《工程实践与科技创新III-A》

课学生大作业报告

项目名称：　　TINA-TI仿真

姓　　名：　　ARTYOM GEVORGYAN（乔姆）

学　　号：　　520030990002

任课老师：　　李安琪

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Content

TINA-TI Circuit Simulation

1. Background

Using TINA-TI software to design and simulate the functional circuit of DC-DC switching regulated power supply of the "TINA-TI Project".

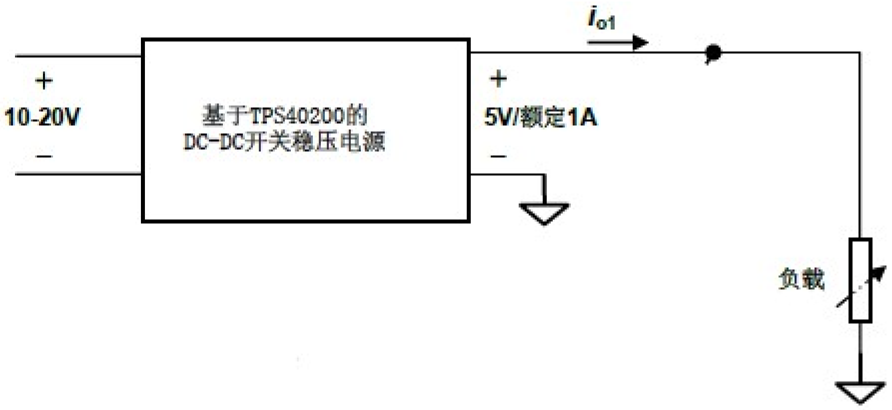


Figure 1. Schematic diagram of part of the voltage regulator source system

2. Basic Circuit Specifications

- Input voltage: can be adapted to DC 10-20V
- Rated output voltage: 5V DC
- Absolute Voltage Accuracy：5V±3%
- Voltage Adjustment Rate： Output Voltage Change Caused by Input Voltage Change

$$\frac{|\text{Output voltage at 20V input} - \text{Output voltage at 10V input}|}{\text{Rated Output Voltage}} \leq 0.5\%$$

- Load Adjustment Rate: Output Voltage Change Caused by Load Change

$$\frac{|\text{Output voltage at full load} - \text{Output Voltage at Half Load}|}{\text{Rated Output Voltage}} \leq 0.5\%$$

- Output Voltage Ripple： Not greater than 100mVpp
- Rated Output Current：1A
- The allowable range of output overcurrent protection trigger value：1.1A~1.9A
- Power conversion efficiency (full load)：80%
- The output terminal shall be able to measure the voltage normally under no load

3. Software overview

TINA-TI is a powerful circuit simulation tool that is well-suited for simulating analog and switched-mode power supply (SMPS) circuits. The tool is ideal for helping designers and engineers to develop and test circuit ideas. TINA-TI provides all the conventional DC, transient and frequency domain analysis of SPICE and much more. TINA has extensive post-processing capability that allows you to format results the way you want them. Virtual instruments allow you to select input waveforms and probe circuit nodes voltages and waveforms. TINA's schematic capture is truly intuitive - a real "quickstart."

4. Selecting Operating Frequency

The operating frequency of the controller is determined by an external resistor RRC that is connected from the RC pin to VDD and a capacitor attached from the RC pin to the ground. This connection and the two oscillator comparators inside the device. The oscillator frequency can be calculated using

$$FSW = \frac{1}{RRC * CRC * 0.105}$$

Where FSW is the clock frequency, and RRC is the timing resistor value in Ω. CRC is the timing capacitor value in F.

RRC must be kept large enough that the current through it does not exceed 750 μA when the internal switch is discharging the timing capacitor. This condition may be expressed by.

$$\frac{VIN}{RRC} \leq 750uA$$

$$\frac{20}{RRC} \leq 750uA$$

$$\frac{20}{750uA} \leq RRC$$

$$26.6K \leq RRC$$

$$FSW = \frac{1}{RRC * CRC * 0.105}$$

$$CRC = \frac{1}{26.6K * 300k * 0.105}$$

$$CRC = 11.9nF$$

5. Current Limiting Resistor

A resistor in series with the power MOSFET sets the overcurrent protection level. Use a low-inductance resistor to avoid ringing signals and nuisance tripping. When the FET is on and the controller senses 100 mV or more drop from the VDD pin to the ISNS pin, an overcurrent condition is declared. When this happens, the FET is turned off, the soft-start capacitor is discharged. When the soft-start capacitor reaches a level below 150 mV, the converter clears the overcurrent condition flag and attempts to restart. If the condition that caused the overcurrent event to occur is still present on the output of the converter, another overcurrent condition is declared and the process repeats indefinitely.

$$C_F \le \frac{\left(\frac{V_{OUT}}{V_{IN} \times f_{SW}}\right)}{\frac{(R_{F1} \times R_{F2})}{(R_{F1} + R_{F2})}}$$

Where

C_F is the value of the current limit filter capacitor in F
V_{OUT} is the output voltage of the converter
V_{IN} is the input voltage to the converter
f_{SW} is the converter switching frequency
R_{F1} and R_{F2} are the values of the scaling resistors in Ω

$$CF = \frac{\frac{Vout}{Vin\ X\ fsw}}{\frac{RF1\ X\ RF2}{RF1 + RF2}}$$

$$CF = \frac{\frac{5}{20\ X\ 300K}}{\frac{RF1\ X\ RF2}{RF1 + RF2}}$$

Let Suppose

$$RF1 = RF2$$

$$CF = \frac{\frac{5}{6000}}{\frac{1}{2}}$$

$$CF = \frac{5}{3000}$$

6. Selection of Film

As the maximum current available is 1.9 Ampere then

$$Iin = \frac{0.1}{Rin}$$

$$Rin = \frac{0.1}{1.9}$$

7. Calculating the Soft-Start Time

An external capacitor CSS, connected from the SS pin to the ground, controls the soft-start interval. An internal charging resistor connected to VDD produces a rising reference voltage which is connected through a 700-mV offset to the reference input of the TPS40200 error amplifier. There is no switching activity when the soft-start capacitor voltage (VCSS) is below 150 mV. When VCSS rises above the 700 mV offset, the error amplifier starts to follow VSST– 700 mV and uses this rising voltage as a reference. When VCSS reaches 1.4 V, the internal reference takes over, and further increases have no effect. An advantage of initiating a slow start in this fashion is that the controller cannot overshoot because its output follows a scaled version of the controller reference voltage. A conceptual drawing of the circuit that produces these results. A consequence of the 700 mV offset is that the controller does not start switching until VCSS has risen to 700 mV. The output remains at 0 V during the resulting delay. When VCSS exceeds the 700 mV offset, the TPS40200 output follows the soft-start time constant. Once above 1.4 V, the 700-mV internal reference takes over, and normal operation begins.

The slow-start time should be longer (slower) than the time constant of the output LC filter. This time constraint may be expressed as described in

$$TS \geq 2\pi(\mathrm{LOUT} * \mathrm{COUT})^{1}/2$$

The calculation of the soft-start interval is simply the time it takes the RC network to exponentially charge from 0 V to 1.4 V. An internal 105 kΩ charging resistor is connected from the SS pin to VSS.

In applications where the voltage is above 8 V, an internal regulator clamps the maximum charging voltage to 8 V. The result of this is a formula for the start-up time

$$\mathrm{Vos} \ = \ 700\,\mathrm{mV}$$

$$\mathrm{Vin} \ = \ 20\,\mathrm{V}$$

$$\mathrm{Vsst} \ = \ 8\,\mathrm{V}$$

$$\mathrm{R} \ = \ 105\ \mathrm{K\Omega}$$

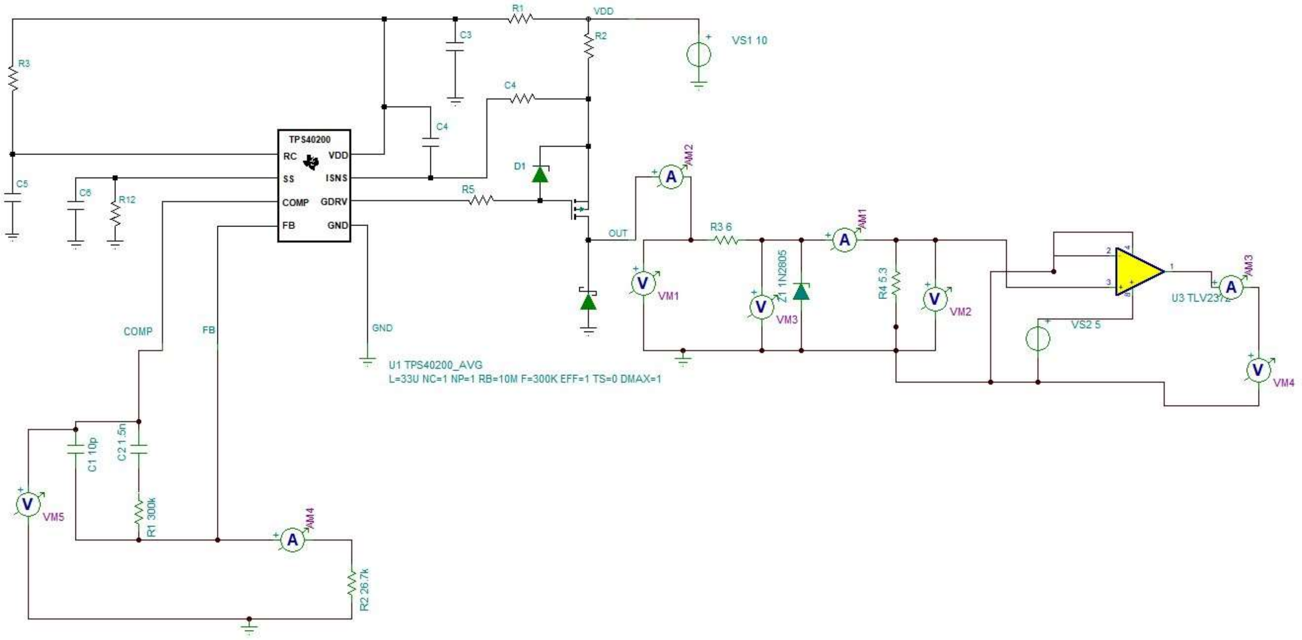
$$TS \geq 2\pi(\mathrm{LOUT} * \mathrm{COUT})^{1}/2$$

$$TS \geq 0.95\,ms$$

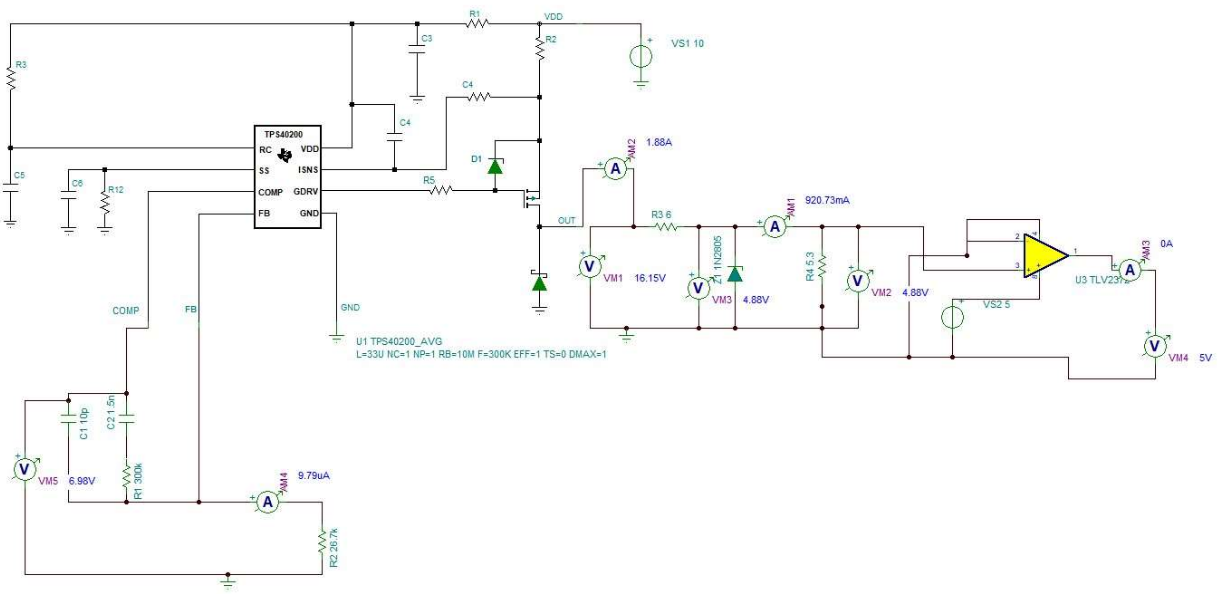
$$\mathrm{Css} = \frac{\mathrm{tss}}{\mathrm{R\,X\,ln}\left(\frac{Vss}{Vsst-1.4}\right)}\,X\,10^{3}$$

$$Css = 0.046\,uF$$

8. Circuit Diagram



9. Output



10. Conclusion

In this project, tps40200 is used as a choppers chopper a device that converts fixed DC input to a variable DC output voltage directly. Essentially, a chopper is an electronic switch that is used to interrupt one signal under the control of another. since the switching element is either fully on or fully off, its losses are low and the circuit can provide high efficiency. However, the current supplied to the load is discontinuous and may require smoothing or a high switching frequency to avoid undesirable effects. In signal processing circuits, the use of a chopper stabilizes a system against the drift of electronic components; the original signal can be recovered after amplification or other processing by a synchronous demodulator that essentially un-does the "chopping" process.
Further we have used zener diode in order to produce stabilize voltage.This voltage remains almost constant even with large changes in current providing the zener diodes current remains between the breakdown current IZ(min) and its maximum current rating IZ(max).
This ability of the zener diode to control itself can be used to great effect to regulate or stabilise a voltage source against supply or load variations

11. Literature list

[1] TPS40200 Wide Input Range Non-Synchronous Voltage Mode Controller. SLUS659G –FEBRUARY 2006–REVISED NOVEMBER 2014, by Texas Instruments

[2] Getting Started with TINA-TI: A Quick Start Guide. SBOU052A–August 2007–Revised August 2008, by Texas Instruments

[3] TINA-TI Introduction & DC Simulations. 2020, by YouTube channel “Electronics with Professor Fiore”

[4] DC Circuits. Chad Davis, University of Oklahoma, 2016

[5] A textbook of DC Circuits: Volume 1. Monzurul Islam, 2013-2014