'INFRARED' LIGHT-EMITTING DIODE APPLICATION CIRCUITS

Serial Connection And Parallel Connection

Figure 1 shows the most basic and commonly used circuits for driving light-emitting diodes.

In Figure 1(A), a constant voltage source (V_{CC}) is connected through a current limiting resistor (R) to an LED so that it is supplied with forward current (I_F). The I_F current flowing through the LED is expressed as $I_F = (V_{CC} - V_F)/R$, providing a radiant flux proportional to the I_F. The forward voltage (V_F) of the LED is dependent on the value of I_F, but it is approximated by a constant voltage when setting R.

Figures 1(B) and 1(C) show the circuits for driving LEDs in serial connection and parallel connection, respectively. In arrangement (B), the current flowing through the LED is expressed as $I_F = (V_{CC} - V_F \times N)/R$, while in arrangement (C), the current flowing through each LED is expressed as $I_F = (V_{CC} - V_F)/R$ and the total supply current is $N \times I_F$, where N is the number of LEDs.

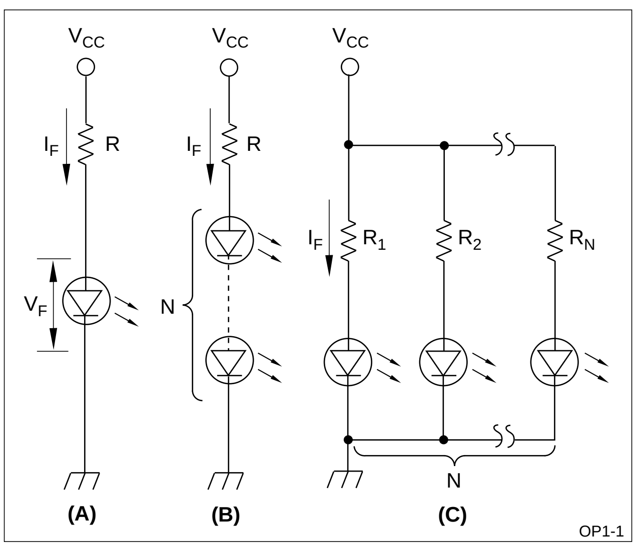


Figure 1. Driving Circuit of Light-Emitting Diode (LED)

The V_F of an LED has a temperature dependency of approximately -1.9 mV/°C. The operating point for the load R varies in response to the ambient temperature as shown in Figure 2.

Constant Current Drive

To stabilize the radiant flux of the LED, the forward current (I_F) must be stabilized by using a constant current source. Figure 3 shows a circuit for constantly driving several LEDs using a transistor. The transistor (Tr_1) is biased by a constant voltage supplied by a zener diode (ZD) so that the voltage across the emitter follower loaded by resistor R_E is constant, thereby making the collector current ($I_C = I_F$) constant. The I_C is given as $I_C = I_E = (V_Z = V_{BE})/R_E$. If too many LEDs are connected, the transistor enters the saturation region and does not operate as a constant current circuit. The number of LEDs (N) which can be connected in series is calculated by the following equations.

$$V_{CC} - N \times V_F - V_E > V_{CE}\ (sat)$$

$$V_E = V_Z - V_{BE}$$

These equations give:

$$N < (V_{CC} - V_Z + V_{BE} - V_{CE}(sat))/V_F$$

Figures 4 and 5 show other constant current driving circuits that use diodes or transistors, instead of zener diodes.

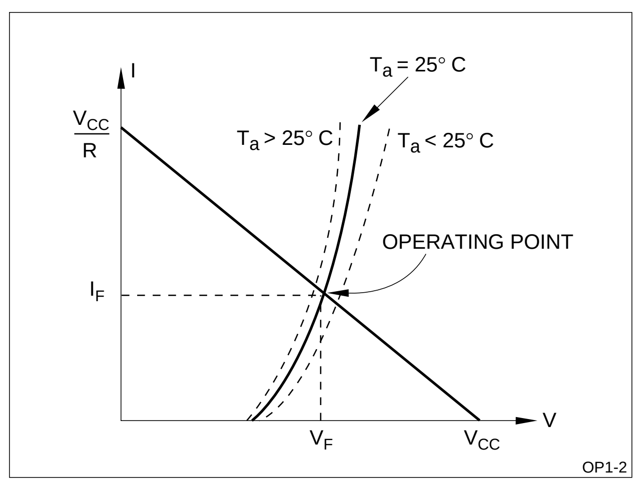


Figure 2. Current vs. Voltage of Light-Emitting Diode (LED)

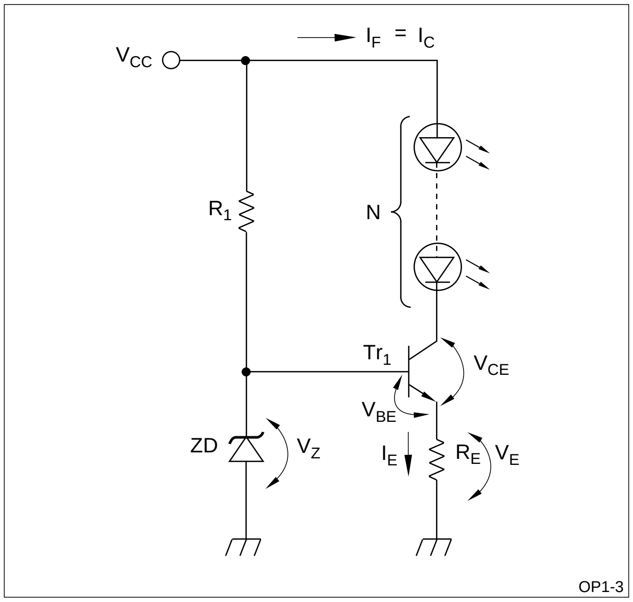


Figure 3. Constant Current Driving Circuit (1)

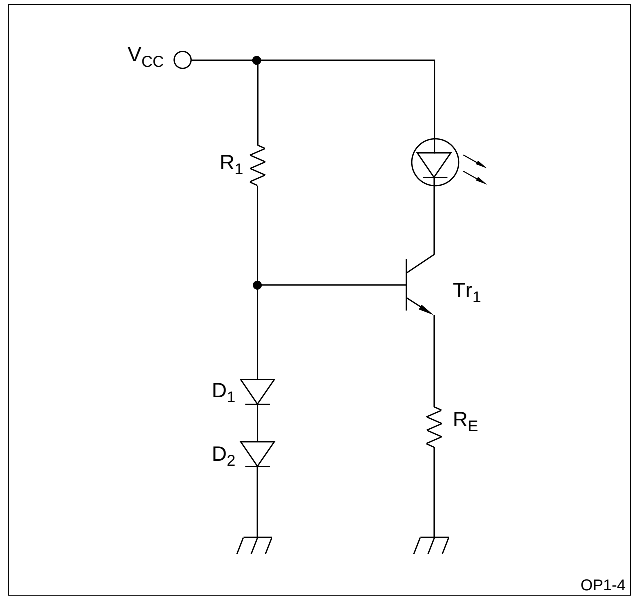


Figure 4. Constant Current Driving Circuit (2)

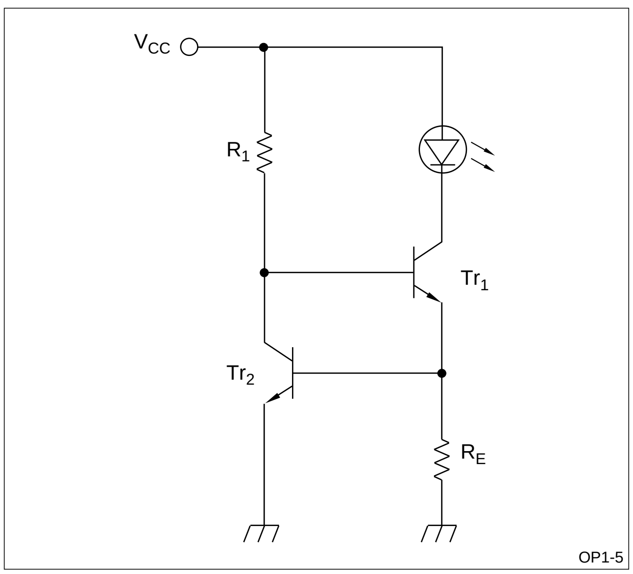


Figure 5. Constant Current Driving Circuit (3)

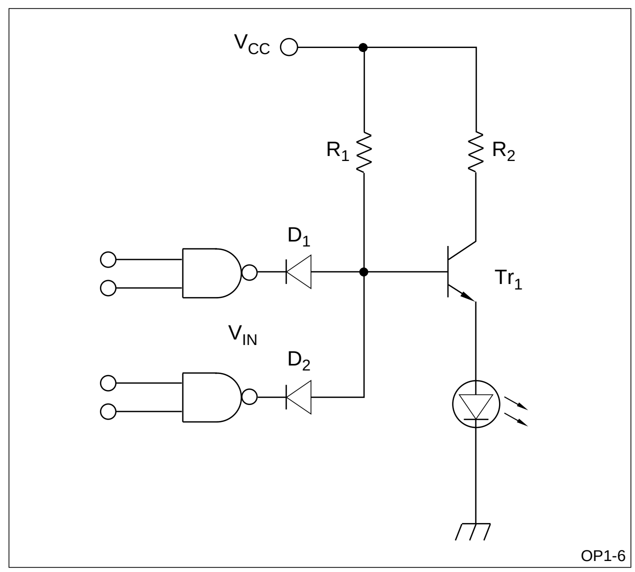


Figure 6. Connection with the TTL Logic Circuit (1)

Driving Circuit Activated By A Logic IC

Figures 6 and 7 show LED driving circuits that operate in response to digital signals provided by TTL or CMOS circuits.

Figure 8 shows a driving circuit connected with a high level logic circuit.

In Figure 6, a high input signal V_{IN} from a TTL circuit makes the NPN transistor (Tr_1) conductive so that the forward current (I_F) flows through the LED. Accordingly, this circuit operates in the positive logic mode, in which a high input activates the LED.

In Figure 7, a low input signal V_{IN} from a TTL circuit makes the PNP transistor (Tr_1) conductive so that the forward current flows through the LED. This circuit operates in the negative logic mode, in which a low input activates the LED.

In Figure 8, the circuit operates in the positive logic mode, and current I_F is stabilized by constant current driving so that the radiant flux of LED is stabilized against variations in the supply voltage (V_{CC}).

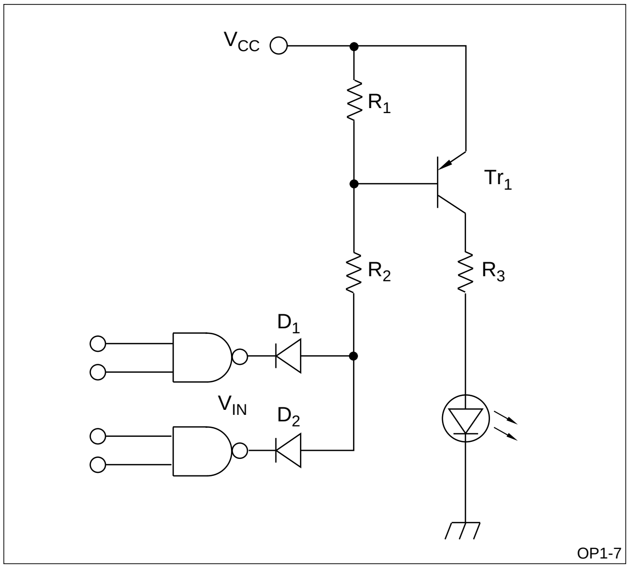


Figure 7. Connection with the TTL Logic Circuit (2)

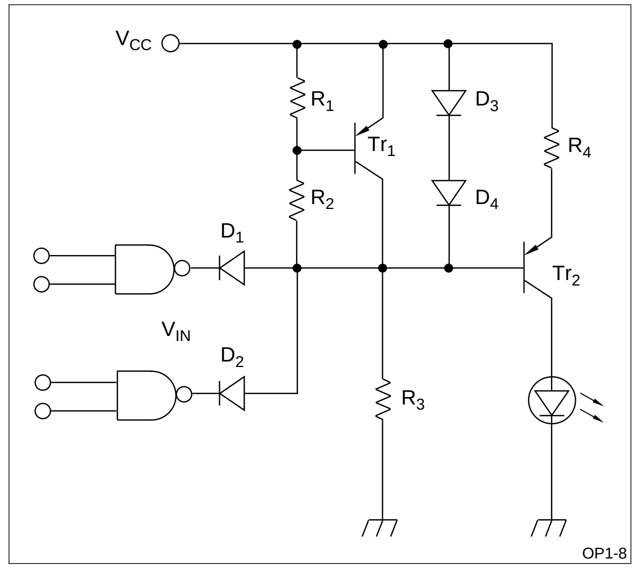


Figure 8. Connection with the TTL Logic Circuit (3)

Driving Circuit With An AC Signal

Figure 9 (A) shows a circuit in which an AC power source supplies the forward current (I_{F1}) to an LED. A diode (D_1) in inverse parallel connection with the LED protects the LED against reverse voltage, suppressing the reverse voltage applied to the LED lower than V_{F2} by using a reverse voltage protection diode of an LED. The LED provides a radiant flux proportional to the applied AC current, (emitting only in half wave).

Figure 9 (B) shows the driving waveform of the AC power source.

Figure 10 (A) shows a driving circuit which modulates the radiant flux of LED in response to a sine wave or modulation signal. Figure 10 (B) shows modulation operation.

If an LED and light detector are used together in an environment of high intensity disturbing light, it is difficult for the light detector to detect the optical signal. In this case, modulating the LED drive signal alleviates the influence of disturbing light and facilitates signal detection.

To drive an LED with a continuous modulation signal, it is necessary to operate the LED in the linear region of the light-emitting characteristics. In the arrangement of Figure 10, a fixed bias (I_{F1}) is applied to the LED using R_1 and R_2 so that the maximum amplitude of the modulation signal voltage (V_{IN}) lies within the linear portion of the LED characteristics. Moreover, to stabilize the radiant flux of the LED, it is driven by a constant current by the constant current driving circuit shown in Figure 3. The capacitor (C) used in Figure 10 (A) is a DC signal blocking capacitor.

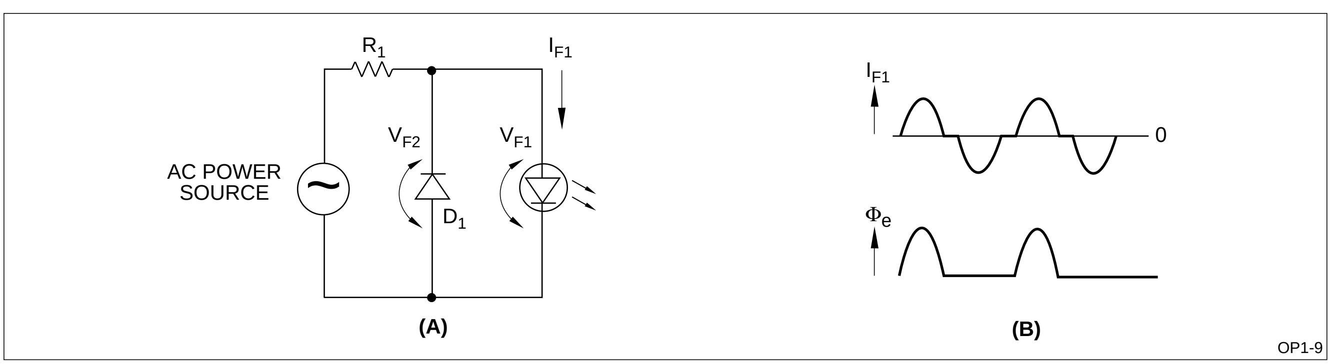


Figure 9. (A) Driving Circuit with AC Power Source
(B) Driving Waveform

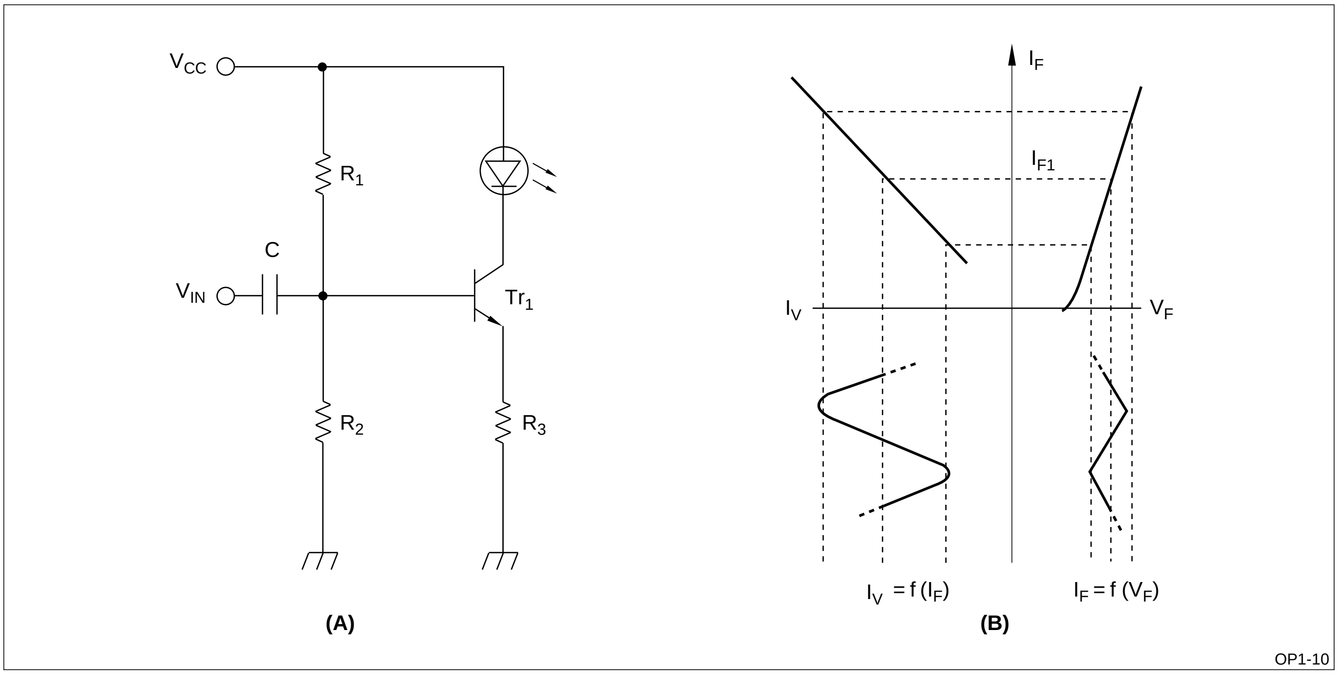


Figure 10. (A) Modulation Driving Circuit
(B) Modulation Operation

Pulse Driving

LED driving systems fall into three categories: DC driving system, AC driving system (including modulation systems), and pulse driving system.

Features of the pulse driving system:

1. Large radiant flux
2. Less influence of disturbing light
3. Information transmission

1. The radiant flux of the LED is proportional to its forward current (I_F), but in reality a large I_F heats up the LED by itself, causing the light-emitting efficiency to fall and thus saturating the radiant flux. In this circumstance, a relatively large I_F can be used with no risk of heating through the pulse drive of the LED. Consequently, a large radiant flux can be obtained.

2. When an LED is used in the outdoors where disturbing light is intense, the DC driving system or AC driving system which superimposes an AC signal on a fixed bias current provides low radiant flux, making it difficult to distinguish the signal (irradiation of LED) from disturbing light. In other words, the S/N ratio is small enough to reliably detect the signal. The pulse driving system provides high radiant flux and allows the detection of signal variations at the rising and falling edges of pulses, thereby enabling the use of LED-light detector where disturbing light is intense.

3. Transmission of information is possible by variations in pulse width or co unting of the number of pulse used to encode the LED emission.

Figures 11 through 14 show typical pulse driving circuits. Figure 15 shows the pulse driving circuit used in the optical remote control. The circuit shown in Figure 11 uses an N-gate thyristor with voltage between the anode and cathode oscillated at a certain interval determined by the time constant of C × R so that the LED emits light pulse. To turn off the N-gate thyristor, resistor R_3 must be used so that the anode current is smaller than the holding current (I_H), i.e., $I_H > V_{CC}/R_3$. Therefore, R_3 has a large value, resulting in a large time constant ($\tau \pm C \times R_3$) and the circuit operates for a relatively long period to provide short pulse widths. The circuit shown in Figure 12 uses a type 555 timer IC to form an astable multivibrator to produce light pulses on the LED. The off-period (t_1) and the on-period (t_2) of the LED are calculated by the following equations.

$t_1 = 1n2 \times (R_1 + R_2) \times C_1$

$t_2 = 1n2 \times R_2 \times C_1$

The value of R_1 is determined so that the rating of I_{IN} of a 555 timer IC is not exceeded, i.e. $S_1 > V_{CC}/I_{IN}$.

This pulse driving circuit uses a 555 timer IC to provide wide variable range in the oscillation period and light-on time. It is used extensively.

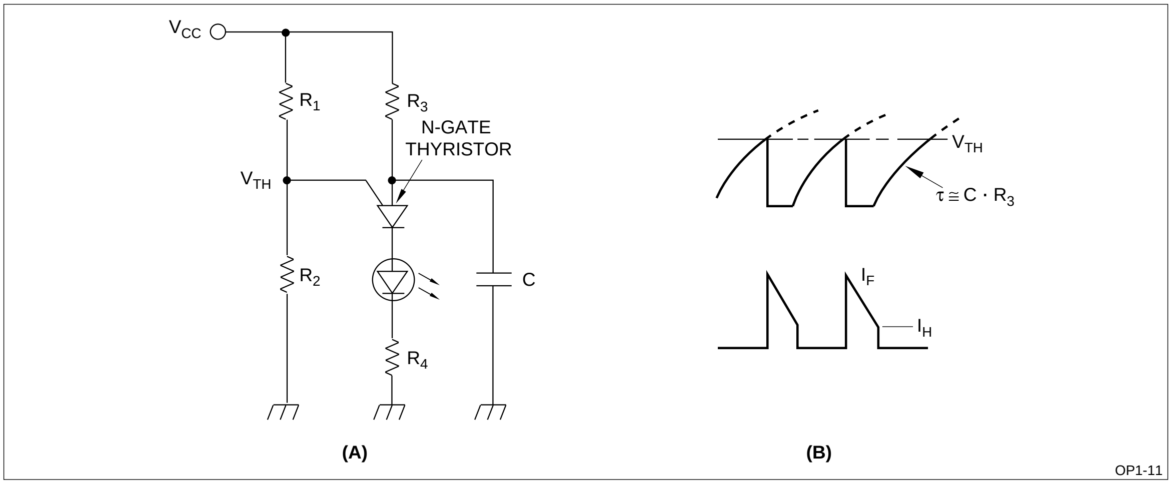


Figure 11. (A) Pulse Driving Circuit using N-Gate Thyristor (B) Operating Waveform

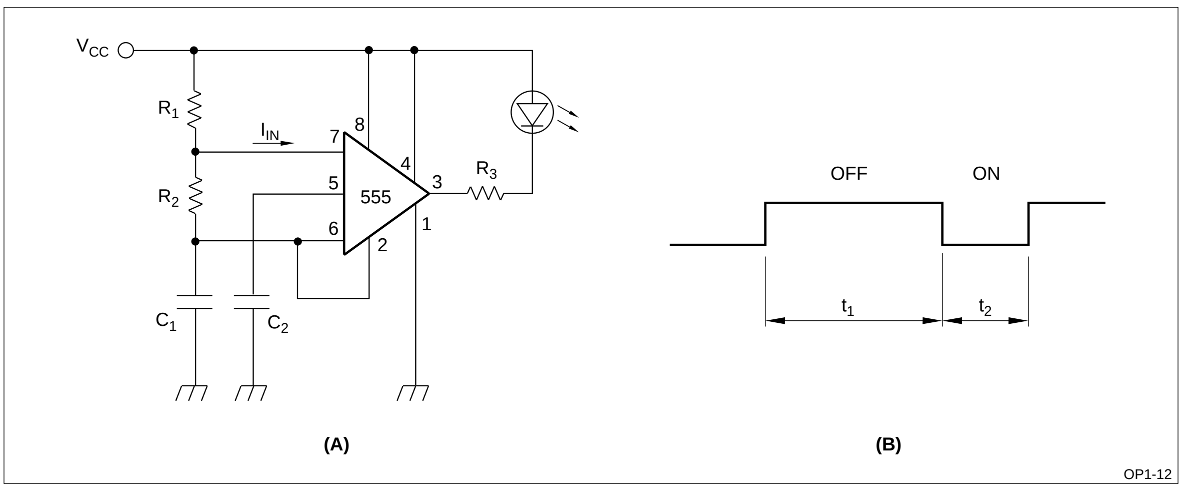


Figure 12. (A) Pulse Driving using a 555 Timer IC (B) Output Waveform

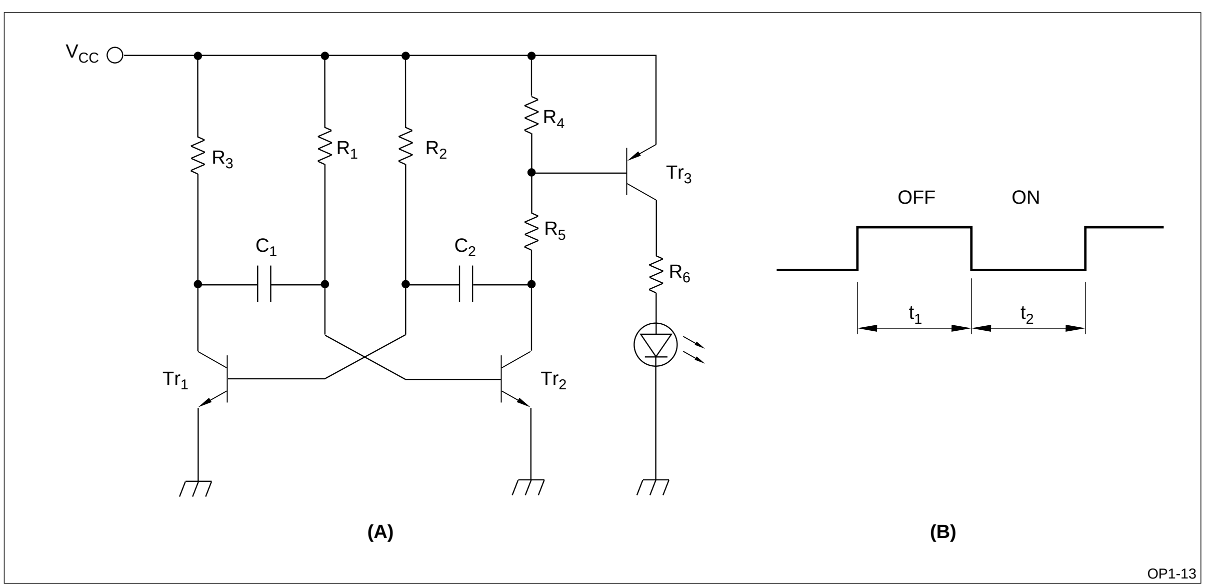


Figure 13. (A) Pulse Driving Circuit using Astable Multivibrator (B) Output Waveform

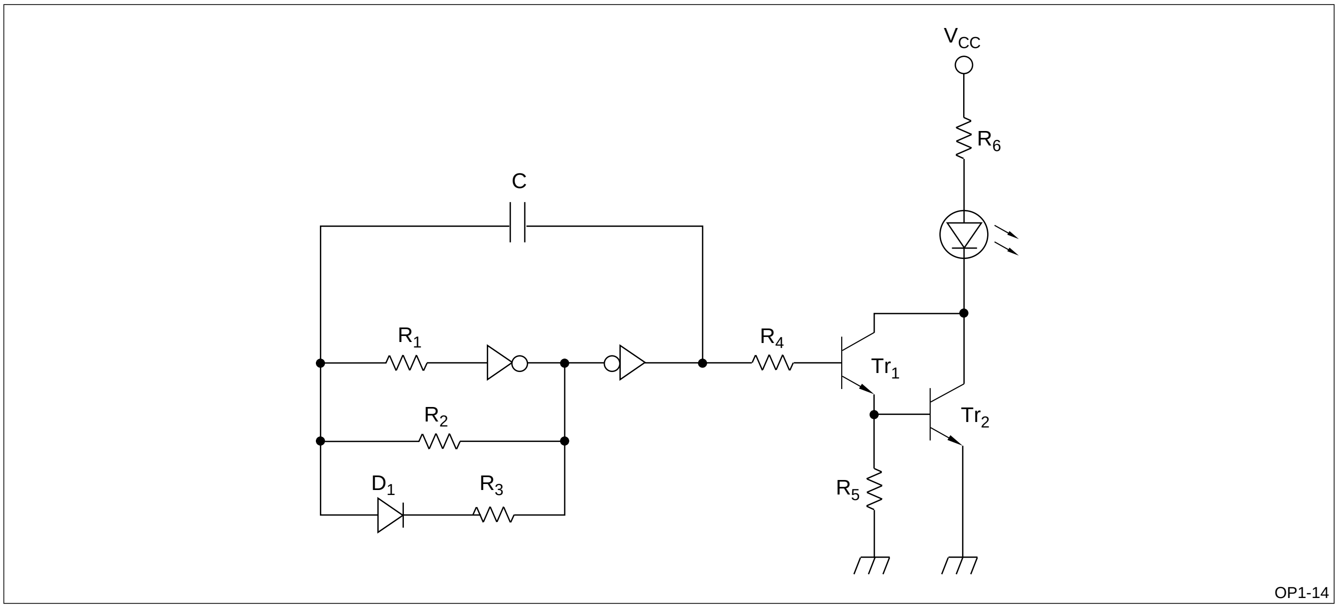


Figure 14. Pulse Driving Circuit using CMOS Logic IC

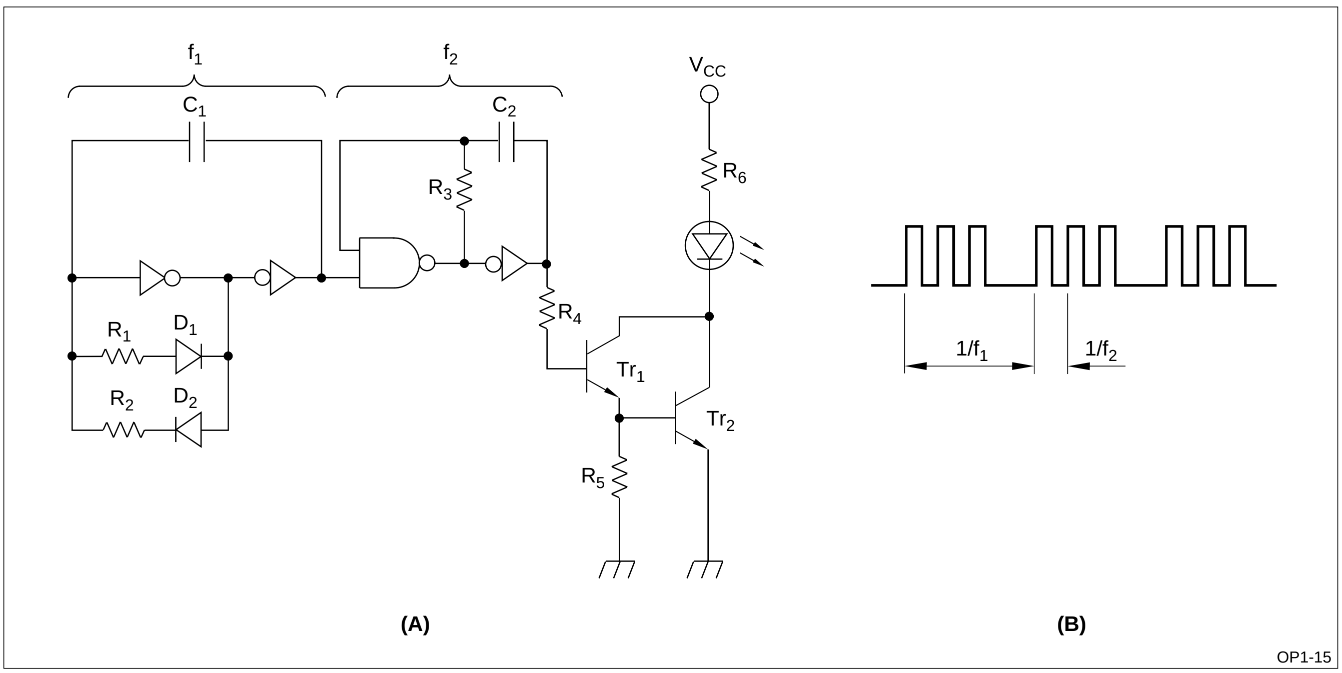


Figure 15. (A) Pulse Driving Circuit
(B) Output Waveform

The circuit shown in Figure 13 uses transistors to form an astable multivibrator for pulse driving an LED. The off-period (t_1) of the LED is given by $C_1 \times R_1$, while its on-period (t_2) is given by $C_2 \times R_2$. For oscillation of this circuit, resistors must be chosen so that the R_1/R_3 and R_2/R_5 ratios are large.

The circuit shown in Figure 14 uses a CMOS logic IC (inverter) to form an oscillation circuit for pulse driving an LED. The pulse driving circuit using a logic IC provides a relatively short oscillation period with a 50% duty cycle.

Figure 15 (A) shows an LED pulse driving circuit used for the light projector of the optical remote control and optoelectronic switch. The circuit is arranged by combining two different oscillation circuits i.e., a long period oscillation (f_1) superimposed with a short period oscillation (f_2) as shown in Figure 15 (B). Frequencies f_1 and f_2 can be set independently.

PHOTODIODE/PHOTOTRANSISTOR APPLICATION CIRCUITS

Fundamental Photodiode Circuits

Figures 16 and 17 show the fundamental photodiode circuits.

The circuit show in Figure 16 transforms a photocurrent produced by a photodiode without bias into a voltage. The output voltage (V_{OUT}) is given as $V_{OUT} = 1_P \times R_L$. It is more or less proportional to the amount of incident light when $V_{OUT} < V_{OC}$. It can also be compressed logarithmically relative to the amount of incident light when V_{OUT} is near V_{OC}. (V_{OC} is the open-terminal voltage of a photodiode).

Figure 16 (B) shows the operating point for a load resistor (R_L) without application of bias to the photodiode.

Figure 17 shows a circuit in which the photodiode is reverse-biased by V_{CC} and a photocurrent (I_P) is transformed into an output voltage. Also in this arrangement, the V_{OUT} is given as $V_{OUT} = I_P \times R_L$. An output voltage proportional to the amount of incident light is obtained. The proportional region is expanded by the amount of V_{CC} {proportional region: $V_{OUT} < (V_{OC} + V_{CC})$} . On the other hand, application of reverse bias to the photodiode causes the dark current (I_d) to increase, leaving a voltage of $I_d \times R_L$ when the light is interrupted, and this point should be noted in designing the circuit.

Figure 17 (B) shows the operating point for a load resistor R_L with reverse bias applied to the photodiode.

Features of a circuit used with a reverse-biased photodiode are:

1. High-speed response
2. Wide-proportional-range of output

Therefore, this circuit is generally used.

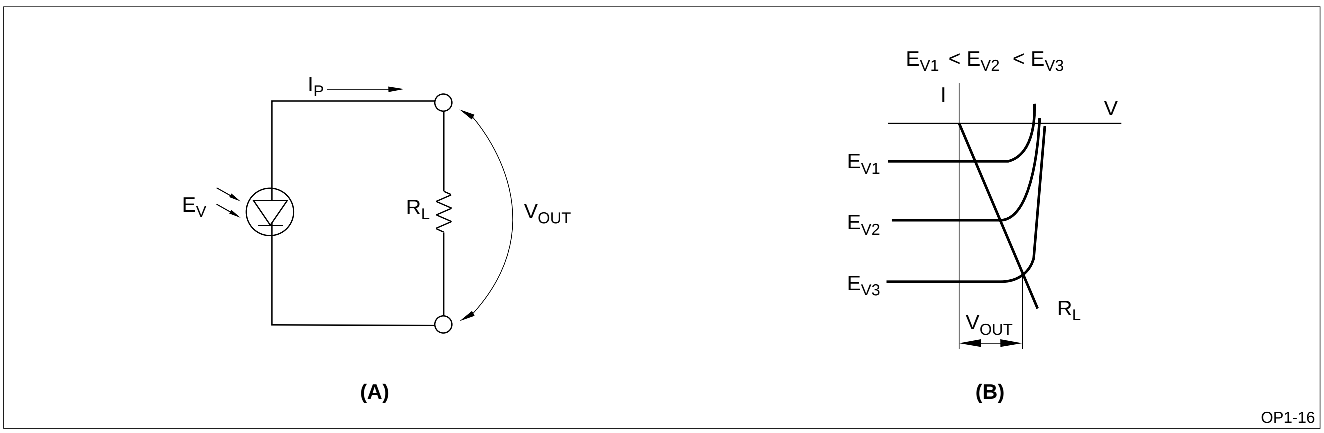


Figure 16. (A) Fundamental Circuit of Photodiode (without bias)

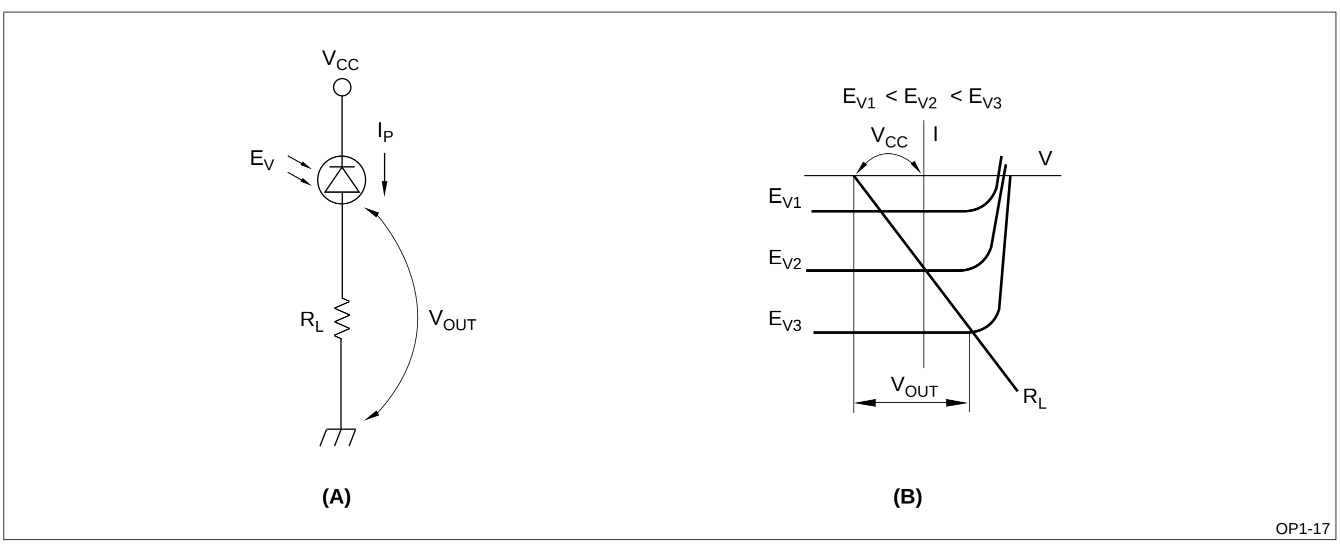


Figure 17. Fundamental Circuit of Photodiode (with bias)

The response time is inversely proportional to the reverse bias voltage and is expressed as follows:

$r = C_j \times R_L$

$C_j = A(V_D - V_R) - \frac{1}{n}$

C_j: junction capacitance of the photodiode

R_L: load resistor

V_D: diffusion potential (0.5 V ~ 0.9 V)

V_R: Reverse bias voltage (negative value)

n: 2 ~ 3

Photocurrent Amplifier Circuit Using The Transistor Of Photodiode

Figures 18 and 19 show photocurrent amplifiers using transistors.

The circuit shown in Figure 18 are most basic combinations of a photodiode and an amplifying transistor. In the arrangement of Figure 18 (A), the photocurrent produced by the photodiode causes the transistor (Tr_1) to decrease its output (V_{OUT}) from high to low. In the arrangement of Figure 18 (B), the photocurrent causes the V_{OUT} to increase from low to high. Resistor R_{BE} in the circuit is effective for suppressing the influence of dard current (I_d) and is chosen to meet the following conditions:

$R_{BE} < V_{BD}/I_d$

$R_{BE} > V_{BE} / \{I_P - V_{CC}/(R_L \times h_{FE})\}$

Figure 19 shows simple amplifiers utilizing negative feedback.

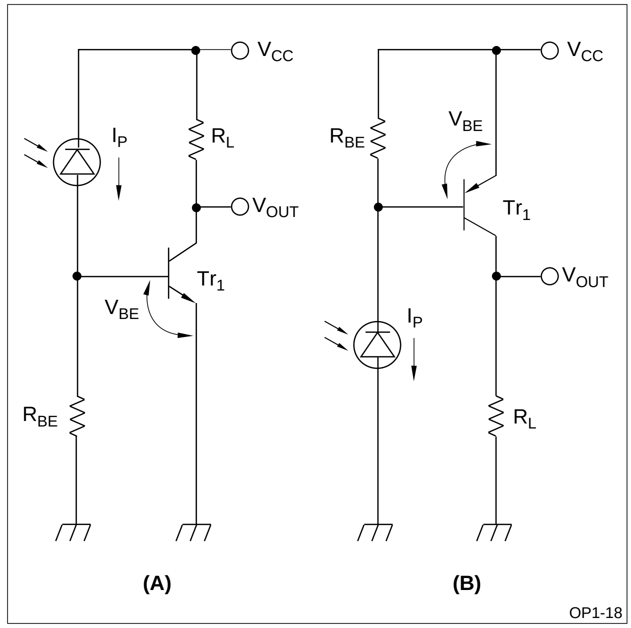


Figure 18. Photocurrent Amplifier Circuit using Transistor

In the circuit of Figure 19 (A), the output (V_{OUT}) is given as:

$V_{OUT} = I_P \times R_1 + I_B \times R_1 + V_{BE}$

This arrangement provides a large output and relatively fast response.

The circuit of Figure 19 (B) has an additional transistor (Tr_2) to provide a larger output current.

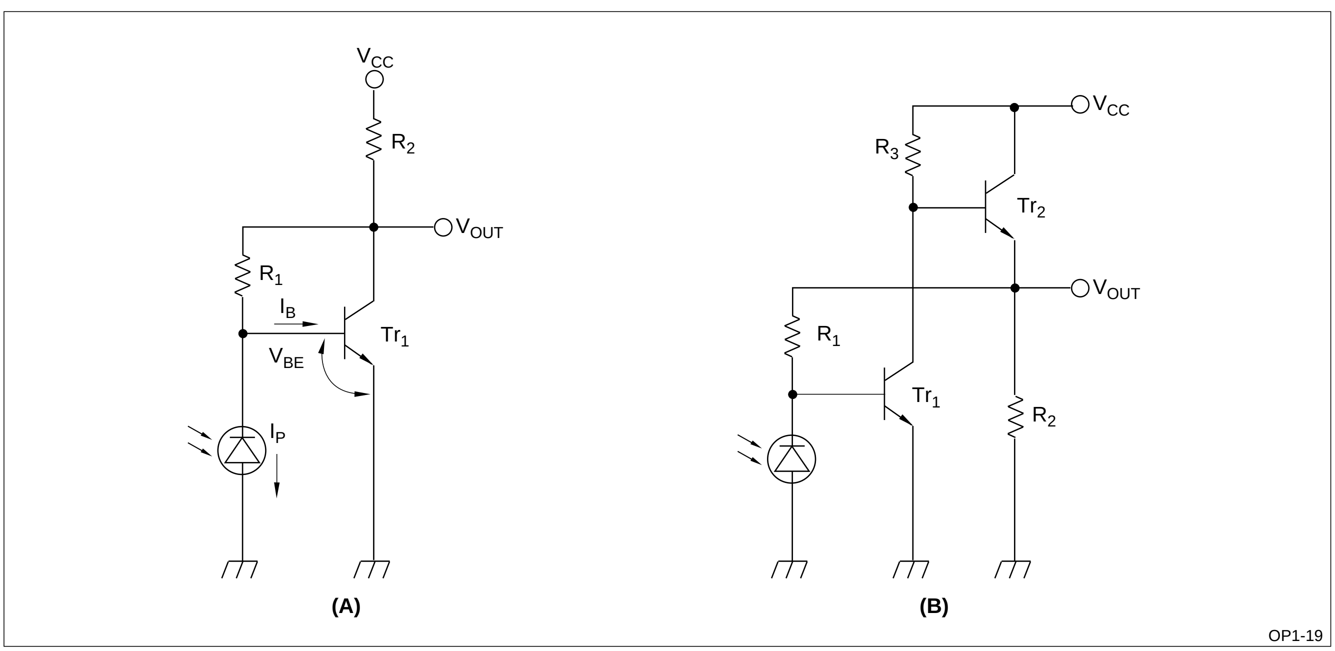


Figure 19. Photocurrent Amplifier Circuit with Negative Feedback

Amplifier Circuit Using Operational Amplifier

Figure 20 shows a photocurrent-voltage conversion circuit using an operational amplifier. The output voltage (V_{OUT}) is given as $V_{OUT} = I_F \times R_1$ ($I_P \cong I_{SC}$). The arrangement utilizes the characteristics of an operational amplifier with two input terminals at about zero voltage to operate the photodiode without bias. The circuit provides an ideal short-circuit current (I_{SC}) in a wide operating range.

Figure 20 (B) shows the output voltage vs. radiant intensity characteristics. An arrangement with no bias and high impedance loading to the photodiode provides the following features:

1. Less influence by dark current
2. Wide linear range of the photocurrent relative to the radiant intensity.

Figure 21 shows a logarithmic photocurrent amplifier using an operating amplifier. The circuit uses a logarithmic diode for the logarithmic conversion of photocurrent into an output voltage. In dealing with a very wide irradiation intensity range, linear amplification results in a saturation of output because of the limited linear region of the operational amplifier, whereas logarithmic compression of the photocurrent prevents the saturation of output. With its wide measurement range, the logarithmic photocurrent amplifier is used for the exposure meter of cameras.

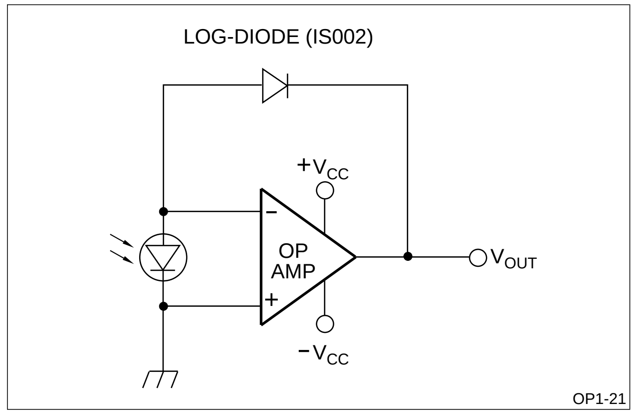


Figure 21. Logarithmic Photocurrent Amplifier using an Operational Amplifier

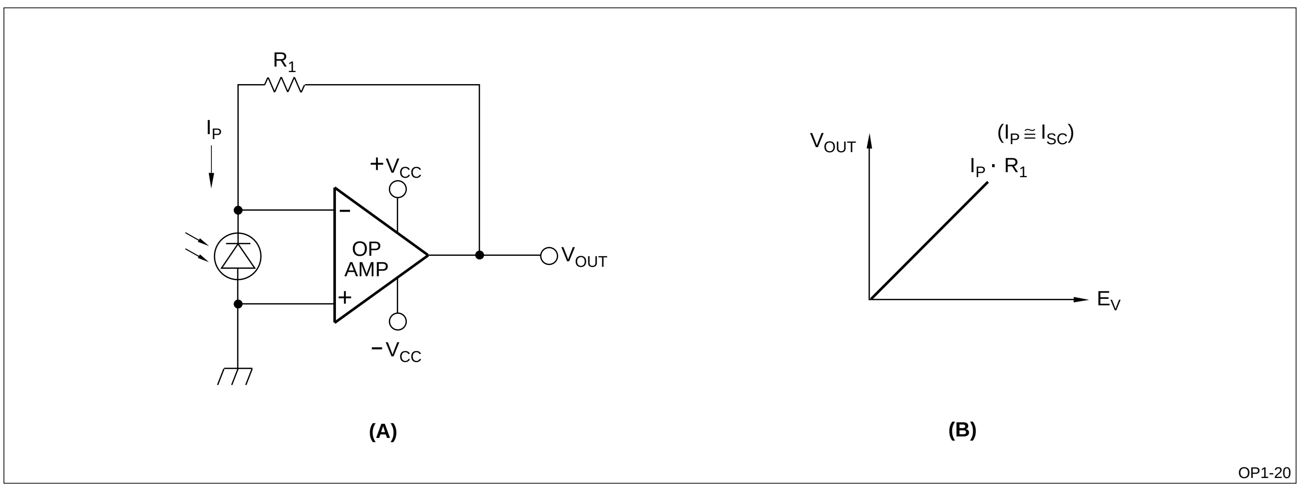


Figure 20. Photocurrent Amplifier using an Operational Amplifier (without bias)

Light Detecting Circuit For Modulated Light Input

Figure 22 shows a light detecting circuit which uses an optical remote control to operate a television set, air conditioner, or other devices. Usually, the optical remote control is used in the sunlight or the illumi nation of a fluorescent lamp. To alleviate the influence of such a disturbing light, the circuit deals with pulse-modulation signals.

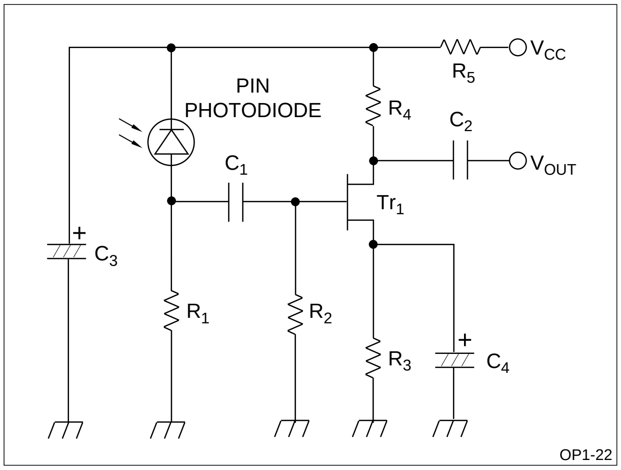


Figure 22. Light Detecting Circuit for Modulated Light Input PIN Photodiode

The circuit shown in Figure 22 detects the light input by differentiating the rising and falling edges of a pulse signal. To amplify a very small input signal, an FET proving a high input impedance is used.

Color Sensor Amplifier Circuit

Figure 23 shows a color sensor amplifier using a semiconductor color sensor. Two short circuit currents (I_{SC1}, I_{SC2}) conducted by two photodiodes having different spectral sensitivities are compressed logarithmically and applied to a subtraction circuit which produces a differential output (V_{OUT}). The output voltage (V_{OUT}) is formulated as follows:

$$V_{OUT} = \frac{kT}{q} \times \log\left(\frac{I_{SC2}}{I_{SC1}}\right) \times A$$

Where A is the gain of the differential amplifier. The gain becomes $A = R_2/R_1$ when $R_1 = R_3$ and $R_2 = R_4$, then:

$$V_{OUT} = \frac{kT}{q} \times \log\left(\frac{I_{SC2}}{I_{ISC1}}\right) \times \frac{R_2}{R_1}$$

The output signal of the semiconductor color sensor is extremely low level. Therefore, great care must be taken in dealing with the signal. For example, low-biased, low-drift operational amplifiers must be used, and possible current leaks of the surface of P.W.B. must be taken into account.

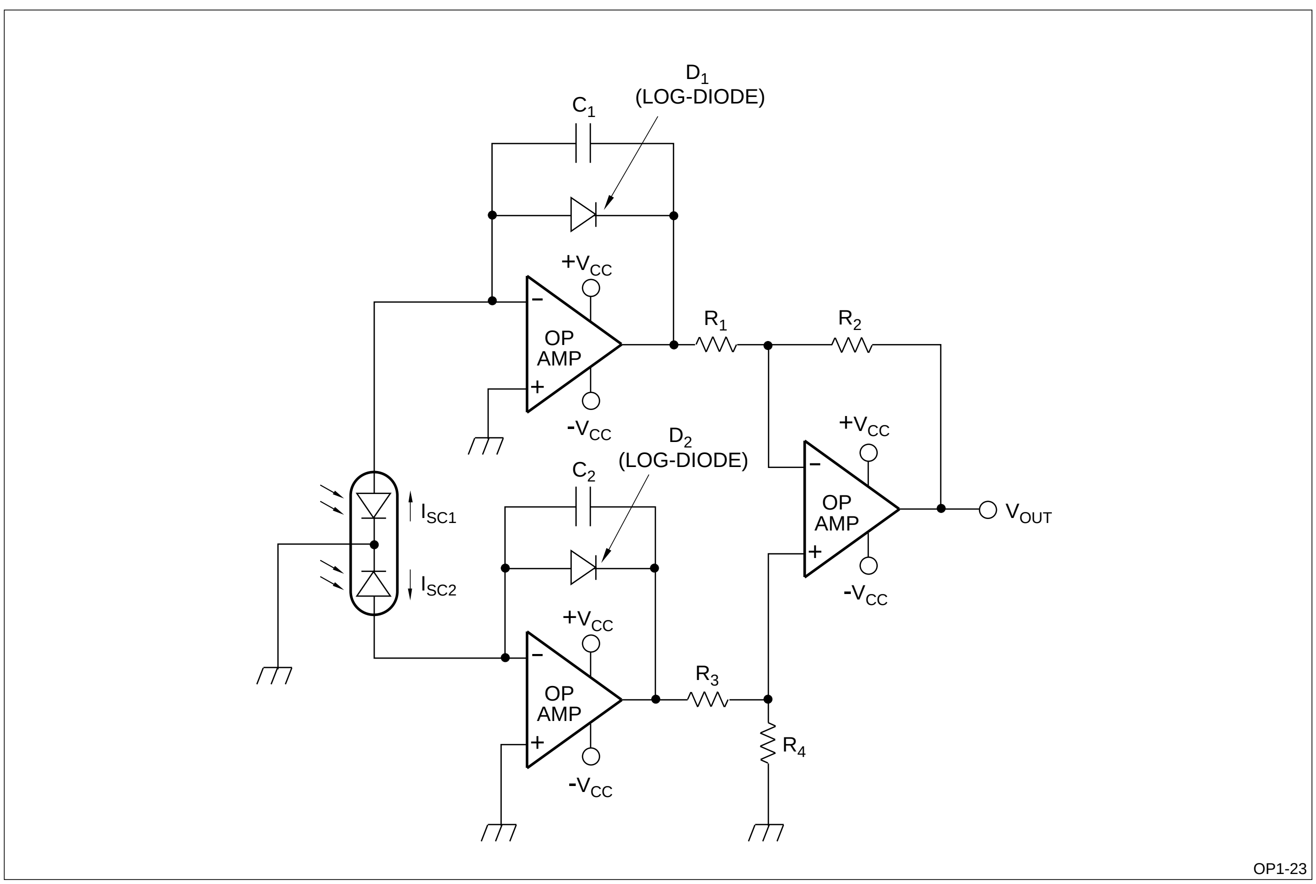


Figure 23. Color Sensor Amplifier Circuit

Fundament Phototransistor Circuits

Figures 24 and 25 show the fundamental phototransistor circuits. The circuit shown in Figure 24 (A) is a common-emitter amplifier. Light input at the base causes the output (V_{OUT}) to decrease from high to low. The circuit shown in Figure 24 (B) is a common-collector amplifier with an output (V_{OUT}) increasing from low to high in response to light input. For the circuits in Figures 24 (A) and 24 (B) to operate in the switching mode, the load resistor (R_L) should be set in relation with the collector current (I_C) as $V_{CC} < R_L \times I_C$.

The circuit shown Figure 25 (A) uses a phototransistor with a base terminal. A R_{BE} resistor connected between the base and emitter alleviates the influence of a dark current when operating at a high temperature. The circuit shown in Figure 25 (B) features a cascade connection of the grounded-base transistor (Tr_1) so that the phototransistor is virtually less loaded, thereby improving the response.

Amplifier Circuit Using Transistor

Figures 26 (A) and 26 (B) show the transistor amplifiers used to amplify the collector current of the phototransistor using a transistor (Tr_1). The circuit in figure 26 (A) increases the output from high to low in response to a light input. The value of resistor R_1 depends on the input light intensity, ambient temperature, response speed, etc., to meet the following conditions:

$R_1 < V_{BE}/I_{CEO}, R_1 > V_{BE}/I_C$

Where I_{CBO} is the dark current of phototransistor and I_C is the collector current.

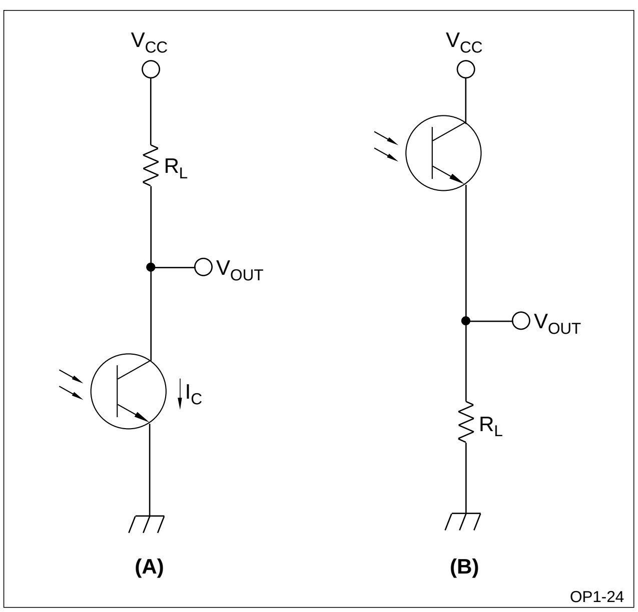


Figure 24. Fundamental Phototransistor Circuit (I)

Modulated Signal Detection Circuit

Figures 27 (A) and 27 (B) show the circuits used to detect a modulated signal such as an AC or pulse signal. The phototransistor has a base terminal with a fixed bias through resistors R_1 and R_2. An R_4 emitter resistor maintains the DC output voltage constant. A modulated signal provides a base current through bypass capacitor C causing current amplification so that the signal greatly amplified.

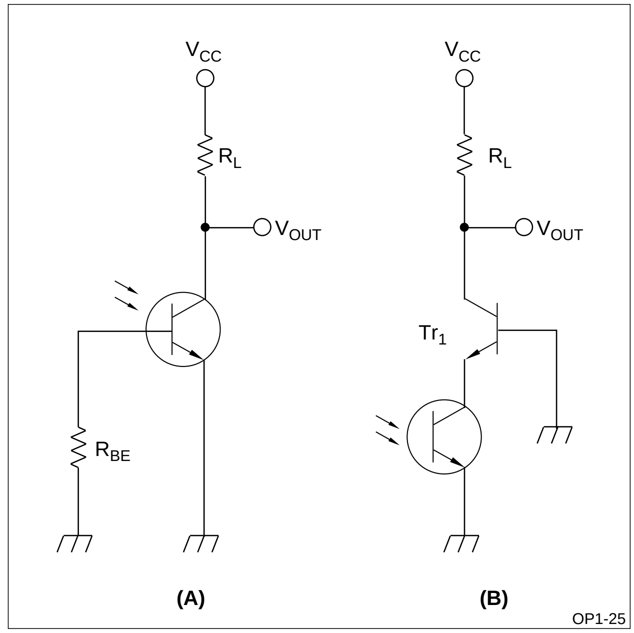


Figure 25. Fundamental Phototransistor Circuit (II)

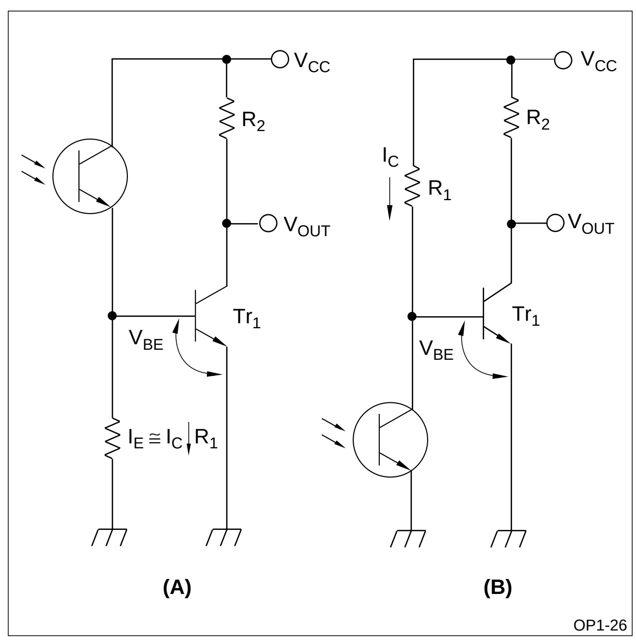


Figure 26. Amplifier Circuit Using Transistor

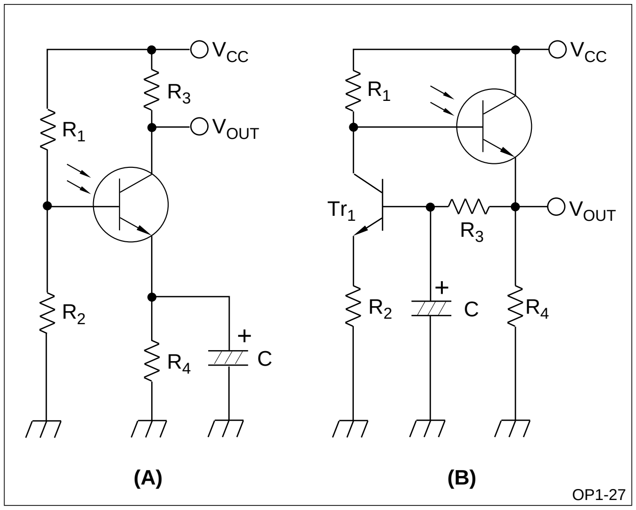


Figure 27. Modulated Signal Detection Circuit

Amplifier Circuit Using Operational Amplifier

Figure 28 shows a current-voltage conversion circuit using an operational amplifier. Its output voltage (V_{OUT}) is expressed as $V_{OUT} = I_C \times R_1$.

The current-voltage conversion circuit for the phototransistor is basically identical to that of the photodiode, except that the phototransistor requires a bias. The circuit shown if Figure 28 (A) has a negative bias (-V) for the emitter against the virtually grounded collector potential. Figure 28 (B) shows the output voltage vs. irradiation intensity characteristics.

Auto-stroboscope Circuit

Figure 29 shows the auto-stroboscope circuit of the current cut type. This circuit is most frequently used because of advantages such as continuous light emission and lower battery power consumption.

When the switch is in the ON-state, the SCR_2 and SCR_3 turn on to discharge capacitor C_4 so that the xenon lamp is energized to emit light. The anode of the SCR_2 is then reverse-biased, causing it to turn off and light emission of the xenon lamp ceases. The irradiation time is set automatically in response to variations in the collector current of the phototransistor. This follows the intensity of reflected light from the object and the value of C_1 in the circuit. In other words, the irradiation time is long for a distant object, and short for a near object.

PHOTOCOUPLER/PHOTOTHYRISTOR COUPLER/PHOTOTRIAC COUPLER APPLICATION CIRCUITS

For the effective use of photocouplers, the usage utilizing the features and fundamental circuits using photocouplers are described below.

Logic Gate Circuit Using Photocouplers

Figure 30 shows logic gates using photocouplers and their associated truth tables. The circuit of Figure 30 (A) forms an AND gate while the circuit of Figure 30 (B) forms an OR gate. These circuits are converted to a NAND gate and NOR gate, respectively, when the R_L load resistor is connected to the collector.

Level Conversion Circuit

Figure 31 shows simple level converters using a photocoupler. The circuit simple level converters using a photocoupler. The circuit shown in Figure 31 (A) converts the MOS level to the TTL level. Because of the small output current from the MOS IC, a photocoupler with a high current transfer ratio (CTR) at low input is required.

The circuit shown in Figure 31 (B) is a Schmitt trigger arranged using a photocoupler and transistor and a convert signal into an arbitrary level.

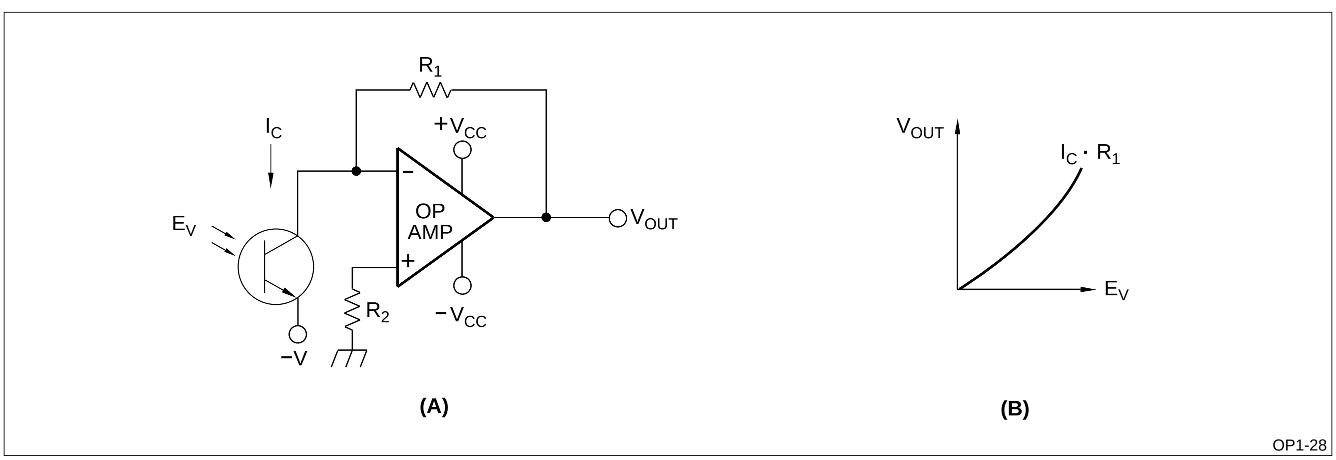


Figure 28. Amplifier Circuit using an Operational Amplifier

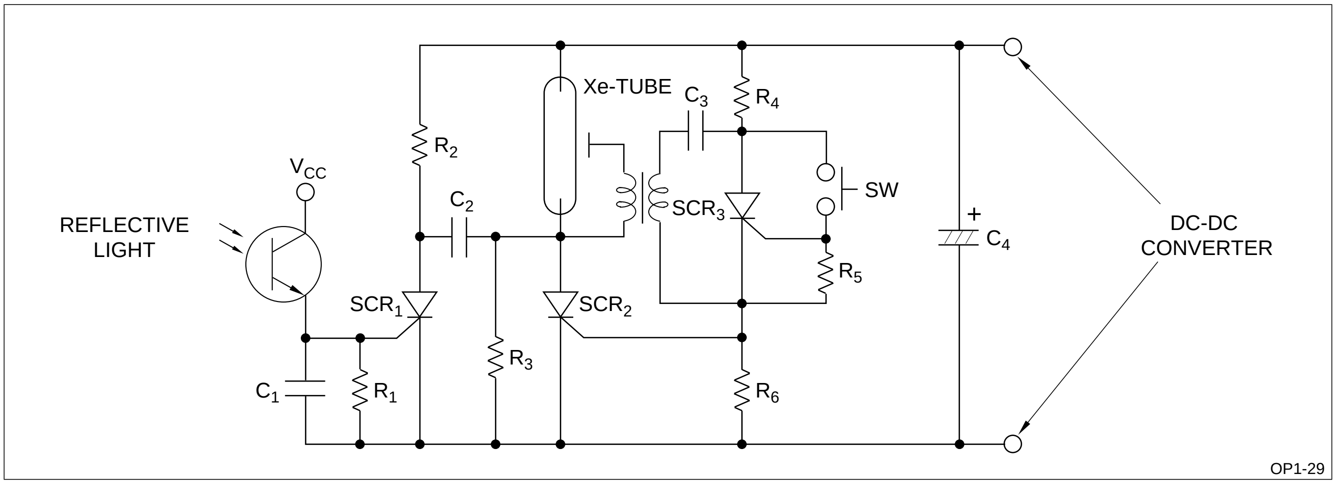
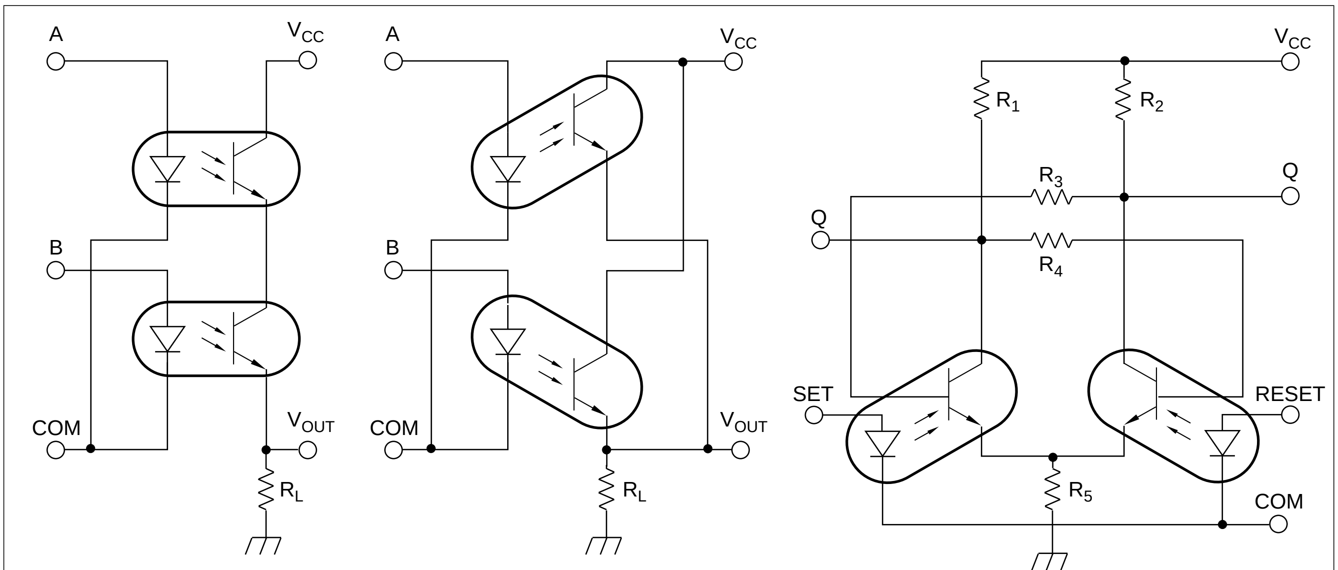


Figure 29. Auto-Stroboscope Circuit



A	B	V_{OUT}
H	H	H
H	L	L
L	H	L
L	L	L

(A) AND GATE AND ITS TRUTH TABLE

A	B	V_{OUT}
H	H	H
H	L	H
L	H	H
L	L	L

(B) OR GATE AND ITS TRUTH TABLE

t_n		t_{n+1}	
R	S	Q	$\overline{Q}$
H	H	X	X
H	L	L	H
L	H	H	L
L	L	X	X

Output marked by "X" are indeterminate

(C) R-S FLIP-FLOP AND ITS TRUTH TABLE

OP1-30

Figure 30. Logic Gate Circuits using Photocouplers

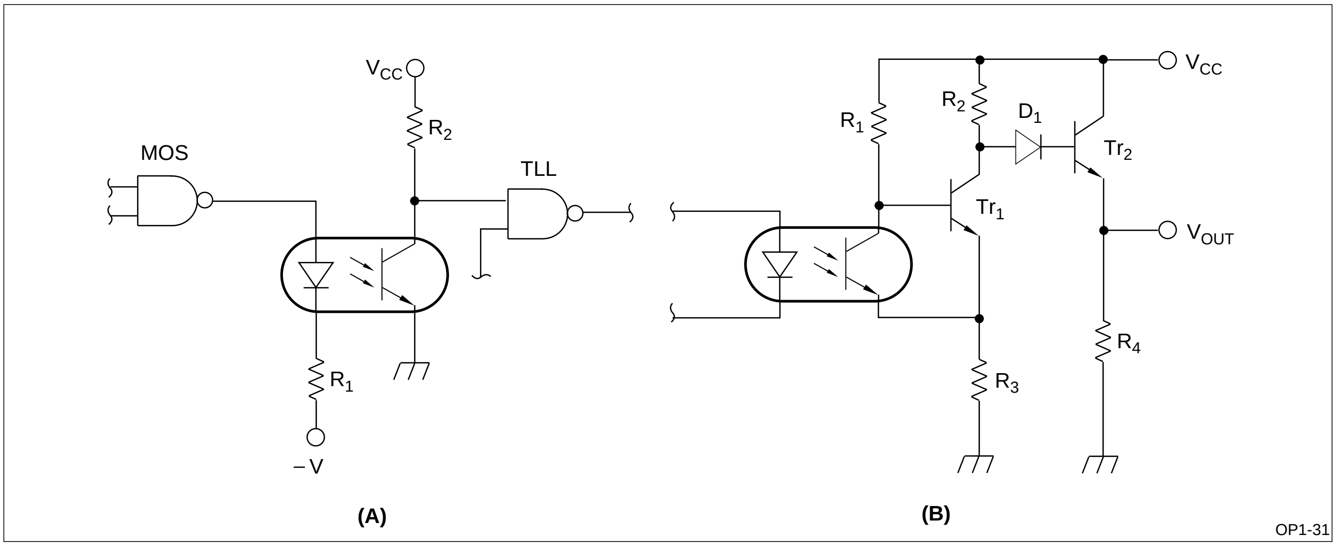


Figure 31. Level Conversion Circuit

Isolation Amplifier

Figure 32 shows a non-modulated isolation amplifier operable with low-frequency signals. In the arrangement, the photocoupler input is biased by DC forward current which is superimposed by a low-frequency signal. This gives the operating region of the good linearity of photocoupler. The DC bias current is adjusted by VR_1.

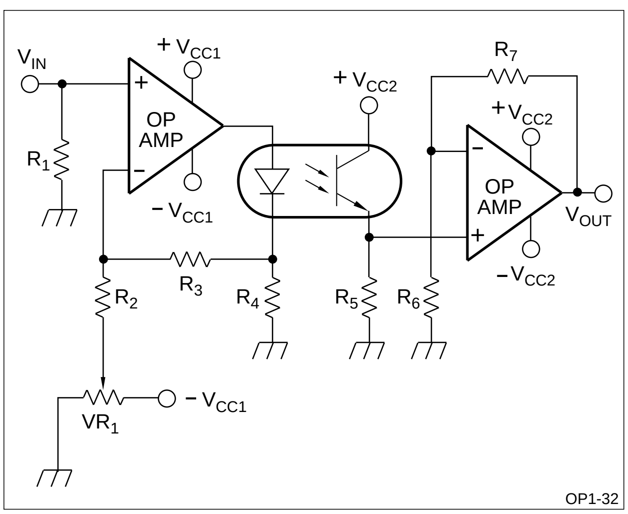


Figure 32. Isolation Amplifier

Noise Protection

Figure 33 shows some noise protection examples. The example shown in Figure 33 (A) includes the parallel connection of a capacitor (C_1) and resistor (R_1) across the input of the photocoupler where relatively long signal lines are connected for example where a computer and a terminal unit. The larger the capacitance of C_1, the greater the effect is expected, although signal propagation time is sacrificed.

The examples in Figure 33 (B) and 33 (C) use a photocoupler with a base terminal. Example (B) is effective against noise, but only in exchange for the response time, while example (C) tends to have low current transfer ratio (CTR).

However, when the photocoupler is operated in the switching mode, the base terminal tends to be affected by noise. Therefore, the use of photocouplers without a base terminal is recommended.

Lamp Driving Circuit and Relay Driving Circuit

Figures 34 and 35 show circuits for driving a lamp and relay, respectively, directly at the output of the photocoupler.

For this purpose, a suitable photocoupler includes a Darlington transistor providing a high CTR. The circuit shown in Figure 34 includes an R_2 resistor for supplying a preheating current to the lamp so as to prevent a rush current in lighting the lamp. The circuit in Figure 35 includes a diode D_1 for suppressing a counter-electromotive voltage produced when the relay is in the OFF-state.

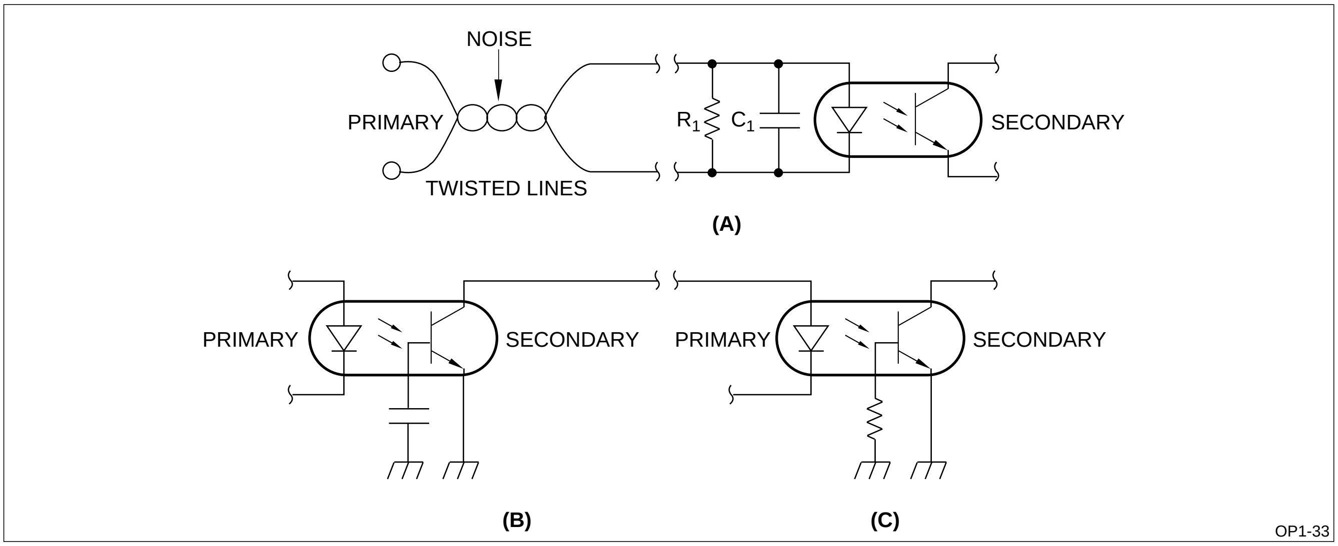


Figure 33. Noise Protection Example

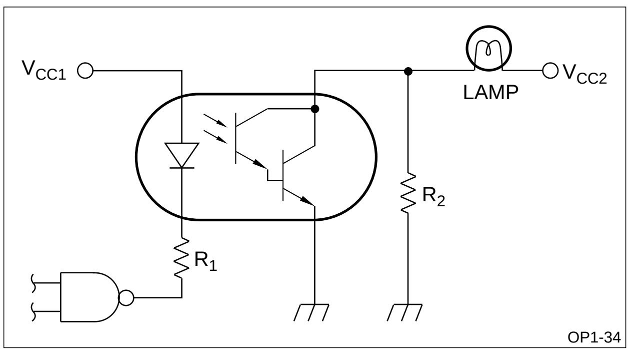


Figure 34. Lamp Driving Circuit

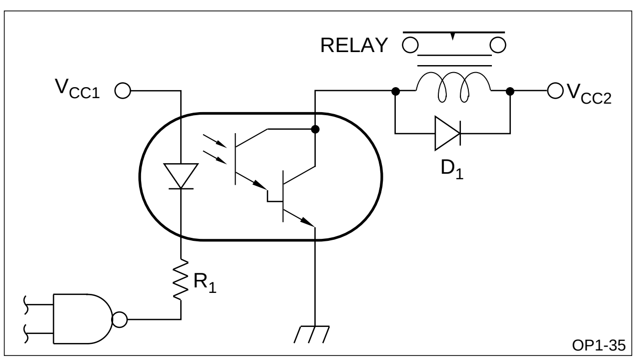


Figure 35. Relay Driving Circuit

Current Monitoring Circuit

The current monitoring circuit shown in Figure 36 is designed to detect and indicate leak current in a circuit using a photocoupler. The LED indicator lights off if the leak current exceeds the V_F/R_1 value.

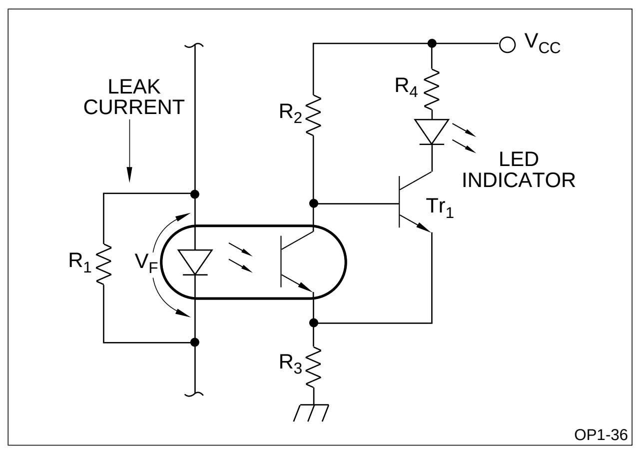


Figure 36. Current Monitoring Circuit

Solid State Relay

Solid State Relay Using Photocoupler

Figure 37 shows a solid state relay circuit using a photocoupler. Figure 37 includes an input circuit, photocoupler, thyristor for triggering, rectifying diode bridge, snubber circuit, and high power triac. In operation, the photocoupler turns on the thyristor for triggering and its ON-current activates the high power triac to drive the load. Because of a low collector withstand voltage and the low output current of the photocoupler, a thyristor for triggering is needed to interface it with power control devices such as a power triac or power thyristor.

By appropriately choosing the R_1 and R_2 values, a high sensitive solid state relay having a wide range of input signal of the photocoupler type is realized. The zero-cross voltage is determined from the voltage division ratio by R_4 and R_5.

Solid State Relay Using Photothyristor Coupler

Figure 38 shows the drive circuit of thyristor using a half-wave control type photothyristor coupler.

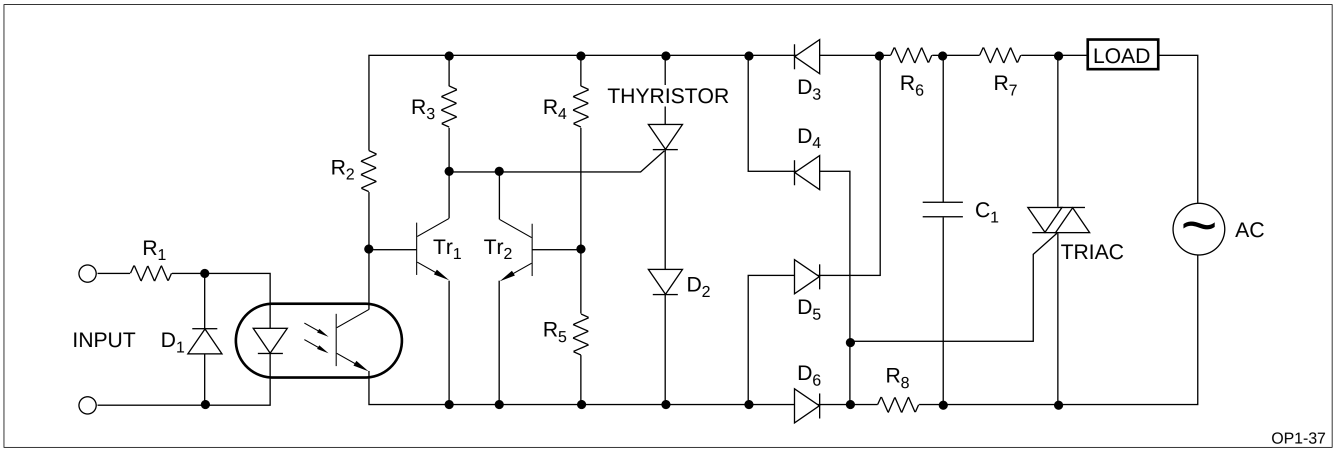


Figure 37. Solid State Relay with Built-in Zero-Cross Circuit

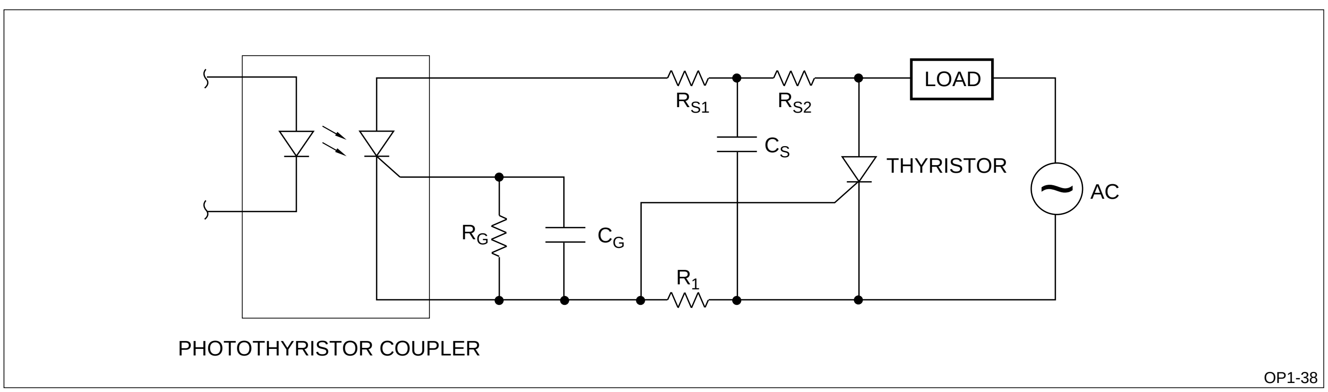


Figure 38. Large Power Thyristor Drive Circuit

Figure 39 shows the drive circuit of triac using a half-wave control type photothyristor coupler. In this circuit, D_1 ~ D_4 rectifying bridges are required for AC control using a half-wave control type photothyristor coupler.

Figure 40 shows the drive circuit of triac using a full-wave control type photothyristor coupler.

In each figure, R_1 is a resistor used to prevent mistriggering of a large power thyristor and triac by leak current (I_{DRM}) when the photothyristor coupler is OFF. Therefore, the setting is required by checking the photothyristor coupler (I_{DRM}) and gate trigger current (I_{GT}) of a large power thyristor and triac. R_{S1}, R_{S2} and C_S form a snubber circuit.

Solid State Relay Using Phototriac Coupler

Figure 41 shows the basic operating circuit of a triac using a phototriac coupler.

Figure 42 shows a circuit example of controlling forward and reverse rotation of the motor, using a control signal as one example of phototriac coupler application circuit.

Input Drive Circuit

Figure 43 shows the input drive circuit of a solid state relay (SSR). (A) and (B) operate with a positive signal, and (C) and (D) operate with a negative signal. (B) and (C) are effective when the output current of control circuit is small.

(E) is a drive circuit using IC (TTL/DTL), which operates when IC is in the "L" state.

(F) and (G) are drive circuits using CMOS IC, each of which cannot drive the primary side of SSR with CMOS IC only; it therefore drives via a transistor.

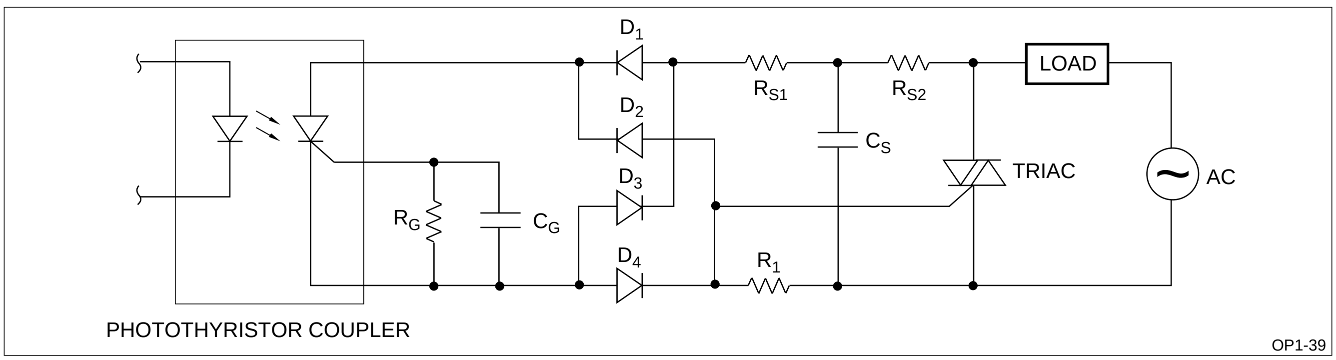


Figure 39. Triac Drive Circuit (I)

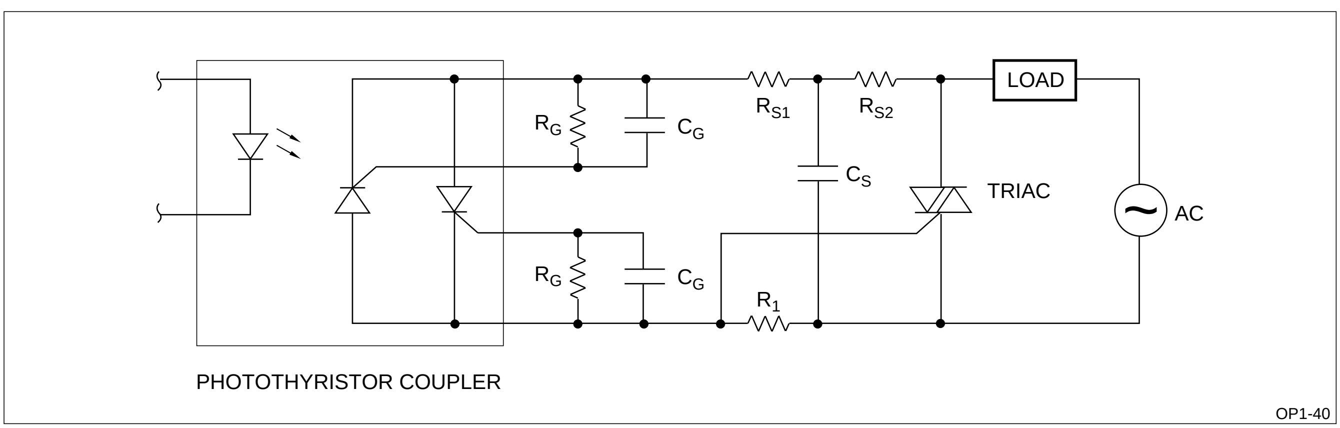


Figure 40. Triac Drive Circuit (II)

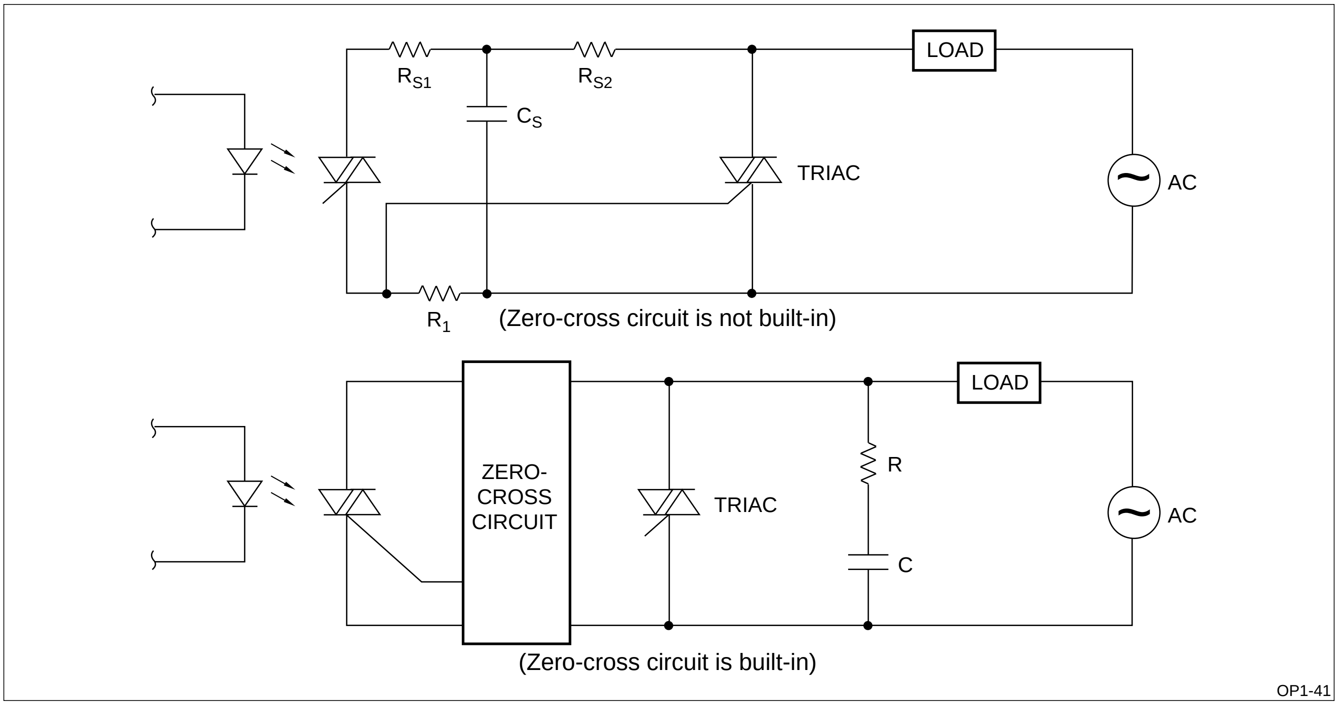


Figure 41. Triac Drive Circuit (III)

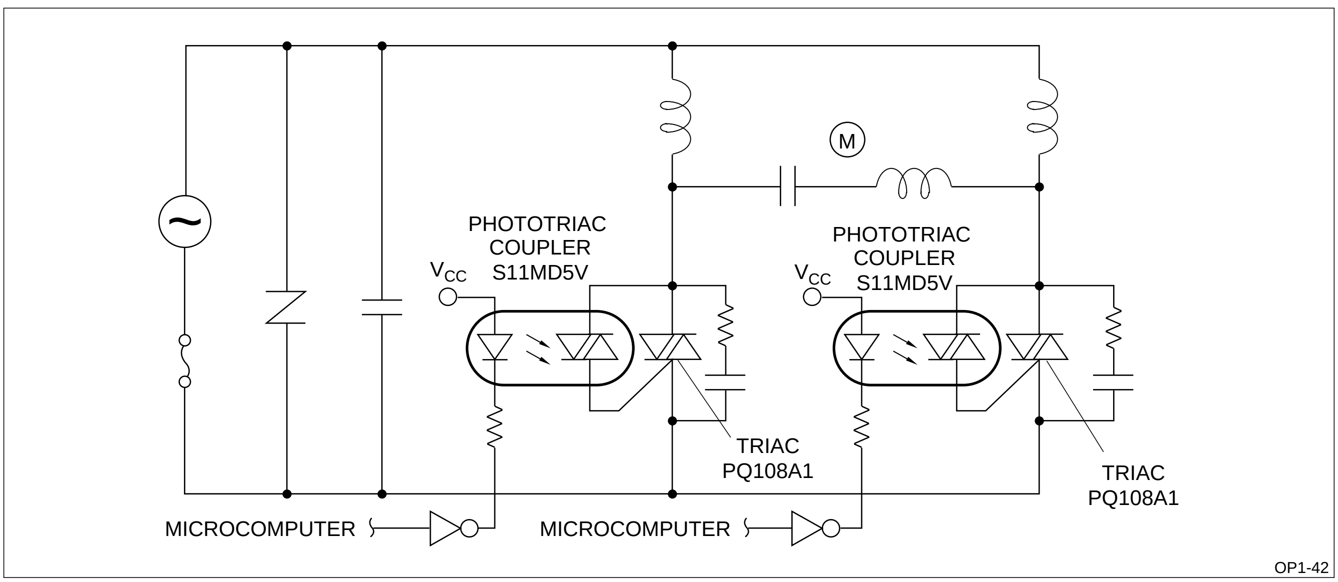


Figure 42. Motor Drive Circuit

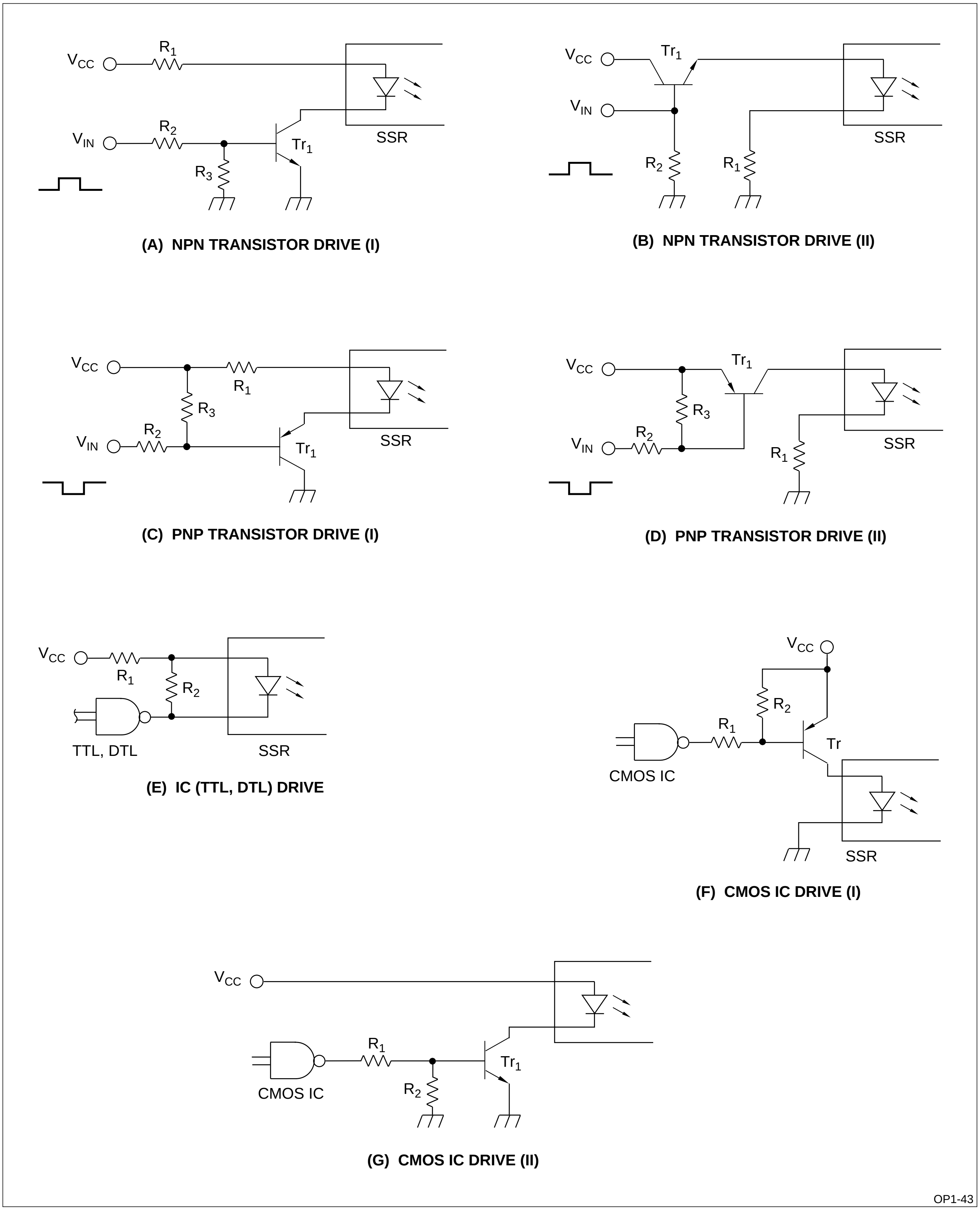


Figure 43. Input Drive Circuit

Arrival Bell Signal Detection Of Telephone

Figure 44 shows a circuit for transmitting an arrival bell signal to a telephone related device while maintaining the electrical isolation between the device and the telephone subscriber line. The ring signal is an AC signal (75 Vrms, 16 Hz) superimposed on the 48 V line.

A non-polarized photocoupler (designed for AC input response) is suited for this purpose.

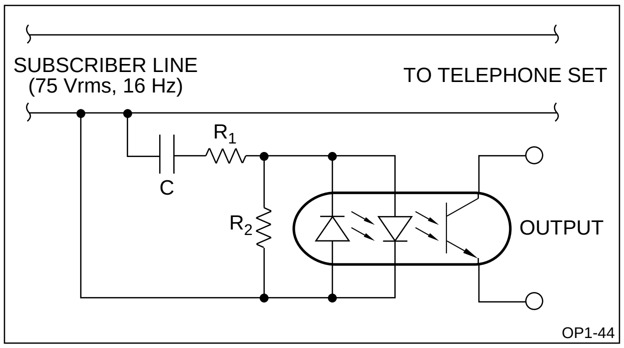


Figure 44. Telephone Arrival Bell Signal Detection

Telephone Line Interface

Figure 45 shows an interface circuit used to link a telephone related device to the telephone line. Through parallel connections of photocouplers, telephone related devices can be linked to the telephone line.

Telephone Line Polarity Detection (Ring Counter)

Figure 46 shows an example of a photocoupler used for the polarity detecting circuit in a telephone line.

Dial Pulse Monitor Circuit

Figure 47 shows an example in which a photocoupler is actuated due to dial pulse current if the circuit is connected to the telephone line, the light detector side of photocoupler operates as a dial pulse monitor circuit.

Power Control Circuit By Bell Signal

Figure 48 shows an application example for ON/OFF switching of the power supply of a particular equipment by a telephone bell signal.

Servo Motor Driving Circuit

Figure 49 shows an inverter-type AC servo motor speed control circuit. A transistorized inverter is featured to readily control an AC motor in a wide speed range. It is increasingly used in appliances such as air conditioners.

The photocoupler is used to drive the power transistor base amplifier so that it interfaces with a microcomputer. Because of the high surge voltage applied to the PWM base signal circuit (input) and driver circuit (output) at the switching of magnetic polarity, a high noise resistance (high dv/dt) photocoupler is used.

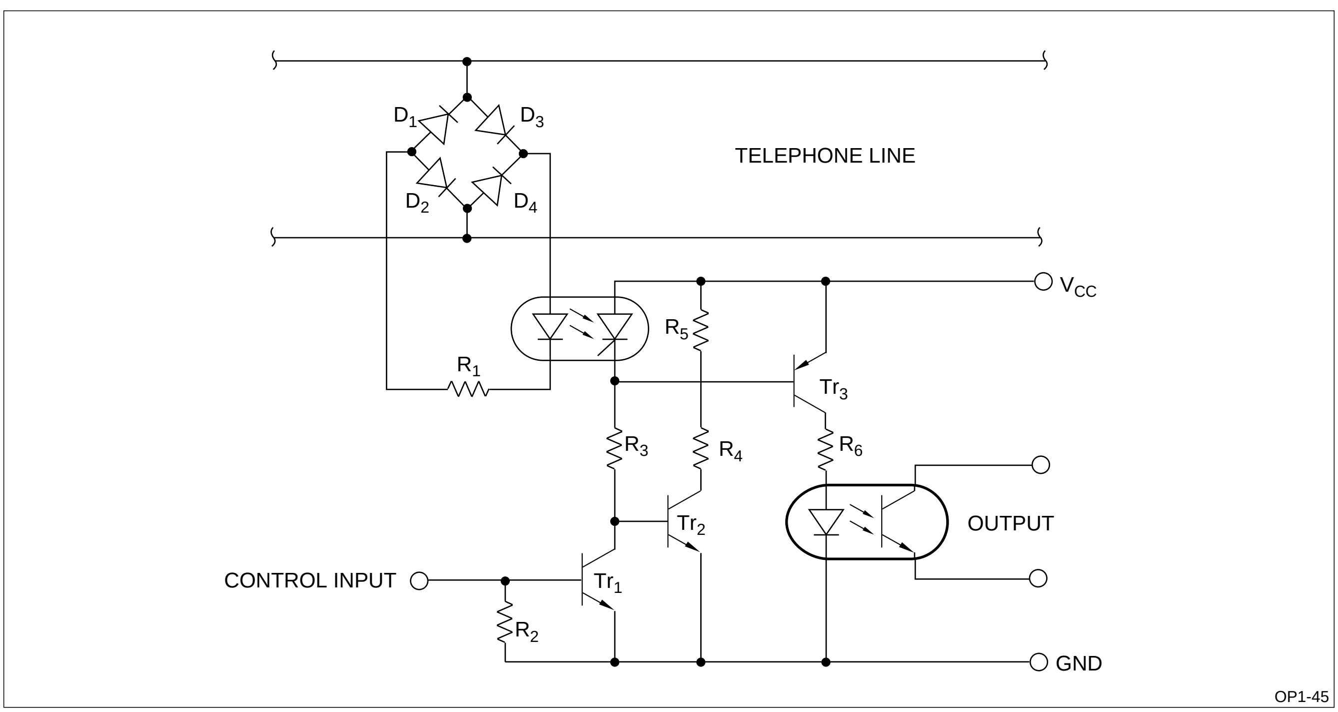


Figure 45. Telephone Line Interface

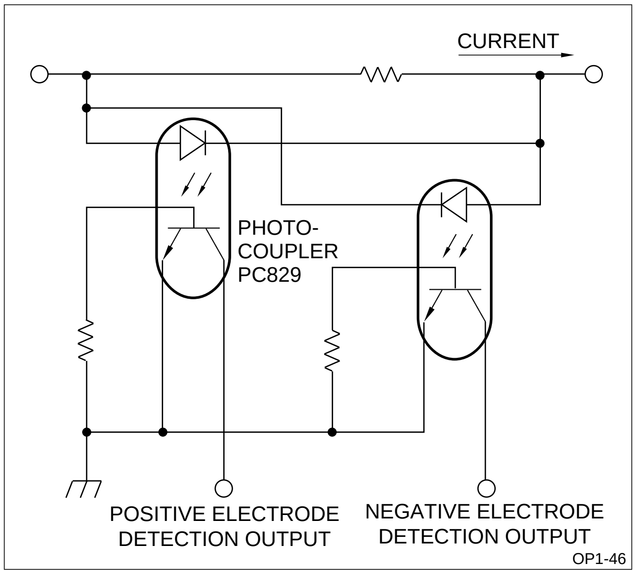


Figure 46. Telephone Line Polarity Detection Circuit

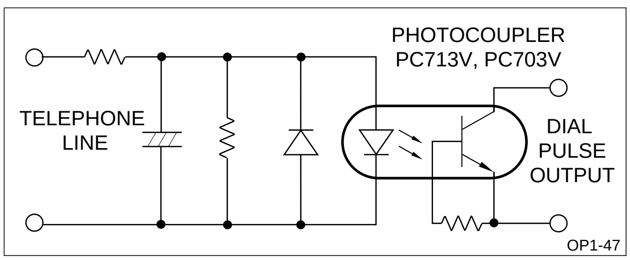


Figure 47. Dial Pulse Monitor Circuit

Servo Motor Braking Control Circuit

Figure 50 shows a servo motor braking control circuit in which a photocoupler is used to separate the control circuit from the brake driving circuit. A serial connection of C_2 and R_7 across the coil is designed to absorb the inductive current by the coil. C_1 is used to absorb high frequency noise on the DC power line.

Switching Regulator Circuit

Figure 51 shows a switching regulator circuit using a photocoupler.

In operation, the AC power line voltage is rectified into a DC voltage and is inverted into an AC voltage of around 50 kHz. It is then converted back to a DC voltage by a choke-input rectifying circuit. The output voltage is determined by the values of R_1, R_2, and ZD.

Chopper Circuit

Figure 52 shows a chopper circuit featuring high response and low signal amplification.

Conventional choppers are formed by FETs and transistors and create problems by switching spike noise which adversely affects the output signal.

Use of a photocoupler allows electrical isolation of the control and amplifying circuits. A small signal can then readily be amplified with no affect from spike noise.

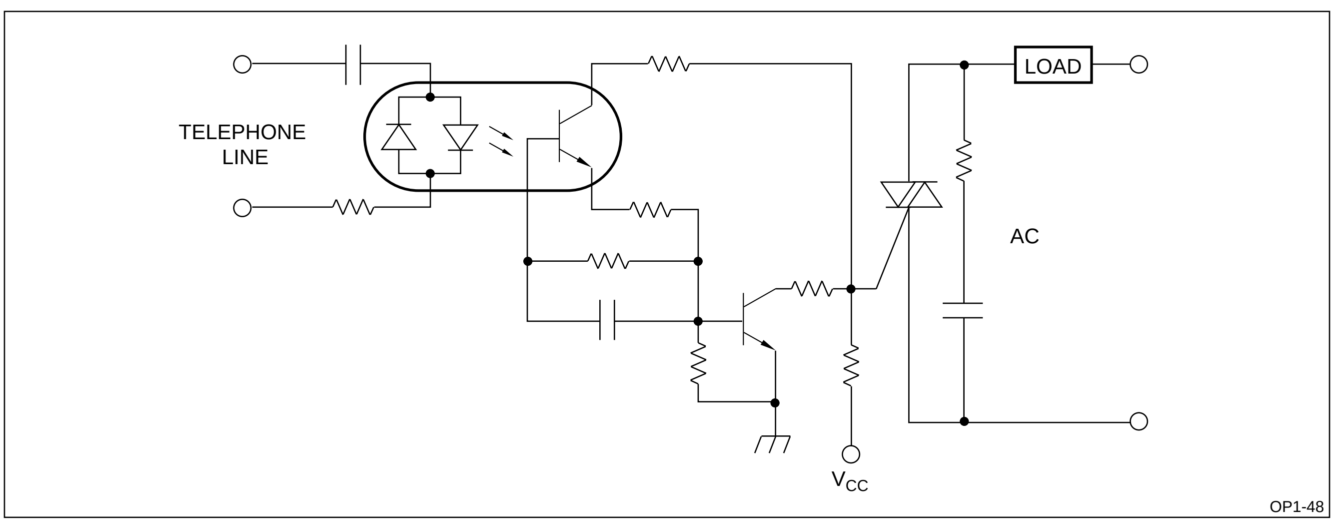


Figure 48. Power Control Circuit by Bell Signal

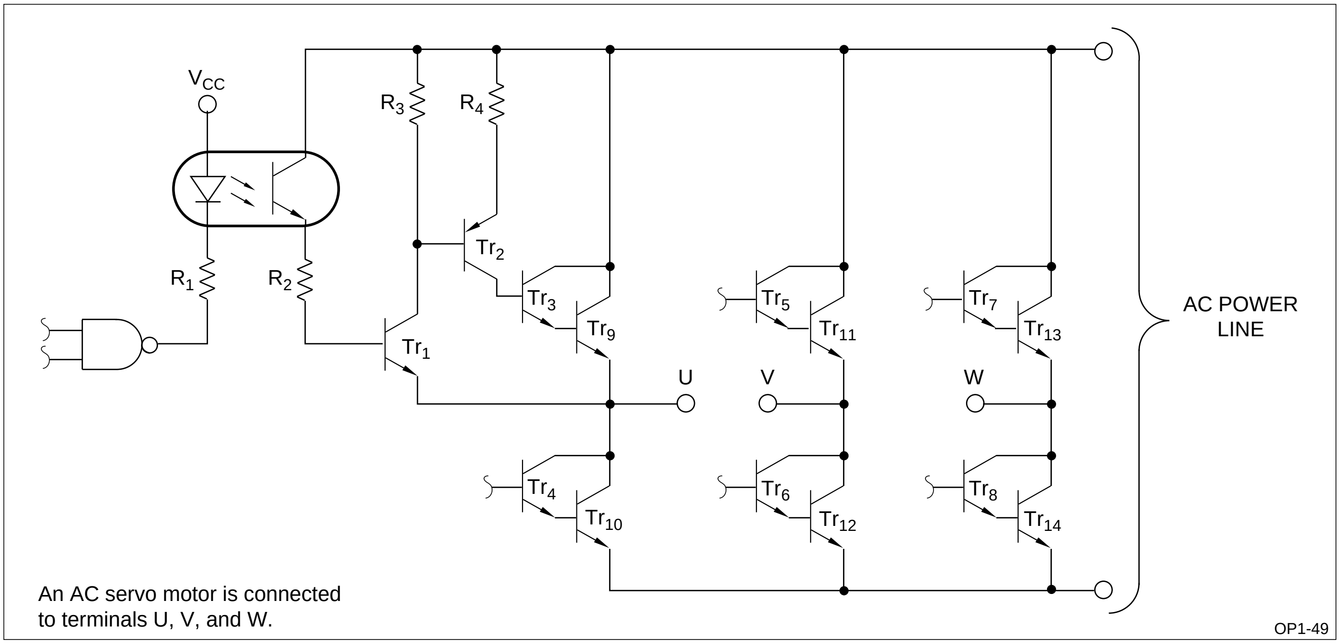


Figure 49. Servo Motor Driving Circuit

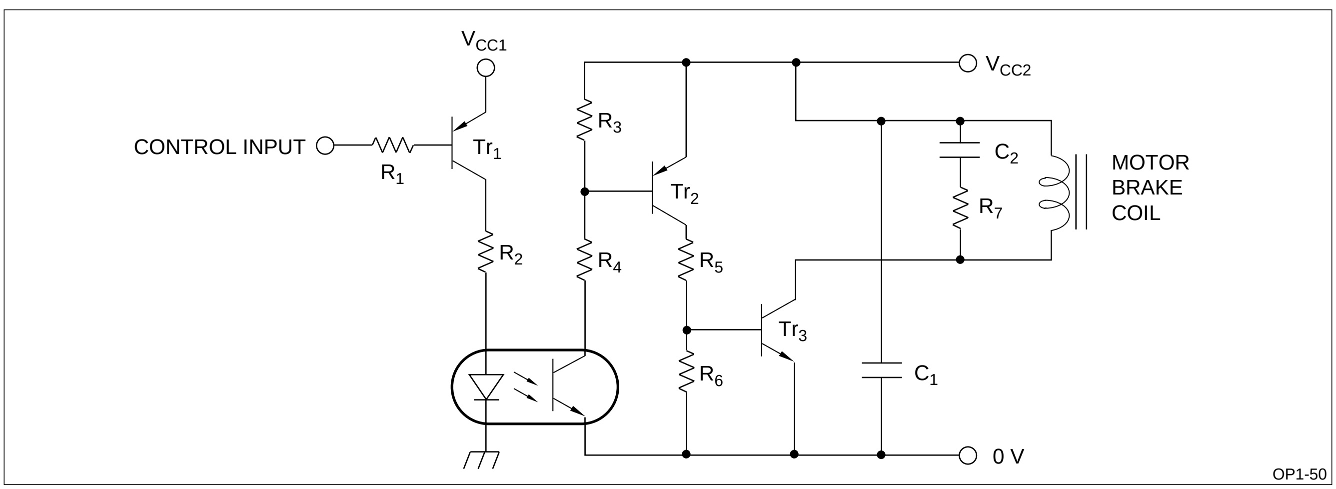


Figure 50. Servo Motor Brake Control Circuit