E-322 Engineering Design VI

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Pledge: I pledge my honor that I have abided by the Stevens Honor System

Homework#2

A Contact-less Thermometer

Imagine going to the mall and the automatic doors not only open up for you but also tell you your body temperature. Wouldn't it be wonderful if a doctor measures your body temperature without actually bringing it into contact, or being free from the hassles of cleaning your food temperature sensor after dipping it into your turkey or chicken. Well, all this could be possible with the help of a thermometer that requires no contact with the substance, for measuring temperature. Yes! I am talking about a contactless thermometer that can be designed by combining the principles of Physics, Electronics and a little bit of programming.

A contactless thermometer can be based on the concept of motion detectors. Most of the motion detectors work on the principle of Pyroelectricity, which is the electrical response of a polar, dielectric material to a change in its temperature. Pyroelectric Infrared Sensors (PIRs) belong to the class of thermal detectors that can measure incident radiation by means of change in temperature. This thermal effect is then transformed into an electric output (Potential Difference) by the Pyroelectric element.

In a motion detector, a Fresnel lens helps the incident Infrared rays to coincide at the Pyroelectric element. Fresnel lenses are good energy collectors and also make the sensor immune to slow changes in temperature. The electric output produced by Pyroelectric crystals is very low. Hence a JFET (Junction Field Effect Transistor) is used as an amplifier. The amplified signal is then subjected to a voltage comparator, which compares the signal to a predefined voltage value. It is mostly used to maintain the voltage at a specific value. Finally, this signal is fed to the output device which is normally a speaker or an LED.

Since humans emit infrared radiation (8-14 μm) that contributes to a very tiny range in the electromagnetic spectrum, PIRs can be used to detect human motion. Moreover, the PIR can be made selective to the specific range of wavelength emitted by humans, through the application of an appropriate absorbing material. This same notion can be used for other substances as well.

Stakeholders

The three stakeholders for this project are the

- **User**: - Doctors, general public, restaurants, etc.
- **Client**: - Thermometer manufacturing companies
- **Designer**: - Stevens Institute of Technology students

This contactless thermometer is primarily designed for people involved in measuring temperature. The most frequent use of this device is going to be at the hospitals, wherein it will be used for measuring human body temperature. Thermometers are also a common instrument found in most of the households, for various purposes. Along with this, it is also popular in the food industry. Hence, this electronic gadget must be easy to operate and should function properly for different temperature ranges. Price is also a major concern, which should be kept as low as possible in order for it to be popular among different classes of people. Other issues such as battery life, portability, user manual, etc. shall also be addressed in this case

With some of the high-tech digital thermometers in market, this product should be unique and reasonable for manufacturing companies to produce it on a large scale. Cost of raw materials, ease of production, troubleshooting, advertising and promotion are some of the crucial issues for this category of stakeholders. Profit margin and competition with similar manufacturing companies is also an issue of concern. Moreover, the depreciation value of this product must be as low as possible.

Assuming that a limited budget is provided to Stevens students for their senior design, ‘making the most’ out of limited resources is a potential requirement. As designers, they have to take into consideration challenges such as conceptual and detailed design, uniqueness, proper functioning and maintenance, and troubleshooting. This device must also be economically feasible in order to lure manufacturing companies and customers. Plus, expertise in different areas is a key requirement for the successful accomplishment of this project.

Initial Evaluation

Designing and manufacturing a contactless thermometer is a potential project for senior design at Stevens Institute of Technology. The preliminary design has already been discussed in the earlier section of this report. In order for it to be a multi-student project, various modifications and enhancement can be made to make this gadget more sophisticated and user-friendly.

The raw materials for this project are easily available and re-producible. This venture can be easily accomplished over a span of two semesters. The overall cost for this project is also low and so financing won't be a problem. Rather than having different thermometers for different temperature ranges, only one instrument can be utilized for measuring temperature of different substances. This can be achieved by having an LED display that lets the user choose the type of substance (for example: human body, food, room), whose thermal energy is being measured. Depending on the selection, this device can be programmed to select the appropriate PIR out of the few available. The Fresnel lens shall collect infrared energy from the substance, which will then be amplified and compared with a pre-defined set of voltages for that particular item. Finally, depending on the voltage comparison, the temperature shall be displayed on the LED display in Celsius and Fahrenheit scale.

This endeavor is an amalgamation of physics, electronics and programming. Fresnel lens requires accurate characteristics such as radius of curvature, focal length, thickness, etc. and hence proper selection and carving is demanded. Thus, expertise in the field of optics is necessary which is mostly found among Physics majors. The circuitry of this device, along with the selection of correct amplifier and appropriate voltage comparators is a major task that can be undertaken by Electrical engineers. Finally, programming of the LED display by using a suitable microcontroller and selection of PIRs can be completed by Computer Science/ Computer Engineering majors. Therefore, this assignment is multi-disciplined.

SWOT Analysis

- **Strength**: The biggest strength of this project is that it requires no contact. This gadget can resolve some of the outstanding issues with current thermometers such as hygiene and proper cleanliness. Depending on the selection of apt PIR, this thermometer is immune to other temperature ranges or extremes. Moreover, it's safer and requires less maintenance as compared to its contemporaries.
- **Weaknesses**: The biggest drawback of this device will be its bulkiness. It is going to be bigger in size and heavier as compared to the current digital thermometers. Instead of automatic 'mode' selection, this device will require manual selection for different kinds of substances. It will also require extra energy, which results into more number of batteries or high-power heavy ones (such as 9V instead of AA or AAA)

- **Opportunities**: One of the effective ways or eradicating some of the weaknesses of this device is to manufacture two separate devices – a clinical thermometer and a food thermometer. Since this thermometer is basically targeted to measure thermal energy in those two areas, it's assumed that it wouldn't be used frequently to measure the temperature of an uncommon substance such as a chemical or something else. Having two separate gadgets will drastically reduce its size and eliminate the task of 'mode' selection.
- **Threats**: The proper functioning of this device is contingent on the correct alignment of Fresnel lens and suitable selection of PIR. Hence, minor errors in programming (that causes the wrong selection of PIR) or misalignment of lens, can result into utter disaster by providing completely misleading results. In case of clinical thermometers, it is very crucial that it provides precise results with the least variation. Hence, manufacturing defects, discrepancies in codes or even a sudden jerk can cause this instrument to malfunction.

References

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