Remote Monitoring of A Static Surface Temperature Using Li-Fi

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Abstract- In advance process control system continuous temperature monitoring is one of the key parameters. Sometime it is required to measure the temperature over a wide range from -200 to 800 degree centigrade with acceptable accuracy, low cost and low power consumption. Platinum Resistance Temperature Detector along with Light Fidelity commercially called as LiFi system which uses infrared light or visible light is one of the available choices for continuous monitoring of temperature. Keeping eye on industrial control. The proposed system ensures safety and operation of man machine and material from high temperature. In this paper PRTD used for temperature acquisition and a LiFi is used for data transmission is discussed and a corresponding scheme is proposed.

Keywords- PRTD sensor, infrared light, Light Fidelity, Surface temperature

I. INTRODUCTION

LiFi commercially known as Light Fidelity was introduced first time by Prof. Harald Haas on July 2011. LiFi is a wireless communication technology that uses the infrared and visible light spectrum for high speed data communication. LiFi, extends the concept of Visible Light Communication (VLC) to achieve high speed, secure, bi-directional and fully networked wireless communications. The LiFi wireless communication system along with a temperature sensor is proposed to monitor the surface temperature continuously. The LiFi transmitter transmits the digital data using light signal produced BY a LED. The remotely placed receiver receives the digital data in the form of light SIGNAL and processes it to detect the original temperature information.

There are four types of temperature sensors that are most commonly used in modern-day instrumentation. Thermocouples, resistance temperature detector (RTD), thermistors, and semiconductor based integrated circuits (IC). Thermocouples are the most commonly used temperature sensor in industrial, automotive, and consumer applications. Thermocouples are self-powered, require no excitation and have a quick response times but highly non linear response.

Thermistors have wide temperature range similar to RTDs but it has a non-linear temperature resistance. This requires a significant correction to interpret the data correctly.

Semiconductor-based temperature sensor is usually embedded on Integrated Circuits (ICs). It consists of two diodes with temperature versus voltage characteristics that can be used to monitor changes in temperature. They offer a linear response but have low accuracy.

An RTD is a resistor with well-defined resistance vs. temperature characteristics. Platinum is the most common material used to make Platinum RTDs because they offer a near linear response to temperature changes. They are stable, accurate and provide repeatable responses and have a wide temperature range.

II. BLOCK DIAGRAM OF PRTD BASED LiFi SYSTEM

The System consists of PRTD sensor data transmitter and a remotely placed receiver. The transmitter part consists of a PRT based temperature sensor, analog to digital converter and a light transmitter. The remote receiver consists of a photo detector, demodulator, processor and a display.

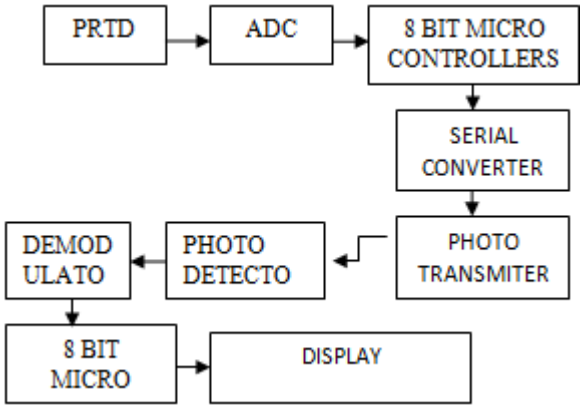

Fig.1 Block diagram of PRTD based LiFi system

III. OPERATIONAL CONCEPT

A four wire PRTD temperature sensing element is used for accurate measurement of temperature. A precession

reference voltage is supplied to PRTD and Analog to Digital Converter (ADC). The expression of Voltage across the PRTD is given by

$$V_{RTD} = V_{REF}\left(\frac{Rt}{R_a + R_t}\right) \quad (1)$$

V_{REF} is the ADC voltage reference.
Rt is the resistance of PRTD at t °C.
Ra is the resistance of the current limiting resistor.

A 24-bit ADC MAX11200 is connected to the PRTD (PTS1206) for converting the analog data to digital data. The PRTD connected to the Analog to Digital Converter (ADC) because of its higher resistance. The PRTD measure the temperature accurately and ratiometrically. The resolution of PRTD is about 0.000926°C per 1 bit change in LSB and a noise-free resolution of 0.0073°C per 1 NFR for a temperature range of -55 C to 155 C.

A 48-MHz 8 bit processor with 24-MHz internal bus frequency process the digital data from the ADC as per the instruction set. With added background instruction, Background debugging system Breakpoint capability it allow single breakpoint setting during in-circuit debugging (plus two more breakpoints in on-chip debug module). Maximum bus loading, multi-master operation, programmable slave address, interrupt-driven byte-by-byte data transfer, 10-bit addressing and broadcast modes are the key features of the processor for the efficient operation.

An Infrared light emitting diode (IR LED) is a special purpose LED usually made of gallium arsenide or aluminum gallium arsenide which emit infrared rays ranging from 700 nm to 1 mm wavelength. Different IR LEDs produce infrared light of differing wavelengths, just like different LEDs produce light of different colors. IR LEDs are in complement with IR receivers for data transmission and reception. Hence these are commonly used as sensors. The Bragg reflector reduces the absorption by the substrate and helps to achieve high external quantum efficiency. The emission spectra are, however,

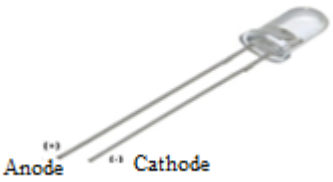

Fig. 2 Infrared LED

Oscillating as a result of the interference of the light reflected by the emitting surface and by the Bragg reflector. The oscillation was removed by coating an anti-reflecting layer on the surface. An output light power of 8 mW operated at 50 mA was obtained, which is four times higher compared with the case of no Bragg reflector.

It is necessary to modulate the emission from IR diode to use it in electronic application to prevent spurious triggering. Modulation makes the signal from IR LED stand out above from the noise.
In receiver side the the IR photodiode is sensitive to the IR light emitted by an IR LED. The photo-diode's resistance and output voltage change in proportion to the IR light received. It is a reverse biased PN junction diode. When photo diode is exposed to light, electrical resistance across the diode decreases there by increasing the reverse current. If the photodiode is not exposed to light, resistance across the diode will be high thus reverse current will be extremely small and Called as dark current. The modulation capability of a LED is described with optical power and electrical current. The LED's optical power output can be linearly modulated with a small input voltage signal.

A photodiode is a semiconductor device that converts light into an electrical current. The photo diodes capability to convert light energy to electrical energy is called quantum efficiency and it is a function of layer thickness, dopping, operating wavelength and absorption coefficient. The current is generated when photons are absorbed in the photodiode. The response time of the photo diode depends on its surface area. As surface area increases the response will slow.

Fig. 3 IR photo diode

Responsivity is the ratio of radiant energy incident on the photo diode to the photo current output. It is expressed in ampere per watt. Spectral Sensitivity of a photo diode gives information about the maximum electrical energy on a particular wave length. The curve, in the device's datasheet tells the sensitivity of the photo diode. From the figure the

output of the photo diode will be maximum at the spectral wave length of 800nm.

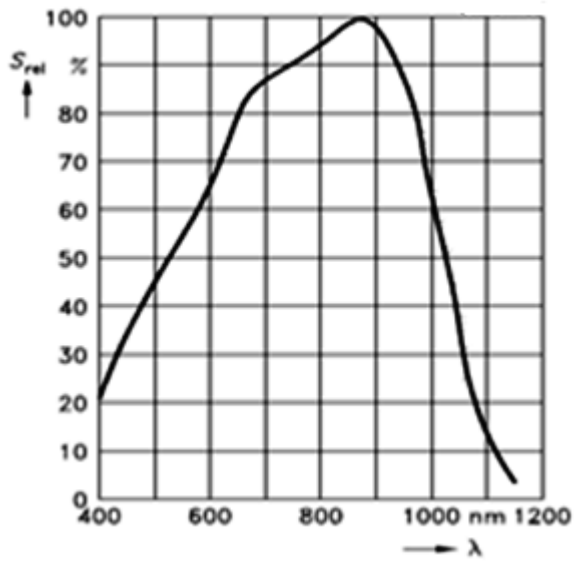

Fig. 4 Spectral sensitivity graph IR photo diode.

The demodulator generates a pulse modulated signal, and decoded by the 8 bit microcontroller. The parallel data output from the microcontroller connected to the display for temperature information. The information is also available in RS232/422 format for further processing and analysis. It can also interface with the distributed control system (DCS) for overall monitoring. The PRTD along with the transmitter module kept in a thermal insulated box and attached with the hot surface. To minimize the outside radiation interference the IR LED kept in a secure position. The receiver module is remotely placed within the range. Keeping eye on safety of man and material continuous temperature data monitoring is possible with this proposed system.

IV. APPLICATIONS

In a heat exchanger heat transfer takes place between the hot body and the cold body. Monitoring of both input and output temperatures is important for the process control. The proposed system helps to monitor input and output temperature remotely.

The temperature of the plant and the controls on the machinery are directly reflected in the energy costs. If it fails to regulate the temperature, the machine will run too hot or the plant's heating and cooling system will interrupt. So regulating the temperature controls can mean significant savings in energy costs.

The temperature controls can also change the materials being used to create the product. The coefficient of expansion is a well known phenomenon among metal manufacturers. This measurement is the amount of variation that a metal will have in size per degree of temperature added or subtracted. In such processing precise measurement are essential and the proposed system can help to obtain accurate temperature measurement.

The temperature monitoring is becoming more and more important in a lot of industries, like food industry, the laboratory, and pharmaceutical industry or even in environmental monitoring.

In food processing industry food products have to be kept at designated temperatures to ensure the freshness of the food for safe to eat. So keeping a close eye on temperatures is vital. This applies to the storage areas, such as the fridges or freezers and preparation.

The temperature monitoring is also important in the laboratory and pharmaceutical industry. A lot of storage and testing environments, including fridges and freezers and even the lab, need to be kept at set temperatures which can be monitored by proposed system

Continuous monitoring of the outer surface of the boiler, furnace, steam pipe, furnace exhaust is vital for monitoring the thermal process. IR based remote monitoring is helpful to archive this keeping eye on safety parameter.

V. CONCLUSION

The LiFi based temperature sensor is useful in the temperature controlled operation in industrials environment. The PRTD has been used as a temperature measuring system which has a wide range depending on the types chosen (-200° C to + 850° C) and satisfactory accuracy. The LiFi based communication system transmits the digital information of temperature to a remotely placed receiver. The combination of these sensor and data transmitter through LiFi ensures continuous monitoring of temperature and safety of persons. This will be providing a platform of automation in industrial process operation.

VII. FUTURE SCOPE

In this proposed system, any obstacle in the path of light interrupts the data transmission. Further, interference due to hot surface radiation can be minimized by transmitting the data using light signal with band limitation so that proximity range of the receiver will improve and environmental interference will reduce. Different types of

sensor can also be integrated in this proposed system facilitating distributed control of system operation.

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