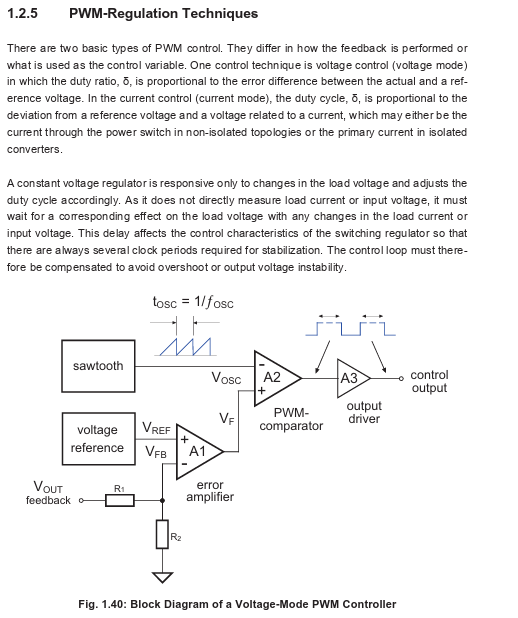
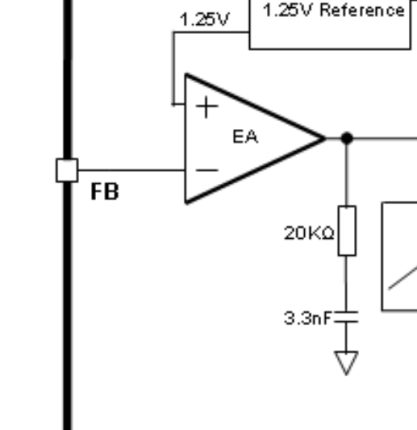
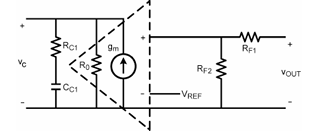
I’ll share pwm regulation techniques page numbers from the book I send you from discord before, dc/dc book of knowledge. Also, I put this book with application notes into same folder, that you can check for lots of things like capacitor types and their properties. I don’t think I can explain pwm regulation better than this. Pages : 46, 47, 48

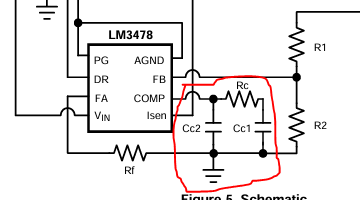
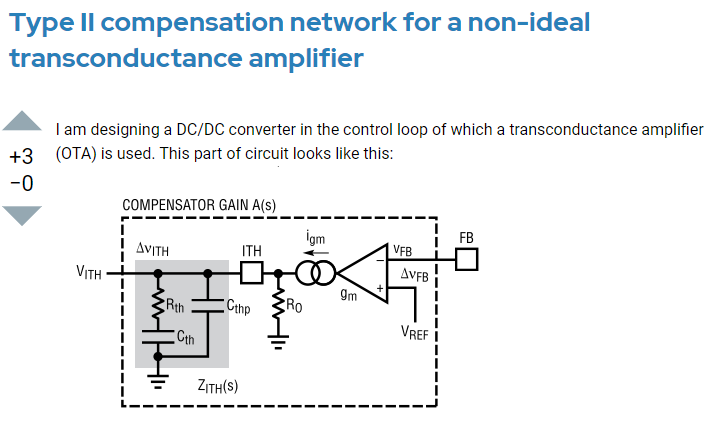


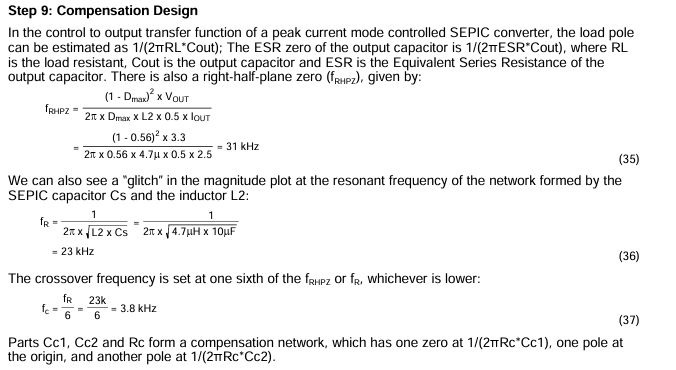
So, now im gonna explain how to implement voltage mode pwm control discretely. Not compensation nor fet driver circuit will be included. Because I show usally how compensator calculation works in current mode. And not gonna show how to implement current mode discretely. Because, it doesn’t make sense to implement discretely expense wise.

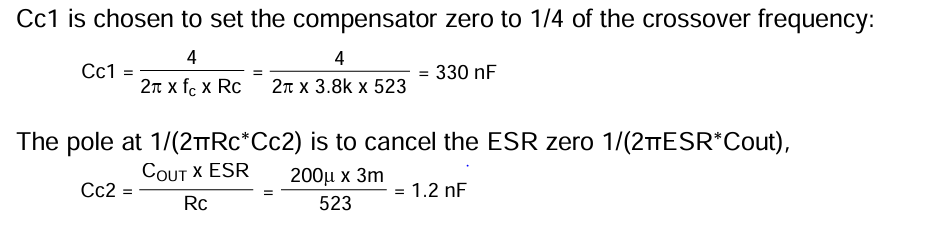
But first I can explain how to do compensator design. We did a lag compensator which is below.

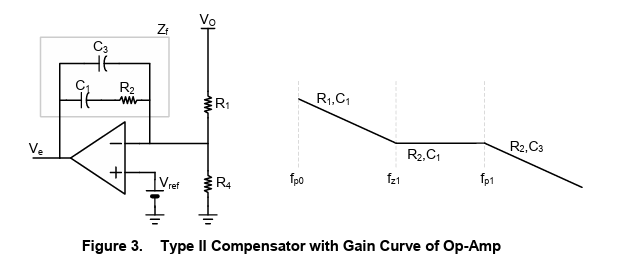
But also you can design type II using SNVA168E application note of cut-off and pole frequency calculations. I show compensator network to point out it’s different. For a second dont think second cc2. Cc1 will have different impedance for different frequencies. So, you can think like Cc1 like a resistor. Rc +Rc1 will give you different gain for different frequencies. So, it is not important to my knowledge if resistor or capacitor is first.

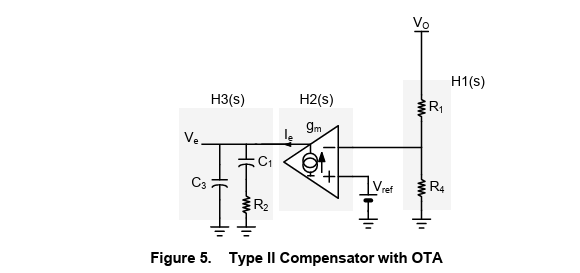




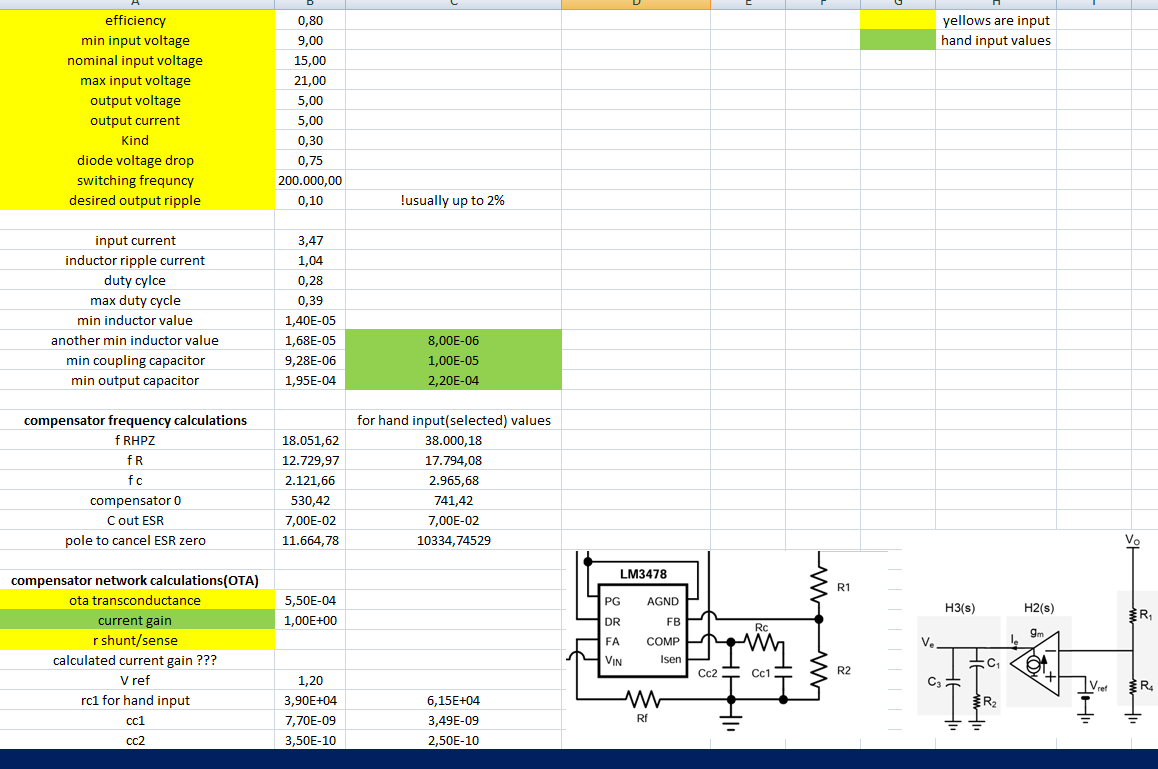


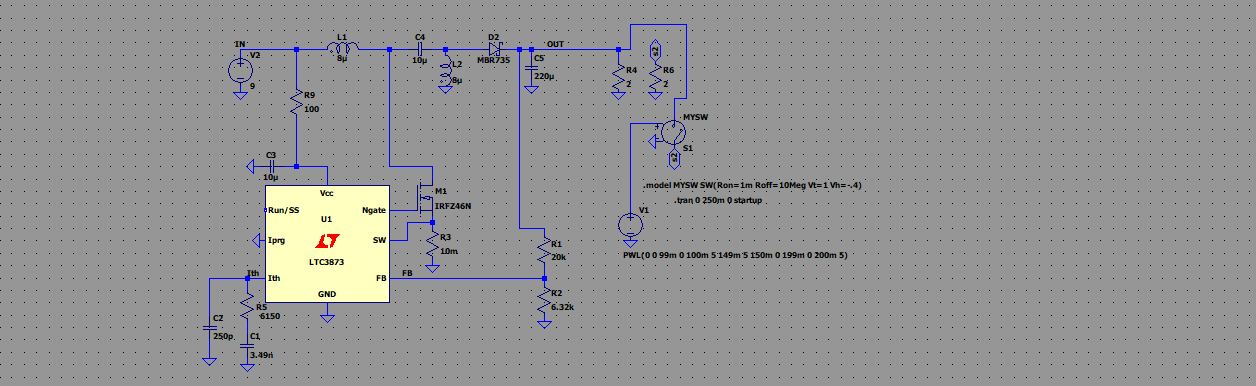
And using SLVA662 to implement an Type II controller using an OTA or Op-Amp. Or just use SNVA168E calculations. I included compensator calculations according to SNVA168E.

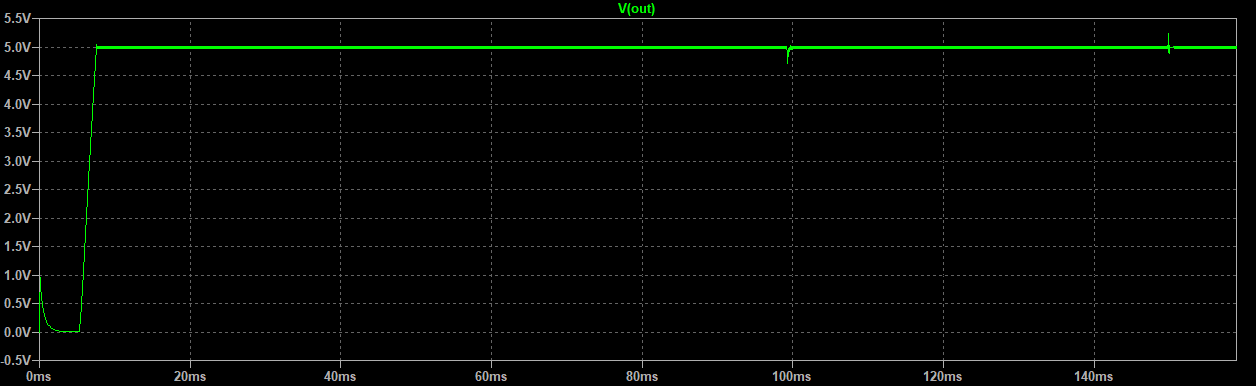


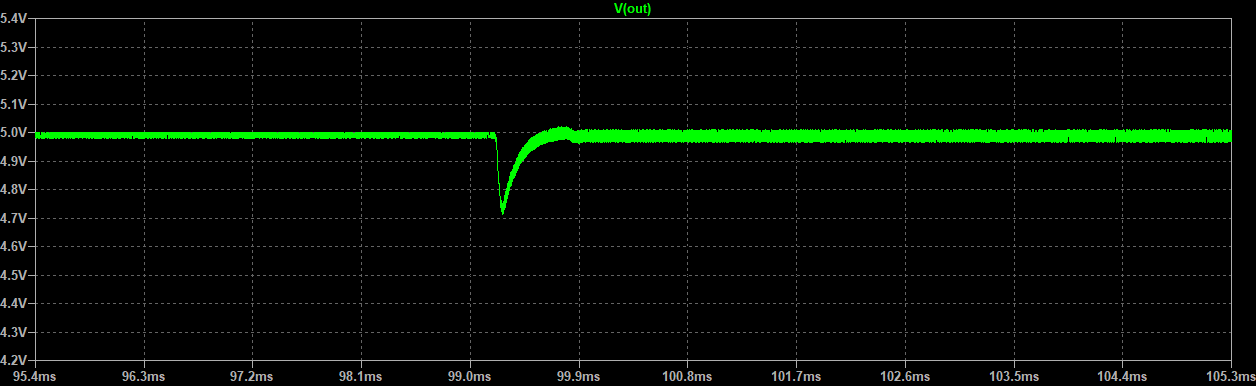


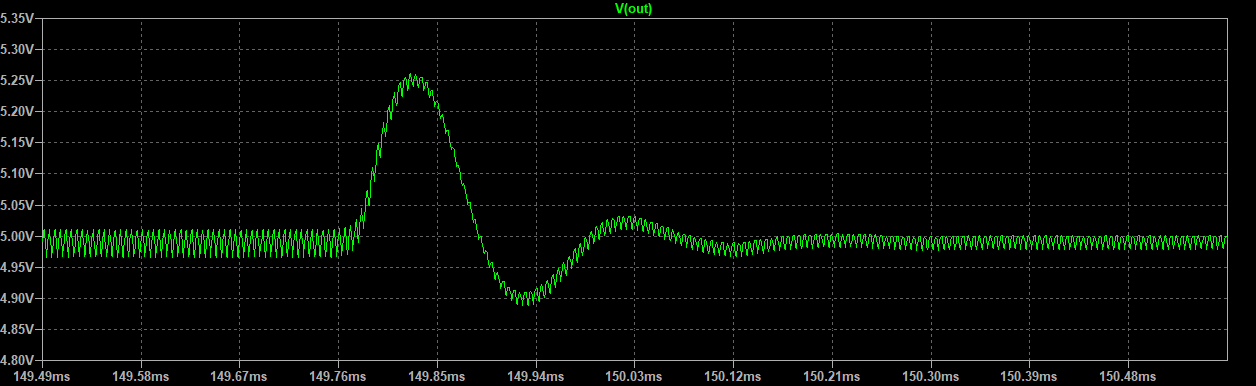
While writing this I calculated for the same power stage we used with Excel I prepared so the result is this. Note, I couldnt find any current sense gain transfer function or formula for current mode sepic converter to use so current gain = 1.



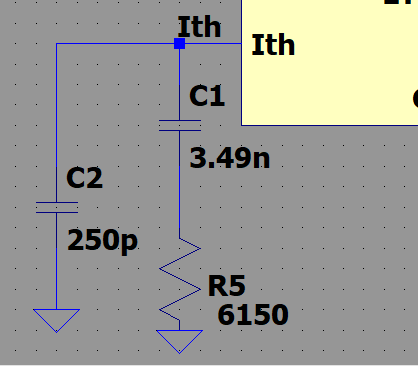


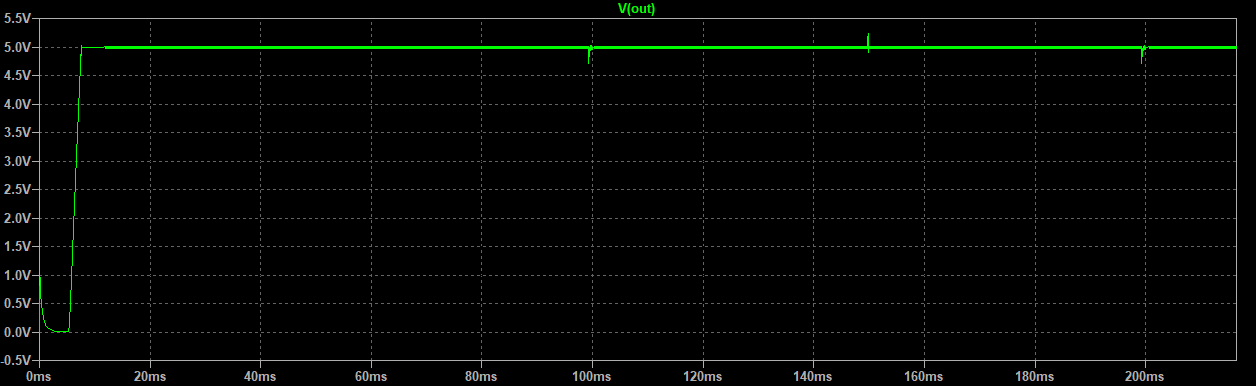


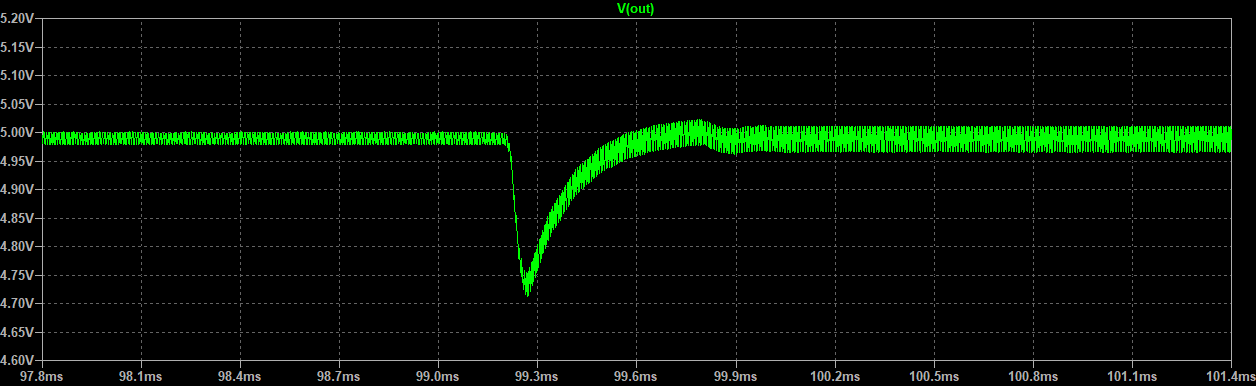


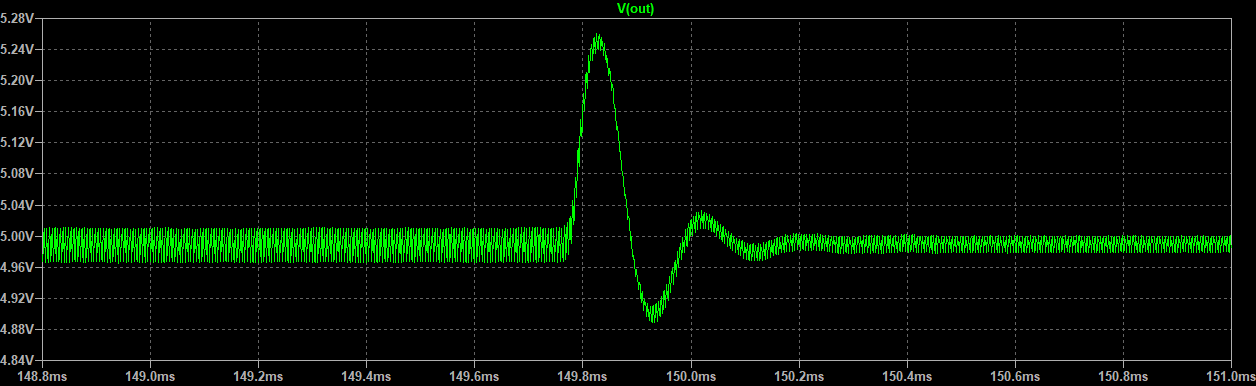


This result much more better and isnt a suprise because it is so muhc closer to lag compensator values I used with trial and error. Also, I tried changing rc1 cc1 places to show you it doesn’t matter like I said. It worked better on simulation. Also, sorry for back and forward situation of this documentation but, desiging controllers usally this type of work.

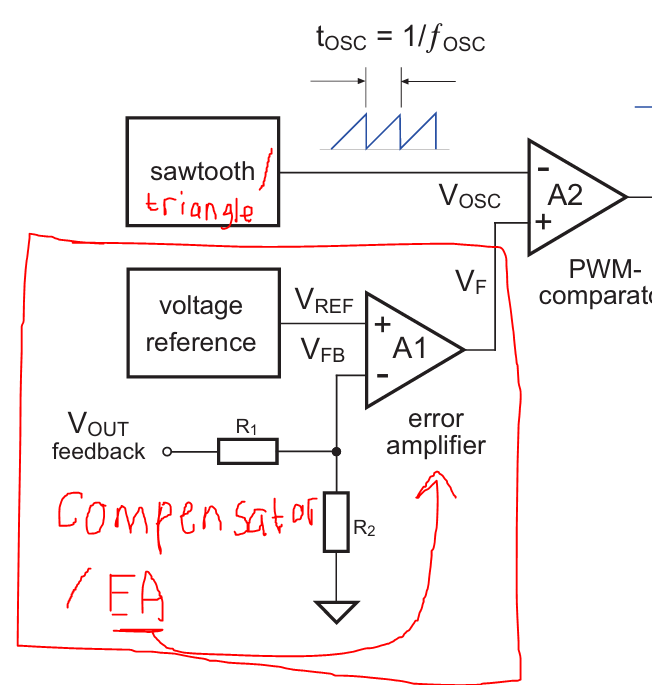




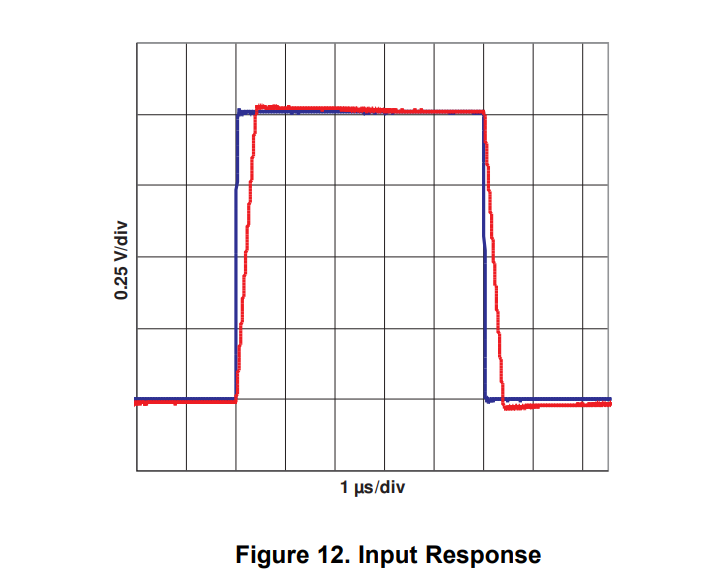




Now, we are going to show you 1 way of triangle wave. But, you can use a 555 or 2 transistors and complementary parts to generat ramp voltage to use.



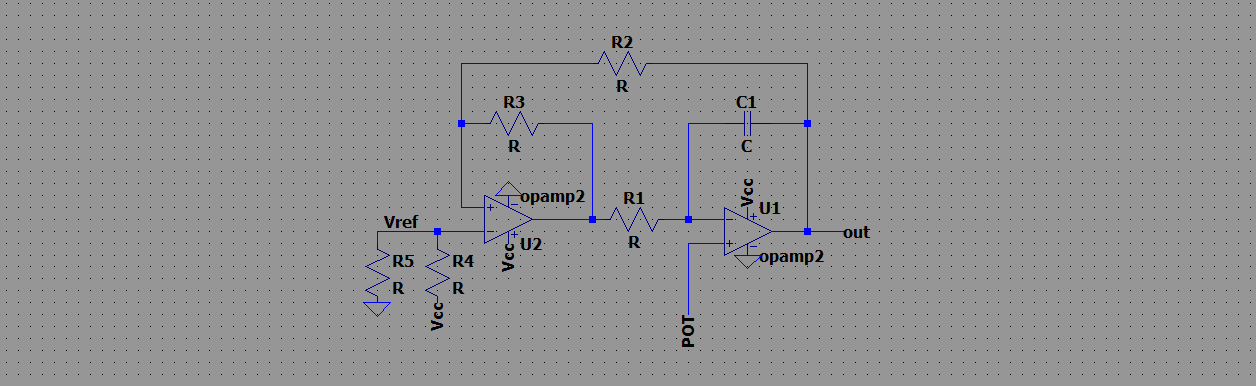
But with using an opamps to generate triangle wave you can simply use one 4 opamp chip for all pwm regulation. 2 opamps for triangle wave, one for error amplifier(compensator), on for pwm comparator. One IC should be better for layout and probably cheaper because at the end you need to use one opamp or ota, one analog comparator, and triangle or ramp generator. Also, It is not ideal to use opamps as an pwm comparator instead of using an analog comperator. But, as long as you don’t go high switching frequency a normal opamp is enough for aspect of speed. For example, you can go up to(with minumum specs of IC by the way) 58kHz – max 80% duty cycle operation under 1 dollar 4 opamp IC that even don’t have that high of a slew rate [TL974IDR](https://www.mouser.com.tr/ProductDetail/Texas-Instruments/TL974IDR?qs=vD%252BlfiDS0%252BOKf6UHUyfKHA%3D%3D). If typical values is thought of, 100kHz- max 80% duty cycle operation.



**Triangle wave**

<https://techpicz.blogspot.com/2012/08/triangular-wave-generator-using-op-amp.html>

Below for single supply



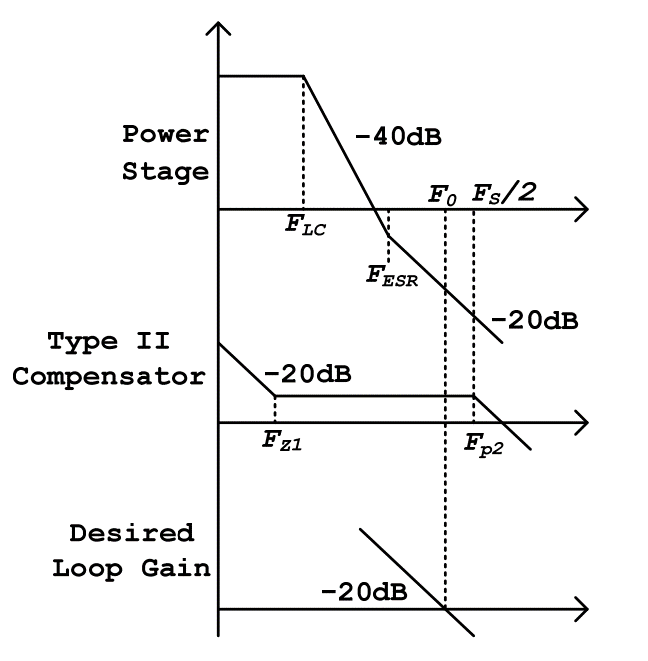
Doesn’t matter which point you out pot. Basically 2 input will be V/2 instead of gnd(for dual +/- supply) but at one input trimmer a pot can be benefical if not oscillation may not start. Also, r2/r3 relation can cause not to oscillate to. R2 shouldnt be so close to r3 as value if circuit doesn’t oscillate.

f = R3 / (4\*R1\*R2\*C1)

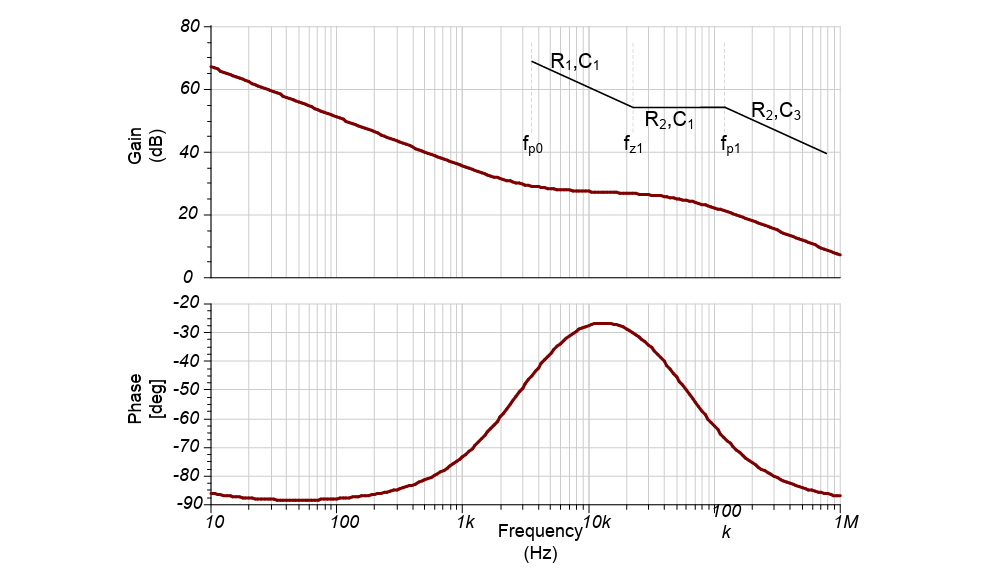
Vo(p-p) = (2\*R2 \* Vsat) / R3

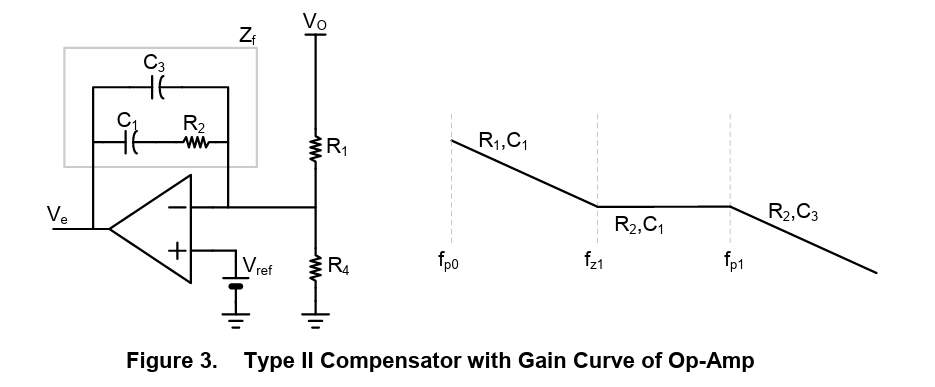
Unfortunately, I couldn’t find a guide for voltage mode sepic and transfer functions of the voltage mode control sepic. In voltage mode oscillator peak peak voltage usually is in the calculation. In current mode, it is not because ramp voltage to pwm comparator is provided with current trough inductor. So, in calculation, current gain used instead. But, we are gonna use same frequency point from excel calculations and slva662 to design compensator and will see the results. Also, in those calculations instead of using Vref vout relation, it uses fb network values. Calculations in Excel…

From last try frequencies are cut off 2965, pole to cancel esr 10.334k, compensator0 741Hz.



We will put that in this graph this is for buck we have same situation if we use high esr caps. And instead of output lc we have compensator 0 which has simular layout in frequency domain. Below is just type II compensator bode plot not specifically for anything from slva662.





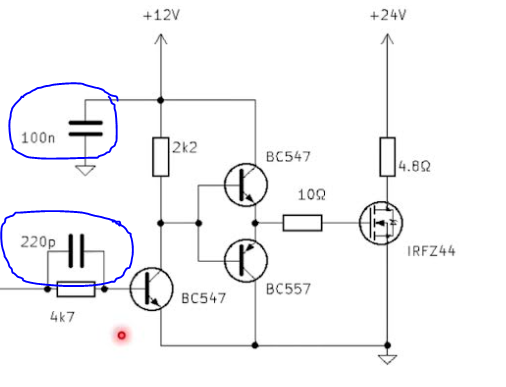
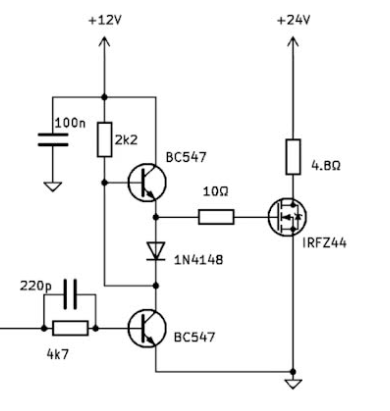
So let fp0=741 , fz1=2965, fp1=10334

So from Excel (I added this part to – name: compensation network calculation(Op-Amp))

But I had terrible result, just terrible.

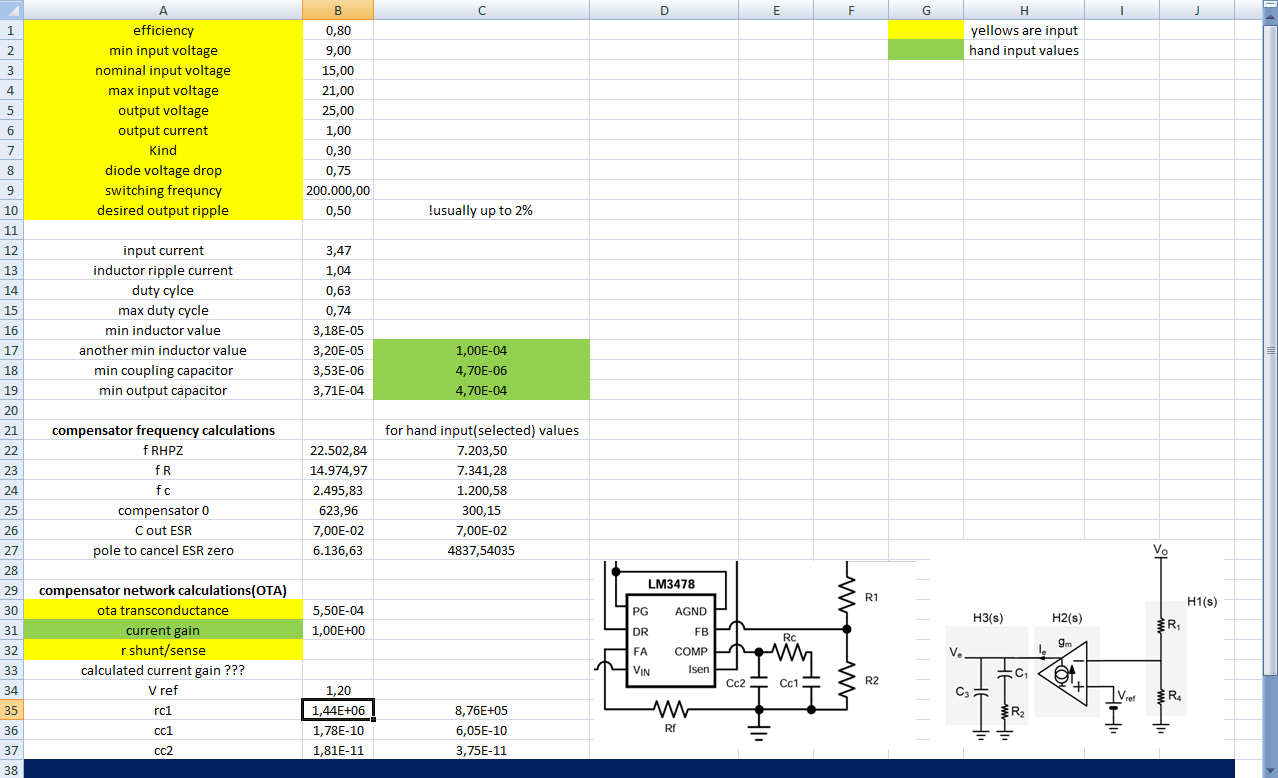
Sorry but I couldn’t find any guide for voltage mode sepic compensation again (search for very long time).

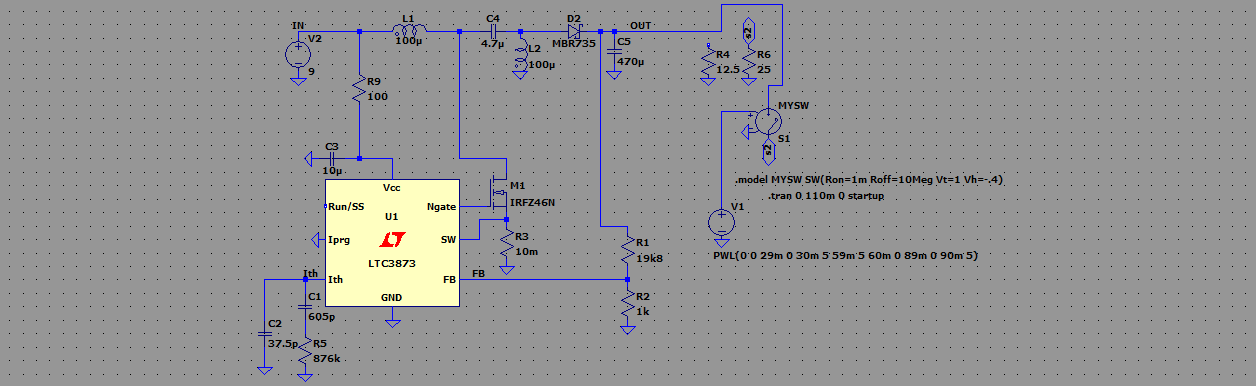
This is how much I can go further. You may succeed with trial and error. And you can check for driver circuit from here: <https://github.com/furkanmakasci/Asynchronous-Buck-Converter> or you can try this type of circuit below, which is the same with the link I send you with missing part I circled with blue,

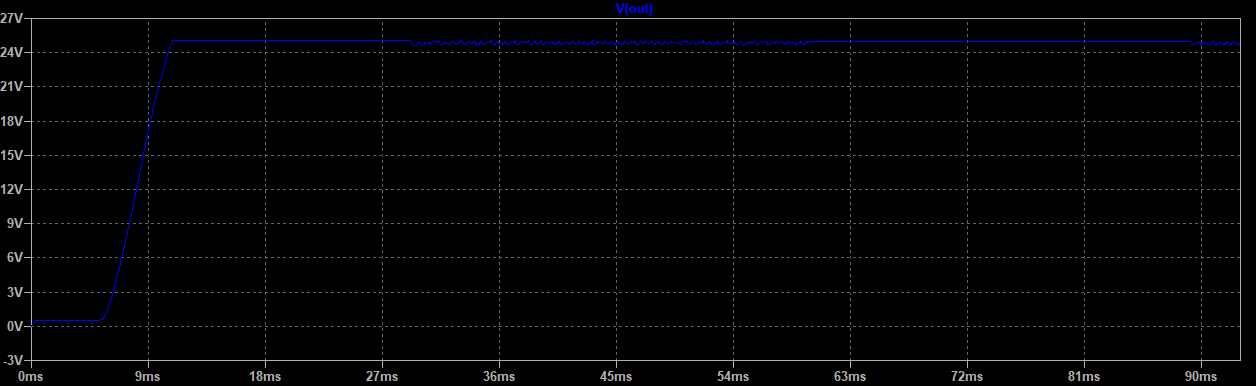
 Or 

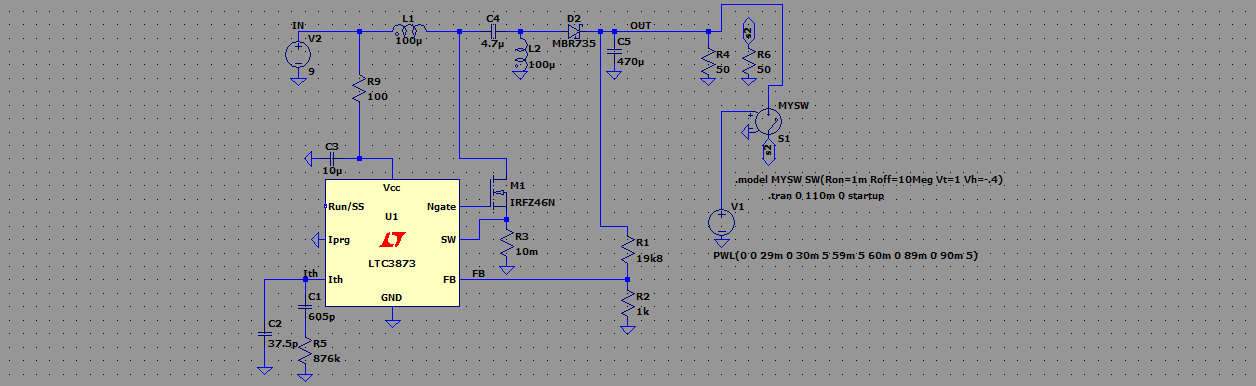
But, safest and easiest way should be use a driver IC for you. If you will implement discere voltage mode control.

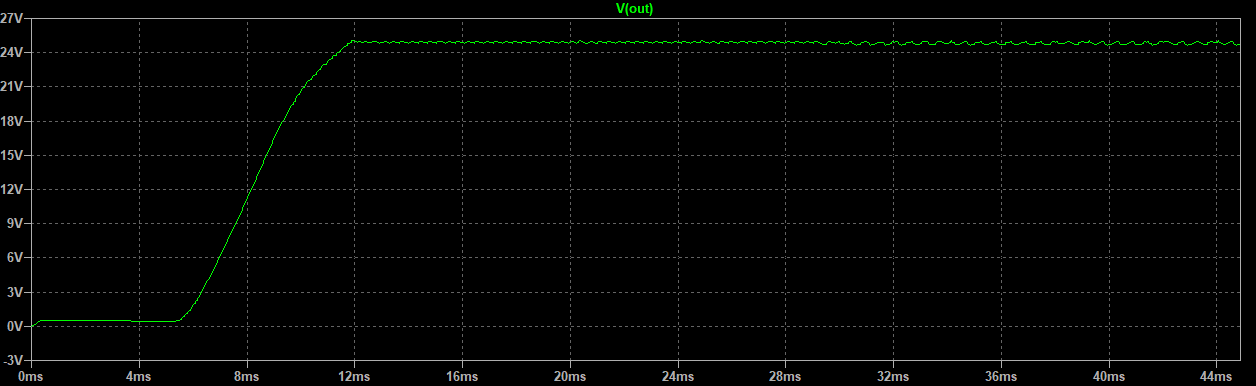
So, to show excel calculation work for current mode nicely. Im gonna try another current mode config for 25V 1A the same input (9-21V nominal 15V). Also, by the way I tried no load conditions for all simulation. You don’t need to worry about no load situations. Also, 9V input to 25V ouput near to max duty cycle of LTC3873 won’t recommend it. 15V is more realistic.

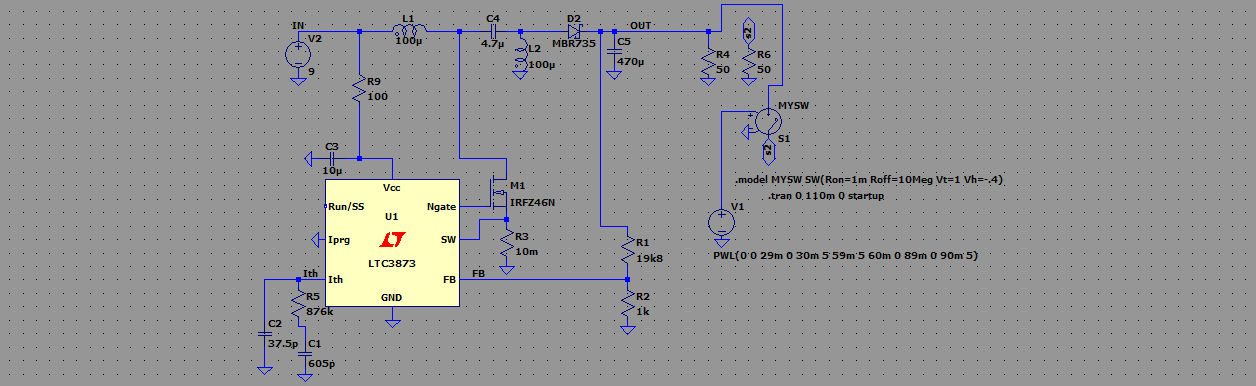


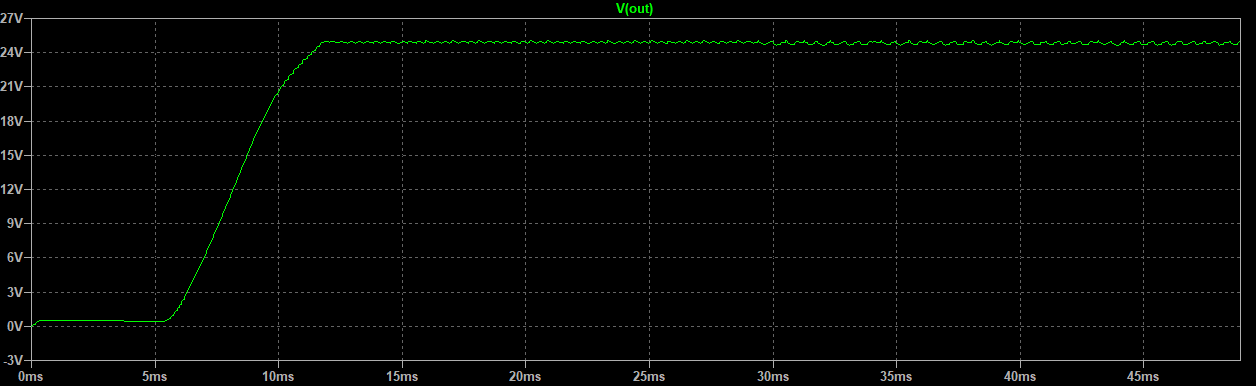






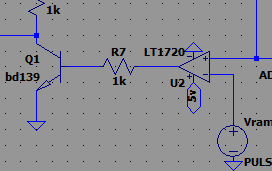


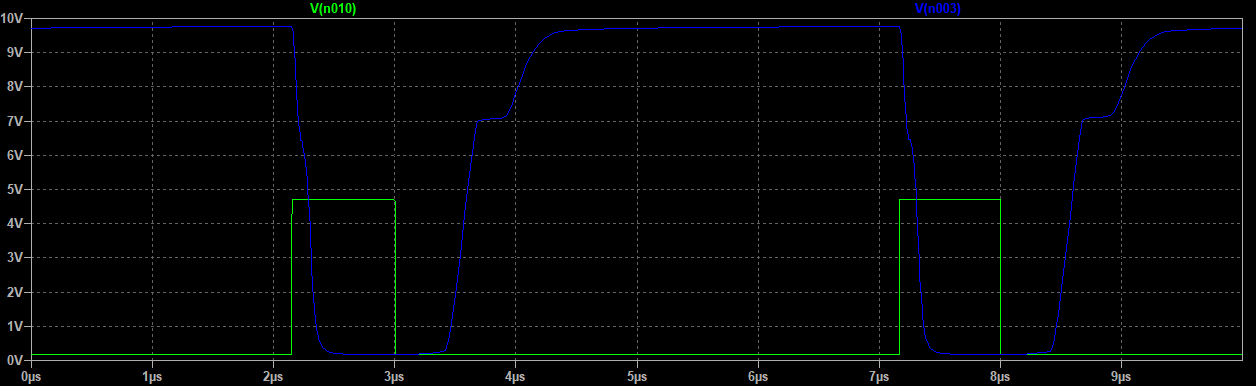


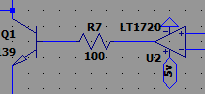


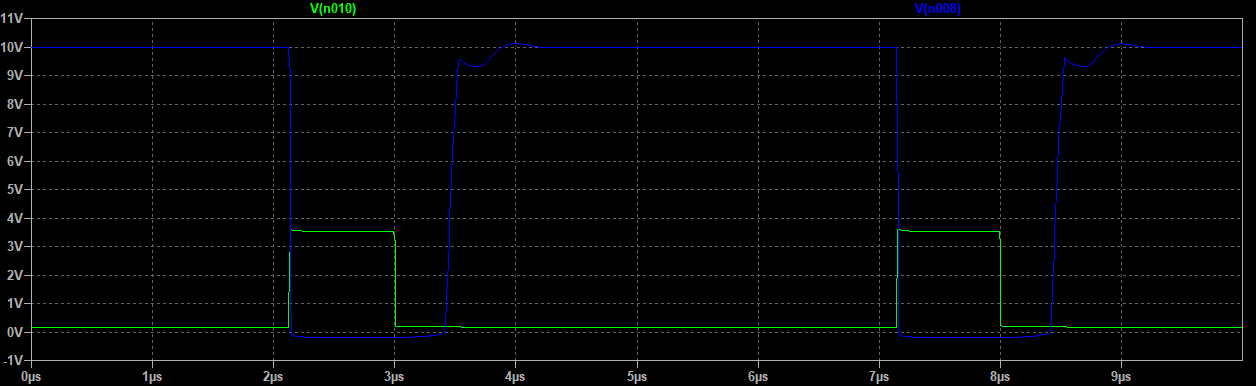
Im gonna draw a circuit according to my project link if you want to implement it. It is easier because here is a low side switch but at least you need 13 or 18 V(if you don’t use LDO linear regulators) to supply linear regulators for circuit. But main thing is driving mosfet. You need at least 10 V if you don’t go with a logic level mosfet. So, if you have 10V linear regulator need 13V input. Also, I used random high speed opamp and analog comparators. Those components don't have any particular cause to use.

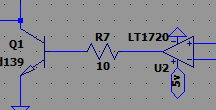
Before I put all circuit need one part of the circuit needs consideration. This driver part a little problematic. Give or take situation…. If there is delay max duty cycle is compromised. Other wise because added capacitor reacts to change there is a reverse pulse and causing opening mosfet with slowe slope. Which causes heating mosfet. But, give or take here is the result. By, the way I tried suited voltage and current range BJTs on LTspice library(Didn’t work well enough). And, because I used before BD135,BD139 and BD140. I used those to not waste time. But, you can use more suitable or similar component if you are going to implement it. Green is analog comparator(pwm comparator out), blue is mosfet gate in graphs.

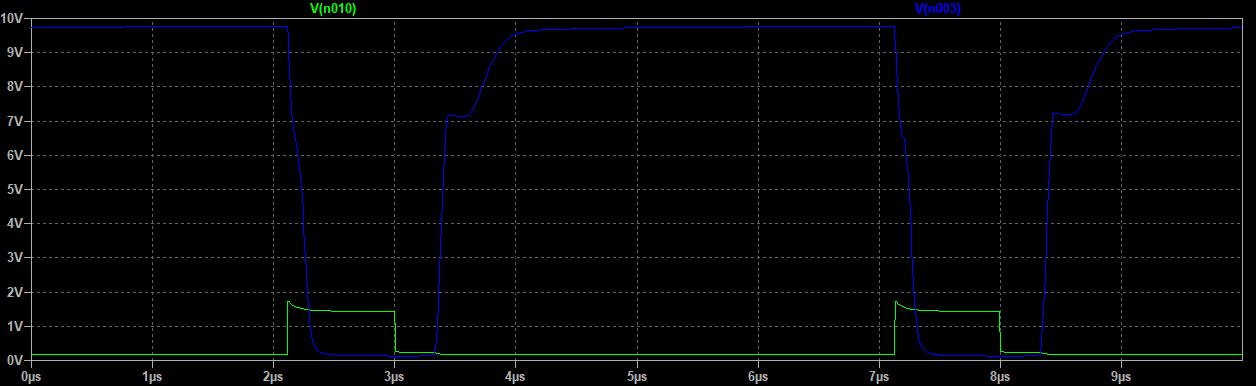




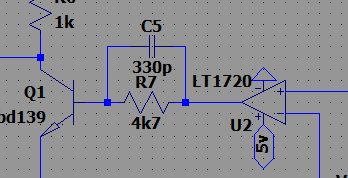


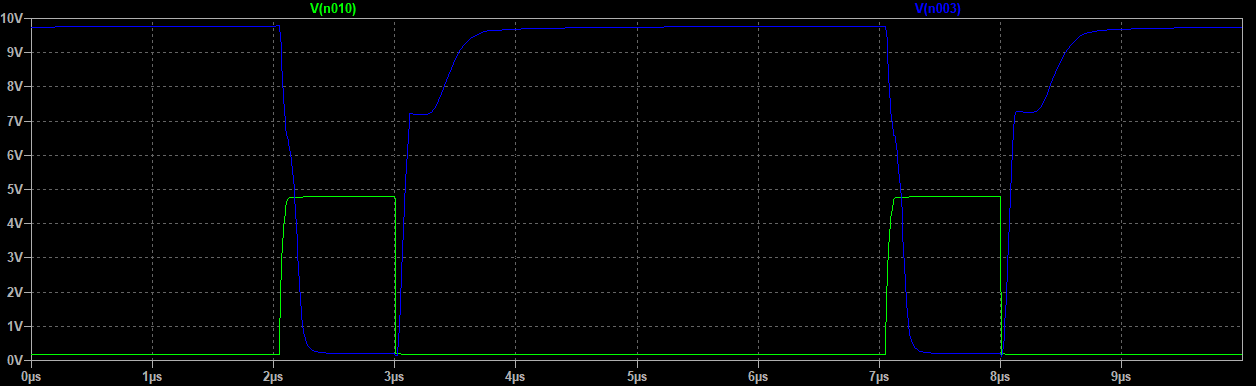




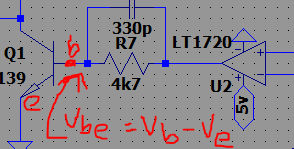


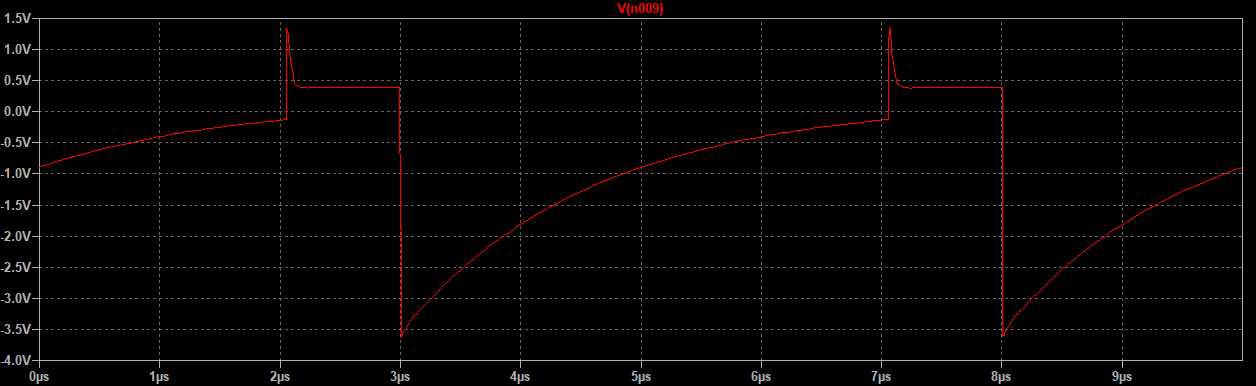
May be problematic if voltage drops below Vbe voltage of transistor.





But be carefull for reverse voltage, don’t know the case for sure. Can below damage bjt with reverse voltage to base of bjt but I think if you don’t exceed max Vbe voltage of BJT it is good. I’ll check if this is bad for bjt I’ll change here :D.





Also, look at efficiency and mosfet power loss under full load(5A). Didn’t include 10V 5V supply waste to calculations.

-With capacitor and 4k7 82,4% efficiency, 1.87 W power loss on mosfet

-With 100 ohm 82,4%, efficiency, 1.88 W power loss on mosfet

So, both is the same I guess.

But if you use 100 ohm be carefull for wattage of comparator IC which you will use.

