Recording the characteristic of a field-effect transistor (FET)

Objects of the experiment

- Recording the characteristic of a field-effect transistor

  Output characteristic $I_D = f(U_{GS})$

Principles

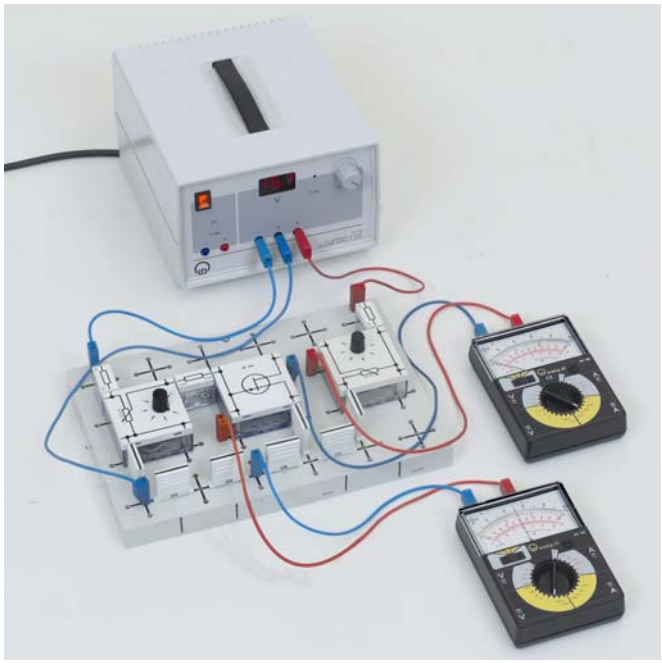
Transistors are among the most important semiconductor components in electronic circuit technology. We distinguish between bipolar transistors, in which the electrons and holes are both involved in conducting current, and field-effect transistors, in which the current is carried by the doped-in carriers of charge (electrons and holes). In field-effect transistors, the conductivity of the current-carrying channel is changed using an electrical field, without applying power. The element which generates this field is called the gate. The current bearing electrodes of a field-effect transistor are named source and drain. The small signal FETs used here are symmetrical, so drain and source are interchangeable.

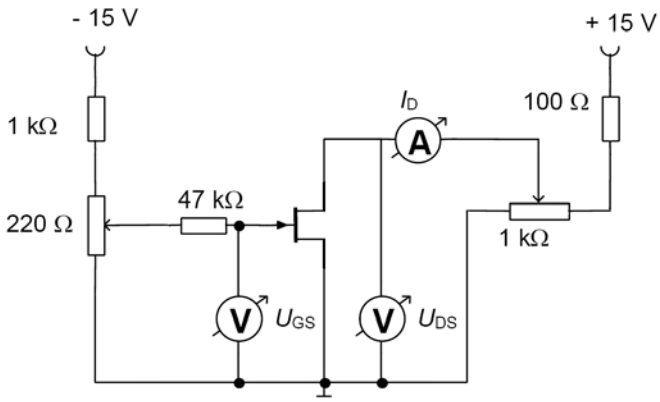
In the experiment, the characteristic of a field-effect transistor, i.e. the drain current I_D is recorded and diagrammed as a function of the voltage U_{DS} between the drain and source at a constant gate voltage U_G.

Apparatus

1 Rastered socket panel, DIN A 4	576 74
1 Set of 10 bridge plugs	501 48
1 STE Resistor 100 Ω	577 32
1 STE Resistor 1 kΩ	577 44
1 STE Resistor 47 kΩ	577 64
1 STE Potentiometer 220 Ω	577 90
1 STE Potentiometer 1 kΩ	577 92
1 STE FET-Transistor BF 244	578 77
1 STE Si-Diode 1N 4007	578 51
1 DC-Power supply 0...± 15 V	521 45
1 Transformer 6 V / 12 V	521 210
2 Multimeters LD-analog 20	531 120
1 Two-channel oscilloscope	575 211
2 Screened cables BNC / 4 mm	575 24
1 Connecting lead, blau, 50 cm	500 422
3 Pair of cables, red and blue, 50 cm	501 45

Setup





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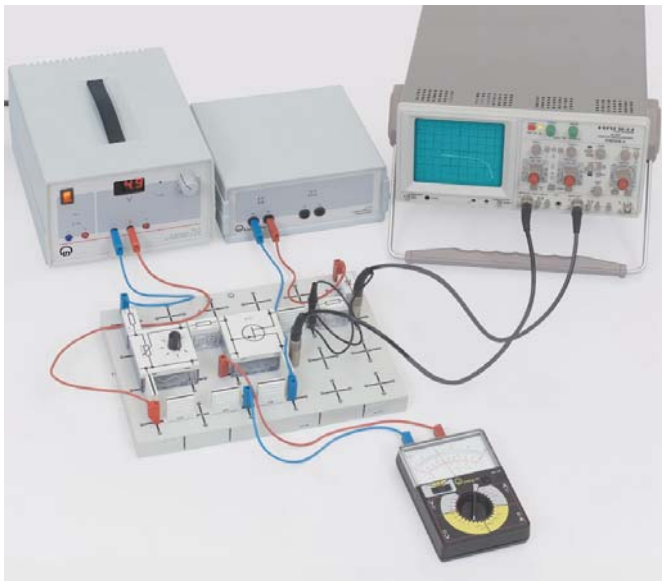
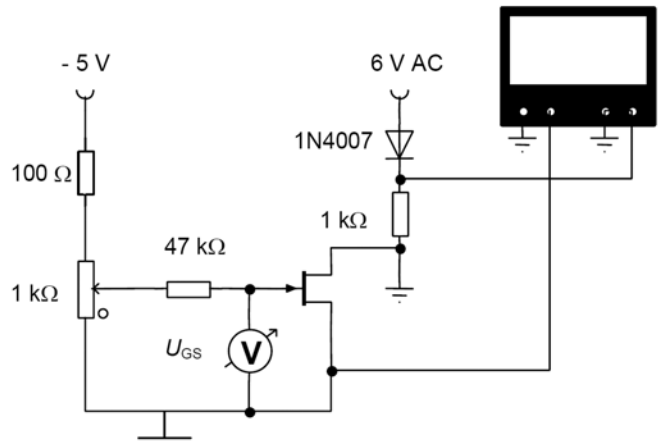
Carrying out the experiment

- Set up the experiment as shown in the figure.
  Voltage divider
  gate-source : resistor 1 kΩ and potentiometer 220 Ω (and resistor 47 kΩ in serie with gate-source-junction)
  drain-source: resistor 100 Ω and potentiometer 1 kΩ
- Pay attention of the measuring range and polarity of the multimeters. First connect the multimeter to measure the gate-source-voltage U_{GS}.
- Set the voltage of the power supply to 15 V.
- Adjust the potentiometer 220 Ω so that the gate-source-voltage U_{GS} = 0 V.
- Now connect the multimeter to measure the drain-source-voltage U_{DS}.
- By turning potentiometer 1 kΩ carefully increase drain-source-voltage U_{BE} – starting with 0 V. Fill in pairs of voltage U_{DS} and current I_D in the table 1
- Repeat the experiment with further gate-source-voltages U_{GS}., f.e. U_{GS} = - 0,5 V and U_{GS} = - 1,0 V.

- For dynamic measurement of the output characteristic set up the experiment as in shown in the following figure:





- Set the voltage of the power supply to 5 V.
- Remark: Because of the common ground in the oscilloskope's circuit the voltage U_{DS} is inverted
- Vary the gate-source-voltage U_{GS} by turning the potentiometer 1 kΩ. The influence of the gate-source-voltage U_{GS} to the output characteristic can be observed directly.

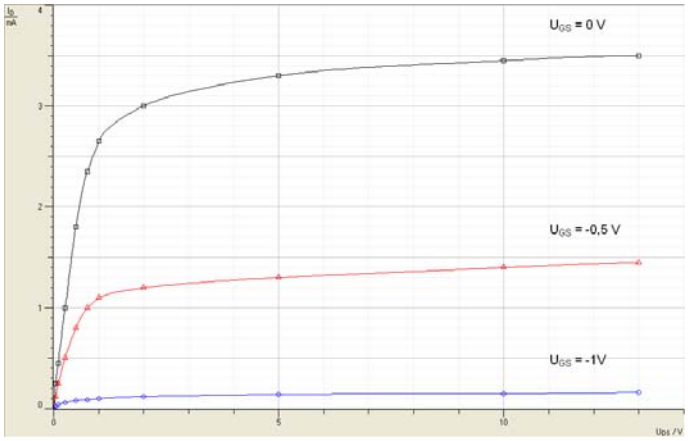
Measuring example

Table : Output characteristic $I_D = f(U_{DS})$, U_{GS} : konst.

$U_{GS} = 0$ V		$U_{GS} = -0{,}5$ V		$U_{GS} = -1$ V	
$\frac{U_{DS}}{V}$	$\frac{I_D}{mA}$	$\frac{U_{DS}}{V}$	$\frac{I_D}{mA}$	$\frac{U_{DS}}{V}$	$\frac{I_D}{mA}$
0	0	0	0	0	0
0.05	0.25	0.05	0.12	0.05	0.02
0.10	0.45	0.10	0.25	0.10	0.04
0.25	1.00	0.25	0.50	0.25	0.06
0.50	1.80	0.50	0.80	0.50	0.08
0.75	2.35	0.75	1.00	0.75	0.09
1.0	2.65	1.0	1.10	1.0	0.10
2.0	3.00	2.0	1.20	2.0	0.12
5.0	3.30	5.0	1.30	5.0	0.14
10.0	3.45	10.0	1.40	10.0	0.15
13.0	3.50	13.0	1.45	13.0	0.16

Because of the tolerances of field-effect-transistors the measured values can differ significantly from the example.

Evaluation and results



Two areas can be distinguished by plotting the table data into a diagram to get the graphs of the output characteristic:

- The drain-current I_D increases linearly with the drain-source-voltage U_{DS} in the first part of the graph (small voltages U_{DS}). This area is called resistive component of the output characteristic. The FET behaves like an ohmic resistor, whose value can be controlled by the gate-voltage U_{GS}.
- For higher voltages U_{GS} (> 1...2 V) the drain-current I_D is nearly constant and does not depend on the drain-source-voltage U_{DS}. This area is called cut-off area. The drain-current I_D is controlled by the gate-voltage U_{GS}. Operated in this area the FET can be used as a constant current source.