

DTMF Signal Controlled House Monitoring System (HMS)

1. Introduction

Nowadays many people are looking for the methods to improve life conditions, comfort and at the same time the simplicity of handling with domestic electric appliances. Fewer skills are required – bigger popularity and fewer problems even for not prepared user. We can use PC for many purposes. Among them there is a need to mention connection to Internet network using telephone line, cable TV, ADSL or radio modem, make LANs, WANs and different PC based monitoring and security systems. But what is the proper decision for the system of domestic level? The solution is to employ low-complexity and low-cost systems, which is capable to perform certain functions designed and programmed under the requirements of the user.

This simple security system satisfies the main market conditions to be attractive for consumers. The main advantages are mobility, small size, low-power consumption, low-cost, possibility to adopt system to new requirements by changing the main program. Ability to connect the device to personal computer for data storage could be also available. The device includes the standard and widely spread electrical elements, thus implementing massive production.

Options that will attract people and companies to choose telephone line communication:

- Low price of installation and service,
- Simplicity of usage,
- Comfortability (phone line sockets available in every flat or house),
- Compatible with all phone line networks,

Telephone standards world is fragmented. Typically each country has its own standards because of both the historical roots of the phone service and the desire to protect the local phone market from outside competition.

Basically the telephone systems work in the same way in different countries, but there are some differences, which can mean that devices designed for one country, do not meet the regulations of other country and work poorly or not at all. The differences in local technical standards range from minor to severe and affect many of the signaling conditions on local loops.

Surprisingly, a telephone is one of the simplest devices we have in our house. It is so simple because the telephone connection to our house has not changed in nearly a century. Even

in the case have an antique phone from the 1920s, you could connect it to the wall jack in your house and it would work fine.

The system is based on Microchip PIC Microcontroller PIC16F84. It employs the Flash memory, which can be programmed up to 1000 times. We use the PICBasic compiler. Also we could write program using assembly language PASM, but it could be used mainly for optimization of source program.

2. Task Analysis

2.1. The purpose of the circuit

Purpose of our course project is to develop DTMF signal controlled house monitoring system based on PIC Microcontroller. The device is connected to phone line and is controlled by DTMF signal emitted by DTMF encoder in stationary or mobile phones. In presence of incoming call the device pick-up the phone and answer the call connecting to the line. User can press buttons and control the system remotely. Function of keys should be known initially (read manual in appendix B). The functions are:

- speakerphone monitoring (you can listen the sound in remote premise),
- room temperature monitor (sound indication),
- output for heating switch (we can turn on/off the external heating),
- input for security check (if it was alarmed, the input must be high),
- alarm controller (we can activate alarm system manually),
- automatic pick-up (raises after 4 seconds or could be changed),

- automatic hung-up (if no buttons are pressed more than 1 minute, it protects from accidental disconnection from the system, for example out of radio coverage in mobile networks),
- monitoring indication is followed by sound signals (read manual).

2.2. Short Telephone Line Analysis

Plain old telephone systems (POTS) telephone line consists of one wire pair, which carries full duplex audio and the operating current for the telephone. The telephone connected to line is powered from current limited 48V power source, so phones on-hook, should measure around 48 volts DC. Practically the operating voltages of telephone systems can vary from 24V to 60V depending on the application, although 48V nominal voltage is the most commonly used.

When telephone is put off-hook the voltage between wires going to telephone drops down to the 3 to 9 volt range and typically a current of 20-60 mA will flow through the telephone. The typical operating current range is 20-35 mA. Any more than 55 or 60 mA and it might harm the phones. So the telephone equipment itself does not need any high voltages to operate. The remaining voltage drop from 48V to 3-9 volts occurs over the copper wire path and in the telephone central electronics. This high voltage is needed in the beginning because the length of the telephone line can be many kilometers, which means lots of wire resistance on the way to drop the voltage. Typical telephone DC resistance around 180 ohms and AC impedance is typically somewhere around 600 ohms. Typically the telephone central provide from 200 to 400 ohms of series resistance to protect from short circuits and decouple the audio signals.

The typical signal to noise ratio of a telephone line is approximately 45 dB or somewhat less. Telephone line signal to noise ratio is not as easy to quantify because noise comes in many forms, such as electrical interference from fluorescent fixtures or hiss from the many amplifier stages in the voice path. Speech correlated noise can be introduced from non-linear speech coding and compression algorithms. Crosstalk from other conversations is another form of noise.

To ring the telephone, the telephone company momentarily applies a 90 V RMS 20 Hz AC signal to the line. Even with a thousand ohms of line resistance, this is still a bit of a shock. The ring signal is much the same, worldwide. It is around 90V at a frequency between 16 2/3 Hz and 50Hz (20-25 Hz quite common). But its timings are wildly different, as are the return tones it generates.

While digital telephone lines are quickly coming to the telecom field, it seems that analogue telephone lines are still here to stay for a long time. Strangely enough, fax machines and modems will keep analog lines available even in buildings with ISDN and digital PBXs.

To ensure the proper functioning of the device we can set certain limits in operating regimes of the device. This is caused by the obvious simplicity of the circuit. There are no elements ensuring constant output or operation principles in the wide range of line parameters. In the case the circuit is not working properly we must check rather it satisfies the following requirements:

Mode	Voltage
Stand-by	55.2V
Talk	11.0V
Ring	44-48V ~24V

Table 1. Requirements for telephone line

2.3. Analogical Circuits Worldwide

The popularity of Smart House concept is rapidly increasing in the most developed countries. In general this system includes domestic electric appliances networking and united information and security system. This concept allows manipulating the house parameters (heating system, temperature and humidity monitoring, common system access to Internet, cable TV and radio, information access between all the devices (that can perform of course such an operation), etc). Of course this system allows different monitoring devices to be connected. The user can hear what is going on in the house or found out the exact position of the noise source in the system. Temperature monitoring can be also used for security improving.

We could speak about analogical systems, but only in action simplicity. The concept of Smart House is very expensive. Sometimes the costs of installation of such a system is more than the total cost of the house used for it. Touch screen LCD displays are often used inside the house for system interaction with user. In such a case very complex soft for manipulating all the parameters of the house must be used, thus resulting in increasing price. The simpler version can be done, if neglecting the usage comfortability we use simple PC to control the devices around us. In this case some problems can occur because of the need to adopt the freeware soft to particular systems or to buy it separately. In this case comfortability is decreased.

Talking in general about the possibility of distant house control and monitoring, we can consider 3 possibilities: control HMS through Internet, mobile phone (system is connected to mobile phone) or simple telephone line. In the last 2 cases we can use DTMF signal to manipulate the system parameters. Each way has its advantages and disadvantages.

Advantages of the Internet connection case is reliability, speed of operation, almost no limitations in functionality of the system (the limit is set up by the programmer only), GUI (allows for user to work in the comfortable OS) etc. This method is widely spreading, even there are some specific disadvantages. The main of them is comparably high cost. Internet requires from system to be more complex, use some standard hardware and software elements. Also old or out of need PC can be used for this purpose. But summing up system with some kind of PC, legal operation system and Internet on line will results in quite high cost. Also the user must ensure the access to Internet at the time he wants to check the system, comparably high power consumption (can be critical for some specific application, where we need to ensure the proper system working even when power is off for some period) and big dimension. Also we can state that the reliability of the PC in such a system can be a critical factor (hard disk working time limit).

There are systems that use connection of the mobile phone to inform the consumer about the motion, vibration etc. inside the room. Because of very small dimensions these systems have very narrow specification, can work only with certain mobile phone (because are adopted to certain version of software), use mobile phone number. Because of very small dimensions they are quite expensive that exceeds their functional value. Among the advantages we could mention their mobility and low power consumption. Usually they can use the battery of the mobile phone as the source of the energy for a certain time, but for a longer period constant power supply must be found. There is almost no possibility to improve their characteristics or functionality.

At last there is a need to mention the telephone line based system. It is a cheap (single-task system) that performs the operations you need, Internet-free control and small power requirements comparing with complex one based on PC. There is also a possibility to reprogram the system in the certain range, changing the periods of task performing; enabling or disabling some initially programmed functions, setting up the password etc. The main disadvantage is a subscriber number, possible phone line distortions and limits of available functions (in general this disadvantages can be of mobile phone based systems also), no graphical and sometimes vocal implementation (it requires from the user to have some initial knowledge about control). System protection from unauthorized access is a common problem for the both cases.

Some of the problems can be solved using more advanced microcontroller for the device, but in general the disadvantages are caused not by the certain device, but by the principle of

operation based on sound, where the information representation isn't as obvious as in the GUI systems.

In the following chapters we will try to analyze the principles of operation of such a device, the algorithm of working and some internal calculation

2.4. Schematic Production

In the process of schematic production we have tried to use as more similar elements as possible. As the source of the control the PIC16F84 was used. It allows rewriting the internal program, thus experiments can be performed without any damage. For this purpose there is 1Kb of Flash memory for program code. In the case of massive production after the development of such a system, there can be used PIC microcontrollers with not rewritable memory (PIC16CR8X) having the same structure. The microcontrollers produced by Microchip are comparably old, thus their functional abilities were tested by the time. There is a huge amount of software for programmers available that result in simplicity of programming.

Additionally to the device the programmer was created. For the decoding of the DTMF signals external hardware DTMF decoder was used. Of course there was a possibility to make DTMF decoder by program inside the PIC, but then the functionality would be less because of small program memory. For the detailed information about the parameters and characteristics features of the PIC and DTMF decoder look Appendix C and D.

Also the power source for 5V were done and inserted as the part of the system. It was done internal because of the system to be more stable and reliable. For all the other circuit parts the standard and quite cheap elements were used. As the indication of the device functioning LED were used at several outputs as indicators. In general here is no need of them for proper device operation, but the purpose was to make the device more friendly and obvious functioning principles.

In order to increase the volume of memory some external chips with I2C interface can be used (optionally for future circuits with larger amounts of sound).

The circuits for auto-rising and sound to the telephone line are similar to those that are used in stationary telephones with ability to determine calling number. For the particular explanation of the circuit elements and entire calculations look for the chapter 4.

3. Structural (Functional) Scheme

3.1. Creation of the Structural (Functional) Scheme

As the main controlling device we have chosen the PIC controller (in general any other controller with similar functionality and memory volume can be used). As the device that forms digital input DTMF decoder was chosen. It has to form unique digital combination that will be accepted by the PIC controller. For each DTMF signal there is a combination that can be uniquely recognized by the controller and will cause certain operation to be performed. There is no specific requirements for the DTMF decoder because in the interested level they are general the same. According the obtained digital signal controller set up some output to high or low level depending on program. Of course there is always possibility to use simple logic for such a simple operation, but the resulting problem will be obtained. Even small amount of logic circuits with certain fixed operation will require several different logic circuits and more place on the board. The resultant circuit becomes more complex and possibility of mistake in design and production also increasing. Using circuits of the fixed logic we can't reprogram the device even in a small range. For some cases it will decrease the reliability of the system and possibly increase the power consumption.

Heating control by the definition must remain on/off even when the interaction between user and system is finished. The output to alarm control is done with the assumption that external device will be capable to turn on/off by the given pulse. Also the construction of the external microphone can be improved in order to increase the sensitivity by adding high quality amplifier.

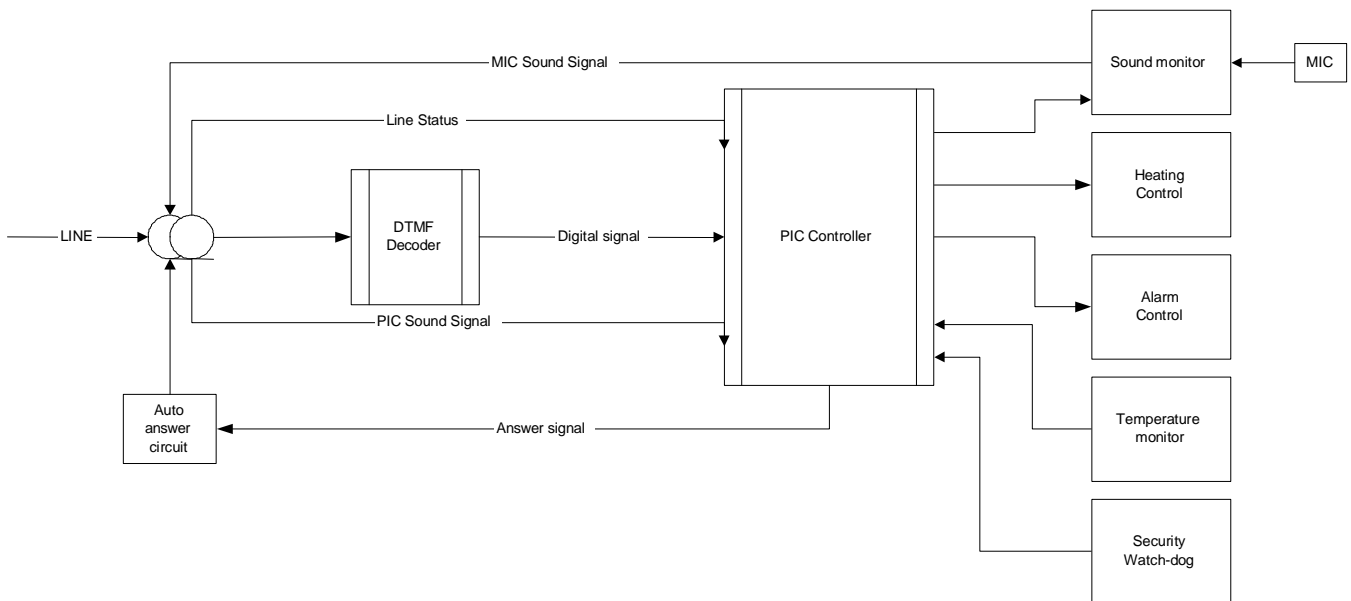


Fig.1 Structural (functional) scheme

3.2. Discussion of the Structural (Functional) Scheme

The interaction between the user and device take place through the simple telephone line. This medium is capable for the transmission of the all control signal and information. When the user is calling up there is an AC voltage in the circuit of approximately 24V. According to the line status connection PIC determines that there is a call and after some time hook up the line. This is done through the auto riser circuit. When the call is finished, it puts down the line. After the line is hooked up, DTMF decoder sends digital 4-bit signal that corresponds to the certain bottom to the controller. According this digital signal the controller performs some operations. Some of these operations are followed by the PIC sound signals to line. The controller can enable sound monitor connected to the microphone at the room. Then the obtained sound signal is sent up to the line in the similar way as the PIC sound signal. Also the PIC can some enable heating device and hold it enabled until the time when it will be o turned off by the user. The device can turn on alarm system. In both cases external alarm and heating devices must be constructed according the function scheme of the PIC.

The simple temperature monitor system is connected to PIC. Using different sound signal PIC can sound the user about the temperature. Also there is a security watchdog that must inform situation with security system: was it activated during the time user is away or not. All the information about the peripheral devices is transformed to the form of the sound signals and then directed to the user.

After the receiving signal to turn off, PIC controller disables auto-riser circuit. Talking in general the amount of the output devices that can be controlled, is limited by the number of available pins and memory that contains the operational program. We can take more advanced controller for increased complexity system.

4. Electrical Scheme

4.1. Electrical Scheme Analysis

First we will consider the connection of the PIC controller to another elements of the circuit.

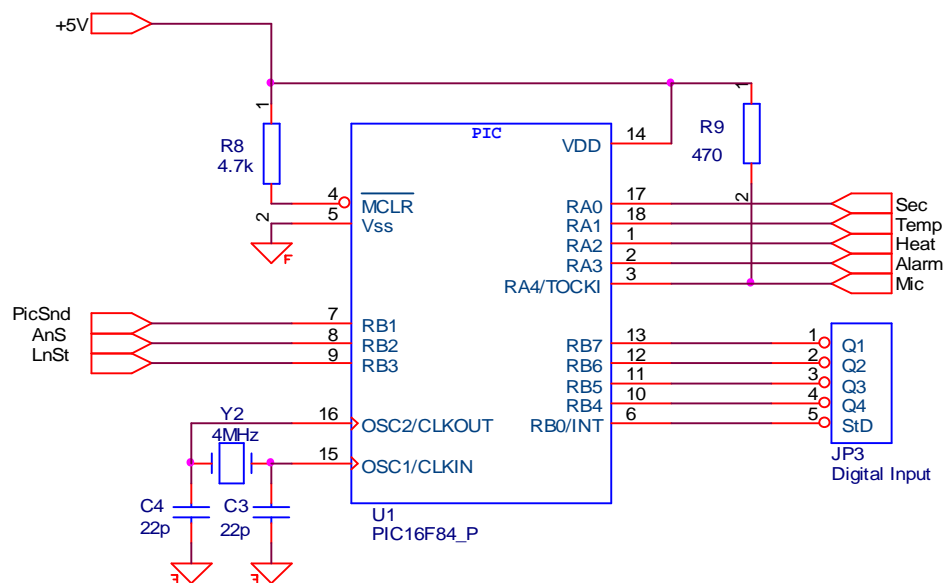


Fig.2. PIC controller circuit

There are 13 I/O pins with individual direction control. The program sets up the status of the pin. Four pins from RB4 to RB7 are set to be digital input from the DTMF decoder. Four of PORTB's pins, RB7:RB4, have an interrupt on change feature. Only pins configured as inputs

can cause this interrupt to occur (i.e., any RB7:RB4 pin configured as an output is excluded from the interrupt on change comparison).

For a change on the I/O pin to be recognized, the pulse width must be at least T_{cy} ($4/f_{osc}$) wide. In our case DTMF decoder sets up a constant digital output until the new signal appears.

The clock input (from OSC1) is internally divided by four to generate four non-overlapping quadrature clocks. In general the PIC16F8X can be operated in four different oscillator modes. We use XT mode (Crystal/Resonator). In this mode a crystal or ceramic resonator is connected to the OSC1/CLKIN and OSC2/CLKOUT pins to establish the oscillation

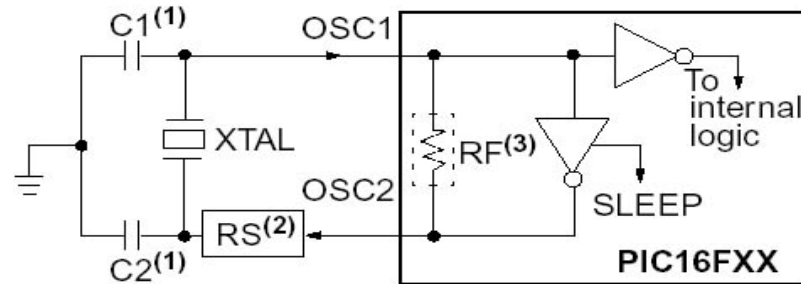


Fig.3. General form of connection of oscillator

Recommended capacitor selection for the oscillator is 15-33pF for both C1 and C2 in the case of frequency 4MHz. Higher capacitance increases the stability of oscillator, but also increases the start up time. Rs may be required at our mode to avoid overdriving crystals with low drive level specification, but in our case we can use the oscillator without it.

Pins RB1, RB2 and RB3 are used as outputs for PIC sound signals, answering function and as input for line status determination. They are internal software programmable weak pull up I/O pins.

$\overline{\text{MCLR}}$ is master clear (reset) input/programming voltage input. This pin is an active low reset to the device.

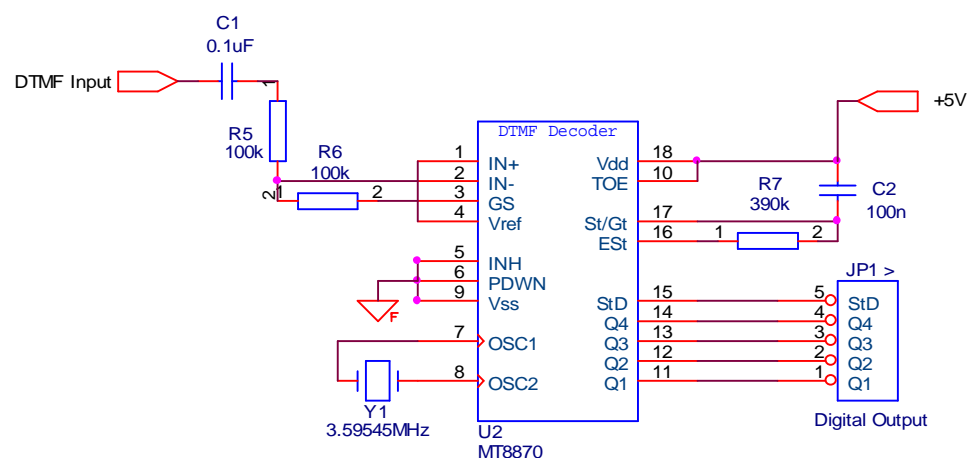


Fig.4. DTMF decoder circuit

It is a complete DTMF receiver with Low power consumption integrating both the bandsplit filter and digital decoder functions. The bandsplit filter section separates the high and

low group tones. It is followed by the digital counting section, which verifies the frequency and duration of the received tones before passing the corresponding code to the output bus. There is a minimum component count achieved by on chip provision of a differential input amplifier, clock oscillator and latched three-state bus interface.

OSC1 and OSC2 are corresponding clock input and output. A 3.579545MHz crystal connected between pins OSC1 and OSC2 completes the internal oscillator circuit.

Connecting TOE pin (Three State Data) to high logic level, it enables the outputs Q1-Q4 (the pin is pulled up internally). Q1-Q4 when enabled by TOE, provide the code corresponding to the last valid tone-pair received. StD pin presents logic high when a received tone-pair has been registered and the output latch updated; then it returns to low logic level. The other information about DTMF decoder pins can be found at the Appendix D.

The steering circuit works in reverse to validate the interdigit pause between signals. Thus as well as rejecting signal is too short to be considered valid; the receiver will tolerate signal interruptions (dropout) too short to be considered a valid pause.

The functional decode table can be found below. The table represents the information about the status of the pins corresponding to certain input signal of the decoder.

We have single end configuration, thus the op-amp is connected for unity gain and V_{ref} biasing an input at $\frac{1}{2} V_{DD}$. All information about the principles of operation of the DTMF decoder can be found at Appendix D

Digit	TOE	INH	Est	Q ₄	Q ₃	Q ₂	Q ₁
ANY	L	X	H	Z	Z	Z	Z
1	H	X	H	0	0	0	1
2	H	X	H	0	0	1	0
3	H	X	H	0	0	1	1
4	H	X	H	0	1	0	0
5	H	X	H	0	1	0	1
6	H	X	H	0	1	1	0
7	H	X	H	0	1	1	1
8	H	X	H	1	0	0	0
9	H	X	H	1	0	0	1
0	H	X	H	1	0	1	0
*	H	X	H	1	0	1	1
#	H	X	H	1	1	0	0
A	H	L	H	1	1	0	1
B	H	L	H	1	1	1	0
C	H	L	H	1	1	1	1
D	H	L	H	0	0	0	0
A	H	H	L	undetected, the output code will remain the same as the previous detected code			
B	H	H	L				
C	H	H	L				
D	H	H	L				

Table 2. Functional Decode Table
(L = logic low, H = logic high, Z = high impedance, X = don't care)

Below the simplest circuit of the programmer will be considered.

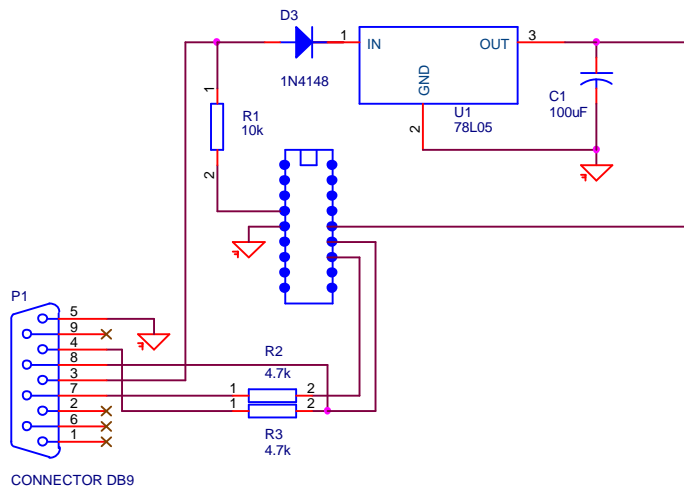


Fig.5. PIC Programmer circuit

This circuit was used to program the PIC 16F84 controller. The resistances are placed for current limitation. The capacitor C1 is required to stabilize the 78L05 output current (filter low distortions).

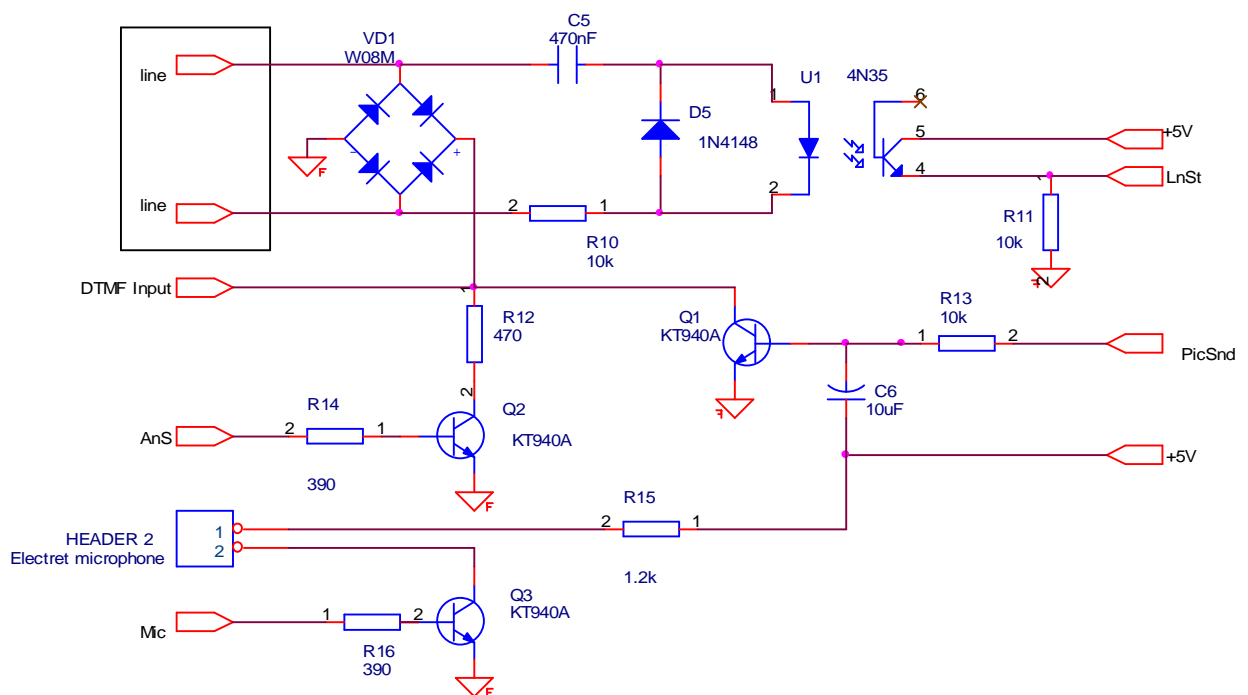


Fig.6. Auto riser and sound to line connection scheme

The rectifier was placed in the circuit to rectify the voltage taken from the line. The values of the resistors were taken to satisfy the condition of safe mode operation of the diodes. The resistors R14 and R16 that are connected to the bases of the appropriate transistors Q2 and Q3 limit the current from the pins Mic and AnS of the PIC controller. The transistor Q2 is working as the switch, where the high output of AnS opens it that decreases the resistance between the line and ground to the value slightly bigger than R12. It results in the line to be raised up.

Connection of the microphone is quite simple and standard, where through polarized capacitor is connected to transistor that amplifies the audio output to the line together with the signals caused by PIC controller. In our case the microphone is powered from a 5V power supply source through a resistor of 1.2k Ω . We have chosen the electret microphone because of its high durability; low cost and low power consumption.

For all transistors in the given circuit we have used KT940A because of availability and high value of power that can be dissipated on it (up to 1.2W). The detailed characteristics of the amplifiers and LED can be found additionally at Appendix E.

The transistor Q1 is acting as amplifier sending the sound to the line. If not making too high requirements to the sound quality, it is enough to inform the user about the situation.

The phototransistors optocoupler is used to separate the line status input of the controller from DC voltage in the line. For this purpose the capacitor is present in series with diode circuit of the optocoupler. In this case only AC voltage appears, that is a signal of ringing up. The diode opens the transistor and there is a high voltage level at the line status input causing the controller to turn on auto rise circuit. The resistor in series and diode must guarantee the proper operation of the circuit.

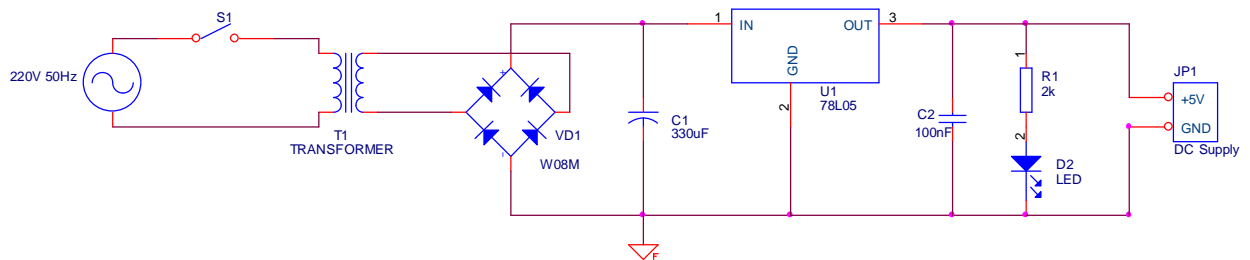
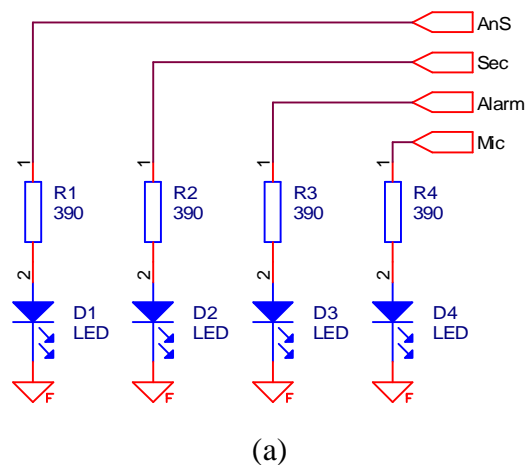
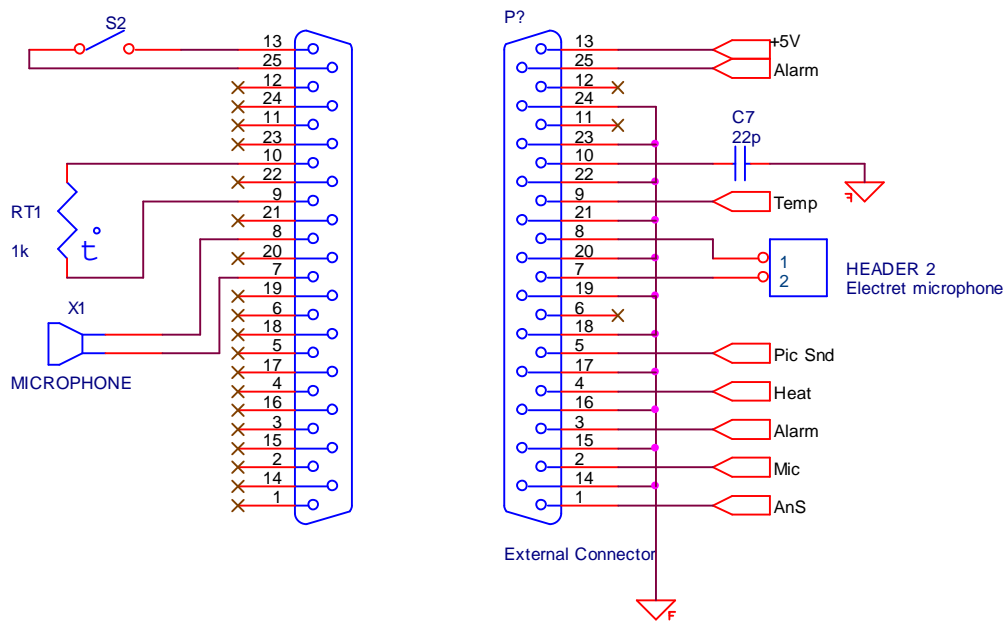


Fig. 7. The circuit of the power supply

The circuit of the power supply is quite simple. Standard 78L05 positive voltage regulator for 5V output voltage is placed. The capacitors are used in order to decrease the possible voltage oscillations.





(b)

Fig.8. LED indicators (a), external connector circuit (b)

The working principle of these circuits is quite simple. The operation of the temperature monitor is based on the assumption that in the certain range resistance of the thermistor changes linearly allowing us to make calculations of the temperature. The switch in the security check circuit plays the role of the separate distant security system to be activated or not. In the case of the security system to be activated, the switch is modeled as closed, causing high input voltage at Sec pin. Alarm pin directly turn off/on alarm system connected to it. The LEDs and appropriate resistances are placed only for making operation obvious and in general case can be omitted.

4.2. Investigation of the Electrical Scheme

The investigation of the circuit we will begin with analyzing the thermistor. The following table and graphs represent experimentally obtained values of the discrete PIC determined values.

Table 2. Investigation of out variable dependence on temperature.

Temperature	OUT variable levels
48.00	29.00
43.00	34.00
38.00	39.00
32.00	46.00
26.00	56.00
24.00	62.00
23.00	66.00
16.00	81.00
14.00	84.00
12.00	89.00
9.00	92.00
6.00	109.00

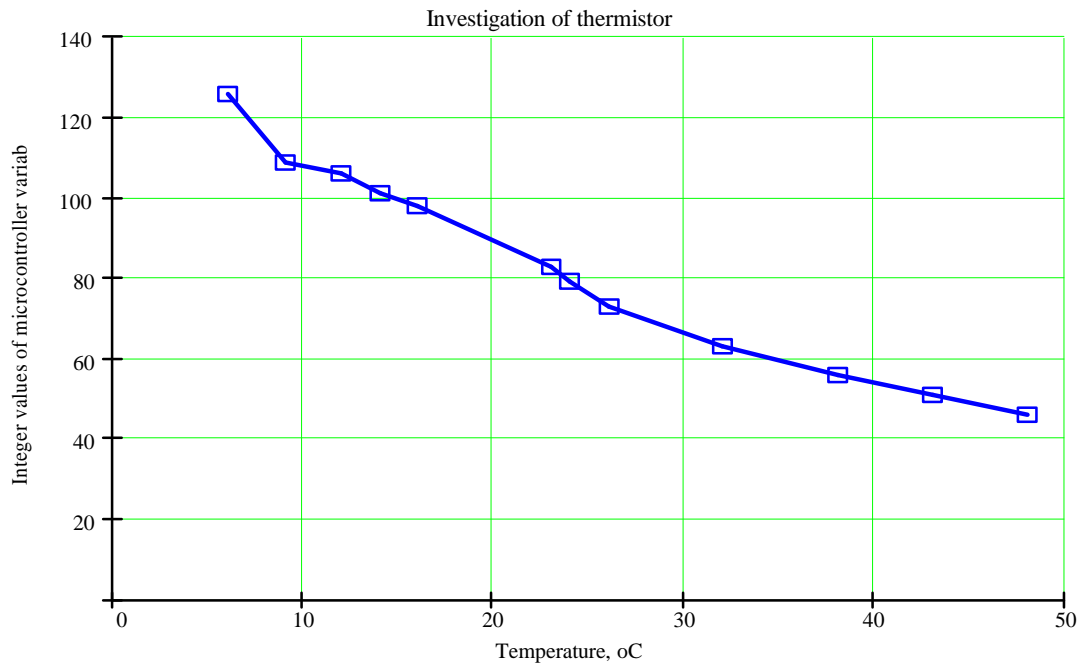


Fig.8. Graphical representation of temperature dependent variable **OUT**

Considering the security check and alarm we can see that because of the diode and resistance to be connected in series we have that voltage drop on the LED is approximately $V_D = 0.7V$, then the resultant voltage on the resistance is as $V_R = E - V_D = 5 - 0.7 = 4.3(V)$. Finally the current flowing can be found approximately $I = \frac{U_R}{R} = \frac{4.3}{390} = 0.011(A)$. Then the power dissipated on resistors can be found as $P = I^2 R = 390 \cdot 0.011^2 = 0.047(W)$ on each resistor. Because of the same current flowing in diodes and resistors, we can measure also the power dissipated at the diodes as $P = UI = 0.7 \cdot 0.011 = 7.7 \times 10^{-3}(W)$. Applying to the datasheets of the diodes we see that the flowing current is almost twice less than maximum allowed, thus we can omit this calculations in the future because of the similar resistances in series in all the other places and amplitude of the acting voltage not bigger 5V.

Considering DTMF we see that the maximum allowed DC power supply voltage is up to 7V, thus our value of 5V satisfies the requirements. The range on any pin is in the range from -0.3 to 5.3V (calculating as of supply voltage with variation of 0.3V in upper directions and ground to lower one). This value we will assume to be the highest possible when considering maximum power dissipation:

$$\min V_I = V_{SS} - 0.3(V)$$

$$\max V_I = V_{DD} + 0.3(V)$$

The maximum allowed current at any pin could be up to 10mA (except the supply one).

At the input of the DTMF decoder there is resistance of $100\text{k}\Omega$. Assuming that the maximum input voltage can be up 55V (only DC component) and 72V (DC +AC when ring). It is obvious that for both cases the resistances of $100\text{k}\Omega$ and $390\text{k}\Omega$ together with very big input impedance (approximately $10\text{M}\Omega$) input resistance of the decoder allow us to reach the safe very small current value.

The maximum power dissipation of the package is 500mW . Thus the power consumed by the circuit must be less than the maximum possible power dissipation.

The decoder consumes approximately $3\text{-}4\text{mA}$ DC supply current. It results in the typical power consumption as

$$P = UI = (3 - 4) \times 10^{-3} \times 5 = 15 \div 20(\text{mW})$$

with the given oscillator.

For all the pins used as outputs the high level is approximately 4.5V . Very small currents at these pins ensures the total power consumption of the chip is almost equal to that calculated above.

We will try to investigate the basic steering circuit. Before the registration of a decoded tone pair, the receiver checks for a valid signal duration (referred to as character recognition condition). This check is performed by an external RC time constant driven by Est. A logic high on Est causes v_c to rise as the capacitor discharges. Provided signal condition is maintained (Est remains high) for the validation period (t_{GTP}), v_c reaches the threshold V_{TS_t} of the steering

logic to register the tone pair, latching its corresponding 4-bit code into the output latch. At his point the GT output is activated and drives v_c to V_{DD} . GT continues to drive high as long as Est remains high. Finally after a short delay to allow the output latch to settle, the delayed steering output flag (StD) goes high, signaling that a received tone pair has been registered.

The output voltage of LM78L05 is form 4.8V to 5.2V depending on the load. There is an internal thermal overload protection and internal thermal regulation. The output current can reach the maximum value of 140mA that is enough for our circuit.

Maximum PIC microcontroller power dissipation is approximately 800mW . It is logic device, based on logic level voltages. All logic level currents are small, hundreds of

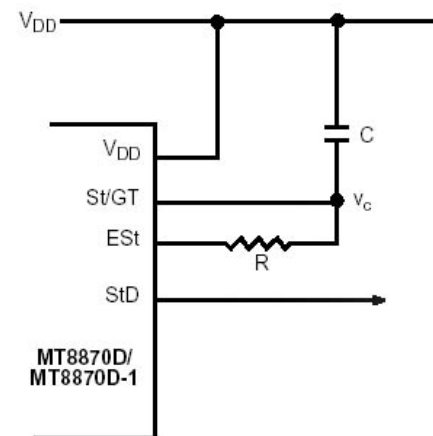


Fig. . Basic steering circuit

microampere range. All the parameters, maximum and minimum conditions can be found in appendix C.

Transistors KT940A is most popular in phone line circuits, because of their parameters suitable for such case. They can be found in appendix E.

5. Programming software and algorithm

5.1 Software

The program was written with Microcode Studio using PicBasic Pro Compiler. It is placed in appendix A.

The PicBasic Pro Compiler (or PBP) is our next-generation programming language that makes it even quicker and easier for you to program Microchip Technology's powerful PICmicro microcontrollers (MCUs). The English-like BASIC language is much easier to read and write than the quirky Microchip assembly language.

The PicBasic Pro Compiler is "BASIC Stamp II like" and has most of the libraries and functions of both the BASIC Stamp I and II. Being a true compiler, programs execute much faster and may be longer than their Stamp equivalents. PBP is not quite as compatible with the BASIC Stamps as our original PicBasic Compiler is with the BS1. Decisions were made that we hope improve the language overall. One of these was to add a real **IF..THEN..ELSE..ENDIF** instead of the **IF..THEN(GOTO)** of the Stamps. These differences are spelled out later in this manual.

PBP defaults to create files that run on a PIC16F84-04/P clocked at 4MHz. Only a minimum of other parts are necessary: 2 22pf capacitors for the 4MHz crystal, a 4.7K pull-up resistor tied to the /MCLR pin and a suitable 5- volt power supply. Many PICmicro MCUs other than the

16F84, as well as oscillators of frequencies other than 4MHz, may be used with the PicBasic Pro Compiler.

The PicBasic Pro Compiler produces code that may be programmed into a wide variety of PICmicro microcontrollers having from 8 to 84 pins and various on-chip features including A/D converters, hardware timers and serial ports.

The current version of the PicBasic Pro Compiler supports all the Microchip Technology PICmicro MCUs, including the 12-bit core, 14-bit core and both 16-bit core series, the 17Cxxx and 18Cxxx devices, as well as the Micromint PicStics. Limited support has been added for PICmicro MCUs based on the original 12-bit core. Support is limited as the 12-bit core PICmicro MCUs have a limited set of resources including a smaller stack and smaller code page size.

We can see that our program has a complex structure of various functions: cycles, condition relations, delays, etc. It works without end, that means that when we power on the microcontroller, sets in the MAIN loop. In online regime it counts the variable M until 200, unless the interrupt from DTMF decoder is sent, this set $M = 0$. At the moment when $M = 200$, the device hung-up and go to wait-for-ring state in RING program cycle. The number pressed on remote phone is characterized by RECOGNIZE cycle. The essence of working is reading 4-bit signal from DTMF decoder output, when interrupt signal is activated. PIC controller after current program jumps to RECOGNIZE cycle and performs recognition of 4-bit code relating with initial values. If code is recognized, program jumps to the certain cycle and performs it. Later it goes to wait for interrupt state. To protect occurrence of error due to accidental disconnections after device hung-up automatically in one minute.

```

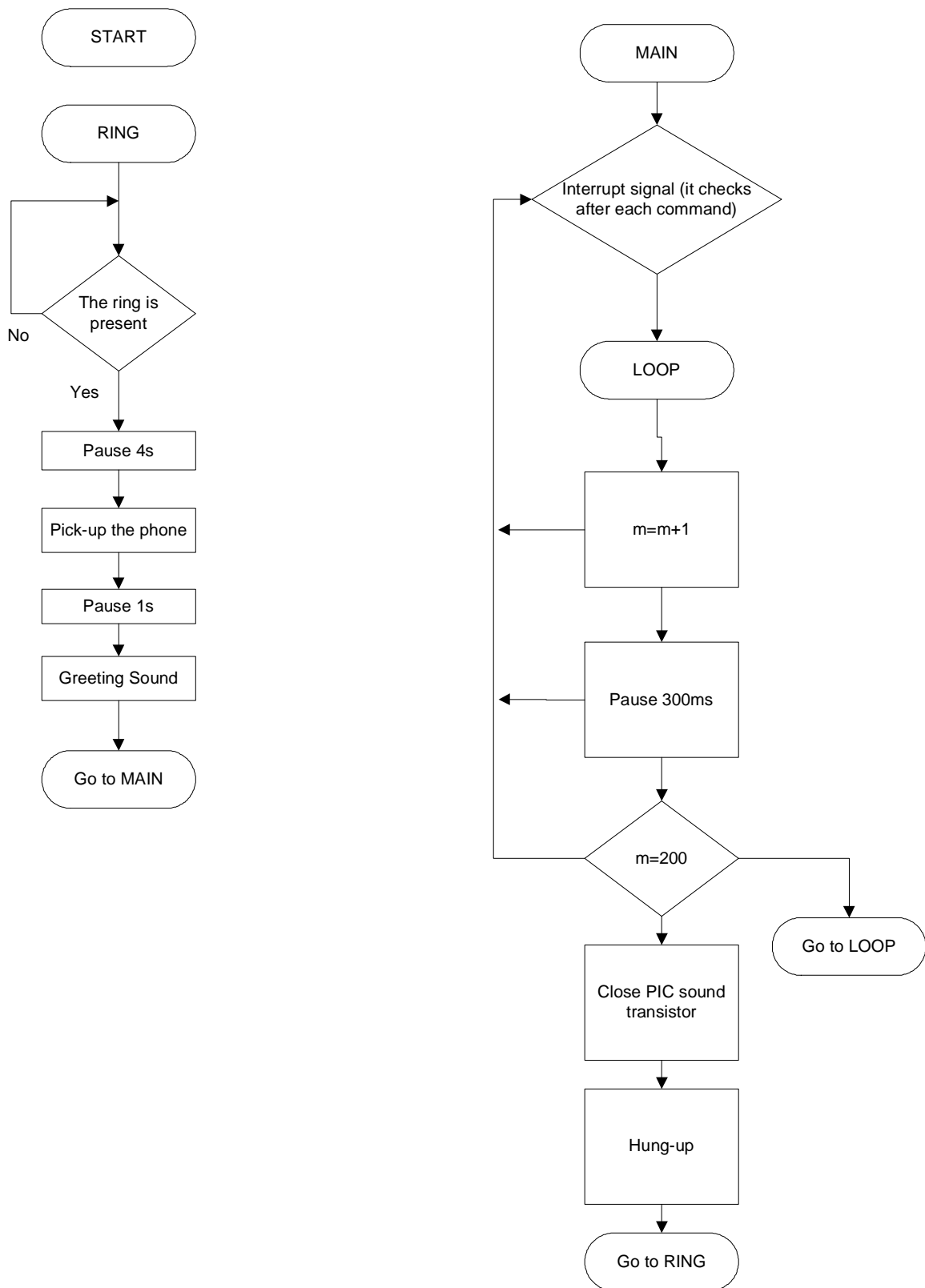
*****
** Name      : dtmfremote.BAS
** Author    : arturas lukosius
** Notice    : Copyright (c) 2003
**          : All Rights Reserved
** Date      : 25.04.03
** Version   : 1.0
** Notes     : DTMF controlled home monitoring system
**          :
*****

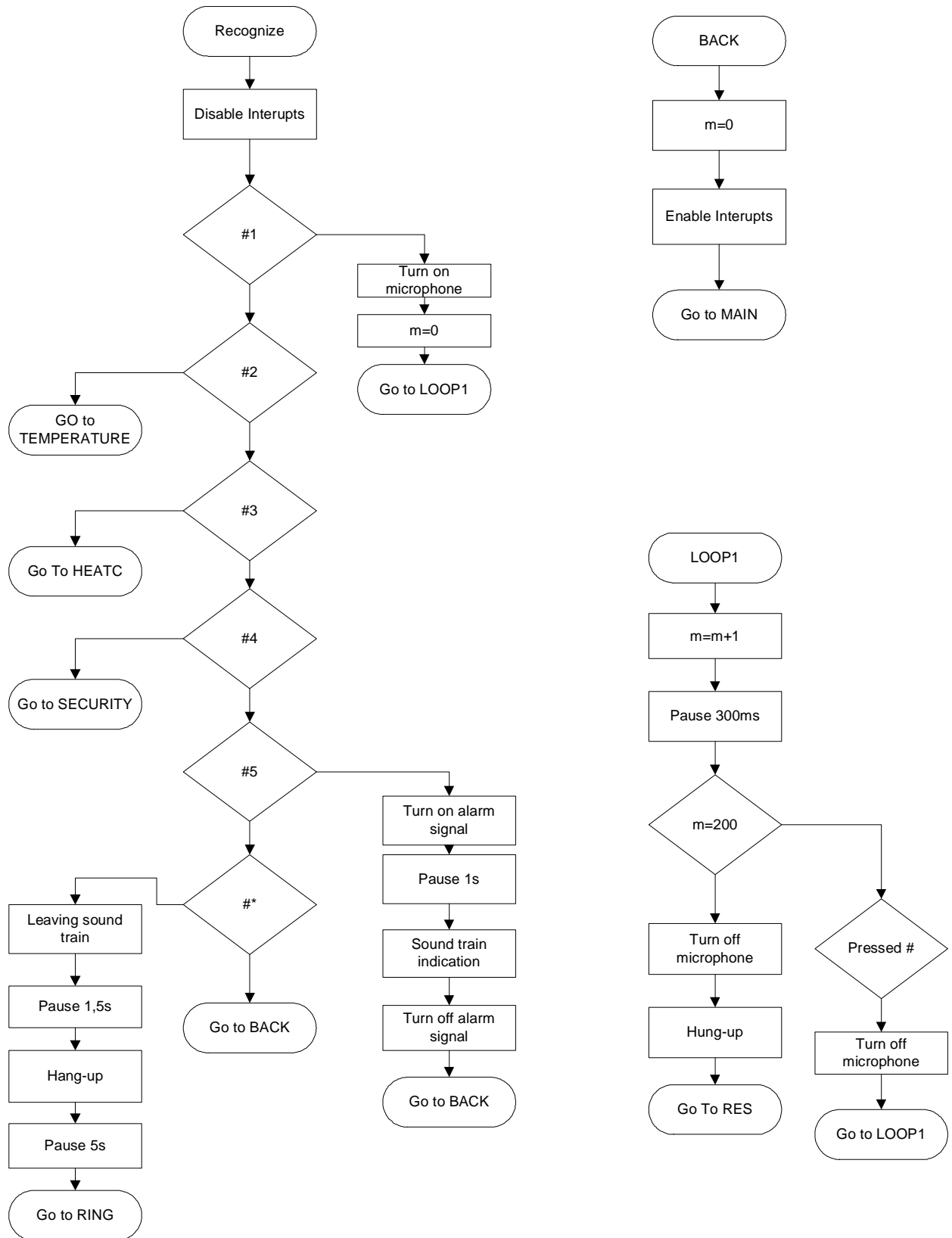
DEFINE OSC 4           ' oscillator 4MHz

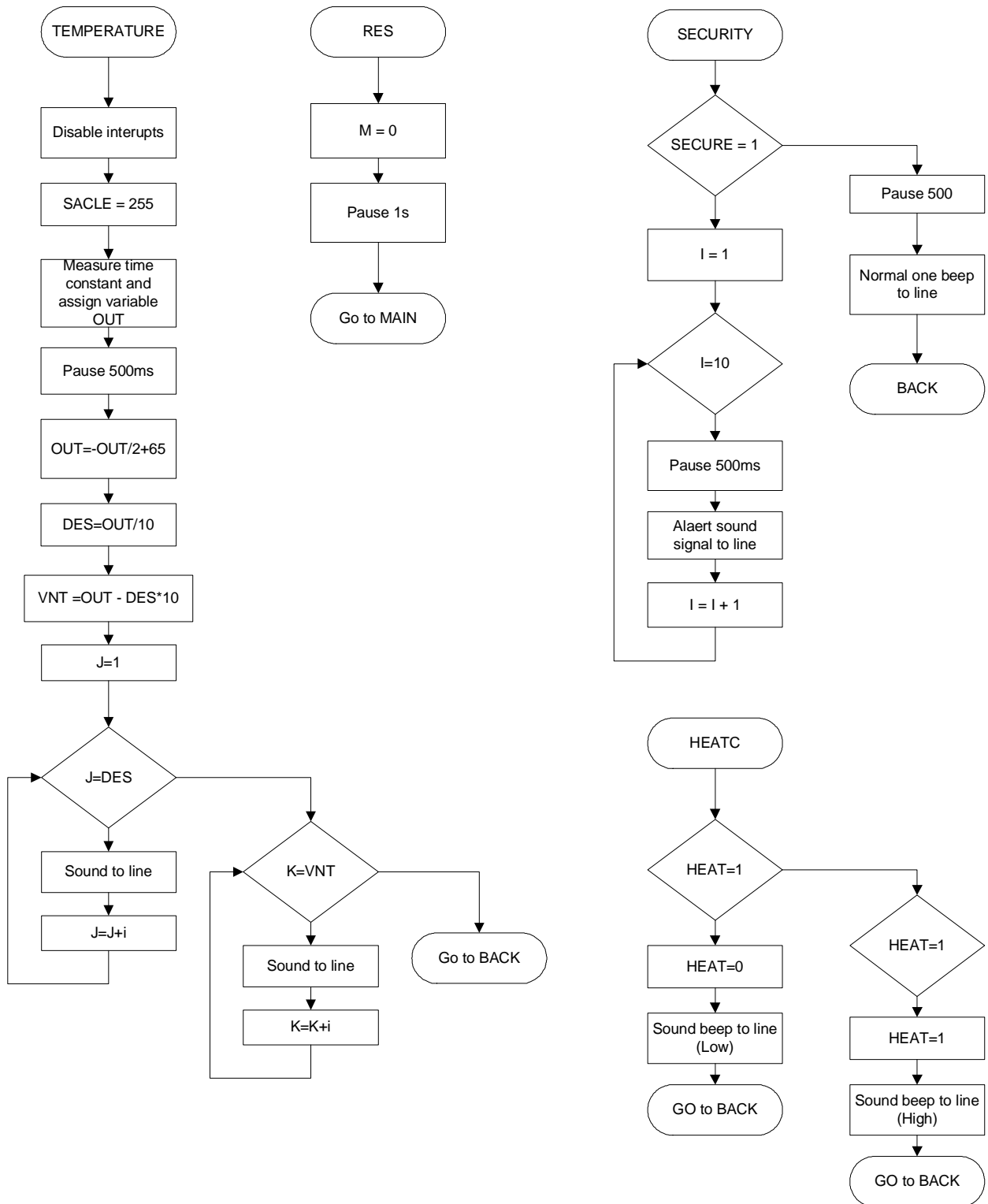
'
' variables
ringp var PortB.3      ' ring pin
mic    var PortA.4     ' microphone
answer var PortB.2     ' answer signal
alarm  var PortA.3     ' alarm
heat   var PortA.2     ' heating control
temp   var PortA.1     ' temperature sensor
secure var PortA.0     ' security check
snd    var PortB.1     ' sound signal
a      var PortB
p      var Bit
i      var Byte        ' index for..
j      var Byte        ' index for..
m      var Byte        ' protection counter
k      var Byte        ' index for..
scale  var Byte        ' scale for adjusting varying RC constants
out    var Byte        ' output variable for temperature value
des    var Byte        ' temperature every 100C
vnt    var Byte        ' temp. every 10C

```

5.2 Program algorithm







Appendix A

PICBasic Program

```

'*****
'* Name      : dtmfremote.BAS                      *
'* Author    : arturas lukosius                    *
'* Notice    : Copyright (c) 2003                  *
'*           : All Rights Reserved                 *
'* Date      : 25.04.03                            *
'* Version   : 1.0                                  *
'* Notes     : DTMF controlled home monitoring system *
'*           :                                       *
'*****

                DEFINE OSC 4                        ' oscillator 4MHz

'
' variables

                ringp  var PortB.3                  ' ring pin
                mic    var PortA.4                  ' microphone
                answer var PortB.2                  ' answer signal
                alarm  var PortA.3                  ' alarm
                heat   var PortA.2                  ' heating control
                temp   var PortA.1                  ' temperature sensor
                secure var PortA.0                  ' security check
                snd    var PortB.1                  ' sound signal
                a      var PortB                    ' a = PortB
                p      var Bit                      '
                i      var Byte                     ' index for..
                j      var Byte                     ' index for..
                m      var Byte                     ' protection counter
                k      var Byte                     ' index for..
                scale  var Byte                     ' scale for adjusting varying RC

constants
                out    var Byte                     ' output variable for temperature

value
                des    var Byte                     ' temperature every 10oC
                vnt    var Byte                     ' temp. every 1oC

                TrisB=%11111001                    ' set pin I/O of PortB
                PortB=0                              ' set value 0 to PortB
                TrisA=%00000011                    ' set pin I/O of PortA
                PortA=0                              ' set value 0 to PortB

'-----
' ring check
'-----

ring:
    m = 0
    If ringp = 1 Then                                ' check if ring appears
        Pause 4000                                   ' delay to answer for 5s
        High answer                                  ' answer signal is on
        Pause 1000
        Sound
snd, [122,6,0,3,123,6,0,3,124,6,0,3,125,6,0,3,126,6,0,3,125,6,0,3,
124,6,0,3,123,6,0,3,122,6]                          ' greeting sound train
        GoTo main                                    ' execute recongnition
    Else
        GoTo ring                                    ' repeat check till ring
    EndIf

'=====
' main program
'=====

```



```

main:
    On Interrupt GoTo recognize      ' Define interrupt handler
    INTCON = $90                    ' Enable INTE interrupt

loop:
    m = m + 1                       ' counts m until 200 if system is
idle
    Pause 300                       ' mainly to protect from
accidental disconnections
    'Serout secure,4,[#m,13,10]
    If m = 200 Then
        option_reg.7 = 1           ' turn off pull-up of portb
        Low snd                    ' low snd pin to avoid errors with
hung-up
        Low answer
        Pause 5000                 ' hung-up
        Goto ring
    EndIf
    GoTo loop

=====
' recognition of DTMF number
=====
    Disable                          ' No interrupts past this point

recognize:
    '-----
    ' "1" - microphone monitoring
    '-----
    If a/16 =8 Then                 ' "1" pressed, PortB = %00001000
        High mic                    ' turn on mic.
        m = 0                       ' reset m counter
        GoTo loop1                  ' jump to subroutine loop1,
appears below
    EndIf
    '-----
    ' "2" - temperature monitor
    '-----
    If a/16 =4 Then                 ' "2" pressed, PortB = %00000100
        GoTo temperature           ' temperature monitor
    EndIf
    '-----
    ' "3" - heat control
    '-----
    If a/16 =12 Then               ' "3" pressed, PortB = %00001100
        GoTo heatc                 ' heat control
    EndIf
    '-----
    ' "4" - security check
    '-----
    If a/16 =2 Then                ' "4" pressed, PortB = %00000010
        GoTo security              ' security check
    EndIf
    '-----
    ' "5" - alarm control
    '-----
    If a/16 =10 Then               ' "5" pressed, PortB = %00001010
        High alarm                  ' send 1s pulse to alarm circuit
        Pause 1000
        Sound snd,[120,50]
        Low alarm
        GoTo back
    EndIf

```

```

' -----
' "*" - hang-up
' -----
If a/16 = 13 Then                                ' "*" pressed, PortB = %00001011
    Sound snd, [0,50,126,6,0,3,125,6,0,3,124,6,0,3,123,6,0,3,122,6]
    option_reg.7=1
    Pause 1500
    Low answer                                    ' hung-up
    Pause 5000
    Goto ring                                    ' go to wait-for-ring state
    Else
    GoTo back
EndIf
' -----
'
' -----

back:
    m = 0
    INTCON.1 = 0                                ' Enable interupt register bit 1
    Resume                                       ' Return to main program
    Enable

' -----
' return from microphone monitoring to base menu
    Disable
loop1:
    m = m + 1                                    ' after 1 min device hung-up
    Pause 300
    'serout secure,4,[#m,13,10]
    If m = 200 Then
        Low mic
        Low answer                                ' hung-up
        Goto ring
    EndIf
    If a/16=3 Then                                ' "#" pressed, PortB = %00000011
        Low mic                                    ' off mic.
        Else
        GoTo loop1                                ' repeat until "#"
    EndIf
    GoTo res
' -----
' heat control. We can press #3 to turn on or off
heatc:
    If heat = 1 Then                                ' if heat is on tturn it off
        heat = 0
        sound snd, [0,15,107,35]
        GoTo back
    Else
        If heat = 0 Then                                ' if heat is off tturn it on
            heat = 1
            Sound snd, [0,15,120,35]
        GoTo back                                    ' return
    EndIf
    EndIf
' -----
' temperature measurement
    Disable
temperature:
    scale = 255
    Pot temp, scale, out                            ' assign temperature variable
value
    Pause 500
    out = -out / 2 + 65                                ' normalized temperature 5..37oC

```

```

        des = out / 10                                ' number of 10oC
        vnt = out - des * 10                          ' number of 1oC
For j = 1 To des
        Sound snd,[107,30,0,15]                      ' beep for every 10oC
Next j
For k = 1 To vnt
        Sound snd,[120,15,0,15]                    ' beep for every 1oC
Next k
        'Serout secure,4,[#out,13,10]

        GoTo back
    '
    ' security checking
security:
        If secure = 1 Then                          ' check if the security system
        responded
For i = 1 To 10                                    ' to alarm mode
        Pause 500
        Sound snd,[120,10,0,1]                      ' alarm alert
        Next i
        Else
        Pause 500
        Sound snd,[120,10]                          ' normal sound. System is idle
        EndIf
        GoTo back
    '
res:
        m = 0
        Pause 1000
        Resume                                       ' return to main program
        Enable                                       ' enable global interrupt

```

Appendix B

Device User Manual

Appendix C

PIC16F84A Data Sheets

Appendix D

Integrated DTMF Decoder

Appendix E

LM78LXX Series 3-Terminal Positive Regulators

Appendix E

Discrete Elements Datasheets