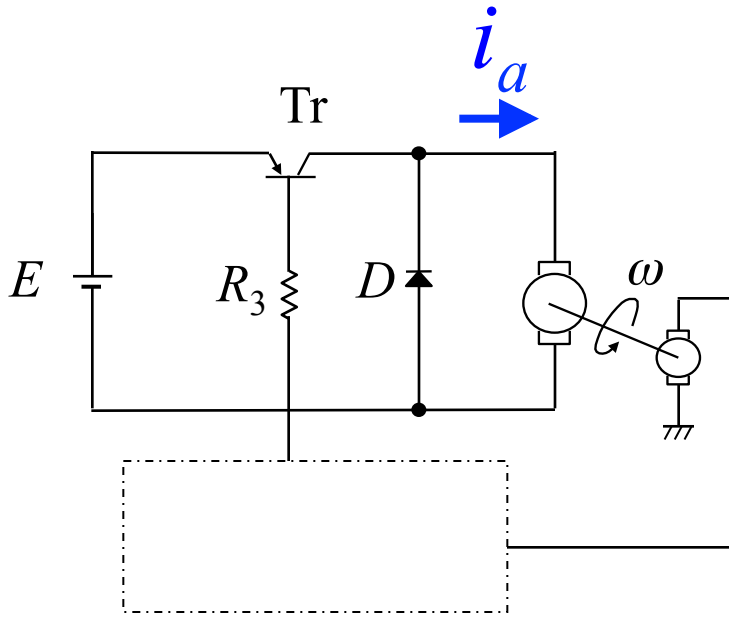


# Power Electronics

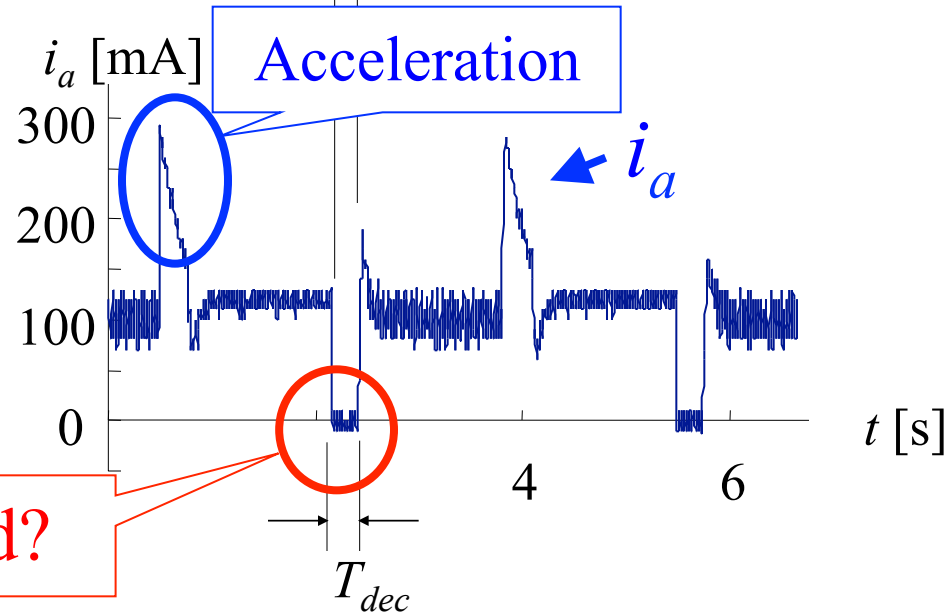
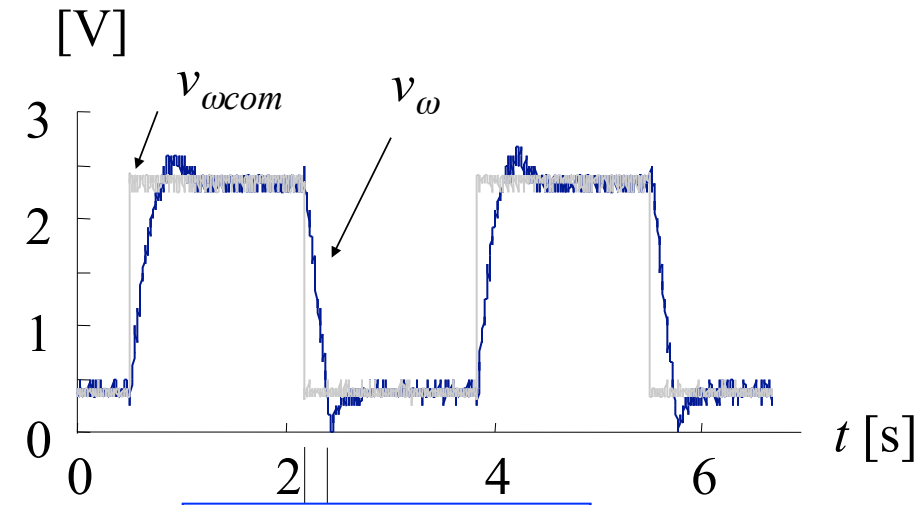
## No. 11: Chopper circuit with a braking function

Takeshi Furuhashi

[Furuhashi\\_at\\_cse.nagoya-u.ac.jp](mailto:Furuhashi_at_cse.nagoya-u.ac.jp)

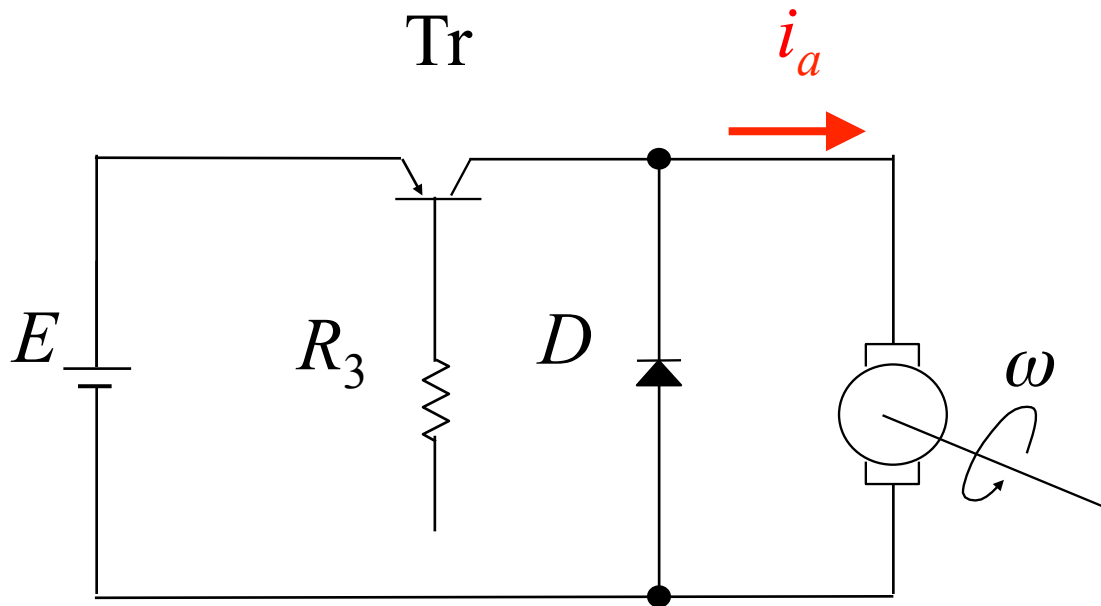


Control circuit of a DC motor using a step-down chopper



Is the brake applied?

Motor speed and armature current



Control circuit of a DC motor using a step-down chopper

Motor torque

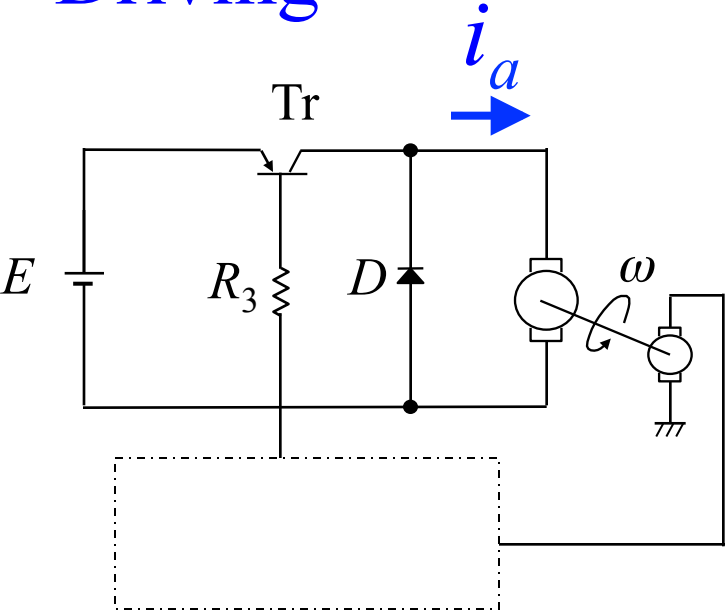
$$\tau = K_{\tau} i_a \quad (7.12)$$

Thus, to apply the brake, armature current  $i_a$  should be

$$i_a < 0$$

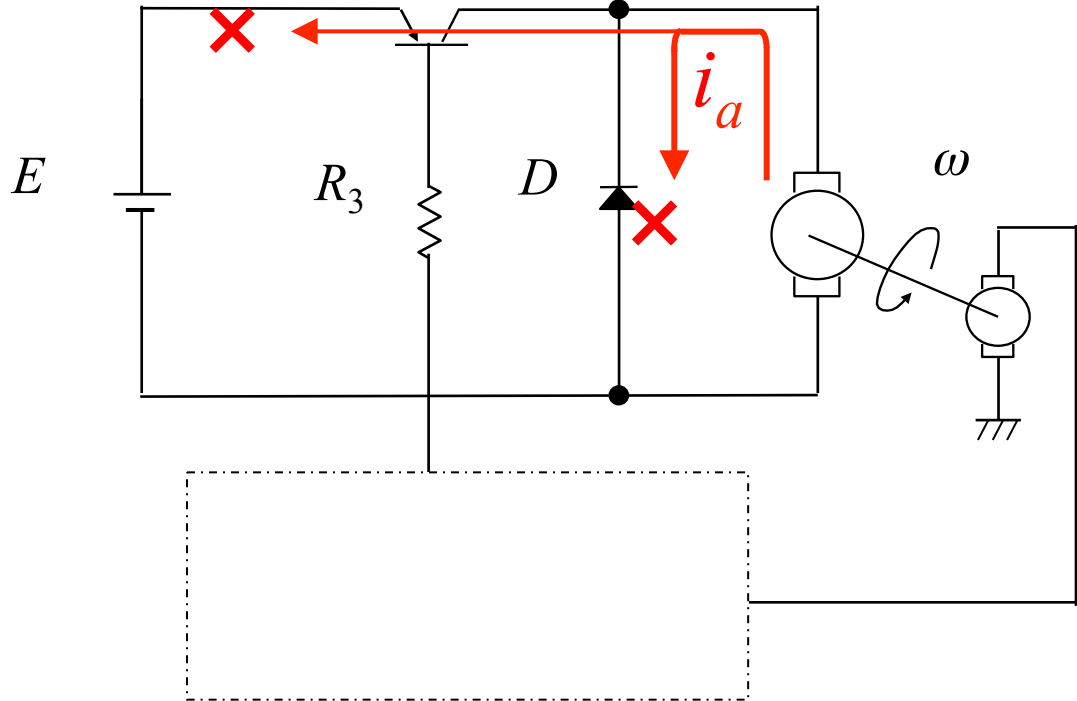
No route to make  $i_a$  reverse

Driving



Control circuit of a DC motor using a step-down chopper

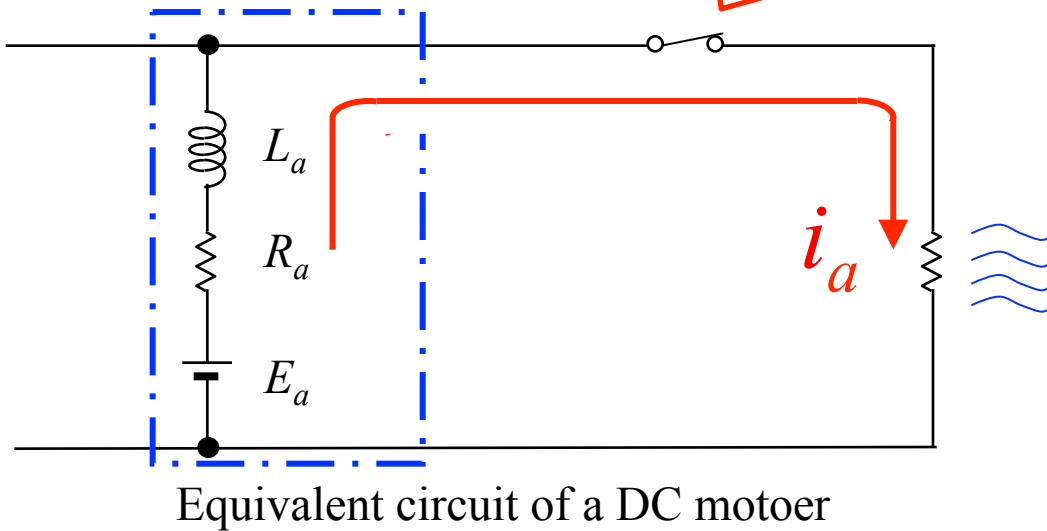
Braking



Control circuit of a DC motor using a step-down chopper

# For applying a brake to an old train

This switch is turned on for braking



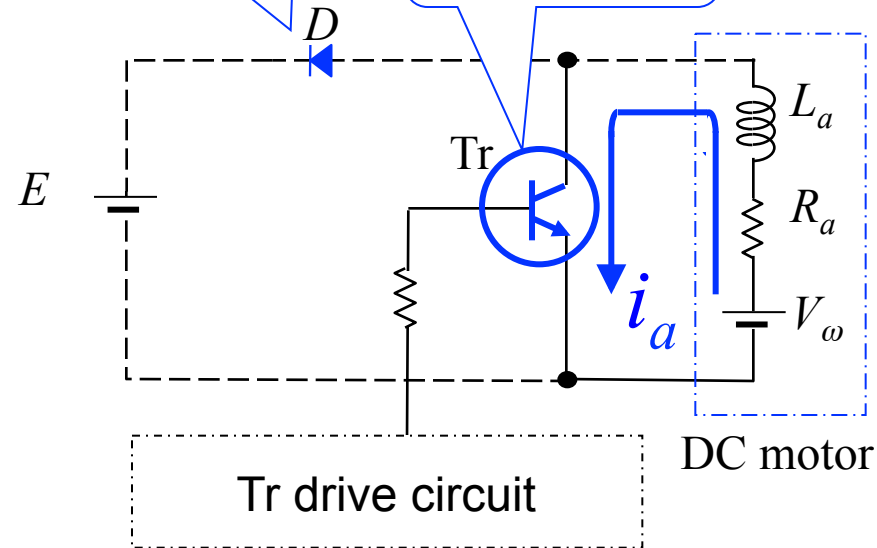
Kinetic energy ➡ Electric energy ➡ Thermal energy

# In the case of a chopper train

Note:  $V_E > V_\omega$

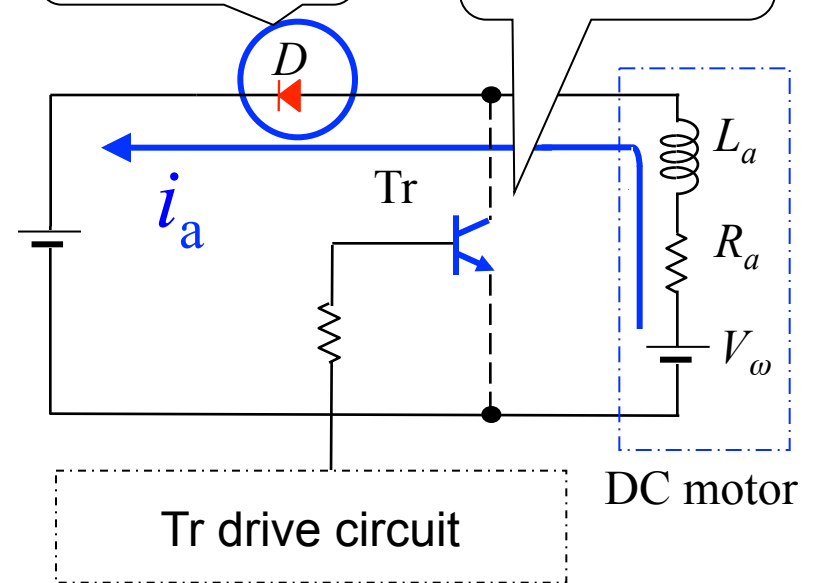
D:OFF

Tr:ON



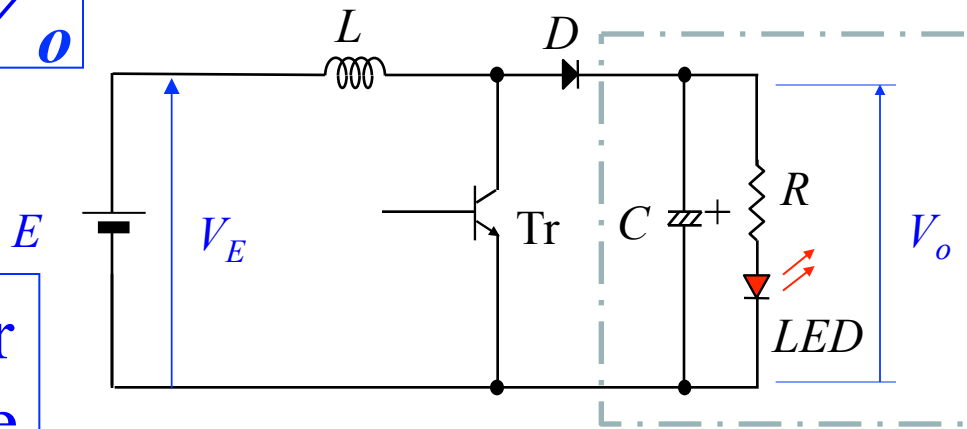
D:ON

Tr:OFF



$$V_E < V_o$$

Power source



Output

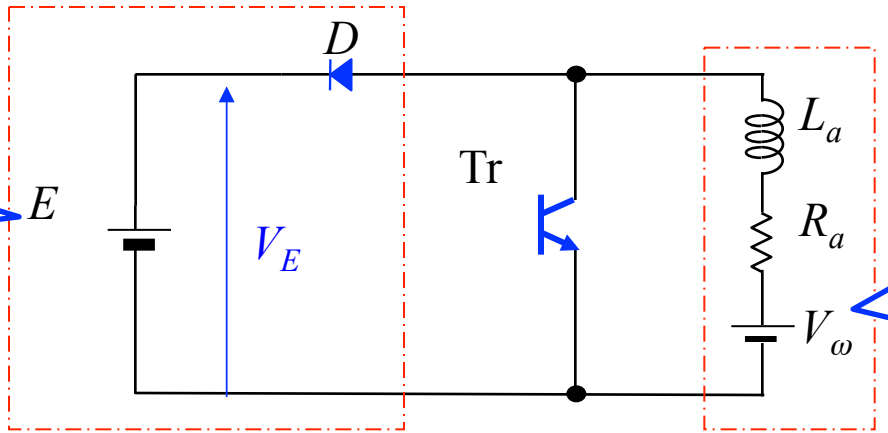
Step-up chopper

$$V_E > V_\omega$$



Exchanging the output and the input

Output

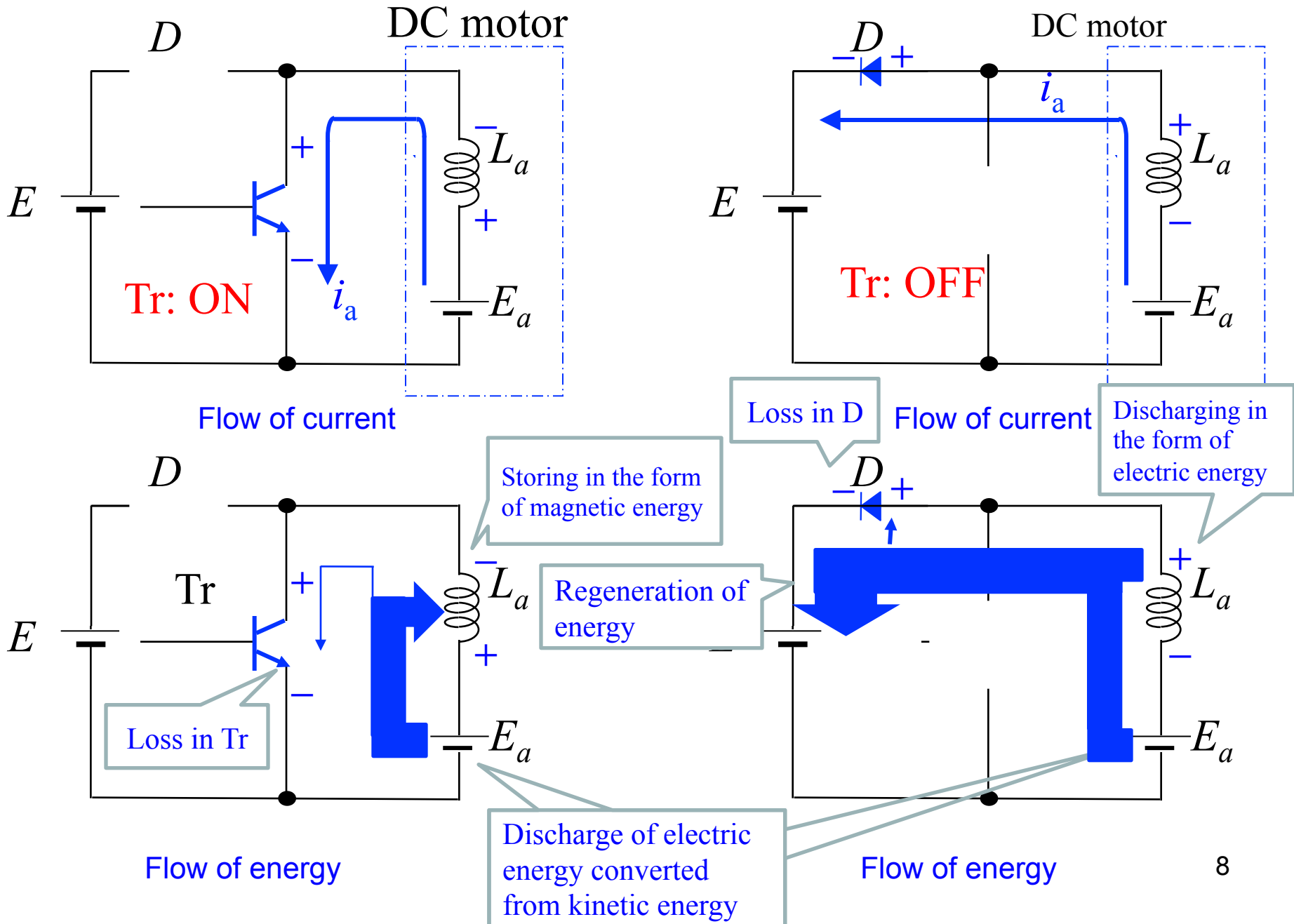


Power source

DCモータ

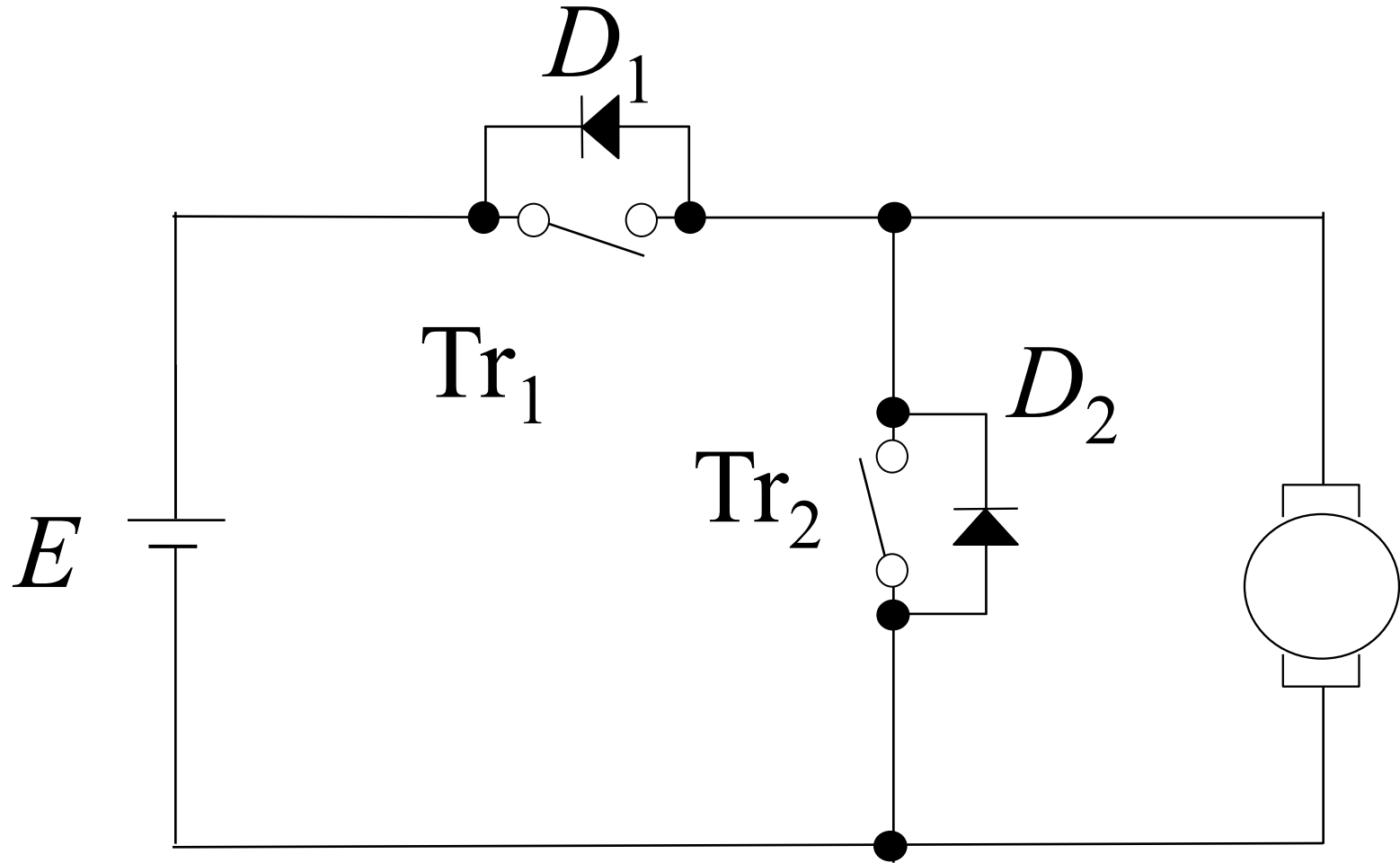
Braking circuit for a DC motor

# Operating modes of a DC motor braking circuit





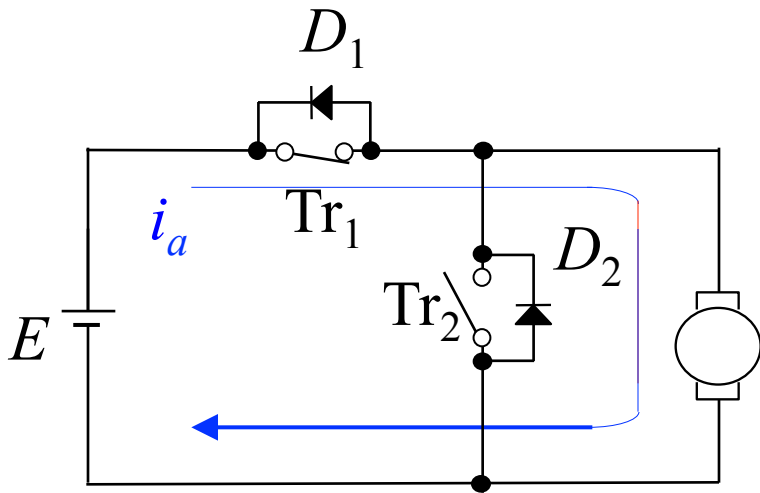
# Incorporation of step-down and step-up choppers



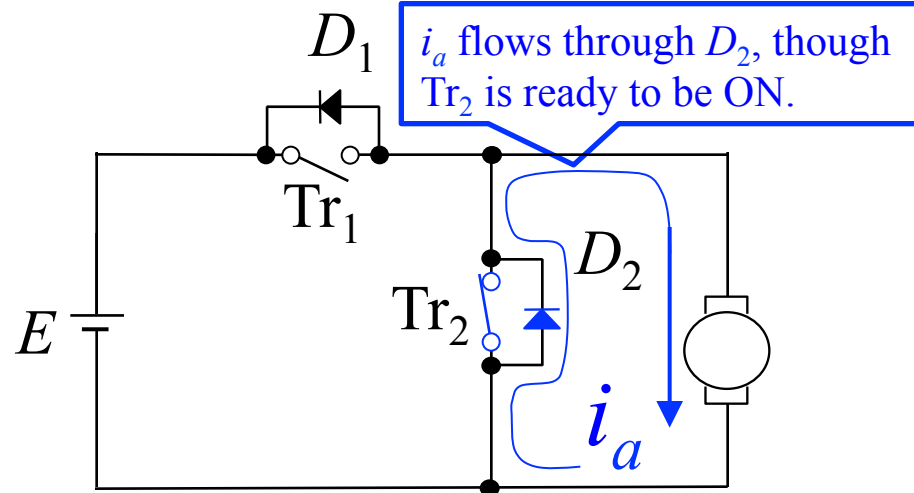
$Tr_1 + D_2 =$  **step-down chopper**

$Tr_2 + D_1 =$  **step-up chopper**

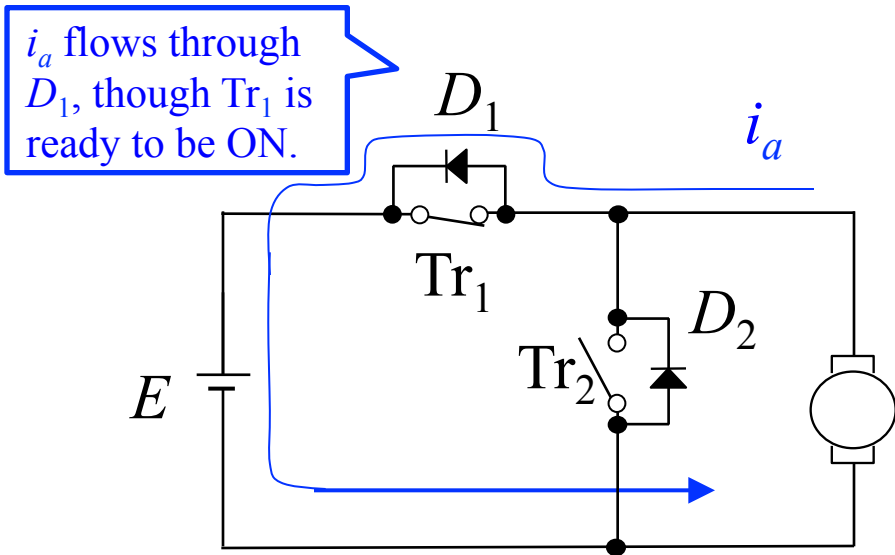
# ON/OFF of transistors and operating modes of the new chopper circuit



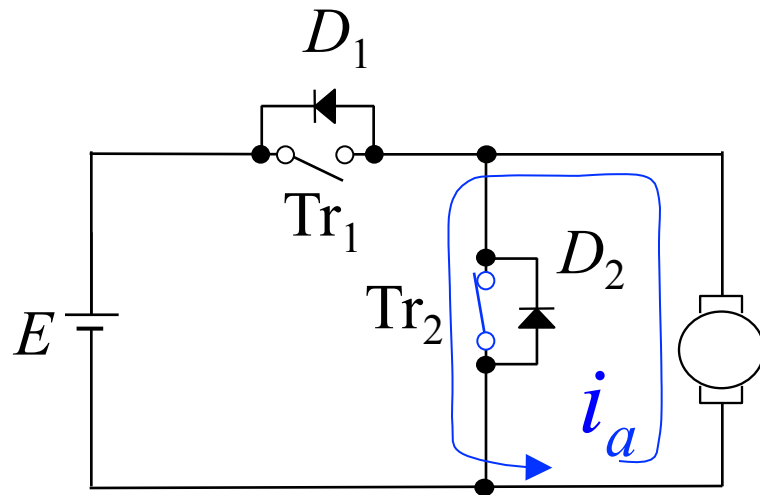
(a)  $i_a > 0$ ,  $Tr_1$ : ON,  $Tr_2$ : OFF



(b)  $i_a > 0$ ,  $Tr_1$ : OFF,  $Tr_2$ : ON



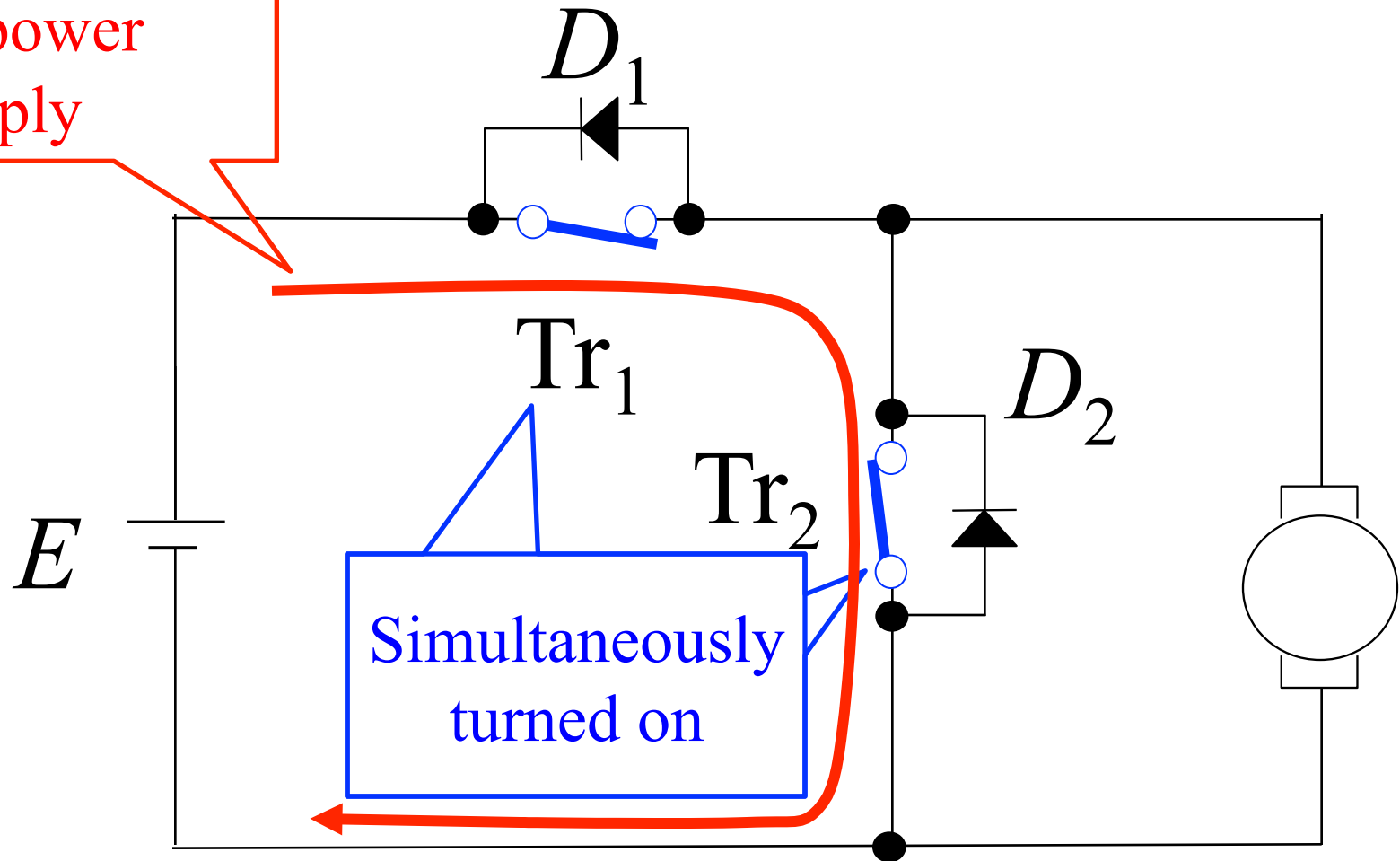
(c)  $i_a < 0$ ,  $Tr_1$ : ON,  $Tr_2$ : OFF

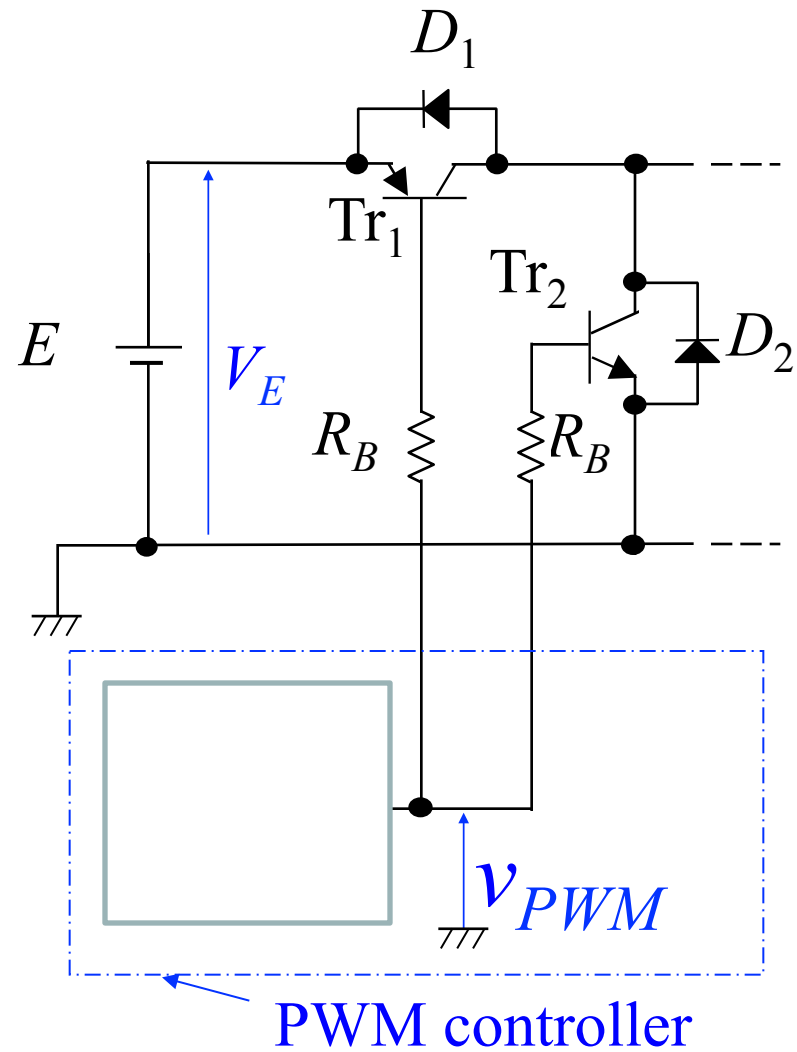


(d)  $i_a < 0$ ,  $Tr_1$ : OFF,  $Tr_2$ : ON

# Prohibited switching

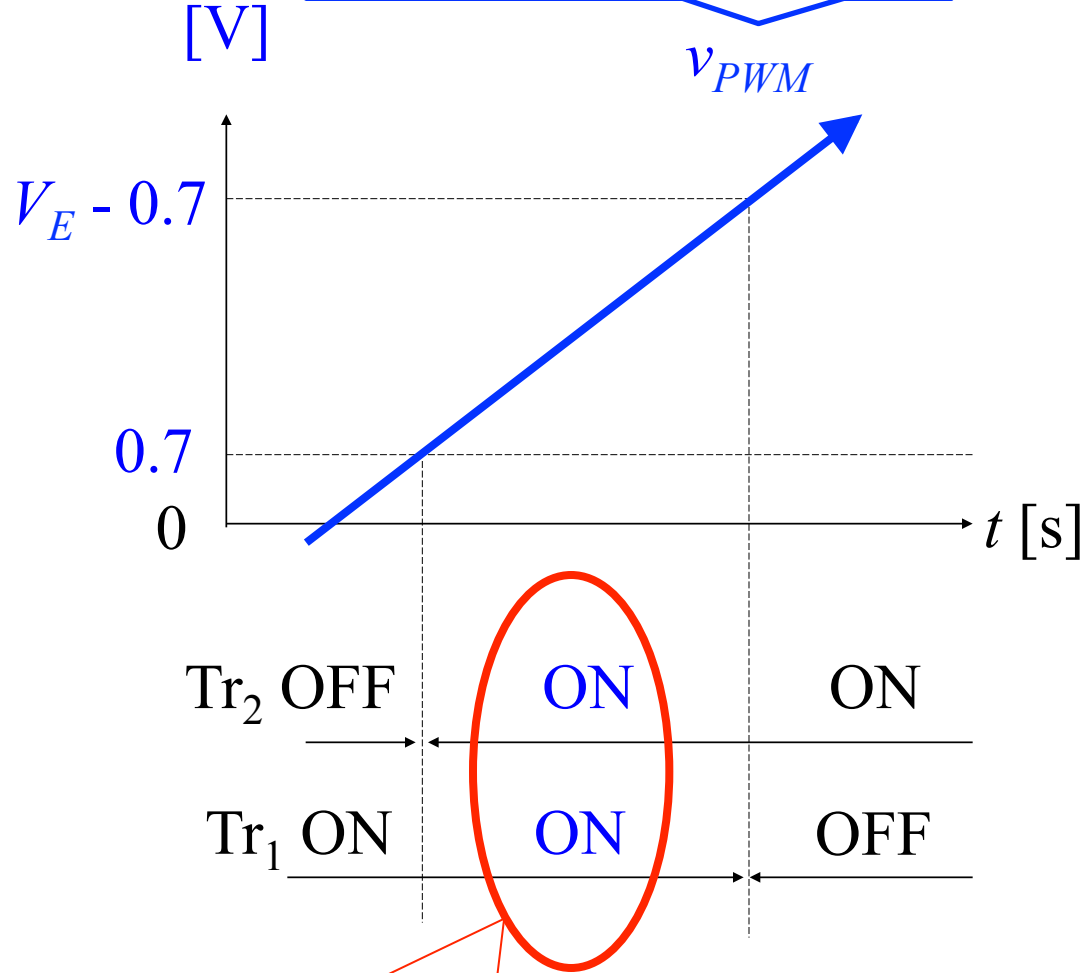
Short circuit  
of power  
supply



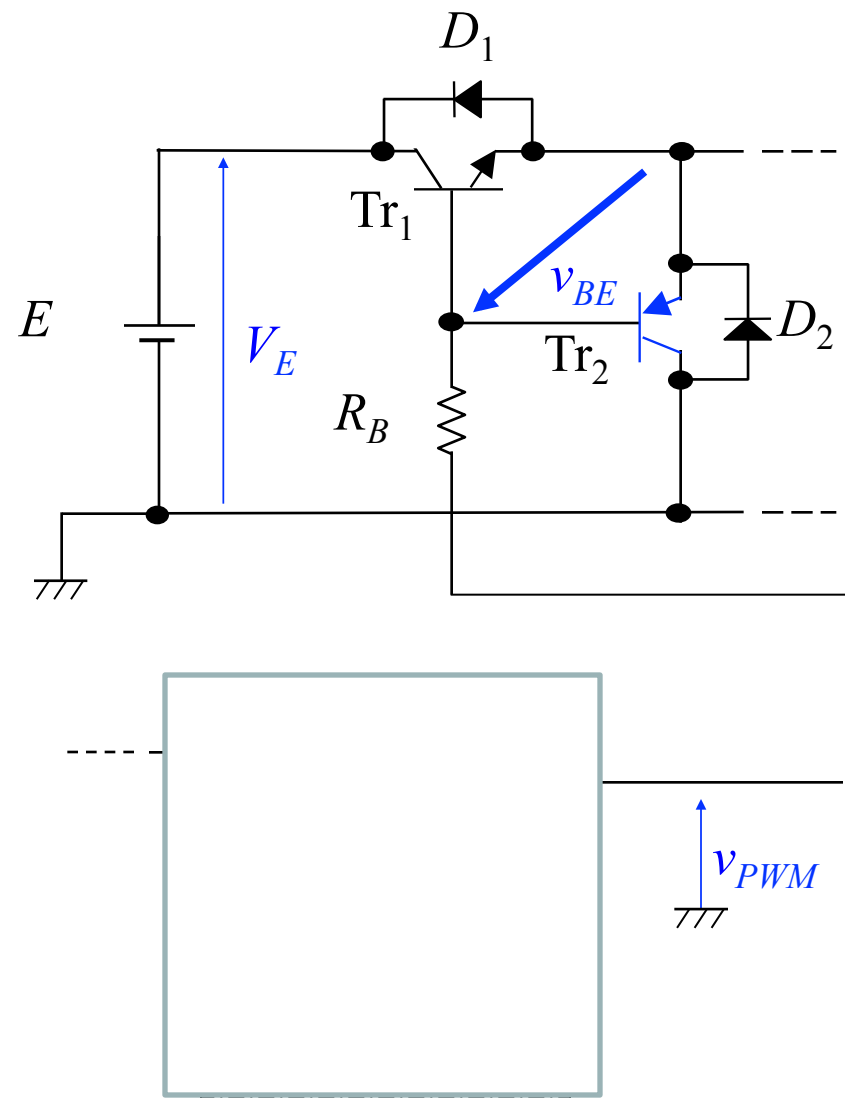


$Tr_1$  : PNP-type transistor  
 $Tr_2$ : NPN-type transistor

In the case when  $v_{PWM}$  increases

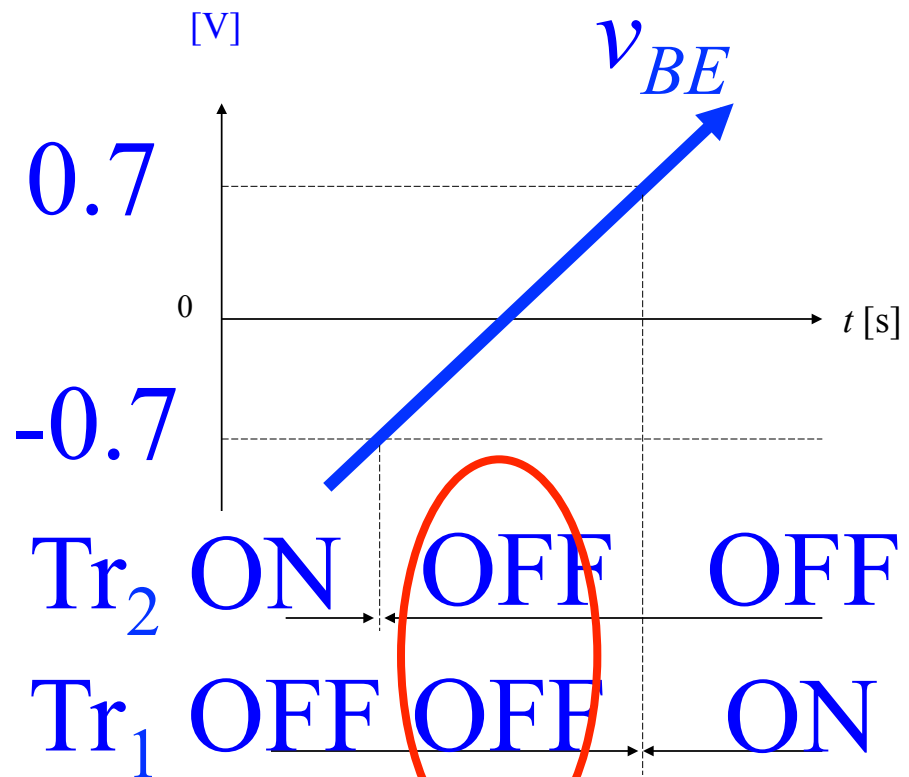


Short circuit of power supply

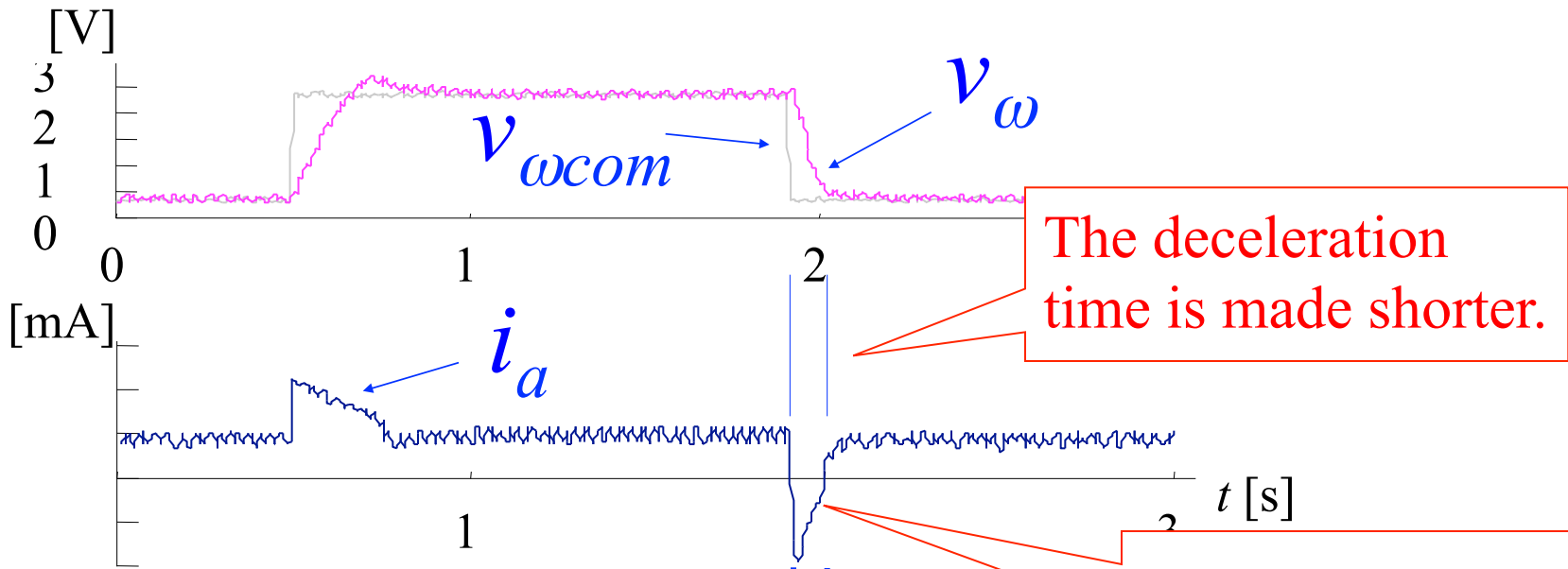


PWM controller

Tr1 : NPN-type transistor  
 Tr2: PNP-type transistor

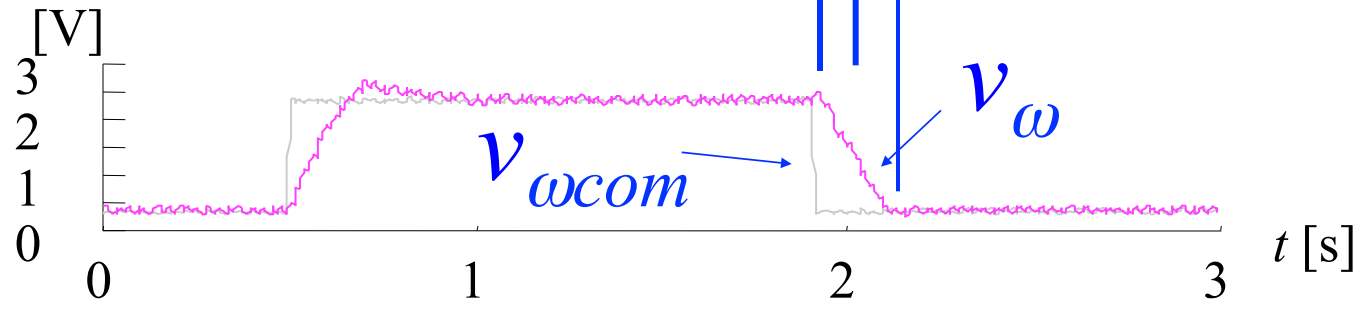


Power supply is not short circuited.



(a) with the brake

$i_a < 0$



(b) without the brake

## STEP 8. Circuit construction practice

Design the circuit that satisfies the following. P gain  $K_p$  and I gain  $K_I$  of the PI controller are 5 and 1000, respectively. If  $SW_1$  is turned on, the motor stops. If  $SW_2$  is turned on, a brake can be applied to  $DCM_1$ . If  $SW_2$  is turned off, the brake is not available.

