EE214 ELECTRONIC CIRCUITS LABORATORY
TERM PROJECT
WIRELESS FIRE DETECTION SYSTEM

1. INTRODUCTION

In large areas, in order to predict any sign of fire, advanced detection systems are utilized. For that purpose, smoke detectors or temperature detectors are used. However, since the smoke of the fire comes with a delay, smoke information is not enough to predict the location of the fire. Nevertheless, utilization of temperature detectors at some strategic locations is a very good choice for fire detection.

Many people do not have fire alarm systems installed in their homes. Many assume that they are able to smell smoke when they are asleep and wake up in time to escape in case of a fire emergency. Well, this is not true at all. Studies have been conducted and it has been proven that people’s sleep are disrupted when there is sound or noise, but it is NOT the case with smell. Our sense of smell is lost when we are asleep, and we will not wake up no matter how strong the smell of smoke is.

Many people do not take fire alarms seriously, and many do not test or check their alarm systems regularly. The only thing that can alert you, your family and colleagues 24/7 from a fire is the sound of a well installed and maintained fire alarm system. Fire alarms are important because they can give you an early signal to something that could be tragic – basically saving your lives.

In order to solve this, electronic control systems can be used which can control the temperature of different locations in real time regardless of how big the environment under consideration is. By this way, fire alarm systems can save your life and you can sleep without any doubt because when something is wrong, a fire is about to start, the fire alarm system alerts you.

2. PROJECT DESCRIPTION

In this project, you are supposed to make a very simple fire alarm system. The system mainly consists of two units, which are the sensing and indicator units. In the sensing unit, you basically get an information on which location the temperature is the highest. For this purpose, you will use three temperature sensors for three different locations. After deciding which location has the highest temperature value, you will send that information to the indicator unit, which shows the system state. In the project, the system can be in three states, which are named as L1, L2 and L3. Each state corresponds to one of the locations and indicates that the highest temperature is measured on corresponding location.

The communication between the sensing unit and decision unit will be utilized by wireless communication. The information will be carried by two sine waves which are sent from a speaker to a microphone. As you can recall, the information on which temperature sensor gives the highest temperature value can be coded by 2 bits since we have only 3 different states in this project, i.e. whether detector-1 or detector-2 or detector-3 senses the highest temperature. Two sinusoidal signals with different frequencies will be generated and the information will be encoded by them. After that, as mentioned above, you will transmit this information as a sound wave. At the indicator unit, the information will be decoded and the highest temperature location will be shown by one of the three LEDs with different colors.

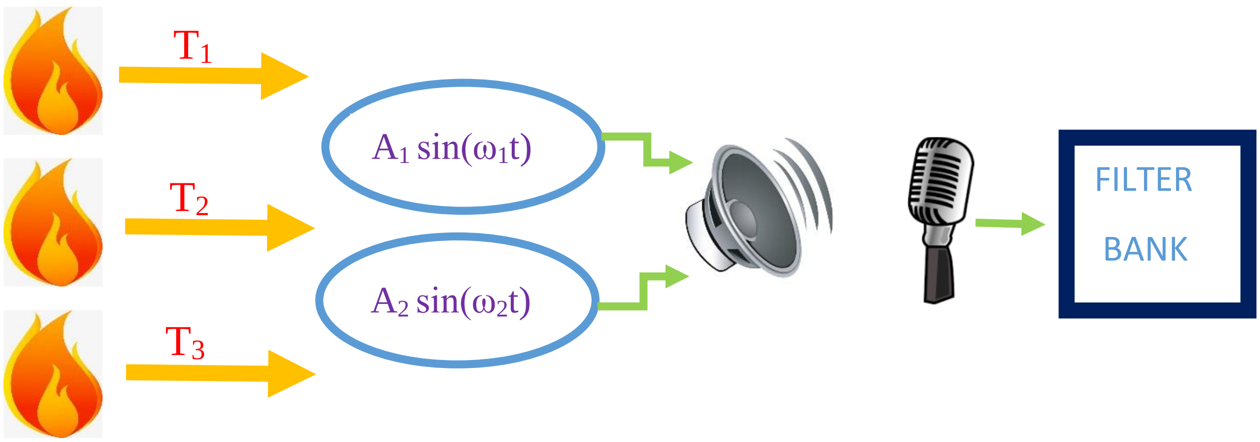

Figure 1. General overview of the sensing and transmission units

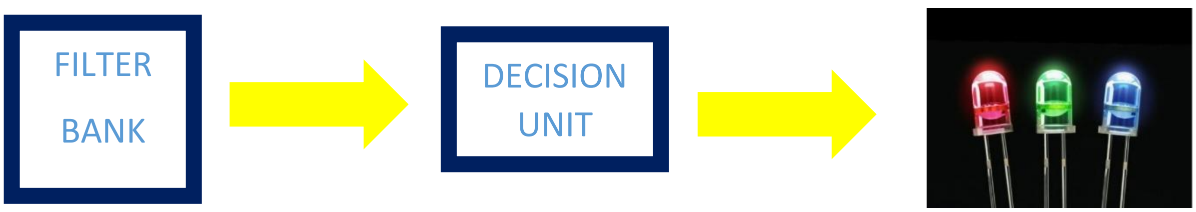

Figure 2. General overview of the decision unit

2.1 Sensing Unit

Your sensing unit will be composed of three temperature sensors and those sensors will give you the temperature information by their output voltage values. You will use those different voltage values for different temperatures in order to manipulate the sinusoidal signals. By this way, you will encode the required information to those sinusoids. The output signal of this unit for different states are illustrated in Table 1.

Table 1: The output signal of the sensing unit for the system states

Condition	System State	Output Signal
T1>T2 & T1>T3	L1	$A_1 \sin \omega_1 t$
T2>T1 & T2>T3	L2	$A_1 \sin \omega_1 t + A_2 \sin \omega_2 t$
T3>T1 & T3>T2	L3	$A_2 \sin \omega_2 t$

2.2 Transmission Unit

You will transmit the output signal of the sensing unit through a speaker by driving it and you will receive this signal by a microphone. By doing so, you will establish a wireless connection between your sensing unit and indicator unit.

2.3 INDICATOR UNIT

You will use the received signal, which is summation of sinusoids with different frequencies, by the microphone and decide which temperature is higher, i.e. which location of the environment is warmest. For this unit, you must use two band pass filters with different center frequencies, which should be chosen according to the frequencies of generated sinusoidal signals in the sensing unit. After deciding the location, you will indicate its direction by turning corresponding LED on.

3. RULES AND REGULATIONS

3.1 ALLOWED COMPONENTS

You are allowed to use +/-25 V output of DC power supply and you may use any types of resistors, capacitors, inductors, diodes, LM35 temperature sensor, LEDs, LDRs, op-amps, transistors, servo motors, passive microphones and passive speakers.

3.2 DESIGN SPECIFICATIONS

Further details about the project will be announced.

3.3 BONUS

Will be announced later.

3.4 GROUPS

The project will be carried out in groups of two students. The students in the same group should be in the same laboratory session.

3.5 IMPORTANT DATES

- April 7 : Project Announcement
- April 30 : Submission of the pre-report. (till 17:00)
- May 1-4 : First Project Session
- May 8-11 : Second Project Session
- May 15-18 : Third Project Session and Fundamental Knowledge Examination
- May 18 : Submission of demo-videos (until 23:59)
- May 19-20 : Demonstrations
- June 4 : Submission of the Final Report (till 17:00)

3.6 DOCUMENTATION

You **must** submit two reports and a video for the term project.

3.3.1 Reports

As stated earlier, pre-report should include an introduction, pre-design of the project with circuit diagrams and overall circuit schematic, theory, formulations, simulation results and a conclusion.

Final report should also include all the parts in the first report for the overall design. In other words, should explain the overall design with an introduction, a block diagram and circuit schematic, operation of each sub-block with theory, formulations, simulation and experimental results. The filters should be modelled using **MATLAB** and **BENCHVUE** results should be presented for the filters in the final report. Final report should also include analyses for the cost and power consumption of the project and you should justify the use of each component. Conclusion of the final report is very important since it reflects your understanding of the project and the experiences you gained during the overall process. The objectives, results and the experiences should be clearly presented. This does not necessarily mean a long report, but definitely a well-organized one.

Late submissions for both reports will lower your report grades as:

- %20 off for one-day late submission
- %50 off for two-day late submission
- %90 off for three-day late submission
- Zero credit for more than three-day late submission.

You are referred to the report guideline which is available on the course website.

3.3.2 Demonstration Video

You should prepare a 6-8 minutes video where partners of each group present the project in a collaborative manner. The video should include the explanation of main blocks, why they are used and how they are designed. This video should be regarded as a formal presentation to the related assistant. Note that you should always appear in the video together with your presentation material.

3.7 GRADING

- Pre-Report : %10
- Final Report : %20
- Presentation Video : %5
- Design and Performance : %65 (partial credits are possible)
- Bonus : up to %30

3.8 REGULATIONS

- Attending the project demonstration is a must for both team members, otherwise, you will fail the course.
- Fundamental knowledge of the students will be tested at the third project session. However, the students, who will not be able to attend to the third project session with a valid excuse, may be tested at the first or second project session with permission of their assistants.
- Students get zeros credit from the project, if they cannot exceed the pre-score of the design test.
- Cheating is strongly forbidden and any indication of cheating will cause you to get zero credit from the project. You can collaborate with your friends by exchanging ideas, not copying the design details or the reports. Using the design of another group with slightly modified component values will also be regarded as cheating.
- Both members of the group are responsible for every single detail of their circuit.

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1. DESIGN SPECIFICATIONS

1.1. SPECIFICATIONS FOR THE SENSING UNIT

The sensing unit consists of three temperature sensors and they should be at least 10cm apart from each other. There are many different temperature sensors that you can find and use in this project, however, LM35 is strongly suggested.

During the temperature measurement, soldering iron or heat gun will be used and great variation of temperature differences between the sensor measurements can be obtained by keeping them apart from the sensors with different distances.

1.2. SPECIFICATIONS FOR SINUSOIDAL SIGNAL GENERATION PART

In this part, you can use any method that you want and learn from EE214 course, **UNLESS** you do not use circuit components other than the allowed ones.

Also, you must generate two sine waves with two different frequencies and these frequency values are as follows:

$f_1 =$ 3kHz

$f_2 =$ 5kHz

There can only be ±5% variation in these frequency values and any violation of this rule will cost you points even if your project works well. The amount of the points that will be deducted will be announced later.

1.3. SPECIFICATIONS FOR WIRELESS TRANSMISSION

In order to utilize wireless transmission, you will use a speaker and an electret microphone. Speaker that you will use in this project must be 50 Ω, 75 Ω or 100 Ω depending on your choice and design. In addition to that, there should not be any integrated circuit that is integrated to the microphone or speaker and violation of this rule will be considered seriously. You should drive the speaker by your own design and you should make the microphone work by yourself. Finally, speaker and the microphone should be at least 10cm apart from each other.

1.4. SPECIFICATIONS FOR FILTER BANK

You should extract the temperature information from the signal received from the microphone. In order to do so, you should design filters. By designing your filters, you can differentiate two different sinusoidal signals. After differentiating each of them separately, you will check the amplitudes of them in the decision unit. However, the filters that you will use **MUST** be bandpass filters in order to utilize high quality differentiation between two signals with two different frequencies. Any violation of this rule, i.e. utilization of lowpass, highpass or any other different filter type, will be considered seriously. Your filters will be considered as not working properly if you do not use bandpass filters.

1.5. Specifications For Decision Unit

In this final part of the project, you will consider the amplitudes of the signals that are extracted from the filter. Any choice of low-reference (logic 0 case) and high-reference (logic 1 case) voltages are welcome and also you can use different low- and high- reference voltages for different frequencies. After you sense and decide which temperature sensor senses the highest temperature, you will indicate that by LEDs. You should use three different colours for LEDs and the colour difference between different LEDs must be clear, i.e. one cannot differentiate so called ”lemon yellow” and “lemon green” as you may can. You can use RGB LEDs or standard LEDs in your design. Utilization of any integrated logic chips is forbidden.

2. BONUS

A student cannot get any bonus credit, unless all steps that are announced in the project document are accomplished. In other words, you must get full credit from the design test to be able to get bonus credit.

2.1. Utilization Of Longer Distances In Wireless Transmission

For this step, you should adjust your speaker driver circuits such that the wireless communication will be performed when the distance between the speaker and the microphone is longer than 10cm. The extra points that you will get will be as follows:

Table 1. Extra points for different distances between the speaker and the microphone.

Distance Between The Speaker and The Microphone	Extra Points
15cm	2
20cm	4
25cm	6
30cm	8

2.2. Detection Of Idle Case (20 Points)

In this project, as explained before, you will encode the information in 2-bits for three different cases. You will use 11, 10, 01 binary states in order to indicate which temperature sensor senses the highest temperature. However, we do not use 00 binary state since it can be effected by noise in the environment.

For this step, you should use the idle state (00 binary state) in order to indicate that the temperature for all three locations are below a certain threshold, i.e. the highest temperature does not indicate any sign of fire. For example, you may sense 26, 28, 32 ^{o}C from the sensors, however, these temperature levels are not sufficient to warn someone about fire. In order to avoid any panic in the house in the middle of the night, you are required to decide a threshold level, below which none of the LEDs will shine. In other words, you will decide a temperature value and this will be the threshold. If the temperature obtained from the sensors are all below this value, you will lighten up another LED to indicate that everything is fine. If one or more of the temperatures are above the threshold, your circuit will work properly as before.

Table 2. Different cases with different temperature values sensed by the sensors.

Case	LED that should be lighten up
($T_1>T_2>T_3$ OR $T_1>T_3>T_2$) AND (at least $T_1>T_{threshold}$)	LED1(Colour1)
($T_2>T_1>T_3$ OR $T_2>T_3>T_1$) AND (at least $T_2>T_{threshold}$)	LED2(Colour2)
($T_3>T_2>T_1$ OR $T_3>T_1>T_2$) AND (at least $T_3>T_{threshold}$)	LED3(Colour3)
$T_1,T_2,T_3 < T_{threshold}$	LED4(Colour4)