CHAPTER 7
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Infrared Shade and Door Lock Control

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INTRODUCTION

The automatic shade and door lock controller were specifically designed to help physically disabled individuals to become more independent in their environment. It consists of three basic units, the main controller, the door lock receiver, and the shade transmitter/receiver. The main controller is programmed to transmit the infrared digitally encoded commands that activate the circuitry that control each device. Each device, either the shade or door lock receiver module decodes each transmitted signal and performs its appropriate function. This enables an individual to control the shades in his domicile and also lock and unlock a door that has been appropriately interfaced. Infrared control reduces wiring in a household since one transmitter is necessary for each room. This simplifies installation and reduces cost. The receiver can be placed anywhere in the room as long as it can detect the transmitted infrared signal. Control over numerous shades and doors from a single location is possible with this approach in an efficient and economic way.

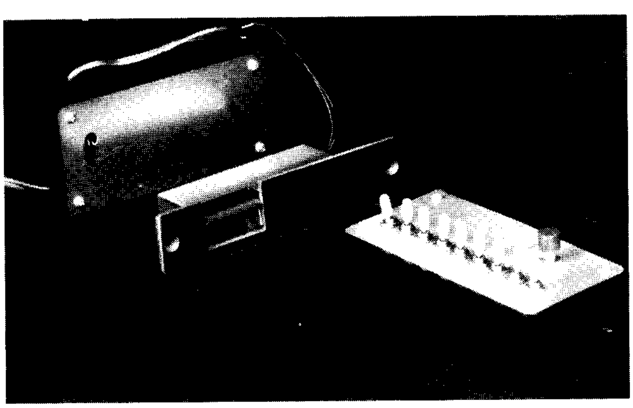

Figure 7.1. Infrared Transmitter and Door lock Controller.

SUMMARY OF IMPACT

The shade and door lock controllers shown in Fig. 7.1 were designed to aid handicapped people control their environment. A disabled person is now able to adjust any shade himself and unlock a door very conveniently through the use of the main controller.

TECHNICAL DESCRIPTION

Infrared Controlled Door Lock

The schematic for the door lock controller is shown in Fig. 7.2. This circuit needed to be a receive-only unit, because the electro-mechanical mechanism of the door lock is normally in a locked position, eliminating the need for feedback. The transmitted PCM (Pulse Code Modulation) infrared signal, sent by the main controller is set to a frequency of 1.8 kHz and is picked up by the infrared photo diode (SFH205 or equivalent) in the receiver. This signal is then fed to the MC3373 (remote control amplifier decoder) where the bits are decoded. After decoding, the signal is amplified by a 2N3904 transistor and then passed through two inverters (CD4049) which filter and shape the signal. The signal is then sent to a MC145028 (remote control decoder). If the preset address is matched, the valid transmission(VT) output will go high, thereby selecting the device. The VT is sent through the MC4049 inverter that sends a negative pulse to trigger a MC555 timer. The timer outputs a 5 second pulse that activates a relay that unlocks for this amount of time.

Infrared controlled shade

The shade controller is shown in Fig. 7.3 and its schematic is shown in Fig. 7.4. This unit also receives encoded infrared signals from the main transmitter. The receive section of this device is virtually identical to the door lock front end except for some modifications in the decode section. The transmitted PCM infrared signal sent by the main controller is detected by the infrared photo diode

(SFH205). This signal is then fed to the MC3373 where it is decoded. After decode, the signal is amplified by a 2N3904 transistor and then passed through two inverters (CD4049) which correct the shape of the signal. The signal is now sent to the MC145027 (remote control decoder), and if the first 5 bits of the 9 bit word match the preset address, then the last 4 bits appear at the part's data outputs. When D9 of the MC145027 goes high, the motor is enabled to raise the shade and the COUNT U/D pins of the counters (MC14029) are enabled so that the counter counts up. When D9 is low the motor is enabled to lower the shade and the counters count down. The three counters together comprise a divide by 1000 counter that reduce the number of encoder pulses from 1700 pps to 1.7 pps. D8 is then set high and activates the MOSFET (IRF51) motor switch that turns the motor on. When D7 is high it enables the CARRY OUT of the last counter to activate the TRANSMIT ENABLE of the MC145026 (remote control encoder). When the encoder TE goes low it sends the encoded signal to an MC555 timer which Pulse Code Modulates it, and then transmits it using an infrared diode. The main controller will increase or decrease its counter by one every time it receives a valid transmission from the shade controller. When the predetermined pulse count has been reached, the main controller sends a signal back to the shade controller setting D8 low (deactivating the motor switch) and D7 low (disabling TE).

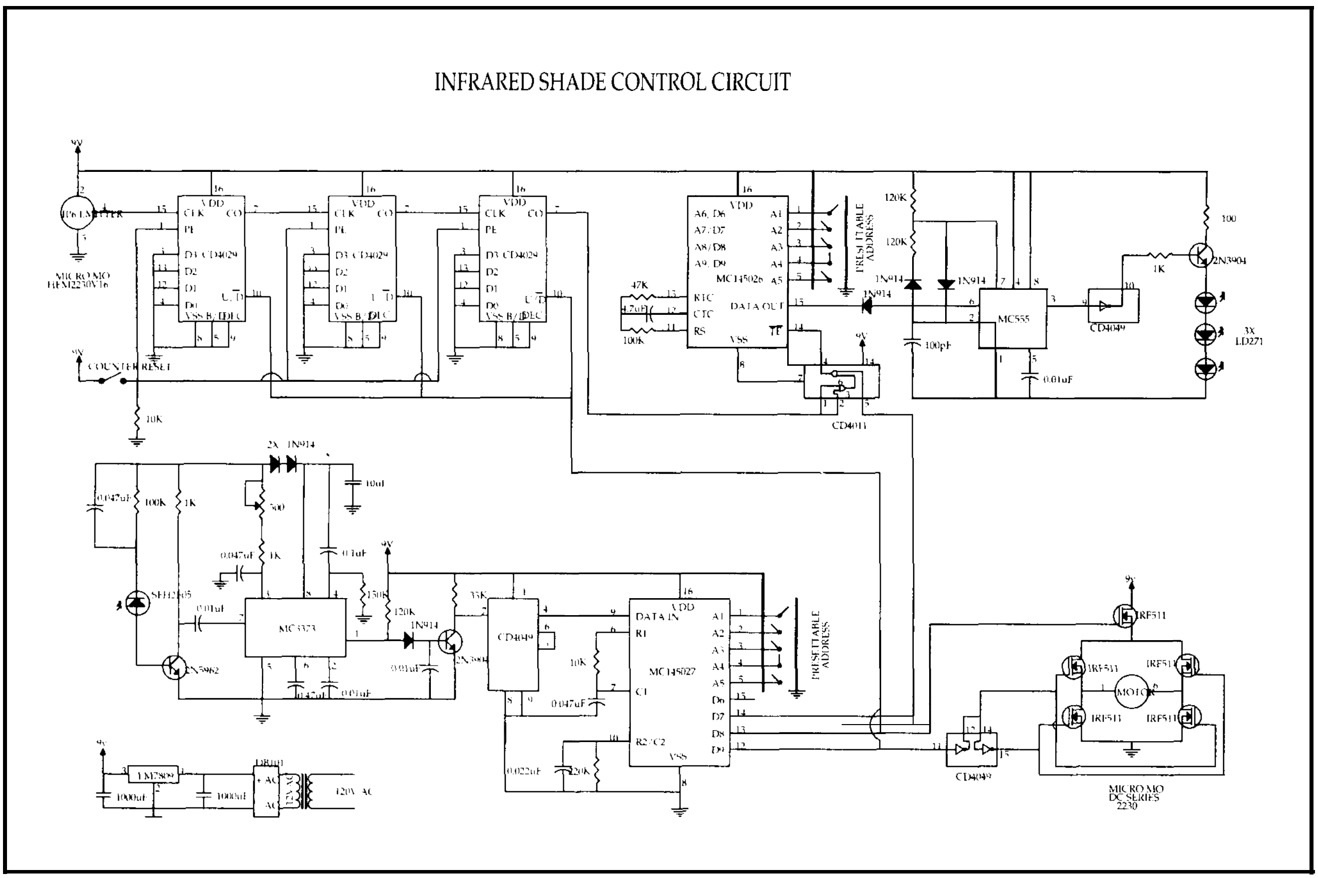

Figure 7.2. Schematic for Infrared Transmitter and Door lock Controller.

Infrared Transmission Unit

As can be seen from the schematic in Fig. 7.5, which depicts the internal design of the transmission unit, integrated circuits identical to those described in the preceding paragraph are used to transmit the infrared codes to the control units. The design and function of the transmitter is identical to the transmission feedback section of the shade controller with one exception. For the transmission unit, switches are available on the external case that allow one to change the address and data sent to each control section. This enabled us to test each device and to conveniently select our address and data values. It also allows us to build additional devices with additional codes and test all of them simultaneously.

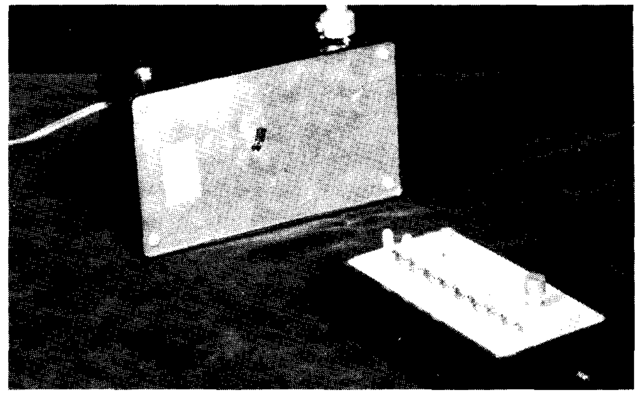

Figure 7.3. Infrared Shade Controller With Transmitter.

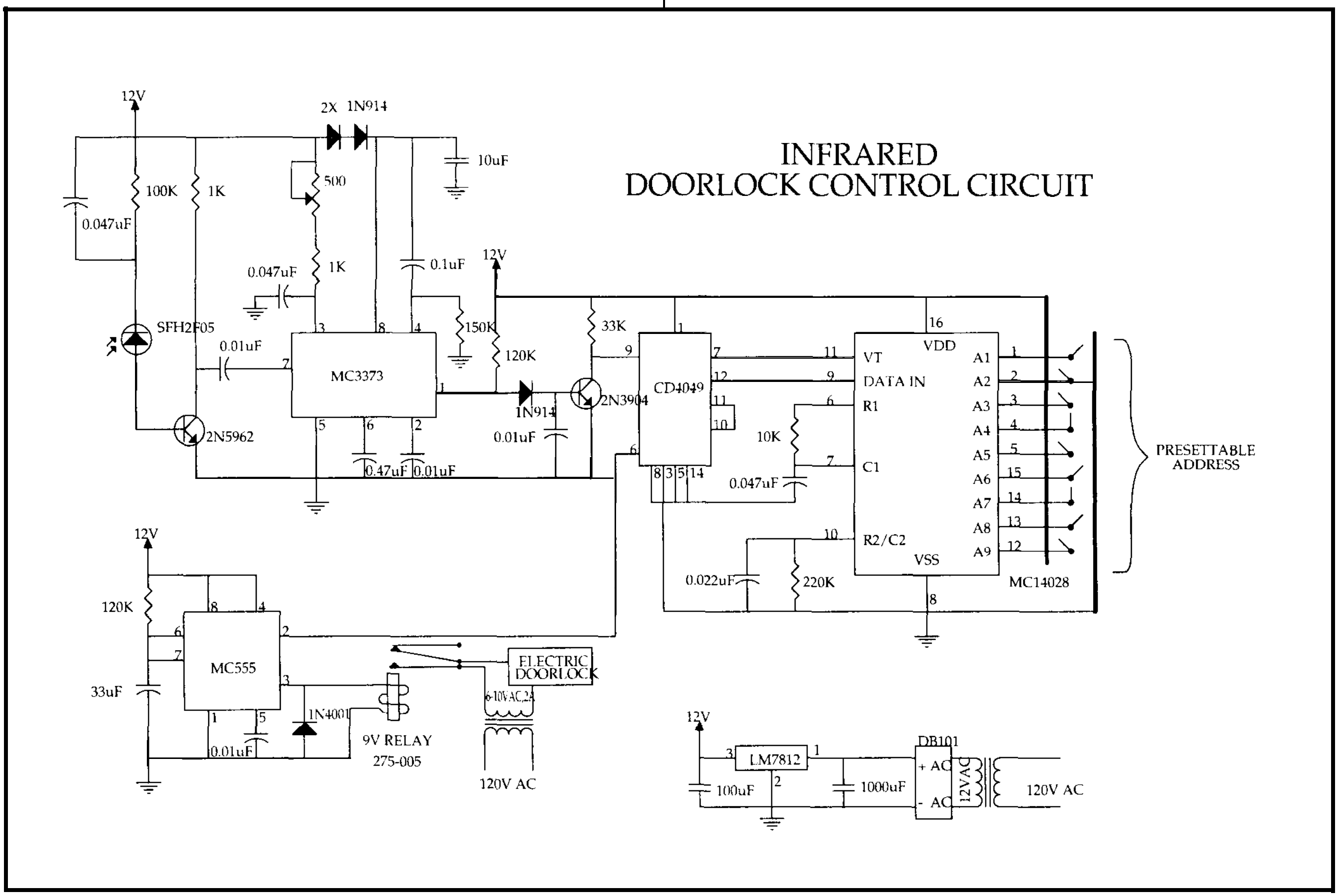

Figure 7.4. Schematic for Infrared Shade Controller With Transmitter

All units have components and power supplies mounted in black plastic boxes. The shade box and a standard shade bracket are mounted to the face frame of the window, where a standard shade can be installed. The door lock box can be mounted in any convenient place, but the electric lock is mounted in the door jam, replacing the existing strike plate. The total cost of the three units was approximately $550.

Integrated Circuit Description

MC145026

This encoder serially transmits nine bits of trinary data as defined by the state of the A1/D1-A9/D9 input pins. These inputs may be in either of three states (O,1, OPEN) allowing 39 = 19,683 possible codes. The transmit sequence is initiated by a low level on the TE input pin. Each time the TE input is forced low the encoder outputs two identical data words. Between the two data words no signal is sent for three data bit pulse widths. If the TE input is kept low, the encoder continuously transmits the current data word.

Each transmitted data bit is encoded into two data pulses. A logic zero is encoded as two consecutive short pulses, a logic one as two consecutive long pulses, and OPEN is a long pulse followed by a short pulse. The input state is determined by using a weak output device to try to first force each input low, and then high. If only a high state results from the two tests, the input is assumed to be hard wired to VDD. If only a low state is obtained, the input is hard wired to VSS. If both a high and a low can be forced at an input, it is assumed to be open and is encoded as such.

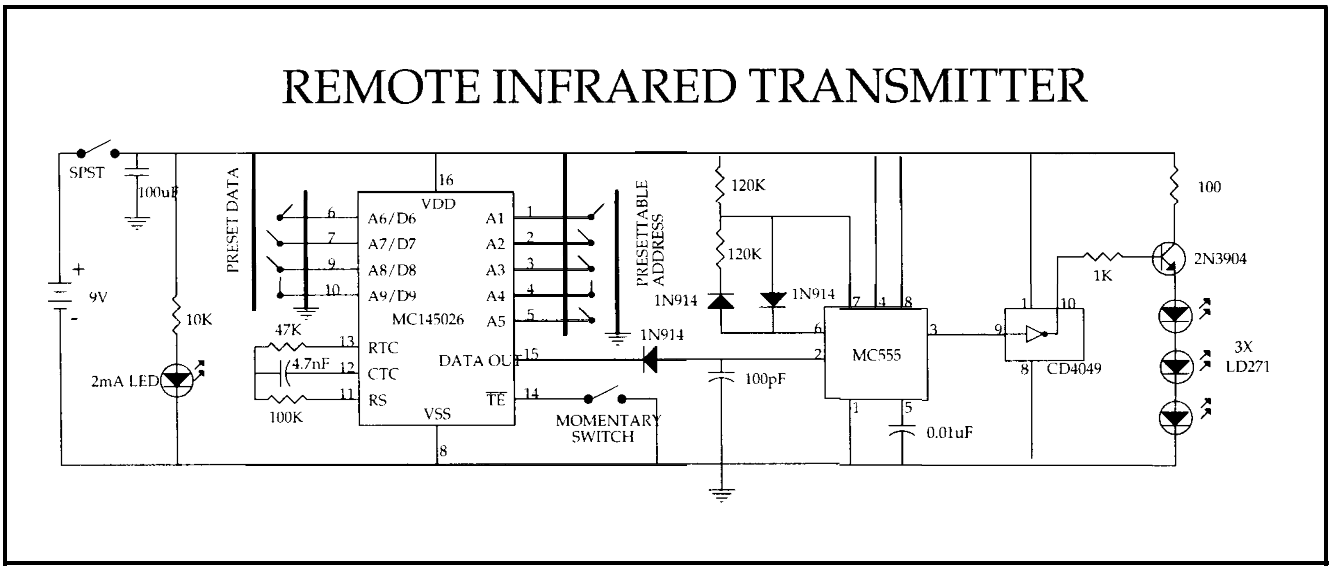

Figure 7.5. Schematic of the Remote Infrared Transmitter.

The TE has an internal pull-up device so that a simple switch may be used to force the input low. While TE is high the encoder is completely disabled, the oscillator is inhibited, and the current drain is reduced to quiescent current. When TE is brought low, the oscillator is enabled, and the transmit sequence begins. The inputs are then sequentially selected, and determinations are made as to the input logic states. This information is then serially transmitted via the DATA OUT pin. Transmission must always be initiated by using the TE pin rather than by holding TE low and applying power to the device because an internal reset occurs after the first transmit sequence.

MC145027
This decoder receives the serial data from the encoder and outputs this data, if it is valid. The transmitted data, consisting of two identical data words, is examined bit by bit as it is received. The first five bits are assumed to be address bits and must be encoded to match the address input at the receiver. If the address bits match, the next four (data) bits are stored and compared to the last valid data stored. As the second encoded word is received, the address must again match, and if it does, the data bits are checked against the previously stored data bits. If the two words of data (four bits each) match, the data is transferred to the output data latches by the Valid Transmission(VT) pin and will remain until new data replaces it. At the same time, the VT output pin is brought high and remains high if either an error is received or until no input signal is received for four data bit times. Although the address information is encoded in trinary, the

data information must be either a one or a zero. A trinary (open) is decoded as a logic one.

MC145028

This decoder operates in the same manner as the MC145027 except that nine address bits are used and no data output is available. The VT output is used to indicate that a valid address has been received. Although address information is normally encoded in trinary, the designer should be aware that, for the MC145028, the ninth address bit (A9) must be either a one or a zero. This part, therefore, can accept only 2 X 38 or 13,122 different codes. A trinary (open) A9 is interpreted as a logic 1. However, if the encoder sends a trinary (or logic 1) and the decoder address is a logic 1 (or trinary) respectively, the valid transmission output length is shortened to the R1 X Cl time constant.

Infrared Temperature Controller

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INTRODUCTION

The infrared temperature controller is a serially activated controller that is designed to be interfaced with an infrared remote controller. The temperature controller consists of four basic units all contained in one package; the infrared receiver, the digital-to-analog converter, the display circuit, and the actual control circuit. The remote controller is designed to transmit infrared pulse code modulated (PCM) signals that activate the temperature control circuit. This enables one to have complete control over the temperature in a room from a single location.

SUMMARY OF IMPACT

The Temperature Controller was designed to aid handicapped people to control the temperature of their surroundings. A disabled person is now able to adjust the temperate of a room by himself conveniently through the use of the infrared remote transmitter/controller.

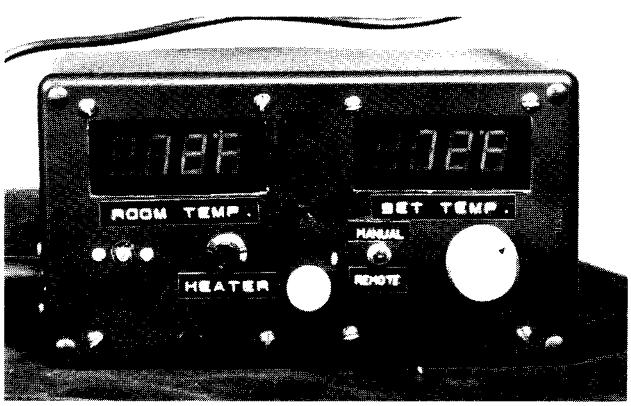

Figure 7.6. Infrared Temperature Controller.

TECHNICAL DESCRIPTION

Temperature Controller

The Temperature Controller is shown in Fig. 7.6, and it's circuit schematic is given in Fig. 7.7. The temperature controller, a serially activated device, acts primarily as a receive unit. The transmitted PCM infrared signal, transmitted by the main controller at 1.8kHz, is detected by the infrared phototransistor in the receiver. This signal is then fed to the remote control amplifier-detector (MC3373) where it is detected and amplified. After detection and amplification, the signal is amplified further by a 2N3904 transistor and then passed through two inverters (CD4049) which correct the shape of the wave form. The signal is then sent to the remote control decoder (MC145027) which receives the serially transmitted 9-bit word and interprets the first five bits as address and the last four bits as data. If the first five bits of the 9-bit word match the preset address, then the last 4 bits (pin's 12,13,14 and 15) appear in parallel at its data outputs.

In order to increase the set temperature range, the 4 data bits (pins 12 through 15) of the decoder are sent into the inputs of a Quad D Latch (HCF4042B) where pin 15 is used as the enable pin and the other three bits remain as data. When the enable is low, the Quad D Latch outputs the same three data bits that are set at its inputs. When the enable is high, however, the outputs are latched at wherever the data inputs are at the particular moment that the chip is enabled. Therefore, when the enable is high the three input data bits can be varied while the three data outputs remain latched, thus providing a total of six different data bits. This allows a possible number of 26 or 64 different temperature settings.

The six digital data bits are then converted to an analog voltage by means of a digital-to-analog converter (AD557). This analog voltage is offset by 500mV using a dual BiFET operational amplifier. This offset can be varied by a potentiometer and allows for the set temperature to be changed between 50 and 113 degrees Fahrenheit in one degree increments. This analog voltage is then displayed digitally as a three digit decimal number with seven-segment displays. This is done by using a 3 1/2 digit analog-to-digital converter (ICL7107) as a digital panel meter to display the analog voltage as the set temperature in degrees Fahrenheit. The analog voltage, representing the set temperature, is then compared to the output voltage of the temperature sensor (LM34), which is proportional to the room temperature, by means of an MC741 operational amplifier implemented as a comparator with hysterisis. The room temperature is also displayed separately in the same fashion as the set temperature. The output of the comparator is then connected to the base of a Darlington transistor pair whose collector is connected to a +5 Volt relay which activates the heater. The purpose of the Darlington transistor pair is to amplify the comparator's output current to meet the relay's nominal current requirement. Thus, when the set temperature is higher than the room temperature, the comparator output goes high which then causes the relay to close the heater circuit and turn on the heater. However, when the set temperature is lower than the room temperature, the comparator's output goes low, which causes the relay to open the heater circuit and shut off the heater. The hysterisis is currently set at approximately 3 degrees Fahrenheit by a potentiometer and is used in the on/off control to avoid frequent cycling of the heater, which can cause inefficient operation and possible damage to the rest of the system.

INTEGRATED CIRCUIT DESCRIPTION

MC3373

The MC3373 is a remote control amplifier-detector. It is intended for application in infrared remote controls. It provides the high gain and shaping needed to couple the signal from an infrared receiving diode or transistor to the tuning control system logic.

CD4049

The CD4049 provides six inverting buffers with high current output capability suitable for driving high capacitance loads. Since input voltages in excess of

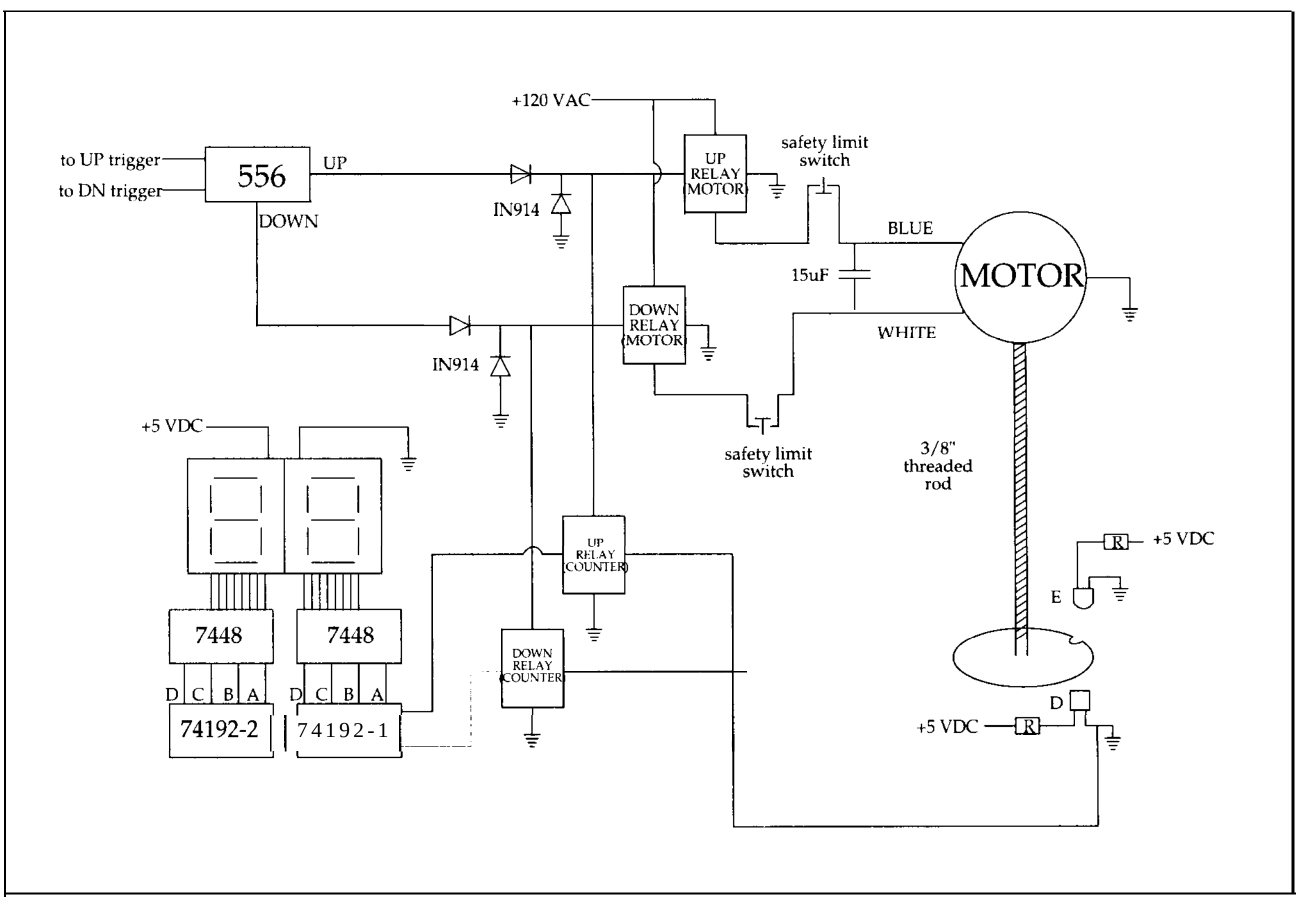

Figure 7.7. Schematic for the Infrared Temperature Controller.

the buffer supply voltages are permitted, the buffers may also be used to convert logic levels of up to 15V to standard TTL levels.

MC145027

This decoder receives the serial data from the encoder and outputs the data if it is valid. The transmitted data, consisting of two identical data words, is examined bit by bit as it is received. The first five bits are assumed to be address bits and must be encoded to match the address input at the receiver. If the address bits match, the next four (data) bits are stored and compared to the last valid data stored. As the second encoded word is received, the address must again match. If this is the case, the data bits are checked against the previously stored data bits. If the two words of data (four bits each) match, the data is transferred to the output data latches by valid transmission (VT) signal and will remain latched until new data replaces it. At the same time, the VT output pin is brought high and will remain high until an error is received or until no input signal is received for four data bit times. Although the address information is encoded in trinary, the data information must be either a one or a zero. A trinary (open) will be decoded as a logic one.

HCF4042B

The HCF4042B is a 4-bit latch with four data inputs (DO to D3), four buffered latch outputs (00 to O3), four buffered complementary latch outputs (0'0 to 0'3) and two common enable inputs (EO and El). Information on DO to D3 is transferred to 00 to 03 while both EO and El remain in the same state. When EO and El are different, DO to D3 do not affect 00 to 03 and the information in the latch is stored. The exclusive-OR input structure allows the choice of either polarity for EO and El.

AD557

The AD557 DACPORT is a complete voltage-output 8-bit digital-to-analog converter that includes output amplifier, full microprocessor interface and precision voltage reference on a single monolithic chip. No external components or trim devices are required to interface an 8-bit data bus to an analog system with full accuracy. The low cost and versatility of the AD557 DACPORT are the result of continued development in monolithic bipolar technologies.

The complete microprocessor interface and control logic are implemented with integrated-injection logic (I2L), an extremely dense and low-power logic structure that is process-compatible with linear bipolar fabrication. The internal precision voltage reference is the patented low-voltage band-gap circuit that permits full-accuracy performance on a single +5V power supply. Thin-film silicon-chromium resistors provide the stability required for guaranteed monotonic operation over the entire operating temperature range, while laser-wafer trimming of these thin-film resistors permits absolute calibration at the factory to within ±2.5 LSB; thus, no user-trims for gain or offset are required. A new circuit design provides voltage settling to ±1/2 LSB for a full-scale step in 800ns.

ICL7107

Intersil's 7107 is the first IC to contain all the active circuitry for a $3\frac{1}{2}$ digit panel meter on a single chip. The 7107 is intended for use with light-emitting diode (LED) displays. In addition to a precision dual slope converter, the circuit contains BCD to seven segment decoders, display drivers, a clock and a reference. To build a high performance panel meter (with auto zero and auto polarity features) it is only necessary to add a display, 4 resistors, 4 capacitors, and an input filter if required.

LM34

The LM34 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to Fahrenheit temperature. The LM34 has an advantage over linear temperature sensors calibrated in degrees Kelvin because the user is not required to subtract a large constant voltage from its output to obtain convenient Fahrenheit scaling. The LM34 does not require any external calibration or trimming to provide typical accuracy's of $\pm\frac{1}{3}°$ F at room temperature and $\pm\frac{1}{2}°$ F over a full -50 to +300° F temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM34's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with unipolar or bipolar power supplies. As it draws only 70 µA from its supply, it has very low self-heating, less than 0.2'F in still air.

INSTRUCTIONS FOR OPERATION

The desired room temperature is set using the remote control. The first five address bits (Al to A5) are preset in the temperature co ntroller as 1, 0, No

Connect, 1, 0 respectively. The last four data bits are arranged as follows: D6 is the enable, D7 is the MSB of data, D8 is a data bit, and D9 is the least significant bit. The temperature is entered as a 6-bit binary number. The lower three bits are set with the enable low and then transmitted. Then the enable is set high, and the same three data bits are transmitted again. Next, the enable is left high and the upper three bits are transmitted; thus, setting the desired temperature.

*NOTE: A 500mV offset is added to the analog value representing the set temperature. Therefore, you must subtract 50 from the decimal value of the temperature you desire and then enter this number as a 6-bit binary number.

Automatic Window Opener For The Home

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INTRODUCTION

An automated device for opening and closing windows in the home has been constructed. The basic mechanism consists of an AC motor coupled to an electronic controller that allows the window to be opened or closed to any extent specified by the user. The motor is attached to a long shaft with a screw thread of a pitch of 16 turns per inch. This thread is set through a bracket attached to the lower window. As the thread turns, the force exerted on the bracket pushes the window in the desired direction. The fine pitch of the thread provides torque amplification that enables the motor to easily raise the window to any position without exerting excessive force. The entire device is reasonably compact but does, however, require a permanent modification of the window sill and window assembly in order to achieve the implementation. A sample window with system installed is shown in Fig. 7.8.

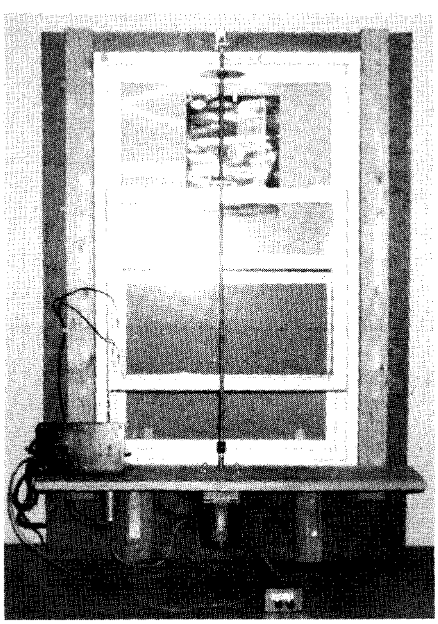

Figure 7.8. Infrared Temperature Controller.

SUMMARY OF IMPACT

The primary target group for this project is handicapped people or people with limited mobility or strength. This project is best suited for someone who is confined to a bed or a wheelchair and is unable to open or close windows manually. It could also be useful for older patients whose movements and strengths are limited. The device is currently set up for either push button or relay input so that it may be manually controlled or can be interfaced to a voice activated computer system that has previously been developed and reported by our group at NJIT. This device should ease the process of routine window adjustment for the disabled individual.

TECHNICAL DESCRIPTION

The overall block diagram of the circuit is shown in Fig. 7.9. The heart of the control circuit is the 556 dual timer chip. The UP(DOWN) trigger inputs on the 556 are wired HIGH, 12 VDc. The trigger inputs are connected to a standard push button switch with one end grounded. The inputs are additionally brought out to the side of a box to a connector that establishes a relay control interface that can be used with the voice activated environmental control system developed at NJIT. When the user pushes the UP(DOWN) button on the controller, the trigger input is momentarily shorted to ground. This energizes the external RC timing circuit of the 556 that sets the UP(DOWN) output pin HIGH for a preset amount of time (in a final production version a potentiometer would be installed in place of the fixed resistor to allow the user to adjust this time interval or window step length).

This long duration pulse on the output pulls in the contacts of the UP(DOWN) relay allowing 120 volts AC to be applied to the motor. In the event that the control circuitry fails, there are two safety limit switches that will interrupt power to the motor and stop the motor from raising or lowering the window further.

As the motor spins it rotates a disc connected to the threaded rod. This disc has a cut-out on the circumference that allows infrared radiation (IR) to pass through twice every revolution. This IR signal is sensed by a detector on the underside of the disc and sends a 5V DC pulse to the UP(DOWN) counter relay. The output pulse from the 556 described above also pulls in the contacts of this relay and allows the 5V pulse to be sent to two 74192 counters connected in cascade to produce a least significant bit (LSB) and a most significant bit (MSB).

The 74192 pair sends binary coded decimal (BCD) to a pair 7448 BCD-to-seven segment display drivers that drive a pair of 7-segment displays. These displays give the user an approximation of where the window sits in its tracks; the higher the number the higher the window. The production version would most likely have the numeric display in the hand held remote controller for easier use and visualization. The entire cost of the device was $475.

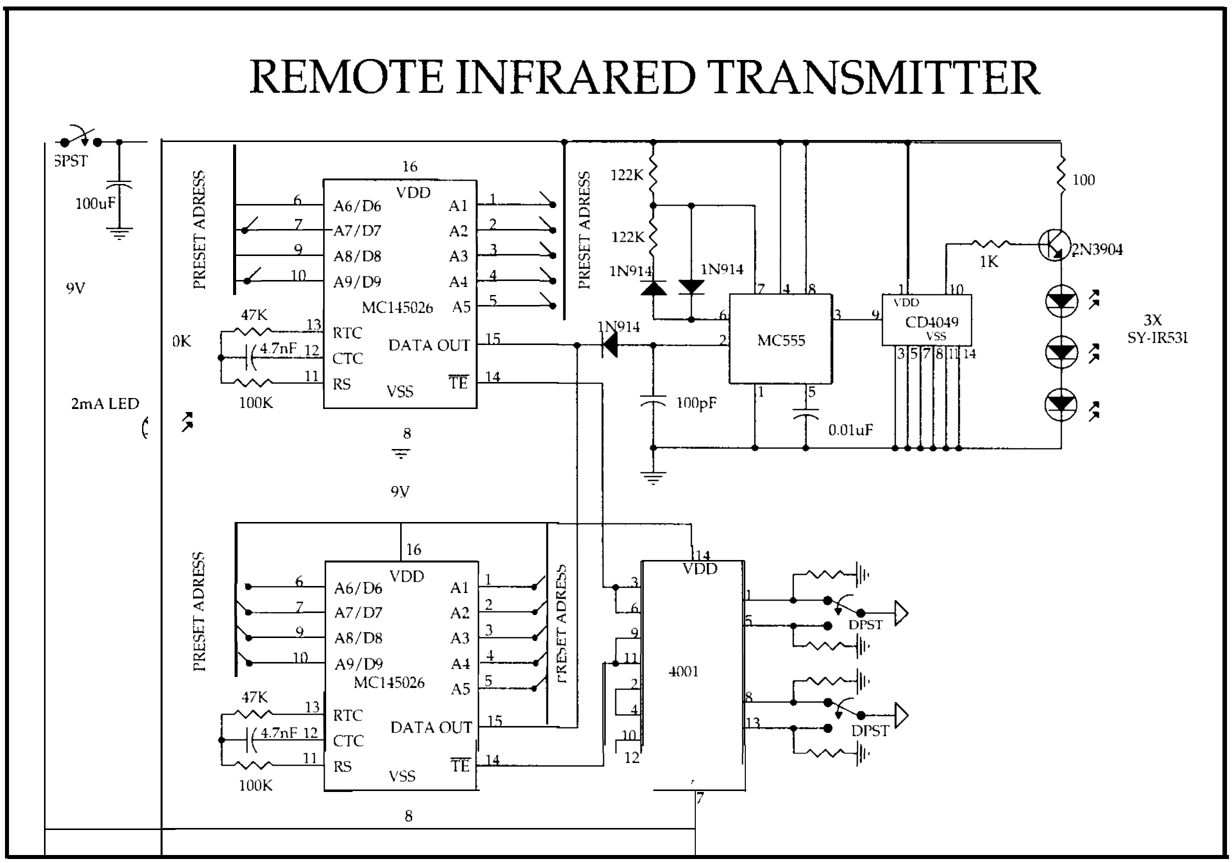

Figure 7.9. Schematic of the Remote Infrared Transmitter

Infrared Intercom Controller

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INTRODUCTION

The automatic intercom controller is a serially activated controller that is designed to be interfaced with an intercom system. It consists of two basic units: the main controller and the receiver/relay controller. The main controller is programmed to transmit the infrared or relay signals that activate the intercom control circuitry. This enables one person to have complete control over the call, listen and push-to-talk buttons from a remote device.

SUMMARY OF IMPACT

The automatic intercom controller was designed to aid physically disabled people in controlling the operation of an intercom system. A disabled person is now able to control the call, listen and push-to-talk buttons from a remote device. The device is shown in Fig. 7.10.

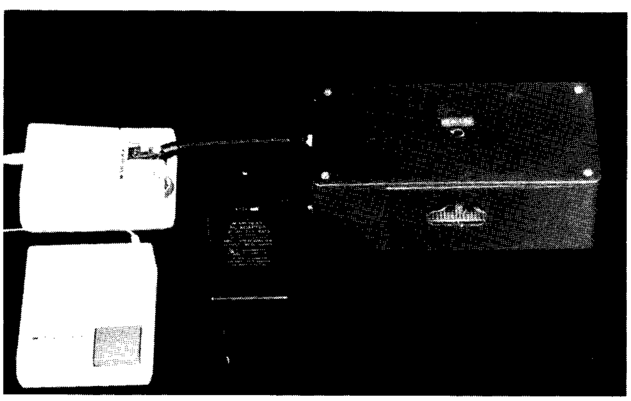

Figure 7.10. Infrared Intercom Receiver and Intercom Interface.

TECHNICAL DESCRIPTION

Infrared Remote Transmitter:

This device, illustrated in Fig. 7.11, is capable of transmitting two separate preprogrammed addresses depending upon which of the two encoder chips (MC145026) is activated. The transmit sequence is enabled by a low level on the TE input of the chip that is supplied by a debounced switch. The address is pulse code modulated (PCM) and transmitted by the infrared emitters at a frequency of 2KHZ. The design of this transmitter is virtually identical to that described for the infrared shade and door lock control.

Infrared Receiver/Relay Controller:

This unit, which is illustrated in Fig.'s 7.11 and 7.12, receives and decodes the encoded infrared signal from the main controller. The overall receiver design is similar to that of the shade and door lock control. The infrared photo diode detects the transmitted signal. This signal is then fed to the remote control amplifier decoder (MC3373) where it is decoded. After decoding, the signal is amplified by a 2N3904 transistor and then passed through two inverters (CD4049) which correct the shape of the signal. The signal is now sent to two remote control decoder chips (MC145028). The chip whose preset address matches the decoded 9 bit transmitted word will provide a temporary high at its valid transmission output. This high level will trigger a flip-flop (4013) which in turn will control the position of a relay. One relay will control the call button of the intercom. A second relay will control the listen/push-to- talk button.

Both units have all components mounted in black boxes. The transmitter power is supplied by an internal 9 Volt battery. The receiver/relay controller power is supplied by an external 9 Volt power supply. The total cost of the two units was approximately $250.

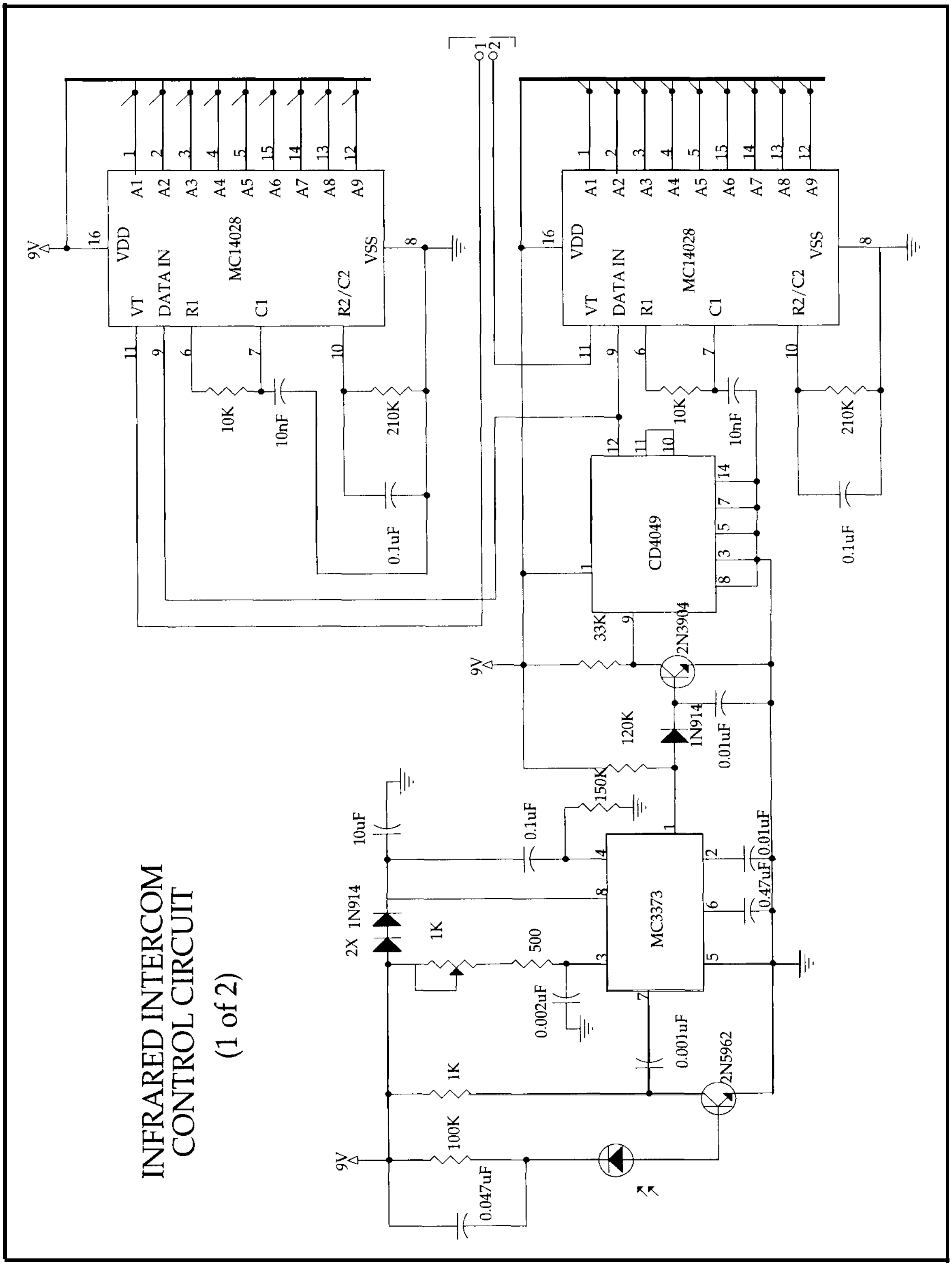

Figure 7.11. Infrared Intercom Control Circuit, part I.

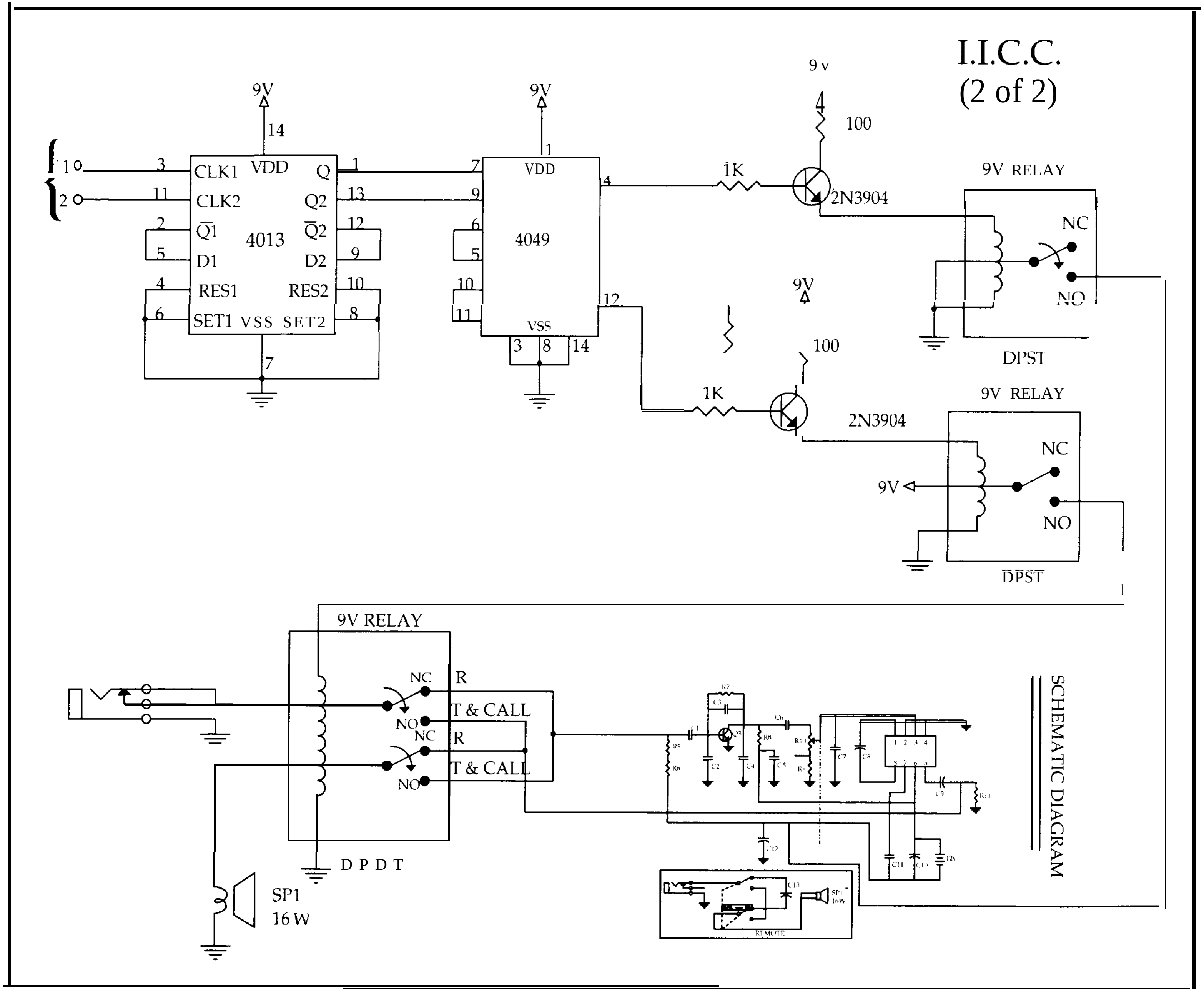

Figure 7.12. Infrared Intercom Control Circuit, part II.