Laboratory Report

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| --- | --- |
| **Subject of the exercise:** | Active electronic components (Exercise 8.) |
| **Date:** | <year>. <month>. <day> |
| **Location:** | BME, Q.BP109 |
| **Students name:** | <name 1> |
|  | <name 2> |
| **Group, desk No.** | Group <No.>, desk <No.> |
| **Supervisor:** | <name> |
| **Subject of the exercise:** |  |

Measurement instruments

|  |  |  |
| --- | --- | --- |
| Digital multimeter (6½ digit) | Agilent 34401A |  |
| Power supply | Agilent E3631A |  |
| Curve tracer | Hameg HM6042 |  |
| Oscilloscope | Agilent 54622A |  |
| Function generator | Agilent 332220A |  |
| Test boards | VIK-08-01 |  |

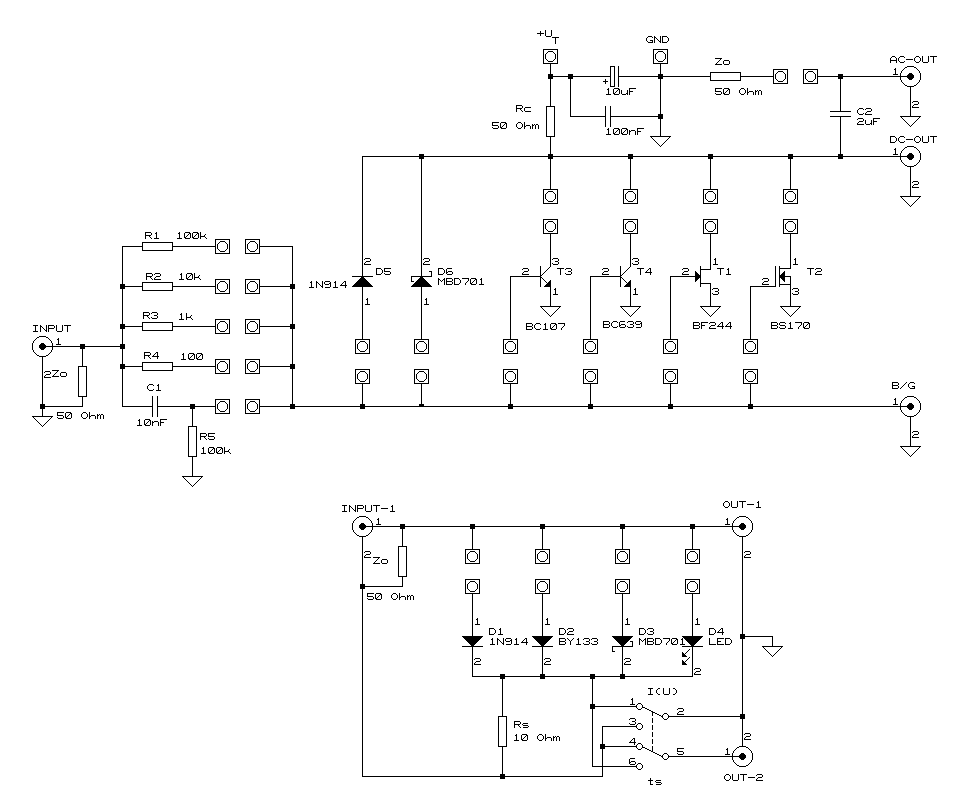


Fig. 8–1. Schematic diagram of the Test board

Laboratory exercises

## Static characteristics of the semiconductor diode

The characteristics can be measured using the test panel which includes the following diodes:

D1 = small-signal Si diode (1N914)

D2 = high current rectifier (BY 133)

D3 = Schottky diode (1N5819)

D4 = LED (3mm)

A diode can be selected using the series jumpers. Connect the generator to the diode through the 10 series resistor.

The static and dynamic characteristics can be measured using the same panel. Use the switch on the side of the panel to swap the two terminals of the resistor.

The measurement setup is shown in Fig. 8–2.

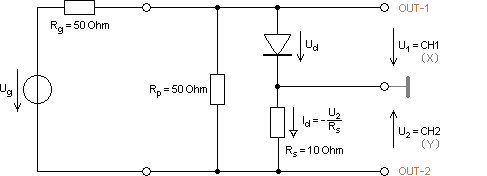


Fig. 8–2. Measurement setup for semiconductor diodes

Plot the U-I characteristics of the diodes with oscilloscope. The forward current of the diode [Id = IF] can be calculated from the measured voltage drop on the RS resistor. Measure the UF forward voltage at IF = 1mA, 10mA and 50mA forward current levels.

*Recommended setup (it should be changed but perfect for as a starting point):*

*Oscilloscope: Ch1: 500mV/cm,*

*Ch2: 10mA/cm, INV mode, 0.1:1 scaling,*

*Display Mode: XY*

*Generator: 100Hz sinus, amplitude: 3Veff, offset: 0V (these initial amplitudes should be changed later)*

Note: it is practical to measure the values of the opening voltage for each diode at a given current value, then switch to a different current value. With this method, it is only rarely necessary to change the instrument settings.

Instrument settings:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Id | 1 mA | **10 mA** | 50 mA | Ud |
| D1 | 1N4148 |  |  |  | V |
| D2 | BY133 |  |  |  |
| D3 | BAT82 |  |  |  |
| D4 | LED |  |  |  |

Table 1.: *Forward voltage of the diodes*

*The measurement can be performed by either using the XY markers of the oscilloscope, or by maximum level measurement (MAX) in normal mode (slower but more precise).*

The I-U characteristic of the four diodes (Id = 10 mA operating point):

Evaluation of the results:

## Dynamic characteristics of the semiconductor diode

Using the same settings as for plotting the DC characteristics, increase the generator frequency until a hysteresis-like phenomenon can be observed in the static characteristic and the maximum difference of the two curves reaches 10mA.

Compare the curves and the “critical frequencies” of the different diodes.

Oscilloscope figure:

Reasoning

## Switching time (storage time) of the semiconductor diode

The switching time of the diode can be measured by setting the switch on the side of the panel to **ts** state. The measurement setup is shown in *Fig. 8–3*.

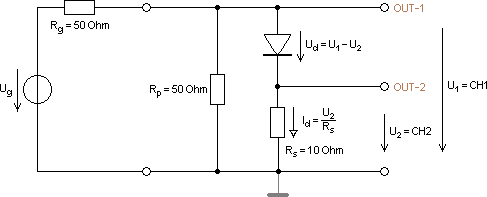


Fig. 8–3. Measurement setup for the dynamic characteristic of semiconductor diodes

*Suggested setup:*

*Oscilloscope: Ch1: 500mV/cm,*

*Ch2: 10mA/cm, 0.1:1 scaling, INV: off;*

*Display Mode: normal*

*Generator: Mod: Pulse, Frequency: 20-50 kHz, Ampl.: High Level = +3V,*

*Low Level = -3V, Duty Cycle = 50%, ts=100 ns (edge time)*

The subject of measurement is the BY133 Si diode.

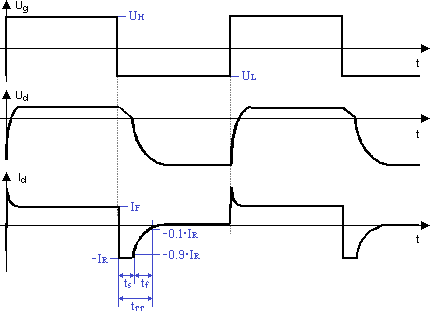


Fig. 8–4. Switching time of the diode. Voltage and current versus time.

According to the Fig. 8–4, measure the  reverse recovery time and the  storage time at ratio IF/IR = 1:2, 1:1 and 2:1. The forward (IF) and reverse current (IR) values can be modified by changing the HL and LL levels of the generator. Recommended current values are in the table below:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| IF | IR | UH | UL | (IF / IR) | ts | tf | trr |
| [mA] | | [V] | | [ns] | | |
| 20 | 40 |  |  | (1 : 2) |  |  |  |
| 20 | 20 |  |  | (1 : 1) |  |  |  |
| 40 | 20 |  |  | (2 : 1) |  |  |  |

Table 2. *Switching time of* *BY133*

Time functions belonging to the three result lines of Table 2 on the oscilloscope screen, supplemented with UH and UL time functions, respectively:

Evaluation of results

## Measurement of operation point setting and switching characteristic of bipolar transistors

The measurement setup is shown in *Fig. 8–5*. The transistor to be measured is of type BC639, select 1 kΩ as the base resistance (RB). The supply voltage UT = +5 V is provided by the external power supply! Before connecting to the test panel, check with a digital multimeter! Measure the bias current Ic with a digital multimeter! Note: the INPUT input of the circuit has a 50 Ω termination!.

DC-OUT

AC-OUT

IC

UT

Ug(t)

RB

1 kΩ

RC

50 Ω

UCE

Rg

50 Ω

UOFFSET

Rin

50 Ω

50 Ω

B/G (out)

INPUT

IB

+UT

Fig. 8–5. Measurement setup for measuring bipolar transistor

4.1 To measure the current gain of a bipolar transistor, an input DC current is required. We can do this by connecting a signal with a positive DC component and a negligibly small (the smallest adjustable) alternating component to the INPUT connector of the test panel: UOFFSET = +1.2 V, Ug=0 V! Measure the value of the collector current Ic with a multimeter. Calculate the base input current using equation (1). Consider the UBE base-emitter voltage as 0.7 V, but it can be accurately measured on the B/G connector.

(1)

Instrument settings:

Calculated value of IB base current:

Measured value of IC bias current:

Current gain :

4.2 To measure the characteristic points of the transistor, connect a triangular signal with a frequency of 100 Hz, a voltage value of UPP = 3 V, a duty cycle of 50%, and a DC voltage of UOFFSET = +1.5 V to the INPUT connector of the test panel! Display the input (INPUT) voltage of the test panel on one channel of the oscilloscope, and the collector-emitter (DC-OUT) voltage of the transistor UCE on the other channel. Using a cursor, check at what input voltage (Uopen, input) the transistor starts to open (i.e. the collector-emitter voltage starts to change)!

Oscilloscope figure, let’s denote the opening voltage Uopen,input:

4.3 **Saturation measurement**: The settings of the previous measurement can be used to measure saturation parameters. Calculate and then measure on the oscilloscope the following values:

* the maximum collector current: IC\_limit,calculated (calculated limit) and measured value
* the input (INPUT) terminal voltage at which the transistor becomes saturated: UGlim,calculated (calculated limit) and measured value

(2)

(3)

IC\_limit,calculated =

UGlim,calculated =

UGlim,measured =

Oscilloscope figure:

Collector-emitter saturation voltage!

UCEsat =

Oscilloscope figure: