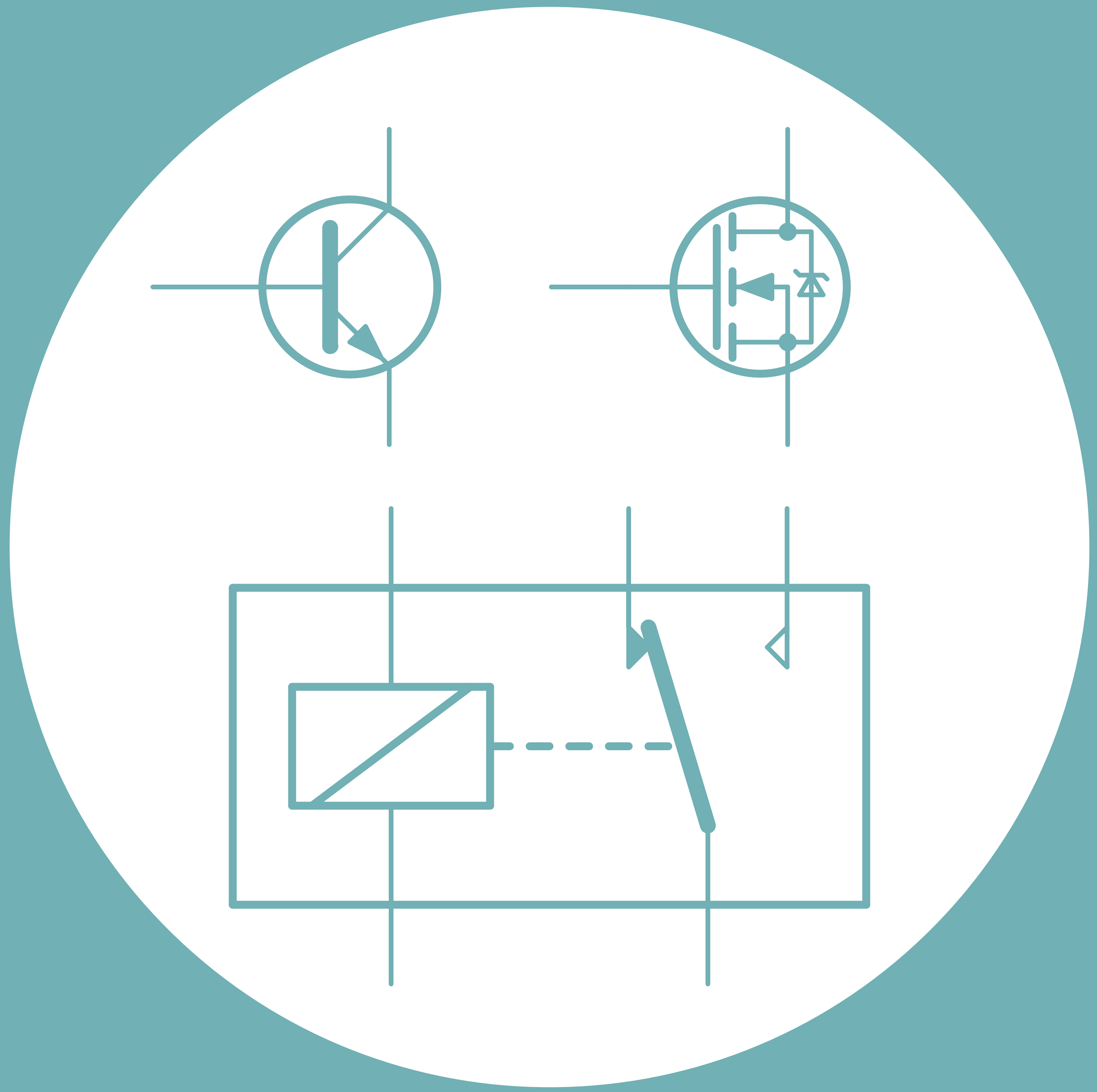
Spínání vnějších obvodů



Hardware, 4.SI (2021/2022)

Střední škola informatiky a právních studií, z. ú.
Petr Zelenka (zelenka@stredniskola.cz)

GPIO vývody Raspberry Pi Pico pracují se **stejnosměrným napětím 3,3 V** a mají **proudové omezení 12 mA**. Většina řízených periferních obvodů používá **vyšší stejnosměrné nebo dokonce střídavé napětí** a tečou jimi **větší proudy**.

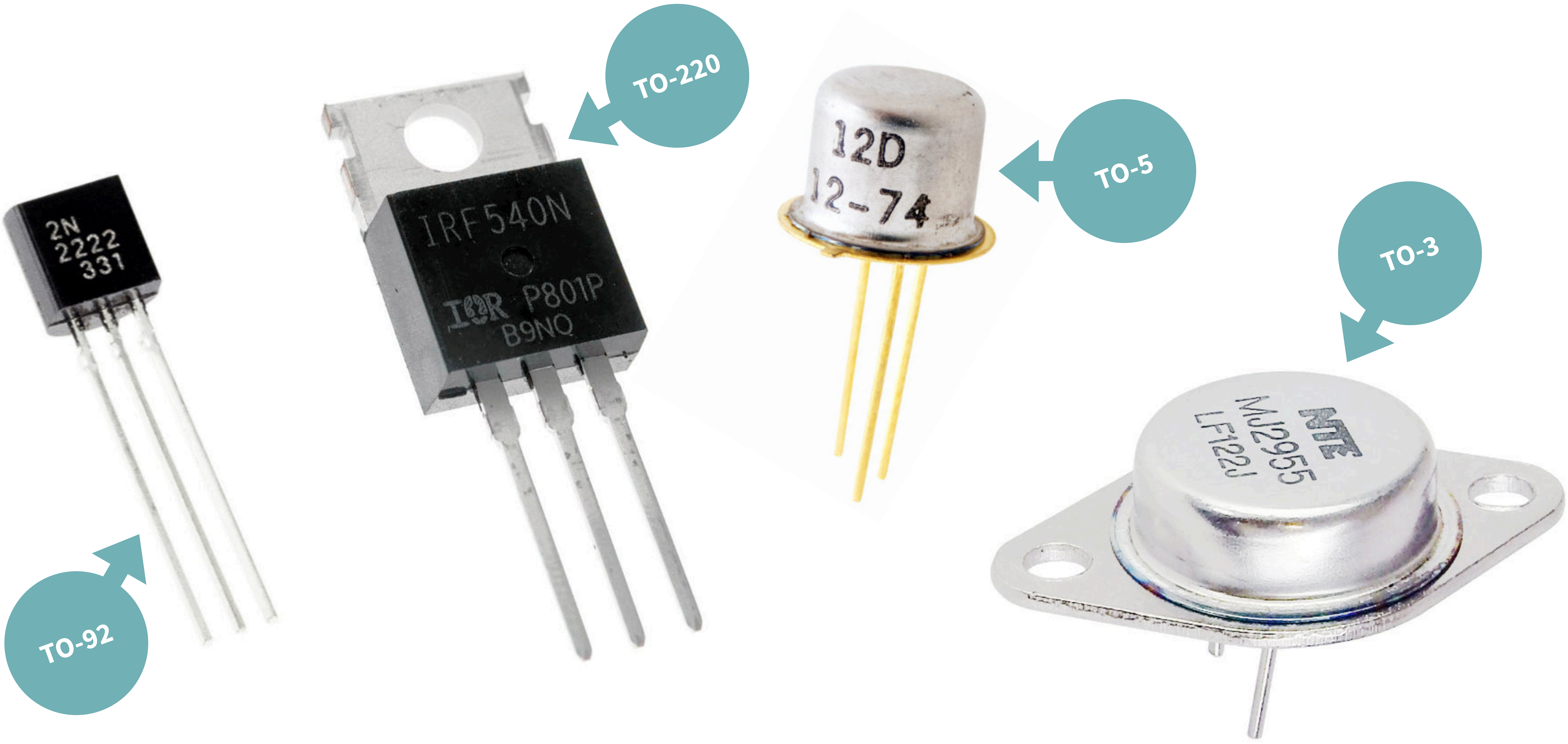
Co s tím?

Tranzistor

- angl. „transistor“
- polovodičová součástka, která spíná **řízený obvod sepnutím řídicího obvodu**
- **řídicí i řízený obvod** mohou používat **různá napětí a proudy**
- existuje mnoho různých druhů tranzistorů s odlišnými parametry a použitím
- existuje mnoho různých zapojení tranzistorů

Pouzdra tranzistorů

- existuje **několik desítek pouzder** pro tranzistory
- pouzdra THT tranzistorů začínají písmeny TO, pouzdra SMT tranzistorů písmeny SOT
- nejběžnější jsou pouzdra
  - **TO-92**: plastové půlkulaté pouzdro pro **tranzistory s nízkým výkonem**
  - TO-5: kovové kulaté pouzdro pro tranzistory se středním výkonem
  - TO-3: kovové kulaté pouzdro pro výkonové tranzistory
  - **TO-220**: hranaté pouzdro pro **výkonové tranzistory**



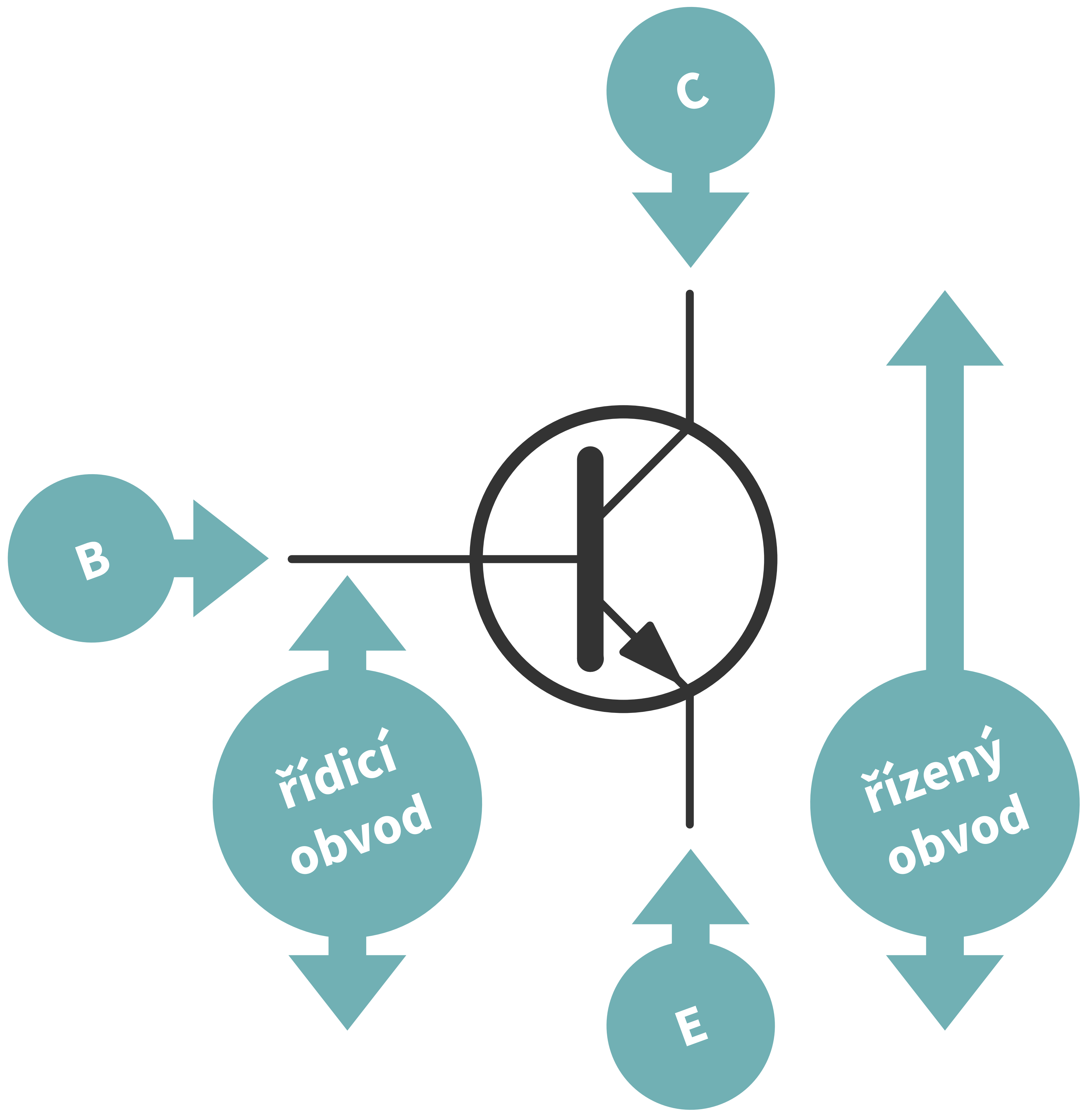
nejběžnější pouzdra tranzistorů

Pokud má nějaká součástka pouzdro např. TO-220,
nelze ještě říci, že se jedná o tranzistor!

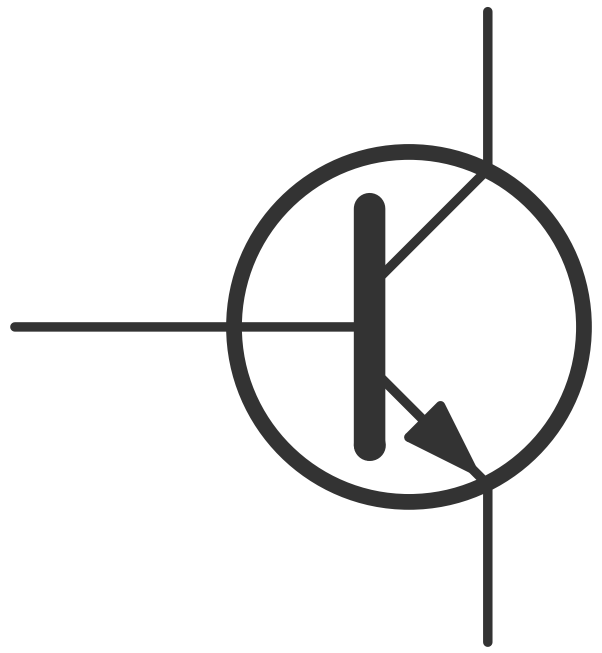
*Ve stejném pouzdře se běžně vyrábějí další součástky
(~ napěťové regulátory, tyristory, dvojice diod, ...).*

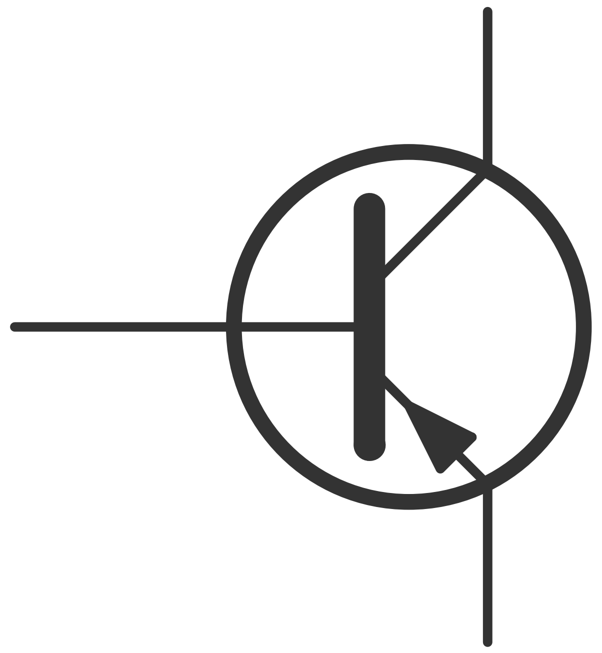
Bipolární tranzistor

- angl. „bipolar junction transistor“ (BJT)
- tranzistor **řízený elektrickým proudem**
- vývody se označují
    - **báze** (angl. „base“, **B**)
    - **kolektor** (angl. „collector“, **C**)
    - **emitor** (angl. „emitter“, **E**)
- řídicí obvod = B–E, řízený obvod = C–E



tranzistor typu NPN





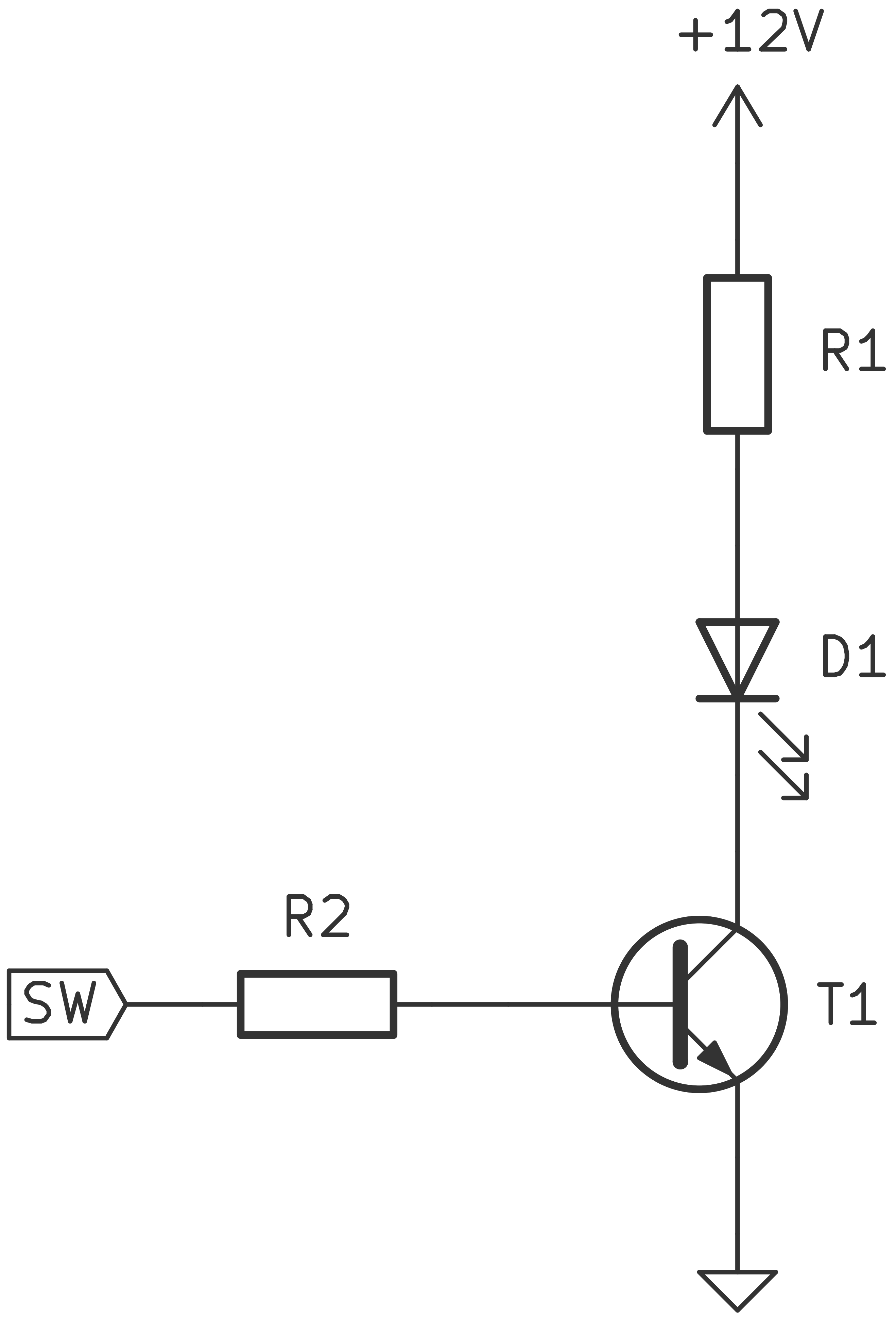
tranzistor typu PNP

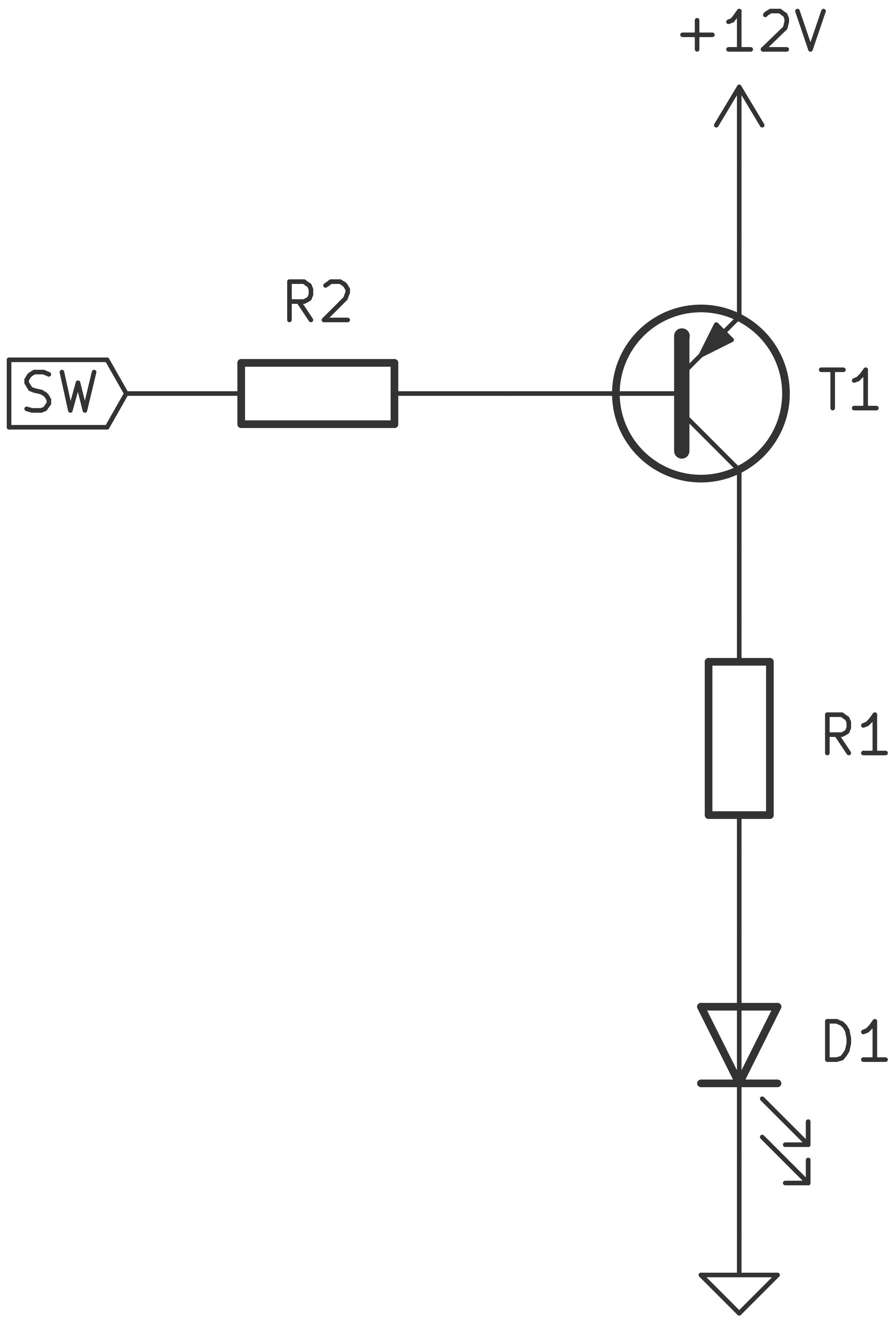
severoamerická značka neobsahuje kolečko

značky bipolárních tranzistorů

Tranzistory NPN a PNP

- tranzistor typu **NPN se spíná kladným napětím báze proti emitoru** (↦ pozitivní logika)
    - emitor se zapojuje směrem k 0 V
- tranzistor typu **PNP se spíná záporným napětím báze proti emitoru** (↦ negativní logika)
    - emitor se zapojuje směrem k V_{CC}





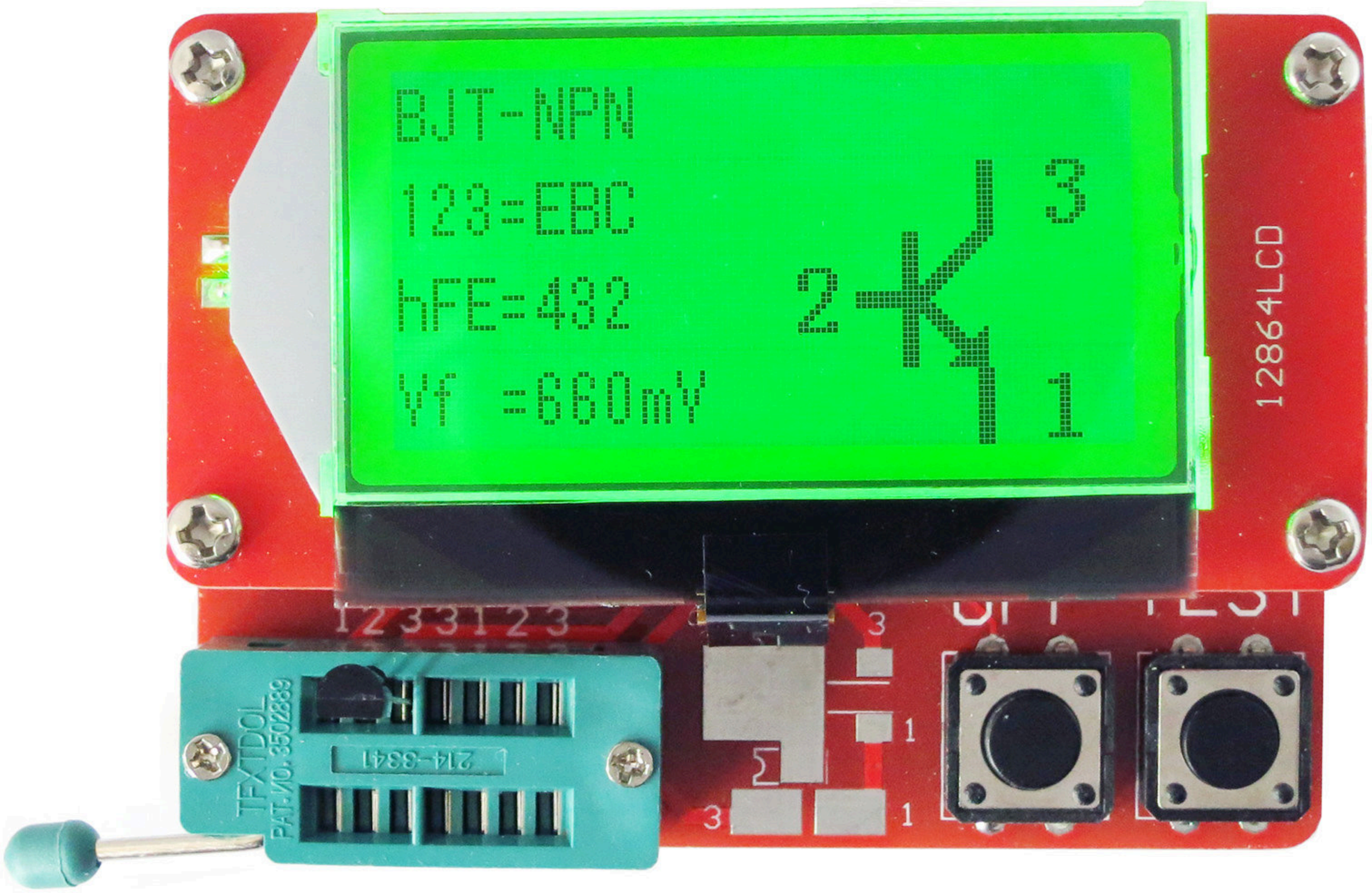
zapojení tranzistorů NPN a PNP

Řízený obvod se musí zapojit **ke kolektoru**

(~ část u emitoru je společná s řídicím obvodem)!

Důležité parametry bipolárních tranzistorů

- **nejvyšší** připustné **napětí v řídicím obvodu** U_{BE} [V]
- **nejvyšší** připustné **napětí v řízeném obvodu** U_{CE} [V]
- **nejvyšší** připustný **proud v řízeném obvodu** (také „kolektorový proud“) I_C [A]
- **proudové zesílení** h_{FE} (někdy také β) [1] (angl. „current gain“)
  je poměr proudů v řízeném a řídicím obvodu
- **úbytek napětí** na tranzistoru **v řídicím obvodu** $U_{BE(SAT)}$ [V]
- **úbytek napětí** na tranzistoru **v řízeném obvodu** $U_{CE(SAT)}$ [V]
- **jmenovité zatížení** P_D [W]



bipolární tranzistor v analyzátoru součástek

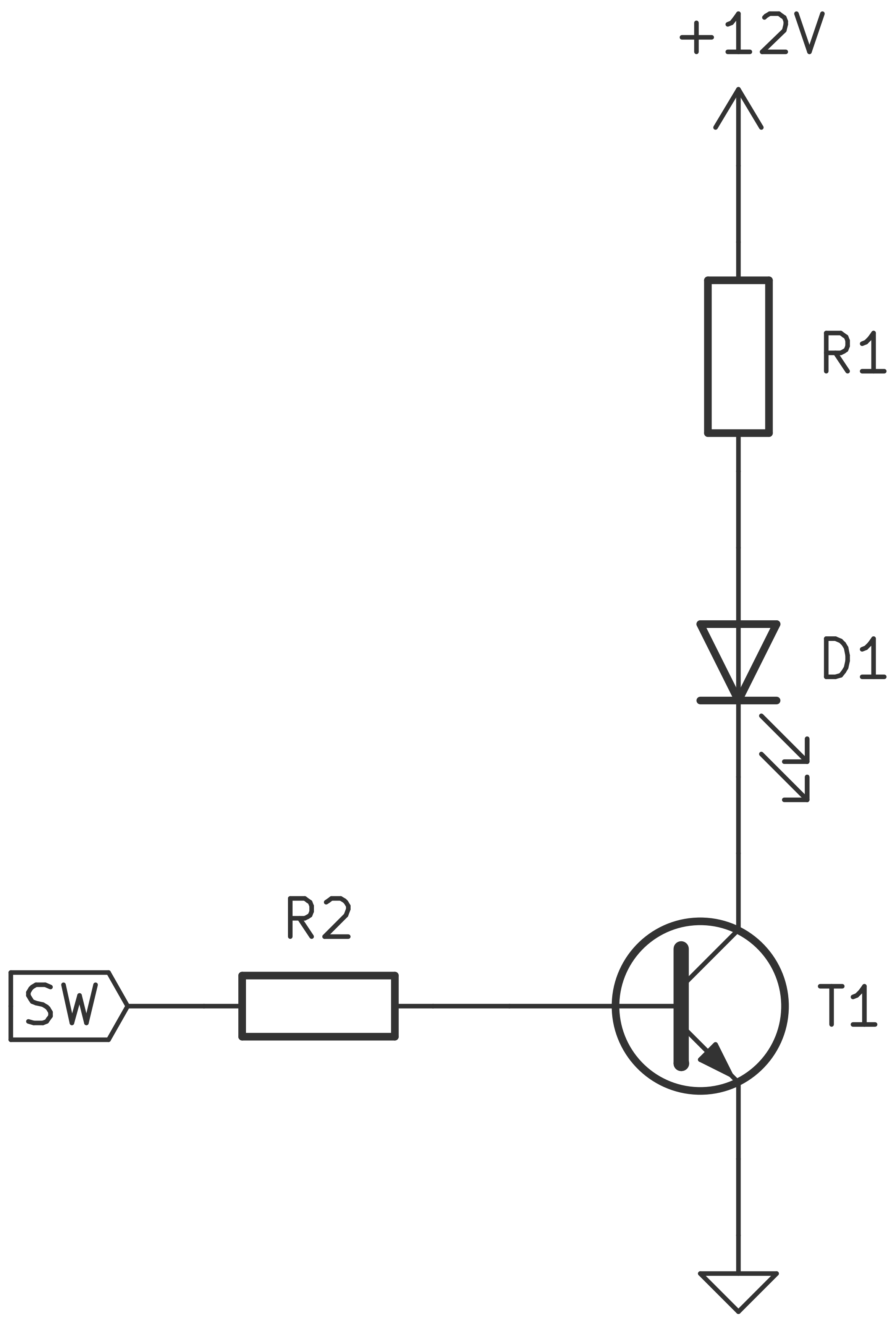
Výpočet hodnoty bázového rezistoru

- **potřebný spínací proud** I_{BE} se vypočítá **z potřebného spínaného proudu** I_{CE} **a proudového zesílení** h_{FE} (~ standardně se uvažuje trojnásobek)

$$I_{BE} = 3 \cdot \frac{I_{CE}}{h_{FE}}$$

- **odpor bázového rezistoru** R_2 se vypočítá pomocí Ohmova zákona **z úbytku napětí na tranzistoru** $U_{BE_{SAT}}$

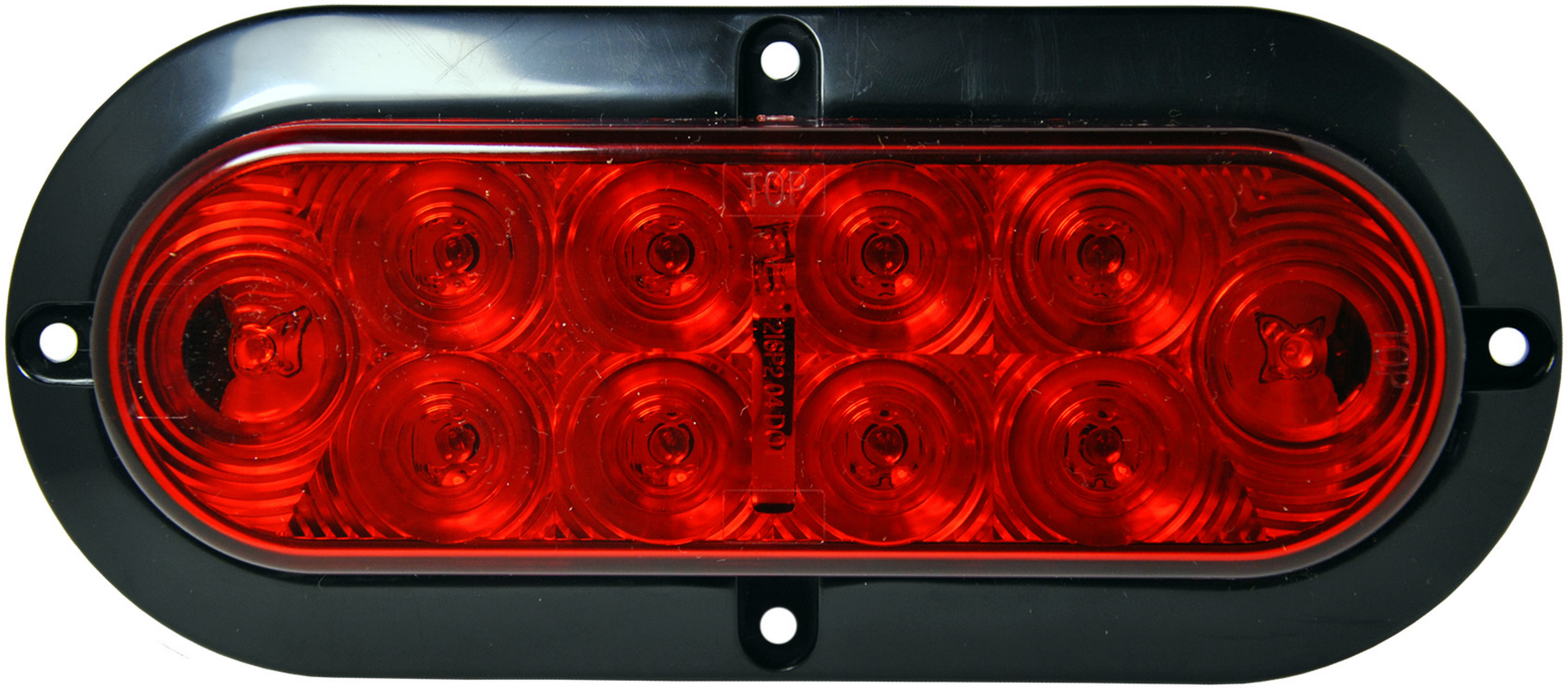
$$R_2 = \frac{U_{BE} - U_{BE(SAT)}}{I_{BE}}$$



Ověření jmenovitého zatížení

- výkon vyzářený tranzistorem nesmí překročit jeho jmenovité zatížení P_D

$$U_{CE(SAT)} \cdot I_{CE} + U_{BE(SAT)} \cdot I_{BE} \leq P_D$$



koncové nebo brzdové LED světlo

$(U_F = 12\,\text{V},\ I_F = 0{,}4\,\text{A})$

PN2222A: NPN Bipolar Transistor

Datasheet: General Purpose Transistors
Rev. 5 (198.0kB)

Product Overview

» View Material Composition
» Product Change Notification
☆ Mark as Favorite

The NPN Bipolar Transistor is designed for use in linear and switching applications. The device is housed in the TO-92 package, which is designed for medium power applications.

Features

- Pb-Free Packages are Available*

Technical Documentation & Design Resources

Application Notes (3) | Package Drawings (1)

Data Sheets (1)

Product	Status	Compliance	Description	Package		MSL		Container		Budgetary Price/Unit
				Type	Case Outline	Type	Temperature	Type	Qty.	
PN2222AG	Obsolete	Pb-free	PN2222A	TO-92	29-11	NA		Bulk Box	5000	»Rochester »Contact Sales Office
PN2222ARLRAG	Obsolete	Pb-free	PN2222A	TO-92	29-11	NA		Tape and Reel	2000	»Rochester »Contact Sales Office
PN2222ARLRMG	Obsolete	Pb-free	PN2222A	TO-92	29-11	NA		Fan-Fold	2000	»Rochester »Contact Sales Office
PN2222ARLRPG	Obsolete	Pb-free	PN2222A	TO-92	29-11	NA		Fan-Fold	2000	»Rochester »Contact Sales Office

Previously Viewed Products

Select Product... Go

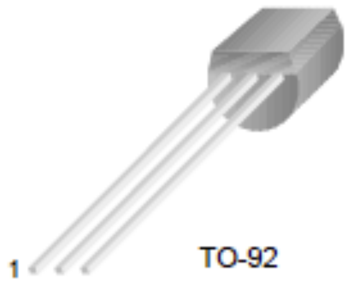
Clear List

Support

Technical Documentation
Design Resources & Documents
Technical Support
Sales Support

PN2222

General Purpose Transistor



TO-92

1. Emitter 2. Base 3. Collector

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage	60	V
V_{CEO}	Collector-Emitter Voltage	30	V
V_{EBO}	Emitter-Base Voltage	5	V
I_C	Collector Current	600	mA
P_C	Collector Power Dissipation	625	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-55 ~ 150	°C

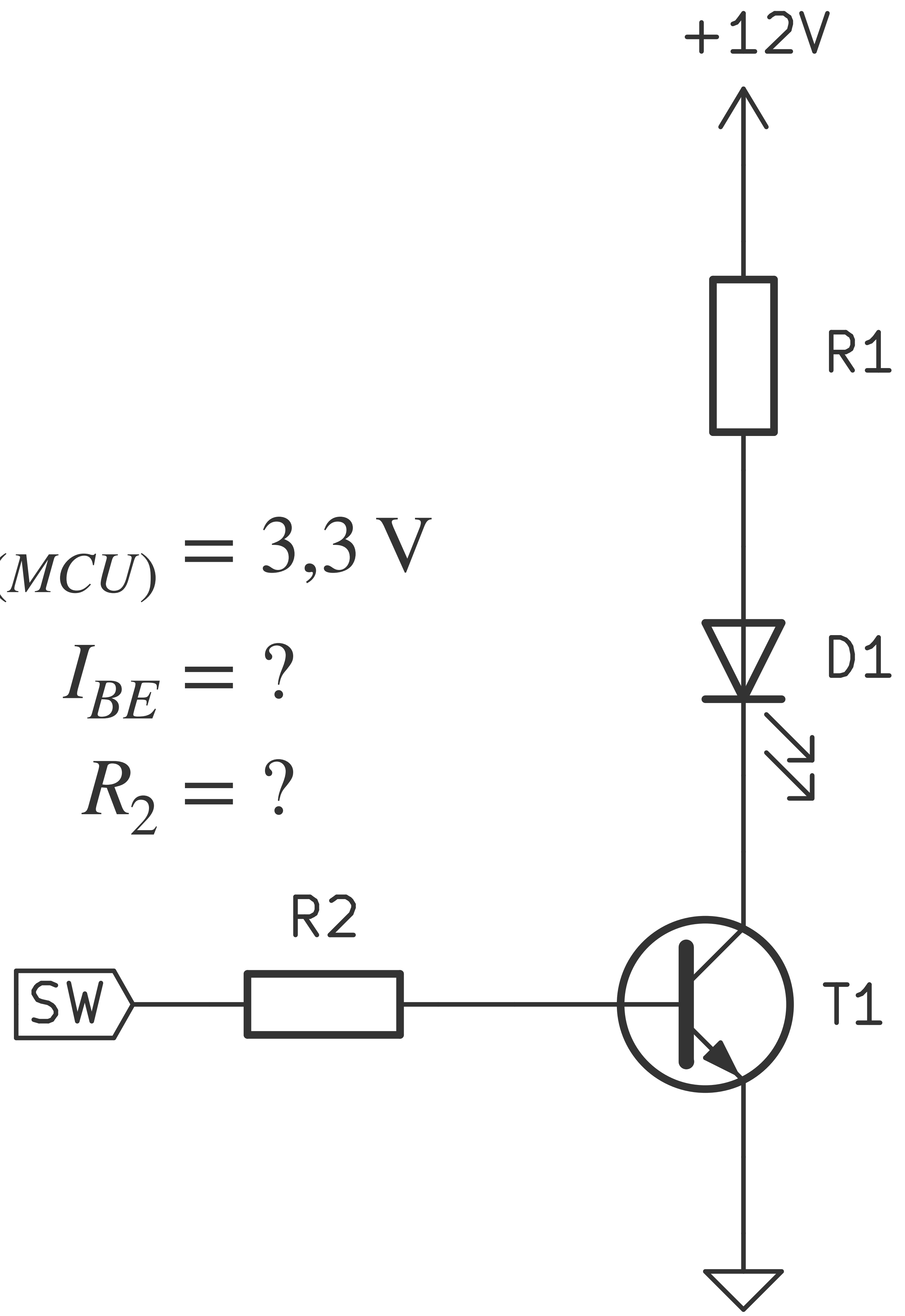
Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Max.	Units
BV_{CBO}	Collector-Base Breakdown Voltage	I_C=10µA, I_E=0	60		V
BV_{CEO}	Collector Emitter Breakdown Voltage	I_C=10mA, I_B=0	30		V
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E=10µA, I_C=0	5		V
I_{CBO}	Collector Cut-off Current	V_{CB}=50V, I_E=0		0.01	µA
I_{EBO}	Emitter Cut-off Current	V_{EB}=3V, I_C=0		10	nA
h_{FE}	DC Current Gain	V_{CE}=10V, I_C=0.1mA V_{CE}=10V, *I_C=150mA	35 100	 300	
V_{CE} (sat)	* Collector-Emitter Saturation Voltage	I_C=500mA, I_B=50mA		1	V
V_{BE} (sat)	* Base-Emitter Saturation Voltage	I_C=500mA, I_B=50mA		2	V
f_T	Current Gain Bandwidth Product	V_{CE}=20V, I_C=20mA, f=100MHz	300		MHz
C_{ob}	Output Capacitance	V_{CB}=10V, I_E=0, f=1MHz		8	pF

* Pulse Test: Pulse Width≤300µs, Duty Cycle≤2%

hodnoty dané MCU

$$U_{BE(MCU)} = 3{,}3\,\mathrm{V}$$
$$I_{BE} = ?$$
$$R_2 = ?$$



hodnoty dané LED

$$U_{CE(LED)} = 12\,\mathrm{V}$$
$$I_{C(LED)} = 0{,}4\,\mathrm{A}$$

hodnoty dané tranzistorem

$$U_{BE(MAX)} = 5\,\mathrm{V}$$
$$U_{CE(MAX)} = 30\,\mathrm{V}$$
$$I_{C(MAX)} = 600\,\mathrm{mA}$$
$$h_{FE} = 35$$
$$U_{BE(SAT)} = 2\,\mathrm{V}$$
$$U_{CE(SAT)} = 1\,\mathrm{V}$$
$$P_D = 625\,\mathrm{mW}$$

souhrn známých a neznámých hodnot

$$I_{BE} = \frac{I_C}{h_{FE}} = 3 \cdot \frac{0{,}4}{35} \approx 34\,\text{mA}$$

potřebný spínací proud je příliš velký (> 12 mA)

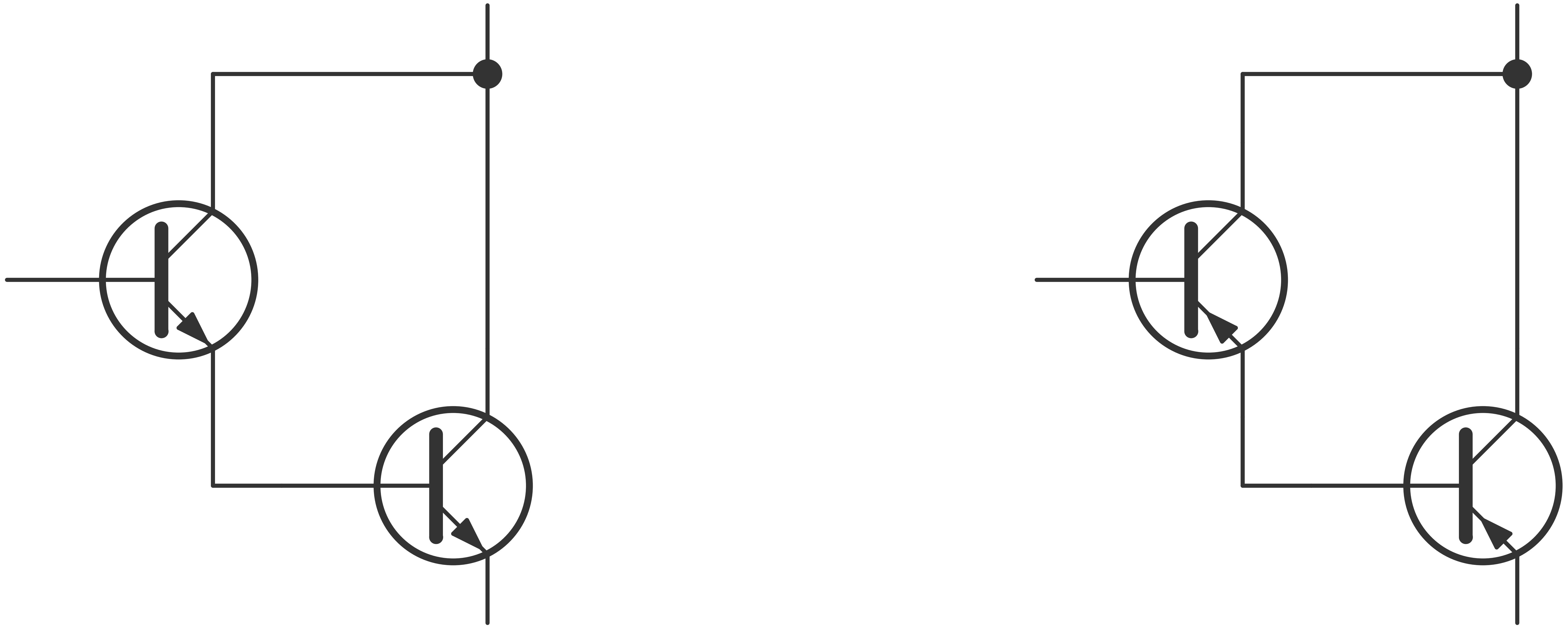
výpočet

Zvětšení proudového zesílení

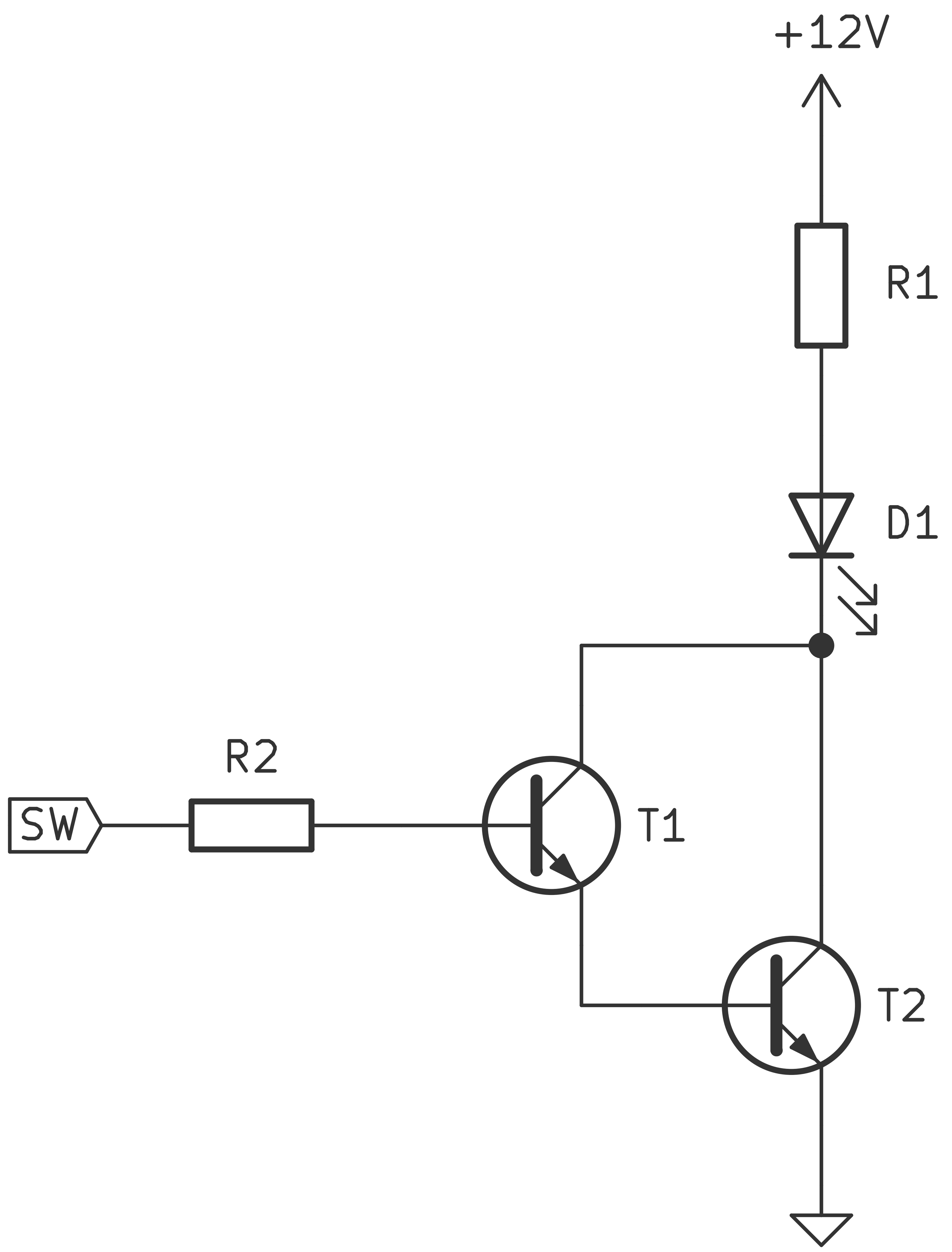
- **pro dosažení většího proudového zesílení** je možné **použít kaskádu tranzistorů** (tzv. „Darlingtonovo zapojení“, angl. „Darlington configuration“), kdy se jejich proudová zesílení násobí

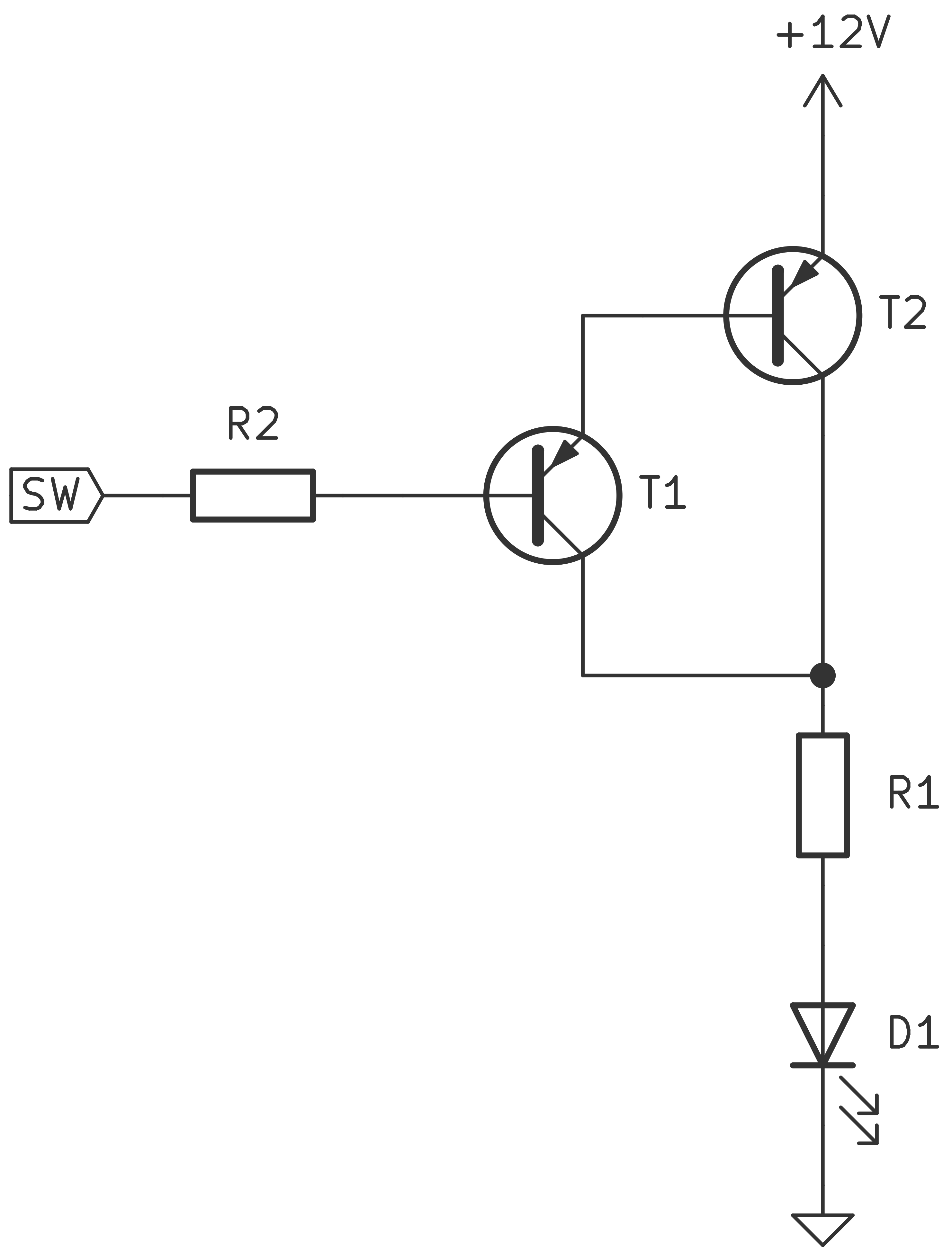
$$\left(h_{FE}\right)_{1+2} = \left(h_{FE}\right)_1 \cdot \left(h_{FE}\right)_2$$

- dvojice kaskádově zapojených tranzistorů se běžně vyrábí (~ „Darlingtonův tranzistor“)
- **tranzistory s velkým proudovým zesílením jsou výhodné** ke snížení proudu tekoucího spínacím GPIO vývodem i v situaci, kdy to není nutně potřeba



Darlingtonovo zapojení





Darlingtonovo zapojení tranzistorů NPN a PNP

TIP120 (LEGACY FAIRCHILD): Medium Power NPN Darlington Bipolar Power Transistor

Datasheet: NPN Epitaxial Darlington Transistor
Rev. 2 (282kB)

Product Overview

» View Reliability Data
» View Material Composition
» Product Change Notification
☆ Mark as Favorite

The Darlington Bipolar Power Transistor is designed for general-purpose amplifier and low-speed switching applications. TIP120, TIP121, TIP122 (NPN); TIP125, TIP126, TIP127 (PNP) are complementary devices.

Replacement Active Part Number: TIP120

Features

- High DC Current Gain - hFE = 2500 (typ) @ IC = 4.0 Adc
- Collector-Emitter Sustaining Voltage @ 100 mA
  $V_{CEO(sus)}$ = 60 Vdc (Min) TIP120, TIP125
  $V_{CEO(sus)}$ = 80 Vdc (Min) TIP121, TIP126
  $V_{CEO(sus)}$ = 100 Vdc (Min) TIP122, TIP127
- Low Collector-Emitter Saturation Voltage
  $V_{CE(sat)}$ = 2.0 Vdc (Max) @ I_C= 3.0 Adc
  = 4.0 Vdc (Max) @ I_C= 5.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors
- Compact TO-220 AB Package
- Pb-Free Packages are Available

Benefits

- -

Applications

- -

End Products

- -

Technical Documentation & Design Resources

Application Notes (1)
Package Drawings (1)
Data Sheets (1)

Availability & Samples | Specifications | Case Outlines

Product	Status	Compliance	Description	Package		MSL		Container		Budgetary Price/Unit
				Type	Case Outline	Type	Temperature	Type	Qty.	
			TIP120 (LEGACY	TO-				Bulk		

Previously Viewed Products
Select Product... Go
Clear List

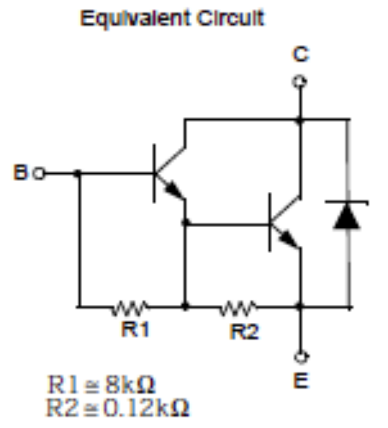
Support
Technical Documentation
Design Resources & Documents
Technical Support
Sales Support

ON Semiconductor®

TIP120 / TIP121 / TIP122
NPN Epitaxial Darlington Transistor

Features

- Medium Power Linear Switching Applications
- Complementary to TIP125 / TIP126 / TIP127



Ordering Information

Part Number	Top Mark	Package	Packing Method
TIP120	TIP120	TO-220 3L (Single Gauge)	Bulk
TIP120TU	TIP120	TO-220 3L (Single Gauge)	Rail
TIP121	TIP121	TO-220 3L (Single Gauge)	Bulk
TIP121TU	TIP121	TO-220 3L (Single Gauge)	Rail
TIP122	TIP122	TO-220 3L (Single Gauge)	Bulk
TIP122TU	TIP122	TO-220 3L (Single Gauge)	Rail

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at T_C = 25°C unless otherwise noted.

Symbol	Parameter		Value	Unit
V_{CBO}	Collector-Base Voltage	TIP120	60	V
		TIP121	80	
		TIP122	100	
V_{CEO}	Collector-Emitter Voltage	TIP120	60	V
		TIP121	80	
		TIP122	100	
V_{EBO}	Emitter-Base Voltage		5	V
I_C	Collector Current (DC)		5	A
I_{CP}	Collector Current (Pulse)		8	A
I_B	Base Current (DC)		120	mA
T_J	Junction Temperature		150	°C
T_{STG}	Storage Temperature Range		-65 to 150	°C

November-2017, Rev.2
Publication Order Number:
TIP122/D

Thermal Characteristics

Values are at T_C = 25°C unless otherwise noted.

Symbol	Parameter	Value	Unit
P_C	Collector Dissipation (T_A = 25°C)	2	W
	Collector Dissipation (T_C = 25°C)	65	

Electrical Characteristics

Values are at T_C = 25°C unless otherwise noted.

Symbol	Parameter		Conditions	Min.	Max.	Unit
$V_{CEO}(sus)$	Collector-Emitter Sustaining Voltage	TIP120	I_C = 100 mA, I_B = 0	60		V
		TIP121		80		
		TIP122		100		
I_{CEO}	Collector Cut-Off Current	TIP120	V_{CE} = 30 V, I_B = 0		0.5	mA
		TIP121	V_{CE} = 40 V, I_B = 0		0.5	
		TIP122	V_{CE} = 50 V, I_B = 0		0.5	
I_{CBO}	Collector Cut-Off Current	TIP120	V_{CB} = 60 V, I_E = 0		0.2	mA
		TIP121	V_{CB} = 80 V, I_E = 0		0.2	
		TIP122	V_{CB} = 100 V, I_E = 0		0.2	
I_{EBO}	Emitter Cut-Off Current		V_{EB} = 5 V, I_C = 0		2	mA
h_{FE}	DC Current Gain(1)		V_{CE} = 3 V, I_C = 0.5 A	1000		
			V_{CE} = 3 V, I_C = 3 A	1000		
$V_{CE}(sat)$	Collector-Emitter Saturation Voltage(1)		I_C = 3 A, I_B = 12 mA		2.0	V
			I_C = 5 A, I_B = 20 mA		4.0	
$V_{BE}(on)$	Base-Emitter On Voltage(1)		V_{CE} = 3 V, I_C = 3 A		2.5	V
C_{ob}	Output Capacitance		V_{CB} = 10 V, I_E = 0, f = 0.1 MHz		200	pF

Note:

1. Pulse test: pw ≤ 300 µs, duty cycle ≤ 2%.

Typical Performance Characteristics

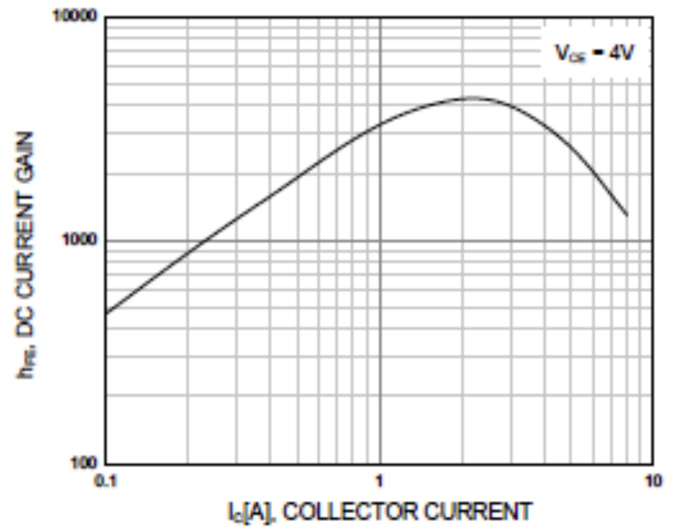


Figure 1. DC Current Gain

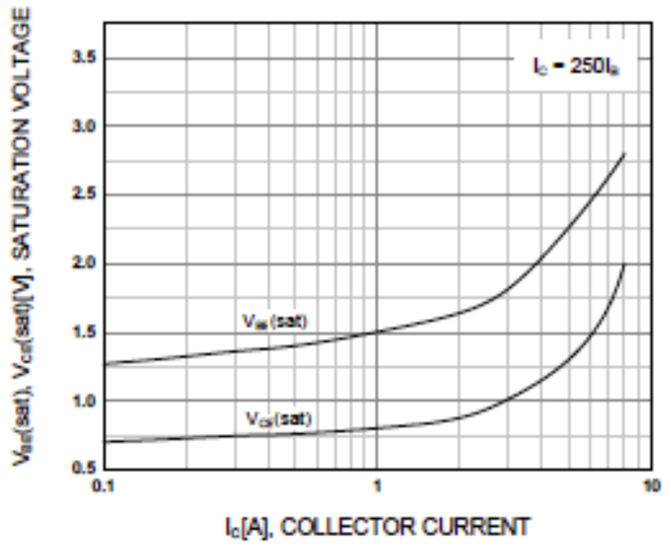


Figure 2. Base-Emitter Saturation Voltage and Collector-Emitter Saturation Voltage

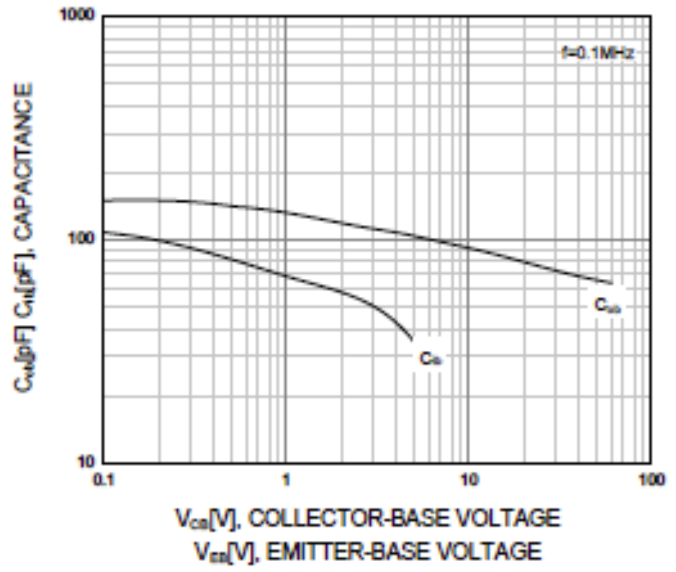


Figure 3. Output and Input Capacitance vs. Reverse Voltage

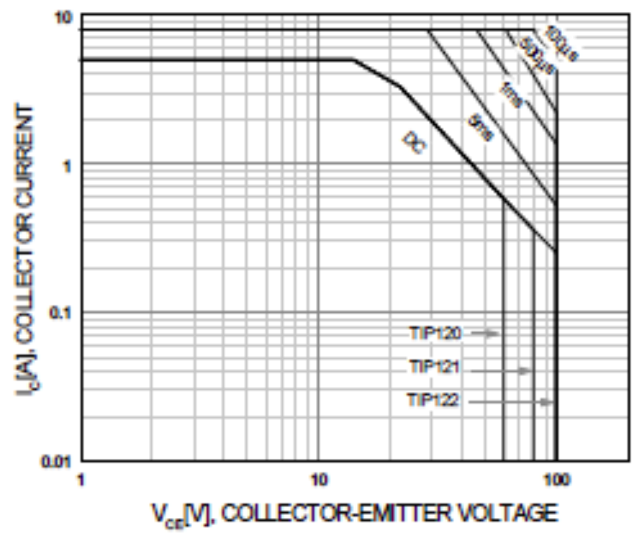


Figure 4. Safe Operating Area

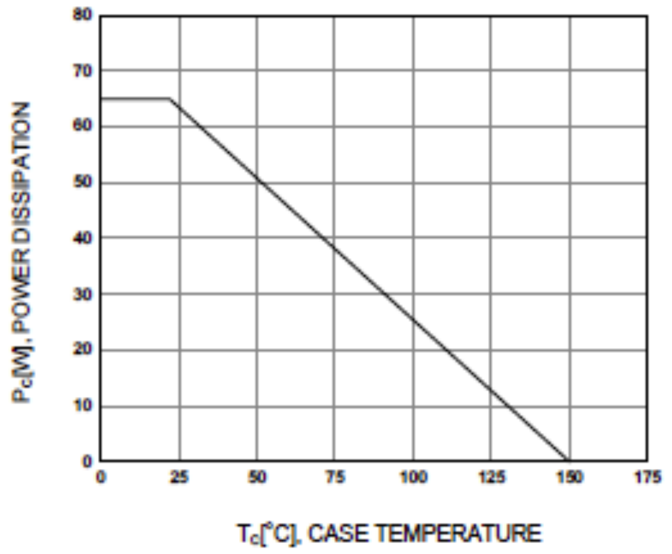


Figure 5. Power Derating

Typical Performance Characteristics

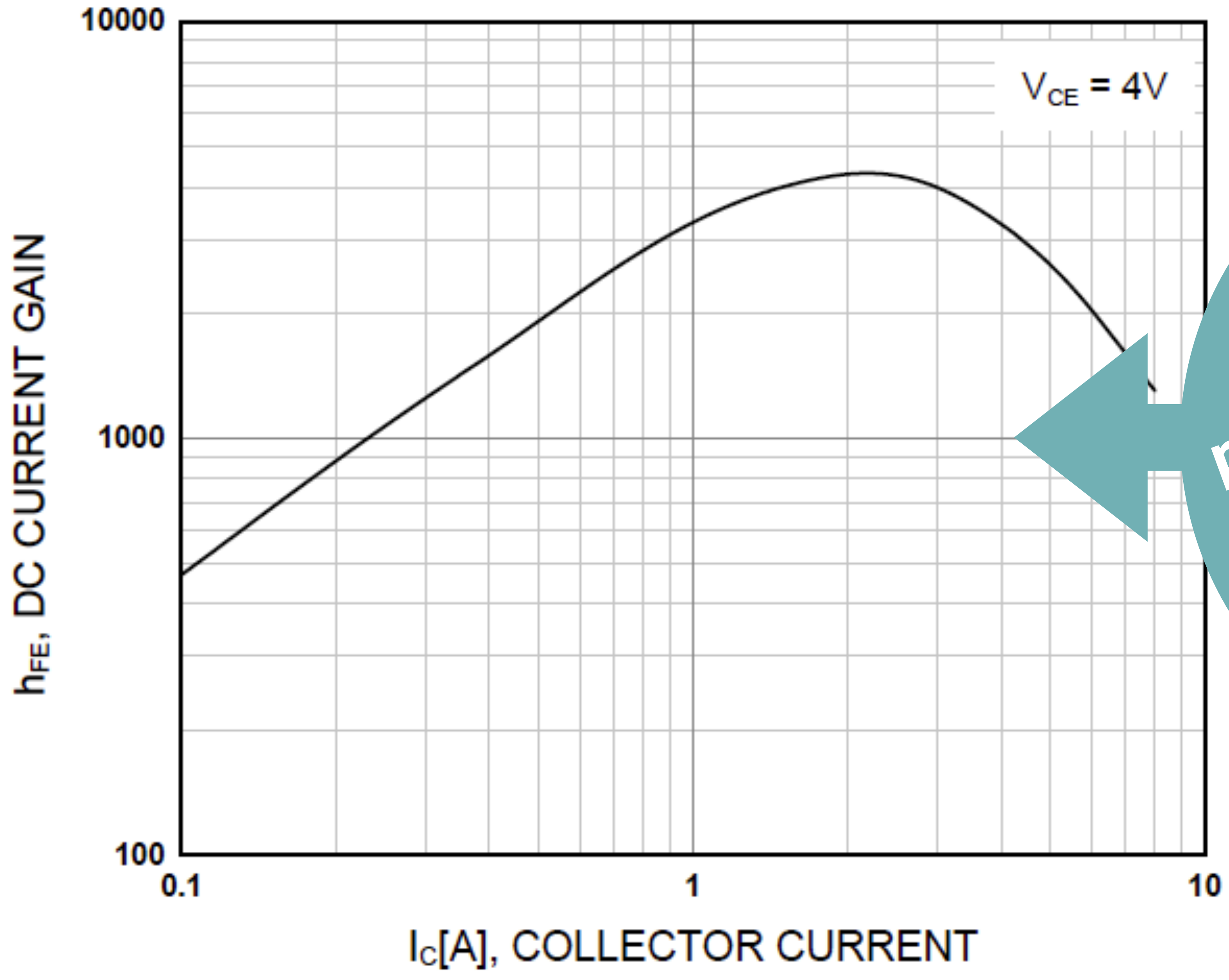


Figure 1. DC Current Gain

proudové zesílení je závislé na proudu ve spínaném obvodu

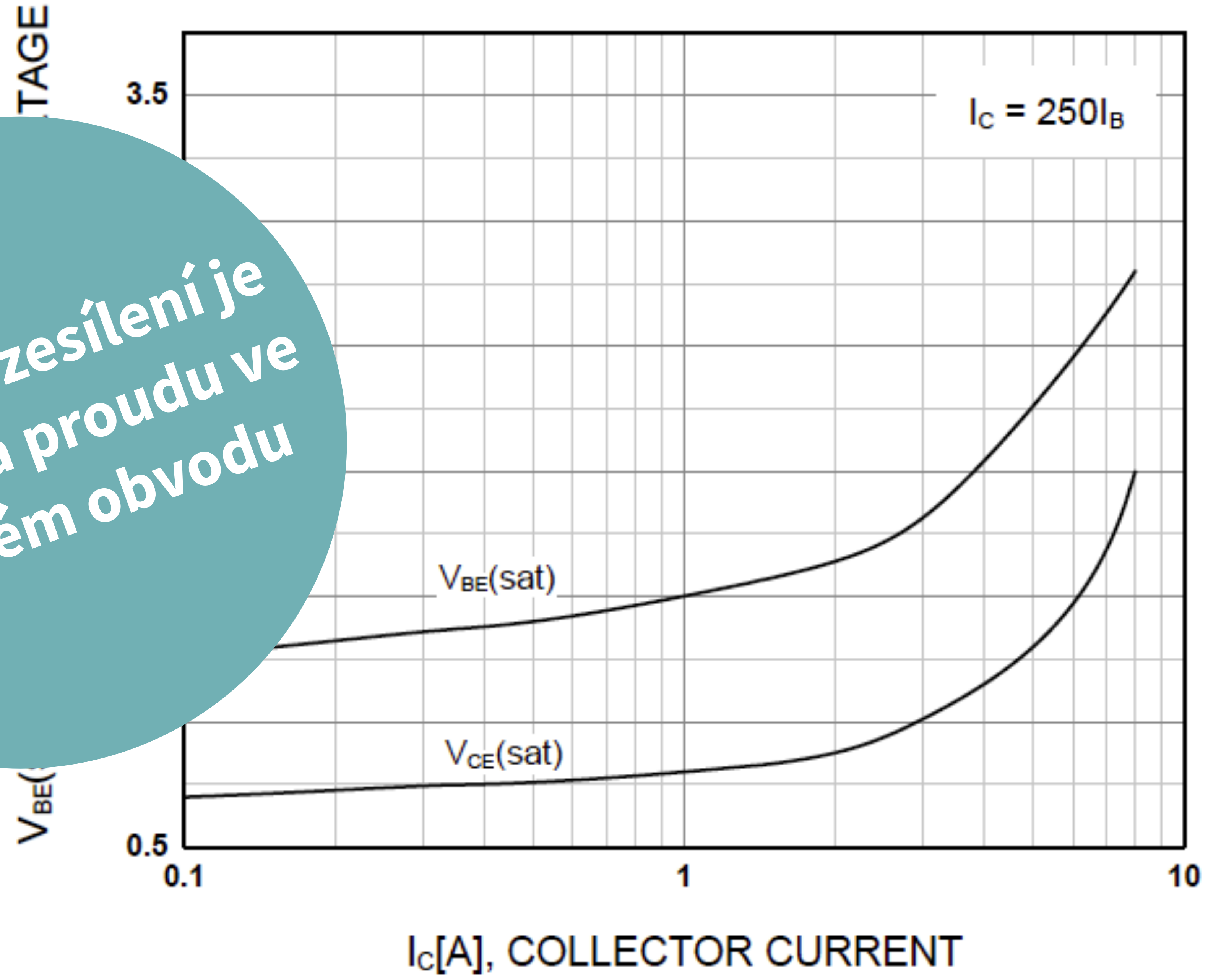
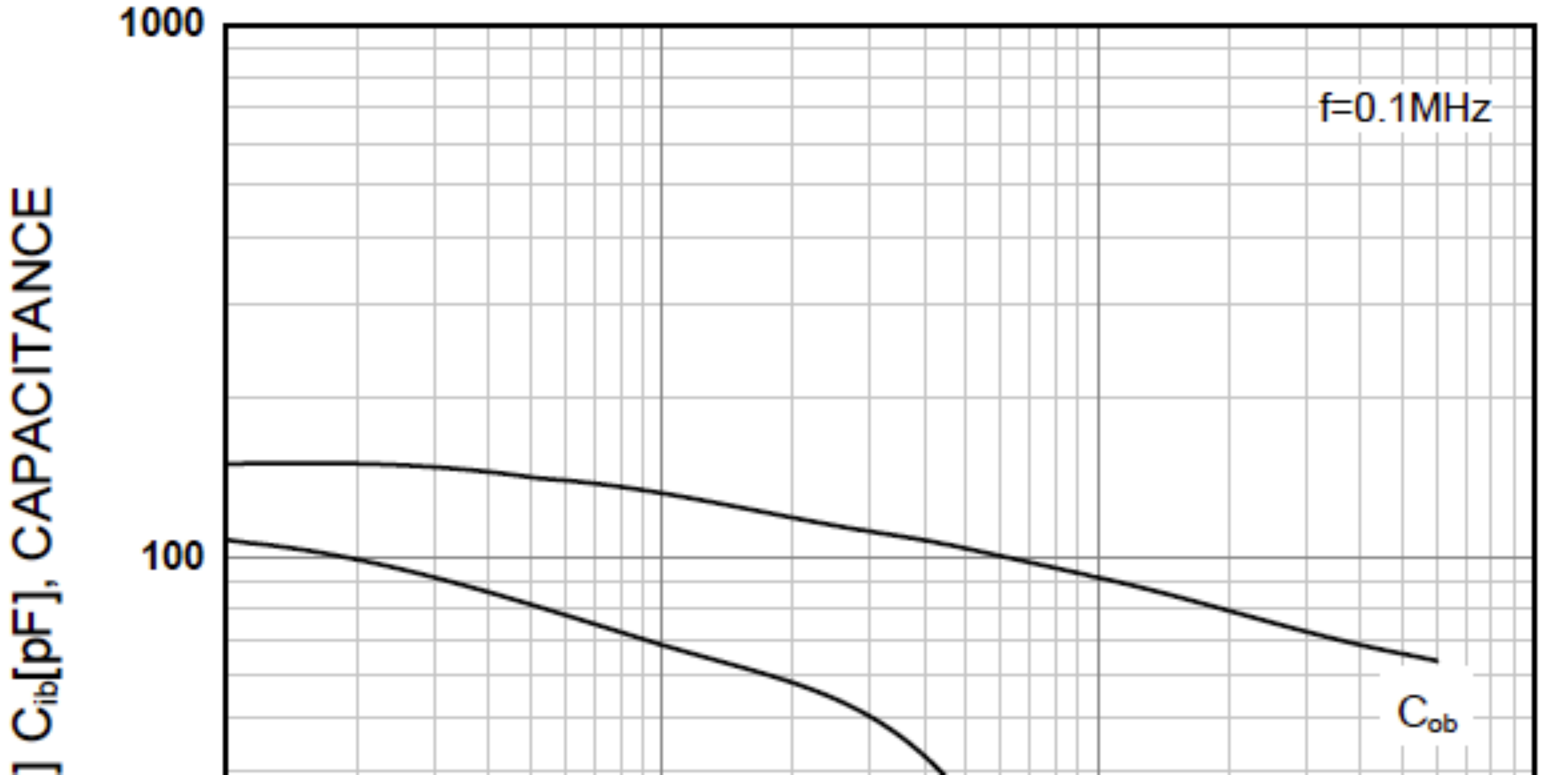
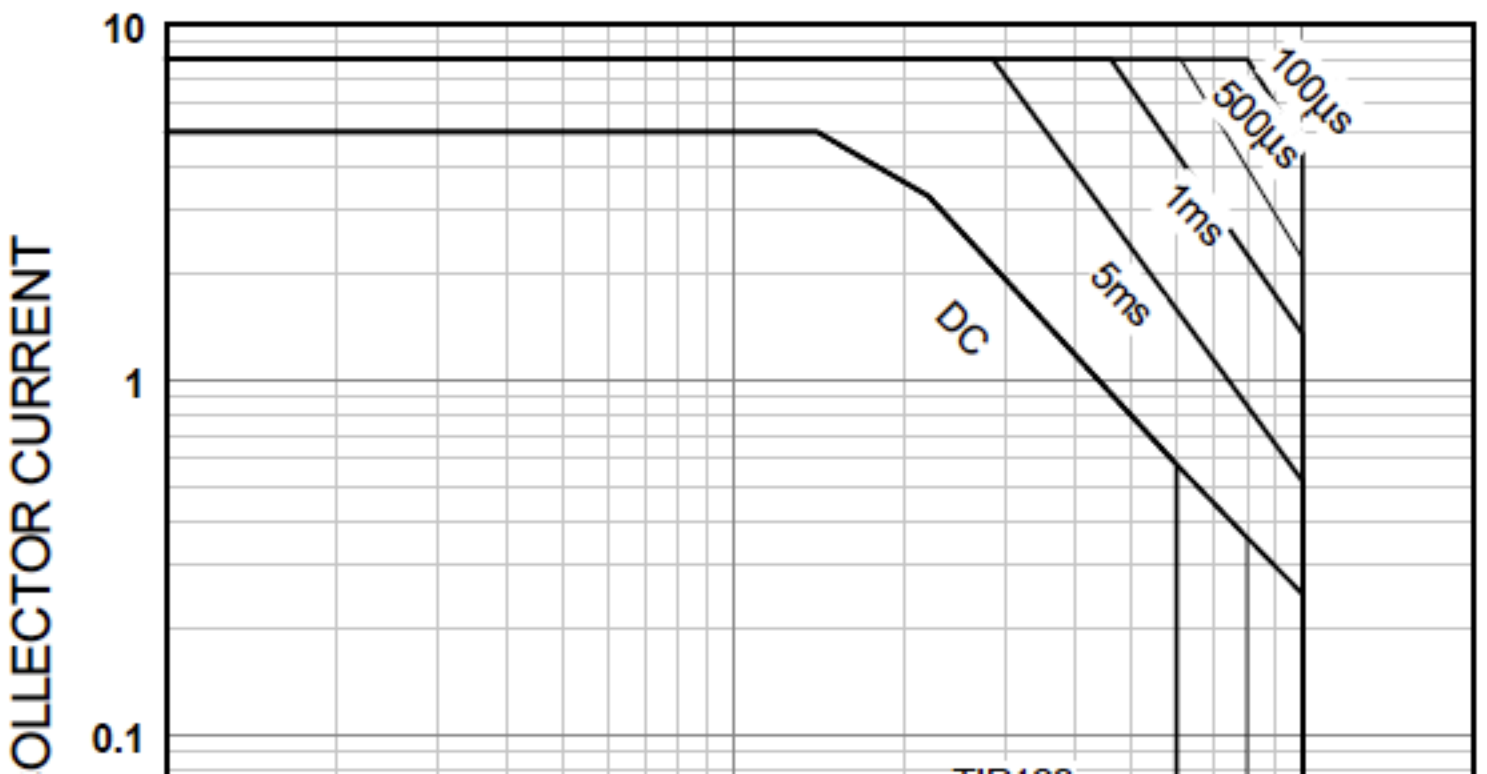


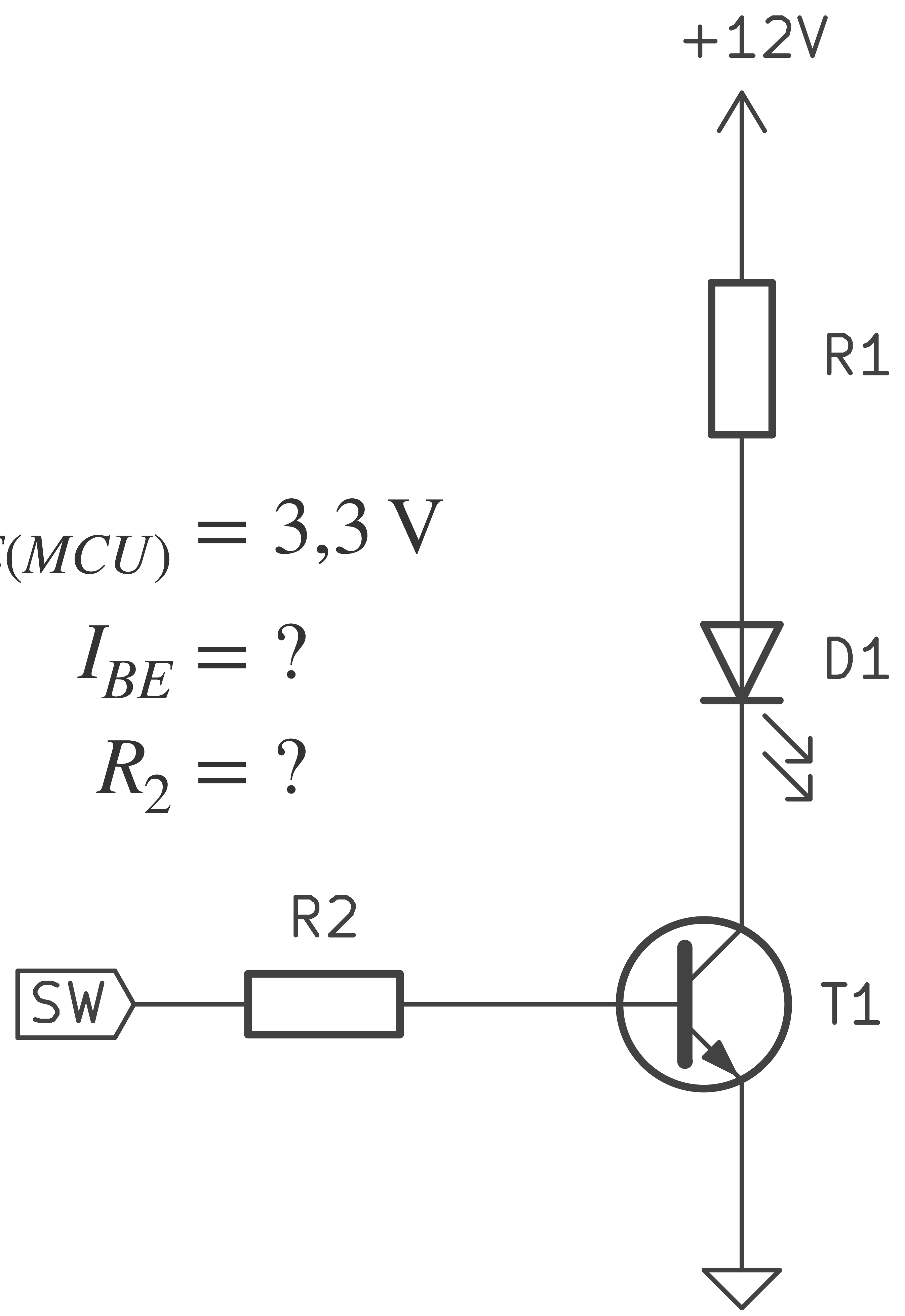
Figure 2. Base-Emitter Saturation Voltage and Collector-Emitter Saturation Voltage





hodnoty dané MCU

$$U_{BE(MCU)} = 3{,}3\ \mathrm{V}$$
$$I_{BE} = ?$$
$$R_2 = ?$$



hodnoty dané LED

$$U_{CE(LED)} = 12\ \mathrm{V}$$
$$I_{C(LED)} = 0{,}4\ \mathrm{A}$$

hodnoty dané tranzistorem

$$U_{BE(MAX)} = 5\ \mathrm{V}$$
$$U_{CE(MAX)} = 60\ \mathrm{V}$$
$$I_{C(MAX)} = 5\ \mathrm{A}$$
$$h_{FE} = 1000$$
$$U_{BE(SAT)} = 2{,}5\ \mathrm{V}$$
$$U_{CE(SAT)} = 4\ \mathrm{V}$$
$$P_D = 65\ \mathrm{W}$$

souhrn známých a neznámých hodnot

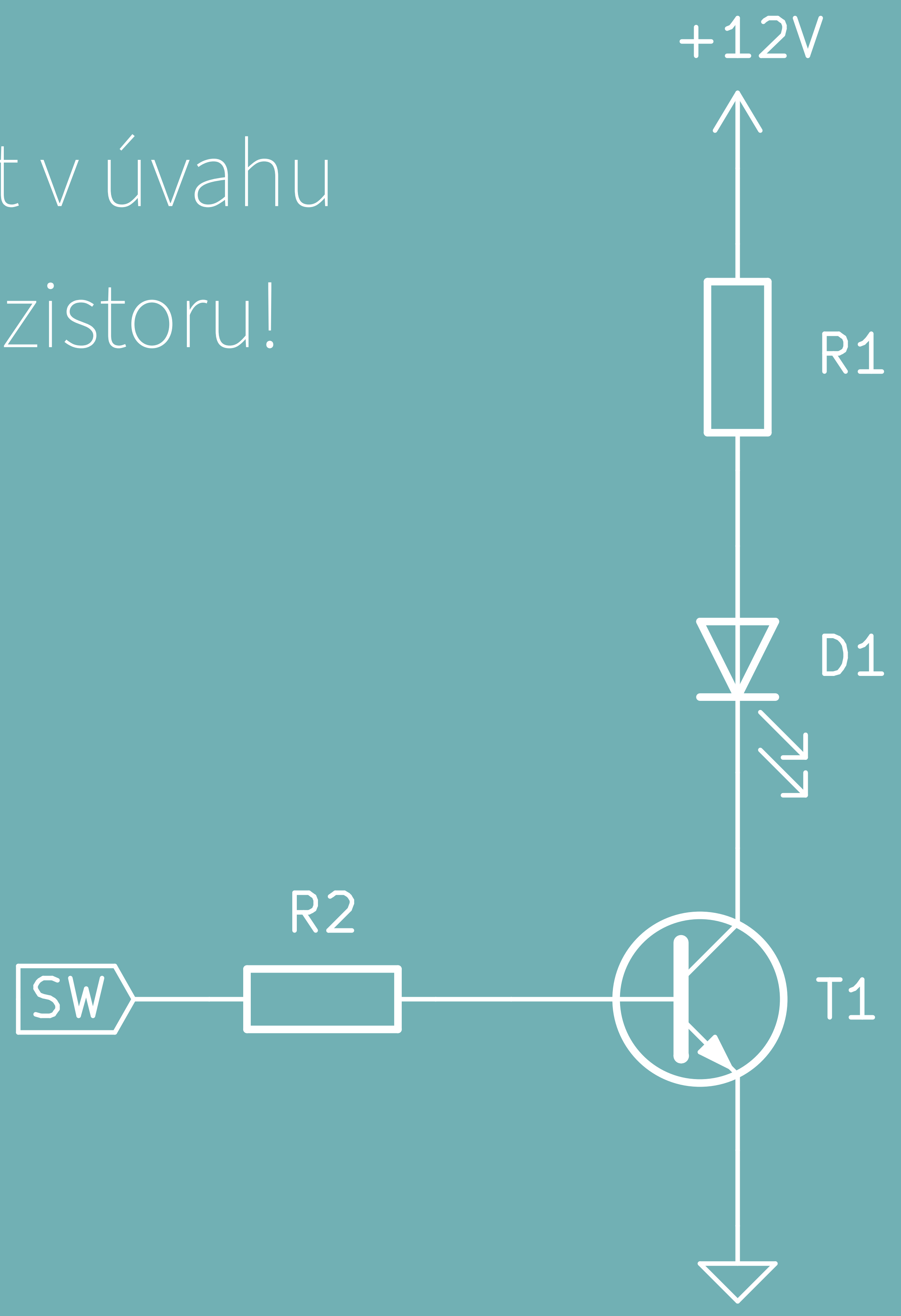
$$I_{BE} = \frac{I_C}{h_{FE}} = 3 \cdot \frac{0{,}4}{1000} \approx 1{,}2\,\mathrm{mA}$$

$$R_2 = \frac{U_{BE} - U_{BE(SAT)}}{I_{BE}} = \frac{3{,}3 - 2{,}5}{0{,}0012} \approx 667\,\Omega$$

$$U_{CE(SAT)} \cdot I_C + U_{BE(SAT)} \cdot I_{BE} = 4 \cdot 0{,}4 + 2{,}5 \cdot 0{,}0012 \approx 1{,}6\,\mathrm{W}$$

výpočet

Při výpočtu odporu předřadného rezistoru R_1 je potřeba brát v úvahu nejen úbytek napětí na LED, ale také úbytek napětí na tranzistoru!

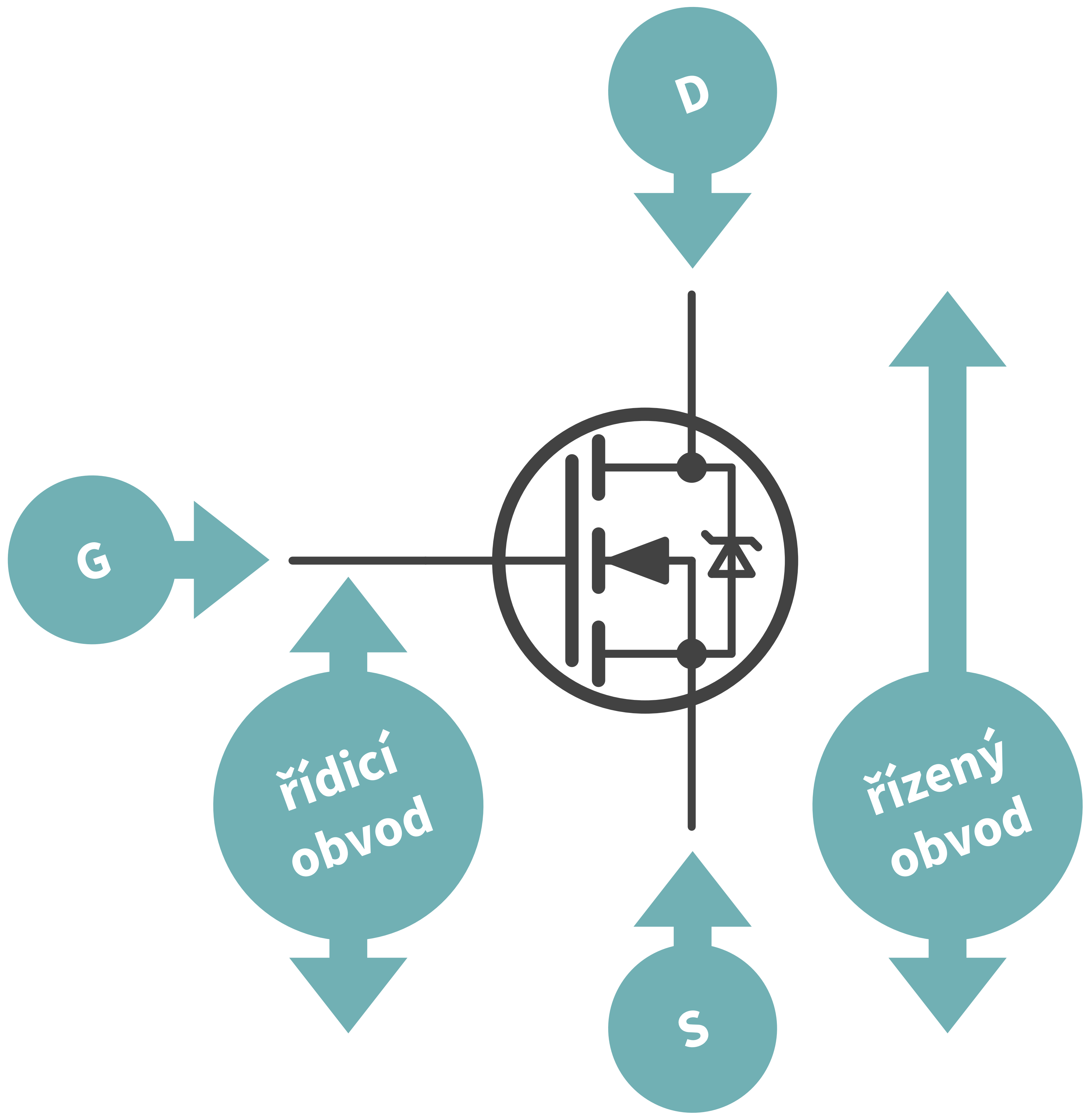


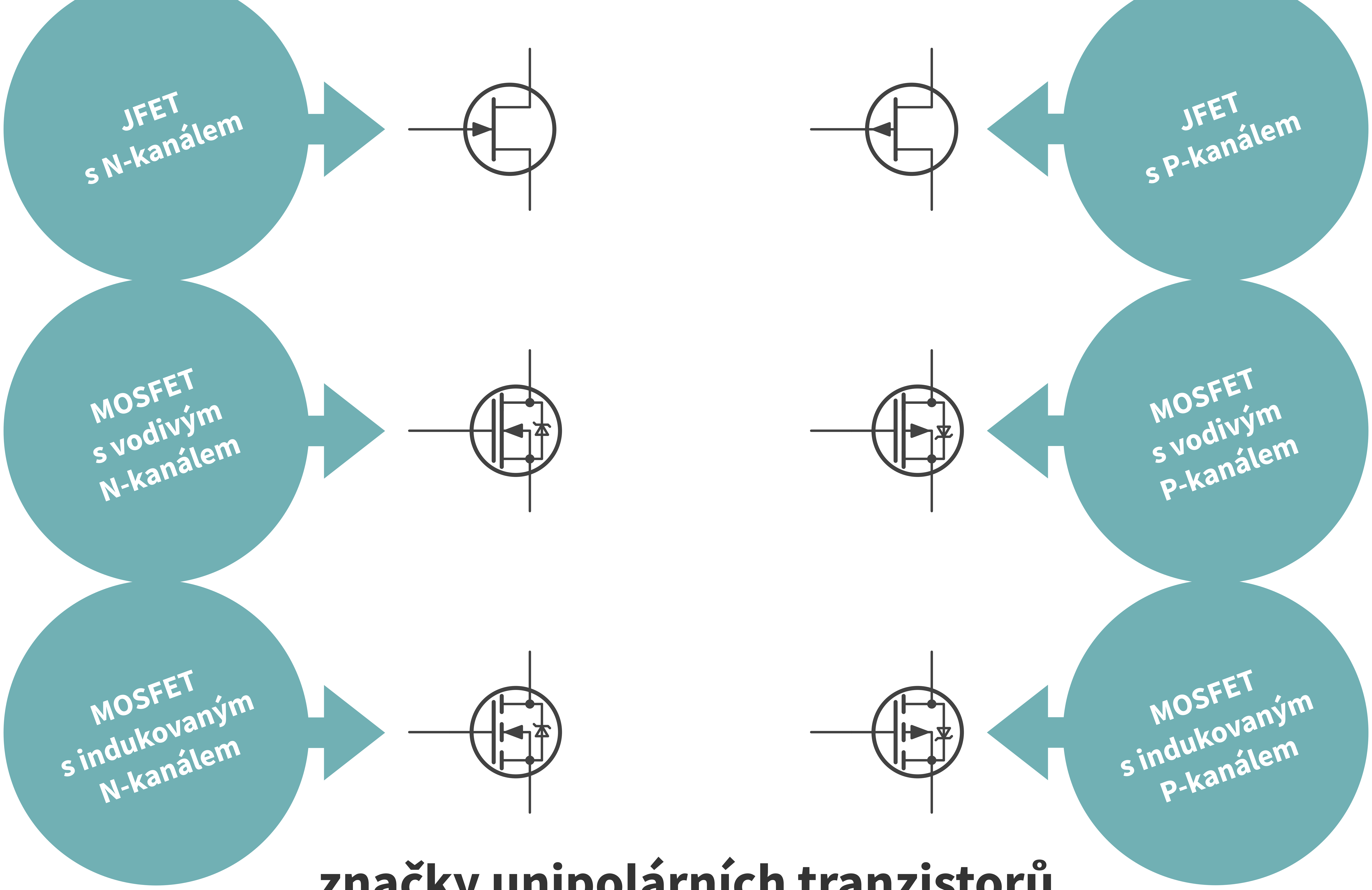
$$R_1 = \frac{U - U_F - U_{CE(SAT)}}{I} = \frac{12 - 1,8 - 4}{0,4} = 15\,\Omega$$

výpočet odporu předřadného rezistoru

Unipolární tranzistor

- angl. „field effect transistor“ (FET)
- česky také „tranzistor řízený elektrickým polem“
- tranzistor **řízený elektrickým napětím**
- vývody se označují
  - **hradlo** (angl. „ gate “, **G**)
  - **zdroj** (angl. „ source “, **S**)
  - **odtok** (angl. „ drain “, **D**)
- řídicí obvod = G–S, řízený obvod = D–S

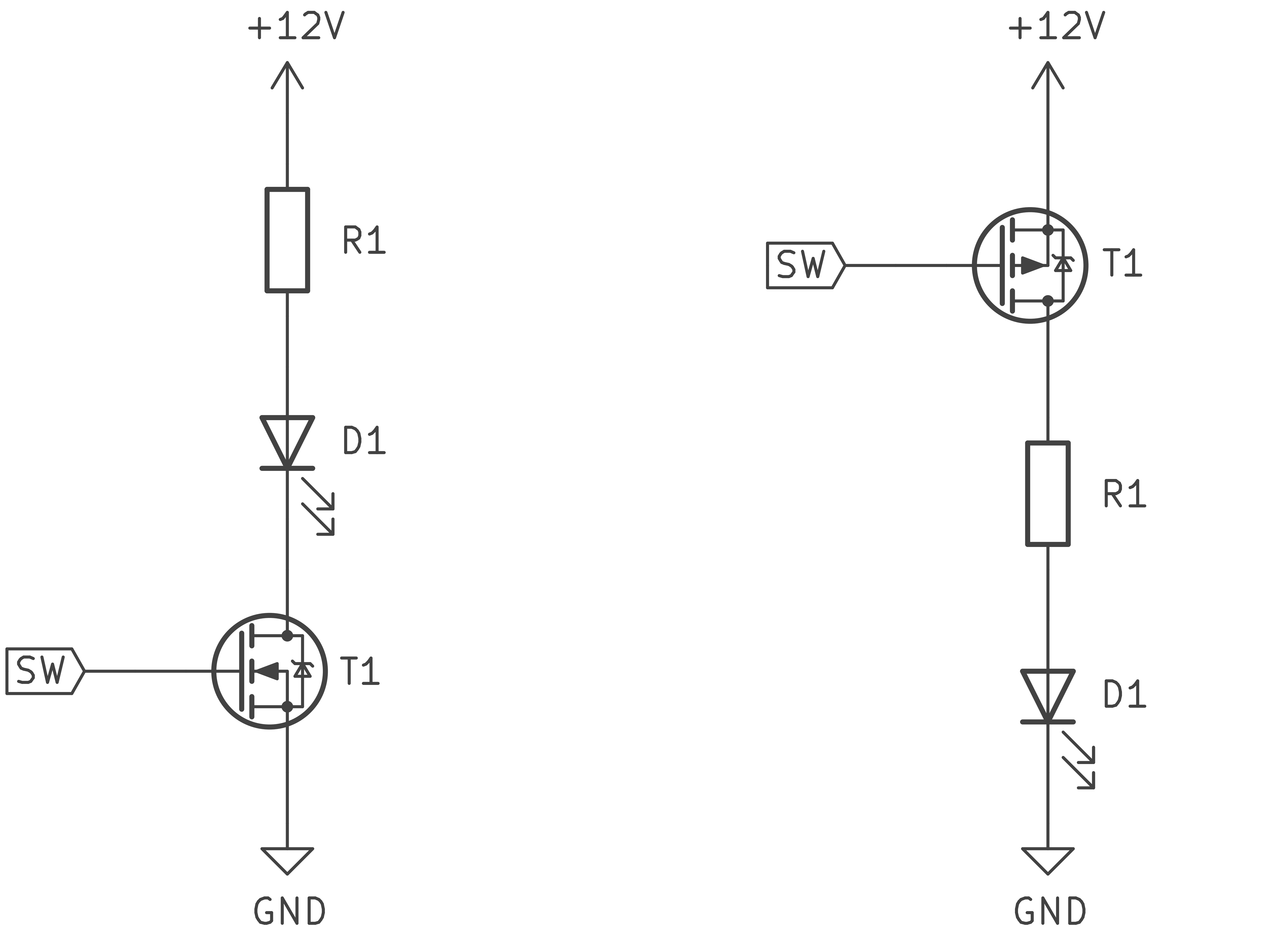




značky unipolárních tranzistorů

Tranzistory s N-kanálem a P-kanálem

- tranzistor **s N-kanálem se spíná kladným napětím hradla proti zdroji** (↦ pozitivní logika)
  - zdroj se zapojuje směrem k 0 V
- tranzistor **s P-kanálem se spíná záporným napětím hradla proti zdroji** (↦ negativní logika)
  - zdroj se zapojuje směrem k V_{CC}



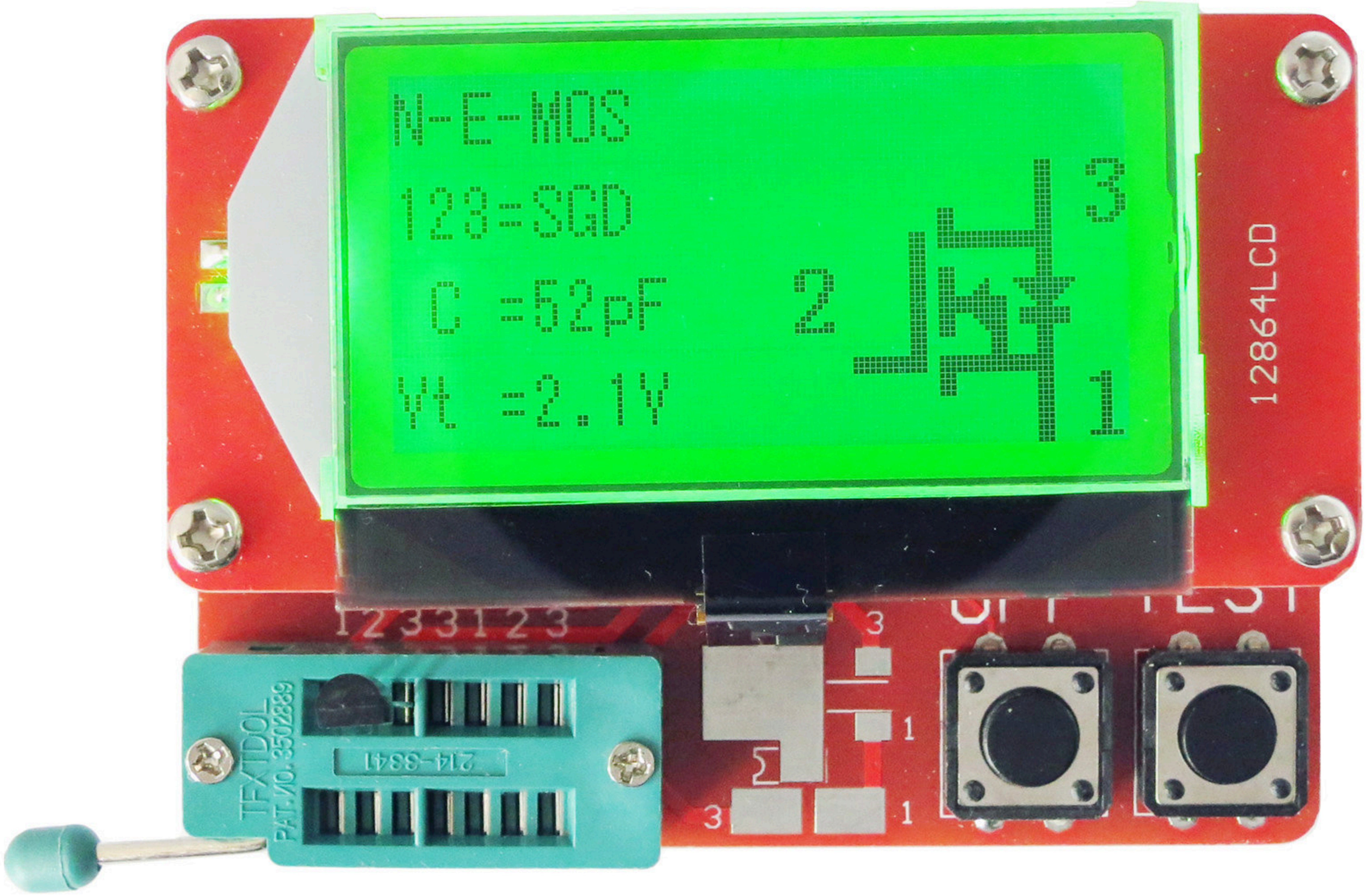
zapojení tranzistorů s N-kanálem a P-kanálem

Řízený obvod se musí zapojit **k odtoku**

(~ část u zdroje je společná s řídicím obvodem)!

Důležité parametry unipolárních tranzistorů

- **nejvyšší** přípustné **napětí v řídicím obvodu** U_{GS} [V]
- **nejvyšší** přípustné **napětí v řízeném obvodu** U_{DS} [V]
- **nejvyšší** přípustný **proud v řízeném obvodu** (také „odtokový proud“) I_D [A]
- **spínací napětí** $U_{GS(ON)}$ [V] pro požadovaný proud v řízeném obvodu
  je nejmenší napětí, které způsobí dostatečné sepnutí tranzistoru
- **úbytek napětí** na tranzistoru **v řízeném obvodu** $U_{DS(ON)}$ [V]
- **jmenovité zatížení** P_D [W]



unipolární tranzistor v analyzátoru součástek

Ověření parametrů unipolárního tranzistoru

- pro unipolární tranzistor postačuje zajistit, že
  - V_{OH} na GPIO vývodu $\geq U_{GS(ON)}$ pro **tranzistor s N-kanálem**
  - V_{OL} na GPIO vývodu $\leq U_{GS(ON)}$ pro **tranzistor s P-kanálem**
  - výkon vyzářený tranzistorem nepřekročí jeho jmenovité zatížení P_D

$$P = U_{DS(ON)} \cdot I_{DS}$$

2N7000: N-Channel Enhancement Mode Field Effect Transistor 60V, 200mA, 5 Ω

Datasheet: N-Channel Enhancement Mode Field Effect Transistor
Rev. 5 (757kB)

Product Overview

- View Reliability Data
- View Material Composition
- Product Change Notification
- Mark as Favorite

These N-channel Small Signal MOSFETs are produced using ON Semiconductor's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while providing rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 400 mA DC and can deliver pulsed currents up to 2 A. These products are particularly suited for low-voltage, low-current applications.

Features

- Voltage Controlled Small Signal Switch
- High Saturation Current Capability
- Rugged and Reliable
- High Density Cell Design for Low $R_{DS(ON)}$

Applications

- Small Servo Motor Control
- Power MOSFET Gate Drivers
- Assorted Switching Applications

Technical Documentation & Design Resources

Application Notes (12)	Data Sheets (1)
Simulation Models (5)	Package Drawings (3)

Availability & Samples | Specifications | Case Outlines

Product	Status	Compliance	Description	Package		MSL		Container		Budgetary Price/Unit
				Type	Case Outline	Type	Temperature	Type	Qty.	
2N7000	Active	Pb-free	2N7000	TO-92-3	135AN	NA		Bulk Bag	10000	$0.0871 Sample Inventory
2N7000-D26Z	Active	Pb-free	2N7000	TO-92-3 LF	135AR	NA		Tape and Reel	2000	$0.0787 Sample Inventory

Previously Viewed Products
Select Product... Go
Clear List

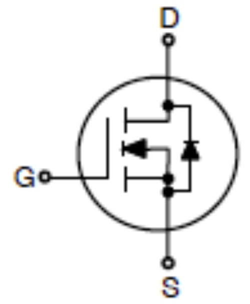
Support
Technical Documentation
Design Resources & Documents
Technical Support
Sales Support

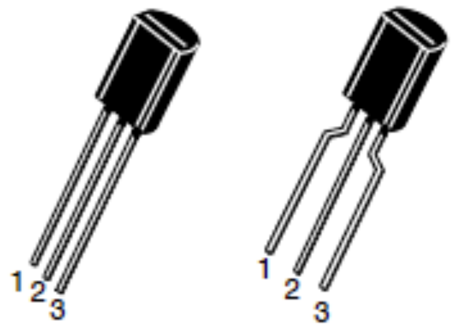
onsemi

DATA SHEET
www.onsemi.com

N-Channel Enhancement Mode Field Effect Transistor

2N7000, 2N7002, NDS7002A

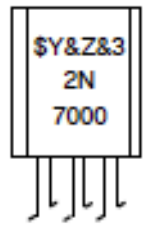




TO−92
CASE 135AN

TO−92
CASE 135AR

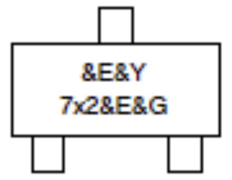
MARKING DIAGRAM



$Y = Logo
&Z = Assembly Plant Code
&3 = Date Code
2N7000 = Specific Device Code

MARKING DIAGRAM

SOT−23
CASE 318−08



&E = Designates Space
&Y = Binary Calendar Year Coding Scheme
7x2 = Specific Device Code x= 0, 1
&G = Date Code

ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

Description

These N−channel enhancement mode field effect transistors are produced using **onsemi's** proprietary, high cell density, DMOS technology. These products have been designed to minimize on−state resistance while providing rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 400 mAdc and can deliver pulsed currents up to 2 A. These products are particularly suited for low−voltage, low−current applications, such as small servo motor control, power MOSFET gate drivers, and other switching applications.

Features

- High Density Cell Design for Low $R_{DS(on)}$
- Voltage Controlled Small Signal Switch
- Rugged and Reliable
- High Saturation Current Capability
- This Device is Pb−Free and Halogen Free

August, 2021 − Rev. 5
Publication Order Number:
NDS7002A/D

ABSOLUTE MAXIMUM RATINGS Values are at T_C = 25°C unless otherwise noted.

Symbol	Parameter	Value			Unit
		2N7000	2N7002	NDS7002A	
V_{DSS}	Drain−to−Source Voltage	60			V
V_{DGR}	Drain−Gate Voltage (R_{GS} ≤ 1 MW)	60			V
V_{GSS}	Gate−Source Voltage − Continuous	±20			V
	Gate−Source Voltage − Non Repetitive (tp < 50 ms)	±40			
I_D	Maximum Drain Current − Continuous	200	115	280	mA
	Maximum Drain Current − Pulsed	500	800	1500	
P_D	Maximum Power Dissipation Derated above 25°C	400	200	300	mW
		3.2	1.6	2.4	mW/°C
T_J, T_{STG}	Operating and Storage Temperature Range	−55 to 150		−65 to 150	°C
T_L	Maximum Lead Temperature for Soldering Purposes, 1/16−inch from Case for 10 s	300			°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

THERMAL CHARACTERISTICS Values are at T_C = 25°C unless otherwise noted.

Symbol	Parameter	Value			Unit
		2N7000	2N7002	NDS7002A	
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	312.5	625	417	°C/W

ELECTRICAL CHARACTERISTICS
Values are at T_C = 25°C unless otherwise noted.

Symbol	Parameter	Conditions	Type	Min.	Typ.	Max.	Unit
OFF CHARACTERISTICS							
BV_{DSS}	Drain−Source Breakdown Voltage	V_{GS} = 0 V, I_D = 10 μA	All	60	−	−	V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 48 V, V_{GS} = 0 V	2N7000	−	−	1	μA
		V_{DS} = 48 V, V_{GS} = 0 V, T_C = 125°C		−	−	1	mA
		V_{DS} = 60 V, V_{GS} = 0 V	2N7002 NDS7002A	−	−	1	μA
		V_{DS} = 60 V, V_{GS} = 0 V, T_C = 125°C		−	−	0.5	mA
I_{GSSF}	Gate − Body Leakage, Forward	V_{GS} = 15 V, V_{DS} = 0 V	2N7000	−	−	10	nA
		V_{GS} = 20 V, V_{DS} = 0 V	2N7002 NDS7002A	−	−	100	
I_{GSSR}	Gate − Body Leakage, Reverse	V_{GS} = −15 V, V_{DS} = 0 V	2N7000	−	−	−10	nA
		V_{GS} = −20 V, V_{DS} = 0 V	2N7002 NDS7002A	−	−	−100	
ON CHARACTERISTICS							
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS}, I_D = 1 mA	2N7000	0.8	2.1	3	V
		V_{DS} = V_{GS}, I_D = 250 μA	2N7002 NDS7002A	1	2.1	2.5	

ELECTRICAL CHARACTERISTICS (continued)
Values are at T_C = 25°C unless otherwise noted.

Symbol	Parameter	Conditions	Type	Min.	Typ.	Max.	Unit
ON CHARACTERISTICS							
$R_{DS(on)}$	Static Drain–Source On–Resistance	V_{GS} = 10 V, I_D = 500 mA	2N7000	–	1.2	5	Ω
		V_{GS} = 10 V, I_D = 500 mA, T_C = 125°C		–	1.9	9	
		V_{GS} = 4.5 V, I_D = 75 mA		–	1.8	5.3	
		V_{GS} = 10 V, I_D = 500 mA	2N7002	–	1.2	7.5	
		V_{GS} = 10 V, I_D = 500 mA, T_C = 100°C		–	1.7	13.5	
		V_{GS} = 5 V, I_D = 50 mA		–	1.7	7.5	
		V_{GS} = 5 V, I_D = 50 mA, T_C = 100°C		–	2.4	13.5	
		V_{GS} = 10 V, I_D = 500 mA	NDS7002A	–	1.2	2	
		V_{GS} = 10 V, I_D = 500 mA, T_C = 125°C		–	2	3.5	
		V_{GS} = 5 V, I_D = 50 mA		–	1.7	3	
		V_{GS} = 5 V, I_D = 50 mA, T_C = 125°C		–	2.8	5	
$V_{DS(on)}$	Drain–Source On–Voltage	V_{GS} = 10 V, I_D = 500 mA	2N7000	–	0.6	2.5	V
		V_{GS} = 4.5 V, I_D = 75 mA		–	0.14	0.4	
		V_{GS} = 10 V, I_D = 500 mA	2N7002	–	0.6	3.75	
		V_{GS} = 5.0 V, I_D = 50 mA		–	0.09	1.5	
		V_{GS} = 10 V, I_D = 500 mA	NDS7002A	–	0.6	1	
		V_{GS} = 5.0 V, I_D = 50 mA		–	0.09	0.15	
$I_{D(on)}$	On–State Drain Current	V_{GS} = 4.5 V, V_{DS} = 10 V	2N7000	75	600	–	mA
		V_{GS} = 10 V, $V_{DS} \geq 2\ V_{DS(on)}$	2N7002	500	2700	–	
		V_{GS} = 10 V, $V_{DS} \geq 2\ V_{DS(on)}$	NDS7002A	500	2700	–	
g_{FS}	Forward Transconductance	V_{DS} = 10 V, I_D = 200 mA	2N7000	100	320	–	mS
		$V_{DS} \geq 2\ V_{DS(on)}$, I_D = 200 mA	2N7002	80	320	–	
		$V_{DS} \geq 2\ V_{DS(on)}$, I_D = 200 mA	NDS7002A	80	320	–	
DYNAMIC CHARACTERISTICS							
C_{iss}	Input Capacitance	V_{DS} = 25 V, V_{GS} = 0 V, f = 1.0 MHz	All	–	20	50	pF
C_{oss}	Output Capacitance		All	–	11	25	
C_{rss}	Reverse Transfer Capacitance		All	–	4	5	
t_{on}	Turn–On Time	V_{DD} = 15 V, R_L = 25 Ω, I_D = 500 mA, V_{GS} = 10 V, R_{GEN} = 25 Ω	2N7000	–	–	10	ns
		V_{DD} = 30 V, R_L = 150 Ω, I_D = 200 mA, V_{GS} = 10 V, R_{GEN} = 25 Ω	2N7002 NDS7002A	–	–	20	
t_{off}	Turn–Off Time	V_{DD} = 15 V, R_L = 25 Ω, I_D = 500 mA, V_{GS} = 10 V, R_{GEN} = 25 Ω	2N7000	–	–	10	ns
		V_{DD} = 30 V, R_L = 150 Ω, I_D = 200 mA, V_{GS} = 10 V, R_{GEN} = 25 Ω	2N7002 NDS7002A	–	–	20	

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

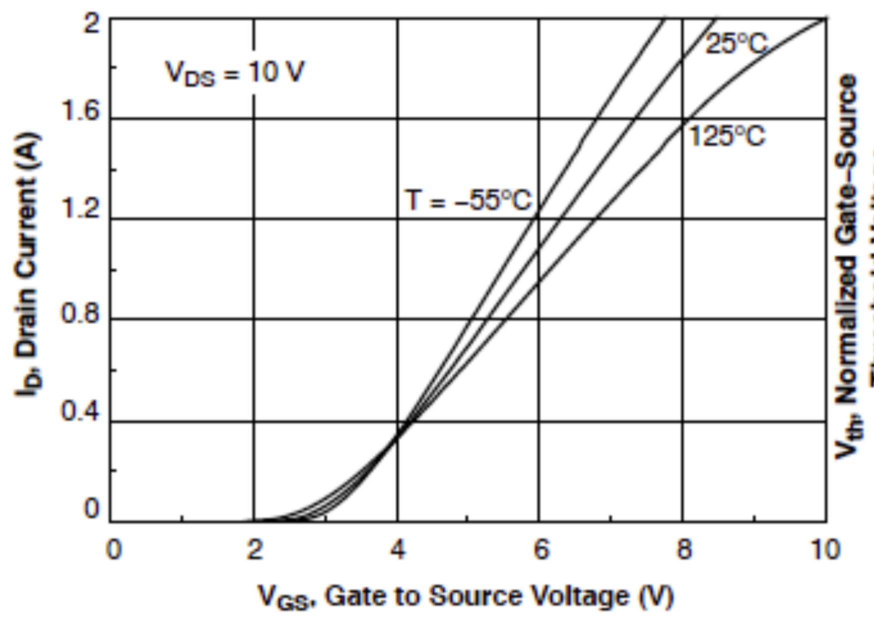


Figure 5. Transfer Characteristics

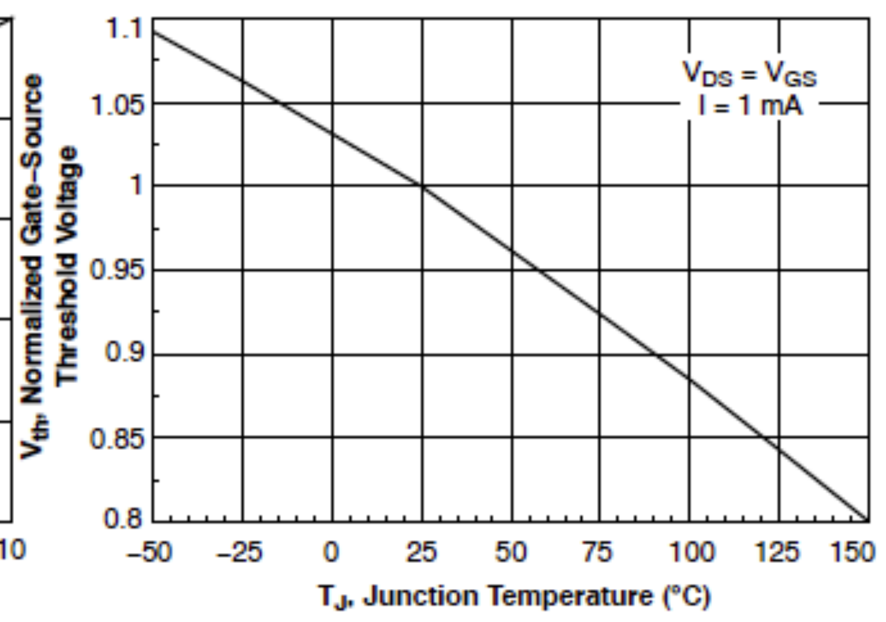


Figure 6. Gate Threshold Variation with Temperature

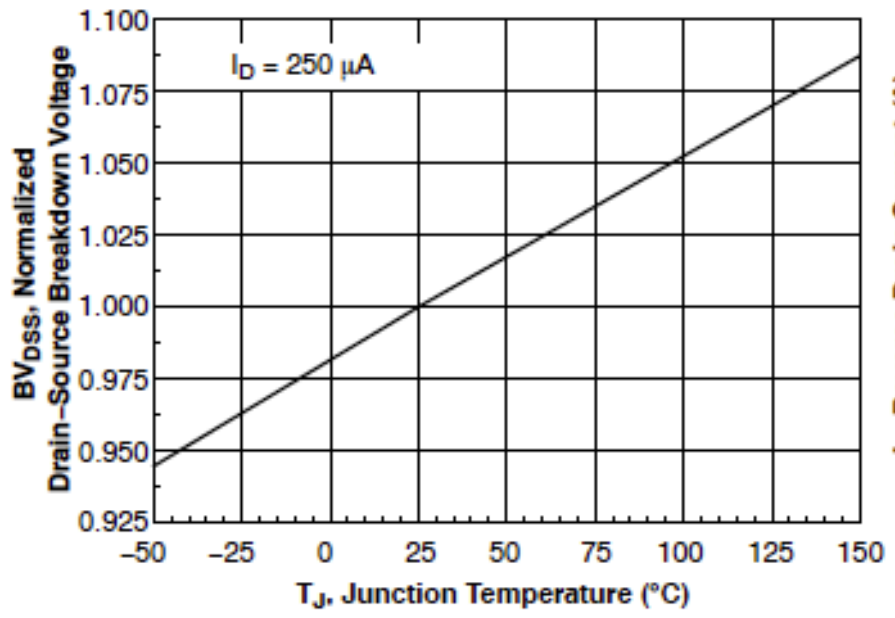


Figure 7. Breakdown Voltage Variation with Temperature

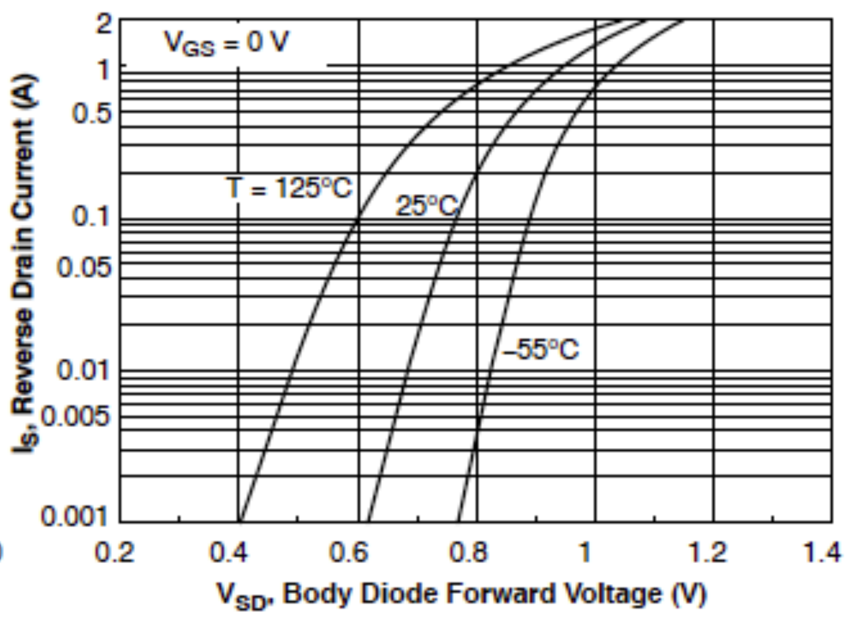


Figure 8. Body Diode Forward Voltage Variation with

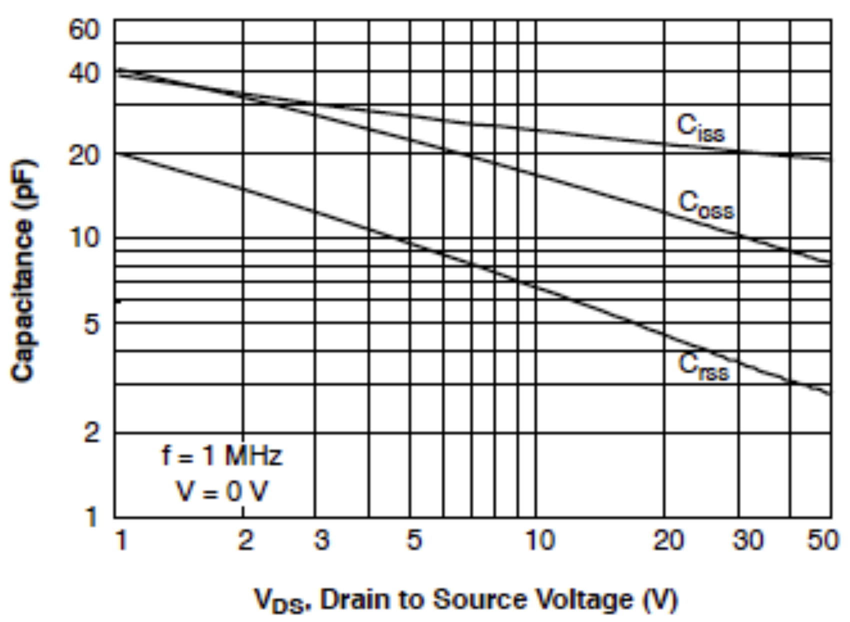


Figure 9. Capacitance Characteristics

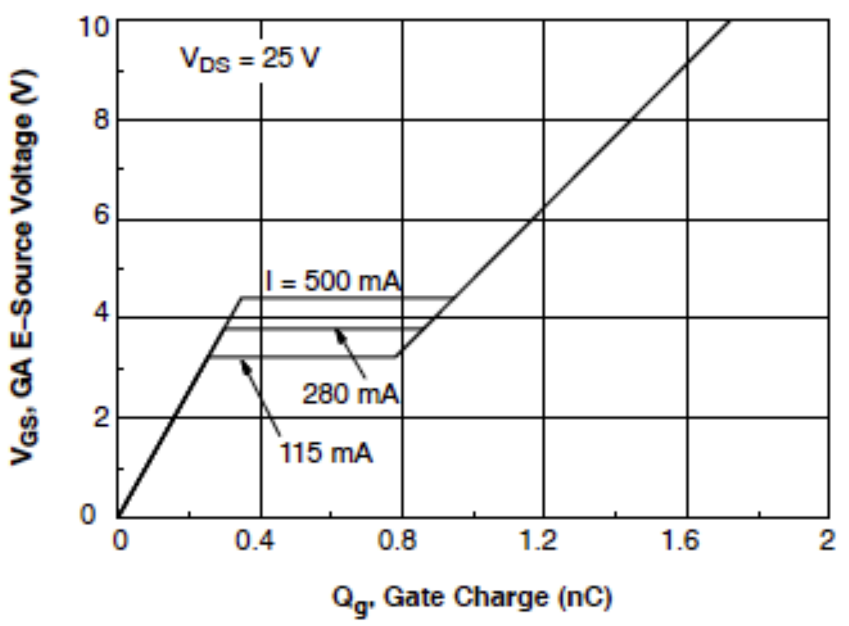
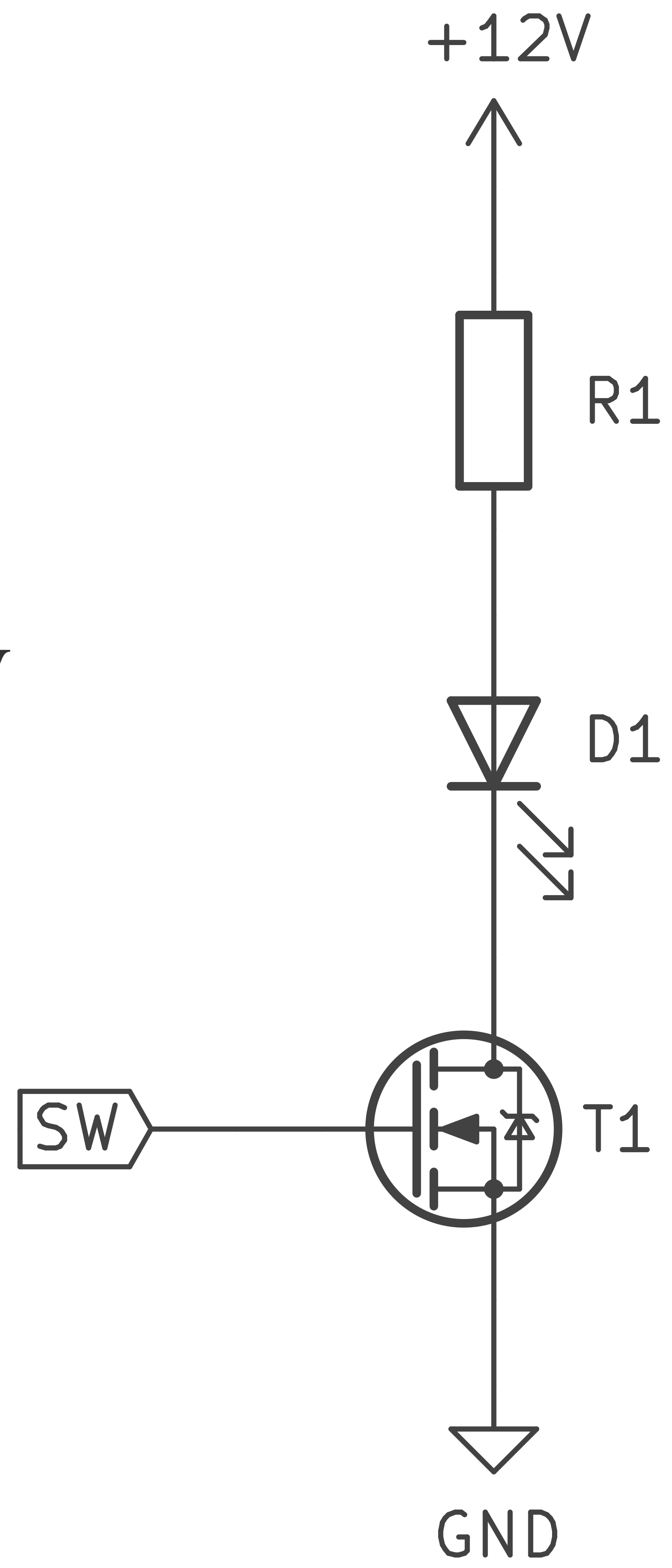


Figure 10. Gate Charge Characteristics

hodnoty dané MCU (~ 3,3 V CMOS)

$$V_{CC} = 3{,}3\ \mathrm{V}$$
$$V_{OH} = 3\ \mathrm{V}$$



$$U_{CE(LED)} = 12\ \mathrm{V}$$
$$I_{C(LED)} = 0{,}4\ \mathrm{A}$$

hodnoty dané LED

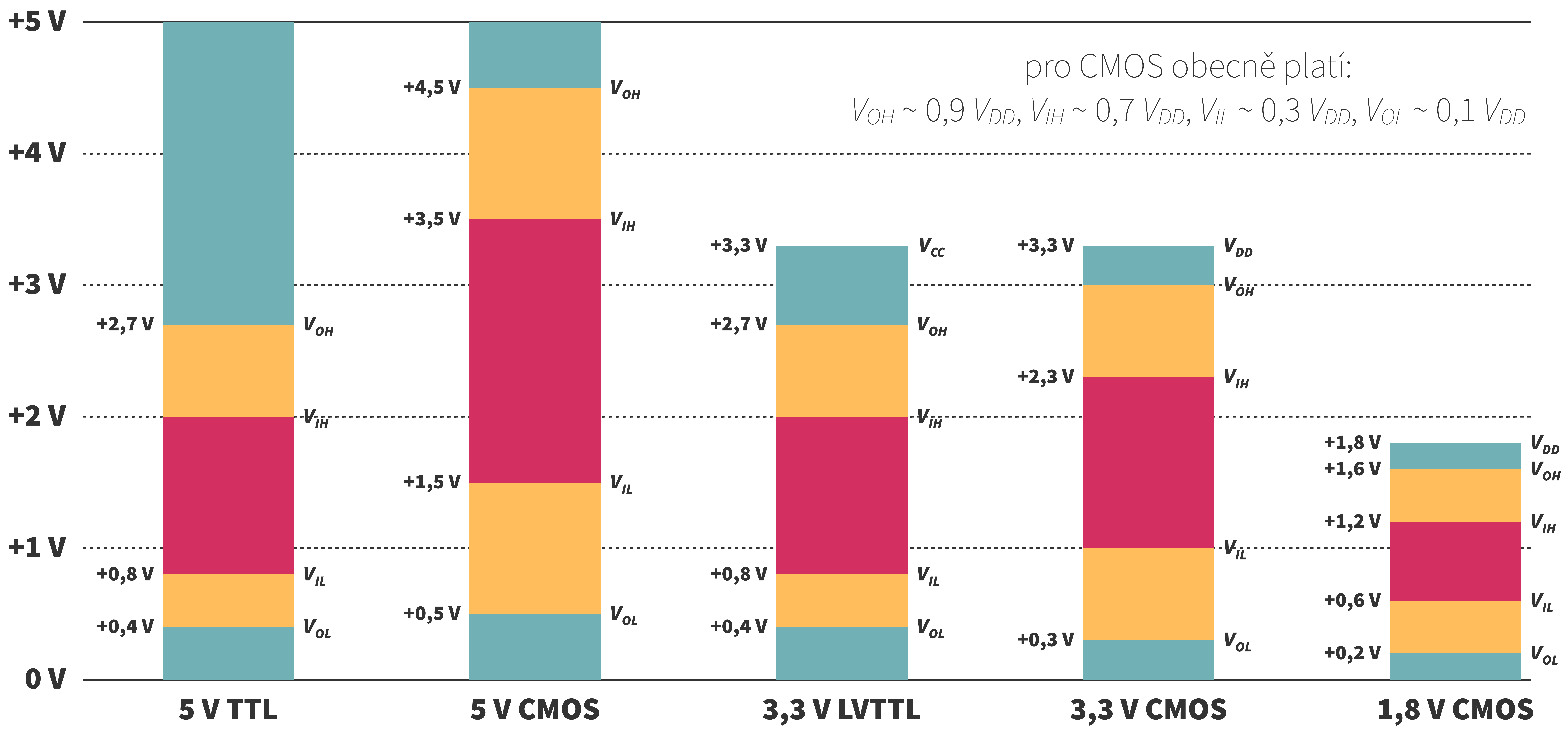
$$U_{GS(MAX)} = 20\ \mathrm{V}$$
$$U_{DS(MAX)} = 60\ \mathrm{V}$$
$$I_{D(MAX)} = 115\ \mathrm{mA}$$
$$U_{GS(ON)} = 2{,}1\ \mathrm{V}$$
$$U_{DS(ON)} = 0{,}2\ \mathrm{V}$$
$$P_D = 200\ \mathrm{mW}$$

hodnoty dané tranzistorem

souhrn známých a neznámých hodnot

Zde není splněna již podmínka připustnosti proudu v řízeném obvodu ($I_{D(MAX)} = 115\,\text{mA} \geq 0{,}4\,\text{A}$).

Nicméně je zde ještě další problém…



různé napěťové standardy pro digitální elektroniku

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

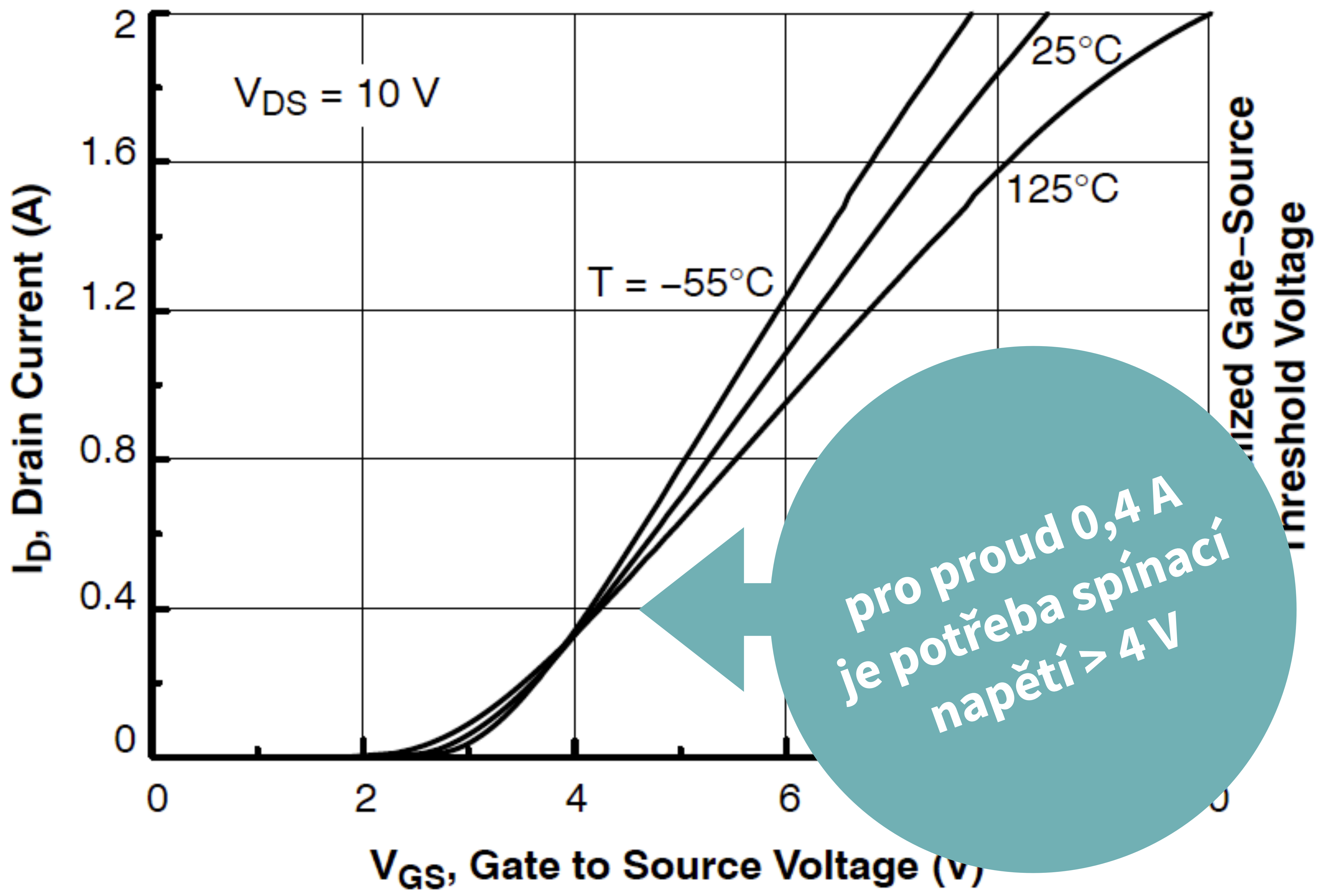


Figure 5. Transfer Characteristics

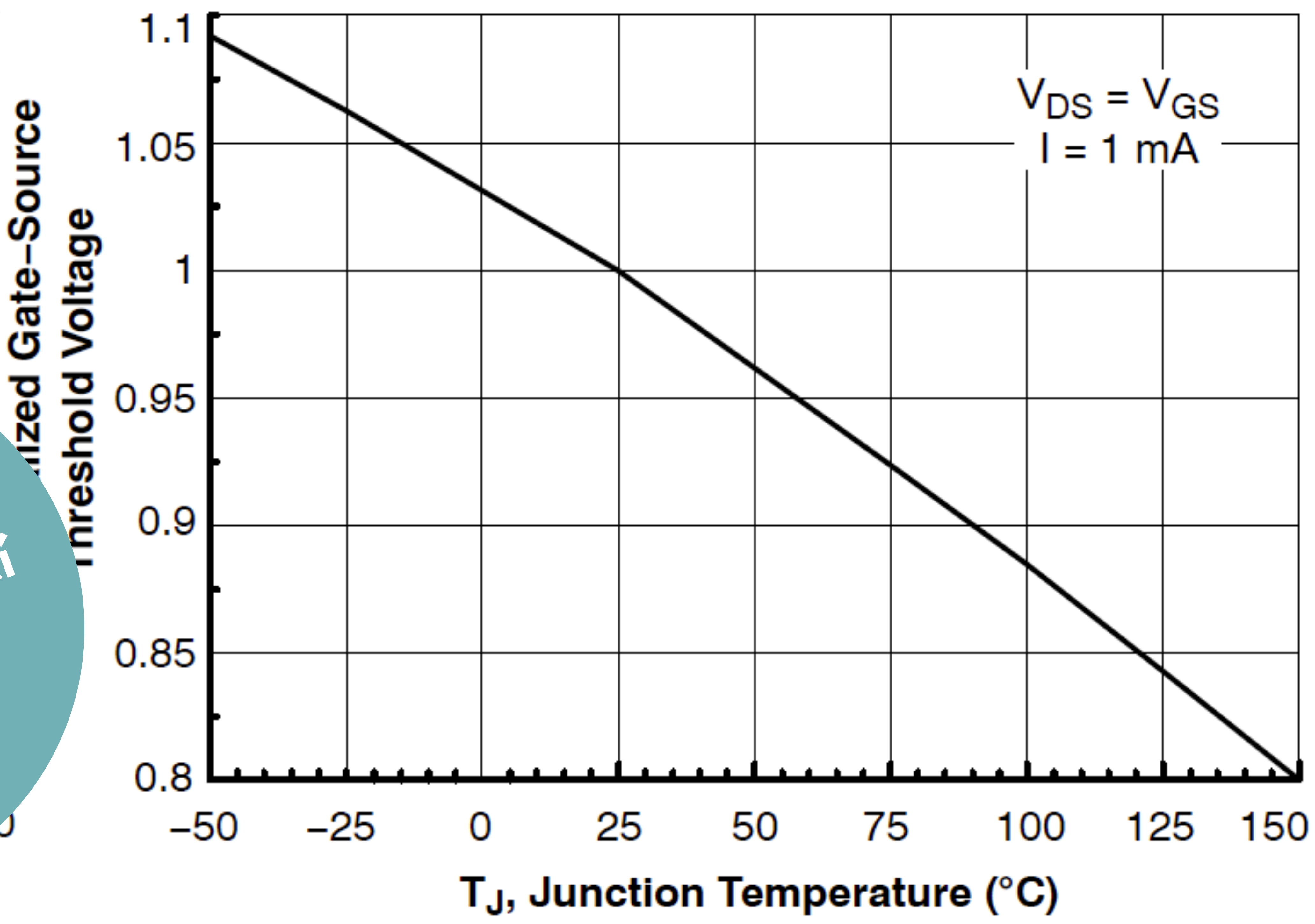
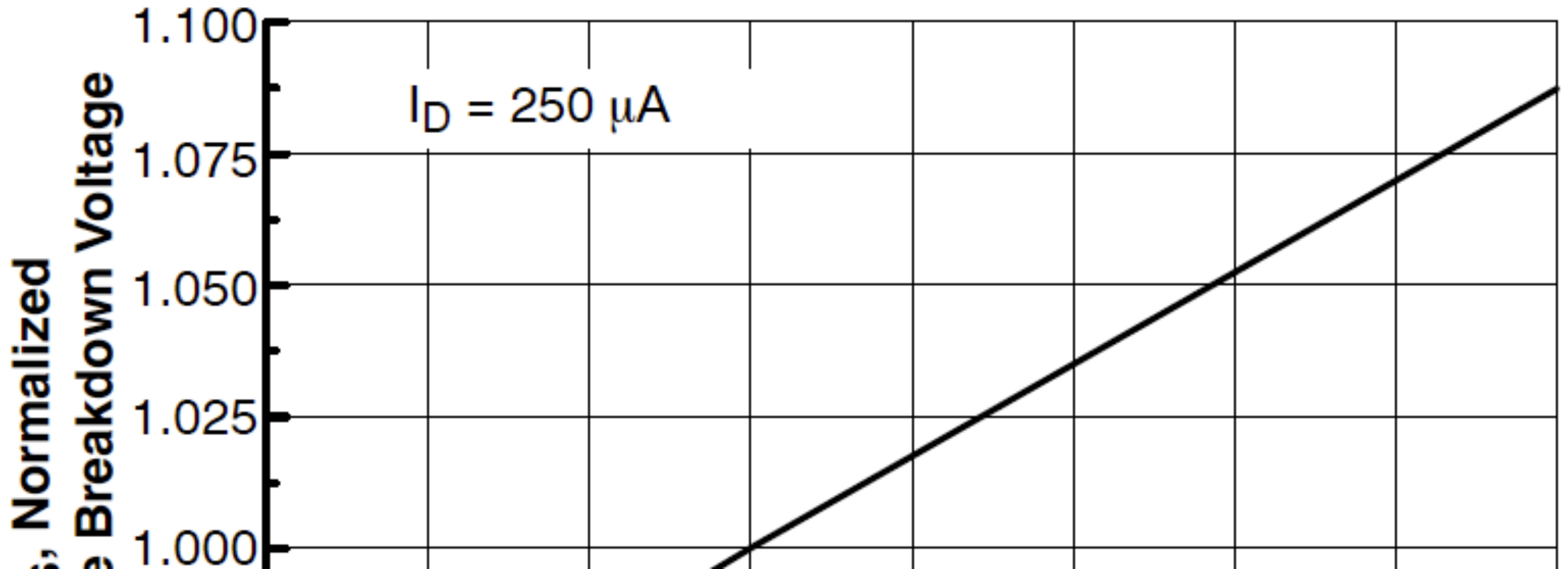
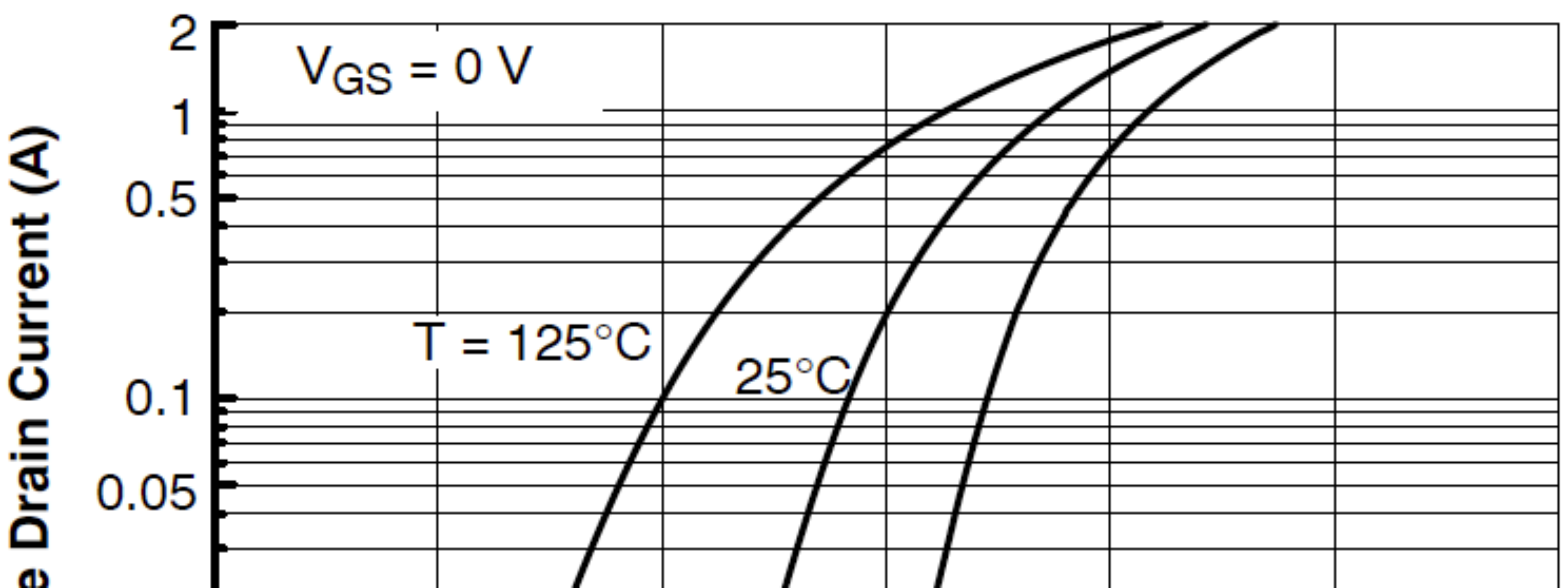


Figure 6. Gate Threshold Variation with Temperature





Featured Product

Alpha and Omega Semiconductor Introduces Digital Multiphase Controller for Telecom and General-Purpose Applications

more »

Products

MV MOSFETs (40V - 400V)

Search by Excel File

Single | Dual | Complementary

Part Number	Status	Recommended Replacement	Package	Configuration	Polarity	Vds	Vgs	Id	Pd	Rds (on) mΩ max				Qg (nC)
								25°C	25°C	10V	4.5V	2.5V	1.8V	
						V	V	A	W	mΩ	mΩ	mΩ	mΩ	
AOD4184A	Full Production	-	TO252	Single	N	40	20	50	50	7	9.5	-	-	14

Support Documents

- ☐ Datasheet
- ☐ Marking
- ☐ Package
- ☐ Tape & Reel
- ☐ Reliability Report

Merge Documents

Buy Now

ALPHA & OMEGA SEMICONDUCTOR

AOD4184A

40V N-Channel MOSFET

General Description

The AOD4184A combines advanced trench MOSFET technology with a low resistance package to provide extremely low $R_{DS(ON)}$. This device is well suited for high current load applications.

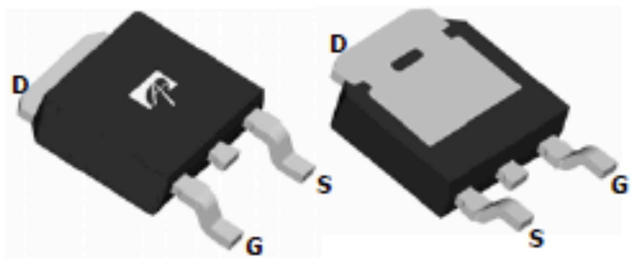
Product Summary

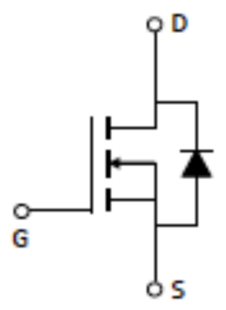
V_{DS}	40V
I_D (at V_{GS}=10V)	50A
$R_{DS(ON)}$ (at V_{GS}=10V)	< 7mΩ
$R_{DS(ON)}$ (at V_{GS} = 4.5V)	< 9.5mΩ

100% UIS Tested
100% Rg Tested

TO252
DPAK

Top View   Bottom View





Absolute Maximum Ratings T_A=25°C unless otherwise noted

Parameter		Symbol	Maximum	Units
Drain-Source Voltage		V_{DS}	40	V
Gate-Source Voltage		V_{GS}	±20	V
Continuous Drain Current [G]	T_C=25°C	I_D	50	A
	T_C=100°C		40	
Pulsed Drain Current [C]		I_{DM}	120	
Continuous Drain Current	T_A=25°C	I_{DSM}	13	A
	T_A=70°C		10	
Avalanche Current [C]		I_{AS}, I_{AR}	35	A
Avalanche energy L=0.1mH [C]		E_{AS}, E_{AR}	61	mJ
Power Dissipation [B]	T_C=25°C	P_D	50	W
	T_C=100°C		25	
Power Dissipation [A]	T_A=25°C	P_{DSM}	2.3	W
	T_A=70°C		1.5	
Junction and Storage Temperature Range		T_J, T_{STG}	-55 to 175	°C

Thermal Characteristics

Parameter		Symbol	Typ	Max	Units
Maximum Junction-to-Ambient [A]	t ≤ 10s	$R_{\theta JA}$	18	22	°C/W
Maximum Junction-to-Ambient [A D]	Steady-State		44	55	°C/W
Maximum Junction-to-Case	Steady-State	$R_{\theta JC}$	2.4	3	°C/W

Electrical Characteristics (T_J=25°C unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
STATIC PARAMETERS						
BV_{DSS}	Drain-Source Breakdown Voltage	I_D=250µA, V_{GS}=0V	40			V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS}=40V, V_{GS}=0V			1	µA
		T_J=55°C			5	
I_{GSS}	Gate-Body leakage current	V_{DS}=0V, V_{GS}= ±20V			±100	nA
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS}=V_{GS} I_D=250µA	1.7	2.1	2.6	V
$I_{D(ON)}$	On state drain current	V_{GS}=10V, V_{DS}=5V	120			A
$R_{DS(ON)}$	Static Drain-Source On-Resistance	V_{GS}=10V, I_D=20A		5.8	7	mΩ
		T_J=125°C		9.6	12	
		V_{GS}=4.5V, I_D=15A		7.6	9.5	mΩ
g_{FS}	Forward Transconductance	V_{DS}=5V, I_D=5A		37		S
V_{SD}	Diode Forward Voltage	I_S=1A,V_{GS}=0V		0.7	1	V
I_S	Maximum Body-Diode Continuous Current				20	A
DYNAMIC PARAMETERS						
C_{iss}	Input Capacitance	V_{GS}=0V, V_{DS}=20V, f=1MHz	1200	1500	1800	pF
C_{oss}	Output Capacitance		150	215	280	pF
C_{rss}	Reverse Transfer Capacitance		80	135	190	pF
R_g	Gate resistance	V_{GS}=0V, V_{DS}=0V, f=1MHz	2	3.5	5	Ω
SWITCHING PARAMETERS						
Q_g(10V)	Total Gate Charge	V_{GS}=10V, V_{DS}=20V, I_D=20A	21	27	33	nC
Q_g(4.5V)	Total Gate Charge		10	14	17	nC
Q_{gs}	Gate Source Charge		3	5	6	nC
Q_{gd}	Gate Drain Charge		3	6	9	nC
$t_{D(on)}$	Turn-On DelayTime	V_{GS}=10V, V_{DS}=20V, R_L=1Ω, R_{GEN}=3Ω		6		ns
t_r	Turn-On Rise Time			17		ns
$t_{D(off)}$	Turn-Off DelayTime			30		ns
t_f	Turn-Off Fall Time			17		ns
t_{rr}	Body Diode Reverse Recovery Time	I_F=20A, dI/dt=100A/µs	20	29	38	ns
Q_{rr}	Body Diode Reverse Recovery Charge	I_F=20A, dI/dt=100A/µs	18	26	34	nC

A. The value of $R_{\theta JA}$ is measured with the device mounted on 1in^2 FR-4 board with 2oz. Copper, in a still air environment with T_A =25°C. The Power dissipation P_{DSM} is based on $R_{\theta JA}$ and the maximum allowed junction temperature of 150°C. The value in any given application depends on the user's specific board design, and the maximum temperature of 175°C may be used if the PCB allows it.
B. The power dissipation P_D is based on $T_{J(MAX)}$=175°C, using junction-to-case thermal resistance, and is more useful in setting the upper dissipation limit for cases where additional heatsinking is used.
C. Repetitive rating, pulse width limited by junction temperature $T_{J(MAX)}$=175°C. Ratings are based on low frequency and duty cycles to keep initial T_J =25°C.
D. The $R_{\theta JA}$ is the sum of the thermal impedence from junction to case $R_{\theta JC}$ and case to ambient.
E. The static characteristics in Figures 1 to 6 are obtained using <300µs pulses, duty cycle 0.5% max.
F. These curves are based on the junction-to-case thermal impedence which is measured with the device mounted to a large heatsink, assuming a maximum junction temperature of $T_{J(MAX)}$=175°C. The SOA curve provides a single pulse rating.
G. The maximum current rating is package limited.
H. These tests are performed with the device mounted on 1 in^2 FR-4 board with 2oz. Copper, in a still air environment with T_A=25°C.

TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

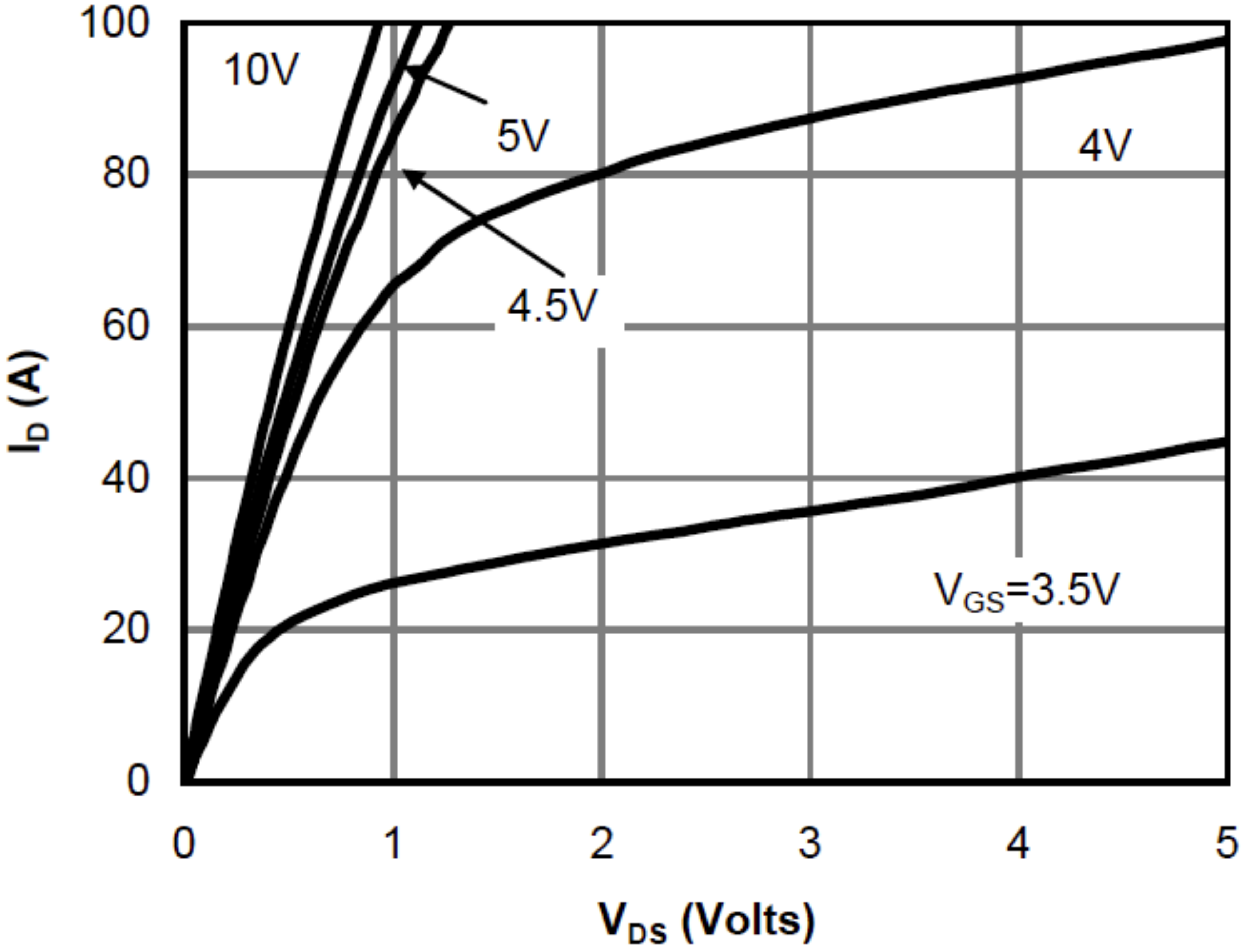


Fig 1: On-Region Characteristics (Note E)

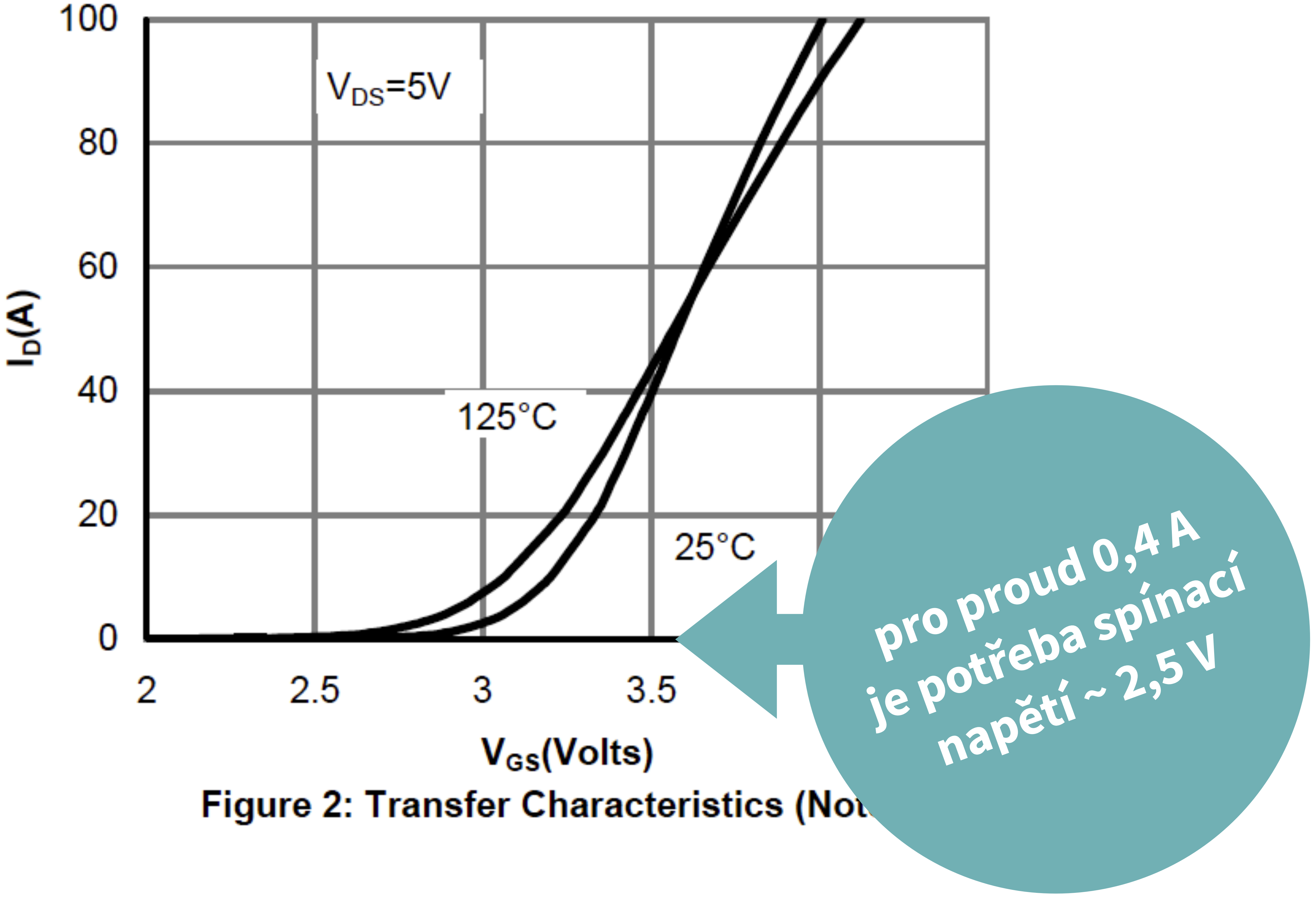
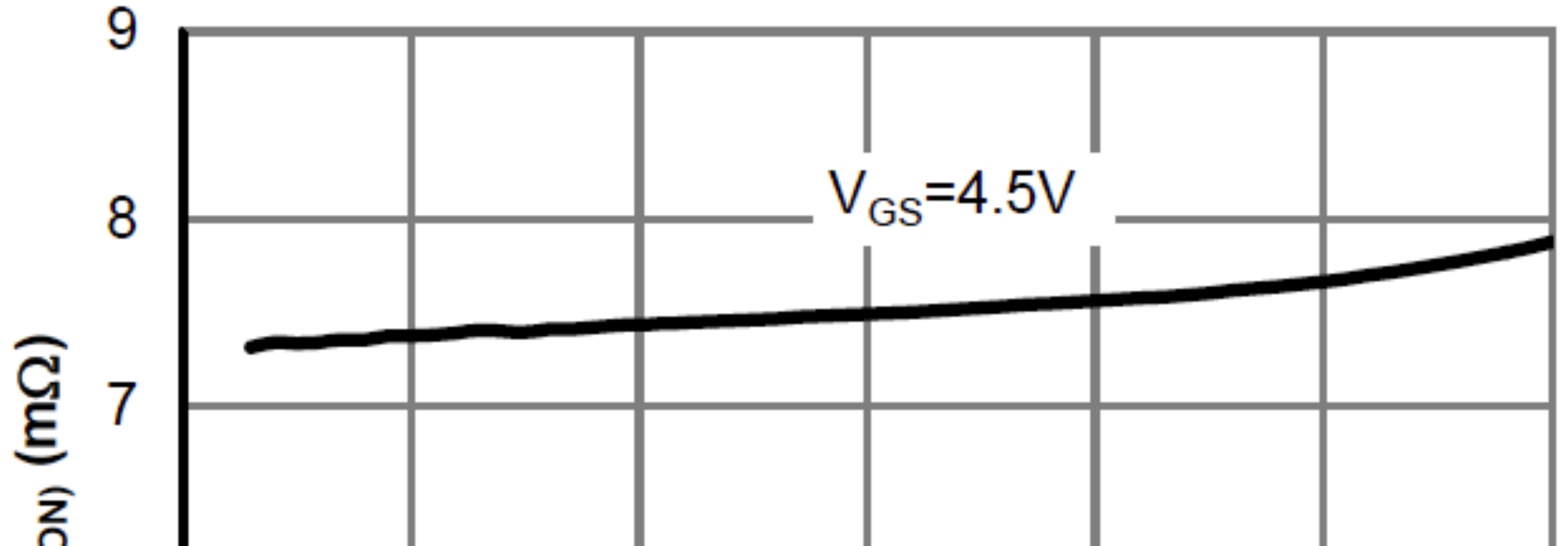
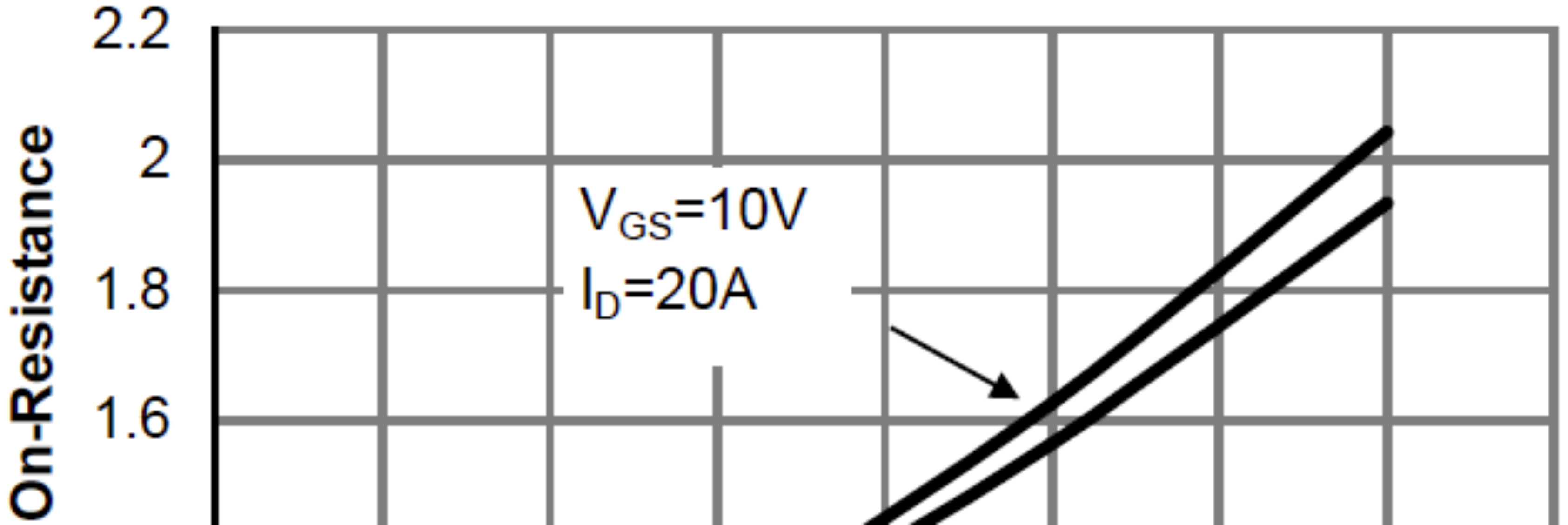
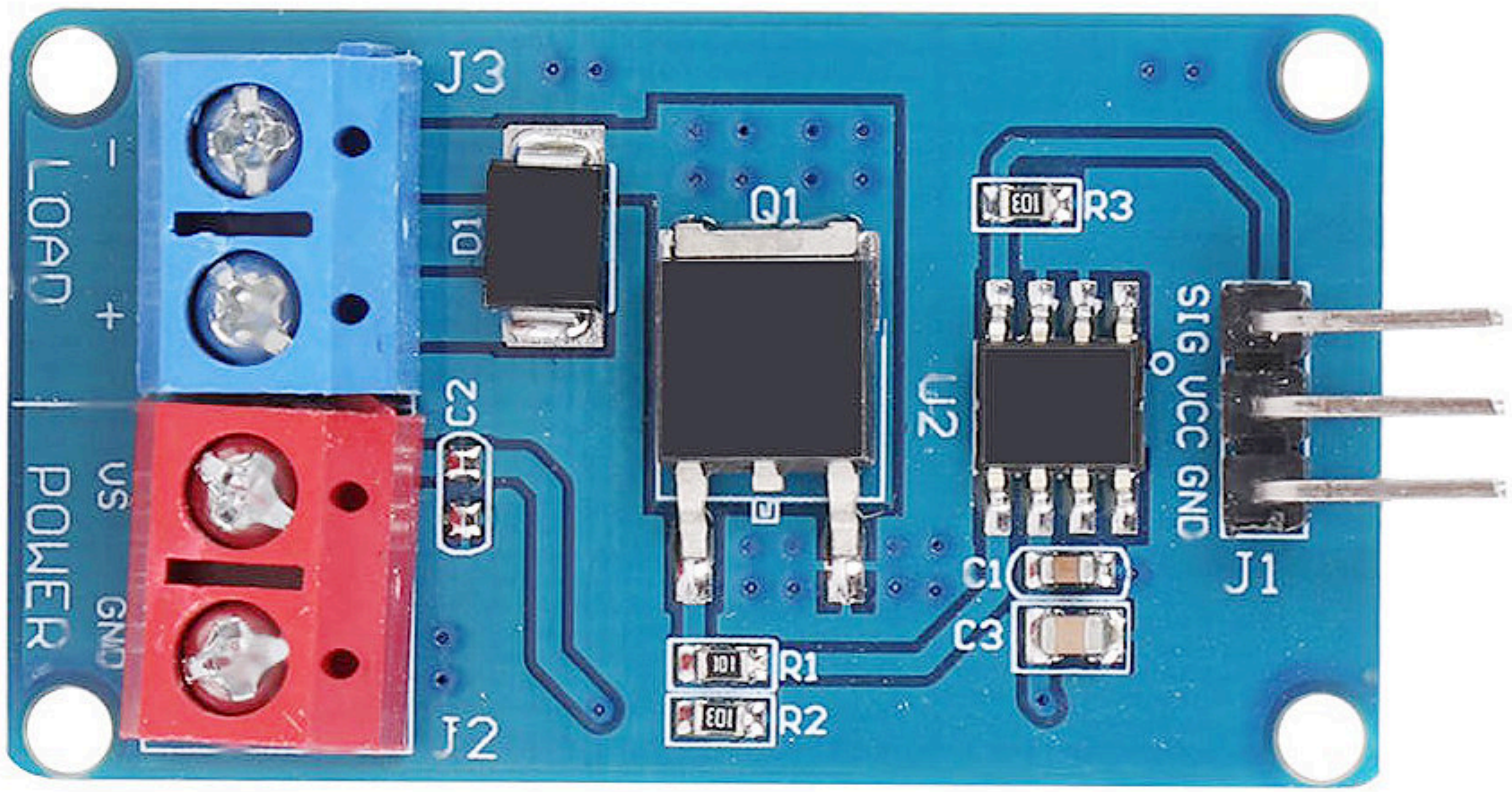


Figure 2: Transfer Characteristics (Not







modul s MOSFET tranzistorem

Výhodou modulů je, že (obvykle) obsahují veškerou potřebnou elektroniku.
Elektrické parametry je ovšem nutné řešit i zde!

Galvanické oddělení obvodů

- **oddělení elektrických obvodů** takovým způsobem,
  aby docházelo k přenosu elektrické energie **bez společného vodiče**

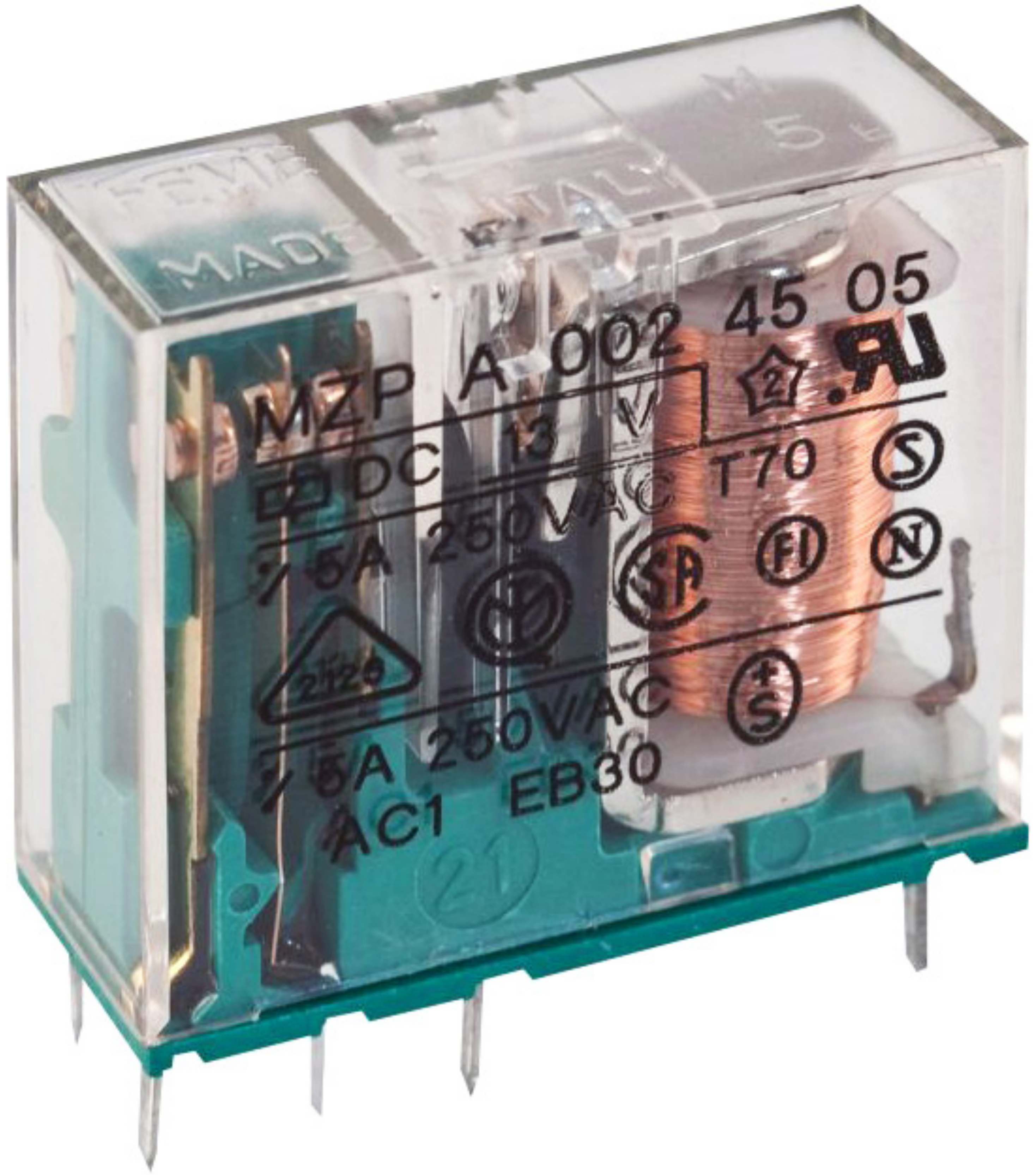
- dvě základní možnosti

  - oddělení **magnetickým polem** (↦ transformátor, relé)

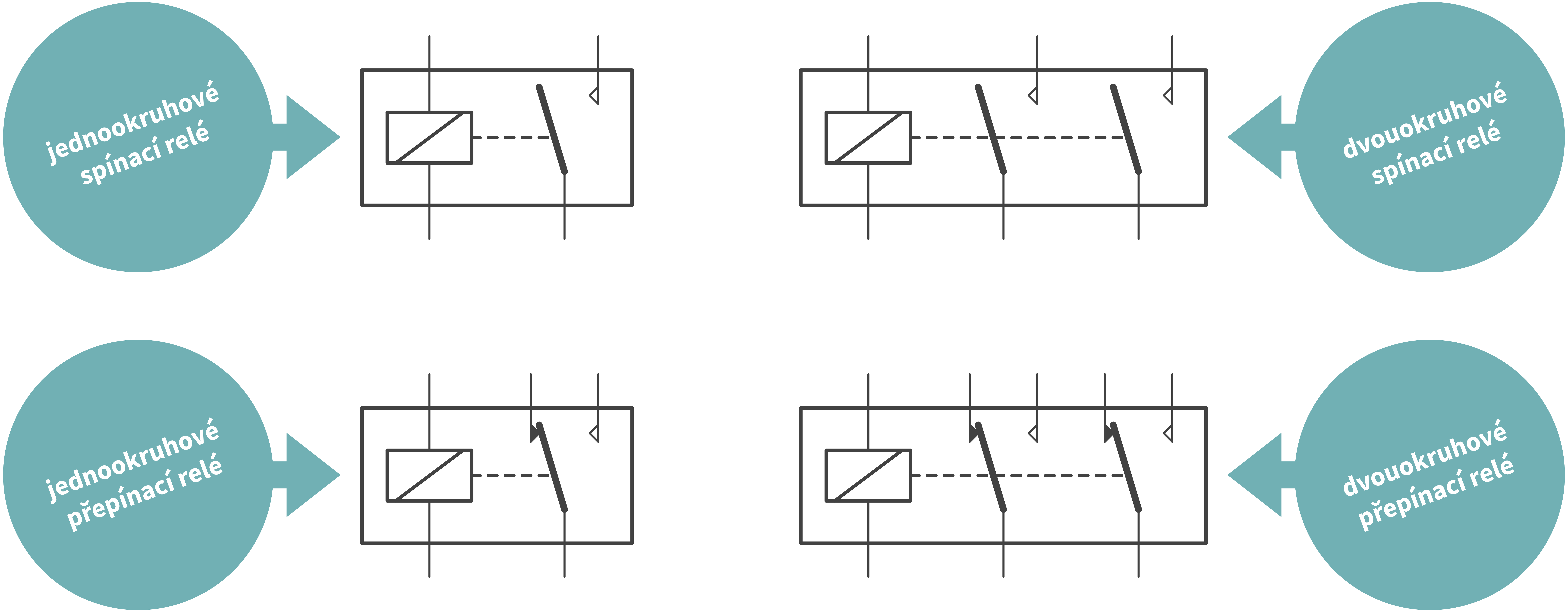
  - oddělení **světlem** (↦ optočlen)

Relé

- angl. „relay“
- **elektromechanický spínač**
- nízká spínací rychlost **neumožňuje použít PWM**
  (~ nejvyšší frekvence spínání řádově ~ 10 Hz)
- při sepnutí a rozepnutí generuje elektromagnetické rušení
  (~ jiskření)
- mechanické části mají omezenou životnost
  (↦ opotřebení kontaktů)



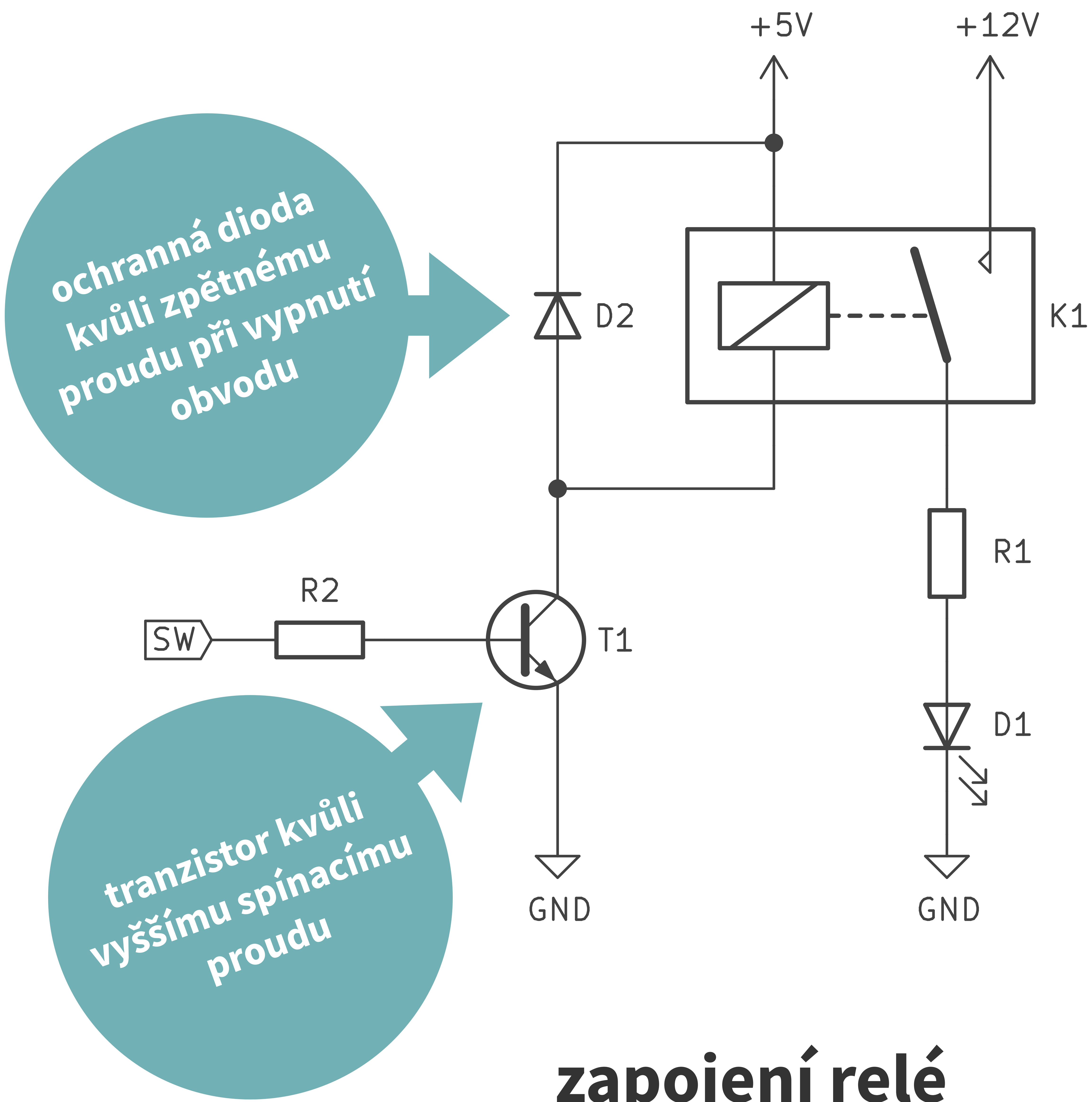
relé



příklady značek relé

Důležité parametry relé

- **nejvyšší** přípustné **napětí v řídicím obvodu** $U_I\,[\mathrm{V}]$
- **nejvyšší** přípustný **proud v řídicím obvodu** $I_I\,[\mathrm{A}]$
- **nejvyšší** přípustné **napětí v řízeném obvodu** $U_O\,[\mathrm{V}]$
- **nejvyšší** přípustný **proud v řízeném obvodu** $I_O\,[\mathrm{A}]$
- **spínací proud** $I_T\,[\mathrm{A}]$ (angl. „switching current“)
  je nejmenší proud, které způsobí sepnutí relé



zapojení relé

Electromechanical Relays

Filter by

Usage

- Interface 4
- General purpose 3
- Special purpose 2
- High power 3
- Power Relay 1

Poles

- 1 6
- 2 8
- 3 3
- 4 6

Products

- G2RV-SR Slim I/O Relay
- G6D4
- G7T
- G2R-_-S
- MY Miniature Power Relay Family
- LY
- MKS
- MM
- G4Q
- G7J

Show all products (13)

Compare | Overview

13 products found

export to excel

Product	G2RV-SR Slim I/O Relay	G6D4	G7T	G2R-_-S	MY Miniature Power Relay Family	LY
						
Terminals	Push-in plus Screw	-	Screw	Push-in plus Screw	Push-in plus Screw	Screw

Terminals

- Push-in plus (3)
- Screw (12)
- PCB terminals (2)
- Quick-connect (2)

MKS(X)

DC-switching relay that can switch 220 VDC, 10 A (resistive load)

The MK-S(X) is the smallest relay in the world that can switch 220VDC 10A resistive load. Applications include the safe and reliable switching of valves, solenoids, contactor coils and other instances where high resistive loads are encountered.

- Suitable for DC-switching
- DC load switching up to 10 A; 220 VDC (resistive load)
- AC load models are capable of switching up to 15 A; 250 VAC (resistive load)
- SPST-NO/SPST-NC contact form enables contact welding detection
- Lockable test button for easy testing

Compare all models CAD Library

MK-S(X) Power Relays Datasheet
PDF 1.39 MB

Specifications & ordering info

Ordering information

Models for DC loads

Contact form	LED indicator & lockable test button	Order code (___ = coil voltage + AC/DC)	Common coil voltages *	
			DC	AC
SPST-NO (1-pole)	yes	MKS1XTIN-10	12, 24, 48, 110, 220	24, 110, 230

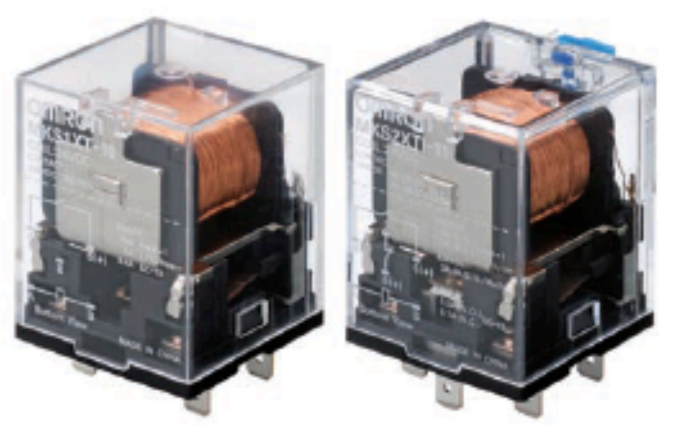
New Product

OMRON

Power Relays
MK-S(X)

MK-S-series Relays with DC-switching Models That Can Switch 220 VDC, 10 A (Resistive Load).

- Switch a DC load of 220 VDC, 10 A (resistive load).
- Models for AC Loads can switch 250 VAC, 15 A (resistive load).
- Lineup includes models with SPST-NO and SPST-NO/SPST-NC contact forms.
- Using a SPST-NO/SPST-NC contact form enables detecting contact welding. (When the NO contacts become welded, the NC contacts will maintain a minimum distance of 0.5 mm.)
- Models available with operation indicators and built-in test buttons.
- RoHS compliant.
- Standards: UL, IEC (TÜV certification)



For the most recent information on models that have been certified for safety standards, refer to your OMRON website.

Ordering Information

When your order, specify the rated voltage.

General-purpose Relays
Models for DC Loads

Contact form / Type	SPST-NO Model	SPST-NO Rated voltage (V)	SPST-NO/SPST-NC Model	SPST-NO/SPST-NC Rated voltage (V)
Standard Models	MKS1XT-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2XT-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220
Models with Built-in Operation Indicators	MKS1XTN-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2XTN-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220
Models with Test Button	MKS1XTI-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2XTI-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220
Models with Test Button and Built-in Operation Indicators	MKS1XTIN-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2XTIN-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220

Models for AC Loads

Contact form / Type	SPST-NO Model	SPST-NO Rated voltage (V)	SPST-NO/SPST-NC Model	SPST-NO/SPST-NC Rated voltage (V)
Standard Models	MKS1T-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2T-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220
Models with Built-in Operation Indicators	MKS1TN-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2TN-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220
Models with Test Button	MKS1TI-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2TI-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220
Models with Test Button and Built-in Operation Indicators	MKS1TIN-10	AC: 24, 100, 110, 120, 200, 220, 230, 240	MKS2TIN-11	AC: 24, 100, 110, 120, 200, 220, 230, 240
		DC: 12, 24, 48, 110, 220		DC: 12, 24, 48, 110, 220

Accessory (Order Separately)
Connecting Socket

Classifications		Built-in diode	Model
Back-connecting Socket	PCB Terminals	No	P7M-06P
Front-connecting Socket	Mounts to DIN Track or via screws	No	P7MF-06
		Yes	P7MF-06-D

Specifications
Ratings
Operating Coil

Item / Rated voltage (V)		Rated current (mA) 50 Hz	Rated current (mA) 60 Hz	Coil resistance (Ω)	Must operate voltage (V)	Must release voltage (V)	Maximum voltage allowable (V)	Power consumption (VA, W)
					Percentage of rated voltage			
AC	24	110	96.3	48.4	80% max.	30% min. at 60 Hz 25% min. at 50 Hz	110%	Approx. 2.3 VA at 60 Hz Approx. 2.7 VA at 50 Hz
	100	26.6	23.1	760				
	110	24.2	21.0	932				
	120	22.2	19.3	1,130				
	200	13.3	11.6	3,160				
	220	12.1	10.5	3,550				
	230	11.5	10.0	4,250				
	240	11.0	9.6	4,480				
DC	12	126		95		15% min.		Approx. 1.5 W
	24	63.2		380				
	48	32.0		1,500				
	110	13.6		8,060				
	220	6.8		32,200				

Note: 1. The rated current and coil resistance are measured at a coil temperature of 23°C with tolerances of +15%/–20% for AC rated current and ±15% for DC coil resistance.
2. Performance characteristic data are measured at a coil temperature of 23°C.
3. The maximum allowable voltage is the maximum value of the allowable voltage range for the operating power supply for the relay coil. There is no continuous allowance.
4. The rated current is approximately 5 mA higher for Models with Built-in Operation Indicators (DC operating coils).

Contact Ratings for Models for DC Loads

Item		SPST-NO: Resistive load	SPST-NO: Inductive load L/R = 7 ms	SPST-NO: Inductive load DC13 class	SPST-NO/SPST-NC: Resistive load	SPST-NO/SPST-NC: Inductive load L/R = 7 ms	SPST-NO/SPST-NC: Inductive load DC13 class
Model		MKS1XT(I)(N)-10			MKS2XT(I)(N)-11		
Contact configuration	NO	Double-break			Double-break		
	NC	---			Single-break		
Contact material		AgSnIn			AgSnIn		
Rated load	NO	10 A, 220 VDC	5 A, 220 VDC	0.4 A, 220 VDC	5 A, 220 VDC	3 A, 220 VDC	0.2 A, 220 VDC
	NC	---			2 A, 220 VDC	0.3 A, 220 VDC	0.1 A, 220 VDC
Rated carry current	NO	10 A			5 A		
	NC	---			2 A		
Max. switching voltage	NO	220 VDC			220 VDC		
	NC	---					
Max. switching current	NO	10 A	5 A	0.4 A	5 A	3 A	0.2 A
	NC	---			2 A	0.3 A	0.1 A
Max. switching capacity (reference value)	NO	2,200 W	---	---	1,100 W	---	---
	NC	---			440 W	---	---

Note: If the L/R of an inductive load exceeds 7 ms with a Model for a DC Load, the arc interruption time must be less than approximately 50 ms to use the Relay. Design the circuit so that the arc interruption time is 50 ms or less.

* These values apply to a switching frequency of 30 times per minute.

Contact Ratings for Models for AC Loads

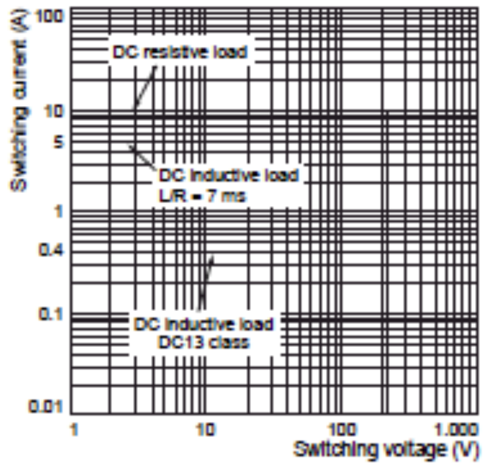
Item		SPST-NO	SPST-NO/SPST-NC
Model		MKS1T(I)(N)-10	MKS2T(I)(N)-11
Load		Resistive load	Resistive load
Contact configuration	NO	Double-break	Double-break
	NC	---	Single-break
Contact material		AgSnIn	AgSnIn
Rated load	NO	15 A, 250 VAC	15 A, 250 VAC
	NC	---	5 A, 250 VAC
Rated carry current	NO	15 A	15 A
	NC	---	5 A
Max. switching voltage	NO	250 VAC	250 VAC
	NC	---	
Max. switching current	NO	15 A	15 A
	NC	---	5 A
Max. switching capacity (reference value)	NO	3,750 VA	3,750 VA
	NC	---	1,250 VA

* These values apply to a switching frequency of 20 times per minute.

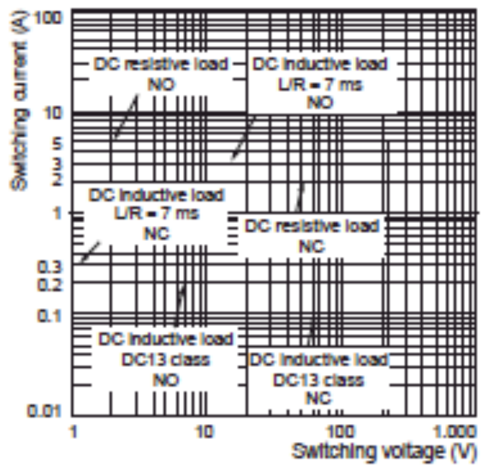
Engineering Data

Maximum Switching Power

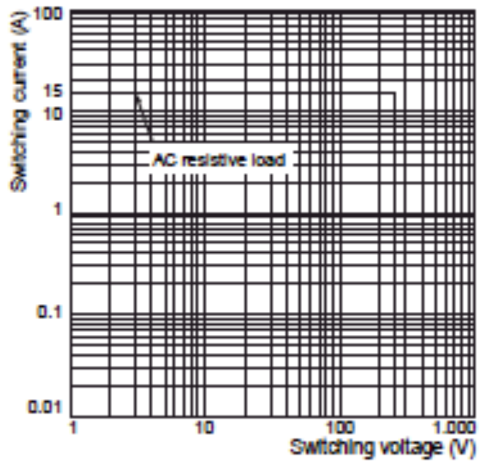
MKS1XT-10, MKS1XTN-10
MKS1XTI-10, MKS1XTIN-10



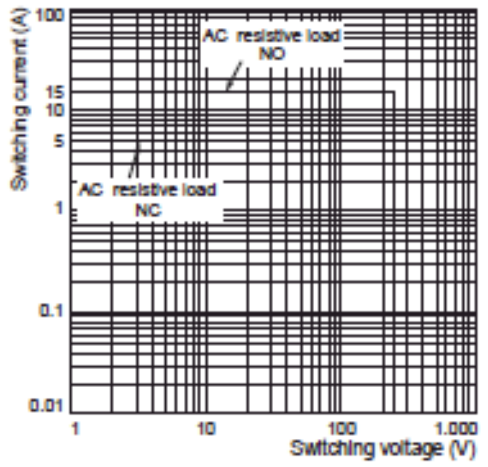
MKS2XT-11, MKS2XTN-11
MKS2XTI-11, MKS2XTIN-11



MKS1T-10, MKS1TN-10
MKS1TI-10, MKS1TIN-10

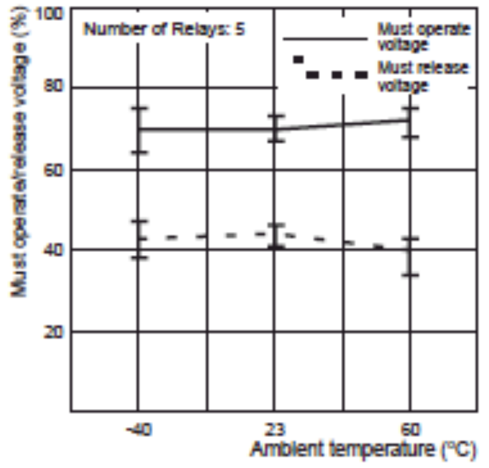


MKS2T-11, MKS2TN-11
MKS2TI-11, MKS2TIN-11

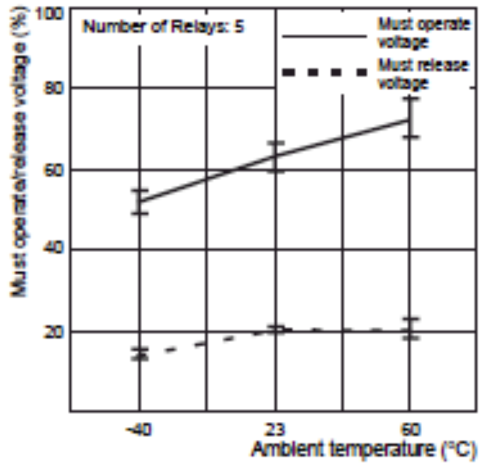


Ambient Temperature vs. Must Operate Voltage and Must Release Voltage

MKS2XT-11
AC Specification (60 Hz)

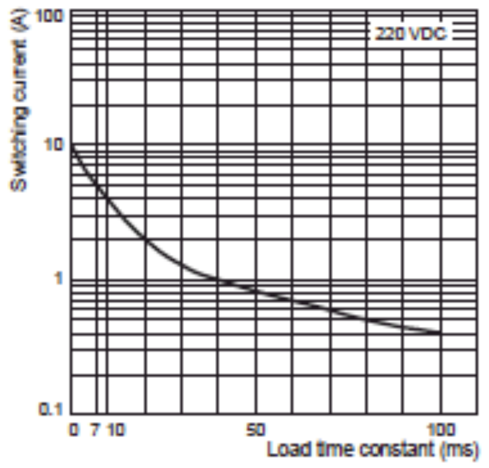


MKS2XT-11
DC Specification

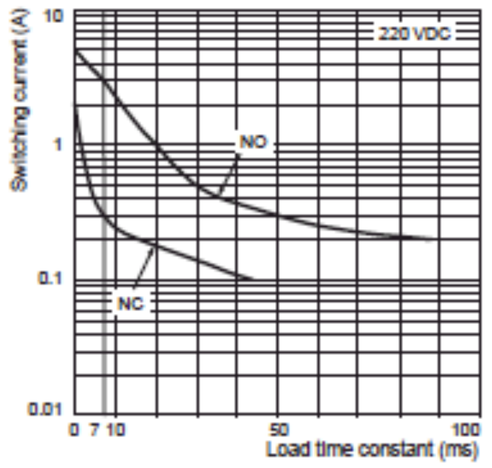


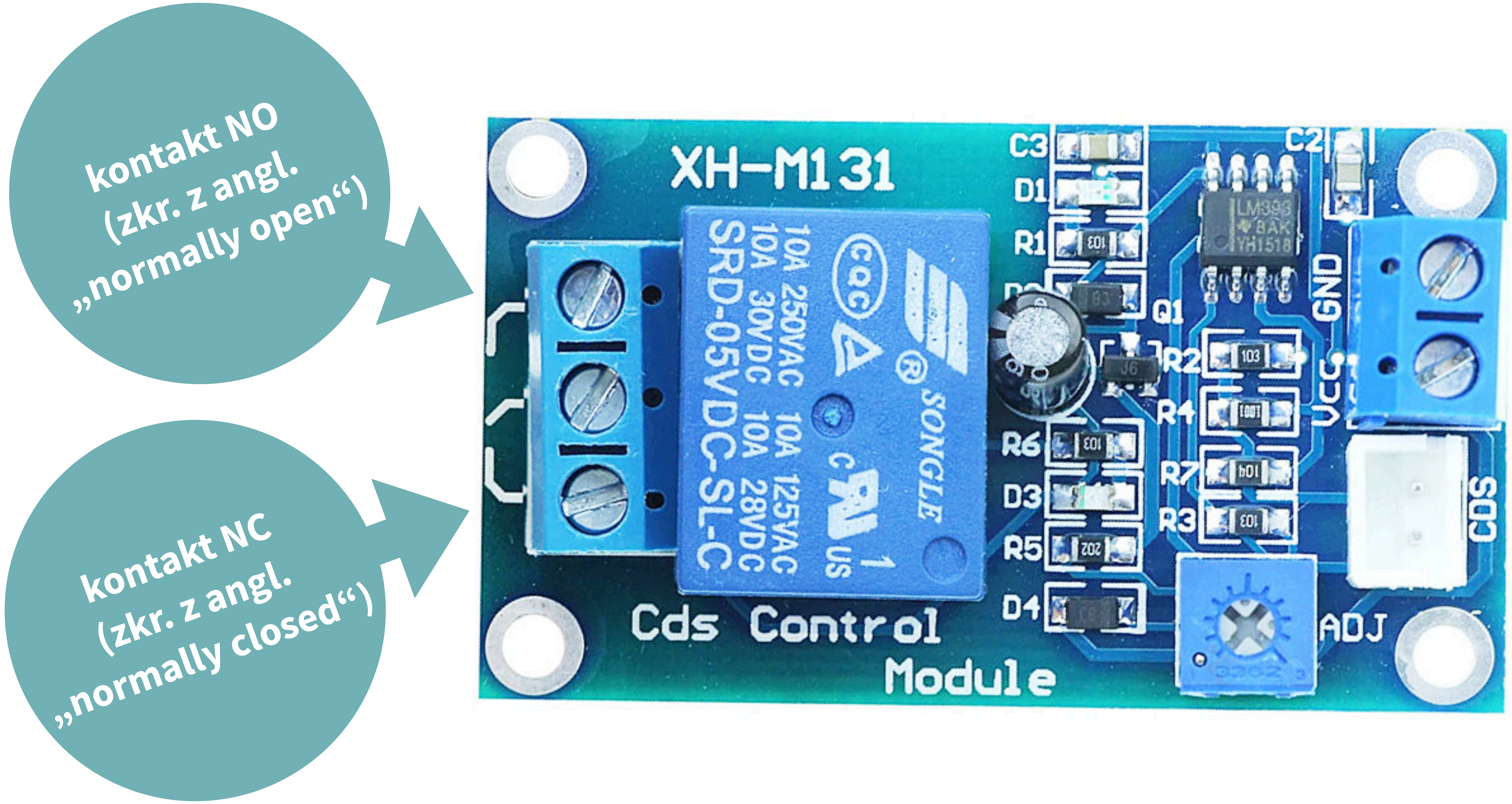
Inductive Load Switching Power (Models for DC Loads)

MKS1XT-10, MKS1XTN-10
MKS1XTI-10, MKS1XTIN-10

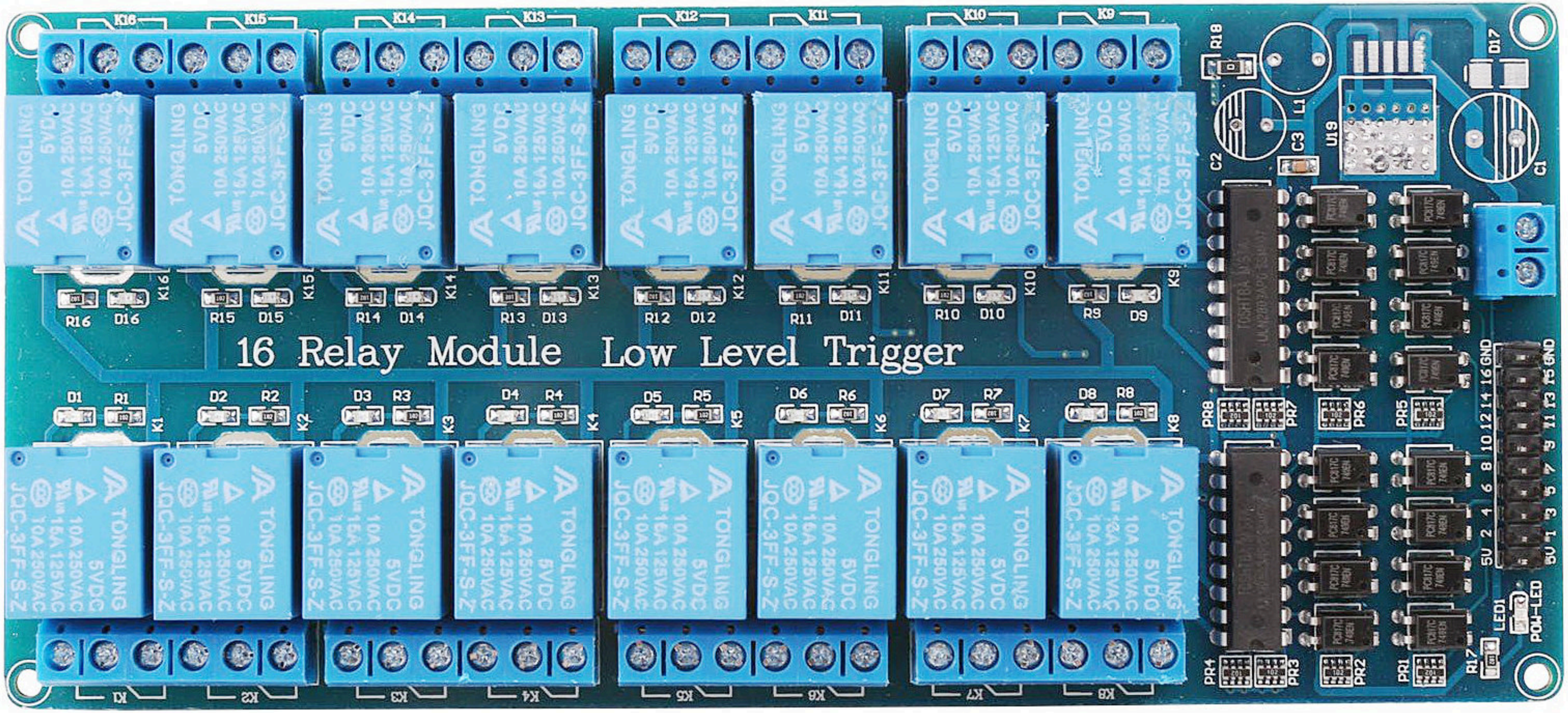


MKS2XT-11, MKS2XTN-11
MKS2XTI-11, MKS2XTIN-11





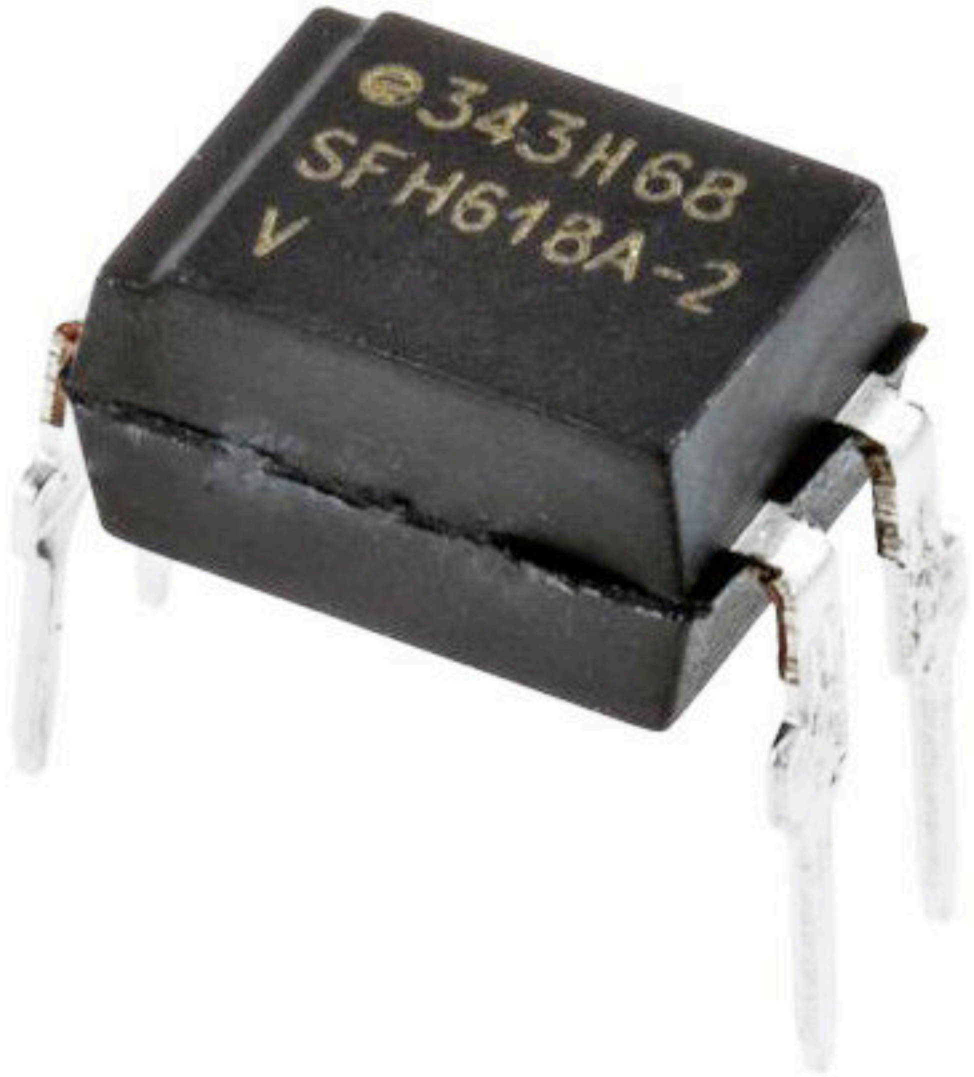
reléový modul s jedním kanálem

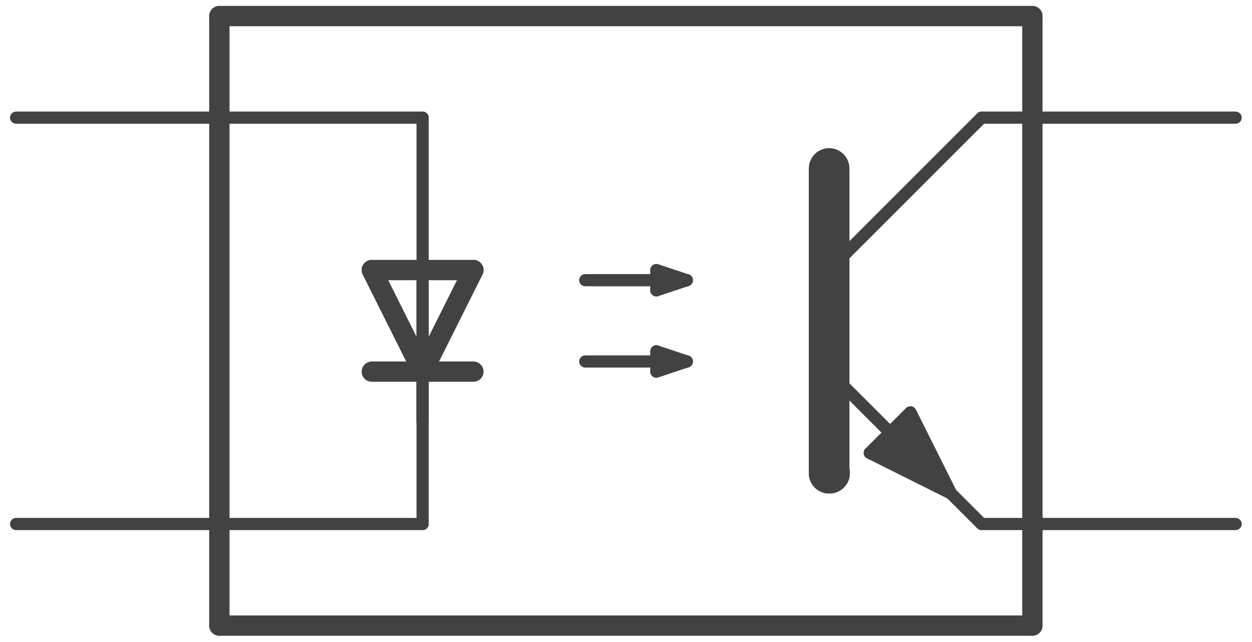


reléový modul s šestnácti kanály

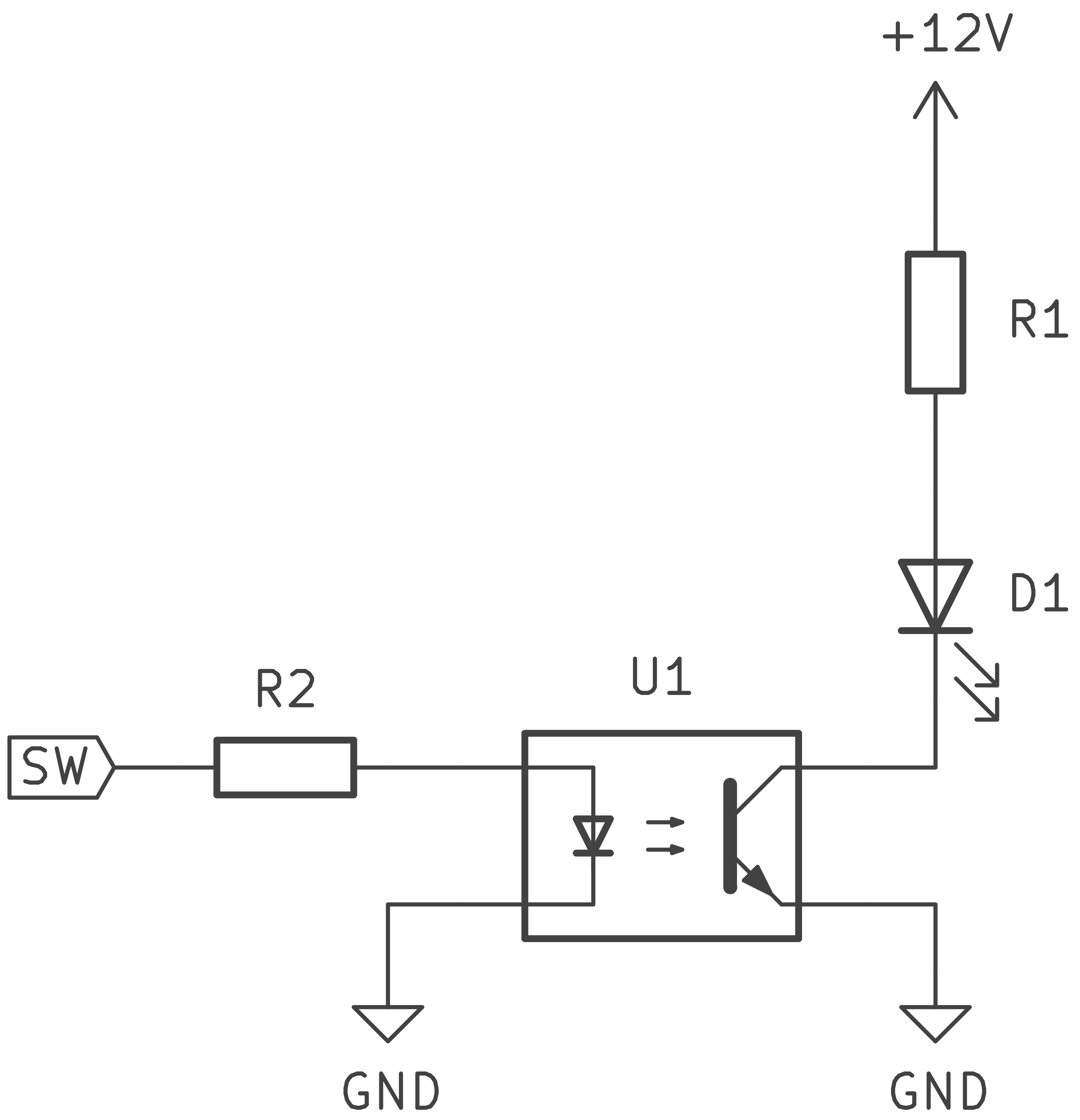
Optočlen

- angl. „optocoupler“ nebo „optoisolator“
- **elektrooptický spínač**
- vysoká spínací rychlost **umožňuje použít PWM**
- kombinace světelné diody (~ vstup) a fototranzistoru (~ výstup) (POZOR: existují optočleny i s jinými druhy optosoučástek)
    - **důležité parametry** vstupu jsou **shodné s diodou**
    - **důležité parametry** výstupu jsou **shodné s výstupem bipolárního tranzistoru**
- použitelný obvykle **jen pro relativně malá napětí a malé proudy**





optočlen a jeho značka



zapojení optočlenu

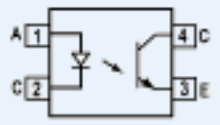
OPTOCOUPLERS / ISOLATORS

As safety products, optocouplers are designed to protect sensitive control circuitry or people from high voltages. They galvanically isolate the low- and high-voltage sides of a circuit by using an infrared emitter to transmit the control signal to a photo detector and reduce electrical noise coupling. Optocouplers from Vishay feature high isolation voltages, wide temperature ranges, and a wide range of output configurations to provide a perfect fit for your application.

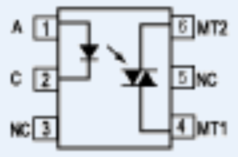
Optocouplers / Isolators | What's New | Document Library | Design Tools | Press Releases | Product Videos

Product Lines

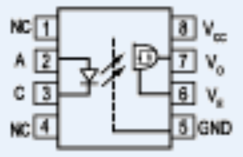
Phototransistor Output (56)



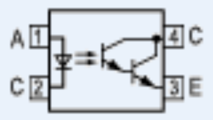
Phototriac Output (28)



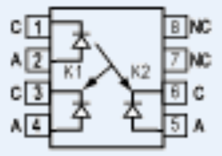
High Speed (16)



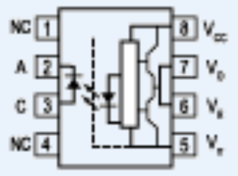
Photodarlington Output (12)



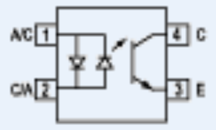
Linear (1)



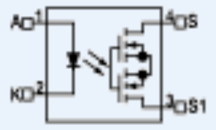
IGBT and MOSFET Driver (8)



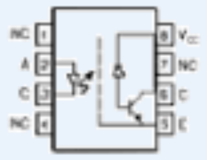
Optocoupler with AC Input (18)



Solid State Relays (29)



Isolated IPM Drivers (2)



QUICK LINKS

Optoelectronics Portfolio
Options Information

SFH618A, SFH6186 PRODUCT INFORMATION

Optocoupler, Phototransistor Output, Low Input Current

Datasheet

FEATURES

- Good CTR linearity depending on forward current
- Low CTR degradation
- High collector emitter voltage, VCEO = 55 V

APPLICATIONS

- Telecom
- Industrial controls
- Battery powered equipment

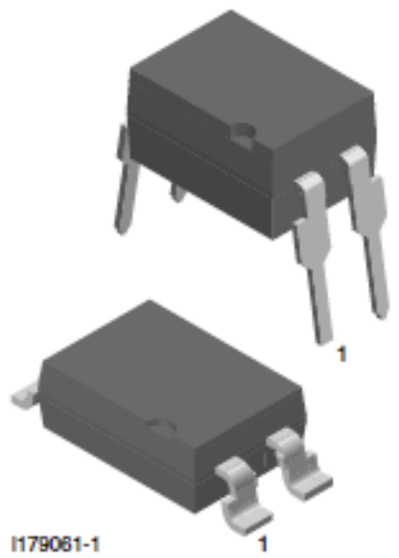
Share Buy Now EDA and CAD MODELS from Ultra Librarian

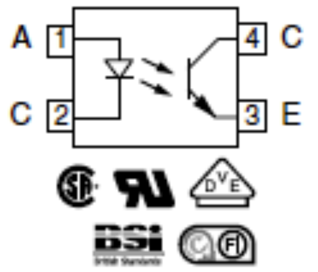
Specifications | Documents | Design Tools | Quality | Request Sample | Technical Questions

Showing 1 to 3 of 3 entries

Package	V_{CEO} (V)	CTR Min. (1) (%)	CTR Max. (1) (%)	Forward Current I_F (mA)	t_{on}/t_{off} (µs)	Operating Temperature (°C)	Isolation Voltage V_{ISO} (V_{RMS})	Safety Standard(s)
DIP-4	55	32	500	1	6, 5.5	-55 to +100	4470 5300	UL, cUL, CSA, VDE, BSI, FIMKO
DIP-4, 400 mil	55	32	500	1	6, 5.5	-55 to +100	4470 5300	UL, cUL, CSA, VDE, BSI, FIMKO
SMD-4	55	32	500	1	6, 5.5	-55 to +100	4470 5300	UL, cUL, CSA, VDE, BSI, FIMKO

Optocoupler, Phototransistor Output, Low Input Current





FEATURES

- Good CTR linearity depending on forward current
- Low CTR degradation
- High collector emitter voltage, V_{CEO} = 55 V
- Isolation test voltage, 5300 V_{RMS}
- Low coupling capacitance
- End stackable, 0.100" (2.54 mm) spacing
- High common mode transient immunity
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

RoHS COMPLIANT

DESCRIPTION

The SFH618A (DIP) and SFH6186 (SMD) feature a high current transfer ratio, low coupling capacitance and high isolation voltage. These couplers have a GaAs infrared diode emitter, which is optically coupled to silicon planar phototransistor detector, and is incorporated in a plastic DIP-4 or SMD package.

The coupling devices are designed for signal transmission between two electrically separated circuits.The couplers are end-stackable with 2.54 mm lead spacing. Creepage and clearance distances of > 8 mm achieved with option 6.

APPLICATIONS

- Telecom
- Industrial controls
- Battery powered equipment
- Office machines

AGENCY APPROVALS

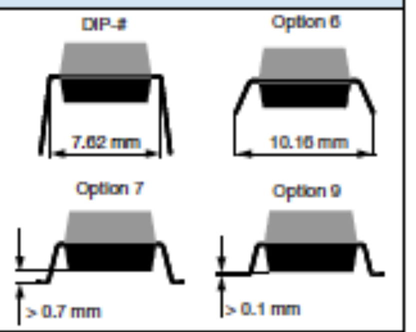
The safety application model number covering all products in this datasheet is SFH618A. This model number should be used when consulting safety agency documents.

- UL1577
- cUL
- CSA
- DIN EN 60747-5-5 (VDE 0884-5) available with option 1
- BSI
- FIMKO

ORDERING INFORMATION

S F H 6 1 8 # - # X 0 # # T

PART NUMBER | CTR BIN | PACKAGE OPTION | TAPE AND REEL

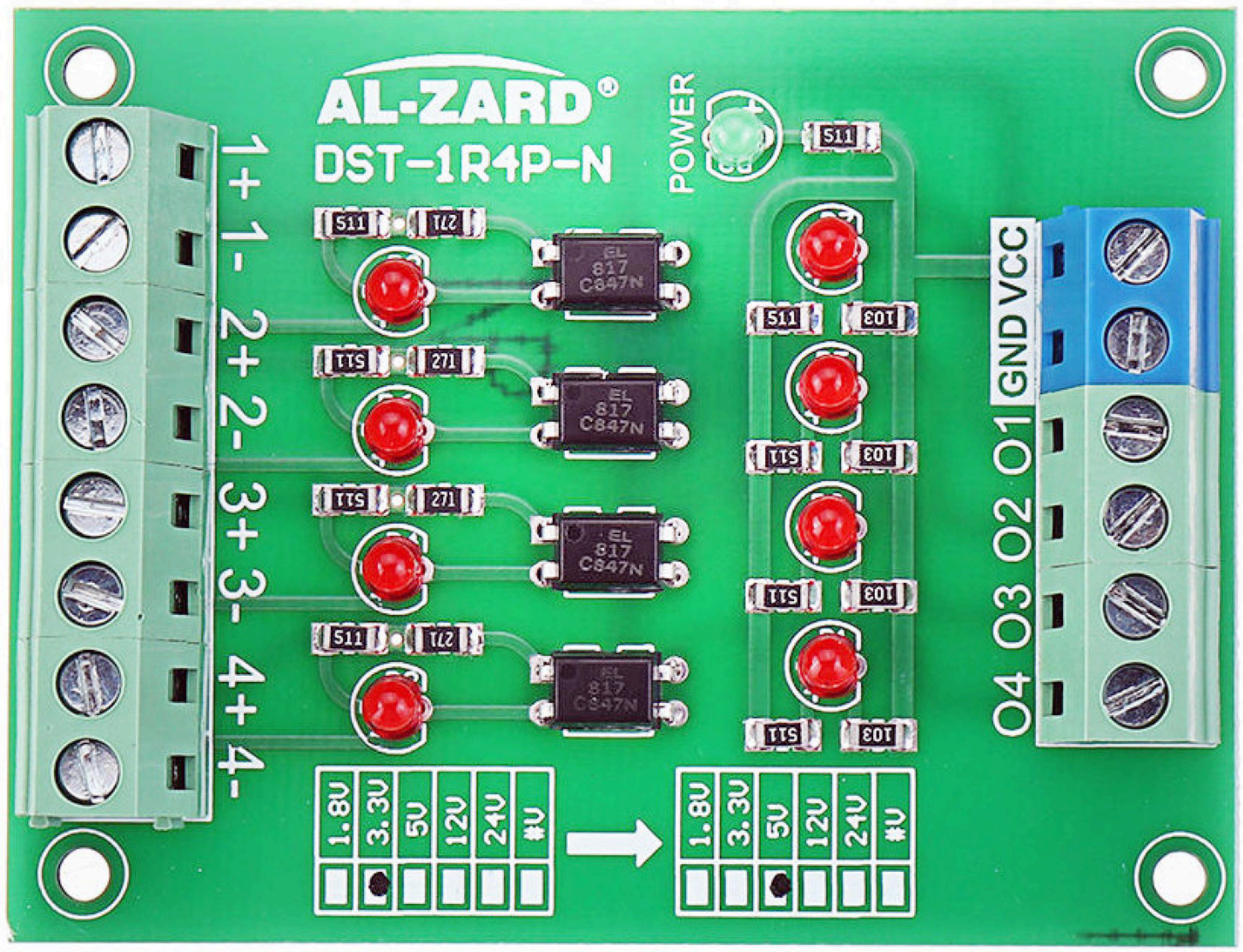


AGENCY CERTIFIED/PACKAGE	CTR (%) 1 mA			
UL, cUL	**63 to 125**	**100 to 200**	**160 to 320**	**250 to 500**
DIP-4	SFH618A-2	SFH618A-3	SFH618A-4	SFH618A-5
DIP-4, 400 mil, option 6	-	SFH618A-3X006	-	-
SMD-4, option 7	-	-	-	SFH618A-5X007T (1)
SMD-4, option 9	SFH6186-2T (1)	SFH6186-3T (1), SFH6186-3T1	SFH6186-4T (1)	SFH6186-5T (1), SFH6186-5T1
VDE, UL, cUL	**63 to 125**	**100 to 200**	**160 to 320**	**250 to 500**
DIP-4	-	SFH618A-3X001	SFH618A-4X001	-
DIP-4, 400 mil, option 6	-	SFH618A-3X016	SFH618A-4X016	SFH618A-5X016
SMD-4, option 7	-	SFH618A-3X017T (1)	-	SFH618A-5X017T (1)
SMD-4, option 9	-	SFH6186-3X001T (1), SFH6186-3X001T1	SFH6186-4X001T	SFH6186-5X001T (1)

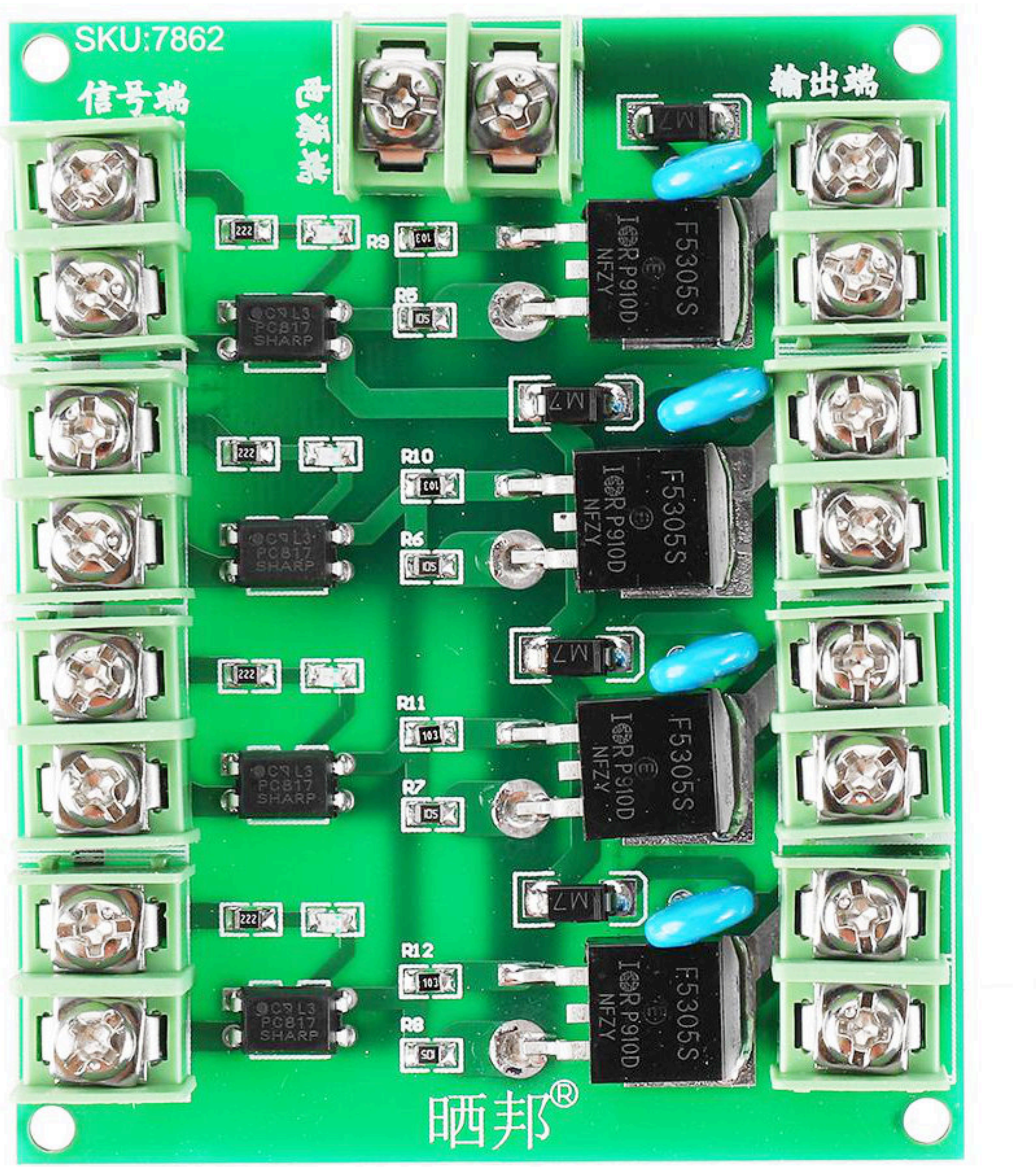
Notes

- Additional options may be possible, please contact sales office

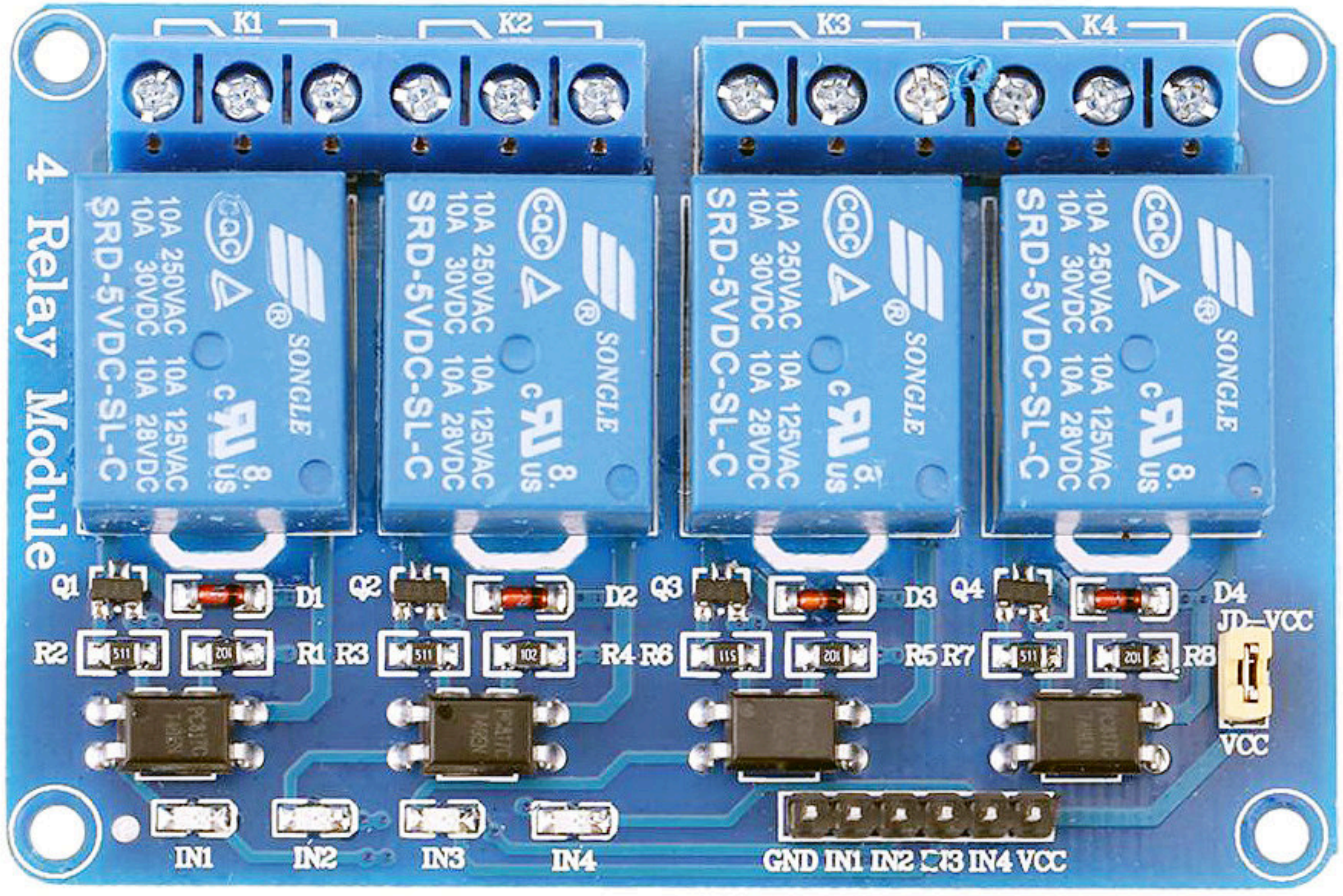
(1) Also available in tubes, do not put T to the end



modul s optočleny



modul s MOSFET optoizolovanými tranzistory

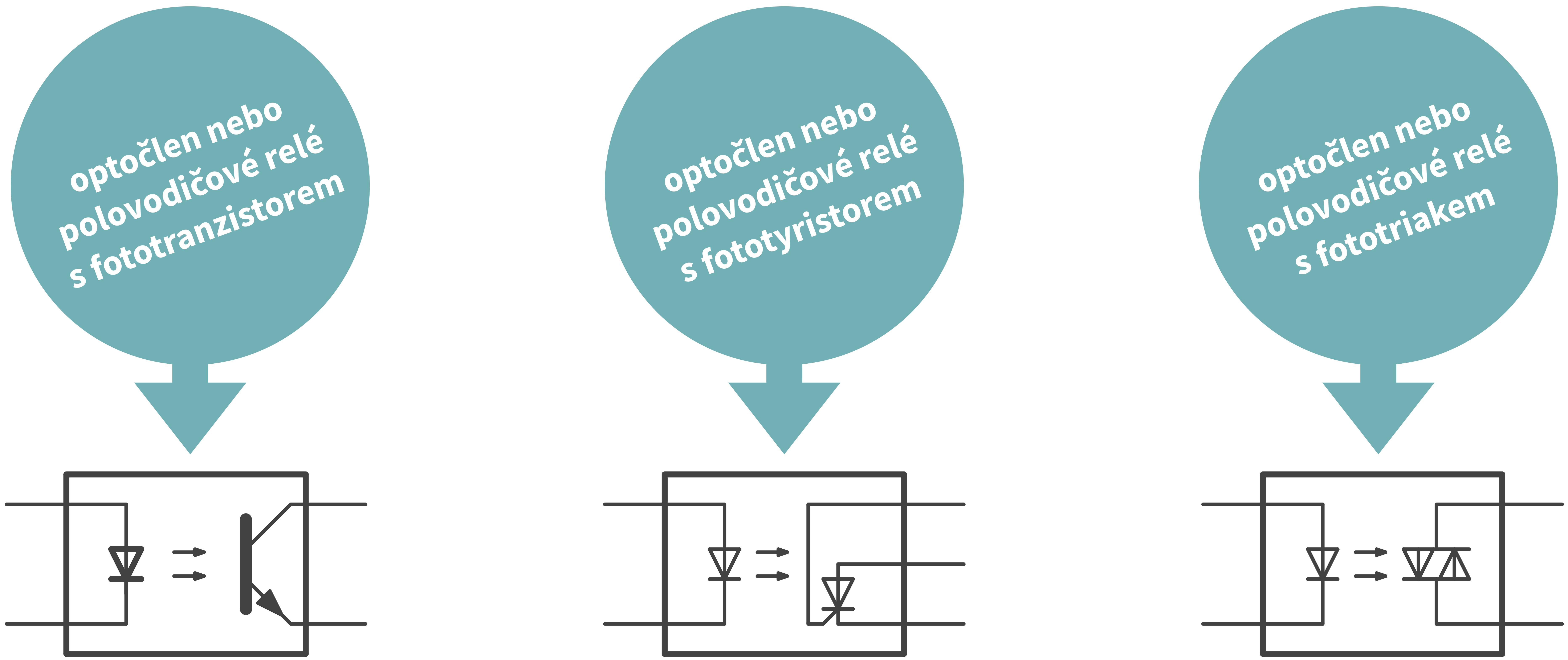


modul s optoizolovanými relé

Polovodičové relé

- angl. „solid-state relay“ (SSR)
- **výkonový elektronický spínač**
- vysoká spínací rychlost **umožňuje použít PWM**
- místo tranzistoru může být použit také tyristor nebo triak (viz dále)
- **důležité parametry** jsou **shodné s relé**

polovodičové relé



značky jiných optočlenů a polovodičových relé

Solid State Relays

Filter by

Usage

☐ Interface	5
☐ Power control	3
☐ On/off switching	6

Control

☐ 1 phase	13
☐ 2 - 3 phase	1

Products

☐ G3RV-SR Slim I/O Relay	☐ G3R-I / -O
☐ G3F / G3FD	☐ G3H / G3HD
☐ G3B / G3BD	☐ G3NA
☐ G3NE	☐ G3PA
☐ G3PJ	☐ G3PE

Show all products (14)

Compare Overview **14 products found** export to excel

Product	G3RV-SR Slim I/O Relay	G3R-I / -O	G3F / G3FD	G3H / G3HD	G3B / G3BD	G3NA
						
Terminals ☐ Push-in plus (2) ☐ Screw (13) ☐ Tab (1)	Push-in plus Screw	Screw	Screw	Screw	Screw	Screw
Ampere	2 A (240 VAC resistive load)	100 mA 2 A	2 A 3 A	3 A	3 A 5 A	90 A

G3NA

Hockey puck style SSR with 5-90A output currents

All models feature the same compact dimensions to provide a uniform mounting pitch. A built-in varistor effectively absorbs external surges. The operation indicator enables monitoring operation.

- 5-90A output current
- 24-480VAC/5-200VDC output voltages
- Built-in varistor
- Operation indicator (red LED)
- Protective cover for greater safety

G3NA Solid State Relays Datasheet
EN PDF 2.56 MB

Compare all models | CAD Library

Specifications & ordering info

Description | Features

Product filters

Common features

Number of phases
1

Product	Application	Mounting method	Rated operational voltage, AC
G3NA-205B-UTU 100-240VAC	ON/OFF control	Screw	24-240 V
G3NA-205B-UTU 5-24VDC	ON/OFF control	DIN rail/screw	24-240 V

OMRON

Solid State Relays
G3NA

The reliable choice for Hockey-puck-style Solid State Relays.
Available in a Wide Range of Currents.

- All models feature the same compact dimensions to provide a uniform mounting pitch.
- Built-in varistor effectively absorbs external surges. (except G3NA-D210B-UTU)
- Operation indicator enables monitoring operation.
- Protective cover for greater safety.
- Certified by UL, CSA, and TÜV.

For the most recent information on models that have been certified for safety standards, refer to your OMRON website.

⚠ Refer to *Safety Precautions for All Solid State Relays*.

The following models are scheduled to close the order at the end of March 2020.
- Models without "-UTU" (Not certified by TÜV)
- Models with rated input voltage "AC 100-120" and "AC 200-240".

Model Number Structure

■ Model Number Legend

G3NA-□□□□□-□
1 2 3 4 5 6 7

1. **Basic Model Name**
   G3NA: Solid State Relay
2. **Load Power Supply**
   Blank: AC output
   D: DC output
3. **Rated Load Power Supply Voltage**
   2: 200 VAC or 200 VDC
   4: 400 VAC
4. **Rated Load Current**

Note: Not all combinations of current and voltage are available.
   05: 5 A
   10: 10 A
   20: 20 A
   25: 25 A
   40: 40 A
   50: 50 A
   75: 75 A
   90: 90 A

5. **Terminal Type**
   B: Screw terminals
6. **Zero Cross Function**
   Blank: Equipped with zero cross function (AC-output models only)
7. **Certification**
   UTU: Certified by UL, CSA, and TÜV

Ordering Information

■ List of Models

Isolation	Zero cross function	Indicator	Applicable output load (See note 1.)	Rated input voltage	Model
Phototriac	Yes	Yes	5 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-205B-UTU DC5-24
Photocoupler				100 to 240 VAC	G3NA-205B-UTU AC100-240
Phototriac			10 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-210B-UTU DC5-24
Photocoupler				100 to 240 VAC	G3NA-210B-UTU AC100-240
Phototriac			20 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-220B-UTU DC5-24
Photocoupler				100 to 240 VAC	G3NA-220B-UTU AC100-240
Phototriac			25 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-225B-UTU DC5-24
Photocoupler				100 to 240 VAC	G3NA-225B-UTU AC100-240
Phototriac			40 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-240B-UTU DC5-24
Photocoupler				100 to 240 VAC	G3NA-240B-UTU AC100-240
Phototriac			50 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-250B-UTU DC5-24
Photocoupler				100 to 240 VAC	G3NA-250B-UTU AC100-240
Phototriac			75 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-275B-UTU-2 DC5-24
Photocoupler				100 to 240 VAC	G3NA-275B-UTU-2 AC100-240
Phototriac			90 A at 24 to 240 VAC (See note 2.)	5 to 24 VDC	G3NA-290B-UTU-2 DC5-24
Photocoupler				100 to 240 VAC	G3NA-290B-UTU-2 AC100-240
			10 A at 200 to 480 VAC	5 to 24 VDC	G3NA-410B-UTU DC5-24
				100 to 240 VAC	G3NA-410B-UTU AC100-240
			20 A at 200 to 480 VAC	5 to 24 VDC	G3NA-420B-UTU DC5-24
				100 to 240 VAC	G3NA-420B-UTU AC100-240
			25 A at 200 to 480 VAC	5 to 24 VDC	G3NA-425B-UTU-2 DC5-24
				100 to 240 VAC	G3NA-425B-UTU-2 AC100-240
			40 A at 200 to 480 VAC	5 to 24 VDC	G3NA-440B-UTU-2 DC5-24
				100 to 240 VAC	G3NA-440B-UTU-2 AC100-240
			50 A at 200 to 480 VAC	5 to 24 VDC	G3NA-450B-UTU-2 DC5-24
				100 to 240 VAC	G3NA-450B-UTU-2 AC100-240
			75 A at 200 to 480 VAC	5 to 24 VDC	G3NA-475B-UTU-2 DC5-24
				100 to 240 VAC	G3NA-475B-UTU-2 AC100-240
			90 A at 200 to 480 VAC	5 to 24 VDC	G3NA-490B-UTU-2 DC5-24
				100 to 240 VAC	G3NA-490B-UTU-2 AC100-240
	---		10 A at 5 to 200 VDC	5 to 24 VDC	G3NA-D210B-UTU DC5-24
				100 to 240 VAC	G3NA-D210B-UTU AC100-240

*All models are certified by UL, CSA, and TÜV.

Note: 1. The applicable load is the value for when the SSR is used with silicon grease applied to the specified heat sink. The applicable load depends on the ambient temperature. Refer to *Load Current vs. Ambient Temperature* in *Engineering Data* on page 6.

2. Loss time increases under 75 VAC. (Refer to page 16.) Confirm operation with the actual load.

Specifications

■ Ratings

Input (at an Ambient Temperature of 25°C)

Model	Rated voltage	Operating voltage	Impedance (See note 1.) Input current	Voltage level	
				Must operate voltage	Must release voltage
G3NA-2☐☐B-UTU(-2) G3NA-475B-UTU-2 G3NA-490B-UTU-2	5 to 24 VDC	4 to 32 VDC	7 mA max. (See note 2.)	4 VDC max.	1 VDC min.
	100 to 240 VAC	75 to 264 VAC	72 kΩ±20%	75 VAC max.	20 VAC min.
G3NA-410B-UTU G3NA-420B-UTU G3NA-425B-UTU-2 G3NA-440B-UTU-2 G3NA-450B-UTU-2 G3NA-D210B-UTU	5 to 24 VDC	4 to 32 VDC	5 mA max. (See note 2.)	4 VDC max.	1 VDC min.
	100 to 240 VAC	75 to 264 VAC	72 kΩ±20%	75 VAC max.	20 VAC min.

Note: 1. The input impedance is measured at the maximum value of the rated supply voltage (for example, with the model rated at 100 to 240 VAC, the input impedance is measured at 240 VAC).
2. With constant current input circuit system.

Output

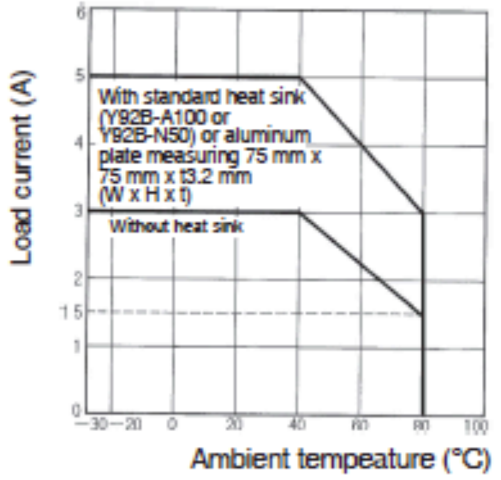
Model	Applicable load					
	Rated load voltage	Load voltage range	Load current (See note 1.)		Inrush current	V_{DRM} V_{CEO} (Reference value)
			With heat sink (See note 2.)	Without heat sink		
G3NA-205B-UTU	24 to 240 VAC	19 to 264 VAC	0.1 to 5 A (at 40°C)	0.1 to 3 A (at 40°C)	60 A (60 Hz, 1 cycle)	600 V (V_{DRM})
G3NA-210B-UTU			0.1 to 10 A (at 40°C)	0.1 to 4 A (at 40°C)	150 A (60 Hz, 1 cycle)	
G3NA-220B-UTU			0.1 to 20 A (at 40°C)	0.1 to 4 A (at 40°C)	220 A (60 Hz, 1 cycle)	
G3NA-225B-UTU			0.1 to 25 A (at 40°C)	0.1 to 4 A (at 40°C)	220 A (60 Hz, 1 cycle)	
G3NA-240B-UTU			0.1 to 40 A (at 40°C)	0.1 to 6 A (at 40°C)	440 A (60 Hz, 1 cycle)	
G3NA-250B-UTU			0.1 to 50 A (at 40°C)	0.1 to 6 A (at 40°C)	440 A (60 Hz, 1 cycle)	
G3NA-275B-UTU-2			1 to 75 A (at 40°C)	1 to 7 A (at 40°C)	800 A (60 Hz, 1 cycle)	
G3NA-290B-UTU-2			1 to 90 A (at 40°C)	1 to 7 A (at 40°C)	1,000 A (60 Hz, 1 cycle)	
G3NA-410B-UTU	200 to 480 VAC	180 to 528 VAC	0.2 to 10 A (at 40°C)	0.2 to 4 A (at 40°C)	150 A (60 Hz, 1 cycle)	1,200 V (V_{DRM})
G3NA-420B-UTU			0.2 to 20 A (at 40°C)	0.2 to 4 A (at 40°C)	220 A (60 Hz, 1 cycle)	
G3NA-425B-UTU-2			0.2 to 25 A (at 40°C)	0.2 to 4 A (at 40°C)	220 A (60 Hz, 1 cycle)	
G3NA-440B-UTU-2			0.2 to 40 A (at 40°C)	0.2 to 6 A (at 40°C)	440 A (60 Hz, 1 cycle)	
G3NA-450B-UTU-2			0.2 to 50 A (at 40°C)	0.2 to 6 A (at 40°C)	440 A (60 Hz, 1 cycle)	
G3NA-475B-UTU-2			1 to 75 A (at 40°C)	1 to 7 A (at 40°C)	800 A (60 Hz, 1 cycle)	
G3NA-490B-UTU-2			1 to 90 A (at 40°C)	1 to 7 A (at 40°C)	1,000 A (60 Hz, 1 cycle)	
G3NA-D210B-UTU	5 to 200 VDC	4 to 220 VDC	0.1 to 10 A (at 40°C)	0.1 to 4 A (at 40°C)	20 A (10 ms)	400 V (V_{CEO})

Note: 1. The load current varies depending on the ambient temperature. Refer to *Load Current vs. Ambient Temperature* under *Engineering Data* on page 6.
2. When an OMRON Heat Sink (refer to *Options (Order Separately)*) or a heat sink of the specified size is used.

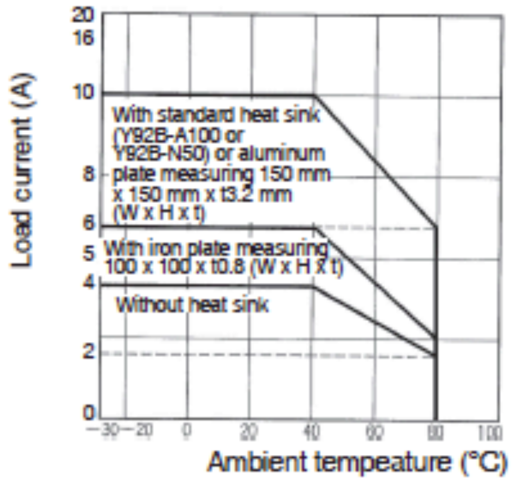
Engineering Data

Load Current vs. Ambient Temperature

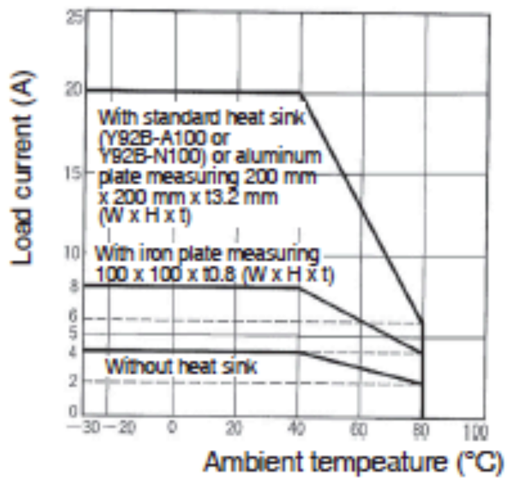
G3NA-205B-UTU



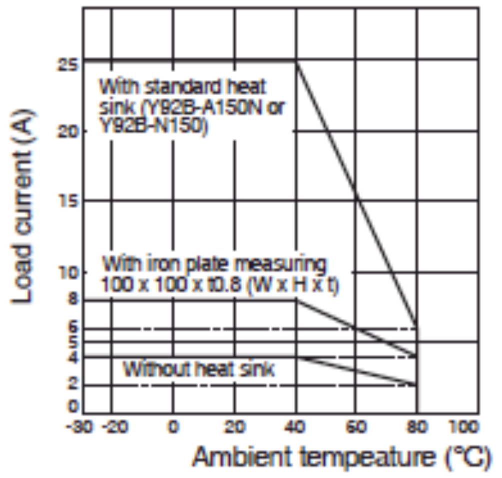
G3NA-210B-UTU
G3NA-410B-UTU



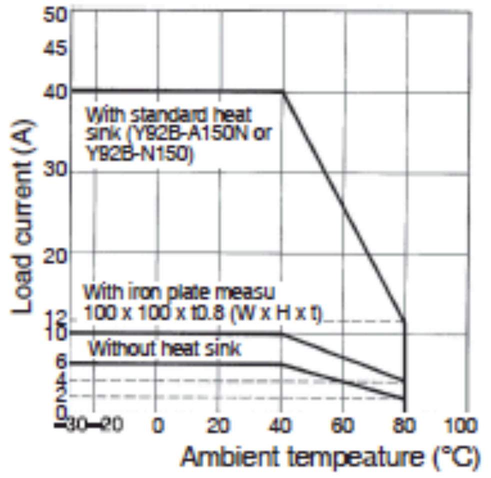
G3NA-220B-UTU
G3NA-420B-UTU



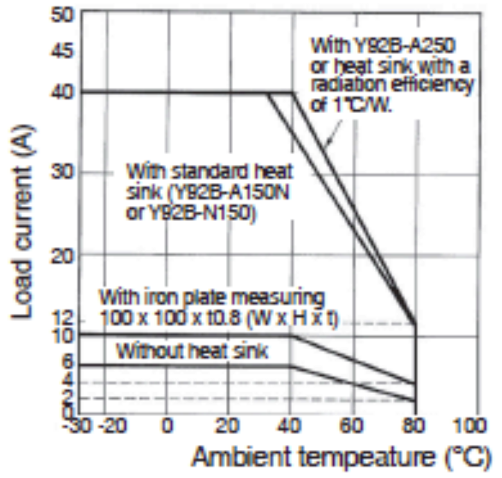
G3NA-225B-UTU
G3NA-425B-UTU-2



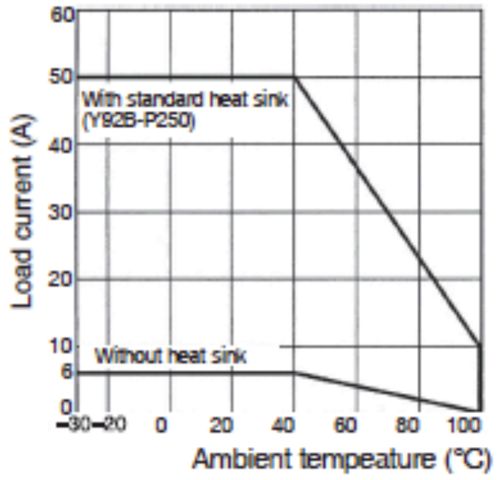
G3NA-240B-UTU



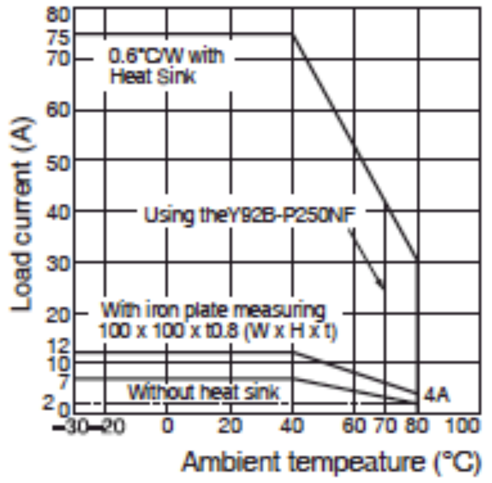
G3NA-440B-UTU-2



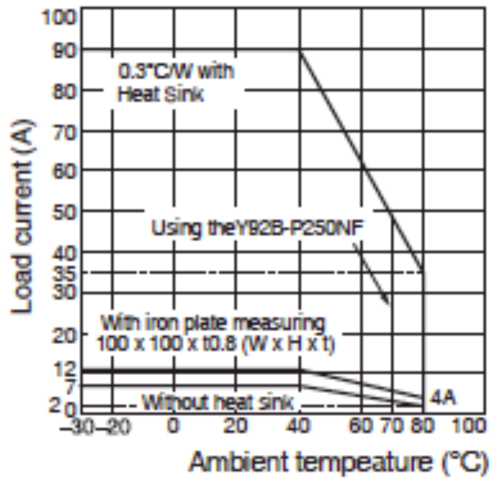
G3NA-250B-UTU
G3NA-450B-UTU-2



G3NA-275B-UTU-2
G3NA-475B-UTU-2

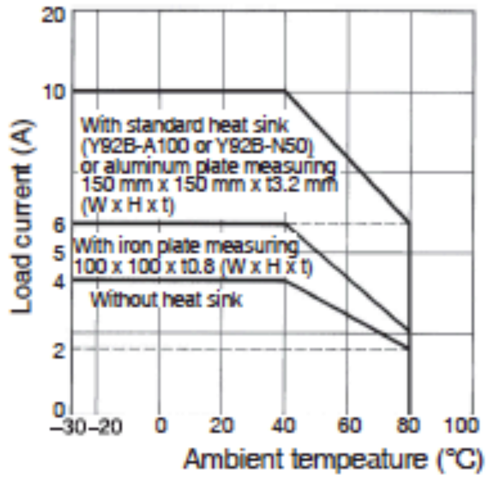


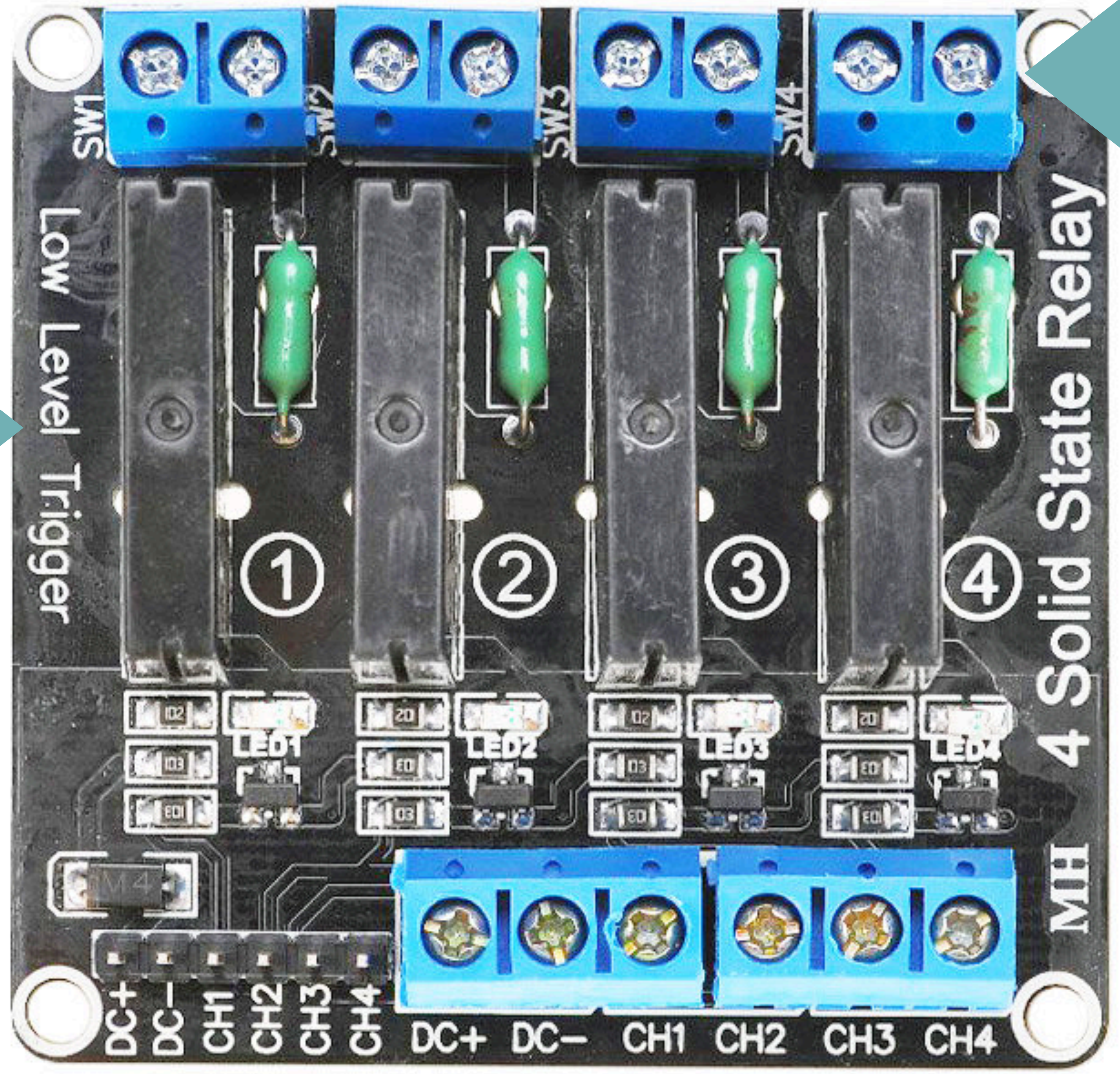
G3NA-290B-UTU-2
G3NA-490B-UTU-2



Note: The ambient operating temperature of the Y92B-P250NF is –30 to 70°C. Be sure the operating temperature is within this range.

G3NA-D210B-UTU





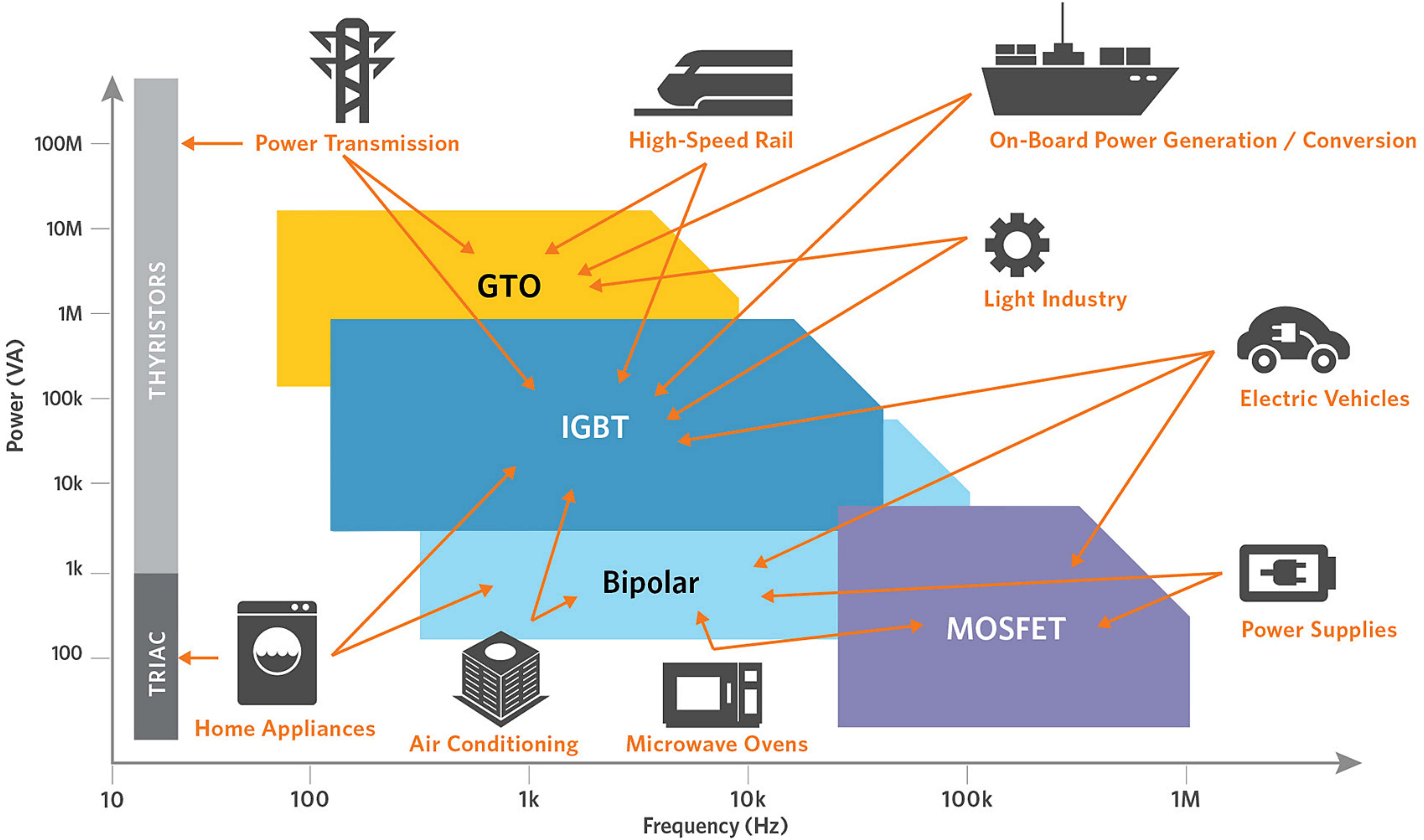
polovodičová relé jsou vždy pouze spínací

čtyřkanálový modul s elektromechanickými relé

Elektrické spínání výkonové elektroniky

- pro **spínání vysokovýkonové elektroniky** se často používají **speciální součástky**
  - **tyristor**
    (angl. „thyristor“)
  - **triak**
    (angl. „triac“)
  - bipolární tranzistor s izolovaným hradlem
    (angl. „insulated gate bipolar transistor“, IGBT)
  - GTO tyristor
    (angl. „GTO thyristor“, zkr. z „gate turn-off“)

Přestože „hradlo“ mají jen unipolární tranzistory a bipolární tranzistory mají „bázi“, používá se tento termín!



Power Transmission
High-Speed Rail
On-Board Power Generation / Conversion
Light Industry
Electric Vehicles
Power Supplies
Home Appliances
Air Conditioning
Microwave Ovens
GTO
IGBT
Bipolar
MOSFET
THYRISTORS
TRIAC
Power (VA)
100M
10M
1M
100k
10k
1k
100
10
100
1k
10k
100k
1M
Frequency (Hz)

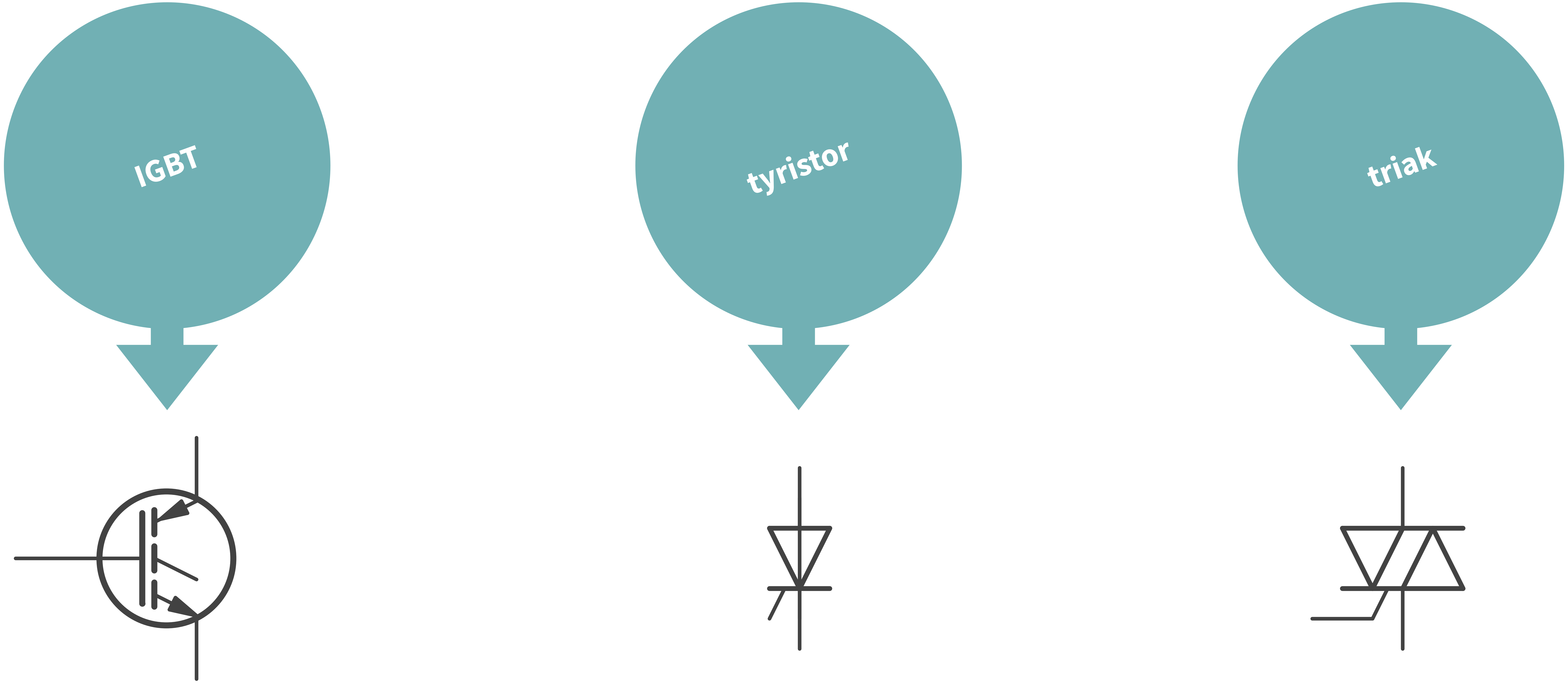

16 Sídliště Řepy
8742
8704
600 V
řádově až 100 A
tyristor

750 V
řádově až 100 A
IGBT


analogový
regulátor
Škoda EDYN 22
(~ baterie 48 V)
25 kV a 3 kV
řádově až 1 kA
tyristor
362 068 - 9
Autorská práva: České dráhy (Praha)


digitální řídicí
počítač
(~ baterie 48 V)
25 kV
řádově až 1 kA
IGBT
660 104-1
650 005-2
České dráhy
Panter

Česká železniční síť používá celkem **čtyři různé napájecí soustavy**.
Dvě stejnosměrné (**3 kV na severu Česka**, 1,5 kV na trati Tábor - Bechyně) a dvě střídavé (**25 kV 50 Hz na jihu Česka** a 15 kV 16,7 Hz na trati Znojmo – Šatov – státní hranice s Rakouskem). Často jsou tedy potřeba **vícesystémové lokomotivy**.



značky výkonových spínacích součástek

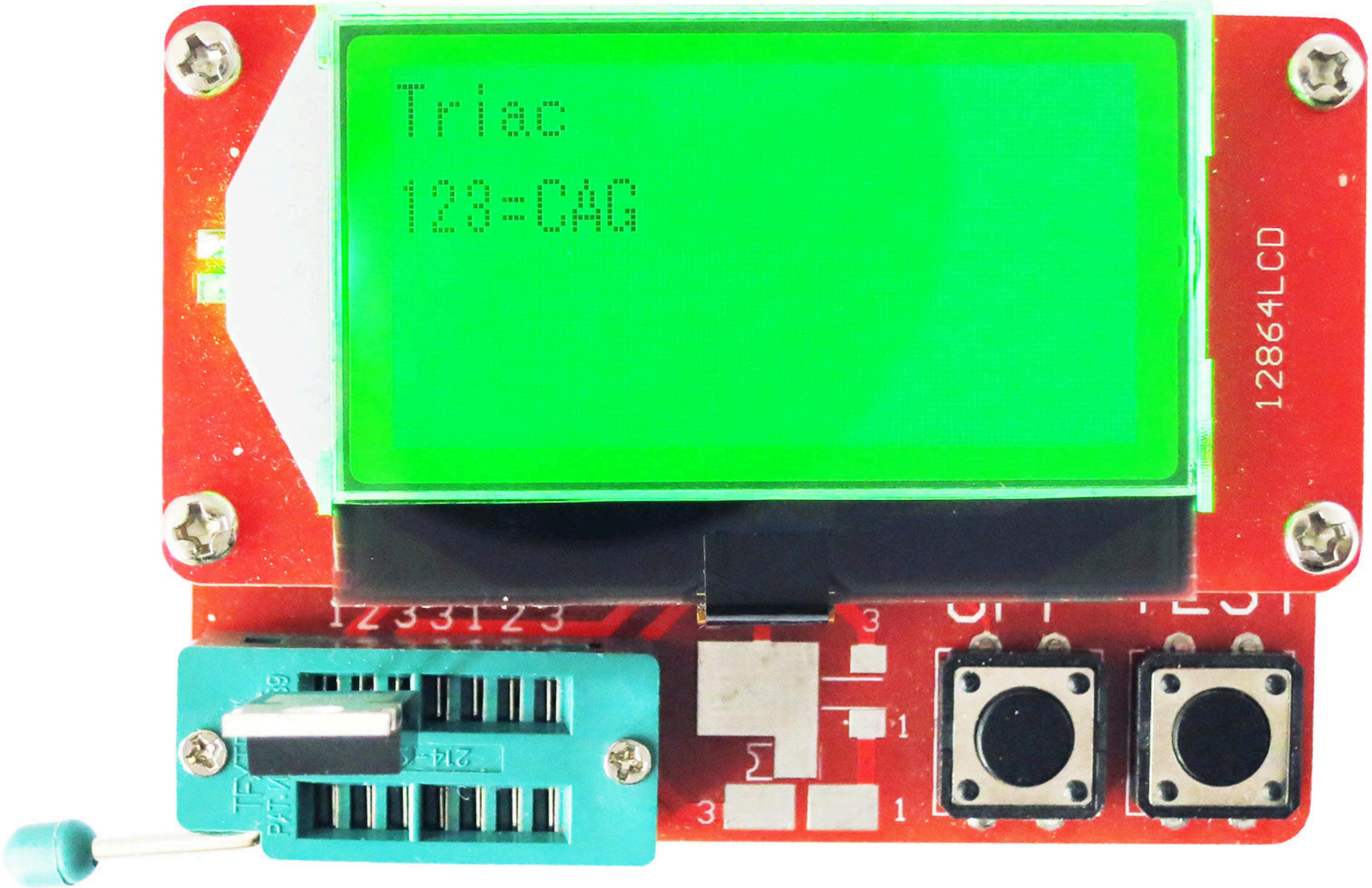
Spínání obvodu tyristorem a triakem

- tyristor se spíná napětím a používá obvykle pro řízení a regulaci obvodů se stejnosměrným proudem

- triak se spíná proudem a používá se pro řízení a regulaci obvodů se střídavým proudem

- **pokud řízeným obvodem protéká** nenulový **proud, obvod je udržován sepnutý** (POZOR: toto je zásadní odlišnost od tranzistorů!),
  výjimkou jsou GTO tyristory, které umožňují vypnutí další elektrodou

tyristor v analyzátoru součástek



triak v analyzátoru součástek

Školní zvonek

(praktický příklad ze SŠIPS, se kterým se denně setkáváte)

Školní zvonek na SŠIPS

- **průmyslový zvonek** 12 V DC + zvonkový **transformátor** 230 V AC/12 V DC
- **Raspberry Pi 3B** + **Automation pHAT** (= relé)
- softwarová část je realizována skripty v jazyce **Python**, které jsou spouštěny **cronem**
    - **ověření pracovního dne** (× víkendy, statní svátky)
      s možností **nastavení dalších výjimek** (~ prázdniny, maturitní zkoušky, …)
    - **sepnutí relé**
      (~ posloupnost kratších zazvonění)
- celkové náklady ~ 3 500 Kč
  (komerční systémy pro školní zvonění se běžně pohybují nad 10 000 Kč)

průmyslový zvonek

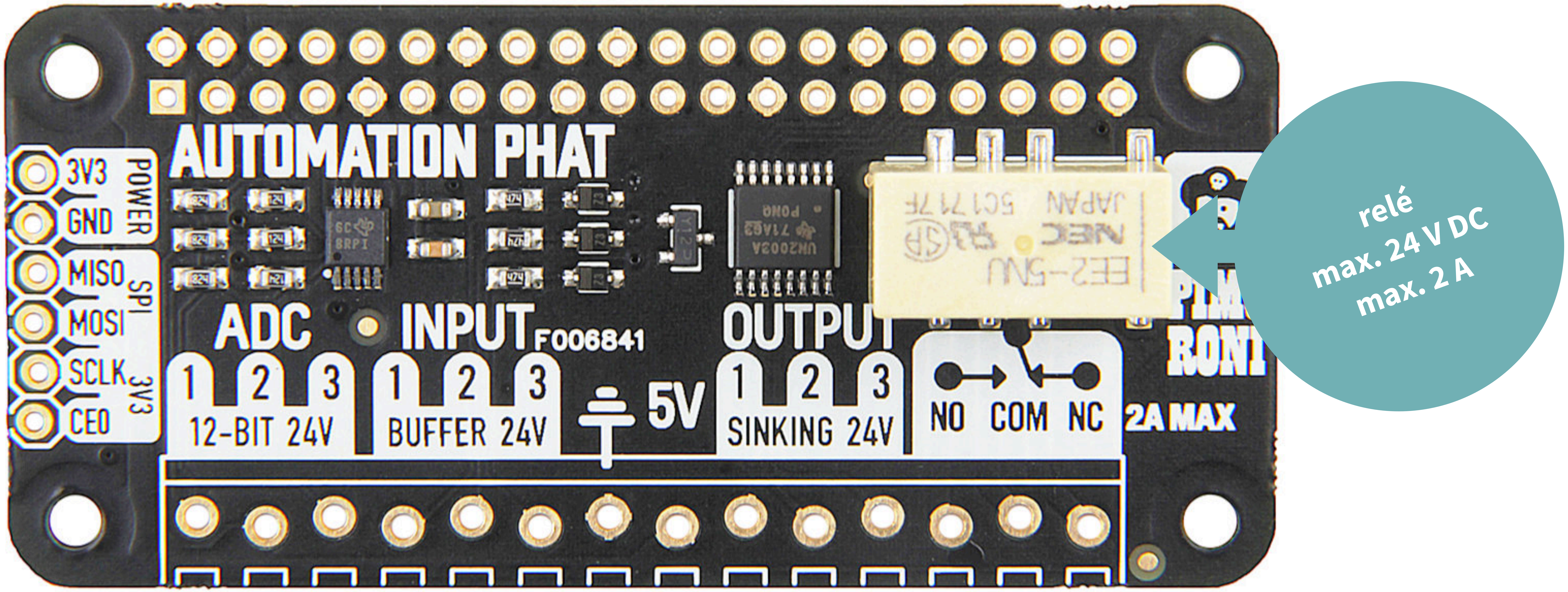
Friedland 581069
12 V DC
700 mA
100 dB

výstup
12 V DC
max. 1,5 A

vstup elektrické rozvodné sítě
(240 V AC, 50 Hz)

Friedland E3538N

zvonkový transformátor



Automation pHAT

konstrukční krabice

Spelsberg TK PS 1809-6
180 × 94 × 57 mm
polystyrenové tělo
polykarbonátový kryt

Co je tranzistor?

Jak funguje?

K čemu se používá?

Co je bipolární tranzistor?

Jak se označují jeho vývody?

Jak se zakresluje ve výkresech obvodů?

Jaké parametry bipolárních tranzistorů nás zajímají?

Čím se liší tranzistory NPN a PNP?

Jak se zapojují?

Co je potřeba ověřit před použitím bipolárního tranzistoru?

Jak se určí hodnoty odporu a jmenovitého zatížení bázového rezistoru?

Co je Darlingtonovo zapojení?

Kdy se používá?

Co je unipolární tranzistor?

Jak se označují jeho vývody?

Jak se zakresluje ve výkresech obvodů?

Jaké parametry unipolárních tranzistorů nás zajímají?

Čím se liší tranzistory s N kanálem a s P kanálem?

Jak se zapojují?

Co je potřeba ověřit před použitím unipolárního tranzistoru?

Co je relé?

Jak funguje?

Kdy se používá?

Jaké parametry relé nás zajímají?

Co je optočlen?

Jak funguje?

Kdy se používá?

Jaké parametry optočlenů nás zajímají?

Co je polovodičové relé?

Jak funguje?

Kdy se používá?

Jaké parametry polovodičových relé nás zajímají?

Jaké součástky se používají ke spínání a regulování výkonové elektroniky?