



# Elektrotechnika i elektronika

Wykład 2

Dr inż.  
Patrik Król

v2021/3

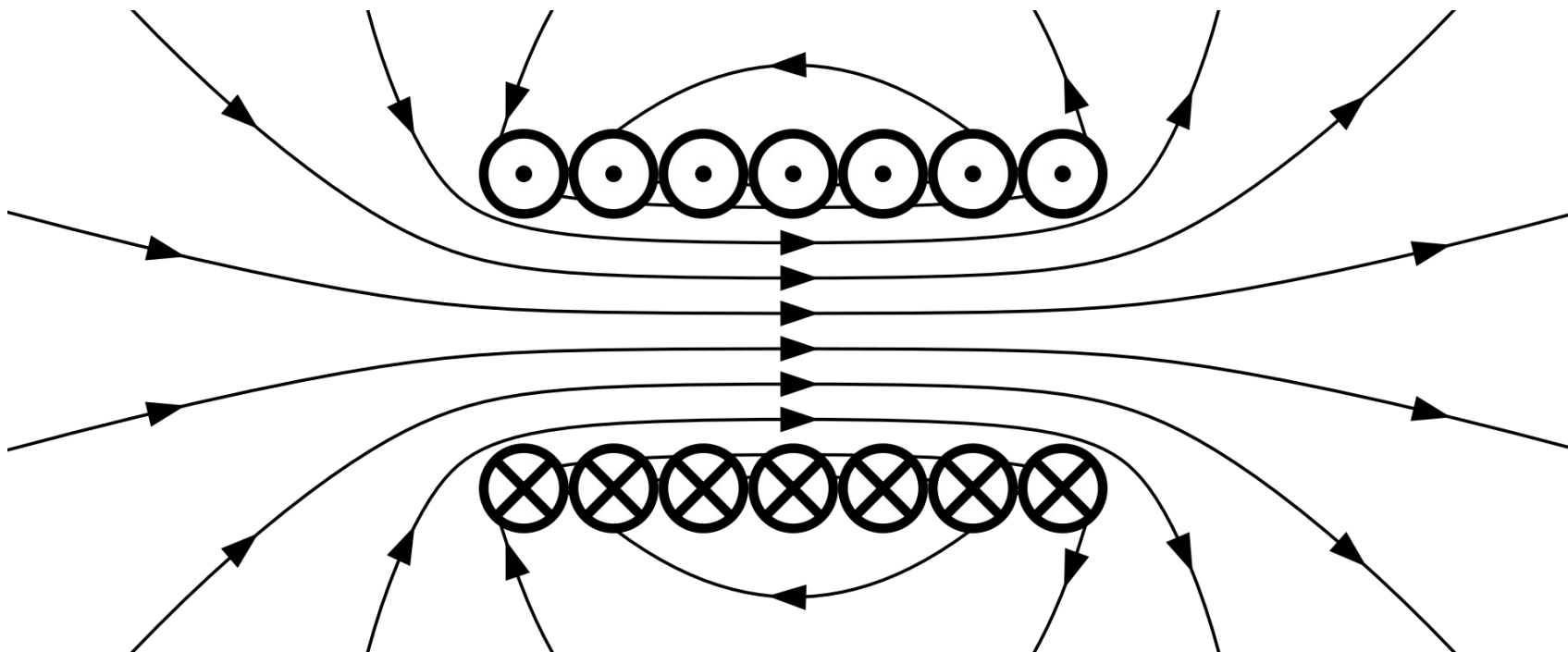
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# Wykład 2

- Pole elektromagnetyczne
- Podstawowe podzespoły cd.: przekaźnik (elektromagnes), tranzystory
- Prąd stały, prąd zmienny
- Silniki elektryczne
- Prądnice
- Karta charakterystyki – co to jest i jak czytać

# Pole elektromagnetyczne



Źródło: [https://en.wikipedia.org/wiki/Electromagnetic\\_field](https://en.wikipedia.org/wiki/Electromagnetic_field)

# Cewka



[loudspeakershop.eu](http://loudspeakershop.eu)

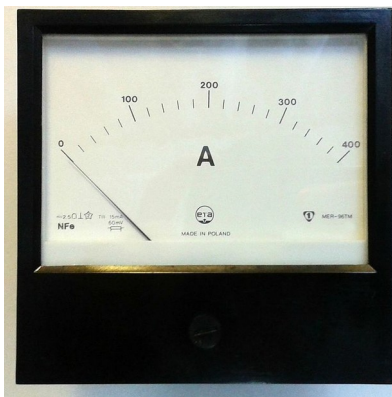
# Elektromagnes



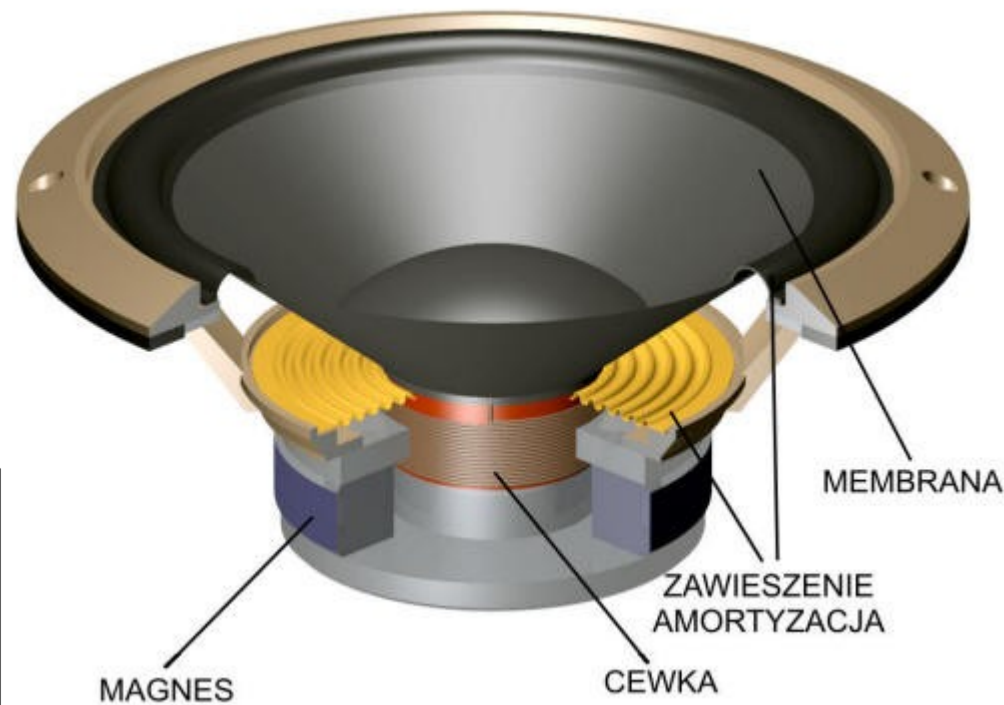
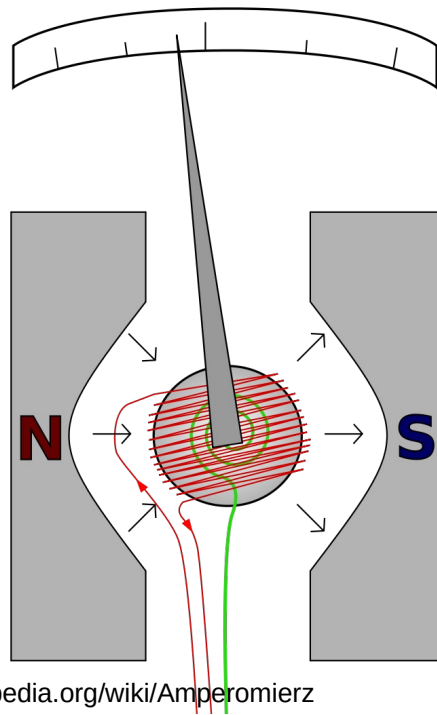
# Gdzie jeszcze może być wykorzystywane to zjawisko?



Źródło: electricmobile.pl

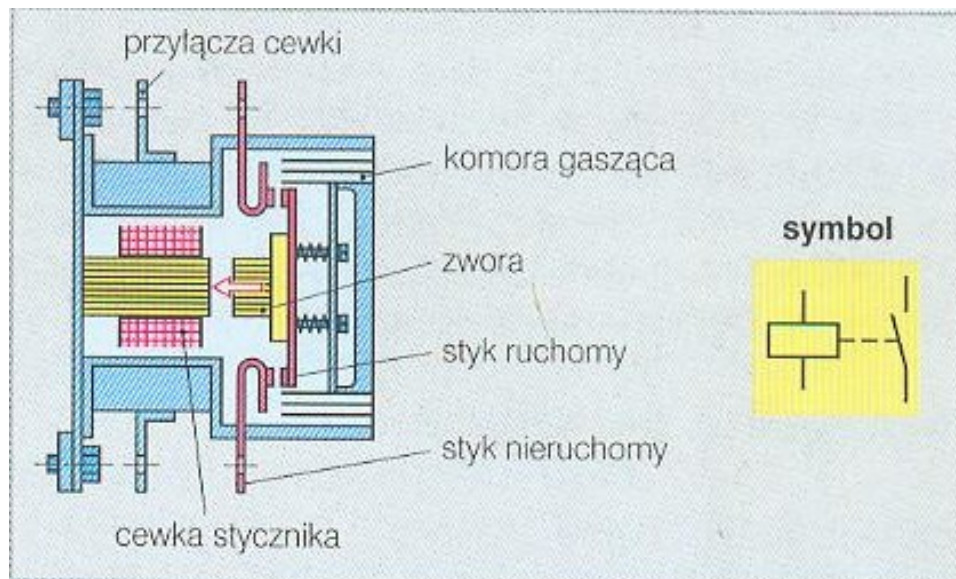


Źródło: <https://pl.wikipedia.org/wiki/Amperomierz>



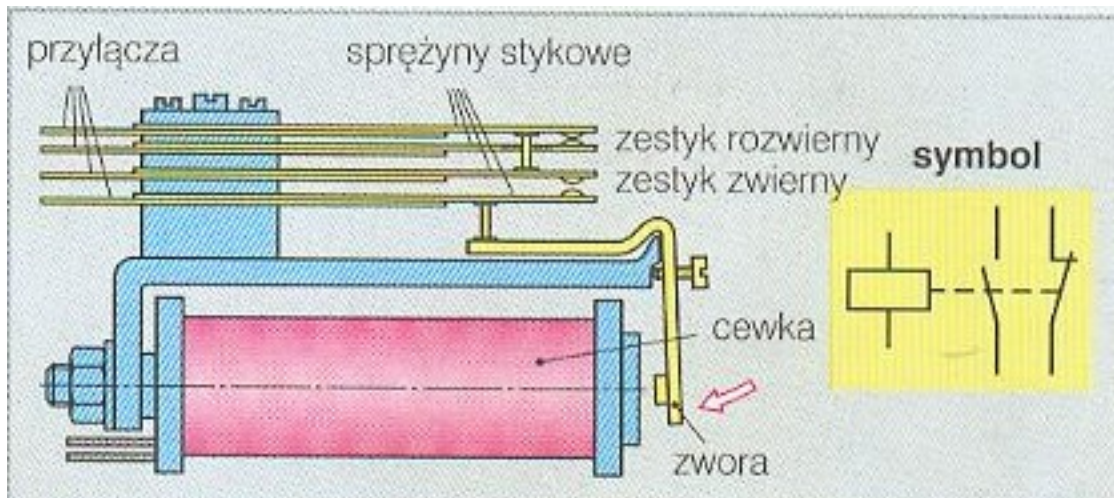
Źródło: [https://eduinf.waw.pl/inf/prg/009\\_kurs\\_avr/2015.php](https://eduinf.waw.pl/inf/prg/009_kurs_avr/2015.php)

# Stycznik



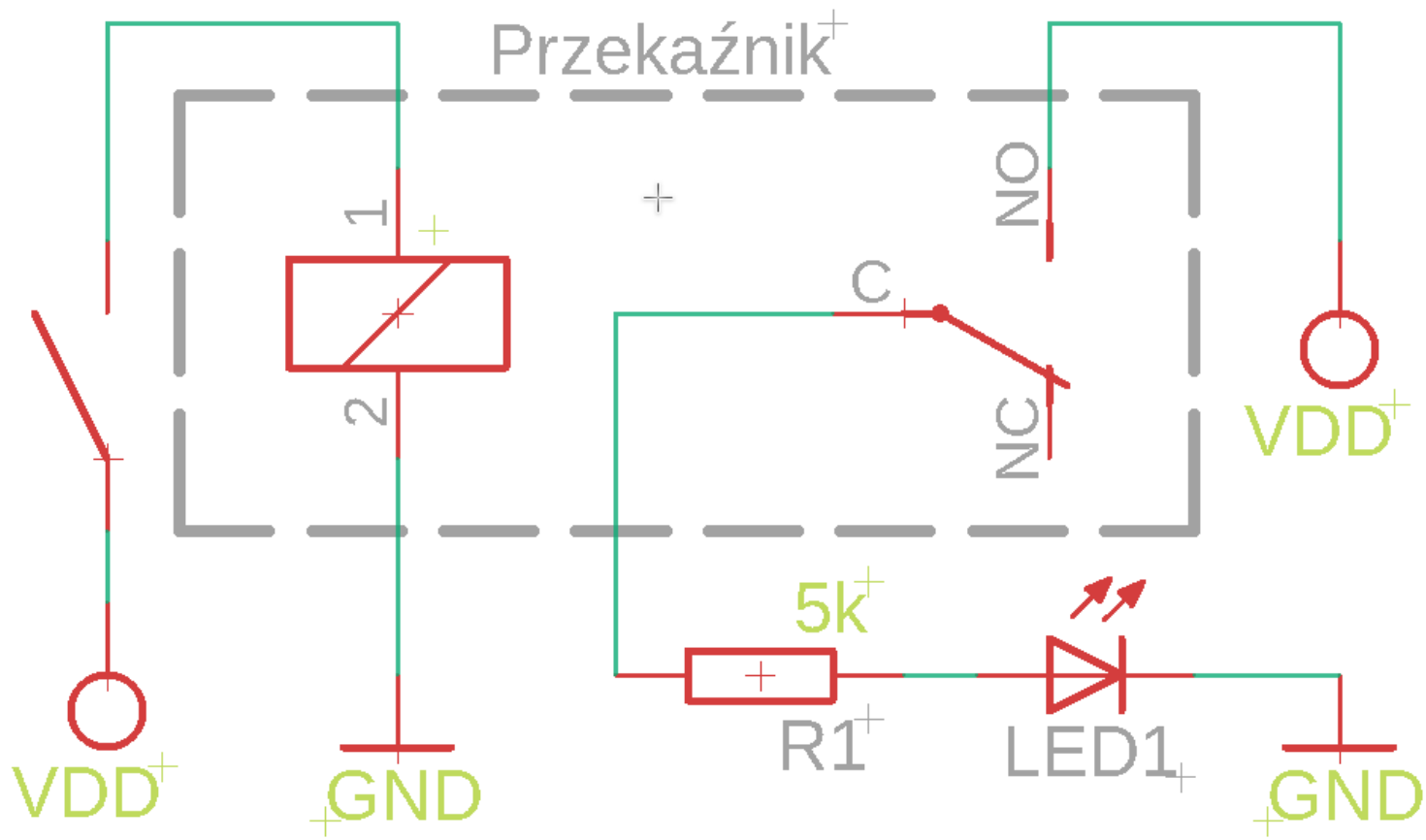


# Przełącznik





# Przełącznik



# Tranzystory - historia



Replika pierwszego działającego tranzystora z 1947

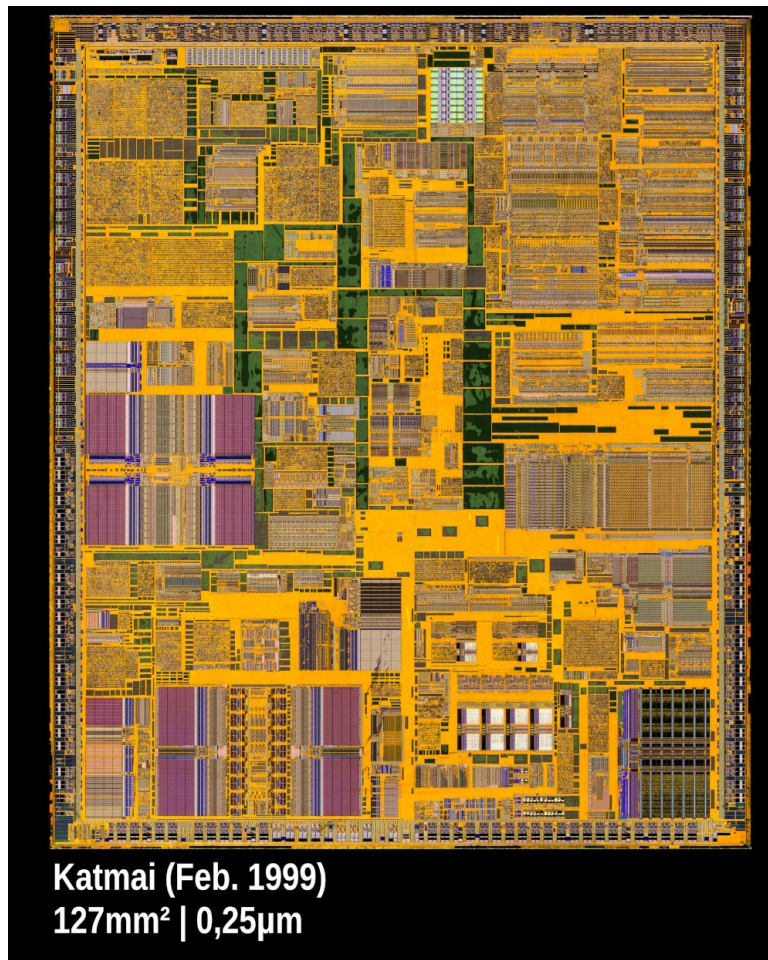
(Źródło: <https://pl.wikipedia.org/wiki/Tranzystor>)

# Dygresja: o procesorach



Rok 1999: Intel Pentium III,  
9.5 + 25 milionów tranzystorów

(źródło: <https://www.purepc.pl/pamietacie-intel-pentium-iii-pierwszy-model-pojawil-sie-20-lat-temu>)



**Katmai (Feb. 1999)**  
**127mm<sup>2</sup> | 0,25µm**

Źródło: <https://www.flickr.com/photos/130561288@N04/37346274254/in/album-72157650403404920/>

Dla ciekawskich:

<https://pl.wikipedia.org/wiki/Fotolitografia> + YT

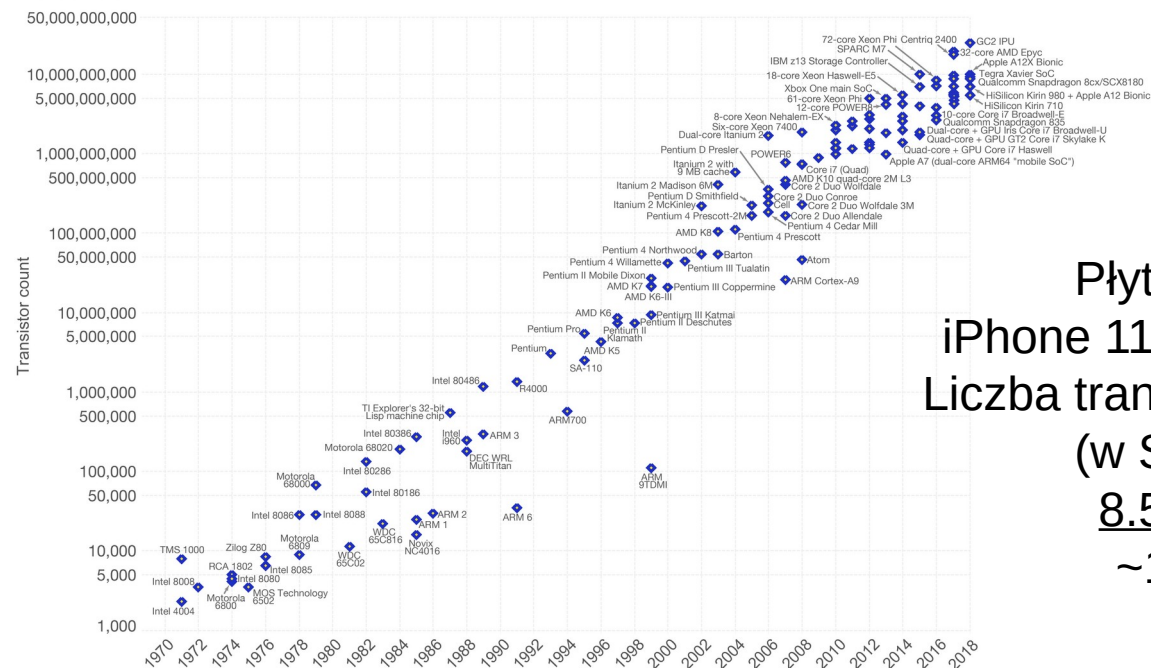


# Tranzystory – terazniejszość?

Moore's Law – The number of transistors on integrated circuit chips (1971-2018)

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's law.

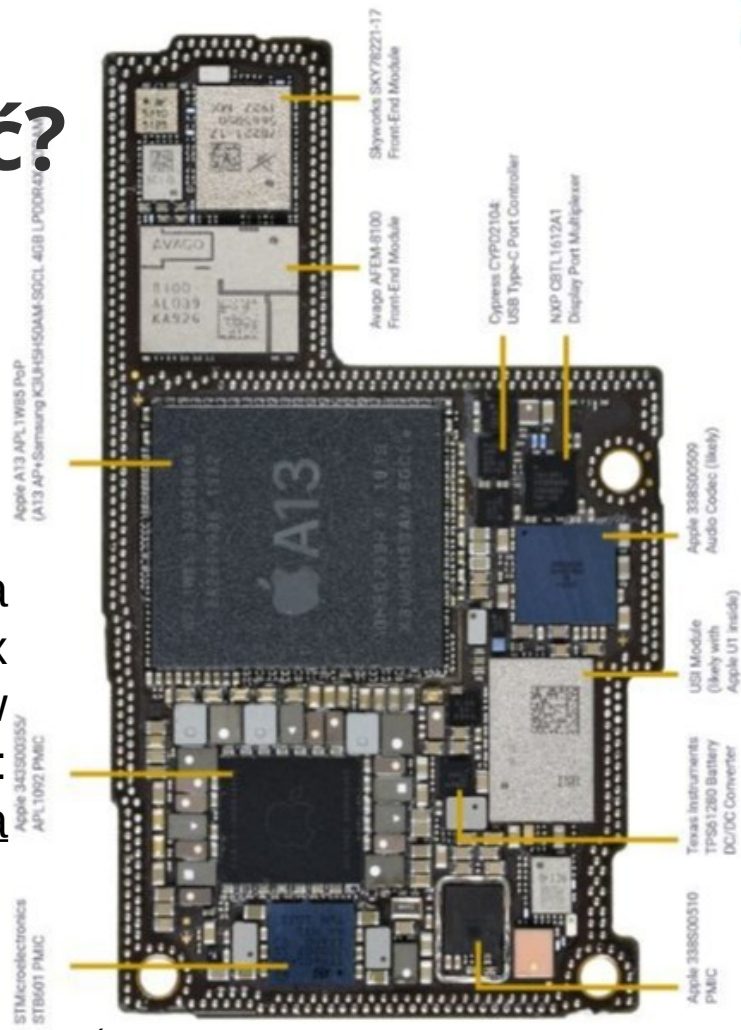
OurWorld  
in Data



Data source: Wikipedia ([https://en.wikipedia.org/wiki/Transistor\\_count](https://en.wikipedia.org/wiki/Transistor_count))  
The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.

Licensed under CC-BY-SA by the author Max Roser.

Płyta główna  
iPhone 11 Pro Max  
Liczba tranzystorów  
(w Soc A13):  
8.5 miliarda  
~100 mm<sup>2</sup>



Źródło: <https://www.vw01.net/en/archives/19185>

Źródło: [https://en.wikipedia.org/wiki/Transistor\\_count](https://en.wikipedia.org/wiki/Transistor_count)

# Co robi tranzystor?

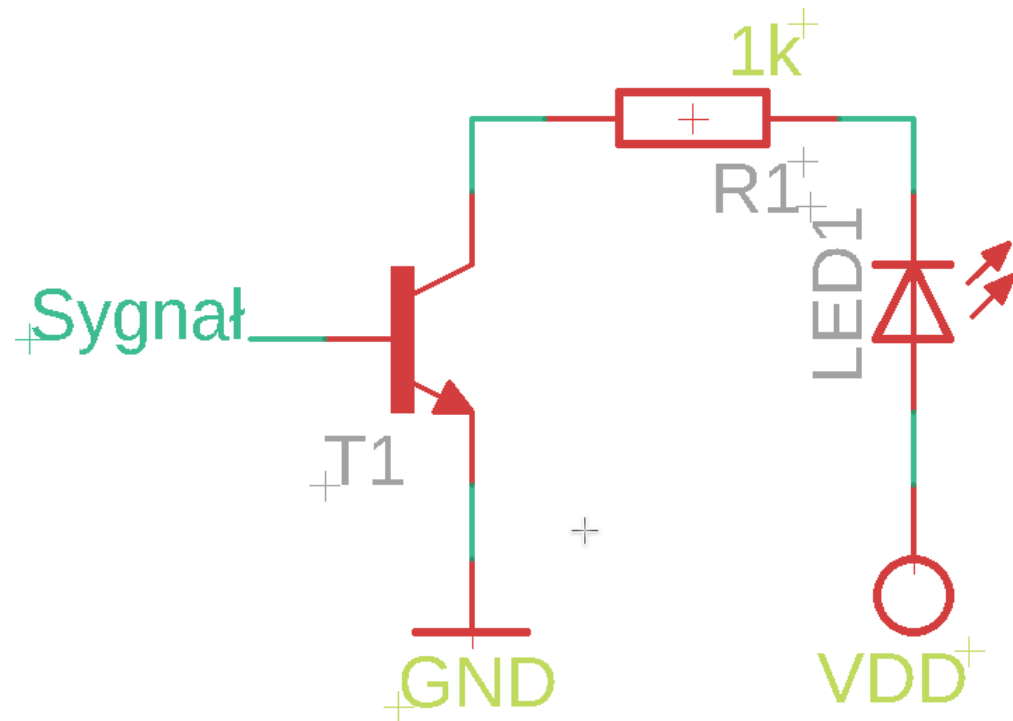
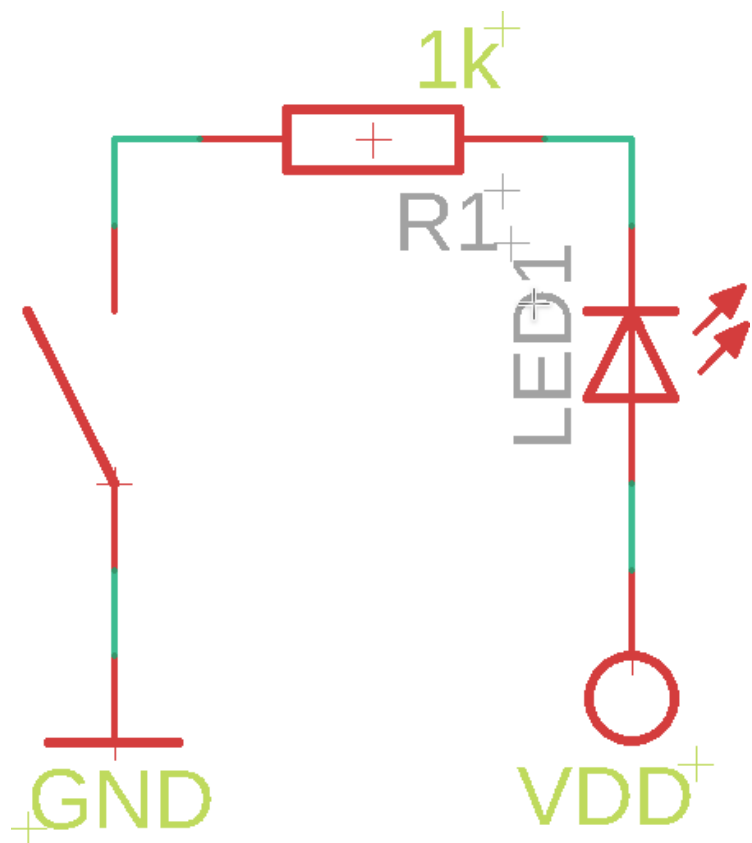


Źródło: <https://www.piekarz.pl/25377-przelacznik-tn3-b-101/>



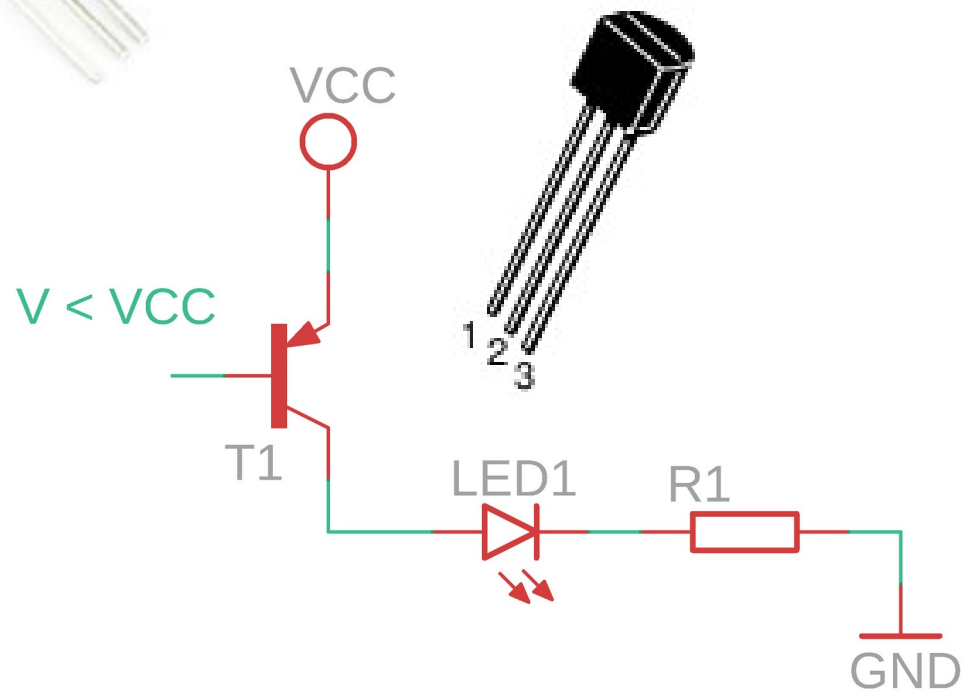
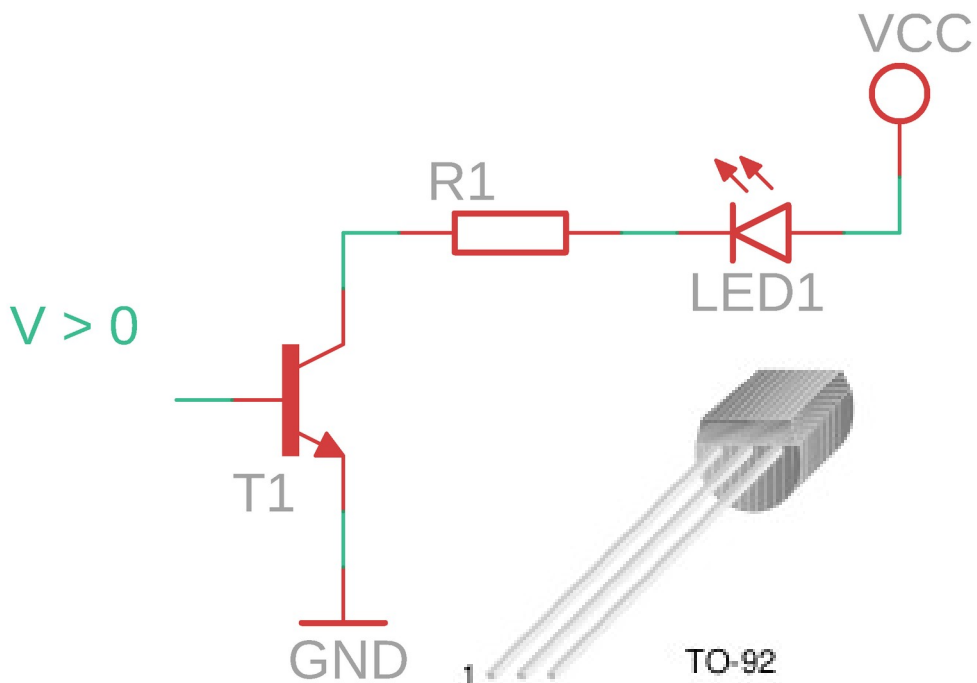
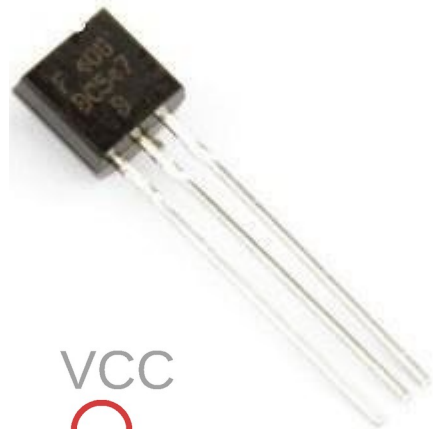
Źródło: [https://en.wikipedia.org/wiki/Audio\\_power\\_amplifier](https://en.wikipedia.org/wiki/Audio_power_amplifier)

# Tranzystor jako włącznik





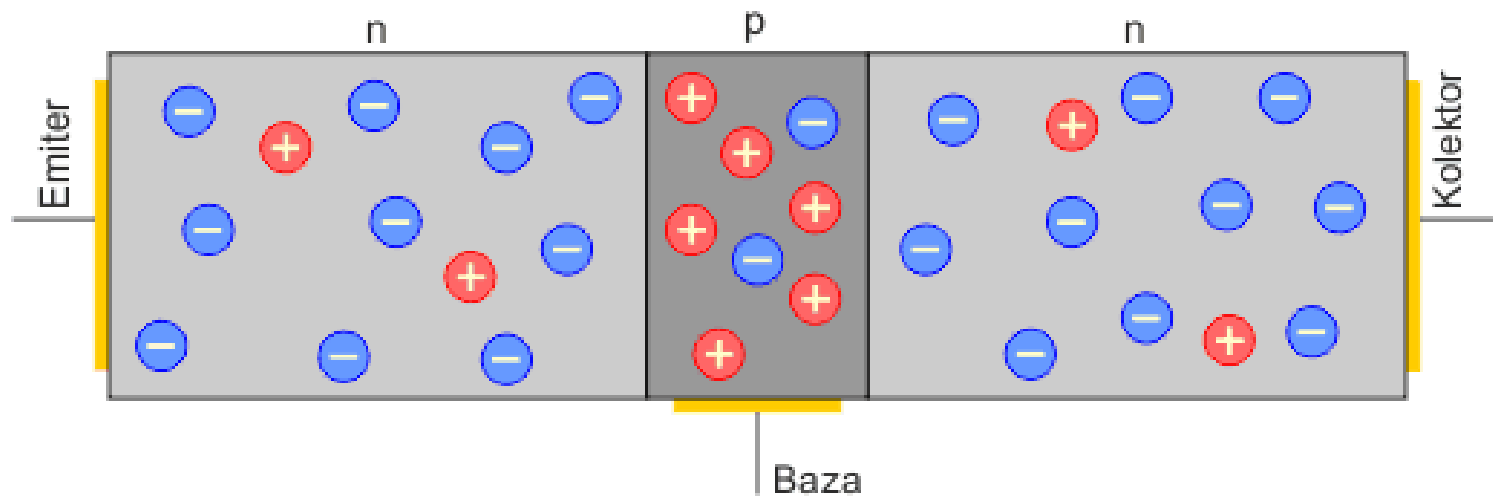
# NPN i PNP



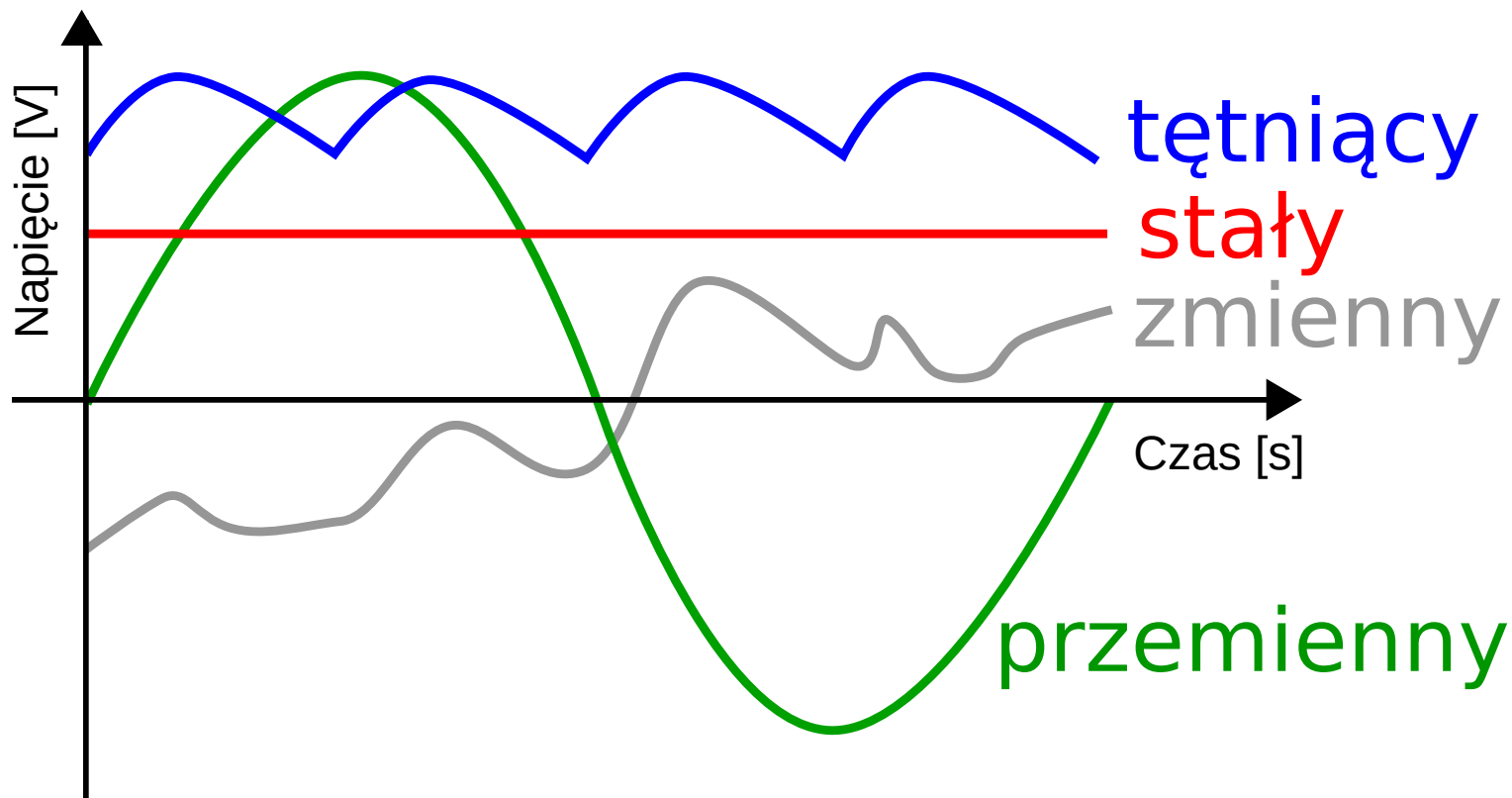
# Inne obudowy



# Jak działa tranzystor?



# Prąd stały i prąd zmienny

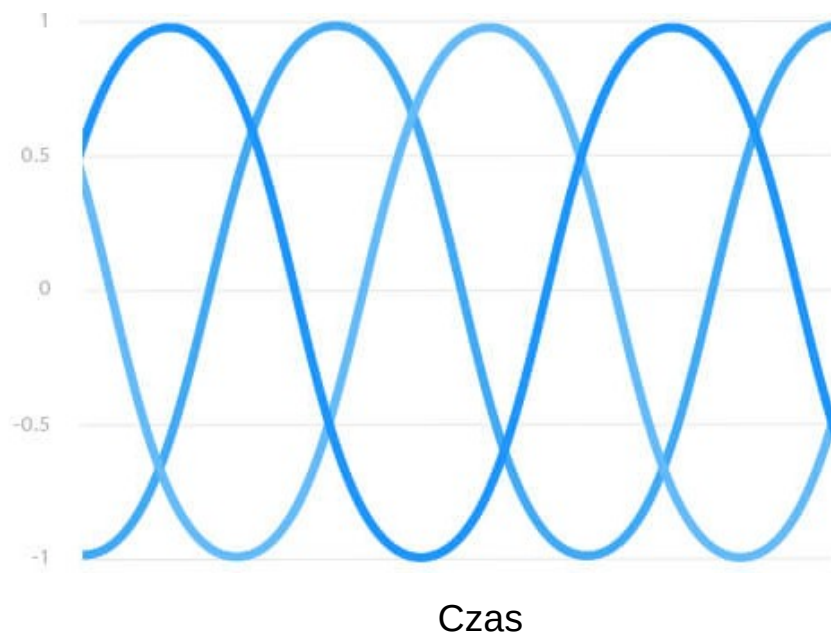


# Prąd jedno- i trójfazowy

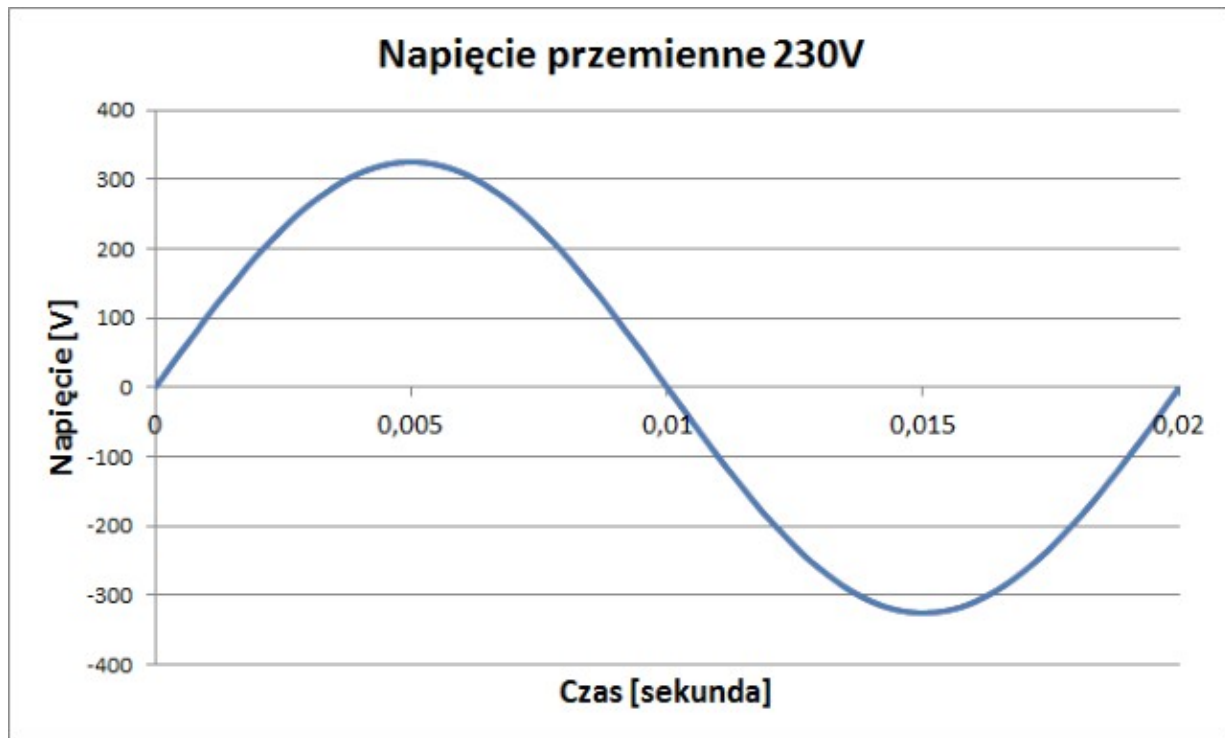
Jednofazowy



Trójfazowy



# Napięcie znamionowe a skuteczne



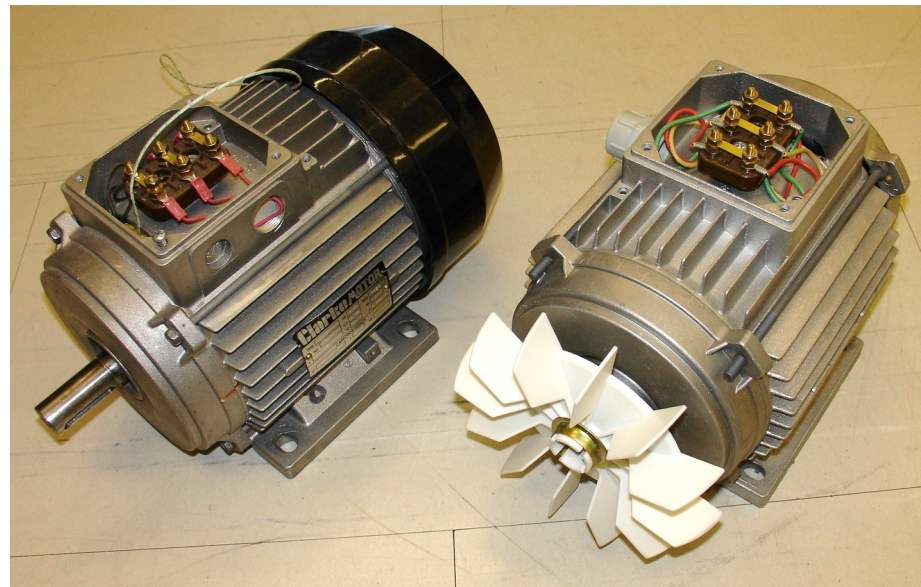
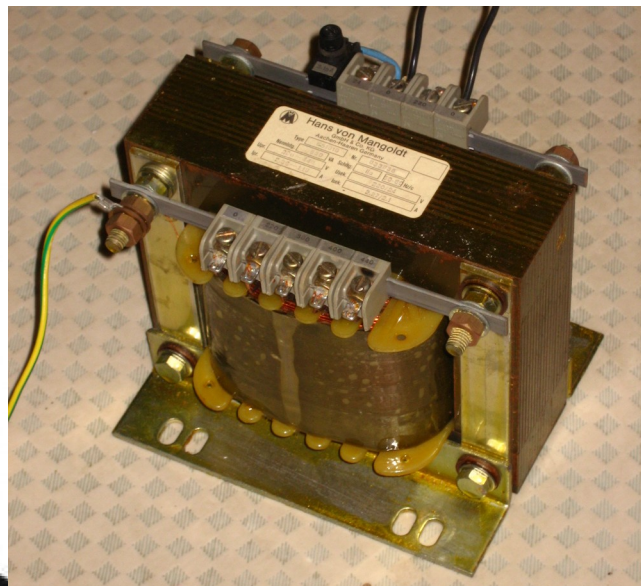
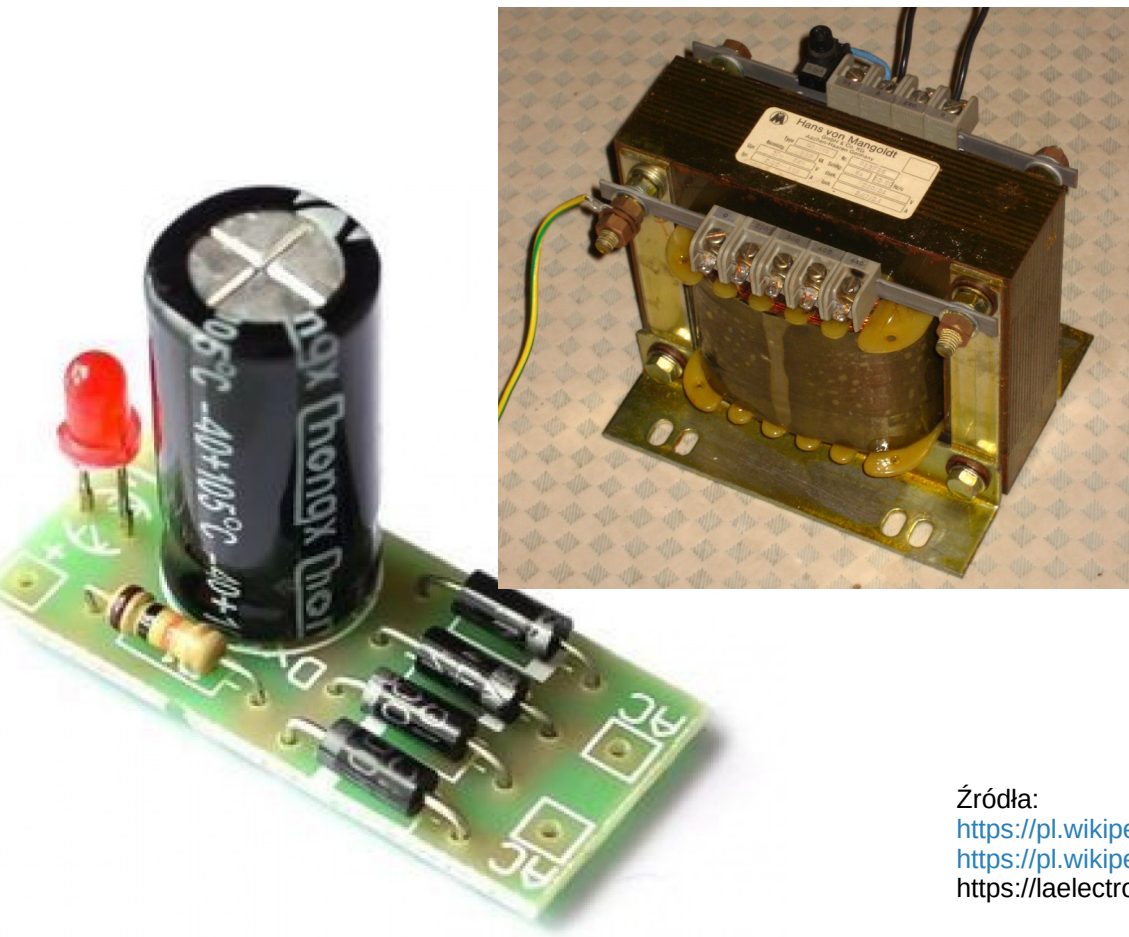
$$U_{sk} = \frac{U_o}{\sqrt{2}}$$

$U_o$  – amplituda napięcia (wartość szczytowa)

$U_{sk}$  – napięcie skuteczne



# Do czego używa się prądu zmiennego?



Źródła:

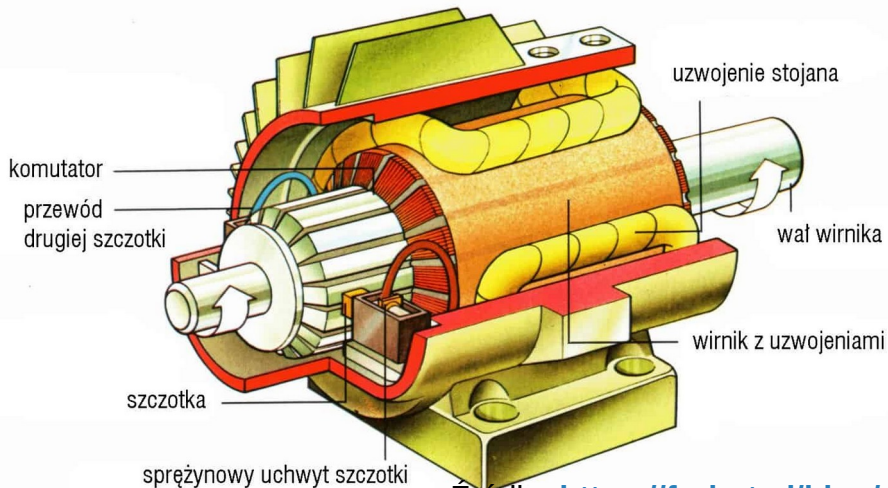
[https://pl.wikipedia.org/wiki/Silnik\\_elektryczny](https://pl.wikipedia.org/wiki/Silnik_elektryczny)

<https://pl.wikipedia.org/wiki/Transformator>

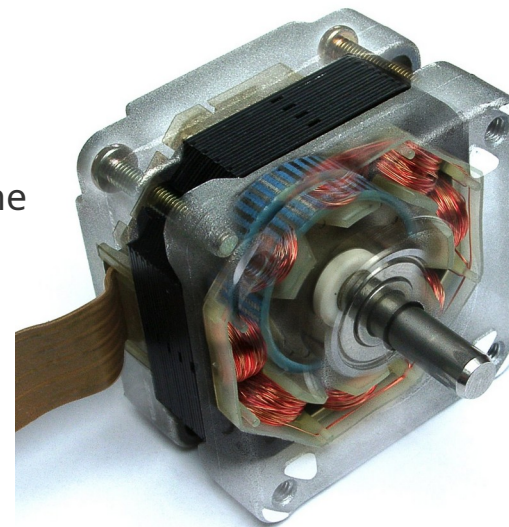
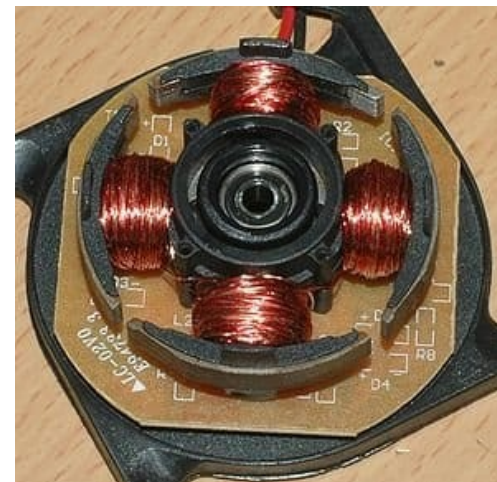
<https://laelectronica.com.gt/modulo-rectificador-de-ac-dc-de-6v16v-1a>

# Silniki elektryczne

- Silniki komutatorowe (szczotkowe)
  - Szeregowy,
  - Bocznikowy,
  - Szeregowo-bocznikowy

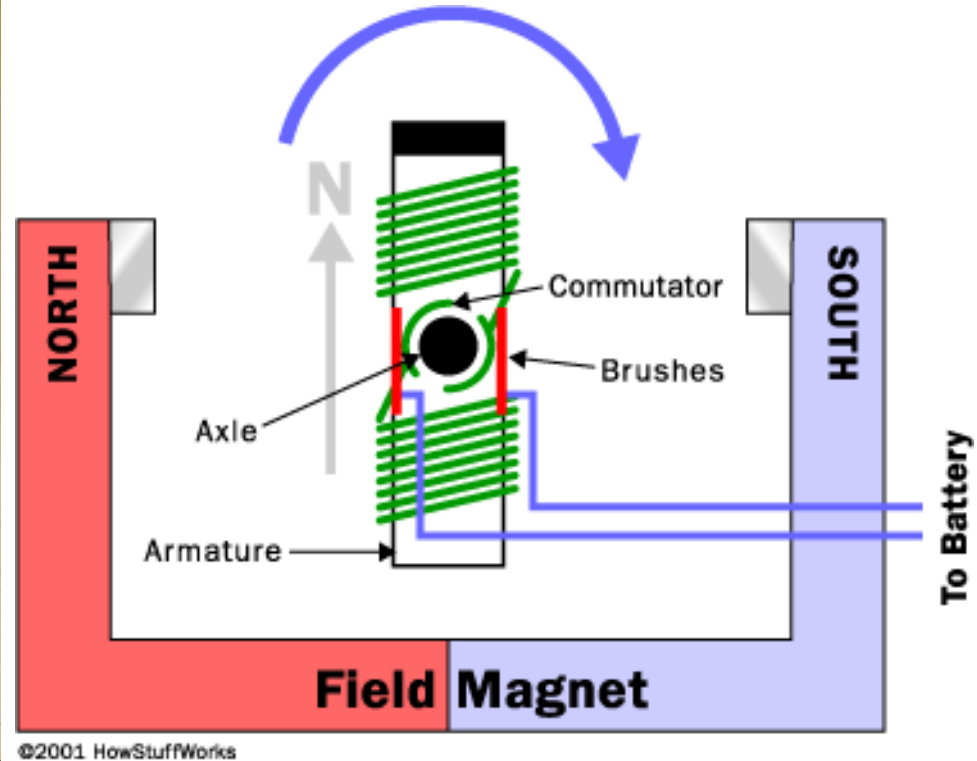
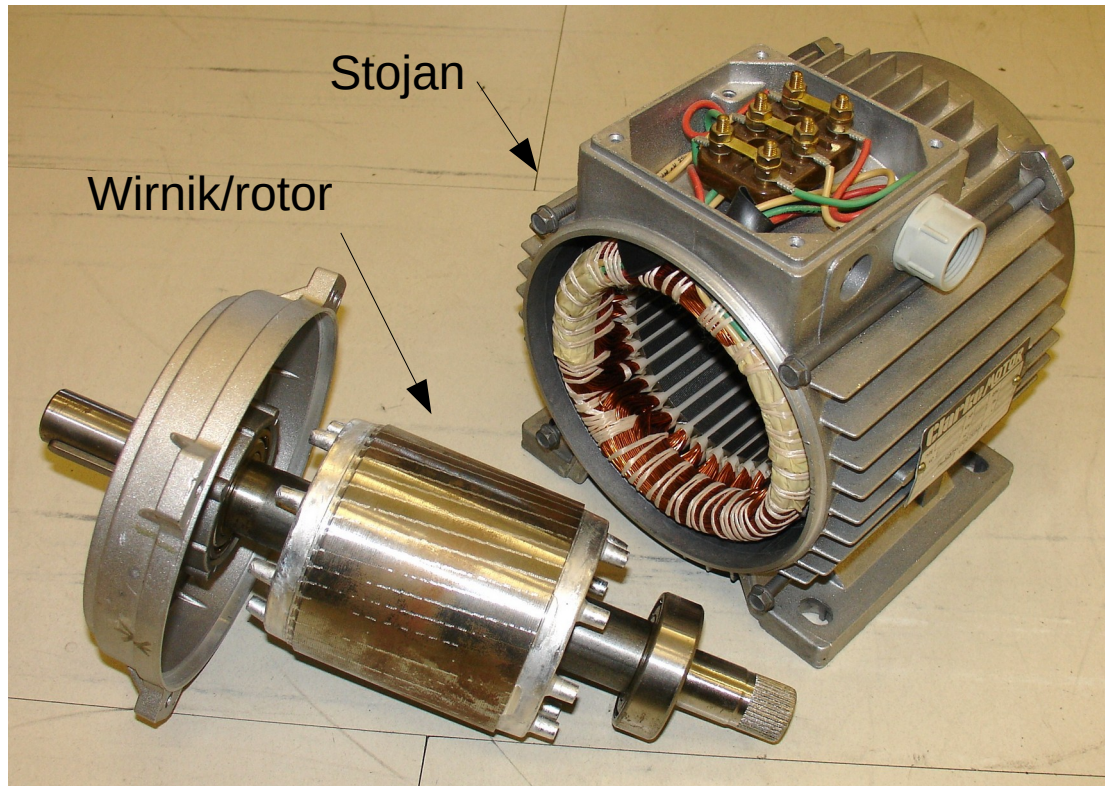


- Bezszczotkowe
  - BLDC
- Silniki krokowe
  - Bipolarne
  - Unipolarne

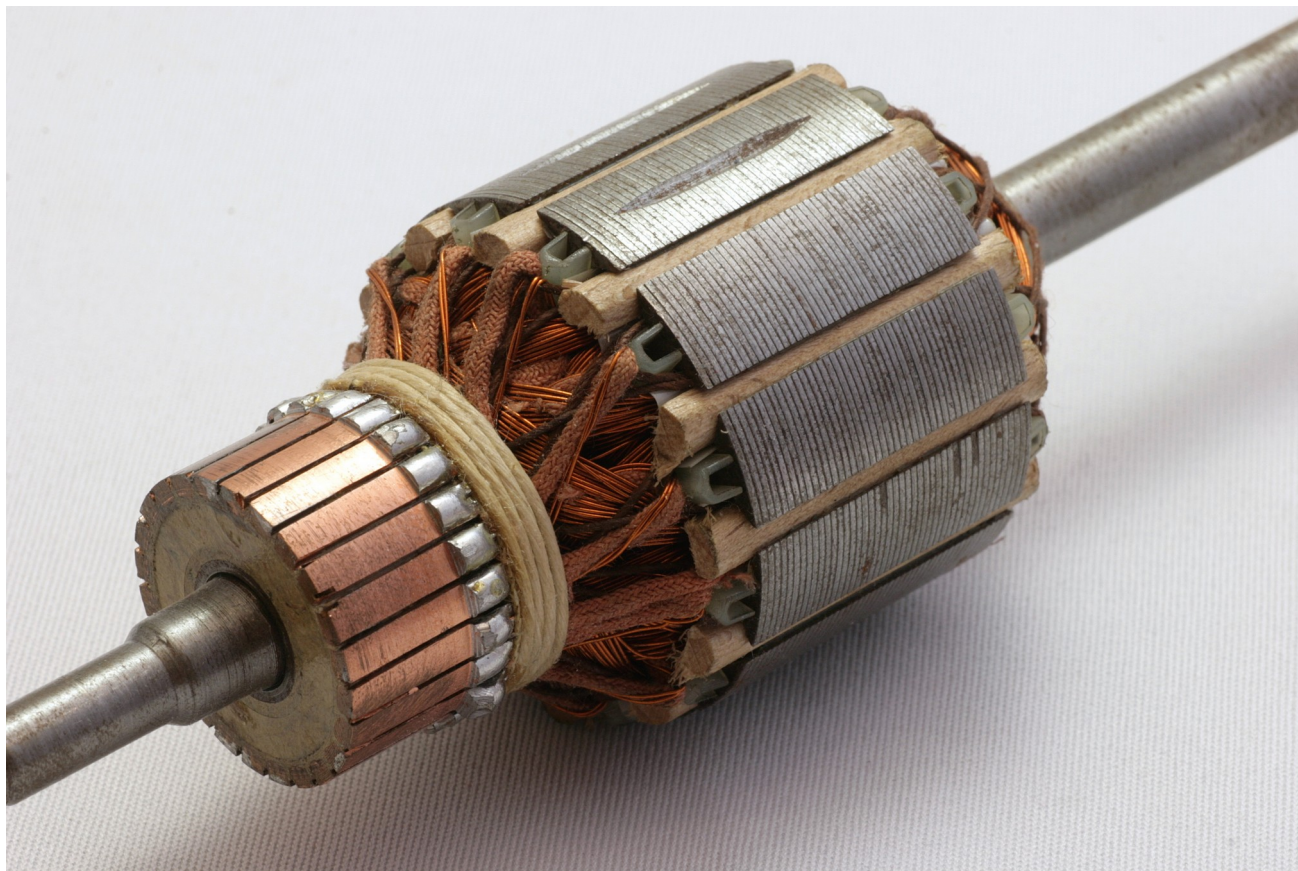
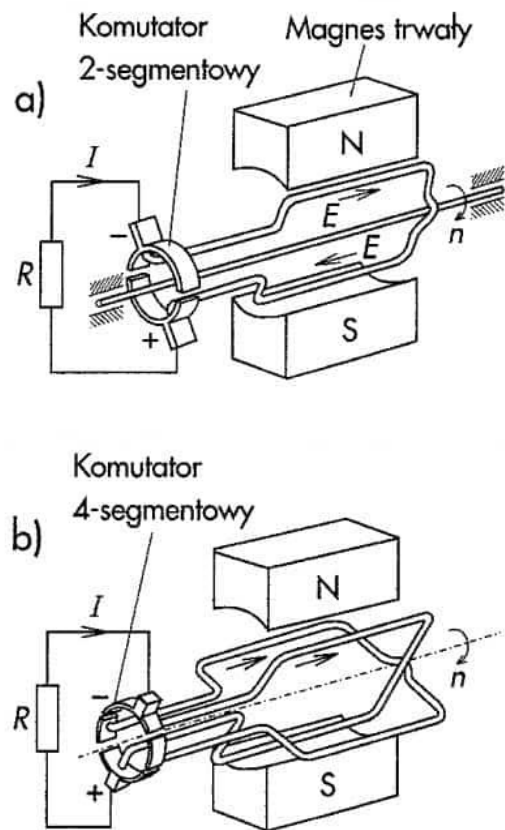




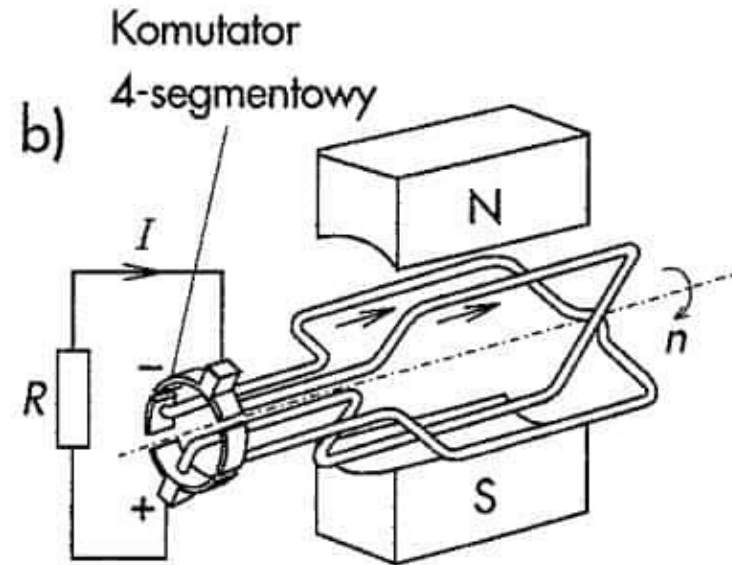
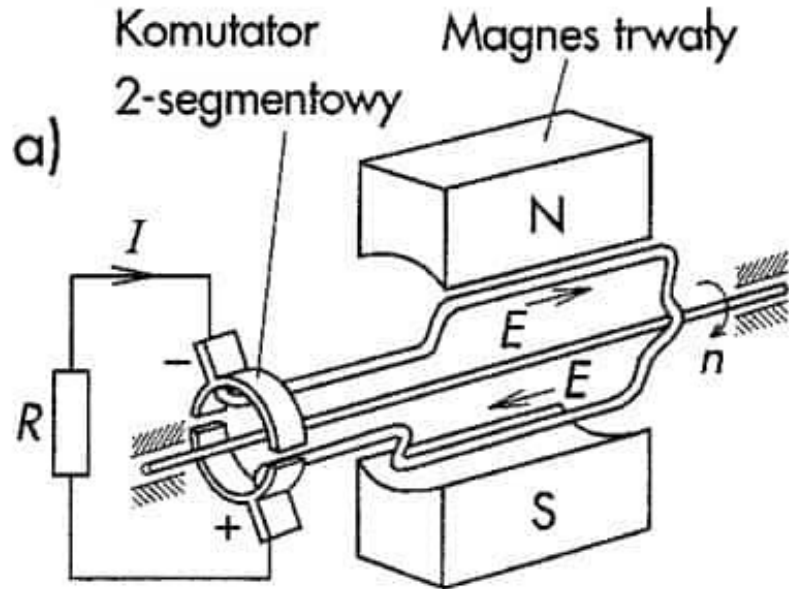
# Jak działa silnik elektryczny?



# Silnik szczotkowy (komutatorowy)

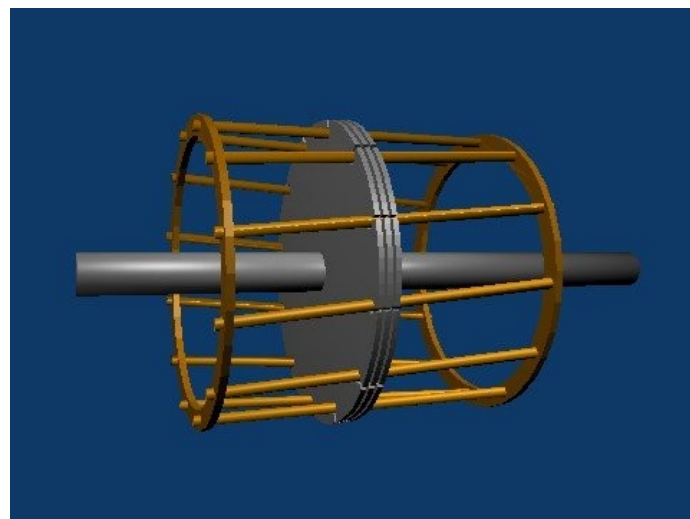
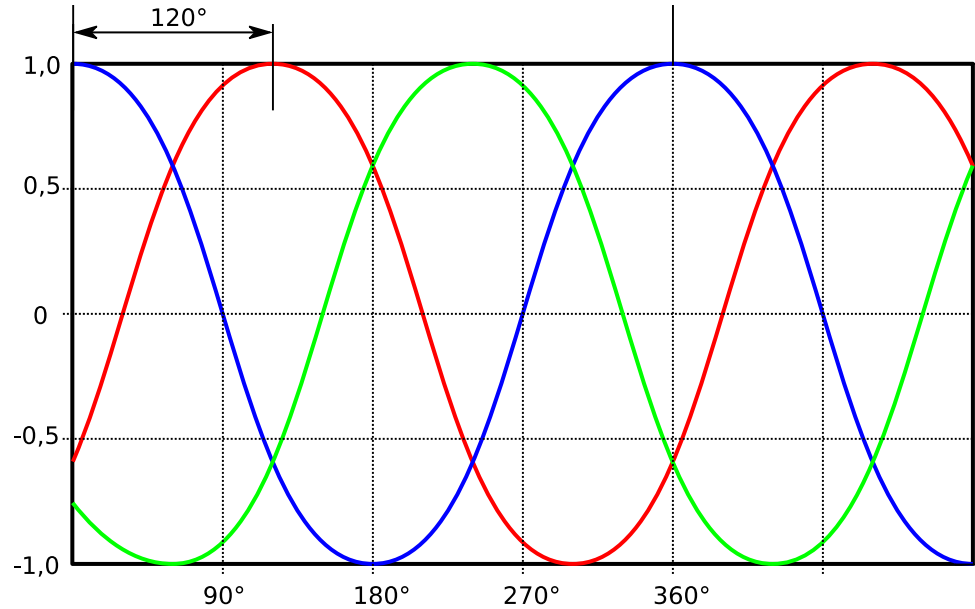
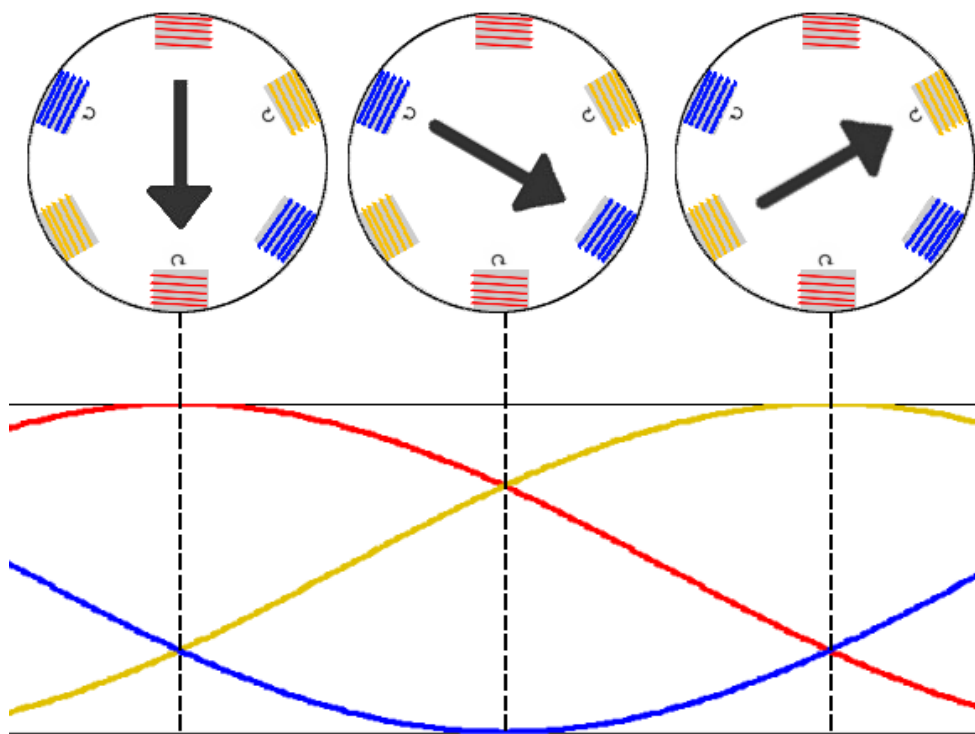


# Zmiana prędkości silnika komutatorowego?





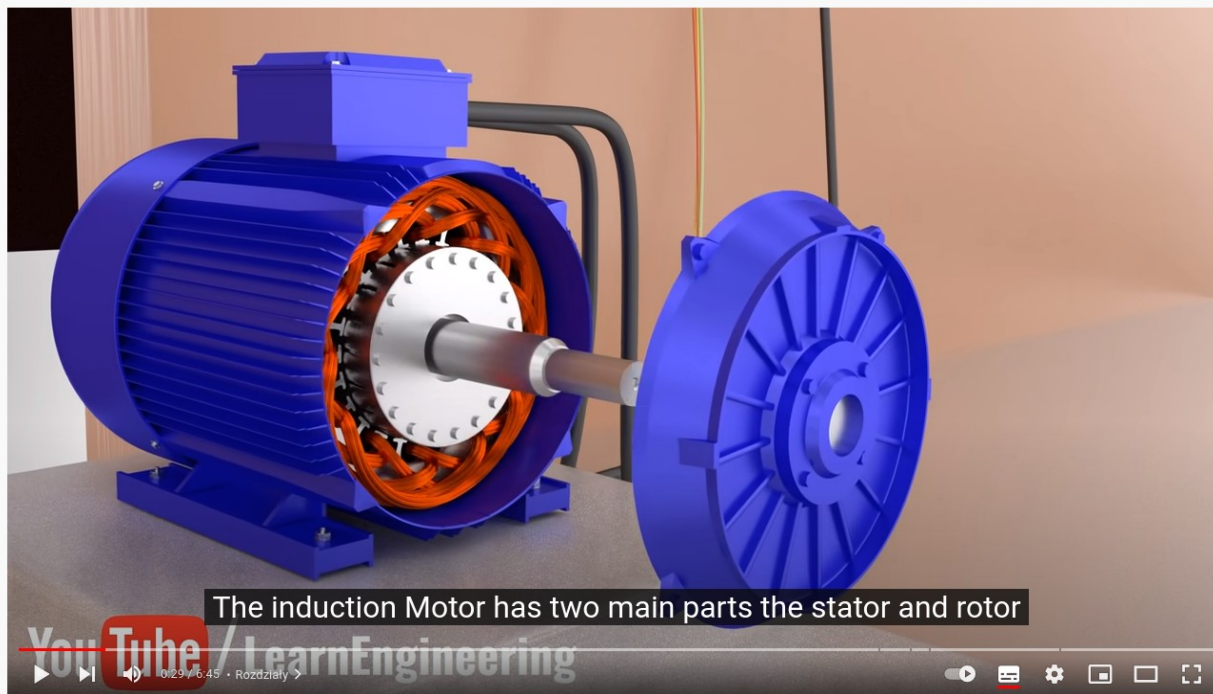
# Silnik trójfazowy



Źródła:  
[https://en.wikipedia.org/wiki/Induction\\_motor](https://en.wikipedia.org/wiki/Induction_motor)  
[https://en.wikipedia.org/wiki/Squirrel-cage\\_rotor](https://en.wikipedia.org/wiki/Squirrel-cage_rotor)



# Film!



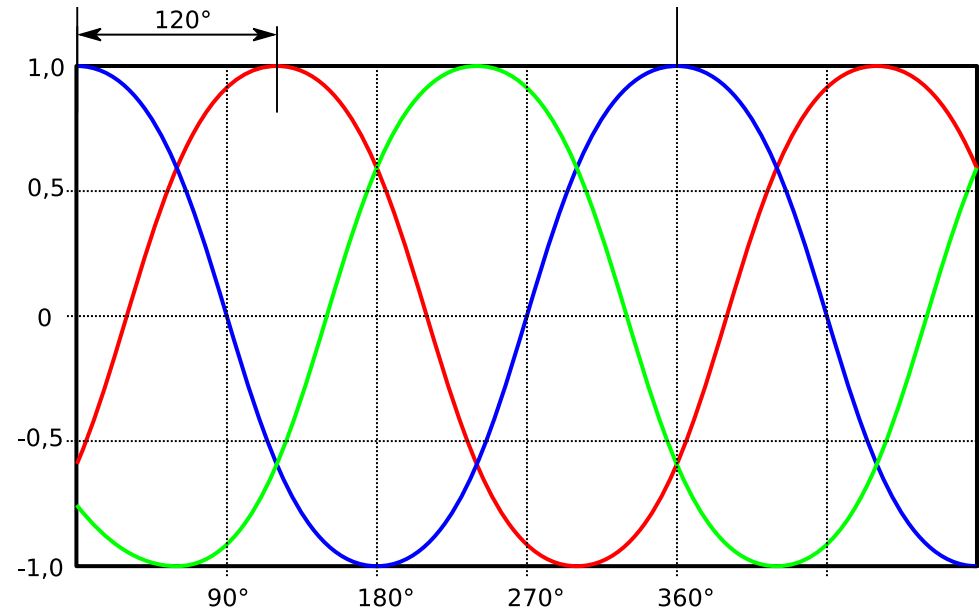
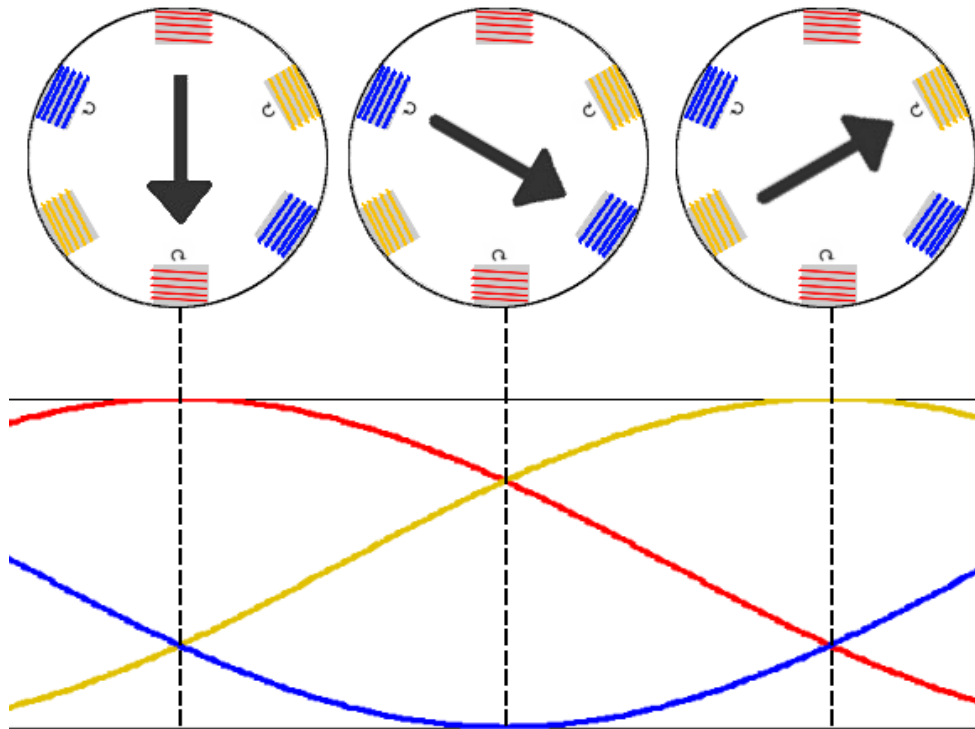
Jak działa silnik indukcyjny działa?



Trochę dłuższy film:  
[https://youtu.be/59HBoIXzX\\_c](https://youtu.be/59HBoIXzX_c)

[https://www.youtube.com/watch?v=AQqyGNOP\\_3o](https://www.youtube.com/watch?v=AQqyGNOP_3o)

# Zmiana prędkości silnika AC?



# Przeмиennik częstotliwości (falownik)

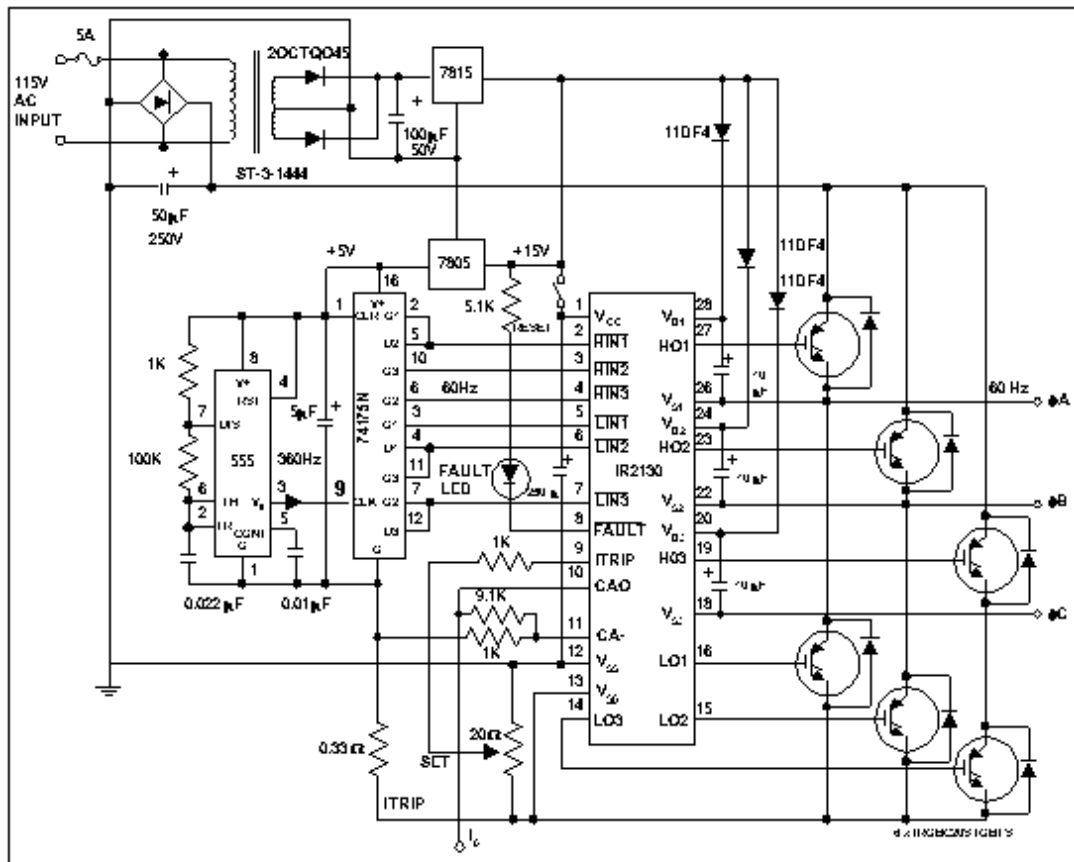
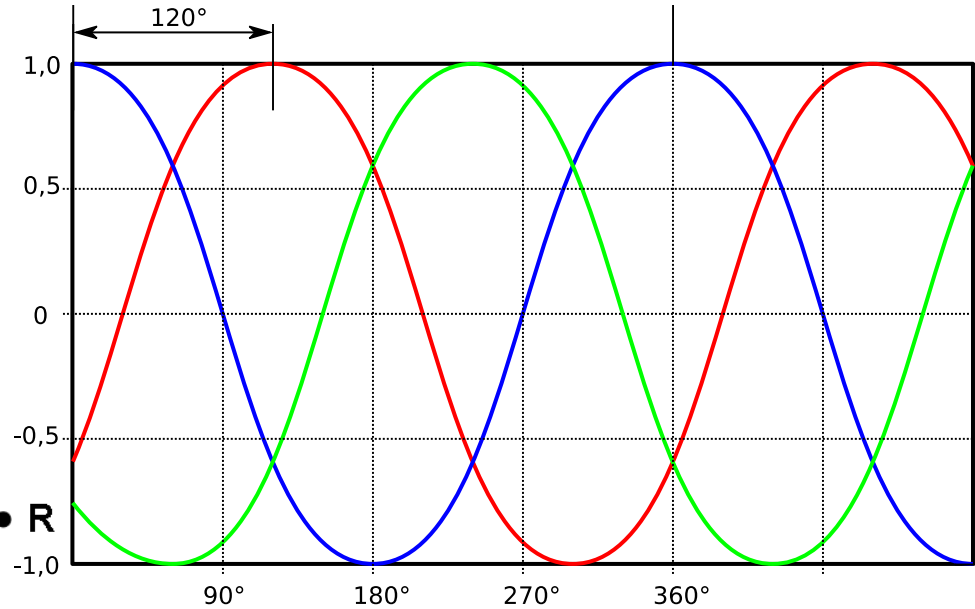
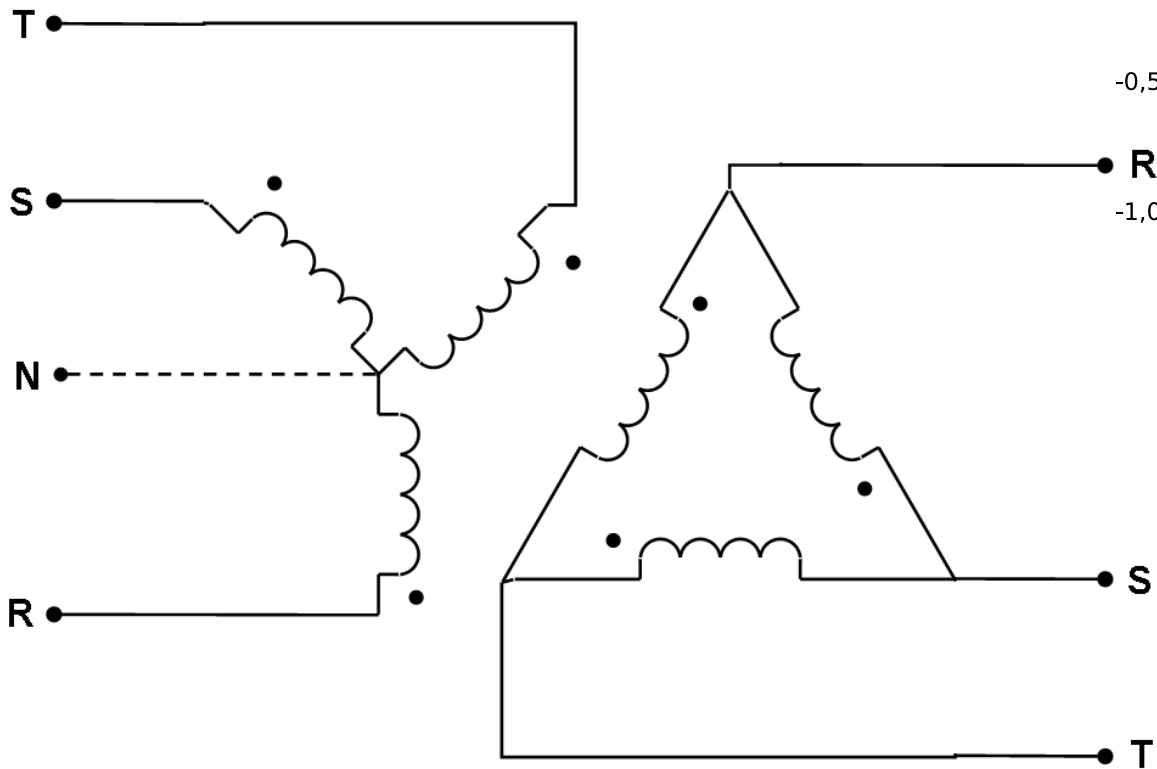


Figure 7. Three-phase six-step motor drive and 6 x HFA04TB60 <sup>®</sup> HEXFRED diodes

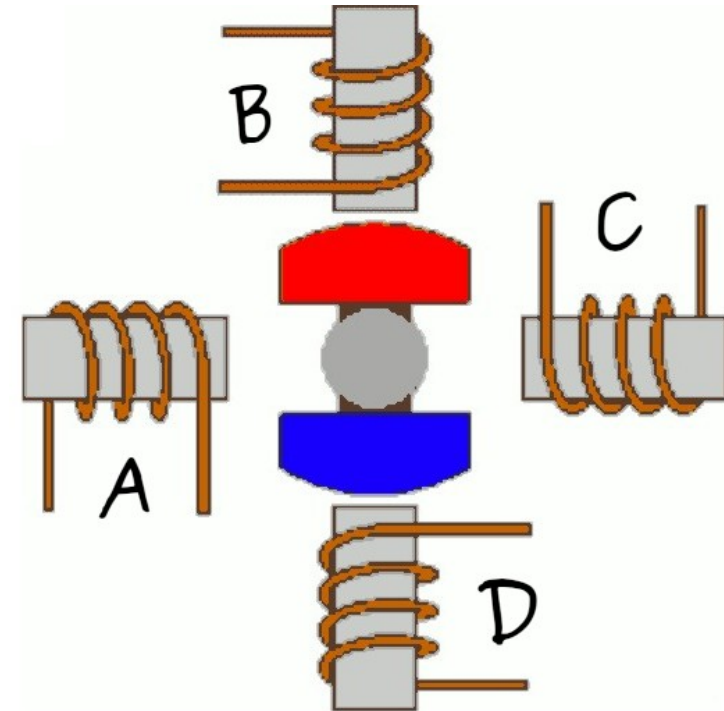


# Trójkąt i gwiazda





# Silniki krokowe

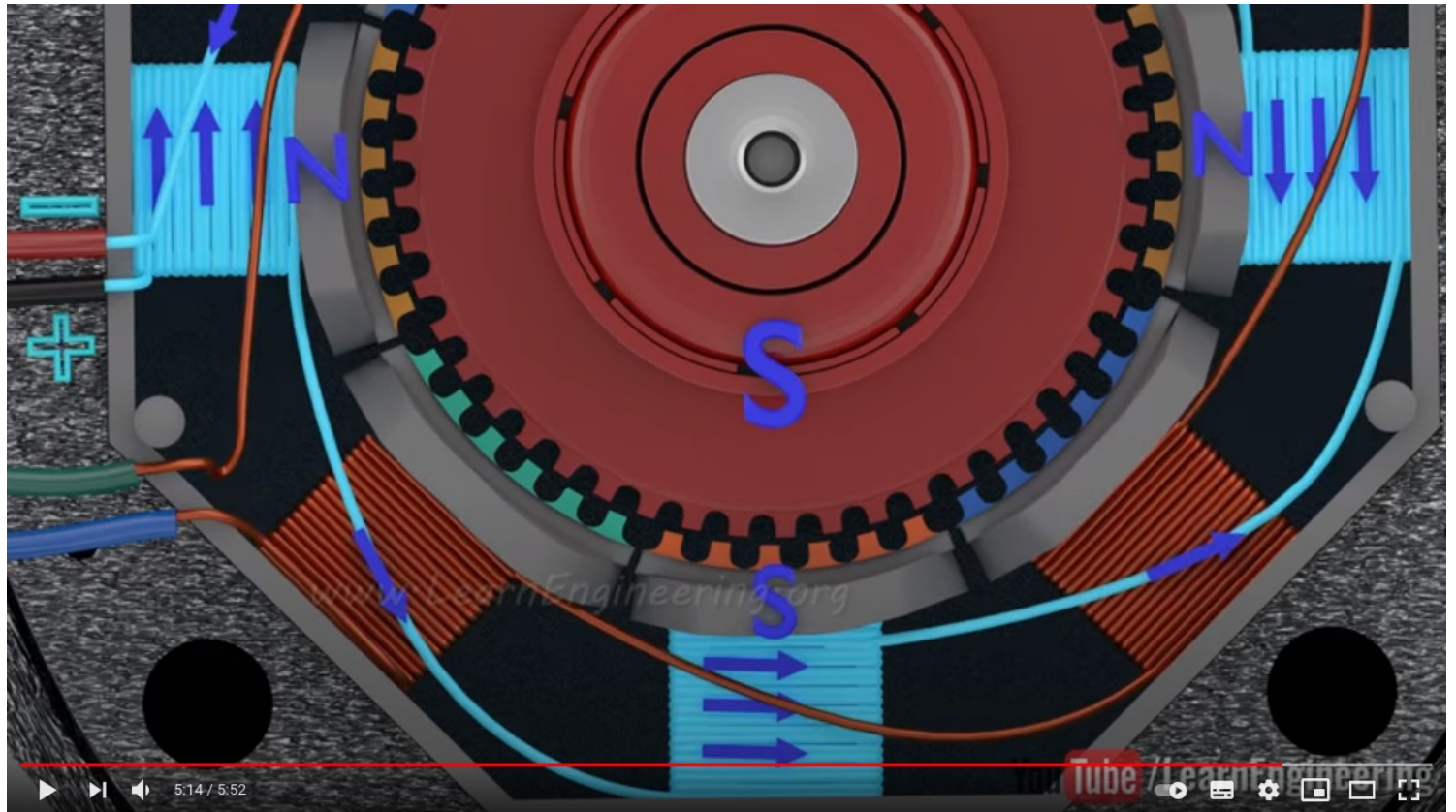


Źródła:

<https://www.serwis-elektroniki.com.pl/3066-2/>

<https://learn.adafruit.com/assets/16205>

# Film!



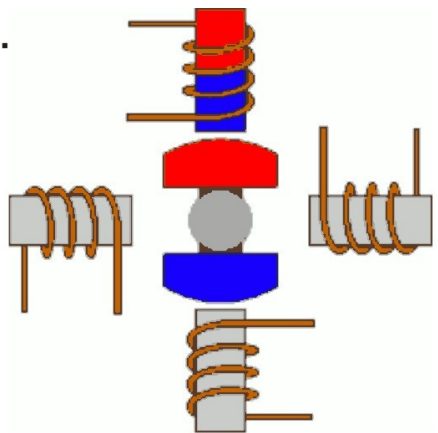
How does a Stepper Motor work ?

<https://youtu.be/eyqwLiowZiU>

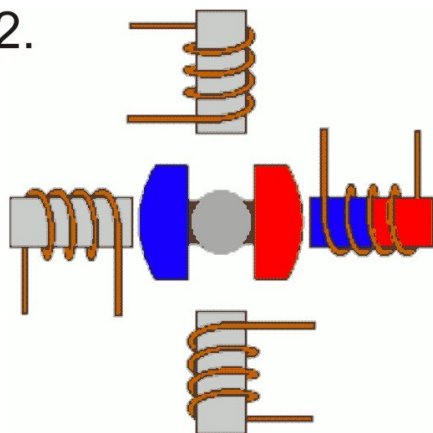
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# Pełne kroki w silnikach krokowych

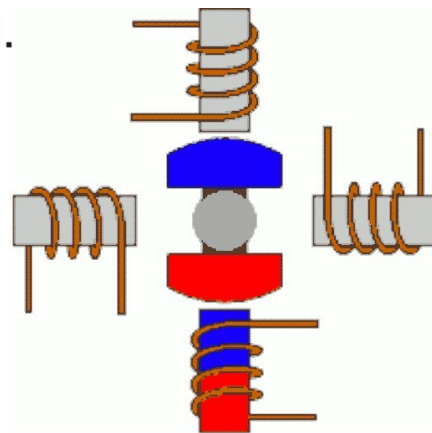
1.



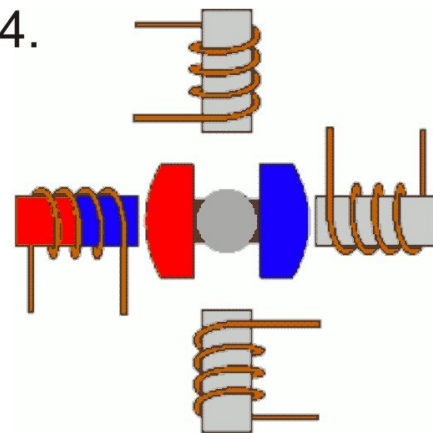
2.



3.



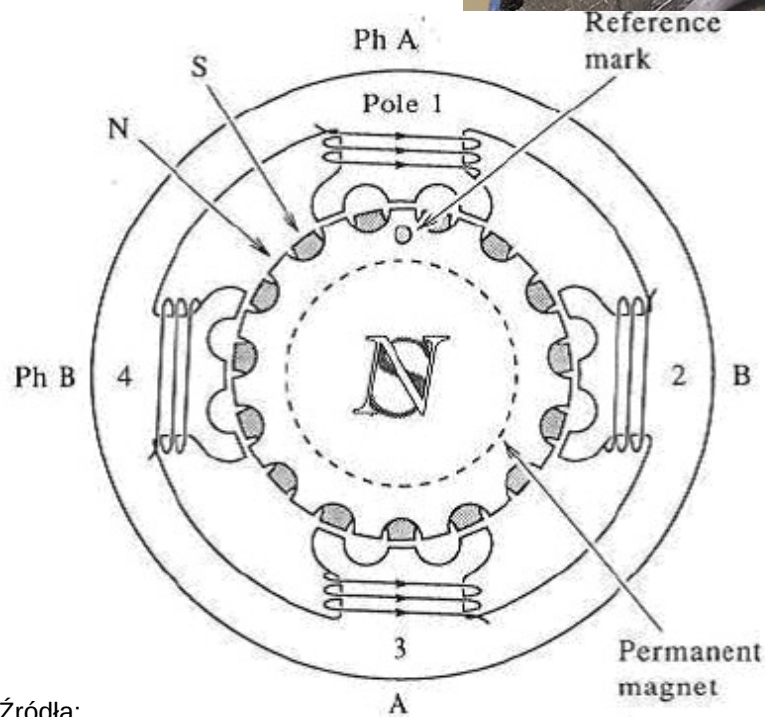
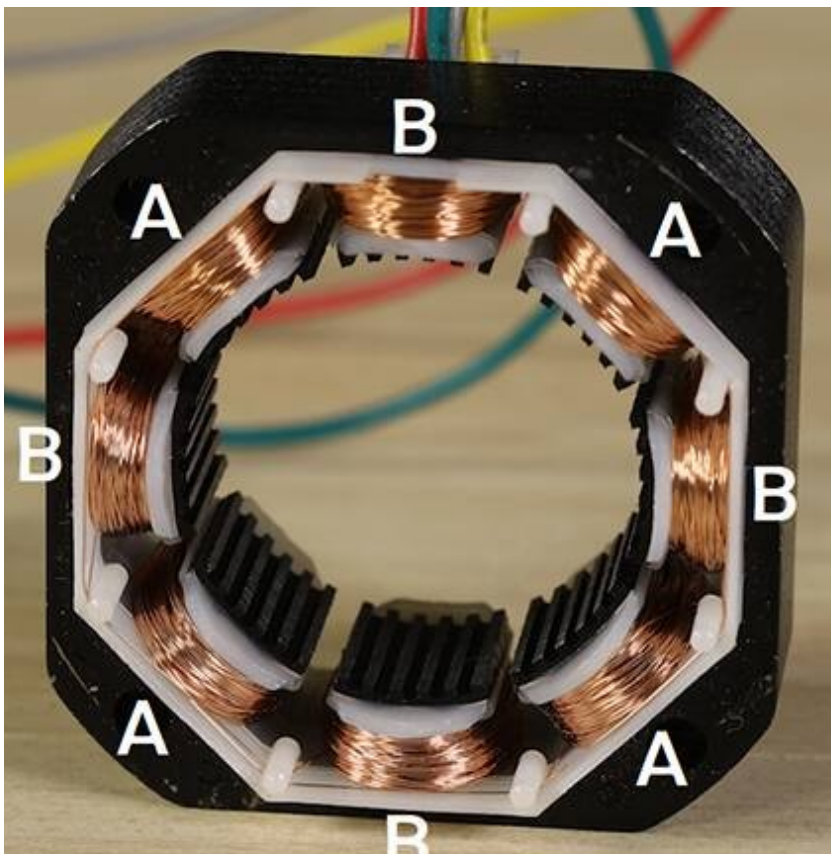
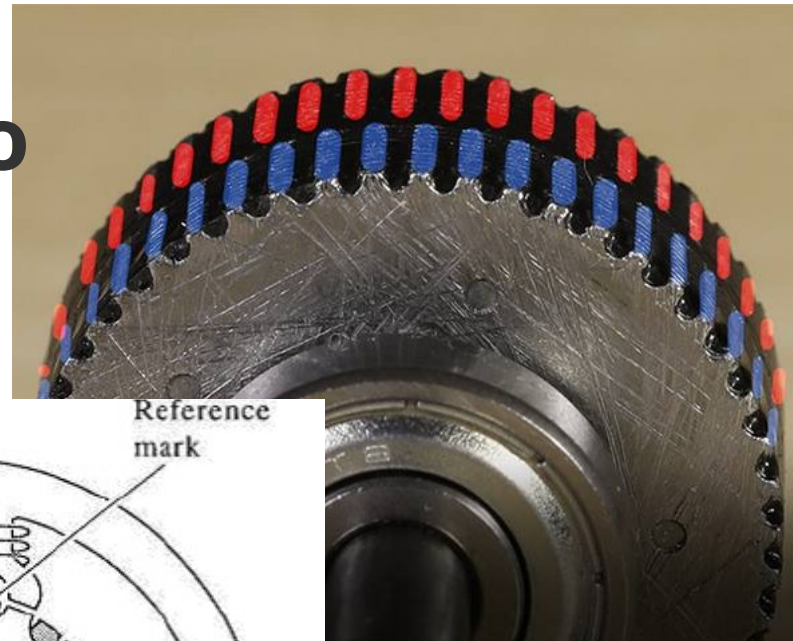
4.



Jak zwiększyć precyzję?



# Budowa silnika krokowego



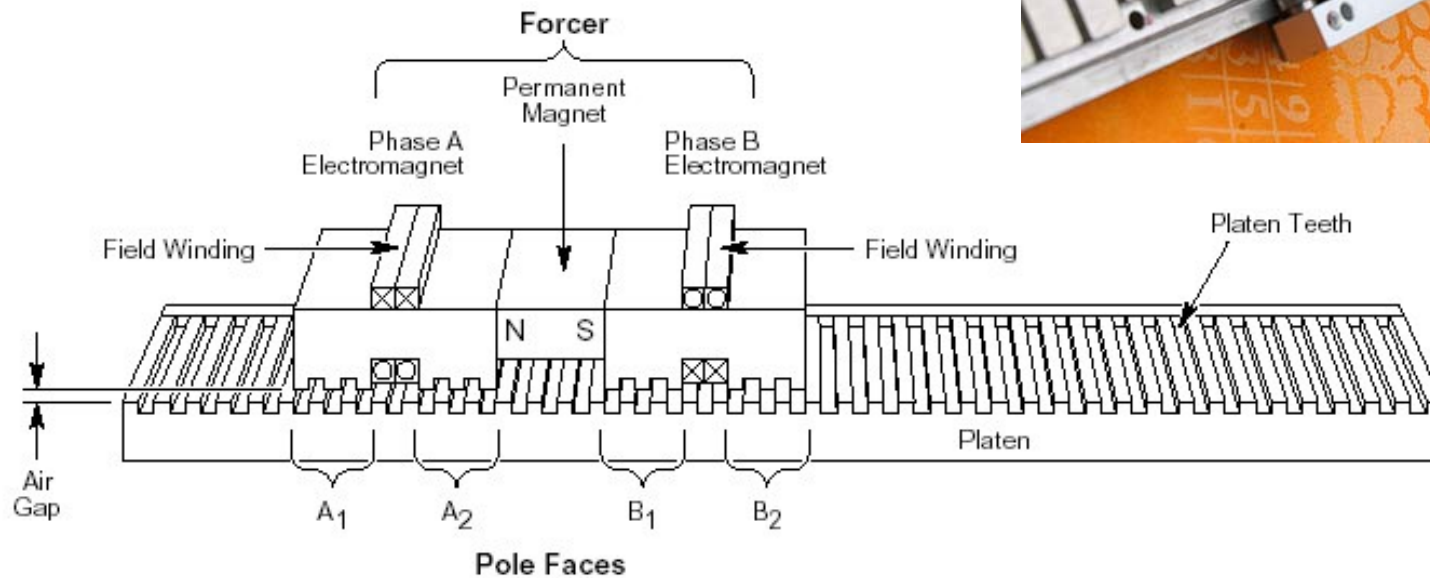
Źródła:

<https://www.digikey.pl/pl/blog/the-basics-of-stepper-motors>

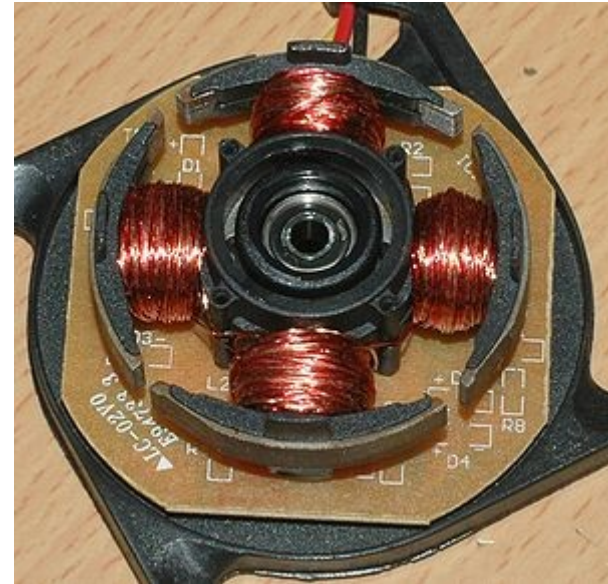
<http://jntuimplab.blogspot.com/2008/01/interfacing-stepper-motor-to-8086-using.html>



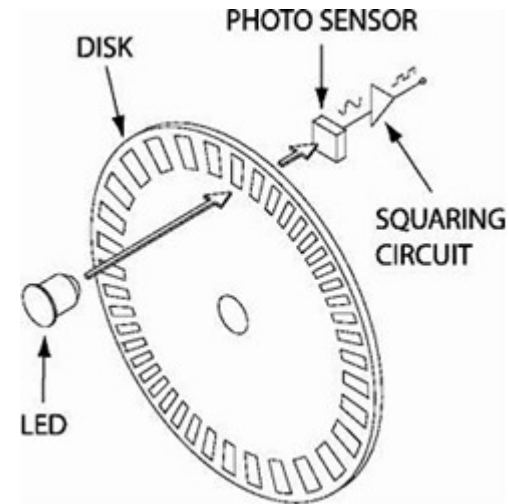
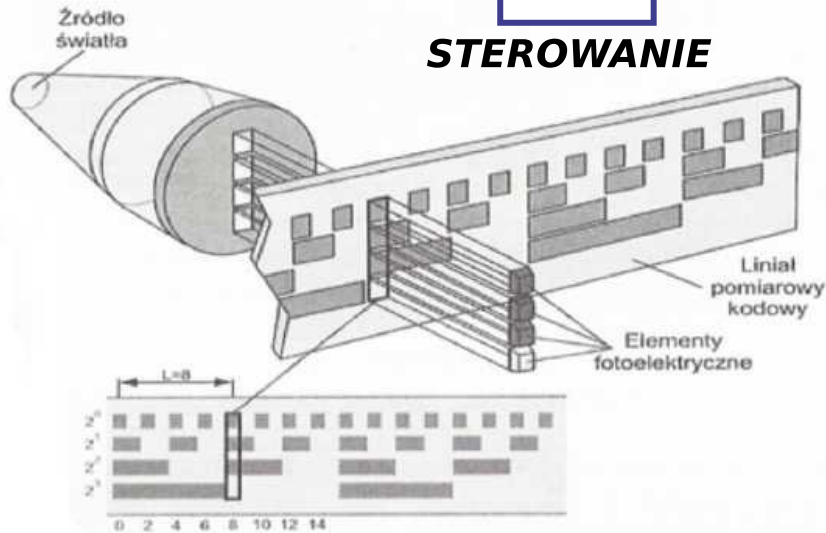
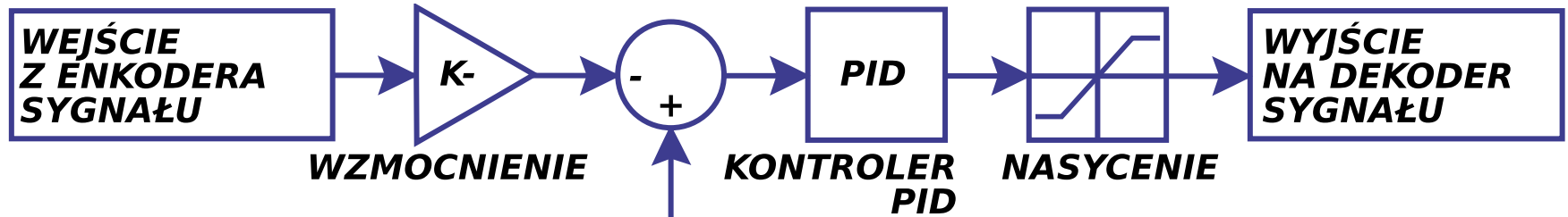
# Silnik krokowy, liniowy



# Silniki bezszczotkowe



# Serwonapęd



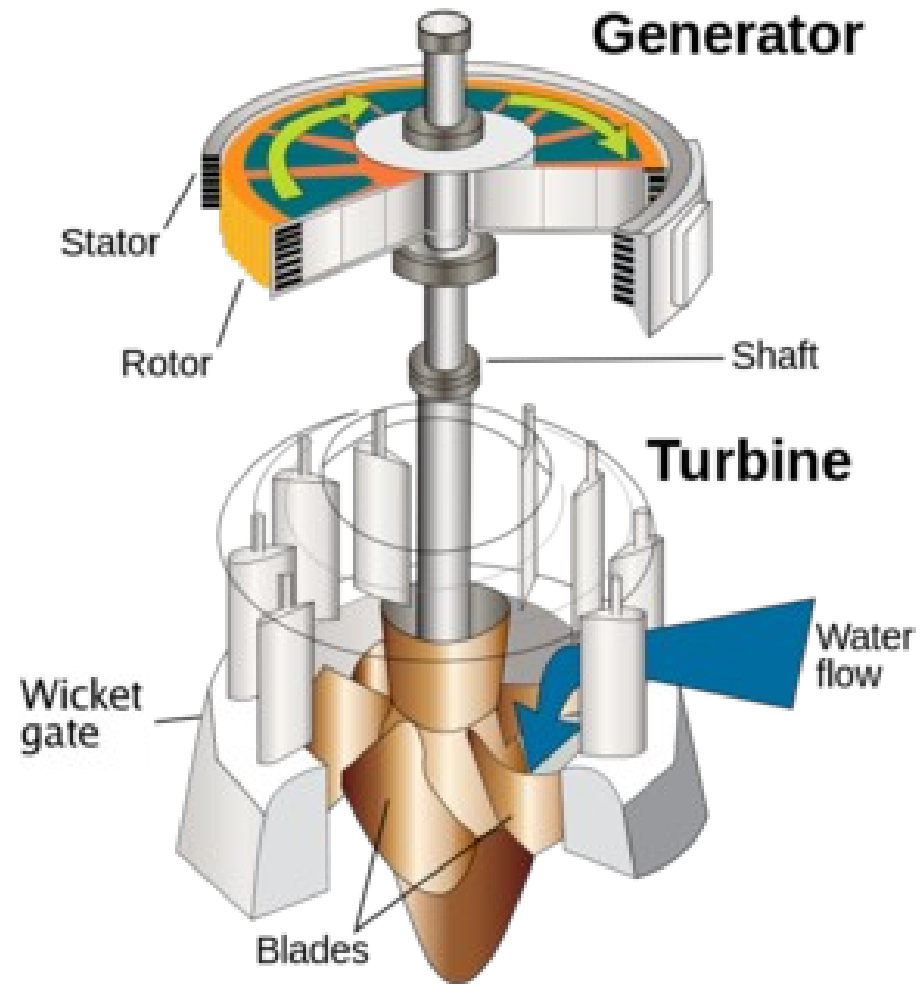
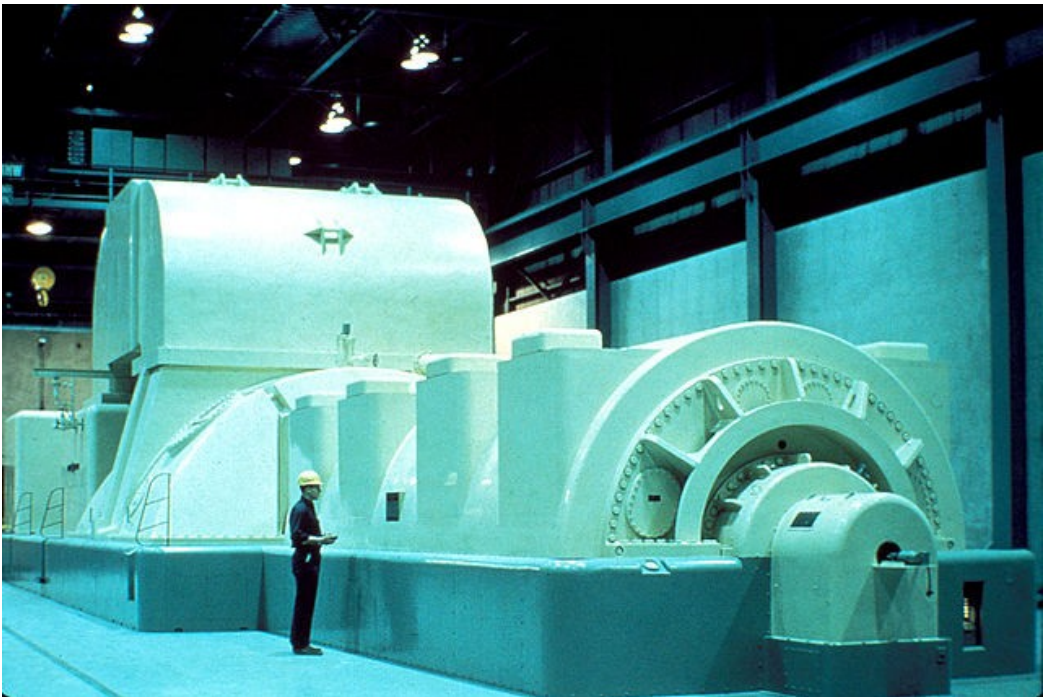
Źródła:

<http://www.asimo.pl/teoria/enkodery.php>

<https://pl.wikipedia.org/wiki/Serwomechanizm>

<https://www.ebmia.pl/wiedza/porady/automatyka-porady/enkoder/>

# Prądnica



# Czytanie kart charakterystyki

LED: 334-15/T1C1-4WYA

## Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit
Continuous Forward Current	I <sub>F</sub>	30	mA
Peak Forward Current(Duty /10 @ 1KHZ)	I <sub>FP</sub>	100	mA
Reverse Voltage	V <sub>R</sub>	5	V
Operating Temperature	T <sub>opr</sub>	-40 ~ +85	°C
Storage Temperature	T <sub>stg</sub>	-40 ~ +100	°C
Soldering Temperature (T=5 sec)	T <sub>sol</sub>	260 ± 5	°C
Power Dissipation	P <sub>d</sub>	100	mW
Zener Reverse Current	I <sub>z</sub>	100	mA
Electrostatic Discharge	ESD	4K	V

## Electro-Optical Characteristics (Ta=25°C)

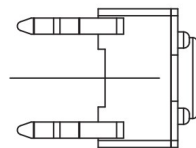
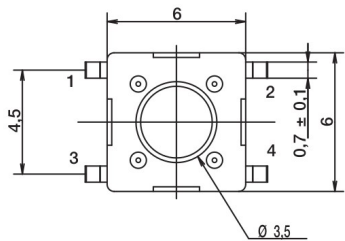
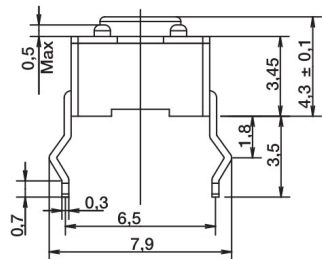
Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
Forward Voltage	V <sub>F</sub>	I <sub>F</sub> =20mA	3.0	----	3.6	V
Zener Reverse Voltage	V <sub>Z</sub>	I <sub>Z</sub> =5mA	5.2	----	----	V
Reverse Current	I <sub>R</sub>	V <sub>R</sub> =5V	----	----	50	uA
Luminous Intensity	I <sub>v</sub>	I <sub>F</sub> =20mA	14250	----	28500	mcd
Viewing Angle	2 θ 1/2	I <sub>F</sub> =20mA	----	15	----	deg
Chromaticity Coordinates	x	I <sub>F</sub> =20mA	----	0.30	----	
	y		----	0.29	----	



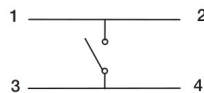
# Czytanie kart charakterystyki

## Przycisk: PTS645-S

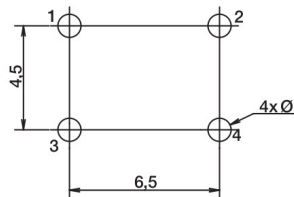
**S** STRAIGHT



SCHMATIC



PCB LAYOUT



**Tactile Switches**

### Specification

FUNCTION: Momentary action  
CONTACT ARRANGEMENT: SPST, N.O.  
TERMINALS: PC pins

### Mechanical

ACTUATION FORCE: 130 grams, 160 grams, 200 grams, 260 grams  
LIFE EXPECTANCY: 100,000 operations.

### Electrical

CONTACT RATING: 50 mA @ 12 V DC.  
DIELECTRIC STRENGTH: 250 V AC min.  
CONTACT RESISTANCE: 100 mΩ max. initial.  
INSULATION RESISTANCE:  $10^{11} \Omega$  min.

### Environmental

OPERATING TEMPERATURE: -20°C to 60°C

# Czytanie kart charakterystyki

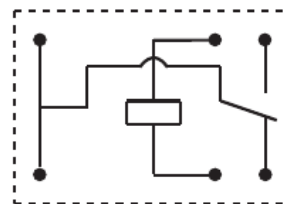


## Absolute Maximum Ratings $T_a=25^{\circ}\text{C}$ unless otherwise noted

Symbol	Parameter	Value	Units
$V_{\text{CBO}}$	Collector-Base Voltage : BC546	80	V
	: BC547/550	50	V
	: BC548/549	30	V
$V_{\text{CEO}}$	Collector-Emitter Voltage : BC546	65	V
	: BC547/550	45	V
	: BC548/549	30	V
$V_{\text{EBO}}$	Emitter-Base Voltage : BC546/547	6	V
	: BC548/549/550	5	V
$I_{\text{C}}$	Collector Current (DC)	100	mA
$P_{\text{C}}$	Collector Power Dissipation	500	mW
$T_{\text{J}}$	Junction Temperature	150	$^{\circ}\text{C}$
$T_{\text{STG}}$	Storage Temperature	-65 ~ 150	$^{\circ}\text{C}$



# Czytanie kart charakterystyk



Przełącznik: HFD41

## CONTACT DATA

Concat arrangement	1C
Contact resistance	100mΩ max. (at 1A 6VDC)
Contact material	AgNi, AgCdO
Contact rating (Res. load)	1A 120VAC, 1A 240VAC / 30VDC 3A 120VAC 2A 120VAC, 5A 120VAC
Max. switching voltage	240VAC / 30VDC
Max. switching current	5A
Max. switching power	600VA / 30W
Mechanical endurance	1 x 10 <sup>7</sup> OPS
Electrical endurance	9.9 x 10 <sup>4</sup> OPS (1A 120VAC, 1A 30VDC, Resistive load, Room temp., 1s on 9s off)

## COIL DATA at 23°C

Nominal Voltage VDC	Pick-up Voltage VDC max.	Drop-out Voltage VDC min.	Max. Voltage VDC	Coil Resistance x (1±10%) Ω		
				H	N	B
3	2.3	0.3	3.9	45	25	20
5	3.8	0.5	6.5	120	70	56
6	4.5	0.6	7.8	180	100	80
9	6.8	0.9	11.7	400	220	180
12	9.0	1.2	15.6	700	400	320
24	18.0	2.4	31.2	2800	1600	1280