Linear voltage controller

1. Objectives

The purpose of this exercise is to learn the properties of a linear voltage regulator built on a common integrated circuit. The scope of the exercise includes the design and measurement of the basic parameters and characteristics of the stabilizer.

2. Components and instrumentation.

In Fig.1 the schematic diagram of the voltage regulator in the form of the basic L200 integrated circuit application is presented. Table 1 shows the basic parameters of the L200 stabilizer

a)

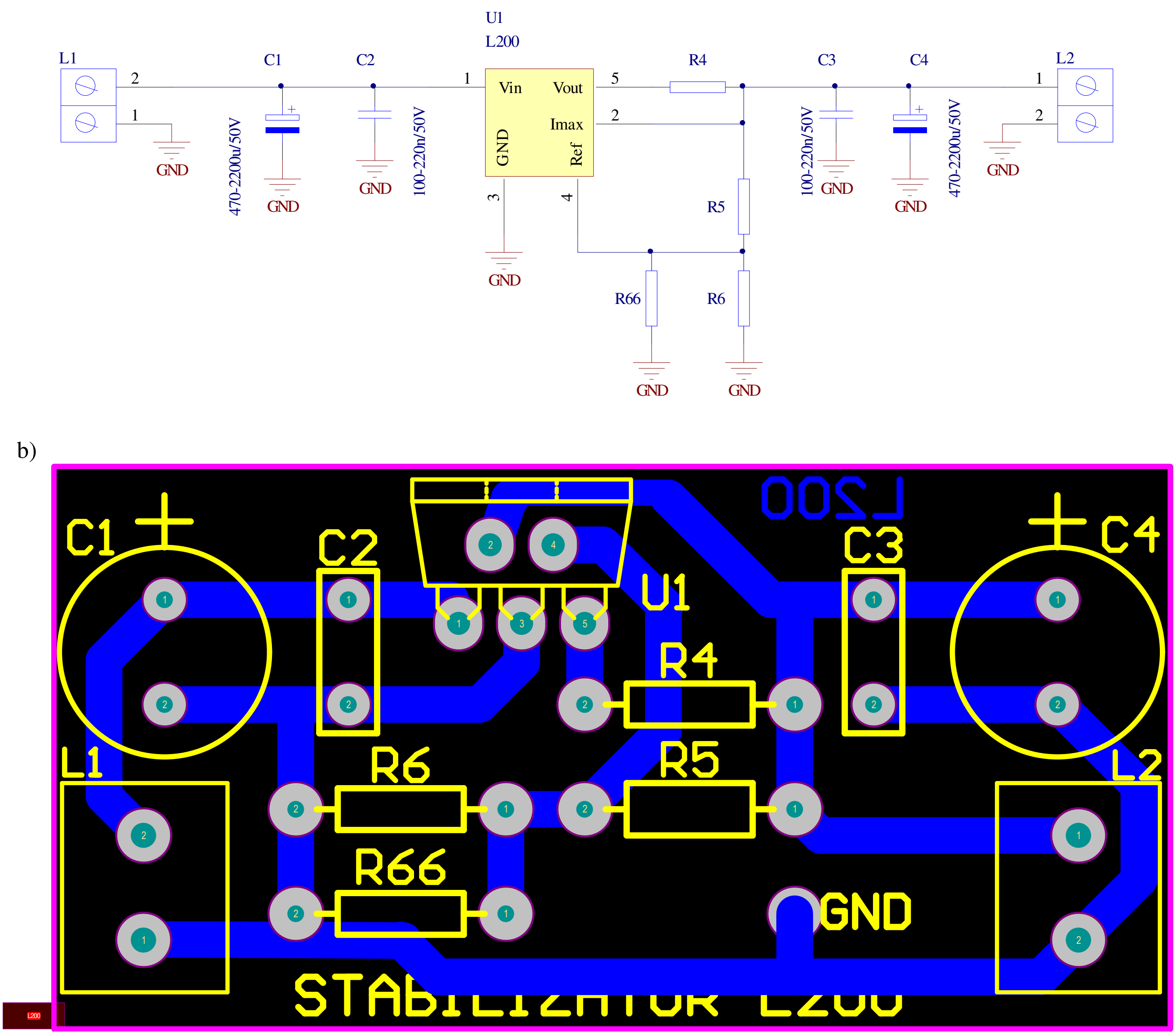

Fig. 1.Linear voltage regulator with current limit - application of IC L200; a)schematic diagram, b)PCB - element side view.

Table 1 Basic parameters of L200 integrated ciecuit

Symbol	Parametr	Conditions	alue			Unit.
			Min	Typ	Max	
Voltage regulator T = 25°C						
U_O	Input voltage range	I_O = 10mA	2.85	<>	36	V
$\Delta U_O/I_O$	Load regulation	I_{min} = 10mA I_{max} = 1,5A	0.1	0.15	1	%
$\Delta U_O/\Delta U_I$	Line regulation	U_I = 8...20V U_O = 5V		0.1	0.4	%
U_O - U_{Imin}	Dropout voltage	I_O = 1.5A	2	2.5	3	V
r_{out}	Output impedance	U_I = 10V, U_O = U_{REF} I_O = 500mA F = 100Hz	1.5	1.5	3	mΩ
U_{REF}	Reference voltage	U_I = 20V, I_O = 10mA	2.65	2.75	2.85	V
Curren regulator T = 25°C						
U_{SC}	Current limit sens voltage (pins 2 and 5)	U_I = 10V, U_O = U_{REF} I_O = 100mA	0.38	0.45	0.52	V
I_{SC}	Peak short circuit current	U_I – U_O = 14V (pomiędzy pin 2 i 5 włączono R_{SC} < 0.01Ω)			3.5	A
$\Delta I_O/I_O$	Current load regulation	U_I = 10V, U_O = 3V I_O = 0.5 A I_O = 1A I_O = 1.5 A		1,4 1,0 0,9		%

The output voltage U_O of the regulator depends on the value of resistors R_5 and R_6 and can be calculated according to the equation:

$$U_O = \left(1 + \frac{R_5}{R_6}\right) U_{REF} \quad . \tag{1}$$

The output voltage can take values within the range UREF < UO <(UI - UREF - UBE), where the UREF is the reference voltage of the L200 circuit (between pins 3 and 4, so on the resistor R6 - typically 2.75V) and the UBE is the voltage Base-Emitter of the transistor regulator included in the structure of the circuit. The maximum output current in the system is limited to the value:

$$I_{O\max} = \frac{U_{SC}}{R_4} = \frac{0{,}45V}{R_4} \quad , \tag{2}$$

so it is determined by the value of the R4 shunt resistor. The design of the stabilizer is reduced to the ratio of R5/R6 according to (1), and the sum of the resistances R5 + R6, which will allow them to determine their specific values. These resistors should be selected in such a way that the current through the divider R5 and R6 is much higher than the polarity of the tip 4 (I4), which is a maximum of 10μA. In practice you can accept

$$R_5 + R_6 \le \frac{U_O}{100 I_4} \approx \frac{U_O}{1mA} \quad . \tag{3}$$

3. Preparation.

NOTICE: The preparation time for classes is estimated at 4 to 6 hours.

3.1. Readings

[1] Lab materials and lectures of the course.

[2] U. Tietze, Ch. Schenk, Electronic circuits. Handbook for Designe and Applications, Springer, 2008, p. 885-892.

[3] P. Horowitz, W. Hill, The Art of Electronics, Cambridge Univ. Press, London, 2015,

3.2. Problems

1. Block diagram and principle of operation of the compensating voltage stabilizer.
2. Name and describe the basic parameters and characteristics of the voltage regulator.
3. Draw examples schematics of voltage regulator circuits.
4. List and describe the basic types of protections used in compensating stabilizers.
5. Integrated circuit L200: construction, operation, parameters and applications.
6. Describe the principles of voltage stabilizer design using the L200 chip.

3.3. Detailed preparation

For the given output voltage and the maximum output current of the voltage regulator, calculate and select elements R4, R5, R6. Prepare appropriate tables for the measurement results and graphs on which the characteristics will be plotted.

4. Contest of the report

4.1. Relationship $U_O = f(U_I)$ measurement, for R_O as parameter

1. Assemble the designed voltage stabilizer on the PCB and attach the heatsink to the L200..
2. Connect the DC power supply to the regulator input and adjust the load in series with the ammeter. Connect voltmeters to the input and output (fig.2).

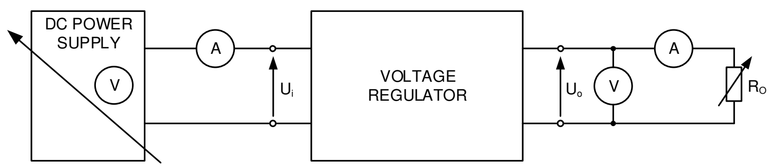

Fig.2. Measurement diagram.

3. Measure and plot the relationship $U_O = f(U_I)$ for given R_O load resistance values.
4. Estimate the ΔUO stability ranges for the given load resistance and calculate the stabilization coefficients SU,

$$S_U = \frac{\Delta U_O}{\Delta U_I} \quad . \tag{4}$$

5. Specify the “Dropout” voltage stabilizer for given R_O resistance values.

4.2. *Relationship $U_O = f(I_O)$ measurement with, U_I as parameter*

6. Measure and plot the relationship $U_O = f(I_O)$, for given value of input voltage U_I. Measurements should be performed by changing the load resistance value from the unloaded state ($R_O = \infty$) to the shorted state ($R_O = 0$).
7. Determine the output voltage stabilization range ΔU_O and the value of the output resistivity of the regulator *Rout.*

4.3. *Reference voltage measurement*

8. Using a voltmeter, measure the reference voltage of the regulator - U_{REF} - voltage drop on R_6. Take the measurement with unloaded stabilizer ($R_O = \infty$).
9. Using a voltmeter, measure the current limit sense voltage USC - voltage drop on R4. Take the measurement when output is shorted($R_O = 0$).

4. Conclusions

1. Determine the effect of R_O on the relationship $U_O = f(U_I)$.
2. Determine the effect of U_I on the relationship $U_O = f(I_O)$.
3. Determine and interpret the values of the stabilization factor S_U and the output resistivity of the regulator.
4. For what value R_O and U_I the regulator works as a voltage regulator and for what values as a current regulator ?
5. Compare measured results with the stabilizer catalog data of L200 ic.

5. Appendixes:

N0.	Line regulation $U_O = f(U_I)$					
	R_O = ……Ω,		R_O = …..Ω,		R_O = ……Ω,	
	S_U = ………..V/V		S_U = ………..V/V		S_U = ………..V/V	
	U_O [V]	U_I [V]	U_O [V]	U_I [V]	U_O [V]	U_I [V]
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20						
21.						
22.						

N0.	Load regulation $U_O = f(I_O)$					
	U_I = …….V		U_I = …….V		U_I = …….V	
	r_{out} = …….Ω		r_{out} = …….Ω		r_{out} = …….Ω	
	U_O [V]	I_O [mA]	U_O [V]	I_O [mA]	U_O [V]	I_O [mA]
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
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