Bidirectional Control

The output current of an optocoupler using a phototransistor or a photo-Darlington device must flow only in one direction, so such a device cannot control alternating cur-

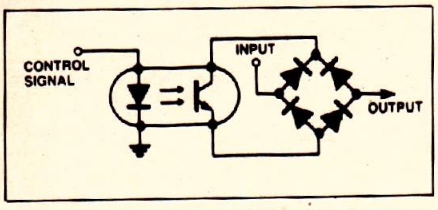


Figure 16. Controlling a bi-directional current using an optocoupler.

rent. This problem can easily be overcome by the use of the circuit of Figure 16, in which the input-to-output current is rectified by a diode bridge circuit before being fed to the output stage of the optocoupled device.

The control signal which switches the output on and off must be unidirectional.

Power Supply

Optocoupling devices can be used to isolate the control voltage of a regulated high voltage power supply from this supply line. The basic circuit which may be used is shown in Figure 17.

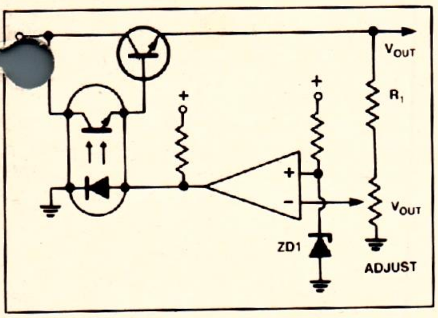


Figure 17. Using an optocoupler in a high voltage series-pass regulator.

A current flows from the stabilised output supply through the high value resistor R1 so that the variable resistor taps off a voltage proportional to the output voltage. This is compared with that across the zener diode D1 using the operational amplifier.

The output signal from this amplifier is fed to the emitter of the optocoupled device which is used to control the series pass transistor and hence to keep the output voltage constant. Thus, the amplifier device output is isolated from the high voltage supply.

A photo-Darlington device may be used in this type of circuit for higher feedback loop gain, but an external pass transistor is always required, since the output devices incorporated into optocouplers can handle only very limited power.

Fast Interface

The 6N139 with its 'split photo-Darlington' output device enables the high speed of the separate photodiode to be combined with the high gain of the Darlington connected internal transistors. Although the CTR has a minimum value of 400% at a 500 ma input current, the device output can switch in a few microseconds.

A fast non-inverting logic interface circuit using this device is shown in Figure 18. The maximum switching speed depends on the load resistor, R2, and the input resistor, R1. If R1 has a value of 180 ohm a current of about 17 ma will flow to the output of the TTL input device from the terminal emitter diode and the use of a 100 ohm load resistor for R2 will then enable data rates of about 300 kbit/s to be obtained. On the other hand, R1 may be increased to 1k8 for a 1.7 ma diode current with R2 2k2 for a maximum data rate of nearly 50 kHz.

Electrocardiograph Amplifer

The use of an optocoupled device to provide complete isolation of a patient from electrocardiography equipment is shown in Figure 19. The electrodes from the patient are connected to the programmable 4250 preamplifier stage which operates from +/−3 V battery supplies, nulling facilities being provided by the variable resistor connected between pins 1 and 5.

The same +3 V battery supply provides the bias for the high gain BC109 transistor which drives the diode emitter of the

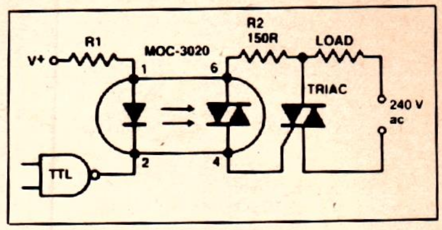


Figure 20. Control of ac power where there is a resistive load, using the MOC-3020.

optocoupling devices.

The output phototransistor of the optocoupler receives a base bias so that some current is always passing through its collector circuit. This enables the positive and negative parts of the signal waveform to be obtained at the output.

This is particularly important application of optocoupled devices, since without the isolation provided by such a device, small currents could be fed into the patient which in certain circumstance could produced death.

The MOC-3020

The small triac in the MOC-3020 output can provide a current of up to 100 ma. This is too small for controlling the mains current passing through the load in almost all applications, but is adequate to trigger an additional external triac.

A circuit of this type is shown in Figure 20 in which the output of the TTL gate, controls the emitter current of the MOC-3020 which triggers the internal triac, the latter triggering the external triac.

The latter device should be selected so that it can hold-off the applied mains voltage and also pass whatever current is required by the particular load being used.

Figure 21 shows the use of the MOC-3020 to switch the ac current through a lamp fed from the 240V mains when the lamp current is less than 100 ma. As the filament of the lamp has a much lower resistance when it is cold, care must be taken to ensure that the initial peak current is not excessive (about 1A for a very short time is permissible).

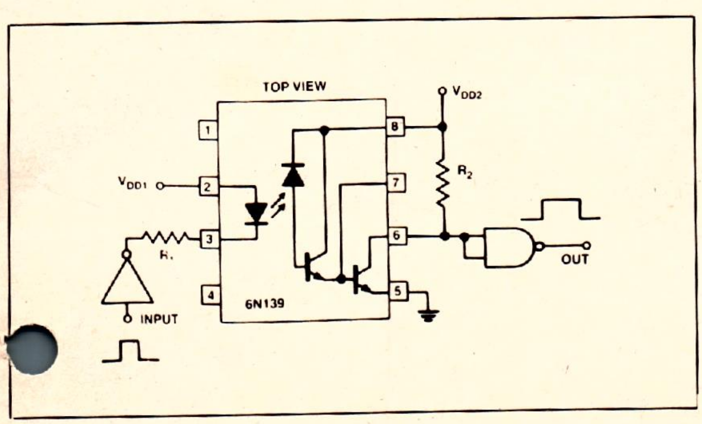


Figure 18. A fast TTL interfacing and isolating circuit using the 6N139.

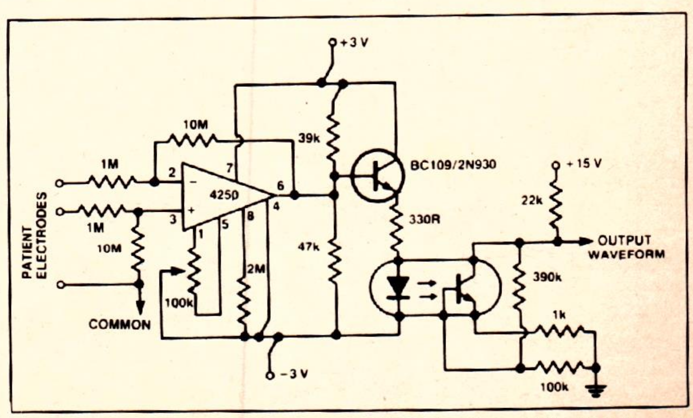


Figure 19. An electrocadiograph preamplifier circuit providing isolation of the patient from the equipment. (Litronix.)

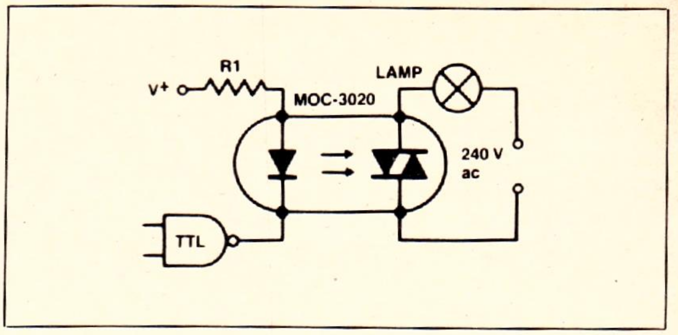


Figure 21. Controlling a lamp on the ac mains using a MOC-3020 (but watch the power rating).

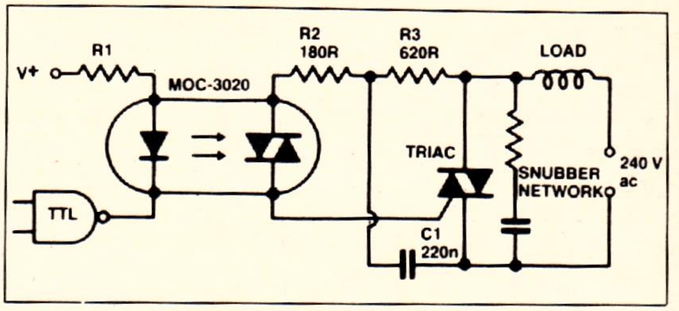


Figure 22. Control of ac power where the load is inductive (i.e. a motor), using the MOC-3020. Note the use of a 'snubber' network. Typical values for the RC network would be R = 180 ohms, C = 220n.

In the circuit of Figures 20 and 21, the load is resistive and conduction of the internal triac ceases when the mains voltage passes through zero during the course of the mains cycle.

In the case of an inductive load (such as an electric motor), however, large back-emf pulses can be generated when the current ceases to flow through the load and this could cause the internal triac of the optocoupler to operate in an improper way.

This problem can be avoided through the use of the type of circuit shown in Figure 22, the values of the components of the 'snubber network' connected across the external triac being dependent on the load inductance and resistance.

Conclusion

Simple optocoupler devices can be employed in a wide range of circuits from the simplest types to quite complex ones. At prices ranging from under one dollar up to a few dollars, they are excellent value! **ETI**

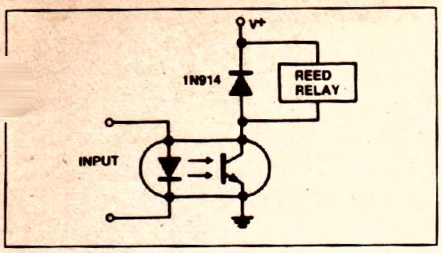


Figure 11. Using an optocoupler to isolate a reed relay.

diode and feeds this diode through a series resistor. The delay time before the relay closes will be dependent on the time taken for the capacitor to charge through the series resistor.

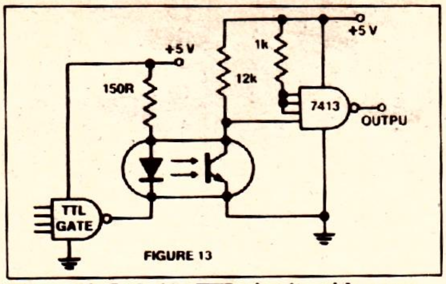


Figure 13. Isolating TTL circuits with an optocoupler.

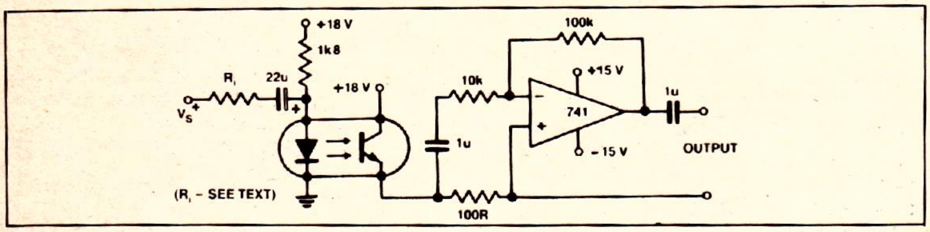


Figure 12. An isolation circuit covering the whole audio range.

Isolated Audio

The circuit of Figure 12 shows how an audio output completely isolated from the audio input signal may be obtained. A positive bias is applied to the input signal, V+,s so that the emitter diode polarity is satisfied.

The value of the input resistor R1 should be chosen so as to limit the modulating input current to a maximum of 5 ma. the 100 ohm load resistor of the phototransistor results in rather a low gain, but the 741 stage provides a gain of about ten so that a resonably large output voltage is obtained.

Lab Notes

The low value of the collector load resistor enables an upper frequency up to 20 kHz to be obtained, while the lower frequency response is determined by the values of the coupling capacitors employed — about 25Hz in the case of the values shown.

The separate + 18 V suppliers are required if complete isolation between the two parts of the circuit is needed. The input resistor R_i may consist of a variable resitor in series with a fixed resistor if it is required to alter the output signal voltage without any danger of receiving an electrical shock from the output circuit when the latter is at a relatively high voltage.

TTL Interface

Optocouplers are widely used in interface logic circuits where the logic signal must be transferred from a circuit at either a high or a low voltage level to a circuit at a very different voltage level.

The circuit of Figure 13 shows how an optocoupling device employing a simple output transistor may be employed to couple the output of a TTL gate to one of the inputs of a TTL 7413 device at a very different voltage level. The 7413 Schmitt circuit provides switching.

A Fairchild report suggests that the base of the output phototransistor of the optocoupling device should be connected to the emitter through a resistor of about 200 kilohm to prevent fast triggring of the outputs.

Another logic circuit for coupling an input to a 7413 device is shown in Figure 14, but in this case the 4N33 with its photo-Darlington output device is used.

It may be noted that in Figure 13 the load resistor (12 kilohm) is much higher than in Figure 14 (100 ohm), but the use of the higher gain of the 4N33 makes up for the lower value of load resistor.

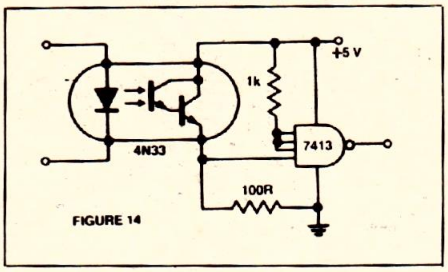


Figure 14. Control of a TTL Schmitt trigger circuit from a 4N33 photo-Darlington device.

The characteristics of the detector determine the speed of response and the bandwidth, since the emitting diodes are fast. The response time can be reduced by the use of a smaller value of load resistor, but many manufacturers quote rise and fall times and bandwidths with load resistors which are so small that the circuit would have an inadequate gain for most applications.

The response speed of an optocoupler can be improved by using the circuit of Figure 10 in which the collector load is effectively reduced to a very low value by the virtual ground input impedance of the operational amplifier.

An even simpler way of obtaining faster response at the expense of a reduced value of the CTR involves connecting a resistor, between the base and emitter of the output transistor. As the value of the resistor is reduced, the response becomes faster until in the limit, when the resistor is a short circuit, one is using the detector as a photodiode.

If one expects to be working with a very small input current, one might expect the use of a high gain device with a photo-Darlington output would be ideal. This is not necessarily true, since the overall efficiency can fall at such currents to the point where a device with a phototransistor would be better.

Simple Latch

The very simple latching circuit of Figure 15 can employ a pair of 4N33 photo-Darlington output devices. Initially, S1 is open and no current flows through either 4N33. If S1 is then closed, a current flows from the positive supply through the diode emitter in the upper 4N33 and through the emitter in the lower 4N33, the output of the upper device being shorted out by S1 during this time.

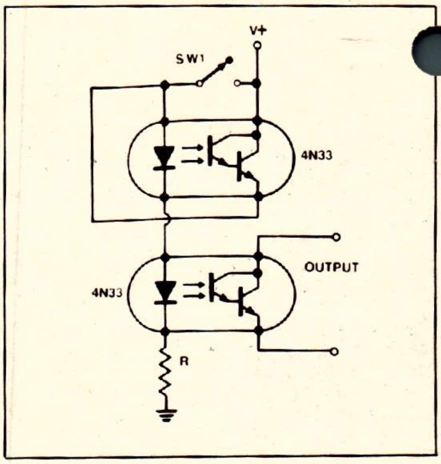


Figure 15. A latching circuit using two 4N33 devices.

When S1 opens, the short is removed from its output circuit, but the response time of the latter is longer than that of the emitter. The current therefore flows through the output of the upper 4N33, through the diode emitter of this same device to maintain the output in its conducting state and through the emitter of the lower 4N33. Thus the output of the lower device remains in its conducting state after S1 has re-opened.

The voltage across the two forward-biased emitting diodes is around 3.5 V and it is convenient to operate these diodes at about 5 ma. Thus, a suitable value for the resistor R is (V+ − 3.5)/0.005 or about 3.9 kilohm with a 24 V supply.

Each curve is for a different MCT2 device, the wide spread being due to variation in the phototransistor gain, the emitter efficiency and the coupling efficiency between the two internal components. The percentage values quoted on each curve are those for a 10 mA input current.

The CTR value of a 4N26 or 4N28 can vary by a factor of about 2.5 between high temperatures (where it is relatively low) and very low temperatures, while devices with Darlington outputs may show variations of double this factor between temperature extremes. Rather smaller variations are more commonly found.

Isolation

Manufacturers of optocoupled device specify a maximum voltage which may be safely applied between the input and output sides of the device. In most devices this is in the range 500 to 8000 V, depending on the device type, but special types can be obtained for higher voltage isolation.

The resistance between the input and output sides of a typical device is often around 10^{11} to 10^{12}ohm. Although this seems very high, if a potential of a few kilovolts is applied across the device, a current of somewhat under 100 na can flow. This is comparable with the current through the output of a high gain device when the input current through the emitter is under 1

If an optocoupler fails under a high applied voltage between its input and output sides, a short circuit will normally develop as a track is formed between the emitting and detecting devices. The problem can be reduced by the use of suitable current limiting resistors or protective devices in either the input or output circuit.

The stray capacitance between the input and output circuit of an optocoupler is typically of the order of 1pF (Table 1). It can provide some unwanted coupling in circuits designed to be able to operate at high speeds, especially when inductive loads are being switched.

The Emitter

The emitting diode will have a maximum continuous current rating, normally some tens of milliamps as indicated in Table 1. In some devices, pulsed currents above the maximum continuous current are permissable.

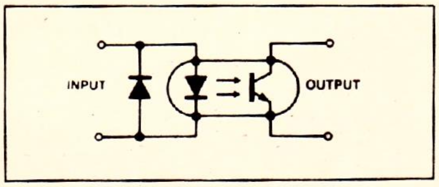


Figure 9. If a reverse voltage is likely to appear across the optocoupler emitter an external diode can be used to 'clip' it.

A maximum value is also imposed on the reverse voltage which may appear across the emitter diode. The application of a higher reverse voltage can cause it to breakdown and perhaps pass a destructive current; however, this problem is easily avoided by connecting an external diode across the emitter diode as shown in Figure 9.

Although gallium arsenide diodes have been the main type used in optocouplers, there is an increasing trend to employ gallium-aluminium-arsenide types, since the latter not only emit photons more efficiently, but also provide a slightly better spectral match to the silicon detector. Thus an appreciable increase in the CTR value can be obtained.

In many optocouplers one must be careful to observe not only the total power dissipated in the complete package, but also the power dissipated in the separate input and output devices, as indicated in Table 1.

The Detector

As with any other phototransistor or photo-Darlington, there is a certain value quoted for the maximum voltage which may be applied between the collector and the emitter with the base unconnected without risk of the device undergoing breakdown; this is BV_{CEO}. Similarly, values may be quoted for BC_{CBO} and BV_{ECO}.

A maximum collector current may also be quoted together with a maximum collector leakage current with base unconnected, I_{CEO}, under specified conditions.

The characteristics of the detector determine the speed of response and the bandwidth, since the emitting diodes are fast. The response time can be reduced by the use of a smaller value of load resistor, but many manufacturers quote rise and fall times and bandwidths with load resistors which are so small that the circuit would have an inadequate gain for most applications.

The response speed of an optocoupler can be improved by using the circuit of Figure 10 in which the collector load is effectively reduced to a very low value by the virtual ground input impedance of the operational amplifier.

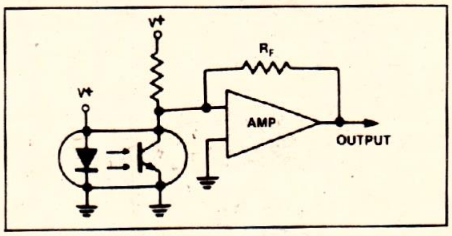


Figure 10. Response speed may be increased by the use of the virtual earth input of an op-amp.

An even simpler way of obtaining a faster response at the expense of a reduced value of the CTR involves connecting a resistor, between the base and emitter of the output transistor. As the value of the resistor is reduced, the response becomes faster until in the limit, when the resistor is a short circuit, one is using the detector as a photodiode.

If one expects to be working with a very small input current, one might expect the use of a high gain device with a photo-Darlington output would be ideal. This is not necessarily true, since the overall efficiency can fall at such currents to the point where a device with a phototransistor would be better.

Applications

Optocoupling devices can be employed to replace relays and pulse transformers in a wide variety of applications in which high isolation may be desirable or essential. They provide fast signal transfer with excellent noise immunity. They are suitable for interfacing with TTL and CMOS circuits and can also be used for analogue signal coupling.

Circuits designed for use with single phototransistor output optocoupled devices can generally employ the 4N26, 4N28 or MCT2, but note should be made of the individual differences listed in Table 1.

For example, the 4N28 is limited to applications in which the voltage across the device does not exceed 500 V, while when the other devices are selected, it may be as a great 1.5 kV.

The phototransistors in the MCT2 and in the dual MCT6 outputs are much higher voltage devices than those used in the 4N26 and 4N28.

The bandwidth of the 4N26 and 4N28 is typically greater than that of the other two types, but so is the isolation capacitance between the input and output. However, these points are not likely to be of any great importance in most applications.

Relay Control

The simple circuit of Figure 11 shows how small input current may be employed to control a reed relay. The inductive back-emf from the relay coil formed when the current ceases to flow through it is by-passed by the 1N914 diode so that this relatively high voltage pulse cannot damage the output transistor of the optocoupler.

The supply voltage used, V+, should have a value about equal to the voltage required by the relay, but should not exceed the V_{CEO} value of Table 1 for the optocoupler used.

Although the use of a reed relay is suggested so that the output current of the optocoupling device is kept quite small, other types of small relay can be controlled with careful circuit design. Obviously this type of circuit provides better isolation than many types of relay.

The circuit can easily be modified that the relay does not close until the input has been applied for a short time. One merely connects a capacitor across the input

Optically coupled triac driver chip interfaces logic to ac load

High isolation combines with control flexibility in a zero-crossing monolithic circuit

by Pat O'Neill,
Motorola Semiconductor Products Inc., Phoenix, Ariz.

□ The high isolation between load and logic that is provided by optical coupling cannot be matched by any other technique. The elimination of ground loop problems and the protection against high-voltage transients that result from the total lack of a common electrical connection (Fig. 1) are ideal for handling the low-level signals encountered in logic-to-logic coupling between equipment, data transmission over twisted pairs, and telephone coupling. Just as often, optocouplers are used to interface logic to alternating-current loads.

Before the development of a monolithic zero-crossing triac driver, this interface was a complicated and expensive proposition. Typically the output device supplied with an optocoupler is an npn transistor or a silicon controlled rectifier, neither of which is suitable for driving an ac line directly. It has therefore been customary to add the circuitry shown in Fig. 2. Any monolithic alternative to this circuitry must of course be capable of handling the same problems.

Three hurdles

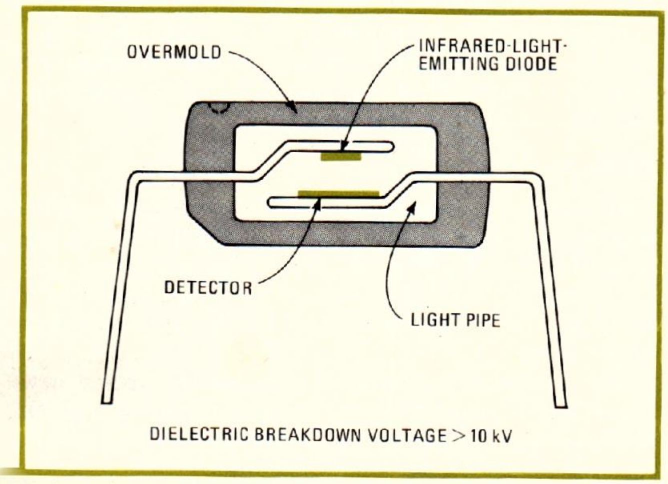
An optical coupler that must drive a 115-volt ac load has three obstacles to circumvent. First, the peak voltage seen on the 115-V ac rms line is over 180 V. To provide a suitable safety margin, the photosensitive output device must be capable of blocking a voltage of 250 V or greater of either polarity.

Second, the gain of a transistor photocoupler is not very great—current transfer ratios of unity are typical—yet up to 100 milliamperes of gate current may be required by a triac driving an ac load. To provide a suitable drive for a triac, the 115-V ac coupler should therefore be able to handle load currents much greater than its input excitation current.

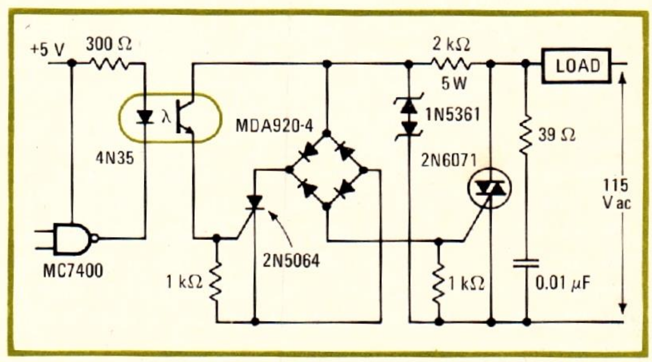
Third, the output device must be able to handle current flowing through the detector in either direction to trigger the triac in its most sensitive quadrants.

Couplers built with phototransistors or silicon controlled rectifiers do not succeed in meeting all three of these needs.

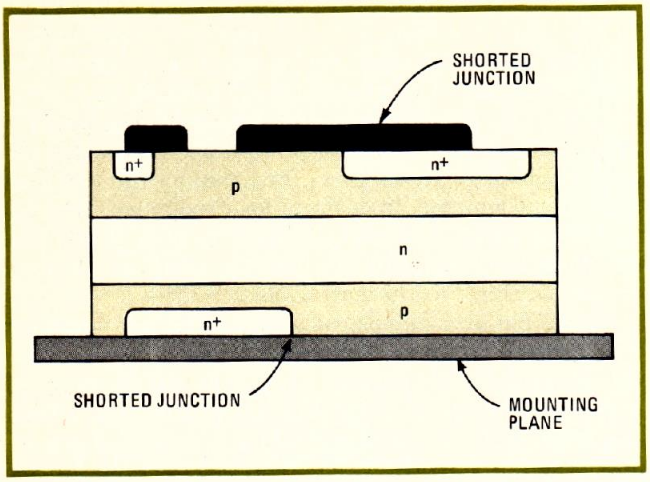
Requirements for the output device of the 115-V ac coupler are similar to those for a triac, so an obvious solution is to try to couple a triac optically to a light-emitting diode. Unfortunately, the structure of a standard vertically diffused triac requires a shorted junction



Optocoupler. An optocoupler has no electrical connection between the input (light-emitting-diode) side and the output (detector) side. Components of this type have found extensive use in low-level interface circuits in data processing and telephony.



2. Logic-to-ac interface. An optically isolated interface between a standard TTL gate and a triac driving an ac load requires this large group of components, interconnections, and circuitry. A monolithic device has been developed that simplifies this interface.



3. Vertical triac. The shorted junctions and deep diffusions of the standard, vertically structured, triac greatly reduce its sensitivity to incident light, making it unsuitable for use as the detector in an optical coupler. This situation led to the design of the integrated triac.

that greatly reduces the sensitivity of the device to incident photons (Fig. 3). Also, the diffusions are so deep as to absorb incident photons before they reach the active region of the device, reducing its sensitivity even more. For these reasons, a standard triac structure is unsuited for use in an optical coupler.

One solution is to make the detector chip a monolithic structure equivalent to a triac (Fig. 4a). Such a triac driver chip can be fabricated by planar diffusions, each of which forms more than one element, so that the layout is very clean and simple.

The cross section of this synthesized structure (Fig. 4b) illustrates how the various regions interact to act like a triac. Introduced in 1977 as the MOC3011, this simple driver works very well in most applications (Fig. 5) and has achieved a considerable degree of popularity in a short time.

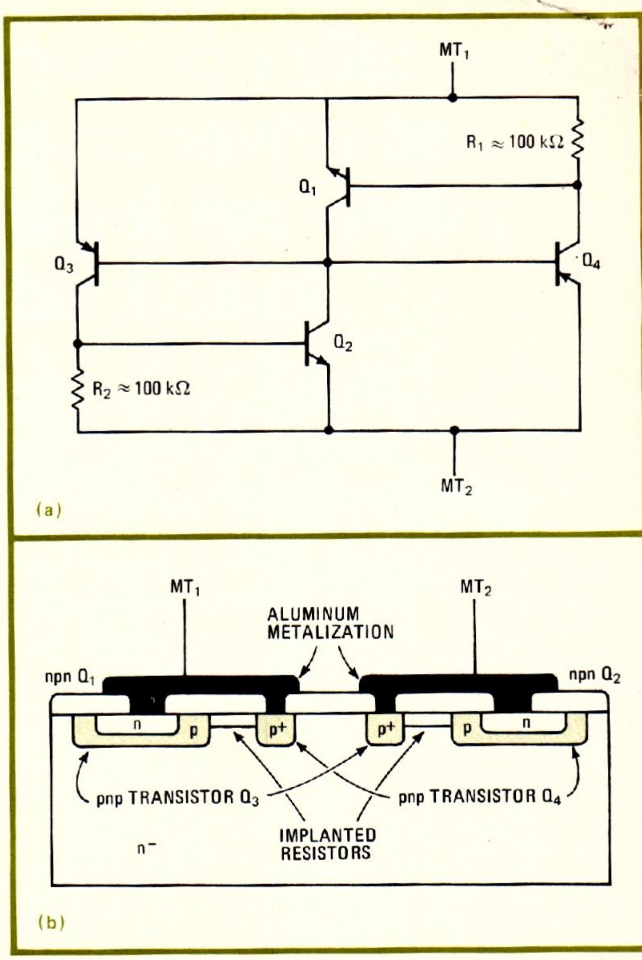
An improved driver

Although the MOC3011 met all of the original goals for the optically isolated triac driver, customer feedback indicated that several features could be added that would greatly increase the utility of the part. One of these was a better resistance to unwanted turn-on because of the occurrence of dv/dt triggering.

Such triggering occurs when a fast rising voltage induces a capacitive current in the collector-base junction of the phototransistors. This current appears to the rest of the circuit to be identical to the photon-induced current that turns the device on.

The unwanted triggering explains the presence of the triac driver snubbing network shown in Fig. 5. The network filters fast transients that might accidentally turn on the triac driver. Without it, the triac driver cannot control an inductive load, since inductive turnoff generates dv/dt values greater than the rating of the triac driver.

The triac driver turns off as soon as it has turned on the triac because the voltage from terminal MT_2 to the gate of the triac is not enough to keep the triac driver on. This condition allows the triac driver to be off most of



4. Planar triac driver. Planar triac driver (a) has structure equivalent to that of a triac circuit. Cross section of the actual chip (b), fabricated by planar diffusions, has two ion-implanted 100-kΩ resistors joining base to emitter in each transistor.

the time, reducing its power dissipation and allowing it to be limited only by its "static" (device turned off) dv/dt, which is higher than that for "commutating" (device turned on).

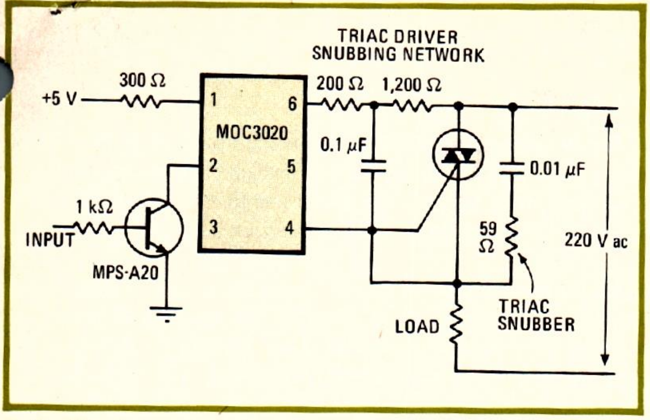
The driven triac is in the commutating dv/dt mode. Consequently, if it is possible to make the static dv/dt of the triac driver greater in value than the commutating dv/dt of the triac, then the triac driver will not compromise the dv/dt of the total circuit.

A new approach

This procedure was not feasible in the original device, because to have done so would have meant reducing the value of R_1 and R_2 (Fig. 4a) so much as to approach the low values of the original shorted junctions, making the device no longer light-sensitive. Clearly a new approach was required.

Another desirable feature to implement in any new design was to make the triac driver sensitive to turn-on only when applied line voltage is near zero. Many advantages are gained by this mode of operation:

- The triac is protected from high in-rush currents and dv/dt damage.
- The generation of electromagnetic interference (emi) by large in-rush currents is greatly reduced.



5. Snubbed. In a typical application circuit for a monolithic non-zero-crossing triac driver, snubber networks across the input and output of the triac protect it from dv/dt effects. Total component count is quite small in comparison with a discrete implementation.

■ The operating life of some loads, such as incandescent bulbs, is extended.

This zero-crossing function is built into most solid-state relays, but posed some difficulties for the MOC3011 when the problem was first encountered. For although the function is relatively easy to implement in hybrids, it is more difficult for monolithic devices. A certain amount of logic is necessary to perform the zero-crossing function, and the majority of logic devices are not compatible with the 300-V ratings of the triac driver.

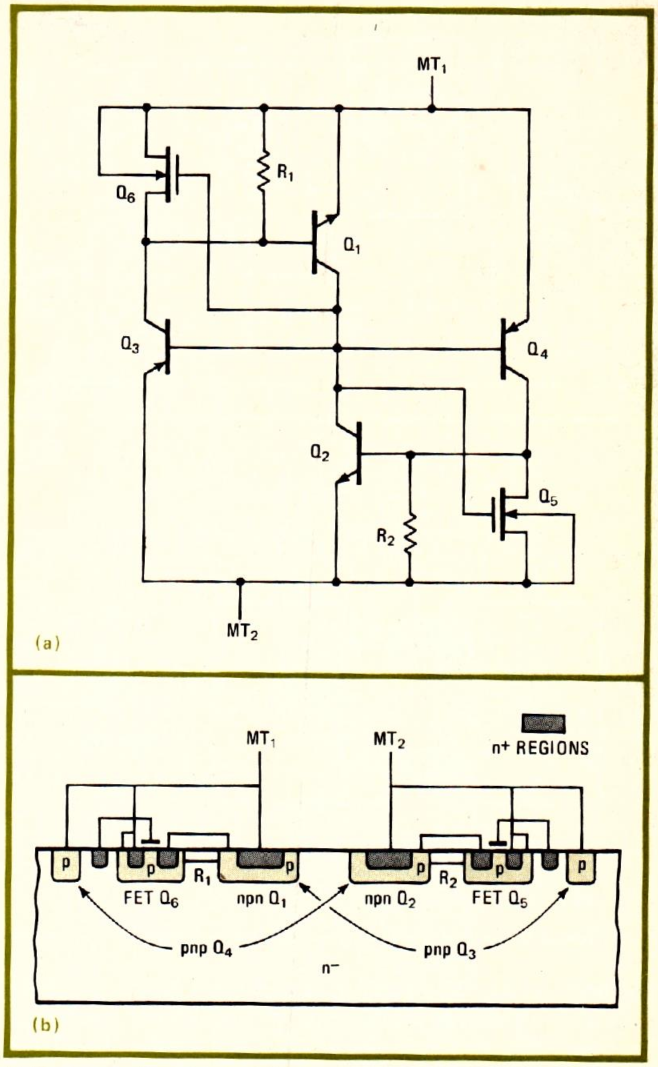
A monolithic zero-crossing triac driver

In the implementation shown in Fig. 6a, two n-MOS enhancement field-effect transistors were added to the original triac driver with their gates tied to the n⁻ substrate. When the voltage from one main terminal to the other exceeds the threshold value of a FET, then the FET turns on, reducing the current gain of the triac to such a low value that the photocurrent generated by the photons from the LED is no longer able to switch the device into the on state. On the other hand, if the device is already in the on state, there will never be enough voltage across the device to turn the FET on, so the FET is incapable of turning the device off once it has been turned on.

This FET action is exactly what is needed to implement the zero-crossing function. At the same time, the dv/dt immunity of the device is extended to much higher values than earlier devices. Because the FETs can turn on very rapidly, they can shunt dv/dt induced currents around the bipolar portion of the circuitry without allowing the triac driver to switch into its on state.

The typical static dv/dt rating of the MOC3030 is 100 V per microsecond as compared to 2 V/μs for the MOC3010 non-zero-crossing device. Since the typical commutating dv/dt rating of triacs is about 5 or 10 V/μs, the triac driver no longer limits the dv/dt immunity of the complete circuit.

Unlike most zero-crossing circuits, the FETs used in this device consume practically no power, so that the leakage through the load in the off state is basically the triac leakage current and primary photocurrents. Other



6. Zero-crossing triac driver. Addition of n-MOS FETs to the integrated triac (a) provides the zero-crossing function and makes the device insensitive to voltage transients. Structure of the zero-crossing triac driver may be further simplified (b).

zero-crossing circuits pass currents of tens of milliamperes in the off state.

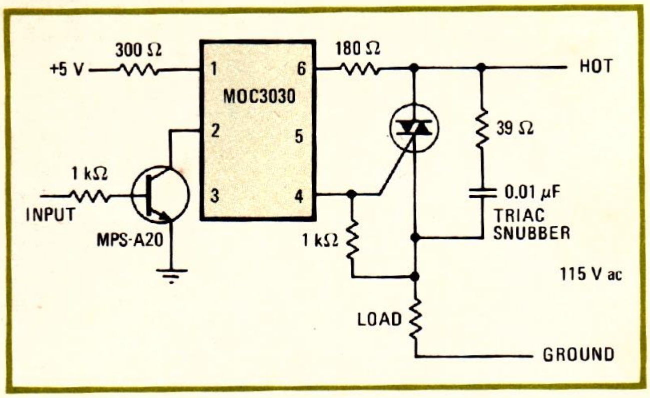
A simplified cross section of the new device is shown in Fig. 6b. Both FETs are located in the p-type tub diffused into the n substrate.

Chip design and processing

The FETs have some rather special requirements. In particular, their gate rupture voltage has to be greater than the blocking voltage of the triac driver. So long as this is true, the triac driver breakdown voltage will protect the FET gates by clamping the applied voltage before the gate ruptures.

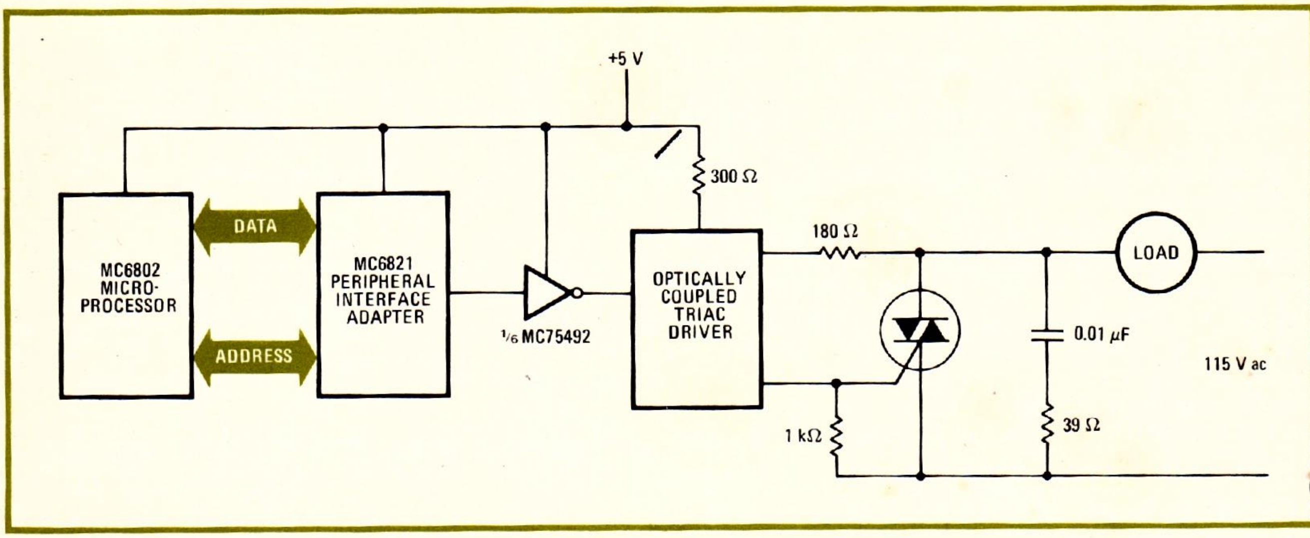
However, this means the FETs must each have a very thick dielectric, making them relatively low transconductance devices, which in turn are more sensitive to contamination problems than FETs with a thin gate oxide. The FETs are produced by ion-implanting each p tub and by using a deposited oxide in order to form the gate dielectrics.

The breakdown voltage of the bipolar devices is aided



7. Dv/dt immunity. Typical zero-crossing optocoupled triac driver has no need of snubbing because of its high static dv/dt immunity. To prevent shock hazards, the load is tied to the ground side of the ac line, which would be costly if pulse transformers were used.

8. Microprocessor control. In a microprocessor-based system, the optically coupled triac driver simplifies the interface of 115-V ac powered peripherals. The triac driver can provide the zero-crossing triggering function as well as all the necessary drive to the triac.



by field plates that extend beyond the junction where necessary to relieve fields concentrated by the relatively shallow diffusions used throughout the device. The 100-kilohm resistors (R^1, R^2 in Fig. 2) help prevent the device from being turned on by dv/dt or leakage currents at low voltages when the FETs are inoperative. These passive components are ion-implanted before the emitter diffusion and protected with deposited oxide to preserve their original value during subsequent processing.

The finished chips are assembled together with gallium-arsenide liquid-epitaxial LEDs in a dual-molded coupler package. The dual-molding technique yields much higher isolation voltages than glass dielectric or die coating techniques. Devices are tested to data sheet specifications and to guarantee product uniformity and reliability.

In the driver's seat

In general, the zero-crossing triac is very easy to use. Figure 7 shows one circuit application that adds two input resistors to the triac driver and triac. The triac driver cannot turn on when the voltage is high. But as the primary photocurrents generated when the LED is illuminated are still present, a 1-kΩ resistor is tied from MT_1 to the gate of the external triac in order to bypass this small current (less than 200 microamperes). (In many applications, this component is not needed because the triac itself is insensitive to the passage of such low currents through the gate.)

The 180-ohm resistor limits the peak current through the MOC3030 to less than 1 ampere to protect the chip and its wire bonds.

The circuit of Fig. 7 has the load located in the "cold" side of the line. This is much to be preferred in many applications to a location on the hot side of the line as it prevents a shock hazard. Optical isolation makes this possible at lower cost than is the case when pulse transformers are used.

Microprocessor-controlled drivers

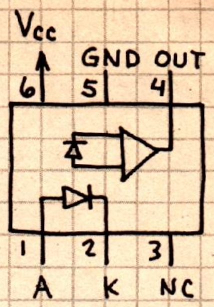
Probably the greatest field of application of zero-crossing triac driver will be in interfacing microprocessors to peripheral devices. Peripherals in these microprocessor-based applications must be taken to include not only teletypewriters and cathode-ray-tube displays, but also refrigerators, air conditioners, ovens, and heaters.

Although the output ports of most microprocessors will not provide the 15 mA necessary to actuate the triac driver, very inexpensive buffers such as the MC75492 are available to do the job (Fig. 8).

The zero-crossing triac driver described above seems to offer nearly everything the designer could want in working with 115-V ac power. An obvious area of improvement to expect will be to raise the blocking voltage high enough for use on 220-V ac power lines. might also be useful to raise the current rating of zero-crossing device to allow driving a high-power triac or heavier loads. □

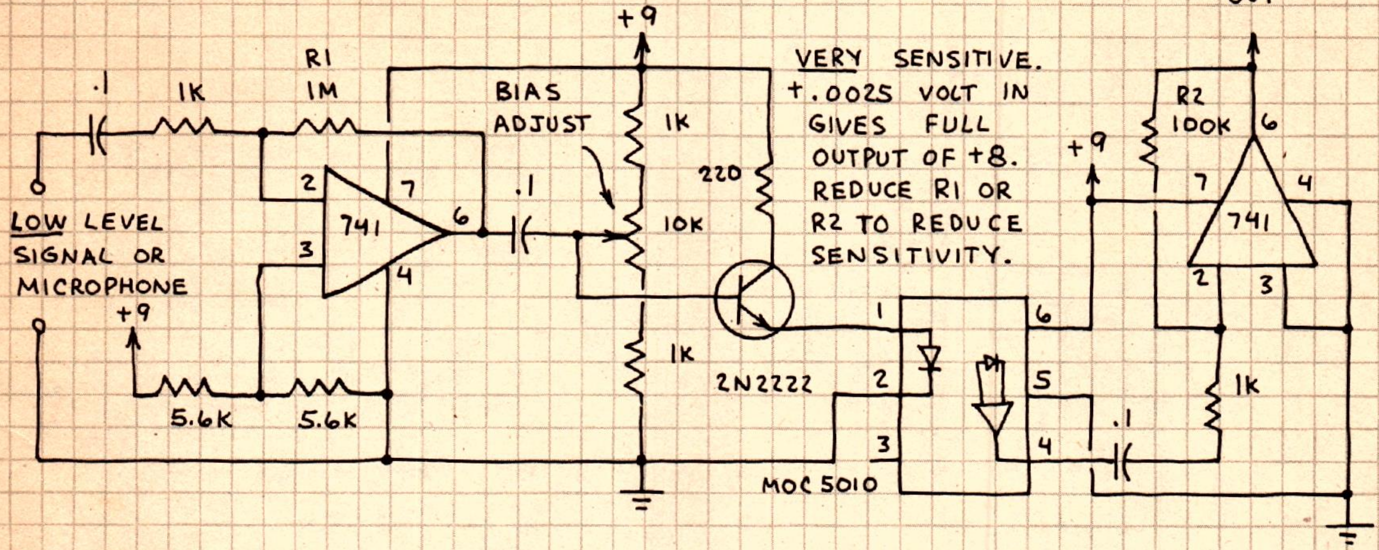
[redacted]PTOC[redacted]UPLER

[redacted]OC5[redacted] LI EAR [redacted]PLIFIE

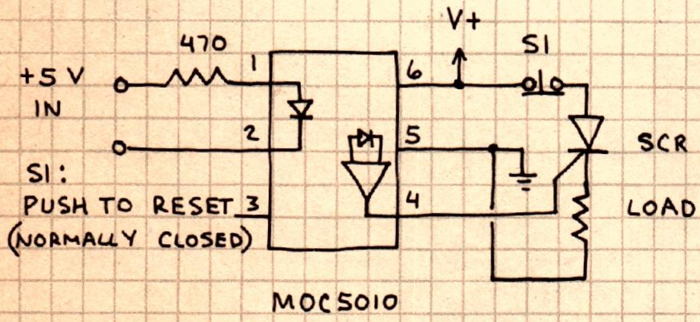


CONVERTS CURRENT FLOW THROUGH LED INTO OUTPUT VOLTAGE. IDEAL FOR TELEPHONE LINE COUPLING AND VARIOUS AUDIO APPLICATIONS.

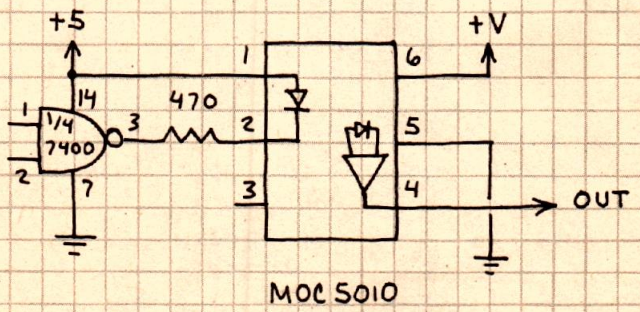
ISOLATED ANALOG DATA LINK



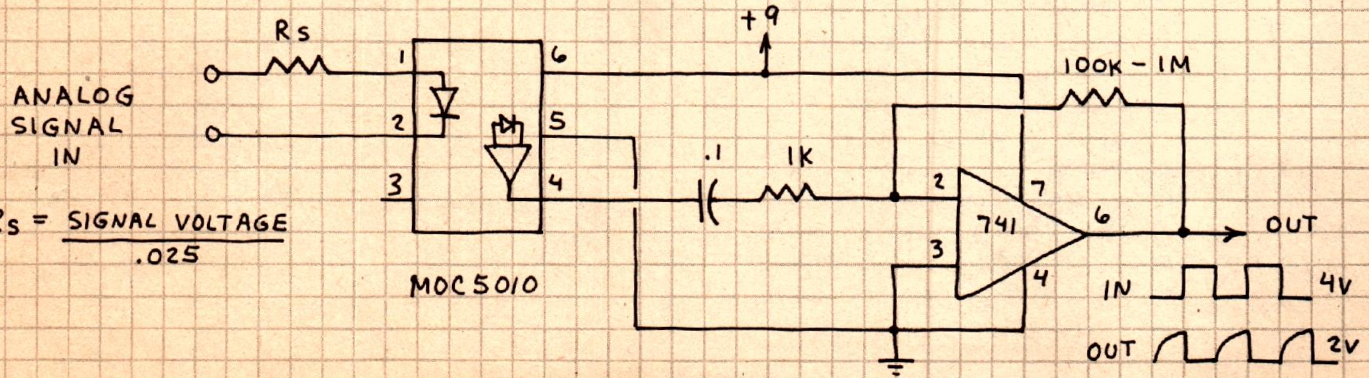
SCR DRIVER



TTL INTERFACING

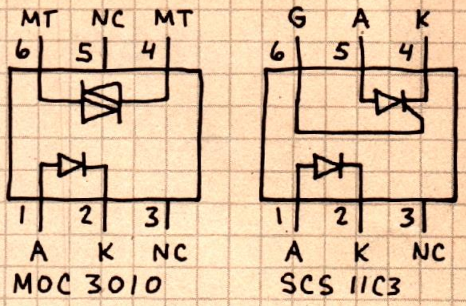


AC SIGNAL ISOLATOR



$R_S = \frac{\text{SIGNAL VOLTAGE}}{.025}$

[redacted]PT[redacted]C[redacted]UPLERS
[redacted]OC301 - SCR
SCS11C3 - TRIAC

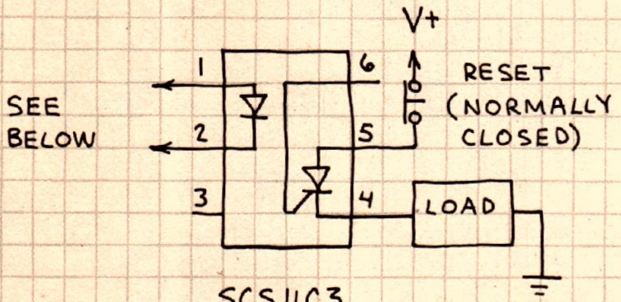


INFRARED LED SWITCHES TRIAC (MOC 3010) OR SCR (SCS 11C3). MOC 3010 WILL SWITCH 120 VOLTS AC AT 100 mA. SCS 11C3 WILL SWITCH 200 VOLTS DC AT 300 mA.

SEE RADIO SHACK'S "SEMICONDUCTOR REFERENCE GUIDE" FOR MORE INFORMATION.

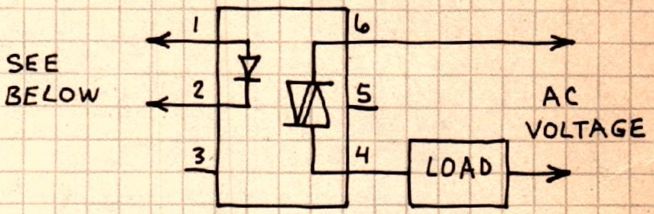
CALCULATOR OUTPUT PORTS

SCR (DC) PORT



SCS 11C3

TRIAC (AC) PORT

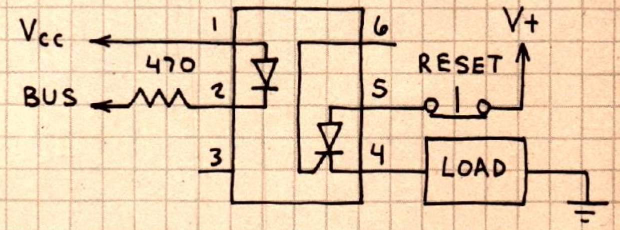


MOC 3010

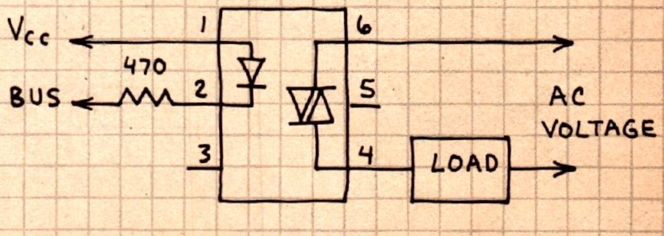
CONNECT PINS 1 AND 2 TO DECIMAL POINT OF LOWEST ORDER READOUT DIGIT. BE SURE TO OBSERVE POLARITY. USE ONLY WITH CALCULATOR HAVING LED READOUT. TYPICAL OPERATION: KEY IN NUMBER WHICH PLACES DECIMAL ANYWHERE BUT FINAL DIGIT. THEN PRESS [−] [1] [.] [0]. NUMBER IN DISPLAY WILL BE DECREMENTED EACH TIME [=] IS PRESSED. WHEN COUNT REACHES 0, DECIMAL MOVES TO LAST DIGIT AND ACTUATES OUTPUT PORT. FOR MORE INFORMATION SEE POPULAR ELECTRONICS, DEC. 1979 (PP. 86-87). SOME CALCULATORS WILL REQUIRE DIFFERENT KEYSTROKE SEQUENCE. IMPORTANT: THESE CIRCUITS MAY VOID THE WARRANTY OF YOUR CALCULATOR OR COMPUTER. FOLLOW MOS HANDLING PROCEDURES TO AVOID DAMAGING CALCULATOR OR COMPUTER. COMPUTER PORTS DESIGNED TO INTERFACE WITH TTL OR LS BUS LINES.

THE LOAD FOR ALL THESE CIRCUITS MAY BE LAMP, MOTOR OR OTHER DEVICE WHICH DOES NOT EXCEED RATING OF OPTOCOUPLER.

COMPUTER OUTPUT PORTS

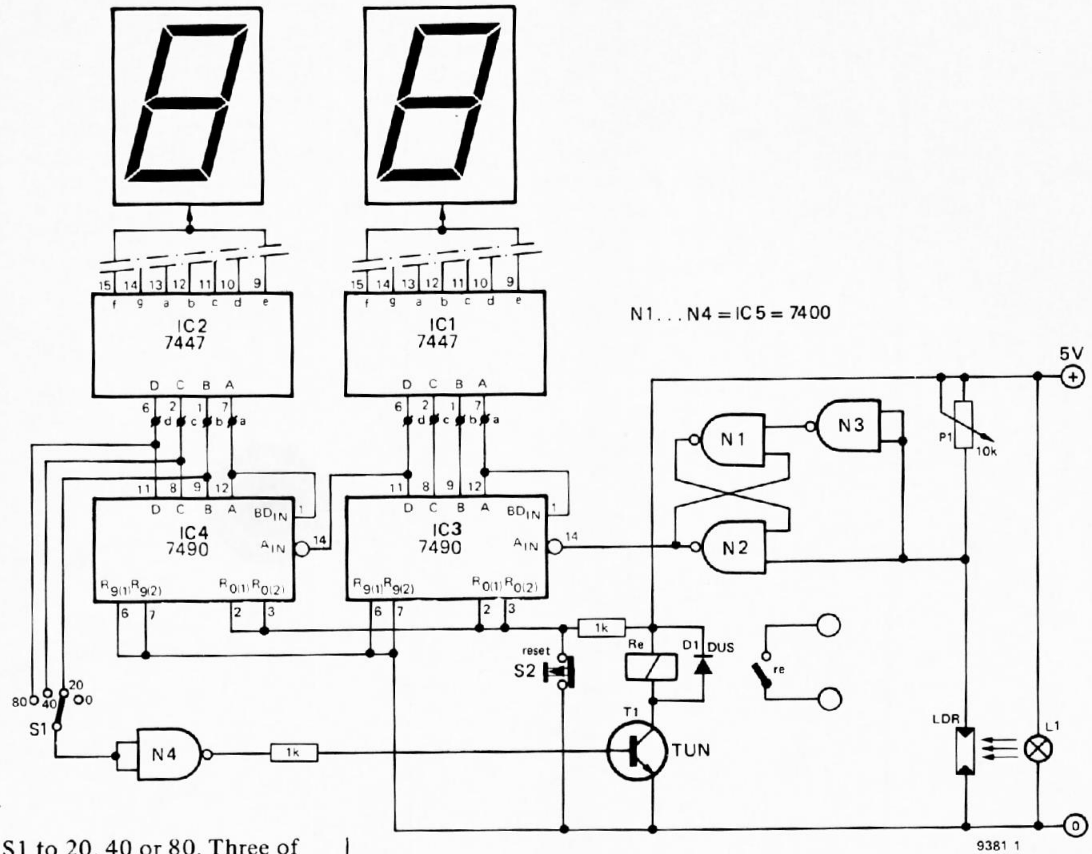


SCS11C3 − DC PORT



MOC 3010 − AC PORT

… coupl… two LEDs

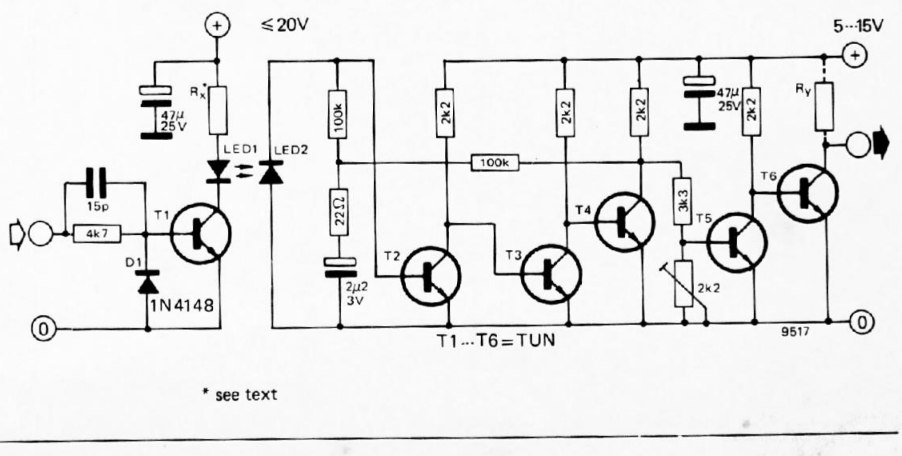


preset by S1 to 20, 40 or 80. Three of the positions of this switch are connected to the 2,4 and 8 outputs of the 10 lap counter IC4. The input of N4 is normally low so the output is high and T1 is turned on, energising relay Re. Power to the racetrack is supplied via the contacts of this relay.
If the number of laps is set to say 40, then when the fortieth lap is completed the 'C' output of IC4 will go high. The output of N4 will thus go low, turning off T1 and opening the relay contacts, which cuts off the power to the track so that the car will stop. One lap counter is required for each lane of the racetrack and the relay contacts should be connected in series so that as soon as the first car completes the course power to the circuit is cut.
Power can be restored and the counter reset by pressing the reset button S2.
The LDR should be mounted in a cylindrical tube to screen it from ambient light, which might otherwise keep the LDR resistance low and block the circuit. The sensitivity may be adjusted by P1.

On the basis of the principle that the conversion of electrical energy to light in a LED must be reversible, its merits for practical use were investigated. The diagram shows positive results. A logic level of at least 2 V is applied to the input of T1. The photo current generated in LED 2 is fed to a three-stage amplifier where it is brought to a level suitable to drive T5 and T6. At very low frequencies the duty cycle varies, but this forms no objection for most applications. The maximum frequency could not be determined owing to the capacitive cross talk between the two LEDs, which begins to play a role above about 40 kHz. The results with all LEDs are not unanimously favourable. The best results were obtained with HP types. Owing to the LED's selectivity as a light sensitive diode, the system is hardly affected by ambient light. Only in a few exceptional cases will it be necessary to screen the LEDs against ambient light, particularly from fluorescent tubes.
R_x should be chosen according to the formula:

$$R_x = \frac{V_b}{I_{LED1}\ max.}.$$

R_y represents the load resistor; for TTL applications, the supply should be 5 V and R_y is 270 Ω.

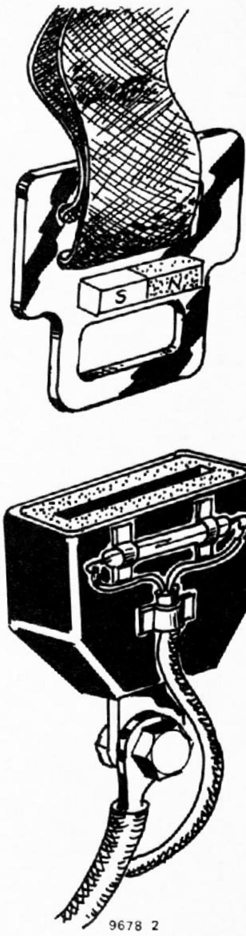


* see text

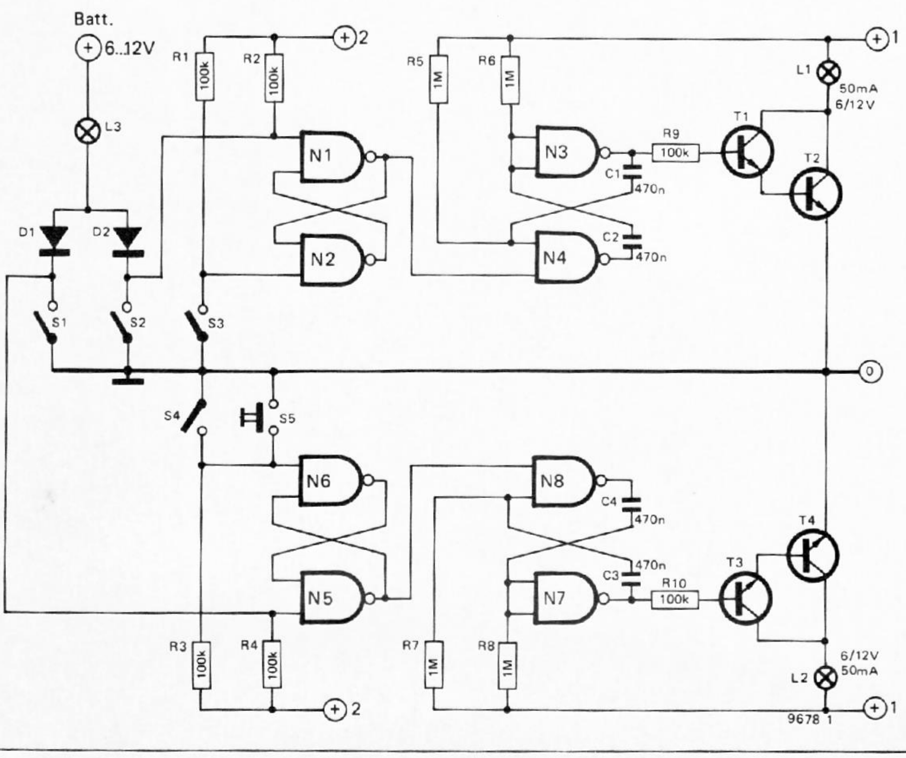
seat belt reminder

In view of the proposed government legislation to make the wearing of car seat belts compulsory, and the prospect of a £50 fine for not complying with the law, some sort of device that reminds driver and passenger to wear their seat belts would be extremely useful. The circuit given here is not intended to be a foolproof device for compelling people to wear seat belts (as is the case with some commercial systems) but is intended simply to jog the memory of the well-intentioned (but absent-minded) driver and passenger.
The circuit senses the fact that someone has entered either the driver or the passenger door by making use of the interior courtesy light door switches. These are normally connected in parallel, but for this purpose they must be isolated by diodes. The interior light will then still function normally, but it is possible to sense the opening of a door when the other is already open.

When the driver's door is opened the flip-flop comprising N1/N2 is set. The output of N1 takes the input of N4 high, so that when the ignition is switched on the astable comprising N3/N4 starts to oscillate, switching T1 and T2 on and off and flashing the warning light. When the door has been closed flip-flop N1/N2 may be reset by pressing the reset button S3, thus disabling the astable.
For the passenger door the same function is performed by N5/N6 and N7/N8, with one difference. If the passenger leaves the car but the driver remains the passenger's warning light will start to flash. This is also the case if the driver enters the car alone but the passenger door has been opened at some time in the past e.g. to load parcels into the car before the start of the journey. For this reason a second reset button S5 is provided for the passenger warning light, which is mounted on the driver's side of the dashboard.
The reset switches S3 and S4 may be manually operated buttons mounted on the dashboard, or with a little ingenuity they may be linked to the seat belts. An example is shown for belts having the buckle rigidly mounted on the transmission tunnel. A reed switch is mounted on the buckle and this is activated by a small magnet glued to the hasp of the belt whenever the hasp is inserted into the buckle.
If this type of system is used then flip-flop N1/N2 may be dispensed with by omitting the link between the output of N1 and one input of N2 and connecting both inputs of N2 to S3 and R1. This has the advantage that if the seat belt is removed after the driver's door has been closed S3 will open, taking the input to N2 high. The output of N1 will thus also go high, enabling the astable multivibrator and flashing the driver's warning light.
It is not possible to do this on the passenger side however, because of the manual reset button S5. If N5/N6 were not connected as a flip-flop then S5 would have to be a latching type so that the input of N6 could be held low even with S4 open (i.e. no passenger). The possibility then exists that S5 might accidentally be left closed on leaving the car, in which case the passenger warning light would flash only while the door was open. S5 must therefore be a momentary action switch, and N5/N6 must be connected as a flip-flop.



9678 2



9678 1

S1 = passenger's door
S2 = driver's door
S3 = driver reset
S4 = passenger reset
S5 = passenger override

N1 . . . N4 = IC1 = 4011
N5 . . . N8 = IC2 = 4011
D1 . . . D2 = 1N4001
T1 . . . T4 = TUN