Contestant number: Delivery time:

Number of points theoretical part:

Theoretical part – a set of questions from electronics

(30 points)

Prepare an answer to each question. You get 1 point for each completely correct answer.

For tasks requiring calculation, use the space within the question or the back of the test. Clearly mark each task with a serial number. Each result must also contain the correct units. A numerical result without units or a sufficiently detailed calculation (or a reasoned result) will not be recognized!

Theoretical electrical engineering

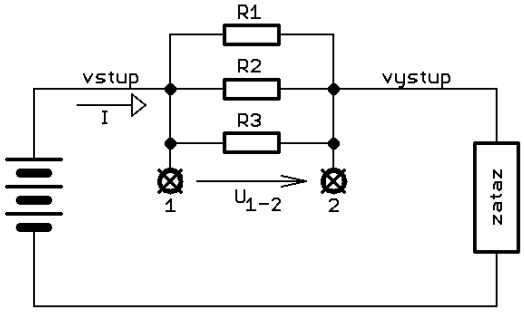
1. Calculate the value of the impedance of an ideal capacitor with a capacity of C = 10 μ F at a frequency of f = 1000 Hz.

Z =

2. On the PCB, the conductor is l = 12 mm long and 0.4 mm wide. The thickness of the cladding of the base material is 35 μ m. Calculate the resistance of this conductor (resistivity of copper ρ = 1.75.10-8 Ω .m)

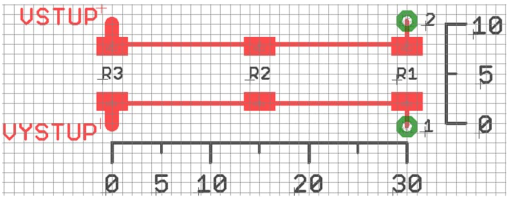
$R_{conductor}$ =

3. The following figure shows a part of the circuit whose task is to measure the current from the battery to the load using a shunt. Three identical resistors are used with the resistance value R1=R2=R3= 10 m Ω . Calculate the magnitude of the voltage between terminals 1 and 2 for the value of the flowing current I = 20 A



U_{1-2} =

The circuit board for this circuit was designed by a student who reasonably did not make it to the ZENIT national finals. His proposal is in the picture. The connecting wires have a width of 0.4 mm, the copper thickness is 35 μm . The grid is in millimeters:



4. Draw a substitute diagram of the actual circuit on the printed circuit board, including the values of the individual elements (neglect the resistance of the soldering pads of the resistors, the input and output wires)

5. Calculate the actual voltage drop between terminals 1 and 2 for a current value of I = 20 A (use the back side for the calculation)

$U_{1\text{-}2\ real}$ =

6. An ideal transformer has 100 primary turns and 1 secondary turn. The primary is connected to the 230V/50Hz network. The secondary is loaded by a circuit with a total resistance of 1 m Ω . Calculate the magnitude of the current flowing through the load and the power dissipated in it. What application is it most likely to be?

I_{sec} =

P =

7. Tomorrow, in the practical part, you will use an object that behaves like a series resonant circuit. Its replacement circuit has element values C = 0.2 fF, L = 1.2665147 H, R = 90 Ω . Calculate its resonant frequency.

f =

Bonus: *You must have noticed the extreme value of capacitance and inductance. This circuit has a very high quality factor. What kind of resonant circuit is it? What will you be working with tomorrow?*

8. Which of the following units are used for physical quantities describing magnetic fields?

Weber	Farad
Tesla	Ampere per meter
Ampere	Volt per meter
Henry	Ohm
Gauss	Volt

9. Sketch the amplitude-frequency characteristic of the low-pass filter (so-called Bode diagram). Mark all the important areas - pass band, cutoff frequency, slope of the characteristic in the damping band, correct units on the axes, etc.

10. The analog-to-digital converter in the meter has a full ±5 V input voltage range and infinite input resistance. We want to use it to measure the DC input voltage in the range of ±500 V. Suggest how to connect the input voltage to the AD converter so that its dynamic range is optimally used. Draw the connection. Calculate the values of all elements (from the E24 series). Ensure that the power loss in this auxiliary circuit is not more than 1 W at maximum input voltage.

11. The power transistor amplifier has a supply voltage of U = 50 V, delivers an output power of P = 2 MW to the load and achieves an efficiency of 65%. Calculate the current flowing from the DC power supply of this amplifier

I_{source} =

12. Draw a schematic diagram of an alternating-coupled common-emitter transistor amplifier. Correctly describe all important nodes and signals.

13. The amplifier with gain A = 31.6 has a voltage U_{IN} = 1 mV at the input. Calculate the magnitude of the output voltage

U_{OUT} =

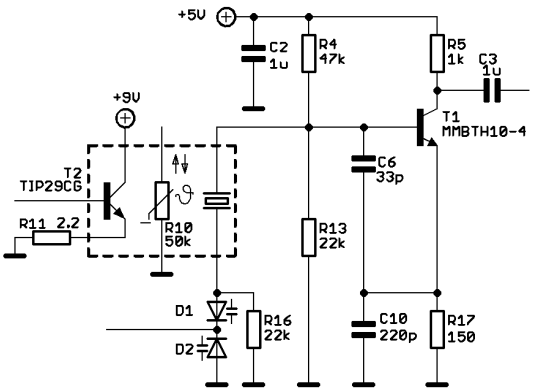
14. What is the mean value of a sine wave if it has a DC component equal to zero and its rms value is 1.4142 V?

U_{mean} =

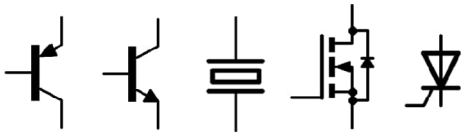
Electronic circuits and general knowledge

15. What is the main difference between a bipolar transistor and a field-effect transistor?

16. What is the function of the wiring in the picture?



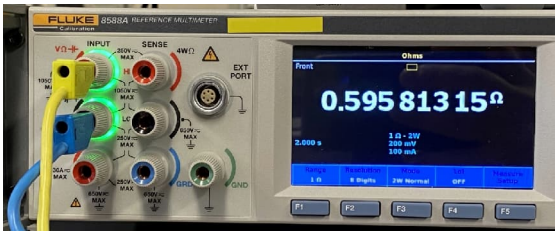
17. Mark which of the following electronic elements does not contain any PN transition (or parasitic)?



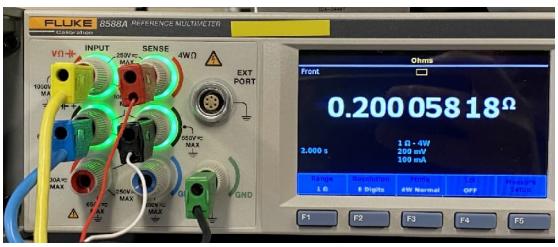
Measurement in electrical engineering

With a very accurate laboratory multimeter (Fluke 8588A), we measured the resistance value of the same resistor in two ways:

- two-wire connection



- and four-wire connection



18. What is the most likely resistance value of the measured resistor?

R =

19. Explain why there is such a huge difference between the measured values? Which of these two methods is used to measure low value resistance?

20. Draw the Wheatstone bridge connection and state the equilibrium condition (there is zero voltage between nodes in the diagonal)

21. The frequency counter is usually a purely digital circuit, which in principle is resistant to changes in temperature, humidity, or working conditions. Which part of it is critical and determines its accuracy and stability?

Numerical technique

22. Write the truth table of a three-input NAND gate

23. Which of the following families of logic circuits is the "slowest" and will generate the lowest switching noise?

ECL FTTL HC HCT 4000 LVDS ACT LVCX

24. Four smoke sensors are placed at regular intervals in the tunnel. Sensors have a logical output. If everything is fine, the output is a log. 0, if they noticed smoke at the output is a log. 1. Design a combinational logic circuit that activates ventilation if any sensor detects smoke.

S1 ----

S2 ---- VENTI-

S3 ---- LATOR

S4 ----

25. Design a logic circuit that triggers an alarm at the monitoring station if any two adjacent sensors detect smoke

S1 ----

S2 ----

ALARM

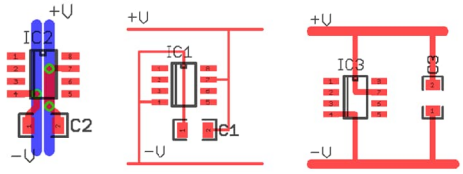
S3 ----

S4 ----

Practical knowledge

26. Which resistor parameter is expressed in units of ppm/°C?

27. Which PCB design will have the best power quality characteristics for an integrated circuit?

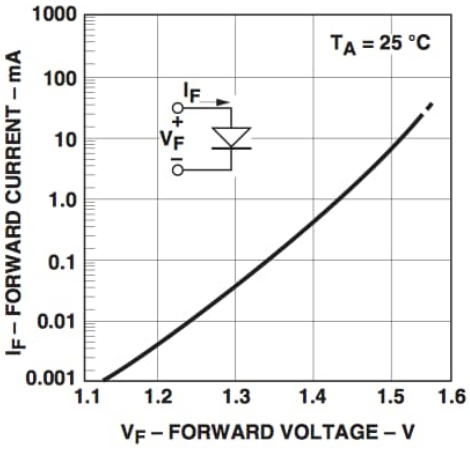


28. In the diagram of any electronic circuit, we find a number of capacitors of values typically 1 nF to 100 nF connected between the supply voltage and ground. It is also often stated that they must be placed close to the integrated circuit. What are they called and what is their function?

29. The theme of the 38th ZENIT in electronics is time and frequency. Rank the following frequency sources in order of stability (1 = best, 6 = worst)

___ RC oscillator with logic gate
___ Ceramic resonator at the microcontroller
___ Crystal oscillator
___ Thermostated crystal oscillator
___ Transistor LC oscillator
___ Cesium atomic clock

30. The microcontroller works with a supply voltage of 5 V and its output pins can drive a load of max. 5 mA. We want to use it to control power peripherals using optocouplers. The HCPL-0631 optocoupler requires an emitter diode operating current of 20 mA and its volt-ampere characteristic is shown in the figure:



Suggest how to connect the optocoupler to the output pin of the microcontroller and calculate the values of all elements for the operating point If = 20 mA. Consider a supply voltage of 5V. Draw the detailed wiring of the circuit, give the values of all the components.