heads or tails of where he gets this data. Can anyone tell me an easy way to extract the steinmetz coefficients from the power loss curves. Not sure if this has been asked before.

Thanks!

ctive at reducing eddy cu
0.5 mm. A solid core of
hickness, while a core c

or Core Loss

equation [1] for core loss
citation:

$$P_{fe} = K_c f^{\alpha} B_{max}^{\beta}$$

re loss per unit volume;
at the frequency f; K_c,
examples are given in Tal
ions, non-sinusoidal ex

Table 1.1 Soft magnetic materials

Materials	Ferrites
Model	Epcos N87
Permeability, μ_i	2200
B_{peak}, T	0.49
ρ, $\mu\Omega$m	10×10^6
Curie temp. T_c, °C	210
P_{fe} mW/cm^3	288 at 0.2 T 50 kHz
K_c	16.9
α	1.25
β	2.35

You and 12 others
20 Comments

Like
Comment

Like · Reply · 6w

Nicola Rosano Easier then youssef advice you can do the following.

If you have core losses curves, simply consider 2 curves around your switching frequency (let's say 100kHz and 200kHz). On the 100kHz curve take 2 points and register power loss and flux induction values. Repeat the same process on the second curve for 1 point only and register power loss and flux induction.

Actually you can build three steinmetz equations (three points) with (B,P and f) noted for each point. Three equations in three variables (Kc,alpha,beta coefficients to define). Done.

Like · Reply · 6w · Edited

Hide 14 Replies

Alexandros Tsourekis Thanks to both of you for the advice. I tried doing some log/ln functions to try and get simultaneous equations. I thought there would have been an easier way to do this. I was using three points for the 100khz because that's the only curve I had. I'll give it another try.

So just to confirm what Nicola Rosano is saying, the steinmetz coefficients would be the same for the 100khz and 200khz? Sorry if it's a bit of a stupid question 🙂

And just as a note to anyone interested in the book, it's an excellent book both in terms of theory and practice, but it's riddled with little typos so just some caution to anyone using it.

Like · Reply · 6w

Paul Shepherd Alexandros Tsourekis It's one of the better values in engineering references out there. Not $200 is a nice thing! And, Professor Hurley is a very friendly guy (I played tour guide at a conference for him one time)

Like · Reply · 6w

Alexandros Tsourekis Paul Shepherd that must have been quite a treat. Didn't mean to take a jab at the book, it's hands down one of the best engineering textbooks I've read

Like · Reply · 6w

Nicola Rosano Alexandros Tsourekis generally steinmetz coefficients are not the same but spreaded on frequency domain - typically divided in 3-4 frequency bands. You can see it easily on the magnetic datasheet.
But if not present, as your case, you can use that method for a simple approximation. It works pretty good.

P.s. just as an example.
Give a quick look to Ferroxcube datasheets for 3C97 or 3F36 material. These coefficients are reported clearly.

Like · Reply · 6w · Edited

Nicola Rosano See page 7 attached link as example.

https://www.google.com/url?sa=t&source=web&rct=j...

Like · Reply · 6w

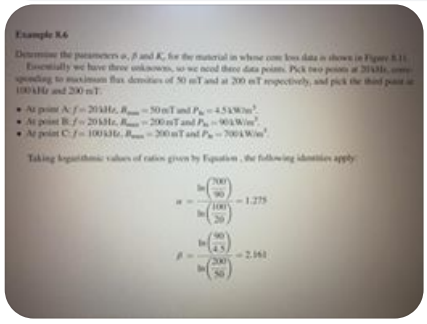
Alexandros Tsourekis Thanks Nicola Rosano, that's clears up a bit of confusion. I see in the ferroxcube datasheet they have power loss curves for more than one frequency but I don't see the actual Steinmetz coefficients published in the material datasheet.

Like · Reply · 6w

Alexandros Tsourekis Sorry I typed that too soon, I'm clearly looking at the very condensed versions of the datasheets

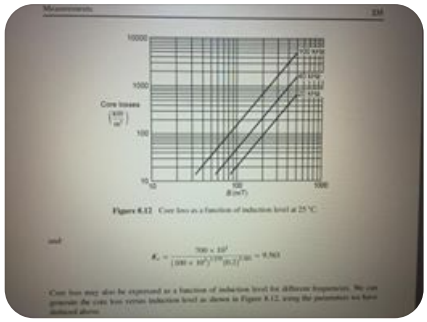
Like · Reply · 6w

back of the back theres an example. I'll leave this here for someone else's reference. In Hurley's textbook chapter 8.3 shows how to get these. Sorry if I wasted your time.



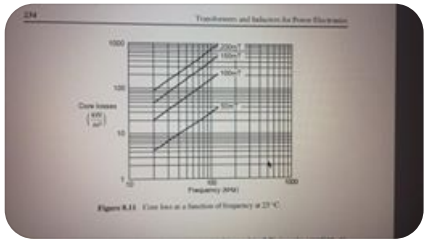
Like · Reply · 6w

Alexandros Tsourekis



Like · Reply · 6w

Alexandros Tsourekis



Like · Reply · 6w

Nicola Rosano Easy told you 🙂

Like · Reply · 6w · Edited

Nicola Rosano I can even add it is not the best book on magnetics (to me). Surely more recent then McLyman 3rd edition.

Note also two things:

1. despite result doesn't change 'log' function the datasheet typically refers is 10 base not Neper base.

2. That curves , just to close the loop, assume your excitation is sinusoidal with DC component null (not valid for hard switching converters in which the excitation is a 'square wave', sometimes, with DC component).

Basically your results will be underestimated.

Like · Reply · 6w · Edited

Alexandros Tsourekis Nicola Rosano I've been mixing and matching books. I find the book is really good at explaining magnetic fundamentals, and yes it is more recent, which is part of its appeal. I agree, using log or ln should not make a difference in the calculation even though the base is 10 on the graph

Like · Reply · 6w

to estimate the loss around your operating point. Square vs Sine has always been within 20% or 30% for my work, good enough for an initial design starting point.

Like · Reply · 5w

Write a reply...

Col Johns Depending on the size of the core and the freq - and the square wave drive - there is a lot of good learning here if you wind the primaries and power up and measure the (no load) temp rise of the cores and compare to calculated - you may be surprised what empirical observations will teach you ...

Like · Reply · 5w

Scott Styles yup. common practice for power system frequency magnetics also.

Like · Reply · 5w

Alfonso Martínez Normally the process is the inversed one, you take the measurements, calculate the regression parameters (Steinmetz's coefficients) and then plot the graphs. Using the parameters given by the manufacturer is usually more accurate than using the graphs.
In the case of TDK I must say it's a bit more difficult since they don't provide the coefficients for their materials (at leat not as directly as Ferroxcube or Magnetics, whose coefficients are available in their webpage).
Also, as Nicola Rosano pointed out, these coefficients are just for sinusoidal excitation. When you have other waveforms like trapezoidal or sawtooth, the losses (and therefore, the coefficients) will be greater.
And after all this preamble, you just got lucky wtih N87:

https://www.netl.doe.gov/.../Core-Loss-Datasheet---MnZn...

In page 6 you have the coefficients for several waveforms. Just bear in mind that your estimation will be a bit off on the safe side, since they measured losses on a big core, where eddy current losses are not negligible.
Sadly this study only covers this ferrite material...

NETL.DOE.GOV
www.netl.doe.gov

2

Like · Reply · 5w

Ray Ridley It's a great book, but don't get yourself too buried in the details. It really doesn't make sense to do the proximity losses the way he does. For a given transformer and topology, he solves the equations at every harmonic, then extracts the harmonic content from the waveforms. It's way too much math when LTspice can get there in a fraction of the time.

I would say the same thing applies to over application of the Steinmetz coefficients. This is nothing more than curve fitting, and the fit changes pretty dramatically with the temperature, frequency, excitation level, and waveshape. Getting buried in the math of it all is pretty meaningless.

Everyone should order a copy.

4

Like · Reply · 5w · Edited

Write a comment...

Arief Noor Rahman
Conversation Starter · February 19

How to clean flux residue under high voltage TO-Leadless package?

This TOLL package is promoted to have very low package parasitic, but now I have a problem like large leakage from Drain to Source at higher voltage, which to my experience it tells me that there is a flux residue between drain and source....

Thanks,

12 34 Comments

Like Comment

Scott Styles could you put a route in the PCB?
Like · Reply · 6w

Arief Noor Rahman sorry, i dont understand what a route is?
Like · Reply · 6w

Col Johns Arief Noor Rahman A small width routed line in the pcb between drain and source ...
Like · Reply · 6w

Arief Noor Rahman like a pcb cut out?

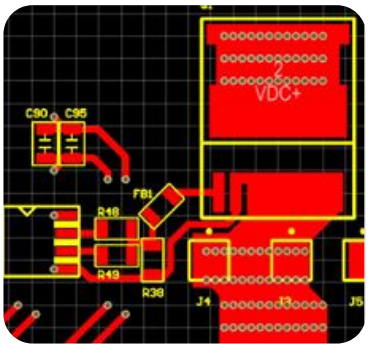
in my case now, i cant do that because I need to use the bottom layer for the power return path...and it needs to be as short as possible, thus its impossible for me now

Write a reply...

Arief Noor Rahman well...i just remove the mosfet, and clean all the flux, and solder again without additional flux...now it works...but, it is very difficult to ensure good solder flow without flux...(i have no idea if my solder tin can flow properly)

Like · Reply · 6w

Arief Noor Rahman



Like · Reply · 6w

Broox Le Leadless packages are almost impossible to reliably clean under. It can be done by ensuring a good solder stand-off height (solder-mask defined pads can help) and then solvent bath cleaning, but it's not usually recommended for production. The noticeable conductivity is most often a problem with water-soluble and fluxes which are 'cleaning required'. Instead, for leadless device packages, it's recommended to use only 'no-clean' solder flux and ensure the amount & reflow process parameters are set to ensure all of the flux will be rendered inert after reflow ('no-clean' fluxes have to be exposed to enough heat for enough time to render them inert & non-conductive).

Like · Reply · 6w · Edited

Bob Gudgel I would re-iterate what Broox just said. Use no-clean flux that -deactivates when the board goes through the reflow oven.
I've been through hell and back with solder flux being conductive even at lower voltages when they were either dirty or still "active". It's awful. Pain in the butt. Good to have a production engineer that understands this stuff if you can find one and have the funds.

Like · Reply · 6w

Arief Noor Rahman i am now just making a pcb prototype, but it still pain in the *, because after i realize this problem, I then remove all the important component clean it from flux residue without any added flux...it was painful...haha

Like · Reply · 6w

Broox Le Note, water soluble and 'cleaning required' fluxes can appear non-conductive when the assembly is warm, but later absorb moisture from the environment to become noticeably resistive.

...I discovered one PCB assembler used the wrong flux on a batch of boards such that some of the white LEDs on the boards had effectively become dim 'night lights' - as just a few micro-amps of current were bleeding through the flux to ground, and visibly lit the LEDs enough to be noticeable in a dark room - and was surprisingly bright when the user's eyes adjusted to the dark.

Like · Reply · 6w

Arief Noor Rahman ya...I once have an inverter with TO247 package mosfet, I forgot to clean the flux residue on the PCB and even at voltage below 30V, the current between the MOSFET pin is already very high...

Like · Reply · 6w

NEVER use water soluable flux for hand soldering or prototype operations. Never. I have banished it from my life. Only good CMs with the right equipment .. I know, the board looks so nice after washing, so shiny! But I have seen flux trapped under dc/dc modules and voltage drift with just your breath.

Like · Reply · 5w

David Edwards Consider putting a physical slot (hole) in the PCB between drain and source under the device. Add several surface mount jumper wires to the back side to bridge the gap if necessary. This will still allow cleaning under the device.

Like · Reply · 6w · Edited

Arief Noor Rahman For my current design, its not possible to do this because there are also another component at the bottom layer

Like · Reply · 6w

Mikael Hjelm If you cannot route under there you can try to remove a part of the solder mask. We do that sometimes under high voltage surface mount caps.

Like · Reply · 6w

Arief Noor Rahman Why remove the solder mask?to increase the vertical gap?

Like · Reply · 6w

Mikael Hjelm Arief Noor Rahman yes. Lessens the risk of anything getting caught under there + the possibility to clean. However the transistor you use is a lot wider than our caps so it might be hard.

Like · Reply · 6w

Arief Noor Rahman yep...thats a real issue as well...i think i need to stick with no clean flux and use it carefully

Like · Reply · 6w

Write a reply...

Daniel Ruiz No-clean flux. Specify it with the contract manufacturer.

Like · Reply · 6w

Charlie Elliott I absolutely agree with what has been said. "No clean" flux doesnt leave corrosive residue BUT if not entirely activated and allowed to properly vent IS conductive. We had this issue under some leaded gate drive transformers a while back. Not very handy where that is your main safety barrier and you have high working voltage. Our keen eared test engineer heard the fizzing sound when flash testing at 4 kv.

Like · Reply · 6w

Charlie Elliott Btw some parts with thermal pads show vias introduced underneath specifically to allow the flux to vent.

Like · Reply · 6w

David Wigton We will add pad/solder breaks (usually small squares) to the pad for solder-ability, rework capability and flux removal even if the component does not include them in there recommended pad pattern. No large solid pads.

Like · Reply · 6w

Dustin Lackey We have had some success specifying underfill which at least fills in the area with nonconductive material.

Like · Reply · 6w

Colorado Mike Doherty Great to see some sound advice here. This is a powerful group!

Arief Noor Rahman Thanks everyone for the kind very useful comment and suggestion,

Great thanks,

Cheers,
Arief

Like · Reply · 6w · Edited

Dan Watts I had the pads for these type of devices selectively plated on the PCB to make them 3 to 5 mil thick. Also no solder mask under the part. After reflow soldering (with organic flux), this leaves a space of 4 to 6 mils (between the PCB and the body of the semi-conductive package). That is enough space to get the wash water (with some Kester 5768 Cleaner added to the water) to flush out all the flux. If cleaning by hand, use hot water in a bucket with a small amount of Kester 5768 Cleaner (1 teaspoon per gallon?). Scrub with an old toothbrush. Dip and scrub a couple of times and then flush for a couple of minutes under running hot water. Then use compressed air to blow dry. The above has work well for me for several years with these leadless HV parts.
https://www.kester.com/.../Bring2mind/DMX/Download.aspx...

KESTER.COM
www.kester.com

Like · Reply · 6w · Edited

Arief Noor Rahman Thanks Dan Watts for your suggestion, but I am in a school lab and it takes time for procuring such thing...sounds great though!

Like · Reply · 6w

Ray Ridley This is the nitty gritty of the new device packages. Great performance, but you have to learn new assembly processes.

Same applies to the GaN packages, much to learn about the process there too. If you want to be ready for the new packages, start learning now before it becomes a critical part of your product development.

Thanks to all for your good suggestions. 😎

1

Like · Reply · 6w

Arief Noor Rahman GaN is good...but somehow it boom very loud...

*Out of topic

Like · Reply · 6w

Ray Ridley Everything will do this if you don't treat it well. Some people here probably remember the failure mode of the old TO-3 metal cans.....

Like · Reply · 6w

Ray Mayer Ray Ridley Oh I remember the days where we had to parallel a bunch of mosfets in high power PSFBs. Sounded like a machine gun burst!

Like · Reply · 6w

Ray Ridley Initiation rites.....

Like · Reply · 6w

Write a reply...

Nathan Ellis Not for production, but for EPC's GaN FETs I've been using a fine needled syringe to blast alcohol under the solder bumps/strips then drying with compressed air. I guess you would really require sufficient clearance to be able to direct any cleaner underneath, but directing with a needle is infinitely better that 'wiping down'.

Like · Reply · 6w

hand assembly prototypes...

Like · Reply · 6w

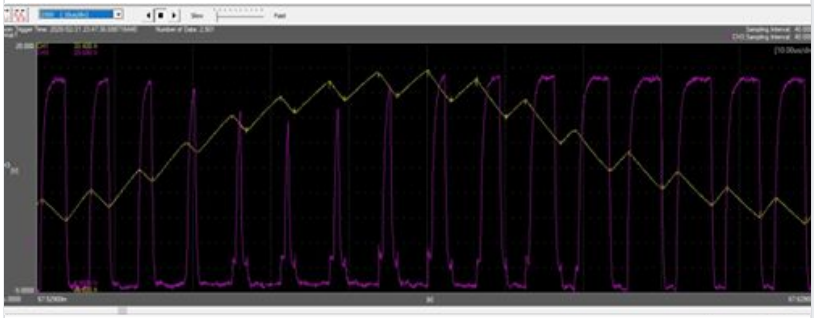
Write a reply...

Write a comment...

Prawn Ayinger
February 21

Good evening all, I am running a Full bridge converter with sine wave PWM modulation.
In the picture attached you can see gate to source voltage waveform (Red) and Output LC filter current (Yellow).
I am trying to understand the cause of the gate spikes at the peak of the current on both turn on and turn off edges. This happens in the region when the lower side turns on. The spike gets worse as I increase the load and I am looking to mitigate it. Miller clamp, additional gate to source capacitance has been used to reduce the effect. The MOSFET in use is C3M0065100K. Gate turn on and turn off resistor values are 47R and 22R respectively. I would appreciate any other suggestions.

Thanks in advance.



4 15 Comments

Like Comment

David Edwards This could be partially or wholly a measurement problem. Are you measuring a low side MOSFET? Also, how are you making the measurement? Perhaps you could post a picture of your measurement setup. Also, does your layout make use of and keep separate the MOSFET's Kelvin source lead and is your measurement taken with respect to that lead?

Like · Reply · 6w · Edited

Prawn Ayinger Hi David, I am measuring a high side MOSFET. I just thought the same that it could be a measurement problem. I am making use of a pico technology differential probe TA044 to measure the gate to source. The kelvin and the power source are tracked seprately and I am measuring it from a test point which is a few cms from the terminal. Could this be the issue? I could try using standard low voltage probes and isolating the scope instead.

Like · Reply · 6w

I have used that style probe (I believe it is made in Taiwan and relabled by many oscilloscope providers). To get a valid high side gate drive measurement one must dress the leads very carefully. Unfortunately, the long grabbers must be cut off and the leads should be tightly twisted, run through one or two high perm long ferrite beads and the wire ends soldered directly to the MOSFET leads near the device body. The twisted leads should be spaced (using wood or plastic) as far as possible away from the circuit under test (5cm to 10cm).

Like · Reply · 6w

Prawn Ayinger David Edwards Thank you for the suggestion. I'll try that and see next week.

Like · Reply · 6w

Darrell Hambley "I am measuring it from a test point which is a few cms from the terminal" but, we still need to know, which terminal? the Kelvin Source terminal or the power source terminal?

Like · Reply · 6w

Prawn Ayinger Darrell Hambley Yes, Kelvin source terminal. The diff probe wires are slightly too long as david pointed out. So I'll tighten the loop on that and get back on Monday.

Like · Reply · 6w

Darrell Hambley Thanks - also, a good method to reduce common mode noise for a scope probe is to wrap the probe cable a few turns around a ferrite. You'll notice a significant reduction in the noise on the scope.

Like · Reply · 6w

Prawn Ayinger Thanks, yes I will try that too!

Like · Reply · 6w

Write a reply...

Darrell Hambley You have a reversed current-sense signal which confuses the discussion. The yellow trace is basically upside down. It also looks like the red trace is the top switch gate to bottom switch source, not top switch gate-to-source. I see 20V/div on the scope which tells me your rail is at about 100V or so for this picture, right?

Like · Reply · 6w

Prawn Ayinger Yes sorry, I only had limited points I could measure at that stage. The low side would be the inverse of it. Its not 20V per div its showing you the axis of the gate voltage which top end is 20V bottom end is -5V. As for current top end is 33.4A so the peak current is approx 28A.

Like · Reply · 6w

Darrell Hambley Thanks for the clarification.

Like · Reply · 6w · Edited

Tony Salsich A schematic would really help...

Like · Reply · 6w

Ray Ridley Please, Pravin Iyengar, post a schematic. These problems make no sense at all without it.

Like · Reply · 6w

Peter Bernard Green May be due to MOSFET body diode recovery in hard switching operation.

Like · Reply · 6w

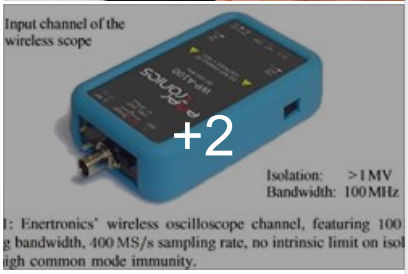
David Edwards
Conversation Starter · February 22

manufacturers relable as their own: https://www.sapphire.com.tw Their website has PDFs of their calibration procedures (and the hidden adjustments under the label).

Aeroscope made a low cost (<$300) wireless scope probe (no longer available). I believe they were crowd funded at first and evolved into IKAscope: https://www.ikalogic.com

Enertronics made the wireless probe WP-A100, but seem to be out of business, but the paper Alex found is worth a read: https://www.pes-publications.ee.ethz.ch/…/3_Concept_and_Exp…

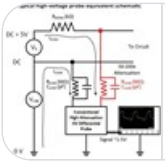
And, of course, Tektronix makes the very expensive (>$20k), very high performance IsoVu probe: https://www.tek.com/isolated-measurement-systems



Darrell Hambley, Jay Philippbar and 11 others — 19 Comments

Like — Comment

Marcus Lim Another option to measure high side gate voltages will be the High-Voltage Fibre Optic probes from Teledyne LeCroy. It uses fibre optics to isolate the high CM voltages from the oscilloscope. https://www.testandmeasurementtips.com/probing-small.../



TESTANDMEASUREMENTTIPS.COM

How To Probe Small Signals on a High Voltage Bus

Like · Reply · 6w

Alex Berestov It seems that competition is up and running.
P.S. The need to define deciBell in a publication for EE provides rather grim outlook for humanity.

Like · Reply · 6w

Alex Berestov It seems that the lesson of A100 is not learned. Very few would buy probe for the price of good 4 channel isolated scope.

Like · Reply · 6w

bandwidth unless the leads are dressed very carefully. The leads should be twisted together and run through high perm long format ferrite beads. The grabber probes should be cut off and the wires ends soldered directly into the circuit under test. The beads form a common mode low pass with the 15pF or so common mode capacitance to ground, which improves the probe's basic performance.

Common mode rejection of these inexpensive probes is around 1000x at 1MHz, less at higher frequencies. A 200V switching signal may produce several volts of common mode signal on top of the differential mode gate drive signal in a hard switched application, hence the need for the additional common mode rejection provided be the ferrite beads.

The twisted pair leads should be spaced several centimeters away from the PCB to avoid capacitive coupling from high dv/dt circuit traces.

Like · Reply · 6w · Edited

David Edwards The Aeroscope probe may be the wave of the future. These type of probes benefit from cell phone and tablet technology. The are powered by rechargeable batteries that last all day and communicate to a PC, laptop, tablet or smart phone by WiFi or bluetooth. In order to make this work they must have on board data acquisition memory and just stream the video data to the remote display/controller device. What a great idea.

Like · Reply · 6w

David Edwards Notice the difference in exposed metal between the Aeroscope and the IKAscope probes. This is probably due to the need to meet strict safety regulations to minimize shock hazard.

So how should one access physically hidden signals with a relatively large probe? Certainly holding it by hand near potentially lethal exposed circuit voltages is not a good option. I like to set up the measurement with the power off and be safely distant before applying power. Perhaps scope tip jacks could be an option (but the tip ring must be accessible).

Another option is to cut a short length of small diameter (0.3cm) Kapton insulated coax and solder one end directly to the gate and source leads of the device under measurement and solder a scope tip jack to the other end.

If the cable must be longer than 20cm or so then a surface mount 50 ohm resistor should be inserted between the gate lead contact point and the center conductor of the coax for impedance matching. A high perm ferrite bead or two around the cable might be a good idea as well.

Like · Reply · 6w

Arief Noor Rahman We have that plenty of that sapphire instrument HV diff probe in our lab, and we use it all the time for high side measurement...

For all silicon switches they are generally good enough, for SiC so far still okay though not perfect, but for GaN maybe too slow to capture all its fast transient and ringing...

I never need to do what David Edwards did, which I guess also depends on how accurate you need it to be...

Like · Reply · 6w

Adam Lawrence Arief Noor Rahman Same for our lab. We use many rebranded Sapphires for applications in the tens to lower hundreds of kilohertz. IsoVu is much better for GaN.

Like · Reply · 6w

Arief Noor Rahman Thats out of question...but considering price of >50x...it is hard to make purchasing decision

Like · Reply · 6w

Ardhendu Das Also check out pinteck probes , they cost around 300-350$

Charlie Elliott My experience using the low cost attenuating diff amp type is they really struggle with fast moving signals. Just the unshielded output cables alone pick up a lot of noise.

Like · Reply · 6w

Charlie Elliott BTW we now include two plated holes in PCB right next to gate and source. We then ditch the sprung tip and go straight in with tinned wire wrap for the gnd. This makes a big difference to remove pickup.

Like · Reply · 6w

Arief Noor Rahman Interesting!is it possible to see the photo of your setup?

Like · Reply · 6w

Charlie Elliott Arief Noor Rahman - Nothing to see - just two holes of the correct diameter next to each other. One sized for the probe tip spike and the other for whatever wire you decide to use and at approx the diameter of the ground ring on the probe. You can do even better with using a miniature co-ax connector.

Like · Reply · 6w

Frank Warnes Could never figure out why tektronix didn't develop the tps2000 isolated oscilloscope further. They seem to have dropped the idea for some reason

2

Like · Reply · 6w

Arief Noor Rahman I think they cant sell with enough Qty to be significant for their business...

Besides, i remembered seeing their marketing material where their screen is just at the lowest quality

Like · Reply · 6w

Frank Warnes Arief Noor Rahman exactly they developed it at a time when screens were small and the most convenient external storage was compact flash but it was isolated and battery powered so you could take it out to a Hybrid vehicle and monitor high side gate signals on an ISG

Like · Reply · 5w

Write a reply...

Roelof Grootjans There is also the option of using the cleverscope (https://cleverscope.com/products/CS448), it seems to have pretty good cmmr at relatively high frequency and is cheaper than the isovu. Should be good for evaluating the miller plateau?

CLEVERSCOPE.COM

CS448 Isolated Oscilloscope | Cleverscope Mixed Signal USB…

3

Like · Reply · 6w

Charlie Elliott Roelof Grootjans I agree with you that this is a great option.

Like · Reply · 6w

Write a reply...

Write a comment...

Paul Shepherd
February 22

Has anyone combined digital command and condition monitoring with an analog modulator? To be more specific, I'm thinking about one of the classic modulators like the UC1843, combined with a microcontroller to add all of the "fancy" things. One random example that I don't think I will do, but shows the kind of potential I am thinking about, is to use the uC to generate the sync pulses and create frequency jitter. For another example, the PWM Modulator could do the current-loop control directly, but the uC might be able to implement the Type II compensator between and A-to-D input and a D-to-A output.

Thanks!

2 24 Comments

Like Comment

A-ARon Jones A hybrid? Sounds like the best of both worlds but it would be expensive and relatively inefficient at low loads (sleep current of processor plus analog components)

But sounds like fun from a designer point of view.

You can do a lot by modulating the feedback pin of a traditional control loop with a PWM signal and choosing a controller with an external frequency sync pin

Like · Reply · 6w · Edited

Paul Shepherd That's exactly my thought. Good point about the uC being a drag at light load. Fortunately, I've transitioned from commercial world, where a $1 DC/DC converter is a crisis, to aerospace, where at $250/circuit board, I'm still the cheapest part in the system. 🙂

Like · Reply · 6w

Paul Shepherd I was playing with a REALLY fancy Linear Tech part (LT8711) last year, and it does a lot of things that I like, but there are some features that I would turn off if I could. That's one of the things that is making me think about this hybrid approach.

Like · Reply · 6w

Joel Holland A-ARon Jones could you explain a bit more about digital control at low/no load?

Like · Reply · 6w

A-ARon Jones Joel Holland it's mostly a matter of the current running to keep the system alive, while most microcontrollers can get to pretty low sleep currents running the ADC (depending on architecture and sample rate) can take as much current as the load.

It's still milli/micro amps but it matters if your system is running off a battery

Like · Reply · 6w · Edited

A-ARon Jones Paul Shepherd is weight and PCB real estate still a major problem in aerospace power supplies?

Like · Reply · 6w

Paul Shepherd A-ARon Jones Yes. Mass has always been the enemy, but volume is also now an issue because I work in cubesats. The tradeoff is that cubesat companies are much more open to COTS components.

Like · Reply · 6w · Edited

A-ARon Jones Paul Shepherd why would other companies not be open to CoT? Too hard to prove the stability of nonlinear control?

Like · Reply · 6w · Edited

where traditional space companies would only buy much more expensive parts. Cubesats, by definition, have a hard time operating at higher orbits (although people are working to change that) where radiation tolerance and wide temperature range are critical. So far, the low altitude and < 3 year operating life of most cubesats lead assemblers/operators/suppliers to prefer commercial and industrial-grade electronics.

Like · Reply · 6w

Write a reply...

Col Johns A small analog ckt could be used to modulate the cap on the osc for spread spectrum too, possibly easier than coding to "control" the sync pin ...

Like · Reply · 6w

Paul Shepherd Absolutely agree. There are a lot of little things that we do to make converters behave exactly as we want it to. Sometimes, we add lots of components to add features, but sometimes we end up adding just as many parts to work around "Features" that we don't want. I certainly wouldn't add a microcontroller just for jitter, but when you add up enough feature "adds" it starts to make sense.

Like · Reply · 6w

Paul Shepherd Or I should say, I _think_ it would make sense. This is why I run these crazy ideas past this group. 🙂

Like · Reply · 6w · Edited

Col Johns Some of the best power supplies I've seen are where the original chip is used in an app it was not intended for - but with a few "add on" ckts around it - did the job exceedingly well (UC3854N springs to mind, multiplier very handy)

Like · Reply · 6w

Write a reply...

David Seal Cypress PSOCs are great for this, but the extended C instruction set to the analog sections are somewhat of a challenge to learn and apply correctly. And if you want to think beyond simple "PWM" techniques for EMI noise reduction on a lightly loaded SM supply, in the Cypress app notes you will find instructions (and code snippets) on a type of spread-spectrum generation that is pseudo-chaotic, which pretty well knocks out any chance of single-frequency or direct harmonic EMI radiation.

Like · Reply · 6w

A-ARon Jones David Seal I have always wondered why people love cypress PSOC products, thanks for the insight

Like · Reply · 6w · Edited

Bob White The marriage of an analog controller with a microcontroller supervisor/monitor/communications interface has been done routinely since the 1980s.

Like · Reply · 6w · Edited

Brian Faley I've personally done dozens of hybrid designs that are still in mass production, using an analog modulator with a digital controller providing reference, on/off, and sequencing commands. Inverters, battery chargers, power supplies. Everything from 10w to 80kW. Despite the promises of digital control, I've never seen one out perform a well tuned analog system using peak or average mode current mode control. It is more expensive, and requires solder to program. Much more robust over current and short circuit protection.

Like · Reply · 6w

wrong .....

Like · Reply · 6w · Edited

Magnus Rosén I have done a hand full of hybrid controllers for BLDC and DC motor control in production for long time. The plant stabilization and parameter setting with FW update saves valuable TTM. Most designs should arrange current/torque loop in a HW pwm controller, voltage/speed could be mixed HW and SW. Pulses/position in SW control. Hybrid configuration saves effort on DSP side and relieve SW from advanced RT and calculation performance.

2

Like · Reply · 6w

Paul Shepherd Magnus Rosén that's what my intuition was... fast loops in analog, slow loops in digital.

Like · Reply · 6w

Charlie Elliott Paul Shepherd - That is also what we do sometimes but depends on the control being implemented.

Like · Reply · 6w

Write a reply...

Vlad Mihai Hi, my BsC thesis (2013) was about such a solution. I designed a TL494-based boost converter, which had its opamps reference voltage from an 8-bit microcontroller. With the mcu I was generating a 20 kHz PWM which was filtered by an RC filter, hence by varying the duty cycle I was varying the voltage reference. In this way the TL494 was doing the whole control loop while the output voltage was adjusted from mcu.

1

Like · Reply · 6w · Edited

Paul Shepherd Vlad Mihai did you look at the impact of the control loop response? Did it keep a relatively consistent dynamic behavior at different output voltages?

Like · Reply · 5w

Vlad Mihai Paul Shepherd no, I didnt see any issue. However, we should not see any due to the fact that I was only providing an adjustable and clean reference voltage for TL494's error amps, while all the control part was done by the ic itself. At least that's the way I see it. The output stability was good, in various scenarios 10% or 90& load. With nowadays MCU you ca do even better, have a look at this mcu DSPIC33EP64GS502. It has everything embedded.

Like · Reply · 5w

Write a reply...

Write a comment...

David Edwards
Conversation Starter · February 19

LTspice Convergence

problems. This message is an attempt to answer that question.

Convergence problems generally may be divided into two categories, initial dc operating point issues and transient analysis issues (although addressing operating point issues often will also help mitigate transient convergence problems). My bottom line advic...
Continue Reading

You, Darrell Hambley, Jay Philippbar and 33 others 12 Comments

Like Comment

Mikael Hjelm Thank you, I really appreciate this. The Norton equivalent sources didn't occur to me.
Like · Reply · 6w

David Edwards Ingen orsak! För länge sedan bodde jag ett år i sverige. . . vackert land.
Like · Reply · See Translation · 6w

Darrell Hambley Wow Dave, Du kannst auch Schwedisch sprechen.
Like · Reply · See Translation · 5w

Chris Roth Thank you for this, David Edwards.
Like · Reply · 6w

Darrell Hambley Dave, Thank you for taking the time to write that up.
Like · Reply · 6w

Paul Greenland Hi Dave, Bob Pease used to tell me that “Spice is no replacement for knowing what you’re doing”. Thanks for the write up.
Like · Reply · 6w

Ray Ridley Or there is the quote from the "Hot Air Rises" book.

"Computers are great. You can simulate the hot spot temperature of a component wrong to 5 decimal places." (paraphrased)
Like · Reply · 6w

David Edwards . Ray Ridley and Paul Greenland, I have yet to encounter a circuit that I couldn't simulate with excellent results, both without convergence problems and with results that matched reality very closely. However, this is only because I have a career of experience both with SPICE and in the lab with power circuits. For me, LTspice replaces several iterations of breadboarding and, once the circuit is up and running and the simulation matches the measurements, LTspice allows examining nodes and branches that are simply inaccessible in the lab.
Like · Reply · 6w

Ray Ridley Indeed, it is a great tool when used wisely. Indispensable.

The point I always try to make is that it doesn't make the hardware testing unnecessary.
Like · Reply · 6w

Ray Ridley Another way to think about it - rarely do things surprise me in a simulation.

Always, the real circuit surprises me.
Like · Reply · 6w

inductance can be critical to producing a useful simulation. One learns what parasitics are important to model after a while. But you are right that simulation is just a tool for the design phase. Nothing gets into production without hardware verification.

Like · Reply · 6w

Write a reply...

Jay Philippbar David, good stuff, many thanks!

Charlie Elliott
Conversation Starter · February 18

Write a comment...

Half bridge LLC with split Cr and clamping diodes - what is there not to like?

Robust handling of load side shorts is an issue in many resonant converter designs as that tank is all pumped up and has nowhere to go!! However IMHO the half bridge LLC with split Cr and the two extra diodes (Dc1 and Dc2) shown below is a very neat way of solving this issue. Why isnt it seen more? Does it make sense to use this at high power? All thought welcome as ever!!

https://vtechworks.lib.vt.edu/bitstream/handle/10919/28982/Ch5.pdf

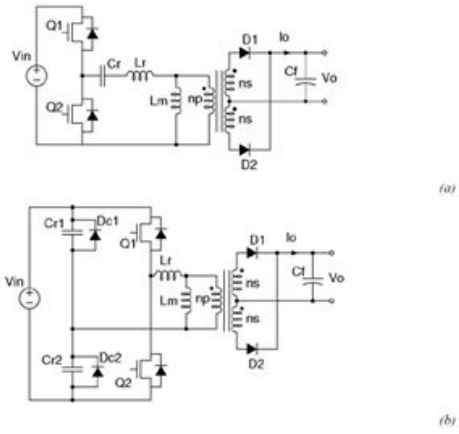


Figure 5.38 Two LLC resonant converter topologies: (a) Original LLC converter and (b) proposed

19 29 Comments

Like Comment

Andrew Ferencz It makes sense especially if you don't want the capacitors to over voltage.

Like · Reply · 6w

Arief Noor Rahman The idea is not as overvoltage protection. Instead to change resonant tank characteristic during short circuit

Like · Reply · 6w

Alex Berestov Series resonant circuit has particular properties. Unless you control peak current i.e. charge control you do not have short circuit protection per se. Going ZCS may destroy switches without short circuit at all.

Like · Reply · 6w · Edited

George T. Ottinger It's what we use.

Like · Reply · 6w

Yuri de Klerk With the clamping diodes you can not make use of the 'boost' function of LLC. So for wider input and output voltage range it is less profitable.

Like · Reply · 6w · Edited

disadvantage to note

Like · Reply · 6w

Yuri de Klerk If the cap voltage stays within the rails, the transformer voltage does too. If this restriction does not exist you can push the transformer to higher Vpp than the rail voltage at full load. For this to function the Fs needs to go below the Fr of the Lseries & Cres. ZVS is still there, but it's more difficult to protect against capacitive switching (ZCS) in case of overload or short-circuit.

Like · Reply · 6w

Yuri de Klerk Because of no 'boost' function, the transformer is dimensioned as Vin/2 : Vout.
This 'll make no-load situation more difficult to control too.
This is however solved nowadays with burst-mode, which on itself has it's own challenges....

Like · Reply · 6w

Manuel Escudero Rodríguez Sorry, but that the voltage in the resonant caps stays within the rails does not limit the voltage in the transformer, you have a series inductor (a.k.a. resonant inductor or leakage of transformer) where you have the rest of the votlage drop. Again, you should dimension your resonant caps big enough so they stay within the rails, and that does not limit boost gain of the converter at all.

Like · Reply · 6w

Yuri de Klerk You seem to be more convinced of your explanation than I am of mine. I will do some research and let you know.
Are you by the way saying there are no disadvantages in using these diodes?

Like · Reply · 6w

Manuel Escudero Rodríguez The excursion of voltage of the caps is limited, so the "maximum" boost gain is limited, what is different to say that there is "no" boost gain. The resonant tannk should be dimension in accordance to maintain the voltage swing of the caps within the rails for the maximum expected load of the converter. Please visit
https://www.infineon.com/.../Infineon-Evaluationboard...

Like · Reply · 6w

Yuri de Klerk Manuel Escudero Rodríguez Thanks for the Infineon pdf. I was introduced to LLC converters in 2002, when it was still a not wide used concept. We used to make the resonant tank impedance (sqrt(Lr/Cr) very close the reflected load impedance (Rac), so Q = 1. In this case the current at full load is lowest and resonant components should be smallest. But the clamp diodes in my case will indeed limit the boost function.
In the Infineon piece they make the resonant tank impedance almost half of Rac. The cap voltage stays much lower off course at nominal load.
Appearantly it is still a workable strategy. I might compare and try this for future designs.

Like · Reply · 6w · Edited

Manuel Escudero Rodríguez I'm glad that our example design and our Application Note might be of help for your future designs.

Like · Reply · 6w

Write a reply...

Daniel Pruna I have used for 2kW design, it works pretty well.

Like · Reply · 6w

Like · Reply · 6w

Yuri de Klerk I simulated it (PSIM) and it works wonderfull, besides the drawbacks I mentioned.
Maybe also tested it, but it was about 9 years ago so not sure..

Like · Reply · 6w · Edited

George T. Ottinger 6000 short circuits (each) in HALT testing on 4 samples of my product, both applying short while running and startup into a short.

Like · Reply · 6w

Hamish Laird Charlie - this is in a very high volume telco supply from about 2006 2007.?it does all you need.

Like · Reply · 6w

Ray Ridley There is another variation where the caps are just put in series with the transformer, one next to Lr and the other in the return leg. Diodes used as mentioned.

Any comments on this versus the figure b proposal?

Like · Reply · 6w

Col Johns One would still be clamping the Vpk on the caps to the supply rail - in fig B the caps sit at HVDC/2 on average - but their AC excursion can be from 0 to HVDC allowing a certain amount of boost function from the LLC (CLL),
for a series cap (to the Tx) the net average volts are 0, again 2 diodes are required - and the excursion is +/- HVDC on the series cap (at half the capacitance) - at first glance the effect would be the same (?).

Like · Reply · 6w

Yuri de Klerk I can not figure this in my mind. A drawing maybe?

Like · Reply · 6w

Kevin Azul

Like · Reply · 6w

Liqi Zhang check this one, medium voltage and high power
https://ieeexplore.ieee.org/abstract/document/8345190

Like · Reply · 6w

Charlie Elliott Liqi Zhang - Any chance of publishing this on researchgate.net so everybody can see the fruits of your hard work?

RESEARCHGATE.NET
ResearchGate | Find and share research

Like · Reply · 6w · Edited

Ray Ridley Or, for this group, just put up the schematic so everyone can see it without having to pay.

Like · Reply · 6w

Col Johns the paper cited is not that relevant ...

Like · Reply · 6w

RESEARCHGATE.NET
www.researchgate.net

Like · Reply · 6w

Liqi Zhang see Part IV

Like · Reply · 6w

Charlie Elliott Liqi Zhang - Thanks

Like · Reply · 6w

Write a reply...

Write a comment...

Bahadır Yıldırım
February 20

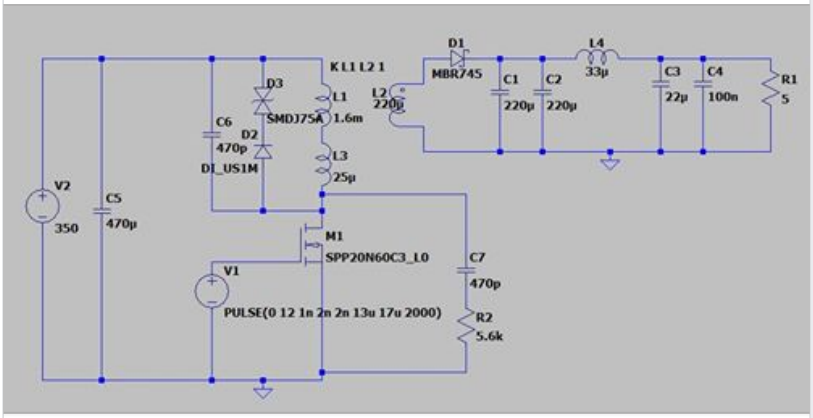
Hello,

I'm the guy who have trouble with flyback converters. Few days ago I asked the question about blowing-up resistors and MOSFETs. After your advice, I realized the reason why they are blowing up. The problem is that transient voltages due to leakage inductance of flyback transformer. In order to compansate voltage spikes, I changed the snubber network which is parallel to flyback transformer. And added one more network to MOSFET's drain to source.

Most of transient voltages have been suppressed. But I can not suppres the first transient voltage that has the highest frequency. In my opinion speed of my components are not enough to suppress first transient voltage. I susptected from rectifier diode which is part of snubber circuit which is connected to flyback transformer. But diode type is UFRR. So I didn't find any solution suppressing first transient voltage. Can you help me please?

You can find the circuit that I'm having trouble with below.

Best regards.



10 47 Comments

Like Comment

capacitance which can make it look like an UFRR property. If I understand correctly, you are struggling with a MOSFET turn-on current spike? If yes, you may want to consider replacing C6 with an RC snubber. I cannot comment on the value chosen for C6, but the transistor will have a low impedance path to V2 at turn-on if you don't add a series snubber resistor. Value to be chosen based on bench waveform measurements. While on the subject of snubbers, R2/C7 values will have virtually no effect. R2 is much too high to be an effective snubber resistor. You might want to experiment with much lower values on the bench.

Like · Reply · 6w

Bahadır Yıldırım Hi Alain, thank you for your advices. When I open the datasheet of IS1M, datasheet says it is UFRR. If that is not UFFR, how can I understand it? In practice, when I use V2 as low voltages like 110VDC, there is no problem. When V2 goes to higher voltages, MOSFET and resistor go to failure. By the way, I'm supplying external to pwm controller. So pwm controller switches in low freq. There is two reasons for failure. First one is when V2 goes higher voltage values, IC starts burst mode and switches at higher frequency. Thus, voltage spikes become bigger than before. Second one is only when V2 (like 140VDC) goes higher voltage values, voltage stresses impact as destructive. But I can't determine.which one is the source of problem.

Like · Reply · 6w

Alain Laprade Bahadır Yıldırım Sorry about that. I was referring to MBR745. Unable to comprehend the description of your technical problems. Best I leave it to others. But do consider the C6 and C7/R2 comments.

Like · Reply · 6w

Bahadır Yıldırım Alain Laprade I will. Thank you.

Like · Reply · 6w

Write a reply...

Tony Salsich Bahadır Yıldırım, there are many app notes on how to solve this. Look at any chip vendor's reference design, but do read the explanations given for the component choices. Look for the term, RCD clamp.

Like · Reply · 6w

Bahadır Yıldırım I tried RCD clamp but didn't work. This one is working better than RCD actually.

Like · Reply · 6w

Tony Salsich This one is very lossy and causes large current spikes for the Mosfet. The RCD clamp is effective if done properly.

Like · Reply · 6w

Bahadır Yıldırım Thank you for your interest. I will recheck that topics.

Like · Reply · 6w

Paul Shepherd Tony Salsich In my experience, the Zener clamp is actually less lossy than RCD snubbers, but of course it depends on the whole circuit.

Bahadır Yıldırım, please post a waveform to show the issue. Even better if you can show the waveform before and after the change. IS your problem in simulation, or on a real circuit board?

Like · Reply · 6w

Bahadır Yıldırım Paul Shepherd I did it in practice. Actually I didn't think to take photo of waveform. Sorry for this. This one is nearly similiar to practice by the way.

Write a reply...

Soumya Chatterjee Make the mosfet and transformer loop very small. Distance of snubber and mosfet very close.

Like · Reply · 6w

Manu Raj Why c6 one end connection to mosfet drain? Connect to D2 cathode.

Like · Reply · 6w

Bahadır Yıldırım I want to bypass first transient so I think C6 can solve it. I will apply your advice. Thank you so much.

Like · Reply · 6w · Edited

Paul Shepherd Try both. Also, slowing down the turn-off of the MOSFET as mentioned below.

Like · Reply · 6w

Alan Manthe I agree that Manu is on the right path. In the present configuration, C6 is charging to full bus and then its energy is going into C7 at turn off. Either remove C6 or make it part of an RCD clamp. If you create the proper RCD clamp across the XFRM primary, then C7/R2 should not be required since the two snubbers are virtually in parallel.

Like · Reply · 6w

Alain Laprade I agree with Manu Raj and Alan Manthe. Reminder that R2 = 5.6 K value is too large, the C7/R2 snubber is basically open circuit during switching transition.

Like · Reply · 6w

Bahadır Yıldırım You mean, If I want fast response, choose higher R2 values?

Like · Reply · 6w

Paul Shepherd I just realized the MOSFET drain node has two different 470pF caps connected to it. The MOSFET-parallel R/C won't have much impact since the other 470pF capacitor is undamped... Even though C7 will get some miller effect from having a larger voltage across it than C6.

Like · Reply · 6w

Bahadır Yıldırım Paul Shepherd I didn't think about miller problem. Actually this mistake was huge. Thank you for warning. I will remove RC snubber that parallel connected to MOSFET.

Like · Reply · 6w

Write a reply...

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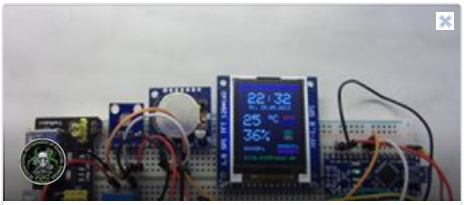

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PLC Programming, HMI

it switches off. This is because of the very nonlinear gate-to-drain capacitance of the device. At high voltages during the end of turn-off device capacitance nearly disappears. Not only may this be bad for the switching device, but it often causes severe high frequency EMI. What to do?

You can control and linearize the dv/dt by adding a surface mount series RC network physically close as possible between gate and drain of the switching device.

Your existing gate resistor should be between three and ten ohms. Choose the RC network resistor value to be one to three times this value (10 to 33 ohms). Choose the capacitor value to be equal to the drain-gate capacitance value when the device has about fifty volts across it (typically this may be 22pF to 47pF). This RC network will steal drive current and linearize and slow down dv/dt, but only at the end half of the switching transition. It will do so without significantly increasing switching loss if you choose the RC network properly.

The R in the RC network is absolutely required to prevent destructive device oscillations.

Like · Reply · 6w · Edited

Rossano Valsecchi Why don't try to put a 22R in series at the gate?

Like · Reply · 6w

Bahadır Yıldırım In practice, there are 47 ohm and 10ohm resistor at MOSFET's gate.

Like · Reply · 6w

Alain Laprade Bahadır Yıldırım What?

Like · Reply · 6w

Bahadır Yıldırım Alain Laprade Sorry for my bad English. There are two resistrors which are connected series. First one is 10 ohm which is connected parallel to backward diode (diode for fast discharging for turn-off). Second one is 47.

Like · Reply · 6w

Write a reply...

Col Johns This is all just a spice model - very different to real world, for example, with the turns ratio shown you get 129V + Vo across the 45V o/p schottky when the fet is on - might work a bit in a sim - but in the real world this mistake would quickly show up ... (i.e. bang)

Get rid of C6 - and put in an RCD snubber - a snubber on the o/p diode helps too ...

Like · Reply · 6w

Bahadır Yıldırım Yes you are right. I couldn't handle the design as work well. I'm new at power electronics. Trying to get some experience. I will try your advices. Thank you so much.

Like · Reply · 6w

Alain Laprade Bahadır Yıldırım Ah, the wonders of discovery We've all been through it. There was no internet to assist me when I was a newbie. Had to rely on more experienced help in the lab. I recall some liked to keep secrets (and sometimes mislead), very frustrating to work with.

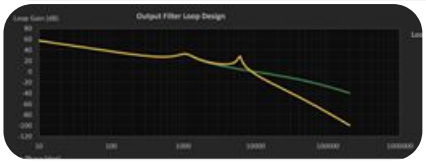
Like · Reply · 6w · Edited

George William Tyler "fast" diodes are often slower to turn on but I doubt that this is your problem. Your snubbers design is suspect.

Like · Reply · 6w · Edited

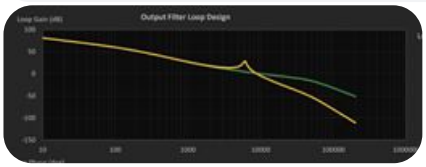
the output capacitor is too small.

Here is the plot for the filter in the loop out of RidleyWorks (assuming CCM voltage mode, but this doesn't affect the 2nd stage filter)



Like · Reply · 6w

Ray Ridley And here is the current-mode response (or DCM)



Like · Reply · 6w

Bahadır Yıldırım I wanted to suppress output ripple. So I used Fcuttof = 1/(2*pi*(L*C)^0.5) filter formula. Formula says If you pick high value capacitor and inductor, you will get low pass filter that has low cut off frequency. I didn't think second stage filter's effects to the primary side. I will recalculate it. Thank you for this detail.

Like · Reply · 6w

Ray Ridley Bahadır Yıldırım read the paper on our design center.

Like · Reply · 6w

David Edwards . Hello Ray Ridley,

After taking a closer look at the schematic it seems that it may be unrealistic in several ways. Besides the questionable output filter values that you noted, the gate drive duty cycle seems that it would lead to very high steady state current that is far beyond the MOSFET's ratings, the transformer leakage inductance is way too high to be practical and the gate series resistance network (not in the schematic, but described in a message) would lead to excessively slow and dissipative switching. If the schematic represents what Bahadır Yıldırım actually is testing, it is not surprising that it fails so easily.

I wonder what the input voltage range requirement is and what the output voltage and current requirements are?

By the way, I commend Bahadır Yıldırım for posting a schematic and making a real effort to describe his problem.

Like · Reply · 6w · Edited

Bahadır Yıldırım First of all, thank you for your comments. That can help to find the right way. I want to see circuit's worst state so I set the max value of duty cycle and leakage inductance. Actually I didn't know output stage is disrupting whole harmony in the circuit. I will restudy with your comments and read more for application notes.

Like · Reply · 6w · Edited

David Edwards . Hello Bahadır Yıldırım,

Please answer the following three questions:

1) What is the input voltage range requirement?
2) What is the output voltage requirement?
3) What is the output current requirement?

Like · Reply · 6w

1) 90VAC to 240VAC
2)16.8VDC x 2 (1 transformer 2 output)
2)2A x 2

Like · Reply · 6w

David Edwards . That is less than 70 watts and should be a piece of cake (easy). Is the input simply full-wave diode-bridge rectified to a bulk capacitor? If so, this design is completely standard and, since you are a newbie, you should strongly consider Ray Ridley's advice and buy his software. The most important part of the design is the transformer and Ray's software should be a big help to you with that.

Like · Reply · 6w · Edited

Bahadır Yıldırım Yes, it's easy but this work is for only infrastructure project. After that I can design properly, I'll ask them for the purchase it.

Like · Reply · 6w

Write a reply...

Ray Ridley Is this a

1) school project?

2) work project?

Like · Reply · 6w

Bahadır Yıldırım It's work project.

Like · Reply · 6w

Ray Ridley What's your deadline for finishing the design?

Like · Reply · 6w

Ray Ridley I would suggest your company spend a little money to get our design software which will take care of all of these issues for you very quickly.

Right now you are shooting in the dark and making decisions that won't work out well for your project.

Once you are in our software family, we give you design support to keep you on the right track. All part of the service.

Like · Reply · 6w

Bahadır Yıldırım Actually, we are designing battery packs. So I decided to design chargers there is no deadline or industrial products. It is a infrastructure work. If I can deal with it, I'll ask them to buy software that can help for designing quickly. Thank you for your kindly offer.

Like · Reply · 6w

Meysam Saeedian
February 21

Dear ALL!

Is there any reference that I can find the matrix transfer function of an LCL filter in the following form?

[igd ; igq]=[g11 g12 ; g21 g22]*[ucd ; ucq]

where

igd and igq are the d/q components of the injected current to the grid in synchronous reference frame,

ucd and ucq are the d/q components of the converter voltage in synchronous reference frame.

1 3 Comments

Like Comment

Meysam Saeedian Colin Tuck no, its not a homework...
Like · Reply · 6w

Write a reply...

Col Johns But, Meysam Saeedian, you are doing a PhD from your profile ...
Like · Reply · 6w

Write a reply...

Write a comment...

Sanchit Mishra
February 20

This is something I have never worked on and probably won't get a chance in the near future but I am very curious about it and want to learn it before I forget about it's importance.

So, in this attached weird looking diagram I took datasheets of a SiC (Cree) and a GaN (Infineon) "RdsON vs Temp" curve and overlaid (and put transparency) them together to match the X (temp axis) and Y (Rds axis) axis (this is why it looks so weird).

The main question I had was --
As temp is in the range (range -50C to 25C), paralleling GaN vs paralleling SiC will behave differently as SiC FET will now have negative thermal coefficient. Are there ready-to-use solutions to design converters which will see both -10C and +30C (like a car driven in Minnesota, and in California) to make sure current sharing is done appropriately ? I can look the solutions up if someone can help me name the "technical terms" I am supposed to look for if there are such terms.

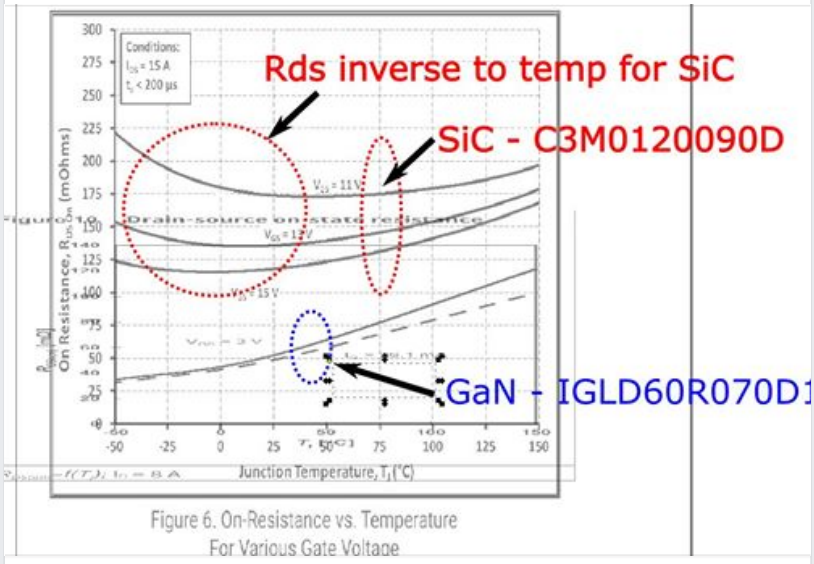


Figure 6. On-Resistance vs. Temperature For Various Gate Voltage

Darrell Hambley and 17 others 19 Comments

Like Comment

David Seal Nice graph. Good observations. I had not seen this presented in this format before. I suggest that you contact the manufacturers directly, or check out their app notes.
Like · Reply · 6w · Edited

Paul Shepherd You are correct. Parallelling FETs in power modules is not a trivial thing to do.
Like · Reply · 6w

Like · Reply · 6w

Sanchit Mishra That's where I thought about it but they didn't discuss ways to eliminate the issues. The overall ppt was very superficial (but they have to be cos of the time constraint and breadth of topics). My main question here was to find existing solutions that are cold weather designs to alleviate the Rds curve situation (which doesn't seem to exist for GaN switch I chose).

Like · Reply · 6w · Edited

Magnus Rosén No practical problem if correct gate drive voltage.
The current sharing at turn on/off parallel WBG devices is a severe problem.
Assuming applications with dominant switch losses, the thermal coefficent value and trajectory is of high interrest...

Like · Reply · 6w · Edited

Thomas Mathews I wonder if, for SiC, and after a little warm up time, the operating point would stabilize near the low-point in the Rds graph that appears to be at around 50C? The question would be: if anything bad is going to happen during that warm up? or, during an abrupt turn-on, as there often is.

Like · Reply · 6w

Sanchit Mishra I was thinking along those lines too. The ambient temperature close to the device is what's dictating the temp in the die (junction). So, even for an electric snow-mobile after a small usage (or forced warm up where converter dumps all the power without delivery it to load) will bring the operating point of the FET to a nice place like you mentioned. But, I have zero experience with any of the things I just wrote down, and I needed help in determining where to look for.

Like · Reply · 6w

Thomas Mathews Run-away is usually associated with a curve that keeps sloping down. Try contacting your SiC supplier to see if they'll let you talk to their regional SiC FAE or ask your distribution FAE if they know who the supplier's FAE is. This may indeed be stable, but proving it to a design-review full of skeptical peers could be difficult. Of course, you can always build a prototype, test the hell out of it, then later use the up-slope on that curve to explain why it's thermally stable.

Like · Reply · 6w · Edited

Thomas Mathews There is probably no closed form proof that the valley will be stable but you could maybe do some simulation or phase-plane diagrams to show that the valley is a stable attractor.

Like · Reply · 6w · Edited

Sanchit Mishra Thomas Mathews Thanks especially for the last comment. That gives me a solid base to begin with.

I'm trying to see if people have plotted their thermo-electrical differential equations and checked for equilibrium points or not. I'll try to find the model in literature (as I think the Rds vs temp is the physics of the heat spreading in the die so there is some thermal model connected to electrical operation/constant heat flux production) and plot the taylor series linearized model as a phase plane.

Like · Reply · 6w

differential equation. At graduate school I had a class on non-linear control systems and the first thing that the professor said was "Without numerical methods or simulation most non-linear control systems cannot be solved. Many non-linear systems, however, can be shown to be stable if the operating trajectory always tends towards an attractor". The rest of the class, to my disappointment, was about proving stability rather than solving non-linear system equations....which is usually impossible.

Like · Reply · 6w · Edited

Write a reply...

Col Johns The curve slopes up at 50 deg C - so runaway unlikely if all on a common heatsink ...

Like · Reply · 6w

Alex Berestov Go get the module rated at the current and voltage design requires.
Desire to use cheap discretes and connect a bunch of them in parallel to save money is understandable. But integrated solutions exist for a purpose. Even then some are good and reliable and some are not.
P.S. A while ago I disassembled damaged IPM rated @ 2400A. It consists of 4 HB modules with tens of IGBT chips each. Sure enough they all connected in parallel. Moreover pair of IPMs presents a FB. 4 of the latter were connected in parallel and worked just fine.
That said one can not guarantee equal sharing of current. But it's not the main problem which is sharing during switching transition. Designers of such modules extensively use chip matching by the parameters they would not disclose besides particular layout and heat removal techniques.

Like · Reply · 6w · Edited

Alex Berestov I did not see your affiliation with T company. The latter use discrete IGBTs. Well, vehicle life span is like 100000 miles on average. It's mere 2000 hrs of operation at average speed of 50 mph. It's probably an exaggeration but ballpark number is about right. Most likely thermal cycling would not even kick in. Which is bigger problem than current sharing.
Now compare this to a drive unit of rolling mill operating 24/7. Guess what's employed there.

Like · Reply · 6w

Dustin Lackey You might want to note that they recommend driving this SiC device with 15V. At that gate voltage the slope at cold is barely negative. So that combined with the fact that operating at cold you already have lots of margin should alleviate the concern for many applications.

As others mentioned this is all ignoring any possible problems with decreasing threshold voltage with increasing temperature during switching ...

Like · Reply · 6w

Alex Borisevich I think it is not very practical to assume that you are going to run it continuously below 30C.
Above 30C devices have a positive slope, so you are fine. It is basically intrinsic negative feedback which prevents thermal runaway (if the devices are on a common heatsink)

Like · Reply · 6w · Edited

George William Tyler Another thing to consider is gate threshold match.

Like · Reply · 6w

Fair to say that only lateral FETs as well as old VDMOS have low enough tempco crossover point for current sharing per say. Bear in mind that SiC MOSFTEs are in reality Baliga pair i.e. cascode. GaN has infinite speed which makes it near impossible to drive. Cheers

Like · Reply · 6w · Edited 1

Fırat Deveci
February 17

Nowadays every advanced SMPS controller has frequency jittering feature.

This helps us to reduce EMI filter size and also costs.

New SMPS controllers have lots of features like that:

Write a comment...

- HV Startup
- Peak Current Sense Resistor Fault Detection
- Internal Slope Compensation
- Leading-Edge Blanking
- Open Loop Protection
- Green Mode
- Frequency Jittering
- Thermal Protection
- Soft Start

With these features, personally, I don't use UC38xx series for a long time.

So if you want to design Flyback or Forward converter, do you still prefer UC38xx series or new controllers and why?

You and 23 others 25 Comments

Like Comment

Col Johns Is this a useful topic ...?

Like · Reply · 6w

Fırat Deveci We can share our thoughts about this. Maybe this conversations helps some people to select right controllers.

Like · Reply · 6w

Col Johns respectfully - the topic is very very broad - and application specific - usually more focused issues are studied here.

Like · Reply · 6w

Arief Noor Rahman Mature design procedure...well known IC....and already passed EMI test for many people

Like · Reply · 6w

application note. Because of all the features, especially protections, it is difficult to go beyond the intended use.
UC3845 , L6565 and other oldies are so well known it is easy to use them for multi-kW designs as well as for 50W.
For low power the ' green ' issues waiting around the corner so special kind of burst modes are a must. In this case the new controllers are in advantage also because low power is their scope of use.

Like · Reply · 6w

Manu Raj Many QR flyabck controllers with gate voltage clamping are available market with wide operating voltage and internal otp etc, if need to design a power more than 30W. Otherwise UC38xx are more easier to use.

Like · Reply · 6w · Edited

Darrell Hambley More than 30 years ago engineers designing power converters for aircraft tried to use frequency jittering in order to fool the EMI test equipment. Most were successful at fooling the equipment. However, the aircraft system engineers started noticing, and pilots started complaining. Systems issues, like a "ghost" signal on the radar screen would jitter back and forth.
The purpose of "meeting EMI" is not to show a nice plot which is below a limit line on a print out. The purpose of meeting EMI is to filter out noise so that is does not distort other systems.

Like · Reply · 6w

Arief Noor Rahman ☕ Thats what i thought about jittering, its just fooling the FFT math, but doesnt necessarily reduce the actual noise

Like · Reply · 6w

Dave Lafferty Darrell Hambley , they are also a nightmare for an AM or FM radio system.

Like · Reply · 6w

Ram Mohan This is similar to what Volkswagen did with their ECU

Like · Reply · 6w

Write a reply...

Stuart Wood For those working in the Areospace industry were we have to use hirel parts we don't get much choice....

Like · Reply · 6w

Chris Merren Sometime in 2000 I designed an IC that uses Spread Spectrum on the clock frequency... It doesn't fool the FFT, it actually lowers the amplitude of the EMI to help meet requirements...however it increases the bandwidth of the noise... The IC was abandoned..however some of my colleagues moved on to another company and released a similar controller... You can do this with most any SMPS controller, if you have an external clock pin...

Like · Reply · 6w

Dave Lafferty Chris Merren , I have tried that but one caution. If the IC has a R/C free running clock it needs to be lower than the min frequency of the spread spectrum.

Like · Reply · 6w

Chris Merren Dave Lafferty On some of the IC's I designed, there is an external clock pin...this feeds into a PLL that will over-ride the internal clock.... As long as the external clock frequency stays ABOVE the internal clock frequency your good...

Like · Reply · 6w

IC's.

Like · Reply · 6w

Chris Merren Dave Lafferty Here are a few I designed at one company that is now no longer...You can figure that company by the numbers... LM2652 and LM2852

Like · Reply · 6w

Dave Lafferty Chris Merren , sorry they were bought out. They not only made great power supply products but their audio IC's were also really easy for the hobby guys to use.

Like · Reply · 6w

Write a reply...

Ray Ridley Clock jitter is a big problem for many sensitive noise applications. And when a power supply is encoutering some kind of instability, the last thing you need is another variable during debug. Maybe pick a controller that lets you turn it on and off during development. (Does that always mean a digital controller?)

Leading edge blanking comes with its own set of unintended consequences. Make sure there is some backup during this period, many of the "advanced" chips don't have that.

Like · Reply · 6w

Chris Merren Ray brings up good points as usual.... Leading Edge Blanking gets to be real tricky at low Duty Cycles... That's why there is Valley Mode Control when using very small Duty Cycles... This is where you monitor the "Down-slope" which can geometrically tell you what the "up-slope" is doing....

Like · Reply · 6w · Edited

Fırat Deveci Ok you all don't like new ICs 🙂
So what kind of controllers do you use?

Can you tell us IC names except UC38xx?

If your comments are correct, all IC manufacturers' engineers work for nothing.

For example, I work with NCL30125 2-T controllers nowadays, 5 years ago I worked with UC3844/45 and I used lots of components to drive two mosfets. This IC helps to reduce the error rate because of component count and of course costs.
****
For military side I prefer to use digital control. It's easy to develop and hard to copy. Industrial/military/medical designs are very different areas and I agree with all comment in these areas.
****

Like · Reply · 6w · Edited

Ray Ridley Fırat Deveci the new ICs are all over the map. Some have made very bad choices and some are very good.

Every one of them will come with hidden “features” that you have to work through. In the course of a power design project you don’t have time to uncover all of these each time you change part type. Hence experienced engineers stick with what they know well.

There are so many to choose from now I don’t know how they make money from them!

Like · Reply · 6w

Col Johns For a (typical) resonant power converter the operating freq is always moving and so provides some spectrum spread on its own - you cannot mess with this for increased freq jitter. Simple PWM control - you can - and possibly some PSFB.

Like · Reply · 6w

Like · Reply · 6w

Venkat Karthik Adapter market needs low standby power. Most of the newest controllers have decent features including X-cap discharge, over power protection apart from what you mentioned. Unitrode IC's cannot achieve low standby (< 50 mW) unless extra circuitry is added. I know few Telecom guys who do not want to touch variable frequency IC's.

1

Like · Reply · 6w · Edited

Jeremy Lister Some are overprotected. Typical problem is one of it won't startup because the controller thinks the output is shorted..because you've fitted a large output cap.
Some digital core controllers look like they have variable one bit

Alex Berestov shared a link.
February 20

https://www.microwavejournal.com/…/33425-living-and-learnin…

Write a comment...

MICROWAVEJOURNAL.COM

Living and Learning with Barrie Gilbert

Barrie Gilbert, the iconic IC designer known for discovering the Translinear…

Jay Philippbar and 6 others — 1 Comment

Like — Comment

Alex Berestov It came in TEK group. However contribution to IC's and analog circuitry makes it relevant for this group as well.

1

Like · Reply · 6w

Write a comment...

Manfred Wimmer
February 20

How to measure the parasitic capacities (in, out and reverse transfer) of a high voltage IGBT?
With an impedance analyzer I can sweep the DC bias up to 40V, but I can't measure Cge while sweeping Vce.
A curve tracer is of no use at all for this purpose, correct?
The IGBTs data sheet is not finished yet and doesn't contain that data.

1 — 5 Comments

Like — Comment

nonlinear, voltage dependent capacitances.

Like · Reply · 6w

Cameron Stewart Any rectifier, FET, or IGBT acts like a voltage controlled varactor diode. As the reverse voltage across a junction pair increases, the capacitance goes down. Junction capacitance is highest at 0V potential.

Like · Reply · 6w

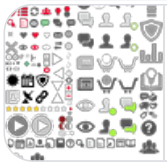
Ray Ridley 1 over the square root of the voltage. Just like skin depth in wire with frequency, go figure.

1

Like · Reply · 6w

Bob White You need a Semiconductor Device Parameter Analyzer, for example the B5100A from Keysight:

https://www.keysight.com/.../b1500a-semiconductor-device...



KEYSIGHT.COM

B1500A Semiconductor Device Parameter Analyzer and Measurement…

Like · Reply · 6w

Bob White Some older versions (e.g. 4145A) are selling on eBay in the US for a few hundred dollars. There is a used B5100A listed with an asking price of $29,000. Lesson summary: these are not inexpensive instruments.

Like · Reply · 6w

Write a reply...

Write a comment...

Nicola Rosano

January 31

Sharing is caring.

Case study: 11kW On board Charger EMC conducted emissions beyond CISPR class B average limits (5-8 dbuV out).

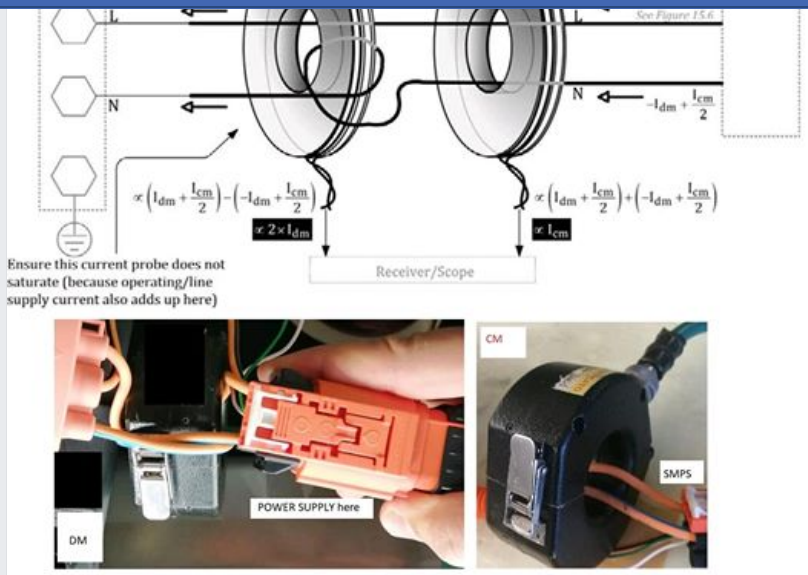
Power Module Structure: interleaved PFC + PSFB (with full wave rectification - no current doubler and full bridge neither).

What I have tried at the beginning (avoiding redundant comments):
- I added small ferrite on mosfets terminals -> improved something but not compliant as well
- I increased Coss on mosfets -> improved something but not compliant as well
- increased X cap (same mechanical case) -> improved something but not compliant as well
- I shielded both power & control cables -> improved something but not compliant as well

If your SMPS fails EMC test resulting "not compliant" - or beyond limits - the first thing to do is to understand witch noise component is dominant by splitting DM noise and CM noise. I did it. Result: the common mode filter was not so optimized AND initial parasitic parameters have been underestimated! On the same Y scale CM noise was huge compared to DM.

If it happens to you I suggest to not lose time with "try and see what happens" approach. The following approach is much more efficient.

Ps1 Yes that are my hands
Ps2 Didn't receive authorization to share before/after measurements (for now 😠)



You and 40 others — 16 Comments

Like — Comment

Luca Di Carlo You didn't solve the root cause of your noise, you just shoot it with a cannon. Anyway the approach you used is absolutely right! Congrats

Like · Reply · 9w · Edited

Nicola Rosano Luca Di Carlo agree. But when the time is running out doesn't matter

Like · Reply · 9w · Edited

Paul Shepherd I agree you have to split CM and DM before you try to solve the problem! If you k ow someone buying LISNs, make sure they invest in one that can separate the two.

Like · Reply · 9w

Venkat Karthik Any specific reason totempole or semi bridgeless topology was not used? I have read they are bad in terms of EMI but improve efficiency in terms of bridge rectifier.

Like · Reply · 9w

Charlie Elliott ☕ Venkat Karthik You probably just answered your own question!

Like · Reply · 9w

Chee How Can consider something in between like dual Boost Bridgeless PFC: No switching node connection to AC line as normal bridgeless PFC, sort of interleaving, but one rectifier diode loss and higher component count

Like · Reply · 8w

Cameron Stewart When in doubt: Install a faraday shield between primary and secondary of your main power transformer to supress common mode noise. Ground it on the primary side.

Like · Reply · 9w · Edited

Ray Mayer Finally, somebody using the RF splitter technique I've tried to convince people to use! Without it, how does one fix a noise problem when one doesn't know what type of noise it is?

Like · Reply · 9w

fair few people out there using that technique. I was shown it in an EMC training course 25 years ago. It is in quite a few of the books as well. It is odd that not all of the equipment providers make provision for it.

Like · Reply · 9w

James Keith Nicola Rosano Can you please tell me what are the specifications or part number of the current probe you are using to separate CM and DM? The picture shows that the differential current you get is 2xIdm after using that method. Does it mean on the spectrum analyzer you see twice the amplitude?

Like · Reply · 8w

Nicola Rosano James Keith Yes for a double amplitude. It's 6dbuV in magnitude.
The probe was from Eaton
http://www.ets-lindgren.com/.../current-probes/9006/900609

ETS-LINDGREN.COM
94111-1 Current Probe

Like · Reply · 8w

Write a reply...

Julio Cortés These measurements can be done with an oscilloscope and a current probe? Or it is necessary to use a spectrum analyzer?

Like · Reply · 6w

Nicola Rosano Julio Cortés you need a spectrum analizer. You are sweeping on frequency range.

Like · Reply · 6w

Julio Cortés I'm using the oscilloscope FFT function. I'm looking for a specific frequency (observed on the conducted emissions spectrum) but I can't find it using the oscilloscope. My guess is that the oscilloscope is limited.

Like · Reply · 6w

Nicola Rosano Julio Cortés if you have time to spend complicating something highly complicated and unpredictable per se, feel free to do it. I recommend a different approach. Plus FFT (of what?) is another story

Like · Reply · 6w · Edited

Julio Cortés I'm trying to understand your approach. Thank you so much for your time.

Like · Reply · 6w

Write a reply...

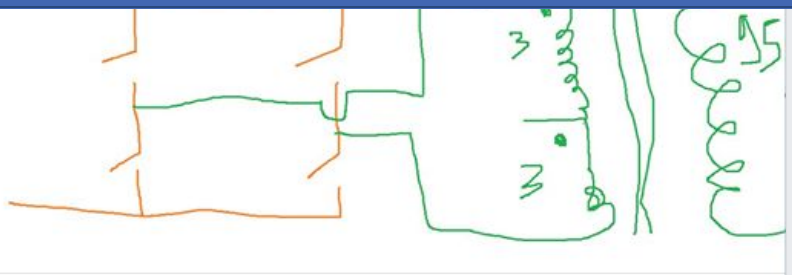
Hicham Boutouche
Write a comment...
February 17

Hi every body,

I would like to know if there is no problem if i use HF center tap transformer for full bridge inverter

i would also to know if there are a tips to respect

Cordially.



5 12 Comments

Like Comment

Col Johns should work fine - you could connect the CT to some rail splitting caps on the HVDC bus - too if you wished ...

Like · Reply · 6w

Hicham Boutouche Col Johns thank you very much,could please more explain why we use this CT.

Like · Reply · 6w

Hassan Athab you need to check the dote convention, i.e the direction of the windings!

Like · Reply · 6w

Tony Salsich There is nothing wrong with the windings as shown.

Like · Reply · 6w

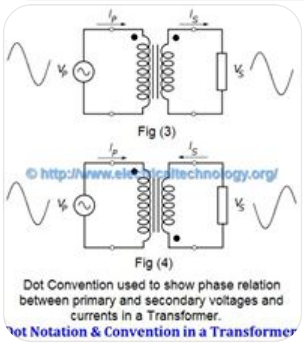
Hassan Athab what about the secondary side?

Like · Reply · 6w

Tony Salsich Would you care to elaborate on your concern?

Like · Reply · 6w

Hassan Athab this image clears my concern (I copied it from google)



Like · Reply · 6w

Jonathan Beaver Hassan Athab What is wrong here with the secondary side? What do you think the effect of reversing the phase would be?

Like · Reply · 6w

Colin Tuck As Tony tried to say above - generally it does not matter what the phasing (dot notation) is on the sec side ....

Like · Reply · 6w

Write a reply...

Ray Ridley This is all very vague.

2

Like · Reply · 6w

about this scheme

Like · Reply · 6w

Ray Ridley Why not just go try it? If it doesn't work, you will learn a lot.

Like · Reply · 6w

Write a reply...

Write a comment...

Kristian Kruse created a poll.
February 18

If you were to buy a new scope, which manufacture would you chose?
A reason why or good and bad experiences are also welcome.

Looking at new scopes in the 500 MHz - 1 GHz range, 4 Ch, preferably with build in Sig Gen for transfer function (bode). It is for power supplies, typical 20 to 100V inputs and 80 to 200KHz switching.

I currently have experience with keysight.

Tektronix	+52
Teledyne LeCroy	+30
Keysight	+12
Rohde & Schwarz	+7
other brand	+2

3 More Options...

4 77 Comments

Like Comment

Broox Le I think you need to include a budget range.
I think AnalogDevices/LinearTech uses LeCroy now.

Like · Reply · 6w

Kristian Kruse Broox Le
It is not completely fixed, I think the goal is finding value for money. 500 to 1000€ difference might make a huge difference in user interface and quality.

I'm not aiming for rigol or similar.
Looking at 10K € range.

Like · Reply · 6w

Broox Le I'm a Tektronix user myself and would like a loaded MDO4000 series, but I did note the ADI/LinearTech labs appeared loaded with LeCroys. ...and AP300's & 310's.

Like · Reply · 6w · Edited

David Seal Besides being really good o-scopes, Anritsu also makes the most rugged field units I have ever seen.

Like · Reply · 6w · Edited

Kristian Kruse David Seal I haven't even consider them, I should look at their equipment as well.
Thx.

Like · Reply · 6w

Richard Marron I love the Rohde and Schwarz's low noise floor.

Like · Reply · 6w

buttons will be coming to an end in the foreseeable future. .....

Announcement will be at APEC.

One question for you - do you really need 500 MHz for a 200 kHz switcher? You pay a lot for the extra bandwidth, and the first thing many power supply designers do is switch on the bandwidth limit so they can get rid of the switching hash and actually get some work done!

Performance of the Bode features of these scope is of great interest to us, obviously. We have been looking at it for quite some time now. There are gotchas to watch out for.....some of them are pretty useless. Still testing....

Like · Reply · 6w

Jonathan Beaver I'm going to be keeping an eye on that with great interest.
Personally, the advice I have given recently to a couple of companies that appear to be heavily investing in software based scopes is to keep equal capability around with hardware based units for troubleshooting purposes.
This may be personal bias, but from watching other engineers use both types of units (so it's not a lack of familiarity with the interface), there seems to be a noticeable amount of friction to changing timebase/trigger/position settings on the fly with most of the software scopes I've seen, which slows down the 'hmmm, I wonder if that looks correct' loop that I seem to go through when troubleshooting something from scratch. That may be more of a systems or embedded hardware engineering perspective, however.
On the other hand, for the ability to easily save/review captures, save capture and probe settings and do other in-depth analysis, it's certainly hard to argue with a software based unit.

Like · Reply · 6w

Ray Ridley Jonathan Beaver thanks for the comments. We have all kinds of scopes in the lab. It is culturally very difficult for people to switch formats I understand that.

It's a challenging time for scope makers that is for sure!

Like · Reply · 6w

Kristian Kruse Ray I might be old fashioned, but I like my buttons for horizontal and vertical scale, and I prefer one for each channel.

As for bode features, I only know the one from keysight. I agree, it definitely could improve.
It is hard to beat the antique 4195a.

The 500MHz might not be required for most , but it will also allow for new and faster designs.

I rarely use the internal BW limit, as I don't know the exact behaviour. I use passive external ones.

Like · Reply · 6w

Ray Ridley Kristian Kruse that's pretty old school! The digital filters are pretty amazing for cleanup but you are right, you can't be sure how they work.

Like · Reply · 6w

Milovan Kovacevic 200kHz switcher may actually be 500kHz or 1MHz switcher in a couple of years. Also, dv/dt is not completely independent of the switching frequency, but you know - it kinda is. In addition, signal electronics on the board can totally run at 100+ MHz, and you want to see some harmonics. Depending on what you do, from none to all of these reasons apply to you.

Like · Reply · 6w

digital scope that displays audio in real time as well as a good old monochrome CRT. especially when tracing it through amplifier stages looking for noise. Not that I won't use a computer-based instruments, but not for all things.

Like · Reply · 6w

Broox Le I too prefer individual knobs & buttons, but they are fast going away on new models in exchange for more display screen area....even tho most current generation scopes have a video out signal to connect whatever size larger display one desires.

Like · Reply · 6w

Kristian Kruse Milovan exactly my motivation for looking at something a bit over spec.
Harmonic is also nice to see, a diode snap off can be pretty fast.
Or a GaN switch 😉
No 20 MHz limit for me..

Like · Reply · 6w

Mike Murphree Ray, many times we needed a high-speed analog scope to find transients and failing components in a misbehaving switcher. I keep one analog scope for that purpose.

Like · Reply · 6w

Broox Le How does an analog scope help find failing components in a way a digital can't? ...and what kind of BW are you thinking of on the analog scope?

Like · Reply · 6w

Write a reply...

Victor Turriate-Gastulo It's a bit subjective, so I woud recommend scheduling demos with the vendors so you get to try your options before buying one. I have played with Tektronix, Keysight and Yokogawa recently. I liked the latest Tektronix 3 and 5 series scopes more. The crisp high definition screen, sales promotions, and the accessories available were some of the deciding factors.

Like · Reply · 6w

Victor Turriate-Gastulo Forgot to mention quality, we have some Yokogawas with knobs wearing out or just not working.

Like · Reply · 6w

Kristian Kruse I know, and I'm working on getting quite the demo show the next couple of weeks.

Bad knobs... Long term quality is something that is long gone, thats why I want some input from you guys.

I'm not amazed by keysight DSO7k, or 4k series. Lot of bad hardware, halfway assed software, noisy equipment and super expensive repair solutions.

Like · Reply · 6w

Victor Turriate-Gastulo I agree, specially on that Keysight comment. I think as far quality goes Tektronix scopes seem to be around the longest (also cost the most), hopefully still holds true with their new family of products. One neat thing of the Yokogawas I forgot to add, though, is that they don't take much space on your bench and are really intuitive

Like · Reply · 6w

David Edwards ☕ Victor Turriate-Gastulo The DM3000 Yokogawa I used had no wear out issues.

Like · Reply · 6w

Kristian Kruse David Edwards nice to know.

Ray Ridley Speaking of knobs - some of our low cost traveling scopes had a problem with the plastic splitting on ALL the knobs after about a year or so. One of the big brands.

Their initial response was to tell us to go and buy new knobs, they wouldn't replace them. Eventually they did since they realized a lot of people were exposed to what we recommend. It's not the cost, it's the principle.

Like · Reply · 6w

Write a reply...

Prawn Ayinger I use yokogawa and really love the depth of memory.

Like · Reply · 6w

Charlie Elliott I voted Keysight but we have seen reliability issues with a couple of our older Agilent ones. Then again perhaps I expect things to last too long!! If you have the budget then look at the Cleverscope CS448.

Like · Reply · 6w

Kristian Kruse Charlie
I have also seen the same issues with 3-7 year old agilent / keysight scopes.
Bad encoders, USB host controllers dying, 50ohm terminations turning on at random, attenuation changing at random while using regular BNC (no probe detect) and sudden loss of calibration.

Like · Reply · 6w

Kristian Kruse Charlie
I looked at cleverscope, it looks interesting, but I prefer a device with a screen.

Like · Reply · 6w

Ray Ridley Charlie Elliott I wouldn't recommend the cleverscope.

Like · Reply · 6w

Charlie Elliott Ray Ridley - I know you are not a fan of the FRA side of the CS448 for a variety of reasons but if you just think of it as a high quality 4 channel (+ digital) isolated scope then it is IMHO great.

Like · Reply · 6w · Edited

Charlie Elliott Kristian Kruse - I know what you mean wrt PC based vs "real" scope. What we really need is somebody to make a little box with knobs and buttons which sents the coms commands and you just use the screen of the PC.

Like · Reply · 6w

Write a reply...

David Edwards I like the Yokogawa DLM3000 oscilloscope because of its small size and big performance. It minimizes the number of buttons, knobs and controls by sharing one set among all channels. One must first select the desired channel then make the intended adjustments. This takes a little getting used to at first but quickly becomes second nature.

It allows using full math in XY mode, which allows plotting solar panel characteristics in real time to easily check maximum power point tracking (yes, some other 'scopes do this too, but not all).

Like · Reply · 6w · Edited

David Seal Nice display resolution, too.

Like · Reply · 6w

Alex Berestov The very option useful in PSU debugging is isolated channels. I've checked LeCroy, Fluke, Schwarz on that regard.
Bleak in comparison to Tek. That's said TPS2024 I'm referring to has short memory and mere 8bits without HiRes option. However ability to see control and output simultaneously without AC coupling the two is priceless, for everything else....
If money is not an option there is high end 12 bit TEK, 9 enob, with optically coupled probes @ 500 and 1000 MHz
Moreover you may consider Enertronics GmbH wireless floating wi-fi scope if it still exists.

Like · Reply · 6w

Kristian Kruse Alex I think the Tek 9 is a fair bit out of budget, without knowing the exact price.
But it sounds nice (and expensive).

Like · Reply · 6w

David Edwards . Hello Alex Berestov,

Tek's new optically isolated probes are truly amazing and unique among such instruments. When properly set up their common mode rejection is unparalleled. However, they cost the Earth. Maybe when competition kicks in the price will come down.

Like · Reply · 6w

Ray Ridley David Edwards looks like something from Star Wars.

Like · Reply · 6w

David Edwards . Hello Ray Ridley,

Here are some of the features and benefits this $26k measurement system:

Bandwidth from DC to 1 GHz
160 dB Common Mode Rejection from DC up to 1 MHz
. 80 dB Common Mode Rejection at 1 GHz
. 60 kV peak Common Mode Voltage
Cable length of 3 or 10 meters (identical performance)
Maximum input amplitude of either +/-50V or +/-2500V (depending on the test head)

The cable has five fiber optic lines (one for power). The tripod serves to minimize stray capacitance to maximize common mode performance. Full performance requires a scope tip jack into the unit under test's ground plane.

Like · Reply · 6w · Edited

by these optical probes for measuring anything on the high side switches, including the gate drive.

But yes, they are rather pricey, starting at about US$20,000.

Like · Reply · 6w

Charlie Elliott Bob White And that cost is per channel AND you have to use a Tek scope😵.

Like · Reply · 6w

David Edwards @ Maneesh Kumar Singh To what are you referring by "these"? Do you mean the really expensive Tek IsoVu probes? If so, are you basing your assertion upon personal experience with these probes? If so, please describe the details of that experience. In particular, did you use scope tip jacks into the unit-under-test's ground plane or did you use a ground lead and clip?

Like · Reply · 6w · Edited

Maneesh Kumar Singh David Edwards I have used these to measure signals with dv/dt of around 200v/ns, this is at high voltage (~8kV) , high side signal . I could not connect this directly to my board because of clearance issues and so we have a twisted pair of high voltage wire and made up our connector which mates to the Tek IsoVu probe. the problem I have faced is not in signal distortion , the signal is pretty good and close to expected. There seem to be ferrite beads in the probe tip which heat up very fast to around 140C within 2min, so I need to limit my measurement time if I am measuring high dv/dt's. I haves seen similar issue with signals which are referenced to ground with similar dv/dt's .I am trying to measure around 2kV across a switch

Like · Reply · 6w · Edited

Write a reply...

Kyle Miller Really love the new Rigol scopes... Very good. Really good prices...

Easy to hack to get all the options...

Like · Reply · 6w

Kristian Kruse Kyle
I have tried the rigol 4k series, it is a good scope. But I have read too much bad stuff about their newer and bigger models. Hacking their scopes is not possible for industrial purposes, at least not where I work.
I also know from experience that they tend to have some buggy firmware/software.

Like · Reply · 6w

Kyle Miller I have a fully paid for upgraded 7000 series at work... It was so good, I bought the 5000 series for myself...

Like · Reply · 6w

Kristian Kruse I would love to have a 4000 series or bigger at home. However I doubt we will use them at my work.
I have a dual channel signal generator form Rigol, and it is pretty neat.

Like · Reply · 6w

Write a reply...

Janaki Ram Gopal Pagolu Voted for Tektronics. I don't own one, but Analog Discovery 2 looks to me like its made for power supply designers working on lower switching frequencies. It has Oscilloscope, Network analyzer, Spectrum Analyzer, Function generator and Impedance Analyzer all in one.
https://store.digilentinc.com/analog-discovery-2-100msps.../

Analog Discovery 2: 100MS/s USB Oscilloscope, Logic Analyzer and…

Like · Reply · 6w · Edited

Kristian Kruse Janaki
It is an interesting device, but in my opinion only for educational and hobby purpose.

It will not work for our line of business, and I wouldn't like to show this kind of equipment if we had customers visit..

Do not get me wrong, it is a neat instrument, and I have considered it as part of my private lab.

1

Like · Reply · 6w

Janaki Ram Gopal Pagolu I agree what you said, it's more for a hobbiest than for a professional. But imagine a top tier company releasing a single product with all those features with added reliability and ruggedness.

Like · Reply · 6w

Ray Ridley We have this in the lab too. Strictly for students and people with time on their hands.

1

Like · Reply · 6w

Broox Le I was thinking something along that line. What do you think of the more professional 'tools that use a laptop for control' like the PicoScope series?

Like · Reply · 6w

Kristian Kruse I have made a few test of the FRA (frequency analysis) function of a few Keysight scopes, and I will soon have the possibility to compare with Rohde & Schwarz.

I did some conducted sucebtibility (PSRR) measurements with a HP4195A to get a baseline of a dual output DC/DC.

I then tested keysight 1k series, 4k series and 6k series.

Generally the noise floor of the scopes is around -80 to -90 dB from 100 Hz to 100 KHz.

The scopes had a deviation from the HP4195A which was generally less than 1 dB @ 63dB.
The injection level was 1Vrms.

I will add some more measurements to the log once I have my hands on R&S, then I will share some actual measurements.

Like · Reply · 6w

Mark Reinders I like Rigol for the value. Great features. Also have high end Agilent for high speed digital work such as SPI and I2C

Like · Reply · 6w

Bruno Torremans Tektronix MDO4000 and PicoScope 5000 series

Like · Reply · 6w

Many of the major companies have made major missteps in the past years, changing their structures to adjust to market conditions.

Things like:

(1) Laying off field apps engineers since finance can't see why they need them (they got rehired)

(2) Not having decent drivers for the HDMI output - seriously, in this day and age??

(3) Not staying up with the latest Windows versions as they come out.

(4) Poor user interface design

(5) noise coupling and rejection issues (you won't find this out until you are deep into the usage.

(6) restricted access to data and computer inside.

The list is pretty endless. Many times the scope you used to love has just become something else. And the changes will continue at a rapid pace.

Of course there are good things going on too. The number of sample bits is a going up, but this contentious issue and you have to be very, very, careful of specmanship and outright misrepresentation of this and many other issues.

Funny, no one ever talks or listens to us at Ridley Engineering. We have a pretty good insight to how users interact with their scopes and what they want, but that's OK. 😎

Like · Reply · 6w · Edited

Magnus Rosén It's the gears in front of the scope that matters. Without good and well working probes the job cant be done. Nowdays I think decent differential voltage probes are the bottle neck for any working with WBG applications. Also want to mention current probing, accuracy, noise floor, drift and BW/tR/F.

Like · Reply · 6w · Edited

Ray Ridley Think that's bottle neck, not beck. Might want to edit.

Like · Reply · 6w

Kristian Kruse Why did the the comment with bode 100 disappear?

Like · Reply · 6w

Ray Ridley Not really the place for advertising a competitor's product. 😎

Come see us at APEC for a much better alternative if you can't afford the AP300.

Like · Reply · 6w

Kristian Kruse Ray strictly speaking, wouldn't a scope with gain phase like capabilities also be a competitor?
Also it wasn't the bit sales pitch, jus some experience.

1

Like · Reply · 6w

Ray Ridley The AP300 is the gold standard for FRA, ever since the HP4195 exited the market. Everyone tries to copy it, but a scope can never offer the dynamic range, channel separation, noise rejection, and calibration/certification capabilities of the AP products. The hardware architecture is just different.

We are not worried about the scopes coming into our space, if anything our sales have gone up since they have raised awareness in the marketplace.

If I were the maker of the 100, I would be very worried about them. At least when the scope can't do everything you wanted it to, you still have a scope for your money.

Like · Reply · 6w · Edited

Like · Reply · 6w

Write a reply...

Col Johns The CleverScope range is not to be overlooked either - their latest isolated probes for high side GaN gate drive measurement are very very good ...

Like · Reply · 6w · 2

Ray Ridley I really couldn't get along with the CleverScope. I really wanted it to work. I gave it 8 hours of my time to try and make a measurement with it, then packed it up back in the box.

I hear things have improved, but this was not a good first impression. Measurement equipment just shouldn't be that hard to operate and get good results.

Perhaps the scope is more capable, and I heard they were doing iso probes.

Same thing happened with Analytic Artistry, Digilent, and other ultra low-cost toys. Four hours to plot an RC filter, then a powered circuit wiped out one of the inputs and it never ran again. You get what you pay for.

Like · Reply · 6w

Bob White Analytic Artistry - Rob Martinelli's company?

Like · Reply · 6w

Ray Ridley Bob White no, a different company.

Like · Reply · 6w

Ray Ridley Maybe Analytic Arts?

Like · Reply · 6w

Ray Ridley Doesn't matter - not a product to spend time on.

Like · Reply · 6w

Write a reply...

Ray Ridley Just for the record - we currently have what is probably the world's record for number of FRAs in one lab. Currently counting 25 from 5 different manufacturers! Quite an enviable collection, I wish I had this to play with 30 years ago.

Most of them are just SO opaque in how to get them working even with our experience.

That's why it is quite common to visit a power electronics company and see a Venable on the shelves that no one can remember how to operate. And it's why you can even find an HP4195 or HP4194 lurking unused in the corner of the lab somewhere that you are working.

Software enhancement is the main thrust for the future for the AP300. The hardware matured long ago, now it is all about the software tools and usability. One button setup for the different measurements is what we are all about now, as our workshop attendees know.

Like · Reply · 6w · Edited · 2

Ray Ridley Now intimately familiar with over 20 different models, and many of their variants! Oh, that things that we have seen.

Bode plots have never been so popular - we like to think we have something to do with that. And of course, hats off to Dean Venable and Middlebrook for keeping the art alive for the lost digital decades.....

Like · Reply · 6w

does work but the PC software is poor and really lets it down. The front panel interface is also not very intuitive IMHO. Every time you come to use it after several months break you have to get the manual out. What is perhaps most dissappointing is that they really dont seem all that bothered about this.

Like · Reply · 6w

Ray Ridley Charlie Elliott well, we always have a trade-in program.

No excuse for poor software these days, but it is quite common to see this. Old instrument designers overlook the software investment that is needed. Venable fell into that trap. New hardware, 1980s software.

And you are right, those that make these choices aren't bothered by them. They tend to be hardware engineers obsessed with specs not interface niceties.

Like · Reply · 6w

Write a reply...

Hamish Laird With years of looking at scope waveforms and trying to decide whether what I am seeing is actually happening common-mode rejection of single-sided scope inputs is right up there in measuring good performance. This CM rejection is often not a problem with lowish dv/dt in smaller low voltage switchmode PSU but is a constant challenge with high voltage power electronics. And still, Tektronix has the best CM performance although the Agilent/Keysite stuff is almost comparable now. Always worth giving a scope a good CM work out before you buy it.

3

Like · Reply · 6w

Alex Berestov Well, the last time I've checked isolated input scopes was just a year or two ago. Any scope besides TEK was impossible to use: all you need was to connect one channel to a switch node, even at moderate voltage well below 500 VRMS.

Like · Reply · 6w

Ray Ridley I would listen to Hamish on this one. You can't muck about with noise when your tiny digital signals are controlling 10,000 A in the power system.

Like · Reply · 6w

Jimbo Hissem I'm enjoying the new 8ch touch screen Tek scopes we purchased. No more daisy chaining scopes to get power up/down timing plots of multiple converters on a control board.

Like · Reply · 6w

Jay Lee Intel only recognizes Tektronix for CPU power

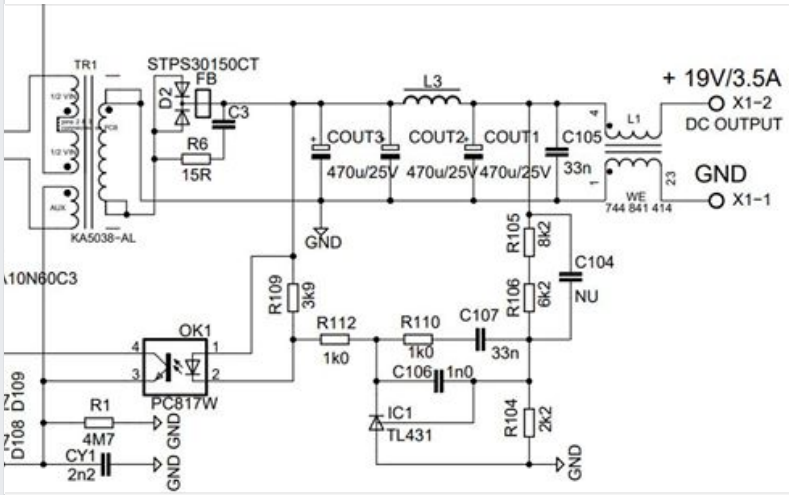
Like · Reply · 6w

Write a comment...

James Keith
February 19

In the attached flyback design, the output common mode choke is rated for 4 Amps. CM choke only sees common mode noise currents and not the differential current (atleast when placed on the input AC line.) What about on the DC side. Should it be rated for DC current? Can anyone please advise? The attached screenshot is from On semiconductor's schematic page.

Part number: https://www.digikey.com/product-detail/en/w-rth-elektronik/744841414/732-1459-ND/1638864



4 13 Comments

Like Comment

A-ARon Jones How does the choke not see differential input current? Seems to violate KCL

Like · Reply · 6w

James Keith A-ARon Jones Wouldn't the flux in DC+ and the flux in DC- cancel each other ?

Like · Reply · 6w

A-ARon Jones James Keith I believe we are talking about the difference between rated current and saturation current. From a flux and impedance perspective yes, but the power rating is differential.

2

Like · Reply · 6w · Edited

Charlie Landino A-ARon Jones The flux in the core is in opposite directions and cancels in the CM choke. The ohmic loss is the same, though - KCL not violated!

1

Like · Reply · 6w

inductance should be given in the datasheet. And actually this leakage inductance is used as the differential mode filter inductance normally in designs and only a capacitor will be enough to filter differential mode noise as well.

Like · Reply · 6w

Bob Gudgel Murat I don't think that the leakage inductance is typically an L where its flux is applied to the core itself ? Which would be why, I believe, they call it leakage ?

Like · Reply · 6w · Edited

Write a reply...

Dustin Lackey The conductors in the choke need to be rated for the DC current which flows through them, even though they flow out and back. The copper wire still has a DC resistance and resulting power loss and temperature rise.

Like · Reply · 6w

Andrew Ferencz The CM choke is 14uH and I don't know if the picture represents the part as I see 6 turns. That means the core permeability is low, 14/36 or about 500nH/t^2. The flux in a core is L * I / N /Ae. I would guess that at 3.5A the core would probably saturate but you cannot tell from the datasheet. But if you look at the insertion loss graph you can see this is mainly for some RF attenuation in the >20MHz region. Basically they are using the choke as an improved lossy bead.

Like · Reply · 6w · Edited

Col Johns The net ampere turns in the core is zero as it is a common mode choke - only an imbalance in the send and return currents gives rise to flux in core - or significant CM currents - which there are generally not ... Andrew Ferencz

Like · Reply · 6w

Stuart Wood The choke is rated at 3.5 Amps. It doesn't matter if it's AC or DC. It's a limit on the I^2R losses.

Like · Reply · 6w

Col Johns and the cooling available ....

Like · Reply · 6w

Col Johns https://www.google.com/url?sa=t&rct=j&q=&esrc=s...

Like · Reply · 6w

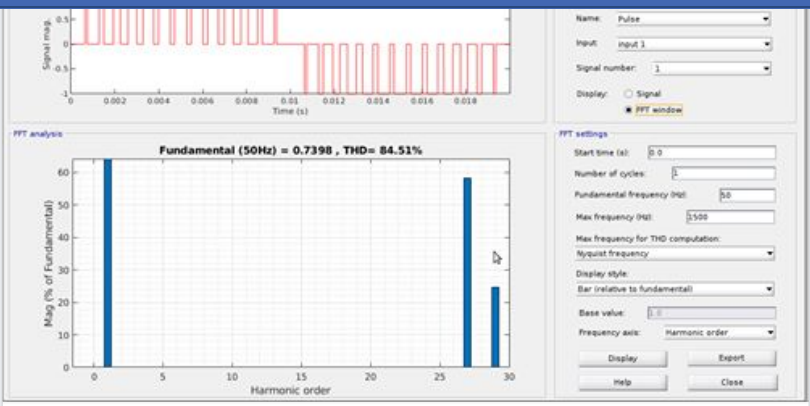
Doddapaneni Venkata Nagesh Babu Usually I see this choke on high current rails with half turn busbars using gapped E cores. For low power not a big benefit. Unless design is targeted to support special equipment such as medical grade , regular design can avoid this I think. For special applications, its between designer and his customer 🙂

Like · Reply · 6w

Write a comment...

Farouk YD
February 17

Hey everyone !
I'm working on a single phase inverter drived with shepwm (the signal above) and I want add a filter so the out put becomes a perfect sin curve, the problem i am facing is that my load is variable so every time I change the load I have to redisgne a new filter.
Can you please give me some advice?
thank you for reading 🙂



You, Jay Philippbar and 6 others 18 Comments

Like Comment

Paul Shepherd If I understand your question correctly, you need the output impedance of the filter to be much lower than your load, or you need a faster current control loop.

Like · Reply · 6w

John MacLeod For normal load range, only voltage control should be in play, so no effect from current control loop. The filter needs to be LC low-pass, with cut-off between modulating frequency and switching frequency but avoiding odd harmonics of mod frequency. Device deadtime injects odd harmonics of the modulating waveform so you don't want any of those hitting the resonant frequency of the filter.

Like · Reply · 6w · Edited

John MacLeod ...once you're in current limit, you don't really care about waveshape being sinusoidal any more.

Like · Reply · 6w

Cameron Stewart This is what corrective feedback and gain phase plots are for.

The corner frequency on an inverter output filter will always change with loading. So you have to plot the gain and phase at the loading extremes, then design the best combination of output filter and loop compensation to work in your application.

I don't recommend running your inverter open loop unless load regulation and distortion are not an issue.

If you are doing pure digital control you have another layer of complexity to deal with: The power output filter is in the 'S' domain and the digital control loop is in the 'Z' domain.

3

Like · Reply · 6w

Hide 12 Replies

Farouk YD Cameron Stewart hey thanks for your reply, have you any references doc article book about it ?!

Like · Reply · 6w

Cameron Stewart Farouk YD

Most of what I know about inverters I learned through a combination of time and frequency domain simulation with LT Spice and working with hardware in the lab.

Dr Ridley offers training courses, books, and on-line papers on the subject. He also offers analyzer equipment and software for bode plotting.

Dr Hamish Laird teaches digital control loop principles.

It sounds like you are new to this and just starting out.

Like · Reply · 6w

wondering is it impossible to do it on a open loop system ?

Like · Reply · 6w

Cameron Stewart You need to define your specification goals first:

1) Nominal output voltage

2) Output frequency

3) Maximum output power

4) Load power factor, min/max, leading / lagging.

5) Load regulation, min/max from nominal output voltage.

6) Maximum distortion.

7) Target switching frequency.

8) Minimum efficiency.

9) Proposed power switching devices: IGBT's vs Silicon Carbide vs ?

10) Input DC rail voltages

Until now you haven't provided any detailed specifications or a starting schematic. So the question is too vague to answer properly.

Like · Reply · 6w

Farouk YD Cameron Stewart
Vout = 230v
f = 50hz
S = 2kva
THD < 5%
And I'm using mosfet.
But I don't know the load it's an ups so load is totally unknown

Like · Reply · 6w

Cameron Stewart If you are using mosfets, how will you handle reverse recovery of the mosfet internal body diodes in your totem pole bridge?

During the pwm dead time, the main output inductor voltage will fly into the body diode, opposite the mosfet that just turned off. That body diode must then go through a reverse recovery, typically when that second mosfet turns off and the original mosfet turns back on.

The body diode reverse recovery problem is serious enough on pwm inverters that most applications end up using IGBT's for the application.

The IGBT's in turn limit the switching frequency due to storage time issues during turn-off.

Adding anti-paralleling diode networks with conventional mosfets ends up being too space intensive to package easily.

But there are other alternatives, such as Silicon Carbide mosfets are Gallium Nitride devices. Each has it's design trade-offs as well.

So again, what is your proposed switching frequency?

Like · Reply · 6w · Edited

Farouk YD Cameron Stewart Aagh I forgot about it thank you, For the switching frequency it's 1,3kHz

Like · Reply · 6w

Cameron Stewart I'm sorry: Is that 13 KHz or 1.3 KHz?

Like · Reply · 6w

Cameron Stewart 1.3 KHz is too low a switching frequency for 50 Hz. The switching frequency should be at least 100 times the AC output frequency.

Like · Reply · 6w

switching frequency

Like · Reply · 6w

Cameron Stewart Farouk YD

Can you explain your algorithm in more detail?

This is central to determining whether your approach is feasible.

Like · Reply · 6w

Cameron Stewart Otherwise nobody on this forum can really help you, unless they have already done something similar.

Why is reducing the switching frequency to 1.3 KHz such a crucial design objective?

Like · Reply · 6w · Edited

Write a reply...

Ray Ridley I like the objective of the original posting a "perfect" sine wave output.

1

Like · Reply · 6w

Write a comment...

James Keith
February 19

In radiated and conducted emissions, there are several components used (ferrite beads, shielding, CM, DM chokes, any dv/dt or di/dt is controlled) to pass the emissions. When it comes to the conducted and radiated immunity tests, what techniques are used in the power supply design to make sure it passes the radiated/conducted immunity standards? Looking at the emissions plot, it may be easy to say that the failing amplitude is due to common mode noise or differential mode noise and use special techniques to damp the ringing on a MOSFET drain, transformer etc. Is it the same methodology used to pass immunity test as well? I haven't seen any documents on the internet which go in detail about how to pass the immunity tests. Documentation is mostly on emissions.

Darrell Hambley and 4 others — 4 Comments

Like | Comment

Rob Oglesbee They are usually duals of each other. It's easier to debug emissions, and once that is good, immunity often follows. That said, Doug Smith at emcesd.com has quite a few general techniques.

High Frequency Measurements Site Index

Like · Reply · 6w

Magnus Rosén First off all there are several "modes" to deal with in immunity. Ranging from multiples of mains frequency 2*60Hz in dips and drops phenomena. Then there are several HF phenomena with similar frequency as CE disturbance from PSU. Some are very narrow band some are wide band (burst or surge). Then there exists air coupled phenomena in VHF/UHF bands. So one can be certain that several and completely different function disturbance may occur. Eventually may some part break down in high energy event. Like VDR or transformer insulation. Most common is the output control voltage/current feed-back elements disturbance. Most likely is optocoupler without sufficient rejection the primary threat for CS, burst, surge and ESD phenomena. Maybe other in the group have other experiences.
Basicly are all immunity phenomenas possible to understand physically and by fairly simple electrical principles. And from that apply common design rules. It is possible to simulate, pspice, simplecs etc to optimize or invent ideas for immunity robustness.

Like · Reply · 6w · Edited

Ray Ridley You can't really prepare yourself for what happens when you finally get to take a product through this process. There is not much you can do to "ensure" it will pass testing except for pre-testing in your own labs. Don't hang your hat on simulation - just get in the lab and do it!

It's a trial by fire event that you will emerge from with much greater understanding.

3

Like · Reply · 6w

Col Johns Get an experienced consulting EMC engineer in to look at your product during the design phases - this will save you untold hours in the test lab - for for emissions and immunity ... and you will learn heaps in a very compressed time frame.

Paul Shepherd
February 18
Write a comment...

Second Edit to ask more specifically: What about REd100sd? It does not appear to be in the files attached to this group. Thanks!

Edit to answer my own question: Clicking on the group Files tab on the left leads to a list of these files. I am getting them installed now.

Quick question on the Conditionally-stable buck converter form the Ridley Engineering website... The LTSpice circuits rely on several Ridley-specific blocks (REnfet, REd100sd, REideal, REap300) that are not included in the zip file. Are these available elsewhere? I am running OSX, so I can't use RidleyWorks (which is where I suspect these building blocks may be distributed). Thanks!

1 2 Comments

Like Comment

Ray Ridley OSX - for the mac, just install a windows partition to run it all. This is what the engineers from Apple do.

Not ideal, but since Apple and Microsoft can't get excel working properly on the mac, its what you have to do.

1

Like · Reply · 6w

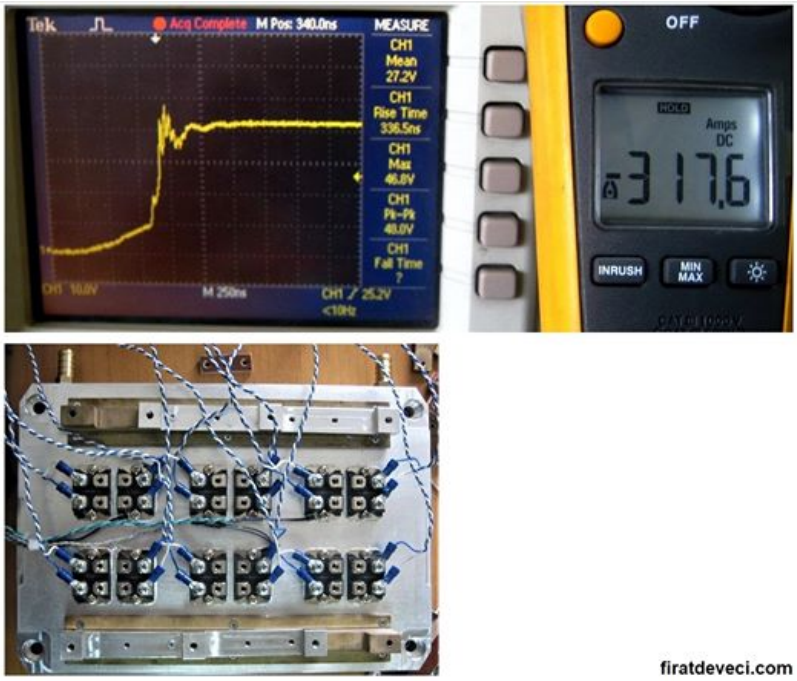
Ray Ridley Once you do that, Paul Shepherd, we can send you a full demo version that will install all the needed subcircuits for you.

Like · Reply · 6w

Write a comment...

This is my first project from 2011 for private company: 48V 300A BLDC Motor Driver with water cooling.

Mechanical placement is very important if you want to decrease the leakage inductance. Nowadays I don't design motor drives (personally, not prefer to design) maybe it will help designers who curious about. This is mosfet voltage measurements at full power.



You and 12 others 17 Comments

Like Comment

Colin Tuck What mosfets are you using ...?
Like · Reply · 6w

Fırat Deveci IXFN230N20T
Like · Reply · 6w

John MacLeod Is that a bit of a lift in Vds prior to turn-off?
Like · Reply · 6w

Fırat Deveci This is Turn off signal.
Like · Reply · 6w

Petrica Barbieru Seem slowly first phase of turn-off... losses are normal?!
Like · Reply · 6w

Fırat Deveci Those days, I'm using 300mA (yes, sad but true) mosfet driver to drive 2 parallel mosfets. It isn't normal of course.

But nowadays I'm using 20Apeak gate drivers 🙂
Like · Reply · 6w · Edited

Petrica Barbieru Fırat Deveci BLDC motor use in encoder loop control system or sensorless? In sensorless may have sensing problems with so low Vds overshoot.
Like · Reply · 6w

Fırat Deveci Sonsored control
Like · Reply · 6w

Venkat Karthik What's the control technique? FOC , trapezoidal etc?

Like · Reply · 6w

Fırat Deveci Venkat Karthik Trapezoidal.

Like · Reply · 6w

Long Nguyen how to you can decrease spike voltage Vds of mosfets when it is running high current. do you used snubber? or other method?

1

Like · Reply · 6w

Fırat Deveci Long Nguyen Mechanical placement is very impirtant, i used onlu 22nF 1R 2W snubber

Like · Reply · 6w

Long Nguyen Fırat Deveci What temperature of heatsink at full power

Like · Reply · 6w

Fırat Deveci Long Nguyen 80 degree.

Like · Reply · 6w

Write a reply...

Graham Ward I always liked those Isotop packages, but they never seemed to prove popular and were always outrageously expensive.

1

Like · Reply · 6w

Scott Styles I can remember being flambéed at work for suggesting these once.

Like · Reply · 6w

Charlie Elliott They are also surprising fragile with respect to the plastic which retains the captive nut. Even with proper torque driver we have had them crack. They do serve as a useful "medium power" step to larger modules but have a lot more competion at lower cost these days.

Like · Reply · 6w

Write a reply...

Write a comment...

Julian Waller shared a link.

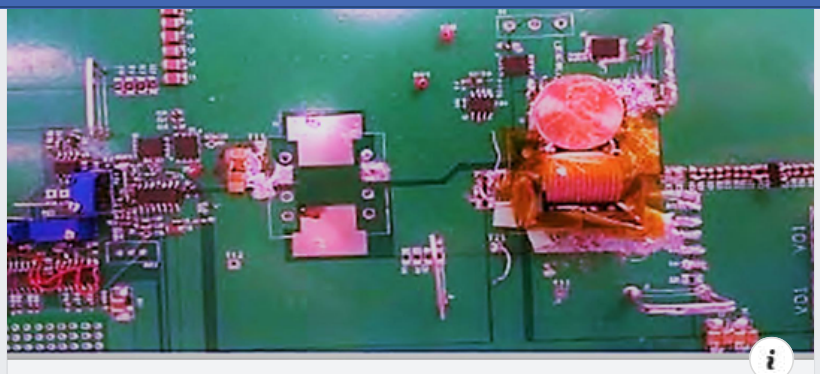
February 3

I am being challenged to improve the size of a buck converters to create 240A @ 0.8V.
I downloaded a paper written by Dr Cuk about a quasi resonant split inductor topology capable of delivering 1V @ 200A from a 48V supply. Entitled **"Single 48V to 1V, 200A Converter Powers Microprocessors"**

https://www.powerelectronics.com/technologies/power-management/article/21864291/single-48v-to-1v-200a-converter-powers-microprocessors-part-3

The design is subject to various patents but I am only really interested in building a few. Does anybody know of a company who has developed this technology that would have standard offerings or be willing

to offer semi custom offerings?



POWERELECTRONICS.COM

Single 48V to 1V, 200A Converter Powers Microprocessors (Part 3)

You and 6 others 33 Comments

Like Comment

Col Johns That is a great challenge - only 192 watts but 240A continuous - presumably multi phase? Can you share some of the regulation specs? i.e. 90 - 5% load change Vout must be within ...? 5% to 90% load step - Vout must be within ...?

Like · Reply · 8w

Julian Waller +/-3% voltage, still figuring out the transient. Multi phase solution with LTM4700. The above technology seems to be the only challenger to get the size down.

Like · Reply · 8w

Col Johns Having studied the ckt a little - no doubt it could get the size down - but a fair bit of engineering effort to get one working well - controlling load steps my well require non linear control techniques ...

Like · Reply · 8w

Julian Waller I see it for what it is just hoping to leverage off someone else who has done it. I don't have time for a full blown development although I would certainly be up for the challenge.

Like · Reply · 8w

Ray Ridley Look at Vicor's products.

There is a huge amount of work to move a breadboard like that shown to a working product. Many are trying multiple approaches to it, and have invested huge resources. I don't know what "building a few" really means, but there is no short cut to it all.

Like · Reply · 8w

Julian Waller I hope to buy one from someone has gone through the pain barrier already and has some commercial offerings. At this stage I would probably be looking at about 10 pc.

Like · Reply · 8w

Julian Waller I am familiar with Vicor's wares particularly their new bus converters which are pretty cool if you are prepared to design mechanical heatsinks to extract heat from both sides of the package. I can look again however with ore focused questions.

Like · Reply · 8w

probably the best solution. The fixed ratio converter circuit topology is not all that novel (basically a series resonant converter) but their packaging is light years beyond anyone else in the industry.

Like · Reply · 8w

Ray Ridley What don't you like about it? I have not seen anything come close to their density and performance.

Like · Reply · 8w

Write a reply...

Col Johns You could always ask Dr. Cuk if he has some properly working demo units he can sell to you ... !

Like · Reply · 8w

Dave Lafferty 200A at 1V or lower sounds like you will need very tight regulation. Is this a constant load or does it vary 50% or more?

Like · Reply · 8w

Bob White Given this is a processor, the load varies from no load to full load and can have load current di/dt measured in tens of amperes per nanosecond. The key to designing power for processors like this having a very low output impedance (millohms) that is constant over the frequency range of "dc to to light".

Like · Reply · 8w

Dave Lafferty Bob White , maybe a multiphase buck with a fast response time? I have never worked in this 200A range but have done some 0-50A multiphase designs.

Like · Reply · 8w

Bob White Multi-phase has been the usual way of doing this. However, this approach is running out of steam. You end up needing too many stages and they are too far from the chip to maintain proper regulation on the die itself. This is giving rise to work on "power-on-package" or "power-in-package". The idea is to shrink the converter to where it can sit on the same interposer board as the die. This is where packaging technology like Vicor's shines.

The ultimate goal, tried by Intel in I think the Haswell generation of processors, is to have the power converter on the die itself to absolutely minimize the power distribution impedance due to the enormous di/dt of the load current.

Check out the Power-Supply-on-Chip (PwrSoC) workshops if this area really interests you.

https://www.psma.com/conferences/PwrSoC

PSMA.COM

PwrSoC | Power Sources Manufacturers Association

Like · Reply · 8w · Edited

Dave Lafferty Bob White , thanks.

Like · Reply · 8w

Alan Finkel Bob White "dc to light"... I wonder how many folks will realize you aren't exactly joking...

Like · Reply · 8w

Write a reply...

(80V, 100V) and capable of 240A. So one would use some means to impedance match .. like a transformer. If you call a forward converter a buck converter (it is) .. then you are getting closer to a solution. I think even Prof. Cuk has some coupled magnetic parts.

I am doing work at IBM where we are using an integrated magnetic converter with an active clamp primary to go from 48V to sub 1V. Our 100A device is very small. We did get a patent on this too but IBM is not in the power converter production business.

https://patents.justia.com/patent/10186949

But Vicor is a leader in this area .. after spending years and millions on circuits, components, and packaging technology. If you want to 'catch up' ... know it is not a weekend project!

PATENTS.JUSTIA.COM
US Patent for Coupled-inductor DC-DC power converter Patent (Patent #…

Like · Reply · 8w · Edited

Ray Ridley Link doesn't work for me.

Like · Reply · 8w

Andrew Ferencz changed it .. was working for me but maybe my browswer had some history.

Like · Reply · 8w

Ray Ridley Where are the pictures??? Not much help without them.

Like · Reply · 8w

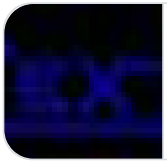
Andrew Ferencz go here

http://patft.uspto.gov/netahtml/PTO/search-bool.html

and search for

10,186,949

I don't know why it is hard to link...



PATFT.USPTO.GOV
US Patent Full-Text Database Boolean Search

Like · Reply · 8w · Edited

Write a reply...

Robert L Rauck Very interesting discussion. Extremely low voltage converters are a very hot area!

Like · Reply · 8w

Ray Ridley This is the "cuk-buck2". Much ado about that in the press, all from Dr. Cuk himself.

Zero-voltage, soft-switched, with a transformer. He calls it a tapped inductor, but its really an autotransformer to me. Doesn't really matter what you call it

Maybe it's good, nobody knows. You won't know until many $$ have been invested in trying it out properly. And then, it is a packaging exercise and you will be 20 years behind Vicor.

We are all waiting to see if anyone takes this further, but there are 20 different ways to get there that people are exploring.

Like · Reply · 8w

always galvanic isolation, ie. 48V => 12V or 5V to intermediate bus with isolation and then down to 1V/240A. This is not just noice issue but think about the minimum duty, its below 2%.

Like · Reply · 8w

Julian Waller 12V is the more realistic intermediate bus.

Like · Reply · 8w

Simopekka Niskanen Julian Waller My point was isolation. There seems to be a lot desings targeting 48Vin based buck-topology, i.e. without isolation. At least this is what suppliers are pushing. To me it is strange.

Like · Reply · 8w

Milovan Kovacevic Simopekka well if you can make a good use of the transformer, it is quite realistic to go directly from 48V to <5, especially with a resonant topology. And you end up using 50% duty cycles.

Like · Reply · 6w

Write a reply...

Ray Ridley The dream of GaN and buck down to <1 V has pretty much discontinued. Transformers are going to be in most of the solutions.

Like · Reply · 8w

Julian Waller Generally an unregulated bus converter supplies a rail of around 12V and then a multi phase buck supplies the current and takes care of the lack of regulation in the bus converter. It sounds as though a solution with 12 phase buck & bus converter is still the best although supplying the rail with Vicor modules may be worth exploring.

Like · Reply · 8w

Julian Waller The Vicor bus converters can convert and isolate nearly 800W down to more manageable proportions. The size a mere 2.4 x 1 inch and 1/4 inch high.

Like · Reply · 8w

Julian Waller It sounds as though multi phase buck from sub 12V bus may be optimal until the next enabling technology arrives. It works and we will just have to live with the size!

Like · Reply · 8w

Bill Stutz I love a solution, for which there is no problem....

Like · Reply · 7w

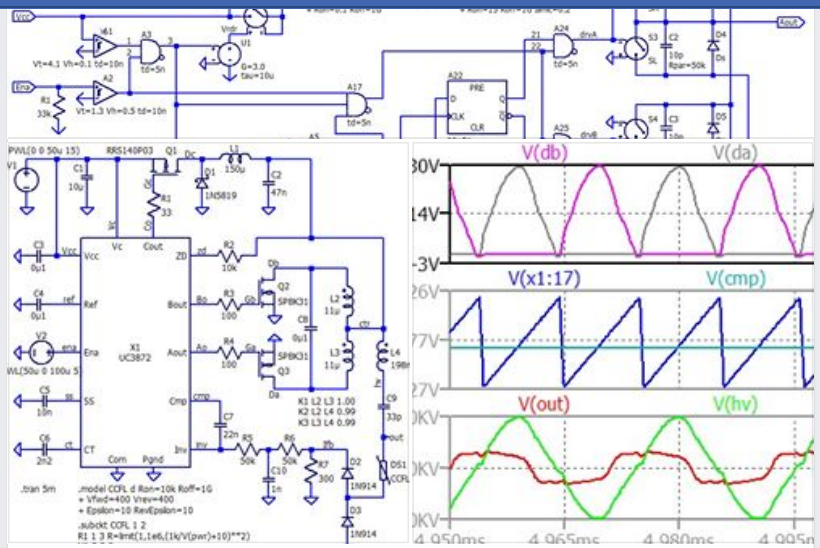
David Edwards
Conversation Starter · February 16

UC3872 Resonant Lamp Ballast Controller

Attached are graphics of the UC3872 model, test circuit and test waveforms.

This model was problematic to create because the datasheet did not include all the necessary internal details, so for some I had to guess based on my experience with other typical IC circuitry. All of the models I have created in the last week or so should be considered preliminary as I have had neither the time nor energy to verify every detail. However, they most likely are sufficiently accurate.

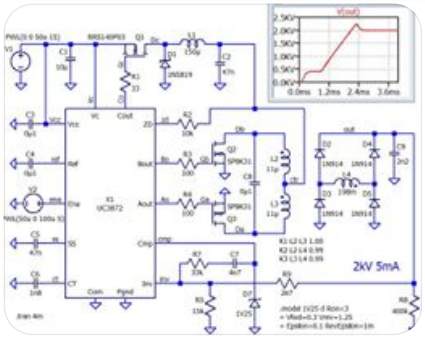
Write a comment...



You and 12 others 14 Comments

Like Comment

David Edwards Here is the UC3872 reconfigured as a voltage regulator. It needs a TL431 on the Comp pin to limit windup and control voltage overshoot.



Like · Reply · 6w

Clive Harvey What would you say is the advantages using this approach compared too the more simple flyback?

I assume it will have the same high voltage issues in the transformer.

Like · Reply · 6w

David Edwards . Hello Clive Harvey,

This controller is fairly old (20+ years) and expensive ($3.63 each for a 2k reel). It's future lifetime depends on its market. CCFLs may not be on the way out, but they are receiving serious competition from LEDs.

Soft start must be set to be very long (a good fraction of a second) or anti-windup measures for the error amplifier must be implemented to prevent large overshoot.

If used to generate a voltage output, one may need to add short circuit protection (not sure - needs looking into).

On the plus side it is set up to detect zero crossing, which is key for a reliable resonant sinewave topology. If it looks interesting enough, you should perform extensive simulations and/or experiments with it and decide for yourself.

Like · Reply · 6w

Clive Harvey David Edwards for my current automotive application I don't think it seems practical.

But for personal interest, I definitely want to learn more about resonate topologies.

Like · Reply · 6w

Without stepping into proprietary territory, what is the nature of your load and what is the purpose of the minimal current 4kV output. Perhaps message me privately if this forum is too public for you.

Like · Reply · 6w

Clive Harvey David Edwards I'll PM

Like · Reply · 6w

David Edwards . Clive Harvey,

Got it. Thanks. I guess you'll be needing very low noise outputs.

Like · Reply · 6w

Clive Harvey David Edwards exactly, but my current sims are showing 500mv ripple at 2Kv, even if I drop down too 100Khz, mainly cause the current ripple is so low.

Like · Reply · 6w

Colorado Mike Doherty Clive Harvey I've done a lot of low ripple (mV) at 2kV. Feel free to contact me.

Like · Reply · 6w

Write a reply...

Col Johns https://www.google.com/url?sa=t&rct=j&q=&esrc=s...

2

Like · Reply · 6w

Clive Harvey Col Johns i read though this when I first started looking at solutions.

I decided that it would be overly complicated, but that said, if we end up needing a cleaner supply, I think it could well become a practical solution.

Like · Reply · 6w

Write a reply...

Col Johns Above, Jim Williams app note for low noise high kV psu's

2

Like · Reply · 6w

David Edwards Very nice, Col Johns. Thanks for posting the link. Recommended reading for everyone on this group.

Very long Jim Williams application note:
https://www.analog.com/.../application-notes/AN118fb.pdf

Like · Reply · 6w

Col Johns Thanks for posting the long version - the detailed hardware photo's at the end make excellent reading on how to probe and separate sections for the newbie ...

Like · Reply · 6w

Write a reply...

Write a comment...

Petchimuthu Karuppasamy
February 13

Hello everyone...
My flyback converter output is 46W. I need to calculate the input power of

bridge efficiency to calculate input power?.Can you pls someone help me to calculate input power of the converter....

1 32 Comments

Like

Tanvir Fakir Is it inverter..?
Like · 7w

Petchimuthu Karuppasamy Tanvir Fakir no it's a power supply
Like · 7w

Tanvir Fakir Petchimuthu Karuppasamy you says power dc to ac .
Like · 7w

Col Johns the real input power is the o/p power / efficiency

the input VA is a different matter ...
Like · 7w

Petchimuthu Karuppasamy Col Johns but our input power is AC only it's converted to DC after bridge rectifier section. I'm right ??
Like · 7w

Col Johns power is power, AC or DC ... it's all in the measurement ...
Like · 7w

Tanvir Fakir Measure input voltage and input current.. multiply will be your power input
Like · 7w

Alain Laprade No. There will be a phase shift --> power factor
Like · 7w

Ray Ridley As Alain Laprade says, this is not correct. This is the apparent input power. Please go and study this on your own before offering advice that will mislead others.
Like · 7w

Tanvir Fakir Ray Ridley I mean to say if PF is greater than 0.9 then losses are zero and appearnt power is input power.. correct..?
Like · 7w

Ray Ridley I'm afraid that doesn't make any sense at all to me.

Apparent power = real power only if the PF is unity.
Like · 7w

Tanvir Fakir Ray Ridley ok thanks
Like · 7w

Janaki Ram Gopal Pagolu Input power calculation depends on type of front-end used.Distortion power factor should be used for your application if CCM PFC is not used.
Like · 7w

'power' that matters is the DC current. If your source is AC, the only 'power' that matters is the in-phase AC component. If your source is AC and you have current that is out of phase or contains harmonic frequencys, you have a power factor less than 1 and you need to do lots of measurements and math to compute it. Some oscilloscopes with voltage/current proves can do a reasonable job too.

Like · 7w · Edited

Ray Ridley There are fundamental misunderstandings about this field in your question.

Input power is output power + losses in the circuit. Very simple.

Power factor is included if you want to know the apparent input power. That is different. Please go and study by yourself the meaning of real power and apparent power.

Also in your question, are you trying to calculate the input power from measurements, or by theory alone? it is not clear what you are trying to do.

Like · 7w

Tanvir Fakir Ray Ridley yes ..lossses may be in term of mA..and if your converter has good pfc then nothing losses

Like · 7w

Ray Ridley Good heavens.....Losses are in Watts, not mA.

Please - be careful with your terminology.

Like · 7w

Graham Ward Tanvir Fakir I'll also add that you can have perfect (unity) PFC but I guarantee you will still have some losses. Optimum PFC merely means you have minimized or ideally eliminated reactive power (losses) in your power supply, however you are still drawing real power to (A) support your load and (B) compensate for losses in the power supply itself. When your switching transistor/s, bridge rectifier, transformer and output rectifier heats up, those losses have to come from somewhere, and they do: your input supply.

Like · 7w

Oliver Sedlacek If you've built it, why don't you measure it. If you've simulated, what does the simulation say?

Like · 7w

Colin Tuck A ball park eff would be 80% therefore input power is in the ball park of 57.5 watts - of course the input VA will be higher than this as the typ PF of rectified mains with cap filter is 0.6 - 0.65, so the input VA will be in the order of 88.5, @ 230Vac rms the mains current will be 88.5 / 230 = 385mA ...

Like · 7w

David Seal Start with the bridge rectifier: on the input side, if there is a bridge rectifier, the "power factor" seen by the AC input is unity, or "1", by definition. The "power efficiency" is different: that is the total input power, minus the major losses from the forward voltage drop of the diodes in the bridge, times 2, and several other minor losses as well. This is usually expressed as a percentage.

Like · 7w · Edited

Col Johns Dear David Seal - unfortunately a bridge rectifier does not guarantee unity power factor as you seem to imply above, it does not shape the input current to be the same shape as the voltage - which is what is required for UPF - the cap input B rectifier generally draws high peaks of current near the mains voltage peak ...

Like · 7w · Edited

power factor. The diodes only conduct when the voltage on the load side is exceeded by the input voltage, and only during the central portion of each sine wave ceasing as the input voltage falls below the load. This is phase-matching, and the lowest harmonic distortion point. There may be specific exceptions, yes, but as a general rule, this action holds true.

Like · 6w

Col Johns Respectfully, David Seal, matching the phase of the fundamental is only part of the issue - do a quick Spice of a cap input filter with load and then compare the current to a BRect with resistive load only - the difference is the harmonics - 0.65 PF vs 1.0 ....

Like · 6w

Ray Ridley So how does everyone feel about these posts?

On the one hand, you can feel good about knowing all the fundamentals of power. On the other, it is pretty scary that offline power is being designed with such a lack of the basics.

managers that assign these jobs probably can't tell the difference, but the measurements will certainly know.

I like to help newcomers, as do many of you, but when power is expressed in mA, it is quite alarming. Not just a language barrier I think.

Like · 6w · Edited

Col Johns It is the old story of Shakespeare's sonnets being (perhaps) written by a million primates on a million typewriters - Ray if you go to India or China and see how power electronics is done .... it 'tis quite unbelievable ....

Like · 6w

Janaki Ram Gopal Pagolu Col Johns I have seen very good power supplies made in India. "unbelievable" in good way or bad way. Just curious.

Like · 6w · Edited

Col Johns Let's just be polite and say it is overwhelmingly impressive at what can be achieved with trial and error and very little test gear or formal training. I am sure it is a different story for electronics used in the space programs of the major Asian powers...

Like · 6w

David Edwards . Hello Ray Ridley,

I am sorry if this comes across as bigoted, but such abject ignorance as presented by the thread starter makes me want to slap my forehead very hard while holding a sharply pointed pencil up to it.

In my opinion, someone who doesn't do their homework before posting is spamming the group. Yes, most fresh engineers start out their career journey devoid of experience and perhaps with a store of education that they yet don't intuitively understand, but this is not a beginner's forum. Wangling to get others to one's work is lazy, rude and abusive in my opinion. One should generally make a good attempt at problem solving first before posting (and show what one has tried that has failed).

Your forum, your choice (but you asked for feedback).

Like · 6w

Phil Lane Pout / 83%

Like · 6w

sometimes good. If I don't get in and delete early, some value has actually been added by other.

But I hear you, David Edwards. You should see the ones that don't get through the screening - truly scary.

That's why events like the Boeing 737 Max happen, but that is just hearsay. 😳

Like · 6w · 1

Ray Ridley Time to close commenting for this post off, I think.

Like · 6w · 1

James Gertsen
February 13

The Scientific Method (a lost art)

"The scientific method involves careful observations, applying rigorous skepticism

about what is observed, given that cognitive assumptions can distort how one
interprets the observation. it involves formulating hypotheses based on observations,

experimental and measuremnt testing in order to refine hypotheses."

Derived from wikipedia

Some might argue that because power electronics is already based on a lot of

solid theory, that these principles does not nessessary apply to the field at large.

I personally do not agree with that. In fact i would say that this method procedure

is at the heart of the industry. Every new PSU design has to follow the same kind of process.

first by setting the specifications and deriving the relevant theory. This would be analogous

to formulating the hypothesis. The hypothesis being would the topology and thought up design

solve the task. The next phase is the prototyping and testing, which is analogous to the

experimental and measurement phase. The purpose in both cases are the same, to refine the

hypothesis (that the design works as intended).

Many people have a general assumption that these principles is something everybody in the

academic world is familiar with. My own experience sadly concludes otherwise, hence the title

of a lost art.

As stated in the top, cognitive assumptions and poor scientific pratice often happens in many

fields of research and engineering. As i have written earlier in this forum, an increasing

overreliance on what computer simulations is capable of, often means that engineers will have less

prototyping not acting as intended, which means they get stuck, because they do not have the necessary

knowledge or tools to approach and deconstruct problems in the lab. I have myself been guilty of such

situation, to my own personal disappointment.

I would have wish, when i was attending university, that there would had been a greater emphasis

on the experimental phase of the process. To be faced with a problem in the prototyping, and then be able

to methodically analyse and deconstruct the situation to derive to an explanation.

I think some people greatly underestimate the value of such a process. To be able to analyse, rule out

possibilities one by one, to eventually arrive to an explanation that enable you to refine your model

and move forward. After all it is through such personal experiences that good engineers are made.

What do you think?

Darrell Hambley and 2 others 19 Comments

Like Comment

Ray Ridley I think that what you are saying is "build more, simulate less"

It is one of our central messages to the new generation.

There is only only simulator you can believe (and not always) and that is the hardware.

A balance is needed. For us, that is about 10% simulation in a project.

Like · Reply · 7w

James Gertsen Hi Ray. In a sense yes that is true. But i don't want people to think that i'm a anti sim guy either. it's value cannot be denied when it comes to speeding up the initial design phase. No one should start rushing into the lab without being able to understand the physics of what is going on on the circuit board. A great problem the way i see it is that the subject curriculum for many engineer student is very densely packed with material they need to familiarize themselves with. This of course means that many only gain a superficial understanding of the theory. Simulation tools is great for design but terrible for learning the actual math and physics happening. If someone only has a superficial understanding of the math and is compensating for it by relying on the simulation tool to do most of the hard work, this will immediately become apparent when things starts to go wrong in the lab. So i am still a firm believer in that one should be able to have a solid fundamental understanding of the theory on a mathematical and physical level. But to learn that one has to study it in a much longer, more deep and thorough way. The result should be that an engineer understand all of the math that is going on in the simulator, so that it only acts as a tool for doing the calculations faster than one could do on pen and paper or on a calculator.

Like · Reply · 7w