SENSORS FOR HOME AUTOMATION

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Abstract: **The aim of this project is to develop a system that will provide remote control of home appliances and also provide security against intrusion when the home host is not at home. This paper is mainly concerned with the automatic control of light or any other home appliances using internet. It is meant to save the electric power and human energy .Home automation systems have drawn considerable attentions of the researchers for more than a decade. The major technologies used to implement these systems include gas sensors, conduct metric gas sensors, potentiometric gas sensors, and smoke alarm.**
A sensor is often defined as a device that receives and responds to a signal or stimulus

Keywords: **Home automation, Conduct metric gas sensor, Potentiometric gas sensor.**

Introduction to Home Automation:

A smart home is a home-like environment that possesses ambient intelligence and automatic control, which allow it to respond to the behaviour of residents and provide them with various facilities. Home automation may include centralized control of lighting, heating, ventilation and air conditioning appliances, and other systems, to provide improved convenience, comfort, energy efficiency and security.
A home automation system integrates electrical devices in a house with each other. The techniques employed include the control of domestic activities, such as home entertainment systems, houseplant and yard watering, pet feeding, changing the ambiance "scenes" for different events (such as dinners or parties), etc.,
The standard approach for building smart homes is to computerize them. A set of sensors gather different types of data, regarding the residents and utility consumption of the home. Computers or devices with computing power (e.g.: micro-controllers) analyse these data to identify actions of residents or events. They then respond to the sections and events by controlling certain mechanisms that are built into the home. A simple example for such a smart behaviour is turning the lights on when a person enters a room. However, more complicated tasks such as detecting if an elderly person is alone and not feeling well.

Major application Categories of Smart Homes:

The first category aims at providing services to the residents by detecting and recognizing their actions or by detecting their health conditions.
The second category of smart homes aims at storing and retrieving of multimedia captured within the smart home.
The third category is surveillance, where data captured in environment are processed to obtain information that can help to raise alarms, in order to protect the home and residents from theft and natural disasters like flood etc.,

Tasks of a Home Automation System:

Heating, Ventilation and Air Conditioning (HVAC):

- HVAC solutions can include temperature and humidity control
- They could include an internet-controlled thermostat, by allowing the user to control the heating and air conditioning systems remotely, or it could be linked to windows to allow automated opening and closing to allow hot air out and cool air in.

Lighting:

- Lighting control systems can be used to control household electric lights.
- Turn off all the lights of the house at a predeter
- mined time.
- Use of motion detectors to automatically turn off the lights in a room after occupants have left and turn on the lights if occupants enter a room.
- Control the brightness of the lights according to the level of ambient light available.
- Change the ambient colour of a room via the lights used.

Security:

- Control and integration of security systems and also the potential for central locking of all doors and windows.
- The consumer can select and watch cameras live from an Internet source to their home or business. Security systems can include motion sensors that will detect any kind of unauthorized movement and notify the user through the security system or via cell phone.
- Detection of possible intrusion by using sensors for detection of movement, sensors for magnetic contact of door/window, sensors for glass breaking, sensors for pressure changes
- Detection of fire, gas leaks, water leaks (fire alarm and gas alarm).

Intercom:

- An intercom system allows communication via a microphone and loud speaker between multiple rooms. Integration of the intercom to the telephone or the video door entry system to the television set, allowing the residents to view the door camera.

Sensors for Home Automation:

A set of sensors are used in the home automation system. These sensors are summarized in the following sections.

- Temperature Sensors
- Motion Detectors
- Sensors for lighting control
- Sensors for access control
- Smoke detectors and Gas detectors
- Sensors for reporting natural disasters

Gas Sensors:

A gas detector is a device which detects the presence of various gases within an area, usually as part of a safety system. This type of equipment is used to detect a gas leak and interface with a control system so a process can be automatically shut down. A gas detector can also sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave the area.

Gas sensors are classified into two types: conductimetric gas sensors and potentiometric gas sensors

Conductimetric Gas Sensors:

Conductimetric gas sensors are based on the principle of measuring the change in the electrical resistance of a material upon introduction to the target gas. The most common type of gas sensor employs a solid-state material as the gas-sensitive element.

The figure shows the taguchi type tin oxide (SnO_2) Carbon monoxide (CO) gas sensor. The device consists of a wire-wound platinum heater coil inside a ceramic former onto which a thick layer of porous tin oxide is painted manually. The film is then sintered at a high temperature so that the appropriate nanocrystalline structure is formed. The electrical resistance of the sintered film is then measured by a pair of gold electrodes and basic potential divider circuit.

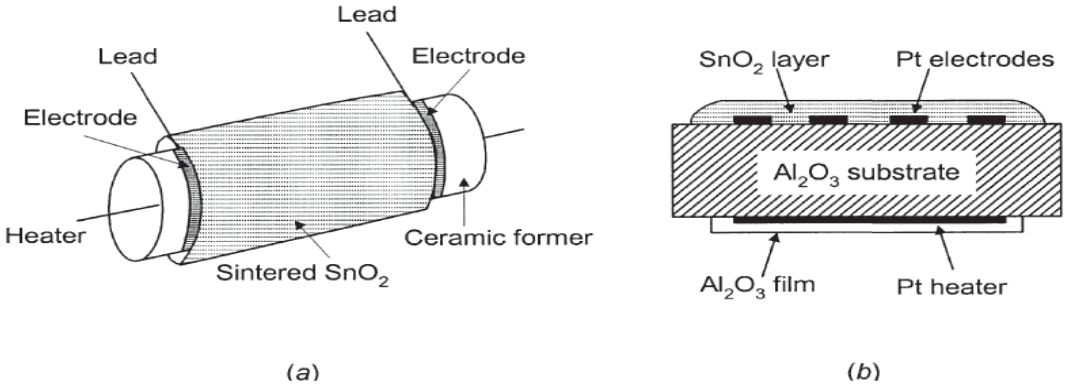

Figure 1: Tin dioxide gas sensor (a) Tubular design (b) Thick film design

The basic reactions that occur within the porous sintered film can be represented by the following reactions.

$$\frac{1}{2}mO_2 + \{vacancy\} + e^- \overset{k1}{\rightarrow} \{O_{m-}\}$$

This reversible reaction is disturbed when the analyte molecule X reacts with the chemisorbed oxygen

$$X + \{O_{m-}\} \overset{k2}{\rightarrow} \{XO_m\} + e^-$$

The change in device conductance can be approximately related to the gas concentration C from the chemical rate constants k1 and k2 where exponent r has a value between 0.5 and 0.9

$$\Delta G \; \alpha \; \frac{k1}{k2} C^r$$

Potentiometric Gas Sensors:

Field-effect gas sensors based on metal-insulator semiconductor structures in which the gate is made from a gas-sensitive catalytic metal. There are two basic devices, in which the structure is configured as either field-effect transistor or gas-sensitive capacitor. The most common device is an n -channel metal oxide semiconductor field-effect transistor device configured in a common source mode.

When the gate was made of a thin layer of palladium, the atmospheric hydrogen would dissociate and diffuse through to the interface, creating a dipole layer and causing a shift in the threshold voltage. Using a circuit to drive a constant current through the device can be used to sense hydrogen. The solid palladium gate has subsequently been replaced by an ultrathin discontinuous metal film so that larger, less diffuse, molecules can reach the oxide surface and be sensed.

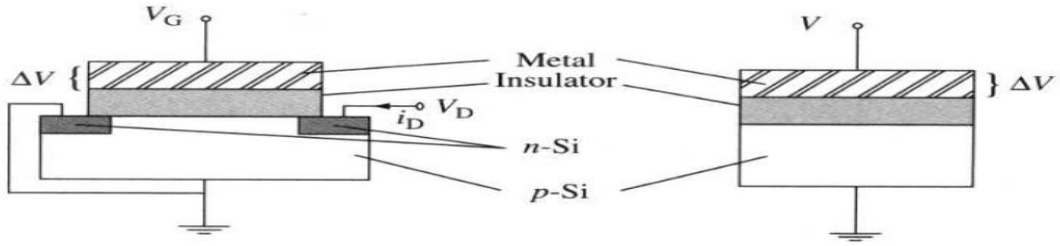

Figure 2: Two types of potentiometric gas sensors (a) n-channel MISFET (b) MISCAP

Motion Detectors:

There are different types of motion sensors such as air pressure sensors, ultrasonic motion sensors, Infrared motion detectors, microwave motion detectors, triboelectric motion sensors, optoelectric motion detectors etc.,

Microwave Motion Detectors:

The microwave detectors offer an attractive alternative to other detectors when it is required to cover large areas and to operate over an extended temperature range under the influence of strong interferences. The operating principle of the microwave detector is based on radiation of electromagnetic radio-frequency. The most common frequencies are 10.525 GHz (X band) and 24.125 GHz (K band).

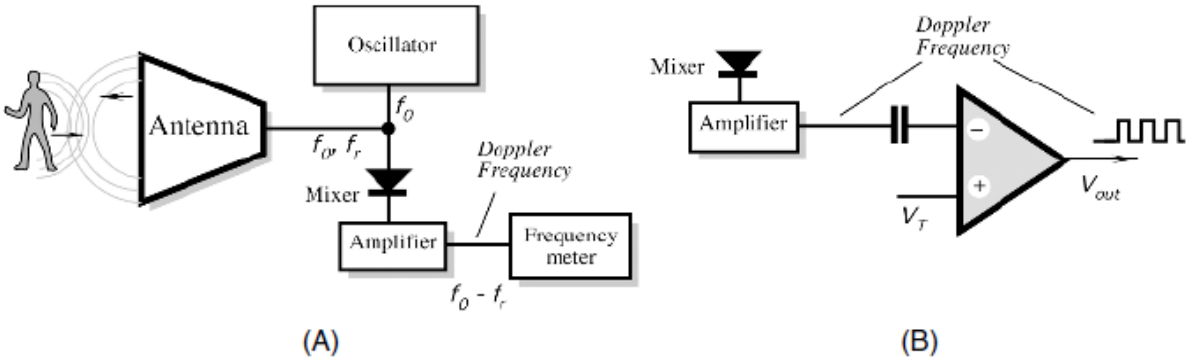

Figure 3: (a) Block diagram of microwave motion detector. (b) Circuit with a threshold detector

The microwave part of the detector consists of a Gunn oscillator, an antenna, and a mixer diode. The Gunn oscillator is a diode mounted in a small precision cavity which, upon application of power, oscillates at microwave frequencies. The oscillator produces electromagnetic waves, part of which is directed through an iris into. The smaller part of the microwave oscillations is coupled to the Schottky diode and serves as a reference signal. The target reflects some waves back toward the antenna, which directs the received radiation toward the mixing diode whose current contains a harmonic with a phase differential between the transmitted and reflected waves. The phase difference is in a direct relationship to the distance to the target. Thus, for the occupancy and motion detector, the Doppler effect is the basis for the operation of microwave detectors.

Triboelectric Motion Detectors:

Any object can accumulate static electricity on its surface. These naturally occurring charges arise from the triboelectric effect (i.e., a process of charge separation due to object movements, friction of clothing fibers, air turbulence). Usually, air contains either positive or negative ions that can be attracted to the human body, thus changing its charge. In other words, an object or humans becomes a carrier of electric charges.

Triboelectric motion detector is composed of a conductive electrode connected to an analog impedance converter made with a MOS transistor, a bias resistor, an input capacitance, a gain stage, and a window comparator. The electrode is exposed to the environment and forms a coupling capacitor with the surrounding objects.

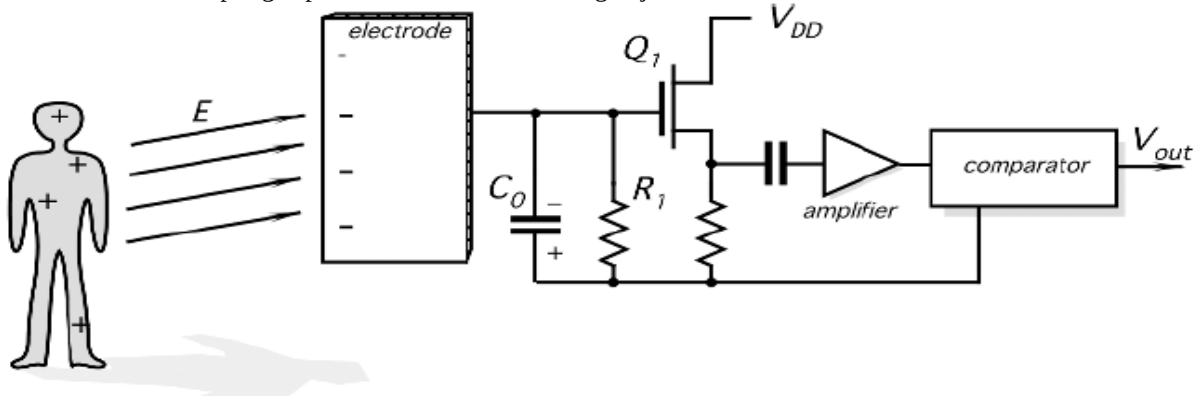

Figure 4: Turboelectric motion detector

If a charge carrier (a human or an animal) changes its position (moves away or a new charge carrying an object enters into the vicinity of the electrode), the static electric field is disturbed. This results in a redistribution of charges between the coupling capacitors, including those which are formed between the input electrode and the surroundings. The charge magnitude depends on the atmospheric conditions and the nature of the objects.

Smoke and Fire Detectors:

A smoke detector is a device that detects smoke, typically as an indicator of fire. smoke alarms, generally issue a local audible or visual alarm from the detector itself. Most smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), while others use both detection methods to increase sensitivity to smoke.

Photoelectric Smoke Sensors:

The principle of using a light source and a photosensitive sensor arranged so that the rays from the light source do not normally fall onto the photosensitive sensor. When smoke particles inter the light path, some of the light is scattered by reflection and refraction onto the sensor. The light signal is processed and used convey an alarm condition when it meets preset criteria.

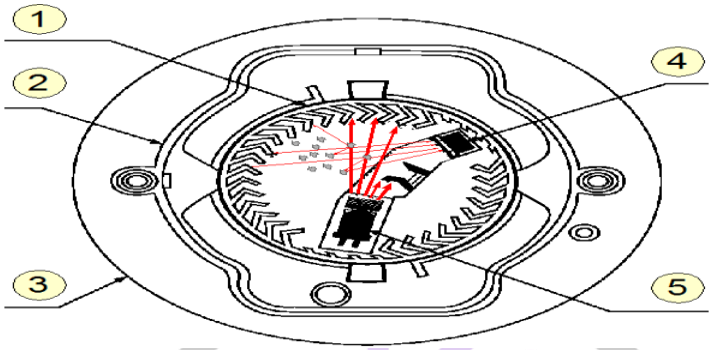

Figure 5: Photoelectric smoke sensor consist of: (1) Optical chamber (2) Cover (3)Case moulding (4) Photodiode (5) Infrared LED

Ionization smoke Detectors:

An ionization smoke detector uses a radioisotope such as americium-241 to produce ionization in air; a difference due to smoke is detected and an alarm is generated. Inside the ionization detector is a small amount of Americium-241. The radioactive element americium has a half-life of 432 years, and is a good source of alpha particles. An ionization chamber is very simple. It consists of two plates with a voltage across them, along with a radioactive source of ionizing radiation.

The principle of using a small amount of radioactive material to ionize the air between two differentially charged electrodes to sense the presence of smoke particles. Smoke Particles entering the ionization volume decrease the conductance of the air by reducing ion mobility.

The alpha particles generated by the americium have the following property: They ionize the oxygen and nitrogen atoms of the air in the chamber. When ionized, you end up with a free electron and an atom missing one electron (with a positive charge). The negative electron is attracted to the plate with a positive voltage, and the positive atom is attracted to the plate with a negative voltage. When smoke enters the ionization chamber, it disrupts this current -- the smoke particles attach to the ions and neutralize them. The smoke detector senses the drop in current between the plates and sets off the horn

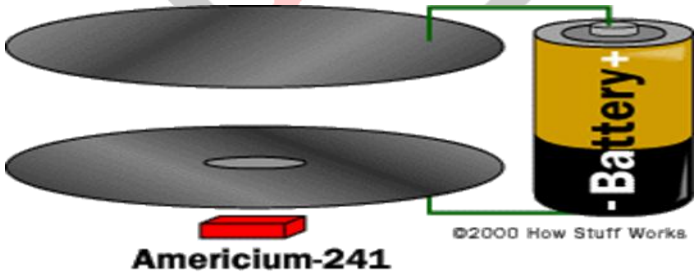

Figure 6: Schematic of an Ionization smoke detector

Sensors for Access Control:

Access control in a home automation system means that electronic access to doors can be provided by electronic door locks, fingerprint keypad lock etc.

Fingerprint Sensors:

Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify individuals and verify their identity.

Capacitive Fingerprint Sensor:

Capacitive fingerprint scanners generate an image of the ridges and valleys that make up a fingerprint. The sensor is made up of one or more semiconductor chips containing an array of tiny cells. Each cell includes two conductor plates, covered with an insulating layer. The cells are tiny -- smaller than the width of one ridge on a finger.

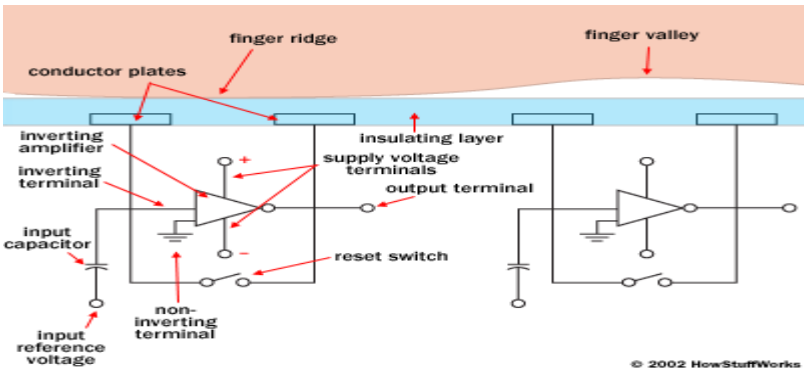

Figure 7: Capacitance fingerprint scanners

To scan the finger, the processor first closes the reset switch for each cell, which shorts each amplifier's input and output to "balance" the integrator circuit. When the switch is opened again, and the processor applies a fixed charge to the integrator circuit, the capacitors charge up. The capacitance of the feedback loop's capacitor affects the voltage at the amplifier's input, which affects the amplifier's output. Since the distance to the finger alters capacitance, a finger ridge will result in a different voltage output than a finger valley. The scanner processor reads this voltage output and determines whether it is characteristic of a ridge or a valley. By reading every cell in the sensor array, the processor can put together an overall picture of the fingerprint.

Sensors for lighting control:

Lighting levels in a room can be controlled according to the light available from natural sources. This can be performed by light detectors. The important types of light sensors are: photodiode, phototransistor, photoresistor.

Photoresistor:

A photoresistor is a photoconductive device. The most common materials for its fabrication are cadmium sulfide (CdS) and cadmium selenide (CdSe) which are semiconductors whose resistances change upon light entering the surface. For its operation, a photoresistor requires a power source. Photoeffect is manifested in the change in the material's electrical resistance

An electrode is set at each end of the photoconductor. In darkness, the resistance of the material is high. Hence, the applied voltage results in a small dark current which is attributed to temperature effect. When light is incident on the surface, the current flows.

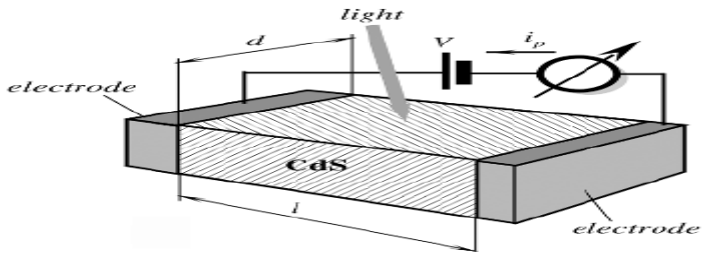

Figure 8: A photoresistor

Phototransistor:

Phototransistor converts the photons into charge carriers and it can also provide current gain, resulting in a much higher sensitivity. The collector-base junction is a reverse-bias diode. If the transistor is connected into a circuit containing a battery, a photo-induced current flows through the loop, which includes the base–emitter region.

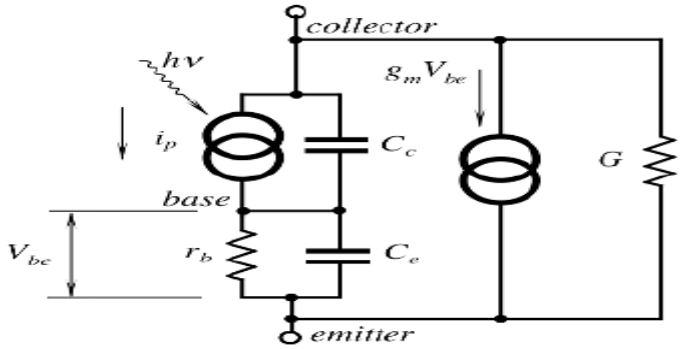

Figure 9: Equivalent circuit of a phototransistor

Photogene ration of carriers occurs in the collector–base region, the larger the area of this region, the greater the number of carriers generated; thus, the phototransistor is so designed to offer a large area to impinging light. A phototransistor can be either

a two-lead or a three-lead device. In the latter case, the base lead is available and the transistor may be used as a standard bipolar transistor with the capability of sensing light.

Temperature Sensors:

The temperature sensors measure the atmospheric temperature and send the data to home automation system which controls the heating, ventilation and air conditioning (HVAC) system inside the house. There are different types of temperature sensors.

Thermocouples:

Thermocouples are formed when two electrical conductors of dissimilar metals or alloys are joined at one end of a circuit. Thermocouples can handle much higher temperatures than RTDs. Typically, they are built around bare conductors and insulated by ceramic powder or formed ceramic.

All thermocouples have what are referred to as a "hot" (or measurement) junction and a "cold" (or reference) junction. One end of the conductor (the measurement junction) is exposed to the process temperature, while the other end is maintained at a known reference temperature. The cold junction can be either a reference junction that is maintained at 0°C. When the ends are subjected to different temperatures, a current will flow in the wires proportional to their temperature difference.

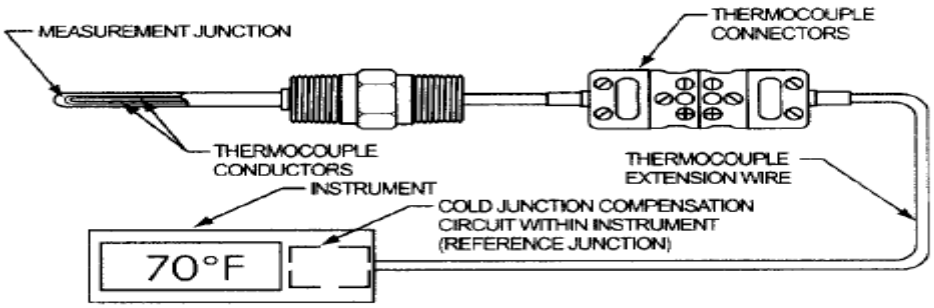

Figure 10: A Thermocouple

Resistive Temperature Detectors:

RTDs employ a change in electrical resistance to measure or control temperature. RTDs consist of a sensing element, connection wires between the element and measurement instrument, and a support for positioning the element in the process. The metal sensing element is an electrical resistor that changes resistance with temperature. The element usually contains a coil of wire or conductive film with conductors etched or cut into it. It is usually housed in ceramic and sealed with ceramic cement or glass.

The sensing element should be positioned where it can reach process temperature quickly. Wire wound devices should be adequately secured in high vibration and shock applications. Extension wires between the element and instrument allow resistance to be measured from great distances.

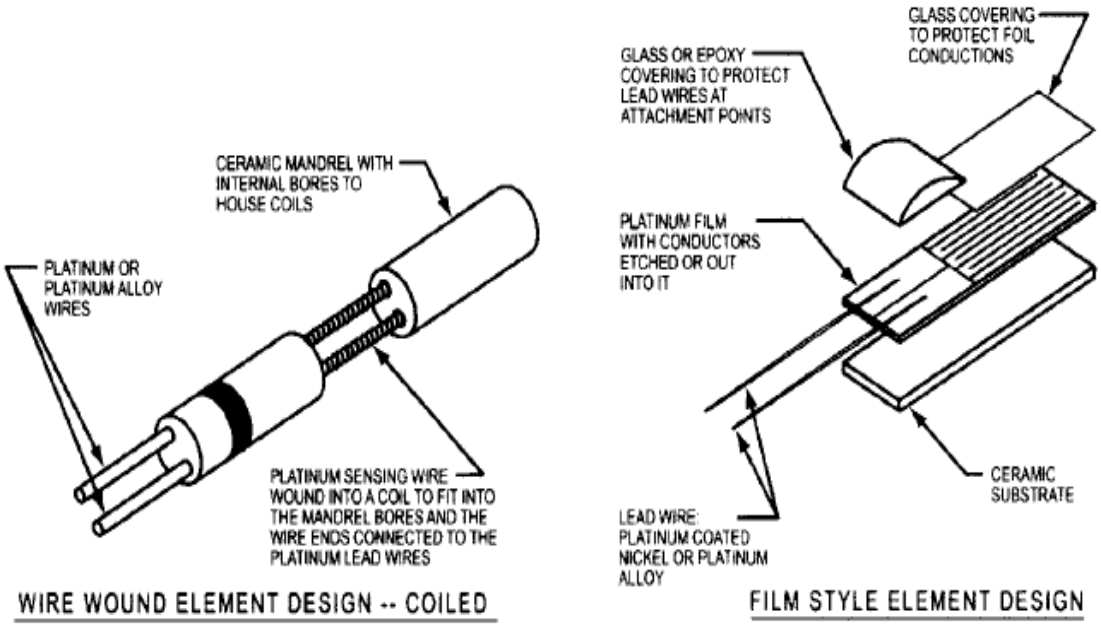

Figure 11: RTDs sensing element designs

Conclusion:

In this paper we looked at the research work related to smart homes from various view point. We proposed the use of home automation as an effective means to reduce consumption of energy and other resources. To that end we suggested several

functions and procedures, and illustrated how home automation can help balance comfort and energy usage, allowing for significant savings

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