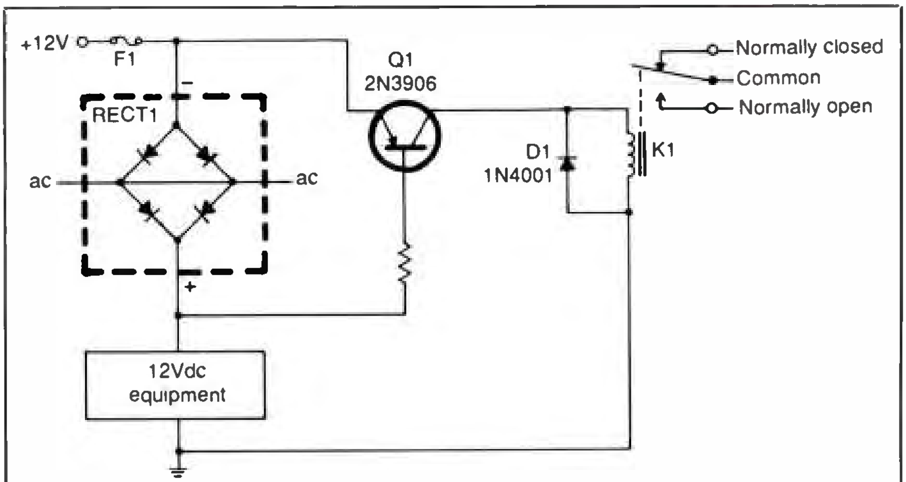
A "Smart" Car Relay

Provides automatic operation sensing and switching for equipment used in an automotive electrical environment

By Dennis Eichenberg

There's a need in the automotive electrical environment for a circuit that develops a control signal when it senses that any electrical device is operating. For example, you might connect an under-dash tape player to existing in-dash speakers. In this application, the speakers are normally connected to the in-dash unit, but the "Smart" Car Relay automatically switches them to the under-dash unit when the latter is turned on. In another application, a power antenna can be made to extend or retract whenever the vehicle's radio is turned on or off.

The "Smart" Car relay described here is just the ticket to provide automatic switching for such applications. This compact, inexpensive and easy-to-build and install project requires no modifications to be made to the equipment whose operation it is used to sense and control. Furthermore, it provides protection against reverse-polarity hookups of the equipment being sensed.



PARTS LIST

D1—1N40001 or similar 50-PIV, 1-ampere silicon power rectifier
F1—Fuse (see text)
K1—12-volt dc, 120-ohm or greater relay with 10-ampere or more contacts (see text)
Q1—2N3906 or similar general-purpose pnp transistor
R1—47-ohm, ¼-watt, 10% tolerance resistor
RECT1—50-PIV, 25-ampere bridge rectifier assembly or individual power diodes (see text)
Misc.—Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); suitable enclosure (see text); in-line automotive fuse holder; small rubber grommets; ½" spacers; lettering kit; machine and sheetmetal hardware; heavy-duty stranded hookup wire; solder; etc.

Fig. 1. Complete schematic diagram of "Smart" Car Relay's circuitry. This is the simplest circuit configuration. Other configurations use relays with more contacts and/or more relays.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the "Smart" Car Relay's circuit. The heart of this circuit is full-wave bridge rectifier *RECT1*, which can be a common rectifier module or four separate silicon power diodes connected into a bridge configuration with the individual diodes connected together as shown. Note that the four diodes are wired so that they are in a series-parallel arrangement. This configuration provides redundancy for the circuit.

When the electrical device whose operation is to be sensed is turned on, current flows from the negative (−) terminal of *RECT1* through the two parallel sets of series-connected diodes to the positive (+) terminal and then through the operating device to circuit ground. Each diode has a forward voltage drop of approximately 0.7 volt. Thus, the potential generated from positive to negative terminals of *RECT1* is roughly 1.4 volts when the monitored device is turned on.

For this application, *RECT1* must have a peak-inverse voltage (PIV) rating of at least 20 volts and a current rating that is at least equal to the peak current plus 20 percent or so of

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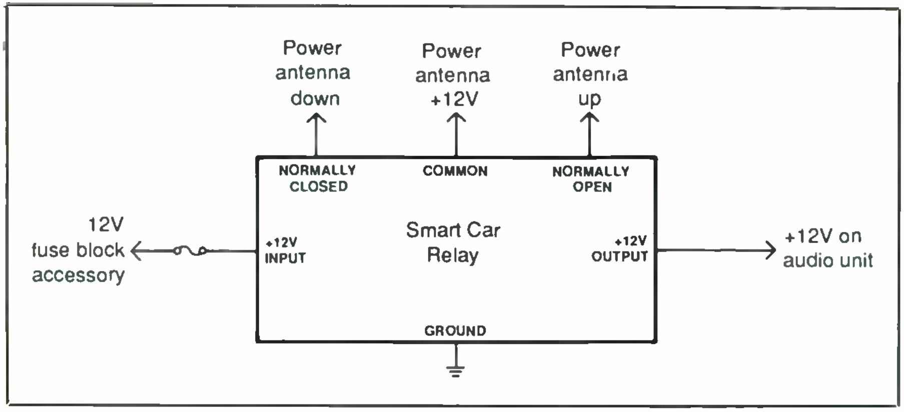

Fig. 2. Typical wiring instructions for using project to control deployment and retraction of an electrically operated radio antenna.

the device being monitored and controlled. For the original prototype, I selected a 50-PIV, 25-ampere bridge-rectifier assembly, which was deemed adequate for just about any sense/control application I was likely to encounter.

The 1.4 volts dropped across *RECT1* is coupled to the base of 2N3906 pnp transistor *Q1* through current-limiting resistor *R1*. Base current for the transistor is limited to 15 milliamperes by *R1*. The emitter of *Q1* is tied to the V+ rail of the vehicle's electrical system, while the collector is tied to ground through the coil of relay *K1*. The relay has a coil rating of 12 volts dc and a resistance of 120 ohms or greater, which limits the current through the transistor to 100 milliamperes or less.

The current rating of the contacts of *K1* must be at least 120 percent of the current normally drawn by the device being controlled. A normally-open contact of *K1* can be used to energize auxiliary relays if additional contacts beyond those available on the relay chosen are required.

Diode *D1* provides protection for *Q1* from reverse-voltage spikes developed by *K1* when the collapsing electromagnetic field around its coil induces a bucking voltage in the coil. Fuse *F1* in series with the project and device being controlled is included to provide a safety device against overcurrent damage. Its current rating, like that of the relay's contacts and bridge rectifier, must be at least 120 percent of the current normally drawn by the device being controlled.

Let us assume that you are going to use the project to automatically switch an in-dash speaker from the output of an in-dash mono radio to the output of an under-dash mono tape player when the latter is turned on. The simple relay contact arrangement shown in Fig. 1 is adequate for this. The "hot" line from the speaker would connect to the COMMON relay contact, the output line from the radio to the NORMALLY CLOSED contact and the output line from the tape player to the NORMALLY OPEN contact.

Under normal conditions, with the radio off or on and the tape player off, the speaker would be connected to the radio's output. Now, if you wish to listen to a tape, you simply turn on the tape player. This causes current to be routed through *RECT1*. The resulting 1.4-volt drop across the rectifier assembly is then coupled through *R1* to the base of *Q1*. When this occurs, *Q1* conducts and energizes *K1*. Now the relay's armature is pulled down, closing the NORMALLY OPEN contact and opening the NORMALLY CLOSED contact. In so doing, the circuit is completed between the output of the tape player and speaker.

If you had planned on using the project to switch speakers in a stereo system, you would have needed a relay that has dpdt contacts for *K1*. (The project is versatile enough to control even more lines than this, depending on the relay contact arrangements or even number of relays used. More about this later. In this event, a separate set of contacts would be used to switch the speaker between the outputs of the radio and tape player in each channel.)

To return to normal conditions, you simply switch off the tape player. Now there is no voltage dropped across *RECT1* and *Q1* cuts off. This causes *K1* to deenergize and restore the circuits between the radio's output(s) and speaker(s).

Construction

There is nothing critical about component layout or conductor routing in this project. Therefore, you can use just about any traditional wiring technique to assemble the "Smart" Car Relay. For example, if you wish, you can design and fabricate a printed-circuit board on which to wire the project. Alternatively, you can use perforated board and suitable soldering or Wire Wrap hardware.

Begin assembly on your chosen circuit-board medium by installing the bridge-rectifier assembly (or individual diodes, if you have chosen to use these instead of the rectifier assembly). Then install transistor *Q1*, diode *D1* and resistor *R1*. Make sure the diode is properly oriented and that the transistor is properly based before soldering any connections these make with the rest of the circuit.

Strip ¼ of insulation from both ends of as many 12-inch-long stranded hookup wires as needed for the relay-contact lugs and the three electrical system connections. Choose wire weight according to the current that will be drawn by the device being

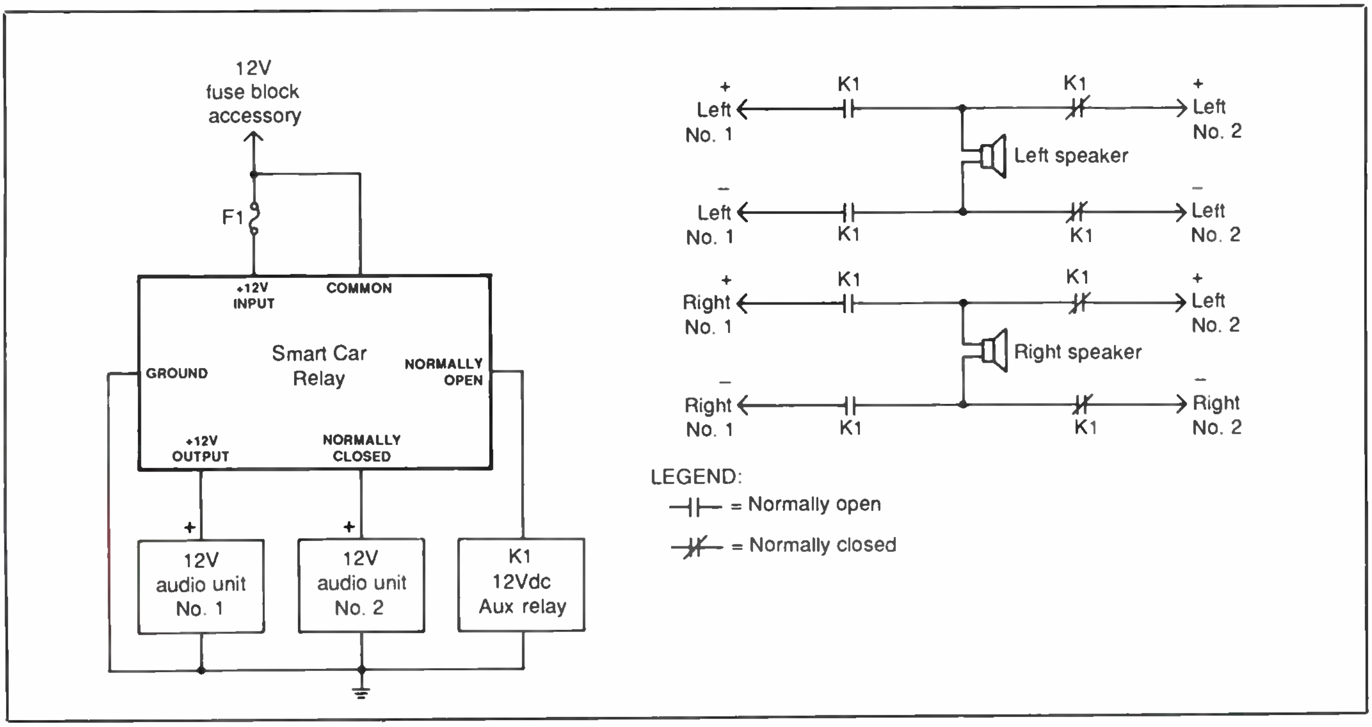

Fig. 3. Automatic speaker switching between two audio units and single pair of stereo speakers. As shown in pictorial, this arrangement requires an additional auxiliary relay.

controlled, but not less than No. 18 in any application. Tightly twist together the fine wires at all ends and sparingly tin with solder. These wires are for the coil and contacts of the relay and for the conductors that connect from the bridge rectifier to the vehicle's electrical system and device being sensed and controlled.

Use an all-metal enclosure or a plastic box that has a removable aluminum top panel as an enclosure for the project. Select one that accommodates all components that make up the project, including any relays that might be used. Machine the enclosure for mounting the circuit-board assembly and routing the free ends of the conductors that are to connect to the outside world. Drill two more holes in the floor of the enclosure for mounting the project inside your vehicle.

If you are using an all-metal enclosure, line the exit holes for the wires with small rubber grommets. If you are using a plastic enclosure, drill the lead-exit holes through the plastic walls and forget using grommets.

Tie a strain-relieving knot in each wire that exits the enclosure inside the enclosure and with about 1 inch of slack. Mount the circuit-board assembly in place using ½-inch spacers, 4-40 or 6-32 × ¾-inch machine screws, lockwashers and nuts. Then thread the free ends of the wires through the holes drilled for them and label each according to the legends detailed in Fig. 2. If you are using a dry-transfer lettering kit, protect the lettering with two or more light coats of clear spray acrylic. Allow each coat to dry before spraying on the next.

When wiring the project into your vehicle's electrical system, take particular care with the sections that carry heavy current. Make sure you provide adequate insulation and that all connections are both mechanically and electrically secure before soldering them. Double check all wiring to make certain that you assembled the circuit correctly.

Decide where in your vehicle you are going to mount the project. Select a location very near the device whose operation is to be monitored and controlled. Resiliently mount the project in the selected location. To do this, drill two holes in the vehicle's chassis work the same distance apart as those you drilled for project mounting in the enclosure. Make these holes slightly smaller than the panhead sheetmetal screws you will be used for mounting purposes.

Place a suitable flat washer on each of two No. 6 or No. 8 sheetmetal screws and follow with a small rubber grommet. Plug the ends of the screws into the mounting holes drilled in the floor of the enclosure and follow with a small rubber grommet on the end of each screw. Then drive the screws into the holes you drilled in the vehicle's chassis work. Fasten the

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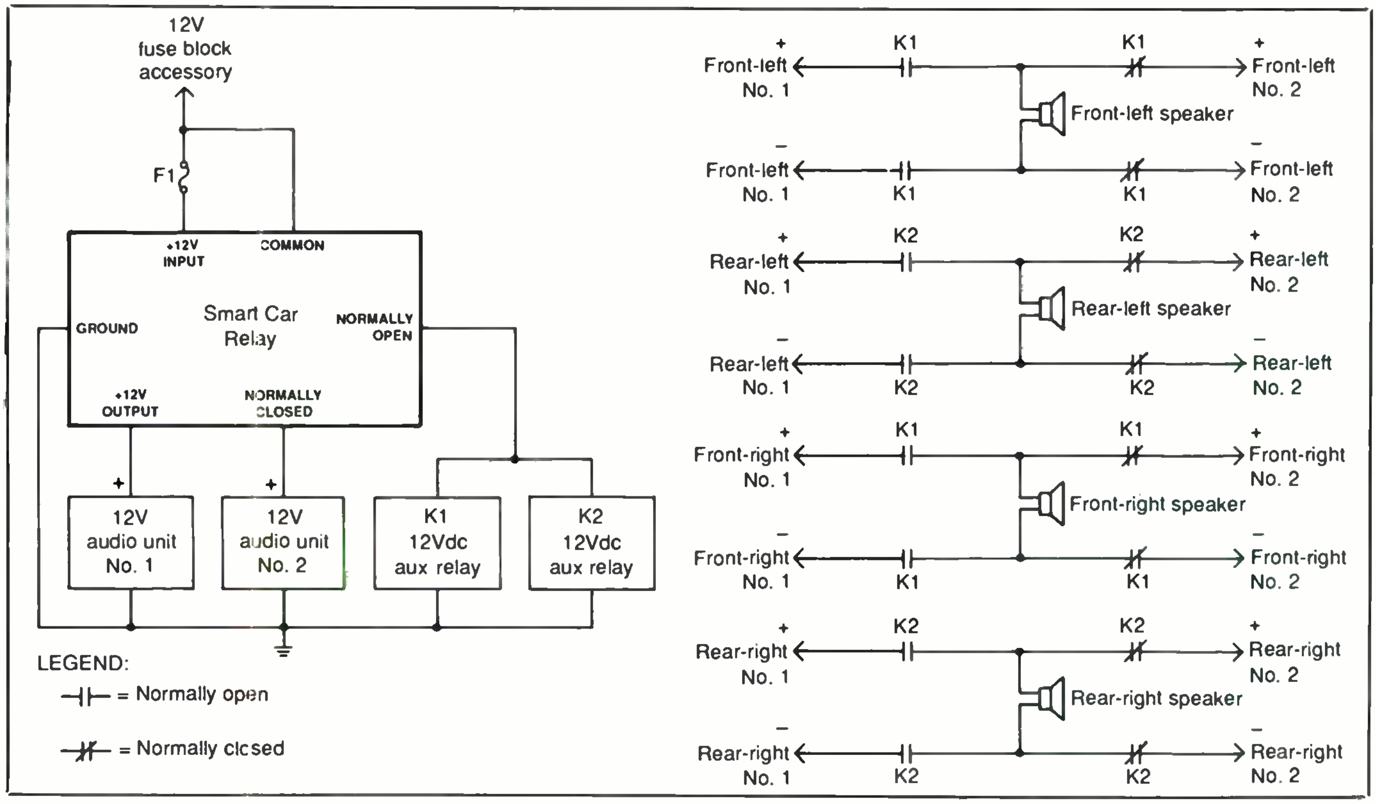

Fig. 4. Automatic speaker switching between two audio units and four speakers. This requires two auxiliary relays.

screws down only tight enough to slightly compress the rubber grommets—not so tight that the project is rigidly mounted.

Now disconnect the +12-volt lead from the device that is to be controlled. Clip the lug from the end of this wire and strip ¼ inch of insulation from the end of the wire. Crimp and solder the same type of lug onto the free end of the +12V OUTPUT wire (coming from the junction of *R1* and *RECT1* +) on the circuit-board assembly and plug this onto the terminal of the device being controlled from which the +12-volt wire was removed.

Crimp and solder one end of an automotive in-line fuse holder (obtainable from any auto supply outlet) to the free end of the +12V INPUT wire (coming from the junction of *Q1*'s collector and *RECT1*'s negative terminal). Crimp and solder the free end of the +12-volt wire that was removed from the device to be controlled to the other lug of the fuse holder. Open the fuse holder and place a suitably rated fuse in it.

Complete the electrical-system wiring by connecting the free end of the GROUND to any convenient chassis-ground point in your vehicle. Terminate the GROUND wire from the project in a ring lug. Then fasten the ring lug to the vehicle's chassis with an existing screw or a separate sheet-

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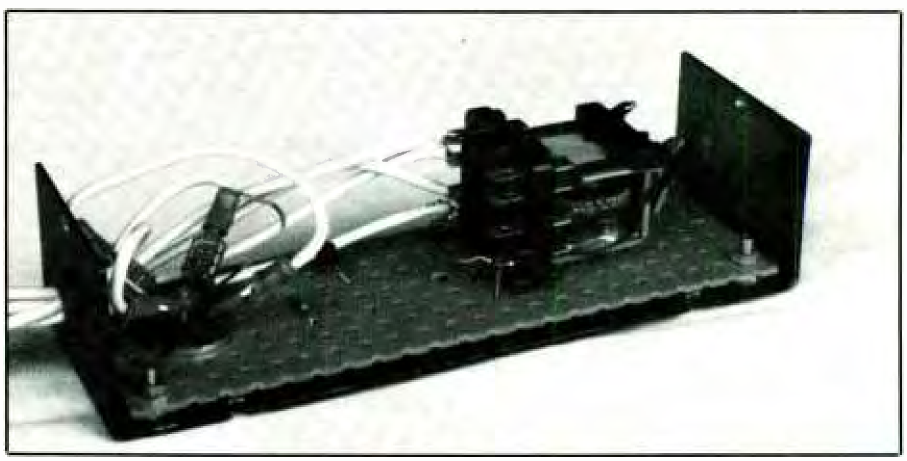

Interior view of author's prototype built on perforated board and housed inside a standard metal utility box.

Smart Car Relay *(from page 53)*

metal screw for which you drill a hole. Whichever way you go, use fine emery paper to sand down to bare, shiny metal and an outside-tooth lockwasher between the ring lug and metal of the chassis.

Installation & Use

The "Smart" Car Relay is extremely flexible and can be used in a wide variety of applications, as mentioned above. Of course, the COMMON, NORMALLY CLOSED and NORMALLY OPEN wires from the project connect to the device being controlled as needed.

Figure 2 illustrates the connections required to provide typical power-antenna control. With the project wired into your vehicle's electrical system as illustrated, whenever you turn on your radio, the antenna will telescope upward to permit radio reception. Turning off the radio will cause the antenna to retract. Before making any connections to the antenna, however, make sure that the project is compatible with it.

Illustrated in Fig. 3 are the connections that must be made to permit driving of two speakers from two audio outputs. Though a general discussion of this arrangement was described above, note here that the speakers shown do not have a common ground. Therefore, all returns must be made separately. This requires five relay contacts altogether. Hence, an additional four-pole relay is needed.

In this arrangement, the +12V INPUT lead connects to the +12-volt source in the vehicle's electrical system and the +12-volt input lead from one of the audio units goes to the +12V OUTPUT lead of the project. The project's COMMON lead then goes to the +12-volt source. The NORMALLY CLOSED lead of the Relay connects to the +12-volt input of the other audio unit, and the NORMALLY OPEN lead connects to one side of the coil of an additional relay (the other side of the relay's coil goes to circuit ground). The additional relay's coil must be rated at 12 volts dc and its contacts must be conservatively rated to handle the current delivered to the speakers.

In addition to the project connections, Fig. 2 shows the schematic connections of the relay contacts to the speakers. If you follow the circuits, you will see that turning on one audio unit automatically disconnects the power from the other audio unit and transfers the speakers to the outputs of the active unit.

Pictorially illustrated and shown schematically in Fig. 4 is a more sophisticated automatic switching arrangement. Here four speakers are switched between two audio units. Two additional four-pole, double-throw relays are required for this application.

The schematic diagrams in Fig. 3 and Fig. 4 are accompanied by a relay-contact legend. The legend shows that normally open contacts are represented by what looks like a capacitor symbol with neither plate curved, while the normally closed symbol is the same with a slash through it.

As you can see from the foregoing, the "Smart" Car Relay is, indeed, a very versatile device. We have touched here on only three possible applications for this device. You will certainly come up with more, based on your needs. ME