Problem

Investigate the relationship between current and voltage for a Zener diode in forward and reverse direction.

Equipment

Plug-in board	06033.00	1
Resistor, 47 Ω	39104.62	1
Resistor, 100 Ω	39104.63	2
Z diode ZF4.7	39132.01	1
Wire building block	39120.00	3
Connecting cables, 25 cm, red	07360.01	1
Connecting cables, 25 cm, blue	07360.04	1
Connecting cables, 50 cm, red	07361.01	2
Connecting cables, 50 cm, blue	07361.04	2
Multi-range meter	07028.01	2
Power supply, 0...12 V-, 6 V~, 12 V~	13505.93	1

Set-Up and Procedure

First Experiment

— Set up circuit as shown in Fig. 1. Connect Z diode in forward direction.

— Select measurement range of 1 V- and 30 mA-. Make sure polarity on the meter is correct and that the meters are connected properly.

— Switch on power supply unit. Increase voltage U_P on the power supply unit from 0 V to 10 V in increments of 1 V. Measure both forward voltage U_F and forward current I_F. Enter measurements in Table 1.

— Switch power supply unit off.

Second Experiment

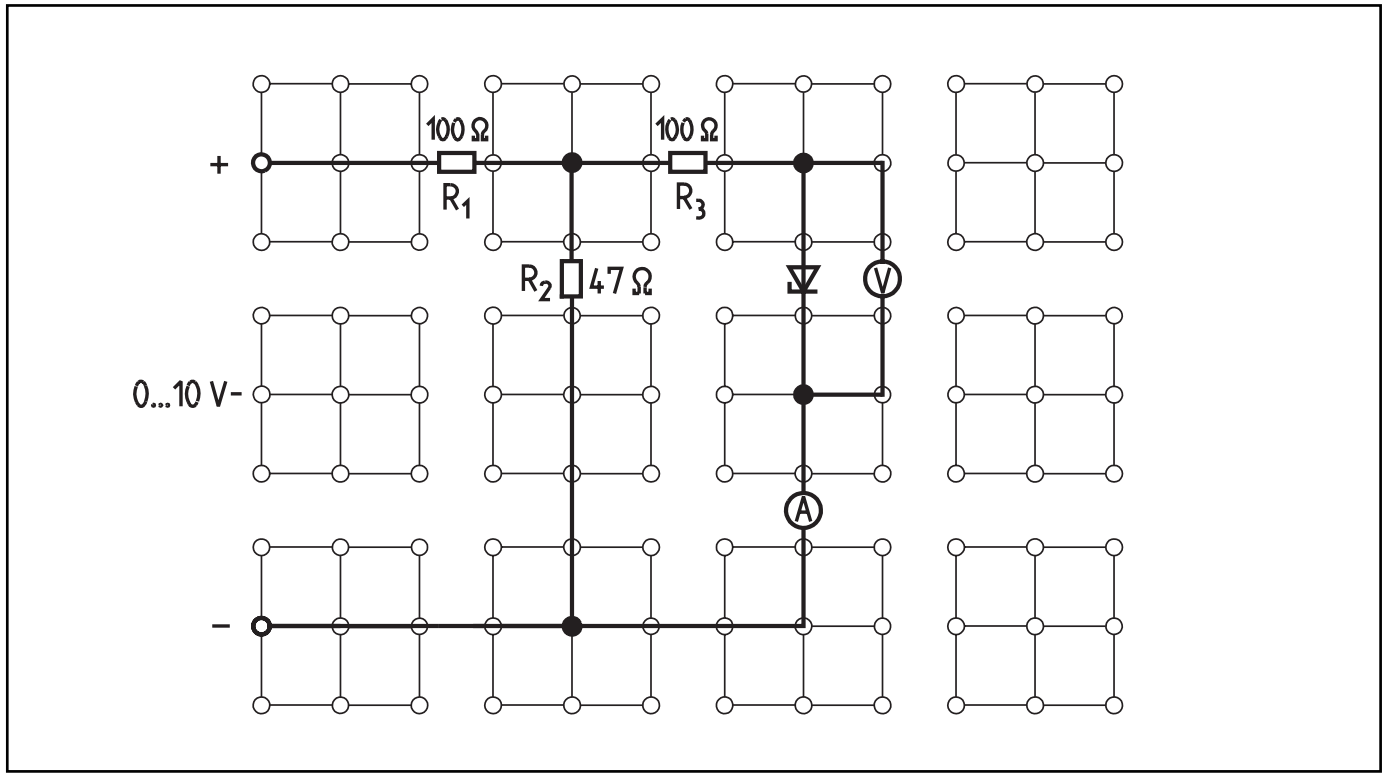
— Set up circuit as shown in Fig. 2.
Note: Make sure to change the polarity of the Z diode.

— Switch measurement range for voltage to 10 V-.

— Switch on power supply unit and increase voltage U_P from 0 V to 10 V in increments of 1 V once again. Measure both reverse voltage U_R and reverse current I_R. Enter measurements in Table 2.

— Switch power supply unit off.

Fig. 1



Measurement Results

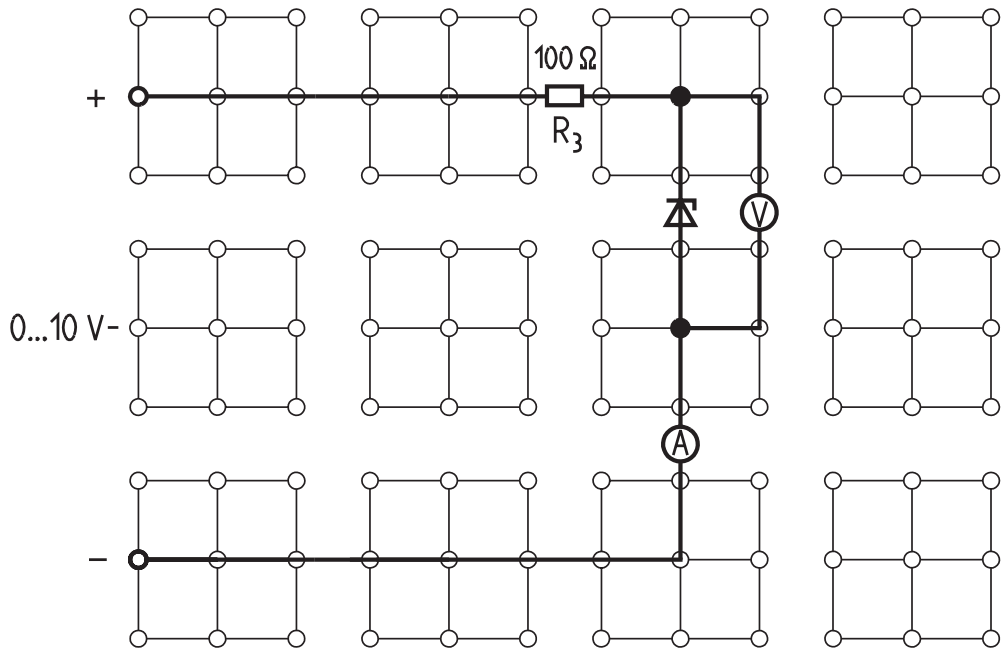
Table 1

Voltage level on power supply unit U_P/V	Forward voltage U_F/V	Forward current I_F/mA
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Table 2

Voltage level on power supply unit U_P/V	Reverse voltage U_R/V	Reverse current I_R/mA
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Fig. 2

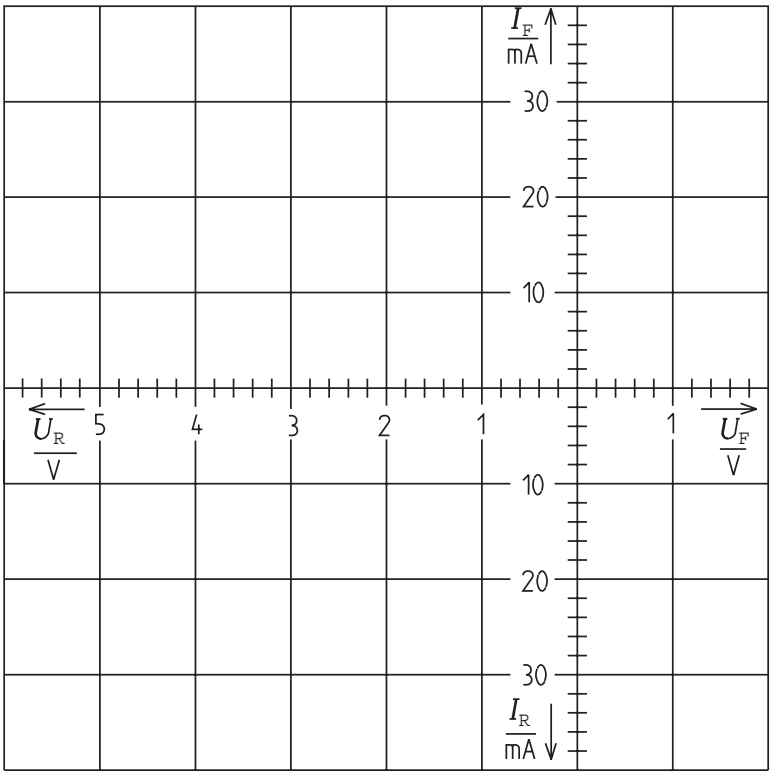


Evaluation

1. Graph the diode current as a function of diode voltage. In the graph, enter the values for voltage and current in reverse direction in the negative range (Fig. 3).
2. Describe the behavior of a Z diode in a circuit. Use the term breakdown voltage in your explanation. Breakdown voltage is the voltage at which a diode connected in reverse direction loses its blocking ability.

3. Answer the question posed in the header.

Fig. 3



4. What purpose does the preconnected resistor R_3 serve?

5. Look at the characteristic curve in Fig. 3 and determine the change in voltage in the reverse direction when the current is increased from 20 mA to 30 mA.
   How can this characteristic of Z diodes be used in practice?

(How do Zener diodes differ from normal rectifier diodes?)

Z diodes are silicone diodes with a high level of p and n area doping. They behave like normal Si-diodes in the forward direction. Voltage connected in the reverse direction produces a strong electrical field in the barrier layer. When the voltage dependent on the pre-selected doping level, the breakdown voltage, is exceeded, the electric field causes pairs of charge carriers to be released, resulting in a sharp increase in current. This causes the diode resistance to decrease. If the external voltage is increased even further, then the diode current increases sharply. This results in an increase in voltage at the preconnected resistor while the increase in voltage at the diode is minimal. It is important to have the right sized preconnected resistor to ensure that the product of the breakdown voltage and diode current (dissipation power) does not exceed the nominal value for the diode type. Exceeding the nominal value alters the barrier layer, rendering it useless and effectively destroying it.
The fact that diode voltage varies only minimally in the breakdown range when the external voltage is varied can be used to create a constant reference voltage and to stabilize voltage. The diode type must be selected according to the desired voltage.

Notes on Set-Up and Procedure
A voltage divider consisting of R_1 and R_2 is preconnected for recording the characteristic curve in the forward direction. This allows the voltage to be set easily in the necessary range from 0 V to about 0.7 V using the potentiometer on the power supply unit.
Voltage from the power supply unit is used to investigate the reverse range of the characteristic curve.
It is not necessary to switch around the connections on the meters and power supply unit when the diode is placed in the circuit with reverse polarity.

Measurement Results
See Tables 1 and 2.

Evaluation
1. See Fig. 3.
2. In the forward direction. Z diodes behave like normal rectifier diodes. No measurable current flows at voltages of less than 0.65 V. The current increases sharply above 0.65 V. In the reverse direction, the current does not start flowing until the breakdown voltage is attained. The breakdown voltage for the diode type used in this experiment is about 4 V. Similar to the forward direction, the current increases sharply with a minimal increase of voltage.
3. Z diodes only differ from Si-diodes when they are connected with reverse polarity. While normal diodes block the current at voltages of up to several 100 V, Z diodes suddenly lose their blocking ability at voltages of just a few volts. The voltage at the diode varies only minimally when the current fluctuates.

Table 1: Z diode in forward direction

Voltage level on power supply unit U_P/V	Forward voltage U_F/V	Forward current I_F/mA
0	0.00	0
1	0.33	0
2	0.58	0
3	0.70	1.5
4	0.72	2.5
5	0.73	4.0
6	0.74	6.0
7	0.75	7.0
8	0.75	8.5
9	0.76	11.0
10	0.77	12.5

Table 2: Z diode in reverse direction

Voltage level on power supply unit U_P/V	Reverse voltage U_R/V	Reverse current I_R/mA
0	0	0
1	1	0
2	2.1	0
3	2.8	0
4	3.9	1
5	4.5	3.2
6	4.6	7.8
7	4.7	11.5
8	4.7	20.0
9	4.8	27.5
10	4.8	30.0

(How do Zener diodes differ from normal rectifier diodes?)

4. The preconnected resistor is there to limit the current. Otherwise, the diode might get too warm and be destroyed.

5. When the current is increased from 20 mA to 30 mA,the voltage at the diode only increases by 0.1 V. This characteristic of Z diodes is useful in creating small and stabile direct voltage.

Fig. 3