Build a Remote Car Starter

This PIC-based project lets you start your car from the convenience of your home or office

Wouldn't it be nice if on those cold, blustery mornings in the dead of winter you could hop right into your nice warm car and instantly drive off with the windows already defrosted? Have you ever wished during those dreaded summer heat waves that you could start your car's air conditioner without having to endure the 100° or more furnace that develops inside your car on sunny days? With the Remote Car Starter described here, you can start your car from the comfort of your home or office. Simply by leaving the heater or air conditioner on when you turn off your ignition lets you get into a cool car in summer or warm car in winter simply by hitting a button on a key-chain-size remote-control unit. When it receives its cue from the remote transmitter unit, the PIC microcontroller in the starter unit does the rest. As you'll see, remotely starting your car's engine is just the beginning of this handy project.

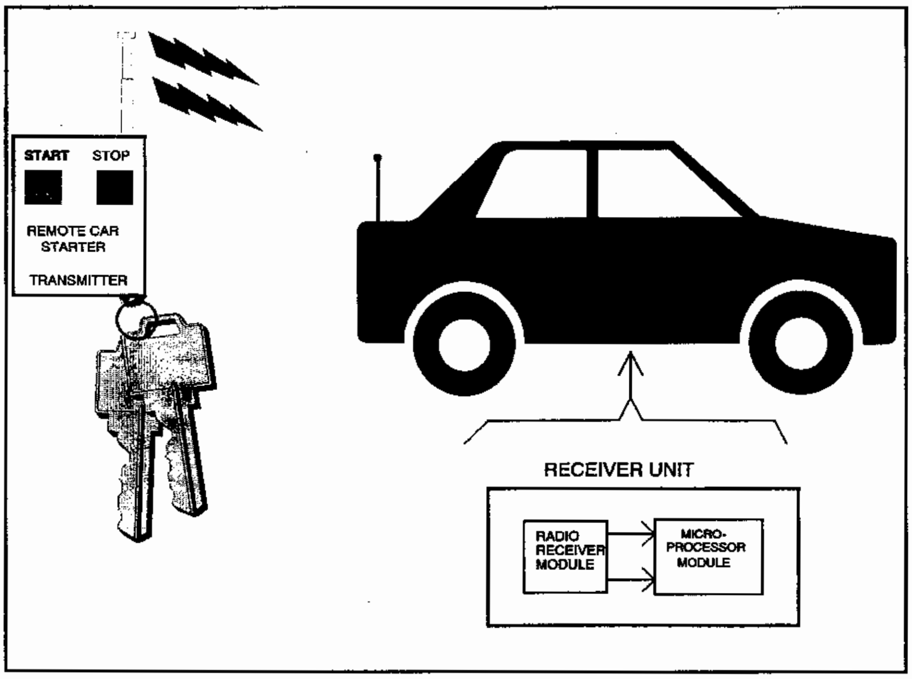


Fig. 1. The Remote Starter system is made up of three basic elements: a radio transmitter, a radio receiver and a PIC-based microprocessor module.

System Overview

The Remote Car Starter has a very simple, full-featured design that will not only start and stop your car's engine but also checks engine rpm for stalling and over-speed and monitors the brake pedal for emergency shut-down. It even provides audible feedback by beeping your car's horn twice to signal a successful start or once in the event that the car's engine shuts down or stalls. Even with these sophisticated features, there's still plenty of memory and I/O left in the microcontroller to provide additional functions, such as remote door lock/unlock, trunk release, etc.

This smart starter doesn't just crank the engine for a predetermined amount of time while simply assuming that the engine will start. It continuously monitors critical automobile parameters and even tries to restart the engine should it stall following a successful start.

The system consists of three functional components: a radio transmitter, a radio receiver and a microprocessor module (Fig. 1). The transmitter and receiver must be purchased as a pair. The transmitter has an advertised range of up to 300 feet, but don't expect much more than 75 to 100 feet without using an external antenna. I found that with a fresh battery and small external antenna, a 300-to-500-foot range was possible. Effective range degraded somewhat on very hot summer days when I left my car in the sun.

Another nicety is the fact that the transmitter and receiver can be coded with one of 59,000 possible codes to prevent other units from activating the Car Starter.

Prices for the transmitter/receiver pair range from $30 to $55, based on transmitter range and quantity purchased. The microprocessor module is based on the Microchip 16C54 PIC 18-pin microcontroller that contains 512 bytes of program memory and 32 bytes of RAM. The 16C54 PIC is an excellent fit for this design because of its size, low cost and very low power consumption. Also, PIC microcontrollers are readily available from many vendors, including Digi-Key.

The remote-control transmitter/receiver pair is a two-channel system. The receiver produces two digital outputs, which represent the state of the two buttons on the transmitter according to Table 1. The two radio receiver signals are 12-volt outputs, which are current-limited by *R6* and *R8* and reduced to 5 volts by zener diodes *D3* and *D5*, as shown in Fig. 2. Pull-down resistors *R10* and *R12* force a logic 0 should the receiver signals fail (open circuit) for any reason. The conditioned receiver signals are then fed directly into a readable port pin on the microcontroller.

The brake-pedal signal is handled the same way as the receiver inputs. The Remote Starter circuit expects to see +12 volts when the brake pedal is pressed and an open-circuit when the brake isn't pressed. The TACH signal is a little trickier. On most cars, the tachometer signal is a waveform that pulses according to the equation: Number of Pulses/Second =

Table 1. Receiver Output Details

Button Pressed	Radio Signal 1 (Signal Enabled)	Radio Signal 2 (Data 2)
None	0	0
Green	1	0
Red	1	1

Table 2. Cylinder Setup Details

U1 Pin 12	U1 Pin 11	Cylinders
0	0	4
0	1	6
1	0	8
1	1	8

0 indicates ground; 1 indicates +5 volts.

N X rpm/2 X 1/60, where *N* is the number of cylinders. The 2 in the denominator accounts for the fact that a spark plug fires only once per two revolutions to allow the a compression stroke and an exhaust stroke. However, some cars have two separate ignition systems. The pulse rate of the tach signal in these systems is half that presented in the equation. The safe approach is to put an oscilloscope on the tach signal to determine what type of system you have.

The tach signal is conditioned like the radio and brake signal, except for additional filtering, provided by *C2*, to remove much of the noise that may be present on the tach line. The conditioned tach signal is fed into the RTCC pin on the microcontroller. Tach pulses on the RTCC pin cause an internal counter to increment, which is used to determine the current rpm of the engine.

Chip *U2* is a simple 7805 fixed-voltage regulator that converts the 12 to 14 volts dc produced by the car's electrical system to the 5-volt range required by the microcontroller. Diode *D1* provides reverse-polarity protection and capacitor *C4* provides filtering of the 5-volt supply.

The three relays are controlled by the microcontroller via IRF 511 power MOSFETs *Q1*, *Q2* and *Q3*. Resistors *R3*, *R4* and *R5* provide extra isolation for the microcontroller, while diodes *D7*, *D8* and *D9* protect against voltage spikes induced by the coils in the relays.

Light-emitting diode *D2* is included for testing purposes only. During normal operation, this LED flashes on and off about once per second, indicating that the microcontroller is functioning correctly. If you wish to lower power consumption of the circuit, you can disconnect this LED before final installation.

The Software

When initially powered, the software vectors to an initialization routine that clears RAM memory and initializes all program variables (Fig. 3). The initialization routine reads two pins on the microcontroller to determine the number of cylinders in the engine. These pins must be connected to the appropriate logic levels based on Table 2. The software then enters an infinite loop that includes a mode-control logic block and unique subroutines for each of the five modes in the system, as illustrated in Fig. 4.

When in Mode 1, all relays are disengaged and the remote-control unit is waiting to receive a command from the transmitter. When the green button on the transmitter is pressed, the Remote Starter first checks to verify that the engine isn't running and the brake pedal isn't currently pressed. If it finds these conditions, the software then advances to Mode 2. If the engine is currently running (key in ignition), the horn relay is pulsed to produce two short beeps.

If the red button is pressed while in Mode 0, the unit simply pulses the horn for one short beep. (This feature is great for finding your car in a crowded parking lot. Simply press the red button an listen for the beep).

Once in Mode 2, the ignition/accessory relay is engaged. The remote unit stays in Mode 2 for 3 seconds to permit the car's electronics to come on-line (including the electronic fuel pump). If the remote-control unit senses that the engine is already running, the start sequence is canceled and the unit returns to Mode 1. The microcontroller continues to monitor the brake pedal and the radio's red button for an abort. Once the settling time has elapsed, the system advances to Mode 3.

Upon entering Mode 3, the microcontroller checks once again that engine rpm is 0 (you wouldn't want to engage the starter motor if the engine is already running). If everything checks out correctly, the starter relay is engaged. The logic in Mode 3 then monitors rpm to determine when the engine has started (the engine rpm is greater than 500 for at least 0.5 second).

PARTS LIST

Semiconductors
D1,D7,D8,D9—1N4001 rectifier diode
D2—Red light-emitting diode
D3,D4,D5,D6—5.1-volt zener diode
Q1,Q2,Q3—IRF510 or equivalent power MOSFET (Radio Shack Cat. No. 276-2072(A) or similar)
U1—PIC 16C54 with RC oscillator option (simple design implementation; must be preprogrammed; Digi-Key is a possible source—call 1-800-DIGIKEY)
U2—7805 fixed +5-volt regulator

Capacitors
C1—100-F, 25-volt electrolytic
C2—22-pF ceramic disc
C3,C4—0.1-F ceramic disc

Resistors
R1,R3 thru R13—10,000 ohms
R2—4,700 ohms
R3—470 ohms

Miscellaneous
RELAY1,RELAY3—Heavy-duty 12-volt spst automotive relay (Radio Shack Cat. No. 275-226 or similar)
RELAY2—Heavy-duty 12-volt dpdt automotive relay (Radio Shack Cat. No. 275-206 or similar)
Printed-circuit board (see text) or perforated board (Radio Shack Cat. No. 276-168A or similar); suitable enclosure (Radio Shack Cat. No. 270-627 or similar); 18-pin DIP IC socket; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Simple Design Implementations, PO Box 9303, Forestville, CT 06011-9303 (tel.: 203-582-8526): complete kit of parts but *not* including transmitter/receiver, $79 (includes all components in Parts List, relays, enclosure, perforated-board, IC socket, male/female nine-pin plug, pre-programmed PIC microcontroller, etc.; pre-programmed PIC microcontroller, $20. Connecticut residents, please add appropriate sales tax.
Assembled key-chain transmitter (No. RF300XT) and receiver (RF300R) are available from Visitech Corp., PO Box 14156, Fremont, CA (tel.: 501-651-1425); other models are available as well. Contact Visitech for details.

Upon successful start, the unit disengages the starter, beeps the horn twice to indicate a successful start and then proceeds to Mode 4. If 3 seconds elapse and the engine hasn't started, the starter is disengaged, the horn is sounded once to indicate an unsuccessful start attempt and the system jumps to Mode 5.

Mode 4 permits the engine to idle for approximately 15 minutes. The Remote Starter continues to check for the brake pedal and red button and shuts down the engine if either is detected. The unit also monitors rpm and shuts down if it exceeds 3,000. If the green button is pressed when in Mode 4, the horn sounds twice to indicate that the engine is running. If the red button is pressed, the engine is shut down and the system returns to Mode 1.

Some cars don't always start on the first try. Mode 5 allows the engine to sit for 5 seconds before a retry is attempted. Only one retry is permitted for each press of the green button. If the car fails to start after the second try, the green button must be pressed to restart the sequence.

Engine rpm is determined by counting the number of tachometer pulses that occur within a certain period of time. The 16C54 has an internal counter (RTCC) that can be incremented via an external pin (RTCC pin 3). This RTCC counter is read and cleared on every other pass through the primary software loop. Since execution time of the software loop is known (approximately 0.1 second), the number of tach pulses per pass of the software can be directly related to engine rpm. The value in the RTCC register relates to rpm via Table 3.

Construction

Assembly of the Remote Car Starter is

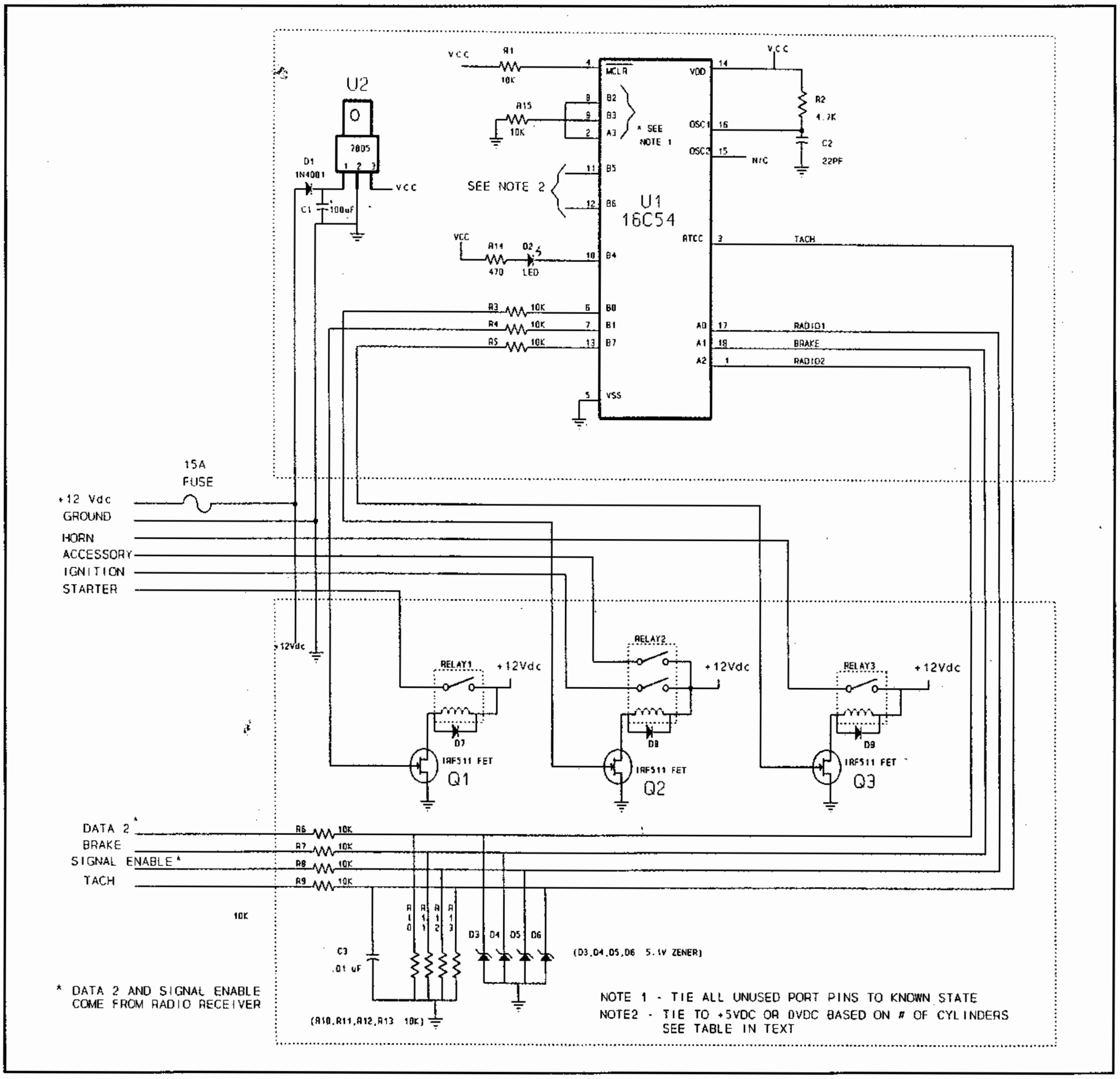


Fig. 2. Overall schematic diagram of circuitry used in the PIC-based microprocessor module.

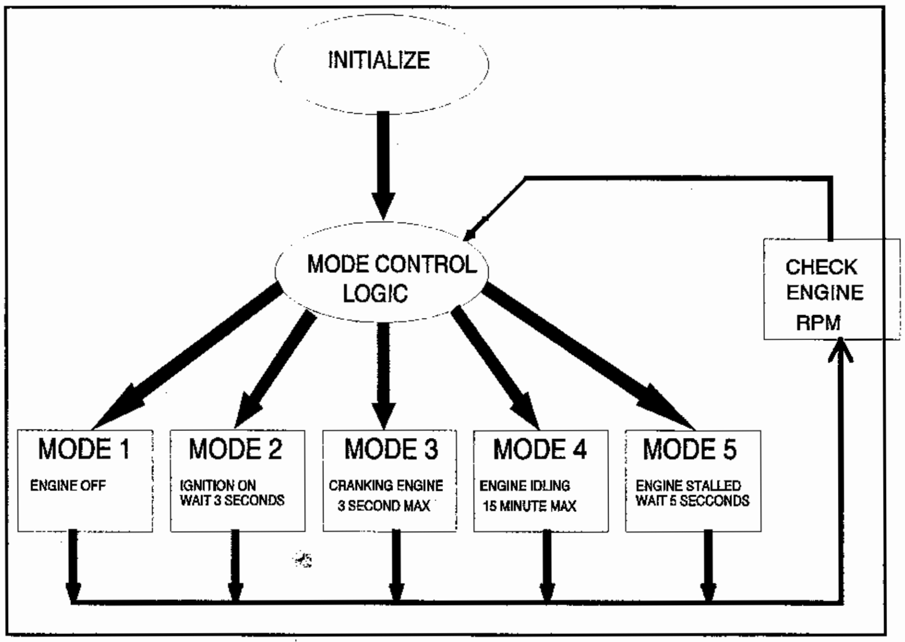


Fig. 3. Initializing diagram for the Remote Starter's software.

relatively simple. You can wire the Fig. 1 circuit on perforated board that has holes on 0.1" centers, using suitable Wire Wrap or soldering hardware or a printed-circuit board of your own design. Whichever way you go, plan on using a socket for *U1*.

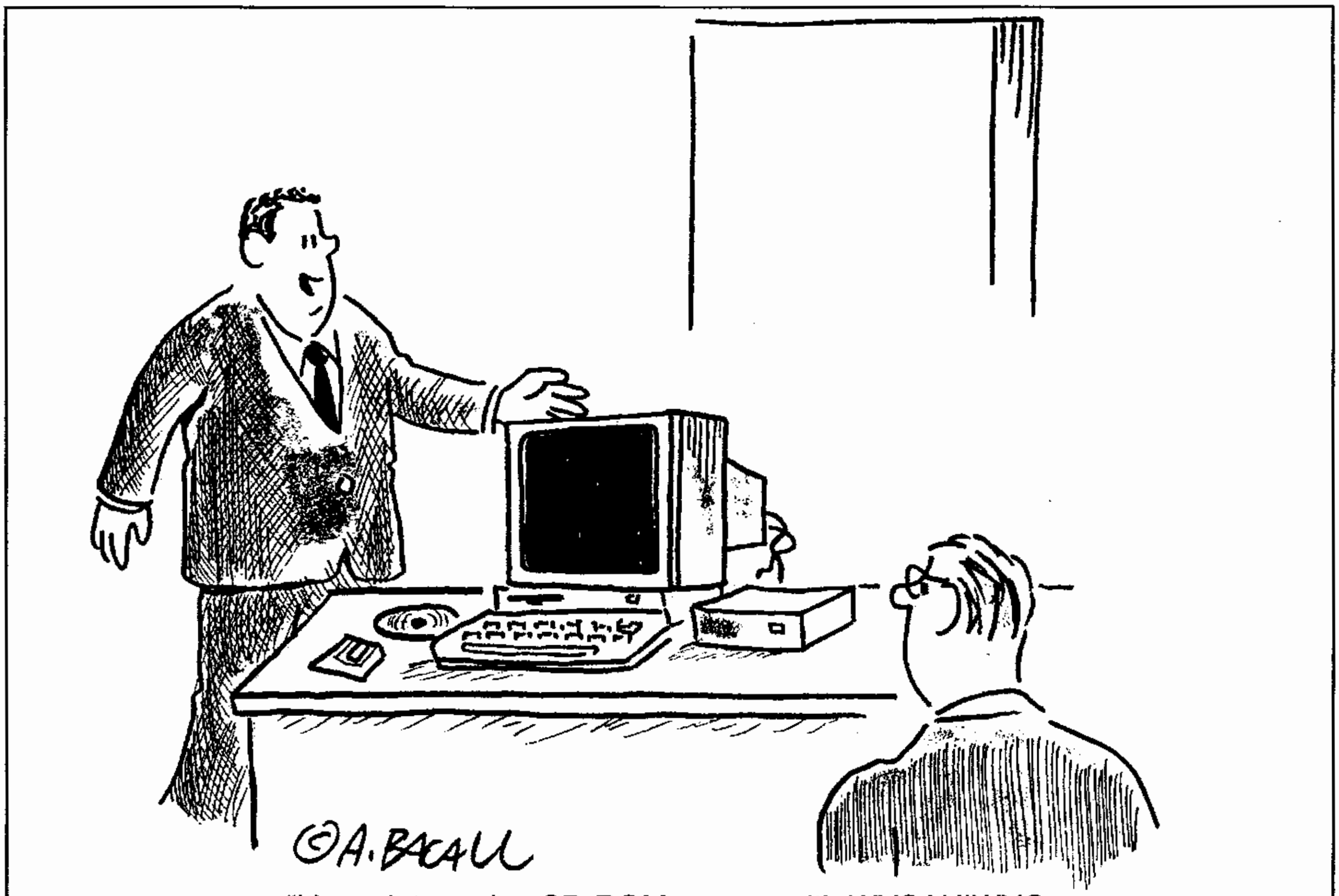
Start wiring the circuit by mounting the *U1* socket into place, but don't plug *U1* into the socket until you're directed to do so later. Follow up by installing the resistors, capacitors, diodes and LED. Make certain that the diodes, LED and electrolytic capacitor *C1* are properly oriented before making any final connections. Then install the transistors and voltage regulator *U2*, making sure that these are all properly based before making the final connections. As you work, you might want to check off each installed component on a photocopy of Fig. 2.

Next assemble the three relays. When wiring the relays, it's very important that you use the appropriate gauge wire leading into and out of the remote starter. Refer to Fig. 5 for appropriate wire gages.

Checkout

When you're finished wiring the Fig. 2 circuit, make sure *U1* still isn't plugged into its socket and apply power to the unit. Using a dc voltmeter or a multimeter set to the dc-volts function to perform the measurements detailed in Table 4.

If any one or more of the tests detailed in Table 1 fails, disconnect power and



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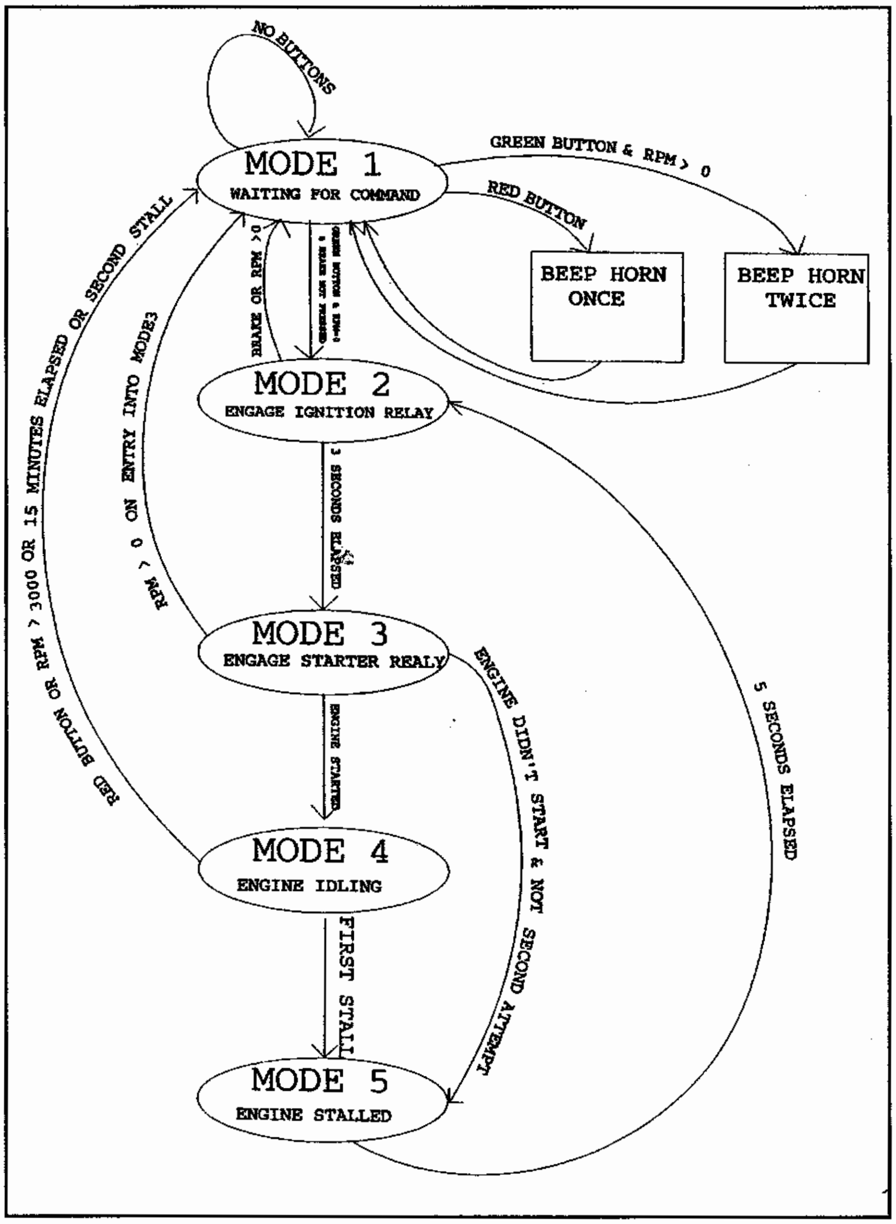

Fig. 4. Remote Starter mode-transition logic diagram.

Caution

The Remote Control Starter presented in this article must be installed only in vehicles equipped with automatic transmissions and Electronic Fuel Injection (EFI). Also, only qualified persons with sufficient automotive experience should perform installation. Please seek the help of a qualified mechanic.

recheck all your work. Do not proceed until you've rectified the problem. Once you're certain that everything is okay, power up and connect one end of a temporary jumper to +5 volts. Touch the other end of the jumper to pin 7 of the *U1* socket and note if *RELAY1* energizes. If so, touch the end of the jumper to pins 6 and 13 of the socket and note if *RELAY2* and *RELAY3*, respectively, energize.

If any of the above tests fails to check out, power down and recheck your wiring. Do not proceed until you've corrected the problem. Once all tests check out correctly, remove power from the unit and plug the 16C54 microcontroller into the *U1* socket, making sure that it's properly oriented and that no pins overhang the socket or fold under between IC and socket. Apply power once again and verify that the LED begins flashing. If it doesn't flash, remove power and recheck your wiring once again.

Attaching the radio receiver to the microcontroller board entails just four wires: +12 VOLTS, GND, SIGNAL ENABLE and DATA 2. Don't forget to set the code in the transmitter and receiver. There are 59,000 possible codes from which to choose. The codes are set by soldering pins in both the transmitter and receiver. Since instructions explaining how to set the codes come with the transmitter and receiver units, I won't detail them here.

It's important that you test the Remote Starter before installing it in your vehicle. The only special test equipment needed is a pulse generator. If you don't have access to one, you can make a pulse generator with a 555 timer chip. The pulse generator should be connected to the TACH input of the Remote Starter.

Set the pulse generator to produce a 33-, 50-, 66-Hz square wave for four, six or eight cylinders, respectively, where the peaks of the square wave are at 0 and 12 volts dc. Also tie the BRAKE input to ground. When the green transmitter button is pressed, Relay 3 (the horn relay) should activate with two quick clicks. When the red button is pressed, Relay 3 should activate with one quick click. Relays 1 and 2 should *not* activate at all. This test confirms the Starter's ability to detect a running engine.

Next, turn off the pulse generator and press the green button. Relay 2 should engage. Three seconds later Relay 1 should engage for an additional three seconds and then disengage. After five seconds, Relay 1 should re-engage for three seconds and then both Relays 1 and 2 should disengage and remain off until the green button is pressed again.

Finally, press the green transmitter button. When relay 1 engages, turn on the pulse generator, which must be

Table 3. How Values in RTCC Register Relate to RPM

RPM	4-Cylinder RTCC	6-Cylinder RTCC	8-Cylinder RTCC
Low (500)	3	5	7
High (3000)	20	30	40

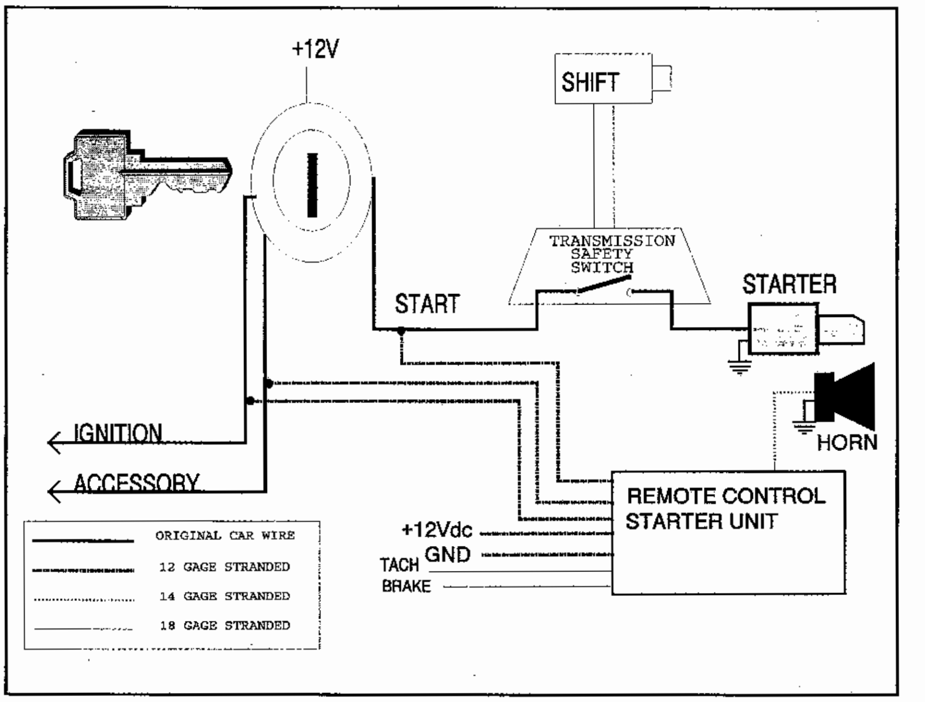

Fig. 5. Wiring details for installing the receiver/microprocessor module in a vehicle.

Table 4. Checkout Measurements for Various Points in Circuit

Pin	Name	Measurement
1	RA	No Check
2	RA3	0 Volt
3	RTCC	0 Volt
4	MCLRB	+5 Volts
5	V_{ss}	Continuity to ground
6	RB0	0 Volt
7	RB1	0 Volt
8	RB2	0 Volt
9	RB3	0 Volt
10	RB4	2 Volts dc (±1Volt)
11	RB5	See Cylinder Setup Table
12	RB6	See Cylinder Setup Table
13	RB7	0 Volt
14	V_{dd}	+5 Volts
15	OSC2	0 Volt
16	OSC1	+5 Volts Through R2
17	RA0	No Check
18	RA1	No Check

turned on within two seconds of relay 1 engaging. Relay 1 should disengage and Relay 3 should give two quick clicks, indicating a successful start. Now tying the brake line to +12 volts should cause all relays to disengage.

Installation

Installation must be performed by a qualified individual. The starter, ignition and accessory circuits must be tapped just after the key. Be sure that the starter-motor circuit is tapped *before* the safety switch in the transmission (see Fig. 5). Failure to do this may allow your car to start even if it's in gear. Since every vehicle is different, listing here the circuits for each make and model car would be prohibitive. The best approach is to seek assistance from a qualified person who has experience with your specific make and model vehicle. ■