Low Power

Applications and Technical Data Book

POWEREX

■ Low Power Triac & SCR Application Tips

11.0 Application Information

Powerex, Inc., 200 Hillis Street, Youngwood, Pennsylvania 15697-1800 (412) 925-7272

11.0 Application Information

11.1 Radio Frequency Interference

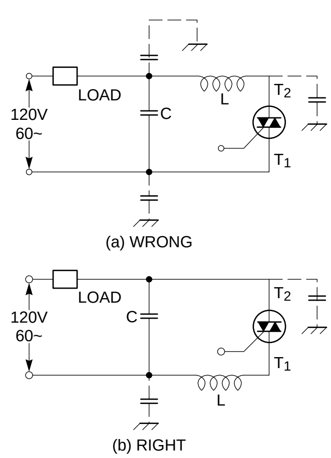
Each time a triac fires in a resistive circuit, the load current goes from zero to the load limited current value in less than a few microseconds. A frequency analysis of such a step function of current would show an infinite spectrum of energy, with an amplitude inversely proportional to frequency. With full wave phase control, there is a pulse of this noise 120 times a second. In applications where phase control is used in the home, such as light dimming, this can be extremely annoying, for while the frequencies generated would not interfere with television or FM radio reception, the broadcast band of AM radio would suffer interference. In such cases and others, RF filtering is required.

The simplest type of RF filter is a single L-C low pass filter. If an L-C resonant frequency of 50kc is chosen, this type of filter will give about 40 dB of noise suppression at the bottom of the broadcast band. As shown in Figure 11.1, the inductor should be placed in series with the terminal 1 connection to the Triac, since the capacitance to ground of the terminal 2 (case) by way of the heatsink, and the capacitance of the line to ground, would shunt the coil if it were in series with terminal 2.

If you look at the circuits of Figure 11.1, you can see the L-C, and triac form a resonant discharge circuit, which depends on the load impedance for damping. For circuit Q's of greater than approximately 2.5, the current through the triac will reverse, as shown in Figure 11.2(a), and a specific triac might turn off if it is a relatively fast device. This condition is worse for light loads, in this case about 100 watts of less, or somewhat inductive loads, which contribute little damping to the circuit. The simple L-C circuit does behave properly however with heavier resistive loads, as shown in Figure 11.2(b). To obtain proper operation under light load conditions, for instance the lamp dimmer with a 60 watt lamp, it is necessary to build in the damping required in the filter. This can be done by adding another resistor and capacitor as shown in the lamp dimmer circuit of Figure 11.3. The component values are chosen to give about the same filtering effect as the L-C filter of Figure 11.1.

Due to the subtle nature of the filter ringing problem, it is often not recognized as such. Since few triacs can turn off during this rapid oscillation, and most triacs seem to work, it sometimes is thought that the triacs are not triggering. Since some diac pulses are longer than others, and with some diacs gate current may still be flowing when the current reverses, changing the diacs appears to solve the problem and therefore some diacs may be thought to be "bad". It is however important to note that even when the devices sometimes

Figure 11.1 Simple L-C Filter



FOR LOAD	>150 WATTS <1000 WATTS
LET	L = 100µH C = 0.1µF

Figure 11.2 Triac Current for the Circuit of Figure 11.1(b)

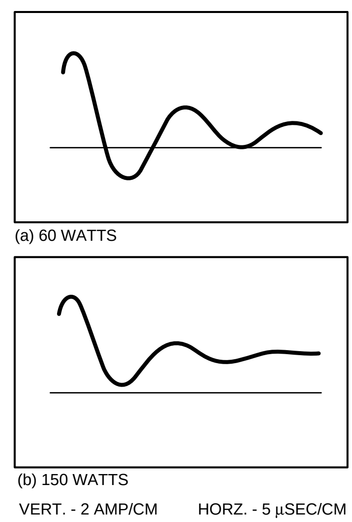
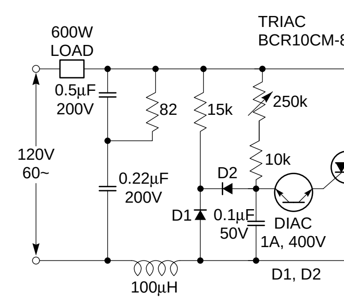


Figure 11.3 Complete Incandescent Lamp Dimmer with R-F Filter



appear to work properly, i.e. they don't turn off or "flicker," the fact that the triacs may start to turn off, and then retrigger, introduces several noise pulses instead of one, and the filter effectiveness is drastically reduced. Use of the damped R-F filter of Figure 11.3 will however cure this problem.

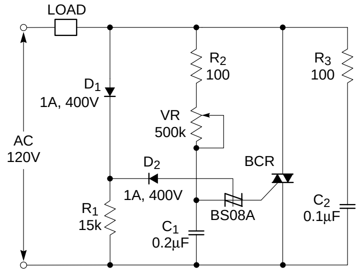
Following are examples of standard application circuits. Basic phase control circuits using thyristors (CR), triacs (BCR) and bi-directional switching devices, motor speed control circuits, and temperature control circuits are described.

Features are given followed by the operating principles.

Basic Phase Control Circuit using Silicon Bilateral Switch (BS08A), Triac (BCR), or SCR (CR).

Example A

- Smooth control is possible in the range of 5 to 90% of load power supply for AC input voltage.
- Suitable for resistive load.
- Phase control range is 10 to 150°



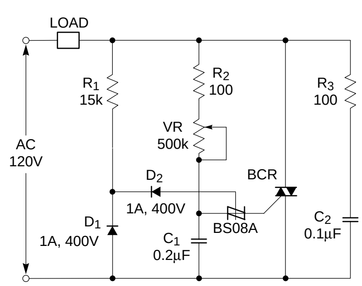
BCR: TRIACS OF 1A TO 30A CLASS CAN BE USED.

The triac BCR trigger phase is controlled by the CR phase-shifting circuit consisting of VR and C_1 and hysteresis is reduced by D_1, D_2, R_1 and the gate of BS08A.

Example B

- Smooth control is possible in the range of 5 to 99% of the load power supply for AC input voltage.
- Suitable for resistive load.
- Phase control range is 10 to 150°.

The triac BCR trigger phase is controlled by the CR phase-shifting circuit consisting of VR and C_1 and hysteresis is reduced by D_1, D_2, R_1 and the gate of BS08A.

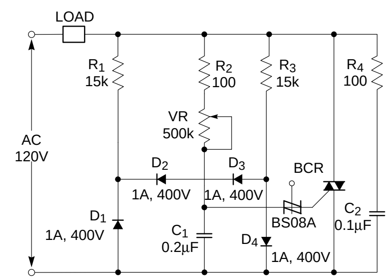


BCR: TRIACS OF 1A TO 30A CLASS CAN BE USED.

Example C

- Smooth control is possible in the range of 5 to 99% of the load power supply for AC input voltage.
- Suitable for inductive load.
- Phase control range is 10 to 150°C.

The triac BCR trigger phase is controlled by the CR phase-shifting circuit consisting of VR and C_1 and hysteresis is reduced by D_1, D_2, D_3, D_4, R_1, R_3.

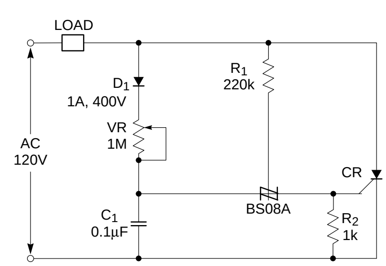


BCR: TRIACS OF 1A TO 30A CLASS CAN BE USED.

Example D

- Smooth control is possible in the range of 1 to 99% of the load power supply for AC input voltage.
- Suitable for both resistive and inductive loads.
- Phase control range is 10 to 170°.

The thyristor CR trigger phase is controlled by the CR phase-shifting circuit consisting of VR and C_1. The voltage of C_1 is reset and hysteresis is reduced by applying the gate current of BS08A to C_1, and by switching the BS08A, applying the gate, R_1, load, power supply and circuit C_1.



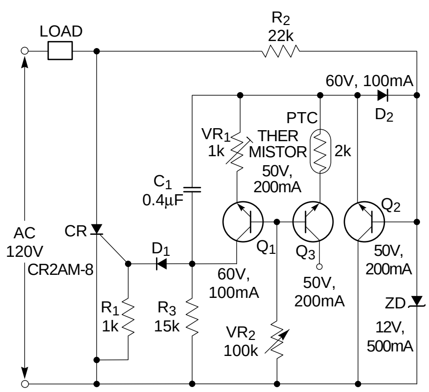
CR: THYRISTORS OF 0.3A TO 20A CLASS CAN BE USED.

11.2 Temperature Control Circuit of an Electric Blanket using a Thyristor

- Electric blankets of up to approximately 100W can be controlled by a thyristor.
- Control by the zero volt switch prevents interference to radio or TV equipment.

By the zero-volt switch control method, trigger voltage of the thyristor CR is set at around zero volt, and the on-off of the device is controlled by the temperature detected by the PTC thermistor. If the temperature of the blanket is lower than a specified value, C_1 is charged up to ZD voltage during the negative cycle of the power supply. When the supply voltage changes to a positive cycle, C_1 discharges through Q_2 and the current flows to the gate of CR. On the other hand, if the temperature rises, resistance of PTC thermistor increases and Q_1 is turned on during the negative cycle of the supply voltage and C_1 is not charged and thus CR is not triggered. Q_3 is inserted for temperature compensation. See Figure 11.4. (Patented by Mitsubishi Electric)

Figure 11.4

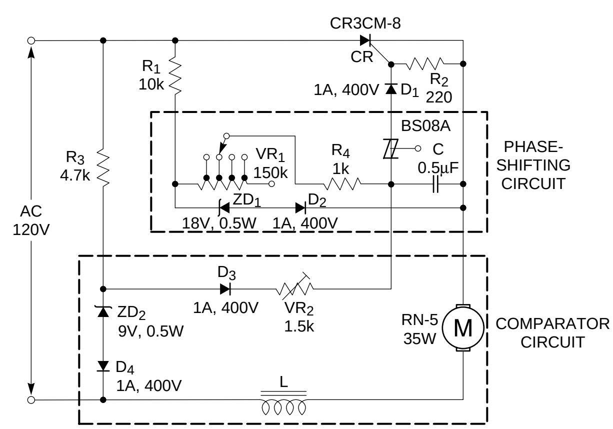


11.3 Constant-speed Control Circuit of a Universal Motor

- The feedback amount is automatically controlled by the motor speed for easy constant-speed operation.
- The feedback amount required for each motor type can be adjusted by resistor VR_2, thus enabling control of various types of motors.

The speed of motor is adjusted by VR1 in the phase-shifting circuit. In the comparison circuit, the reference voltage supplied by the Zener diode and the armature voltage are compared, and C in the phase-shifting circuit is charged by the difference of voltages. The effect of feedback is negligible as the sum of VR_1 and C is small during high-speed operation, but during low-speed operation, when the sum of CR_1 and C is large, even a small feedback is effective and constant operation is improved at low-speed operation. See Figure 11.5. (Patented by Mitsubishi Electric)

Figure 11.5



11.4 Speed Control Circuit of a Juice Mixer

- This circuit allows non-stage speed control by the half wave phase control.
- Timer circuit allows automatic repetition of running and stopping.

If SW_1 is turned on, Q_1 is always turned off and Q_2 is always turned on, and the thyristor CR is triggered by the phase angle set by VR_1 to control motor speed. If SW_2 is turned on, the self-running multi-vibrator consisting of Q_1, Q_2 and C_1, C_2, R_1 and R_2 is activated and the on-off operation of Q_2 is repeated. When Q_2 is turned on, the phase of CR is controlled by VR_1 and the motor operates, and speed control is enabled. But when Q_2 is turned off, CR is not triggered and the motor stops. See Figure 11.6.

11.5 Earth Leakage Breaker

- Electric shock or fire caused by earth leakage can be prevented by detecting earth leakage and tripping the breaker.

- The circuit can protect equipment from damage due to overload or short-circuit.

If the circuit is normal,

$$I_1 + I_2 = I_{01} = 0,$$

and the voltage is not induced on the secondary coil of zero-phase rectifier (ZCT). But, if earth leakage occurs, the sum of currents flowing through ZCT, I_{01} does not equal 0, and the voltage is induced on the secondary coil. The inductive signal is converted into a proper thyristor trigger signal by IC M54122 and enters the thyristor gate circuit driving the thyristor and tripping the breaker. See Figure 11.7.

11.6 Gas/Petroleum Ignition Circuit

- When the power supply is in the negative half cycle, spark discharge occurs. Compact and small-capacity resistor R_1 and a thyristor can be used as the current does not flow from the power supply of the thyristor.

- High-voltage pulses of more than 14kV are output to cause ignition of gas of kerosene.

Capacitor C_1 is charged through R_1 and D_1 during the half cycle of positive power supply and C_2 is charged through R_2 using the reverse voltage applied to D_1. In this case, R_1, R_2, C_1 and C_2 should be selected to make $R_1C_1 << R_2C_2$, SBS is turned on as C_2 reaches the switching voltage after C_1 is fully charged, and the gate current flows to the thyristor CR. The electric charge charged in C_1 is instantly discharged through CR, and after C_1 is charged with the reverse polarity, it is discharged again through D_2 and the coil, and then it is charged again with the original polarity. Thus high voltage is generated (more than 14kV) on the secondary side of the coil by the current flowing through the coil to produce spark discharge at the discharge gap. See Figure 11.8

Figure 11.6

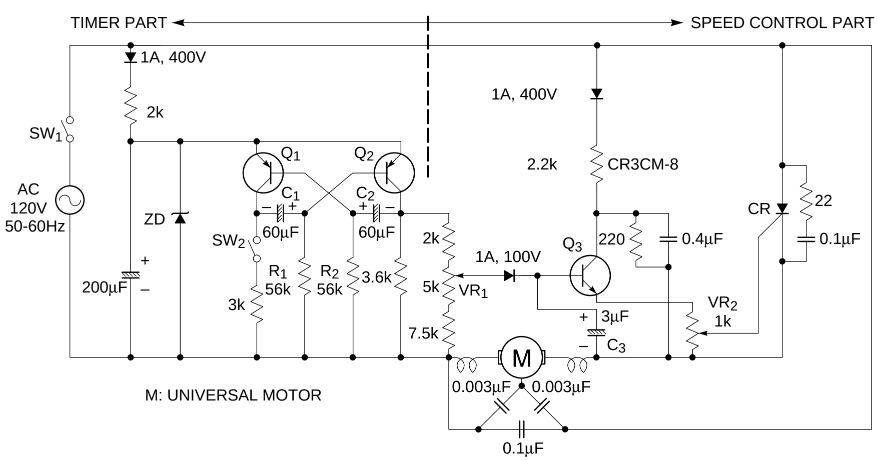
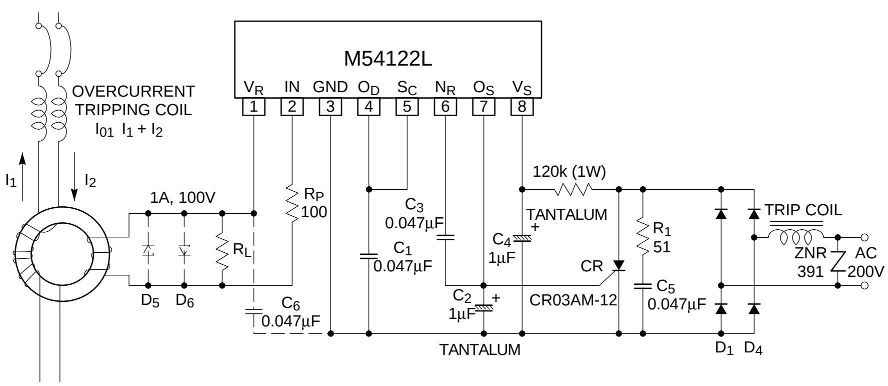


Figure 11.7



CR: CR2AM-12 CAN BE USED AS WELL AS CR03AM-12
D_5,D_6: NOT REQUIRED IF ZCT INCLUDES PROPER MEASURES TO COPE WITH LEAKAGE
M54122L: MITSUBISHI ELECTRIC

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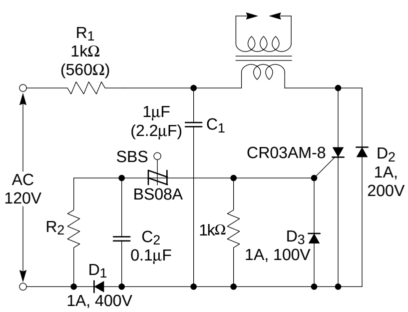
11.7 Ignition Circuit Used Internal-combustion Engine

- Use of contactless contact breaker and electronic advancers reduces the number of deteriorating parts to ensure high reliability and performance.
- Suitable for the ignition unit of small engines used in motor cycles, outboard motors, or snow mobiles.

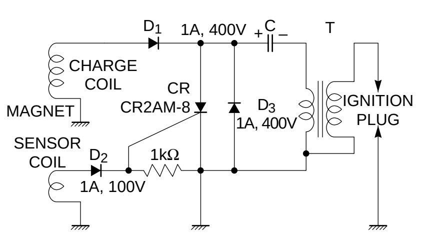
Rotation of the rotor of the magnet induces voltage in the charge coil and the sensor coil. Capacitor C is charged, with polarity as illustrated in Figure 11.9, through diode D_1 by the voltage induced in the charge coil. If the signal voltage for ignition control generated in the sensor coil is applied to the gate of thyristor CR through D_2 the CR is set on and the electric charge of capacitor C_3 is discharged through the primary coil of the ignition coil. The ignition coil is excited by this current, and high voltage is generated in the secondary coil to produce sparks at the ignition plug.

Figure 11.8



GAS IGNITION UNIT ....R_1 = 1kΩ, C_1 = 1µF
PETROLEUM IGNITION UNIT ....R_1 = 560kΩ, C_1 = 2.2µF

Figure 11.9



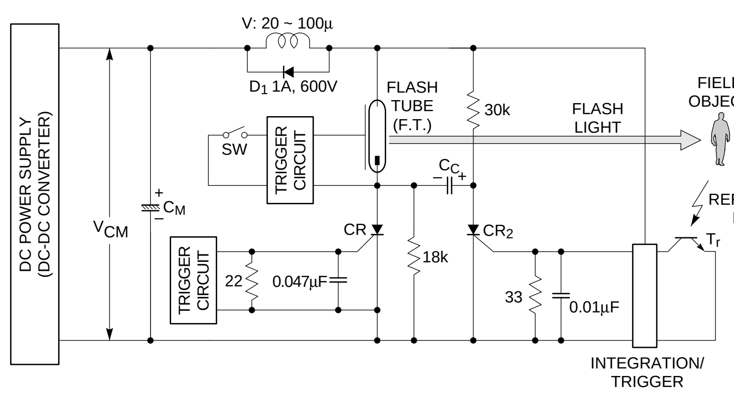
CR: CR3CM-8, CR03AM-8 CAN BE USED AS WELL AS CR2AM-8 AS SHOWN ABOVE

11.8 Strobe Circuit with Serial-type Automatic Dimmer

- The circuit reduces waste of discharge energy of CM by stopping the discharge current.
- Continuous flashes at short intervals can be generated.

After F.T. is triggered and conducted by closing the switch SW, synchronized with the shutter of a camera, the thyristor CR_1 is triggered to produce a flash. When a flash is emitted to the field object and the reflected light reaches the required intensity, the thyristor CR_2 is triggered. When the C_C voltage, charged with the polarity as shown in the Figure, is applied to CR_1 as reverse voltage, CR_1 is turned off and the flash of F.T. stops. See Figure 11.10.

Figure 11.10



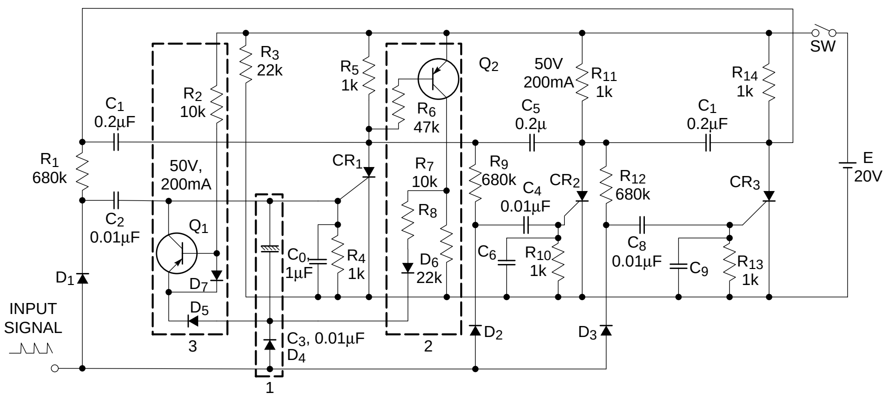
CR_1: CR3AMZ-8 – CR3JM-8
CR_2: CR3EM-8

11.9 Thyristor-type Ring Counter

- With a built-in starter circuit 1, starter capacitor charge circuit 2 and starter capacitor charge circuit 3 housed in a conventional ring counter circuit, the ring counter starts immediately if the input signal is applied.
- Thyristor-driven anode-connected ternary counter.

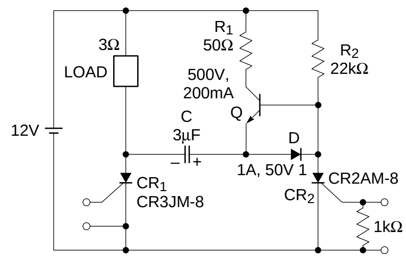
As the input signal is applied to the gate of thyristor CR_1 through C_0, CR_1 is turned on first. If CR_1 is turned on, then Q_2 is turned on and C_0 is charged up to the supply voltage through R_7 and D_6. As the starter circuit 1 has nothing to do with the next input signal, ring counter operation is enabled. If SW is turned off, Q_1 is turned on and the charge of C_0 is discharged immediately, making the circuit suitable for repetitive operation. See Figure 11.11. (Patented by Mitsubishi Electric)

Figure 11.11



C_1~D_7: 1A, 100V
CR_1~CR_3: CR02AM-4

Figure 11.12



11.10 DC Static Switch

- The DC static switch returns to normal by applying the off signal again if commutation fails.
- The fast response ensures high-speed switching.
- Low power dissipation during the off-state period.

If the input signal is applied to the gate of thyristor CR_1, as illustrated in Figure 11.12, CR_1 enters on state, and current flows to the load. As the base current flows to the transistor Q through resistor R_2 and capacitor C, Q enters an on state and C is charged with the polarity as shown in Figure 11.12. If the signal enters the gate of auxiliary thyristor CR_2, CR_2 enters an on state and the discharge current flows from C through diode D, CR_2 and CR_1, and CR_1 enters an off state. Then C is charged with the reverse polarity as illustrated. During this period, Q enters an off state as the voltage of D falls. When C is completely discharged, CR_2 returns to off state. If CR_2 returns to an off state, C is discharged through Q in preparation for the next operation.

If commutation fails during this commutation period, both CR_1 and CR_2 enter an on-state, but CR_2 returns to an off-state and C is discharged with the polarity as illustrated in Figure 11.12 because the value of R_2 is large, only a small amount of current flows to CR_2, and the current bypass circuit is provided, consisting of R_1, Q base and C. Therefore, CR_1 can be placed off state again by applying the off-state pulse signal to the gate of CR_2.

11.11 Electric Foot Warmer

- Non-stage and wide-range control of the temperature of an electric foot warmer is possible.

The temperature is controlled by trigger pulses generated by VR, PTh, R_1, BM, R_3 and C_4 and by the control of the trigger phase of triac BCR. If the temperature exceeds a specified value after the temperature is set by VR, the resistive value of positive-type thermistor PTh increases and the conductive angle of BCR becomes smaller and so the temperature falls. If the value decreases, the conductive angle becomes larger and the temperature rises.

The bimetal switch BM detects sudden temperature rises and turns the BCR to an off state and stops the power supply. R_2 is provided to prevent retriggering of SBS.

As the charge current of C is the current flowing through resistor R_2 multiplied by h_{EE} of transistor Q, C can be charged quickly and a large resistive value of R_2 can be set so that the current is less than the holding current of CR_1. Thus, power dissipation is minimized during the off state of DC static switch.

Proper selection of h_{FE} of transistor Q and resistive value of R_2 enables normal operation at repetitive frequency of 1kHz. See Figure 11.13. (Patented by Mitsubishi Electric)

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11.12 Zero-volt Switch using Triacs

- A heater of 1 to 1.6kW can be controlled in a range of 40 to 160°C.

- A zero-volt switch does not counter problems due to high-frequency noise.

The saw-toothed wave voltage generated in a saw-toothed wave oscillator is superimposed between the base and emitter of Q_1 in the Schmidt circuit, and is used to repeat the on-off operation of the Schmidt circuit. The duty cycle of on-off operation is determined by VR and Th. Q_4 is turned off only during a short period near the phase of 0 to 180 degrees of the power supply by Q_3 and Q_5, and the current flows to the gate of the triac through C_4 and R_{22} in the pulse generating circuit of the final stage. During other periods, Q_4 enters an on state, and the current does not flow to the gate. But if Q_1 enters an off state in the Schmidt circuit, Q_4 is always placed in an on state and the triac is not triggered. See Figure 11.14. (Patented by Mitsubishi Electric)

11.13 Zero-Volt Switch of Triac and Thermo IC M54101P (For use of Heater Control)

- Control of the zero-volt switch does not cause interference to radio or TV equipment.
- High reliability is ensured by the small number of parts in the control circuit.

The M54101 is a digital integrated circuit for thermal control such as heaters. Load temperature is detected by temperature detector PTC and if the temperature is lower than a specified value, an output pulse in the vicinity of zero volt of the supply voltage is generated by transistor Q to trigger a triac. The load temperature can be

Figure 11.13

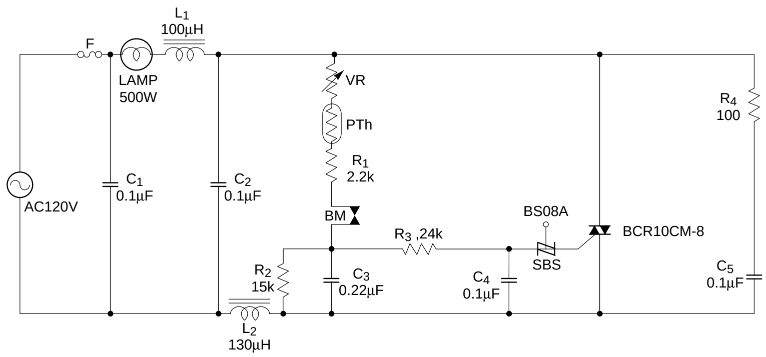
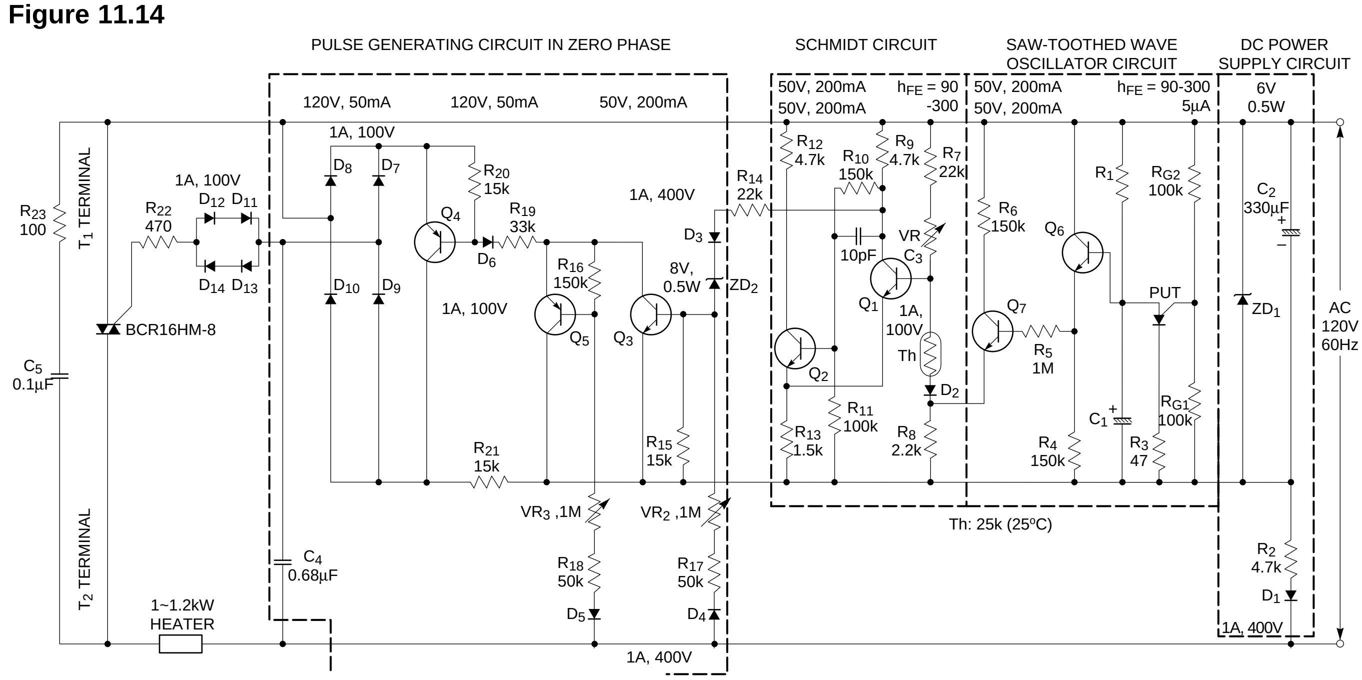


Figure 11.14



EXAMPLE: CYCLE IS 100 SEC WHEN R_1 IS 1M AND C_1 IS 100µF specified at any value by changing VR_1. See Figure 11.15

11.14 Zero-volt Switch Using a Triac and Zero-volt Control IC M5172L (Water Heater)

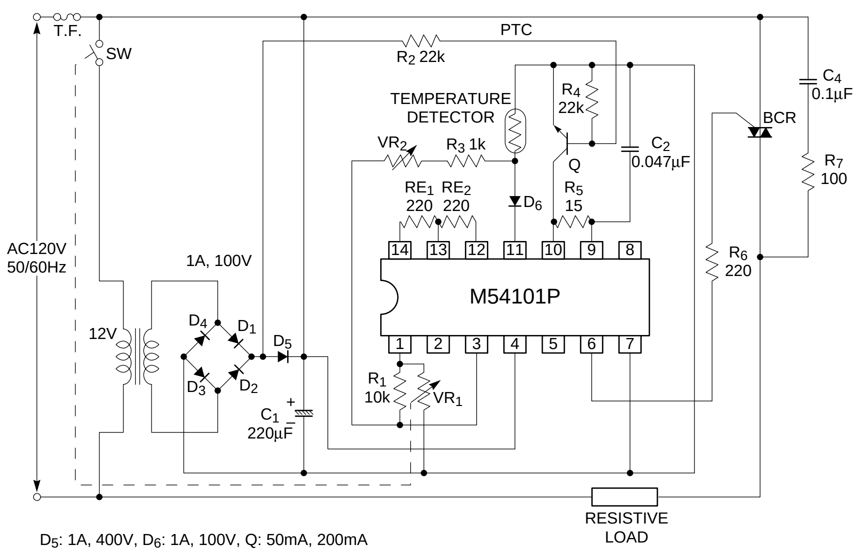
- Control of zero-volt switch causes no radiowave interference.

- High reliability is ensured by the small number of parts.

- Used for resistive load.

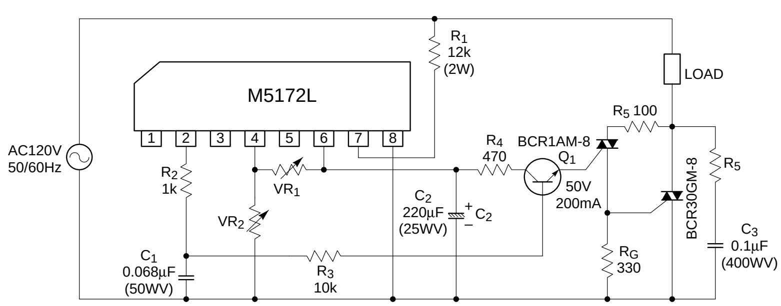
The M5172L is a linear semiconductor integrated circuit for zero-volt control of a thyristor, and by delaying the output pulse, zero-volt control of a triac is enabled. If the temperature of water is lower than a specified value, pulses are generated in the vicinity of zero-volt. The pulse width of this output is enlarged by the delay circuit, consisting of C_1 and R_2 and amplified by transistor Q_2. By applying this output to the gate of the triac and using a thermistor for VR_1, the temperature can be automatically controlled. See Figure 11.16.

Figure 11.15



D_5: 1A, 400V, D_6: 1A, 100V, Q: 50mA, 200mA
BCR: BCR3AM-8, BCR10CM-8, BCR16HM-8, BCR30GM-8, ETC.
M54101P: MITSUBISHI ELECTRIC

Figure 11.16



M5172L: MITSUBISHI ELECTRIC

11.15 Temperature Control Circuit by Zero-volt Switch

- Control of the zero-volt switch and the use of general use comparator IC dispenses with radiowave interference.

- Used for resistive load.
- Figure 11.17 shows a zero-volt switch circuit suitable for temperature control of heaters used in home electric appliances for heating and cooking equipment.

This circuit employs an NTC thermistor for the temperature detector device. One of the two IC M51207 comparators is used for the temperature comparator and the other is used for zero-volt detector of AC power supply. The temperature detector unit and AC power supply unit are electrically insulated by a photo-coupler. When switch SW is turned on, and if the detector temperature is lower than a specified value, the temperature detector comparator is set high. In this condition, the zero-volt detection comparator 2 enters a low state in the vicinity of zero-volt at both ends of all-wave rectifier circuit. The triac is triggered in the vicinity of zero-volt of AC supply voltage (II and III modes) and the power is supplied to the load of heater.

If the detected temperature exceeds a specified value as the temperature of the heater rises, comparator 2 of the temperature detector circuit is set low and the comparator is set high, irrespective of the state of input at pin ⑧, and the power supply is stopped. The Triac BCR10CM can control a heater with the wattage of more than 500W. The required size of a heatsink fin is 60 x 60 x t2.3mm. BCR10PM is an insulated type.

11.16 Single-phase Capacitor Motor Speed Control Circuit

- Negative feedback control allows large load variation and large start-up torque, making the device suitable for the speed controller of washing machines.

- Employment of BS08A for the trigger device of triac makes the control circuit comparatively cheap.

In general, wide-range speed control of a capacitor motor is not achieved simply by controlling the phase. In this circuit, the speed of a motor is detected by the pilot generator (PG) and by the voltage (terminal voltage of C_2) in proportion to the rotating speed. The specified voltage (determined by Zener diode ZD_1, ZD_2, resistor R_2, R'_2 and R''_2) are compared, and the charge current of capacitor C1 is controlled by applying the difference of the voltages between the gate and emitter of transistor (Q) and by amplifying it. The charge constants of capacitor C_1 varies according to this control, and therefore, the breakover phase of silicon bidirectional switching device (BS08A), i.e., trigger phase of triac (BCR10CM), changes and the power supply of the motor can be adjusted, enabling constant speed control. See Figure 11.18. (Patented by Mitsubishi Electric)

Figure 11.17

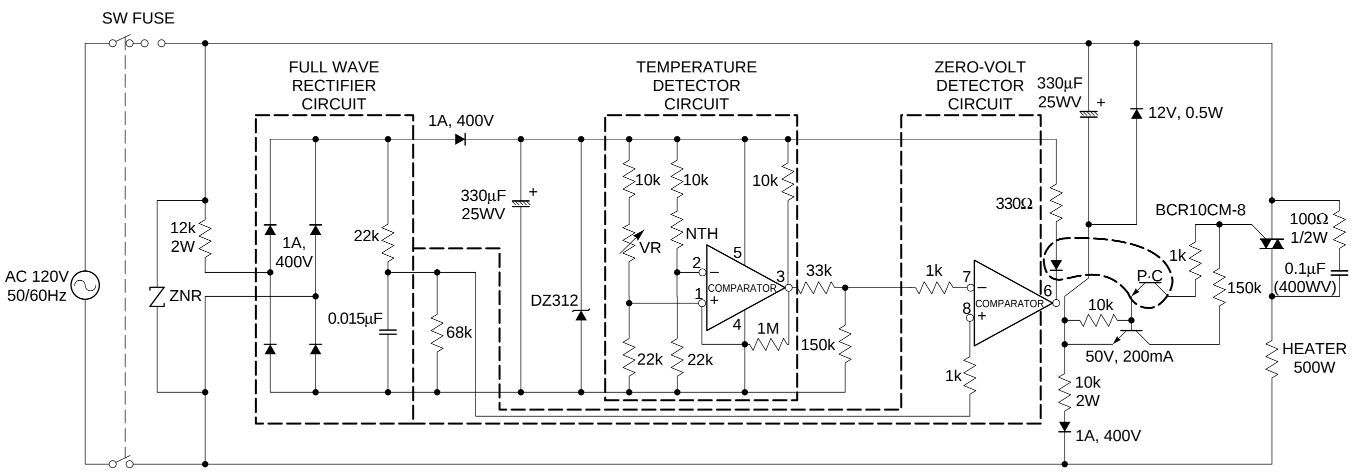
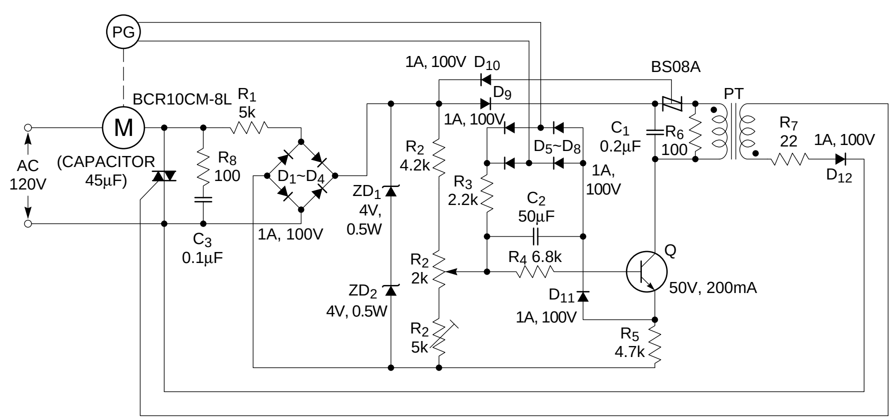


Figure 11.18



11.17 Rush Current Control Circuit of Halogen Lamp (Using Photocopiers)

- The rush current can be reduced by the soft-start drive.

- Reduction of rush current enables the use of cheap devices with low rated current, and thus more economical equipment design.

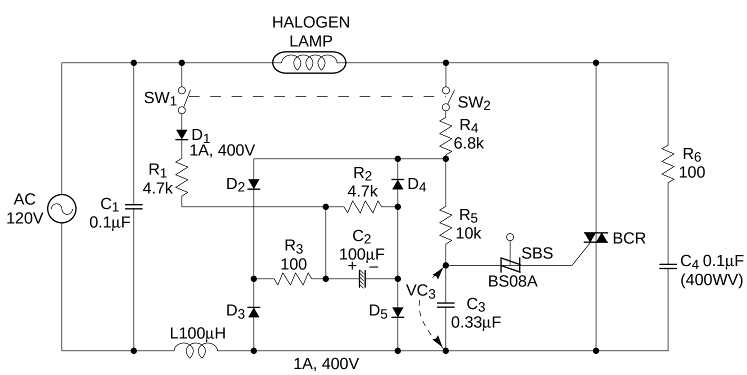
The soft-start is enabled by bypassing the charge current to C_3 at the early stage of switching. If the voltage VC_3 of C_3 reaches the switching voltage V_S of SBS, the SBS is set on and BCR is also set on. During the first several ten cycles after the power supply is turned on, the charge current for D_2, D_5, C_2 and C_3 are bypassed to delay the phase when VG_3 becomes Vs. If G_2 is charged, the bypass current does not flow and, in normal conditions, the switching phase is settled at a value determined by the charge constants of R_4, R_5 and C_3. Figure 11.19. (Patented by Mitsubishi Electric)

11.18 On-off Operation Circuit for Rush Current Control of the Transformer

Reduction of rush current by the soft-start drive makes the device suitable for on-off control of transformers and motors.

A multi-vibrator consisting of Q_1 and Q_2 determines the on-off cycle of a triac. If Q_1 is conducted, the impedance of transistor Q_3 gradually decreases by the delay circuit consisting of a capacitor C_7 and a resistor R_6. The generated phase of trigger pulses for the triac BCR gradually advances to enable the soft-start. See Figure 11.20

Figure 11.19



Capacity of Halogen Lamp	Rush Current (Peak Value)	Applicable Device	
		Without Soft Start	With Soft Start
500W/100V	68A	BCR10CM	BCR10CM
800W/100V	103A	BCR16CM, BCR16HM	BCR12CM
1000W/100V	130A	BCR30GM	BCR16HM, BCR16CM
1200W/100V	170A	BCR30GM	BCR30GM

11.19 Battery Charger (I)

- If the battery is connected in reverse direction, the circuit prevents the current flow and damage to the charger.

- The reverse connection is displayed by the display lamp.

The output voltage stepped down by a transformer of home-use AC power supply is rectified by the all-wave rectifier diode and is applied to the triac. If the battery is connected normally, the gate current flows to the triac BCR gate from the battery, and the triac is set on and the battery is charged. If the battery is connected in the reverse direction, the gate current of BCR is blocked by D_1, the battery is not discharged and no current flows to diodes from D_1 through D_4. As DC current is supplied to the light-emitting diode LED, it is illuminated to indicate the reverse connection. See Figure 11.21. (Patented by Mitsubishi Electric)

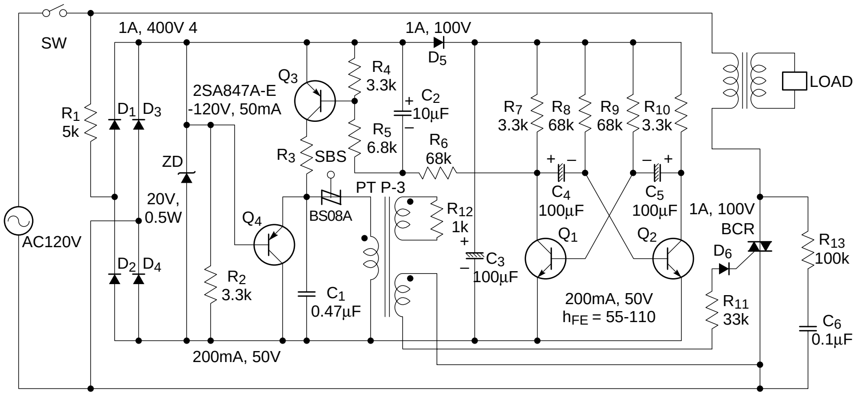
11.20 Battery Charger (II)

- The battery is charged by connecting it to the terminals of a charger. Polarity does not need to be matched.

- For safety measures, even if the input terminals are connected to AC power supply, the voltage appears to the output terminals only when a battery is connected.

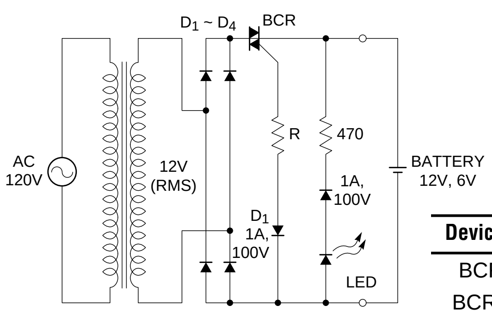
The circuit is operated by the trigger mode II (T_2 pin (+) gate (-)) and by the function of the circuit that triggers one of the two triacs in accordance with the polarity of the connected battery. As the gate

Figure 11.20



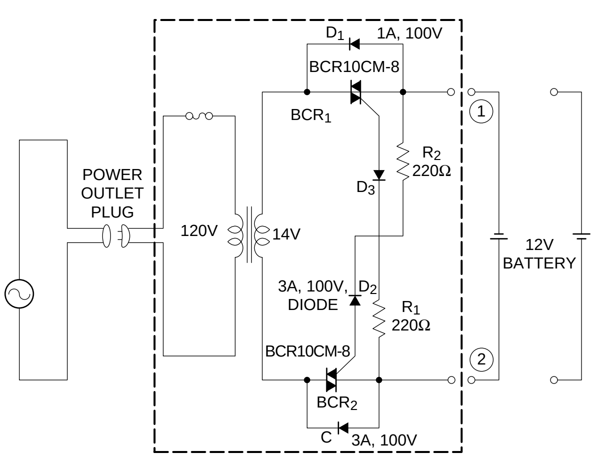
BCR: BCR3AM-8 ~ BCR30GM-8L, ETC.

Figure 11.21



Device Name	Register R
BCR3AM	47Ω/3W
BCR10CM	100Ω2W
BCR16CM	100Ω/2W

Figure 11.22



current is not applied to the triac when a battery is not connected to the charger, no voltage appears at the output terminals of the charger.

If the battery output terminal (1) is connected to the positive side of the battery, the gate current flows to BCR_1 in loop from the battery, T_1 terminal of triac BCR_1, diode D_3, resistor R_1 and to the battery by the residual voltage of the battery, and BCR_1 is set on. During the positive half cycle of AC power supply, the charge current flow from the secondary coil of a transformer, BCR_1, battery, diode D_3 to the secondary coil, and the battery is charged.

On the other hand, if the battery is connected to the charger with reverse polarity, exactly the reverse operation takes place, and during the negative half cycle of AC power supply, the charge current flows through triac BCR_2 and diode D_1, and the battery is charged. See Figure 11.22 (Patented by Mitsubishi Electric)

11.21 Battery Charger (III)

A battery is automatically charged if it is connected with the specified polarity. It does not operate if it is connected in reverse direction, shorted, or opened.

If a battery B is not connected between A and A' when the power supply E is turned on, as illustrated, the triac BCR is set off and no current flows in the secondary coil of transformer T. If A and A' are shorted, no current flows in the secondary coil of transformer T. If a normal battery B is connected as illustrated, the

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relaxation oscillator circuit of PUT, using the battery as its power supply, oscillates in a specified cycle determined by R_4 and C_1. Therefore, pulses are generated at both ends of resistor R_3 and are applied to the base of transistor Tr, and Tr is set on in accordance with the cycle of relaxation oscillator circuit. If Tr is set on, the pulse gate current flows to the gate of BCR in a loop from battery B, gate of BCR, resistor R_1, Tr and to battery B. By contrast, when the positive half cycle of sine wave voltage half-wave rectified by a rectifier diode is applied at terminal T_2 of triac BCR, BCR is set on and starts to charge automatically when the BCR gate current flows. The pulse current flows to the gate of BCR irrespective of the voltage phase, and if R_4 and C_1 are specified so that the pulse frequency is more than 1kHz, a triac can be triggered without making the conductive angle of BCR too small. If the terminal of battery B is accidentally connected in the reverse direction, the current to the gate of the triac is blocked by transistor Tr and the battery is not charged or discharged as the triac is set off. See Figure 11.23 (Patented by Mitsubishi Electric)

Figure 11.23

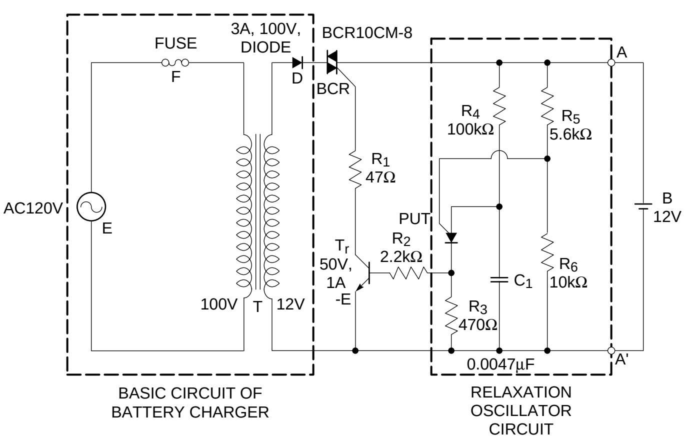
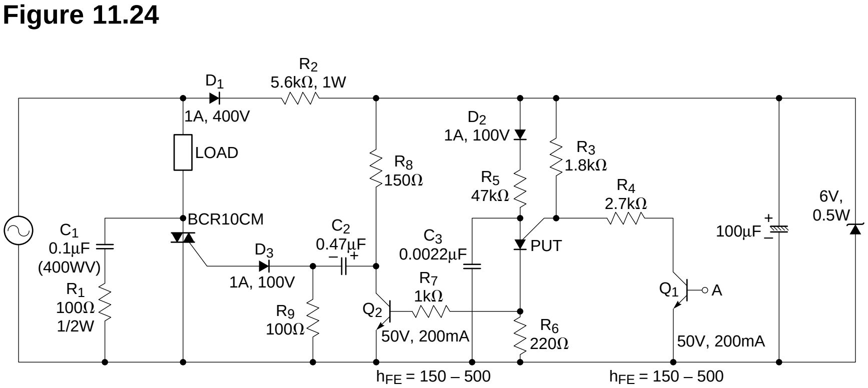


Figure 11.24



11.22 On-off Switch using a Triac

- A triac can be triggered using the output of an IC in modes II or III.
- A pulse transformer is not required.

The signal from the IC is applied to Q_1. If the signal is high, Q_1 is set on and the PUT oscillates approximately at 10kHz and Q_2 repeats on-off operation accordingly. On the other hand, C_2, R_3 and R_9 are charged as illustrated, the charge of C_2 is discharged from C_2, Q_2, triac BCR (T_1 to G) and D_3 whenever Q_2 is set on. The charge current of C_2 flows from the gate of a triac, the triac is triggered in modes II and III. As the oscillator frequency of PUT is set at 10kHz, occurrence of radio noise is suppressed. See Figure 11.24 (Patented by Mitsubishi Electric)

11.23 De-icing Timer Circuit for an Electric Oven

- Suitable for disconnection control of a magnetron.
- Half-wave conduction blocking circuit prevents the flow of excess current to the triac.

If switches SW_1 and SW_2 are turned on, an unstable multivibrator consisting of PUT_1 and PUT_2 function and transistor Q_1 repeats the on-off operation at a specified interval. The triac BCR is set on while Q_1 is off and the power is supplied to the magnetron. While Q_1 is on, the BCR gate is shorted, no gate current flows, and BCR is set off. In this way, the triac repeats on-off operation and the power is supplied to the magnetron intermittently.

If Zener diode ZD and transistor Q_2 prevent the flow of excess current by half-wave conduction, in which only the sensitive modes of the triac are triggered as the gate current decreases when the discharge voltage of capacitor C decreases, then only the SW_2 is turned off. If the charge voltage is less than the Zener voltage of ZD, transistor Q_2 is turned off and Q_1 is turned on and no current flows to the gate of a triac. Therefore, no current under a specified value flows to the gate of BCR. See Figure 11.25 (Patented by Mitsubishi Electric)

11.24 DC Power Supply Circuit for 100V and 200V

- A specified DC voltage is output from either 100V or 200V source without switching.

If the plug is inserted at a 100V power outlet, gate current flows to the gate of triac BCR through resistor R_3 during both positive and negative cycles, as the thyristor (Thy). Thy is set off if the ratio of resistors R_1 and R_2 are selected so that the charge voltage of C_1 is less than the Zener voltage of the Zener diode. As a result, BCR is set on during both half cycles and the amplifier circuit in the later stage provides DC voltage approximately two times larger than AC voltage.

If the plug is inserted at a 220V power outlet, the charge voltage of capacitor C_1 is larger than the Zener voltage and gate current flows to Thy. Thy is set on and BCR gate and terminal T_1 are shorted. Thus, BCR is set off during the negative half cycle, and capacitor C_2 is not charged. C_2 is charged only during the positive half cycle and functions as a half-wave rectifier. Therefore, the output DC voltage is equal to the input AC voltage.

As stated above, the same DC voltages are output by the selection of half wave and full wave for the AC supply voltages of 100V and 200V. See Figure 11.26. (Patented by Mitsubishi Electric)

11.25 Pulse Amplifier Circuit Using Thyristor

- High-frequency pulse of approximately 1kHz can be amplified.
- Small capacity required for thyristors and transistors reduces power dissipation.
- The circuit can be used to trigger thyristors of large capacity.

When thyristor CR is set off, C is charged through Q. If CR is triggered by the external signal, the base-emitter of Q is reverse-biased by D_1 and Q is put in an off state. This state after C is discharged completely, Q turns to an on state again and starts to charge C. See Figure 11.27 (Patented by Mitsubishi Electric)

Figure 11.25

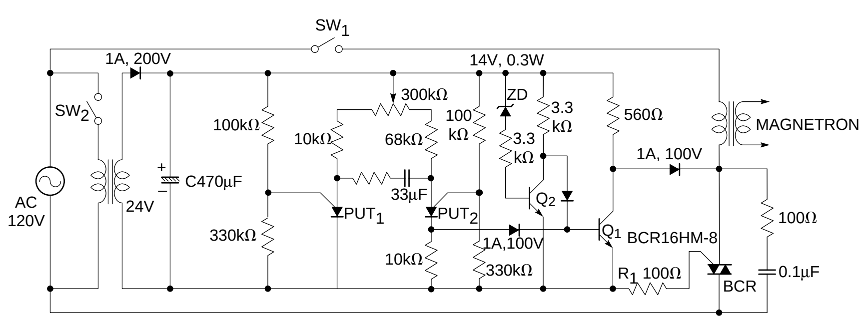


Figure 11.26

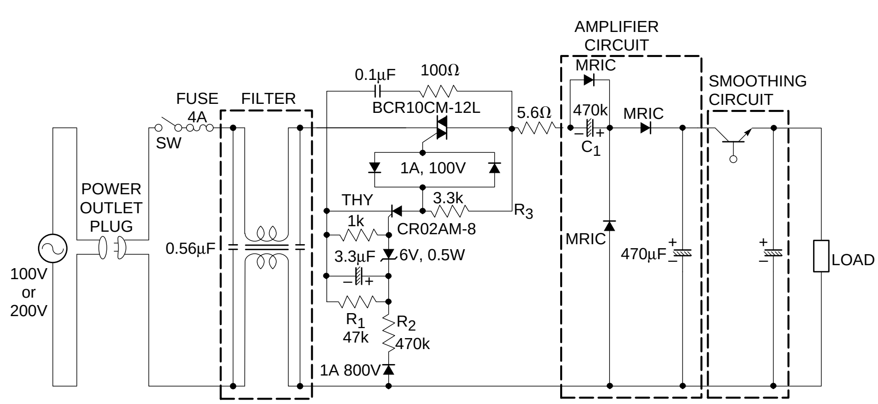


Figure 11.27

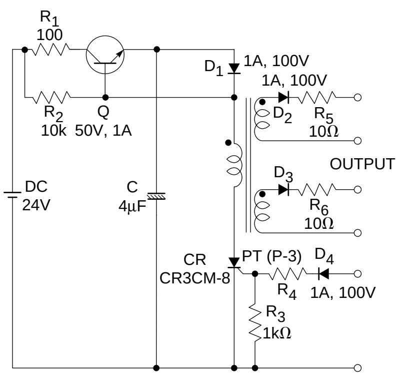
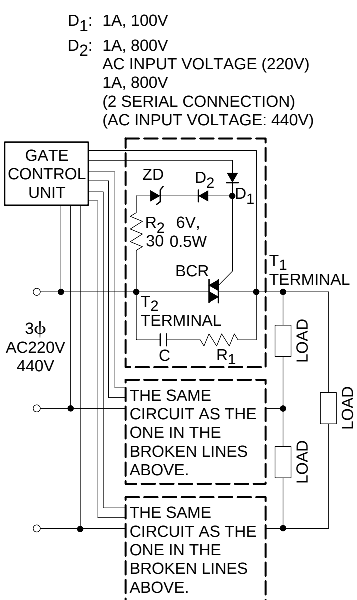


Figure 11.28



11.26 3-Phase AC Power Supply Control Circuit Using a Triac

To control the 3-phase AC power supply, the gate trigger signal should have an electrical angle of more than 60 degrees or double pulse with a distance of more than 60 degrees and the circuit becomes very complicated. But a control circuit with the same function is realized with this simple circuit as illustrated in Figure 11.28.

The flow of current in one direction from T_2 terminal to T_1 terminal of the triac is controlled by the gate control unit. The reverse current is controlled by triggering the triac with the gate current flowing from the load, T_1 terminal, gate terminal, diode D_1, Zener diode ZD and resistor R_2. The power is controlled from 0 to 100% by changing the ignition phase angle from 210 to 0 degrees. Zener diode ZD prevents mis-operation due to noise from the main circuit. (Patented by Mitsubishi Electric)

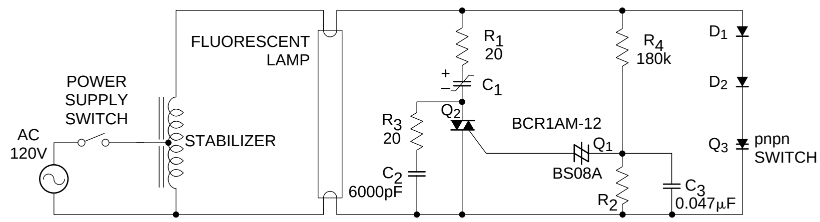
11.27 Electric Starter for Fluorescent Lamps

Employment of a non-linear saturable capacitor, triac and reverse-blocking two-terminal thyristor provides a cheap, compact and light-weight electric starter for fluorescent lamp with short turn-on time.

If the power supply switch is turned on, the bi-directional switching device is set on at a proper phase θ of the positive half cycle of the power supply at the early stage of startup, and triac Q_2 is triggered. If Q_2 is turned on, non-linear saturable capacitor C_1 with charge saturation characteristic under a specified charge voltage is charged quickly by the power supply through the stabilizer with polarity as illustrated.
C_1 enters quickly into the saturation area and the current flowing to the stabilizer decreases instantly, and the high-voltage pulses of $e = L\,(di/dt)$ are generated in the stabilizer. The reverse-blocking two-terminal thyristor Q_3 is triggered by this pulse and a pre-heating current flows to the filament of the fluorescent lamp. The conducting current of Q_3 becomes zero at the phase θ_2 of the negative half cycle of power supply and Q_3 is turned off. Then, the near-the-peak voltage of the negative half cycle of the supply voltage is suddenly applied at both ends of the fluorescent lamp, Q_1 and Q_2 are turned on again and C_1 is charged quickly, with the reverse polarity as illustrated. With the same mechanism, high-voltage pulses with the reverse polarity are generated in the stabilizer and the turn-on pulse is applied at both ends of the fluorescent lamp.

Then the same operation continues and the light is turned on if the filament is sufficiently heated. (Approximately 0.5 seconds after the power is supplied.) If the lamp is turned on, the voltage applied at both ends of the lamp decreases, and Q_1, Q_2 and Q_3 are set off. Then pre-heating and high voltage pulses are stopped.
See Figure 11.29.

Figure 11.29



(CIRCUIT CONSTANTS ARE USED FOR 32W TYPE.)

UNIT: Ω