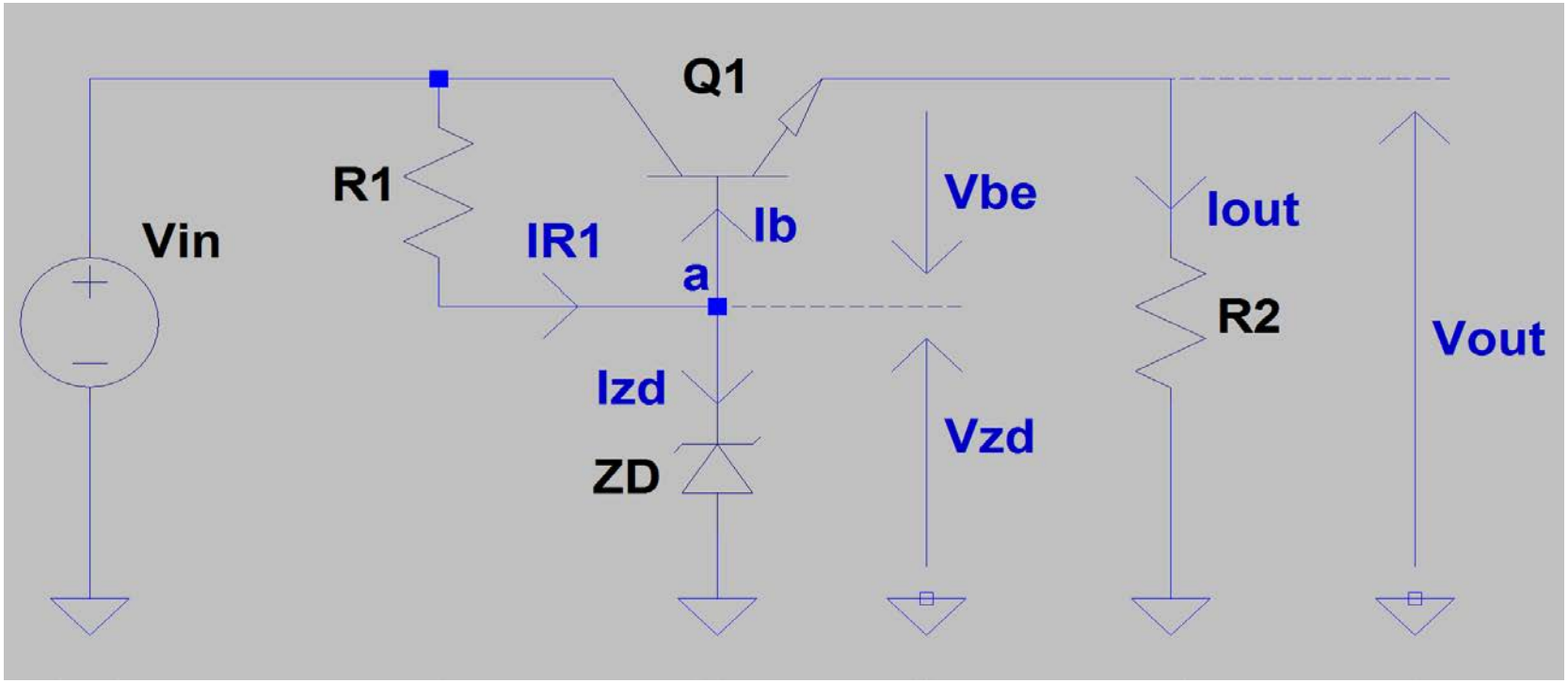
Stabilizatori napona sa bipolarnim tranzistorima



$$V_{out} = V_{zd} - V_{be}$$

$$I_{R1} = \frac{V_{in} - V_{zd}}{R_1} = I_{zd} + I_b$$

$$R_1 \leq \frac{V_{in\_min} - V_{zd}}{I_{out\_max} \Big/ h_{FE\_min} + I_{zd\_min}}$$

Primer 1

- Projektovati stabilizator napona sa tranzistorom za izlazni napon 5V i potrošač ćija se struja menja od 0,1 do 1A, ukoliko je poznato da se ulazni napon menja u granicama od 8 do 10V.

- Prvo je neophodno odrediti napon zenerove diode:
- $V_{zd} = V_{out} + V_{be} = 5V + 0{,}6V = 5{,}6V$

Izbor tranzistora

- Nakon toga potrebno je odrediti maksimalnu snagu disipacija na tranzistoru kako bi se odabrao odgovarajući model tranzistora
- $P_{d\_max} = \left(V_{in\_max} - V_{out}\right) \cdot I_{out\_max} = (10V - 5V) \cdot 1A = 5W$
- Dakle potreban nam je tranzistor sa sledečim parametrima: V_{br}>10V, I_{c_max}>1A, P_{d_max}>5W i h_{FE}>100.
- Tranzistor koji zadovoljava ove uslove je na primer 2SCR574D: $V_{br}=V_{CEO}$=80V, I_{c_max}=2A, P_{d_max}=10W i h_{FE}=120 do 390.

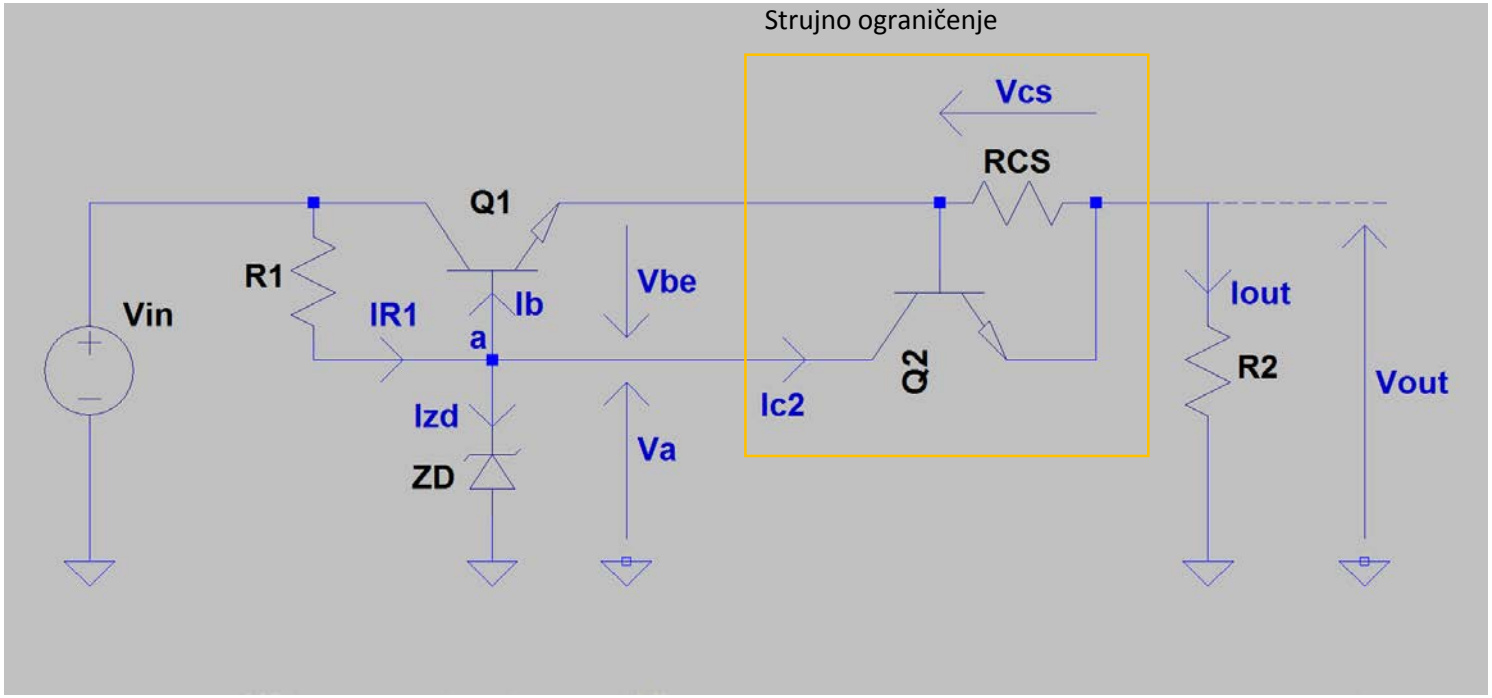
Proračuni komponenti

- $R_1 \leq \frac{V_{in\_min} - V_{zd}}{I_{out\_max}/h_{FE\_min} + I_{zd\_min}} = \frac{8V - 5{,}6V}{1A/120 + 5mA} = 180\Omega$

- $P_{zd_{max}} = V_{zd} \cdot \left(\frac{V_{in\_max} - V_{zd}}{R_1} - \frac{I_{out\_min}}{h_{FE\_max}} \right) =$

$$= 5{,}6V \cdot \left(\frac{10V - 5{,}6V}{180\Omega} - \frac{0{,}1A}{390} \right) = 0{,}135W$$

Prekostrujna zaštita



$$I_{R1} = I_b + I_{zd} + I_{c2}$$

$$I_{out\_CL} = 1{,}1 \cdot I_{out\_max}$$

$$R_{CS} = \frac{V_{be}}{I_{out\_CL}}$$

Dejstvo strujnog ograničenja

- Pri dostizanju vrednosti strujnog ograničenja za napon na čvoru *a* V_a važi sledeća jednakost:
- $V_a = R_2 \cdot I_{out_{CL}} + V_{CS} + V_{be} = R_2 \cdot I_{out_{CL}} + 1{,}2V = V_{zd}$
- $za \quad R_2 \leq \frac{V_{zd} - 1{,}2V}{I_{out\_CL}}$ zener dioda izlazi iz proboja

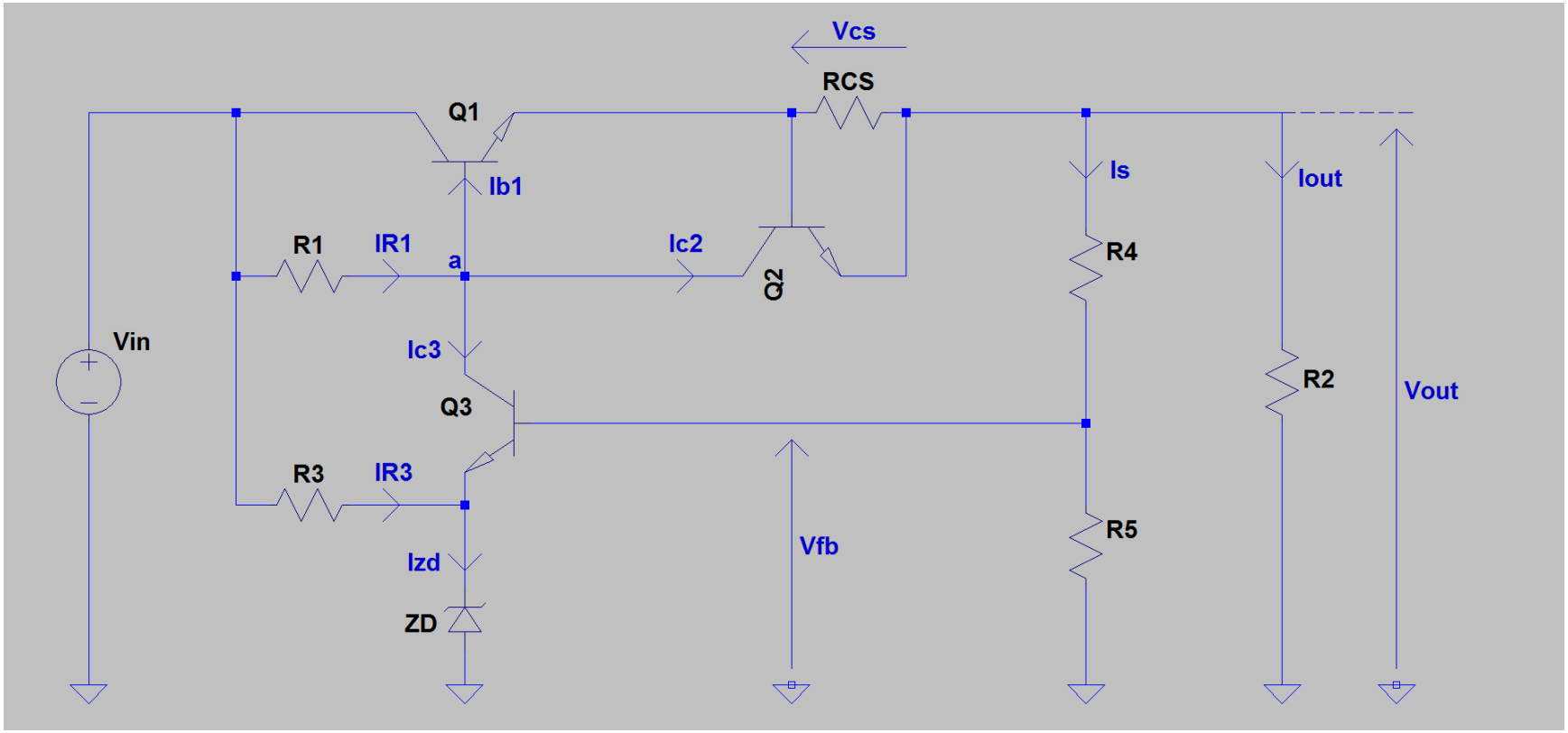
- Za $R_2 = 0$, snaga disipacije na Q_1 je maksimalna i data je izrazom:
- $P_{dmax} = I_{out\_CL} \cdot \left(V_{in\_max} - V_{CS}\right) = I_{out\_CL} \cdot \left(V_{in\_max} - 0{,}6V\right)$

Tranzistor Q2

- $V_{ce2\_max} = V_{CS} + V_{be} = 1{,}2V$
- $I_{c2\_max} = \frac{V_{in\_max} - V_{be} - V_{CS}}{R_1} - \frac{I_{out\_CL}}{h_{FE\_max}}$
- $P_{d2\_max} = V_{ce2\_max} \cdot I_{c2\_max}$

- Nedostatak koje ima opisano kolo je povećanje izlazne otpornosti uvođenjem otpornika R_{CS}.

Prekostrujna zaštita i naponskom povratnom spregom sa izlaza



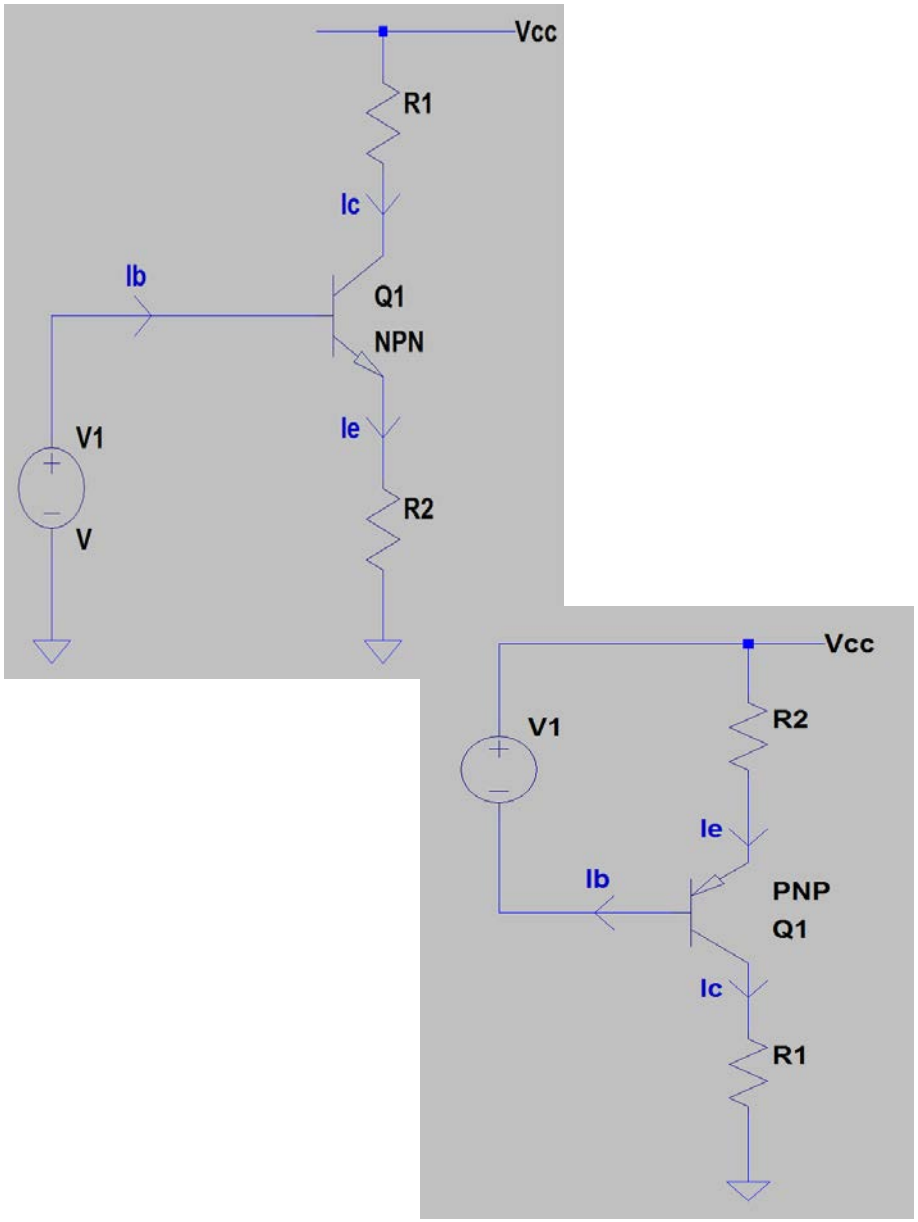
Proračun komponenti

- Za $I_{R_4-R_5} \gg I_{b3}$ razdelnik možemo smatrati idealnim
- $V_{fb} = \frac{R_5}{R_4+R_5} \cdot V_{out} = V_{zd} + V_{be3}$

$$\Rightarrow \quad V_{out} = \left(1 + \frac{R_4}{R_5}\right) \cdot (V_{zd} + V_{be3})$$

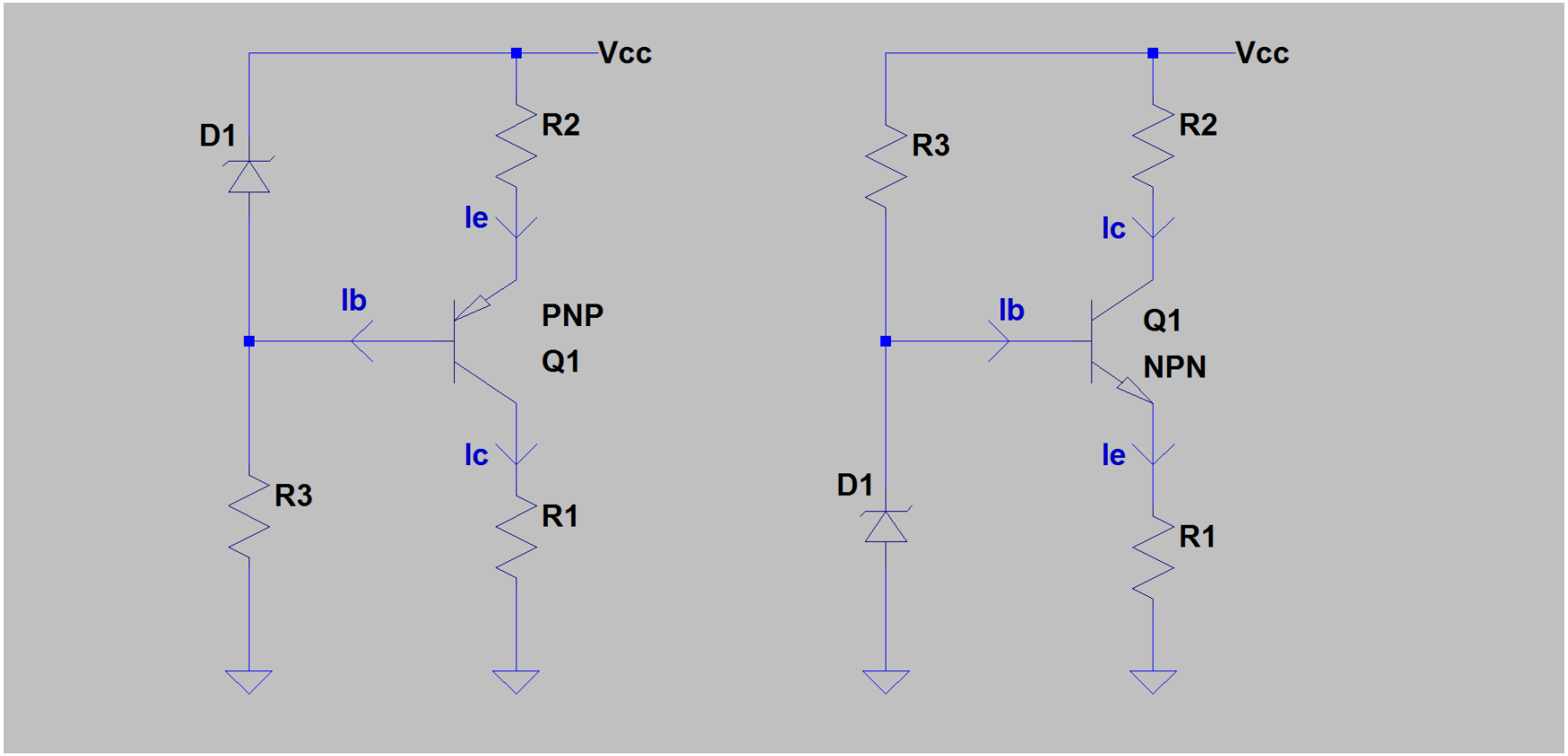
- R_1 obezbeđuje baznu struju tranzistora Q_1
- $R_1 < \frac{V_{in\_min} - V_{out} - V_{CS\_max} - V_{be1}}{(I_{out\_CL} + I_s) / h_{FE\_min}}$
- R_3 obezbeđuje potrebnu struju da bi zener dioda sigurno bila u proboju
- $R_3 \leq \frac{V_{in\_min} - V_{zd}}{I_{zd\_min}}$

Strujni izvori – strujni regulatori

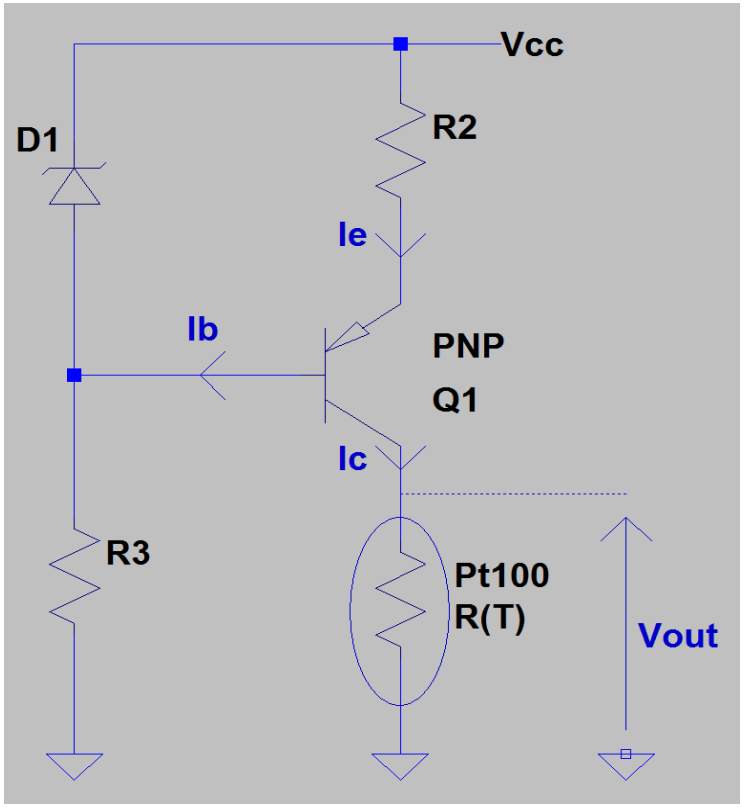


- $V_1 = V_{be} + I_e \cdot R_2$
- $I_e = \frac{V_1 - V_{be}}{R_2} = const$
- Za veliko h_{FE}
- $I_c = I_e$
- $V_{cc} - R_1 \cdot I_c - V_{ce} - R_2 \cdot I_e = 0$
- $0 \leq R_1 < \left(\frac{V_{cc} - V_{ce\_sat}}{I_c} - R_2\right)$

Realizacija

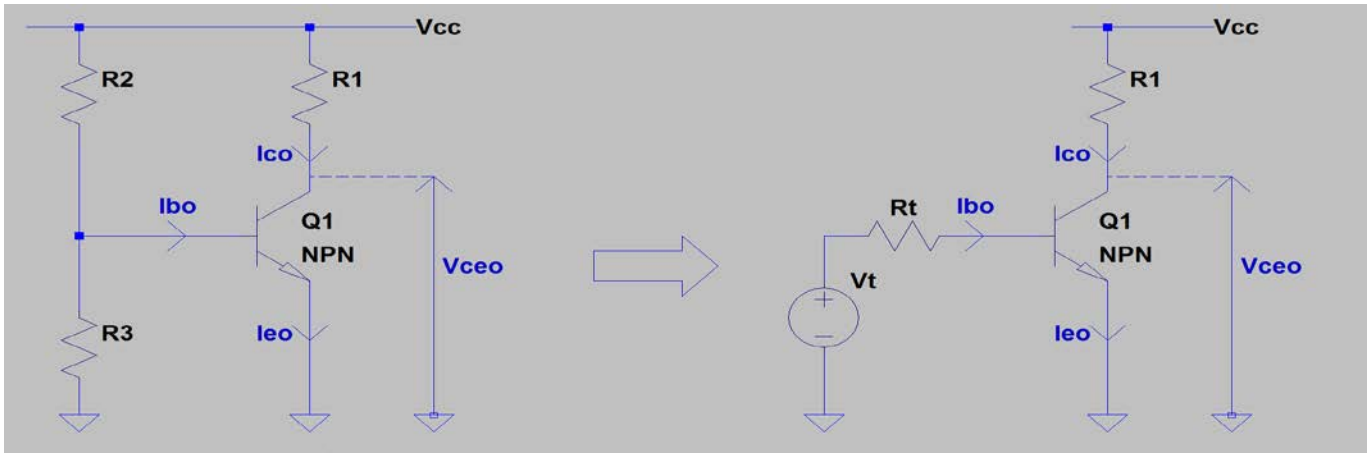


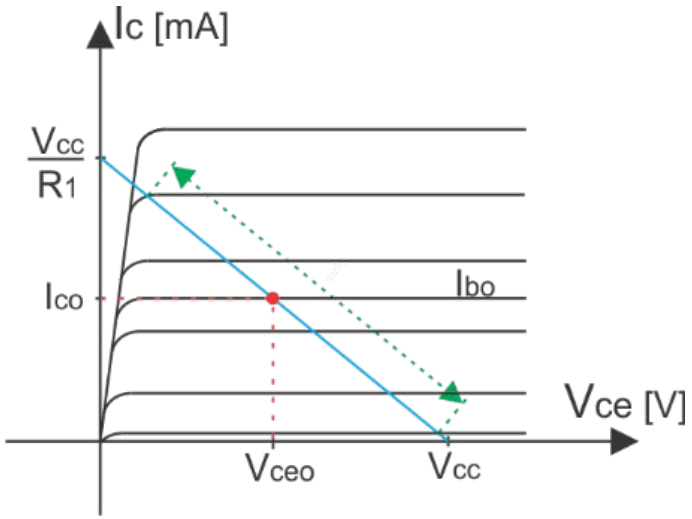
Transmiter za Pt100



$V_{out} = I_c \cdot R(T)$ *pri čemu je* $I_c = const$

Polarizacija tranzistora



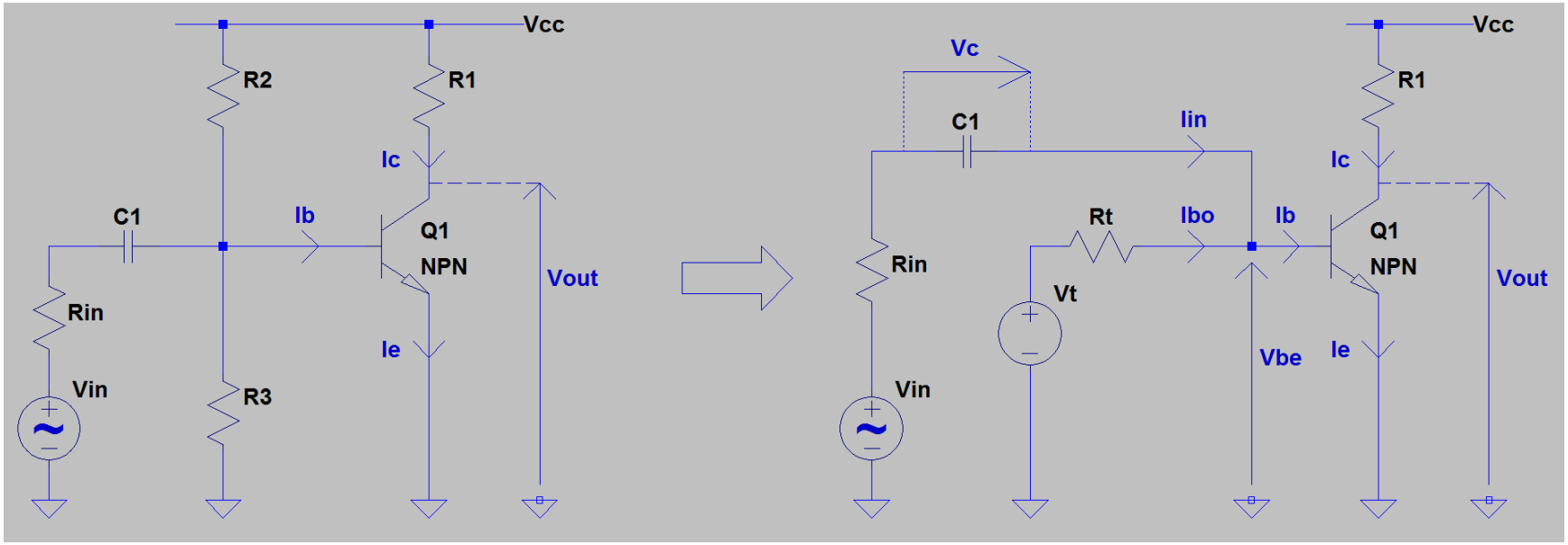


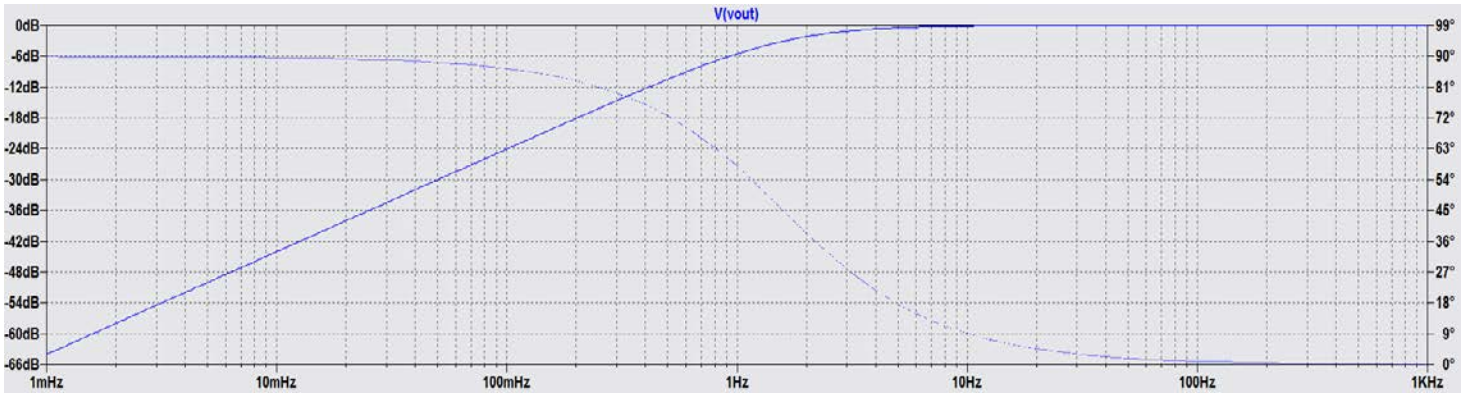
$$V_t = V_{cc} \cdot \frac{R_3}{R_2 + R_3} \qquad i \qquad R_t = \frac{R_2 \cdot R_3}{R_2 + R_3}$$

$$I_{bo} = \frac{V_t - V_{be}}{R_t}$$

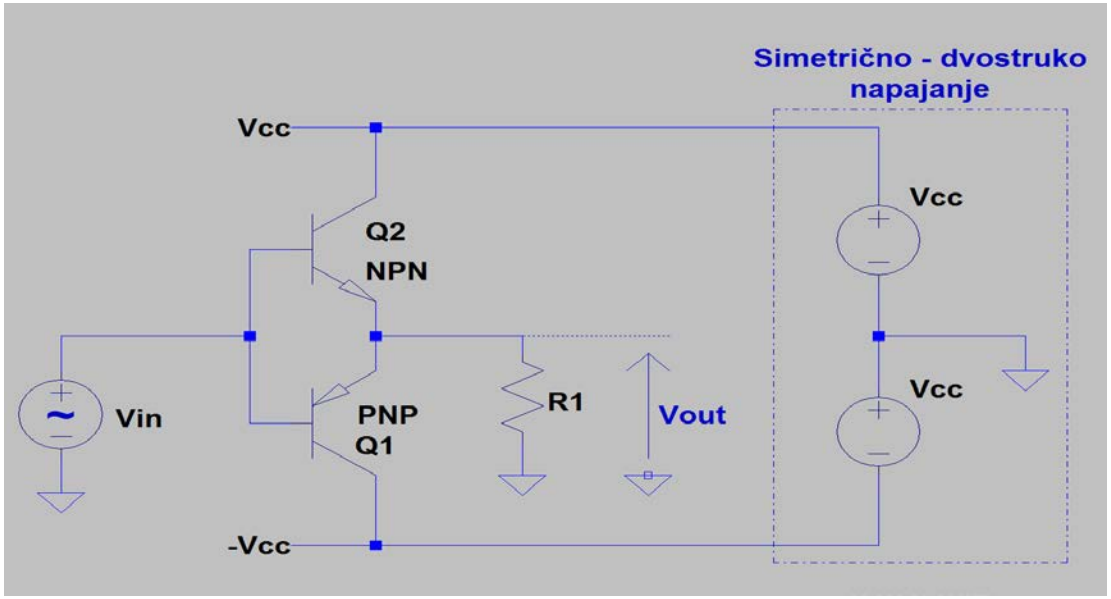
$$I_{co} = h_{FE} \cdot I_{bo} = h_{FE} \cdot \frac{V_t - V_{be}}{R_t} \qquad i \qquad V_{ceo} = V_{cc} - R_1 \cdot I_{co}$$

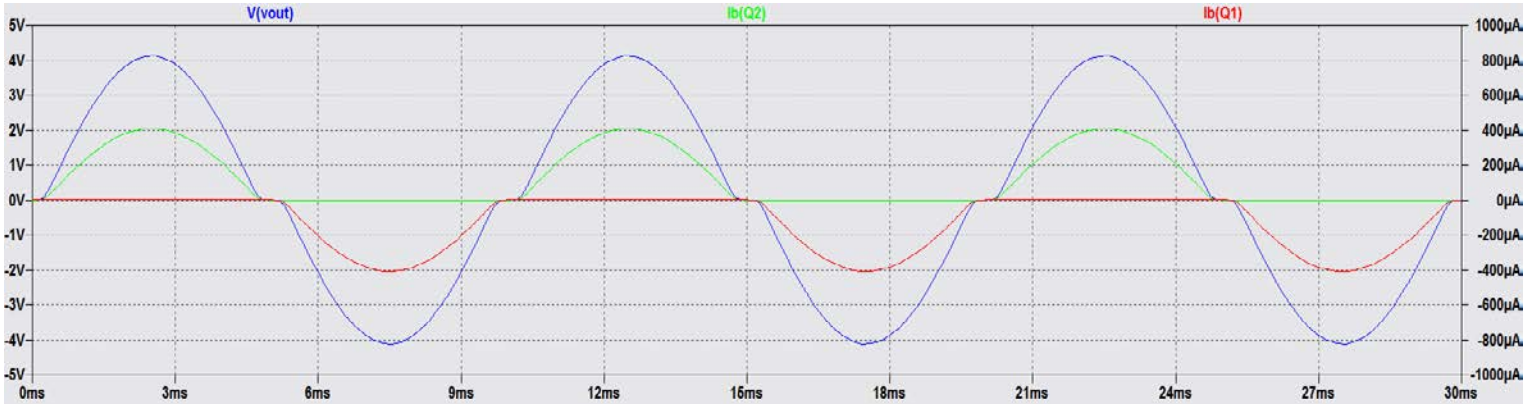
Kapacitivna sprega za naizmenične signale



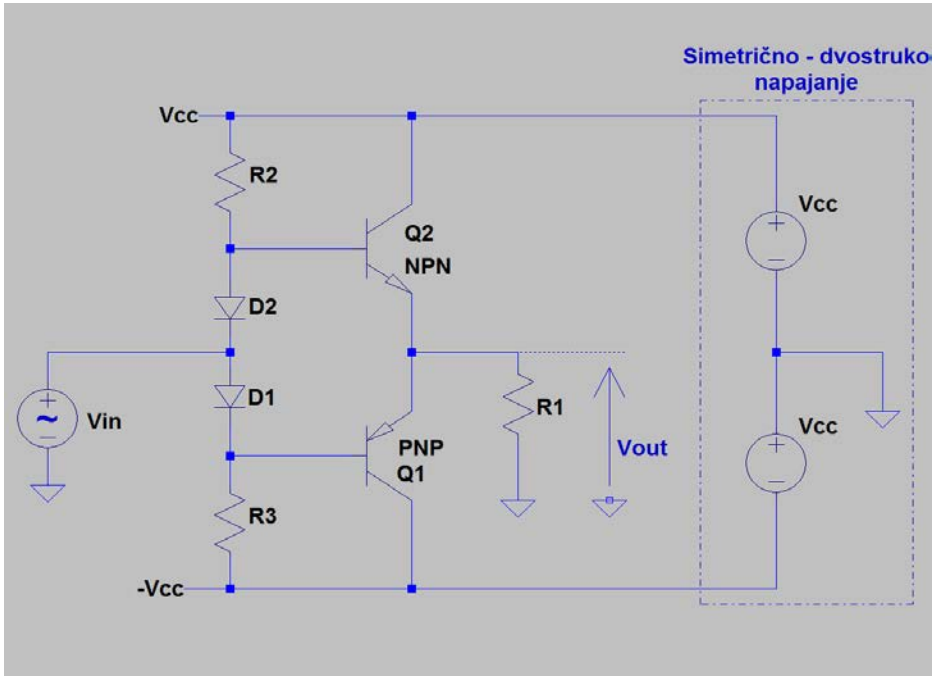


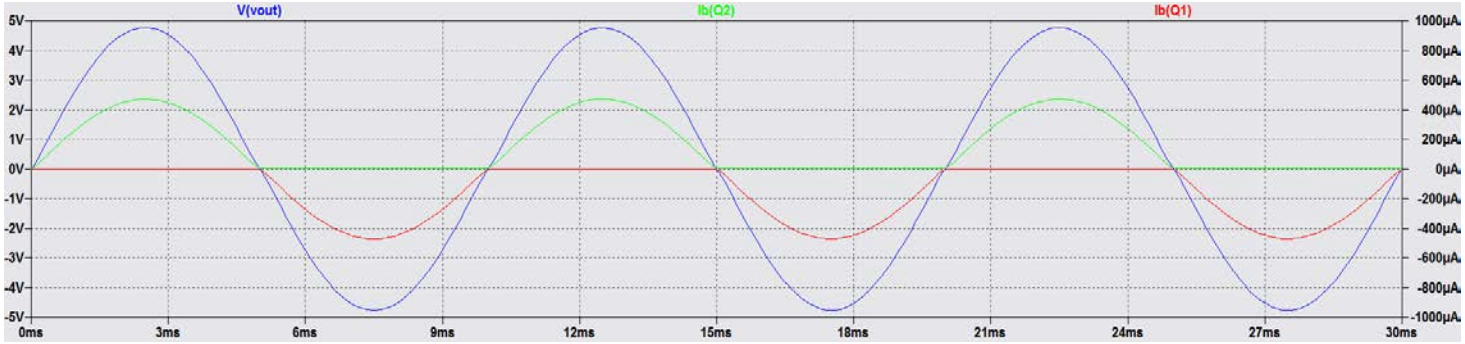
Puš-pul pojačavač 1



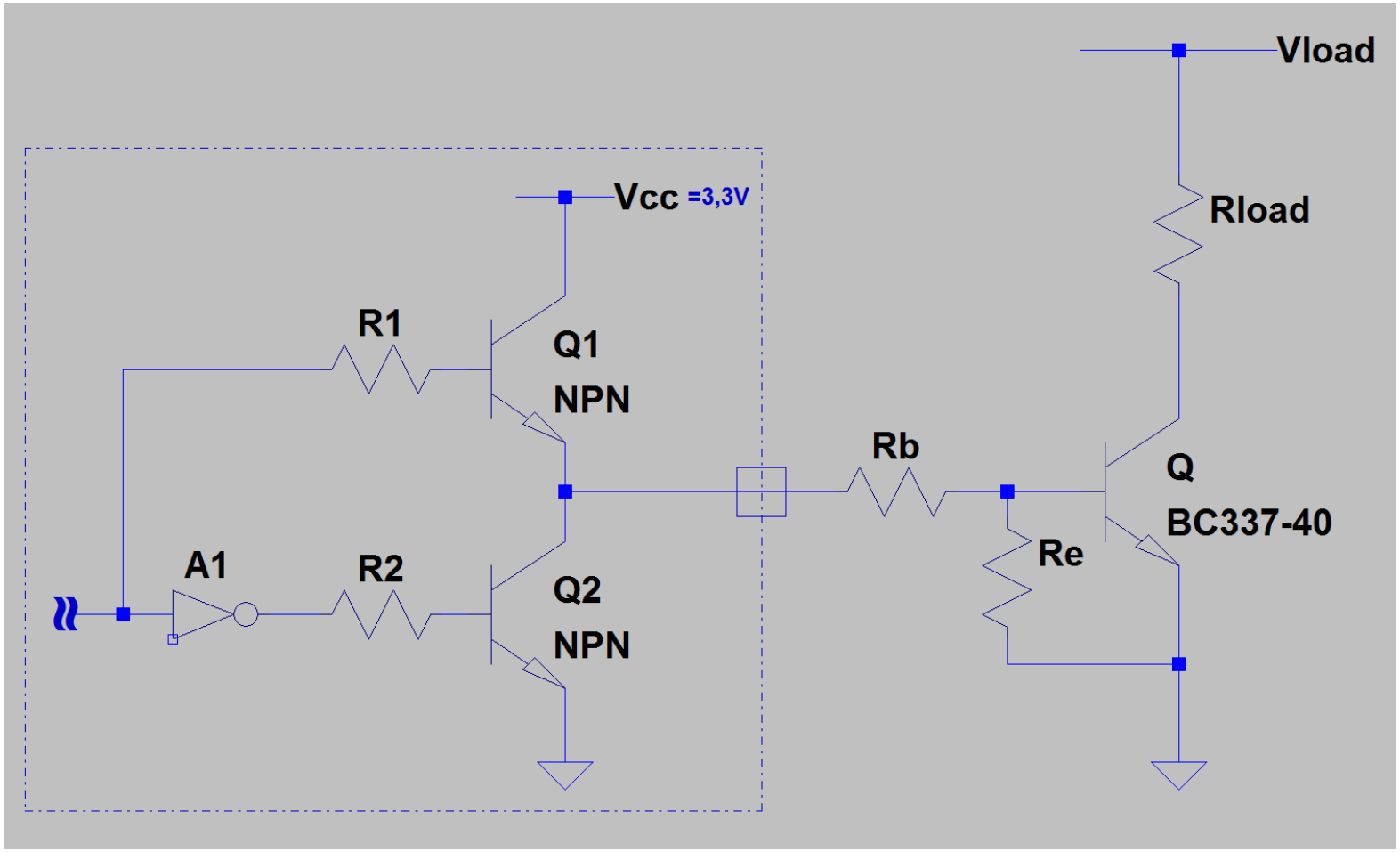


Puš-pul pojačavač 2





NPN tranzistor kao prekidač



PNP tranzistor kao prekidač

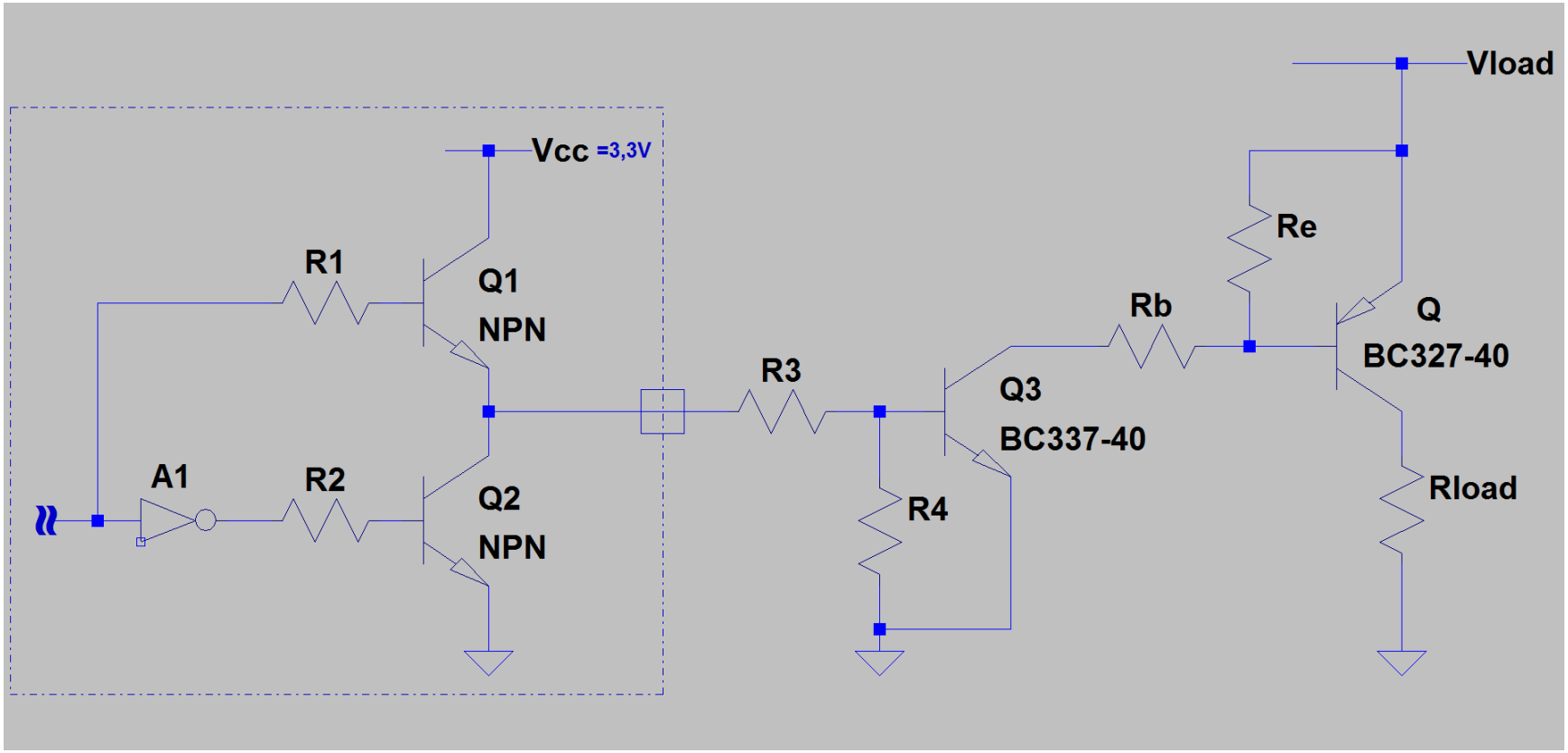


Table 37-7. I/O pin characteristics.

Symbol	Parameter	Condition		Min.	Typ.	Max.	Units
I_{OH} (1)/ I_{OL} (2)	I/O pin source/sink current			-20		20	mA
V_{IH}	High level input voltage	V_{CC} = 2.7 - 3.6V		2		V_{CC}+0.3	V
		V_{CC} = 2.0 - 2.7V		0.7*V_{CC}		V_{CC}+0.3	
		V_{CC} = 1.6 - 2.0V		0.7*V_{CC}		V_{CC}+0.3	
V_{IL}	Low level input voltage	V_{CC} = 2.7- 3.6V		-0.3		0.3*V_{CC}	
		V_{CC} = 2.0 - 2.7V		-0.3		0.3*V_{CC}	
		V_{CC} = 1.6 - 2.0V		-0.3		0.3*V_{CC}	
V_{OH}	High level output voltage	V_{CC} = 3.0 - 3.6V	I_{OH} = -2mA	2.4	0.94*V_{CC}		
		V_{CC} = 2.3 - 2.7V	I_{OH} = -1mA	2.0	0.96*V_{CC}		
			I_{OH} = -2mA	1.7	0.92*V_{CC}		
		V_{CC} = 3.3V	I_{OH} = -8mA	2.6	2.9		
		V_{CC} = 3.0V	I_{OH} = -6mA	2.1	2.6		
		V_{CC} = 1.8V	I_{OH} = -2mA	1.4	1.6		
V_{OL}	Low level output voltage	V_{CC} = 3.0 - 3.6V	I_{OL} = 2mA		0.05*V_{CC}	0.4	
		V_{CC} = 2.3 - 2.7V	I_{OL} = 1mA		0.03*V_{CC}	0.4	
			I_{OL} = 2mA		0.06*V_{CC}	0.7	
		V_{CC} = 3.3V	I_{OL} = 15mA		0.4	0.76	
		V_{CC} = 3.0V	I_{OL} = 10mA		0.3	0.64	
		V_{CC} = 1.8V	I_{OL} = 5mA		0.3	0.46	
I_{IN}	Input leakage current				<0.001	0.1	µA
R_P	I/O pin Pull/Buss keeper resistor				25		kΩ
R_{RST}	Reset pin pull-up resistor				25		
t_r	Pad rise time	No load			4.0		ns
			slew rate limitation		7.0		

Notes:
1. The sum of all I_{OH} for PORTA, PORTC, PORTD, PORTF, PORTH, PORTJ, PORTK must for each port not exceed 200mA.
   The sum of all I_{OH} for PORTB must not exceed 100mA.
   The sum of all I_{OH} for PORTQ, PORTR and PDI must not exceed 100mA.
2. The sum of all I_{OL} for PORTA, PORTC, PORTD, PORTF, PORTH, PORTJ, PORTK must for each port not exceed 200mA.
   The sum of all I_{OL} for PORTB must not exceed 100mA.
   The sum of all I_{OL} for PORTQ, PORTR and PDI must not exceed 100mA.

Induktivni potrošači

Zaštitno kolo