SENSORS AND SIGNAL CONDITIONNING

S. Narsinga Rao, [1] Proff. K. Malakondiah (Rtd), [2] Dr. R. Lakshmi Narayana [3]

[1]Research Scholar, Instrumentation Department, SKU, Ananthapuramu, A.P, India,

[2] Proff.K. Malakondiah (Rtd), Instrumentation Department, SKU, Ananthapuramu, A.P, India,

[3]Academic Assistant, Department of Instrumentation, Sri Krishnadevaraya University, Anantapur, A.P.

Abstract

The general problem of sensor signal conditioning is approached from the point of view of separating the intrinsic sensor properties from those associated with inserting the sensor into a conditioning circuit. This gives rise to a check list of attributes which would be useful to localize problems which may arise in using sensing devices. A second part of the presentation provides a survey of traditional sensor conditioning techniques, going from simple analog op amp solutions to sophisticated digital technology using DSP and look up tables of correction coefficients. A final section covers the use of a promising new passive analog technology to adjust resistance values using Rejustor. It is demonstrated that the Rejustor performance compares favourably to its digital counterpart, the digital potentiometer. It is concluded that the Rejustor could provide a simple and elegant solution to many sensor signal conditioning problems.

Key words: Sensor signal conditioning, detectors, Analog sensor signal processor, DSP.

Introduction:

Modern fire detection systems not only apply increasingly intelligent methods to detect fires but also imitate defined processes automatically and provide emergency services on the ground with important information. Early and reliable fire detection using appropriate detectors has top priority. The detection criteria for automatic detectors are determined by the combustion products produced by the fire. Multi-sensor detectors is a great example of how fire detection technologies have evolved over the years. Designed to sense smoke, heat and/or CO, multi-sensor detectors help reduce false alarms by comparing the inputs from the multiple sensors before deciding whether the source of the input is an actual fire or one of many false alarm conditions. Having been established for a number of years, multi-sensor detectors are now being used to replace existing smoke detectors, as well as being the first choice for installation in many new building projects.

The purpose of fire detection systems is to detect a fire in its earliest stage and activate the alarm. From its initial phase, a fire is subject to various conditions, which have different effects on its development. The interaction of fire cause, combustible material and air supply can produce a smoldering fire, an open fire or a combination of the two. The combustion process generates temperatures, fire gases and smoke. The latter can take a variety of forms, from invisible aerosols to black sooty smoke, depending on the combustible material and the progression of the fire. Fire detectors must be able to detect these different fire phenomena characteristics of the fire development quickly and reliably. A number of different detection technologies are applied. They include the following:

Heat detector: This detects high temperature above ambient value and higher rate of temperature rise. These are based on the changes with the increase of temperature due to heat - physical, chemical properties like expansion, variation of electric resistance/capacitance, reaching melting point, insulation failure, loss of magnetic property, occlusion of gases in solid. Heat detectors are made using metal, non-metal, bimetal, liquid or gases as medium for detection.

Fixed Temperature Type: It is one of the most common types of heat detector. Fixed temperature detectors operate when the heat sensitivity eutectic alloy reaches the eutectic point changing state from a solid to a liquid.

• Thermal lag delays the accumulation of heat at the sensitive element so that a fixed-temperature device will reach its operating temperature sometime after the surrounding air temperature exceeds that temperature.

• The most common fixed temperature point for electrically connected heat detectors is 136.4°F (58°C).

• Technological developments have enabled the perfection of detectors that activate at a temperature of 117°F (47°C), increasing the available reaction time and margin of safety. This type of technology has been available for decades without the use of batteries or electricity

Smoke detector: This detects level of smoke particles. Based on optical ability like obscuration, scattering variation in refractive index, photo electric properties, changes in conductivity of ionized air due to presence of smoke particles

Smoke Detectors (Combustion Products) Property damage caused by a fire is directly related to the,

, Intensity of fire: The intensity of fire depends upon the time available for its growth, type and geometrical configuration of combustibles and ventilation.

, Duration of fire: The duration of fire depends upon the quantity of combustible and the point at which extinction process starts.

• Life risk is predominantly posed by hot toxic products of combustion, which travel faster and further than fire. The amount and speed of travel is directly proportional to the intensity of fire.

• In order to ensure life safety and reduce property loss there is a need to detect fire in an incipient stage, which will provide a reasonable interval of time for inmates to escape to a place of safety and extinguish the fire with minimum loss. Smoke detectors are ideally suited for such purpose.

• Smoke detectors basically work on two properties of smoke particle in air:

, The electric conductivity of ionised air varies with the density of smoke particles (aerosols).

, Visibility and path of light through smoky air is reduced, disturbed when compared to clean air..

• They are called ionisation type or optical type smoke detectors, respectively.

Ionisation Type Smoke Detectors It comprises of a chamber housing cathode and anode which are charged through battery source. The air between cathode and anode is ionised in the presence of radioactive elements. Air gets in through the filter to enter the chamber.

• Under the normal circumstances, pre-set current pass through the circuit. Under the fire condition, when smoke enters the chamber through filter by virtue of presence of smoke particles, the electric conductivity of air between electrodes reduces and current pass through circuit lowers down. The lowering of current after the predetermined value sends a signal for fire alarm.

Beam Detectors (Heat and Smoke) these types of detectors are used as a beam of light projected at photo sensing receiver to detect physical changes which occur in the air above fire. Changes could be accumulation of smoke particles at ceiling level as well as disturbance caused by rising hot air or gas currents. It is a combination detector of heat and smoke.

• The system consists of an Emitter Unit producing light beam in infrared spectrum which is aligned to be sensed by receiving unit.

• An emitter and receiving unit are normally fixed in a convenient and readily accessible position on end walls. The emitter unit produces pulses of infrared light which approximately 4 micro seconds in duration and repeated 1000 times per second. The light leaves the emitter unit in form of a beam which spreads up to diameter of 1 metre over the path of 100 metres.

• At the far end of the system is a receiver unit, which by the use of a photo transistor, detects the presence of the infrared light beam. The received signal is then analysed for the presence of smoke and/or heat conditions for alarm.

Smoke Detection The light beam is used as a conventional obstruction type smoke detection system with directly illuminated receiver. When smoke drifts into the space between the emitter and receiver units, the brightness of the received light pulses is reduced and hence the phototransistor produces a smaller output.

• In a comparator circuit the brightness of the pulses at any given time is compared with the brightness of standard light for 10 minutes or so. When a reduction of more than 50% occurs within the duration of this 10 minutes interval, a smoke alarm is initiated.

• As build-up of drift on lenses etc. and small power losses due to misalignment of the beam occur over periods of days rather than minutes, these are automatically compensated for in the comparator circuit.

Flame detectors:

The optical flame detector is a detector that uses optical sensors to detect flames. There are also ionisation flame Electromagnetic Radiation Fast Response Detector Conventional devices like heat and combustion detectors required a definite increase in the temperature of the atmosphere or production of visible or invisible aerosol. In the case of heat detectors, the rate of rise of temperature will be slow due to low energy level in the fire while combustion into the detector.

• This shows that combustion detector can operate only when the fire develops into such a size as to produce sufficient energy to accelerate the products of combustion through the layer of warmer air in the vicinity of a detector.

• Therefore, there has to be a time lag necessarily between the incidence of fire and detection. Experimental data available also indicate that the response time of these detectors range between 40-300 seconds depending on the distance between source of fire and detector and the nature of material involved in the fire detectors, which use current flow in the flame to detect flame presence and thermocouple flame detectors.

Advantages of multi-sensors detectors

High Current Capability

Low Cost

Familiar "Low-Tech" Sensing

Sensor all kinds of materials

Long life

Longest sensing range

Very fast response time

Resistant to harsh environments

Very predictable

Long life

Easy to install

Detects through some containers

Can detect non-metallic targets

Senses all materials

Conclusions:

A fire sensor system based on the simultaneous detection CO, CO_2, and smoke concentrations, is demonstrated. The rates of increase of these three components are used in the fire alarm algorithm to determine the presence of a fire. The algorithm monitors the rate of increase of smoke level, and when this rate exceeds its threshold rate, the rates of increase of CO and CO_2 concentrations are checked. When either the rate of increase of CO or CO_2 concentration exceeds its threshold rate, a fire alarm is initiated. The fire detection system was found to perform better than a smoke detector operating alone. In cases where the smoke detector did not alarm, the algorithm was able detect the fire. However, in cases where the smoke detector did alarm, the Final Manuscript submitted to the Fire Safety Journal Chen et. al., Fire detection using smoke and gas sensors 15 algorithm detected the fire in a much shorter time. The nuisance sources did not cause the fire detection system to generate false alarms. An advantage of the fire alarm algorithm is that the signal to noise ratio for the temporal derivatives of measurements improves more rapidly with increasing time window length than does the signal to noise ratio for the mean of data points within the time window; this allows the alarm threshold to be set at a more sensitive value without causing noise-generated false alarm. A second advantage is that the alarm point is insensitive to constant offsets in the gas concentration measurements. Although, the fire detection system was originally conceived to be deployed in cargo compartments of aircraft, it can also be applied to buildings, ship compartments, submarines, living compartments in space, and concealed cavities used for running electrical wires and plumbing. Future work will focus on the improvement of the minimum detection of CO and CO_2 concentrations by using separate lasers for each chemical species, and selecting stronger absorption lines where these two chemical species do not overlap.

References:

[1] Gagnon, R.M., 1997. Design of Special Hazard & Fire Alarm System. Delmar Cengage Learning.

[2] National Fire Protection Association. [Online]Available at: [Accessed 11 April 2011].

[3]Nolan, D.P., 2000. Encyclopaedia of Fire Protection. Thomson Delmar Learning

[4] Maurice, J.A., Jr., 2008. Fire Protection Systems. Cengage Learning Technology & Engineering.

[5] Fire Detection & Protection System. [pdf] Available on: [Accessed 12 April 2011].

[6] Blake, D. (2000), Aircraft Cargo Compartment Smoke Detector Alarm Incidents on U.S.-Registered Aircraft, 1974-1999, DOT/FAA/AR-TN00/29.

[7] Blagojevich M., Petkovich D., and Simich, D. (2001), New Algorithm for Adaptive Alarm Threshold in Fire

Detection System, 12th International Conference on Automatic Fire Detection.

[8] Milke, J. A. (1999), Using Multiple Sensors for Discriminating Fire Detection, Fire Technol. 35:195-209.

[9] Gottuk D. T., Peatross M. J., Roby, R. J., and Beyler, C. L. (2002), Advanced Fire Detection Using Multi-Signature Alarm Algorithms, Fire Safety Journal 37:381-394.

[10] Marman, D. H, Peltier, M. A., and Wong, J. Y. (1999), Fire and Smoke Detection and Control System, US Patent No. 5,945,924.

[11] Rose-Pehrsson, S. L., Hart, S. J., Street, T. T., Tatem, P. A., Williams, F., Hammond, M. H, Gottuk, D. T., Wright, M. T. and Wong, J. Y. (2001), Real-Time Probabilistic Neural Network Performance and Optimization for Fired Detection and Nuisance Alarm Rejection, 12th International Conference on Automatic Fire Detection