The Darlington circuit (Item No.: P1402000)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 16-19	Electricity	Electronics	The Darlington circuit

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Difficult	10 Minutes	10 Minutes	2 Students

Additional Requirements:

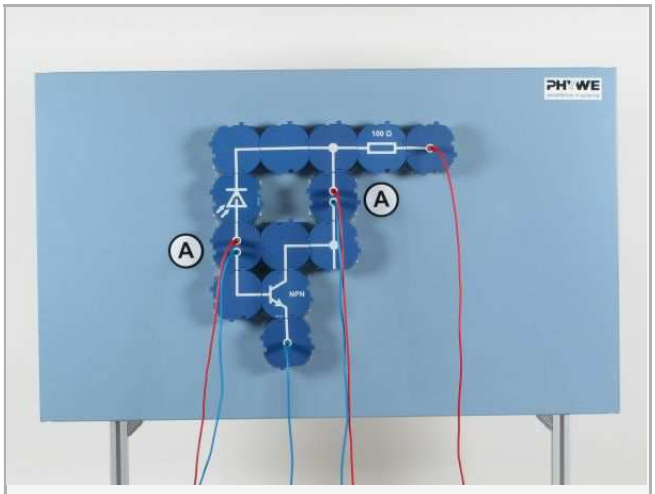
Experiment Variations:

Keywords:

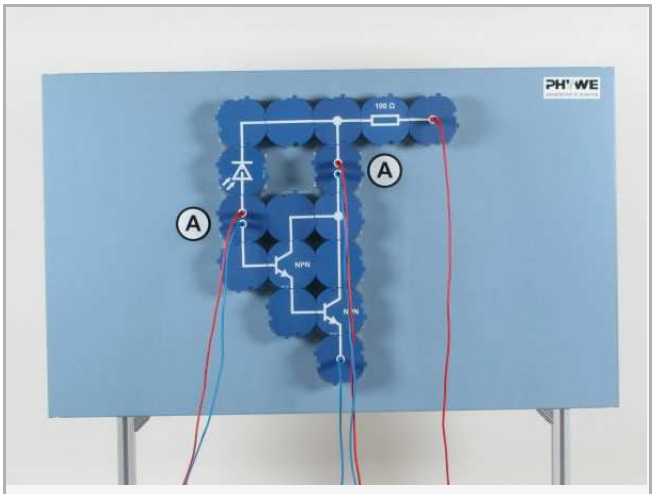
Principle and equipment

Principle

It is to be shown that current amplification can be substantially increased by the combination of two transistors in a Darlington circuit.



Experimental set-up Part 1



Experimental set-up Part 2

Equipment

Position No.	Material	Order No.	Quantity
1	Multimeter ADM2, demo., analogue	13820-01	2
2	PHYWE power supply, universal DC: 0...18 V, 0...5 A / AC: 2/4/6/8/10/12/15 V, 5 A	13500-93	1
3	Demo Physics board with stand	02150-00	1
4	Transistor BC337,module DB	09456-00	2
5	Clamp on holder	02164-00	1
6	Connector interrupted, module DB	09401-04	2
7	Junction, module DB	09401-10	2
8	Resistor 100 Ohm,module DB	09413-10	1
9	Photodiode,module DB	09453-00	1
10	Connector, straight, module DB	09401-01	2
11	Connector, angled, module DB	09401-02	4
12	Connector, T-shaped, module DB	09401-03	2
13	Boss head	02043-00	1
14	Universal clamp	37715-00	1
15	Support rod, stainless steel, 500 mm	02032-00	1
16	Flashlight, w/o battery,medium	08164-00	1
17	Connecting cord, 32 A, 1000 mm, red	07363-01	3
18	Connecting cord, 32 A, 1000 mm, blue	07363-04	3
19	Battery cell, 1.5 V, baby size, type C	07922-01	2

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Set-up and procedure

1st. Experiment

- Label the transistors as T $_1$ and T $_2$
- Set up the experiment as shown in Fig. 1 with transistor T_1 ; select the 1 0 IJA measurement range for the measuring instrument in the base circuit
- Select the 3 mA measurement range for the measuring instrument in the collector circuit
- Set the power supply to a voltage of 6 V-
- Fix the torch to the edge of the board with the holding material and use it to so light the photodiode, that the photocurrent does not exceed the value of $I_B = 5\mu A$
- Note the values measured for the base current and the collector current of the transistor
- Repeat this procedure using transistor T $_2$

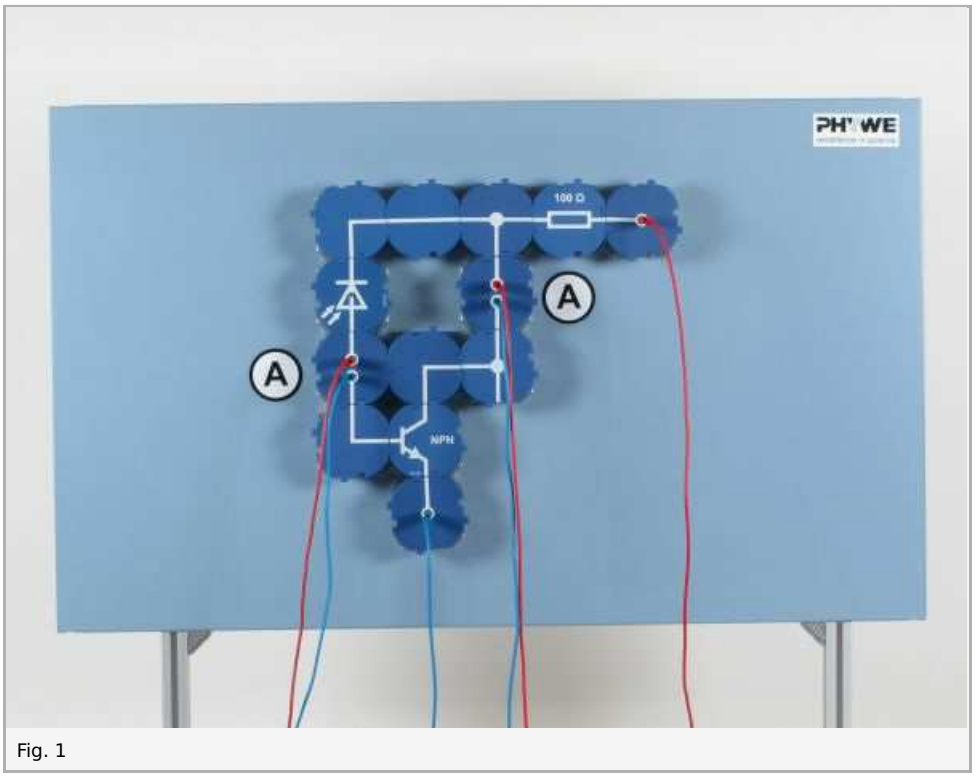

Fig. 1

2nd. Experiment

- **Extend the experimental set-up as shown in Fig. 2 and switch over to the 100 mA measurement range for the collector current I $_{CD}$**
- **Note the value measured for the collector current I $_{CD}$ of the Darlington circuit**
- **Illuminate the photodiode as in the 1st. experiment; note the value measured for the base current I $_{BD}$ of the Darlington circuit**

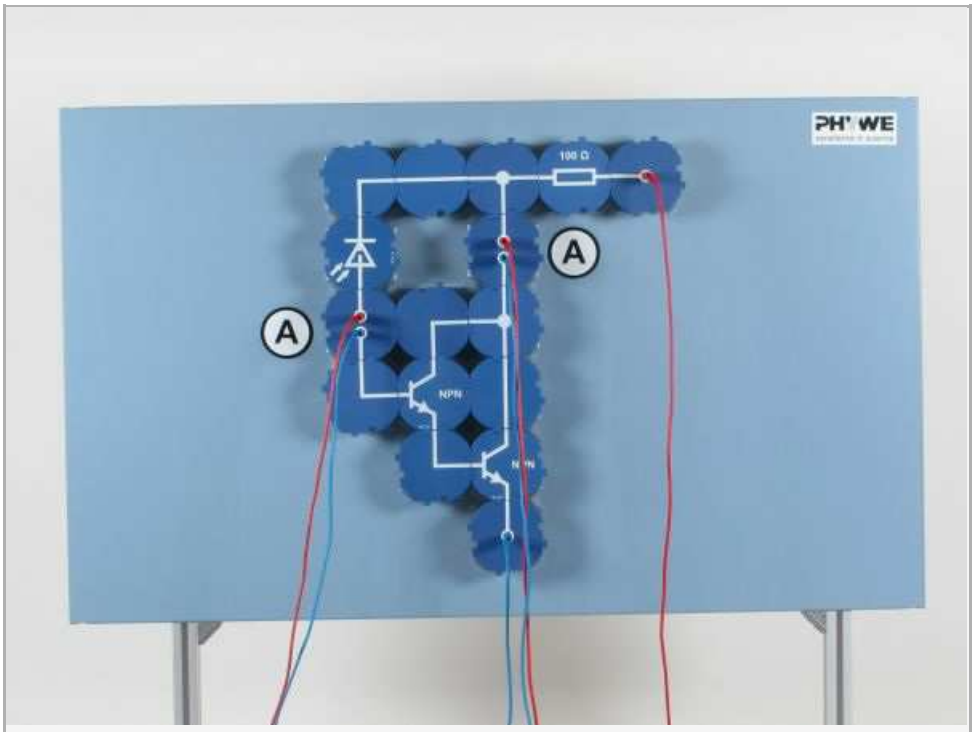

Fig. 2

Observation and evaluation

Observation

$I_{\mathrm{CD}} = 51\ \mathrm{mA}$
$I_{\mathrm{BD}} = 0.4\ \mu A$

Table 1

Transistor	Base current	Collector current
T_1	$I_{\mathrm{B1}} = 3\ \mu A$	$I_{\mathrm{C1}} = 1.25\ \mathrm{mA}$
T_2	$I_{\mathrm{B2}} = 3\ \mu A$	$I_{\mathrm{C2}} = 0.85\ \mathrm{mA}$

Evaluation

The photocurrent of the photodiode is amplified by transistor T_1 from $I_{\mathrm{B1}} = 3\ \mu\mathrm{A}$ auf $I_{\mathrm{C1}} = 1,25\ \mathrm{mA}$. When the circuit is expanded to a Darlington circuit by a second transistor, then the current is amplified further from $I_{\mathrm{C1}} = 1,25\ \mathrm{mA}$ to $I_{\mathrm{CD}} = 51\ \mathrm{mA}$. The current has so been increased by a factor of approx. 17,000.

In a Darlington circuit, the emitter current that is amplified by the first transistor is used as base current for the second transistor, where further amplification occurs. The total current amplication of a Darlington circuit is approximately equal to the product of the current amplifications of the individual transistors:

$B_{\mathrm{ges}} \approx B_1 \cdot B_2$

Table 2

Transistor	Amplification
T_1	$B_1 = \frac{I_{C1}}{I_{B1}} = 417$
T_2	$B_2 = \frac{I_{C2}}{I_{B2}} = 283$
Darlington circuit	$B_{tot} = \frac{I_{CD}}{I_{BD}} = 127500$
	$B_1 \cdot B_2 = 118000$

Remarks

The amplification values of the transistors used can differ greatly from each other. For this reason, the measured values determined may differ greatly from those given here. The 100 Ω resistor serves to limit the collector current and so to hinder thermal destruction of the transistors.