Hello,

I am currently designing a synchronous buck converter based on your controller – the LM5116. My converter requirements are:

- Vin- 30V- 60V
- Vout- 12V
- Iout max- 10A
- Iout current limit - ~14A

The graphs in this message were taken under 30V Vin and no load.

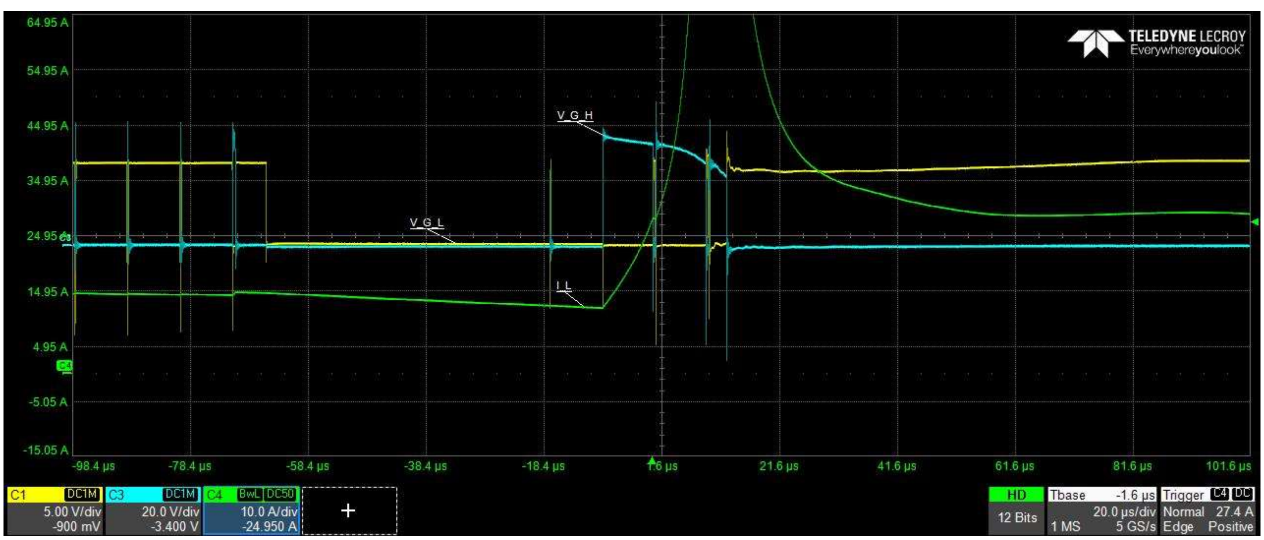
I was very pleased with the emulated current mode system and my converter preformed well in dynamic loads with great stability and had great efficiency over-all.

Then I got to evaluating the short-circuit response and ran into some issues.

My short circuit is applied by two short and wide copper wires soldered to the last tantalum output capacitor, the short is made by shorting the two wires by hand – thus creating a very strong output short. Of course shorting the two wires creates some debouncing but that doesn't bother me.

Most of the time – the current limit preforms well, the inductor peak current is limited at about 14.5A and there is no current runaway. My inductor is designed to enter saturation (20% fall) at about 16A with an MPP core, so not very far from my peak current but still far enough.

But sometimes I am witnessing a wild response that sends my inductor current well above 150A uncontrollably. I still haven't figured what type of short contact (or timing) causes this exactly but there are some similarities that always stay from fault to fault, the response looks like this:

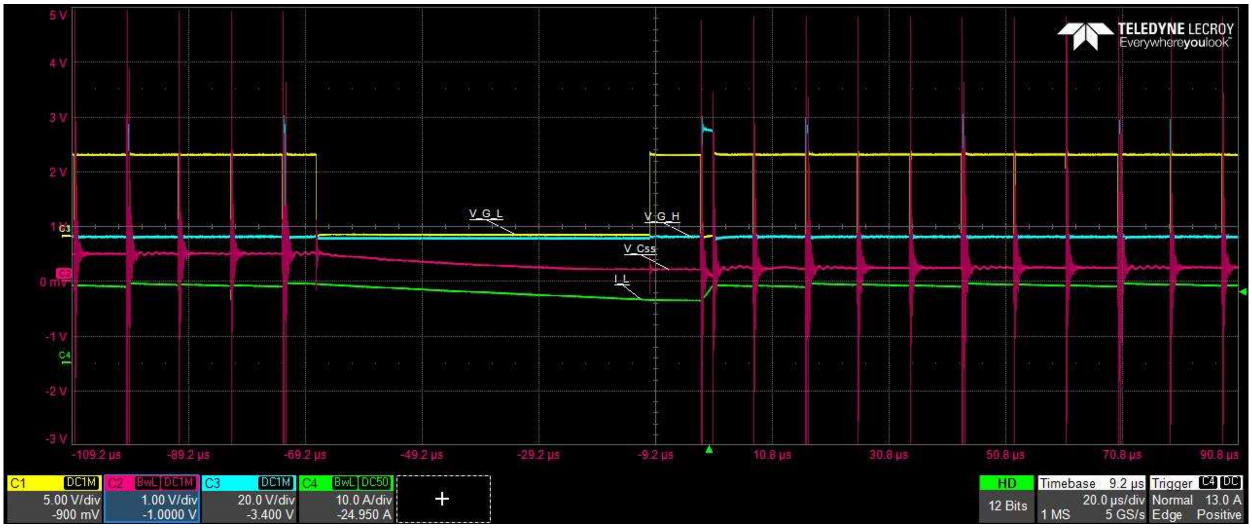


Here you can see the high side gate, low side gate, and the inductor current.

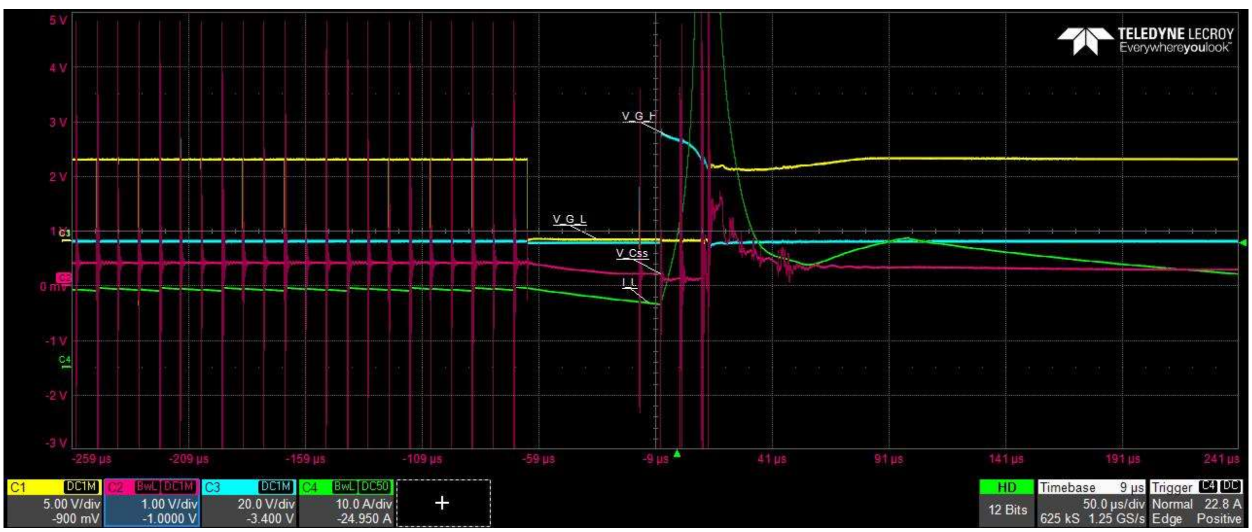
As seen in the graph – the wild current runaway occurs shortly after the LM5116 restarts because of the hiccup mode. This timing is always repetitive, the runaway is always right when the converter wakes up from the last hiccup cycle. The V_G_H fall is due to Vin falling with the hard short.

As you can see, at this fault the switches are switching at maximum duty cycle and that is what causes the uncontrollable rise in inductor current. Almost seems like the controller wakes up without soft start and without current limit comparator to end the response.

This is compared to how a normal "hiccup wakeup" looks like (the fault doesn't happen very often – about once every 10 shorts or so):

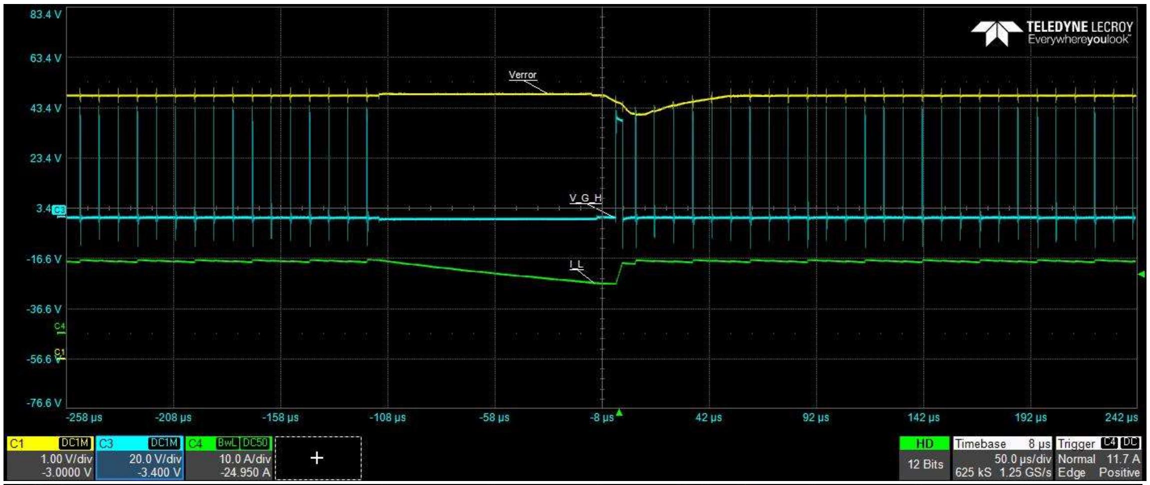


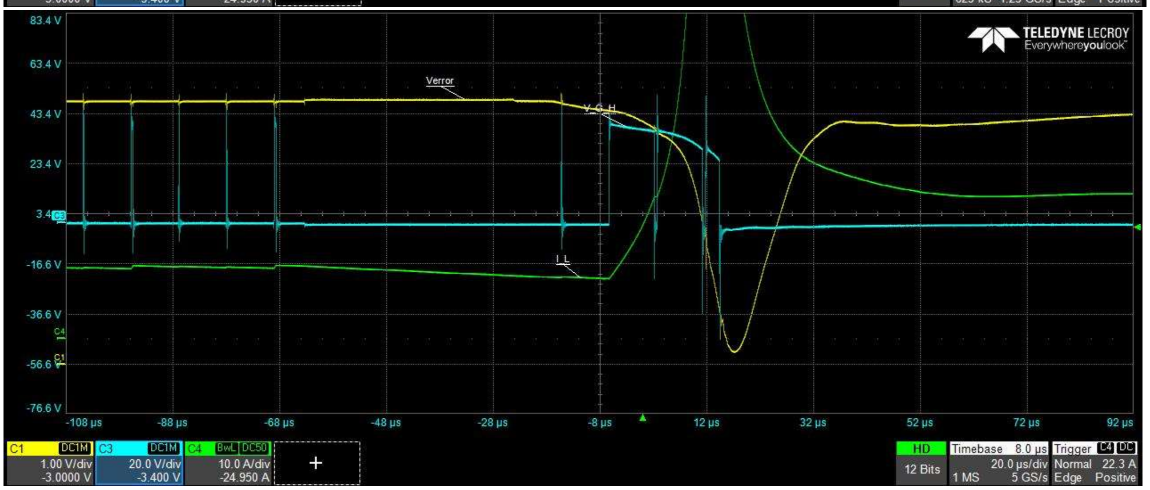
Here I added the voltage at the SS pin to show that the controller indeed shorts the capacitor to restart the hiccup cycle with a soft start, here it is when it wakes up without soft start:



The soft start capacitor also discharges successfully.

This made me to check the error amplifier output to see if it looks different with \ without fault:





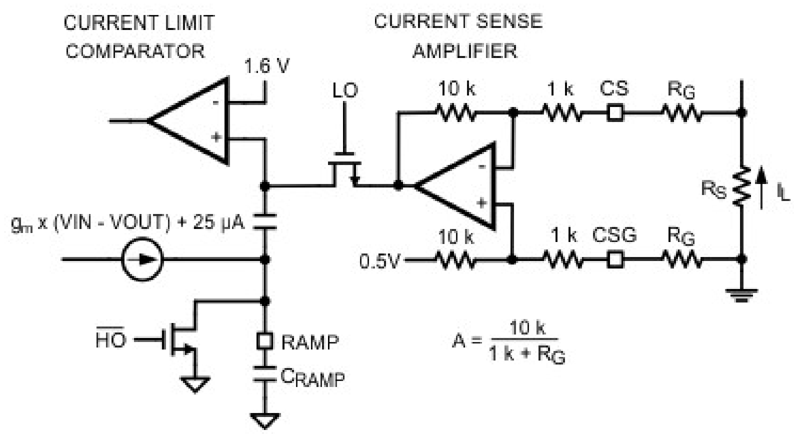
In both cases the error output doesn't seem to discharge very fast or very low so it is plausible that the converter wakes up very violently.

Another odd repetitive event is that the first switching cycle in every fault is always enabling both high side and low side switches together for a short pulse of about 100ns:

This should be illegal by the controller and is quite dangerous for the input capacitors. I'm also guessing that at this moment the current emulation isn't working as intended.

I have a guess for what's enabling the unlimited rise of current even with a current limit comparator.

My guess is when the converter restarts with maximum duty cycle – the emulation circuit isn’t able to sense the valley current well enough



Because of the very short LO switch cycles, it may be possible that we are working with a very dangerous timing with the upper capacitor that should charge to $(IL * Rs * 10) + 0.5V$ but if the switching time is very short and charge-enable switch has high resistance then maybe the emulated valley current is not getting high enough, this wont let the inductor current trip the 1.6V threshold.

I managed to sense the Vramp on the emulation capacitor and that part of the emulation works fine. So my guess is the problem is either in the comparator, in the current amplifier or the effect I mentioned above.

But still- the response I still can't figure out is why does the controller wake up at max duty cycle – sending the inductor current to unlimited heights.
I don’t have the Evaluation board of the controller but that might be my next step to understand if the problem is with my design or with the controller.

If you have any conclusions about this, or any ideas to what I have wrong I would be happy for your help. I can't use this controller if I am unsure it will protect the inductor at every short I throw at it.