# Một số sơ đồ mạch ĐKĐT

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11. Các mạch logic
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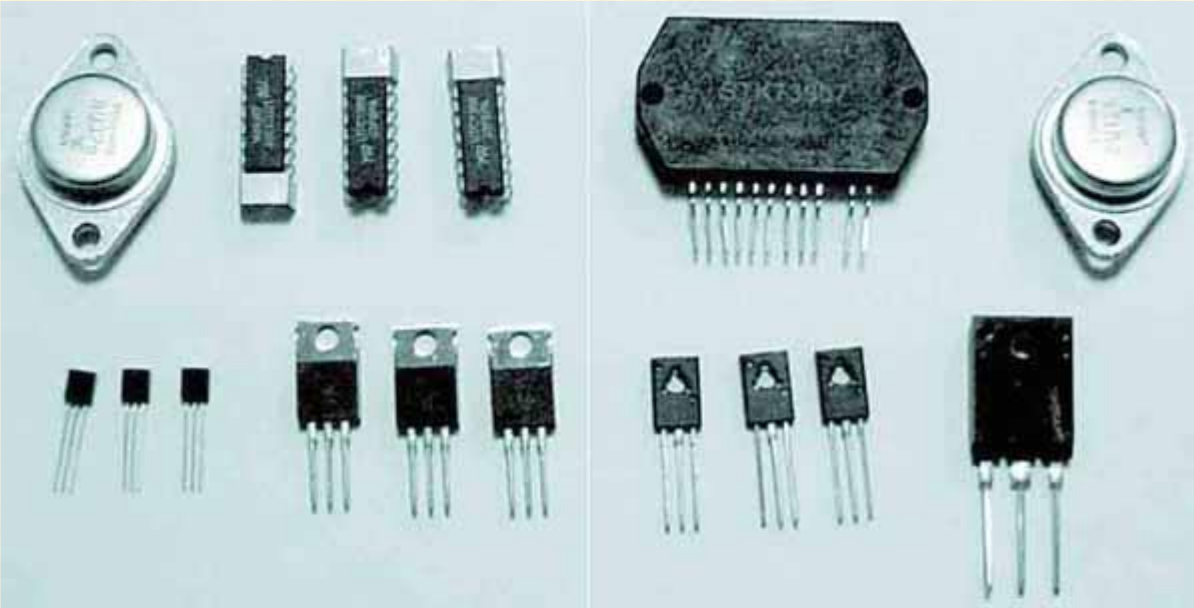
13. Thu phát sóng radio
14. Thu phát siêu âm

# Mạch điều khiển transitor

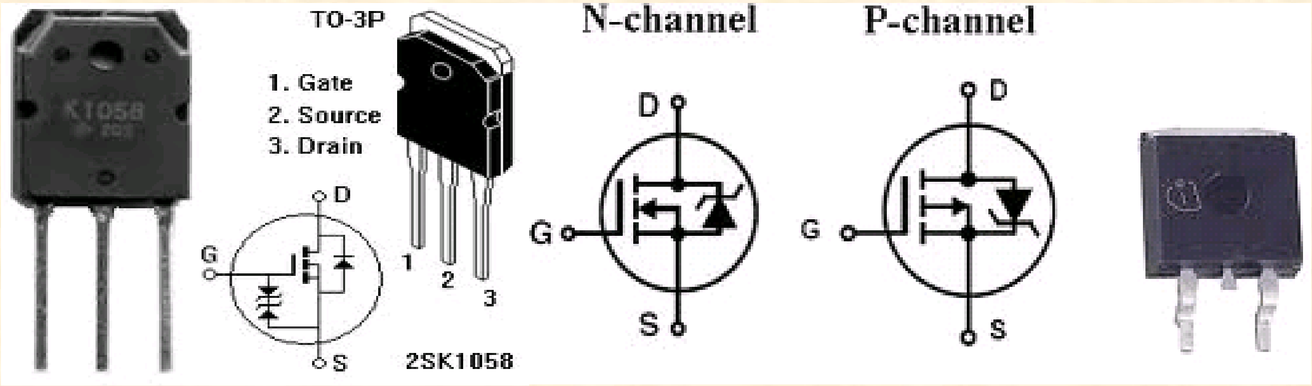
## BJT transitors

**(Bipolar junction transistor)**

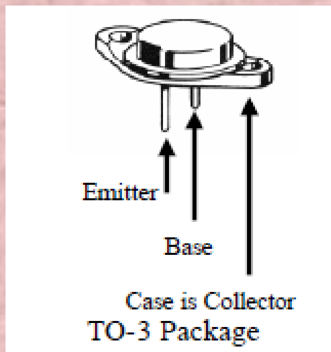


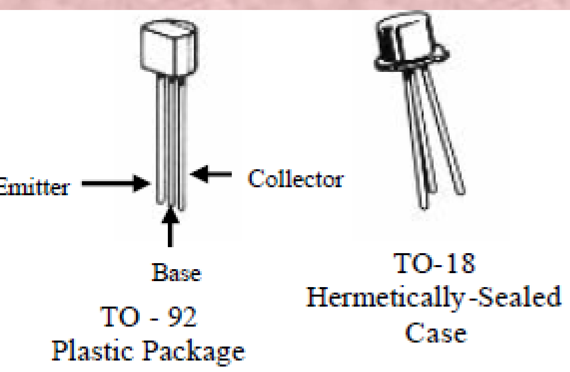
## MOSFET transitor

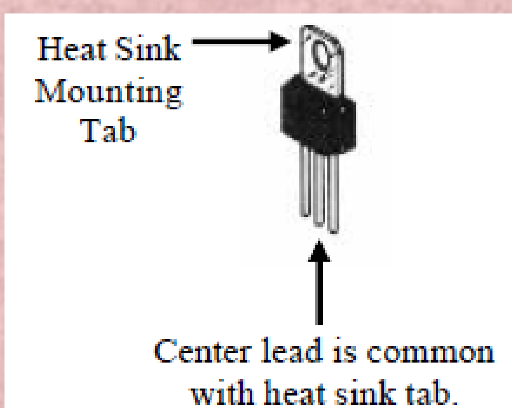
**(Metal-Oxide Semiconductor Field-Effect Transistor)**

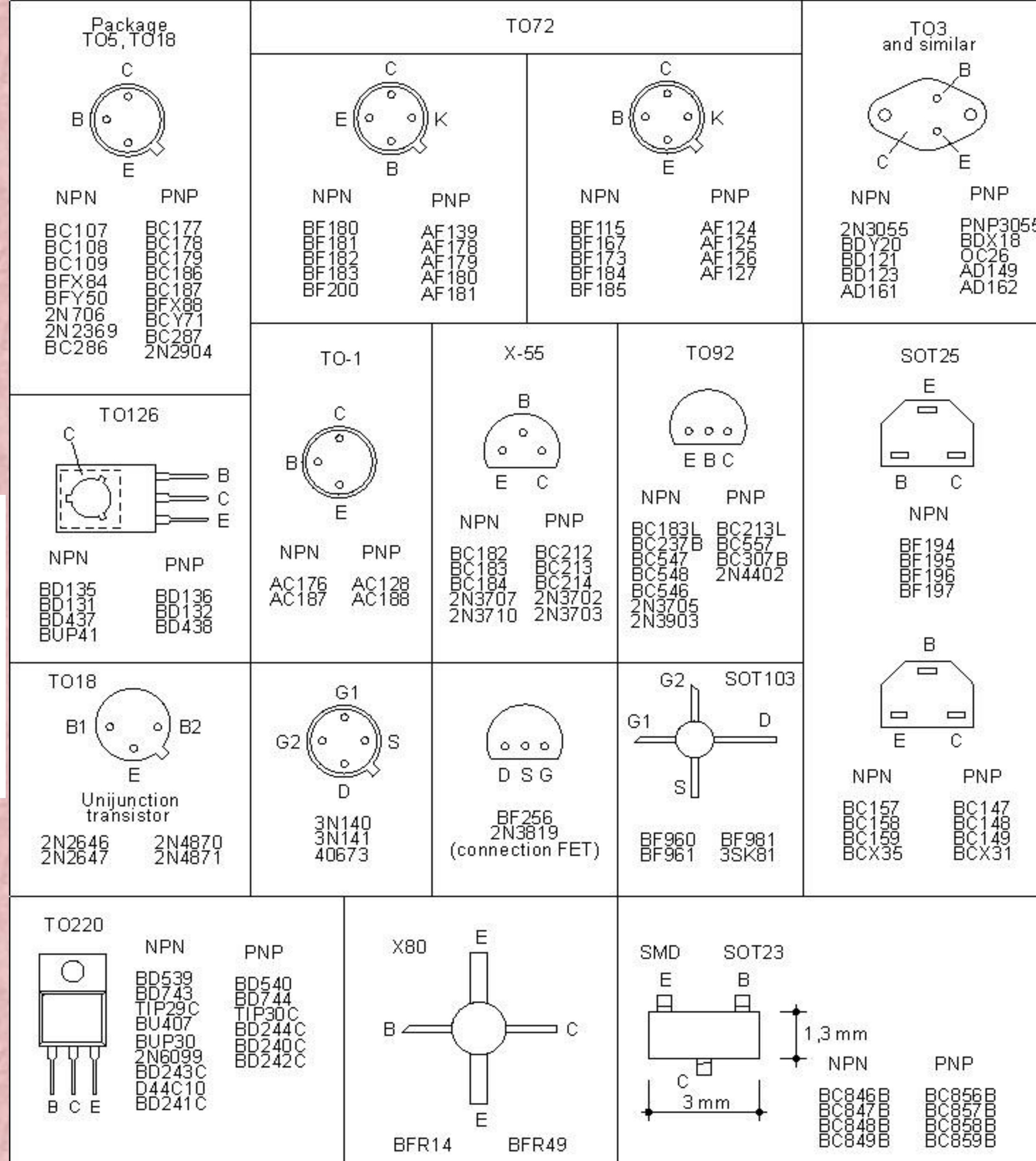


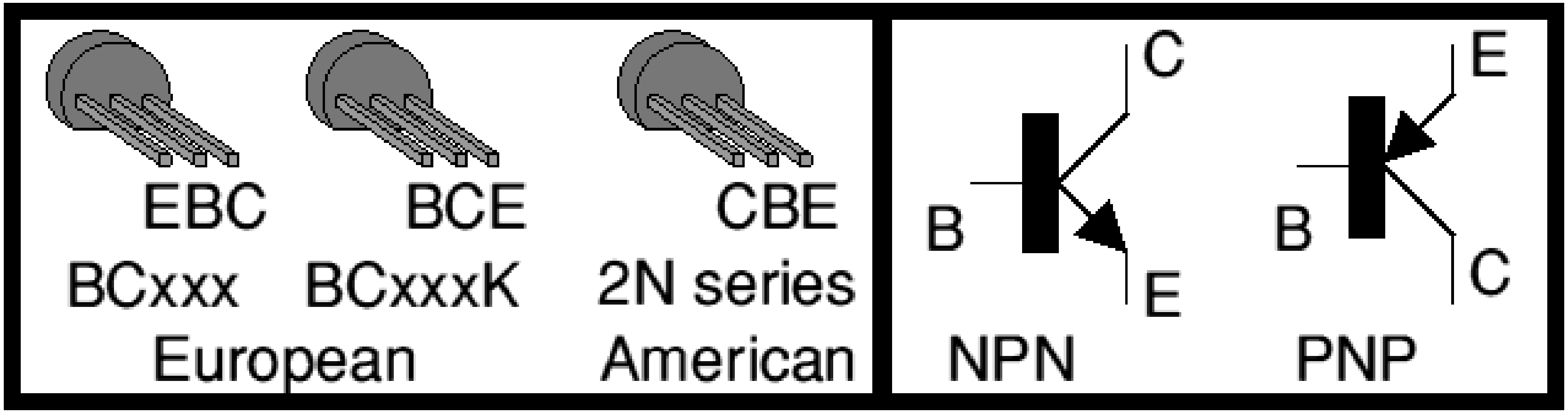
# Transitors pinout

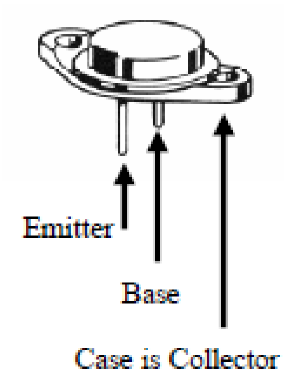


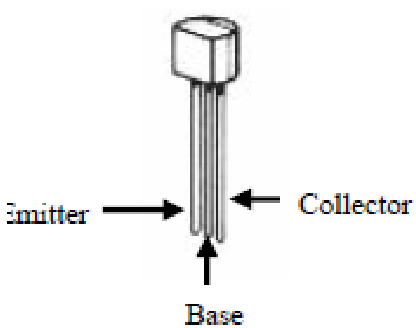





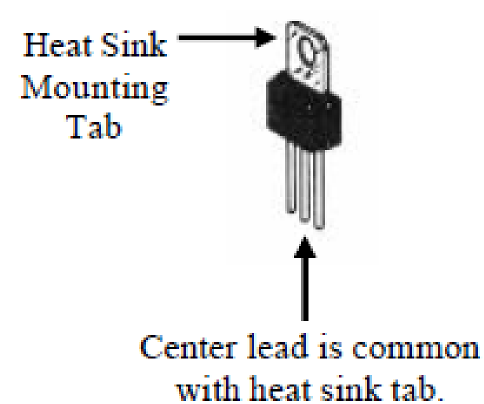



TO-3 Package



TO - 92
Plastic Package


TO-18
Hermetically-Sealed
Case



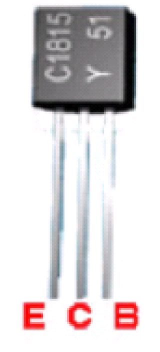
Các bóng bán dẫn như thế này thường có trong gia đình ba người, để BC 556, BC557 và BC558 là một 'gia đình' như BC 546, BC547 và BC548. Hậu tố 'C' (ví dụ BS557C) cho biết nhóm thu được: thường A là 100-250, B là 200-500 và C là 400-1000. Sau đó, một số gia đình có hậu tố L là tốt, vì vậy bạn có thể có BC546L (hoặc thậm chí BC546AL): những L hậu tố này có người thu gom ở trung tâm. Các loại 4QD chúng tôi sử dụng không phải là loại L (thực sự là của chúng tôi là hậu tố K, hoặc không có hậu tố) và các chân như trong sơ đồ bên dưới, bên trái. Chúng tôi có thể cung cấp gói 100 bóng bán dẫn với mức giá rất cạnh tranh!

Ký  hiệu ( trên thân Transistor )

*   Hiện nay trên thị trường có nhiều loại Transistor của nhiều nước sản xuất nhưng thông dụng nhất là các transistor của Nhật bản, Mỹ và Trung quốc.

Transistor Nhật bản : thường ký hiệu là A..., B..., C..., D...   Ví dụ A564, B733, C828, D1555 trong đó các Transistor ký hiệu là A và B là Transistor thuận PNP còn ký hiệu là C và D là Transistor ngược NPN.   các Transistor  A và C thường có công xuất nhỏ và tần số làm việc cao còn các Transistor B và D thường có công xuất lớn và tần số làm việc thấp hơn.

Transistor do Mỹ sản xuất. thường ký hiệu là 2N...   ví dụ 2N3055, 2N4073  vv...




Bắt đầu bằng số 3, tiếp theo là hai chũ cái. Chữ cái thức nhất cho biết loại bóng : Chữ A và B là bóng thuận , chữ C và D là bòng ngược, chữ thứ hai cho biết đặc điểm : X và P là bòng âm tần, A và G là bóng cao tần. Các chữ số ở sau chỉ thứ tự sản phẩm.   Thí dụ : 3CP25 , 3AP20 vv..

3. Cách xác định chân E, B, C của Transistor.

Với các loại Transistor công xuất nhỏ thì thứ tự chân C và B tuỳ theo bóng của nước nào sản xuất , nhựng chân E luôn ở bên trái nếu ta để Transistor như hình bên. Nếu là Transistor do Nhật sản xuất : thí dụ

Transistor  C828,  A564 thì  chân C ở giữa , chân B ở bên phải.

**Nếu là Transistor Trung quốc sản xuất thì chân B ở giữa , chân C ở bên phải.**

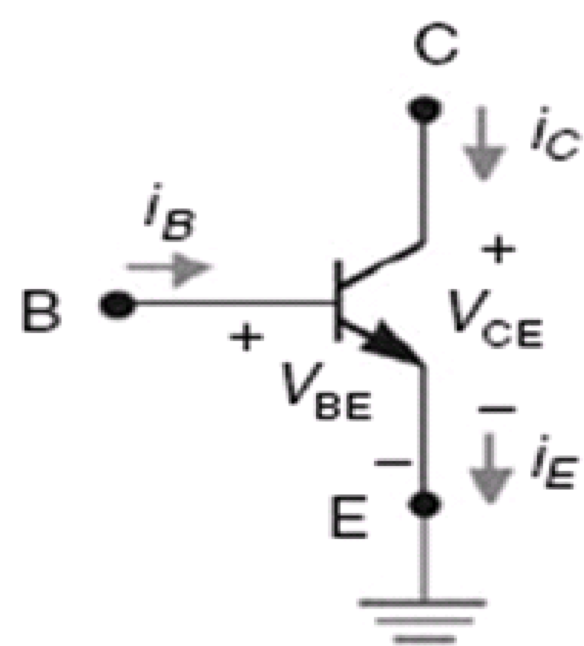
**Tuy nhiên một số Transistor được sản xuất nhái thì không theo thứ tự này => để biết chính xác ta dùng phương pháp đo bằng đồng hồ vạn năng.**

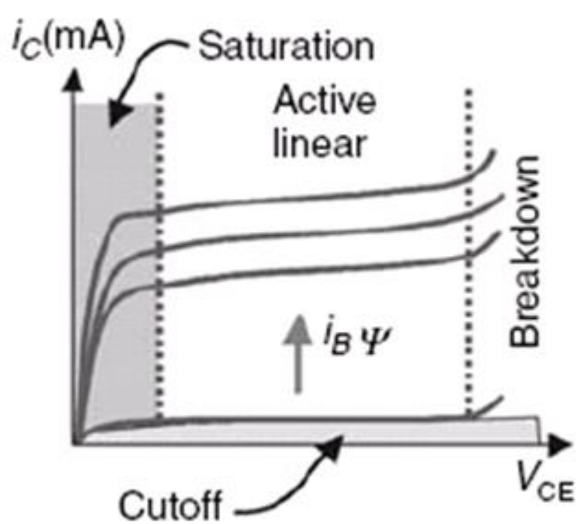
**Với loại Transistor công xuất lớn thì hầu hết đều có chung thứ tự chân là : Bên trái là cực B, ở giữa là cực C và bên phải là cực E.**

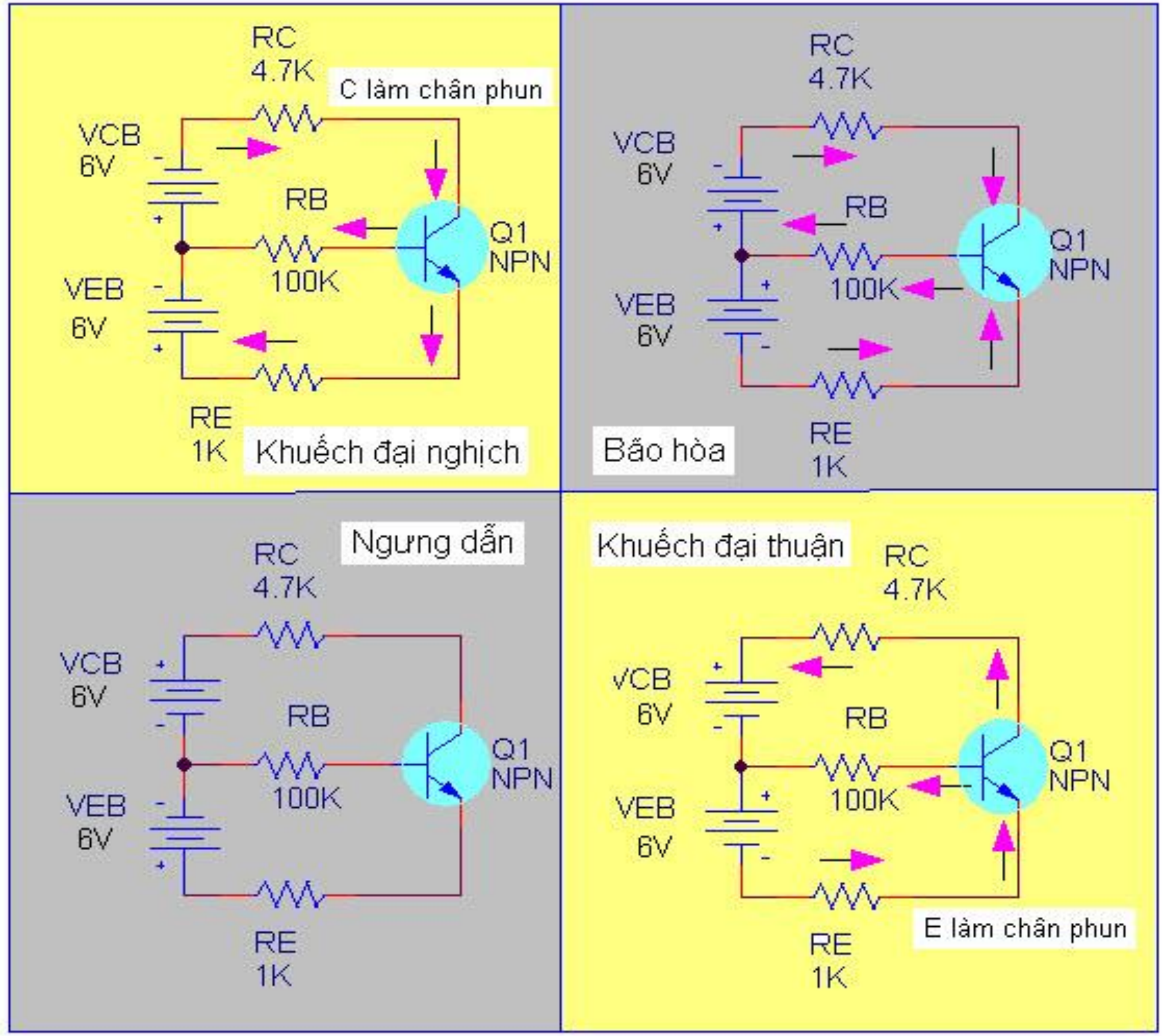
**Đo xác định chân B và C**

**Với Transistor công xuất nhỏ thì thông thường chân E ở bên trái như vậy ta chỉ xác định chân B và suy ra chân C là chân còn lại.**

**Để đồng hồ thang x1Ω , đặt cố định một que đo vào từng chân , que kia chuyển sang hai chân còn lại, nếu kim lên = nhau thì chân có que đặt cố định là chân B, nếu que đồng hồ cố định là que đen thì là Transistor ngược, là que đỏ thì là Transistor thuận..**



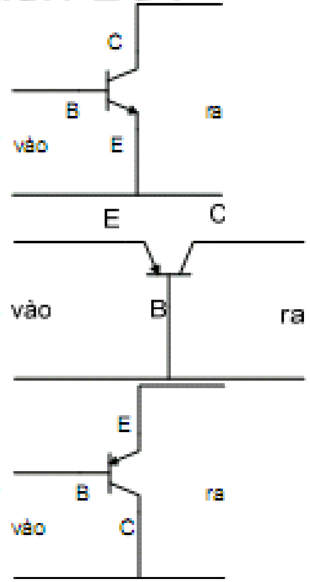



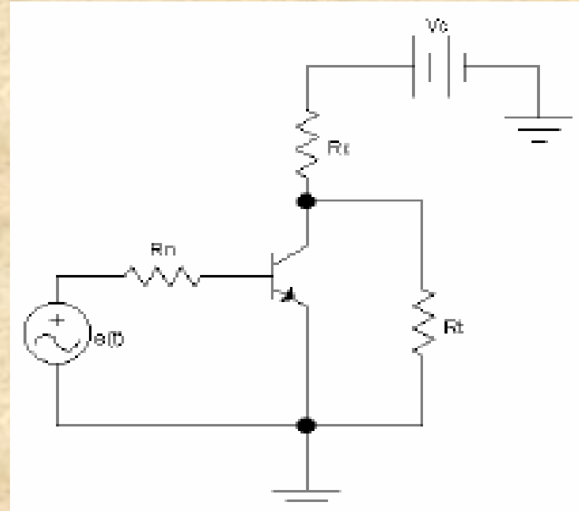

4 vùng làm việc của một transistor NPN

# Các cách mắc mạch BJT

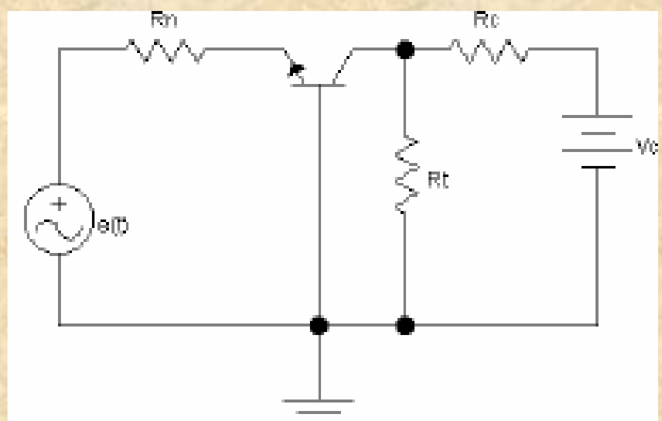
- E-C (Emitter Common).
  - Vào B ra C, E chung vào và ra
- B-C (Base Common).
  - Vào E ra C, B chung vào và ra
- C-C (Colector Common).
  - Vào B ra E, C chung vào và ra




## Sơ đồ E-C (E chung)

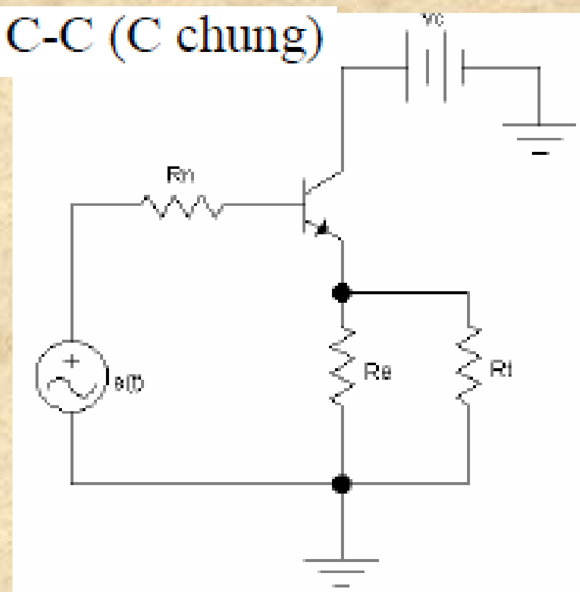



## Sơ đồ B-C (B chung)




Mạch này không có tính khuếch đại mà chỉ làm tầng đệm để phối hợp trở kháng

## Sơ đồ C-C (C chung)

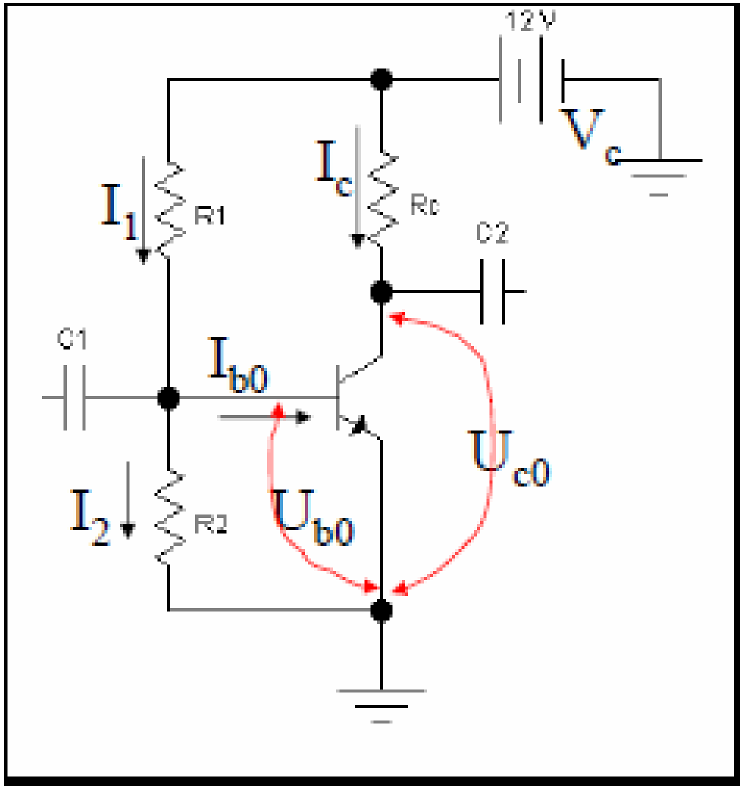



Tín hiệu ra bị phản hồi âm mạnh nên trở kháng vào lớn và trở kháng ra nhỏ

# Phân cực cho BJT

- Là tạo một điện áp ban đầu cho cực B của BJT để vượt qua ngưỡng $U_0$ ban đầu (Si là 0,6 vôn và Ge là 0,2 vôn)
- Phân cực bằng điện áp
- Phân cực bằng dòng điện
- Phân cực bằng phản hồi
- Điện áp tại chân B (mạch E-C) sau khi đã phân cực sẽ là:
- $U_b = U_{be0} + e(t)$
- với e(t) là nguồn tín hiệu cần khuếch đại. Muốn khuếch đại được thì $U_{be0}$ phải lớn hơn hoặc bằng biên độ $e(t)+U_{0+}$.

# Phân cực bằng điện áp

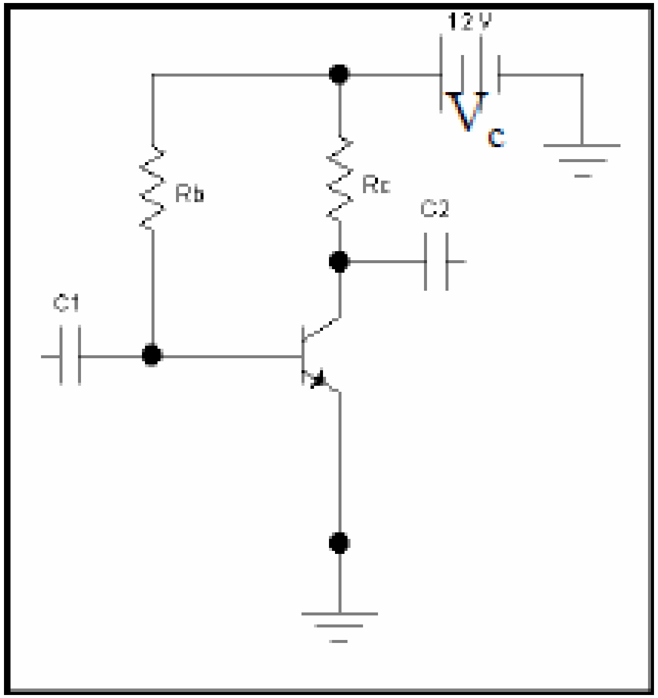



- Chọn dòng $I_{b0}$ (kí hiệu 0 chỉ đại lượng phân cực)
- Chọn dòng $I_2 = (5 \div 10)I_{b0}$ (qui ước lấy $I_2=10I_{b0}$). Dòng phân cực càng lớn càng tốt nhưng sẽ gây tổn hao công suất nhiều.
- Chọn $U_{be0}$ (0,6 vôn với Si và 0,2 vôn với Ge) hay $U_{b0}$

$$R_2 = \frac{U_{b0}}{I_2}; \quad R_1 = \frac{V_c - U_{b0}}{I_2 + I_{b0}}$$

$$R_c = \frac{V_c - U_{c0}}{I_{c0}} = \frac{V_c - U_{c0}}{\beta I_{b0}}$$

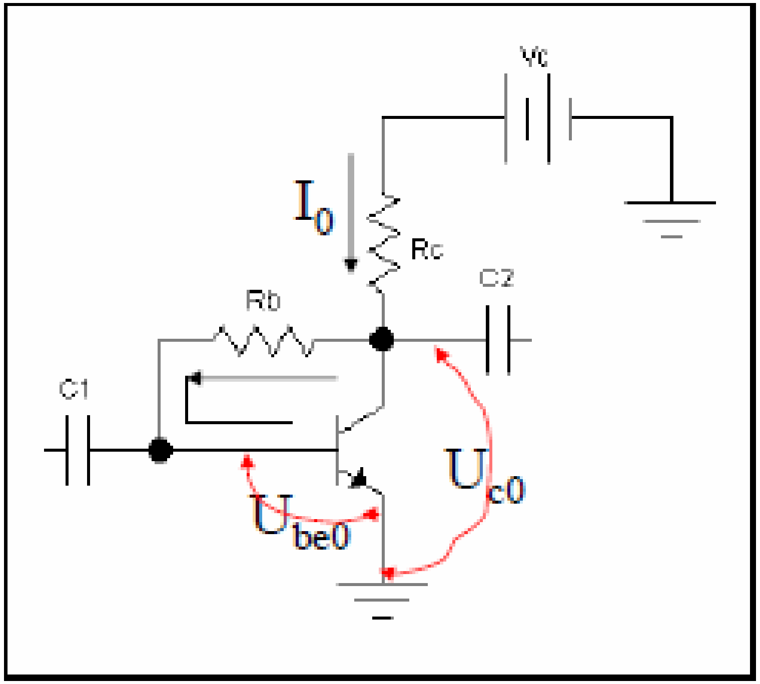
# Phân cực bằng dòng điện




$$R_b = \frac{V_c - U_{b0}}{I_{b0}}$$

- Chọn trước $U_{be0}$, $I_{b0}$

# Phân cực bằng phản hồi




$$I_0 = I_{c0} + I_{b0} = (\beta + 1) I_{b0}$$

$$U_{c0} = V_c - I_0 R_c$$

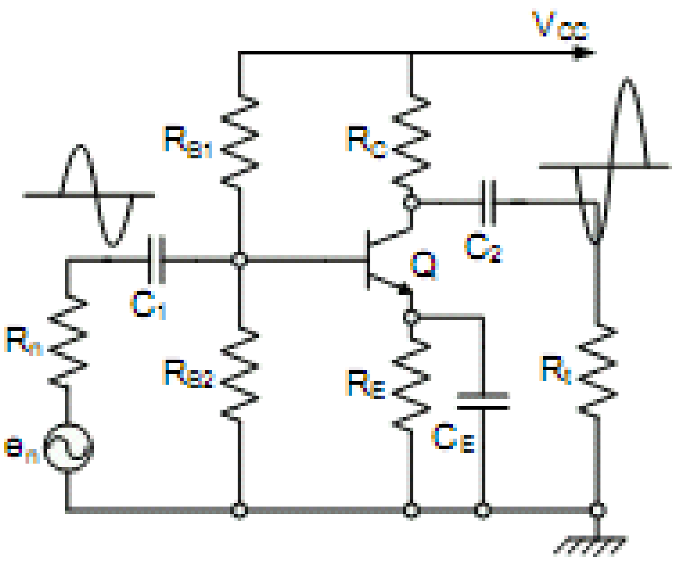
$$R_b = \frac{U_{c0} - U_{be0}}{I_{b0}}$$

$$R_c = \frac{V_c - U_{c0}}{I_0}$$

- Chọn trước $I_{b0}$, $U_{be0}$
- Chọn trước $U_{c0}$

# Mạch khuếch đại E-C

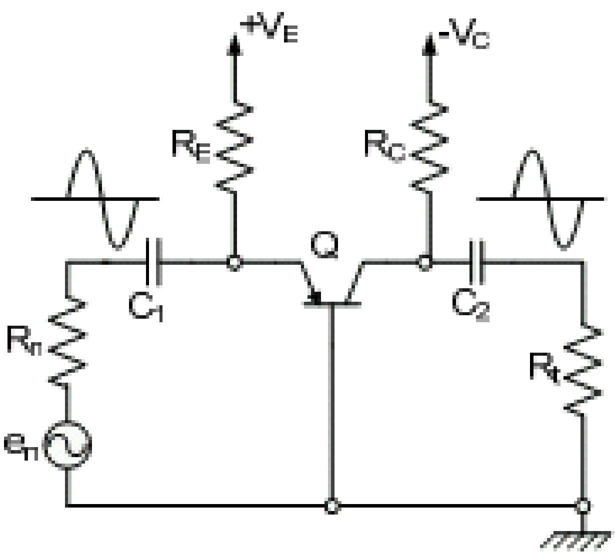
- Hệ số khuếch đại công suất:
  - $K_P = K_U.K_I$.
- Pha của tín hiệu:
  - $K_I < 0$ nên tín hiệu ngõ ra ngược pha tín hiệu ngõ vào.




- Mạch khuếch đại E-C có biên độ $K_I$, $K_U$>1 nên vừa khuếch đại dòng điện, vừa khuếch đại điện áp.
- Mạch khuếch đại E-C với $K_I$, $K_U$ có dấu âm nên tín hiệu ngõ ra ngược pha với tín hiệu ngõ vào.
- Điện trở vào và điện trở ra của mạch E-C có giá trị trung bình trong các sơ đồ khuếch đại.

# Mạch khuếch đại B-C

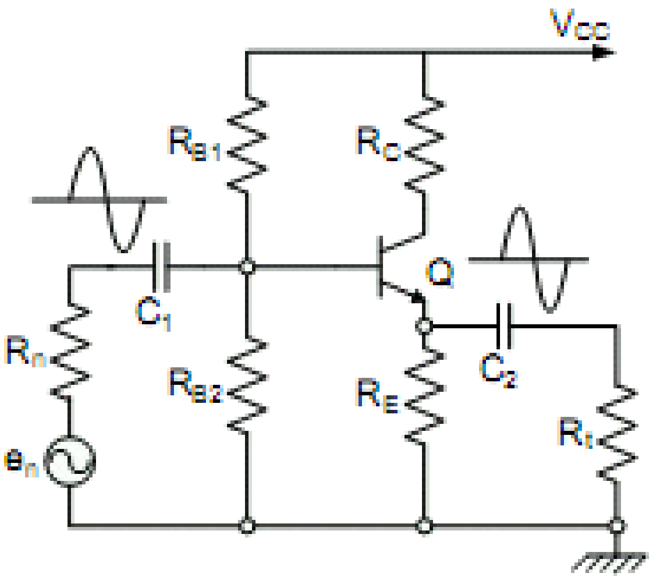
- Hệ số khuếch đại công suất:
  - □ $K_P = K_U.K_I$.
- Pha của tín hiệu:
  - □ $K_I > 0$ nên tín hiệu ngõ ra cùng pha tín hiệu ngõ vào.




- □ Mạch khuêch đại B-C có biên độ $K_I < 1$, $K_U > 1$ nên mạch không khuếch đại dòng điện, chỉ khuếch đại điện áp.
- □ Mạch khuếch đại B-C với $K_I$, $K_U$ có dấu dương nên tín hiệu ngõ ra cùng pha với tín hiệu ngõ vào.
- □ Điện trở vào của mạch B-C có giá trị nhỏ nhất trong các sơ đồ khuếch đại.

# Mạch khuếch đại C-C

- Hệ số khuếch đại công suất:
  - □ $K_P = K_U.K_I$.
- Pha của tín hiệu:
  - □ $K_I > 0$ nên tín hiệu ngõ ra cùng pha tín hiệu ngõ vào.

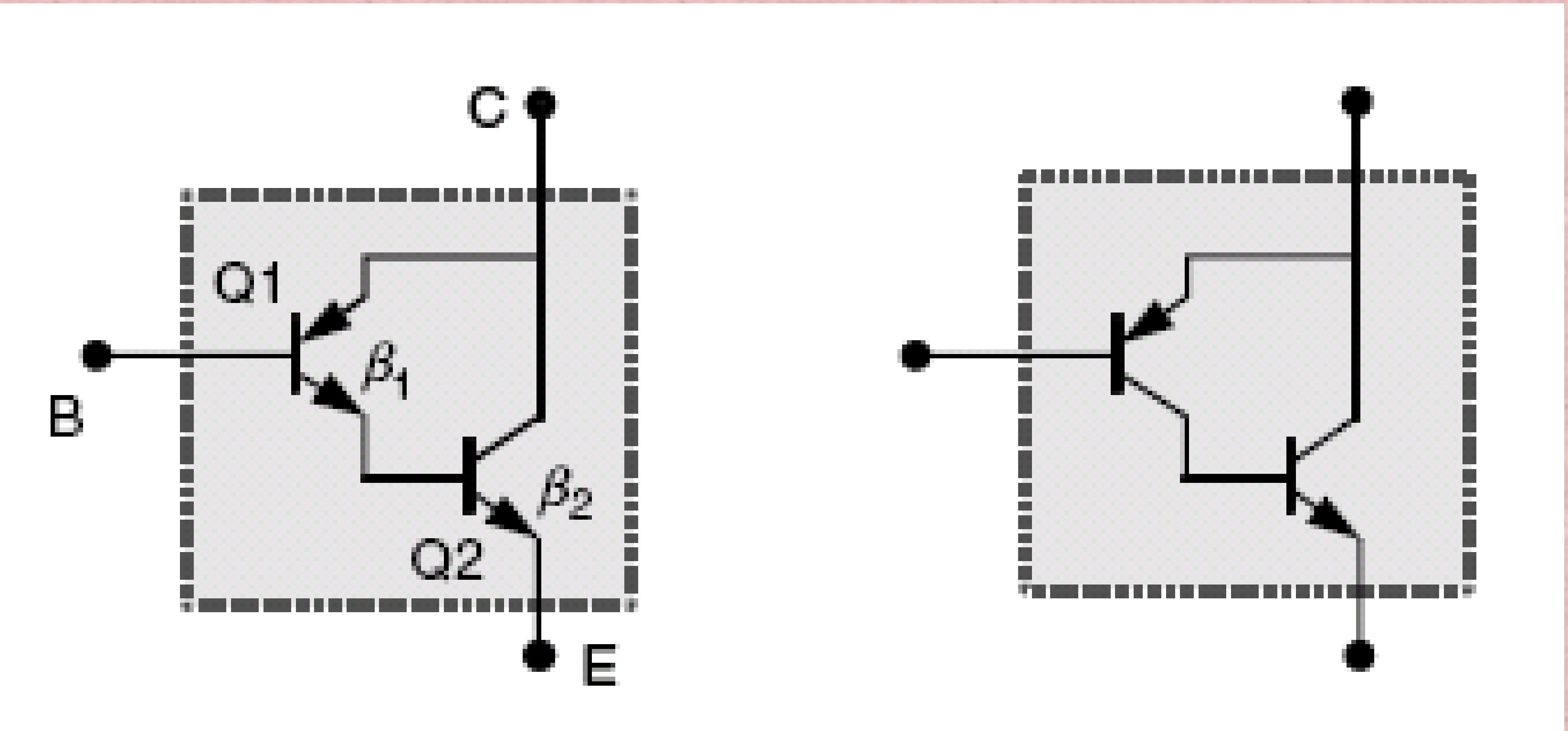



□ Mạch khuếch đại C-C có biên độ $K_I > 1$, $K_U \approx 1$ nên chỉ khuếch đại dòng điện, không khuếch đại điện áp.

□ Mạch khuếch đại C-C với $K_I$, $K_U$ có dấu dương nên tín hiệu ngõ ra cùng pha với tín hiệu ngõ vào.

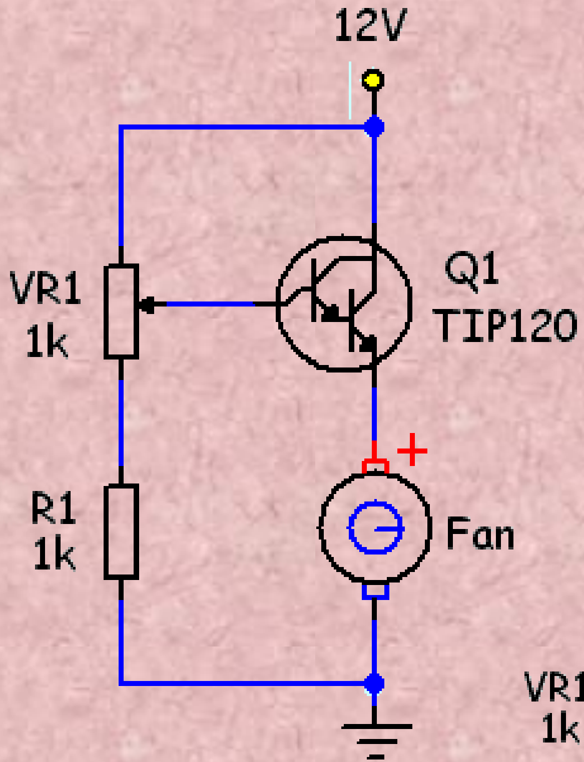
□ Điện trở vào của mạch C-C có giá trị lớn nhất trong các sơ đồ khuếch đại. Mạch này dùng phối hợp trở kháng rất tốt.

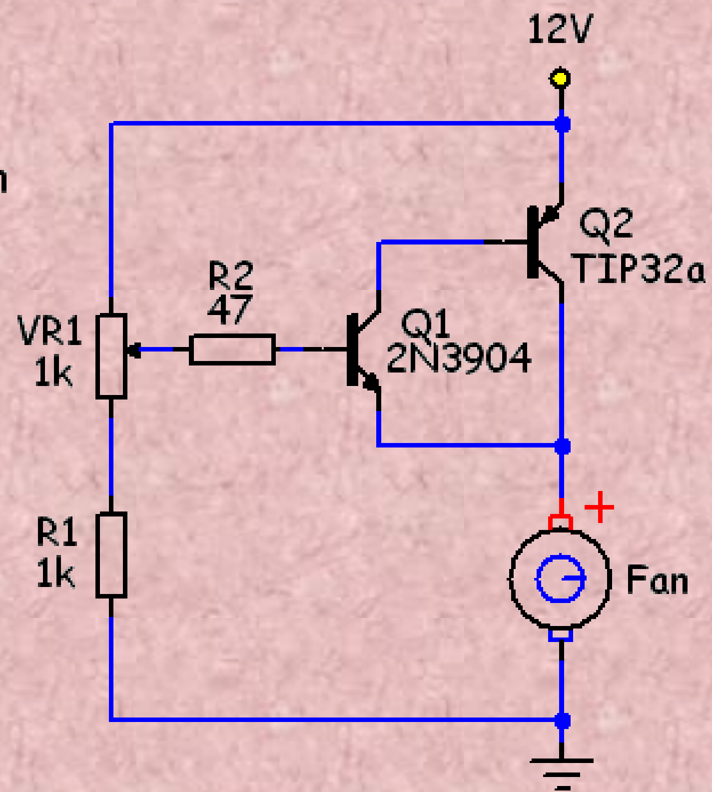
Transitor mắc theo sơ đồ Darlington

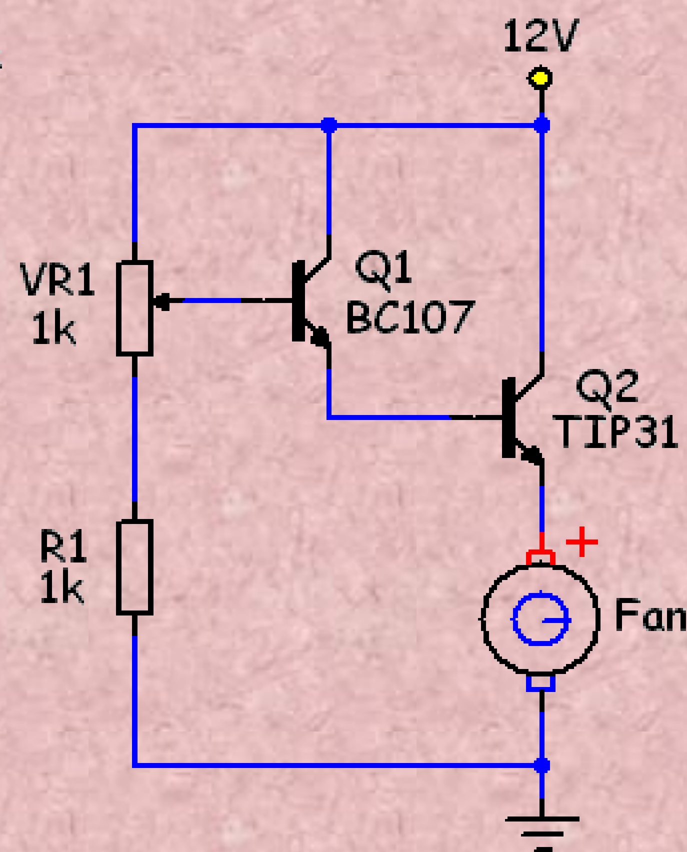



$$i_{C2} = \beta_2 \cdot i_{B2} = \beta_2 \cdot (\beta_1 \cdot i_{B1}) = (\beta_2 \cdot \beta_1) \cdot i_{B1} = \beta_D \cdot i_{B1}$$

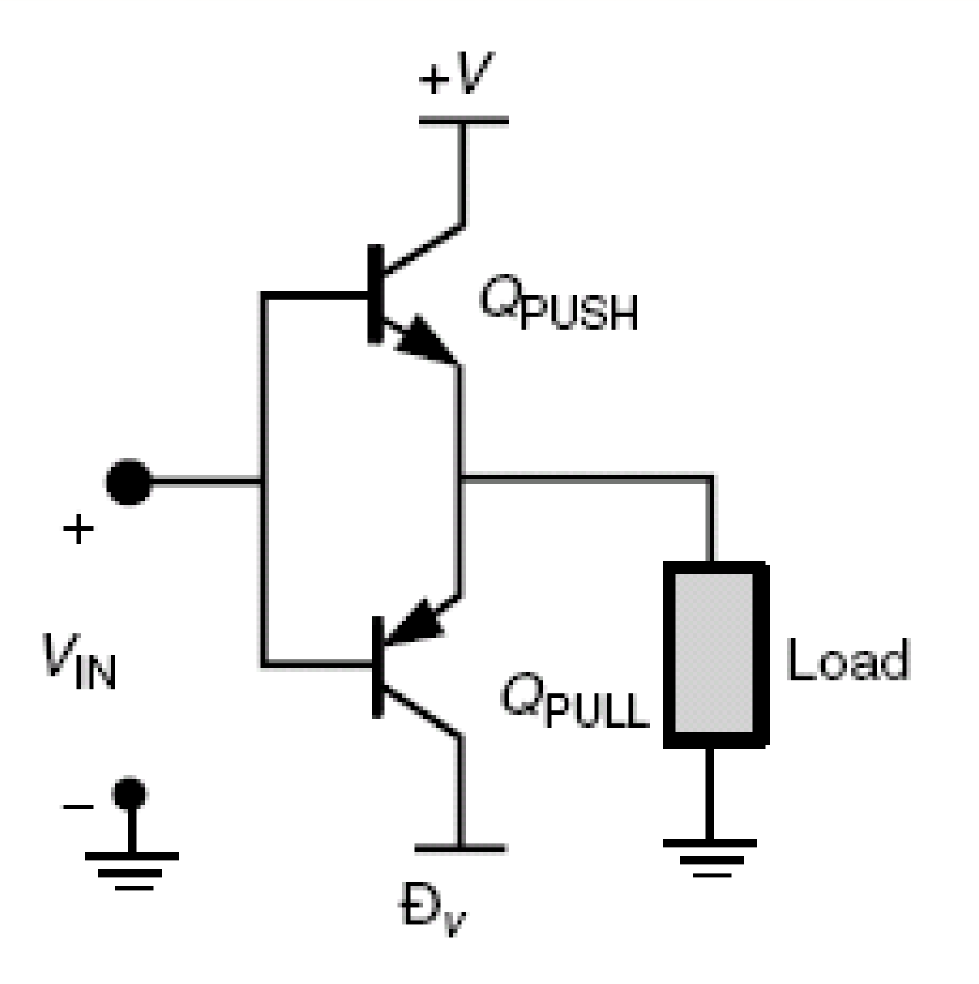
# Transitor Darlington application



## Mạch đẩy - kéo

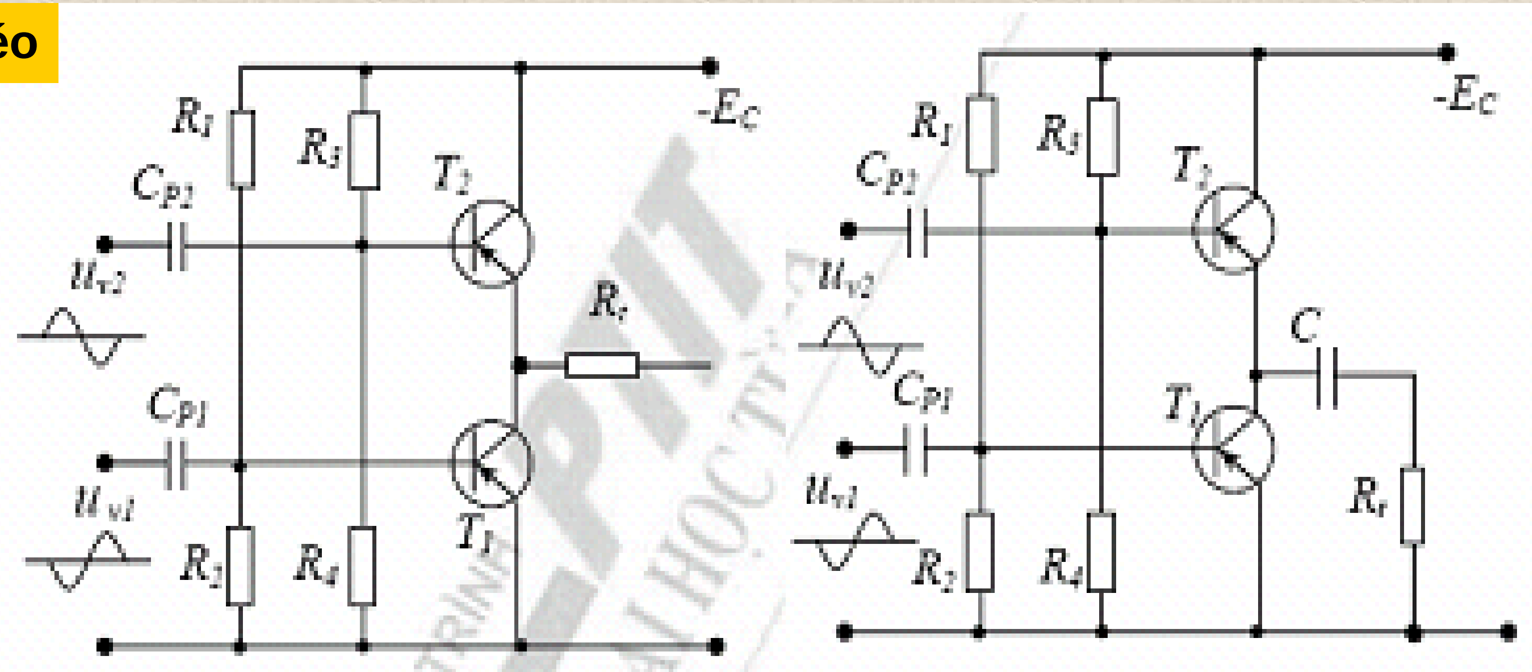



Switching push-pull amplifier.

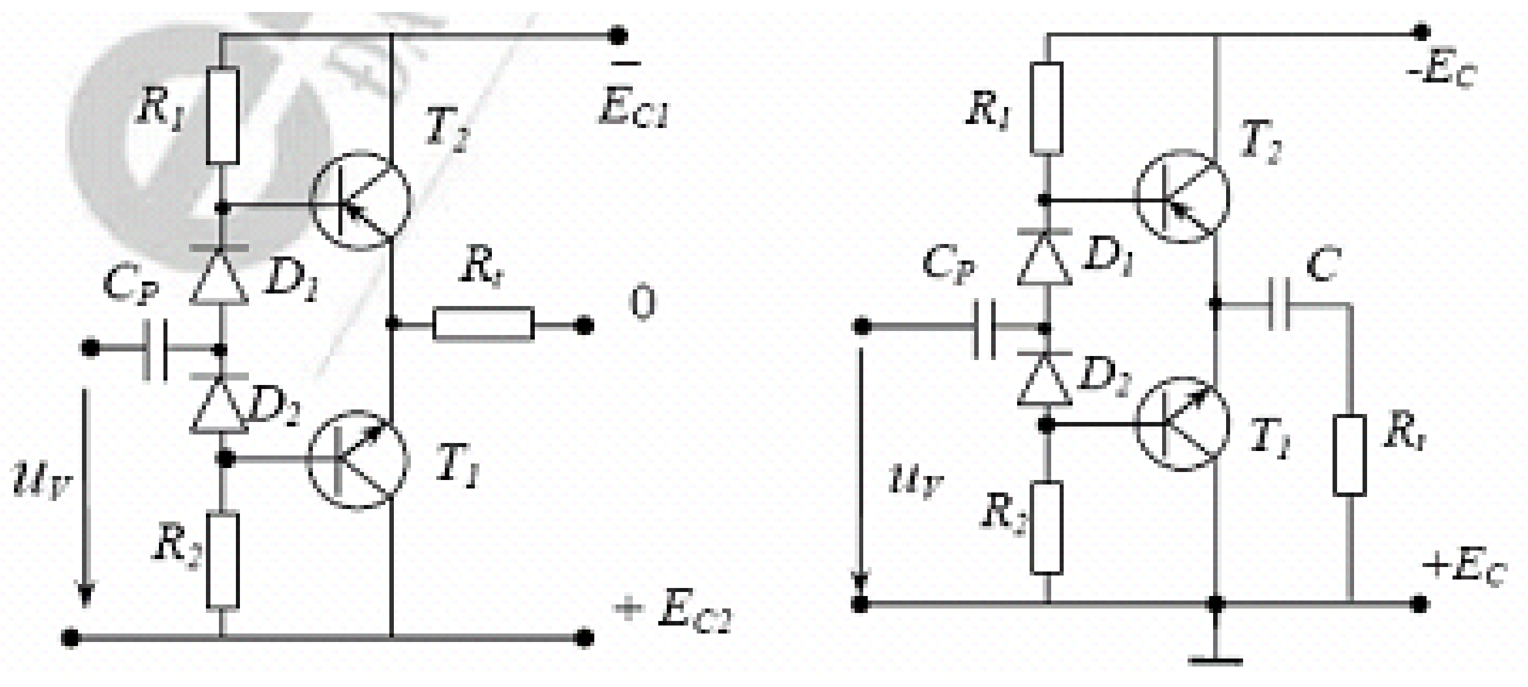
Pulse-width modulation

# Mạch đẩy - kéo

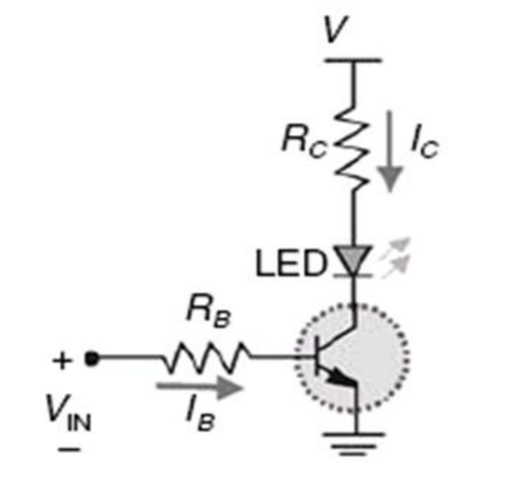
dùng các Transitor cùng loại



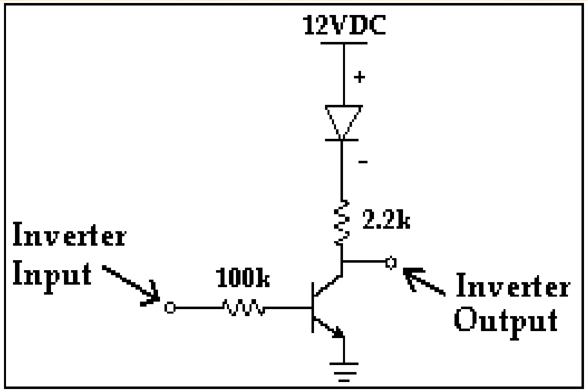

dùng các Transitor khác loại

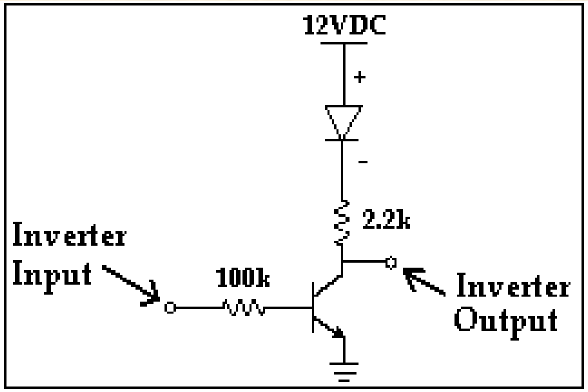


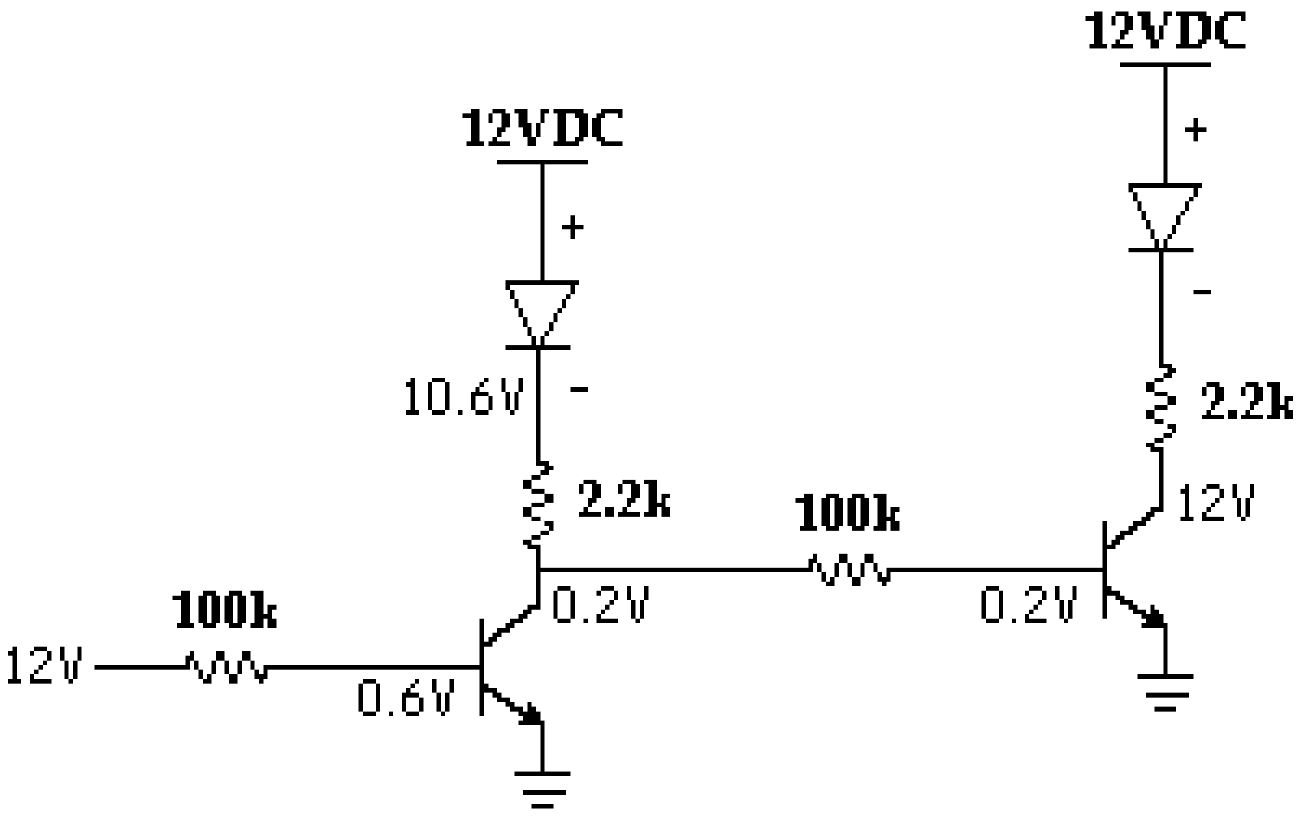
# Sử dụng Transitor như một công tắc …



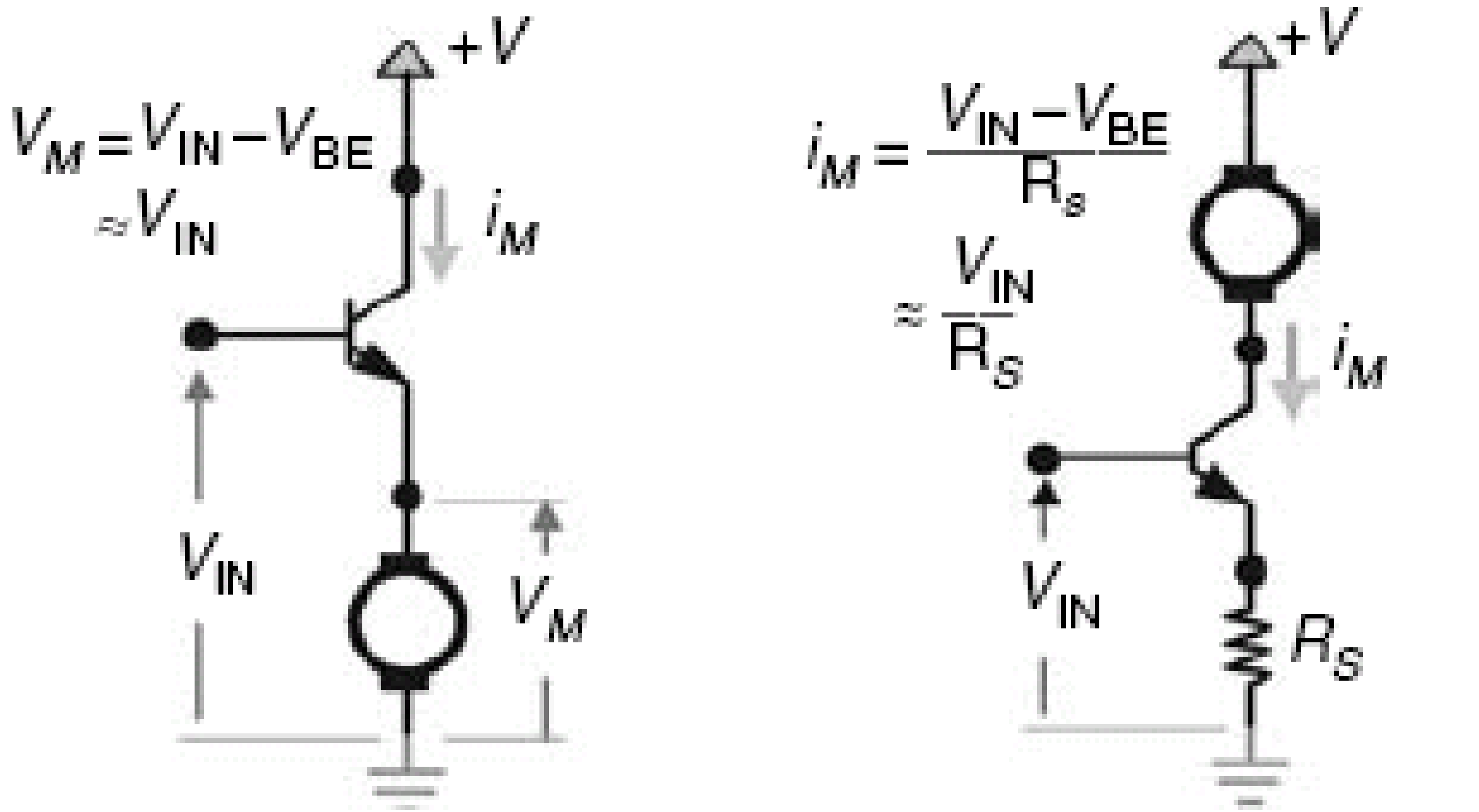

Using BJT as a switch to turn off/off a LED



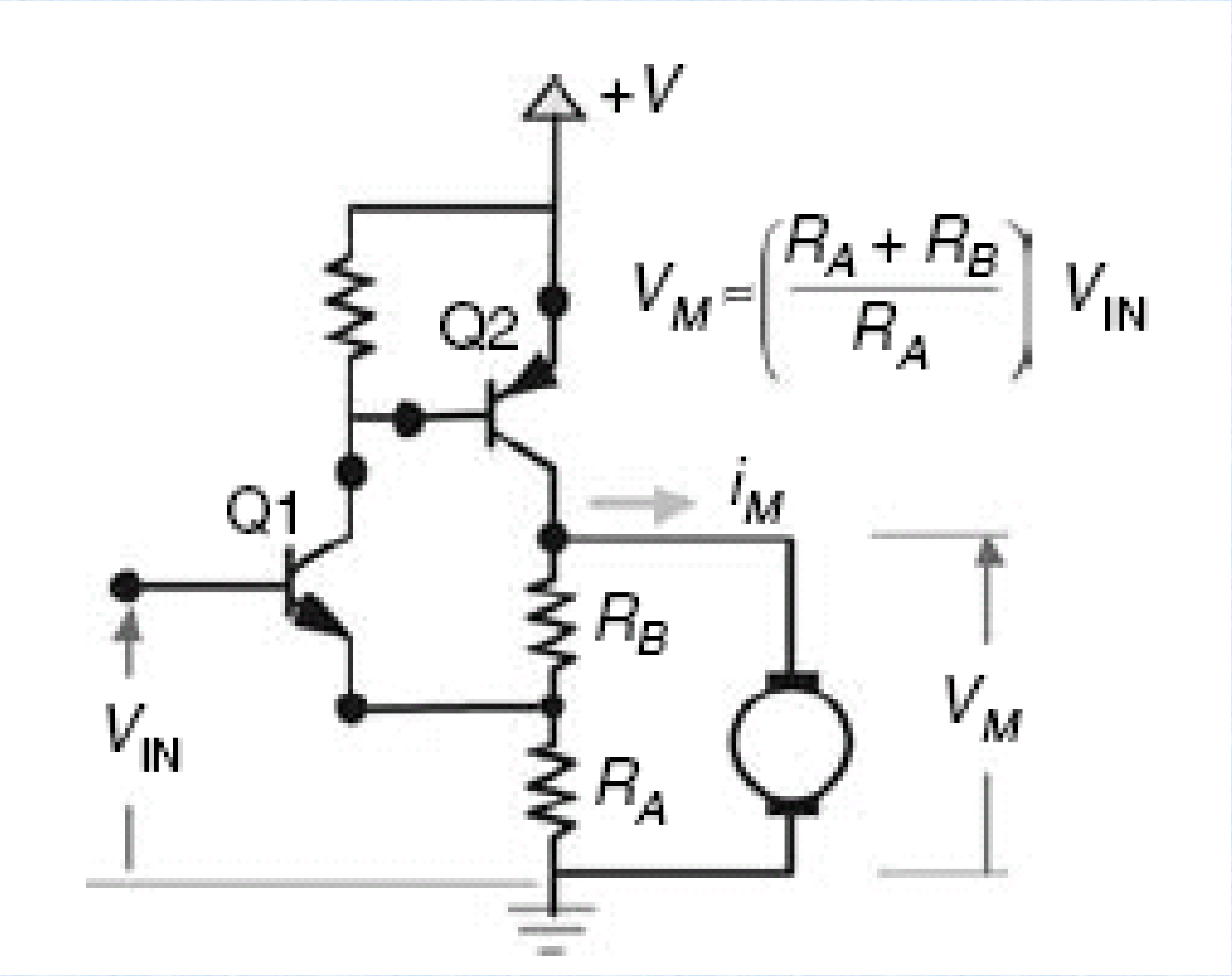



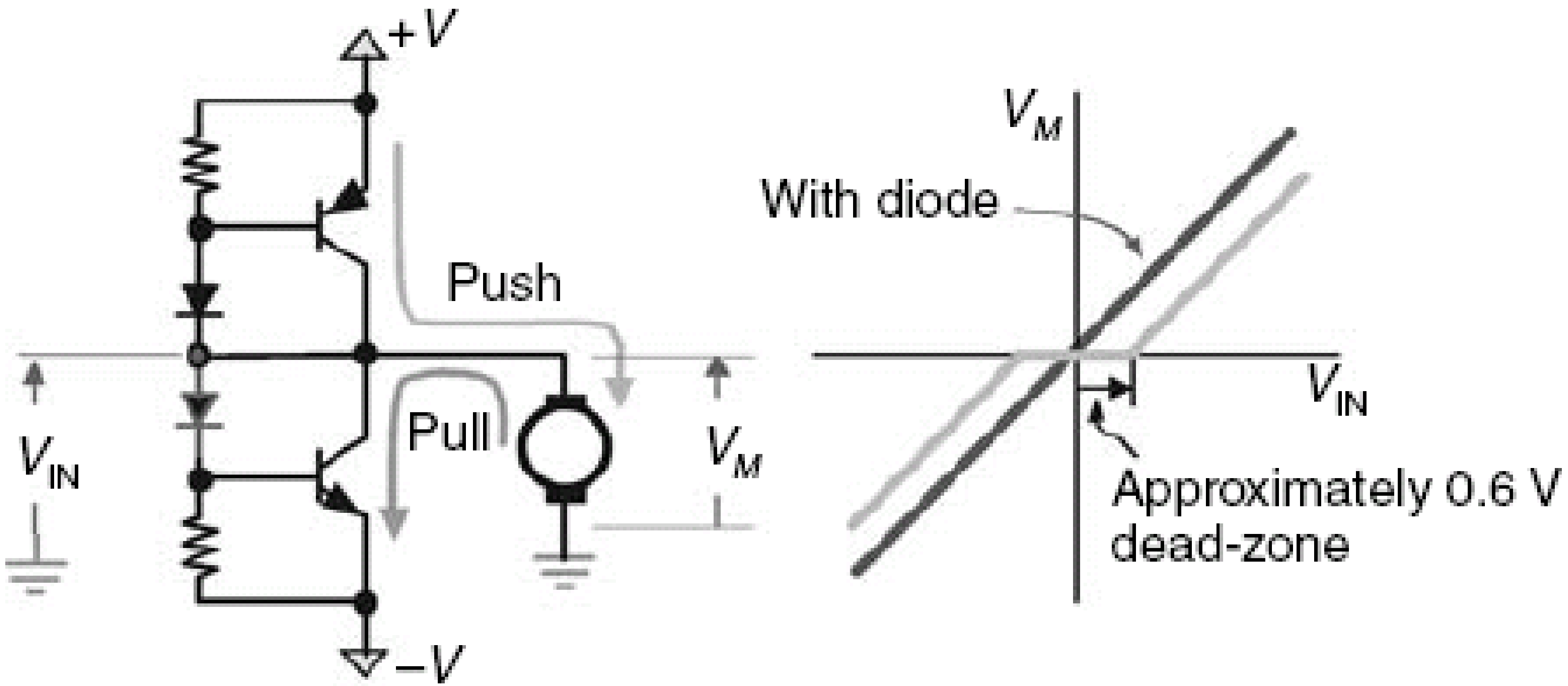
# 2 phương pháp mắc transitor để điều khiển động cơ điện



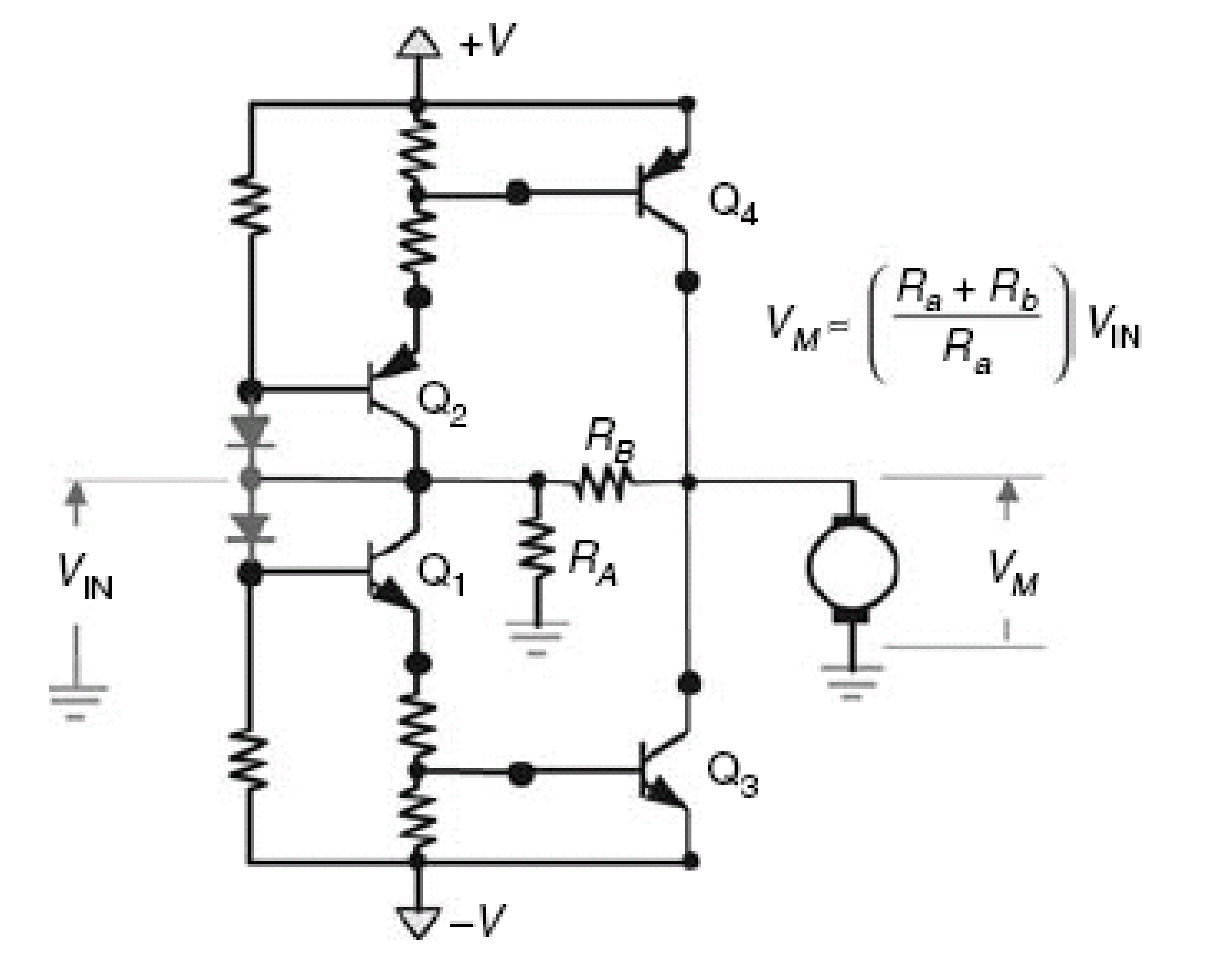

(a) Voltage-mode driver (b) Current-mode driver



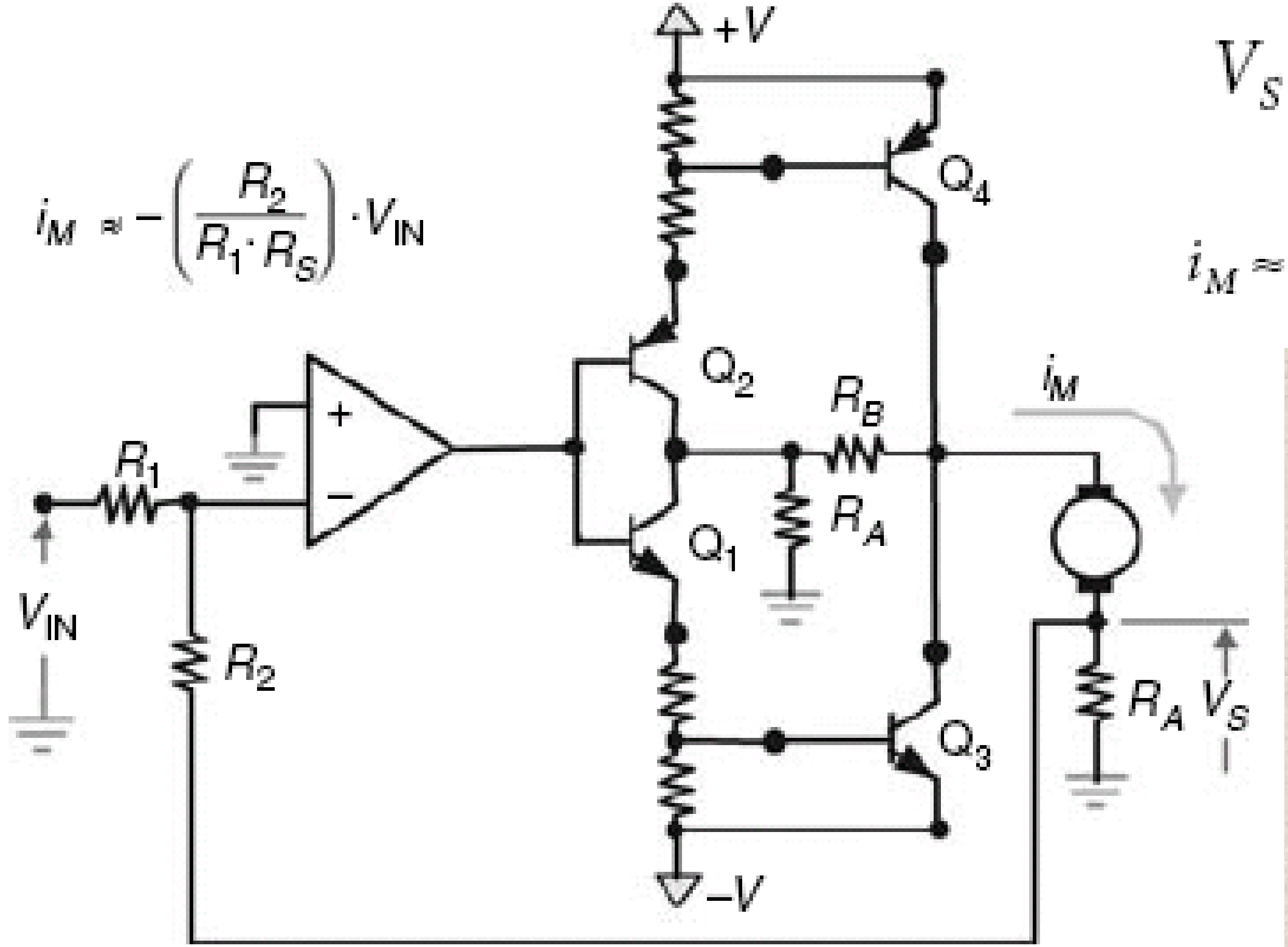

Variable gain voltage-mode amplifier.




Bipolar voltage-mode amplifier.




Bipolar variable gain voltage-mode amplifier.



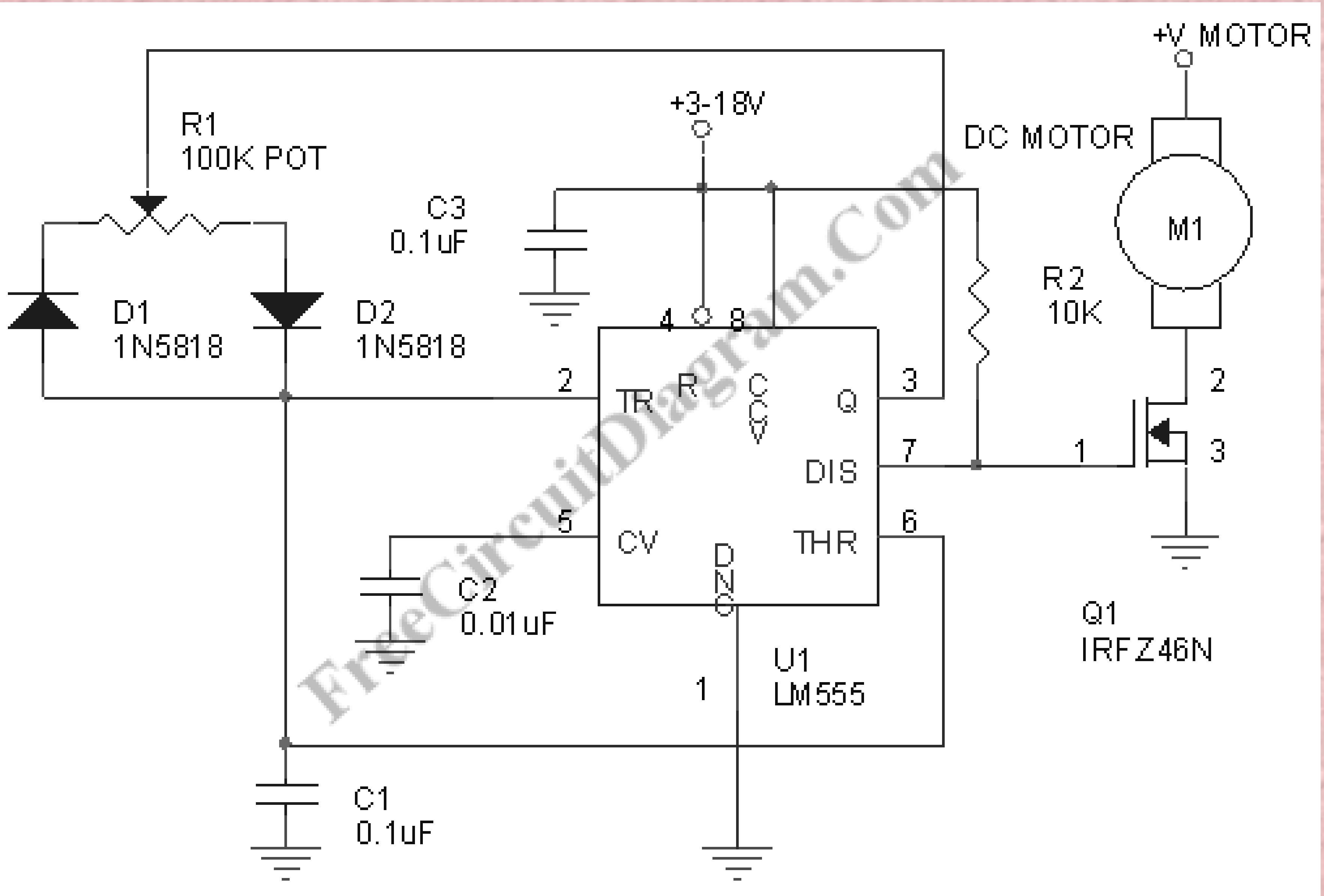

$$V_S \approx -\left(\frac{R_2}{R_1}\right) \cdot V_{IN}$$

$$i_M \approx -\left(\frac{R_2}{R_S \cdot R_1}\right) \cdot V_{IN}$$

$$i_{MAX} < \frac{V}{R_M + R_S}$$

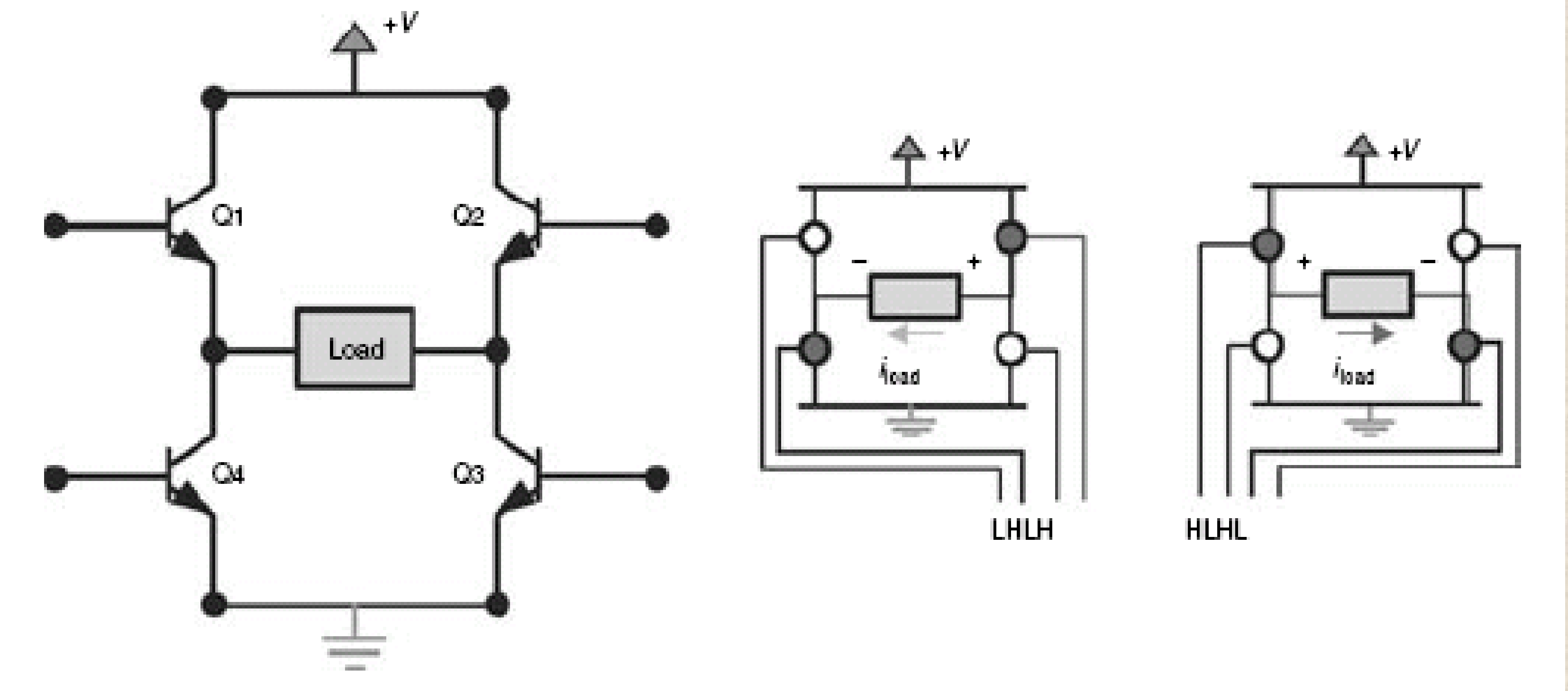
Bipolar variable gain current-mode amplifier.

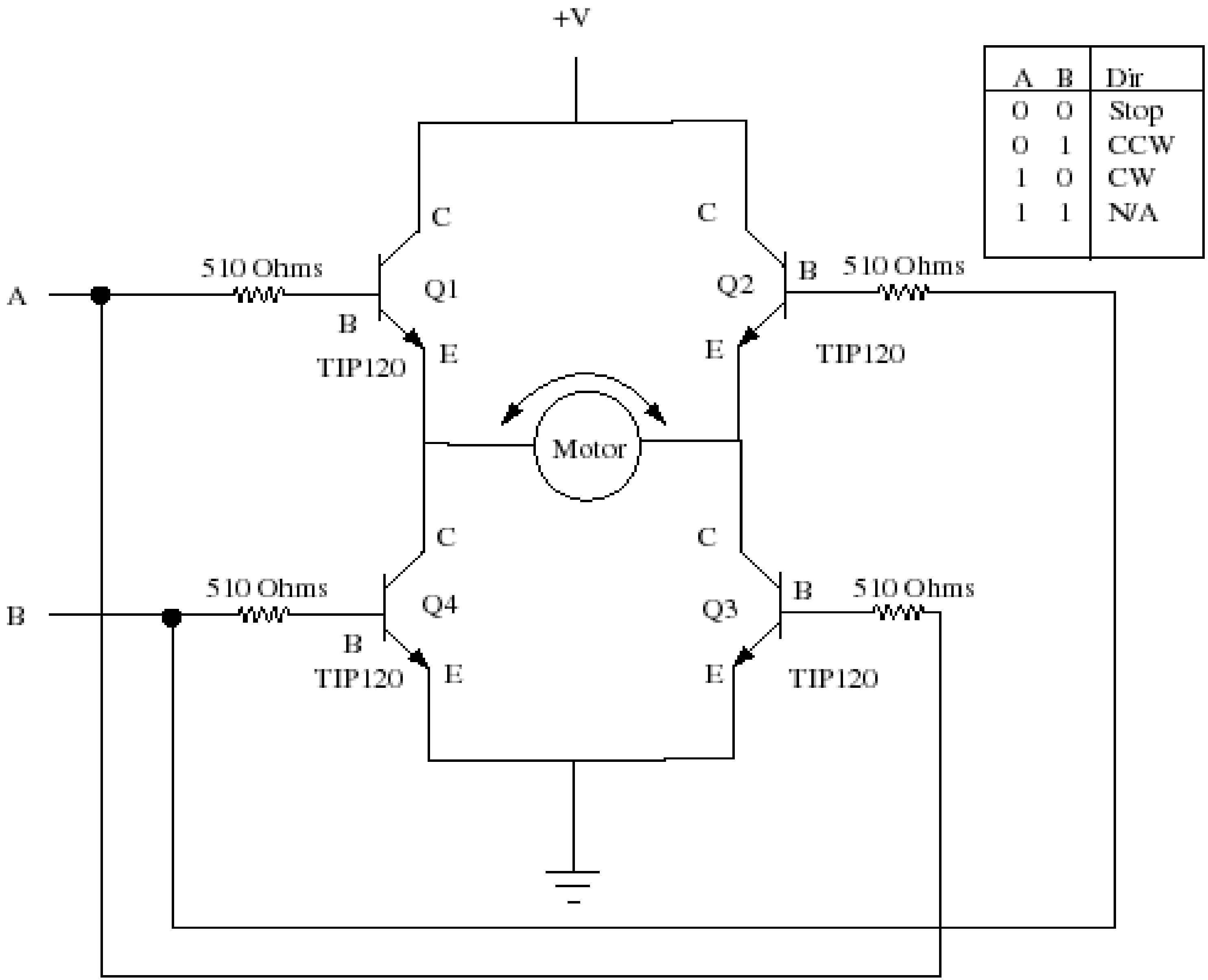
# Điều khiển tốc độ động cơ bằng phương pháp điều chế độ rộng xung



# H-bridge driver.

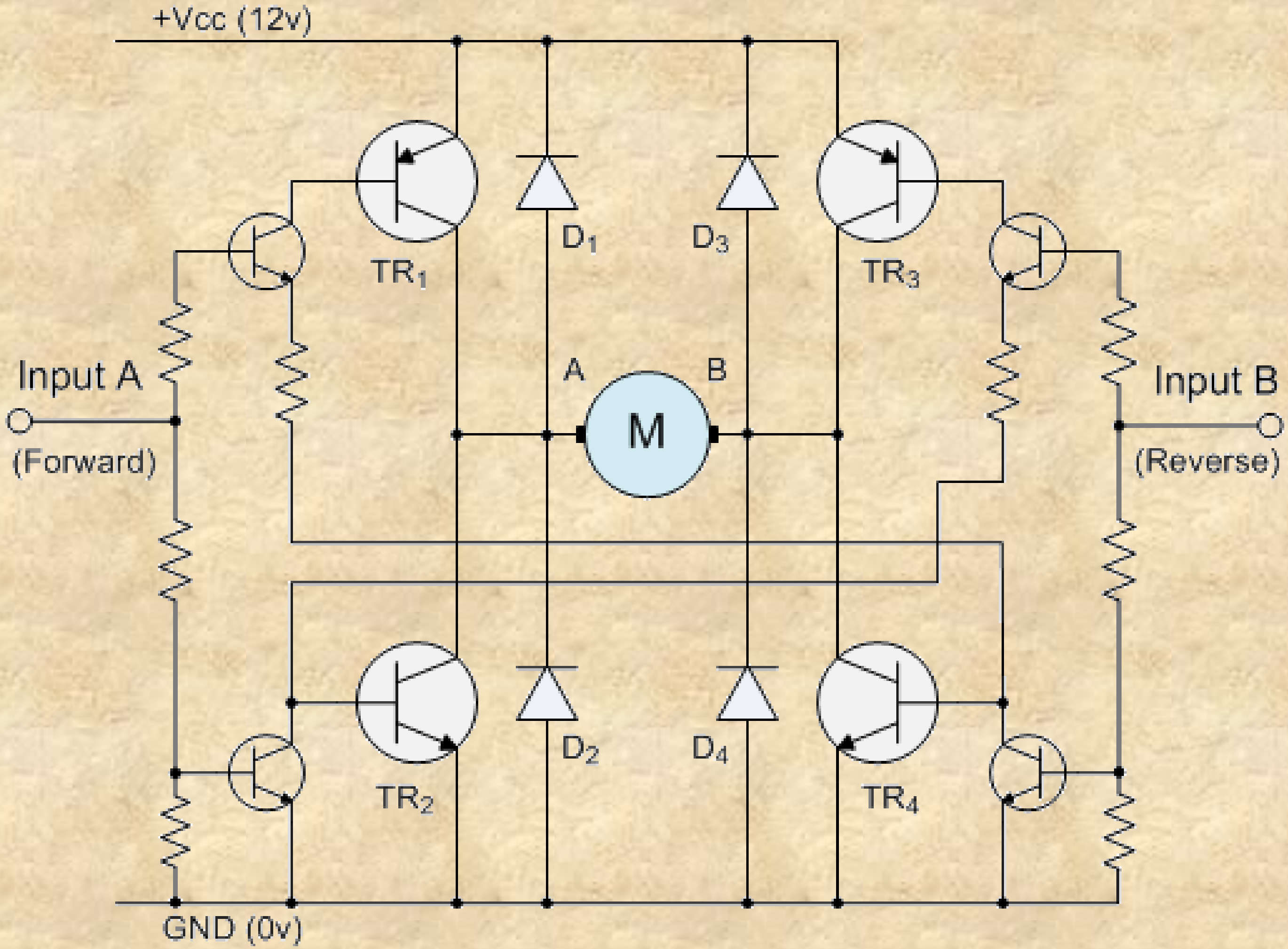
**An H bridge is an electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards. H bridges are available as integrated circuits, or can be built from discrete components**



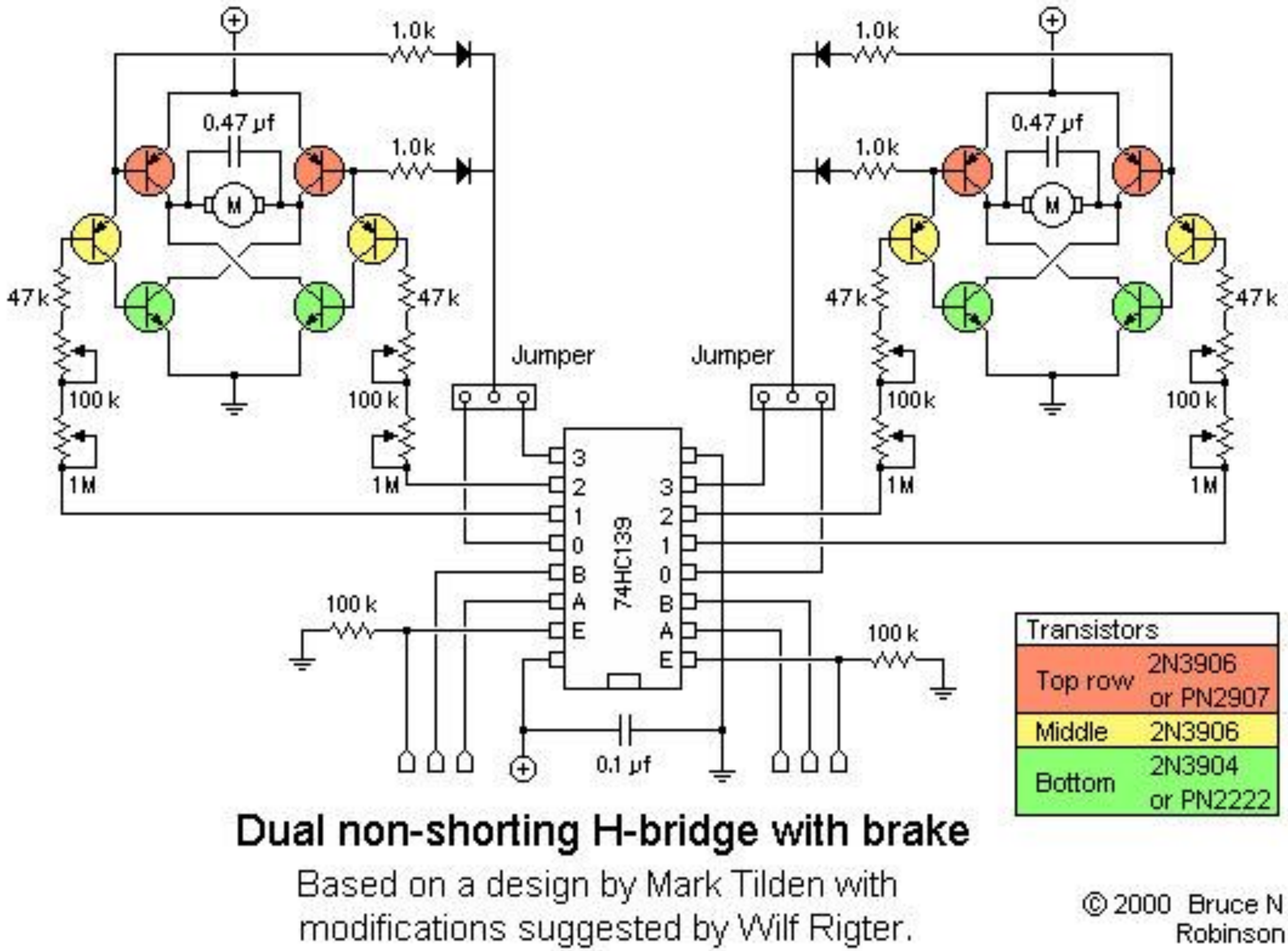



| A | B | Dir |
|---|---|---|
| 0 | 0 | Stop |
| 0 | 1 | CCW |
| 1 | 0 | CW |
| 1 | 1 | N/A |

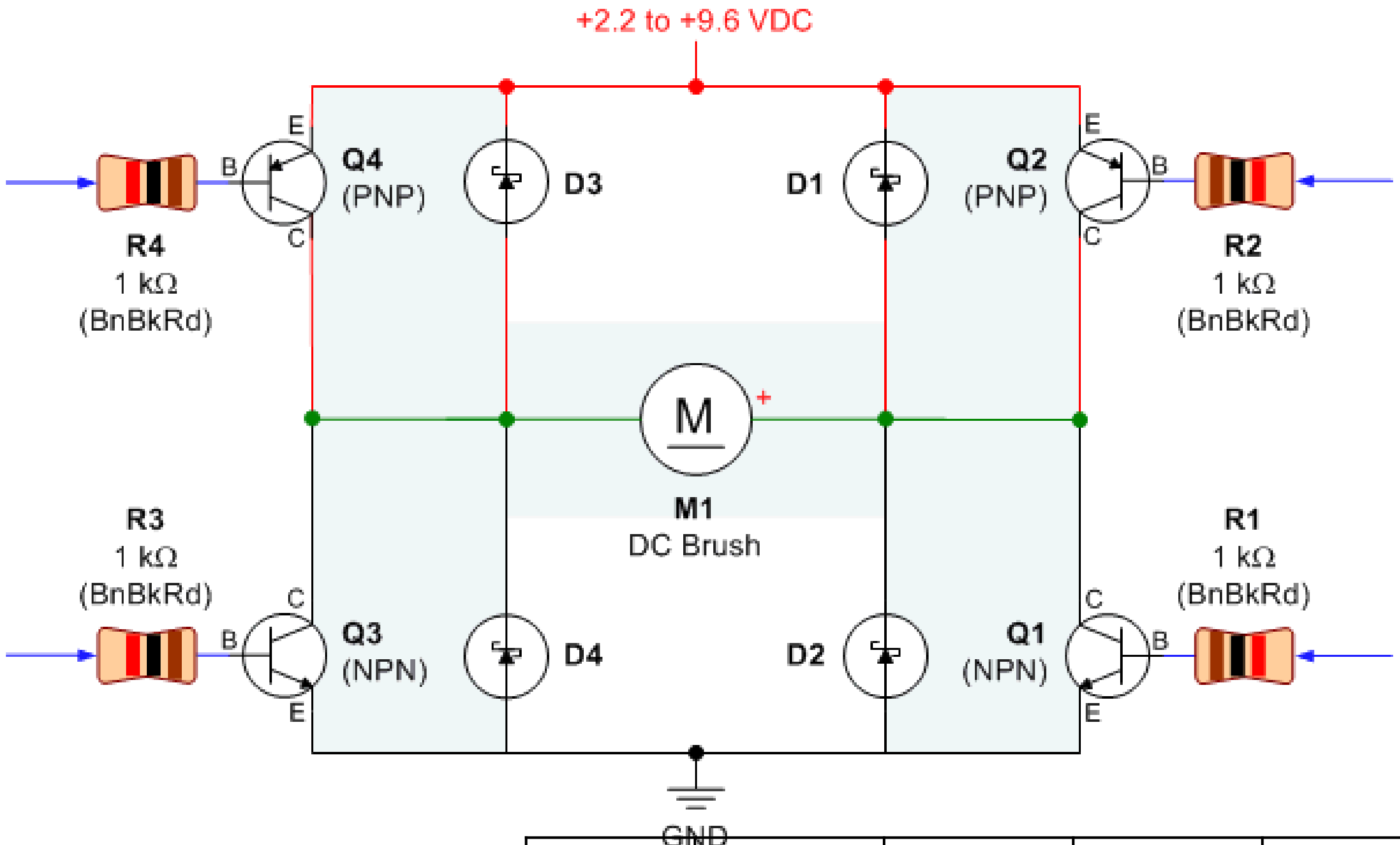
**Basic Bi-directional H-bridge Circuit**



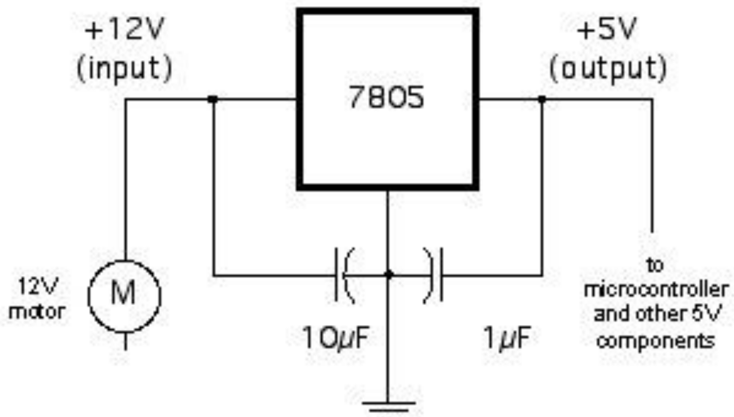

Control the speed of a DC motor with a single transistor has main disadvantage, the direction of rotation is always the same, its a "**Uni-directional**" circuit. In many applications we need to operate the motor in both directions forward and back. One very good way of achieving this is to connect the motor into a "**Transistor H-bridge**" circuit arrangement and this type of circuit will give us "**Bi-directional**" DC motor control ....



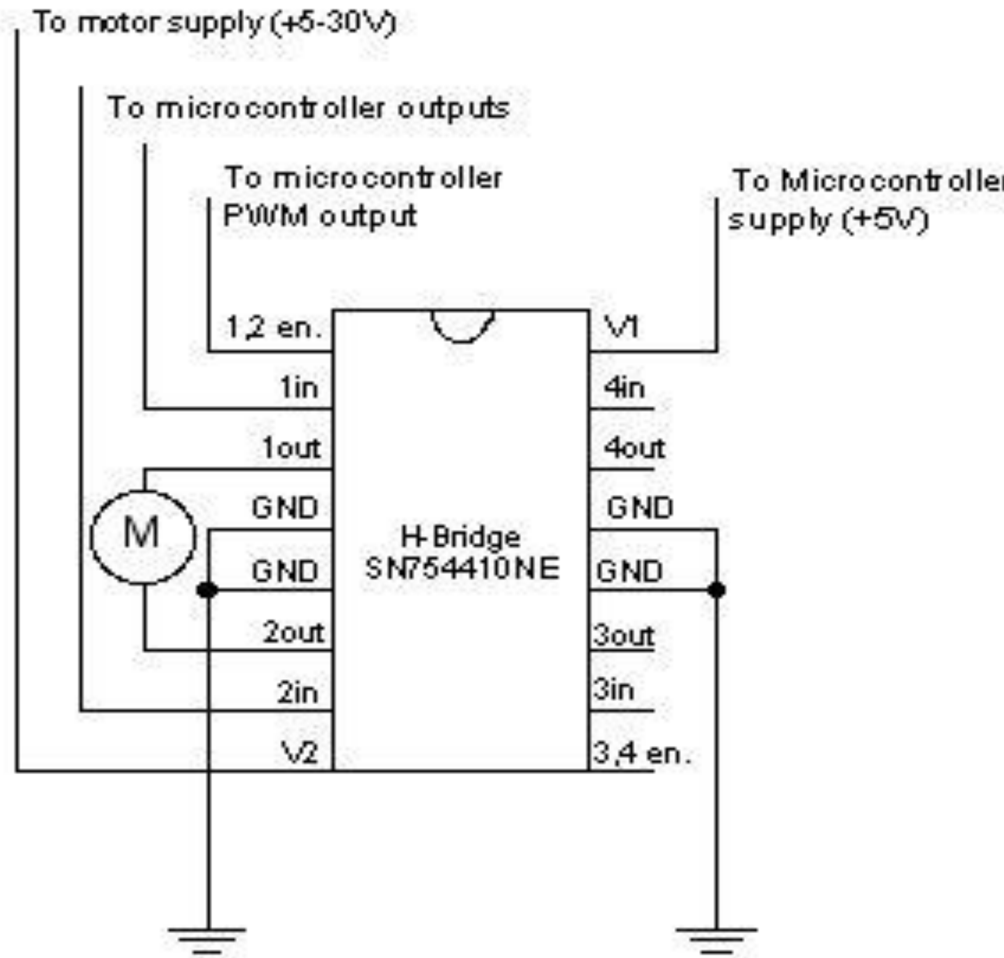

Source:http://www.solarbotics.net/library/circuits/driver_robinson.html




| Command | R1 | R2 | R3 | R4 |
|---|---|---|---|---|
| **Coast/Roll/Off:** | GND or disconnected | +VDC or disconnected | GND or disconnected | +VDC or disconnected |
| **Forward:** | GND or disconnected | GND | +VDC | +VDC or disconnected |
| **Reverse:** | +VDC | +VDC or disconnected | GND or disconnected | GND |
| **Brake/Slow Down:** | +VDC | +VDC or disconnected | +VDC | +VDC or disconnected |

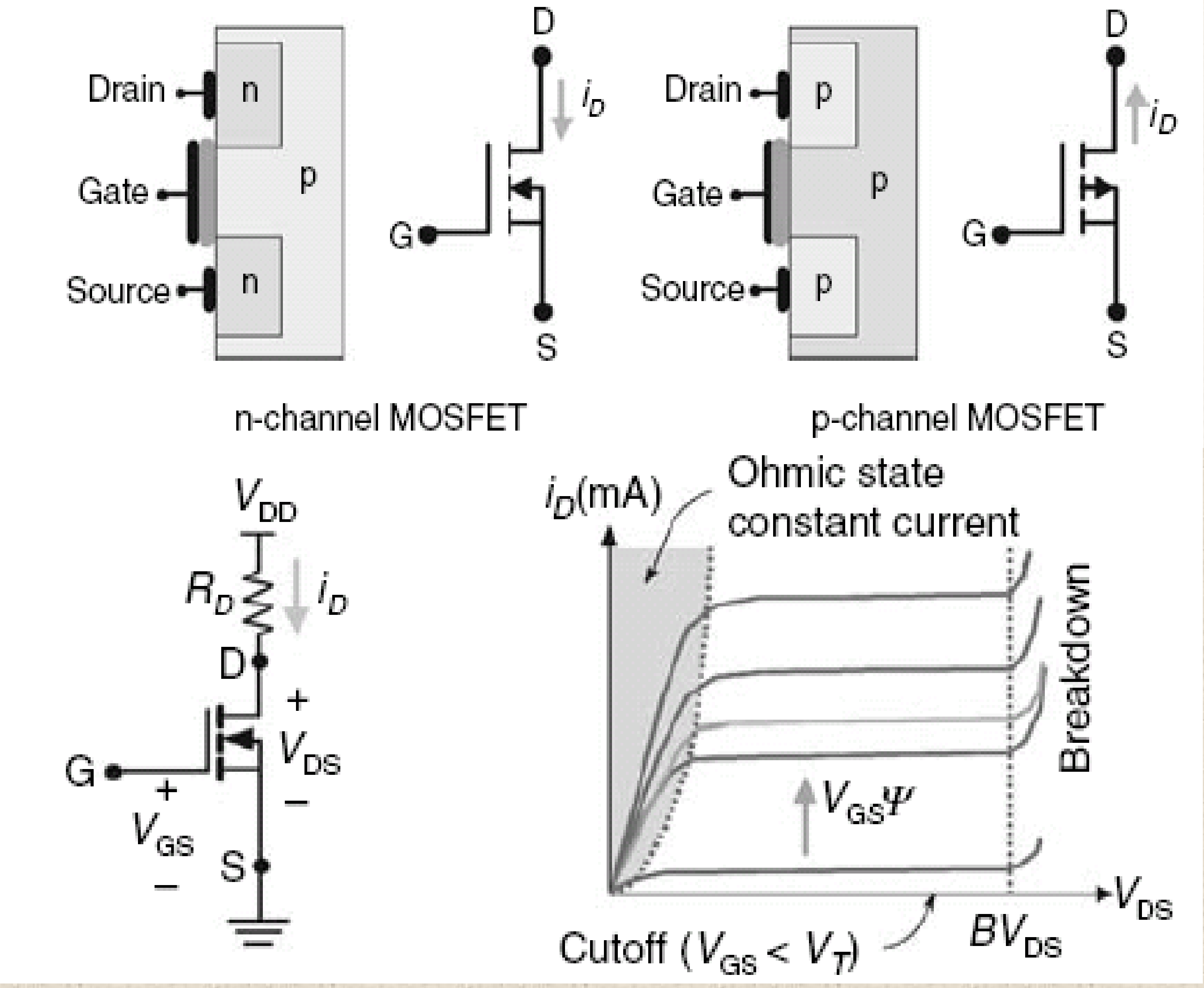


+12V
(input)
7805
+5V
(output)
12V
motor
M
10μF
1μF
to
microcontroller
and other 5V
components

To motor supply (+5-30V)
To microcontroller outputs
To microcontroller
PWM output
To Microcontroller
supply (+5V)
1,2 en.
1in
1out
GND
GND
2out
2in
V2
V1
4in
4out
GND
GND
3out
3in
3,4 en.
M
H-Bridge
SN754410NE

# MOSFET transitor



1. *Cutoff*—When the potential across the gate and the substrate (source) $V_{GS}$ is less that the turn-on (threshold) voltage $V_T$, the MOSFET is in the *cutoff* region and there is negligible current flow through the drain (D) terminal, i.e.,

$$\begin{cases} V_{GS} < V_T \\ i_G = 0 \end{cases} \Rightarrow \begin{cases} i_D \approx 0 \\ V_{DS} \approx V_{DD} \end{cases}$$

Typically, $V_T \approx 1$–$2$ V. In this mode, the transistor from D to S can be viewed as an open connection.

2. *Active Region*—When the $V_{GS} > V_T$, the MOSFET is in the *active* region, where

$$V_{GS} > V_T \quad \text{and} \quad \begin{cases} i_D \propto (V_{GS} - V_T)^2 \\ V_{DS} > V_{GS} - V_T \end{cases}$$

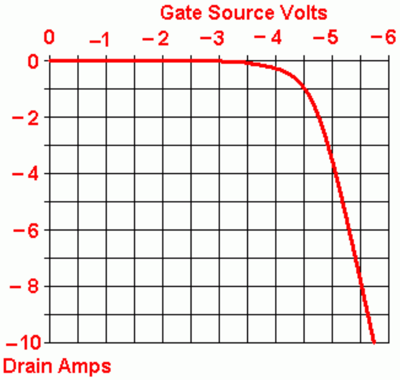
In this mode, the transistor can be viewed as a voltage-controlled current amplifier, where the drain current $i_C$ is proportional to square of the difference between the gate-source voltage and the threshold voltage. The drain current is controlled by the gate-source voltage $V_{GS}$. The power dissipation across the transistor $P_{FET}$ is

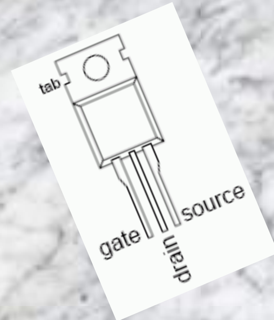
$$P_{FET} = i_D \cdot V_{DS}$$

3. *Ohmic State*—When $V_{GS}$ is large enough so that the drain current is determined by the drain source circuit, the MOSFET is in *saturation* and

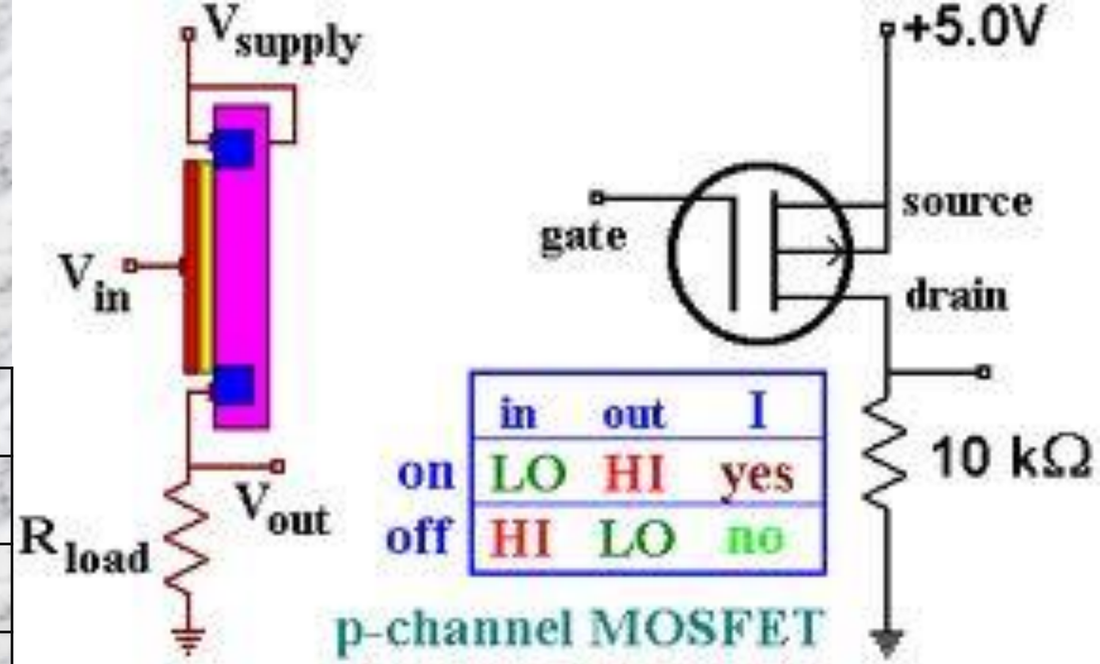
$$V_{GS} \gg V_T \quad \text{and} \quad \begin{cases} i_D = V_{DD}/R_D \\ V_{DS} \approx i_D \cdot R_{ON}(V_{DS}) < V_{GS} - V_T \end{cases} \tag{21.14}$$

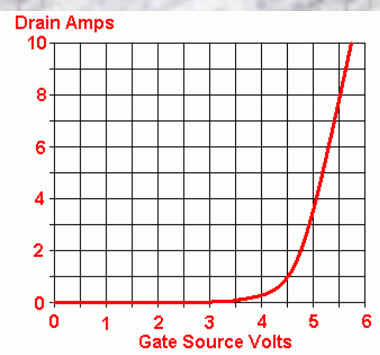
In this mode, the transistor can be viewed as a closed switch between the terminals D and S with a voltage controlled resistance $R_{ON}$. The drain current $i_D$ is controlled (determined) by the drain circuit. At rate current, the $V_{DS}$ drop during saturation ranges from 2 to 5 V.

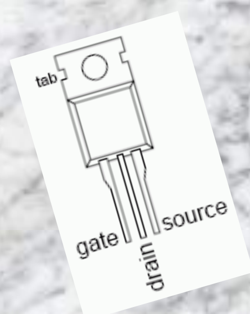


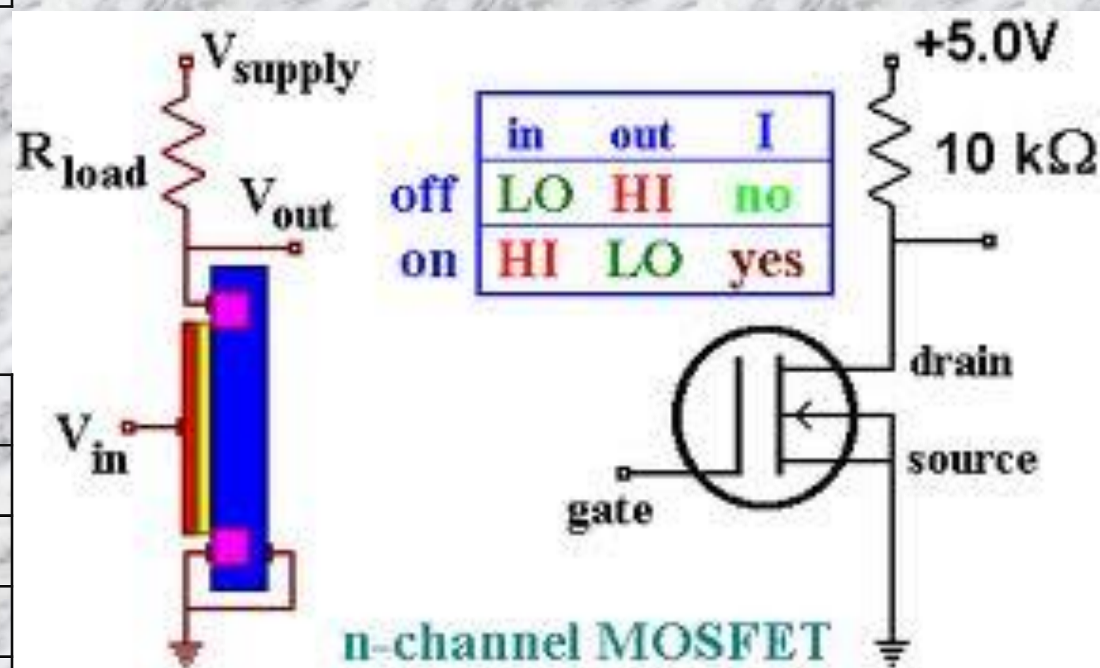

| | | |
|---|---|---|
| IRF 9610 | P-Channel | 2A,20W |
| IRF 9620 | P-Channel | 3A,40W |
| IRF 9630 | P-Channel | 6A,74W |
| IRF 9640 | P-Channel | 11A,125W |

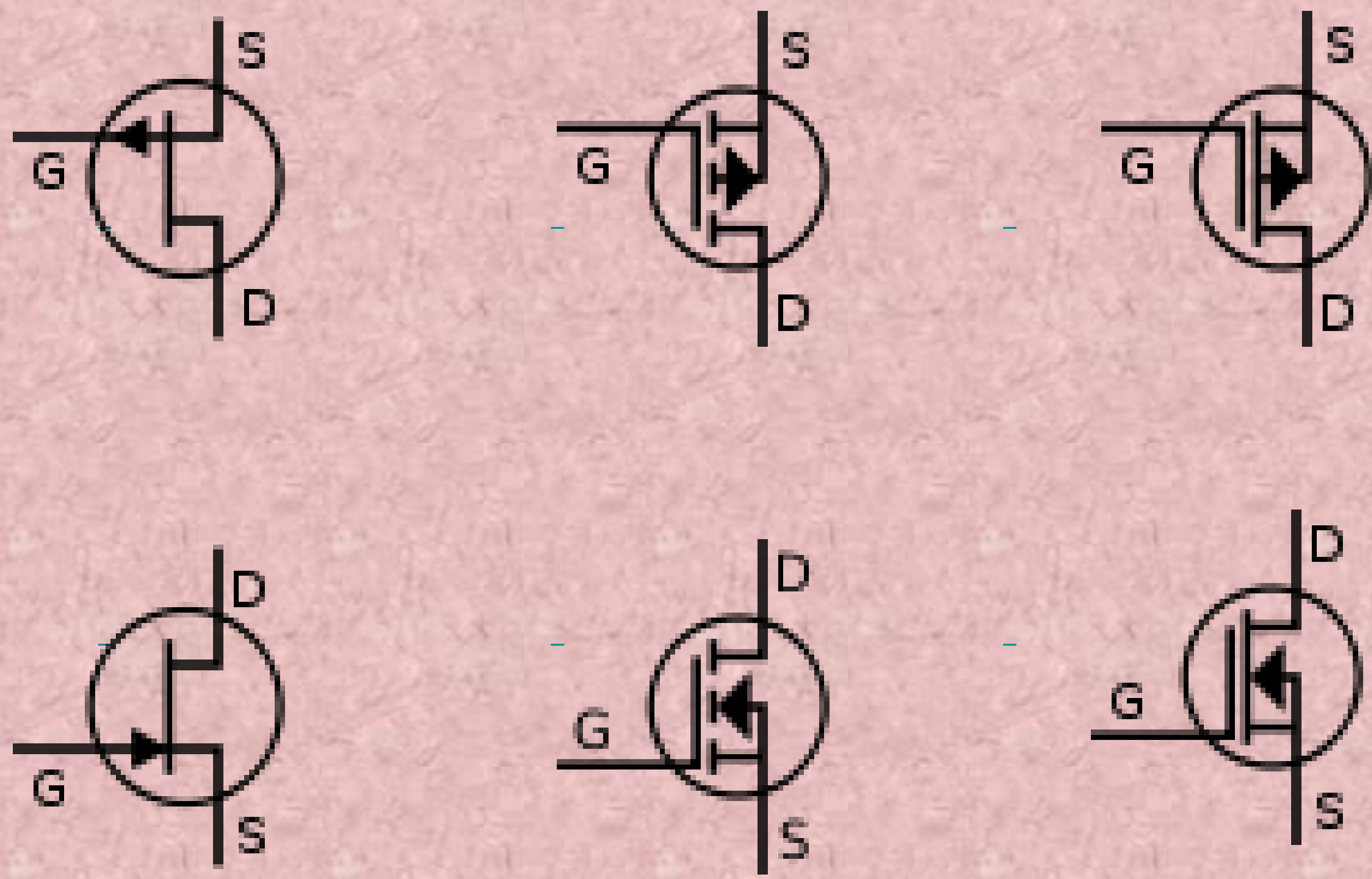



| | | |
|---|---|---|
| IRFI 510G | N-Channel | 4A,27W |
| IRFI 520G | N-Channel | 7A,37W |
| IRFI 530G | N-Channel | 10A,42W |
| IRFI 540G | N-Channel | 17A,48W |
| IRFI 620G | N-Channel | 4A,30W |






P-channel

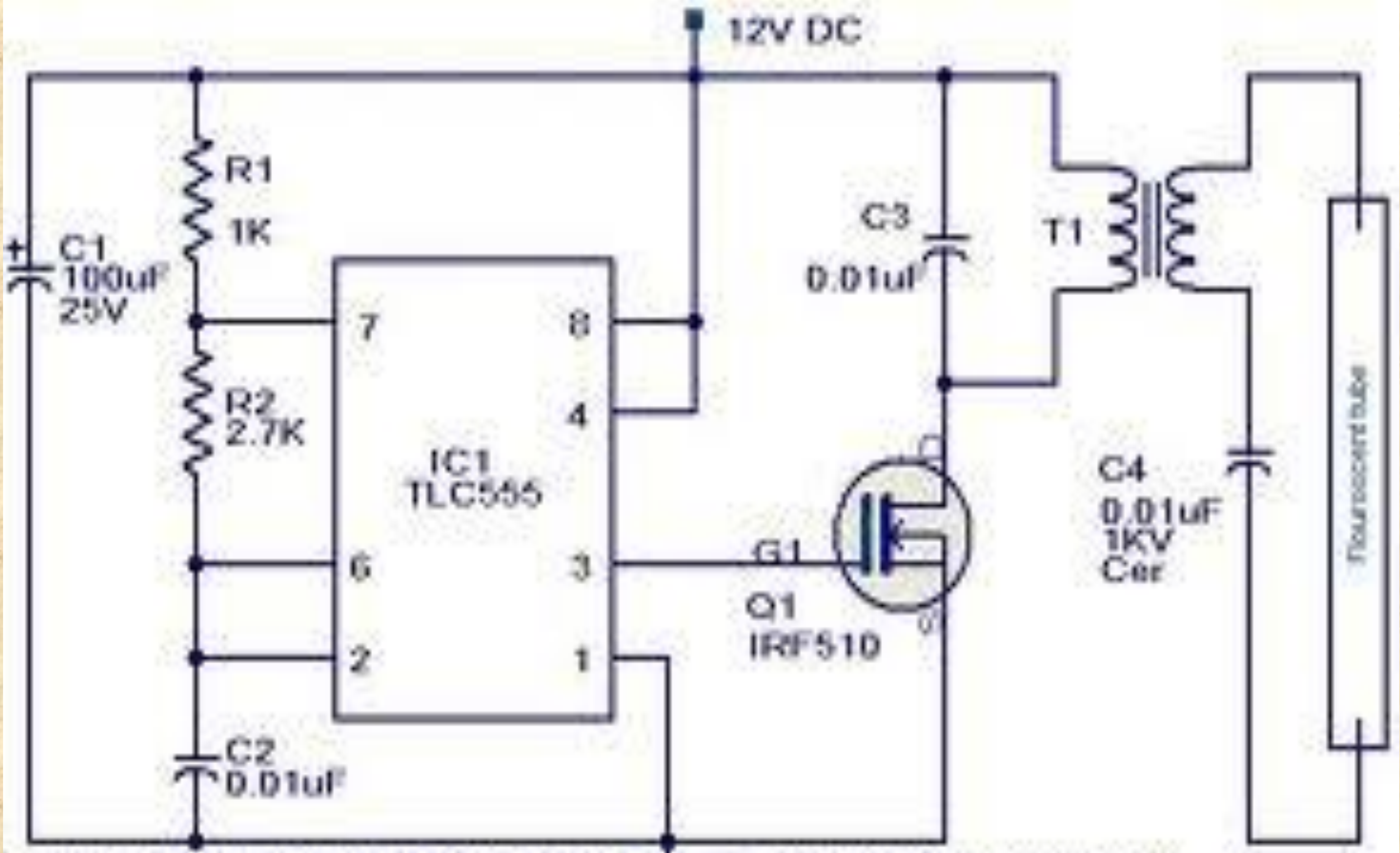
N-channel

JFET

IGFET enh

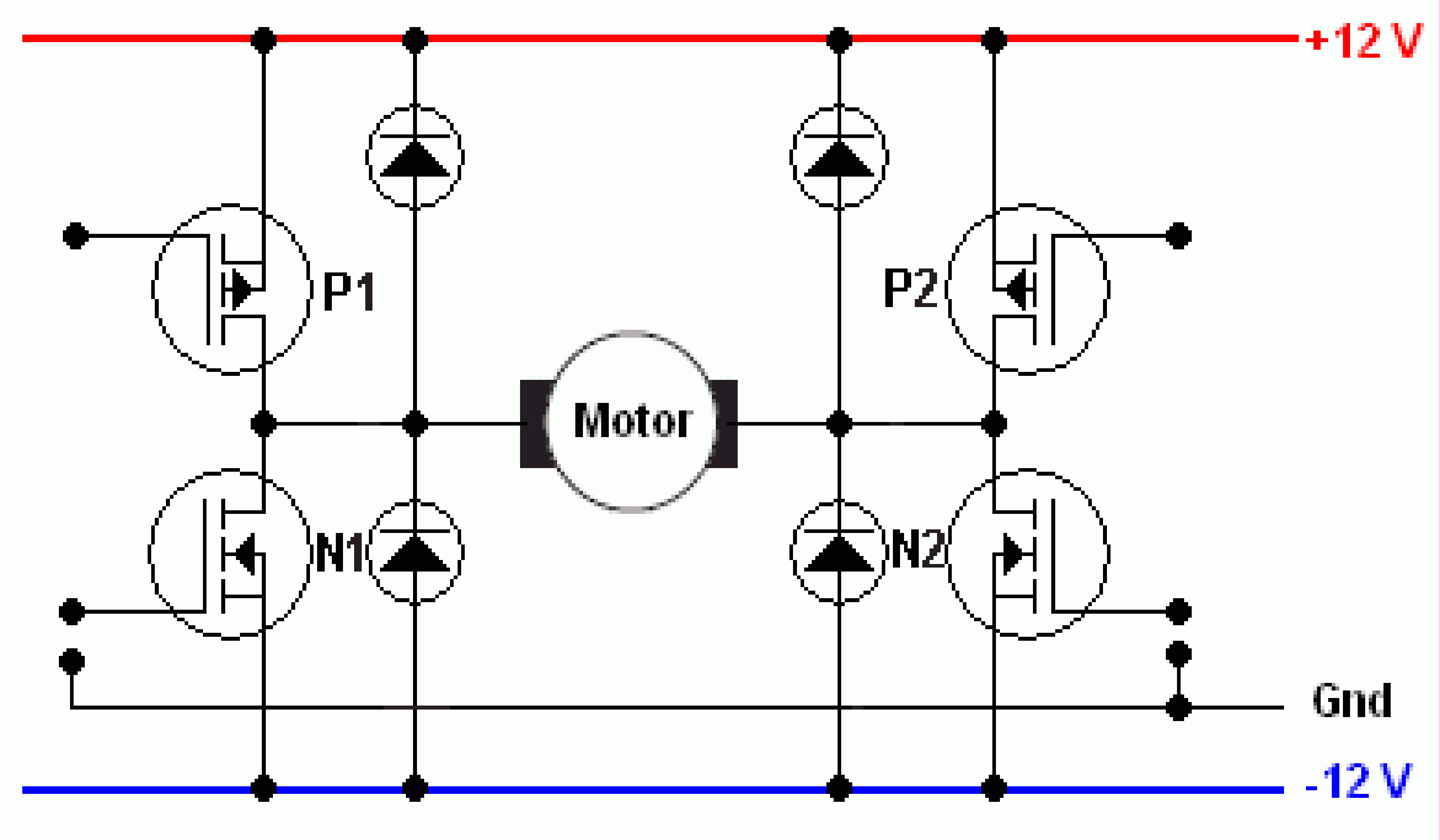
IGFET dep

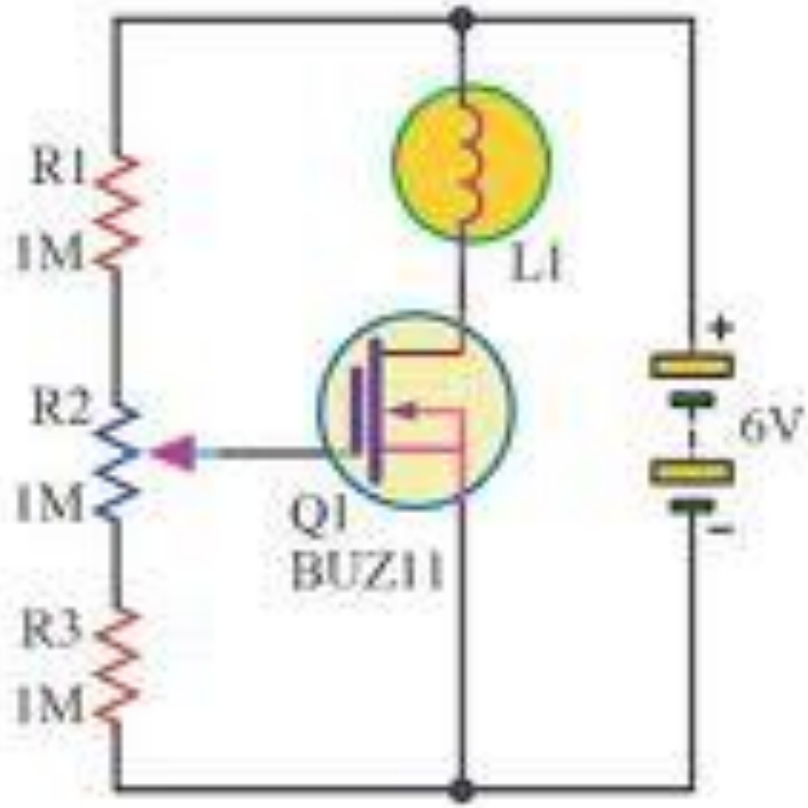

1. Bố trí các chân: chân G ở bên trái, chân S ở bên phải còn chân D ở giữa
2. Kiểm tra Mosfet bằng đồng hồ vạn năng
* Kiểm tra Mosfet: ở trạng thái còn tốt, khi đo trở kháng giữa G với S và giữa G với D có điện trở bằng vô cùng (kim không lên cả hai chiều đo) và khi G đã được thoát điện thì trở kháng giữa D và S phải là vô cùng.
Bước 1 : Chuẩn bị để thang x1KW
Bước 2 : Nạp cho G một điện tích (để que đen vào G que đỏ vào S hoặc D)
Bước 3 : Sau khi nạp cho G một điện tích ta đo giữa D và S (que đen vào D que đỏ vào S) => kim sẽ lên.
Bước 4 : Chập G vào D hoặc G vào S để thoát điện chân G.
Bước 5 : Sau khi đã thoát điện chân G đo lại DS như bước 3 kim không lên.
Với Mosfet hỏng khi đo giữa G và S hoặc giữa G và D nếu kim lên = 0 W là chập, đo giữa D và S mà cả hai chiều đo kim lên = 0 W là chập D S
3. Đo kiểm tra Mosfet trong mạch .
Khi kiểm tra Mosfet trong mạch, chỉ cần để thang x1W và đo giữa D và S => Nếu 1 chiều kim lên đảo chiều đo kim không lên => là Mosfet bình thường, Nếu cả hai chiều kim lên = 0 W là Mosfet bị chập DS



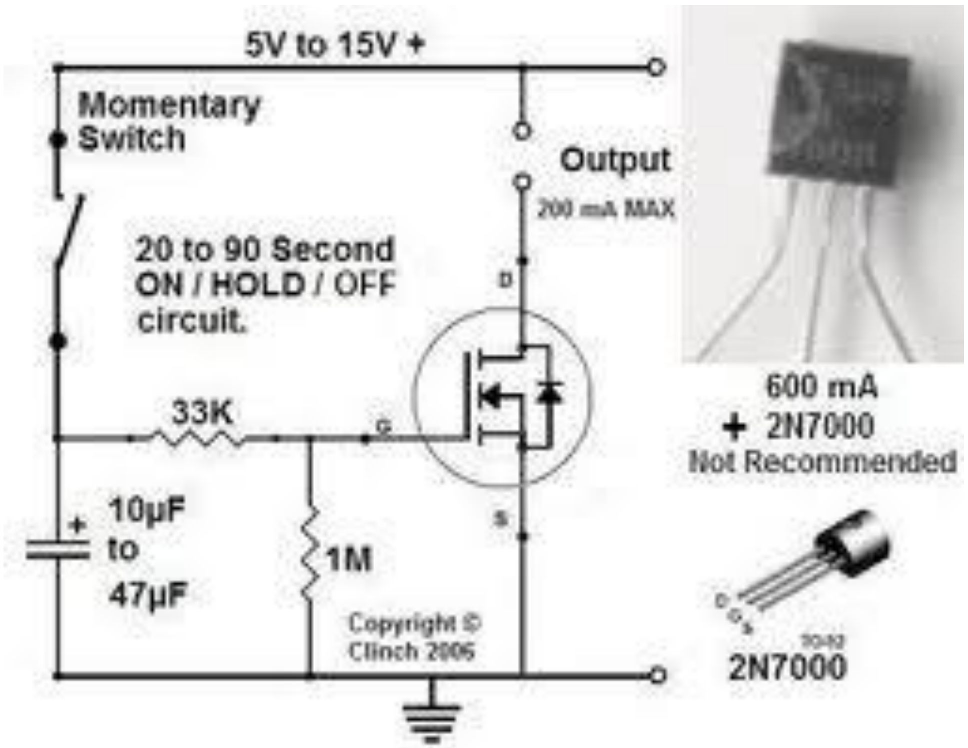
12V Floroscent tube driver circuit www.circuitstoday.com

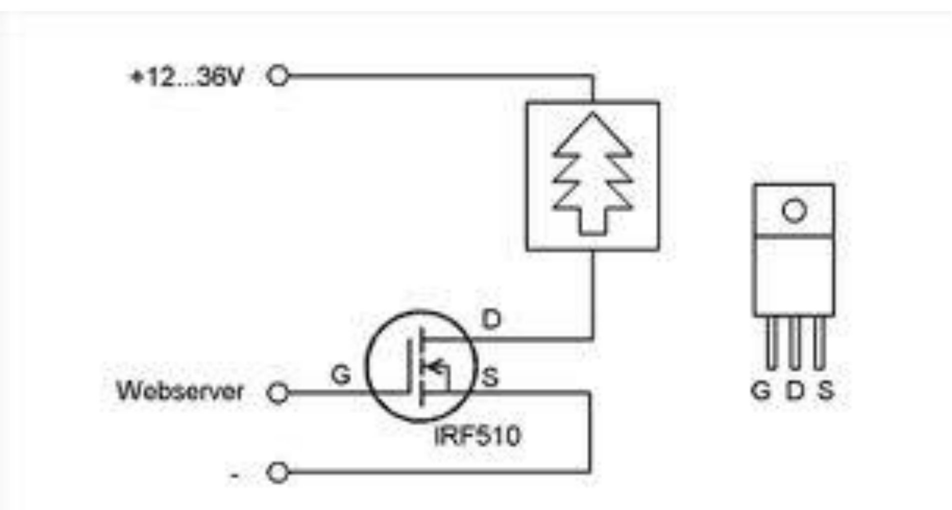
**This arrangement is using MOSFETs as switches. This is called an H Bridge because of the H layout of the circuit. It's possible to buy H Bridge controller chips. These make motor control easier. If P1 and N2 are on, the motor runs forwards. If P2 and N1 are on, the motor runs backwards. If P1 and N1 are on, both MOSFETs are destroyed by the short circuit. If P1 and P2 are on, the motor, acting as a generator, brakes to a halt.**

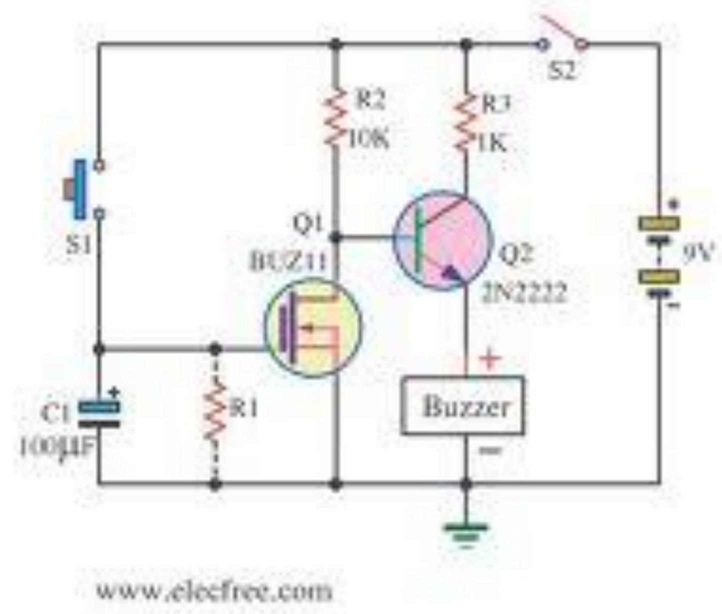


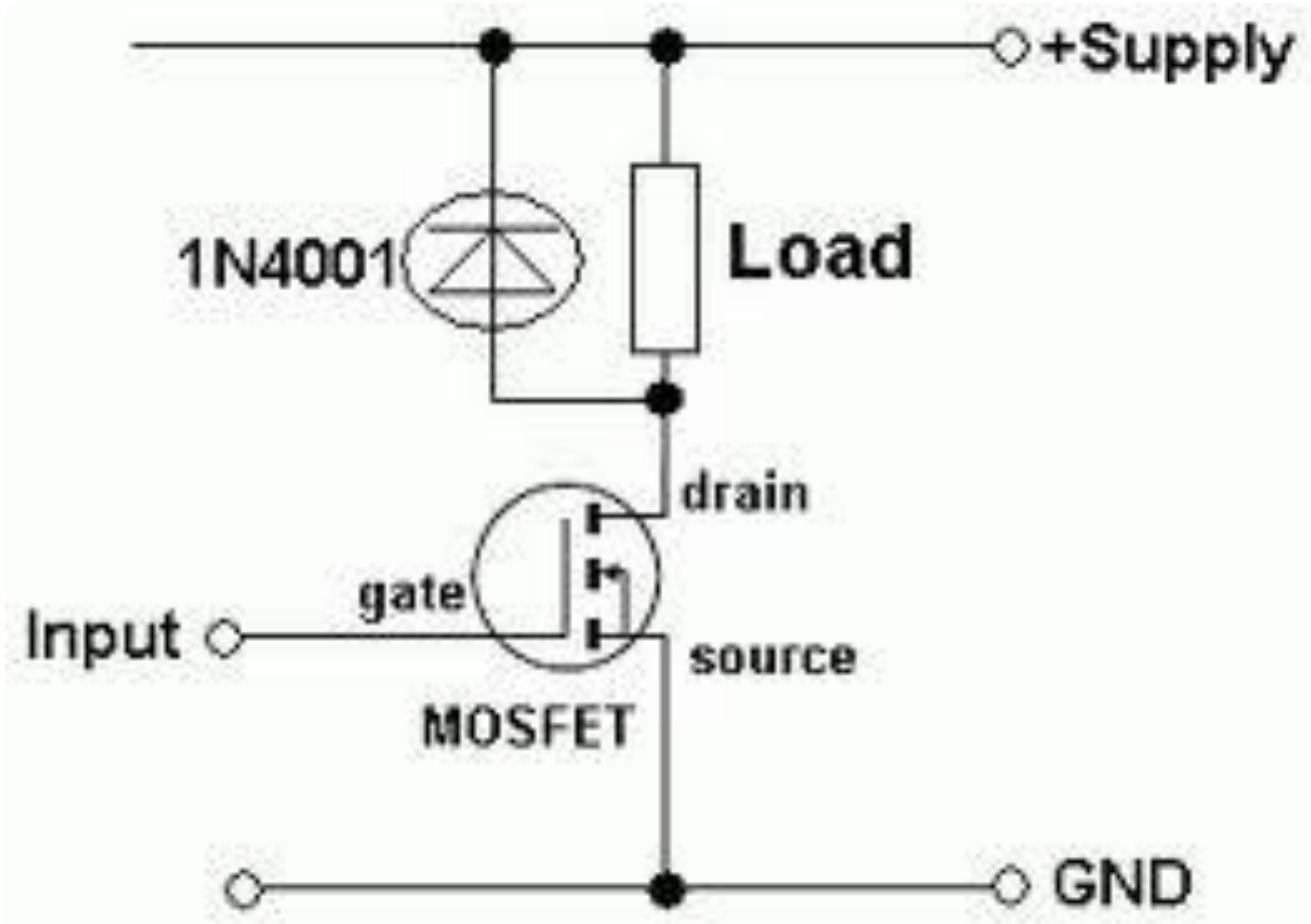


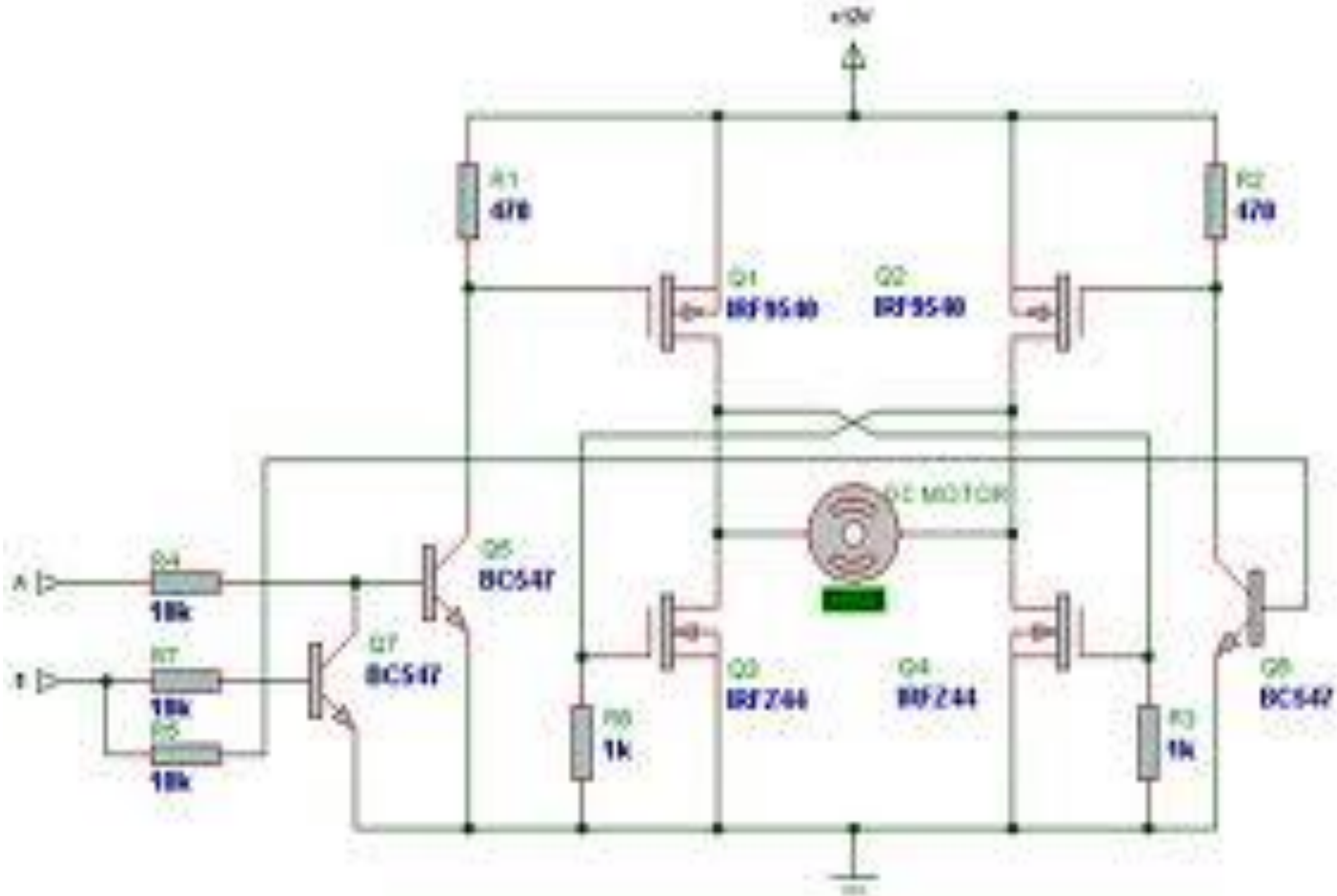

www.elecfree.com


5V to 15V +
Momentary
Switch
Output
200 mA MAX
20 to 90 Second
ON / HOLD / OFF
circuit.
D
33K
G
S
10µF
to
47µF
1M
Copyright ©
Clinch 2006
600 mA
+ 2N7000
Not Recommended
2N7000


+12...36V
D
G
S
Webserver
IRF510
-
G D S


S2
R2
10K
R3
1K
S1
Q1
BUZ11
Q2
2N2222
9V
+
C1
100µF
R1
Buzzer
−
www.elecfree.com


+Supply
1N4001
Load
drain
gate
Input
source
MOSFET
GND



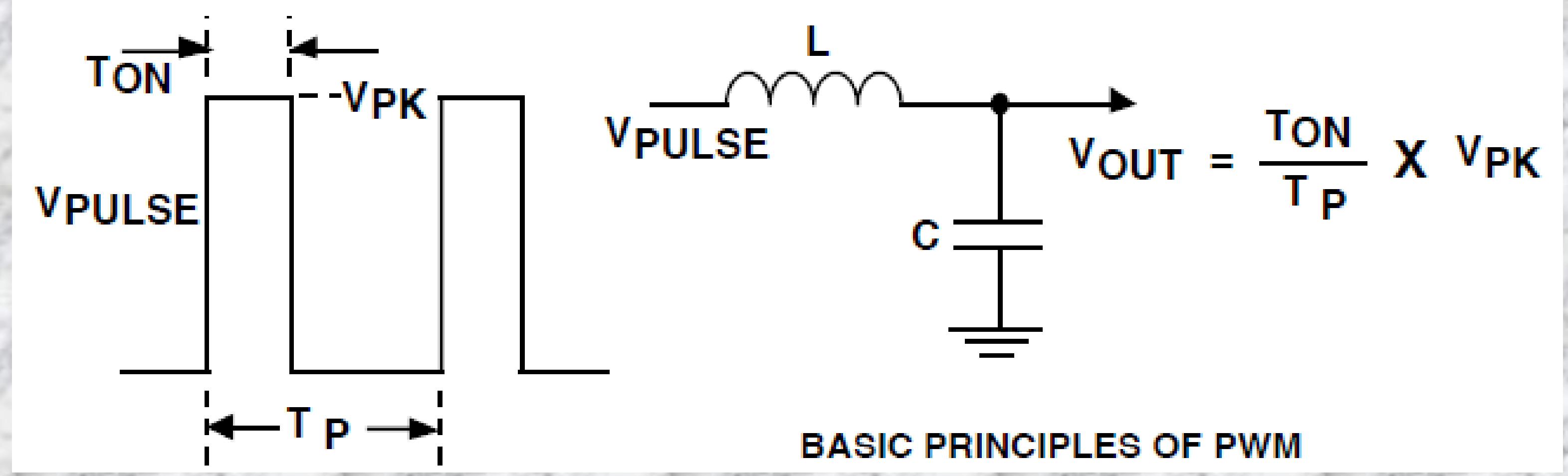
R1
470
R2
470
Q1
IRF9540
Q2
IRF9540
DC MOTOR
Q5
BC547
Q7
BC547
Q3
Q4
IRFZ44
R6
1k
R3
1k
Q6
BC547
A
10k
10k
10k

Comparing BJT with MOSFET, we can conclude the following:

- Both can be used as current amplifiers.
  - BJT is a current-controlled amplifier where the collector current $i_C$ is proportional to the base current $i_B$.
  - MOSFET is a voltage-controlled amplifier where the drain current $i_D$ is proportional to the square of the gate voltage $V_G$.
- Both can be used as three terminal switches or voltage inverters.
  - BJT: switching circuit give rise to TTL logics.
  - MOSFET: switching circuit give rise to CMOS logics.
- BJT usually has larger current capacity than similar sized MOSFET.
- MOSFET has much higher input impedance than BJT and is normally off, which translates to less operating power.
- MOSFETs are more easily fabricated into integrated circuit.
- MOSFETs are less prone to go into thermal runaway.
- MOSFETs are susceptible to static voltage (exceed gate breakdown voltage ~50 V).
- BJT has been replaced by MOSFET in low-voltage (<500 V) applications and is being replaced by IGBT in applications at voltages above 500 V.

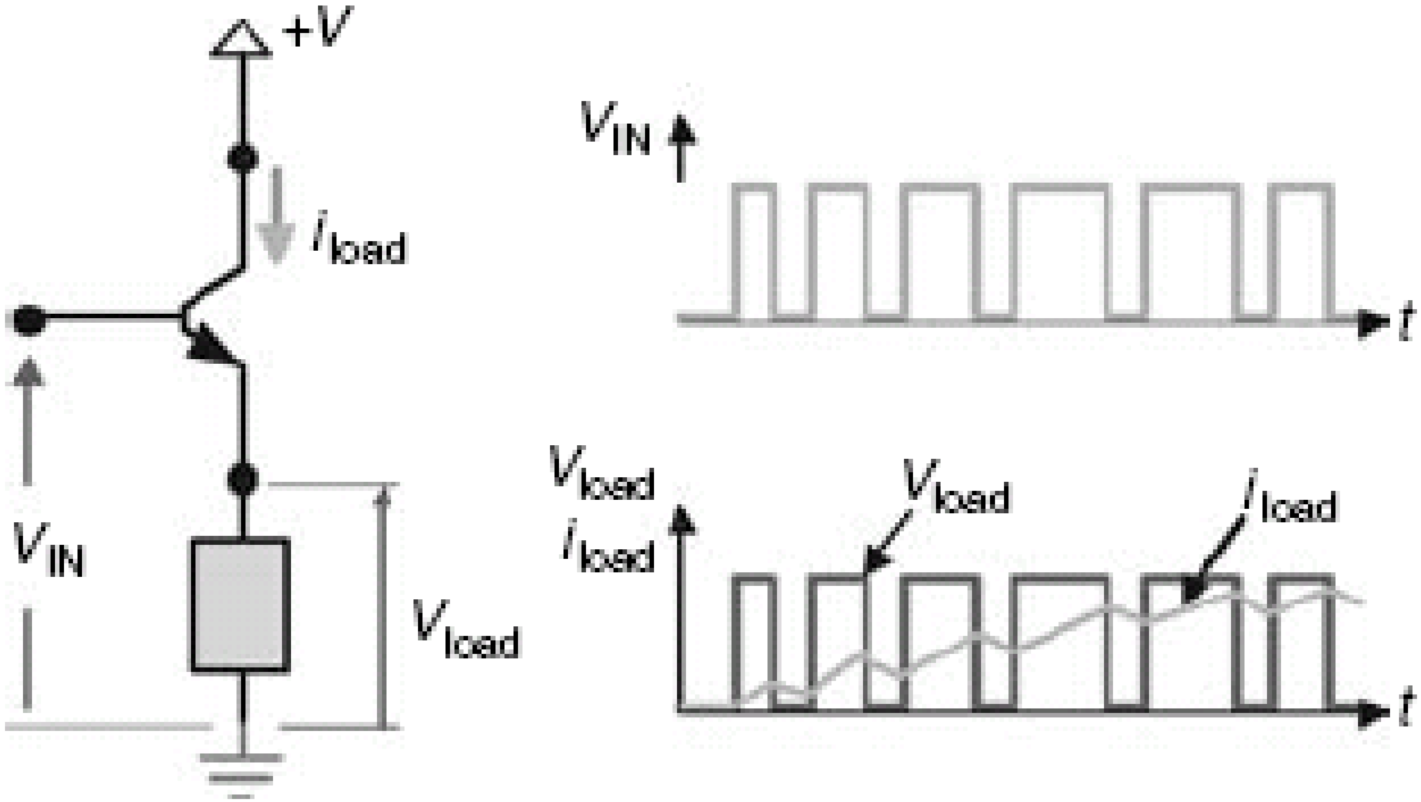
# Mạch điều chế độ rộng xung (PWM)

PWM, or Pulse Width Modulation, is a method of controlling the amount of power to a load without having to dissipate any power in the load driver



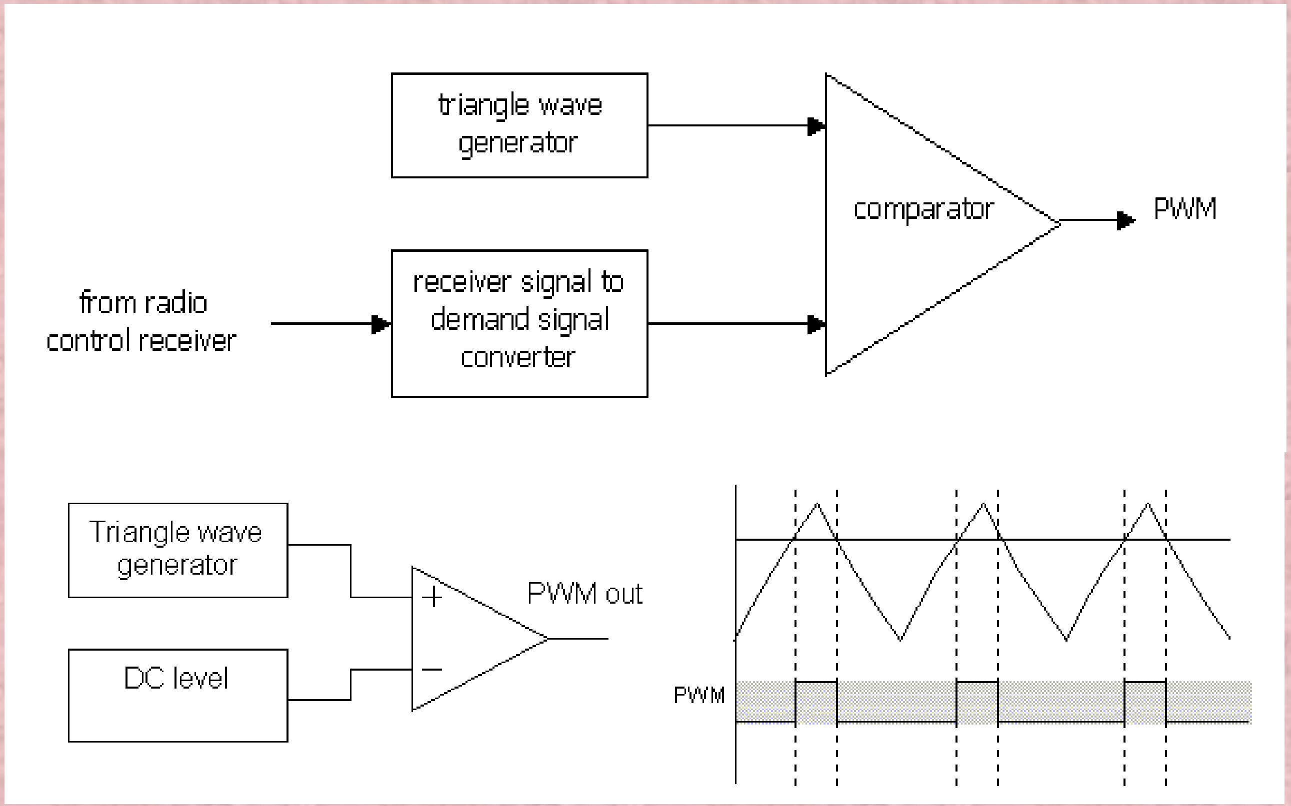

The PWM signals can be generated in a number of ways:

1. Analogue method
2. Digital method
3. Discrete IC
4. Onboard microcontroller




Simple switching amplifier with switching input.

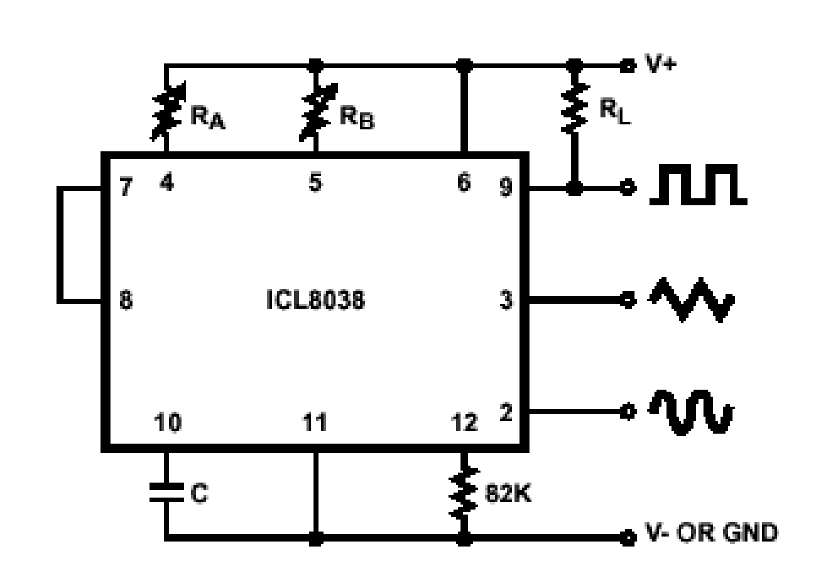
# A block diagram of an analogue PWM generator




The DC signal can range between the minimum and maximum voltages of the triangle wave.

When the triangle waveform voltage is greater than the DC level, the output of the op-amp swings high, and when it is lower, the output swings low

ICs specially designed for generating triangle waves are available. Perhaps the most commonly know is the ICL8038, which is quite long in the tooth now but is still perfectly adequate

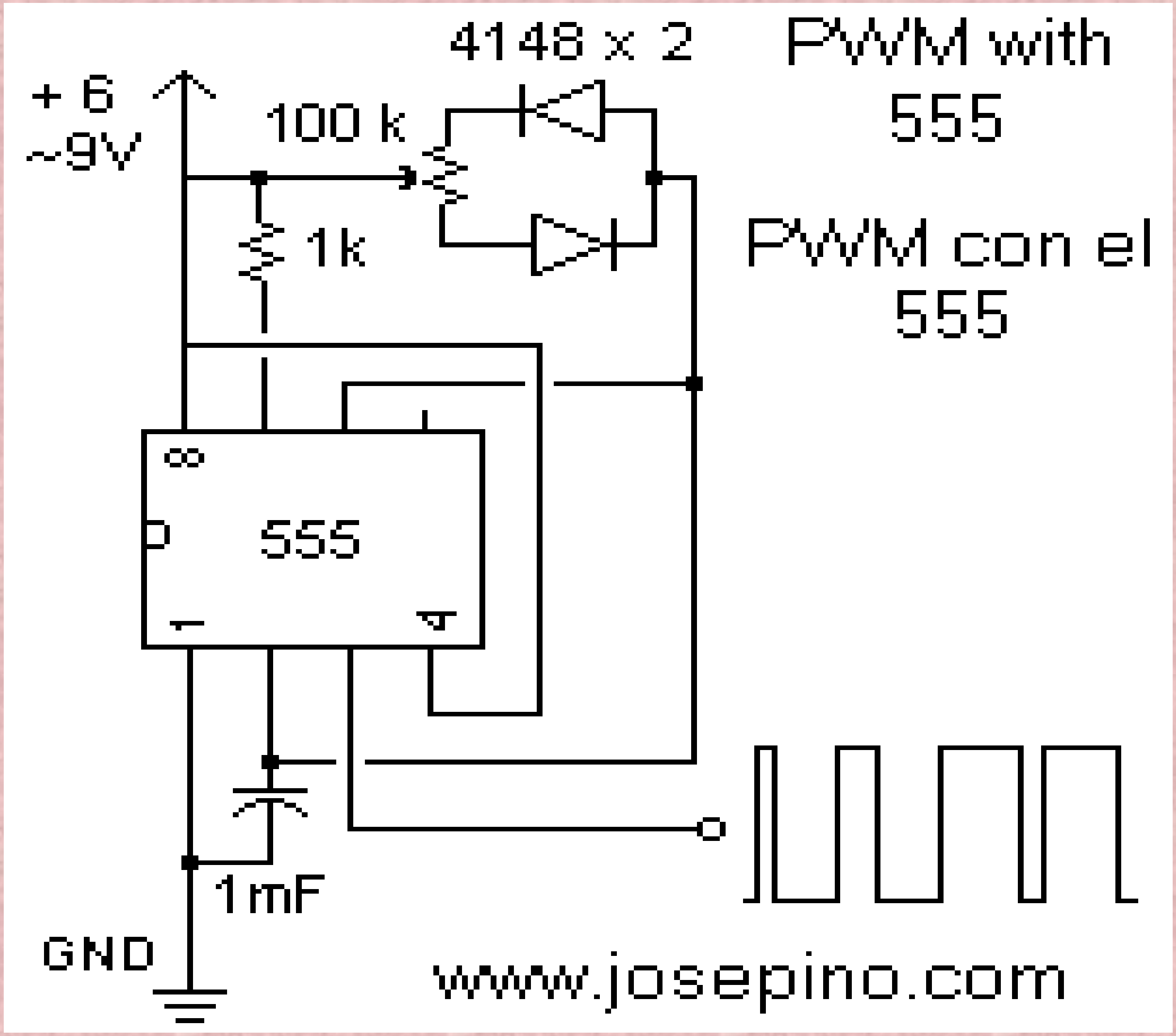



Set $R_A$ equal to $R_B$ for a regular triangle wave (equal rising and falling edges). The frequency of the triangle wave is then given by the equation:

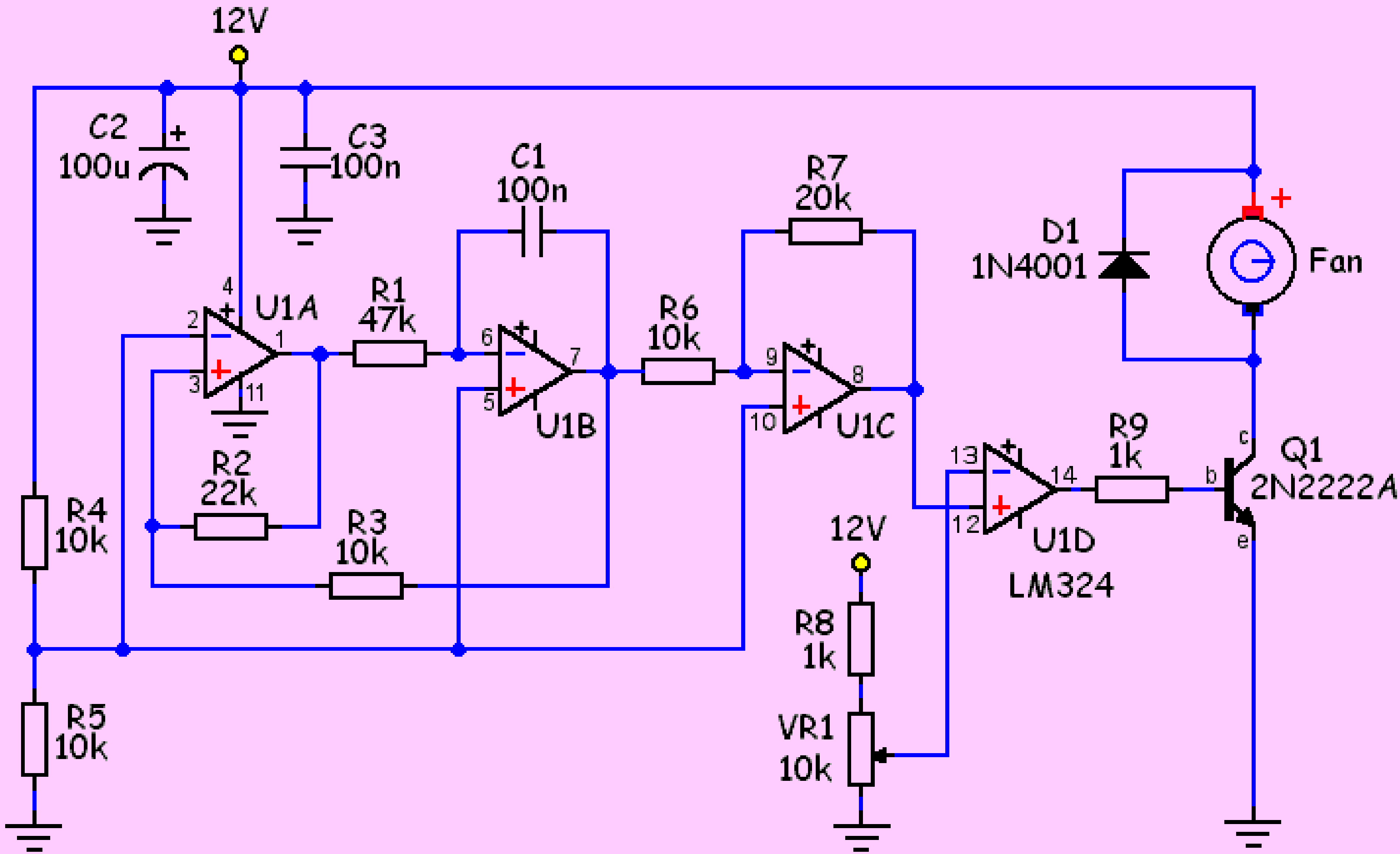
$$f = \frac{0.33}{R_A C}$$

The capacitor value should be chosen at the upper end of its possible range. The waveform generator can be operated either from a single power supply (10V to 30V) or a dual power supply (+/-5V to +/-15V). The triangle wave swings from 1/3 of the supply voltage up to 2/3 of the supply voltage, so on a +12V single supply it would swing from 4V to 8V

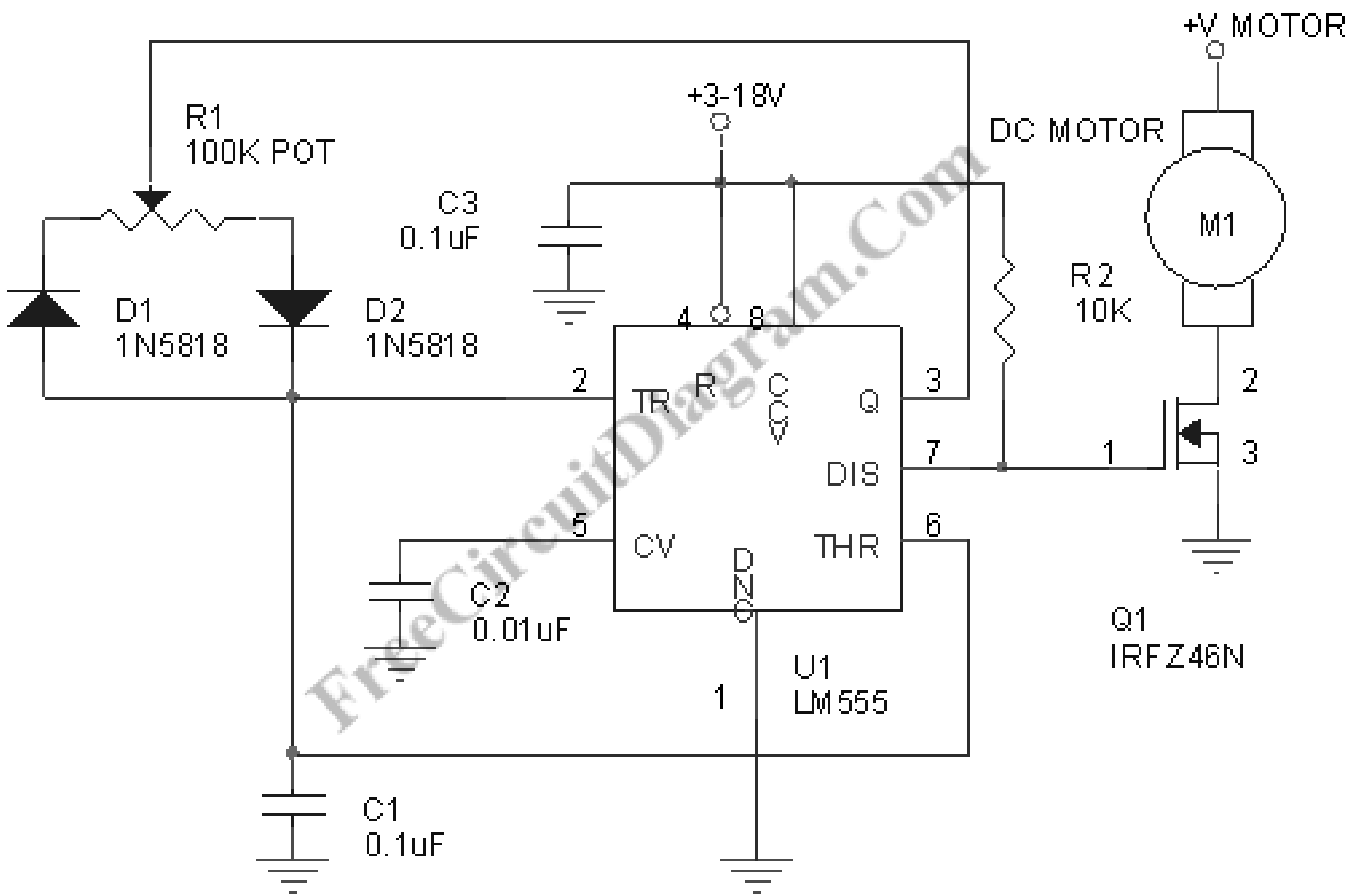
# Sử dụng Timer 555  điều chế PWM



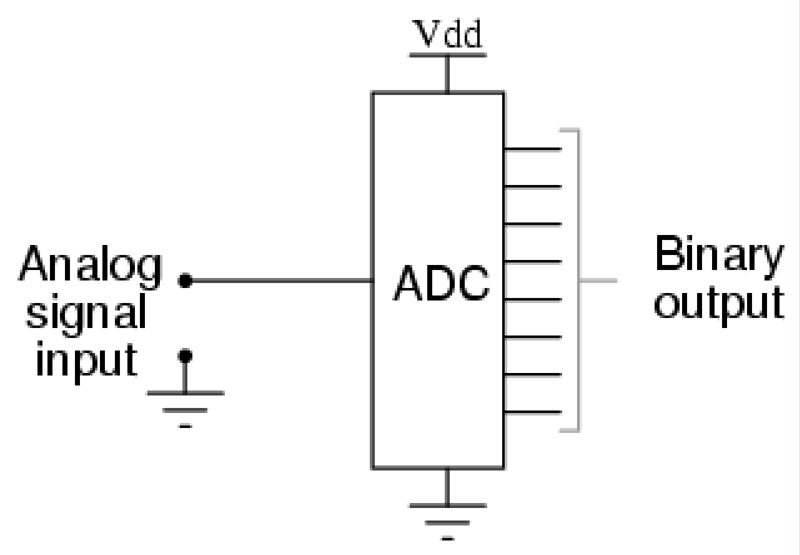
# Sử dụng LM324 trong mạch PWM điều khiển động cơ

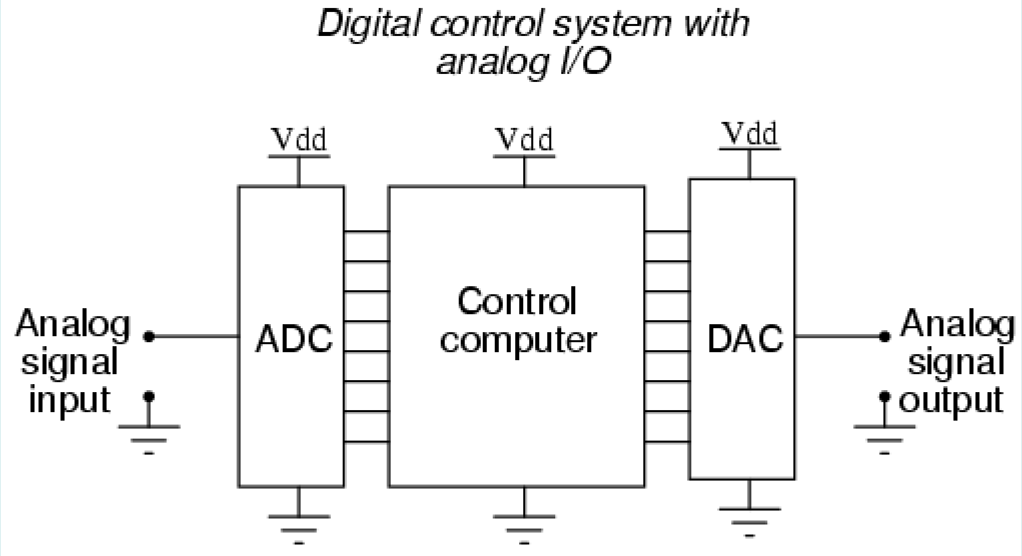


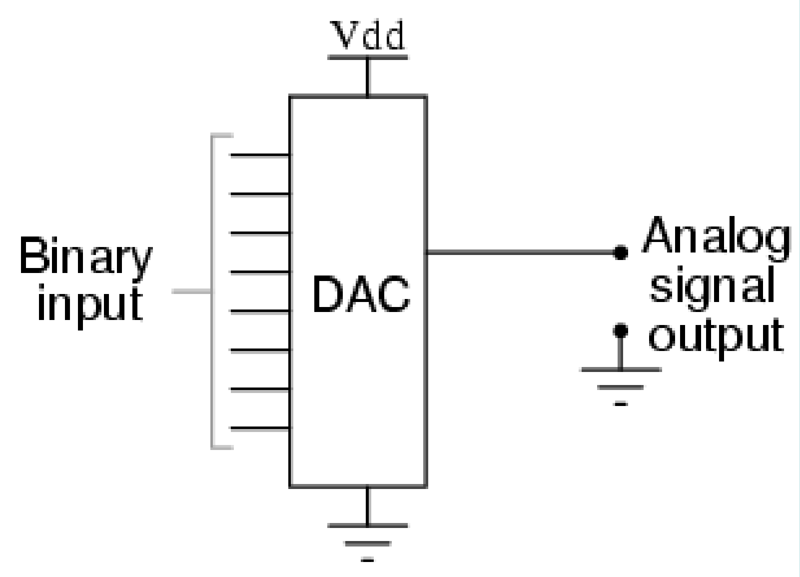
# Sử dụng Timer 555 trong mạch PWM điều khiển động cơ



# Mạch biến đổi ADC

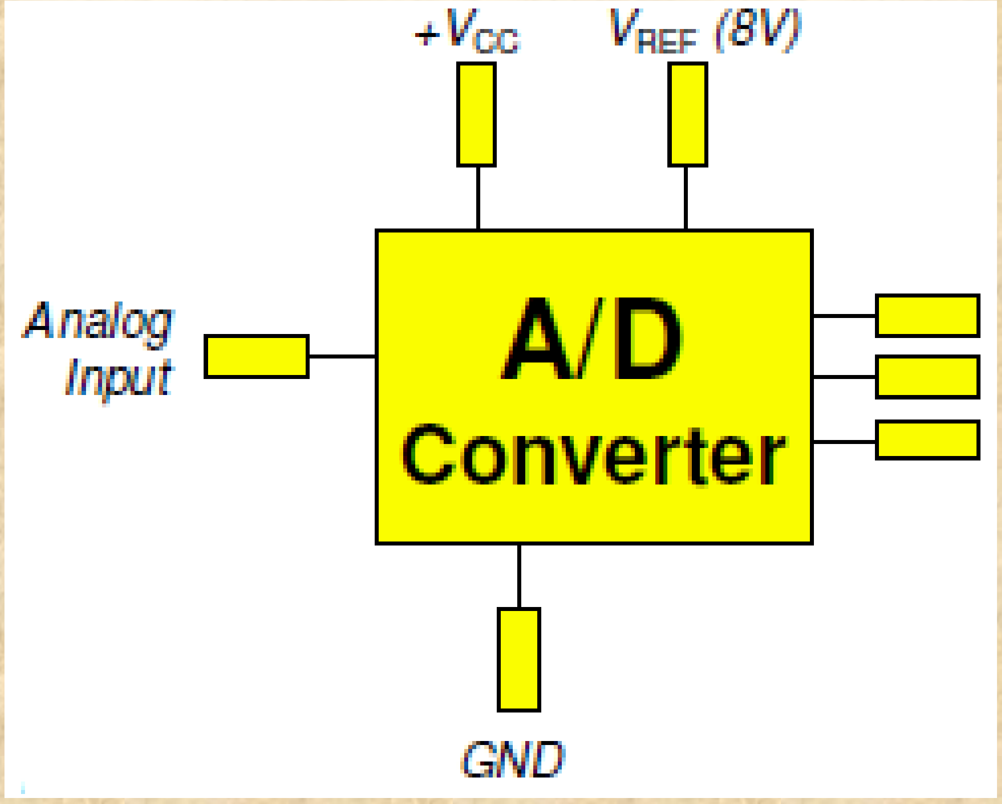


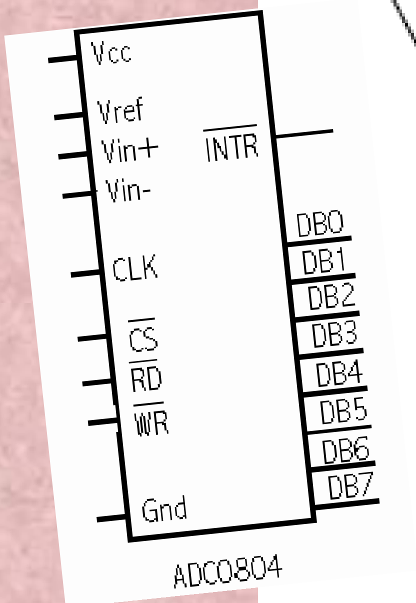
For a 3-bit ADC, there are 8 possible output codes.

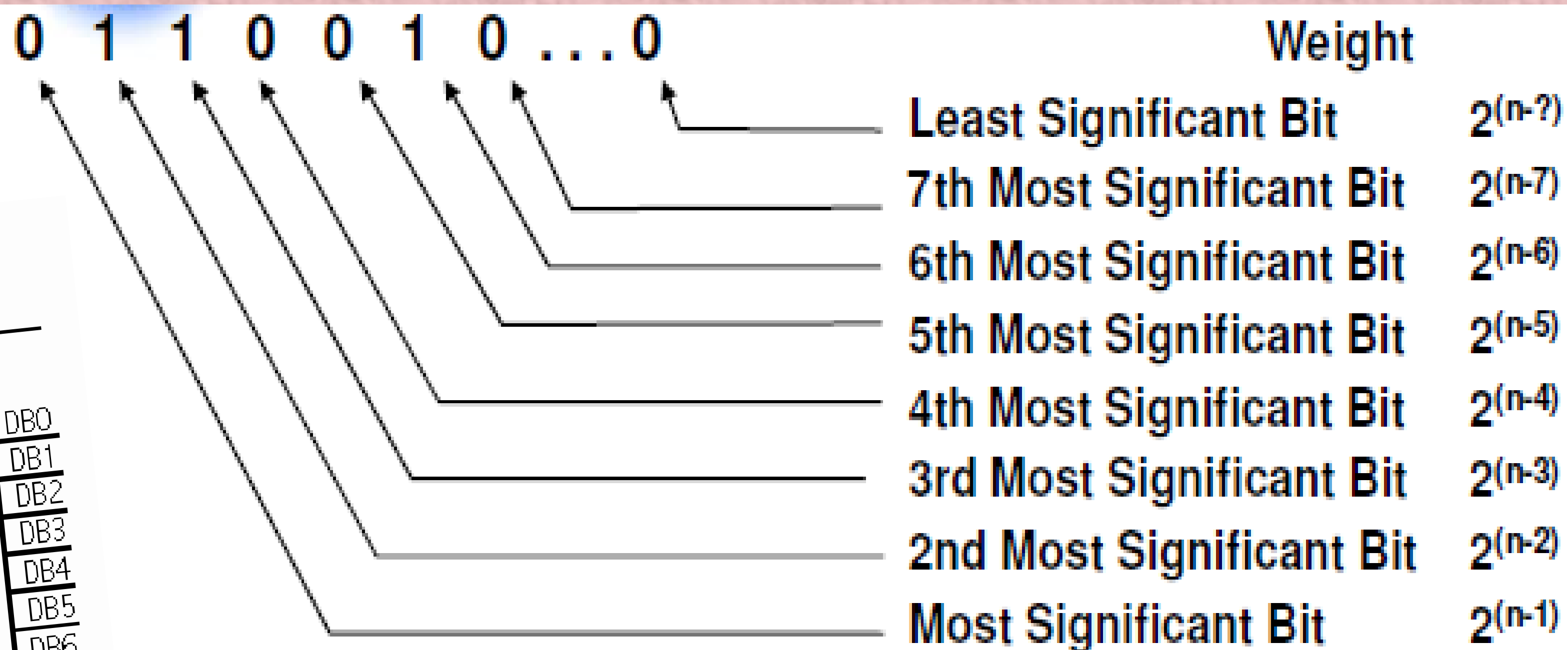
- In this example, if the input voltage is 5.5V and the reference is 8V, then the output will be 101.
- More bits give better resolution and smaller steps.
- A lower reference voltage gives smaller steps, but can be at the expense of noise




*0V < 000 < 1V*
*1V < 001 < 2V*
*2V < 010 < 3V*
*3V < 011 < 4V*
*4V < 100 < 5V*
*5V < 101 < 6V*
*6V < 110 < 7V*
*7V < 111 < 8V*

# *Least Significant Bit (LSB) and Most Significant Bit (MSB)*



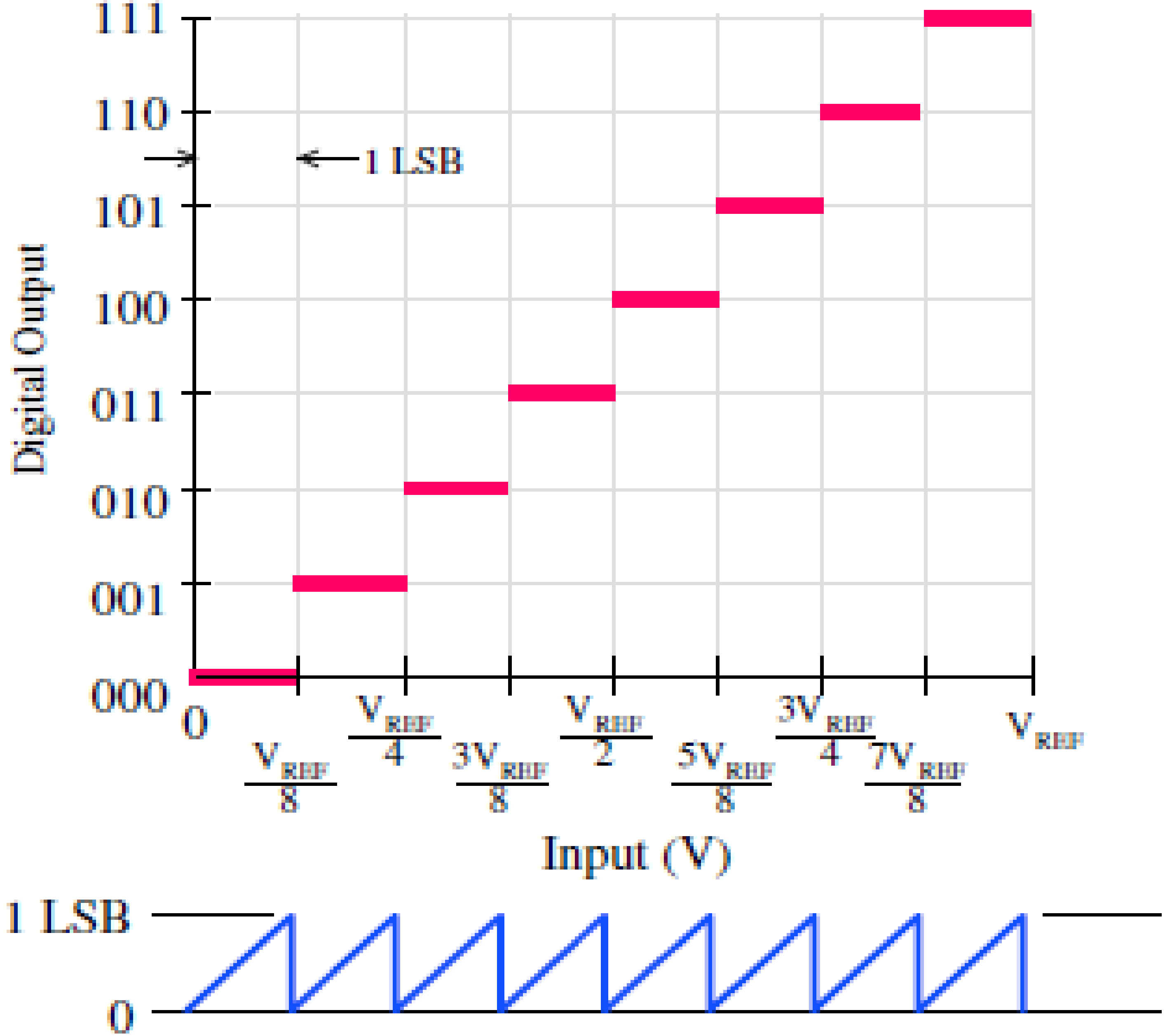




**Bit Weights of an 8-Bit Word**

| MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|
| B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

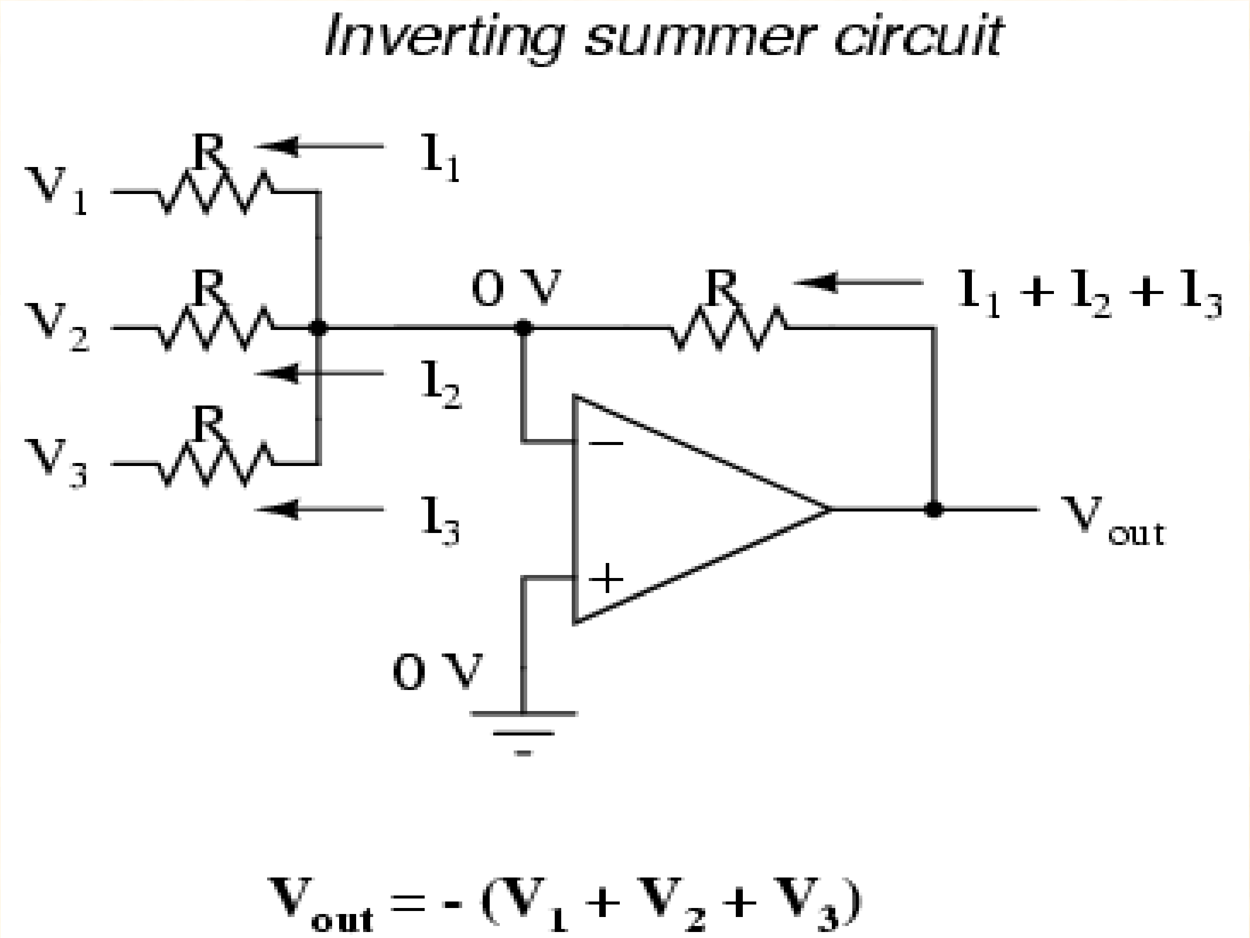
## The value of an LSB depends upon the ADC Reference Voltage and Resolution

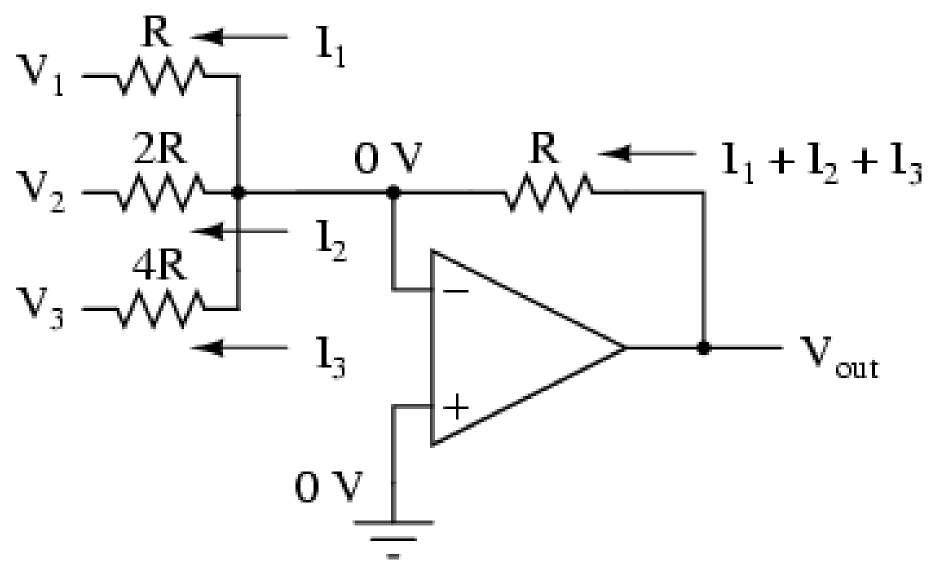
| $V_{REF}$ | Resolution | 1 LSB |
|---|---|---|
| 1.00V | 8 | 3.9062 mV |
| 1.00V | 12 | 244.14 μV |
| 2.00V | 8 | 7.8125 mV |
| 2.00V | 10 | 1.9531 mV |
| 2.00V | 12 | 488.28 μV |
| 2.048V | 10 | 2.0000 mV |
| 2.048V | 12 | 500.00 μV |
| 4.00V | 8 | 15.625 mV |
| 4.00V | 10 | 3.9062 mV |
| 4.00V | 12 | 976.56 μV |



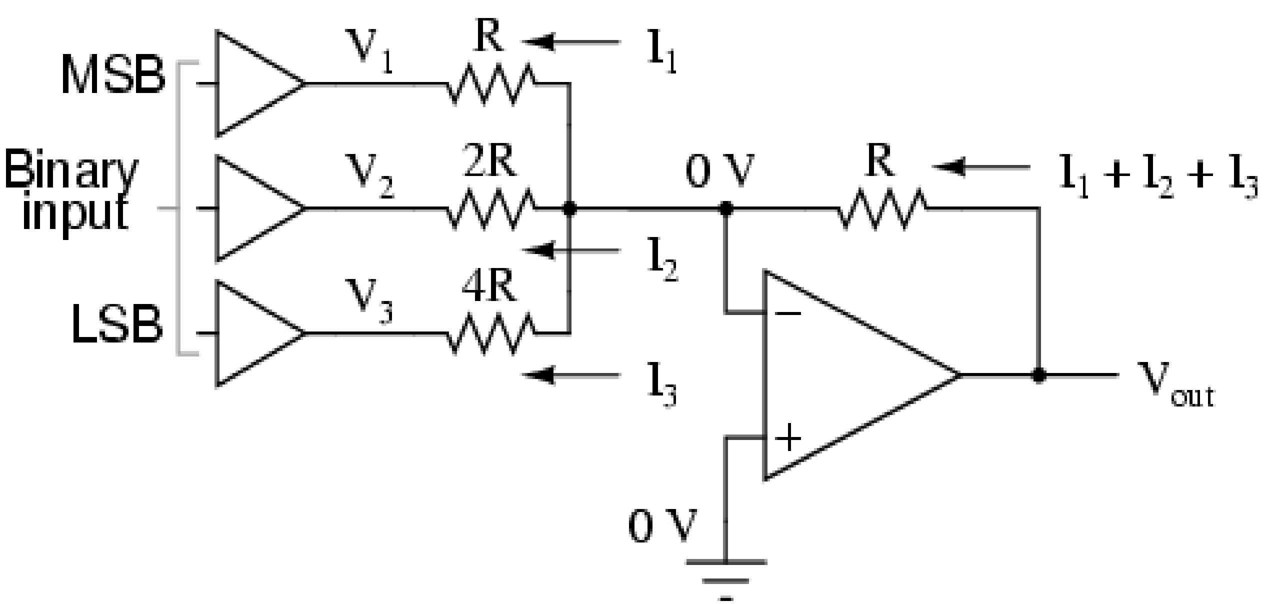

**The Magnitude of the Error Ranges from Zero to 1 LSB**

This DAC circuit, otherwise known as the *binary-weighted-input* DAC, is a variation on the inverting summer op-amp circuit. If you recall, the classic inverting summer circuit is an operational amplifier using negative feedback for controlled gain, with several voltage inputs and one voltage output. The output voltage is the inverted (opposite polarity) sum of all input voltages

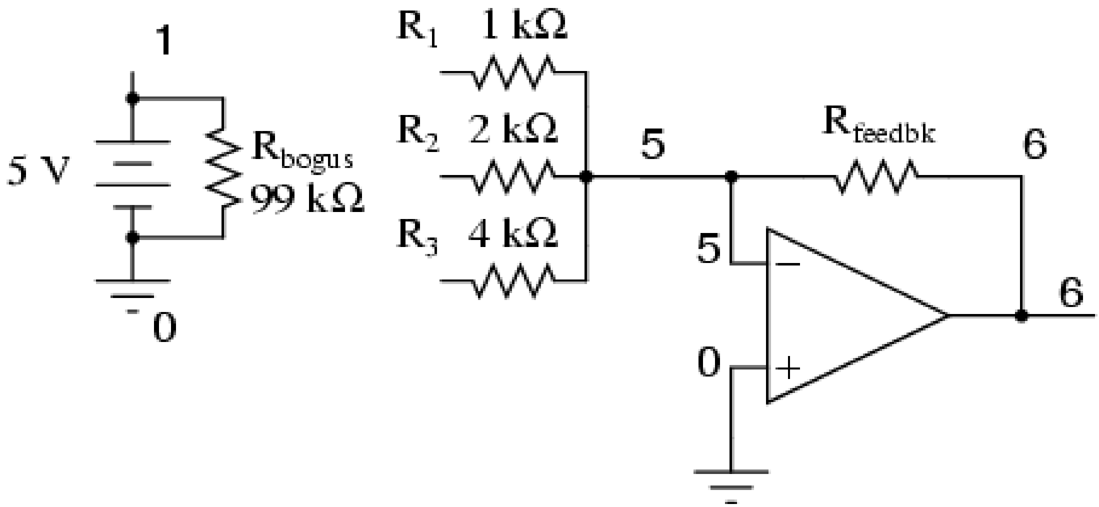




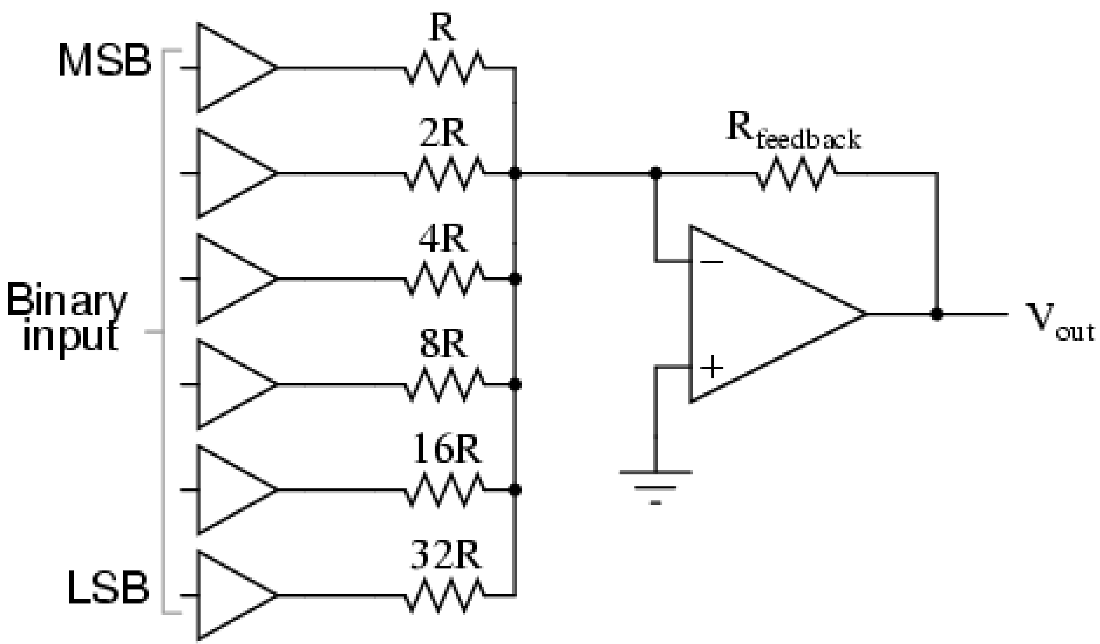

$$V_{out} = -\left(V_1 + \frac{V_2}{2} + \frac{V_3}{4}\right)$$

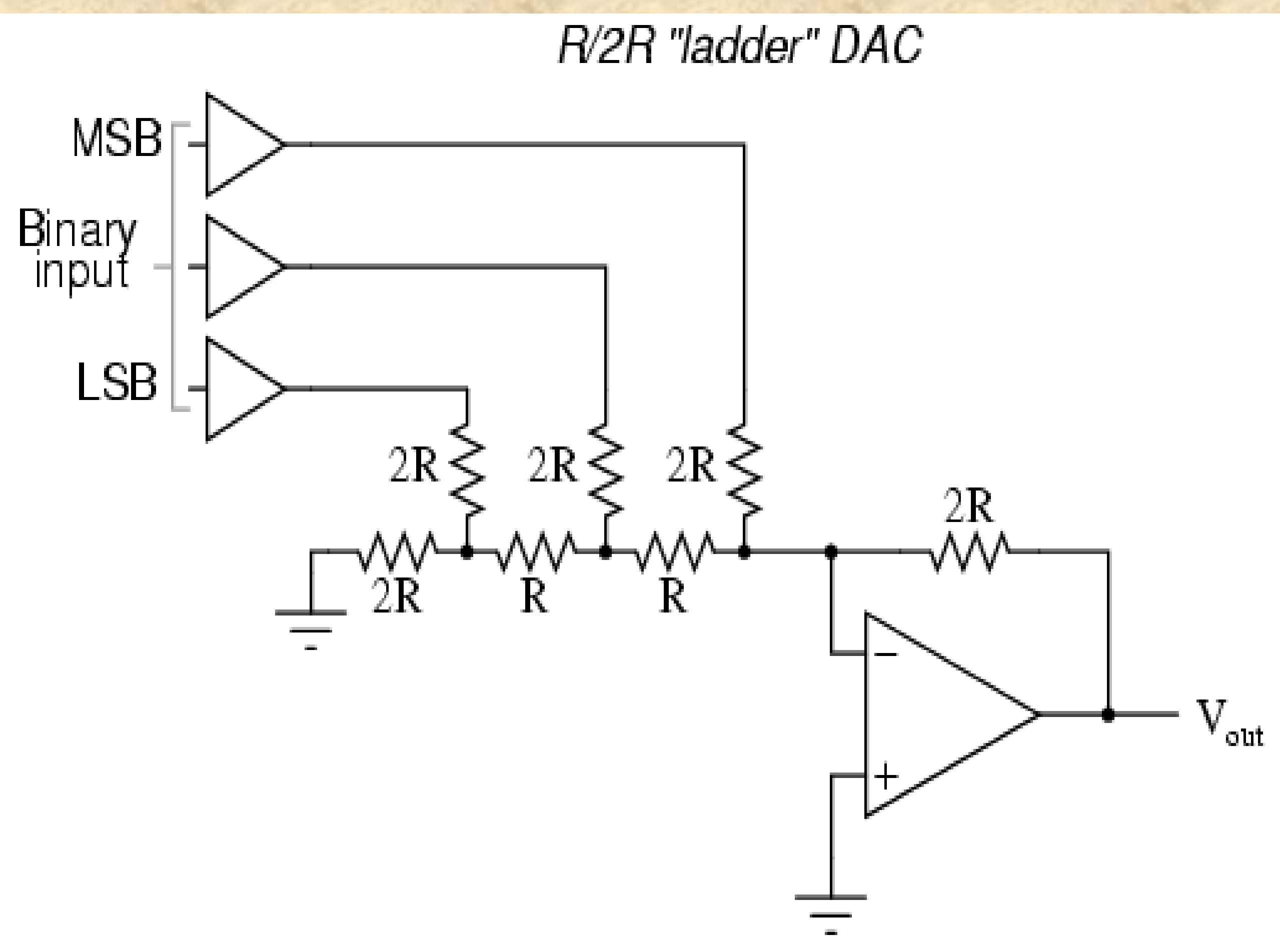



| Binary | Output voltage |
|---|---|
| 000 | 0.00 V |
| 001 | -1.25 V |
| 010 | -2.50 V |
| 011 | -3.75 V |
| 100 | -5.00 V |
| 101 | -6.25 V |
| 110 | -7.50 V |
| 111 | -8.75 V |




*6-bit binary-weighted DAC*





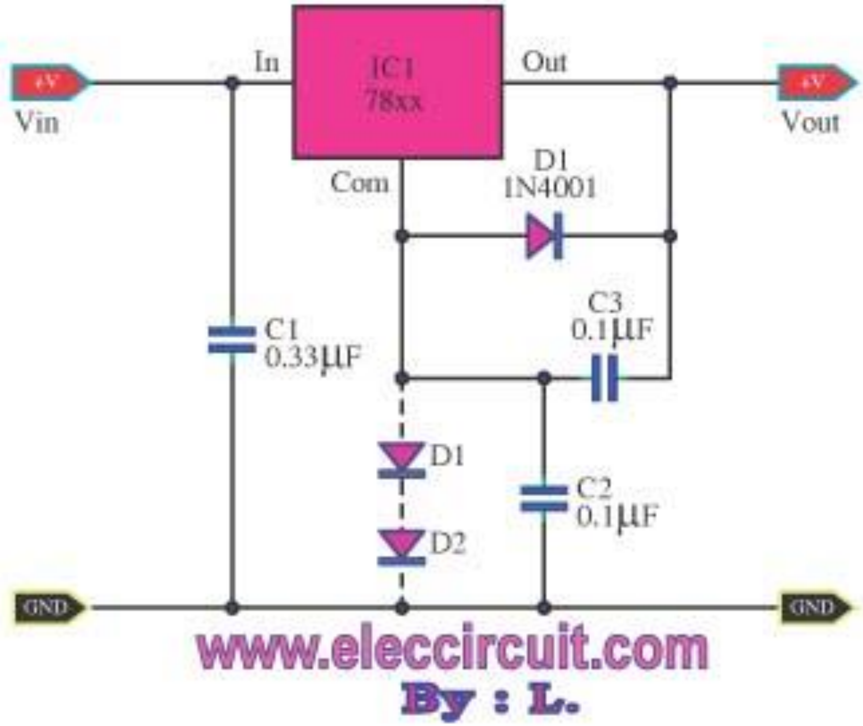

| Binary | Output voltage |
|---|---|
| 000 | 0.00 V |
| 001 | -1.25 V |
| 010 | -2.50 V |
| 011 | -3.75 V |
| 100 | -5.00 V |
| 101 | -6.25 V |
| 110 | -7.50 V |
| 111 | -8.75 V |

# Mạch ổn định điện áp

- Sử dụng diode zener
- Mạch lọc
- Mạch R-C
- Sử dụng vi mạch 78xx và 79xx

# Mạch biến đổi điện áp

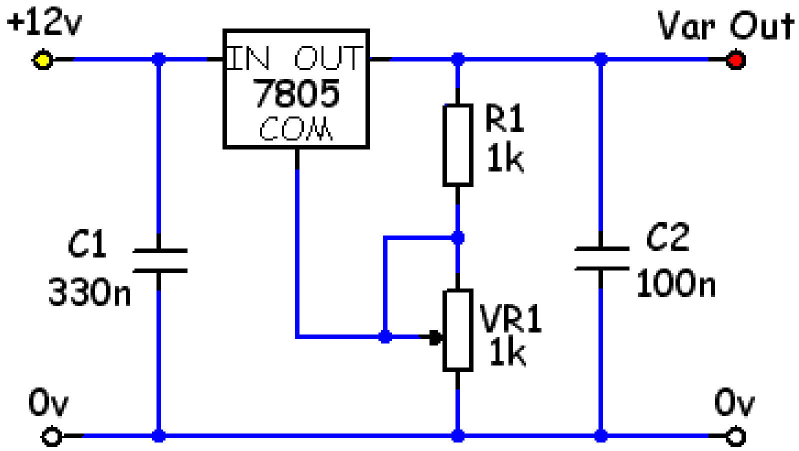
- Mạch hạ áp
- Mạch tăng áp
- Mạch tạo nhiều mức điện áp
- Mạch đẩy-kéo
- Mạch cầu




**Then, to improve the output voltage of voltage regulator better.**

**By placing a diode German Niam D1, to protect the Commonwealth to prevent the reverse bias exceeds 0.2 volt when the short-circuit. , that is, not to prevent regulator damage.**

**In addition, adding a capacitor C2 to, it also ensures that the circuit will have a better image stability. The diodes D1 and D2 (for example) increases the output voltage to rise about 1.3 volts.**




*Vout = 5(1 + VR1/R1) + (Iq * VR1')*

Iq is typically about 4mA

Four most commonly used switching converter types:
Buck: used the reduce a DC voltage to a lower DC voltage.
Boost: provides an output voltage that is higher than the input.
Buck-Boost (invert): an output voltage is generated opposite in polarity to the input.
Flyback: an output voltage that is less than or greater than the input can be
generated, as well as multiple outputs.

Some multiple-transistor converter topologies will be presented:
Push-Pull: A two-transistor converter that is especially efficient at low input voltages.
Half-Bridge: A two-transistor converter used in many off-line applications.
Full-Bridge: A four-transistor converter (usually used in off-line designs) that can generate the highest output power of all the types listed.

**BUCK REGULATOR**

The most commonly used switching converter is the Buck, which is used to down-convert a DC voltage to a lower DC voltage of the same polarity. This is essential in systems that use distributed power rails (like 24V to 48V), which must be locally converted to 15V, 12V or 5V with very little power loss.

The Buck converter uses a transistor as a switch that alternately connects and disconnects the input voltage to an inductor

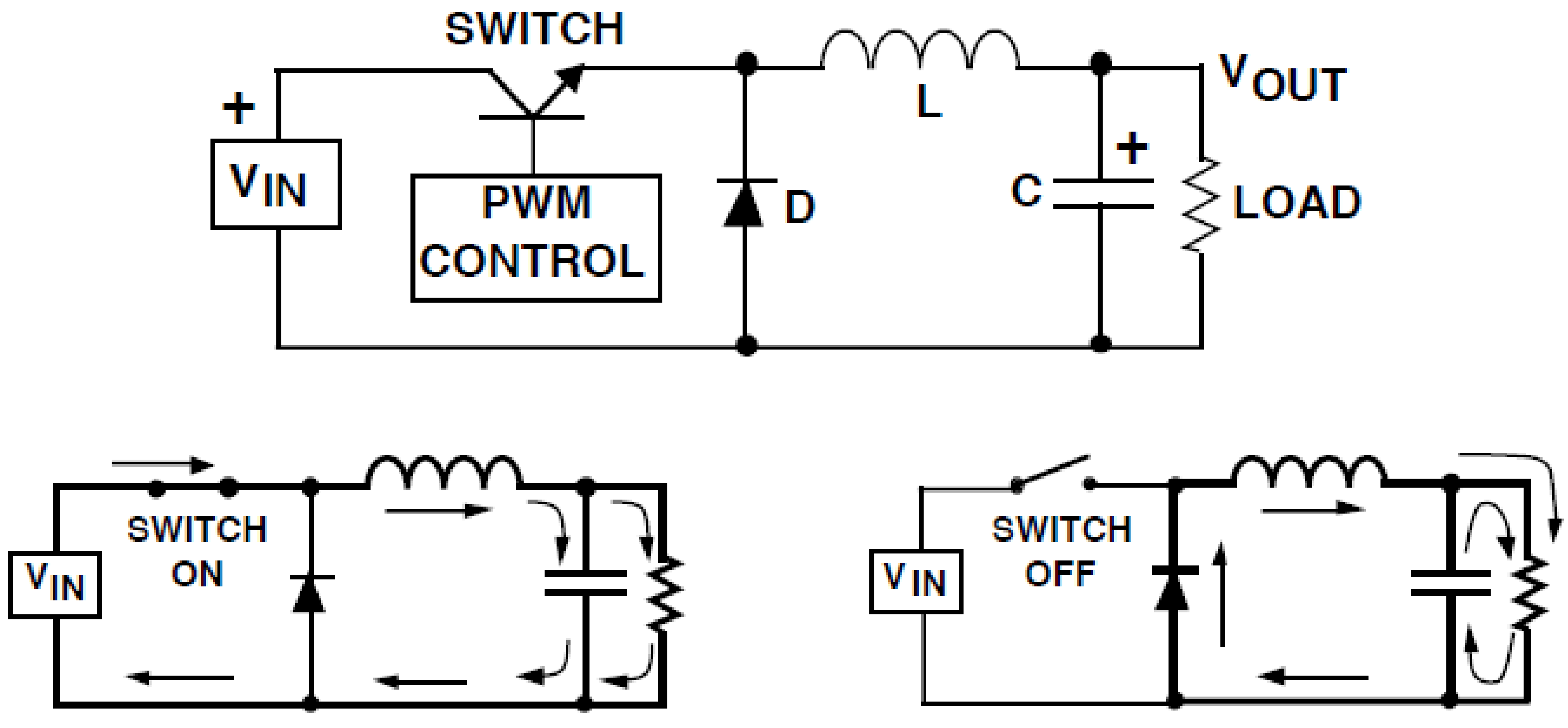
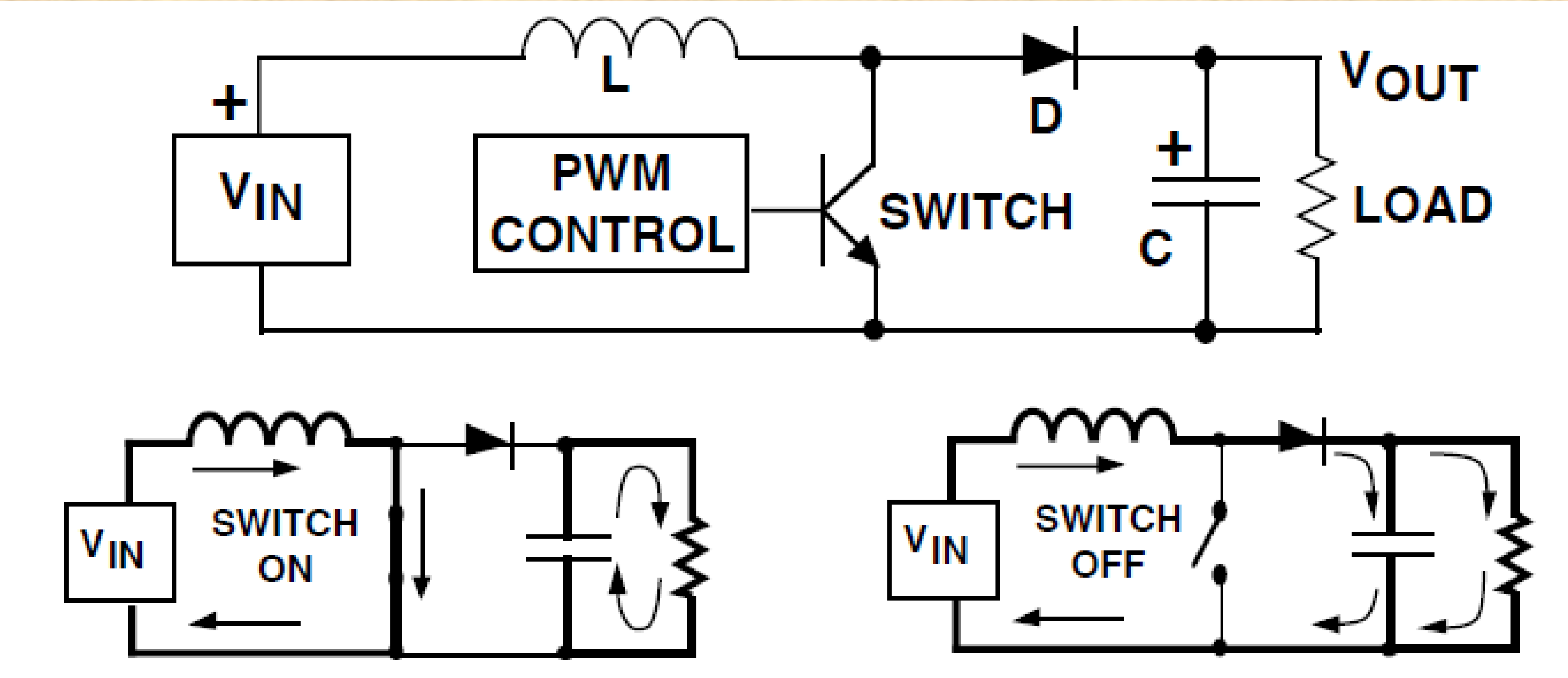



FIGURE 29. BUCK REGULATOR

**BOOST REGULATOR**

The Boost regulator takes a DC input voltage and produces a DC output voltage that
is higher in value than the input (but of the same polarity). The Boost regulator is shown in Figure 31, along with details showing the path of current flow during the switch on and off time.



# BUCK-BOOST (INVERTING) REGULATOR

The Buck-Boost or Inverting regulator takes a DC input voltage and produces a DC output voltage that is opposite in polarity to the input.  The negative output voltage can be either larger or smaller in magnitude than the input voltage.

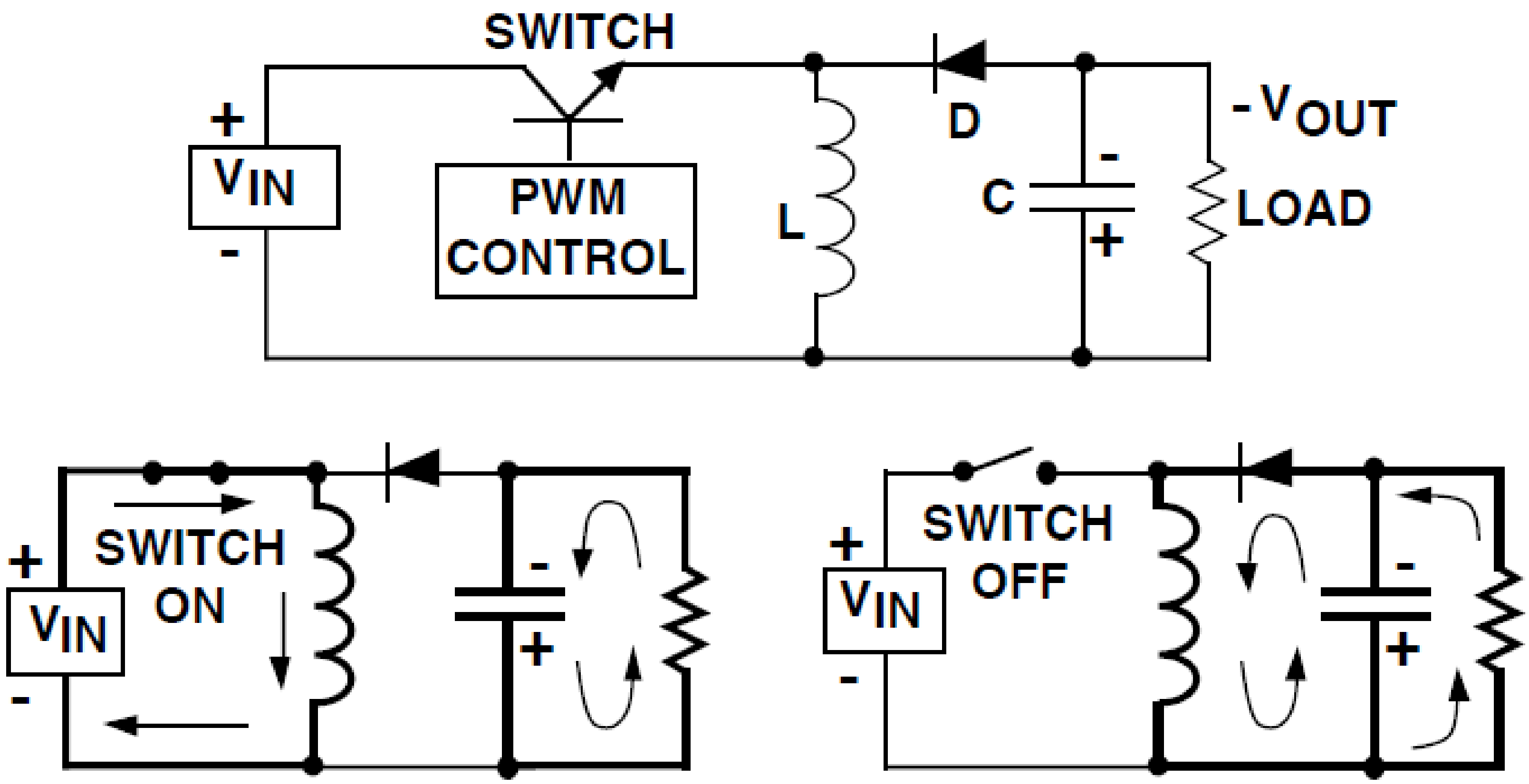
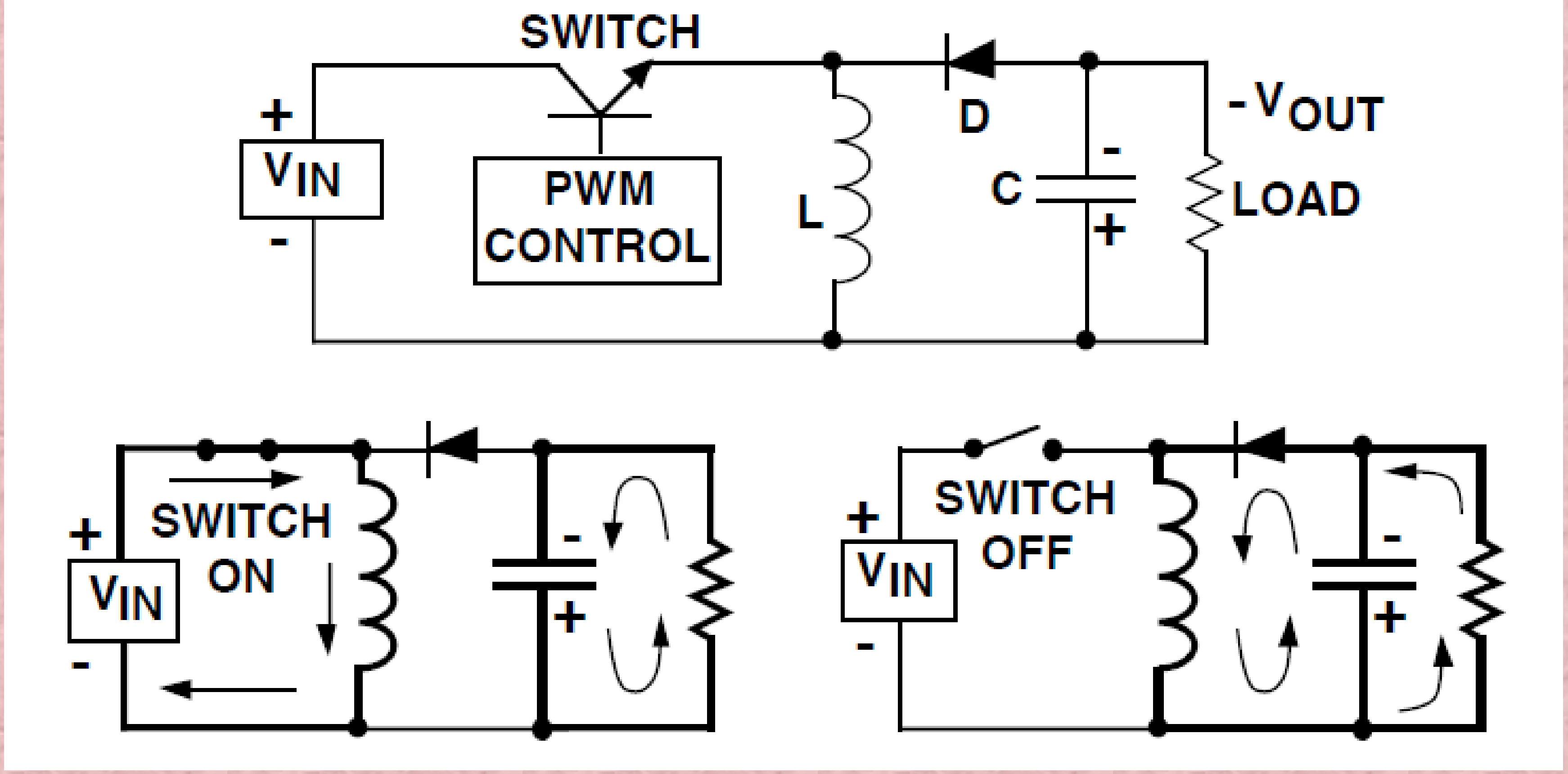



FIGURE 32.  BUCK-BOOST (INVERTING) REGULATOR

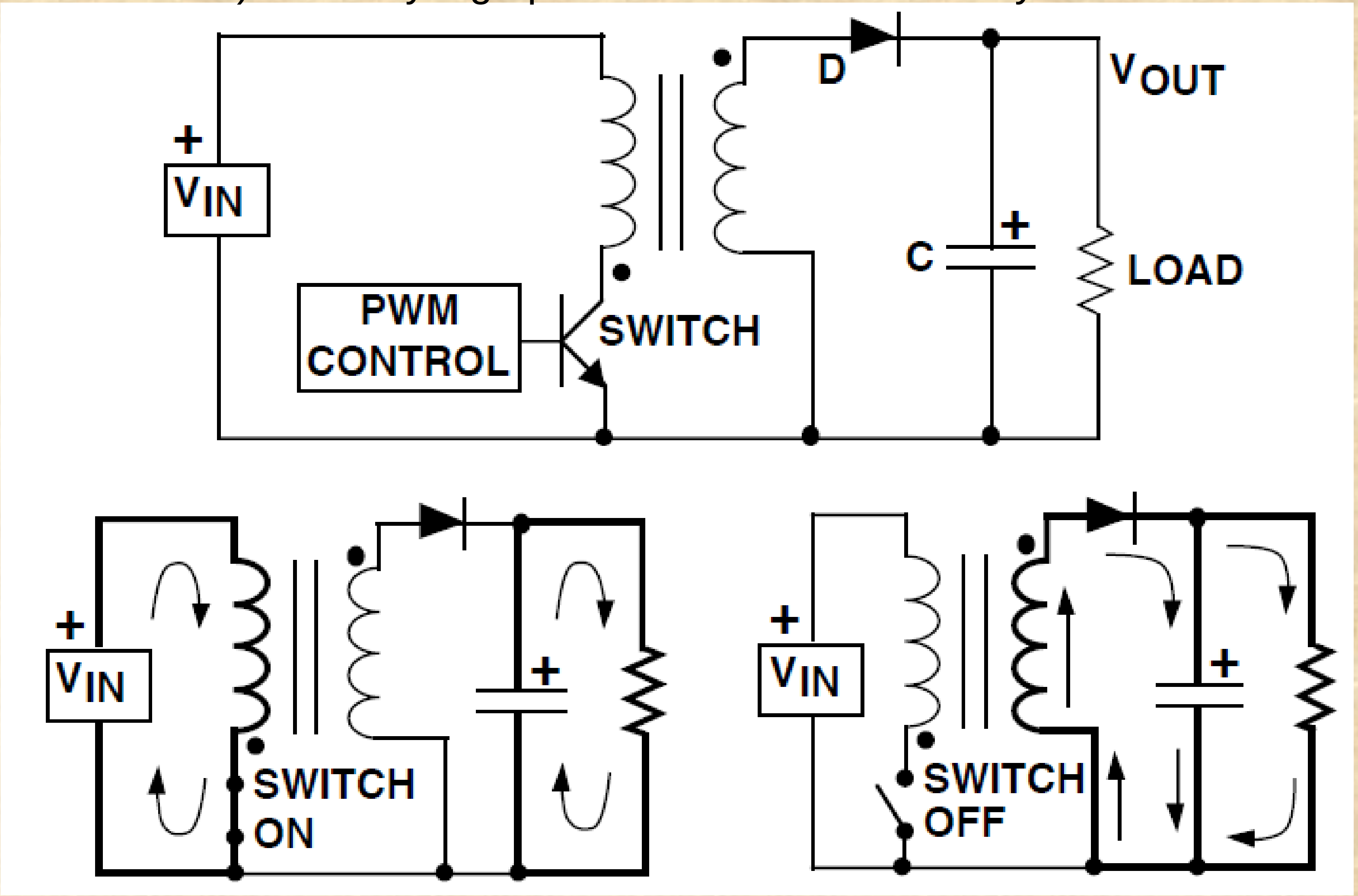
**BUCK-BOOST (INVERTING) REGULATOR**

The Buck-Boost or Inverting regulator takes a DC input voltage and produces a DC output voltage that is opposite in polarity to the input. The negative output voltage can be either larger or smaller in magnitude than the input voltage.



## FLYBACK REGULATOR

The Flyback is the most versatile of all the topologies, allowing the designer to create one or more output voltages, some of which may be opposite in polarity. Flyback converters have gained popularity in battery-powered systems, where a single voltage must be converted into the required system voltages (for example, +5V, +12V and -12V) with very high power conversion efficiency



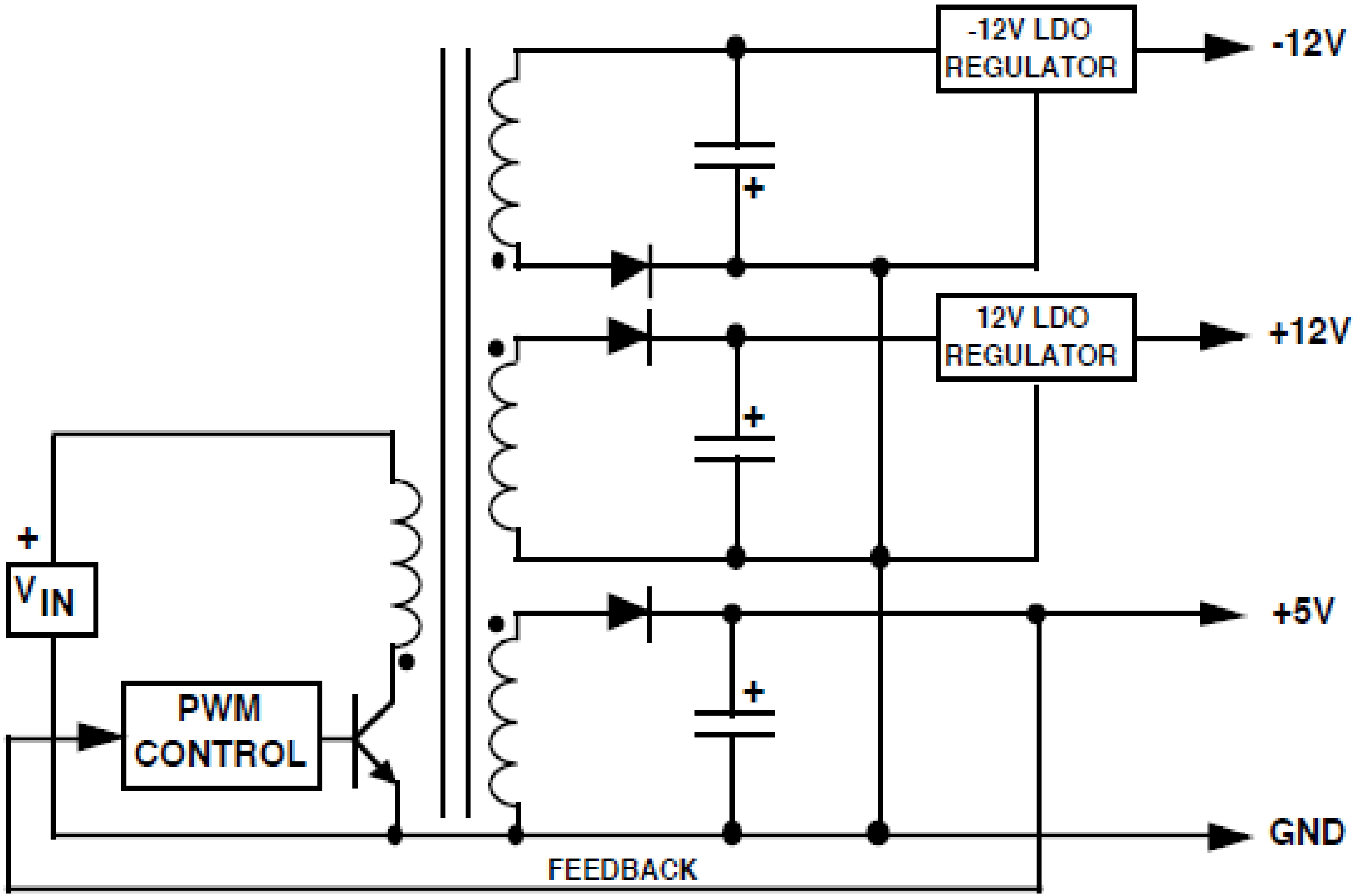
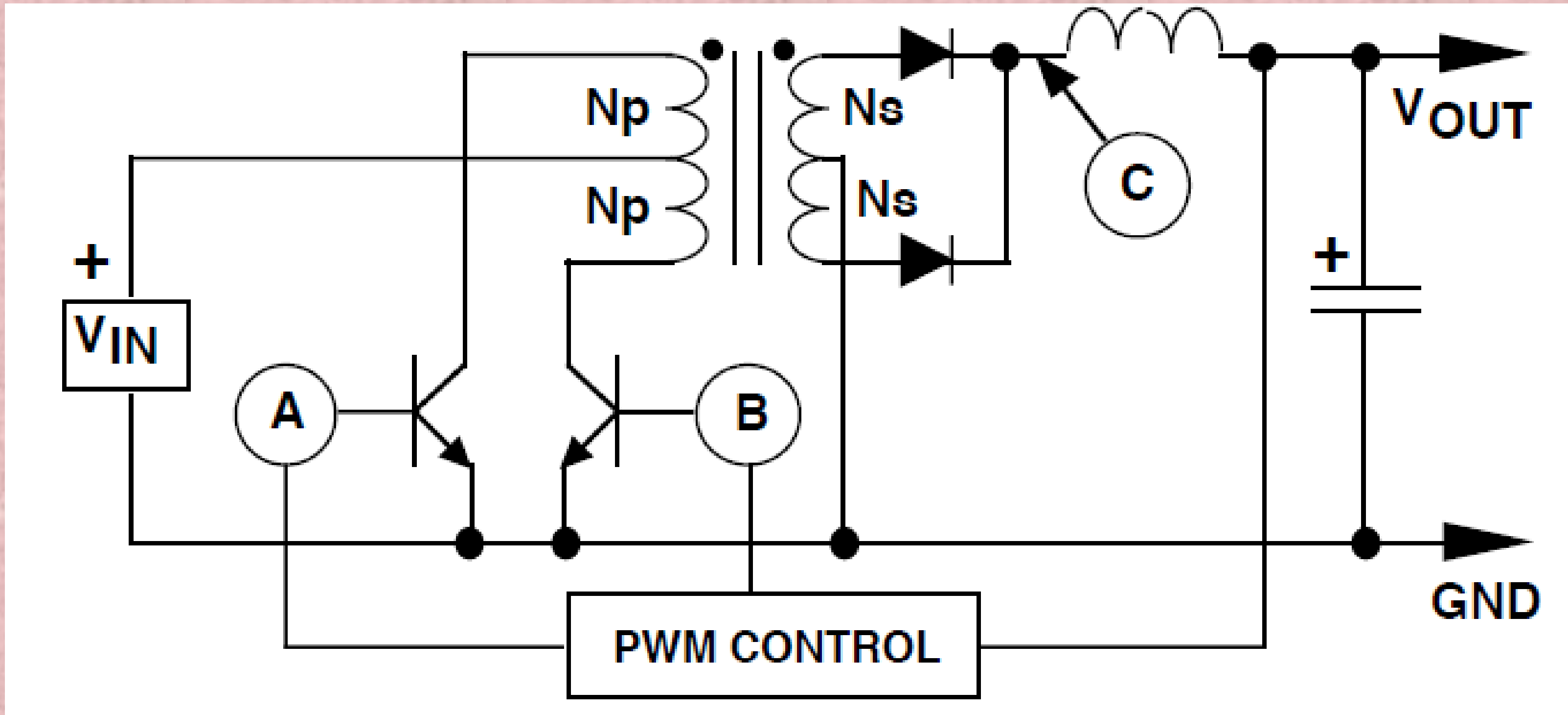



FIGURE 34. TYPICAL MULTIPLE-OUTPUT FLYBACK

**PUSH-PULL CONVERTER**

The Push-Pull converter uses two to transistors perform DC-DC conversion



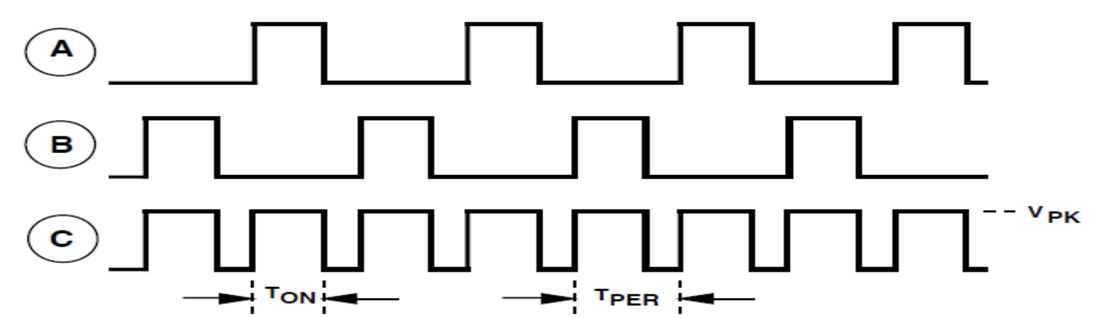




FIGURE 36. TIMING DIAGRAM FOR PUSH-PULL CONVERTER

**HALF-BRIDGE CONVERTER**

The Half-Bridge is a two-transistor converter frequently used in high-power designs. It is well-suited for applications requiring load power in the range of 500W to 1500W, and is almost always operated directly from the AC line.

Off-line operation means that no large 60 Hz power transformer is used, eliminating the heaviest and costliest component of a typical transformer-powered supply. All of the transformers in the Half-Bridge used for power conversion operate at the switching frequency (typically 50 kHz or higher) which means they can be very small and efficient.

A very important advantage of the Half-Bridge is **input-to-output isolation** (the regulated DC output is electrically isolated from the AC line). But, this means that all of the PWM control circuitry must be referenced to the DC output ground.

If a 230 VAC line voltage is rectified by a full-wave bridge and filtered by a capacitor, an unregulated DC voltage of about 300V will be available for DC-DC conversion. If 115 VAC is used, a voltage doubler circuit is typically used to generate the 300V rail.

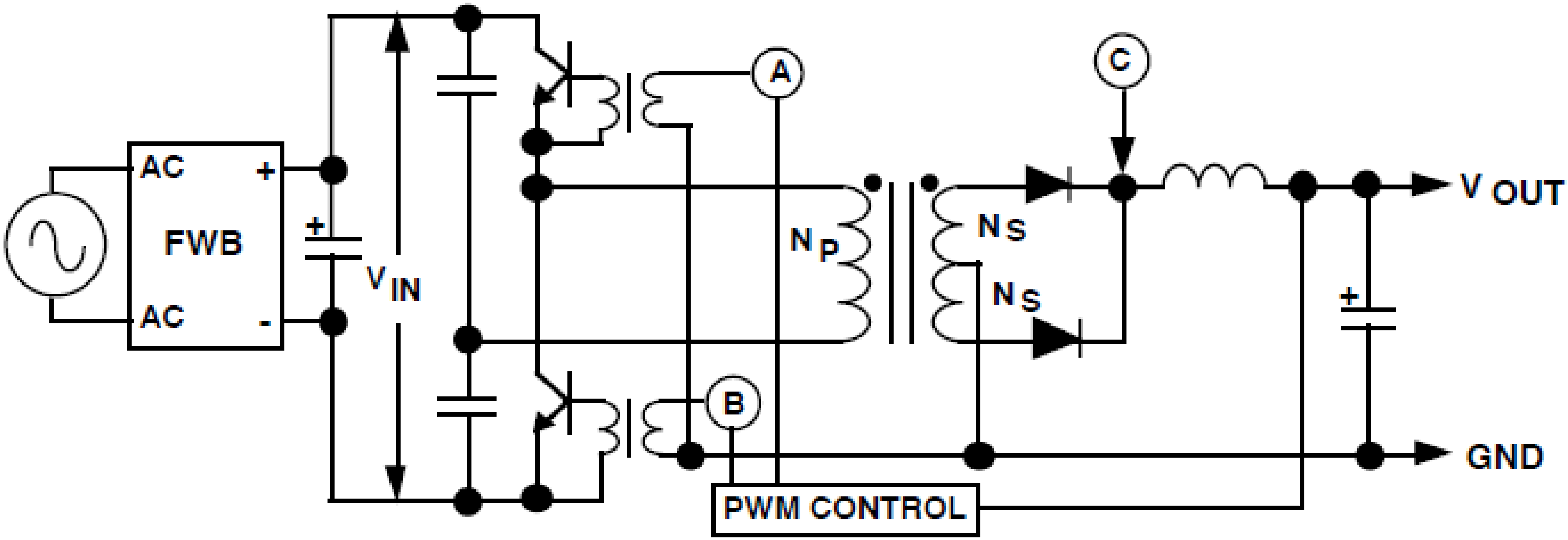



FIGURE 37. HALF-BRIDGE CONVERTER

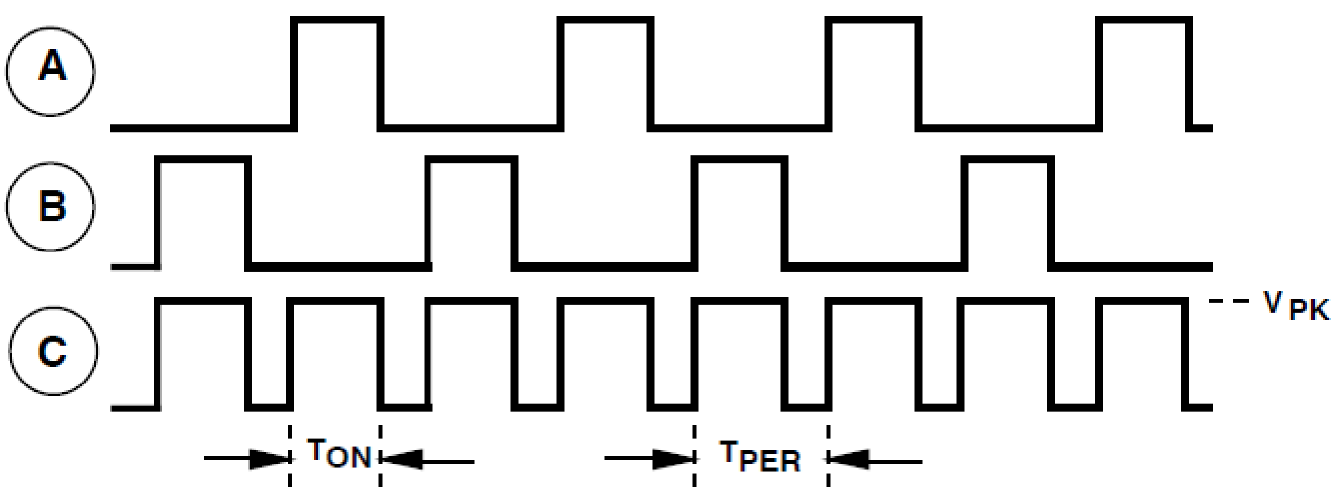



FIGURE 38. TIMING DIAGRAM FOR HALF-BRIDGE CONVERTER

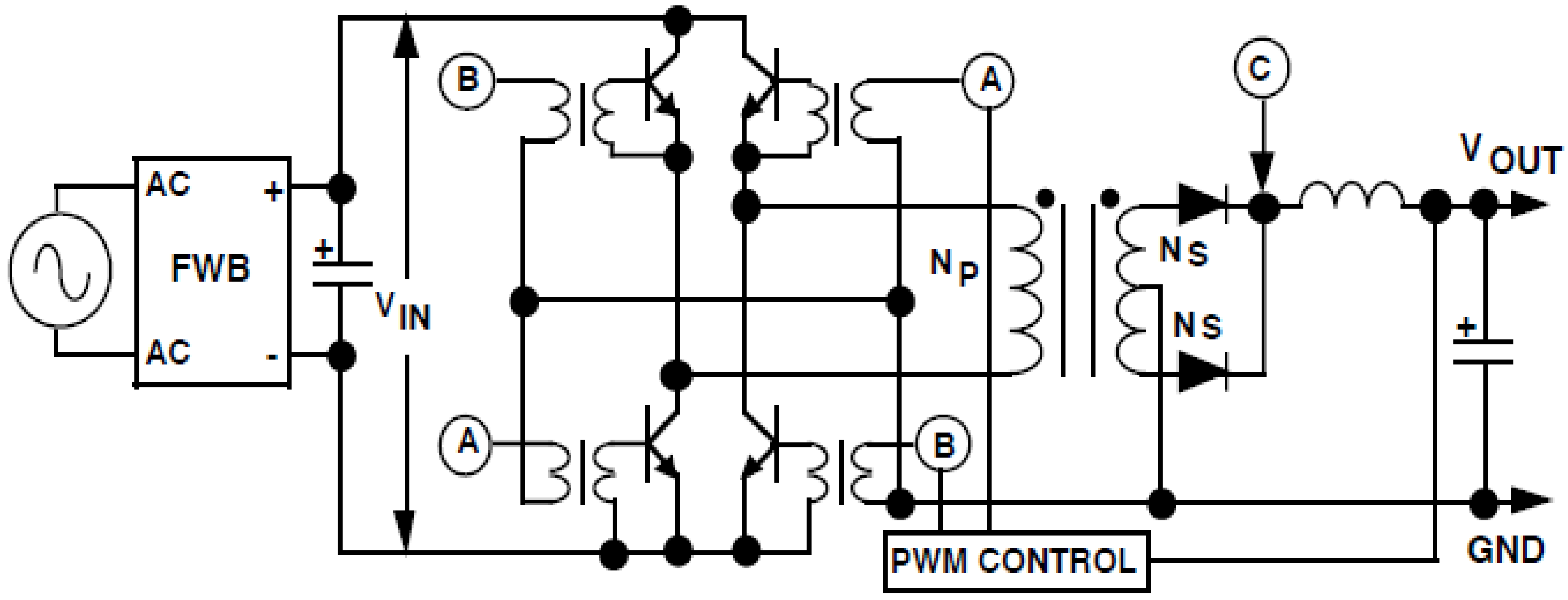
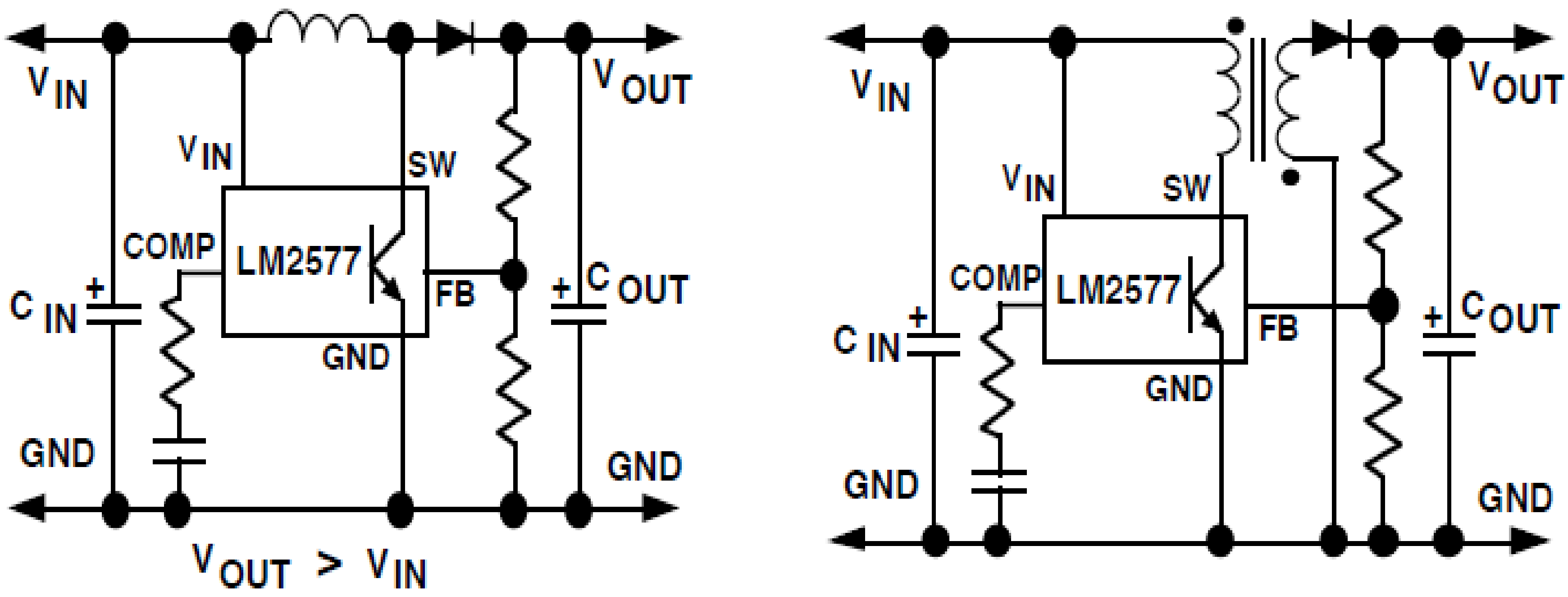



FIGURE 39. FULL BRIDGE CONVERTER




BOOST REGULATOR

FLYBACK REGULATOR

FIGURE 49. BASIC APPLICATION CIRCUITS FOR THE LM2577

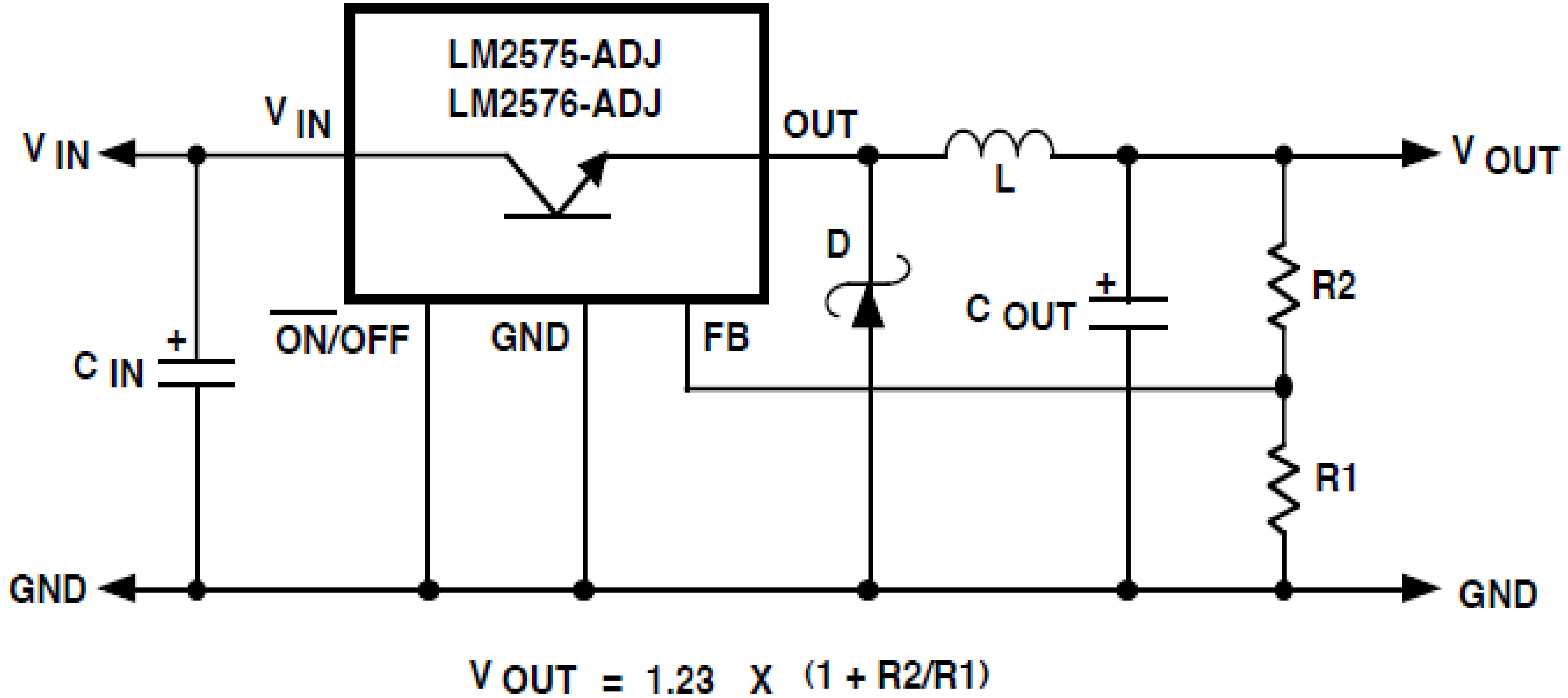



FIGURE 53. LM2575 AND LM2576 BUCK REGULATOR APPLICATION

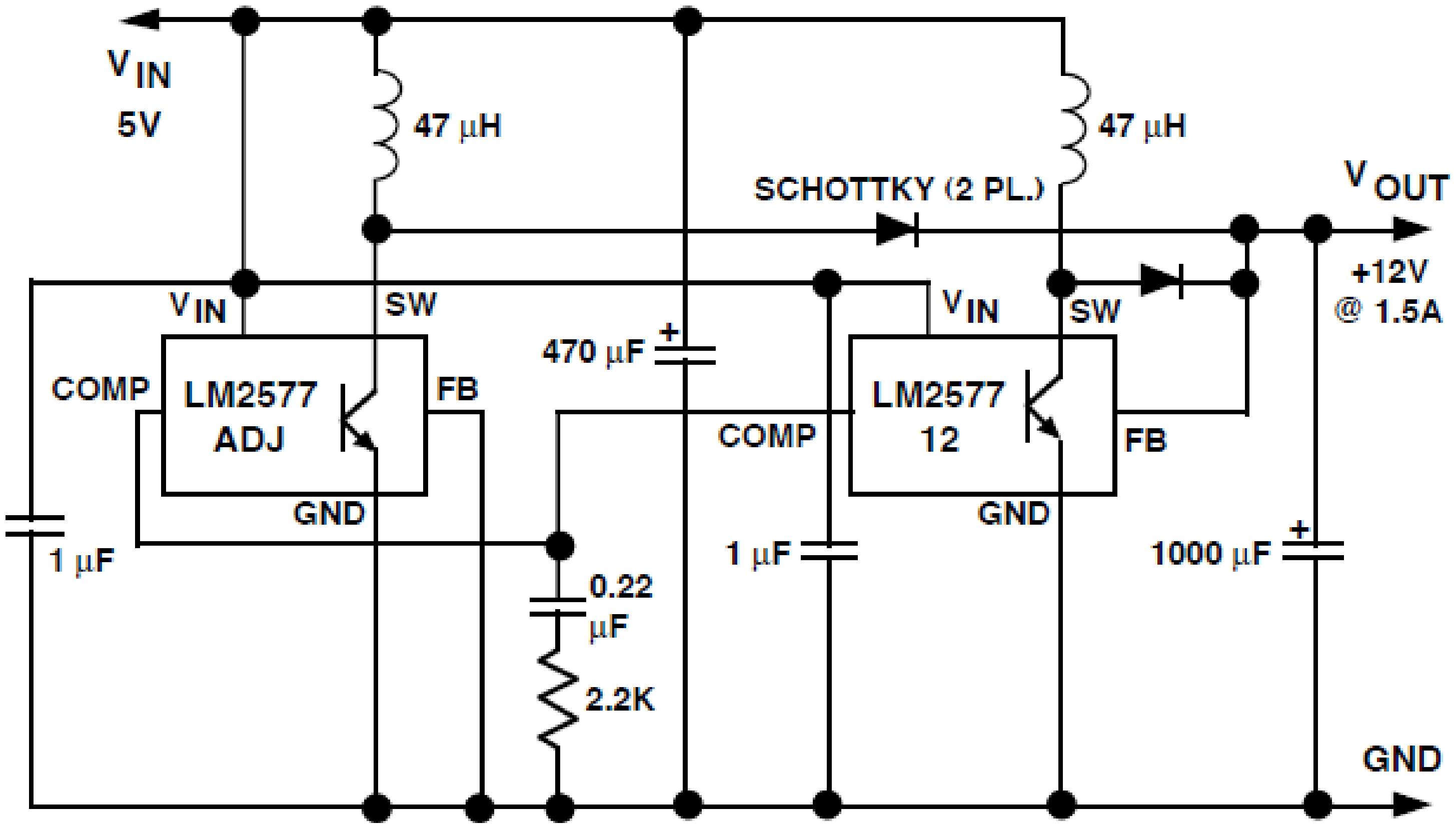
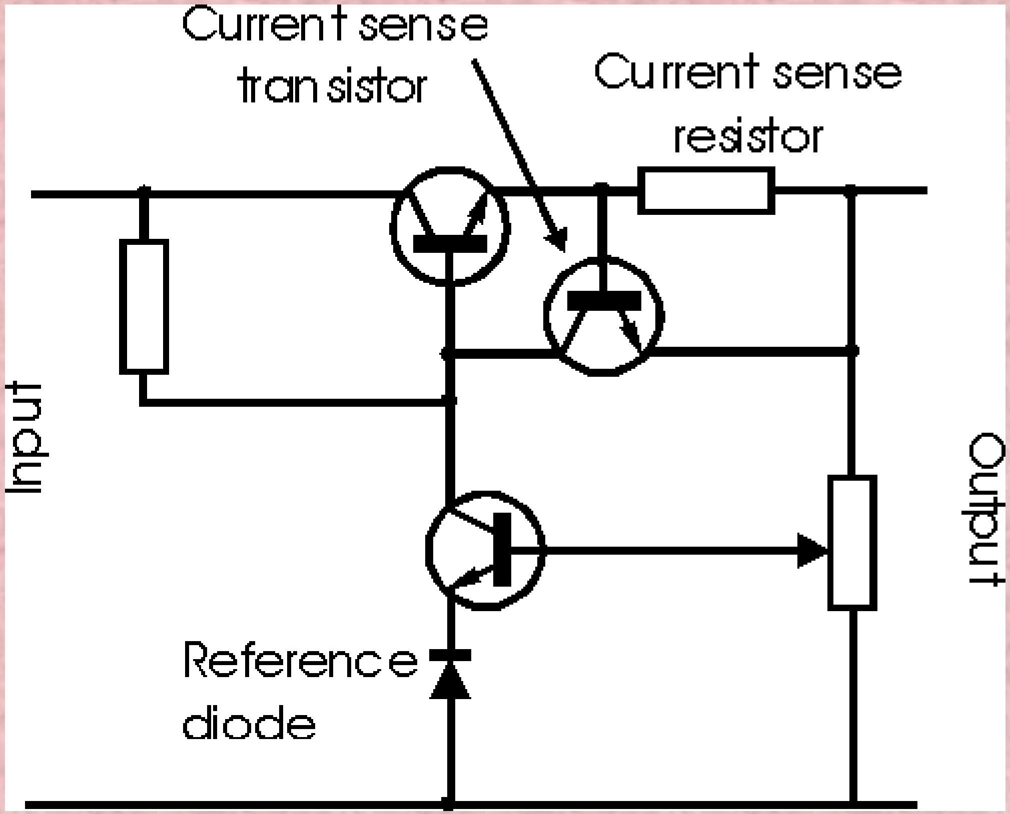



FIGURE 50. DUAL LM2577 BOOST CIRCUIT

# Mạch hạn chế dòng điện




When the power supply is supplying current below the maximum level, current flows through the sense resistor and a small potential difference develops across it. The value of the resistor is chosen so that at when the maximum allowable current flows from the power supply, a voltage equal to the turn on voltage of the current sense transistor is developed across it. This is typically 0.6 volts, assuming that a silicon transistor is used.

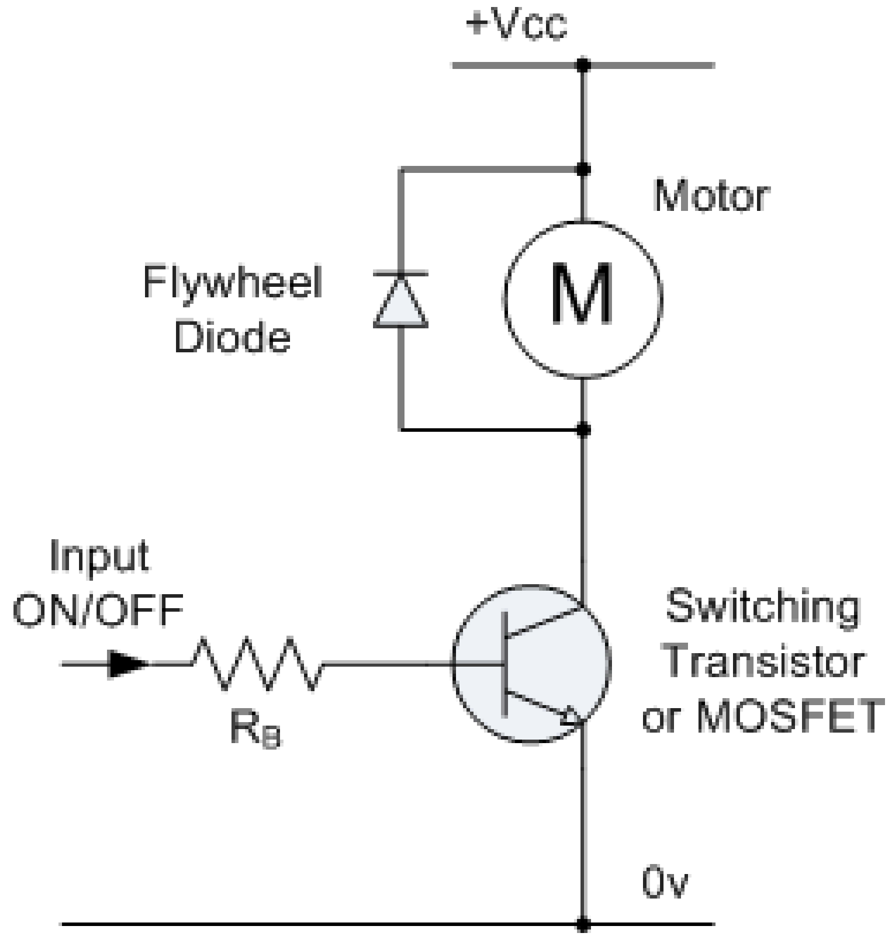
As the voltage across the current sense resistor reaches 0.6 volts, so the current sense transistor starts to turn on. When it does this, the voltage it the base of the main power supply pass transistor is pulled down, thereby preventing any increase in the output current of the power supply. In this way it is very easy to calculate the value for the sense resistor using Ohms Law. It is simply 0.6 / maximum current. The current sense transistor should have a sufficiently large current capacity to be able to take the current the base of the main series pass transistor.

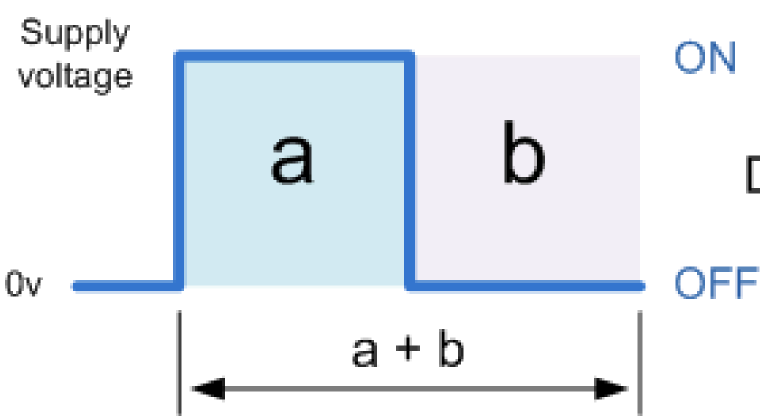
# Mạch điều khiển động cơ bước

- BJT transitors

- MOFET transitor

Stepper motors can be controlled directly using transistor switching techniques .
The speed and position of a stepper motor can be accurately controlled using pulses so can operate in an Open-loop mode



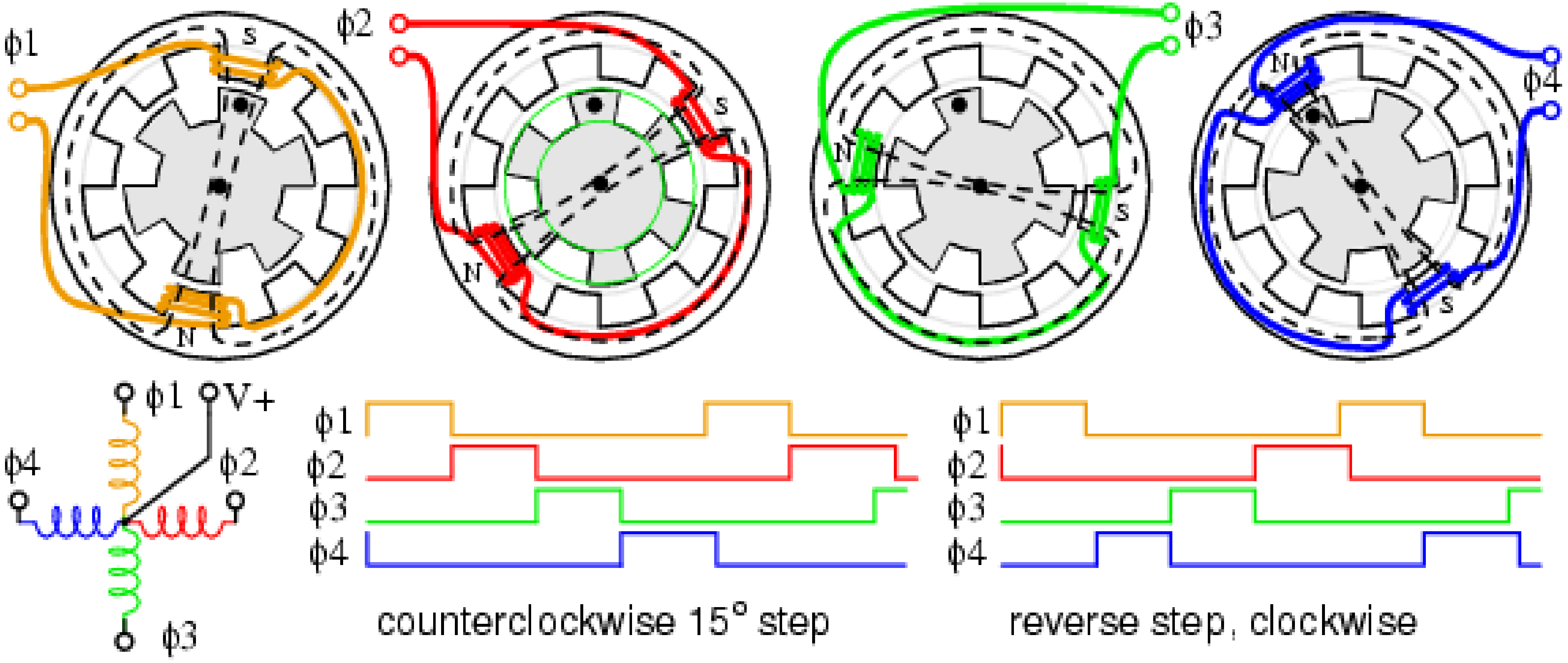



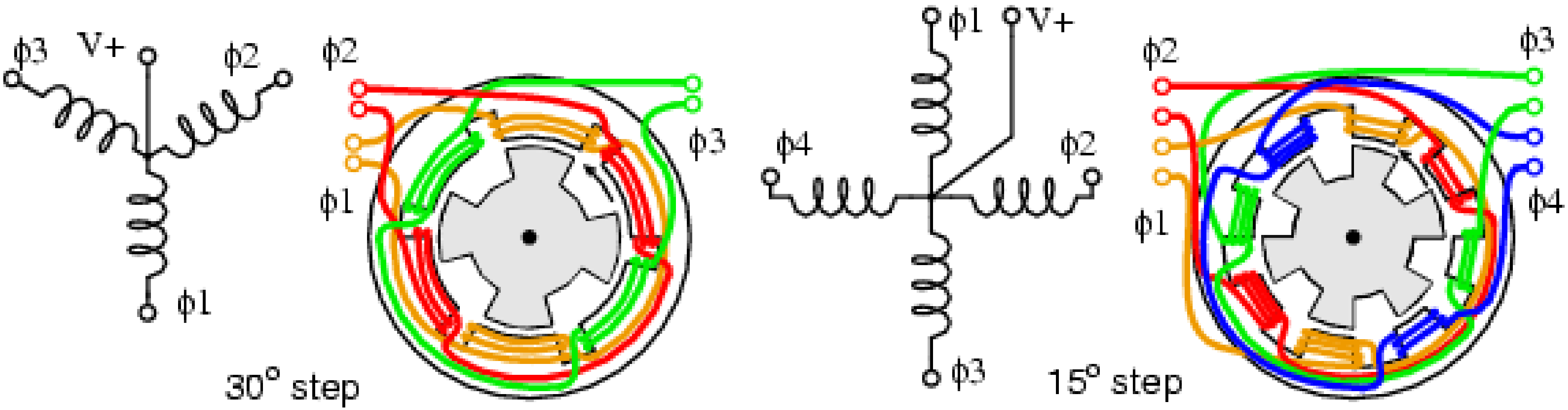

$$\text{Duty Ratio } \beta = \frac{a}{a+b}$$

# Động cơ bước kiểu từ trở thay đổi (Variable reluctance stepper)

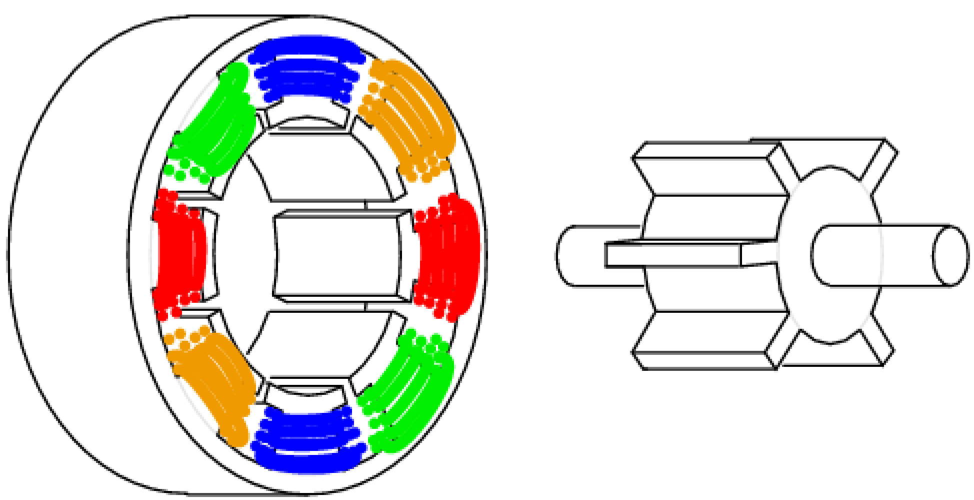
$\theta_S = 360^o/N_S$ $\theta_R = 360^o/N_R$ $\theta_{ST} = \theta_R - \theta_S$

where: $\theta_S$ = stator angle, $\theta_R$ = Rotor angle, $\theta_{ST}$ = step angle
$N_S$ = number stator poles, $N_P$ = number rotor poles

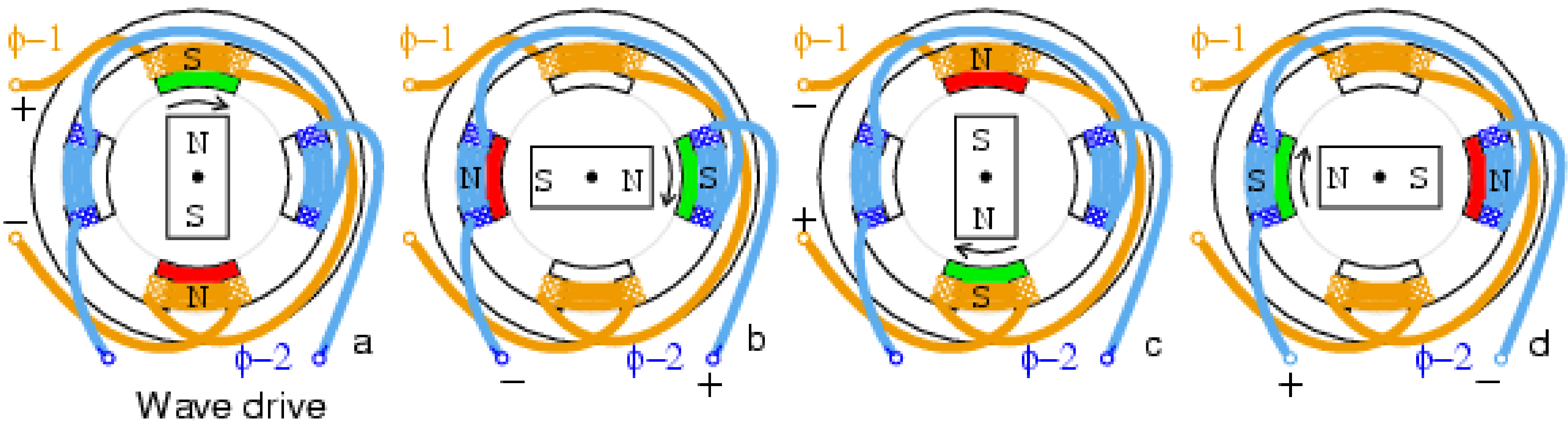




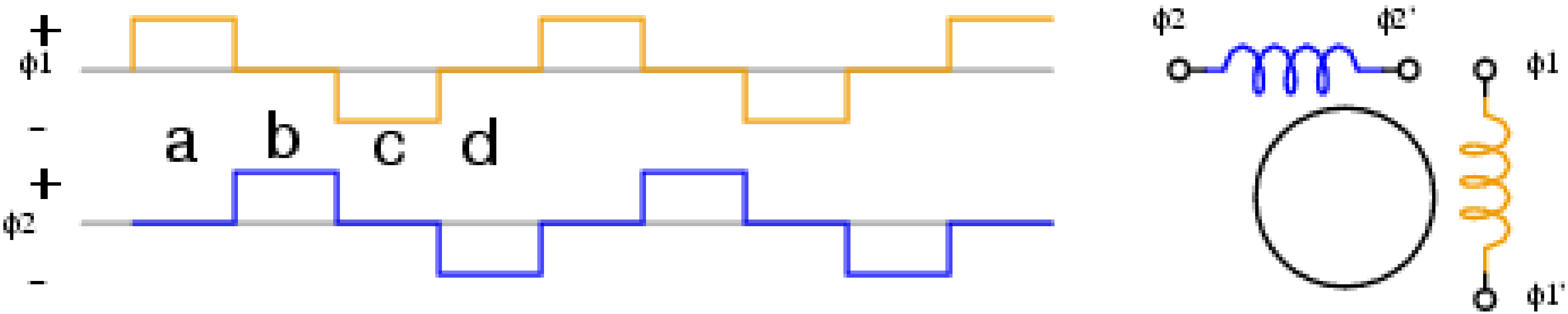

*Three phase and four phase variable reluctance stepper motors*



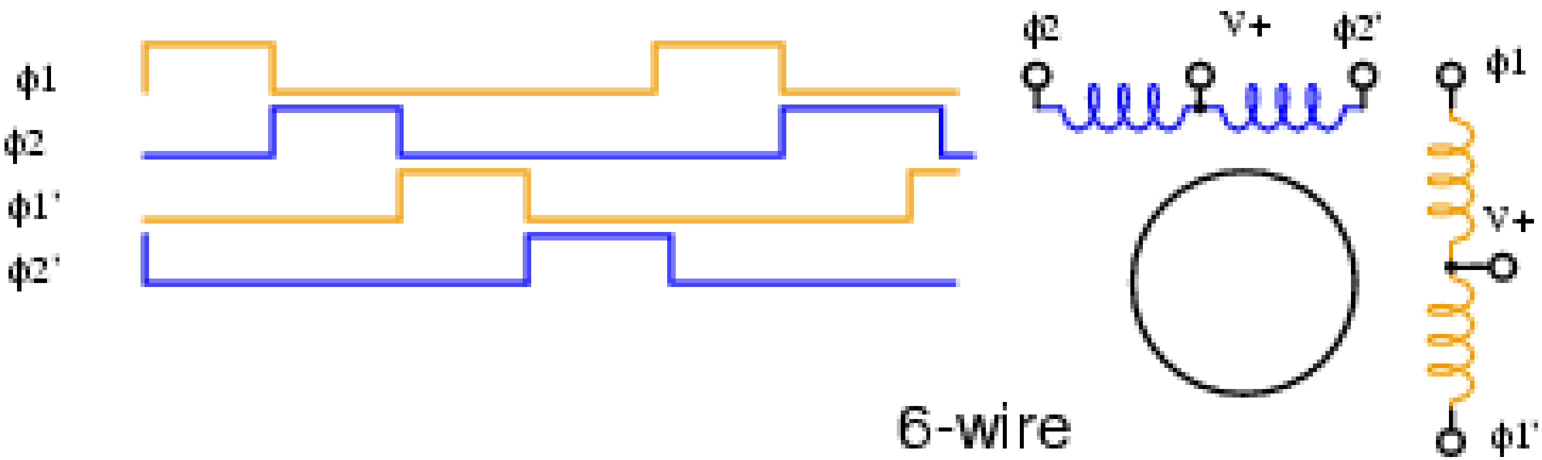
# Động cơ bước có rotor nam châm vĩnh cửu
# Permanent magnet stepper



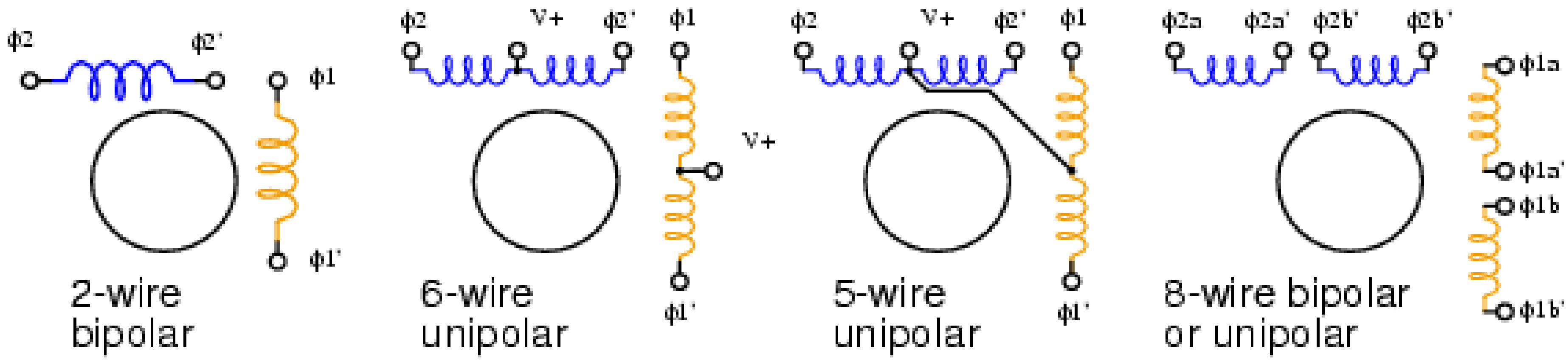

*PM wave drive sequence (a) φ1+ ,   (b) φ2+ ,   (c) φ1- ,  (d) φ2-.*




*Waveforms: bipolar wave drive*




*Waveforms: unipolar wave drive.*




*Stepper motor wiring diagrams*

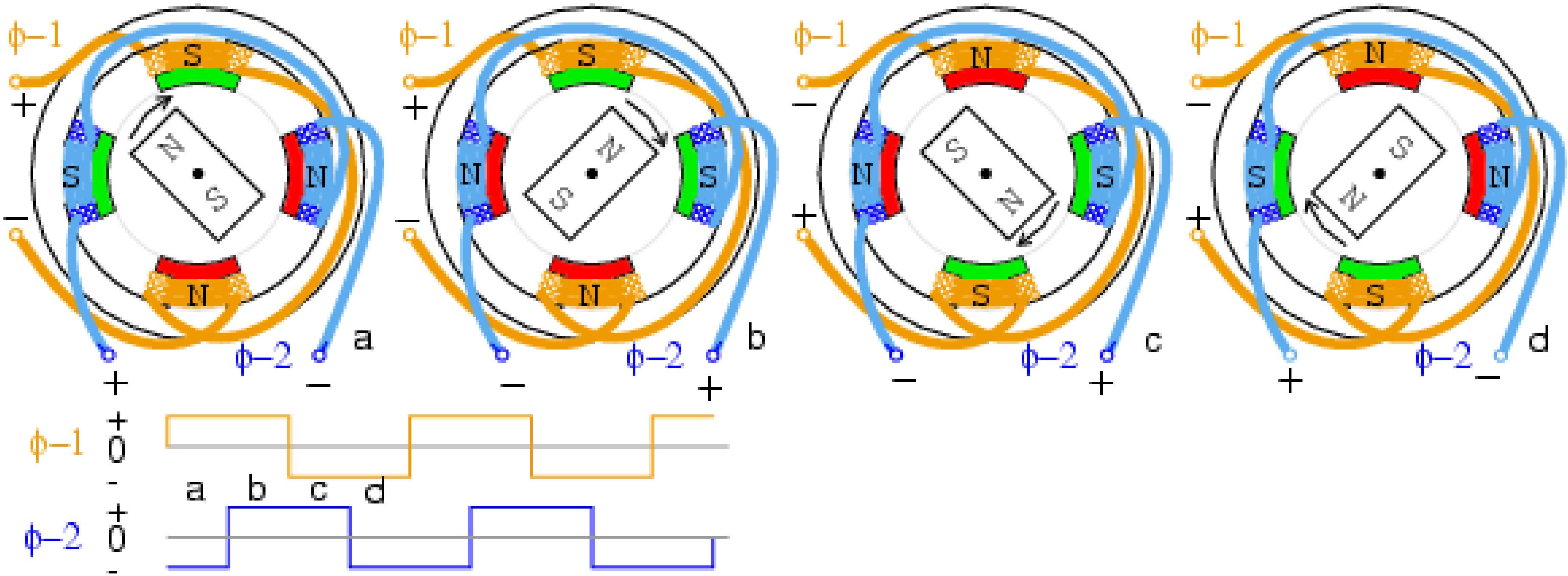
The 4-wire motor can only be driven by bipolar waveforms.

The 6-wire motor, the most common arrangement, is intended for unipolar drive because of the center taps. May be driven by bipolar waves if the center taps are ignored.

The 5-wire motor can only be driven by unipolar waves, as the common center tap interferes if both windings are energized simultaneously.

The 8-wire configuration is rare, but provides maximum flexibility. It may be wired for unipolar drive as for the 6-wire or 5-wire motor.
A pair of coils may be connected in series for high voltage bipolar low current drive, or in parallel for low voltage high current drive.

# *Full step, bipolar drive*



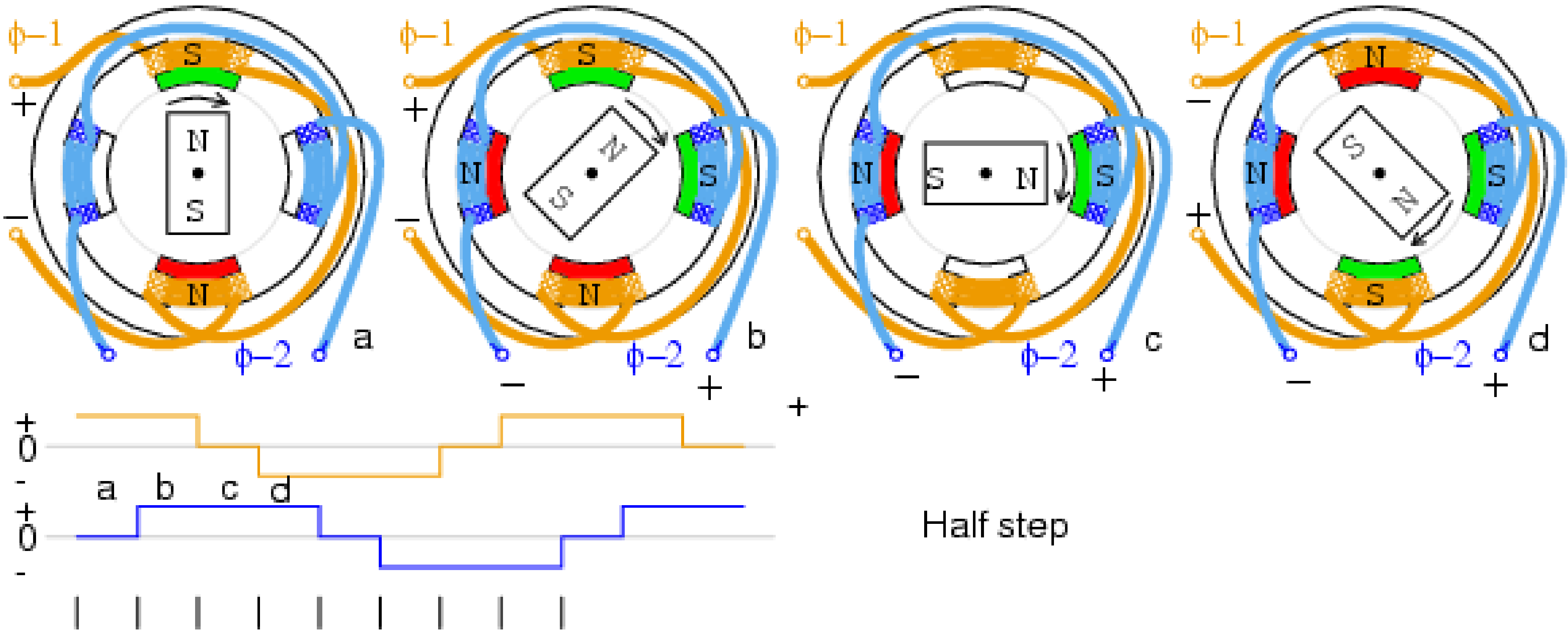

*Full step* drive provides more torque than wave drive because both coils are energized at the same time. This attracts the rotor poles midway between the two field poles.

Full step bipolar drive has the same step angle as wave drive.

Unipolar drive (not shown) would require a pair of unipolar waveforms for each of the above bipolar waveforms applied to the ends of a center tapped winding. Unipolar drive uses a less complex, less expensive driver circuit.

The additional cost of bipolar drive is justified when more torque is required

# Half step drive

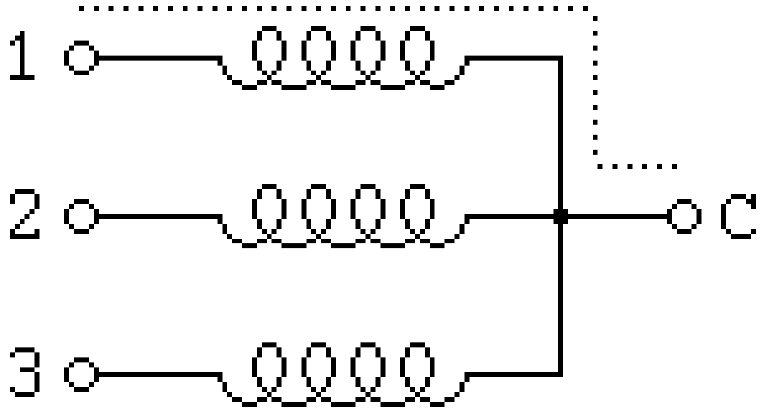


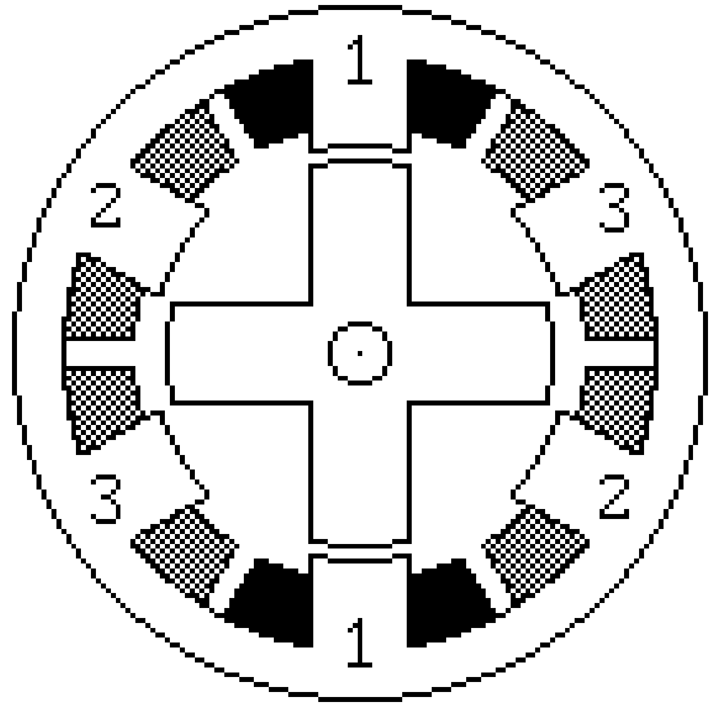

Half step

Half step drive is a combination of wave drive and full step drive with one winding energized, followed by both windings energized, yielding twice as many steps. The unipolar waveforms for half step drive are shown above.

The rotor aligns with the field poles as for wave drive and between the poles as for full step drive

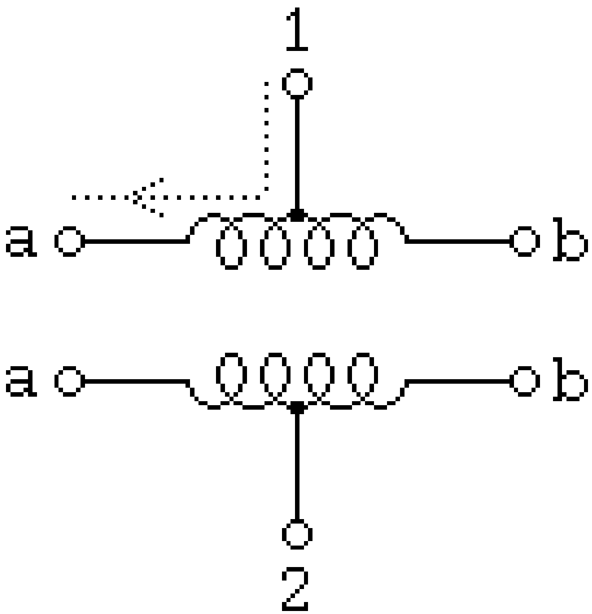
# Variable Reluctance Motors

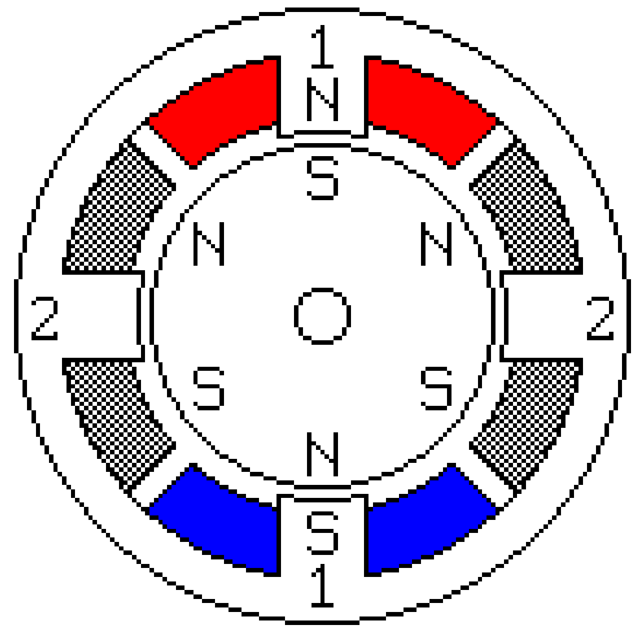



The cross section shown is of 30 degree per step variable reluctance motor. The rotor in this motor has 4 teeth and the stator has 6 poles, with each winding wrapped around two opposite poles

# Unipolar Motors

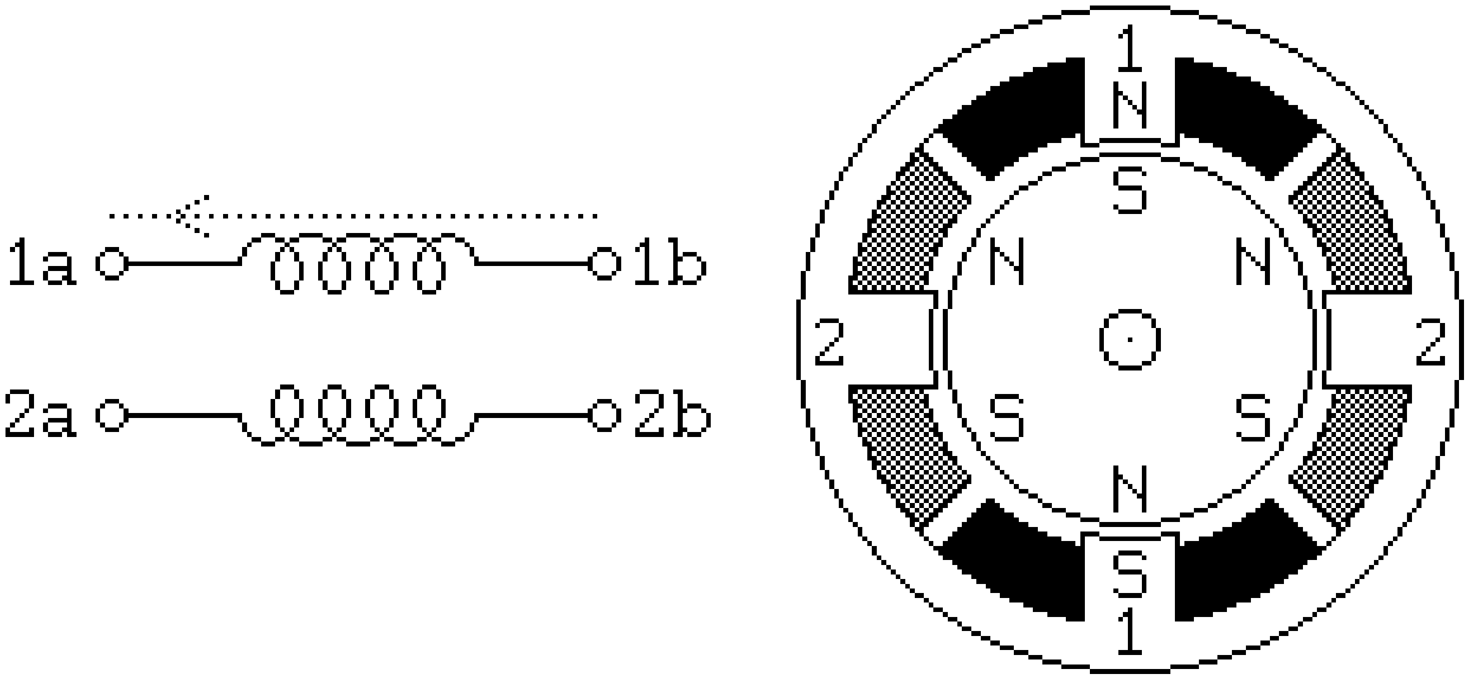



Unipolar stepping motors, both Permanent magnet and hybrid stepping motors with 5 or 6 wires are usually wired as shown in the schematic, with a center tap on each of two windings. In use, the center taps of the windings are typically wired to the positive supply, and the two ends of each winding are alternately grounded to reverse the direction of the field provided by that winding

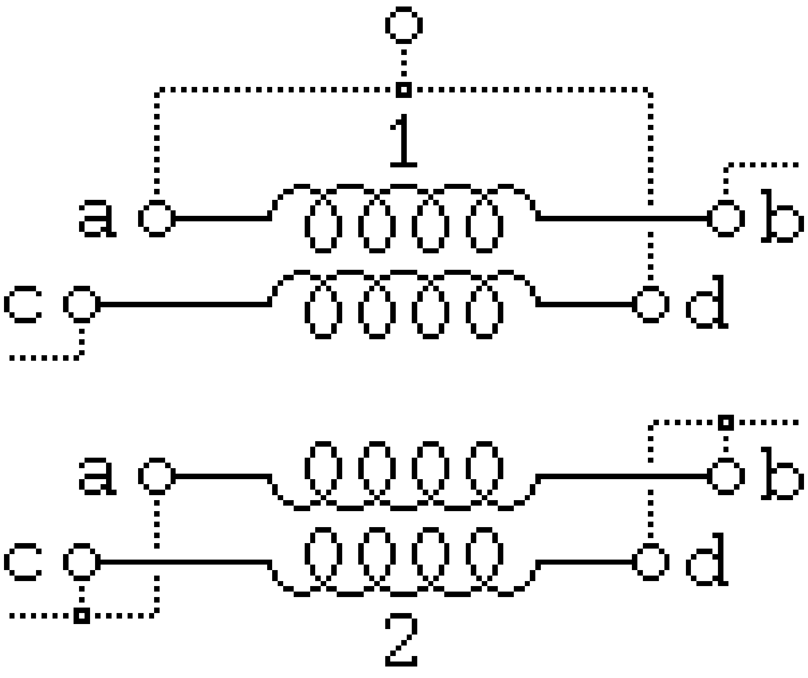
The motor cross section shown in Figure is of a 30 degree per step permanent magnet or hybrid motor -- the difference between these two motor types is not relevant at this level of abstraction

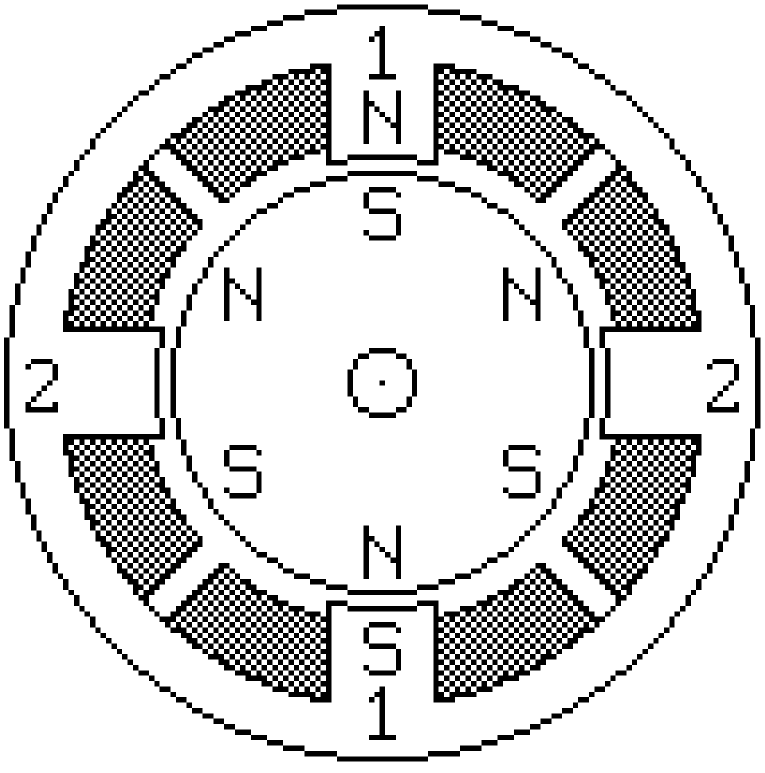
# Bipolar Motors




Bipolar permanent magnet and hybrid motors are constructed with exactly the same mechanism as is used on unipolar motors, but the two windings are wired more simply, with no center taps. Thus, the motor itself is simpler but the drive circuitry needed to reverse the polarity of each pair of motor poles is more complex

# Bifilar Motors



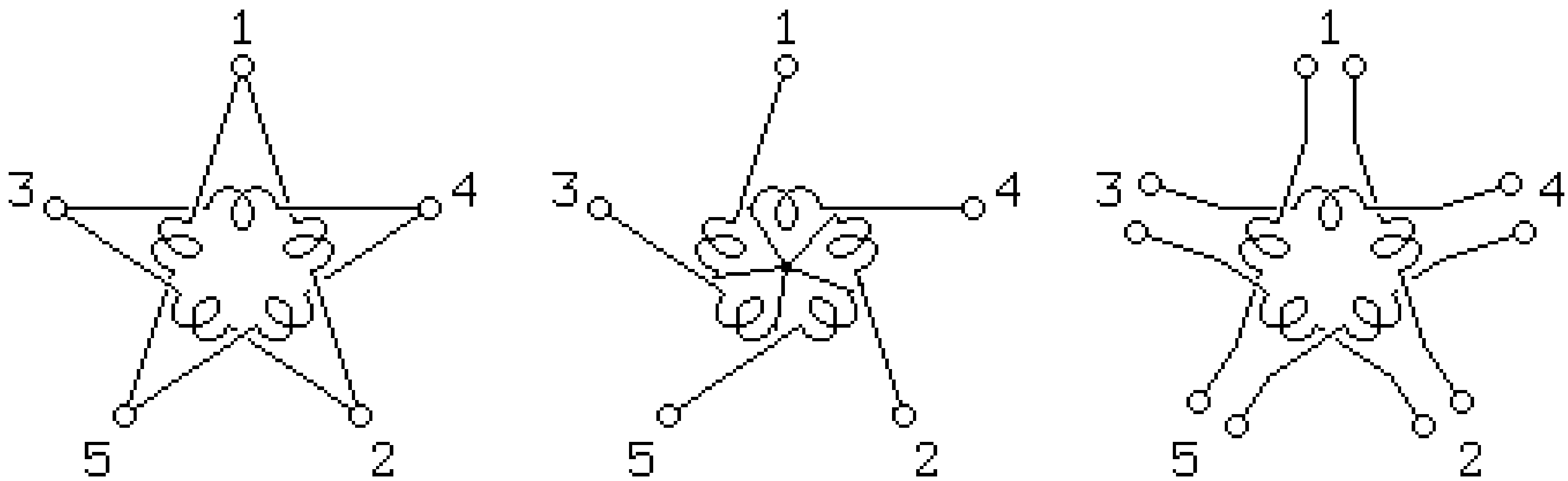




Bifilar windings on a stepping motor are applied to the same rotor and stator Geometry as a bipolar motor, but instead of winding each coil in the stator with a
single wire, two wires are wound in parallel with each other.
As a result, the motor has 8 wires, not four

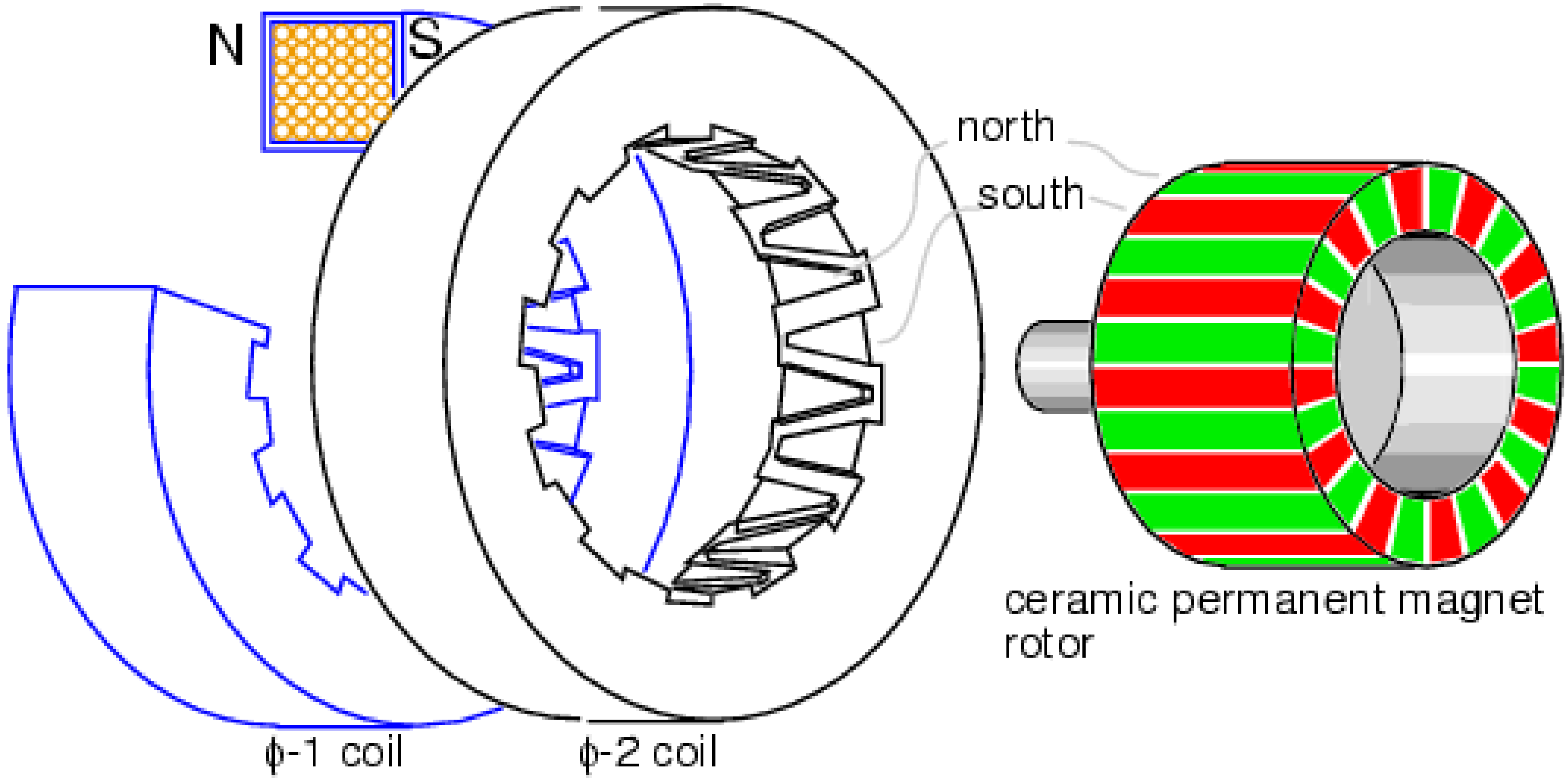
In practice, motors with bifilar windings are always powered as either unipolar or bipolar motors. Figure 1.4 shows the alternative connections to the windings of such a motor

To use a bifilar motor as a unipolar motor, the two wires of each winding are connected in series and the point of connection is used as a center-tap. Winding 1 in Figure 1.4 is shown connected this way.
To use a bifilar motor as a bipolar motor, the two wires of each winding are connected either in parallel or in series. Winding 2 in Figure is shown with a parallel connection; this allows low voltage high-current operation. Winding 1 in Figure is shown with a series connection; if the center tap is ignored, this allows operation at a higher voltage and lower current than would be used with the windings in parallel.

# Multiphase Motors




A less common class of permanent magnet or hybrid stepping motor is wired with all windings of the motor in a cyclic series, with one tap between each pair of winding in the cycle, or with only one end of each motor winding exposed while the other ends of each winding are tied together to an inaccessible internal connection.
In the context of 3-phase motors, these configurations would be described as Delta and Y configurations, but they are also used with 5-phase motors, as illustrated in Figure. Some multiphase motors expose all ends of all motor windings, leaving it to the user to decide between the Delta and Y configurations, or alternatively, allowing each winding to be driven independently.

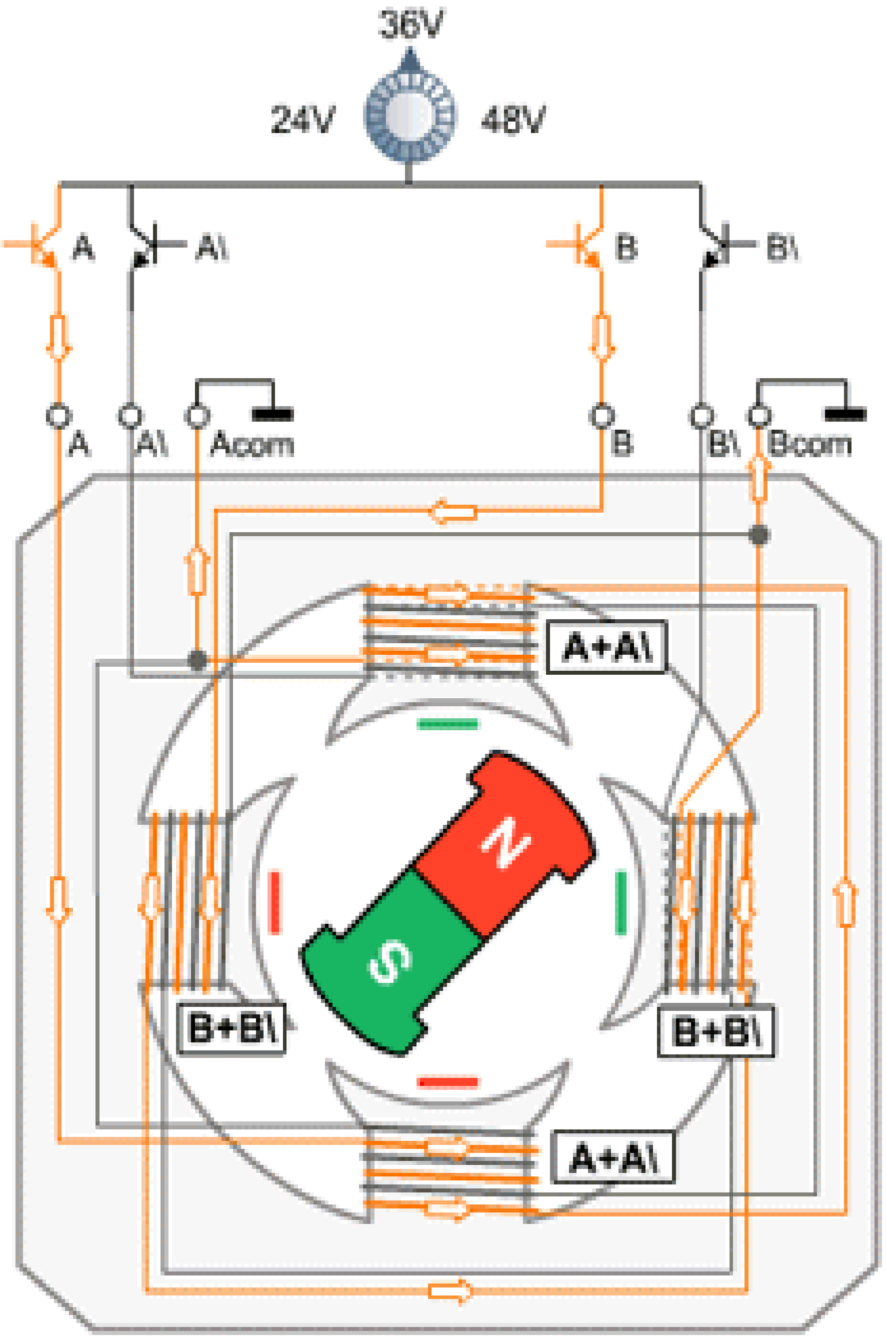



*Permanent magnet stepper motor, 24-pole can-stack construction*

# Full Step Sequence

In the full step sequence, two coils are energized at the same time and motor shaft rotates.
The order in which coils has to be energized is given in the table below.

| Full Mode Sequence | | | | |
|---|---|---|---|---|
| Step | A | B | A\ | B\ |
| 0 | 1 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 |
| 2 | 0 | 0 | 1 | 1 |
| 3 | 1 | 0 | 0 | 1 |



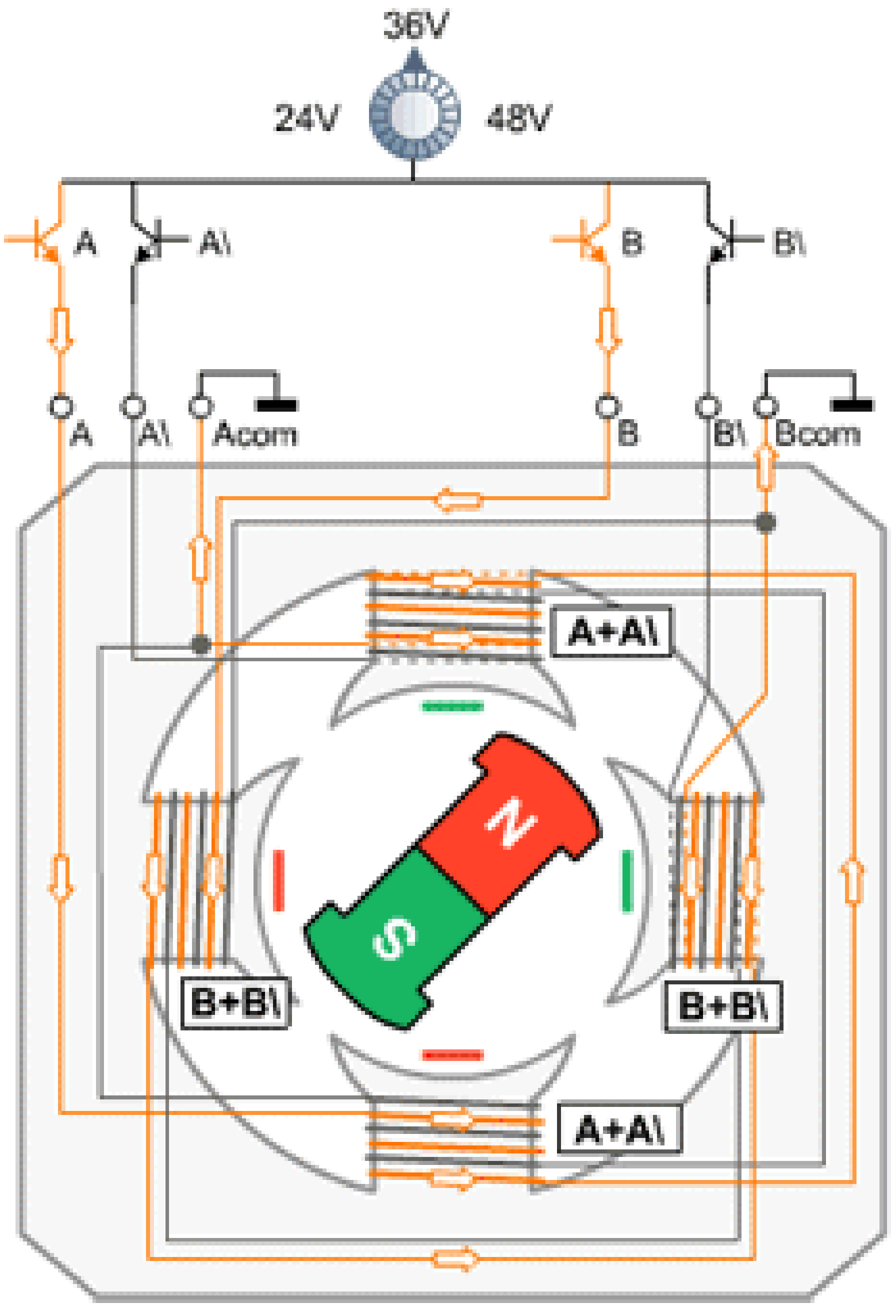

**6 Lead Unipolar Driver**

Unipolar control is the most simple and cost-effective way to drive a stepper motor, but results in approximately 30% less torque in comparison to the nowadays widely used bipolar drivers. Since the cost advantage is very small today due to cheap integrated circuits, bipolar drivers are now used in most new applications.

**Stepmode**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | 0 | | 1 | | 2 | | 3 | |
| H | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | | | | | | | |
| A | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| B | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| A\ | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| B\ | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| | | | | | | | | |
| dez | 12 | 4 | 6 | 2 | 3 | 1 | 9 | 8 |

| Half Mode Sequence | | | | |
|---|---|---|---|---|
| Step | A | B | A\ | B\ |
| 0 | 1 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 |
| 2 | 0 | 1 | 1 | 0 |
| 3 | 0 | 0 | 1 | 0 |
| 4 | 0 | 0 | 1 | 1 |
| 5 | 0 | 0 | 0 | 1 |
| 6 | 1 | 0 | 0 | 1 |
| 7 | 1 | 0 | 0 | 0 |



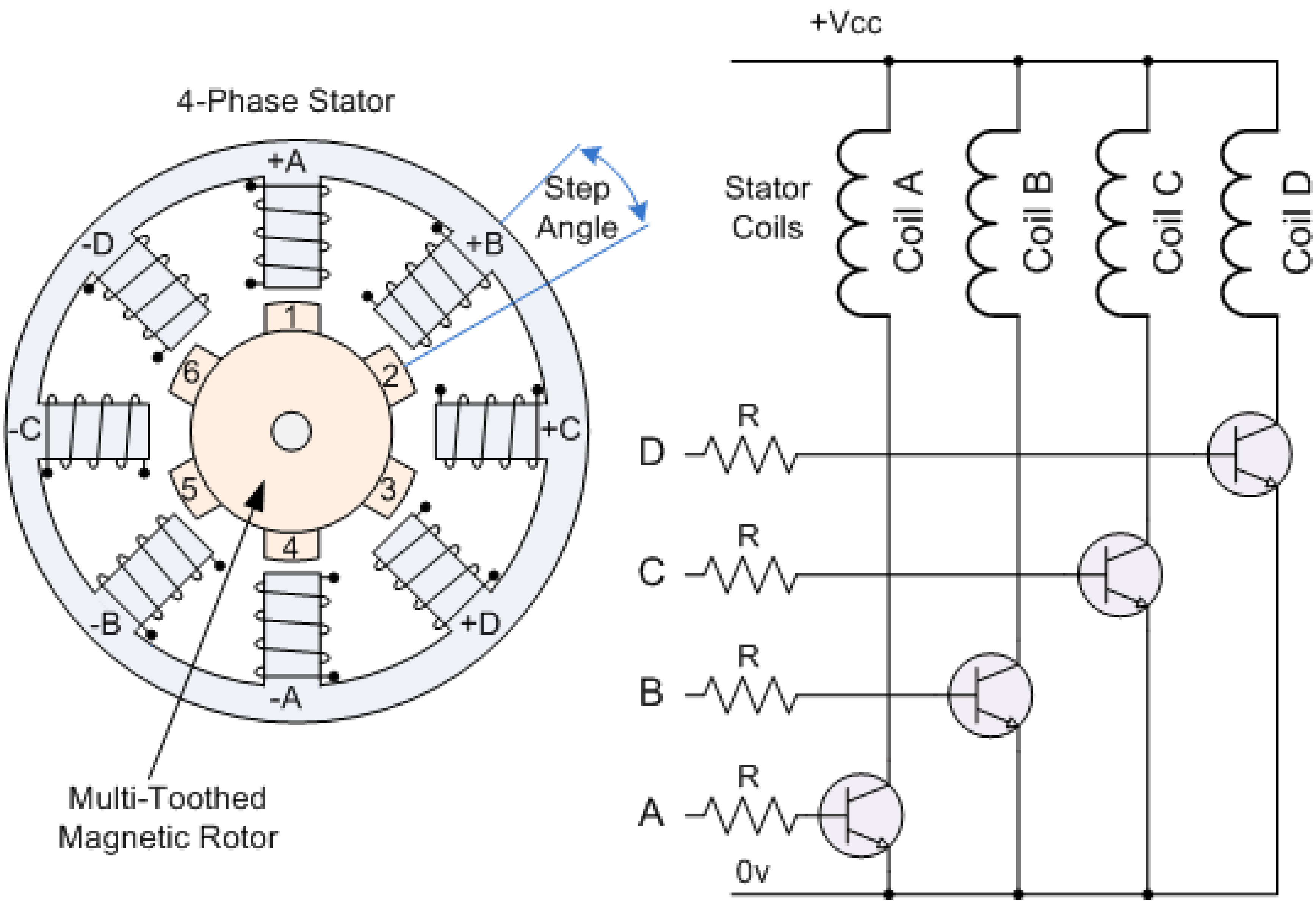

### 6 Lead Unipolar Driver

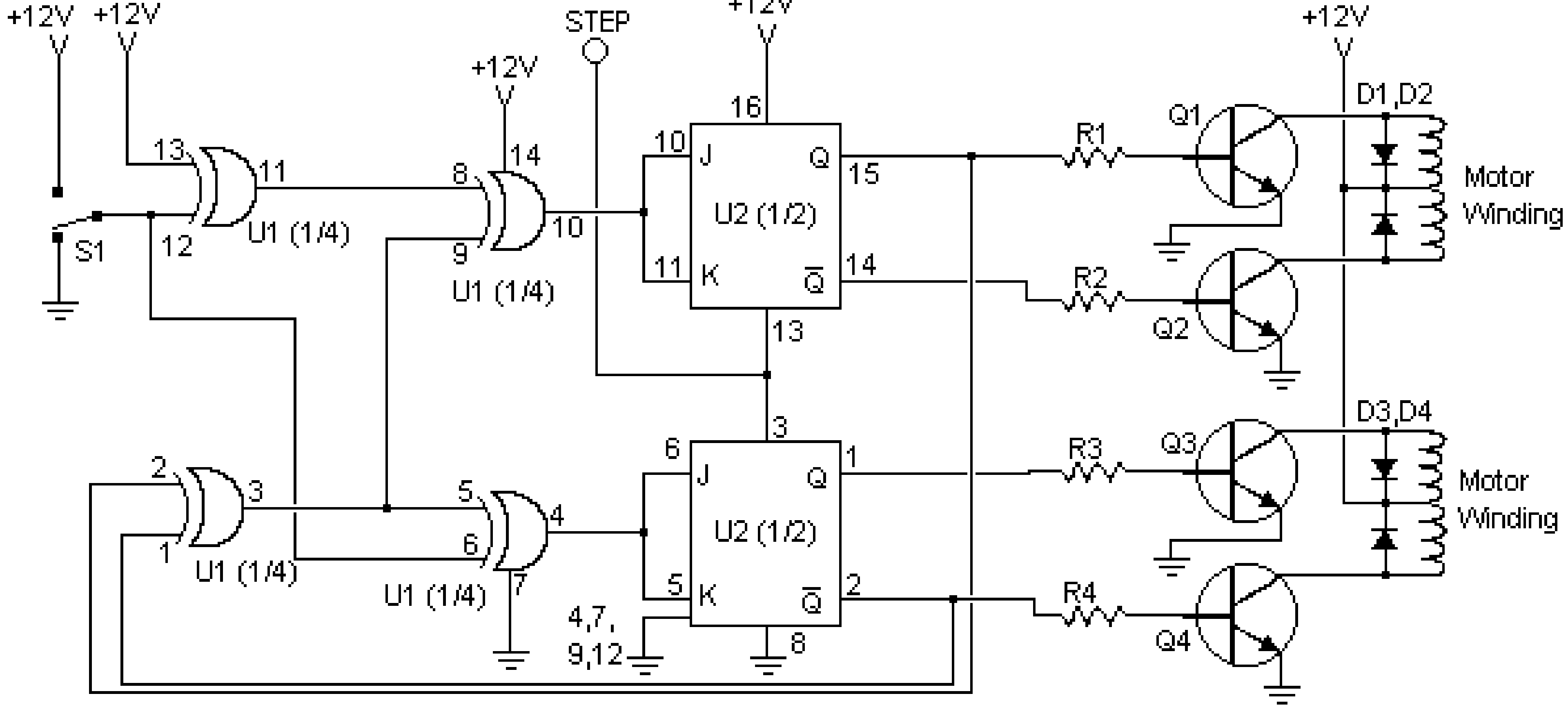
Unipolar control is the most simple and cost-effective way to drive a stepper motor, but results in approximately 30% less torque in comparison to the nowadays widely used bipolar drivers. Since the cost advantage is very small today due to cheap integrated circuits, bipolar drivers are now used in most new applications.

**Stepmode**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **F** | 0 | | 1 | | 2 | | 3 | |
| **H** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **A** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| **B** | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| **A** | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| **B** | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| **dez** | 12 | 4 | 6 | 2 | 3 | 1 | 9 | 8 |

## Stepper Motor and Control Circuit.

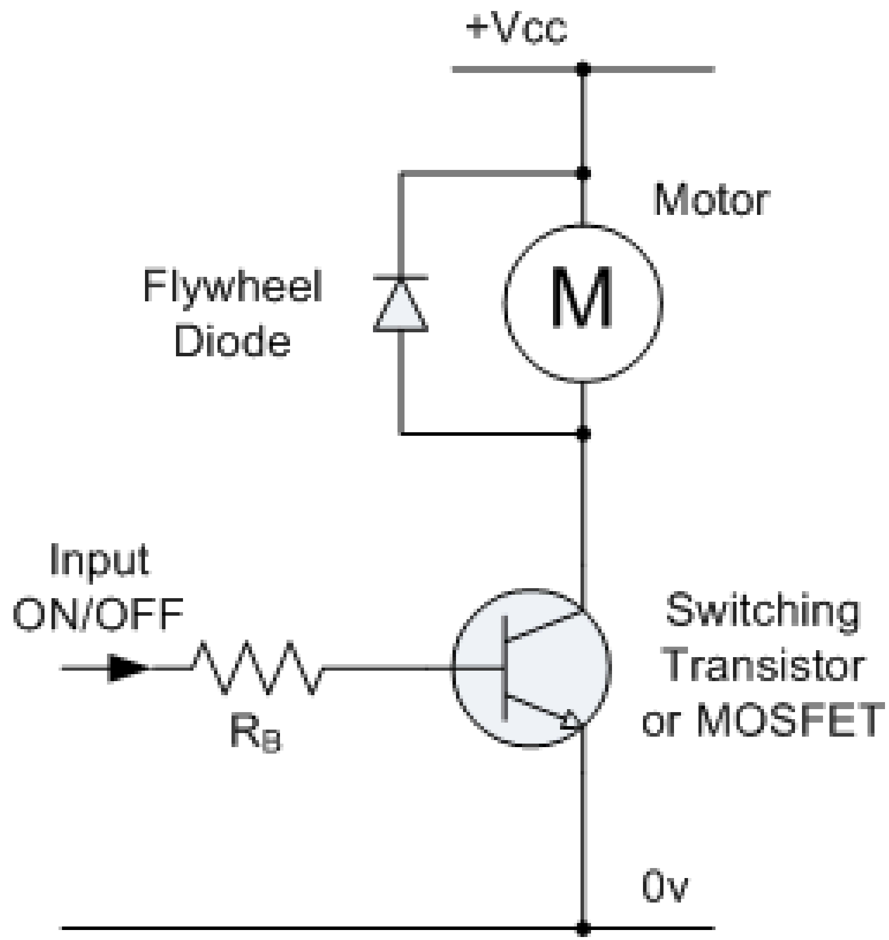


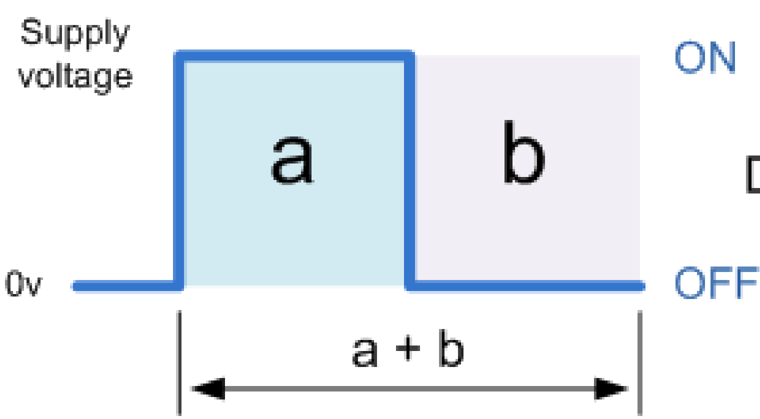



**Một mạch điều khiển động cơ bước**

| Part | Total Qty. | Description | Substitutions |
|---|---|---|---|
| R1, R2 ,R3, R4 | 4 | 1K 1/4W Resistor | |
| D1, D2, D3, D4 | 4 | 1N4002 Silicon Diode | |
| Q1, Q2, Q3, Q4 | 4 | TIP31 NPN Transistor (See Notes) | TIP41, 2N3055 |
| U1 | 1 | 4070 CMOS XOR Integrated Circuit | |
| U2 | 1 | 4027 CMOS Flip-Flop | |
| S1 | 1 | SPDT Switch | |
| MISC | 1 | Case, Board, Wire, Stepper Motor | |

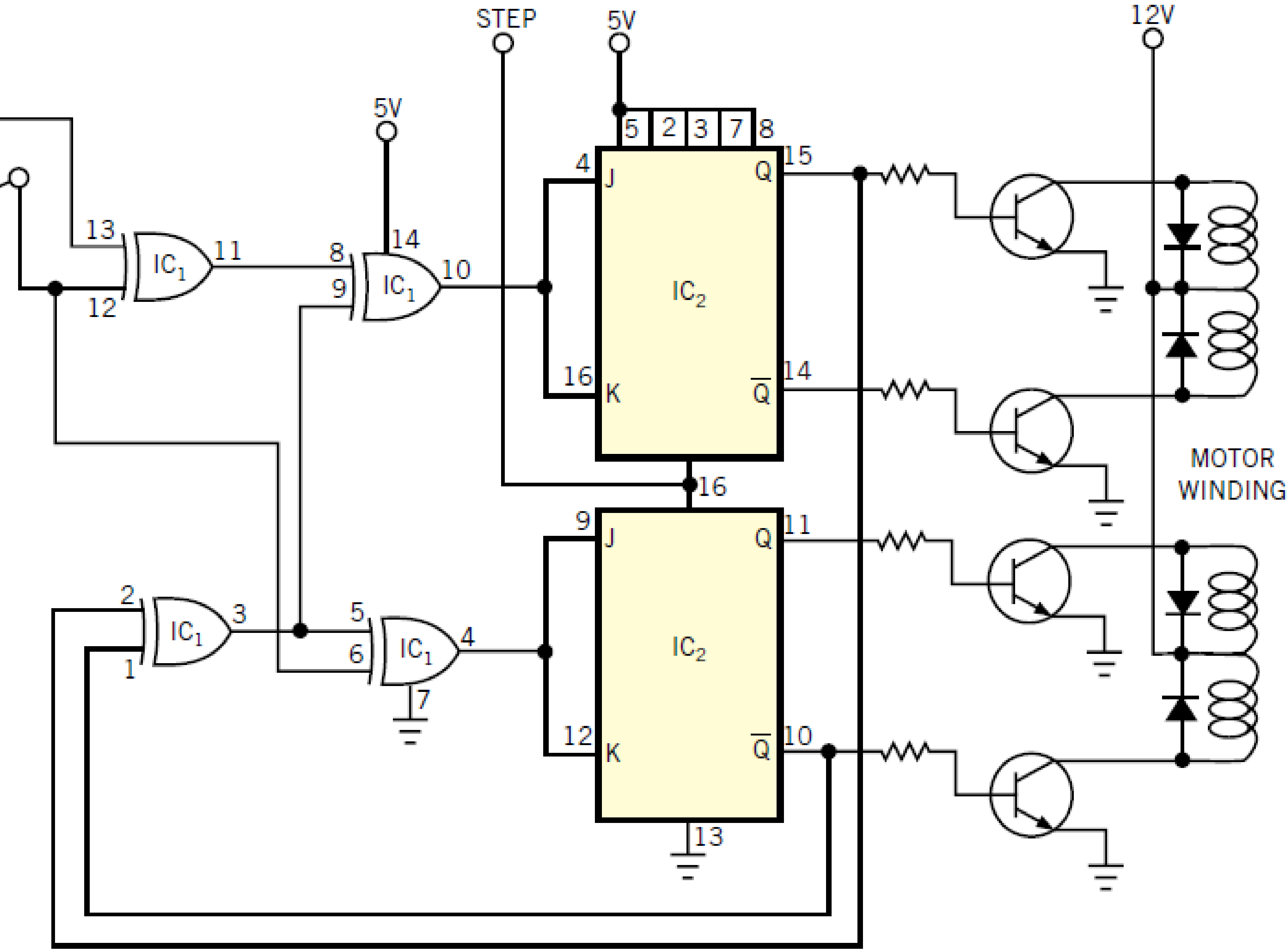
Stepper motors can be controlled directly using transistor switching techniques .
The speed and position of a stepper motor can be accurately controlled using pulses so can operate in an Open-loop mode




Duty Ratio $\beta = \frac{a}{a + b}$

e 1




A stepper-motor controller requires only a few logic circuits.

**NOTES:** $IC_1$: SN74HC86.
$IC_2$: SN74LS76A.

# Mạch cách ly quang

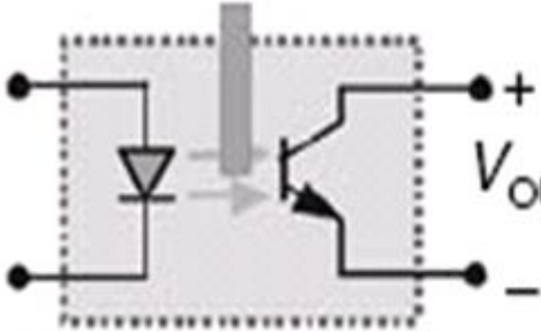
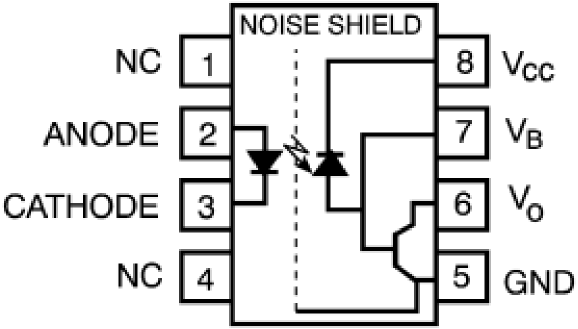
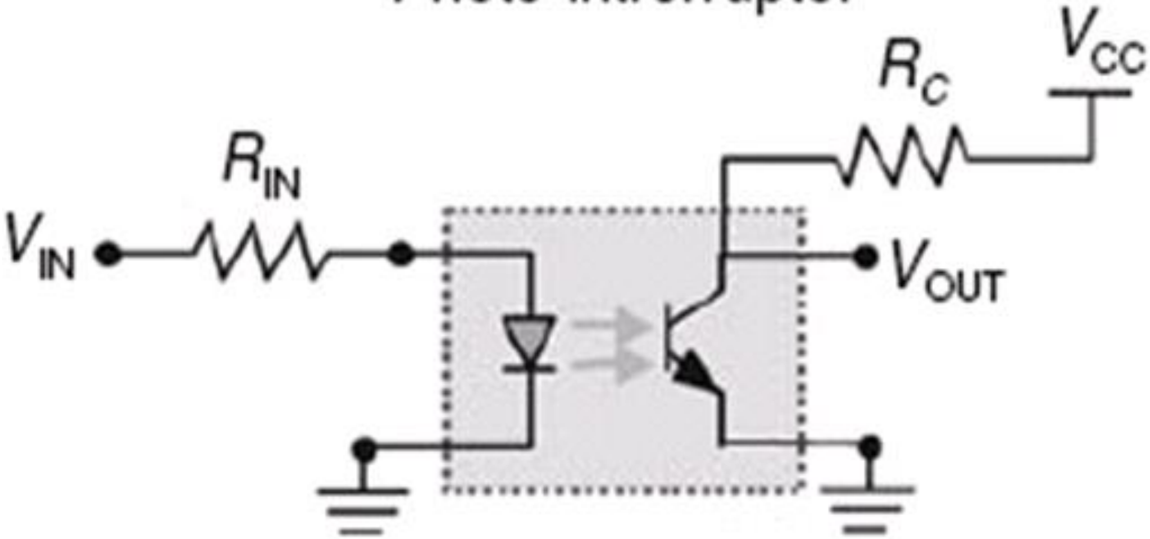



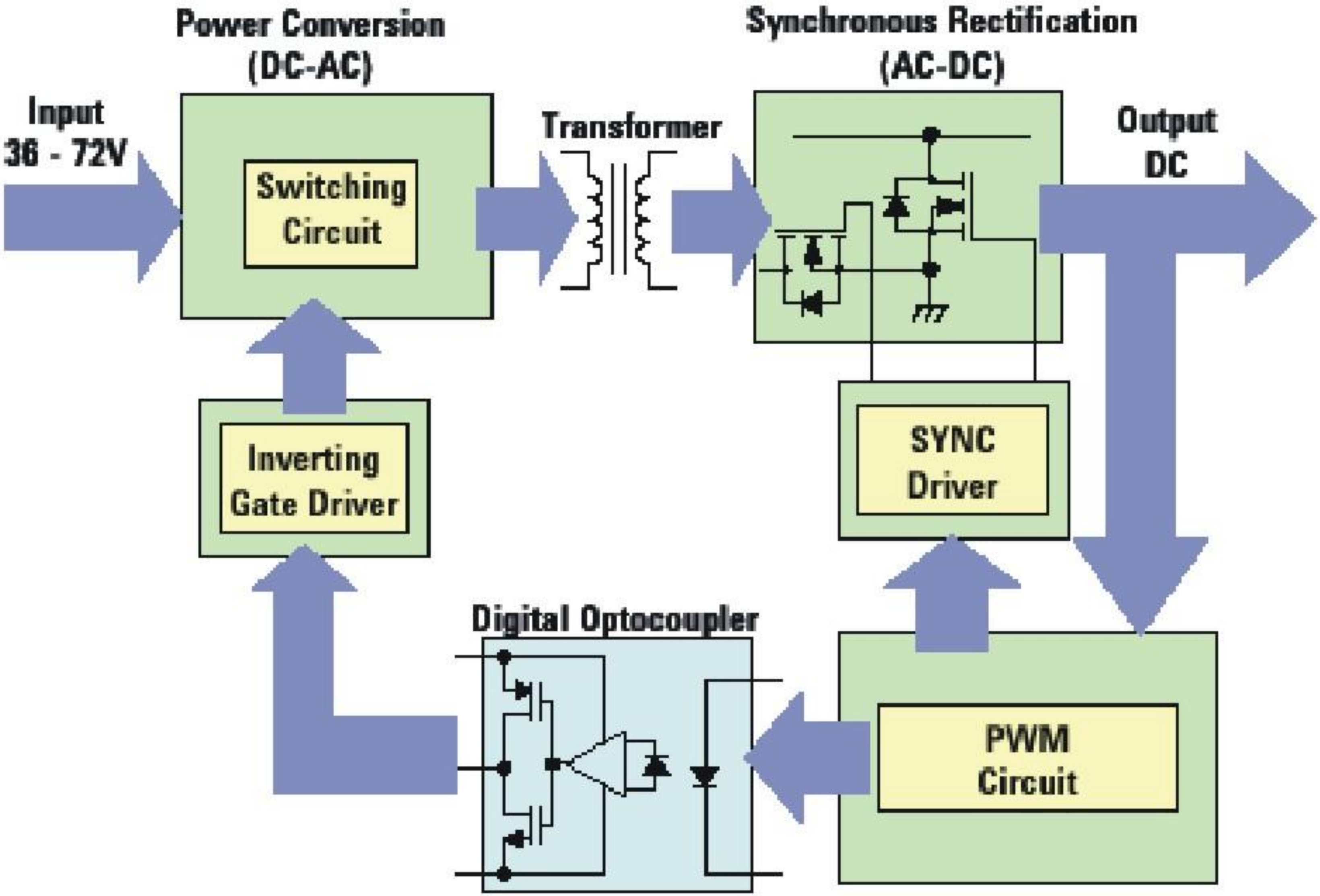

Photo-intrerrupter

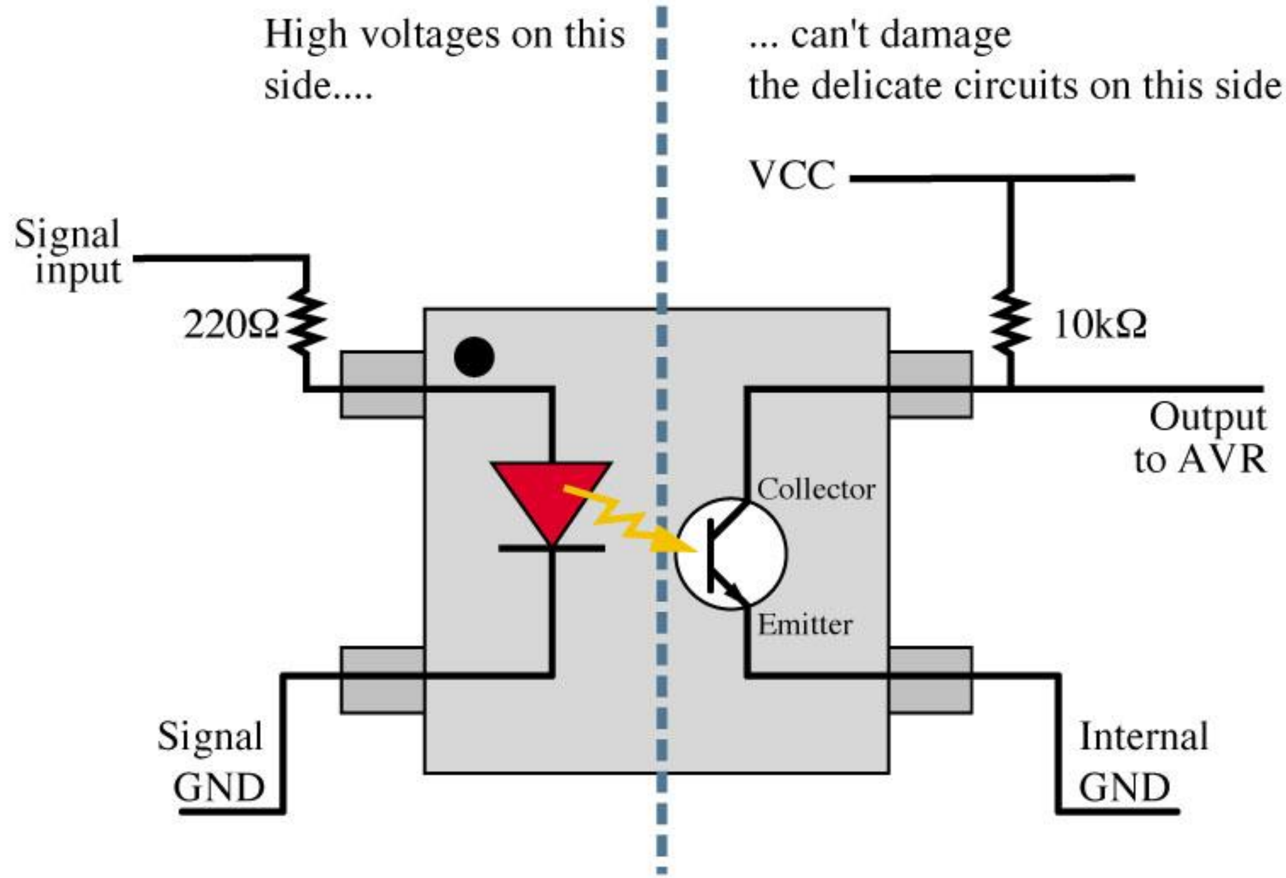



6N135
6N136
HCPL0501 (Surface Mount 6N136)

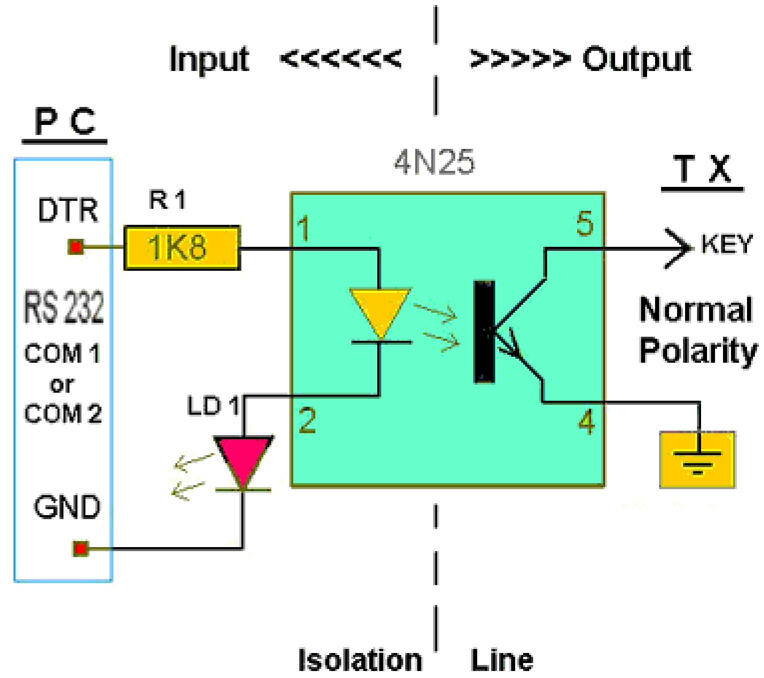



Opto-isolator


Power Conversion (DC-AC)
Switching Circuit
Input 36 - 72V
Transformer
Synchronous Rectification (AC-DC)
Output DC
Inverting Gate Driver
SYNC Driver
Digital Optocoupler
PWM Circuit

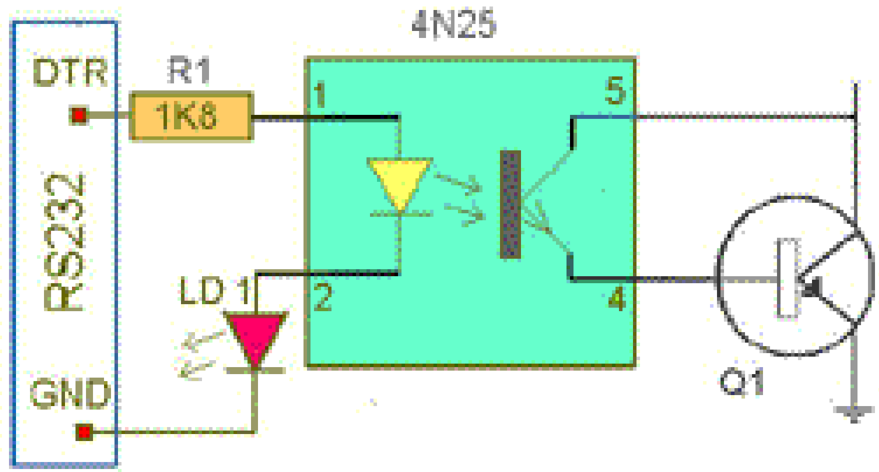



**An optocoupler, also called opto-isolator, is an electronic component that transfers an electrical signal or voltage from one part of a circuit to another, or from one circuit to another, while electrically isolating the two circuits from each other. It consists of an infrared emitting LED chip that is optically in-line with a light-sensitive silicon semiconductor chip, all enclosed in the same package. The silicon chip could be in the form of a photo diode, photo transistor, photo Darlington, or photo SCR.**




4N25 = Opto coupler
R1 = 0.25 Watts resistor
LD1 = Led diode (red)

FIG. 1

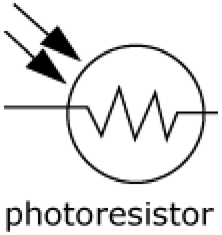


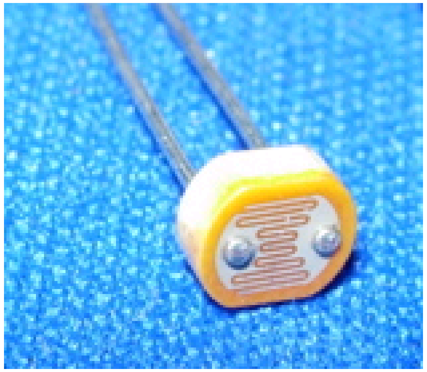

4N25 = Opto coupler
R1 = 0.25 Watts resistor
LD1 = Led diode (red)
Q1 = BD 237

FIG. 2

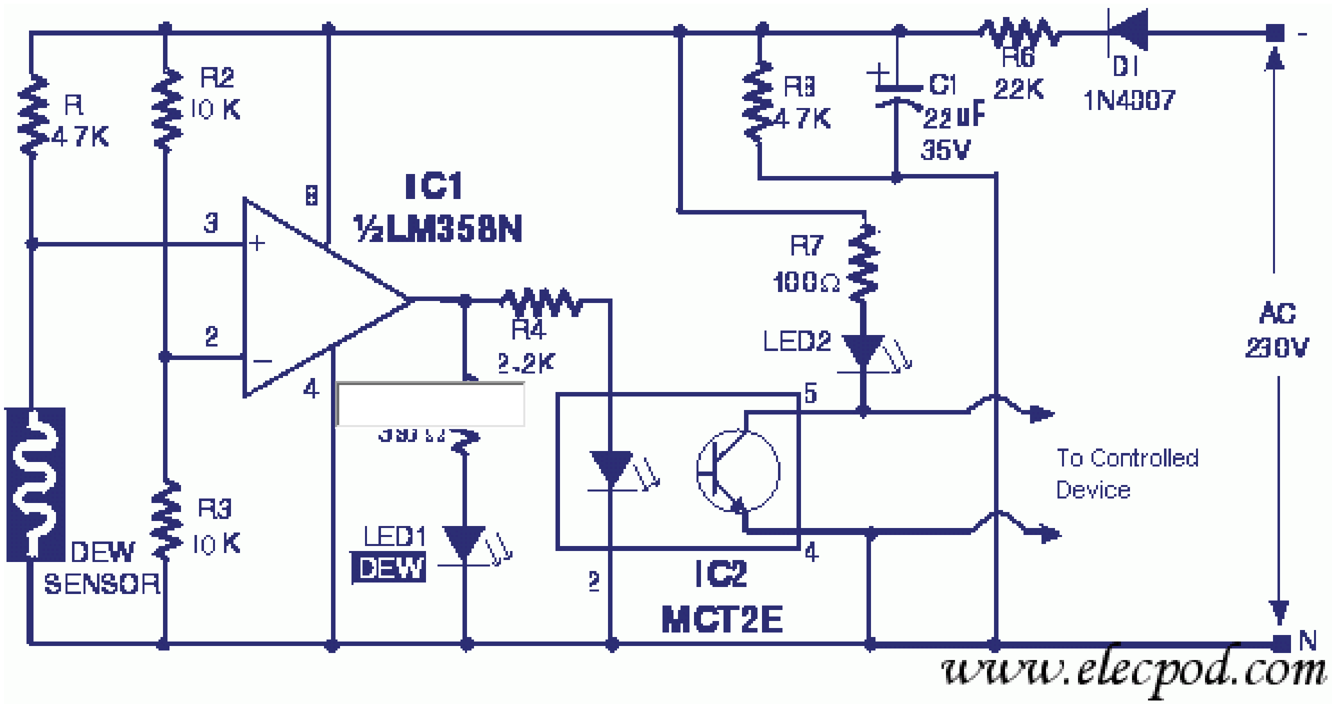
**The isolation voltage of 4N25 opto coupler device is 2,5 KV (peak) and the collector to emmiter breakdown voltage (pin 4,5) has a maximum of 30 Volts. The isolation resistance is 10E11 Ohms !**
**The circuits has also an external Led diode (LD 1) in order to be able to monitor the "key" pulses. That is very useful during setup configuration between com-ports. If you have selected the right com-port, the LED will be lighting, following the CW code (if you press F1, F2, F3 ... "hot-keys" on CT or SDI).**
**Please, put as LD1 a normal size RED Led (abt 6mm diam.) Sometimes the smaller size Leds need a very low current to illuminate and that is a problem.... maybe a small Led will always light**

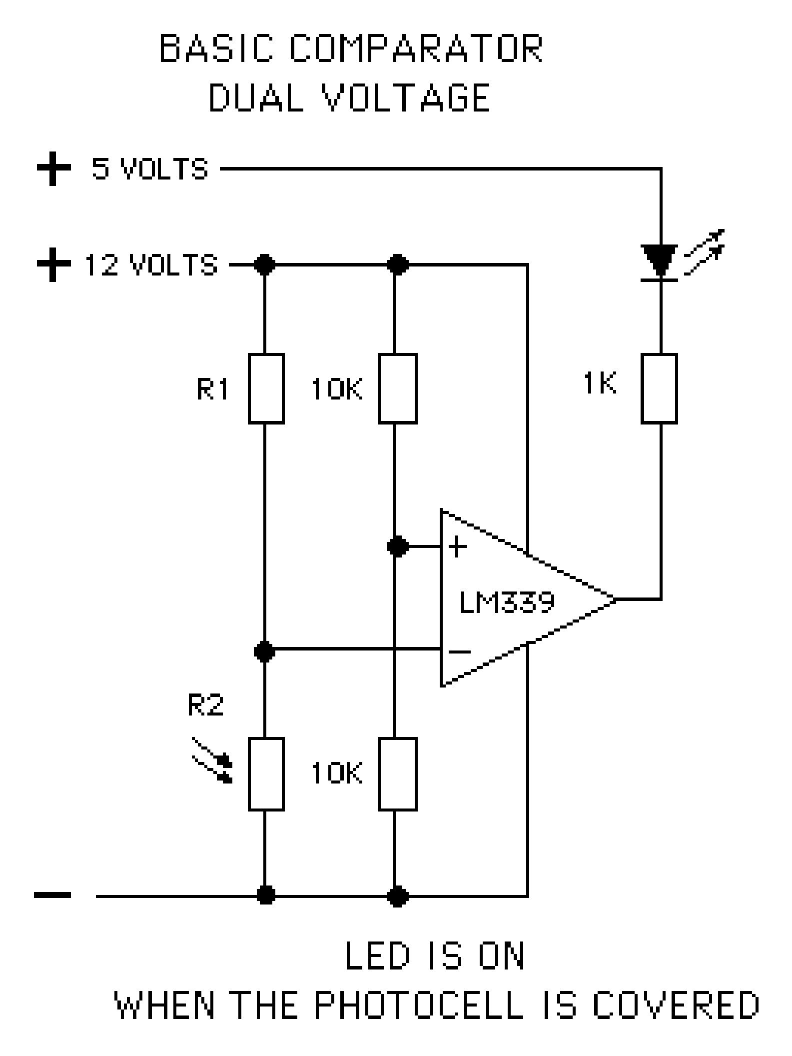
# Mạch sử dụng các phần tử quang

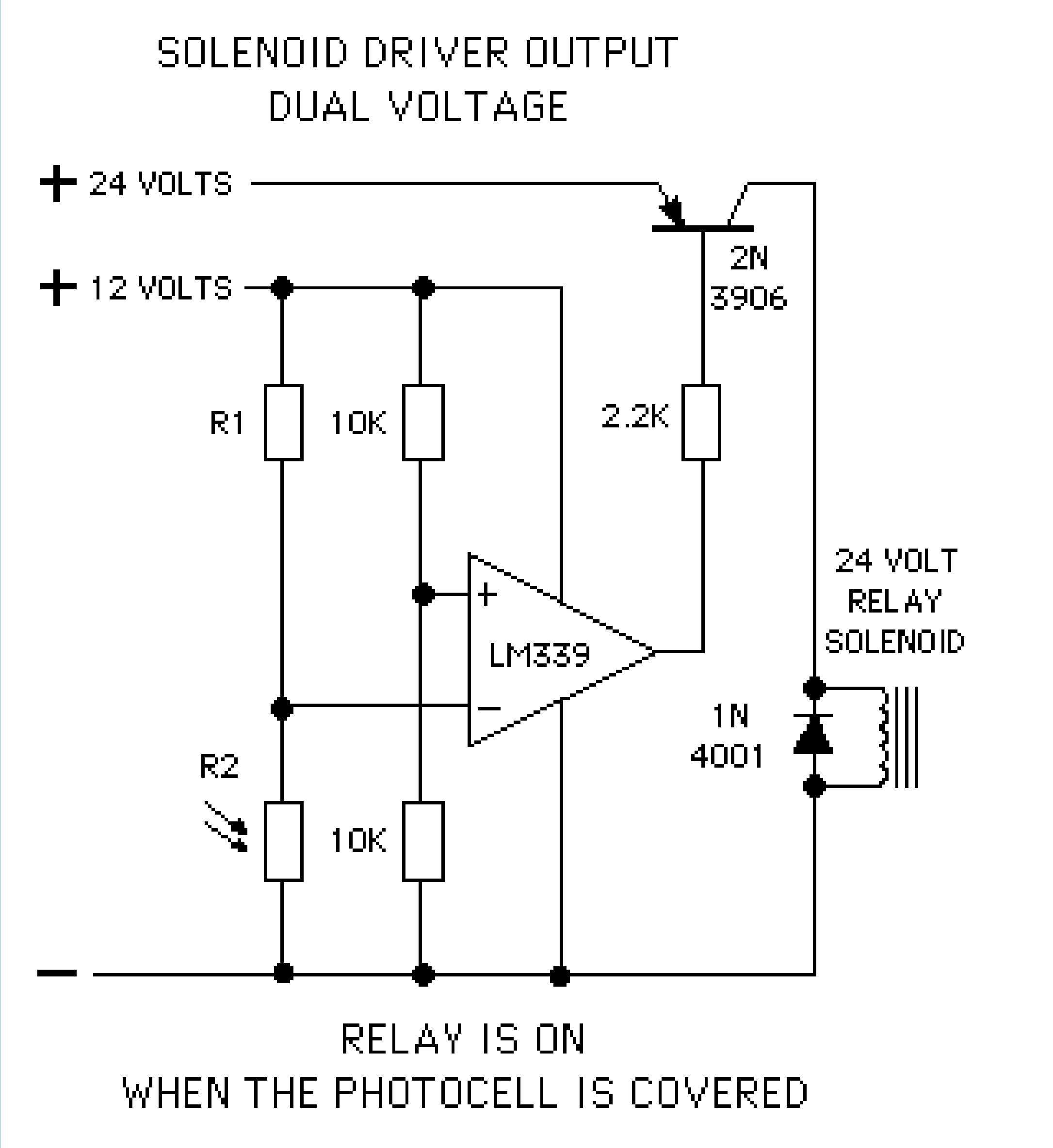


# Dew sensitive switch with opto-coupler



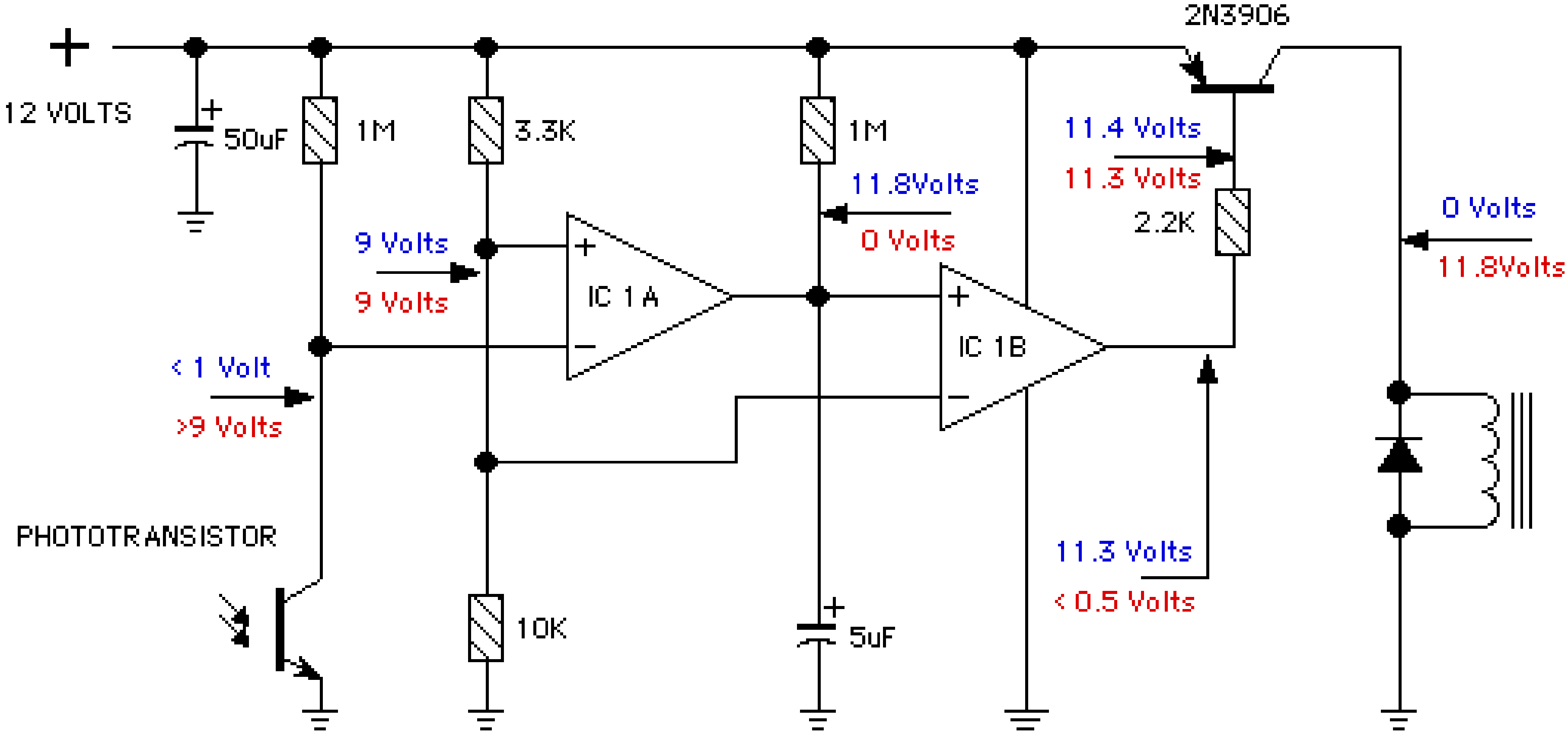

BASIC COMPARATOR
DUAL VOLTAGE
+ 5 VOLTS
+ 12 VOLTS
R1
10K
1K
LM339
R2
10K
—
LED IS ON
WHEN THE PHOTOCELL IS COVERED


SOLENOID DRIVER OUTPUT
DUAL VOLTAGE
+ 24 VOLTS
+ 12 VOLTS
2N
3906
R1
10K
2.2K
LM339
24 VOLT
RELAY
SOLENOID
1N
4001
R2
10K
—
RELAY IS ON
WHEN THE PHOTOCELL IS COVERED

# LIGHT ACTIVATED RELAY with 5 SECOND RELEASE DELAY



Comparator LA/TD Relay A

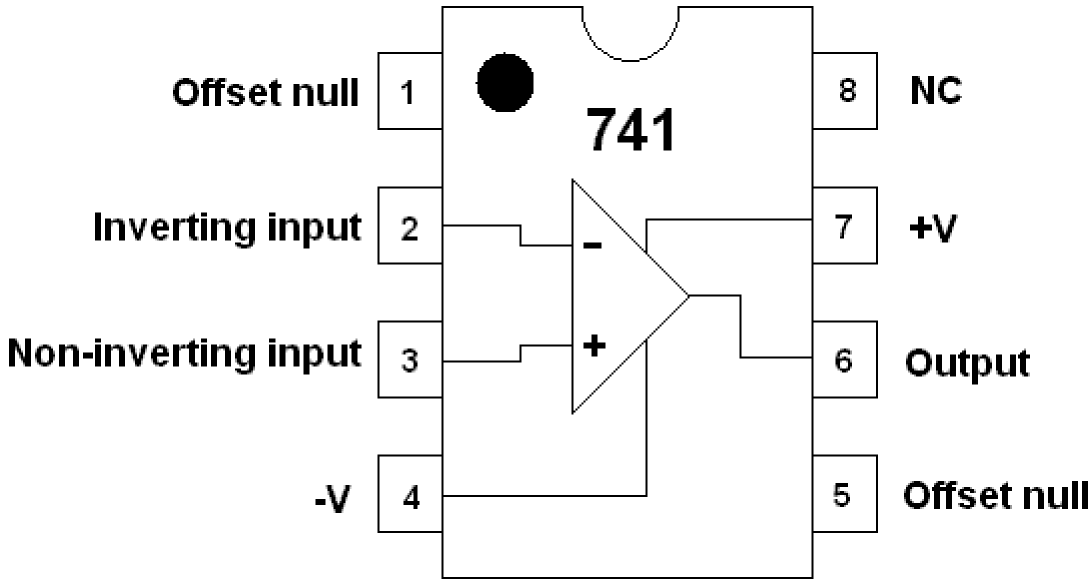


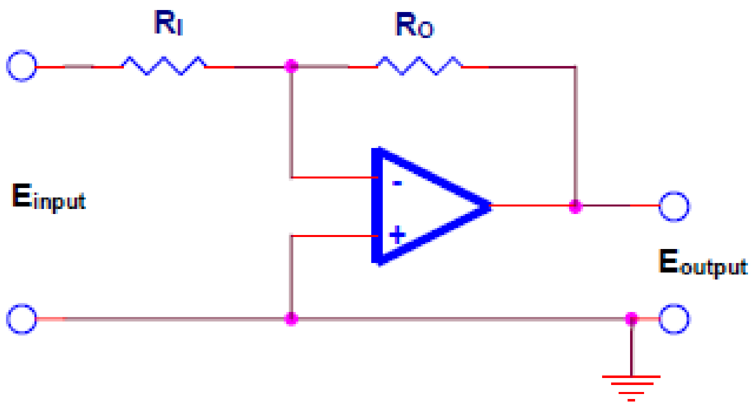

http://home.cogeco.ca/~rpaisley4/CircuitIndex.html

Volts - PHOTOTRANSISTORS UNCOVERED

Volts - PHOTOTRANSISTORS COVERED

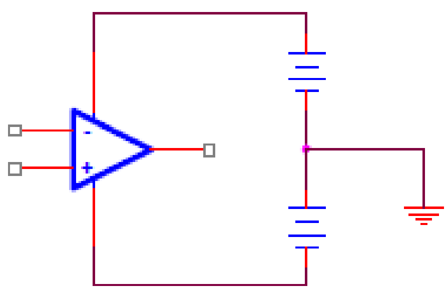
# Khuếch đại thuật toán



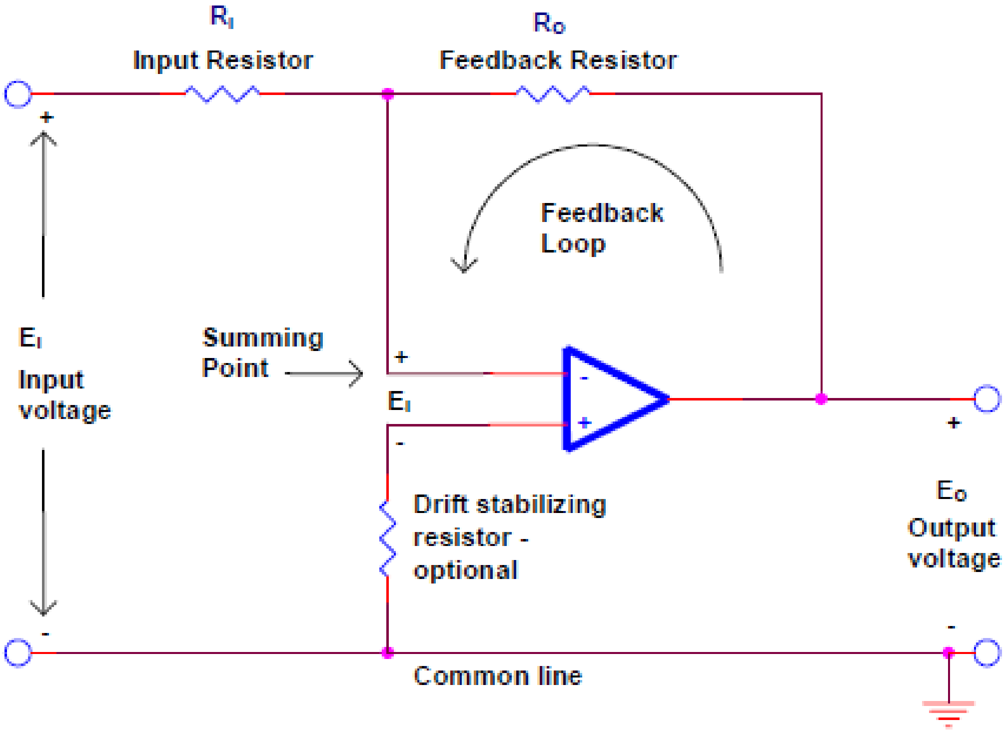



$$\frac{E_{output}}{E_{input}} = -\frac{R_O}{R_I}$$

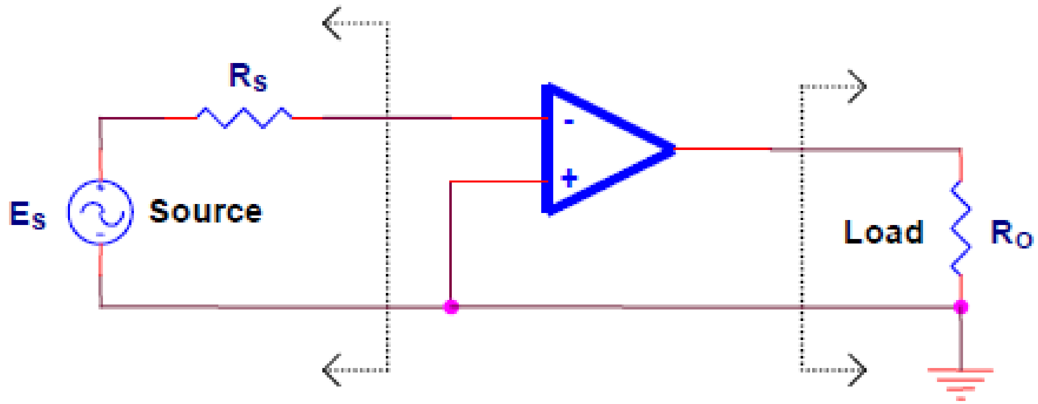
**Operational Amplifier with Feedback**




**Power Supply Connections**

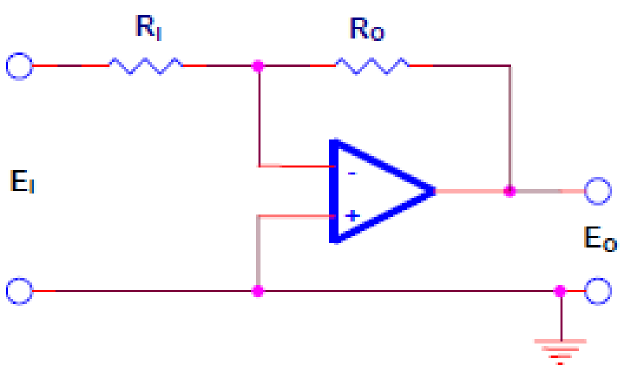



**Notation and Terms Used in Closed Loop Circuits**



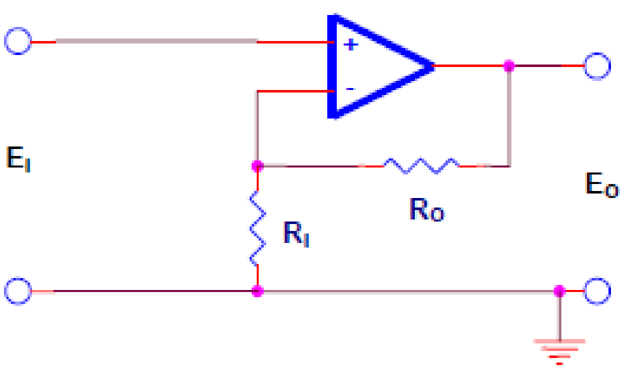

## Open Loop Operation

(a) Inverting



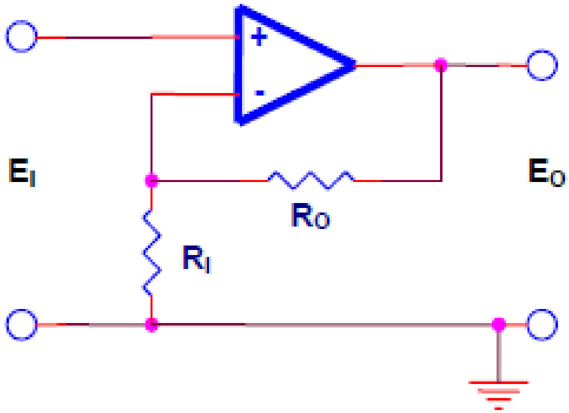

$$E_O = \frac{-R_O}{R_I} E_I$$

(b) Non-Inverting



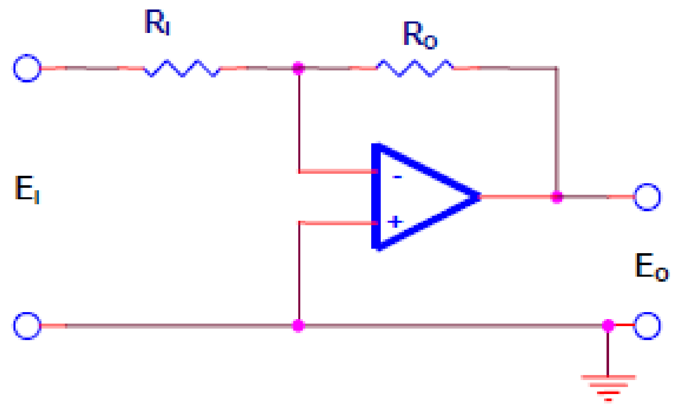

$$E_O = \left(1 + \frac{R_O}{R_I}\right) \cdot E_I$$

## Two Important Feedback Circuits



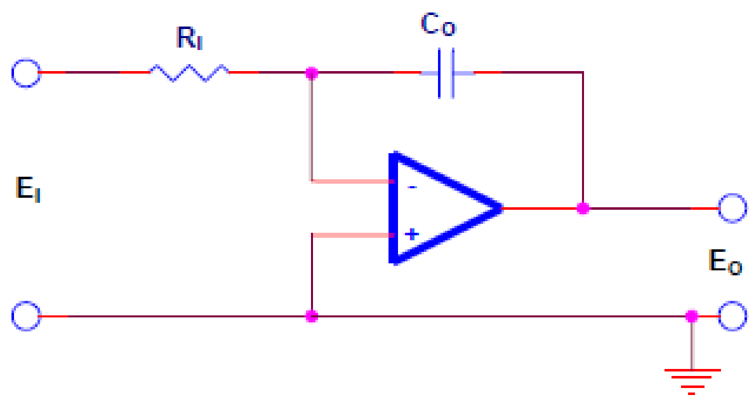

$$E_O = \left(1 + \frac{R_O}{R_I}\right) \cdot E_I$$

**Non-Inverting Amplifier**



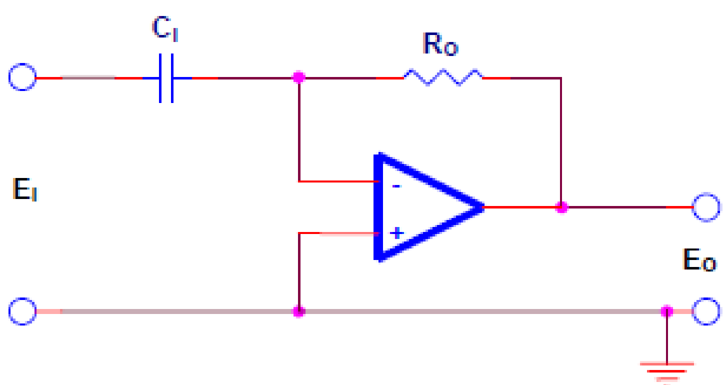

$$\frac{E_O}{E_I} = \frac{-R_O}{R_I}$$

**Inverting Amplifier**



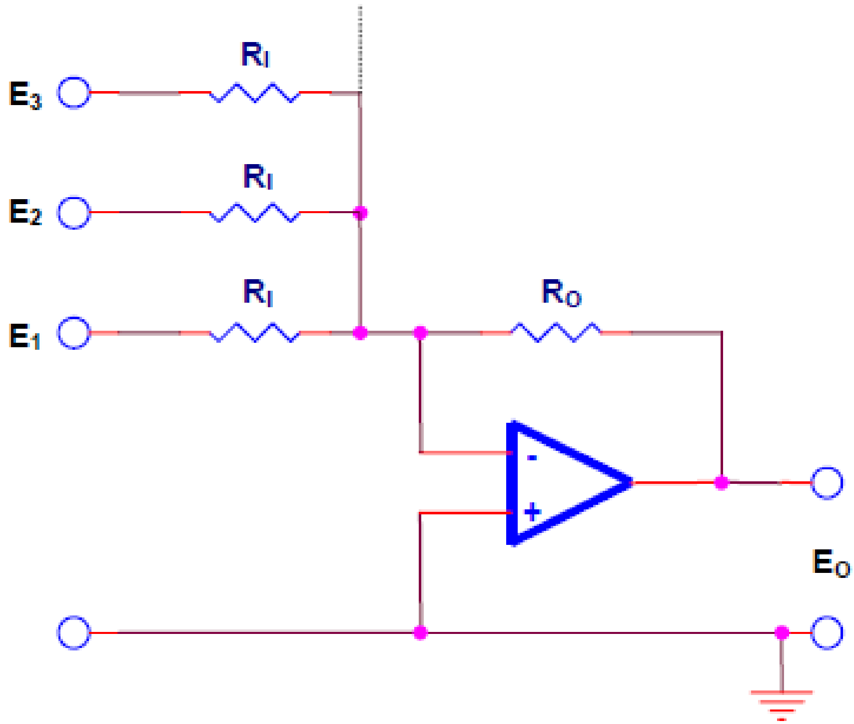

$$E_O = \frac{-1}{R_I C_O} E_I dt$$

**Integrator Circuit**



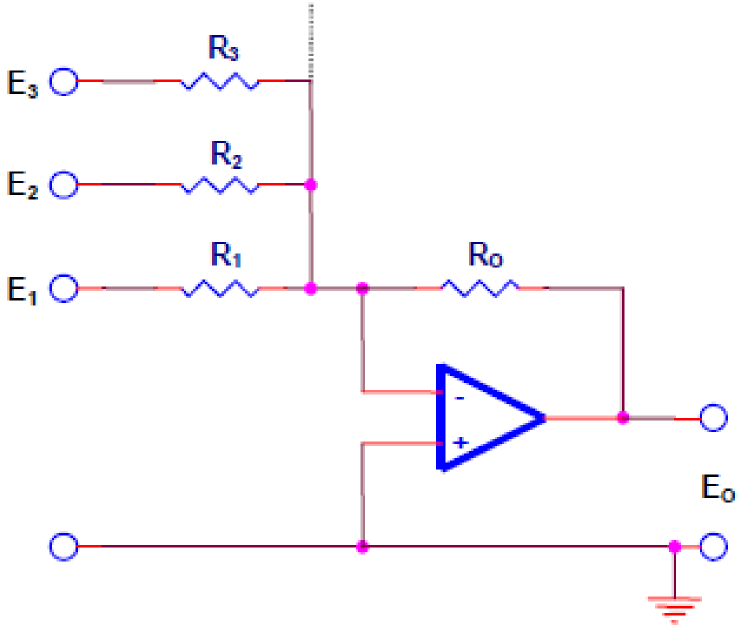

$$E_O = -R_O C_I \frac{dE_I}{dt}$$

**Differentiator Circuit**



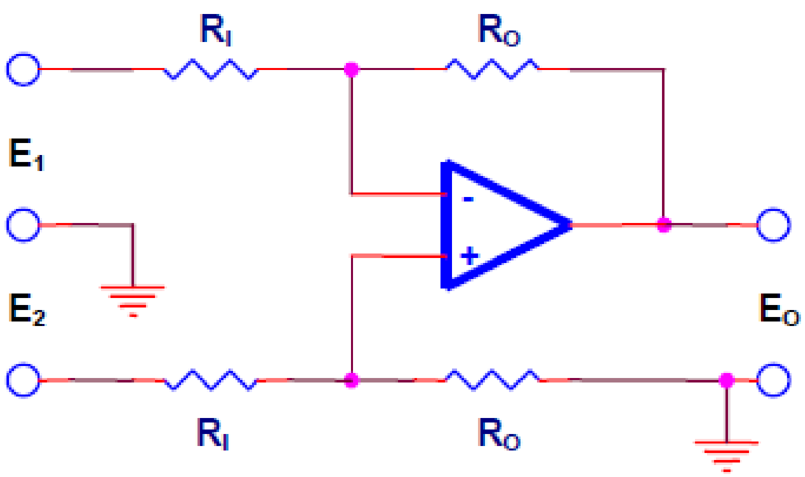

$$E_O = \frac{-R_O}{R_I}(E_1 + E_2 + E_3 + ...)$$

**Voltage Adding Circuit**




$$E_O = -R_O\left(\frac{E_1}{R_1} + \frac{E_2}{R_2} + \frac{E_3}{R_3} + \ldots\right)$$

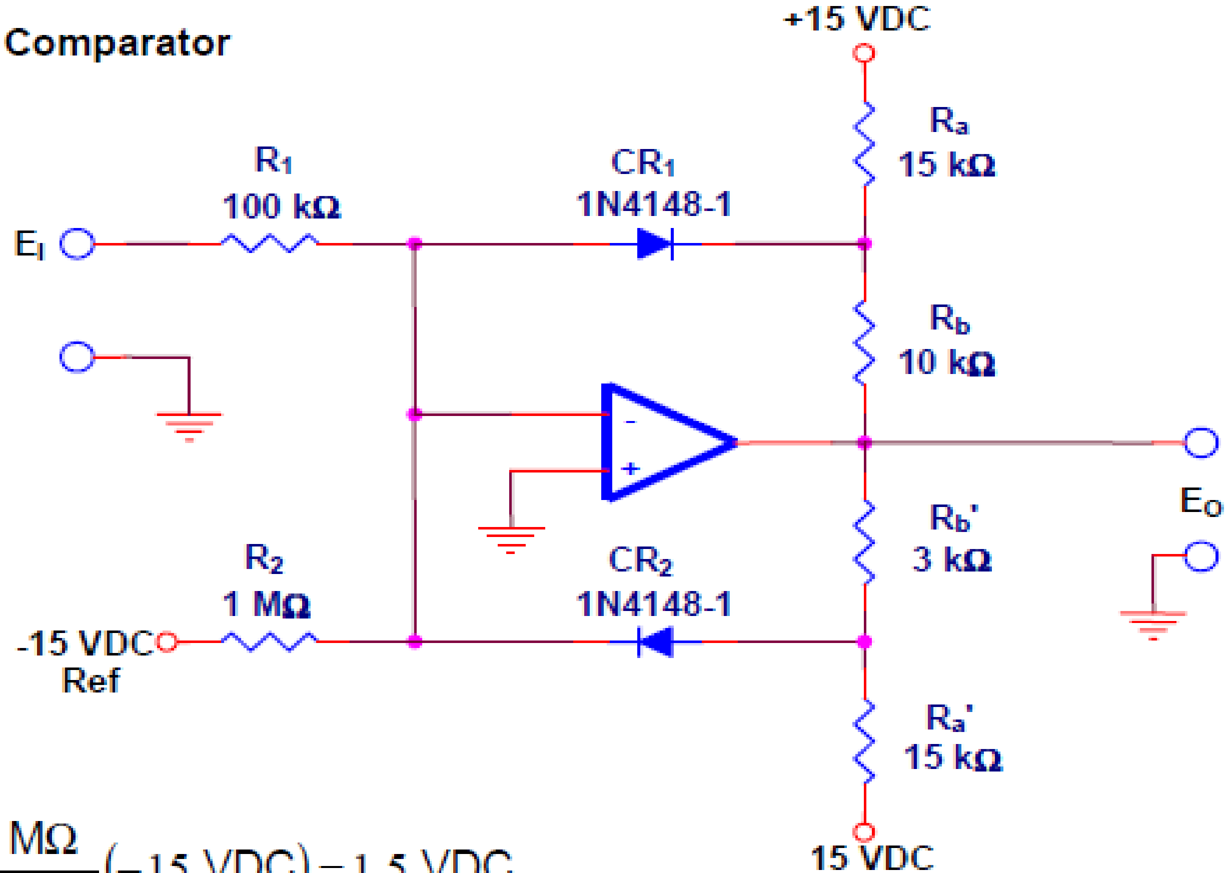
**Scaling Summer Circuit**




$$E_O = \frac{R_O}{R_I}(E_2 - E_1)$$

**Differential Input Amplifier Circuit**

**Fully Clamped Voltage Comparator**



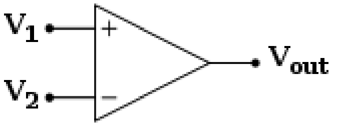

$$\text{Threshold} = -\frac{R_2}{R_1}V_{ref} = -\frac{1\ \text{M}\Omega}{100\ \text{k}\Omega}(-15\ \text{VDC}) = 1.5\ \text{VDC}$$

$$\text{Negative clamping level} = \frac{-(+V_{sup})Rb}{Ra} = \frac{-15\ \text{VDC}\cdot 10\ \text{k}\Omega}{15\ \text{k}\Omega} = -10\ \text{VDC}$$

$$\text{Positive clamping level} = \frac{-(-V_{sup})Rb}{Ra} = \frac{+15\ \text{VDC}\cdot 3\ \text{k}\Omega}{15\ \text{k}\Omega} = +3\ \text{VDC}$$

$$E_O = -10\ \text{VDC for } E_I > 1.5\ \text{VDC}$$

$$E_O = +3\ \text{VDC for } E_I < 1.5\ \text{VDC}$$



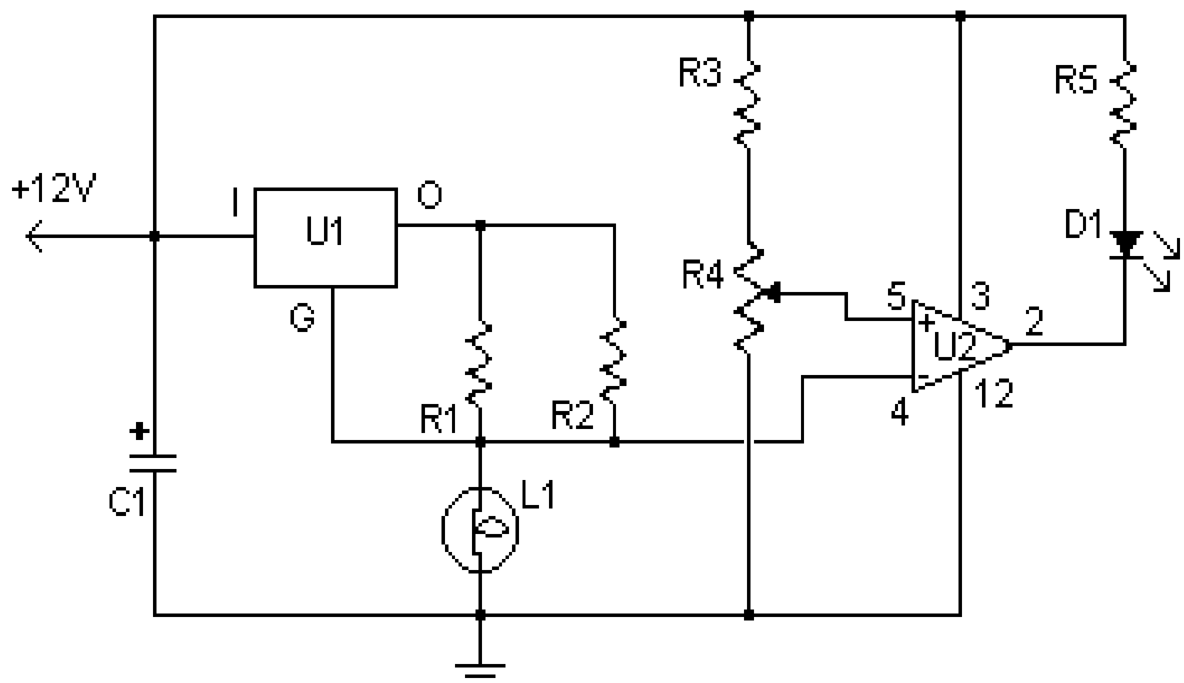

Comparator

Compares two voltages and outputs one of two states depending on which is greater

$$V_{\text{out}} = \begin{cases} V_{\text{S+}} & V_1 > V_2 \\ V_{\text{S}-} & V_1 < V_2 \end{cases}$$

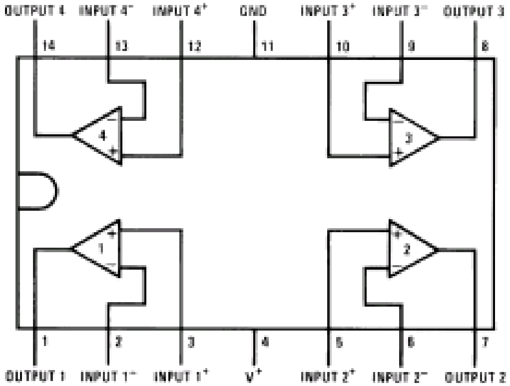
**This simple circuit uses an incandescent lamp to detect airflow. With the filament exposed to air, a constant current source is used to slightly heat the filament. As it is heated, the resistance increases. As air flows over the filament it cools down, thus lowering it's resistance. A comparator is used to detect this difference and light an LED. With a few changes, the circuit can be connected to a meter or ADC to provide an estimation on the amount of air flow**

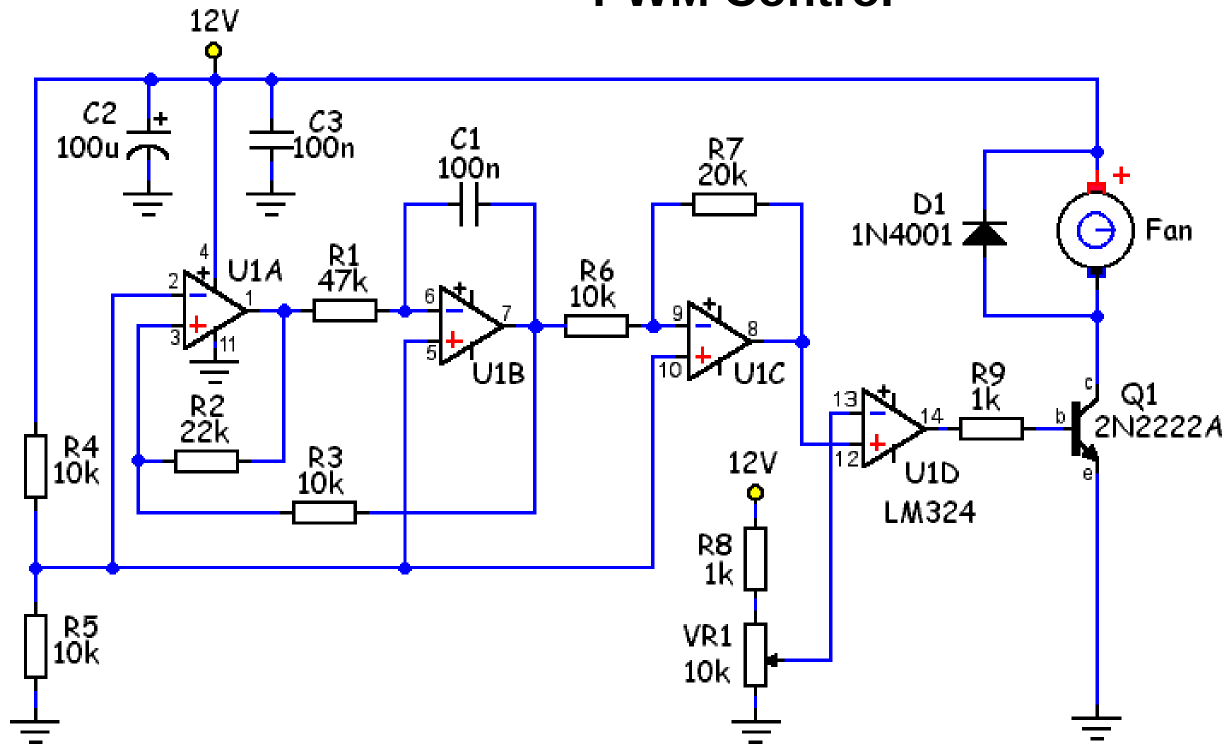
| Part | Total Qty. | Description |
|---|---|---|
| R1 | 1 | 100 Ohm 1/4W Resistor |
| R2 | 1 | 470 Ohm 1/4W Resistor |
| R3 | 1 | 10k 1/4W Resistor |
| R4 | 1 | 100K 1/4W Resistor |
| R5 | 1 | 1K 1/4W Resistor |
| C1 | 1 | 47uF Electrolytic Capacitor |
| U1 | 1 | 78L05 Voltage Regulator |
| U2 | 1 | LM339 Op Amp |
| L1 | 1 | #47 Incandescent lamp with glass removed |
| D1 | 1 | LED |
| MISC | 1 | Board, Wire, Sockets for ICs, etc. |




The glass will have to be removed from L1 without breaking the filament. Wrap the glass in masking tape and it in a vise. Slowly crank down until the glass breaks, then remove the bulb and carefully peel back the tape. If the filament has broken, you will need another lamp

# PWM Control

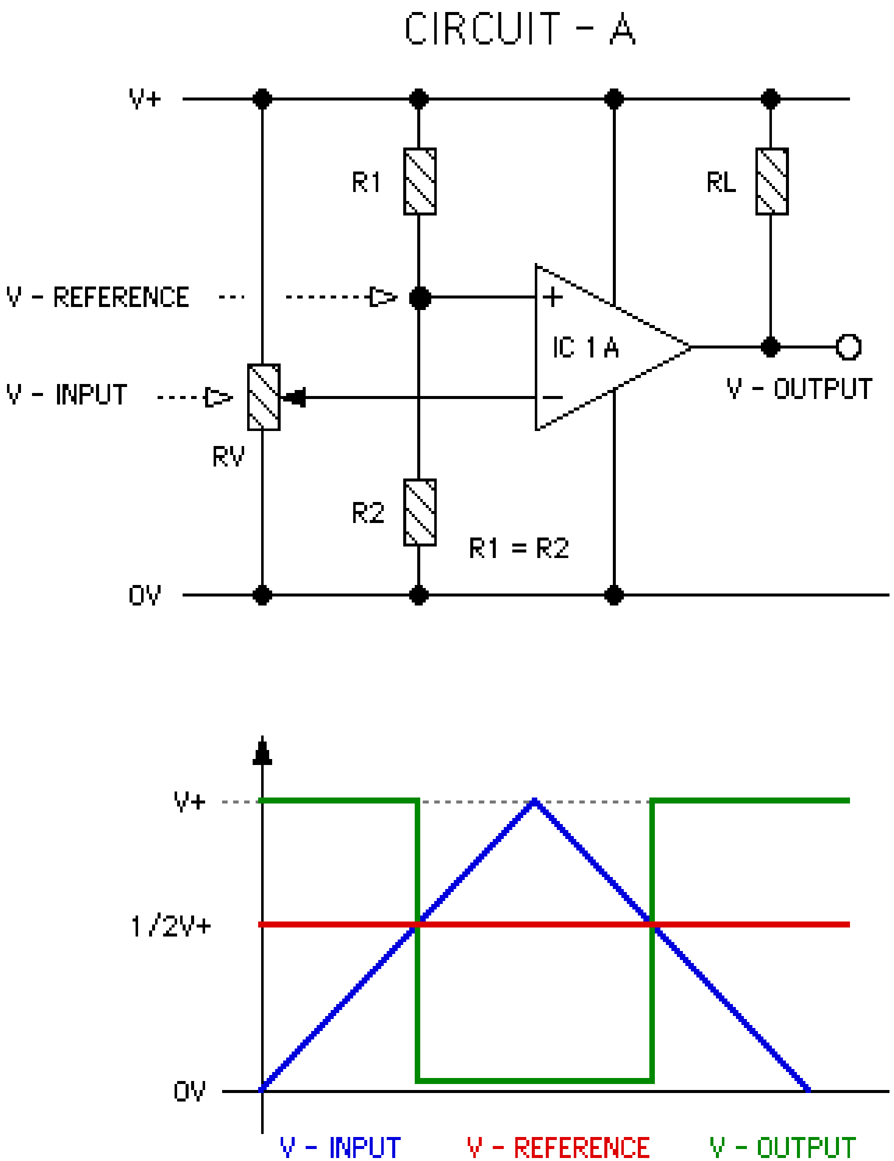

OUTPUT 4
INPUT 4⁻
INPUT 4⁺
GND
INPUT 3⁺
INPUT 3⁻
OUTPUT 3
OUTPUT 1
INPUT 1⁻
INPUT 1⁺
V⁺
INPUT 2⁺
INPUT 2⁻
OUTPUT 2

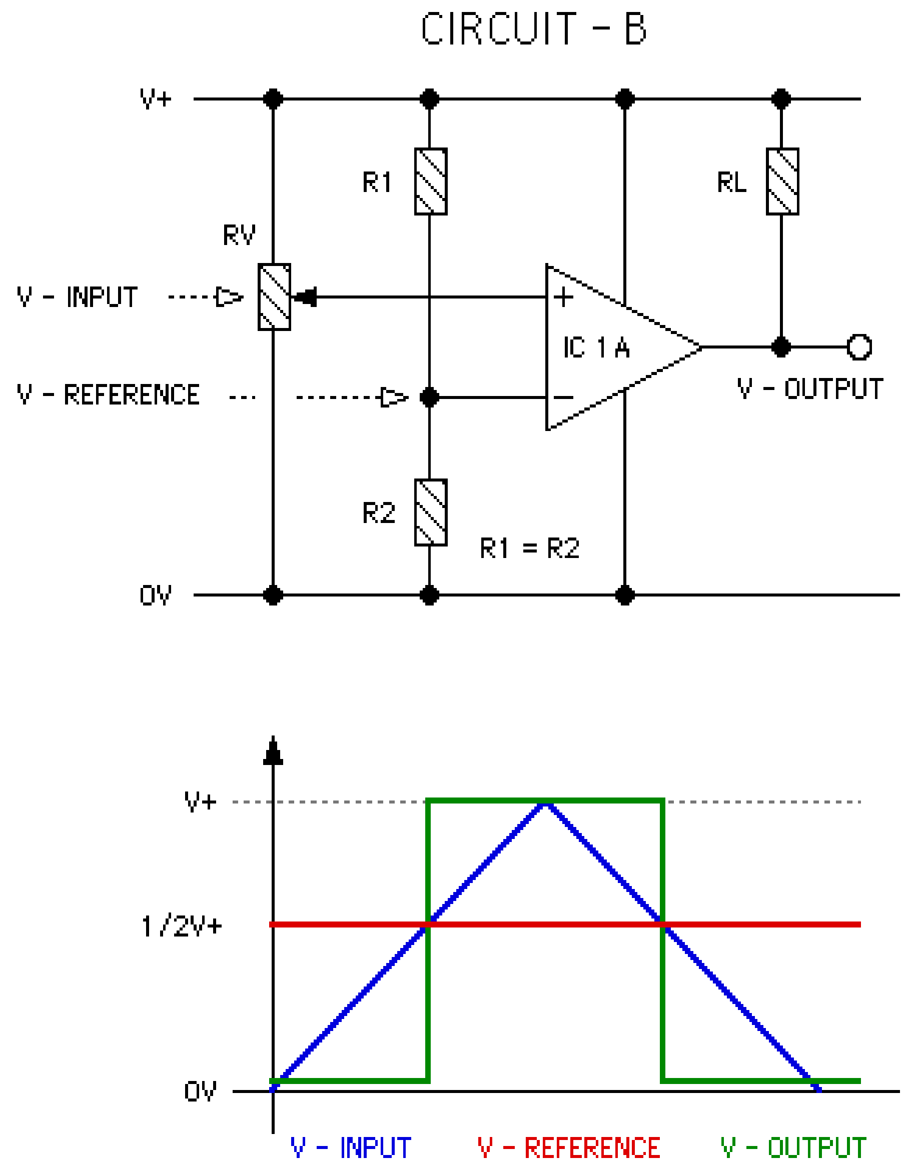

12V
C2
100u
C3
100n
C1
100n
R7
20k
D1
1N4001
Fan
U1A
R1
47k
R6
10k
U1B
U1C
R2
22k
R3
10k
R4
10k
R5
10k
R9
1k
Q1
2N2222A
U1D
LM324
12V
R8
1k
VR1
10k

# BASIC OPERATION OF VOLTAGE COMAPARATORS



Comparator Operation




http://home.cogeco.ca/~rpaisley4/CircuitIndex.html

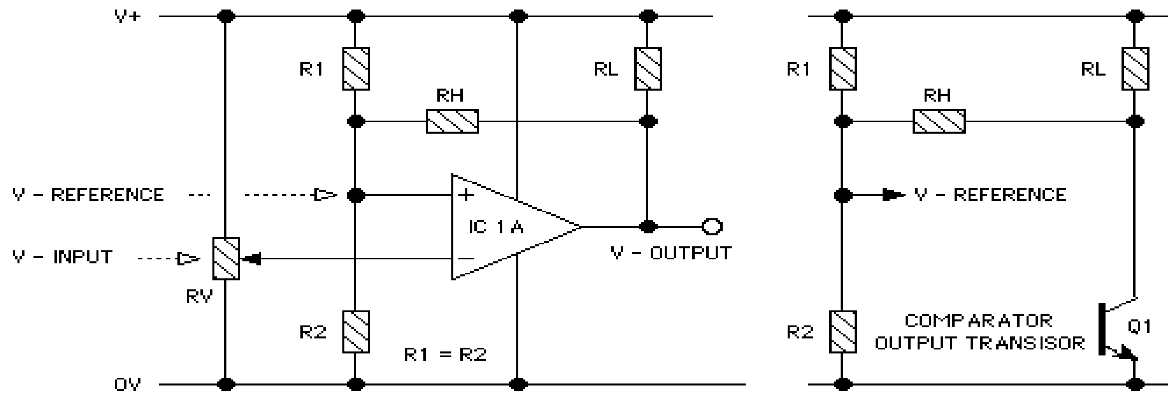
# ADDING HYSTERYSIS TO COMPARATORS



Comparator Hysteresis b

CIRCUIT - A with HYSTERYSIS

EQUIVALENT CIRCUIT




V+ = 12VOLTS

R1 = 10K

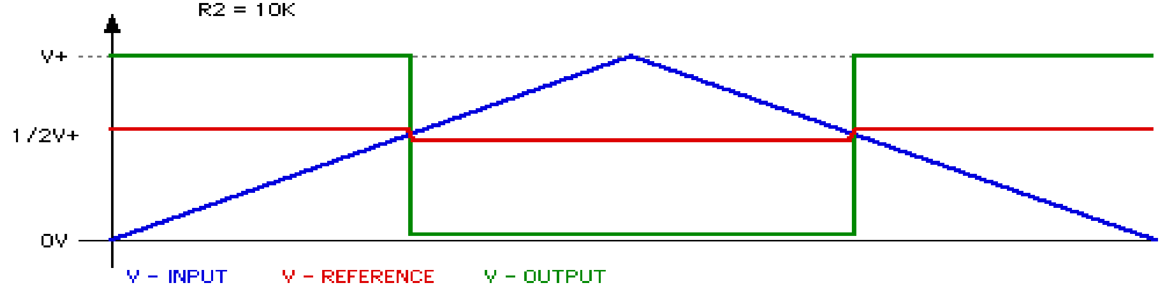
R2 = 10K

RH = 100K

RL = 1K

V - REFERENCE Q1 ON = 5.71V

V - REFERENCE Q1 OFF = 6.28V




## FINDING COMBINED RESISTANCES

OUTPUT TRANSISTOR - ON

$$\frac{1}{\frac{1}{R1} + \frac{1}{RL + RH}} = R1combined$$

OUTPUT TRANSISTOR - OFF

$$\frac{1}{\frac{1}{R2} + \frac{1}{RH}} = R2combined$$

## CALCULATING REFERENCE VOLTAGES

OUTPUT TRANSISTOR - ON

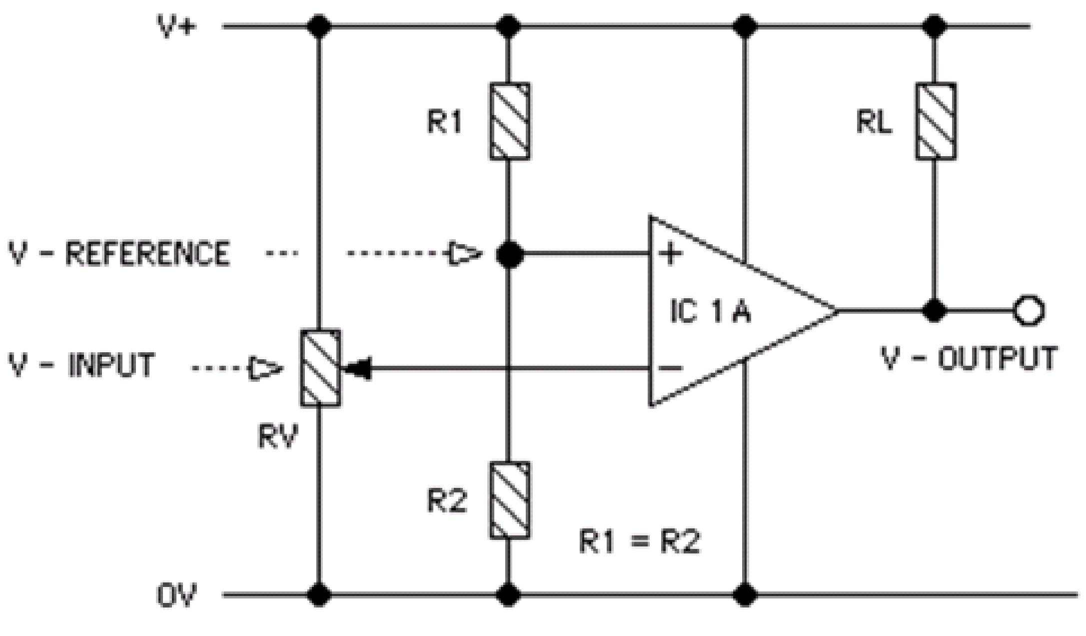
$$\frac{V+}{R1combined + R2} \times R2 = V - REFERENCE$$

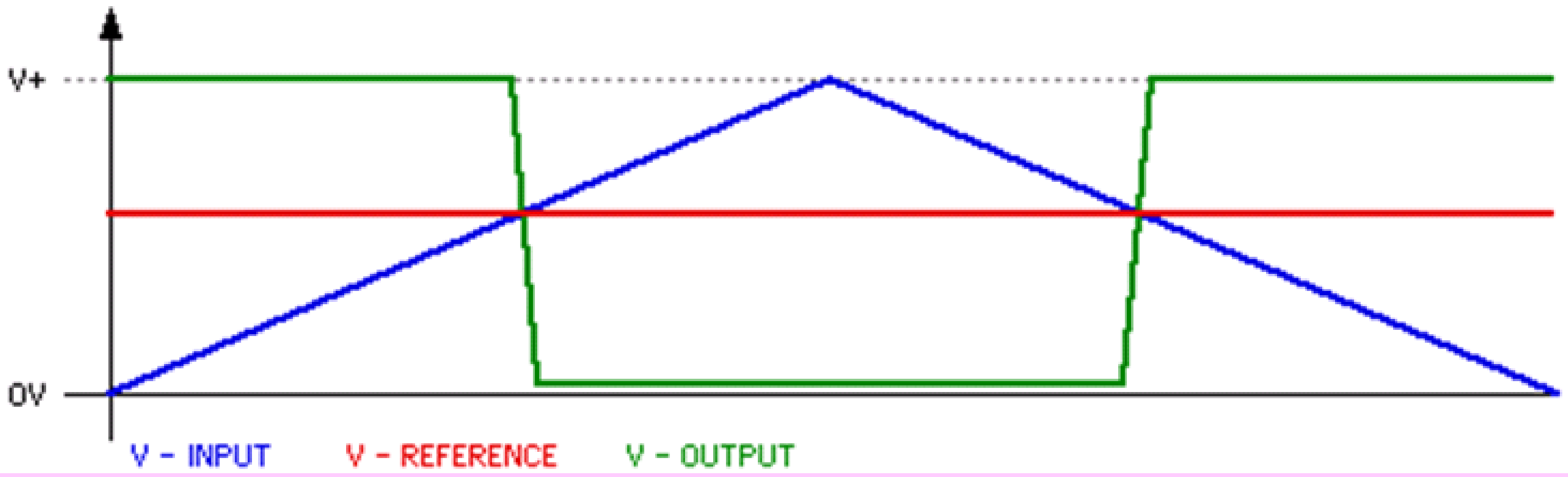
OUTPUT TRANSISTOR - OFF

$$\frac{V+}{R1 + R2combined} \times R2combined = V - REFERENCE$$

- THE VOLTAGE DROP ACROSS THE COMPARATORS OUTPUT TRANSISTOR HAS BEEN IGNORED IN THE ABOVE CALCULATIONS

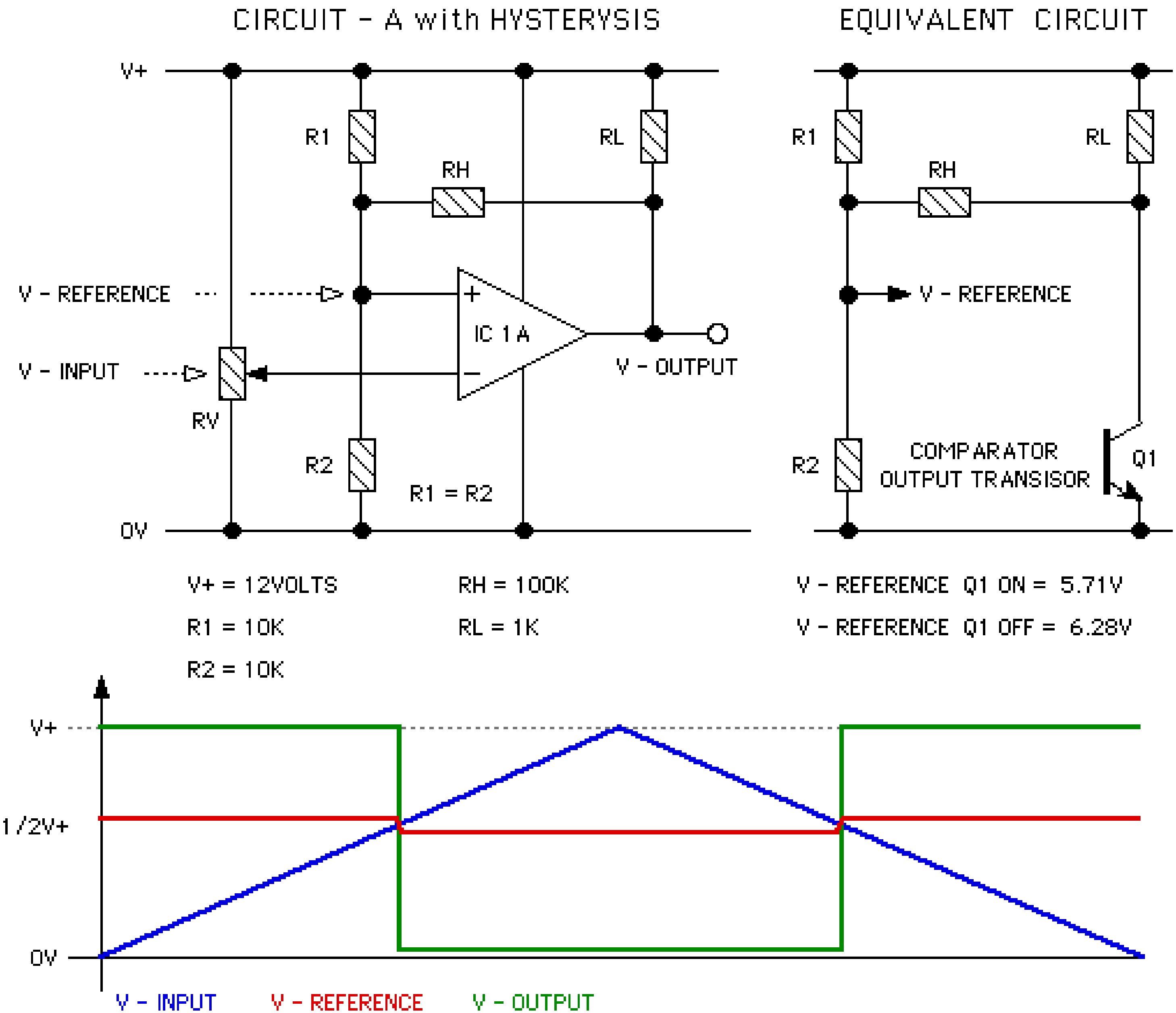
http://home.cogeco.ca/~rpaisley4/CircuitIndex.html


V+
R1
RL
V - REFERENCE
IC 1A
V - INPUT
V - OUTPUT
RV
R2
R1 = R2
0V


V+
0V
V - INPUT
V - REFERENCE
V - OUTPUT

# ADDING HYSTERYSIS TO COMPARATORS

 Comparator Hysteresis b



## FINDING COMBINED RESISTANCES

OUTPUT TRANSISTOR - ON

$$\frac{1}{\frac{1}{R1} + \frac{1}{RL + RH}} = R1combined$$

OUTPUT TRANSISTOR - OFF

$$\frac{1}{\frac{1}{R2} + \frac{1}{RH}} = R2combined$$

## CALCULATING REFERENCE VOLTAGES

OUTPUT TRANSISTOR - ON

$$\frac{V+}{R1combined + R2} \times R2 = V - REFERENCE$$

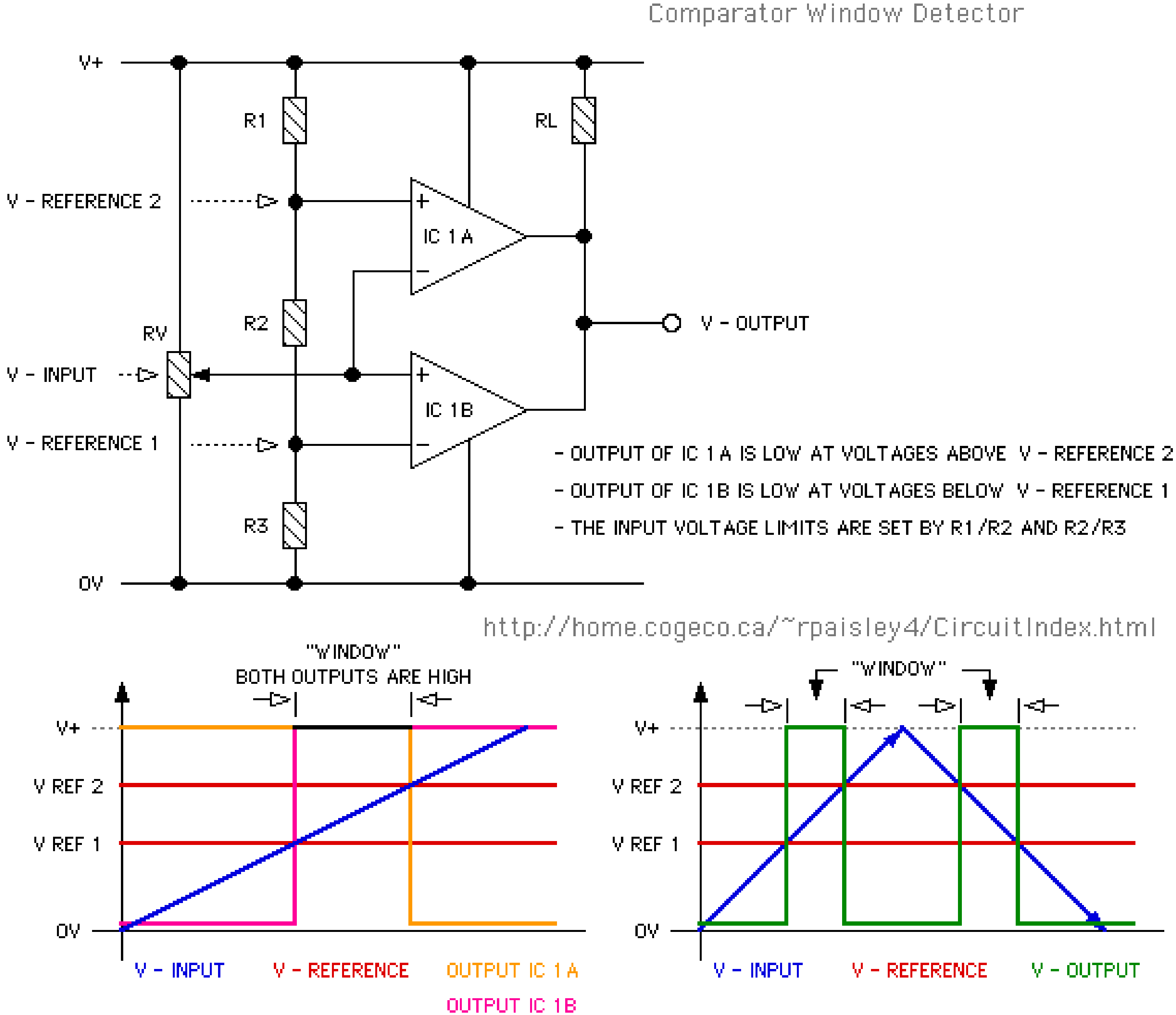
OUTPUT TRANSISTOR - OFF

$$\frac{V+}{R1 + R2combined} \times R2combined = V - REFERENCE$$

- THE VOLTAGE DROP ACROSS THE COMPARATORS OUTPUT TRANSISTOR HAS BEEN IGNORED IN THE ABOVE CALCULATIONS

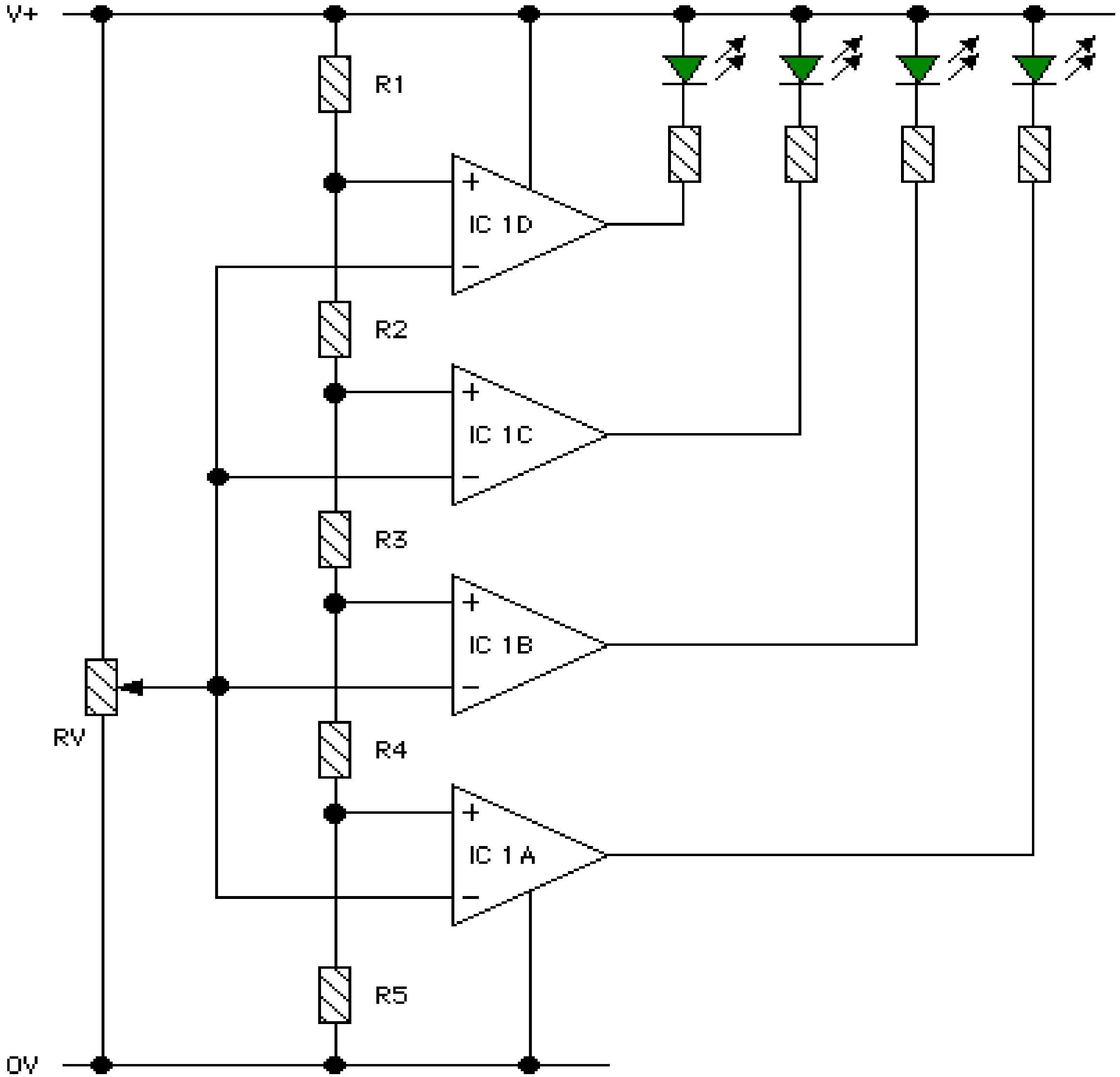
# VOLTAGE WINDOW DETECTOR CIRCUIT





# 4 LEVEL - VOLTAGE DETECTOR

©ROB PAISLEY 2005 Comparator 4 Level




R1, 2, 3, 4, 5 - SELECTED TO GIVE THE DESIRED DETECTION VOLTAGE LEVELS

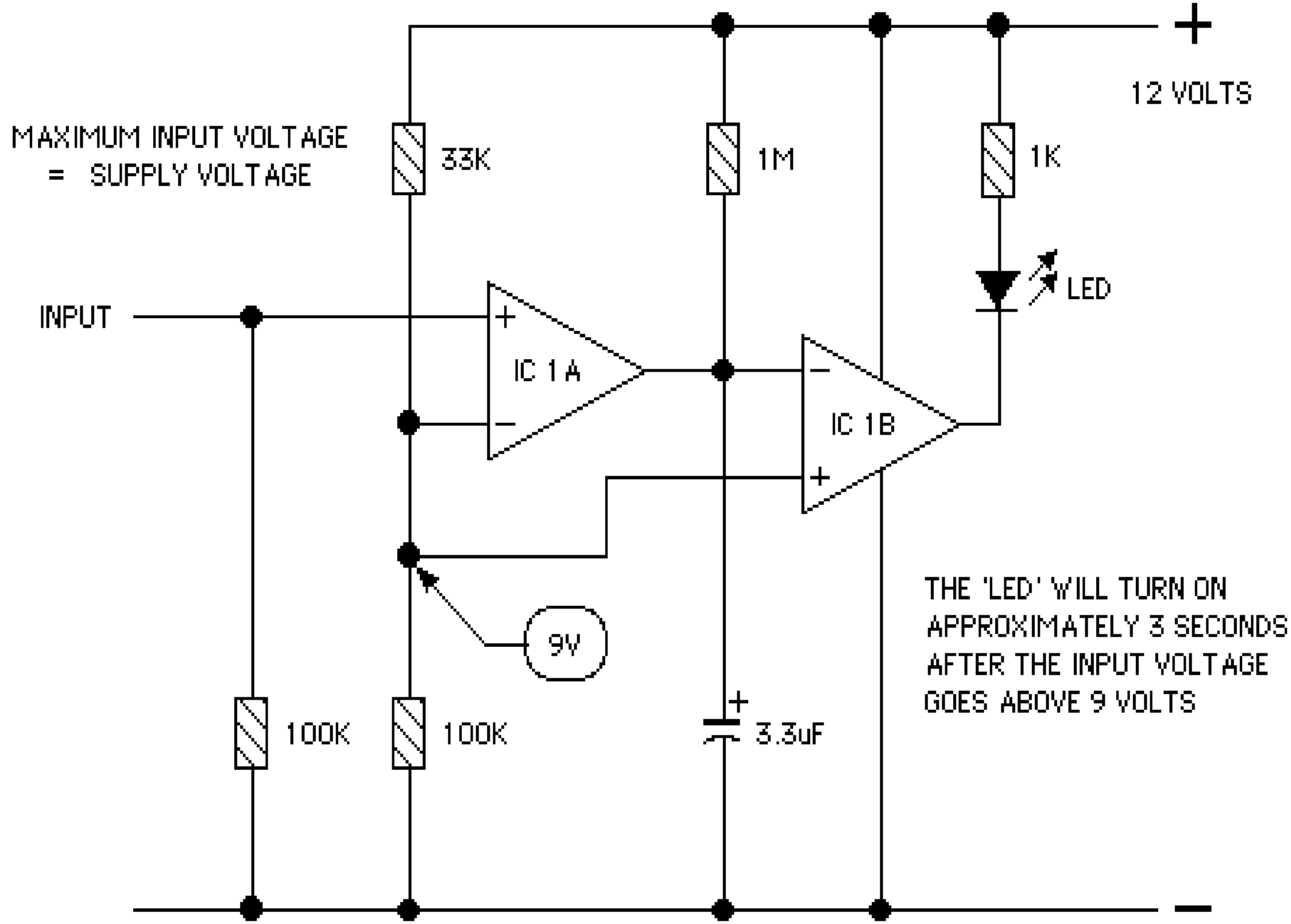
AS EACH LEVEL IS PASSED THE CORESPONDING LED TURNS ON

http://home.cogeco.ca/~rpaisley4/CircuitIndex.html

# TIME DELAY CIRCUIT



Comparator Time Delay b




IC 1A, IC 1B – 1/2 LM393 or 1/4 LM339

http://home.cogeco.ca/~rpaisley4/CircuitIndex.html

Comparators can be made to perform a basic memory function by wiring them as a 'SET / RESET' type of FLIP/FLOP. This type of circuit can be used in unplugable walk around throttles to remember the direction of the train when the controller is disconnected. In the next diagram the comparator will remember which switch was pushed last. If the 'SET' button is pushed the LED will be on, the 'RESET' button will turn the LED off. A higher current version is also shown.
When the output of the comparator is off the voltage at the PLUS input will be the same as the supply voltage. With the PLUS input voltage higher than the MINUS input voltage the output will remain off.

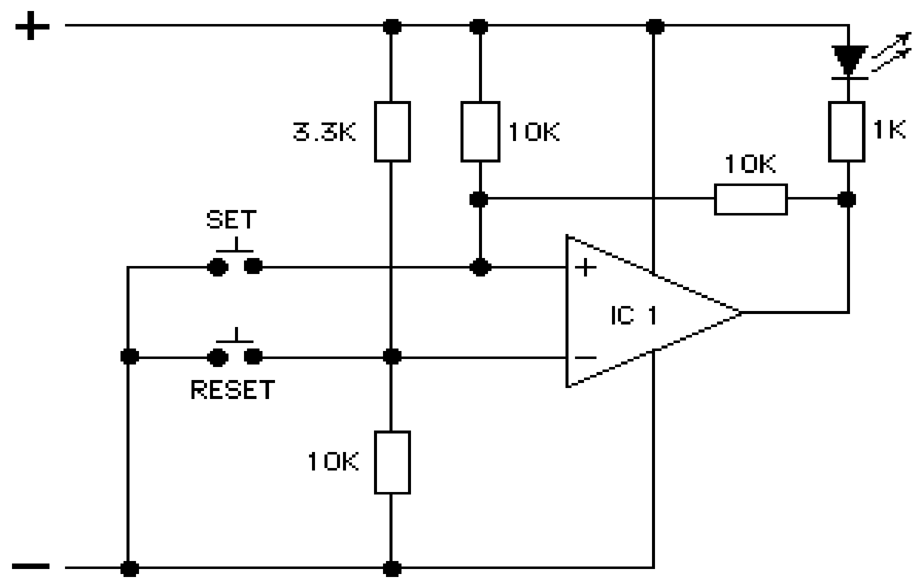
When the SET button is pushed the voltage at the PLUS input will go to zero and the output will turn on.

When the SET button is release the voltage at the PLUS input will rise to 1/2 of the supply voltage and the output will remain turned on because the voltage at the PLUS input is remains below the voltage at the MINUS input.

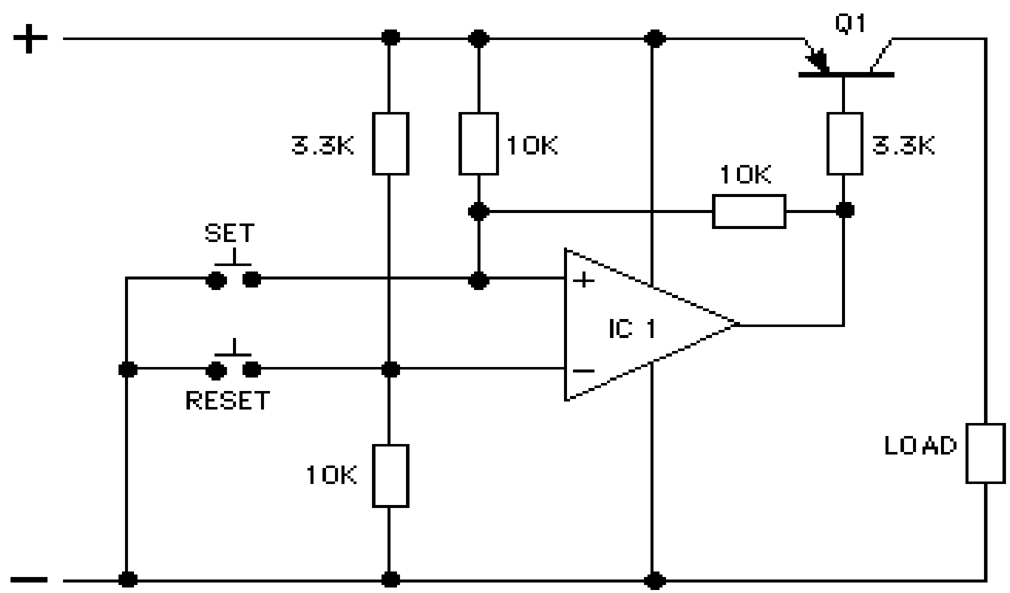
When the RESET button is pressed voltage at the MINUS input will go to zero from its normal level of 3/4 of the supply voltage. The output will turn off because the voltage at the MINUS input is below the voltage at the PLUS input. When the output turns off the voltage at the PLUS input will rise to the supply voltage level.

When the RESET button is released the voltage at the MINUS input will rise to 3/4 of the supply voltage. The PLUS input voltage will stay above the voltage at the MINUS input and the output will stay turned off.

FLIP/FLOP CIRCUIT
MADE WITH A COMPARATOR

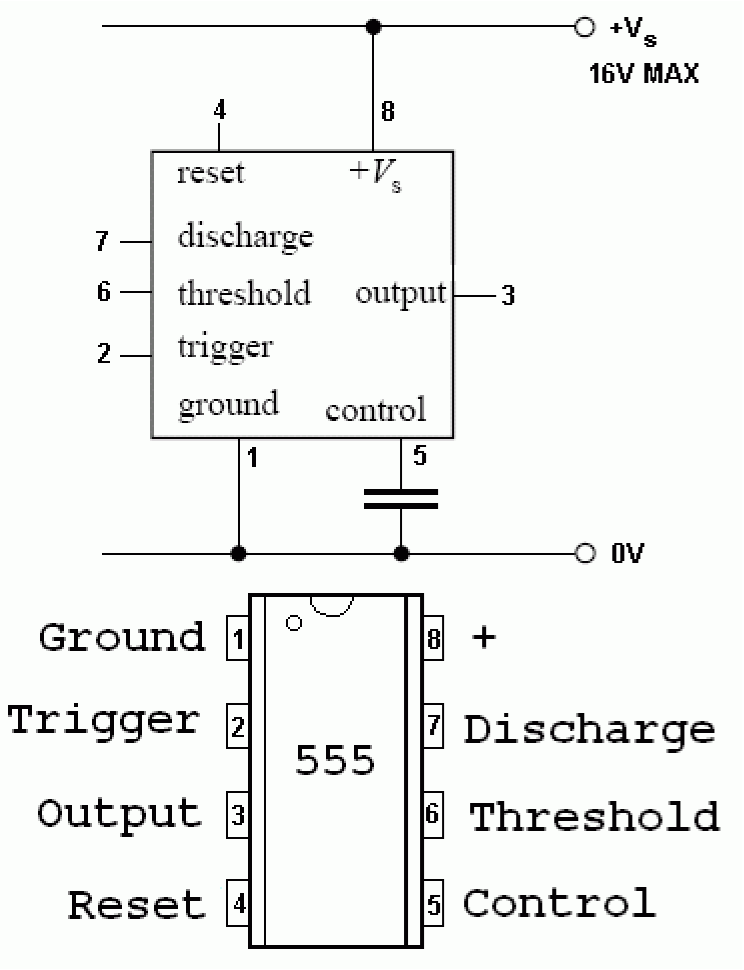


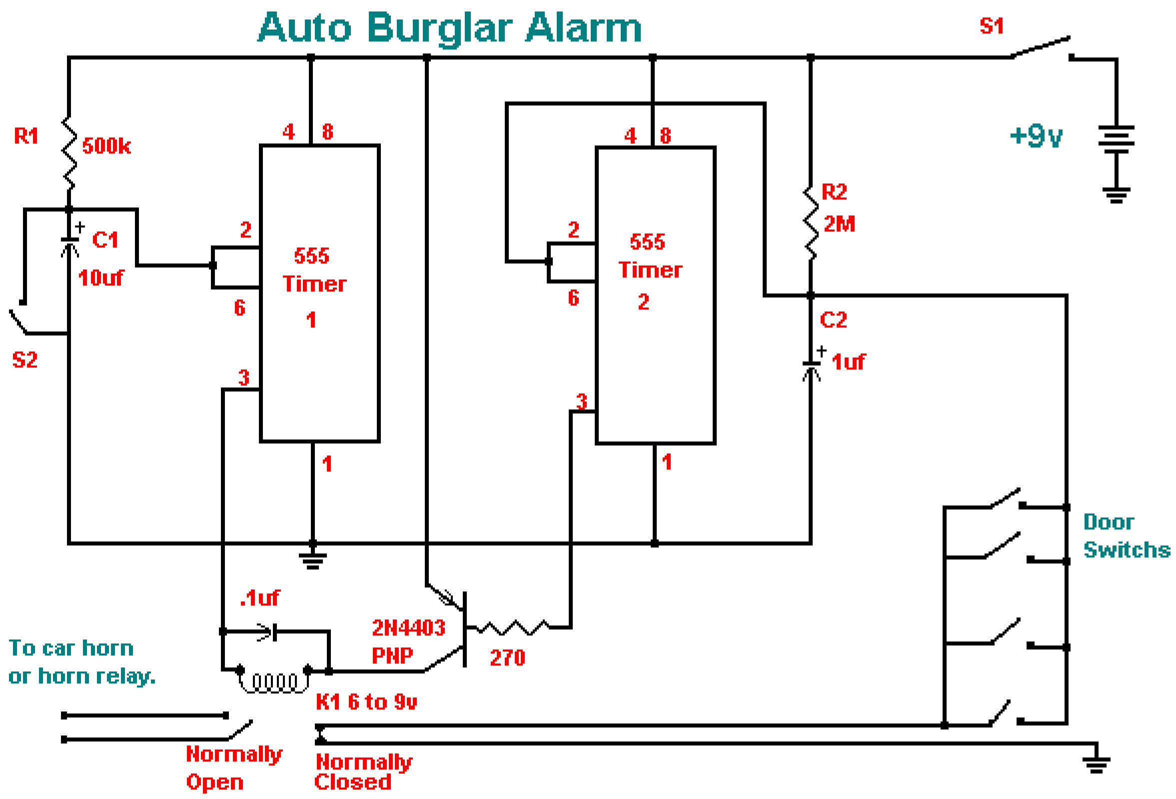

HIGH CAPACITY COMPARATOR FLIP/PLOP



# Timer 555

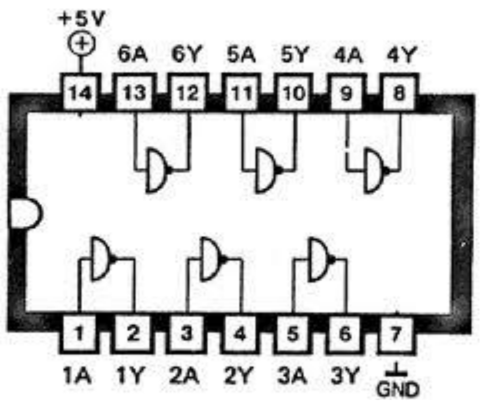
- BJT transistors
- MOFET transistor

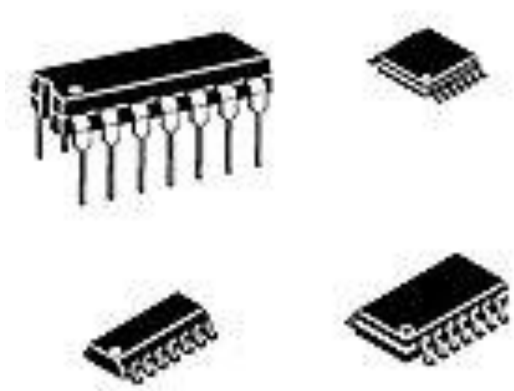


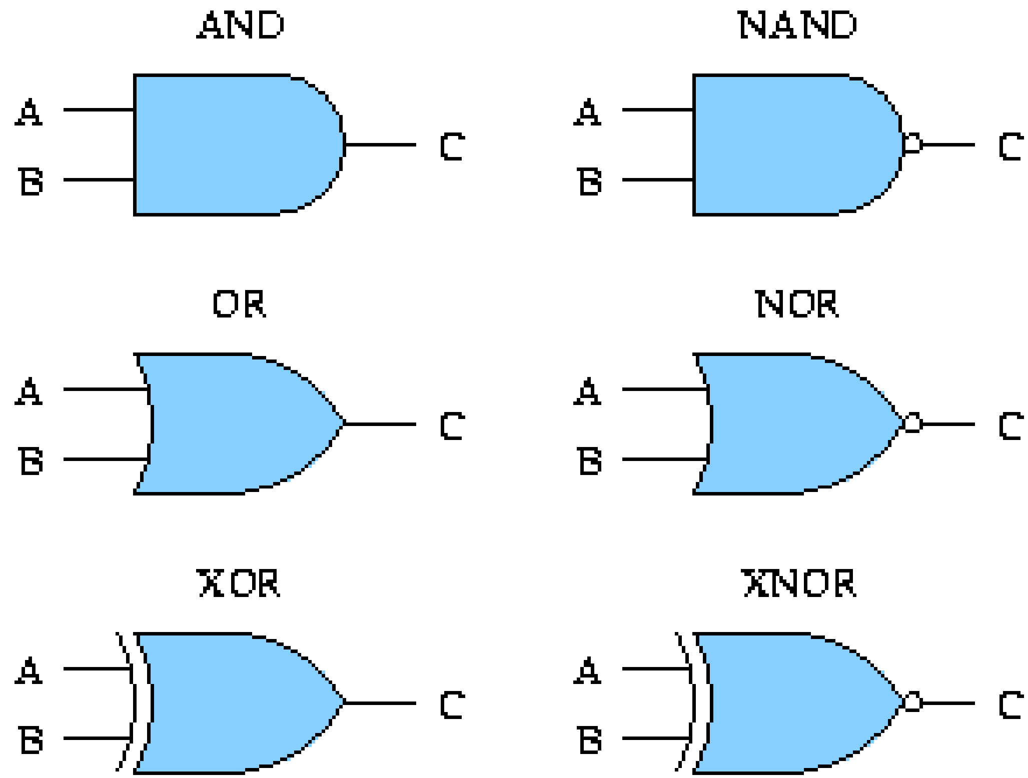



This alarm circuit is based on two 555 timers. The alarm will sound your car horn if anyone opens the car door while the circuit is armed. The timers will allow you to leave the car without sounding the horn. To turn the circuit on S1 must be closed. To set the alarm, open S2 ( it is normally closed ) this will give you about 5 seconds to get out and close the door. The exit delay time is set by R1 and C1. If anyone opens the doors for more then two seconds the horn will sound until power is removed from the circuit. The 2 second time is set by R2 and C2. If you open the door, you must deactivate the alarm by closing S2. This very basic circuit could be used for a home also

# Các cổng logic






| A | B | AND | OR | XOR | NAND | NOR | XNOR |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |

**In 1854 George Boole developed a mathematical system for formulating logic statements with symbols, so the problems could be written and solved in a similar manner to ordinary algebra. His system is called Boolean Algebra and it is used in the analysis and design of digital systems.**

**The basic building blocks of digital circuits are called logic gates. A gate is a circuit that performs a simple logic operation. Gates can have one, two, three or more inputs and the basic gates have a single output dependent on the inputs. Each output is also called a digital ‘bit’ of information (or ‘bit’ for short).**

**The behavior of a gate can be shown in a truth table which systematically lists all the possible input states for a gate and the corresponding output states.**

## AND gate

If both A & B are the same, then the output is true

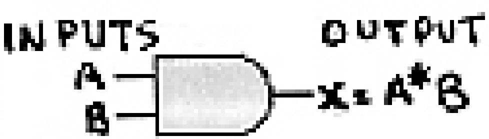
f = A . B  . = AND

( * = . )

**Truth table**

| A | B | X=A*B |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Two Inputs AND Gate




The output is 0 for any case where one or more inputs are 0

## OR gate

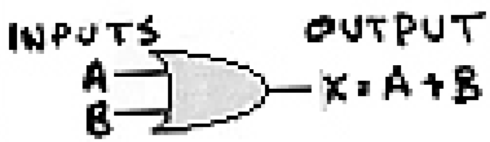
If either A or B or both inputs are high, then the output is high

F = A + B  + = OR

**Truth table**

| A | B | X=A+B |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

Two Inputs OR Gate




The output is 1 for any case where one or more outputs is 1

## NOT gate

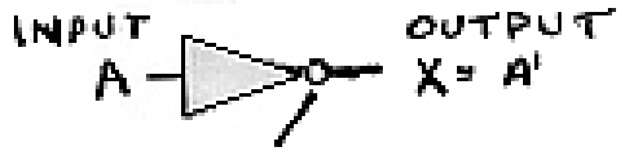
A not gate converts the output to the opposite of the input

x = A'

**Truth table**

| A | X=A' |
|---|---|
| 0 | 1 |
| 1 | 0 |

NOT Gate (an inverter)




Presence of small circle always denotes inversion

*1' = 0 because NOT 1 is 0*
*0' = 1 because NOT 0 is 1*

The NOT operation is also referred to as inversion or complementation, and these terms are used interchangeably.

## NAND gate

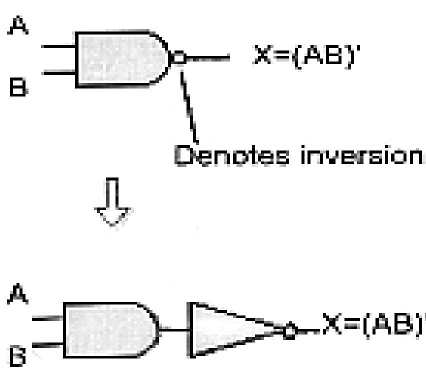
NAND is the same as the AND gate symbol *except* that it has a small circle on the output. This small circle represents the inversion operation. Therefore the output expression of the two input NAND gate is: X = ( AB )'

Truth table

| INPUTS | | AND | NAND |
|---|---|---|---|
| A | B | X= AB | X= (A B)' |
| 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |

Two Inputs NAND Gate

INPUTS OUTPUT




A NAND gate is equivalent to a negative – OR gate

## NOR gate

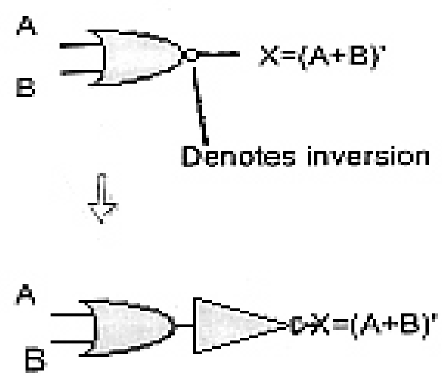
NOR is the same as the <u>OR</u> gate symbol *except* that it has a small circle on the output. This small circle represents the inversion operation. Therefore the output expression of the two input NOR gate is: X = ( A + B )'

Truth table

| INPUTS | | OR | NOR |
|---|---|---|---|
| A | B | X= A+B | X= (A +B) |
| 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |

Two Inputs NOR Gate

INPUTS OUTPUT




A NOR gate is equivalent to a negative – AND gate

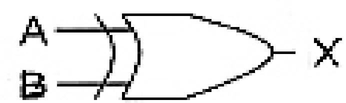
## XOR gate

Can be formed by a combination of other gates.

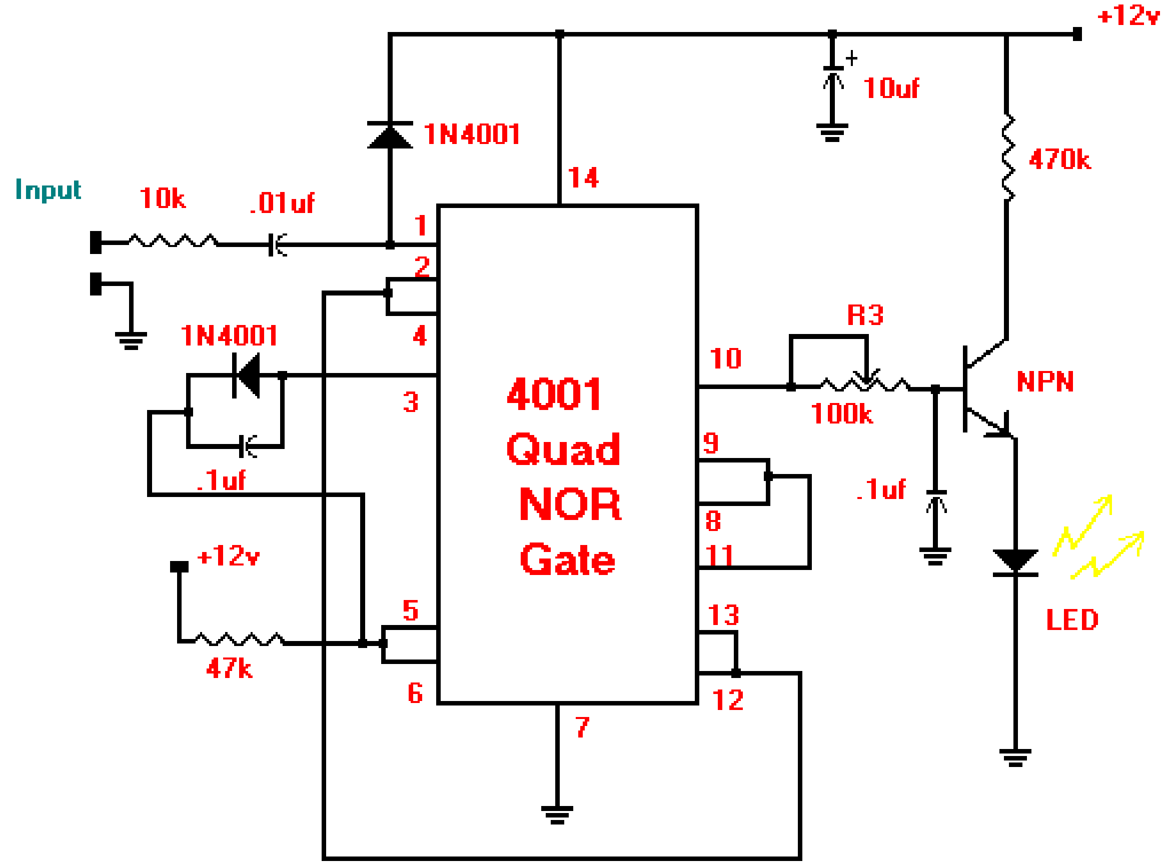
Truth table

| INPUTS | | OUTPUT (X) |
|---|---|---|
| A | B | $A \oplus B$ |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

Two input XOR Gate



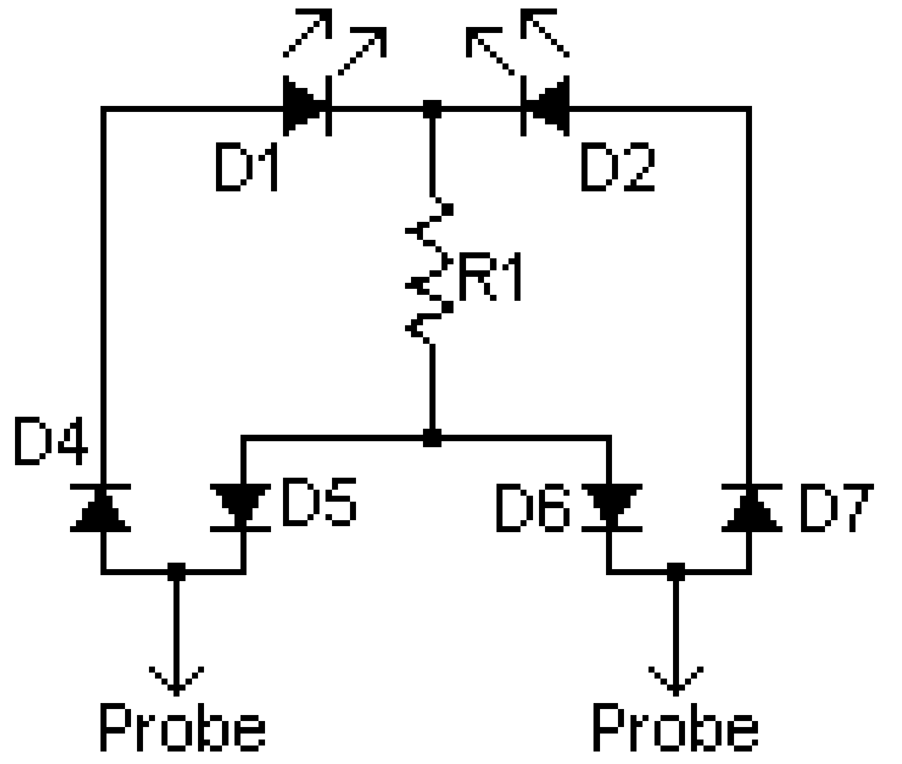

The XOR gate output is HIGH if one (and only one) of the inputs is HIGH; otherwise it is LOW




## Automotive Speed Indicator

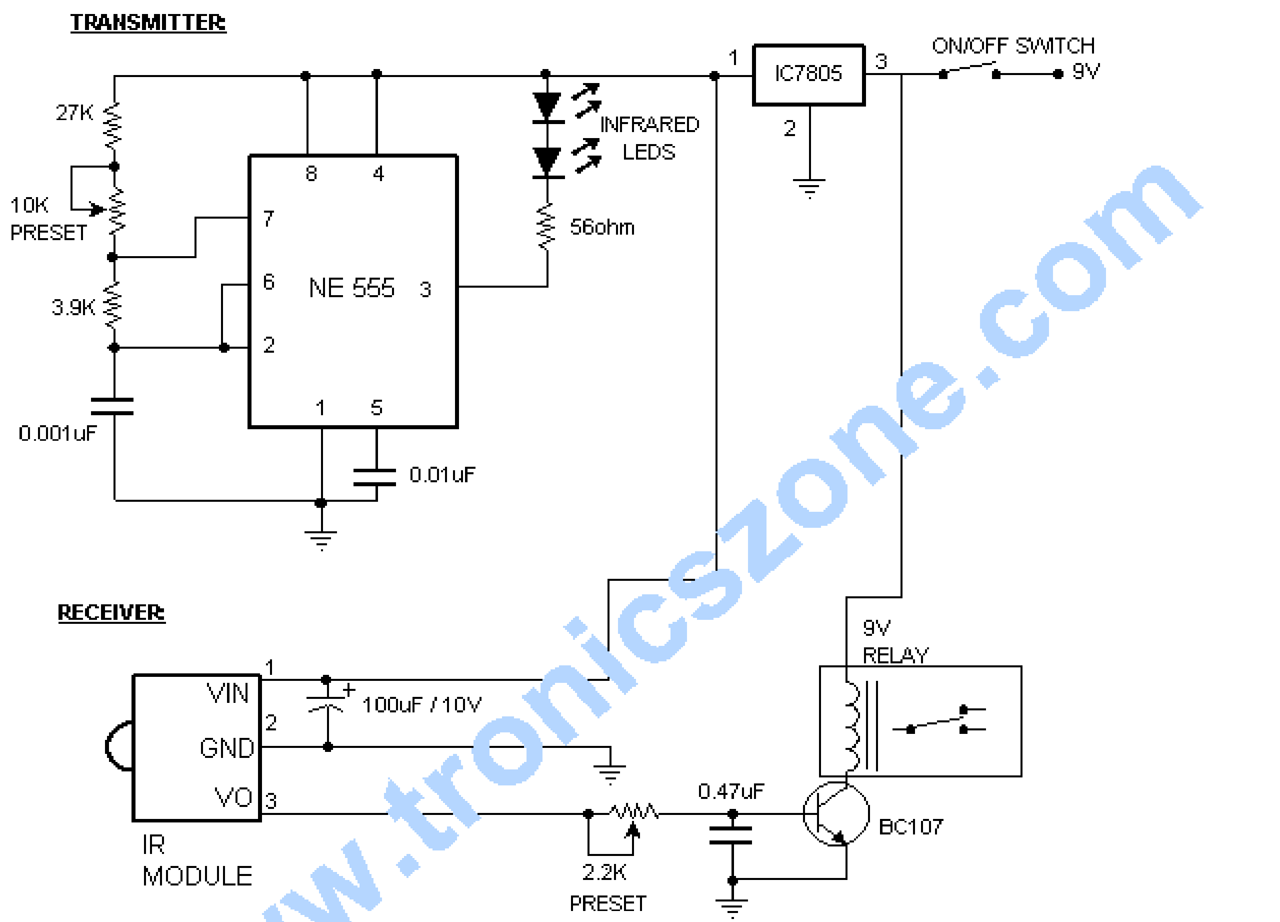
The speed of an automobile can be indicated by detecting the pulses generated by the ignition system and causing an LED to light. The circuit utilizes a quad NOR gate IC chip. Two of the gates are configured as a one shot multivibrator which produces a fixed duration pulse each time the primary circuit of the automobile ignition system opens the circuit to the ignition coil. The other 2 gates are used as buffers which provide an accurate rectangle pulse. As the number of pulses per second increases, the voltage fed to the base of of the NPN transistor becomes high enough to cause it to conduct and turn on the LED. The speed at which the LED lights is set by R4. The input of the circuit is connected to the distributor side of the ignition coil or to the tachometer connection on those cars that are equipped with electronic ignition.

| Part | Total Qty. | Description | Substitutions |
|---|---|---|---|
| R1 | 1 | 1K 1/4W Resistor | |
| D1 | 1 | Green LED | |
| D2 | 1 | Red LED | |
| D4, D5, D6, D7 | 4 | 1N4001 Silicon Diode | 1N4004, 1N4005, 1N4007 |
| MISC | 1 | Board, Wire, Case, Probes | |

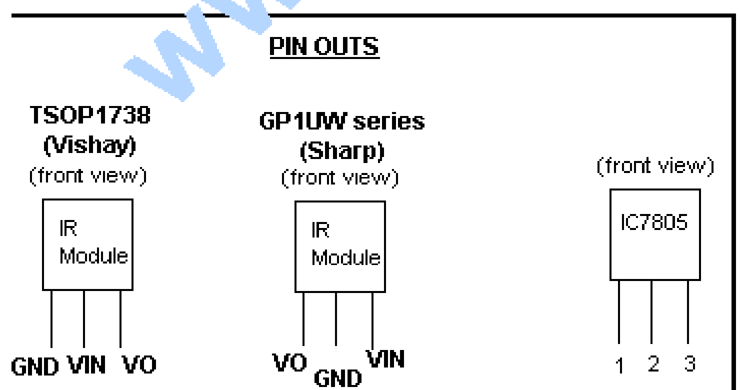



To use the circuit, just connect your probes to the source under test. If D1 lights up, the left most probe (on the schematic) is connected to positive. The opposite is true if the left probe is negative. If both LEDs are on, the source being probed is AC

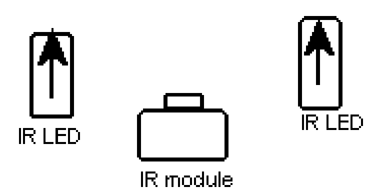
Be careful when using this tester not to probe a source greater than about 12V

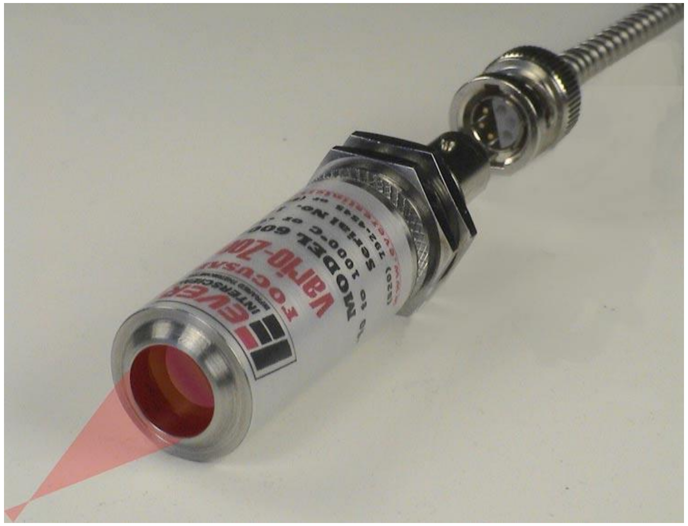


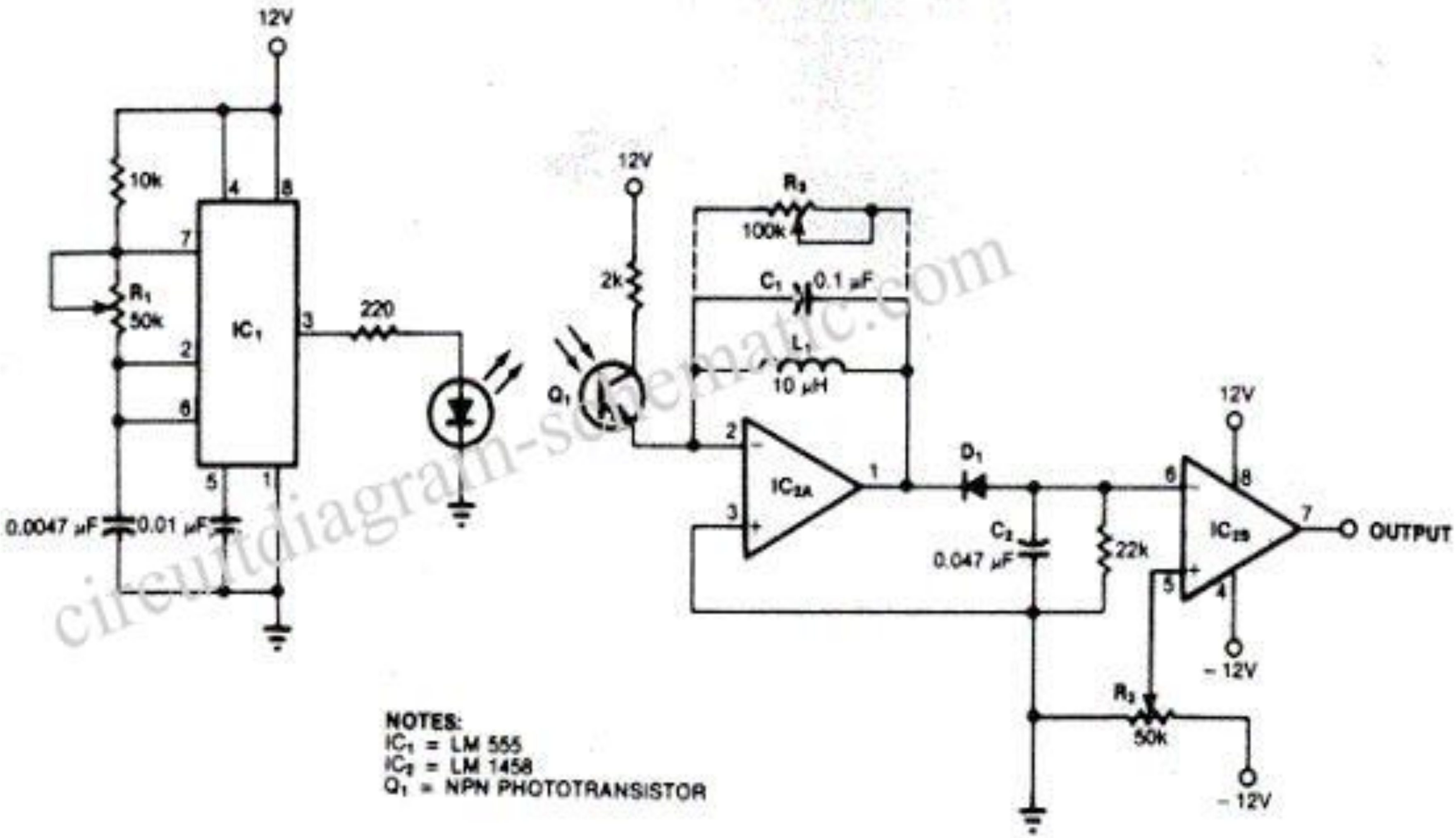

**PIN OUTS**




Suggested arrangement for PROXIMITY DETECTOR:









**NOTES:**
$IC_1$ = LM 555
$IC_2$ = LM 1458
$Q_1$ = NPN PHOTOTRANSISTOR