Weeder Technologies

Pro-Kit

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IR Remote Control Receiver

By Terry J. Weeder

Have you ever wanted to make good use of all those remote control units from TVs, VCRs, stereo equipment, etc., which have been stacking up over the years? Have you ever wanted to add remote operation to your electronic projects? This, simple-to-build low cost construction project, will receive and convert the output of virtually any infrared remote control transmitter - using a 40KHz carrier - to logic levels which can be used to control all your favorite toys, from robotics to rail roads. This basic "building block" can even be used to turn on and off just about anything in your home (lamps, fans, radios, alarms, electric locks, space heaters, air conditioners) without leaving the comfort of your own lounge chair. Anything which operates on electricity, can be controlled with that $3.00 remote control - found in abundance at surplus dealers and ham fests. The only limit being that of your imagination!

The IR Remote Control Receiver as explained here, has 7 individual TTL level outputs which can be programmed to correspond to any button on your remote control and be set up for either: latching outputs which toggle between "high" and "low" each time the button is pressed, or momentary outputs which switch and remain “high” for the duration the button is pressed. Programming is a simple procedure of placing the unit in the programming mode, aiming your remote control transmitter at the project and pressing buttons to let it “learn” and record the data streams transmitted by your particular remote.

About Remote Controls

The standard infrared remote control transmitter used to control your TV, stereo, VCR, cable box, etc., uses a photo diode which transmits in the near infrared range and is pulsed on and off at a 40KHz rate.

This 40KHz carrier is modulated by being transmitted in short bursts as shown in figure 1. By alternating the exact length of the burst, or the time between bursts, it is possible to encode intelligent data on the IR signal; this being the method used by these remote control transmitters to indicate which button is being pressed. Figure 1a shows an IR signal from a transmitter which encodes the digital data stream on the carrier by alternating the length of the burst, while figure 1b shows one which alternates the time between bursts. There are also a small number of remotes which alternate both length of burst, and time between bursts.

A typical receiver in a host product will for instance, decode the individual logic levels in the data stream by comparing this pattern of bursts with an internal clock operating at the same frequency as one within the transmitter. Although the frequency of this clock used for timing varies among remote control manufacturers, as does the choice of alternating the length of the burst or that of the time between bursts, the same basic principle applies and can be utilized.

In most cases the IR signal consists of a pattern of anywhere from 12 to 16 bursts of 40KHz infrared - there is however, a small percentage which use a longer data stream. Some models continuously repeate this pattern, while others send their data stream only once or twice, then cease transmitting even though the remote’s button is still depressed.

Circuit Theory

The circuit is made simple by the self contained infrared Receiver/ Demodulator (MOD1). A block diagram of the IR module is shown in figure 2. The modulated IR signal is detected by the photo diode which has its peak sensitivity in the near infrared range. After passing through a preamplifier/limiter, the built-in band pass filter then rejects all signals outside the pass band of 40KHz. This reduces or eliminates false operation caused by other light sources. The remaining signal is fed to the demodulator, integrator, and comparator which outputs a clean TTL level pulse stream without the carrier. Figure 3 demonstrates the output pulse of the IR module with respect to the remote control transmitter’s signal being received at its input. Note, how the presence of an IR burst (figure 3a) produces a low at the output of the IR module (figure 3b).

Refer to the schematic diagram shown in figure 4. The heart of the circuit is IC1 (part no. PIC16C54), an 8-bit CMOS microcontroller manufactured by Microchip. This microcontroller has one 8-bit I/O port and one 4-bit I/O port. Because each I/O pin can be used and configured individually, it was possible to arrange

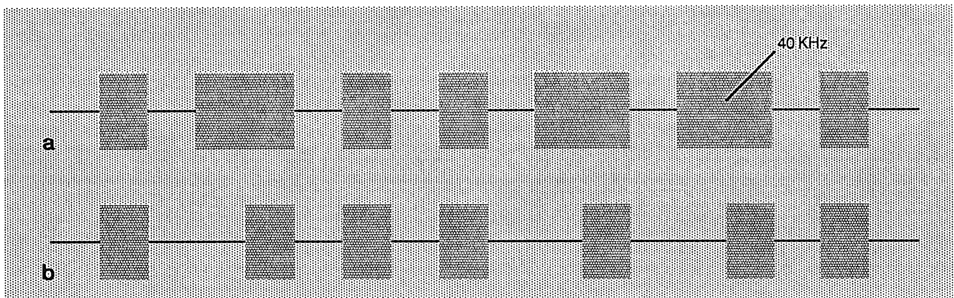


Figure 1

them to greatly simplify PC board layout and require only a single-sided board. This is the reason for the non-uniform use of I/O pins as shown in the schematic.

IC1 is linked to and stores all its data in IC2 (part no. 93LC46), a 1K serial EEPROM (Electrically Erasable Programmable Read Only Memory) also manufactured by Microchip. In this application the 93LC46 uses a 3-wire interface. Of the three wires there is a CHIP SELECT, CLOCK, and DATA IN/OUT. Because the DATA IN and DATA OUT share the same line, a 1K resistor (R2) is used to limit the current flow during those transition times between WRITE and READ when there are conflicting logic levels.

IC1 communicates with the 93LC46 by placing a high on the CHIP SELECT pin. Data is then transferred serially to and from the 93LC46 on the positive transition of the clock pin. Each READ or WRITE function is preceded by a start bit, an opcode - identifying the function to be performed (read, write, etc.) - then a 7-bit address, followed by the 8 bits of data which is being written to, or read from that address. Immediately preceding and following all WRITE operations, the microcontroller sends instructions to the 93LC46 which enables/disables the WRITE function, thereby protecting the data thereafter.

During the programming mode, IC1 reads the IR data streams from MOD1 and converts them to data patterns which can be stored in IC2. These data patterns are used for comparison while in normal operation. More on this later.

Power for the circuit is conditioned by IC3, a low current 5-volt regulator which will accept any DC voltage between 7 and 25 volts. C1 and C2 stabilize the operation of the regulator. Crystal (XTAL1) sets the internal oscillator of IC1 to 4MHz. JMP1 is actually two closely spaced pads on the board which, when momentarily jumpered with a screwdriver, will place IC1 in the programming mode and light LED1.

The Program

A PIC16C54 microcontroller pre-programmed with the IR Remote Control Receiver firmware is available from the source mentioned in the parts list. As mentioned earlier, the exact protocol used to indicate the different logic levels in the data stream transmitted by a typical IR remote control varies from manufacturer to manufacturer. Because of this, when recording the data streams related to each button on the remote, the firmware in IC1 is configured not to try to identify logic "1"s or "0"s, but instead, to measure the width of each IR burst and the time between bursts; storing these values in memory. This pattern can then be used to find a match while in normal operation.

When measuring, unfortunately there is only 16 8-bit registers available in IC1 to process and hold these values before sending them to memory. Since both the bursts and time between bursts must be measured, a 16-burst pattern will require 32 measurements. Because we are only concerned with a change in length rather then the actual length, the most significant 4-bits of each measured value is not important and can be stripped off allowing each 8-bit register to store both the burst length, and time

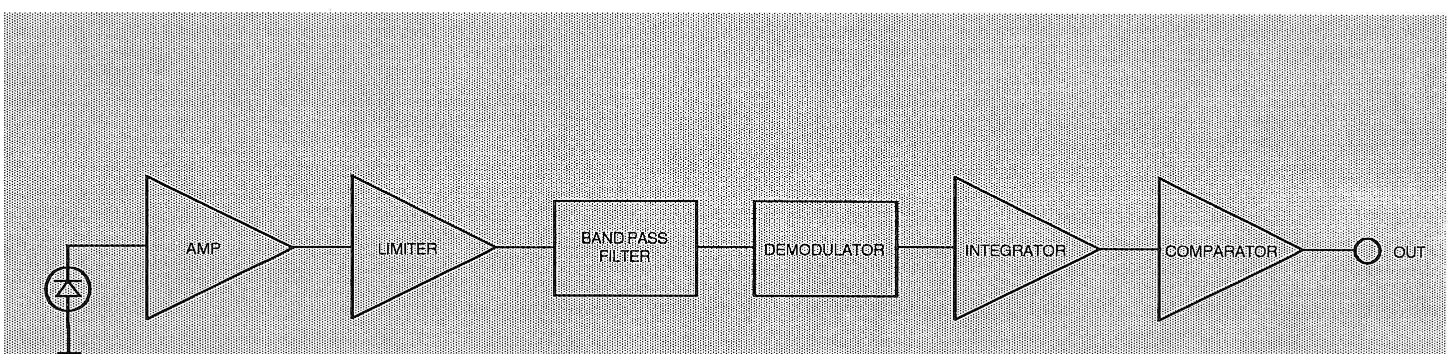


Figure 2

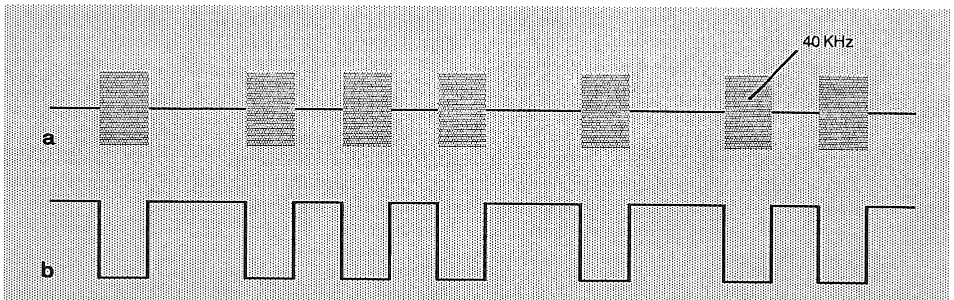


Figure 3

between bursts. In cases where the remote transmitter uses a data stream longer then 16 bits, the pertinent data relating to which button is being pressed was always found at the end, therefore the microcontroller (IC1) automatically measures and records the latter 16 bits in all data streams. The IR Remote Control Receiver was tested using a universal remote control which was programmed to simulate 496 different remote transmitters. 93% of those worked using the scheme mentioned above.

After being placed in the programming mode by detecting a low on pin 5 of port-B, IC1 waits for the presence of a IR signal - pressing of a button on the remote control transmitter. A set of up to 32 bursts are sampled from the beginning of the IR signal's data stream, measured, and the latter 16 are stored in IC2; this pattern being assigned to output pin #1. IC1 then flashes the LED to indicate that the recording process is complete for that button. Depending on the duration in which the remote control's button is held down following the flash of the LED, the output pin is configured for either "toggle" or "momentary" operation. IC1 waits for the next button to be pressed on the remote control transmitter and repeats the above procedure; assigning this next pattern to output pin #2, and so forth. After 7 patterns have been received and stored, IC1 turns off the LED and returns to normal operation.

During normal operation, IC1 waits for any IR signal to be received, determines its burst pattern in the same way as in the programming mode, and looks for a match in memory. If a match is found, IC1 either toggles the state of the linked output pin, or holds the pin high until the IR signal ceases; depending on the configuration of the individual output pin as defined in the programming mode.

Construction

All components fit nicely on a PC board measuring just less then 2" x 2-1/4". This pre-fabricated PC board may be purchased from the source mentioned in the parts list.

Refer to the parts placement diagram shown in figure 5 and begin by soldering in the two IC sockets used for IC1 and IC2. Next, mount all resistors and capacitors, paying particular attention to the orientation of the polarized capacitor C2. Solder in the crystal (XTAL1) and the voltage regulator (IC3). The LED should be mounted with the long lead going to the terminal labeled "A" and the short lead to "K". Finish by mounting the IR module; including the soldering of the two tabs for a good ground connection to the case.

After all components have been mounted, closely examine the solder side of the PC board for solder bridges and/or cold solder joints and re-solder if necessary. Carefully plug IC1 and IC2 into their sockets using the orientation as shown in the parts placement diagram.

Operation

To test the Remote Control Receiver, use the setup shown in figure 6. This circuit will turn on a separate LED for each output pin which goes high; easily letting you check out the unit and get a feel for how it works. Until an exact application and circuit has been determined, temporarily solder 7 solid conductor wires to the output terminals on the PC board and run them to a solderless breadboard to be used for your test circuit. The solderless breadboard will allow you to make experimental changes without having to solder and de-solder.

Place fresh batteries in your remote control transmitter and setup the receiver so that you can aim the transmitter directly at the receiver's IR module at a distance of three or more feet. DO NOT hold the transmitter closer then three feet during this initial programming phase. The author experienced at least one remote contol transmitter model whose output was strong enough to overdrive the receiver's IR module at a distance of up to two feet, and cause distortion which in turn affected the data being recorded. Also, make sure that there is no fluorescent lights shining directly on the IR module of your receiver. Some of these lights use a pulse frequency close to 40KHz and will interfere with the critical "recording" operation, causing corrupted data to be inadvertently stored in memory.

Apply power to the Remote Control Receiver. Locate the two square pads on the PC board directly underneath the IR module and, using a small screwdriver, briefly short them together; this will cause the LED to light and remain on. Point the transmitter at the receiver and press and hold the button you wish to assign to output pin #1. After approximately 1/2 second the LED will flash off then back on. If you want output pin #1 to be configured as "toggle", immediately release the button on the transmitter. If you want it to be configured as "momentary", continue to hold the button down until the LED flashes a second time. Note, that those transmitters that do not output a continuous stream of IR can not be configured for momentary operation and will not cause the LED to flash a second time. Next, choose the button you wish to assign to output pin #2 and repeat the above procedure. Continue until all 7 outputs have been dedicated to a button on your transmitter. After the last output pin has been programmed, the Remote Control Receiver will automatically end the programming mode and turn off the LED. You must continue through and program all outputs before the programming mode will be terminated.

Now press those buttons on the remote control transmitter and watch as the appropriate LED turns on and off in your test circuit. You can assign more then one output to a single button on the transmitter. For instance, one output pin could be setup to toggle between high and low each time the button is pressed, while another (set to momentary) could indicate how long that same button is held down.

Be aware that the author did find some units which transmitted two different data patterns for each button, toggling between these two patterns each time the same button was pressed. This is the bulk of the 7% which was considered incompatible with this project.

Figure 7 shows an output being used to drive a DC load of up to 500mA. This circuit can be repeated on all output pins to control 7 different loads. Applications which come to mind include controlling motors in robotics, or turning on any 9-volt battery powered device. If larger loads are required, figure 8 shows an interface to a relay. Although a 12V relay is shown, any relay operating on a voltage from 7 to 25VDC can be used simply by using its specific voltage to power the Remote Control Receiver.

Parts List

Resistors (All are 1/4-watt, 10% units)

R1, R3, R4, R5, R6, R7, R8, R9 - 620 ohm

R2 - 1,000 ohm

Capacitors

C1 - 47 uF, 35-WVDC, electrolytic

C2 - 10 uF, 35-WVDC, electrolytic

C3, C4 - 15 pF, ceramic disc

C5, C6, - 0.1 uF, Mylar

Semiconductors

IC1 - PIC16C54-XT/P (Pre-programmed) 8-bit microcontroller (Microchip)

IC2 - 93LC46 serial EEPROM (Microchip)

IC3 - 78L05 low power 5-volt regulator

LED1 - light emitting diode

Other components

MOD1 - 40-KHz Infrared Remote Control Receiver Module (Digi-Key part no. LT1060-ND or equivalent)

XTAL1 - 4 MHz crystal

The following items are available from Weeder Technologies, PO Box 2426, Ft Walton Beach, FL 32549. 850-863-5723.

- An etched and drilled PC board (WTRCR-B), $8.50.
- All Board mounting components including pre-programmed PIC16C54 (WTRCR-C), $23.50.
- A pre-programmed PIC16C54 only (PIC-RCR), $16.00

All orders must include an additional $4.00 for shipping and handling. Florida residents add sales tax.

For AC applications, figure 9 uses an optoisolator and triac to switch the line current coming from a standard 120VAC wall outlet. This circuit will control just about anything which plugs into an AC outlet. **CAUTION!** Great care should be observed when working with 120VAC. Note that most triacs have their metal tabs tied directly to one of the main terminals, hence, **you will be shocked** if you touch this tab while 120VAC is applied. If large loads are being used which require mounting of the triac to a heat sink, use insulated mounting hardware such as Radio Shack #276-1373 and always check for shorts to ground with an ohmmeter prior to plugging into an AC outlet.

For you model railroad buffs, figure 10 shows a circuit which will control the track switches. Two output pins are required per switch - one for each direction - and they must be configured as momentary. The Remote Control Receiver can also be used to control all the other accessories in your setup.

The preceding is just a small example of some of the applications which come to mind, and typical circuits which can be used. Slight alterations may be required in your particular setup. The Remote Control Receiver described here is a low-cost, very easy to assemble, starting block for all your projects which you wish to incorporate infrared remote operation. After building and experimenting with this project, you'll find that the possibilities are unlimitted.

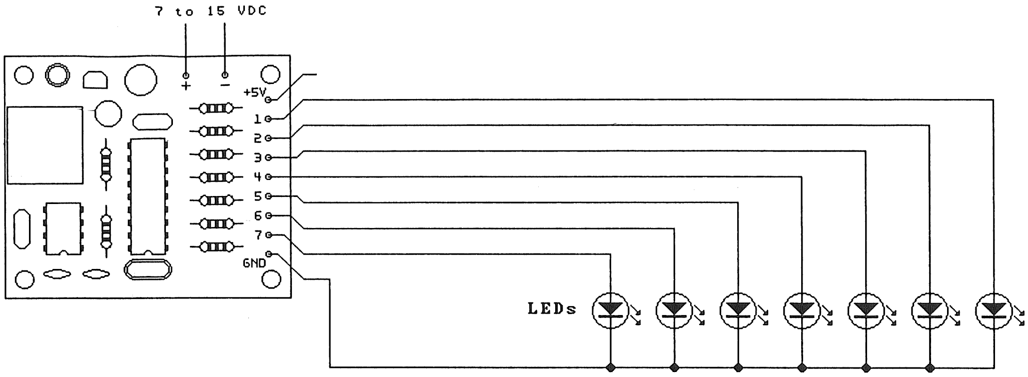


FIG. 6

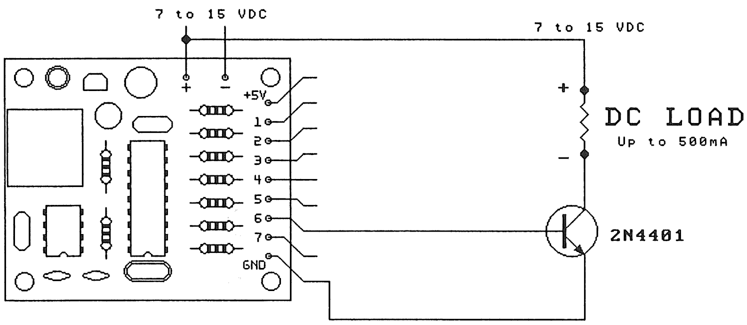


FIG. 7

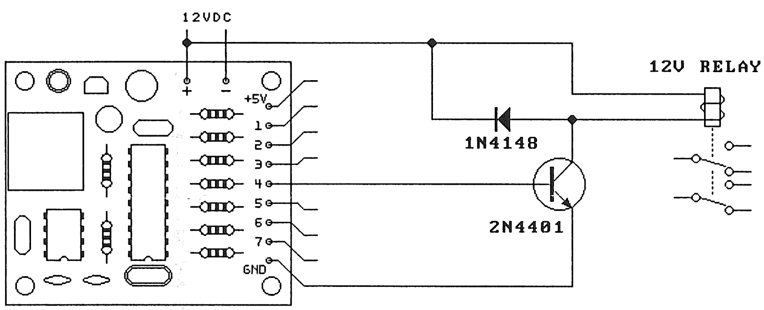


FIG. 8

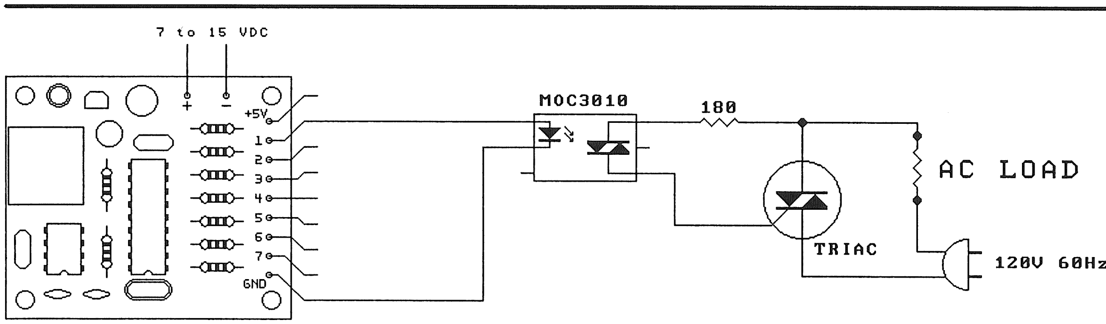


FIG. 9

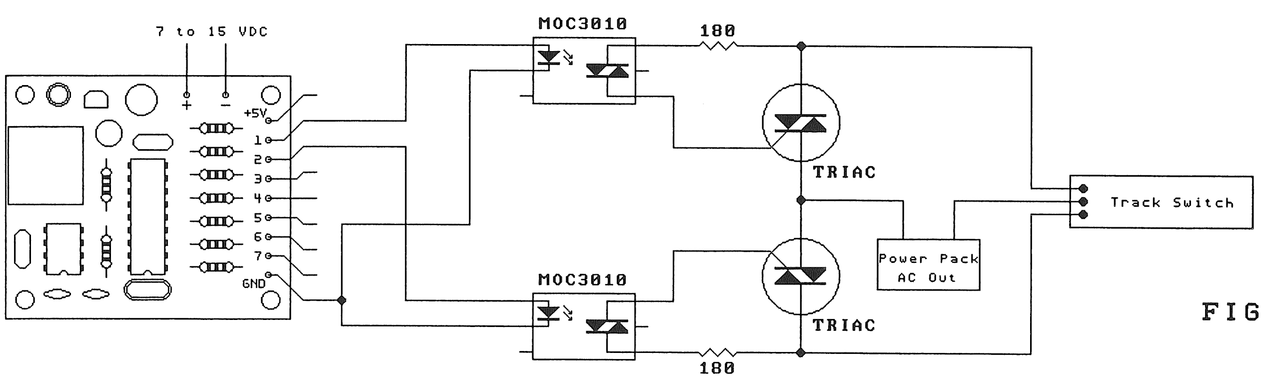


FIG. 10

IR REMOTE CONTROL RECEIVER
WTRCR

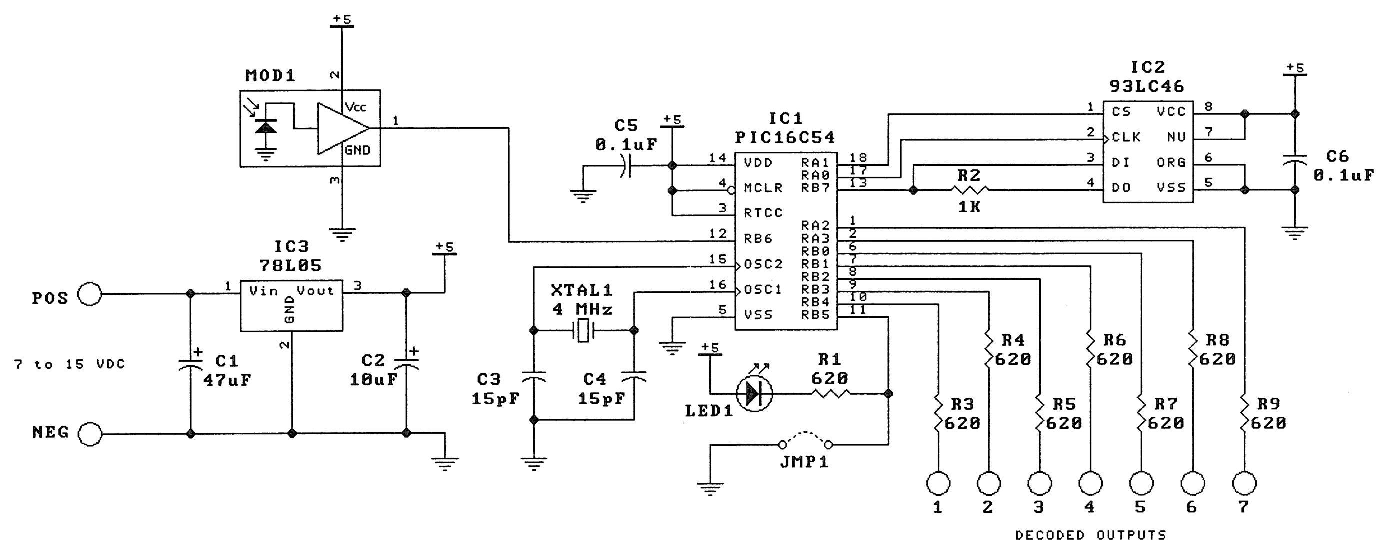
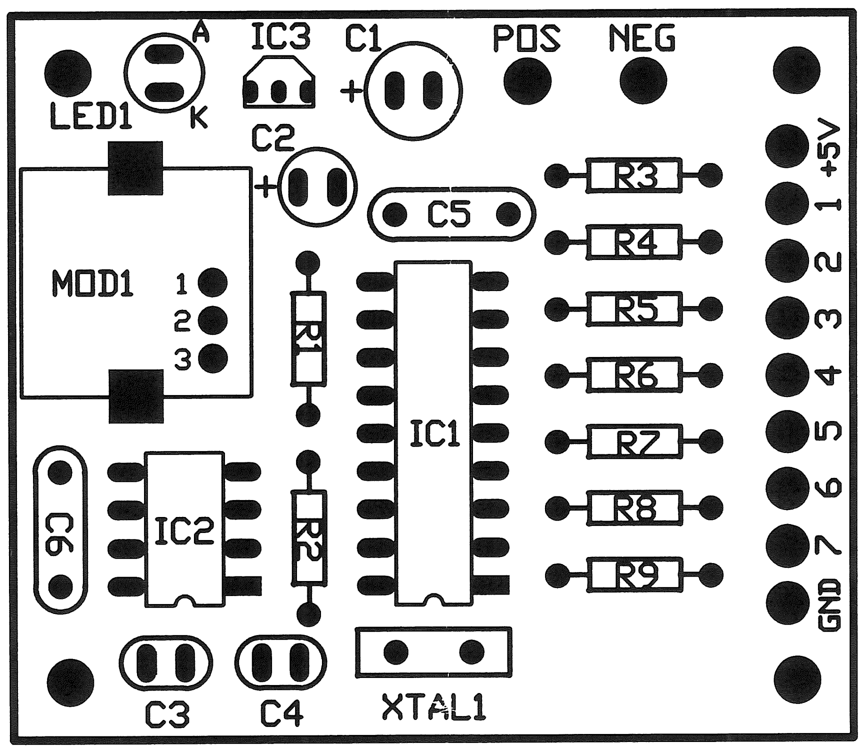


Figure 4



WTRCR Scale=2

Figure 5